Advanced Propulsion Concepts for the HYDRA-70 Rocket System

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ERIC HAWLEY

Contact Information
Ph: (301) 744-1822
Fax: (301) 744-4410
hawleyej@ih.navy.mil

INDIAN HEAD DIVISION
NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MD

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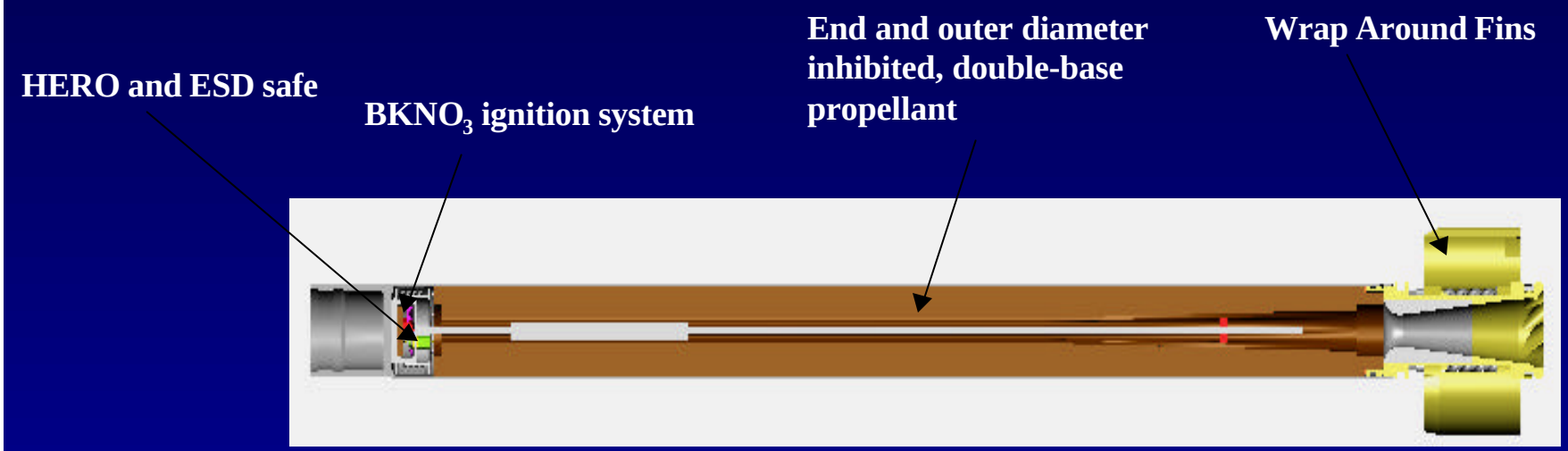
Background

- **The Hydra 70 is a tri-service area suppression weapon system.**

- **Uses multiple warheads**
  - **HE**
  - **Smoke**
  - **Flare**
  - **Sub Munitions**
- **Used on multiple platforms**

Helicopters	Fixed Wing
AH-1	A-7
AH-64	A-10
OH-58	F-4
UH-60	F-16
UH-1	F/A-18
MH-60	A-4
MH-6	A-6

MK 66 Rocket Motor Description



MK 66 MOD 4 ROCKET MOTOR

- **Length:** 41.7 in
- **Weight:** 13.6 lbs
- **Diameter:** 2.75 in
- **Avg. Thrust:** 1413 lbs
- **Total Impulse:** 1515 lb-sec
- **Burn Time:** 1.07 sec
- **Range:** 6 km
- **Temperature limits:** -50°F - 150°F

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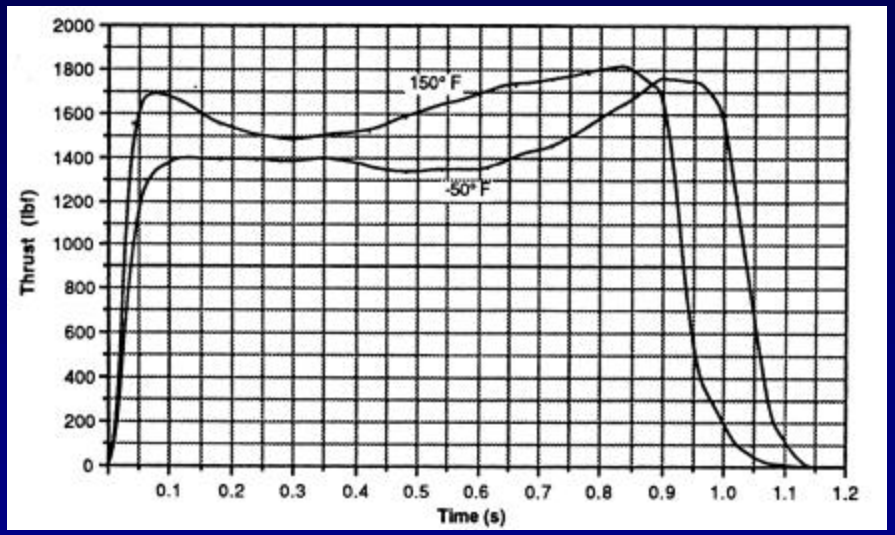
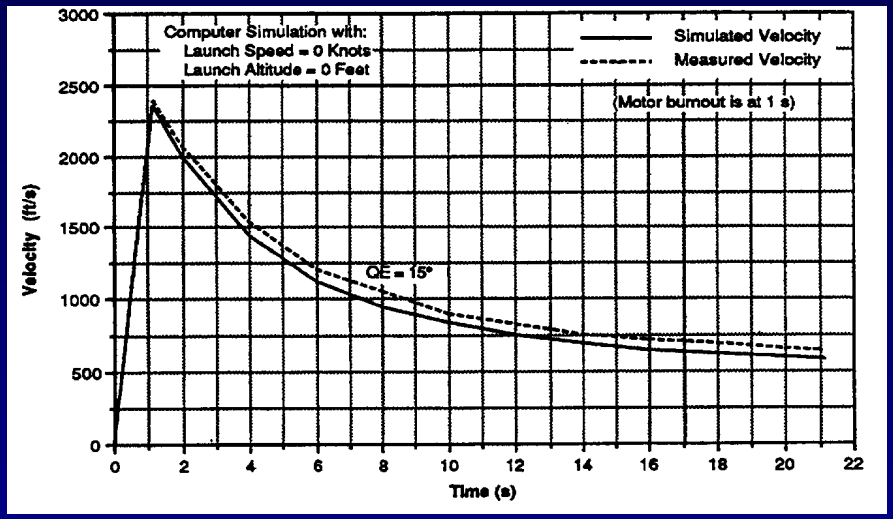
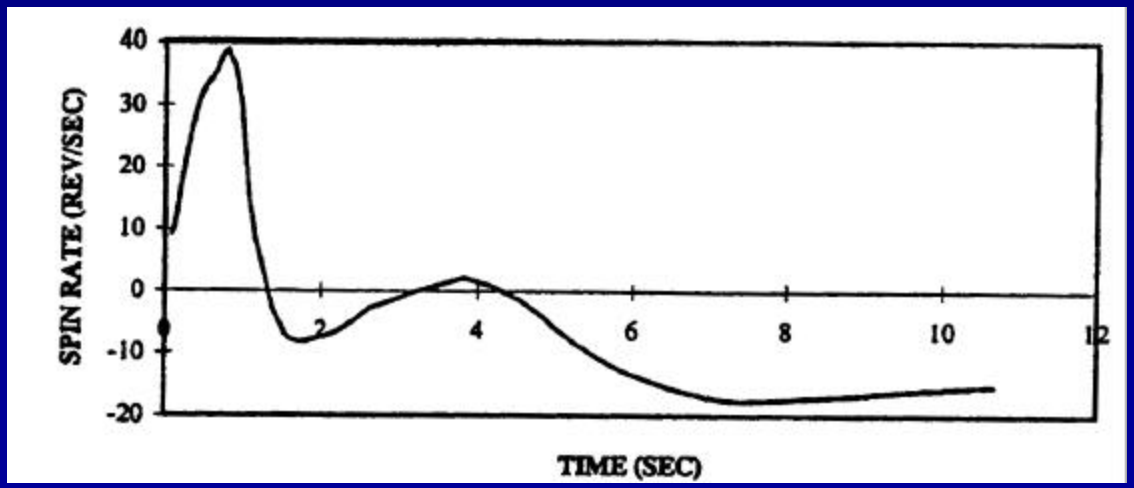
MK 66 Rocket Motor Performance

MK 66 Thrust Curves



MK 66 Velocity Profile





MK 66 Spin Profile

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Objectives

- The Army is seeking to incorporate guidance and control (G&C) technology into the Hydra 70 Rocket System, and would like a rocket motor optimized for such operation.
- In addition, there are opportunities to improve the unguided performance of the rocket motor.
- Objective: make a good rocket motor even better.

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Requirements

- **Unguided Requirement: Decreased dispersion**
- **Notional Guided Requirements (achieved through more motor control)**
  - **Increased range (12 km)**
  - **Lower peak acceleration**
  - **Consistent velocity**

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Design Constraints

- **Physical Boundaries**
  - Must support 2.75 inch infrastructure (launchers, containers)
    - No change in outer diameter or length
- **Smoke Requirement**
  - Minimum smoke propellants required
    - Smoke obscures targeting system lazing for guided rounds
    - Minimum smoke improves survivability of warfighter
    - Limits available propellants
- **Dual Use Rocket Motor**
  - One rocket motor used for guided and unguided applications
    - Two rocket motors add logistical complexity and cost

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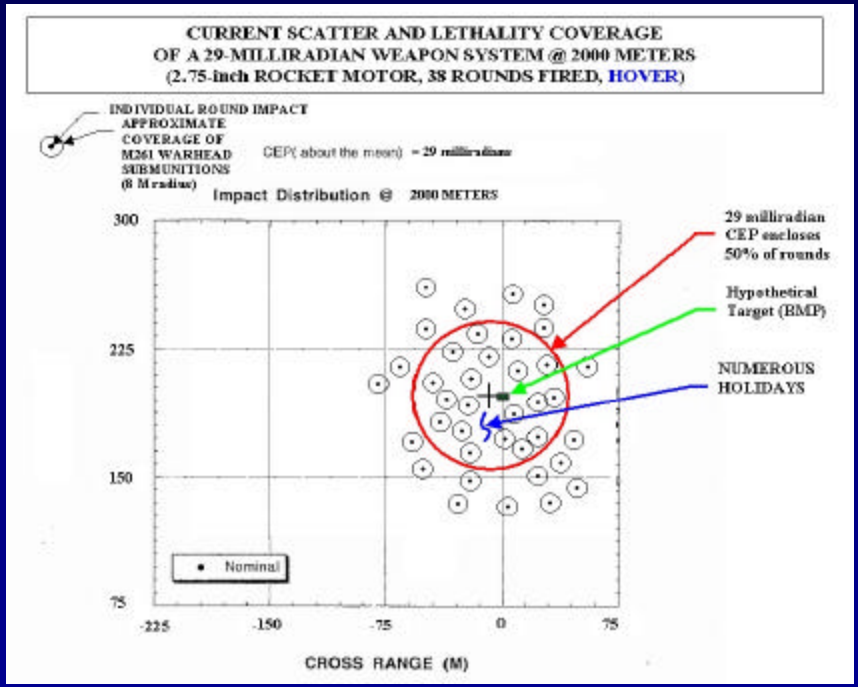
Unguided Dispersion

- **Current dispersion of unguided motor is 29 mils CEP**



- **2 major factors contribute to rocket dispersion**
  - **Aircraft (pylon and launcher perturbations, pilot aiming)**
  - **Thrust misalignment**

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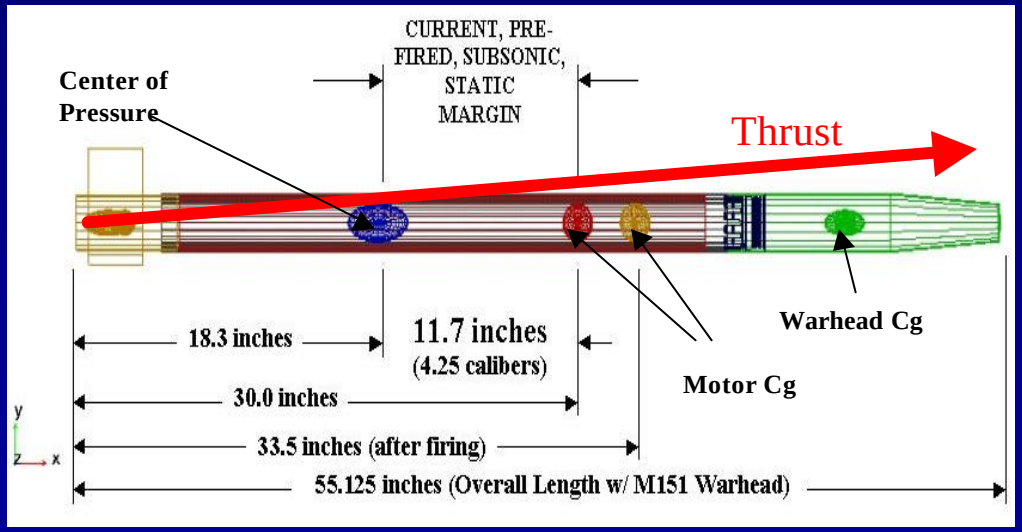
Unguided Dispersion (cont.)

- **Thrust misalignment: Current rocket motor has a thrust angle misalignment tolerance of +/- 0.3 deg**
  - **Major contributors:**
    - **Nozzle to motor tube joint**
    - **Motor imbalance**



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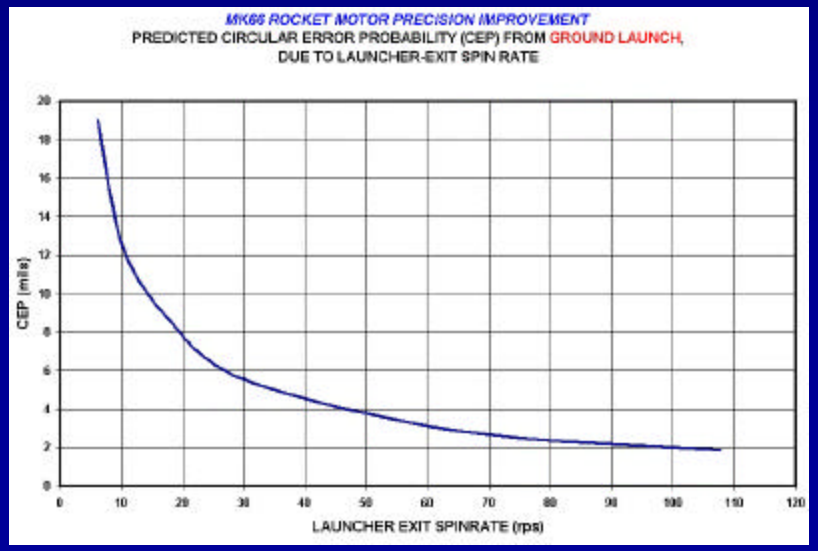
Unguided Dispersion (cont.)

- Potential solutions for nozzle/motor tube joint
  - Threaded nozzle/motor tube joint
    - Drawbacks: Cost and complexity
  - Tighter interface tolerances
    - Drawbacks: Does not remove all misalignment; added cost
- Potential solution for motor imbalance
  - Most dispersions occur during first 0.10 seconds of flight
  - CEP can be reduced by increasing the rocket motor launcher exit spin rate



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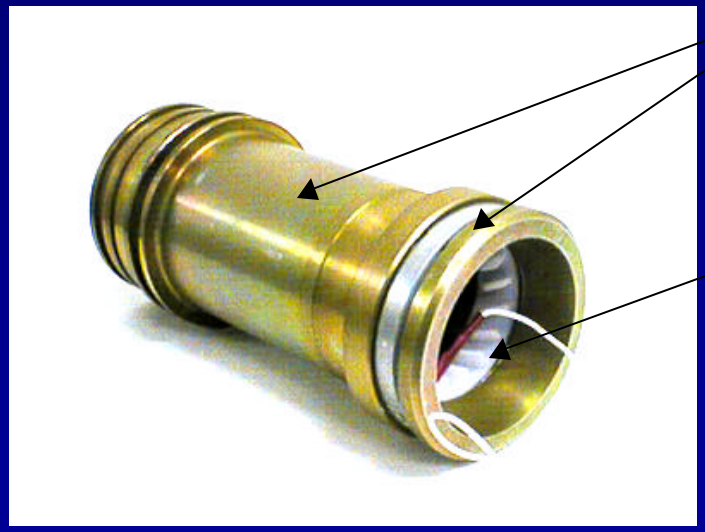
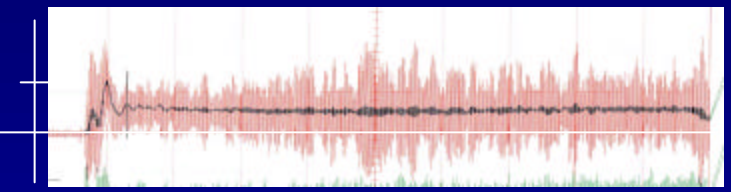
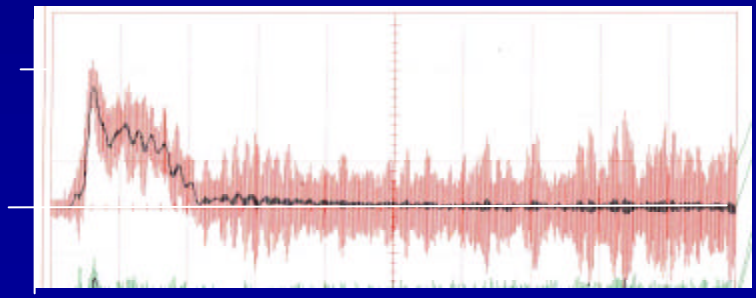
Unguided Dispersion (cont.)

- **Increasing the torque provided by nozzle increases launcher exit spin rate (must shut off or motor will destroy itself in flight)**
  - **High torque nozzle concept can be used to generate high torque for ~.10 sec**





BASELINE



HIGH TORQUE NOZZLE

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Unguided Dispersion Conclusions

- **Technologies exist that can significantly decrease unguided rocket motor dispersion**
- **Methods have been tested successfully**

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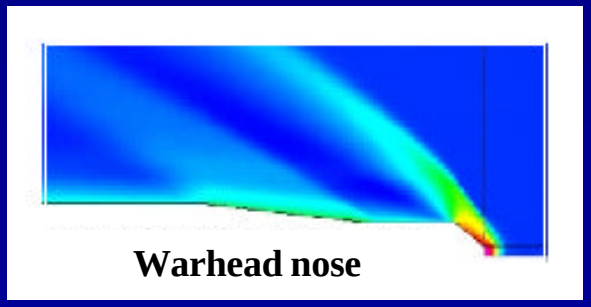
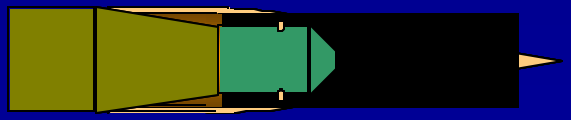
Increasing Range

- **Current rocket has ~6 km max range**
  - **Preferred guided range: 10 - 12 km**
  - **Potential solution**
    - **Range can be increased by using a detachable, snap-on fairing to reduce C_D of warhead**
      - **Meets 10 deg or Von Karman requirements for supersonic aerodynamic efficiency**
      - **Material must survive up to 300 lbf aerodynamic drag force and brief aerodynamic heating, while crushing undetectably under the thousands of pounds of fuze-target impact.**





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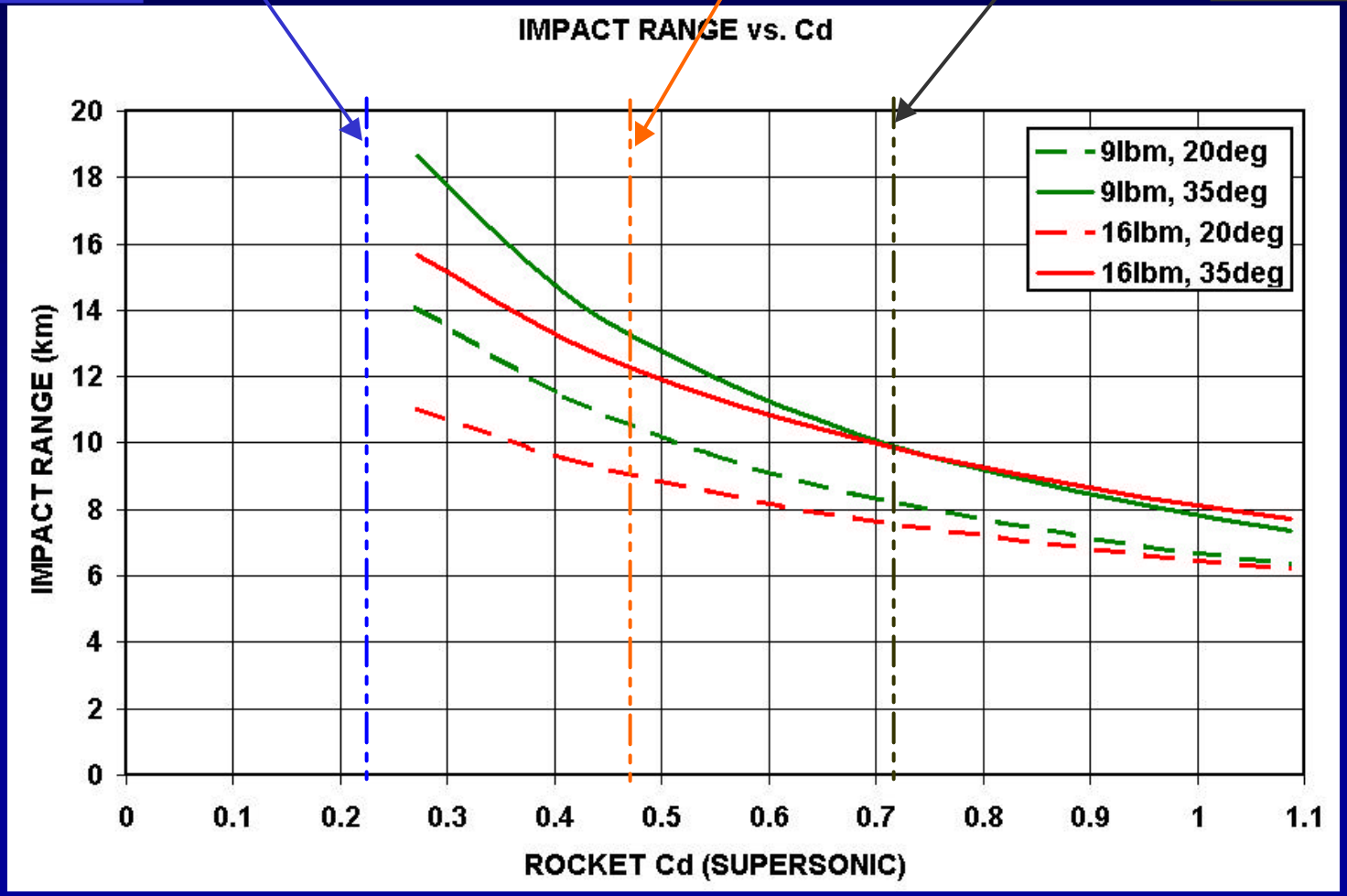
Increasing Range

Theoretical Maximum Performance

Proposed Nose-cone

Current Performance



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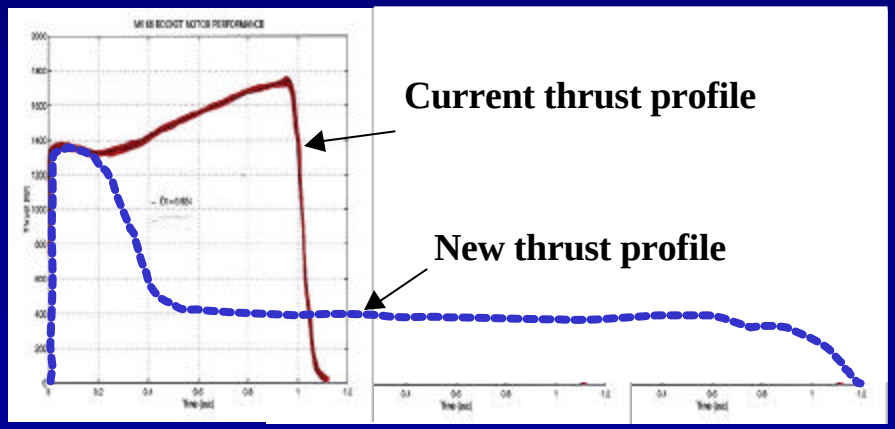
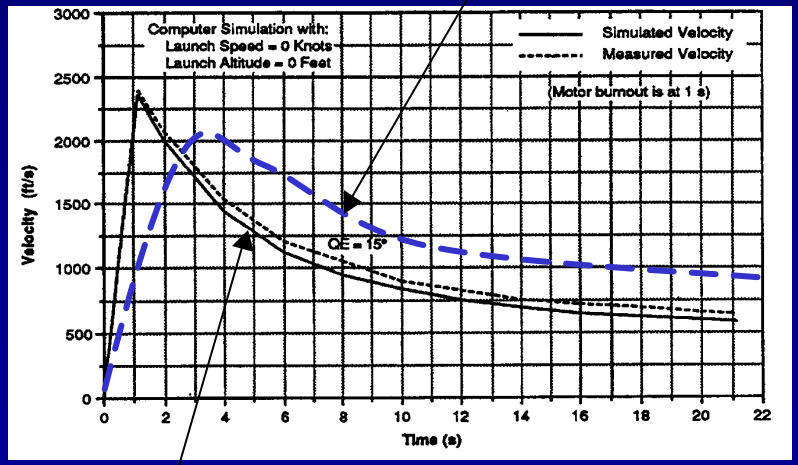
Altering the Thrust Profile

- **A boost sustain rocket motor can increase give a more constant velocity profile**
  - **Must maintain high initial thrust to maintain accuracy through down wash and to ensure safe separation from aircraft**





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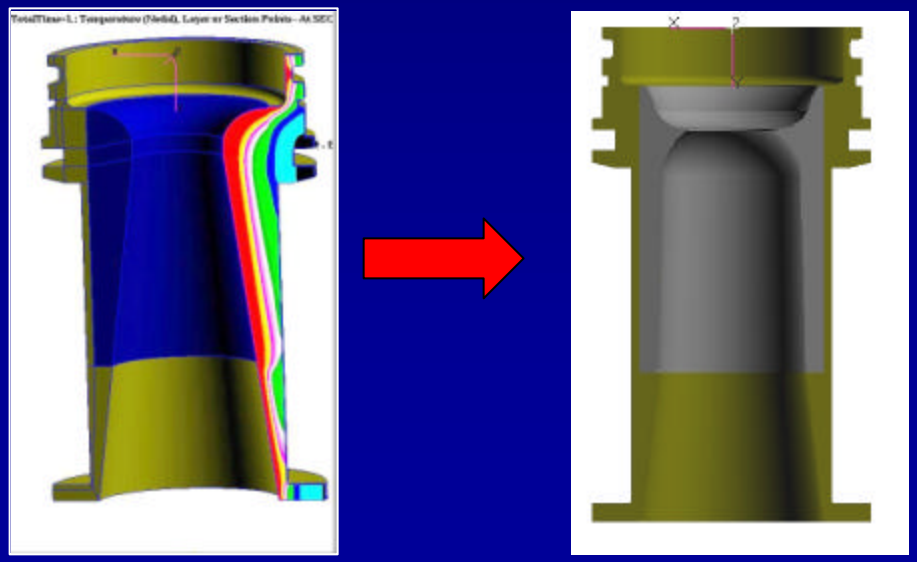
Altering the Thrust Profile

- **Boost sustain methods**
  - **Eroding nozzle throat**
    - **Method used in CKU-7/A ROCAT**
    - **May be able to use current propellant grain**
  - **Two-part propellant grain**
    - **Use propellants w/ different burn rates to produced desired thrust**
  - **Both methods have been applied to other rocket systems**



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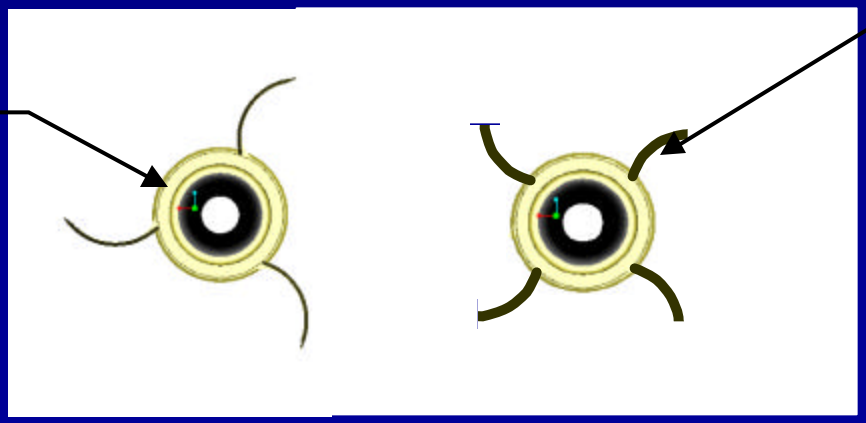
Improved Rocket Control

- **Current rocket motor is difficult to guide**
  - **Roll reversal**
  - **Fins not designed for guided flight**
  - **Potential Solution**
    - **Optimize fin number & size to guidance control surfaces**
      - **Fins too small, rocket skids**
      - **Fins too big, rocket difficult to turn**
    - **Remove roll reversal**

3-FIN, NEUTRAL-MOMENT, FIN ASSEMBLY



4-FIN, NEUTRAL-MOMENT, FIN ASSEMBLY (may provide more consistent lift profile for guided round, with comparable performance on unguided round)

Proposed Nozzle Configurations

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Conclusions

- There are many options using current technologies to improve Hydra rocket motor
- Technologies exist that can meet the requirements of both guided and unguided rocket motors.

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Questions

Contact Information

ERIC HAWLEY

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hawleyej@ih.navy.mil