Phoenix Missile Hypersonic Testbed (PMHT)

Project Concept Overview

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Need and Goals

• Need:
  – A low cost hypersonic research flight test capability to increase the amount of hypersonic flight data to help bridge the large developmental gap between ground testing/analysis and major flight demonstrator X-planes

• Goals:
  – Develop an air launched missile booster research testbed to:
    • Accurately deliver research payloads
    • Through programmable guidance
    • To hypersonic test conditions
    • At low cost
    • With a high flight rate
Objectives

• 5.5 ft$^3$ of payload capacity
• Exceed (with different trajectories):
  – Mach 5 with at least 500 psf dynamic pressure
  or
  – Dynamic pressure of 2000 psf with at least Mach 3
• Unit test cost under $500K
• Test flight rate minimum of 2 flights/year
• Utilize surplus air launched missiles and NASA aircraft
PMHT Concept

PMHT would be air-launched from NASA F-15B using F-14 launch hardware from within F-15B flight envelope and internally guided to test condition

- Utilize surplus AIM-54 Phoenix missiles from US NAVY as booster for Supersonic/Hypersonic Flight Research
- Utilize surplus F-14 hardware to mount Phoenix missile to NASA F-15B
- NASA F-15B operates from Dryden Flight Research Center
- F-15B transits to Pacific Missile Test Range at specified launch conditions (alt/Mach)
- Missile launch from F-15B and internally guided to test condition(s)
- Missile descent and splashdown into the Pacific
- Alternate mission profile could be operated over land within restricted airspace and impact the ground for payload recovery
PMHT Configuration

Theoretical Research Payload Capability
Diameter - 15 inches
Length - 89 inches
Effective Volume - ~7 cu ft.
Allowable Weight - ~250 lbs.

Utilize experience with F-15B flight test fixtures such as PFTF

Utilize surplus flight-proven F-14 hardware

Design Concept

Research payload
Autopilot/Servos
Guidance and Nav
AIM-54 Internal Hardware Schematic

- All internal components removed from guidance and armament sections to make space for payload and new guidance computer and INU
- Components to be removed include warhead, old guidance computer, and radar tracker
Basic Payload Concept

- Basic Payload Concept
- Radome
- Guidance Section
- Armament Section
- Propulsion Section
- Control Section
- Wings
- Primary Payload Section
- Secondary Payload Section
- New Guidance Section
- Rear Payload Volume TBD
- Control Surfaces
Payload volume consists of two areas (primary and secondary) separated by a bulkhead at the location of a launch lug.

- All internals of guidance and armament sections removed.
- Secondary payload immediately aft of primary.
- Length of secondary payload is TBD, but in the neighborhood of 12-18 inches.
- Payload instrumentation and power interfaces are TBD.
Missile Preflight Activities

• Mount the payload-integrated missile on the aircraft
• Power aircraft using external ground power
• Power Phoenix on external power via cockpit switched power relay
• Connect Ground Servicing Equipment (e.g. Laptop) to Phoenix GSE port
  – Upload guidance waypoints for planned trajectory
  – Upload controller and/or payload constants
  – Collect Phoenix telemetry via hardwire to GSE
• Verify system health and safety monitoring from aircraft rear cockpit display
  – Payload and missile systems instrumentation data available through on-missile data bus
• Verify INS performance
• Command MOAT (Mission on Aircraft Test) from rear cockpit
• Ready A/C for takeoff
Notional Ground Path

Missile data is telemetered through Western Missile Pacific Test Range to Control Room for Immediate Data Review.
Sample Theoretical Trajectories

- The missile is capable of reaching useful high-speed test conditions
  - 8 seconds > mach 5.0
  - 50 seconds > mach 4.5
  - Weight reductions improve performance
- High altitude test conditions in excess of 300kft are also kinetically possible
  - Controllability of the store will limit this to <150kft without additional control mechanisms
- High dynamic pressure test conditions are also kinetically possible
  - Structural and actuator authority limitations will reduce capability from kinetic theory
Possible Research Program Participants

• University Collaboration
  – Interested in utilizing the ARMD NASA Research Announcement (NRA)
• Industry Collaboration
• NASA Specific
  – ARMD
  – ESMD
  – SMD
• Other Government Agencies
  – DoD
  – DARPA
  – etc.
Possible Payloads

- **Propulsion**
  - Super/hypersonic inlet flight validation
  - Scramjet engine component validation including combustors and isolators
  - Fundamental combustion and flameholding

- **Aerodynamics**
  - Boundary layer laminar to turbulent transition experiment
  - External burning for transonic drag reduction
  - Supersonic parachute testing

- **Systems**
  - High speed flush air data system (FADS) validation
  - Avionics system flight validation

- **Materials & Structures**
  - High temperature seals
  - High temp leading edge validation
  - High temp instrumentation
  - TPS validation

- **Guidance, Navigation, and Controls**
  - Hypersonic control law validation
  - High speed GPS testing

- **Science**
  - High altitude research

- **Others?**
Estimated Development Milestone Schedule

• Evaluation of system performance envelope (*prelim. estimates complete*)
• Aircraft/missile separation analysis (*prelim. estimates complete*)
• Aircraft/adapter pylon hardware interface design and fit check (*complete 10/14/06*)
• Aircraft performance analysis with captive missile (*prelim. estimates complete*)
• Development of 6-DOF Simulation (*in progress*)
• System requirements definition (*in progress*)
• Aircraft/missile GVT (Mar 07)
• System Requirements Review (SRR) (Mar 07)
• Aircraft/adapter pylon electrical interface definition (Apr 07)
• Miniaturized guidance & flight control computer prelim. design (Apr 07)
• FTS and TM system prelim. design (Apr 07)
• Prelim. navigation & control law development (Apr 07)
• Preliminary Design Review (PDR) (May 07)
• Initial envelope expansion & performance flights with captive inert missile (Jun 07)
• Critical Design Review (CDR) (Nov 07)
• HIL/VIL V&V ground testing (FY08 Q2)
• Aircraft/missile separation flight test (FY08 Q3)
• Live fire flight test (FY08 Q4)
• Research payload flight tests (as nec. In FY09 and out)
Phoenix Fills Gaps in Flight Test Envelopes

- Bridges the large developmental gap between ground testing/analysis and major flight demonstrator X-planes

- Bridges the gap between envelopes of existing piloted/ unpiloted flight test platforms

- Provides subscale flight research data beyond the envelopes of existing piloted/ unpiloted flight test platforms to increase the amount of relevant flight data

- Air-launch allows launch altitude, attitude, and location to be flexible

- Guided testbed allows placement of payload at desired conditions

- Research payload can be checked-out in a captive-carry flight environment at altitudes

- Leverages NASA Dryden’s existing aircraft assets and NAWC Weapons Division’s operational experience
Questions?