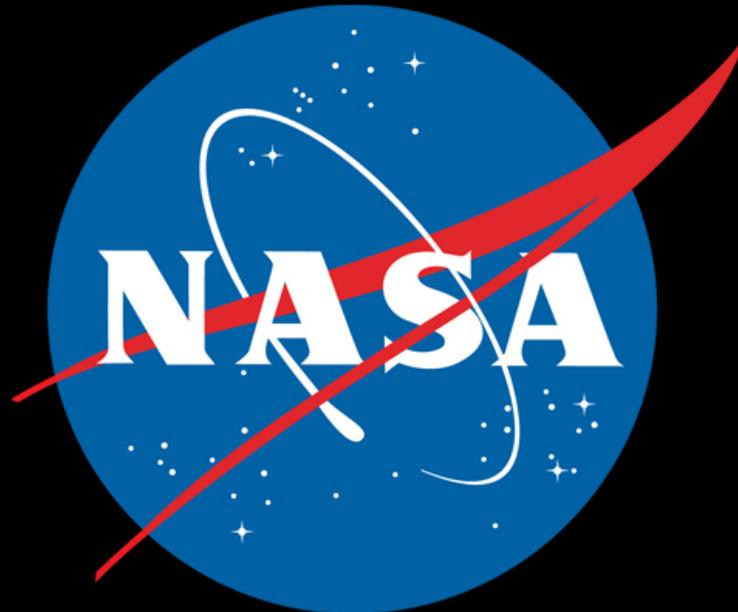


Overview of NASA's Commercial Space Efforts



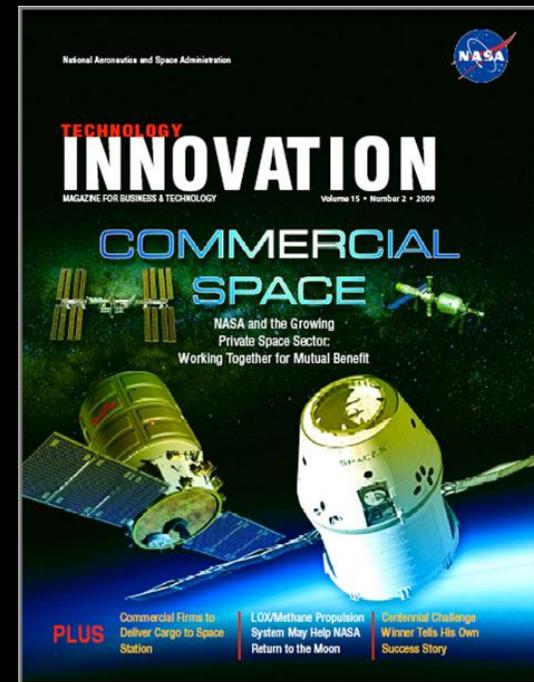
Doug Comstock

Director, Innovative Partnerships Program – NASA Headquarters

NASA Advisory Council, Commercial Space Committee
Washington, DC February 16, 2010

Commercial Space and NASA

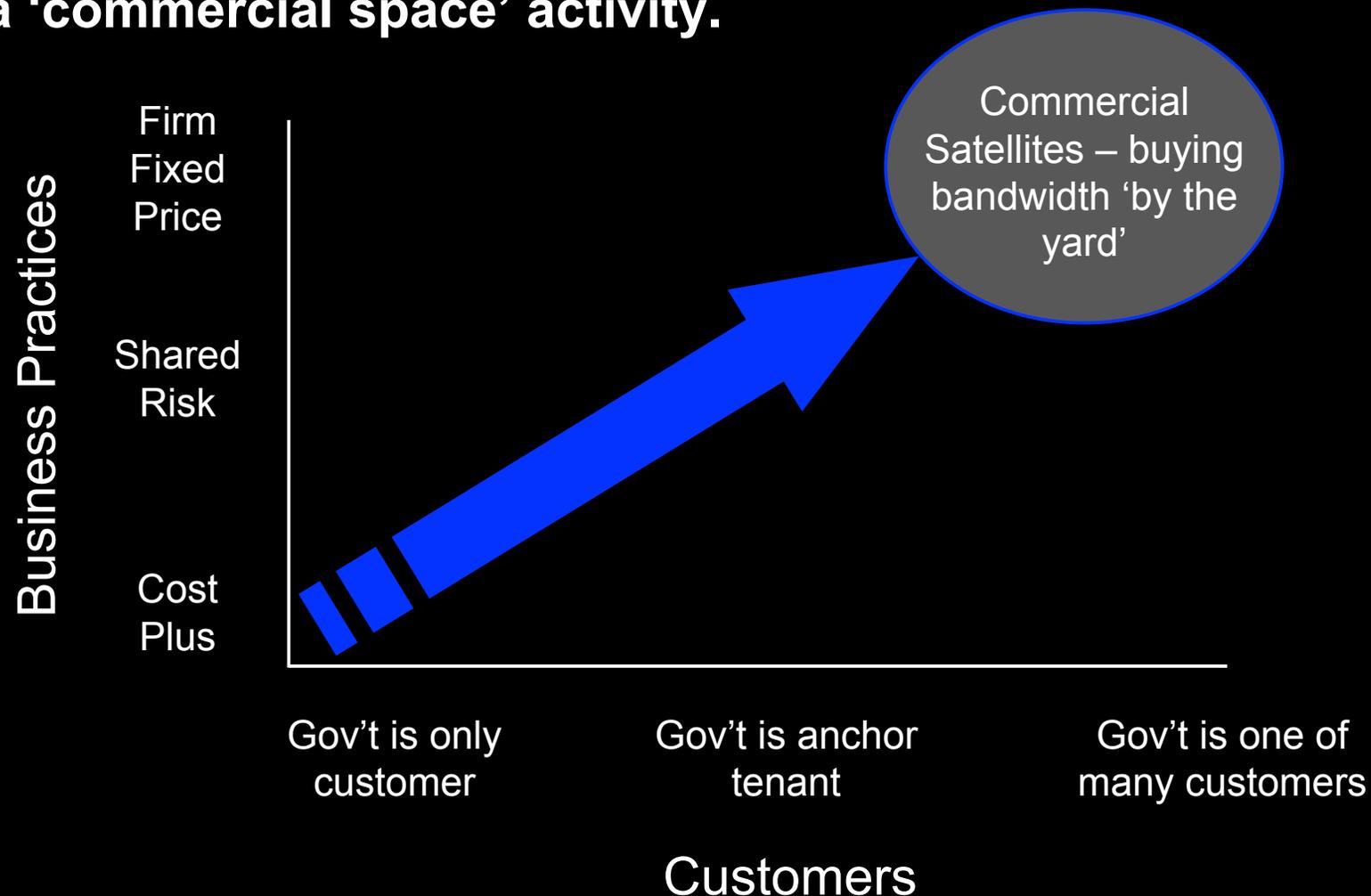
- There are three key themes that underscore some of the changes underway in how NASA is engaging the commercial space community:
 - Private sector role as partner rather than contractor.
 - Government purchase of services instead of hardware.
 - Creating broader opportunities for innovation.



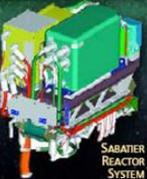
IPP's recent edition of Technology Innovation focused on NASA's activities related to Commercial Space.

What is Commercial Space?

- No single discrete definition, but rather a context for understanding different aspects of what makes something a 'commercial space' activity.



Summary of NASA Commercial Space Activities

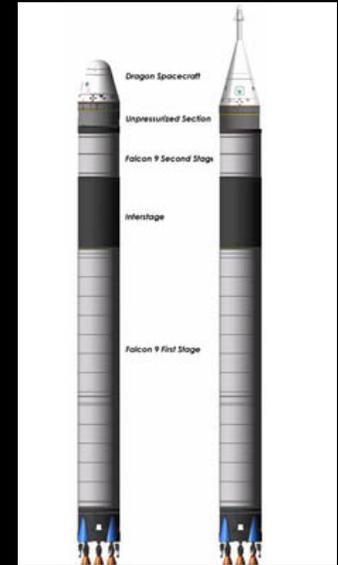
	COMMERCIAL SPACE Accomplishments	Accomplishments to date have met and exceeded the 2006 Commercial Space Plan	Current and Planned Near Term Activities	Future Activities
ESMD	<ul style="list-style-type: none"> SpaceX completes all milestones for COTS Phase 1 and delivers Falcon 9 to KSC Orbital Sciences completes Cargo Module PDR 	<ul style="list-style-type: none"> ESMD and IPP Seed Fund support includes lunar drilling robotics and oxygen from simulated lunar regolith 	<ul style="list-style-type: none"> New commercial initiatives include Low Impact Docking System and development of lunar surface systems Studying feasibility of using suborbital missions for microgravity research including life & physical sciences & technology development Simulate commercial human spaceflight capabilities 	<ul style="list-style-type: none"> Applying the COTS model to new areas consistent with ESMD commercial space policy Lunar, Mars, NEOs/Asteroid, and other exploration with commercial space partnering Space tourism complementing exploration Space resource commercialization, such as ISRU and/or space solar power for lunar applications
SOMD	<ul style="list-style-type: none"> Signs firm-fixed-price multi-billion-dollar contracts for commercial resupply services (CRS for space station) ISS National Lab MOUs with NIH and USDA, including biotech and other commercial ISS payloads 	<ul style="list-style-type: none"> Commercial water production services contract for ISS signed with Hamilton Sundstrand that will be using a Sabatier-based reactor system Contract with Zero-G for aircraft parabolic flight services 	<ul style="list-style-type: none"> ISS serving as engineering testbed for future commercial communication technologies, including recent testing of Delay Tolerant Networking (DTN) to enable ISS to serve as an Internet node for cloud computing on-orbit Currently testing sub-systems demonstrations for solar-electric power conversion that have ground-based and space-based applications 	<ul style="list-style-type: none"> Commercial LEO and lunar habitats complementing NASA missions On-orbit satellite servicing, space debris management, on-orbit fuel depots and other commercial space operations services
SM D	<ul style="list-style-type: none"> Earth science activities involving commercial remote sensing NASA Lunar Science Institute established, including commercial ISRU Initiatives Spin-off of advanced optics and detectors to industry 	<ul style="list-style-type: none"> Work continues on international science and commercial partnering, such as NLSI agreements with Korea, Canada and the United Kingdom Use of commercial remote sensing satellites for Earth science 	<ul style="list-style-type: none"> Remote sensing instruments as secondary payloads on commercial systems Partnerships on instruments and technology development, or small science investigations Enabling commercial space weather information products, such as warning to communications systems operators 	
ARM D	<ul style="list-style-type: none"> Research on broad spectrum of fundamental technologies (e.g. materials, computation fluid dynamics, vehicle health maintenance) with possible applicability to commercial space Research on technologies relevant to launch and return of reusable spacecraft 	<ul style="list-style-type: none"> Evaluation of re-entry technologies, including those that support reusable applications 	<ul style="list-style-type: none"> Further development of technologies to facilitate reusable access to space Research for point-to-point suborbital flight including commercial global flight projects such as DOD Small Unit Space Transport Insertion (SUSTAIN) 	
IPP + OTHER	<ul style="list-style-type: none"> SBIR and STTR efforts including docking sensors, power systems, avionics and others IPP work with NASA Mission Directorates on Seed Fund projects for Inflatable Lunar Habitat, Li-Ion Battery and others Peter Homer wins \$200K Astronaut Glove Challenge 	<ul style="list-style-type: none"> IPP Seed Fund support of lunar habitat development including inflatable technologies Armadillo Aerospace wins \$350,000 Level 1 prize of Lunar Lander Challenge FAST sponsors technology development for several SBIR companies in a simulated space environment on parabolic aircraft flights KSC commercial launch site, and SpaceX Falcon 9 at KSC; work on launch pad at Complex 40   	<ul style="list-style-type: none"> Centennial Challenges prizes advancing innovation and technology needed for commercial space IPP Seed Funding work with NASA Mission Directorate involving universities, private sector and other agencies, and SBIR/STTR efforts related to commercial space FAST will use commercial suborbital services as they become available Development of Wallops Flight Facility Mid-Atlantic Regional Spaceport (MARS) for commercial launch such as COTS-Orbital Sciences Taurus II  	<ul style="list-style-type: none"> IPP programs supporting commercial LEO and lunar resource utilization such as lunar regolith programs, space solar power for lunar operations, micro-gravity and others; Earth viewing/global monitoring initiatives Commercial space partnerships with U.S. and/or international entrepreneurs, including work complementing Spaceport America in New Mexico 

Key to Abbreviations: ATC Air Traffic Control ARMD Aeronautics Research Mission Directorate COTS Commercial Orbital Transportation Services DOD Department of Defense ESMD Exploration Systems Mission Directorate EVA Extra Vehicular Activity FAA Federal Aviation Administration FAST Facilitated Access to the Space Environment for Technology Development and Training IPP Innovative Partnerships Program ISS International Space Station LEO Low-Earth Orbit MOU Memorandum of Understanding NEO Near-Earth Object

NIH National Institutes of Health NLSI NASA Lunar Science Institute NRA NASA Research Announcement OSC Orbital Sciences Corporation PDR Preliminary Design Report RFI Request for Information SBIR Small Business Innovative Research SMD Science Mission Directorate SOMD Space Operations Mission Directorate STTR Small Business Technology Transfer

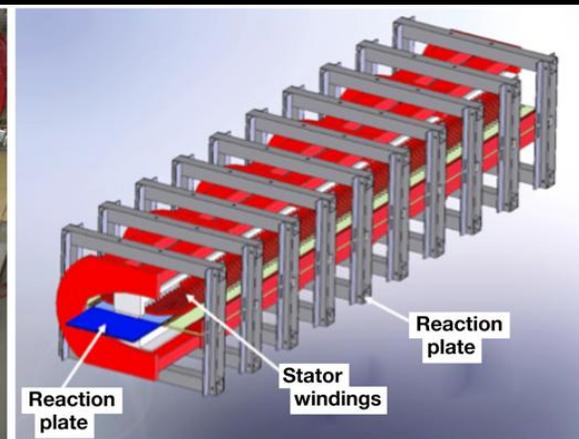
Commercial Space and NASA

- **Private sector role as partner rather than contractor.**
 - We are beginning to see a shift in relationships between the government and the private sector from the traditional roles of customer-contractor to one of partners.
 - The Commercial Orbital Transportation (COTS) program is a prime example of this, where NASA is partnering with SpaceX and Orbital Sciences to develop new space transportation capabilities.
 - Other examples include licensing NASA technology for development of commercial space habitats and revolutionary propulsion systems, as well as IPP Seed Fund projects where cost-shared technology development among partners advances important technologies of common interest, such as propellant depots and LOX/Methane rockets.



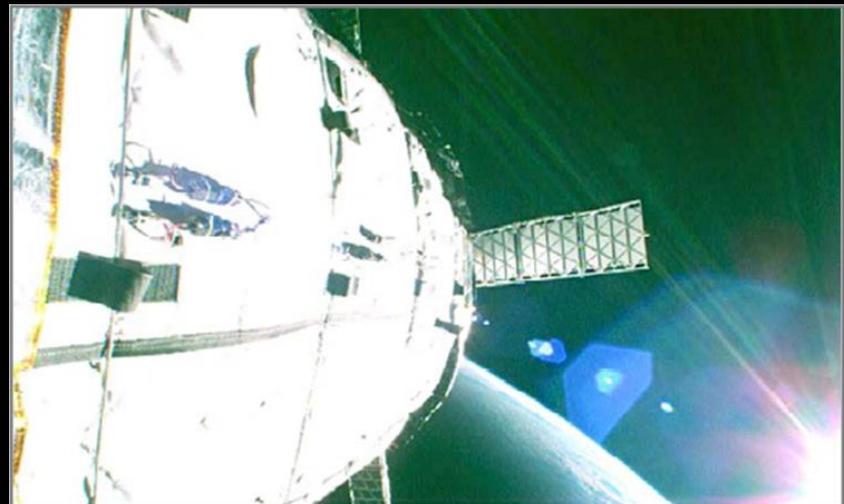
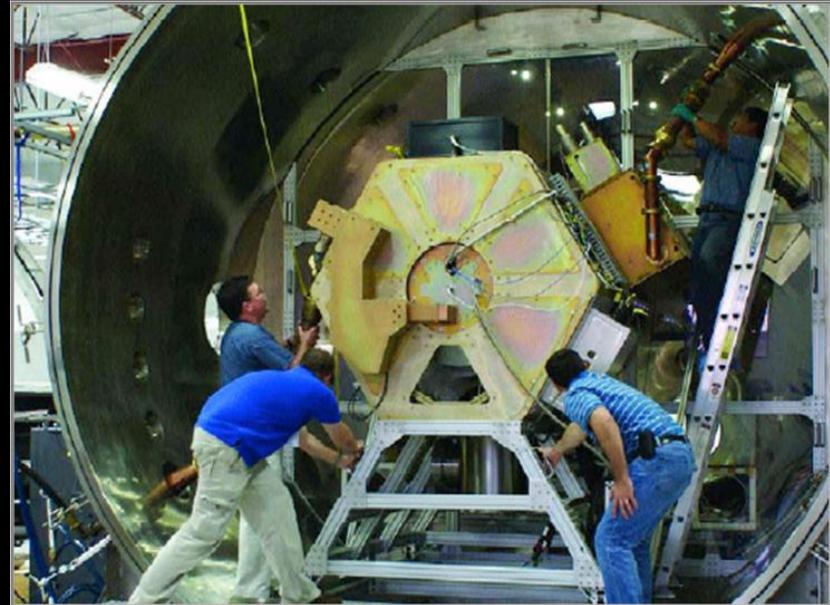
IPP Seed Fund Partnerships – Leveraged R&D

- The First Stage of a Highly Reusable Reliable Launch System (FS-HRRLS) demonstrated alternative technologies that could reduce the cost of access to space.
- The HRRLS focuses on the development of a high-speed electromagnetic launch system to capitalize a portion of the reusable launch system costs on the ground.
- The current state of the art of bench proto-type equipment, developed in the previous decade, was limited to 60 mph and 15 lbs.
- The HRRLS demonstration project increased this speed to 300 mph and lower the weight to 10 lbs.



Licensing

- **Ad Astra 200 kW VASIMR prototype plasma rocket engine.**
 - Technology licensed from NASA.
 - First Space Act Agreement in 2005.
- **Bigelow Genesis I spacecraft.**
 - Technology licensed from NASA.
 - First Space Act Agreement in 2002.



Commercial Space and NASA

- **Government purchase of services instead of hardware.**
 - The second important change is the transition to a model where the government is buying services from commercial providers rather than paying for development and operation of hardware.
 - The biggest example of this – for billions of dollars in launch services with commercial service providers – is the Commercial Resupply Services contracts to provide cargo delivery to the ISS.
 - Another example is the Sabatier water production system that is being deployed on the ISS where NASA will pay for services provided rather than for the development of hardware.
 - Looking forward, an example is lunar communications needed in the future that could be a commercial service provided to users rather than a NASA-owned system.



FAST Facilitated Access to the Space Environment for Technology Development and Training

- Helps emerging technologies mature through access to space-environment testing
- Uses commercial space services
 - Initially, zero and reduced-gravity parabolic flight services
 - Later, suborbital and orbital flights when available
- Open to all companies, universities and government labs
- NASA pays for flight time, participant pays for their own project preparations
- In August 2009, 19 projects flown in zero and lunar gravity
 - 7 universities, 9 private companies – 5 NASA Labs
- Planning another flight week in 2010



Administrator Bolden Announces CRuSR

Speech to Nat'l Assoc. of Investment Companies, Oct. 20, 2009*

- NASA must determine efficient and effective ways to leverage the power, and innovation of American industry and the American entrepreneur.
- In the 1920s, the U.S. Post Office became a major customer for airmail, which created the demand that justified the private investment in many airlines.
- NASA is doing something similar right now. We are engaged in a new program — the Commercial Reusable Suborbital Research program — that will buy space transportation services from the emerging reusable spaceflight companies to conduct science research, technology development, with a keen focus on education.”

* http://www.nasa.gov/pdf/395165main_Bolden_NAIC_Speech.pdf

Commercial Reusable Suborbital Research

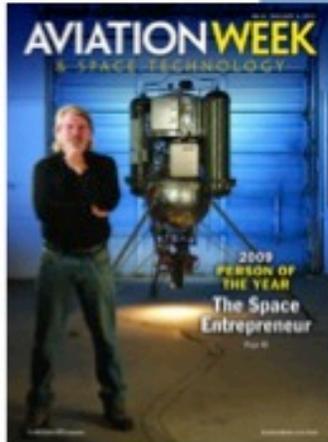
- **Through a user-focused program, NASA-sponsored researchers, engineers, technologists and educators will be able to conduct hands-on activities in near-space for the first time.**
- **This new environment provides several technical benefits to NASA.**
 - Reducing the risk for use of new technologies in future missions.
 - Developing and testing medical procedures.
 - Access to 3-4 minutes of microgravity for discovery and testing.
 - Routine recovery of payload.
 - Frequent flights.
- **Provides new options for career development and public engagement.**
 - Inspiring new careers in aerospace.
 - Training the workforce of the future.
 - Creating greater excitement in the space program.
- **Providing a competitive market for the emerging commercial space industry.**

Commercial Space and NASA

- **Creating broader opportunities for innovation.**
 - The third major shift focuses on the creation of broader opportunities for innovation that address NASA's needs but also those of commercial space and other markets.
 - Such opportunities can be found through NASA's Centennial Challenges competitions that are open to the citizen inventor.
 - Commercial parabolic flight services are being used by NASA's FAST program to mature innovative technologies in reduced gravity, and NASA is partnering with other agencies and the private sector to conduct research on the International Space Station as a National Laboratory.



Centennial Challenges 2009 WINNERS



Masten Space Systems and Armadillo Aerospace win Lunar Lander Challenge and as Space Entrepreneurs are honored as the "Persons of the Year"



Paul's Robotics, a student team beats 22 others to win \$500,000 in the Regolith Excavation Challenge



Ted Sothern and Peter Homer display their prize winning Astronaut Gloves



LaserMotive climbs to one kilometer with beamed power to win \$900,000



Deputy Administrator Garver

Announces Commercial RLV Technology Roadmap study

NASA Press Release 09-238, October 13, 2009

- "NASA is committed to stimulating the emerging commercial reusable launch vehicle industry,
- There is a natural evolutionary path from today's emerging commercial suborbital RLV industry to growing and developing the capability to provide low-cost, frequent and reliable access to low Earth orbit.
- One part of our plan is to partner with other federal agencies to develop a consensus roadmap of the commercial RLV industry's long-range technology needs."

Commercial RLV Technology Roadmap Study

- NASA partnership with USAF and FAA-AST
 - Focused primarily on understanding “commercial industry needs”
- Primary Goal:
 - Accelerating development of Commercial Reusable Launch Vehicles
 - **that have significantly lower cost, and improved reliability, availability, launch turn-time, and robustness compared to current launch systems.**
- Planned Outputs:
 - Roadmaps with recommended government technology tasks and milestones for the four different vehicle categories
 - **Including initial budget and resource requirement estimates**
 - Final roadmap planned for publication in May 2010
- For more information, <http://csi.arc.nasa.gov/crlv>

NASA-USAF Co-sponsoring Annual Event to Enable Technology Exchange in Industry

- NASA working with USAF
 - Annual tech exchange
 - IPP is NASA lead
 - 2009 at WPAFB
 - 2010 at Ames
 - Rotates thereafter
- CRASTE Purposes:
 - Facilitate technology transfer
 - Enable partnerships
 - “Marriage broker” service among firms
 - Forum for understanding industry technology needs
- **CRLV Tech Roadmap**



2009 CRASTE
Commercial and Government Responsive Access to Space Technology Exchange

October 26 - 29, Dayton, Ohio

What is CRASTE?

The Commercial and Government Responsive Access to Space Technology Exchange (CRASTE) is a joint Air Force Research Laboratory (AFRL) and NASA technology exchange forum for the space launch community to meet, discuss, and collaborate on technologies that deliver improved, responsive, and cost effective access to space capability.

The CRASTE is an excellent opportunity for space access customers (DoD and NASA) to present their space access requirements and objectives. The event is designed to bring large military system integrators and emerging entrepreneurial space companies together to identify and promote viable solutions to space access challenges.

NASA and AFRL initiated a Reusable Launch Vehicle (RLV) technology roadmapping effort to identify technologies with the largest impact for enabling future space access capabilities. The primary goal of NASA and AFRL is accelerating development of Commercial Reusable Launch Vehicles (CRLV's) with significantly lower cost, improved reliability, availability, and robustness compared to current launch systems.

Commercial space organizations attending the CRASTE have an opportunity to provide analysis, options and recommendations for the roadmap to the government team during one-on-one, closed door discussions. Based on the discussions, the government will make recommendations in the form of technology tasks and milestones for the upcoming roadmaps. CRLV categories will then be compiled and documented, along with initial budget and resource requirements.

In addition to one-on-one discussions with the Government, the CRASTE provides multiple networking opportunities to facilitate potential collaborations among the attendees. Members of the space community are exhibiting at the CRASTE and private meeting rooms are available for attendee use throughout the CRASTE.

Why should I attend?

The CRASTE is the optimal forum to:

- Gain insight on future commercial/responsive access to space research directions and programs from Air Force and NASA executives.
- Hear updates on the latest technology developments and breakthroughs from an array of government and industry speakers.
- Meet with and provide private input to the AFRL/NASA RLV road mapping team.
- Network with members of the CRASTE community and explore possible collaborations.
- Broaden and update familiarity with and connections to members of the space launch community through the informative exhibit show.

How do I register?

To register for this important event, including one-on-one contractor meetings and roadmap review meetings, visit the CRASTE website at:
<http://www.usasymposium.com/craste/default.htm>

CRASTE is ITAR restricted and only U.S. Persons (citizens and permanent residents) may attend.

CRASTE Contacts:

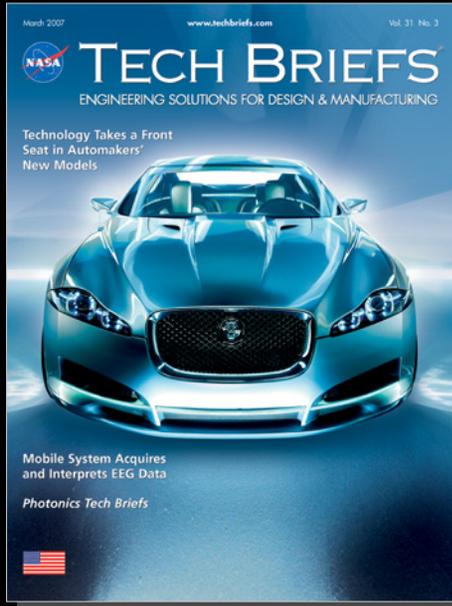
Air Force Research Laboratory Mr. Bruce Thieman Responsive Space Lift Capability Lead AFRL/RBOT Bruce.Thieman@WPAFB.AF.MIL	NASA Dr. Robert J. Shaw Chief, Business Development and Partnership Office NASA Glenn Research Center Robert.J.Shaw@nasa.gov]
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Symposium Coordinator
Ms. Cathy Griffith, GDIT
Cathy.Griffith@gdit.com

What Can IPP Provide to Entrepreneurs?

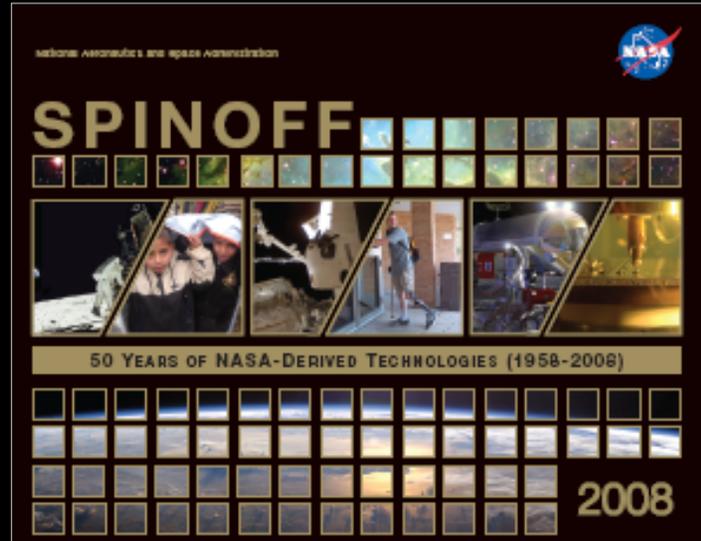
- **Funding or Leveraged Resources.**
 - NASA SBIR/STTR funds several hundred small businesses each year.
 - Centennial Challenges offers millions in prize purses.
 - IPP Seed Fund seeks partnerships with private sector and other Federal labs.
 - FAST and CRuSR buy privately-provided micro-g services.
- **Technology and Software.**
 - Access through licensing or other partnerships.
- **Test and Demonstration Facilities/Capabilities.**
 - Access to NASA's facilities through partnerships.
 - Access to the space environment through FAST and CRuSR.
- **Expertise.**
 - Access to NASA's technical expertise through partnerships.
- **Facilitation to enable partnerships.**

IPP Outreach & Publications



<http://www.techbriefs.com/>

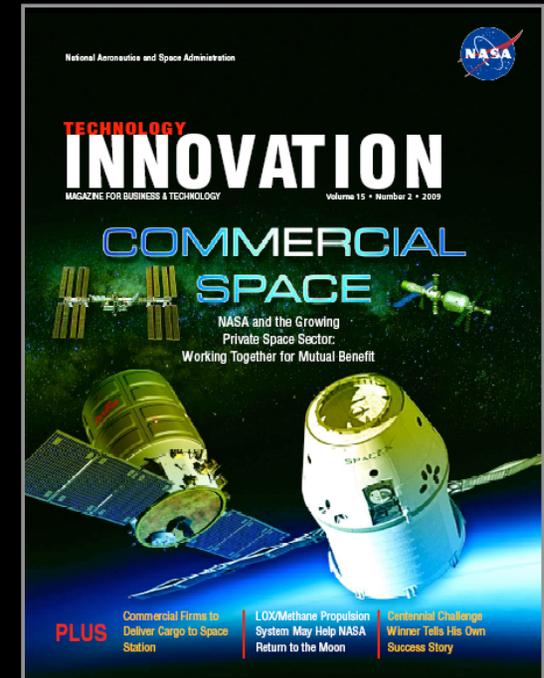
Electronics & Computers
Semiconductors & ICs
Mechanics
Information Sciences
Materials Software
Manufacturing & Prototyping
Machinery & Automation
Physical Sciences
Bio-Medical Test & Measurement



<http://www.sti.nasa.gov/tto/>
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searchrecord](http://www.sti.nasa.gov/spinoff/searchrecord)



NASA @ Home & NASA City
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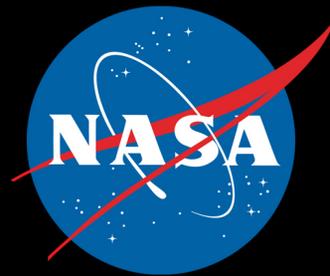


[http://ipp.nasa.gov/innovation/
index.html](http://ipp.nasa.gov/innovation/index.html)

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What's Next?

- **NASA will accelerate and enhance its support for the commercial spaceflight industry to make travel to low Earth orbit and beyond more accessible and more affordable.**
- **Imagine enabling hundreds, even thousands of people to visit or live in low Earth orbit, while NASA firmly focuses its gaze on the cosmic horizon beyond Earth.**
- **An enhanced U.S. commercial space industry will create new high-tech jobs and spin off other new businesses that will seek to take advantage of affordable access to space.**
 - Administrator Bolden, Feb. 1, 2010, FY11 Budget Rollout



National Aeronautics and Space Administration

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