Astronomy, Doughnuts, and Carrying Capacity

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Astronomy and Satellite Constellations:
Pathways Forward
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The case for space environmentalism

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Simon Garrington[7], Michael Kramer[8,9], Samantha Lawler[10], James Lowenthal[11], Jonathan McDowell [12]
and Mark McCaughrean[13]

but are other environmental
and ecological concepts
valid / relevant / useful?
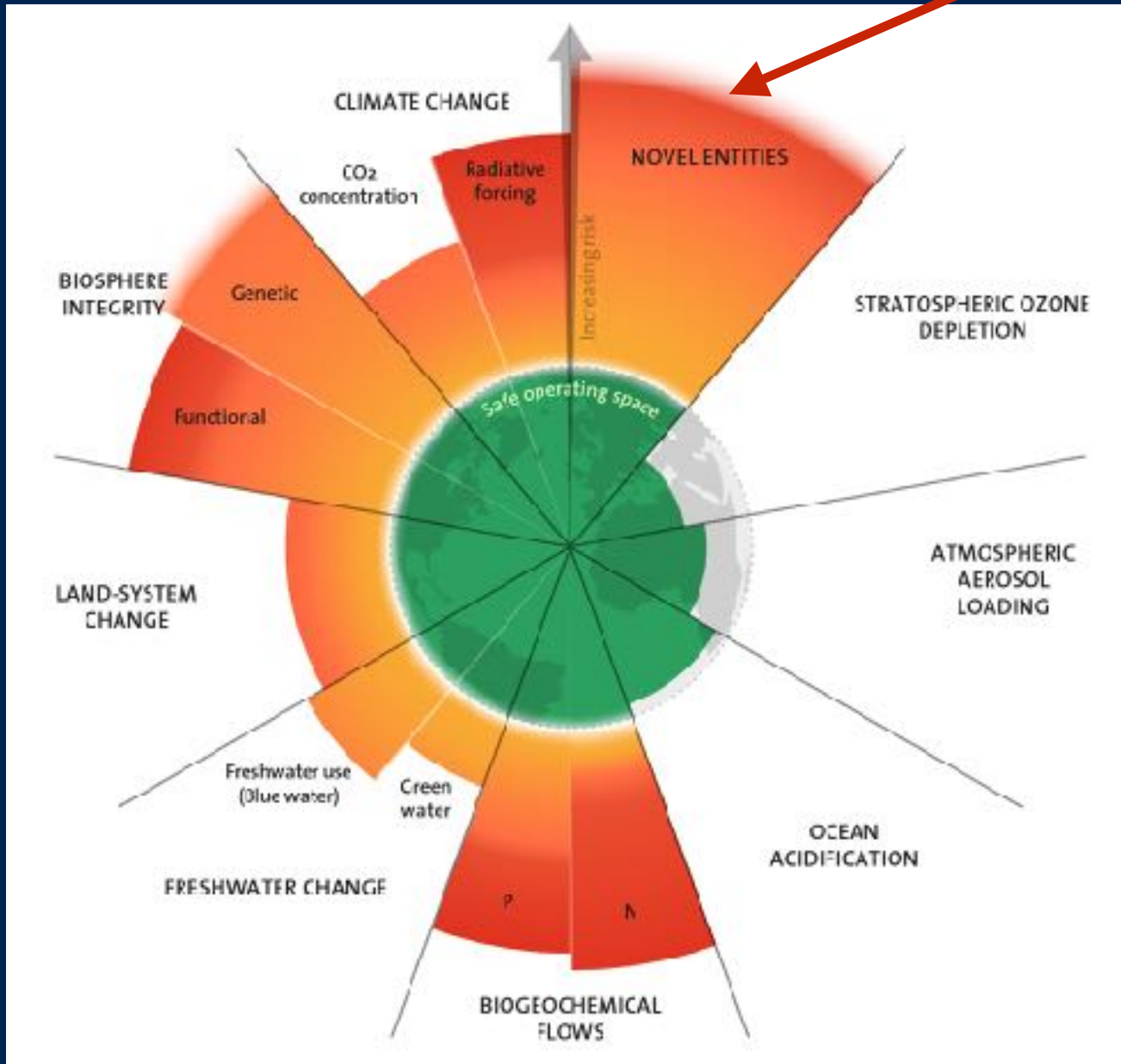
- Ecosystem?

    orbital space?   X

    economic system
    + orbital space?   ~

- Carrying Capacity?

    used inconsistently
    in multiple fields   X

    ecology:
    equilibrium level   X

- Tipping Point?

    normally requires
    resource depletion   ~

JASON debris model
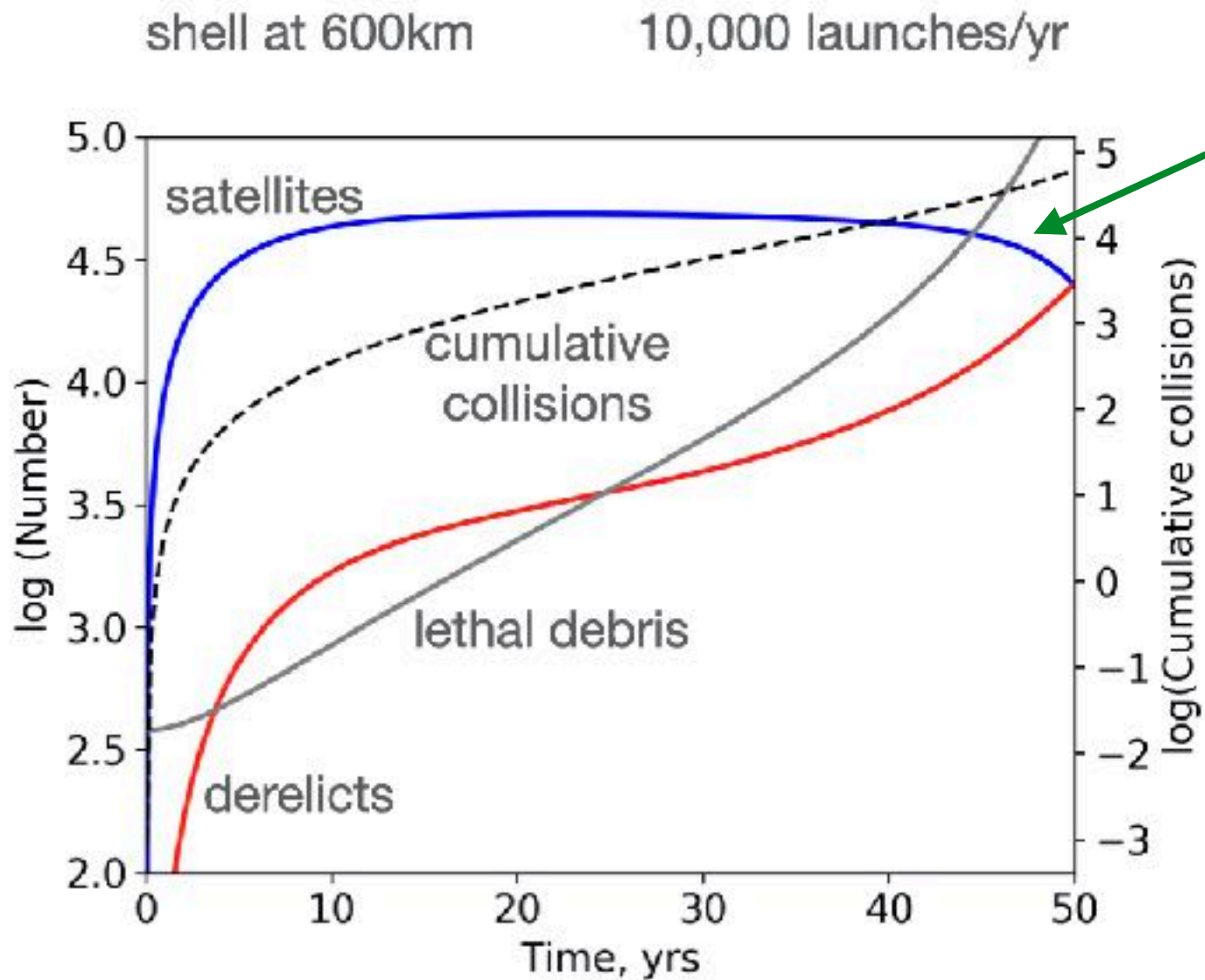
tipping point decades away

Collision risk?
Optical interference?
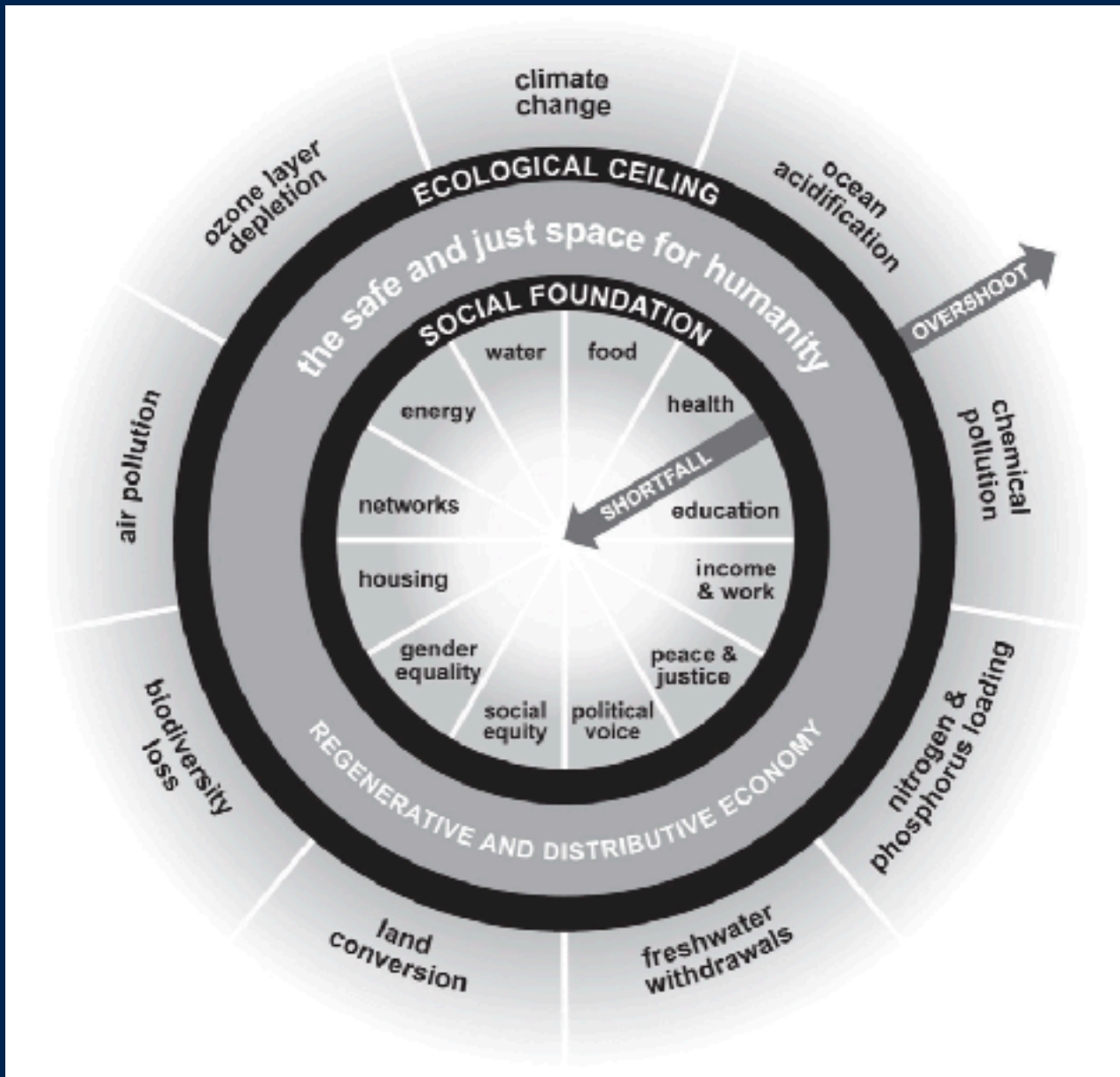Sky brightness?

planetary boundaries framework 2023

Richardson et al 2023
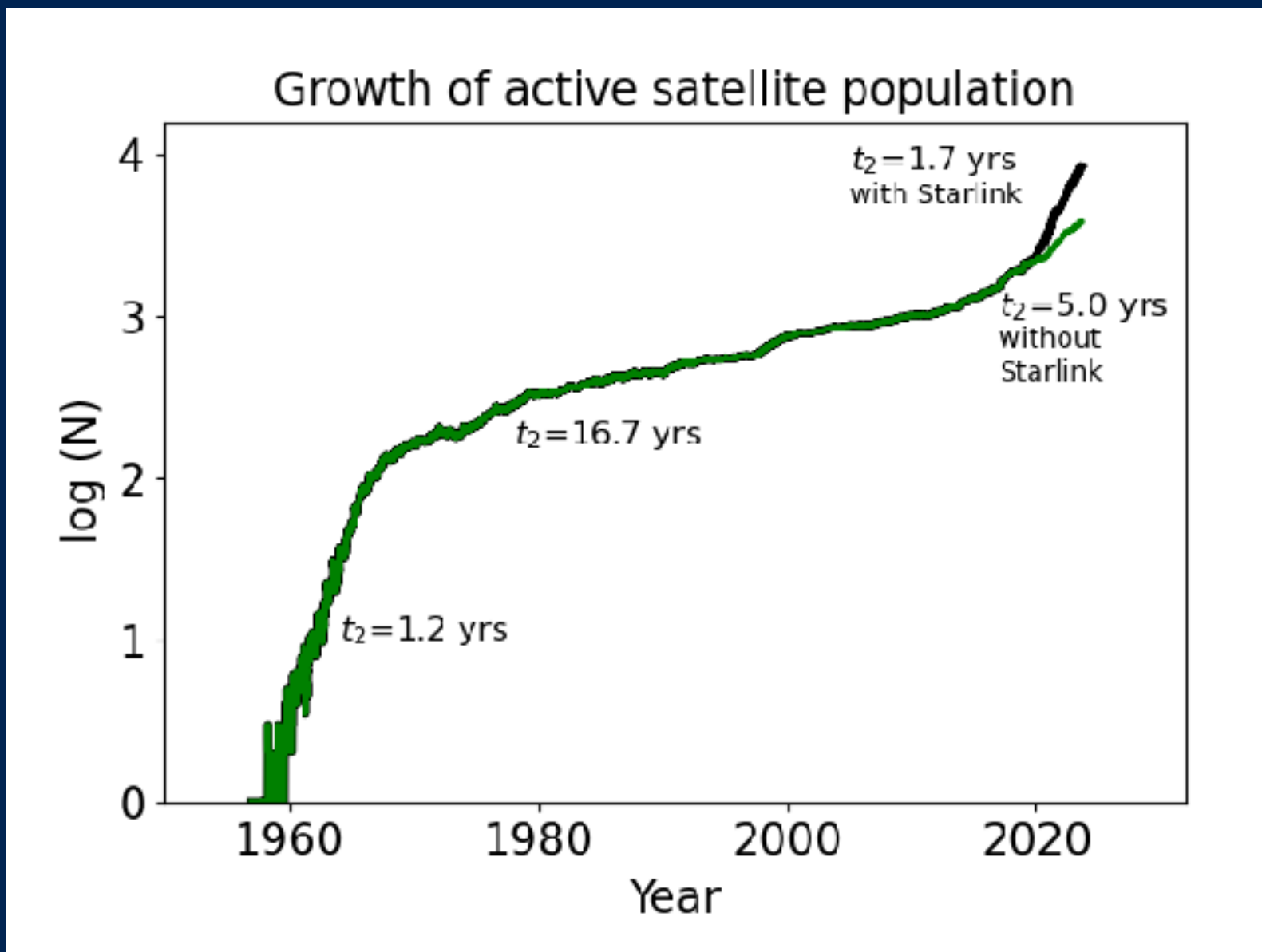
Doughnut Economics

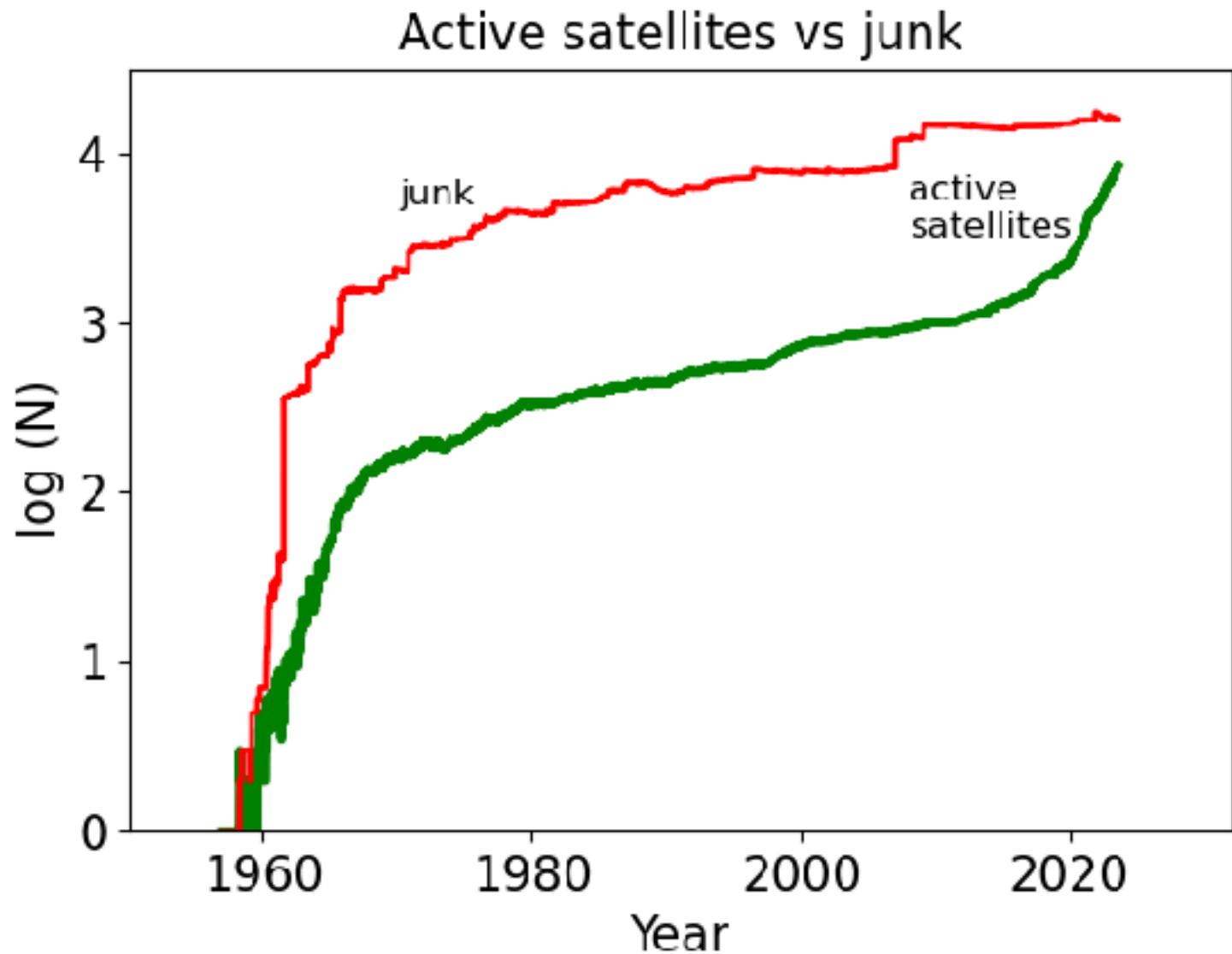Raworth (2017)

outer
and inner
boundaries

Staying in the safe zone
incompatible with
endless growth?

Three exponential growth epochs
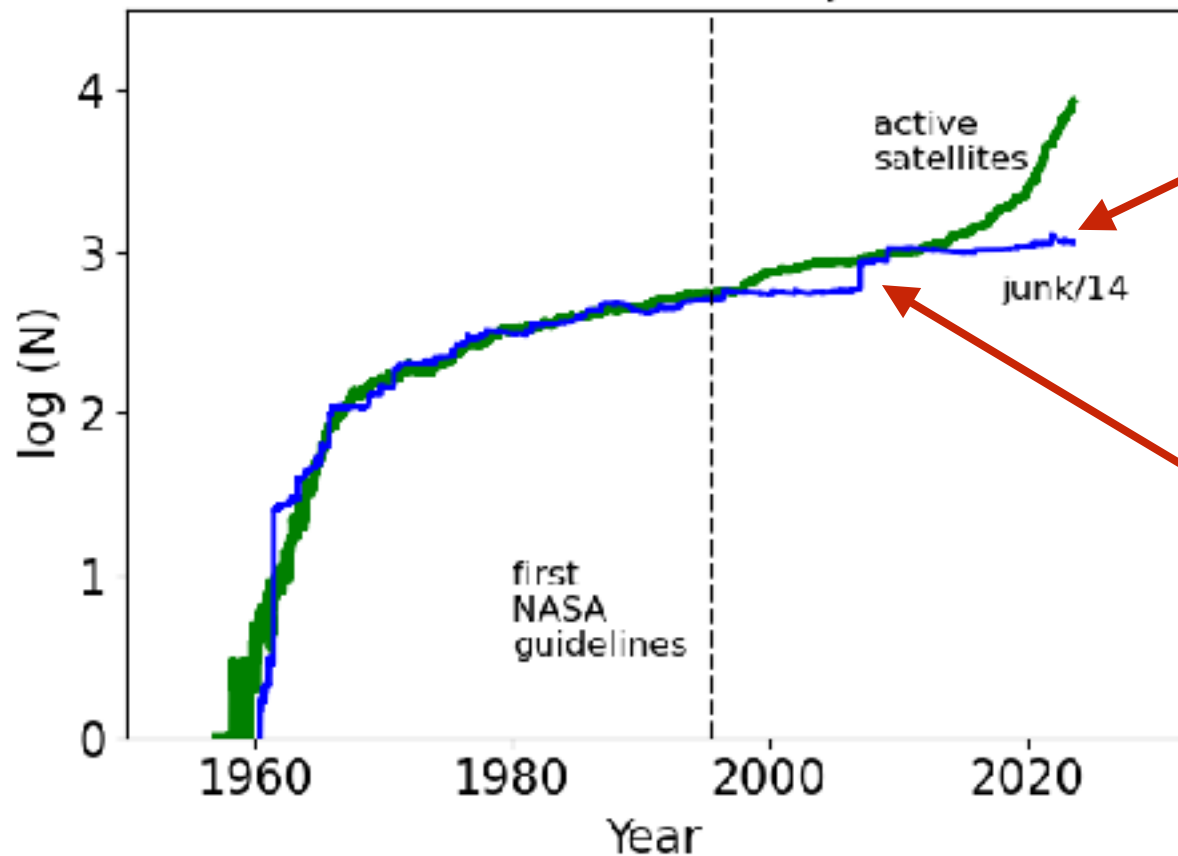

data from McDowell General Catalog

Growth of active satellite population

$t_2=1.7$ yrs with Starlink

$t_2=5.0$ yrs without Starlink

$t_2=16.7$ yrs

$t_2=1.2$ yrs

log (N)

Year

Junk growth

Active satellites vs junk

junk=debris
plus leftovers

Debris mitigation works   but...

more descending from LEO

collisions are crucial

Liability
issues
will
grow

need an agreed
collision risk metric
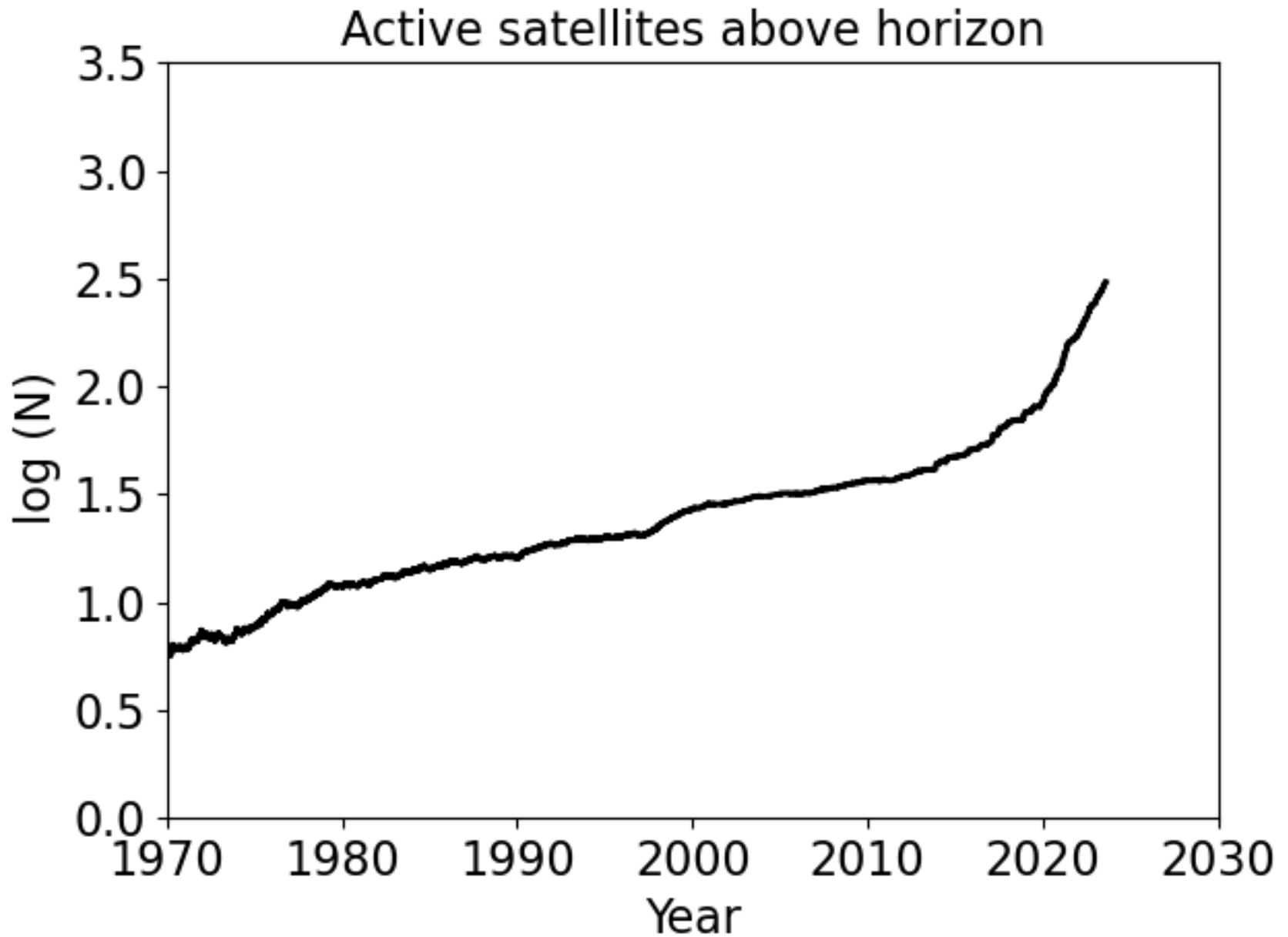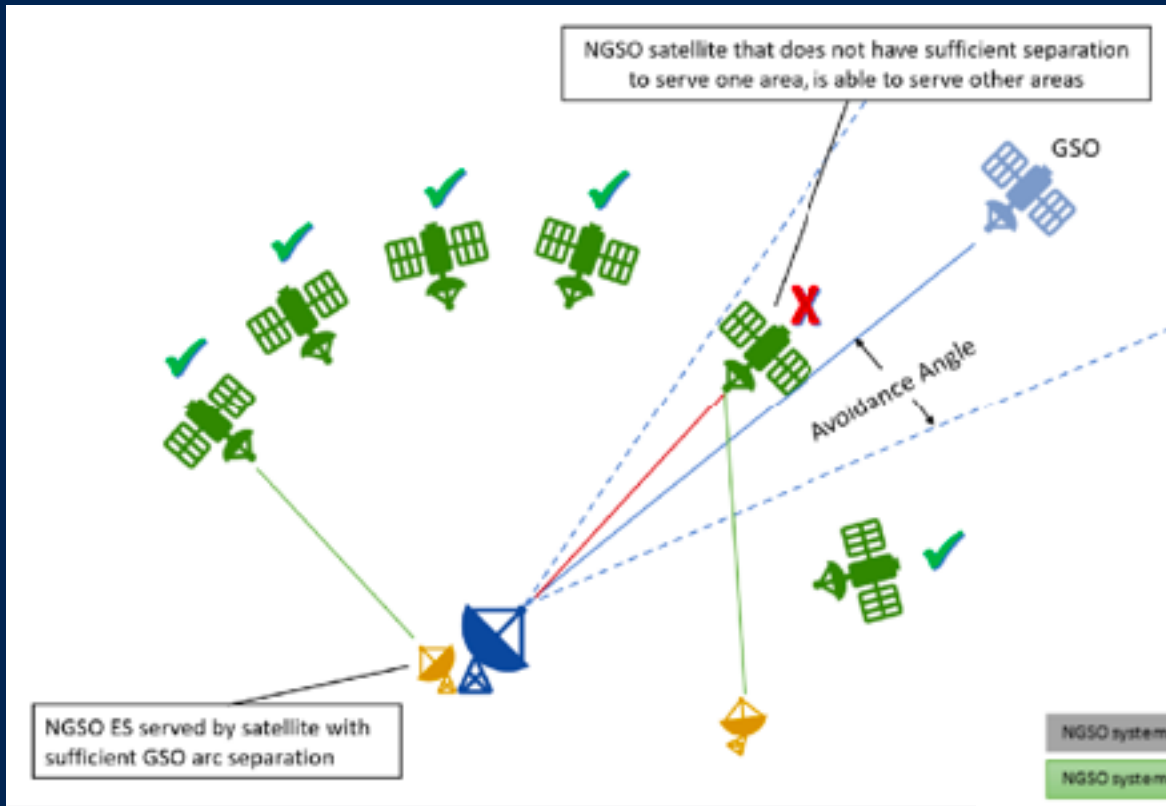

Require
Third Party
Liability
Insurance

Satellites per sky

data from
McDowell
General
Catalog

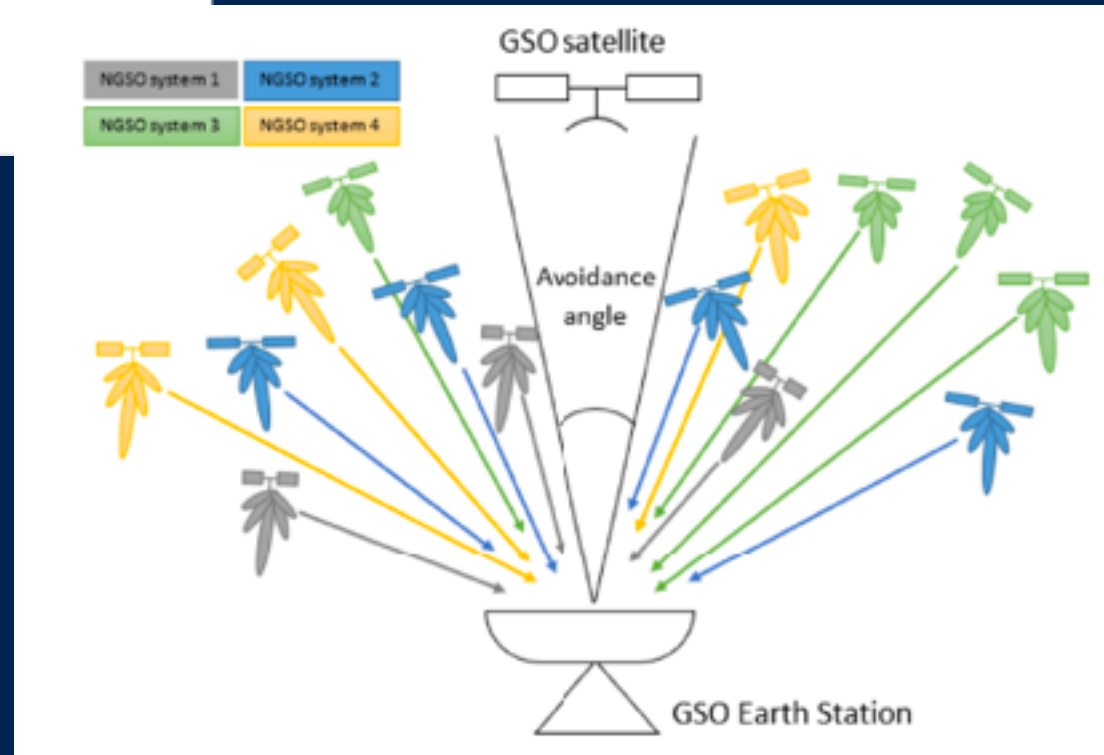simplified
height and
orbit model

Active satellites above horizon

comms overcrowding

NGSO satellite that does not have sufficient separation to serve one area, is able to serve other areas

GSO

Avoidance Angle

NGSO ES served by satellite with sufficient GSO arc separation

line-of-sight collisions

Viasat white paper

aggregate power interference

GSO satellite

NGSO system 1   NGSO system 2
NGSO system 3   NGSO system 4

Avoidance angle

GSO Earth Station

Mean distance

data from McDowell General Catalog

simplified height and orbit model

Typical intersatellite distance
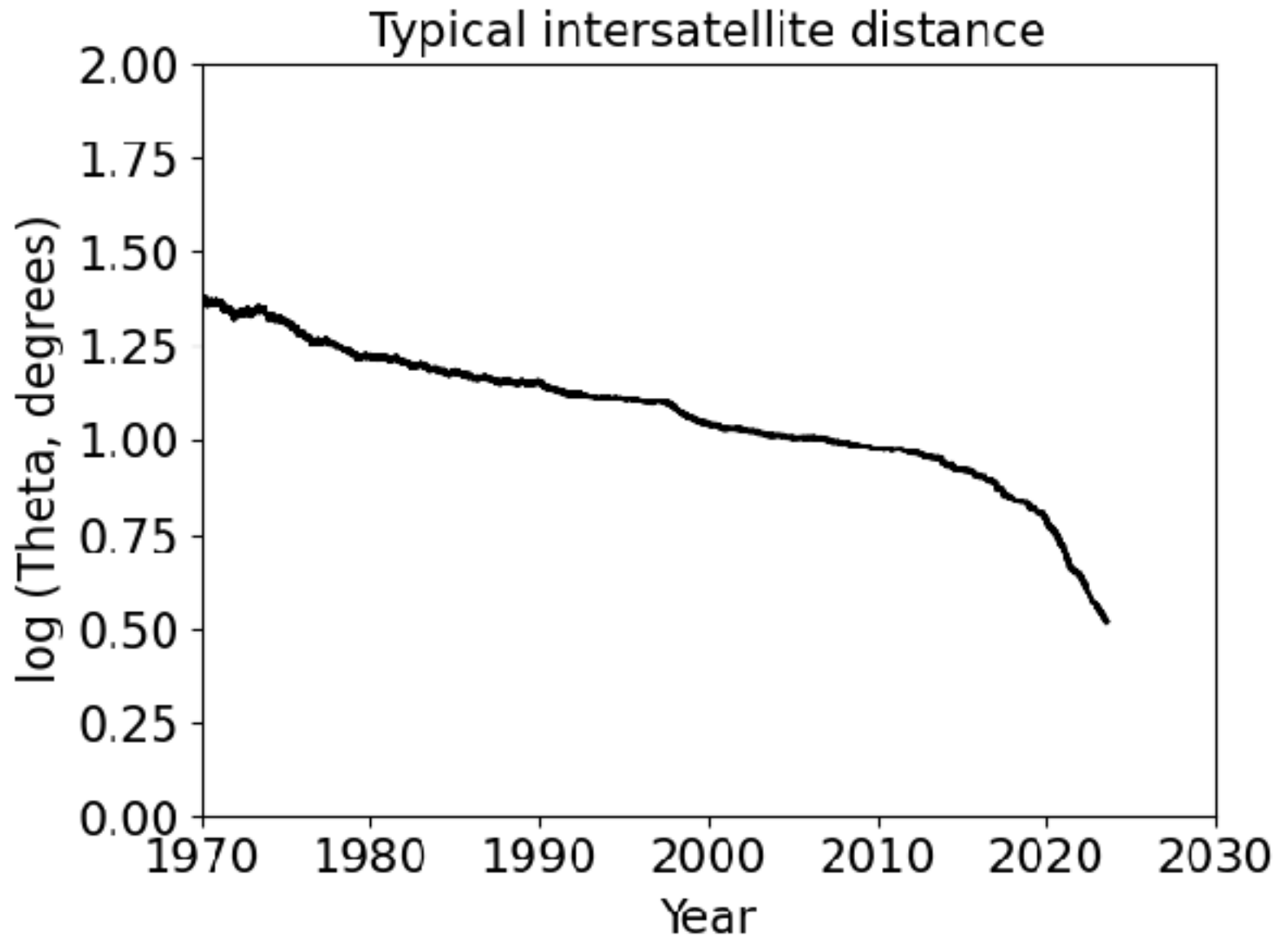
The problem is the numbers not the brightness

- Be cautious with ecological concepts
- New Space: doubling every two years
- Debris Mitigation works
- Need new collision liability framework
- Operators have same interference problem as Astronomy
- We are approaching degree-scale separation

How many is enough?