

# GOVERNING THE EMERGING RISK POSED BY ASTEROID MANIPULATION TECHNOLOGIES

Steering asteroids is possible and will be done for economic or strategic gain.

This technology exposes humanity to new risks from mistakes, wars, and terrorism.

Space governance is required if we want to reduce this risk to negligible levels.

## INCENTIVES TO MOVE ASTEROIDS CLOSER TO EARTH

### Economic

Vast amounts of metals are accessible, dwarfing humanity's current total reserves.<sup>1</sup>

Asteroid matter can be processed into key resources for space infrastructure such as fuel, water, radiation shielding, energy production systems, and construction material — all of which are extremely expensive to launch from the Earth.<sup>2</sup>

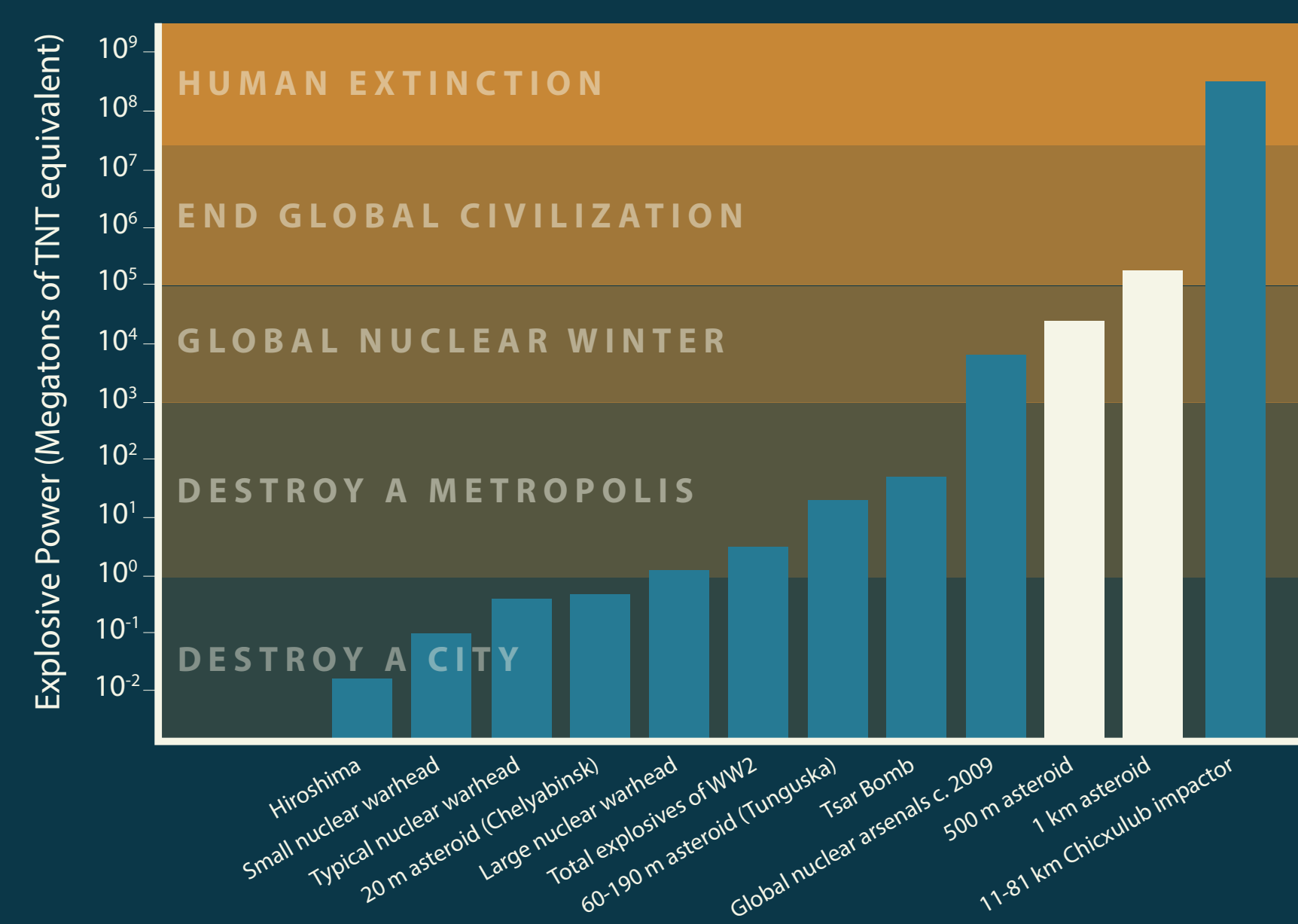
### Military

Humanity will soon be capable of weaponizing asteroids. As compared with nuclear weapons, manipulated asteroids may soon be:

- More destructive
- More difficult to defend against
- Easier to attain because they employ only dual-use, legal, and cost-effective technologies

Military installations on an asteroid in Earth orbit could yield a *decisive strategic advantage*, thus increasing the chances of an arms race in space.

## DESTRUCTIVE POWER OF WEAPONRY AND ASTEROIDS



**Figure 1:** Destructive power calculations for 500 m and 1 km asteroids performed by the authors. All other destructive power estimates were drawn from existing literature. The destructive outcome ranges were estimated by the authors based on existing literature. All citations available upon request. The Chicxulub impactor is believed to have rendered the dinosaurs extinct.

## HUMANITY FACES NEW DANGERS

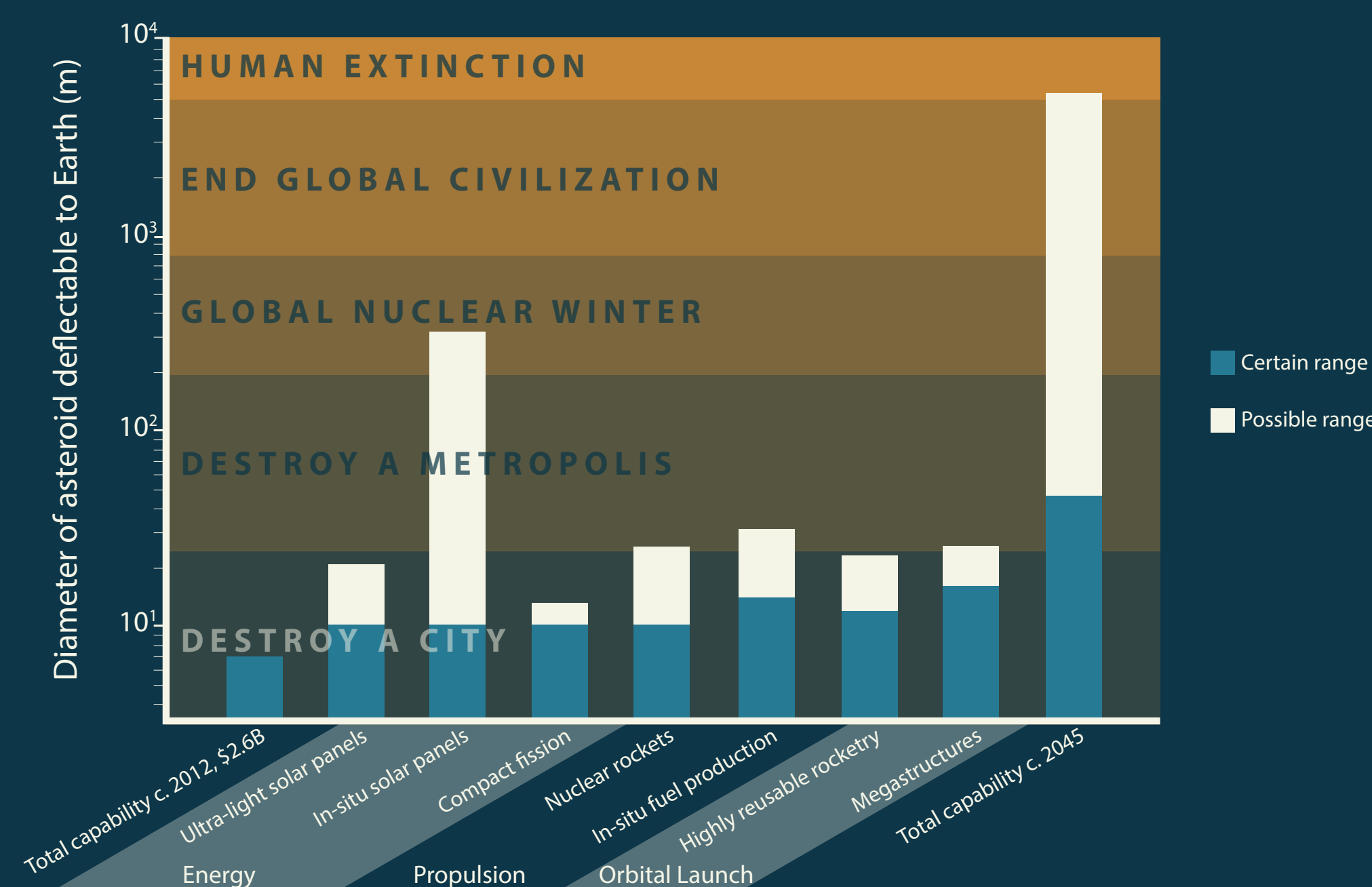
Anyone commanding modern space propulsion technologies wields destructive power *far* beyond that granted by nuclear weapons.

Through accident or malevolence, asteroids can be diverted into the Earth's path.

Asteroids brought near the Earth are possible targets for military or terrorist strikes, plausibly endangering humanity in the process. Such an asteroid could be:

- Diverted so that it collides with the Earth
- Shattered by an attack or an attempt to deflect it, causing fragments to collide with the Earth

## PROBABLE EXPANSION OF ASTEROID DEFLECTION CAPABILITY BY 2045



**Figure 2:** Total capability in 2012 is drawn from Brophy, et al. 2012.<sup>2</sup> All other presented data ranges are based on original research by the authors, drawing on literature that details existing prototypes and engineering appraisals for each technology.

## HUMANITY CAN BE PROTECTED FROM THESE DANGERS

### Differential technological development

- **Improved detection** will give us more time to respond to threats.
- **Increased asteroid manipulation ability** will increase the advantage of attack over defense.

### Differential engineering projects

- **Defensive deflection capacity** (such as forward-deployed diversion engines) can be prepared in advance for defending the Earth.<sup>3</sup>
- **Orbital infrastructure** (such as power sources, fuel depots, and power transmission) could be mustered for asteroid diversion in an emergency.
- **Orbital launch megastructures** (mass drivers, tethers, etc.) would allow bigger missions but would also reduce incentives to bring asteroids close to Earth and would improve humanity's overall defensive capabilities.

### Governance

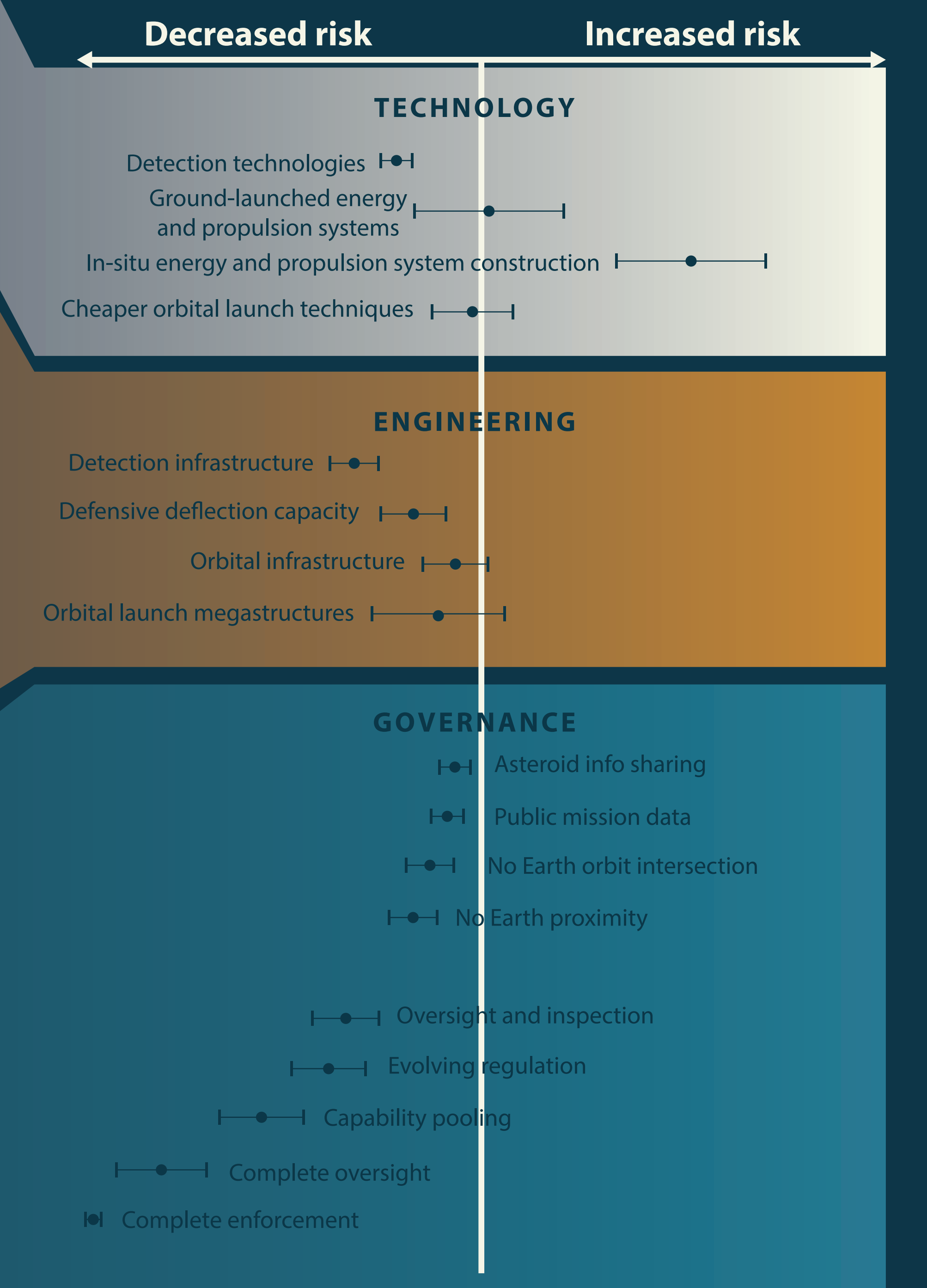
#### International agreements

- **Asteroid info sharing:** Require all nations to continuously share all asteroid trajectory data.
- **Public mission data:** Require that the UN be provided with the mission details of all asteroid interaction efforts.
- **No Earth orbit intersection:** Require that the manipulated trajectory of any asteroid larger than 20m in diameter never intersects with the Earth's future position.
- **No Earth proximity:** Require that no objects larger than 20m in diameter be brought closer to the Earth than high lunar orbit.

#### International institution

- **Oversight and inspection:** An institution analogous to the International Atomic Energy Agency to monitor compliance with regulations.
- **Capability pooling:** Combine all efforts for asteroid monitoring and Earth defense.
- **Complete oversight:** All use of space technologies reviewed and tracked.
- **Complete enforcement:** Independent, veto-free, and enforced governance of all use of space technologies.

## RISK CHANGES DUE TO ADVANCES IN TECHNOLOGY, ENGINEERING, AND GOVERNANCE THROUGH 2045



**Figure 3:** Each entry in the governance section is cumulative. That is, each entry also includes all of the governance points above it. All data ranges drawn from original research by the authors.

## REFERENCES

- 1 - Lewis, J.S., 1996. Mining the Sky: Untold Riches from the Asteroids, Comets, and Planets. Basic Books.
- 2 - Brophy, J.R., Friedman, L. and Culick, F., 2012, March. Asteroid retrieval feasibility. In 2012 IEEE Aerospace Conference (pp. 1-16). IEEE.
- 3 - Mazanek, D.D., Brophy, J.R. and Merrill, R.G., 2013. Asteroid retrieval mission concept-trailblazing our future in space and helping to protect us from Earth impactors. Planetary Defence Conference 2013.

Additional references available upon request.



**Vision of Earth**

[www.visionofearth.org](http://www.visionofearth.org)

Kyle Laskowski - [kyle.laskowski@visionofearth.org](mailto:kyle.laskowski@visionofearth.org)

Ben Harack - [ben.harack@visionofearth.org](mailto:ben.harack@visionofearth.org)

Alana Watson - [alana.watson@visionofearth.org](mailto:alana.watson@visionofearth.org)