



National Aeronautics and Space Administration

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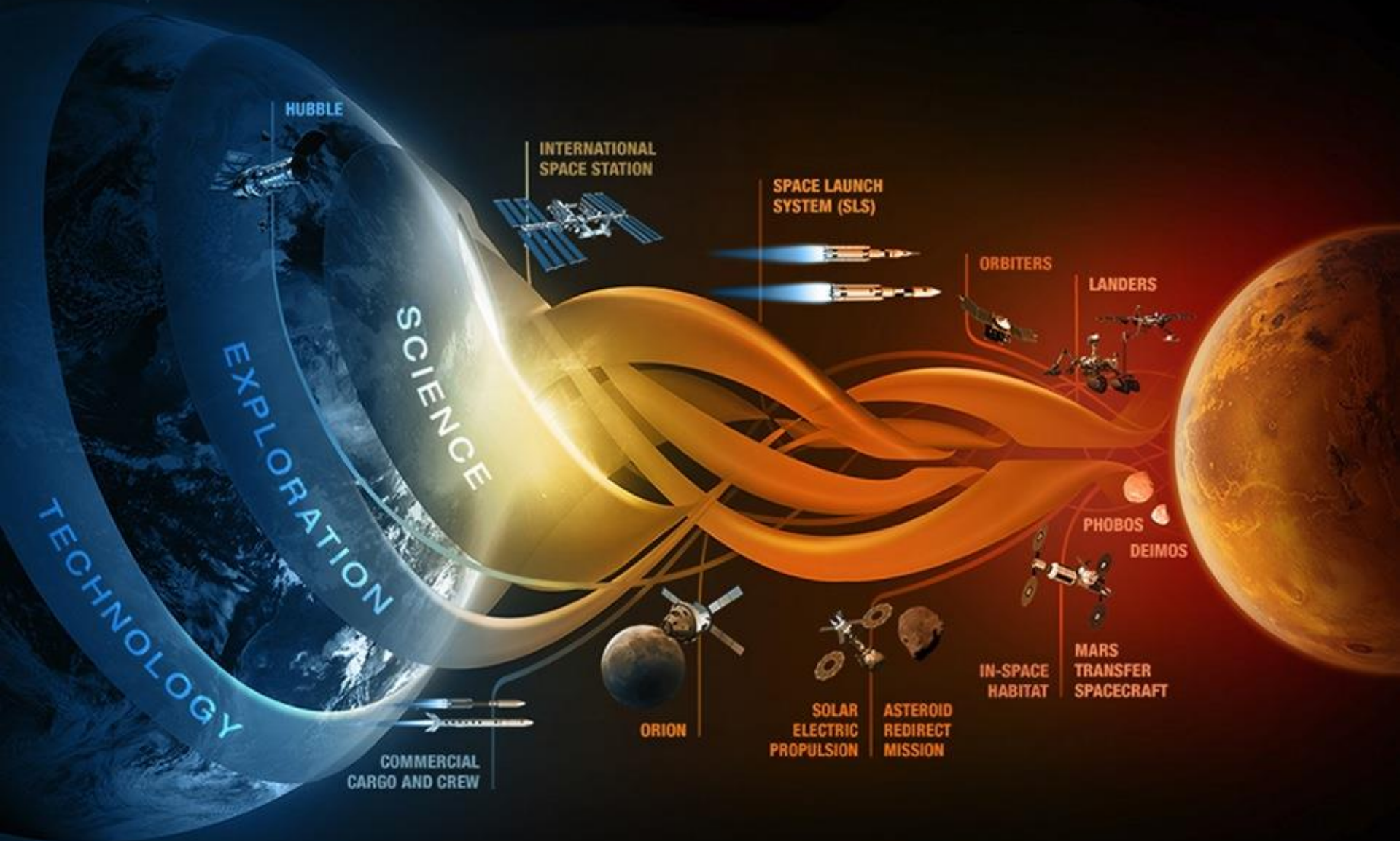
SPACE LAUNCH SYSTEM

SLS Technology Insertion Approach

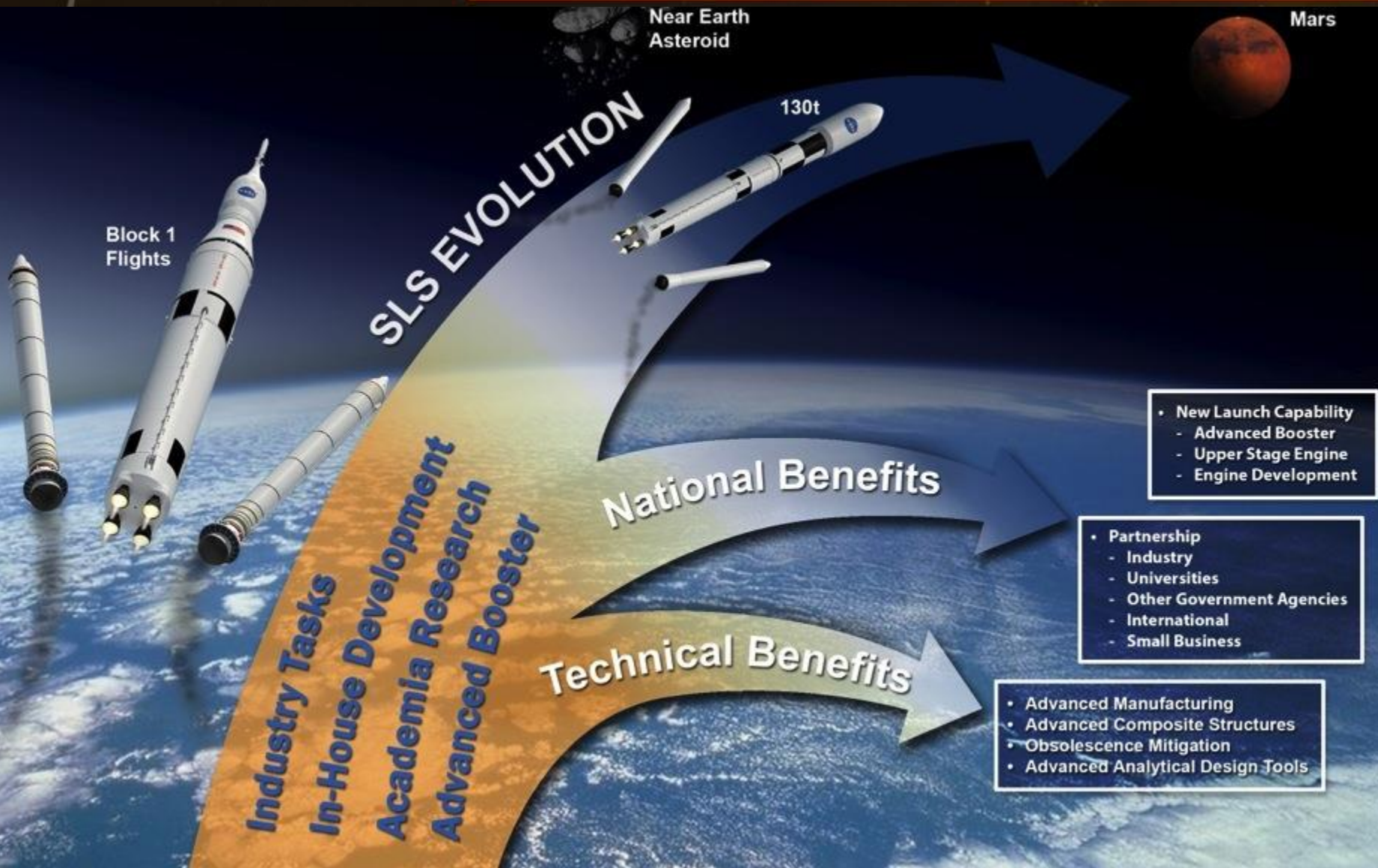
Fred Bickley, PhD
Space Launch System Program



THE JOURNEY TO MARS



EVOLVING THE VEHICLE



THE WORLD'S MOST POWERFUL ROCKET

Orion

5, 8.4 or 10 Meter
Payload Fairings

Interim Cryogenic
Propulsion Stage

Upper Stage

Core Stage

Block I
70 metric tons

Block II
130 metric tons

Five-Segment
Solid Rocket Boosters

Liquid or Solid
Advanced Boosters

4 RS-25 Engines



SLS Spacecraft/Payload Integration and Evolution (SPIE)

Manager
Deputy Manager
Assistant Manager
Assistant Manager
SLS Chief Technologist

Chris Crumbly
Steve Creech
Andy Schorr
Lori Mullins (On Detail)
Fred Bickley

Advanced Development
Fred Bickley

Industry
Bryan Barley

Academia & In-House
Melinda Nettles

Advanced Booster
ATK: Angie Jackman
Dynetics: Sam Stephens
NGC: Bryan Barley

Formulation/Evolvability
Angie Jackman

Payload Integration
Angie Jackman

Evolvability
Tom Krivanek/GRC (Fairing)

Payload & Hardware Integration
Jim Lomas

Interfaces/Integrated Ops/ Mission Ops
Brian Mulac

Secondary Payloads (FP)
George Norris

Requirements/Verification/ CM/Risk/CoFR
Tim Griswold

ISPE Structural Test Article
Keith Higginbotham

Adapter/Payload Attachment Production/Test/Operations
Brent Gaddes

MSA
Brent Gaddes

LVSA
Craig Liverett

ICPS
Chris Calfee
Steve Sexton

Engineering Interface
CE: Jeff Dilg
Deputy, Integration: J Brown
Deputy, Evolution: Keith Dill
Deputy, Evolution: George Young

Program Planning & Control

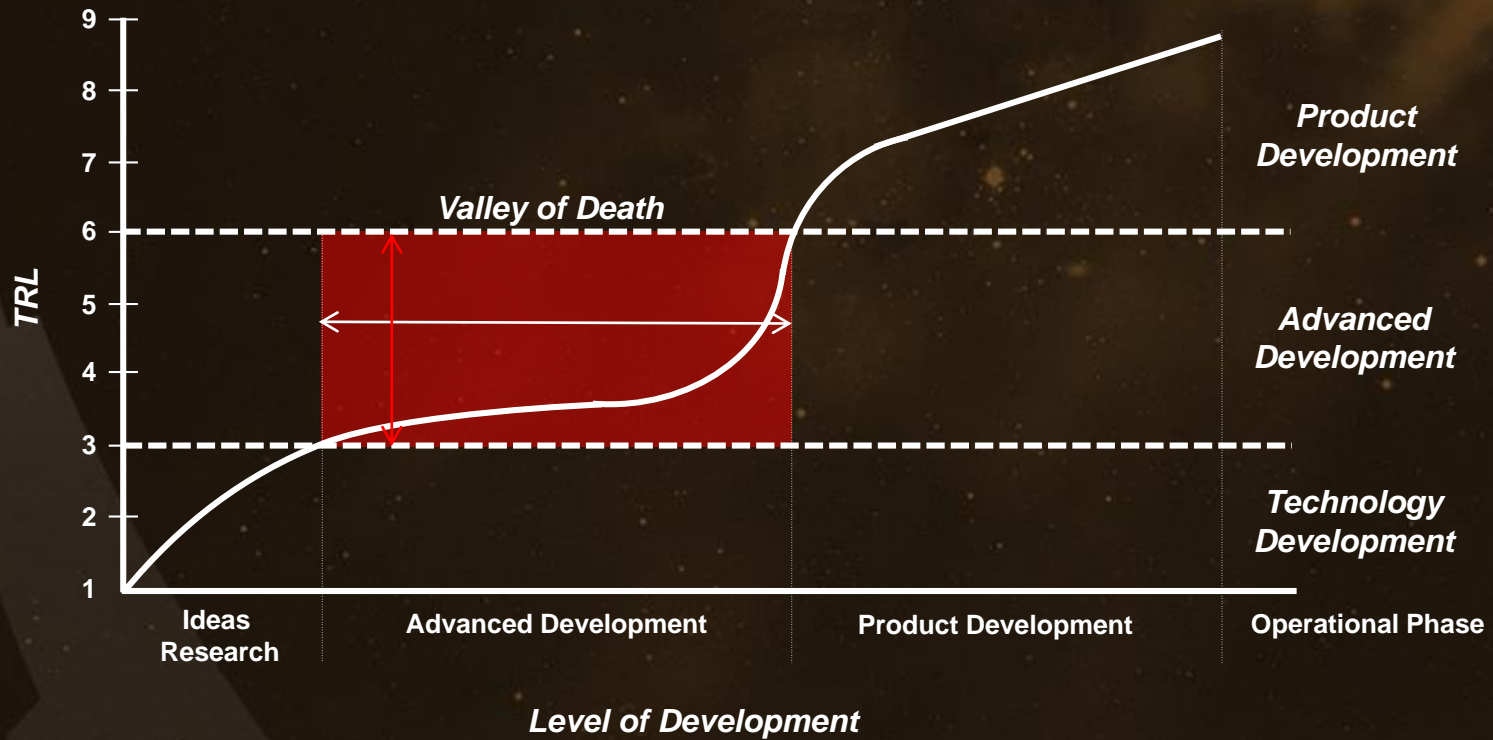
S&MA

Procurement

Configuration Management



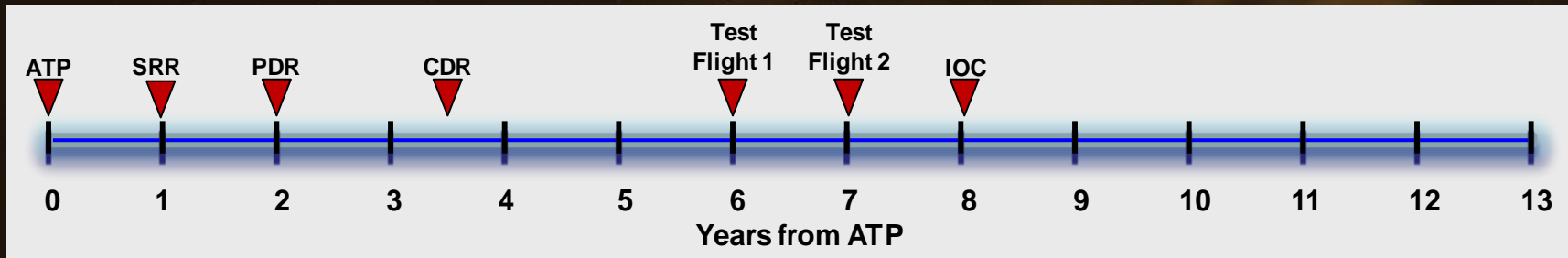
Technology Transition



SLS Approach to Block Upgrades

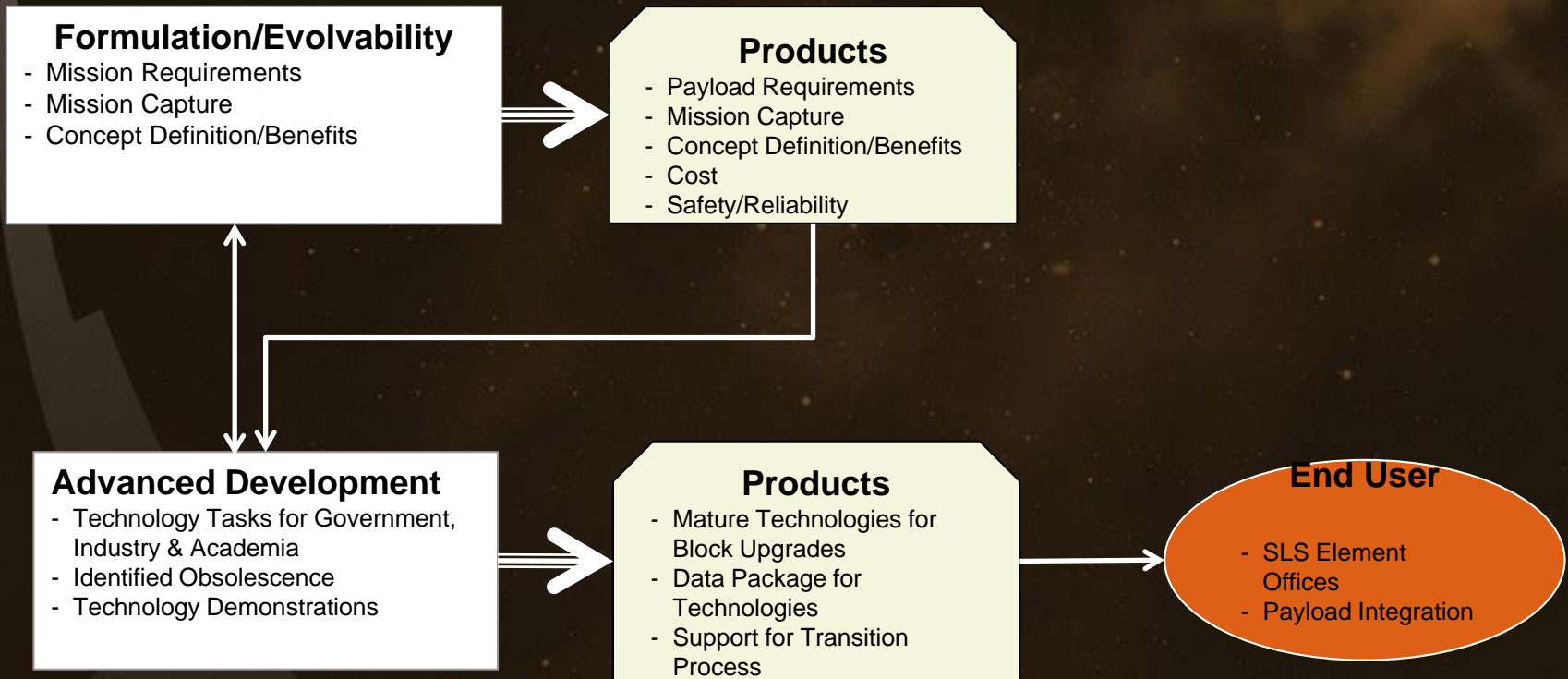
Improvements in Performance, Safety, Reliability, Cost, and Operations

Notional Schedules



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

Technology Needs



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 Mar'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
University of Michigan: Advanced LES and Laser Diagnostics to Model Transient Combustion-Dynamic Processes in Rocket Engines: Prediction of Flame Stabilization and Combustion Instabilities
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
Northrup Grumman: Demonstration of a Common Bulkhead LOX/RP Composite Cryogenic Tank

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