



# Space Technology at NASA

Presented at the  
1<sup>st</sup> Workshop on Isotope Federal Supply and Demand  
Bethesda, Maryland

by  
Dr. Tibor Balint  
NASA HQ – Office of the Chief Technologist  
January 11, 2012

- Office of the Chief Technologist Roles
- Space Technology Roadmaps
  - Isotopes in the Roadmaps
- Nuclear Systems Working Group
- Summary



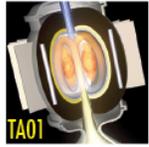
- **NASA Chief Technologist:**
  - Serves the Administrator as the principal NASA advisor on matters concerning Agency-wide technology policy and programs
  - Advocates externally for NASA's research and technology programs
- Delegated to **NASA Deputy Chief Technologist:**
  - Integrates, coordinates and tracks the technology investments across the Agency working to infuse technologies into future NASA missions and facilitating Agency technology governance (e.g., risk acceptance, reporting)
  - Documents, demonstrates, and communicates the societal impact of NASA technology investments
  - Leads technology transfer and technology commercialization activities across the Agency, facilitating internal creativity and innovation efforts
- Delegated to **Space Technology Program Director:**
  - Directs management and budget authority of the Space Technology Programs

# Space Technology Roadmaps

## Technology Area Breakdown Structure

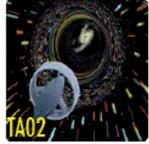


TA01



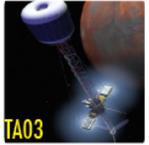
- LAUNCH PROPULSION SYSTEMS

TA02



- IN-SPACE PROPULSION TECHNOLOGIES

TA03



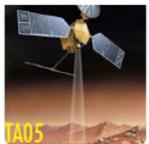
- SPACE POWER & ENERGY STORAGE

TA04



- ROBOTICS, TELE-ROBOTICS & AUTONOMOUS SYSTEMS

TA05



- COMMUNICATION & NAVIGATION

TA06



- HUMAN HEALTH, LIFE SUPPORT & HABITATION SYSTEMS

TA07



- HUMAN EXPLORATION DESTINATION SYSTEMS

TA08



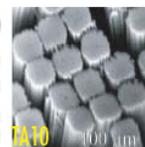
- SCIENCE INSTRUMENTS, OBSERVATORIES & SENSOR SYSTEMS

TA09



- ENTRY, DESCENT & LANDING SYSTEMS

TA10



- NANOTECHNOLOGY

TA11



- MODELING, SIMULATION, INFORMATION TECHNOLOGY & PROCESSING

TA12



- MATERIALS, STRUCTURES, MECHANICAL SYSTEMS & MANUFACTURING

TA13



- GROUND & LAUNCH SYSTEMS PROCESSING

TA14



- THERMAL MANAGEMENT SYSTEMS

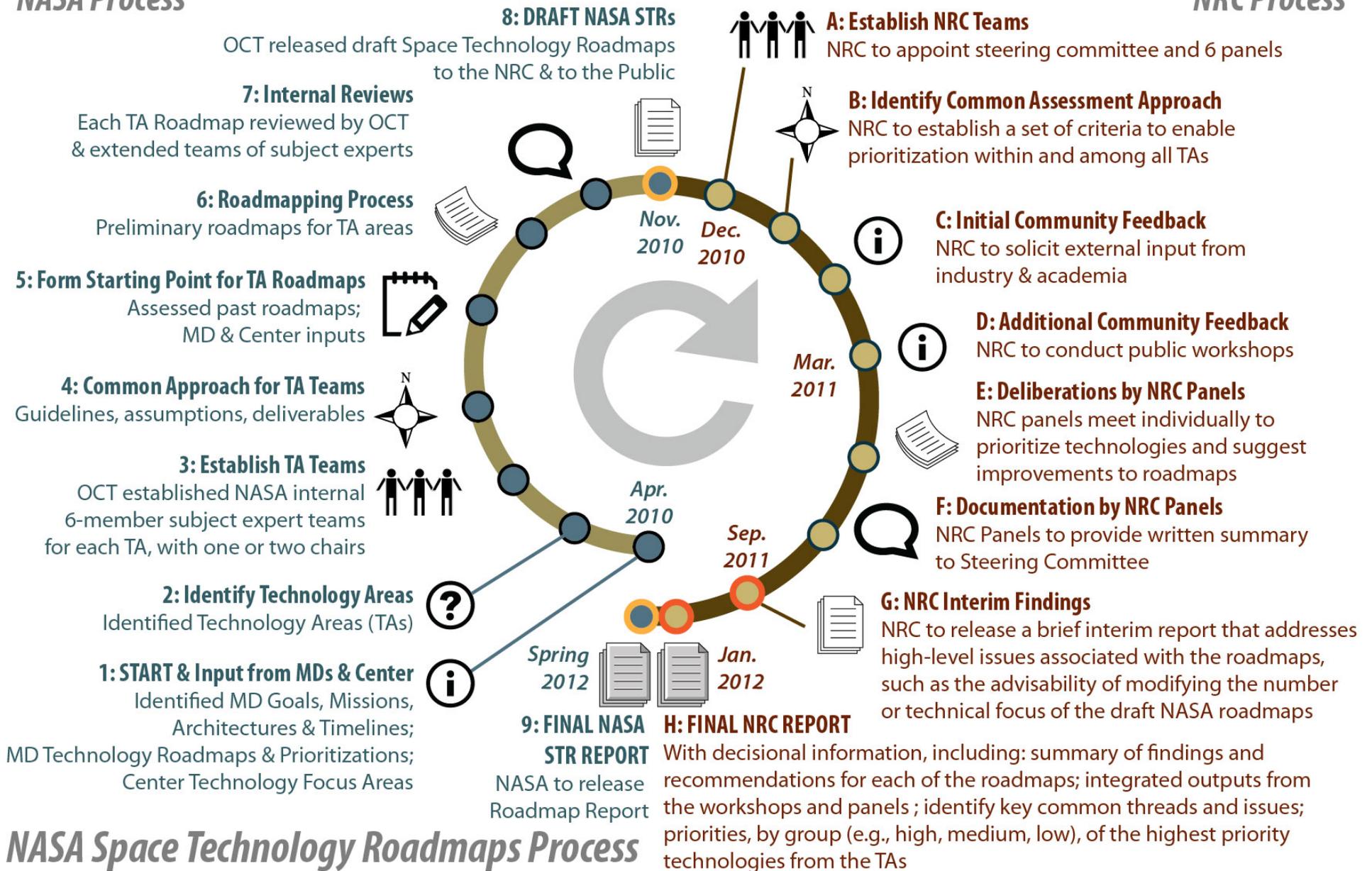
<http://www.nasa.gov/offices/oct/home/roadmaps/index.html>

# Space Technology Roadmap Process



## NASA Process

## NRC Process

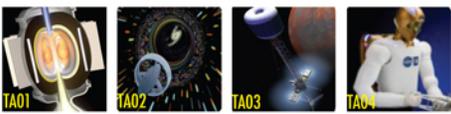


## NASA Space Technology Roadmaps Process



# Isotopes Related Technology Areas in the Roadmaps

## TA03 – Space Power & Energy Storage



### TA01 • LAUNCH SYSTEMS

**SOLID ROCKET PROPULSION SYSTEMS**

- Propellants
- Case Materials
- Nozzle Systems
- Hybrid Rocket Propulsion Systems
- Fundamental Solid Propulsion Technologies

### LIQUID ROCKET PROPULSION SYSTEMS

- LH<sub>2</sub>/LOX Based
- RP/LOX Based
- CH<sub>4</sub>/LOX Based
- Detonation Wave Engines (Closed Cycle)
- Propellants
- Fundamental Liquid Propulsion Technologies

### AIR BREATHING PROPULSION SYSTEMS

- TBCC
- RBCC
- Detonation Wave Engines (Open Cycle)
- Turbine Based Jet Engines (Flyback Boosters)
- Ramjet/Scramjet Engines (Accelerators)
- Deep-cooled Air Cycles
- Air Collection & Enrichment System
- Fundamental Air Breathing Propulsion Technologies

### ANCILLARY PROPULSION SYSTEMS

- Auxiliary Control Systems
- Main Propulsion Systems (Excluding Engines)
- Launch Abort Systems
- Thrust Vector Control Systems
- Health Management & Sensors
- Pyro & Separation Systems
- Fundamental Ancillary Propulsion Technologies

### UNCONVENTIONAL / OTHER PROPULSION SYSTEMS

- Ground Launch Assist
- Air Launch / Drop Systems
- Space Tether Assist
- Beamed Energy / Energy Addition
- Nuclear
- High Energy Density Materials/Propellants

### TA02 • IN-SPACE PROPULSION TECHNOLOGIES

**CHEMICAL PROPULSION**

- Liquid Storable
- Liquid Cryogenic
- Gels
- Solid
- Hybrid
- Cold Gas/Warm Gas
- Micro-propulsion

**NON-CHEMICAL PROPULSION**

- Electric Propulsion
- Solar Sail Propulsion
- Thermal Propulsion
- Tether Propulsion

### ADVANCED (TRL <3) PROPULSION TECHNOLOGIES

- Beamed Energy Propulsion
- Electric Sail Propulsion
- Fusion Propulsion
- High Energy Density Materials
- Antimatter Propulsion
- Advanced Fission
- Breakthrough Propulsion

### SUPPORTING TECHNOLOGIES

- Engine Health Monitoring & Safety
- Propellant Storage & Transfer
- Materials & Manufacturing Technologies
- Heat Rejection
- Power

### TA03 • SPACE POWER & ENERGY STORAGE

**POWER GENERATION**

- Energy Harvesting
- Chemical (Fuel Cells, Heat Engines)
- Solar (Photo-Voltaic & Thermal)
- Radioisotope
- Fission
- Fusion

### ENERGY STORAGE

- Batteries
- Flywheels
- Regenerative Fuel Cells

### POWER MANAGEMENT & DISTRIBUTION

- FDIR Management & Control
- Distribution & Transmission
- Wireless Power Transmission
- Conversion & Regulation

### CROSS CUTTING TECHNOLOGY

- Analytical Tools
- Green Energy Impact
- Multi-functional Structures
- Alternative Fuels

### TA04 • ROBOTICS, TELE-ROBOTICS & AUTONOMOUS SYSTEMS

**SENSING & PERCEPTION**

- Stereo Vision
- LIDAR
- Proximity Sensing
- Sensing Non-Geometric Terrain Properties
- Estimating Terrain Mechanical Properties
- Tactile Sensing Arrays
- Gravity Sensors & Celestial Nav.
- Terrain Relative Navigation
- Real-time Self-calibrating of Hand-eye Systems

### MOBILITY

- Simultaneous Localiz. & Mapping
- Hazard Detection Algorithms
- Active Illumination
- 3-D Path Planning w/ Uncertainty
- Long-life Extr. Enviro. Mechanisms
- Robotic Jet Backpacks
- Smart Tethers
- Robot Swarms
- Walking in Micro-g

### MANIPULATION

- Motion Planning Alg., High DOF Sensing & Control
- Robot Arms (light, high strength)
- Dexterous Manipul., Robot Hands
- Sense/Fusion for Grasping
- Grasp Planning Algorithms
- Robotic Drilling Mechanisms
- Multi-arm / Finger Manipulation
- Planning with Uncertainty

### HUMAN-SYSTEMS INTEGRATION

- Crew Decision Support Systems
- Immersive Visualization
- Distributed Collaboration
- Multi Agent Coordination
- Haptic Displays
- Displaying Range Data to Humans

### AUTONOMY

- Spacecraft Control Systems
- Vehicle Health, Prog/Diag Systems
- Human Life Support Systems
- Planning/Scheduling Resources
- Operations
- Integrated Systems Health Management
- FDIR & Diagnostics
- System Monitoring & Prognosis
- V&V of Complex Adaptive Sys's
- Automated Software Generation
- Software Reliability
- Semi Autonomous Systems

### AUTON. REMOUEVISE & DOCKING

- Rendezvous and Capture
- Low Impact & Androgenous Docking Systems & Interfaces
- Relative Navigation Sensors
- Robust AR&D GN&C Algorithms & FSW
- Onboard Mission Manager
- AR&D Integration & Standardiz.n

### RTA SYSTEMS ENGINEERING

- Human safety
- Refueling Interfaces & Assoc. Tools
- Modular / Serviceable Interfaces
- High Perf., Low Power Onboard Computers
- Environment Tolerance
- Thermal Control
- Robot-to-Suit Interfaces
- Common Human-Robot Interfaces
- Crew Self Sufficiency

### TA05 • COMMUNICATION & NAVIGATION

**OPTICAL COMM. & NAVIGATION**

- Detector Development
- Large Apertures
- Lasers
- Acquisition & Tracking
- Atmospheric Mitigation

**RADIO FREQUENCY COMMUNICATIONS**

- Spectrum Efficient Technologies
- Power Efficient Technologies
- Propagation
- Flight & Ground Systems
- Earth Launch & Reentry Comm.
- Antennas

### INTERNETWORKING

- Disruptive Tolerant Networking
- Adaptive Network Topology
- Information Assurance
- Integrated Network Management

### POSITION, NAVIGATION, AND TIMING

- Timekeeping
- Time Distribution
- Onboard Auto Navigation & Maneuver
- Sensors & Vision Processing Systems
- Relative & Proximity Navigation
- Auto Precision Formation Flying
- Auto Approach & Landing

### INTEGRATED TECHNOLOGIES

- Radio Systems
- Ultra Wideband
- Cognitive Networks
- Science from the Comm. System
- Hybrid Optical Comm. & Nav. Sensors
- RF/Optical Hybrid Technology

### REVOLUTIONARY CONCEPTS

- X-Ray Navigation
- X-Ray Communications
- Neutrino-Based Navigation & Tracking
- Quantum Key Distribution
- Quantum Communications
- SQIF Microwave Amplifier
- Reconfigurable Large Apertures

### TA06 • HUMAN HEALTH, LIFE SUPPORT & HABITATION SYSTEMS

**ENVIRONMENTAL CONTROL & LIFE SUPPORT SYSTEMS & HABITATION SYS.**

- Air Revitalization
- Water Recovery & Management
- Waste Management
- Habitation

### EXTRAVEHICULAR ACTIVITY SYSTEMS

- Pressure Garment
- Portable Life Support System
- Power, Avionics and Software

### HUMAN HEALTH & PERFORMANCE

- Medical Diagnosis / Prognosis
- Long-Duration Health
- Behavioral Health & Performance
- Human Factors & Performance

### ENVIRONMENTAL MONITORING, SAFETY & EMERGENCY RESPONSE

- Sensors: Air, Water, Microbial, etc.
- Fire: Detection, Suppression
- Protective Clothing / Breathing
- Remediation

### RADIATION

- Risk Assessment Modeling
- Radiation Mitigation
- Protection Systems
- Space Weather Prediction
- Monitoring Technology

### TA07 • HUMAN EXPLORATION DESTINATION SYSTEMS

**IN-SITU RESOURCE UTILIZATION**

- Destination Reconnaissance, Prospecting, & Mapping
- Resource Acquisition
- Consumables Production
- Manufacturing & Infrastructure Employment

### SUSTAINABILITY & SUPPORTABILITY

- Logistics Systems
- Maintenance Systems
- Repair Systems

### "ADVANCED" HUMAN MOBILITY SYSTEMS

- EVA Mobility
- Surface Mobility
- Off-Surface Mobility

### "ADVANCED" HABITAT SYSTEMS

- Integrated Habitat Systems
- Habitat Evolution

### MISSION OPERATIONS & SAFETY

- Crew Training
- Environmental Protection
- Remote Mission Operations
- Planetary Safety

### CROSS-CUTTING SYSTEMS

- Modeling, Simulations & Destination Characterization
- Construction & Assembly
- Dust Prevention & Mitigation

### TA08 • SCIENCE INSTRUMENTS, OBSERVATORIES & SENSOR SYSTEMS

**REMOTE SENSING INSTRUMENTS / SENSORS**

- Detectors & Optical Elements
- Electronics
- Optical Components
- Microwave / Radio Frequency
- Large Aperture
- Cryogenic / Thermal

### OBSERVATORIES

- Mirror Systems
- Structures & Antennas
- Distributed Aperture

### IN-SITU INSTRUMENTS / SENSORS

- Particles: Charged & Neutral
- Fields: Waves
- In-Situ

### TA09 • ENTRY, DESCENT & LANDING SYSTEMS

**AEROASSIST & ATMOSPHERIC ENTRY**

- Rigid Thermal Protection Systems
- Flexible Thermal Protection Systems
- Rigid Hypersonic Decelerators
- Deployable Hypersonic Decelerators
- Instrumentation & Health Monitoring
- Entry Modeling & Simulation

### DESCENT

- Attached Deployable Decelerators
- Trailing Deployable Decelerators
- Supersonic Retropropulsion
- GN&C Sensors
- Descent Modeling & Simulation

### LANDING

- Touchdown Systems
- Egress & Deployment Systems
- Propulsion Systems
- Large Body GN&C
- Small Body Systems
- Landing Modeling & Simulation

### VEHICLE SYSTEMS TECHNOLOGY

- Architecture Analyses
- Separation Systems
- System Integration & Analyses
- Atmosphere & Surface Characterization

### TA10 • NANOTECHNOLOGY

**ENGINEERED MATERIALS & STRUCTURES**

- Lightweight Structures
- Damage Tolerant Systems
- Coatings
- Adhesives
- Thermal Protection & Control

### ENERGY GENERATION & STORAGE

- Energy Storage
- Energy Generation

### PROPULSION

- Propellants
- Propulsion Components
- In-Space Propulsion

### SENSORS, ELECTRONICS & DEVICES

- Sensors & Actuators
- Nanoelectronics
- Miniature Instruments

### TA11 • MODELING, SIMULATION, INFORMATION TECHNOLOGY & PROCESSING

**COMPUTING**

- Flight Computing
- Ground Computing

### MODELING

- Software Modeling & Model-Checking
- Integrated Hardware & Software Modeling
- Human-System Performance Modeling
- Science & Engineering Modeling
- Frameworks, Languages, Tools & Standards

### SIMULATION

- Distributed Simulation
- Integrated System Lifecycle Simulation
- Simulation-Based Systems Engineering
- Simulation-Based Training & Decision Support Systems

### INFORMATION PROCESSING

- Science, Engineering & Mission Data Lifecycle
- Intelligent Data Understanding
- Semantic Technologies
- Collaborative Science & Engineering
- Advanced Mission Systems

### TA12 • MATERIALS, STRUCTURES, MECHANICAL SYSTEMS & MANUFACTURING

**MATERIALS**

- Lightweight Structures
- Computational Design
- Flexible Material Systems
- Environment
- Special Materials

### STRUCTURES

- Lightweight Concepts
- Design & Certification Methods
- Reliability & Sustainability
- Test Tools & Methods
- Innovative, Multifunctional Concepts

### MECHANICAL SYSTEMS

- Deployables, Doors and Interfaces
- Mechanism Life Prediction Systems
- Electro-mechanical, Mechanical & Micromechanisms
- Design & Analysis Tools and Methods
- Reliability / Life Assessment / Health Monitoring
- Certification Methods

### MANUFACTURING

- Manufacturing Processes
- Intelligent Integrated Manufacturing and Cyber Physical Systems
- Electronics & Optics Manufacturing Process
- Sustainable Manufacturing

### CROSS-CUTTING

- Nondestructive Evaluation & Sensors
- Model-Based Construction & Sustainment Methods
- Loads and Environmental

### TA13 • GROUND & LAUNCH SYSTEMS PROCESSING

**TECHNOLOGIES TO OPTIMIZE THE OPERATIONAL LIFE-CYCLE**

- Storage, Distribution & Conservation of Fluids
- Automated Alignment, Coupling, & Assembly Systems
- Autonomous Command & Control for Ground and Integrated Vehicle/Ground Systems

### ENVIRONMENTAL AND GREEN TECHNOLOGIES

- Corrosion Prevention, Detection, & Mitigation
- Environmental Remediation & Site Restoration
- Preservation of Natural Ecosystems
- Alternate Energy Prototypes

### TECHNOLOGIES TO INCREASE RELIABILITY AND MISSION AVAILABILITY

- Advanced Launch Technologies
- Environment-Hardened Materials and Structures
- Inspection, Anomaly Detection & Identification
- Fault Isolation and Diagnostics
- Prognostics Technologies
- Repair, Mitigation, and Recovery Technologies
- Communications, Networking, Timing & Telemetry

### TECHNOLOGIES TO IMPROVE MISSION SAFETY/MISSION RISK

- Range Tracking, Surveillance & Flight Safety Technologies
- Landing & Recovery Systems & Components
- Weather Prediction and Mitigation
- Robotics / Telerobotics
- Safety Systems

### TA14 • THERMAL MANAGEMENT SYSTEMS

**CRYOGENIC SYSTEMS**

- Passive Thermal Control
- Active Thermal Control
- Integration & Modeling

### THERMAL CONTROL SYSTEMS

- Heat Acquisition
- Heat Transfer
- Heat Rejection/Energy Storage

### THERMAL PROTECTION SYSTEMS

- Entry / Ascent / Descent
- Plume Shielding (Convective & Radiative)
- Sensor Systems & Measurement Technologies

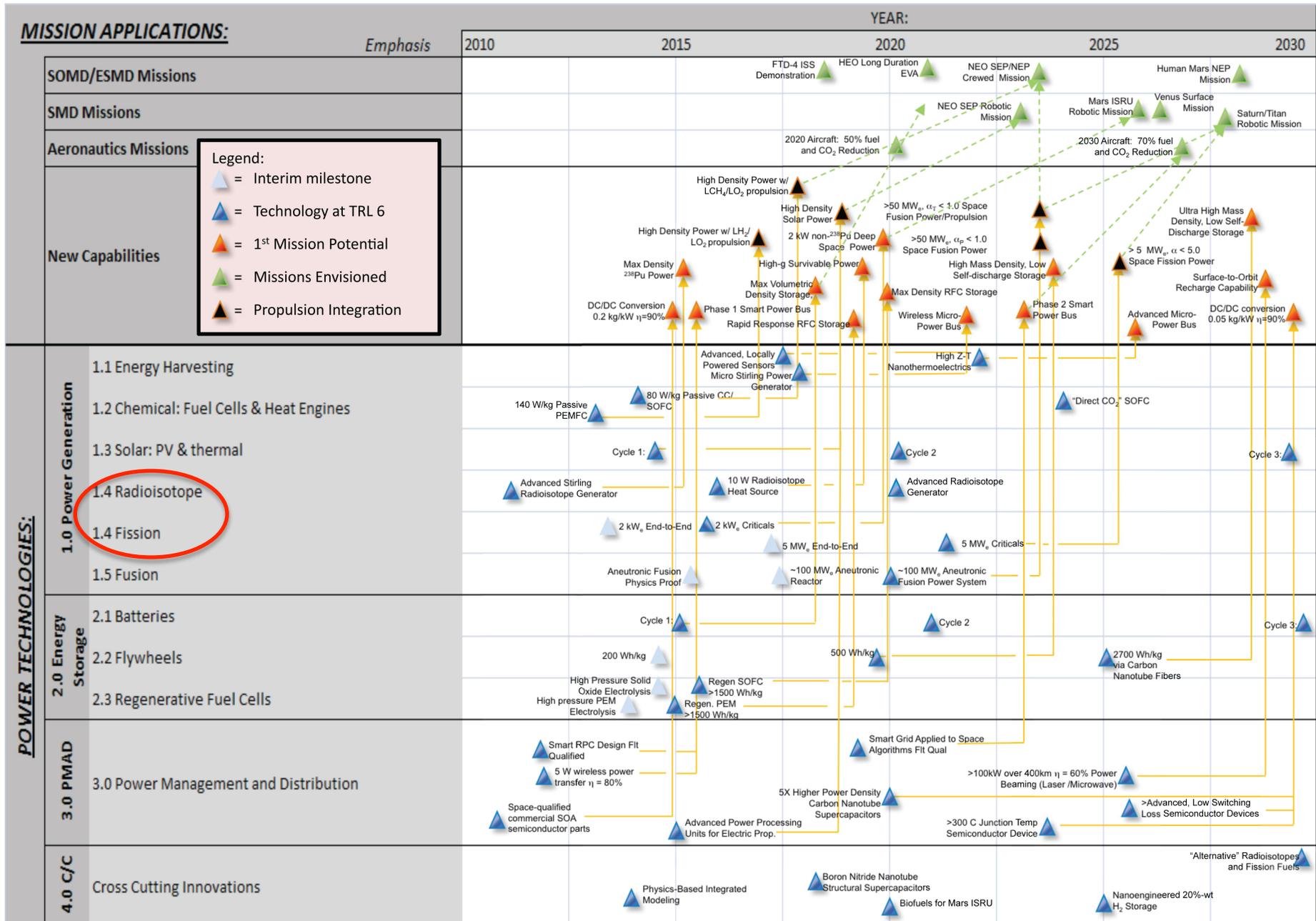
Space Instruments Sensors

Materials/Structures

Thermal

# Space Technology Roadmaps STR • TABS TECHNOLOGY AREA BREAKDOWN STRUCTURE

# TA03 Technology Area Breakdown Structure



# Nuclear Systems Working Group (NSWG)



- Advance the use of nuclear power and propulsion technologies ahead of current state-of-the-art for future NASA programs, projects, and commercial space.
- Provides avenue for **Agency-level coordination, planning, and integration** between stakeholders for technology development.
- Focus on **near- and long-term technology development strategies** that:
  - Minimize duplication effort
  - Identify areas of synergy
  - Identify areas of infusion with the commercial sector
  - Identify potential partnerships
  - Identify the Agency's nuclear resources (workforce, technology)
  - Provide recommendations to align with associated programs projects, and technology development efforts
  - Recommend investments to ensure a diverse portfolio



December 14, 2011

The **NASA NSWG** shall report to and function in an **advisory capacity to the Chief Technologist, and to the NASA Technology Executive Council (NTEC).**

- **OCT** provides a home within NASA for
  - **Agency-wide** technology **coordination**
  - **New technology development** that can be infused to Mission Directorate, and National needs
- The NASA-wide Nuclear Systems Working Group (**NSWG**) Lead reports to the NASA Chief Technologist and to NTEC on relevant topics, including
  - Radioisotope Power Systems (e.g., static and dynamic conversion based)
  - Nuclear Power Generation (e.g., fission and fusion)
  - Nuclear Propulsion (e.g., nuclear thermal and nuclear electric)
- **Specific Agency needs will be addressed next by Len Dudzinski**