Task Force on Technology Readiness

Evolving Capabilities in CETDP Thrust Areas

Current → 5 years → 10 years → > 15 years

Cross-Enterprise Technology

Roadmap

for

Exploration Of the Solar System

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August 25, 1999

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Technology Roadmaps: Introduction & Background

- Roadmaps are best available forecasts by TAM's based on:
  - Currently understood customer requirements & long range plans
  - Reasonable extrapolation of existing funding levels
  - TAM's commitment to work with customers to infuse new, revolutionary technologies that enable revolutionary missions
- Time frame: technology is demonstrated on earth (not flight qualified), given continued funding and successful infusion to higher TRL focussed program
- To achieve the forecasts will require close coordination by the CETDP and its Enterprise customers, and higher TRL focussed programs, where applicable
- Roadmaps will be continually updated based on customer feedback
- The CETDP will only address an affordable subset of customer needs

Evolving Capabilities in CETDP Thrust Areas

Current	5 years	10 years	> 15 years
Athena-Class Local Rovers; Autonomous Sampling; Science from Multiple Instruments	High Risk Access Multi-Robot Systems (e.g. cliff descent)	Global Area Multi-Asset Robotic Networks for Measurement & Communications	Self-Sustaining, Permanent Robotic Outposts & Deep Space Infrastructures

Surface Systems

Evolving Capabilities in CETDP Thrust Areas

Current	5 years	10 years	> 15 years
Data mining and visualization tools	Autonomous event recognition for STEREO and interferometry	Data fusion of multiple sensors and images into a single coordinated model	Onboard planning, control, and monitoring for interstellar probe

Thinking Space Systems

Evolving Capabilities in CETDP Thrust Areas

Current

Miniature in-situ physical & spectroscopic (TDL, micro Lidar, mass spec) instruments; Simple in-situ chemical instruments; Miniature remote sensing camera-spectrometer

5 years

In-situ sample prep & handle on a chip; In-situ geo-chronology; Surface penetrating mini-radar; Lidar and sub mm sensing of atmospheres; Thermal IR spectrometers; Camera/microscope systems on a chip

10 years

Chemical labs in a teacup; In-situ atomic/isotope analysis; Micro-biological analyses and advanced mass spec on a chip; Miniature radar sounders & mappers

> 15 years

In-situ chem/bio labs on a chip; Physical meterological packages for global planet deployment; Rugged instruments for hostile environments (Venus, Jupiter, Neptune, Kuiper bodies)

Breakthrough Sensors & Instrument Component Technology

Evolving Capabilities in CETDP Thrust Areas

Current	5 years	10 years	> 15 years
Advanced Thermal Protection Systems and Materials; Automated Rendezvous & Docking; Localized Shielding Technology for Space Radiation; Powered Aerobot Concept Designs	Aero-Assist Capability for Entry Speed > 7.3 km/s; Terminal Descent/Propulsion Deceleration Capability; Landing & Hazard Avoidance; Planetary Protection (In-Space)	Balloon technology for Scientific Surveys; Surface Sampling from Airborne Platforms	Aircraft Technology for Surveillance

Atmospheric Systems & In-Space Operations

Evolving Capabilities in CETDP Thrust Areas

Current	5 years	10 years	> 15 years
Proof-of-concept inflatable rovers for planetary surfaces; Long-life thin-film materials for inflatables & solar sails; radiation shielding materials to protect S/C electronics	Inflatable ballutes for aerocapture; advanced thermal protection system materials for planetary entry vehicles; light-weight inflatable solar arrays for SEP solar sail demonstration mission	Large inflatable antenna structures; large solar collectors for non-nuclear power; solar sail structures for low-cost rapid transit; balloon materials for planetary atmospheres; tethers for small body sample return	Highly integrated gossamer S/C with electronics, sensors, and actuators embedded in multi-functional membranes; evolvable gossamer S/C that reconfigure their shape and function in response to changing mission conditions; Laser propelled sails for precursor interstellar exploration missions

Ultra-Lightweight Structures and Space Observatories

Evolving Capabilities in CETDP Thrust Areas

Current	5 years	10 years	> 15 years
Relative 2-vehicle autonomous navigation & guidance in Earth-orbit experiments	Multi-vehicle relative navigation and high-precision formation flying	Autonomous reconfiguration; large angle & displacement formation maneuvers	>100 spacecraft constellations in planetary orbits

Distributed Spacecraft

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Current	5 years	10 years	> 15 years
Capability to cut spacecraft power demands for rad-hard devices for all applications; Ultra-Low-Power, Radiation Tolerant Digital Electronics	µ-subsystems: *In situ* & Distributed Sensors; µ- Nav; µ-Prop; On-chip power; Multi-function structures	µ-spacecraft to do all single and multi S/C missions, surface system missions, and to enable gossamer missions to the edge of the solar system	"Nano", self-repairing spacecraft for missions beyond the solar system; Nano-scale devices and systems

Micro/Nano Sciencecraft

Evolving Capabilities in CETDP Thrust Areas

Current	5 years	10 years	> 15 years
Science requirements set independently from engineering solutions yielding costly missions	Collaborative infrastructure in place to support science and engineering integration; Interactive mission design trades; operability prediction	Concurrent science and engineering performed by globally distributed teams; Immersive distributed collaboration	Concurrent science and engineering performed by globally distributed teams

Next Generation Infrastructure

Evolving Capabilities in CETDP Thrust Areas

Current

Both SCARLETT concentrator solar array and 20 cm ion electric thruster demonstrated in space (Deep Sace 1); 60 w/kg, 100 volt arrays available commercially

5 years

Advanced Stirling converter for the Advanced Radiosotope Power System; 500 volt solar arrays and 2-stage Hall electric thruster

10 years

500 w/kg thin film lightweight arrays; 30 kw ion electric thruster available for interstellar missions

> 15 years

2000 w/kg thin film, lightweight arrays; Megawatt-class plasma electric engines

Advanced Power & On-Board Propulsion