National Aeronautics and Space Administration

GROUND PROCESSING TECHNOLOGIES FOR SPACE FLIGHT CHALLENGES AND OPPORTUNITIES

Ground Systems Architecture Workshop

James Reuther
Director for Strategic Integration
Office of the Chief Technologist
March 3, 2011

Office of Chief Technologist
Roles/Responsibilities

- OCT has six main goals and responsibilities:

1) Principal NASA advisor and advocate on matters concerning Agency-wide technology policy and programs.
2) Up and out advocacy for NASA research and technology programs. Communication and integration with other Agency technology efforts.
3) Direct management of Space Technology program.
4) Coordination of technology investments across the Agency, including the mission-focused investments made by the NASA mission directorates. Perform strategic technology integration.
5) Change culture towards creativity and innovation at NASA Centers, particularly in regard to workforce development.
6) Document/demonstrate/communicate societal impact of NASA technology investments. Lead technology transfer and commercialization opportunities across Agency.

Space Technology: A Different Approach

- **Strategic Guidance**
  - Agency Strategic Plan - Develop Both Push and Pull Technologies
  - Agency Portfolio Prioritized Based On:
    - Space Technology Grand Challenges
    - Space Technology Roadmaps

- **Full Spectrum Of Technology Programs That Provide An Infusion Path To Advance Innovative Ideas From Concept To Flight**

- **Competitive Peer-Review And Selection**
  - Competition Of Ideas Building An Open Community Of Innovators For The Nation

- **Overarching Goal Is To Reposition NASA On The Cutting-Edge**
  - Technical Rigor While Pushing The Boundaries Of Physics
  - Take Informed Risk And If We Fail, We Fail Fast And Learn In The Process
  - Seek Disruptive Innovation Such That With Success The Future Will No Longer Be A Straight Line
  - Foster An Emerging Commercial Space Industry

Space Technology Formulation Principles

Space Technology shall:

- Advance broadly-applicable technology.
- Produce technology products for which there are multiple customers.
- Meet the Nation's needs for new technologies to support future NASA missions in science and exploration, as well as the needs of other government agencies and the Nation's space industry in a manner similar to the way NACA aided the early aeronautics industry.
- Employ a portfolio approach over the Technology Readiness Level spectrum.
- Competitively select research by academia, industry, and the NASA Centers based on merit.
- Leverage the technology investments of our international, other government agency, academic and industrial partners.
- Establish a deliberative panel of internal and external stakeholders, including industry and other government agencies, to review and advise OCT on technology development priorities through a transparent and balanced process.
- Result in new inventions, new capabilities and the creation of a pipeline of innovators trained to serve future National needs.

NASA's New Focus On Technology

New Vision – U.S. Space Policy of 2010

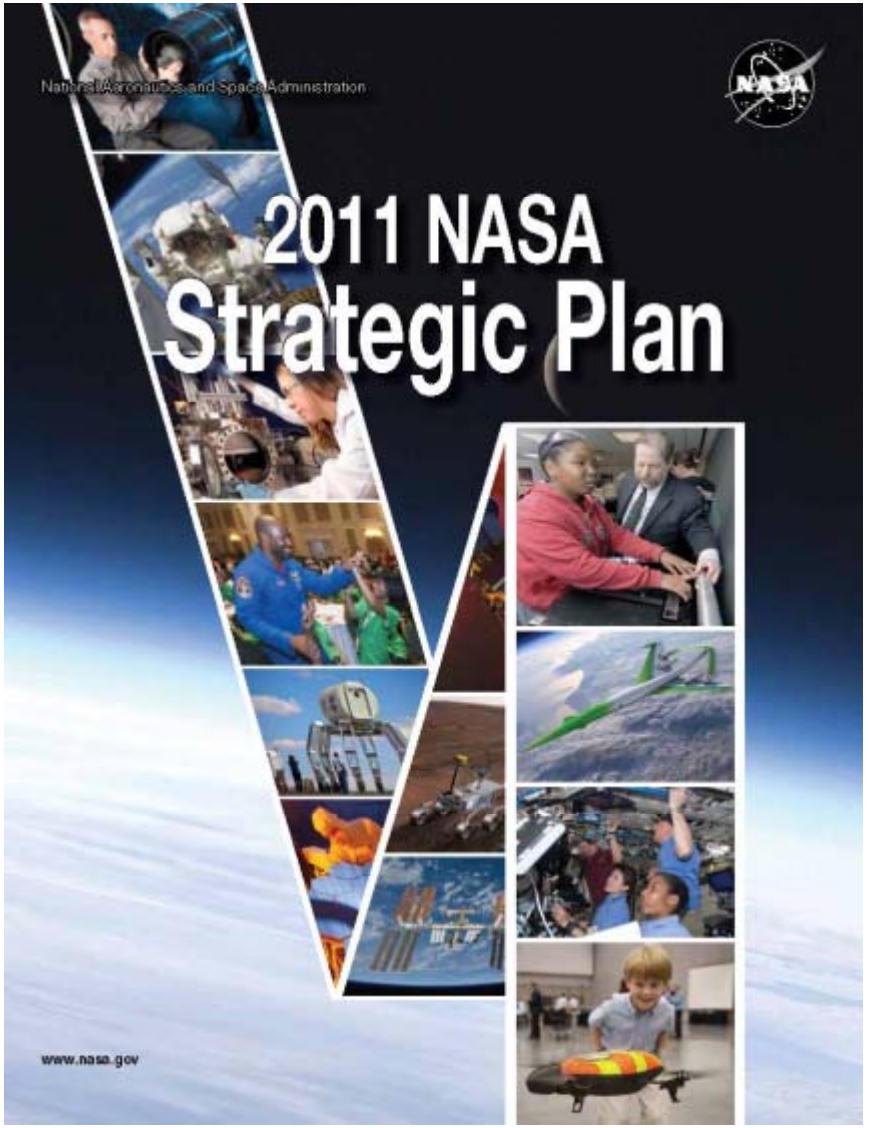
"Implement a ***new space technology development and test program***, working with industry, academia, and international partners to build, fly, and test several key technologies"

New Focus - NASA Authorization Bill of 2010 (Sept 2010)

It is critical that NASA ***maintain an Agency space technology base*** that helps align mission directorate investments and supports long-term needs. This program will complement mission-directorate funded research and support, where appropriate, multiple users. The program shall also seek to partner, building upon its Innovative Partnerships Program and other partnering approaches.

New Plan - NASA Strategic Plan, Feb 2011

Contains a specific Space Technology goal statement with supporting outcomes and objectives: ***"Create the innovative new space technologies for our exploration, science, and economic future."***



NASA Space Technology Grand Challenges

We will prioritize our technology portfolio considering…

Space Technology Grand Challenges, a set of important space-related problems that must be solved to efficiently and economically achieve our missions.

Where's Ground Processing Covered?
Economical Space Access

Why? For NASA operations costs (ground processing) can currently constitute roughly 40% of the total mission costs.

Space Technology Grand Challenges

Expand Human Presence in Space

Economical Space Access

Space Health and Medicine

Telepresence in Space

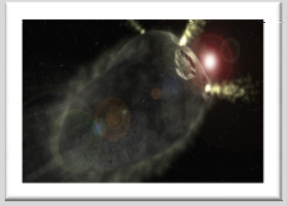
Space Colonization

Manage In-Space Resources

Affordable Abundant Power

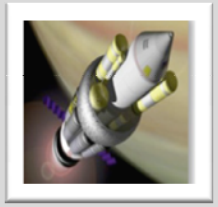
Space Way Station

Space Debris Hazard Mitigation



Near-Earth Object Detection and Mitigation

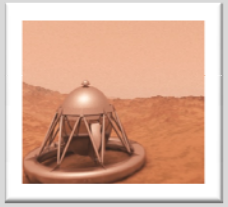
Enable Transformational Space Exploration and Scientific Discovery



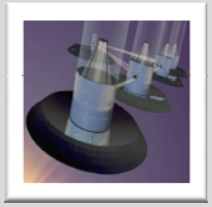
Efficient In-Space Transportation

High-Mass Planetary Surface Access

All Access Mobility



Surviving Extreme Space Environments



New Tools of Discovery

For More Information on the Space Technology Grand Challenges:
http://www.nasa.gov/offices/oct/strategic_integration/grand_challenges_detail.html

NASA Space Technology Roadmap Motivation

- **Historically NASA contributed significantly to the advancement of technologies to meet both NASA missions and fuel the Nation's high tech economy**

- **More recently, funding and strategic guidance for NASA technology programs over the past two decades have endured repeated change cycles**

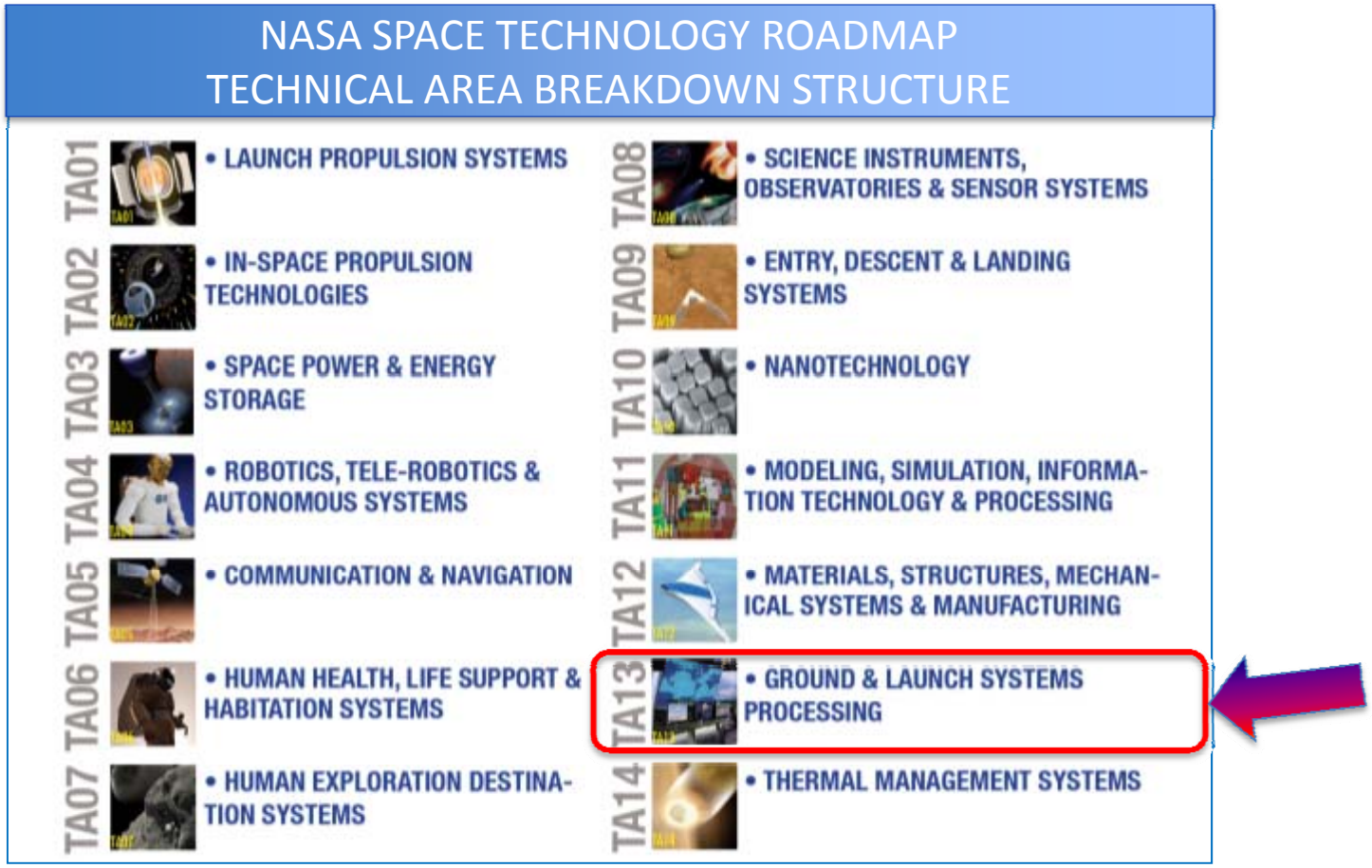
- **In Order for NASA to more effectively and efficiently develop space technologies moving forward, it is necessary to establish a sustained set of clearly identified and prioritized technology development goals**

- **The NASA Space Technology Roadmap, drafted by NASA, and reviewed and vetted for technology investment identification and prioritization by the NRC, will serve NASA as a decadal-like survey, to provide sustained technology investment goals.**

NASA Space Technology Roadmap

We will prioritize our technology portfolio considering…

The NASA Space Technology Roadmap, drafted by NASA, and reviewed and vetted for technology investment identification and prioritization by the National Research Council (NRC), will serve NASA as a decadal-like survey, to provide sustained technology investment goals**.**



For More Information About The Space Technology Roadmaps: http://www.nasa.gov/offices/oct/home/roadmaps/index.html

Technology Area 13:
Ground and Launch System Processing

Includes New Innovations to Improve...

- Mission Integration and Planning
- Mission Training for Both Ground and Flight Crew Personnel

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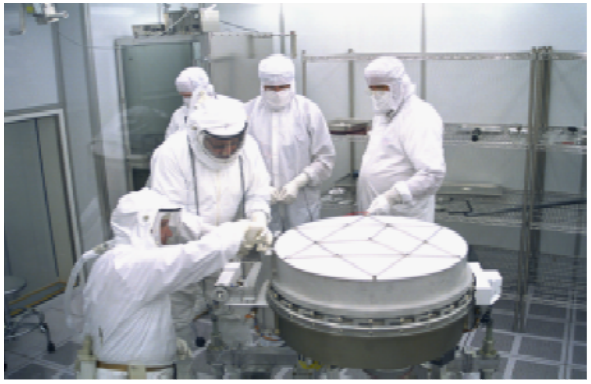



Ground & Launch System Processing Include New Innovations For …




Fabrication, Assembly, Integration And Repair Of Scientific Instruments, Spacecraft, And Launch Vehicles





Technology Area 13:
Ground and Launch System Processing

Includes New Innovations to Improve Activities Such as:

Preparing A Crew For Flight

Technology Area 13: Ground and Launch System Processing

Includes New Innovations to Address Improvements in Activities Such as:

Hardware Transportation

Range Safety Operations

Contingency Planning And Operations

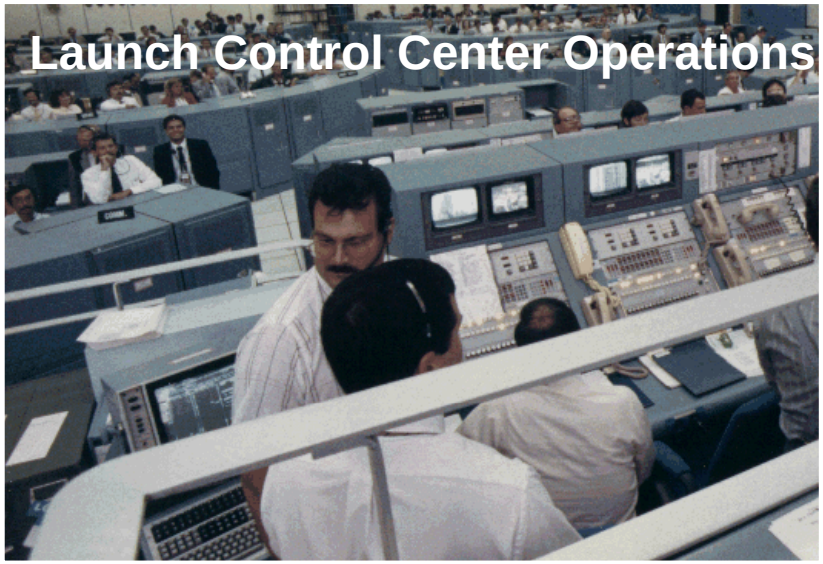
Launch And Landing Weather Analysis

Technology Area 13: Ground and Launch System Processing

Includes New Innovations to Improve and Streamline Activities Such as:

- Launch Control Center Operations
- Communications & Problem Resolution
- Telemetry
- Mission Control Center Operations, Command Processing, and Archiving

Mission Control Center Operations



Technology Area 13:
Ground and Launch System Processing Activities

Includes New Innovations to Address Challenges in Activities Such as …

Environmental Impact Mitigations For Ground and Launch Operations

Technology Area Overview

- **HIGH RECURRING COSTS**. . . are the bane of our nation's Space Program. . . and significantly and negatively impact our ability to fulfill NASA's mission

NASA STS Budget - FY09 Actual = $2,979.5M		
Flight Hardware ($M)	$1,483.60	50%
Flight and Ground Operations ($M)	$1,037.40	35%
Ground Systems and Infrastructure ($M)	$458.50	15%

Representative Cost Breakdown of Human Space Flight – **Nearly a 50/50 split** between Flight HW and Flight/Ground Operations and Infrastructure. . .

Nearly $3B for five missions (STS-126, STS-119, STS-125, STS-127 and STS-128), with an aggregate "Ground Operations Cost Ratio" (GOCR)" across US Space ventures of 40 percent

- **Current Ground Systems and Infrastructure account for 40% to Total Launch Costs**
- **The goal is to reduce the Ground Systems and Infrastructure Costs to 16%**

Technology Area Overview

- **What are the challenges and cost drivers in our current Ground and Mission operations?**
  - Dated, Vehicle-unique infrastructure
  - Labor intensive operations (“The standing army”)
  - Proliferation of duplicative systems
  - Lack of sufficient insight into system configuration/ system performance margins
  - Low mission availability due to weather restrictions and significant maintenance/ refurbishment required between missions
  - Conservative risk and safety postures

Technology Area 13:
Ground and Launch System Processing

Problem: Corrosion is a “silent killer” of the world’s critical infrastructure and costs the world economy over $2 trillion annually.

Corrosion of reinforcing steel in concrete is an insidious problem facing NASA, government agencies, and the general public. These problems include structures, highway and bridge infrastructures, and buildings.

Liquid Applied Coatings
Prevent Corrosion

Solution: Liquid Applied Coatings for Protection of Steel in Concrete

This liquid galvanic coating technology developed by NASA is applied to the outer surface of reinforced concrete to protect the embedded rebar from corrosion (most rebar corrosion prevention must be applied directly to rebar). The coating contains one of several types of metallic particles—magnesium, zinc, or indium—and can be applied with a conventional brush or sprayer.

–The liquid galvanic coating technology developed by NASA has been successfully licensed to Cortec Corporation and Surtreat Holding LLC.

–Cortec conducted trials in 2004 and 2005 in Australia, France, and the United States. Cortec has developed a new phase-3 coating, which the company believes improves the potential of the original technology.

–Surtreat installed the Liquid Galvanic Coating System at the U.S. Army NaHa Port, Okinawa, Japan in May 2007.

Technology Area 13:
Ground and Launch System Processing

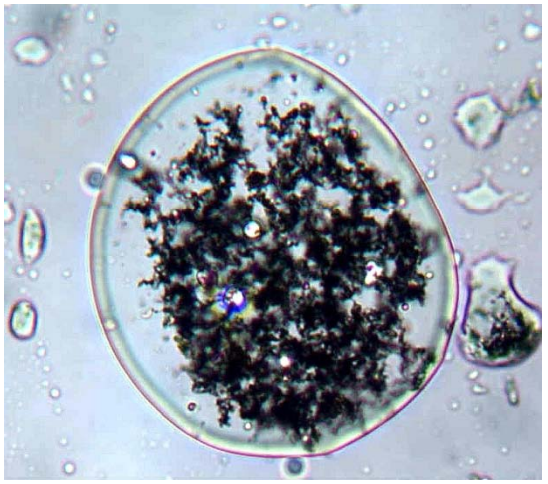
Problem: Pollutants caused by ground processing

Solution: Emulsified Zero Valent Iron (EZVI)

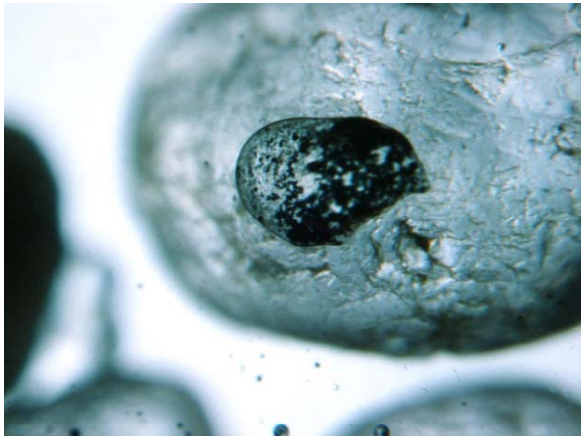
NASA collaborated with the University of Central Florida and GeoSyntec Consutants, Inc. to develop EZVI, a groundwater treatment system designed to eliminate chlorinated solvent pollution in impacted aquifers. EZVI encapsulates nano-scale or micro-scale iron particles in a water-in-oil emulsion. Both the water and iron particles react with the contaminants that naturally diffuse into the emulsion droplet's interior, rendering them non-toxic.

EZVI was successfully developed and tested under NASA's Small Business Technology Transfer Program, and subsequently patented by NASA and licensed for commercial use throughout the US. To date, EZVI has been deployed in over sixteen US States as well as at one location in France and Japan. A US industrial site was successfully removed from the US Superfund National Priority List within one year after the application of EZVI.

NASA's Government Invention of the Year and Commercial Invention of the Year Awards for 2005



EZVI droplet showing micro-scale iron in interior of water-in-oil emulsion droplet



EZVI droplet on an individual sand grain

Technology Area 13:
Ground and Launch System Processing

Problem: Planning and scheduling for complex, multifaceted operations.

Solution: Ground Processing Scheduling System (GPSS)

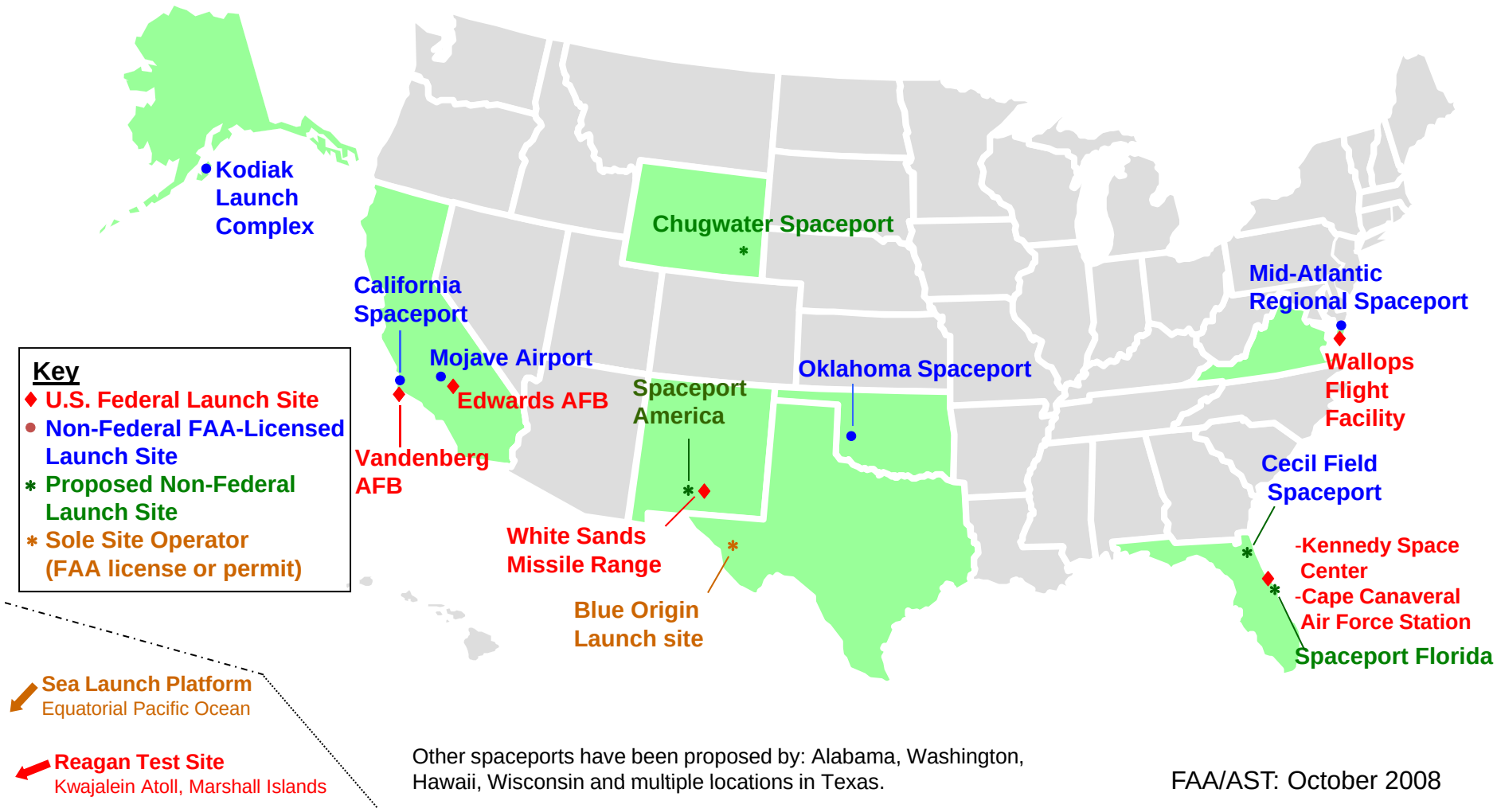
The Ground Processing Scheduling System (GPSS) software, originated at Ames, is another successful transfer from aerospace to commercial markets. Mr. Monte Zweben, a former deputy branch chief, designed and developed several planning and scheduling systems, including a software system for complex, multifaceted operations known as the Gerry scheduling engine.

Since Space Shuttle flow managers at Kennedy Space Center needed a more efficient scheduling system, Kennedy brought Ames, Lockheed Space Operations Company, and Lockheed Missiles and Space Company together to transfer the technology of the Gerry scheduling engine to the Space Shuttle program.

The GPSS successfully became the accepted general purpose scheduling tool for operations. The system was also adopted for scheduling Space Shuttle orbiter refurbishing, saving NASA about $4 million annually.

Red Pepper Software Company, founded by former NASA employee Monte Zweben, commercialized Ames' Ground Processing Scheduling System software.

Technologies to Support Both Commercial and Government Active and Proposed Launch Sites

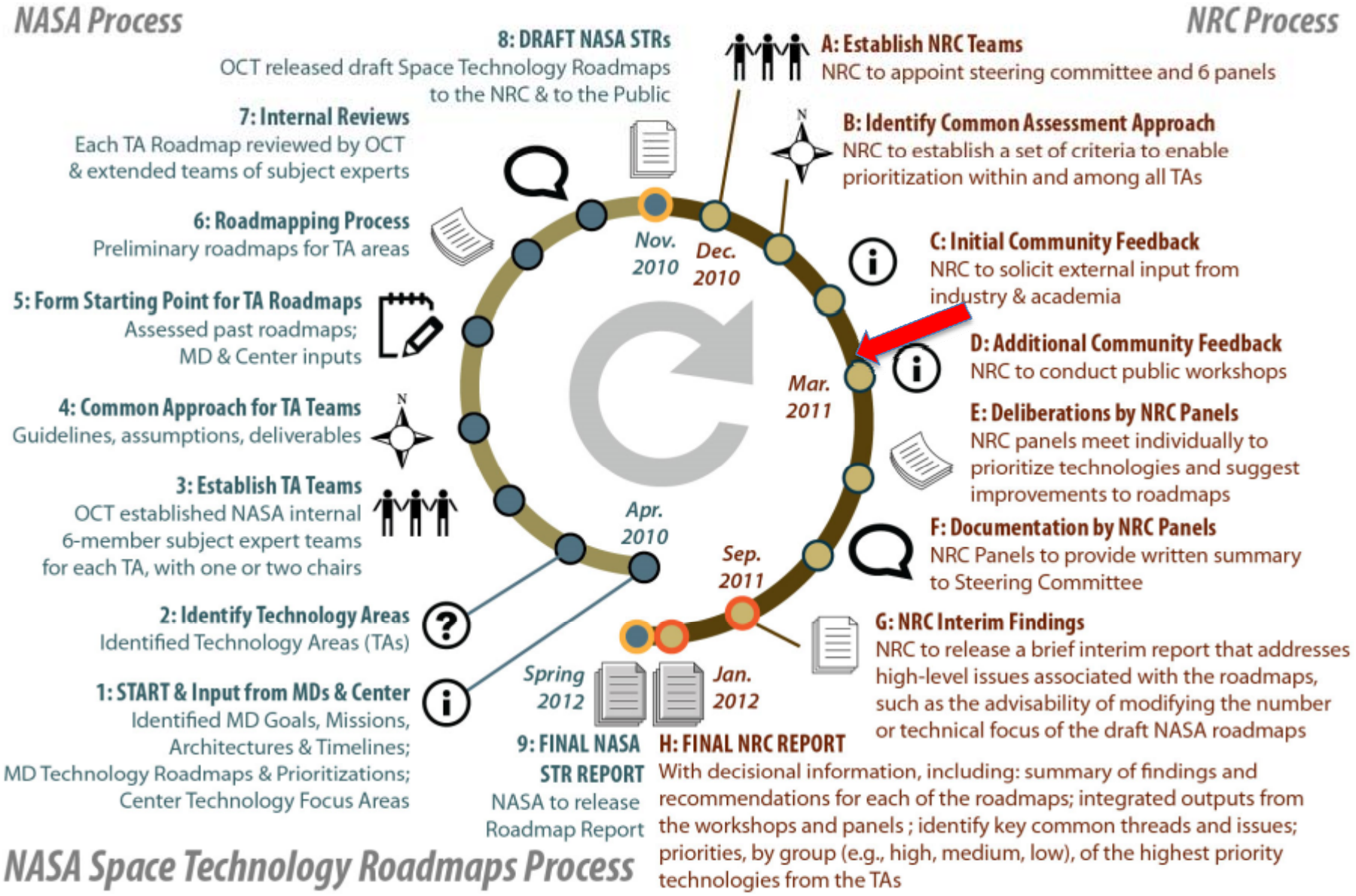


Other spaceports have been proposed by: Alabama, Washington, Hawaii, Wisconsin and multiple locations in Texas.

FAA/AST: October 2008

Technology Development To Support All Launch Sites and Mission Control Rooms

Space Technology Roadmap Development Process – You Can Participate!



Opportunities:
NASA Innovative Advanced Concepts (NIAC)

Managed at NASA Headquarters

Studies exploring future space missions

Involve industry, academia & NASA to revolutionize space access, operations & utilization

Objective: NIAC is focused on early studies of visionary, long-term concepts

- Aerospace architecture, system, or mission concepts (TRL 1-2, 10+ years from application)
- OCT is re-establishing this effort as the *NASA Innovative Advanced Concepts* program
  - Guided by NRC findings and recommendations*
  - Run internally from HQ, and allowing internal NASA/JPL participation

Acquisition Strategy

- **Phase 1:** Examine the overall viability of an innovative system or concept
- **Phase 2:** Study major feasibility aspects (cost, performance, development time, key issues) and potential infusion path; competitively selected from successful Phase I
- Selections will be based on independent peer review of all qualified proposals; competition of ideas

*NRC report, Fostering Visions for the Future: A Review of the NASA Institute for Advanced Concepts, 2009

Awards

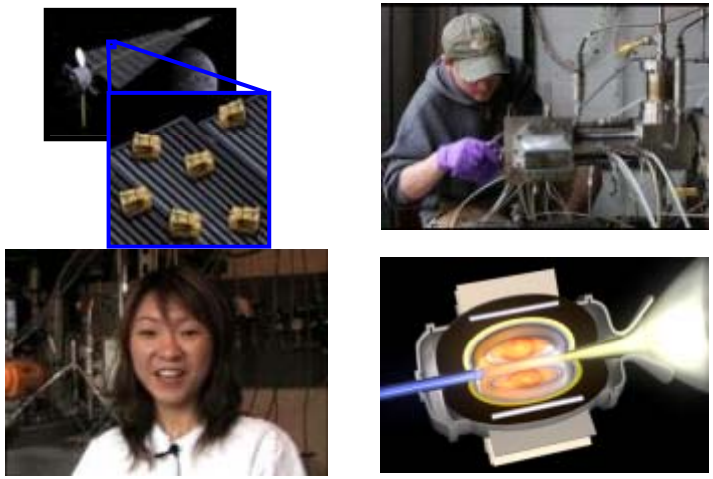
- **Phase 1**: Up to 1 year, $100K; 15-20 per year
- **Phase 2**: up to 2 years, $500K; 3-8 per year

Collaboration

- Proposals welcome from all sources, including academia, industry, all US government agencies (including NASA and JPL), and partnerships.

Opportunities:
Space Technology Research Grants and Fellowships

Level II Program Office: GRC



Objective: Accelerate the development of push technologies through innovative projects with high risk/high payoff

- **Grants:** Low TRL technology portfolio for foundational research in advanced space systems; *Space Technology equivalent to ARMD Fundamental Aeronautics Program.*
- **Fellowships:** Competitive selection of U.S Citizen / permanent resident graduate student that shows promise for future application toward NASA missions and strategic goals

Acquisition Strategy

- **Grants**: NRA calls anticipated once or twice annually
- **Fellowships:** Selected candidates will perform graduate student research on their respective campuses, at NASA Centers and not-for-profit Research and Development (R&D) labs. Each student matched with a technically relevant and community engaged researcher who will serve as the student's professional advisor.

Awards

- **Grants**: Typical 12 months awards at $250K. 100+ per year
- **Fellowships:** Building up to 500 active students per year.

Collaboration

- **Grants:** Academia, not-for-profit R&D labs & NASA Centers lead proposals; others team.
- **Fellowships:** Strong collaboration is anticipated between NASA Centers/R&D Labs & Academia

Opportunities: Centennial Challenges

Level II Program Office: MSFC

Since 2005, 19 competitions held in six Challenge areas, $4.5M in prizes awarded to 13 different teams

Objective: Seek innovative solutions to technical problems that can drive progress in aerospace technology of value to NASA's missions in space operations, science, exploration and aeronautics.

- Opportunity for direct public participation in NASA's research and development efforts with cash prizes as incentives
- Achieve breakthrough tech development via prizes & non-traditional aerospace

Acquisition Strategy

- In selecting topics for prize competitions, NASA consults widely within and outside of the Federal Government.
- Awards are only made for successful demonstrations of design solutions
- NASA provides the Prize Purse and the competitions are managed at no cost to NASA by external non-profit organizations.

Awards

- Typical Prize amount is $1-5M
- 100% of funds identified is for prizes. No funding for labor or travel
- FY 2011 PBR will allow NASA to pursue new and more ambitious prize competitions.

Collaboration

- Proposals welcome from the public for participation in NASA's research and development efforts .

http://www.nasa.gov/offices/ipp/innovation_incubator/centennial_challenges/index.html

Opportunities: Small Business Innovation Research (SBIR) and Small Business Technology Transfer Research (STTR)

Level II Program Office: ARC

2009 NASA SBIR grant for an advanced Lunar Surface Navigation system

Inflatable Technology to develop a rigidized thin film antenna for large aperture ground-based antenna; i.e. lunar ground station

Objective: To engage and provide opportunity to small businesses to participate in Federal Research activities and encourage cooperative research and development with non-profit research institutions, such as a university; with a primary objective of developing and facilitating the transfer of technology from research institutions through the entrepreneurship of small business contracts that result in technology to meet NASA's needs.

- Provide opportunities to participate in Federal Research activities
- Encourage cooperative research and development with non-profit research institutions

Acquisition Strategy

- Current Authorization provides for SBIR funding at a minimum of 2.5 percent of NASA's extramural research and development expenditures
- Modeled after SBIR, STTR is a separately funded activity; with funding set at a minimum of 0.3 percent of extramural research and development expenditures

Awards

- **Phase 1**: Up to 400 awards per year
- **Phase 2**: Up to 200 awards per year

Collaboration

- Proposals welcome from small business concerns, in partnership with non-profit research institutions; such as a university.
- The percentage of new firms participating in NASA's SBIR/STTR programs each year has been in the 30-50% range, yielding new applicants each year. New participants have submitted between 20-35% of the total number of proposals in any given year.

http://sbir.gsfc.nasa.gov/SBIR/SBIR.html

Opportunities:
Center Innovation Fund

Managed at each NASA Center

Objective

To stimulate and encourage creativity and innovation within the NASA Centers. The activities are envisioned to fall within the scope of NASA Space Technology or technology addressing a significant National need.

Acquisition Strategy

- Through the Center Chief Technologist, Centers will conduct competitions to select ideas/projects and provide appropriate oversight. Detailed feedback on these activities will be required before the end of each FY.
- Center activities will be scored and will affect funding distribution in subsequent years

Awards

- The funds will be distributed among the ten NASA centers to allow Centers to support low TRL innovative technology initiatives that leverage Center talent and capability.

Collaboration

- Partners will be sought out by the Centers for the pursuit of innovation that is of common interest to leverage these resources
- Partners will include other NASA Centers, private sector firms, universities, other government agencies and FFRDCs.

Opportunities:
Game Changing Development

Level II Program Office: LaRC

Objective: Solicit innovative ideas enabling new capabilities or radically altering current approaches to launch, build, and operate space systems.

- Matures technologies through the mid-TRL regime to enable useful game changing capabilities for scientific discovery, and human and robotic exploration
- Projects are intended to be capability-oriented and to move ideas from discovery to use.
- GCD emulates the outcomes of the DARPA approach at technology development
- Guided by NRC's Findings and Recommendations*

Acquisition Strategy

- Concept Studies will be competed to flesh out idea(s), quantify their challenges and identify approaches to overcome them
- A subject matter expert Project Manager (PM) may recommend the idea for a new project start. If *game changing,* the Chief Technologist may authorize the PM to release a BAA
  - The BAA asks for many ideas to achieve the project goals from the community. The PM and a committee of experts assess and award multiple elements per project.

* NRC report, America's Future in Space, 2009

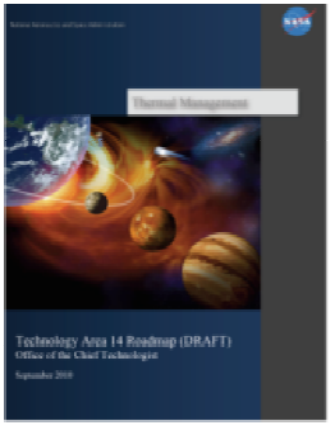
Awards

- **Concept Studies**: $300K-$500K; ~120/year (~60 in FY11)
- **Small Projects**: 2 - 3 years, ~$3M/year; ~12 new project starts/ year (~6 in FY11)
- **Large Projects**: 2 - 3 years, ~$12M/year; ~12 new project starts/ year (~6 in FY11)

Collaboration

- Teams will include Govt Agencies, academia and industry.

Conclusion



- NASA Has A New Vision, Focus, And Plan For Technology Development
- NASA Recognizes The Significance Of Ground And Launch Processing And The Technical Challenges It Poses
- The National Research Council Is Collecting Input From Industry, Academia And The Public – **You Can Provide Input and Shape the Future** of Technology Development In This Important Area
- NASA Has Many Opportunities For Technology Development **For Your Participation**:
  - Technology Fellowships
  - Space Technology Research Grants
  - Centennial Challenges
  - SBIR/STTR Research and Technology Development Projects
  - NASA Innovative Advance Concepts
  - Multiple Solicitations – Some Announcements in 2011!

The Greatest Opportunity

In addition to making ground and launch processing more economical thereby enabling more exploration and scientific missions…. **Your participation** can help generate new industries and spin-off applications and help us develop a cadre of new technology-savvy innovators to fuel the Nation's high-tech economy.