Space Technology Demonstrations Using Low Cost, Short-Schedule Airborne and Range Facilities at the Dryden Flight Research Center

NSRC
John Carter, John Kelly, Dan Jones, James Lee
Dryden Flight Research Center
6-4-13
Brief Overview

We need to expedite advanced space technologies on new space systems.

These technologies need to be demonstrated in a relevant environment before being installed in new space systems.

This presentation introduces several low cost, short schedule space technology demonstrations using airborne and range facilities available at the Dryden Flight Research Center.

Just because it doesn’t look like a rocket doesn’t mean that you can’t reduce rocket technology risk!
Location, Location, Location!
An Alliance with EAFB allows access to . . .

- Restricted Airspace
- Rogers Dry Lake
- The Precision Impact Range
- Tracking and Communication
Launch Vehicle

Flight Control Design Challenges

- Large, highly flexible vehicle structure
- Propellant tanks with lightly damped lateral sloshing modes
- Uncertain dynamic characteristics of payload envelope (elastic, slosh)
- Widely varying operating conditions
- Complex multi-engine Thrust Vectoring Control
- Robustness and Redundancy requirements for human rating

Solution: adaptive control

Adaptive control provides additional robustness by using sensed data to adjust the gain on-line; senses off-nominal upper and lower limits in real time.

The solution can be tested *in flight* quickly and easily ...
F-18 Experiment Configuration

- Replicate SLS dynamics using the on-board F-18 research computers
- Use a research autopilot to fly a pitch-over trajectory
- Turn adaptive controls on/off and examine effect

1. Accelerate to 0.75M
2. Zoom to 70° pitch angle and decelerate to RFCS envelope (< 250 kts)
3. Arm and engage research controller
4. Begin to track a constant +0.2g trajectory for 30 seconds (-1 deg/sec pitch over)
5. Disengage and recover at -30° pitch angle

Initial altitude 15 kft

Peak altitude 28 kft

Representative Pitch Axis Flight Trajectory*

*From Orr and VanZwieten, AIAA 2012-4549
The F-15 Flight Testbed—Advancing Technology through Captive-Carried Flight

- Active Propulsion experiments
- Aero experiments
- Fiber Optics experiments
- Supersonic envelope
- Fully instrumented
- Low cost and quick schedule

Shuttle Thermal Protection System
Advanced Inlet design
Supersonic Boundary layer
The F-15 Propulsion Flight Test Fixture (PFTF)
Advanced Rocket Propulsion Experiments

- Rocket Based Combined Cycle (RBCC)
- Pulse Detonation Engine (PDE)
- Several Altitude-Compensating Nozzle (ACN) concepts
- Numerous other advanced propulsion experiments
Rockets

- One Test
- Don’t get test article back
- $Millions
- Limited schedule
- Long lead time

Test Beds

- Almost Unlimited tests
- Get test article back for reuse
- $Thousands
- Flexible schedule
- Short lead time
Not only high-speed test beds, but test beds that can reach high altitudes for long periods of time

- **ER-2**
  - 65,000 ft, 6 – 10 hrs, 6,000 mile range

- **Global Hawk**
  - 65,000 ft, 31hrs, 10,000 mile range

- **Ikhana (MQ-9 Reaper)**
  - 40,000 ft, 24 hrs, 10,000 mile range

- High altitude sensing
- Observations above water vapor
- Modern Transponders/Communication

[http://www1.nasa.gov/centers/dryden/aircraft/index.html](http://www1.nasa.gov/centers/dryden/aircraft/index.html)
Access to Restricted Airspace . . .
Short Schedule, High Value Testing and Demonstrations
Power-Beaming Centennial Challenge
SNC Dream Chaser Approach and Landing Tests
ALHAT Field Demonstration
(Autonomous Landing and Hazard Avoidance Technology)
Mars Science Lander
Curiosity Radar testing

F-18 Radar Calibration of the on chute portion of the MSL descent

Helicopter testing mimicking the rocket powered MSL descent, looking for radar clearance around the rover
Mars Science Laboratory
Landing Radar Testing
Dryden Aircraft Descriptions and POC’s
http://www1.nasa.gov/centers/dryden/aircraft/index.html