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Bruce Askins, NASA, Marshall Space Flight Center
Paul R. Lemke, P.E., ARES Corporation
William L. Lewis, Triumph Aerospace, Jacobs ESTS
Carol C. Covell, Jacobs ESTS

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APPLICATION OF THE LIFE SAFETY CODE TO A HISTORIC TEST STAND

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Introduction

- **Work performed by Constellation Program, Ares Projects, Flight & Integrated Test Office and the MSFC Engineering Directorate**
- **Validation of Ares I Structural Dynamics Models**
  - Ares I Integrated Vehicle Ground Vibration Test (IVGVT)
- **Reuse of Existing Test Facilities**
  - MSFC Test Stand 4550
- **Application of Current Building Codes to Existing Facilities**
  - Cost and schedule impacts
- **Presentation will:**
  - Examine applicable life safety requirements and the context in which they were evaluated
  - Means by which occupant safety was ensured

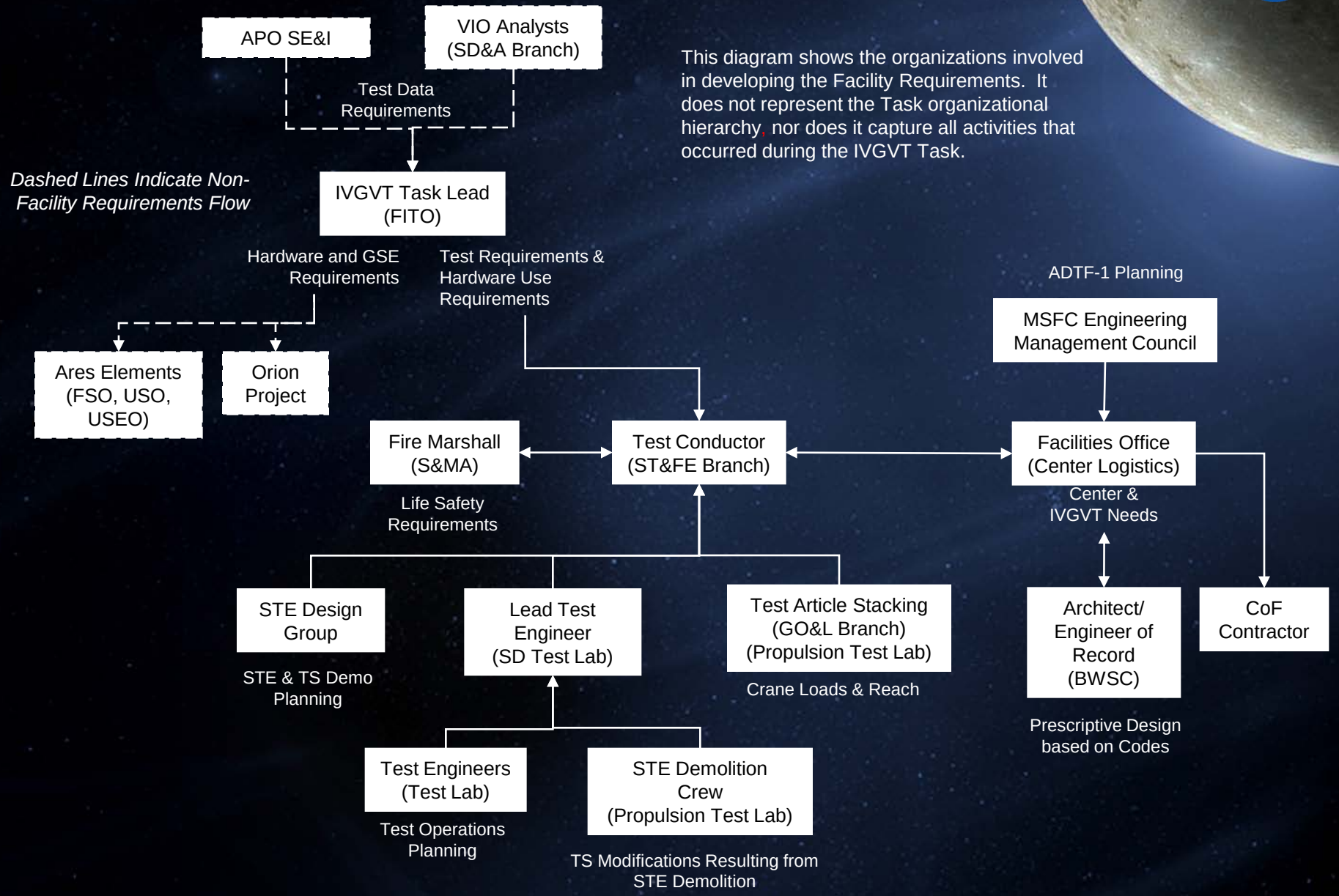
Outline

- **Test Program Context**
- **Facility Requirements Development**
- **Building Description**
- **Technical Issues**
  - Building Codes
  - Initial Life Safety Evaluation & Response
  - Ammonium Perchlorate Leaching Issue & Response
  - Final Solution to Life Safety Issues

Test Program Context

- **Structural dynamics models of human-rated launch vehicles are historically validated through ground vibration testing**
  - Saturn I Dynamic Test Program
  - Saturn V D-500
  - Space Shuttle HVGVT and MVGVT
- **Early 2006 Planning for testing of ADTF-1 Ares I proto-vehicle commenced at MSFC**
- **Fall 2006 Ares FITO assigned responsibility for all Ares testing**
- **Fall 2006 ADTF-1 and associated GVT cancelled**
- **Fall 2006 Ares FITO inaugurates IVGVT**
  - Capstone Development Test to validate Ares I Structural Models
  - FITO selects MSFC Test Stand 4550
- **2010 IVGVT cancelled due to budget constraints**
- **Spring 2011 TS4550 closed out**

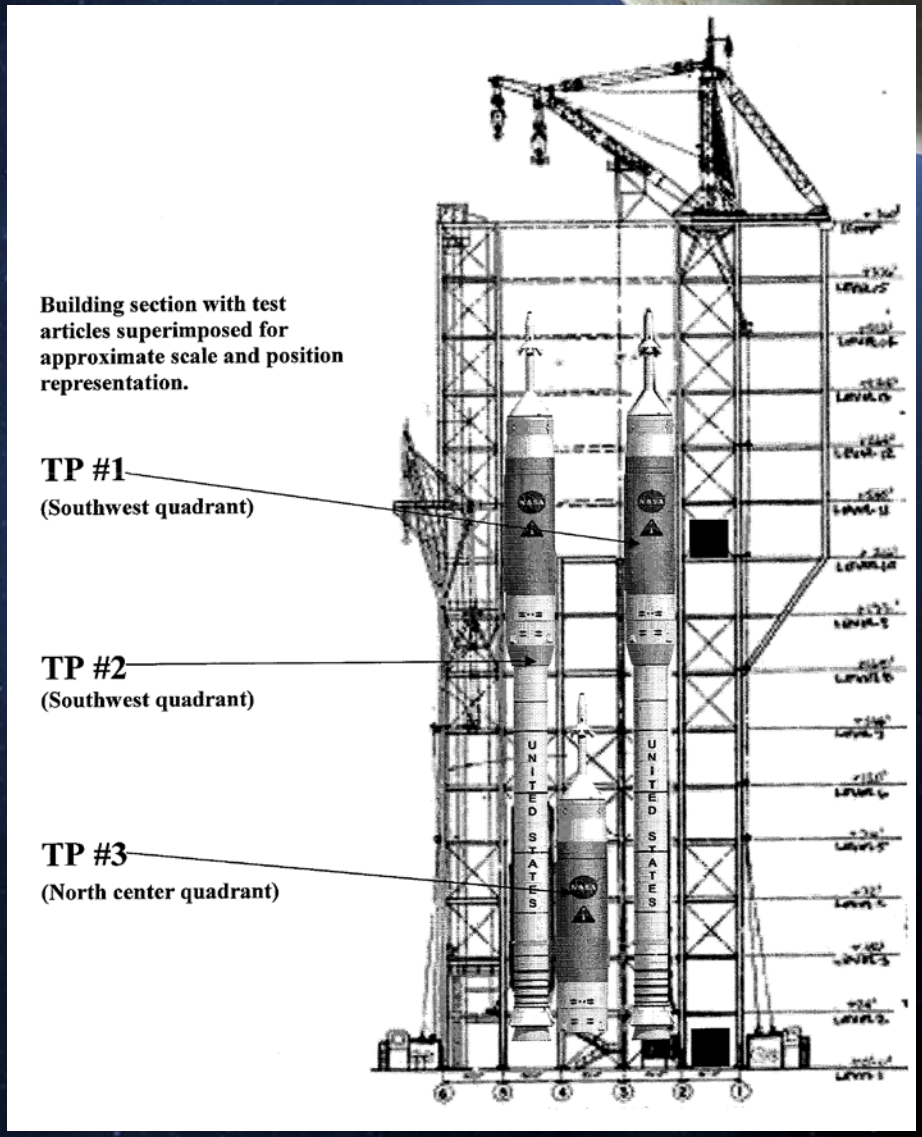
Facility Requirements Development



This diagram shows the organizations involved in developing the Facility Requirements. It does not represent the Task organizational hierarchy, nor does it capture all activities that occurred during the IVGVT Task.

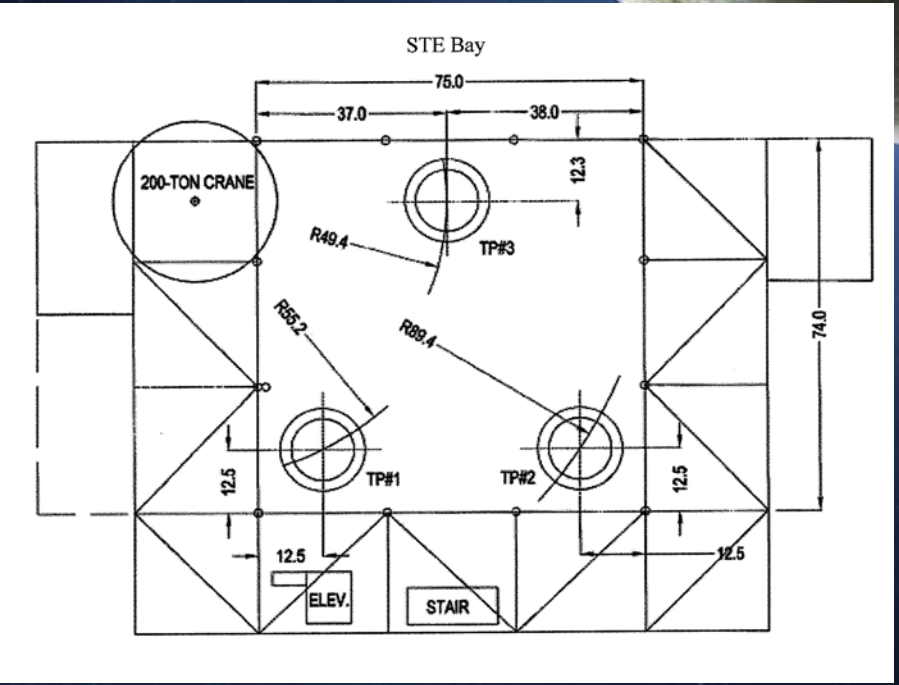
Building Description

- Built in 1964 for Apollo Program
- Renovated in 1977-1978 for Space Shuttle MVGVT
- Mothballed for 28 years
- Height: 360 feet (425 ft w/ crane)
- North wall: 144 x 75 ft. door starting at 216 ft. level to roof



Building Description

- Plan area: 100x125 feet
- 15 levels
- Open 75x75 ft. core
  - Acts like an atrium with chimney effects
- Removable roof panels
- All steel construction
  - Unprotected columns
- No windows
- Single open tread staircase



Technical Issues

- Building Codes
- Initial Life Safety Evaluation & Response
- Ammonium Perchlorate Leaching Issue & Response
- Final Solution to Life Safety Issues

Technical Issues
Building Codes

- **NASA Standard 8719.11 §6.1 states that:**

  All NASA buildings shall comply with the following:

  Appropriate provisions of NFPA 101 (Requirement).

  Applicable State and local building codes (Requirement).

- **Applicable Building Codes**
  - 2003 International Building Code (IBC)
  - 2003 International Fire Code (IFC)
  - 2002 NFPA 13: Standard for the Installation of Sprinkler Systems
  - 2003 NFPA 20: Standard for the Installation of Stationary Pumps for Fire Protection
  - 2002 NFPA 72: National Fire Alarm and Signaling Code
  - 2006 NFPA 101: Life Safety Code

Technical Issues
Building Codes

- **Life Safety Code Occupancy Type**
  - Evaluated by Architect of Record as Industrial Occupancy
  - Concerns over appropriateness raised at design reviews
    1. No manufacturing or production of end items would occur in the building;
    2. The building configuration (high rise building with a small foot print) was atypical for a manufacturing or production facility;
    3. The Occupant Load Factor of 100 square feet per person given by NFPA 101 – Table 7.3.1.2 would result in accommodations for a population that was several orders of magnitudes larger than the maximum probable population of the building.
- **Evaluated Storage and Business Occupancy Types**
- **Special-Purpose Industrial Occupancy.**

  An industrial occupancy in which ordinary and low hazard industrial operations are conducted in buildings designed for, and suitable only for, particular types of operations, characterized by a relatively low density of employee population, with much of the area occupied by machinery or equipment.

Technical Issues
Initial Life Safety Evaluation & Response

- **May 2007 MSFC Fire Marshall's Fire Protection Assessment**
- **TS4550 Life Safety Issues**
  - Required number of egress paths
  - Enclosure of the existing staircase
  - Lack of the NASA required fire suppression system

Technical Issues
Initial Life Safety Evaluation & Response

- **Number of egress paths**
  - Evaluation
    - "Due to the facility's open nature, massive volume, and low fire-loading, a fire will be slow developing, quickly identified by occupants, and take a long time to build up dangerous levels of smoke"
    - While there was no specific exception in NFPA 101, in similar situations a single means of egress was permitted
    - Operational factors considered
      - TS4550 is located in an area of MSFC which is considered a hazardous location and to enter the test area personnel have to be cognizant of the inherent risks associated with the area and the specific risks associated with the area in which they would be working.
      - The size of the population who would be exposed to any risks associated with a single means of egress was limited to the test operation personnel and escorted visitors. The assumed maximum population was on the order of 20 - 30 people while non-hazardous operations were occurring and a population of less than 10 when hazardous operations were occurring.
      - The building itself was non-combustible and there would be very limited combustible materials brought into the building.
  - Waived requirement for a minimum of two paths if:
    1. The population was limited to a maximum of 25 persons
    2. The combustible loading in the building be strictly limited to what was absolutely required for operations

Technical Issues
Initial Life Safety Evaluation & Response

- **Enclosure of the existing staircase**
  - Evaluation
    - While the total load of combustibles was low, it was possible due to the configuration of the platforms that a fire producing dense smoke could be located adjacent to the stairs.
    - As there was only a single means of egress planned for the building this posed the risk that the only means of egress could be obstructed by a small, slow growing fire located near the stairs.
  - Fire Marshall recommended enclosure of the existing staircase
  - After estimates determined the cost of enclosure was > 2X the available budget alternatives were explored
    - Fire Marshall was receptive of waiving requirement if the Test Conductor provided a detailed fire hazards analysis which demonstrated there were no credible fire scenarios that would imperil the building occupants
    - Fire Marshall agreed until a variance was granted the design basis could be changed from enclosing the existing staircase to adding a second protected exterior staircase

Technical Issues
Initial Life Safety Evaluation & Response

- **Lack of the NASA required fire suppression system**
  - Evaluation
    - Neither NFPA 101 nor the IBC require an automatic fire sprinkler system for TS4550
    - NASA-STD-8719.11 Paragraph 7.3.1
      - "Automatic sprinkler protection shall be provided for all new building/facility construction. Sprinklers shall be provided in renovation projects over 2,500 square feet (232.26 square meters) or involving over 50 percent of the building."
    - Due to the configuration and construction of TS4550 an AWS would provide negligible fire hazard risk mitigation
      - Significant financial burden > $2M
      - Impacts to Task schedule would delay First Flight of Ares I
  - Fire Marshall recommended the Test Conductor request a variance from the requirement from NASA HQ S&MA based on the above evaluation

Technical Issues
Ammonium Perchlorate Leaching Issue & Response

- **While evaluating the fire hazards associated with the test articles it was determined the H-18 Inert Propellant used in the First Stage Test Articles had trace amounts of Ammonium Perchlorate (an oxidizer)**
- **First Stage Contractor identified that in "high humidity environments" the AP could leach to the surface of the test article core**
  - AP could act as an ignition source for the bulk inert propellant
- **First Stage Contractor identified that while H-18 could not self-sustain combustion it would produce copious amounts of dense, dark smoke when exposed to an external heat source**
- **Fire Marshall determined that due to these factors the contents of the building could not be considered low hazard and revised his initial fire hazards assessment**
  - Two means of egress were required
  - Existing staircase had to be enclosed if it was to be a means of egress

Technical Issues
Ammonium Perchlorate Leaching Issue & Response

- **Response**
  - MSFC Engineering, MSFC Facilities Office, and FITO explored means of securing additional funding
  - MSFC Engineering designed a nitrogen gas purge system to provide an dry, inert atmosphere inside the First Stage Test Article
    - April 2008 MSFC Fire Marshall agreed to the fire risk mitigation and concurred with the evaluation that the Inert Propellant was the only credible fire hazard present in TS4550
    - Based on the plan the Fire Marshall waived the requirement for a second means of egress and enclosure of the existing staircase

Technical Issues
Final Solution to Life Safety Issues

- **Gaseous Nitrogen was not an ideal solution**
  - Cost of maintaining the nitrogen charge for several years
  - Operational impacts
  - Personnel safety risks
    - Personnel working around a pressurized test article
    - Potential for hazardous levels of nitrogen accumulating in the building and confined spaces
- **First Stage Contractor assay of the chemical composition of historical inert propellant loads**
  - Assay determined AP leaching would not occur
  - Other compounds would preferentially leach to the surface forming a water proof barrier
  - June 2009 MSFC Fire Marshall accepted the results of the First Stage Contractor's assay and determined AP leaching was not a credible hazard
    - Nitrogen purge system was not necessary

Summary

- Appropriate reuse of existing test facilities is fiscally responsible, but Project Managers need to be aware of the risks associated with reuse of test facilities.
- Project Managers need to engage experts in the assessment of life safety regulations, fire codes, and building codes as early in the Project lifecycle as possible. Architects and architectural engineers should be considered a stakeholder in the test planning equal to the test requesters and the test engineers.
- Project Managers should always assume during the initial planning stages that, if it is necessary to modify a test facility to accommodate the proposed test, the life safety features will have to be updated to comply with the current building codes.
- Project Managers need to recognize that architects and architectural engineers will default to a prescriptive design based on strict adherence to the building codes and will only prepare a performance based design if requested by the client.
- Project Managers need to recognize that test engineers and architectural engineers both use terminology and idioms which are specific to their discipline and background and terms are not exclusive to a discipline. Project Managers should always ensure that when technical information is being discussed that all parties are defining the lexicon in the same way.

Questions and Answers

Contacts

- **Bruce Askins**
  NASA
  Marshal Space Flight Center
  Huntsville, AL 35812-9999
  (256) 544-1096
  bruce.askins@nasa.gov
- **Paul R. Lemke, P.E.**
  ARES Corporation
  200 Sparkman Drive, Suite 1
  Huntsville, AL 35805
  (256) 489-5200
  plemke@arescorporation.com
- **William L. Lewis**
  Triumph Aerospace, Jacobs ESTS Group
  Marshall Space Flight Center
  Huntsville, AL 35812-9999
  (256) 544-2194
  ladd.lewis@nasa.gov
- **Carol C. Covell**
  Jacobs ESTS Group
  Marshall Space Flight Center
  Huntsville, AL 35812-9999
  (256) 544-6754
  carol.c.covell@nasa.gov