Preserving the Orbiter: Stabilization, Disassembly, Relocation and Storage of an Historic Space Shuttle Mock-Up

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Abstract: *This paper reviews the condition assessment, preliminary conservation stabilization, disassembly, and relocation of the 43-meter-long mock-up of the first Space Shuttle Orbiter, in the historic Design Engineering Implementation (DEI) Room at the NASA-Rockwell facility in Downey, California. Establishment of minimum environmental requirements and review of proposed plans for disassembly, transport and storage of the orbiter mock-up by the conservator are discussed, as well as implementation and supervision of the project. Design and fabrication of a special double-walled tent-like housing within the same building is described, along with the implementation of a long-term monitoring program.*

Introduction

In late spring, 2003, an important artifact from the beginning of NASA's Space Shuttle (Orbiter) Program had reached a critical moment. In its original location since 1972, the only existing full-size mock-up of the spacecraft would have to be moved to another location. Here it would wait to become the centerpiece of the future Downey Space Museum. Given its construction of plywood veneer over a wood frame, and its massive size, this was a formidable prospect. This paper summarizes the work performed by Griswold Conservation Associates for the City of Downey, California. The goals of the project were to fully document the condition of the mock-up, evaluate proposals for its disassembly and transport, stabilize or remove vulnerable components, and supervise its move to a large storage enclosure. An ongoing monitoring program is also discussed.

The vast collection of buildings and large hangars in Downey, about fifteen miles southeast of Los Angeles, is the site of many milestones in the history of 20th century aviation and spaceflight. It was here that North American Aviation developed the P-51 Mustang fighter plane during World War II, and later the first supersonic bomber, the XB-70. North American Rockwell built the Apollo lunar module here, and in 1972, the facility became the birthplace of the Space Shuttle when Rockwell International won the government contract to build its components at the facility, now called the Space Transportation Systems Division.[1] Boeing Corporation's Space Systems Division subsequently occupied the facility throughout the NASA period.[2]

The Space Shuttle mock-up was originally built to fulfill a requirement of the contract bidding process, but remained a useful tool for the program for the next several decades. In spite of the relatively ephemeral materials of its construction, it lasted for years as an accurately proportioned simulation of the exterior and interior spaces and features of the

actual vehicle, modified over the years to reflect updates in design. The mock-up lacks a left wing in a measure to eliminate redundancy and to save space. The flight deck, crew quarters, cargo bay, and engine compartment are authentically fitted with every detail, often represented by simple painted wood shapes or silk-screened plastic or metal sheeting. This verisimilitude allowed engineers to accurately check prototypes of planned equipment in their intended location. Some prototype items, such as a machined metal restraint for astronaut's boots at the airlock to the cargo bay remain in place. Mock-ups of payload equipment and containers were also tested for fit, and one array of simulated electronic equipment on a specialized pallet remains bolted in the cargo bay today. The Remote Manipulator System (RMS), a jointed, rotating arm made for deploying payloads, built by Canada, is faithfully represented by an accurate, non-working replica in aluminum. It is bolted to the port side of the payload bay.

Located in the Design and Engineering Integration Room, or DEI Room, the orbiter mock-up was used for a number of other purposes. It was a centerpiece of public relations and a visual aid for communications with members of congress and other government officials, who frequented a two-tiered complex of office and conference spaces across from the mock-up. A balcony gave an impressive view of the shuttle, surrounded by dramatic paintings of as-yet only imagined space stations and orbiters operations. The shuttle mock-up also served as a training tool for astronauts and other spaceflight team members. A sea of electrical and electronics cables fed the mock-up, and oxygen supply outlets to the astronauts' space suits were reportedly located nearby. The mock-up may have been used during investigations into the Challenger disaster in 1986.[3]

The DEI Room was only a small corner of an enormous warehouse-like building. Beyond the mural-clad partition walls lay a vast beehive of industrial activity, built to accommodate multi-station aircraft and spacecraft assembly and fabrication operations fed by a complex of overhead gantries running on more than a mile of tracks.

In 1999, the Downey plant of the Boeing Space Systems Division was closed, and the property was acquired by the City of Downey. In 2000, the city council confirmed purchase of the Space Shuttle mock-up from NASA.[4] Making use of the vast indoor spaces afforded by several of the buildings and the large, open airfields surrounding them, the city leased out space for feature film productions by major Hollywood studios. This provided a steady revenue stream to the city while plans for re-development of the facility took shape. Plans include a museum facility to interpret the rich aviation and aerospace history of the site, but specifics have yet to be determined.

In the meantime, the Space Shuttle mock-up would need to be moved to make way for a new major film production, with elaborate sets taking up much of the interior of the building. The DEI Room would be dismantled in the process. Incredibly, the transformation of the building into a sound stage would include a vast lake set into the floor.

Alternative sites for storing the mock-up were sought, and several options were reviewed by the conservator in consultation to Loren Behr, director of the new museum. It was clear that all of the nearby available structures, hangars built to protect aircraft from inclement weather decades ago, would present a much less stable and protective environment compared with the present building. A comprehensive plan was needed for the long term care of the mock-up. On July 8, 2003, the Downey City council approved a proposal from Griswold Conservation Associates, LLC to perform conservation services in connection with its relocation to an area within the building, beyond the perimeter of the movie set being constructed inside. This area, adjacent to a group of large enclosed rooms, was determined to be large enough to house the mock-up. A temporary shelter would have to be designed and built to help mitigate abrupt changes in environment during filming, and to protect the mock-up during excavation of the cement floor and construction of the set. The addition of a large body of water within the building presented special concerns regarding the stability of the environment. Since alterations of the building were already underway, the plan to save the Space Shuttle had to be implemented quickly.

The project to move and re-house the Space Shuttle mock-up was divided into four phases: condition documentation and assessment; development and implementation of a Supervision and Monitoring Plan for moving the mock-up; and monitoring the components of the mock-up during storage. The fourth phase, relocation and re-assembly of the mock-up, was left undefined in the proposal, given the many unknown factors regarding the status of the future museum.

Phase I: Condition Documentation and Assessment

A team of four assistants worked closely with the conservator to describe the various components of the mock-up and their condition. Each team member was given pre-printed forms that included spaces to write brief descriptions of a particular item, condition notes, and a simple diagram. A small drawing of the Space Shuttle was included on the form so the surveyor could indicate the approximate location of the item addressed. Check boxes aided the worker in indicating recommendations for removal or stabilization, and for assigning elevated priority status as needed. Along with the forms, the team member received a glossary of technical terms pertaining to the spacecraft.

As the forms were filled out, the conservator consulted with each assistant to ensure common vocabulary was being used to describe the conditions found. Acting as a rover among the group, the conservator could ensure a fairly uniform standard of reporting. This also allowed the conservator to build a photographic reference collection of special conditions found by the team, to supplement the photo survey being conducted at the same time.

The conservator was primarily responsible for the photo survey, focusing on recording the state of the entire mock-up inside and out, before any elements were removed or otherwise altered. A Nikon D-100 digital SLR camera was used with a Tamron 28-300mm zoom lens. The built-in flash was used to ensure simplicity and uniformity of

lighting conditions. By having one person responsible for photographing the entire structure, redundancy was minimized and a logical "rhythm" of taking photos, section by section, was observed. This proved invaluable in sorting and cataloging the images afterward, and should help anyone using the report in later phases to locate a particular item or feature. Image files were shot in JPEG format, with average individual file sizes around one megabyte. Since many hundreds of images were being cataloged, larger file sizes would have overtaxed the disc storage capacity available at the time, and would have slowed the processing speed of the databases to be used to view the condition records and their related images.

Given the speed with which the condition survey was to take place, copies of the hand-written forms and the photo image catalogs comprised the full condition report submitted to the city prior to dismantling the mock-up. There was no time to develop a database-driven recording regime, where laptop computers would be used for direct entry of data. Because the film production company was eager to begin demolition and construction of the set, time was of the essence. To create such a database, with checklist format entry screens linked to text descriptors, the many details of fabrication and the full range of materials encountered and potential conditions would have to be known in advance. Relying instead on simple forms and the communal development of terms and descriptive protocols allowed a massive object to be recorded in less than a week. In the future, the data recorded by hand will be entered into a Filemaker Pro 5.0 database, and coordinating images will be linked to each record through a separate relational database. A third database will allow treatment-related data and monitoring observations to be added to each record.

To keep track of the many images, the conservator reviewed several digital media management software programs. One program, iView Media Pro (v.1.5), allowed a large text caption to be associated with each image in a printed catalog. This was considered an important advantage, and the program was found to be extremely efficient to use. It was only available for the Macintosh operating system, however. Therefore, PDF files were created of each catalog using Adobe Acrobat 6.0 to create a catalog document readable on any platform.

Catalogs of images were divided into groups relating to the various general areas of the mock-up, including the payload bay, the flight deck, the exterior fuselage, the engine compartment, etc. The catalog files were then burned onto CD-R discs along with the related image files. A separate disc contained copies of the related databases. With the latest versions of database programs such as Filemaker Pro versions 6 and 7, large image files can be related to database records without directly importing them into the document, speeding up data management and display tasks such as sorting and searches.

The shuttle was constructed in four main sections, including: 1) the nose, flight deck/crew quarters and forward half of the fuselage; 2) the aft portion of the fuselage, the tail assembly/engine compartment, and the engines/ Orbital Maneuvering System (OMS); 3) the starboard wing; and 4) the two starboard cargo bay doors. Sections 1 and 2 were joined at vertical seams in the fuselage, covered on both sides by steel mending

plates and rows of bolts fitted with washers and hex nuts. The seams were covered with painted tape. The wing was supported on its own steel carriage, also on casters, and simply placed next to the fuselage, the seam covered with painted fabric tape.

On the port side of the mock-up, a wooden staircase and observation platform had been erected, giving access to the crew compartment hatch opening and forming a viewing gallery into the cargo bay. Beneath this platform were several large, metal electrical equipment boxes with myriad cables feeding various locations under the mock-up. These features were photographed for future reference, but were excluded from the survey. Where possible, fasteners were disengaged and cable ends rolled and stored inside the mock-up. The black fabric curtains skirting the steel undercarriage of the mock-up were diagrammed and stored for possible future reinstallation.

Because the shuttle body sheathing was simulated using thin plywood veneer over wood ribs and cross braces, an undulating pattern reflecting the underlying supports was noticeable. There were also small gaps and discontinuities in the surface planes at joints in the sheathing. These were noted and recorded for monitoring during and after the move.

During the condition assessment process, a number of items were flagged for removal from the mock-up for separate storage. Many items were small, incidental objects such as imitation fire extinguishers, silvered fabric window cover panels, wooden blocks representing equipment or flight gear, and other items related to the original use of the shuttle. In addition to these readily identified items, a number of ephemeral objects relating to various experimental and interpretive activities were found within interstices or underneath coverings or supports. These included stacks of numbered signs and photographic scales, pieces of NASA stationery and signage, marking pens, etc. All were inventoried and photographically recorded before and after removal.

Some pieces of the shuttle itself required removal during this phase of work. The largest of these items was the front landing gear assembly, to be removed in one piece and secured to a wooden pallet, specially padded with polyethylene foam blocks, Volara® sheeting, and Tyvek® (a proprietary spun-bonded olefin made by DuPont Corporation). Cotton twill or polyester strapping was used to secure the assembly to the pallet, with drywall screws placed well away from the artifact.

Several loose items were too large to remove from the small hatch openings, such as detached hatch covers. These were packaged in Tyvek® and 1/4" polyethylene foam sheeting, and secured in place. Tyvek® was chosen as the material to use in direct contact with the mock-up and its components since it would minimize abrasion during transport and handling, and allow water vapor to pass away from the object, minimizing the possibility of condensation.

Some items were found to be damaged or loose. These required stabilization in place in anticipation of jolts and vibration during the moving process. Several of the clear plastic, prismatic light panels in the crew quarters were cracked and/or loose due to

missing fasteners, and vinyl plastic coverings were losing their grip due to embrittlement of the adhesive holding the Velcro® patches to the painted plywood. These were secured using temporary means including cotton twill tape ties where possible. Where the weight of hanging, degraded plastic sheeting posed a risk of further tearing, it was removed and stored separately.

Phase II: Development and Implementation of a Supervision and Monitoring Plan

Before the city enlisted the aid of a conservator, a Request for Proposals was issued to a group of potential bidders capable of moving large artifacts or aircraft. The city received several detailed work plans for disassembly, support and transport of the sections of the mock-up once the location within the same building was chosen as the destination, accessible along a path about a quarter of a mile from the DEI room.

A firm specializing in the handling and storage of artworks and artifacts, LA Packing, Crating and Transport, Inc., was chosen to perform the move. Interviews with the conservator led to further refinements of the work plan. The plan relied on the welded steel framework and existing heavy-duty casters already in place under the flimsy plywood construction of the mock-up, to provide the main support during the move. This framework was reinforced with additional steel braces welded in place. Due to the risk of fire, protocols for "hot work" were implemented, including fire-shield blankets and pads, fire extinguishers at hand, and monitoring for sub-surface temperature spikes using a hand-held, infrared temperature sensor gun.

The LA Packing crew performed the disassembly under the direction of the conservator. Photo documentation continued throughout the process, and the disassembly crew submitted notes to the conservator showing details needed for future reassembly. Special bracing was required to support the RMS assembly once the fuselage sections were separated. To gain access to structural members of the fuselage and undercarriage, the vinyl covers were removed at their Velcro® attachment points, and either rolled on large diameter Sonotubes® covered in Mylar® film, or partially rolled in place. The conservator decided to cut the existing painted tape over the mending plates, leaving it in place for future reference and possible repair or replication. Part of the tape was already peeling off, and this was re-attached using a reversible adhesive. Once all preparations had been made, the four main components were separated using tractor/forklifts, sometimes in tandem.

Evidence of previous configurations of the mock-up was revealed upon separation of the wing from the fuselage. Black and white paint configurations and other markings made with adhered striping tape suggested an earlier configuration, seen in an early photograph. Further research showed that the meeting point of the OMS system housings flanking the vertical stabilizer with the back end of the cargo bay door reflected an earlier version, later changed by NASA. Thus the mock-up was found to embody evolutions in design of the first orbiter.

Concurrent with the disassembly process, an Omega Nomad datalogger was placed in the DEI Room to record temperature and relative humidity readings for one week to establish a baseline for future monitoring. Unfortunately, the datalogger was lost when demolition of the DEI Room happened slightly ahead of schedule. Spot measurements taken with a digital thermo-hygrometer at varying times throughout the process allowed a rough baseline range to be established in the absence of a complete diurnal tracking of environmental conditions. Since the stated goal of the relocation was to simply achieve and maintain conditions similar to those found in the DEI Room, the high and low extremes were the most significant data points to establish. These would, of course, need to be adjusted for seasonal changes based on general meteorological data available.

The path of travel was prepared concurrently with the preparation of the new enclosure for the mock-up components. Overhead gantries were relocated, and missing grates over drain channels in the floor were replaced. Several standing conduit pipes emerging from the floor were removed as well. The greatest obstacle was the east wall of the DEI room itself. The mock-up must originally have been brought into the Room through a large steel roll-up door at the north wall, directly opposite the tail assembly. This option was no longer available due to demolition of the floor already underway beyond it. A large opening in the east wall would have to be made ahead of the shuttle's nose. (The city photographically documented all murals, following standards established for the Historic American Buildings Survey (HABS).

The ongoing demolition inside the building, and the impending demolition of the east wall opening made special protective measures necessary. The entire path of travel to the new location was curtained off using 6 mil polypropylene sheeting with large, overlapping seams secured on both sides with duct tape. Both sides of the opening were tented and fitted with positive pressure blowers to create the required environment for abatement of the potentially asbestos-laden wall during demolition by the contractor.

At the far end of the path, a 150-foot long enclosure, 50 feet wide and 34 feet high, was being constructed. An inner "tent" of Tyvek® would stand 2 to 4 feet away from an outer wall of polypropylene sheeting. In theory, this would create a buffer zone to help mitigate rapid changes in temperature and humidity.

Only ten-foot wide rolls of Tyvek® were available on short notice. As a result, many linear feet of joints between vertically- and horizontally-hung sheets would need to be sealed. Red construction-grade duct tape has been used previously on architectural conservation projects to secure Tyvek® wrappings around foam protective panels, for exterior window protection, the joins becoming more stubbornly adhered over time. Based on this experience, the conservator suggested using this tape on both sides of the seams during construction. Any off-gassing due to the use of non-archival tape/adhesive would be far offset by the vast air volumes enclosed. Early failures of adhesion during the construction of the enclosure necessitated re-application of the tape, better pressed in place against a firm surface.

The enclosure was comprised of a north, west, south and east wall, and a ceiling. The Tyvek® and the plastic sheeting were stretched above and below the existing superstructure framework of the gantry, forming a ceiling with the same buffering air space between the membranes. The east wall of the enclosure was formed by fastening and taping the sheeting to the wall of the building defining the side rooms, each with their own closable doorways. Once the south wall was erected after placement of all the shuttle components, the only access was through a set of locked doors in the east wall outside of the enclosure, leading to the adjacent storage rooms. As an added measure of security, a six-foot chain link fence was erected around the enclosure, topped with razor wire.

The move of the main mock-up sections took place over three days. As predicted, the existing casters that had been used over 30 years earlier to place the shuttle rolled easily again under the careful tugging of two tractors, but only for a few inches. Suddenly, the forward fuselage section stopped moving and movement was seen at the observation platform on the port side. Although the platform appeared to be free of the shuttle, one spot was not visible, behind the stairs and below the hatch opening. It became clear that the original hatch, presumed either lost or to have never existed, was found. Removal of the carpeting and plywood flooring revealed the hatch, perfectly intact on its hinges, built into a hollow in the stairs.

Once free, all sections rolled the entire distance without incident. Three members of the conservator's staff spotted each section as it moved along, prepared to signal a halt at any moment.

The payload bay doors had been strapped to large wooden pallets built for the purpose. The pallets were to provide rigid support and a lifting platform under the extended forks of the forklift. In fact, the added weight and the long span was more flexible than the curved doors themselves, and one wood member of the pallet cracked during transport, requiring reinforcement. Thanks to the padding and strapping configuration, the doors were unharmed except for a small indentation at the interior edge of the plywood sheathing.

No emergency response was necessary during the move. Repair of the damage incurred to the cargo bay door would be cosmetic and minor, and therefore was deferred until the re-installation phase.

A monitoring plan was written, defining the storage conditions to be met as part of the tenant's building use terms, and the means by which these would be monitored and mitigated by the conservator and others. Temperature and relative humidity must remain within the general range established in the DEI Room. Elevated conditions for more than a 24-hour period would require intervention, including the use of de-humidifier units and fans. Pest management was a key concern, and the tenant would be required to contract with an approved pest management company fur the duration of their occupancy. Security was of the utmost priority, since theft, vandalism and damage from abuse could cause irreversible loss of historic fabric.

In order to implement the plan, the conservator and city representatives would need unrestricted access to the mock-up, even during closed set operations of the film production. Use of lights, wind generators, pyrotechnics, and other tools of movie magic are beyond the control of the conservator, but the conditions resulting inside the Space Shuttle enclosure could be extreme. Timely monitoring and response would be of the essence.

Phase III: Monitoring of Mock-Up Components In Storage

The Tyvek® envelope remains generally intact after one year, with some minor gaps where the tape adhesion has not been properly re-established. These areas appear stable, but reinforcement with simple alligator-type clips may be recommended in the future.

There have been water leaks in the roof near the southwest corner of the enclosure, with some pooling of rainwater near the outer barrier wall. Sandbags have been brought in as a protective measure here, and water was removed immediately using wet/dry industrial vacuum units. Absorbent booms are now to be placed around the entire perimeter of the enclosure.

Monitoring the internal environment using dataloggers has been problematic due to equipment failure, but we now have a set of data to use for comparison with spot readings of T and RH taken in the DEI Room before removal of the Space Shuttle. In general, the temperature and relative humidity are fluctuating within a range similar to the original storage conditions prior to the move, allowing for differences in seasons, etc. Temperature inside the enclosure fluctuated approximately 6 to 10 degrees diurnally, with moderate trends up and down between extremes of 58 and 78 degrees F. Relative humidity fluctuates diurnally about 10 to 15%, generally between 45 and 72%, with an anomalous dip to 28 percent (presumably during dry Santana wind conditions common to the area). The efficiency of the enclosure in buffering environmental changes relative to both the interior of the building and outdoor conditions is in the process of being evaluated through the use of additional dataloggers. Early indications are that the enclosure does, in fact, slow down changes, but similar extremes of temperature and relative humidity are reached within 48 hours both within and without.

While the collected data is far from ideal museum storage conditions, where stable temperature between 68 and 72 degrees F and RH between 45 and 55% are maintained, it is within the realm expected given the state of the building and the passive nature of the enclosure. Interior conditions are certainly more stable and change less dramatically than outside conditions. More importantly, they are an improvement over the range suggested by daytime spot readings collected during June through July before the move in the DEI room (see table below).

Date	*Time*	*Temp. (F)*	*RH (%)*
6/12	*1 p*	*73*	*37*
6/17	*11a*	*74*	*42*
7/2	*11a*	*72*	*68*
7/2	*2p*	*79*	*61*
7/9	*8a*	*62*	*50*
7/9	*11a*	*74*	*47*
7/15	*9a*	*72*	*63*
7/15	*1p*	*80*	*54*
7/16	*9a*	*74*	*45*
7/16	*2p*	*81*	*31*

Table 1. Spot conditions recorded in DEI Room.

The spot readings are taken during summer, during the day. The variations seen suggest even more fluctuation during diurnal periods. A general characterization of summer conditions in the DEI room would be temperature between about 55 and 80 degrees F, and RH between 25 and 70 degrees F.

The graphed data from the dataloggers shows that conditions vary within the enclosure at different heights, the one datalogger being placed on top of the cargo bay at the top of the stairs. RH conditions vary less at the upper level, and are within a more moderate range of both T and RH than readings logged within 7 feet of the floor.

While RH was seen to rise to over 70 percent, this was not sustained for more than 12 hours. Sustained RH levels within the enclosure above 70% for several days would warrant the use of de-humidifiers to help normalize the conditions. This may become necessary once data is collected after filling the lake, or during periods of filming where hot lights combined with wind machine-driven waves and mist may create harsh conditions within the building.

Dust has accumulated on the floor and on Space Shuttle components. This was expected, especially given the demolition and construction underway in the building. The rate of future deposition is expected to lessen. A test area has been cleaned for future monitoring. A general surface cleaning campaign may be recommended within the next 6 months once airborne dust levels have been reduced.

No signs of insect or rodent infestation have been seen. Since an Integrated Pest Management Program had not yet been implemented as required, the conservator placed several sticky traps around the interior perimeter of the enclosure. The conservator will review all proposed pest mitigation procedures.

Security continues to be a priority. City representatives and the conservator must have access as needed to the closed set, certainly a problem when secrecy must shroud the latest Hollywood blockbusters. It may be recommended to install a video surveillance system, perhaps accessible through a website.

As the observations made during the past year demonstrate, ongoing monitoring and enforcement of storage condition requirements will be key to the long-term preservation of the Space Shuttle mock-up. The baseline documentation compiled by the conservation team provides a reliable basis for demonstrating ongoing deterioration and damage, but detailed records of the rate of change and mitigation measures taken will prove extremely useful in designing future phases of treatment as the Space Shuttle mock-up become the centerpiece of a new museum

Acknowledgments

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The Space Shuttle Orbiter mock-up seen by floodlight in the DEI Room.

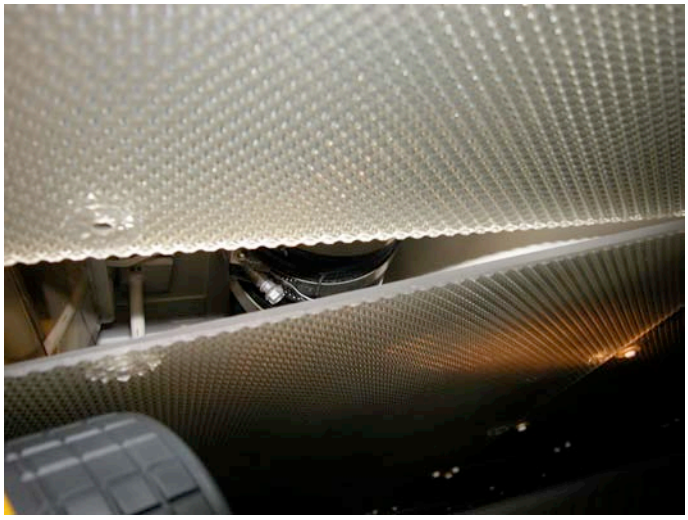
The forward flight deck.

Metal boot restraint on ceiling of payload bay airlock.

Missing section of simulated rubber insulation on ceiling window of flight deck. Note exposed pine wood. Debris has fallen onto the top of the glass from the ceiling.

Window covers stored loosely in a wall pouch.

Torn vinyl plastic sheeting and degraded adhesive tape and Velcro attachments on flight deck.

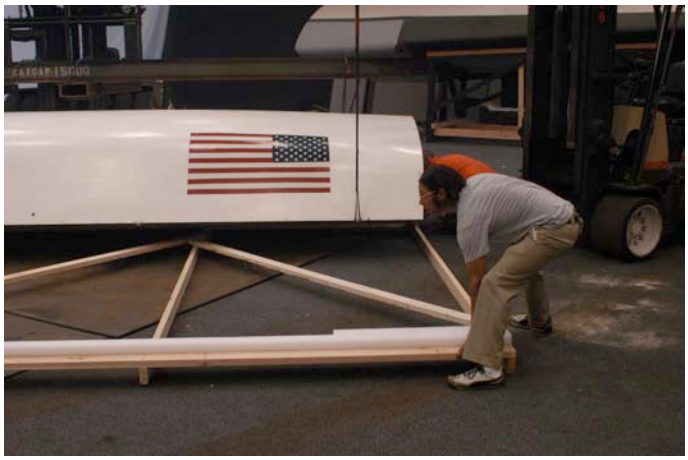


Failing fasteners at prismatic lighting lenses made of acrylic.

American flag decal on underside of wing is detaching from the painted plywood substrate.

A forklift and a scissor lift were used to stabilize and remove the payload bay doors.

Rotating one of the payload bay doors into storage position.

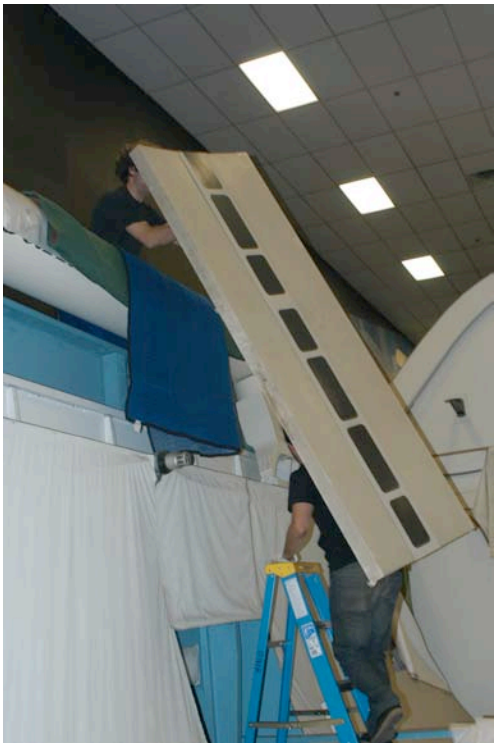


Positioning to support pallet framework for one of the payload bay doors.

A payload bay door in place on its pallet.

Welders adding additional bracing and joint reinforcements to existing steel trusswork supports under fuselage.

View of the Mock-up from the observation deck of the DEI Room during disassembly.



Removal of interior panels from payload bay to gain access to substructure for separation of the fuselage.

Curtain wall corridor in place, seen from inside the demolition zone.

Wood framing and plywood skin of a payload bay panel see from the reverse.

The wing, supported on steel trusswork, after separation from the fuselage.

The internal structure of the wing was visible after separation from the fuselage.

The removal of the wing exposed part of an earlier configuration of paint scheme and details delineated in adhesive vinyl striping tape.

Observation stairway and platform are visible on the port side of the Shuttle.

Internal framework of the payload bay exposeed after partial removal of vinyl covers.

Installation of the outer polyetylene sheeting layer of the storage tent.

Conservation assistant documenting conditions as they are exposed during disassembly.

Hanging shreds of urethane foam gaasketing at edge of payload bay door.

Curtain wall corridor from inside, showing storage tent construction in progress.

Temporary protective covers made of Tyvek and painters' low-tack blue tape were applied over vulnerable graphic details on the exterior of the fuselage during the move.

Outer polyethylene layer of storage tent almost completed.

Disassembly of the nose landing gear assembly.

Detail of the underside of the nose landing gear assembly showing deliberately flattened portion of the painted wooden tires. Note chip losse and abrasions.

Placement of the nose landing gear assembly on its pallet.

The painted wooden wheels of the nose landing gear padded with Tyvek and braced to the pallet. Ethafoam polyethylene foam planks and wedges were used for additional support.

The nose landing gear assembly placed on its pallet in the storage room adjacent to the tent.

Tyvek sheeting is installed on the inside of the storage tent, forming an air space of approximately one meter from the exterior tent wall.

Storage tent, with both layers in place, ready to receive the Mock-up components.

Tyvek sheet sections inside the storage tent awaiting closure of the seams, while the floor is cleaned.

Installation of bracing under sections of the "Canadarm" in the payload bay.

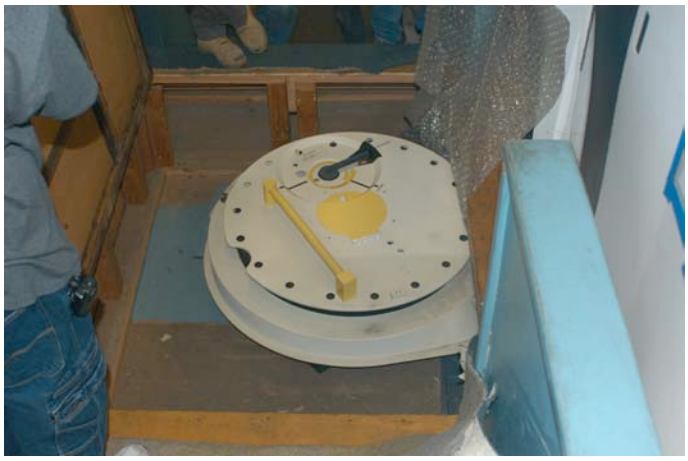
Demolition in progress inside the building, with curtain wall corridor in the background.

Transporting the first of the Mock-up sections to the storage tent.

Placement of a payload bay door in the storage tent.

Beginning to separate the nose and forward fuselage from the aft sections.

Discovery of the hidden port hatch cover to the crew quarters inside a compartment in the observation platform landing. Deep U-shapped hinges were hidden below the platform and were not visible from any angle.



The exposed hatch cover. The cover was raised and braced from the inside with ethafoam wedges and twill tape ties.

The fore and aft sections of the fuselage separating at the vertical joint during the initial stages of the move.

The fore section of the Mock-up is towed through the opening in the mural wall, entering the curtain wall corridor.

The fore section entering the corridor.

The fore section of the Mock-up is towed around a tight corner toward the storage tent.

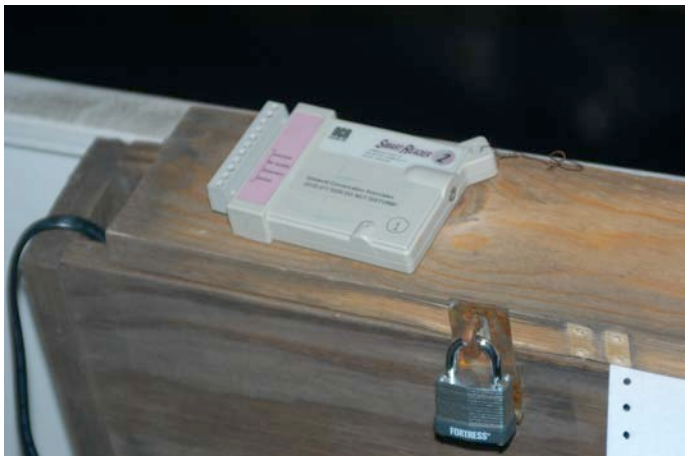
The fore section of the Mock-up entering the storage tent.

Rolling the payload bay vinyl covers in Tyvek sheeting on Sonotubes for long-term storage.

The aft section of the Mock-up during transport.

The aft section of the Mock-up turning the corner in the curtain wall corridor.

Placement of the aft section in the storage tent.



Dataloggers recorded the temperature and humidity in the DEI Room before disassembly and removal of the Mock-up.

The Mock-up inside the closed storage tent. A chain link fence topped with barbed wire was erected around the perimeter to enhavce security.

Early failure of improperly sealed tape joints in the Tyvek wall.

Failure of tape joints at the ceiling level caused some sheets to fall. Inspection of the tape joints lower down showed that the adhesion between the tape and the Tyvek could be quite strong when properly attached.

Dataloggers were placed in two locations inside the tent to monitor environmental conditions during storage.

Winter rains revealed a building roof leak not apparent during initial inspections. Water entered the storage tent at the perimeter on the south side, but did not contact the Mock-up.

Sandbags were hastily deployed along the path of travel of the water leak.

Loren Behr of the City of Downey accompanies the conservator during a monitoring inspection visit.