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Design Project Spotlight: NASA Vehicle Assembly Building High Bay 3 Platform Modifications The Next Great Steps

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"The Next Great Steps"
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45TH SPACE CONGRESS - CAPE CANAVERAL, FL
THE NEXT GREAT STEPS
SPACE FLORIDA
ECONOMIC DEVELOPMENT COMMISSION
NASA

PROJECT SPOTLIGHT

VAB HIGH-BAY 3 PLATFORMS

THE NEXT GREAT STEPS

Vehicle Assembly Building,
Kennedy Space Center

RS&H

James A. Balmer, PE

Structural Engineer

- Civil Engineering, University of Alabama, Birmingham, 1996.
- General structural infrastructure support at Cape Canaveral Air Force Station, beginning in 1998,
- Structural engineer in support of the Titan and Atlas programs for Lockheed Martin Astronautics.
- 2001 to 2017, worked in support of NASA KSC projects through RS&H.
- Provides aerospace structural engineering support as needed through his sole proprietorship and tutoring tomorrow's leaders.

Alice M. Schultz, AIA

Architect

- FL architect with 29 years experience, focus on southern climate Industrial Facilities and Commercial Construction, including Unique Structures.
- BArch Boston Architectural College, 1994; Certificate in Sustainable Design, 2011.
- 14+ yrs service on multi-discipline A&E team in support of aerospace infrastructure, primarily for design of launch facilities for NASA KSC.
- Provides design for access, functional space utilization, infrastructure security, high-performance facilities which integrate complex building systems.

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Course Description

» With the conclusion of the Shuttle program, High Bay 3 became the first portion of the VAB to undergo the evolution to support things to come. In their twilight, the Shuttle teams that witnessed the transformation from the Apollo program lent their expertise and wisdom, gained from their years of service, to guide conceptual development of the form and function of the platforms. NASA Leadership from Charlie Gambaro was key in this process. RS&H was engaged to design what others suggested would be impossible: create a highly versatile, readily adaptable set of platforms, to meet the initial requirements of the SLS rocket –the most powerful rocket in the world –as well as accommodate the vertical integration of various rockets in future spacecraft processing.

Learning Objectives

» Inform participants of the VAB's background and share how the original vision –which included the expansion capability –included the expectation that things would need to change

» VAB HB3 has been transformed. Attendees will be enlightened with aspects of the Next Great Steps for the VAB, steps KSC will be able to take because our fore-fathers got this right, as envisioned by Charlie Gambaro, et al

» Provide an overview of the platform functionality, as highlighted by KSC Center Director Bob Cabana

» Participants will learn of the potential of the building (building on a good foundation); the inherent reasons versatility is available.

VAB

ENVISIONED

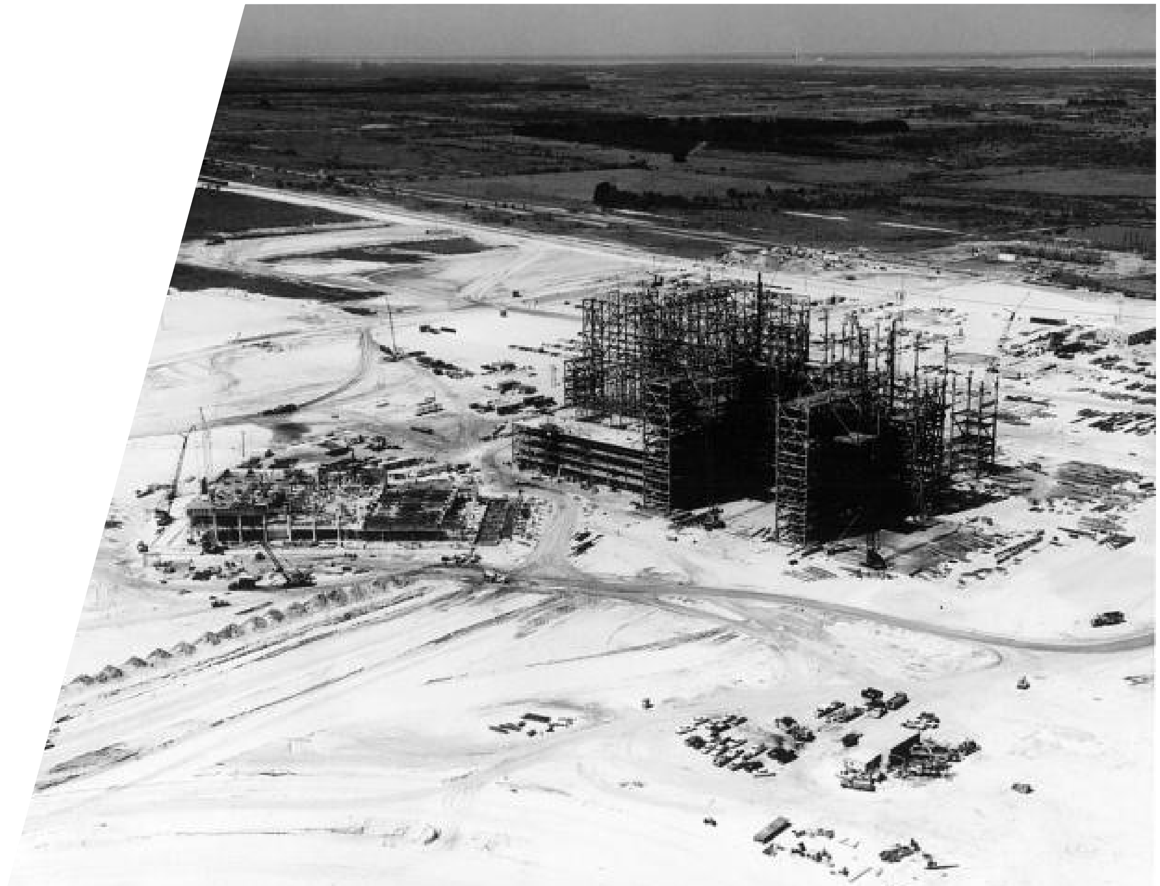

Photo credit: NASA University of Florida press, Gateway to the Moon.

VAB

INITIAL, APOLLO ERA,

LONG-RANGE PLANS

Photo credit: NASA

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JAB

VAB

ADAPTATION

THE SPACE SHUTTLE

Photo credit: NASA

VAB HB3

NEXT GENERATION

View of HB3 today, looking up to the 325-ton crane. Photo credit: NASA

Engineers Creed

As a Professional Engineer, I dedicate my professional knowledge and skill to the advancement and betterment of human welfare.

I pledge:

To give the utmost of performance;

To participate in none but honest enterprise;

To live and work according to the laws of man and the highest standards of professional conduct;

To place service before profit, the honor and standing of the profession before personal advantage, and the public welfare above all other considerations.

In humility and with need for Divine Guidance, I make this pledge.
(Adopted June 1954)

The National Society of Professional Engineers 75th Anniversary

National Society of Professional Engineers

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CONCEPT

KINETIC ARCHITECTURE

Kinetic Architecture, Concepts Explored

- **Ki·net·ic** (kĭ-nĕtĭk) adjective, Greek *kīnēt(ós)*, moving < *kinein*, to move.] Of, pertaining to, or produced by motion.
  - Nature of rocket assembly (horizontal, vertical) – segments come into the Transfer Aisle, lifted by crane off trailer/transporter and positioned, then stacked atop the mobile launcher base
  - Vertical stacking requires crane lifting. Platforms have to be able to move in, to close (e.g. to connect the segments) retract and re-connect as segments are added, and retract for the CT to move the rocket on the ML to the launch pad. Open platforms versus enclosed/conditioned rooms (of Shuttle)
    - *CLV Ares-1 was planned for vertical integration within VAB HB3; translating platforms were designed for installation at elevations appropriate for mating the vehicle segments and connecting umbilicals from the MLT to the rocket.*
    - *SLS Block 1 vehicles are being designed for vertical integration, elevations for mating vehicle segments and umbilicals will differ between vehicles (multiple rockets)*
  - VAB can accommodate an erector, where vehicle segments might be assembled via horizontal integration. Then the crane would lift the rocket and position

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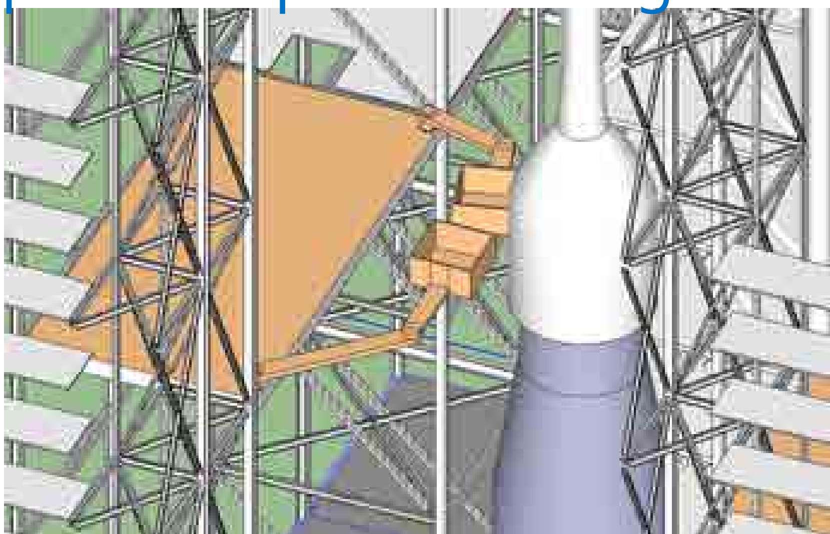
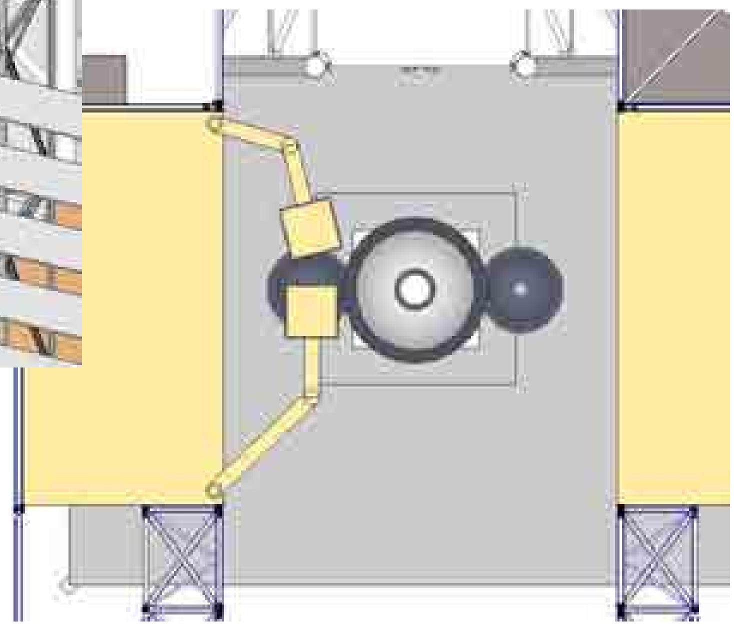
JAB

Concept development during brainstorming

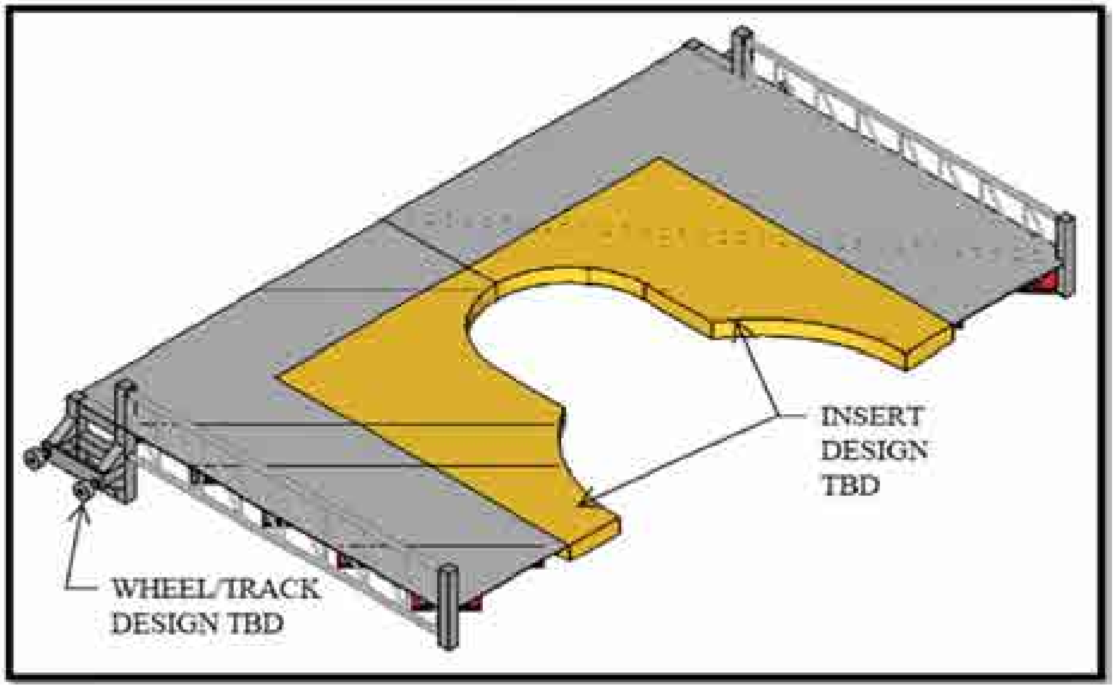


- One that rotated about a vertical axis at the inboard columns



» Various sorts of platform architecture, “out of the box” ideas:
  - A concept that hinged at the inboard column line,
  - A concept that was essentially four articulating arms

Simple, sliding tray with insert selected



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DESIGN

SIMPLE, YET QUITE COMPLEX

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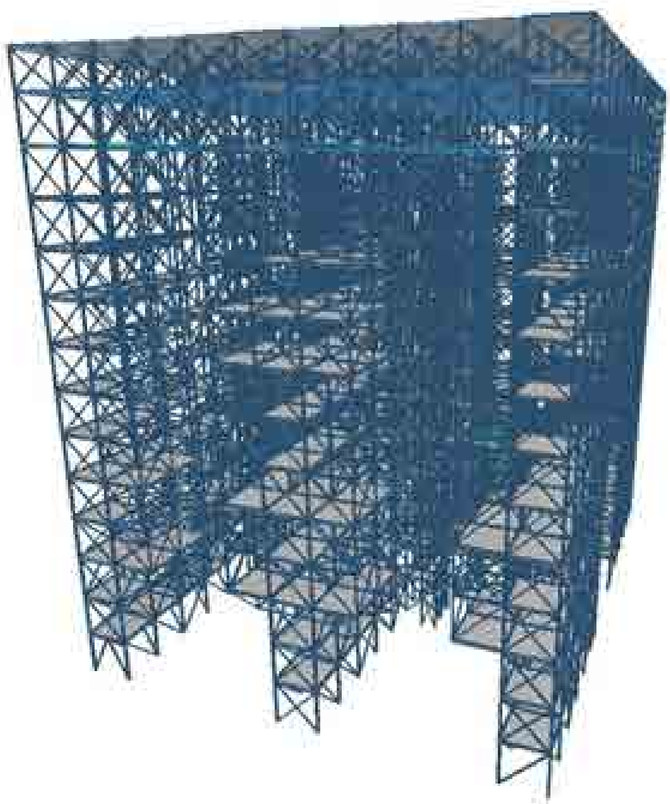

Structural Challenges, Design

» VAB Infrastructure Analysis – Large structure with complex and significant loadings at discreet locations that will vary over time.

- Crane Operations
- Adjacent High Bay Operations
- Wind Events
- Thermal Events

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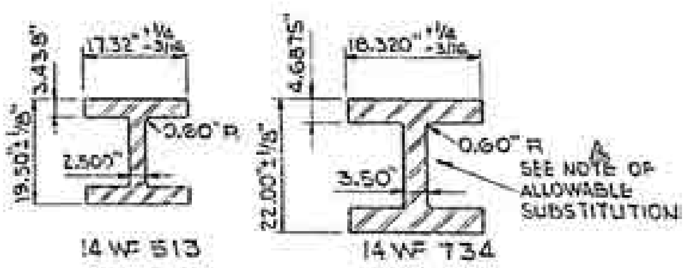

COLUMN SECTIONS
N.T.S.

Structural Challenges, Design

- Custom Steel shapes were developed for the facility. The shapes served NASA's needs back in the 1960's. These had to to be re-developed. Some locations, it was possible to use today's commercially available sections. Others, in particular the 14WF513 had to be made from plate.
- These shapes are defined in Volume 5 on sheet 5-24 of Drawing Number 203-28,297

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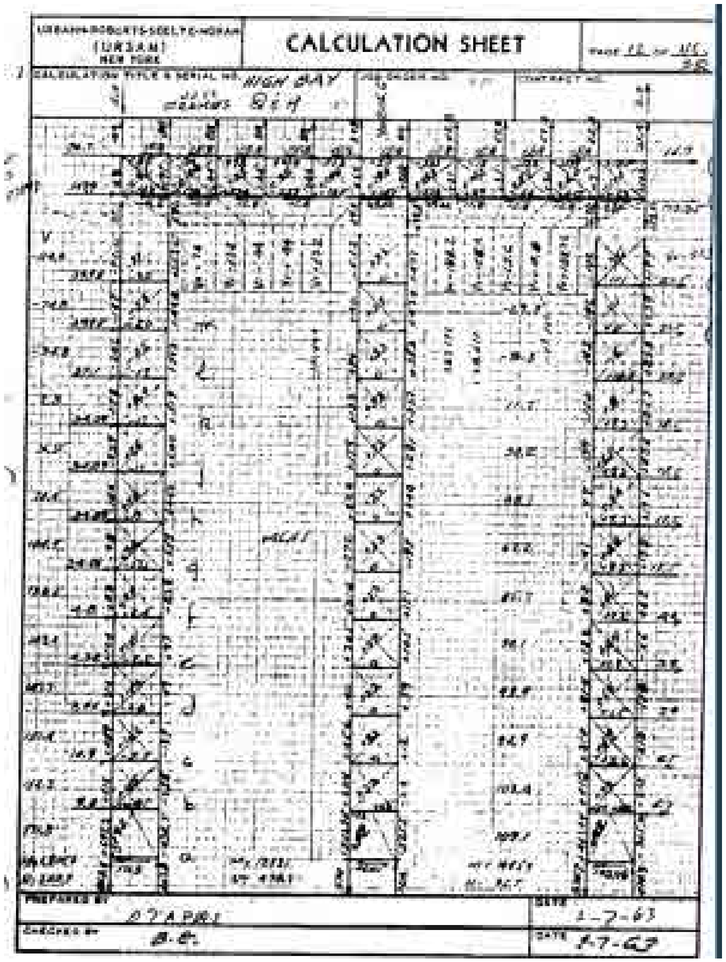
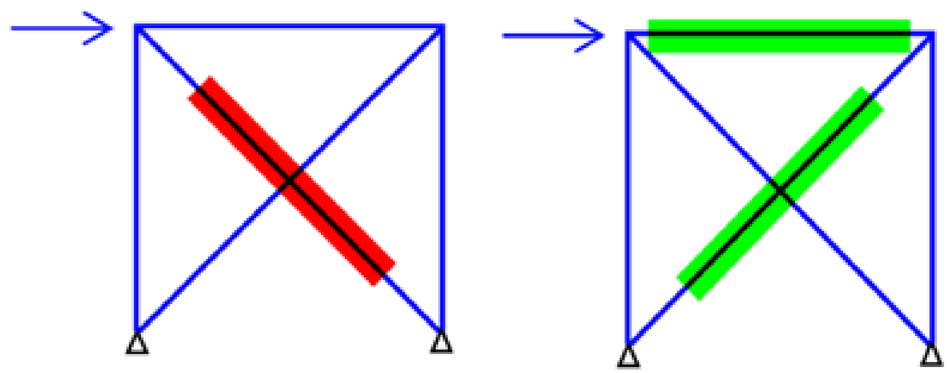


Structural Challenges, Design

» Validating/Verifying 1960's design using 2010 technology



Structural Challenges, Design

» Platform Weight vs Performance

- The 1960's design used platforms dead loads and locations based on the fore-fathers expectations of the Next Steps in space exploration.
- The 2010 vision drove the need to improve and expand the locations served and the concentration of loading. As a consequence, new platforms needed to be lean and versatile.

Structural Challenges, Design

» Relocating, necessitated the kinetic – moveable, removable architecture.

» “Bring it here. We can serve it!”

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Structural Challenges, Design

» Advanced analysis techniques

- Because the technology exists to investigate these complexities, we explored countless scenarios and options. This provided NASA with the confidence of knowing they can fulfill any possible operational need.

View from Platform E, looking up and through to Platform A. Photo credit: RS&H / Alice Schultz

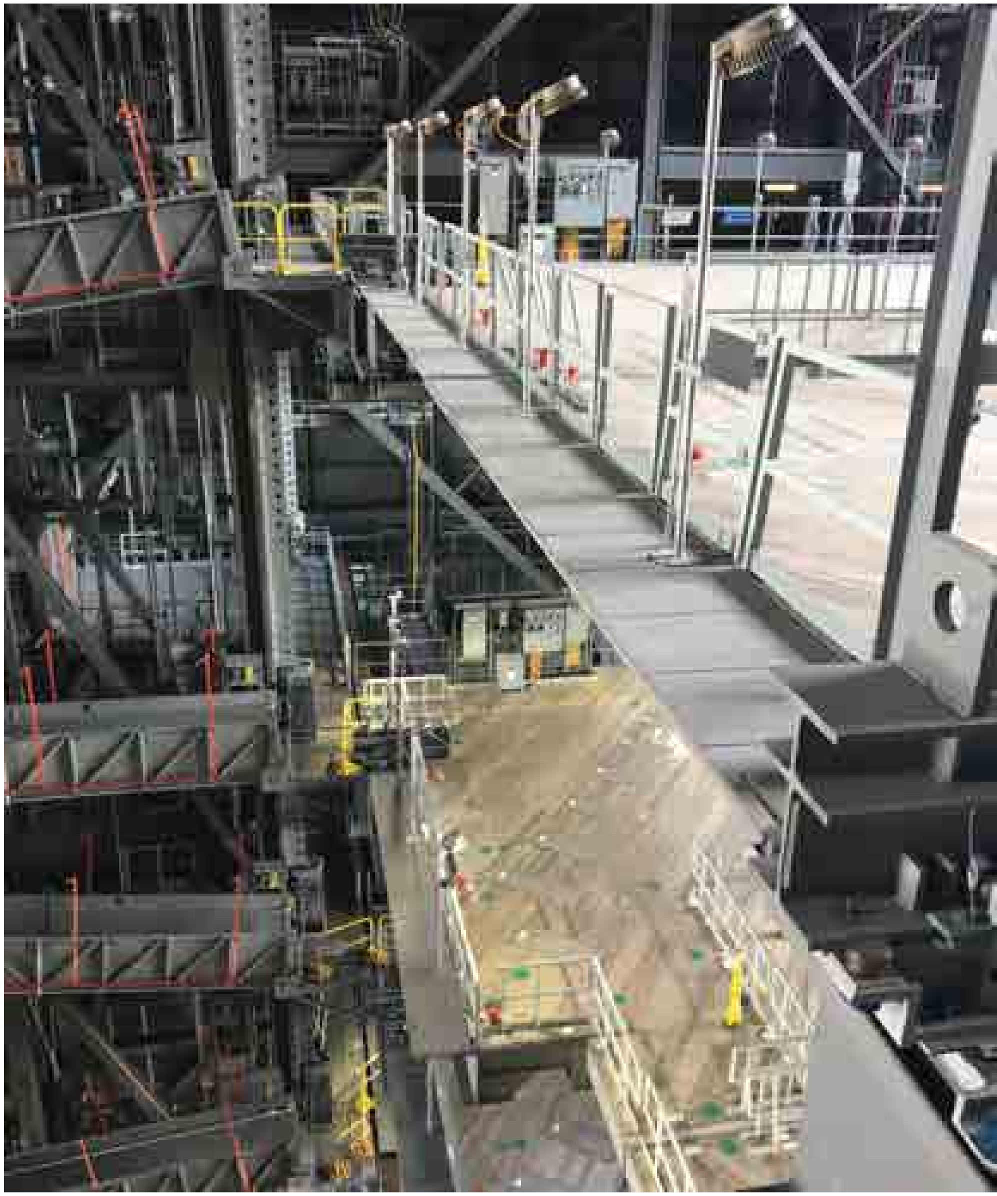
JAB

Architectural Challenges, Design

» The kinetic architecture allows for a completely relocatable, moveable system, including egress.

» Challenges in design of multiple moving parts –translating a platform bigger than a basketball court, weighing more than 30,000lbs

» The flexibility of the platforms requires the flexibility of the systems (electricity, fire protection, hydraulics, lighting, pneumatics, water) to be used by the platforms



Architectural Challenges, Design

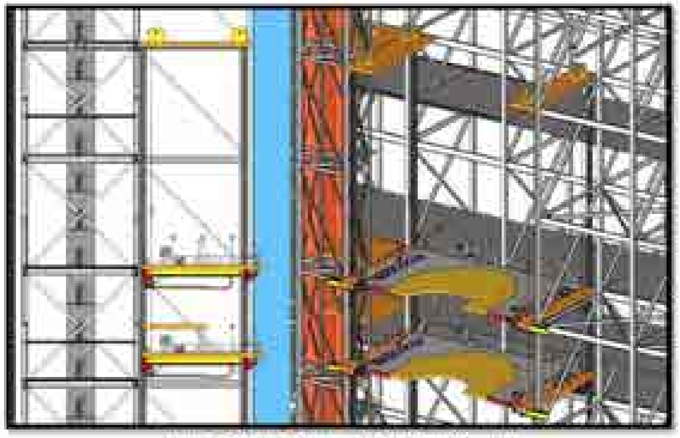


Figure 154: Initial Movement of Platform Segment

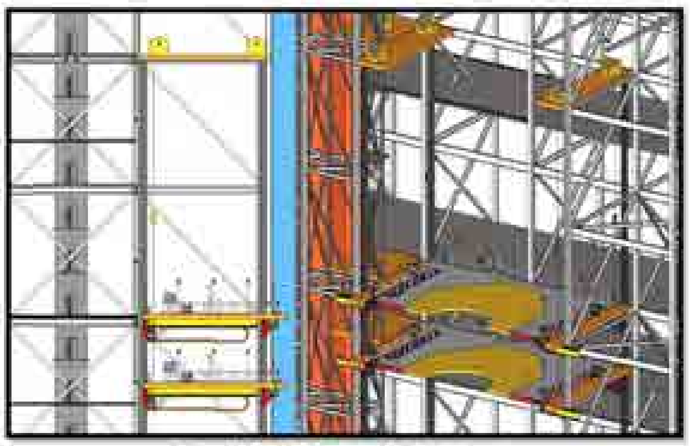
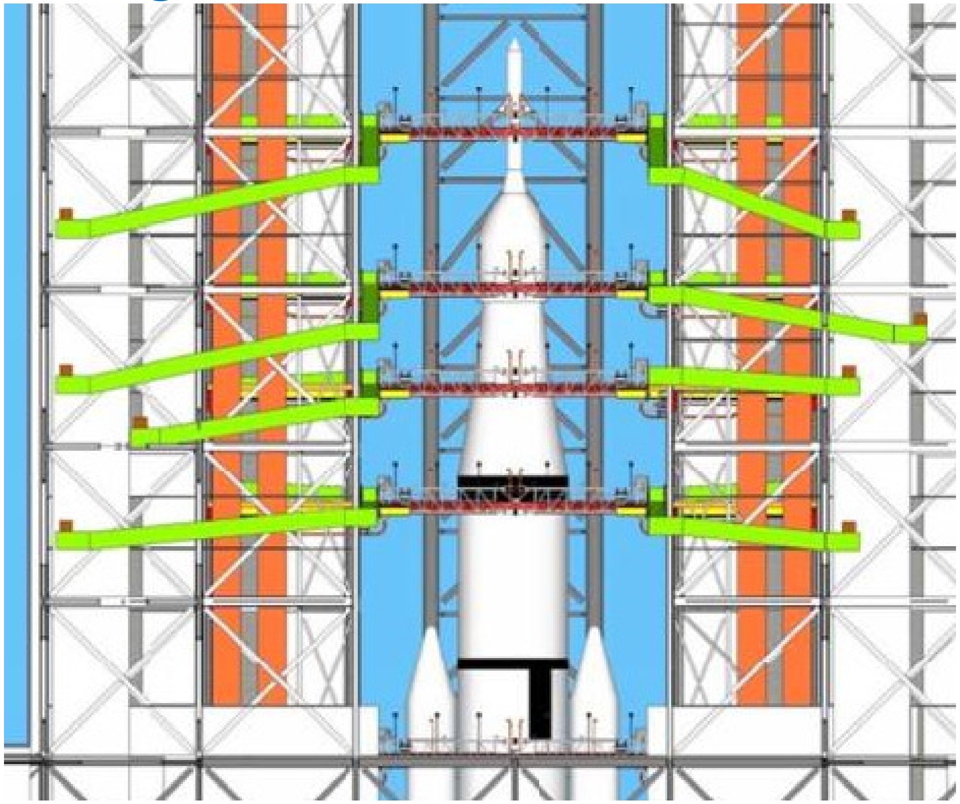


Figure 155: Final Position of Platform Segment



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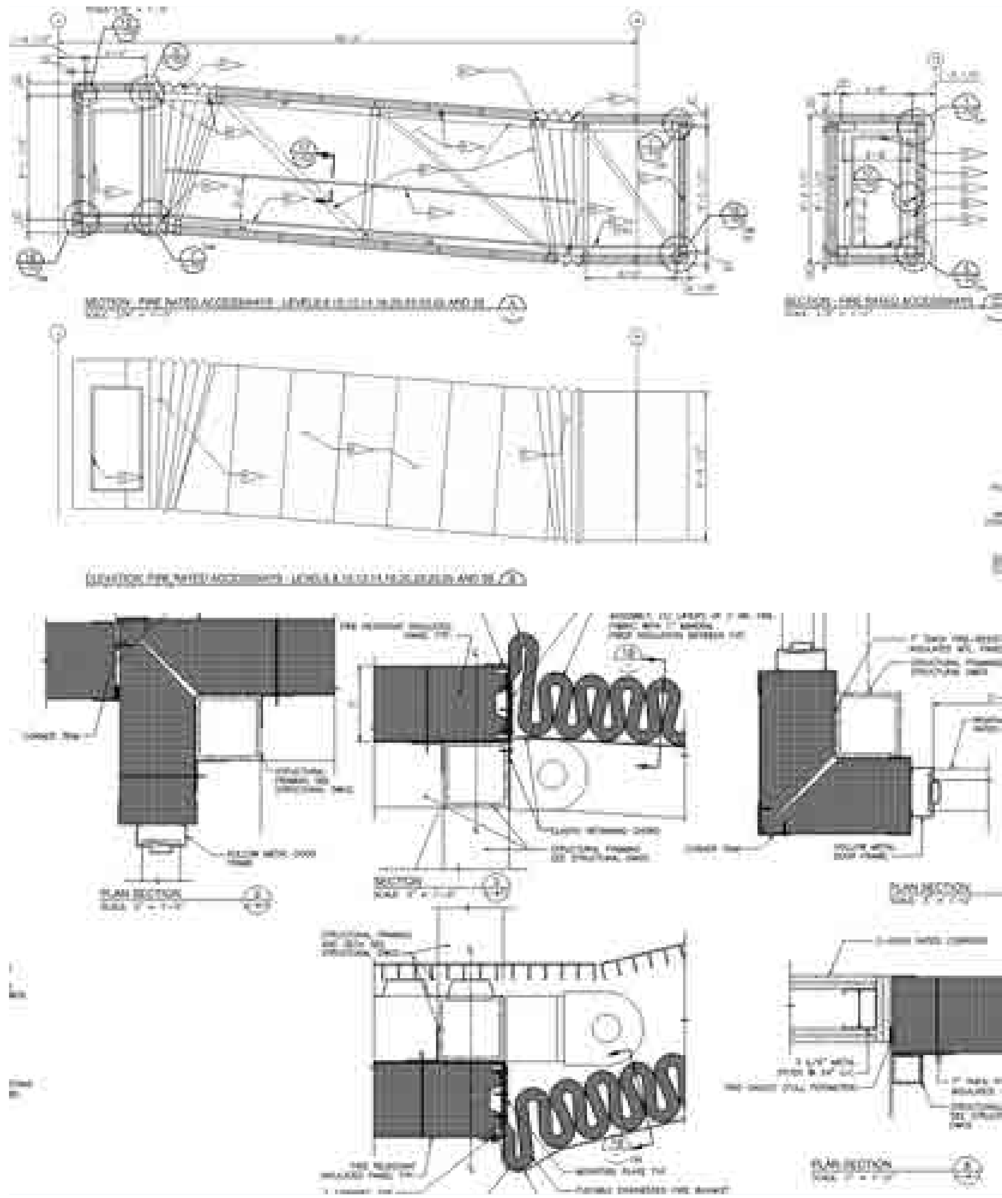
Architectural Challenges, Design

- Depending upon where platforms are located, persons will be able to access platforms from level elevator landings.
- In the event of an emergency, however, persons need to evacuation to 2HR fire-rated enclosure of building stairs, to exit
- Life Safety paths –
  - 2HR accessways –moveable corridors, inspired by airport jet-way
  - Open ramps; ramps, gangways



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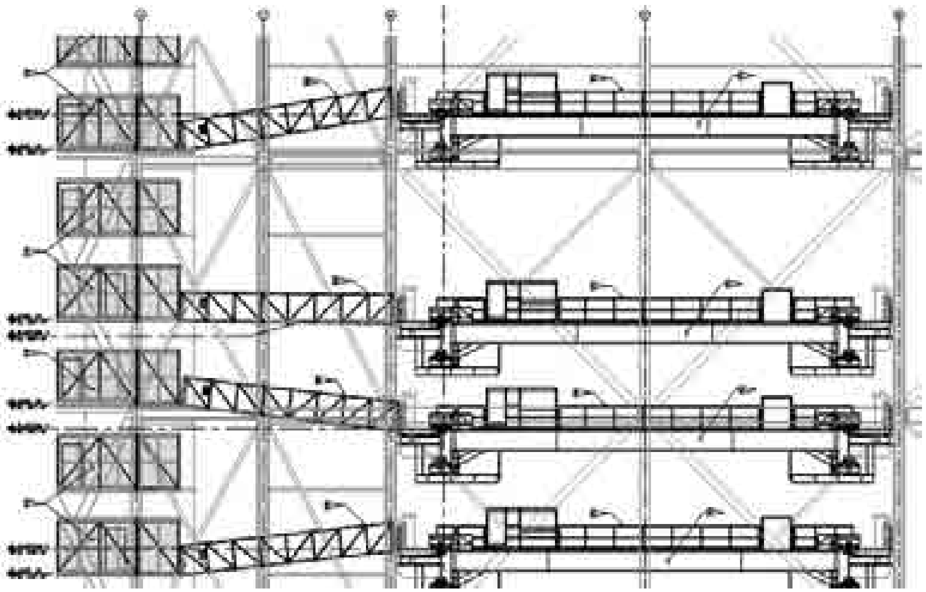
Architectural Challenges - Design

» Open Ramps for Platform Access / Egress



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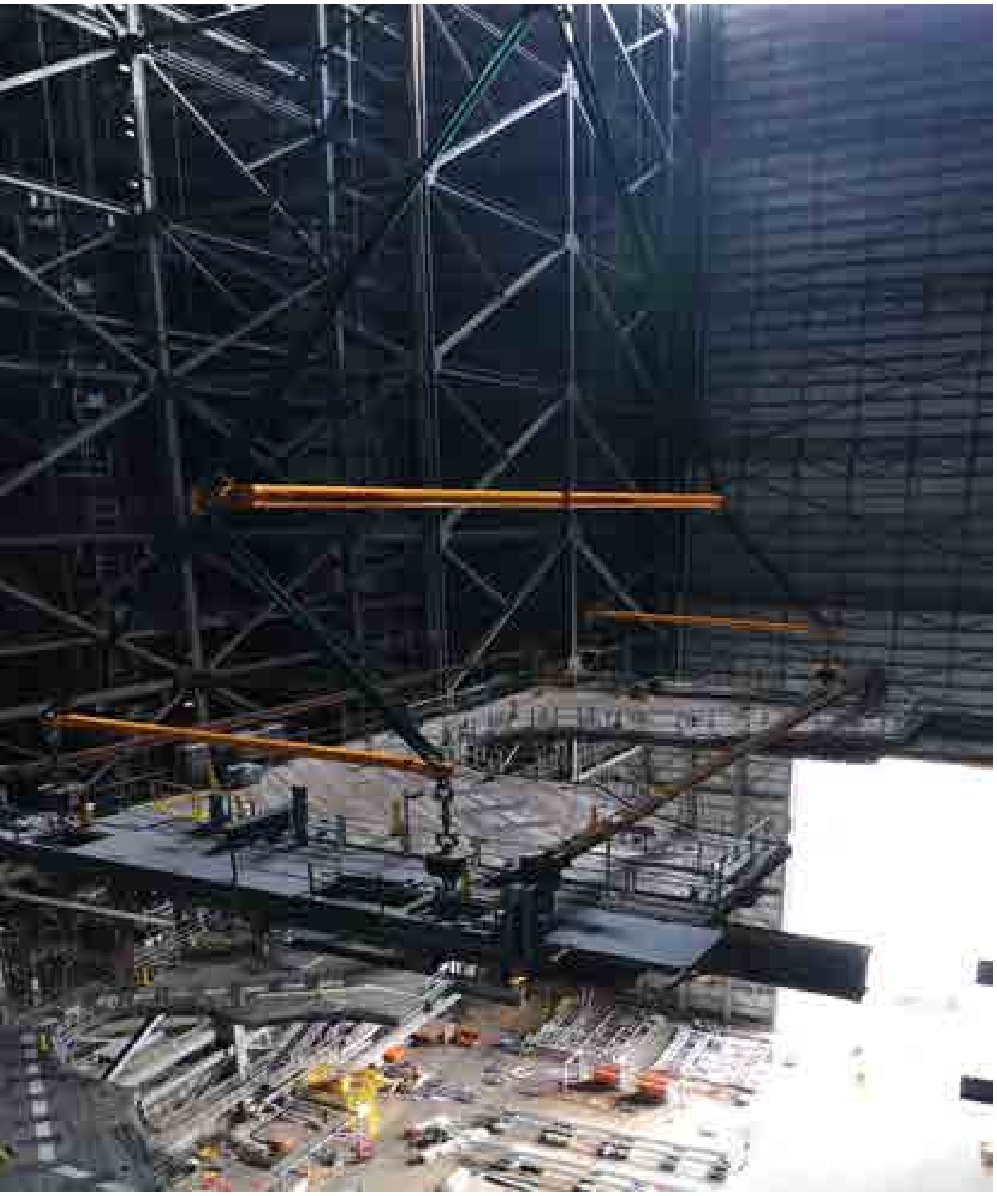
VAB HB3

CONSTRUCTION

Platform “E” walk-down; Photo credit: RS&H/Alice Schultz



Design Challenges Validated in Construction

- Friday, April 15, 2016, Platform J-North was installed
- The process went smoothly,
- One minor hiccup when aligning the platform with the top of the track; the situation was easily resolved
- All pins inserted within 15 minutes;

Platform J-North Installation
Photo credit: Dan Hull, NASA

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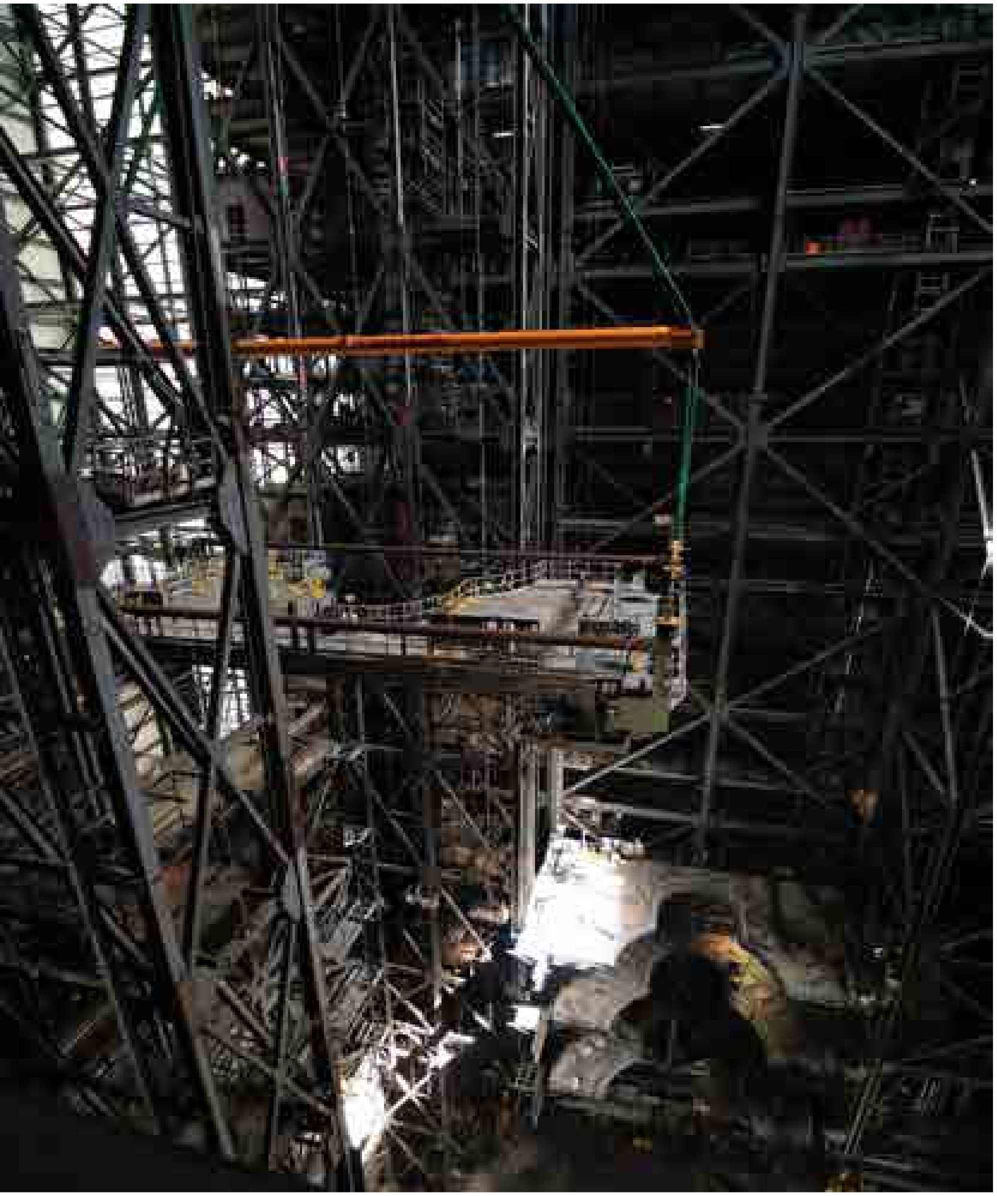


Construction Challenges, Feats

- Transportation of platforms from the fabrication site in Mims involved design of trailers, and traffic-managements.
- Erection (slings) were developed for installation of platform halves.
- Delamination discovered in the facility framing, had to be evaluated.

Platform G-South Installation
Photo credit: Dan Hull, NASA

JAB

Construction Opportunities

» Inorganic Zinc (IOZ) coating so well installed/adhered that it was difficult for the contractor to remove, to weld new members

» Mock-ups for skid-resistant/ slip-resistant epoxy floor coating led to an evaluation of the skid-resistance/slip-resistance inherent within the inorganic zinc coating on steel, and milled surface finish of aluminum planking

Platform G – South Installation
Photo credit: Dan Hull, NASA

Realizing the Vision, Mission Complete

- It was a simple concept, yet it carried a complex set of requirements –for all platform systems to travel with the platform and be re-configured within hours.
- The NASA management team held fast and got things done.

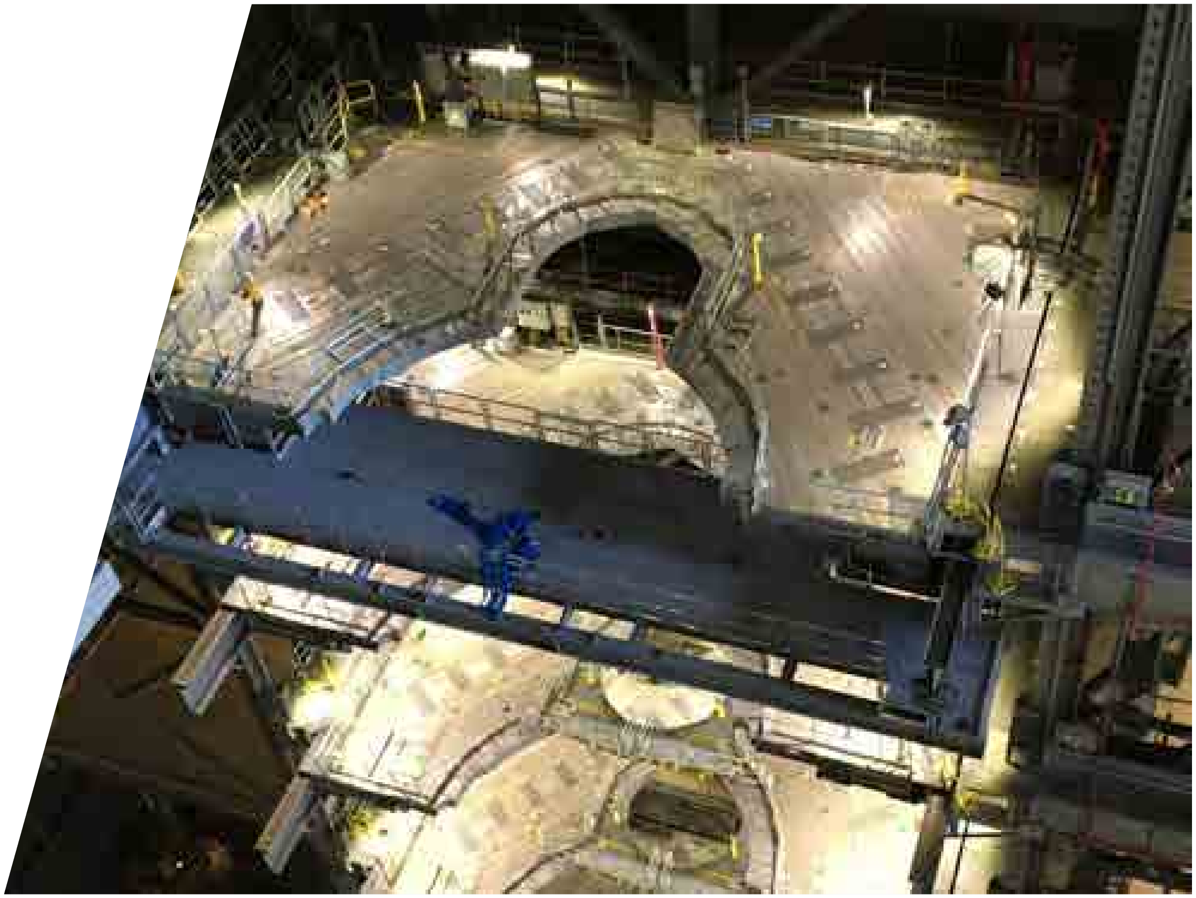
Final Platform Installation
Photo credit: NASA/Frank Michaux

JAB

VAB HB3

OPERATIONS

Construction Aid Platform installed at Platform F, ready for modifications for the Handling & Access work stands.



Construction Aid Platform Photo credit: RS&H/Mike Kendrick

Conclusion, Key Ingredients to Success

» Visionary Leadership from NASA

» Operations, Handling & Access community experience

» Contractor's capability

» Diligent inspectors, observing work in progress

» Local talent and key sub-contractors

VAB HB3

SUCCESSFUL MISSION, COMPLETED BY MANY

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Platform "A" beam; Photo credit: NASA/Dimitri Gerondidakis

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Learning Outcomes

- KSC is preparing to launch the next family of rockets.
- The VAB's background and original vision –which included expansion capability and the expectation that things would need to change (next step –has enabled implementation of this new design)
- VAB HB3 has been transformed and is ready for the Next Great Steps because our fore-fathers got this right, and modern visionaries led this effort.
- The platforms can be repositioned and glide in and out, "just like your kitchen drawer."
- HB3 has been transformed. We hope from what you have learned that you think more highly of the VAB, and recognize the potential of the building (building on a good foundation); the inherent reasons versatility is available.

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Final Platform Installation
Photo credit: NASA/Frank Michaux

Service Platform Photo credit: RS&H/Mike Kendrick