Phoenix Missile Hypersonic Testbed (PMHT)

System 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
Phoenix Missile Hypersonic Testbed

Research Objectives:

• Provide subscale flight research data beyond the envelopes of existing piloted/unpiloted flight test platforms – Increase the amount of flight data
• Bridges the large developmental gap between ground testing/analysis and major flight demonstrator X-planes
• Perform research at real flight conditions
• Test a variety of experiments with many launches

Research Approach:

• Develop low-cost super/hypersonic flight research facility using surplus AIM-54s and NASA F-15B
• Develop research payload volume (~6ft³) by removal of warhead/GNC/radar hardware
• Utilize small light-weight avionics to replace existing GNC hardware

Benefits of Approach:

• Low cost
• Guided capability allows placement of payload at desired conditions
• Launch altitude, attitude, and location are flexible
• 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
PMHT Concept

- 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
Development Objectives

• 6 ft³ 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
Possible Research 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
  - Precision impact guidance algorithms
- **Science**
  - High altitude research
- **Others?**
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.
PMHT Configuration

Theoretical Research
Payload Capability
Diameter - 15 inches
Length - 70 inches
Effective Volume - ~6 cu ft.
Allowable Weight - ~250 lbs.

Utilize surplus flight-proven F-14 hardware and NAWC-WD experience with missiles

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

Design Concept

Research payload
Guidance and Nav
Autopilot/Servos
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.

Control Section (144 lb)
Propulsion Section (511 lb)
Armament Section (184 lb)
Guidance Section (184 lb)

13 feet
15 inches
PMHT Configuration

- Redesigned/Modified Hardware
- Unmodified Hardware

- Primary Payload (57")
- Mission Computer, INU, TM, FTS
- Secondary Payload
- Bulkhead between Primary & Secondary Payloads
- Wings & Fins (4 of each)
- Blast Tube
- Propulsion Unit
- Battery
- Exit Cone
- Potential Rear Payload Space
- Hydraulic Servo Actuators (4)
- Power Conditioning & Electronic Servo Controller
- Igniter Safety Mechanism
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.
Nomenclature

- Carrier Vehicle
- Boost Vehicle
- Pylon Assembly
PMHT 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 Electronic Ground Servicing Equipment to boost vehicle
  - Upload guidance waypoints for planned trajectory
  - Upload controller and/or payload constants
- Verify system health by monitoring from aircraft rear cockpit display
  - Payload and missile systems instrumentation data available through on-missile data bus
- Verify INU 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
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
Questions?