NASA Technology Area 1: Launch Propulsion Systems

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Technology Area Overview

• Domain
  – Earth to LEO Launch Propulsion Systems (Space Access)

• Does not include
  – Beyond LEO Transportation
  – Ground Systems other than launch assist
  – Launch Vehicles
    • Select subsystems in other TAs

• TA divided into 5 technical focus areas
## Traceability to NASA Strategic (draft) Goals

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<tr>
<th>Goal</th>
<th>LPSTA Alignment</th>
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<td>1. Extend and sustain human activities across the solar system.</td>
<td>Launch propulsion technologies advance human access to space.</td>
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<td>2. Expand scientific understanding of the Earth and the universe in which we live.</td>
<td>Launch propulsion technologies facilitate efficient scientific access to space.</td>
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<td>3. Create the innovative new space technologies for our exploration, science, and economic future.</td>
<td>Research into launch propulsion technologies builds and sustains the nation’s leadership in access to space.</td>
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<td>4. Advance aeronautics research for societal benefit.</td>
<td>Advances in air-breathing technologies have strong synergy with access to space.</td>
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<td>5. Enable program and institutional capabilities to conduct NASA’s aeronautics and space activities.</td>
<td>Launch propulsion technologies provide and maintain a base for NASA programs and institution to build on for access to space.</td>
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<td>6. Share NASA with the public, educators, and students to provide opportunities to participate in our mission, foster innovation and contribute to a strong National economy.</td>
<td>Expanding the nation’s propulsion technology research leads to new opportunities for academic institutions and for student STEM skills.</td>
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Traceability to NASA (and OGA) Missions

- Assessed Agency Mission Planning Manifest
  - 2011 draft

- SMD
  - Continuous tempo of 5–8 payloads per year
    - 3–5 small, 2–3 medium, 1 large payload every few years
  - No investment in LPSTA
  - Needs low cost, reliable access to space

- ESMD
  - Heavy Lift Propulsion Technology Plan (HLPT)
  - Human Exploration Framework Team
  - Commercial Crew
  - Commercial Cargo

- SOMD
  - Depends on ESMD for LPSTA development

- ARMD
  - Hypersonic roadmaps

- DoD
  - HLPT Common Engine Study (NASA/USAF)
  - Hypersonic roadmap joint with USAF/USN
Emerging Domestic Commercial Space Sector
- Low-Cost Access to Space
- Potential New Markets

Other U.S. Government Agencies
- Low-Cost, Reliable Access to Space
- Supports the Need for Large-Diameter Payloads
- Operationally Responsive Space

Increased University Involvement in Fundamental Propulsion Research
- Supports Science, Technology, Engineering and Mathematics Education

Supports Robust Industrial Base
- Enhanced Supplier Base Stability
- Reduced Reliance on Foreign Sources
• Reviewed existing Launch Propulsion Systems Technology Area (LPSTA) databases

• Solicited input from industry

• Involved Agency experts for input

• Reviewed by Red Team of NASA senior experts

• Documented and summarized per OCT guidance

• Roadmaps were then reviewed by special team established by OCT before submittal to NRC
Databases Consulted

- Space Launch Initiative (SLI) Technology Plan
- USAF/NASA 120-Day Study Technology Team Data Package
- National Aerospace Initiative (NAI)
- Next Generation Launch Technology (NGLT)
- Advanced Planning and Integration Office (APIO) In-Space Transportation Roadmap
- Heavy Lift Propulsion Technologies (HLPT) NASA/USAF Engine Study
- Integrated High Payoff Rocket Propulsion Technology (IHPRPT)
- Capability, Requirements, Analysis, and Integration (CRAI) Database
- Alternate Horizontal Launch Space Access Technology Roadmap
- NASA Fundamental Aeronautics Program Hypersonics Project 6-Month and 12-Month Reviews (with roadmaps)
- “USA Fundamental Hypersonics” presentation to 16th AIAA/DLR/DGLR International Space Planes and Hypersonic Systems and Technologies Conference
- National Aeronautics Research and Development Plan
- Report to Congress: Roadmap for the High-Speed and Hypersonic Programs of the Department of Defense
- National Hypersonics Plan: Access to Space Team Roadmap
- Boeing National Institute of Aerospace (NIA) Hypersonics Report
- National Research Council (NRC) Decadal Survey of Civil Aeronautics
- Gryphon Integrated Product Team (IPT) Kickoff Meeting and Roadmap
- NASA Hypersonics Project Planning Meeting
Industry & Other Government Agencies (OGA) Input

- Aerojet
- Andrews Space
- ATK
- Boeing
- Lockheed Martin
- Northrop Grumman
- Pratt & Whitney/Rocketdyne
- SpaceX
- United Launch Alliance (white papers supplied)

*Industry survey was not exhaustive but intended to be representative as validation of TA01 team roadmap assumptions*
Mission and Launch Vehicle Manifest Through 2035

Key NASA Missions & Milestones

- SMD Milestone
- ESMD Milestone
- ARMD Milestone
- SOMD Milestone
- Other

Mission manifest includes a range of flight types:
- Small: 0-2 t payloads
- Medium: 2-20 t payloads
- Heavy: 20-50 t payloads
- Super Heavy: > 50 t payloads
- Air-Breathing Launch Propulsion/Flight Tests

Mission manifest generates a launch vehicle manifest

Propulsion system technologies map to launch vehicles
**Focus of Technology Investments (Figures of Merit)**

**Life Cycle Cost (LCC)**

| Production | Expendable Systems | $ |
| Operations | Reusable Systems | $ |

Move from high-maintenance expendable infrastructure to low-maintenance reusable infrastructure

**Performance (Game Changing)**

- **System and Operational Concepts** – System or launch concepts that enable new capabilities or efficiencies that are not attained in current operational systems
  - i.e., higher reliability and shorter launch centers enable Earth orbit assembly missions

- **Propulsion System/Subsystem Efficiency and Capability** – Propulsion elements or subsystems that significantly improve payload lift efficiency or capability beyond current operational concepts
  - i.e., higher Isp, energy density, margins

**National needs to sustain and expand world leadership supported by input from other government agencies and industry**

*To make a significant change in either LCC or system performance, system robustness (margin) and reliability must be increased.*
Benefits—Launch Propulsion System Goals

Long Term
- Greater than 50% (game changing) recurring cost reductions
- Greater than 50X increase in reliability
- Enable new capabilities

Mid-term
- 50% recurring cost reduction
- 10X increase in reliability
- Enable new capabilities

Near Term
- 25% recurring cost reduction
- 5X increase in reliability

BASELINE
Shuttle, EELVs, Small Launchers

2010 2015 2020 2025 2030 2035

NOTE: Goals developed by TA01 based on past studies and reports. No systems analysis was performed to support these goals.
STR Process

**NASA Process**

1: **START & Input from MDs & Center**
   - Identified MD Goals, Missions, Architectures & Timelines;
   - MD Technology Roadmaps & Prioritizations;
   - Center Technology Focus Areas

2: **Identify Technology Areas**
   - Identified Technology Areas (TAs)

3: **Establish TA Teams**
   - OCT established NASA internal 6-member subject expert teams for each TA, with one or two chairs

4: **Common Approach for TA Teams**
   - Guidelines, assumptions, deliverables

5: **Form Starting Point for TA Roadmaps**
   - Assessed past roadmaps; MD & Center inputs

6: **Roadmapping Process**
   - Preliminary roadmaps for TA areas

7: **Internal Reviews**
   - Each TA Roadmap reviewed by OCT & extended teams of subject experts

8: **DRAFT NASA STRs**
   - OCT released draft Space Technology Roadmaps to the NRC & to the Public

**NRC Process**

A: **Establish NRC Teams**
   - NRC to appoint steering committee and 6 panels

B: **Identify Common Assessment Approach**
   - NRC to establish a set of criteria to enable prioritization within and among all TAs

C: **Initial Community Feedback**
   - NRC to solicit external input from industry & academia

D: **Additional Community Feedback**
   - NRC to conduct public workshops

E: **Deliberations by NRC Panels**
   - NRC panels meet individually to prioritize technologies and suggest improvements to roadmaps

F: **Documentation by NRC Panels**
   - NRC Panels to provide written summary to Steering Committee

G: **NRC Interim Findings**
   - NRC to release a brief interim report that addresses high-level issues associated with the roadmaps, such as the advisability of modifying the number or technical focus of the draft NASA roadmaps

H: **FINAL NRC REPORT**
   - With decisional information, including: summary of findings and recommendations for each of the roadmaps; integrated outputs from the workshops and panels; identify key common threads and issues; priorities, by group (e.g., high, medium, low), of the highest priority technologies from the TAs

**NASA Space Technology Roadmaps Process**
Summary

- LPSTA Draft Roadmap is a balanced portfolio of fundamental, midrange, and mature technology needs
- Technology investments address needs for the next 25+ years
- Technologies include evolutionary advancements in existing capabilities and game-changing candidates for the future
- Benefits can be found across all launch vehicle classes
- Opportunities exist to submit comments and additions through the NRC review process
- Several areas have been neglected in the past but must be restored to maintain national capability and leadership

*Foundational technology is key to making sustained significant advances in the future.*