Commercial Reusable Suborbital
CRuSR
Research Program

Mission Statement:
Facilitate NASA-sponsored researchers, engineers, technologists and educators access to near-space, regularly, frequently, and predictably at reasonable cost with easy recovery of intact payloads

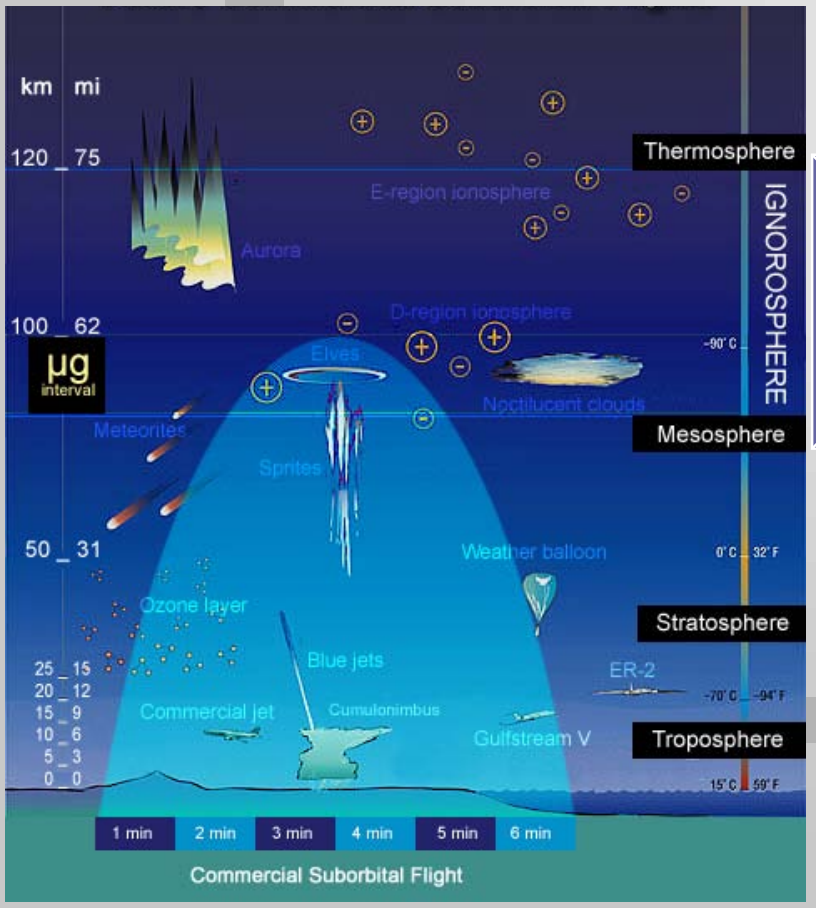
Mike Skidmore
CRuSR Level 2 Program Manager
NASA Ames Research Center

Presentation to
AIAA Commercial Space Group
General Meeting 8
6 Jan 2010

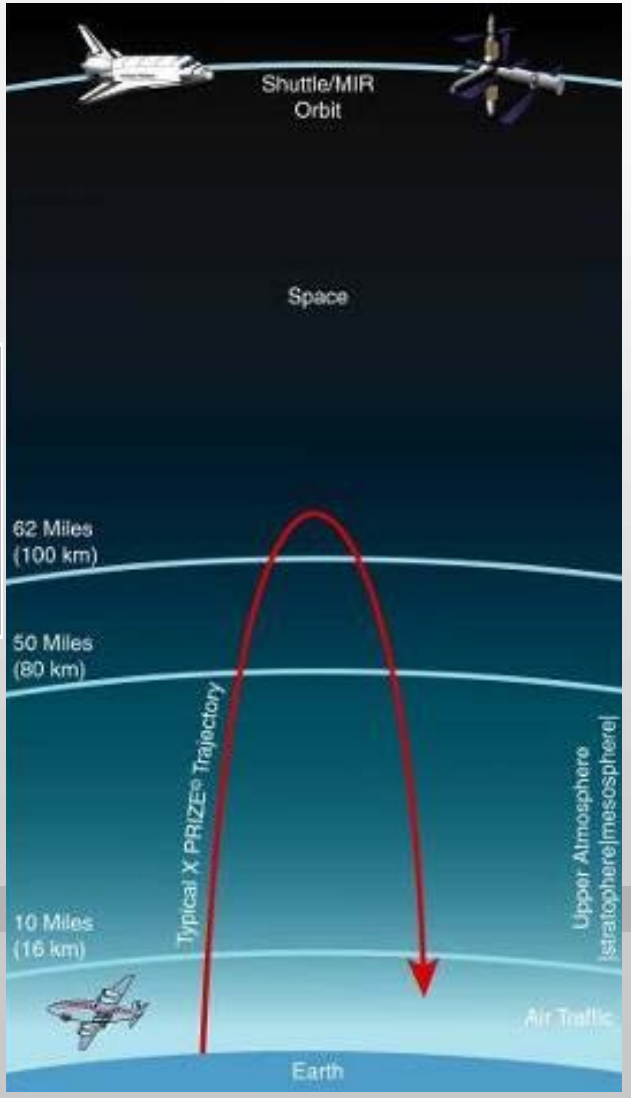
Near-Space?

Commercial Reusable Suborbital Flight

- Nominal 3-6 minutes micro-G
- Access to "ignorosphere"



- too low for orbital spacecraft
- too high for aircraft / balloons



What is CRuSR?

Next-Gen Access to Suborbital Research in Near-Space

- CRuSR Goals
  - Buy space transportation services from emerging reusable spaceflight companies to conduct science research, technology development, and exploit enormous educational potential of spaceflight
  - Engage scientific, technical, and educational (user) community to encourage and promote use of this new opportunity to access near-space
  - Be a Pathfinder to facilitate user access to near-space by supporting development, integration, and flight of the maximum number of scientific payloads on all available commercial reusable suborbital vehicles

"…the Commercial Reusable Suborbital Research program… will buy space transportation services from the emerging reusable spaceflight companies to conduct science research, technology development, with a keen focus on education."

Remarks by NASA Administrator Charles Bolden
at the National Association of Investment Companies Washington, DC; 20 Oct 2009

White House Policy Guidance

- White House direction to Blue Ribbon Panel (7 May 2009)
  - "The review panel will assess a number of architecture options, taking into account such objectives as:
    - Supporting missions to the Moon and other destinations beyond low Earch orbit
    - **Stimulating commercial space flight capabilities**
    - Fitting within the current budget profile for NASA exploration activities"

NASA Administrator Policy Guidance

- "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's founding legislation states that we will 'seek and encourage, to the maximum extent possible, the fullest commercial use of space.' NASA must determine efficient and effective ways to leverage the power and innovation of American industry and the American entrepreneur."
- "As the NASA Administrator one of my greatest challenges — the job I was given by the President — is to lead our NASA team in inspiring the next generation of Americans to once again seek become interested in math, science, engineering, and technology so that our nation can maintain its technological leadership in the world."

Remarks by NASA Administrator Charles Bolden
at the National Association of Investment Companies Washington, DC; 20 Oct 2009

CRuSR Level 1 Program Manager Policy Guidance

Executive Summary from Charles Miller presentation to Japanese US Science Technology and Space Applications Program

- Obama Administration established objective
  - "Stimulating commercial space flight capabilities"
- Low-Cost and Reliable Access to Space (LCRATS)
  - Critical to nation (civil, commercial, national security)
    - Primary Issue: "How do we achieve LCRATS?", not "Should we?"
    - Three attempts in last three decades failed

CRuSR Level 1 Program Manager Policy Guidance (cont)

- NASA is developing a new (very old) approach
  - National Advisory Committee for Aeronautics (NACA) partnership approach is proven, successful
    - Stimulated world-leading aeronautics industry a Century ago
- NACA Approach: Build an industry, not a program
  - Inclusive interagency partnership (NACA was interagency)
  - Do not pick any one or two winners, concepts, solutions, etc.
  - Broadly stimulate emerging commercial space transportation industry
  - NASA is beginning to implement a NACA approach

Commercial Reusable Suborbital Developers

A sample of those who have flown and aspire to Near-Space

Virgin Galactic - Scaled

Blue Origin

XCOR

Armadillo Aerospace

Masten Space Systems

- Horizontal & vertical launch & recovery options
- From 0-6 passengers
- From 0-3 crew
- First full-up test flights in late 2010

Why Commercial Reusable Suborbital?

Approximations

	Expendable Near-Space	Reusable Near-Space	Parabolic Aircraft Flights
Cost/Person	N/A	$200K	Included in payload cost
Cost/Payload	~$0.5M - $1.2M	~$2.5K/kg	~$8K
Time in Microgravity (Continuous)	20 minutes	4+ minutes	23 seconds
Quality of Microgravity	High	High	Comparatively Low
Launch Frequency	Once / month	Multiple flights per day possible	Multiple flights per day possible
Maximum g-Loading	20 g	2 – 4 g	2 – 4 g
Human Tended Science	No	Yes	Yes
Reliability	≥ 99%	TBD	≥ 99%
Late Payload Load / Early Payload Recovery	Special Arrangement	Yes	Yes

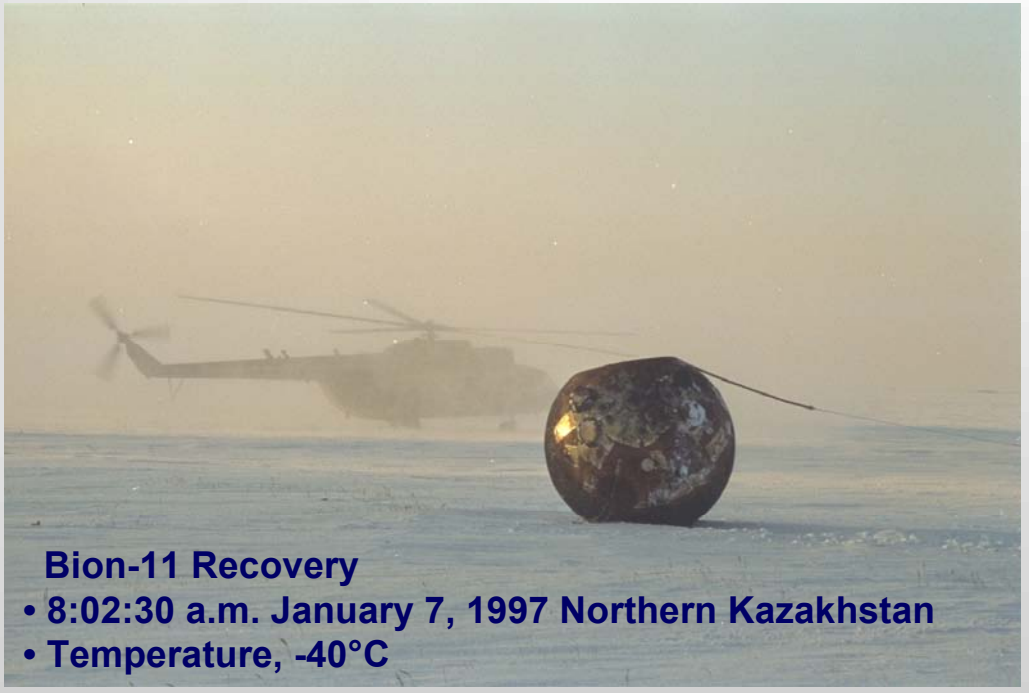
Critical Factors for Spaceflight Research

- ACCESS TO SPACE
- More specifically
  - Low-Cost and Reliable Access to Space (LCRATS)
- Similar needs for many complex experiments
  - Late load
  - Controlled environmental conditions on orbit
  - Rapid Payload recovery
  - Benign shock and "g" loads during recovery
  - Mission design favorable to research imperatives
  - Ability to interact with experiment while in orbit
  - Ability to quickly iterate on successive flights

"The perfect is the enemy of the good."

"Le mieux est l'ennemi du bien." Voltaire: *Dictionnaire Philosophique* (1764)

- Every scientific payload must be adapted to the specific spaceflight "system"
  - Space Shuttle - CEV - ISS
  - Orbital Free-flyers
    - Commercial
      - DragonLab
    - Foreign
    - SmallSat
    - NanoSat
  - Expendable Near-Space
  - **Reusable Near-Space**



- Co-manifested payloads must not interfere with each other
- The Mission/Project Managers job is to get the mission launched while ensuring the maximum scientific return

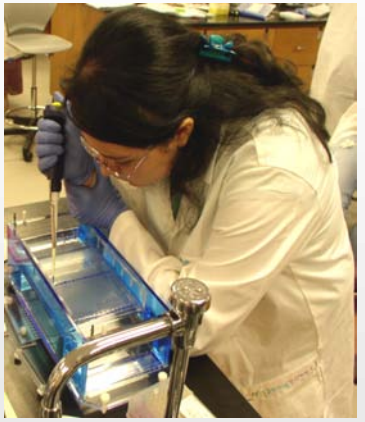
The goal is publishable scientific data

CRuSR Activities: FY2010

- Organize Level 2 Program Office
- Work with NASA science, technology, & education programs to identify spaceflight research payload candidates (users)
- Work with payload providers to characterize each vehicle's Suborbital Flight Environment (Acceleration, quality of μG, etc.)
- Work within NASA,with the FAA, and other regulatory agencies to facilitate safe and effective access to Near-Space
- Facilitate the operations of a commercial payload development/integration industry that will work to move experiments safely and effectively from the laboratory onto Near-Space platforms
- Work with users & industry to identify areas where NASA can best focus our resources (support relevant meetings and conferences)
- Develop procurement strategy to buy space transportation services
- Work to identify and transfer NASA technologies needed by Near-Space Industry (launch providers, payload developers, payload integrators, etc.)

An Opportunity to Really Engage Students

- Rapid access and flight flexibility fits with academic timelines of university students, graduate research, degree cycles, publishing goals
- Partially replaces lost opportunities for low-cost flight engineering and science research experience (e.g. GASCAN in orbiter bay)
- Provides low-risk science/tech assessment and proof of concept for future larger, longer-duration more costly research programs (DragonLab, ISS)
- Possibilities:
  - 1, 10, 25 kg payloads as ballast for other payloads
  - Payloads can hitch rides when margins allow
  - "Pocket payloads" option when deemed safe
  - Student analysis/processing of video data
  - "Teachers in Space" have 15 free flights now



CRuSR Needs Your Help

- CRuSR is soliciting input from user, provider, regulatory, and commercial infrastructure communities so that it may better support the use and development of a robust and vibrant Near-Space industrial community

"… America needs NASA and private industry to work to achieve our national goals in space. This means that NASA must determine efficient and effective ways to leverage the power, and innovation of American industry and the American entrepreneur."

"Help us determine how we can create a more effective partnership between the genius of the American entrepreneur and the power of the federal government."

Remarks by NASA Administrator Charles Bolden
at the National Association of Investment Companies Washington, DC; 20 Oct 2009

CRuSR

"Do what you can, with what you have, where you are"
Theodore Roosevelt

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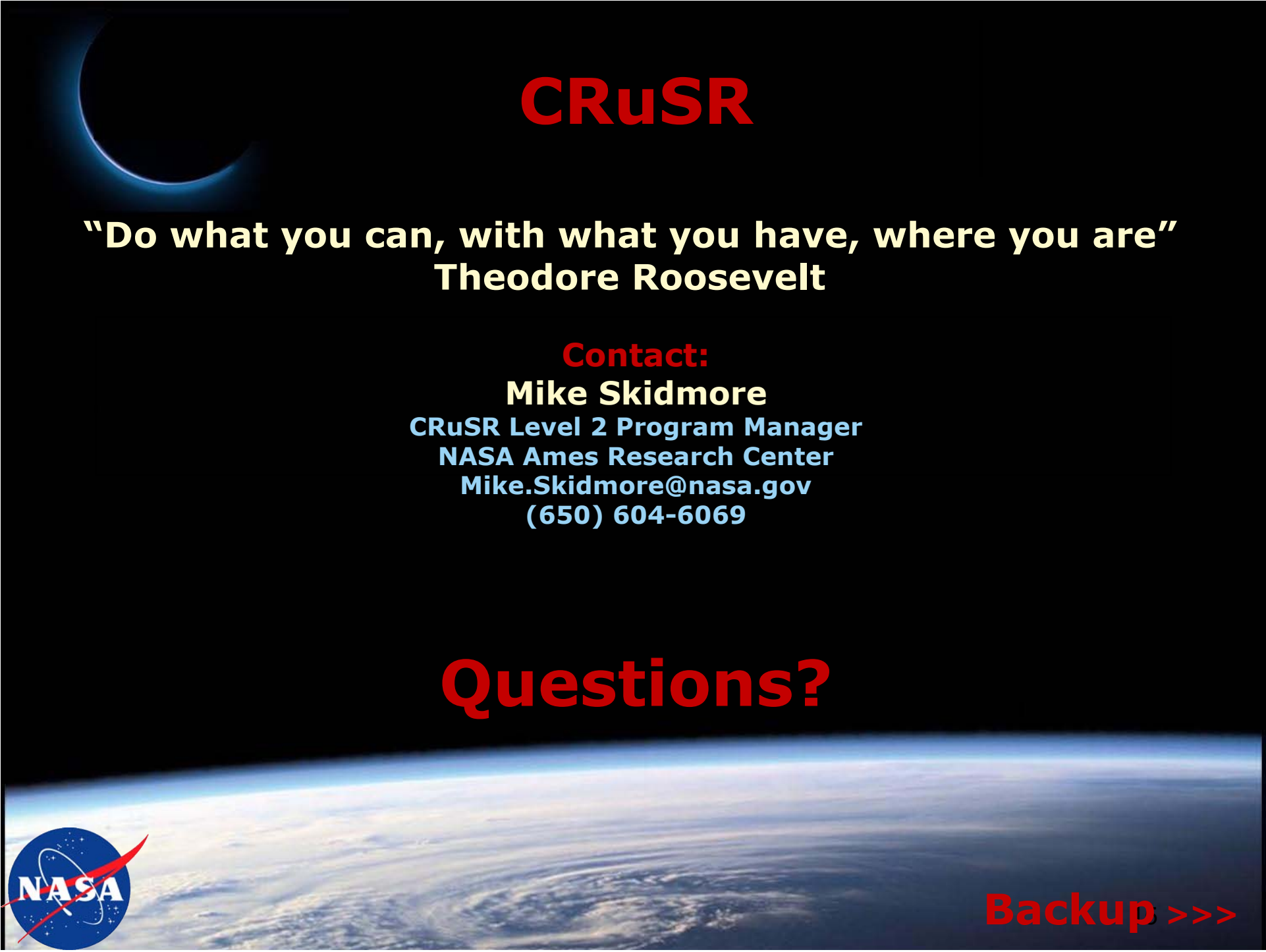
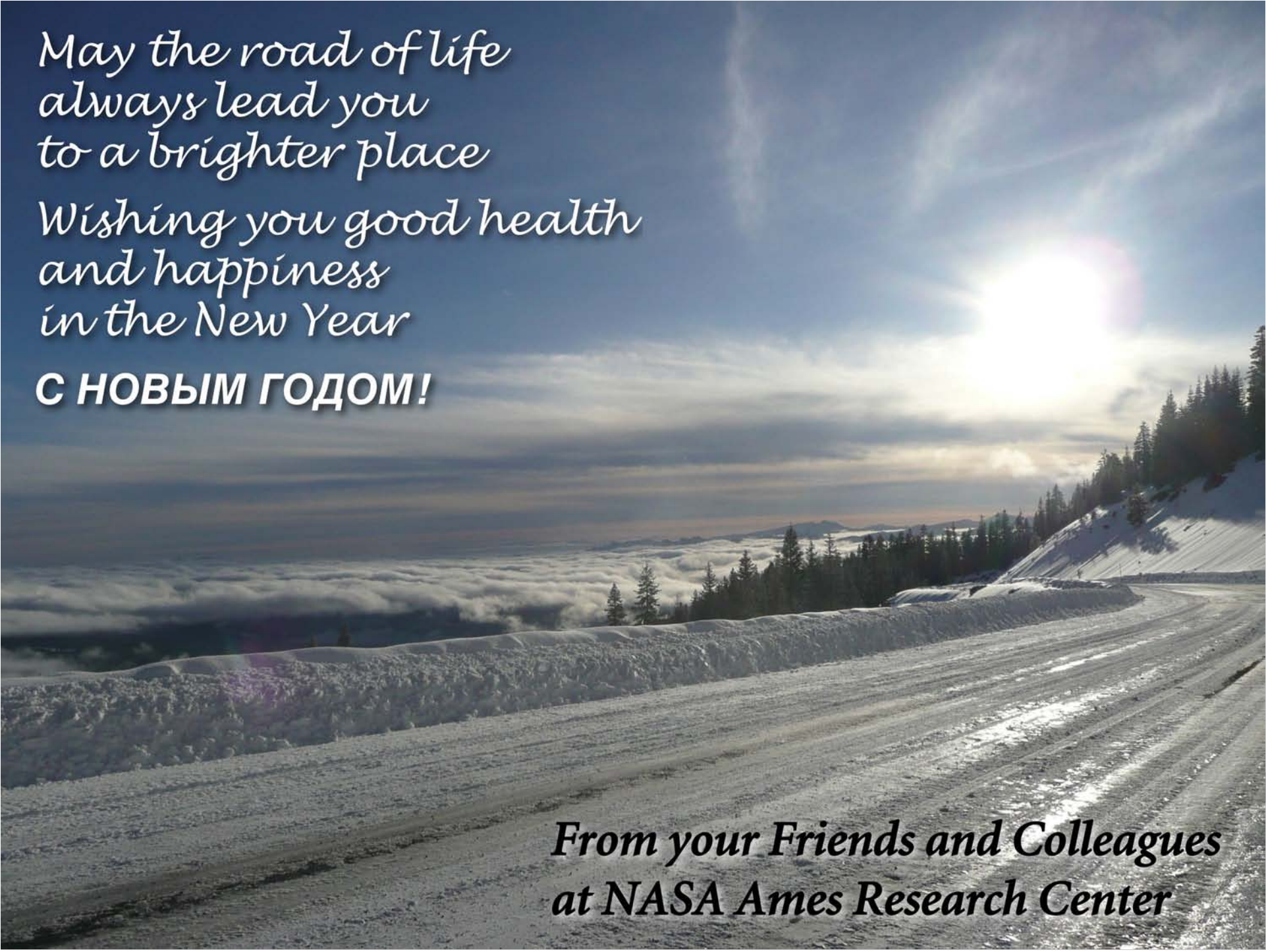
Questions?



Backup >>>

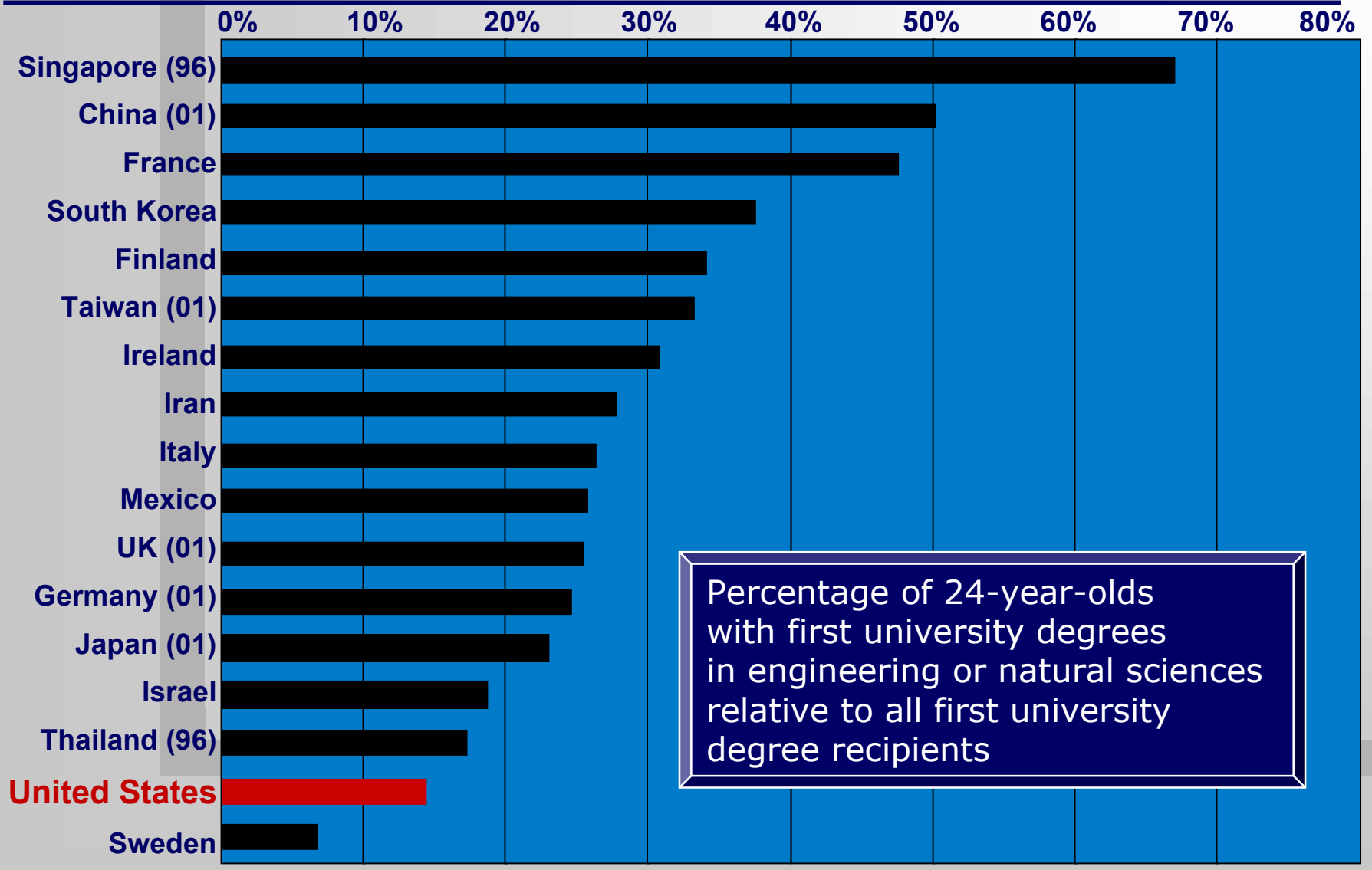

May the road of life
always lead you
to a brighter place
Wishing you good health
and happiness
in the New Year
С НОВЫМ ГОДОМ!
From your Friends and Colleagues
at NASA Ames Research Center

Why Initiate the CRUSR Program?

- Our planet, nation, institutions, and society are at significant risk. The "Gathering Storm" is here. NASA has a great opportunity to act.
- Low-cost, reliable access to space is critical to our civil, commercial and national security and provides new opportunities for international cooperation on global challenges. It's "use it, or lose it" time for NASA.
- An emerging community of commercial near-space vehicle providers, spaceport hubs, space services providers, space travel explorers, space researchers and students needs government support and facilitation. One goal is to create reusable launch vehicles (RLVs) to Earth orbit.
- The predecessor to NASA (National Advisory Committee for Aeronautics - NACA) did it for aeronautics. We can do it again for astronautics with RLVs. Let's help the nation "build an industry, not just a program".

NASA will become more effective at working with the private sector on innovative utilization, as well as technology development.

We have a problem



Source: National Science Board Science and Engineering Indicators 2004
All data gathered in 2002 except as noted in parentheses

Flight Hardware/Payload Development

Initial Concept for NASA sponsored experiments

- Plan to develop a "micro-monitor" to characterize flight environment parameters for each vehicle type, and each mission to support research analysis
- Collaborate with researchers to
  - Characterize payload concepts, vehicle interfaces, options for standardization and modularity
  - Define options for streamlining research payload development, support test and integration with vehicles, and ensure payloads will be safe for human crew and passengers

BioServe
Syringe System

NanoRack
1 - CubeLab

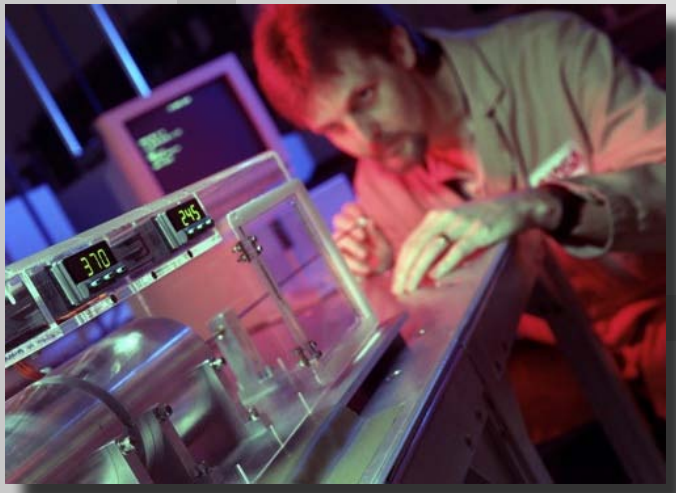
NanoRack Insert
6 - CubeLabs

FastRack
2 - Lockers + Power

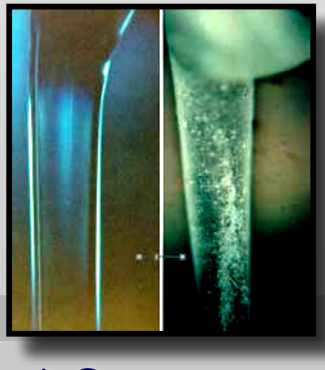
4+ Minutes of Microgravity

Testing

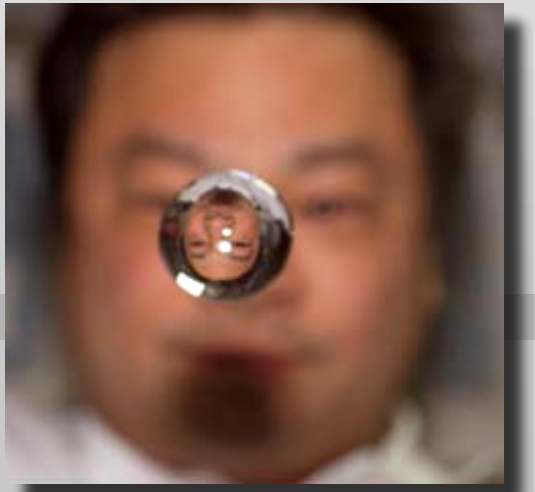
Emergency Procedures



Technology Development/Maturation



1-G



Science

Photos: Courtesy,
Scaled Components, LLC

4+ Minutes of Microgravity (cont)

- Sensing
- Vertical Atmospheric Sampling
- Gene Expression
- Fluids
- Physiology
- Emergency Procedures
- Countermeasures
- Cardiovascular Deconditioning
- Workforce Development
- Resistive Exercise Devices
- Inner Ear Neural Signal
- Dust Particle Agglomeration
- Metal Alloy Phase Separation
- Glovebox Investigations
- Combustion
- IR and NIR Optics
- Technology Testing
- STEM Education
- Cell Cultures

Ignorospheric Science

(Meso- and Thermospheric)

- Aurora Borealis – interaction with space weather
- Atmospheric tides and flows
- Extraterrestrial dust capture
- Transcontinental particulate transport
- Ozone
- Thermal reflectivity or absorption
- Thermo-clines?
- High elevation, low density atmosphere life?
- Weather effects or drivers

Technology Maturation

- "Build a little; test a little" development process
  - Fly cheaply, frequently and often
  - Take risks
    - Try options and learn from mistakes/failures
    - Explore far-out concepts
- Develop standard operations and procedures, e.g.:
  - Systems health management and maintenance
  - Configuration management of software that "learns"
  - First aid or medical procedures in microgravity
- Learn the cost of development and implementation
  - How much time does it take to design and implement a certain technology?
  - What can go wrong?
  - Can the process be improved?

Are there other markets for Near-Space?

- Rapid long-distance transport
- Catastrophe investigation
- ???

CRuSR Near-term Objectives

- Educate the scientific, technological, & educational (user) community about the opportunities presented by this new access to space
- Facilitate user access to Near-Space through the emerging Commercial Reusable Suborbital community
- Work with FAA and other regulatory agencies to facilitate safe and effective access to Near-Space
- Facilitate the operations of a commercial payload integration industry that will work to move experiments safely and effectively from the laboratory onto Near-Space platforms
- Work to transfer NASA technologies and processes critical to the transition of experiments from laboratories onto Near-Space platforms

CRuSR Near-term Objectives (cont)

- Work with established spaceports to encourage commercial activities that facilitate the growth of suborbital space research
- Work with government (DoD, other agencies) and industry to leverage resources across the R&D community to develop access to Near-Space
- Work with government's administrative infrastructure to define strategies and approaches that facilitate research access to Near-Space
- Engage education community to integrate their expertise and creativity into Near-Space research so integration of Scientific, Technical, Engineering, and Mathematical (STEM) educational assets and Near-Space are mutually beneficial and self-sustaining

CRuSR Near-term Objectives (cont)

- Facilitate development of open interactive websites where:
  - Research community can exchange information and ideas to facilitate development of an active and knowledgeable user community
  - Launch provider community can share information to develop common community responses to items of interest, develop standard payload interfaces, and communicate capabilities to potential users
  - Broader Near-Space community (launch providers, users, service providers, government) can exchange information and develop innovative collaborations with established spaceports to encourage commercial activities that facilitate the growth of suborbital space research