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OF POOR QUALITY

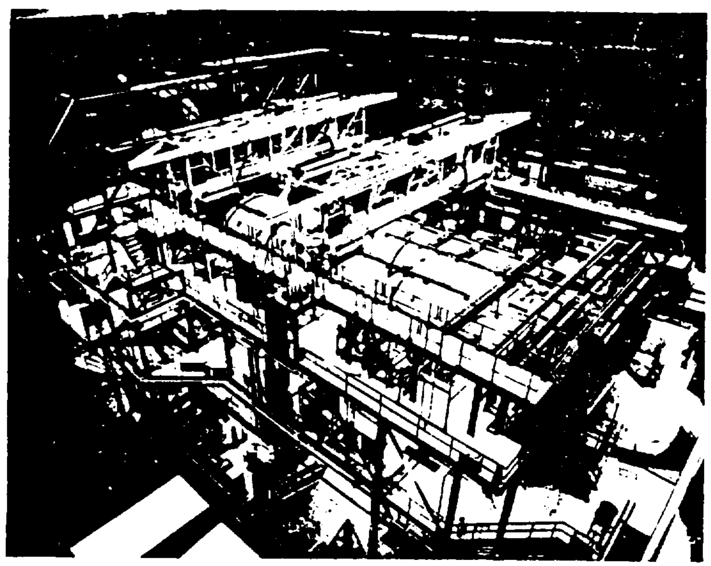
ORBITER PROCESSING FACILITY: ACCESS PLATFORMS
KENNEDY SPACE CENTER, FLORIDA
"FROM CHALLENGE TO ACHIEVEMENT"

by Michael Haratunian, P.E.
President
Seelye Stevenson Value & Knecht

ABSTRACT

The challenge presented to Seelye Stevenson Value & Knecht (SSV&K) by the National Aeronautics and Space Administration (NASA) was to provide a system of access platforms and equipment within the Orbiter Processing Facility to completely service the orbiter. NASA presented unusual design criteria to the firm: create a structure that allows service access to all areas of the orbiter without the need to step or lean on any portion of the craft; create a design that does not interfere with the movement of the orbiter during roll-in or roll-out of the facility; and, due to the concurrent development of the final version of the orbiter's geometry, design the structure with minimum clearances using preliminary data for Outer Mold Lines.

Towards this end, SSV&K developed a system of platforms that is responsive to the maintenance and testing requirements of the orbiter between space missions.



Orbiter Challenger in OPF.

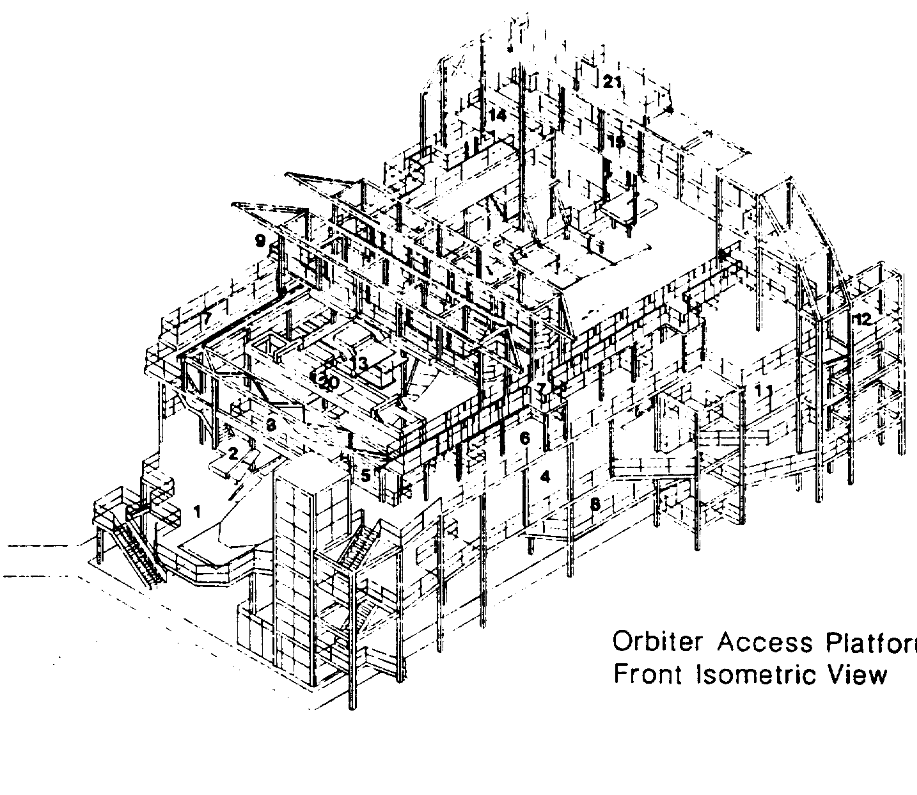
INTRODUCTION

Specified design criteria was met by the firm through research and development. Numerous studies were made using the clearance and load criteria specified by NASA. Final design was met by the interplay of concepts between NASA and SSV&K engineers during the detailed review of each section's needs. For example, the hydraulic actuators used for the platform's movements were chosen after discarding previous suggestions: use of an electric motor was rejected due to the danger of sparking within a hazardous environment; a non-sparking motor was eliminated due to excessive cost; and the use of compressed air was also contemplated, but was rejected due to lack of its availability at the site. Oil hydraulic actuators, fully sealed to prevent oil spillages, were finally chosen as the most advantageous method of providing the platform movement.

The design of the overhead bridge was also developed through close collaboration. The need for further access to the top of the Orbiter and payload bay was desired. Towards this end, the concept of an overhead structure was quickly recognized. By adding movement to this overhead structure, its versatility was greatly increased. A combination of longitudinal, transverse, vertical and rotating movements were subsequently developed.

The platform system which was ultimately developed consists of a series of fixed, moveable and cantilevered platforms. The moveable platforms include flip-up, flip-down, telescoping horizontal and vertical, scissor-type and completely moveable units. The overall platform structure is some 140 feet long, 91 feet wide and 58 feet high, and can support substantial dead loads, hoist loads, and live loads. Fixed stationary platforms were first developed, for required access elevations of the orbiter by working closely with NASA as the concurrent design of the orbiter was progessing. From these fixed areas, the moveable platforms were subsequently designed. These non-stationary platforms, closing within eight inches of the orbiter, are moved by manual or mechanical means in accordance with the size, location and type of motion required. To permit the orbiter uninterrupted access and egress into the OPF, the platforms flip-up, retract or swing free from the main structure. They are closed around the orbiter once it is in place and ready for servicing. Another feature of the design included the ability to cut back on the platform edges without affecting the structure's integrity. Therefore "hard steel", as we called it, was set back seven inches from the edge of platform. This seven inch section became known as "soft steel".

To facilitate design, a working scale model was constructed by SSV&K: This model proved to be a great aid to the firm and NASA in furthering the design to the construction stage.



Orbiter Access Platform
Front Isometric View

NASA Clearance Envelopes

The concurrent design of the orbiter along with OPF platforms presented an unusual design challenge for the firm. Achieving platform clearances specified by NASA required close collaboration between NASA and SSV&K engineers. During orbiter roll-in/out, jacking, and leveling, a minimum of 18 inch as clearance was permitted from the orbiter's Outer Mold Lines to each platform edge. Once the orbiter is in position and ready for servicing, eight inches was permitted between the platform and the orbiter. During the moveable operation of a platform, four inches clearance from any moveable part of the platform to the orbiter was allowed. As mentioned earlier, the outer seven inches of each panel was constructed of "soft steel" to allow notching, penetrations or cutting away without affecting the structural integrity of the panel. The main structural support of each platform was set back seven inches from the panel edge. This became known as "hard steel". This ability to cut away portions of the platforms greatly increased the flexibility of the platform's design.

Load Criteria

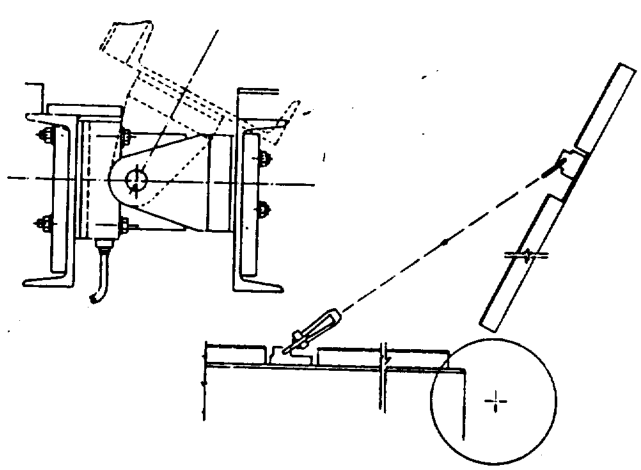
Another challenge presented to the firm was to design cantilevered and moveable platforms that also meet unusual live loads and deflection restrictions. SSV&K engineered a structural design that met deflections limited to L/360 of the span for nearly all platforms. Cantilevered elements, and the panels that swing-up and down were limited to L/240 of the span for live loads and equipment wheel loads.

Platform Movements

The movements of the platforms are an integral aspect of the design scheme. To provide complete accessibility as well as to maintain required clearances, platform extremities are made of hinged panels. The hinges are designed for both the swinging movement of the panels and as a support when the panels are in service.

The direction of a platform's movement was determined by the clearances below and above each platform. When a platform swings up, the hinge uses an integral bolt stop; when it swings down, the same hinge is rotated 180 degrees, and is supplemented with a toggle latch. This design permitted the use of a simple clevis-type hinge.

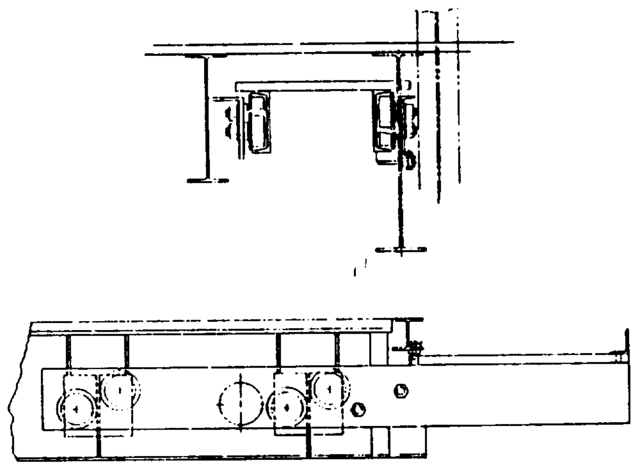
Several means of panel actuation are provided for swing-up platforms: a simple bar for lighter panels and manually operated winchs, and hydraulic rotary actuators for larger, heavier platforms. Hydraulic rotary actuators consist of a vaned heavy-duty torque motor with integral load-carrying bearings. In this case, the unit functions as both a hinge and actuator.



Swing Up/Down Platform
Hinged w/Actuator

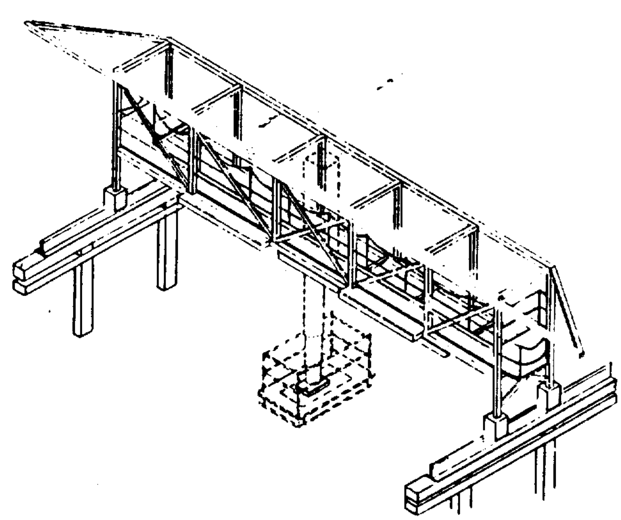
Where clearances were such that a hinged platform interfered with the orbiter's movement, platforms were made extensible by telescoping.The telescoping platforms are manually activated and have anti-friction bearing rollers that ride on hardened steel guides.

Manually operated hoists are also used for lighter swing-up and down platforms. These are of a simple-geared winch type with removable hand cranks.



Horizontal Telescoping Platform

Augmenting the main structure of platforms are two 50,000 pound moveable bridges that traverse along the length of the orbiter's 60 foot payload bay. Each bridge has two vertically telescoping platforms that move laterally across the width of the bridge as well as in a 360 degree rotation. These four vertically telescoping platforms (also called telescoping buckets) further enhance accessibility into and about the orbiter. A dual electrical motorized trolley system directs these 9 foot x 3 foot buckets traversely. They are positioned vertically using an electrically powered variable speed two-rope winch which actuates the telescoping bucket support. These buckets are supported by two electrically motor drawn bridges which use a chain drive system. The bridge rides on flanged wheels upon a rail equipped with anti- trip rollers for stability.



Rolling Bridges w/Buckets

APPLICATIONS OF MOVEABLE PLATFORMS

Using the series of movements, the platforms are flexible enough to successfully service the orbiter in accordance with each section's special needs.

Beginning with the front section of the craft, Platforms 1, 2, and 3 provide service personnel access to the nose, using flip-up and down movements. When these platforms are raised, they are secured away from the entering orbiter's nose section. Once the orbiter is in place, these platforms flip down and permit servicing of the instrumentation in this section, including antennae, the Orbiter Reaction Control Subsystem, and Startracker Well.

The Startracker Well requires a Class 10,000 clean room for servicing. To meet this need, a moveable anti-static nylon closure was devised to ride on fixed guide tracks and sliding assemblies. An air distribution system was also designed providing a positive air atmosphere.

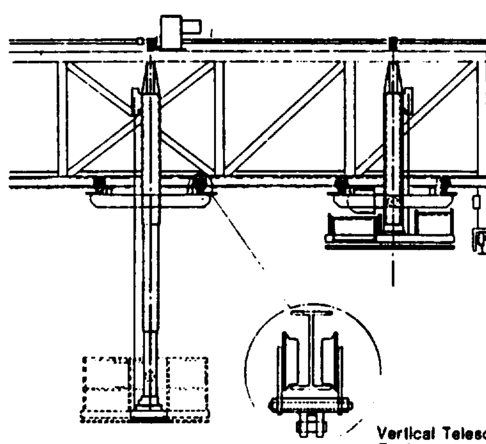
To permit the use of normal service equipment and consoles, these platforms are designed to hold a live load of 100 pounds per square foot, or 2,000 lbs. concentrated load over a 2'-6" square area.

Servicing the wing sections are Platforms 4 and 8. These also flip-up and down permitting safe roll-in, jacking, and leveling of the orbiter. The larger platforms in this section are powered by hydraulic actuators, while the smaller panels are manually raised and lowered, using a special hook designed for this purpose. These platforms permit service personnel to perform general maintenance on the wing, such as replacing the thermo-tiles. Platforms 4 and 8 can handle live loads of 100 pounds per square foot.

The payload bay area, 60 feet long with a 15 foot diameter, posed another special challenge in the design of the platform system: providing access to this section with the payload bay doors in a fully opened, closed or 145 degree, partially opened position.

This was accomplished using the combined movements of Platforms 11, 11a, 12, and 13. Platform 13 swings up and down along the length of the payload bay doors, and is therefore able to service the skin of the orbiter when the doors are fully closed. It also provides access into the payload bay cavity when the doors are fully extended by precisely fitting over the opened doors.

The overhead bridge and telescoping buckets further facilitate accessibility using four separate movements: the bridge with the telescoping buckets can move laterally along the length of the bay; the bucket platforms telescope vertically, up to 20 feet in either direction, thereby servicing the payload bay cavity itself or servicing the orbiter's skin when the cargo bay doors are closed; it can rotate 360 degrees and can also move along the width of the bridge, and therefore the orbiter. The 360 degree movement is controlled by a hand cranked gear reduced system operated from the bucket. A catwalk runs along the length of each bridge. This serves as a crossover platform as well as a service platform for the bridge and bucket drive system. Each bucket can support a 500 lb. load, while the bridge can accomodate 1000 lbs.

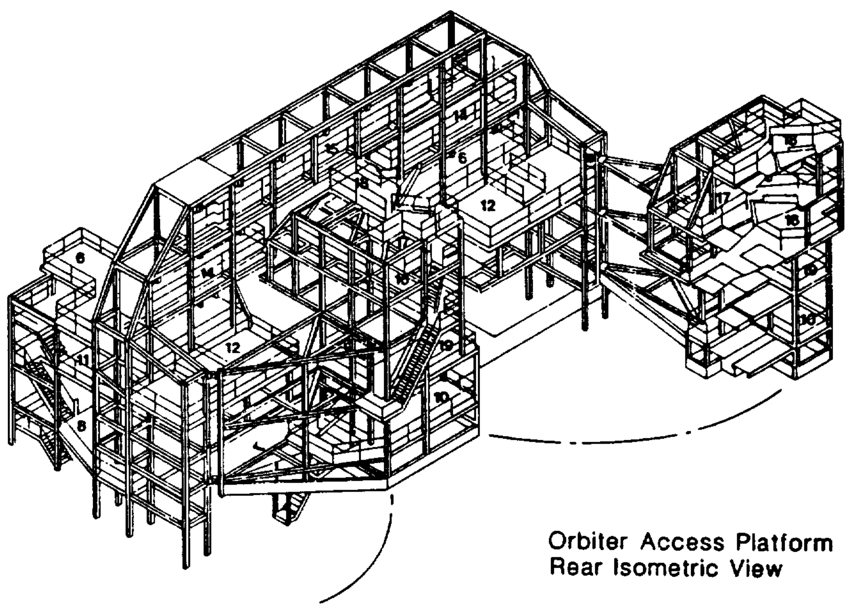


Vertical Telescoping - Buckets

The design of the two bridges included provisions for support of the Zero- Gravity device used in opening and closing the payload doors.

Clearance of the C-Frame Support posed a serious problem. The C-Frame, which is attached to the Cargo Door Strong Back, swings down in an arc past the plane of the main platform truss line. Clearance envelopes were therefore developed and truss members positioned and shaped to give maximum clearance. There are six C- Frame locations on each side of the orbiter.

Platforms 10, 16, 17, 18 and 19 service the Rear Section, comprised of the Vertical Fin, Air Brake Actuator, Elevons, Orbiter Maneuvering System Pod and Main Engines. These platforms, composed of five levels, actually constitute a single structure, hinged to the fixed platforms.



Orbiter Access Platform
Rear Isometric View

Split into two hinged sections, the overall size of each is 17 feet x 20 feet x 50 feet high. Platforms 10, 16 and 19 swing up and down and service the engines and parts of the fin. They operate using hydraulic actuators and also telescope horizontally.

This section posed a major challenge: provide personnel access to external and internal service points at the rear of the Orbiter while also permitting the orbiter unobstructed movement during roll-in and roll-out.

After much research and study, the two 50 foot high rear swing platforms were each attached the main platform structure using a column as a pivot point, and then were swung from this point on a single rail embedded in the building floor. Each half of the platform structure has a 103 degree maximum swing, weighs a total of 98,000 lbs. and is operated by an electric motor drive.

The design of platforms which service the rudder and air brake actuators presented a further challenge to the firm. This required two sets of platforms of different configurations that can occupy the same area at different times. To meet this challenge, Platforms 17 and 18 were placed in this section with hinges at right angles to each other. Panel sections 3 and 6 of these platforms service the outer skin of the rudder, while sections 4 and 5 of the platforms service the rotary actuators inside, as well as the inner surface of the speed brake. Using this design, the two platforms can occupy the same area.

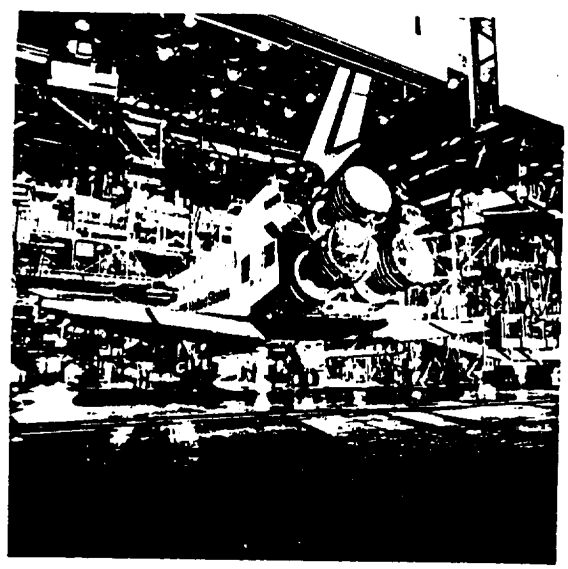
Removal of the Orbiter Manuevering System Pod required very close coordination between NASA and SSV&K, due to the concurrent design of the handling fixture and their respective platforms. Platforms 6, 11, 12 and 15 were designed to handle this section. The trolley and hoist used to remove the Pod is supported from platform 15. The Pod is then transferred to the overhead building crane.

Platforms 5, 6, 20 and 21 are stationary platforms. Platform 6 acts as a transit level to other platforms. Platform 21 is used for testing the antennae.

CONCLUSION

The concurrent design of the orbiter and the facility that would maintain it required close collaboration between SSV&K and NASA. The design of the system of platforms was the most challenging of the entire Orbiter Processing Facility concept. Near the end of the platform system's design, NASA developed, as a final check, a clearance envelope using a computerized matrix for the orbiter. A similar envelope was developed for the OPF platforms and their movements. Entry of the orbiter was then demonstrated using these two clearance envelopes. Only one platform within the entire system interfered with the orbiter clearances, which was easily rectified by cutting back part of the 7 inch soft steel section.

Our engineers recognized the need for a versatile and responsive system of movable and stationary platforms to meet all the needs of the service personnel in the maintenance and repair of the orbiter. The series of movements that were subsequently developed, and the mechanisms that permitted these movements, have resulted in a flexible system that permits free access around and within all areas of the orbiter.



Shuttle entering the Orbiter Processing Facility (OPF).

The principle SSV&K engineers of the OPF platform project were Fidele V. Plastini, P.E., project manager, Albert Thompson, P.E., structural, and James Campbell, P.E., mechanisms. Assisting in the preparation of this paper was Jill Bonamusa and Fidele V. Plastini. Graphics by Michael Bell, Peter Ruiz, and William Soto. The NASA KSC Project Manager was Ron Hinson.

Photos courtesy of NASA.