StarGrind & Armory Practice – Using Earth's Best Bad Habits as a Last Ditch Stand Against Short Warning Time NEO Impacts

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…if all else… … …fails.

points of departure:
2021 PDC
- **6 months to impact**
- **take what's at hand**
- go for it all-out
- shoot now

➔ deflect or abort later

points of departure:
2023 PDC
- **still** 11 **years to impact**
- **very large asteroid**
- nuclear decision
- **times a-changin'**

➔ sub-nuclear needed

points of departure:
2024 PDC$_{25}$
- **still** 16 **years to impact**
- **deceptively small asteroid**
- **long uncertain location**
- late decision, little support

➔ late quick solution needed

points of concern:
climate change
- **global impact certain**
- **many tools ready at hand**
- fake news & false balance
- wait now, wait later

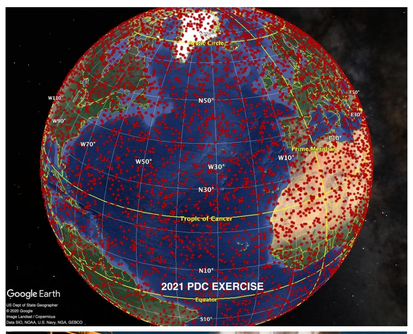
➔ act now or suffer later

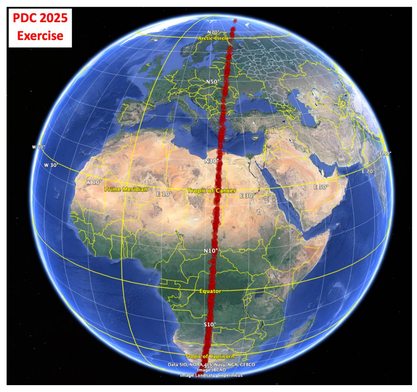
points of practice:
1997 XF$_{11}$ to Dimorphos
- was 31 years to ***no*** impact
- very large asteroid
- **action follows attention**
- DART hits **25 years after**

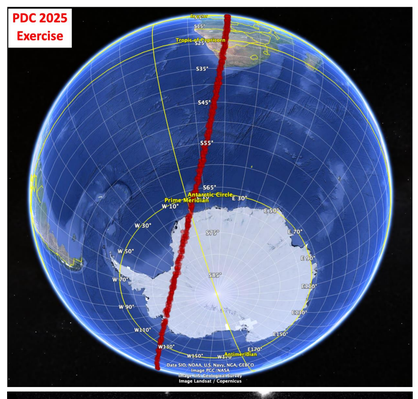
➔ sub-nuclear tested ☑ **once**

points of arrival:
(99942) Apophis
- discovered >20 years ago
- **1-in-7500 years opportunity**
- **no dedicated mission @ T-4**
- late decision, little support

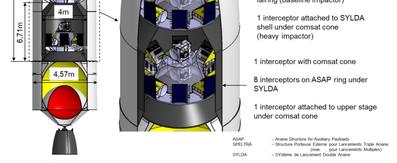
➔ late quick solution needed

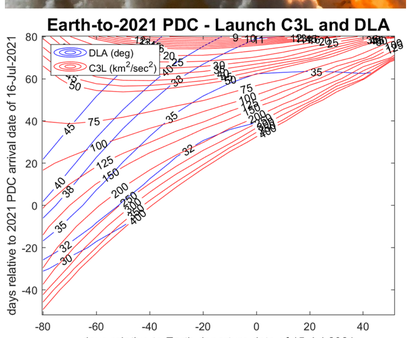




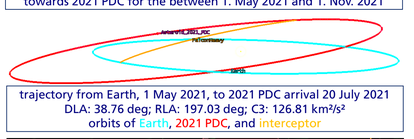


- very big launcher
- many small impactors
- AsteroidSQUADS/iSSB
- 1st version @ PDC 2011
- then, just a big test & exercise of opportunity

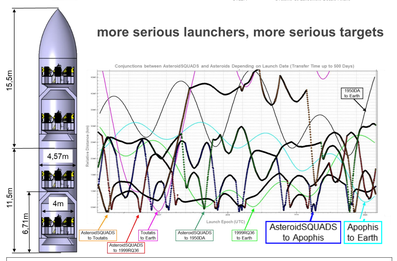


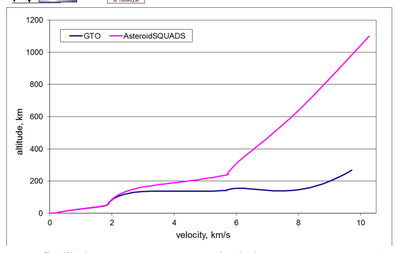


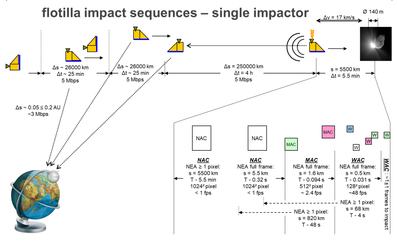
Declination of the Launching Asymptote (DLA) and injection characteristic energy (C3) for an interceptor going from Earth towards 2021 PDC for the between 1. May 2021 and 1. Nov. 2021



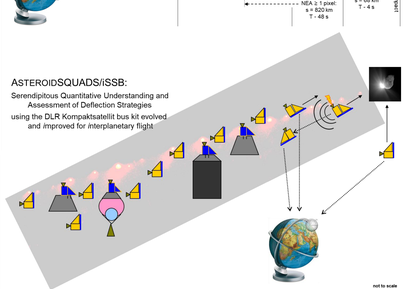
trajectory from Earth, 1 May 2021, to 2021 PDC arrival 20 July 2021
DLA: 38.76 deg; RLA: 197.03 deg; C3: 126.81 km²/s²
orbits of Earth, 2021 PDC, and interceptor

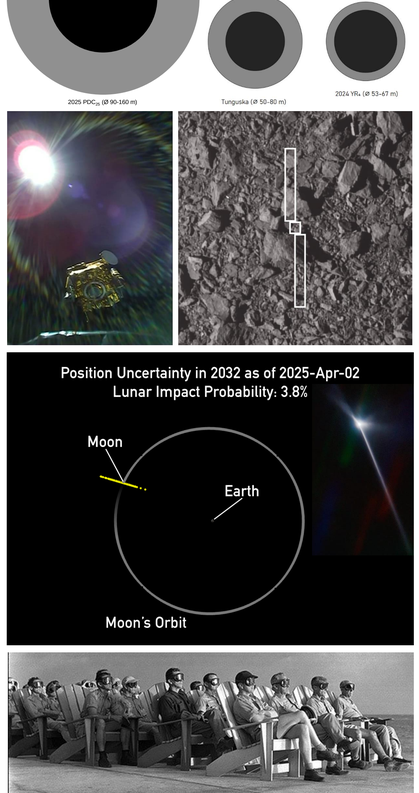




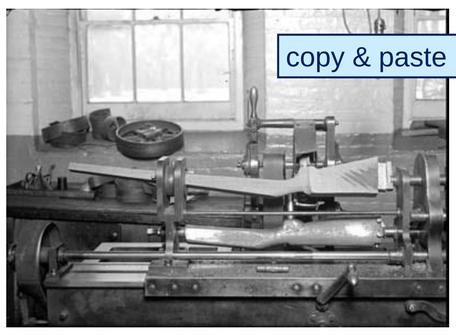


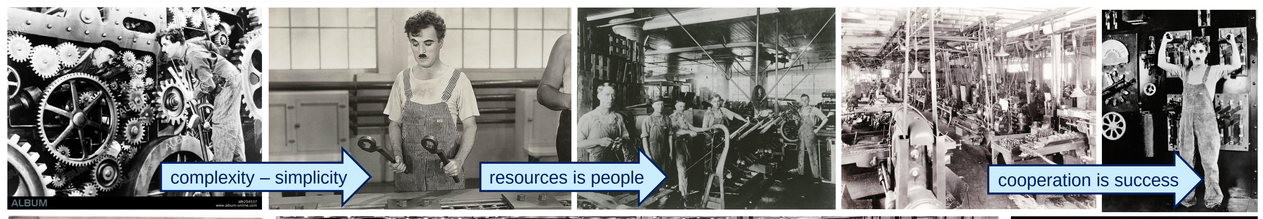
514 s launch segment 90.7° azimuth (hidden), 179.77 km altitude 7.728 km/s, phasing arc (green), ellipse with apogee of 7012.12 km (blue), interplanetary injection at perigee (orange)

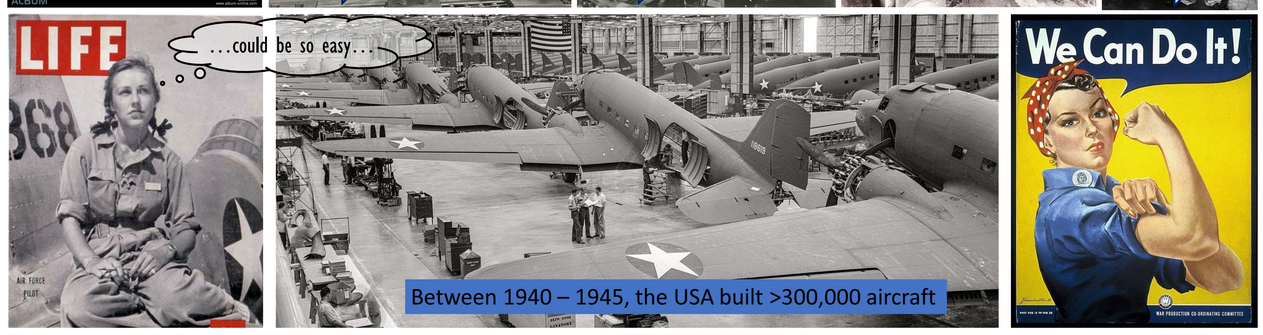


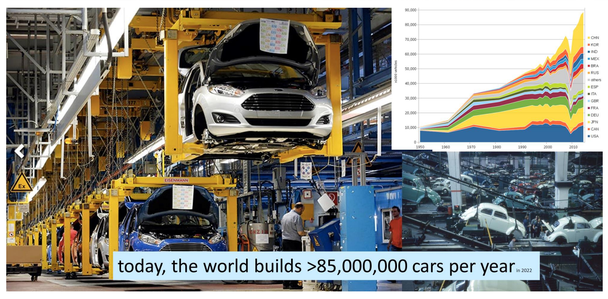


practice asteroids for the tricky 20's









- >85M vehicles built in 2022 worldwide
- average weight per car in the U.S.: 1,945 kg
- >165 Mt moving product mass per year
- equivalent of 2 to 3 Planetary Sunshades

…rolled out to 40 g/m²:
- 48,000 m² = (220 m)² per avg. car
- >4 M km² per year
- ≈2 Planetary Sunshades per year

- >1.4 G mobile phones built in 2021
- >16 G mobile devices operate worldwide
- typical mass 120 … 250 g → 0.3 Mt/year
- 10's to ≈2000 ICs per mobile device (incl. cars)

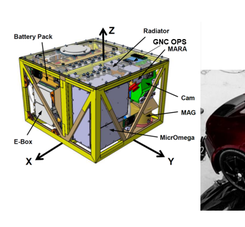
…in a sunshade of various small sails:
- 2 M km² → ≥200 M sails of (100 m)²
- 2 M km² → ≥2 T mini-sails of 1 m²
- IC supply > several Sunshades/year

new one comes in –
serious money goes out for 2 years

serious money comes in –
new one goes out 2 years later

← 4x 2 GHz OBC 2x 40 MHz →
← 128 GB Flash 0.88 GB →
← 12 Mpx Camera 1 Mpx →
← 54 MB/s WiFi 30 KB/s →
← buzzes motor jumps →
← Hall eff. MAG fluxgate →
← MEMS ACC almost… →
← included charger next time →

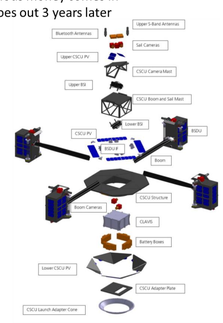
(almost to scale)



new one comes in –
serious money goes out for a few years

← Fe, Al structure CFRP →
← 100's CPUs 5 →
← many Cameras 7 →
← 5G WiFi Bluetooth →
← 4+10's motors 4 →
← 1 vehicles 4 →
← 100's mechanisms 10's →
← 200 kWh battery 10's Wh →

serious money comes in –
new one goes out 3 years later



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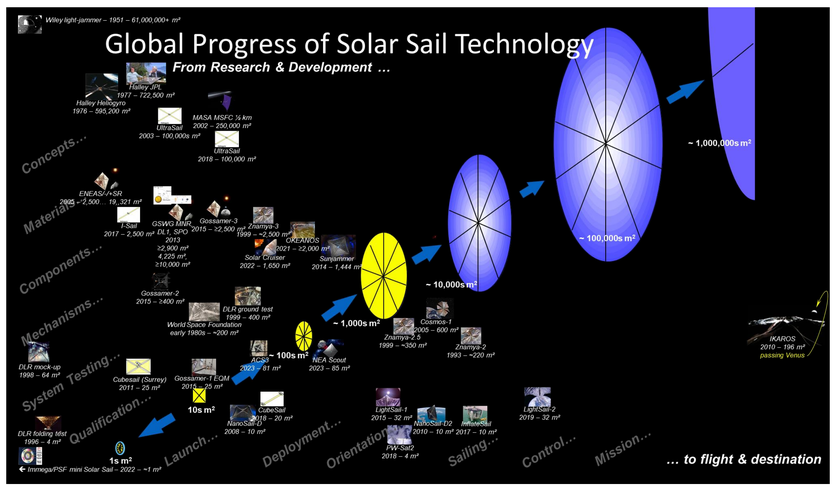

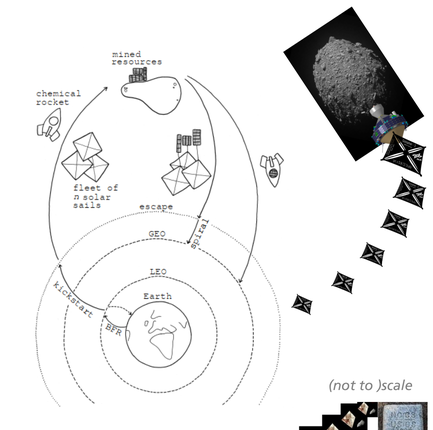

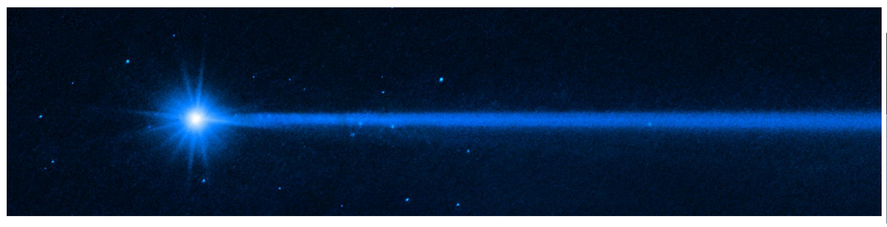

EXERCISE – EXERCISE – EXERCISE – EXERCISE – EXERCISE – EXERCISE

For 14 years of 'fun papers' we have practiced to defend Earth from challenging asteroids using small spacecraft, shoebox-sized nanolanders, and membranes thinner that a human hair sailing on nothing but sunshine. *Keep 'em coming!*

We welcome 2024 PDC$_{25}$!

EXERCISE – EXERCISE – EXERCISE – EXERCISE – EXERCISE – EXERCISE

The times, they are a-changin' and the future is certain – give us time to work it out.