

# AAFM

*Association of Air Force Missileers*

Volume 6, Number 1

"Victors in the Cold War"

March, 1998

## Guardian Challenge 1998



The 1998 Missile and Space Competition is scheduled for May 4-8, at Vandenberg AFB, California. Airmen, officers and civilians from space and missile units around the world will again compete to be "Best of the Best." Teams from operations, maintenance, communications, security and helicopter operations will again vie for individual, team and unit trophies.

For 1998, the competition returns to the wing format, as it was during the days when the Strategic Air Command ran the event. For the missile teams, it means that four units, the 90th, 91st and 341st Space Wings and the 321st Missile Group will be competing for the prized Blanchard trophy for the thirty second time. This will be the last year for the group from Grand Forks - the unit inactivates in July.

The *Association of Air Force Missileers* will be on hand again, with our traveling display and new computer controlled slide show. *AAFM* will provide commemorative coins to each of the competitors from the missile and space units. The coin features the 1998 competition patch and the *AAFM* logo.

## Missile Heritage

One of the primary goals of our association is to preserve the heritage of United States Air Force missiles and the people who design, develop, test, operate, maintain and support them. During our first year, we established the Missile Heritage Fund to ensure we could accomplish this goal. Each year, museums are asked to submit applications for missile and missile-related displays and projects, and a committee of *AAFM* board members determines who is awarded grants.

While our program is small by the standards required by many museums, we have donated almost \$37,000 in our first five years - over \$22 per member. Our grant committees have been very selective - they have chosen projects that were highly visible, in areas that attracted visitors and directly involved with specific missiles or systems. We have had to disappoint several museums - the number of applicants and the amounts asked for are far larger than our budget allows us to fund.

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**National Atomic Museum's Thor**

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## A Word from the Association

**Elections** - Please return the enclosed postcard to vote for the four board positions that must be filled this year.

**End of Year Financial Status** - *AAFM* continues in a sound financial condition. Our income for 1997 totalled \$28,723.34, including funds carried forward from 1996 (\$2,509.95), Dues (\$20,654.10), Donations (\$2,367.00), Interest (\$192.29) and earnings on investments (\$3,000.00). Expenses were \$28,609.38, including Admin/operations (\$4,824.97), Publicity/Advertising (\$733.40), Postage (\$3,387.82), Printing (\$6435.85), Grants (\$10,000.00), Awards/trophies (\$2,701.44) and Meetings (\$525.90). We carry forward \$113.96 to 1998, have reserve dues of \$37,342.85, with \$4,255.04 in checking and reserve dues in an investment account (liability of \$33,177.74, but worth \$41,451.91). Paid up memberships at the end of 1997 were 1307, about 200 more than last year, and total members was 1645.

**Lifetime Honorary Members** - This was the second year for us to honor some of our strong civilian friends and supporters. They are David Spain, Patrick AFB, Irene Johnigan, Warren AFB, Ken Towers, Grand Forks AFB, Mildred Roberts, Ellsworth AFB, Joe Sesto, Vandenberg AFB and Steve Kubick, Malmstrom AFB.

*AAFM* is a non-profit, tax-exempt organization under section 501 (c) 3 of the IRS Code. The Newsletter is published four times a year.

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**AAFM Slide Show** - I am putting together a computer controlled slide show to complement our traveling display. I have about 300 photographs and patches, but can always use more, especially from systems other than Minuteman and Titan I. A good copy of your photo from a commercial color copier (like Copy Copy) can be used, or I can return originals after scanning. Watch for the display at Guardian Challenge and local area meetings.

## Letters to the Association

Address your letters to *AAFM*, Box 5693, Breckenridge, CO 80424, or send by e-mail to AFMISSILEERS@compuserve.com. Letters may be edited to fit - content/meaning will not be changed.

**AAFM has received a number of calls and letters from people who are buying old Atlas or Titan sites - many ask for names of people who served at these sites. If you would like to contact one of these owners or interested parties, we can put you in touch with them.**

Dear *AAFM* My wife and I have planned for many years to purchase and renovate an "old" missile site for our retirement home. Last year, our dream came true - we acquired one of the nicest Atlas F sites left in the country - 578th SMS Site S-12, Corinth West, Texas. We are getting ready to move onto the site sometime before summer, 1998 and start our "lifelong" project.

I have been successful in acquiring a complete set of engineering drawings for all the sites in the 578SMS. What I have not been able to find is historical information, service rosters and actual site photos.

We would like to erect a plaque dedicated to those who served at this site and would appreciate any information your organization could provide. Additionally, we would like to decorate the wall at the bottom of the entry stairway with the 578th SMS patch, but I have not been able to find a color picture of it anywhere.

Any help would be greatly appreciated and I would enjoy talking with anyone stationed at this site. Once we get moved "down there", members of from your organization will be more than welcome to come visit.

Mr. and Mrs. Rikki Kirschner, Mountain View, CA

Dear *AAFM* I would be interested in talking with members that were in Atlas and Titan I. Any informa-  
 (continued page 3)

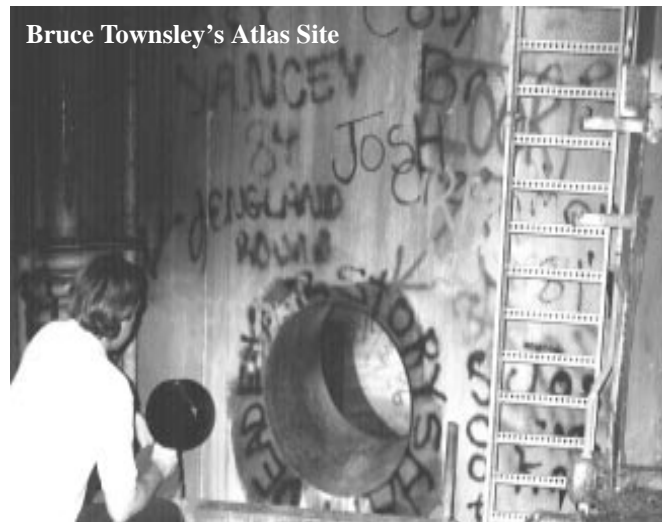
tion they could share would be greatly appreciated. I have many people ask to see photos of operational status, including exterior site layout, entrance and missile silo doors, launch control center and entrance, missile in the silo and topside and structures and floors in the silo. I am also looking for information on daily tasks while on duty. Gary G. Baker, Roswell, NM, mbr no SA047

Dear AAFM I purchased Dyess AFB Atlas F site S-5, 20 miles southeast of Abilene near Oplin. The LCC and the silo itself are dry. The LCC is intact (structurally) and two of the four blast doors are operable. All equipment has been removed. The internal structure is no longer suspended and sits on blocks on the LCC floor. Much of the electrical wiring is intact.

S-5 contains all the floors, spiral stairway, and counter weights. The water level in the silo is just above the bottom floor. The rest of the silo is relatively rust-free, with all beams and supports in original primer coat - and more recent graffiti modifications. Sections of some floors were removed, apparently to allow the removal of other equipment, but it can be walked top to bottom. Like the LCC, there is no functional equipment in the silo. The seals on the launch doors are good

I plan to remove the existing interior walls (debris at this point) and convert it to a livable area. As for the silo, I'll pump out the water and keep it dry for the time being. When I have finished the LCC I have thought of looking into the possibility of restoring it as a museum. Bruce Townsley, Mbr No SA043

Bruce Townsley's Atlas Site



**Heritage (cont)** - Our first year, we provided \$280 to the SAC museum for their "America's Shield" project, \$820 to the March Museum for a Minuteman MPT (which had to be returned at direction of the AF Museum) and \$900 for Titan I restoration at the South Dakota Air and Space Museum.

In 1994, the Hill museum got \$2,800 for a Snark display, the Titan Missile Museum \$1,000 to preserve Titan II films and photos and the South Dakota museum \$1,200 for a Minuteman video. The 44th Missile Wing donated remaining funds from their unofficial closing activities to our heritage fund.

In 1995, the 351MW donated remaining closing ceremony funds to us, so our grant rose to \$10,000. We gave the South Dakota museum \$1,500 for a Titan I RV, the Titan museum \$605 for a Titan II engine display, the Mighty Eighth AF Heritage Center \$605 for a photo display and the Air Force Museum \$5,790 for an introductory video for their new missile display. We began memorializing members who have died in 1995.

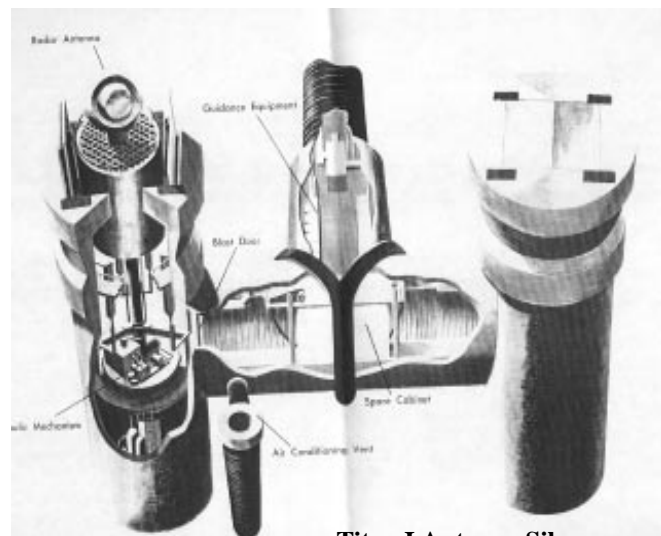
In 1996, we donated \$2,200 for pads for Atlas and Thor missiles for the new SAC Museum, \$800 for video equipment for docent training for the Titan museum, \$5,000 to the Malmstrom Museum to relocate displays and \$2,00 to the Warren museum for new displays.

In 1997, we provided \$2,500 to the March museum to relocate the Minuteman from the old 15AF headquarters, \$3,000 to the Chanute Museum for a "Chanute and the Cold War" display, \$1,525 to Vandenberg for lighting displays and \$2,500 to the National Atomic Museum at Kirtland to restore a Thor missile.

When you visit any of the museums that have benefited from our grant program, let them know that you are part of that effort. It has only been because of the generosity of our members that we have been so successful in preserving our missile heritage.

**Do you have information about any of the "false alerts" requiring crews to put keys in launch switches during the 1970s? If so, contact AAFM**

**Donate to the AAFM Missile Heritage Fund and assist in funding missile displays. Patches, lapel pins, cups, publications and other items provided to you to recognize your donation**



Titan I Antenna Silos

## The Titan I Guidance System

by Gary A. Hoselton, of Portland, Oregon, an Airman First Class Guidance System Mechanic, 569th SMS, Mountain Home AFB in the days of Titan I. He is life member L138. After leaving the service, Gary installed an Athena computer from Beale at Oregon State University.

### The Missile and its Operational Complex.

The Titan I Intercontinental Ballistic Missile was a transitional design, having characteristics of both pioneering and modern missiles. It used liquid oxygen, loaded immediately before launch, and guidance was radio-inertial, which then was more accurate than all-inertial. It had a self-supporting structure, was a multistage missile for greater fuel efficiency, there were multiple missiles per complex, and the missiles and the guidance antennas were stored underground in blast-hardened silos. But, it had to be raised above ground for launch, which made it vulnerable for a few minutes prior to lift-off. Titan I was approved for construction in April 1955, first launched February 1959, on alert in April 1962, off alert April 1965 and shipped to storage when early missiles were replaced by the much more reliable and cost effective Titan II, Minuteman and sea-launched missiles.

Titan I was steered to target by a radio-inertial guidance system. The missile's autopilot flew the missile, using inputs from a two-gyro inertial platform for the first minute of flight through pitchover (and roll if needed), and subsequently using inputs from the inertial platform modified by pitch, roll, and yaw commands re-

ceived from the ground guidance system. Once clear of the atmosphere, the first stage ran out of fuel, explosive bolts fired, two separation rockets fired to separate the stages, and the second stage motor and vernier nozzles fired to life. The second stage motor had a fixed mount, so steering was accomplished by four small swiveled verniers. Ground guidance sent second stage and vernier shutdown commands about 500 to 600 miles down-range. Then, if the missile was within the programmed "box" in space, ground guidance pre-armed the warhead and said "bye-bye". Titan I was then moving about 17,000 miles per hour on a ballistic trajectory towards its target, five to six thousand miles out. The reentry vehicle, sheathed in Corning ceramic, reentered the atmosphere at fifteen times the speed of sound, and could be depended upon to detonate its nuclear warhead within a mile or so of the target.

A Titan I squadron had three missiles at each of three complexes, and a spare missile stored on base. Each 98 foot long missile sat vertical in an underground silo, with RP-1 (kerosene-like fuel) stored on board. At the start of the launch sequence, LOX was loaded and the missile and was raised by a massive elevator mechanism for above-ground launch. Once up and locked, ground guidance locked on to the missileborne guidance system. The missile could be launched fifteen minutes after the lox loading process started. The powerhouse could raise one missile at a time, so the second and third missiles could be launched at 7 1/2 minute intervals after the first. A Titan I complex was just that, the largest and most complex operational ICBM system ever built. Sort of like the B-36 bomber and the battleship Missouri; in that they successfully countered enemy capabilities, their development produced the inventions and innovations needed to develop the simpler, cheaper, and much more reliable successors that we have today.

**Origin of the Ground Guidance System** The Titan I guidance system was developed by Bell Telephone Laboratories (BTL). It started as a WW II shipboard radar, built by Western Electric Company, and grew to include an analog guidance computer for guiding early experimental rockets and the Nike-series missiles. The analog computer used two large motor-driven oil-filled sine-cosine potentiometers and lots of op amps to generate  
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**Titan I** (cont) -the guidance equation. A bank of ten-turn potentiometers provided variables to the guidance equation, so that roll-over and changes in acceleration could be programmed. The whole thing was sequenced by some little Western Electric 6167 ten-step pixie tubes. It used electron tubes, for this was before the proliferation of the transistor, and mean time between failures was acceptable for that era, but short.

By the early 1950's improvements in missile range and velocity demanded a vast speed and accuracy improvement in computing the guidance equation. The immense cost of launches required greater reliability of equipment. At BTL's request, Sperry Rand's Remington Rand Univac division undertook development of the first transistorized digital computer to be produced in numbers, the Univac Athena. It had a 24 bit word parallel processor using ones compliment arithmetic. Program input was via 7-hole punched mylar tape, memory was a 256 word magnetic core "scratchpad" and an 8192 word rotating magnetic drum, and output was a Remington adding machine with solenoids in place of the keys. Input/Output between Athena and the remainder of the guidance system was handled via relays, and occurred ten times per second. The Athena circuits, logic design, and commands were replicated in subsequent Univac and Control Data Corporation computers. The Athena was quite large, consisting of ten cabinets plus console on a 13.5 by 20 foot floor pan, plus two motor-generator sets remotely located. The first half-dozen Athena's were van-mounted, as was the BTL ground guidance system at that time. About 26 Athena's were built, and, almost unbelievably, none are known to have suffered an operational failure, either in military or civilian service.

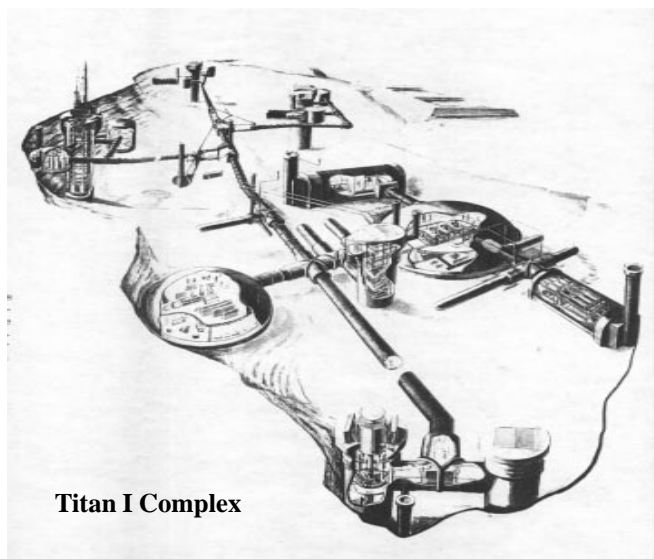
**Huge Guidance System** In a Titan I complex, the launch crew worked and slept on the spring-suspended second level of the underground control center. The second level contained the bulk of the guidance system, as well as the telephone exchange and HF radios which maintained contact with SAC headquarters and the airborne command post. Of the guidance system's 42 e-z-eye green cabinets, typically 3 feet wide and 6 feet tall and stuffed with electronics, 23 of them filled much of the second level. Five cabinets and four massive motor-generators were in an equipment room on the first floor of the con-

trol center, 11 cabinets were in the antenna terminal, and one was on the third level of the equipment terminal alongside each missile.

**Guiding Missile Flight** The program containing the guidance equation and trajectory constants for each missile was received on a 10 inch reel of punched mylar tape. The guidance officer loaded the contents of the tape onto Athena's drum memory, verified that it loaded without error, and stored the tape in a locked safe in the bottom of the paper tape reader cabinet. The guidance officer also dialed in variable constants, such as the current index of refraction of the atmosphere, at his guidance console every four hours. He used a custom Pickett aluminum slide rule, with special scales for Titan I, to calculate several of the variables. When the launch message was received, he powered up the guidance system. Anyone in the control center felt and heard the growl of the guidance system motor-generators coming up to speed. Then he raised one of two large, silo-contained, Western Electric dish antennas, commonly used in high-powered radar applications. The radome was large enough for two technicians to comfortably stand inside of while working on the goodies. Two massive concrete blast doors opened upwards and the 20 foot tall antenna assembly slowly rose above the desert floor and locked into place. The antenna slewed in azimuth and elevation, to point at the missile being raised, and the range computer set the radar receiver's range gate to open at just the right time to receive a signal from the missile and no other source. At the same time, the Athena disabled its drum write function and its control console, to insure that no perturbation or error in operation corrupted the guidance program. When the missile was above ground and powered, the radar antenna locked onto the little edge-of-a-cigarette-pack antenna high on the missile, and the ground guidance system began communicating with the three rugged Western Electric blue boxes located way up in the transition structure under the nose cone. One might think that a radar antenna sent a signal to the missile, and received a reflection of the signal off the skin of the missile. This was the earlier scheme, but it had the embarrassing disadvantage of locking on the metal sheds or vehicles in line with the missile, objects which remained on the ground after missile lift-off. Titan I used a radio

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link, which the ground antenna sent a signal to the missile and then, after a precise delay, the missile transmitted a strong crisp signal back to the ground antenna. Hence, Titan I had radio/inertial guidance scheme using a radar antenna on the ground. It was controlled by its inertial autopilot for the first several minutes after lift-off. After a minute of flight, the inertial system pitched the missile northward, to begin gaining speed and altitude. As the ground antennas were located about a half mile south of the missile launch point, flames from the first stage engine broke communication between the missileborne antenna and the ground guidance antenna, so the inertial system also rolled the missile about 180 degrees to reestablish line-of-sight contact between the antennas. From this point onwards, ground guidance controlled the flight path of the missile, through pitch, roll, yaw, and shutoff orders delivered via the blue boxes to the inertial autopilot. The return signal from the missile was focused by the ground antenna's large parabolic reflector onto a horn, which was physically split into four quadrants. If all four quadrants received the missile return at the same time, then the ground antenna was pointed exactly at the antenna on the missile. If the upper quadrants received the missile return before the lower quadrants do, then the missile antenna had risen above where the ground antenna pointed. The missile return was resolved into azimuth, elevation, and range by the ground guidance receiver and range computer, and this information used to reposition the antenna and sent to the Univac Athena computer. In microseconds, Athena computed any change needed to steer the missile onto a ballistic path to target, and issue pitch, roll, and yaw orders. These were sent the quarter mile out to the ground antenna and transmitted to the missile. This communication repeated ten times per second. When the guidance program in Athena determined that the missile was properly on course and velocity to reach the target, it issued commands to shut off the second stage and vernier engines and pre-arm the warhead. Lastly, Athena printed out the calculated miss distance in tenths of a mile. Fifteen minutes later, the warhead reentered the atmosphere and hit its target. If another missile was to be launched, the guidance officer had little time for prayers and paperwork.



Titan I Complex

**Redundancy for Success** Each site had two radar antennas in their own hardened underground silos. If a raised antenna was destroyed, the guidance officer raised the other antenna to guide the remaining missiles. Another redundancy was the "handover" scheme. The guidance system at each site contained azimuth, deviation, and range coordinates for a point in the air over each missile at the other two sites, typically 20 to 30 miles away. For example, if A-site's ground guidance system failed but their missiles were otherwise launchable, C-site could slew their antenna to a point in the sky over the missile to be launched by A-site, and attempt to capture the missile as it rose over the horizon and guide it to target. The lift-off signal was transmitted from A to C via a dedicated commercial telephone circuit. As there were three missiles at each of three sites, the guidance system at each site contained complete information for 9 missiles. A more mundane redundancy was the installation of dual motor-generators for the guidance system and for the Univac Athena computer, four MG's in all. The guidance officer periodically swapped MG's and antennas.

**Missiles on Alert** Strategic Air Command required that all weapons and crews on Alert status be exercised daily, to prove readiness. For aircraft on alert, the crew would rush out each morning and run up engines, check radios, and inspect the bird. An aircraft and crew might be on alert for three weeks, then in maintenance or off flying

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**Titan I** (*cont*) - around for six weeks. Not so in missiles; the sites were always on alert and the crews were on alert almost continuously (or so it seemed!). Each morning at a Titan I site, the crew went through as much of an alert exercise as was practical, within the confines of safety. Missile and antenna silo door were not opened, to preserve the integrity of the complex.

The guidance officer's morning exercise was to power up the ground guidance system and exercise it. The best exercise is to acquire and guide a missile, and that is what he did. The "missile" was the Guidance Exerciser Set, a copy of the older Bell Labs analog guidance system turned backwards to simulate missile flight. It occupied three cabinets in the control center. Being old and built with vacuum tubes, it was trouble-prone, so much so that the guidance officer could often differentiate a failure to complete exercise as being the fault of the GuidX rather than the guidance system. However, the complex generally went off alert until a successful guidance exercise was obtained. So, a guidance technician was promptly thrown into a leaky old H-19 chopper and soon deposited within the complex fence. Avoiding the rotor blades, he ran to the entry portal, obtained permission to enter, rushed down the stairway that corkscrewed around the freight elevator, sped into the lower level of the control center, begged the cook to include him for lunch and maybe dinner, and, zip!, upstairs to the second level to check in with the guidance officer. He fixed some faults in an hour, others took several days. If redundant Guidance Exerciser Sets had been designed into the system, it would have definitely been better!

**Reliability** As the BTL ground guidance system had evolved over some years, it was an amalgam of older tube-type gear, newer portions built with transistors, and even a few small enclaves of magnetic amplifiers. The transistorized portions, primarily digital, were virtually trouble-free, problems usually being in solder-joints or switches. The Athena computer never failed; the four technicians who serviced it were the original "Maytag Repairmen". The vacuum tube portions, primarily analog such as the radar receiver and the guidance exerciser, failed all too often. When there was a problem in the transistorized cabinets, it was generally a single fault, but a problem in a tube-type function often was caused by

multiple faults which had to be isolated and repaired one at a time.

**Test and Calibration** To guide an ICBM to target accurately, the guidance system had to know where, on the earth, its antennas were located. There was a white collimation tower (like an oil derrick) at the site, with an RF test set at its base which generated signals simulating a missile. The signals traveled up a waveguide and out an opening near the top of the tower. The radar antenna was slewed to point at the waveguide opening and the radar receiver was locked on to the signal. A precision "Made in Japan" telescope was permanently attached to the horizontal axle of the antenna. Looking through the telescope, one could see a target attached to the tower. The telescope was zeroed in on that target, so that the relationship of the radar beam and the telescope was known.

Second, there was a target atop a concrete pedestal near the perimeter fence, the location which was surveyed each year by an Air Force team shooting the stars over several bitter cold nights in midwinter, when the air was as still as could be. The antenna was slewed until the surveyed target was square with the crosshairs in the telescope, and the antenna azimuth and elevation was set to agree with the location of the target. Antenna azimuth and elevation outputs then agreed with constants resident in the guidance program. The procedure was repeated for the other antenna. Third, a precision accelerometer (an inverted Hooke joint pendulum in a chrome-plated cocoon) was located in the base of each antenna. Its output went to a level computer in the antenna terminal. If an earthquake or blast should slightly move the antenna, the level computer corrected antenna position outputs accordingly.

Four other RF test sets, like the one at the collimation tower, were located in the Titan I complex. There was one on the third level of each missile's equipment terminal. Its output went by waveguide to a point on the missile silo wall facing the missileborne antenna. This allowed testing the guidance receiver, decoder, and transmitter blue boxes in the missile without raising the missile. The final RF test set was in the antenna terminal, with a "Y-ed" waveguide routed into each antenna silo, so that an antenna could be tested without elevating it above ground.

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**Titan I (cont) - Prologue** The six Titan I squadrons closed between March and June, 1965. What happened to the guidance systems? Some of the first Univac Athena computers released went to work in academia, at Tulane University, University of Colorado, installed over the Logan River in a University of Utah water laboratory, College of Idaho, Kansas University, and others. Interest in Athena waned soon after Digital Equipment Corporation put the first minicomputer on the market, the PDP-8, in 1966. The radar antennas and their controllers were probably reused on other DoD projects. Hopefully, the guidance exercise sets ended up as ballast in sonic deep dark place.



## Memories of the TTF

*By Colonel (Retired) Dick Schoonmaker, member number A0100, who now lives in Englewood, Colorado*

The school house for Titan II maintenance training was at Vandenberg during the 1960s at a facility called the Titan Training Facility (TTF). It was located just west of the Titan I complex on North Vandenberg. The facility was a replica of a TII site complete with silo and missile. An interesting sight as you drove up to the complex was a huge piece of concrete just off the road. It was part of a silo door from the Titan I site up the hill from the TTF. During a missile retract after a propellant load test the missile exploded in the silo and threw the door some 300 yards. (Jan 1996 Newsletter)

After Titan II training at Sheppard in June 1962,

we were assigned to the 395th Strategic Missile Squadron. Some months later we became part of the 4315th Combat Crew Training Squadron. Some of us in the third class out of Sheppard were to become TTF maintenance instructors, with the first students arriving in late 1962. Martin Marietta personnel trained us and we were placed on three teams, two or three officers each, with a cadre of enlisted personnel who were specialists in certain missile functions. The TTF would train operational unit maintenance crews in the procedures and requirements necessary to bring Titan II to alert. Training encompassed receipt and checkout of a missile in the MIMS (MAB?), transport to the site, missile installation and removal, propellant loading/off loading, guidance installation/check-out, and the many tasks associated with the silo aerospace ground equipment (AGE). The silo had work platforms, pump rooms, diesel, silo door system, etc., almost a complete operational site. Water was used in place of actual propellants but RFHCO suits were worn to make the operations realistic. There was a partial LCC for combat crew use as part of their training so as to become familiar with maintenance procedures and the coordination expected of them.

We began our instructor training using Martin supplied "blue line" tech data, and along with Martin, made changes as we performed the receipt to launch tasks. The infamous PERT charts, electrical schematics and trouble shooting guides were worked and reworked until all felt we were ready for our students. We had outstanding people to guide us. Major Dusty Rhoades was our first boss, then Major Jim Snavey. My team lead was Captain Jerry Petricek, a superb pilot, leader, and friend. The Senior NCO was MSgt Keller, ramrod straight, highly experienced, a natural leader who led by example and was the kingpin to our successful operation. Our NCOs were all SSgts or above and had a wealth of experience from tours with Atlas, Thor, aircraft, or systems comparable to the AGE used on site. Members of the 3901st Strategic Missile Evaluation Squadron participated along with us so as to be ready when the first crews returned to their bases to begin work.

Our first students came from Davis Monthan AFB and they helped set the standard of excellence that was to prevail in all the base teams. Tech data was cor

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**TTF** (cont) -rected, procedures refined and improved, and soon a receipt to launch cycle operation was second nature. A Lieutenant Walt Yeager was one of the best. He not only had a successful Air Force career but went on to head up, and still does, part of the Titan IV program with Lockheed Martin. There were so many others - I can recall their faces, but names escape me. I remember one Captain who urged everyone to buy a new stock, Polaroid, and predicted great financial rewards. Boy, was he right, but what Lieutenant had money to do so? The ultimate success of Titan II can be attributed to these people and those who followed for their dedication to excellence. Once the initial cadre was trained the site was shutdown and training became the responsibility of the bases. I believe the missile went to a museum, but where? The site?? Again a question mark. We were all reassigned within the 4315CCTS.

Some interesting things happened, some amusing now, but one not so at the time. I had taken over a morning shift (Petricek was flying) from a team that had completed a propellant off-load and we would do an onload. The lines were still hooked up and connected to the holding trailers topside. Water flowed and then a voice on the radio net stated that the missile had tilted and was up against the work platforms on levels two or three. The thrust mount had not been properly configured and the weight of the water caused the bird to shift. 1st Strategic Aerospace Division Safety, as normal, was on scene but the guy was new and unfamiliar with how we did business. Needless to say we soon had Disaster Control, Hospital, Fire department and many shining Eagles all over the site. It took many minutes of explaining what had happened, that there was no danger from propellants, no one was injured (only my ego), and that by reversing the flow of water the missile would right itself, which it did. I had almost completed the mandatory seven years of service for eligibility for Captain (yes, seven years then) and expected it would take another seven once the boss got finished with me. Fortunately, a great boss and team leader prevailed and other than a good chewing and weeks of ribbing, all ended well. The missile was not damaged, only a rubber bumper on the work platform was creased. Other incidents were finding snakes in the sump or on the work platforms. They would come in under the silo door which we did not seat

after closing to save training time and we also had problems with the T-Locks. We survived the Silver Clouds several times. The cloud being pieces of Atlas missiles (Ds and Es) that often blew in those early days and the parts would be blown over our site which was east of their launch pads. We had a good masonry blockhouse for shelter.

I am forever indebted to MSgt Keller and the other TTF NCOs who taught me a great deal about leadership, loyalty, integrity, and command. During my watch as 3901SMES commander, I again witnessed these same qualities in our NCOs, dedicated people who gave of themselves for others, their units, and their country. To all of you from McConnell, Ellsworth, DM, Grand Forks with whom I served, thanks.

## Rivet Hawk

*By David Stumpf, member number A1008, who is authoring the history of Titan II and is involved with the Titan Museum in Green Valley, Arizona.*

In the early 1970's, the Air Force faced a dilemma with the original guidance system for the Titan II program. Design work on the original AC Spark Plug "Gold Ball" system had begun in 1958. Nearly two decades later, advances in the electronics industry made the system difficult to support as major suppliers, such as IBM which made the drum memory unit for the onboard computer, were not interested in maintaining the capability of building obsolete equipment in small lot sizes. In some cases the older components simply did not exist as suppliers had phased them out of their product line.

Fortunately, a readily available state of the art replacement was available, a modified Delco Electronics Carousel inertial guidance system. The Carousel IV inertial navigation system was standard equipment in the Boeing 747 and had been retrofitted into Boeing 707 and McDonnell Douglas commercial aircraft. Modification of the basic Carousel IV inertial reference unit for space applications was relatively simple, repackaging the instrumentation for the thermal environment as well as vibrational stresses of a missile launch. The modified system was given the name Universal Space Guidance System (USGS) and was composed of the Carousel IV inertial measurement unit and the Magic 352 computer (the commercial aircraft computer was the Magic III series).

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**Rivet Hawk** (cont) - The USGS system had already flown in the Titan IIIC program, the first launch was on 13 Dec 1973. Prior to RIVET HAWK six launches with one failure in the guidance system had taken place. The Titan II autopilot was used with minor modifications as was most of the airborne wiring. The umbilicals to the missile did not need to be replaced.

While the missile silo environment, as well as the missile flight profile, were obviously significantly different than that seen by the Carousel IV and Magic III systems, the missile installation had a major beneficial difference; the system would be on virtually all the time. In aircraft it was turned on and off several times a day depending on aircraft operations. One up and running, the system was most stable if simply left on.

Two Titan II missiles were selected for the test flight program. The first, B-17 (61-02771) was removed from 308th SMW Site 374-4 and arrived on 12 Dec 1975. The between-tanks truss that carried the guidance equipment needed to be rebuilt since the new system weighed slightly more than half that of the old system and occupied slightly less than half the space. To minimize developmental costs, consisting primarily of recalculation of target trajectories, the truss was reworked so that with the installed equipment the total weight and balance remained the same as the original truss. In addition, the new software was written to emulate the signal timing of the old guidance system so as far as the missile guidance system was concerned, it was as if no change had taken place. While the first stage wiring harnesses were used without modification, the Stage II wiring had to be completely reworked.

Charlie Radaz was the Martin engineer in charge of interfacing the new system into Stage II at Vandenberg AFB, Jim Greichen was the Martin Denver program manager. In November, 1975 the USGS program hardware modification began. Since USGS had flown successfully 11 times on Titan III-A satellite launches, the wiring harness rework was a fairly straight forward problem. Working through the Air Force Logistics Center, Hill AFB, Ogden, Utah, Martin Company had the contract for modifications to install the USGS platform, designing all the adaptors and wiring changes, as well as an additional telemetry transmitter for the RIVET HAWK flight. All

the modifications were done at VAFB.

Denver did the initial design on the mechanical adaptors, working closely with Delco and TRW representatives. A 10-foot diameter wooden mock-up of the current truss and guidance section was built and sent to Radaz and his group at VAFB. They then took out the guidance wiring harness from an current second stage, carefully measuring and photographing all of the attachment points, from the terminal points that interfaced with the first stage to the terminal connectors on the actual equipment housings. The harness was laid into the wooden mock-up and reattached. This gave them an exact mock-up to work from in designing the new harness and attachment points. The same autopilot was being used, the same thrust sensors, the only changes were to take the information from the sensors at a logical connection point, the terminal board interface, and rewire from that point forward to the computer. Once the changes had been made, the new harness was removed from the mock-up and reinstalled on Stage II of B- 17.

Stage I was installed in 395-C on 29 March 1976 as part of the Olympic Arena activities. Stage II was installed on 5 May 1976 and Alert/Ready status was attained on 18 June 1976. At 0214 28 June 1976, launch crew S-113, Captain R. B. Graves, MCCC; First Lieutenant G. M. Gillum, DMCCC; Staff Sergeant D. W. Boehm, BMAT; and Staff Sergeant K. R. Savage, MFT, began the launch countdown. Key turn took place at 0614 and within seconds a GUIDANCE HOLD occurred due to an INERTIAL GUIDANCE SYSTEM NO-GO signal. The shock produced during prevalve opening was sensed by the inertial measurement unit, triggering the hold. Robert Popp, the Delco representative for the RIVET HAWK program, remembers that about 30 minutes prior to launch, one of the Martin engineers had asked him if the hammer of the flowing propellants would be a problem. The new software had retained both a MEMORY and BLAST DETECT modes so the Delco team felt that the countdown could be resumed by pressing RESET if the hold occurred. Here was the chance to find out as the launch window continued to slip by. The IGS was returned to the READY mode, the countdown recycled and after downrange checks, the countdown resumed 18 minutes later. The second attempt, at 0240, encountered no

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**Rivet Hawk** (*cont*) - problems. Lift-off occurred at 0240:53.364. The flight to target was successful but the RV impacted 2 miles long and slightly wide of the intended target. Review of the telemetry from the guidance system, as well as extensive computer modeling revealed an error in the software. The unique feature of the USGS inertial measurement unit was the rotating X-Y platform. This feature mitigated a source of error in the X-Y plane that had to be accounted for in a non-rotating system. The newer computer in the system allowed the continuously changing X-Y instrument outputs to be monitored and update the platform alignment. On the USGS equipment used on Titan III, the platform rotated at one revolution per minute, for the Titan II program the decision was made to slow the platform down to one-quarter revolution per minute due to a failure rate with the one rpm system that was unacceptable for the Titan II program.

It seems that Titan II USGS programmers failed to provide a program path for the updating of the instrument coefficients after one minute, rather, it was after one revolution or 4 minutes. The resulting uncompensated instrument errors actually grew exponentially and by 4 minutes were unacceptably large. This was not known at the time but by a quirk of fate, the instrument error compensation values at the time of launch were 4 minutes old and the RV impacted long and somewhat cross range. Postlaunch review of the guidance software revealed all of this and the fix, which did not require another launch, was to refresh the instrument compensation factors after 90 degrees of rotation, or with a one quarter rpm system, once a minute as before.

## The Hound Dog - An Early Cruise Missile

The North American Aviation Hound Dog, initially designated the GAM-77 and later the AGM-28A and B, was designed originally for a short three-year life span as a standoff weapon for the B-52. The missile was to have been replaced by the Skybolt air-launched ballistic missile, but the Skybolt program was canceled in 1962. The missile would stay in service over 15 years before it was replaced by newer weapons like SRAM and ALCM. North American was awarded the contract to build Hound Dog in August 1957, and they relied heavily on work done on the Navaho intercontinental cruise missile.

The first powered flight of Hound Dog occurred in April 1959, the first guided flight in October and the Air Force accepted the first production missile in December of that year. Over the next three and a half years, North American produced 722 missiles for SAC.

The missile was 42 feet 56 inches long, with a wing span of 12 feet. It weighed 12,000 pounds fully fueled with its single warhead, and was powered by a Pratt Whitney J-52 turbojet engine. North American's Autonetics Division developed the inertial guidance system in conjunction with a star tracker. One missile hung under each wing of a B-52 between the fuselage and the inboard engines. The missile had a range of about 700 miles, flew at Mach 2 plus and could evade enemy defenses by flying turns or doglegs to its target.

SAC activated Airborne Missile Maintenance Squadrons in 1962 at each of the B-52 bases to provide the maintenance for the Hound Dog and its sister decoy missile, the Quail. These units had between 77 and 90 officers and airmen who had previously been assigned to Armament and Electronics Maintenance Squadrons.

During its service life, Hound Dogs were deployed at twenty seven bases where SAC had B-52s. A total of 295 B-52 bombers were configured to carry the missile during its lifetime. In 1972, SAC began deploying the Short Range Attack Missile (SRAM), and began phasing out the Hound Dog. The last missile left service in June 1975.

## Air-launched Missiles, 1950

*Part two of excerpts from Ballistic Missiles in the USAF, 1945-1960, Jacob Neufeld, Office of Air Force History*

By 1950, the USAF program for development of missiles had changed considerably from the original 1946 plan (Dec 1997 Newsletter). The following projects survived:

### Air-to-Surface

MX-674, a Bell Aircraft vertical bomb called Tarzon.  
MX-776, a Bell Aircraft subsonic missile called Rascal I, with a 100 mile range, to be followed by Rascal II with a 150 mile range.

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### Airlaunch, 1950 (cont) Air-to-Air

MX-904, a Hughes Aircraft fighter-launched weapon called Falcon, to be followed by a bomber-launched version.

By June of 1953, the missile program had evolved into a National Guided Missile Program. The only air-launched missiles under USAF development at that time were the Rascal and the Falcon.. Interestingly, the Sparrow and Sidewinder were being developed, but by the United States Navy.

### Coming Events -

**321st Missile Group Inactivation**- July 1-2, 1998, Grand Forks AFB, ND. Contact the 321MG Mission Realignment Office, 701-747-4336, fax 701-747-3666, e-mail mg.ccr@mg.grandforks.af.mil.

**51MMS, 40th Anniversary Reunion** - May 13-16, the Inn at Lompoc, California. Contact Roy Aldridge, 347 Brookwood Dr, Duncanville, TX 75116, 972-296-2696, fax 972-296-7473, e-mail royealdrige@worldnet.att.net

**AAFM National Meeting** - Oct 21-25, Cocoa Beach, FL, contact *AAFM* for registration information.

Hill AFB Museum's Snark



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