



Dryden Flight Research Center

*NASA Advisory Council
Commercial Space Committee*

September 18, 2012

David McBride, Center Director

Agenda



- Introduction to Dryden
 - Vision & Mission
 - Competencies
- Current Missions
- Space Committee Questions
- Dryden's Future in Space

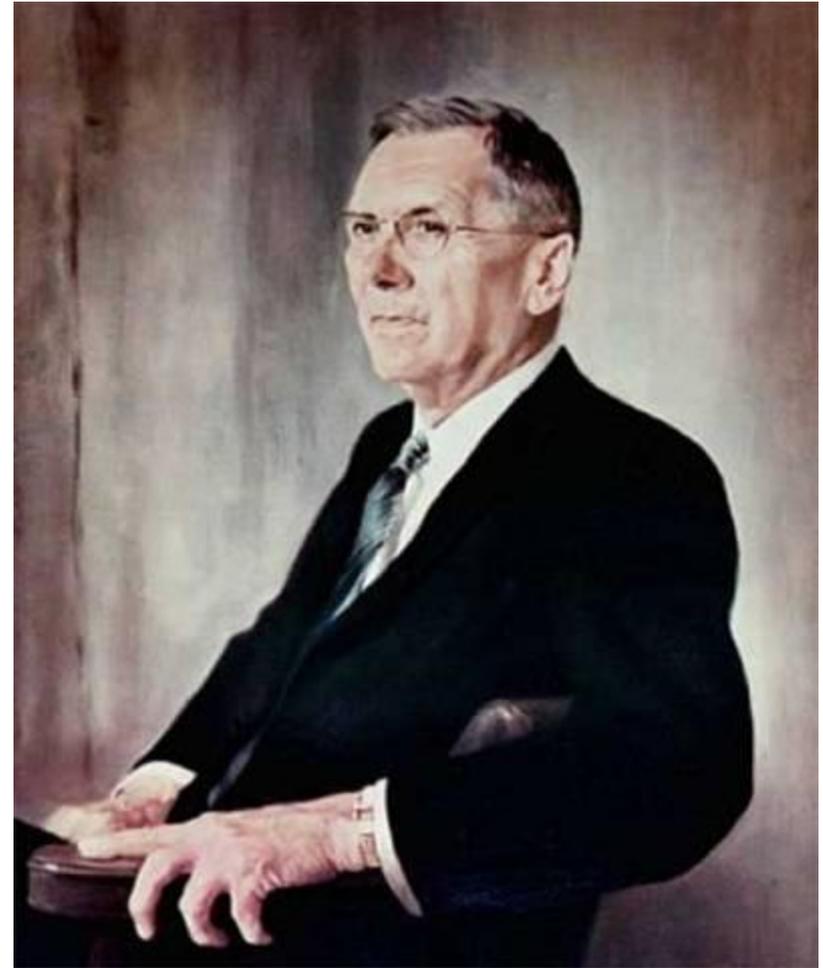
Our Namesake



Why there is a need for flight research,

“ . . . to separate the real from the imagined and to make known the overlooked and the unexpected. . . ”.

Dr. Hugh L. Dryden,
Administrator of NACA,
First Deputy Administrator of NASA



To Separate the Real from the Imagined – Through Flight



To Separate the Real from the Imagined – Through Flight

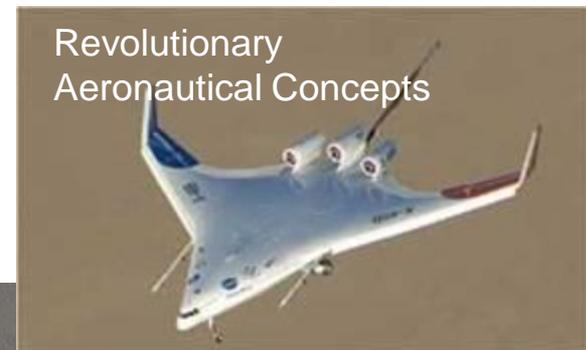


Advancing Technology and Science Through Flight



- Mission Elements

- Perform flight research and technology integration to revolutionize aviation and pioneer aerospace technology
 - Validate space exploration concepts
 - Conduct airborne remote sensing and science observations
 - Support operations of the Space Shuttle and the ISS
- ... for NASA and the Nation



Dryden Flight Research Center

Edwards Air Force Base



- Remote Location
- Varied Topography
- 350 Testable Days Per Year
- Extensive Range Airspace
- 29,000 Ft Concrete Runways
- 68 Miles of Lakebed Runways
- 301,000 Acres
- Supersonic Corridor

Summary of Dryden Flight Research Center

Unique National Asset: Location, Capabilities, Facilities



- Core Competencies

- Atmospheric Flight Research and Test
 - Flight Safety and Risk Management
 - Flight Project and Mission Management
 - Flight Research Technology
 - Flight Test Operations
 - Experimental Aircraft - piloted and unpiloted



FY12 Vital Statistics:

Civil Servant Staff
~ 555

On-site Contractors
~ 650

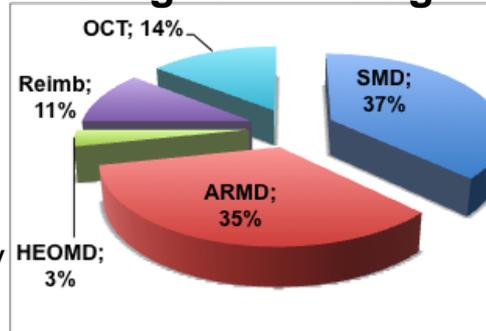
Budget
~ \$263M

- Facility Capability

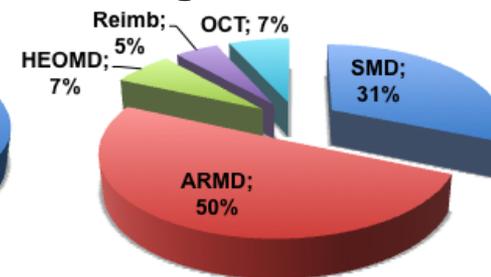
- Flight Operations & Engineering Staff
- Experimental and Testbed Aircraft
- Unmanned Aircraft Systems
 - Extensive experience in securing Certificates of Authorization (COA) for UAS flights
- Airborne Science Platforms
- Range and Aircraft Test Facilities
 - Western Aeronautical Test Range
 - Research Aircraft Integration Facility
 - Flight Loads Laboratory
 - Dryden Aircraft Operations Facility



Program Funding



Program Workforce



Mission Activity



ARMD/ISRP/Environmentally Responsible Aviation



- X-48B/C

- Evaluate low speed stability and control of blended wing body configuration in free-flight
- Evaluate flight control algorithms
- Evaluate prediction and test methods for blended wing body class vehicles



- Development of Subsonic Research Aircraft Testbed (SCRAT) research platform aircraft

- Adaptive Compliant Trailing Edge (ACTE) planning and design
- Discrete Roughness Element (DRE) PDR



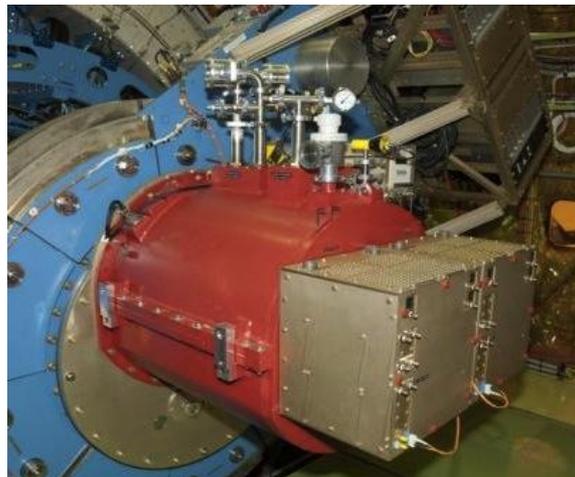
Multiple Altimeter Beam Experimental LIDAR (MABEL)

Greenland & Iceland
April 1 – April 27, 2012



- **Satellite Sensor Calibration/Validation**
 - “Collect airborne laser altimetry data (specifically data over sea ice and the Greenland ice sheet) to develop algorithms for MABEL's satellite counterpart ICESat-2
 - ICESat-2 will use a similar strategy to measure elevation of the earth, in particular, elevation of the ice sheets and sea ice in the polar regions”

SMD/Astrophysics/SOFIA



Key Space Committee questions



- How is the Agency's Commercial Space Strategy perceived at DFRC?
- What is DFRC doing to promote Commercial Space ?
- What are the Center's plans for transitioning from Shuttle and Constellation to the new Agency direction that includes Commercial Space, and how are those plans progressing ?
- How is DFRC planning to use its facilities for commercial space activities ?
- How is DFRC addressing excess capacity issues ?

Even though Dryden is thought of as an Aeronautics Center,

Applying atmospheric flight test expertise to space systems development proves to be an effective approach:

- Flight test expertise (PA-1)
- Systems Engineering
- Avionics Integration
- Flight Instrumentation
- Flight Test Planning
- Flight Test Objectives
- Range Operations

Dryden has formed important partnerships with both government and commercial space organizations in order to support and conduct atmospheric tests

DFRC experience and engineering judgment have expedited efforts such as the Orion PA-1 flight test

DFRC has a central role in managing commercial suborbital flight activities through the Flight Opportunities Program

We will continue to play significant rolls for all atmospheric flight testing in the Exploration and Space Technologies areas of NASA

Dryden has Performed 663 Rocket Powered Flights from 1946-2010



Summary

- Rocket propelled flights Bell X-1 thru Pad Abort-1
- Total flight operations—663
- Total manned flight operations—654

Manned Flight - Rocket Powered Operations (glide flights not included)

- 135 Bell X-1, 23 Bell X-1A, 25 Bell X-1B, 24 Bell X-1E
- 134 Douglas Skyrocket D-558-2
- 198 North American X-15
- 115 Lifting Bodies (M2-F2, M2-F3, HL-10, X-24)

Unmanned - Rocket Powered Operations

- 6 B-52 / Orbital Sciences Pegasus Launches
- 2 B-52 / X-43 Hyper-X (Mach 7 & Mach 10)
- 1 PA-1 White Sands Missile Range



NASA Space Operations at Dryden



- Primary alternate landing site
- On-orbit communications support for International Space Station (ISS) and Shuttle Orbiter
- Telemetry support
- Shuttle Carrier Aircraft (SCA) maintenance and support
- 59 DFRC landing operations
 - 135 total flights

Exploration Systems

Launch Abort Flight Test



- Orion crew exploration vehicle includes a launch abort system (LAS) that assures crew escape after failure
- Lead Flight Test Vehicle Development and Test
 - Systems Engineering & Integration
 - Safety and Quality Assurance
 - Development Flight Instrumentation
 - Abort Test Booster Procurement Lead
 - Crew Module Integration and Test
 - Launch Facilities & Ground Support
 - Lead Flight, Ground, & Range Operations



Key Space Committee questions



- How is the Agency's Commercial Space Strategy perceived at DFRC?

We at DFRC see this current strategy as the perfect mix of commercial activity:

- *Commercial Space Orbital (SpaceX, Boeing, Sierra Nevada and others)*
- *Commercial Suborbital activity (Masten, Xcor, Virgin Galactic, Up Aerospace, Near Space, and others)*
- *The wide open, competitive nature of these activities fits well with the DFRC culture. We as a center are thriving in this atmosphere, reaching out and finding strong connections and ways to meaningfully contribute to the atmospheric testing that is vital to all of this activity.*
- *We do perceive a rather heavy overhead burden from the CCDEV Insight/Oversight Product Integration Team activities on the Commercial Orbital companies.*



- **Flight Test Airworthiness Process at Edwards**
- **Hangar Space**
- **Flight Termination System equipment and Analysis**
- **Coordination with Air Force for ground and range safety**
- **Ground Operations support**
- **Control Room operations**
- **F-18 in-flight simulator**
- **Range Operations (tracking, telemetry)**
- **Chase/photo/video support**
- **Flight data storage and retrieval**
- **Vehicle flight test preparation**
- **Life support functions (Ejection seat loan and support, pressure suits)**
- **Pad Abort Test preparation**

Sierra Nevada Dream Chaser flight test program



Engineering Test Article (ETA) Drop Tests (Late 2012/Early 2013)

- 6 drops, Uninhabited, Unpowered
- Autonomous
- Flight Termination System (FTS)



Sub Orbital Vehicle (SOV) Tests (2013/2014)

- Piloted, powered, ejection seat
- 4 Unpowered, 6 powered tests
- Powered Tests use Supersonic Corridor (Mach >3, Alt > 100k ft)



Pad Abort Test (2015/2016)

- Uninhabited
- Flight Termination System (FTS)
- Launch from Edwards range



Flight Opportunities Program

- Established to facilitate the maturation of technology payloads to higher TRL's through flights in relevant environments, and
- To foster growth in the emerging commercial suborbital platform industry

- Chartered under NASA's Space Tech Program, Managed at Dryden . . .
 - 60+ years of high-speed, rocket-powered suborbital flight heritage
 - Proven Airworthiness and Flight Safety Review process



Key Space Committee questions



- What is DFRC doing to promote Commercial Space ?

The DFRC Flight Opportunities Program has become known throughout the nation as the leading provider of commercial suborbital launches and payload development.

DFRC has a strong connection with local commercial space companies in Mojave, Cal., which is a hot bed of commercial space activity. We are actively trading ideas and looking for unique, value added partnerships.

DFRC has a strong, supportive relationship with the management of Mojave Space Port which has made possible many successful public affairs events and meetings with government officials which have positively influenced the Commercial Space activity for our nation.

The DFRC Aero Institute is a unique outreach organization which regularly promotes commercial space activity throughout the nation.

Key Space Committee questions



- What are the Center's plans for transitioning from Shuttle and Constellation to the new Agency direction that includes Commercial Space, and how are those plans progressing ?

We feel that we are almost completely transitioned.

By Mar 2013, essentially all of the Shuttle Assets will be dispositioned.

We are strongly tied with both the Commercial Orbital and Suborbital Space communities.

We are actively engaged, looking and developing new ideas to benefit Commercial Space.

Future of Human Exploration of Space at Dryden



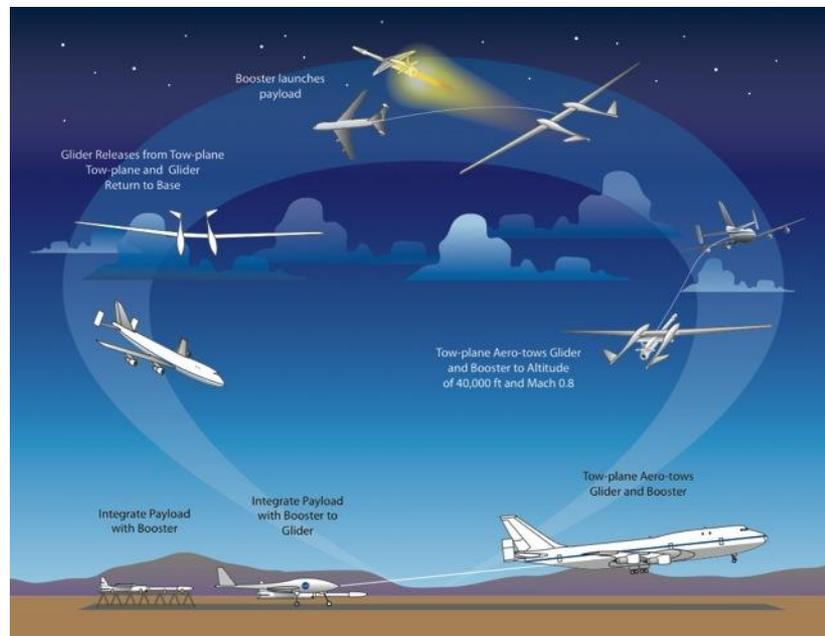
- Launch Abort Systems
 - Systems Engineering & Integration
 - Flight, Ground, & Range Operations
- Planetary Lander Flight Simulation
- Commercial Crew
 - Systems Validation
- Mid-air Recovery of Payloads
- Recovery of Space Capsules
- Alternative Launch Concepts
- ...



Air-Launch From A Towed-Aircraft



- Air-Launching rocket boosters from a remotely piloted, towed aircraft
- Potential partners are DARPA, NASA, AFRL, Academia/Science, Industry
- More versatile (geometry) than launching from a piloted, powered, carrier aircraft



- Potential to reduce the cost of launching payloads to orbit by as much as 40%
- Approach is scale-able from small microsats to large (10-20k lbs) payloads

Key Space Committee questions



- How is DFRC planning to use its facilities for commercial space activities ?

We are planning to share the facilities that we currently use for aircraft applications such as simulation and flight loads facilities to support space activities as appropriate.

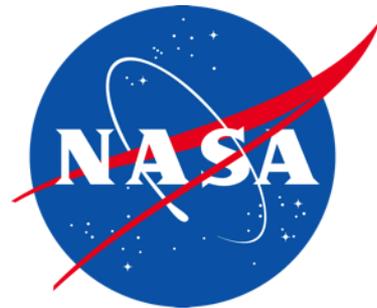
We at DFRC are also planning to re-use launch facilities such as the X-33 launch pad to host new commercial flight activities on the Edwards range.

- How is DFRC addressing excess capacity issues ?

DFRC currently has no excess capacity issues. We are short on both labor and facilities for the work load we currently have.

Questions?





Mid-Air Recovery of heavy items (~25,000 lb) from Commercial Launches (capsules, Rocket Engine modules, etc) will lower the operational cost of future commercial launches



1. Helicopter in formation with the parafoil

4. Helicopter climbs to pull drogue line forward until grapple meets drogue

2. Open grapple is steered to intercept drogue line



3. Grapple closes around drogue line



5. Load is gradually transferred from parafoil to helicopter

6. Parafoil cutaway to reduce drag

Masten Xeus Vertical Lander: Unique vehicle to increase payload access on other planets

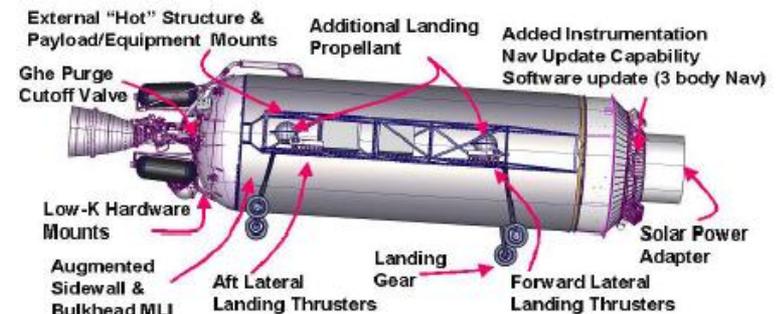


- Concept for a Lunar Landing Vehicle Based on Centaur Upper Stage
 - Most of Delta-V for Lunar Landing Done in Vertical Orientation Using RL-10 Engines, Vehicle then Rotates to Horizontal Orientation for Landing Using Separate Landing Engines
- Vehicle Concept Being Pursued by Madsen in Mojave
 - Have Teamed-Up with United Launch Alliance (ULA) on Proposals
 - Centaur Upper Stage at Madsen Facility in Mojave, Studying Modifying Stage for Vertical Landing Tests
 - Tests would Use Madsen Liquid Rocket Engines, Initially Vehicle would Take Off and Land Vertically
 - Eventually would want to Test Vertical to Horizontal Rotation Maneuver



Orientation During Most of Descent to Lunar Surface, RL-10 Firing to Slow Vehicle

- DFRC Role Vertical Landing Flight Tests of Vehicle on Edwards Range
 - Vertical Landing Vehicles Possible Future Business Area for DFRC
 - Planned Vehicles Getting Too Large with Too Much Performance for Flying at Mojave
- Currently Several DFRC Personnel Participating in Telecons, Reviewing Proposals Being Put Together by Madsen and ULA



**Landing Orientation
Separate Landing
Rockets**