Abstract

The transportation and handling of space flight hardware always demands the utmost care and planning. This was especially true when it came time to move the International Space Station lab module "Destiny" from its manufacturing facility at the Marshall Space Flight Center (MSFC) to the launch facility at the Kennedy Space Center in Florida.

Good logistics management was the key to the coordination of the large team required to move the lab from the MSFC manufacturing facility 12 miles to the Huntsville International Airport. Overhead signs, power lines, and traffic lights had to be removed, law enforcement had to be coordinated and a major highway had to be completely shut down during the transportation phase of the move. The team responded well, and the move was accomplished on time with no major difficulties.

Title

International Space Station Laboratory "Destiny" Hardware Move From MSFC to KSC

Introduction

The transportation of large and costly space flight hardware presents unique challenges to a transportation team. This was particularly true during the handling and transportation of the International Space Station lab module "Destiny" from its manufacturing facility at the Marshall Space Flight Center (MSFC) in Huntsville, Alabama to the launch facility at the Kennedy Space Center (KSC) in Florida.

Because of the relatively heavy weight of the lab module, the Super Guppy aircraft used to take the module from MSFC to KSC was unable to use the relatively short runway at Redstone Arsenal where MSFC is located. Instead, the 10,000 ft runway at Huntsville International Airport was used, mandating a trip outside of the protective bounds of Redstone. Complicating matters more were two interstate highway overpasses that were too low for the lab module in its container to pass under. The underpass problem dictated a route that involved traveling the "wrong way" for about six miles on the interstate highway and the construction of a crossover from the frontage road to the interstate. Along the length of the route, numerous overhead power lines, traffic lights, and signs had to be raised or removed. In addition to the transportation concerns, federal, state, and local law enforcement had to be coordinated.

The MSFC Logistics Engineering group had the responsibility for the planning and execution of the move. The task was divided into manageable pieces and assigned to appropriate MSFC organizations.

Organization

Overall responsibility for the move from MSFC to KSC rested with the Johnson Space Center (JSC) transportation office. This office provided the NASA Super Guppy aircraft and loadmasters. Since this team would be with the lab module from beginning to end in transportation it made sense to have them coordinate the entire move. This ensured that Space Station program requirements were met and that there was a seamless transition from center to center during the actual move. The MSFC Logistics Engineering Group retained responsibility for the ground transportation in Huntsville (see figure 1.)

*** Insert Figure 1 Here ***

The Security Department had the challenging job of not only keeping the lab module secure, but also coordinating law enforcement support for the convoy through four different police jurisdictions. The decision was made early on in the planning to do the move in the middle of the night in order to enhance security, and minimize the impact on Huntsville drivers. In addition, access to move plans and schedules was limited to those

who had a need to know. Media coverage was coordinated ahead of time, but they were asked not to broadcast until after the lab was safely aboard the Super Guppy.

The Facilities Engineering Department was responsible for coordinating the real-time removal of the large overhead signs on Interstate 565 in Huntsville. Additionally, they were responsible for coordinating the raising of traffic lights and power lines. This task was made more challenging because I-565 could only be closed for a short period of time.

The Safety and Quality departments provided support to ensure that the move was performed as planned and safely. They reviewed all documentation and provided representatives during the move to verify every step of the procedures.

The Logistics Engineering Group (LEG) provided overall coordination of the move as well as the coordination of communications, weather support, and photographic coverage. All of the support equipment such as cranes, tractor-trailers, personnel lifts, slings, and aircraft support equipment was identified and scheduled by the LEG. The LEG generated all of the contracts for the movement of power lines, traffic lights and signs. During the move, LEG representatives coordinated all operations.

Planning

The planning process was begun approximately a year before the actual move. The primary reason being the long lead-time required for the construction of the crossover from the frontage road to I-565. This effort had to be coordinated with the Alabama Department of Transportation and the MSFC Facilities Engineering Department. In addition to the crossover construction, coordination with the Space Station program office was needed to ensure that the shipping configuration of the lab module was compatible with the transportation modes and procedures being planned.

Six months prior to the move, all of the organizations necessary for the move had been contacted and the contracting process begun. Detail planning for all aspects of the move was also begun. During this time, it was found that some addition handling equipment needed to be manufactured in order to be able to remove and reinstall some of the overhead signs at Huntsville International Airport. Design and fabrication of that equipment began immediately.

Three months prior to the move, weekly status meetings were begun with the move team leadership in order to make sure that all of the coordination between team members was happening according to plan.

In the weeks prior to the move, the I-565 crossover was tested with a truck carrying weights in order to verify its load carrying ability and adequate size. All other equipment (cranes, slings, electrical power connections, etc) was checked out prior to the move to ensure as much as possible that no mechanical problems would occur during the move.

As an extra precaution, it is MSFC practice during critical moves to have appropriate technicians nearby to repair any equipment malfunctions as quickly as possible.

The day before the move, all of the cranes were tested with a weight equivalent to 110% of the maximum load that would be lifted during the actual move. This is done to ensure that brakes and holding valves function properly. In addition, the cranes are run through the full range of motion expected during the move to ensure smooth and trouble free operation.

It should be noted that the final shipping date remained fluid until the last week due to changes in the configuration of the lab module, making the coordination of the move considerably more challenging since activties were planned down to the minute. Because of the complexity and cost of such an involved event, an extremely detailed schedule was generated to ensure that all of the planned activities could be accomplished within the given time frame.

Execution

The actual move began with the arrival of the Super Guppy aircraft at Redstone Arsenal airfield. The shipping container that would hold the lab module was offloaded from the aircraft using a cargo lift trailer (CLT) similar to the Air Force's K-Loaders. The container, called the Super Guppy Shipping Fixture (SGSF) was then lifted from the CLT to an oversized trailer equipped with a three-point attach system. The attach system is designed so that torsion and bending loads induced into the trailer from the uneven road surfaces are not transferred into the SGSF and lab module.

*** Insert Pictures 1 & 2 ***

Picture 1 caption: Unloading SGSF from Super Guppy Aircraft
Picture 2 caption: Transferring Empty SGSF from CLT to Trailer

Lab module processing before transportation was done in a large clean room, to ensure against particle contamination. After processing was complete, it was wrapped in two protective antistatic bags and vented through desiccant canisters. The operations to lift the lab into the SGSF would be done in the clean room airlock.

The first step of the process to load the lab module into the SGSF was to remove the SGSF from the trailer and set it onto the airlock floor and close the outer airlock door. Hook height limitations prevented the lab module from being loaded into the SGSF while it was still on the trailer. The inner airlock door was then opened and the lab module moved into the airlock on air bearing pallets.

Everyone on the move team has to be specially certified to work with critical hardware. The operators and riggers have an especially rigorous process that includes physical examinations and proficiency tests. Only those who qualify can handle hardware like the lab module, which costs the equivalent of a nuclear aircraft carrier.

Before the lift of the lab module started, the team assembled in the lift area for a pre-lift briefing. The purpose of this briefing is to make sure that all of the team members understood exactly what was going to happen and what their role in the lift was going to be. It also provided an opportunity for team members to ask questions and discuss any concerns that they might have.

Full duplex voice activated wireless headsets were used for team member communication during the lift. This tool was especially important because the large size of the lab module prevented line of sight communication with hand signals. The lift area was cleared of non-essential personnel and talking was limited to lift-related issues only.

*** Insert Picture 3 Here ***

Picture 3 caption: Lab Module Lift Into SGSF

The actual lift of the lab module was done with two hooks from the same overhead crane using a specially designed lifting beam. As the module was lifted, it was noticed that it was not level in the transverse direction. Because of the last-minute manufacturing activities for the lab, an accurate center-of-gravity (CG) estimate was not available. The SGSF would not be able to interface with the CLT prior to aircraft loading if the CG was not on the centerline. Ballast was added to the SGSF container to mitigate this problem. The module was attached into the SGSF container using trunion and keel latches identical to those found in the Space Shuttle. This was done so that transportation loads could be monitored and verified to be less than launch loads. After the lab lift, the SGSF cover was lifted into place and latched. The whole assembly was then lifted onto the SGSF trailer. It should be noted that all of the lifts in this sequence were considered critical because an incident during any of them could damage the lab.

After the SGSF was secured to the trailer, the operators and riggers were sent home to rest before the late night convoy. The management team held a teleconference with the weather forecasters for an update before giving the order to begin preparing the convoy route. After a favorable report, the crews began staging equipment in preparation for the removal of signs and the moving of traffic lights and power lines.

Sign removal started later in the evening with the removal of a cantilevered sign that did not extend all the way across the interstate. The large signs were not removed until the highway was closed around midnight. The highway was closed at the same time that the convoy left the Space Station manufacturing facility. The travel time from the manufacturing facility to I-565 was about an hour. The maximum speed of the convoy was 5 mph in order to prevent undue stress on the lab module.

*** Insert Picture 4 Here ***

Picture 4 Caption: Convoy from Space Station Manufacturing Facility to Huntsville International Airport

The convoy which consisted of over 20 vehicles (mostly law enforcement) traveled 12 miles and around three overpasses and in the opposite direction of normal traffic. The convoy proceeded with no problems until it arrived on the grounds of the Huntsville International Airport. The team was beginning to feel confident that 12 months of planning would end successfully when with no warning, the automatic irrigation system installed in the landscaping activated. The resulting spray onto the side of the SGSF, although of no immediate danger to the lab module, posed a hazard to the SGSF environmental control system. The team responded by covering the sprinkler heads with orange traffic cones until the SGSF had passed by then moving the cones from behind the trailer to the front and so on. Although it made for a somewhat comical picture, the team's quick response prevented any damage or delay. After arrival at Huntsville International Airport, the lab module was loaded onto the Super Guppy for the trip to KSC.

*** Insert Picture 5 Here ***

Picture 5 Caption: The Super Guppy Aircraft Departs for the Kennedy Space Center

Sign and power line crews began replacing signs and traffic lights immediately after the convoy passed in order to keep to a minimum the amount of time that I-565 was closed. The planned 6 hour closure of I-565 was reduced to a 4 hour actual closure due to the efficiency of the sign crews.

Conclusion

There are four principles that were put into place for the Space Station Lab Module, "Destiny" move from the manufacturing facility in Huntsville, Alabama to the Kennedy Space Center in Florida.

> **Plan Ahead** – In this case, failure to plan well ahead would have resulted in a major delay for the Space Station program because of the time it took to construct a crossover and put into place the numerous contracts for police, sign removal, and utility movement. Route surveys and analyses are a critical part of the planning for any oversized hardware move. The logistics management team was put into place early on to ensure continuity and personal ownership throughout the planning and execution process.
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> **Delegate** – This principle is vital to the success of any large event. Too much reliance on a single person could spell disaster if that person becomes unavailable for some reason. Delegation should, however, be done with great care. A team member who fails to keep up with tasks can be a real detriment to the project. Care was taken in this case to choose team members who would take personal responsibility for the accomplishment of their assigned tasks.

Communicate – Frequent, thorough and meaningful communication between team members contributes tremendously to the success of a project. Regular meetings were conducted as needed to facilitate discussion of issues that needed to be brought before the whole team. Team members discussed ancillary issues at other times as needed. Cookouts and other events were conducted along the way to create a family type atmosphere and build relationships between the team members. A close, caring environment makes everyone more willing to do whatever it takes to get the job done. Communication during the move was centralized to a mobile communications center containing most of the management team. This arrangement allowed for quick informed decisions as real-time situations arose.

Expect the Unexpected – No amount of planning will prevent problems from happening during an event. The key to overcoming unexpected difficulties is having key people on hand who can respond when it happens. For instance, the critical move team keeps mechanics on hand during lifting and convoy operations in order to quickly fix any problems with mobile cranes or trucks. This policy has prevented long delays with space hardware sitting in unprotected locations several times.

Good logistics management techniques are the key to the continuing success of the Marshall Space Flight Center's critical move team. In the past six years, the team has moved nearly a hundred different critical space items without a single mishap. The handling and transportation of the International Space Station Lab Module, although more complex than most, used the same logistics management principles applied in every critical move event.