

Wireless!

The forces and strategies that shaped a revolution



Lecture 25: Case Study 1: Motorola's Iridium:
Putting a cellular system into space

and

Where are we Today? Where might we be going?

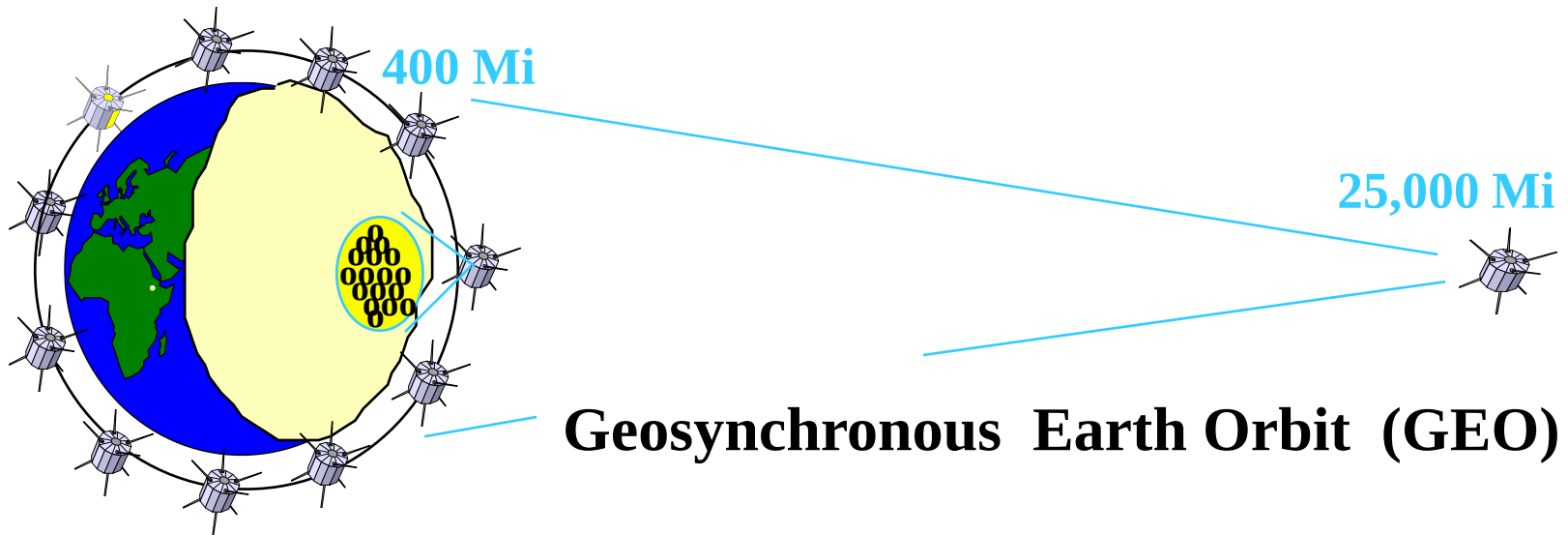
Lecture 26- Classwork

1. Assume that you are the strategist for a company that is considering making an investment in Motorola's Iridium. You have been asked to analyze the system description in "L26- Pre-lecture reading 2021- Case Study 2- Motorola's IRIDIUM- Putting cellular Base Stations in Space" and offer your opinion as to whether your company should invest or not. Write a brief recommendation, including any reasons you think are important.

GEO and LEO; a really big, stationary cell vs many smaller moving coverage areas

Low Earth Orbit (LEO)

One satellite covers up to 10 million sq Km (the US)
with 48 spot beams (~one per state); moving cells, some reuse



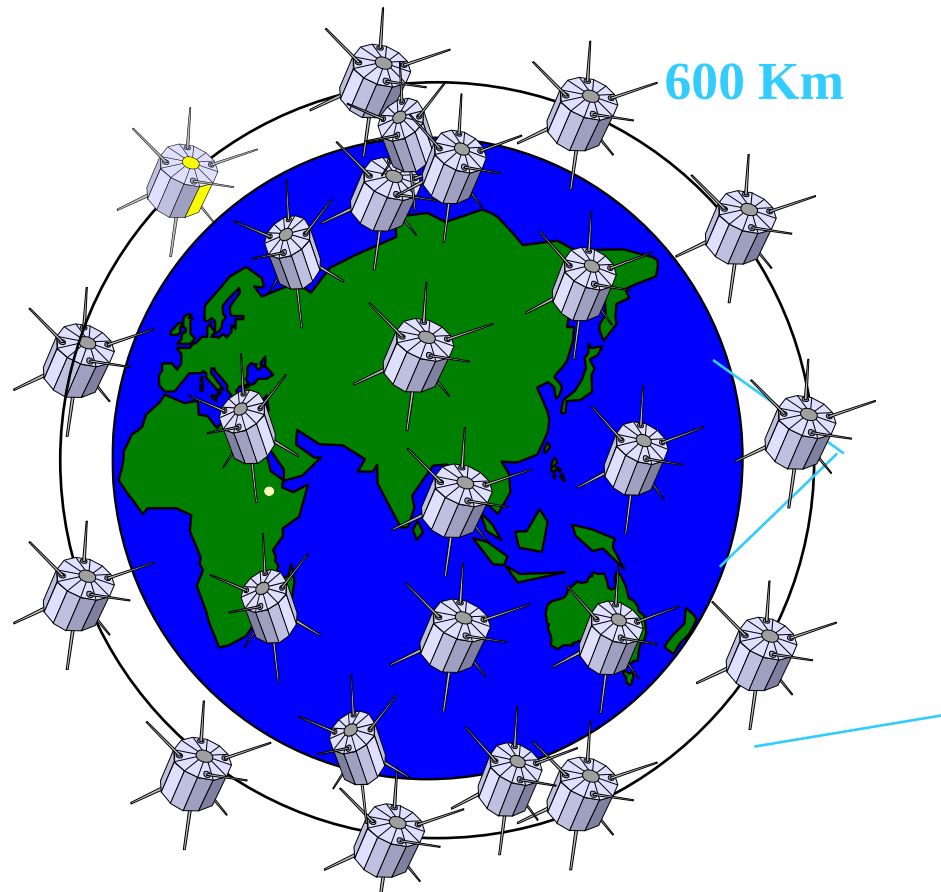
Geosynchronous Earth Orbit (GEO)

3 satellites cover the globe, no reuse,
no coverage at poles, stationary coverage,
1/4 sec delay, more power

Iridium: A \$4B Project (became \$7B)

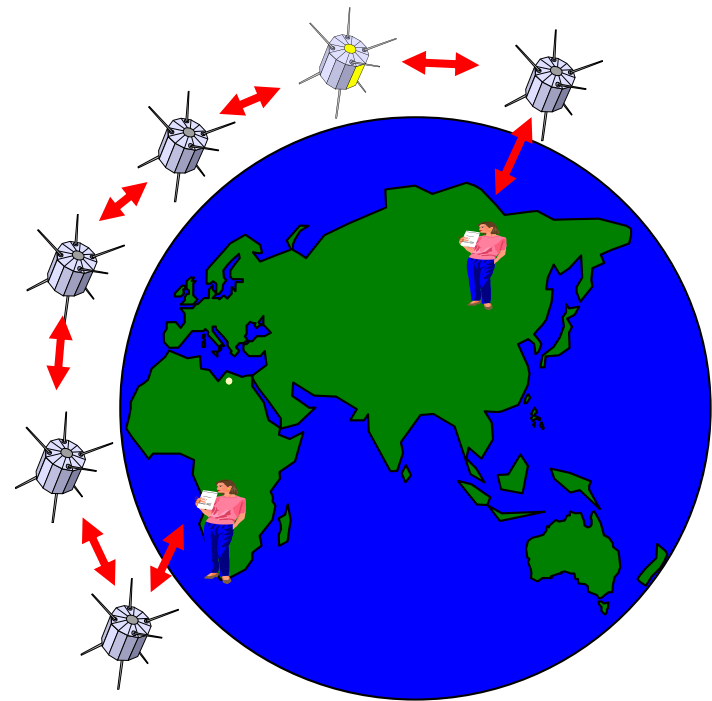
66 satellites (6 orbits x 11 satellites)

Crowded at the poles

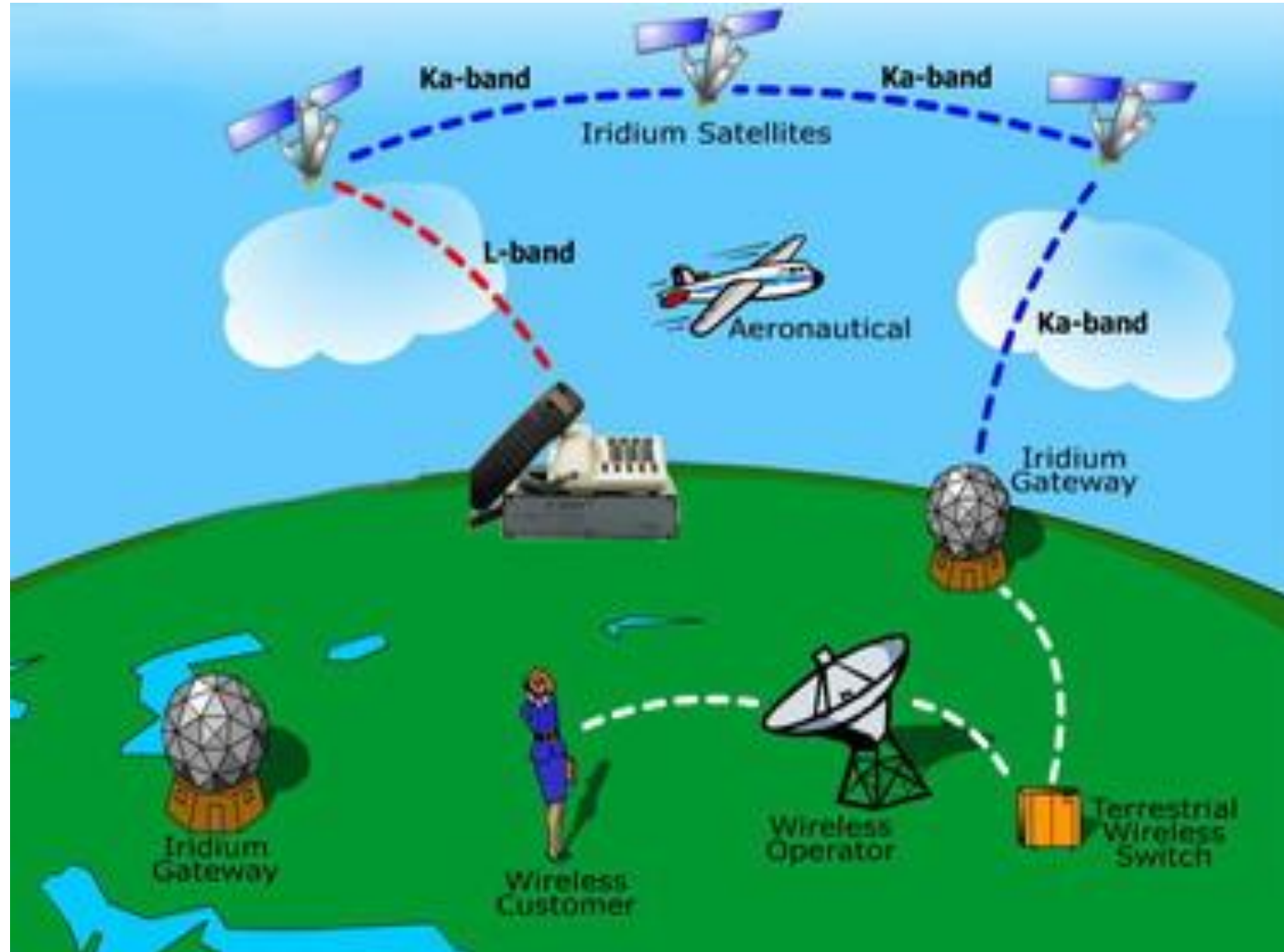


The Iridium Vision

- Voice and data everywhere
 - Nowhere on earth unconnected
- Switching in the sky
 - Can use 20 GHz between satellites. and to ground Stations ("gateways") (satellite to user needs lower frequencies)



Iridium network



Limited spectrum for the user to satellite link

- ❑ Only 8 MHz for user to satellite (at 1.6 GHz)
- ❑ Limited reuse (x 5 in US)
- ❑ As a result of the limited spectrum
 - Heavy voice compression– poor quality
 - About 2000 voice channels in US
 - But 80% wasted
 - Maybe 5-10X the cost per user of cellular?
 - ❑ Cellular was charging 50 cents/min at the time

Some other issues

- ❑ International regulations
- ❑ Coverage (buildings, trees)
- ❑ Technology risk? (Cost, schedule)
 - They did pretty well on the technology

Some “Guesses” made in 1995

- ❑ **Satellites will only serve non-cellular areas**
 - Poor voice quality; high cost
- ❑ **Economics are plausible, but:**
 - Spectrum allocations uncertain (cost; worldwide coordination)
 - Cost overruns likely?
 - Growth rate critical for economics, but:
 - ❑ Must draw from low density areas that don't have cellular
 - ❑ Bit rates too low for information services like Internet access
- ❑ **Too many risk factors**
 - Initial investors will lose; a decade will be needed to evolve “best uses” for satellite systems

A rapid demise (as reported in the news)

Iridium communications service was **launched on November 1, 1998** and went into Chapter 11 **bankruptcy on August 13, 1999**. Its financial failure was largely due to **insufficient demand** for the service, coupled with a **massive initial capital cost** running into the billions of dollars. The **increased coverage of terrestrial cellular networks** and the rise of **roaming agreements between cellular providers** proved to be fierce competition. The **cost of service was also prohibitive** for many users, despite the continuous worldwide coverage of the Iridium service. In addition, the **bulkiness and expense of the handheld devices** when compared to terrestrial cellular discouraged adoption among potential users. Mismanagement has also been cited as a major factor in the original program's failure.

Too many risk factors

And a new, more modest life

But at the last minute, a group of investors saved the constellation of satellites, buying the system at a fire-sale price. The system that cost Motorola more than \$5 billion to build ultimately sold for \$25 million, or about half a penny for every dollar it originally cost. Because of its cost structure, the old Iridium needed a million subscribers or more to even get close to breaking even. The new Iridium is paying subcontractor Boeing 10% of what the old company paid to operate and maintain the satellites. That lowers the break-even point to about 60,000 subscribers.

<http://www.forbes.com/2001/11/30/1130tentech.html>

2007 status

Iridium Satellite LLC claims to have 225,000 subscribers as of October 2007, an 11% increase from the total at the end of the second quarter 2007. Revenue for the third quarter of 2007 was US\$74.2 million with EBITDA* of US\$22.5 million. [Revenue in 2006 was US\$212.4 million and EBITDA was US\$53.9 million.

The system is being used extensively by the US Department of Defense for its communication purposes. The commercial gateway provides voice, data and paging services for commercial customers on a global basis. Typical customers include maritime, aviation, government, the petroleum industry, scientists, and frequent world travelers. Iridium satellites are now an essential component to communications with remote science camps, especially at the South Pole (why?)

*EBITDA: Earnings before interest, taxes, depreciation, and amortization ("overstates" profitability)

And then Iridium NEXT

- ❑ Anticipated to begin launching in 2015, Iridium NEXT will substantially enhance and extend Iridium mobile communications services, delivering:
 - Higher data speeds
 - Advantages of IP technology
 - Backward compatibility with current handsets, devices and applications
 - Powerful new services and devices
- ❑ Financing (~\$2B) in place for new satellites
- ❑ Satellites will carry sensors (e.g., global warming) and can add GPS services
- ❑ Rates up to 1 Mbps???
- ❑ Calls still about \$1/min
- ❑ Handsets still bulky and about \$1200

Iridium Today

Bringing It Back to Earth

Iridium is a global satellite communications company, providing access to voice and data services anywhere on Earth.

With its constellation of satellites, Iridium's network connects people and devices in the world's most remote places — and close to home.

Individuals & Personal Users



I'm looking to find a device for my personal use »

Businesses & Organizations



I'm looking to find a solution for my business or organization »

Governments & NGOs



I'm looking for a rugged, secure solution »

Developers & Partners



I'm looking to develop a product with Iridium »



Where are we Today?

- ❑ Satellite based Cellular and Internet Communications has seen a big revival
- ❑ Elon Musk and SpaceX (Founded in 2002)
 - Falcon series of Rockets
 - Reusable Technologies
 - “Pizza Box” Satellites
 - Scalability- 143 satellites launched on a single mission in January 2021 (Transporter 1 on Falcon 9)
 - Reduced Launch Costs
- ❑ Emerging Ecosystem: Satellite based cellular/internet companies, e.g. Starlink, Kuiper, Lynk
- ❑ 6G will include NTNs (Non Terrestrial Networks)

Pizza Box Satellites in Transporter-4 on Falcon 9



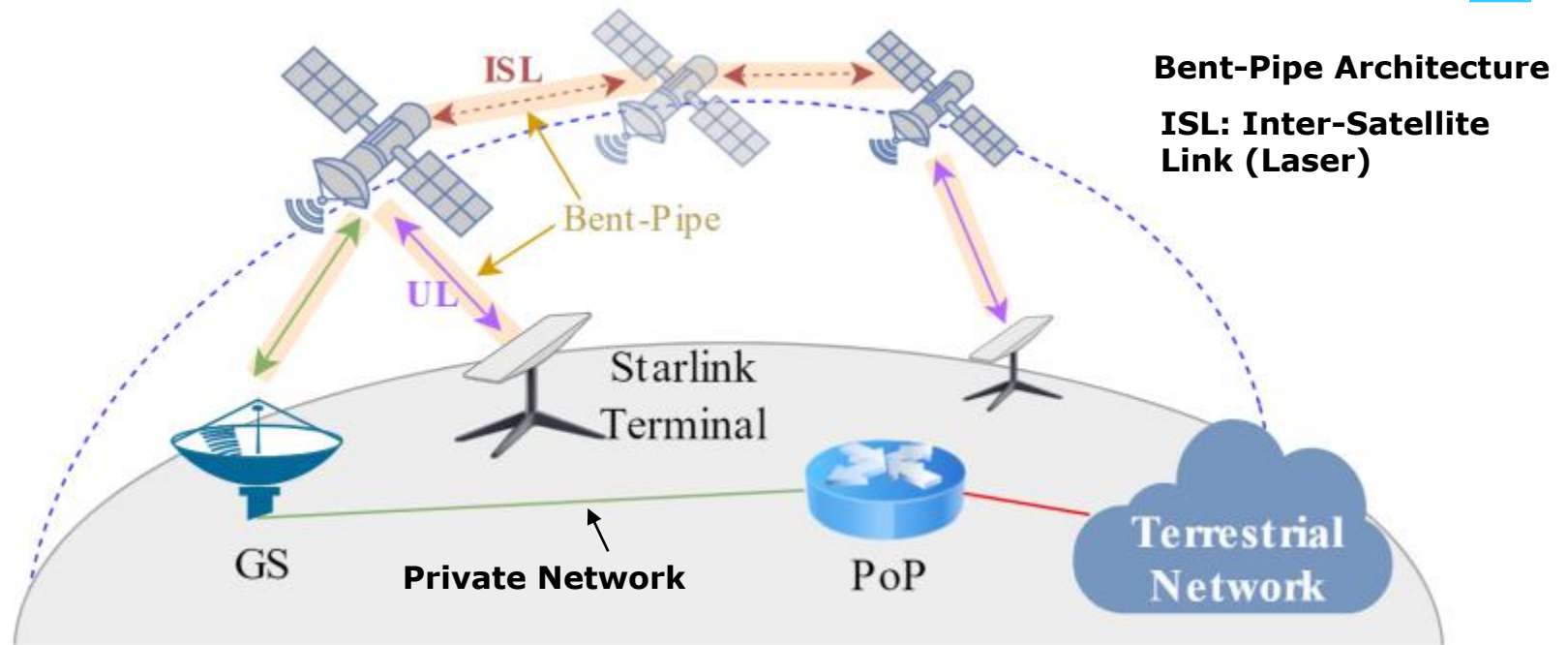
Starlink Today

- ❑ Starlink Internet Satellite Network
 - Over 10000 satellites in ORBIT, coverage in over 150 countries
- ❑ **2026 Trend:** By April 14, 2026, SpaceX had already completed 37 dedicated Starlink missions, launching 1,002 satellites in under four months
- ❑ **2025-2026 Rate:** The company is now launching over 2,300 satellites per year
- ❑ Network Architecture is different
- ❑ User Terminals and Devices are different

Starlink Coverage

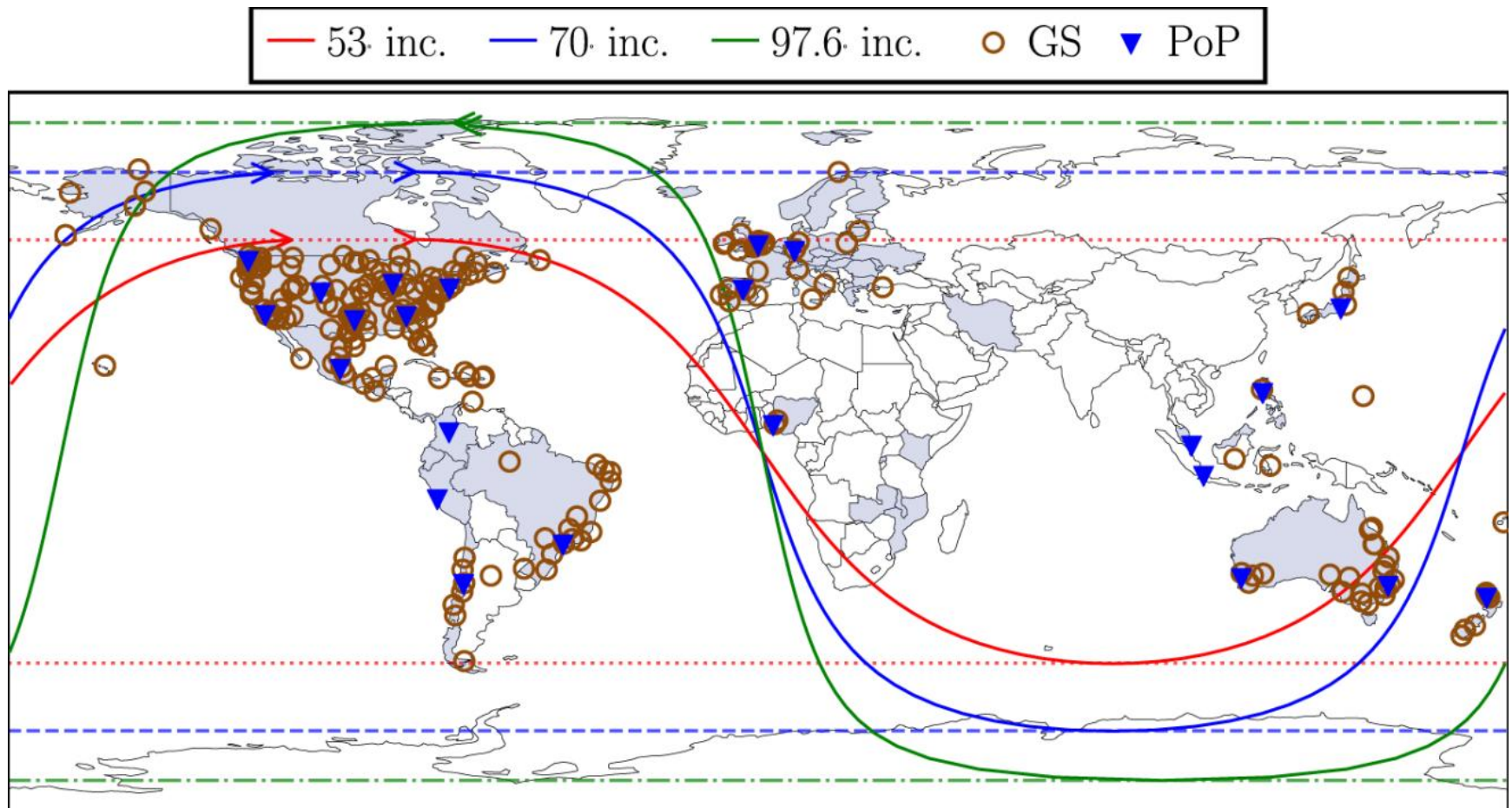


How Starlink Works



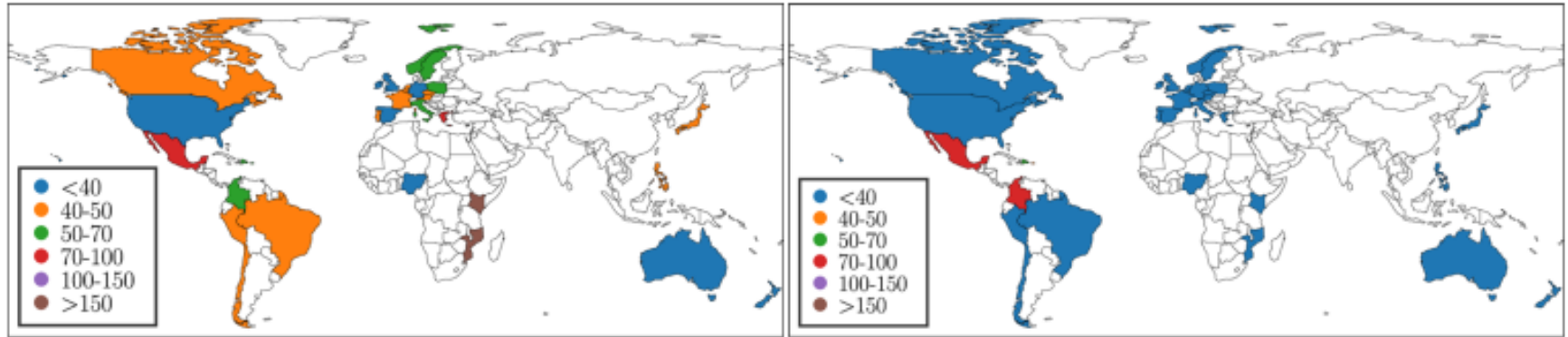
- ❑ Starlink (user) terminal (called 'Dishy') that communicates with satellites visible above the 25-degree elevation using a phased array of Ku-band antennas (DL: 10.7-12.7 GHz, UL: 13.7-14.5 GHz)
- ❑ Ground stations (GS) communicating over the Ka-band (26.5-40 GHz)
- ❑ GS are connected over a private network to a PoP, which enables traffic to route to the Internet

How does Starlink geographical network look?

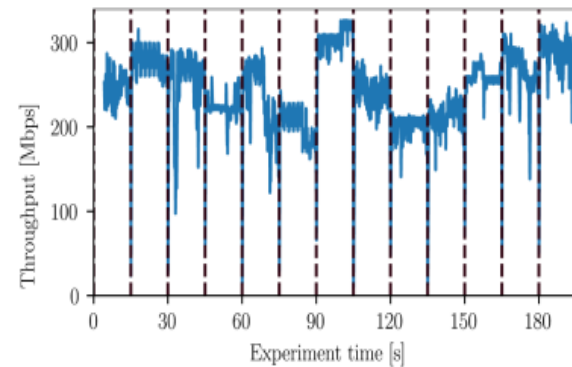
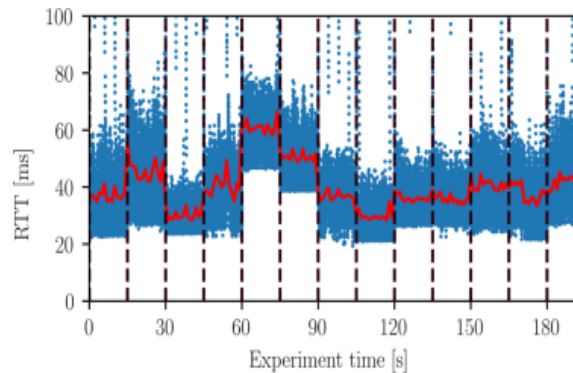
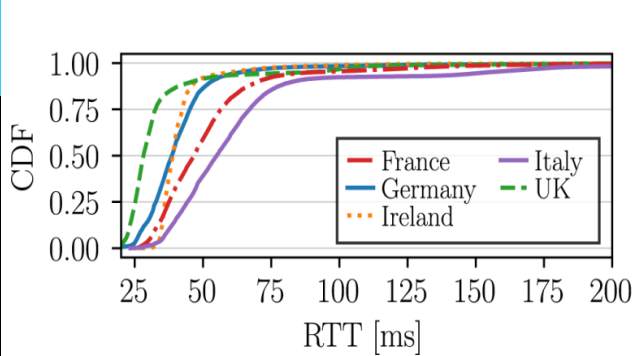


3 Orbital Shells of Starlink inclinations (angle to equator) along with Ground Station (GS) and Point-of-Presence (PoP) locations

What about performance (RTT)?



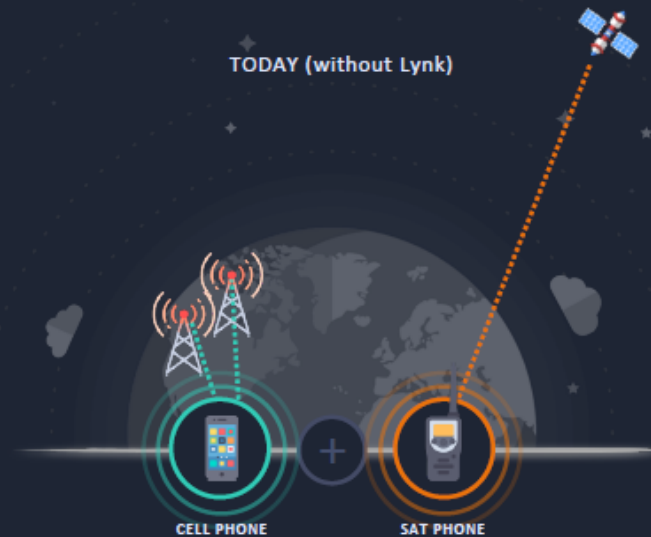
Median of minRTT (in ms) via Starlink (left) and top-3 serving ISPs (right)



<https://blog.apnic.net/2024/07/11/a-multifaceted-look-at-starlink-performance-the-good-the-bad-and-the-ugly/>

Lynk

Lynk is building a network of small satellites to provide affordable mobile broadband coverage everywhere on the planet



Limited terrestrial base stations provide local coverage, with a very expensive and separate satellite phone and subscription required for global coverage



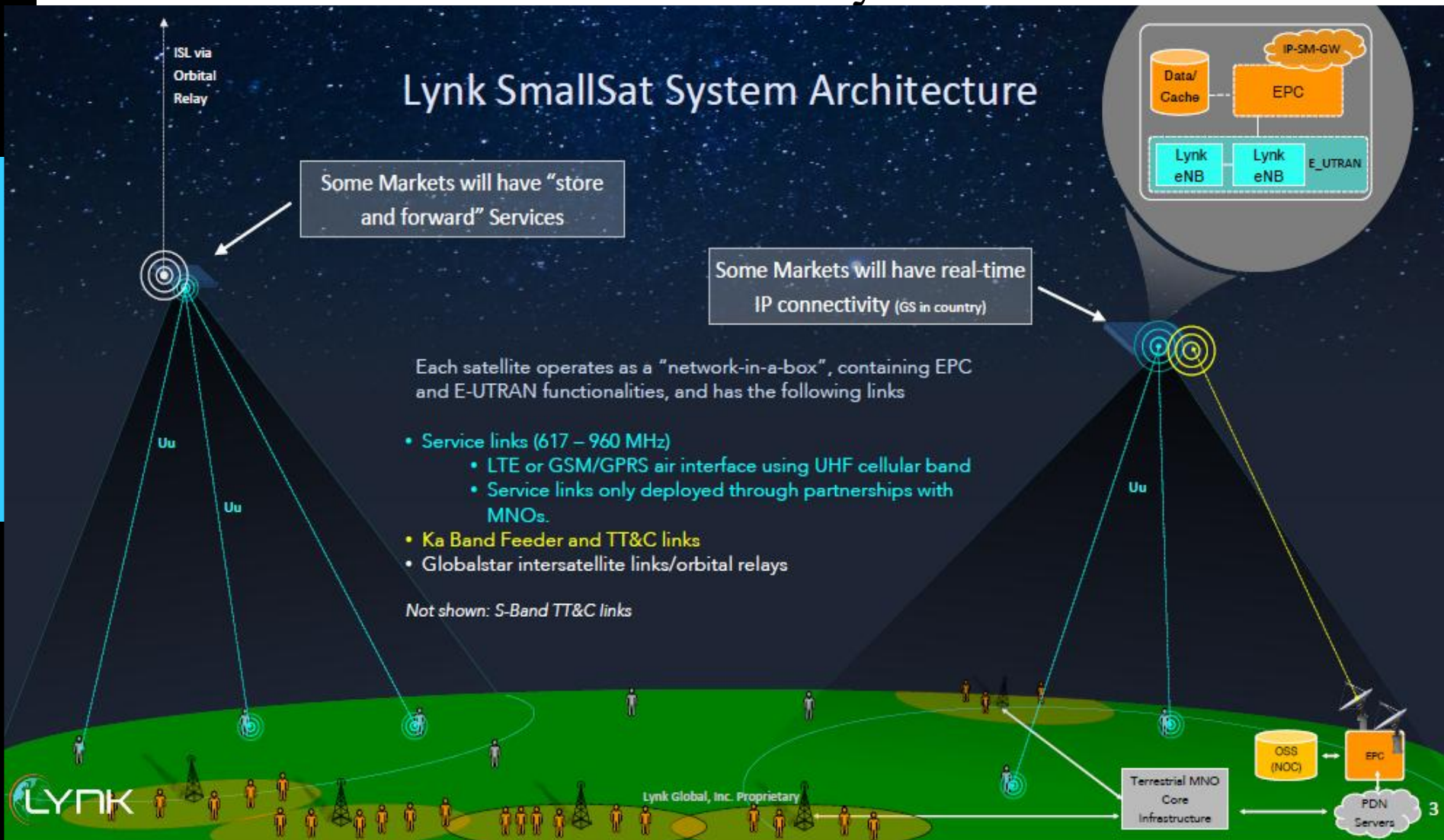
With Lynk, subscribers receive coverage from cell towers when they have it and satellite coverage when they need it, all from their existing phone



Lynk Global, Inc. Proprietary

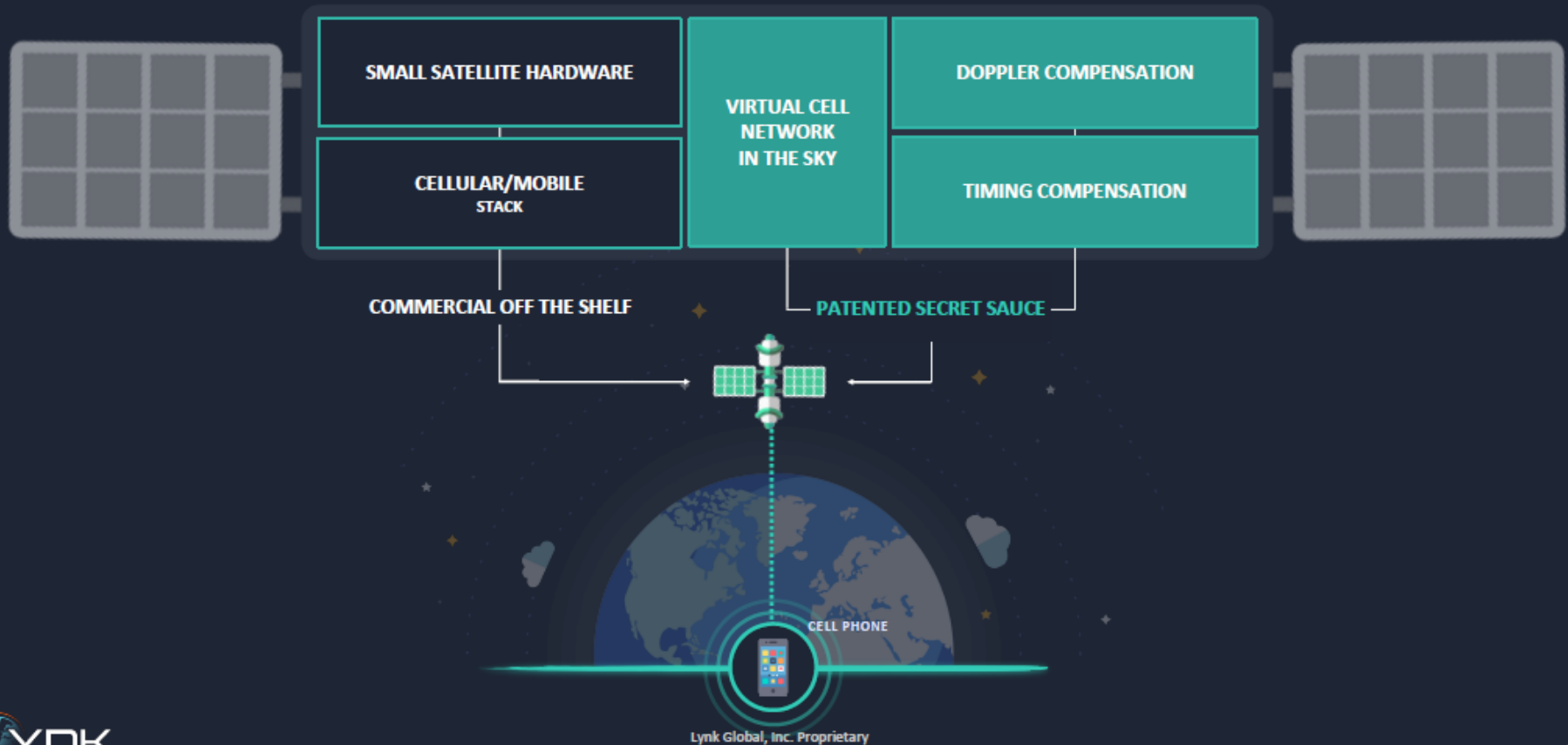
“Basestation in the Sky”

Lynk SmallSat System Architecture

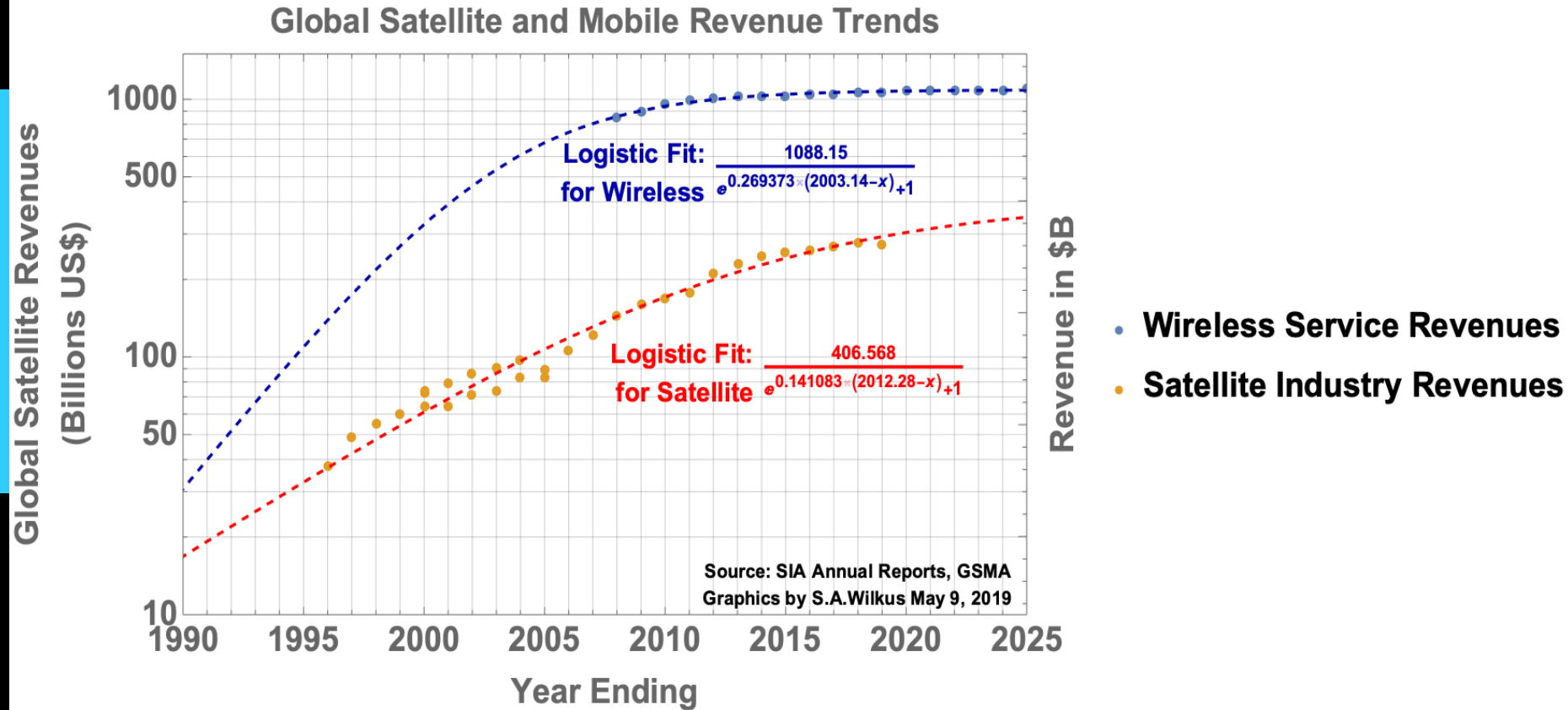


Satellite as Cell Tower

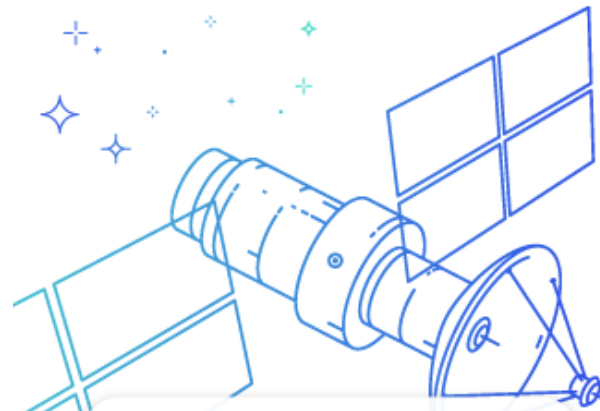
Secret Sauce - Cell Tower in Orbit



Emerging Ecosystem: Satellite based cellular companies: Cellular vs Satellite?



Where are we going?



Is it worth it?

Avg. Internet



monthly cost

\$65

that's

\$1.13

per mbps

Starlink



monthly cost

\$99

that's

\$0.96

per mbps

How do Americans feel about *switching to Starlink* internet?



51% of Americans

say they **plan to sign up** for Starlink satellite internet once the beta program becomes available to them.



Only 5% of Americans

currently use a satellite internet connection, but **64%** say they'd **consider switching** with the rollout of Starlink.



55% of users

say they'd switch to Starlink internet **at a higher cost** if it resulted in faster internet speeds for their household.

Will they switch?

Before switching to satellite internet, the **most important factors** people are taking into consideration are:

High-quality streaming **74%**

High-fidelity video calls **72%**

Online gaming performance **56%**

