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Let's go

The bridge to possible

Low Earth Orbit Satellites

Leveraging Cisco Technologies to Improve Your LEOsat Deployments

Ian Procyk, Technical Solutions Architect

Oli Boehmer, Principal Architect

Dave Zacks, Distinguished Engineer

#HighBitRate

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BRKOPS-2586

By Way of Introduction ...

I am a **Distinguished Engineer** in the Cisco Transformation team, and have been with Cisco for 24 years.

I work primarily with large, high-performance Enterprise network architectures, designs, and systems. I have over 39 years of experience with designing, implementing, and supporting solutions with many diverse network technologies.

I have a strong background in, and focus on, customer requirements, and integrating these into the products and solutions Cisco builds.

I have a special interest in **Flexible Hardware, Network Fabrics, End-to-End Assurance & Analytics, and ML/AI for Networking.**

Dave Zacks
Distinguished Engineer
dzacks@cisco.com @DaveZacks

By Way of Introduction …

I joined Cisco in 2011 and has remained **focused on wireless technologies** since. I apply over 20 years of field experience helping customers architect, implement and support complex wireless deployments across all verticals.

Internally, I lead the Cisco's Mobility Technical Advisory Group, a global team of wireless specialists helping to ensure that customer's feedback crosses paths with engineering's priorities and new product development.

Before coming to Cisco, I held positions with a start-up IT consulting firm based in Vancouver and the Canadian Coast Guard. I started my career in IT at the University of British Columbia where I was involved in one of the first large scale WLAN deployments in the country.

Ian Procyk
Technical Solutions Architect
iprocyk@cisco.com

By Way of Introduction ...

I am a **Principal Engineer** in our CX organization, and with Cisco for 23 years.

My main tasks is working with our largest Enterprise and Service Provider customers in Europe to design and implement complex, cross-architecture deployments. Lately, I've been focusing on network automation and programmability, applying DevOps principles to today's networks.

I live in rural Northern Germany and have been using LEO Satellite Service for almost three years now.

Oliver Boehmer
Principal Engineer
oboehmer@cisco.com

Agenda

- Introduction to LEOsats
- LEOsat Operational Details
- What's Up There?
- Constellation Dynamics
- Phased Array Antennas
- Mobility And Laser Inter-Satellite Links
- Real World Deployments – Dave
- Real World Deployments – Oli
- Real World Deployments – Ian
- LEOsat Programmability
- LEOsat Futures And Opportunities
- Conclusion

We all know

that the future is in the Cloud(s), right?

but look beyond that...
and you just might conclude that it's in SPACE too!

Low Earth Orbit Satellites (LEOsats)

Changing the Game

Space Launch Economics

ULA
NASA
SPACEX
Other launches

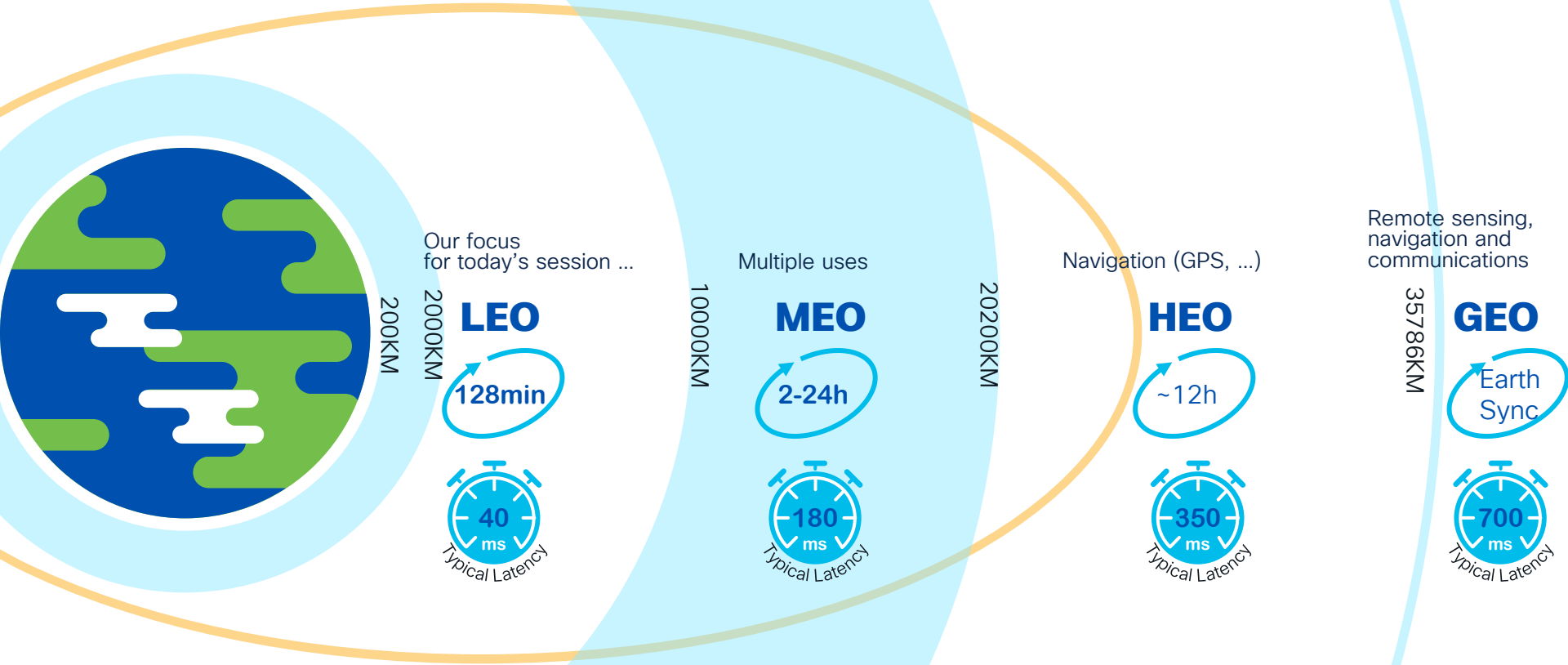
$51,200
$25,600
$12,800
$6,400
$3,200
$1,600
$800
$400
$200
$100

Shuttle
Saturn V
Delta IV Heavy
Falcon 9
Falcon Heavy
Starship Super Heavy
(ESTIMATE)

Image Credit: Mashup from Blue Origin, Wikipedia & Others

1960 | 1970 | 1980 | 1990 | 2000 | 2010 | 2020 | 2030

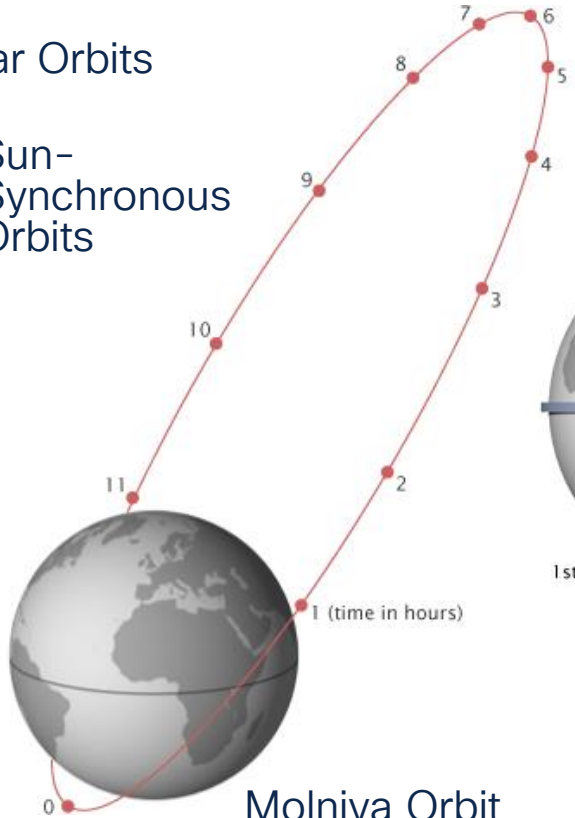
Satellite Orbits



More about Orbits

Polar Orbits

Sun-Synchronous Orbits

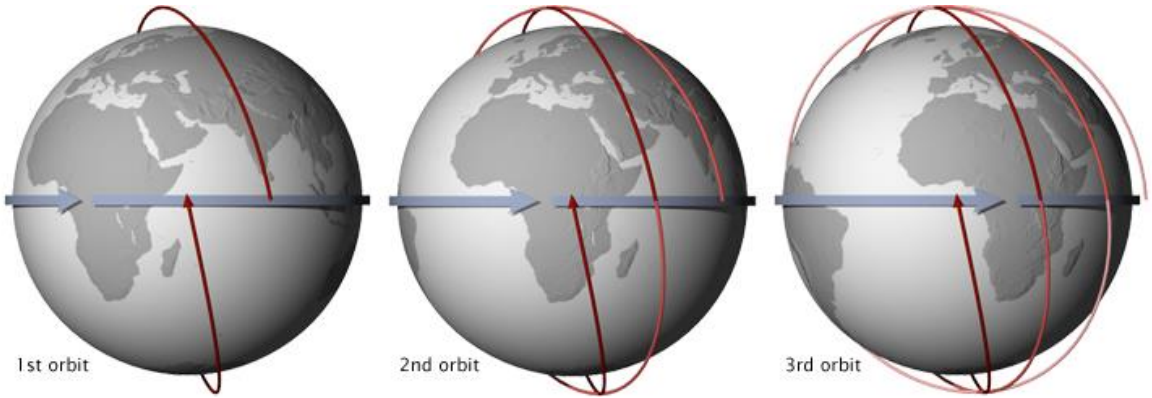


Molniya Orbit

Comms and remote sensing over high latitudes

Remember, the Earth rotates …

So satellites in lower orbits are constantly passing over different areas of the Earth on every orbit …



Traditional View of Satellite Communications

Geosynchronous Operation

Geosynchronous Orbit

Rotates in sync with Earth rotation
Around 35,000 km altitude
Static location in the sky from ground observation

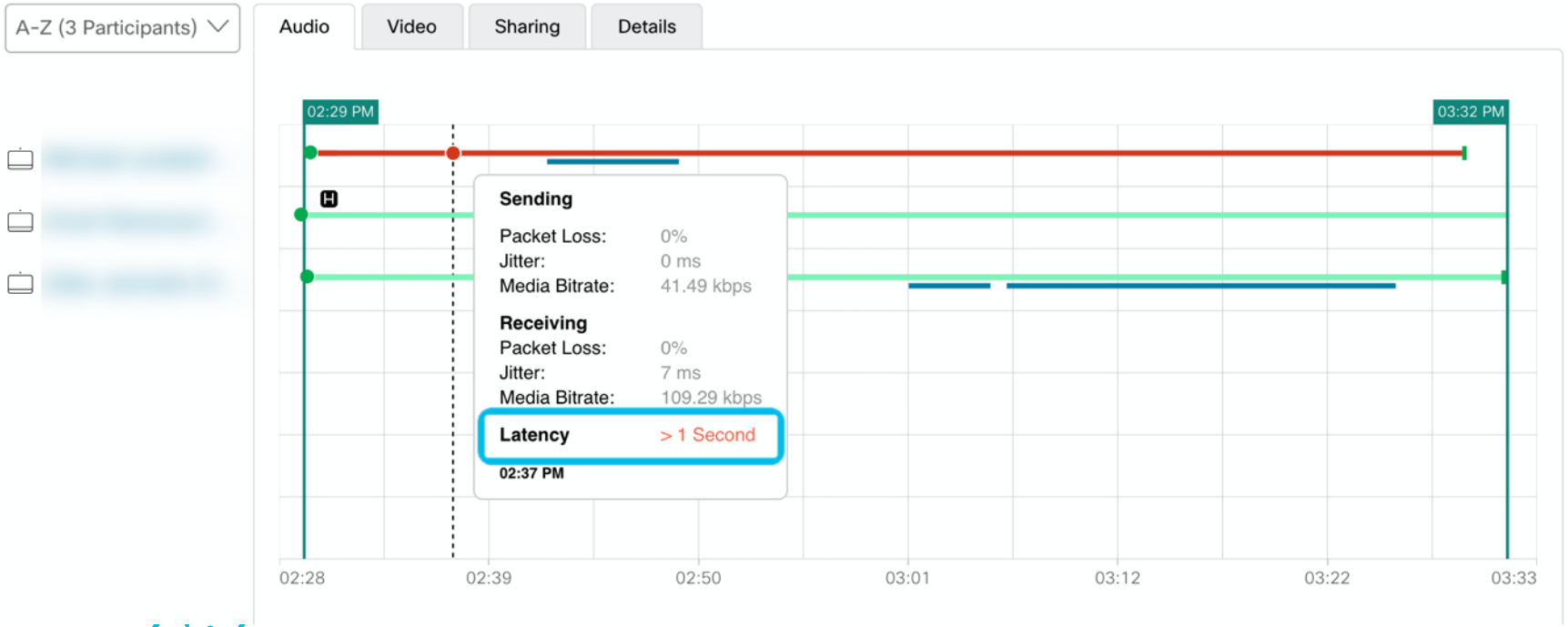
Moderate Performance

Throughput: 0-100Mbps max, 5-10Mbps typical
Latency: ~120msec each way
Roundtrip: ~477 msec round-trip latency
Typical: ~600+ msec latency
Large spot coverage due to limited geosync satellites

Note: Coverage illustrative only, Not to scale

Traditional View of Satellite Communications

Geosynchronous Performance – Real-World



Low Earth Orbit (LEO) Satellite Constellations

Low Earth Orbit Operation

- Located at ~500km altitude (varies)
- Constantly moving from ground observer viewpoint
- Many LEO satellites in constellation
- Starlink = 4,425 in initial planned deployment)

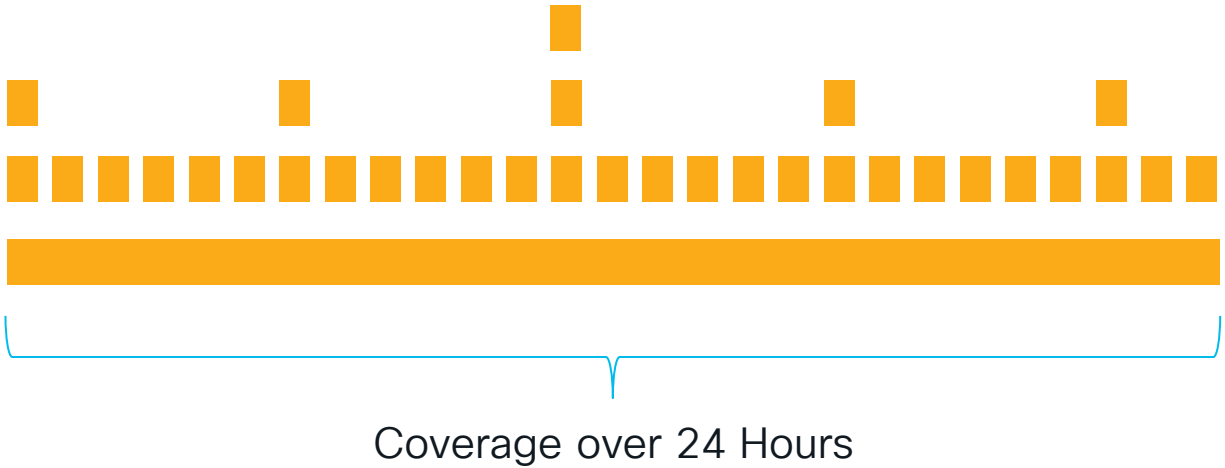
Improved performance

- Throughput~: 200Mbps down, 25Mbps up (Starlink ~8x increase)
- Latency~: 20-40 msec typical, ~10x+ decrease
- Smaller spot coverage due to closer satellite location
- Per-satellite bandwidth of ~20Gbps currently (estimated)
- Aggregate bandwidth of ~80Tbps+ across 4,425 satellites

Note: Coverage illustrative only, not to scale

Connection Coverage

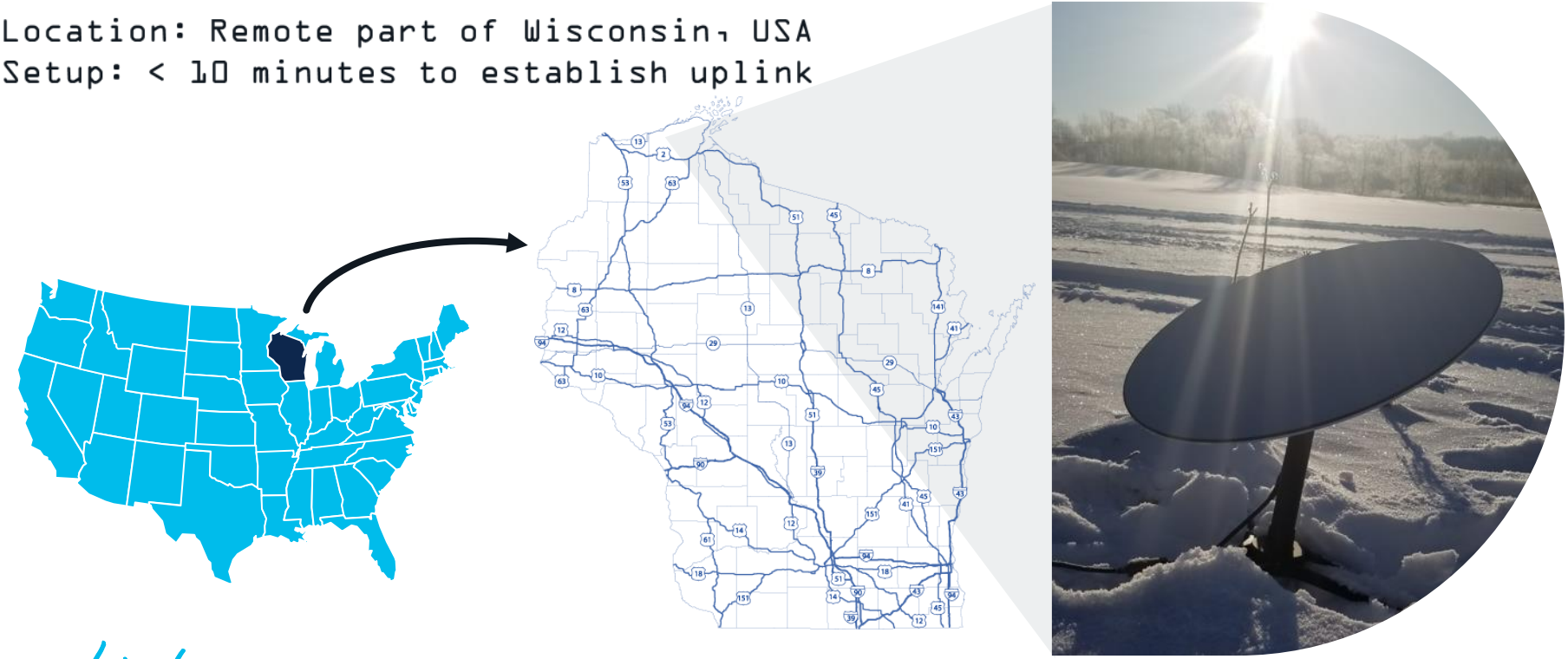
No. of Sats	Connection Time
1	Few minutes per day
10	Every several hours
100	Every 5 to 20 minutes
1500	Continuous



LEOsat View of Satellite Communications

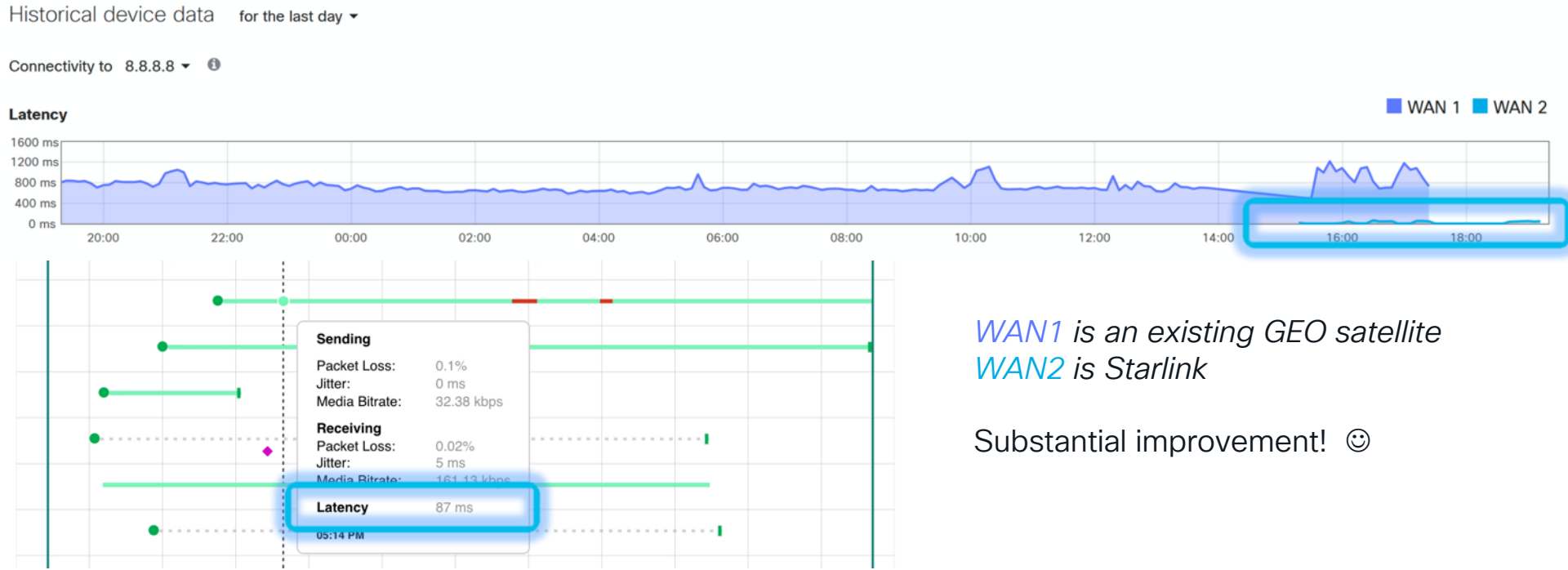
Example of Performance – Real-World

Date: Feb. 2, 2021
Location: Remote part of Wisconsin, USA
Setup: < 10 minutes to establish uplink



LEOsat View of Satellite Communications

Example of Performance – Real-World



WAN1 is an existing GEO satellite
WAN2 is Starlink

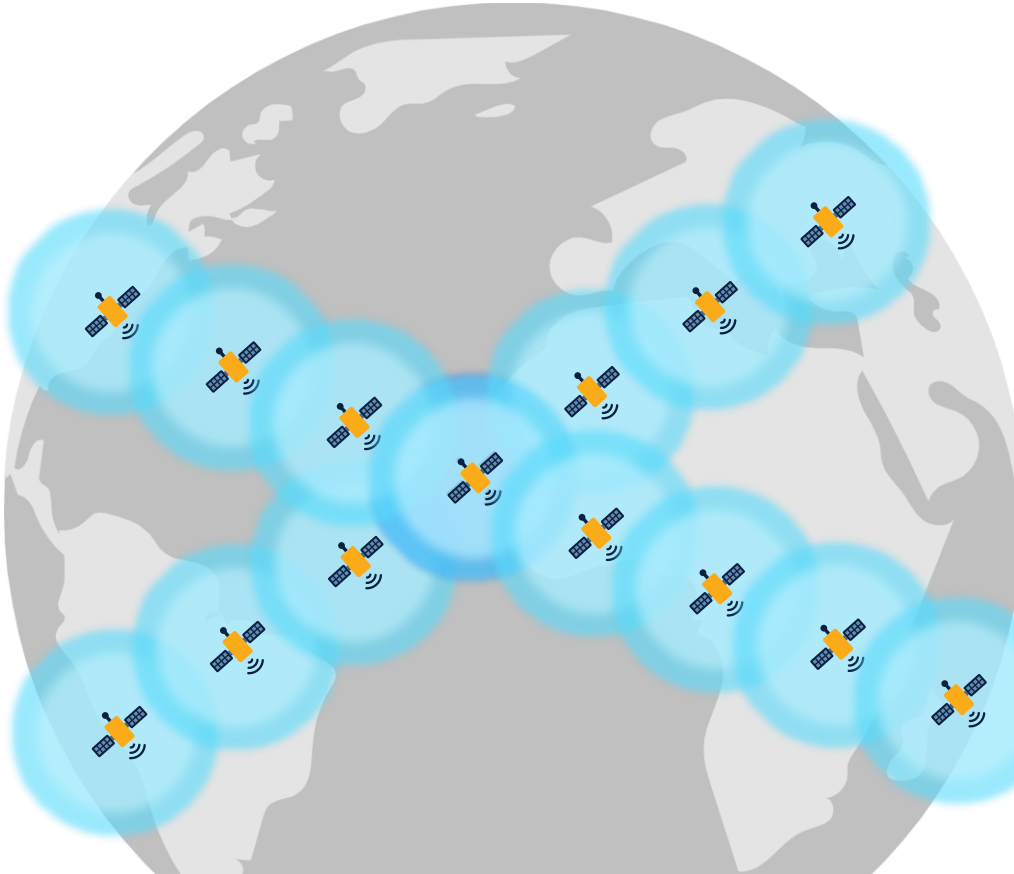
Substantial improvement! ☺

Starlink Operational Details

SpaceX Starlink – Initial Deployment

First launch Feb 22nd, 2018 - Operational since November, 2019

2020 Public Testing	**5289** Satellites in Orbit*	**Available in most locations on Earth**
Ka Band 26.5-40 GHz	**2.2M+** Active Subscribers*	**Ku Band** 12-18 GHz



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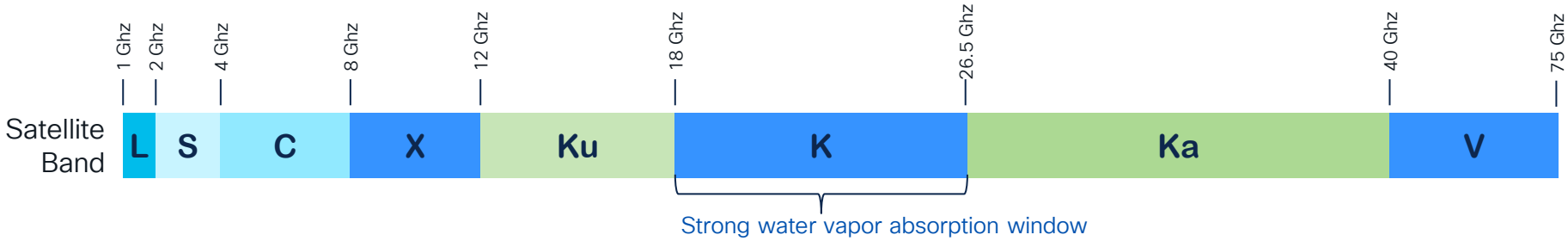
* As of January, 2024

Satellite Bands



Bandwidth

Lower — Higher

Antenna Size

Larger — Smaller

Rain Fade Susceptibility

Less — More

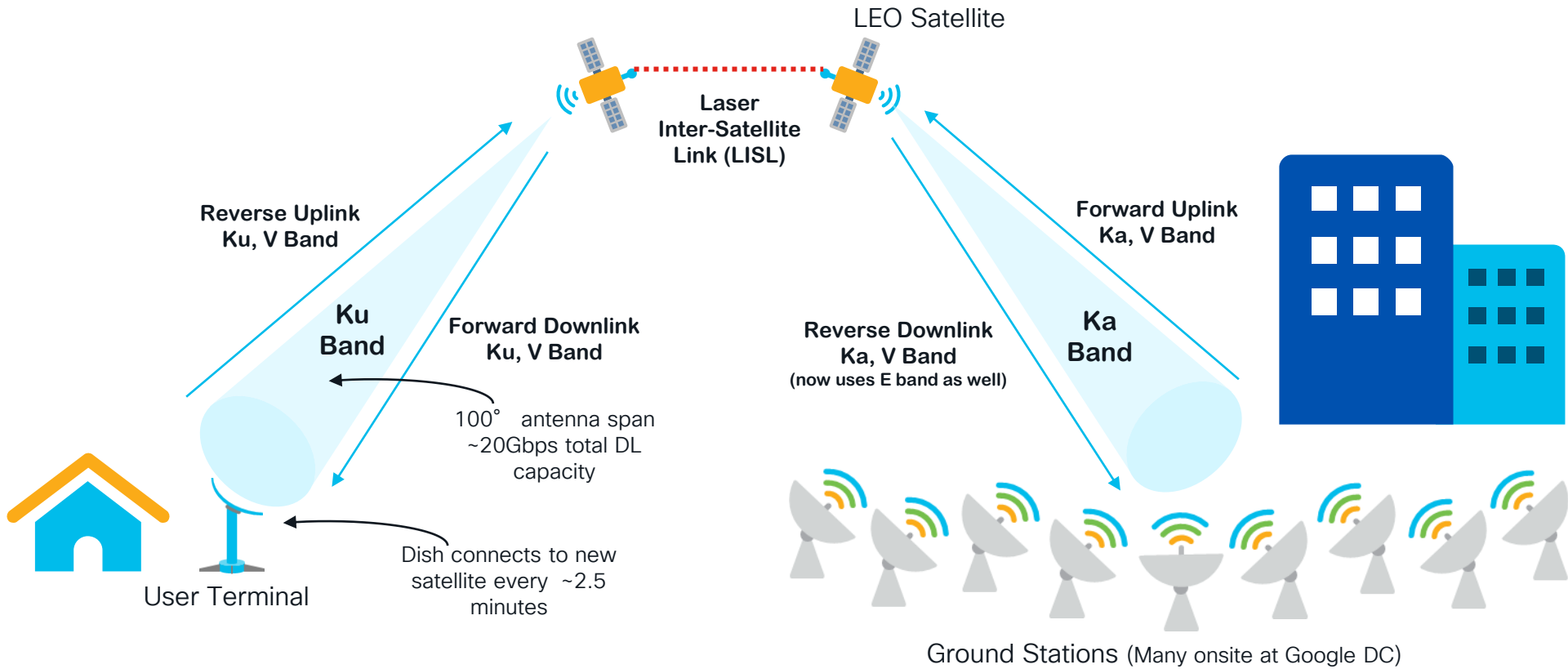
Signal Propagation*

Further — Shorter

Spectrum

Narrower — Wider

Starlink Operational Architecture

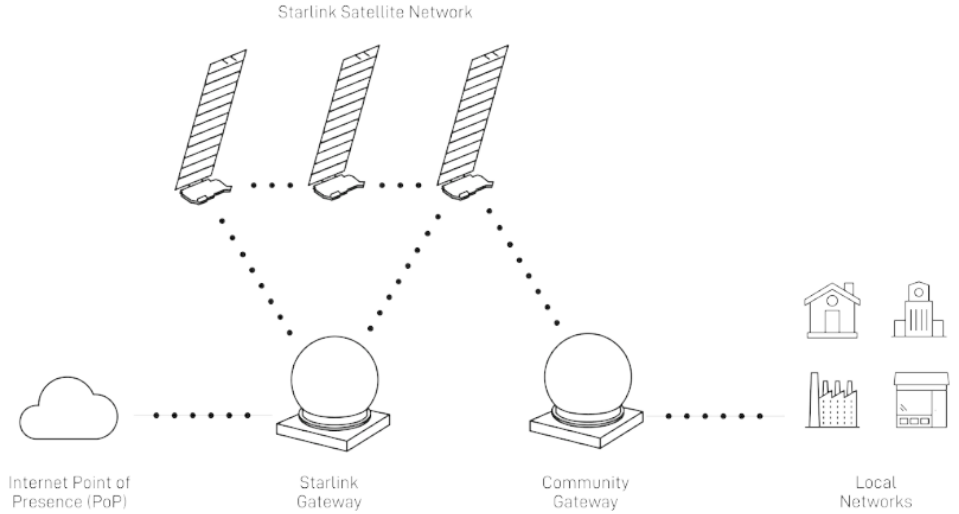


Source: https://www.redorbit.com/spacex-plans-to-reduce-number-of-v-band-starlink-satellites/
Source: https://dgtlinfra.com/elon-musk-starlink-and-satellite-broadband/


TRUCK
TURNING
UBC
B 6233

Ground Stations

https://www.starlinkinternet.info/community-gateway



Starlink Community Gateways

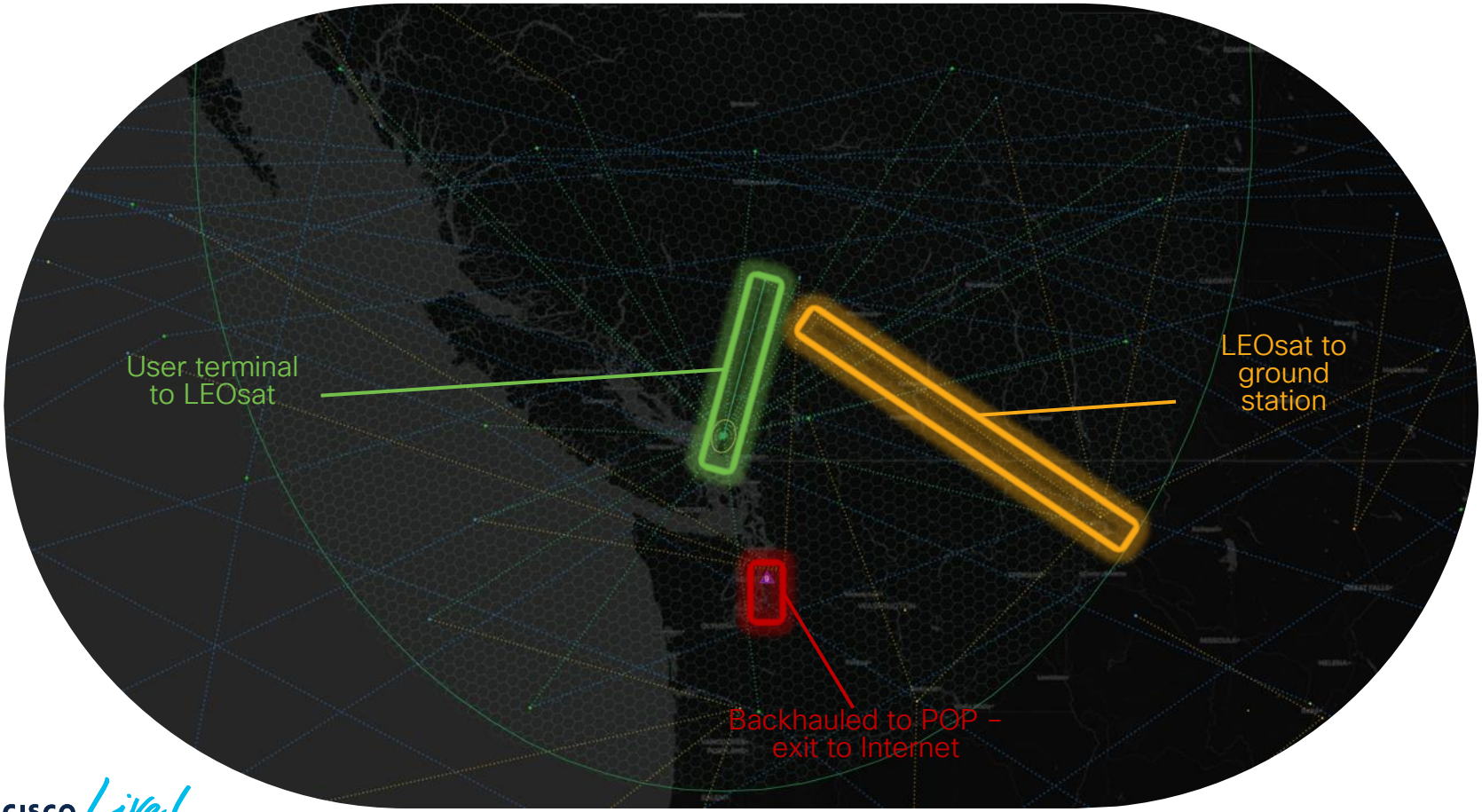
With Community Gateways, Starlink satellites are able to deliver fiber-like speeds with local providers distributing connectivity to homes, businesses, and governments using last-mile fiber, fixed wireless and mobile wireless.

The Community Gateway traffic transits through Starlink's global laser mesh network and utilizes our high bandwidth Gateways operating in a dedicated Ka spectrum band.

Source: https://www.elonx.net/Starlink-compendium/

Photo Credit: Starlink gateways near North Bend (Reddit User: /u/daedalus_j)

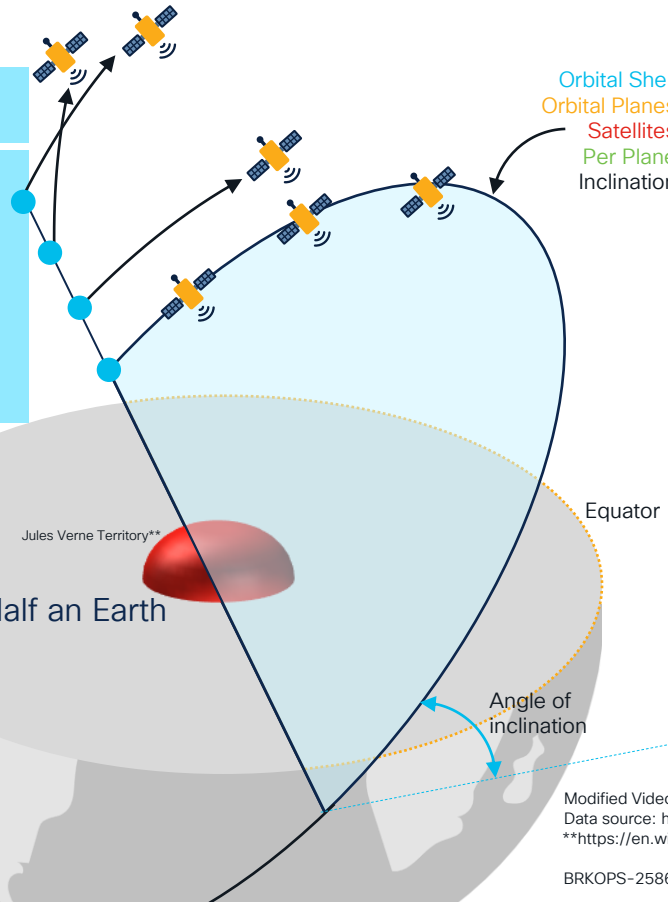
How the LEOsats Move – Example



What's Up There?

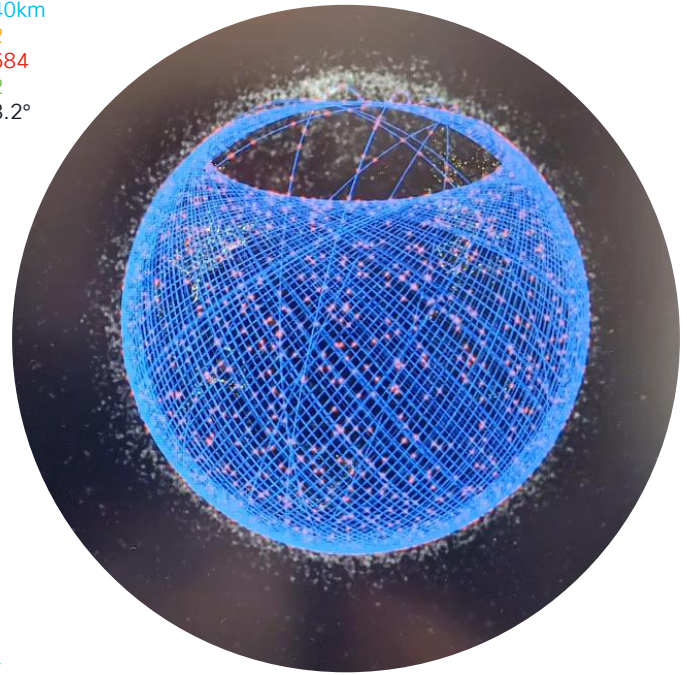
Starlink Phased Deployment

Orbital Shell	Orbital Planes	Sats per Plane	Total
570km 70°	36	20	720
560km 97.6°	6/4	58/43	520
550km 53°	72	22	1584
540km 53.2°	72	22	1584



Starlink Constellation

as of January, 2024 there are 5,200+ satellites in orbit



Modified Video clip: sky.rogue.space
Data source: https://en.wikipedia.org/wiki/Starlink#Constellation_design_and_status
**https://en.wikipedia.org/wiki/Journey_to_the_Center_of_the_Earth

How Often does SpaceX Launch New LEOsats?

SCIENCE • EDITORS' PICK

SpaceX Launches Rocket With 143 Satellites – The Most Ever Flown On A Single Mission

Jonathan O'Callaghan Contributor ⓘ

Jonathan is a freelance space journalist that covers commercial spaceflight, space exploration, and astrophysics

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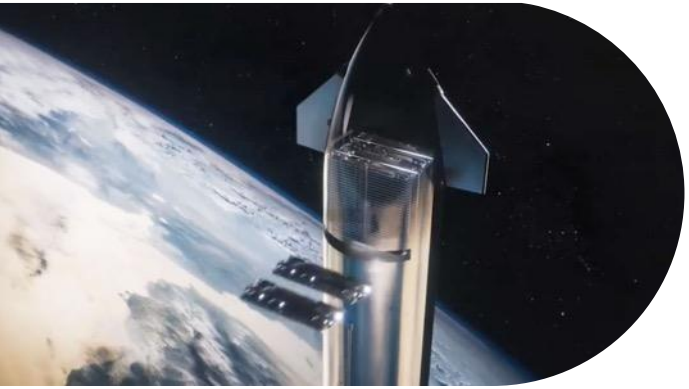
Jan 24, 2021, 10:14am EST

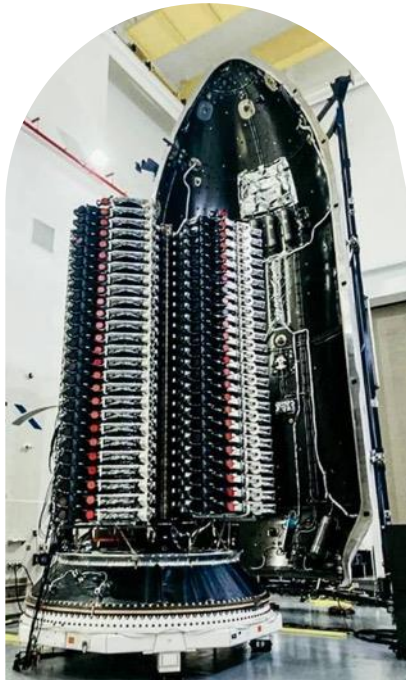
Source: https://www.forbes.com/
Source: Dave's Man Cave

Constantly!

I tune in for a lot of the launches

Starlink Launch Config





60 typically deployed in a single launch

https://en.wikipedia.org/wiki/Starlink#/media/File:Starlink_Mission_(47926144123).jpg
https://www.nasaspaceflight.com/2023/01/Starlink-5-2-launch/

LEOsat Players are Growing

January 15, 2021

ONEWEB SECURES INVESTMENT FROM SOFTBANK AND HUGHES NETWORK SYSTEMS

- *OneWeb has raised $1.4 billion in total financing*
- *SoftBank to take a seat on OneWeb Board of Directors*

London, 15 January, 2021 - OneWeb, the Low Earth Orbit (LEO) satellite communications company jointly owned by the UK Government and Bharti Global, announced today that it has secured additional funding from SoftBank Group Corp. ("SoftBank") and Hughes Netwo Systems LLC ("Hughes"), bringing OneWeb's total funding to $1.4 billion. The capital ra date positions the Company to be fully funded for its first-generation satellite fleet 648 satellites, by the end of 2022.

Amazon marks breakthrough in Project Kuiper development

LEOsat Competitor Space

GeeSpace
240 LEO Planned

Lynk
5110 LEO Planned

Starlink
5,200 LEO Active
(4396 – Phase 1)
(7518 – Phase 2)
~12000 in total by 2027

OneWeb
634 LEO Active
(as of May, 2023)

AST SpaceMobile
170 LEO Planned

TeleSat
15 GEO Active

VIASat
4 GEO Active

Iridium Certus
75 LEO Active

AMAZON Kuiper
3236 LEO planned

Source:
https://interestingengineering.com/innovation/Starlink-here-are-6-of-spacexs-biggest-rivals-for-satellite-internet-dominance

6300
rocket launches since 1957

14450
satellites launched

32160
debris regularly tracked

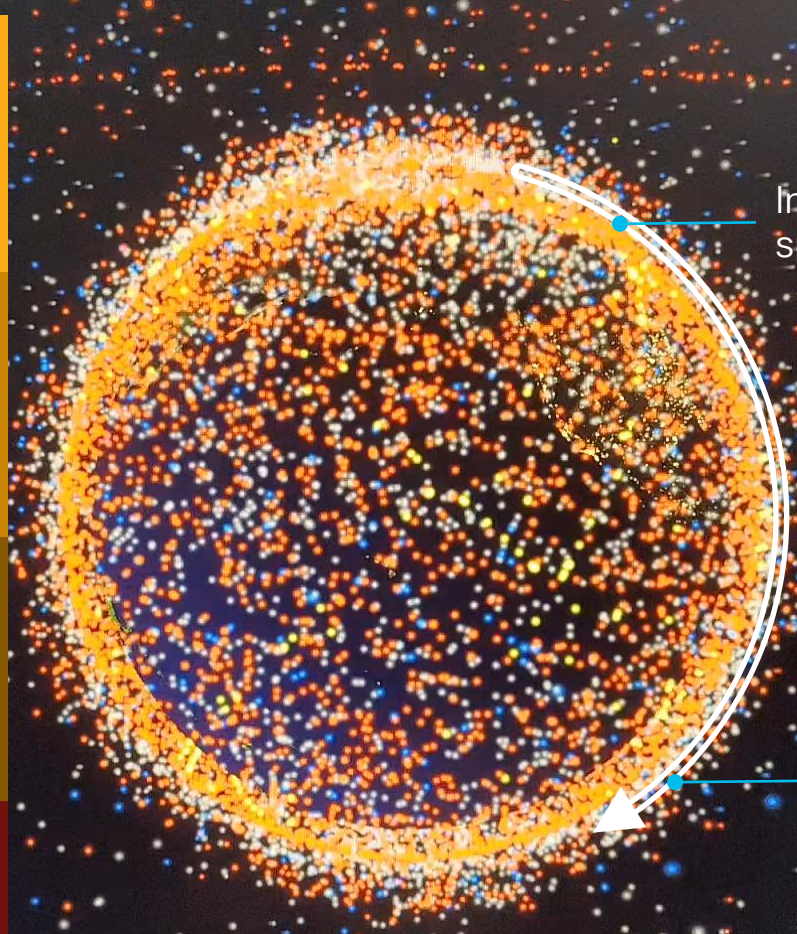
9610
Satellites still in space

630
collisions resulting in further debris

6800
satellites still functioning

10400
tonnes of debris

https://www.esa.int/Space_Safety/Space_Debris/Space_debris_by_the_numbers



In a 400km Orbit,
space junk lasts 1 year

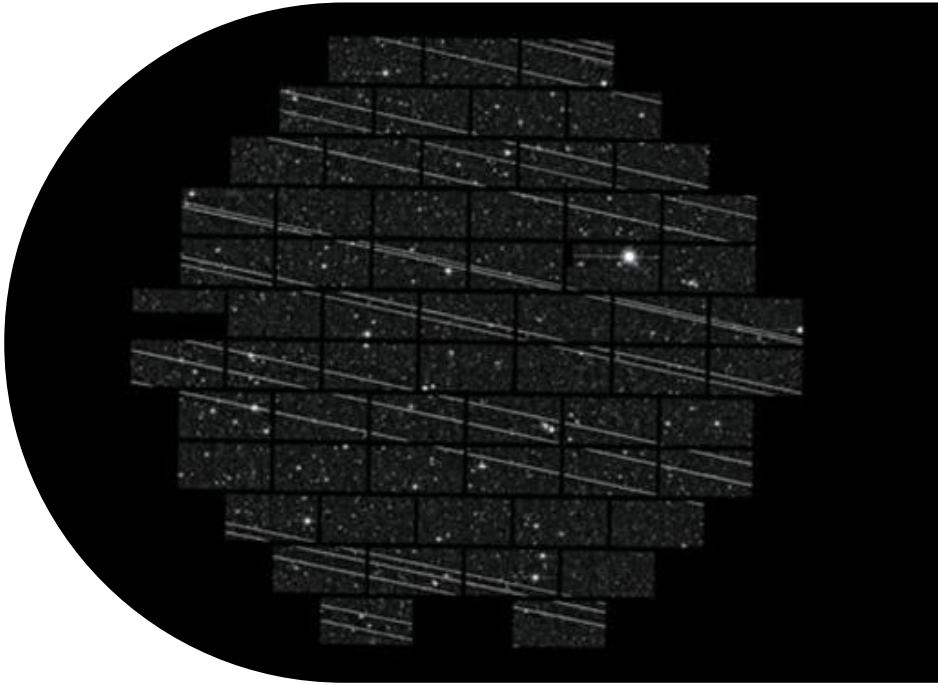
In a 650km Orbit,
space junk lasts 25 years!

There's A Lot Of Junk Up There!

Modified Video clip: sky.rogue.space

Astronomer's Issue – Sky Clog

NATIONAL OPTICAL-INFRARED ASTRONOMY RESEARCH LAB/NSF

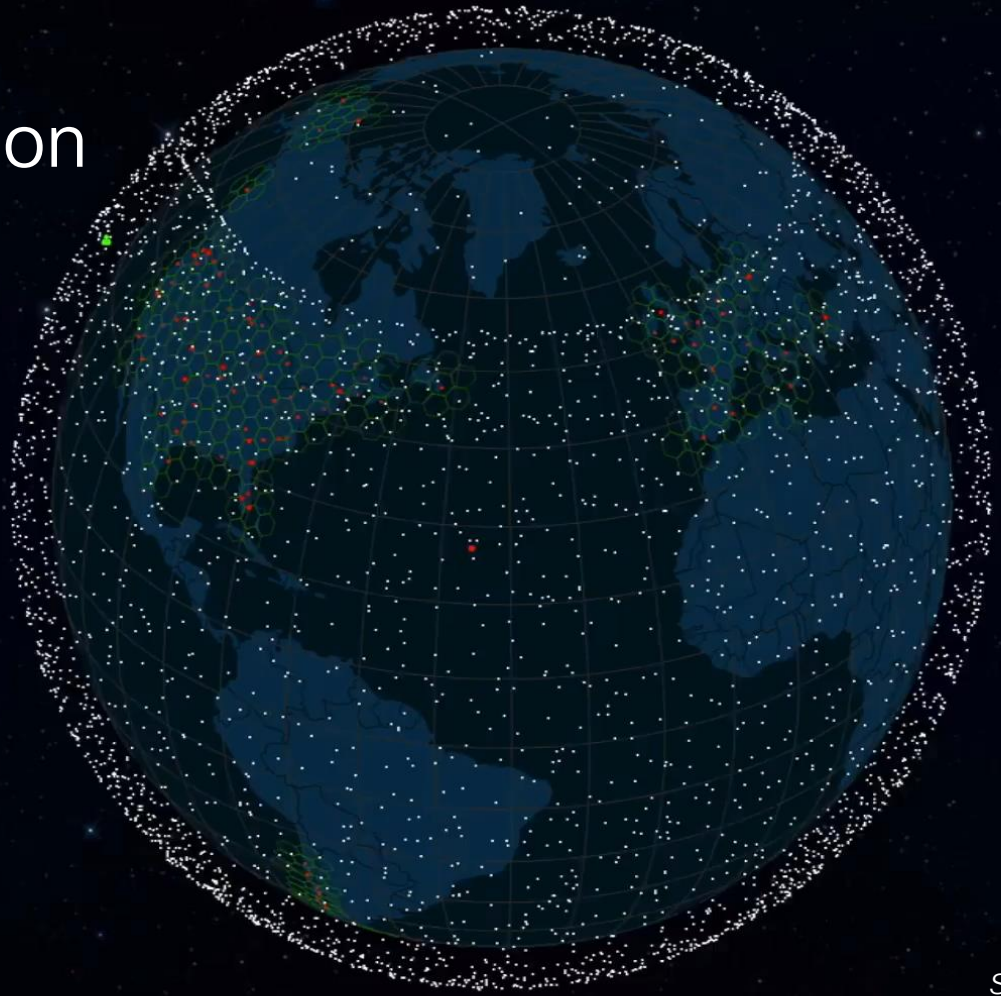


DELVE SURVEY, CTIO/AURA AND NS

Example of Starlink satellites leaving 19 trails of light on a telescope image

https://www.sciencenews.org/article/Starlink-spacex-satellites-amazon-oneweb-global-internet-astronomy

Starlink Constellation



Source: satellitemap.space

Constellation Dynamics

Dan

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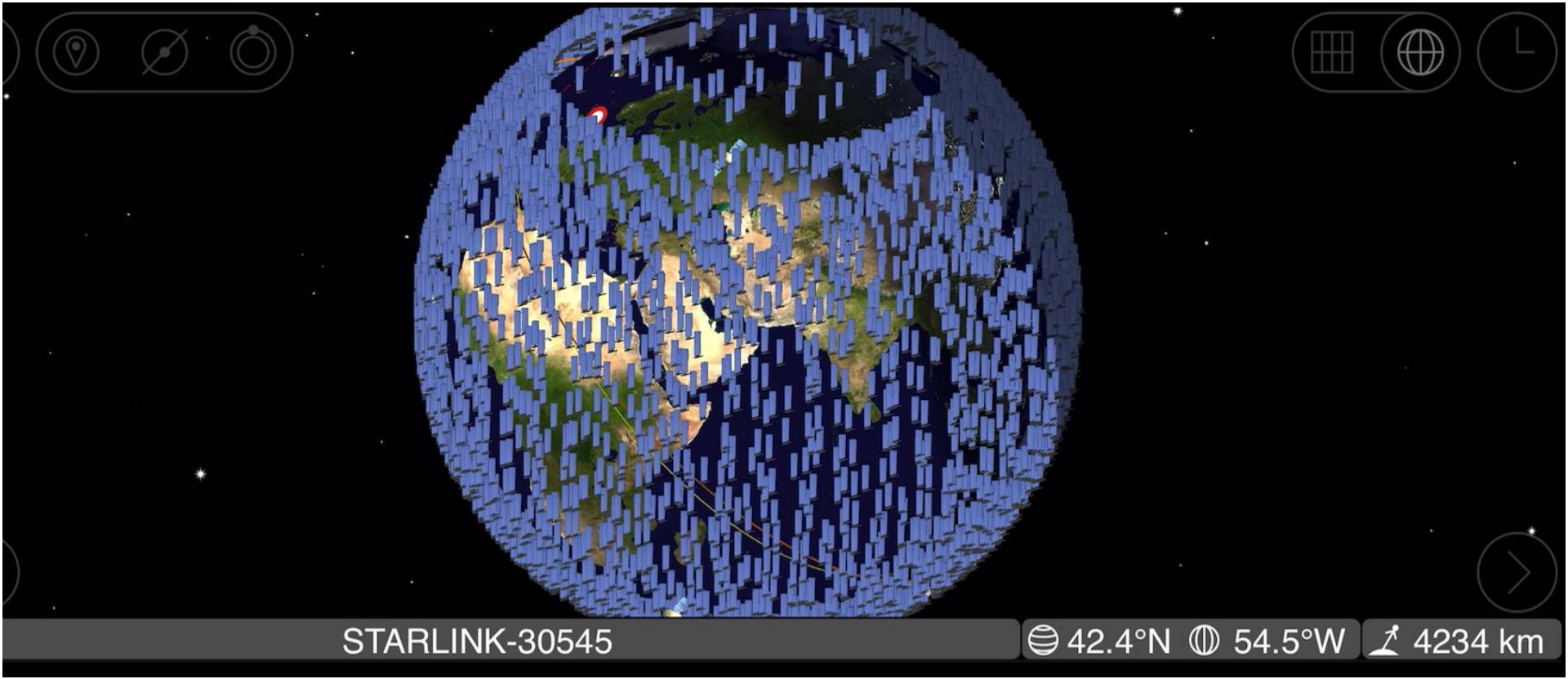
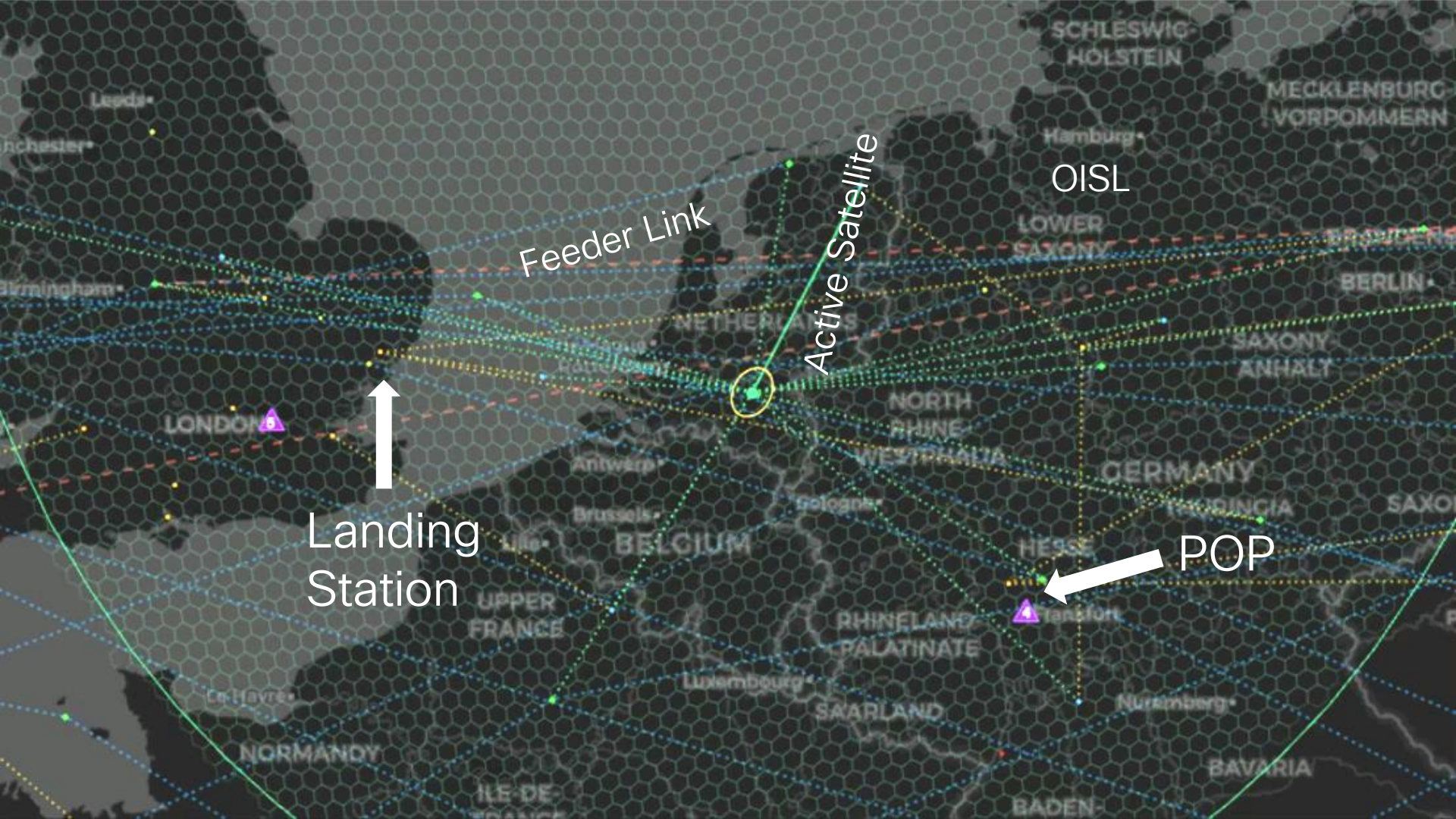
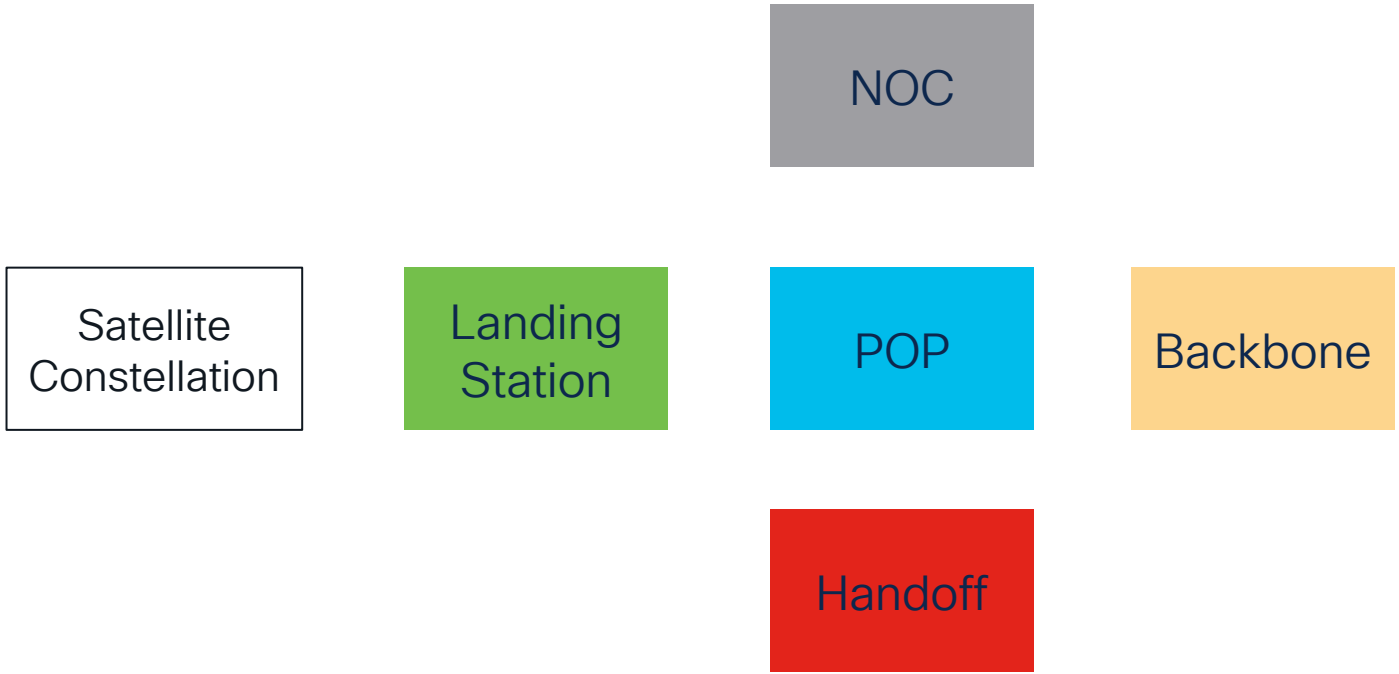


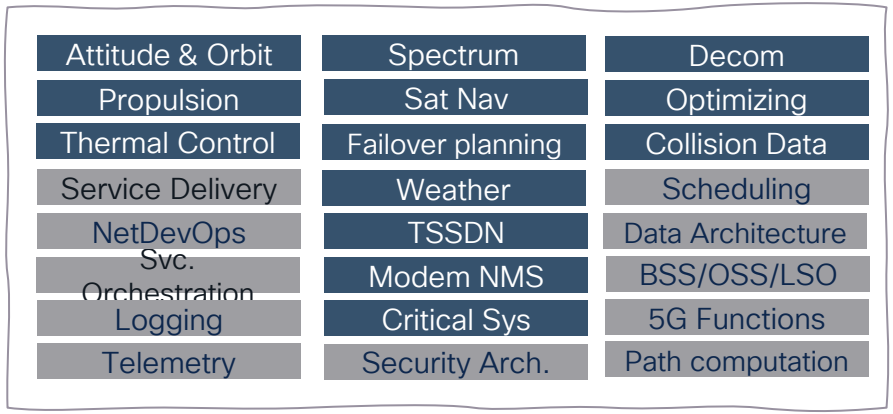
Circular Orbits | Polar & Inclined | 12-16 turns/day | 7-12 mins/handover


Feeder Link
Active Satellite
OISL
Landing Station
POP
SCHLESWIG-HOLSTEIN
MECKLENBURG-VORPOMMERN
Hamburg
LOWER SAXONY
BERLIN
SAXONY-ANHALT
NETHERLANDS
NORTH RHINE-WESTPHALIA
GERMANY
LONDON
Antwerp
Brussels
BELGIUM
HESSE
Frankfurt
UPPER FRANCE
RHINELAND-PALATINATE
Luxembourg
SAARLAND
Nuremberg
Le Havre
NORMANDY
BAVARIA
ILE-DE-FRANCE
BADEN-

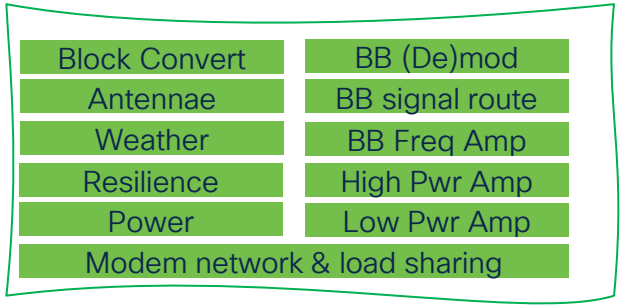
Architecture



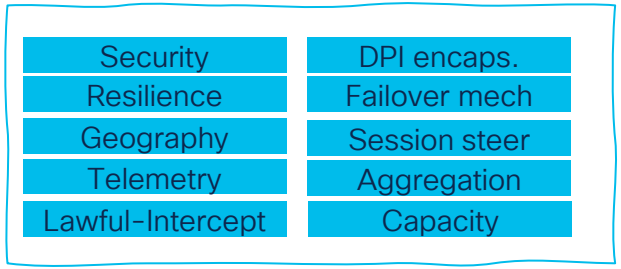
Architecture

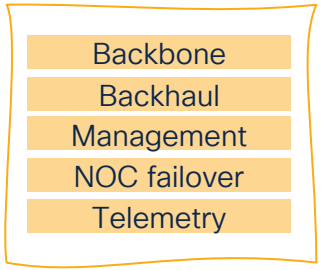


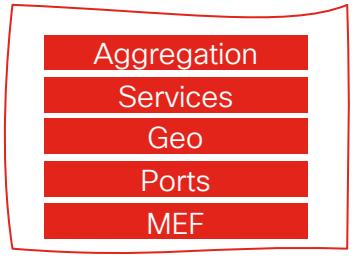
Consider:
- Individual path tracking and adjustments
- Space environment mgmt.
- POP/LS failover
- Multi-layer mgmt. and orch. dependencies
- Central SLA assurance and reporting



Consider:
- Atmospheric depolarization
- Radome, weather, maritime skew
- Power chain
- Satellite handoff







Consider:
- Service assurance & aggregation
- In-band measurements?
- High rate-of-change to global network path routing
- Leverage time-boxed satellite movement

Consider:
- Out-of-band management
- Leverage Internet connectivity
- Careful capacity constraints for critical management traffic
- Backhaul requirements in failure scenarios

Consider usual telco interconnection stuff.
SLA on newer constellations.

Segment Routing Suitability

- No path signalling – dynamic source routing
- External path computation
- Granular traffic control
- Lightweight (SWaP)

The Life of a Packet – 5G NTN Example Network

UT	Satellite 2 + gNodeB DU/RU		Satellite 1		Feeder Link		PE		gNodeB CU		UPF		Application
PDU	PDU	PDU	PDU	PDU	PDU	PDU	PDU	PDU	PDU	PDU	PDU	PDU	PDU
SDAP	SDAP	SDAP	SDAP	SDAP	SDAP	SDAP	SDAP	SDAP	SDAP	GTP-U	GTP-U	ETH	ETH
PDCP	PDCP	PDCP	PDCP	PDCP	PDCP	PDCP	PDCP	PDCP	PDCP	UDP	UDP	L1	L1
GTP-U	GTP-U	GTP-U	GTP-U	GTP-U	GTP-U	GTP-U	GTP-U	GTP-U	GTP-U	IP	IP		
RLC	RLC	UDP	UDP	UDP	UDP	UDP	UDP	UDP	UDP	ETH	ETH		
MAC	MAC	IP	IP	IP	IP	IP	IP	IP	IP	L1	L1		
5G PHY	5G PHY	ETH	ETH	ETH	ETH	ETH	ETH	ETH	ETH				
		SR SVC	SR SVC	SR SVC	SR SVC	SR SVC	SR SVC	IP	ETH				
		SR LSP	SR LSP	SR LSP	SR LSP	SR LSP	SR LSP		L1				
		ETH	ETH	ETH	ETH	ETH	ETH						
		OPT PHY	OPT PHY	GSE	GSE	L1	L1						
				DVB-S2	DVB-S2								






Phased Array Antennas

Ian

Basic Antennas

A basic antenna will transmit the same power in all directions

Phased Array Antennas – Multiple Elements

Phased array antennas can contains 100s of antenna elements.

As the waves travel outward from the antennas
they constructively and destructively interfere with each other

https://www.ruaviation.com/news/2016/1/14/4629/?h

Phased Array Antennas – Narrow Beam

Phased array antennas can contains 100s of antenna elements.

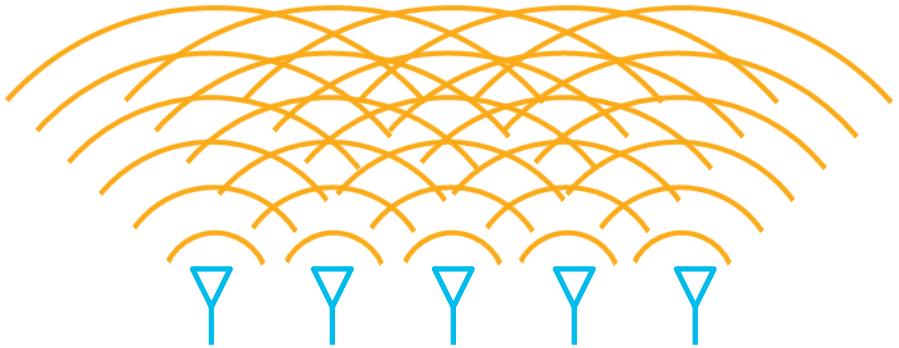
Through software we can concentrate the beam in one specific direction and cancel out in all other directions

The result is a single composite antenna with a very narrow beam perpendicular to the antenna

Phased Array Antennas – Controlling Direction

Phased array antennas can contains 100s of antenna elements.

By adding a slight delay to each signal



Phased Array Antennas – Controlling Direction

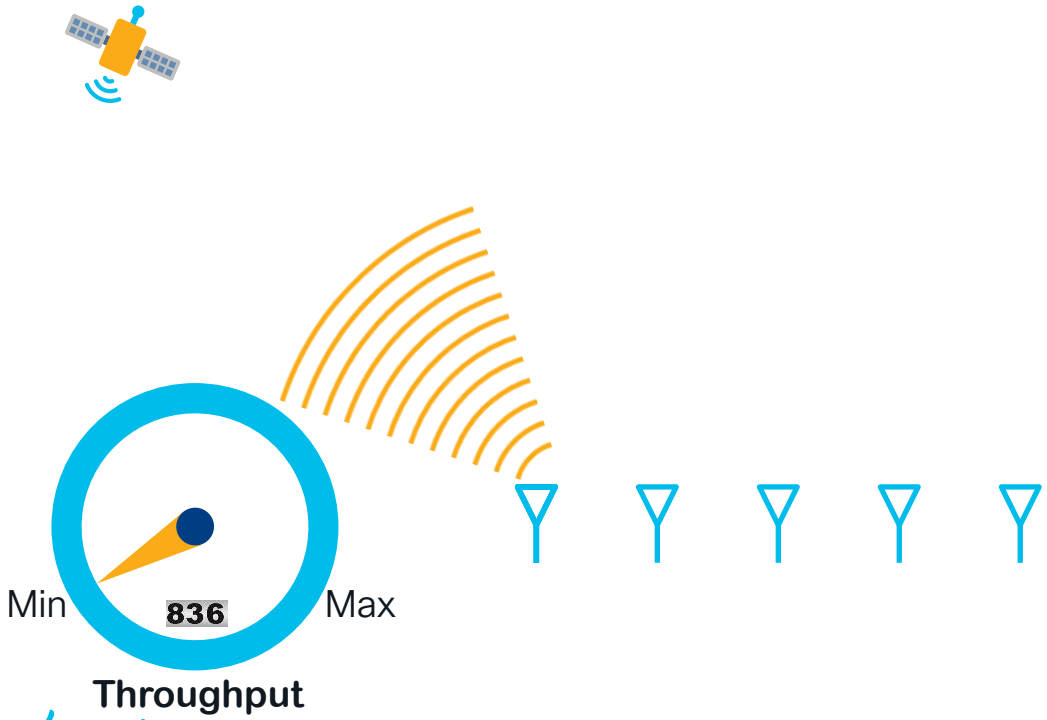
Phased array antennas can contains 100s of antenna elements.

We can change the direction of the beam
to optimally follow the path of the LEO Sat

The result is a single composite antenna with a very narrow beam
perpendicular to the antenna

Phased Array Antennas – Throughput

Throughput will vary whilst connecting and as the LEOsat moves across the sky



For illustrative purposes only.

Starlink Phased Array Antennas

	GEN 1 User Terminal	GEN 2 User Terminal
Size	D58.9cm	50cm x 30cm
Weight	7.3kg	4.2kg
Height	64.5cm	61cm
Op. Temp	-30℃ to +50℃	-30℃ to +50℃
Power	PoE	PoE
Outdoor	IP54 (Modem indoor only)	IP54 (Modem outdoor)
Heating	Integrated	Integrated
WiFi Modem	2 x MU-MIMO	3 x MU-MIMO
Ethernet Port	Onboard dish	Requires adaptor
Price	USD599 + USD90-120pm	USD599 + USD90-120pm

Cat Butt Attenuation

(Different to dBi – Dog Butt Interference)

https://soyacincau.com/2022/01/10/cats-are-very-fond-of-the-self-heating-Starlink-satellite-dish-by-spacex-and-its-a-big-problem/

... and more antenna options for mobile applications ...

... plus

Starlink Business

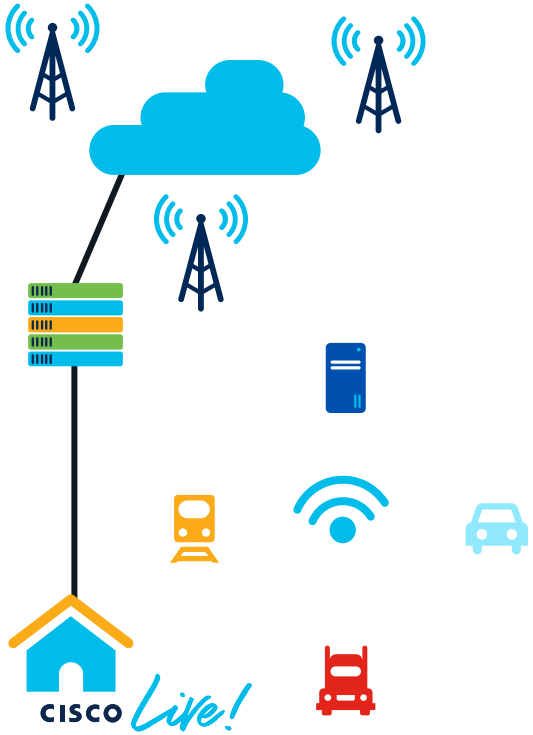
(higher speed, lower latency)

Mobility Support

Mobility

Traditional

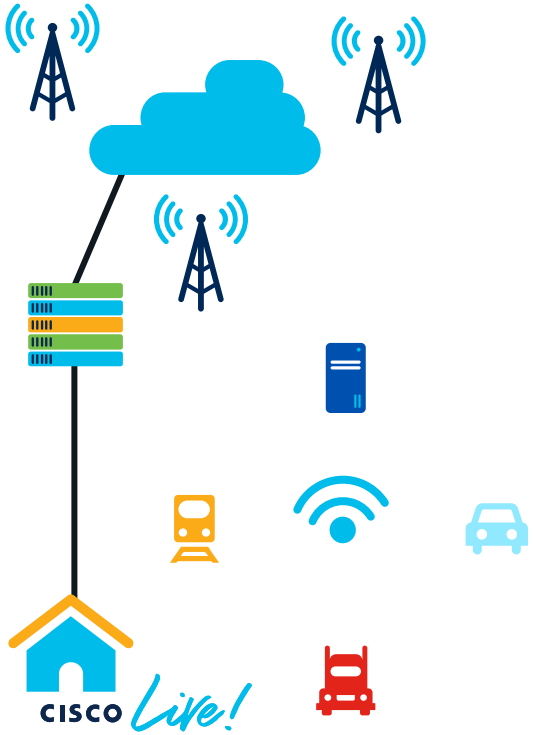
Network stationary
UE stationary/mobile



Mobility

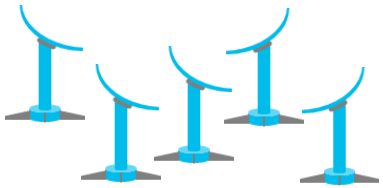
Traditional

Network stationary
UE stationary/mobile



LEO

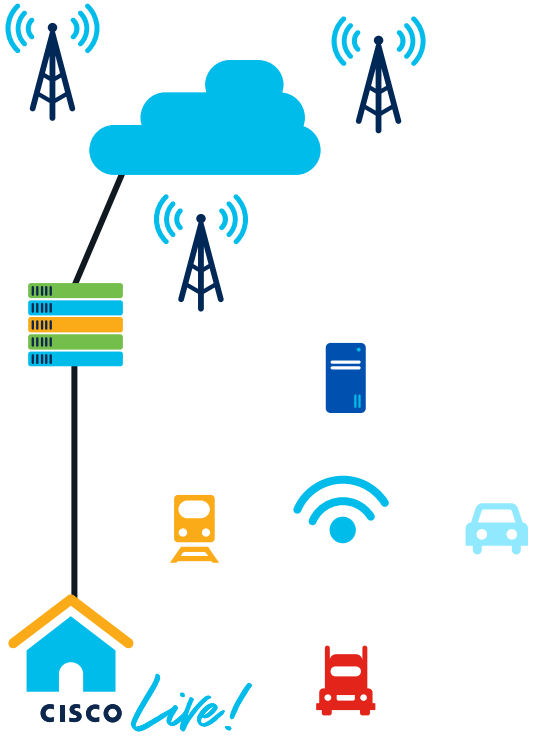
Network mobile
UE stationary



Mobility

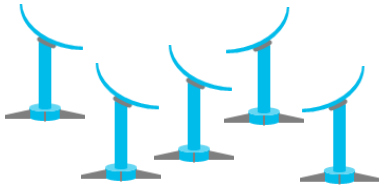
Traditional

Network stationary
UE stationary/mobile



LEO

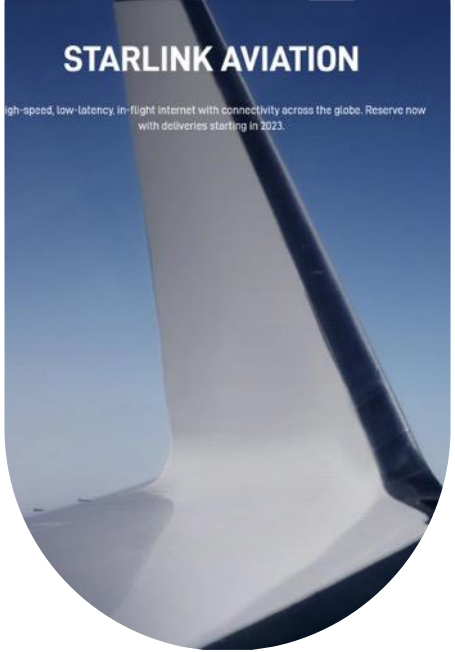
Network mobile
UE stationary



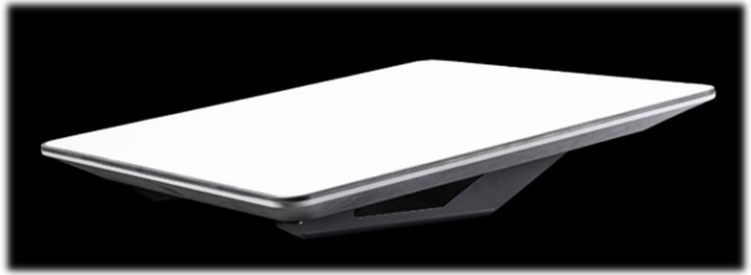
LEO Mobility

Network mobile
UE mobile

Starlink Mobility Offerings



Flat High-Performance antenna



Bad idea

Roaming (Cell-phone) Mobility via LEOsats

Existing phones and mobile networks are set up to accommodate bullet train speeds not orbital velocities

LYNK

320 km/h

V

7.8 km/s

AST SpaceMobile

Technology Enhancements To Support Direct Handset Connectivity	
Doppler Shift	Doppler compensation allows for a phone to see LEO as a fixed tower
Software Defined Radios	Allows for frequency hopping to connect various licenced spectrums
Larger LEO antennas	Allows communication with low-power, low-signal-strength phones
Cell Timing	Mobile phones require highly accurate timing

No changes to existing cell phones

Larger Antenna & More Power – Cell Phones

https://ast-science.com/

AST Spacemobile
400sqm (Planned)
Several 1000kgs

Starlink Gen2
25sqm
1250Kgs

Lynk
4sqm

A Marriage Made In Low Earth Orbit

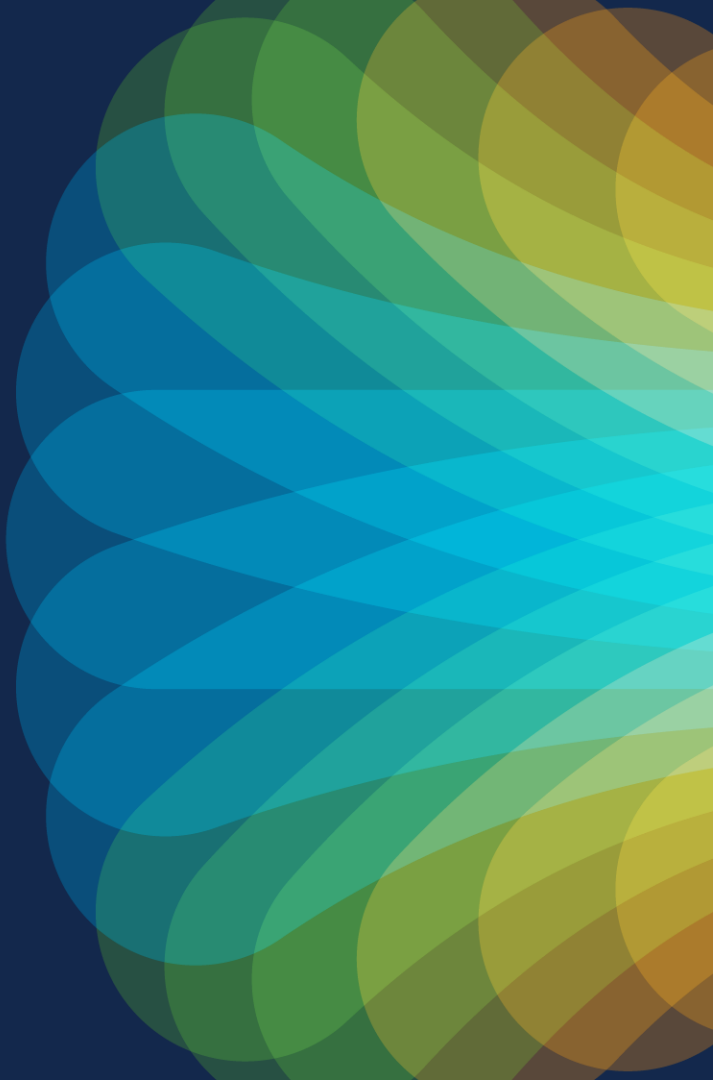
Many partnerships are being formed

Many MNO

Many MNO

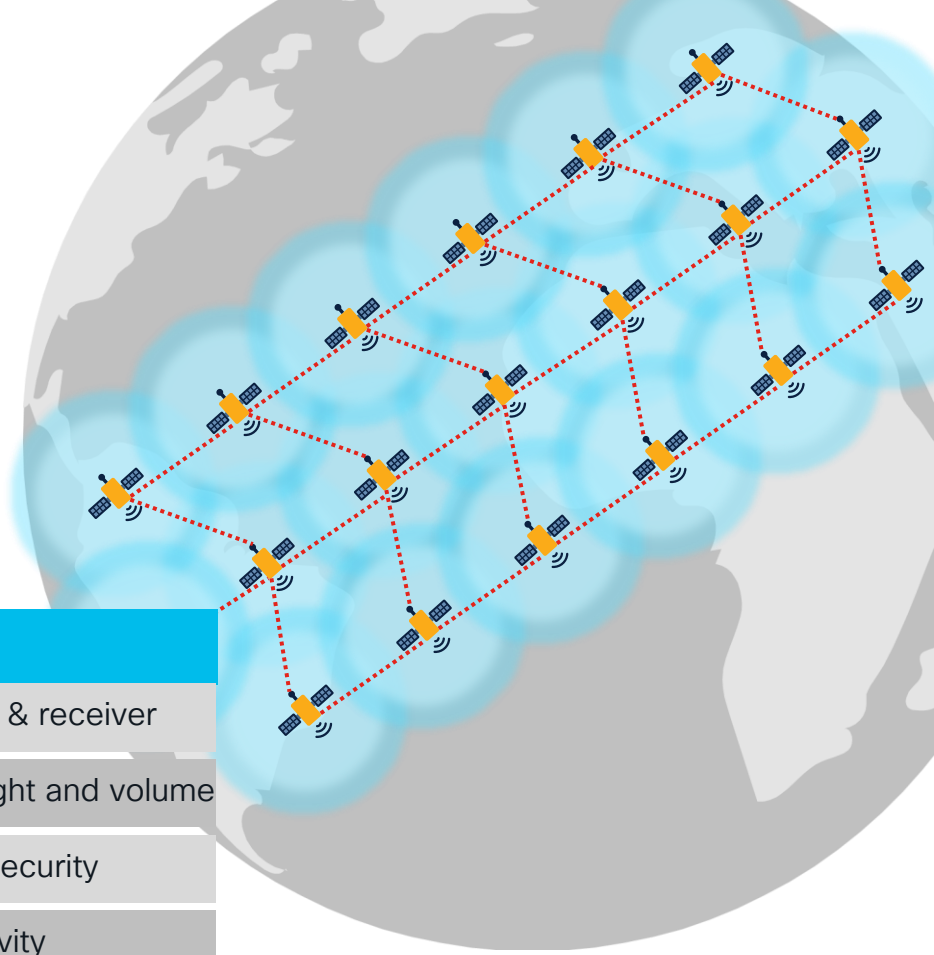
Initial offers are texting services and low bw broadband

Laser Inter-Satellite Links



Laser Inter-Satellite Links

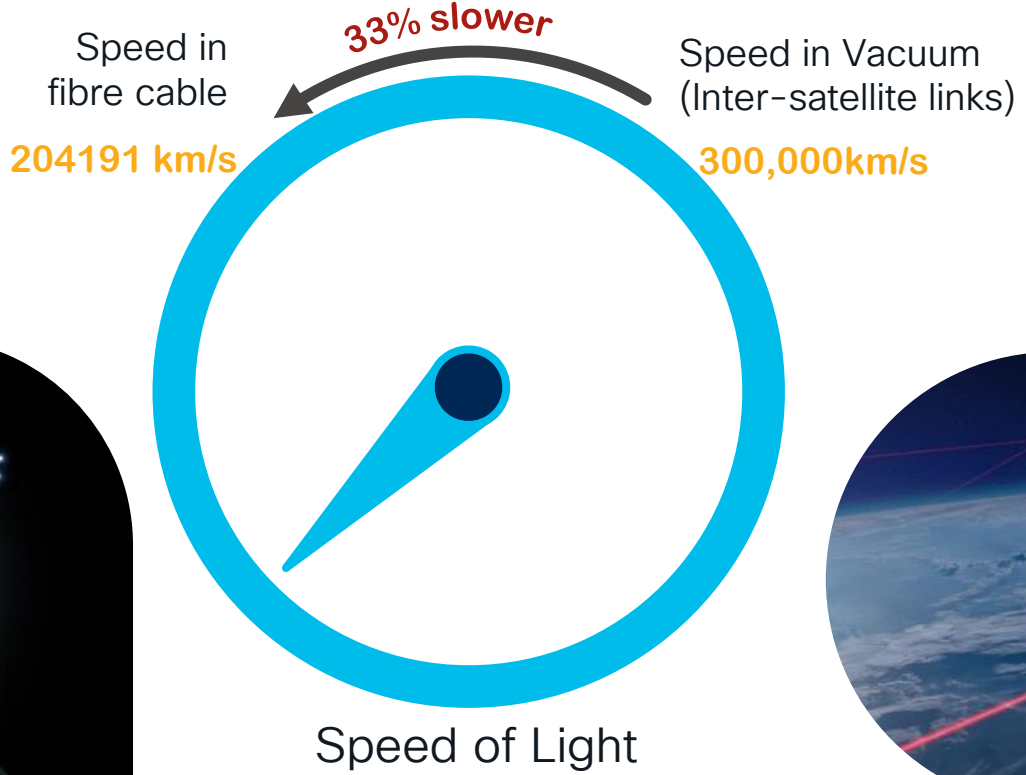
Signals in FREE SPACE
REDUCE LATENCY



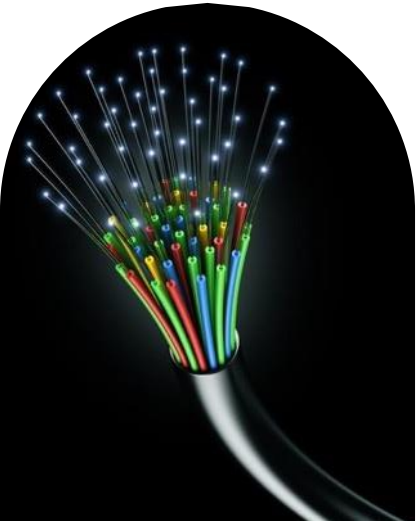
Advantages of Laser over RF	
Higher Capacity	Up to 10 Gb/s between one laser transmitter & receiver
Antenna Size	Smaller antenna sizes, resulting in lower weight and volume
Narrow Beam	Eliminates interference and provides higher security
Low TX Power	Due to lower beam spread and higher directivity

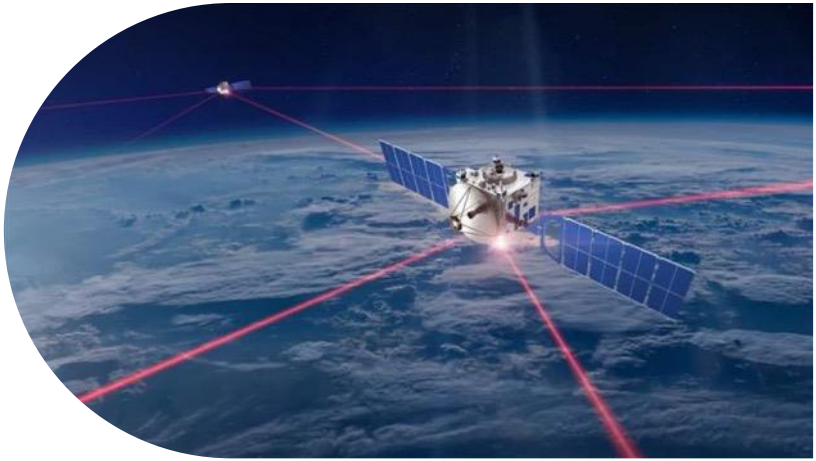
Note: Coverage illustrative only, not to scale

Free Space and the Speed of Light

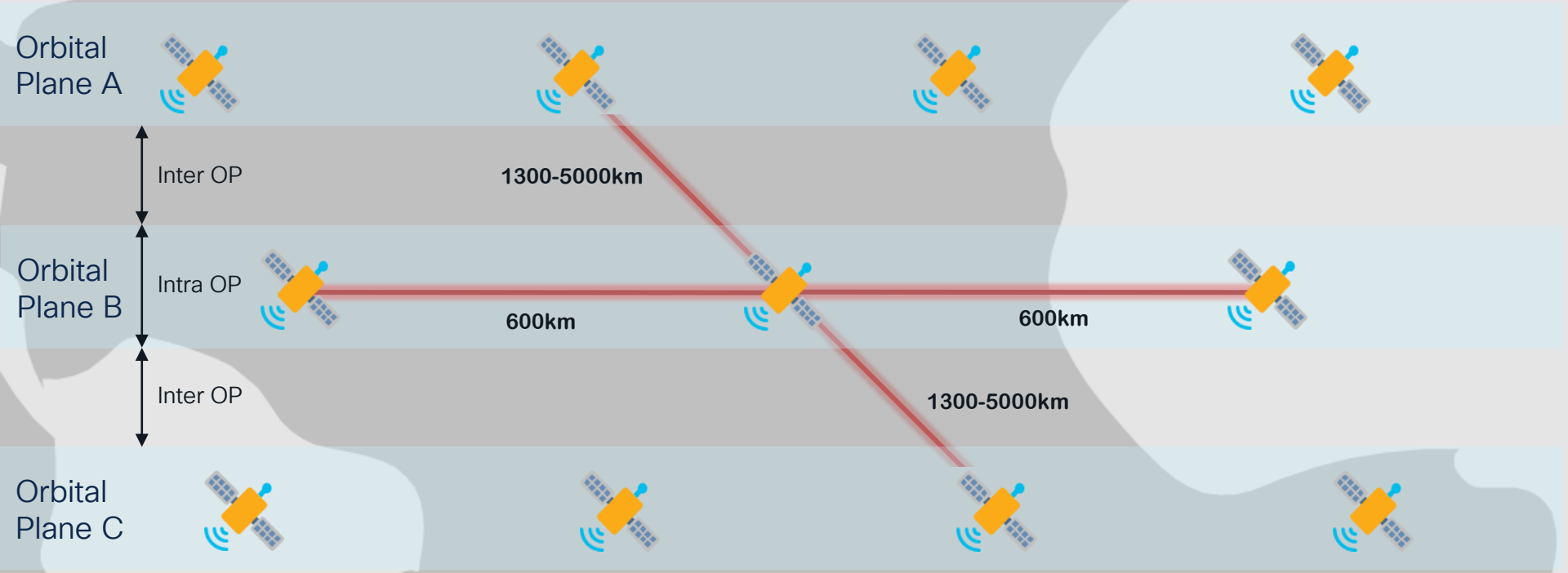


Index of Refraction (Ratio of Speed of Light)	
Vacuum	1
Air	1.003
Fibre	1.4682





Starlink Laser Inter-Satellite Links



Mesh routing in space

https://arxiv.org/abs/2103.00056

Starlink Laser Inter-Satellite Links – Fun Facts!

9000 Space lasers deployed

5.6Tbps+ peak throughput

Delivering 42 PETABYTES
of customer data a day (42 million gigabytes)

Laser Link Highlights

Longest link distance	5400 km
Number of acquisitions per day	266,141
Longest link duration	Weeks
Max. data rate	200Gbps
Fastest acquisition	12 seconds
Min. altitude link	122km <<< maintained while de-orbiting a satellite! ☺

Source: PCMag, https://uk.pcmag.com/networking/150673/starlinks-laser-system-is-beaming-42-million-gb-of-data-per-day

Real World Deployments

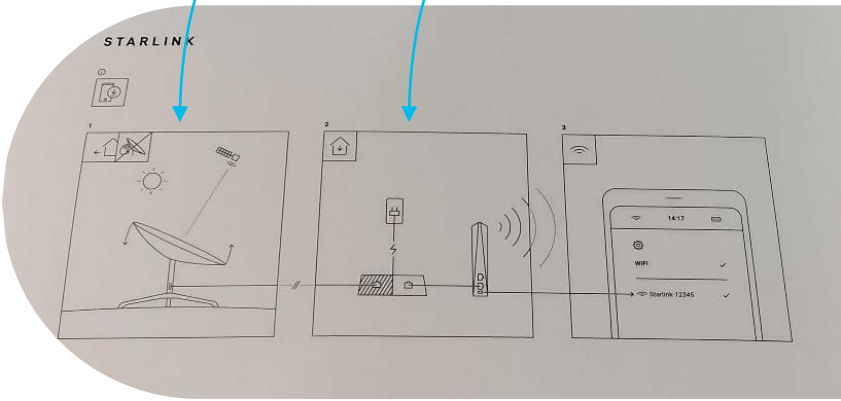
Dave Zacks	Dave's Deployment & SD-WAN Demo
Oli Boehmer	Residential Experience
Ian Procyk	Starlink in Construction, Disaster Response
Oli Boehmer	LEOsat Programmability

Dave

Dave's Deployment

Dave’s Deployment @ Home

“Point at sky” “Turn on power”



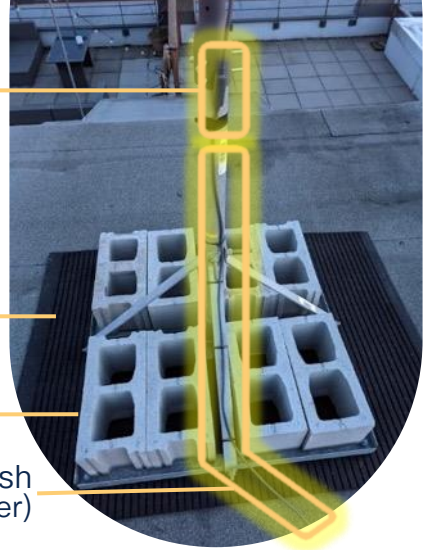
Installation Instructions

Dave's Deployment @ Home

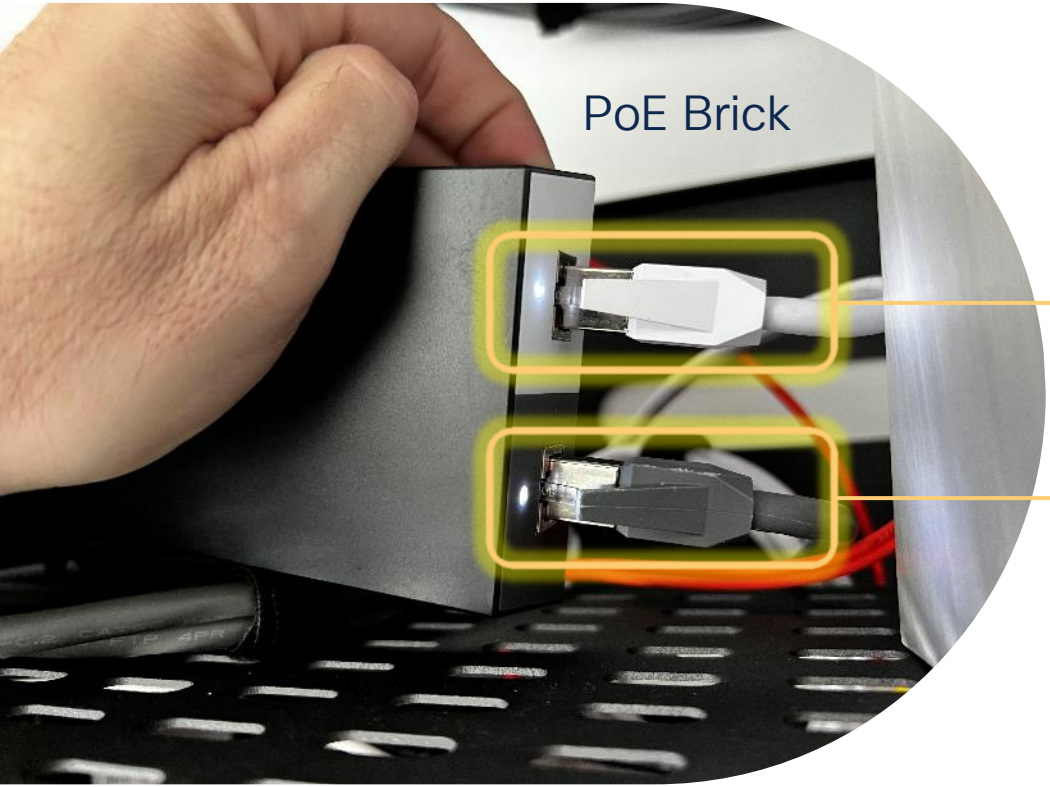
Of course, there is always more to it than that …

Finished the initial installation as night fell in Vancouver, BC …

3D view from roof



Dave’s Deployment @ Home



White cable – Connection to router (Starlink’s, or your own)

Grey cable – PoE to dish

Dave's Deployment @ Home

Large spool of PoE cable to antenna (Gen 1 dish, hardwired)

To the firewall

... via fibre (using media converter)

To antenna via PoE brick

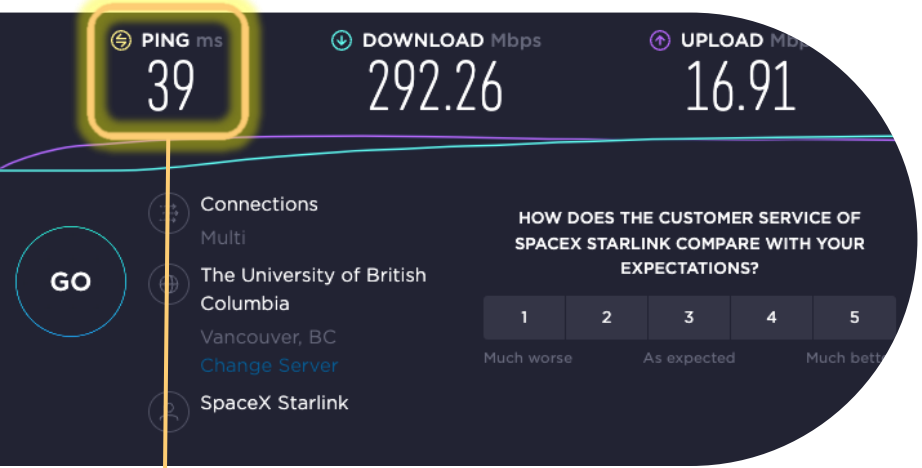
Dave's Deployment @ Home

Powering my home office ☺

I have Gigabit via cable, with Starlink as my secondary / failover / load-share link. But I can make it my primary uplink anytime I want to play. ☺

And I use Starlink as my primary uplink for many of my security camera feeds …

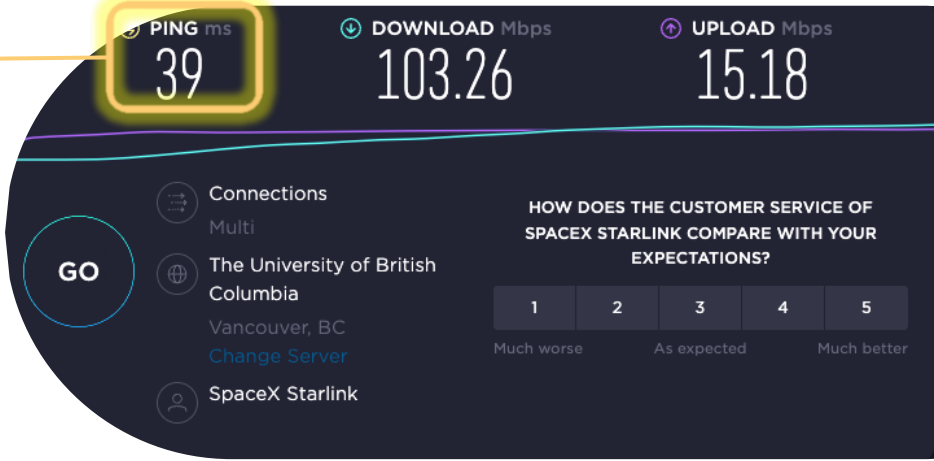
Dave's Deployment @ Home



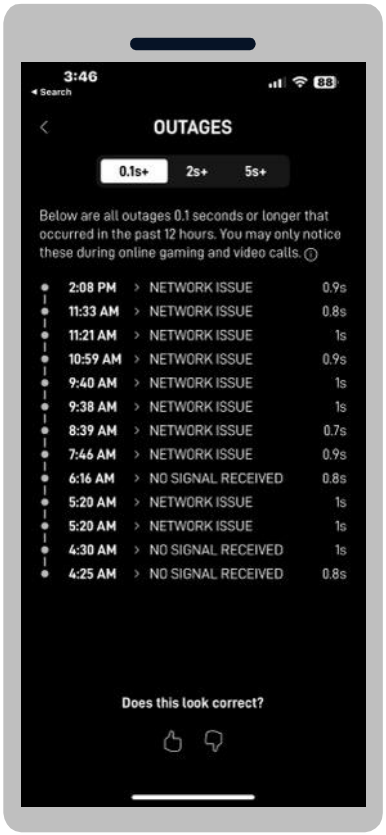
Typical max speeds I would see ...

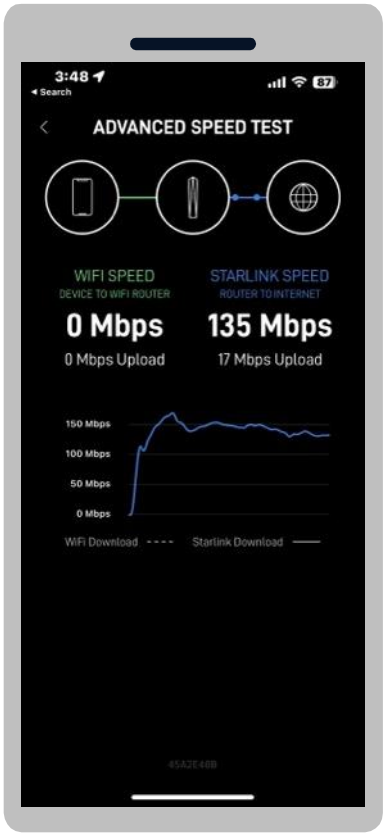
Low latency

Average speeds



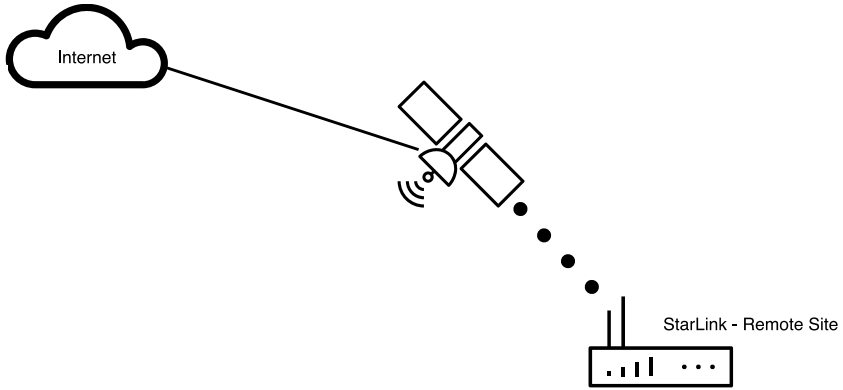
Starlink App



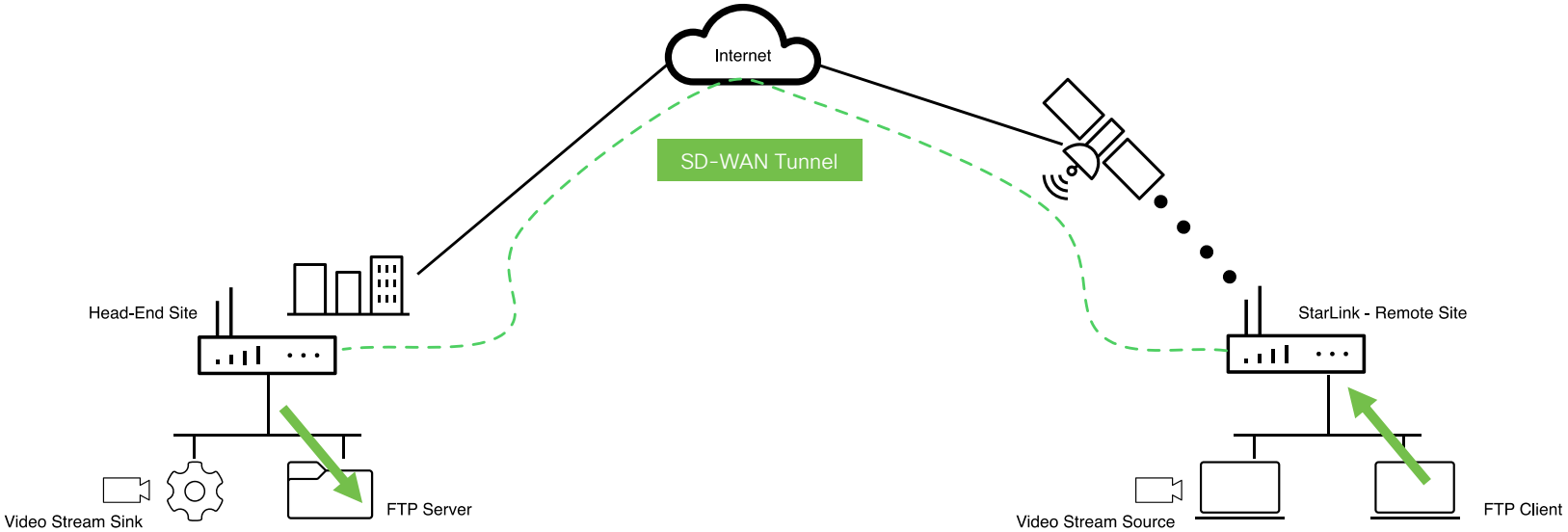


SD-WAN and Starlink

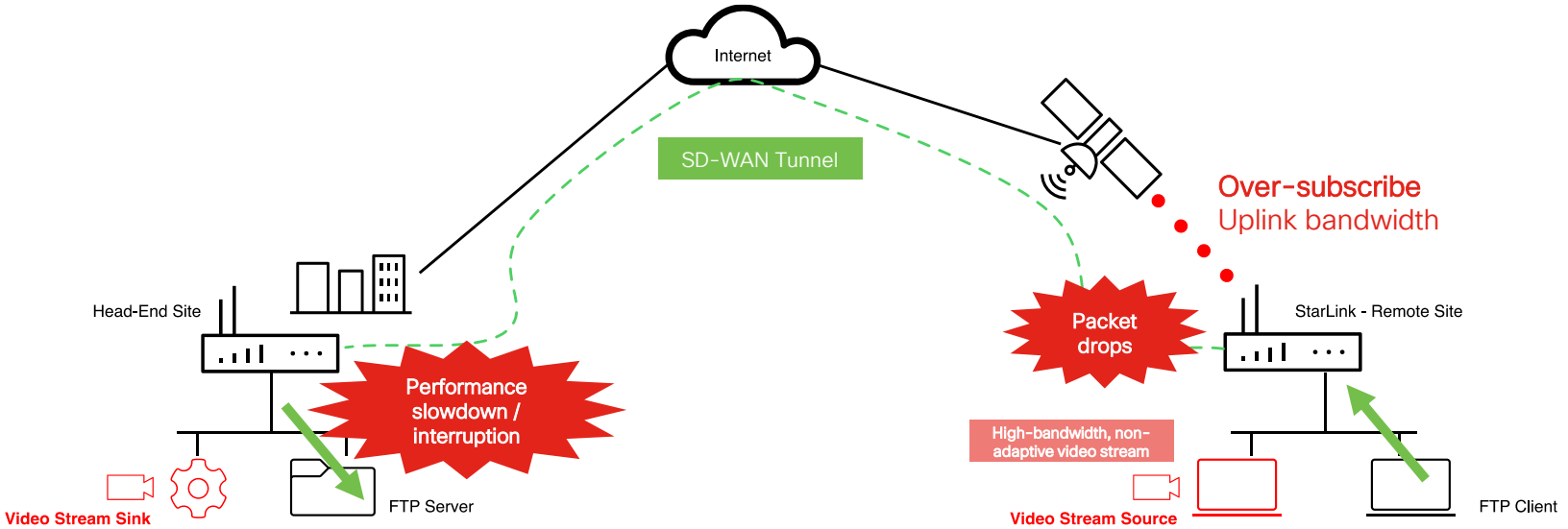
Starlink – SD-WAN Demo



Starlink – SD-WAN Demo



Starlink – SD-WAN Demo



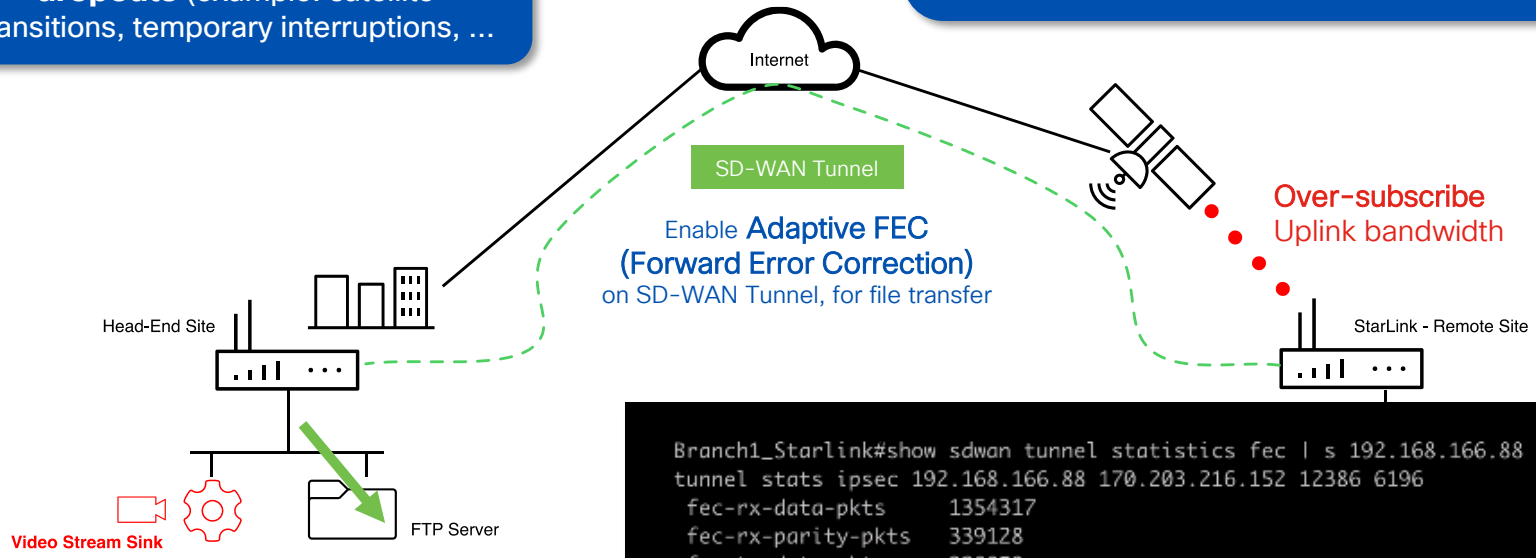
Starlink – SD-WAN Demo

How FEC works in Cisco SD-WAN

For every 4 data packets, transmit an extra **parity packet**

Any single packet loss within the group of four packets can be re-built dynamically from the other packets + parity data

Useful for occasional minor dropouts (example: satellite transitions, temporary interruptions, …




```
Branch1_Starlink#show sdwan tunnel statistics fec | s 192.168.166.88 170.203.216.152
tunnel stats ipsec 192.168.166.88 170.203.216.152 12386 6196
 fec-rx-data-pkts      1354317
 fec-rx-parity-pkts    339128
 fec-tx-data-pkts      328859
 fec-tx-parity-pkts    82213
 fec-reconstruct-pkts  16523
 fec-capable           true
 fec-dynamic           false
Branch1_Starlink#
```

Example of operation

Can be "on-always", or operate as FEC-Adaptive which only kicks in on detecting packet loss

Starlink – SD-WAN Demo

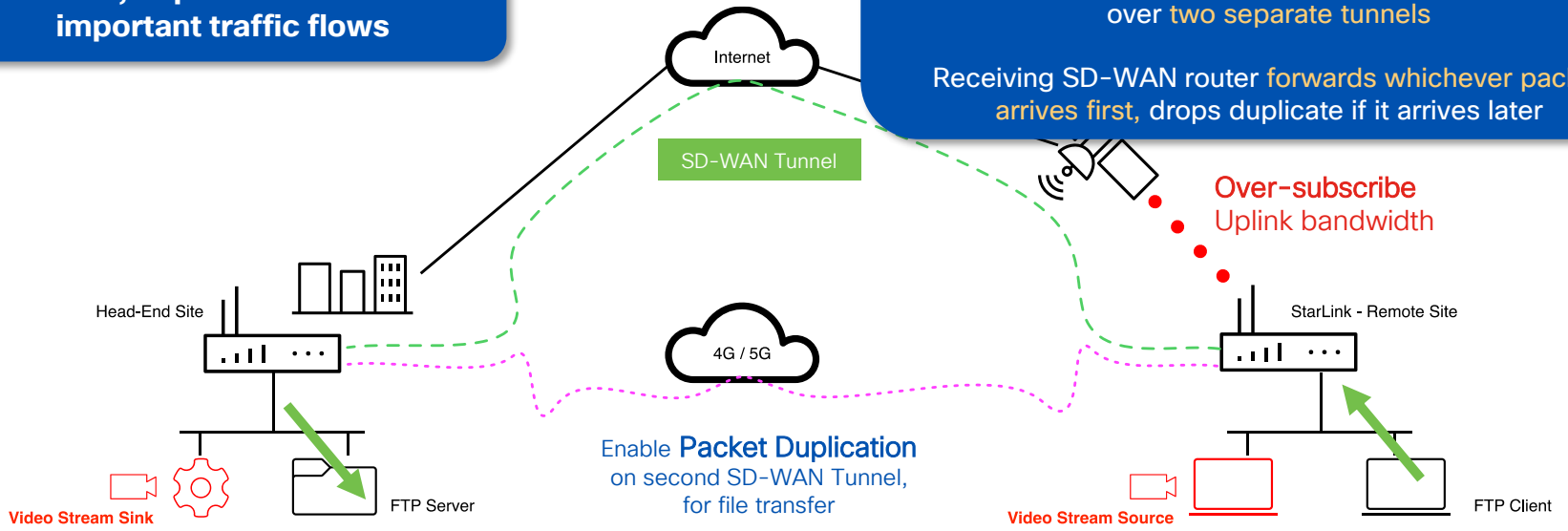
Useful for longer-term possible issues, to protect the most important traffic flows

How Packet Duplication works in Cisco SD-WAN

Designate all, or a portion, of traffic to duplicate

Send copies of matching packets (with sequence numbers) over two separate tunnels

Receiving SD-WAN router forwards whichever packet arrives first, drops duplicate if it arrives later



Operates as "on-always", but can be selective about what traffic is duplicated (via policy)

Demo of operation! ☺

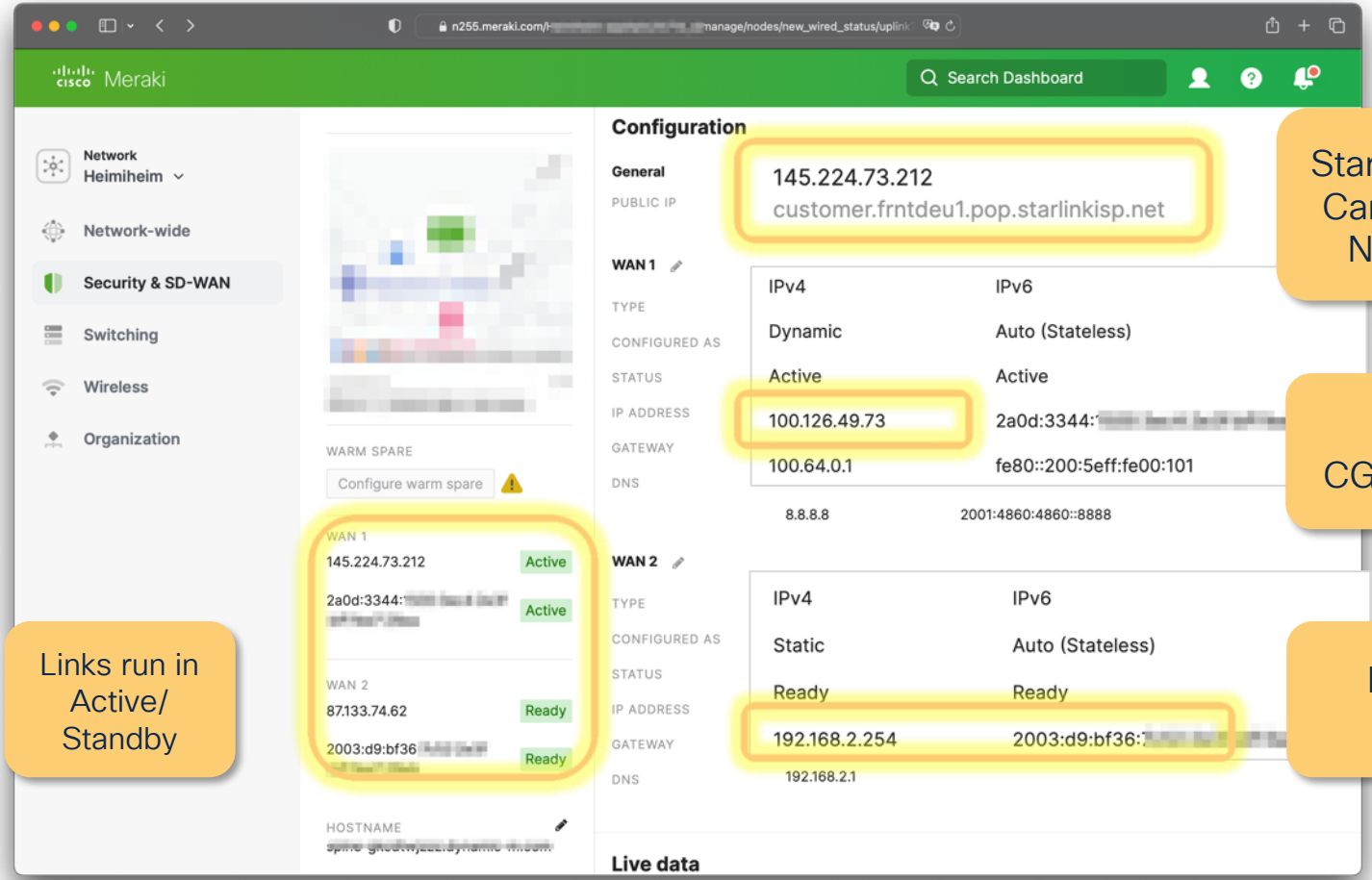
Oli's Deployment

Oli Boehmer
Principal Engineer, CX

Improving Connectivity (and Life!) in Rural Germany

My Setup – Dual Internet Uplinks

With Starlink being the active one



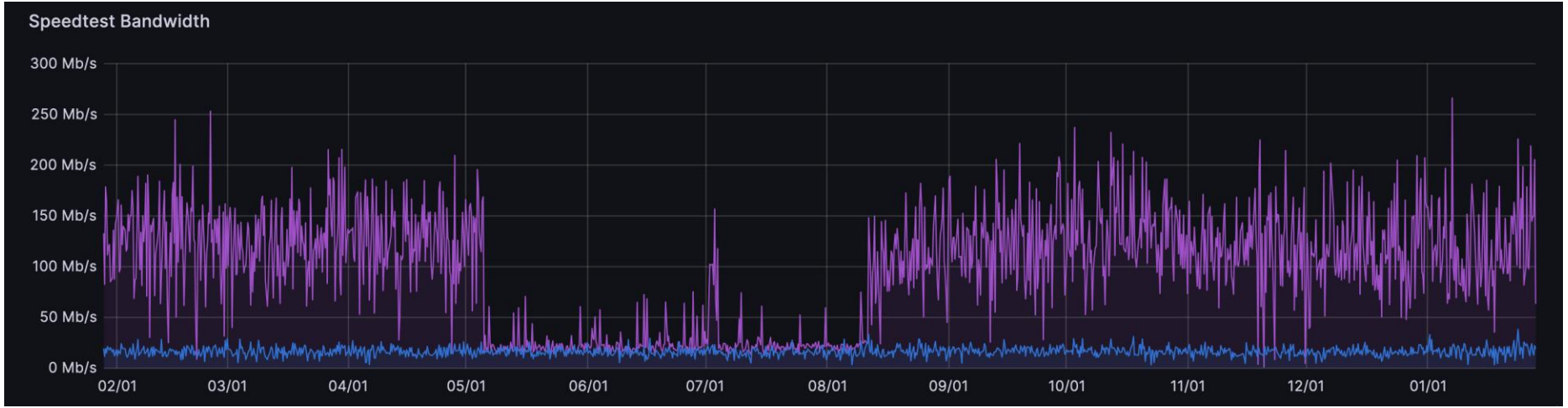
Starlink Gateway Frankfurt Carrier-Grade NAT (CG-NAT) outside address

Starlink DHCP CG-NAT inside address

Deutsche Telekom Router

Links run in Active/ Standby

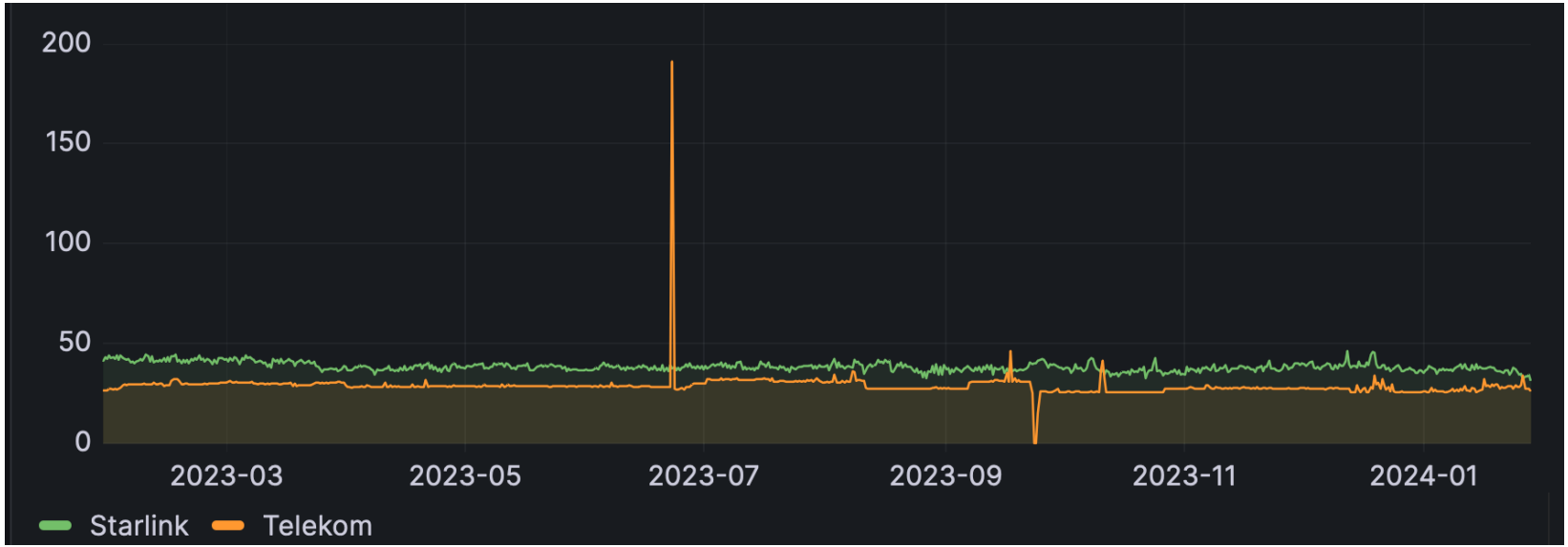
Throughput over the past ~12 months



min ^	max	avg	current
1.27 Mb/s	266 Mb/s	97.1 Mb/s	63.4 Mb/s
3.17 Mb/s	38.3 Mb/s	16.5 Mb/s	18.9 Mb/s

Excellent Latency (as expected)

LEO (green) shows more constant RTT vs. terrestrial link (orange)



Construction & Disaster Response Use Cases

Ian

In the Media...

TECH

CBS 8 San Diego using Starlink technology to steady TV live shots

CBS 8 San Diego deployed SpaceX Starlink technology to provide seamless connectivity to CBS 8 Studios for transfers, communication, and live television transmission.

Starlink wedge terminal feeds a Dejero link bonding Gateway

https://www.cbs8.com/article/tech/cbs-8-san-diego-using-starlink-to-steady-tv-live-shots/509-49844a2e-4ac2-4de3-be1c-8330449122a9

Français

Government of Canada | Gouvernement du Canada

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MENU

Canada.ca > Trans Mountain Expansion Project

Building the Trans Mountain Expansion Project

Pipeline construction is now underway, with Trans Mountain Corporation (TMC) anticipating that construction will be completed by late 2023.

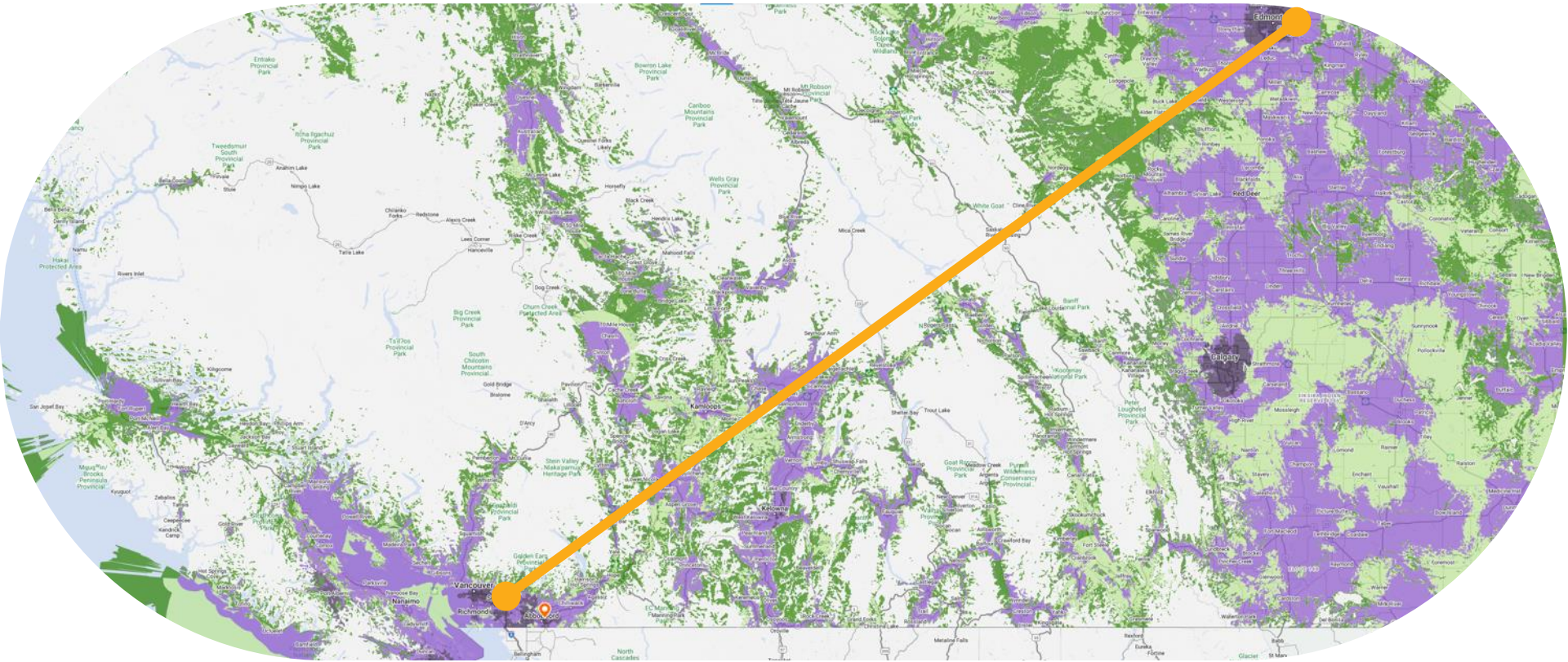
The Trans Mountain Corporation (TMC) has hired over 13,500 people to work on sites in Alberta and British Columbia.

With a focus on Indigenous, local and regional workers, the project is providing good jobs for heavy equipment operators, trades people, environment and safety specialists, engineers and construction managers.

Source: https://www.canada.ca/en/campaign/trans-mountain/building-the-pipeline.html

But How Do You Deal With The Canadian Rockies?

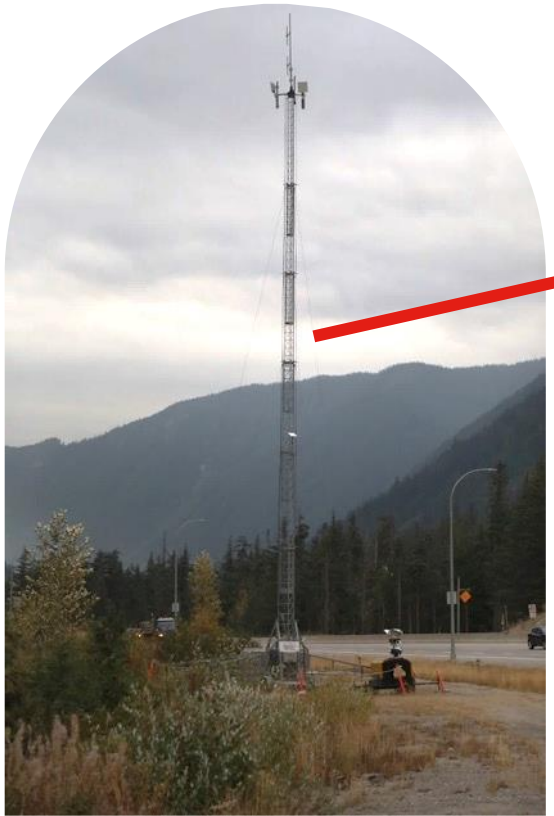
Cellular Coverage Along The Route



Portable Towers with Starlink Keep Crews Connected

Fixed / Portable Communications Infrastructure

What's On The Tower?



1. Starlink backhaul
2. VHF Repeater
3. 2.4 & 5GHz Wi-Fi (Sectorized)

Radio Over LEOsat ...

System Type	CONVENTIONAL	CONVENTIONAL IP NETWORK	SINGLE-SITE TRUNKING	MULTI-SITE TRUNKING	ENHANCED MULTI-SITE TRUNKING
			NXDN: Type-D TRKG	NXDN: Type-C TRKG P25: PHASE 1/2 TRKG	NXDN: Gen2 P25: PHASE 2 TRKG
					
No. of Radios					
Trunking	N/A	N/A	DECENTRALIZED CONTROL	CENTRALIZED CONTROL	CENTRALIZED CONTROL WITH SERVER BASED ARCHITECTURE
No. of Sites	SINGLE	UP TO 16 (unicast) UP TO 48 (multicast)	SINGLE	UP TO 48	UP TO 1000
Advantages	COST & CAPACITY BASELINE	COST EFFECTIVE COVERAGE	COST EFFECTIVE CAPACITY	CAPACITY AND COVERAGE	CAPACITY, COVERAGE AND CONTROL

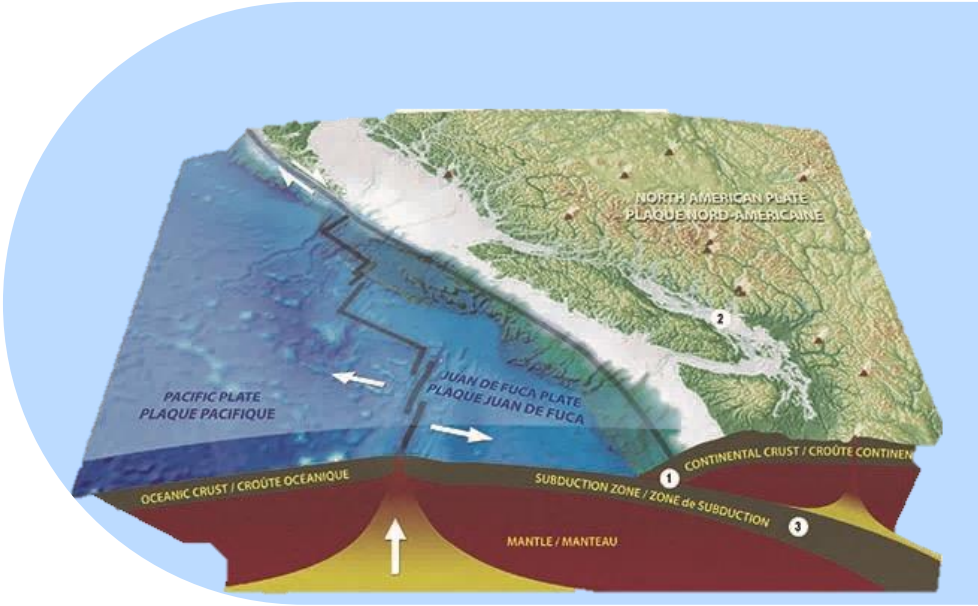
Source: https://comms.kenwood.com/en/solutions/system/

LEOsat in Disaster Response

cisco Live!

In 1964 all we lost was telephone...

https://upload.wikimedia.org/wikipedia/commons/4/4e/AlaskaQuake-FourthAve.jpg



https://vancouver.ca/home-property-development/understanding-earthquakes.aspx

9.2 Magnitude 1964 Alaska Quake

Problem Statement

Reliable communications (voice/data) is the backbone of disaster response

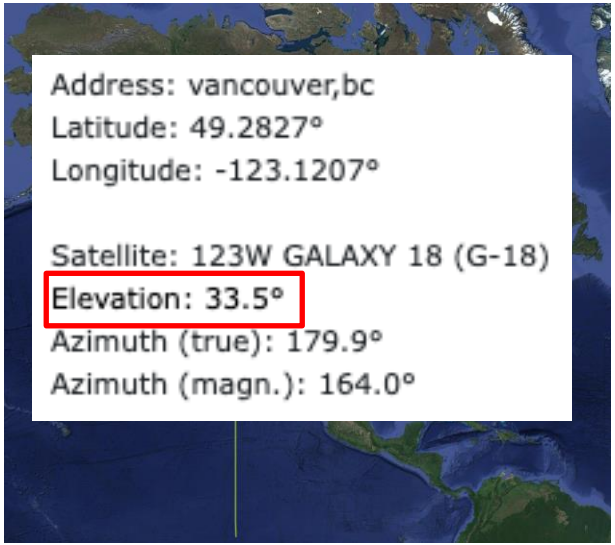
Layer 1 issues will prevent fast restoration of many wireline services

Cellular communications impacted due to power and uplink fragility.

Over the last 10 years agencies have become dependent on cloud hosted services (mapping, e-mail, documentation, video-conferencing etc).

VSAT to the rescue?

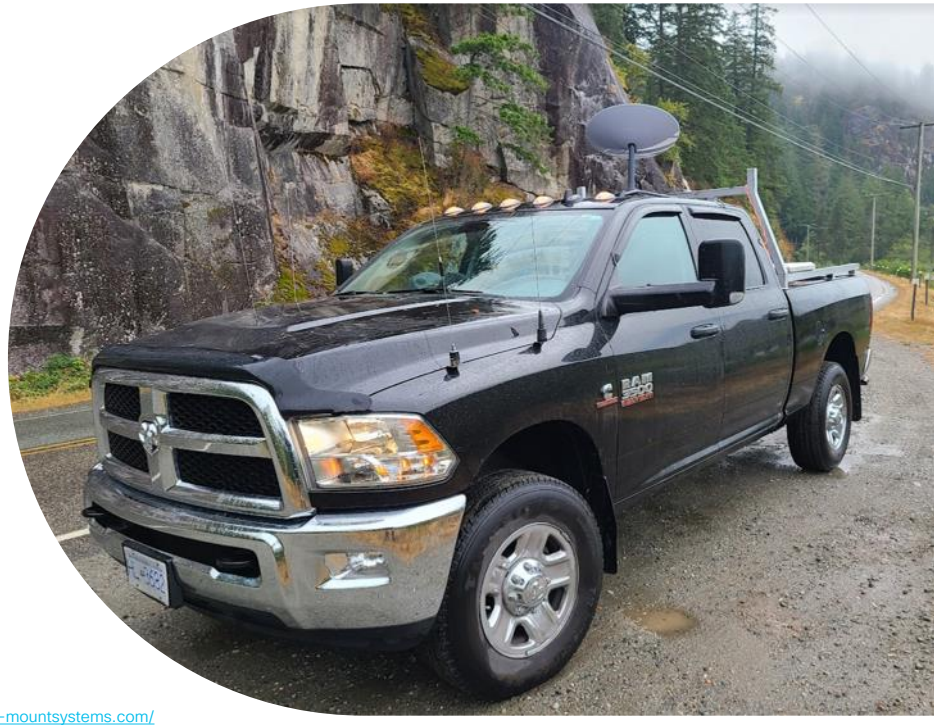
VSAT to the rescue?



https://www.dishpointer.com

How LEOsats Benefit Public Safety

- Trivial to setup and operate
- Highly portable
- Able to work in mountainous terrain vs geo-stationary



https://star-mountsystems.com/

Concerns

- Ease of access = lots of people = bandwidth contention
- Will my packets land outside the affected area?

https://www.reddit.com/r/Starlink/comments/kkrh0e/st_johns_nl_canada_Starlink_gateway_photos_and/
https://www.telesat.com/wp-content/uploads/2020/07/teleport-calgary.jpg

LEOsat Programmability

Oli Boehmer
Principal Engineer, CX

cisco Live!

Telemetry and Starlink

There is an undocumented API, which is used by Starlink's mobile app

- Uses gRPC
  - Is not trivial to learn
  - Output is a binary and is not human readable

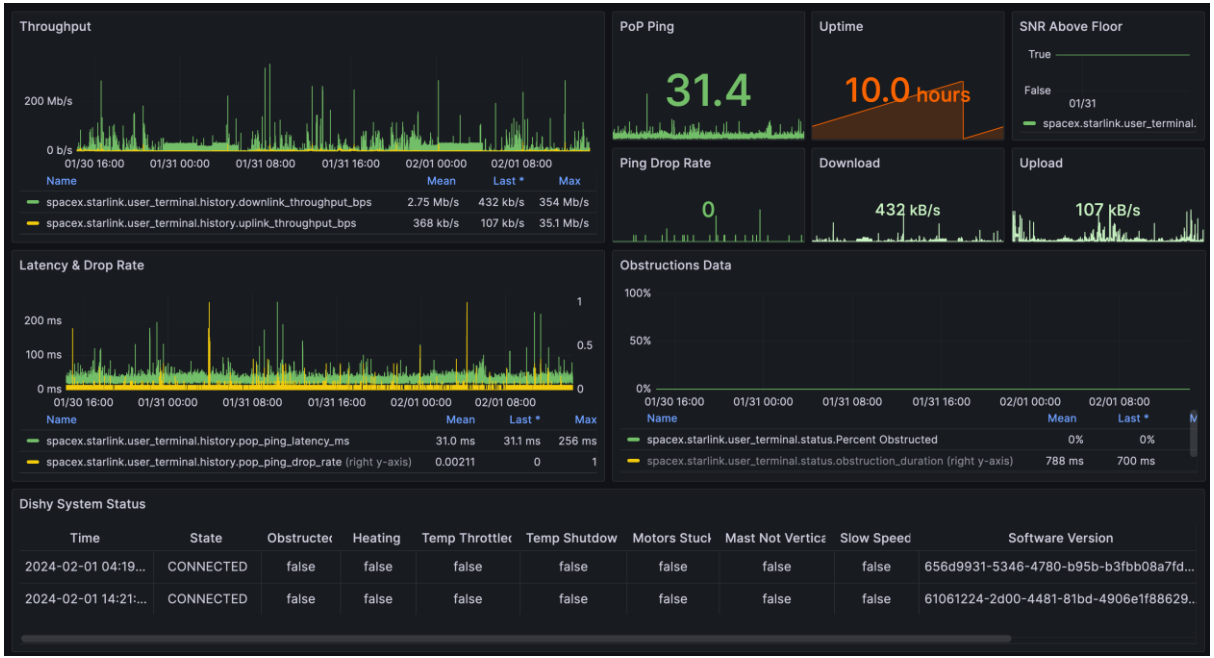
What if I don't want to learn how to interact with gRPC endpoints?

- gRPCurl << curl but for gRPC!
  - Output can be as simple as plaintext in a JSON array
  - **`grpcurl -plaintext -d '{"getStatus":{}}' \`**
    `192.168.100.1:9200 SpaceX.API.Device.Device/Handle`

Great example project: Sparky8512 Github - Starlink GRPC Tools

Sample Grafana Dashboard

`dish_grpc_influx.py`



Script: https://github.com/sparky8512/starlink-grpc-tools/blob/main/dish_grpc_influx.py

Dashboard: https://github.com/sponsianus/dishy_grafana/blob/main/grafana-provisioning/dashboards/starlink/starlink.json

“It’s not real unless I see it”

– most humans

How can I try this out?

1. Have a Starlink unit
2. Try these projects out

- aaburger85/node-red_starlink
  - What I demo'd
- Sparky8512/Starlink-GRPC-tools
  - Comprehensive functions

LEOsat Future & Opportunities

Dave

LEOsats will Democratize Connectivity

LEOsats will enable mass-scale Digital Nomadism …

Work from a low-cost location, with better quality of life

Photos by Brina Blum, Airfocus and Persnickety Prints on Unsplash

Hybrid Work from Anywhere in the World

A — Vancouver — $1.3M

B — Regina — $321K

C — Silicon Valley — $1.52M

D — Kansas City — $235K

Starlink and Microsoft Azure Bring You Azure Space

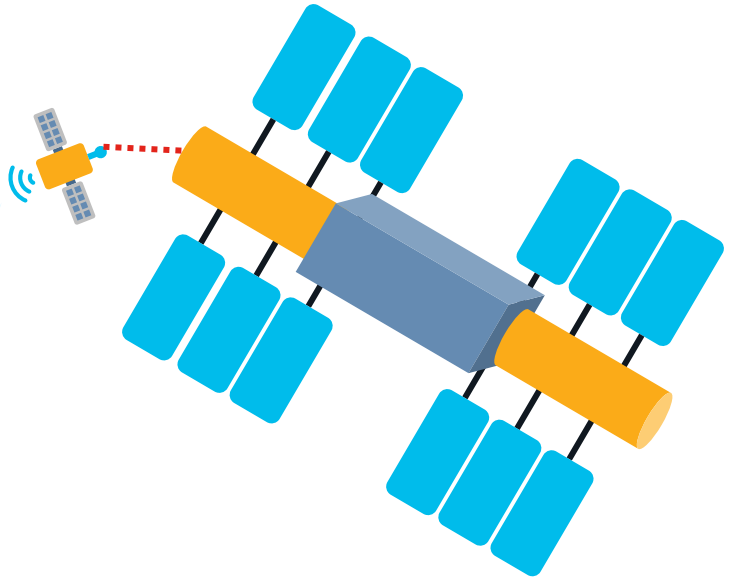
Microsoft teams up with SpaceX to launch Azure Space to bring cloud computing into the final frontier

By Chelsea Gohd October 21, 2020

- Azure Modular Data Centre
- Self-contained
- Deployable Anywhere
- For remote connectivity or expansion of existing

Edge Computing in Space

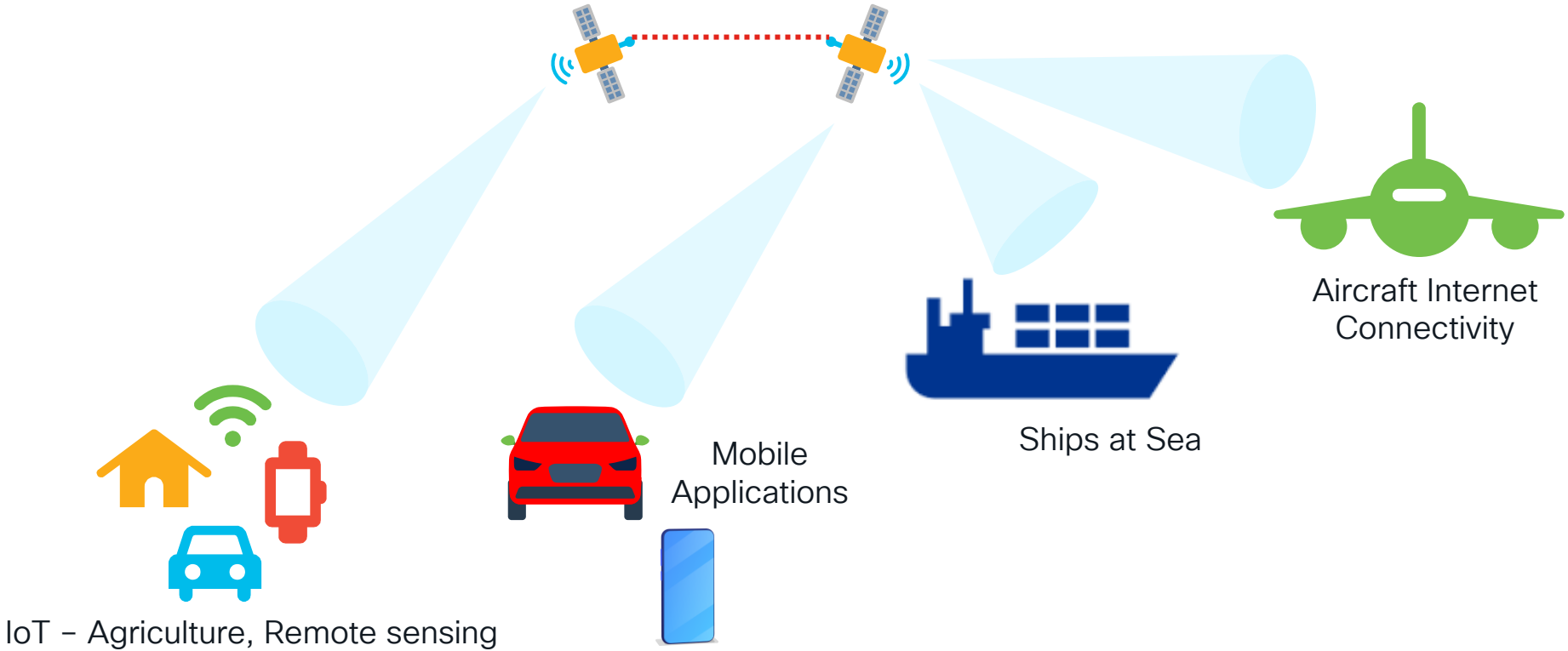
https://www.ibm.com/cloud/blog/ibm-develops-a-unique-custom-edge-computing-solution-in-space



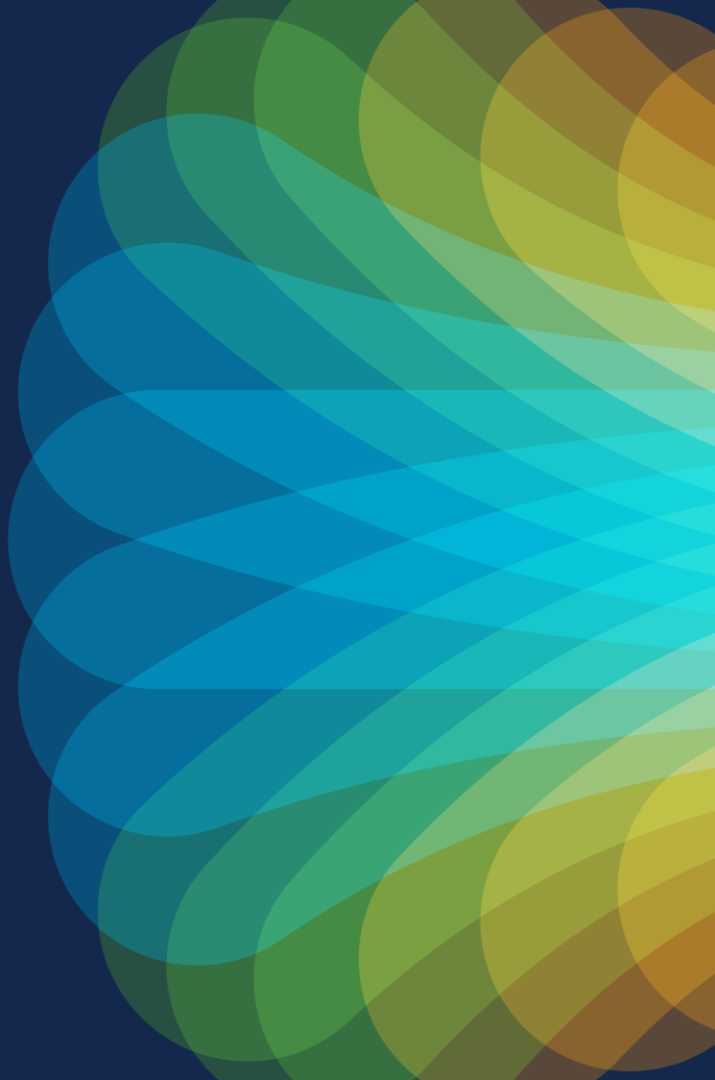
Possibility: Edge Compute on ISS

What goes up, doesn't necessarily have to come down…

The LEOsat Revolution – Unlimited Use Cases



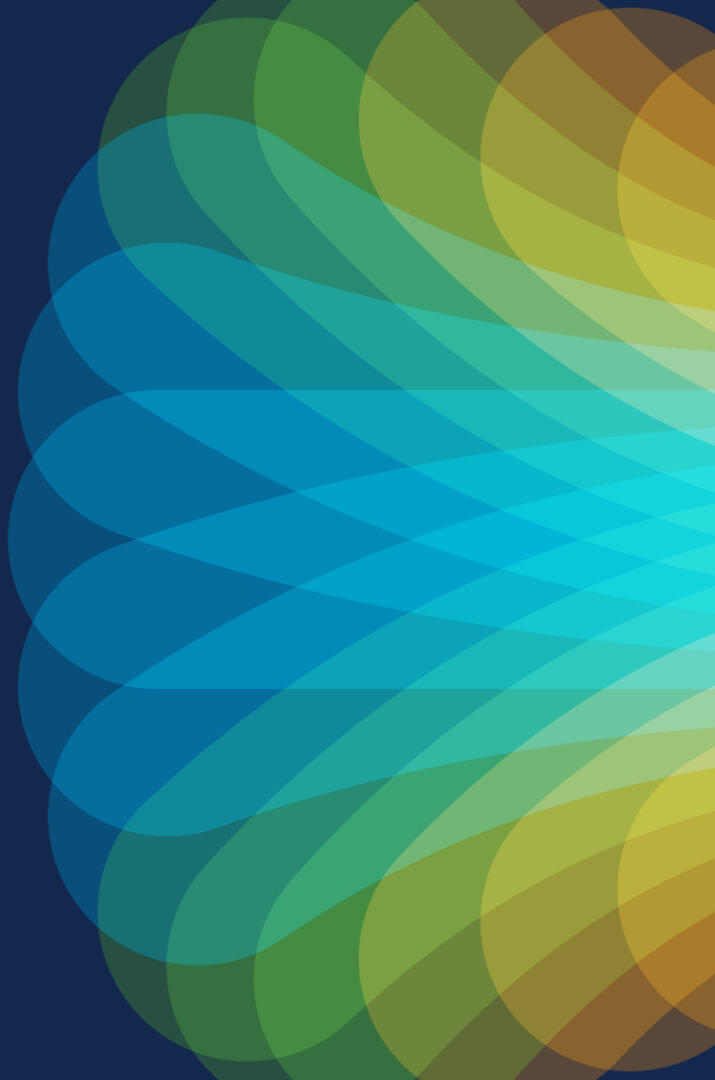
The Beginning...




Space may be dark ...
but the future of LEO satellite
communications is
bright

The bridge to possible

Thank you



cisco Live!


cisco Live!
Let's go