

Probabilistic Design of a Planetary Defense System

by

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Outline

- ❖ Systems Engineering & Literature Survey Identifies Four Threat Mitigation Techniques:
 - Thruster
 - Impactor
 - Standoff Nuclear Explosion
 - Mass Driver
- ❖ Deterministic Results
- ❖ Probabilistic Results

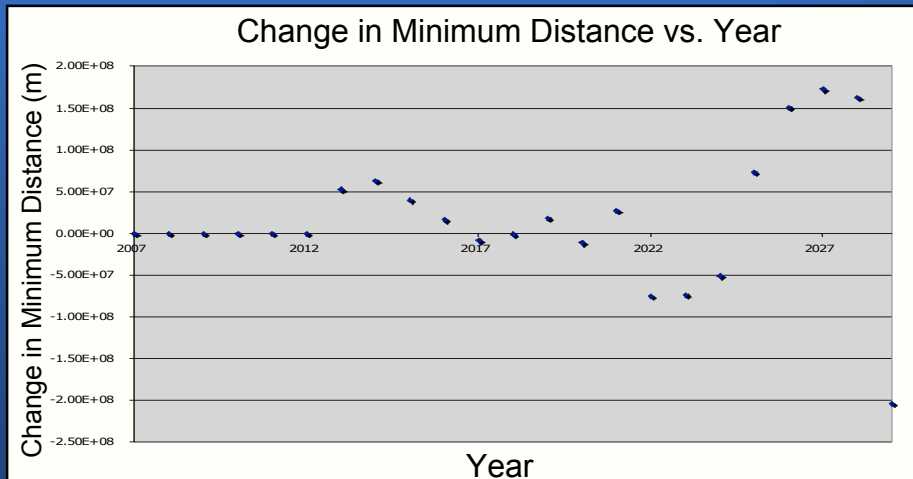


<http://www.cartoonstock.com/directory/a/asteroid.asp>

Deterministic Results: Thruster vs. Impactor

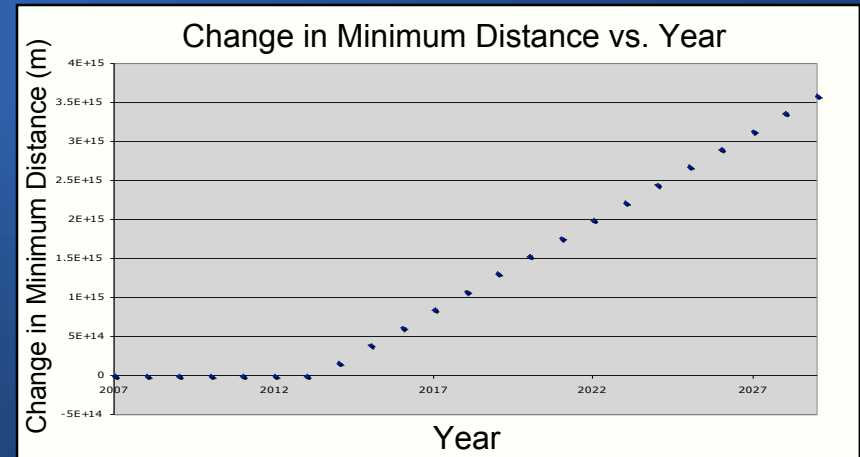
Thruster

- ❖ Rocket delivers thrust through NEO center of mass (CM)
- ❖ Saturn IV-B capabilities http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19710065502_1971065502.pdf
 - 475 sec burntime
 - 1001kN of thrust
- ❖ Deterministic effects:



Impactor

- ❖ Velocity vector and mass of Deep Impact Mission impactor <http://deepimpact.jpl.nasa.gov/tech/impactor.cfm>
 - 370kg impactor
 - ~50km/s relative speed
- ❖ Adiabatic inelastic collision
- ❖ Deterministic effects:



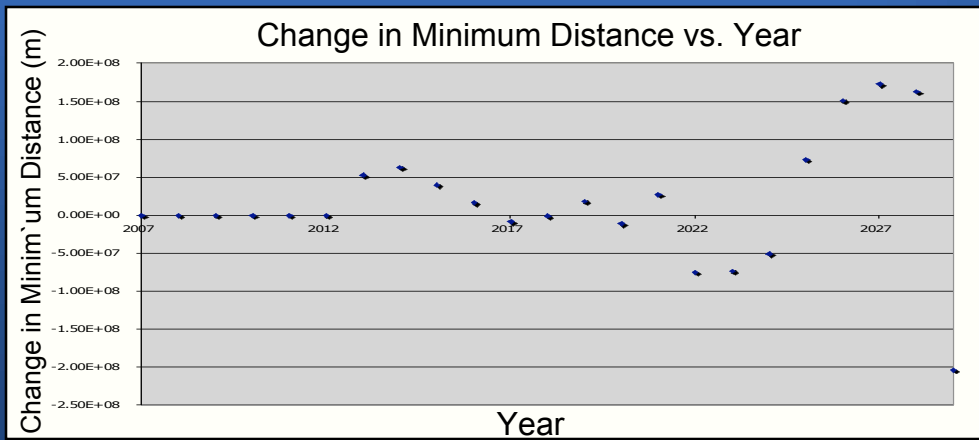
Deterministic Results: Nuclear vs. Mass Driver

Standoff Nuclear Explosion

- ❖ Neutron radiation of NEO causes surface evaporation, acts as propellant Gennery, D., AIAA 2004-1439
- ❖ Imparted momentum vector coefficients chosen to be

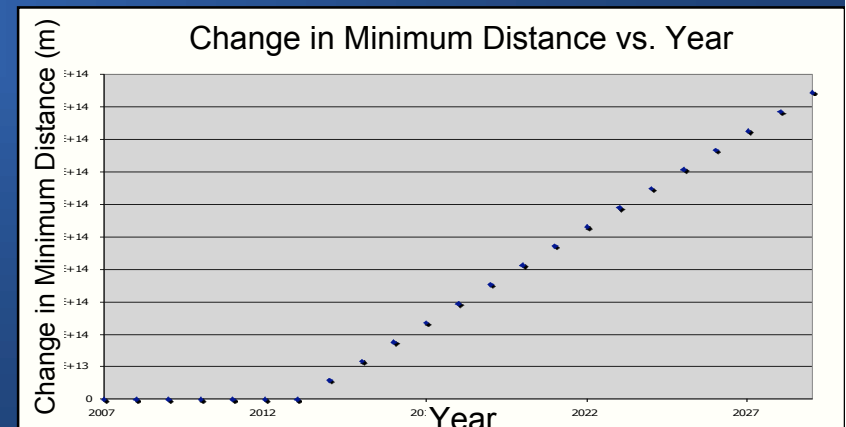
$$\left(\frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}} \right)$$

- ❖ Deterministic effects:



Mass Driver

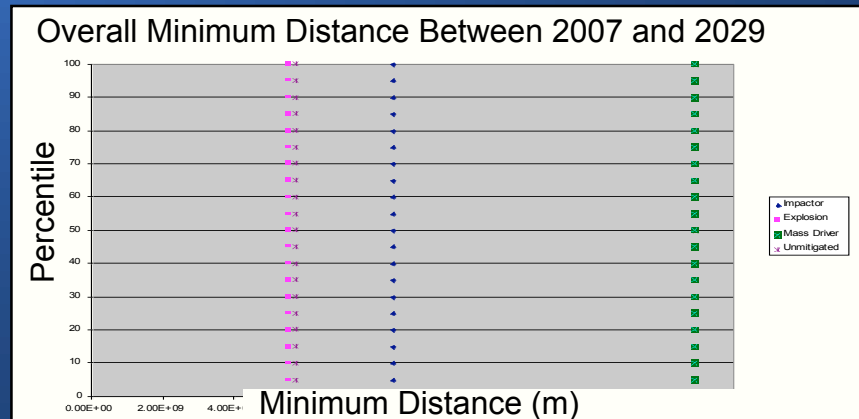
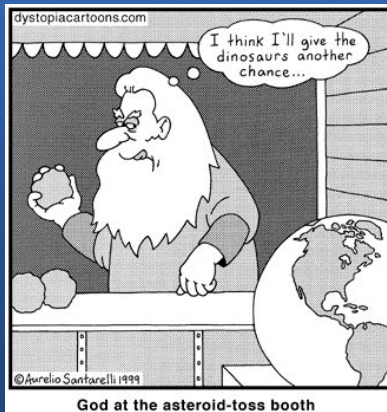
- ❖ Use performance estimates of Spaceworks Engineering's MADMEN Olds, J. et al, NASA CP-NIAC 02-02
 - 100 kg/hr ejection
 - 100m/s ejecta speed
- ❖ Assume subsystem cooperation to impart velocity vector coefficients of $\left(\frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}} \right)$
- ❖ Deterministic effects:



Probabilistic Results

- ❖ Design variable uncertainty examined with Monte Carlo Simulation over shown ranges
- ❖ Design variable uncertainty found to be insignificant
- ❖ Future work can examine effect of NEO uncertainty (e.g., trajectory, mass)

Design Variable	Units	Low	High
No. of Warheads	none	1	5
Explosive Energy	Mton	5	25
Mass of Impactor	kg	320	420
V_ImpactorX	m/s	1.40E+04	2.30E+04
V_ImpactorY	m/s	-1.70E+04	-8.00E+03
V_ImpactorZ	m/s	-2.00E+02	-1.20E+02
Running Time	hours	1	10
M_PropellantX	kg/hr	80	120
M_PropellantY	kg/hr	80	120
M_PropellantZ	kg/hr	80	120
V_Propellant	m/s	80	120



Questions?

- ❖ Visit the poster entitled: Probabilistic Design of a Planetary Defense System
- ❖ I will be the docent, so feel free to ask questions there