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THE CHALLENGE OF LOGISTICS FACILITIES DEVELOPMENT

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ABSTRACT

The paper discusses the experiences of a group of engineers and logisticians at John F. Kennedy Space Center in the design, construction and activation of a consolidated logistics facility for support of Space Transportation System ground operations and maintenance. The planning, methodology and processes are covered, with emphasis placed on unique aspects and lessons learned. The project utilized a progressive design, baseline and build concept for each phase of construction, with the Government exercising funding and configuration oversight.

ACRONYMS

APS	- Automated Procurement System
ASRS	- Automated Storage and Retrieval System
BOC	- Base Operations Contract (EG&G)
C Of F	- Construction of Facilities
DFRF	- Dryden Flight Research Facility, CA
EAFB	- Edwards Air Force Base, CA
EG&G	- EG&G Florida, Incorporated
ELS	- Emergency Landing Site
HCC	- Hardware Control Computer
JSC	- Johnson Space Center, TX
KIMS	- Kennedy Inventory Management System (Was SIMS)
KSC	- Kennedy Space Center, FL
LASS	- Logistics Automated Storage System
LCC	- Launch Control Center
LC39	- Launch Complex 39
LRU	- Line Replaceable Unit
LSOC	- Lockheed Space Operations Co.
MCC	- Movement Control Computer
MDTSCO	- McDonnell Douglas Technical Services Co., Inc.
MSC	- Material Service Center
MSFC	- Marshall Space Flight Center, AL
PGOC	- Payload Ground Operations Contract
POL	- Propellants, Oils and Lubricants
RFP	- Request For Proposal
R&D	- Research and Development
SIMS	- Shuttle Inventory Management System (Now KIMS)
SPC	- Shuttle Processing Contract
SRU	- Shop Replaceable Unit
VAB	- Vehicle Assembly Building
VAFB	- Vandenberg Air Force Base, CA
VLS	- Vandenberg Launch Site
VPSA	- Vehicle Processing Support Area

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BACKGROUND

In the early 70's, KSC logistics managers recognized a need for improving logistics storage facilities for the Shuttle Operations era. A Construction of Facilities (C of F) budget project was initiated to cover projected needs. As is often the case, the project was delayed repeatedly in view of higher priority tasks. When Center management decided that the Shuttle era could best be served at KSC by three self sufficient contractors, the need became more apparent. It was decided that of these three, Shuttle Processing Contract (SPC), Base Operations Contract (BOC) and Payload Ground Operations Contract (PGOC), the SPC would benefit more from a new facility. The SPC inventory was the largest, was housed in sixteeen separate locations around the center and at Cape Canaveral Air Force Station, and would increase steadily as flight and ground support parts transitioned to KSC from the development Centers, Marshall Space Flight Center (MSFC) and Johnson Space Center (JSC).

Since the C of F project continued to suffer priority woes, it was decided to include a new logistics facility requirement in the Request for Proposal (RFP) for the SPC. This RFP was for a three year base period, a three year priced option and three three year unpriced option periods, a total of fifteen years. The RFP required the successful bidder to include the cost of developing, building and outfitting a logistics facility at Launch Complex 39 (LC 39) sufficient for needs of the entire contract period. Further, it called for the facility to be ready for occupancy in time to allow vacating of existing storage facilities to begin early in the third year of the basic contract period.

On final review, NASA Headquarters ruled out building the new facility as a part of the basic SPC contract. However, they kept in the schedule for vacating existing storage facilities. This action implied, and resulted in, approval of the C of F request for a new LC 39 Logistics Facility and therein lay the Challenge of Logistics Facility Development.

After many years of frustration, some of us were finally getting a chance to design and build a facility from the ground up to suit the needs of Shuttle Program Logistics at KSC, a dream come true, or perhaps, a nightmare.

The Challenge of Time

Scarcely had elation over approval of the C of F project worn off before realization of the seemingly impossible timing requirement set in. Normally, the design and construction of a major facility had averaged between three and five years at KSC. Past methods included internal development of requirements specifications for the building, an Architect and Engineering contract for design, a contract for construction (after baselining the design) and several contracts for systems and equipment outfitting. All of these contracts were advertized, awarded and managed by the government.

It was obvious to engineering and logistics management that a new method was required, if the schedule was to be met. A decision was reached that the time line needed a "design-build" concept. Simply stated, the concept calls for design of the project in the same phases as it will be built; i.e. Foundations, structure, roof, floor, systems/equipment, offices, etc. Once each phase design is baselined, proceed with authorization for construction.

The predominant expertise and interest for accomplishment of the project resided with the successful bidder on the SPC, Lockheed Space Operations Company (LSOC). They would be sole user of the new facility. Their management had already decided on specifications and requirements as a part of their original proposal before NASA HQ dropped the facility from the RFP. Further, most line logistics managers hired by LSOC had worked on the competing Boeing Company proposal. The best thinking of both bidders was available under one roof. Therefore, KSC chose, and NASA HQ approved, tasking the SPC to furnish and outfit the facility with close funding and configuration surveillance by KSC design engineering.

The team of NASA and SPC engineering, procurement and logistics personnel was set up for full time management of the project. Tasks were assigned and provisions were made for daily, weekly and monthly meetings and/or reviews as required. The project proceeded well through specification development. Major internal battles were fought to assure open minds for receipt of new ideas once a design contractor was selected. Since most participants had been in logistics or design for many years, "my" way had to be turned into "our" way or the "new" way. Once together, the specification was advertized for a design contractor.

Possibly, the major key to a successful design/build venture is selection of the proper contractor. The SPC chose The Austin Company of Atlanta, Georgia, which had designed and built many such logistics facilities over the last thirty years. After the initial get acquainted and evaluation period, which extended through the approximately 30% design review on several phases of the project, NASA agreed with the SPC recommendation to contract with The Austin Company for the "build" as well as design.

It was decided that each phase of the project design would be baselined for configuration and cost at the 60% design point. This meant that any change after that point required SPC and NASA Configuration Control Board approval. The SPC and Austin negotiated a guaranteed maximum cost for the building (C of F) and the equipment outfitting [Research and Development (R&D)]. A part of each change action was the mandatory NASA review and concurrence with funding considerations in each budget area.

Many factors worked together for a smooth operation. All team members and companies involved were dedicated to a "success" flow. NASA had only one interface, the SPC. The SPC had only one interface, The Austin Company. Austin managed all subcontracts and rolled up all warranties into a single one of their own to the SPC. This type of contract methodology may not be appropriate for all new facility projects. However, where time is of the essence, where requirements are relatively firm, where NASA and contractor interests are identical and the right contractor is chosen, it works amazingly well to get the most facility for the dollars spent. As stated, time drove us to the concept, but even if more time for planning and design were available, the concept could be applied to advantage.

The major potential for difficulty or abuse lies in the design/build contractor's subs for areas where he has little or no primary expertise, such as automated systems hardware and software development. The basic contract should require him to withhold a substantial amount of the cost of these systems from the subs until final payment, to assure end result performance in accordance with specifications. Consideration should be given to breaking out such efforts for direct procurement.

Another time related pitfall should be avoided if at all possible; i.e. use of the facility or systems prior to completion of the contracted effort as scheduled. No matter how good the performance or intentions of the participants, the pressure is there and the addage is true, "If you use it, you've bought it."

Although not directly time related, care must be exercised to determine the financial health of subs and suppliers before contracting with or ordering from them. Otherwise, the quality and timeliness of their product can be an impact.

The Challenge of Location

The best location for a logistics facility is as near as possible to the work it supports. In our case, it's at (KSC's) Launch Complex 39, where the nation's Space Transportation System elements are maintained, assembled, processed and launched. Simple enough on the surface but we're talking about a building with a footprint of 251,440 sq. ft. (5.7 acres), roughly the same as the Vehicle Assembly Building (VAB). At the time it was built the VAB was the world's largest building. When you add out buildings, external storage yards, loading/maneuvering areas and parking lot you have approximately fifteen acres.

The nearest area of sufficient size which would not add undue congestion to processing operations was about one half mile from the heart of LC 39. Even then we experienced a delay in start of construction until new homes could be found for loggerhead turtles which had established prior residence. One consideration of a faster moving nature was the vehicle traffic increase due to employees and deliveries. The typical fashion, widening of two miles of access road and installation of two traffic signal lights wasn't completed until nine months after occupancy.

In general, the location has met with approval. Delivery routes are much shorter. The central location is more efficient from a manning level. Aside from centralizing parts and materials storage, the facility allowed centralization of Logistics personnel, both NASA and SPC. The facility has a full cafeteria and bus service is excellent to the VAB/LCC or Headquarters areas, where sundry stores, credit unions, barber shops and dispensaries are located. Also, personal and business vehicles are afforded excellent parking. The building includes a central SPC travel office and five classrooms for process training purposes.

Centralization of material assets and personnel was a major consideration in designing and furnishing of the LC 39 logistics facility. However, one half mile is considered too far for many pick-up or delivery actions in support of processing operations. SPC logistics maintains eighteen Material Service Centers (MSC's) and seventy three bench stock locations in point of use areas for instant pick-up/issue. All inventory assets are managed in the Kennedy Inventory Management System (KIMS), which is the recently activated third generation of the Shuttle Inventory Management System (SIMS). These systems will be discussed further under the "Challenge of Automation".

The Challenge of Sizing and Layout

Any new storage facility expected to be utilized for many years should be sized for the expected normal/maximum line item projections, plus a minimum of at least 20% increase over projections. In our case, projections were made for the total inventory required to support STS ground and flight hardware at a launch rate of 24 flights per year. This estimate was 200,000 line items. When late program relocation of depot repair and increases due to need for stockage of life of the program parts for obsolete/no longer procurable items were considered, we increased the projection to 250,000 line items for internal storage. Outside storage was estimated to be another 10,000 line items (cable, propellents, oils and lubricants).

After analyzing the requirements for office, equipment, transfer aisles, receiving, shipping, packaging, quality, staging areas, rest rooms, breakrooms and other creature comforts, the total facility was sized. Layout concentrated on material flow into, within and out of the building. Fast and slow moving items were identified and storage equipment was selected/located for layout of the shortest path for fast moving items. The areas required for environmentally controlled storage (regular air conditioning, cool rooms and freezers) was determined. Personnel flow paths were considered as well as delivery and service paths for goods and services.

Overall building area and allocation of space worked out as follows:

Ground Floor Area -	251,340 Sq. Ft.	*
Office, cafeteria, classrooms	25,200 Sq. Ft.	
Warehouse	226,140 Sq. Ft.	
Additional Office Area	64,176 Sq. Ft.	*
Upper floors	50,400 Sq. Ft.	
Mezzanine	13,776 Sq. Ft.	
Outbuildings -	22,900 Sq. Ft.	*
Yard Storage -	122,650 Sq. Ft.	*
Total Space Utilized	*461,066 Sq. Ft.	

Most of us felt that this size would serve well into the 1990's. However, conservative members of the team insisted on additional planning for expansion, which has proved well founded. Design and structural capability included foundations and columns for mezzanine floors over the shipping, receiving and portions of the Vehicle Processing Support Area (VPSA) which can add 51,600 sq. ft. inside the facility. Also, foundations were installed under the yard area for a 160 foot extension which would increase the main warehouse by 72,000 sq. ft. While the square footage is impressive, the volume of storage is the real measure of building storage capability.

The original plan was based on a layout which called for approximately thirty percent more area on the ground floor with a building height of about 20 feet. After considerable discussion, it was decided to raise the roof height to 40 feet and reduce the building footprint. Here again, the move was very economical. Actual storage volume was practically doubled for an approximate cost increase of only twenty five percent. Foundation, floor and roof represent the same cost for either height. The increase was in relatively inexpensive wall panels, columns, air handlers and materials handling equipment for the high lifts involved.

Several advantages achieved by in-depth study of material and paper flow were:

- o Inclusion of a complete packaging shop adjacent to shipping.
- o Narrow storage aisles with wire guided fork lifts increased capacity.
- o Adequate staging areas for points where material must be handled.
- o Smooth flow into, within and out of the facility.
- o Efficient environmental control of storage and office areas.
- o Optimum location of personnel in relation to the work area.

Despite the best of planning intentions, several location oriented problems have arisen during the first year of use as follows:

- o Restrooms and breakroom for warehouse workers should have been on the ground floor in lieu of on the mezzanine.
- o The cafeteria should have been on the edge of the building in lieu of in the center. Deliveries, and waste handling, would have been easier and cleaner.
- o Receiving records should have been on the ground floor adjacent to receiving in lieu of on the mezzanine.

Similarly, several sizing activities could have been more appropriate such as:

- o Empty container storage is inadequate. With more costly, reuseable containers, you still require the same volume storage after issue of the part. This was overlooked.
- o Custodial storage of non stocked material and equipment should be included in area sizing, then tripled to assure adequacy.
- o The need for supporting aging systems that are out of production increases storage requirements beyond reasonable forecast methods.
- o Storage requirements for Orbiter tires were overlooked;i.e. special fire protection and segregation.

The Challenge of System/Equipment Selection

Perhaps as in no other phase of logistics facility development, selection of systems and equipment requires a more extensive team with the time and funding to do the job. Get the right people involved early in the design cycle and assure that the review cycle is lengthened as necessary so that all alternatives are explored. Of particular importance is to assure that the reviews include Operation and Maintenance (O & M) and user personnel, actual "doing" people, not just managers and planners. For instance, storekeepers, forklift operators, parts pickers and drivers should be taken on investigative trips to observe similar equipment in action and provide input to the proposed design. Also, computer operators and programmers should play a major role in automation equipment selection. Past experience is important; however, it should be used to improve future operations and not to limit selection to "what we are familiar with".

Handling Equipment

As mentioned before, extending the height of the building dictated high storage racks and high lift equipment. This was a major concern to users and safety personnel. Trips were arranged to inspect and actually operate similar equipment already in use and to discuss its' effectivity with users. These trips led to selection of the following:

Automated Storage and Retrieval System

- o For small binable parts (180,000 line items)
- o Seven aisles each with:
  - 36 Foot storage height
  - 3420 Bar Coded Trays (2 ft x 3 ft)
  - 1520 10" deep
  - 1900 6" deep
  - Manual, Semi-automatic or automatic operating modes
  - A maximum of 48 locations within each tray
- o With all trays at maximum sub-division = 23,940 Trays x 48=1,149,120 locations
- o Brings material to the man.

ManAboard Fork Lift

- o Wire guided for narrow aisle 36 ft high pallet rack storage and retrieval.
- o Picks and deposits on either side of aisle.
- o Brings man to the material.
- o Battery powered for reliability.
- o On board Data Terminal for remote receive and transmit.
- o 4000 lb. capacity. 9260 locations

Side Loader Fork Lift

- o Wire guided for narrow aisle 36 ft high cantilever rack bulk storage and retrieval.
- o On board data terminal
- o Battery powered, 4000 lb. capability.

Automated Conveyor System

1200 linear feet of computerized conveyer with four lift stations to convey small binable parts from receiving through quality inspection to ASRS for storage and from ASRS to shipping. This system is equipped with laser tote scanners which route the bar coded tote to its' storage location or to shipping as appropriate.

Facility Systems

Air conditioning, power and communications systems are all standard for todays' environment with few exceptions. Multiple systems or emergency back-up was required in all cases. Environmental storage requirements for flight parts inventories are very demanding (72°F ± 5° and below 50% relative humidity) and dictated oversized, split systems. Computer systems demand separate source feeders or an uninterrupted back-up power system. This facility went with a separate source feeder.

Communications systems include standard telephone, televideo conference and hazard/area warning networks. The fire alarm/fire prevention system is more sophisticated. It is tied in to the central KSC fire alarm system to the station at LC 39. It has individual building area alarm networks to pinpoint the fire location and individual area, in rack sprinklers at three levels. Air conditioning interrupts are tied into the alarm system, with built-in overides for test purposes. The system is considered current state of the art and required more activation time than any other building system. Early inclusion of fire and safety, as well as O&M personnel could have saved time and expense.

Automated Data Systems

This paper will only touch on systems used in the facility for management of the logistics functions. The big question in automation seems to be how far shall we go, with recognition that the capability to go further should be provided as far as practicable. Numerous small systems for efficient handling of individual portions of the work exist and will not be discussed here except to say that initial construction should include as many spare comm wires as you can stuff in. Every conceivable future terminal or user location should be identified and the hardwires pulled during construction. With the mushrooming use of PC's, some good single user systems will need to be expanded, so you might as well prepare for it in advance.

Major systems at the LC 39 logistics facility begin with the Kennedy Inventory Management System (KIMS) which is a mandatory use, Government Furnished Equipment (GFE), third generation of the Shuttle Inventory Management System (SIMS). All KSC contractors must use KIMS. It is an extensive data base which includes capability for all storage and transactions necessary to manage and control stocked inventories, with report capability to satisfy Government and user visibility needs.

In addition, this facility has a Hardware Control Computer (HCC) for managing the ASRS aisles and the automated conveyor. This system has been extremely difficult to activate and led to the remarks on necessity to withhold sufficient payment from subcontractors to assure final performance.

Another LC 39 logistics facility system is the Movement Control System (MCS), an RF link between a base computer, the man aboard fork lifts, the side loader fork lifts, and several general purpose fork lifts for delivery, storage and retrieval of large palletized items.

Both the HCC and MCS will be tied into the Logistics Automated Storage System (LASS) presently being designed which will be activated soon. LASS will serve as a complete management system for this facility only and will include features not available in KIMS; such as, a perpetual inventory sub system, first-in first-out issue control of time sensitive items and total capability to manage item flow within the facility. In early operation, both LASS and KIMS will require receipt, location and issue loading. However, future electronic tie-in is planned.

Finally, the NASA-wide Equipment Management System (NEMS) is used at the facility for consolidated property accountability management and reporting. This is another GFE system which contractors at KSC must use.

In the world of automation only one thing is sure - growth. Make every system responsive to the user and easy to change. Then keep an open mind but don't go overboard for every new item that hits the market. Bear in mind that every doing organization has inventory to manage and a lot of innovation can be expected. Keep your eyes open and be ready to adopt what works best for your operation.

The Challenge of Human Consideration

In the end, people are the most valuable asset. A facility is a system made up of systems and people. The quality of understanding and the interface between the two is the key to efficiency. The more people are allowed to influence design, selection and operation of systems and equipment, the more efficiently they will operate.

One aspect of the LC39 logistics facility addressed employee comfort by installing 446 systems furniture work stations in office areas. The facility was the first location at KSC to incorporate this quiet, efficient office concept across the board. So far, reaction has been favorable. It is felt that more attention to the layout and color could have added variety to individual work stations, which tend to become monotonous. These offices are all equipped with anti-static carpet. Corridors are also carpeted, which has proved to be a mistake, at least on the first floor. Rubber tile would have been as comfortable and much easier to maintain. We feel that the style of office landscaping used at the facility will eventually be used throughout KSC.

In some locations, offices have a 40 foot ceiling, an inefficient and depressing condition. Better planning for housing "on floor" personnel could have improved this condition, especially when contrasted with excellence of work stations mentioned above.

One "people" aspect involves the lack of pneumatic tubes where transfer of paperwork is required. A comprehensive network should have been provided. Another shortfall was failure to obtain complete data packs on some of the facility systems and equipment which forced the individual "people" to obtain their own.

The Challenge of Challenger

Everyone in the space business was affected by the Challenger accident. SPC logistics personnel were possibly affected more than most, in ways no one could anticipate. First, we all saw it happen right above our heads. Suddenly our spacious, new facility didn't seem quite as important. However, we did what we could at considerable difficulty to our daily work. Within hours our receiving area (15,000 sq.ft.) was converted as a collection point for 51L debris; likewise our POL area and cable storage yard were turned over to the recovery effort. A double sized portable US Air Force hanger blossomed on the cable yard overnight. All this space dedication was necessary but it prevented realization of full efficiency of the facility, perhaps for a long time to come. We recently were told that the debris must remain "as is" until certain legal requirements can be satisfied. It is a small price for us to pay when you consider what has already been paid by those astronauts we strive to serve.

While the facility was a challenge to develop, we feel it will continue to serve as an asset in meeting our real challenge, the safe return to space.

Challenger also affected our facility in other ways. The mothballing of VLS activity until 1992 will require relocation of inventory and Ground Support Equipment (GSE) to KSC, adding to storage requirements. Similarly, many items of KSC GSE, which will be inactive for extended periods, requires inside storage.

The final Challenger impact fits the category of "best laid plans of mice and men." The NASA/SPC team had planned transition of inventory from existing storage locations to the new facility in a manner which would continue support to launch operations and maintain visibility at all times. Suddenly, operations were stopped and a massive modification/refurbishment effort was instituted. Fast moving operations parts became slow moving and slow items became fast, right in the middle of the move. During this very confusing period, the SPC was hit with many forced layoffs because of the curtailment in launch processing. Together these conditions led to the most difficult portion of the new facility activation.

Conclusion

The design/build concept works well where requirements are known, where an effective Government/Contractor team is formed, where a good prime contractor is selected and where time is the prime factor. It would work better in circumstances where adequate design review time was available and where the workforce is fully mobilized to input "floor level" knowledge into the process. After all was said and done, the facility was finished on schedule and within budget, both of which are rare events.