Commercial Space Transportation - *A Roadmap to the Future*

by

Daniel J. Rasky, PhD

Senior Scientist, NASA Ames Research Center

Director, Space Portal, NASA Research Park

Moffett Field, CA 94035

(650) 604-1098 / Daniel.J.Rasky@nasa.gov

Contributors: Bruce Pittman, Lynn Harper, Mark Newfield, Jim Grady

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The law that created NASA, the National Aeronautics and Space Act of 1958, as amended, gives NASA an often overlooked mission.

NASA's founding legislation states that we will "seek and encourage, to the maximum extent possible, the fullest commercial use of space."

Remarks by the NASA Administrator
Gen Charles Bolden

National Association of Investment Companies
Washington DC, October 20, 2009

Commercial space is an important and growing segment of the US space industry…

…NASA under Gen Bolden will actively support and advocate its development.

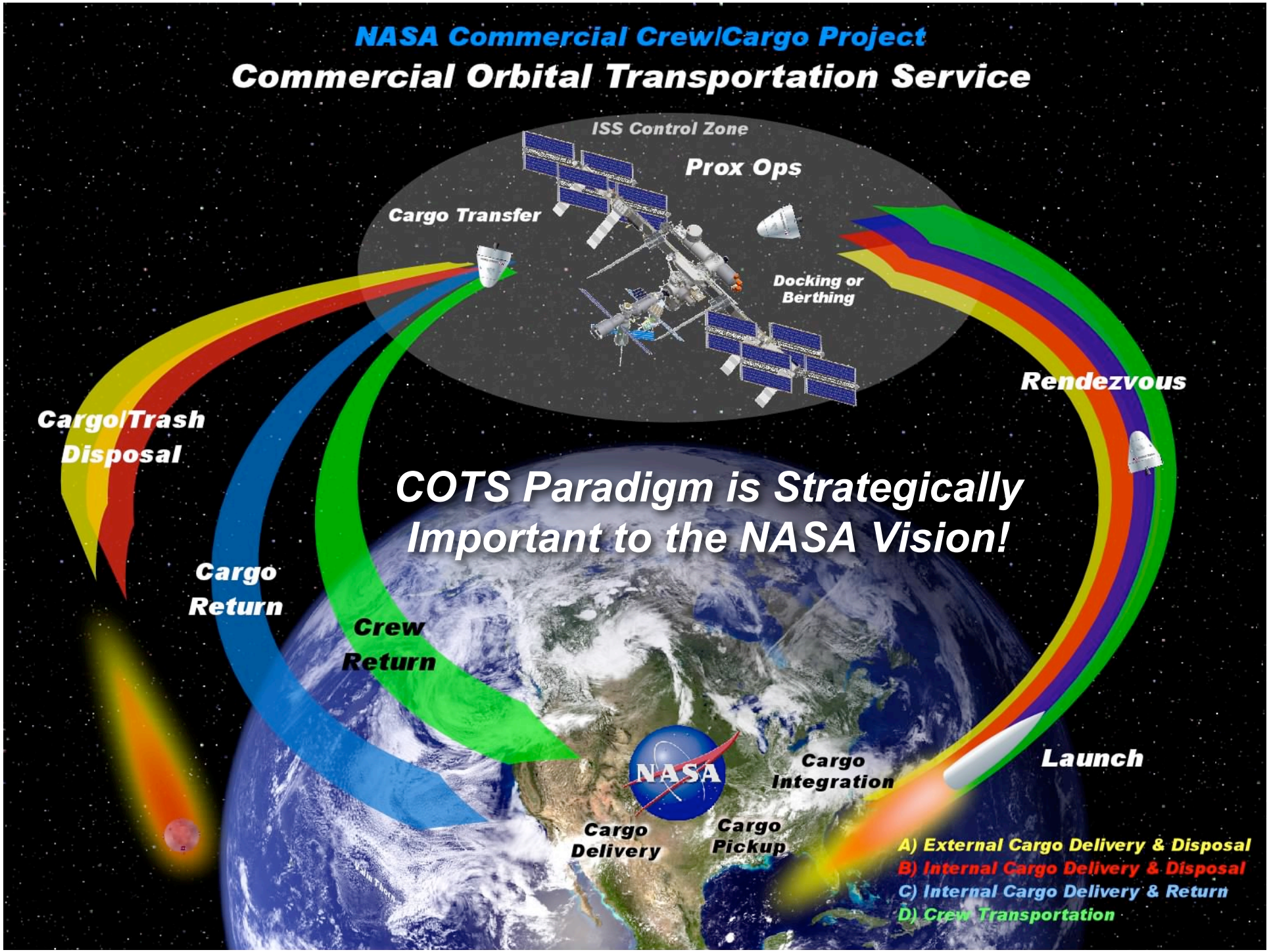
Blue Origin

Scaled Composites

SpaceX

XCOR

Orbital Sciences

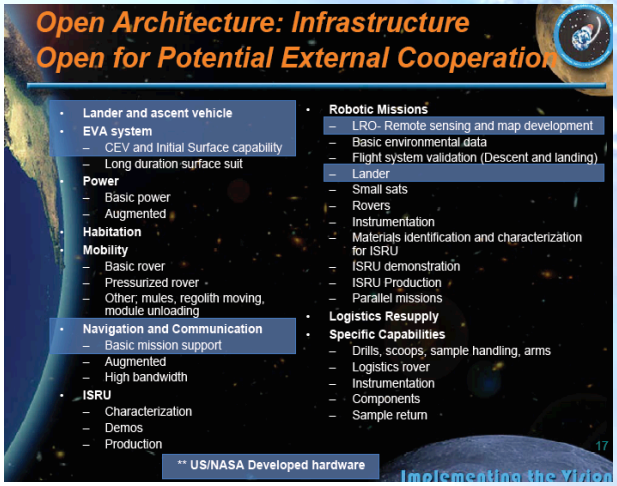

NASA Commercial Crew/Cargo Project
Commercial Orbital Transportation Service
ISS Control Zone
Prox Ops
Cargo Transfer
Docking or Berthing
Rendezvous
Cargo/Trash Disposal
COTS Paradigm is Strategically Important to the NASA Vision!
Cargo Return
Crew Return
NASA
Cargo Integration
Launch
Cargo Delivery
Cargo Pickup
A) External Cargo Delivery & Disposal
B) Internal Cargo Delivery & Disposal
C) Internal Cargo Delivery & Return
D) Crew Transportation

Time of Fundamental Change for NASA

Apollo Model

From NASA as <u>the</u> customer funding prime contractors on a cost plus fixed fee basis

Insufficient Government Resources



COTS Model

To NASA as <u>a</u> customer and partner, working with other customers, financiers, and emerging space companies on fixed price basis to secure capabilities, services and products

Emerging Space Industry…

Blue Origin

Scaled Composites

XCOR

SpaceX

Orbital Sciences

… how can NASA best support and promote their success?

By Learning from History

The Origin of NACA

1915 . . . .

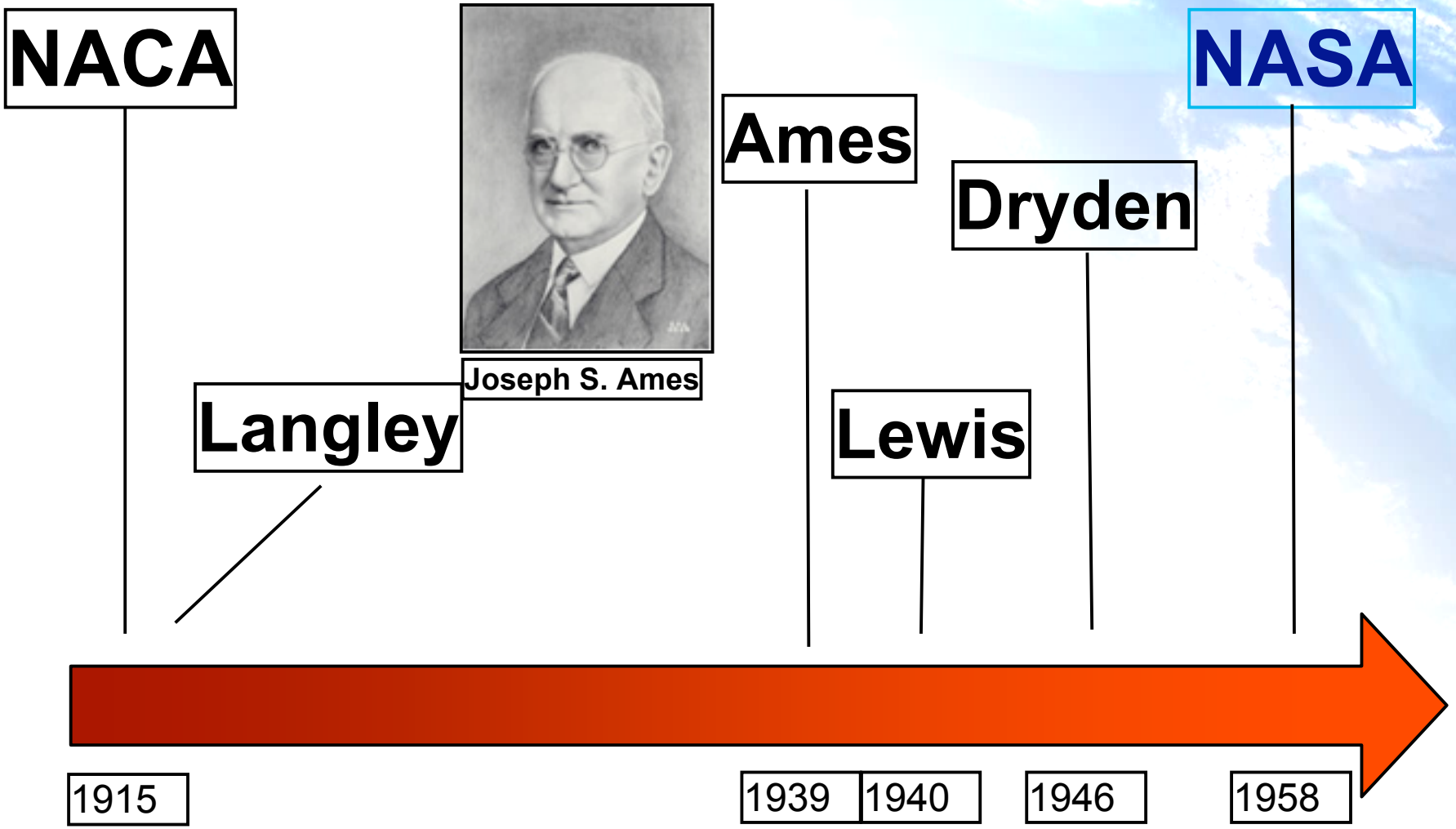
March 3, 1915—A rider to the Naval Appropriations Act established the National Advisory Committee for Aeronautics (NACA). The Committee was instituted to "supervise and direct the scientific study of the problems of flight, with a view to their practical solution."

April 2, 1915—President Woodrow Wilson appointed the first 12 members of the National Advisory Committee for Aeronautics (NACA). Orville Wright was a member from 1920 to 1948.

1916–1917—NACA called the first joint meeting of the aircraft industry and Government agencies. This conference was instrumental in the creation of the Manufacturers Aircraft Association and in the recommendation for the formation of the Aircraft Production Board for WWI aircraft production.

July 17, 1917—Langley Memorial Aeronautical Laboratory, the site for NACA's first experimental aeronautical facility, was founded. These facilities and their successors contributed to the advancement of aeronautics and space flight for the indefinite future.

NACA Laboratories & NASA



NACA was instrumental in the development of the "fledgling" US aeronautics industry...

...from its inception in 1915 thru 1958 and the creation of NASA

Sonja Alexander
Headquarters, Washington
202-358-1761
sonja.r.alexander@nasa.gov

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NASA ANNOUNCES COMMERCIAL RLV TECHNOLOGY ROADMAP PROJECT

WASHINGTON -- NASA is partnering with the U.S. Air Force Research Laboratory to develop a technology roadmap for the commercial reusable launch vehicle, or RLV, industry.

"NASA is committed to stimulating the emerging commercial reusable launch vehicle industry," said Lori Garver, deputy administrator at NASA Headquarters in Washington. "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."

The study will focus on identifying technologies and assessing their potential use to accelerate the development of commercial reusable launch vehicles that have improved reliability, availability, launch turn-time, robustness and significantly lower costs than current launch systems. The study results will provide roadmaps with recommended government technology tasks and milestones for different vehicle categories.

"Low-cost and reliable access to space will deliver significant benefits to all NASA's existing missions, from science to human exploration to aeronautics, as well as to our nation's security and to national economic growth," said Doug Comstock, director of NASA's Innovative Partnerships Program at NASA Headquarters. "Part of our plan is to apply lessons learned from the recent past and also the great successes of the National Advisory Committee for Aeronautics in stimulating the American commercial airplane industry nearly 100 years ago."

Commercial Reusable Launch Vehicle (CRLV) Technology Roadmap Study

Sponsored by the NASA Innovative Partnership Program (IPP), and the Air Force Research Laboratory (AFRL)

Study leads:

Daniel J. Rasky, PhD

Senior Scientist, Space Technology Division

NASA Ames Research Center

W. Jesse Glance, Jr., Lt Col

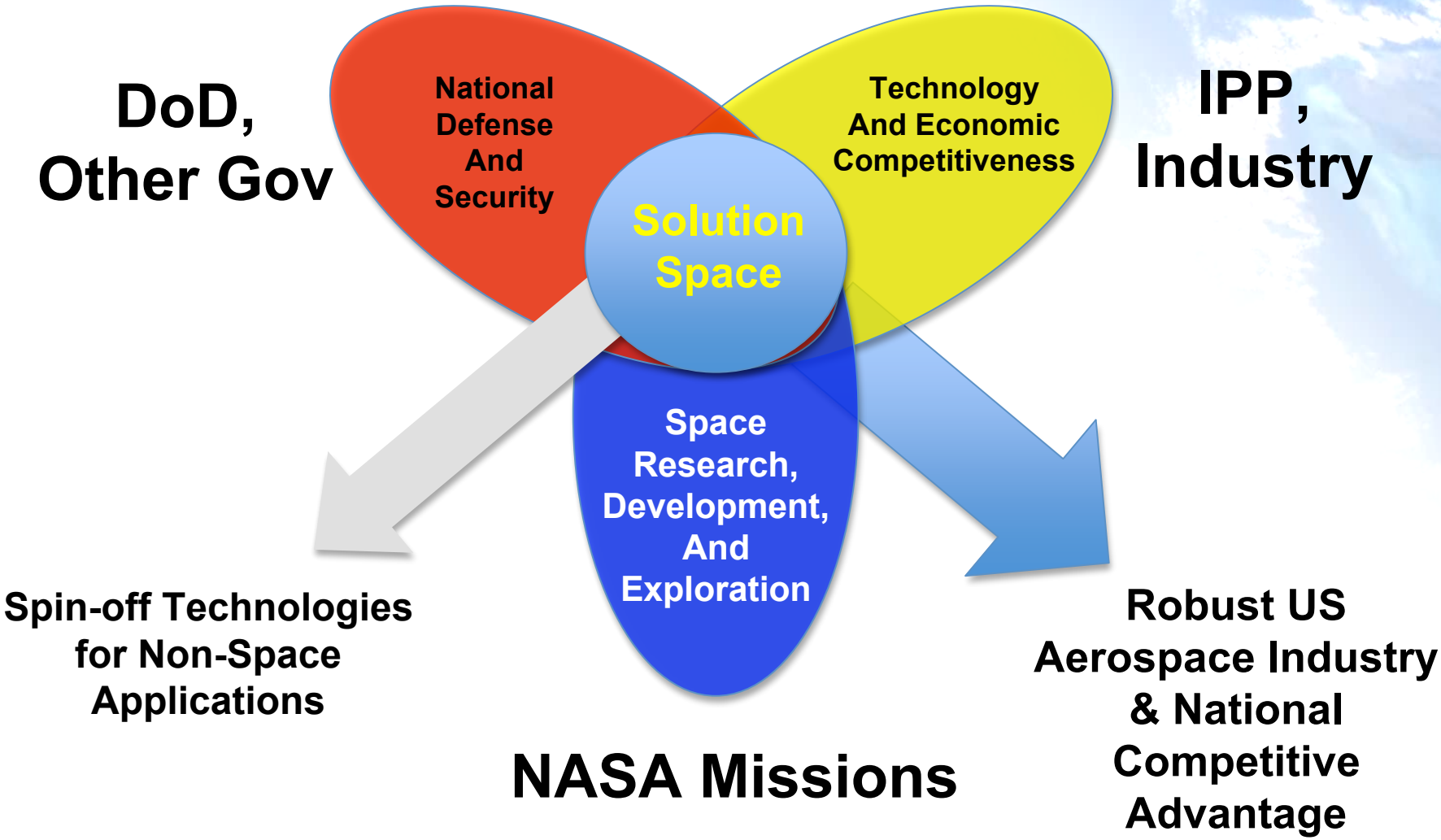
USAFR

Air Force Research Laboratory

Daniel.J.Rasky@nasa.gov: 650-604-1098 Walter.Glance@wpafb.af.mil: 301-213-6618

CRLV Technology Roadmap

… Addressing National Needs



Commercial Space
(How can NASA facilitate?)

- **Unique Facilities**
- **Specialized Expertise**
- **Innovative Acquisition and Collaboration Mechanisms**
- **Programmatic Insight and Oversight**
- **Infrastructure and Support Services**
- **High Value Nonrecurring Engineering**
- **First Article Products**
- **Open Market for NASA needs to alternate (non-traditional, NewSpace) suppliers and sources**

Objective:

- ***Study will focus on identifying technologies and assessing their relative utility for enabling future space access capabilities***
- Primary Goal: **Accelerating development of Commercial Reusable Launch Vehicles (CRLV's)**
- Performance Goals:
  - **Significantly lower cost**
  - **Improved reliability, availability, launch turn-time**
  - **And improved robustness compared to current launch systems**

CRLV Technology Roadmap

- **Key Technologies:**
  - *Entry, Descent and Recovery Systems, (including TPS)*
  - *Propulsion, OMS and ACS*
  - *Structures and Materials*
  - *Avionics, Communications and Flight Control*
  - *Vehicle (Internal) Energy & Thermal Management Systems*
  - *Life Support and Safety Systems*
  - *On-orbit Operations and Equipment*
  - *Ground Support, Operations and Processing Equipment*
  - *Advanced Concept Technologies*

Approach:

- **Four categories of space access vehicles will be considered:**
  1. *Reusable, sub-orbital vehicles (e.g., Virgin Galactic, Blue Origin, XCOR, Masten, Armadillo, Rocket Plane, etc.)*
  2. *Expendable and partially reusable, orbital vehicles (e.g., SpaceX, Orbital, etc.)*
  3. *Reusable, two-stage orbital vehicles (e.g., Kistler)*
  4. *Advanced vehicle concepts (e.g., single stage to orbit, air-breathing systems, in-flight refueling, tethered upper stage, ...)*
- **NASA/USAF will begin the study by soliciting feedback from the emerging commercial space industry about technologies that would most benefit their existing and near-term vehicle systems.**
- **Initial inputs obtained from one-on-one interviews with 19 companies at the CRASTE 2009 conference, October 26-29, 2009**

Approach:

- NASA/USAF will add to the initial list technologies needed for advanced vehicle concepts, as well as longer range technologies needed for the first three vehicle categories.
- For this work NASA/AFRL will draw upon agency expertise as well as vehicle systems studies and analyses.
- NASA/USAF will then evaluate the combined inventory of needed technologies an capabilities and sort them with respect to their value for accelerating CRLV development.
- Where possible, current NASA/USAF programs investing in needed technologies and capabilities will be noted.
- The Sandia Technology Roadmapping Structure/Approach (SAND97-0665) is being used for Roadmap development

Products:

- Roadmaps with recommended government technology tasks and milestones will be compiled and documented, along with initial budget and resource requirement estimates.
- Initial roadmaps will be constructed by February, 2010
- These will be reviewed and refined by an independent review panel of distinguished experts in space transportation systems
- Final Roadmaps will be published in May 2010

Team:

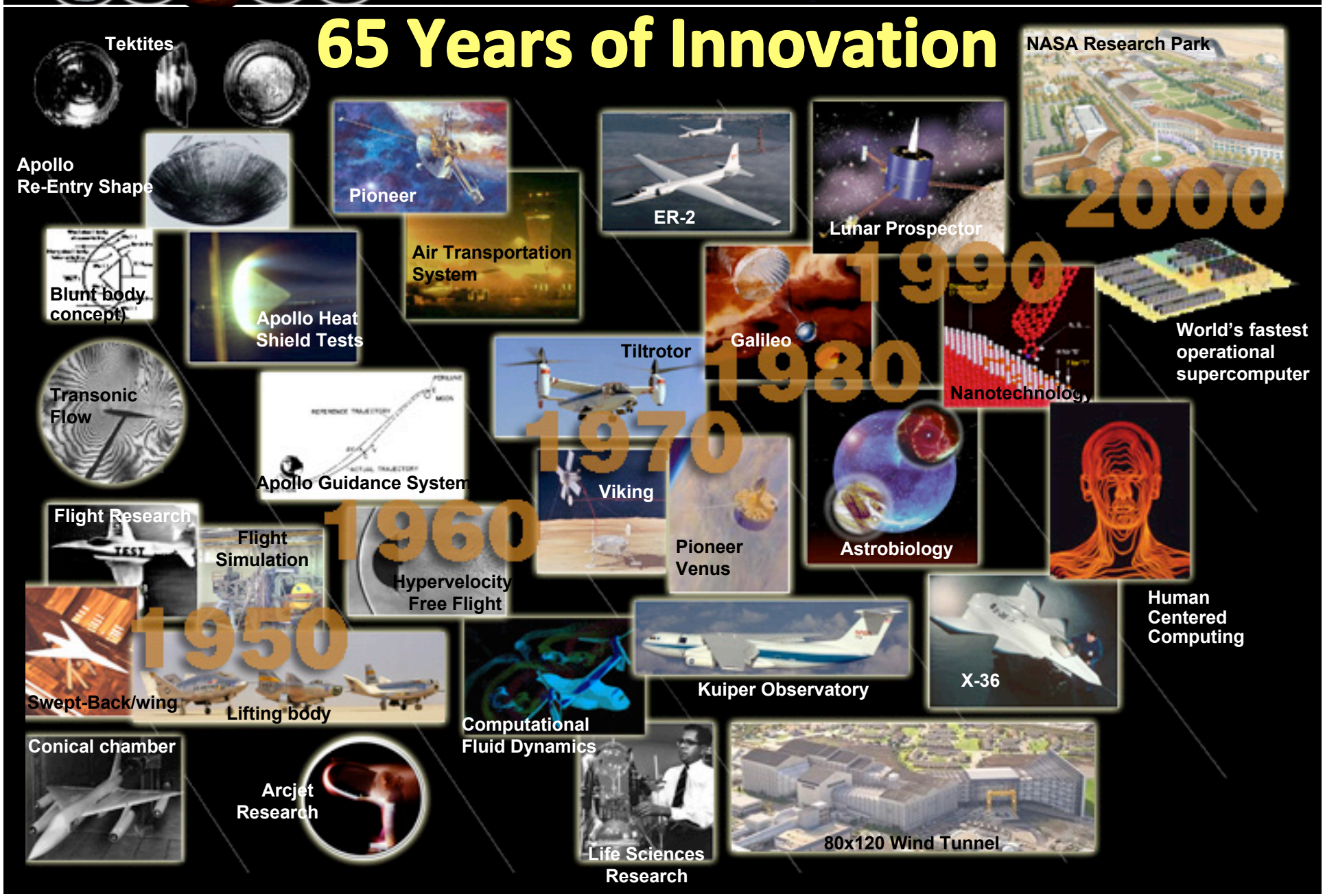
- **The Team that will perform this work is made up of:**
  - **Oversight: Doug Comstock/NASA, Charles Miller/NASA, Minoo Dastoor/NASA, Bruce Thieman/AFRL, Thomas Jacobs/AFRL**
  - **Leads: Dan Rasky/NASA & Walter Glance/AFRL**
  - **Technical Support – NASA: Joe Shaw/GRC, David Hunstman/GRC, Julie Fowler/LaRC, Ron Merski/LaRC, John Kelly/DFRC, Russ Barber/DFRC, Mark Nall/MSFC, David Stephenson/MSFC, Bruce Morris/MSFC, William Hosler/JSC, Brian Hall/WFF, Lloyd Eldred/LaRC, Brian Hollis/LaRC, Brian Jensen/LaRC, Hyun D.Kim/GRC, Sungwan Kim/LaRC, Roger Lepsch/LaRC, David Manzella/GRC, Kevin Melcher/GRC, Ajay Misra/GRC, Mark Newfield/ARC, Hugh Perkins/GRC, Jill Prince/LaRC, Sai Raj/GRC, Charles Smith/ARC, Charles Trefny/GRC, William Winfree/LaRC, James Yuko/GRC, Gregor Hanuschak/ARC, Jennifer Cole/DFRC, Bruce Pittman/ARC, Tony Ginn/DFRC, Bruce Webbon/ARC, Raj Ventekapathy/ARC**
  - **Technical Support – AFRL: Nils Sedano, Jeremy Andrews**
  - **Technical Support – FAA: Nick Demidovich**

Developing Commercial and Military Aviation
Government Supported and Guided
NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
NACA
The National Advisory Committee for Aeronautics (NACA) was founded in 1915 with the intent of being an advisory committee that would coordinate research underway elsewhere. However, it quickly became a leading research organization in aeronautics and the new field of astronautics, pushing back the boundaries of flight through the first supersonic flights and also some of the research that would lead to the human space program under its successor, NASA, to which the NACA passed the torch in 1958.
Opening the Space Frontier
Government Directed and Led
NASA
Developing Commercial Space
Government Supports and Guides
A NEW ERA OF EXPLORATION
Opening New Worlds
Government Directs and Leads

Backup Slides

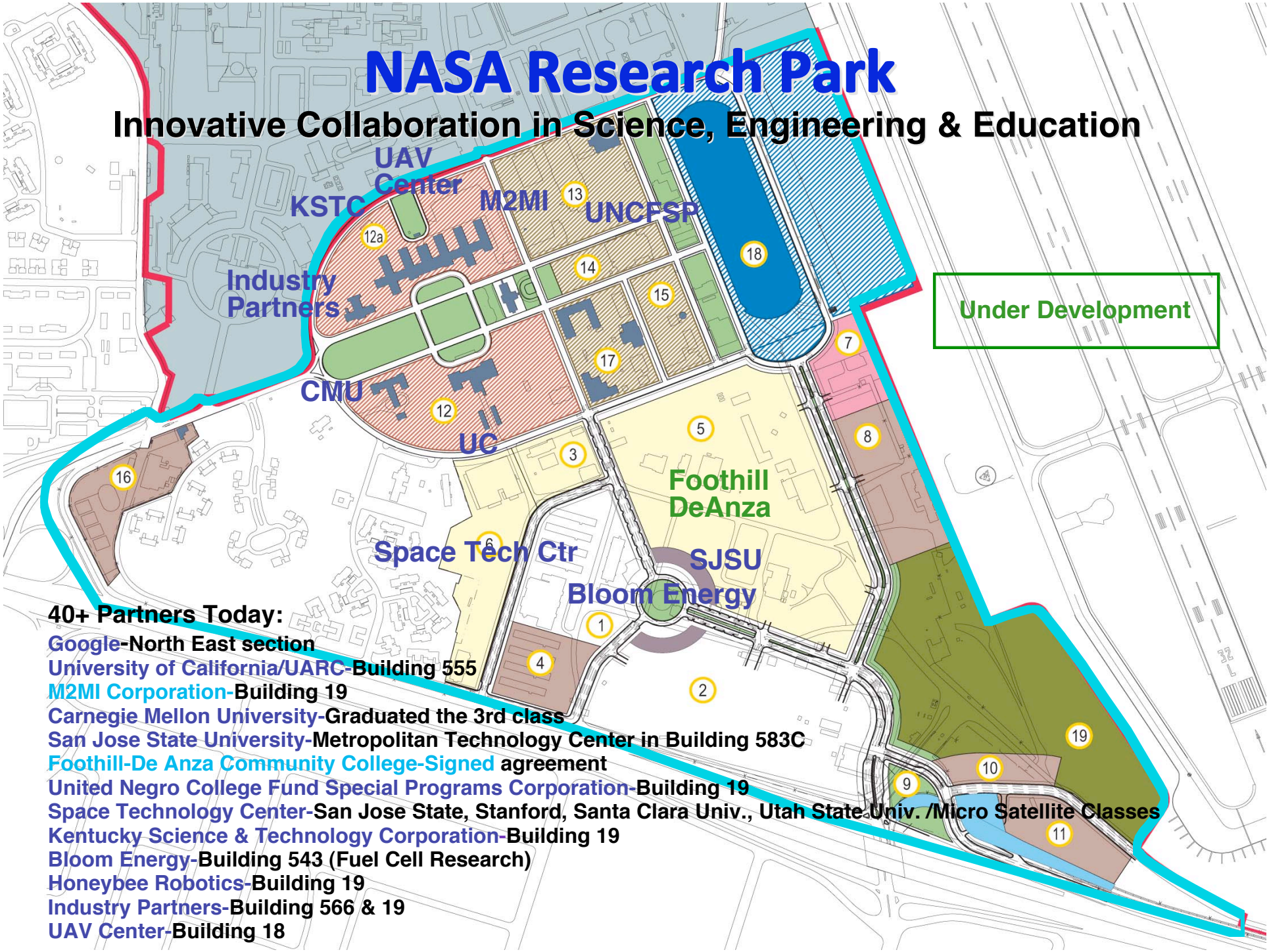
Ames Research Center *in Silicon Valley*

65 Years of Innovation



NASA Research Park

Innovative Collaboration in Science, Engineering & Education



40+ Partners Today:

Google-North East section
University of California/UARC-Building 555
M2MI Corporation-Building 19
Carnegie Mellon University-Graduated the 3rd class
San Jose State University-Metropolitan Technology Center in Building 583C
Foothill-De Anza Community College-Signed agreement
United Negro College Fund Special Programs Corporation-Building 19
Space Technology Center-San Jose State, Stanford, Santa Clara Univ., Utah State Univ. /Micro Satellite Classes
Kentucky Science & Technology Corporation-Building 19
Bloom Energy-Building 543 (Fuel Cell Research)
Honeybee Robotics-Building 19
Industry Partners-Building 566 & 19
UAV Center-Building 18

Space Portal

- **Established in 2006 in the NASA Research Park at Moffett Field**
- **Formed to serve as a "Friendly Front Door" to companies interested in working with NASA**
- **Goals:**
  - ***Promote the vision of the President, Congress and NASA to establish a self-sustaining commercial space economy***
  - ***Infusing entrepreneurial practices into the civil space program***
  - ***Accelerating development of the new space economy for public benefit, economic advancement and exploration***
  - ***Acting as a catalyst for mutually beneficial partnerships that leverage resources among NASA, industry, universities, nonprofits and government***
  - ***Organizing and executing pioneering developments and demonstrations that open new markets***
  - ***Engaging the public and inspiring the next generation of space scientists, engineers, explorers and entrepreneurs***

Entrepreneurial Space Paradigm

Space Customers

- ✦Government, DOD
- ✦Biotechnology
- ✦Microgravity Materials

Space Investors

- ✦Venture Capital
- ✦Government
- ✦Private

Space Industries

- ✦Space Laboratories
- ✦Entertainment
- ✦Tourism, Other

Space Industries

- ✦Launch Services
- ✦Orbital Platforms
- ✦Small to Large Satellites
- ✦Capsule Return Systems

Fostering development of Space Customers and Emerging Space Industries will attract Space Investment and lead us to the tipping point for commercial space

Entrepreneurial Space Partners

Google

ASRC FEDERAL

Cisco Systems

High Frontier

XCOR Aerospace

Lunar Transportation Systems Inc

Virtue Arts

Ecliptic

Masten Space Systems

Paragon Space Development Corporation

RPK

t/Space

SpaceDev

AeroAstro

TGV-Rockets

SpaceX

Scaled Composites

Virgin Galactic

Is it time for a new NACA?

The National Advisory Committee for Commercial Space (NACCS)?

Dawn of a New Era in Space

Helping to tackle the world's biggest challenges:

- ***Emerging global pandemics***
- ***Global climate change***
- ***Resource shortages***
- ***Sustainable living***
- ***Protection of our home planet***

Dawn of a New Era in Space

Creating whole new industries and millions of jobs

Improving the quality of life for this and future generations

A New Era Brought on by

- *Advancements in information technology and the internet*
- *Micro-electronics and miniaturization*
- *Biotechnology and nanotechnology*
- *New space transportation systems from emerging space companies* ***(Falcon-9 from SpaceX and SpaceShipTwo from Virgin Galactic)***
- *New space orbital facilities* ***(International Space Station, SpaceX Dragonlab, Bigelow Orbital Labs)***
- *Public/private partnerships with forward thinking companies interested in space activities (****Google Lunar-X prize)***
- *Evidenced in part by the recent NASA Research Park Exploration and Sustainability Expo (April 21, 2009)*

A New Era that will provide

- *Massive participation by students and regular citizens in space activities*
- *Expanded use of robotics, automation and miniaturization dramatically lowering costs of space activities*
- *Employment of tele-presence, tele-operations and tele-science to enable complex and difficult space tasks*
- *Extensive space monitoring of Earth to identify global resources and risks*
- *Monitoring of our space vicinity to identify planetary threats*
- *Exploring and development of extra-terrestrial resources helping to relieve shortages on Earth*
- *Dramatic expansion of space tourism, entertainment and even rehabilitation*
- ***Important advancements in space biotechnology providing new understanding and approaches for treating disease and the effects of aging***

How Do We Know?

- *From Hosting Five National Workshops on New Uses of Space* (see http://www.alliancespace.net/)
- *Interactions and collaborations with notable individuals*
  - ***Nobel Laureate Baruch Blumberg***
  - ***Biotech Entrepreneur Craig Venter***
  - ***Space Entrepreneur Elon Musk***
  - ***Space Explorer Astronaut Don Pettit***
  - ***Space Biotech Pioneers Cheryl Nickerson and Tim Hammond***
  - ***Visionary X-Prize Entrepreneur Peter Diamandis***
  - ***Visionary Leader Gen. Pete Worden***
- *Working closely with a number emerging space companies:* ***SpaceX, Virgin Galactic, Ecliptic Enterprises, XCOR, Bigelow Aerospace, Blue Origin***
- *Support and participation in numerous commercial and emerging space forums:* ***Space Investment Summits, ISDC, Space Access, AIAA Space 2006-9, FAA AST, NewSpace***
- *Providing critical program creation support and guidance for NASA's Commercial Orbital Transportation Services (COTS) program*

A New Era that needs a new perspective, approach and investment strategy for our activities in space

A New Era that requires Space 2.0 -

a space program for the 21st Century...