NASA Science Mission Directorate
NASA Headquarters
Washington, DC

Prologue
Technology Capability Portfolio

Harley A. Thronson, Jr., Assistant Associate Administrator/Technology[1]
Giulio Varsi, Deputy Assistant Associate Administrator/Technology[2]

December 2005

[1] Now in the HST Development Office, NASA Goddard Space Flight Center
[2] Retired

Table of Contents

1 Introduction and Background 1
1.1 Context and Content of this Report 2
2 Overview of Capability Roadmap Process and Products 6
2.1 The Technology Capability Portfolio Development Process 6
2.2 Individual Capability Portfolios 9
3 Conclusions and Acknowledgements 9
4 Acronym and Abbreviation List 10

1 Introduction and Background

On January 14, 2004, President George W. Bush set the nation's space program in a new direction with the presentation of the *Vision for Space Exploration* (*Vision*). The fundamental goal of the *Vision* is to advance United States scientific, security, and economic interests through a robust space exploration program. In support of this goal, the United States will:

- Implement a sustained and affordable human and robotic program to explore the Solar System and beyond;
- Extend human presence across the Solar System, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations;
- Develop the innovative technologies, knowledge, and infrastructures both to explore and to support decisions about the destinations for human exploration; and
- Promote international and commercial participation in exploration to further U.S. scientific, security, and economic interests.

On January 27, 2004 the "*President's Commission on Implementation of United States Space Exploration Policy*" (The Aldridge Commission) was chartered to prepare recommendations for implementing the *Vision*. In particular, the June 2004 Commission's report identified seventeen technology areas that are critical to attaining the President's exploration objectives within schedule and at affordable costs. The report also recommended that NASA (Agency) form a special team for each technology area to develop roadmaps that lead to a mature capability. In summer 2004, NASA responded, establishing the Advanced Planning and Integration Office (APIO). The APIO, in turn, commissioned roadmap teams to recommend strategic and capability priorities, options and alternatives, technology strategies, and other key elements necessary to enable the *Vision*.

Beginning in October 2004, thirteen strategic roadmap teams were formed to explore options and establish pathways for implementing the *Vision*. They were to include broad human and robotic science and exploration goals, priorities, anticipated discoveries as well as high-level milestones, options, and decision points.

Fifteen roadmap teams were also formed to provide recommendations into the types of technology and capability investments that the Agency needs to make in order to achieve NASA's highest priorities. These fifteen roadmaps resulted from combining some of the seventeen areas from the Commission's report and adding selected technology areas that NASA management deemed critical to achieve major goals of the *Vision*. At the time of the APIO commissioning, the Science Mission Directorate (SMD) leads for the capability roadmaps — Thronson and Varsi — urged that additional roadmaps be undertaken, pointing out that the Aldridge Commission's original catalog of technologies was not prepared through a diligent systems analysis responsive to the *Vision*. These additional areas included in-space operations, planetary protection, advanced materials, and surface operations. At the time, it was decided instead by APIO to follow the first year's roadmapping activity with a subsequent activity that would consider those areas not included in the first-year set. However, the SMD lead, with the approval of the SMD Associate Administrator, chose to form a sixteenth team, for in-space operations roadmapping in parallel with those of the main APIO effort.

The sixteen capability roadmaps, with common abbreviations for some, are:

- High Energy Power and Propulsion (HEPP)
- In-Space Transportation (IST)
- Advanced Telescopes and Observatories (ATO)
- Communication and Navigation (COMM)
- Robotic Access to Planetary Surfaces (RAPS)
- Human Planetary Landing Systems (HPLS)
- Human Health and Support Systems (HHSS)
- Human Exploration Systems and Mobility (HESM)
- Autonomous System Robotics and Computing (ASR)
- Transformational Spaceport and Range
- Scientific Instruments and Sensors (SIS)
- In-Situ Resource Utilization (ISRU)
- Advanced Modeling and Simulation (AMS)
- Systems Engineering Cost Risk Analysis
- Nanotechnology (NANO)
- In-Space Operations (ISO)

1.1 Context and Content of this Report

The capability roadmaps were scheduled to be completed in September 2005 and published a month or so later. In early May 2005, the process was significantly accelerated in order to affect the FY 05 Operating Plan, the FY 06 Budget Plan, and the FY 07 budget development process. Given this decision to accelerate the schedule, the Agency determined that all roadmap efforts — both strategic and capability — would be terminated by May 22, 2005. In the few remaining weeks, the teams and the APIO quickly condensed their results into brief *Roadmap Executive Summaries* and the teams disbanded. The May 22nd *Executive Summaries* — widely circulated within NASA and elsewhere — were intended to provide timely inputs to long-range architecture study teams established by NASA Administrator, Dr. Michael Griffin.

Subsequent to the May delivery, the SMD Assistant Associate Administrator for Technology recognized the importance of collecting and documenting more completely, the results of the significant investment of the experts' time and of the public's funds in constructing the roadmaps. He decided that completing the effort and compiling documents would be extremely valuable to both the Directorate, as well as the Agency, particularly as the triennial strategic planning activity would begin about the time that a complete set of capability roadmaps would become available in autumn, 2005. The Associate Administrator for SMD approved this decision and the completion of the effort with the publication of these "*Technology Portfolios*." All of the original sixteen capabilities were offered support to finalize their work into a *Portfolio*. Ten accepted:

- High Energy Power and Propulsion (HEPP)
- In-Space Transportation (IST)
- Advanced Telescopes and Observatories (ATO)
- Communication and Navigation (COMM)

- Robotic Access to Planetary Surfaces (RAPS)
- Autonomous Systems, Robotics, and Computing (ASR)
- Scientific Instruments and Sensors (SIS)
- Nanotechnology (NANO)
- Advanced Modeling and Simulation (AMS)
- In-Space Operations (ISO)

These are major enabling capabilities for the Science Mission component of the President's *"Vision for Space Exploration"*.

The capability roadmapping process required a single, common set of missions and major activities in space to maintain internal consistency and stability of the process. These are shown in Figures 1.1a and 1.1b, which were approved by the Directorates as input to this process. However, the teams recognized that the architecture ultimately chosen for implementing the *Vision* might contain missions and decision dates that differ substantially from those currently referenced. Therefore, the teams considered additional missions as viable alternatives as NASA evolves its programs in response to on-going discoveries, findings, and technical and programmatic challenges. Thus, the set of capabilities identified is intrinsically robust and can accommodate program evolution. The roadmap timelines described — based on expected development times — can be adjusted to conform to the overall schedule that will develop as the *Vision* is implemented.

The set of Capability Portfolios in this report consists of:

- This *Prologue*, which includes: (1) the background to the extensive technology roadmapping process for implementing the *Vision*; (2) a summary of the capability roadmap process and (3) the capability roadmap mission planning milestones referenced by all teams (Figures 1.1a and 1.1b).
- Ten capability portfolios that detail each capability roadmap and identify key data derived from detailed analyses. This report is also available on CD from the authors.

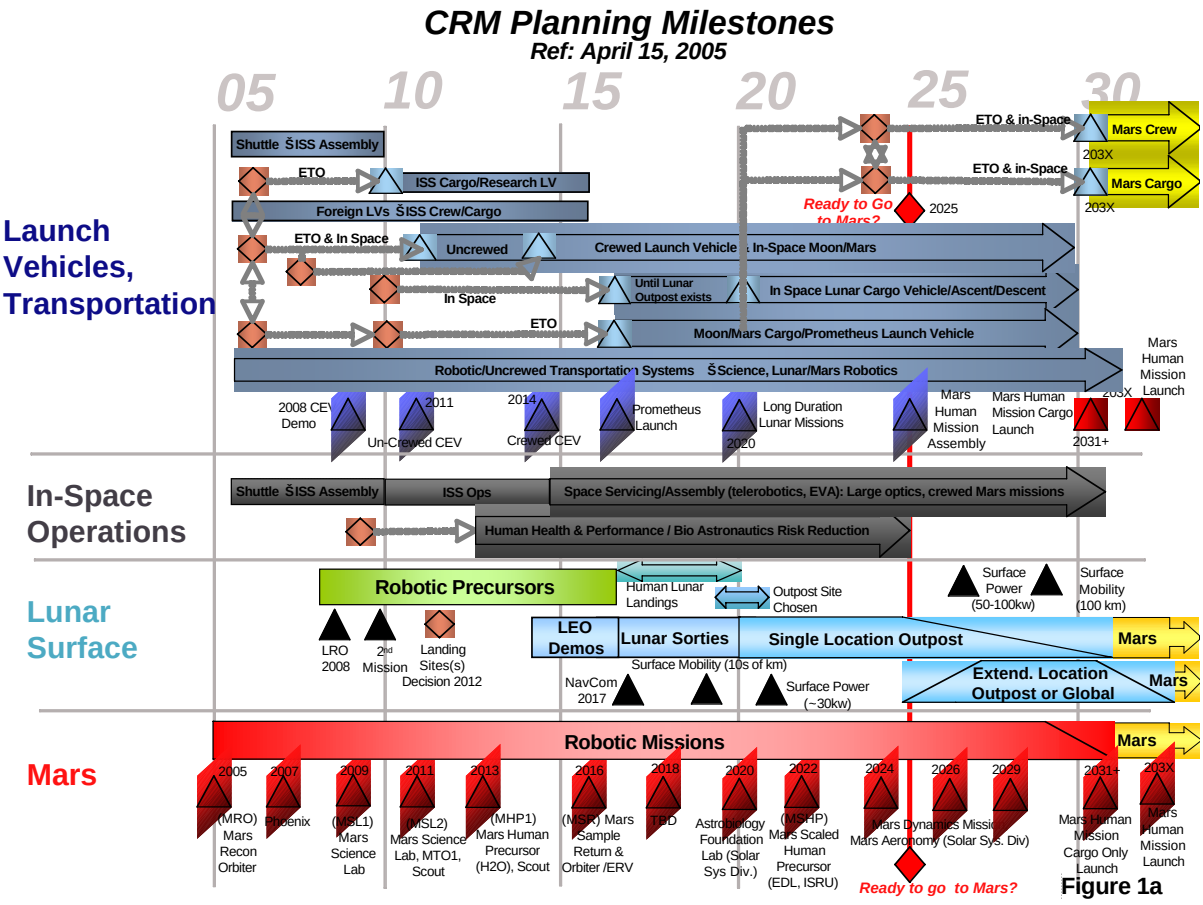

Figure 1.1a. Assumed Capability Roadmap Planning Milestones

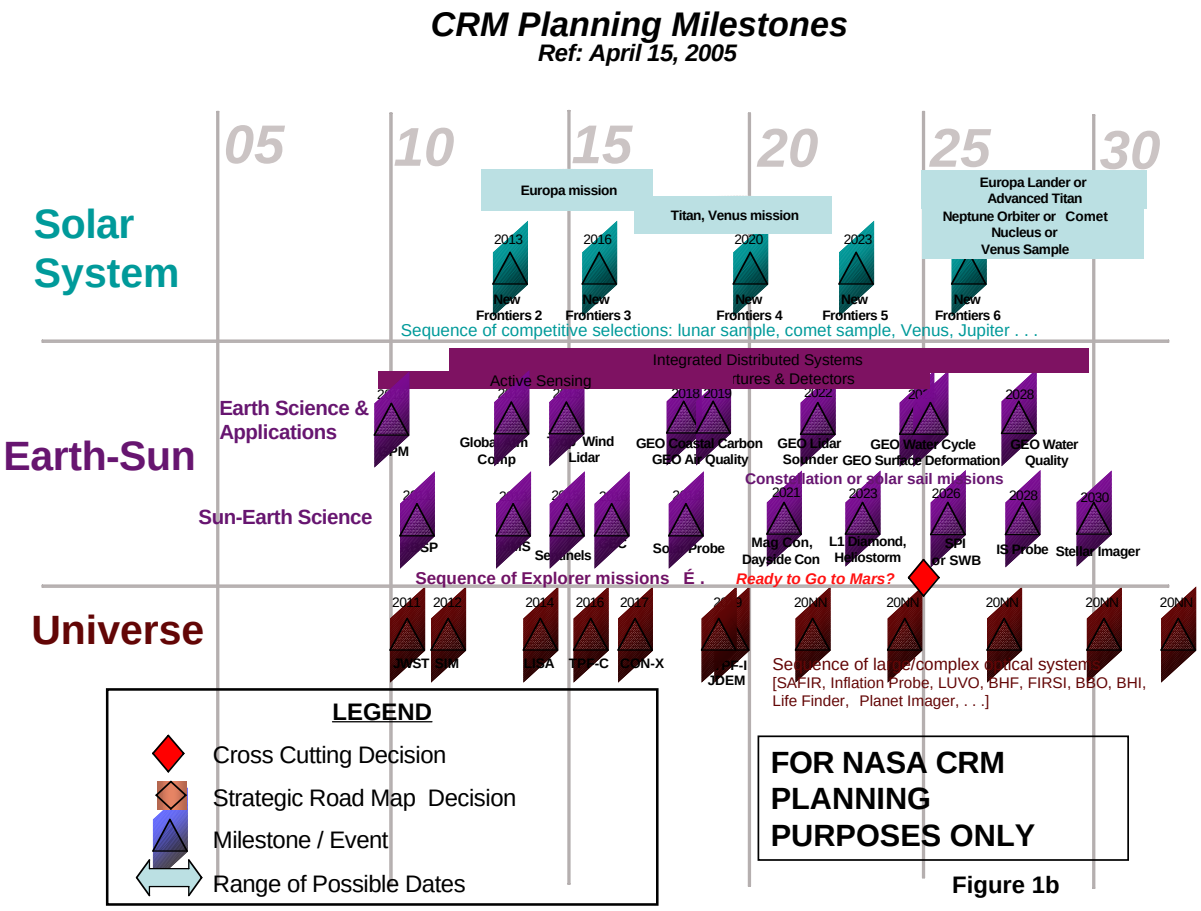

Figure 1.1b. Assumed Capability Roadmap Planning Milestones (continued)

2 Overview of Capability Roadmap Process and Products

This section presents a summary of the process used to develop the sixteen capability roadmaps and their May, 2005 *Executive Summaries*, and the ten *Capability Portfolios* presented here.

2.1 The Technology Capability Portfolio Development Process

From the beginning, the intent of the portfolio development effort was to form a national consensus by involving participants from across the nation. The portfolio teams comprised technical experts from academia, industry, NASA, and other government agencies. Each team was co-chaired by a NASA and non-NASA subject matter expert. The membership comprised approximately of two thirds non-NASA and one third NASA technical experts and leaders: it averaged about 15 people. This structure was meant to ensure a national perspective and mitigate institutional and special interest biases. In November 2004, APIO issued a Request for Information (RFI) and invited the public to participate in a workshop where the authors of the RFI responses could brief the roadmap chairs on their perspectives and ideas. More than 500 white papers were submitted and presented at the workshop.

Throughout the effort, thorough discussions were held regarding the scope and content of each roadmap area. A group of APIO coordinators was asked to identify interfaces and dependencies between the fifteen roadmaps and eliminate duplication or overlap of scope between roadmaps. Coordinators from NASA HQ Mission Directorates ensured that resources were available to the teams and provided management direction and oversight. In particular, for the Science Mission Directorate, senior technologists were polled early in the process to identify gaps or oversights in the content of the relevant technology capability roadmaps.

The teams were chartered to provide the technical knowledge and expertise required to develop the roadmaps and identify the capabilities needed to meet the *Vision*. The capability roadmap teams identified and analyzed technologies and technical challenges, assessed the current state of the art, estimated the development time to achieve the capabilities, and identified key architectural and strategic decisions that would affect the direction of the roadmaps. In addition, NASA leaders of most of the teams that produced the final ten portfolios in this set were asked to estimate the costs to achieve major capabilities identified in their roadmap. These costs were submitted separately to the NASA HQ Directorates.

As the roadmap efforts progressed, several teams coordinated information with relevant strategic roadmap teams in order to aid the development of implementable strategies. To guide and assess independently the roadmap activity, NASA requested that the Aeronautics and Space Engineering Studies Board of the National Academy of Sciences (NAS) provide a two-step evaluation of the capability roadmaps.

The first step was to have a NAS expert panels assess each of the capability roadmaps at an interim state and provide verbal feedback on their progress. As the strategic roadmaps were being developed in parallel with the capability roadmaps, the capability roadmap teams made assumptions about certain aspects of a strategic architecture on which to base their capability development. This

was done with the intention of updating the roadmaps later to reflect the output of the strategic roadmaps. Due to the early termination of the roadmapping process, only this first step was largely completed.

Thirteen of the sixteen roadmap reviews took place during the month of March 2005with the NAS panels providing excellent feedback. The three remaining roadmaps completed their briefing materials. However, termination of the roadmapping effort, as noted above, did not allow for a NAS review of these three. In addition, those roadmaps that were relevant to the Science Mission Directorate (SMD) were critically reviewed internally, both in advance of the NAS presentation and again in the summer, 2005, with the explicit goal of consistency with long-range plans and priorities of this Directorate.

In April 2005, the strategic roadmaps provided interim reports that included key strategies. The missions and milestones provided by the Directorates are shown in Figures 1.1a and 1.1b. These figures were used in the *Roadmap Executive Summaries* for planning purposes to ensure that all sixteen capability roadmap teams were using the same dates and mission assumptions. The teams worked extensively to avoid unnecessary overlap and to identify and ameliorate inconsistencies among the teams. An example of the supporting tools developed by the teams is the capability "crosswalk" in Figure 1.2, intended to show the relationships between roadmaps.

The final integration of the strategic and capability roadmaps was scheduled to occur with the roadmap integration team and architecture synthesis process. Several elements of the capability roadmap products were not completed due to the acceleration of the schedule and termination of the roadmapping effort. These include:

- Identification and assessment of capability gaps that were not included in the original scope of the fifteen roadmaps
- Integration with the strategic roadmaps
- Cost and risk estimates
- Identification of breakthrough technology investment areas
- Infrastructure assessments (i.e. skills, competencies, workforce, and facilities)
- Cross-trades among capabilities

As noted above, subsequent to the termination of the strategic and capability roadmapping process, the SMD authorized the completion of the process and the production of the ten portfolios presented here.

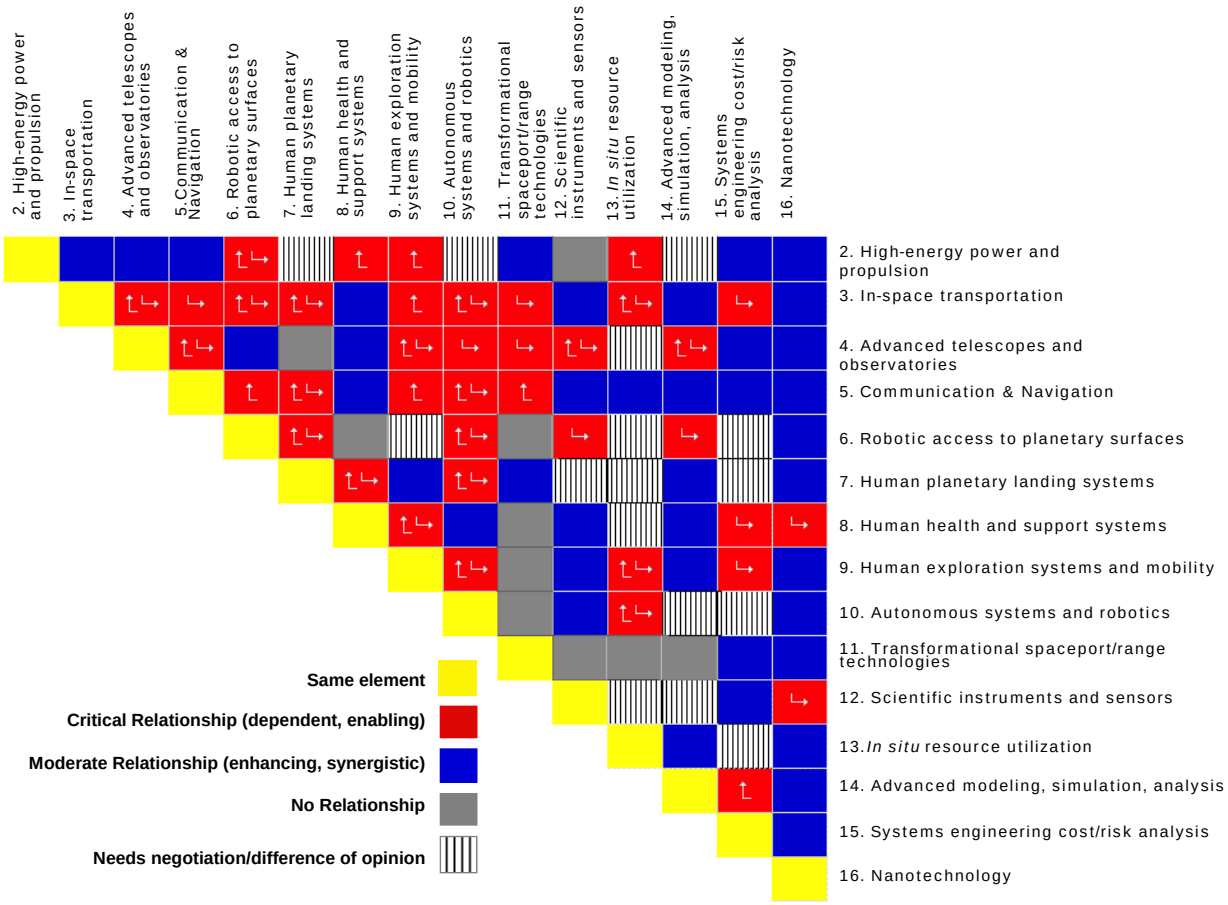

Figure 1.2. Dependency Crosswalk Tool

2.2 Individual Capability Portfolios

The accompanying ten individual capability portfolios include:

- Portfolio description
- Benefits of the capabilities
- Key architecture / Strategic decisions that affect the direction of the capability development
- Major technical challenges
- Major technologies
- Capabilities assessment (capabilities on the roadmap)
- Capabilities scope (Capability Breakdown Structure)
- Capability portfolio development
- Relationships to other portfolios
- Infrastructure assessment

3 Conclusions and Acknowledgements

These documents are the result of a year of hard work and dedication from NASA, industry, other government agencies, and academic experts from across the nation. It provides a summary of the capabilities necessary to execute major elements of the *Vision for Space Exploration*. The May 2005 summary report was provided to the Exploration Systems Architecture Study (ESAS) team for consideration in development of the architecture for the human return to the Moon and investment strategy to support NASA future mission, programs and budget requests. This more extensive material will be submitted to the NASA Directorates and made broadly available.

This work was supported primarily by the Science Mission Directorate (SMD), NASA Headquarters, and was printed at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not constitute or imply its endorsement by the United States Government or the Jet Propulsion Laboratory, California Institute of Technology.

The contribution by SMD to the process was supported by Associate Administrator, Alphonse Diaz. Rita Willcoxon led the original capability roadmap teams, which formed the basis from which the technology capability portfolios were developed. The in-space operations portfolio, was based on work begun at the *Second Loya Jirga* in Boulder, Colorado, in February, 2005. T. J. Feeley contributed significantly to managing the complicated process that produced these final portfolios. Editing and printing of the portfolios were managed by Chris Weaver and Steve Prusha at JPL.

The May, 2005, capability roadmap summaries were led by a team consisting of R. Willcoxon (Chair), D. Coulter, J. Crooke, T. Inman, R. Mueller, V. Regenie, H. Thronson, and G. Varsi.

4 Acronym and Abbreviation List

The following is an exhaustive list in acronyms and abbreviations used through the portfolios.

τ	Transmissivity or Optical Depth
(B)NTP	(Biomodal) Nuclear Thermal Propulsion
A/D	Analog/Digital
ABM	Anomalous Behavior Models
ACE	Advanced Composition Explorer
ACP	Advanced Chemical Propulsion
ACS	Advanced Camera for Surveys, Attitude Control System
ACT	Advanced Compton Telescope
ACTDP	Advanced Cryocooler Technology Development Program
ADBS	Advanced Docking Berthing System
ADM	Atmospheric Dynamics Mission
ADR	Adiabatic Demagnetization Refrigerator
AFL	Astrobiology Field Laboratory
AFM	Atomic Force Microscope
AFRL	Air Force Research Laboratory
AI	Artificial Intelligence
AIRS	Atmospheric Infrared Sounder
ALADIN	Atmospheric Laser Doppler Instrument
AMSA	Advanced Modeling, Simulation and Analysis
AMSD	Advanced Mirror System Demonstrator
AMSU	Advanced Microwave Sounder Unit
APAS	Androgynous Peripheral Attachment System
APIO	Advanced Planning and Integration Office
APL	Applied Physics Laboratory (Johns Hopkins University)
APS	Active Pixel Sensor
AR&C	Autonomous Systems, Robotics and Computing Systems
AR&D	Autonomous Rendezvous and Docking
ARC	Ames Research Center
ASIC	Application-Specific Integrated Circuit
ASR	Autonomous Systems and Robotics
ASTEP	Astrobiology Science and Technology for Exploring Planets
ASTID	Astrobiology Science and Technology Instrument Development
AT	Aeronautical Technologies
ATCS	Active Thermal Control Systems
ATO	Advanced Telescopes and Observatories
AVGS	Advanced Video Guidance Sensor
BATC	Ball Aerospace and Technologies Corporation
BBO	Big Bang Observer Mission
BHFP	Black Hole Finder Probe Mission
BHI	Black Hole Imager
BLIP	Background Limited Infrared Photodetector
BW	Bandwidth
C&DH	Command and Data Handling
C&N	Communications and Navigation
CALIOP	Cloud-Aerosol LIDAR with Orthogonal Polarization
CALIPSO	Cloud-Aerosol LIDAR and Infrared Pathfinder Satellite Observation
CBS	Capability Breakdown Structure
CCD	Charge Coupled Device
CE&R	Concept Exploration and Refinement
CEV	Crew Exploration Vehicle
CEVLVUS	Crew Exploration Vehicle Launch Vehicle Upper Stage
CFC	Carbon Fiber Composite
CFM	Cryogenic Fluid Management
CMB	Cosmic Microwave Background
CMBPoL	Cosmic Microwave Background Polarization Mission
CMB-POL	Cosmic Microwave Background Polarization Mission
CMOS	Complementary Metal Oxide Semiconductor
CNC	Carbon Nanotube Composite
CNT	Carbon Nanotube
Con X	Constellation-X
COTS	Commercial-off-the-Shelf
CRAI	Capability Requirements Analysis and Integration

CRISM	Compact Reconnaissance Imaging Spectrometer for Mars
CRL	Capability Readiness Level
CRL	Critical Readiness Level
CRM	Capability Roadmap
Cryo	Cryogenic
CSSR	Comet Surface Sample Return Mission
CTS	Constellation Transportation System
DART	Demonstration for Autonomous Rendezvous Technology
DASS	Distributed and Advanced Spacecraft Systems
DBF	Digital Beam Formation
DC	Direct Current
DCL	NASA GSFC Detector Characterization Laboratory
DDL	NASA GSFC Detector Development Laboratory
DGB	Disk-Gap-Band
DIaK	Data, Information, and Knowledge
DIMES	Descent Image Motion Estimation System
DMSP	Defense Meteorological Satellite Program
DoD	Department of Defense
DoE	Department of Energy
DRM	Design Reference Mission
DRS	Disturbance Reduction System
DSMS	Deep Space Mission System
DSN	Deep Space Network
DSP	Digital Signal Processor Chip
ECS	External Control System
EDL	Entry, Descent and Landing
EDS	Earth Departure Stage
EDU	Engineering Development Units
EELV	Evolved Expendable Launch Vehicle
EG	Europa Geophysics Mission
EHA	Electrohydrostatic Actuators
EIP	Einstein Inflation Probe Mission
ELV	Expendable Launch Vehicle
EMA	Electromechanical Actuators
EP	Electric Propulsion
ESA	Electronically Scanned Arrays
ESA	European Space Agency
ESAS	Earth Science & Applications from Space
ESMD	Exploration Systems Missions Directorate
ESMF	Earth Science Modeling Framework
ESMR	Electrically Scanning Microwave Radiometer
ESSAC	Earth Science Strategic Advisory Group
ESSP	Earth System Science Program
ESTO	Earth Science Technology Office
ETS	Exploration Transportation System
EUV	Extreme Ultraviolet Spectrometer
EUVE	Extreme Ultraviolet Explorer
EUXO	Extreme Universe X-Ray Observatory
ev	Electron-Volt
EVA	Extravehicular Activity
EXOSAT	European Space Agency's X-Ray Observatory
Far-IR	Far-Infrared
FDIR	Fault Detection, Isolation, and Recovery
FEEP	Thrusters and Field Emission Electric Thrusters
FIDO	Field Integrated Design and Operations
FIR	Far-Infrared
FIRSI	Far-IR Space Interferometer
FIRST	Far Infrared and Submillimeter Telescope Mission
FLOAAT	Function Specific Level of Autonomy and Automation Tool
FOD	Foreign Object Damage
FOM	Figures of Merit
FOV	Field-of-View
FPA	Focal Plane Assembly
FPGA	Field Programmable Gate Array
FSD	Full Scale Development
FTS	Fourier Transform Spectrometer
FUSE	Far Ultraviolet Spectroscopic Explorer
FUV	Far Ultraviolet
FY	Fiscal Year
GaAs	Gallium Arsenide
GEC	Geospace Electrodynamics Connection Mission
Gen X	Generation X Mission
GEO Coastal C	Geo Coastal Carbon Mission
GEO Global Precip	Geo Global Precipitation Mission
GEO	Geostationary Earth Orbit
GEOSAT	Geodetic Satellite Mission
GESTALT	Grid-Based Estimation of Surface Traversability Applied to Local Terrain
GGP	Geo Global Precipitation Mission
GHz	Gigahertz

GLAS	Geoscience Laser Altimetry System
GLAST	Gamma Ray Large Area Space Telescope
GNC,GN&C	Guidance, Navigation and Control
GPHS	General Purpose Heat Source
GPS	Global Positioning System
GPS/GNSS	Global Positioning System/Global Navigation Satellite System
GRACE	Gravity Recovery and Climate Experiment
GRC	Glenn Research Center
GRO	Gamma-Ray Observatory Mission
GSFC	Goddard Space Flight Center
GSM	Global Soil Moisture Mission
GTA	Global Tropospheric Aerosols Mission
HALE	High Altitude Long Endurance
HDTV	High Definition Television
HEO	High Earth Orbit
HEPP	High-Energy Power and Propulsion
HESM	Human Exploration Systems and Mobility
HHSS	Human Health and Support Systems
HIGO	Heliospheric Imager and Galactic Observer
HiRISE	High Resolution Imaging Science Experiment
HOEs	Holographic Optical Elements
HPLS	Human Planetary Landing Systems
HRes CO2	High Resolution CO2
HST	Hubble Space Telescope
HVPS	High Voltage Power Supply
HW	Hardware
HWIL	Hardware in the Loop
I&C	Instrumentation and Control
IAP	Integrated Actuation Package
ICESat	Ice, Cloud, and Land Elevation Satellite
IDL	Interactive Data Language
IEEE	Institute of Electrical and Electronics Engineers
IHS	Inner Heliosphere Sentinels Mission
IMAGE	Imager for Magnetopause-to-Aurora Global Exploration Mission
IMLEO	Initial Mass in Low Earth Orbit
IMUs	Inertial-Measurement Units
INL	Idaho National Laboratory
InSAR	Interferometric Synthetic Aperture Radar
IP	Inflation Probe
IP	Intellectual Property
IPS	Integrated Power Systems
IR	Infrared
IRAC	Infrared Array Camera (HST)
IRS	Infrared Spectrograph
ISHM	Integrated Systems Health Management
ISP	In-Space Propulsion Program
ISP	Interstellar Probe Mission
ISRU	*In Situ* Resource Utilization
ISS	International Space Station
IST	In-Space Transportation
ISTP	In-Space Propulsion Technologies
ITAR	International Traffic in Arms Regulation
ITRS	International Technology Roadmap for Semiconductors
ITSP	Ionosphere/Thermosphere Storm Probes Mission
IVHM	Integrated Vehicle Health Management
IVHM	Integrated Vehicle Health Monitoring
JDEM	Joint Dark Energy Mission
JET-X	Joint European X-Ray Telescope
JHU	Johns Hopkins University
JIMO	Jupiter Icy Moons Orbiter
JPL	Jet Propulsion Laboratory
JPO	Jupiter Polar Orbiter
JPOP	Jupiter Polar Orbiter Probes
JSC	Johnson Space Center
JWST	James Webb Space Telescope
JWST	James Webb Space Telescope
K	Kelvin
KSLOC	Thousands of Source Lines of Code
kW	Kilowatt
L1, L2	Earth Libration Points
LANL	Los Alamos National Laboratory
LASCO	Large Angle and Spectrometric Coronagraph Experiment
LASER	Light Amplification by Stimulated Emission Of Radiation
LENS	Large Energy National Shock Tunnel
LFSM	Low Frequency Soil Moisture
LEO	Low Earth Orbit
LF	Life Finder Mission
LFF InSAR	L-Band Formation Flying InSAR
LHP	Loop Heat Pipe
LIDAR	Light Detection and Ranging

LISA	Laser Interferometer Space Antenna
LITE	Lidar In-Space Technology Experiment
LLO	Low-Lunar Orbit
LM	Lockheed Martin
LOLA	Lunar Orbiter Laser Altimeter
LRO	Lunar Reconnaissance Orbiter
LRU	Line Replaceable Unit
LSSM	Large-Scale Systems Model
LTA	Lighter Than Air
LUVO	Large Aperture Ultraviolet Optical Observatory
LUVO	Large UV/ Optical Telescope
LV	Launch Vehicle
M&S	Models and Simulation
Mag	Magnetometry Mission
Mag Con	Magnetospheric Constellation Mission
MARSIS	Mars Advanced Radar for Subsurface and Ionospheric Sounding
MAXIM	Micro Arcsecond X-Ray Imaging Mission
MC	Magnetospheric Constellation Mission
MBC	Model-Based Contracting
MCM	Multichip Module
MCP	Microchannel Plate
MDAS	Modeling and Data Assimilation System
MDI	Michelson Doppler Imager
MDL	NASA JPL Microdevices Laboratory
MEMS	Micro-Electro-Mechanical Systems
MEO	Medium Earth Orbit
MEPAG	Mars Exploration Program Analysis Group
MER	Mars Exploration Rover
MFL	Mars Foundation Laboratory
MFP	Mean Free Path
MGS	Mars Global Surveyor Mission
MHD	Magnetohydrodynamic
MHRSM	Mars High Resolution Spatial Mapper
MIDP	Mars Instrument Development Program
MIPS	Multiband Imaging Spectrometer for SIRTF
MIRI	Mid Infrared Instrument
MIT	Massachusetts Institute of Technology
mK	milliKelvin
MLA	Mercury Laser Altimeter
MLI	Multilayer Insulation
MLS	Microwave Limb Sounder
MMH	Monomethyl Hydrazine
MMIC	Monolithic Microwave Integrated Circuit
MMOD	Micro-Meteoroid Orbital Debris
MMRTG	Multimission Radioisotope Thermoelectric Generator
MMS	Magnetospheric Multiscale Mission
MMW-NEP	Multimegawatt Nuclear Electric Propulsion
MODIS	Moderate Resolution Imaging Spectroradiometer
MOLA	Mars Orbiter Laser Altimeter
MPS	Main Propulsion System
Mbps	Megabits Per Second
MRO	Mars Reconnaissance Orbiter
MS&A	Modeling, Simulation and Analysis
MSFC	Marshall Space Flight Center
MSR	Mars Sample Return
MSU	Microwave Sounder Unit
MTO	Mars Telecommunication Orbiter
MTP	Mars Technology Program
MTRAP	Magnetic Transition Region Probe
Mux/demux	Multiplexer and Demultiplexer
mW	Milliwatt
NASA	National Aeronautics And Space Administration
NEAR	Near Earth Asteroid Rendezvous - Shoemaker
NEMS	Nimbus E Microwave Spectrometer
NEP	Noise Equivalent Power
NEP	Nuclear Electric Propulsion
NERVA	Nuclear Engine For Rocket Vehicle Applications
NFAC	National Full-Scale Aerodynamics Complex
NIH	National Institutes Of Health
NIRCam	Near Infrared Camera
NIRSpec	Near Infrared Spectrometer
NIST	National Institute of Standards and Technology
NLR	Near Laser Rangefinder
NMP	New Millennium Program
NNI	National Nanotechnology Institute
NO	Neptune Orbiter
NOAA	National Oceanic and Atmospheric Administration
NPOESS	National Polar-orbiting Operational Environment Satellite System
NPP	NPOESS Preparatory Project
NRA	NASA Research Announcement

NRC	National Research Council
NRO	National Reconnaissance Office
NRT	Near-Real-Time
NS	Nuclear Systems
NSBF	National Scientific Balloon Facility
NSCAT	NASA Scatterometer
NSET	Nanotechnology Science, Engineering and Technology
NSF	National Science Foundation
NSI	NASA Standard Initiator
NSTAR	NASA Solar Electric Propulsion Technology Application Readiness
NSTC	National Science and Technology Committee
NTO	Nitrogen Tetroxide
NTP	Nuclear Thermal Propulsion
NTS	Nevada Test Site
NW	Nanowire
OMS	Orbital Maneuvering System
ORNL	Oak Ridge National Laboratory
OSS	Office of Space Science
OSSE	Observing System Simulation Experiment
OSW	Ocean Surface Winds
PAE	Program Analysis and Evaluation
PFF	Precision Formation Flying
PI	Planet Imager Mission
PIDDIP	Planetary Instrument Development and Definition Program
PIE	Post Irradiation Evaluation
PLSS	Personal Life Support System
pm	Picometer
PMAD	Power Management and Distribution
PP	Planetary Protection
ppb	Parts per Billion
PRF	Pulse Repetition Frequency
PTCS	Passive Thermal Control Systems
PTeP	Parallel Telemetry Processor
PV	Photovoltaic
QE	Quantum Efficiency
QGG	Quantum Gravity Gradiometer
QuickScat	NASA Quick Scatterometer
RAM	Reconnection and Microscale Mission
RAPS	Robotic Access to Planetary Surfaces
RAR	Real Aperture Radar
RAT	Rock Abrasion Tool
RBSP	Radiation Belt Storm Probes Mission
REP	Radioisotope Electric Propulsion
RF	Radio Frequency
RHEM	Robotic & Human Exploration of Mars
RHESSI	Ramaty High-Energy Solar Spectrographic Imager
RHLE	Robotic & Human Lunar Exploration
RLEP	Robotic Lunar Exploration Program
rms	Root Mean Square
ROI	Return on Investment
ROSAT	Roentgen Satellite X-ray Observatory
RPS	Radioisotope Power System
RTG	Radioisotope Thermoelectric Generator
S/C	Spacecraft
SACS	Sail Attitude Control System
SAFIR	Single Aperture Far Infrared Observatory Mission
SAR	Synthetic Aperture Radar
SC	Stratospheric Composition Mission
SCAMS	Scanning Microwave Spectrometer
SCAWG	Space Communication Architecture Working Group
SCOPE	Solar Connections Observatory for Planetary Environments Mission
SDO	Space Dynamics Observatory
SDRs	Software Defined Radios
SEC	Sun Earth connection
SECCHI	Sun Earth Connection Coronal and Heliospheric Investigation
SECRA	Systems Engineering Cost/Risk Analysis
SELP	Search For Earth-Like Planets
SEP	Solar Electric Particle, Solar Electric Propulsion
SEU	Structure and Evolution of the Universe
SHDS	Sail Health and Diagnostics System
SI	Stellar Imager
SI&S	Scientific Instruments and Sensors
SiGe	Silicon Germanium
SIM	Space Interferometry Mission
SIR	Shuttle Imaging Radar
SIRTF	Space Infrared Telescope Facility Mission (renamed Spitzer Space Telescope)
SIS	Scientific Instruments and Sensors

SIT	Sea Ice Thickness Mission
SLA	Shuttle Laser Altimeter
SLOC	Source Lines of Code
SMD	Science Mission Directorate
SOA/SOP	State-of-the-Art / State-of-the-Practice
SOFIA	Stratospheric Observatory for Infrared Astronomy
SOHO	Solar and Heliospheric Observatory Mission
SOI	Solar Oscillations Investigation
SOT	Solar Optical Telescope
SP	Solar Probe Mission
SPECS	Submillimeter Probe of The Evolution of Cosmic Structure
SPI	Solar Probe Imager
SPIRIT	Space Infra-Red Interferometer Telescope
SR	Sample Return, Strategic Roadmap
SRG	Stirling Radioisotope Generator
SRI	Space Research Institute
SRM	Strategic Roadmap
SRTM	Shuttle Radar Topography Mission
SS	Space Shuttle
SScAC	Space Science Advisory Group
SSD	Solid State Detector
SSE	Solar System Exploration
SSED	Solar System Exploration Division
SSES	Solar System Exploration Subcommittee
SSM/T	Special Sensor Microwave/Temperature
SSP	Solar Sail Propulsion
SSPA	Solid State Power Amplifiers
SSSC	Sun-Solar System Connection
STEREO	Solar Terrestrial Relations Observatory Mission
STS	Space Transportation System
SW	Software
SWIR	Shortwave Infrared
SWMF	Space Weather Modeling Framework
SXI	Solar X-Ray Imager
T/R	Transmitter/Receiver
TCP	Technology Capability Portfolio
TDI	Time Delay and Integration
TDRSS	Tracking and Data Relay Satellite System
TDT	Transonic Dynamics Tunnel
TES	Thermal Emission Spectrometer (Mars Global Surveyor)
TES	Tropospheric Emission Spectrometer (Aura satellite)
THEMIS	The History of Events and Macroscale Interactions During Substorms
THz	Terahertz
TIMED	Thermosphere Ionosphere Mesosphere Energetics and Dynamics Mission
TIPS	Tera Instruction Per Second
TIROS	Television Infrared Operational Satellite
TOF	Time-of-Flight
TOPEX	Topography Experiment
TPF	Terrestrial Planet Finder
TPF-C	Terrestrial Planet Finder-Coronagraph
TPF-I	Terrestrial Planet Finder-Interferometer
TPS	Thermal Protection System
TRIP	Thermal Radiation and Impact Protection
TRL	Technology Readiness Level
TRMM	Tropical Rainfall Measuring Mission
Tropical ITM	Tropical ITM Coupler Mission
TSR	Transformational Spaceport/Range
TT&C	Tracking Telemetry and Control
TVC	Thrust Vector Control
TVCA	Thrust Vector Control Actuator
TWTAs	Traveling Wave Tube Amplifiers
Tx/Rx	Transmitter/Receiver
UAV	Unmanned Aerial Vehicle
UE	Universe Exploration
UM	Uncertainty Models
UM	University of Michigan
UN	Uranium Nitrate
URETI	University Research, Engineering and Technology Institutes
US	Upper Stage
UV	Ultraviolet
UVO	Ultraviolet/Optical
UW	University of Wisconsin
V&V	Verification and Validation
VAP	Venus Aeronomy Probe
VHF	Very High Frequency
VIMS	Visible and Infrared Mapping Spectrometer
Vis	Visible
VISE	Venus in-situ Experiment, Venus In-situ Exploration

VR	Virtual Reality
VTM	Virtual Testing Model
VV&A	Verification, Validation and Accreditation
WISE	Wide Field Infrared Survey Explorer
WMAP	Wilkinson Microwave Anisotropy Probe
WSFC	Wave Front Sensing and Control
XNAV	X-Ray Pulsar Navigation
XRDF	X-Ray Diffraction Fluorescence Spectrometer
ZBO	Zero Boil-Off