# 'OFF-SITE' FACILITIES RELEVANCY: A RETROSPECTIVE OF CRS FIRM'S VISIONARY MANNER IN UNCOVERING CHALLENGES IN DESIGNING PRODUCTION-MODULARITY FACILITIES

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## PREFACE

The CRS Firm's Industrial Building Type is, in retrospect, a revelation in its ability to have current relevant application on many levels for strategic thinking about the "offsite" or "modular" design-fabrication process and the facilities that house them. Awarded a CRS Foundation Fellowship, I came upon their work in the 'industrial' sector by accident. The original intent of my scholarly inquiry at the CRS Center was in the firm's communication methods. During the endeavor, I came across meeting minutes on the 'industrial' subject. These particular notes caught my interest. I wanted to know more about what this research-based firm had learned that might add to my own enthusiasm for the 'offsite production' facility.

## INTRODUCTION

This paper provides unique insights to the industrial architecture building type, mode (manner of doing something), style. This paper is relevant for today's designers of modular off-site architecture as it suggests consideration of the architecture that houses the process and its heritage as a driver of innovation.

Part one will cover the CRS Firm's contribution to the "industrial" building type's aesthetics found in the firm's innovative programming phases and documented in Future Thrusts --an update of CRS Self-Evaluation/Digest of CRS Board Meeting 08.01.2008.[1] Using Chrysler/Detroit and Herman Miller/Furniture Production Campuses, CRS isolated factors and studied or as they uniquely called it "squatted" to uncover prototypes concerning: (a) new energy spaces, (b) landscape inclusion, (c) supplemental research in modularity, and (d) separate prototype lanes.

Part Two extends 'industrial' beyond the CRS Firm and covers the historical mode and style development of the Industrial Building/"Off-Site" Production Facility with its inherent use of: (1) repetitive patterns of material and structure for cost efficiencies and rapid construction demands, (2) maximum use of 'green' efficiencies: lighting opportunities (task and general), air ventilation and modular storage bins, and (3) proximity to railroad lines and offsite/onsite modular parts.
Part Three will cover the relevancy of the Industrial Building today and reference its heritage.

## PART ONE: CRS FIRM INSIGHTS RELATING TO INDUSTRIAL ARCHITECTURE

Caudill Rowlett Scott started as a two-man firm in Austin, Texas in 1946. This small partnership grew over time to become CRS, the largest architecture-engineering-construction corporation in the United States until its decline in the late 1980s. For this paper, it is important to describe how projects were approached by the CRS Firm, which in turn, will clarify how the firm arrived at new core insights for the evolution and potential of the industrial building type design. Ultimately, the way CRS approached program and design specifically helps architects refresh their strategic thinking processes and supplies a "toolkit" of general applicability to the industry.

Figure 1: CRS Intra Office Process
CRS Center Archives, College of Architecture, Texas A&M University

In the article *The Lure of the Industrial* in magazine Texas Architect, the author Brantley Hightower refers to Le Corbusier's *Towards a New Architecture* and his own thesis on the industrial building to which he states: "there is a purity to these forms that is beguiling-they are defined by the simplest realities of program and structure."[2] While Industrial Architecture is aptly described here as "forms", the CRS mission and discipline forces professionals to thoughtfully engage visionary concepts concerning purposefulness and function based on the industrial or manufacturing client's needs.

The lasting legacy of CRS is linked to its approach to the design process.[3] According to this author, CRS embraced four elements: research, problem-seeking, program solving and teamwork. These elements are still widely utilized by contemporary firms. Notably, if one looks up HKS (the worldwide architectural firm that eventually evolved from CRS in the 1980's) on the web today –link headings on the site list the guiding acronym CADRE –Collaboration, Research and Development, Design Process and Problem Solving.[4]

**The first of the four elements**

The first of the four elements was research which, as they employed it, was a marketing graphic communication tool used by CRS. Uniquely, where other firms put out resumes and brochures of their work and accomplishments, CRS' marketing materials were research based. The teams' sketches during any building's design process became their reports and exhibits, which in turn, lead to the firm's press releases and public relations -what we call 'branding' today. As specified in CRS's procedure manuals (Intra-office Communication), all team members were required to develop research reports which in turn would serve as information for future projects and promotional advertising for the firm.[5] The CRS archives at the CRS Center in College Station, Texas demonstrate this steadfast protocol for all the firm's projects, including its industrial designs. The documentation in these reports gives architects and their clients new perspectives on industrial design as CRS forced themselves to question, to observe and validate change early in the projects progress.

For example, in one of CRS' research notes, (Chrysler Corporation Factory Future Study) the firm considers 'quality of life' spaces such as exercise and seminar rooms for pro-health and continual education of staff. [6] These suggestions for an industrial program were an innovative proposition (for its time). As will be explained in Part Two, focuses on productivity results of the laborer were embedded in industrial architecture early. It is in considering an unconventional 'program' that shows sensitivity to emerging human psychology and HR (Human Resources) factors only barely emerging at the time.

Even before CRS was established, research was inherently important to both of the founding partners.[7] John Rowlett and William Caudill were Professors at the Texas A & M University College of Architecture when architectural research was in its infancy. Clearly, they were influenced by being part of a larger campus experience where they were exposed to other Departments where innovative basic research was blossoming. Specifically, Bill Caudill, the leader in this staunch advocacy for academic architectural research throughout the life of CRS, believed that it was the best way to achieve innovation "more than through reading the Frank Lloyd Wright *Bible* or the Corbu (sic) *Bible*".[8]

It was this researched innovation approach that became the foundation for encouraging and mentoring their in-house architects to think beyond one project at a time. Example, 1940's report: *Take a Good Look at your Schools: An Approach to Long-Range Planning of School Buildings.*[9] Additionally, post-evaluation studies of occupant response to buildings' air-conditioning led to numerous publications, seminars, and workshops (Example: Architecture and You, How To Experience and Enjoy Buildings.[10]

In this sense, CRS was the pioneer in architectural research and this orientation was paramount in lifting the firm to international prominence. With a multiplicity of design firm offices, their reach extended nationally and internationally, allowing them to extend their 'thinking innovatively' through exposure to a variety of cultural viewpoints. Additionally, this culture of reporting research served as mentoring processes for architects in leadership capacities.

**Second of the Four Elements**

Problem seeking as graphic 'Snow cards' ensures architects master listening -the problem or poignant point heard visually on an index card.

While the concept of programming was not at the time a requirement for a pre-design stage in the AIA (American Institute of Architect) contracts for legal services, CRS and their associates nevertheless developed a template that could guide any architect through the programming process. "Graphic analysis techniques became a trademark for the firm" and enabled easier communication between the architect and the client (Stackable 26).[11] In addition, by producing on-the-spot graphic representations, a greater understanding and clarity of vision was achieved. "Analysis cards", called "snow cards" at CRS, offered quick visual arrangements of partis, bubble diagrams and verbal goals that relayed as directly as possible to the client and the team those problems that needed to be overcome in a specific project and how that might be achieved.

Snow cards were used as miniature Charrettes which followed the five step programming outline devised by CRS. The cards were usually 5x7 inches or smaller and were compiled into an analysis booklet for each project. Often the snow cards would be drawn coinciding with a client interview while other times prepared in direct response to an interview at a later time. The 'snow card' compilation found in the end notes of this paper is an excerpt from the lengthy graphic analysis process of the University of Florida multi-purpose Natatorium Facility in Gainesville, Florida.[12]

**Third of the Four Elements**

Problem solving as a 'Squatter' ensures team architects sit and listen to the building's future user.

CRS came up with the term "squatters" which can be related to the French term 'Charrette.' The name originated when CRS highlighted processes within standard services of an architect processes (AIA's five basic services are defined as Schematic, Design Development, Construction Documents and Contract Administration) to ensure steps were not forgotten and lost in the fast paced environment of architectural practice and communication. The term also connotes sitting or getting down at the same level with the real user of the building. Specifically, for example and as poignantly noted in CRS notes, - know their fears, assume nothing, understand all players.

The new jargon CRS developed shows the firm's fierce dedication to rigor in documenting research, discovery and the client's communication processes:

'Snow card' (Thumb nail sketches)
'Squatters' (Sitting and Hearing)
**'**Future Thrusts' (Visioning)

**The Fourth of the Four Elements**

Teamwork ensures a synergetic philosophy and approach to better solutions. It is in the firm's collaborative **Future Thrusts[13]** self-evaluations and strategizing that the special significance of 'Industrial Architecture' appeared in my investigations.

In the 1970s, CRS firm leadership began to label a section of their Board Meetings "Future Thrusts." The intent of these sessions was to scrutinize, update, discuss, and digest their internal CRS "self-evaluation." The meeting minutes evolved from these sessions. The form, each time, defines a short and a long-term challenge followed with similar subcategories: (1) Objective, (2) Current Posture, (3) Goal, and (4) Method for Change.

Particularly relevant to this paper, in the session labeled Future Thrust 4000.0301 (August 1, 1980)[14], the short term challenge is defined as Project Management/Project Delivery (subcategories summarized – (1) Objective: produce timely, correct, complete and in budget contract documents; (2) Currently –dismal, (3) Goal -two years to require a positive plan; (4) Method -new energy to additional guidance and implementation of 'quality control' to name one.

In the long-range section of this particular 'Future Thrust', juxtaposing the short-term management issues, the focus is on "development of industrial clients." Under (1) objective: "America is on the verge of re-industrialization as it appears that the international economic climate will dictate major improvement industrial capabilities, processes, and product"; (2) goal: 'availability overseas' and OPEC. Most important to highlight is the fourth item -Method: "our design capabilities are an essential part of our thrust, as certainly a new type of industrial building will emerge."

Following this 'Future Thrusts' August 1, 1980 session, the following relevant CRS projects appear soon after: (a) Herman Miller Seating Manufacturing Facility (1981), (b) Herman Miller Energy Center, Great Lakes Fabricators and Erectors in Zeeland, Michigan (1982), (c) Consolidated Diesel Engine Plant, North Carolina (1984), and (d) Chrysler Corporation Factory Future Study (1986).

Notably, here is a paraphrased example of a Team Report from the Chrysler Corporation Factory Future Study documentation.[15] This report and others demonstrates the unconventional brainstorming and innovative insights derived by this team taking the time to report on their findings. [16]

These examples of CRS's culture shows how the firm was beginning to grapple proactively and in a visionary manner with the challenges and change that industry would pose to Industrial Design. More recently, in 2009-2012, published contemporary 'coffee table' industrial projects (specific references to:(1) Building Type Study 886: Introduction: Industrial Facilities Beyond the Bland Box by Joann Gonchar, AIA Architectural Record, 03.2009[17]; (2) Metal Architecture[18]; and (3) Texas Architecture[19]) demonstrate awareness of or thinking in relation to CRS notes described above: (a) industrial resources brought in by cartons that streamline in on tracks and rotation devices, (b) 'quality of life' recreational facilities on site plans and building floor plans, (c) prototype (new testing of products) lanes in addition to production line lanes.

**PART TWO: UNLIKE OTHER BUILDING TYPES, THE EVOLUTION OF INDUSTRIAL STRUCTURE FORM CAUSED ARCHITECTURE AND DESIGN TO COLAESCE AROUND AND ADAPT TO FUNCTION**

The Industrial Building and its development can be linked to several pioneering spaces, forms and materials.[20] Referencing the Introduction, Historic Industrial Architecture -consider the 1873 cast-iron loft building by Richard Morris Hunt (Roosevelt Building, New York City) and the 1930 single level steel frame factory by Albert Kahn (Ford Richmond Assembly Plant - Richmond, California). Both structures demonstrate a break with prior architectural design. Factories had been steadfast in use of brick and concrete materials. Early floor plans with many levels took advantage of gravity in the manufacturing process. In the design of industrial buildings similar to these notable examples, the owner and their architects decisively moved towards a more cost effective building based on and complimenting the purposes and processes of the times.

This break-through in industrial building design had at its core concepts captured in today's **Lean/Six Sigma Certification** for Process Improvement based on achieving excellent product, effective deliverables, and scrutinizing every process to ensure cost and quality.[21] Looking back, the owners and their architects involved in the industrial processes embedded early on similar lean notions and incorporated them in design. Change involved purposefulness and did not fear it, but rather embraced it. Seeking efficient methods of production and quality deliverables did not necessarily mandate consideration of architectural beauty or aesthetics. Yet surprisingly, the architecture which is the subject of this discussion often achieved its own aesthetic. Examining the spectrum from historical to current industrial buildings, we find handsome and engaging pieces of work. Therefore, striving to minimize inefficiencies and accommodating manufacturing processes can and has led to sublime design.

The old Oliver Evan's Flour Mills System where the raising and loading of raw materials to the upper level later contributed to the development of the silo technique. In the grain transformation processes, grain loaded at one end of the building proceeded through the stones and funnels of the mill to a vessel tied along side to it -obviating the need of interior workmen.

Looking at the automobile industry, it too followed this paradigm of encouraging its architecture to re-invent itself around machinery and the manufacturing process. Production line elements were assembled step-by-step, from top to bottom of the structure, with the car arriving ready to drive on the ground level. The plant was usually built out of concrete, an inexpensive, strong and incombustible material. This type of architecture had to keep up with the extraordinary pace and growth of industry at the time.

As industry and the times change, so does its architecture. In Part one of this paper, I mentioned how CRS extended the industrial building program with seminar and exercise rooms in part due to the emergence of research in environmental psychology. History shows many examples of architects of industrial buildings with no fear in completely abandoning the paradigm of the multi-level factory. In 1915, the multi-story model shifted to organizing both work and manufacturing all on a single level. This philosophy changed the specified design materials as well. Steel frame structures focused on the technical and mechanical machines they housed, causing the super-imposed decorated facades and eclectic forms of the multi-level building to be discarded. These aesthetics were superseded by the repetition and combination of **simple patterns**, with an emphasis on key concept elements: space, light and ventilation.

**Space, light and ventilation** are basic elements of today’s sustainability checklists in all types of Architecture. Historically, industrial architecture used these same design features in a much earlier incarnation and with a different perspective (how to keep the labor force working as many hours per day productively to produce goods efficiently and with quality) and suggests that environment and industrial architectural design went hand in hand.

Good lighting oriented to the north for all-day illumination became a factory design standard. Notably, more recent steel framed factory construction uses the saw tooth roof to admit light.

Previously, in 1885, the city codes of Brooklyn, New York allowed thinner walls to permit more light to enter by way of group windows using iron spandrels. The cast-iron construction is predominantly a bearing façade and so when the non-bearing “curtain wall” (use of steel, glass and terra-cotta) came into use, it allowed 75% glass to dominate the façade. This, of course, began to specifically attribute design of the light patterns to function -storage, office and production line. This gives the façade a whole new choice of patterns versus the overall historical monolithic look with uniform windows throughout.

Elevations not only reflect the various ‘function’ and uses of the interior spaces in section with glass but also the opportunity to identify stairwells, light shafts and elevators.

**Central power** to run factories started with water as with Slater Mill in Pawtucket, Rhode Island in 1793. The most important requirement for a mill site was access to the river for power and to road or canal for transportation. The length of the building equaled the length of the longest drive shaft; the width was established by laying out the machinery length along the line shafts, and then placing walls as close to its central machines as possible to let the most day lighting into the work space. The rectangular plan worked best in providing light as well as in distributing the power.

The **longitudinal shape** remains prevalent in industrial architecture today. In the Woodbury Treatise of 1882, the proper **‘bay size’** of a mill of 1882 was defined as 32 by 62 feet and became the traditional standard used subsequently by engineers. This phenomenon can be seen repeatedly throughout the United States. Today, in corporate multi-story architecture, the current sustainable design thinking uses this shape for cooling and shading a building with the sun’s orientation. Both commercial developers and their engineers articulate their ‘bay size’ (length by width repetition piece) requirements early in programming and schematic design phases with their architect. The pre-determined ‘bay size’ is attributed to a formula calculated to maximize rents and obtain leases.

The manufacturing and industrial building is always subject to fire and this threat must be a prime design consideration. Again, the owners and architects of the industrial form paid attention to this early. In 1860, wood was available and, therefore, the original material of choice in America. Later, of course, wood proved too much of a fire hazard and stone and brick became the preferred materials, while also symbolizing solidity, power and wealth. Stairs designed in isolation of the main manufacturing space limited fires from sweeping upward rapidly and offered potential for loading platforms for each floor. Basements and attics became unique studies in air flow and temperature control. “Carpenters valued trapdoor monitors, the hoist, and the cupola; architects detailed joists pockets cut into the floor beams; the sun helped light the shop floor.” [22] In 1870, the term **fire-resistive construction** (“slow burning”) appeared in **building codes**: (a) heavy timber framing was not-fireproof but fire-resistant enough not to fail before a fire was suppressed (the outer few inches became charred during a fire; the inner wood retained its strength and continued to support the floor or roof above); (b) thick plank flooring detailed to lay directly on beams without any accompanying joists to let the interior wood framing members, if damaged by fire, fall away from exterior brick walls without damaging them.

The Industrial Building’s history continually demonstrates Architecture and Design keenly aware of and adaptive to function in other ways. The American settlers, 17th and 18th centuries, brought with them the techniques of Western Europe, in particular from the British Isles, Holland, the Germanic countries, and a few from France. In 1783, with independence from Britain, the U.S. looked to France to be competitive against and distinct from the model of technological inventiveness -Britain. One can see and trace similar patterns in American and French industrial architecture and development: same mills and forges, same boom in the mechanization of the textile industry, and dispersion of water-powered industrial sites (hydraulic energy).[23]

From the start, the U.S. had opportunities and challenges pertaining to industrial sites: densely forested country, waterways (hundreds of thousands in 1700), and variety of plentiful underground resources (iron). These challenges and opportunities seem to produce, not hinder, far-reaching innovative contextual and technical processes. By 1820 through 1840, the United States became a great industrial power and remains so today. Its architecture keeps with this reputation. [24]

**Return on Investment**

In 1880, railroad car manufacturer George M. Pullman began the self-sufficient factory and company town thirteen miles south of Chicago. Advertised as "superior living quarters in a healthful setting far from urban problems,"[25] Pullman believed he would attract good workers and enhance productivity. Today, we might call his vision environmentally sustainable as it relates to Planned Unit Developments, where houses, stores, businesses and places of worship are all in walk-able distances of each other.

Labor force housing has long been associated with industrial heritage sites along with the clock tower (because the workers did not trust the industrialist with the correct time to stop and start the work day). Likewise, unlike other building types, these industrial sites encompassed thought beyond its four walls to a larger contextual plan relevant and linked to their resources: the river, the railroad, the worker, the coal, the road, the wheat, etc.

As an example, a museum rarely encompasses such a demanding list of adjacencies as the industrial. This came to my attention recently, on visiting a museum (Crystal Bridges Museum in Arkansas built by Sam Walton's (Wal-Mart) daughter), where for the first time I experienced a museum that consciously and deliberately with function contextually related to its adjoining environment. This particular museum, unlike many, incorporated hiking, landscape and outdoor sculpture opportunities beyond the stand-alone concept of a museum such as the Guggenheim in New York City. This begins to open a whole array of ideas of future adjacencies to the industrial building and how it may change in the future.

**Series of Expansions Based on "Bay Size"**

Machines moved from fixed, being together into sequentially arrangements to speed up the production line. With growth, Architects 'sequentially' reiterated the bay size as an organic architectural pattern. With this building paradigm to expand the buildings form and/or 'aesthetic attachments' –the process was to add another longitudinal bay. Steel framed factory buildings developed rapidly after 1880 and added more than simply shelter for an industrial process; they featured wide floor-space completely free of columns. Structure serves as integral part of the industrial process as the equipment, for instance, the large crane way (57' wide and 860 long) became integral not only with the structure's column connections as it became linked to the product's machinery and process. The product became affordable because architecture and process made it so.

**The adaptive reuse** of industrial heritage is liberating. Look at all the imagination by owners in producing not only economic profitability but preservation. A strong example is the Ghirardelli Chocolate Factory in San Francisco or in London, the Tate Museum. Little waste in our 'green' and lean initiatives of this century, industrial architectural conversions adapt and reuse these voluminous space buildings into prototypes demonstrating flexibility of uses. Often inner cities take the industrial brick building of yesterday and turn them into lofts, office, retail, or warehouse spaces. Again, unlike other building types, the evolution of the Industrial Building caused architecture and design to coalesce around and adapt to function. Its relevancy is perpetual.

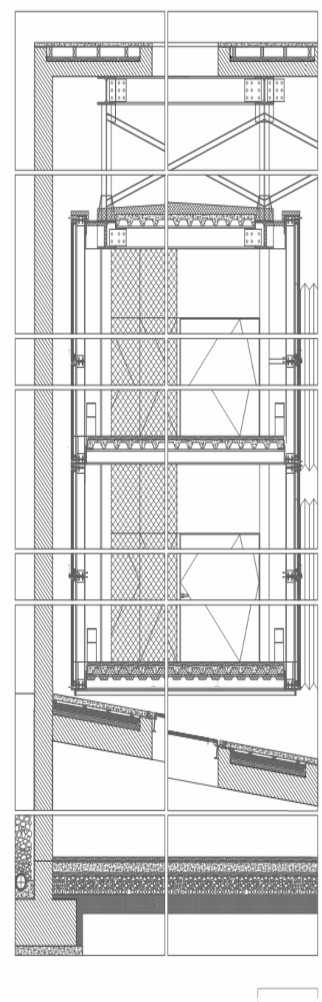

Figure 4: Cartons come into Industrial Building
Cerejeira Fontes Arquitectos Guimarães, Portugal

Reiterating, the idea of new products, new means of organizing work, and architecture that supported this result almost organically provided much focus for the specialized industrial architect. In the early 1900s, the industrial building typically manufactured all vehicles or all products on a single site. This too evolved and revolutionized the architecture thru which form followed function.

### PART THREE: RELEVANCY FOR THE PROFESSION NOW

I believe the relevancy and the utility of the Industrial Building today, yesterday is highly significant. The way CRS approached their industrial building initiative in the early 1980s with strategic thinking processes and results left a legacy "toolkit". The heritage of this building type continually shows: (1) bold architects and owners who had the uncanny ability to address change rather than fear it, (2) architectural form which had a quintessential function in the life of the production facility and (3) demonstration that sublime aesthetics were not limited by building function.

In the magazine Design Intelligence, an article called *Trends Forecast & Foresight Scenarios* [26] announced the publication of (a) architectural rankings, (b) issues of relevance to the future, and (c) projections for 2012. The article does not mention the relevancy of the Industrial Building for today's trends nor allude to its heritage as a driver of innovation. In the Architect Record article *Beyond the Bland Box,* Author Gonchar *states* "it is curious then, that in more recent decades, the utilitarian demands of industrial processes and manufacturing operations have only rarely produced inspired architecture."[27]

This is misguided. For example, the article's recommendations for 'musts' for the new age ("Green is not just good, it's necessary"; "higher expectations for energy and environmental performance"; "systems, processes and procedures that in the aggregate support a new way of delivering the goods") directly relate to the core CRS industrial concepts above. Instead, the article focuses on healthcare and the inability of academia to be relevant to the architectural profession in teaching new professionals to grasp industry essence. Both these items, to me, are neither convincing nor insightful. How is design relevancy accessed? And, why isn't anyone picking up on the design relevancy of the industrial prototype?

I question whether architectural design can ignore referencing the 'industrial building type' as contributing to (1) a sustainable and lean form 'continuum', (2) design by function leading to aesthetic relevancy, (3) extraordinarily innovation where often other building types stagnate, and (4) an appreciation for the bold owners and architects who specialize and innovate in this field.

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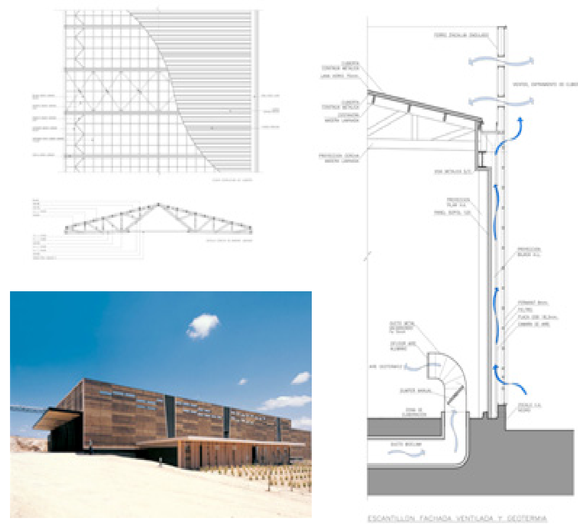

Figure 5. Olisur- Olive Oil Factory
GH+A Architects La Estrella, Chile

### ENDNOTES

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2. Brantley Hightower, "The Lure of the Industrial*" Texas Architect*, November/December 2009, 44.
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10. William Wayne Caudill, FAIA, William Merriweather Pena, FAIA, Paul Kennon, AIA, *Architecture and You How To Experience and Enjoy Buildings,* Whitney Library of Design, 1978.
11. (Stackable 26)' Snowcards' (CRS Archives, CRS Center, Texas A&M University, College Station, TX)
12. Nasturtium Gainesville, Florida

    The ambitious project, designed in 1976, is still home to the Florida Gators men's and women's basketball, gymnastics, swimming, diving,

indoor volleyball and track. The following section describes the Natatorium project in relation to the programming division:

1. In establishing goals, the snowcards for the University of Florida Natatorium noted the most basic of client requests. Ideas presented were numbers of people they were expecting to attract, the budget goal, and projected completion date.
2. The snow cards also assessed the means of approaching the architectural process: efficiency and accessibility were important, as was the emphasis on "placing top priority on student participatory athletics" As well as varsity sports ("University of Florida Mass Seating Natatorium Facility").


13. *ibid*
14. *ibid*
15. Paraphrased Notes by M. Callahan from:
"Chrysler Corporation Factory Future Study" (*Research Notes on Industrial -123.088/CRS Center August 18, 1986, page 3)
"An Approach to Industrial Plant Design", Rese*arch-Arch*itecture Report No. 14, (CRS Archives, CRS Center, Texas A&M University, College Station, TX)
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"1987 Report: Eastman Kodak" ( 667.0155 CRS Archives, CRS Center, Texas A&M University, College Station, TX)
CRS and Herman Miller Research Corporation, "Ideas: Toward a Prototype Factory that Can Flex," (May 14,1982 CRS Archives, College Station, TX)
16. **Amenities Design:** Generally, the design of existing facilities does little to emphasize team, food service and training areas. The factory of the future will require enhancement and integration of these areas into the manufacturing area.


**New Facility:** Greenfield

A new facility provides a clean sheet for both layout and employee mindset development. *This offers greater flexibility than designing a new facility on an existing site or renovation of an existing facility.

**Consider seriously the following:**

a) Manufacturing Flexibility (remember there is outdated machinery AND high volume, new equipment)
b) Product diversity requires transfer line technology
c) Smaller more focused plants or business units may be an appropriate strategy?
d) Process-Driven Design Product needs a Tooling Design Area
e) Involve manufacturing representatives
f) Involve high work areas to provide input for improvement on-site

**Separations**

1. Combine: rough machinery operations + forming
2. Separate finished machining and assembly in another facility
3. Outsourcing Services: Utilities, Maintenance, Operations
4. Technology advances training: equipment, vendors, installation by GC

**Employees:**

1. Numbers who use the Facility: Growth (800-1200 employment)
2. Communication Problems inherent
3. Training Constant –machine technology constantly changing
4. Wages or 'pay for performance' programs
5. Fear Factor: outsourcing components

**Procurement Procedures**

Planning: 14 days with minimal modifications
Reporting: tied directly now from production machinery to CIM
Inventory Control tracking: three touches –unload, stores to work cell, installation
Material Handling Automatic Storage/Retrieval Systems
Minimize storage cost to maximizing space utility
Use of returnable, multi-purpose containers


17. Joann Gonchar, "Building Type Study 886: Introduction: Industrial Facilities Beyond the Bland Box," *Architectural Record*, April 2009, 91.
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27. *Ibid*