

Earth Observation Technologies for Climate Change Adaptation and Monitoring: Future Projections from Decadal Trends

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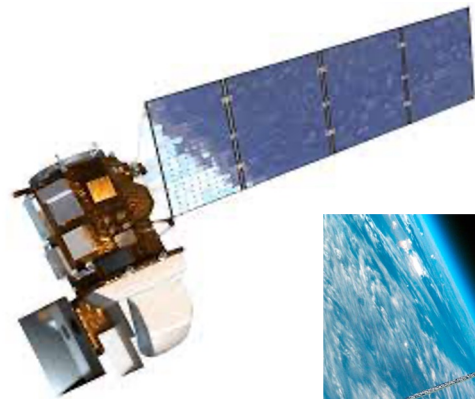
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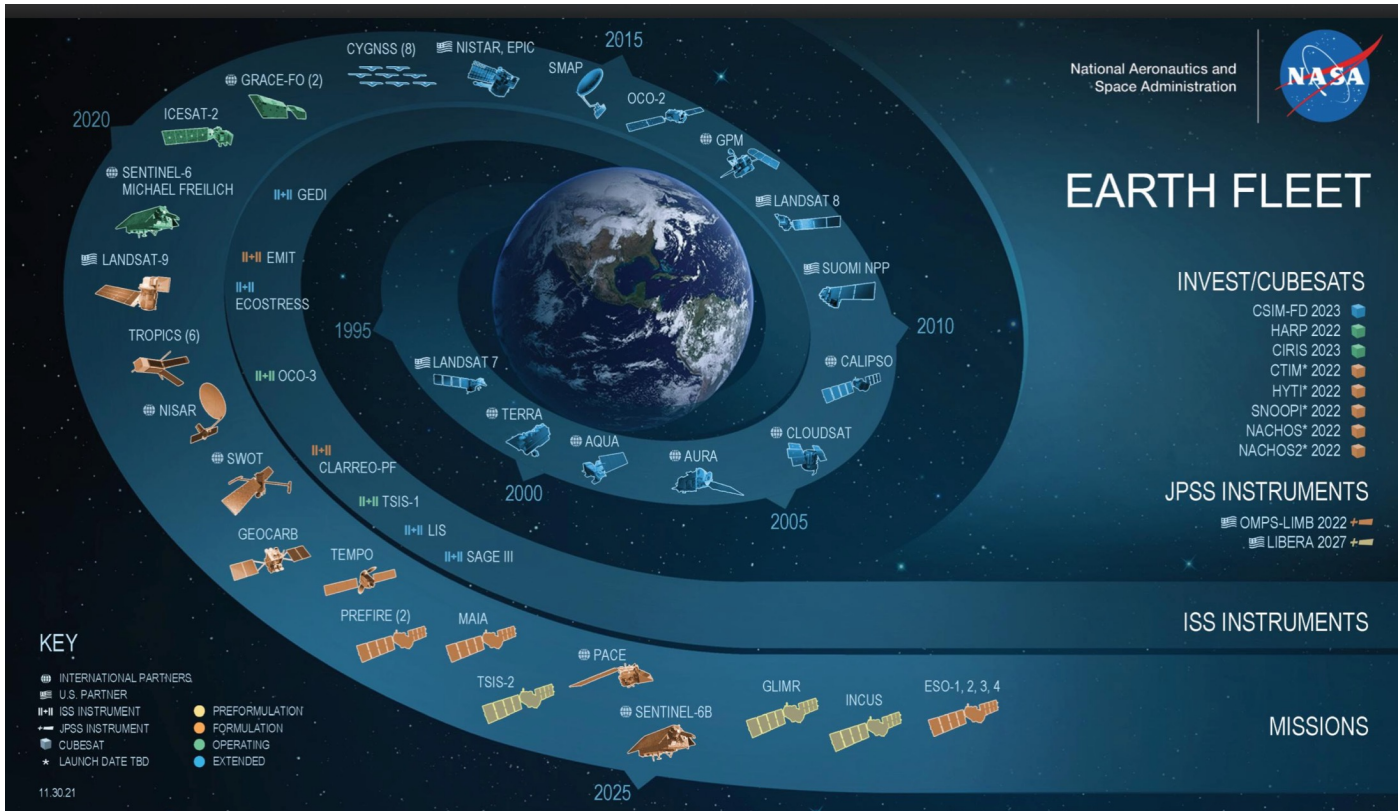
Olivier de Weck (MIT)



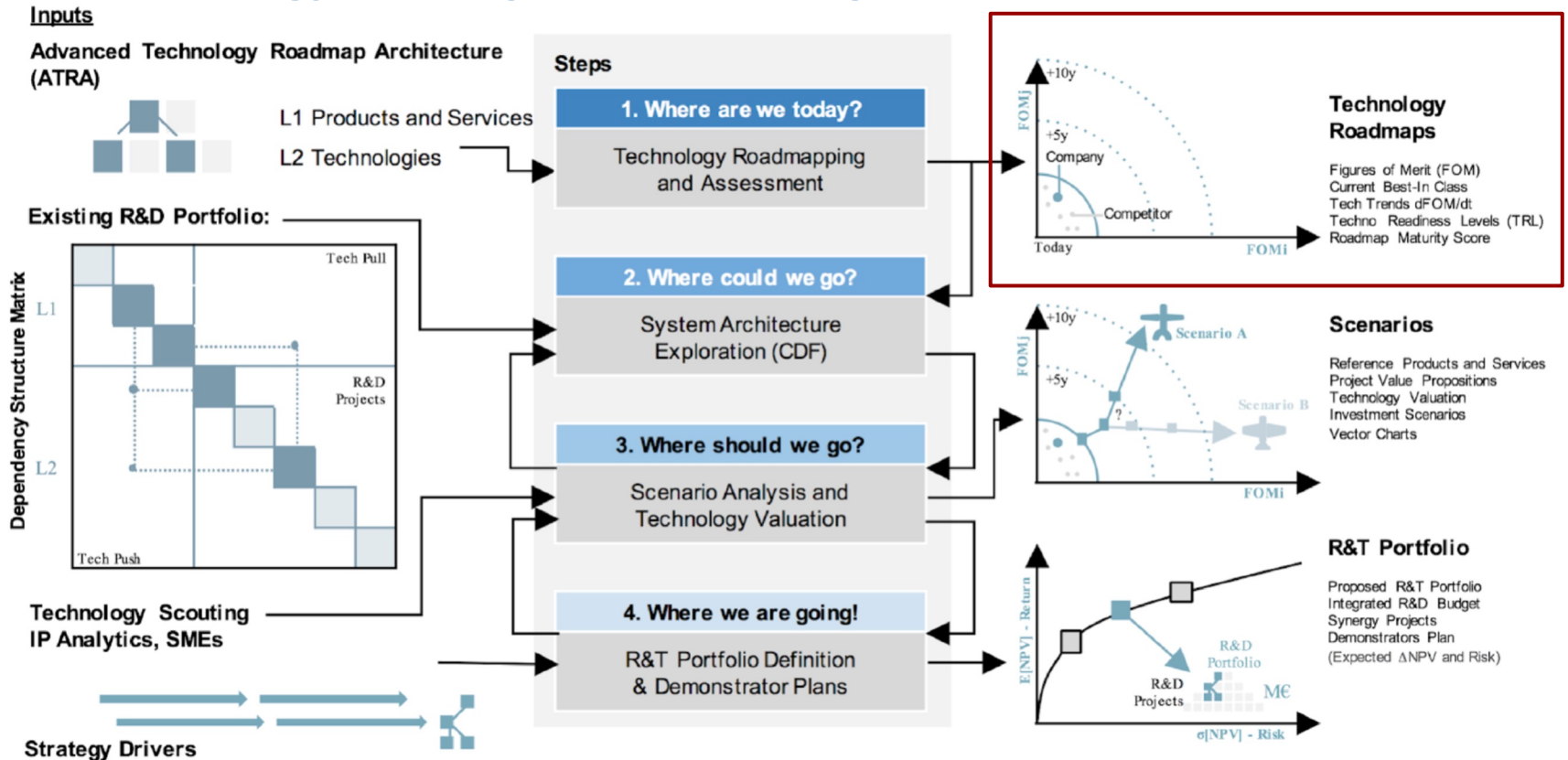
Early Stage Innovations NASA Grant 80NSSC21K0219 -
Space Technology Missions Directorate

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Systematic technology roadmapping can be useful for guiding future investment decisions based on planned missions



Advanced Space Technology Roadmapping Architecture (ASTRA) methodology is being developed to guide development and investments



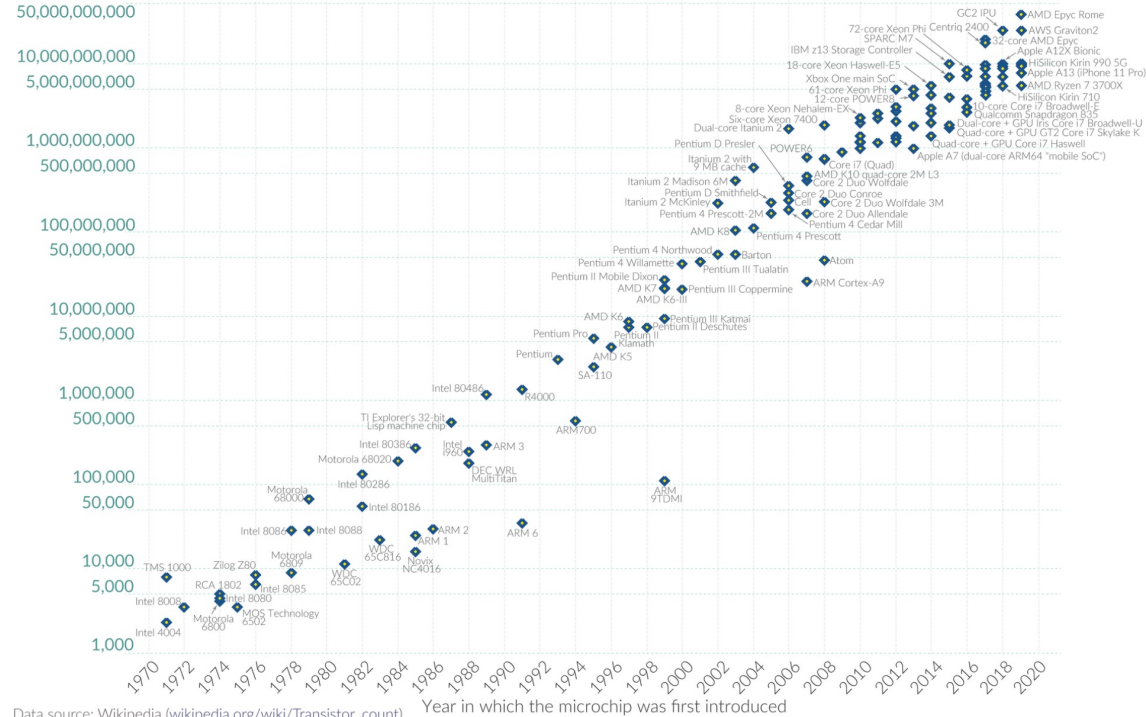
Moore's Law: Progression of computing over time

Moore's Law: The number of transistors on microchips doubles every two years

Moore's law describes the empirical regularity that the number of transistors on integrated circuits doubles approximately every two years. This advancement is important for other aspects of technological progress in computing – such as processing speed or the price of computers.

Our World
in Data

Transistor count

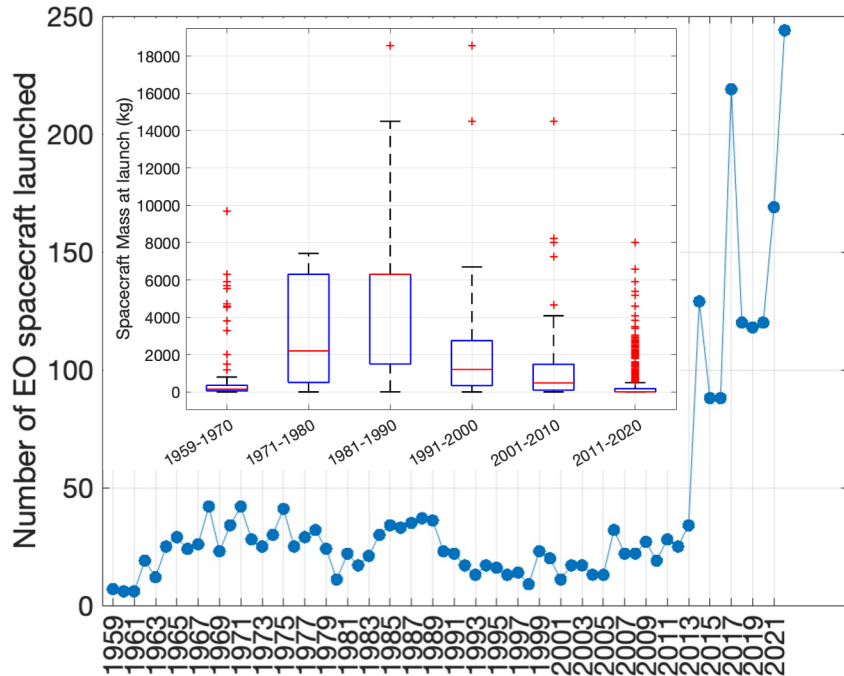


Data source: Wikipedia (wikipedia.org/wiki/Transistor_count)

OurWorldInData.org – Research and data to make progress against the world's largest problems.

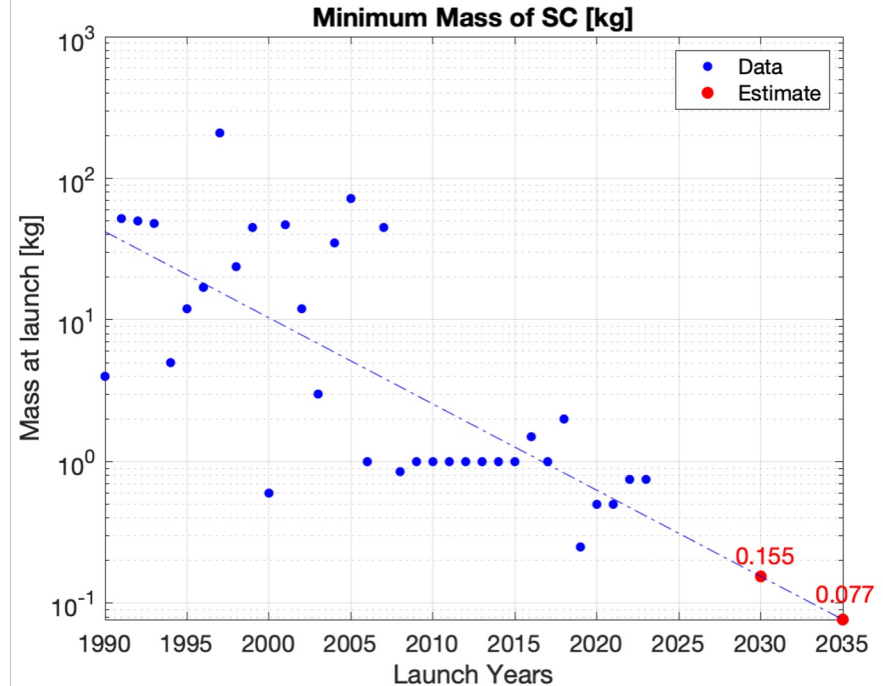
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Spacecraft launch activity has accelerated. A decadal assessment shows median mass of launched spacecraft has consistently declined since 1991



- spacecraft with primary mission 'earth observation' or 'science' –
- only civil and commercial spacecraft included

Source: Seradata.



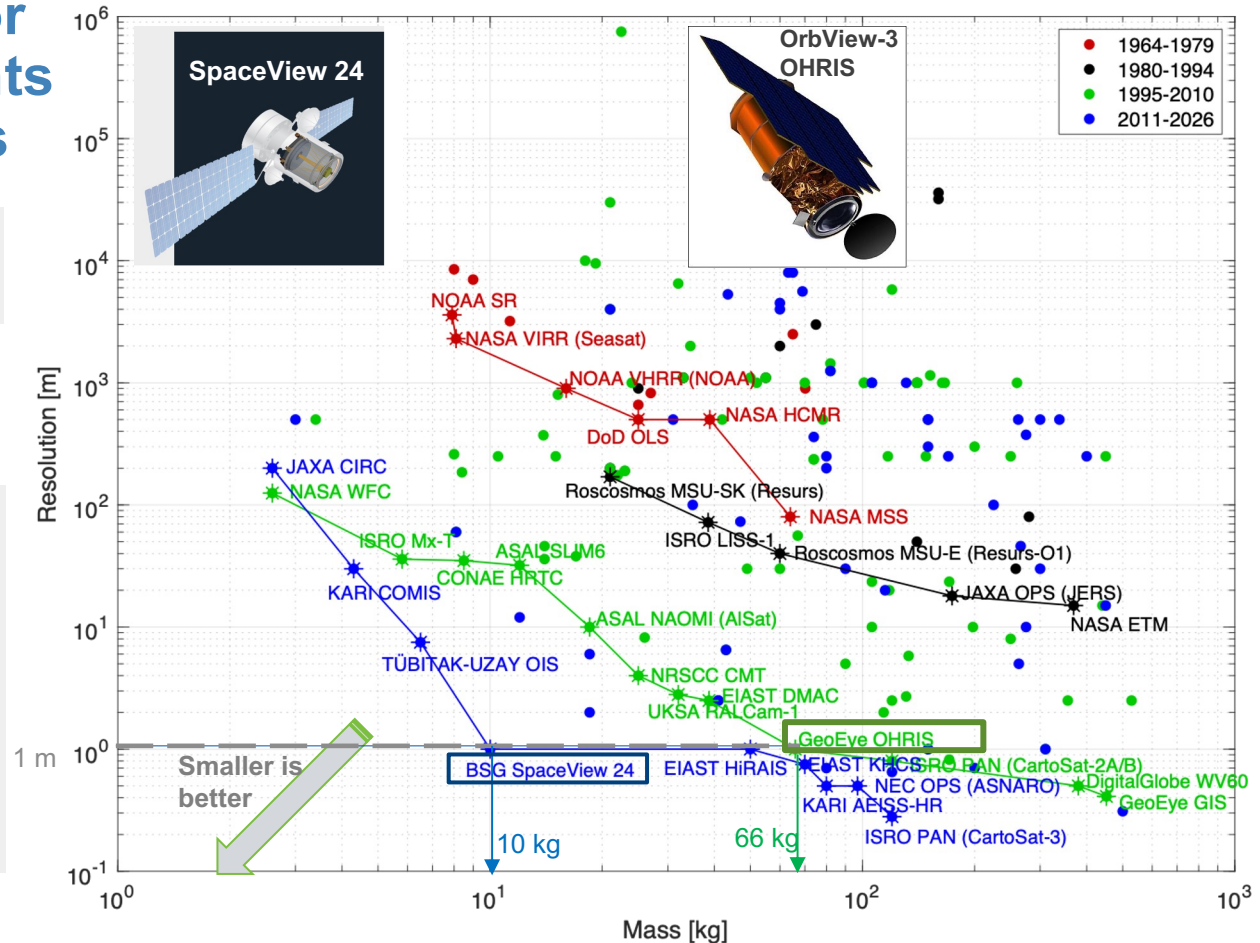
Mann-Kendall test (for directionality) shows statistically significant ($p < 10^{-7}$) decreasing trend in minimum mass launched over time

Pareto Frontiers for Imaging instruments in 15-year intervals

Trends in miniaturization can be quantified using this approach.

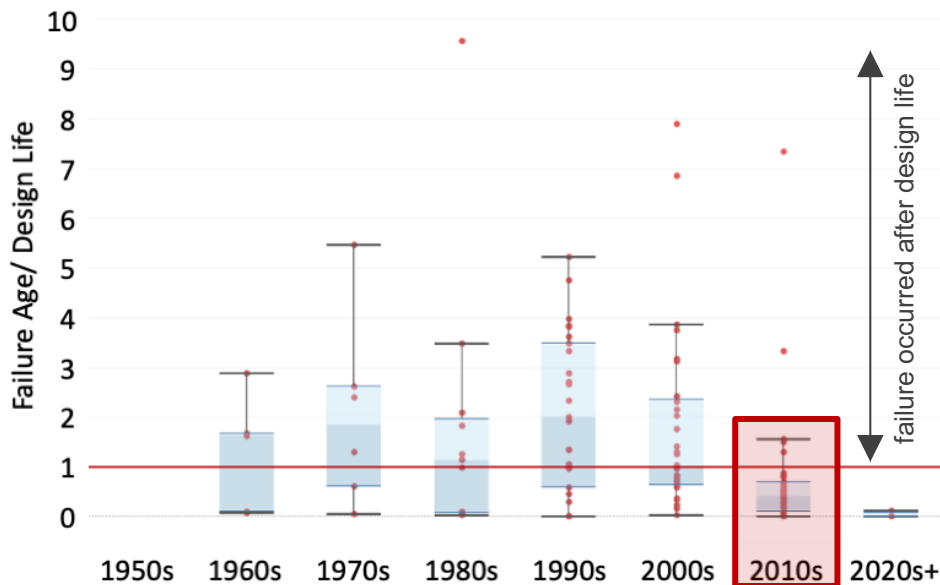
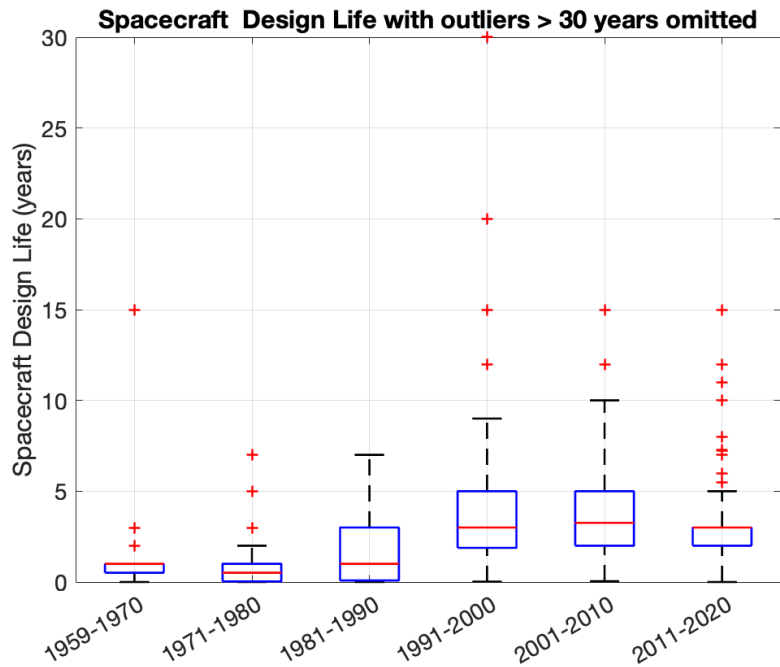
Planned missions can be examined against the 'state-of-the-art' to determine:

- level of advancement (ambition of targets)
- feasibility of budgets and schedule



Source: NASA Space Science Data Coordinated Archive (NSSDCA)

EO spacecraft median 'Design Life' (specified by manufacturer) trended upwards till 2010. On-orbit payload anomalies are occurring before design life duration of spacecraft launched in last decade.



Source: Seradata

Summary

1. The average number of **spacecraft launched annually** was 19.4 during 2000 - 2010. This increased over **5 folds** to an average of 103.4 spacecraft launches per year during 2010 – 2021.
2. The median mass of launched EO spacecraft per decade since 1959 has a parabolic trend, where median mass peaked in 1981-1990 and has since consistently declined. In the 2011-2020 period, the median mass of a launched spacecraft was 5 kg, primarily due to the proliferation of cubesats.
 - Projection of **current trends to 2030 and 2035 estimates minimum mass of less than 0.1 kg.**
3. **The frontier of optical imagers' mass and resolution has consistently improved** since 1964.
 - A 1-m resolution was achieved by a 66 kg EO spacecraft in **1995-2010** period, while a 10 kg spacecraft achieved the same resolution in the **2011-2025** period.
4. Trends in miniaturization for EO spacecraft have led to:
 - lower spacecraft cost
 - but lower spacecraft longevity

Questions?