SPACE LAUNCH SYSTEM

SLS Technology Insertion Approach

Fred Bickley, PhD
Space Launch System Program

www.nasa.gov/sls
Evolving the Vehicle

SLS Evolution

National Benefits
- New Launch Capability
  - Advanced Booster
  - Upper Stage Engine
  - Engine Development
- Partnership
  - Industry
  - Universities
  - Other Government Agencies
  - International
  - Small Business

Technical Benefits
- Advanced Manufacturing
- Advanced Composite Structures
- Obsolescence Mitigation
- Advanced Analytical Design Tools

Industry Tasks
- In-House Development
- Academia Research
- Advanced Booster

Block 1 Flights
THE WORLD’S MOST POWERFUL ROCKET

Orion

Interim Cryogenic Propulsion Stage

Block I
70 metric tons

Five-Segment Solid Rocket Boosters

Core Stage
4 RS-25 Engines

Upper Stage

5, 8.4 or 10 Meter Payload Fairings

Block II
130 metric tons

Liquid or Solid Advanced Boosters

THE WORLD’S MOST POWERFUL ROCKET

www.nasa.gov/sls
Technology Transition

Level of Development

TRL

Valley of Death

Ideas Research | Advanced Development | Product Development | Operational Phase

1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9

Advanced Development

Product Development

Technology Development
SLS Approach to Block Upgrades

**Improvements in Performance, Safety, Reliability, Cost, and Operations**

Notional Schedules

* NASA, Office of Chief Technologist (TRL 1-6)
Technology Needs

**Formulation/Evolvability**
- Mission Requirements
- Mission Capture
- Concept Definition/Benefits

**Products**
- Payload Requirements
- Mission Capture
- Concept Definition/Benefits
- Cost
- Safety/Reliability

**Advanced Development**
- Technology Tasks for Government, Industry & Academia
- Identified Obsolescence
- Technology Demonstrations

**Products**
- Mature Technologies for Block Upgrades
- Data Package for Technologies
- Support for Transition Process

**End User**
- SLS Element Offices
- Payload Integration
## Current Advanced Development Tasks

### In-house Tasks:
- Cryogenic Mat’l & Process Development–Mitigate Obsolescence
- Hexavalent Chromium Free Primer for Cryo
- MPS Low Profile Diffuser
- Solide State Ultracapacitor to Replace Batteries Lattice
- Boltzmann Modeling Zero-G Propellants
- Hot fire Test LOX/H2 Additively Manu’f Injector Affordable for EUS
- Testing of Additively Manu’f Turbomachinery
- Additive Manufacturing Infrared Inspection
- Computed Tomography Sensitivity & Verification of Engine Components
- Additive Manuf. Propellant Ducts, Manifolds & Bellows
- Adv. Manuf. Of Lightweight C-C Nozzle Ext. for Upper Stage
- Performance Improvement of Friction Stir Welds by Better Surface Finish
- Composite Dry Structure Cost Improvement Approach
- Q2 Inconel 625 Mat’l Properties Development
- Q4 titanium 6-4 Mat’l Properties Development
- Pyroshock Characterization of Composite Materials (NESC funded)
- Booster Interference Loads (NESC funded)
- Advanced Booster comp. Case/PBI NBR Insulation Dev (NESC funded)
- Advanced Booster Combustion Stability (NESC funded)

### Academia Tasks:
- Auburn University: High Electrical Density Device Survey for Aerospace Applications
- Louisiana State University: Improved Friction Stir Welds Using On-Line Sensing of Weld Quality
- Massachusetts Institute of Technology: Modeling Approach for Rotating Cavitation Instabilities in Rocket Engine Turbopumps
- Mississippi State University: Algorithmic Enhancement for High Resolution Hybrid RANS-LES and Large-Scale Multicore Architectures
- University of Florida: Development of Subcritical Atomization Models for Liquid Rocket Injectors and Two-Phase Flow Heat Transfer
- University of Maryland: Validation of Supersonic Film Cooling Numerical Simulations Using Detailed Measurement and Novel Diagnostics
- Flame Stabilization and Combustion Instabilities University of Utah: Acoustic Emission Based Health Monitoring of Structures
- Pennsylvania State University: Characterization of Aluminum/Alumina/Carbon Interactions under Simulated Rocket Motor Conditions

### Awarded Industry Tasks:
- Aerojet: AUSEP Engine Study
- Exquadrum, Inc: AUSEP/DESLA Concept Development
- Moog: AUSE High Press LOX Flow Control Valve Manufacturing Study
- Northrup Grumman: System Requirements and Affordability Assessment for an AUSE
- Pratt & Whitney Rocketdyne: Requirements, Logistics, and System Assessment of an AUSE
- ULA: Integrated Vehicle Fluids (IVF) Testing

### Advanced Booster Engineering

#### Demonstration and Risk Reduction Tasks (ABEDRR):
- Dynetics & Aerojet: Modernization of the F-1B Engines, Combustion Stability, and Cryotank Manufacturing
- ATK: Demonstration of a FWC for High-Energy Propellant SRB
- Northrop Grumman: Demonstration of a Common Bulkhead LOX/RP Composite Cryogenic Tank

Details of individual tasks can be found at [www.ntrs.nasa.gov](http://www.ntrs.nasa.gov) (search for NASA/TM-2015-218201) in the SLS SPIE Advanced Development FY14 Annual Report.
SLS Advanced Development Group Technology Focus Areas

◆ SLS Industry Task Focus Areas
  • Exploration Upper Stage (EUS)
    - Light weight structures and materials, including composites
    - Advanced LOX/LH2 engine
    - Cryogenic storage for long duration missions
    - Advanced/Additive Manufacturing (Selective Laser Melting)
  • Universal Stage Adapter
    - Light weight structures and materials, including composites
    - Design

◆ SLS In-House and Academic Task Focus Areas
  • Propulsion
  • Stages, including upper stages
  • Advanced boosters
  • Shrouds
  • Operations
  • Payload accommodations
  • Analytical modeling
  • Advanced manufacturing
  • Materials development