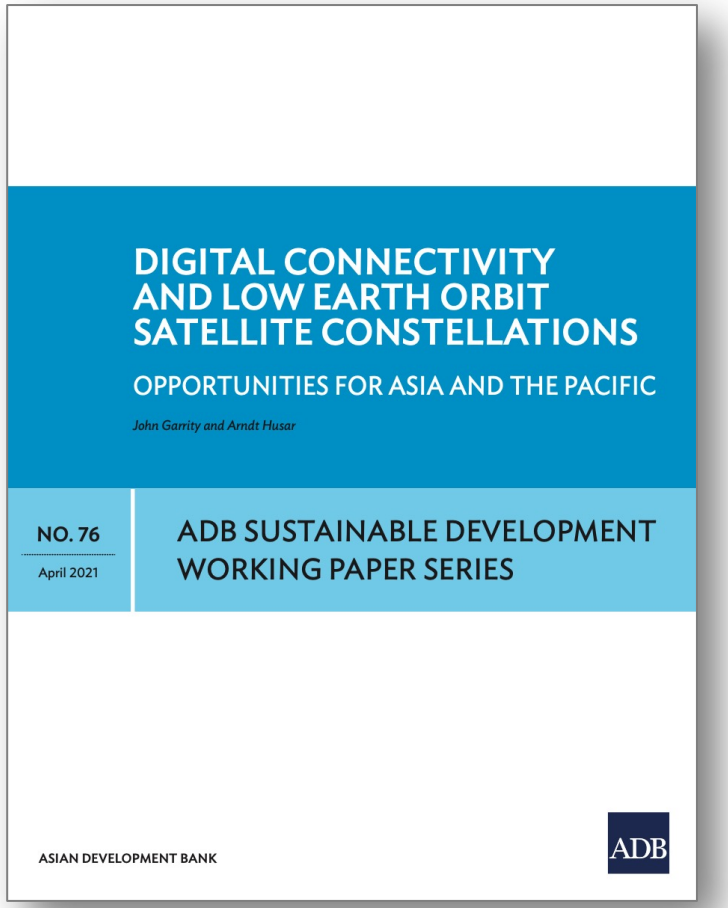

DIGITAL CONNECTIVITY AND LOW EARTH ORBIT SATELLITE CONSTELLATIONS:

OPPORTUNITIES FOR ASIA AND THE PACIFIC

John Garrity, Consultant (Digital Connectivity), Digital Technology for Development, jgarrity.consultant@adb.org

AN ‘EMERGING CONNECTIVITY INNOVATION’ … 30+ YEARS IN THE MAKING

How it started: (1990s)

KRISTI COALE SCIENCE 10.14.1997 10:20 AM

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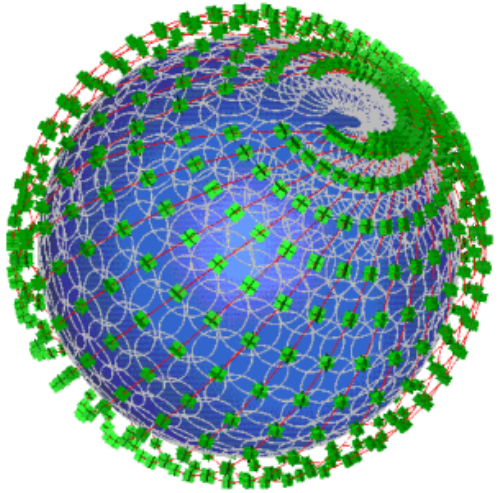


https://www.wired.com/1997/10/teledesic-mounts-lead-in-new-space-race/
http://personal.ee.surrey.ac.uk/Personal/L.Wood/constellations/teledesic-3d.html

How it ended: (early 2000s)

“…in the end the financial, technical and business risks associated with Teledesic could not be retired.”

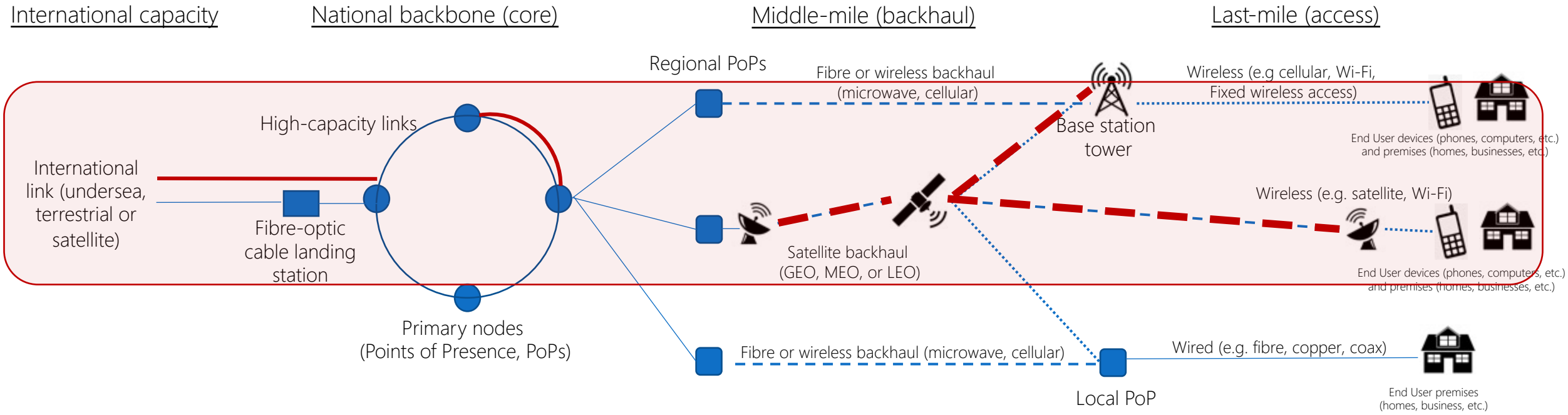
- Tren Griffin (Teledesic employee #4)

https://25iq.com/2016/07/23/a-dozen-things-i-learned-being-involved-in-one-of-the-most-ambitious-startups-ever-conceived-teledesic/

CONTENTS

SATELLITE CONNECTIVITY FILLS NECESSARY ROLE IN INTERNET ECOSYSTEM

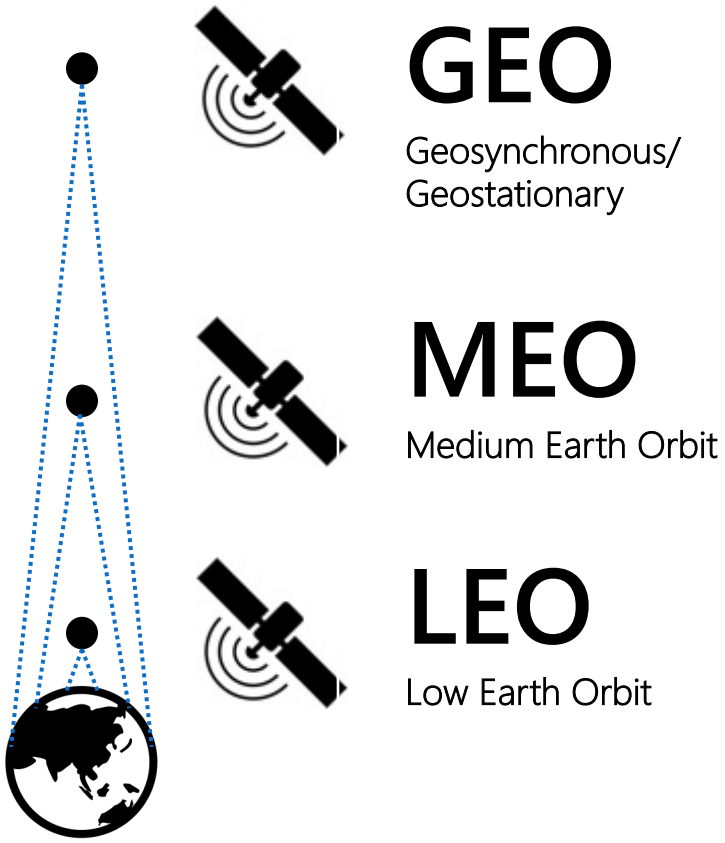
Telecommunications Network Infrastructure Elements
red lines highlight where satellite is utilized



Satellite in communications networks is predominantly utilized in last-mile and middle-mile links, but in few country cases, satellite continues to be the main, or only, source of international connectivity and in few country cases, national backbone networks utilize satellite (in addition to wireless microwave)

ITU Last Mile Internet Connectivity Solutions Guide, https://www.itu.int/en/ITU-D/Technology/Pages/LMC/LMC-Home.aspx

FEATURES (& "BUGS") OF DIFFERENT ORBITAL ALTITUDES



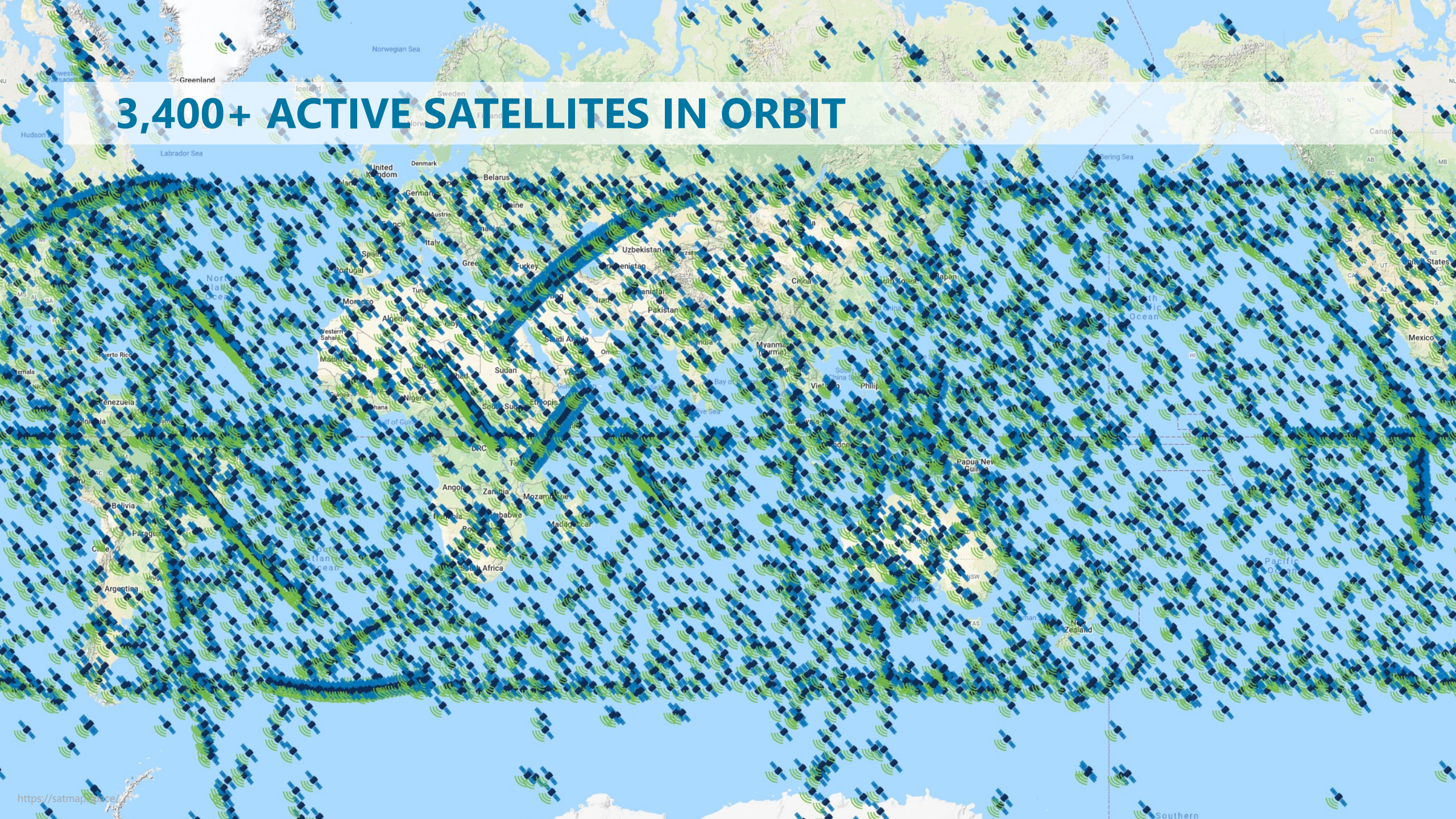
GEO
Geosynchronous/
Geostationary

MEO
Medium Earth Orbit

LEO
Low Earth Orbit

Altitude	Latency (roundtrip)	Orbital Period	Number of satellites to span globe	Cost per satellite	Effective lifetime of satellite
35,786 km	~477ms	24 hours	3 (if necessary)	~US$100M to ~US$400M	15 to 20 years
2,000 to 35,786 km	~27ms to ~477ms	127 minutes to 24 hours	5 to 30 (depending on altitude)	~US$80M to ~US$100M	10 to 15 years
160 to 2,000 km	~2ms to ~27ms	88 minutes to 127 minutes	Hundreds or Thousands (depending on altitude)	~US$500,000 to US$45M	5 to 10 years

ITU Last Mile Internet Connectivity Solutions Guide, https://www.itu.int/en/ITU-D/Technology/Pages/LMC/LMC-Home.aspx


3,400+ ACTIVE SATELLITES IN ORBIT
https://satmap.space/


BY ALTITUDE:
LEO
MEO
GEO
https://satmap.spac

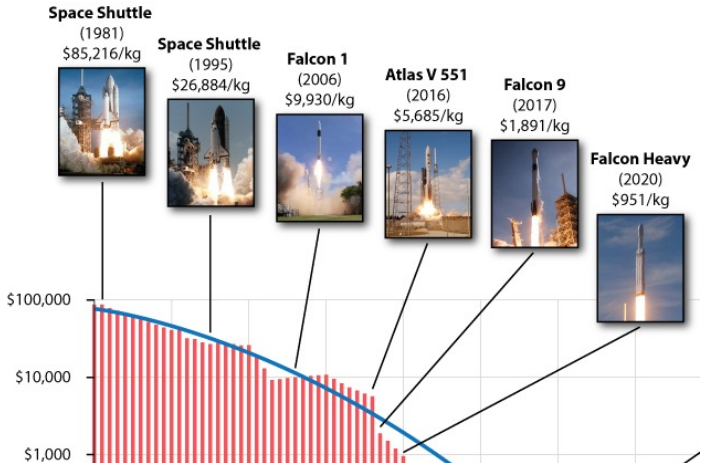
CHANGES SINCE THE LAST MAJOR LEO INVESTMENTS ('90s)

Demand (2000 vs 2020)

- **2,143x increase in total internet data traffic growth:**
  75 PB/month vs 161 EB/month (Cisco)
- **10x increase in individuals using the internet:**
  400m users vs >4b in 2020 (ITU)
- Digital applications and services via internet connectivity infrastructure utilized across all sectors and segments of the economy

Supply

- Significant reduction in cost of launch into orbit
  (cost per kilogram of payload delivered into LEO; log scale; inflation adjusted)



- Significant reduction in cost of computing (~Moore's Law)

Sources: Cisco (2000, 2020); ITU (2000, 2020); Launch costs; Computing

COMPARISON OF LEO CONSTELLATIONS IN DEPLOYMENT

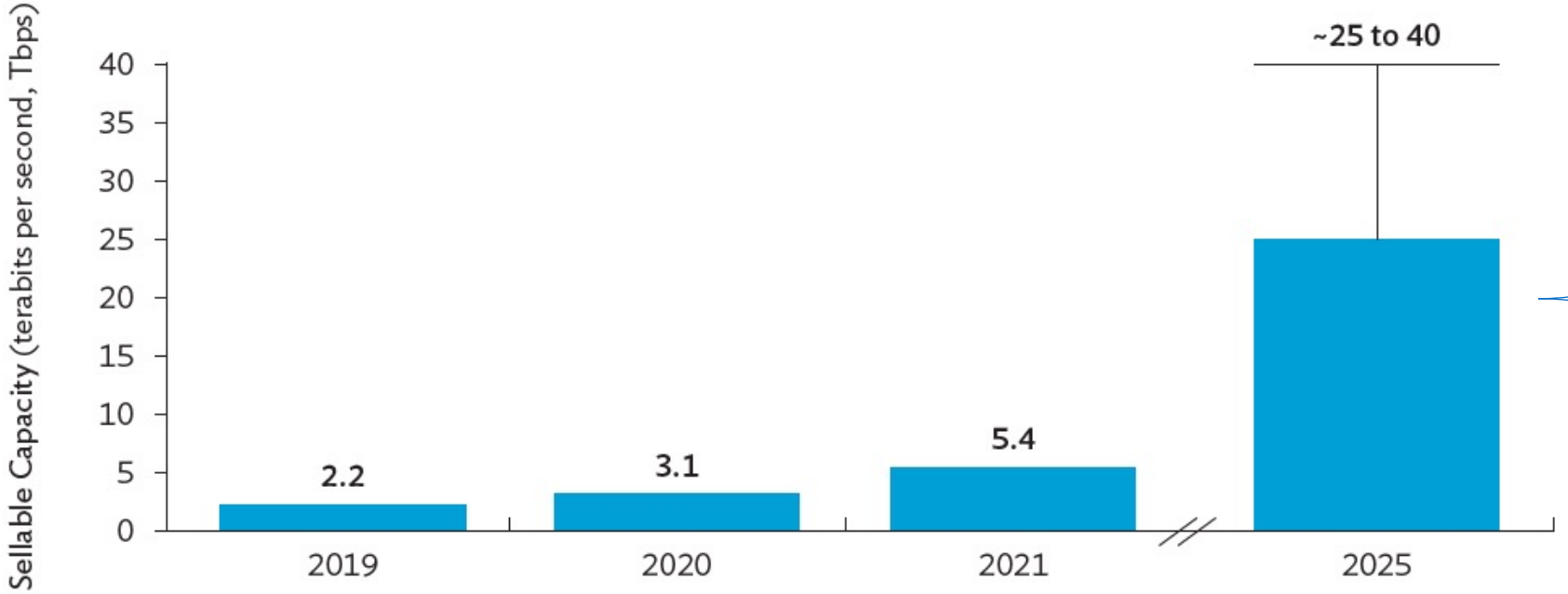
	SpaceX Starlink	OneWeb	Telesat Lightspeed	Amazon Project Kuiper
Number of LEO satellites launched	1,445	182*	1 (Telesat LEO 1)	0
Constellation size to initiate commercial service	1,584*	648	298	578
Estimated total bandwidth throughput at the start of commercial operations	23.7 Tbps	1.56 Tbps	15 Tbps	unknown
Planned expansion (total future constellation size)	12,000	2,000	1,600	3,236
Frequency	Ku-band	Ku-band	Ka-band	Ka-band
Orbit	560 km	1,200 km	1,000 km	590–630 km
Satellite mass	227–260 kg	150 kg	800 kg	unknown
Satellite life	5–7 years	~5 years	10–12 years	unknown
Latency	<50 ms	<50 ms	<50 ms	unknown
Required reported capital expenditure	$10 billion	$2.4 billion	$5 billion	$10 billion
Vertical markets publicly targeted	Consumer broadband, cellular backhaul	Backhaul, government, mobility, broadband	Government mobility, carrier-grade requirements	Broadband, backhaul

* Updated since publication of white paper

For detailed sources, see Table 3 in ADB paper, "Digital Connectivity and Low Earth Orbit Satellite Constellations: Opportunities for Asia and the Pacific"; https://www.adb.org/publications/digital-connectivity-low-earth-orbit-satellite-opportunities

IMPACT OF LEO: SIGNIFICANT INCREASE IN CAPACITY (>10X)

Forecasted Growth in Satellite Bandwidth Capacity, 2019 – 2015

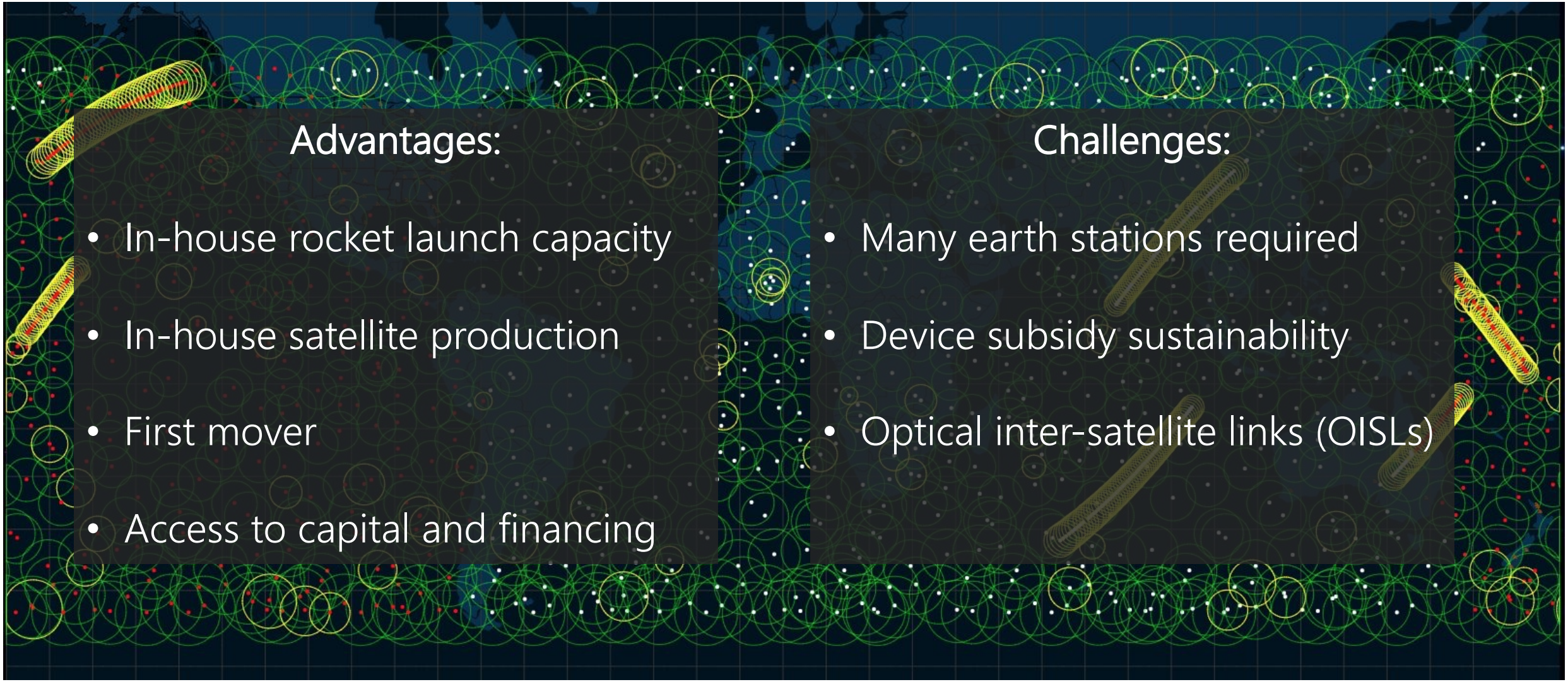


	Entity	Capacity Expected
LEO	Starlink	23.7 Tbps
LEO	Telesat	15 Tbps
LEO	OneWeb	1.5 Tbps
MEO	SES/O3b	10 Tbps
GEO	Viasat	3.0 Tbps
GEO	Echostar	0.5 Tbps

Similarly, Exane/BNPP (investment bank) forecasts satellite broadband capacity to increase from an estimated **2 Tbps** at the end of 2020, to **20 Tbps** by end of 2021, and **60 Tbps** by the end of the decade.

For detailed sources, see Figure 6 in ADB paper, "Digital Connectivity and Low Earth Orbit Satellite Constellations: Opportunities for Asia and the Pacific";
https://advanced-television.com/2021/02/12/report-satellite-broadband-capacity-to-grow-tenfold-by-year-end/

SPACEX STARLINK: ADVANTAGES & CHALLENGES



Advantages:

- In-house rocket launch capacity
- In-house satellite production
- First mover
- Access to capital and financing

Challenges:

- Many earth stations required
- Device subsidy sustainability
- Optical inter-satellite links (OISLs)

https://satellitemap.space/

RISKS AND CHALLENGES FOR LEO SATELLITE BROADBAND

- Significant capital expenditure requirements
- Affordability of terminals & service
- Regulatory barriers to market entry
- Radio frequency interference issues
- Satellite / space debris monitoring & coordination
- Astronomy concerns

POLICY & REGULATORY CONSIDERATIONS TO PREPARE FOR LEO SATELLITE CONNECTIVITY SERVICE

- Ensure flexible and streamlined license procedures for domestic internet service providers and satellite broadband providers.
- Allow for satellite provision of international internet capacity without a requirement for domestic ground stations to route traffic to and from satellite transponders.
- Reduce or remove import tariffs, quotas, or local manufacturing requirements for satellite user terminals.
- Engage in regional discussion and cooperation both in terms of regulatory convergence to improve the "ease of doing business" for LEO satellite connectivity as well as for potential demand aggregation between markets.
- Deploy universal access funding to support public access through community Wi-Fi deployments.
- Invest in developing accurate, publicly available, mobile coverage and network infrastructure availability maps to better identify geographic areas that are unserved and underserved by current service providers.
- Consider supporting consumer financing for user terminals.
- Support demand generation activities.
- Set timely expectations for spectrum coordination, both between satellite operators and between satellite and terrestrial systems.

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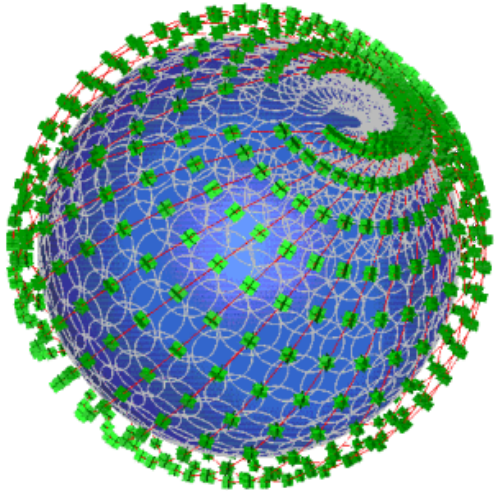

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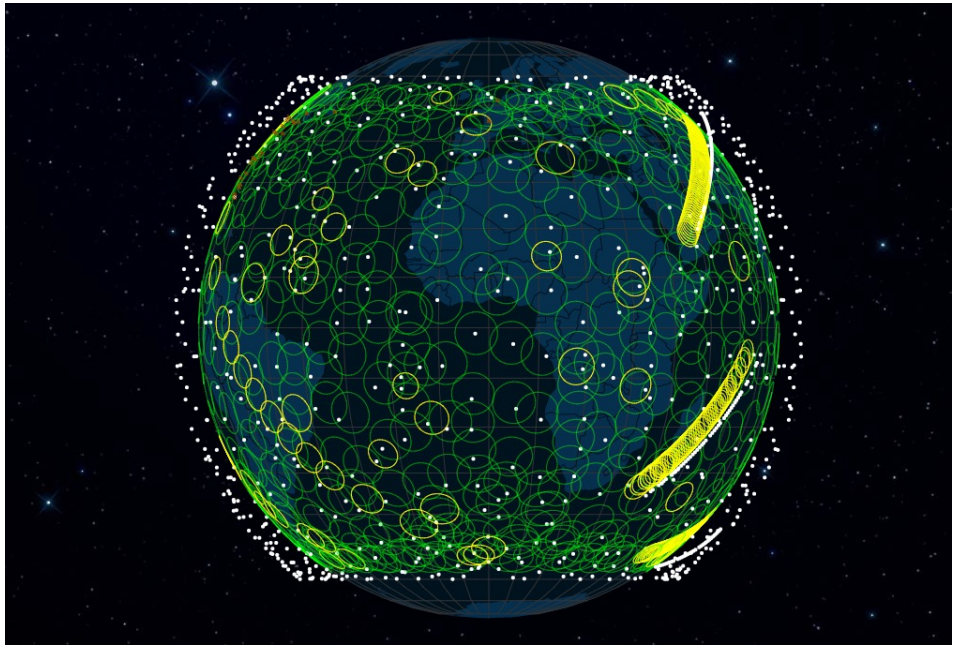
How it’s going (2021):



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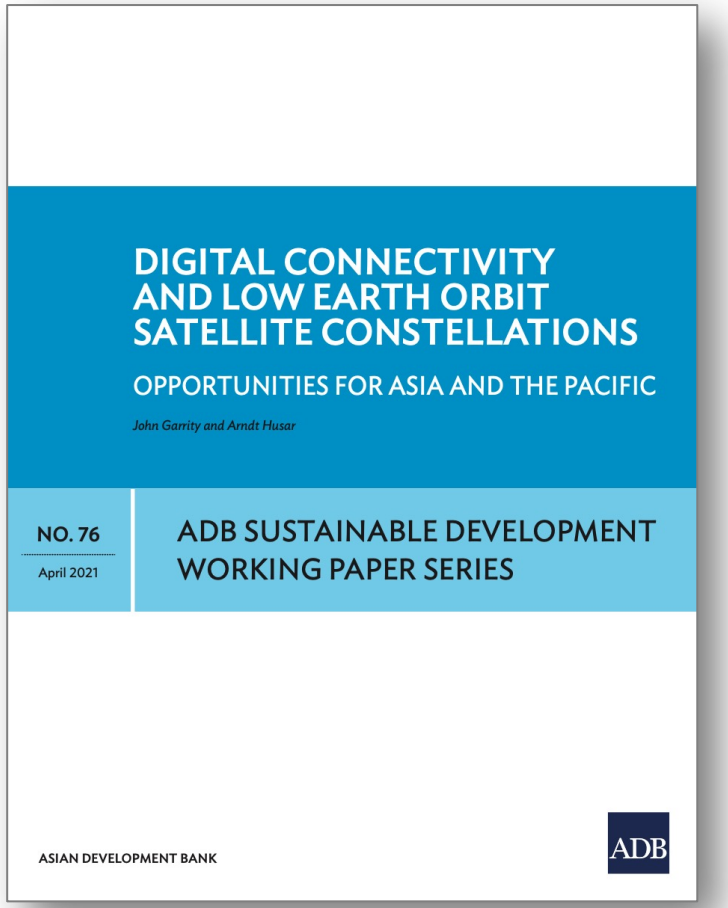

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