The Vehicle Motion Simulator Story

MTS Sales Meeting

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Presented by

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Background

- **NASA Space Launch System (SLS)**
  - Next generation heavy launch vehicle
  - Human spaceflight beyond Earth orbit

- **Kennedy Space Center (KSC)**
  - Launch equipment design
  - Vehicle assembly (stacking) and launch operations

- **Launch Equipment Test Facility (LETF)**
  - Support NASA-KSC design branch
  - Launch equipment verification/validation
  - Investigate and resolve critical issues

{SLS Umbilicals Video}

Launch Vehicle Comparison

NASA SLS

Launch Equipment Test Facility

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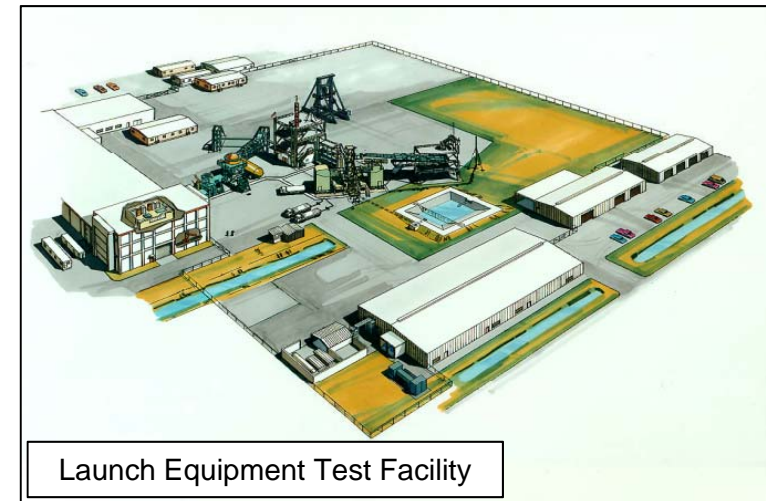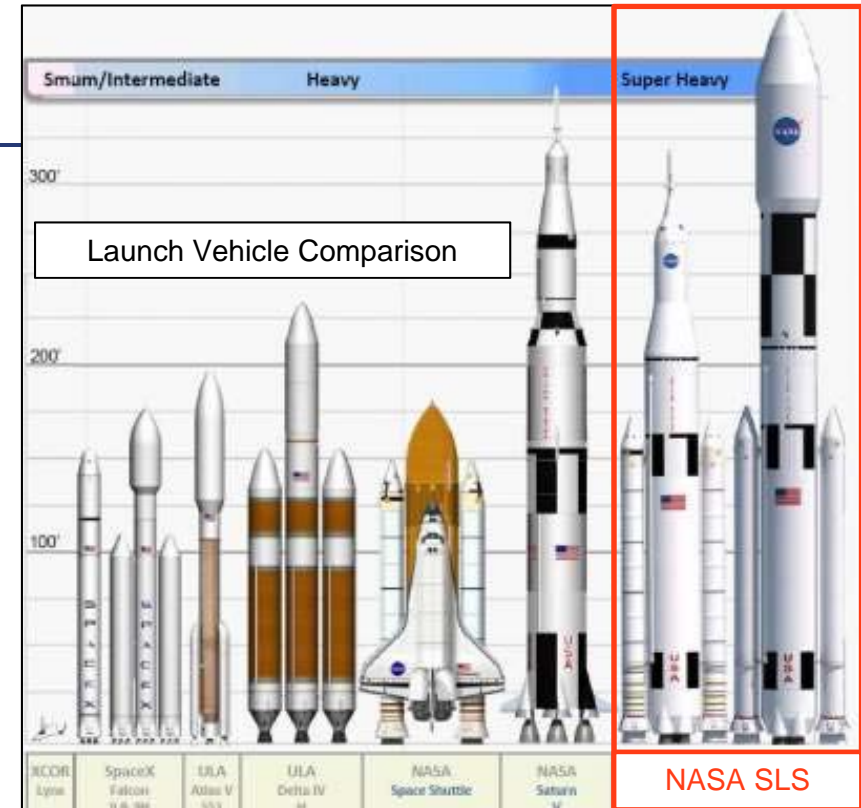
Background

What is a Vehicle Motion Simulator (VMS)?

- **Carries launch vehicle "like" skin sections**

- **Mate umbilical arms to skin sections**

- **VMS moves like launch vehicle to simulate:**
  - Mating operations during stacking
  - Motion during crawler transport to pad
  - Wind induced motion at launch pad
  - Shrink / slosh" during tanking
  - T-O separation at launch

- **Simultaneously test:**
  - Fluid / electrical connections
 - Mechanism compliance
  - Separation systems

Legacy NASA Umbilical Test – Courtesy NASA

Legacy NASA Umbilical Testing – Courtesy NASA

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A Long, Long Time Ago….

- **Apollo and Shuttle Programs**
  - Legacy Vehicle Motion Simulators
    - Orthogonal motion only
    - Limited functionality
    - 45 year old equipment

  {Early Motion Simulator Video}

- **Constellation Program (2006)**
  - New launch equipment to qualify
  - More complex simulation requirements
    - ASRC procurement
    - Collaboration with NASA Glenn Research Center (GRC)
    - "Test like you fly"
    - Increased accuracy and reconfiguration capability
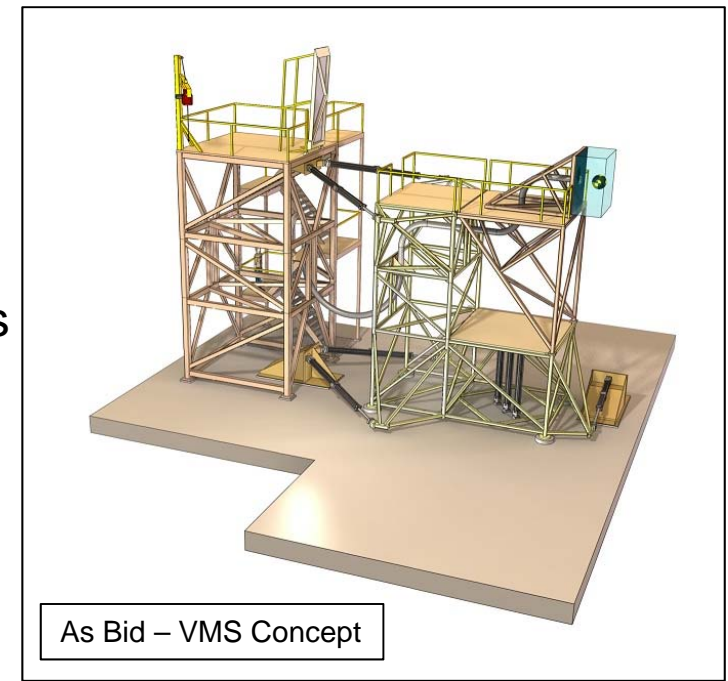
  Here's where the story begins……

Legacy 3 Axis Simulator

Legacy 2 Axis Simulator

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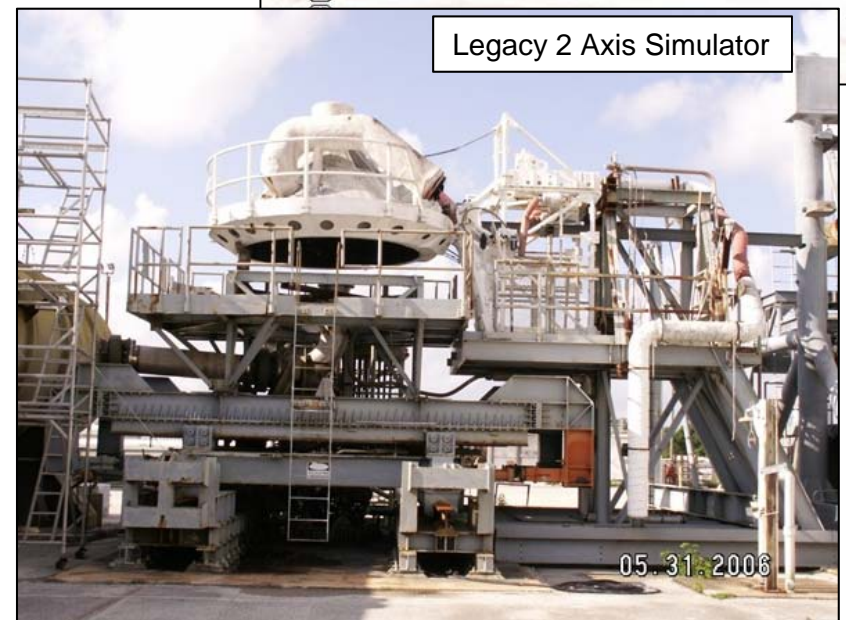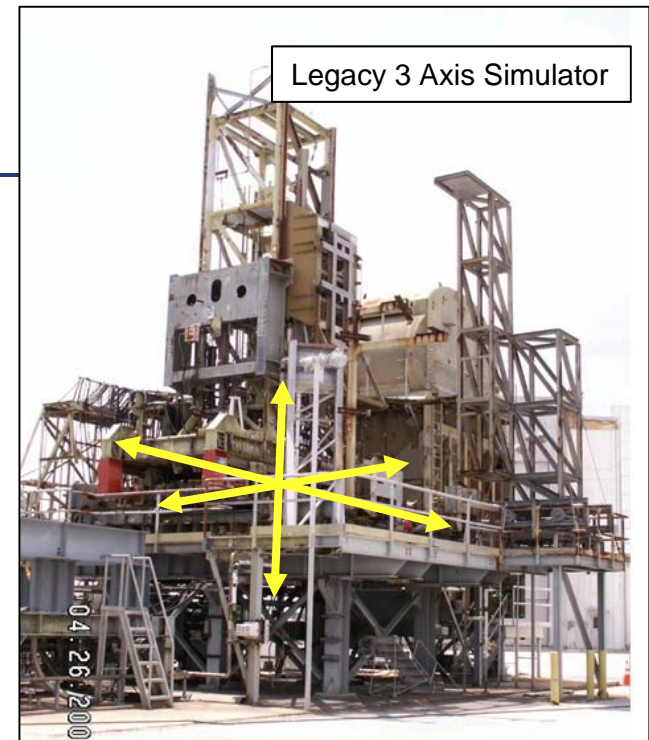
Requirements & Procurement

Chapter 1: "The Search for Requirements and Suppliers"

- **The Government's Challenge**
  - Incomplete requirements & specification development
  - Understanding supplier capabilities & viable suppliers

- **Pre-Bid Supplier Discussions**
  - Generic/abstract technical discussions
  - Relevant capabilities, experience, projects

- **"Best Value" Procurement and Bid**
  - Understanding requirements and decision drivers
  - Making the most of the site visit
  - Balancing detail and conciseness
  - Pragmatic solutions; KISS with creativity
 - Professionally prepared bid <u>which reflects</u> the request for quote

MTS MAST Simulator – Univ. of Minnesota

As Bid – VMS Concept

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Design & Review Process

Chapter 2: "Avoiding a Design by Committee"

- **MTS' Challenge**
  - Requirements compliance – with unknowns
- **An Exceptional MTS Team at the Core**
- **Stakeholders**
  - Organized and appropriately structured discussions; face-time
  - Reconciling design with requirements
  - Well documented reviews
- **"A mile in the customer's shoes"**
  - Solutions based on understanding; collaboration
  - Proactive discussion to limit/eliminate poor design; address details
- **Schedule**
  - Constantly monitored, schedule risks proactively addressed and slips mitigated
  - Managing the customer, or in this case, customer<u>s</u>
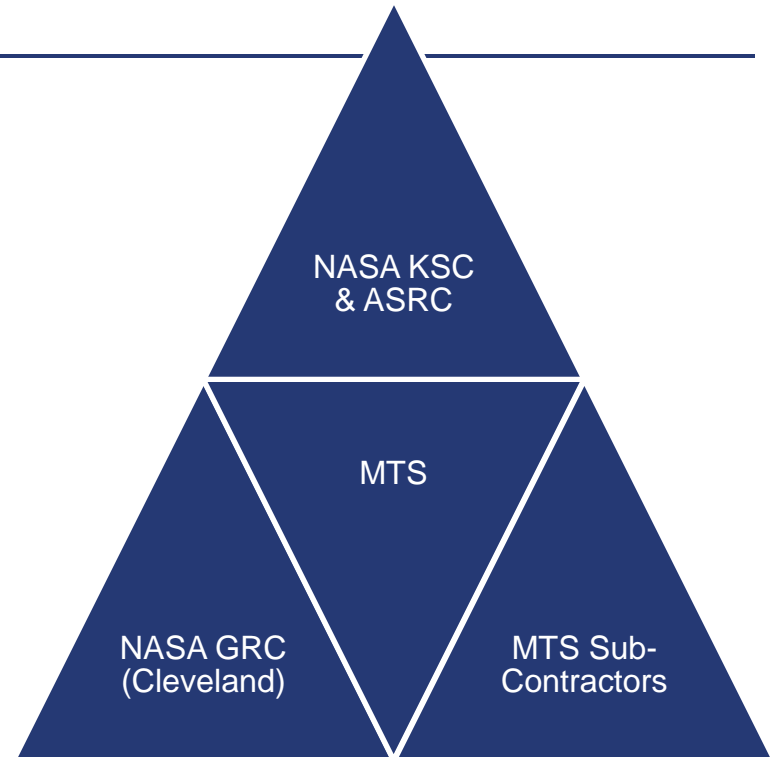
Fabrication & Installation

Chapter 3: "Some Assembly Required"

- **MTS' Challenge:**
  - Coordinating internal & subcontracted tasks, and customer tasks
  - Managing the customer…again

- **Take Time to Understand Local Rules**
  - Avoid schedule delays

- **An Exceptional Team (…again)**
  - Build confidence by demonstrating safe and accurate work

- **Communication**
  - Proactive integration effort prevents conflicts
  - "Stuff happens" – vet solutions and deal with them quickly
  - Proactive problem resolution requires teamwork

VMS1 Construction

Final VMS1

Fabrication Damage

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Commissioning & Activation

Chapter 4: "A Period of Adjustment"

- **MTS' Challenge:**
  - Taming the One-of-a-Kind "Beast"
- **An Exceptional Team (…again)**
  - Sometimes needs a fresh set of eyes
- **A Methodical Approach**
  - A robust foundation is inherently predictable
  - Difficult issues mitigated by leveraging company knowledge
  - Engage the customer at the appropriate time – training mitigates tech calls
- **When It Breaks, Fix It Permanently**
  - Understanding cause & eliminating it builds customer confidence
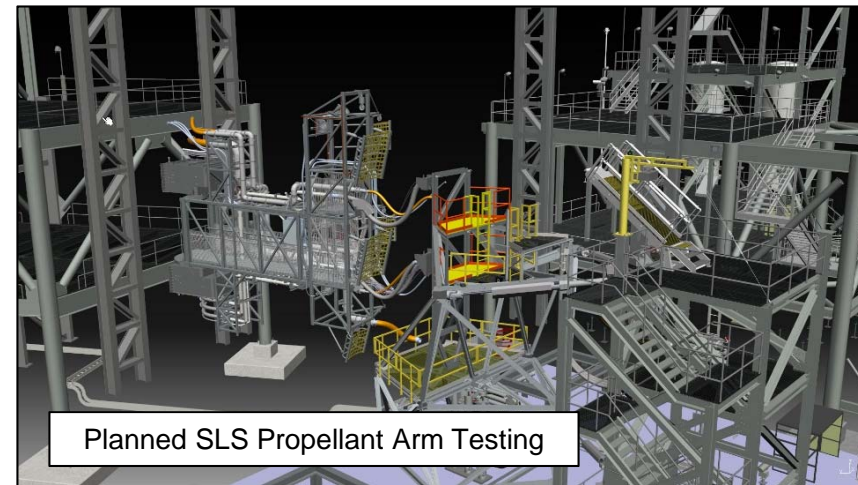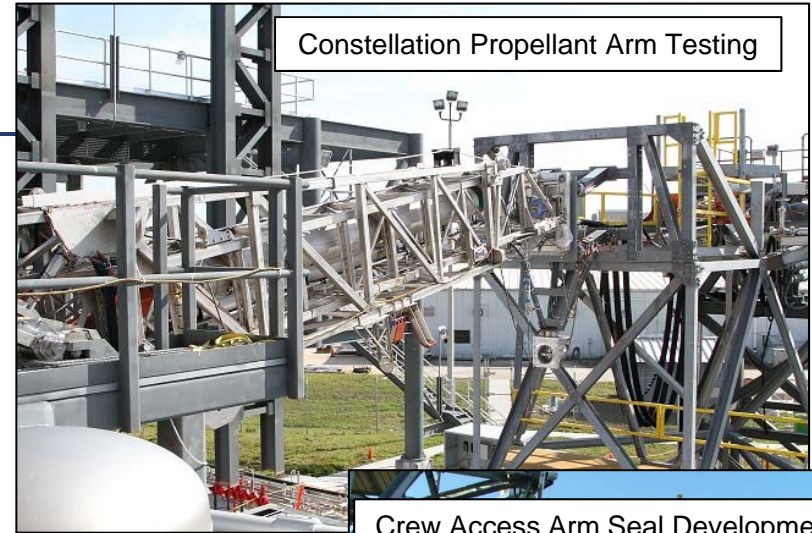

LETF Control Room

05.19.2010

Failed Spirolox Rings

Operations & Maintenance

Chapter 5: "If you build it, they will (eventually) come" {LETF and VMS1 Ribbon Cutting} {Only use first 3:52}

- **The Government's Challenge:**
  - "I forgot what this button does?"

- **Transferring Knowledge**
  - Well documented manuals – crafted from the user's perspective
  - Well structured training, and an effective trainer

- **Providing Useful Support After the Sale**
  - Knowledgeable local support for service
  - Good notes and as-built information
  - Providing a reasonable "lifeline" for questions

Constellation Propellant Arm Testing

Crew Access Arm Seal Development

Planned SLS Propellant Arm Testing

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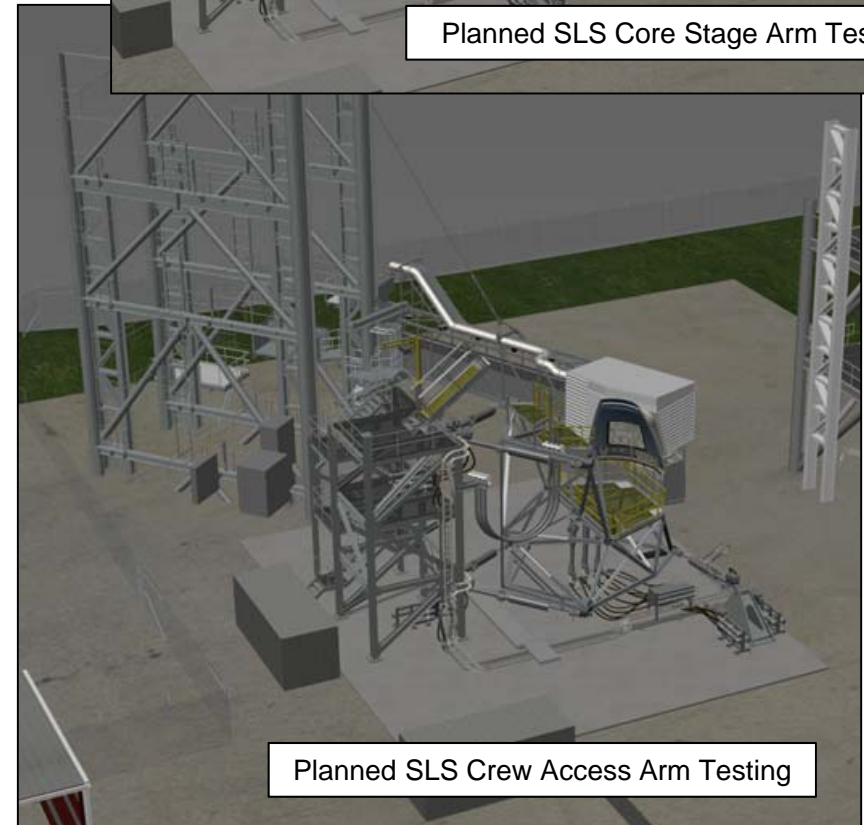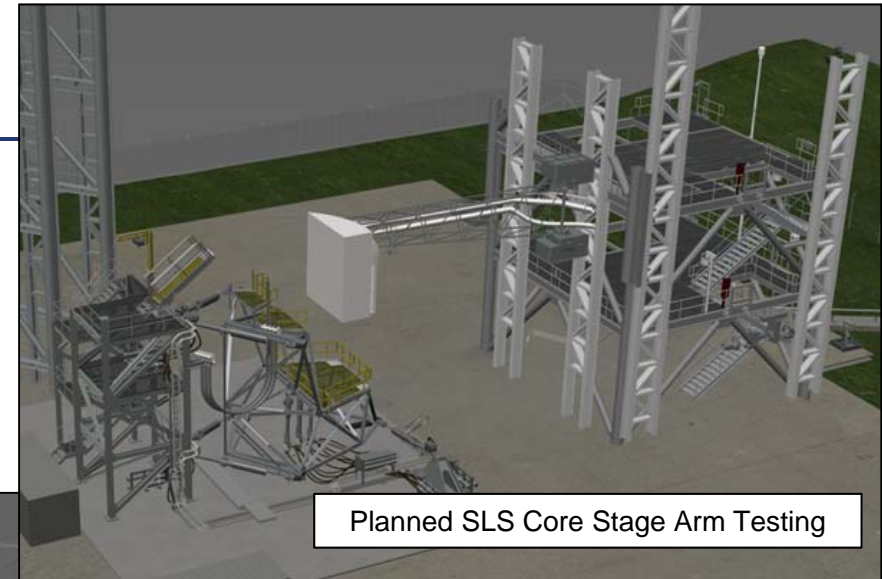
A Second VMS

VMS 2 Installation

The Sequel: "Return of the VMS"

- **VMS2 Highlights:**
  - New SLS program = more testing capability
  - Compressed schedule for umbilical testing
  - Provide mitigation for potential single-point failure of VMS1 test fixture

- **Leverage Previous Team & Knowledge**
  - Build on lessons learned for all aspects of project
  - Continuity in technical approach and technical team

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In Summary

- **Good Performance is more important than Good Reputation**
  - Follow-through is the difference

- **Experiences With Poor Performers at KSC = "Never More…"**
  - Bad reputation built on repeat issues, or unresolved ones

- **You Get What You Pay For**
  - "Pay now, or pay later" syndrome
  - No design is perfect; learn from it and move on

Planned SLS Core Stage Arm Testing

Planned SLS Crew Access Arm Testing

The Vehicle Motion Simulator Story

End

Thank You….

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