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The Origins and Evolution of S^2C at Sandia National Laboratories: 1949 to 1996

William L. Stevens
Consultant to Surety Assessment Center, 12300
Sandia National Laboratories
Albuquerque, New Mexico 87185

Printed September 2001

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The Origins and Evolution of S²C at Sandia National Laboratories: 1949 to 1996

William L. Stevens
Consultant to Surety Assessment Center
Sandia National Laboratories
PO Box 5800
Albuquerque, New Mexico 87185-0428

Abstract

This report captures in an unclassified manner some of the events and conditions that account in major part for the ways that certain disciplines associated with the U.S. nuclear weapons program arose. The disciplines are three: nuclear weapon and weapon system safety, security, and use control, collectively called S^2C. The focus is on the cultures that existed at the time, so current observers can better understand origins and evolutions. Particular attention is given to explaining why Sandia National Laboratories did certain things (mostly to make particular technical choices) the way they did when other options either were available or would seem to have been so.

[redacted]

ABOUT THE AUTHOR

This report is derived from my three-decade career specializing as an engineer involved in a specific aspect of the U.S. nuclear weapons program; namely prevention of accidents, incidents, and other unwanted events that could have disastrous effects on the viability of national security. This concern became termed S^2C, for Safety, Security, and Control. My career interest began in 1952 when I was assigned as a commissioned officer in the U.S. Army's first battalion doing the ordnance tasks for the nuclear artillery shells, missile warheads, and demolition munitions being transitioned from R&D to the national stockpile of nuclear weapons.

After a brief postwar return to engineering for a major petroleum corporation, I reentered my career interest by gaining employment at the Sandia Corporation, the AEC facility that was to become the Sandia National Laboratories. Early assignments were as a project engineer on development of the nuclear warhead for the nation's first long-range ballistic missile system, during the crisis mood of the sputnik era, and later on development of a large strategic bomb. Gradually, my assignments turned toward technical management in nuclear safety—first for the AEC/DoD safety study process that treated the entire human-machine weapon system and later for the design of the nuclear weapon entity of those systems.

Over the years, I was drawn into support work for the staffs of several major interagency national-level studies that considered the future roles and missions of the civilian and military agencies in the nuclear weapons program, focusing on the institutional, infrastructural aspect of S^2C. My principal assignment, however, was in leading evolution of an innovative design concept that was to provide highly significant enhancement of the level of nuclear detonation safety in the national stockpile.

Shortly before retirement in 1985, I was honored to receive the DOE Weapons Program Award for Excellence for contributions to safety. I have been privileged to continue my involvement in this program as a consultant to Sandia's principals in S^2C. This report is one product of my work for the last decade as a consultant.

TABLE OF CONTENTS

LIST OF FIGURES

PREFACE

The goal of this report is to capture in an unclassified manner some of the events and conditions that account in major part for the ways that certain disciplines associated with the U.S. nuclear weapons program arose. The disciplines are three: nuclear weapon and weapon system safety, security, and use control, collectively called S^2C. Each discipline is defined in the ***Introduction*** section of this report. The focus is on the cultures that existed at the time, so current observers can better understand origins and evolutions. Particular attention is given to explaining why Sandia National Laboratories did certain things (mostly to make particular technical choices) the way they did when other options either were available or would seem to have been so.

This working paper is a living document in that it is continually subject to revisions in order to reflect input from persons selected to review contents. A record of these revisions will be kept in the SNL Surety Assessment Center.

The style of presentation is personal, informal and candid, citing specific contributions of named persons. A limited number of such persons are identified as having been "key" to the success of Sandia's efforts in S^2C, and their contributions are summarized in biographical sketches as an appendix. In the interests of timeliness and economy, I have made liberal use of extractions from other documents that I wrote while on-roll at Sandia or as a consultant, hopefully with enough bridging paragraphs to achieve reasonable coherence.

Originally I drafted this report for wide dissemination within the nuclear weapons community, as Official Use Only. In the course of reviews, I learned that the rather comprehensive level of detail called for a higher security classification. Accordingly, the report exists in two versions: a classified report SAND99-1803 and this pared down report. For readers with appropriate access, I recommend the classified version that contains more detail and the outcomes of certain contentious but classified events.

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FOREWORD

Certain facts, general beliefs, and convictions guided the behavior of the Sandians who played major roles in this story.

- A Moral Equivalent of War. The nuclear weapons program was seen as a moral equivalent of war, to adapt President Lyndon Johnson's characterization of the War on Poverty of the late-1960s. Sandia's early leaders came mostly from military, national defense contractor, or Manhattan Project service and knew well the urgency of national security. They understood that the national policy was to substitute nuclear weapons systems for massive deployments of conventional forces long before this was apparent to the public. Their constant reminder was the Directive Schedule—a time schedule for delivery of nuclear weapons to the military services set by the Atomic Energy Commission and its successors. This schedule was based on the Nuclear Weapon Stockpile Memorandum; a document prepared annually for personal approval by the President of the U.S. The Directive Schedule provided the essential link between Sandia's internal projects and its overriding charge "to render an exceptional service in the national interest" (Ref. 1, Frontispiece). The delivery dates and rates were taken as absolute requirements and the record for meeting them is unblemished to my knowledge.

  NOTE: The record of the AEC/ERDA/DOE in meeting the delivery date critical to the operational deployment of the applicable weapon system was challenged during one of the periodic reviews of roles and missions of that agency and the national defense establishment. Sandia's Robert L. (Bob) Peurifoy and Richard (Dick) N. Brodie prepared a documented account that every "slip" in schedule was attributable to another agency. This finding effectively ended a contentious situation that could have led to a change in basic responsibilities among the agencies (Ref. 52, Appendix C).

- Continuity of Effort. The weapons R&D portion of the U.S. nuclear weapon program was funded and managed under auspices of the Joint Committee on Atomic Energy at a relatively constant (in real dollars and manpower) level during the several decades after the first moratorium on full-scale nuclear testing in 1958. This practice was more or less continued by successor congressional and executive agencies. To most Sandians, this reinforced the notion that the task and, therefore, their lifetime careers were continuous. There would be a Mark N+1 to follow the Mark N bomb or warhead that challenged one now (see Figures 2 and 3). Also, you would still be on roll and be sought out should stockpile experience eventually reveal a design or production flaw on one of your earlier projects. It was jokingly said that you just couldn't bury your past mistakes deep enough.

- Stewardship of the Stockpile. The U.S. nuclear weapons program was born and grew under concepts of civilian custody and control of the national stockpile. To most Sandians involved in the weapons mission, this generated a sense of trust and responsibility that extended beyond the day-to-day tasks of working cooperatively with the single ultimate customer: the national defense establishment that consists of the military service(s) that would actually deploy the weapons and the Department of Defense (DoD) agencies and offices that would manage the overall national security posture. Personnel assignments in the military and executive appointments in the DoD tend to be relatively brief in tenure and high turnover is often the rule. Stewardship was enhanced by the career continuity provided in the civilian agencies.

- Challenges to Roles and Missions. Roles and missions assignments in the U.S. nuclear weapons program over the years may be characterized as somewhat ambiguous and impermanent. While at any given time responsibilities might seem clear, the interagency arrangements could easily be challenged and changed for the tasks on the horizon when improved weaponry capabilities could be promised. To most Sandians, this meant roles and missions had to be earned in a competitive arena by demonstrating high performance on each task and continuing onto the next opportunity. No role or mission could be considered permanent.

- Ethos. Readers interested in gaining an appreciation of the ethos of Sandia in 1985 are referred to the document "*Ethos*" (Ref. 172). This excellent work prepared by Sandia's on-roll historian, Necah Furman, for the annual Fall Management Conference contains sections on genesis, evolution, ethos, lines of business, image to outsiders, differences among the laboratories, relationships with Bell Telephone Laboratories, and destiny. The document is available in the Sandia library.

- Tasks of National Importance. To my knowledge, Sandia did not have an official statement of objectives until the 1980s. I recall drafting one for Vice President 1000 Glenn A. Fowler at his request in 1968, and I responded to his counsel to produce the following:

"To maintain advanced technological laboratories and programs which will continue to make important contributions to the nuclear weapons capability and the general welfare of the United States."

When faced with a decision as to whether or not to pursue a prospective new R&D initiative, the first test for Sandia was that it clearly must be of high national importance.

Certain considerations have evolved over the years to guide execution of the S^{2}C part of Sandia's roles and missions. These variously became policies, practices, principles, themes, threads, attributes or the like; and this report is mostly concerned with how they played in the story. The following listing is not necessarily complete nor is it in any particular meaningful order.

1. Specialty. Nuclear weapons are considered special rather than as an alternative to conventional weaponry (Witness: the Armed Forces Special Weapons Project was the name given successor to the military's group that succeeded a part of the Wartime Manhattan Project). The risks inherent in their existence are apart from the common.

Attempts to compare them to other risks in human experience are at best counterproductive. For example, although both nuclear weapons and civilian nuclear power reactors use certain radioactive materials, the implications of a serious accident would seem to defy any meaningful comparison. Nevertheless, bureaucratic interests continually have been tempted to institute such "standards."

2. <u>Standards for Achievement of S^2C Goals.</u> Elements of nuclear weapon S^2C are measured qualitatively and quantitatively against an agreed-upon threshold of acceptable risk of occurrence of certain unintended events (e.g., accidents or loss of possession). Such thresholds must be reached before a weapon or weapon system can be deployed and agreement as to that achievement must extend to the President of the United States. Whereas warm feelings may be generated by characterization of risks by terms such as "small, but finite," "vanishingly small," or "virtually impossible," the public must be encouraged to realize that risks cannot be zero and cannot ever be really known.

3. <u>No Premium for "Safer."</u> Given existence of agreed-upon thresholds of acceptable risk, there should be no justifiable need to expend critical resources for exceeding the threshold. Said another way, there should be no reward for promoting one design approach over another on the assertion that one is "safer." Instead, both must reach the threshold and then competition can proceed on the basis of other important considerations such as cost, size, weight, etc.

4. <u>Conditions for S^2C Assessments.</u> Within an agency having responsibilities for S^2C assessments, three conditions have proved to be essential:

   - unswerving commitment of agency management at all levels,
   - a degree of independence on the part of the staff performing and presenting the assessment, and
   - deep immersion of that staff in the sciences and technologies relevant to the endeavor (not just the assessment methodology).

   Of these three conditions, the last named is most important.

5. <u>S^2C is a Line Responsibility.</u> This condition may be self-evident from the above; however, a test may help to illustrate. The director of the laboratory, not some subordinate staff person, should present the statements on adequacy of S^2C in national-level arenas. This is done by means such as specific testimonies and reports to the Congress and the executive branches of the federal government.

6. Directness of Remedial Actions. Owning up to existence of deficiencies in S^2C that become evident upon review of new information is an attribute to be rewarded and providing remedial measures promptly (and usually at absorbed financial costs) is expected. This process can involve agency embarrassment, but this must be done in an open way (e.g., it may be necessary to "redline" a weapon type and thereby recommend standing down its deployment until retrofit hardware or other corrective measure is in place).

1. INTRODUCTION

1.1 Definitions

The term Nuclear Weapons Surety (coined some forty years after the first nuclear weapons were employed to end World War II) is of relatively recent origin. The elements of surety have been defined and emphasized sequentially, as national and world events caused changes in the roles that nuclear weapons played.

Reliability was the initial concern. Since the amount of fissile material (enriched uranium or plutonium metal) available in the 1940s was sufficient to make only a few weapons, each nuclear weapon would have to work properly in intended use (war) with high confidence. Weapon designers at Los Alamos Scientific Laboratory (LASL) adopted a goal that the probability of a weapon not producing the full yield for intended use should be less than one in fifty thousand uses, or in probability notation 2 in 100,000 or 2×10^{-5}. This low-"dud" rate at the time perhaps represented the extreme of technological capability and called for measures uncommon to weapon ordnance experience. Designers turned to the practice of redundancy for the component parts of the weapon, i.e., the use of duplicate components in ways that reduce the probability of system failure even if one of the two or more duplicates fails in use. Redundancy was essential because some of the components used in the weapon's electrical subsystem were devices produced for ordinary commercial applications (e.g., spring-powered clock timers from household ovens) or for military applications (e.g., tail-warning radar from bomber aircraft) and had relatively high-dud rates. The practice of redundancy also extended to the nuclear subsystem of the weapons by making the electric detonators that began the compression process for implosion-type bombs have dual (two, connected in parallel) bridgewires.

By the early 1950s, the amount of fissile material available to produce nuclear weapons was increasing and was projected to reach levels that would support a larger stockpile of nuclear weapons. The question of a proper reliability goal was posed by LASL's Director, Norris Bradbury, in anticipation of this significant change in U.S. nuclear weapon posture. Bradbury teamed with the DoD's Chief, Armed Forces Special Weapons Project, Major General Kenneth Nichols, to assign the study to the existing joint Weapons Reliability Committee (Ref. 1). Study participants included Dr. Norris Bradbury; Dr. Hendrik Bode, Director of Mathematics at Bell Telephone Laboratories (BTL) and a national pioneer in the discipline that later became "Systems Analysis," and Dr. Walter A. MacNair, Vice President for Systems Research at Sandia (formerly at BTL) as Chairman. Findings declared that nuclear weapons indeed had "special" character in comparison to conventional weapons, especially that nuclear weapons had "a fundamental and unavoidable complexity" and a reliability "not subject to verification" short of use in war. The new reliability goal was determined to be 1 in 100, 10^{-2} per weapon-use—a reduction of several orders of magnitude that would greatly simplify certain areas of weapon design and production.

The Weapons Reliability Committee's report had several impacts that led to certain management practices for reliability and the subsequent elements of surety:

- Reviews by high-level authorities in both the civilian and the military agencies of the national nuclear weapons community are needed as significant changes in policy, practice, technologies, and other events occur. This report describes the series of such reviews that have been conducted over the years, some under presidential auspices.

- Technological disciplines may be needed to handle the concerns derived from surety considerations. In 1951 Sandia began to create and sustain a reliability-assessment specialization concentrated in a single organizational entity configured to have a measure of "independence" from line organizations.

For this report, the notion of probability of occurrence of a specific, unwanted event serves to define all elements of surety, although the goal is not always defined in quantitative terms. Thus,

- Reliability = the probability of success in intended use of a nuclear weapon.

- Delivery Crew Safety was the next concern to develop as the size and variety of the stockpile grew. The concern was the safety (freedom from harm) of the crew after release of a bomb from the delivery bomber aircraft. During the trajectory to the target, the bomb's status changes from a ready-to-release condition wherein a series of arming components is still in place to interrupt the sources of electrical power from the bomb's fuzing and fixing components. At and after intended release, one-after-another of the series elements becomes armed (able to pass electrical signals), awaiting a signal from the fuzing components to detonate the weapon. If the detonation were to occur prematurely at a position above the target, the bomb's blast or nuclear radiation effects could destroy or seriously disable the aircraft—a crew safety concern.

- The mathematical and statistical techniques developed by Sandia were applicable to crew safety calculations, and a quantitative probability goal evolved for the agencies of the military services that wrote the requirements documents given to weapon designers. Later, it was recognized that the crew safety criterion applied in concept to the risk of a premature nuclear detonation on other friendly forces (a "flare dud" in the sense that it missed the target).

- Premature Detonation = the probability of a premature detonation in intended use of a nuclear weapon such that the resultant effects disable the delivery system or other friendly forces, given the occurrence of intentional release-to-the-target.

- The nominal quantitative goal became 1 premature detonation per 1,000 releases, or 10^{-3}. For some special situations, the goal became 10^{-4}.

- Nuclear Detonation Safety was the next concern to arise with the essentially concurrent events of introduction of a fundamentally different weapon design and of deployments of nuclear weapon systems from sites in the Continental U.S. and afloat to forward bases in European and Pacific Theaters.

Until the advent of the sealed-pit type of implosion nuclear weapon in the mid-1950s, nuclear detonation safety in peacetime was not a consideration. The fissile material was controlled by containing it in a capsule that could be placed inside a hollow pit or projectile/target assemblies, thus keeping it separated from the rest of the nuclear weapon ordnance hardware. This control was absolute, not probabilistic, for all conceivable situations except deliberate, unauthorized human actions. Even the latter required the military to somehow obtain the fissile material assembly from the civilian (Atomic Energy Commission) agent holding its custody in a co-located facility. The fissile material assembly was to be inserted into the weapon only in preparation for war, actually in the bomb bay of the delivery aircraft. Some later weapon designs had an in-flight insertion mechanism able to insert fissile material in a subcritical assembly into the pit using mechanically driven screws. The physical separation even in this high-readiness configuration provided a high degree, but not absolute degree, of safety. As the pit assemblies came to contain more-and-more fissile material to meet military requirements for high yields, the margin of safety decreased.

With the sealed-pit type of design that was attractive mainly because of a significant improvement in efficient use of fissile material, the fissile material was sealed inside a shell of high explosive during the weapon production process. The probability that this assembly could produce a nuclear detonation spontaneously or as the result of a credible physical insult such as in a severe accident situation became the controlling factor. As is treated later, this probability was set at a threshold of acceptable risk of one nuclear detonation in one million per exposure, 1 in 1,000,000 or 10^{-6}. The definition of an acceptable detonation was one in which the contribution of the fissile material reaction to the total yield would not exceed four pounds TNT-equivalent. The weapon electrical system was designed to have a probabilistic goal commensurate with that provided for the sealed-pit assembly.

> NOTE: In 1974, in conjunction with the controversies of the Fowler letter (page 115), James (Jim) D. Appel wrote a historical review of numerical nuclear detonation safety requirements specified by the DoD in Military Characteristics documents. For the earliest sealed-pit weapons, the requirements were in the range of 1 in 20,000 to 1 in 100,000 (Ref. 176).

Thus, definitions were:

Nuclear Detonation Safety (1952-1968) = the threshold probability of occurrence of a nuclear detonation due to spontaneous or accidental causes.

Security was a concern from the beginning of and throughout the U.S. nuclear weapons program, and we focus here on physical security.

Security (Information) = the probability of loss of critical design or operational use information such as to endanger national defense capability.

Security (Physical) = the probability of loss of physical possession of a nuclear weapon to entities that could endanger national defense capability.

Use Control became a serious concern in the late-1950s when the realities of forward deployment of U.S. nuclear weapons to non-U.S. NATO nations came to be appreciated to contain new elements of risk of deliberate, unauthorized use. Control of the risk of such use has been considered to be threat-dependent and is treated by threat scenarios that cannot meaningfully be defined probabilistically. Conceptually, however:

Use Control = the probability of an adversary entity being able to produce a nuclear detonation, given failure of physical security measures.

Plutonium dispersal safety was a concern upon the advent of the sealed-pit design, since detonation of the weapons high-explosives subsystem would aerosolize and disperse plutonium oxide in a respirable form known to be capable of producing cancer in those persons inhaling particles of small aerodynamic size.

Plutonium Dispersal Safety = the probability of a high-explosive detonation of a nuclear weapon of the sealed-pit type caused by an accident such that the resultant plutonium oxide particles can be inhaled by persons in the vicinity and downwind.

This issue came to public attention after the nuclear weapon accidents at Palomares, Spain, in 1966 and at Thule, Greenland, in 1968. This type of safety became an issue attendant to the debates on the planned deployment antiballistic missile (ABM) systems near major cities of the late 1960s.

Safety, Security and Use Control, S^2C refers to the process of managing the three areas of risk, with Control meaning Use Control as that term is treated here. S^2C, to my knowledge, was coined to describe an area of national-level responsibility that is both joint and shared by two agencies: the AEC/ERDA/DOE and the DoD.

The first packaging of these three disciplines probably was in December 1975 in an essay that Marv Gustavson of LLL and I co-authored upon commission from the ERDA/DoD "Transfer Study." The unclassified essay, "*Dual Judgment Roles in Safety, Control and Security of Nuclear Weapons*" is treated in context later in this paper. The S^2C high-level management issue was revisited during the "*Starbird Study*" conducted by DOE/DoD in 1980. This study led to a recommendation to establish a DOE/DoD oversight committee for S^2C. That didn't happen, but the DOE/DMA did establish an intra-DOE S^2C Committee in 1983. In 1987, the role of high-level oversights of S^2C was assigned to the DOE/DoD Nuclear Weapon Council created by public law.

Surety = This term has been adopted by the DOE since 1984 when the title of the Annual Report to the President on Nuclear Weapon Safety was changed to replace Safety with Surety.

To my knowledge, "Surety" was first mentioned by Colonel Vince DeBossier of the U.S. Army Nuclear and Chemical Agency when he led the extension of the role of a part of the Army's original nuclear weapon agency from nuclear weapon system safety (a term defined later) to include appraisal of certain operational considerations relevant to deployment of nuclear weapons in Europe. Later, the term was appropriated by DOE/AL to cover its involvement in both DoD/DOE and intra-DOE system safety studies. Next, Sandia appropriated the term when Al Narath in 1991 gave the title Surety Assessment Center to the directorate-level organization created under Dick Schwoebel. Then, Surety came to mean four of the disciplines under Schwoebel; namely, S^2C plus Reliability.

This report considers S^2C, not Surety. Reliability is not categorically ignored, however, and is brought in as necessary to properly cover an S^2C consideration. The definitions of terms contained above apply, except that focus is on the positive measures taken to avoid the unwanted events, instead of focus on probabilities.

1.2 Tradeoffs of S^2C With Other Weapon System Considerations—A Perspective

Figure 1 lists 14 considerations that are taken into account and balanced in order for nuclear weapon systems to be capable of filling a basic role in national defense. The considerations are displayed in a two-by-two matrix that differentiates between emphasis in peacetime and in wartime use and also whether the thrust of the effort needed is to seek improvement or to seek reduction. S^2C is a peacetime emphasis on improvement to maximum levels consistent with achieving acceptable levels of performance in the remaining 11 considerations. This formulation for nuclear weapons differs from ones that could be constructed for conventional weapons where, for example, effectiveness at low cost of procurement of hardware could be maximized. Nuclear weapons are indeed special because of their potential benefit to national security and their potential for detriment.

		EMPHASIS	
		IN PEACETIME	IN WARTIME
THRUST OF EFFORT	To Improve	Safety Security Control (Over Unauthorized Use)	Deliverable Effectiveness Survivability Flexibility Battle Management
	To Reduce	Maintenance Logistical Movements Training Required	Reaction Time Operational Constraints Collateral Damage

Source: Briefing materials used by Robert L. Peurifoy, Jr., Vice President, SNL.

Figure 1. Some Considerations Affecting Deployment of Nuclear Weapons in National Defense

2. THE EARLY YEARS (1945-1960)

2.1 S^{2}C for First Generation (Capsule-Pit) Nuclear Weapons, 1945-1956

A basic reference for this discussion is my paper entitled, "Early Evolution of the Nuclear Weapons Safety Program" (Ref. 2).

2.2 The World War II Bombs: Little Boy, Fat Man, B3 and B4, 1945-1952

Initial interactions and negotiations among the newly created governmental agencies responsible for nuclear weapons—the Atomic Energy Commission formed in 1946 and the Department of Defense formed in 1947—were strongly influenced by the design features of the weapons. These subjects are treated in appropriate detail in Necah Furman's Sandia National Laboratories, The Postwar Decade (Ref. 1) and are discussed here briefly to provide a context for later events.

2.3 Safety of the High Explosive/Nuclear Subsystem, 1945-1954

A fundamental assumption in nuclear weapon safety is that an accidental detonation of the weapon's chemical high explosive (HE) will originate at a single location (point) in the HE. There is a non-zero probability, however small, that the detonation could occur at more than one point, but it has been agreed among skilled design specialists that this probability is so small that it can be disregarded.

The original U.S. nuclear weapons—Fat Man and Little Boy, achieved safety of the nuclear system by the principle of keeping the nuclear components ("cores" or "capsules") separated from the ordnance parts until final assembly for a strike mission. Only after final assembly was nuclear safety a concern. For the gun-assembled type of weapon, Little Boy (Hiroshima), there was no HE; instead, a propellant charge was initiated to cause assembly of the nuclear components. Thus, one-point safety was not at issue.

For the first U.S. nuclear weapon to benefit from postwar design improvements (Mk 4, which entered stockpile in 1949), nuclear safety was a design goal. This was accomplished by using a mechanically inserted nuclear component. Until then, the core was stored at a safe distance away from the HE sphere. Final assembly was accomplished inside the bomb bay after takeoff—an operation requiring about 30 minutes. Later calculations by Los Alamos showed that some of the weapons of this type indeed were not one-point safe in that the probability of a nuclear yield.

given a one-point detonation of the bomb's HE, would have been considerably higher than allowable today.[1]

For the next several weapon development programs, use of the design principle of separation was continued, but with more and more automation of the capsule-insertion function. By the mid-1950s, national security needs, such as higher nuclear yields with the limited supply of special nuclear materials, less strike preparation time, etc., affected a significant change in bomb design. The amount of special nuclear material and its proximity of it to the large HE sphere precluded a determination that the weapon would be one-point safe in accident situations.[2] Accordingly, the Los Alamos designers used a mechanical safing scheme to prevent the weapon from becoming supercritical in accidental detonations. The scheme was to place inert material inside the pit as the weapon was built and to allow its removal only in the bomb bay after takeoff. But, the general U.S. design practice for the early 1950s was to achieve one-point safety inherently in the design, rather than by mechanical safing.

Nuclear weapons of the early 1950s used wet-cell electrochemical storage batteries located inside the weapon to provide the energy needed to fire the detonators. Early versions of the batteries had to be "charged" from an external source of electrical power, and after installation inside the weapon had a useful life of less than one month. In fact, charge-time and charged-life limited the capability of the nuclear weapons; all other preparatory operations required less time and were effective longer. This resultant relatively low state of operational readiness was quite acceptable to the military services responsible for delivery to the target because warning times before enemy strikes were believed to be much longer. Since the batteries were not installed inside the weapon until the weapon system was being prepared for a strike mission, there was no such concern as peacetime nuclear safety for the weapon's electrical system.

Wartime nuclear safety was seen as a responsibility of the military service that prepared the weapon for a strike mission and deployed the weapon system to the target. I was a nuclear warhead electrical system specialist in the U.S. Army in 1952-53 and observed an event that perhaps was the first nuclear weapon safety incident.

The ordnance battalion involved was the first formed to (1) receive a nuclear warhead from the storage site (facilities to be discussed later), (2) prepare it for a mission and transfer it to the operational artillery unit, and (3) perform the final arming operations of inserting the nuclear capsule and replacing the green SAFE plug with the red ARM plug. (The last was my task as the forward assembly officer.) These plugs, a carryover from the World War II bombs, interrupted or connected the circuits between the batteries and the arming and firing subsystem, both the positive and negative (ground) lines.

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[1] This discussion is drawn from a paper written by a career-long national authority in one-point safety, Robert K. Osborne of the Los Alamos National Laboratory, retired (Ref. 1 of Ref. 2).

[2] Actually, computer memory capability of the time was too low by a factor of 1000, and computer speed was too slow by a factor of 100 to allow solution of the requisite hydrodynamic and neutron transient equations. Sufficient computer capabilities were unavailable until 1965.

The warhead preparation process required extensive component assembly and testing by the highly trained military crews and the final operation required an electrical test after the electric detonators had been installed on the high-explosive sphere—a reliability test to assume that all connections had been made. In training, the weapon prototype ("trainer") had inert detonators and HE sphere. For training, common practice was for the instructors to devise and wire in fiendishly clever circuit faults that would have to be diagnosed and corrected by the assembly technicians. Both instructors and technicians tended to be college graduates in engineering, and these "games" reached high levels of challenge. During a simulated final test, a technician reacted to an abnormal tester indication that he knew meant premature availability of battery power. He would remove the ARM plug to regain safety. The detonator bridgewires fired. Had this event occurred in a real operation, the result would have been an explosion of hundreds of pounds of high explosive and certain deaths of the crew and other occupants of the igloo.

The incident reporting procedure involved a cadre of enraged military officers descending on Sandia's Project Group Division Supervisor, Ray Schultz. The technical lead for the cadre was Lieutenant Earle C. Williams, who several years later would join Sandia as project engineer for the W40. I don't know what, if any, measures that Sandia designers took then to identify and correct classical "sneak circuits," such as this one caused by unanticipated breaking removal of the voltage biasing a vacuum tube in a firing circuit.

> <u>NOTE</u>: About two decades later, another serious incident of unanticipated type of human error resulted in partial arming of a War Reserve weapon. During a special testing procedure to detect occurrence of a reliability problem caused by distortion of soft contact pins on electrical connectors within the weapon, voltage was unintentionally applied to arming circuits. This was the result of the test operator performing certain cable connections in an unprescribed sequence. One of the Sandia engineers involved, Stanley D. Spray, would vividly recount this lesson learned throughout his subsequent three decades of dedicated nuclear safety work at Sandia.

2.4 AEC/DoD Responsibilities Controversies

By 1952 the question of how responsibilities for the development, production, and stockpiling of nuclear weapons should be divided among the AEC and the DoD/Military Services had become sufficiently contentious to impede progress and high-level negotiations were under way. Ref. 1 contains carefully researched sections describing the role of Sandia President Donald A. Quarles in preserving the AEC design responsibilities for all of the nuclear weapon electrical system and parts of the arming, fuzing, and firing system. That story (pages 530 to 553) is based on two papers (Refs. 3 and 4) that I wrote about a year before my retirement decision (1985) in support of the Sandia History Project. In my view, Don Quarles' personal deep insights and skills in expressing his conviction literally saved Sandia. Had he not prevailed, AEC weapon responsibility would have been limited to the "Nuclear System," defined as follows:

> "...comprised of the fission and/or fusion material, together with those components required to convert the system from the safe condition to an explosion. This definition specifically excludes the fuzing system of the weapon."

Presumably, Los Alamos Scientific Laboratory's role in nuclear subsystems would have been unchanged, and Sandia's role would have been limited to the warhead firing subsystem. Sandia, however, would no longer be responsible for the arming and fuzing subsystem and the mechanical features that house these subsystems (e.g., the ballistic case). In the context of the times, safety was seen as a wartime concern because the nuclear components were not to be installed in peacetime. The notion of "safing," as used today as a function of the weapon electrical subsystem, was yet to be developed. Thus, the first two controlling documents in the U.S. nuclear weapons program after the AEC Act of 1946 did not address S^2C, and they have been continued essentially unchanged to the present.

> "Agreement Between the AEC and DoD for the Development, Production, and Standardization of Atomic Weapons," 21 January 1953, Ref. 4.

> "Missile and Rocket Responsibilities," Memo: Chairman AEC to Chairman Military Liaison Committee, 22 January 1953, Ref. 3.

This experience illustrates an "Enduring Theme" for S^2C; namely, that the allotment of responsibilities for nuclear weapons matters between the design and production agencies involved is likely to be a contentious process that might recur and might have to be resolved on a case-by-base basis. Don Quarles' role in nuclear safety in 1957 events is described later.

2.5 Safety of the Electrical Subsystem, 1945-1952

Beginning with the Fat Man nuclear bomb design of World War II, the safety of the electrical system of implosion-type nuclear weapons has been obtained by a design principle fundamentally different from those drawn from the body of experience for conventional HE weapons. In general, conventional bombs and warheads have used a positive interruption in the initiation-to-explosion sequence of events (analogous in plumbing for a water line not to connect two mateable pieces of pipe until flow is wanted). In general, nuclear weapons have used a positive interruption in the electrical power source-to-initiation sequence, i.e., in the "weapon electrical system (WES)" in the Sandia vernacular (analogous to a blocking valve in a water line). This departure from precedent occurred as a result of the WWII decision at Los Alamos to pursue electrical initiation schemes rather than mechanical detonating fuse schemes. The technology that emerged, called explosive bridgewire (EBW) detonators, remained classified for many years, impeding somewhat a more broadly based appreciation of the alternative design principle of electrical system safety.[3] In fact, the U.S. Navy's safety communities insisted until

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[3] Thus, at Sandia the nuclear safety technical specialization has primarily involved electrical engineering, as contrasted to the nuclear power industry where pressure vessels, valves, piping, etc., led to involvements of

relatively recently that nuclear weapons for Navy deployment have a physically removable component that the local commander could hold until intended use of the weapon. The penalty to readiness of the weapon system resulting from the mechanical act of replacement later became intolerable for the fleet ballistic missile warheads.

2.6 Safety of the Second Generation Electrical Subsystem, 1954-1956

Nuclear weapon development programs at Sandia have been and are managed by small organizations of engineers and technicians formed especially for that particular effort called weapon project groups. Project groups are assigned overall responsibility for program execution, and in the early years, the degree of autonomy was essentially absolute. The development workload virtually exploded in 1950, driven in large part by demand for the weapons using the smaller, more efficient nuclear physics designs of Los Alamos, both in bombs (Figure 2) and warheads for missiles/rockets (Figure 3). With this expansion, the number of project groups proliferated, with the potential for every project using its individual preference in choosing an electrical system design.

Inability to acquire new technical staff rapidly was a limiting factor; and the resultant scarcity of on-roll electrical specialists, in part, led to formulation in April 12, 1952 of Sandia's Electrical Systems Coordinating Group (ESCG). Over its four-year existence, the ESCG was influential in evolution of the philosophical and technical bases for early nuclear weapon design safety. The membership was comprised of the supervisors of the electrical systems project groups in the two directorates responsible for weapons development—ranging from four to seven groups over the years. Three persons had essentially continuous membership and each served as chairman: Donald (Don) R. Cotter, Joseph (Joe) J. Dawson, and Leon D. Smith. The original charter was "coordination of the mutual interest phases of various fuzing programs now under way . . . to prevent duplication of effort and to provide designs that are compatible to as many programs as possible." Fields of activity were:

"1. Serve as a clearing house for information on the various component development programs currently under way.

2. Study and comment on new fuzing proposals.

3. Strive for a common fuzing system, including test equipment and procedures, for as many weapons as possible.

4. Establish standard designs for commonly used components. For example, a standard set of relay types of suitable characteristics could be approved so that any new junction box design could select from this group for its relay requirements. Thus, procurement and development time would be saved that now is lost due to the use of specially designed assemblies. Many similar examples can be cited.

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mechanical or nuclear engineering dominantly. This was to become significant for Sandia's later participation in the latter field.

Figure 2. Bomb Programs in Development, Production, and Stockpile

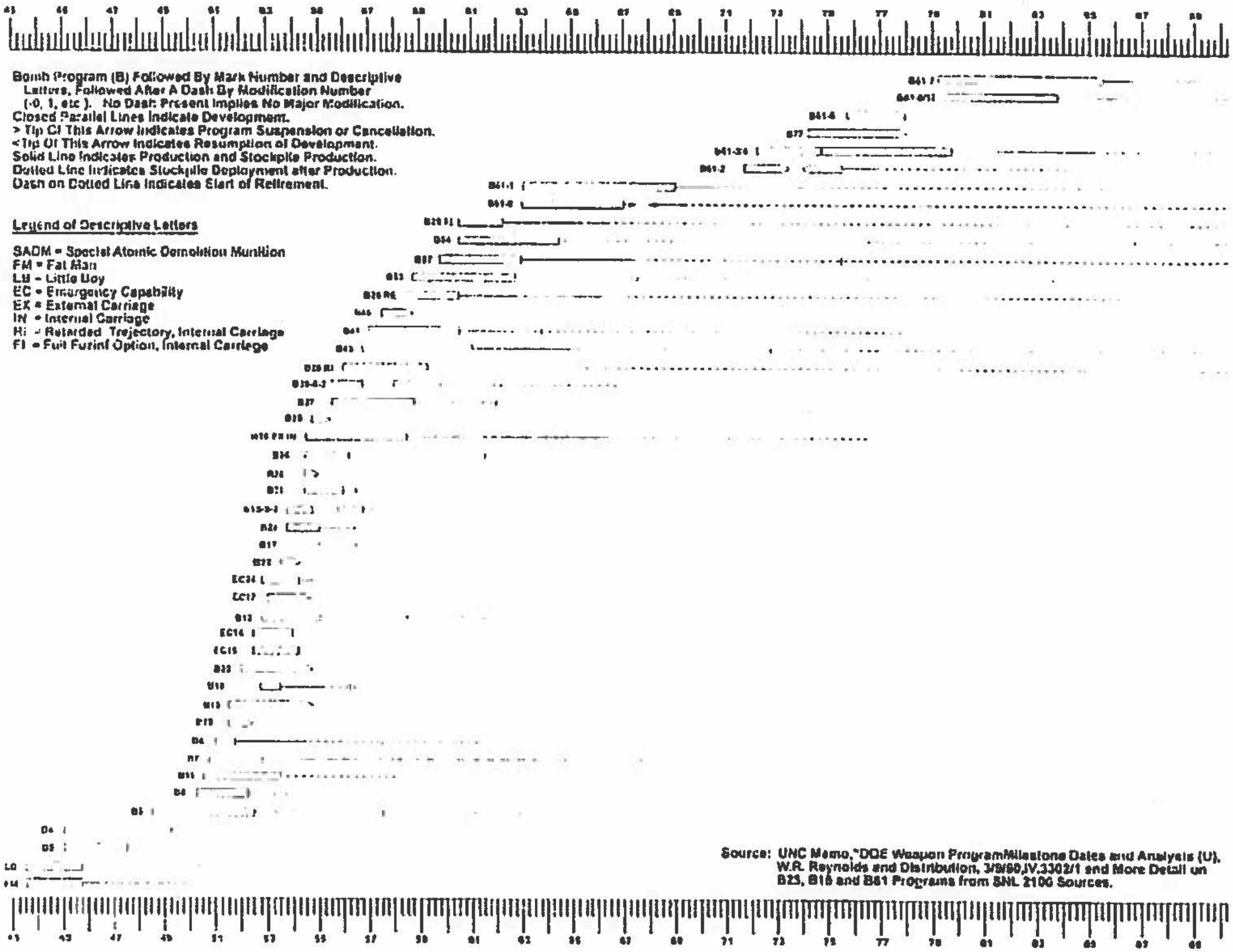

Figure 2. Bomb Programs in Development, Production, and Stockpile

OFFICIAL USE ONLY [redacted]

OFFICIAL USE ONLY [redacted]

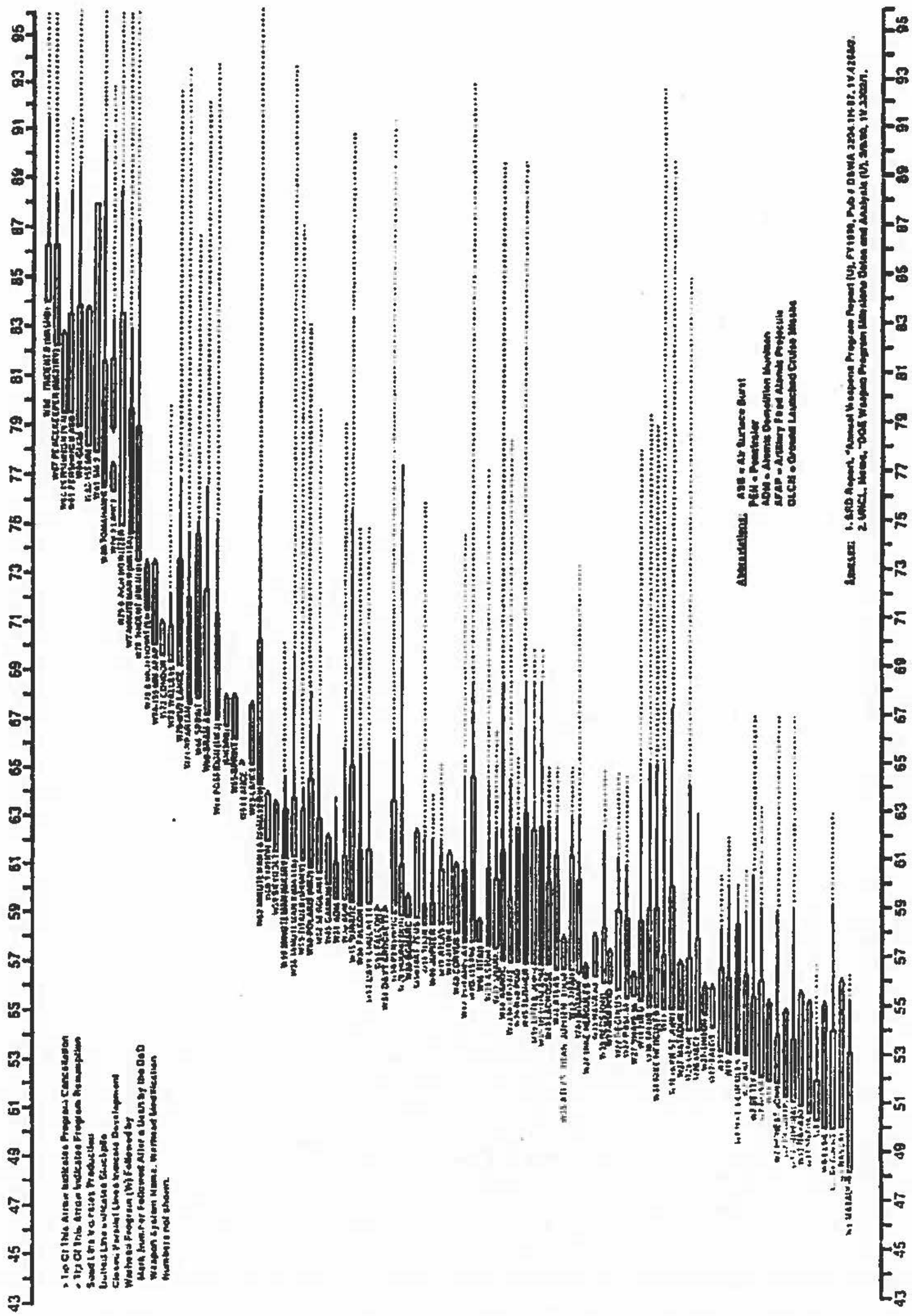

Figure 3. Warhead Programs in Development, Production and Stockpile

5. Make recommendations to component development groups on the needs of the various weapon programs and establish basic characteristics of components where used by several weapon programs."

Source of quotations: Minutes, 1st Meeting of ESCG, 4/14/52, Ref. 2 of Ref. 2.

Over its first 2-1/3 years, the ESCG gradually digressed from its "systems" goal into becoming a "clearing house of nut and bolt problems," and a reform was instituted on 8/14/54 to return to "cross fertilization of ideas and the dissemination of information."

During delivery to the target (wartime), nuclear safety was obtained principally by a switch that held open the electrical circuits between the batteries and the several components comprising the weapon's arming, fuzing, and firing subsystem. This switch, called a Ready/Safe or Arm/Safe switch, was an electromechanical device whereby the application of 28 volts DC to an electric motor caused sets of electrical contacts to be closed or opened. The equipment that provided the electrical power from the delivery aircraft (or missile/rocket) to the nuclear weapon became known as Aircraft Monitor and Control (AMAC), and responsibility for its procurement was assigned to the cognizant military service. This arrangement was to become another of the highly contentious AEC/DoD interfaces over the years and would heavily impact nuclear safety.

In September 1954, the first of a new generation of weapon electrical systems was committed to development, i.e., use of thermal battery packages to supply both low-voltage (28 VDC) and high-voltage (2500 VDC), the lower voltage for arming and fuzing and the higher for charging the x-unit. Thermal batteries are essentially inert until initiated by an electrical pulse, at which time heat is produced and dry chemical compounds react to produce voltage. Preparation time is instantaneous, and shelf life is unlimited. This Sandia-sponsored development was a factor in creation of a family of "wooden bombs"—so named because they, in concept, could be treated with almost no special care (as though they were a piece of wood). Thermal batteries were then being considered for weapons having either the insertable capsule type of HE/nuclear subsystem or the proposed new type of implosion design featuring the "sealed pit" (wherein the special nuclear material is integral with the HE subsystem). The earliest application was for a retrofit of a capsule-type bomb (B15-2 first production 3/57), and the second was for the first sealed-pit warhead (W25-0 first production 6/57). An "Emergency Capability" version of the W25-0 was produced in 12/56, but it did not have the full complement of electrical system components.

With the advent of wooden bombs, the Arm/Safe Switch took on added importance to safety since the peacetime configuration then had the electrical power source (thermal batteries) installed. These switches became Sandia's first nuclear safety components; however, their importance as such was not at once recognized, appreciated, or supported by Sandia management—as illustrated by the following episode.

Delfred (Dell) M. Olson, an electrical subsystem design engineer for the TX-15/TX-39 project group in 1954, recalls that his component, the high-voltage arm/safe switch, was experiencing development-for-production problems and had become the critical item that threatened Sandia's ability to meet schedules. Del was called before a program review session chaired by Vice President, Development, Robert E. (Bob) Poole, Bell Telephone Laboratories veteran who had been Sandia's top manager for weapons programs since 1945. Bob Poole was not sympathetic to the need to solve the technical problem if that would jeopardize meeting the schedule and made clear to Del Olson that schedule slippage was unacceptable. Said another way, it would be acceptable to trade some degradation in safety for schedule. So much for top management's initial commitment to nuclear safety! Del and his colleagues were able to correct the deficiency in time to allow schedules to be met.

Advent of the sealed-pit design emphasized the emergence of a nuclear weapon electrical system safety discipline since the weapon then contained all of the elements needed for detonation at all times during operational stockpiled life. No longer could one clearly differentiate between a peacetime and a wartime weapon configuration. During 1955, a nuclear safety philosophy evolved through successive discussions by the ESCG, principally led by division supervisors Don Cotter (TX-28) and Lee Hollingsworth (TX-15/TX-39). Don Cotter appears to have originated the requirement for a trajectory sensing switch that would sense that a weapon was in its intended delivery-to-the-target mode and close, allowing the electrical power from the low-voltage thermal batteries to advance toward initiating the high-voltage thermal batteries.[4] Don Cotter favored use of both a low-voltage and a high-voltage arm/safe switch—the former being driven by the aircraft's AMAC, whereas Lee Hollingsworth opted for only the low-voltage ready/safe switch. The discussions, however, resulted in a standoff and both of the approaches were implemented in the stockpile. The differences in philosophy later proved to be important. (See "The Goldsboro Accident, 1961" to follow.)

For this discussion, it is important to note in retrospect that the ESCG arrangement did not provide for any meaningful degree of independence of view on the part of those analyses considering questions of nuclear safety. Indeed, both Don Cotter and Lee Hollingsworth were project group leaders responsible for weapon developments. They reported to different managers at the next level of supervision (department manager), and their divisions were in different directorates.

2.7 Security and Use Control in the Early 1950s

The information protection aspect of security (e.g., clearances and classification) dominated attention of the AEC's Director of Security, one of nine divisions in AEC Headquarters. This story is told in Atomic Shield 1947/1952 and Atoms for Peace and War 1953-1961, Volumes II and III of the official history of the AEC (Refs. 5 and 6). Sandia played no special security role in this area.

The physical protection of facilities aspect of security is hardly mentioned in the official AEC histories. Since the first director (8/47-5/54) was an Admiral and the second (10/50-11/67) was a retired Navy Captain with experience in security, it seems likely that security standards for AEC

4 See the discussion on Environmental Sensing Devices for later application to warheads.

facilities would be commensurate with those of the military services. Indeed, physical security for the three National Stockpile Sites (NSSs) that became operational from 1949 to 1952 was the responsibility of the military service upon whose base the site was located. Technically, the sites were commanded by the Armed Forces Special Weapons Project (AFSWP) and the AEC employee (GS-7 level) who served as Custodian of the nuclear capsules was a resident guest. By 1952, Sandians also became resident guests to assist AFSWP and the military service in inspection and quality assurance functions for stockpiled weapons and components. As nuclear weapons became widely dispersed and placed in higher states of readiness in late 1954, Operational Storage Sites were authorized for the Continental U.S., to be manned by military service personnel (Source: Defense Special Weapons Agency 1947-1952, Ref. 7). Sandia played no special security role for these sites.

Use control, in concept, was maintained by the President who would issue an order to the Chairman of the AEC to release nuclear capsules to the appropriate military service user (Ref. 5)

2.8 Advent of Systems Safety and Use Control

In early 1957, the newly appointed Secretary of the Air Force, Donald A. Quarles, visited Sandia Base and was briefed on current nuclear weapon development programs. After having served as Sandia's President for 18 months from March 1952 through July 1953, Don Quarles had been appointed as Assistant Secretary of Defense for Research and Development (the first occupant of that high position that was created by the Defense Reorganization Act in the Eisenhower years). Two major technological breakthroughs: LASL's conception of the sealed-pit nuclear weapon and Sandia's concept of "all-electric" safing devices occurred during the 3-1/2 years since his close involvement with nuclear weapon designs; and he, reportedly, was concerned about nuclear safety implications of the W25 to be used on the Air Force's GENIE (MB-1) air-defense missile carried by fighter/interceptor aircraft.

2.9 The Atomic Weapon Safety Board, 1957

Don Quarles' concern about nuclear safety led to the creation of a board of military officers chaired by Field Command of the Armed Forces Special Weapons Project at Sandia Base, New Mexico. Navy Captain William Klee (reportedly scheduled for retirement) was the senior officer. The "Klee Committee," as the Board became known, was formed on February 8, 1957, and examined in detail designs of the 14 nuclear weapon projects using sealed-pits (involving eight Mark-numbered entities) then in development. The committee's report, issued on March 25, 1957, contained 18 recommendations for remedial actions, some calling for fundamental changes in Sandia's designs (Ref. 8).

2.10 Sandia's Electrical Systems Department, 3/56 to 2/59

The lead for Sandia's safety involvements fell to Sandia's year-old Electrical Systems Department. Leon Smith had proposed the creation of an organization that would be charged with the design of certain critical parts of the electrical subsystems of nuclear weapons across all weapon projects. This concept was Sandia's first application of the "systems engineering" technical discipline that had evolved at Sandia's parent Bell Telephone Laboratories, and Leon Smith was promoted to become the department manager. Don Cotter, as a division supervisor under Leon Smith, had served as an unofficial technical advisor to the Klee Committee and was assigned to respond to findings of the Klee Committee.

Despite internal accusations of "nit-picking" and "incredible what-iffing" on the part of the Klee Committee, Sandia responded most positively during a year-long study by Sandia, LASL, and LLL, presenting a course of remedial action in four reports to the AEC Chairman signed by Sandia President James W. (Jim) McRae (Refs. 10 – 13).

2.11 The U.S. Air Force's Nuclear Weapon System Safety Study Group, 1957-1958

Within less than two months after issuance of the Klee Committee final report, the Air Force Special Weapons Center located on Kirtland AFB adjacent to Sandia Base had formed the nation's first dedicated nuclear safety organization and published the first safety study as we know these documents today. The organization became known as the Directorate of Nuclear Safety (DNS) and was led by a Colonel and staffed mostly by officers on rotational assignments. (There were a few civil servant employees, mostly administrative.) The group that actually performed the studies, later to be titled the Nuclear Weapon System Safety Study Group (NWSSG)), was all-military, with field-grade officers representing the major operational Air Force commands (e.g., Strategic Air Command and Tactical Air Command), logistical command (e.g., Military Airlift Command), and the Field Command, AFSWP. The chairman almost always was a Colonel from the DNS.

Within the first year of operation, the NWSSGs issued 13 study reports—a remarkable achievement indeed. From the first study, Sandia was invited to provide a voting member, and Del Olson (then a section supervisor in the Electrical Systems Department) was assigned that role. Del actively participated in the evolution of the process of weapon system safety studies that several years later became institutionalized nationally for the DoD and the three military services and some five years later for the AEC. (See DoD Directive 5030.15 discussion to follow.) Del warrants the title of Father of Nuclear Weapons System Safety Groups as regards Sandia's contributions. His internal Sandia writings (e.g., Ref. 14) and oral interviews are a rich source of information on evolution of the NWSSG process. In particular, Del attributes the origin of the powerful notion of "positive measures" to control weapon and weapon system safety behavior (described later) to Lt. Colonel John W. Rawlings, the Logistical Air Command member of early NWSSGs. Lt. Colonel Rawlings realized that weapon and weapon system hardware could not by themselves provide the extremely high level of safety needed and that the disciplined behavior of the military service personnel would have to be factored in. This thinking was crucial to the establishment of the DoD's Human Reliability Program and "Two-Man Rule" for personnel performing critical duties associated with nuclear weapons.

2.12 Advent of Environmental Sensing Devices for Warheads (ESDs), 1958

I can describe this subject in personal terms because I was involved in essentially every event. My first job at Sandia began in May 1957 as a member of technical staff assigned as a project engineer. I was involved in development of the warhead electrical subsystem for the XW-35 thermonuclear warhead for the nation's first ballistic missile weapon systems, the intercontinental ATLAS and TITAN I, and the intermediate-range THOR and JUPITER. I was recruited to Sandia by Section Supervisor Bob Peurifoy and worked under him jointly with warhead system engineer C. Herman (Herm) Mauney, who had just returned to Sandia after military service.

The electrical subsystem originally was a straightforward adaptation of the high-voltage thermal battery variety common to the "wooden bomb" designs that Bob Peurifoy had helped develop for the first sealed-pit warhead (TX-XW-15-2). Because of the need for extreme miniaturization, the high-voltage arm/safe switch was to be operated by an electrical pulse, rather than by a continuous 28 volt DC signal from the missile. This made the subsystem essentially "all-electric," and pulse-operated, at that. For the XW-35, Bob Peurifoy decided upon a back-up design that would not be pulse-operated. He turned to a new type of firing set that was being developed as an advanced concept by Herm Mauney and others in the systems group. The heart of the new design was a rotary chopper that fed a transformer/rectifier to convert and step up a continuous 28 volt DC signal to the needed high voltage DC that charged a capacitor in the x-unit. Following the "sputnik" scare during the fall of 1957, the XW-35 program became of the highest national priority.

By early 1958, the XW-35 had been canceled when unfavorable results of full-scale nuclear tests (Operation Plumbob) indicated nuclear safety problems for LASL. The XW-28 nuclear subsystem was determined to be adaptable as a replacement design, becoming the XW-49. Bob Peurifoy decided to use a rotary chopper/converter approach rather than the high-voltage thermal battery design of the XW-28 and committed to a seven-month development period. In rapid succession, the high-voltage, pulse-operated arm/safe switch considered for the XW-35 was replaced by the technically less-risky design of a low-voltage, pulse-operated switching component. Even that device was discarded as not being needed for safety. The rationale (theme) was that the XW-49 electrical subsystem was "inert" in the absence of two independent 28 volt DC arming signals that would be given only in-flight after irrevocable commitment (launch) of the missile in wartime. This was the electrical subsystem that I, as project engineer, was tasked to brief to the Preliminary Safety Study of the NWSSG in January 1958.

During the course of the study, the NWSSG's secretary (Major Floyd Trogdon—later to become a Major General and intimately involved in jurisdictional issues on USAF/Sandia responsibilities for re-entry vehicles) was instructed to insert the following "boiler-plate" paragraph into the proceedings:

> "This warhead, like all other warheads investigated, can be sabotaged, i.e., detonated full-scale. Any person with knowledge of the warhead electrical circuits, a handful of equipment, a little time, and the intent, can detonate the warhead. Thus the physical security system is the primary deterrent to intentional detonation of the warhead."

Bob Peurifoy's reaction upon learning of this concern and the NWSSG's proposed solution by reliance on security rather than safety systems was both immediate and forceful. He had me obtain a prototype trajectory sensing switch being developed for the TX-28 and package a pair into the XW-49 to interrupt each channel of one of the arming lines to the firing set. This switch (MC-874), an inertia-operated device based on a rack-and-pinion mechanical design, was to be incorporated by a "crash" retrofit program that provided "mod kits" to the Air Force by August 1959. The intent was to guard against an unintentional human act on the part of "friendly troops" in the process of handling a nuclear warhead as an entity before its installation into the payload (e.g., mated to an adaption kit). Such a concern was cited in a recent speech (Ref. 15) by John S. (Johnny) Foster, who as Director of LLL on a visit to a military site had observed a technician probing a warhead interface connector with a volt-ohm meter, apparently performing an unauthorized circuit continuity test. Knowing of the special relationship between Johnny and Don Cotter (they were skiing buddies as well as weapon associates), I suspect that the component we later came to know as "Environment Sensing Device" (ESD) was born at this time. Don Cotter, of course, had been a proponent of a "Trajectory Sensing Switch" in bombs for several years as a weapon project division leader, as evidenced by the TX-28 electrical system where he had held design responsibility before becoming a weapon system division leader.

The Sandia safety design initiative of ESDs was not welcomed by the U.S. Army's design agency for adaption kits, Picatinny Arsenal. An Army project officer for the JUPITER application of the XW-49, Captain Samuel Skemp, objected to Sandia's proposal to incorporate ESDs into the XW-49 in a manner such that the ESDs would close arming circuits upon experiencing the deceleration attendant to re-entry into the earth's atmosphere. He argued that the safety enhancement, if any, would come at the cost of possible interference with the functioning of Picatinny's adaption kit during the critical time of re-entry. ESDs were viewed as being in competition with the adaption kit, which also used trajectory sensing (for arming rather than for safing). Rather than to contest Picatinny's views on the extremely compressed time scales of the U.S.'s ICBM/IRBM program in post-sputnik years, Sandia designers Bob Peurifoy, Herm Mauney and I inverted the physical orientation of the ESDs to operate on the launch phase of the trajectory. The name of the devices was changed during this process—from trajectory sensing devices to ESDs—to avoid the arming connotation and to emphasize the safing role by sensing a normal environment. Additionally, ESDs became only one way to achieve the safety goal, and the larger term Handing Safety Devices (HSD) was coined to cover the totality of ways.

> <u>NOTE</u>: The XW-49 episode illustrates a rather unsettling reality in the area of division of responsibilities for nuclear weapon safety; namely, Sandia has no formal charter that sets forth either authority or autonomy in nuclear weapon

arming, safing, and fuzing.[5] ESDs became a reality because the Air Force system safety study group endorsed the concept on its merit. The Army never did accept the need for ESDs. In fact, the same Army officer who contested their use in JUPITER was to have a pivotal role some 15 years later in an issue of Sandia/Picatinny design prerogatives, a story to be told in the PERSHING II section of this report.

2.13 The Tri-Laboratories' First Nuclear Safety Manifesto, 1957-1959

Don Quarles, by then Deputy Secretary of Defense, by letter dated July 29, 1957, to Lewis L. Strauss, Chairman of AEC, requested a study on the possibilities of increasing the safety of nuclear weapons (Ref. 9). As a result of a conference with Brigadier General Alfred D. (Dodd) Starbird, AEC/DMA, the heads of the nuclear weapons laboratories agreed that Sandia would assume primary responsibility for a study and the ultimate preparation of a coordinated report. Later, the study was delayed in order to let it become the second phase of a total effort—the first phase being publication of reports on the existing degree of design safety in those sealed-pit weapon systems treated in the Klee Committee (Refs. 10-13).

The report on possibilities of increasing safety for future weapons was prepared by Carl R. Carlson, Supervisor of Systems Engineering Division. (Carl had replaced Don Cotter who was promoted to Department Manager in the project engineering organization.) Through his supervisory responsibilities, Carl was in contact with others in the national nuclear weapon system safety community, including Fred Charles Iklé of the Air Force's Project RAND.

Carl Carlson's approach early on included a review of prior nuclear weapon accidents and incidents in order to place the concerns in perspective. He found a lack of data, no deep understanding of precisely what had occurred, and no suitable channel to notify Sandia's engineers about future events as they occur. The Chairman of the newly formed Air Force Nuclear Weapons System Study Group, Colonel John J. Dishuck,[6] aided in analysis of earlier accidents in Air Force operations. Carlson's work was a factor in establishment of the Joint Nuclear Accident Coordinating Center (JNACC) at Sandia Base in 1958, with a DoD branch at FC/AFSWP (now DSWA) and an AEC branch at AEC/ALO. The AEC's weapon laboratories were invited by the NWSSG directly to participate in the response team dispatched promptly for investigations. (See Figure 8 for a summary of actual responses.)

Carl Carlson's penetrating analyses led to the basic conclusion that the real opportunities for increasing nuclear safety must reside in changes to weapon electrical systems—either in the AEC's bomb or warhead or in the DoD's delivery system.

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[5] For elaboration, see my two draft working papers (Ref. 2 and 3) on the agreements made in 1953 between AEC and DoD for nuclear weapons and missiles and rockets. Also see W. J. Howard's remarks on divisions of responsibilities (Ref. 16).

[6] Upon his retirement from the Air Force, John Dishuck served in the nuclear weapon system safety study division at Sandia, 1967 to 1973

This conclusion apparently was difficult to accept even within the AEC weapons laboratories, since at the time the Lawrence Radiation Laboratory (LRL) was advocating, and having Sandia Livermore work on, mechanical safing subsystems for LRL's nuclear subsystems as the preferred means.

> NOTE: Johnny Foster was Director LRL at the time. In an address on nuclear safety evolution given in 1997 (Ref. 15) he mentioned this episode. The earliest mechanical safing mechanism was designed in a hurry by an LRL physicist, and Sandia Livermore's engineers were assigned to arrange for production. During stockpile surveillance testing, the design later was found to have a serious flaw that caused a system failure. Metal surfaces in sliding contact had been affected by the oxygen-free environment, instead of the atmospheric environment present during development testing, such as to increase the torque requirement for the spring-wound driving motor beyond its capability. Sandia engineers had failed to negotiate with U.S. Navy counterparts for electric power sufficient to operate an electric driving motor. This reliability problem led to a costly retrofit and the Navy did not soon forgive the errors.

That the final report (Ref. 17) took about a year in coordination is evidence of this difficulty.[7] Nevertheless, the thrusts of the report's and subsequent remedial actions were:

1. Electrical System Safing Against Accident Arming and Releasing Bomb/Aircraft Systems

   (a) T-249A

   The T-249, an almost universally used Aircraft Monitor And Control (AMAC) box located in delivery aircraft to control arming, safing, and delivery option selection for nuclear bombs, was found deficient in two respects. Firstly, it was easy to arm a bomb since only two simple switching operations were needed. Secondly, if a bomb had somehow armed it could not be safed unless a power switch was reactivated. The division of responsibilities for AMAC equipment had been set earlier, with Sandia having design responsibility and the military services having design acceptance, procurement, and installation responsibilities. A standoff developed when Sandia released a final design of a redesigned switch, the T-249A, with better human-factor-engineered control reflector switching; and the military services declined to fund implementation.

   NOTE: This was an early example of differing priorities between safety advocates in the AEC and weapon-system acquisition/operational-readiness advocates in the DoD regarding funding for safety enhancement—a subject of special interest to the Presidential Blue Ribbon Task Group during 1985.

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[7] Carl resigned from Sandia in frustration with his experiences with LRL, worked for the DIKEWOOD Corporation, which had been formed in Albuquerque, New Mexico, by two of his ex-Sandia colleagues. He returned to Sandia on September 16, 1963. He died January 25, 1971.

(b) T-280

The T-280, a switch proposed by Sandia to be mounted in the aircraft's cockpit remotely from the T-249A but in series electrically with it, would require a second responsible crew member to affirm intent to release a nuclear bomb from an aircraft. This switch, colloquially known as the War-Peace Switch, was a measure to further protect against inadvertent release, the emerging safety concern highlighted by Carlson's work. Incorporation of the T-249A in 1958 and the T-280 in 1959 into aircraft of the Strategic Air Command came shortly after SAC aircraft had been placed on ground alert. (See Figure 5.) This change in readiness posture was to have significant impact on nuclear safety, as addressed in the next section of this report.

2. Electrical System Safing Against Deliberate, Unauthorized Human Acts

During preparation of the AEC's report, Fred Charles Iklé[8] of the U.S. Air Force's RAND Corporation was studying nuclear weapon safety and focused on the risk of an accidental or unauthorized nuclear detonation. His report, published on October 15, 1958 (Ref. 18), raised attention at a national-level to the risk; and it supported continuing research by the AEC weapons laboratories for improved hardware. Iklé's work, in part, led to formalization of the concept of today's Human Reliability Program for persons in safety-critical positions and, perceptively, to the use of "some form of lock sealed inside the warhead" as a safing device—conceptually of course, an early mention and perhaps the first conceptualization of a Prescribed (later called "Permissive" by the DoD) Action Link, PAL. During this period, Iklé visited Sandia and examined relevant hardware developments.

(a) Environmental Sensing Devices (ESDs)

Carlson's report (Ref. 17) discussed the use of trajectory sensing switches as described above and mentioned the IRBM/ICBM application.

(b) The Locked Warhead Connector

Carlson's report suggested the use of a locked cap on the warhead signal input connector to provide mechanical isolation of critical electrical circuits, where the missile or bomb's trajectory environment was insufficient to operate an ESD. Although never widely implemented by AEC designers, the locked-cap concept was used by the U.S. Army in the early 1960s for missile systems already fielded (e.g., HONEST JOHN and NIKE HERCULES) and by Sandia for an Atomic Demolition Munition (W45/Medium ADM).

8 Fred Iklé later served as Undersecretary of Defense, Policy in the DoD.

2.14 Sandia's Participation in Early Nuclear Weapon System Safety Group Studies, 1958-1960

The process of sorting out a role for the Atomic Energy Commission and its weapons design laboratories in studies of the acceptability of nuclear safety for each nuclear weapon system to be fielded by a military department involved about two years of high-level management attention. The fascinating correspondence file reflects the depth of conviction and resolution of the AEC's principals in the process. They included:

- Brigadier General Alfred D. (Dodd) Starbird, U.S. Army, Director of Military Application, U.S. AEC, July 1, 1955-January 25, 1961;
- Major General Kenner F. Hertford (Retired), Manager of Albuquerque Operations Office, U.S.AEC, October 1, 1955-July 31, 1964; and
- Dr. James W. (Jim) McRae, President, Sandia Corporation.[9]

The Air Force Special Weapons Center (AFSWC) had conducted three nuclear weapon system safety studies in 1957. At year-end, through the Department of the Air Force's Chief of Staff, AFSWC requested of Brigadier General Starbird that the AEC continue to participate in forthcoming studies of the "formal safety working group" that had evolved. AEC participation for the studies completed had been by Del Olson and later by Robert F. (Bob) Kail, a member o the technical staff at Sandia. Kail had served as a full member of the group and had signed the reports.[10] Brigadier General Starbird's reply was positive as to participation, but he named a person from the AEC/ALO as the AEC representative with the provision that he would be "...supported technically at group meetings by members of the Sandia Corporation and by representatives of other AEC organizations and contractors as required and appropriate." Starbird further stated, "It should be understood that the AEC representative cannot officially sit as a voting member of the formal safety working group but rather is present to ensure that the AEC gives to the group all possible assistance."

Although he originally had agreed with Brigadier General Starbird's views, Sandia's President Jim McRae soon recanted and supported the practice that had evolved at Sandia.

> NOTE: The remarkably current wording of McRae's letter to Starbird, which I only recently encountered in the Nuclear Safety Information Center (NSIC) files, established precepts for participants. Some twenty years later, I articulated the principles as follows:
>
> "There are three attributes which in the main account for the past success of the process; namely,

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[9] Sandia's key person and actual author was Carl R. Carlson, who had replaced Del Olson.

[10] Bob Kail died of cancer in late-1960, while serving as technical advisor to the Air Force's safety study group. He was known as an outspoken advocate of the independence of nuclear safety study specialists and was very highly respected among his peers and colleagues

- Management Commitment—unswerving dedication to the precept that adequacy of safety, security, and control is a primary, positive objective on which future success of the endeavor may depend.
- Independence of View—provisions which assure that assessments of safety, security, and control features are made reasonably independent[11] of the primary mission of the endeavor.
- Technical Competency—priority assignments of high performance-rated engineering and scientific personnel in the field of safety, security, and control.

Of these three, the greatest return is paid by the last and it becomes compellingly paramount in determining success" (Ref. 19).

The notion of "independence" for technical advisors has been implemented at Sandia by placing these persons in an organization separate from the ones responsible for the principal output (or operation). Thus, the function was born in the "Electrical Systems Department," rather than in a "Project Engineering Department," and one way or another, an appropriate degree of organizational independence has been maintained over the years.

By January 20, 1958, the Air Force had formally established the Nuclear Weapon System Safety Group (NWSSG) and listed as members six Air Force Commands or Offices, DoD/Field Command/Armed Forces Special Weapons Project, AEC/ALOO), and AEC/ Sandia Corporation.

Also about this time, the Joint Chiefs of Staff had decided that individual military services would have "the responsibility for continuing critical analysis of the safety aspects of its weapons systems employing sealed pit atomic warheads." Each military service began to implement the decision. The U.S. Army's plan was to charge each of its "joint committees"[12] already in being for each nuclear weapon system under Army cognizance (i.e., XW-31/HONEST JOHN, XW-31/NIKE HERCULES, XW-39/REDSTONE, and XW-35/JUPITER) with forming a safety subcommittee with conducting the analyses. The Chairman, who was to report to the Chief of Ordnance, was to be Mr. S. Julian Pulley,[13] and there would be seven members: five Army (including Picatinny Arsenal), one FC/AFSWP, and one Sandia Corporation. This plan was forwarded to the AEC's weapons design laboratories by AEC/ALO, and Los Alamos and Sandia commented.

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11 In his informal comments on the above wording, Sandia's Executive Vice President William J. (Jack) Howard said, "Can you phrase this so it doesn't sound like independence is, per se, a goal but is a method of assuring that considerations are included which might not be, if only the guys charged with the responsibility for prompt warmaking were the judges (alone)?" I later added the phrase, "...in a manner which does not require them to act in behalf of their agency as its spokesman or advocate."

12 Being superseded at the time by Project Officer's Groups (POGs), which are continued today. AEC/AL did not participate in joint committees.

13 Julian Pulley was to serve as chairman of the group, renamed the Nuclear Weapon System Safety Committee (NWSSC), until his death in 197_. His replacement was Harold Wells (retired USAF officer).

Carl Carlson wrote Sandia's response; it was signed by Jim McRae. This document remains a valid expression today of the proper roles of the DoD and the AEC weapons laboratories in nuclear weapon safety. It is reproduced as Appendix A of this report.

AEC/ALO's reply to the Army did not concur with the Army's proposal on the basis of conflict of interests between the primary goal of the joint committees to coordinate and one of its subcommittees to analyze and judge. Further, AEC/ALO affirmed that AEC/DMA policy did not permit either AEC or AEC-contractor participants to be voting or signing members of a safety study group.

Just prior to his departure as President, Sandia Corporation (late September 1958), Jim McRae personally wrote to Brigadier General Starbird of AEC/DMA requesting another review of Sandia's participation in the Air Force's NWSSG. Dr. McRae continued to favor Sandia providing a full voting representative. In his October 20, 1958, reply to AEC/ALO, Brigadier General Starbird stated that he had not changed his mind, i.e., the AEC should not become a full-voting member and that he now was concerned about Dr. McRae's observation that Sandia was participating fully in similar studies by the Army and the Navy. Finally, Brigadier General Starbird tasked AEC/ALO to investigate and report to him just how the studies were being conducted. The resulting review, handled by staff action officers Lt. Col. Sam Goldenberg, USAF for AEC/DMA and Milton A. Rex, AEC/ALO's Director, Storage Division, occupied much of 1959. These persons also were involved in support of the "Ad Hoc Steering Committee for the Technical Nuclear Safety Review of Atomic Weapons" in drafting DoD Directive 5030.15, "Safety Studies and Reviews of Atomic Weapon Systems."

Two documents were issued as the final events in this stage of evolution:

- On December 29, 1959, a memo from AEC/DMA assigned the AEC/ALO the responsibility for carrying out all AEC functions in the subject program, with the exception of the AEC coordination on nuclear safety rules that would be accomplished in DMA with assistance by ALO and laboratory representatives as required.

  NOTE: The issue of AEC coordination on nuclear safety rules, particularly the validity of the AEC's need for a field review, was to arise again in AEC/DoD discussions in the 1970s and will be discussed in a later section of this report.

- On February 23, 1960, a Memo to File from Milton A. Rex, AEC/ALO, entitled "AEC Participation in Safety Studies and Reviews of Atomic Weapon Systems" established an understanding between AEC/ALO (Lee Hancock and Milton Rex) and Sandia (Robert E. [Bob] Henderson, Eton H. [Drape] Draper, and Don Cotter) on responsibilities. In brief, the AEC/ALO representative would be the official member and would cast the AEC vote. The Sandia (or other laboratory) representative would serve as "technical consultant and advisor" to the AEC/ALO representative. The two would "present a common front in the working group discussions," to the point of referring unresolved differences of opinion to their supervisors for "resolution and establishment of AEC/ALO positions." This memo has not been superseded and remains a valid description of practice.

2.15 Nuclear Weapons System Safety Study Process is Institutionalized, 1960

On June 10, 1960, efforts of the AEC/DoD Ad Hoc Steering Committee for the Technical Review of Atomic Weapons culminated in issuance of DoD Directive 5030.15 "Safety Studies and Reviews of Atomic Weapon Systems." This document established a program of safety studies and reviews for each of the nuclear weapon systems deployed by the military services. It also established the drafting, coordinating, and obtaining approval by the President for nuclear safety rules for generation of a weapon system. Since only the DoD deploys a nuclear weapon, the document carries a DoD label; however, it was conceived as, and has been implemented as, a joint agency agreement between the DoD and AEC/ERDA/DOE.

DoD Directive 5030.15 was based in large part on extending the practices of the Air Force's Nuclear Weapon System Safety Group (NWSSG) to the other military services. The NWSSG had begun operation at Kirtland AFB, New Mexico, in 1957 and by June 1960 had completed about 70 studies or reviews. The essential addition to NWSSG practices was the provision for nuclear safety rules. The directive remains in effect today essentially unchanged—remarkable vitality for a governmental document over a 3-1/2 decade period. Major tenets of the initial version follow:

> Goal: "... to assure that atomic weapon systems incorporate the maximum safety consistent with operational requirements."
>
> Comment: The nuclear weapon system safety study process inherently involves resolution of a conflict of interest between the basic war-fighting mission of nuclear weapons ("operational requirements") and the concern that an accident or other unwanted events involving a nuclear weapon would seriously affect national security or public health ("safety"). This statement of the goal has been interpreted as a decided tilt in favor of safety in the trade-off deliberations. In fact, the earliest known expression of a goal was stronger in that regard:
>
> > "... to determine an optimum balance between required nuclear safety and the desired operational readiness."[*]
>
> Subject: "... As a minimum, the standards against which safety rules shall apply are as follows:

[*] This statement is contained in a brochure "USAF Nuclear Weapon System Safety Group" issued in 1959. The same brochure also states: "General LeMay recently directed that all Air Force agencies perform a comprehensive review of their activities. It was further directed that strong, immediate and continuing support be provided ... "

1. There shall be positive measures to prevent weapons involved in accidents or incidents or jettisoned weapons from producing a nuclear yield."

   Comment: This standard pertains to the design of the nuclear weapon entity in all configurations that apply in the stockpile-to-target sequence— for example, ranging in complexity from a "bare" nuclear bomb in a storage igloo to the same bomb mounted on the bomb release rack of a fully prepared delivery aircraft on Quick Reaction Alert. Thus, the standard pertains to the probabilistic analysis of the arming, fuzing, and firing subsystems of a bomb, as was done by Sandia in response to the Klee Committee report, and the consideration of these analyses by the NWSSC. In precisely the same sense, the standard applies to the analysis of the nuclear safing system, as was done routinely be either Los Alamos or Livermore. At the level of more complexity, the standard applies to the qualitative judgment that the NWSSG makes on the total weapon system.

   Over the years, the probabilistic analysis has essentially been discontinued, and qualitative judgments apply throughout. Probabilistic analyses are made by groups other than the NWSSGs.

"2. There shall be positive measures to prevent deliberate arming, launching, firing, or releasing except upon execution of emergency war orders or when directed by competent authority."

   Comment: This standard pertains not to a nuclear yield from a nuclear weapon, but to an unwanted action involving a nuclear weapon system, i.e., deliberate releasing of a nuclear bomb from a delivery aircraft, deliberate launching of a missile/rocket system with a nuclear warhead, deliberate firing of a nuclear projectile or torpedo from a tube, or—to cover the only remaining generic type of nuclear weapon—arming of an Atomic Demolition Munition (ADM). In the context of its drafting, it surely pertains to the principal concern of Fred Charles Iklé in his research report of 1958 (Ref. 18).

"3. There shall be positive measures to prevent inadvertent arming, launching, firing, or releasing."

   Comment: This standard pertains to the other way of obtaining the unwanted action described in the Comment for Standard 2. above; namely, inadvertent instead of deliberate.

"4. There shall be positive measures to insure adequate security."

   Comment: This standard has been interpreted over the years to require the presence of hardware features (e.g. fences) and/or procedures (identification badging) to delay physical access to nuclear weapons by persons not authorized such access. It does not mean that such features or procedures (i.e. "positive measures") will be inspected by the NWSSG to access their adequacy. That task is handled by Inspector General (or similar) programs of the agency maintaining possession of the weapons.

Studies and Reviews: The directive provides for four types of nuclear weapon system safety studies or reviews: "Initial Safety Study," "Pre-Operational Safety Review," "Operational Safety Review," and "Special Safety Studies as necessary."

> Comment: The U.S. Air Force safety program, upon which the DoD program is based, provided for Preliminary and Final Safety Studies, the latter to occur some seven weeks (or earlier) before submittal of the nuclear safety rules to the Joint Chiefs of Staff, in anticipation of subsequent coordination with the AEC and approval of the Secretary of Defense. The requirement for an Operational Safety Review reportedly resulted from the position taken by Brigadier General Dodd Starbird, AEC/DMA, that a safety study should be conducted after a weapon system has been deployed and procedures for operation are complete, to include traveling to the deployment site to review procedures.[15]

2.16 Origins of Plutonium Dispersal Safety, 1956

Advent of the sealed-pit design for nuclear weapons gave impetus to a second type of nuclear safety; namely, plutonium dispersal safety. In contrast to a nuclear detonation safety accident where the consequences of an accident could be enormous (if not catastrophic) in terms of loss of life or property, the consequences of a plutonium dispersal safety accident would not necessarily be life-threatening to the populace, and damaged property could be restored by decontamination operations. In recognition of the qualitative differences between the new sealed-pit weapons and the old capsule-type, a high-level AEC DoD overview group—Joint Board on Future Storage of Atomic Weapons—was established in late-1956. The special problem area of plutonium dispersal was assigned to a technical subgroup called the Nuclear Safety Working Group.[16]

As shown by Figure 4, the Nuclear Safety Working Group was comprised of persons drawn from the health physics and weapons effects sections of the nuclear weapon programs—as contrasted to nuclear detonation safety, where participants came from weapon development and operational-use backgrounds. For example:

- The chairman was the AFSWP's Scientific Advisor, a position that had focused on obtaining and applying weapon effects data as blast and thermal environments.
- The AEC's principal representative was a civilian from the Division of Operational Safety instead of from the Division of Military Application.
- The Sandia representative, Dr. James (Jim) Shreve, was from the Research organization, with a specialization in weapon effects. Neither the Los Alamos nor Livermore weapon laboratories chose to participate.

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15 This conviction on the part of Brigadier General Starbird appears to be the basis of the provision added for the first (August 8, 1974) revision in DoD Dir. 5030.15 for the cognizant military service to support the Atomic Energy Commission (AEC) during the AEC Safety Rules coordination process for DoD Safety Rules. Such support may involve a "Field Review" by an AEC/ERDA/DOE team led by OMA.

16 This name misled, since the group was concerned only with a plutonium dispersal and not in any sense with the larger concerns of a nuclear detonation. The latter area, however, had not been recognized as a problem at the time and did not exist as an institutionalized concern.

Thus, began an institutional arrangement where the two main areas of nuclear safety were to be treated as essentially unrelated concerns.

The philosophical safety approach for plutonium dispersal that evolved was to assume that an accident involving dispersal would occur and to adopt procedural measures that would limit the physical extent of dispersal. The criterion adopted was to place a maximum value on the mass of plutonium contained in an ensemble of nuclear weapons that would be permitted in open storage. The maximum was determined by the radiological dose to the lungs received by an individual who was located on the boundary of the exclusion region of a storage facility. Based on detailed reviews of a series of tests involving one-point detonations of nuclear weapon primaries and exposures of animal to the radiation environments, the working group set a plutonium mass limit. The basis was that upon concurrent detonation of the chemical high explosive in all of the weapons in the ensemble, the plutonium aerosols produced would lead to an expected dose of 15 rem to an individual located 600 meters away—a distance representative of fence lines of the time. As shown by Figure 4, the Joint Board met in mid-1958 and adopted the working group's proposal as a "rule" to be enforced in storage operations of the AEC and the DoD. This arrangement was to be continued, with the Board meeting biennially to consider the working group's proposals.

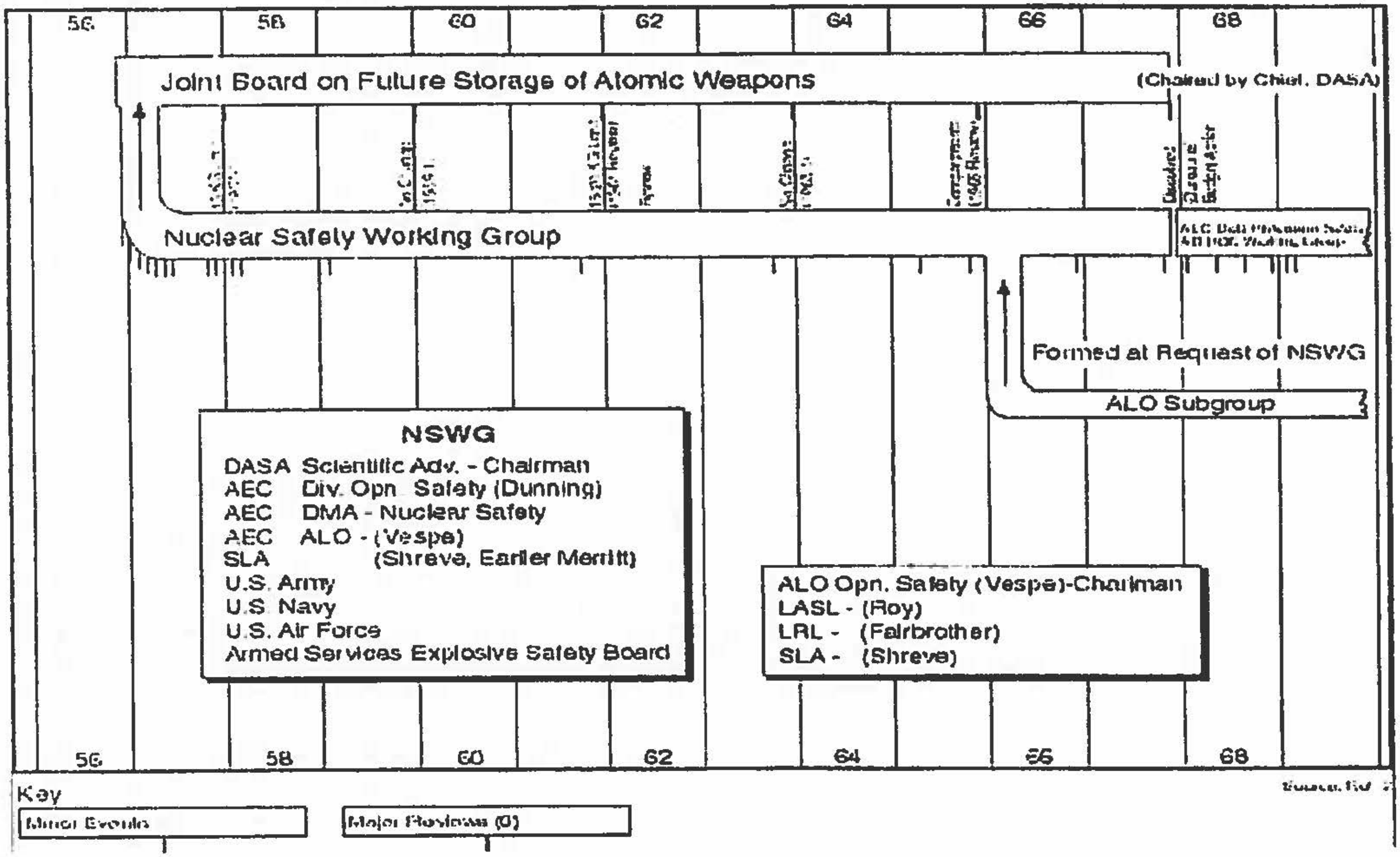

Figure 4. Historical Overview of Groups Considering Plutonium Weight Limits

3. THE WORLDWIDE DEPLOYMENT YEARS, 1960-1963

As indicated by Figure 5, two developments combined in the late 1950s to drastically change the nature of nuclear weapon safety. Nuclear weapons of the sealed-pit design began to enter the stockpile in 1957, replacing in SAC's inventory, the large thermonuclear bombs using insertable-capsule designs. For a year or so earlier, SAC had begun to place a part of its strategic bomber force on "Quick Reaction Alert." This consisted of having fully fueled bombers, loaded with bombs having nuclear capsules contained in the Automatic In-Flight Insertion (AIFI) mechanism, and maintained around-the-clock on ground alert. The AEC was not made aware of this change in readiness deployments (the NWSSG studies considered only the new sealed-pit bombs) until reliability problems arose from trying to keep the "hot" (actually thermally hot) nuclear capsules in the guide tube of the AIFI. From a nuclear safety viewpoint, this configuration was worrisome because the nuclear subsystem was not safe to the level considered acceptable for peacetime deployments and the electrical subsystems had not benefited from the scrutiny attendant to the Klee Committee's efforts. So, a new design concept and a new deployment/readiness posture occurred essentially concurrently.

3.1 Forward Deployments In NATO, 1960

In early-1960 after completion of international agreements and changes to the Atomic Energy Act of 1954, wider deployments of U.S. nuclear weapons to Europe began—both at U.S. and NATO operational sites in Europe. The Joint Committee on Atomic Energy visited Europe in December 1960 and upon return became quite critical of the arrangements to ensure that U.S. custody was maintained for weapons assigned to non-U.S. NATO delivery units. The fascinating story of how this concern evolved into the Permissive Action Link (PAL) program, championed by the new administration in Washington under President John F. Kennedy (Secretary of Defense Robert McNamara; and especially McGeorge Bundy, National Security Council, and Presidential Scientific Advisor Jerome Wiesner) is covered elsewhere. This aspect of the PAL story is not treated further here. The PAL program from its inception and continuing today has been concerned with the field of controlling the <u>use</u> of nuclear weapons as contrasted to the <u>safety</u> of those weapons against accidental insults and the hardware and procedures for each discipline are carefully kept separate but high in importance.

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Sandia's solution was to provide ESDs in the AIFI electrical circuits. This episode illustrates the national value of having a single agency consider all aspects of nuclear weaponry in the broadest and most complete context practicable—in this case, Sandia in coordination with its two sister laboratories.

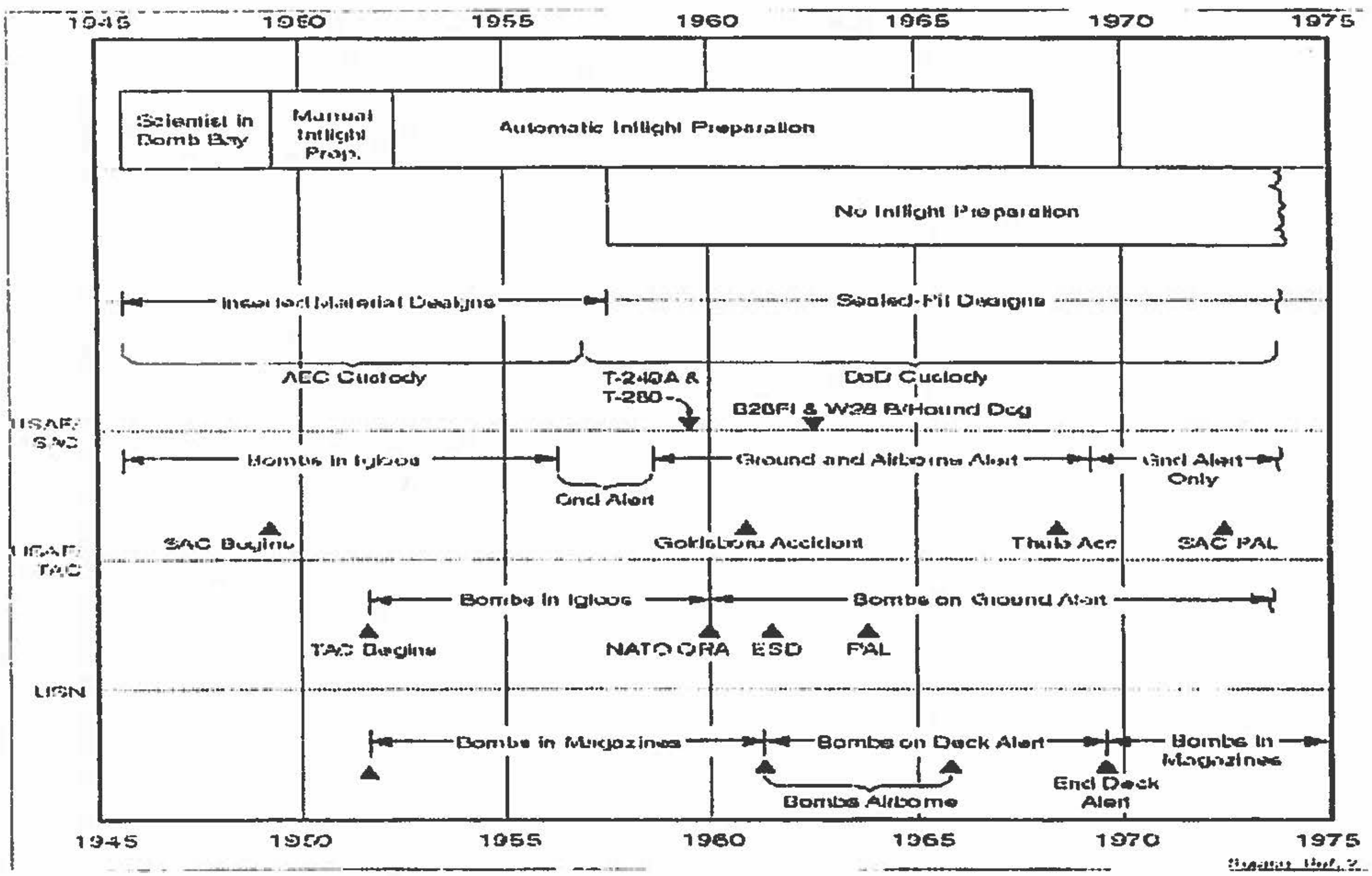

Figure 5. Summary of Early Development in Nuclear Weapon System Safety, 1945-1975

3.2 Retrofits of the Stockpile to Incorporate Environmental Sensing Devices, 1959-1961

My first involvement with nuclear safety came upon my lateral transfer from the W49 project group to the warhead electrical systems department. Actually, Herm Mauney and I exchanged jobs, at Bob Peurifoy's instigation. In May 1959 I was assigned to replace Eugene E. (Gene) Ives as Sandia's coordinator for a multimillion dollar program to equip all nuclear warheads to be deployed in Europe with devices that would improve nuclear safety during transportation, handling, and storage operations. This effort was an expansion of the XW-49 experience described earlier and was championed by Don Cotter for Sandia-Albuquerque and by William J. (Jack) Howard for Sandia-Livermore. Gene Ives drafted the Sandia policy letter to the AEC to set up a highly expedited program for incorporating Handling Safety Devices, principally Environmental Sensing Devices, into all appropriate weapon designs then in R&D, in production by means of in-process changes and in the stockpile by the provision of retrofit kits that would be installed in Europe by military crews. Sandia's Executive Vice President (since 1957) Sigmund P. ("Monk") Schwartz had taken a personal interest in the ESD program, especially for the MC-1107 inertial switch that was to be developed for wide application— essentially to be a "universal" component throughout the stockpile.

I was astonished to learn that the weapon project groups responsible for packaging ESDs into the warheads under their design cognizance in general resented being directed to do so as a Sandia policy decision—an intrusion on their individual design prerogatives. Furthermore, some weapon project leaders were uncomfortable in trying to explain to their military service and DoD agency contacts just why a remedial safety design change was really necessary. This process wasn't helped at all by the labeling of ESDs as "goofproofers," to protect against procedural errors on the part of weapon handlers. (The term "goofs," I guess, came from Walt Disney's "Goofy" animal character.) I am told that a Sandia top-level manager was bluntly informed that the Air Force had no "goof off" personnel, despite Sandia's apparent accusations. I set to work to articulate the Sandia position in the role of ESDs in draft policy documents to be signed by Sandia's President and to convey the policy to each weapon project group. There was at the time no "design safety" organization in Sandia's R&D organization. This was driven home to me as I compiled block diagrams for the weapon/weapon system applications of ESDs. Not only was there was no commonality among project groups, but there also were different philosophies as to how to place the ESDs in the arming circuits, even within some project groups responsible for multiple missile applications.

Sandia's management decision to develop a single ESD, the MC-1107, for most of the stockpile applications was, of course, quite cost effective but decidedly risky. The risk was mainly due to the questionable ability of the U.S. commercial hardware production complex to accommodate the extreme miniaturization of the MC-1107 brought about by its commonality feature. This meant challenges such as holding a tolerance of 20 millionths-of-an-inch on the diameter of the piston that would meter air flow in the cylinder into which it would be fitted in order to respond to velocity change in the missile system. As concerns developed during prototype testing, Sandia turned to the unusual measure of establishing a Task Group representing all organizations having a responsibility in the project—under the eyes of Monk Schwartz with his vast experience in such matters at the Western Electric Company of the Bell System. No organization wanted to have the blame for failure to meet design requirements and component delivery schedules, and there was some careful maneuvering and some fingerpointing as "problems" were identified. It seems to me at times that only two of us involved had absolute allegiance to the cause of on-time delivery: Ken Gillespie, the Division Supervisor responsible for the design of the XMC-1107 as a component and I, as the Member of Technical Staff assigned as coordinator for systems development aspects. I like to point out some of the near-heroic contributions Ken, his staff, and of others made in support—perhaps the most noteworthy being invention of the clean room by Willis Whitfield in the area of advanced manufacturing process development. In retrospect, I credit a commercial supplier with "saving" the effort by adapting his proprietary process of coating moving parts with a metallic material that controlled friction losses.

Don Cotter apparently believed the ESD story was sufficiently important to record that he prevailed on Herm Mauney and me to write a Sandia report (Ref. 177).

> <u>NOTE</u>: These episodes regarding the early ESD and those on the PAL programs illustrate two aspects of Sandia's operating philosophy and practices that contributed heavily to accomplishments in those crucial years of the nuclear weapons program. Firstly, Sandia managed to be involved in all stages of the nuclear weapon program from the conception to the implementation in a special way, i.e., establishing feasibility early on by demonstrating the hardware capabilities of filling a conceptual need—far in advance of any stated "requirement" by potential users. There were many R&D "think tank" operations in the U.S. working effectively in conceptual areas and many hardware developers filling contractual requirements, but a scarcity of coupling. Secondly, Sandia placed trust and confidence in members of the technical staff to operate in the field essentially alone in situations highly charged with jurisdictional and fiscal issues that could affect corporate position. These situations elsewhere traditionally called for chain-of-command and industrial hierarchical practices that hardly facilitate rapid, technically competent actions.

3.3 Emergency Destruction, Disablement, or Denial (D^3) of Nuclear Weapons, 1960s

The age-old concept of denying to the enemy the option to use against you in battle the very weapons that he had earlier captured from you. e.g., "spiking the gun," was applied to U.S. nuclear weapons by 1960 and became of even greater interest with the forward deployments to NATO in the early 1960s. The method of denial was to destroy the weapons in-place just before overrun or other takeover was judged to be imminent by firing explosive charges that had been fastened to the skin of all of the weapons in an array. Burning of the weapons by a liquid hydrocarbon fuel fire was a last-ditch option.

Procedures for this method of denial were contained in Technical Publication 50-8 "Emergency Destruction Of Nuclear Weapons," a manual drafted by the DoD's Field Command/Defense Nuclear Agency in 1961. Under the Joint Nuclear Weapons Publication System (JNWPS), Sandia's Military Liaison Directorate received the technical information ("source material"), drafted a procedural manual, and circulated the proposed manual to the three principals for approval: AEC/AL, FC/DNA and offices of the military services involved. The nuclear weapon system safety organization at SNLA or SNLL was the technical advisor for AEC/AL of all JNWPS manuals and its signature was required as a prerequisite for approval.

3.4 The "POPCORN" Phenomenon: A Nuclear Detonation Concern

A study by LASL in 1960, prompted by a question posed by FC/DNA, revealed that for multiple carriage of bombs on aircraft, a "POPCORN" phenomenon (related to the effects of a one-point detonation of a nuclear weapon on nearby nuclear weapons) could occur for certain bomb designs. The initiating events were either accidents or intentional detonation of the HE [i.e., "Emergency Destruction (ED)]. This work was extended to treat other weapons in carriage, storage, and transportation situations (Ref. 20).

From time-to-time, the military services would raise questions about possible problems attendant to changes in operational deployment configurations. In 1964, the U.S. Army became concerned about the mass destruction of weapons at storage sites. SNL responded by offering to develop a firing system network that would provide delays in the firing of ED charges in a weapons array. The offer was not accepted, but SNL continued the project to the stage of evaluation of prototype systems.

> NOTE: In earlier years, the only scheduled visits of Sandians to U.S. and Non-U.S./NATO weapon sites were by managers in the Military Liaison Directorate, especially the long-time director (1947-1968) Arthur B. (Art) Machen and one of his department managers. These visits were intended to ensure a continuing personal contact with Sandia employees who were residents there attached to a military unit for "field engineering" purposes. Additionally, staff members from the weapon systems safety division were technical advisors for the Operational Safety Review events for some system deployed in Europe. A Sandia supervisor, division, or section of that division, traditionally was a member (not just advisor) of the AEC team that conducted a nuclear safety Rules Reviews per DoD Directive 5030.15.

As discussed later (page 103), just before I re-entered the weapon safety area, I was a technical advisor to AEC staff during a comprehensive tour of headquarters, storage sites and operational sites in Europe, led by ATSD(AE) and MLC Chairman, Carl Walske. Apparently, Walske had promulgated a requirement to the effect that the military services should be capable of destroying all weapons at a site promptly upon receipt of an authorized command. I was impressed by the fielding efficiency shown by the troops in ED exercises at every site we visited, but also astonished upon reflection at the collateral damage that a real mass ED event would cause. At the time, I was ignorant on plutonium dispersal technology, but the memory would resurface, in spades, a few months later when I was transferred to the safety area at Sandia. As will become clear, I became a strong advocate of having Sandia managers observe military operations in the field firsthand.

The evolution of these D^3 matters and an annotated time line is contained in Ref. 22.

3.5 Advent of Prescribed Action Links (PAL), 1960-1962

As contrasted to ESDs, I was not personally involved in this story, and I rely on documents and conversations with those directly involved and impressions of the times. The history is well told in Gustavus J. (Gus) Simmons' report (Ref. 23).

The technical story of the evolution of PAL can be traced to a routine 1960 briefing of LASL's Weapons Division Leader, Harold M. Agnew, by Sandians Leon Smith and Don Cotter, on advanced development of components for electrical system safety. Environmental sensing devices could not be used for demolition munitions weapons because there was no unique environment to be sensed in deployment. Sandia's advanced component development engineer, Donald F. (Don) Wilkes, working under division supervisor Robert P. (Bob) Stromberg, had invented an electromechanical switch that could serve as an ESD. The electromechanical switch could be located inside the weapon case and operated (closed) by an electrical signal passed from a source outside of the weapon. The signal would be a series of pulses that would constitute the unique environment: a code, but not in a cryptographic sense.

Harold Agnew was invited to accompany the JCAE on the aforementioned December 1960 trip as scientific advisor. Upon his return, he made an association between the JCAE's concern about custody and the ability of Sandia's coded switch to enhance control of use of nuclear weapons until coded intelligence was provided. Subsequently, Harold Agnew, Johnny Foster of LLL, and Don Cotter were to suggest hardware development options for nuclear weapon use control.

During 1961, the subject of need for hardware options to improve custodial control of U.S. nuclear weapons in NATO led to conduct of Top Secret studies by three high-level committees chaired by the military services of DoD officials. These studies are known by the names of the chairmen or agency:

- The Stern Committee, Marvin Stern, Assistant Director, Defense Research and Engineering, DoD, spring 1961.
- The Partridge Committee, General Earl E. Partridge, Retired, summer 1961.
- The DASA/Special Weapon Arming Committee, winter 1961-1962.

Some studies did not advocate use of any hardware option at all, believing that security measures alone were sufficient.

Del Olson was assigned to support these studies as technical advisor, beginning his long involvement in use control matters. In the study process, the military services insisted that the nomenclature of the coded switch option be changed from the early Prescribed Action Link to Permissive Action Link (PAL), a subtle but critical reference to the controversial and contentious arguments taking place between civilian and military interests.

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Adaption kits were made available to U.S. Air Force units having custodial control of the missiles in 1961, some seven months after funding was made available by AEC authorization—a remarkable display of the emergency capability provided by the AEC's nuclear weapons complex. This electromechanical device, which had to be operated on the ground before the weapon system could be committed to the target, was later given the nomenclature of Category A PAL.

On June 6, 1962, President John F. Kennedy signed National Security Action memorandum 160 "Permissive Action Links for Nuclear Weapons in NATO." This document made the expedited incorporation of PALs in all U.S. nuclear weapon systems deployed in NATO support roles a national policy, and it directed the AEC weapons laboratories to develop advanced PALs to provide even higher levels of use control. The AEC was provided a supplementary funding appropriation of $23 million for the tasks.

During this time, Sandians were invited to display the prototype and early production PAL hardware in a multitude of civilian and military agency briefings in Washington, DC. Initially, Don Cotter and Leon Smith presented the briefings, with Cotter covering the nuclear weapon system aspects, and Smith covering the PAL device itself. The PAL hardware display, including the controller electronic boxes and the battery power supplies weighed about 25 pounds and became a carry-on package that surely was noted by the flight attendants for TWA's daily flights between Albuquerque and Washington.

Don Cotter and Leon Smith later were invited to join U.S. military service officers in Europe to help devise a code management and release system to operate the PALs upon authorization coming from the President. Cotter gave a vivid account of this work in an interview made shortly before his death (Ref. 24). Kenneth D. (Ken) Flynn and Gene Ives, both Members of Technical Staff in weapon systems engineering divisions, replaced Cotter and Smith later as the PAL batteries and battery chargers began to develop reliability problems. Gene Ives describes this experience in a June 1987 interview with Necah Furman as a part of Sandia History Project. By being on the scene to help the military personnel work out hardware and procedural problems and to feed information back to Sandia to initiate design changes, Gene and Ken were able to diffuse some of the extreme resentment on the part of the military. Some of the thinking was that AEC civilians had forced their PAL hardware on the military and that the hardware was so unreliable as to endanger the success of their operational missions. The resentments, however, continued to be held by some military personnel. I can relate episodes of being personally accused by retired or active duty military serving in various capacities, some as AEC employees.

NOTE: Since the earliest deliberations on the role of PAL in the nuclear weapons program, Sandia steadfastly has taken the position that nuclear detonation safety design features must be kept independent of use control features. Separation has been maintained physically by not sharing weapon hardware functions and philosophically by keeping safety and use control in different R&D organizations. The basic reason for the independence of function is to maximize safety consistent with operational requirements. Because both safety and use control devices are normally open switches in the warhead arming circuits, the closure issue becomes the who, why, where, when and how for closure of the switches. For safety, closure should occur as late in the stockpile-to-target sequence as practicable, i.e., after irrevocable commitment to the target in wartime. For use control, the closure should occur as soon as practicable after receipt and processing of proper authorization to commit in order to achieve the degree of operational readiness. The concern becomes the posture that exists between peacetime and wartime. (See Figure 1 for a listing of the considerations involved in this "gray" area.) Sandians are in the unique position of having deep involvement in total weapon system considerations via the roles of technical advisors to nuclear weapon system safety study groups and as participants in the process of concurrence with the proposed nuclear safety rules to be approved by the President.

NOTE: Perhaps the clearest example of the seemingly inevitable conflict between safety and operational readiness was the question of when the coded signal should be delivered to the B61-5 deployed in QRA status on F-4 aircraft in NATO support roles. (The first nuclear weapon to have the Enhanced Nuclear Safety hardware is described later.) The problem was that the aged F-4 would not be equipped with hardware that would provide the unique signal in-flight. The choice was to prescribe whether the unique signal was to be given on the ground by the loading crew or the safety device was to be bypassed by operating a bypass switch located on the case of the bomb. The Air Force elected to use the bypass feature, making the peacetime alert states exist without one of the two nuclear detonation safety features in place. I argued that the loading crew should deliver the unique signal at the time that they enter the PAL code (which time I was led to believe was as late in the sequence as practicable). The Air Force elected to bypass the unique signal ready/safe switch (strong link) at loading and to stand the entire QRA in that less-safe configuration. In a later section I describe how we resurrected the AEC Field Review provision of the nuclear safety rules approval process to bring this matter to higher-level management attention, perhaps not high enough.

3.6 Formation of Sandia's First Systems Safety Organization, 1960

In 1960, Del Olson was promoted from Section Supervisor (then the first level of supervision at Sandia) to Division Supervisor to head a new grouping of system engineering functions.

becoming responsible for bomb electrical systems. Del's Section Supervisor Robert A. (Bob) Dawirs had responsibility to support the nuclear weapon system safety study groups of the three military services per DoD Directive 5030.15, issued in June 1960.

Del Olson and Bob Dawirs (and his successor Bill Hoagland), with Don Cotter as Department Manager, should be credited with formulating Sandia's philosophy and practices for participation in the national nuclear weapon system safety study process. (See Walter D. (Dan) Buchly's report, Ref. 25, for a thorough summary of Sandia's roles in the total process.) They acquired the technical staff from the Weapon Systems Development part of Sandia, persons who were very much immersed in the relevant technology. Figure 6 displays the names and tenures of these safety specialists through 1963. Two of the members of technical staff later had important roles in nuclear safety that will be described later, i.e., Don Bickelman and Stan Spray. Note that tenures after 1960 tend to be brief relative to Sandia's norm and that resignation was also relatively common. This work was extremely demanding as to effort required and time spent away from the laboratory and frustrating as to dealing with the ambiguities inherent in the evolving safety study methodology. For most studies, the Sandia representative was the only technically trained person present. Furthermore, they tended to understand the national significance of their role and felt that Sandia management was unappreciative—as evidenced by being buried in a systems development section without an appropriate title.

Del Olson and Bob Dawirs should be credited with beginning the process of analysis (from a systems engineering sense) of arming, fuzing, and firing (AF&F) subsystems. Safing was mostly concerned with the ready/safe switch in bombs and the Aircraft Monitor and Control (AMAC) equipment in the aircraft that operated the switch and with the barometric switches in bombs that provided trajectory sensing to ensure the safe-separation of the delivery aircraft and the bomb after release. These considerations depended upon reliability assessment techniques and Sandia was the national technological leader. At the time, I was absorbed as a brand new supervisor located across the hall working on warhead electrical systems and appreciated little of the bomb work. I recall that the AF&F technical staff leaders included Jim de Montmollin (ready/safe switches), Al Mandell (AMAC), and John Zimmerman (barometric fuzing). Within a few years, I would inherit these functions and some of the staff.

3.7 The Goldsboro, North Carolina, Accident, January 1961

During a B-52 airborne alert mission, structural failure of the right wing resulted in two weapons separating from the aircraft during aircraft breakup at 2,000 – 10,000 feet altitude. One bomb's parachute deployed and the weapon received little impact damage. The other bomb fell free and broke apart upon impact. No explosion occurred. Five of the eight crew members survived. A portion of one weapon, containing uranium, could not be recovered despite excavation in the waterlogged farmland to a depth of 50 feet. The Air Force subsequently purchased an easement requiring permission for anyone to dig there. There is no detectable radiation and no hazard in the area.

DOE document classification guidance issued during the drafting of this report (Historical Records Declassification Guide CG-HR-2, 7/2/97) specifies that "Elaboration above and beyond information provided on any incident contained therein is classified," where "therein" refers to a joint Department of Defense/Department of Energy report on the histories of nuclear weapons accidents. The paragraph above has been extracted from the DoD/DOE report. My original comments on the Goldsboro accident are contained in the Confidential Restricted Data version of this report, SAND99-0847.

Because of the classification action described above, I do not comment on the accident episode, especially on details of results of post-mortem examination[17] of the recovered bomb parts.

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A hardware modification designed by Sandia that would have changed favorably responses of bomb hardware to the accident environment was available in the AEC/DoD pipeline at the time in the form of a modification kit to be installed in the bomb inventory by the U.S. Air Force (Alt 197). The inventory of this particular type of bomb was "red-lined" (taken off of deployment status and stored in igloos) until the alteration was completed. This change proposal had resulted from Sandia's earlier reviews in response to the Klee Committee report (Ref. 8).

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17 Sandia Henry D. (Don) Bickelman was invited to the Air Force's accident response team dispatched within eight hours of the accident from Kirtland AFB. He accompanied a representative from AEC/AL and two from Los Alamos. Analysis of the nuclear destruction safety aspects was conducted by Jim de Montmollin, Bill Hoagland and Del Olson. Jim wrote the formal Sandia report, SC-DR-81-61.

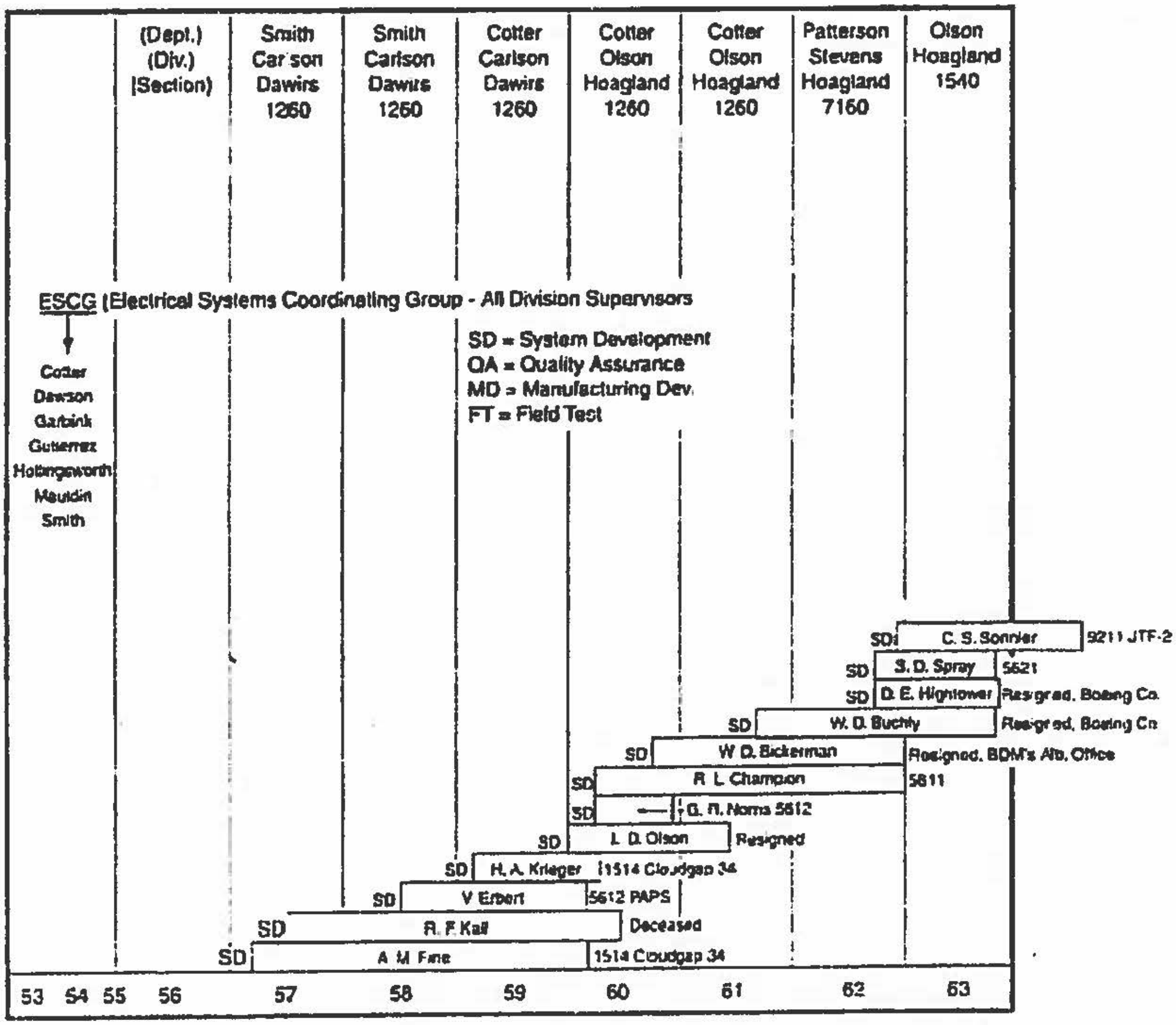

Figure 6. Nuclear Weapon System Safety Specialists at SNLA, 1957-1963

To my knowledge, there was then, and perhaps even now, no follow-up procedure in the nuclear weapon safety community that would determine if safety field retrofits are actually put into the weapons on a timely basis. The next Operational Safety Review would do that, but it usually was to be done years later. In retrospect, someone could have suggested a Special Safety Study.

> NOTE: I collected all of the official public statements on nuclear detonation safety that I could locate in 1980 for Orval Jones and published the collection. (See Ref. 102.)

3.8 The Tri-Laboratories' Second Nuclear Safety Manifesto, 1960-1961

The principal impetus for issuing a second statement by the AEC's nuclear weapon design laboratories to present recommendations for improving nuclear weapon safety was the sudden wide introduction of forward-deployed, maximum readiness nuclear weapon systems. The first statement (Ref. 17) was motivated by introduction of weapons with sealed-pit nuclear subsystems and focused on the nuclear weapon entity as the prime vehicle for improvements; the second (Ref. 27) also addressed the broader topic of the system of practices, procedures, and infrastructure in support of the total nuclear weapons program. From a technical and jurisdictional viewpoint, another major motivation was to emphasize the need for concentration on protection against threats involving deliberate, unauthorized human acts—this time in the context of forward deployments, instead of the threats of inadvertent or deliberate acts of one's own forces. At the time of the drafting, there was spirited competition within the laboratories on division of design responsibilities for advanced PAL concepts, led by Sandia's Don Cotter. Johnny Foster had begun a research program (X Division) at LRL under Dr. Marvin (Marv) Gustavson at least three years earlier, partly in conjunction with the already cited work of Fred Charles Iklé at the RAND Corporation.

> NOTE: The interval between the two manifestoes on nuclear safety was less than three years. The two driving forces, advent of sealed-pit/wooden bomb designs and forward deployments, in reality were intertwined, and their relationships were complicated by the increasing likelihood of severe accident incidental to deployments on alert postures. As is told here, weapon designers did not fully appreciate the accident threat for another six years. This oversight can, in part, be attributed to lack of a weapon design conscience function at Sandia or elsewhere in the AEC complex.

As a newly promoted Division Supervisor (August 16, 1961), I replaced Del Olson and became responsible for Sandia's nuclear weapon system safety activities and in the process became the Sandia principal for this report. Drafts had been prepared and coordinated by Del Olson, Bob Peurifoy and LRL's Marv Gustavson. Del Olson was assigned to AEC Headquarters Division of Military Application staff on loan from Sandia. In order to help process the flood of nuclear safety rules coming from the military services' system safety studies, Del was Sandia's first employee to be placed on rotational assignment to a federal agency, but the assignment was short-lived because the bureaucracy could not allow continuation of Del's Sandia retirement and other benefits. Leon Smith was transferred to another part of the nuclear weapons program; Don Cotter was promoted to Director of Management Staff in a reorganization.

My experience with nuclear safety had been limited to the ESD episodes described earlier, and I took advantage of being thrown into the middle of the design safety policy and practices report for a "quick read" and study. At the time I could detect no distinction between the discipline of nuclear weapon system safety and the discipline here that I later came to call Nuclear Weapon Design Safety. Del Olson's contributions to the manifesto included writing these basic principles used to ensure "adequate nuclear safety:"

"1. Energy sources are isolated from critical components (such as the detonators or the mechanical safing material) by interposing several components, which respond to different and independent conditions. In an abnormal situation these components are designed to provide either passive or active isolation. Arm/safe switches and thermal-sensitive fuse links are respective examples of passive and active isolation elements, which are used. During the normal arming, fuzing and firing sequence these components perform active or passive transfer or transform functions.

2. Energy is stored in such a state that it must be transformed to some other state in order to be utilized for the operation of critical components. Energy stored at 28 volts in a battery, for example, must be transformed to a high voltage state in order to fire the weapon detonators.

3. Energy of a magnitude significantly greater than that of most anticipated spurious signals is required for operation of critical components. The use of high-energy detonators is an example of the use of this principle.

4 Energy is derived from certain environments, which tend to be unique to the weapon's normal mode of delivery for use either as the primary energy for operation of critical components or for control of other components, which serve to transfer or transform stored energy for operation of critical components. Inertial generators and acceleration switches are examples of some of the devices that are used.

5. Time interdependence is required between arming functions. For example, a requirement may exist that certain arming signals be received in a particular sequence or concurrently with other signals, thus reducing the possibility of arming from other than the intended sources.

6. The "fail-safe" design approach is used to assure that component or subsystem failures, envisioned as spontaneous, environmentally induced, or as resulting from accidental human actions, will serve to safe the weapon rather than to arm it."

Source: SC-4630 (WD), October 1961, Ref. 27.

Some readers may note, with interest, how the thinking about active and passive isolation has changed over the years from that given in the first listed basic principle.

The thrust of my coordination task was to seek removal of Marv Gustavson's hard-sell section on LRL's extreme version of PAL. Of course, I knew little about PAL since that technology was being separated out of safety by Don Cotter and Leon Smith and held close because of extreme sensitivities with the military services. My feeble attempts to delete Marv Gustavson's wording failed, and he informed me quite bluntly that I had done all the toning down that he would accept. He presented the choice that rewording should cease, or LRL would withdraw its endorsement of the report. Sandia acquiesced and the following recommendation remained: "8. Techniques for making nuclear weapons more tamper-resistant should be investigated." I was to continue a most rewarding consultation relationship with Marv Gustavson, until his early death.

The issue of laboratories' design responsibilities was to continue until the June 6, 1962, decision by President Kennedy (National Security Action Memorandum 160) to equip nuclear weapons deployed in NATO with PAL devices and to direct the AEC's weapons laboratories to continue exploring advanced technologies for improved PALs. By subsequent decision of AEC/DMA, Sandia was assigned primary responsibility and adapted LRL's work—the highly sophisticated, extremely tamper-resistant subsystem concept. Orval Jones resurrected the letter from AEC/DMA that made this assignment in mid-1997 upon listening to Johnny Foster's Banquet Speaker talk on the history of nuclear weapon safety (Ref. 15) and recalling the fragility of Sandia's roles. An extract of this letter is Appendix C.

My personal technical contribution to SC-4630 was limited to recognizing an Achilles heel in protection against deliberate, unauthorized human actions, i.e., the extreme detail on weapon electrical system circuits and on component functioning contained in manuals and technical training courses, both provided by Sandia's Military Liaison organization for the military service for use in possible future retrofits and explosive ordnance demolition training. I had included in SC-4630 an appendix that examined the manuals for two thermonuclear weapons as to content of detailed design information and number of copies to be made for distribution. As mentioned on page 23 here, my sensitivity to providing detailed electrical circuit schematic drawings to military users (and to civilian users without need-to-know, for that matter) came from a personal experience about eight years earlier.

3.9 Electromagnetic Radiation and Lightning Threats to Weapon Safety, 1961-1963

In addition to the previously described tasks of nuclear safety and AF&F subsystems design guidance for bombs, I inherited responsibilities for technical means to determine the susceptibility of U.S. nuclear weapons to damage by the emissions of "friendly" communications and radar search equipment in the vicinity.

Once again, the approach taken was a systems approach involving a broad spectrum of technical activities ranging from:

- researching on EMR fields and coupling mechanisms.
- developing analytical techniques.

- measuring the energy introduced into EEDs,
- exposing instrumented weapon prototypes,
- simulating EMR fields, and
- conducting field trials.

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Reference 178 is my formal report on the episode, including presentation of analytical models and test data to affirm validity of the Sandia approach. Subsequent participation by Sandia in Admiral's tests was severely curtailed.

> NOTE: I cite the U.S.S. Enterprise episode only to illustrate that a nuclear safety conscience function, as I see it, should include somewhere in the organization a well-informed advocacy for balance of safety and operational readiness considerations. One point of view would insist that this conscience function should not be present in the nuclear safety organization, and its position on safety issues should be "pure." My practice was to keep the safety analysts (staff and direct supervisor) pure, and for me to consider the balances at the next level of supervision, and to refer the results of both to higher management levels via briefings, progress report notes, or formal report. This practice, in my view, was decimated in 1991 by Al Narath's abolition of the supervisory level that in my time strived to seek balance, i.e., Department Manager (or Division Supervisor until the subordinate level of Section Supervisor was abolished) (see page 169).

When the Navy later reported the firing of rocket motors on a nonnuclear missile mated to aircraft located on the flight deck of an aircraft carrier, I helped arrange for expedited and strengthened research and development activities aimed at accurately characterizing the EMR environments (including lightning), instrumenting the nuclear weapon ordnance devices known to be susceptible to premature operation by EMR, and examining remedial hardware or procedural changes to mitigate the effects of EMR.

The only problem uncovered was in a family of electrically initiated, explosively (or other chemical reaction) operated devices (EEDs) that served to switch electrical circuits, to generate a gas to do mechanical work, or to begin generation of electrical power (e.g., the thermal battery power supplies). Once the credibility of premature operation of EEDs at credible levels of EMR environment was established by Sandia, an emergency-priority search was initiated to identify in the entire nuclear weapon stockpile any situation whereby use of EEDs that could present a nuclear detonation safety concern. One such deficiency was found—use of an EED as the major safing device between the high-voltage thermal batteries and the X-unit capacitor bank in the B27 nuclear bomb. Immediate action was taken to place the bombs in inert storage configurations (thus "red-lining" or ceasing operational capability of the using military agency) and to redesign the circuits to replace the EED with a non-susceptible device (a solenoid-operated relay switch). This event of 1962 was yet another case of a remedial action program undertaken by the AEC for nuclear detonation safety reasons in the five years since advent of sealed-pits. The earlier cases were the retrofits of AMAC and ESDs.

> NOTE: Such retrofit actions are at the initiative of the weapon designer, rather than being a response to a deficiency uncovered by the user and are a hallmark of the U.S. nuclear weapons safety program.

3.10 Maturity Reached in Sandia's Nuclear Weapon System Safety Program, 1961-1963

On April 17, 1962, AEC/ALO announced its intent to begin a process of nuclear weapon safety studies and reviews to cover manufacturing or assembly operations for its plants at Pantex, Texas, Burlington, Iowa, or Medina, Texas, and requested Sandia to participate. Sandia's system safety studies organization has provided a voting member for all studies of this type and in later years for similar studies of atmospheric and underground full-scale nuclear tests and Plowshare experiments. This, of course, is in contrast to nuclear weapon system safety studies where Sandia's technical advisor is not formally given a vote.

As indicated by Figure 7, the rate of accidents involving the sealed-pit type of nuclear weapons decreased after 1961's two serious ones. However, the involvement of Sandia's system safety study specialists in investigations of two significant incidents (not accidents) proved to be of high importance in providing essential feedback into the weapon design process.

In 1962, four Mk 28 FI bombs in a quadruple package that had been downloaded following QRA status at an overseas base were found to have their high-voltage ready/safe switches in the armed position. Following a tenacious and exhaustive seven-month investigation by Paul R. Souder in my division, the cause was determined to have been a loose nut that had shorted an unused, obsolete radar-heating circuit to an arming line inside an Air Force junction box in the aircraft such as to bypass the T-249 AMAC.

ACCIDENT NUMBER	DATE	LOCATION	WEAPON CONFIGURATION: ASSEMBLED WEAPONS	UNASSEMBLED WEAPONS	COMPONENT ONLY	TYPE OF ACCIDENT	NUCLEAR WEAPON HE RESPONSE: HE BURN	HE DETONATE	CONTAMINATION
1	02/13/50	Puget Sound, WA	-	X		Jettison, 8000'	-	X	-
2	04/11/50	Manzano Base, NM	-	X	-	Crash into mountain	X	-	
3	07/13/50	Lebanon, OH	-	X	-	Crash in dive	-	X	-
4	08/05/50	Fairfield-Suisun AFB, CA	-	X	-	Emergency landing, fire	-	X	
5	11/10/50	Over water, outside US	-	X	-	Jettison	-	X	
6	03/10/56	At sea (Mediterranean)	-	-	X	Aircraft lost	-	-	-
7	07/27/56	SAC Base	-	X	-	B-47 crashed into [illegible]		-	
8	05/22/57	Kirtland AFB, NM	-	X	-	Inadvertent jettison	-	X	X
9	07/28/57	At sea (Atlantic)	-	X	-	Jettison, 4500' & 2500'		-	
10	10/11/57	Homestead AFB, FL	-	X	-	Crash on takeoff, fire	X	X (low order)	
11	01/31/58	SAC base overseas	X	-	-	Taxi exercise, fire	X		X
12	02/05/58	Savannah, GA	-	X		Mid-air collision, jettison	-		-
13	03/11/58	Florence, SC	-	X	-	Accidental jettison	-	X	
14	11/04/58	Dyess AFB, TX	X	-	-	Crash on takeoff	-	X	X
15	11/26/58	Chennault AFB, LA	X	-	-	Fire on ground	X		
16	01/18/59	US base, Pacific	-	X		Ground alert, fuel tanks on fire	-		
17	07/06/59	Barksdale AFB, LA	X	-	-	Crash on takeoff, fire	X	-	X
18	09/25/59	Off Whidbey Is., WA	-	X	-	Navy aircraft ditched		-	
19	10/15/59	Hardinsburg, KY	X		-	Mid-air collision, impact	X (2/2)		
20	06/07/60	McGuire AFB, NJ	X		-	Missile fire	X	-	X
21	01/24/61	Goldsboro, NC	X		-	Mid-air breakup	-	-	
22	03/14/61	Yuba City, CA	X	-	-	Crash after abandonment	-	-	-
23	11/13/63	Medina Base, TX	-	-	X	Storage igloo at AEC plant	X	X	X
24	01/13/64	Cumberland, MD	X	-	-	Mid air breakup, crash	-	-	
25	12/05/64	Ellsworth AFB, SD	X	-	-	Missile re-entry vehicle fell		-	
26	12/08/64	Bunker Hill AFB, IN	X	-	-	Taxi crash, fire	X (3/5)	-	X (1/5)
27	10/11/65	Wright-Patterson AFB, OH	-	-	X	Transport a/c fire on ground	-	-	X
28	12/05/65	At sea, Pacific	X	-	-	Aircraft rolled off elevator	-		-
29	01/17/66	Palomares, Spain	X			Mid-air collision, crash	-	X (2/4)	X (2/4)
30	01/21/68	Thule, Greenland	X	-		Crash after abandonment	-	X (4/4)	X (4/4)
31	Spring '68	At sea, Atlantic	X	-	-	Lost weapon	-	-	
32	09/19/80	Damascus, AR	X	-	-	Missile fuel explosion	-	-	-

NOTES:

1. USAF 09/19/77 press release to Richard Foster, Eye-Witness News Boston, obtained under the Freedom of Information Act, supplemented by DOD per Appendix 2.
2. The term "Assembled Weapon" means either that the separable nuclear capsule was installed but was not in the bomb's pit or a sealed pit type of weapon with the nuclear material integral with the HE subsystem. "Unassembled Weapon" means that the separable nuclear capsule was not installed in the weapon. (The USAF press release for accidents 1-11 used the term "assembled weapon" for the above plus where a capsule was on the aircraft.)
3. Contamination from all accidents except 29 & 30 was low in radioactivity and highly localized in area affected.
4. In the parentheses, the first number indicates the number of weapons that had the named response, and the second number gives the total involved in the accident.

Figure 7. Summary of Accidents Involving U.S. Nuclear Weapons

NOTE: The DoD did not consider this nuclear safety event to be an accident as that term was (and still is) defined and did not have to call out a response task force. I intervened and supported Paul Souder's marvelous sleuthing, using my division's AMAC hat rather than its weapon systems safety hat. In this case, Sandia provided a conscience function.

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By the process of seeking technical involvement in accidents and incident investigations, the weapon system safety study staff earned an essentially automatic invitation from the Air Force to participate. Similarly, involvement of weapon design specialists from Los Alamos and Livermore yielded insights that led to subsequent improvements in weapon capabilities. AEC staff and weapon laboratories' involvement in weapon accidents and major incidents are shown by Figure 8.

Don Bickelman and LASL's Tom Scolman (later a major player in safety of full-scale nuclear tests) convinced the Air Force not to perform the Render Safe Procedures contained in manuals published under Sandia's cognizance. The RSP procedure would have involved essentially complete tear down to remove the HE/nuclear subsystem on site and to package it separately for return to the U.S. I can only imagine the reaction of non-U.S. NATO forces if such an event were made known. This episode was to reinforce my career-long commitment to change Explosive Ordnance Demolition (EOD) philosophies and practices to allow maximizing nuclear safety and use control. My adversary was Sandia's Military Liaison Directorate who wrote the manuals and seemed to owe more allegiance to the military EOD teams than to safety. This battle was finally won completely only after my retirement in 1985.

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	Date	Location	Weapon Condition	Initial Response		
		No.Wpns/Type/Carrier	And Disposition	Military EOD Team	AEC	
1	11/4/58	Dyess AFB, Texas (Abilene, Texas) B-47	Impacted with high order HE detonation. Residue shipped to AEC	Local USAF, Dyess	SLA – W.B. Leslie LASL – W.W. Carter ALO – None	Health Physics Wpn. Physics
2	11/26/58	Chennault AFB, LA. (Lake Charles, LA.) B-47	Fire – HE burned, Parts shipped to AEC.	Local USAF, Chennault	SLA – None LASL – D.R.Smith ALO – None	Wpn. Engin
3	7/6/59	Barksdale AFB, LA (Shreveport, LA.) C-124	Fire – Residue shipped to AEC	Local USAF, Bossier Base	SLA-R.N Bayless LASL-W.W. Carter T.T.Scolman ALO-K.N. Voy	Wpn.Engin. Wpn.Physics Wpn.Physics
4	10/15/59	Hardinsburg, KY. (Near Ft. Knox, KY.) B-52	Bombs thrown clear on crash. Parts shipped to AEC	USA – Ft. Knox (2) USAF- 3 teams, later	SLA-R.F.Kail LASL-None ALO-P.H. Schneider	Nuc. Safety
5	6/7/60	McGuire AFB, NJ	Fire, HE melted. Residue shipped to AEC	USAF, Griffiss AFB Rome, NY (3 ½)	SLA-M. Cowan LASL-F. Dunn ALO-W.A Earl	Pu Specialist Wpn. Physics
6	1/24/61	Seymour-Johnson AFB, NC (Goldsboro, NC.) B-52	1-Impacted and broke apart. 1-Parachute retarded, intact. Residue shipped to AEC	Local USAF, S-J AFB	SLA-H.D.Bickleman LASL-D.R.Smith T. T. Scolman ALO-R. Speer	Nuc. Safety Health Physics Wpn. Physics
7	3/14/61	Yuba City, CA B-52	Both bombs impacted on crash. HE collected and burned. Other parts shipped to AEC	Local USAF, Beale AFB	SLA-H.D.Bickleman LASL-D.R.Smith W. Nobles ALO-D. Hart	Nuc. Safety Health Physics
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9	1/13/64	Cumberland, MD B-52	Both bombs broke apart on impact. Parts were shipped to AEC	USA EOD team in transit was diverted	SLA-W.D.Buenly LASL-None ALO-W.F.White	Nuc Safety
10	12/5/64	Ellsworth AFB SD (Rapid City, SD) MINUTEMAN	Re-entry vehicle fell down silo. Warhead shipped to AEC	Local USAF Ellsworth AFB	SLL-R.K.Petersen LRL-N.D Benedict ALO-D.P Dickason	Nuc Safety Nuc Safety
11	12/8/64	Bunker Hill AFB, IN. (near Kokomo, IN) B-58	1- consumed in fire; 1- mostly consumed; 1- scorched; and one 2- were intact. All returned to the AEC.	Local USAF Bunker Hill AFB	SLA-O.L.Oren G.E.Tucker LASL-H.R.Maltrud ALO-P.H.Schneider	Nuc Safety Health Physics Wpn. Physics
12	1/17/66	Palomares, Spain B-52	Two detonated low order and two were relatively intact. All shipped to AEC.	USAF, Torrejon AFB Spain	SLA-S.W.Asselin LASL-W.H.Chambers D.F.Evans ALO-O.J. Hart	Nuc Safety Wpn. Physics HE Specialist
13	1/21/69	Thule, Greenland B-52	Three detonated high order HE and one less violently. Debris shipped to AEC	USAF, Hq. SAC, Omaha	SLA-R.P Lambert LASL-J.C.Parker ALO-P.R.Smith	Nuc Safety HE Specialist
14	9/19/80	Damascus, AR Titan II	Mechanical damage Debris shipped to DOE.	Little Rock AFB Hq SAC	SLA-R.L.Pearson Jr LASL-William Chambers M&H-Roberts Lemmons ALO-Jack F.Burke	Nuc Safety Wpn Physics Packaging

Figure 8. Summary of Initial Responses to Major Accidents and Incidents Involving Nuclear Weapons of the Sealed-Pit Type

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(b)(2)

3.11 Test Device Safety Studies During the Period of Nuclear Tests in the Atmosphere, 1961-1962

Upon the U.S.S.R.'s resumption of full-scale nuclear tests in 1961 (in abrogation of the moratorium of 1958), the U.S. formed Joint Task Force 8 under Brigadier General Alfred D. (Dodd) Starbird to conduct nuclear weapons tests in the atmosphere. Brigadier General Starbird appointed Lt. Col. Roger Ray, U.S. Army, as his range safety officer for tests at Christmas Island (air drops) and Johnston Island (high altitude missile shots). From an administrative nuclear safety view, the modus operandi was the conventional one of preparing Standard Operating Procedure (SOP) documents and having them reviewed by technical staff officers. There were no formal system safety studies in the vein of those for DoD weapon systems, and at the time there had been no DOE safety studies. From a technical nuclear safety viewpoint, however, key persons from the AEC weapons laboratories, principally Sandia, included nuclear safety and arming and fuzing specialists headed by Del Olson.[18]

The initial test series, known as Dominic I, included 34 nuclear tests—28 airdrop tests between April 25, 1962 and October 30, 1962, four missile-launched tests at Johnston Island between July 9, 1962 and October 20, 1962, and two launches of operational missiles by the U.S. Navy: Frigate Bird (launched from a Polaris submarine on May 6, 1962) and Swordfish (launched from a surface ship and detonated underwater on May 11, 1962). Available records for the operational tests show no evidence that a special weapon system safety study was conducted; these weapons were launched according to operational procedures studies conducted earlier.[17] There was no formal involvement of the AEC in these operational tests—a situation to be rectified upon advent of the Limited Test Ban Treaty in 1963.

3.12 Nuclear Test Safety Studies, 1963-1975

In consideration of the treaty banning nuclear tests in the atmosphere (1962), the Joint Chiefs of Staff recommended four safeguards, and these were endorsed by the President:

Limited Test Ban Treaty Safeguards

"1. The conduct of comprehensive, aggressive, and continuing underground nuclear test programs designed to add to our knowledge and improve our weapons in all areas of significance to our military posture for the future.

2. The maintenance of modern nuclear laboratory facilities and programs in theoretical and exploratory nuclear technology which will attract, retain and insure the continued

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[18] Other Sandians deployed to the Pacific areas included William R. (Bill) Hoagland and James B. (Jim) Wright at the airdrop staging area, Barbers Point, Hawaii, and Wayne D. Olson at the missile staging point, Johnston Island.

[17] The Polaris weapon system differed from the operational in that the missile was equipped with a range safety device that could have destroyed it in-flight upon command

application of our human scientific resources to these programs on which continued progress in nuclear technology depends.

3. The maintenance of the facilities and resources necessary to institute promptly nuclear tests in the atmosphere should they be deemed essential to our national security or should the treaty or any of its terms be abrogated by the Soviet Union.

4. The improvement of our capability, within feasible and practical limits, to monitor the terms of the treaty, to detect violations, and to maintain our knowledge of Sino-Soviet nuclear activity, capabilities, and achievements."

Safety studies for the first safeguard (underground nuclear device tests at the Nevada Test Site and other potential on-continent locations) became the responsibility of a new group known as NV-HEG for Nevada Operations Office's Hazards Evaluation Group. The NV-HEG reported to the Manager, AEC-NVO, with members appointed by the Manager's Scientific Advisors from the AEC's laboratories and the DoD. Sandia's long-term members of the group were Melvin L. (Mel) Merritt for fallout production and general interests and Robert E. (Bob) Reed for "fuzing and firing."

Safety studies for the third safeguard (readiness for atmospheric nuclear device tests) became the responsibility of a new group known as the JHEG for Joint Hazards Evaluation Group. "Joint," in this case referred to the combination of AEC and DoD interest explicit in the types of airdrop and missile-delivered tests envisioned. The JHEG which reported to the Commander, Joint Task Force 8, was chaired by Dr. Robert R. (Bob) Brownlee of LANL (later by Dr. John S. Malik of LANL and Dr. Robert E. (Bob) Yoder, long-term members of the JHEG). Sandia's members were Parker F. Jones, Supervisor of the Systems Safety Division, and Jack Reed, a specialist in blast effects. Robert L. (Bob) Hilty of DOE/AL's Weapon System Safety Branch also was a long-term member.

The NV-HEG was to be a major player in the underground test of the high-yield W71/SPARTAN ABM warhead conducted in Amchitka, Alaska, in 1971. The JHEG was to consider tests that were not to occur; however, in the study process the JHEG developed important philosophical approaches to safety. Upon cessation of the READINESS program in 1975, both the NV-HEG and the JHEG were dissolved.

> NOTE: In 1967, while rethinking the allowable risk for atmospheric full-scale nuclear tests in the Pacific, Bob Brownlee of LASL wrote an extremely lucid paper (Ref. 28) on the general reaction of society to particular levels of probabilistic risk. Brownlee's concern was with tsunamic waves from a hypothetical nuclear detonation at sea level, given a fuzing and firing error in the test. His paper was cited favorably in the first report by the AEC on nuclear reactor safety (WASH 1250). I extracted a passage for publication in Ref. 129.

3.13 Joint US/UK Field Tests on Plutonium Dispersal, 1963

The U.S.S.R.'s abrogation of the moratorium on full-scale nuclear testing in the atmosphere provided an opportunity in 1963 to conduct more thorough field tests of nuclear weapons in order to provide a detailed understanding of the phenomena of plutonium aerosol creation and dispersal. A site on Sandia's Tonopah Test Range in Nevada was prepared, complete with particle-measurement grids suspended by balloons and a large array of ground-based instrumentation. Sandia's Jim Shreve and UK/AWRE's Ken Stewart were the scientific directors for the test series. Based on preliminary analysis of test results, the AEC-DoD Nuclear Safety Working Group recommended no change to the mass limit rule set in 1957. This test series continues to provide the only definitive measurements for the "source term" of a plutonium dispersal incident.

3.14 Status of the Nuclear Weapon System Safety Group, 1963

As indicated by Figure 6, the technical staff of nuclear weapon system safety specialists at SNLA had reached a high of six during 1962. By reference to Figures 2 and 3, one can note that 1962 was also near the peak level of activity of new weapon systems entering deployments in the national defense force structure. All of the twelve persons who had served on that staff since its inception in 1957 had been recruited from Sandia's weapon engineering development organizations to capitalize on their understanding of the nuclear weapons program. Furthermore, these assignments were considered by management to be short-term job rotations intended to broaden the individual's career potential. Beginning in 1963, upon cessation of full-scale nuclear testing in the atmosphere, Sandia undertook major technical initiatives in advancing weapon technologies to which inadequate attention had been afforded during the hectic years of testing and all-out engineering development for stockpile. (Note the abrupt pause in new programs in the "McNamara era" of the mid-1960's.) The staffing of the newly created Advanced System Development Directorate 1600 depleted the safety staff, causing a shift in source of staff to the then-declining areas of Manufacturing Development and Quality Assurance.

3.15 Nuclear Weapon Electrical System Design Practices Documented, 1963

In late-1962, Sandia's weapon systems organization began to draft a report (Ref. 29) that would review state of the art in weapon electrical system design and would offer specific design guidance in the area of bomb fuzing and firing. The report also analyzed design problems and approaches that had been used over the years, including a discussion of 14 anomalies (accidents, incidents and other significant mishaps) caused by design errors (6), procedural errors (2), accidents (2), random circuit failures (3) and undetermined failure (1). The cause of the later event, premature HE detonation of a B43 released in a non-nuclear test drop from a B-52, was solved after the report (Ref. 24) was issued in April 1963. This event was a safe-separation problem for a wartime situation, and not a nuclear detonation in peacetime concern. The following topics were discussed under the heading of Circuit Design: redundancy, circuit isolation, two-input approach, sequencing, ground circuits, connectors and cabling, resistance considerations, unusual environments (fire, electromagnetic radiation, lightning and nuclear radiation) and testing.

The authors of the report were Alfred R. (Al) Mandell and Stanley D. (Stan) Spray. Al Mandell had been involved in weapon electrical systems continuously from the Manhattan Project, and Stan Spray had been a lead design project engineer on the B57, where bent pins on electrical connectors had been a most troublesome problem. This report constituted a status report for the state of nuclear detonation design safety. There was no organizational entity at Sandia for this discipline at the time and would not for another five years.

3.16 Formation of Sandia's Systems Approach for Safety in Weapon Design, B61, 1961-1964

As mentioned earlier, I was literally dumped into the area of weapon system safety and bomb AF&F on August 16, 1961, as a newly promoted Division Supervisor who inherited the organization that Del Olson and Don Cotter had built and had left for other endeavors.

As can be determined from Figures 2 and 3, a major hiatus in the U.S. nuclear weapon program began in the early 1960s, in part as a result of the nuclear test moratorium of 1958 and the advent of the Robert S. McNamara era in the DoD (e.g., the use of cost-effectiveness studies). The extreme paucity of weapon development projects threatened to destroy the capabilities of the weapon design teams and the weapons production complex. The "weapons community" within AEC and DoD reacted by commissioning a new bomb-development program, the B61 tactical, thermonuclear, full-fuzing option bomb. (The argument being that one bomb program required about three times the effort for one warhead.)

As Division Supervisor of the Electrical Systems Division responsible for bomb systems definition (August 1961 to April 1964), I used the B61 project as a vehicle upon which to advance a "systems approach" to weapon development. This approach involved the broadest consideration of the role of the new bomb in national security posture and the appropriate design features to accommodate the role to be assumed. In this regard, systems thinking (attributable to the leadership of Smith, Cotter and Peurifoy) at Sandia could be contrasted to project thinking, where strict and narrow conformance to the "requirements" established by the military service/DoD user is inviolate.

The first contribution of note was to challenge the basic design approach of having a different bomb for each operational scenario. I examined in detail the origin and apparent rationale for each statement of "requirements" in the MCs and found an incredible lack of focus on the specific needs and roles for the bomb: in short, an unmatching set of parameters gleaned from the historical base of previous MCs. My draft working paper (not located for this writing) set forth for internal design team review the fragile nature of the MCs and called for an assertive position by Sandia/Los Alamos on realistic parameters. In my view, the thinking stimulated by this approach was as factor in Los Alamos' and Sandia's initiatives in the B61 subsequently becoming the most versatile weapon in the stockpile.

3.17 The President's National Security Action Memorandum on Nuclear Weapon Safety Responsibilities, 5/61

Certain ambiguities concerning AEC and DoD responsibilities arose as a consequence of extensions in deployment of nuclear weapons from strategic operations at bases in the continental U.S. to tactical operations at forward bases. The AEC Chairman testified to the JCAE in 1959 as to the need to clarify by legislation responsibilities of AEC and DoD with respect to weapons in DoD custody. The issue arose again in December 1960 in connection with a request of President Eisenhower to approve a nuclear weapon dispersal plan. As a result of a JCAE visit to NATO in late 1960, JCAE Chairman Holifield wrote President Kennedy citing the need for clarification of responsibilities. On May 8, 1961, National Security Action Memorandum 51 was issued stating in part:

> "With regard to the broader question concerning responsibility within the government for the safety of nuclear weapons, the President has directed that that Department of Defense have immediate administrative responsibility for identifying and resolving health and safety problems connected with the custody and storage of nuclear weapons. He has further specified that the Atomic Energy Commission will participate in the consideration of these problems as a matter of continuing responsibility. He has instructed that any issues which cannot be directly resolved by the DoD and the AEC will be referred to him, through this office for decision.
>
> Accordingly, it is requested that the Department of Defense, in cooperation with the AEC and such other agencies as may have a direct interest in this matter, undertake promptly a study of what additional administrative and statutory provisions may be required in relation to the safety of nuclear weapons and nuclear weapons systems and to report to the President through this office as soon as possible the results of their study, courses of action agreed upon, and any actions which are recommended for the President to take."

This NSAM satisfied the JCAE and no legislative change was suggested.

4. THE LEVEL-OF-EFFORT YEARS, 1964-1968

With the cessation of full-scale nuclear testing in the atmosphere in 1962, Sandia entered a period of operation under a funding and management practice that I later termed "Level-of-Effort" (LoE) and have described in considerable detail in a series of essays and memoranda, some of which are included here as references. For this discussion, the relevant aspect of LoE is that conduct of Advanced Systems R&D became a legitimate mission and attracted commitment of technical talent throughout Sandia to an extent that was unprecedented. Review of Figures 2 and 3 shows that there were essentially no really creative nuclear weapon development projects from 1962 until advent of the antiballistic missile warhead projects in the late-1960s. "Advanced" meant in advance of scheduled normal weapon projects authorized by the DoD—not "exploratory" as the effort much later was to be labeled and managed. This distinction as to intended ultimate use of the technology is important to appreciation of the times.

4.1 Advanced Developments in Use Control, 1962-1965

The main reference for this section is my draft working paper "Blackhatting—A Review of Adversary Simulation Activities in Nuclear Weapon Use Control Programs at Sandia National Laboratories" dated November 1981 (Ref. 31). I was not directly involved in those use control matters involving permissive action links (PALs) and gathered the material outlined here in preparation for becoming responsible for the division that did adversary simulation analyses of PAL hardware.

Figure 10 shows a timeline that relates in sequence of development the types of PAL devices described later in this paper, for purposes of clarity in presentation.

To review earlier discussion, the evolution of use control activities began with the Congressional Joint Committee on Atomic Energy's trips to NATO countries in late-1960. National Security Action Memorandum (NSAM) 160, issued by President Kennedy in 1962, directed the expedited incorporation of PAL switches in nuclear weapon systems in NATO support. This activity became a "crash program" at SNL for several years. NSAM 160 also directed that the AEC's weapons laboratories be tasked with development of advanced subsystems to provide even higher levels of use control to include "mechanisms to assure self-destruction of a weapon if efforts are made to bypass the permissive link" (herein called PAPS, Permissive Arming and Protection System). Early development of the more advanced PAPS subsystem was undertaken by LLL; however, by mid-1963 the work was transferred to SNLA by AEC/DMA decision.

The definitions of terms given below facilitate the ensuing discussion of design and design effectiveness of use control devices and subsystems.

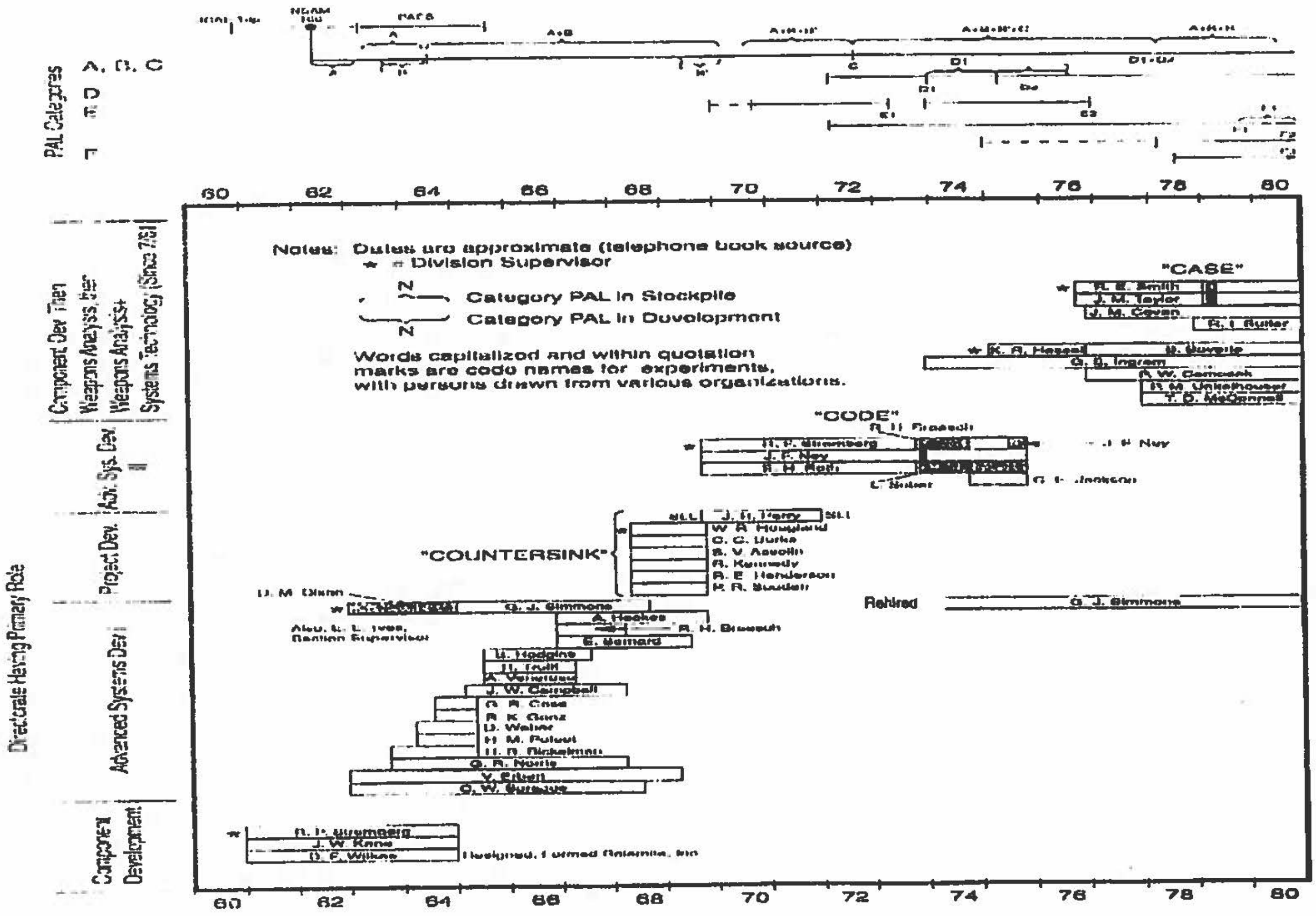

Figure 9. Nuclear Weapon Adversary Simulation/Use Control Specialists at SNLA, 1961-1981

Use Control = In broadest terms, use control is the prevention of unauthorized uses of nuclear weapons, given that access to the weapons has been gained.[20] For this report, the definition is restricted to those nuclear weapon hardware features that protect against intentional but unauthorized nuclear detonations.

Permissive Action Link (PAL) = A coded device that inhibits unauthorized arming of a nuclear weapon.

Command Disablement Subsystems (CD = Ways to render inoperable one or more parts of a nuclear weapon for a time delay against a specific threat.

Adversary Simulation ("Blackhatting") = An effort organized to counter those measures taken by a designer (a "Whitehat") that provides protection against specific unwanted manipulations of a physical entity by an adversary (a "Blackhat"). The effort includes an analysis and/or experiment where the adversarial threat is simulated by a person or group other than the designer in order to maintain a high degree of independence in assessment. For use control, adversary simulation involves only the protective hardware, not the code management and other administrative procedures.

Design Analysis = Effort directed toward identifying weaknesses in the hardware design such as to indicate corrective actions the designer can employ to eliminate, or otherwise avoid, the weakness.

Effectiveness Assessment = Effort directed toward determining the degree of protection provided by the design. The first-generation PAL switch was an electromechanical device invented by D. W. (Don) Wilkes, a member of an advanced development component division supervised by R. P. (Bob) Stromberg. The device was quite noisy while operating, and the acoustic emanation was recognized as a potential way for compromising the code to which the device was set. Bob Stromberg reveals that prototype hardware was delivered to a facility of the National Security Agency in Washington, D.C. for a "code-picking" attempt that lasted about two weeks and was unsuccessful. This finding, however, did not satisfy John Kane, another technical staff member in Bob Stromberg's division. Following some highly imaginative experiments in secluded structures, John Kane devised a way to pick the code and in doing so he became an early "Blackhatter."[21] By the same token, Don Wilkes was the "Whitehatter." He later became interested in ways to counter advanced PAPS systems and participated as a Blackhatter. Both were in the same division, making it difficult to support the claim that "independence" must be an essential attribute in effective and credible adversary simulation. The episode did, however, suggest that deep immersion in the relevant technology (i.e., small electromechanical switches) might be a more important attribute than independence.

There was a period of keen competition at SNL between advocates of electromechanical and of electronic switches for the follow-on PAL switch. John Kane continued to blackhat the former.

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20 See R. N. Brodie's paper on broader aspects of nuclear weapon control. Ref. 32.
21 Kane's work was at once classified as Top Secret and documented appropriately.

and a highly competent electronic specialist, Division Supervisor J. E. (Chuck) Gross was appointed to blackhat the latter. Chuck Gross was in the same department as the division doing the component design—interestingly, the radar development department that had originated the loyal opposition concept of blackhatting at SLA.

When PAL switches were committed for incorporation into nuclear weapons, the nuclear weapons systems safety division supervised by Del Olson added a new section to handle PAL, supervised by M. M. (Max) Newsom. Later that year (1963), AEC/DMA directed that secure container system R&D responsibility be transferred from LLL to SLA and Del Olson re-oriented the division toward PAL/PAPS altogether. Gene Ives supervised the PAL/PAPS systems section and Max Newsom supervised the PAPS component design section. Gene Ives assigned two members of his section, Don Bickelman and G. R. (Glenn) Norris, to arrange for blackhatting of the two principal candidate technologies. To avoid the pitfalls associated with the extreme specialization on nuclear weapons which then characterized the SLA staff, contracts were let with the Stanford Research Institute and the fledgling local-area firm Braddock, Dunn and McDonald (now BDM). Contracts covered the period July 1963 to November 1965.

The five-years 1963-1968 was an unusual period at SNL in that a combination of circumstances elevated the advanced development program from a modest portion of total R&D (say 10-15%) to the major program (say over 40%, and research activities amounted to another 10%). Atmospheric nuclear testing ended in 1963, and the four safeguards for the nuclear weapons program adopted by the Congress as a condition for the Limited Test Ban Treaty required the conduct of aggressive weapons R&D. Technical staff became available as testing activities wound down. Additionally, weapon system acquisition practices were affected by the systems analysis/cost-effectiveness approach of Secretary of Defense Robert McNamara, and the regulating cancellations and stretched-out time scales released weapons engineering (Phase 3) staff at the AEC's laboratories for reassignments.

Use control subsystems became one of the several major thrusts of Sandia's advanced development program in mid-1963. It was clear at the onset that use control development would be fundamentally different from traditional nuclear weapon ordnance engineering because there was no "performance specification" against which to design, test, and evaluate. Neither the threats nor the appropriate responses to the threats had been defined. This situation led to establishment of a "Counter-Effort" division. John Kane from component development group and H. M. (Horace) Poteet, an electronics specialist were borrowed, on a temporary basis, as tutors.

Under Gus Simmons, blackhatting of PAPS subsystems became institutionalized at SLA.

By mid-1965, the advanced development projects related to nuclear weapons were complete. (Refs. 6a and 6b of Ref. 31) the technology shelved to await a customer, and the development Whitehat team disbanded. Gus Simmons and his division began to work on non-weapons applications of the technology (Ref. 6c of Ref. 31).

4.2 Nuclear Weapon System Accidents: Cumberland MD and Bunker Hill AFB, IN, 1964

In June 1963, the nuclear weapon development organization at Sandia Albuquerque was extensively reorganized, and in the process I began my second, however brief it was to be, direct involvement in nuclear weapon system safety. I had inherited intact the nuclear weapons systems safety section under Bill Hoagland in August 1961, upon Del Olson's assignment to AEC/DMA in Washington and my promotion to replace him as division supervisor, and had been responsible for its functioning for about six months until Del's return. At that time, Del was given back the section, augmented by Gene Ives as a staff member. My second "tour" of duty was to last only 10 months, ending in April 1964 with a lateral transfer to Don Cotter's management staff directorate. Thus, I was on hand for one of the two nuclear weapon accidents discussed below.

On January 13, 1964, a B-52 strategic bomber carrying two bombs (the type that I knew well, having been involved in the development project) broke apart in flight and crashed on Big Savage Mountain near Cumberland, MD. Both bombs broke apart on impact. Dan Buchly was assigned by Bill Hoagland to join the Air Force's accident response team formed to depart Kirtland AFB promptly. LASL did not provide a representative, but Walt White from DOE/AL responded. We learned that an Explosive Ordnance Demolition (EOD) team of the U.S Army, which was in-transit at the time, was diverted to the crash site and was operating on-scene. The Air Force team was preparing to remove the bombs quickly from the site with heavy material handling equipment in order to reduce media coverage. I can recall Dan Buchly's anxiety over disturbing the bombs without knowing the condition. I supported Dan's concern and this stand by "the AEC" led eventually to a carefully considered process of packaging and transporting the bombs to a designated AEC facility. Dan resigned from Sandia afterwards, but not before writing the Sandia Report that documented the overall nuclear safety program (Ref. 25).

On December 8, 1964, a B-58 strategic bomber, carrying in a pod configuration four thermonuclear bombs on the wings slid, off of an icy runway at Bunker Hill AFB, Indiana, on a taxi exercise, crashed and burned. Oscar L. ("Oz") Oren was the Sandia safety specialist who joined the Air Force's accident response team from Kirtland AFB, along with a LASL and an AEC/ALO representative. All bomb hardware was returned to an AEC facility. I was not involved in this accident response and investigation, and I recall no particular concern within Sandia's weapon development organizations with respect to accident environments and weapon hardware behavior therein.

4.3 Advent of Fault Tree Analysis Methodology, Late 1964 to Mid-1966

For a more detailed discussion of this topic, see References 33 and 145.

When I was laterally transferred on April 1, 1964, (as a division supervisor) to Don Cotter's Advanced System Studies staff, Sandia was monitoring a contract let in 1962 to Mathematica, Inc., that would formulate a computer code to prepare and evaluate probability equations for complex electromechanical systems (e.g., a nuclear weapon arming system). Mathematica had been formed as a Princeton University spin-off by Oskar Morgenstern, credited with linking in 1944 game theory conceived by John Von Neumann and economic behavior. The Sandia sponsor was Arthur M. (Art) Breipohl of Cotter's staff. Art had been a reliability assessment engineer and was completing his Ph.D. in Electrical Engineering at the time. By late-1964, George R. Ellison of Cotter's staff had set up a parallel project within Sandia to write a code using the FORTRAN computer language in common use at Sandia—as contrasted to Mathematica's use of IPL-V language foreign to Sandia. George arranged with me to have Sandia hire a colleague of his at Oklahoma University, Richard W. (Dick) Worrell, to team with him on this effort, code-named ESAP (Eventpoint Systems Analysis Program).

These computer programs were directed to solution of reliability equations, including those for premature operation of a weapon systems' safe-escape hardware. There was no intent to my knowledge to apply it to nuclear detonation safety. Upon my promotion to Department Manager on Cotter's staff in January 1, 1965, I inherited the project as a manager and upon learning more about its potential value to nuclear weapon systems development became a stronger advocate.

In order to demonstrate applicability of the methodology, George Ellison arranged a trial run using a hypothetical version of a kitchen electrical stove (not self-cleaning), hence the project name HOTPOINT. The code and computer hardware combination simply was unable to handle this level of complexity beyond producing equations of only several orders-of-exactness. This experience reinforced the value of applying simplifying assumptions to reduce exactness requirements significantly—making the methodology essentially little better than that afforded by the skills of existing reliability engineers at Sandia. Nevertheless, I continued a low-key sponsor of ESAP throughout the remainder of my staff assignment—another two years. More about ESAP and nuclear safety follows in the events of 1968.

4.4 Plutonium Dispersal Safety of Nuclear Power Sources for Aerospace Systems, 1965

After a several-year stint with the Dikewood Corporation in Albuquerque, Carl Carlson was rehired by Don Cotter on August 16, 1963, to serve on Don's management staff. While at Dikewood, Carl, under contract to Sandia, wrote a report that summarized the use control program (Ref. 161).

As part of a program evaluation review for Sandia's taskings in the AEC's Aerospace Nuclear Safety (ANS) program, Carl was sought to write a treatise to aid in probing the total ANS effort. I did not learn about this work until some two decades later when I was reviewing the history of use of probabilistic risk assessment techniques in the nuclear weapon program (Ref. 135). Carl's remarkable six-page document examines nuclear weapon safety experience for "axioms, algorithms, parables, and precautions perhaps transferable to the aerospace context" (Ref. 34). Its major thrust was to make the case for making the safety theme one of assuring intact re-entry of radioisotopic thermoelectric generators (RTGs), given mission abort, rather than the theme in use at the time that relied on burnup upon re-entry. Carl was aware of the reentry vehicle thermal protection technology used at Sandia for weapons and saw its application here. I include the treatise here as Appendix D because I believe it to be one of the most deeply thoughtful, penetrating and insightful statements on safety.

Gene Blake, a veteran and talented mechanical engineer from the weapons development program (e.g., the W49 on which I had worked), coupled Carl's theme with observation that NASA's assumption for an abort rate for the Apollo Manned Landing program was way out of line with Sandia's missiles and rockets experience. NASA used a value of about 1 abort per 1,000 launches, and Gene suggested that 1 in 10 was more realistic. Apparently Gene Blake's argument was persuasive and the RTGs for Apollo were protected. Perhaps you can recall the test. Apollo 13 (consecutively numbered mission) was aborted, the moon-landing module containing the RTG reentered in free fall and the RTGs probably are now located deep within the Marianas Trench in the Pacific Ocean. Aerosolized plutonium oxide was not dispersed worldwide.

4.5 Nuclear Weapon System Accident, B52 / Palomares, Spain, 1/66

The B-52 and KC-135 collided during a routine high altitude air refueling operation. Both aircraft crashed near Palomares, Spain. Four of the eleven crew members survived. The B-52 carried four nuclear weapons. One was recovered on the ground and one was recovered from the sea on April 7 after extensive search and recovery efforts. Two of the weapons' high explosive materials exploded on impact with the ground, releasing some radioactive materials. Approximately 1,400 tons of slightly contaminated soil and vegetation were removed to the United States for storage at an approved site. Representatives of the Spanish government monitored the clean-up operation.

Sandian Stuart V. (Stu) Asselin of the weapon systems safety study group accompanied the Air Force's initial accident response team from its Directorate of Nuclear Safety at Kirtland AFB, NM (along with one person from DOE/AL and two from Los Alamos).

Sandian Jack Howard, who was at the time serving as the DoD/Chairman Military Liaison Committee and Assistant to the Secretary of Defense (Atomic Energy), was the lead official in the DoD's participation in the accident recovery process. The principal focus was on recovery of debris, cleanup of crops, and soil contaminated by the dispersal of plutonium from the two weapons that experienced HE detonation, and search and recovery for the missing fourth bomb.[22] Their activities were politically sensitive and received extensive coverage by the press. This accident was the first involving widespread contamination. Its occurrence on foreign soil required national-level negotiations to decide upon the level of contamination that would be "acceptable" following cleanup. Dr. Wright Langham of Los Alamos became the principal scientific spokesman for the AEC's on-scene accident recovery team.

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[22] Sandian R.C. (Randy) Maydew led aerodynamic analyses to reproduce most probably bomb trajectories, an effort that predicted the bomb's location to be within about 3,000 feet of where it was finally located by grid-search technique which the Navy insisted on continuing.

4.6 Aftermath of Palomares and Related Events, 4/66 – 4/68

In the aftermath of the Palomares accident, the U.S. Air Force Scientific Advisory Board established the Ad Hoc Committee on Weapon Retrieval, chaired by Dr. Edward Teller, Associate Director of LRL (hence, the label "Teller Committee"). Following its initial meeting (April 1, 1966), the Committee made six recommendations, the major one being to consider incorporation of a mechanical safing feature in the nuclear weapon to further reduce the risk of a nuclear yield in an accident.[23] An urgent study was to determine of feasibility of such a feature. Given demonstration of feasibility, the recommendation would require retrofit of all nuclear bombs, use of the feature in all future bombs and warheads, and retrofit of all warheads scheduled to leave the CONUS (Ref. 15 of Ref. 2).

On December 22, 1966, LRL's Marvin Martin released a paper that contained a candidate feature to accomplish the Teller Committee's charge. It was derived from a mechanical safing feature of the HE/nuclear system that had been demonstrated to be practical by LRL for designs of the early 1960s. Jack Howard had been back at Sandia for about six months from his "dual-hat" service as Chairman, Military Liaison Committee and Assistant to the Secretary of Defense (Atomic Energy), but continued his deep interest and involvement in nuclear safety and use control matters. By letter addressed to Dr. Teller on March 10, 1967, Howard urged careful thought before changing the policy of not mixing nuclear safety and use-control requirements, as would be done implicitly by the approval of LRL's recommendation.[24]

> NOTE: Jack Howard's letter to Edward Teller (Ref. 162) in my opinion remains relevant to the issue of mixing nuclear detonation safety and use control in S²C. I intend to include a declassified copy here as Appendix E. Interestingly, Johnny Foster repeated his preference for mechanical safing in his speech on safety at Sandia in 1997 (Ref. 15).

The U.S. Air Force's Teller Committee met for the second (and final) time in February 1967 and made two additional recommendations to the Air Force Scientific Advisory Board via letter dated November 20, 1967. These recommendations were to:

1. improve field survey instruments to detect plutonium contamination, and
2. continue development of crash locators and underwater location transducers on a priority basis.

The former was directed at correcting the lack of funding for the U.S. Air Force's program to develop a new instrument.[25] The latter led to installing Crash Position Indicators in logistical

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23 Mechanical safing of HE/nuclear systems was at issue in the preparation of the first tri-laboratories nuclear safety manifesto in the late 1950's (Ref. 17).

24 Reproduced as Appendix E.

25 The Air Force program apparently never materialized and LRL's FIDDLER instrument, funded by the AEC, was developed and became the national standard.

transport aircraft and to Sandia's demonstration of a prototype device that could be fastened to a bomb to aid in a search at sea. Additionally, the Air Staff formed a Special Study Group to consider "the methods by which further reduction in the probability that an accident may trigger a nuclear yield," as well as the methods suggested by the Teller Committee at its first meeting in August 1966. Briefings of this group by the AEC weapons laboratories are discussed later.

4.7 One-Point Nuclear Detonation Safety, 1967-1968

About the same time that LRL's safety/use control proposal was being considered, a major event in the evolution of nuclear detonation safety requirements began to unfold; namely, a new understanding of the meaning of "one-point safety" for the HE/nuclear system.

DELETED

The definition in use at the time stated:

> "... the nuclear system shall produce no more than four pounds HE (high explosive) equivalent nuclear yield in the event of detonation of the HE by any means other than the application of normal arming and firing signals to the firing system..."
> (Source: MCs dtd 2/11/63).

Design practice at Los Alamos called for tests and computations to investigate the effects of detonating the HE at the outer surface of the HE—as would be expected to occur when the HE was insulted by external events such as fragments or heating in a fire.

DELETED

Indeed, the probability of nuclear yield was stated to be about 1 in 1,000 for a particular "point," as contrasted to the general understanding of the requirements as 1 in 1,000,000. Since the probability of the detonation occurring at that point per se was also unlikely, say 1 in 1,000, the overall probability would be the product of the two probabilities, or in 1,000,000.

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> NOTE: In my opinion, this episode of combining conditional probabilities illustrates a fundamental weakness in Probabilistic Risk Assessment, in that it tends to fail to account properly for error propagation among the individual terms. See Ref. 135 for elaboration.

The so-called "modern" understanding of one-point safety that evolved, transmitted from DoD/MLC to AEC/DMA by letter on April 3, 1968 (Ref. 49) and in use today, states:

"In the event of a high explosive detonation initiated at any one point, the probability of achieving a nuclear yield greater than the equivalent of four pounds of TNT shall not exceed 1 in 10^{-6}."
(Source: MCs for the W87, dtd 8/17/82).

4.8 An Example of "Independence" in Weapon Systems Safety Studies, 1967

By the mid-1960's, full-scale nuclear test events, including the "Plowshare" peaceful uses experiments, had been swept under the system safety study requirement umbrella of AEC Manual Chapter 0560. Each of the three laboratories had a voting member on the study group.

For Project Gasbuggy (a natural gas stimulation project in New Mexico in 1967), Sandia's member, Bob Reed, objected to LLL's proposal to mechanically unsafe the non-one-point safe primary of the test device before lowering the device down the hole. Reed's view prevailed and the test was postponed to make changes required to unsafe downhole. LLL's Test Director, Harry Reynolds, personally attacked Reed and petitioned (unsuccessfully) Sandia's Jack Howard, then back from the MLC, to remove Reed from safety study groups. This incident involved systems safety and did not, yet, spill over into design safety (Ref. 173).

4.9 Nuclear Weapon Design Safety Philosophy Dialogue, 1966-1967

By mid-1966, Bob Peurifoy, who had been transferred laterally as Department Manager to Livermore several years earlier, had replaced Andrew A. (Andy) Lieber as leader of the Livermore contingent of Don Cotter's management staff. Earlier in 1966, Don Cotter had been granted leave-of-absence from Sandia to serve as Special Assistant for Southeast Asia Matters to the DoD's Director Defense Research & Engineering (DDR&E), Johnny Foster. About this time, Jack Howard was ending his service as DoD Chairman, Military Liaison Committee and considering returning to Sandia. Leon Smith appreciated that Jack Howard's experience in Washington (the first Sandian to have that) would be valuable to Sandia and arranged for Jack to have an important position by offering to be moved laterally to lead Cotter's staff, freeing Leon's Advanced Systems Development Directorate for Jack. This directorate became most prestigious in the final years of Monk Schwartz' tenure as President of Sandia. John Hornbeck replaced Schwartz in fall 1966 and a new era in Sandia management philosophy began.[26]

The three department managers under Leon Smith in the management staff directorate were Carl Carlson, Bob Peurifoy and me. Bob Peurifoy initiated a system study process among the three to consider the status of nuclear weapon safety in the national defense posture with emphasis on potential future Sandia roles. I was at the time focused on evolution of a new cost control and budgeting system for Sandia (the "Case System") and stood on the sidelines as Peurifoy and

[26] For elaboration on these events, see my lengthy report "Sandia National Laboratories: The Level-of-Effort Years," written in September 1995 for the Sandia general history project (Ref. 152).

Carlson began a dialogue that featured exchange of essays over almost a year (Refs. 35 through 38).

The nuclear safety dialogue essentially ended in late-1967 when Bob Peurifoy returned to Albuquerque to lead the department vacated when Carl Carlson had taken leave-of-absence to join the AEC's Combined Operations Planning group formed at Oak Ridge Laboratory to do systems analyses, mostly projection of need for special nuclear materials for the weapons program. Cliff Selvage replaced Bob Peurifoy at Livermore. In December 1967, along with others at Sandia, I was asked to review a Sandia Corporation Technical Memorandum on Sandia's roles in nuclear weapon safety written by Thomas D. (Tom) Brumleve of Selvage's staff. Tom Brumleve was a Member of Technical Staff who had been hired directly at Sandia Livermore, had been assigned for awhile to the staff there that served as technical advisors on weapon system study groups of the DoD and AEC. He had developed into a leader of, and important contributor to, nuclear safety considerations in general—he was their "guru" for safety and his views and philosophy were actively sought over the years.

The "Brumleve memo," in my view, failed to recognize positive contributions of Sandia to national nuclear safety in its zeal to appeal for reforms. Its title "Let's Get Serious About Nuclear Safety" was accusatory per se and surely would have drawn the attention of Sandia's detractors, adversaries and competitors. That would have been okay, if really warranted. Brumleve cited as a metric of not being serious the number of staff members assigned to assessing the reliability of nuclear weapons and to safety—the disparity being quite large. As is to be developed in the next section of this report, Brumleve succeeded in generating considerable debate and attention within Sandia. The potential for severely damaging Sandia's ability to be effective in a national sense led to the report being recalled and a single copy placed in a permanent record file.

> NOTE: The Brumleve report episode touches on the issue of "whistle blowing" in matters such as public health and safety or national defense. The Sandia Corporation Technical Memorandum category of publications had been used over the years as an outlet for presenting technical information or opinion for internal distribution only. This vehicle was valued sufficiently to be championed widely. The decision to respond to the concerns raised in a positive program of management action apparently was seen as appropriate and proper, even if accusations of suppressing a dissenting view could later be levied.

4.10 HE Detonation and Plutonium Dispersal Safety Concerns, 1966-1975

In 1966, Jack Howard as ATSD(AE) and MLC Chairman requested that the AEC laboratories examine the possibility of destroying nuclear weapons in-place without the high-visibility attendant to the conduct of military operations to obtain the ED charges from storage, position them on weapons, string out the detonation cord needed to destroy the weapon array in a single event, evacuate friendly troops, etc. SNL developed a "strap-on" denial system that featured a self-contained shaped charge and following a visit to the U.S. European Command in 1967 [redacted] Sandian Jack Howard, the system was demonstrated to the DoD and military services, with [redacted] interest on their parts. Some three years later, the ATSD(AE) Carl Walske requested from [redacted] AEC a system that would selectively destroy critical weapon components other than the HE [redacted] detonation. A system was developed and evaluated in the field by the DoD over the year [redacted] 7/75 (Ref. 21).

4.11 State of Nuclear Weapon Design Safety in 1967

With the creation of the Advanced Systems Development Directorate 1600 under Leon [redacted] mid-1964, the process of provision of design guidance for weapon project engineers [redacted] drastically. No longer was there a group of warhead and bomb electrical systems specialists [redacted] generated new approaches, developed them to the stage of demonstration of feasibility and participated in the transfer of the technologies to the project specialists in the weapon development groups. The latter groups would become essentially self-sufficient and Del [redacted] would become the lead department manager under William A. (Bill) Gardner as director (laterally transferred from the environmental test organization).

The state of nuclear weapon design safety in 1967 as regards the weapon hardware under [redacted] laboratories cognizance was captured in an article solicited by the Air Force's Directorate of [redacted] Nuclear Safety (DNS). The article, prepared by the weapon systems development staff that provided Sandia's technical advisor to DNS's Nuclear Weapon System Safety Study Group (NWSSG) under Del Olson, described ten "design guidelines:"

No Nuclear Yield	-	Inherent one-point safe primary.
Signal Isolation	-	Separate the electrical monitor and AF&F [redacted]
Unique Arming Signals	-	"Unique" means sensing an environment [redacted] delivery.
Fail-Safe	-	Component failure or accidental functioning [redacted] safe the weapon.
Environmental Protection	-	Use of filters and joint seals to cope with electromagnetic radiation from "friendly" transmitters.
Two Separate Signals	-	Independently provided by the AF&F [redacted]
Sequential Events	-	AF&F components operate only in a prescribed [redacted] order ("normal").
Simple Control	-	Tester or controller indications should be [redacted] understood.
Test Equipment Isolation	-	Limit tester and monitor current levels to 100 milliamperes.
Operational Simplicity	-	Use a removal element, e.g., a Strike Enable [redacted]

The article (Ref. 39) also featured simple block diagrams in a bomb shape format that [redacted] some of the design guidelines in a typical release-to-target sequence.

5. ADVENT OF ENHANCED NUCLEAR SAFETY DESIGNS, 1968-1972

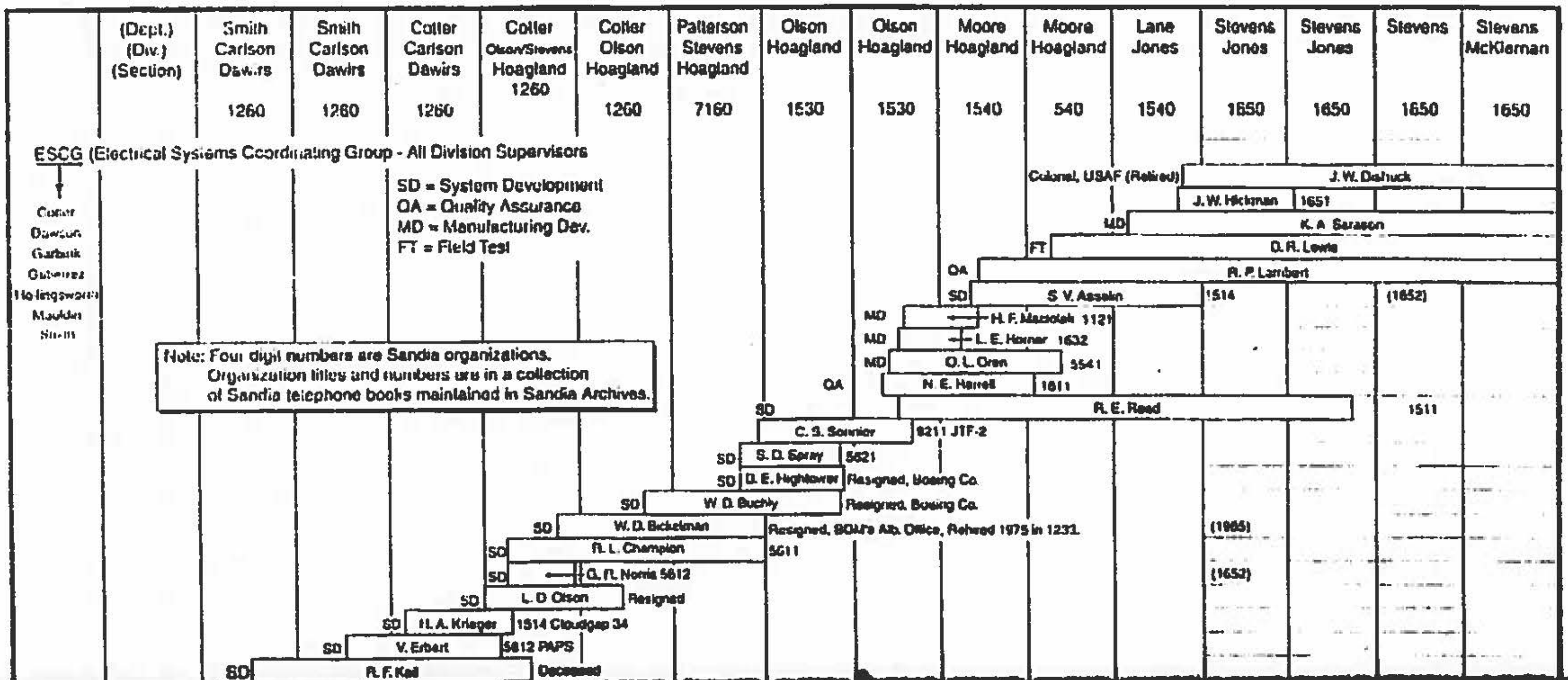
5.1 The Thule, Greenland, Accident, 1/68-5/68

Following the Palomares accident in January 1966, the Strategic Air Command's airborne alert flying operation was curtailed. Supposedly, this was because rethinking at high national levels revealed high and rising costs for a national security measure that had become less important as the other two legs of the "triad" forces (ground-launched and submarine-launched intercontinental ballistic missiles) took over time-sensitive strategic targets.

About two years later (on January 21, 1968), a B-52 stationed in New York State crashed and burned on the ice near Thule AFB, Greenland. All four nuclear bombs were destroyed in the conflagration/impact environment and the resultant HE detonation caused plutonium contamination of the sea ice. Contaminated ice, snow, water, and debris were removed to a storage site in the U.S. over the course of a four-month accident recovery operation. Following this accident, SAC's airborne alert operations were terminated altogether.

Roy P. Lambert, who for about 2-½ years had been Sandia's technical advisor for Air Force nuclear weapon system safety studies, was assigned to join the accident response team formed at Kirtland AFB. Roy's detailed knowledge of the bombs proved valuable in the extended days of searching, recovering, identifying and packaging for shipment to CONUS sites the damaged weapon components and other debris. Jack W. Hickman, a young product of the Technical Development Program (TDP) that provided postgraduate education for newly hired engineers, replaced Roy after several weeks on the ice at Thule. Figure 10 shows the nuclear weapon systems safety staff at SNL for this period.

Jim Shreve, then supervisor of the Aerospace Nuclear Safety Research Division, was assigned to the accident response team to add his expertise on generation and dispersion of plutonium oxide particles to the expertise of LASL's Wright Langham on plutonium health hazards. The two scientists became directly involved in negotiations with representatives of the Danish Nuclear Commission to determine the degree of cleanup of the ice that would be acceptable to the government of Denmark.



[redacted]

Figure 10. Nuclear Weapon System Safety Specialists at SNLA, 1965-1972

5.2 AEC/DoD Nuclear Materials Safeguards Committee, 2/68-4/69

In March 1967, an Ad Hoc Advisory panel on Safeguarding Special Nuclear Materials (the "Lumb Panel," after its chairman) reported to the AEC on the risks of diversion of certain radioactive materials in the non-weapons operations of the AEC. In its report, the panel recommended an independent review of the safeguards against diversion in the national AEC/DoD weapons program, and by February 1968 a joint committee was established to conduct a one-time, one-year study. The committee was co-chaired by DoD (Deputy Director, Defense Atomic Support Agency) and AEC (Special Assistant to the Director, Office of Safeguards and Management[27]) officials. Dr. Max Roy of Los Alamos was the AEC weapons laboratories' member, and Dr. Marv Gustavson, Livermore, and I were official technical observers during the study.

At this time, I was serving as a department manager under Leon Smith in Advanced Systems Research 5500. I sought assignment as technical observer to learn about the possibilities of Sandia being considered for a role in this emerging area of national concern. Although I could offer no special expertise in the relevant technologies, I volunteered to serve on the transportation of special nuclear materials subcommittee. This subcommittee dealt in all forms from raw material to nuclear weapons in the custody of either the AEC in development, production or retirement, or the DoD in deployment and logistical movements. This concern was reasonably close to those I had encountered only briefly some five years earlier in nuclear weapon system safety. The committee's approach featured field trips to each type of facility worldwide that was involved in handling SNM and this turned out to be perhaps the best preparation imaginable for the next two decades of my career at Sandia. Most notable was a tour of U.S. NATO headquarters, storage sites and operational sites led by Carl Walske, DoD MLC Chairman and ATSD(AE). His high rank in the DoD warranted VIP treatment for the group, including transportation by Army helicopters operating at about 500 feet above the magnificent terrain of West Germany in the summer.

NOTES:

1. One of the four AEC members was William T. Riley, Director of the Division of Security—marking for the first time known to me the direct involvement of an AEC physical security official in the total U.S. nuclear weapons safety program. Disagreements between AEC and DoD security specialists were rampant at the time: the AEC holding that the Atomic Energy Act required direct participation of AEC for weapons in custody of DoD.

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[27] The Director of this newly formed division was well known to Sandia. Brigadier General Delmar L. Crowson retired from the Air Force while serving as the AEC's Director of Military Application (2/64-6/67) to join the AEC as a civilian.

2. Marv Gustavson was denied a theater clearance for the NATO trip, openly attributed to his continuing advocacy of advanced use control features in nuclear weapons. I recall the military's hostility to Carl Walske because of PAL especially as expressed by an Air Force Lieutenant Colonel in safety work at USAF Headquarters, then in Wiesbaden, FRG, to me in a social gathering in the Air Force's Von Stuben hotel. Later, I connected this incident with introduction to the AEC/ALO civilian assigned to cover the Army's nuclear weapon system safety studies. He was the same Lt. Col. USAF but then retired.

The final report of the AEC-DoD Nuclear Materials Safeguards Committee (Ref. 41), while aimed primarily at diversion of materials and weapons, led to provision of equipment and procedures aimed at combating terrorists' threats and other "acts of banditry." This need was to become apparent some three years later following the Olympic Games in Munich. Notable among the equipment that evolved were the Safe, Secure Trailer (SST) fleet with an associated nationwide continuous communications system for AEC transportation operations and portable radiation detection devices which were later used by the AEC's Nuclear Emergency Search Team (NEST) in the 1970s.

My dimming recollection of evolution of the SST is as follows:

1. I recalled the work of Tommy Sellers in development of the Distance Measuring Equipment for the Dominic full-scale nuclear tests of 1962-63 and for Joint Task Force 2 for determining the position of military fighter/bomber jet aircraft in low altitude flights. Through Jim de Montmollin, I determined that the then-current technology could tell the location of ground-based transportation vehicles at all times and relay that to a control center. I wrote an appropriate recommendation that was adopted for the committee's final report.
2. I brought the matter to the attention of the appropriate Sandia advanced development organization under Robert G. (Bob) Clem and he sponsored a study of feasibility.
3. Much later when I had become involved in nuclear weapon safety and was briefed on the status of the project, I suggested to Bob Clem that the Secure Trailer design should be modified to include protection of the contents (e.g., weapons) during logistical movements. The secure trailers were to become known as the Safe, Secure Trailer (SST).

NOTE: As was the case for plutonium dispersal safety, safeguards (now more commonly termed "security") concerns evolved essentially independently from nuclear detonation safety and this trend continues.

5.3 Quantitative Requirements for Nuclear Weapon Safety (The "Walske Letter"), 1967-1968

As the one-point safety requirement discussions between AEC and DoD continued, a similar dialogue began in 1967 for a nuclear detonation caused by premature operation of the arming, fuzing and firing subsystems of nuclear weapon systems. MLC Chairman Carl Walske (9/12/66 to 5/31/73) consulted with Sandians Del Olson, John M. (Jack) Wiesen, Arlyn N. Blackwell and Tom Brumleve in arriving at a new understanding of premature requirements to be contained in future MCs for bombs and warheads. Walske was concerned about the ambiguities in requirement statements and about political ramifications of a plausible misinterpretation of them. A typical MC statement of the time was:

> "The probability of a premature nuclear detonation from random component failure within the warhead for the conditions noted herein shall not exceed 10^{-6} (one in 1,000,000) during storage, transportation, handling and maintenance of the warhead, mated or unmated to the adaption kit, during prefire checks of the warhead section and prior to initial arming."
> (Source: Adapted from MCs for the W66)

The problem was that the numerical probability requirement was dimensionless, e.g., it didn't address probability rate: per nuclear weapon, per weapon system, per stockpile per year, etc. If, as Walske postulated, it means per nuclear weapon, an interpretation could be that the national risk was about one in 100 (10^{-2}), obtained by multiplying 10^{-6} by the number of weapons in the national stockpile (say, 10^{4}). Politically, an estimated risk of one in 100 clearly was unacceptable to anyone in authority. Discussion revealed that Sandia's design intent was one in 1,000,000 per accident (one weapon involved in that accident). Walske suggested that the requirement allow for accidents <u>and</u> for the everyday situation of normal operations. The question was how much lower the probability should be for normal environments than for abnormal (e.g., accident) environments and the discussion led to 10^{-6} for abnormal and 10^{-9} for normal. Then, one could determine the "political" risk to be one in 100,000 (10^{-5}), obtained by multiplying 10^{-9} detonations per weapon over its lifetime by 10^{4} such weapons—probably an acceptable level of risk. These discussions culminated in the issuance of new, standard MC paragraphs by Walske on March 14, 1968, including:

STANDARDS FOR WARHEAD AND BOMB PREMATURE PROBABILITY MC PARAGRAPHS

WARHEAD MC's

a. The probability of a premature nuclear detonation of a warhead due to warhead component malfunctions, in a mated or unmated condition, in that absence of any input signals except for specified signals (e.g. monitoring and control), shall not exceed:

   (1) Prior to launch, for the normal* storage and operational environments described in the STS, 1 in 10^9 per warhead lifetime.

   (2) Prior to launch, for the abnormal** environments described in the STS, 1 in 10^6 per warhead exposure or accident.

b. The probability of a premature nuclear detonation of a warhead due to warhead component malfunctions after launch and prior to the receipt of the final warhead arming signal shall not exceed 1 in 10^4. (This is a generalized, minimum standard which may require amplification when applied to a specific weapon. Additional premature probability criteria may be included for the after launch situation depending on the various degrees of safety required for the specific employment concepts.)

* Normal environments are those expected logistical and operational environments, as defined in the weapon's stockpile-to-target sequence and military characteristics in which the weapon is required to survive without degradation in operational reliability.

** Abnormal environments are those environments as defined in the weapon's stockpile-to-target sequence and military characteristics in which the weapon is not expected to retain full operational reliability.

Source: Reference 49, reproduced here as Appendix G.

5.4 Establishment of Sandia's Nuclear Weapon Design Safety Organization, 1968

By 1967, Sandia Livermore's staff member principal advocate for nuclear weapon design safety, Tom Brumleve, was actively campaigning to have published a formal Sandia Development Report that presented his views on the need for reforms in Sandia's program (Ref. 42). Tom's earlier (1965) document on the subject (in the Sandia Technical Memorandum format that constituted a personal view) had been recalled by Don Cotter with the management direction to Brumleve to support his views with specific cases instead of generalities. Although the rewrite addressed the specific episode of Sandia Livermore's development of the mechanical safing subsystems, the treatment was judged to be insufficient to support the conclusions presented. Tom's department manager, Bob Peurifoy, declined to approve publication. Instead, the report was circulated to selected reviewers by Jack Howard, who had recently been promoted to Vice President, Weapon Development 1000.

In late-February 1968, Jack Howard convened a rather large and broadly representative group of directors, department managers, the division supervisors who were responsible for nuclear weapon system safety study support. In addition, one staff member, Tom Brumleve, was also part of this group. I believe this session was Sandia's first management review of nuclear safety. Its findings were the guide used for the next several decades in that discipline. Jack Howard personally wrote the memorandum (Ref. 43) that presented the findings in four areas:

1. U.S. Air Force Special Safety Study Group

   Del Olson was assigned to prepare the Sandia portion of the tri-laboratories briefing of this group that had been formed to consider implementation of recommendations of the "Teller Committee" (post-Palomares study). Del was a department manager in the weapon development directorate at the time. He was selected probably because of his prior involvement in weapon system safety. The nuclear weapon system safety division under Parker Jones was in a sister department under Sam Moore, who had no particular safety expertise. Del Olson was to remain Jack Howard's choice for safety briefings to groups outside Sandia for decades to come.

2. Abnormal Environments

   Tom Brumleve, with the help of Parker Jones, was assigned to decide what sort of effort should be devoted to defining abnormal environments. This resulted in formation of a task group and publication of a report "Accident Environments" (Ref. 186) some two years later.

3. Walske's $10^{-6}/10^{-9}$ Nuclear Safety Design Criteria

   Although much discussion occurred on the meaning and desirability of these criteria, there is no record of the sense of the discussions.

4. A New Sandia Safety Philosophy

   Director Leon Smith was assigned to recommend a nuclear weapon safety philosophy for Sandia. As cited earlier, Carl Carlson and Bob Peurifoy had evolved a dialogue on this subject (Peurifoy's initiative of 7/66). Leon Smith had endorsed Peurifoy's idea for development of safing devices that required unique signals for their operation, rather than a simple 28-volt DC signal (Ref. 38). In September 1967, Carlson was on leave of absence to the AEC's Combined Operations study group at Oak Ridge, Tennessee, and Peurifoy had transferred from Livermore to Albuquerque in to replace him. Peurifoy was not at Jack Howard's meeting.

5.5 The Tri-Laboratories' Third (But Unrecognized) Nuclear Safety Manifesto, Spring 1968

In consonance with the findings of the Teller Committee concerning the need for further study for means of improving nuclear safety, representatives of the AEC's three nuclear weapon design laboratories were invited to brief the AEC/DMA, DoD/MLC, and the Air Staff Special Study Group on April 30, 1968, and May 1, 1968. The three-part briefing included, in order of presentation:

- *Warhead and Bomb Electrical Systems Design* presented by Sandia's Del Olson.
- *One-Point Safety Status* presented by Los Alamos' Dr. Bob Osborne, and

- *Concepts for Possible Future Enhanced Nuclear Safety* presented by Livermore's Dr. Marv Gustavson (Refs. 46, 47, and 48, respectively).[28]

To my knowledge, the briefings were not assimilated in a report and were not disseminated further in the national nuclear weapons complex. Thus, this effort did not culminate in issuance of an expression of intent to pursue technological or procedural enhancements of nuclear safety. Del Olson's briefing took note of "the new MC requirements of 10^{-6} and 10^{-9}" but made no reference to the impact on Sandia. Indeed, in his letter to AEC/OMA to promulgate the requirements (3/14/68), DoD/MLC Chairman Dr Carl Walske stated, "Based on informal discussion in the field with AEC and Laboratory personnel, it is our understanding that the adoption of the attached standards will not result in any increase in weapon development times or costs."

5.6 Studies to Recommend a Nuclear Weapon Design Safety Philosophy for Sandia, Spring 1968

In response to Vice President Jack Howard's charge to recommend a nuclear weapon design safety philosophy for Sandia, Director Leon Smith tasked two of his department managers to independently make suggestions on expedited time scales.

Cliff Selvage, who had only recently replaced Bob Peurifoy at Livermore, supported Tom Brumleve's approach to interview key members of the technical staff both at Livermore and Albuquerque and use the recently developed "Delphi" technique to obtain a consensus view by iteration of interviews. Twenty persons interviewed at each location had experience in the areas of weapon project development, advanced systems development, nuclear safety, use control, component development and reliability. Questions focused on three aspects of safety: Sandia's responsibilities, accidents, and national risk (Ref. 44).

My approach at SNLA was to examine how various events since my earlier involvement in nuclear safety (1961-64)) should or might influence the thrust of future weapon designs. I considered both the events that had occurred external to the AEC's programs and internal in the technological capabilities of the AEC's design laboratories. This approach was a simple application of the long-range planning concept for research and development that I had evolved during experience in staff work from 1964-1968. This methodology led to the realization that significant promise for improvements in nuclear safety was evidenced by the body of advanced technological capabilities that had been generated in the mid-1960s by the laboratories. However, applications had not been found in the few new nuclear weapon systems that had survived the scrutiny of the McNamara era in the DoD.[29] My recommended solution was for

[28] Three out of Dr. Gustavson's four categories of new concepts had been implemented in the stockpile a decade later. The fourth, another form of mechanically safing the HE nuclear system, has been considered and reconsidered since but not adopted.

[29] In reviewing Sandia's files for this paper, my first use of a graphical presentation of key events in a chronological order, i.e., timelines, appears to have been for Reference 45 in 1968. Figure 15 of this report is a

Sandia to undertake a structured advanced development project that would draw in the total talent of the laboratories' design specialists by creating a tangible focus in the form of a new strategic bomb proposal. In brief, the bomb would be the test bed for the technologies that promised a safer national security posture for air-delivered weapons, by expanding the traditional concern about preventing a nuclear detonation in an accident such as the Palomares event to including the concern about preventing a radioactive material dispersal even though there would be no nuclear contribution.

As I recall, I orally presented my recommendations to Leon Smith, using the presentation aids filed as Reference 45. The outcome of this episode was Jack Howard's decision to elevate the nuclear safety effort at Sandia to the departmental level under me to search for new technological approaches to nuclear safety in weapon designs.

5.7 Project CRESCENT – Advanced Systems Development of a Super-Safe Bomb, 1968-1970

In early 1968, the outlook for nuclear weapon development, either the full-fledged Phase 3 weaponization projects or advanced development projects in anticipation of future Phase 3 status, was dim indeed. The B61-1,2 Phase 3 was ending; the W69/SRAM A Phase 3 was about two-thirds complete; the W68/Poseidon Phase 3 was about one-third complete; and the only new Phase 3s were the two antiballistic missile warheads, the W66/Sprint and the W71/Spartan. I shared the results of my study to recommend a new safety design philosophy with William C. (Bill) Myre, then a department manager in the advanced systems development directorate. Bill was attracted by the potential engineering challenges that would be presented by a bomb that had to survive the most extreme "friendly" environments conceivable. So he and I set about to have such a project authorized. At the time, I was in Leon Smith's advanced systems studies directorate and maintained periodic liaison contacts with the AEC/Division of Military Application's R&D staff. I briefed them on the concept of an accident-proof "Alert Bomb" for strategic aircraft delivery. There soon followed an official request from AEC/DMA to the three weapons laboratories to conduct advanced development projects that would stimulate the Air Force to think about the need for increased nuclear safety. Both design teams undertook projects: Project CRESCENT by Sandia Albuquerque/LASL and Project AMBASSADOR by Sandia Livermore/LLL. Both projects were to be active for about 2 ½ years. This project is not particularly relevant here and is not addressed further.

Project CRESCENT had two self-imposed requirements for:

- accident situations (e.g., fire, aircraft crash/mid-air breakup, free-fall impact, or lightning strike), the probability of the weapon producing either a nuclear yield or a one-point detonation of the high explosive would be made as low as practicable; and

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typical application. A collection of my timelines is filed in the Nuclear Safety Information Center (NSIC) as Ref. 153.

- incident situations experienced in "normal" use (e.g., a set of electrical malfunctions in the delivery aircraft that applied signals to the attached nuclear bomb), the probability of the weapon producing a nuclear yield would be made as low as practical (Ref. 50).

Major emphasis was on the prevention of dispersal of plutonium aerosols created by the HE detonation, and the scheme adopted was to maximize the strength of the bomb's structural case in order to set an upper bound on the penalties of containing conventional critical components within a "hard" case and thermal insulation. In brief, results of analytical studies and structural testing featuring scaled models showed that the desired improvements to prevent HE detonation would require an increased bomb diameter of several inches with proportional increase in weight—attributes probably not attractive to the Air Force. Subsequent studies to develop alternative ways to prevent HE detonation are covered later in this report.

In the weapon electrical system area, Project CRESCENT had more direct payoffs in nuclear safety evolution, namely:

1. a pulse-train-operated ready/safe switch in the bomb;
2. new aircraft monitor and control (AMAC) equipment in the aircraft to provide the pulse-train signal; and
3. hardened environmental sensing devices (ESDs) in the bomb.

The CRESCENT ready/safe switch proved to be an early major demonstration of potential benefits of new design approaches for enhancing nuclear weapon electrical system safety—then collectively termed enhanced electrical safety (EES).

5.8 Formation of Sandia's Nuclear Weapon Safety Department, 1968-1969

On July 1, 1968, Sandia President John A. Hornbeck implemented a major reorganization of Sandia. Hornbeck's thrust was to place scientists drawn from Bell Telephone Laboratories and Ph.D. scientists from Sandia in key positions that would facilitate his shift from emphasis on engineering to science. (See Ref. 152, page IV-2-4 for a summary of these appointments.) At the same time, a new directorate was formed in Jack Howard's weapon development vice presidency to facilitate management of three development support functions that had a degree of independence from the organizations directly responsible for development; namely, reliability assurance, military liaison and publications, and nuclear safety. The military liaison group was downgraded from the directorate level upon retirement of its career-long leader to become a department, reliability assurance remained at the department level, and nuclear safety was expanded in scope and raised to the department level.

As I recall these events, I viewed my reassignment as manager of the nuclear safety department with mixed emotions. On one hand, I was pleased not to be demoted because I was beginning to understand that John Hornbeck did not appreciate having management staff work done by anyone except his people from BTL or some Sandia Ph.D.s. Leon Smith, Carl Carlson, and I were especially marked when we had upset John Hornbeck during the mid-1967 study of the AEC's Weapons Development Complex (see Ref. 52, pages 18-20). At the same time, I was somewhat anxious because I had not been associated with Jack Howard in any meaningful way and his agenda and modus operandi' were unknown to me. I was comforted by reporting to Harlan Lenander as my director, since I had worked with him in weapon project development as a division supervisor and felt that I would have his full support.

I can't recall the details, but I believe that my suggestions were to be provided with a half-dozen-or-so members of the technical staff whom I would be allowed to approve by name, a qualified division supervisor, and sufficient funding for a two-year effort. This was presented to Jack Howard—in the sense of a bargain where we would either produce a new technological approach to design safety that would constitute a fundamental improvement (measured not in tens-of-percents, but in orders of magnitude) or be disbanded and reabsorbed in development work. Whether this "bet" was ever a reality or not, I took it as my challenge and communicated it in various ways to the staff.

Staffing of the new Nuclear Safety Department was facilitated by the relatively new process of laboratory-wide advertising of openings in an employee bulletin publication along with the institution of a policy of open bidding wherein organizations could not easily block transfers. Stan Spray became available as a division supervisor on lateral transfer from work in advanced arming, fuzing and firing subsystem advanced development. Stan had worked for me as a staff member briefly in 1962-1963 (Figure 6) and I admired his capabilities. Alan M. Fine signed on. He had also been the first to join the nuclear weapons system safety study group over a decade earlier (Figure 6) and was completing work on a use-control project (Project CLOUDGAP). In January 1969, staffing was essentially complete when I transferred Jack Hickman in from another division in my department. James D. (Jim) McClure bid in, having just completed course work for a Ph.D. in engineering. Glenn R. Norris bid in, bringing experience in systems safety (Figure 6) and use-control black hatting (Figure 9). J. W. (Jay) Grear bid in, bringing extensive component development experience (part of which was as a section supervisor) and recent advanced systems development experience. Later, I recruited Dick Worrell to convert his EVENTPOINT systems computer program from reliability to safety application. Then, my staffing goal of six was complete (Figure 11).

[redacted]

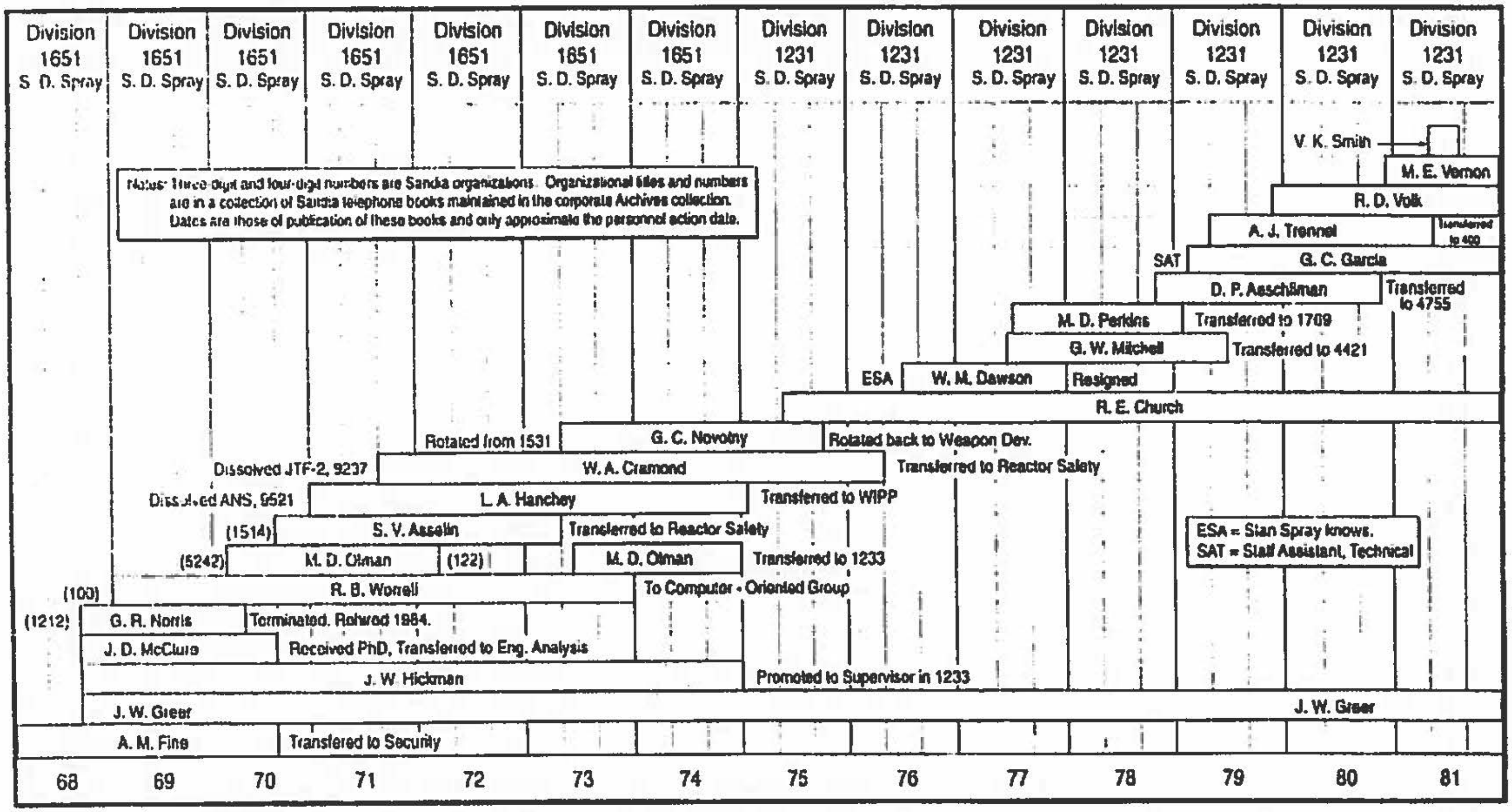

Figure 11. Nuclear Weapon Design Safety Specialists at SNLA, 1968-85

5.9 Review of the State of Nuclear Weapon Safety, 1968-1969

In late-1968, during the extended process of acquiring a staff for the newly created division that was charged with developing a new technological approach, I concentrated on a personal appraisal of the state of nuclear weapon safety in a broad sense of that term (e.g., including nuclear detonation safety, plutonium dispersal safety, and criticality safety). I organized my thoughts in a rather detailed technical memo (Ref. 154) that became my personal agenda for the next several years. The memo was labeled as a Draft Working Paper to encourage selected reviewers to comment orally, by mark-up of the text and return of the draft to me for iterations, or by separate memo to me. This practice was to become standard for me, and over the years I wrote draft working papers on a variety of subjects, as indicated by the partial listing in Appendix M.

My review of the state of nuclear safety included discussions with colleagues within Sandia and the other weapons laboratories. I searched for a theme around which to package my general conclusions and recommendations in order to lend a sense of timeliness and importance and settled on the main weapon development issue extant, the deployment of antiballistic missile (ABM) defense systems. This choice was the result of consultation with Marv Gustavson of LLL—a process that I rather faithfully renewed every several years and found most stimulating and rewarding.

After Vice President Jack Howard reviewed an early version of the draft working paper and found unsatisfactory my cursory treatment of plutonium dispersal, I undertook a crash course in the relevant history and technology for that part of nuclear safety. I had included this area of risk merely for the sake of completeness in review, but Jack Howard brought to bear his personal experience from the Palomares weapon accident of 1966. Plutonium dispersal safety became a crusade for me, as will be evident from ensuing sections of this report.

5.10 Origins of Plutonium Dispersal Safety Risk Management, 1969

During 1968 while in the process of acquiring a technical staff for the newly created division, I became Sandia's representative for the politically active topic of considering safety aspects of the forthcoming deployment by the U.S. Army of an Antiballistic Missile (ABM) system. The ABM work provided an opportunity to review recent events in the evolution of the national nuclear weapon <u>system</u> study safety process (as contrasted to focus on the nuclear <u>weapon</u> entity alone).

As a result of a decision to publicly announce the selection of deployment sites for the SAFEGUARDS/SENTINEL ABM system, the U.S. Army's representatives (usually colonels) encountered strong and unexpected interest in the safety of the system, particularly from university-connected groups near Chicago and Boston and their congressional representatives. In January 1969, the Army's manager for the ABM program, Lieutenant General Dodd Starbird, arranged for a joint AEC/DoD Safety Advisory Group to draft a handbook report that would become the source data for his officers should technical issues on nuclear safety arise.

This episode yielded a timely and remarkably broad learning experience for me about all aspects of nuclear weapon safety. I learned about LASL's one-point safety practices from Gene Eyster who had worked with Duncan MacDougall in invention of the concept. Gene wrote a classic essay on the philosophical/technical rationale for the concept (Ref. 53), and we developed a personal relationship that continued even after both of us retired. Similarly, I learned about Lawrence Livermore Laboratory's safety approach from Richard (Rich) Wagner, then project scientist for the W71 and later chairman MLC. Picatinny Arsenal's representative, Al Moss, was much respected in the nuclear weapons community for his non-parochial approach to problem solving. Of course, General Dodd Starbird was involved in nuclear safety throughout most of his long career in the Army, DoD, ERDA, and DOE agencies, and I was privileged to be associated with him several times for events described elsewhere in this report.

I recall being appalled at the primitive quality of arming, fuzing and firing technology displayed by the Picatinny Arsenal and how it would affect overall national progress in nuclear weapon safety. This initiated a special interest and involvement on my part that would climax with the Pershing II weapon system episodes described in some detail later.

As a result of the nuclear weapon accidents at Palomares, Spain, and at Thule, Greenland, the public information media had become better informed. The concern over dispersal of plutonium from an accident at an ABM site near large cities became the dominant concern. The Advisory Group's work on plutonium dispersal led to the first "marriage" of the technological capabilities of Los Alamos in the health physics (consequences) aspects of the risk and of Sandia in the plutonium aerosol dispersion physics (accident scenario) aspects. This event marks the advent of coordinated efforts to better manage the risk of plutonium dispersal. (Reference 55 cites the excellent papers by Los Alamos' Wright Langham and Sandia's James Shreve, both deceased.) The new technological capability was made possible by publication of a Sandia Development Report that gave (1) a source term for the generation of plutonium oxide aerosols for nuclear weapon HE detonations; (2) in atmospheric transport and dispersal model DIFOUT; and, (3) development of a set of safety criteria for storage and transportation of weapons (i.e., confirmation of the "20 kilogram rule"). This work, somewhat embarrassingly, came some six years after the Operation Roller Coaster field experiments (page 75), but was kept alive by Sandia's participation in the Aerospace Nuclear Safety (ANS) program for space applications of radioactive thermoelectric generations. Robert E. (Bob) Luna (Ph.D. in Aerospace and Mechanical Sciences, Princeton University, 1965) was hired directly into the ANS program and was the principal author of the report (Ref. 56). He was to continue a career-long interest and specialization in plutonium dispersal technologies and some of that work is cited in context later in this report.

> NOTE: In early 1969, debates about deployment of the SENTINEL/ SAFEGUARD ABM system led to issuance of a policy statement by AEC Chairman Glenn T. Seaborg in the role of the AEC and its laboratories in nuclear safety aspects of deployments of U.S. nuclear weapon systems. This policy statement is contained here as Appendix J and Reference 191.

5.11 Implications of Quantitative Standards for Nuclear Safety Risks, 1969-1970

Consideration of the possible implications of the quantitative nature of the standards for nuclear weapon safety promulgated by the Walske Letter of 1968 was an essential part of my review mentioned above (Ref. 194). I had some background information on probabilistic risks of a nuclear detonation from earlier safety assignments, but didn't have a clue on how to calibrate risks of plutonium dispersal and other risks such as loss of possession of weapons.

- <u>Task Group on Risk Acceptability</u>
  One of my early interests in my new job in nuclear safety was to consider a novel design approach that would incorporate a built-in weapon destruction mechanism that would detonate the weapon's high explosive deliberately in the event of a severe accident or use control bypass attempt. (Carl Carlson called it "Safety PAPS.") I commissioned a small but select Task Group on Risk Acceptability to consider the risk level for a plutonium dispersal that the public might perceive as acceptable in order to achieve a higher goal of assuring safety and use control. The task group's reports are cited in References 198 to 201. The conclusion was that a probabilistic goal would have to be so high that the resultant constraints on nuclear weapon design could not be tolerated. The area of deliberate, unauthorized acts proved to be especially troublesome, leading to cessation of the tasking.

- <u>Perspectives on National Risk</u>
  In late 1969, sensing my frustrations in trying to evolve probabilistic goals for safety concerns, my close colleague Carl Carlson examined the question of what history of weapon operations says about risk of a nuclear detonation and circulated his analysis in an internal memo (Ref. 166). Carl's calculations led to a prompt dialogue with Tom Brumleve who favored a project to collect data on the performance of weapon components obtained from stockpile surveillance testing in order to be able to make statistical estimates about safety for the weapons that used those components (Ref. 167). For several years Tom had favored the notion of establishing a national level of risk and allocating that risk to the constituent risk categories for deployment of nuclear weapons, for full-scale nuclear testing of devices for weapons, and for Plowshare experiments, the latter being the area of his current assignment at SLL (Ref. 168).

- <u>Search for a Sandia Position on Numerical Analysis of Safety</u>
  In order to further stimulate internal discussion on the concepts of statistical requirements, national risk and stockpile experiences as preparation for suggesting a Sandia position, in the spring of 1970 I wrote and circulated a draft working paper (Ref. 169) that contained extensive background and historical information on the subjects. At the time, the capability to use fault-tree methodologies to provide numerical estimates for launch safety of Minuteman ICBM missiles was being advanced by Bell Telephone Laboratories for the Air Force's prime contractor, Boeing Aircraft Company. The SLL project group for the W62/MINUTEMAN/ Mk12RV seemed anxious to apply numerical

analysis to the nuclear warhead. Don Gregson, my Livermore colleague, and I negotiated an agreement not to assign probabilistic estimates to nuclear safety analyses (Refs. 170 and 171), and this position continued. My disenchantment with the miniscule and unsupportable numerical values obtained by the DoD contractors was a prime motivation to seek a new technological approach for nuclear weapon designers for safety. This will be discussed later.

5.12 Establishment of a Role for Nuclear Weapon Design Safety Specialists, 1969-on

At this writing, the former title of Department Manager has been missing from Sandia's technical management structure for about five years, and I suspect that memories of its functions are dimming. I devoted much thought to that subject during my 1966-1967 work to formulate and implement Sandia's case system for budgeting and cost control. (Reference 57 contains a discussion of that work.) In brief, I had considered the role of department manager to be the key to making the case system work. I was presented with the opportunity to practice my thoughts with the new program of design safety. One aspect of this, that in retrospect, seems most responsible for the success that ensued was the function of personally handling all matters of setting policy and the administrative chores (e.g., writing progress reports) that would consume inordinate energy from the technical staff. This preference on my part accounts for the voluminous draft working papers that I wrote and left behind in files on safety policy and practices (see Appendix M). It was my choice to do it this way, rather than turn to the more common practices of lengthy staff meetings. Stan Spray was highly skilled in the latter mode, and I attribute that as a main factor in his remarkable success in design safety.

Although I have not located a written statement on the matter, I am told that some top managers at Sandia referred to the Nuclear Safety Department as a "conscience" and "police" function to be carefully kept "independent" of the line function of the laboratory. I do not recall ever assigning a conscience function to my staff nor did I ever suggest that they should police anything. Instead, I set the firm policy that nuclear design safety was a function of the line organization (e.g., starting with the weapon development project engineer and up that line of supervision to the President of Sandia). As indicated by Figure 12, the new division (1232) under Stan Spray had the role of developer of new safety concepts, advocator (sponsor) of use of those concepts by line project organization and advisor on the design safety matters of concern to the intra-agency DoD/DOE Project Officer's Groups. Note that per Figure 12 none of the three groups (divisions) in the department were charged with being an assessor or a certifier of the level of safety provided by line project organizations or anyone else.

ROLE	Safety Group		
	SYSTEMS STUDIES	SAFETY ASSURANCE STUDIES	ASSESSMENT TECHNOLOGY
	(1231)	(1232)	(1233)
ADJUDICATOR (VOTER)	ALO OPERATIONS NVO OPERATIONS DMA RULES REVIEW	— — —	— — —
ADVISOR	DOD SYSTEMS STUDIES ACCIDENTS AND INCIDENTS	POG SAFETY SUBGROUPS SL WEAPONS PROJECTS	ERDA/NRC SECURITY
MONITOR	SL OPERATIONS (PAP, ETC.)	—	—
ASSESSOR	—	—	—
ADVOCATOR (SPONSOR)	—	SL EXPLORATORY DEV.	—
CERTIFIER	—	—	—
DEVELOPER	—	NEW SAFETY CONCEPTS	ASSESSMENT METHODOLOGIES

Figure 12. Roles of Sandia Laboratories Nuclear Safety Specialists

5.13 Guidelines for Development of a New Nuclear Weapon Design Safety Subsystem, 1969-

As yet, I have been unable to find a document that lists the general guidelines that I issued, or the staff evolved and adopted, for the ongoing project to develop a new approach to nuclear weapon design safety. The following is my recollection and certainly is open to question and comment. The approach should (not in order of importance):

1. Not be dependent on probabilistic arguments or analysis

   I wanted to be able to present convincing arguments based on demonstrated behavior of certain components and subsystems when subjected to normal and abnormal environments. I used the example that the items of safety hardware should be placed on the table, their expected behaviors should be asserted, and skeptics should be invited to challenge the validity of the assertions. I emphasized that this was to be a "participatory process."

I drew strength of conviction from listening to the frustration of the systems studies staff who had been charged with being the technical advisors. This group was to study elaborate fault tree analyses containing numerical estimates of the probability of expected behavior—the overall probability usually claiming two-digit negative exponents (e.g., 10^{-12}), when it was clear that no actuarial data base for the numbers could exist.

The convincing event, however, was the findings of Project HOTPOINT. By adapting earlier work on development of a computer program intended to provide exact solutions of nuclear weapon reliability equations, department staff members calibrated, in a rough sense, the potential magnitude of difficulty of attempting to understand all of the ways that a practical electrical system could malfunction to produce an unsafe condition. To avoid imposition of security classification procedures on a contractor to Sandia, an unclassified schematic drawing of an electrical system was devised for use as a test bed. The system, which had switching functions considered to be reasonably representative of early U.S. nuclear weapons, was that of a hypothetical electric stove, hence the name HOTPOINT. The results of preliminary runs of the computer code (a version of EVENTPOINT, which featured set theory manipulation routines) on Sandia's fastest scientific computer of the time suggested that some 10^6 potential failure paths would have to be considered—a clearly impractical task.

We encouraged the use of fault-tree models that would present the logic picture of system behavior and would also allocate probabilities indicating the feasibility of the argument to succeed. At the time, we had in EVENTPOINT the best analytical tool for solution of fault trees in the nation—as was demonstrated in the Reactor Safety Study some five years later.

2. <u>Be based on a "simplifying notion"</u>

   By early 1969, appreciation of the basic intractability of analytical solutions of equations describing premature operation of practical electrical systems in accident environments became an impetus in the search by the nuclear safety design division's staff for a conceptual approach that would be judged convincing in meeting safety requirements.[30] The goal was to formulate a simple pattern of behavior of electrical system hardware such that when insulted environmentally (e.g., in an accident such as a fire), behavior will be based on well-understood physical properties or principles. This approach asked not the question, "How will the system behave in a fire" but asked, "Will the system behave in a fire in the way we have predicted beforehand?" The resultant development was the simplifying notion of "weak-link/strong-link/exclusion region," conceived by mid-1969, published internally at Sandia by spring 1970 (Ref. 58), and briefed formally to the DoD by late 1970 (Ref. 59).

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[30] To my knowledge, the only attempt by Sandia at quantitative probability analysis in accidents was an article published in the U.S. Navy's Nuclear Weapons Safety, Secret Restricted Data, publication in September 1969. This article reported an application of reliability analysis techniques to a safety situation.

3. <u>Be based on a "deep understanding of" abnormal environments</u>

   Between 1969-1972, a parallel effort of the nuclear safety design division and several materials processing organizations was to investigate the properties of materials commonly used in nuclear weapon ordnance components when subjected to severe environmental insults. The early and naïve goal, overstated here for emphasis, was to create a handbook that would describe such behavior analytically, for use by Sandia's weapon designers for components contained inside the exclusion region. Such a handbook would complement those widely found in engineering technical publications for normal environments. For the first two years (1969-1971), emphasis was on the "bare" components (e.g., samples of plastic coatings for copper wires); for the next year and a half (1971-1972) the focus was on "encapsulated" components (e.g., printed circuit boards surrounded by plastic to provide protection); and by early 1972, sufficient evidence existed to upset the traditional engineering understandings of electrical circuit behavior when used in weapon ordnance when subjected to "abnormal" environments (Ref. 60). In brief, the startling and alarming conclusion was, that for all printed circuit board/polymeric encapsulants tested and within a specific range of temperature/time conditions, shorting between electrical circuits is to be expected because of charring phenomena. This finding in effect shattered the image of order conveyed to the designer by circuit diagrams and layouts. Unpredictability became a buzz word of the time.

Figure 13 displays graphically the changes in electrical resistance of polymeric materials commonly used in nuclear weapon hardware. (The display is commonly called "The Kepler Curve" in honor of the Sandia National Laboratories Department Manager, R. Glen Kepler, under whom the work was done.) Figure 14 shows photographs of a printed circuit board; one shows the board in pristine condition before being encapsulated for a test. The other shows that board after the test, which involved the flow of very high currents in a ground circuit. (The top layer of encapsulant has been cut away for clarity.) Charring and metal splatter caused by the high current resulted in unintended conductive paths between circuits. This particular board was used in a nuclear weapon type for which development had just been completed (W72/WALLEYE) and some five units had been produced for stockpile. At once, Sandia's technical management urged DOE/AL to halt production and recall the units then in DoD possession but not yet deployed (in the logistical "pipeline" to stockpile). A design remedy was identified, and corrective hardware (electrical fuses to prevent high current flow) was developed, produced, retrofitted into the recalled units, and incorporated in the subsequent production run.

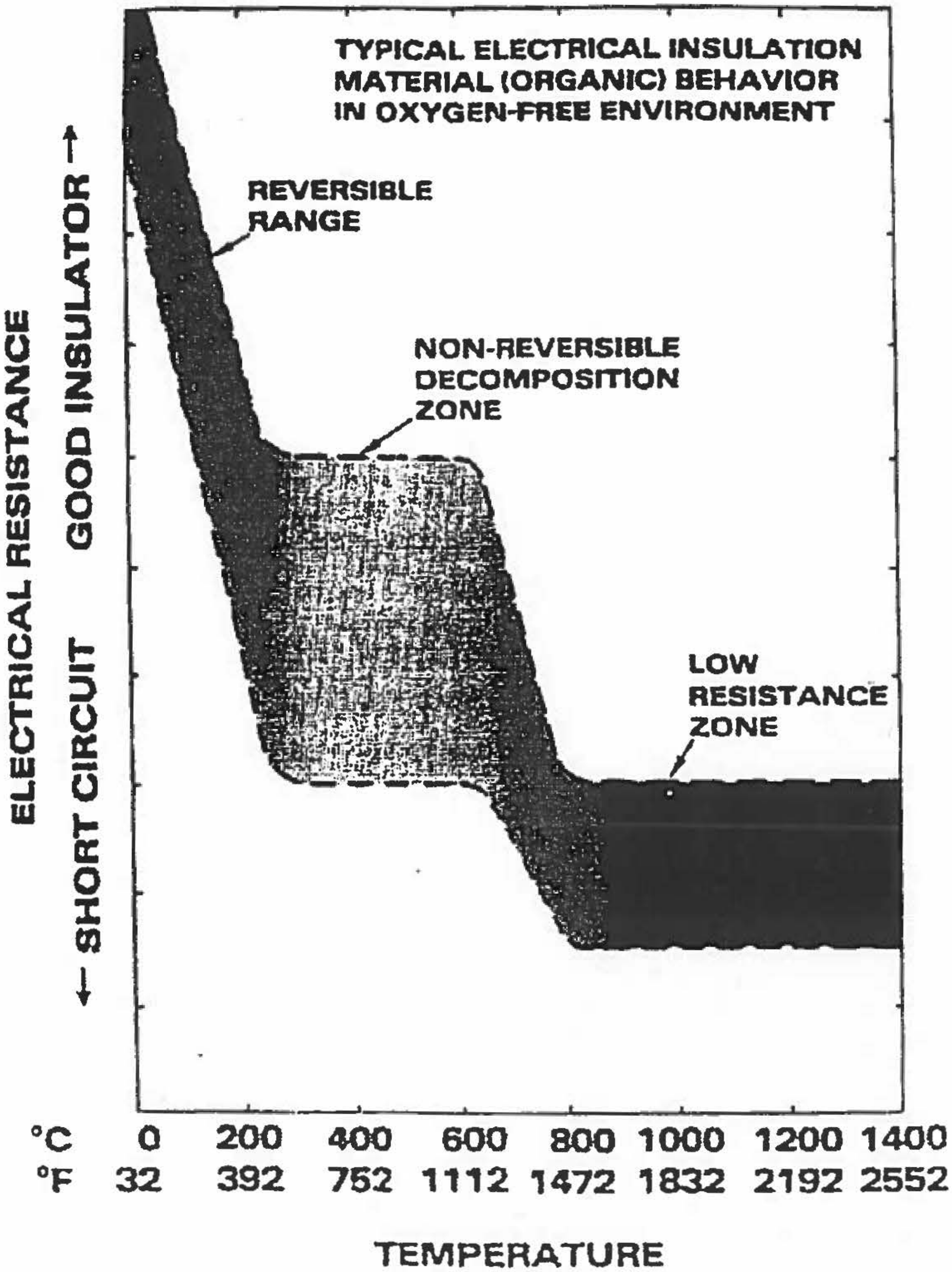

Figure 13. Typical Electrical Insulation Material (Organic) Behavior in Oxygen-Free Environment

NOTE: This episode was at least the fifth exercise of the weapons laboratories' "conscience" in nuclear weapon design safety, even in the face of having to admit inadequacy of its own designs and to "red-line" the stockpile for that particular type of nuclear weapon.

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DOE 6.2(a)

Sandia Albuquerque was responsible for the rest: the B39-2 ready/safe switch retrofit, the B27 high-voltage ready/safe switch retrofit due to susceptibility to electromagnetic radiation from "friendly" transmitters (page 60), and this episode.

5.14 First (and Last?) High-Level, Intra-Sandia Design Safety Review, 1969

Only a few months after formation of Stan Spray's Safety Assurance Studies Division 1632, I was directed to attend a high-level [e.g., President John Hornbeck, Executive Vice President Jack Howard, Vice President (Livermore) Tom Cook], intra-Sandia review of nuclear safety provisions for the W71/Spartan antiballistic missile weapon system, to be held in Tom Cook's office in Livermore. There was no precedent for this; however, I had reached an understanding (with Jack Howard, I believe) that there would be only one design safety concept developer for all of Sandia and that would be Stan Spray's division. Since Stan had been in operation for about a month, I took the responsibility. Of course, I knew very little about the design details of the W71 or about design safety for that matter. I wonder today just who called this meeting and why!

As mentioned, in spring 1968, I had identified the role of plutonium dispersal in weapon accident situations as an emerging concern nationally and had begun to become informed on that subject. From the briefings on the W71 given by the project group, I began to focus on the plutonium dispersal concerns raised by two design features.

I recall a rather heated oral exchange with Tom Brumleve of the Sandia Livermore safety staff as to what quantitative probabilistic goal would be appropriate for such concerns. My range of $10^{[illegible]}$ to $10^{[illegible]}$ would have called for special protection in the way of shielding fragments from premature or otherwise unwanted detonation from causing a detonation of LLL's primary (one-point or multi-point?). Sandia Livermore's proposal began to die, to be replaced with a conventional electrical design. Similarly, I suspect that someone in the room intended to question LLL's designs about their choice of a command destruct component—as that feature later went away.

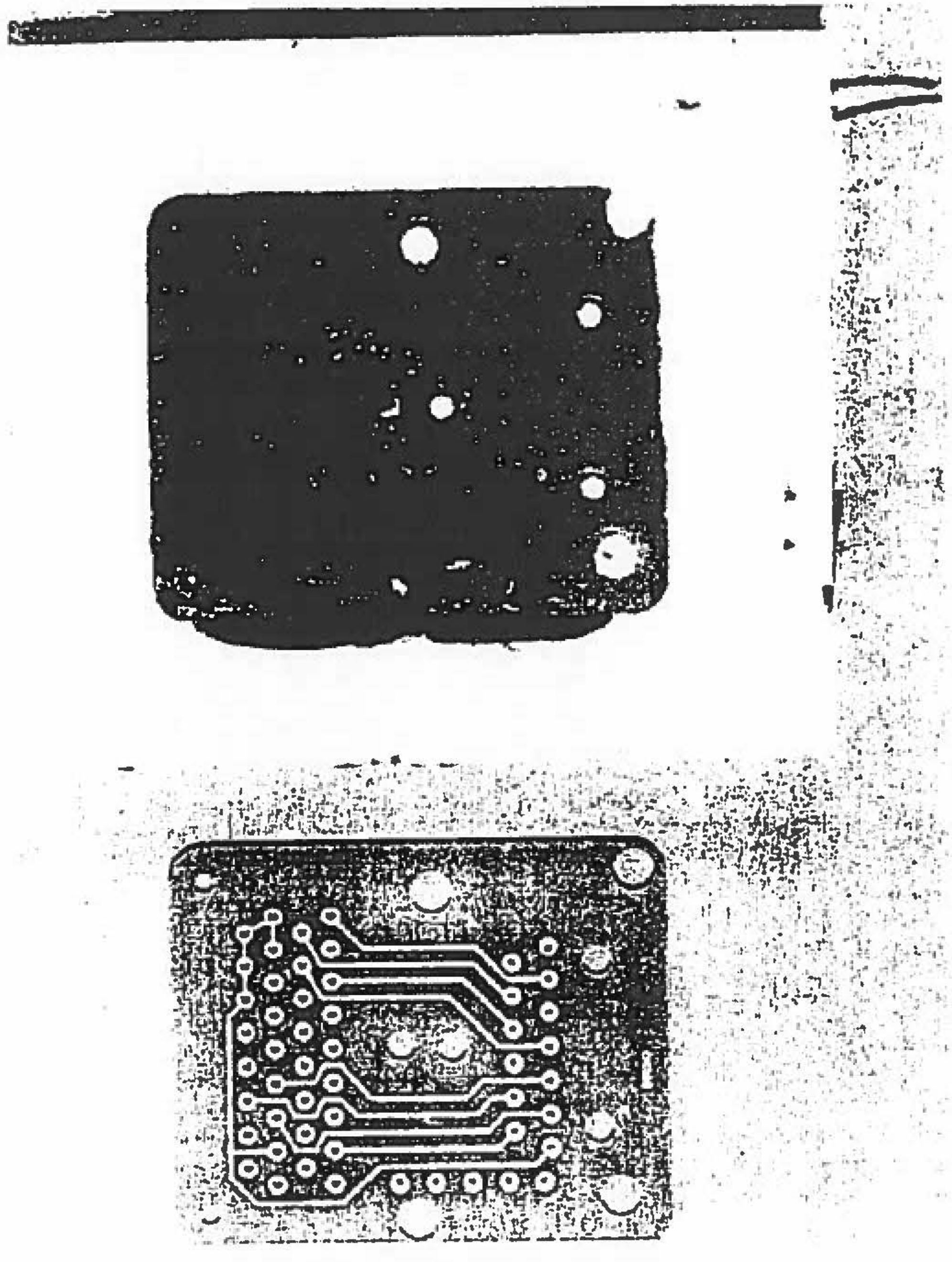

Figure 14. Result of a Simulated Electrical Fault that Damaged an Encapsulated Printed Circuit Board

5.15 AEC Headquarters' Review of Its Nuclear Safety Program, 1969-1970[31]

In late-1969, I also served as Sandia's representative for the first intra-AEC review of the adequacy of the AEC's nuclear safety program that was concerned with all operations involving nuclear weapons development, testing, production, storage and transportation prior to and after transfer of custody to the DoD. During the review, I was requested by the study committee to draft a philosophical framework for thinking about nuclear safety in the AEC's part of the national nuclear weapons program. The resulting paper (Ref. 61) included two innovative suggestions:

1. the use of probabilistic models of each operation with nuclear weapons in order to assess the risks presented and to prioritize resource allocations for remedial action (this technique later was to acquire the popular name of Probabilistic Risk Assessment [PRA] and was used to study nuclear power reactor safety in the mid-1970s); and
2. the expansion of risks covered by the AEC's program to include plutonium dispersal, along with nuclear detonation safety.

These suggestions, along with others made by the committee, were buried in bureaucratic maneuvering within the AEC headquarters and were not to emerge for another three to five years.

The two subjects, PRA and Pu Dispersal, were to become my personal agenda over the remaining 1½ decades of my career at Sandia. Figure 15 is a timeline graphic that illustrates key events in the evolution of PRA at Sandia for activities other than the nuclear fuel cycle. Sandia's efforts in the latter area are documented elsewhere, particularly in the files of the Sandia History Project. Each of the events shown on Figure 15 by circled numbers is discussed in other papers of mine and most events after "8" and for years after 1968 are mentioned in context later in this report.

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[31] For more details on this topic, see Ref. 61.

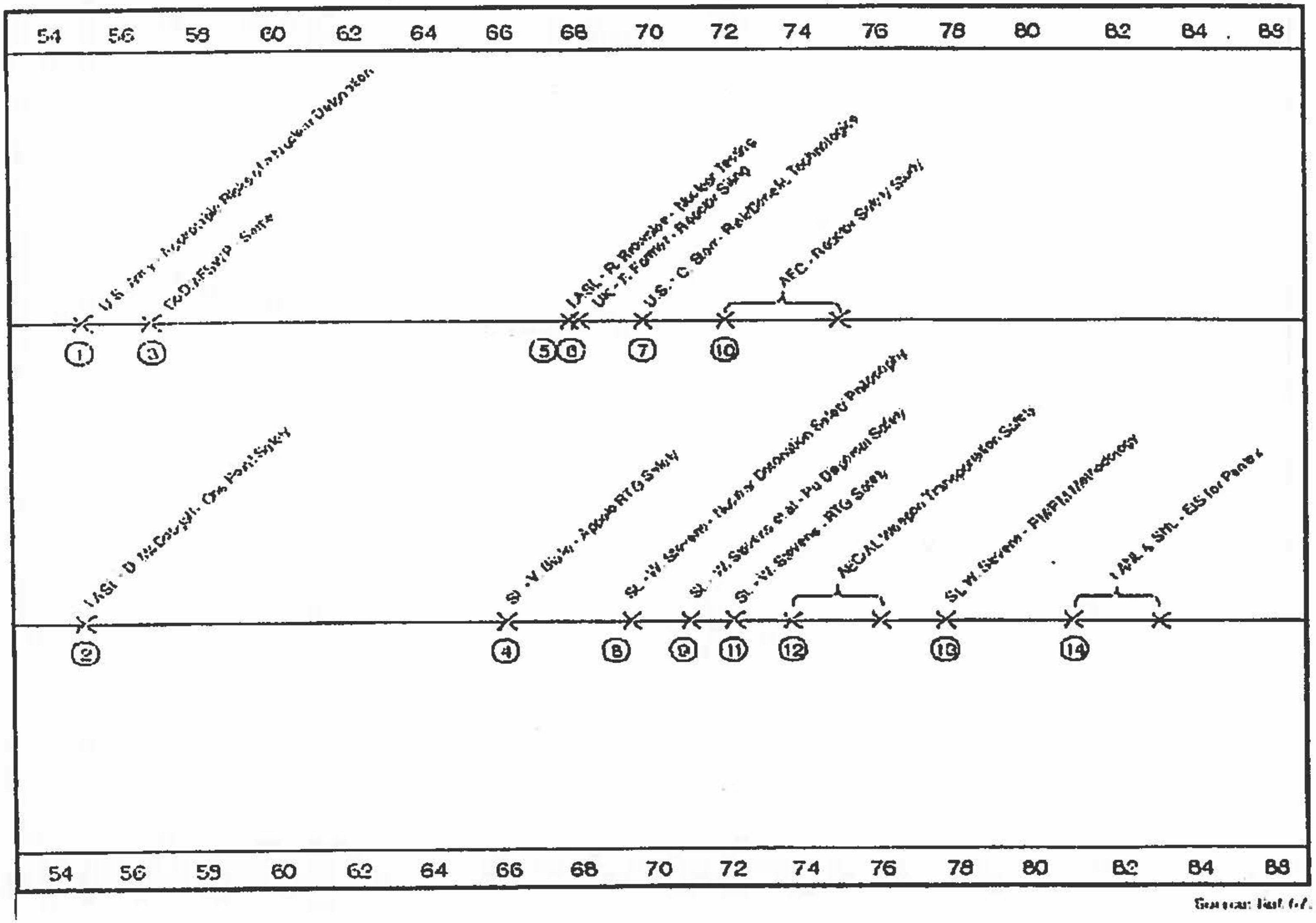

Figure 15. Timeline Graphic for Probabilistic Risk Assessment at Sandia for Activities Other than Nuclear Fuel Cycle

5.16 Radioactive Material Contamination Studies, 1971-1972

In March 1971, Sandia Vice President Jack Howard appointed a committee of three department managers to assess existing threats to nuclear weapon operations from abnormal (accident) environments from the viewpoint of increasing concern about matters pertaining to ecology. The committee was composed of Thomas B. (Tom) Lane, Herm Mauney, and me. We focused on plutonium contamination arising from accidental or intentional detonation of a weapon's high explosive; we used a risk assessment methodology to establish a perspective on threats; and we concluded that the situation warranted "a vigorous contamination safety program—within the AEC/DoD complex and priority for that program should be second only to that of nuclear safety." The two most notable threat situations were identified as logistical transportation and aircraft standing alert. The final report (Ref. 62) was transmitted for intra-AEC distribution by Jack Howard on July 21, 1971.

In the fall of 1971, the Sandia/Los Alamos weapon design team established a contamination safety study group consisting of three members from each laboratory "to determine what weapon design approaches are available to reduce or eliminate the contamination safety concerns" (Ref. 63). The group determined that several design approaches were available (seven were examined in some detail). The final report, dated April 20, 1972, concluded that the team's approaches for the Phase 2 proposal of the High Yield Bomb (the program that evolved from the Alert Bomb/CRESCENT studies of 1969-1971) should be based on insensitive high explosive (IHE)—perhaps the plastic bonded triaminotrinitrobenzene (TATB) formulation then in an early development stage. The group had precluded consideration of a system being pursued by the Sandia/Lawrence Livermore team at the time.

5.17 Security and Safety of Nuclear Weapons in Logistical Transportation, 1970-1974

In my opinion, Sandia's effective entry into the area of nuclear weapon security began with the commitment of technical staff and funding in the weapon development directorates to development of hardware to protect weapons during logistical transportation by the DOE. In 1971, a large department (1550) was created under Gene Blake with John T. Risse, Edwin E. (Ed) Bruce and Milton R. (Milt) Madsen as division supervisors—all had led weapon development projects, except engineering mechanics specialist Risse. The department concentrated on development of the Safe, Secure Trailer (SST) system, the Safe, Secure Railcar (SSR) system, and several types of Accident Resistant Containers (ARCs).

> NOTE: In 1996 when I was preparing historical material for the Sandia Surety Heritage study (page 178), I stirred up a debate about the origins of the SST. John Kane contested my version that the SST was a Sandia R&D initiative that sought and obtained authorization for full development, testing and procurement from AEC/ALO. John cited a letter from H. C. Donnelly, AEC/AL to John A. Hornbeck, President, SLA, dated June 18, 1978, requesting Sandia to study logistical shipments and recommend development options. In writing this report,

> I found the probable cause of confusion in Dennis Miyoshi's draft input for the Sandia History Project, "Sandia History Input from 5200" (Ref. 64). I may even have seen or helped draft the letter that General Donnelly sent to Sandia. This letter exchange was a rather neat way of obtaining funding from a part of the AEC budget other than Weapons R&D. As I recall, funding came from ALO's operational budget.

At this time, there was no institutional avenue for Sandia to become involved in R&D for logistical movement of weapons in DoD custody. I had determined on my own that those movements constituted perhaps the greatest risk in the weapons program—a risk of plutonium dispersal, not so much one of nuclear detonation safety. The only lever that I had was the prerogative of sign-off approval or disapproval of proposed changes to joint AEC/DoD publications, principally TP-20-7 that treated safety concerns other than nuclear detonation safety. Logistical storage and movements were addressed in TP-20-7 by specifying the mass of plutonium that would be placed at risk of dispersal by accidents or other initiating events (such as explosive ordnance demolition or emergency destruct operations). Although Sandia obtained a tasking to do R&D for safety and security of DOE operations, there was no entry path for DoD operations. During 1968-69, I was especially concerned because I had been given the rare opportunity to observe DoD operations worldwide. Few, if any, Sandians had that experience. Even though security was the subject of one of the AEC/DoD nuclear weapon system safety study standards, this provision in my experience was largely a joke. The study groups tended to merely take note of the physical presence of security hardware (e.g., perimeter fences), procedures (e.g., identification badging at fence entry points) and, later, response force deployment, given a threat of intrusion, takeover, etc. The Inspector General function of the military services, the DoD (through the Armed Forces Special Weapons Project and successor agencies), or the AEC/ERDA/DOE conducted field inspections to ensure compliance with specifications.

The literature on developments and deployments of the SST is extensive and needs no elaboration here (e.g., descriptions and a photograph of an SST are contained in the Sandia General History Book, Ref. 86).

The story of the Accident Resistant Container (ARC) project is not documented well, and I believe is more relevant here. With fielding of a prototype SST in late-1971 that demonstrated surface-transportation risks could be ameliorated, Sandia's emphasis turned to development of ARCs that could survive air transportation accidents. An entire division under John T. Risse was assigned to this substantial R&D project. When preliminary results of the Nuclear Weapon Transportation Safety Hazard Evaluation Group (NWTSHEG) study revealed that aircraft crashes were the dominant threat, AEC/ERDA/ALO decided to impose a moratorium on air shipments of plutonium-bearing weapons and test devices. This removed the need for the aircraft version of ARC, and the project was reconstituted as an R&D technology demonstration project. During the R&D process, Brigadier General Frank Kamm, then Director of Military Applications at ERDA, urged development of an ARC for Army helicopter operations in Europe; hence, the Helicopter Accident Resistant Container, HARC, project. A relatively large number of prototype units had been ordered for the planned field evaluation test programs and by the time the program was revised, the units had been delivered to Sandia and placed in "dead storage." By 1979 this proved to be highly significant, as described on page 113.

5.18 The Minority Opinion Provision in Safety Studies and Reviews, 1960-1975

Governing documents for conduct of weapon systems safety studies provide that "all members participating... shall sign the report; minority views of the members shall be included." Since Sandia participants are technical advisors only, they may convince one or more voting members to adopt and sponsor their minority view to generate a minority opinion.

Several examples of minority opinions and associated "independence" in evaluations and points of view are included in this report for purposes of illustration of the concept. Examples do not do justice to the power of the concept because many of the more significant disagreements began as minority positions but gained support to become majority views. These are not identified as such in the reports.

Over the first fifteen years of DoD Directive 5030.15 (1960-1975), there were about 50 minority opinions submitted. The rate of submittals was high in the early years and gradually fell. Intra-DoD or military department disagreements were relatively frequent reasons for minority opinions. These often are mere expressions of long-standing jurisdictional position and are irrelevant here. Over 90% of the total of minority opinions were submitted by the only civilian voting member, AEC/ERDA—with initiation or implicit concurrence by the Sandia technical advisor. For about 30% of the total submittals, the civilian member was joined by one or more military member, by far most often by the member from Field Command, AFSWP/DASA/DNA.

> <u>NOTE:</u> On the relatively few NWSSG studies where I served as technical advisor over the years, I valued most highly the participation of the Field Command military service officer. In general, they were technically qualified, or inclined, often being the only such person other than the Sandian. Perhaps the fact that they were collocated with Sandia on Sandia Base and enjoyed easy access to the technical analysis process explains the close and supporting relationship. On the other hand, the offices of both the Air Force and the Navy groups involved in the NWSSG's were only several miles distant at Kirtland AFB. We honored the objectivity provided by the Field Command member by the light-hearted identification of their uniform as "the purple suit." See my paper "*The DNA Role in Nuclear Weapon System Safety*" (Ref. 98) for elaboration. In my opinion, NWSSG's had only three votes that really counted: by the AEC, by the Field Command, and by the rest of the military integrated as a vote. For example, voting could result in a 5-2 count against an issue when in reality the impact could be considered 2-1 in favor, with the minority view prevailing.

NOTE: A notable example of independence and objectivity of view was the contribution of Sandia's Bob Reed in 1967 for the safety study for a Plowshare event cited on page 78 here. Bob Reed had an extraordinary ability to argue a point persuasively. He had become a leader in establishing a philosophical framework for the systems safety study process by the time that I re-entered the area in late 1968. In mid-1969, he obtained a transfer from safety to the newly emerging security work on the Safe, Secure Trailer and did outstanding work there. His five-year tenure in safety had been by far the longest (Figure 10).

Perhaps the best known example of an effective minority opinion was the one originally rendered in 1970 for Phase 2 of the Pre-Operational Safety Review of the Polaris A3 Fleet Ballistic Missile System by the tri-party AEC, FC/DASA and Naval Weapon Evaluation Facility (NWEF, located on Kirtland AFB). The concern was postulated capability of a knowledgeable crew member to tamper with certain metallic shields protecting sensitive missile launch circuits to cause a powered flight of a Polaris missile. For Phase 3 of the study, the Navy had proposed certain immediate measures to correct the vulnerability and the FC/DNA and NWEF members withdrew support of the minority opinion. The AEC member, Richard (Dick) M. Shay, stood alone in the minority opinion. Dick Shay's perseverance elevated the matter to the attention of AEC/DMA in the format of a briefing that demonstrated the relative ease of penetrating the protective shield. AEC/DMA concurred and arranged for Shay to brief Carl Walske, DoD/ATSD(AE). This eventually resulted in the Navy being required to make hardware and procedural changes to the fleet involving millions of dollars. Dick Shay was presented a High Quality Increase in salary by DOE/AL in 1974 for this and other safety work (Ref.171).

NOTE: Dick Shay was supported by Sandia Livermore in provision of a technical advisor in these studies. He asked me for technical assistance later. The shield material was a metallic alloy that I had encountered in my first technical job in an oil refinery. I had personal experience in cutting tubing made from that specific alloy. I arranged for Shay to consult directly with Sandia's metallurgy staff and the demonstration of penetration mentioned above evolved.

NOTE: Memoranda summarizing this subject were written in 1975 by Parker F. Jones, supervisor of the Systems Safety Division in my department (Ref. 173). These are representative of his high-quality output displayed over his career in systems safety that ended with his death. While on-roll, Parker Jones exemplified to me the steady, wise counsel that the group of engineers with World War II experience had brought to Sandia in first-level weapon project and system development jobs. See Ref. 151 for elaboration and the names of others.

6. THE DECADE OF EXERCISE OF DUAL AGENGY RESPONSIBILTIES, 1973-1983

6.1 The SAFEGUARD Antiballistic Missile System Safety Issue, 1972-1973

Since 1960, the governing AEC/DoD directive for nuclear weapon system safety studies and reviews (DoD Directive 5030.15) had required an Initial Safety Study to be concluded early in the formal weapon system development program. The U.S. Army's Nuclear Weapon System Safety Committee (NWSSC) had elected to conduct four "preliminary" safety studies during the on-again-off-again development period for the Antiballistic missile (ABM) effort between 1965-1971. The latter type of study had no official status under this directive, and most of the one-hundred-or-so recommendations that the NWSSC had made were not implemented by the time that the official Initial Safety Study was conducted on May 25, 1972. By that time, the state of understanding of nuclear safety of weapon electrical systems in abnormal environments had matured to the point where Sandia's technical advisor to the NWSSC, Donald R. (Don) Lewis[32] had become apprised of the unpredictability of traditional hardware/circuits. His input to the NWSSC (with my personal commitment to support him) was influential in the formulation of a NWSSC unanimous position. The position stated that the U.S. Army's adaption kit design would not meet the qualitative standard of DoD Directive 5030.15, i.e., would not provide measures to prevent a nuclear detonation of the AEC's nuclear warhead in accident (abnormal) environments.

The negative finding on nuclear safety for the Initial Safety Study was seen as a clear threat to the time scales of the national ABM program, which by then was of high interest—in consonance with ABM treaty negotiations with the USSR. In July 1972, the Army's SAFEGUARD project office challenged the NWSSC's finding and arranged to present its case to Dr. Carl Walske, DoD/ATSD (AE). Walske requested AEC's participation in the briefing session to be held in his office at the Pentagon. The AEC's contingent included the AEC voting member of the NWSSC (George L. Trimble) and the two Sandia department managers, Don Gregson from SLL for W71/Spartan and me for W66/Sprint to whom the NWSSC's technical advisor reported. When the Army's briefer projected a slide that indicated the nuclear safety criterion to be met was 10^{-9} nuclear detonation/accident, Dr. Walske forcefully inquired how the criterion had been reduced from the standard 10^{-6} nuclear detonation/accident, which he personally had imposed in 1968 (Ref. 49, now commonly referenced as "the Walske Letter"). The briefer explained that the 10^{-9} applied to the total weapon system, and 10^{-6} was still valid as a nuclear-warhead-alone criterion—the difference of 10^{-3} being allocated to the Army's adaption kit.

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32 Don Lewis has served as technical advisor to systems safety study groups for over 32 years, June 1966 to date, with a several-month interlude to try another field. He was initially involved with the U.S. Army, then AEC/AL on assembly plant operations, and later with the U.S. Navy.

Walske objected to this seemingly legalistic violation of his intent behind 10^{-6} as a weapon system requirement. He then asked the general question of whether or not even the 10^{-5} value was supportable. When no one spoke, I responded with a statement that the R&D work at Sandia in the period between the preliminary and initial safety studies suggested that hardware response would be unpredictable in abnormal environments; however, the Army's 10^{-5} estimate could be valid for normal environments. Indeed I knew, but did not mention, that the Army's analysis had used a computer code (the "GOCODE") developed at Kaman Sciences by a person who earlier had been a staff member in Sandia's nuclear weapon reliability organization which had concerned itself only with "normal" environment premature probabilities. I also reminded Walske that the MLC/ATSD(AE) staffs (including Walske) had been alerted to the abnormal environmental R&D work by me in their visit to Sandia in November 1970 and that the AEC had earlier ceased production and recalled units produced for the W72/Walleye weapon system found by intra-AEC technical review to be deficient in this respect. Finally, I offered to expedite the transfer of the technology base on abnormal environments from Sandia to Army design agencies upon Army request. The NWSSC chairman, the late Julian S. Pulley, remarked that my proposal was irrelevant, since the NWSSC used only qualitative standards of DoD Directive 5030.15 and did not recognize the quantitative standards of the MCs! Walske grimaced.

Following the briefing, Walske issued directives, which resulted in two important safety reforms:

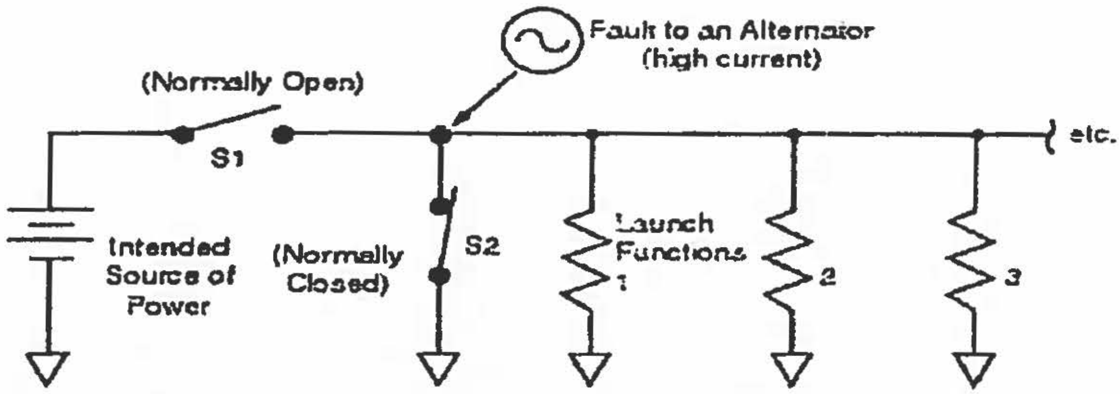
1. The creation of a special organization to assess quantitatively the nuclear detonation safety of the total SAFEGUARD weapon system during the one-and-one-half years remaining before system deployment. The organization, suggested by me to avoid the philosophical issue raised by Pulley, featured two tiers: an Army/AEC Steering Group and an Abnormal Environment Task Group to do the technical assessment.
2. The revision of the DoD directive on project liaison groups (POGs) to mandate that POGs would invariably have a nuclear safety subcommittee.

   and

   The assignment of a staff member of the MLC/ATSD(AE) to monitor reports of POGs to identify potential safety issues early, in time to avoid threatening weapon system time scales.

SNLA Nuclear Safety staff member Jack Hickman was my choice for the working group, chaired by a Bell Telephone Laboratories counterpart (somewhat awkward since BTL was SNL's "parent"). I recall the day that Jack reported to me the frustrations that he was having because the study process was crammed with visits to facilities, leaving him insufficient time to do analyses on the volumes of technical reports from contractors that were accumulating in his office. I volunteered to cover the next week's visits for him, allowing Jack to analyze.

Jack Hickman's extraordinary analysis skill and use of Spray's division's data base revealed the existence of a single-fault failure mode in SPRINT launch circuits (BTL responsibility), as shown by the simplified block diagram below. Abnormal environments (e.g., shorting of stout wiring for the output of a large AC alternator or generator in the system to the point indicated), could impose sufficient energy to burn open safety switch S2 and "fire" the launch functions connected in parallel for needed quick response.



The outcome of special assessment was the identification and correction of deficiencies, particularly in the Sprint missile launch circuits, and the identification of conditions that were judged to be unpredictable as to behavior in abnormal environments and uncorrectable on program time scales (Ref. 65). The latter conditions were circumvented by the adoption of nuclear safety rules[11] that would prevent connecting the nuclear warhead to the adaption kit until the completed missile system was about to be lowered into the silo cell. This measure, of course, resulted in an operational difficulty but was seen as essential to safe deployment.

6.2 Papers on Nuclear Power Reactor Safety, 1973

In 1973, as a result of the national decision to dissolve the Atomic Energy Commission (AEC) and place its functions into two new governmental agencies and also in 1973 Sandia had suffered its first and only major layoff and reduction of staff, Sandia's President, Morgan Sparks tasked Department Manager Bob Peurifoy to examine Sandia's potential involvement in the field of nuclear power reactors. Research and Development (R&D) work for such reactors was assigned to the new Energy Research and Development Administration (ERDA), along with all nuclear weapons work, and licensing work for reactors was assigned to the new Nuclear Regulatory Commission.

In support of Peurifoy's tasking, I contributed several draft working papers intended to present technical and philosophical opinions on the current status of nuclear power reactor safety from

[11] Such a procedural positive measure was suggested to Dr. Walske by Sandia Vice President, W. J. Howard, who had preceded Dr. Walske as Chairman, MLC.

the viewpoint of a nuclear weapon safety specialist (References 66, 67, 68 and 69). The two main areas of reactor safety addressed by the papers were reactor siting practices and emergency core cooling systems in reactor design.[34] The concept for a SAFETY FIRST nuclear power reactor (Reference 68) is especially interesting even today when the subject of new design approaches featuring "inherent" safety is still highly active.

6.3 Study of ERDA/AL's Nuclear Weapon Transportation Operations (Probabilistic Model/Positive Measures Methodology), 1973-1977

The extensive study (1973-1977) of ERDA's operations for transportation of nuclear weapons, nuclear test devices, and related radioactive materials ranks high among the several "system studies" conducted by Sandia over the years.[35] The methodology used was a variant of Probabilistic Risk Assessment (PRA) that I had conceived and applied during the study and later called "Probabilistic Model/Positive Measures (PM/PM)."

The Probabilistic Model aspect of the methodology used for this study was essentially the same as for the classical PRA technique, i.e., estimation of the risk per year of experiencing an accident severe enough to result in the unwanted event of interest (e.g., dispersal of plutonium in the atmosphere). The study began with the collection and statistical evaluation of all accident rate data available nationally for the three modes of transportation used by ERDA—rail, truck and air. Concurrently, the entire stockpile of nuclear weapons was examined to determine the tolerance to withstand severe environmental insults without detonation of the weapon's high explosive and attendant dispersal of plutonium. When these data were factored into the analysis, the probability of dispersal of plutonium per year could be estimated for each transportation operation.

The Positive Measures aspect of PM/PM is a significant departure from the classical PRA technique. In the vernacular of nuclear weapon safety, a "positive measure" is a tangible design feature or procedural action whose existence is relied upon to ensure that the desired level of safety will be achieved. In most cases, a positive measure exists solely to enhance safety. This provision had proved to be extremely powerful in the nuclear weapon area and is in direct contrast to the negative approach characterized by "thou shalt not" or "it can't really happen." By identifying the positive measures already in use in the ERDA operations (e.g., a 55-mile per hour speed limit for trucks, long before this limit was made a national standard) and quantitatively determining their influence on the probabilistic model, the estimate of dispersal could be refined and reduced to reflect ERDA's operations instead of national practices. So far, this technique is the same for PRA.

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[34] Both areas where to become paramount concerns in the implications of the Three-Mile Island nuclear power reactor accident some years later.

[35] Other studies of excellence might include the studies colloquially called "The Wooden Bomb," "Pebbles/Halberd," and FORWARD LOOK. See Ref. 86 for descriptions.

Next, and most important, PM/PM requires the identification and quantification of influence of potential positive measures that could be adopted to reduce risk significantly. By noting the relative, not the absolute, risk probabilities before and after application of the potential positive means, the merit and cost of each can be calculated. The remarkable success of PM/PM here was that the study's findings led to prompt and drastic reforms in ERDA's operations to incorporate the potential positive measures, including:

- A moratorium on air shipments, since results showed that crashes of commercial and military aircraft on take-off and landing were the dominant source of severe, and intolerable environments.
- Redesign of ERDA-owned rail cars to increase thermal insulation for accidents involving fuel fires.
- Reliance on procurement and deployment of a fleet of safe, secure trailers for movements by truck, together with a system for continuous communication between convoys and a control center.

The study group's (called the Nuclear Weapon Transportation Safety Hazard Evaluation Group) final report (Ref. 70) remains a valid example of excellence in systems analysis and has been used repeatedly as source data for other studies of national interest, including transportation operations incidental to the nuclear power reactor fuel cycle (NUREG-0170) and transportation of nuclear weapons by the DoD in Europe. (See the "Forward Look" study discussed later.) In 1973 (Ref. 71), I suggested a broader application of PM/PM to include nuclear detonation safety in addition to plutonium dispersal safety.

In 1977, I attempted to have the PM/PM technique considered for use in other non-weapon projects at Sandia by offering to arrange an internal-Sandia study of PRA featuring symposium-like presentations to a study group (Ref. 72). My proposal included a paper on philosophical and historical treatment of the PM/PM technique (Ref. 73) and a paper on the state of nuclear power reactor safety reviewed from a PM/PM perspective (Ref. 74). This attempt died for lack of a sponsor at the director level within Sandia.

6.4 Security of Fixed-Site Facilities for Nuclear Weapon Operations, 1973-1976

A basic reference for this section is Dennis Miyoshi's 1984 report on security, Ref. 64.

As the Vietnam War ebbed, Sandia's R&D on intrusion detection sensors and systems shifted toward applications to fixed-site facilities of high national value, especially to nuclear weapons facilities of the AEC/ERDA.

In late 1973, a joint program with the U.S. Air Force was initiated whereby SNL would design, develop, and arrange for procurement of intrusion detection systems that could be installed at USAF nuclear weapon sites worldwide. These systems included sensors for both internal structure and exterior areas and sophisticated signal processing equipment. Closed circuit TV systems were eventually deployed to more than fifty storage sites. The Air Force had the tri-service responsibility for DoD fixed-site security R&D, under the label of Base Installation Security System (BISS), but the applications were for all DoD facilities.

In March 1974, SNL formed a new directorate level organization, Nuclear Security Systems Directorate 1700, and Orval E. Jones was promoted from a research department to become the Director, under Glenn Fowler as the responsible Vice President 1000. The directorate soon had three areas of work in separate departments: transportation systems, sensor systems, and nuclear fuel cycle activities (waste management and power reactor safety).[16] Much of the staffing and technology in the transportation and fixed-site security areas came from direct transfer of an intact department that had evolved in Bob Peurifoy's Weapon System Development directorate 4300, in order to provide mission status for this emerging area of national need.

After mid-1974, a fourth area was added to support activities of the ERDA's Office of Safeguards and Security, including international interests in safeguarding nuclear materials. In the fall of 1977, William C. (Bill) Myre succeeded Orval Jones as Director and continued for over a decade in that position. All of these new missions had been recommended in Bob Peurifoy's study for Morgan Sparks in 1973 (see page 111).

6.5 The First Revision of the Directive for Weapon System Safety Studies, 1973-1974

DoD/MLC chairman, Carl Walske, supervised the first revision to DoD Directive 5030.15, Atomic Weapon System Safety Studies and Reviews (dated June 1960). His nuclear safety specialist, Captain William Sweet, U.S. Navy, did the drafting. As manager of the Nuclear Safety Department, I was contacted by Captain Sweet for informal comments on the several drafts. In my opinion, this several-year effort had as primary motivation Walske's desire to change the coverage from peacetime operations and also to include high status of readiness, including war. In particular, he wanted nuclear safety rules to address the process of recovering from high readiness to normal readiness. Coverage was broadened to include all operations.

> NOTE: The AEC/ALO successfully lobbied to add the undefined act of prearming to the existing acts to be prevented by the four safety standards, i.e., to the four gerunds of arming, launching, firing, or releasing, without offering any written explanation. This action was fait accompli before I could object to possible impact of the logical inconsistency. In perspective, the paucity of changes in the August 8, 1974, revision testify to the remarkable merits of the original version.

[16] This area was the initial implementation of the work recommended the study that Sandia President Morgan Sparks tasked Bob Peurifoy to conduct on the nuclear power reactors and fuel cycle in 1973. It was split off and became a directorate in 1974, with A. W. (Bill) Snyder promoted to become its director

6.6 Sandia Questions the Safety of Air-Delivered Weapons in Quick Reaction Alert, the "Fowler Letter," Fall 1974

In September 1973, Bob Peurifoy was promoted to become Director of Weapon Development 1500 under Glen Fowler, Vice President 1000. By year-end, Peurifoy had completed a review of the impact of the new understanding of abnormal environment situations on the composition of the U.S. nuclear weapon stockpile and concluded that the air-delivered portion of the stockpile constituted a high-safety risk that required priority attention to remedy deficiencies. He proposed a retrofit to incorporate ENDS subsystems into the older bombs that were exposed to abnormal environments during operational deployment (the B28FI, B43, B57 and B61-1), and Glenn Fowler agreed. Fowler arranged to present the retrofit initiative to Sandia's top-level management council, Small Staff. On February 1, 1974, W. Ray Reynolds presented a briefing, with results that reportedly varied from indifference to direct opposition. The latter reaction was championed by Vice Presidents Tom Cook in charge of Sandia Livermore and Al Narath in charge of Research, who argued that recommending a retrofit would be a suggestion that Sandia had been imperfect, that new weapons development programs would be scheduled to eventually replace the older ones, and that a retrofit program would waste resources on the stockpile instead of on challenging R&D advances. These views prevailed. Apparently, Executive Vice President Jack Howard remained passive on the subject, even though his record would have suggested that he could be expected to support safety initiatives. He had, however, not been involved in the evolution of this particular initiative.

In April 1974, Fowler and Peurifoy gave the retrofit briefing to Major General Ernest (Ernie) Graves, ERDA/DMA in Washington in hope of gaining his support. By this time, Insensitive High Explosive Technology was advanced and was included in the retrofit program. General Graves and staff were passive recipients of the proposal, and Fowler and Peurifoy decided to make their concerns a matter of formal record. The letter from Fowler to Graves dated November 15, 1974 {drafted by Charles (Charlie) Burks, the Department Manager for the B61 program} would prove to be an event of extreme influence on the national nuclear weapon safety program—perhaps comparable only to the Klee Committee's review of the stockpile in 1957, attendant to the introduction of sealed-pit nuclear weapon designs. The letter (Ref. 75) became known as "the Fowler Letter," or in some DoD circles, "the Halloween Letter," for its alleged sudden shock to Don Cotter, then DoD/ATSD(AE).

Briefly, the Fowler Letter recommended a joint ERDA/DoD program to improve the nuclear safety status of the air-delivered stockpile over the decade 1975-1985 by either retiring or retrofitting seven weapon types with a weak-link/strong-link/exclusion region safety subsystem and replacing four weapon types with weapons scheduled to be newly produced later and having the modern safety subsystem.[17] Until these or similar actions could be taken, Sandia recommended that the Secretary of Defense be notified of the risks inherent in maintaining Quick

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[17] All of the weapon systems involved used nuclear warheads or bombs that had been designed by the Sandia/Los Alamos team. Thus, Vice President Glenn A. Fowler, under whom Sandia Albuquerque weapon development programs were managed, was the appropriate signer. Sandia Livermore was not directly involved. This was the official story.

Reaction Alert (QRA) operations with the weapons and that the AEC recommend restriction of such QRA operations to missions "absolutely required for national security reasons."

Response to the Fowler Letter can be characterized as mostly delaying actions in the guise of requiring detailed safety studies of each of the weapon systems involved. Military Liaison Committee (MLC) Chairman Don Cotter and ERDA/DMA Director Ernie Graves visited Sandia and were shown a special exhibit in the secluded High Bay of Building 892, featuring weapon hardware that had been subjected to severe abnormal environments (e.g., fire and crushing) during SNL tests and stockpile accidents. The exhibit and accompanying narration by Stan Spray was to become known as the "The Burned-Board Briefing" (after Figure 14 shown here). Cotter and Graves reportedly openly reacted so angrily to the briefing that their comments defied reason. MLC Chairman Don Cotter's Executive Secretary, Colonel Richard N. (Dick) Brodie, soon took action to have the use of IHE be mandatory for the only new weapon in development at the time, the B77.

> <u>NOTE:</u> In mid-1985, I had made an estimate of total briefings and persons briefed over the period since January 1975, about 245 and 2,200. About 800 persons were non-Sandians, including key military and civilians in the national nuclear weapons community and/or their staffs (e.g., several Secretaries of Military Departments, Flag Officers to Lt. General, Chairmen of the DoD/MLC, Panels of the Air Force Scientific Advisory Board, and the Sandia Board of Directors). By 1990, the total had reached some 5,000 persons briefed.

6.7 Nuclear Safety Concerns for the PERSHING II Weapon System Development Period, 1974-1981

The next major development program by the U.S. Army for a nuclear-weapon-capable weapon system after the ABMs of the late-1960s was the PERSHING II. This program had such important nuclear safety concerns that it is discussed here in more detail than for other weapon systems in order to illustrate the nuclear weapon and nuclear weapon system processes at the time. Another important concern, that of deliberate, unauthorized launch (DUL) arose as the weapon system approached deployment. That story is discussed in a separate section of this report.

> <u>NOTE:</u> After the SAFEGUARD ABM nuclear safety episodes described earlier, I continued to act as a staff member for the SNLA safety involvement's with the U.S. Army. Don Lewis, whom I have commended here for his tenacity in those issues, appeared to be burned out with the Army's NWSSC, and our staff had fallen to two at the time. I continued in this role until retirement in 1985.

- Arming, Fuzing and Firing Subsystems for the Army's Pershing II Missile, 1974

In the fall of 1974 in response to DoD/DDR&E's expression of interest, Sandia entered a year-long technological competition with the Army's Picatinny Arsenal for development of AF&F subsystems for two versions of the proposed Pershing II theater missile system—an air-burst re-entry vehicle and an earth-penetration re-entry vehicle. Picatinny had been responsible for all of the Army's AF&F subsystems since the NIKE HERCULES and HONEST JOHN weapon systems of the mid-1950s. In 1971, SNL had been asked to comment on its ability and willingness to undertake the additional tasks of assuming the nuclear weapon responsibilities of the Army as contained in the 1953 agreements. SNL's response to AEC/DMA affirmed capability, but stated that willingness should not exist "unless (or until) the Army has convinced itself that we could do an eminently satisfactory job for it ...." (Ref. 9 of Ref. 76, the latter being a history of SNL's involvements in the field of AF&F subsystems).

The Army's Source Selection Board ruled in August 1975 in favor of SNL's proposals for both AF&F subsystems. This board was chaired by a Colonel who had been Commander, Picatinny Arsenal and as a junior officer had worked with SNL as the Army's project engineer on the JUPITER intermediate-range ballistic missile system in the late-1950s. Even earlier, he had replaced me as a First Lieutenant in the Army's first nuclear weapon ordnance battalion in 1953 at Sandia Base, NM. The next higher level in the Army's hierarchy, the Source Selection Authority, overruled the Board on the air-burst version and concurred on the penetrator version. Their rationale was one of nuclear weapon safety and the argument in my technical opinion was flaky at best. The authority was commanded by Army Colonel Samuel Skemp who, as mentioned earlier, as a Captain had objected to Sandia's ESD safety initiative (page 33). Soon after this decision was rendered, he retired and became an employee of the commercial firm (AVCO), which was by then under contract to Picatinny Arsenal to produce the adoption kit. SNL designers later estimated the costs to the nation of this decision to be 15 to 20 pounds in weight penalty and about $30 million in life-cycle costs. The penetrator version was later canceled.

- Rewrite of Army Pamphlet 50-2 on Safety Design

Through sponsorship of the Army's Nuclear and Chemical Agency (or its predecessor agency), Picatinny Arsenal's safety group (under Warren Reiner with Ed Arbor as technical lead) attempted to revise Army Pamphlet 50-2, the document that contained guidance on design features for safety in Army nuclear weapon systems. This, in my opinion, was a blatant try at making Picatinny's adoption kit for the W85/PERSHING II be the sole provider of safety, essentially ignoring the contribution of the Enhanced Nuclear Detonation Safety design in Sandia's W85.

As I recall, I managed to have a member of Stan Spray's staff assigned to the effort to lobby for a generic set of guidelines that favored no agency. In the end, Picatinny's ploy failed, and the document issued was reasonably objective.

- Safety Working Group of the Project Officer's Group, 1976

The PERSHING II program marked an early (if not first) implementation of Carl Walske's initiative to require that the principal ERDA/DoD weapon system project development coordinating agency, the Project Officer's Group (POG) establish a Safety Working Group (SWG) comprised of technical safety specialists to advise it on safety matters. I had personally lobbied Walske's staff to make the change to the DoD directive to require SWGs—this, of course, being the institutionalization of the group that had functioned so well for the SAFEGUARD ABM episode (page 110) and the Technical Working Groups (TWGs) of the ERDA/DoD Stockpile Safety Study then in process (page 137). The SNL member of the SWG was from the weapon project group, and Stan Spray's nuclear safety design group provided an advisor/observer. This group did exceptionally fine work, in my opinion.

- Technical Analysis Role for the NWSSC

Picatinny Arsenal's safety group was assigned the function of conducting the technical safety analysis that was to be the input to the Nuclear Weapon System Safety Committee. The politics were that the NWSSC tried to categorically ignore the work of the SWG/POG. I appointed myself as the Technical Advisor to the ERDA voting member of the NWSSC, George Trimble of DOE/AL, and pressed successfully for recognition and acceptance of SWG/POG work.

- Abuse of the Nuclear Weapon System Safety Study Process, 1976-1982

DoD Directive 5030.15 that governed the NWSSC process required an Initial Safety Study to be conducted "... as soon as the Military Department concerned determines significant data are available." The U.S. Army's NWSSC in apparent coordination with its de facto parent, the Nuclear and Chemical Agency with which it was physically collocated, used the Initial Safety Study provision to obtain periodic "approval" of the design features of the PERSHING II weapon system as the development progressed over a six-year period, 1976-1982. The ploy was to subdivide the Initial Study into three stages and the stages into parts, such that there were five studies in total. In early 1981 at the Part I Stage III event, the issue of deliberate, unauthorized launch (DUL) was considered, and a Special Safety Study was scheduled for later that year for this issue. (See DUL/PERSHING II section on page 147.)

6.8 ATSD(AE) Rich Wagner's Visit to SNL, 10/8/81

LLNL's Richard L. (Rich) Wagner replaced James P. (Jim) Wade as DoD/ATSD(AE) and Chairman Military Liaison Committee. When he visited SNL, I was tasked by Bob Peurifoy to brief him on the national nuclear detonation safety program from a SNL perspective. I used the SAFEGUARD ABM and PERSHING II episodes to alert Rich to our emerging concerns that could affect the schedule for deployment of PERSHING II on his tour of duty. In particular, I alerted him to the inadvertent or deliberate, unauthorized launch concern that is described here on page 167. My annotated viewgraph presentation is Ref. 77.

6.9 The ERDA/DoD Stockpile Safety Study, 1975-1976

On May 6, 1975, the DoD/MLC approved a charter for a joint ERDA/DoD evaluation of nuclear safety for the entire nuclear weapon stockpile. This charter was the main response to the Fowler Letter dated November 15, 1984, which questioned the safety of the air-delivered portion of the stockpile (Ref. 196). The charter was patterned directly after the AEC/DoD arrangement of 1972 for evaluation of nuclear safety of the SAFEGUARD ABM. A steering group would establish uniformity in approach among the Technical Working Groups (TWGs) to be formed by each of the three military services and ERDA, to resolve conflicts, to ensure timely completion, and to establish priorities of reviews for the one-year study effort (Ref. 78).

The evaluations conducted by the technical working groups are remarkable in their high quality of technical analysis and in uniformity of approach. The former may be attributed to the enlightened policy of the military services and the three ERDA weapons laboratories in making assignments to the TWGs based on technical competence rather than prior experience in the qualitative arena of system safety studies per DoD Directive 5030.15. The latter may be attributed in major part to the personal contribution of Sandians Stan Spray and Jay Grear, who devised and successfully advocated a study methodology that produced a single definition of "modern safety standards" (a term contained in the charter)—a rating system for weapon hardware response that categorized the degrees of safety judged to exist, and a severity-likelihood index of abnormal environments (Figure 16) to facilitate arriving at priorities for remedial actions.

Figure 17 indicates the large magnitude of the total national effort, which became known as the ERDA/DoD Stockpile Safety Study, and the subsequent consideration of the TWG's findings by the Nuclear Weapon System Safety Group (NWSSG) of the military services (as required by the charter).

6.10 The Joint Chiefs of Staff Stockpile Improvement Study, 1975-1977

Concurrently with conduct of the ERDA/DoD Stockpile Safety Study effort, an essentially independent effort was conducted under DoD auspices as a "technical review of the current, near-term and future nuclear weapon systems with respect to safety, security, command, and control." As events developed, this effort focused on use control aspects of nuclear weapon systems. Nuclear detonation safety was not covered, in deference to the ERDA/DoD study. Radioactive material dispersal safety was defined to be within the scope, but nothing of consequence was done. Security, similarly, was largely ignored. Results of the Joint Chiefs of Staff Stockpile Improvement Study were not provided to Sandia or ERDA/DOE, even though Sandian Bill Hoagland had been a full-time participant by invitation.

6.11 The POPCORN Issue Revisited, the Study of 1975-1977

By means of a co-signed letter to AEC/DMA dated June 13, 1975, officials of the Los Alamos and Livermore weapons laboratories announced that, in the past year, "a significant extension to previous analyses had occurred," and results indicate that "there may be a problem (Ref. 79)."[38]

> NOTE: This letter, which touched off a several-year major restudy of nuclear weapon storage configurations and procedures, is an example of stockpile stewardship "whistle blowing" to report openly a safety-related situation that might be seen by some critics as a deficiency in performance by the contractors.

Although the LASL/LLL letter suggested that the restudy of the POPCORN phenomena could be included in the ERDA/DoD Stockpile Safety Study already under way, the effort was assigned to a task group chaired by the DoD/FC-DNA, with members from the DOE's LASL and LLL and various technical and liaison agencies of the military services. The final report was issued on September 13, 1977 (Ref. 80).

6.12 Plutonium Mass Limit Controversies, 1975-1976

An early initiative of Don Cotter as chairman of the DoD's Military Liaison Committee (appointed in the fall of 1973) was to direct the DoD's Defense Nuclear Agency to conduct a study on nuclear stockpile operating and support costs. As a part of this study, a Field Command unit of DNA (located in Livermore and then under Colonel Marvin B. Sullivan, USAF) conducted a study to examine economic, health hazard, and political costs of long-range transportation of plutonium-bearing nuclear weapons by logistical aircraft. Colonel Sullivan used probability-versus-consequence diagrams to develop an argument that the DoD's public responsibility demands a low-risk policy, and the number of flights should be reduced by increasing the number of nuclear weapons carried by an aircraft up to the maximum physically practicable, rather than to observe the existing Pu mass limit. In some cases the existing limit resulted in being able to load only a few weapons per aircraft. He further argued that the political risks support his position, since the risk falls as the number of flights decrease. Cost savings of about $18 million per year were estimated.

During 1974, Colonel Sullivan presented his findings in briefing format to various persons, including an ERDA contingent in Albuquerque, New Mexico, on September 18, 1974. (This

[38] Earlier POPCORN concerns and definitions are discussed on page 49

was at the request of Sandia's Executive Vice President Jack Howard, who had been briefed earlier.) Representatives of the ERDA weapons laboratories, principally Gene Eyster of LASL, Marv Gustavson of LLL, and Bob Luna of SLA, argued that the more serious health hazard consequences of higher Pu mass limits, given that an accident occurs, should be factored into the considerations and that an upper limit should be imposed. On February 15, 1975, a report by Colonel Sullivan recommending a 60 kilogram mass limit was presented to the DoD/MLC members; and on March 30, 1975, the report was forwarded for comments to members of an ERDA study group on ERDA weapons transportation operations. This group, the Nuclear Weapon Transportation Safety Hazard Evaluation Group (NWTSHEG), had been studying the subject since 1973. Its members, including Drs. Eyster and Gustavson, continued to object to the DNA arguments for relaxing limits, based on results of NWTSHEG's detailed risk assessment. The NWTSHEG's work, published as ERDA 77/10 in January 1977, identified air transportation of Pu-bearing nuclear weapons as a high-risk operation in ERDA operations. This report (Ref. 70) was a factor in an ERDA decision to discontinue such flights.

The MC Chairman reportedly shelved the DNA proposal, and no further action was noted until mid-1977, as discussed later.

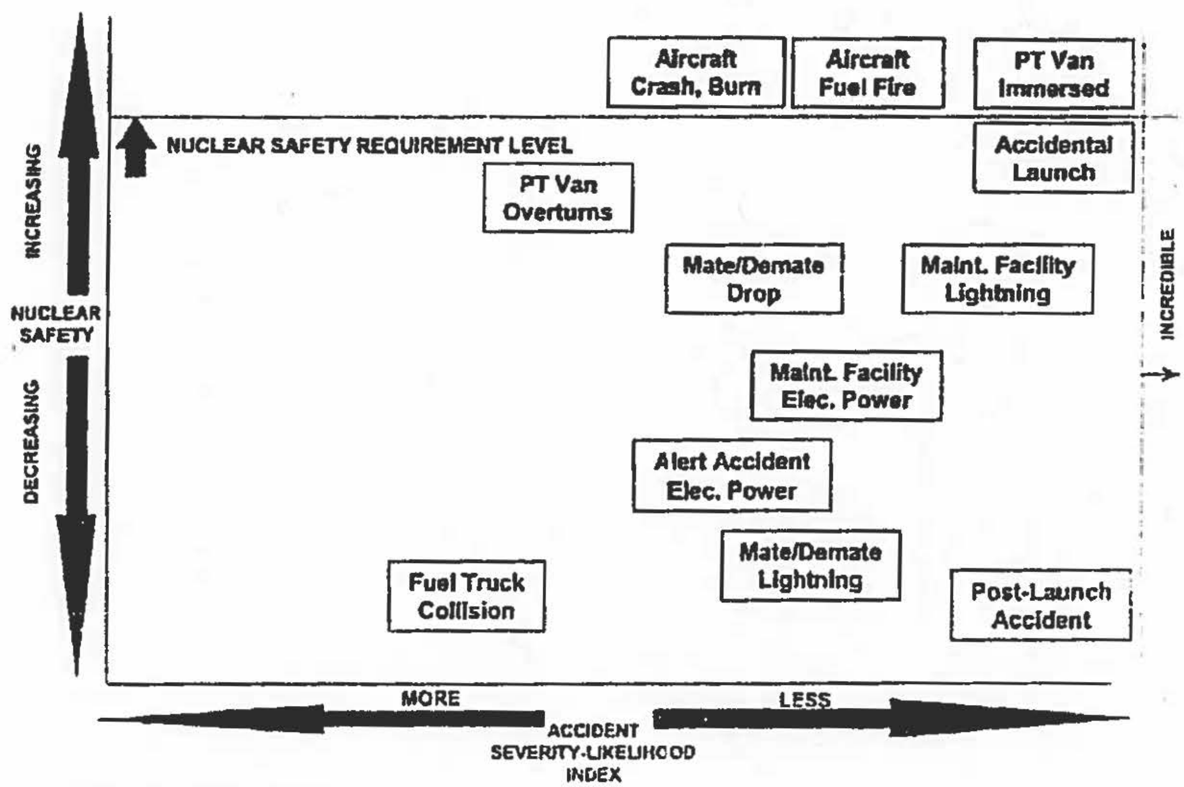

Figure 16. Severity-Likelihood Index. Re-entry Vehicle Weapon System Example

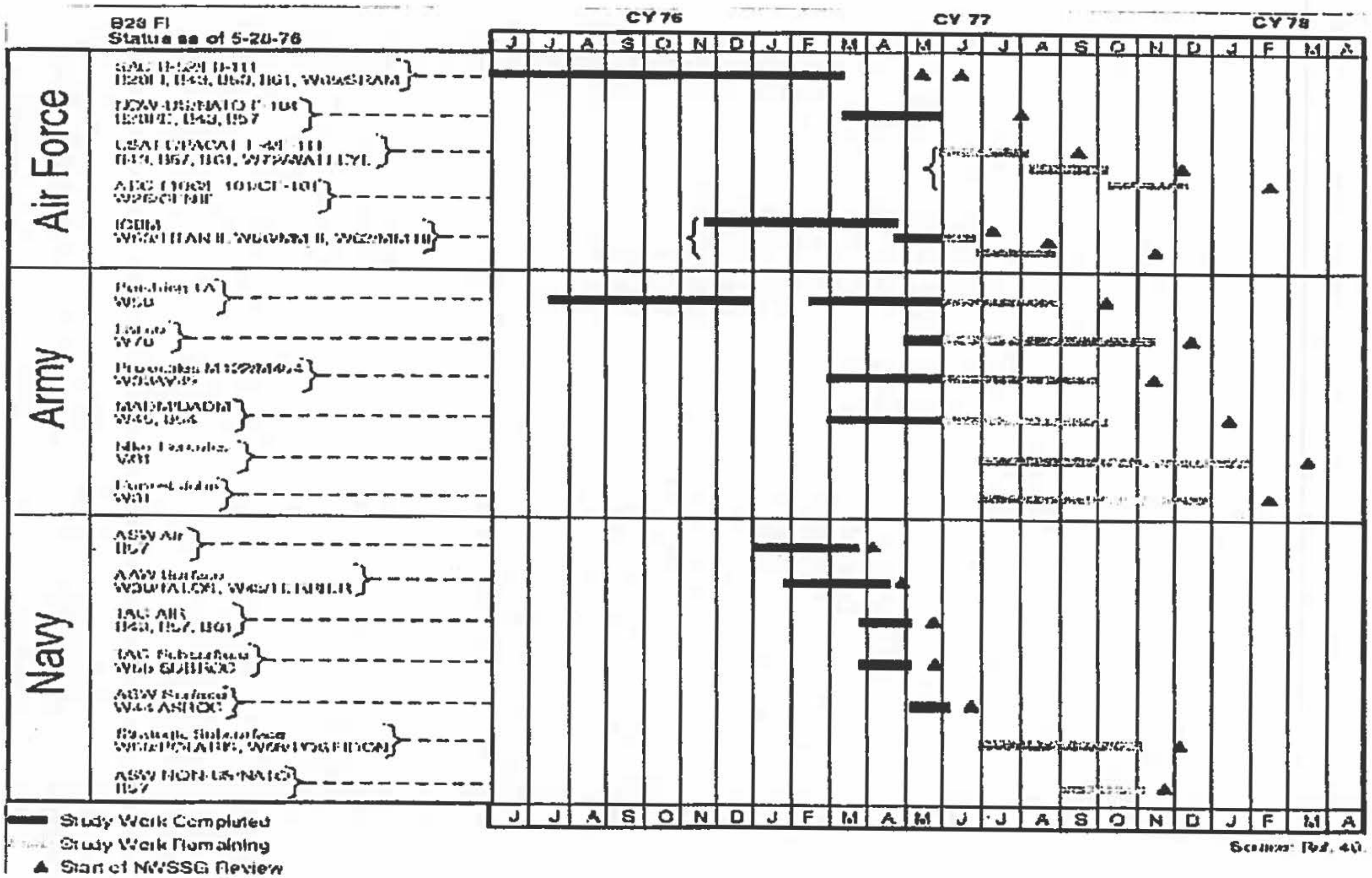

Figure 17. ERDA-DoD Stockpile Safety Studies, CY75 and CY76

6.13 The ERDA/DoD Transfer Study: The Concept of Dual-Agency Responsibilities, 1975-1976

The Energy Reorganization Act of 1974 required a thorough review of the desirability and feasibility of transferring the military application and restricted data functions, which ERDA inherited from the AEC, to the DoD or other federal agencies. The review, officially entitled, "*Funding and Management Alternatives for ERDA Military Application and Restricted Data Functions" but commonly called "the Transfer Study*," was conducted during 1975 by the participants listed in Figure 18.

Bob Peurifoy was the Sandia member of the Field Drafting Group and Technical Advisory Group for the Sandia/Los Alamos nuclear weapons program. As recognized by Peurifoy and Don Cotter (who had left Sandia and was then Chairman MLC and ATSD(AE) in the DoD), S^2C was the pivotal issue in deciding whether or not nuclear weapons program management and funding would be transferred from ERDA to the DoD. This issue was seen as civilian versus military control of nuclear weapon safety and use control. Accordingly, I was tasked by Peurifoy to address the issue by outlining the evolution of these attributes of nuclear weapons. The first draft paper (Ref. 81) focused on custody of nuclear weapons and required interviews of key persons in the ERDA/Albuquerque Operations Office, especially Walt White who was a party to the original transfer of weapon parts from the War Department's Armed Forces Special Weapons Project to the AEC at Sandia Base, New Mexico. A later draft, (Ref. 82) and a paper on possible implications of the transfer on nuclear safety (Ref. 83) became the impetus for the commissioning by the study's director, ex-Sandian Gordon Moe, of a paper on safety and use control of nuclear weapons. The paper (Ref. 84), co-authored by me and Marv Gustavson of the Lawrence Livermore Laboratory, was the origin of the now-common term used to describe AEC/DoD relationships, "dual-agency judgment and responsibilities," and preservation of this concept provided the telling argument in the final report (Ref. 85). This paper is attached here as Appendix H.

> NOTE: Colonel Richard N. Brodie, USAF, was the DoD's liaison officer to the study group and was then the Executive Secretary of DoD's Military Liaison Committee. Brodie and I began a ten-year collaboration that became almost continuous after Brodie retired from the USAF and joined Sandia's technical staff.

In the late 1970s, for whatever causes or combination of causes, the health of the dual-agency judgment and responsibilities arrangements for nuclear safety began to deteriorate at an increasing and serious rate. Potential contributing causes may have included the replacement of ERDA by the DOE and attendant reduction of the weapons program in the hierarchy, demise of the "watchdog" and advocate Joint Committee on Atomic Energy, retirements or other removals of long-term safety advocates such as General Dodd Starbird, downgrading of the role and status levels of the DoD's Defense Nuclear Agency, and changes in staffing and management interest at the MLC/ATSD(AE). There was, however, no observable indication of a conspiracy or other expression of intent to degrade.

SENIOR ERDA/DOD REPRESENTATIVES

D.R. COTTER, Assistant to the Secretary of Defense (Atomic Energy)
Department of Defense

A.D. STARBIRD, Assistant Administrator for National Security, ERDA

ERDA STUDY DIRECTOR

C.R. MOE, Technical Assistant to the Assistant Administrator for National Security, ERDA

AML LIAISON

T.K. CLARK, Executive Assistant to the Assistant Administrator for Nuclear Energy, ERDA

DOD LIAISON OFFICER

Col. R.A. BRODIE, Military Liaison Committee, Department of Defense

SENIOR SCIENCE/MANAGEMENT CONSULTANTS

S.J. BUCHSBAUM, Executive Director, Research, Communications Sciences Division, Bell Telephone Laboratories

R.C. DONNELLY, [illegible] Associates, Inc.

T.C. FURNO, Experts Futures Consultants, Inc.

M. GELL-MANN, Professor, Department of Physics, California Institute of Technology

C.M. HERZFELD, Technical Director, Defense, Communications, & Energy Group, ITT Aerospace

C.J. HITCH, President, Resources for the Future, Inc.

H.K. MARK, Director, Ames Research Center, National Aeronautics & Space Administration

A.D. WHEELON, Vice President, Space and Communications Group, Hughes Aircraft Co.

ERDA HEADQUARTERS ADVISORS

Maj. Gen. J.K. BRATTON, Director, Division of Military Application

J.A. GRIFFIN, Director, Division of Classification

L.A. JACOBVITZ, Legal Counsel (Acting on behalf of the Office of General Counsel), Albuquerque Operations Office

H.E. LYON, Director, Division of Safeguards and Security

J.C. POOR, Director, Division of International Security Affairs

R.L. ZANETELL, Fiscal Advisor, Office of the Comptroller

FIELD DRAFTING GROUP

D.L. BOSTOCK, Y-12 Plant, Union Carbide Corporation

J.C. HOPKINS, Los Alamos Scientific Laboratory

D.M. KERR, Los Alamos Scientific Laboratory

J.W. KURY, Lawrence Livermore Laboratory

H.N. MEYER, ERDA, Albuquerque Operations Office

R.L. PEURIFOY, Sandia Laboratories

R.F. PIPPERT, Kansas City Plant, Bendix Corporation

J.M. SCOTT, Sandia Laboratories

R.L. WAGNER, Lawrence Livermore Laboratory

TECHNICAL ADVISORY GROUPS

WEAPONS

L. GUTIERREZ, Sandia Laboratories
D.P. MacDOUGALL, Los Alamos Scientific Laboratory
R.L. PEURIFOY, Sandia Laboratories
H.L. REYNOLDS, Lawrence Livermore Laboratory
V.C. VESPE, ERDA, Albuquerque Operations Office
R.L. WAGNER, Lawrence Livermore Laboratory

RESEARCH

C.D. DORROUGH, Lawrence Livermore Laboratory
A. NARATH, Sandia Laboratories
R.F. TASCHEK, Los Alamos Scientific Laboratory

REIMBURSABLE/JOINT DOD PROGRAMS

A.D. McGUIRE, Los Alamos Scientific Laboratory
D.L. NIELSON, Lawrence Livermore Laboratory
J.M. SCOTT, Sandia Laboratories

SAFEGUARDS

O.E. JONES, Sandia Laboratories
G.R. KEEPIN, Los Alamos Scientific Laboratory
J.L. OLSEN, Lawrence Livermore Laboratory

LASERS

E.H. BECKNER, Sandia Laboratories
K. BOYER, Los Alamos Scientific Laboratory
J.L. EMMETT, Lawrence Livermore Laboratory

INTELLIGENCE

W.L. HOWARD, Sandia Laboratories
W.M. McCLELLAND, Lawrence Livermore Laboratory
A.T. PEASLEE, Los Alamos Scientific Laboratory

ENERGY R&D

E.F. HAMMEL, Los Alamos Scientific Laboratory
D.R. SHUSTER, Sandia Laboratories
K. STREET, JR., Lawrence Livermore Laboratory

SUPPORT STAFF

K.T. STUMP, Sandia Laboratories

R. BARTELL, ERDA, Division of Military Application
R.A. BOWEN, ERDA, Division of International Security Affairs
T.L. MEAD, Sandia Laboratories

F.A. MINTON, ERDA, Office of Assistant Administrator for Planning and Analysis
C.L. PURTEL, ERDA, Division of Military Application
K.R. SCHNEIDER, ERDA, Division of International Security Affairs

VICKIE JOHNSON
TINA OCALA
KITTY DENNISON
JANICE GREEN
ANNA HARGETT
MINNIE EARL HARGETT
BESSIE KELLER
LINDA STAPLES
SANDY WENNER

RD CLASSIFICATION ADVISORS

Division of Classification
E.L. ELLMAN
W.A. STRAUSER

CONTRACT SUPPORT

BOOZ, ALLEN & HAMILTON, INC.

L. AITKEN, Private Consultant

([illegible] others, including Laboratory Directors, Operations Office Managers, and their staffs contributed substantially to the study.)

Figure 18. Principal Study Participants, "Transfer Study"

6.14 Abortive Attempts to Reinstitute a DoD/DOE Agreement, 1976-1978

In Fall 1977, MLC Chairman Don Cotter, in an economy move to reduce staff size, abolished the staff billets (officers of the military services in ranks 0-6 and less) assigned to the Military Liaison Committee while retaining a staff for his other responsibilities as the ATSD(AE). In this process, the nuclear safety staff was reduced from three officers to one, and the remaining one was to be a billet assigned to the DNA, not to the ATSD(AE). Also, the senior grade level was reduced from 0-6 (Colonel/Navy Captain) to 0-5 (Lt. Colonel or Navy Commander), the lowered level being commensurate with the action officer coordination arrangement with the military services that seemingly had gained favor in the Pentagon and at DOE Headquarters. During the fall of 1978, Dr. James P. Wade, a career DoD civil servant, replaced Cotter, and the action-officer arrangement was continued.

The Army's safety action officer at the time was U.S. Army Colonel (Retired) Joe Luger, who was an open, avowed opponent of any legitimacy to DOE's involvement, particularly DOE/ALO or Sandia, in matters concerning nuclear weapons in DoD custody. His antics in joint ERDA/DOE meetings and his caustic writings, endorsed by the Department of the Army's Deputy Chief of Staff for Plans and Operations (DCSOPS), became so flagrant as to appear to be out of control. He managed, by non-concurrence maneuvers, to stifle attempts to formalize and endorse the dual-agency judgment practice that had been accepted as national policy via the Transfer Study. For example, in March 1976, the staff of the DoD/ATSD(AE) suggested that a Memorandum of Understanding (MOU) between ERDA and DoD on nuclear weapon safety be drafted. This action terminated the intra-DoD coordination of a proposed National Security Decision Memorandum[*] that had been drafted by the AEC and forwarded to the DoD/ATSD(AE) in March 1974. Following action-officer-level discussions between AEC and DoD, the AEC representative redrafted the MOU and forwarded it to DoD/ATSD(AE) on September 29, 1977. The DoD/ATSD(AE) obtained comments from the military services (apparently this was the first such coordination attempt), redrafted a MOU, and forwarded it formally to the DOE for comment before submission through Office of the Secretary of Defense for final coordination and approval. This version was transmitted to the manager of DOE/ALO and the President of SNL by DOE/DMA on May 24, 1978. This was the first formal opportunity to bring the matter to the attention of the senior management. I was assigned by Jack Howard to coordinate Sandia's response. The intra-Sandia coordination process included a review of the evolution of the MOU. The response was a memo date June 20, 1978, from Sandia President Morgan Sparks (signed by Jack Howard) to DOE/DMA Major General Joseph K. Bratton, which, in strong language, urged that the DoD's version be judged inadequate by DOE and that the DOE request a return to the earlier versions for which the DOE and DoD/ATSD(AE) action officers had been making excellent progress (Ref. 195). In this process, I learned that the source of the objectionable language that, in effect, would have made DOE entirely subordinate to DoD

* This National Security Decision Memorandum would replace National Security Action Memorandum 51 date May 8, 1961, which had been inactivated on February 3, 1969, by National Security Advisor Henry Kissinger as a part of a general reduction in older directives. The AEC's appeal to reissue National Security Action Memorandum 51 was not answered.

in nuclear safety—instead of DOE and DoD having the dual-agency judgment responsibilities—was the Army's action officer, Joe Luger.

Following further interactions between the DOE/DMA staff and Sandia (including another strongly worded letter from Sparks to Bratton dated August 8, 1978), DOE/DMA Major General Bratton personally participated in a rewrite of a PDM and a MOU, and Sparks used my draft reply in saying "We endorse without reservation, and support enthusiastically, your revised drafts ...."

6.15 Sandia's Initiatives for Security and Plutonium Dispersal Safety in DoD Logistical Operations, The FORWARD LOOK Study, 1976-1979

FORWARD LOOK was a 2½-year major study of the security (access control), safety (plutonium dispersal safety) and survivability (utility of weapons following enemy attacks) aspects of nuclear weapon deployments of the DoD in the 1980-1990 decade. The study was sponsored initially by Don Cotter, the ATSD(AE)/MLC Chairman and later by his successor James P. (Jim) Wade. Andy Lieber led the study that drew upon a broad spectrum of Sandia's technical staff. An excellent summary of the results of FORWARD LOOK is contained in the Sandia General History (Ref. 86, pages 202-204) and in the "memoirs" that Andy wrote upon his retirement and amplification is not needed here.

FORWARD LOOK drew heavily on earlier work on plutonium dispersal safety by the staff of the Safety Assessment Technologies Division under Dick Smith.

- John M. Taylor, together with associates Bob Luna, Hugh Church, and Norm Grandjean, applied the computer codes developed to analyze ERDA/DOE transportation and fixed-sites (e.g., Pantex) to all DoD sites worldwide to quantify the impacts of increased numbers of weapons placed at risk.

- During 1973-76, Dick Smith led a part of the NWTSHEG study that developed the Accident Resistant Container (ARC) technology (see pages 105-106).

Perhaps the most important result of FORWARD LOOK was the remarkable display of S^{2}C hardware and prototype subsystems presented at Sandia in the fall of 1978 for an invited contingent of high-level officials of DOE, DoD and, especially, each of the military services. Dubbed "County Fair," the displays featured bus tours of outdoor exhibits manned by Sandia designers in an interactive mode. County Fair was an illustration of one of Sandia's great strengths in R&D, i.e., the display of prototype hardware to potential users with the opportunity for them to examine and (often) to personally operate the device or subsystem.

> NOTE: The use control aspect of County Fair was demonstration of emergency destruct components that could be positioned on weapon external surface and operated to destroy weapon internals, thus assuring denial of the capability to use

the weapon, given defeat of the access denial systems also demonstrated. This provision was presented by Donald W. (Don) Doak of the weapon development directorate under Bob Peurifoy. In sorting out roles and missions, Bob and Bill Myre agreed that if a given measure for protection involved penetration of the weapon skin or response of components inside it was a weapon development directorate prerogative; otherwise, the security directorate could be responsible (e.g., fences).

NOTE: Historical writings by Sandians on security (or safety, control or safeguards for that matter) should consider the extreme sensitivities these subjects evoke in other agencies as regards fundamental responsibilities. Security (access control, in my personal definition) is the responsibility of the agency having custodial possession of the entity being secured. Thus, Sandia could never specify what security features DoD should employ. With this in mind, I cite Sandia's participation in the upgrade of physical security for operational and storage sites in NATO as being of high-national value. Herm Mauney managed the efforts and should be consulted in order to understand the special set of sensitivities. By the way, the Air Force was appointed as the program manger for the DoD. The Army was heavily involved and presented a special "problem" for Mauney.

6.16 The Sandia Stockpile Initiative, Fall 1977

A complete, but classified, case study of the DOE/DoD Stockpile Improvement Study and its antecedent, the Sandia Stockpile Modernization Study, is contained in Reference 87. The discussions below highlight only those aspects considered particularly relevant to the purposes of this report.

By the fall of 1977, Sandia Albuquerque's Dr. Richard N. (Dick) Brodie,[40] an executive staff assistant to Robert L. Peurifoy, Jr. (then Director of Weapon Development 4300), had begun to examine the nuclear weapon stockpile-planning process, primarily from a nuclear safety and use-control point of view. He used the ERDA/DoD Stockpile Safety Study as a basis. The study report (Ref. 88) developed a time-phased plan for redressing higher priority concerns by retirements, retrofits, or replacements with weapons of modern design, all within the then-planned capability of the DOE's nuclear weapons laboratories and production complex.

NOTE: Dick Brodie's plan, in my opinion, is a truly outstanding illustration of systems analysis wherein he examined the capacity of the DOE's integrated contractor complex to execute the time-phased production program. I resurrected the methodology as a consultant in 1987 for a study of DOE's weapons development program (Ref. 89).

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[40] Brodie had, as a Colonel, USAF, served as executive secretary, DoD/MLC, prior to his retirement. Also, he had been the DoD liaison officer for the Transfer Study in 1975-1976.

Sandia's stockpile improvement study was reviewed by DOE/ALO, and DOE/ALO developed a field-coordinated report that was transmitted to DOE/DMA on August 15, 1978. The proposal, known as the Stockpile Modernization Study, was forwarded to the DoD/ATSD(AE) on September 9, 1978. By March 20, 1979, the DoD had endorsed, in principle, the goal of improving overall safety and control of the stockpile; however, DoD emphasized that replacement was the favored method. Retrofits could be considered if on a non-interference basis with new weapon production. DoD accepted only two of the retrofit programs proposed by DOE, called for additional studies on ten other weapon systems,[41] and recommended exclusion of 17 others for various reasons. While only three hardware retrofit programs were undertaken, objectives for six were achieved over time by change deployments and early retirements.

> NOTE: In the decade covered, the office in DOE/OMA that coordinated preparation of the report had rapid turnover, with at least three directors. Thus, Sandia provided programmatic continuity.

6.17 Intra-DOE Laboratories Challenges to SNLA Nuclear Safety Roles, 1977-1981

The SNLL/LLNL weapon design team first encountered the Enhanced Nuclear Detonation system (ENDS), conceived by Stan Spray's division at SNLA for the B77 strategic bomb in May 1974, some two years after ENDS had become accepted as the standard design approach for all new developments. The B77 was to be the California team's first full bomb program and presented a significant challenge in technological areas new to them. (For the earlier B27 and B41 programs, some parts of the weapons were developed at Sandia Albuquerque or LASL.) By mid-1977, the extremely high costs of the B77 had become of widespread concern in the DOE complex and LLNL placed the blame on ENDS, claiming that SNLA's design was pricing new weapons "out of the market" (Ref. 90). Whereas later reviews indicated that the B77's high cost was attributable to the choice of a relatively large variety of new technologies essentially across-the-design; ENDs seemed to be at the time a convenient scapegoat.

LLNL established a nuclear detonation safety design project and designed several components to provide safety for the detonators of the IHE primary of the B77. Reports of the work were circulated for review, one in a blank envelope to SNL Vice President Components! The early approach that involved an electronic logic circuit was judged conceptually weak because of obvious susceptibility to bypass by a single event or stimulus. The next approach, however, was to become the focus of high technical management attention for years to come.

In 1977-78, MSAD I (Mechanical Safing & Arming Detonator I) continued to evolve rather rapidly from a simple lock to restrain a wire that was to be withdrawn by a motor to a unique signal-driven safing device conceptually compatible with the ENDS, MSAD II.

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[41] The Army, reportedly led by nuclear safety action officer Joe Luger, proposed an alternative to the DOE's proposal for the W31, and a lengthy intra-Army review was initiated. This proposal did not survive.

In December 1977, the B77 was canceled because of inordinate costs. In early 1979, LLNL announced intent to commit MSAD I to the W84/GLCM program; and throughout 1979 the matter was considered at various levels of management, especially at a SNL Small Staff Meeting on July 10, 1979. SNLL Vice President Tom Cook informed LLNL that MSAD would be carried as a backup design to replace one of the two strong links in the W84. Some eight months later on March 3, 1980, LLNL's Harry Reynolds decided to make MSAD II the primary option. By late 1981, LLNL's W84/GLCM project scientist leader was trying to extend LLNL's control over safety by proposing a high-voltage safing switch to replace the remaining strong link. Furthermore, a drive to make LLNL/SNLL team independent of SNLA was begun by LLNL's Bill Shuler (Ref. 90).

> NOTE: I include this part of the MSAD episode to illustrate that nuclear safety design responsibilities are not prescribed in interagency agreements and the current situation at any time should not be taken for granted. Reference 90 is a draft working paper of mine that gives opinions on the causes for differences in approach between the LLNL/SNLL team and the SNLA ENDS approach, as well as citing intra-SNLA competition. The reference mentions typical arguments about ENDS, such as "increased safety," "all-the-eggs-in-one-basket," "threshold of acceptable risk," new design and production contractors into safety device arenas, and most importantly, further desegregation of safety responsibilities within DOE laboratories.

6.18 Nuclear Weapon System Safety Rules Approval, 1961-1978

Perhaps the most influential aspect of the national nuclear weapon system safety study effort has been the provision in DoD Directive 5030.15/3150.2 for developing and processing of nuclear weapon system safety rules. These documents may be consulted for detailed descriptions of the provisions. As stated therein:

> "Safety rules provide the procedural safeguards that, together with the weapon system design features and technical and operational procedures, ensure maximum safety consistent with operational requirements during operations with nuclear weapons and nuclear weapon systems."

For nuclear weapon systems, the Secretary of Defense approves rules before the weapon system can be granted an Initial Operational Capability (IOC) and be deployed in the national defense structure. The process leading to approval includes sequentially:

- proposal of a set of rules by the Nuclear Weapon System Safety Group (NWSSG) of the issuing Military Departments(s) of the DoD,
- approval by that Department(s),
- coordination with the AFSWP and successors,
- approval by the Joint Chiefs of Staff (JCS),
- coordination with the AEC/ERDA/DOE, and

- notification of the President.

A history of the controlling documentation of the process is given in Reference 127, "A Summary of Presidential and Other High-Level Directives and Correspondence on Nuclear Weapon System Safety and Control."

- Coordination vs. Concurrence Actions

  Since the beginnings of nuclear weapon system safety in the late 1950s, a basic disagreement has existed between the DoD and the AEC/ERDA/DOE as to whether involvement of the latter in the nuclear safety rules approval process is one of formal coordination or formal concurrence. The AEC declared that its required action was one of concurrence before final approval (Ref. 197 and Appendix J). Interim approval may be given by the Secretary of Defense when, in his judgment, it is "... operationally necessary to deploy weapons in the interest of national defense." This did not require AEC concurrence, but apparently did require coordination.

- The AEC Headquarters Safety Actions

  DoD Directive 3150.2 states that the Secretary of each Military Department shall "... support the DOE during the DOE safety rules coordination process ...." In the early years, this process included two steps led by the Systems Safety Branch of AEC/DMA.

  1. Action Memorandum. This document was prepared for signature by the Chairman of the AEC to grant concurrence with proposed nuclear safety rules actions. Coordination included obtaining comments from AEC/AL and Sandia.

  2. AEC Field Review. In the early years, the AEC normally called for a "Field Review" prior to granting concurrence on final rules. This action was arranged by a branch officer who would serve as a member and chairman of a group comprised of voting members from AEC/AL and Sandia. The arrangements with the Military Department were made via DoD/ATSD(AE) channels. The group almost always asked for and usually received a visit to a military installation to witness planned operations— preferably, to the first military unit having IOC approval.

Apparently because the Sandia member of a Field Review was given voting status as contrasted to technical advisor status for the earlier safety studies, by the time of my initial involvement in nuclear safety (1961). Sandia's policy was to appoint as the member a supervisor (section or division) in the systems safety organization.

<u>NOTE</u>: These two actions in practice were the main ones handled by the small staff of military officers assigned to the Systems Safety Branch of AEC/DMA. The actions in effect put Sandia on a high level as regards approval of safety rules and this allowed an independent review that culminated in a memo from Sandia's President to AEC/DMA that presented Sandia's comments and approval recommendations.

When I rejoined Sandia's nuclear safety organization in 1968, the practice of requesting Field Reviews had about ceased. I fought successfully to retain the option as DoD and AEC/ERDA/DOE governing directives were revised over the years. In 1978, I had occasion to request a Field Review, as discussed below.

6.19 The B61-5/F-4 Safety Rules Episode: Civilian vs. Military Control

In late 1977, the first nuclear weapon to incorporate the majority of state-of-the-art improvements in S^{2}C reached production status, and the Air Force began processing nuclear weapon system safety rules. Such rules are written for each weapon system, i.e., the delivery aircraft in this instance, that apply to a nuclear weapon type. The F-4 application presented a singular concern in that the relatively old fighter/bomber had not been provided with the monitor and control hardware needed to provide the bomb with the required prearming electrical signals after take-off. The Military Characteristics document written by the Air Force had allowed for this discrepancy by requiring Sandia designers to incorporate a two-way switch on the outside surface of the B61-5 that would allow overriding "one of the two safing components in the bomb." Such a bypass would negate much of the overall enhancement in nuclear detonation safety provided in the design.

The nuclear safety rules package presented to Sandia by DOE/OMA for the B61-5/F-4 called for the selector switch to be placed in the override position during mating of the bomb to the aircraft for Quick Reaction Alert (continuous ground alert) and remaining so for the entire QRA period. In a letter dated December 23, 1977, Sandia advised DOE/OMA of its concern about bypassing the very design safety feature that would protect against faults in the F-4 that would introduce errant voltages into the bomb, without a clearly compelling operational need to do so. In the past four years, the F-4 had experienced at least five such incidents, one actually operating a bomb safety component.

Apparently, DOE/DMA was offended by Sandia's objection and directed that henceforth Sandia would not reply directly to DOE/DMA, but would provide comments to DOE/AL who would consolidate comments, attempt to resolve issues, and forward appropriate comments/concurrence to DOE/DMA. When informed that DOE/AL had without field consultation already given approval for interim rules, Sandia's Executive Vice President Jack Howard took exception in a strongly worded TWX (Ref. 174).

NOTE: Jack Howard showed me a draft of Ref. 174 that ended with the observation the DOE/OMA was following a path that could result in a lack of civilian signatures on safety rules and this would be "a situation I believe is unfortunate if not illegal." I suggested replacing the last clause with "if not contrary to statutory intent" and Jack made that change.

At my suggestion, DOE/OMA arranged for a Field Review for B61-5/F-4 nuclear safety rules and I stewed over naming a Sandia voting member. In anticipation of potential for an intra-DOE disagreement, I searched for a member who clearly would represent Sandia's top management. After consultation with Sandia's legal staff (BTL, on-loan), I nominated my director, Leon Smith—believing, in good faith, that his level was that of an "officer" of Sandia. Leon later was informed that the "officer" level began at Vice President and, therefore, he did not qualify.

NOTE: Sandia officers are required to retire at age 65. I wonder if this episode was a factor in Leon Smith's election to continue as a director substantially beyond age 65?

The Field Review was held at a U.S./NATO airbase in West Germany, with the result of recommending approval of the proposed rules. In a memo to DOE/OMA, Leon Smith expressed the technical opinion that the bypass at loading was not essential to meeting the stated operational timeline for readiness and that bypass during the last opportunity prior to take-off was the better choice. I am certain that the impending retirement of the F-4 mission was a factor in deciding not to elevate the disagreement at the time.

6.20 DoD/DOE Long-Range Planning Group (Starbird Study), 1979-1980

This study was initiated by the DoD/ATSD(AE) and was in effect the second study of the transfer issue, although the ERDA's weapons responsibilities had been transferred to the Department of Energy in 1977 upon dissolution of ERDA. Lt. General Dodd Starbird, U.S. Army Retired, who by then had become a consultant, chaired the study. Again, Bob Peurifoy was Sandia's member of the study group and he obtained my services in support. Figure 19 is a list of principal participants.

The subject of nuclear weapon safety was not on the study's agenda initially. When the study group visited Sandia in late 1979, Peurifoy had me give a briefing on the recent deterioration in ERDA/DOE-DoD relations in safety and the demise of presidential-level directories that would formalize the dual agency judgment and responsibilities practice (Ref. 91). The thrust of my remarks was that, despite the fact that the national policy documents that had formed the basis for the joint DoD/DOE program had been rescinded, revoked, replaced, or otherwise de-emphasized, the program was continuing to function. Such a situation seemed fragile for the long run and not in the spirit of the finding for dual-agency responsibilities for safety per the Transfer Study of 1976. Lieutenant General Starbird, a long-time advocate of nuclear safety and a sponsor of the Transfer Study, decided to add the subject of nuclear safety to the agenda of the group. Perhaps the most telling indication of fragility was my presentation that compared, side-by-side, the wordings of the final draft proposals of the DOE/DMA for a Presidential Decision Memorandum and a DoD/DOE Memorandum of Understanding with the then current DoD draft that, almost a year later, was still circulating at action-officer levels in the DoD.[42] It was clear to some in the audience that a serious threat to the dual agency nuclear safety program was emerging. Later, Dick Brodie and I prepared material, which became the basis for an appendix (one of four), to the group's final report (Ref. 92) on Safety, Security and Control (S^2C).

Also on the matter of S^2C, I was assigned by Sandia's Jack Howard, who was serving as an advisor to Starbird, to prepare a strawman draft paper on formally institutionalizing the dual-agency concept. The draft (Ref. 93), after comments by Howard were accommodated (Ref. 94), became the support for a recommendation in the final report for establishing a DoD/DOE high-level oversight committee for S^2C matters.[43]

Perhaps my more important involvement was the drafting of a detailed paper that discusses the deterioration of the level-of-effort management and funding practice instituted by the AEC for the nuclear weapons program. This paper (Ref. 95) stressed the impact of retirements and other dissociations of ten persons (called "lions" in the paper) who had been instrumental in the practice's evolution, support, and advocacy. Perhaps the paper was a factor in Starbird Study's strong endorsement of the practice and the wisdom of continuing it by not transferring any responsibilities to the DoD. The paper was edited and reissued:

- in 1985 in relation to the Nunn-Warner and Domenici amendments on transfer of production responsibilities for nuclear weapons to the DoD (The "Blue Ribbon Study"), and
- in 1987 in relation to an intra-DOE study of planning for the nuclear weapons complex (The "Hymer Study").

Other safety-related papers that I wrote in support of Bob Peurifoy were on the subjects of:

1. Utility of the DoD's Military Liaison Committee (Ref. 96).
2. Functions of the DoD's Design Review and Acceptance Group (Ref. 97).
3. Roles of the DoD's Defense Nuclear Agency in Nuclear Weapon Safety (Ref. 98).

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[42] As mentioned, Joe Luger had heavily influenced the DoD draft.

[43] A DoD/DOE committee was not implemented; however, the DOE/DP later established an intra-DOE oversight committee, now called the S^2C Committee. Vice President Orval Jones was Sandia's member initially, followed by Bob Peurifoy.

[redacted]

STUDY GROUP I*

RANK	NAME	PARENT ORGANIZATION
MGen	John C. Toomay	ATSD (AE) - - USAF (Ret.)
Col	Kyle D. Barnes, Jr.	HQ AFSC, USAF
Lt Col	Randall E. Beaty	HQ DNA
Maj	Roger S. Case, Jr.	HQ USAF/RDPT
RAdm	Glenwood Clark	USN, Strategic Systems Project Office
Mr.	Thomas Clark	DOE/ALO
Lt Col	Jimmy W. Comer	HQDA, ODCSRDA, SRAO
Mr.	N. S. Dienes	DOE/ALO
Capt	Leslie J. Horn	USN, HQ Naval Material Command
Mr.	W. J. Howard	Sandia Laboratory
Dr.	Hugh R. Lehman	LANSL
LCDR	George W. MacPherson	USN, Strategic Systems Project Office
Mr.	H. N. Meyer, Jr.	DOE/ALO
Mr.	R. L. Peurifoy, Jr.	Sandia Laboratory
Dr.	Gough C. Reinhardt	LLNL

STUDY GROUP II*

BGen	David M. Mullaney	ATSD (AE)
Capt	D. M. Alderson	USN, OSG/CNA
Capt	Wayne L. Beech	USN, DOE/OMA
Dr.	Richard N. Brodie	Sandia Laboratory
Lt Col	Martin D. Centala	USAF, HQ DNA/SOPR
Mr.	Nelson W. Eaton	OSD (C)
Mr.	John A. Eisele	OSD (PA&E)
Dr.	Sydell Gold	LLNL
Mr.	David J. Hessler	OSD (C)
Dr.	Reynaldo Morales	LANSL
Col	William A. Myers	USAF, OATSD (AE)
Col	E. Nelson O'Rear	USAF, AF/XOXFS
Lt Col	William M. Raymond	USA, NCA

STUDY GROUP III*

Dr.	F. Charles Gilbert	DOE
Dr.	Delmar W. Bergen	ATSD (AE) – on loan from LANSL
Mr.	Vladimir Berniklau	ALO
Cdr	Barry S. Birch	USN, Joint Cruise Missile Project
Ms.	Mary G. Cariyon	ALO
Lt Col	Edward V. deBoeser	USA, JCS
Mr.	Howard B. Ellsworth	OUSD (R&E)
Mr	Larry F. Forsythe	DOE/OMA
Dr.	Paul W. Keaton	LANSL
Mr.	William M. Lamb	DOE/ASDP
Mr.	Billie C. Moore	DOE/NVO
Dr.	Walter E. Nervik	LLNL
Dr.	Richard L. Wagner	LLNL

*Most participated on a part time basis only.

Figure 19a. Principal Study Participants, "Starbird Study" (Page 1 of 2)

The Steering Committee consisted of the following members:

DOD

RAdm	P. Carter	OP-65
MG	R Cody	DNA
BG	J. Chain	AF/XOX
BG	N. Fulwyler	DAMO-SS
BG	D. Mullaney	DATSD (AE)
BG	D. Vesser	JCS/J-5

DOE

MG	W. Hoover	OMA
Dr.	F.C.Gilbert	NMP
Mr.	H. Roser	ALO

The Senior Consultants were:

RANK	NAME	PARENT ORGANIZATION
Mr.	N. Augustine	Martin-Marietta Aerospace
MG	J. Bratton	USA CORP of Engineers
Dr.	E. Fubini	Chairman, DSB
Dr.	W. Kaufmann	MIT
Dr.	D. Kerr	LANSL, DOE
Dr.	M. May	LLNL, DOE
Mr.	G. Moe	PSR (Executive Secretary)
Mr.	P. O'Deen	Coopers & Lybrand
Mr.	H. Roser	ALO, DOE
Dr.	J. Ruina	MIT
Dr.	G. Tape	President, Associated Universities, Washington, D.C.

In addition to the Steering Committee and the Senior Consultants, more than 50 people were involved directly in the conduct of the study. Their names and parent organizations are as follows:

STUDY DIRECTOR AND STAFF

RANK	NAME	PARENT ORGANIZATION
Lt Gen	Alfred D. Starbird	ATSD (AE) - USA (Ret.)
VADM	Patrick J. Hannifin	ATSD (AE) - USN (Ret.)
Dr.	Theodore Gold	ATSD (AE) - on loan from Sandia Labs, Livermore
Maj	John W. Riggs	USAF
YNC	James J. Taylor	USN
YN1	James B. Jones	USN
SSGT	Robert S. Childress	USA
Mrs.	Mary Jane Kelley	USAF
Miss	Suzanne Carrington	USA
Miss	Diane Offenbacker	USN
Mrs.	Cheryl Richardson	DOE
Mrs.	Tracey Nelson	DOE

Figure 19b Principal Study Participants, "Starbird Study" (Page 2 of 2)

6.21 Briefing Package on Nuclear Weapon Safety, 1980-81

Following the TITAN II intercontinental ballistic missile accident at Damascus, Arkansas, in the fall of 1980, DOE/DMA Major General William W. Hoover, USAF as DOE/DMA, requested that the weapons design laboratories prepare a package of information on nuclear weapon safety that could be used by federal employees to make information releases (briefings) to the public to ensure the adequacy of the safety of nuclear weapons. Sandia was asked to coordinate the effort and Executive Vice President Jack Howard assigned the task of preparing the material to Orval Jones, then Director of Nuclear Security Systems 1700. I was assigned to assist Jones for several months. Jones was expert on physical security technology and institutions, but had no relevant experience in nuclear weapons technology, especially safety.

> NOTE: In the summer of 1980 as I was preparing for a rather lengthy Operational Safety Review in Europe, I recommended a change in Sandia's policy on who would participate as technical advisor for the DoD's weapon accident response team. By memo (Ref. 99), I suggested that the Director, Weapon Development of either the Albuquerque or the Livermore design team be the representative, as contrasted to the former practice of being the staff member that supported the particular military service's system safety study group. This resulted in Bob Peurifoy representing Sandia at Damascus, Arkansas.

The result of Jones' intensive study of nuclear weapon safety is a set of transparencies and associated briefing notes (Reference 100), supported by the following six documents:

1. A source book on nuclear weapon safety, 41 pages (Ref. 101).
2. A summary of official public information on nuclear safety, 128 pages, (Ref. 102).
3. A summary of unofficial public information, 86 pages (Ref. 103).
4. 117 possible questions and answers, 67 pages (Ref. 104).
5. A chart summarizing status of nuclear safety features in weapons, 1 page (Ref. 105).
6. A summary of safety features in each stockpiled nuclear weapon, 243 pages (Ref. 106).

Although this package has existed in the files of Sandia's Nuclear Safety Information Center (NSIC), it has found little use. LLNL and LANL preferred a highly abbreviated and generalized version. LLNL created such a version and forwarded it for comments. Only the sixth-named document was kept current and used in emergency response operation centers as a reference.

> NOTE: Several years later I was tasked to support Orval Jones when he was SNL's member of the DOE's S^2C Committee. In recalling the process of preparing this briefing package, Orval mentioned to me that the experience had led him to change his mind about the utility of Sandia having any on-roll career specialists in particular disciplines, as contrasted to having technically qualified staff that could be used in a variety of roles during a career. He became

convinced that Sandia needed a "professor" (his term) in nuclear safety and so labeled my role as such. Apparently, Orval has continued this opinion, since the notion of a surety professor appears in the 1997 report on Sandia's Surety Heritage to which he contributed (page 178 and Ref. 149).

6.22 Sandia Input to the Annual Report to the President on Nuclear Safety (Surety), 1976-1984

In 1970, National Security Advisor Henry Kissinger issued National Security Decision Memorandum (NSDM) 5, which revoked, rescinded, or reissued all earlier directives of a specified vintage. NSAM 160 on PAL was reissued and NSAMs 51 and 272 on safety were rescinded.

Efforts to reissue National Security Action Memorandum 51, which prescribed AEC participation in the consideration of nuclear safety matters, were extremely contentious in DoD and AEC staff-level negotiations and showed little progress until the report of the ERDA/DoD Transfer Study was accepted in January 1976. A Memorandum of Understanding was not issued until 1983—some 13 years in negotiation. A Presidential Directive, normally produced before an MOU is appropriate, has not been issued.

NSAM 272 was replaced in content by NSDM 96 issued later in 1970. It expressed direction of the President, in part, as:

- An annual report be forwarded to him at the beginning of each calendar year describing the nuclear weapons safety rules in effect for all weapon systems and noting changes in those rules during the past year.
- The President be informed promptly of the rules approved for new weapons systems and of any significant changes with regard to existing systems.
- The President requests that a proposed format for the annual report be forwarded to him for his review by January 15, 1971.

Since the coverage apparently was limited to nuclear safety rules processing, SNL roles were essentially unchanged from those for NSAM 272.

By a letter dated July 16, 1975 addressed to ERDA from the National Security Council of the Office of the President, ERDA was requested to prepare an annual report to the President on nuclear weapon safety and security, in a manner similar to that done by the DoD under NSDM 96 since 1970.

No record of SNL involvement or notice of reporting for calendar year 1975 has been located. A memo from ERDA/DMA Safety and Facilities Director (Colonel-Level) requesting input from the "field" referred to the 1976 Second Annual Report to the President on Nuclear Weapon Safety and Security. The input requested was to comment on a draft report that had been prepared by the ERDA staff (three field-grade military officers plus several civilians who had retired from military service in-place). In order to meet the 23-day deadline imposed for input, I took the lead as Nuclear Safety Department Manager. I consulted with fellow department managers working in security fields (e.g., Gene Blake and Andy Lieber) and in other aspects of nuclear safety. I drafted a suggested rewrite of the Executive Summary section of the report and forwarded the package to ERDA/DMA/S&F directly. The SNL material was included in the final report verbatim; however, SNL was not requested to review that report for comment prior to its issuance.

The thrust of SNL's 1976 rewrite was to cite and describe initiatives and significant contributions of the ERDA national laboratories in S^2C, adding use control to safety and security. Otherwise, the report would likely have continued to be a summary of only Operational Safety Review and safety rules matters.

By letter dated June 18, 1976, from the National Security Council to ERDA and DoD, the report's format was changed to that of a combined agency report, and this practice was to last for eight years. The modus operandi' for a combined report was for the DoD and ERDA/DOE to prepare sections covering their operations essentially independently and for staff-level officers in Washington DC to draft an Executive Summary. These two elements were to be combined and forwarded in draft to field agencies for comment. Thus, only the Executive Summary was intended to be "joint," but in practice each participant commented on all sections at staff levels or occasionally at decision-making levels through cover letters forwarding comments.

A summary of contributions from the weapons laboratories over the years to the Annual Report is given in Figure 20. I found that an especially valuable aspect of SNL's input to the Annual Surety Report was its value as a coordinated, laboratory-wide position, which can be expressed in other forms of communications on S^2C, such as the annual testimonies of the DOE weapons laboratories to congressional committees n the armed services.

- 1978, Morgan Sparks to House Armed Services Committee (on Enhanced Nuclear Detonation Safety Utility).
- 1980, Morgan Sparks to Senate Armed Services Committee (On the Stockpile Modernization Program).
- 1986, Morgan Sparks to House Armed Services Committee (On the Stockpile Modernization Program).

Among the notable other contributions by SNL to the process (shown in Figure 20, the sixth column) have been:

- Articulating and stressing the value of the "Dual Agency" concept that has been challenged by DoD agencies from time to time, but reaffirmed periodically by major national-level studies.
- Coordinating inputs among the three DOE weapons laboratories.
- Introducing plutonium dispersal risks as a national concern.

Report No./ Calendar Year	Report Type	SNL Process: Coordination	SNL Process: Sign Input	SNL Process: Sign Approval	Notable Contributions	Remarks (Success?)
1 - 1975	ERDA					
2 - 1976	"	Nuc. Safety Dept.	Nuc Safety Dept. IV.2764	Not Applicable IV.2785	Added R&D by the labs on S^2C	Rewrote Exec. Summary
3 - 1977	"	"	President IV.2765	President IV.2766/1	Added "Dual Agency" Concept	Referenced ERDA/ "Transfer Study"
4 - 1978	DOE	"	President IV.2766/2	?	Objected to LLNL 'selling' approved concepts	DOD/DoE wanted to focus on 'problems' - SNL finessed. See IV.2733.
5 - 1979	"	"	President IV.2767		Stockpile Modern. Study Emphasis	Suggested S.M. Study be given to the 'Starbird' Study
6 - 1980	Combined DOD/DOE	"	President IV.2768/2		Pu dispersal concern introduced	Comment on deteriorating stewardship of S^2C
7 - 1981	"	"	President IV.2772/5		Contested adequacy of DOD security in NATO	President Reagan endorsed concern
8 - 1982	"	Mgt. Staff 0400	Exec. V.P. IV.2768/2		Stockpile Improve. Program update	
9 - 1983	"	Nuc. Safety Dept. IV.2769	V.P. 7000 IV.2770/6		Contested statements "All Safe" stockpile	per NSDD 150: give DoD/DOE differences
10 - 1984	"	"	V.P. 5000 IV.2775/21 (S^2C Comm.)		SNL: Comprehensive report for new U.S. Presidents	USAF contested SNL input on F-1 Safety Rules.
					Dual Agency concerns	Withdrawn to refer to Pres. Blue Ribbon Task Group

Note: Coordination by W. L. Stevens until retirement 9/30/83.

Figure 20. Notable Contributions for the DOE Nuclear Weapons Laboratories to the Annual Reports to the President on Nuclear Weapons Study, 1976-1984

6.23 Briefings and Testimonies on the Stockpile Improvement Program, 1980-1981

In Spring 1980, I vented frustrations about the seeming lack of national resolve to follow through on the DOE/DoD Stockpile Improvement Program (SIP) in preparing drafts for Sandia President Morgan Spark's testimonies to congressional committees on armed services for FY81 and for him to note the situation in signing the Sandia input to the DOE section of the Annual Report to the President on Nuclear Weapons Surety for 1979 (Ref. 172). Sparks' testimony to the House Committee on Armed Services on April 16, 1980 noted "... the requested funding was not included in the budget. We continue to believe that the program is valuable and we hope that it will be funded in the fiscal 1982 budget."

On June 13, 1980, Bob Peurifoy, Charlie Burks, and Stan Spray briefed the Inspector General of the Air Force, Major General Howard Leaf, on nuclear weapon accidents, history, and ENDS. This was the first and only involvement of that office in nuclear weapon system safety matters to my knowledge—nuclear safety was handled as an entirely separate discipline from aircraft flying safety, personnel safety, etc.

On October 29, 1980, Charlie Burks addressed the DoD's Military Liaison Committee Chairman Jim Wade, the MLC and DOE officials ASDP Duane Sewell and DMA MG William W. Hoover during the annual MLC visit to DOE offices and weapons laboratories. Burks discussed the background of the SIP, with emphasis added by the nuclear weapon accident at Damascus earlier that month and the nuclear weapon significant incident involving two of the air-delivered weapon systems.

On December 10, 1980, Bob Peurifoy briefed MG Ed Giller (USAF, Retired) on the safety concerns. General Giller informed Air Force Chief of Staff LTG Lewis (Lew) Allen of the matter. General Allen had spent several years early in his career at LASL, being a co-author of the classic scientific report on nuclear weapon vulnerability to nuclear radiations from enemy countermeasures (the Goad-Allen report). In fact, I recall that he was the only Chief of Staff who had not been a command pilot. Air Force Inspector General Howard Leaf re-entered the considerations. He was briefed along with Colonel William E. (Bill) Endres, Commander of the Directorate of Nuclear Safety by Bob Peurifoy on January 15, 1981. General Leaf's interests led to nuclear weapon system safety enhancements in the way of changes to fire fighting capabilities at SAC bases and to QRA operations of starting engines on B-52s.

> <u>NOTE:</u> Major General Howard Leaf, USAF/IG, commissioned USAF consultant Harold (Hal) Smith, then on the staff of the Air Force Scientific Advisory Board, to appraise the validity of the basic finding of the TWGs and of Sandia that behavior of older weapon ordnance to severe abnormal environments was "unpredictable." Smith's "expert opinion" (Ref. 179) was the incredibly naïve assertion that behavior was indeed predictable to high degree and that prediction was that the ordnance would become inoperable because shorts to ground in the electrical subsystem would abound, precluding application of electrical power to

safety sensitive components. He saw the problem as a reliability concern, rather than one of nuclear safety. Hal Smith, who over the years had been a regular consultant to LRL/LLL/LLNL, was appointed to the Nuclear Weapon Council {successor to the MLC and ATSD(AE)} in 1993 and served through 1997.

6.24 The DoD/DOE Plutonium Dispersal Analysis Group, 1977-1981

After a several-year hiatus, the issue of increasing the limitation on the quantity of plutonium-bearing nuclear weapons allowed to be in an ensemble for logistical storage or transportation was revived. On July 28, 1977, DoD/MLC Chairman Don Cotter announced that the MLC had approved an increase for storage[44] that roughly amounted to 300%. The DoD/DNA Headquarters tasked its Field Command at Kirtland AFB to "take the necessary action to change TP 20-7 to conform ...." The TP 20-7 Nuclear Safety Criteria is a technical manual published through the Joint Nuclear Weapons Publication System (JNWPS). Any change to it requires the concurrence of at least three agencies: a military service, the DoD via its DNA, and the DOE via DOE/AL. Obtaining concurrence of the last-named also involves concurrence by the appropriate combination of the DOE's weapons laboratories. I led the process whereby DOE declined to concur, and the matter quickly escalated in DoD/DOE management-level attention.

Attempts to accommodate the DoD's desires for operational flexibility and economies and the DOE's concerns about safety continued for about a year, mostly in the form of wordsmithing exercises for the text and footnotes of TP 20-7. The three DOE weapons laboratories held fast to the conviction that the proposed blanket increase was ill-advised and suggested as an alternative that each specific situation should "require evaluation of the peculiarities of the particular site by technically qualified persons who consider the hazards both to the individuals at site boundaries and to the general populace." (My words contained in a memo by Jack Howard, Ref. 107). This position was presented to the MLC orally on October 4, 1978, by Jack R. Roeder of DOE/AL and Bob Luna of SNLA.

In the spring of 1979, Bob Luna, Hugh Church, John Taylor, and I responded to an urgent request from the U.S. Navy for evaluation of the potential health consequences of an accident/incident involving plutonium-bearing nuclear weapons that might be stored at a site under construction in Hawaii.[45] This work conducted onsite in Hawaii led to refinements of an analytical technique for quantifying consequences in terms of doses of radioactive materials dispersed by an accident, giving additional credence to the site-specific approach advocated by the DOE. In the fall of 1979, at the request of DoD/DNA, the techniques were applied by Sandia to two sites in Europe and one in the CONUS.

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[44] The thrust of DNA's arguments in the mid-1970s was to increase the limit for transportation, and no mention was made of storage concerns. Apparently, the impetus here was to accommodate higher-density storage in certain igloos in NATO, while others underwent physical security construction upgrades.

[45] The U.S. Supreme Court decided in 1978 that the U.S. Navy was not required to produce an unclassified "hypothetical" EIS for its nuclear weapons storage facility in Hawaii.

On November 1, 1979, Jim Wade, DoD/ATSD(AE), tasked the DoD/DNA to contract for a definitive study of storage of plutonium-bearing nuclear weapons. About a year later, DNA produced proposed terms of reference (TOR) for a joint DoD/DOE review of the plutonium mass limits issue. This TOR was forwarded to DOE/DMA's Major General William W. Hoover for comments. Sandia President Morgan Sparks' letter (Ref. 108) to Major General Hoover early in 1981, which I drafted, objected to the TOR approach as favoring unilateral DoD control of the process. Instead, it suggested joint conduct of a systems study using the analytical methodology developed by the DOE weapons laboratories in 1973-1977 for the DOE's Nuclear Weapon Transportation Safety Hazards Evaluation Group and applied by Sandia to certain DoD transportation operations in the FORWARD LOOK Study of 1980 (both studies are discussed here). The study would be the third to be conducted in a format similar to that used for the SAFEGUARD ABM issue of 1972-1973 and the ERDA/DoD Stockpile Safety Study of 1975-1976. My proposed charter was attached to Sparks' letter. The Sandia approach was endorsed by Major General Hoover, and the proposed charter was forwarded to the DoD/ATSD(AE) on March 3, 1981. Following further coordination of the charter, the first meeting of the DoD/DOE Plutonium Dispersal Analysis Study Steering Group was held on August 20, 1981.

6.25 Accident Response Group (ARG) and Nuclear Emergency Search Team (NEST) Emphasis, Early 1980s

The nuclear weapon system accident on January 31, 1958, at a "SAC Base (overseas)," involved highly localized radioactive material contamination and cleanup operations on a military installation (classified location even today). At the time, the potential problem area of contamination from dispersal caused by detonation of the high explosive in the new sealed-pit type of nuclear weapon was being considered by the Nuclear Weapon Safety Working Group chaired by the Armed Forces Special Weapons Project's Scientific Advisor. Sandia's research organization was providing a member, Mel Merritt early on, followed by Jim Shreve. Although this accident did not involve a detonation and the configuration was other than a sealed-pit weapon, the group had the appropriate technology at hand. The Sandian who was invited by the USAF to assist in decontamination on-site was William M. (Bill) Cowan from the research organization. (See page 43 for discussion of this arrangement.) This accident occurred only eleven days after the USAF had formed its Nuclear Weapon System Safety Study Group at Kirtland AFB. Thus, this accident response support function originated under auspices of AFSWP/DASA/DNA/DSWA.

As mentioned earlier, at the time Sandia's Carl Carlson was reviewing all earlier accidents and incidents in his study of nuclear weapon safety for the AEC. That interest was a factor in the formation on 2/27/58 of the Joint Nuclear Accident Coordinating Center at Sandia Base. AEC was represented by a first-level branch organization at AEC/AL. In practice, all future nuclear weapon accidents and major incidents involved only the USAF, and AEC notification usually came via NWSSG channels before JNACC. The AEC/DOD agreement document (Ref. 185) dates the origin of the "Broken Arrow" code name for a nuclear weapon accident that was later to gain worldwide fame.

In the aftermath of the Palomares accident of early 1966, MLC Chairman/ATSD(AE) Jack Howard led the process of issuing a revision to the AEC/DoD agreement on accident response (Ref. 187) and revising DoD Directive 7730.12 (Ref. 188). The thrust of this effort was to reinforce the role of the DASA, which had been a major source of support staff for Howard for the Palomares accident (the MLC part of the office's total staff was thin at best). After the Thule accident of early 1968, MLC Chairman/ATSD(AE) Carl Walske issued, on June 10, 1970, a higher-level interagency AEC/DoD Memorandum of Understanding (Ref. 189). A major thrust of this effort was to formalize the roles of the AEC and its weapons laboratories in accident response. The AEC was to be notified promptly and given the option to respond by sending a team to the site anywhere worldwide. This document was the origin of the notion of an Accident Response Group (ARG). The flurry of activity that followed involving AEC/ERDA/DOE headquarters and field organizations and the weapon's laboratories is indicated by Figure 21.

The implementing document for DOE participation was AEC Manual Chapter 0470 issued in early 1972. Not much happened until 1977 upon issuance of an agreement between Energy Research and Development Agency (ERDA) and the DoD (Ref. 190). This led to establishment of a formal role for the staff of the Military Applications Office at ERDA Headquarters near Germantown, Maryland, with construction and manning of an AEC emergency response coordination center in a vault beneath the headquarters building.

> NOTE: As I mention in context later, I consider the extreme of emphasis that developed on ARG/NEST to have had a seriously detrimental impact on nuclear weapon S^2C because it competed for the energies of the very ERDA/DOE and laboratory personnel who also had line responsibilities in S^2C. I don't quarrel with the ARG/NEST as a national capability—it's a matter of degree.

By 1974, an activity that can be considered as a parallel to the ARG area had evolved from roots in the Security part of S^2C, the Nuclear Emergency Search Team (NEST). Rather than being driven by a weapon accident as for ARG, NEST was driven by the threat of loss of possession or control over a weapon, weapon test devices, weapon parts (especially those containing radioactive material), etc. The principal threat was use of the item to cause dispersal of radioactive materials that could endanger the health of the general population or otherwise have impact of national significance. William E. (Bill) Nelson of LLNL, William H. (Bill) Chambers of LANL, and William C. (Bill) Myre of SNL became the scientific/technical principals, all having earlier roles in nuclear weapon R&D projects.

> NOTE: In mid-1974, Giller I (named after MG Edward Giller, ERDA/Director of Military Application) was the first major field exercise of NEST. Bill Myre recalled that I was the nominal Sandia manager actively participating in the deployment of Sandians to accident sites in support the military services. Bill appointed me to aid him by overseeing the residual center for the NEST team at Kirtland AFB after the team departed by an Air Force C-130 for the exercise site on White Sands Proving Grounds (set up to simulate a foreign nation that had stolen a weapon). By the time of the first nuclear weapon accident exercise in 1975 (NUWAX-78), NEST had two exercises and two real-life partial responses.

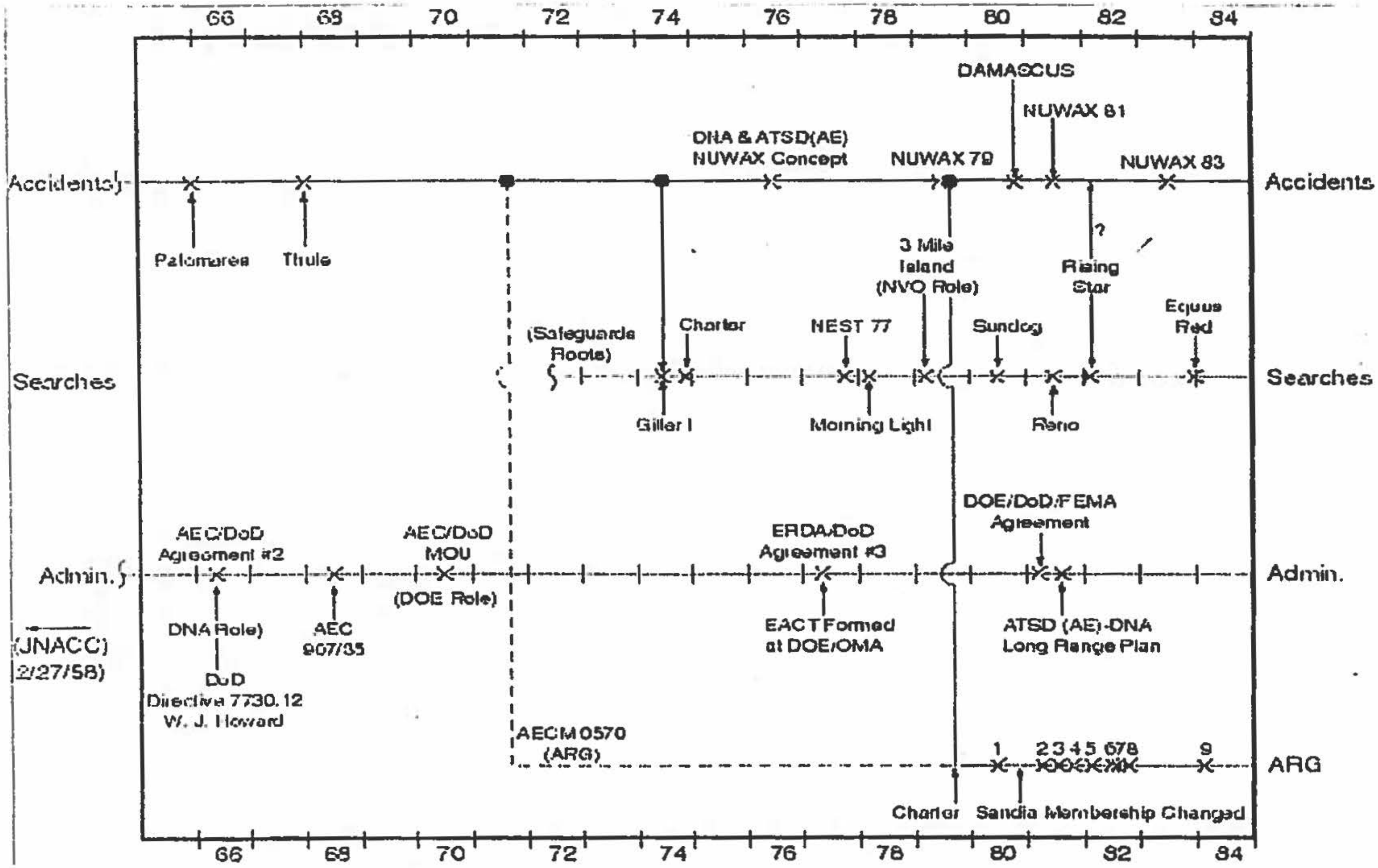

Figure 21. Time-Line for Nuclear Weapon Accident and Search Team Activities

Following the first field exercise of the ARG, NUWAX-79, the scope of ARG activities was seen as large enough to warrant funding and management arrangements that would amount to a scheduled program in the DOE. The Accident Response Capability Coordinating Committee (ARCCC) was formed and became operative by mid-1980. My department provided staff support for the Sandia director appointed as a member, Leon Smith. Roy Lambert became the lead technical person at Sandia, continuing the interest and skill that he had displayed at the last two real accidents at Thule, Greenland, in 1968 and Damascus, Arkansas, in 1980.

Sandia's role in ARG/ARCCC was minor compared to those of LLNL and LANL. I took special interest in the technological capability of the laboratories to define the extent of dispersal of plutonium oxide aerosols following detonation of weapon high explosive and drew on the talents of Bob Luna, Hugh Church, and John M. Taylor. LLNL competed directly by establishing in 1979 the Atmospheric Release Advisory Capability (ARAC) Center at LLNL.

> NOTE: In 1996, ARAC had become "a national emergency response service for real-time assessment of accidents/events involving the release of hazardous, natural, chemical, nuclear, or biological material to the atmosphere. ARAC delivers realistic graphic dose/exposure assessments to emergency decision makers to assist in the protection of populations at risk. Since 1979, ARAC has responded to more than 70 alerts, accidents and disasters, and supported more than 800 exercises. Besides accidental radiological releases, we have assessed natural disasters such as volcanic ash cloud and earthquake induced hazardous spills, manmade disasters such as the Kuwait oil fires, and toxic chemical releases." (Ref. 183.)

In early 1981, the ARG/ARCCC took on an added dimension when the newly formed Federal Emergency Management Agency (FEMA) became by fiat the federal lead agency for domestic U.S. events. There followed a classical bureaucratic struggle within the DOE as L. Joseph (Joe) Deal and his allies elsewhere in DOE attempted by rewrite of governing DOE orders to impose nuclear fuel cycle and power reactor safety practices on the nuclear weapon program in general and weapon accidents in particular. As is described in several places in this report, I fought such attempts, time and time again, as they arose in various guises and with various sponsors throughout the remainder of my Sandia tenure and later as a consultant. We won this episode, thanks in part to the fine technical paper that John Taylor contributed on the subject of Emergency Planning Zones (Ref. 181). Correspondence on this general subject is contained in Nuclear Safety Information Center (NSIC) File IN.228, including my thoughts (Ref. 182).

6.26 Nuclear Weapon Transportation for the Pantex Plant, Environmental Impact Statement, 1981-1983

My PM/PM methodology for risk assessment was extended and applied in the preparation of an Environmental Impact Statement for the DOE's Pantex Plant near Amarillo, Texas, both for the production and storage operations (by LANL) and for transportation in and out of the plant (by Sandia). (See References 109, 110, and 111.) A significant innovation that I suggested was the notion of a "threshold of acceptable risk" level of less than one chance in a million opportunities per year of experiencing a plutonium dispersal accident due to operations at Pantex. The threshold of risk notion was used in the EIS instead of the traditional "worst credible accident" scenario approach that had been required in nuclear power reactor fuel cycle programs.

Acceptance of the final EIS report in 1983 amounted to tacit acceptance of the refined PM/PM approach, although there has been no test in courts. Later, the approach was considered for formal adoption in the DOE's order on transportation of nuclear weapon materials. It was applied to DoD transportation and storage operations worldwide in the period 1981-1986, following the FORWARD LOOK study (Ref. 86).

In the course of promoting the use of PM/PM for the Pantex EIS, I updated and extended earlier papers on PM/PM) in the preparation of Reference 111. My final papers on this general subject are Reference 112, prepared at the request of Orval Jones for the DOE/DP's S³C Committee (post my retirement).

6.27 The Plutonium Dispersal Safety Project (PDSP), 1981-1984

Basic references for this section and others treating the subject of radioactive material dispersal safety are the annotated timelines contained as TL-1A (1956-1979), TL-2A (1978-1985), and TL-48 (1977-81) in Ref. 153.

After the DOE's response to the Titan II missile accident in October 1980, LLNL provided to a DOE review group quantitative estimates of the dose contours that would be expected had the nuclear warhead undergone detonation of its chemical HE as a result of the fuel explosion. SNL's representatives on the review group had made similar estimates for internal purposes and noted a large discrepancy between the two estimates. Subsequent coordination revealed that the LLNL's source term for the mass of special nuclear material aerosolized in the hazardous range of particle sizes was highly conservative (overstated) and accounted for most of the difference. Firm channels of inter-laboratory technical coordination were established to avoid such problems in the future.

My reactions to the above incident included having John Taylor draft a proposal for research on the source term (Ref. 180). This led to a tri-DOE weapons laboratory study with SNL as the lead and principal funder. This study began in earnest in the fall of 1981 and was to improve understanding of the "source term" for release of Pu from detonation of the chemical HE surrounding a Pu-bearing pit of a nuclear weapon. This study complemented a project under way (May 1980) before the Titian II accident to investigate the source term for burning of the HE, as contrasted to detonation of the HE. This project, the Plutonium Aerosolization Study, was conducted on Sandia Base at the Inhalation Toxology Research Institute operated by the Lovelace Foundation, under funding sponsorship of LLNL.

> NOTE: The data obtained from these experiments was used by LLNL to justify the Fire Resistant Pit (FRP) that in 1994 was described in unclassified language

by Sid Drell and Bob Peurifoy in Reference 147. I found LLNL's analysis unconvincing at my retirement in October 1985. Bob Luna's comments were especially helpful to me.

Sandia's part of the PDSP included an in-house, rather large (e.g., about $3.5 million over 3-1/2 years) research project led by Bob Luna.

6.28 Deliberate, Unauthorized Launch (DUL) Concerns, PERSHING II Weapon System Deployment, 1981

The second of the four standards for nuclear weapon system safety studies and reviews since 1960 has required that "There shall be positive measures to prevent deliberate arming, launching, firing or releasing" of nuclear weapons. In the terminology used in this report, the second standard really is concerned with use control, rather than safety, of a nuclear weapon system. For missile systems, the technology used in the NWSSG process to treat this concern was termed a "Deliberate, Unauthorized Launch (DUL)" study. The study methodology tended to be closely held, for understandable reasons of security against possible unintentional disclosure of ways to bypass the positive measures relied upon to prevent the launch. Since the end event was a launch, not a nuclear detonation of a warhead, there was a tendency in the 1960s and 1970s to regard DUL as mainly a DoD concern for those weapon systems that contained a PAL device to preclude detonation even with a launch. DUL issues were addressed by a special analysis for those weapon systems without PAL—mostly, bombers and ballistic missiles. The analyses were done by a DoD agency or contractor and presented to NWSSGs for a judgment as to adequacy of the positive measures provided.

In preparation for the Pre-Operational Safety Review for the PERSHING II weapon system scheduled for March 1983 for which I was to be technical advisor, I examined the practices and technologies relevant to DUL studies and circulated a set of presentation aids (Ref. 113) within SNL to stimulate discussions on DoD and DOE responsibilities in the areas of S^2C. I cited examples of current controversies involving the W84/Ground Launched Cruise Missile, a LLNL/SNLL program, and the W85/PERSHING II, a LANL/SNLA program.

> NOTE: The W84/GLCM episode that I described in Ref. 114 remains classified as to detail.

- The T-1 Countdown Episode

  Based on experience with the earlier PERSHING Ia weapon system, U.S. Army operational history analysts concluded that many of the reliability failures detected by simulated launch exercises were due to human errors during the countdown-to-launch phase. This led to a "requirement" for PERSHING II to include in routine Quick Reaction Alert status the "T-1 Option" (so named because the operational countdown would proceed down to launch minus one second). This operation was to be allowed for a weapon systems in the Quick

Reaction Alert configuration, complete with missile motor igniters installed and a war reserve W85 nuclear warhead installed in the warhead section of the system—i.e., all the elements needed for a nuclear detonation were present except that the PAL system in the W85 would not be operated. During the T-1 countdown, all human actions necessary for a tactical launch, flight and nuclear detonation were to be performed with "simulated" codes and safing signals entered. The exercise required removal of the ball lock pins that secured the missile to the launcher structure and actually turning the Launch Key on the system's control unit.

I was astonished earlier in the development program when the T-1 Option concept was mentioned and believed that it was so absurd that it would be discarded during the considered reviews built into the DoD's development approval process. When the T-1 Option was included in the Operational Concept presented for approval at the Pre-Operational Study, I drafted a statement concluding that there would be inadequate positive measures to meet the first and third system safety standards (nuclear detonation and DUL) and recommended that the option should be deleted. The NWSSC voting membership voted against my proposed statement (5-2, with only DOE and Field Command, DNA members in favor), and the statement became an official minority opinion.

> NOTE: The PERSHING II first stage rocket contained a Safe and Arm Device of an out-of-line explosive train type that was to be operated by a coded signal. This provision may be traced to the initiative of the PERSHING II Project team member, U.S. Army Captain John C. Hogan. Captain Hogan had worked closely with SNL's project leader, Ray Reynolds, in using the strong link technology for this device. Also, he had been instrumental in leading the weapon system contractor, Martin Marietta, to conduct DUL studies just before the Pre-Operational Safety Review. Several years later, upon Captain Hogan's retirement, Ray Reynolds processed a hiring application for John, but Executive Vice President Jack Howard denied approval. About a decade later John Hogan joined SNL's team as a Martin-Marietta employee and later as a Sandian.

7. CHALLENGES TO DUAL AGENCY RESPONSIBILITIES AGREEMENTS, 1983-1994

Within the first decade after abolition of the Atomic Energy Commission in 1973, the concept of dual agency responsibilities for S^2C had been intensively reviewed by two high-level governmental task groups and was reaffirmed without major changes being proposed. The ERDA/DoD *Transfer Study* of 1975-76 had defined and adopted the concept and the DOE/DoD *Starbird Study* of 1979-80 added an endorsement. The next decade would see more reviews and tests of efficacy.

In mid-1982, Sandia's safety statesman, Executive Vice President Jack Howard, elected to take early retirement at age 50. His unexpected departure necessitated changes in the way that Sandia handled S^2C concerns.

7.1 The DoD/DOE Memorandum of Understanding, 1982-1983

In the early years of the 1980s, evolution of nuclear safety in the U.S. nuclear weapon program was characterized by a recovery from the weaknesses in stewardship for S^2C in evidence during the 1977-1980 period. Although the recovery surely was the result of a combination of events, the foundations were drawn from the reaffirmation of the dual-agency responsibilities concept by the *Starbird Study*.

After completing his work as executive assistant for the *Starbird Study* in early 1980, Dr. Theodore (Ted) Gold terminated his employment with Sandia (from a leave of absence) and became a deputy to Rich Wagner, DoD/ATSD(AE). In this assignment, Ted Gold became the implementer of a principal recommendation of the *Starbird Study* that he earlier had helped to draft:

> Finding #7: The concept of dual-department responsibility for S^2C of nuclear weapons needs Presidential-level reaffirmation. There is no governing policy directive now in force and no integrated management.
>
> Recommendation: Treat S^2C as an entity. The DoD and DOE Secretaries should continue to seek a Presidential Directive reaffirming dual-department responsibility and should establish, under ATSD(AE) and ASDP, dual-agency oversight group to write the yearly safety report to the President, and also to advise and consult concerning the S^2C program. ATSD(AE) should take the initiative to write a definitive, integrating DoD Directive. DNA should provide technical support to ATSD(AE) on S^2C efforts.

Ted chose to abandon attempts to draft a Presidential Decision Memorandum (PDM) and focused instead on drafting a lower-level Memorandum of Understanding (MOU) between the DoD and the DOE that would cover the entire area of joint nuclear weapons activities. Safety, security, and control (S^2C) would be just one of the areas of responsibilities considered. This enlightened approach allowed re-endorsement of existing working arrangements (principally, the 1953 Agreement Between the Atomic Energy Commission and the Department of Defense for the Development, Production, and Standardization of Atomic Weapons) and the precedents that had evolved over three decades.

In effect, Ted Gold's draft captured the intent (he actually used some wording verbatim) of National Security Action Memorandum 51 of 1961 for nuclear safety and adopted current practice for use control and security as continuing responsibility. The applicable text from the MOU that became effective on January 17, 1983, follows:

> E. The obligation of the DoD and the DOE to protect public health and safety provides the basic premise for dual-agency judgment and responsibility for safety, security, and control (S^2C) of nuclear weapons. This checks-and-balance role shall continue. The DoD and the DOE share the responsibility to:
>
> 1. Identify and resolve health and safety problems connected with nuclear weapons. In particular, the DOE has continuing responsibility to participate with the DoD in the consideration of these health and safety problems for nuclear weapons in DoD custody.
> 2. Prevent unauthorized use of a nuclear weapon through the use of positive control measures. In general, the DoD establishes operational requirements, and develops and implements procedures to ensure control of nuclear weapons while the DOE develops control hardware features. The DoD and the DOE jointly participate in the assessing the effectiveness of control features.
>
> Source: Ref. 115.

<u>NOTE</u>: Dick Brodie and I were in frequent contact with Ted Gold in this endeavor. Note that my emphasis on joint and shared responsibilities and Brodie's emphasis on overall responsibilities survived.

In the process of coordinating Sandia's inputs to Ted Gold in drafting the MOU, I attempted to encourage dialogue within Sandia's top management to appreciate the nuances in shared, joint, dual and singular DoD/DOE responsibilities for S^2C. I wrote a memo on this subject (Ref 116), as a precursor to the memo that President George Dacey's should sign when the final MOU draft was up for approval. To my dismay, Dacey replied that there was no real difference between "shared" and "joint" responsibilities in his mind. As I prepare this report, I note that the joint nature of safety responsibilities that I envisioned perhaps has been eroded; i.e., that DOE and DoD are jointly required to render a judgment as to the adequacy of positive measures that is total account for the level of risk. The issue of joint and shared judgments was at the heart of the W69/SRAM-A safety episode outlined later in this report, and I use that episode to give substance to this nuance in language.

7.2 The Third Revision of the DoD Directive on Nuclear Weapon Safety Studies, 1983-1984

Following issuance of the DoD/DOE MOU in 1983, Dr. Glen T. Otey, DoD/ATSD(AE)[46] intensified the process of revising DoD Directive 5030.15, *Safety Studies and Reviews of Nuclear Weapon Systems* dated August 8, 1974. This document is considered to be remarkable among joint agency directives in that it has remained unchanged in thrust since original issuance in June 1960; however, its updating was needed to change organizational titles and responsibilities and to codify practices that had evolved. Glen Otey's approach over almost two years of coordination was to have one-on-one sessions with the chairman of the military services' system safety study groups, the branch chiefs in the DoD/DMA, the DOE/AL, and the DOE/DMA safety groups, and various action officers in the Pentagon. Informally, he obtained input and comments from others, including Dick Brodie, Frank. J. Murar, and me. By late 1983, a new version had been coordinated, and it entered the approval chain at DoD in early 1984.

The version dated February 8, 1984, and renumbered as DoD Directive 3150.2 makes at least two significant improvements, in my opinion.

1. The DoD/ATSD(AE) was assigned overall responsibility for the nuclear weapon system safety program, marking the first time that this responsibility was formally assigned on anyone. The responsibility "... review and evaluate periodically programs established to implement this directive" is derived from an internal DoD memo from the Secretary of Defense and is responsive to recommendations of the Starbird Study.
2. Reports on safety studies and reviews will contain a statement of the action that the cognizant military service intends to take on each recommendation and will be forwarded into DoD/DOE channels within four months of study completion. This provision ended the Army's practice since the mid-1970's of not publishing reports and intended actions for long periods—several years had become typical.

The revision was not successful in at least one respect, in my opinion, despite extraordinary efforts by Glen Otey. Early drafts of the revision provided a safety standard addressing the prevention of radioactive material dispersal in weapon accidents, as well as to continue the charge to prevent a nuclear detonation. Although this "fifth standard" did not survive, the revision does have a weaker charge: "Measures for reducing hazards that could lead to detonation of the warhead high-explosive, ignition of rocket motor propellant, or other events of serious consequences also shall be considered ...."

[46] Otey was a department manager at SNL on leave of absence for this assignment.

7.3 The DOE Defense Program's S²C Committee, 1983-1985

Shortly after promulgation of the DoD/DOE Memorandum of Understanding on S²C in April 1983, the DOE's Assistant Secretary, Defense Programs (ASDP) Herman E. (Herm) Roser commissioned the formation of a DOE S²C Committee. The S²C Committee was to be comprised of a senior individual from each laboratory and Operations Office and from the Safety, Environment and Emergency Actions Division of DOE/DMA. Its chairman was to be designated by the DOE/Deputy ASDP. The committee was to "meet periodically to discuss current topics and possible new initiatives, identify measures that may require additional interagency attention, and ensure a heightened awareness of the overall importance of S²C."

Orval Jones, then Vice President 7000, served as Sandia's representative and Dick Brodie and I did staff work for Orval. In July 1983, Bob Peurifoy was promoted from Director, Weapon Development 4300 to Vice President, Technical Support 7000 and replaced Orval. I recall that one of the tasks of the S²C Committee was to obtain an S²C policy statement for DOE via the mechanism of having the S²C Committee moderate the sharp differences in views held by the Peterson/Jones faction at DOE/OMA and the Otey/Gold/Stevens/Brodie faction at DOE/ATSD(AE) and Sandia. The draft policy statement died in 1985 when the President's Blue Ribbon Task Group found it unsuitable for its use. Essentially none of the Peterson/Jones "independence" and "checks and balances" harpings are contained in the draft Annual Report for that year. In my opinion, this episode revealed in open S²C Committee sessions all of the important issues needed for DOE/OMA to clean its house on S²C policy. The simple fact is that the Peterson/Jones faction was still fighting the wording of the DoD/DOE MOU because it seemed to contradict their view. I saw this as a dangerous, and probably losing, campaign with the DoD (Ref. 192).

7.4 Safety, Health and Environmental Appraisal Committee, 1983-1984

During my two-year service on the committee accountable to the Vice President of Technical Support 7000 for appraisal of non-nuclear safety of facilities used by that organization, I successfully advocated and promoted (Ref. 118) the use of the PM/PM variant of the Probabilistic Risk Assessment methodology to Sandia's sled track facility. The analysis made by Richard (Dick) E. Smith[47] of my department was especially noteworthy in that it led to appreciation of the potential risks of using in the future improved rockets whose propellants could become explosive rather than merely propulsive.

Additionally, I contributed papers on a suggested philosophical treatment of industrial safety risks (e.g., Ref. 119), perhaps a factor in the changing of the committee's name <u>and emphasis</u> from the traditional "Environment Safety and Health" to "Safety, Health and Environment" challenging DOE Headquarters' apparent emphasis via ES&H (there was an Assistant Secretary

[47] Dick Smith had been the principal member of technical staff for the PM/PM methodology for the NWTSHFG study in the 1973-76 time period and has continued to be Sandia's expert in this area.

of Energy for such) to safety and health of employees and the public over environmental concerns.

7.5 Papers on AEC/DoD Divisions of Responsibilities, 1984

In support of Executive Vice President Jack Howard's repeated urging for caution in engaging in matters involving the interfaces of responsibilities between the AEC/ERDA/DOE and the DoD and upon his early retirement from Sandia, I did extensive file research and produced two papers on evolution of the two agreements of 1953 on:

- Development, production and standardization of nuclear weapons (Ref. 3).
- Fuzing of nuclear warheads used on guided missiles and rockets (Ref. 4).

7.6 Initiation of SNL's Computer Code Security Program, 1983-1985

In mid-1983, the Safety Assessment Technologies Division 7233 under Dick Smith began a systems study to examine the state-of-art of computer software codes as regards susceptibility to subversive human actions that could cause the code to produce a malevolent outcome that would effectively bypass the S^2C protection it was intended to provide. A technical staff of four (Ref. 120) was assigned a two-year study that clearly established susceptibility of software through a series of experiments whereby the team, principally James (Jim) Gosler, consistently "cracked" security codes in use in military and commercial endeavors, especially copy protection routines. Also, Jim Gosler wrote a code that he advertised to contain a malevolent routine, presented the code to adversary simulation teams to find the routine, and monitored the unsuccessful efforts at detection. When be demonstrated the malevolent action during a briefing of SNL's Small Staff (arranged by Vice President 7000 Bob Peurifoy), the issue of whether or not computer software could be relied upon at a very high degree of confidence as a nuclear detonation safety or use-control device by SNL seemed moot.

> NOTE: After my retirement in September 1985, I became aware of the continued evolution of SNL's subversive code work and that technological agencies of the military services, the DoD, and other federal intelligence/security agencies joined to make a national capability in this area.

7.7 Conduct of Deliberate, Unauthorized Launch Studies for U.S. Army Nuclear Weapon Systems, 1984-1985

Please refer to SAND99-0847.

> NOTE: In review of documentation on DUL in the Nuclear Safety Information Center (NSIC) vault, I learned that much of the files had been transferred out to "Jim Gosler's organization." I hope that all historically important documents about S^2C can be indexed in the Nuclear Safety Information Center (NSIC), even if held elsewhere.

7.8 President's Blue Ribbon Task Group (BRTG) on Nuclear Weapons Program Management, 1985

In effect, the subject study was the second update of the Transfer Study of 1975-76, the first update being the *Starbird Study* of 1980. The BRTG's final report (Ref. 122) reaffirmed the earlier studies' recommendations not to transfer any responsibilities from the DOE to the DoD and to continue the dual agency judgment and responsibilities for nuclear weapons S^2C. Figure 22 is a list of participants in the study.

I was tasked to support Sandia's member of the Executive Secretariat of the BRTG,[48] Vice President 7000 Bob Peurifoy. One of my contributions was a paper outlining the level-of-effort funding management practice of the AEC/ERDA/DOE for the nuclear weapons complex (Ref. 123). This paper was an update of one I prepared in 1980 (Ref. 95) for the *Starbird Study* (Ref. 92).

Another of my contributions was to draft a background paper on nuclear weapon system S^2C, in collaboration with Major Michael (Mike) Saunders, USAF, of the Executive Secretariat. I had known Mike Saunders for several years; he was earlier assigned to the Directorate of Nuclear Safety at Kirtland AFB. This paper, a nine-page narrative on S^2C with annexes on definitions of terms and recent initiatives, became Volume IV of the Report of the Executive Secretariat (Reference 124) and a basis for Appendix 1 of the BRTG's report (Reference 122).

The task group devoted one of its nine conclusions and recommendations to S^2C, as follows:

1. The President might consider issuing a directive reaffirming the DoD/DOE dual-agency (checks and balances) responsibilities for nuclear weapon safety, security, and control.

In arriving at this recommendation, the task group used a case study on the Stockpile Improvement Program (SIP) (Ref. 87, written by Dick. Brodie) as a vehicle to examine the recent effectiveness of the dual-agency working arrangements for S^2C contained in the Saunders/Stevens paper. In brief, the task group was distressed by the observation that implementation of the SIP had taken over five years and made a recommendation to strengthen high-level oversight of S^2C via a new Presidential directive.

48 The Executive Secretariat was chaired by Ted Gold.

TASK GROUP MEMBERS

WILLIAM P. CLARK, JR., Chairman
Lawyer, Rogers and Wells
Former Secretary of the Interior
Former Assistant to the President for National Security Affairs
Former Deputy Secretary of State

JAMES R. SCHLESINGER, Vice Chairman
Executive Board Member and Counselor, Georgetown University
Center for the Strategic and International Studies
Former Secretary of Energy
Former Secretary of Defense
Former Chairman of the Atomic Energy Commission
Former Deputy Director of the Bureau of the Budget

HAROLD M. AGNEW
Former President of GA Technologies Inc.
Former Director of Los Alamos National Laboratory

ALAN C. FURTH
Vice Chairman and Director, Santa Fe Southern Pacific Corp
Chairman and Director. Federal Reserve Bank of San Francisco

JEANE J. KIRKPATRICK
Senior Fellow, American Enterprise Institute
Former Ambassador to the United Nations

FREDERICK J. KROESEN
General, US Army, Retired
Former Commander in Chief, US Army, Europe

WILLIAM J. PERRY
Managing Partner, H&Q Technology Partners
Former Under Secretary of Defense for Research and Engineering

Figure 22 Principal Participants for the President's Blue Ribbon Task Group

7.9 Formation of the Nuclear Weapon Council, 1987

Although the recommendation of the Blue Ribbon Task Group for a Presidential Directive was not implemented, the following recommendation was:

> "The Military Liaison Committee should be altered in both mission and membership. It should become a senior-level DOD/DOE group to coordinate nuclear weapon acquisition and related matters, and to oversee joint activities."

The Nuclear Weapon Council created in early 1987 by Public Law 99-661 replaced the MLC. One responsibility was to "... consider safety ... issues for existing weapons and for proposed new weapon starts." The three members were:

1. Director, Defense Research and Engineering (DDR&E), Chair.
2. Vice Chairman, Joint Chiefs of Staff (JCS).
3. Senior DOE Representative appointed by Secretary of Energy.

For most of the first 3 ½ years of operation of the NWC, the position of DOE Assistant Secretary, Defense Programs (ASDP, DP-2), which is at the level that requires confirmation by the U.S. Senate, was not filled. Instead, on-roll members of the Defense Programs staff were assigned as Acting ASDP. This situation did not escape critical notice by the Drell Panel in its review of a nuclear safety program in 1990. As developed later, the role played by Acting ASDP Troy Wade II (August 1987 to June 1989) in the W69/SRAM-A episode is especially noteworthy.

On October 19, 1990, the Senate confirmed appointment of Richard A. Claytor (Captain, US Navy, Retired), and he became the first full-fledged DOE representative, at the level of DOE/ASDP (DP-2).

7.10 Safety Treatise and Safety Evolution Papers, 1985-1987

In anticipation of my retirement and to provide a source data for a treatise on a classified nuclear weapon safety to be written by Dick Brodie upon commission from the S^{2}C Committee, I drafted papers[49] on the following subjects:

1. Structure and staffing of the national nuclear weapon and weapon system safety program (Ref. 126). This is an update and expansion of a paper prepared for the *Starbird Study* in 1980 (Ref. 91).

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[49] Although written in 1984-85, these papers were not typed and published until 1988. They became references for the Dick Brodie's treatise and the studies described on the next page.

2. Summary of presidential and other high-level directives and correspondence on nuclear weapon system safety and control (Ref. 127). This paper is related to Reference 91 also.
3. Design philosophies and practices for nuclear weapon safety (Ref. 128). This is an expansion of a paper prepared for DOE/DMA's briefing package on nuclear safety in early 1981 (Ref. 101)
4. Quantitative standards for nuclear weapon safety in design (Ref. 129). This is an expansion of a paper prepared for DOE/DP's S^2C Committee in 1984.
5. Summary of accidents and significant incidents involving U.S. nuclear weapons (Ref. 130).

Additionally, at the request of Vice President 7000 Bob Peurifoy, I drafted two papers on the evolution of nuclear safety, Ref. 2 for 1950s and 1960s and Ref. 40 for the 1970s and 1980s (through 1985). These papers were classified CFRD as collections; however, I intended and believed that each subsection was unclassified and since have had both papers declassified.

7.11 Dick Brodie's Treatise on Nuclear Weapon Safety Program, 1987

In 1987, Dick Brodie prepared a report (Ref. 131) that reviewed the U.S. nuclear weapon safety program from 1945 to 1986, sponsored by Orval Jones as SNL's member of the DOE's S^2C Committee. The report treats nuclear detonation safety and plutonium dispersal safety, but neither use control nor security concerns. In my opinion, it gives the best possible overview of the subject and should be widely used in the national nuclear weapons community. There were 111 copies distributed externally and 129 internally. The report contains no references (that not being Dick's style). This situation led me years later as a consultant to undertake a project to improve access to appropriate references that I had collected while on-roll and were (or should have been) contained in the Nuclear Safety Information Center, as discussed later.

7.12 Sandia's Policy Statement and Plan for Nuclear Weapon Safety Assurance, 1987-1993

In mid-1987, Vice President of Technical Support 7000 Bob Peurifoy commissioned a committee of seven department managers of varied technical interests under director Herm Mauney to conduct a six-month review of Sandia's nuclear safety processes and to recommend modifications that should be considered. The committee was tasked to focus on the validation (certification?) aspects of the process. I was not involved in any direct way, being at the time inactive as a consultant, so this account is based on review of the documents referenced. I am pleased to note, however, that the source data documents that I had drafted several years earlier (page 156) were included as referenced in the committee's report (Ref. 163). This was precisely the utility of these documents that motivated me to draft them.

In my view, the most important recommendation was articulation, adoption, and implementation of an SNL policy statement for nuclear detonation safety. The proposed policy statement (April 1988) was promulgated essentially as proposed and published in October 1990 under the signature of Sandia President Al Narath in the document entitled "*Weapon Nuclear Safety Assurance Plan for Sandia National Laboratories.*" The policy statement is reproduced as Figure 23. The bulk of this effort was conducted under President Irwin Welber and endorsed by Narath following his becoming President in early 1989. This widely distributed document (Ref. 164) that contained descriptions of every area of responsibility in the process, was issued under the caption "Reviewed and Approved: A. Narath, President Sandia National Laboratories." A current version at this writing is Ref. 165.

7.13 DOE/DP's Nuclear Weapon Safety Management Process Review (The "Moe Panel" Study), 1988

Before my retirement in September 1985, I had taken note of emerging conflicts on policy and practices on nuclear safety and accident response matters within the DOE Headquarters organizations involved in the nuclear weapon safety process, principally in the Safety, Environment and Emergency Actions Division under the Director of Military Application. (See page 42 of Ref. 126 for organization.) Until the early 1970s, the office was at the lower "branch" level and was concerned mainly with the processing of nuclear safety rules. The staff was headed by an 0-6-level officer of a military service on active duty and staffed with an 0-4 to 0-5-level officer from each of the military services, plus a civilian who had retired in-place from military duty.

After the Rocky Flats fire in 1969, the branch was elevated to be "division" and the two functions of environmental safety and health and of emergency response were added to make a total of three branches. Civil service employees drawn from within the DOE and added over the years tended to favor the safety philosophies used in their earlier assignments and attempted to apply them directly to nuclear weapon safety. One such person, Theodore (Ted) Dobry, came from the aerospace nuclear safety program (with its focus plutonium dispersal safety) and was especially vocal in pushing for use of nuclear fuel cycle safety philosophies in nuclear weapon safety, including Probabilistic Risk Assessments. Concurrently, the emergency action response mission began to dominate the attention of the division with the advent of the Emergency Operations Center located in the basement of the headquarters building and the scheduling and planning of large-scale field exercises of the Accident Response Group and the Nuclear Emergency Search Team.

> NOTE: Ted Dobry's safety philosophy was well-known to some Sandians, especially to Bob Luna, from his involvement in the AEC staff assigned to the Aerospace Nuclear Safety Program.

Sandia National Laboratories Policy Statement for Weapon Nuclear Safety Assurance

Weapon nuclear safety is a joint and shared responsibility of the Department of Energy (DOE) and the Department of Defense (DoD).* In support of this DOE responsibility, it is the policy of Sandia National Laboratories that

Weapon nuclear safety has first priority in the design, development, production, stockpile maintenance, and evaluation of all nuclear weapons.

Military Characteristics that express national nuclear safety requirements will be met in the combined engineering judgement of the Laboratories.

Weapon nuclear safety is designed into nuclear weapons on a first-principle basis, utilizing independent safety subsystems in which the design is engineered to provide safety in a predictable manner when subjected to normal and abnormal environments.

The assigned Weapon Development Directorate is responsible for assuring that this policy is implemented.

The Systems Evaluation Directorate is responsible for performing detailed independent assessments of each weapon and reporting its findings.

The Executive Vice-President responsible for a weapon program is accountable for reviewing and approving the nuclear safety design theme of the Sandia-designed portion of the weapon, and for its implementation, at key points, throughout the development process; and, along with the Executive Vice-President responsible for nuclear safety assessments, for advising the President of Sandia National Laboratories of their concurrence regarding the adequacy of weapon nuclear safety for each new system and, periodically, for existing systems.

All assigned nuclear safety responsibilities in support of full-scale testing shall be conducted with comparable care, consistency, and review as given nuclear safety in a weapon development program. The Executive Vice-President responsible for Radiation Effects and Testing is accountable for reviewing and approving the nuclear safety design theme of the Sandia-furnished Arming and Firing System/Subsystem.

All participation in external independent nuclear safety review processes, e.g., Nuclear Weapon System Safety Group and Nuclear Explosive Safety Study/Survey activities, shall be conducted with the same care and consistency given nuclear safety design in a weapon development program, and the results shall be reviewed periodically with the Executive Vice-Presidents and the President of Sandia National Laboratories.

All Sandia National Laboratories nuclear safety activities shall be conducted and documented in a manner that is amenable to external audit.

A. Narath, President
Sandia National Laboratories

* Memorandum of Understanding (MOU) Between the Department of Defense (DoD) and the Department of Energy (DOE) on Objectives and Responsibilities for Joint Nuclear Weapon Activities," dated January 17, 1983, signed by Secretary of Defense C. Weinberger and Secretary of Energy D. P. Hodel.

Figure 23. Sandia National Laboratories Policy Statement for Weapon Nuclear Safety Assurance

By the mid-1980s, the SE&EA Division was attempting to revise the DOE's procedural manual chapter for nuclear safety and Ted Dobry was insisting on converting the process to suit his personal preferences. Apparently, he was alleging that the existing procedures were inadequate, in the mode of a "whistle blowing" campaign internal to the division. The report on NASA's Challenger Accident provided a convenient impetus (or a politically correct excuse) for him to hope that a management review of the DOE's safety management process would resolve the matter in his favor. A study group was formed under contract with Pacific Sierra Research, Inc., to be led by one of its senior officers, Gordon Moe. Members of the group are listed in Figure 24.

As part of my tasking as consultant to Vice President of Technical Support 7000 Bob Peurifoy, who served as the Technical Advisor to the Moe Panel, I drafted a strawman set of discussion topics for the study group (Ref. 132). Gordon Moe remarked later that the paper had been useful in sharpening the focus of the group as it prepared its briefing aids. I don't know if the group issued a formal report, but I do know that Gordon gave a series of briefings on the results throughout the DOE complex.

> NOTE: In my draft working paper for the Moe Panel Study (Ref. 132), I discussed these matters and suggested: "Effectiveness of the NWC can be significantly enhanced by assuring that it will have a Standing Committee on S^2C and that the DOE's ADWPS nuclear safety principle be an observer at meetings of that committee." The Moe Panel went even deeper with #2 below.

According to the Drell Panel Report of 1990 (discussed later), the principal recommendation of the Moe Panel in July 1988 may be summarized as follows:

1. Emphasize responsibility of DOE line management for nuclear weapon safety and strengthen its ability to carry out this responsibility.
2. Provide active top-level DOE leadership on safety issues. Particular steps to implement this leadership include assuming chairmanship of the NWC when considering safety issues and creating a Nuclear Weapon Council Weapons Safety Committee (NWCWSC) to be chaired by the DOE's Deputy Assistant Secretary for Military Applications (DASMA).
3. Ensure a broad, balanced review and analysis of safety issues with substantive issues being elevated to the NWC and with the Secretaries of DoD and DOE being kept fully informed.

[redacted] OFFICIAL USE ONLY

DOE NWSRG	GROUP MEMBERSHIP

REVIEW GROUP MEMBERS - WIDE EXPERIENCE

GORDON O. MOE, CHAIRMAN
THOMAS R. CLARK
RICHARD N. CODY
EUGENE H. EYSTER
GERALD W. JOHNSON
PHILIP A. ODEEN
HOWARD T. STUMP, ADVISER TO CHAIRMAN

SANDIA NATIONAL LABORATORIES TECHNICAL ADVISER

ROBERT L. PEURIFOY
WILLIAM L. STEVENS (CONSULTANT)

DOE/DASMA EXECUTIVE SECRETARY

RICHARD N. BRODIE
ERIC K. MATSON

PSR STAFF SUPPORT

WILLIAM W. CARTER
J. J. KELLY
JUDY HAMILTON

Figure 24. Principal Study Participants, "Moe Study"

[redacted] OFFICIAL USE ONLY

7.14 The Internal Review of Sandia's Practices for Raising Nuclear Safety Concerns, 1989

On March 1, 1989, Vice President Technical Support 7000 Bob Peurifoy arranged for a board of inquiry drawn from Sandia's legal staff to determine whether or not Sandia had adequately made known its nuclear safety concerns over the years to appropriate federal government officials. The briefing package prepared by Nuclear Safety Department Manager Jim Ney used three nuclear weapons to typify three eras of weapon development: (1) Pre-1968, by the B28FI; (2) Interim Period, by the W69, and (3) Modern, by the W80—all three weapons deployable with the B-52 (Ref. 135). This effort, a.k.a. "The Murder Board," in my interpretation of the documentation since I was not involved, is affirmation that Sandia had discharged its formal obligations (technical support and assistance) fully and fairly in making known its concerns and, additionally, had performed special "out-of-channel actions" to bring safety-related concerns to the attention of high government officials (Ref. 136). The latter cited especially the Annual Nuclear Weapons Surety Report to the President as an example.

7.15 The W69/SRAM-A Episode—My "Real They" Story, 1988-1990

> <u>NOTE:</u> Of course, I realize that the events related here are subject to more than one interpretation and that I may not even have all of the story. Nevertheless, this version serves to illustrate some aspects that might escape notice in a less opinionated treatment, including the roles of deep personal commitment to a belief, perseverance, knowing how the "system" really works, and the value of serendipity plus a leak to the media.

Figure 25 is a timeline summary of safety-related events for the W69/SRAM-A, taken from Ref. 135.

After noting a lack of response by the nuclear weapons community to addressing nuclear safety of the W69/SRAM-A weapon system, Sandia Vice President Bob Peurifoy by letter of February 26, 1988, invited the DOE Assistant Secretary of Defense Programs (ASDP, Acting), Troy E. Wade II to arrange for the Nuclear Weapon Council to visit Sandia for a briefing on concerns about the safety of older weapons in the stockpile. There was no reply.

On March 15, 1988, Sandia President Irwin Welber met with DOE Undersecretary of Energy, Joseph F. Salgado, and raised the safety concern as one of three issues. Salgado commented that he agreed with the seriousness of the concern and that both the Secretary of Energy and Secretary of Defense should have been briefed on the matter. He identified ASDP Acting Troy Wade as the appropriate action person. There followed in 1988 an exchange of correspondence between DOE/ASDP Troy Wade and DoD/ATSD(AE) Robert G. (Bob) Barker that in retrospective examination I must characterize as evasive actions.

[redacted] OFFICIAL USE ONLY

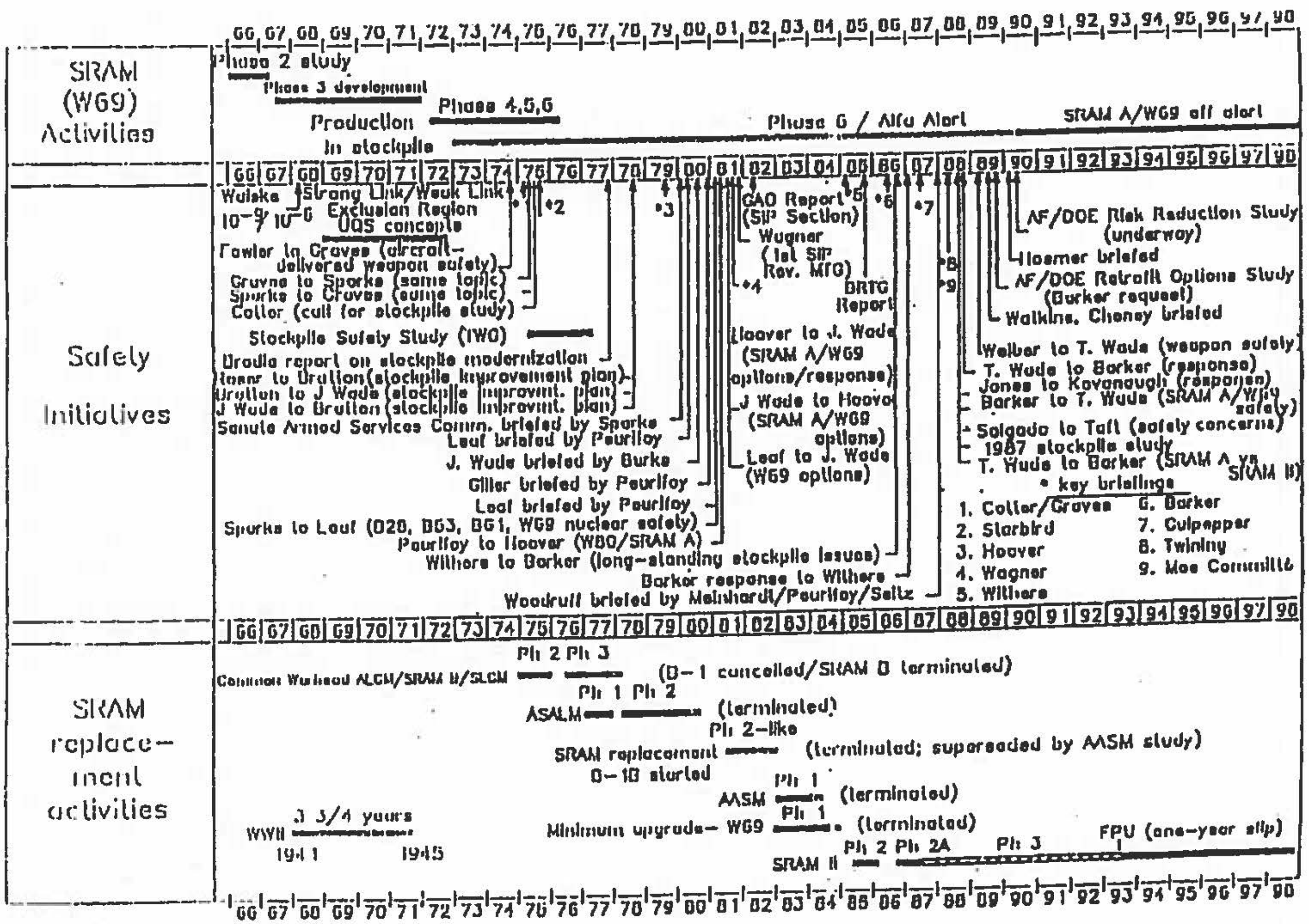

Figure 25. Timeline of Safety-Related Events, SRAM/W69

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In mid-1988, the seemingly unrelated (at least loosely related) internal review of management practices for the nuclear safety program under the cognizance of the DOE/Deputy Assistant Secretary for Military Application (DASMA) began. The study was led by Gordon Moe, a senior officer of Pacific Sierra Research, Inc., a contractor to DASMA for the study. As the study progressed, the issue of the W69/SRAM-A loomed more and more important in providing a definitive case for examining the overall program management weaknesses that became the essence of the Moe Panel's findings, discussed in this report in an earlier section. The result of the Moe Panel Study that bears most directly on the W69/SRAM-A is the following concluding thought:

> "Attention to safety has waned, and we still have risks from weapons that will remain in the stockpile for years. The potential for a nuclear weapon accident will remain unacceptably high until the issues that have been raised are resolved. It would be hard to overstate the consequences that a serious accident could have for national security."

One of Sandia President Irwin Welber's final acts (before Al Narath would return to Sandia from BTL to become the President on April 1, 1989) was to sign a letter expressing Sandia's continuing concern about the failure of the national nuclear weapons community to adequately address the remaining principal nuclear safety deficiencies in the national defense forces. At this time, the W69/SRAM-A issue was some 15 years old and had been active over Welber's three-year tenure at Sandia. Welber's letter, however, was addressed to the relatively low-level official in DOE weapon program management, Troy Wade II, the Acting Assistant Secretary Defense Programs. The draft letter presented to Welber was to be addressed to a higher appropriate level, the Undersecretary of Energy, but Welber elected to soften the wording and lower the level—with the rationale that maintenance of good relationships with the immediate reporting level, ASDP, would be enhanced this way. Welber's letter was not answered.

The next set of events in this episode was one of serendipity. Senator John Glenn (D-OH) was in New Mexico campaigning for re-election of Senator Jeff Bingaman (D-NM) and the two plus some staff were given a half-day set of briefings at Sandia on April 26, 1989. Senator Glenn reportedly became interested in the thrust of Bob Peurifoy's briefing on weapon safety and asked if newly appointed Secretary of Energy James (Jim) D Watkins, U.S. Navy Admiral, Retired, had been briefed. Senator Glenn remarked that he was soon to be with Admiral Watkins for a visit to the DOE's Savannah River Plant and would take up the issue. This upcoming event, of course, broke the tacit barriers to information flow in the DOE and DoD that the Wade-Barker faction seemed to have arranged. Gordon Moe was rehired under contract to brief Secretary Watkins and Secretary of Defense Richard (Dick) Cheney of the new administration team

> <u>NOTE:</u> My information is that Gordon Moe specified that Bob Peurifoy must be present at the briefing. At the time, Peurifoy was on vacation in Texas and was called to attend. His boss, Executive Vice President Lee Bray, declined to approve the travel advance and President Al Narath wanted Peurifoy to attend a Sandia Small Staff meeting that day. Peurifoy notified Moe of inability to attend.

[redacted]

After some discussions, President Al Narath approved the travel and Peurifoy attended.

In the fall of 1989, the Nuclear Weapon Council Weapon Safety Committee was formed to bring safety issues before the parent NWC. The NWCWSC commissioned two safety studies: transportation of nuclear weapons and deployment of the W69/SRAM-A. By the charters written by Co-Chairman DoD/ATSD(AE) Bob Barker, these studies had to be quantitative in nature, with requirements to estimate specific probabilities of risk—in contrast to the qualitative judgments that had been rendered in a minority opinion by the DOE member of the joint DoD/DOE nuclear weapon system safety study group to the effect that the weapon system did not meet established standards for safety (Ref. 175). In practice, study methodology for the W69/SRAM-A was an application of the fault tree analysis technique developed by the Boeing Company for the U.S. Air Force (pages 73 and 74), and major parts of the studies were performed by Probability Risk Assessment staff specialists at Sandia.

During the routine process in 1989 of preparing Sandia's input to DOE/DASMA for the DOE/DoD Annual Report to the President on Nuclear Surety for 1988, Sandia staff member participants encountered a wall of resistance to incorporating the W69/SRAM-A issue into the report, the opposition coming from the junior officers of the military services assigned to the staff of DoD/ATSD(AE) Bob Barker and of DOE/DASMA Troy Wade II.

In the spring of 1990, the routine process of testimonies by DOE Undersecretary of Energy and the three nuclear weapons laboratories' directors to the U.S. House of Representatives and Senate committees and panels on armed services (involved with funding for the nuclear weapons program) featured questions on W69/SRAM-A safety addressed directly to laboratory directors. Responses of LLNL's Roger Batzel, LANL's Sig Heckler and SNL's Al Narath indicated concern, with the strongest expression by LLNL.

Several days later on May 25, 1990, R. Jeffrey (Jeff) Smith, Washington Post Staff Writer, broke the story that the DoD had decided not to remove the SRAM-A weapon system from alert operational status, recounted the testimonies of the laboratory directors, mentioned the Special Safety Study not then complete, and aired DOE/DoD squabbles extant. On June 5, 1990, the House Armed Services Committee, joined by the corresponding committee for the Senate, impaneled three eminent physicists[53] to evaluate the safety issues and provide advice: Dr. Sidney D. Drell of Stanford University, Dr. John S. Foster, Jr., of TRW Corporation, and Dr. Charles H. Townes of University of California, Berkeley. The "Drell Panel" (Sid Drell became Chairman) is discussed in a later section of this report. On June 8, 1990, DoD Secretary Cheney ordered temporary downloading of the SRAM-A force, pending outcome of the study in process.

As a result of Gordon Moe's frustrations about his inability to convince certain audiences that Sandia's technical safety arguments on the W69/SRAM-A weapon system were valid and the matter was of serious national concern, Howard Stump and I (as consultants) were tasked in mid-

53. Sid Drell was Deputy Director of the Stanford Linear Accelerator Center; Charlie Townes was a Nobel Laureate; and Johnny Foster headed the Defense Science Board.

June 1990 to provide supplementary examples of incidents and controversies about nuclear safety that had arisen over the years in order to better understand the situation. On a highly expedited and abbreviated basis, I drafted a document (Ref. 133) that summarized notable past disagreements in the nuclear safety arena between Sandia's technical position and the position of agencies of the military services. Almost as an afterthought, I added Part C as a possible explanation as to why wide divergences in assessments of safety risks can occur among otherwise objective and qualified persons when presented with the same input data. I was told that Gordon was appreciative of this document. I know that he renewed efforts to present the case.

In July 1990, the formal report of the Joint DoD/DOE SRAM-A Safety Study was issued. It, in essence, affirmed quantitatively the earlier quantitative minority opinion finding of the Nuclear Weapon System Safety Study Group that nuclear safety was inadequate.

On December 9, 1990, Secretary of Defense Dick Cheney made permanent the temporary ban on peacetime loading of the SRAM-A for strategic aircraft on alert that he had issued in June. The final report of the Drell Panel released on December 18, 1990, acknowledged Cheney's action.

> NOTE: The prevalent notion that somehow the DOE weapons laboratories' directors triggered resolution of the issue is in my opinion nonsensical. In fact, anecdotal accounts suggest that they were considered themselves "caught cold" and that Al Narath later claimed that he was "blindsided."
>
> In my opinion, the W69/SRAM-A episode was resolved only at considerable personal costs. Gordon Moe's zeal in advancing the argument to stand down the weapon system apparently drew displeasure among the military and military-contract oriented. This was a mainstream business of Pacific Sierra Research, Inc., where Moe was Vice President for its Washington, DC, office. Gordon left the firm and entered post-graduate work at Boston University, obtaining a MS in the artificial intelligence field. After two more years working in that field, he rejoined Pacific Research as a staff member and is there today.

7.16 The Panel on Nuclear Weapons Safety of the House Armed Services Committee: The "Drell" Panel, 1990

Summarization of the report of the "Drell Panel" is beyond the scope of this report; however, some observations are considered relevant:

1. The 49-page report (Ref. 134) is the first broadly based presentation of the national nuclear weapon safety process in unclassified form easily accessible to the public and thus fills a long-time need. Additionally, the eminence of its authors in the U.S. scientific and governmental arena assured a wide audience because of their findings. A copy of the news release is included here as Appendix I.

2. The issue of the W69/SRAM-A deployment became moot during the study when the Secretary of Defense announced his decision to remove the weapon system from alert status on bombers of the Strategic Air Force. Speculatively, this would have been a recommendation in the report, instead of being noted as an action of the government "to take immediate steps to reduce the risk of unintended, accidental detonations that could result in dispersing plutonium into the environment in potentially dangerous amounts or even generate a nuclear yield."

7.17 Creation and Replacement of the Nuclear Weapon Council Weapon Safety Committee (NWCWSC), 1989-1994

Over a year after the Moe Panel study was completed, the recommendation to create the NWCWSC was implemented with the charge to bring safety issues before the parent Nuclear Weapon Council. The two special safety studies commissioned by the NWCWSC were noted earlier in the W69/SRAM-A section.

The NWCWSC was to be co-chaired by DoD/ATSD(AE) and DOE/DASMA(DP20), with members to include flag officers of each of the three military departments and the DOE Weapons Facilities Office, DP-64. Advisors/observers included the DoD/Defense Nuclear Agency, DOE/AL, and the three DOE weapons laboratories. Executive Vice President Orval Jones served as the Sandia Technical Advisor, from 1989 until late 1991 when Al Narath reorganized Sandia and created a Directorate-level safety office, as treated in a later section here. During this period, Jim Ney served as Orval Jones' close associate.

The NWCWSC operated for over five years. In early 1994, the parent NWC considered combining its Standing Committee and its Weapon Safety Committee, in the expressed interest of "efficiency" (although the format was to hold two-hour meetings of the NWCWSC once a month). In the opinion of original NWCWSC DOE member, Dr. Richard D. Hahn DP-64, this move would amount to emasculation of the weapon safety function. His internal DOE memorandum dated January 4, 1994, that gave a minority opinion in opposition to combination is contained as Appendix L.

In Dr. Hahn's and my views, the two early issues addressed by the NWCWSC were handled on "party lines," where the potential vote situation for the parent NWCSC was 5-1 DoD over DOE (with co-chair votes, 6-2), with no option for a veto. One of these issues was the W69/SRAM-A discussed in detail earlier here and the other was nuclear weapon transportation. The two issues were examined by special safety studies chartered by the Co-Chairman, DoD/ATSD(AE) Robert B. (Bob) Barker. Dr. Barker specified that Probabilistic Risk Assessment methodologies must be used to obtain quantitative estimates of risk—in direct opposition to DOE's long-standing position that behavior of the weapon system hardware was unpredictable and therefore not amenable to such quantification. The results of the W69/SRAM-A study, discussed in a broader context earlier here, supported the DOE's concerns that safety was inadequate.

NOTE: For the W69/SRAM-A issue, the DoD/ATSD(AE) in 1989-90 essentially controlled the agendas of the high-level S^2C management groups. Bob Barker was Executive Secretary to the NWCSC. He was also co-chair of its Weapon Safety Committee. Barker's former colleague for LLNL's full-scale nuclear testing program, Troy E. Wade II, was then Acting DOE/Assistant Secretary for Defense Programs, a roughly parallel level at DOE.

Review of attendance lists for NWCWSC meetings shows a trend toward lower and lower levels of agency management involvements. Indeed, the modus operandi' essentially became that of "action officer"—a long-standing DoD/Pentagon practice. Sandia's representation was lowered two levels when newly appointed director Richard L. (Dick) Schwoebel replaced Orval Jones and his technical advisor level dropped when Stan Spray replaced Jim Ney as principal support. Neither Schwoebel nor Spray had experience in nuclear safety policy issues. In the latter several years, Sandia representation tended to be handled by a Sandian living in the Washington, D.C. area on a special assignment other than safety. In brief, the NWCWSC did not enjoy consensus as to need at "working levels," being seen as a policy decision imposed by the Secretaries of Defense and Energy.

NOTE: My opinion on this reorganization and ensuing changes is that the S^2C management review process took a turn toward becoming seriously ineffective. The concepts, of independence in view and deep immersion in S^2C technologies became essentially missing at the table, as history tells us will be the trend when S^2C concerns are mixed with and made subordinate to other seemingly urgent and compelling tasks in the overall weapons program. Operator and programmatic dominance was inevitable. Ironically, one of the U.S. Army action officers for the nuclear safety committee activities of the NWC was the same Joe Luger who had been most obtrusive and vehement in his opposition to DOE roles in safety some 15 years earlier (see page 125).

The combination of committees occurred in mid-1994.

7.18 DoD/DOE Joint Policy Statement on Nuclear Weapons Surety, 1991

Several months after resolution of the W69/SRAM-A safety issue, the Secretaries of Defense and Energy that had been directly involved, Dick Cheney and James Watkins, cosigned the joint policy statement on S^2C given below. This statement fulfilled the first half of Recommendation 7 of the Drell Panel: "The Secretaries ... should issue a joint policy directive emphasizing the importance of safety and security dimensions of our nuclear weapon systems in the new post-Cold-War world, and formulating an appropriate strategy for redressing safety concerns in the existing stockpile in a timely manner by combination of retirements, improvements, and development of new weapon systems."

Joint Policy Statement on Nuclear Weapons Surety

The policy of the Department of Defense and Energy is to support the national security of the United States through developing and maintaining an effective nuclear deterrent. Nuclear weapons and nuclear weapon systems require special consideration because of their policy implications and military importance, their destructive power, as well as the potential consequences of an accident or unauthorized act. Therefore, safety, security, control, and effectiveness of nuclear weapons are of paramount importance to the security of the United States.

In developing and maintaining the nuclear deterrent, the Departments of Defense and Energy will jointly preserve the public trust by protecting the public health, safety, and the environment. Therefore, nuclear weapon system safety, security, control, and the effectiveness will continue to be evaluated throughout the entirety of each nuclear weapon system's life cycle. Our Departments remain dedicated to protecting the security of the Nation in a manner consistent with health, safety, and environmental needs.

NBT

Source: Ref. 138.

NOTE: In April 1991, Robert L. (Bob) Peurifoy, Jr., Vice President Facilities 7000, retired (age 60).

7.19 Formation of Sandia's Nuclear Surety Directorate/Center, 1991

In late 1991, less than three years after he returned from years at Bell Telephone Laboratories to become President of SNL, Al Narath decreed a sweeping organizational change that even today remains in place, but appears to have essentially no visible support. This change was to eliminate one of Sandia's six levels of technical supervision—a move that in concept that long had been seen as needed and prudent. Narath, however. apparently personally overruled counsel to eliminate the level of Director that was intermediate between Department and Vice President in the hierarchy of Division, Department, Director, Vice President, Executive Vice President and President. Instead, he eliminated Department Manager.

NOTE: Since 1969, Sandia's program management and financial accounting case system had been built around the role of Department Manager. I devoted several years to the conception and implementation of the case system and knew the details firsthand. Fortunately in my view, the end of the Cold War and

> subsequent cessation of development of new weapons precluded a management disaster that would have seriously endangered the future of Sandia—and perhaps all of the laboratories.

Jim Ney, who had replaced me in 1985 as Manager, Nuclear Safety Department, had his nuclear safety specialization ended when Narath chose an existing Director to head a new organization to be called the Surety Assessment Center 300. In order to continue in safety, Jim was demoted and became a Division Supervisor (renamed Department Manager!). Ph.D. scientist Richard L. (Dick) Schwoebel was assigned to lead the Center, perhaps in recognition of his splendid performance in leading Sandia's investigation of the probable cause of the high-explosive shell premature detonation accident aboard the U.S. Iowa battleship in 1989. Dick had no weapon development or other safety experience, having been a scientist in materials research most of his career.

> NOTE: I was astonished upon observing that the Surety Assessment Center was a flat organization with some 16 departments reporting to the Director. Surely, that defied concepts of span-of-control in technical management.

7.20 "Unfettered" Studies of the Elements of S²C, 1990-1994

Concurrently with the generation of proposals for revising DOE and DoD nuclear S²C standards discussed below, Sandia conducted a set of internal studies on each of the elements of S²C. All were undertaken under Dick Brodie's leadership with this notion of taking an "unfettered" (unrestrained) view of what requirement statements might devolve from a high-level goal. The study encouraged members to do "brainstorming," "innovative" and "out-of-the-box" thinking. To me, the positive results indicate that this was a wise choice. The downward cascading devolution would lead to end-requirements from which the enabling technologies would be identified. The loop would be closed by demonstration that the concepts implemented would meet the requirements. The goal was to make the unintended event (e.g. a nuclear detonation) be "virtually impossible." The first unfettered study was on command and control. It was sponsored by Sandia's Surety Guild and was completed on September 30, 1991. The second such study was on nuclear safety and was completed on October 28, 1992. The third such study on physical security was under way in spring 1993, but I have no further documentation. The final study, to consolidate the three into a single, integrated set of requirements, is outlined in files of Dick Brodie that I obtained only recently (Ref. 125). All studies featured the two-part/combination standard concept that I describe next.

7.21 Proposals for Revisions to DOE and DoD Nuclear Safety Standards, 1990-Date

The events described here for proposing revisions to the governing DOE and DoD standards for the nuclear weapon system safety evaluation processes began in late-1990 in aftermath of the W69/SRAM-A episode described earlier. The dilemma arose over the tradeoffs between the DOE's design-safety features present in a particular nuclear weapon or weapon system and the

DoD's operational deployment configuration that could impose severe environments on the nuclear weapon entities. I was not involved in any way, but became aware that studies had been under way before June 1994 when I became a consultant for Dick Schwoebel, Director of Surety Assessment 300. This account is drawn from files of Dick Brodie and Clyde Layne that I recently obtained and have incorporated into the Nuclear Safety Information Center files.

The reasons to revise standards were identified by Dick Brodie as:

- Military expressed unhappiness that stringent accident prevention and accident mitigation measures, etc., don't contribute to meeting standards.
- Not all undesirable events seem to be addressed in the current standards.
- Interpretation of current standards vary by group and by individuals within a group.
- Systems "passed" by safety groups were later judged to be unacceptable.

He then identified what revised standard should do as:

- Be unambiguous in their meaning and intent.
- Be explainable and understandable to a wide audience (including those inside and outside the weapons surety community).
- Address all undesirable surety events.
- Be reasonably aligned with expectations of those in high decision-making positions.
- Allow consistent and repeatable application.
- Be achievable by existing weapons/weapon systems.

The above was followed by this sentence:

"(Differences between DOE and DoD standards should be based on common sense and be explainable)."

Sometime in 1990, Dick Brodie conceptually formulated a novel and brilliant simplifying notion that promised to resolve the problem areas in nuclear weapon system S^2C. He would replace the existing single-part standards that addressed only prevention of prescribed unintended events (e.g., a nuclear yield) with two-part standards that addressed both prevention and mitigation of severity of the actions that could cause the prescribed unintended event to occur and the event itself in the same way as for the existing standard. He explained the rationale for the two part approach as follows:

- Align the standards as close to the real decision-making process as possible.
- In general, if the decision-making process finds that current design/usage of a weapon/weapon system is acceptable for continued operation, then the evaluation process using the standards should reflect that the weapon/weapon system meets the standards (Note: this may require an "as currently being deployed" or other qualifiers.)

- If a weapon/weapon system is found to be deficient in one part of a standard but has sufficient compensating attributes in the other part to offset the deficiency, then the weapon/weapon system would meet the standard.
- If a weapon/weapon system is found to be deficient in one part of a standard but is found to meet the standard through compensating attributes in the other part, there should be provisions in the implementing directive requiring a plan/program to address the deficiencies. (Note: this provision should be kept completely separate from the evaluation process.)

NOTE: The material in the paragraphs marked by a square above are from visual aids of Dick Brodie dated February 23, 1993.

As has been developed earlier in this report, the most effective ways of influencing conduct of DoD operations has proved to be by fixing corresponding DOE operations (e.g., weapon transportation) and by encouraging DoD to adopt similar measures.

On June 23, 1992, the DOE/Defense Program's S^3C Committee tasked a working group to propose S^3C standards that would apply to DOE orders and then modify them as needed for proposal for those DoD operations considered by joint DOE/DoD agreements. The working group was chaired by the newly created DOE Weapons Safety office at headquarters (DP20.1) and members were appointed for DOE/AL, DOE/NV, DOE/SAN and from the weapons laboratories. Dick Schwoebel was the Sandia member, with direct support from Dick Brodie and Clyde Layne.

By early 1993, two conflicting positions had developed and hardened to the point of becoming irreconcilable by further working group negotiations. DOE/HQ and SNL proposed a version based on two-part standards and implementing guidance. DOE/Field Offices (AL, NV, and SN), LLNL and LANL proposed a version based on single-part standards, each of which must be met (no combination of parts) and on a narrow definition of use control (includes only intended mode use). Furthermore, the DOE/AL member, Ben Corley, and others asserted that the DOE/HQ-SNL proposal "will shut down the (weapons) complex." Both proposals were presented by DOE/HQ for resolution by the S^3C Committee. After inaction, Dick Schwoebel, by a letter dated April 14, 1994, to DOE/DP20.1 Dr. James M. Turner, DoD/DASMA Weapons Surety Office (DP-20-1) proposed re-opening consideration of that proposal. Dick Brodie passed away on March 29, 1994, and Dick Schwoebel retired on October 3, 1995.

NOTE: This experience seems to affirm the observation that I made in May 1985 just prior to retirement that the S^3C Committee was "...devolving from high-level management membership to middle-level representation," leaving a void for the former (Ref. 193).

In 1988, Congress created the Defense Nuclear Facilities Safety Board (DNFSB) to provide oversight external to the DOE for the DOE's defense nuclear facilities (e.g. nuclear materials processing plants such as Savannah River). The impetus was the "increasing number of public health and safety issues that accumulated at aging defense nuclear facilities" especially at Rocky Flats. The DNFSB as an independent organization was placed within the Executive Branch to provide advice and recommendations to the Secretary of Energy and an annual report to the Congress. By summer 1989, the President had nominated and the Senate confirmed five members:

1. John T. Conway (Chairman), engineer and attorney, JCAE Staff ('56-'68), Con. Ed. Co. ('70-'78).
2. John W. Crawford, Jr. (Member), no information on background.
3. Joseph J. DiNunno (Member), engineer, naval nuclear power reactors, AEC, SNAP.
4. J. Eggebberger (Vice Chairman), nuclear reactor and fuel cycle, earthquake engineering.
5. Herbert John Cecil Kouts (Member), nuclear reactor safety research, including AEC and NRC.

Notably, none of the five had any prior involvement in weapon development or production, either conventional or nuclear. "Nuclear safety" experience cited in official bibliographies really meant nuclear reactors or nuclear fuel cycle safety.

By means of Recommendation 93/1 of January 27, 1993, the DNFSB four years later in effect expanded its charter to include "nuclear explosive safety," i.e., by including facilities that assemble, disassemble and test nuclear weapons (notably the Pantex Plant). In particular, the DNFSB focused on the DOE orders for nuclear safety and quality assurance at these facilities, especially DOE Order 5610.10. Apparently, the DNFSB's criterion would be to ensure that operational safety of Pantex would be "commensurate with" that of nuclear materials facilities such as Savannah River. With this event, the attempts over the years within the ERDA/DOE to replace the nuclear weapon systems safety practices described in this report with practices that I attribute to nuclear fuel cycle interests, to include the Nuclear Regulatory Commission and the National Research Council of the National Academy of Science, may have become moot. Time will tell.

7.22 Revisions of DOE Nuclear Explosive Surety Standards, 1995-1996

As I view the record, the DNFSB's Recommendation 93-1 applied pressure to DOE organizations to break the 1993 stalemate on revision of its nuclear safety orders that I have discussed. In July 1995, DOE/AL reissued its AL SD 5610.10&11 to include a version of the two-part surety standards that had been debated before the DOE/DP's S^2C group in 1993. On April 29, 1996, DOE/DP followed with replacement of its orders DOE 5610.10 with DOE 0 452.1 that included two-point surety standards similar (but not identical?) to DOE/AL's. DOE 0 452.1, which contains these standards.

Nuclear Explosive Surety Standards. All DOE nuclear explosive operations shall meet the following qualitative surety standards to prevent unintended nuclear detonation, fissile material dispersal from the pit, or loss of control.

There shall be positive measures to:

1. Minimize the possibility of accidents, inadvertent acts, or authorized activities that could lead to fire, high explosive deflagration, or unintended high explosive detonation.
2. Minimize the possibility of fire, high-explosive deflagration, or high explosive detonation, given accidents or inadvertent acts.
3. Minimize the possibility of deliberate unauthorized acts that could lead to high explosive deflagration or high explosive detonation.
4. Ensure adequate security of nuclear explosives.
5. Minimize the possibility of or delay unauthorized nuclear detonation.

Several observations from these experiences are relevant to this report

1. Brodie's two-part/combination standards concept, in essence, is an expression of the Probabilistic Model/Positive Measures methodology that Dick Smith, Bob Luna; and I developed for the 1973-1977 study of ERDA/AL's nuclear weapon transportation operations (page 105), only without the trappings of probability assignments.
2. The contest to adopt them was abandoned at a relatively low level of Sandia and DOE management. There is no record of Sandia support beyond Director Dick Schwoebel, although Vice President Roger Hagengruber was kept informed of progress and endorsed Brodie's concept.
3. The DOE's orders covering nuclear safety now include standards on all elements of S^2C, but the DoD's standards remain essentially as conceived in 1960.

NOTE: The DOE's fifth standard on plutonium dispersal adopted in 1990 is essentially the one that I had suggested to an AEC study group in 1969 (page 103) and Dick Brodie and I had suggested to Glen Otey for inclusion in DoD standards in 1984 (page 151).

7.23 Nuclear Weapon Safety Files in the Nuclear Safety Information Center, 1993

In mid-1993 as consultant to Glen Otey, I began a project to locate and index the documents on S^2C that I had written or had filed, at the time that the filing system was being converted from the several systems maintained by department secretaries to the centralized Nuclear Safety Information Center conceived by Stan Spray. This effort produced suggestions for cross-indexing such that users can easily find documents that they recall only by some key words, buzz words or pet phrases and to provide enhanced continuity as more and more users retire (Refs. 139

and 140). Additionally, I compiled a list of the documents that I had originated, contributed to, or otherwise considered important in the Nuclear Safety Information Center (NSIC) collection (Ref. 141). Finally, I prepared a memo that listed the documents (13 in number) that I would recommend for persons seeking to better understand the nuclear weapon and weapon system safety discipline and processes (Ref. 142). Dick Brodie's treatise was the first on that list. I later collected the timelines and related graphics on S²C, which I had used over the years, into a single document (Ref. 153).

> <u>NOTE</u>: A few years later, I received a telephone call from someone in the Secretary of Energy's office inquiring if I knew anything about the involvement of the Danish government in the Thule nuclear weapon accident of 1968. I described the Nuclear Safety Information Center (NSIC) files, knowing that there were reports on Thule filed there, and suggested they contact the Nuclear Safety Information Center (NSIC) asset that they in essence owned. Later, I was told that the report needed was quickly identified and acquired in Washington—precluding the need to set in motion an expensive investigation.
>
> I consider the matter of these suggestions as incomplete at this writing.

7.24 Use of Probabilistic Risk Assessment (PRA) Techniques in Nuclear Weapon Safety, 1994

During one of my visits to Sandia for consultation with Glen Otey in mid-1994, a staff member in the Surety Assessment Center 12300 who had worked in my department over a decade earlier expressed concerns about a document on nuclear weapon safety that was being circulated for comments as a draft, with final publication imminent. The document was the report of the Surety 2000 Safety Working Group, some 36 individuals within the DOE (17), SNL (9), LANL (2), LLNL (2), DoD/DNA (1) some other organizations that I didn't recognize (5), and its two principals: Captain U.S. Navy David Olson, DOE/DP-20.1 Chairman; and David Carlson, SNL, assigned to DOE/DP-20.1.

> <u>NOTE:</u> I do not mince words here in order to best express my reaction to the Surety 2000 report (Ref. 143), in the context of the totality of this report. The first draft was another blatant end-run around the S²C assessment process that was evolved at SNL over the years in an attempt to have the author's preference advanced. In this case, the preference was for Probabilistic Risk Assessment techniques used in the nuclear fuel cycle field, to replace the SNL techniques based on first principles, positive measures, etc. The proposal could have resulted in technical direction being imposed on the weapon laboratories by DOE headquarters staff. It would make "defensibility" in "peer" reviews the main thrust of assessments, to replace in part SNL's reliance on "independent" assessments by technical staff deeply immersed in the relevant technologies. There are, of course, other points of view extant on Surety 2000 and the value of PRA that can be accessed in Directorate 12300.

I was insulted by the statement that I knew to be false: "... while probabilistic risk assessment and other techniques for quantitative assessment have been developed and applied for many years in other fields, their application to nuclear weapons is relatively new." With Glen Otey's support, I drafted a set of presentation aids (transparencies) and annotated notes to document the use of quantitative risk assessment techniques in the nuclear weapons program from 1955 to 1985 (my retirement year). I reviewed, but did not address in my presentation aids, the internal SNL decision by SNL President Al Narath in December 1989 to conduct a six-month review of the applicability of PRA to nuclear weapon system safety (Ref. 144) and the reports on that work. I met with Glen Otey, Dave Carlson, and Dick Schwoebel in Glen's office to express my views. Later, I made a presentation using the aids to a staff audience, which included invitee Dave Olson (who by then had retired and was on-roll at SNL) (Ref. 145).

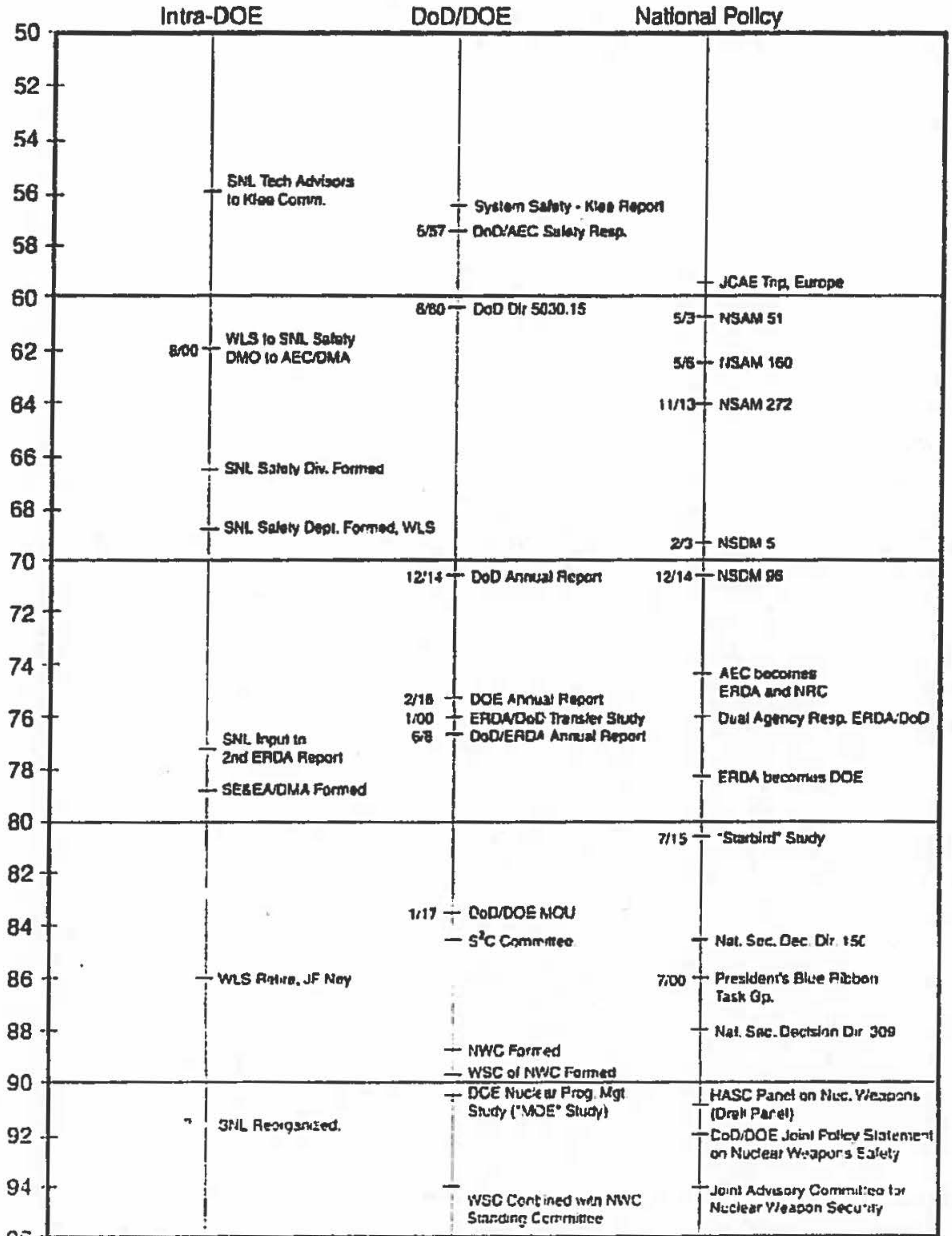
7.25 SNL's Input to the Annual Report to the President on Nuclear Weapon Surety, 1994

In a consultation session with Surety Assessment Center Director Dick Schwoebel, I detected a sense of frustration about the decreasing value of the Annual Surety Report to the President in informing senior governmental officials on the state of S^2C in the national stockpile. The process of coordinating the preparation of SNL's input had become to me an essential way of focusing SNL technical management at least once a year on S^2C issues and of advancing the issues that survived internal review to DOE Headquarters for review, adoption or revision and coordination with the DoD agencies to produce a joint agency report. Jim Ney had continued the process and seems to have made it even more inclusive within Sandia. Figure 26 summarizes evolution of this process.

After review of SNL's correspondence with DOE Headquarters on this subject, I drafted a set of presentation aids (transparencies) and annotated notes to document the history of Sandia's involvements in the annual report from 1976 to 1994. The 33-page document is Ref. 146.

> NOTE: I had made the annual report process a personal crusade to involve SNL management in S^2C by drafting the initial input and circulating it within SNL, DOE/AL and DOE/OMA, with iterative drafts and cover letters that addressed the comments received. When I took stock of the success of this venture (Ref. 150), I treated it as a failure, except for interest and involvement on the part of a few: Bill Myre, Bob Peurifoy and Orval Jones at SNLA and Don Gregson at SNLL.

Another initiative was to make quadrennial reports in years coincidental with Presidential elections be a melded (inter-labs and DoD/DOE) statement. It failed due to lack of support. It could have become counterproductive, at the DOE/DOE action officer level anyhow. Former influential member of the Air Force's Directorate of Nuclear Safety at Kirtland AFB and an acquaintance of mine, Colonel Jim Greening, then at ATSD(AE), saw our draft as a "big brother" approach. I suggested that the 1988 annual report could reinstitute this approach if it, by then, could have S^2C Committee support



Source: Ref. 146.

Figure 26. Time-Line for Evolution of the Annual Report to the President on Nuclear Weapons Surety

7.26 The Drell/Peurifoy Paper on Technical Issues of a Nuclear Test Ban, 1994

Just as the Drell Panel Report of 1990 (Ref. 134) effectively described the national process for nuclear safety, the Drell/Peurifoy paper of 1994 (Ref. 147) describes the technical aspects of nuclear weapon safety, reliability and verification in the context of proposals for a comprehensive ban on nuclear weapon testing. I was honored to review in late draft the sections on nuclear safety and note that my summary of nuclear weapons accidents was included as Table I.

I will not speculate or comment on the impact that the paper has had already in national-level debates and Presidential decisions on nuclear testing—or may have in the upcoming debates on a Comprehensive Test Ban Treaty. History may record that the paper was the cornerstone of evolution of the concept of "stockpile stewardship" that became the justification for support of the national nuclear weapons program after the Cold War. I believe this will happen.

7.27 Sandia's Surety Heritage Report, 1995-1997

I learned about this project to conduct two-hour interviews with 17 "senior statesmen and current surety leaders" with the goal "to understand the essential element of Sandia's surety heritage and its implications for future surety programs" almost by accident. In late 1995, Bob Peurifoy agreed to participate in this project that apparently had been initiated by Dr. Laura R. Gilliom, who had been assigned program management and funding functions for surety-related work at Sandia. After being interviewed and responding to a set of structural questions, Bob apparently suggested that I be included in the list of interviewees and so informed Laura. That inclusion didn't happen. By mid-1996, I had extended my consultant arrangement at Sandia to have periodic liaison sessions with William C. (Bill) Nickell, the recently appointed Director of the Surety Assessment Center 12300. Bill showed me a notice for a seminar to present a synthesis of the findings of the group that had conducted the interviews. Bill was astonished that I had not been contacted and remedied that situation promptly. The seminar was postponed and five interviewees were added to the list—including Jim Ney and me. I was then immersed in the process of reviewing drafts of the Sandia General History book, but took this interview as higher priority—the two projects being somewhat complementary, however.

I provided a handwritten 29-page response to the set of questions and much later had these typed and documented (Ref. 148). I especially enjoyed the exercise of identifying 31 major events and issues in S²C that I believe were most important—and the individuals who were the main contributors.

I was most pleased with the report on the project (Ref. 149), which I received late in 1997 and read as I finished the first draft of this report. I commend all who contributed.

[redacted]

7.28 Review of S^2C Sections of Draft Chapters, Sandia General History Project, 1995-1996

As consultant to Glen Otey, 4100, and Bill Nickell, 12300, I reviewed several versions of drafts of the chapters of the Sandia General History book and provided detailed comments. The comments that bear on S^2C are contained in References 154 through 157. Additionally, I drafted two lengthy volumes on overall SNL history that contain sections on all three elements of S^2C: Reference 151 covering 1956-65 under the title of *Developing the National Nuclear Weapon Stockpile*, and Reference 152 covering 1996-70 under the title *The Level-of-Effort Years*. Almost all of the information on S^2C in these two documents is also included as text in this report under specific topical headings. Also for the history project, I collected the unclassified timelines that I could locate on S^2C and some R&D management topics in one volume, Reference 153, filed in the Nuclear Safety Information Center (NSIC).

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APPENDIX A

MAY 5 1958

Mr. K. F. Hertford, Manager
Albuquerque Operations Office
P. O. Box 5400
Albuquerque, New Mexico

Re: Safety Analysis of Weapon Systems with Sealed-Pit Warheads.

References: 1. SRD Memo, Hertford to McRae and Bradbury, dtd 3/10/58, Sym: ALP:ABW, Q-74802, Same Subject.

2. SRD Memo, Schomburg, OCO, to Manager, ALOO, and Manager, SAN, dtd 2/21/58, Sym: ORDTN, Q-72477, Same Subject.

To preface our remarks on the subject of the above references, we believe some very general comments are in order. Certainly, you are aware of the manner in which the number of safety boards and requests for safety studies have been mushrooming. We trust you are equally aware of the drastic and still increasing work load this situation has imposed on the development organization. We have been striving to provide full support in all areas to insure solid technical inputs in all such deliberations in a maximum attempt to clear the air and prevent a recurrence of the near panic caused by the AFSWP "Klee Report" of last year. We have already passed the point at which this outside support is interfering with our internal studies and work toward increasing weapon safety.

Whether intentional or not, the implication exists that the AEC and specifically the nuclear and engineering laboratories have a lesser interest and a smaller stake in the matter of nuclear weapon safety than have the DOD and its various military agencies. This, of course, is untrue and, in fact, our stake is perhaps larger.

The greatest difficulty in studying the overall safety problem (and this is a problem which can <u>not</u> be attacked piecemeal if we are to arrive at "optimally safe" designs) is that the various segments of the DOD are uncertain as to what incidents and situations they desire most to be protected against. The matter of agreement within the DOD is therefore a lost hope without this prerequisite. The approach of these extra-AEC studies has as a consequence been to pinpoint some specific area of concern and to concentrate on influencing design on that point. There is a very real danger here in that such narrow consideration, if implemented, can hamper safety efforts in more important areas. We sincerely believe the Navy preoccupation at the present time with removability of all or part of an already inert power supply is an excellent example of this fallacy. In this instance we could provide better safety with either or both a "buried goof-proof device" and a "locked" warhead connector while at the same time improving saboteur/psychotic resistance. Providing access into the warhead for power supply removability is contrary to all philosophy for reducing human error probability.

We submit that the greatest service which can be performed by DOD safety boards in their own and the national interests is a thorough and competent analysis of all the operational factors and environments to which weapons are likely to be subjected and then to arrange the potential danger points in order of importance for each warhead. Thus apprised of the overall safety picture as seen by the DOD, the AEC designers can focus full design effort on first things first.

As a corollary, of course, the DOD must also decide what they are willing to pay for increased safety in terms of reliability, flexibility, and operational readiness since we feel certain that the evolution of present designs has already exhausted whatever reservoir of "free" safety it might have at any time existed.

To comment on the particular request of Reference 2, we feel it is highly desirable to have the safety aspects of each particular application deliberated in the respective joint committee and working group functions. As official members of these bodies, we are then in the best position not only to provide sound technical inputs on the warhead installation but also to participate in a thorough safety review of the adaption kit and other DOD contractor supplied weapon system components.

J W McRae
PRESIDENT

CRC/1261/llw

Distribution:
1/9A - K. F. Hertford, Manager, ALOO
2/9A - Brig. General Alfred D. Starbird, DMA
3/9A - H. A. Fidler, Manager, SAN
4/9A - N. E. Bradbury, Director, LASL
5/9A - Edward Teller, Director, UCRL-Livermore
6/9A - R. W. Henderson, 1000; Attn: L. D. Smith, 1260
7/9A - R. E. Poole, 8000
8/9A - R. K. Smeltzer, Central Record File, 7221-3
9/9A - J. W. McRae, 1

APPENDIX B

Not used.

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APPENDIX C

From: A. W. Betts, USAEC, WASHDC

To: S. P. Schwartz, Sandia Corp, Albuquerque, NM
J. S. Foster, LRL, Livermore, CA
N. E. Bradbury, LASL, Los Alamos, NM

Info: K. F. Hertford, USAEC ALOO, Albuquerque, NM
E. C. Shute, USAEC, San Berkeley, CA

DTG 261935Z

FEB 62

Subject: Research & Development Effort on Weapon Command Control

3. In view of the above, I hereby designate the Sandia Corporation as the Primary Agency responsible for research and development on command control devices. I make this choice based on my observation that most of the schemes envisioned involve non-nuclear hardware. I would like LRL and LASL to restrict their activities in this area to approaches that relate directly and intimately to the nuclear system, unless asked for assistance by Sandia Corporation. I assume that any, ideas generated by LRL and LASL would be passed on in conceptual form to Sandia for more detailed investigation.

(Excerpted from SRD TWX)

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APPENDIX D

THE AEROSPACE NUCLEAR SAFETY PROBLEM

C. R. Carlson - 5520

This treatise is intended to aid in probing the total aerospace nuclear safety problem. Emphasis is placed on some of the subjective and non-technical facets, for it is necessary to appreciate that hazards to the program are not simply related to hazards to people. The aerospace nuclear effort cannot afford to be put on the defensive because it is intrinsically expendable. Safety engineering will have to be centrally organized, strong in its self-policing, and aggressive toward remaining above reproach. Otherwise it may not survive.

(Editorial Addition: Dated 3/1/65)

Major responsibility fell to Sandia Corporation during the chaos of passion and prejudice that erupted quite suddenly in 1957 over the safety of nuclear weapons. To some degree this experience was a precedent for the assignment of further safety responsibility in the field of aerospace nuclear devices. It is meet and necessary, then, to examine this precedent experience for axioms, algorithms, parables, and precautions perhaps transferable to the aerospace context.

The most obvious distinction to be made between the aerospace and nuclear weapon problems is that the space missions giving rise to hazards have no fundamental role in self-preservation, no pressing urgency, and no tangible benefits to the overwhelming majority of persons potentially to be "threatened". Unlike the weapon program, vociferous and organized opposition in the name of safety for humanity might here succeed in shutting off the entire nuclear effort. It must be anticipated, therefore, that hazards, if they are to be rationalized, must <u>inherently</u> appear negligible -- at most no larger than those associated with the so-called "acceptable" hazards. For, unjust though it may be, even these "standards" are frequently under fire. Any overt comparison with nuclear weapon hazards is certainly to be avoided; the peril of such an association is too great a risk.

The "number game" of probability determinations continually plagued the weapon safety problem. For engineering decisions hazard probabilities are useful in a relative sense, but proffered as a measure they inevitably become absolute and hence unsupportable and vulnerable to attack. Psychologically, a hazard probability invites a charge as surely as a bullfighter's muleta. As a corollary it <u>never</u> proved useful, in the missionary sense, to make comparisons between weapon safety hazards and the uncertainties of day-to-day living, or to the frequencies and severities of natural disasters. It should be expected that like rationales in the aerospace context would go equally unheeded.

Within the spectrum of conceivable aerospace mishaps, the nature of the radiation hazards created can range from similarity to a weapon accident to complete disparity. In the former category, for example, a very early launch failure that results in submergence and excursion of a reactor payload could closely resemble a one-point weapon detonation. In the disparate category might be put the dispersal, in air or in fresh-water supplies, of large quantities of very active α emitters--kilogram quantities of Pu^{239} as a specific example. (The quantity of α emitters of comparable activities resulting from weapon accidents or even from full scale bursts has usually been a negligible consideration.) Between these extremes hazard comparisons may assume all levels of propriety, being perhaps better where the aerospace source involves reactor fission-product inventories and less clear for isotopic sources.

The geographic aspect of the aerospace problem is recognizably different. Weapon <u>accidents</u> can occur only in areas where weapons are produced, stored, exercised, and transported -- areas where officially the hazards have been accepted. Weapon <u>incidents</u> arising from deliberate, covert, hostile, or psychotic causes are still a matter of serious import, attested to by the elaborate safeguard measures taken by the Government. It must be assumed that this grave concern over radiologically affecting non-consenting populations will not exempt aerospace nuclear adventures. The political realities which culminated in the test ban agreements and which apply as well to the Plowshare program cannot, with consistency, be summarily ignored in any long term aerospace nuclear program.

Technological fixes in the weapon safety problem --premature reliability, the sensing of delivery environment, command and control features, administrative and security measures -- have been simpler to implement and to make understood because a nuclear weapon has tacitly been regarded as benign until it has been detonated. This attitude may successfully be conserved toward aerospace reactors, but isotopic generators aboard aerospace vehicles are clearly another breed. A single news announcement that a quantity of active strontium "equivalent to that produced in a 100-kt fission burst" has been dispersed in the atmosphere is not unlikely to be treated by friend and foe as <u>de facto</u> violation of the spirit if not the letter of the test ban treaty. It is also true that many nations, including nuclear have-nots, are routinely sampling the atmospheric burden of radioactivity. Additional injections of radioactive debris of any sort will be detected and reported. In some quarters it must be expected that such detections will be equated with and announced as bomb burst residue. In consequence a "leaning over backwards" response could hamstring space nuclear projects for years.

Political realities, emotional in their origin, can appear or be created overnight to sweep aside or engulf the most orderly and rational of technological approaches. The number one lesson to be derived from weapon safety experience is to avoid to the greatest extent being placed on the defensive. Fortunately no arm-waving opposition to aerospace nuclear projects appears yet to be developing. It can, however, be triggered by (a) a truly serious misadventure, (b) an exaggerated official concern over a minor accident, (c) too publicized an R&D program emphasizing hazard evaluation and control, or even by (d) an "educational" campaign to allay public fears that have not really yet been expressed.

Among the technical realities to be faced at this stage of the game are the following:

1. Complete re-entry burnup is not so simple an expedient as originally supposed. Further, it can never be as complete as the vaporization within a nuclear fireball. It is inevitable that, should public question arise, this very comparison will be made, and in a context disadvantageous to aerospace programs.

2. For the whole spectrum of post-launch system failures, re-entry heating or, at least, adequate re-entry heating is not a common subsequent environment.

3. For the present, reliability of command and control devices, energy-storage packs -- batteries, explosives, and propellants, and other possible active components and subsystems to perform safety functions cannot be counted upon for very long lifetimes in the space environment.

4. The engineering approach to some form of intact re-entry, particularly for small compact packages like the fuel capsule of an isotopic generator, is a more straightforward program for which there exists a more comprehensive background of experience. The nature of the supporting test program is also more tractable and less sophisticated compared to that for re-entry burnup.

The basic safety problem in any radiological context -- aerospace, weapon, or ground reactor -- lies in the fact that <u>absolute hazard cannot be defined</u>, and is not likely to be defined perhaps for generations. A careful distinction must be made between the source of hazard and the hazard itself. If the source can be contained and controlled, the safety problem is manageable. The fallacy arises in the assumption that a <u>source</u> can be subdivided over a large volume, area, or population and that by this process the <u>hazard</u> can be defined as negligible. In fact, however, losing or intentionally giving up containment and control of the source has no defensible bearing on the definition of hazard. For example, the assumption of uniform dispersal of any source is technically unsupportable, hence the resultant "hazard" becomes as objectionable as an objector chooses to make it. In the aerospace program it is, of course, unavoidable that control of the radioactive source be relinquished in most cases, but it is not so obvious that containment must likewise be given up -- this is a major point in favor of intact re-entry. If containment can be reasonably assured by engineering means, control may in many instances be regained -- for example, by buying back a recovered package. The engineering solutions to containment, not only upon impact but over many years in natural environments, can be sought in the laboratory and in the field rather than in space.

It also seems reasonable to postulate that the safety problem is minimized as the number of persons <u>likely</u> to be affected (not necessarily threatened) is minimized. The burnup approach denies this postulate entirely.

At this point in time it is possible to lay out elaborate technological and scientific programs in quest of aerospace nuclear safety. Any of these possess time scales measured in years. Aerospace nuclear projects, however, are clearly not to be entirely suspended for such periods. A positive first aid program is absolutely necessary until engineering wonder drugs are available. If, in the meantime, voluntary restrictions and prohibitions on questionable aerospace nuclear adventures are not applied from within, where options for later relaxation can be retained, far less sympathetic prohibitions <u>will</u> eventually be placed from without.

If the premises discussed to this point are reasonable, the following gross conclusions follows:

1. Burnup as a solution should not be the only approach to safety.

2. A concrete proposal for engineering solutions to achieve some form of intact re-entry and source containment should be made for isotopic power supplies.

3. A series of voluntary controls on aerospace nuclear projects should be agreed upon within the community and placed in effect until longer term R&D solutions are ready for application.

The rules of restriction and prohibition to be negotiated under 3 above cannot be popular, but they should be a matter of strong mutual self-interest. The following suggestions and discussion might form a portion of the initial inputs.

I. REACTORS

Because, like weapons, power reactors are fundamentally benign before they have gone critical, they are potentially the safest of aerospace nuclear payloads. Incorporating those design features now in existence to facilitate eventual burnup, they should be passed for orbital flights subject to these additional provisos:

a. The reactor control system and all associated command, enabling and actuator mechanisms should incorporate the best fail-safe and premature-resistant technology that experience from the atomic weapon program, or from any other source, can provide.

b. The possibility of a reactor excursion following launch or pre-orbital aborts must be inhibited to the greatest extent possible by reliable, active systems for dismemberment of the core prior to impact. Such systems should respond to both command signals and signals derived from the environment.

c. Until long term reliability of reactor shutdown controls is judged acceptable, an orbital reactor should not be turned on unless an agreed upon minimum life of the orbit is achieved. A possible definition of the minimum life might, for example, be the sum of the expected power-generating life of the core plus ten times the half life of Cs^{137} - a total of something over 300 years.

II. ISOTOPIC GENERATORS

It is unfortunate that these devices are the cheapest and easiest of nuclear power components to apply to aerospace missions. The most useful of the beta and gamma emitters are precisely those isotopes which have been branded world-wide as the killers and maimers of unborn generations. On the other hand the very design nature of the isotopic generators makes them much better suited to intact recovery.

a. Launch of beta and beta-gamma emitters in SNAP generators should be suspended until intact re-entry and containment has been reasonably demonstrated and applied to these systems.

b. Fuel forms for isotopic generators should be changed to highly insoluble compounds for use in intact re-entry containers.

The alpha-emitters pose a difficult problem. A precedent has already been set with the SNAP-9A, but a mishap not yet free of possible consequences has also occurred with this system. Alpha emitters have been near-totally ignored as a weapon fallout hazard; however, the quantities and activities of these materials in SNAP systems insure that they will be quite detectable when injected into the upper atmosphere.

Pu^{238}, in particular, is an order of magnitude or two less a food and water cycle hazard than is Sr^{90}. But, by inference from MPC standards, it is at least two orders of magnitude worse a hazard than Sr^{90} in air. On the other hand, if it could be guarenteed that Pu^{238} particles could be dispersed in sizes much larger than a few microns, its threat to the human body through lung ingestion seems nearly to disappear. Pu^{238} may have to be recognized as the focus for compromise and horse trading. Absolute prudence would place it under the same general restriction as Sr^{90} and Cs^{137}; pragmatism may dictate that more fingers-crossed chances be accepted with Pu^{238} to keep the isotopic generator effort at least partially active. There seem to be some interim measures, like packaging the Pu^{238} in predetermined size (insoluble) particles for dispersal during or immediately after re-entry burnup of the container; this might be considered as one prerequisite to further flights.

III. OTHER SYSTEMS

It may or may not be necessary to negotiate rules for other systems depending upon their time scales and the timeliness of significant progress from safety engineering programs.

ORION

Orion-like vehicles are presently proscribed under the terms of the test ban treaty. Any flight of ORION would require international agreement during which the safety aspects would receive more than sufficient attention.

SLAM

This vehicle will almost certainly be treated as a weapon system for which safety criteria and acceptance standards are likely not to be a responsibility of the aerospace community.

ROVER, NERVA, POODLE, PHOEBUS, etc.

These propulsion systems will require separate treatment appropriate to their mission profiles. Providing neither nuclear powered ground takeoff nor ultimate return to earth are to be considered, the reactor units may be treated under rules similar to reactor power supplies. POODLE is a special case of the isotopic generator. Its geometry may not be well suited to intact re-entry but on the other hand its fuel form may make it difficult to burn up. Clearly, a careful analysis will be required to establish a best safety approach.

LUNAR AND PLANETARY MISSIONS

It seems clear that ingestion hazards of any sort resulting from impact of radioactive sources upon the moon or planets of the solar system will be precluded by the life support systems necessary to later exploration of these bodies. Thus it does not seem necessary to be concerned for safety reasons about extra-terrestrial impact of pure alpha and beta emitters. Gamma sources, however, and this includes fission product inventories of reactor payloads, could indeed constitute a potential radiation hazard to astronauts.

In connection with the proposed priority program for engineering solution of the intact re-entry problem it is suggested that major emphasis be placed on containment of the source during re-entry and impact. To make earth penetration and burial an early goal may be too ambitious. If containment can be achieved it is possible to turn to other than technological means for recovery of control. The United States might, for example, publicize world-wide by every known means a generous bounty offer for return of recovered sources. The emphasis should be placed on the value of these sources rather than the hazard. If the image of a monetary payment as a bounty or ransom rather than as an indemnity can be achieved, instructions and equipment for safe handling and return of source containers can be more successfully and cooperatively disseminated.

An object of this kind of program (and of container design itself) should be to bias in favor of intelligent discovery and thus further to protect uninformed peoples. One might investigate, for example, into psychological choices for shape and appearance of the container that would suggest danger and avoidance to illiterate and superstitious peoples.

It is quite clear that a centralized formulation of policies and criteria, both interim and long term, needs to precede any multi-directional technical program in the field of aerospace nuclear safety. The philosophy outlined in these preliminary suggestions might be paraphrased as one which adopts the general criterion "minimum risk to the program--a more stringent requirement than minimum risk to people." No other approach seem reasonable until the world has learned to live with radioactivity as it has learned to live with alcohol, tobacco, and the automobile.

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APPENDIX E

Dr. Edward Teller
Associate Director
Lawrence Radiation Laboratory
Post Office Box 808
Livermore, California 94551

March 10, 1967

Dear Edward:

Marv Martin's paper of December 22, 1966, points out a need for continuing study for ways of improving the odds against a peacetime nuclear accident, and suggests a solution. I agree with the need for studies such as your SAB committee suggests, and feel that such consideration could lead to several interesting design techniques for future weapons. Since the first formal nuclear safety studies in 1957, much progress has been made in continually expanding protection against peacetime nuclear accidents; first focusing on equipment failure (premature), then human errors, then unusual environments (crashes, etc.), and lately deliberate unauthorized actions (command and control). At each stage, we have been able to understand more of the total environment that nuclear weapons are actually exposed to, and improve safety by improvements in equipment and operational procedures. A study based on today's accumulated knowledge, of the relative cost versus net gain of additional safety features might show that a further significant gain can indeed be made within practical costs to the system.

The basic technical problem today in providing a high level of peacetime nuclear safety centers around the need for quick reaction weapons which can be converted from "perfectly safe" to "perfectly reliable" with a minimum of time and effort by the users. This is done by judicious choice of arming signals to tell the weapon when to convert. In general, these arming signals are generated by phenomena normally encountered only in the actual weapon trajectory, such as acceleration, velocity, or pressure change. Such signals are used to control that end operation most critical to achieving nuclear yield - either the firing of the detonators on inherent one-point safe systems, or the extraction of the safing material on mechanically safed weapons. We traditionally choose two such phenomena per weapon system, and try to design the system around the two resulting signals so that bypassing of these signals by spurious phenomena in any set of conditions is extremely unlikely. This involves putting the devices controlled by those signals as far downstream (toward the critical end operation) as possible, and making these devices as fail-safe as possible. For inherently one-point safe systems, both of the arming signals have been used to prevent operation of the firing system.

Marv has suggested that mechanical safing of nuclear systems (even though one-point safe), using techniques controllable by a coded signal, could be a

[redacted]

significant gain in safety, in that functionally the pit is independent of the electrical firing system. Even if the dets all fired simultaneously through some freak signal, no nuclear yield would result. A similar gain might be practical by other techniques which operate downstream from the detonator. For example, mechanical movement of one det from its proper position (traditional in conventional ordnance) until it received a correct coded signal, might be effective. Having a deliberate asimultaneity time-delay in one det line or an auto-destructor for the secondary, to be removed by the correct coded signal, might be practical. Coded control of modernized versions of the inflight-insertion mechanism (IFI) and the nuclear safing system (ANA), or of any end-operation which is functionally downstream from the detonator systems might give us an improvement in nuclear safety at an acceptable price.

Examination of additional devices for safety enhancement of our warheads should be done carefully and accurately by people qualified to judge both the real hazard and the price of the fix. Perhaps additional protection should be afforded only for the part of the stockpile-to-target sequence where the hazard exists (e.g. silo-based warheads may need protection in transit but not in the silo. The missile would be relieved of the weight and reliability costs of the protective device by adding it to the container instead of the warhead). We have added series components to enhance various kinds of safety to the point where they might conceivably become counter-productive. Marv Martin's argument for a new use for ANA faces an audience pained by recent evidence of the reliability price exacted by current mechanical safing systems. An even worse cost, the actual lowering of the real safety of the weapon, might accrue from a careless quest for a safety. (We could increase danger of lightning-induced full scale premature yield from power entering the warhead through wires for the PAL device).

A coded switch in a nuclear weapon can be either a nuclear safety feature or a command and control feature or both. Mixing nuclear safety requirements and command and control requirements must be carefully studied before using coded switches primarily for nuclear safety reasons. Release of a stockpile for PAL control should not remove necessary safety features.

I urge that committee sponsorship and members be carefully evaluated by both DoD and AEC.

Sincerely,

W. J. Howard

APPENDIX F

Not used.

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APPENDIX G

DEPARTMENT OF DEFENSE
Military Liaison Committee
to the
Atomic Energy Commission
Washington, D.C. 20545

14 Mar 1968

Brigadier General Edward B. Giller
Assistant General Manager for Military Application
U.S. Atomic Energy Commission

Dear Ed:

In an ATSD(AE) letter to DMA/AEC, dated 24 March 1967, the AEC was asked to participate in a DASA sponsored analysis of safety criteria as expressed in Military Characteristics.

Our analysis of safety criteria has been completed and the safety standards for premature probabilities for warheads and bombs are listed in the inclosure. These standards are similar to those proposed by Sandia Corporation to Field Command, DASA, except that the general premature probability requirement for the after launch situation (paragraph b of the warhead MC's) has been made more restrictive. Other specific requirements may be stated for individual weapon systems depending on the operational concept.

The Department of Defense has adopted these standards as a guide for the preparation of Military Characteristics. They will have general application to most weapons but modifications may be required in specific cases; for example, atomic demolition munitions and nuclear artillery projectiles.

We are very much interested in a continuing assessment of how warheads and bombs meet these characteristics, both separately and in conjunction with their associated delivery systems. Therefore, we request that the AEC provide a report to the Design Review and Acceptance Group (DRAAG), covering their analyses and evaluations of the warhead premature probabilities for the situations described in specifically stated MC's, and subsequently publish periodic reassessments with regard to the degree of conformance to the MC's. In addition, we further request that the AEC participate, in keeping with the AEC/DOD Agreement on Project Officers Liaison Procedures, in analogous joint AEC/DOD analyses and evaluations of the premature probabilities of the over-all weapon system (warhead plus the necessary fuzing and firing systems or, as applicable, the bomb-aircraft system).

Based on informal discussion in the field with AEC and Laboratory personnel, it is our understanding that the adoption of the attached standards will not result in any increase in weapon development times or costs.

We appreciate the excellent cooperation and assistance provided by the Albuquerque Operations Office and the Sandia Corporation in the analysis.

Sincerely,

/s/ Carl

CARL WALSKE
Chairman

Inclosure

cc:
ACSFOR
DIR, DASA
ATSD(AE)

STANDARDS FOR WARHEAD AND BOMB PREMATURE PROBABILITY MC PARAGRAPHS

WARHEAD MC's

a. The probability of a premature nuclear detonation of a warhead due to warhead component malfunctions, in a mated or unmated condition, in the absence of any input signals except for specified signals (e.g. monitoring and control), shall not exceed:

(1) Prior to launch, for the normal* storage and operational environments described in the STS, 1 in 10^9 per warhead lifetime.

(2) Prior to launch, for the abnormal** environments described in the STS, 1 in 10^6 per warhead exposure or accident.

b. The probability of a premature nuclear detonation of a warhead due to warhead component malfunctions after launch and prior to the receipt of the final warhead arming signal shall not exceed 1 in 10^4. (This is a generalized, minimum standard which may require amplification when applied to a specific weapon. Additional premature probability criteria may be included for the after launch situation depending on the various degrees of safety required for the specific employment concepts.)

BOMB MC's

a. The probability of a premature nuclear detonation of a bomb due to bomb component malfunctions, in the absence of any input signals except for specified signals (e.g. monitoring and control), shall not exceed:

(1) Prior to receipt of the pre-arm signal, for normal* storage and operational environments described in the STS, 1 in 10^9 per bomb lifetime.

(2) Prior to receipt of the pre-arm signal, for the abnormal** environments described in the STS, 1 in 10^6 per bomb exposure or accident.

b. The probability of a premature nuclear detonation of a bomb due to bomb component malfunctions, after the receipt of the pre-arm signal, which will endanger the delivery aircraft shall not exceed 1 in 10^3. (Other detailed criteria for this operational environment depend upon the specific bomb and its method of employment and therefore must be evaluated for the military characteristics for that particular weapon.)

*<u>Normal</u> environments are those expected logistical and operational environments, as defined in the weapon's stockpile-to-target sequence and military characteristics in which the weapon is required to survive without degradation in operational reliability.

**<u>Abnormal</u> environments are those environments as defined in the weapon's stockpile-to-target sequence and military characteristics in which the weapon is <u>not</u> expected to retain full operational reliability.

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APPENDIX H

DUAL JUDGMENT ROLES IN SAFETY, CONTROL AND SECURITY OF NUCLEAR WEAPONS

H. R. Gustavson
Lawrence Livermore Laboratory

W. L. Stevens
Sandia Laboratories

This paper was prepared on request of the ANS Study Group to provide background for the Management and Funding Alternatives for ERDA Military Application and Restricted Data Functions Study.

In addition to their primary responsibility for maintaining an adequate combat capability, the military forces of the United States have always had a number of other serious concerns, including safety (e.g., the prevention of losses arising from accidents), control (e.g., the ability to apply systems selectively) and security (e.g., the preclusion of loss of capability or equipment by sabotage or theft). For non-nuclear weapons modest shortfalls in any of these desirable capabilities or qualities can often be tolerated because of the limited results which can be attained by the use of one or a few conventional weapons.

For nuclear weapons these concerns for safety, control and security take on totally new dimensions. The individual weapons have such a large destructive potential that the issues of adequate safety, security and control are elevated into issues of national policy. The possibly catastrophic consequences from an unauthorized nuclear detonation have been a matter of national concern since such weapons were first created. This concern is evidenced by the fact that nuclear devices can only be used, even in experimentation, with direct and specific Presidential authorization.

Since 1945 our national defense needs and the nuclear technology available to meet these needs have changed. During this period a set of procedures has been developed and institutionalized to meet the necessities of preserving military effectiveness while precluding unauthorized nuclear events. The heart of this procedure is a system of dual agency judgment wherein DoD and ERDA assume complementary roles to insure that both national goals are met.

The purpose of this paper is to review briefly the history of this interactive process in the context of changing national needs and the growing technical capabilities available to meet these needs. This is done separately for the three areas of concern: safety, control and security. Individually and collectively these reviews indicate that the United States has been well served by the dual judgment mechanism.

<u>General Background</u>

Certain key events have impacted on each of the areas under discussion here and deserve treatment as a backdrop to the separate area discussions which follow. The creation and first use of atomic weapons occurred in 1945. International negotiations immediately began followed shortly by an intense domestic debate on military as contrasted with civilian control. This issue was resolved decisively in favor of civilian control with the creation of the Atomic Energy Commission in 1946. As a part of this act the Military Liaison Committee was established with a chairman whose responsibilities included transmission to the AEC of defense nuclear munitions requirements. In the following year, 1947, the Department of Defense was formally established.

In 1952 the first thermonuclear device was exploded. This and other major technical changes began to appear in the nuclear weapons in the years immediately subsequent. The design of early US nuclear weapons featured nuclear material packaged in the form of a capsule which was not mated to the rest of the weapon system until late in the delivery cycle. By late 1956 the first nuclear weapons of a new design, the "sealed-pit type" wherein the nuclear material and ordnance components are an integral manufactured assembly, were introduced to the stockpile.

During the 1950's there were also changes in the nonweapons area which created a need for and guaranteed ready acceptance of these new technologies. Rocket delivery became a practical reality. National security needs changed and requirements arose to achieve and maintain higher states of readiness. The need for technical inspection and monitoring of nuclear weapons by AEC design teams to assure reliability was reduced. An increasingly large portion of the national weapon stockpile was transferred from AEC to DoD. The size of that stockpile began to grow rapidly in order to support the wide variety of defense needs. By the end of the 1950's nuclear weapons had been widely deployed. Forward basing in Europe and other theaters was an established part of defense posture. Some of these weapons were stationed under US custodianship in position for delivery by allied nation vehicles under bilateral arrangements.

During the 1960's the widespread deployment and the proliferation of ICBM's in high-readiness posture, the NATO Quick Reaction Alert forces, and changes in military planning and altered political perceptions, gave rise to increasing concern with control aspects of nuclear weaponry. A somewhat analogous wave of concern with security has occurred in the 1970's as numerous instances of terrorism and banditry gained worldwide attention.

Safety

While safety has been considered an important issue since the very first device test, the relatively low states of readiness demanded for national security in the early years of nuclear weaponry permitted considerable flexibility in meeting safety requirements. Weapons were stored in a partially disassembled state under AEC custodianship, inspection and monitoring. Conceptually the plans spoke of declaration of war, mobilization including delivery of weapons to the military, and final weapon assembly enroute to target.

The increased states of readiness required for national security and the technical innovations implemented to meet these needs (e.g., the introduction in 1956 of "sealed-pit type" weapons) changed safety issues dramatically. Subsequent changes in military plans and delivery modes rapidly increased the range of environments to which nuclear weapons might be exposed even in peacetime.

As the Strategic Air Command decreased its response time by ground and airborne alert exercises, the rate of weapon accidents also increased.

In mid-1957 an all-military safety board issued a report on the potential impacts of the new type of nuclear weapon. The resulting intensive, searching reexaminations of weapon design and weapon system procedures led to the first of the dual agency relationships, the nuclear safety rules process described below.

Certain ambiguities concerning AEC and DoD responsibilities arose as a consequence of extensions in deployment of nuclear weapons from strategic operations at bases in the continental US to tactical operations at forward bases. The AEC Chairman testified to the JCAE in 1959 as to the need to clarify by legislation responsibilities of AEC and DoD with respect to weapons in DoD custody. The issue arose again in December 1960 in connection with a request of President Eisenhower to approve a nuclear weapon dispersal plan. As a result of a JCAE visit to NATO in late 1960, JCAE Chairman Holifield wrote President Kennedy citing the need for clarification of responsibilities. On May 8, 1961, National Security Action Memorandum 51 was issued stating in part:

> "With regard to the broader question concerning responsibility within the government for the safety of nuclear weapons, the President has directed that the Department of Defense have immediate administrative responsibility for identifying and resolving health and safety problems connected with the custody and storage of nuclear weapons. He has further specified that the Atomic Energy Commission will participate in the consideration of these problems as a matter of continuing responsibility. He has instructed that any issues which cannot be directly resolved by the DoD and the AEC will be referred to him, through this office for decision.
>
> "Accordingly, it is requested that the Department of Defense, in cooperation with the AEC and such other agencies as may have a direct interest in this matter, undertake promptly a study of what additional administrative and statutory provisions may be required in relation to the safety of nuclear weapons and nuclear weapons systems and to report to the President through this office as soon as possible the results of their study, courses of action agreed upon, and any actions which are recommended for the President to take."

This NSAM satisfied the JCAE and no legislative change was suggested.

The goal of weapon system safety studies conducted continually since about 1960 is "maximum safety consistent with operational readiness." The military services chair and provide members for the study with appropriate logistical and operational responsibilities and the ERDA provides an ERDA voting member and a technical advisor from the nuclear weapon design laboratories. The studies generate a set of safety rules which govern the proposed deployment as regards nuclear safety. While a weapon system is in development, safety study groups are formed to follow the weapons development and assure adequate safety criteria. Interim safety rules are approved before the weapon becomes operational. After a field safety study, final rules are approved by the Secretary of Defense, and with the concurrence of the Administrator of ERDA, the rules are forwarded to the Office of the President in an annual report.

It is noteworthy that while issues of responsibilities have required referral to the President for resolution, all nuclear safety questions involving technical detail have been resolved short of such referral. Some of the AEC/ERDA minority views, as well as those which evolved into majority views, led to major impacts on weapon systems, for example, in the case of additional protection of launch circuits in the POLARIS/POSEIDON fleet ballistic missile and in the case of additional protection against the effects of accidents in the SAFEGUARD air defense weapon system.

Certain design features of nuclear weapons do not contribute to military effectiveness—they exist solely for weapon protection. Some of these features may even delimit the ways in which a weapon may be effectively used. In general, initiatives for improvements in safety devices and features lay with the nuclear weapon laboratories of AEC/ERDA. Notable examples include:

(1) Accidental Release of Bombs (Two-Man Control)

Recognition of inadvertant release of ready bombs from flying aircraft as the major safety problem attendant to airborne alert posture in the late 1950's led to development of special bomb release rack locks by the Air Force and improved Aircraft Monitor and Control equipment by AEC weapons laboratories. The existing T-249 AMAC control box was fitted with a mechanical lock and seal to prevent inadvertent operation, the T-249A control box was developed to prevent a previously armed bomb from being left in an unsafe condition by improper manipulation of the switch on the control box, and a new bomb arming control feature, the T-380 Readiness Switch (colloquially a "War/Peace" switch) was developed and installed. The latter device facilitated further extension of the Air Force's human reliability program in the form of the two-man rule concept. Today this concept has advanced to the following type of fundamental practice established for the operations with nuclear weapons:

A minimum of two authorized persons, each capable of detecting incorrect or unauthorized procedures with respect to the task being performed, and familiar with pertinent safety requirements, shall be present and in a position to observe all operations performed on any atomic weapon. No lone individual shall be afforded an opportunity to take any action which will cause, then or later, an unauthorized nuclear detonation.

(2) Environmental Sensing Devices

Starting in 1959, environmental sensing devices (ESD's) were developed and retrofitted into the nuclear weapons stockpile. ESD's provide a positive interruption of critical arming circuits until the weapon is committed to the target (e.g., launched in the intended way). These devices alleviated problems being faced by operational forces because of susceptibility of nuclear warheads to nuclear detonation from human error and/or equipment malfunctions and from sabotage. Similar features protect bombs until dropped.

(3) Abnormal Environments

In the late 1960's the ERDA nuclear weapon laboratories established advanced development programs to improve technical understanding of the implications of designing nuclear weapons for safety in the abnormal (e.g., accident) environments, including development of new types of safety devices and features. A study was made of the abnormal environment safety of stockpile systems with priority to aircraft-delivered systems because of the frequency of weapon pre-arming incidents and the history of aircraft-related accidents involving nuclear weapons. This study is an example of the continuing task of assessing the potential impacts of changes in technologies or in plans for operational deployments. Currently, a joint ERDA/DoD plan is being evolved to identify remedial actions for the stockpile, where needed, at the weapon system level.

(4) Continuing Development

Changes in military posture, requirements and means of delivery are continuing to create new safety issues. Furthermore, improved safety is considered to be of importance by all parties. The military service requirements for steady increases in safety are paralleled by a major emphasis on research and development in this area by retrofit to existing systems, but major advances require total replacement and are likely to be introduced as part of a broader stockpile modernization and retirement plan.

Control

As with safety the early years of nuclear weaponry permitted use of a wide variety of techniques to insure control since readiness was not a significant issue. Relatively lengthy procedures of custodianship transfer receipting, inspection and monitoring could be readily accommodated, in part, because the stockpile size was small and the number of storage sites few in number. Mobilization for use involved hours, if not days.

The growing trends towards readiness, larger numbers, forward deployment, and use of non-US means of delivery occurring gradually in the 1950's, focused ever increasing attention on the national ability to apply these weapons selectively and under precise command authorization.

A 1960 JCAE report expressed concern over security of weapons deployed in non-US NATO support, for instance possible sabotage of a weapon system in Europe, and "fictional possession" by the few US military custodians at NATO-manned sites. Control aspects of this concern are discussed first.

After study by several high level committees chaired by military services and DoD officials, the need for Permissive Action Links (PAL's as the coded switches were called) was endorsed. In June, 1962, President Kennedy issued National Security Action Memorandum 160 which directed incorporation of PAL's into all land-based weapons in NATO. NSAM 160 also directed the AEC/ERDA to task its nuclear weapon laboratories with development of advanced systems to provide higher levels of weapons control. PAL switches were first retrofitted into a weapon system in Europe some few months after project authorization.

It is pertinent that the first PAL switch was a modification of a switch already proved feasible in an AEC/ERDA exploratory development program for safety—a pulse-train operated switch for those bombs and warheads having trajectory environments not compatible with conventional ESD's. The nuclear weapon design laboratories of ERDA were by mid-1962 already deeply involved in control technology and had a number of innovations in preliminary development which were later introduced into the stockpile.

The forward basing situation also led to issue of a National Security Action Memorandum, No. 272, on November 13, 1963, to formalize procedures for establishment of safety rules for nuclear weapon systems. Procedures required that proposed safety rules, including procedures governing the use of PAL devices, be coordinated with the AEC prior to approval by the Secretary of Defense and notification of the President of intent to deploy. NSAM 272 also required a "listing of the DoD and AEC organizations that have studied the problem and take responsibility for the technical judgments on which conclusions as to adequacy of safety measures are based."

The control developments given major impetus in the 1960's have continued to mature. Several categories of control equipment are now available and use in nuclear weapons to meet diverse military needs. As in so many areas, some of the latest technology can be introduced by retrofit but most major advances must await warhead replacement.

It should be noted that in parallel with the developments outlined above the military services have also been making major changes. These have dealt for the most part with perfecting the control linkage between command authority and the warhead. These are most important parts of the total process with the control chain only being as strong as its

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weakest link. Both DoD and ERDA have worked in close cooperation on these issues in attempting to insure both adequate flexibility to meet military contingencies while ensuring that unauthorized use does not occur.

Security

Maintaining and protecting weapon systems in the face of possible hostile actions is also (along with safety and control) a traditional area of military concern. Until the late 1960's normal military measures and military programs on human reliability were generally considered adequate to meet nuclear weapon security concerns. The additional measures and equipment introduced for purposes of control (described above) were seen as desirable augmentations of security and indeed there is considerable overlap between these two concerns.

During the late 1960's and with ever increasing force in the 1970's the more general resort to high levels of violence by organized groups operating under no recognized national authority have exacerbated security concerns. Banditry and terrorism have seemingly become ubiquitous.

In 1968-69 the area of security measures applicable to diversion threats for materials and weapons for transfer or transferred to DoD was studied by a joint AEC/DoD group. Prompt remedial actions were taken by both agencies to strengthen some identified weaknesses. Subsequent hardware developments and systems analyses have led to step-function improvements in safeguard capabilities for weapons in ERDA custody, notably the use of foamed plastics for access denial, continuous communications for weapons in transit, safe/secure trailers, and site security systems. Military and DoD agencies upgraded physical protection requirements for weapons in their custody, particularly as regards response forces. The potential usefulness of ERDA-developed technical features in DoD operations is under study, particularly capability to deny (or destroy) the usefulness of weapons through built-in features which can be operated on command.

The value of continuing ERDA/DoD dialogue may be illustrated by current concern over transportation of weapons. In recent years DoD has re-examined logistical transportation of nuclear weapons and for a compelling security advantage has directed maximum use of aircraft. A current study of ERDA air, truck, and rail transportation operations suggests that radioactive contamination safety risks are highest for air transport. Further definitive studies to illuminate broad aspects of security-safety tradeoffs will be needed. Information from ERDA and DoD studies is being exchanged for consideration in the review of the operations of each agency.

More generally, the problem is one of achieving a satisfactory level against sabotage and/or theft while not unduly encumbering military operations. The natural ERDA and DoD advocacy roles in each of these areas has led to opportunities for improvement in both areas.

Conclusions

In the areas reviewed of nuclear safety, control and security of nuclear weapons, dual agency judgments have yielded important benefits. The identification of military effectiveness requirements primarily by DoD and measures to preclude unauthorized events primarily by ERDA has indeed proven to be a natural partitioning of responsibility which insures that any conflicts in requirements are given adequate scrutiny. It has avoided the imposition of an unnatural requirement on either agency to work seemingly at cross-purposes to its major mission and competences. Resolution rather than confrontation has been achieved by the establishment of joint agency working and study groups and by the timely review of future problems at the early developmental stages. What once were technical innovations have come to be established practice and specified military requirements. The military services are continuing to develop and perfect operational innovations such as the human reliability program which, along with the equipment innovations which are pursued as long-term research and development objectives by ERDA, serve to advance the national objectives in these areas. As a secondary benefit, the checks and balances derived from dual involvement also provides an additional safeguard against oversight or inadequacy with regard to both military effectiveness or the preclusion of unauthorized events. But it is the primary mission of insuring that adequate scrutiny is given to situations where these twin goals interact that provides the continuing justification for a dual advocacy mechanism.

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APPENDIX I

NEWS RELEASE

House Armed Services Committee

2120 Rayburn Office Bldg.
Washington, D.C. 20515

FOR RELEASE: Tuesday, December 18, 1990 10 A.M.
For further information, contact Lynn Reddy (202) 225-2191

PANEL URGES HIGH PRIORITY FOR NUCLEAR SAFETY ISSUES

WASHINGTON -- A panel of three eminent physicists told the House Armed Services Committee today that "enhanced safety" should be the top priority of the U.S. nuclear weapons program.

The panel expressed concern "that serious [safety] issues...known for at least a decade remained unattended for so many years." They found that "many older [weapons] remain in today's nuclear stockpile that do not meet present...design criteria."

Chairman Les Aspin, D-Wis., said the report "suggests that we need to reassess our priorities for nuclear weapons, and put safety clearly ahead of military effectiveness instead of the other way around. In fact, the remarkable thing shown by this report is how little military effectiveness will have to be sacrificed to get big payoffs in safety."

Rep. William L Dickinson, R-Ala., the committee's ranking Republican, said "the panel's report is even-handed. It also

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One safety concern is that an unintended nuclear yield -- an atomic explosion -- could result from an accident. Another is that through conventional explosion or fire, highly poisonous plutonium could be released into the environment even without a nuclear yield.

In addition to long-identified problems that have not been addressed, the panel also noted that recent advances in computer modeling raised new concerns. "A major consequence of these [modeling] results is a realization that unintended nuclear detonations present a greater risk than previously estimated (and believed) for some of the warheads in the stockpile," the report read. The specific warheads were not identified in the unclassified version of the panel's report.

The chief means of enhancing nuclear weapon safety are the addition of Enhanced Nuclear Detonation Safety (ENDS) devices, the use of Insensitive High Explosives (IHE), safer missile propellant and special designs for containment of plutonium called fire resistant pits.

ENDS are elements built into the detonation process of the weapon. Some are designed to be robust enough to resist the effects of aircraft crashes and fires, thus preventing detonation. Others elements in the detonation process are designed to break on impact in a crash or otherwise malfunction to prevent detonation.

Insensitive High Explosive is much less likely to detonate in a fire or crash, reducing the risk of spreading plutonium.

Fire resistant pit refers to the container for plutonium within nuclear weapons that is able to withstand high temperatures and thus prevent the release of plutonium in a fire.

The panel recommended these safety measures as priority goals:

o That all nuclear weapons be equipped with ENDS. A little over half are so equipped now.

o That all nuclear bombs loaded onto aircraft be equipped with insensitive high explosive and a fire resistant pit. Only about 25 percent of the warheads in the U.S. arsenal have IHE and only 10 percent have a fire resistant pit.

The W88 warhead is not equipped with IHE and the D5 missile third stage contains a high energy propellant. Warheads in the D5 are placed around the third stage rocket motor rather than above it as is the case in land-based weapons. This is done to shorten the overall length of a missile which must fit vertically into a submarine.

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APPENDIX J

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

Appendix J

January 17, 1969

Honorable Sidney R. Yates
House of Representatives

Dear Mr. Yates:

Thank you for your letter of December 20, 1968, in which you inquired about the role played by the Atomic Energy Commission in connection with the establishment of nuclear missile installations such as that to be located at Libertyville, Illinois.

The Commission participates with the Department of Defense in the consideration of health and safety matters connected with the custody and storage of nuclear weapons. This responsibility includes participation in programs for the prevention of an accidental nuclear detonation as well as the furnishing of technical advice and assistance in the control of radiological health hazards which might result from lesser accidents or incidents involving nuclear weapons. The Commission does not play a role in such purely military matters as determination of overall military requirements or selection of sites for military installations, and plays no role in the weighing of political and social implications of such installations.

The U. S. nuclear weapons system safety program is most comprehensive, thorough, and vigorous in its pursuit of maximum safety consistent with operational requirements for each type of nuclear weapon system, beginning with the development of the system and continuing throughout its service life. This program is codified in Department of Defense Directive 5030.15 which was coordinated with the Commission prior to publication. It promulgates the U. S. nuclear weapons systems safety standards against which safety rules for each system must be measured, and in this connection requires that each nuclear weapon system be provided positive measures to:

a. prevent weapons involved in accidents or incidents or jettisoned weapons from producing a nuclear yield;

b. prevent <u>deliberate</u> arming, launching, firing, or releasing except upon execution of emergency war orders or when directed by competent authority;

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c. prevent inadvertent arming, launching, firing, or releasing; and

d. insure adequate security.

For your convenience, a copy of the DoD Directive is enclosed.

Technically competent representatives from AEC field offices and laboratories actively participate with safety specialists from the Military Services and the Defense Atomic Support Agency in Design Review and Analysis Groups and safety subcommittees during system development, and also in Initial and Preoperational Weapon System Safety Studies prior to the Initial Operational Capability (IOC) date of the system. The purpose of these reviews and studies is to assure that the features incorporated in design and the procedural measures applied to each system meet the standards described above. In addition, no nuclear warheads are released to the DoD by the AEC until they have been tested and certified to adequately satisfy very rigid nuclear safety criteria for use in the military weapon systems for which they have been designed. These tests provide assurance that, in the event of an accidental detonation of the conventional high explosive trigger component of a weapon by other than the intended electrical initiation system, no significant nuclear yield contribution will result. Multiple other design features and verification tests provide assurance against accidental premature functioning of the warhead electrical initiation system.

For the SENTINEL system, as for other systems, one of the specific functions of the Preoperational Safety Study, in which AEC representatives will participate, will be to draft proposed safety rules. These proposed safety rules will be reviewed by the Army Materiel Command and the Army Nuclear Weapons Surety Group, coordinated with the Director, Defense Atomic Support Agency, and forwarded to the Joint Chiefs of Staff for their approval. When approved by the Joint Chiefs of Staff, the safety rules will be forwarded to the Secretary of Defense and to the Atomic Energy Commission. When in the judgment of the Secretary of Defense it is operationally necessary to deploy weapons in the interest of national defense, he may deploy them and issue interim rules, which have been developed by the procedure described above, without the concurrence of the Atomic Energy Commission; however, before the rules become final they will be reviewed and concurred in by the Commission.

If you desire further assistance in this matter, please let me know.

Cordially,

/s/ Glenn T. Seaborg

Chairman

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APPENDIX K
Key Persons at Sandia National Laboratories Involved in the Evolution of Nuclear Weapon Safety, Security and Control (S^2C)

Key contributions of Sandians to S^2C have been cited in context of events described in the text of this essay. The Index section contains the names of those persons in alphabetical order.

As discussed in the text on page 105, in 1996 I contributed to the study "Sandia's Surety Heritage" (Ref. 149). One of the questions asked in the study was "Who were the key individuals behind past advances and what specifically did they do?" In my response (Ref. 148), I identified contributions of some two dozen persons in the areas of nuclear detonation safety, plutonium dispersal safety, use control and security. As I review my response now, I find that I did not treat security fairly, and I apologize to the major contributors in that discipline. In 1984, Dennis S. Miyoshi (Reference 64) compiled a history of the nuclear security systems directorate and commendably cites key individuals.

The discussion to follow cites in roughly chronological order contributions to S^2C by Sandians that I consider to have been especially noteworthy. I have arbitrarily limited the list to ten whose roles are highlighted in S^2C. These are, alphabetically:

Richard N. (Dick) Brodie*
Carl R. (C^2) Carlson*
Donald R. (Don) Cotter*
Kenneth (Ken) Gillespie
William J. (Jack) Howard*
Robert E. (Bob) Luna
Delfred M. (Del) Olson
Robert L. (Bob) Peurifoy, Jr.*
Leon D. (Leon) Smith*
Stanley D. (Stan) Spray*

* = biographical sketches attached.

Of course, these individuals had close associates in S^2C. It is really not possible to clearly separate the contributions of each. In recognition of this important reality, I mention some key associates. For example, most readers would recall the significant contributions of J. W. (Jay) Grear as they read about Stan Spray or of William R. (Bill) Hoagland as they read about Del Olson.

Don Cotter and Leon Smith performed as a team in the late 1950s and early 1960s in applying a "systems engineering development" approach to nuclear detonation safety and use control elements of S^2C. This approach added dimensions of considering these special concerns in a framework of importance to overall national defense, to complement the importance that the project and component groups gave to meeting requirements, delivery schedules, performance characteristics, etc. In brief and perhaps as an overstatement, Cotter brought intangible, conceptual and "big picture" thinking and Smith brought disciplined engineering that produced tangible hardware to implement the concepts. The early availability of prototype hardware and ability to commit to highly expedited development-to-production times was a Sandia specialty that often tipped the scale during contentious debates over incorporation of safety and control devices into stockpiled and in-production weapons.

Smith and Cotter, as department managers in the late 1960s, nurtured evolution of the philosophical framework for nuclear weapon systems safety and use control, principally articulated by Carl Carlson and guided evolution of a practical structure for the roles of Sandia's technical staff, principally implemented by Del Olson. Carlson's contribution may be best appreciated by his perusing the first AEC manifesto on nuclear safety of 1957-59 (Ref. 17) and Olson's by the second AEC manifesto of 1960-61 (Ref. 27) and by the reports that outlined Sandia's roles (Refs. 14 and 25). In the early 1960s, Smith and Cotter personally led the process of incorporation of PAL (in Europe), assisted principally by Gene Ives.

Jack Howard may be credited with leading the process of institutionalizing the roles of the AEC's national laboratories in nuclear weapon system safety accident response, capitalizing on his experience as chairman of the DoD/Military Liaison Committee during the Palomares, Spain nuclear weapon accident episode of 1966. Howard returned to Sandia with a set of unique credentials as to deep understanding of AEC/DoD and inter-laboratories relationships. He became, in my view, a statesman for safety whose influence began high and increased as his counsel was sought again and again as safety issues arose in the Washington arena. His dialogue with Edward Teller on mechanical safing of nuclear primaries in 1967 influenced greatly the future designs and the possibility of a huge stockpile retrofit program.

One of Jack Howard's personal specializations was appreciation of the problem area of dispersal of plutonium oxides caused by detonation of weapon high explosives in accidents— this, of course, being paramount in the Palomares accident recovery operation. He used and relied on the talents of Sandia's Jim Shreve and Jim's associate, Bob Luna, in this work and supported a continuing technical expertise at Sandia over the years.

Perhaps Jack Howard's most outstanding contribution to safety came shortly after his return to Sandia from the MLC assignment when he commissioned the creation of the nuclear safety design and assessment technical specialization that generated the technological capabilities later called "modern nuclear safety" or Enhanced Nuclear Detonation Safety (ENDS). Stan Spray and Bill Stevens led this effort and both continued in this specialization for the remaining decades of their careers. Stan Spray became the master of nuclear weapon design safety, gaining respect throughout the national and international weapon safety communities. Upon his formal retirement from Sandia, Stan plans to treat the story of how ENDS revolutionized the technological approach to safety, just as I have attempted here to capture the story for the policy and management aspects of safety.

In my opinion, Bob Peurifoy was the master advocate and implementer of S^2C improvements for the national stockpile. His contributions were essentially continuous throughout his four-decade career.

In the early 1950s as a newly hired Member of Technical Staff, Bob Peurifoy began the project to incorporate the first nuclear detonation safing device (a Ready Safe Switch operated by a signal from the delivery aircraft in-flight for the first "wooden bomb." As a Section Supervisor in the late 1950s, he adapted the inherently safer rotary chopper/converter warhead electrical system then in exploratory development and had it incorporated within highly expedited weapon system program time-scales for the warhead of the nation's first intercontinental ballistic missile weapon systems (W49-0). This started a new generation of warhead electrical subsystems that would be the standard for decades. He also formulated the need for the first Environmental Sensing Device (ESD) and led the crash development project to have it incorporated into the W49-0.

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in these efforts, he was supported by staff members Herm Mauney and Bill Stevens.

As a Department Manager at Sandia Livermore in the mid-1960s, Bob Peurifoy initiated a dialogue with colleagues Carl Carlson and Bill Stevens (all under Director Leon Smith) that was instrumental in formulating the concepts that later became Enhanced Nuclear Detonation Safety (ENDS) about five years later.

Beginning with his promotion to director of weapon development in 1973 and continuing in ever-increasing vigor after promotion to Vice President in 1983, Bob Peurifoy can be credited with an unswerving, solid commitment to implement modern nuclear safety technologies into the national stockpile. In this effort, he was supported by one of the most remarkable of all Sandians, the late Dick Brodie, whom Bob hired after retirement from the Air Force. Brodie's masterpiece contribution was the Stockpile Improvement Program of the late 1970s.

As impressive as the contributions cited above were, I consider that Bob Peurifoy's vital and lasting gift was his championing and defending of the nuclear weapons laboratories' critical roles in the S^2C institutional framework, both internally and in the national arenas. Time and time again, he sought and obtained a position as technical adviser in the series of major high-level studies of ERDA/DOE DoD responsibilities that occurred between 1975 and 1990 and succeeded in convincing officials and authorities of the value of continuing the essential relationships. This work has effectively continued after his retirement in 1991. Jack Howard also can be credited for personal contributions to these major studies and for helping to have Peurifoy involved.

The major enhancements of S^2C to which Sandians contributed could not have been realized without the ability to develop and produce the hardware exemplified by ESD, PAL, and ENDS no matter how successful were the systems and project leaders who advocated these features. This realization demands recognition of the value of Sandia's weapons component career specialists, and over the years Ken Gillespie exemplified the highest level of excellence in that profession that was the steady, reliable underpinning. Other safety component designers who warrant special mention include Don Carnicom, Bob Fox, and Bob Pinkham.

Sandia's missions and roles in security and safeguards for nuclear materials and weapons were derived from a 1973 internal study commissioned by President Morgan Sparks and directed by Bob Peurifoy. Orval Jones was promoted from a research position to lead a new directorate-level organization and Bill Myre succeeded him. Upon Orval's promotion to Vice President, Bill Myre can be credited with institutionalizing the roles and missions of Sandia in nuclear weapon security in the mid-1970s, just as Jack Howard had done for safety. Herm Mauney deserves special notice for his skillful coordination of contentious security interfaces with military agencies.

Bob Luna maintained a career-long specialization in the area of atmospheric dispersal of contaminants and in a balanced consideration of the attendant risks to the general populace. He led development of an analytical model of dispersion that quantified the risks and presented decision-makers with data and tools that elevated this highly emotional risk to new levels of assessments. Luna became a mentor for a small group of Sandians who adapted his work to nuclear weapons and nuclear power fuel cycle concerns, including John Taylor's and Dick Smith's work on transportation and fixed-site facilities analyses.

Richard N. (Dick) Brodie

Richard N. (Dick) Brodie in his seventeen brief years at Sandia laid down a record of accomplishments in nuclear weapon development counsel and advice that is without parallel in the field. His accomplishments were so well regarded by his peers and associates that upon his untimely death from cancer in 1994 his name was placed on the Weapons Training Center that he had championed—the only instance of a Sandian being so honored by name.

Upon graduation from North Texas University in 1956 with a BA in Mathematics, Dick joined the U.S. Air Force and rose rapidly in rank as a pilot of high-performance fighter/interceptor jet aircraft, some armed with nuclear weapons. When an unexplainable health episode arose to limit his flying career, his mathematical talents were exploited to lead a hydrodynamics research group at Kirtland Air Force Base in Albuquerque. He had received both the MA in 1963 and Ph.D. in 1969 in Mathematics from the University of Texas, Austin, in Air Force Institute of Technology program. The computer code developed under his leadership enjoyed wide use in analysis of vulnerability/survivability of weapon systems when exposed to enemy countermeasures. His final assignment was as a Colonel serving the DoD as Executive Secretary to the Military Liaison Committee, then chaired by ex-Sandian Donald R. Cotter. His remarkable grasp of the technological and political aspects of the nuclear weapons program was noted and admired by Sandia's Robert L. (Bob) Peurifoy, Jr. during the 1975 ERDA/DoD "Transfer Study." Bob hired Dick as his special assistant in 1976—the first instance of such a position at Sandia. Later, Dick's role was expanded to become a principal advisor to top management.

As an advocate, Dick Brodie's hallmark contributions were the inception, formulation, articulation, and promotion of a systematic, time-phased ERDA (later DOE) and DoD program to significantly upgrade the state of safety and use control of certain nuclear weapon systems then in, or proposed for, the U.S. inventory of nuclear weapons. This effort continued over 1½ decades and was successful by 1990 with the removal of the last deficient weapon system from operational deployment. Another lasting legacy is the Weapon Technology week-long course originated by Dick and inspirationally taught by Dick to thousands of Sandians and colleagues in DOE, DoD and other involved agencies. Literally on his deathbed, he passed on the content and culture to Dr. John C. Hogan, who continues Dick's course today.

In August 1993, Dick Brodie was awarded the DOE Distinguished Associate Award and the citation reads in part for " distinguished and unique contributions to the surety of nuclear weapons and nuclear weapons systems and for his outstanding leadership" in national security areas focused on weapon safety and use control.

Carl R. (C^2) Carlson

Carl R. (C^2) Carlson joined Sandia Corporation's New Weapon Systems Studies Division in the Research Directorate in early 1953 upon graduation from Purdue University. While his degree was Master of Science in Physics, he had successfully completed coursework for the Ph.D.—lacking the dissertation. His specialty was to become systems analysis, although the discipline of that name today was essentially in infancy at the time. C^2 (C-squared, in the vernacular) participated in early systems analysis conducted at Sandia, especially in the classic "wooden bomb" and "laydown" bomb delivery mode studies and his fine work was noted by Donald R. (Don) Cotter. Don Cotter promoted C^2 twice in 1947, first as a Section Supervisor in Systems Engineering Division under Cotter and second as Cotter's replacement as the Division Supervisor when Cotter was promoted Department Manager in weapon project development. In these capacities, C^2 was instrumental in articulating nuclear weapon safety concepts developed by the three AEC nuclear weapons laboratories and in establishing the joint AEC/DoD nuclear weapon accident/incident reporting system. The extreme frustrations that he reported during attempts to "coordinate" the differences in technological approaches to nuclear safety among the laboratories caused him in 196_ to resign from Sandia. C^2 joined the Dikewood Corporation in Albuquerque, which had been formed by two former Sandians.

In September 1963, Carl Carlson was rehired at Sandia by Cotter for the staff of his Directorate of Advanced Systems Studies—Sandia's first "think tank." In early 1965, he was promoted to Department Manager in Cotter's directorate and remained there until fall 1967, when he was placed on leave-of-absence to join the AEC's Combined Operations Planning organization. There he did systems analysis for the AEC's nuclear materials production complex until he returned to work in 1969 for Cotter in a staff position. Upon Cotter's departure from Sandia, C^2 continued to do staff studies until his untimely death in 1972. He was perhaps Sandia's consummate systems concepts thinker and was indeed gifted in expressions of his thoughts (See Appendix D for an example).

Donald R. (Don) Cotter

Donald R. (Don) Cotter came to New Mexico in 1947 on doctor's orders to seek a better climate for relief from a respiratory disorder. He had to stop his electrical engineering course work at Lehigh University and to rely on his wartime Army training in radar to join Los Alamos' Z-Division in production, testing and assembly of ordinance for early nuclear bombs. In 1951, Don joined Bob Henderson, Don Shuster and others from Sandia for Operation GREENHOUSE, the AEC test series at Enewetak Atoll in the Pacific to do arming of the test thermonuclear devices of Los Alamos. Upon return to Sandia, Don was promoted to supervisor of a division developing the electrical system for first nuclear bomb and warhead for tactical weapon systems. Early in his career he displayed a remarkable, even uncanny, ability to focus on the broadest aspects and implications of a task and to involve and inspire talented colleagues at Sandia and elsewhere to join in. Don would become a systems study specialist and Leon Smith would become the systems hardware developer specialist – a teaming with high payoffs for national security (see Leon D. Smith's sketch for description of their work on S^2C in the early 1960s).

In late 1961, Don Cotter was promoted to Director of Advanced Systems Studies to lead a small group which would conduct studies of promising future areas of R&D and would perform certain staff functions for SNL's President Seigmund P. ("Monk") Schwartz. Don's new group also would do information research and coordination of agenda for important visitors. The directorate, Sandia's first staff, became both a source of innovative thinking by its select staff members and a reservoir ("mail drop" in Don's terms) to receive and consider ideas, notions and proposals from interested persons throughout the laboratory. Cotter arranged to have Interdisciplinary Colloquia/Seminars in which key Sandia, LASL and LNL staff would participate along with noted outside national and international experts and specialists, Henry Kissinger, John Lehman (later Secretary of the Navy) and Richard Perle (then staff assistant to Senator Henry Jackson, later Assistant Secretary of Defense for Policy).

In 1966, Don Cotter was called by long-time colleague Johnny Foster (formerly, Director of the Lawrence Livermore Laboratory of the AEC) to service in the Department of Defense, including as Deputy Director of the Advanced Research Projects Agency for which he received the Civilian Meritorious Medal for technological contributions related to the Southeast Asia conflict. Following brief tours at AEC Headquarters and the Central Intelligence Agency with colleague James Schlesinger, in 1973 he received a Presidential appointment as Chairman of the Military Liaison Committee to the AEC and Assistant to the Secretary of Defense (Atomic Energy). In 1978, he served as special advisor to the Chairman, Senate Armed Services Committee and did other policy consulting. He died in 1991 after a long illness at age 69.

William J. (Jack) Howard

William J. (Jack) Howard joined the Z-Division (ordnance) of Los Alamos Scientific Laboratory upon graduation from New Mexico State University in 1946 with a BS in Mechanical Engineering. The Z-Division was the forerunner of Sandia Corporation, which was formed some two years later. Jack's early assignment was in the field testing part of the Applied Physics Department. Within a year he was drawn into the newly created Atomic Energy Commission's nuclear test series: Operation SANDSTONE in 1948 on Enewetak Atoll in the Pacific in engineering logistics support work (see pages 286 and 298 of Reference 1 of the text) and Operation BUSTER-JANGLE in 1951 at Nevada Proving Grounds as Project Leader for air pressure recording.

In 1952 when Sandia created a new directorate for development of warheads for guided missiles, Jack Howard was promoted to department manager to lead projects for large guided and ballistic missile weapon systems. Some four years later, he was transferred laterally to Livermore, California, to lead Sandia's engineering department for the laboratory being created there. By late-1956, Jack Howard became the first Director of Systems Development/Livermore and played major role in establishing its technical capabilities and culture.

Jack Howard was on leave of absence from Sandia from late-1963 to mid-1966. He had accepted Presidential Appointment/Senate Confirmation for the position of Chairman of the Military Liaison Committee to the AEC and Assistant to the Secretary of Defense (Atomic Energy). He succeeded Lawrence Livermore Laboratories' Gerald W. Johnson in that position, continuing the practice of selection from one of the three AEC weapon's laboratories. During his tenure, the national nuclear weapon program adjusted to the cost-effectiveness emphasis for weapon system acquisition employed by Secretary of Defense Robert McNamara and the nation experienced the first major nuclear weapon accident on foreign territory, the Palomares, Spain accident of January 1966. Jack was awarded the Department of Defense Medal for Distinguished Public Service, and the citation read in part:

"... His extensive knowledge of military weaponry, matched by a keen insight into the operational needs and capabilities of the military forces qualifies him as a principal and valued advisor. His contribution to communication among the military services and between them and the Atomic Energy Commission will be of lasting benefit to the nation's security. In formulating and guiding the implementation of national policy in a highly sensitive and dynamic area, he displayed exceptional perspective and judgement. Motivated by a deep patriotism and distinguished by courage and dedication, he has earned the respect, trust, and appreciation of his associates in the highest levels of national decision. Mr. Howard's distinguished record of service in a vital aspect of United States defense posture exemplifies the highest standards of citizenship."

Upon return to Sandia, Albuquerque, in mid-1966, Jack Howard served as Director of Advanced Systems Development for a few months before promotion to Vice President, Components and Systems. In April 1973 he was promoted to Executive Vice President and served for a decade as Sandia's chief executive in R&D programs. In 1976, he served as a U.S. Delegate to the Strategic Arms Limitations Talks in Geneva, Switzerland. He retired at age 60 after nearly 36 years of distinguished service to Sandia and the nation.

Robert L. (Bob) Peurifoy, Jr.

Robert L. (Bob) Peurifoy, Jr., joined Sandia Corporation's (Weapon) Systems Development Directorate 1200 in 1952 upon graduation from Texas A&M University with a BS in Electrical Engineering. His early assignments were as Member of Technical Staff in development of arming, fuzing and firing subsystems, initially for the first postwar new type of fission bomb, Mark V, and later for the "crash program thermonuclear bomb projects, including the first "wooden bomb." Before the latter project was complete, he was tapped for the first of a series of special assignments to consider Sandia's potential technological involvement in R&D endeavors that appeared suddenly on the horizon. His study, completed in 1955, on how to do arming, fuzing and firing for the nation's first generation of intercontinental ballistic missiles became the concept that was adapted essentially without change by the two industrial contractors of the U.S. Air Force's Western Development Division. Thus began a three-decade tradition for Air Force reentry vehicle programs.

Development of the warhead electrical subsystem for the first thermonuclear warhead to be used on the land-based intercontinental and intermediate-range ballistic missile systems. In 1958 he was promoted to the next level to manage to complete warhead development project. During this time, Bob was again tapped to consider Sandia's technological capability to contribute to a project at Los Alamos Scientific Laboratory to create a machine to produce energy from controlled fusion reactions.

In 1961 upon completion of the warheads for ICBM/IRBM weapon systems, Bob was promoted to the middle level of technical management and transferred to a weapon component development organization responsible for explosively driven devices—this being the third promotion in his nine-year career. In 1964, he was laterally transferred to Sandia's Livermore California laboratory to lead development of systems field testing instrumentation and later to lead studies in advanced weapons systems research.

In 1967, Bob Peurifoy returned to Sandia's Albuquerque laboratory to lead exploratory development in the area of hardening weapon hardware to enemy countermeasures and soon afterwards was tapped for yet another special assignment—formulate and lead an engineering approach to Sandia's first major project that would be sponsored and funded by the U.S. Navy: namely, the arming, fuzing and firing subsystems for the reentry body of the Poseidon Mk 3 fleet ballistic missile weapon system. Ironically, this task was a consummation of his 1955 proposal for similar work on Air Force weapon systems. In early 1973, Sandia President Morgan Sparks asked Bob to lead a study to determine Sandia's potential involvement in the field of nuclear power reactors and fuel cycle. This study, coming soon after dissolution of the AEC and creation of the Energy Research and Development Administration (ERDA), was instrumental in Sandia's subsequent formation of a directorate-level organization to perform selected tasks for the new Nuclear Regulatory Commission.

In 1973, Bob Peurifoy was promoted to Director, Weapon Systems Development, where he was to remain for a decade and oversee the development of the Stockpile Modernization Program and five new weaponization projects. In 1977, he was a recipient of the prestigious ERDA Distinguished Associate Award and the citation read:

"For outstanding technical and management contributions to a broad range of activities in the development of nuclear weapon systems. Under his direction technically complex ordnance engineering tasks on warheads for strategic missile systems, including the reentry bodies for the U.S. Navy POSEIDON and TRIDENT systems, continue to be performed with an exceptional record of meeting critical deadlines within funding constraints and without sacrificing quality of system performance."

In 1983, Bob Peurifoy was promoted to Vice President, Technical Support where he was responsible for weapon testing, nuclear safety, reliability, quality assurance and military liaison activities, as well as planning and operating building and other infrastructure facilities. On March 15, 1991, Bob Peurifoy retired after 39 years of most distinguished service to Sandia and the nation.

Leon D. Smith

Army Air Corps First Lieutenant Leon D. Smith served as a weaponeer in the ordnance squadron of the 509th Composite Group that was formed to deliver atomic bombs. He was one of the three weaponeers and, by toss of the coin, became the backup for the Hiroshima and Nagasaki drops. In early 1946, Leon was mustered out of the military in a 30-minute process to join the Z-Division of Los Alamos group destined to Bikini Atoll to support Operation CROSSROADS, the nation's first postwar nuclear test. This time, Mr. Leon Smith, Electrical Engineer, would be the weaponeer for fuzing a bomb.

After CROSSROADS, Leon specialized in design of arming, fuzing and firing subsystems for bombs, with time out for doing that work for the devices that Los Alamos had developed for the AEC's first test series SANDSTONE in 1948. In the early 1950s he was on of six supervisors of an Electronic System Division for early fission bombs and warheads. Leon and colleague Don Cotter suggested and led implementation of the first in a series of innovative technical management initiatives that would fundamentally improve Sandia's capability to handle vicissitudes in weapon development programs wrought by virtual explosions in military requirements. An Electrical System Coordinating Group was formed to voluntarily introduce "systems" thinking in an arena dominated by urgent time pressures of the individual weapon projects, resulting in economics in allocation of scarce resources through avoiding duplications of effort and standardization. Systems engineering as a discipline had only recently evolved (at Sandia's parent Bell Telephone Laboratories) and this was an early and effective application. In 1956, Leon's innovation was elevated to the higher organizational level of a department and he was promoted to be its first manager. Many of the incoming members of technical staff recruited for the stockpile buildup thrust of the late 1950s hired into Leon's group to meet the technological challenges presented.

Leon's reputation for setting high standards for performance and demanding total commitment to the task grew, and in 1961 he was promoted to the director level to apply his skills to the area of electromechanical component development. He teamed a second time with Don Cotter to lead Sandia's initiatives in providing the environmental sensing device (ESD) and permissive action link (PAL) components that would play a major part in the revolution in national commitment to nuclear weapon Safety, Security and Use Control (S^2C). Leon and Don were made members (unofficially) of the high-level military teams that evolved on-site the politically sensitive command and control system for NATO – in the public view by the infamous code-containing briefcase that afterwards was always with the President.

In 1964, Leon and Don Cotter again teamed to lead emergence of an advanced systems development program that would challenge the technical staff to create new options for national security in advance of any stated military requirement. The ensuring period is thought by some observers to have been one of Sandia's finest times – its Camelot. For example, its project to develop and test prototype small, multiple re-entry vehicles compatible with the advanced ballistic missile systems of the military services would lead to the highly successful series of re-entry bodies for the Navy's fleet ballistic missiles. Leon personally led the sensitive negotiations with AEC, Navy, and Navy contractors that married the best features of each – all in the national interest. Sandia's role was to design, develop and have produce (in the AEC's complex) the arming, fuzing and firing subsystem for the Poseidon and follow-on weapon systems at cost (reimbursed to the AEC by the Navy).

Leon's leadership continued in the S^3C area and extended into related interests in intelligence agency research support and in test ban treaty verification programs for over two decades. He retired in 1988.

Stanley D. (Stan) Spray

Stanley D. (Stan) Spray joined Sandia Corporation as a nuclear bomb development project engineer in 1954 upon graduation from the University of Arizona with a degree in electrical engineering. From 1954 to 1966, Stan was a staff member involved in the design of weapon electrical systems (safing, arming, fuzing and firing). (Stan had a two-year tour in the Army from 1955-1957 during this period.) This work included design activities in the aircraft monitor and control systems (AMAC); advisor to the (AE/DOE) Nuclear Weapon System Study Group (NWSSG); weapons projects development (lead electrical engineer on the B57 bomb); and several years in the Phase 1 & 2 division focusing on new weapon concepts. He was promoted in 1966 to supervise a group responsible for development of advanced arming, fuzing, and firing systems for missile-delivered weapons.

In 1968, Stan began a 30-year career specialization in nuclear weapon safety, when he was selected to form and lead Sandia's first division devoted to the assessment of the degree of nuclear safety present in existing nuclear weapons when exposed to accident environments. Part of the mission was to develop safety principles and hardware that would enhance safety in future weapons. The latter work culminated in what was called a remarkable breakthrough technology that become known a Weak Link/Strong Link/Exclusion Region, or ENDS (Enhanced Nuclear Detonation Safety). ENDS became the standard weapon design approach and was incorporated into all new nuclear weapon programs beginning in the mid-1970's, and was retrofitted into older weapons scheduled to remain in the national stockpile. For this work in nuclear safety, in 1983, he was among the first Sandians to receive the Award of Excellence for the DOE's Nuclear Weapons Program.

In 1989, Stan became supervisor of the System Safety Division, which supported the DOE in the assessment of the Nuclear Weapon System Safety Group (NWSSG) for the Army, Navy, and Air Force weapon systems. The Division also supported the assessment of the assembly/disassembly activity at the Pantex Plant and the nuclear test activities at the Nevada Test Site (Nuclear Explosive Safety Study Group [NESSG]). He also became the program manager for Sandia's nuclear weapon Accident Response Group (ARG), which supported DOE's emergency response capability. This involved emergency response exercise planning, training, technology development and program management.

In this period, Stan also initiated the development of the Nuclear Safety Information Center (NSIC) to preserve nuclear safety critical information and make it readily available to assessment and design personnel. He also initiated the development of the Nuclear Surety Training (NST) program to transfer experience and knowledge of nuclear weapon safety principles and assessment methodology to new staff and management, and the "We Were There" series of video interviews with individuals who were at U.S. nuclear weapon accidents. He has given numerous papers on safety at national and international conferences. He has shared this safety background and experience via briefings and classes with over 10,000 individuals.

Stan was promoted to Senior Scientist Engineer in 1997 with the responsibility of supporting the Director of Surety Assessment with respect to advice on technical and policy issues. He held that position until retirement in December 1998.

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APPENDIX L

APPENDIX L

United States Government — Department of Energy

memorandum

DATE: January 4, 1994

REPLY TO ATTN OF: DP-64 (R. Hahn, 3-3757)

SUBJECT: Nonconcurrence: Reorganization of Nuclear Weapons Council Standing Committee (NWCSC) and Weapons Safety Committee (WSC)

TO:
Chairman, Weapons Safety Committee, DP-20
Associate Director for Weapons Safety, DP-20.1
Assistant Staff Director for the Nuclear Weapons Council, DP-20.2
Acting Director, Office of Development, Testing, and Acquisition, DP-25

This memorandum was originally prepared for the June 10, 1993, combined NWCSC-WSC meeting. The essence and need for this memorandum have not changed. I feel very strongly about the WSC and its intended function to provide a forum to carry out the joint responsibilities of the Department of Energy (DOE) and the Department of Defense (DOD) on nuclear weapons safety during all weapons phases from design to retirement. To assure that safety issues are addressed in a completely objective manner, it is my opinion that is why the WSC was established to have equal DOE-DOD voting membership. In fact, during the early days of the WSC, several deployment safety issues were voted to be addressed/not addressed along "party lines." Examples include W-69, airbase weapons alert, and airborne moving/shipping. These issues were addressed only after substantial further study and DOE persistence.

I agree that in combining the Standing Committee and Safety Committee, the combined Departments do gain "efficiency." I do not support that a 2-hour meeting once a month on weapons safety is an overburden on anyone. But what we lose in this reorganization is: (1) Joint Departmental responsibility as reflected by equal voting representation on safety matters which should be paramount in all design, deployment, retirement, and dismantlement activities; (2) If there were a fundamental disagreement between DOE and DOD on any safety issue, DOE always loses the argument 5-1 or 6-2, depending on whether you count the co-chairs' votes. There are no provisions for a DOE or DOD co-chairman veto which could counter this problem as Admiral Mitchell suggested in May 1993; (3) The most knowledgeable DOE field weapons safety people, who are involved in day-to-day implementation of safety in all weapons phases, are eliminated as members; (4) Some Standing Committee members are admittedly more policy and acquisition oriented; (5) Observers/advisers (experts) do not/have not carried the weight of committee members. In my opinion, these shortcomings far outweigh the improvements of combined committee efficiency.

Thus, as a charter member of the original WSC, I am requesting this <u>entire statement be read verbatim</u> into the record of the January 6, 1994, combined meeting (or whenever that meeting is held) so that my minority opinion is presented to the Nuclear Weapons Council whenever the final recommendations for the combining of the Standing Committee and Safety Committee are made (as provided in the draft Memorandum of Understanding).

Respectfully submitted,

Richard D. Hahn

Richard D. Hahn
WSC Member, DOE

cc:
J. Pebley, DP-25

APPENDIX M
Compilation and Annotation of Draft Working Papers on S²C and Related Subjects

This appendix compiles citations for certain reports, papers, and essays that I wrote, or collected, on S²C and related subjects during my tenure as manager of the Nuclear Safety Department 1650/1230/7230 from 1968 to 1985 and as a consultant afterwards. These documents often are in the format "Draft Working Paper" for distribution to interested or involved persons to seek their comments for subsequent revisions by iteration. In later years, I favored the format of annotated briefing notes over draft working papers, the former technique taught to me by Dick Brodie, and most of these are included here. The purpose of both types was twofold: (1) to record my learning process and to do research on learning more about new subjects or issues; and (2) to suggest positions, practices or policies to resolve issues.

The listing of documents is alphabetical by subject. For each subject, the first notation is the location in the Nuclear Safety Information Center (NSIC) of the file folder that was used during the period 1968-1985 and the number of documents contained therein. Documents not filed in these folders are then listed chronologically and brief notes and annotations are included where needed for context in the evolutionary process contained in the text of this essay. The Index section of the report contains the same set of subjects and ties the subjects to the References section. In general, documents listed in the References section are not repeated in this appendix.

Subjects

Abnormal (Accident) Environments
Accidents and Significant Incidents
Accident Response
Aircraft Monitor & Control Equipment
Adversary Simulation ("Blackhatting")
Custody and/or Security
Deliberate, Unauthorized Launch (DUL)
Denial, Disablement & Destruction (D³)
DOD Directive 5030.15 and Successors
DOE Order 0560 and Successors
Duel Agency Responsibilities
Electromagnetic Radiation (EMR) & Lightning
Emergency Destruction (ED)
Enhanced Nuclear Detonation Safety (ENDS)
Explosive Ordnance Demolition (EOD)
Intrinsic Radiation from Nuclear Weapons
Mechanical Safing & Arming Device (MSAD)
Memorandum of Understanding (DOD/DOE MOU)
Military Characteristics (MCs)
Nuclear Power Reactor & Fuel Cycle Safety
Nuclear Weapon Detonation Safety Standards
Nuclear Safety Philosophy, Policy and Practices
Nuclear Safety Standards, Requirements & Responsibilities
Nuclear Safety Rules
Nuclear Weapon System Safety Study Groups (NWSSGs)
Nuclear Weapon Transportation
One-Point and Popcorn Nuclear Detonation Safety
Personnel Assurance and Human Detonation Safety
Plutonium Dispersal Safety
Probabilistic Risk Assessment (PRA)
Roles of Nuclear Safety Specialists S²C Committee for DOE DP
Security & Custody
Stockpile Safety Study of ERDA/DOD
Use Control, Physical Access & Terrorism

My day file folders from 1967 through 1985 are contained in NSIC IV.3852 through IV.3865.

Abnormal (Accident) Environments

There is no file collection. IV.3290 is marked "Accident Environments," but it contains only three documents—none relevant.

UNC Memo, "Characterizing Abnormal Environments," W. L. Stevens, 1650, to Distribution (13 Department Managers) dtd. 3/14/73, 12 pages, IV.3853/23.

> Suggests that the Enhanced Nuclear Detonation Safety (ENDS) concept being developed obviates the need to improve quantitative definitions of abnormal environments and that Project Officer Groups should define such for each weapon in the stockpile—instead of trying to write "common" definitions.

Accidents and Significant Incidents

CFRD Paper, "Exercise of Weapon Systems Not on Alert Status (U)," W. L. Stevens, 1230, to Distribution, 9/8/76, IV.3857/8 pages +Attachments.

> Discusses the need for exercise of stockpiled nuclear weapon systems and gives examples of related safety "incidents": W25/AIR2A Ready/Safe Switch Overheating and B28PI/B-52 BDUs.
>
> NOTE: This paper was expanded and updated 6/3/77, as IV.3857/8.
> See also the section on Explosive Ordnance Demolition, especially 4V.110 of 8/69.

Accident Response

File collections: IV.3940 contains 63 numbered documents, "Accident Investigation and Administration" (ARG correspondence 1958-1980) IV.3960 same subject, but to 1991 contains 95 numbered documents; IV.228 contains documents on the Accident Response Group; IV.3165 (Titled "DNA- Emergency Planning") contains 35 numbered documents.

UNC Memo, "Comments on AEC Responsibilities in Nuclear Weapon Accidents/Incidents." W. L. Stevens, 1650 to W. J. Howard, 1000, and T. B. Cook, 8000, through H. E. Lenander, 1600, 12/10/68, 9 pages, IV.3940/53.

UNC Memo, "Information Packages for Nuclear Weapon Accident Response (U)." W. L. Stevens, 1230, to G. J. Hildebrandt, 4320, 7/28/80, 1 page, IV.3860/12.

> Suggests creation of "bomb books" containing information collected specifically for accident responses, real and exercises—instead of using EOD manuals. This was done.

UNC Memo, "Security Perimeters, Evacuation Distances, National Defense Areas, etc. for Nuclear Weapon Accidents, W. L. Stevens, 1230, to Distribution, 6/1/81, 5 pages, IV.3861/29

Contains the author's thoughts and suggestions for control of local real estate during accident response.

UNC Memo, " Emergency Preparedness (EP) Planning," W. L. Stevens, 1230, to Distribution, 6/18/81, 13 pages, IV.3861/27.

Discusses the dangers of sweeping nuclear weapon accident response procedure into the mold established for nuclear fuel cycle and reactor accidents.

UNC Transmittal Memo, "EMR Restrictions at Nuclear Weapon Accident Sites (U)," W.L. Stevens to Distribution, 7/8/81, 7 pages, IV.3861/26.

UNC Memo, "Attitudes on DOE Roles in Weapon Accident Response," W. L. Stevens, 1230 to Distribution, 2/16/82, 9 pages, IV.3862/41.

UNC Memo, "Comments on Draft Nuclear Weapon Accident Response Procedures (NARP) Manual, dated April 7, 1982," W. L. Stevens, 1230, to J. R. Roeder, USDOE/ALO/OSD, 5/17/82, 7 pages, IV.3862/26.

Questions and plans for treatment of operational and technical aspects of accident response.

UNC Memo, "Comments on Draft DOE 5530, Response to Accidents Involving Nuclear Weapons (U)," W. L. Stevens, 1230, to J. R. Roeder, USDOE/ALO/OSD, 4/14/82, 7 pages, IV.3862/27.

Contains comments on eleven topics, mostly on operational and technical subjects—as contrasted to the administration and agency interfacing emphasis in the draft.

UNC Memo, "Suggested Positions on Degree of Hands-on Participation by Sandia Employees in Nuclear Weapon Accident Recovery Operations," W.L. Stevens, 1230 to Distribution, 2/11/82, 5 pages, IV.3862/44.

UNC Memo, "Some Distinctions Between Accident Response Group (ARG) and the Nuclear Emergency Search Team (NEST)," W. L. Stevens, 7230 to W. C. Myre, 5200, 4/2/84, 5 pages, IV.3864/8 and IV.3960/24.

Discusses future AEC responses to accidents and responsibilities of ARG and NEST for any "lost" weapon situation. Comments on a proposal by LRL's Duane Sewell.

UNC Memo, "Nuclear Weapon Accident Preparedness," W.L. Stevens, 1230 to J. R. Roeder, DOE/ALO/OSD, 12/23/81, 2 pages, IV.3165/7.

> Argues against applying NRC reactor safety policies to nuclear weapons facilities, as was being pushed by L. Joe Deal of DOE/HQ. This view was adopted by DOE/AL and the effort ceased. W. J. Howard wrote a high-level memo on the same subject.

UNC Memo to File, "SNL Involvement in DNA's ARAC Feasibility Study," W. L. Stevens, 1230, 9/1/81, IV.3165/15.

> Argues against an attempt by DNA and DOE/OMA staff offices to get SNL funded for a study that could require use of LLNL's ARAC capability for "site specific surveys" associated with plutonium dispersal threats.
>
> See also: Accident Environments File Collection; IV.3290/1 for letter from Harold Agnew, LASL Director, to H. C. Donnelly, AEC/AL on DNA's role in accident response.

Adversary Simulation ("Blackhatting")

The file collection entitled "Blackhat Activities" is IV.3287, and it contains four documents. None of these are particularly applicable to this essay on S^2C. See also 3V.564.

Aircraft Monitor and Control Equipment (AMAC)

The file collection is IV.3764 and it contains 36 numbered documents.

UNC Memo, "Nuclear Safety and the AMAC Stand-off," W. L. Stevens, 1650, to Distribution, 10/17/69, 5 pages, 4V.1573/52.

> Suggests formation of an intra-Sandia study group to consider a new AMAC system compatible with the Project CRESCENT bomb advanced development concept. This effort was organized by S. D. Spray and his memo with the above title is attached to Stevens' cover memo.

Deliberate, Unauthorized Launch (DUL)

No file collection on this subject has been located.

CFRD Draft Briefing Notes, "Evolution of Measures to Control Deliberate, Unauthorized Launches of Nuclear Weapon Capable Missiles (U)," W. L. Stevens, 1-14-83 (Revised), 57 pages, IV.3862/1.

Summarizes evolution of DUL from SAC's "buddy system" through Pershing II and discusses unresolved questions and issues.

UNC Memo, " Deliberate, Unauthorized Launch (DUL) of Pershing II," W. L. Stevens, 7231 Acting to R. M. Shay, USDOE/ALO/WSSB, 2/9/83, 2 pages, IV.3863/14.

Denial, Disablement, Destruction (D^3S) of Nuclear Weapons.

A file collection of L.D. Smith is IV.2895 and it contains relevant documents.

See also: 3V.129 for discussion of non-violent disablement and IV.2719/1 for Pre-Disenablement.

SRD Memo, "Suggestions for a Long-Range Solution To The Weapon Disablement Problem," W. L. Stevens, 1650, to W. C. Myre, 1210, and D. E. Gregson, 8310, RS 1650/002, 8/9/68, 7 pages, IV.3852/32.

Discusses the concept of " implosion inhibition," based on ideas of Robert L. Peurifoy, Jr.

SRD Memo, "Weapon Disablement," W. L. Stevens, 1650 to D. E. Gregson, 8130, RS 1650/018, 10/23/68, 2 pages, IV.3852/24.

Discusses improvised weapon destruct systems and PAL systems.

SRD Memo, "Destruction of Nuclear Weapons (U)," J. A. Hornbeck, President Sandia Corporation to Major General E. B Giller, USAEC/AGMMA, RS 1/1681, 9/27/68, 3 pages, IV.3852/24.

I believe that I coordinated drafting of this memo that presents Sandia's recommendations.

SRD Memo, "Thoughts Arising from The Weapon Denial Symposium (U)," W. L. Stevens, 1650 to Distribution, RS 1650/068, 12/1/72, 5 pages, IV.3852/2.

Discusses safety rules and EOD procedures, Pu dispersal safety (including mention of a vu-graph depiction hypothetical results of a Pu dispersal at Bunker Hill AFB and Kirtland AFB) and weapon transportation, EOD manuals and PAL bypass, and Johnny Foster's Gull generator/PAL code idea.

SRD Draft Working Paper, "Some Technical Questions and Policy Issues Related to Violent Destruction of U. S. Nuclear Weapons (U)." W. L. Stevens, 1230, RS 1230/035, 6/1/77, Revised 6/10/77, 14 pages, IV.3857/6. Later revised and issued as IV.2858/25.

This memo led to establishing the Stockpile Interfaces and Responsibilities Study, an attempt to assure responsibility and consistency in Sandia's treatment of S^2C concerns, particularly D^3S. The memo contains an early version of suggested Sandia policy statements for S^2C, including security. See 3V.129.

CFRD Memo, "Measure of Weapon Disable/Destruct (U)," W. L. Stevens, 1230 to A. A. Lieber, 1310, 12/19/77, 5 pages, IV.3857/1.

Gives thoughts and approaches to set a performance measure on various disable/destruct methods.

CFRD Memo, "D^3S and the Stockpile (U)," W. L. Stevens, 1210 to L. D. Smith, 1200, 7/17/78, 2 pages, IV.3858/14.

Suggests a D^3 S study of the stockpile. No response.

SRD Draft Memo (Not Issued), "D^3 S and the Stockpile—Baseline Terrorist Case (U)," W. L. Stevens, to Distribution, RS1230/045, 10/9/78, 3 pages, IV.3858/6.

My response to IV.3858/14, above.

CRD Memo, "Notes on Incremental vs. Ultimate Safety and Control Improvements," W. L. Stevens, 1230, 10/19/78, 6 pages, Attached to IV.3858/2.

Contains works prepared for W. J. Howard in contesting LLL's position against IHE effectiveness.

UNC Time-Line and Annotated References, "Nuclear Weapon Destruction, Disablement, or Denial, Evolution," W. L. Stevens, Late 1990, 8 pages, IV.3860/2.

This is one of a set of four. Others are on Nuclear Detonation Safety, HE/Nuclear Subsystem Aspect, Evolution (IV.3860/1); Nuclear Detonation Safety, Arming and Firing Subsystem Aspect, Evolution (IV.3860/3), and Nuclear Weapon Use Control Evolution (IV.3860/4).

SRD Working Draft, "Some Nuclear Safety Issues Related to Disablement of U.S. Nuclear Weapons (U)," W. L. Stevens, 1230, 4/25/78, RS 1230/041, 18 pages, transmitted by UNC Cover Letter, "Stockpile Interfaces and Responsibilities Study (U)," W.L. Stevens, 1230 to Distribution, 4/26/78, 1 page, IV.3858/25.

DOD Directive 5030.15 and Successors

The file collection is IV.3340 and it contains 18 numbered documents. The folder is labeled "DOD Directive 5030.15."

UNC Draft Memo, "The Notion of 'Prearming' in Nuclear Safety (U)," W. L. Stevens, 1230 to Distribution, 11/19/76, 4 pages, IV.3859/23.

Discusses possible detrimental impacts of the addition of 'prearming" to the set of "arming, launching, firing, or releasing of nuclear weapons" in the 8/8/74 revision of DoD Directive 5030.15.

UNC Memo, "The Four Nuclear Weapon System Safety Standards Per DOD Directive 5030.15," W. L. Stevens, 1230 to Files, 2 pages, IV.3859.25

Discusses origins and intents of the second and third standards as regards the terms "arming, launching, firing or releasing."

UNC Draft Working Papers, "Some Personal Opinions on the Impact of DOD Directive 5030.15 on Design of Nuclear Detonation Safety and Control Features of Nuclear Weapons (U)," W. L. Stevens, 1230, 3/26/79, 25 pages, transmitted to Distribution by Memo from W. L. Stevens, 4/18/79, IV.3859/23.

Discusses in detail the four standards as related to nuclear detonation safety and to use control.

UNC Memo, "Thoughts On The National Nuclear Weapon System Safety Process As Governed By DOD Directive 5030.15," 12 pages, attached to UNC Memo," Revision of DOD Directive 5030.15 on Nuclear Weapon System Safety, W. L. Stevens, 7230 to R. J. Peterson, DOE/DMA/DP226.3, 6/1/83, 3 pages, IV.3340/4.

Contains a lengthy, candid and somewhat tutorial discussion of the subject and argues against extensive changes to DOD 5030.15.

UNC Memo, "Proposed Revision to DOD Directive 5610.3," W. L. Stevens, 7230 to R. J. Peterson, USDOE/OMA.DP-226.3, 5/31/85, 2 pages, IV.2722/34.

Contests Bob Peterson's suggested revision and suggests that the DOE/OP's S^{3}C Committee is "rapidly devolving from high-level management membership to middle-level representation."

DOE Order 0560 and Successors and Nuclear Explosive Safety Studies (NESSs)

The file collection for this subject has not been located.

UNC Memo, "Implementation of DOE Order 5610.3 and AL Order 5610.3," W. L. Stevens, 1230, to J. R. Roeder, DOE/ALO/OSD, 10/26/82, IV.3862/7.

Contests DOE/AL's attempt to expand coverage to include damage to the nuclear explosive and personnel injury, on the basis that these are line responsibilities of the contractor, M&H.

See also: IV.3861/22 of 7/21/81.

UNC PRIVATE Memo, "Opinions on the Current State of the DOE's Nuclear Detonation Safety Program (U)," W. L. Stevens, to Distribution, 6/6/84, 9 pages, IV.3864/6, with 5 sets of enclosures.

Contains opinions assembled in the way of a stock-take, perhaps in anticipation of approaching retirement of the author. Coverage includes states at DOE/AL, DOE/AL/OSD, DOE/AL/AM for S&S, DOE/OMA/SE&EA/SSB, DOE/OMA/SE&EA DOE/DDMA, LLNL, and within Sandia.

UNC Draft Memo, " Nuclear Explosive Safety Study of a Nuclear Explosive, Like Assemblies," W. L. Stevens, 7230, 7/13/84 (Not Sent) 1 page, IV.3864/5.

This memo, in the format of a suggested memo from R. L. Peurifoy, Jr., 7000 to DOE/ALO/AMOS&S, comments on differing views of the Los Alamos/Sandia and Livermore/Sandia design teams.

<u>NOTE:</u> The file collection for Nevada Test Site Operations safety is IV.3833. There are 53 numbered documents.

UNC Memo, "Comments on Nuclear Explosives Safety Program Per ERDA manual Chapter 0560," W. L. Stevens, to Col. James G. McCray, DRDA/DMA/SSB, 1/20/75, 2 pages, IV.3833/23.

Challenges ERDA/NV's position that security matters are not with in the scope of NESS groups.

Dual Agency Responsibilities

No file collection on this subject has been located. Origin of this concept is discussed on page 123 of SAND99-1308, this report, Ref. 84, IV3054/61 or IV.374/9 of 12/75 applies.

UNC PRIVATE Draft Memo, "Dual Agency Judgments in National Nuclear Weapon Safety Matters," W. L. Stevens, 1230 to Morgan Sparks, 1, G. A. Fowler, 1000 and L. D. Smith, 1200, 2/17/78, 4 pages, IV.3858/28.

UNC Memo, "Implementation of the Starbird Study Recommendations," W. L. Stevens to Distribution, 7/18/81, 10 pages, IV.3861/20.

Considers basic responsibilities between DOE and DOD on S^2C in context of Ted Gold's draft MOU. Mentions joint, shared and singular responsibilities.

See also: Memorandum of Understanding section especially 4V.1628 of 6/20/78.

See also: IV.3222/36 and IV.3858/12 for letter from Morgan Sparks (by W. J. Howard) to DOE/DMA.

Electromagnetic Radiation (EMR) and Lightning Environments

The file collection is IV.3941 and it contains 36 numbered documents.

UNC Memo, "Nuclear Detonation Safety and EMR Environments for U.S. Army Theater Weapon Systems (U)," W. L. Stevens, 1230, 2/7/77, 16 pages, IV.3857/14.

UNC Memo, "Lightning Environments for Nuclear Weapons," W.L. Stevens, 1230 to Distribution, 11/26/79, 2 pages, IV.3859/2.

Gives thoughts on treatment of lightning threats in safety themes and as "credible" environments.

SRD Memo, "Pershing 1a Safety Rules (U)," W. L. Stevens, 1230 to Captain W. Beech (USN), DOE/OMA/DSE&EA, RS 1230/81/02, 1/27/81, 3 pages, IV.3861/40.

Addresses technological aspects of lightning vulnerability of the Pershing 1a and suggests that the issue be elevated to the national level.

UNC Memo, "Lightning Protection for Nuclear Weapons," W. L. Stevens-1230 to C. C. Burks, 4310, 3/3/81, 20 pages, IV.3861/38.

Records personal prejudices and inclinations of the author, to stimulate dialogue.

See also: Accident Response and Accident Environments File Collection, IV.6290/2 for Lightning Events, 1961-68.

Emergency Destruction (ED)

UNC Memo, "Destruction of Nuclear Weapons By Burning in a Liquid Hydrocarbon Fuel Fire," W. L. Stevens, 1230 to Distribution, 12/22/76, 1 page, IV.3856/3.

Contains proposal by Sandia to discontinue this method of emergency destruction.

SRD Memo, "U.S. Policy for Emergency Destruction (U)," W. L. Stevens, 7230 to A. A. Lieber, 330, RS 7230/8201, 6/25/82, 4 pages, IV.3862/19.

UNC Memo, " Strawman Write-ups of Concerns, Operational Safety Review '85," W. L. Stevens, 1230 to Stuart Wright, DOE/AL/WSSB, 6/18/85, 6 pages, IV.3865.

Discusses three concerns: logistical movements by helicopters, fire-fighting for nuclear weapons involved in fuel fires, and emergency destruction (ED).

Enhanced Nuclear Detonation Safety (ENDS)

No file collection on this subject has been located.

UNC Memo, "Nuclear Safety Design Guidelines (U)," W. L. Stevens-1650 to L. A. Hopkins. Jr., 9500, 11/12/68, 1 page, IV.3852/30.

This is perhaps my earliest expression of intent for direction to be taken by Stan Spray's safety design division to begin on 11/15/68, favoring quantitative approaches over the qualitative.

UNC Briefing Text, " Design for Safety: Weak Link/Strong Link Concepts," W.L. Stevens, SNL, Briefing for DoD's Military Liaison Committee, 11/17/70, 4V.1593/30, 15 pages.

Contains my notes for the first extra-Sandia briefing on the concepts that later became known as ENDS.

UNC Memo, "Revised Standards for Nuclear Safety" W. L. Stevens, 1650 to Dept. Mgrs. 1200, 1500, 8100 and 1640, 8/31/72, 15 pages, IV.3852.

This was a draft memo that proposed a new nuclear weapon design safety approach (later called ENDS) for weapons development and in stockpile. The file copy is marked with changes based on comments received. The document includes a strawman memo that I drafted from Carl Walske, DoD/MLC to John S. Foster, DoD/DDR&E, on the practice of the military services in unilaterally weakening the "Walske" safety criteria.

UNC Memo, "Revision of Nuclear Safety Standards," W. L. Stevens, 1650 to W. J. Howard, 1000, 9/16/72, 5 pages, IV.3243/3.

Contains the first opinion of W. L. Stevens on the impact of ENDs on the nuclear safety process.

Explosive Ordnance Demolition (EOD)

The file collection is IV.3927 (through 1983) and it contains 104 numbered documents.

This subject has interfaced with S^2C in several important ways. The discipline of EOD changed drastically from concentration on unexploded shells and land mines on the battlefield (World War I) to removal of danger to the general populace caused by unexploded bombs and warheads in cities (World War II, England). The discipline became highly technological in nature when Germany realized the terror value and began to install clever, deadly anti-disarming features into the ordnance. This concern carried over to U.S. nuclear weapons in the form of EOD personnel "requiring" full disclosure of weapon designs in order to prescribe safe EOD procedures, to publish the procedures in military manuals and to train EOD personnel in execution of the procedures.

An early concern of mine was the availability of highly sensitive, detailed information on electrical circuits for weapon safing, arming and firing in EOD manuals and the worldwide distribution of the manuals (See page 58 of the text). After leading the process to eliminate the information and restrict distribution of manuals, my concerns shifted to the EOD practice of requiring the tearing apart of weapons that had been involved in accidents or serious incidents in order to remove the nuclear material from the high explosives that surrounded the material (so-called "Render Safe Procedures"). EOD teams were trained to do RSP and naturally insisted on doing RSP on every applicable actual nuclear weapon accident and accident exercise, on which I studied. For example, the Navy EOD team insisted on tearing down the B28FI bomb recovered at sea at Palomares on the barges at sea. This process is not suited to such field operations and requires very special equipment found only in the AEC/ERDA/DOE weapon production plants. Two of the AEC/DOD accident response team members successfully convinced military authorities that the bomb was safe to transport to a U.S. site for examination, precluding the need for RSP. The two were Stu Asselin of Sandia and a young Air Force officer from the DASA.

For almost twenty-five years, I engaged in conflicts with Sandia's military liaison organizations to correct these S^2C deficiencies and even at my retirement the solution was in view, but not at hand. My successor, Jim Ney, continued the battle and won in the late 1980s.

SRD Draft Working Paper, "Explosive Ordnance Disposal Procedures for Nuclear Weapons—A Re-Examination (U)," W. L. Stevens, 1650, RS 1650/036, 8/69, 73 pages, IV.3186/1, 4V.110.

> Reviews the broad area of EOD and concludes that the existing procedures are technically invalid. This report includes tables, summaries, incidents of partial arming of nuclear weapons, weapon components operated in major accidents and incidents and initial responses to accidents and incidents for sealed pit weapon.

UNC Memo, "Proposed Tech Manual TP 60-XX," W. L. Stevens, 1650 to I. M. Moore, 1610, 10/16/70, 1 page, IV.3852/15

UNC Memo, "New EOD Philosophy," W. L. Stevens, 1230 to L. D. Smith, 1200, R. L. Peurifoy, Jr., 4300 and W. J. Spencer, 8100, 9/7/78, 2 pages, IV.3927/43.

Recommends non-concurrence on a proposed W31 EOD manual because it included too much detailed design information.

UNC Memo, "EOD Training on Nuclear Weapon Component Identification," W. L. Stevens, 1230 to Distribution, 10/9/78, 7 pages, IV.3858/7.

See also the ARG/NEST sections.

CNSI Memo, "EOD Actions in Normal and Higher States of Readiness (U)," W. L. Stevens, 1230 to J. F. Burke, USAEC/ALO 7/28/80, 7 pages, IV.3860/14.

Recommends elimination of "wait periods" and "Render Safe Procedures" in EOD manuals for modern designs of nuclear weapons.

UNC Memo, "EOD Policy and EOD Training," W. L. Stevens to Distribution (Not Sent), 7/82, 10 pages, IV.3862/17.

UNC Memo, " Disposal of Damaged Nuclear Weapons In-Place," W. L. Stevens, 11/3/82, 5 pages, IV.3862/3.

See also: Accident Response.

UNC Memo, "EOD Training," W. L. Stevens, 7230 to Distribution, 1/23/84, 2 pages, IV.3864 transmitting SRD Memo, "On A Suggested SNL Policy for Explosive Ordnance Disposal Matters (U)," W. L. Stevens, 7230, RS7230/84/02, 10/16/80, 37 pages, and IV.3862/17, listed above.

Presents views on rethinking the DOE's approach to EOD and the technical content of EOD manuals.

UNC Draft Working Briefing Notes, "A Proposed Approach to Rethinking Technological Aspects of Explosive Ordnance Disposal for Nuclear Weapons," W. L. Stevens, 2/84, 41 pages. IV.3811/1, IV.2719/33. Not contained in IV.3864 (1984 Day File).

Insensitive High Explosives (IHE)

The file collection is IV.3417 and it contains 7 numbered documents. IV 3417/2 is the DoD's policy statement on incorporating IHE in developing nuclear systems.

See also the section on Plutonium Dispersal Safety.

Intrinsic Radiation from Nuclear Weapons

No file collection on this subject has been located.

CRD Draft working Paper, " On Intrinsic Radiation from Nuclear Weapons (U)," W. L. Stevens, 1230, 18/10/79, 18 pages, IV.3859/3.

> Summarizes the history of treatment of intrinsic radiation concerns in TP20-7 "Nuclear Safety Criteria" and suggests a change on approach.

UNC (An unclassified version of the above is IV.3860, dated 3/3/80).

UNC Memo, "SNL Role in Intrinsic Radiation (INRAD) Study by MLC," W. L. Stevens to R. L. Peurifoy, Jr., 4300, 10/13/80, IV.3860/8.

Logistical Transportation

The file collection for this subject, if any, has not been located.

UNC Memo, "Some Opinions on Safety in Transport of Nuclear Weapons," W. L. Stevens. 1650 to Distribution, Undated (Probably late '74), 6 pages, IV.3853/6.

> Contains my opinions on the state of plutonium dispersal safety considerations in logistical transportation, particularly as regards plutonium mass limit increases being proposed by Colonel Marv Sullivan, FC/DNA.
>
> See also IV.3865 of 6/18/85.

Mechanical Safing and Arming Detonator (MASD)

There is no file collection on this subject.

UNC Memo, "MSAD and the W84 Program (U)," W. L. Stevens, 1230 to W. J. Howard, 2 through G. A. Fowler, 1000 and L. D. Smith –1200, 7/5/79,IV.3859/20.

> Addresses whether MSAD is worth doing at all and what it would take to do MSAD well. This is an example of the relatively rare need to elevate a safety issue to high-level Sandia management attention, especially avoidance of "safer" claims.

CFRD Memo, "Adequacy of Safety Provided by MSADII (U)," W. L. Stevens to Distribution. 10/15/82, 2 pages, IV.3862/9.

> Alerts Sandia management to a possible conflict of interest event.

CFRD Draft Letter, Same as above (Untitled Letter, Paraphrase), T. B. Cook to William B. Shuler, LLNL/ADMA, 3/29/83, 4 pages, IV.2719/15.

CRFD Memo, "Comments on the W84 (U)," J. W. Grear, 4/6/83, 11 pages, IV.2719/16.

Memoranda of Understanding (MOU)

The file collection is IV.3350 and it contains 21 numbered documents. The folder is labeled " Presidential Decision Memo/Memorandum of Understanding."

See also IV.3054 "Safety Requirements," 89 documents. See also Dual Agency Responsibilities section.

UNC Memo, Comments on Proposed MOU on Nuclear Weapon System Safety Rules dtd 5/29/78 "(Untitled: Paraphrase), W. L. Stevens, 1230 to Distribution, 6/8/5, 33 pages, IV.3858/19 and IV.3350/10.

> A collection of 6 attachments providing background information for SNL directors on the subject.

UNC Memo, "Comments on Draft MOU on Nuclear Weapon System Safety Rules" (Untitled: Paraphrase), Morgan Sparks (by W. J. Howard) to MG J.K. Bratton, USDOE/DMA, 6/20/78, 58 pages, IV.3222/36, 4V.162B, and is a part of IV.3858/12.

> Disagrees with draft version by the DoD. Supports dual agency responsibilities concept.

UNC Memo, "Agreements on Processing of Nuclear Weapon System Safety Rules (U)," W. L. Stevens, 1230 to Distribution, 8/1/78, 17 pages, IV.3858/12.

UNC Memo, " Proposed Presidential Directive and DOD/DOE Memorandum of Understanding on Nuclear Weapon System Safety Rules," W. L. Stevens, 1230 to Distribution, 11/30/79, 13 pages, IV.3859/8.

> Contains side-by-side, line-in-line-out markups of three interactions in evolution of a PDM/MOU.

Military Characteristics (MCs)

The file collection is IV.3243 and it contains 7 numbered documents.

Nuclear Power Reactor and Fuel Cycle Safety

There is no file collection. One collection is in my day file for 1973, i.e., IV.3853.

(References 66 through 69 of the text).

Private Memo, " Comments on Transportation of Nuclear Reactor Fuel," W. L. Stevens, 1650 to Distribution, 8/73, 12 pages, IV.3853/18.

Contains critical comments on the AEC's Environmental Impact Statement For Reactor Fuel Transportation.

UNC Memo, "Senate Hearings on Transportation of Hazardous Materials," W. L. Stevens, 1650 to Distribution, 6/19/74, 2 pages, IV.3853/9.

Nuclear Safety Standards, Requirements, & Responsibilities

The file collection is IV.3054, and it contains 89 numbered documents

UNC Draft Memo, " Interpreting Safety Goals," W. L. Stevens to Distribution, 2/18/71, 6 pages, IV.3852/13.

Contains early thoughts on using quantitative goals for nuclear safety, e.g., probability of an occurrence and probability of specific, undesired consequence, given an occurrence.

CFRD Memo, "Background on the 'Walske Letter'," R. L. Peurifoy, Jr. 4300 to LTG A. D. Starbird, 12/20/79, 2 pages, IV.3859/2.

Transmits the "Walske Letter" and comments of Peurifoy/Stevens for use in the "Starbird Study".

UNC Time-Line and Annotated References, "Nuclear Detonation Safety, Arming and Firing Subsystem Aspect, Evolution," W. L. Stevens, Late, 1980, IV.3360/3.

This is one of a net of four. Others are on Nuclear Detonation Safety, HE/Nuclear Subsystem Aspect, Evolution (IV.3860/1); Nuclear Weapon Destruction, Disablement, or Denial, Evolution IV.3960/2 and Nuclear Weapon Use Control Evolution (IV.3860/4).

Nuclear Safety Philosophies, Policies and Practices

The file collection is IV.3139 and it contains 68 numbered documents. The folder is labeled "Safety Philosophy".

See also: Mechanical Safing and Arming Detonator (MSAD) section.

SRD Draft Working Paper, "Peacetime and Wartime Nuclear Safety Risks for Device/Weapon Electrical System Designs Used in Full Scale Nuclear Testing (U)," W. L. Stevens, 1650, 5/71, 16 pages, Transmitted by UNC PRIVATE Memo, FLAX Nuclear Safety," W. L. Stevens, 1650 to G. E. Branvold, 8170, 6/9/71, 1 page, IV.3833/42.

> Reviews evolution of quantitative nuclear safety design requirements for weapons, weapon systems and device testing and suggests use of Walske-like" criteria for the latter activity.

UNC Draft Memo, " National Nuclear Weapons Safety Practices," W. L. Stevens, 1230 to Distribution, 2/13/76, 3 pages, IV.3856/32.

> Discusses need for a national center of excellence for nuclear safety to be located in Albuquerque, NM.

UNC Draft Working Paper, " A Reappraisal of the U.S. Nuclear Weapon System Safety Program," W. L. Stevens, 12/76, 18 pages, IN.1182/1, with:

> <u>Appendix A:</u> A Description of the National Nuclear Weapon Safety Study Program, 16 pages.
> <u>Appendix B.</u> Dual judgment Roles in Safety, Control and Security of Nuclear Weapons, 8 pages.
> <u>Appendix C:</u> Principles Guiding Nuclear Weapon Safety Activities at Sandia Laboratories, 4 pages.
> <u>Appendix D:</u> Coverage of Some Risks for Nuclear Weapons by Groups and Other Activities, 9 pages.

> This lengthy memo discusses four concerns and possible alternative actions to address each: (1) lack of institutional framework to resolve issues and disagreements, (2) lack of national directives for dual agency responsibilities, (3) low quality of technical analyses for safety studies, and (4) insufficient coverage of risks other than nuclear detonation.

CFRD Draft Working Paper, "War and Peace and In Between—Nuclear Detonation Safety Aspects of Theater Nuclear Forces in Europe (U)," W. L. Stevens, 1230, 3/10/77, 41 pages, IV.3857/10.

> Discusses safety aspects of the process of " wind - down" from high states of readiness.

UNC Memo, "Nuclear Safety Design 'Requirements'," W. L. Stevens, 1230 to H. W. Schmitt, 4340, 4/13/77, 15 pages, IV.3857/11.

Gives references and notes on eight documents concerning "requirements" for nuclear weapon electrical subsystems.

UNC Draft Memo, "Picatinny Arsenal's Requirements for Nuclear Safety in Designs," W. L. Stevens, 1230 to Distribution, Draft, 7/25/77, 7 pages, IV.3857/5.

UNC PRIVATE Draft-Working Paper, "Some Key Events and Dramatis Personae in the Nuclear Weapon System Safety Program Over the Past Decade," W. L. Stevens, 2/1/78, 14 pages, IV.3858/33.

Discusses the writer's premise of serious erosion in this safety program at all levels of consideration.

CFRD Draft Working Paper, "Some Key Nuclear Weapon Safety Developments By the DOE Weapons Design Laboratories Over the Past Decade (U)," W. L. Stevens, 1210, 2/14/78, IV.3858/32.

See also; Dual Agency Responsibilities section.

UNC Memo, "Draft SL Positions on Certain Special Concerns Regarding Nuclear Weapons," W. L. Stevens, 1230 to Distribution, 7/13/78, 11 pages, IV.3858/15.

This memo contains suggested policy statements for Sandia in the areas of nuclear detonation safety, radioactive material dispersal safety, explosive ordnance demolition, use control and security. It was prepared for Sandia's internal Stockpile Interfaces and Responsibilities Study (IV.3858/23) and it became the basis for the memo listed below (IV.3850/10).

UNC Memo, " Strawman DOE Position Paper on Safety, Control and Security," W. L. Stevens, 1230 to Distribution, 9/7/78, 7 pages, IV.3858/10.

These statements were based on the content of IV.3858/15, above, but were adapted to the role of the DOE's Nuclear Weapon Coordinating Committee.

UNC Memo, "MA's Draft Policy Statement on CDS (U)," W. L. Stevens, 1230 to W. J. Howard, 2, 12/09/78, 6 pages IV.3858/1.

Discusses implication of an expanded role (proposal) of DOE/AL in S^{2}C matters.

See also. Ref. 174 (W. J. Howard on F4 Rules), IV.3139/20.

UNC Article, "Some Involvement of Sandia Laboratories in U.S. Air Force Nuclear Safety and Surety Activities," W. L. Stevens, 1/9/79, 7 pages, Transmittal Letter from Morgan Sparks to Col. Wendell E. Cosner, USAF/DNS, 1/12/79, IV.3859/32.

Published in USAF/DNS's Nuclear Safety magazine. Discusses Sandia's roles and missions in S²C.

CFRD Memo, " Some Philosophical Thoughts on the W79 Pantex Safety Study, Abnormal Environments and Use Control (U)," W. L. Stevens, 1230 to Distribution, 7/21/81, 15 pages, IV.3861/22.

Discusses the proliferation of "safety" concerns that the DOE seems to expect NESS groups to handle and potential impacts on Sandia.

UNC Memo, "Request for Comments on Draft DOE Policy Paper on Nuclear Safety Matters," W. L. Stevens, 7230 to Distribution, 6/622/83, 11 pages, IV.3863/5.

Attaches strawman draft reply to be signed by SNL President to MG W.W. Hoover DOE/DMA regarding subject policy paper draft, questioning the notion of "independent judgement" vs. "dual agency judgments."

See : Dual Agency Responsibilities.

UNC Memo, "Comments on Annual Report to the President on Nuclear Weapons Surety, 1983," W. L. Stevens, 7230 to Lt. Col. G. T. Palmer, USAF, DOE/OMA/SE&EA, 3/5/84, 1 page, IV.3864/9.

Mentions avoiding the advertisement of safety R&D vs. safety accomplishments, and in particular attributions to individual laboratories Nuclear Safety Rules

No file collection on this subject has been located. At one time, there was a folder "Safety Rules: General". See also Memoranda of Understanding (MOU), page 261. See also IV.3054 Safety Requirements," 89 documents.

UNC Memo, "Example of Time Taken Between Approval of Interim and Final Nuclear Safety Rules" (untitled paraphrase), P.F. Jones and F.J. Murar to W.J. Howard, 2/9/78, 4V.1628/9.

UNC Memo, "AEC/ERDA/DOE Non-Concurrence in Nuclear Safety Rules," W. L. Stevens, 1230 to L. D. Smith, 1200, 2/23/78, 2 pages, IV.2719/35.

Cites two examples of threatened (not actual) non-concurrence: SAFEGUARD ABM System and POSEIDON.

UNC Memo, " Procedures for Nuclear Weapons Safety Rules" (Untitled, Paraphrase), MG J. K. Bratton, USAEC/DMA to Morgan Sparks, SNL President, 3/24/78, 1 page, IV.3054/60.

"There should be no question that SL, as the principal technical adviser to DOE on nuclear weapons safety matters, should communicate directly with me or any weapons safety issue which you believe should be called to my attention."

CFRD Draft Working Paper, "A Suggested Methodology for Sandia Laboratories' Handling of Nuclear Weapon Concerns Having Negative Warfare, Waging Potentials," W. L. Stevens, 1230 Based on Inputs from an Ad Hoc Committee," 6/78, 53 pages, transmitted by CFRD memo, "Strawman Version of Stockpile Interface Responsibilities Committee Preliminary Findings (U)," W. L. Stevens, 1230 to Distribution, 6/14/78, 1 page, 3V.129.

> Discusses some areas of Sandia concern: nuclear detonation safety, radioactive material dispersal safety, use control, weapon destruction/disablement/denial and explosive ordnance demolition and their possible interactions. Uses nonviolent disablement as an example.

UNC Memo, "Status of Safety Rules (U)," W. L. Stevens, 1230 to W. J. Howard, 2, 4/13/79, 2 pages, IV.3859/24.

> Is a news note on status of rules processing, a subject of personal, continuing interest to W. J. Howard. Mentions Joe Luger's attempt to rewrite rules for most Army systems.

UNC Memo, "Status of Nuclear Safety Rules Involving OVERRIDE Switches," W. L. Stevens, 1230 to W. J. Howard, 2, G. A. Fowler, 1000 and L. D. Smith, 1200, 8/9/79, 3 pages, IV.3859/18.

> Update on status of certain rules.

UNC Memo, "B61-3, 4 and 5 Signal Selector Switch and the F-4 Weapon System," W. L. Stevens to Distribution, 9/6/79, 1 page, IV.3859/11.

SRD Rough Draft Memo, "F-4 Safety Rules (U)," Morgan Sparks to MGW.W. Hoover, DOE/DMA, RS 1230/80/04, 3/31/80, 3 pages, IV.3860/15.

> Draft version of Sandia's concurrence action on F-4 safety rules and the general issue of concern about operations with other air-delivered weapon systems. (No copy of final letter located in this file.)
>
> See also: "Pershing Ia Safety Rules," IV.3861/40.

SRD Memo, "Operator Dominance on Nuclear Safety Rules Issues (U)," RS 1230/82/18, 6/1/82, 10 pages, IV.3862/24.

> Cites example of reluctance of USAF to adopt safety measures that offset operations, preferring that DOE redesign the nuclear weapon.

Nuclear Weapon System Safety Group Studies (NWSSGs)

There are several file collections, one for each military service.

UNC PRIVATE Memos, "Recent U. S. Army Nuclear Weapon System Safety Studies" and "Lance Special Safety Study," W. L. Stevens, 1230 and J. L. Wirth, 8340 to W. J. Howard, 2, G. A. Fowler, 1000 and T. B. Cook, 8100, 3/23/78, 5 pages, IV.3858/20.

> Discusses the actions/inactions of specific persons/offices, especially those of Joe Luger.

UNC PRIVATE Rough Draft Memo, " The Politicization of Nuclear Weapon System Safety Studies by the U. S. Army (U)," W. L. Stevens, 1230 to Distribution, 7/78, 19 pages, IV.3858/5 and IV.3859/10.

> Describes the antics of Joe Luger.

UNC PRIVATE Memo, "Concerns On the U. S. Army's Nuclear Weapon System Safety Committee (NWSSC)," W. L. Stevens, 1230, with assistance of S. D. Spray and J. W. Grear, 12 pages, IV.3861/35.

> Describes the antics of Picatinny Arsenal's Ed Arber on Pershing II safety studies.

UNC Memo, "Role of the Army's Nuclear Weapon System Safety Committee (NWSSC)," W. L. Stevens Distribution, 4/26/82, 6 pages, IV.3862/32.

"One-Point" and "Popcorn" Nuclear Detonation Safety

The file collection is IV.3484 and it contains 58 numbered documents.

UNC Time-Line and Annotated References, "Nuclear Detonation Safety, HE/Nuclear Subsystem Aspect," W. L. Stevens, late 1980, IV.3860/2.

> This is one of a set of four. Others are on Nuclear Weapon Destruction Disablement, or Denial, Evolution (IV.3860/1); Nuclear Detonation Safety, Arming and Firing Subsystem Aspect, Evolution (IV.3860/3); and Nuclear Weapon Use Control Evolution (IV.3860/4).

SRD Memo, "Popcorn Guidance (U)," W. L. Stevens, 1230 to Distribution 3/17/8, 7 pages, IV.3861/34.

> Reports on the successful effort of Joe Luger, US Army (Retired) to block promulgation of technological guidance on the POPCORN phenomenon to military agencies, through non-concurrence on TP20-7

Personnel Assurance Program (PAP) and Human Reliability Program (HRP)

No file collection for this subject has been located. Use AskSam to search.

PRIVATE Rough Draft Memo, " Personnel Assurance Program (PAP) and Nuclear Safety," W. L. Stevens, 1650 to Distribution, 11/26/74, 12 pages, IV.3853/2.

> Contains a discourse on the ERDA PAP in late 1974, summarizing practices at the weapons laboratories and other weapons facilities.

UNC Draft Memo (NOT SENT), "Policy on Assignments to the Personnel Assurance Program," W. J. Howard, 2 to Distribution, 12/10/75, 2 pages, IV.3855/5.

UNC Draft Memo, " Suggested Policy on Access to Nuclear Weapons and Explosives by Employees of Sandia Laboratories (U)," W. L. Stevens, 1230 to Distribution, 11/5/76, IV.3856/9.

UNC Paper, "Guidance to Employees of Sandia Laboratories, Albuquerque Who Visit the Pantex Plant," W. L. Stevens, 1230, 3/41/77, 5 pages, IV.3857/13.

UNC Memo, "Personnel Assurance Program (PAP) Meeting," W. L. Stevens, 7230 to Carlos Garcia, USDOE/ALO/EA&H, 6/12/85, 2 pages, IV.2722/32.

Plutonium Dispersal Safety

No file collection for this subject has been located, Use AskSam to search "Plutonium Dispersal".

SRD Memo, "Informal Comments on Recent Visit to European Nuclear Weapon Installations (U),"W. L. Stevens-1650 to Distribution, RS 1650/016, 10/10/68, 7 pages, IV.3852/25.

> Reports on field trip to Europe by AEC/DOD Committee on Nuclear Materials Safeguards, focusing on emergency destruction and weapon transportation. This may contain my earliest thoughts on Pu dispersal (e.g., "All Orally" Army weapon), just after the revolution in Czechoslovakia.

UNC Draft Memo, "Suggestions for a Plutonium Contamination Safety Program," W. L. Stevens, 1650 to H. E. Lenander, 1600, 8/3/72, 8 pages, IV.3852/4.

> Suggests formation of a technical division in Dept. 1650 to focus on contamination safety in a way analogous to Stan Spray's work in nuclear detonation design safety. No interest developed.

CFRD Memo, "Plutonium Weight Restrictions (U)," W. L. Stevens, 1650 to H. E. Lenander, 1600, 10/20/69, 1 page + "attached memo" (not attached to file copy), IV.3852/22.

Transmits W. L. Stevens' first draft memo on Plutonium dispersal safety. Memo not found.

UNC Memo, "Selected Reference on Plutonium Scattering," W. l. Stevens, 1230 to Distribution, 4/20/76. 7 pages, IV.3856/21.

UNC Memo, "Transportation of RTG's for the Nuclear Weapons program, W. L. Stevens, 1230 to V. E. Blake-1710, 10/12/76, 2 pages, IV.3856/10.

CNSI Memo, "TP20-7 Plutonium Mass Limits", H.E. Roser, Manager DOE/AL to MG J.K. Bratton, DOE/DMA, 7/26/78, IV.3417. 3p.

Discussion of this issue of changing Pu mass limits is contained on page 141 of the text of SAND99-1308, this report. By this letter, DOE/AL declined to accommodate DoD's mandated change to a higher limit for all operations. This led to several years of joint studies on the subject.

UNC Paper, "A Perspective on Plutonium as a Radiological Hazard," John M. Taylor, 1233, 3/1/78, 17 pages, transmitted to Sandia distribution by memo from W. L. Stevens, 1230, "Comments by Sandians on Hazards from Plutonium," 1/30/79, IV.3859/31.

Presents a perspective on health hazards from dispersal of plutonium to the populace based on a survey of the literature. Cover Letter suggests that Sandians refrain from commenting on such hazards.

UNC Study Outline, "A Methodology for Decision-makers on Acceptable Storage Limits for Plutonium at Weapons Sites" (Untitled; Paraphrases), John M. Taylor, Transmitted to file by memo from W. L. Stevens, 1230, "Pu Mass Limits (U)," 2/16/79, 2 pages, IV.3859/27.

Presents a Sandia counterproposal to DNA's risk assessment methodology.

See also: Probabilistic Risk Assessment section.

UNC Memo, " Proximal Dispersion of Contaminants Center," W. L. Stevens, 1230 to Distribution Directors, (U)," 11/25/80, IV.3860/5.

Suggests a Sandia initiative to build a national-level capability in this area. LLNL later did this, called Atmospheric Release Coordinating Center.

UNC Memo, "Plutonium Mass Limits for Transportation by Logistical Aircraft," W. L. Stevens, 1230 to R. L. Peurifoy, Jr., 4300, 2/27/81, 2 pages, IV.3861/39.

In response to suggestions by USAF Inspector General Howard Leaf, this memo suggests measures to reduce the term "Prevention of dispersion, given an accident during logistical transportation of weapons by air."

CRD Memo, " Comments on Draft Environmental Impact Statement Annex on Nuclear Weapons Storage Facilities and Activities," W. L. Stevens, 1230 to G. P. Facer, DOE/DMA/SE&EA, 3/17/81, 3 pages plus 15-page attachment, IV.3861/36.

Comments on a DNA- sponsored study by Kaman Tempo of risks associated with a hypothetical weapon storage site (actually for a specific site).

UNC Memo, "Nuclear Weapon Configurations for Non- Operational Movements," W. L. Stevens-1230 to Distribution, 8/17/81, 2 pages, IV.3861/21.

Suggests use of accident resistant containers (ARCs) for logistical movements of theater –based weapons.

UNC Memo, "Risk of Pu Dispersal in Nuclear Weapon Maintenance Operations," W. L. Stevens to Distribution, 10/28/82, 3 pages, IV.3862/6.

UNC Memo, "Nuclear Weapon Accidents and Latent Cancer Fatalities," W. L. Stevens, 1230 to W. J. Howard, 2 through: G. A. Fowler, 1000 and L. D. Smith, 1200, 2/19/82, 14 pages. IV.3862/39.

UNC Memo," Minimum Detectable Lung Burdens Following Acute Plutonium Exposure," 1/27/82, 1 page, IV.3862/45, transmitting paper of same title, John M. Taylor, 4551 to R. E. Luna, 4551, 12/16/81, 5 pages.

CFRD Memo, "A Maxi Accident Consequences Scenario (U)," W. L. Stevens, 1230 to distribution, 3/30/82, 2 pages, IV.3862/49.

UNC Memo, "Risk of Pu Dispersal in DOE Non-Transportation Operations," W. L. Stevens, 7230 to T. B. Cook, 20, through: O. E. Jones, 7000 and J. M. Wiesen, 7200, 2/23/83, 8 pages, IV.3863/13.

Assembles documents on this subject, in relation especially to "Gravel Gerties".

SFRD Briefing Notes, "Plutonium Dispersal Risk in Nuclear Weapon Transportation Operations (U)," RS 7230/83/43, (document being located for filing in NSIC. It's in R. N. Brodie, 25 collection).

UNC Memo, "Observations on the State of Security Safety Interactions for Nuclear Weapon Operations in Europe (U)," W. L. Stevens, 7230 to Distribution, 11/7/84, 8 pages, IV.3864/2.

Probabilistic Risk Assessment (PRA)

The file collection is IV.3346 and it contains 20 numbered documents. The folder is labeled "Risks."

SRD Rough Draft, "A Unified Approach to Specifying Allowable Risks For Releases of Radioactive Materials (U)," W. L. Stevens, 1650 RS 1650/075, 8/28/73, 45 pages, IV.3853/20.

> Detailed essay on use of probabilistic risk assessment to all types of safety involving Sandia's assessments. Reviews the work of Chauncey Starr and Frank R. Farmer.

UNC Draft Paper, "Conceptual Approaches for Treating Engineering Aspects of Low Probability, High Consequence Risks to the General Populace," W. L. Stevens, 1230, 11/12/77, 28 pages, INJG601/7.

> Amplifies and arranges my notes from review of the literature on the subject of high consequence risks to the populace.

UNC PRIVATE Memo, "PM/PM and Me," W. L. Stevens 1210 to distribution, 1/78, 6 pages, IV.3858/37.

> Gives summary of origin and usage of Probabilistic Model / Positive Measures, INJG601/7, above.

CRD Memo, "Comments on DNA's Generic EIS Annex," W. L. Stevens, 1230 to J. R. Roeder, USDOE/ALO/OSD, 5/20/81, 4 pages, IV.3861/30.

> See also: CRD Memo IV.3861/36.
>
> Suggests that DNA's contractor, Kaman Tempo, not use a PRA approach, but use the PM/PM methodology being developed by the DOE weapons laboratories for the Pantex EIS.

UNC Memo, "Perspective on Use of Quantitative Estimates of Probability on Risk Assessments," W. L. Stevens to Distribution, 6/11/82, 1 page, IV.3862/22, transmits three draft working papers:

> Appendix A, On the Credibility of Probability Estimates of the order One-in-One Million Events Per Year, 15 pages.
>
> Appendix B, Predictions Involving Small Probabilities (F. W. Muller), 7 pages.

Appendix C, On the Use of "Realistic" or Conservative" Analyses in Risk Assessments," 12 pages.

UNC Briefing Aids, "A Risk Assessment Approach for the DOD/DOE Plutonium Dispersal Analysis Study," W. L. Stevens, Undated (probably 1983), 19 pages, IV.260/31.

These briefing aids were used during a trip to EUCOM by W. L. Stevens.
See also: Pu Dispersal.

Roles of Nuclear Safety Specialists

UNC Letters, "Comments on Revision of AL Chapter 0560" (Untitled Paraphrase), W. L. Stevens, 1230 to W. F. White, ERDA/AL, 1/18/77, 2 pages, IV.3857/15.

Discusses legislator, sheriff, objectivity, independence, etc., roles for Sandia's NESS members.

UNC PRIVATE Draft Working Paper, "On the Role of Sandia Laboratories' Technical Advisor in System Safety Studies," W. L. Stevens, Revision 2, 6/18/79, 17 pages, IN.378/24.

This discussion paper was stimulated by the general lack of support that NWSSGs gave to recommendations of the TWGs in the ERDA/DOD Stockpile Safety Study.

S^2C Committee of the DOE/ Defense Programs

The file collection is IV.2718 and it exists in several volumes.

UNC PRIVATE Memo, "DOE Oversight on S^2C Matters," (Untitled: Paraphrase), W. L. Stevens, 7230 to J. M. Wiesen, 7230, 5/17/83, 3 pages, IV.3863/10.

Discusses inappropriate actions at DOE/HQ levels and suggests S^2C Committee consider remedies.

See also: Dual Agency Responsibilities, DOE Orders and DOD Directive 5030.15 and Successors.

Security (& Custody)

No file collection on this subject has been located.

UNC Draft Working Paper, "Terrorism and Nuclear Safety, Security and Safeguards (U)," W. L. Stevens, 1650 to Distribution, 7/16/74, 5 pages, IV.3853/5.

Discusses differences in the Three "Ss" and which group at Sandia should be the initial contact for emergency response.

SRD Draft Paper, IV.3098/2, "Draft Paper on Custody of Nuclear Weapons, W. L. Stevens, 8/21/75, IV.3098/2, 18 pages.

UNC Memo, "Loss of Weapons," W. L. Stevens, 1650 to V. E. Blake, 1710, 12/9/74, 3 pages, IV.3853/1.

Contains thoughts on security from a safety person.

CFRD Memo, "The Black Dot Mousetrap (U)," W. L. Stevens, 1230 to Distribution, 12/4/75. 4 pages, IV.3885/3.

Describes an unintentional situation of lack of consideration of trade-offs among various aspects of "security" and "safety" for nuclear weapons.

CFRD Rough Draft Memo, "The Third Party Problem in Safety/Security (U)," W. L. Stevens, 1230 to Distribution, 3 pages, IV.3856/3.

Discusses threats of person(s) causing a nuclear weapon incident to occur without having to be present.

UNC Draft Working Memo, "Notes on Concerns Related to Custody of Nuclear Weapons (U)," W. L. Stevens, 1230 to A. A. Lieber-1310 and R. L. Peurifoy, Jr.-4300, 8/16/76, 7 pages, IV.3856/15.

Presents definitions of terms in S^2C, in preparation for the FORWARD LOOK study.

UNC Draft Working Paper, " On the Risk of In-Place Nuclear Detonations from Deliberate, Unauthorized Acts of Insiders," W. L. Stevens, 12/76, 24 pages IV.3856/5.

UNC Draft Working Paper, "On Adequate Security of Nuclear Weapons, The Fourth Nuclear Safety Standard," W. L. Stevens, 1230, 10/16/78, 8 pages, attached to IV.3858/4.

See also: NWSSG section.

Stockpile Safety Study, ERDA/DOD

The file collection is IV.3418 and it contains 15 numbered documents. The folder is labeled "Joint ERDA/DOD Nuclear Safety Evaluation of Stockpiled Weapon--General Correspondence."

SRD Memo, "Overview of Results of Systems Safety Studies for Upgrading Air- Delivered Weapon Systems (U)," W. L. Stevens- 1230 to Distribution, 1/25/78 Revision, 40 pages, IV.3858/35.

> Contains comments on Air Force and Navy NWSSG's concerning the TWG's recommendation relative to disconnection of cables and removal of elements for air-delivered weapon systems. This is a study of safety vs. operational readiness issues.

Use Control, Physical Access

No file collection for this subject has been located. Use AskSam for search for the Control and PAL. See also 3V.574, 3V.575, and XV.31.

UNC Draft Memo, "Why and How to Keep Safety and Command and Control Separate," W. L. Stevens, 10/1/71, 2 pages, (the last is numbered 13, indicating this is a section from another document), IV.3853/10.

SRD Draft Working Paper, " On Pre-Disenabled Designs to Achieve Safety Control and Security of Nuclear Weapons (U)," W. L. Stevens et. al., RS 1230/79/011, 10/24/79: Revised 1/30/79, IV.2719.

> Suggests an R&D initiative by LASL/SL and LLL/SLL design teams, similar to those leading to IHE.

UNC Time-Line and Annotated References, "Nuclear Weapon Use Control Evolution (IV.3860/4)," W. L. Stevens, late 1980, IV.3860/2.

> This is one of a set of four. Others are on Nuclear Detonation Safety, HE/Nuclear Subsystem Aspect, Evolution (IV.3860/1); Nuclear Detonation Safety, Arming and Firing Subsystem Aspect, Evolution (IV.3360/3); and Nuclear Weapon Destruction, Disablement, or Denial, Evolution (IV.3860/4).

CFRD Memo, "Technology Denial Concept for the Control Subsystems (U)," W. L. Stevens, 7230 to Distribution, 5/17/82, 1 page, IV.3862/11, transmits CFRD Memo, R. E. Smith, 7233 to W. L. Stevens, 7230, 9/8/82, "A Significant Improvement on Active Protection Systems (U)," 4 pages.

> Discusses a concept of destroying certain use control hardware after invocation of the denial penalty to preclude "reverse engineering" by adversaries.

CFRD Memo, "Certain Possible Susceptibilities to Adversary Actions, Pantex Plant (U)," W. L. Stevens, 1230 to L. D. Smith-1200, 2/15/82, 7 pages, IV.3862/42.

Discusses threats of small, arms projectiles on nuclear weapons and test devices.

UNC Memo, "DOE Security Affairs Council (SAC)," W. L. Stevens 7230 to W. C. Myre, 5200, 5/28/85, 2 pages, IV.3865/2.

Presents candid comments, requested by Orval Jones, on a DOE/HQ proposal to separate security from S^2 C concerns by forming another group within DOE.

OUO Draft Working Paper, "On the Risk of In-Place Nuclear Detonations from Deliberate, Unauthorized Acts of Insiders," W. L. Stevens, 12/76, 23 pages, IV.2743/4.

Discusses susceptibility of U. S. nuclear weapons by a person(s) allowed to be present to perform an authorized act, with focus on the two-man rule. This memo was a factor in the DOE/AL decision to use protective covers over weapon hardware at Pantex.

See file IV. 2743 of Jim Ney for this subject and IV.3351/2 for Gene Ives' response memo.

CFRD Rough Draft Memo, "The Third Party Problem in Safety/Security (U)," W. L. Stevens, 1230 to Distribution, 5/17/77, 3 pages, IV.s30/1.

Adds another threat to "insiders" and "outsiders"; namely, a third party with skill and knowledge, who can gimmick equipment so as to later function to cause an unwanted action without having to be physically present then.
See also: Security.

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INDEX

A

B

DELETED

C

DOE 6.2(a)

[redacted]

D

E

F

G

H

I

J

DELETED

DOE b2(a)

K

L

M

DELETED

DOE 6.2(a)

DELETED

DOE 6.2(a)

N

O

P

Q

R

S

T

U

V

DELETED

DOE 6.2(a)

X

DELETED

DOE 6.2(a)

[redacted]

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1	MS0457	George Novotny, 2001
1	MS0479	Bill Tedeschi, 2113
1	MS0481	Mark Rosenthal, 2114
1	MS0481	Kent Meeks, 2131
1	MS9034	Robert Monson, 2263
1	MS9036	Martin Hinckley, 2266
1	MS9014	Dennis Beyer, 2267
26	MS0632	John Hogan, 2907
1	MS0429	Steve Rottler, 2100
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1	MS0421	Ron Detry, 9800
10	MS0428	Dave Carlson, 12300
1	MS0492	David Olson, 12332
1	MS0492	Nuclear Safety Information Center, 12332
1	MS1219	John Taylor, 5907
1	MS9018	Central Technical Files, 8945-1
2	MS0899	Technical Library, 9616
1	MS0612	Review & Approval Desk, 9612

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