Office of Chief Technologist
Game Changing Development Program

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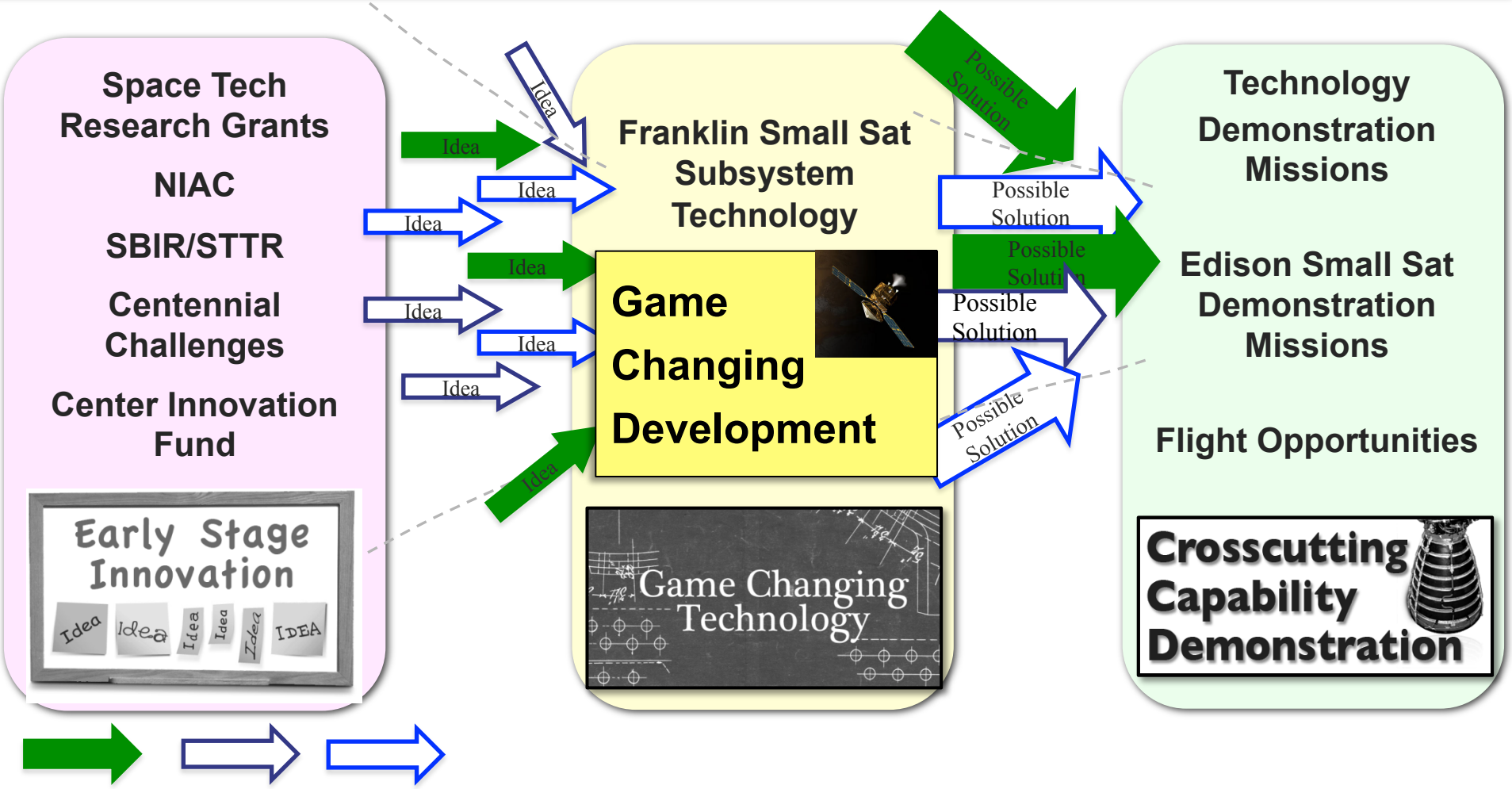
NAC Technology and Innovation Committee

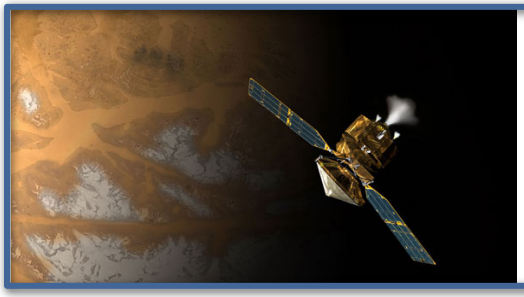
Outline

- New Program Introduction
- A Different Approach at NASA R&T Management
- An Open, Peer Review-Centered Program Development Process
- Accelerated Start Projects Set the Tone for the New Program
  - '*New* Accelerated *Projects*' (3)
  - Joint NASA-DARPA *Concept Studies* (3)
- Initial Interest Derived from Recent Request for Information
- Concluding Remarks

OCT Program Overview



Game Changing Development (GCD) Program

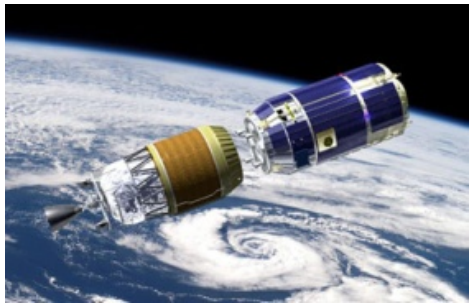


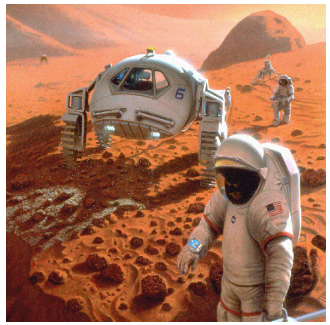
GCD matures technologies through the mid-TRL regime to enable useful game changing capabilities for scientific discovery, and human and robotic exploration

- *Projects are **capability**-oriented*
  - *Will ID **supporting technologies** from targeted capabilities*
- *Investments are in **Game Changing/Disruptive** capabilities*
- *Strong emphasis placed on **infusion** for mission or commercial **applications***
- *GCD **emulates** the outcomes of the **DARPA approach** at technology development*

A Different Approach at NASA R&T Management

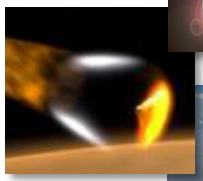
- Program focused by strategically defined Grand Challenges
- Projects and projects' content are selected based on competition
- Peers engaged in selections and reviews
  - *NASA Chief Technologist is selection official*
- Of limited duration (2yrs nom., 3yrs max.), with defined start and end
  - *Completion conditional on passing critical gates, at least yearly*
- Project Manager has full authority, and responsibility
  - *Project implementation tailored to specific project*
  - *Project Manager is on a term/temp appointment*



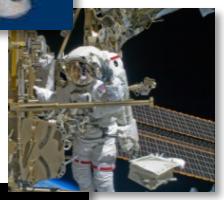


Space Technology Grand Challenges

Make space part of humanity's natural environment…



Achieve economical, on-demand space access



Enable in-space commercial/ marketable services

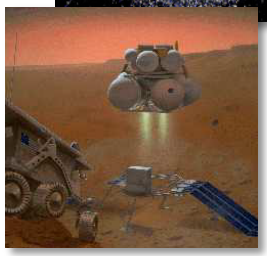
Improve spacecraft safety and protect astronaut health

Fully understand climate change and natural disasters

…manage space as a natural resource…

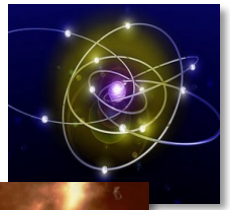
Portable and economical energy on demand

Understand and manage the near-Earth environment

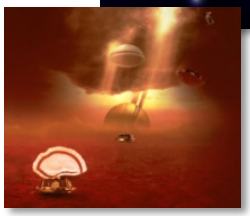


Invent tools of exploration that exploit in-situ resources

…and blaze our trail into the universe.



Understand laws of the universe



Discover Earth–like worlds and life beyond Earth

Enable publically accessible virtual presence and exploration

Where will **your** ideas take us?

What challenges will **you** add to this list?

GCD Process Elements

Program Office at *Langley Research Center*
Directorate Office at *NASA HQ*

- **Competitions** for "*Concept Studies" NRAs and New Project BAAs* will be open to NASA Centers, other government agencies, academia, and industry; teaming is encouraged.
- **Concept Studies** will be competed (through NRAs) to flesh out the details of ideas/ concepts, assess their feasibility, quantify their challenges and identify approaches to overcome them. (**Results made public)**
- **GCD Project Managers** (PMs) will periodically be approved to define *New Projects* based on Concept Studies, but also on inputs from Early Stage Innovation and other sources.
- **New Project Solicitations** will ask (through BAAs) for as many ideas on how to achieve the project goals as the community might envision, rather than ask for bids on a single, predetermined approach. In most projects, multiple performing teams will work in parallel to mature the technologies according to the project plan.
- **Awards:** Each year, the Program will award both *Concept Studies* lasting generally 6 months and *New Projects* lasting for 2 to 3 years under the direction of a PM.

GCD Process, Steady State

~20-30 new ideas every 6 months

Concept Studies

Early Stage Ideas

New Idea NRA

- 6 Month Calls
- Challenge Goals
- Competitive Selection

Ideas from Industry, Universities, Entrepreneurs, and Government

TRL 3

Contracts

Concept Studies

- 6 month duration
- Define Feasibility

+

- *Early Stage Innovations*
- *Advanced Research Projects*
- *... other sources*

~5-8 new projects every 6 months

Project Formulation

NASA Chief Technologist

- Selects New PM Led Projects
- Authorizes New Project BAA
- Source Selection for Performing Teams

Project Manager/GCDPO

- New Project Formulation
- "Go/Stop" metrics
- Manage approved projects

~several activities for each project

Project Execution

New Project BAA Release

- PM team evaluates responses
- Competitive selection of multiple performing teams
- 4-8 months to let contracts

Contracts

Project Execution

- 2 years with 1 year option
- Frequent informal reviews
- Not one-size-fits-all
- High risk: ~40% end early

TRL 5/6

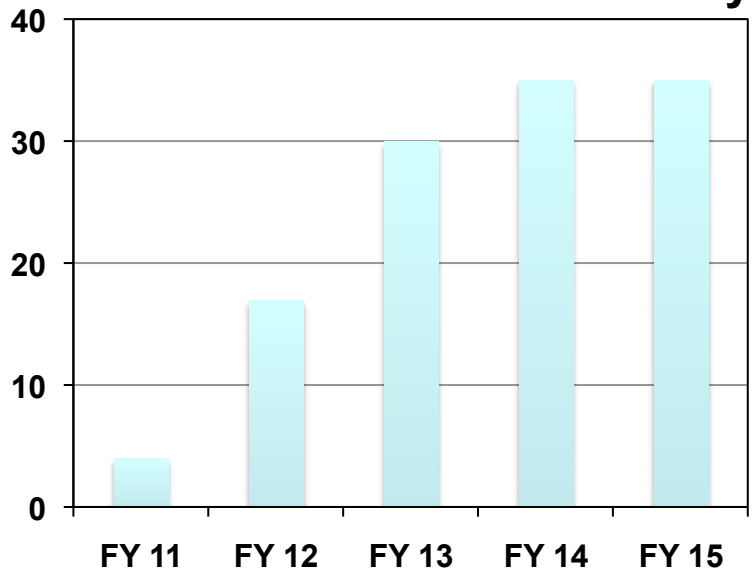
New Capability, Supporting Technologies Ready for Flight Demonstration

Initial Resources

For FY 11, expect up to:

- 15-20 concept studies
  - ~$300-500K/study
- 3-5 new projects
  - small projects ~ $3M/yr
  - large projects ~ $12M/yr
- *several activities per project*

Projects running simultaneously



For FY 12+, expect up to:

- 40-60 concept studies each year
- 10-16 new projects each year
- *several activities per project*

6 Accelerated Tasks

New Projects

- Hypersonic Inflatable Aerodynamic Decelerator (HIAD)
- Nano Energetics Propulsion Project (NEPP)
- Composite Cryotank Technologies and Demonstration Project (CCTD)

Concept Studies

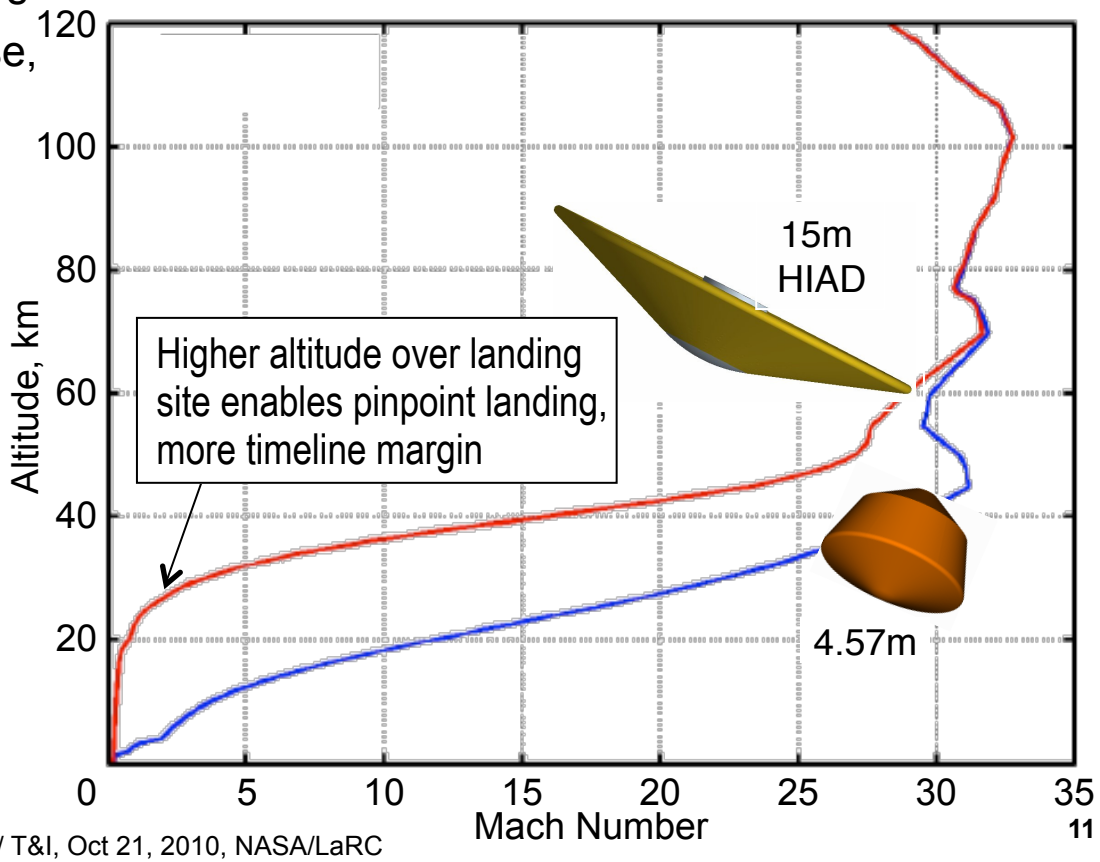
- Beamed Energy Propulsion Study (BEPS)
- Horizontal Launch Study
- Manned GEO Satellite Servicing Study

Motivation for Inflatable Aerodynamic Decelerators (IADs)

Science payload size and site altitude are limited by Viking EDL architecture

- Current entry systems are limited in physical size by launch vehicle shroud diameters.
- At Mars in particular, the thin atmosphere makes it difficult to decelerate large masses and limits the surface altitudes that can be reached

- Inflatable Aerodynamic Decelerators are stowed during launch and cruise,
  - » enables cruise science
- After inflation, IADs behave
  - – like rigid devices (aerodynamics are scalable), but are lighter,
  - – increasing delivered payload.
- IADs decelerate at high altitudes
  - – reducing heating and
  - – increasing timeline margins for
    - » smaller footprints
    - » & access to higher altitudes



Objective and Status for Hypersonic Inflatable Aerodynamic Decelerators (HIADs)

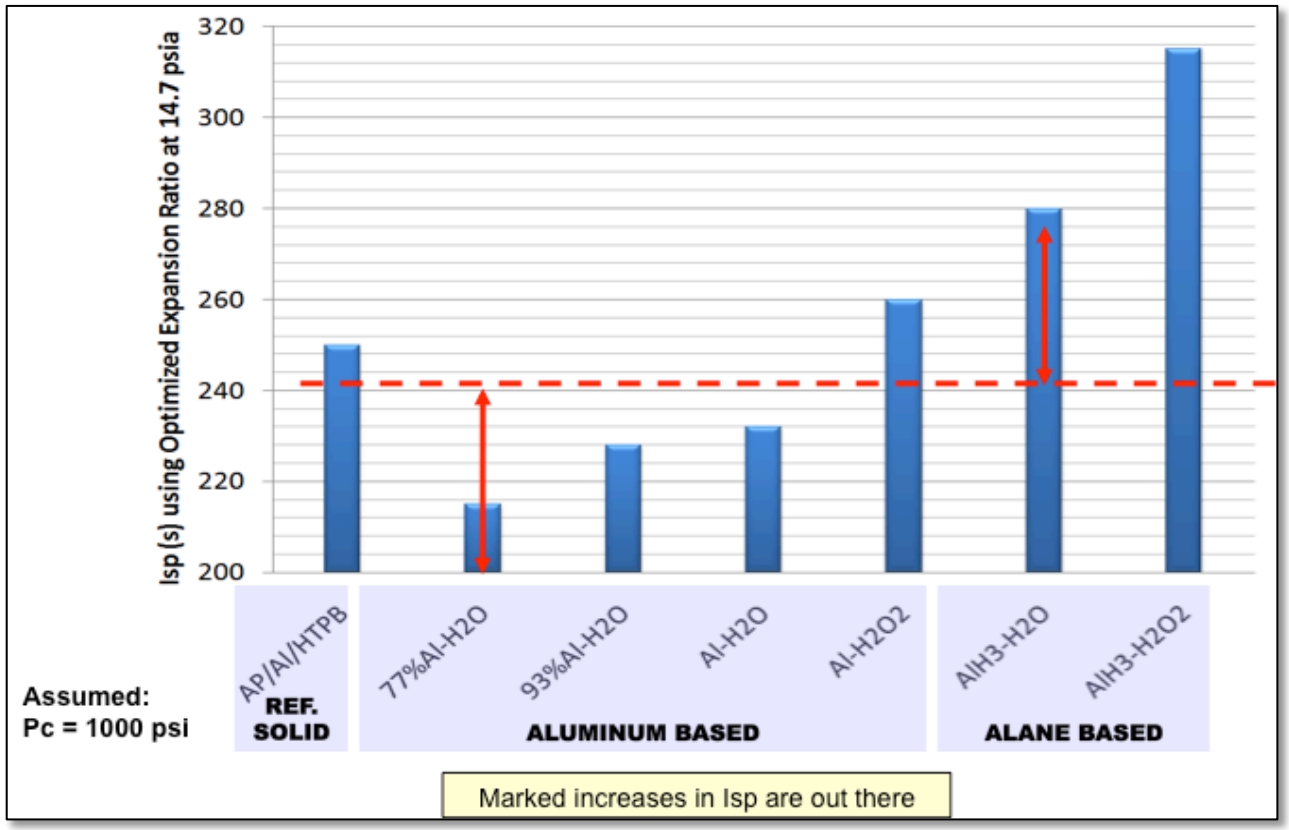
- **Objectives: Mature the necessary systems for 8-15 meter diameter HIAD**
  - Relevant to a broad range of SOMD, ESMD, and SMD missions (e.g. ISS down mass, Mars robotic, Exploration robotic precursors, NEO exploration)
  - Maximize use of cost-effective flight demonstrations including cost-sharing platforms

- **Status: Draft plan developed building on prior ARMD investments**
  - Development and qualification plans for the thermal protection system technologies
  - Flight experiments to demonstrate
    - Performance of Thermal Protection systems in relevant heating environments.
    - Guidance and control approaches.
  - Development of relevant-scale structural concepts.
  - Development of relevant-scale system demonstration concepts for a range of applications
  - *Project reviewed 5 Oct by Chief Technologist*

Motivation for Nano Energetics Propulsion

- **Motivation: Early investigations of incorporating nano-scale materials (i.e. aluminum, nickel, diamond etc.) into propellant chemistries show the potential for improved launch vehicle performance**
  - Increases in burn rates, flame temperatures, and density Isp,
  - Improved combustion efficiency and engine stability, and
  - Reduced ignition energy

Example
Theoretical Performance
Solids-Al and AlH_3



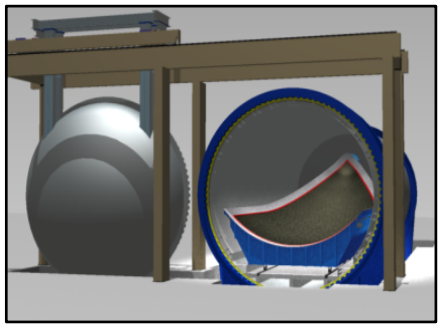
Status for Nano Energetics Propulsion

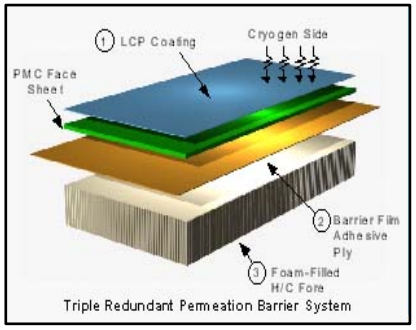
Objectives: Investigate and develop the potential benefits of nano-propellants

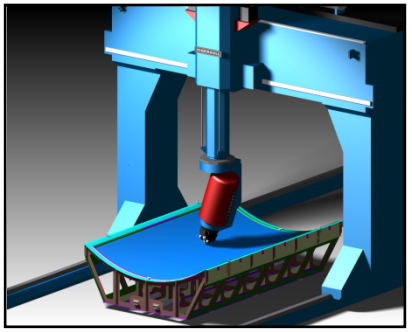
- Evaluate and characterize numerous nano-scale based propellant chemistries to include solids, gels, liquids, and hybrids
- Perform system analyses with identified risks and gaps to understand system level impacts and key decision points
- Select promising candidate chemistries and demonstrate their use at a meaningful scale in appropriate ground based tests and flight demonstrations
- Establish an infusion path for successfully demonstrated propellants to support future NASA missions

- **Status:**
  - First Technology Assessment Group (TAG) held in September. 6 candidate propellants evaluated, prioritized, and recommended to NEPP Office.
  - First order system analyses will be complete for 8 applicable NASA missions by EOY. The first one the end of October.
  - Integrated master schedule with KDP's, critical path, financial phasing plan are complete with the next rev of the project plan to be completed in early November.

Motivation and Objectives for Composite Cryotank Technologies and Demonstration







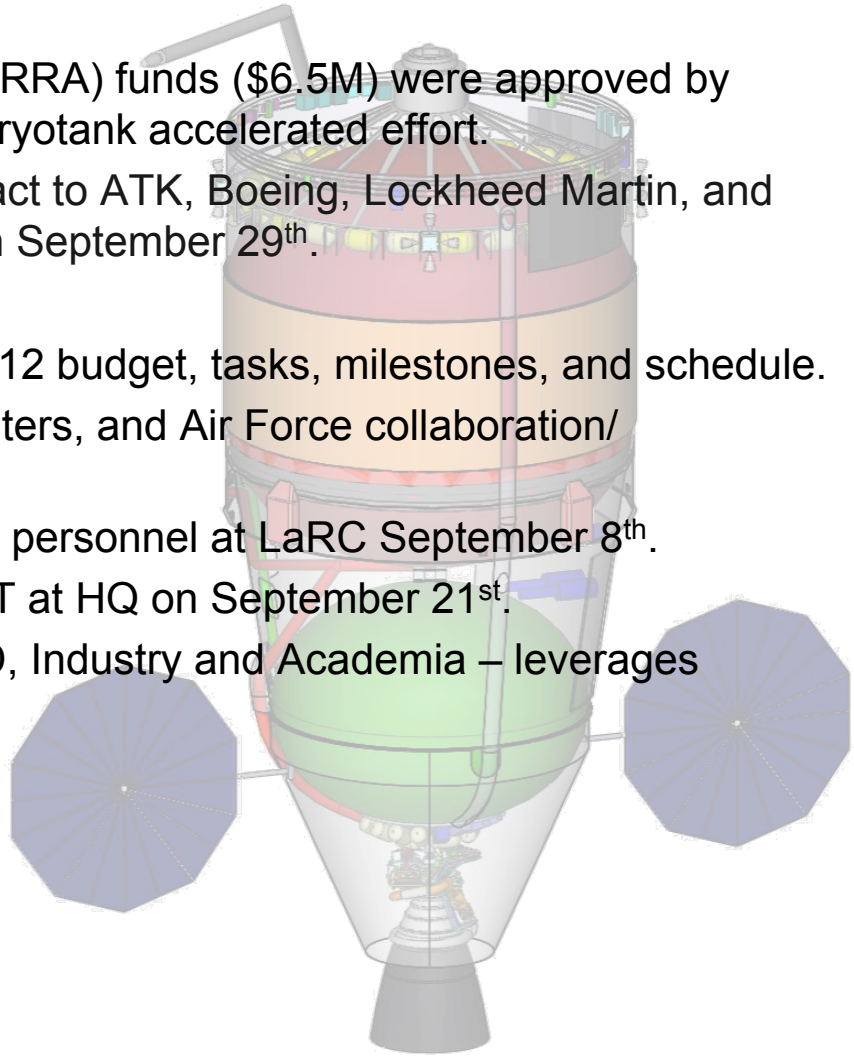
Conventional Autoclave vs Out-of-Autoclave Technology

Advanced Materials and Manufacturing

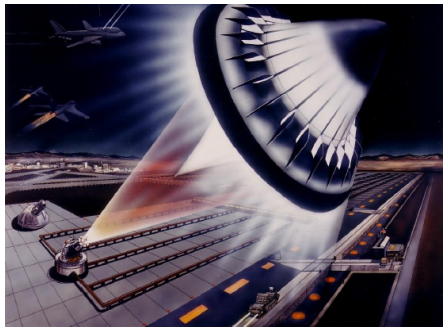
- **Motivation: Composites are the most important materials for the future of aerospace vehicles since the first uses of aluminum**
  - Enabling to increased performance, capability, and strategic leadership
  - Affordability, reduced mass, more efficient manufacturing for composite cryotanks will improve access to space
  - Multiple customer needs + spin-off capabilities
    - NASA, DoD, and commercial customers -- enhances aerospace global competiveness
    - Enabling architectures -- In-space propulsion, propellant depot, LOX tank capabilities
- **Objectives: Develop and demonstrate advanced technologies to reduce cost and reduce weight of LH2 composite cryotanks (currently TRL 4-5)**
  - Target HLV (8.4m-10.0m) architectures and systems requirements, multiple customers, spin-off capabilities, potential space technology demonstration
  - Two 5-meter test articles (autoclave and non-autoclave)
  - 20-25% cost savings and 25-30% weight savings

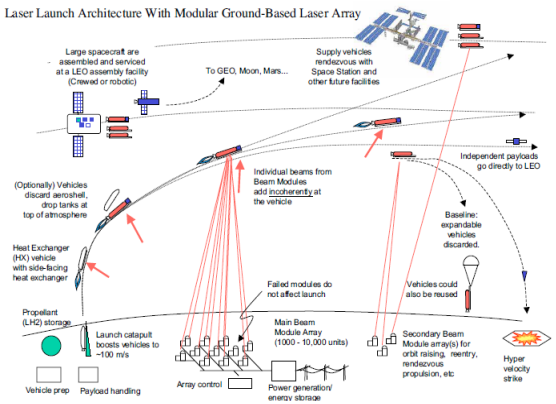
Status for Composite Cryotank Technologies and Demonstration

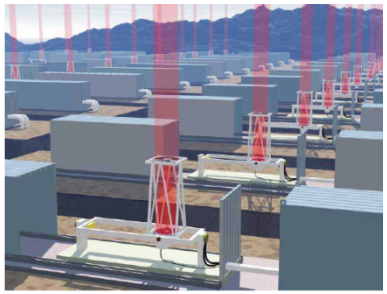
- **Status:**
  - American Recovery and Reinvestment Act (ARRA) funds ($6.5M) were approved by Congress on **August 5th** for the Composite Cryotank accelerated effort.
    - Awarded tasks via LARC SMAART contract to ATK, Boeing, Lockheed Martin, and Northrop Grumman for Phase 1 efforts on September 29th.
    - Contract Kickoff meeting **October 19th**.
  - Developed the detailed plan for FY11 and FY12 budget, tasks, milestones, and schedule.
  - Held discussions with participating NASA centers, and Air Force collaboration/ cooperation.
  - Reviewed Project plans with Game Changing personnel at LaRC September 8th.
  - Reviewed Project plans for approval with OCT at HQ on September 21st.
  - Advancing collaboration between NASA, DoD, Industry and Academia – leverages investment.



Beamed Energy Propulsion (BEP) Study





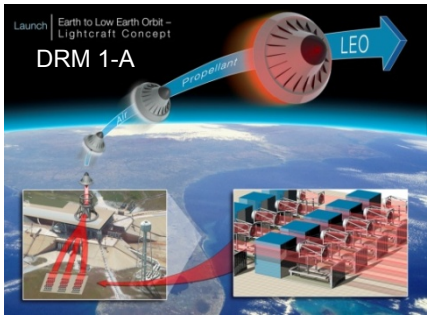


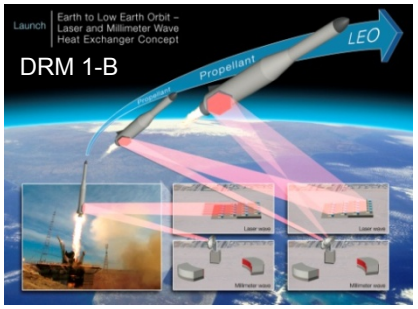
Motivation: DARPA wants to determine whether to invest in BEP for launch to orbit; NASA has this interest plus in-space applications.

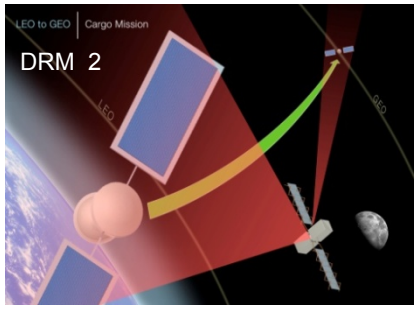
End Goals of 6-month Study:

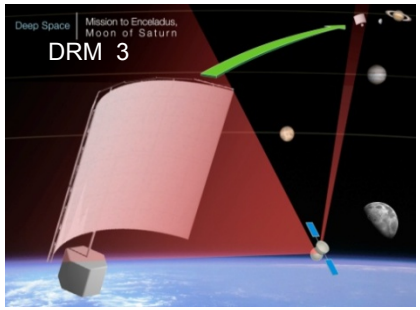
1. Prove or disprove feasibility of ETO via BEP, or at a minimum, provide significant new insights (esp. atmospheric effects)
2. Determine advantages of BEP, if any, compared to conventional technologies.
3. Identify spaceflight demonstrations needed to verify feasibility
4. Identify analogous ground-based demonstrations, including ground-based sites for BEP for ETO.
5. Note, if any, synergies with X Prize in BEP

Beamed Energy Propulsion: DRM's, Teams, and Status









GRC COMPASS Team with external experts' team studying laser (DRM 1A) and microwave (DRM 1B) as power sources, also similar team of experts leading the DRM 2 of LEO to GEO

GSFC MDL defining architecture around various propulsion methods

Who: GRC, GSFC, KSC, AFRL, Air-Borne Laser (ABL) team, AFIT (teacher / students), spectrum management, and many external experts (including Centennial Challenge winner)

Status:

- Study plan and Project Manager/Principal Investigator approved by NASA and DARPA
- Technical feasibility issues identified and being addressed
- DRMs being detailed, assuming launching 10 -100 kg payload
- Submitted first paper on the atmospheric effects on power beaming
- ABL personnel engaged with high power laser operation and ground demonstrations
- Conducted DRM 1-A mission analysis; assessing results

Horizontal Launch Study Objectives

- Assess Horizontal Launch options/architectures for both civil & military
- Open up the trade space to several payload classes
  - micro to medium sized payloads
  - staging speeds from subsonic to supersonic for each payload class.
- Each payload class / staging scenario will be assess with respect to:
  - existing first stage platforms with no modifications
  - existing first stage platforms with minor modifications
- Identify technology gaps for each payload class solution
- Identify near-term capabilities based on conventional turbojet-powered carrier vehicle (taking off from a runway and returning)
- Identify near term investments or demonstrations needed to mature technologies for future horizontal launch systems development.

Horizontal Launch Study Status

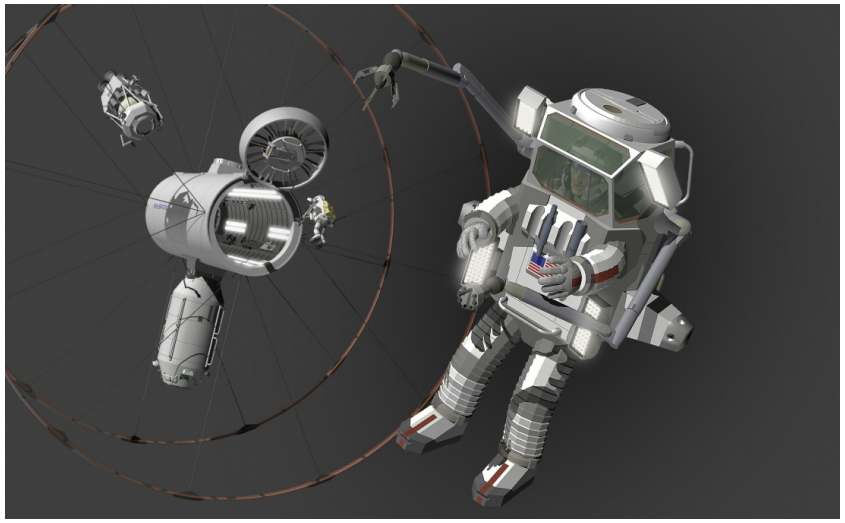
- Core Team formed and working
  - Members from AFRL, DARPA, ARC, DFRC, GRC, LaRC, MSFC
  - Kick Off meeting at LaRC August 18
    - Finalized Study Terms of Reference (TOR)
    - Draft Study Matrix & Figure of Merit (FOM)
  - Next F2F Meeting at GRC September 21
    - Review of existing studies, finalize study matrix & FOMs

- National Institute of Aerospace conducting literature search
  - NIA is employing ~6 students to cull through decades of studies
  - Indentify information gaps with respect to the draft study matrix & FOMs

- Initiating Quick start contracts
  - Utilizing existing contract mechanisms at AFRL, LaRC, DFRC, GRC
  - SOWs developed and task orders will be in place by September 15th

Manned GEO Satellite Servicing Study

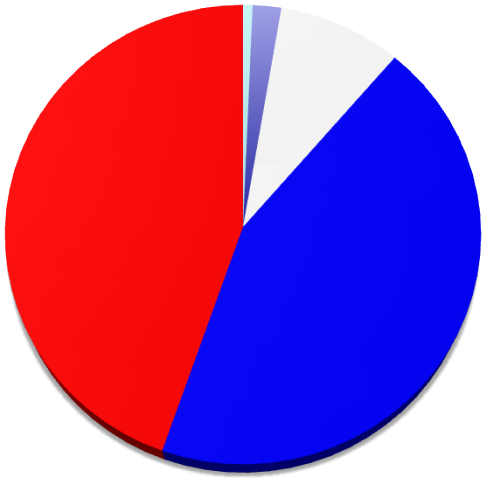
- Joint NASA/DARPA study to assess options for human servicing of satellites in GEO to deliver:
  - Recommendations for DARPA/NASA technology investments to support FY12 POM/PPBE definition
  - Realizable mission architectures which provide context for above
- Government team composed of personnel from:
  - NASA: GRC, GSFC, JSC, LaRC, MSFC
  - DARPA/DOD resources – NRL, Aerospace Corp, Schafer, BAH, SME's
  - Academia – UMD, MIT
- Three Phase Approach
  - Historical Data Collection
  - Trade Space Development and Notional Mission Definition
  - Mission Assessment, Technology Recommendation Development



Manned GEO Satellite Servicing Study Status

- Initial stakeholder status meetings held (Aug 24-26)
- Core Team Initial Meeting held (Sep 21-23)
- Aerospace Historical Survey Final Report delivered (Sep 23)
- Project Charter complete – to stakeholders for signature
- 4 Function Teams identified and engaged in Trade Space assessment
  - Hardware to GEO
  - Crew Transportation to/from GEO
  - Human Presence in GEO
  - Human/Robotics Synergy
- Forward Plan
  - First full F2F Team Meeting in Arlington (Oct 19-21)
  - Function Team assessments and product development
  - Mid-Term Stakeholder Status Meeting (early Dec)
  - RFI/Open Workshop under consideration (Jan)

Initial Interest Derived from Recent Request for Information

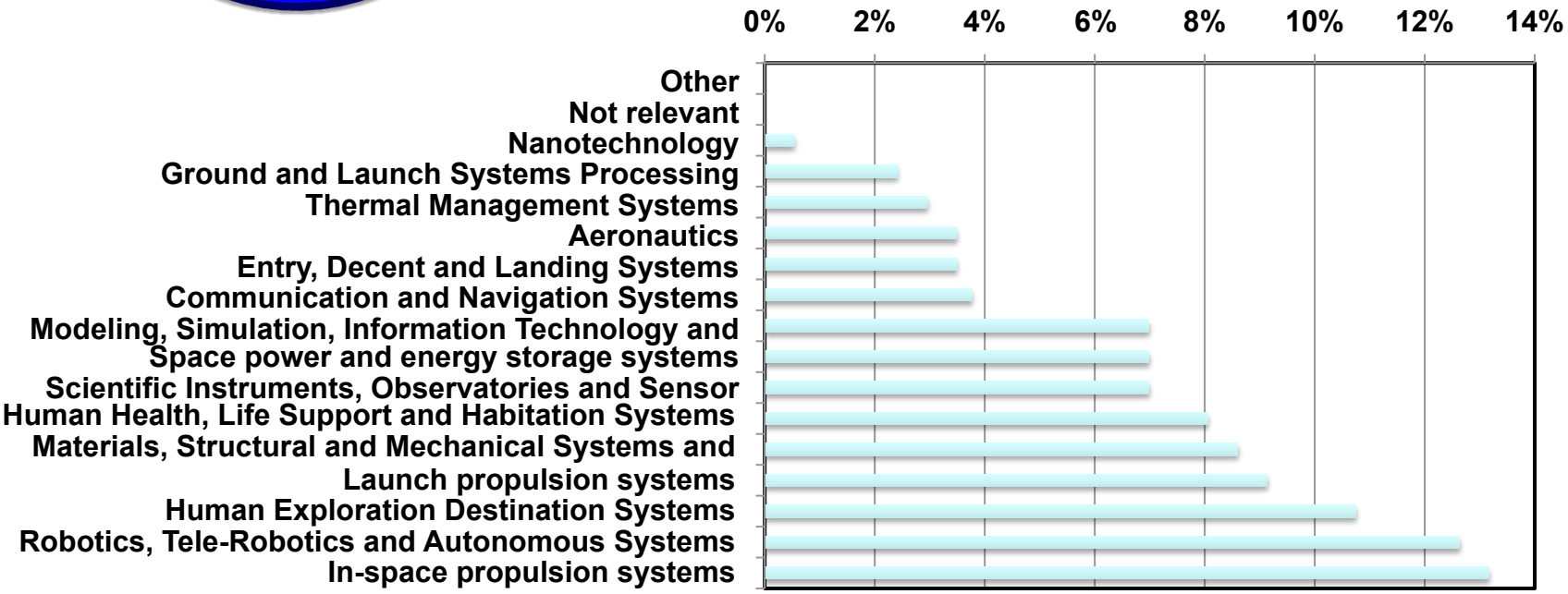


- Other Government
- Academia
- Other
- NASA
- Industry

number of returns: 500

in review: 352

reviewed: 150



Game Changing Development Program - Summary

The Game Changing Development Program (GCD) bridges the technology maturation gap, maturing advanced space technologies that provide innovative capabilities enabling entirely new NASA missions for scientific discovery, and human and robotic exploration.

GCD competes its research. It encourages teaming with participation from industry, academia and government. International collaborations are accepted.

GCD is preparing for a fast-paced series of *concept studies* followed by *selected projects* carried out by multiple performing teams.

With support largely from other NASA MD's, DARPA and the ARRA, the GCD portfolio has been seeded with game-changing *concept studies* and *new projects*, that pave the way for a comprehensive program development