NIAC (NASA Innovative Advanced Concepts)

Phase 1 & 2 Studies (2011 – 2014)

An Optimal Mitigation Strategy Against the Asteroid Impact Threat with Short Warning Time

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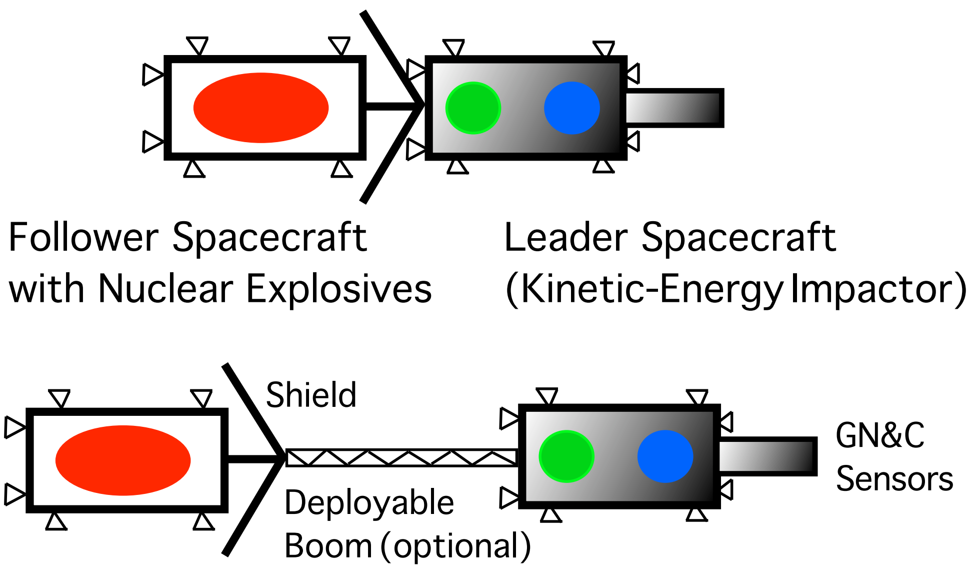
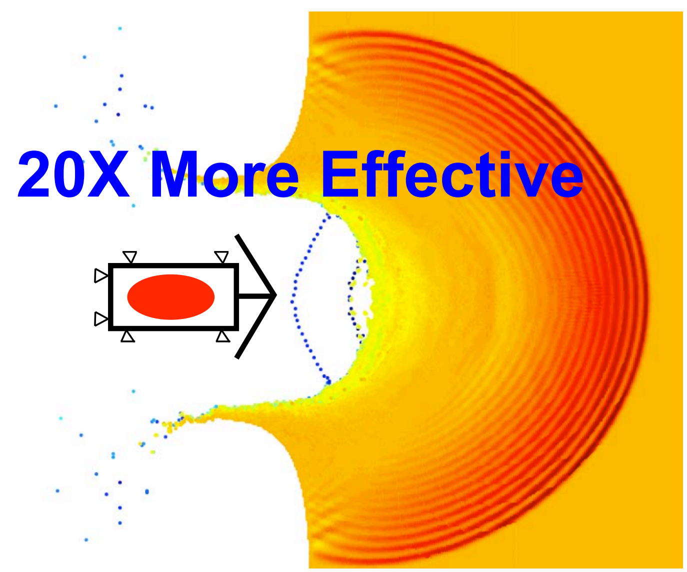
NIAC Study Objective (2011 – 2014)

To develop an innovative yet practically implementable mitigation technique for the most probable impact threat of an asteroid or comet with short warning time (i.e., when we don't have sufficient warning times for a deflection mission)

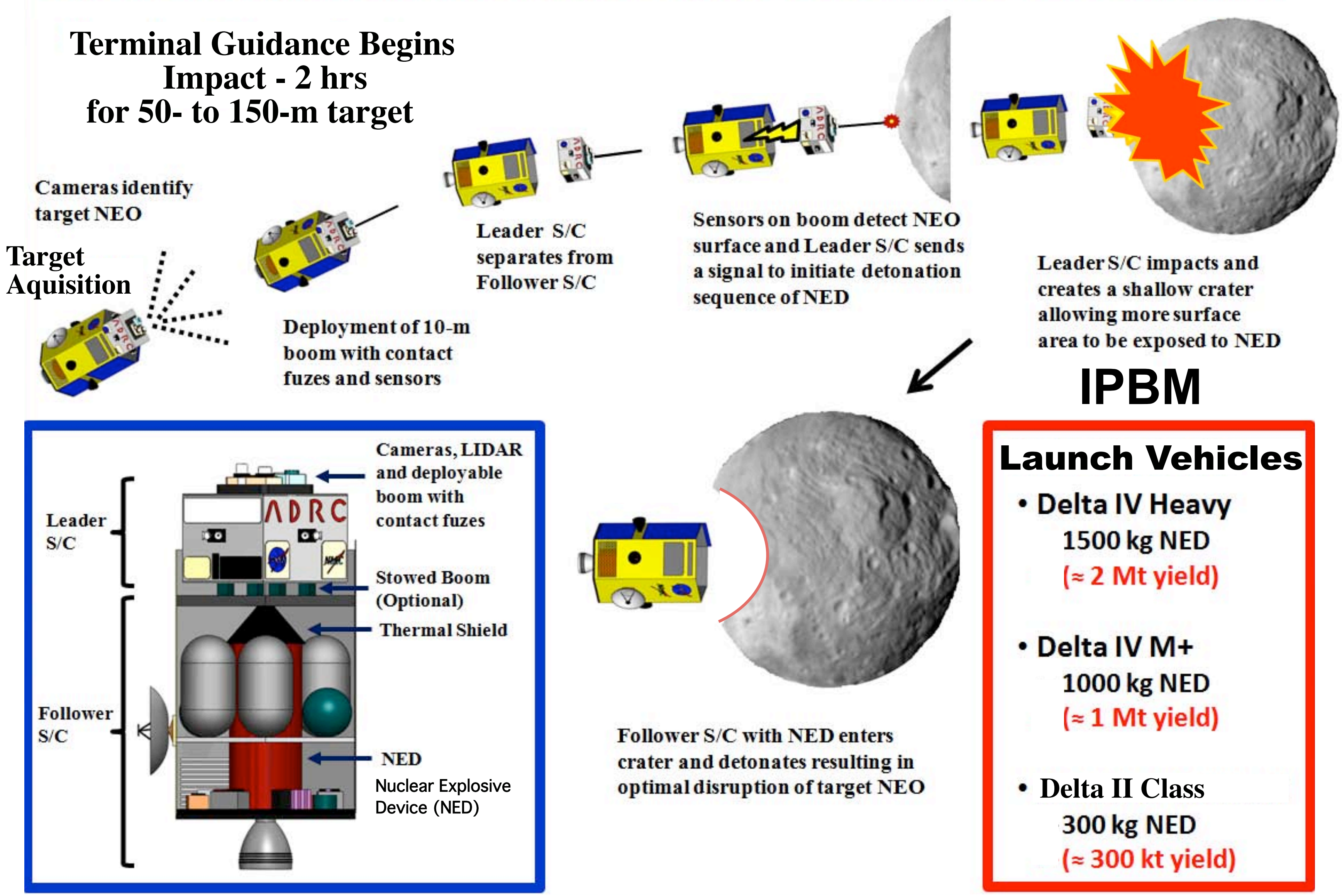
NIAC Phase 1 Proposal (2011)

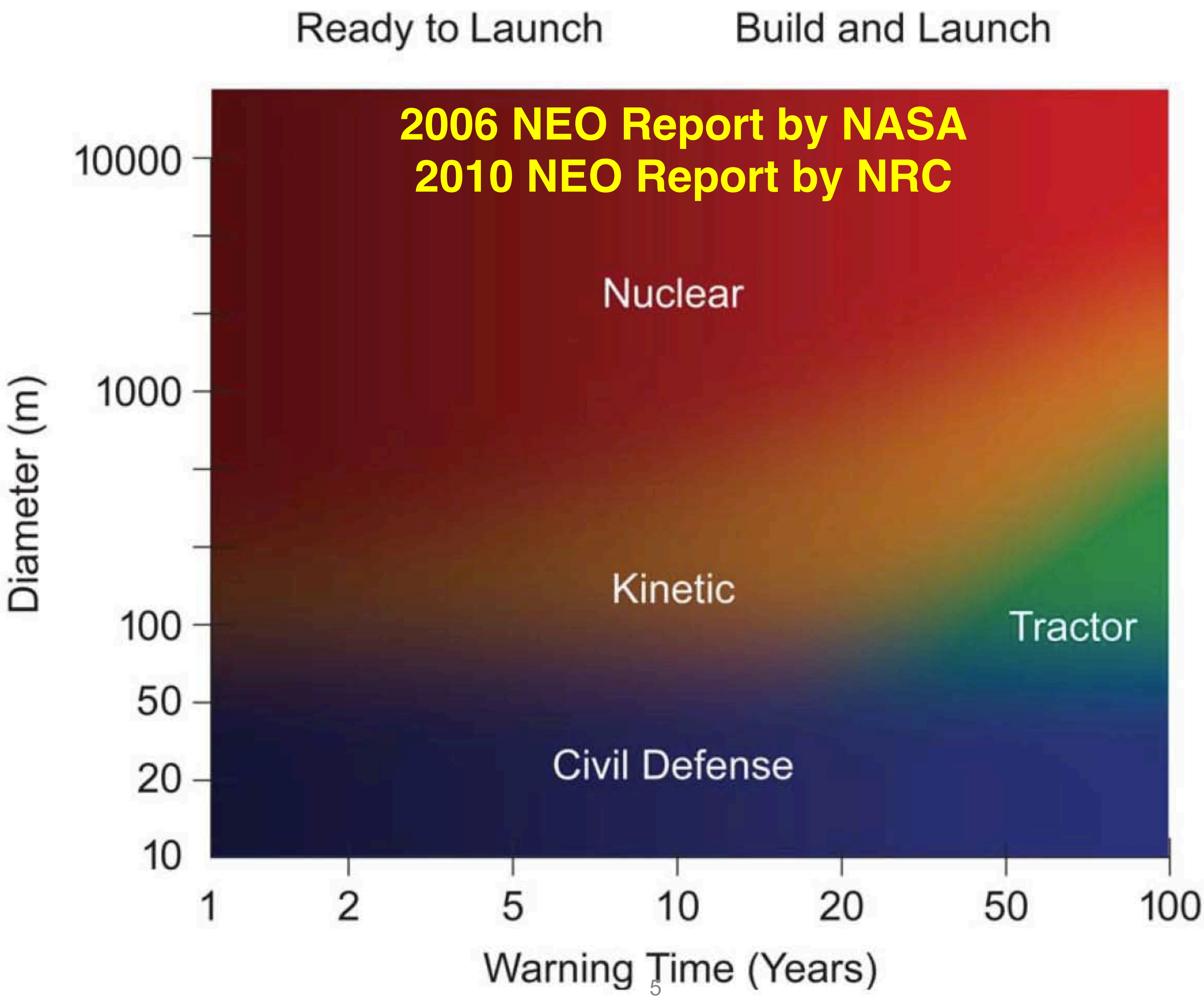
- **Late intercept missions, with short warning time < 1 yr, will result in a hypervelocity arrival closing (relative) velocity of 5 to 30 km/s.**
- **ΔV = 10 km/s requires a 96% propellant mass (300-s Isp)**
- **ΔV = 30 km/s requires a 99.99% propellant mass ratio**
- **Impact velocity of nuclear explosive devices (NEDs) is limited as 300 m/s max (2005 NRC Report on NEPWs)**

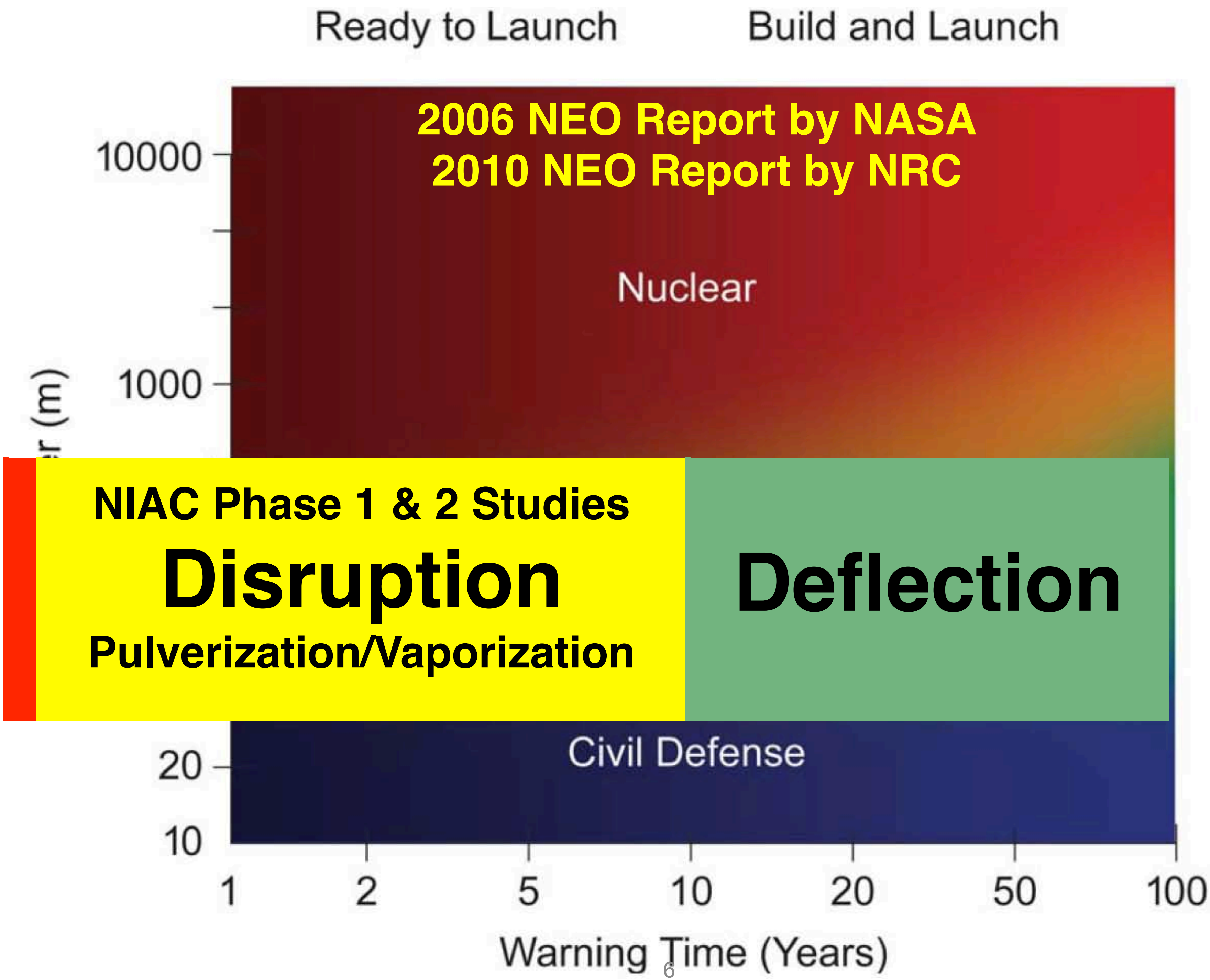




Precision Terminal Intercept Guidance




Ready to Launch
Build and Launch
2006 NEO Report by NASA
2010 NEO Report by NRC
Nuclear
Kinetic
Tractor
Civil Defense
Diameter (m)
10000
1000
100
50
20
10
1
2
5
10
20
50
100
Warning Time (Years)



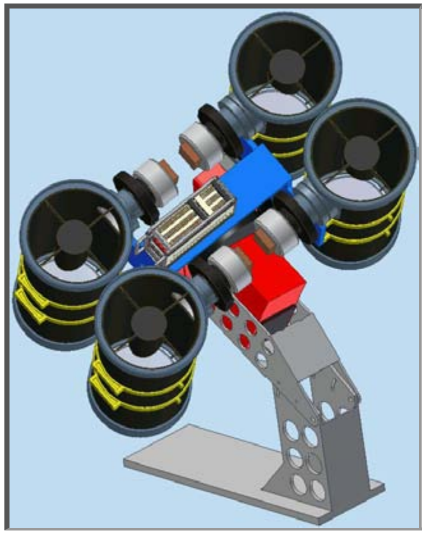
Ready to Launch
Build and Launch
2006 NEO Report by NASA
2010 NEO Report by NRC
10000
1000
20
10
Nuclear
NIAC Phase 1 & 2 Studies
Disruption
Pulverization/Vaporization
Deflection
Civil Defense
1
2
5
10
20
50
100
Warning Time (Years)

NIAC Project Outcomes (1/2)

- The Hypervelocity Asteroid Intercept Vehicle (HAIV) mission concept of blending a kinetic impactor with nuclear subsurface explosion
- 7 journal articles + 30 plus technical papers
- 3 Ph.D. (graduated) + 3 MS (graduated) + 3 Ph.D. (current)
- The HAIV mission concept should further exploit the ATLAS last alert system for active last-minute planetary defense (1 week – 3 weeks)

ATLAS Last Alert System
(Asteroid Terrestrial-Impact Last Alert System)

ATLAS project head Dr. John Tonry with a conceptual drawing for an ATLAS telescope. The project would use two of these 20-inch telescopes. *Credit: UH/IfA*



An early ATLAS design concept.

- **A $5M project started in 2013 (due to the Chelyabinsk event)**
- **The ATLAS is currently scanning the sky with a prototype camera and telescope, and will be fully operational in 2015-2016.**
- **So far, only for civil defense (evacuation)**
- **One-day alert for a 8-m, 30-kt "town killer"**
- **One-week alert for a 45-m, 5-Mt "city killer"**
- **Three-week alert for a 140-m "county killer"**

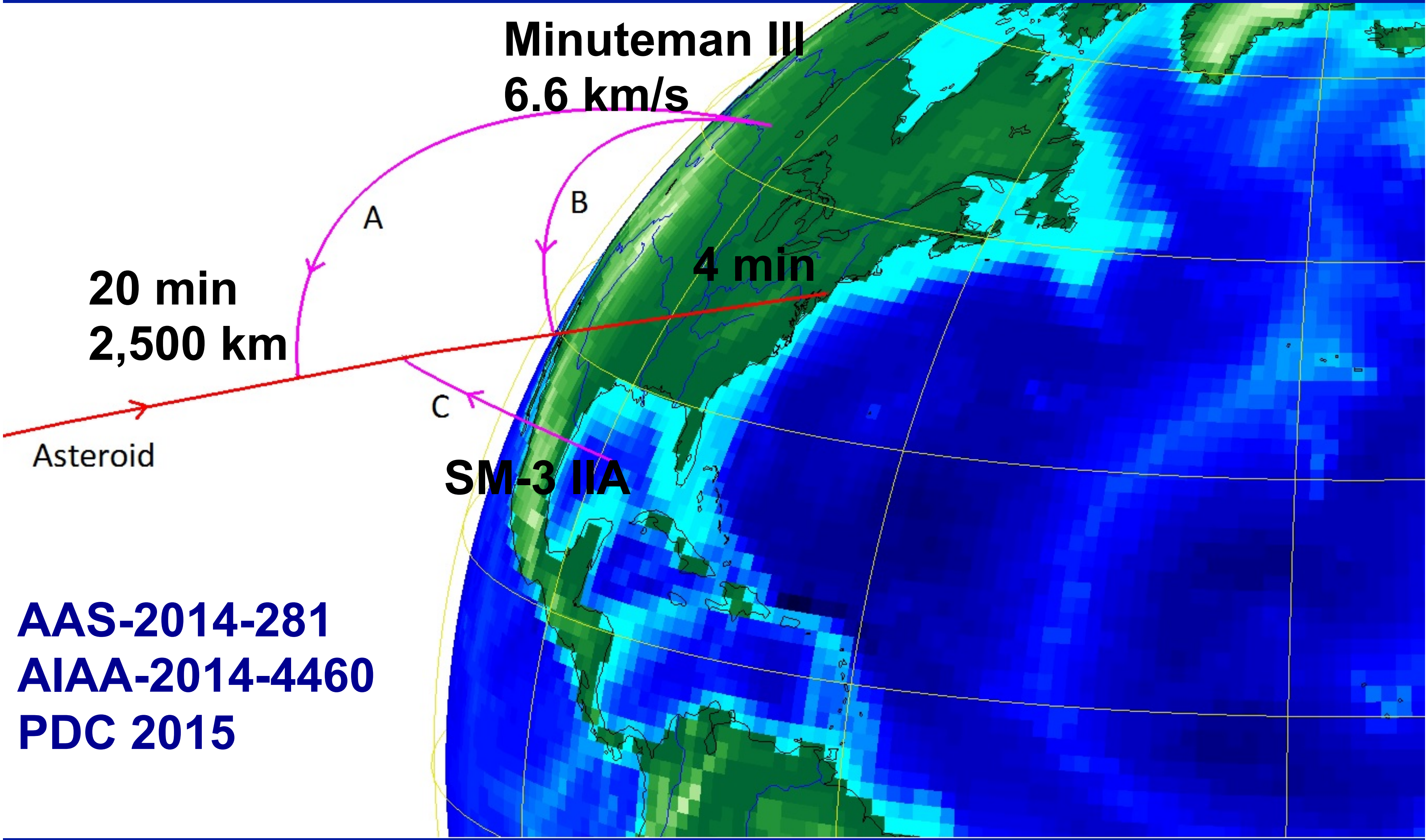
NIAC Project Outcomes (2/2)

- **If a HAIV/IPBM system (≈ $200M- $500M) becomes ready to launch at anytime in the future,**

  - ✓ **Given one-week warning from the ATLAS, an asteroid (> 45 m) can be intercepted/fragmented far outside the orbit of moon.**
  - ✓ **Given three-week warning from the ATLAS, an asteroid (> 140 m) can be intercepted/fragmented far outside Earth's gravitational field.**

- **Note that ALL other "non-nuclear deflection" options will require much earlier warning of at least 10 to 20 years.**

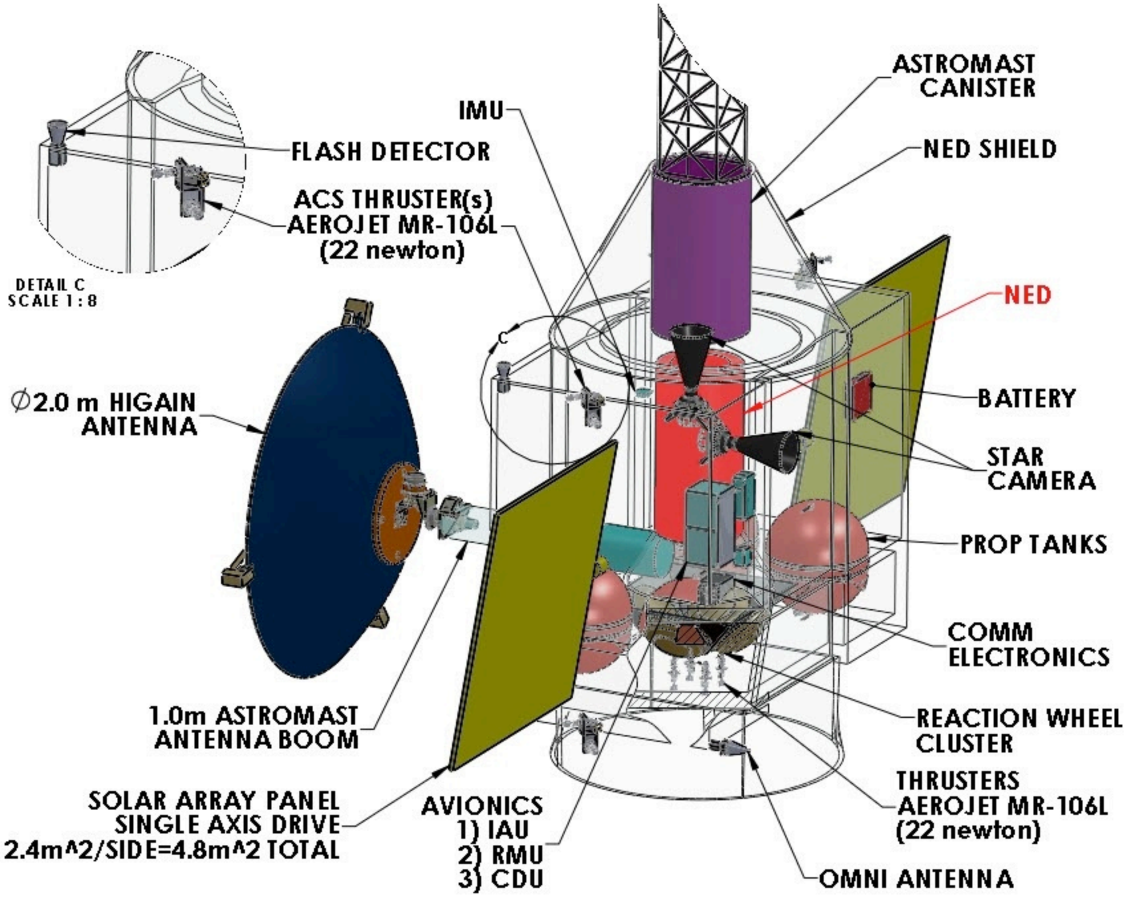
Suborbital Nuclear Intercept/Pulverization Mission Scenario



AAS-2014-281
AIAA-2014-4460
PDC 2015

HAIV Design by NASA GSFC for a Flight Validation Mission ($500M)

Atlas V



Acta Astronautica
Vol. 106, 2015, pp.139-159

HAIV Design by the Mission Design Lab (MDL) of NASA Goddard Space Flight Center

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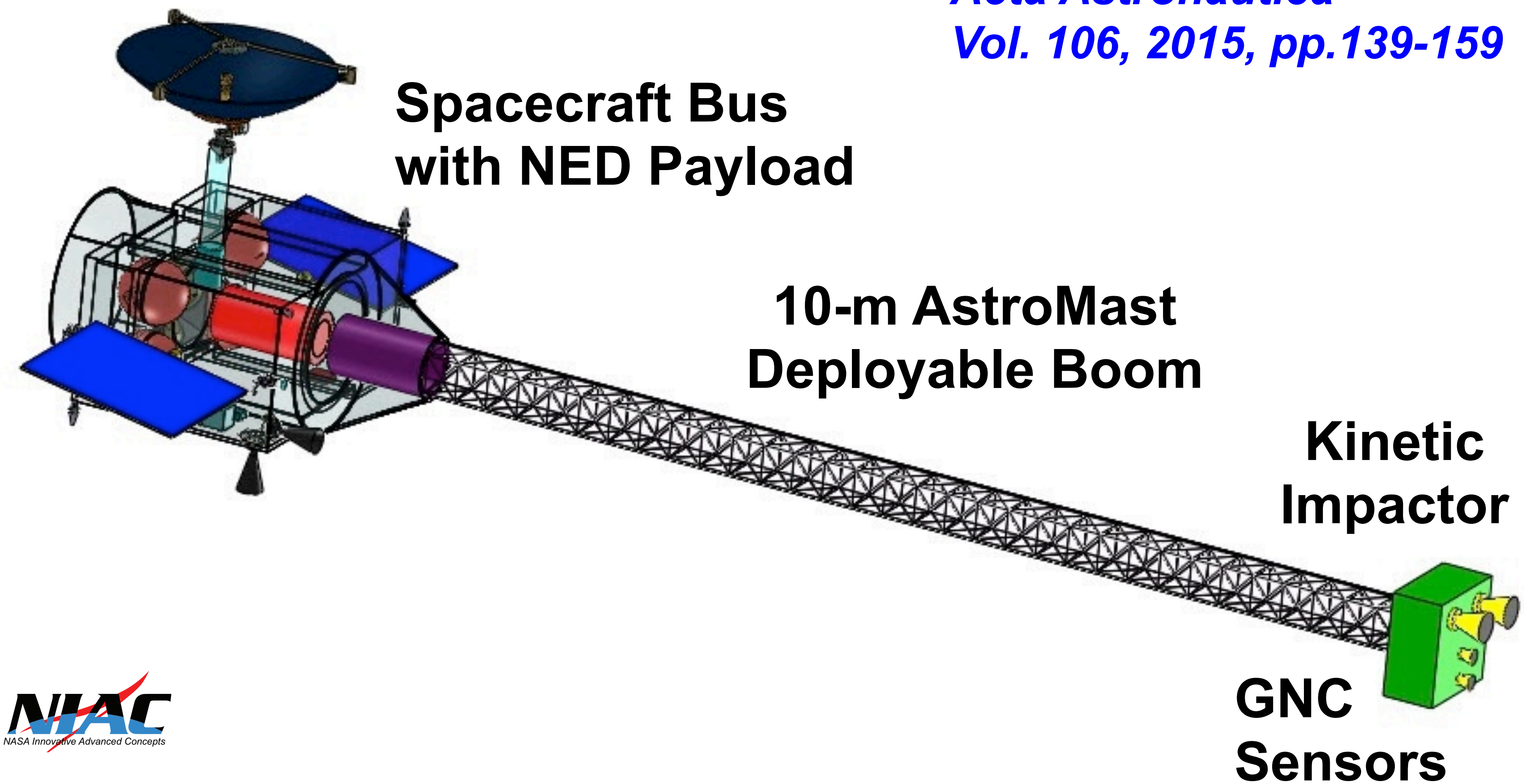
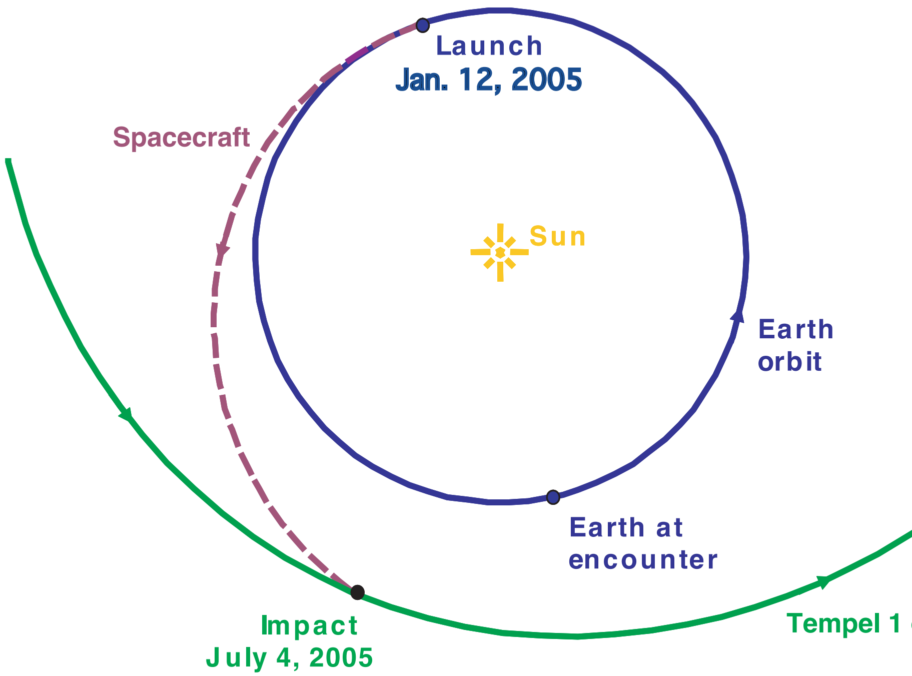
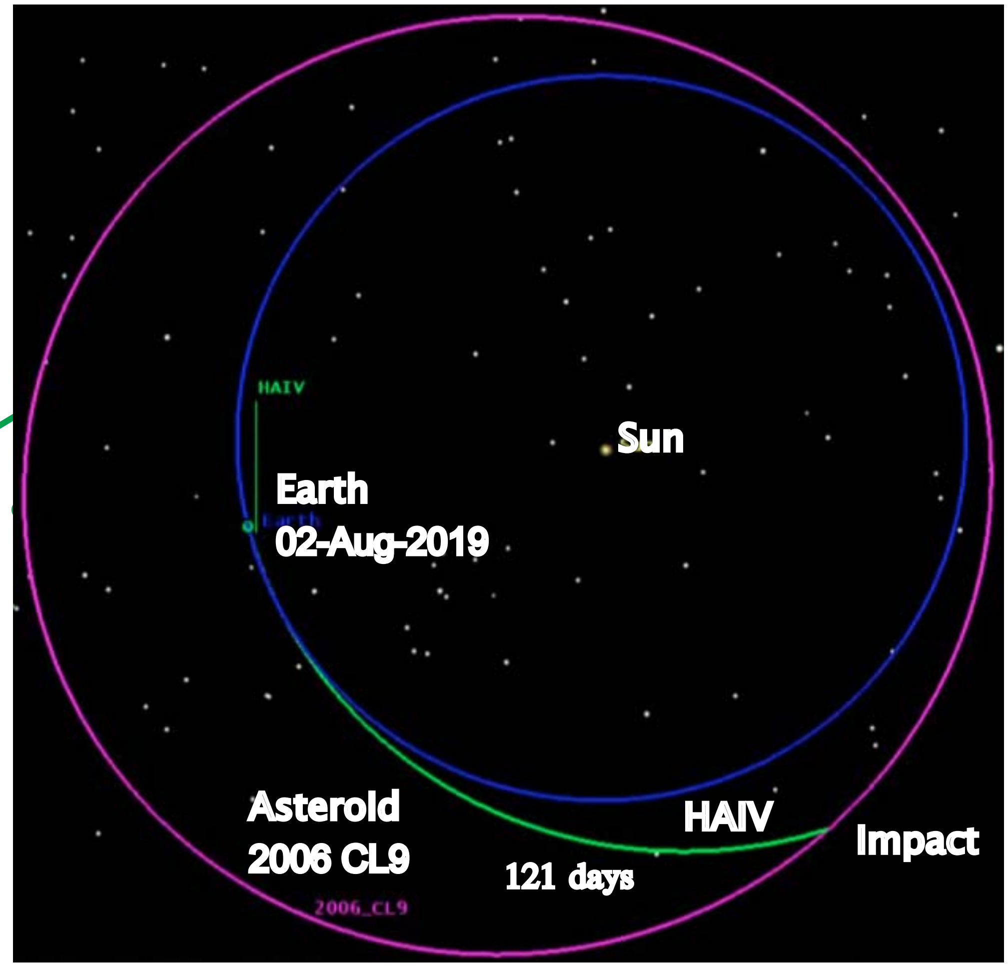


HAIV Flight Validation Mission Trajectory

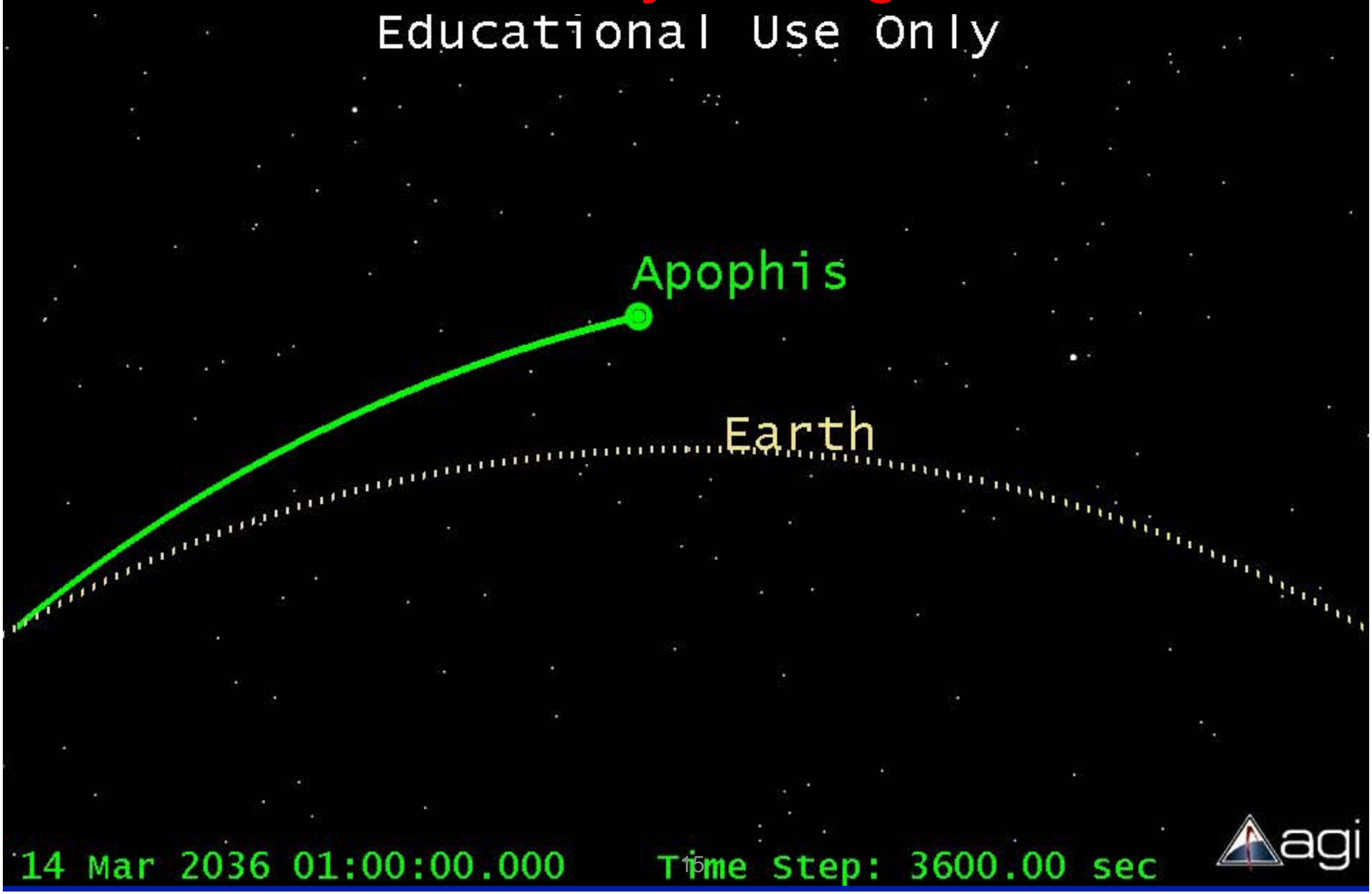


2005 Deep Impact Mission Trajectory



Hypervelocity Asteroid Intercept Vehicle (HAIV) Interplanetary Ballistic Missile (IPBM) Concept

Pulverization and Dispersion of a 300-m Asteroid with a 30-day Warning Time



NIAC Study Summary

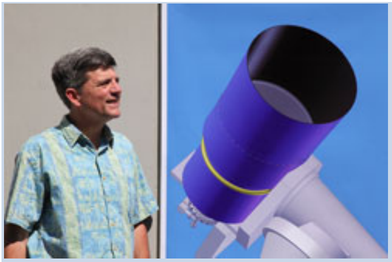
Early Warning (> 10 yrs) → "Build and Launch" (Deflection)

> 2 yrs → "Build and Launch" (Deflection vs. Disruption)

< 1 yr → NIAC NASA Innovative Advanced Concepts — **"Ready to Launch" (Disruption)**

IPBM/HAIV
$200M - $500M

ATLAS Last Alert



ATLAS project head Dr. John Tonry with a conceptual drawing for an ATLAS telescope. The project would use two of these 20-inch telescopes. *Credit: UH/IfA*

3-week (> 140 m) → **1-week (> 45 m)** → "Ready to Launch" (Interplanetary)

1 day – 1 wk → "Ready to Launch" (inside/outside lunar orbit)

Thank You !