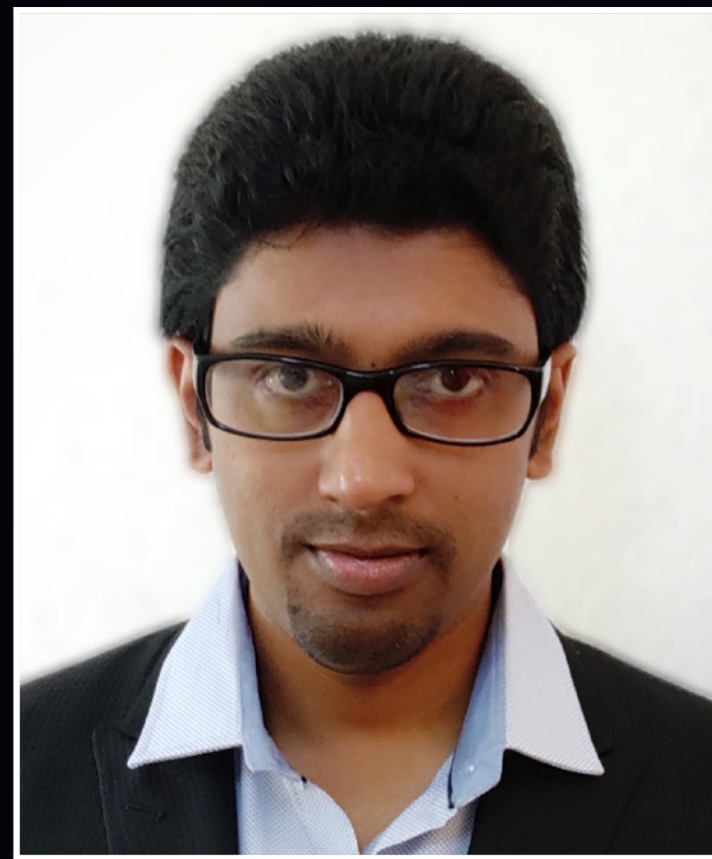


LEOCONN

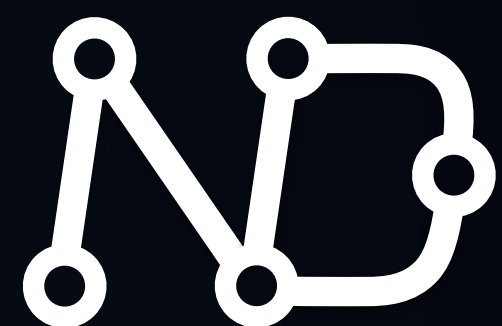
Webinar on LEO satellite networking



Ankit Singla



Debopam Bhattacharjee



ETH zürich



- 1 What is this all about?
- 2 Who cares?
- 3 Open challenges and opportunities

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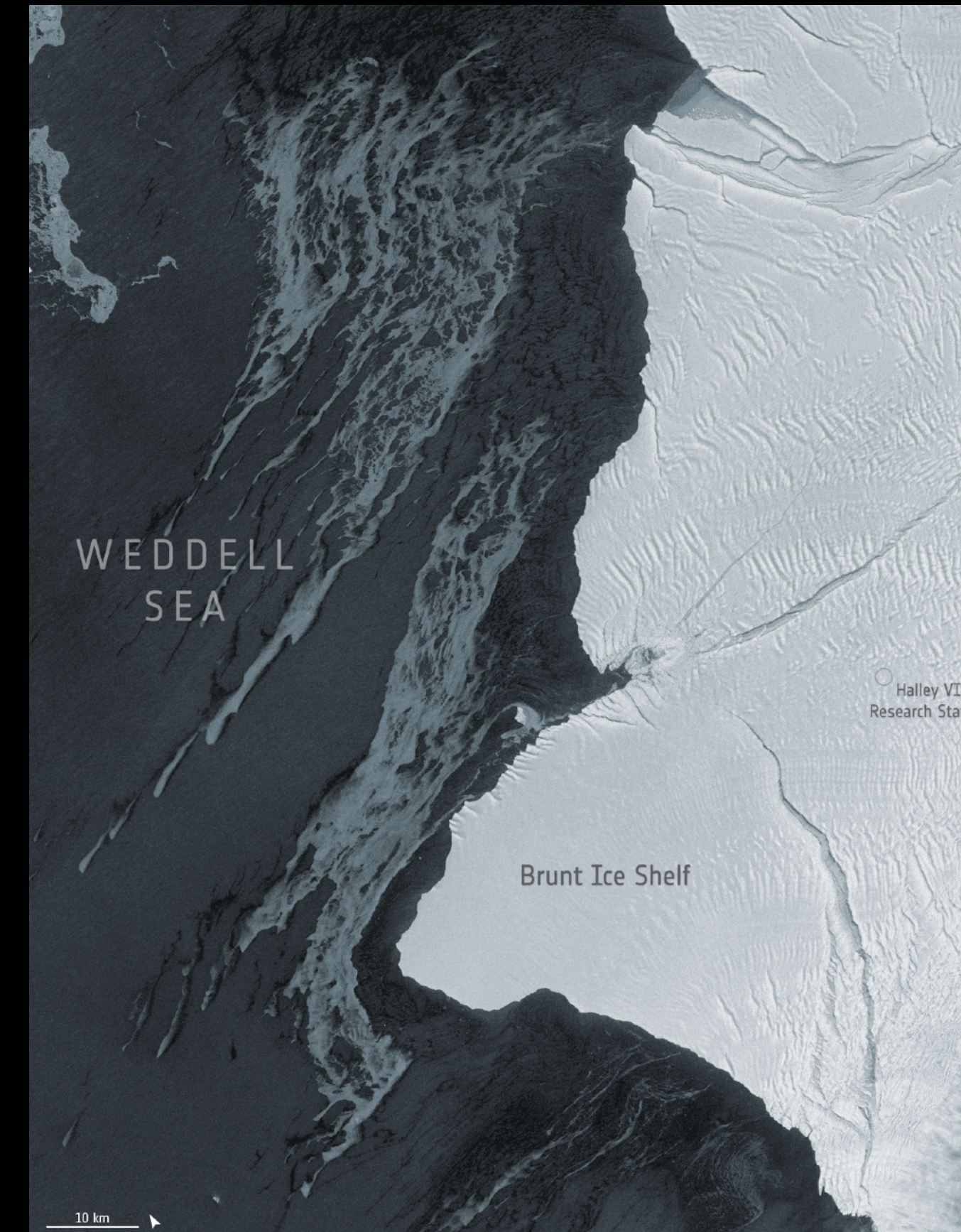
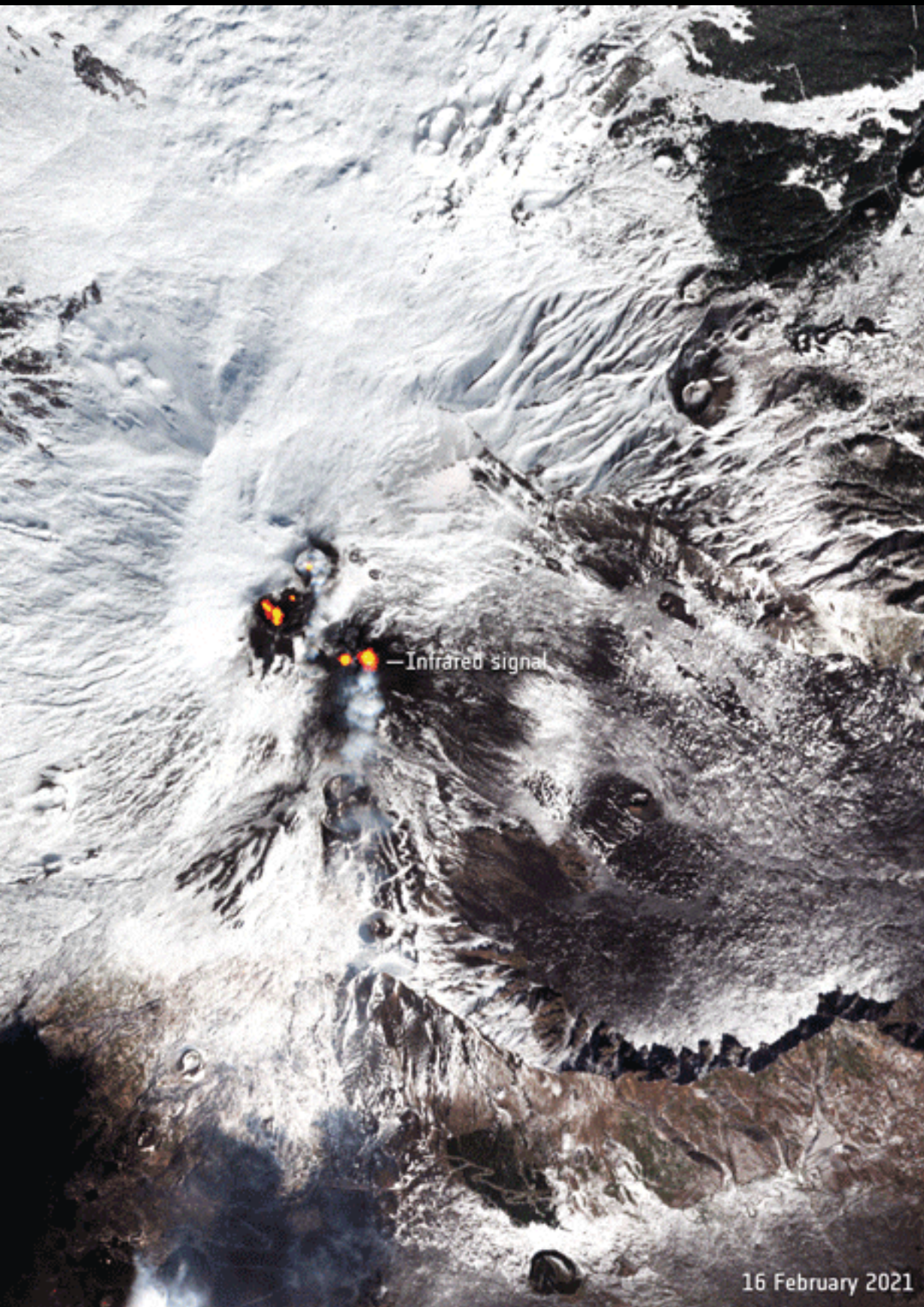
Broadband satellites



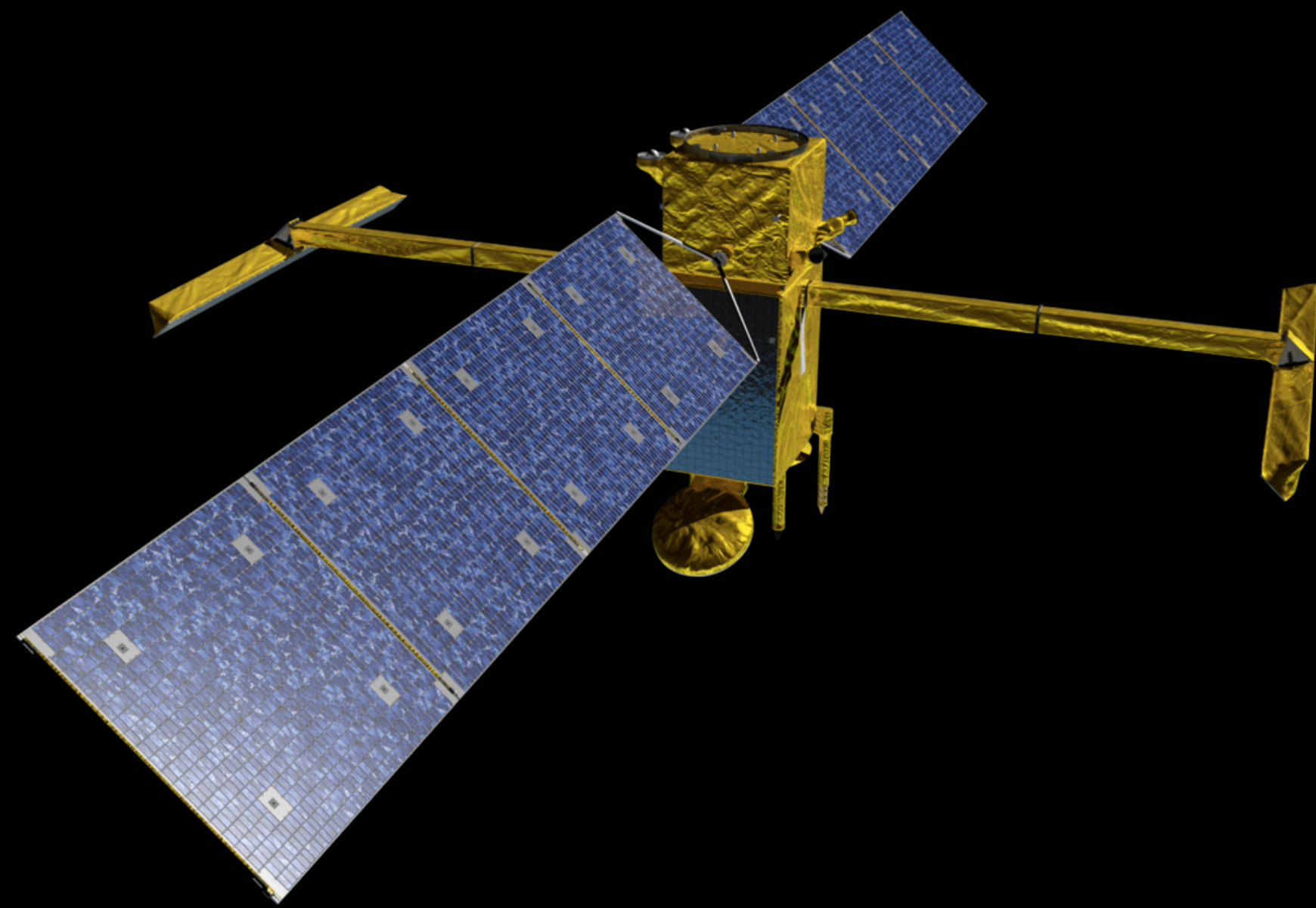
Imaging satellites



Imaging satellites



Imaging satellites



Satellites take “pictures”



Download to ground stations



Process, use, store

Imaging satellites

100s of satellites

10s to 100s of TB/day

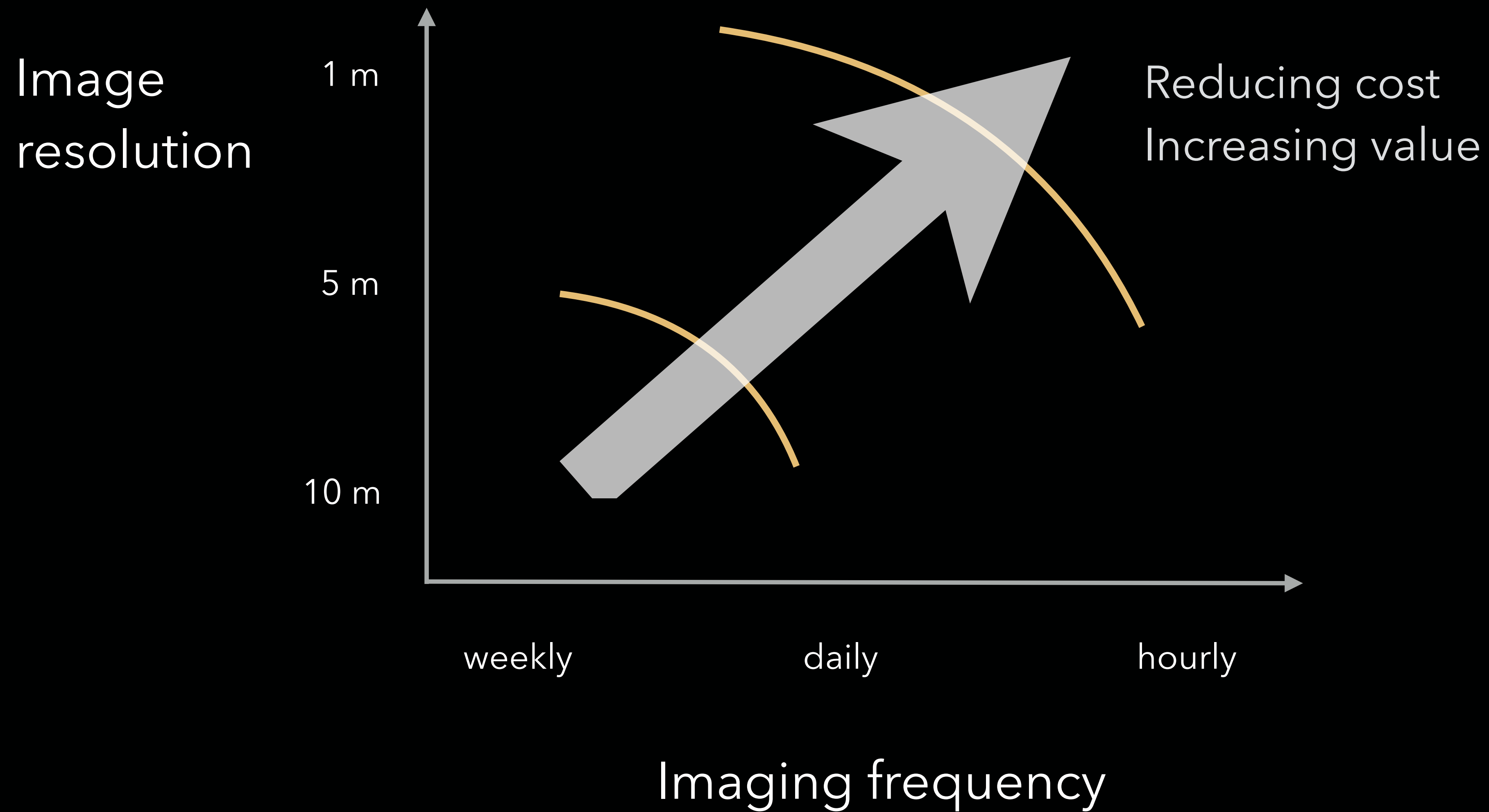
Data download bottlenecks

Data processing bottlenecks

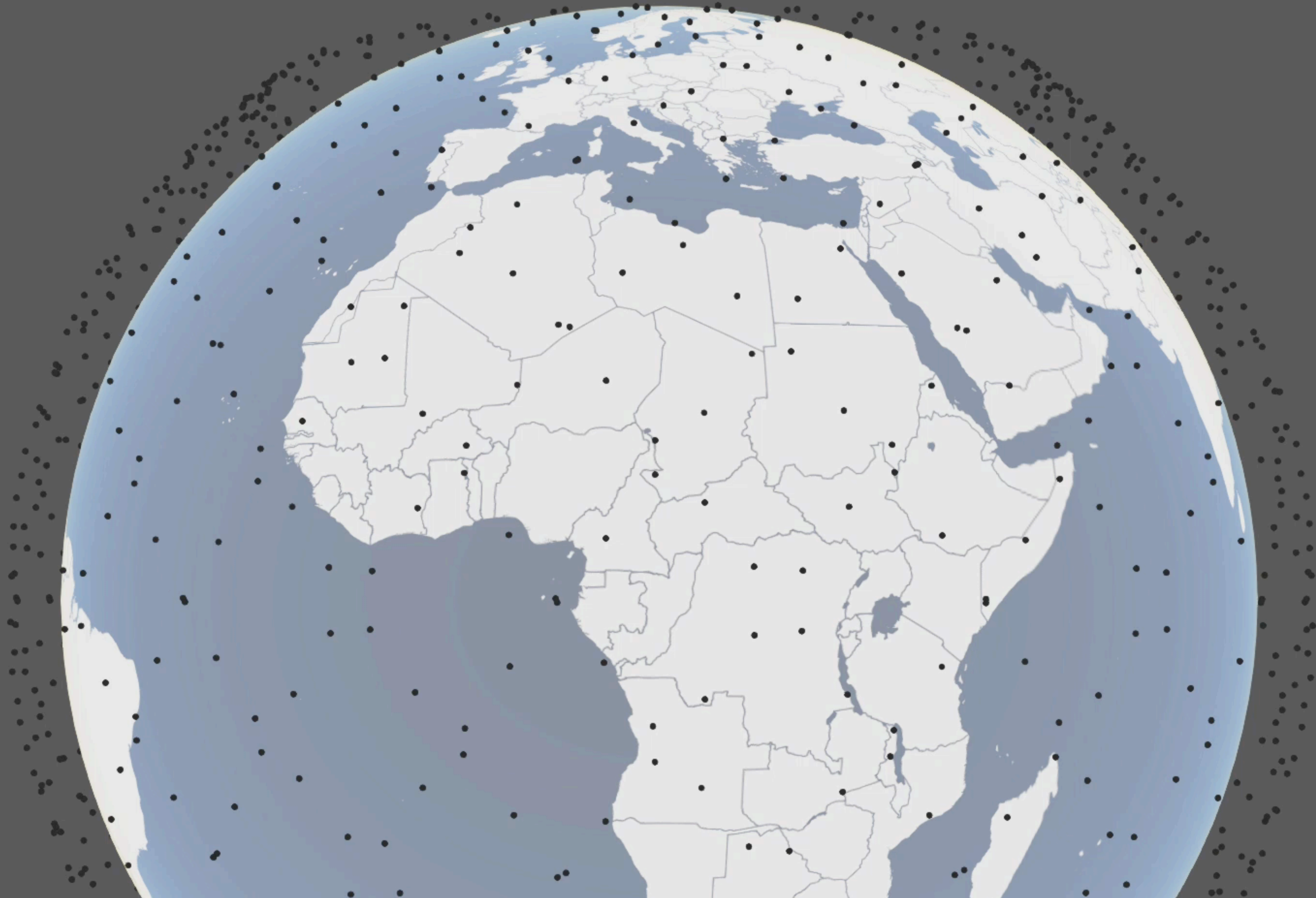
Many networks & systems challenges!



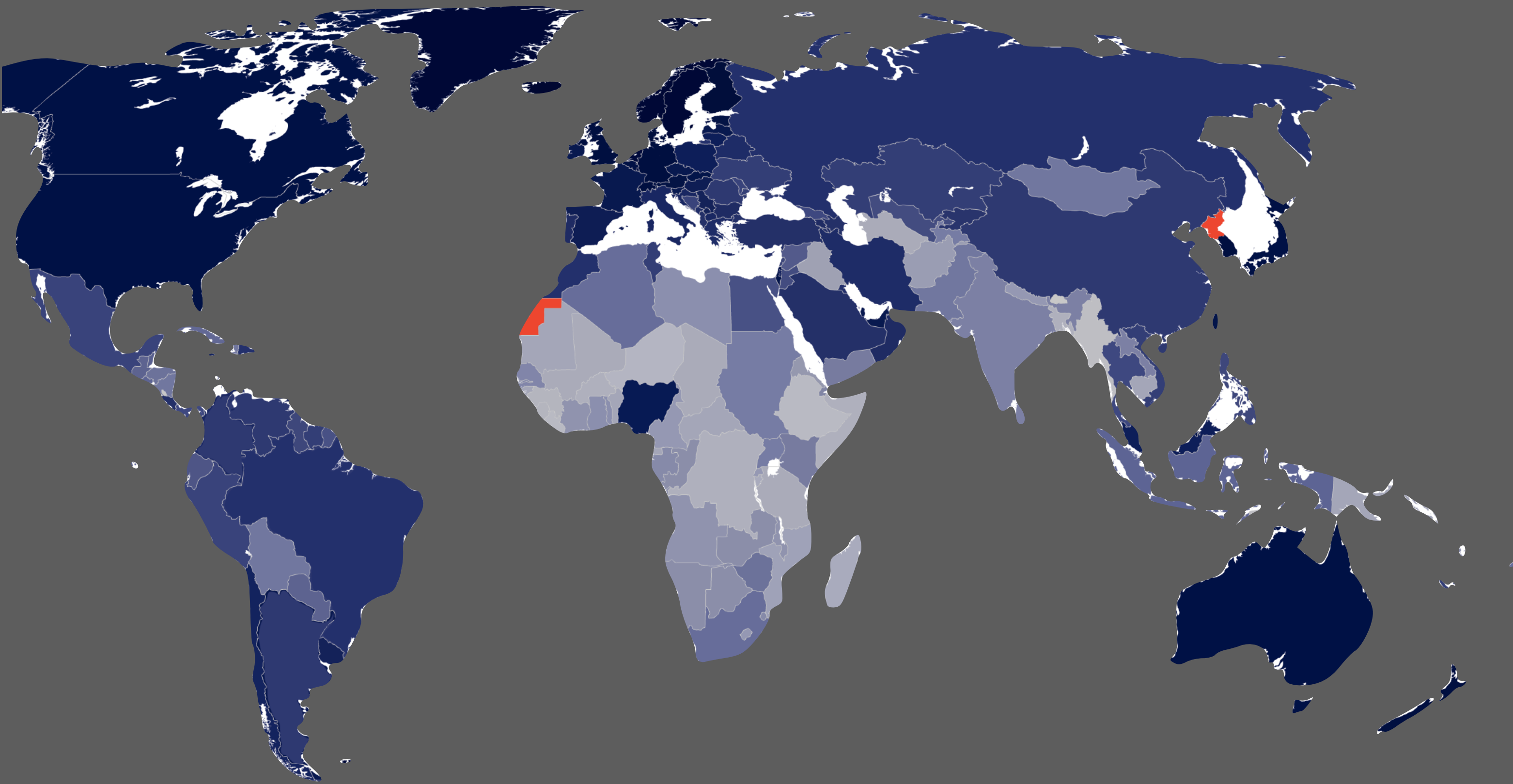
Imaging satellites



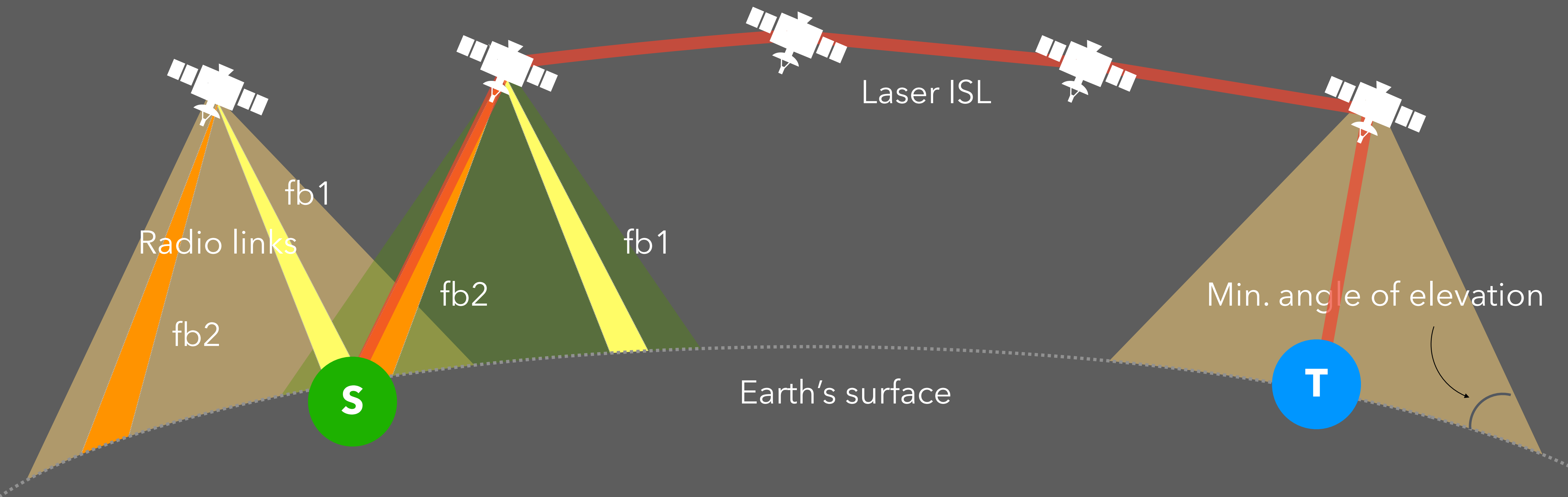
Broadband satellites



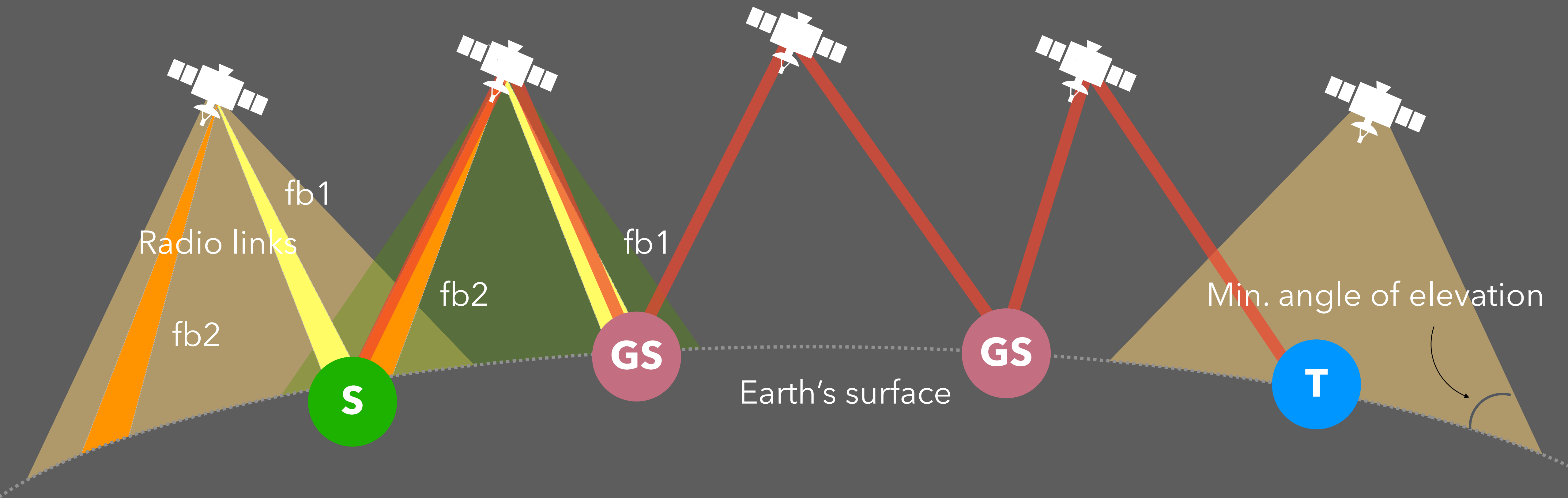
Global coverage, high bandwidth, low latency



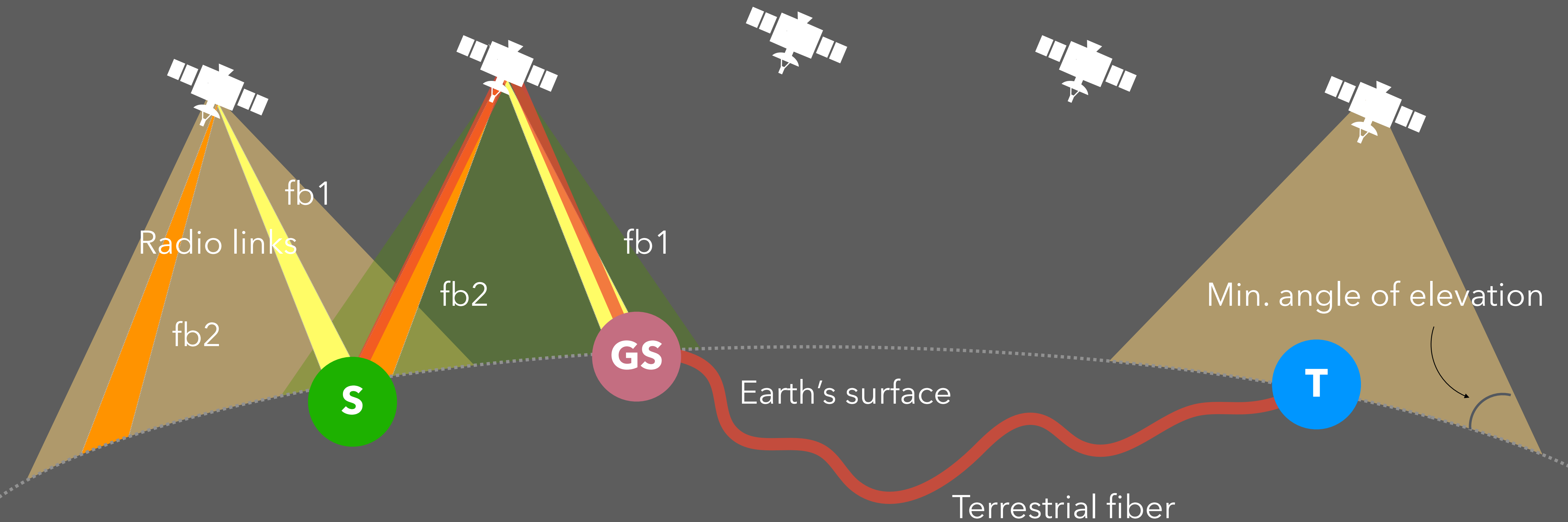
How does LEO connectivity work?



How does LEO connectivity work?

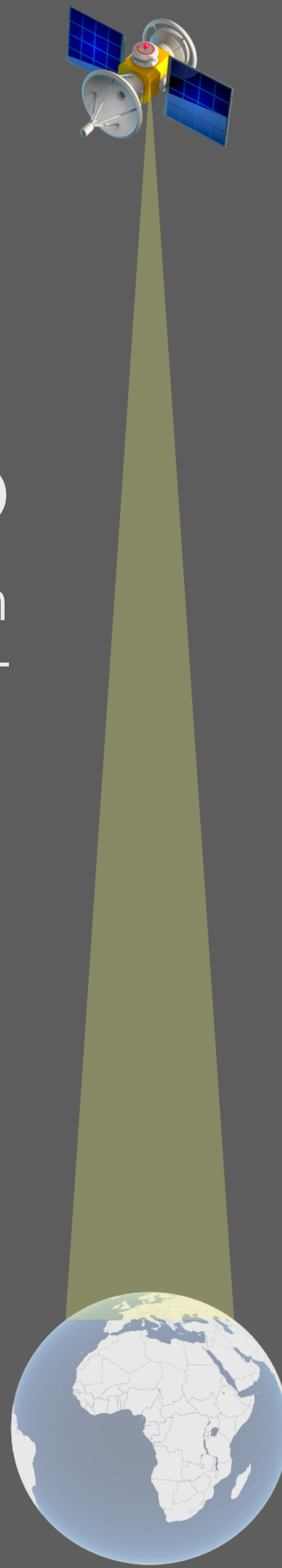


How does LEO connectivity work?



GEO v LEO

GEO
35,768 km
238.4 ms RTT



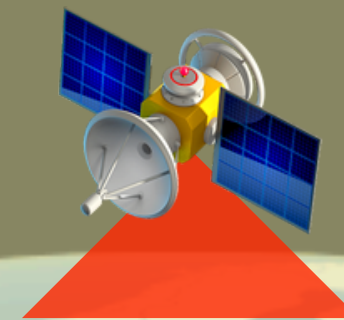
GEO v LEO

GEO

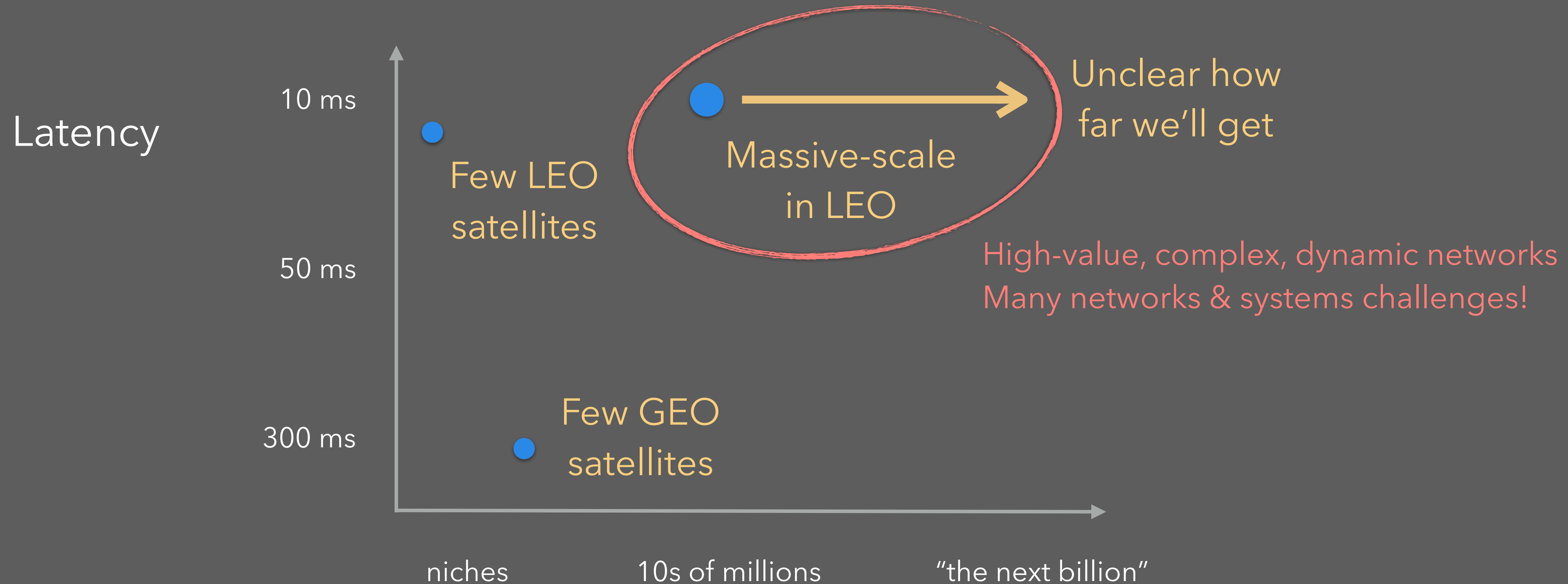
35,768 km
238.4 ms RTT

LEO

550 km
3.7 ms RTT



Latency, capacity, and constellation design



Network capacity ~ market size

Broadband satellites



Imaging satellites



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Hectic industry activity

“Ground station as a service” from Microsoft Azure and AWS

Google and Planet Labs partner on imaging

Microsoft and KSAT on imaging ground stations

Microsoft partnering with Starlink, SES, Viasat

SES partnership touches both imaging and DC connectivity

Google and Starlink on DC connectivity

Mynaric with a large constellation operator for ISLs

Talks by several of the top players

“Ground station as a service” from **Microsoft Azure** and AWS

Google and **Planet Labs** partner on imaging

Microsoft and **KSAT** on imaging ground stations

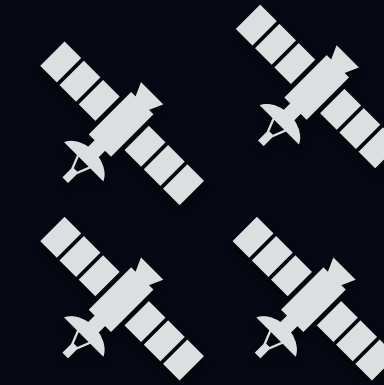
Microsoft partnering with Starlink, **SES**, Viasat

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Mynaric with a large constellation operator for ISLs

Welcoming **400+** registered attendees to LEOCONN



35 space sector companies, incl. imaging, ground station networks, broadband, ...



10

network vendors



10

cloud companies



9

ISPs / Telcos



10 countries'

govt. agencies

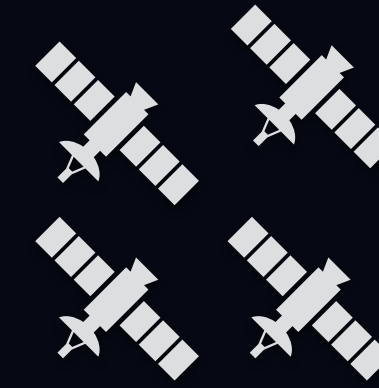
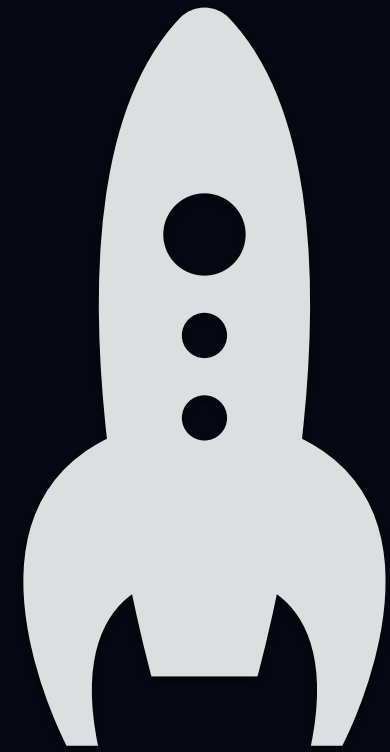


29 of the

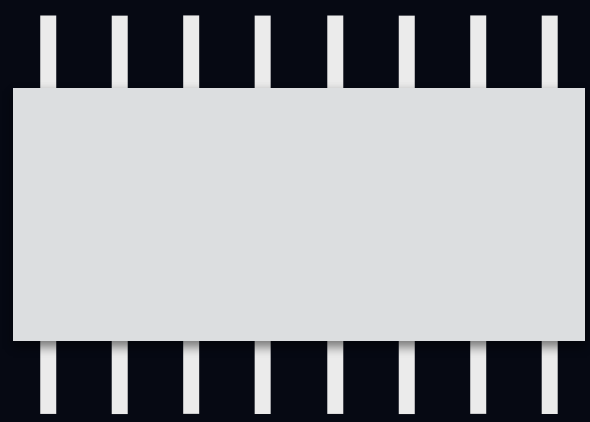
30 top universities

- 1 What is this all about?
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400+ diverse registered attendees!

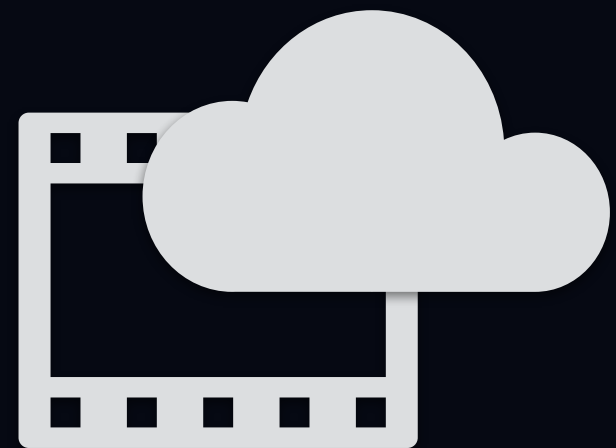


35 space sector companies, incl. imaging, ground station networks, broadband, ...



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29 of the

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Imaging satellites



Limited downlink bandwidth, a few hundred Mbps

A few minutes of visibility from one ground station

Uplink even more severely constrained (e.g., 1000x)

Many flavors of scheduling

Apply techniques from video streaming analytics?

Protocol design? ACKs are expensive!

Problem known for more than 2 decades – <https://www.ietf.org/proceedings/48/I-D/pilc-asym-01.txt>

Ground station networks



Rapidly increasing demand from growing satellite fleets

Various constraints on placement of stations

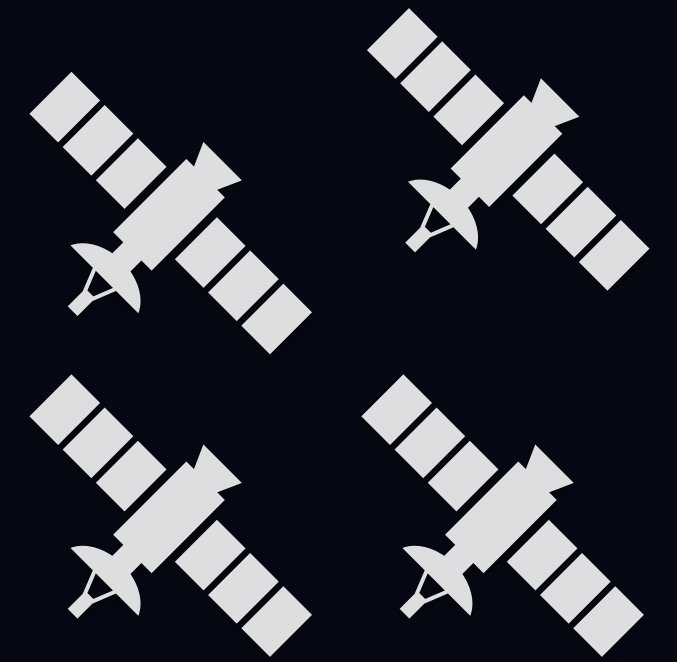
Need to move large amounts of data terrestrially

Leverage distributed footprint to schedule downloads effectively

How to resolve competing customer demands?

Optimal placement? use data centers, IXPs, cable landing points?

Broadband constellations



1000s of routers at 27,000 km/hr

Highly dynamic, but predictable

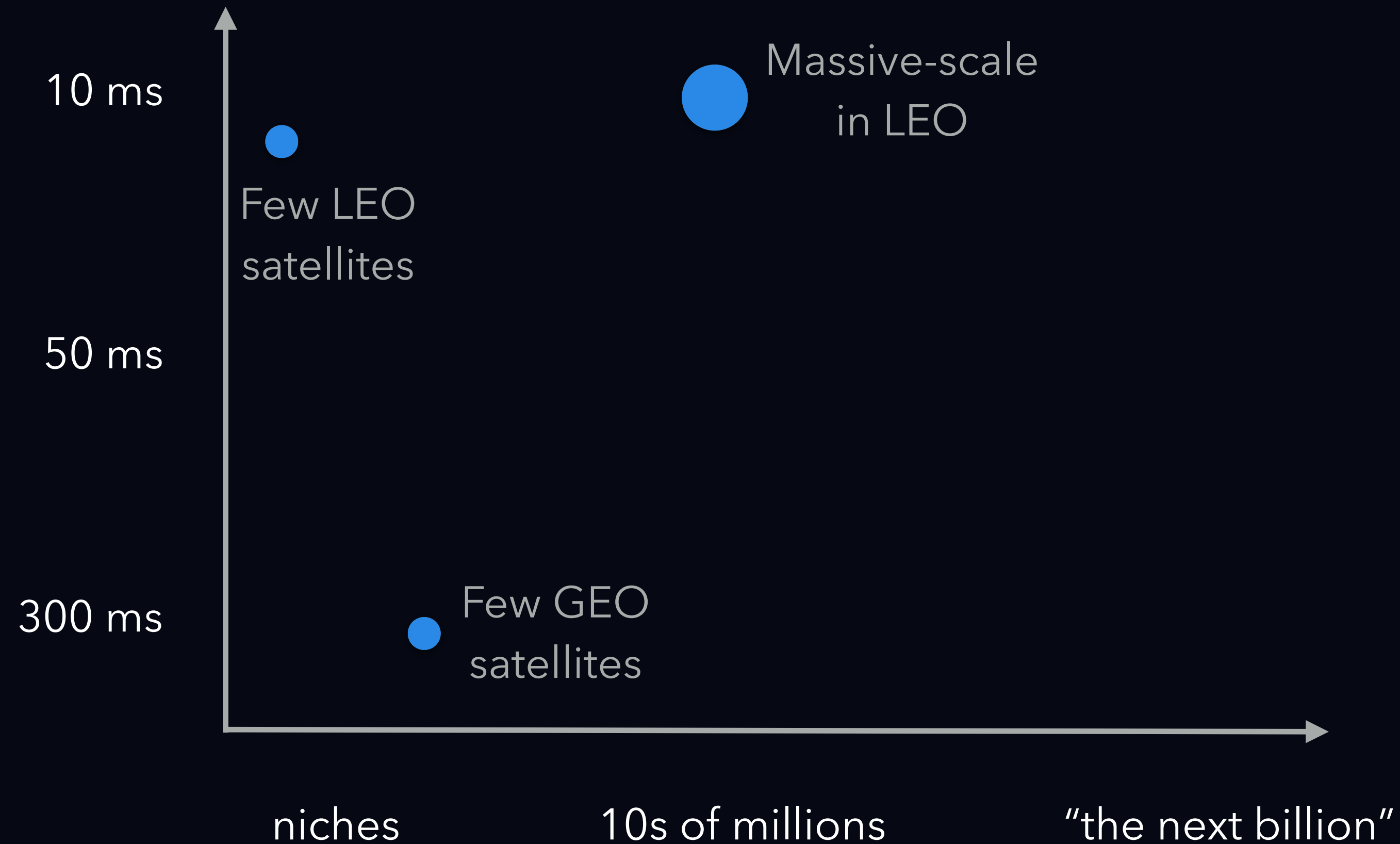
Frequent path structure and latency changes

New challenges in the entire network stack: topology design, routing, congestion control, and application performance.

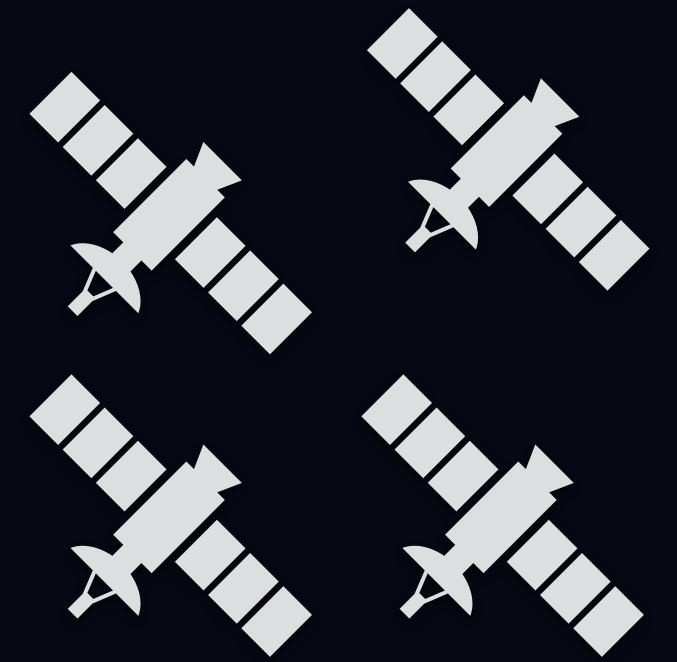
Debopam and Giacomo's talks tomorrow will cover many aspects.

Broadband constellations

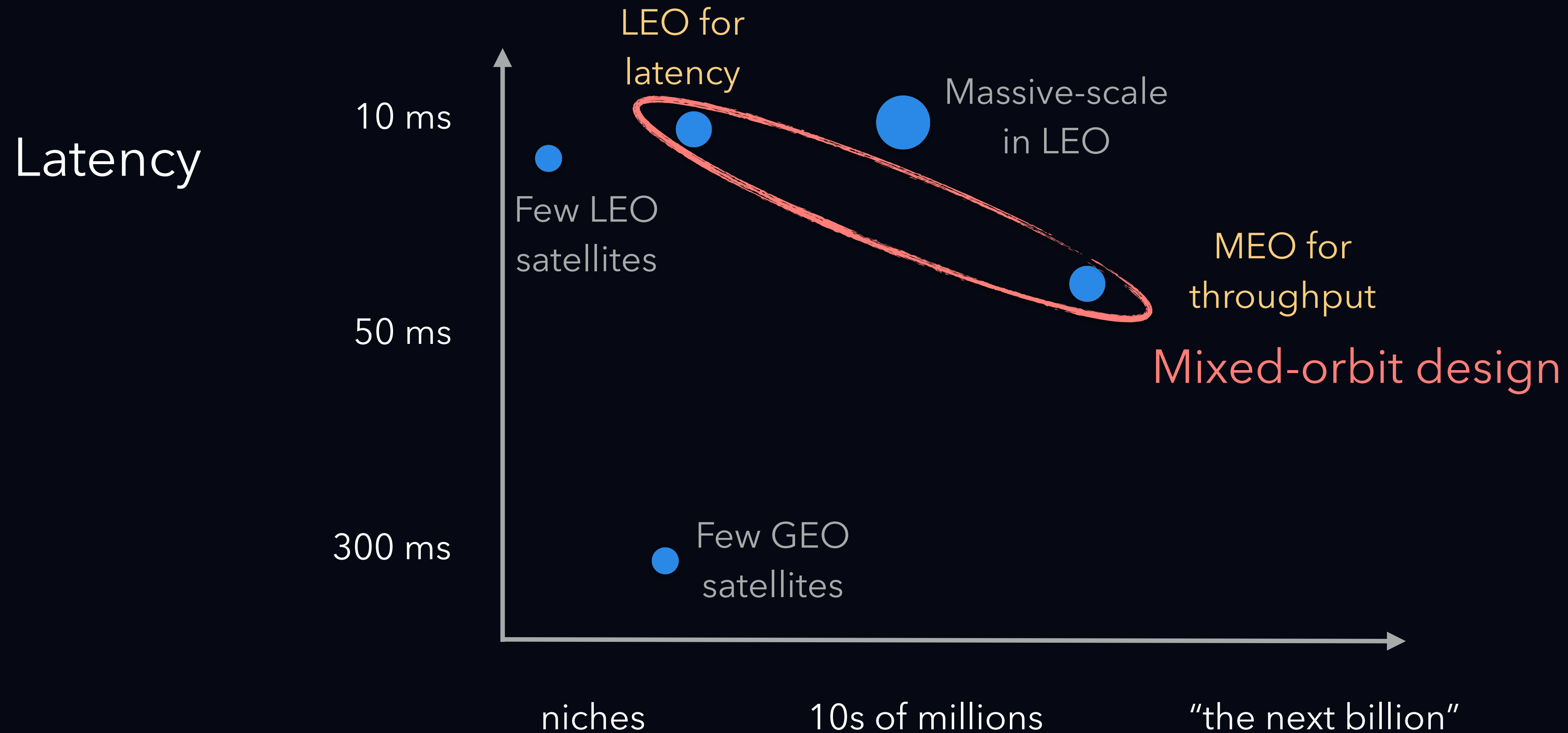
Latency



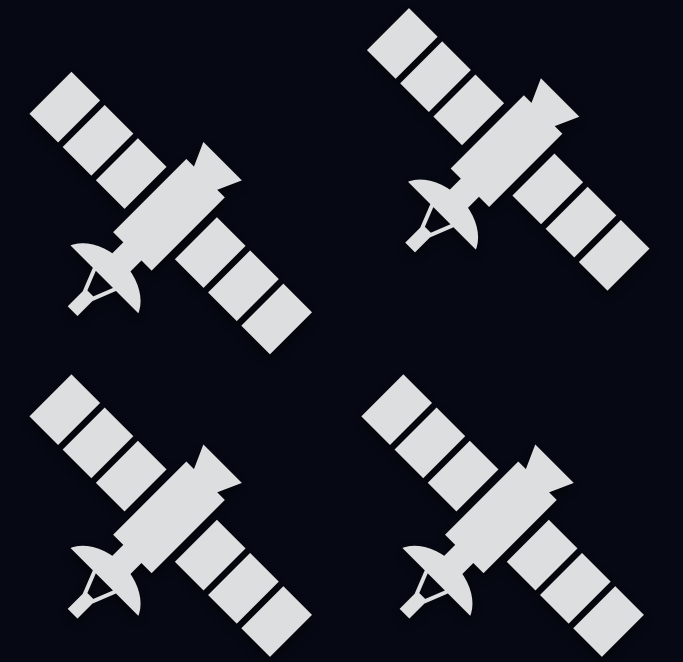
Network capacity ~ market size



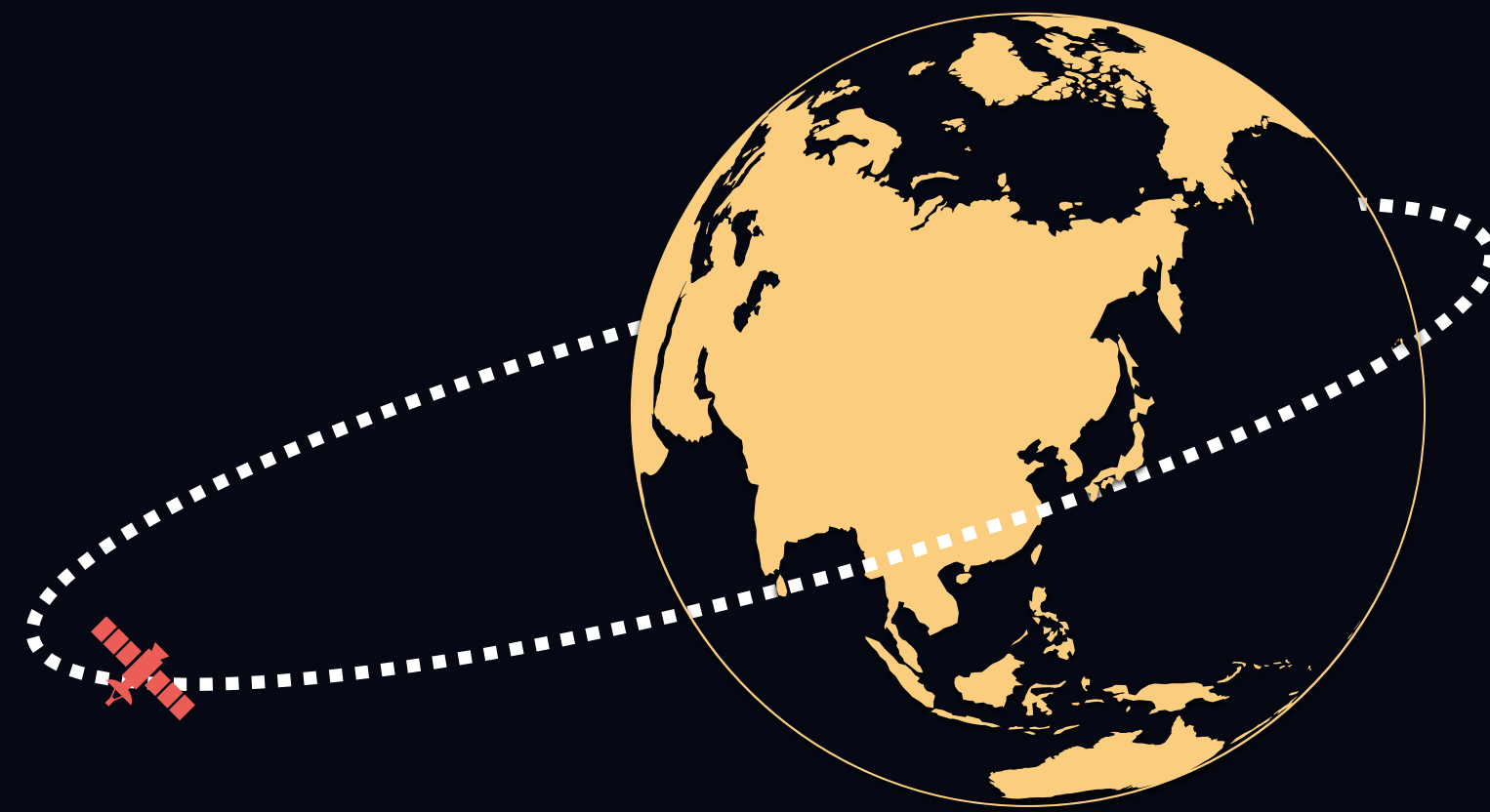
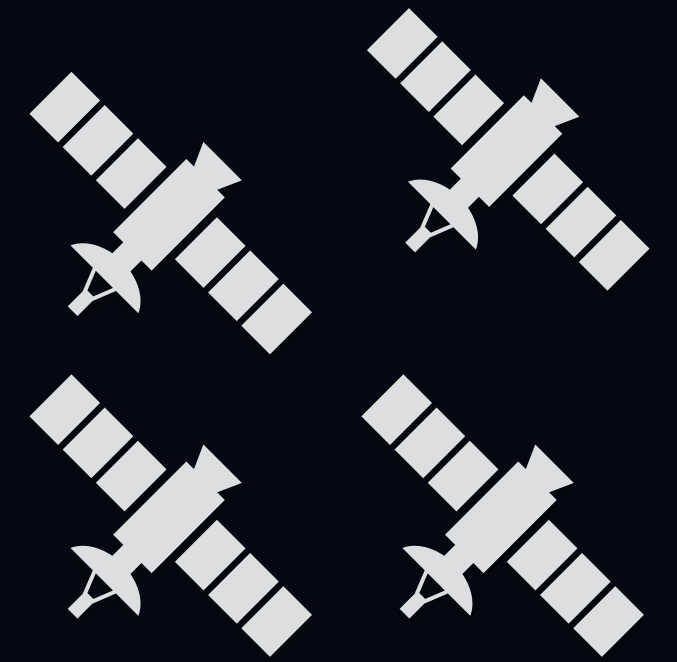
Broadband constellations



Network capacity ~ market size



Broadband constellations



Eccentric orbits for targeted coverage?

Again, could mix with other orbit types

Eccentric “Molniya” orbits have been used in military communication systems

Network vendors



Unusual operating environment for ground stations

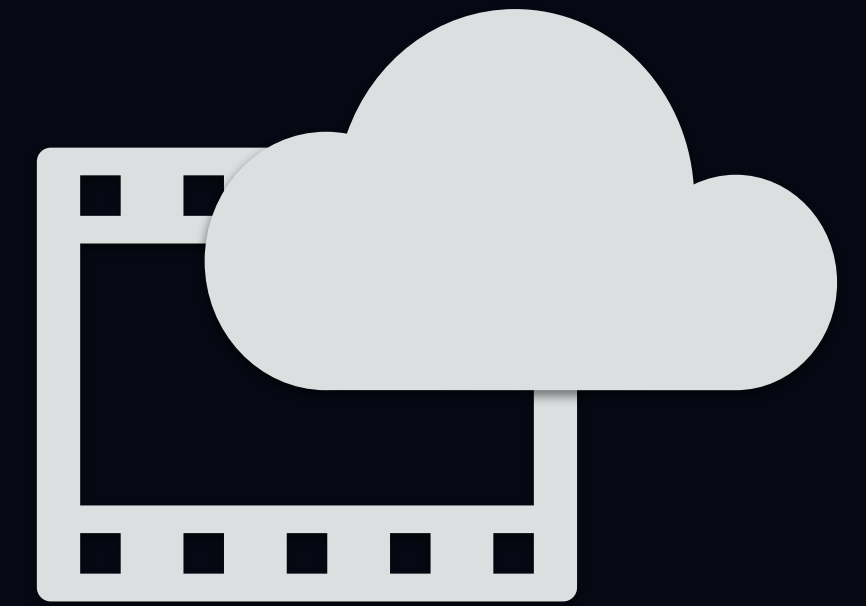
Frequent path structure and latency changes

Packet re-ordering due to path changes

New protocols that efficiently maintain connectivity?

Plan traffic engineering over time to enable smooth traffic changes?

Cloud and content companies



Very different from today's WAN links

Latency changes over time

Packet reordering

High bit error rates, random loss

Are SD-WAN solutions mature enough to integrate the dynamics?

How to use mixed-mode connectivity effectively?

Potential value in getting the raw channel (minus FEC) from SatNet

Define SLOs for such connectivity, especially for reselling?

Telcos, ISPs



Not everyone will want to send all their traffic to SatNet

Not everyone can afford a \$500 user terminal

Managed services for enterprise customers: low-latency on SatNet?

Integrate with cheaper last-mile technology and resell?

Government agencies



New type of broadband offering

The barrier to broadband-via-space is much lower

How should these new offerings change broadband-for-all strategy?

Is it worth building country-targeted constellations?

Academics



All of the above?!

Academics + industry?



SatNetLab: a platform for experimentation

Start with university sites with sat-net equipment

one-time cost — \$500-1000 for dish + installation

operational yearly cost — \$1000-2000

Facilitate measurements, test congestion control

App performance under loss and delay variation

Collaboratively launch nano-satellites for research?

LEOCONN agenda

10 exciting talks!

Ample time for questions / breaks

Industry panel

Thanks to Debopam Bhattacharjee
and Elham Ehsani

You are welcome to connect with us!

