U.S. ARMY RDECOM

Presented to:

NDIA Targets, UAVs & Range Operations Symposium

Reusable Surrogate Missile Targets

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TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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03 Oct 2012

Why Missiles?

Why Recoverability?

Application Space

MAST Tech Demo Project

Future Technology Path

Why Missiles?

- **Blue**
  - **Nothing represents the shock, acceleration, and vibration environment of a missile airframe.**
    - **Subsystems can be tested for failure inexpensively, and with recoverable results.**

- **Red**
  - **As we technology moves forward, our enemies grow more advanced. “We won’t be fighting cave-dwellers forever.”**
    - **We have to keep up with the evolving threat world.**
  - **MWS, IRCM, DIRCM, ASE suite, etc. are developed to counter the weapons of greatest threat.**
    - **We have to test to the greatest threat.**
  - **Threat missiles are dynamic and their signatures require Open Air Range (OAR) testing.**
    - **Signatures collected from static targets are unrealistic simulations; we need a dynamic testbed to present real signatures.**

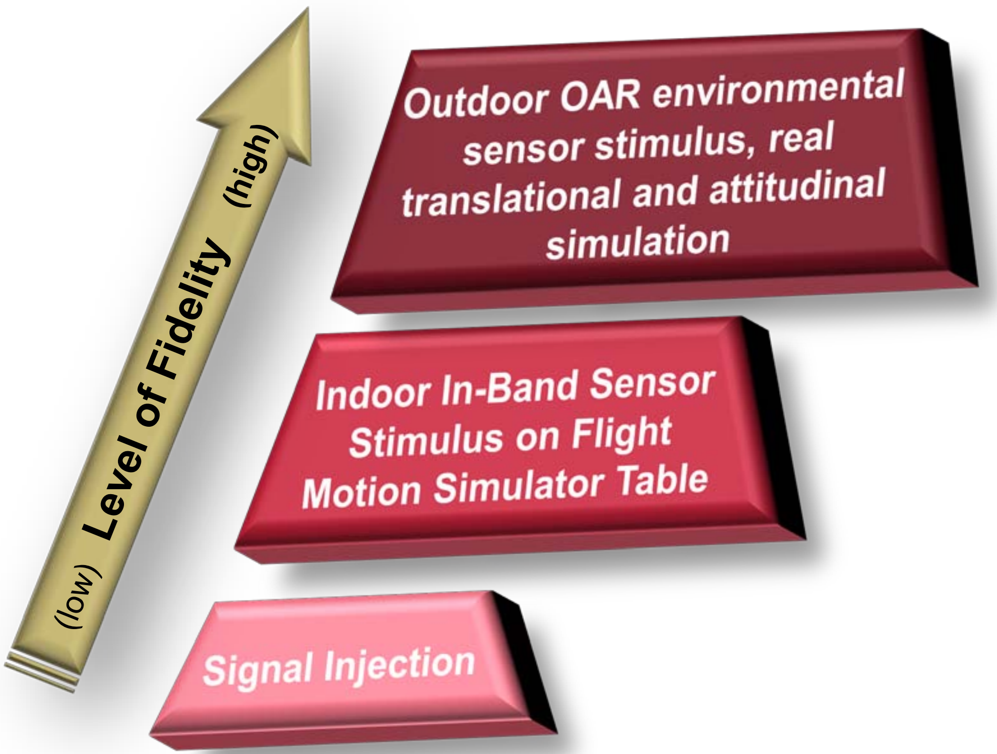
Why Missiles?

- Sensor testing? First thought by many people is to run UUTs in traditional hardware-in-the-loop indoor environment.
  - Signal injection: Useful for checking software & electronics hardware
  - In-band radiation: Useful for characterizing optics and checking software & electronics hardware
  - Upshot: great for testing functionality in a static physical environment with lots of repeatability
  - Downshot: approximated scene, no acceleration/shock/vibration environment.

- Put it on an aircraft and fly it.
  - Aircraft with human pilot necessary for many of the weight classes that need to be tested against. Airworthiness, and test planning are big hurdles.
  - UAV flight is possible, but doesn't represent the dynamics of rocket-powered flight; simulation fidelity is low, cost of a capable UAV and test prep is high.

HW/SW Testing Hierarchy

- **Reusable surrogate missiles are a** *testbed.*
- **Provide greatest scene fidelity**
- **Provide a closed-loop OAR scenario that can be carried out safely and non-destructively.**
- **Provides a new platform for R&D, D/OT&E, V&V.**



Why Missiles? E.g.: ASE

Perceived Threat Irradiance ($W \bullet m^{-2}$) - Amount of power per unit area incident on a surface (e.g., the MWS entrance aperture). Spectral Irradiance ($W \bullet m^{-2} \bullet \mu m^{-2}$).

- A measurement of the ASE sensor's measured power in the waveband of interest
- Based on the threat SRM signature, range, relative geometry, atmospheric attenuation, solar loading, reflections, optical heating, etc.

Threat Radiant Intensity ($W \bullet sr^{-1}$) - Amount of radiation emitted from a particular area within a given solid angle in a specific direction. Spectral Radiant Intensity ($W \bullet sr^{-1} \bullet \mu m^{-2}$).

- A measurement of the threat's emitted radiation in the waveband of interest
- Based on the spectral, spatial and temporal signatures of the threat SRM

$$E_s(\lambda\lambda t) = \frac{I_M(\lambda\lambda t)\tau_{SM}(\lambda\lambda t) r_n(\lambda\lambda)}{R_{SM}(t)^2}$$

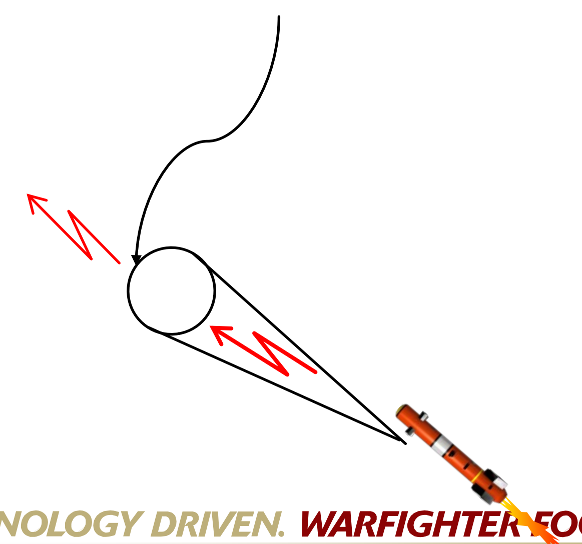
$E_s(\lambda\lambda t) =$ spectral irradiance at the ASE Sensor

$I_M(\lambda\lambda t) =$ spectral source radiant intensity of the threat

$\tau_{SM}(\lambda\lambda t) =$ spectral transmission ASE to missile

$r_n(\lambda\lambda) =$ spectral response of the ASE sensor

$R_{SM}(t) =$ slant range from ASE to threat missile

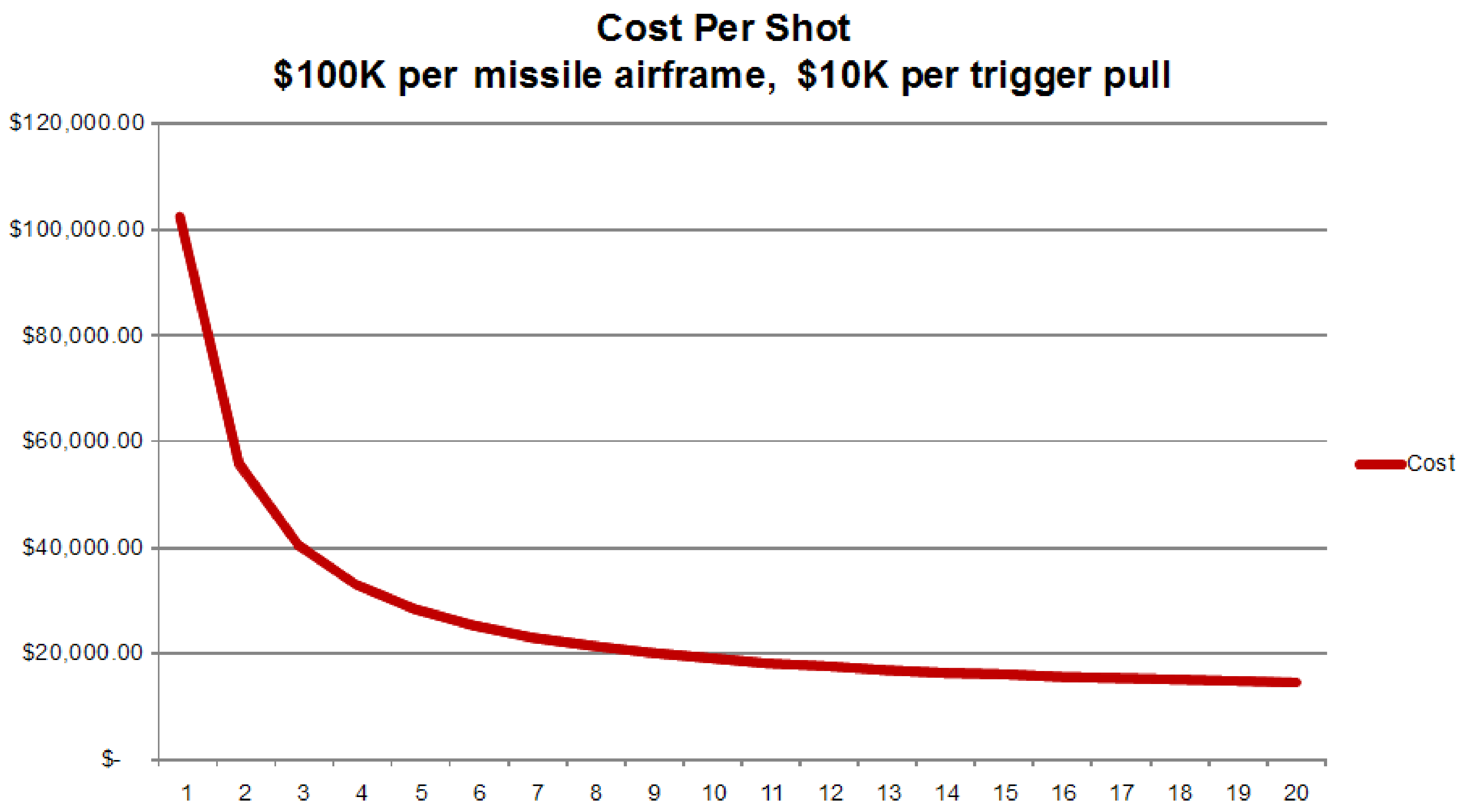


Why Recovery?

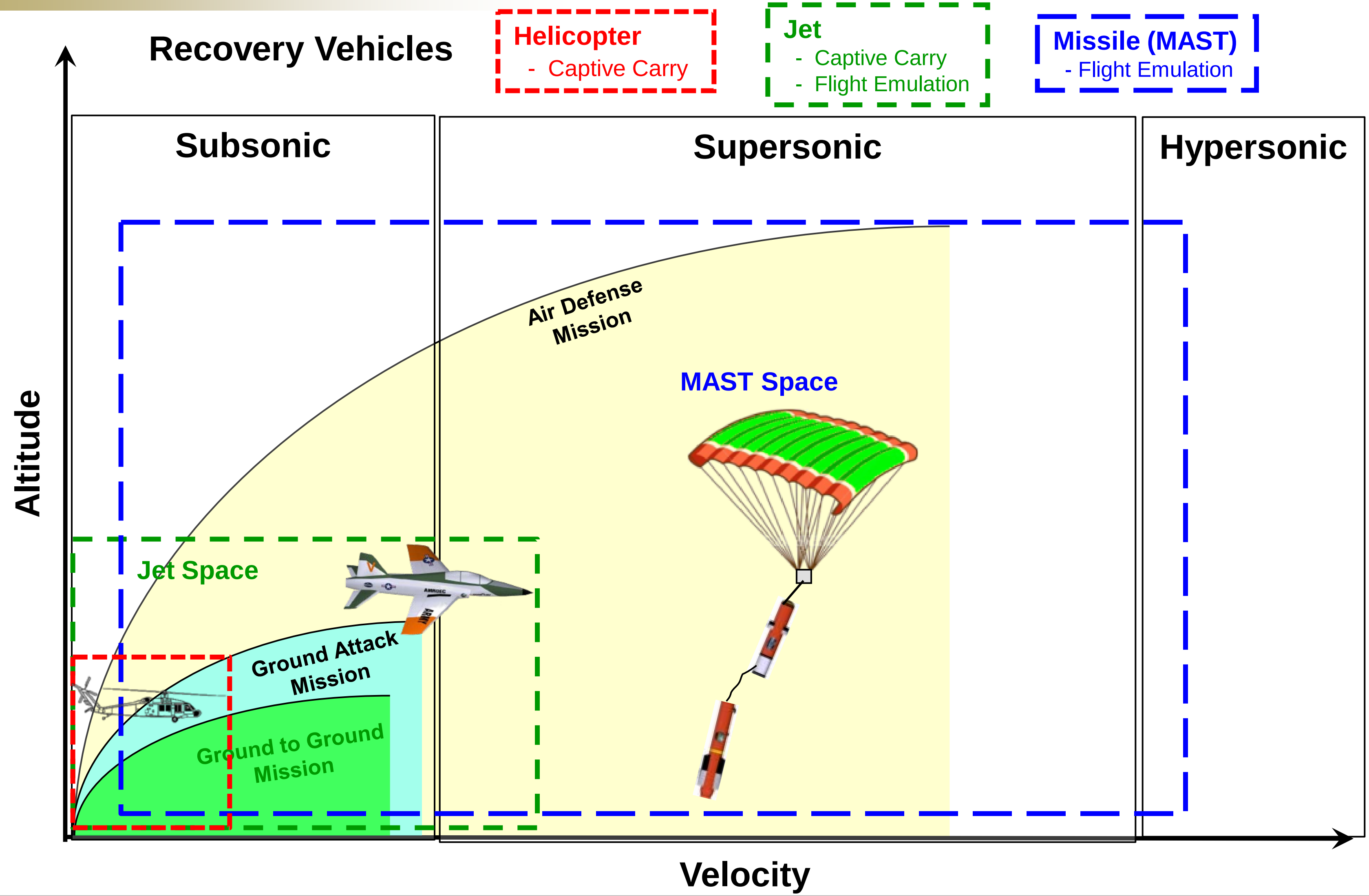
- **No schedule slips due to unavailability of threat assets.**
  - COST
- **Retain on-board TM recordings to back up TM in case of RF interference or drop-out.**
  - COST
- **Keep missile targeted assets intact**
  - COST
- **Return any developmental hardware safely to developers**
  - COST
- **Retain for reuse the most expensive part of the missile: electronics & optics**
  - COST

Impact on aerodynamics: Low
Impact on test validity: Low
Impact on cost of test asset: Low
Impact on schedule: Low

Why Recoverability?

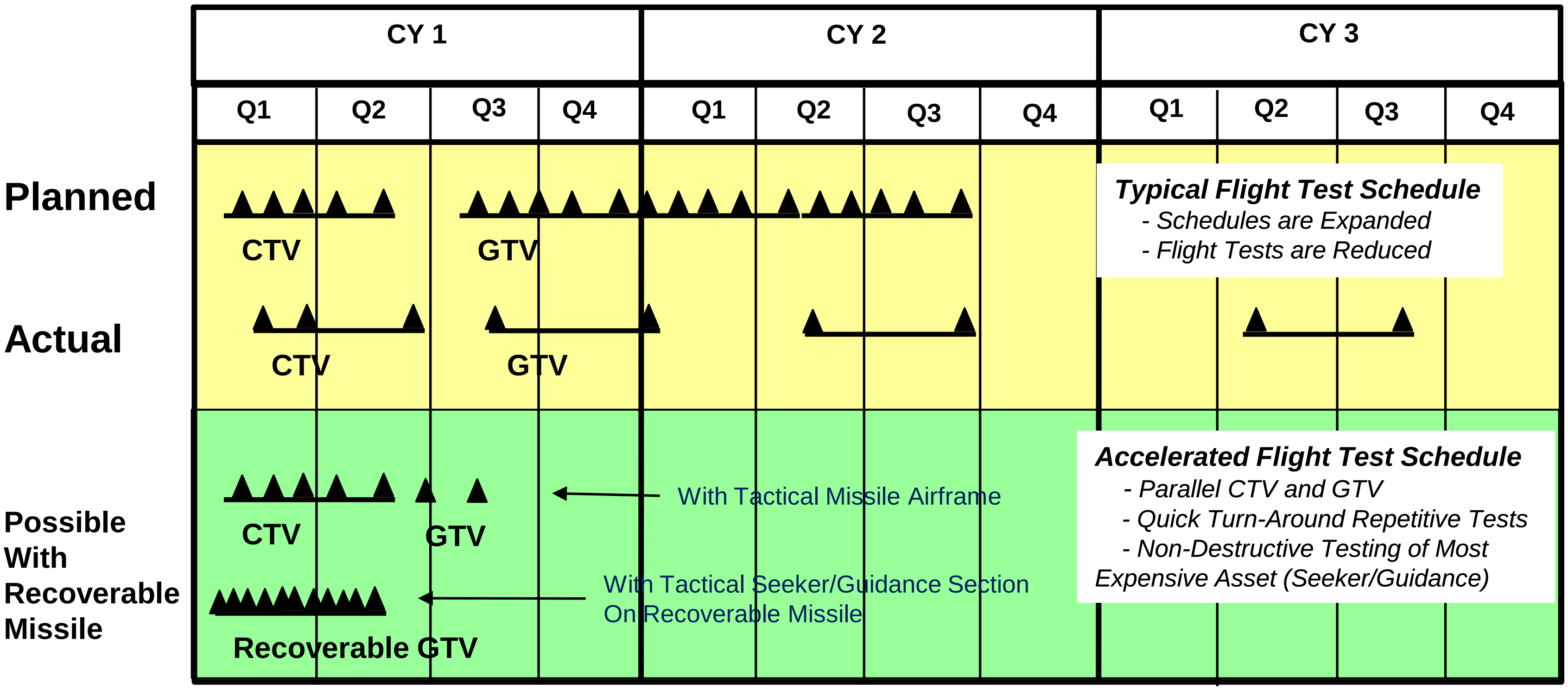


MAST Recoverable Seeker Technology Test Space



Recoverable Missile Airframe Simulation Testbed (MAST) Technology = Paradigm Shift

Reusable Surrogates for Missile Development Programs



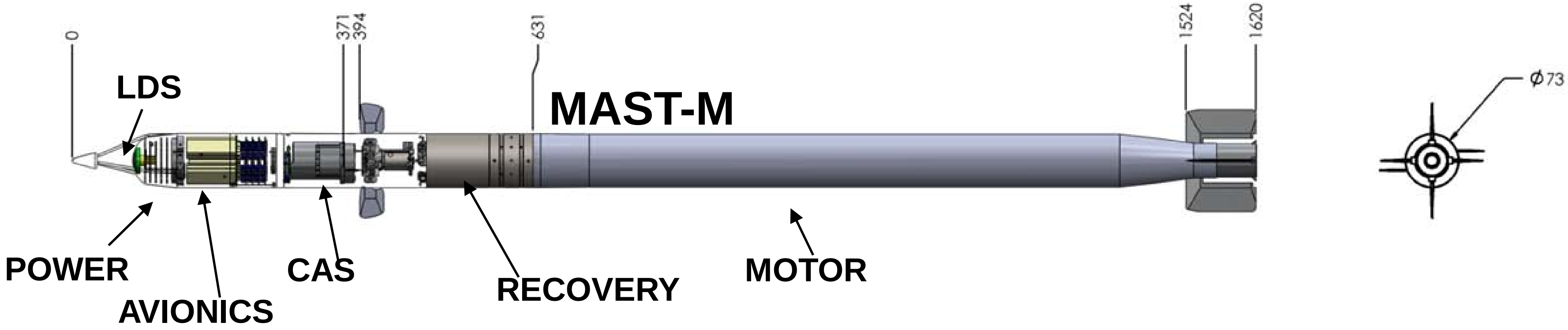
▲ **Flight Test**

CTV – Control Flight Test (unguided airframe/control tests)
GTV – Guided Flight Test

Recoverable Missiles can condense Flight Testing, Significantly Reducing Development Costs and Schedule

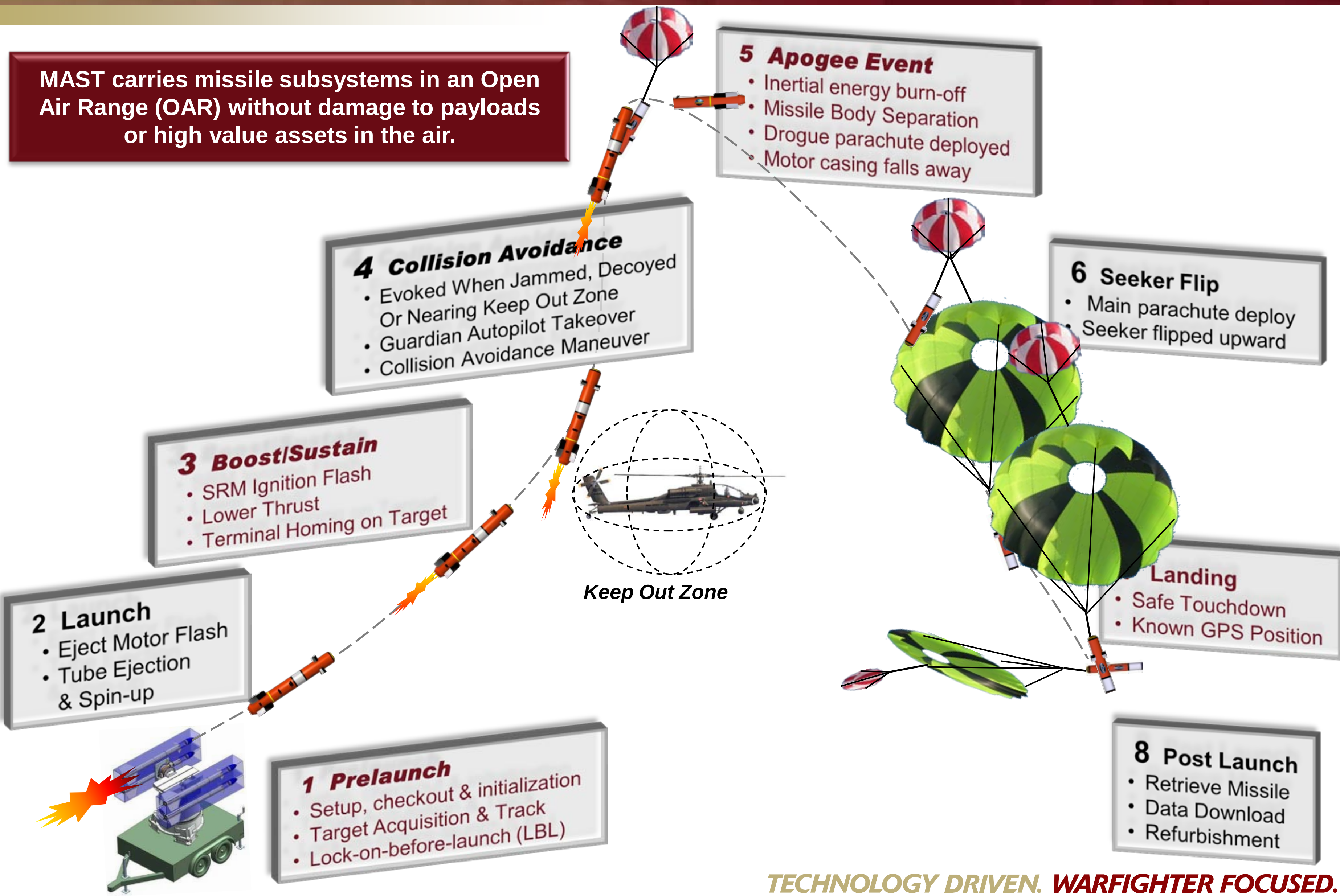
Current Development

- Missile Airframe Simulation Testbed, MANPADS formulation (MAST-M) is the first technology demonstration of a Reusable Surrogate Missile.
- Chosen for form factor and impending need expressed by a customer
  - Spinning airframe
  - Small Diameter
- Reusable electronics and GPS/IMU
- Representative motor signature (spatial, temporal, spectral matching)
- Scalable recovery system
- Demonstration timeframe: Q3 FY13



MAST Concept of Operations

MAST carries missile subsystems in an Open Air Range (OAR) without damage to payloads or high value assets in the air.



MAST Technology Challenges (1 of 3)

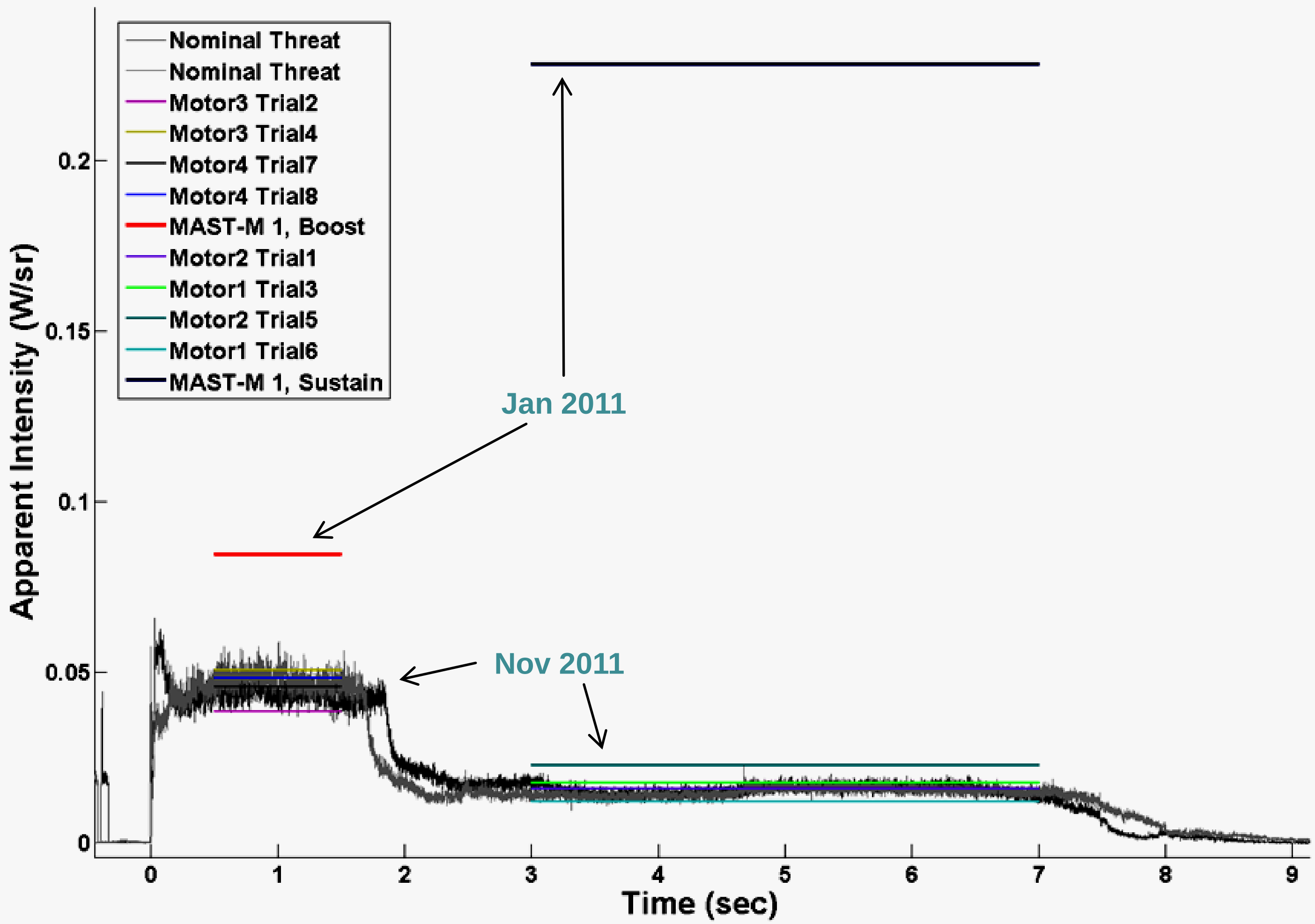
"Look Like a MANPADS" ***(Signature Matching)***

MAST must present accurate on-aperture UV and IR signatures to the ASE that closely match that of the threat MANPADS of interest for the eject, boost and sustain phases of flight.

- Presently, there are no missile surrogates that can match on-aperture signatures for ASE testing.
- The Challenge for MAST is to:
  - Match threat temporal thrust profile (eject, boost & sustain vs. time)
  - Match threat spectral signature in the UV and 2 color IR bands
  - Match threat signature spatial extent (size vs. time)

Development of Low Cost Surrogate Motors Opens Up OAR Test Possibilities

Signature Band of Interest Burn Comparison



MAST Technology Challenges (2 of 3)

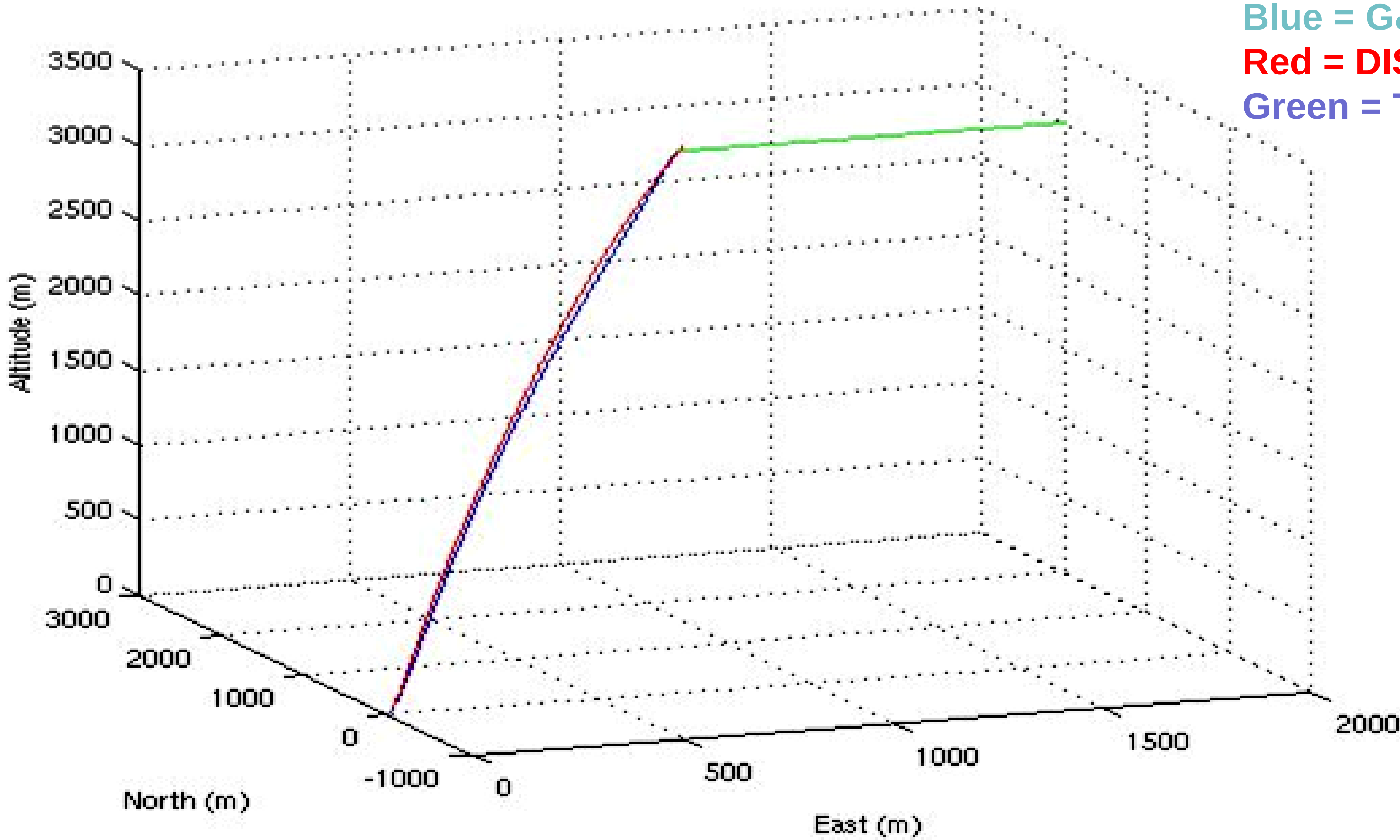
"Fly Like a MANPADS" ***(Trajectory Matching)***

MAST Guidance, Navigation and Control (GNC) must fly a trajectory that matches that of the threat MANPADS of interest.

- Presently, there are no missile surrogates that can match threat trajectories.
- The Challenge for MAST is to:
  - Emulate the pro-nav intercept trajectory of the actual threat with a surrogate of different size and GNC scheme
  - Provide an Guardian Autopilot to accurately compute missile state, take control at a pre-programmed keep-out zone, and perform collision avoidance to insure non-destructive ASE testing

Development of Trajectory Matching GNC Allows Flight Emulation of Multiple Threats

DISAMS Versus G&C 6-DOF



Blue = G&C
Red = DISAMS
Green = Target

Current G&C 6-DOF flies a Threat-like Trajectory

MAST Technology Challenges (3 of 3)

"Fly it Again" ***(Safe Recovery)***

MAST must safely recover the payload in order to provide low cost, non-destructive ASE testing.

- Presently, there are no surrogate missiles that are recoverable.
- The Challenge for MAST is to:
  - Safely recover a high speed (mach 2+) missile payload
  - Recover the payload in a cost effective manner to reduce refurbishment costs
  - Provide a reliable recovery system to allow safe testing of valuable and hard to acquire threat assets as well as domestic subsystems.

Safe, Reliable, Cost Effective Missile Recovery Opens Up Many Other Test Use Cases

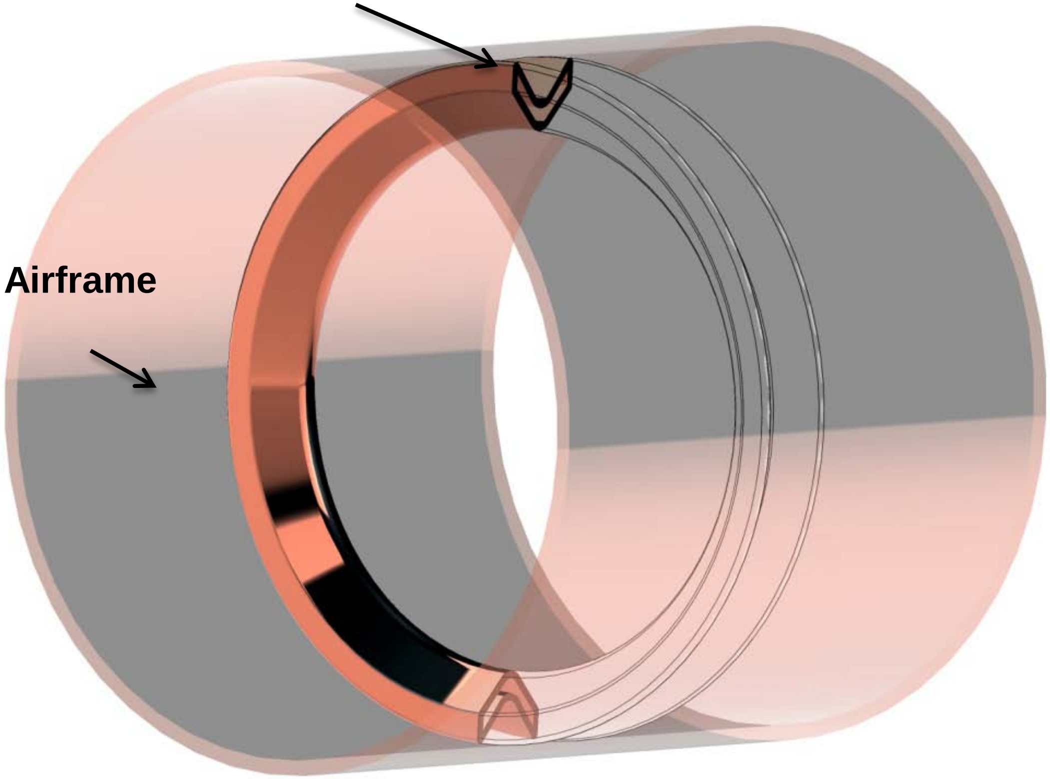
Separation Device Concept #1

Advantages

- Compact size
- Reliable separation
- Lightweight
  - weight: 80 grams

Shape Charge

Airframe



12.5 grams of RDX
= 52.3 Joules of Energy

Disadvantages

- Fragmenting
- Requires eSAF
- High energy

Concept #1 Tested

Separation Device Concept #2

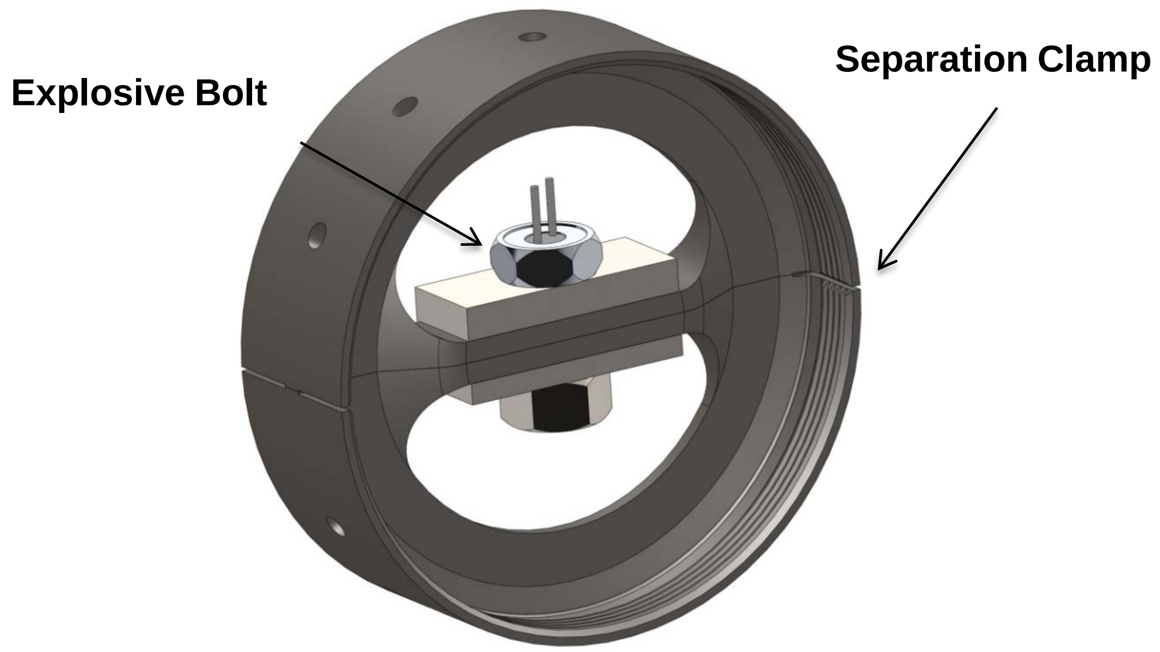
MAST Missile Technology

Advantages

- Compact size
- Inherent separation force
- Lightweight
  - weight: 97 grams

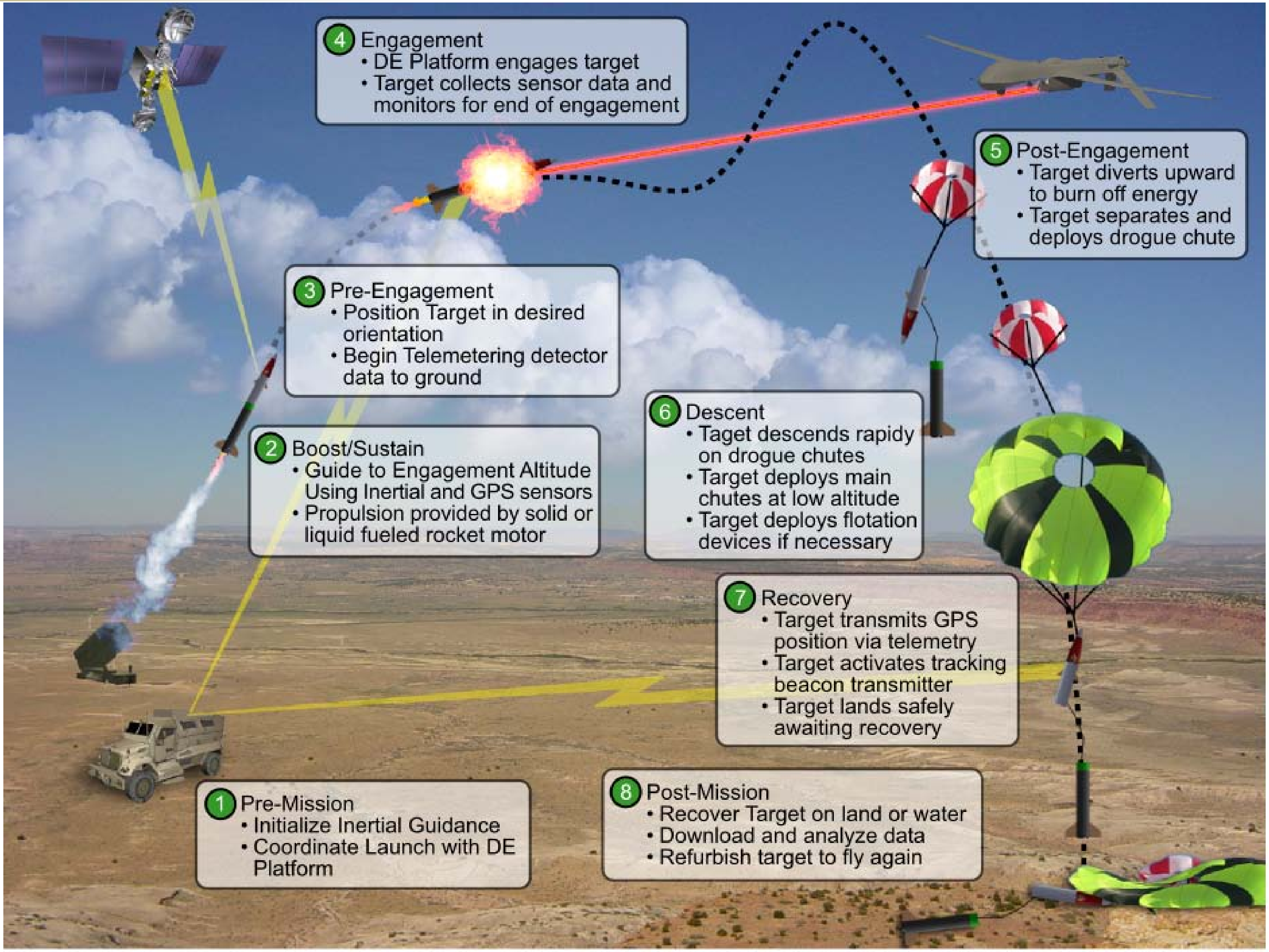
Disadvantages

- Fragmenting bolt



.01 grams of RDX
.016 grams of Lead Azide
.078 grams TNT
= 0.2409 Joules of Energy

Future Developments



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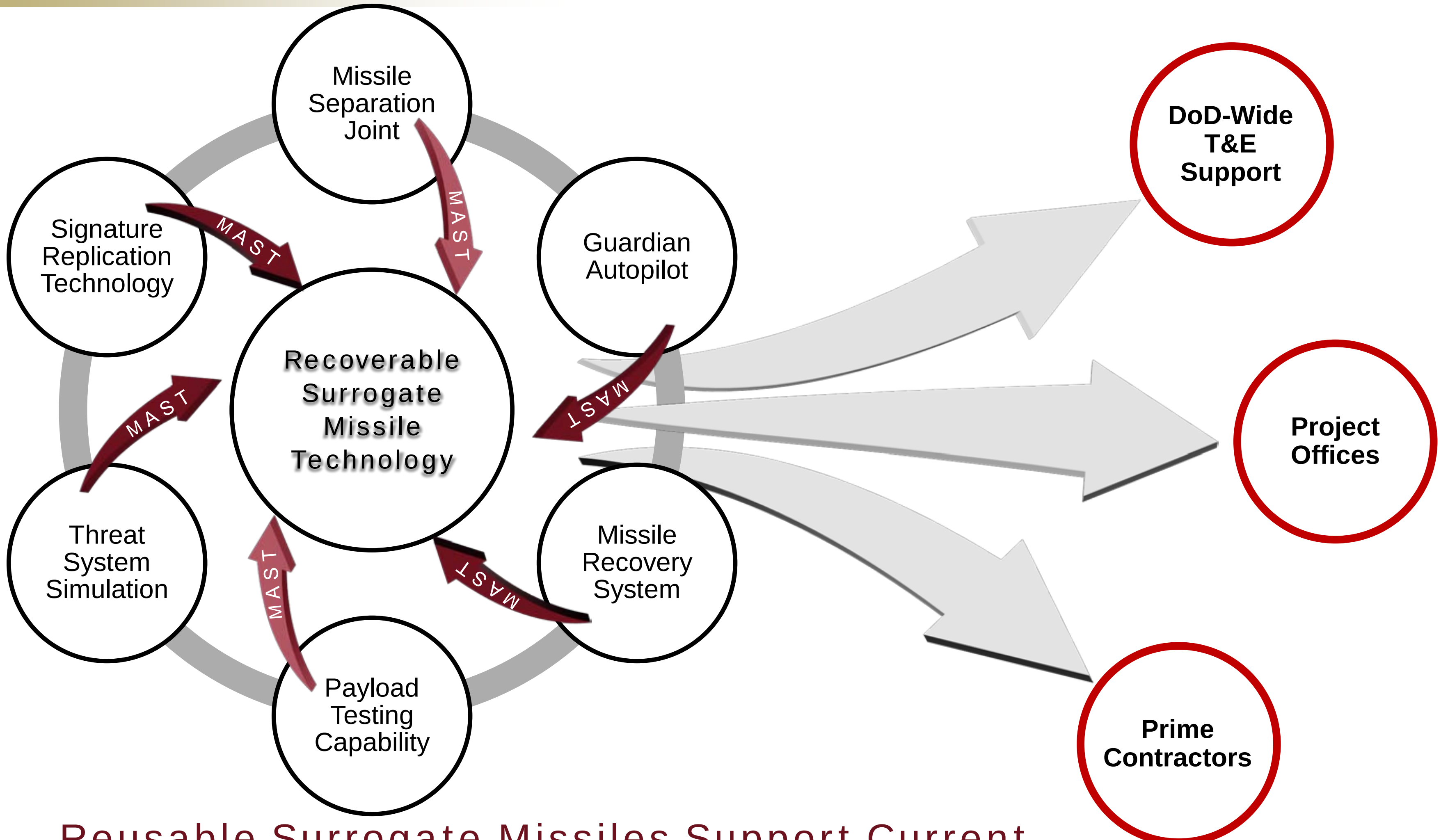
Expanding Testing Capabilities



Reusable Surrogate Missiles Support Current and Future Missile Engineering Processes and Improves Final Products

Questions