HIGH-RESILIENCE LOW-LATENCY INDUSTRIAL EXPERIENCES

DTN WG - IETF116 (Tokyo, 28.03.2023)

1. **Introduction**: Use-cases why we ended up in DTN (5min)
2. **Findings**: Measurement results and DTN cooperation (10min)
3. **Future**: Challenges and opportunities for DTN (5min)

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DELTA CYGNI LABS - FINLAND

CORE TEAM

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MARKO KUULA,
KEY ACCOUNTS

IGOR LEVOCHKIN
FRONT-END LEAD

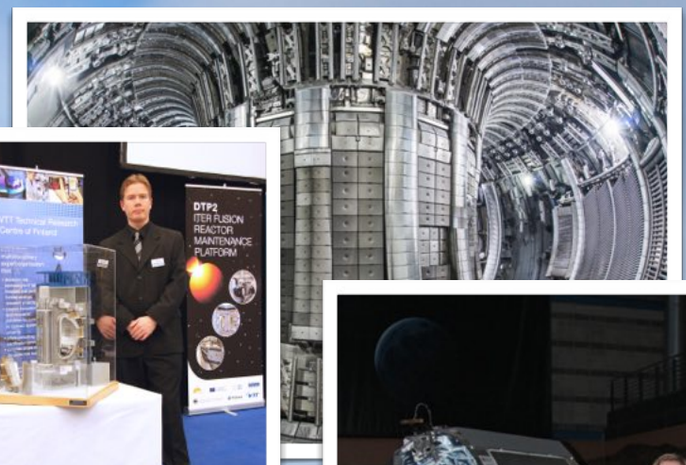
MARCO CARANDENTE
BACK-END LEAD

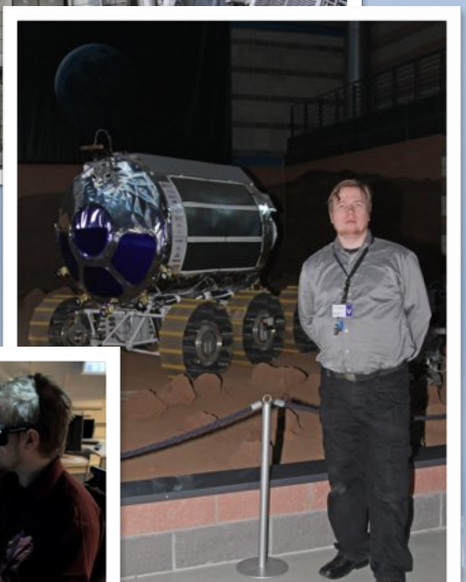
Locations	Finland; Germany; USA; Brazil
Experience	10+ years industrial distributed systems
Products	XRTC® POINTR®
Customers	45 Corporates
Users	50.000+ in 125 countries
Industries	Automotive, Energy, Marine, Machinery, Medical

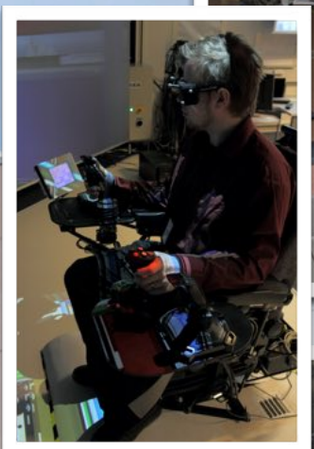
VTT

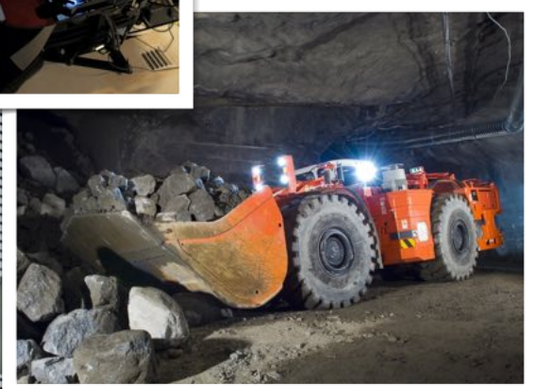
Technical Research
Centre of Finland

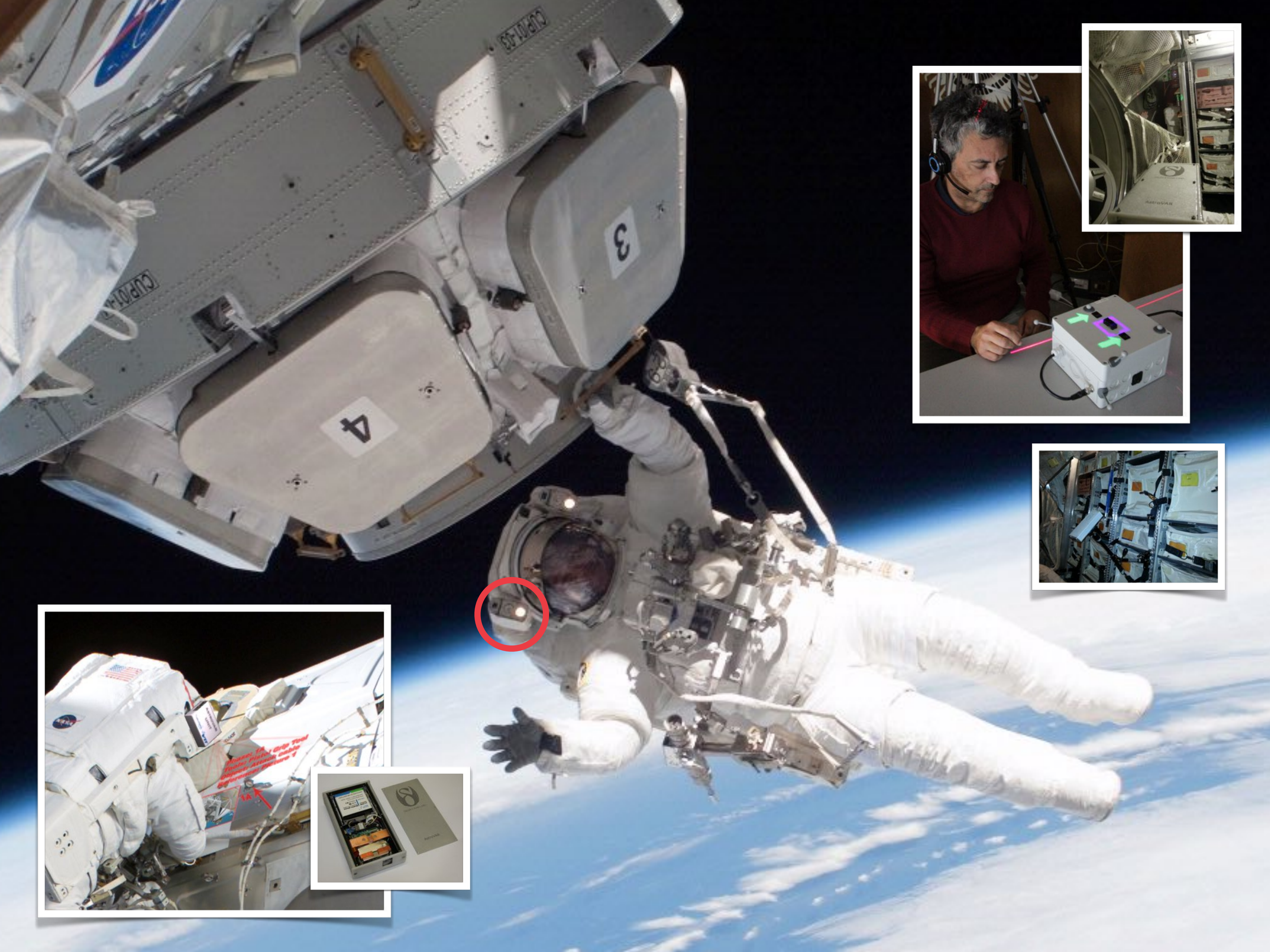
HUMAN MACHINE INTERACTION
AND
VIRTUAL ENGINEERING

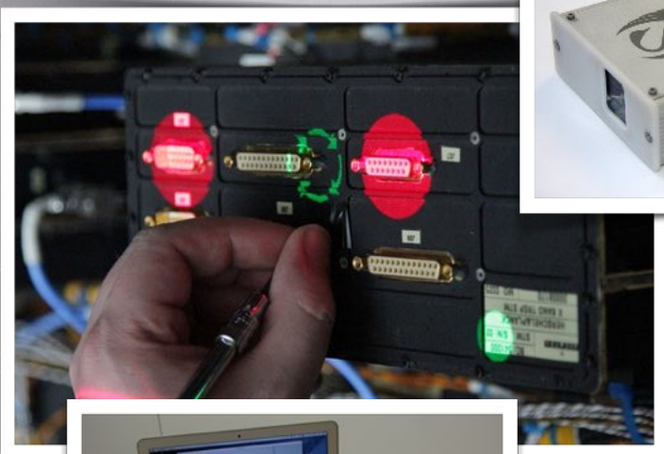


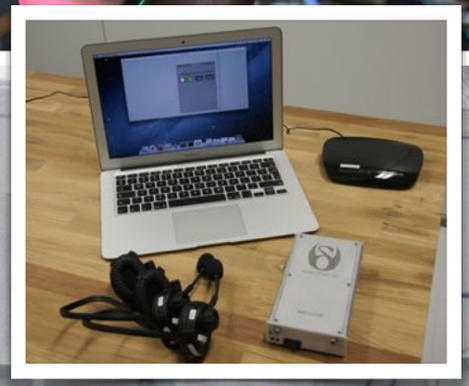












Business as usual!
Let's do it!

WebRTC

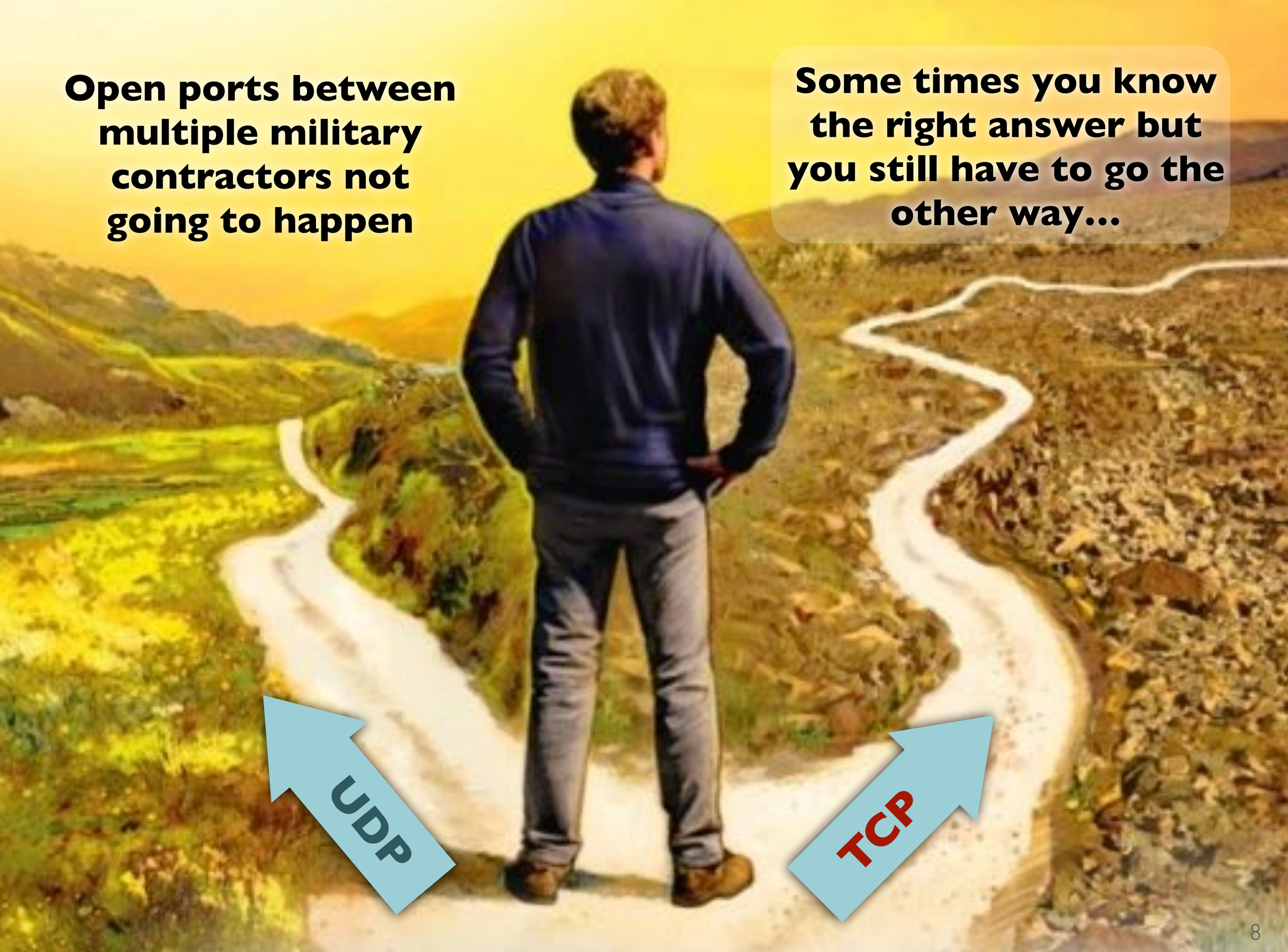
UDP
UDP
UDP
UDP
UDP
UDP

UDP

Let's open some ports, shall we?

Open ports between multiple military contractors not going to happen

Some times you know the right answer but you still have to go the other way…



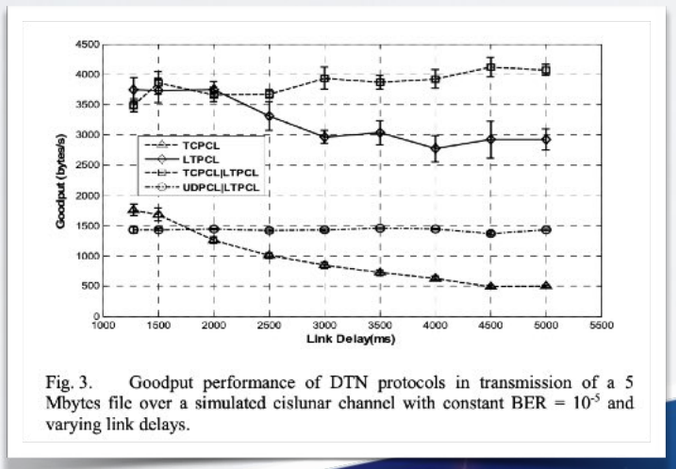
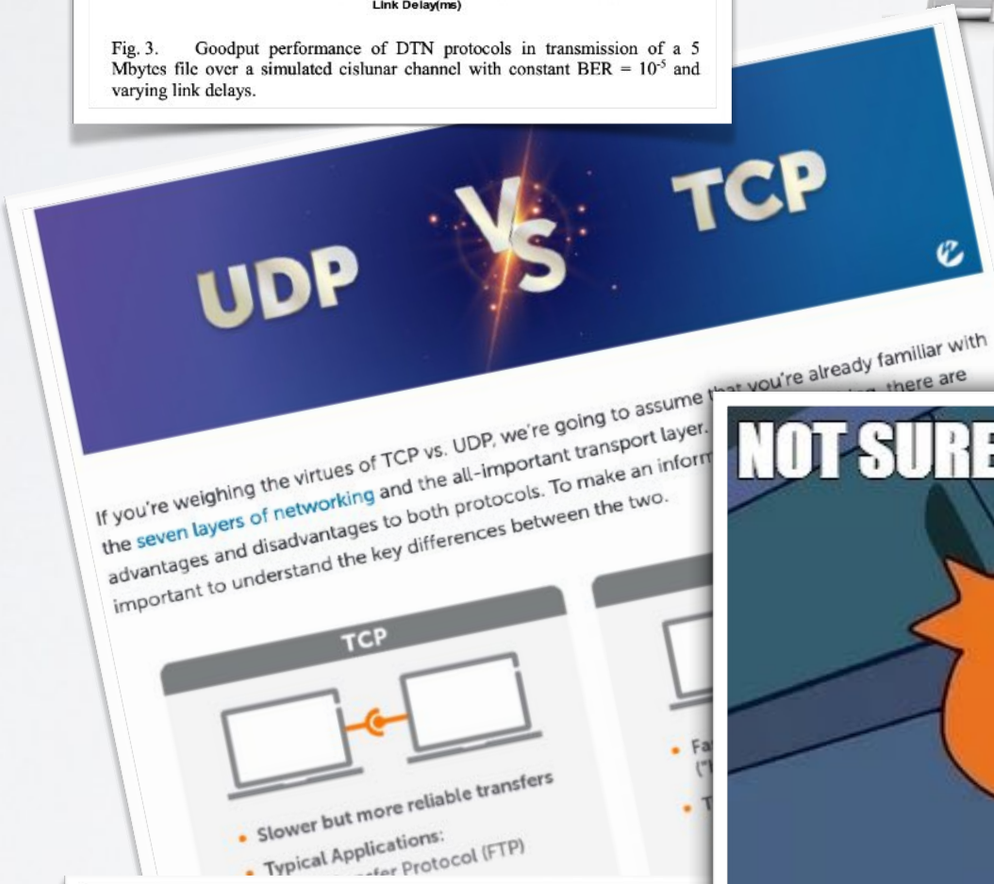


Fig. 3. Goodput performance of DTN protocols in transmission of a 5 Mbytes file over a simulated cislunar channel with constant BER = 10^{-5} and varying link delays.



It's Time to Replace TCP

John Ouste
Stanford Un

January 1

This position paper has been updated since its original pub clarification. Updates are in italics; none of the original text for pointers to comments on the paper, see the Homa Wiki: HOMA/overview#replaceTcp.

No guarantee of message delivery
No acknowledgments, retransmissions, or timeouts.

No guarantee of order of delivery
No packet sequence numbers, no reordering, no head-of-line blocking.

No connection state tracking
No connection establishment or teardown state machines.

No congestion control
No built-in client or network feedback mechanisms.

That's where UDP can be incredibly useful when you require fast streaming and accuracy is less important. UDP is considered a connectionless protocol because it doesn't require a virtual circuit for data transfer. UDP simply sends packets with a much lower bandwidth overhead and latency. Though some packets might be lost or received out of order, UDP is useful for live streaming and other real-time applications.

UDP: When Speed Matters

Connectionless protocol

One to one, one to all, one to many (multicast, unicast, broadcast).

grams are sent as dual packets.

order as data is

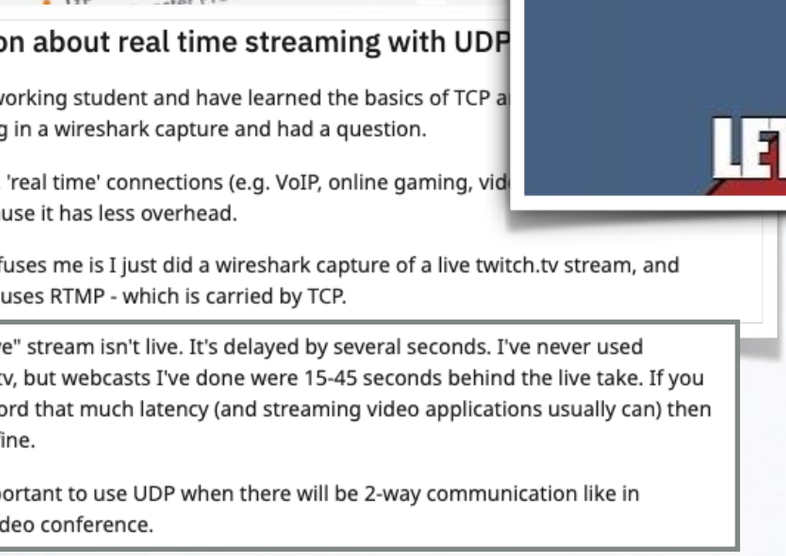
TCP: When Accuracy Matters

Connection-based protocol that includes a handshake and authentication.

One to one (unicast).

The sequence

mary reason why the UDP ata. TCP delivers a reliable, TCP buffers all the packets ream in order to the appli- vices":


Question about real time streaming with UDP

I'm a networking student and have learned the basics of TCP a something in a wireshark capture and had a question.

Generally, 'real time' connections (e.g. VoIP, online gaming, vid UDP, because it has less overhead.

What confuses me is I just did a wireshark capture of a live twitch.tv stream, and noticed it uses RTMP - which is carried by TCP.

The "live" stream isn't live. It's delayed by several seconds. I've never used twitch.tv, but webcasts I've done were 15-45 seconds behind the live take. If you can afford that much latency (and streaming video applications usually can) then TCP is fine.

It's important to use UDP when there will be 2-way communication like in VoIP/video conference.

SUCCESS!

With comments…

… see you later?

Feedback resulted in POINTR

Security is matter of life and death…
Multiple enterprise boundaries…

https://us-cert.cisa.gov/bsi/articles/knowledge/principles/least-privilege

An official website of the United States government Here's how you know

CYBERSECURITY & INFRASTRUCTURE SECURITY AGENCY

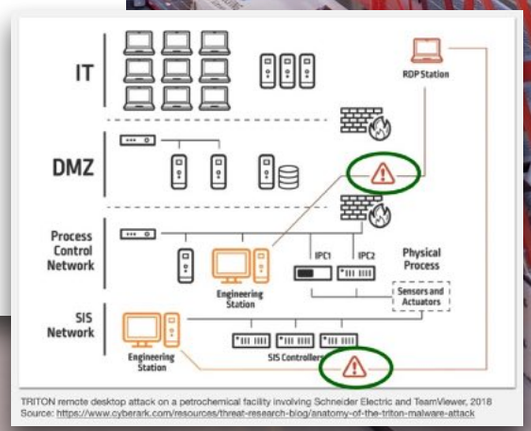
According to Saltzer and Schroeder [Saltzer 75] in "Basic Principles of Information Protection," page 9:

> Least privilege: Every program and every user of the system should operate using the least set of privileges necessary to complete the job.

TeamViewer Community — Blog | Support Forum | Knowledge Hub | Service | Security Handbook | English (en)

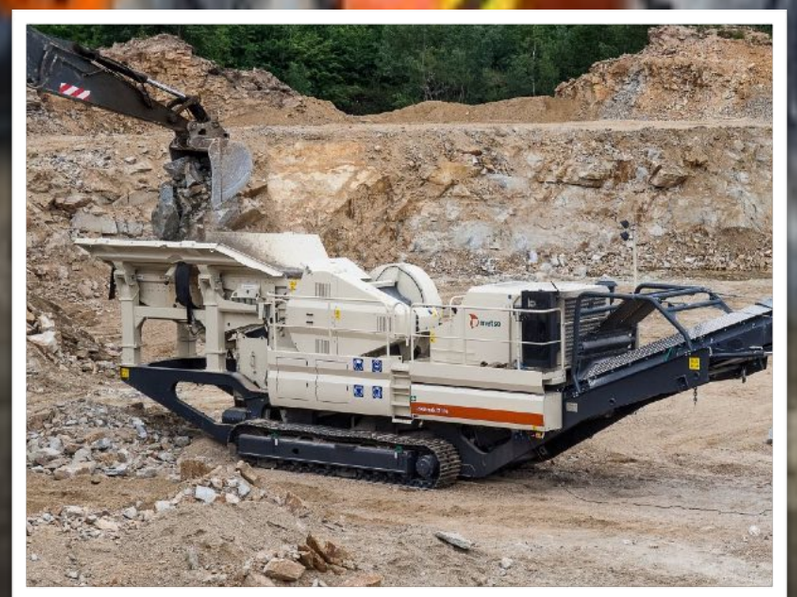
When looking at the record of activities on the platform, it becomes clear that while I am sleeping, someone enters my PC from a device that is not associated with my account without the need of any verification or authorization. It should be noted that I have never assigned income to any device that is not associated with my account.

(Reuters) - Hackers broke into the computer system of a facility that treats water for about 15,000 people near Tampa, Florida and sought to add a dangerous level of additive to the water supply, the Pinellas County Sheriff said on Monday.



TRITON remote desktop attack on a petrochemical facility involving Schneider Electric and TeamViewer, 2018
Source: https://www.cyberark.com/resources/threat-research-blog/anatomy-of-the-triton-malware-attack

Baseline is variable connectivity…
Legacy systems will be involved…



Disruptions, disturbances and delays nominal…

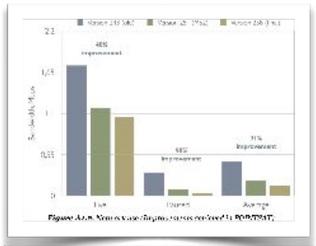
Offline steps in day-to-day process…

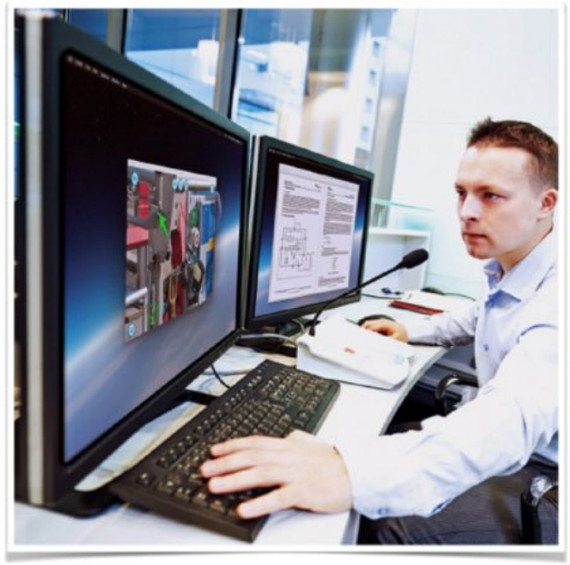
POINTSAT

ACTIVITY	Entry
STATUS	Completed
THEMATIC AREA	Energy, Maritime and Aquatic

Objectives of the service

Finnish high tech company **Delta Cygni Labs** is transforming industrial services with the new remote collaboration solution POINTR. Powered by augmented reality, POINTR is secure, reliable, scalable, easy-to-use solution for industry.

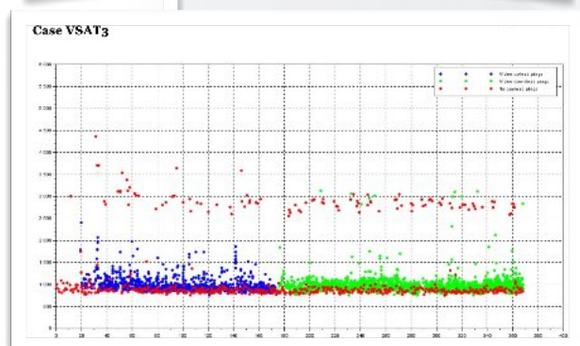


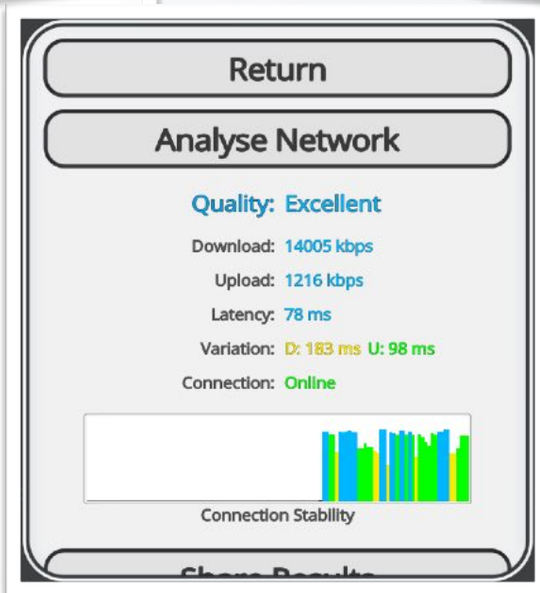


The objective of the POINTSAT project was to strengthen the POINTR offering for maritime, offshore, mining and energy sectors by integrating satellite communication capability and advanced interaction for harsh environments.

The particular focus of the project is on the maritime applications. POINTSAT involved two industrial collaboration partners: **Valmet** (marine solutions and automation) and **KONE Marine** (vertical transportation in maritime sector).

WORKING ENVIRONMENT IN THE DOCK





- Delay Tolerance
- Disruption Tolerance
- Store and Forward
- Design from Extremes

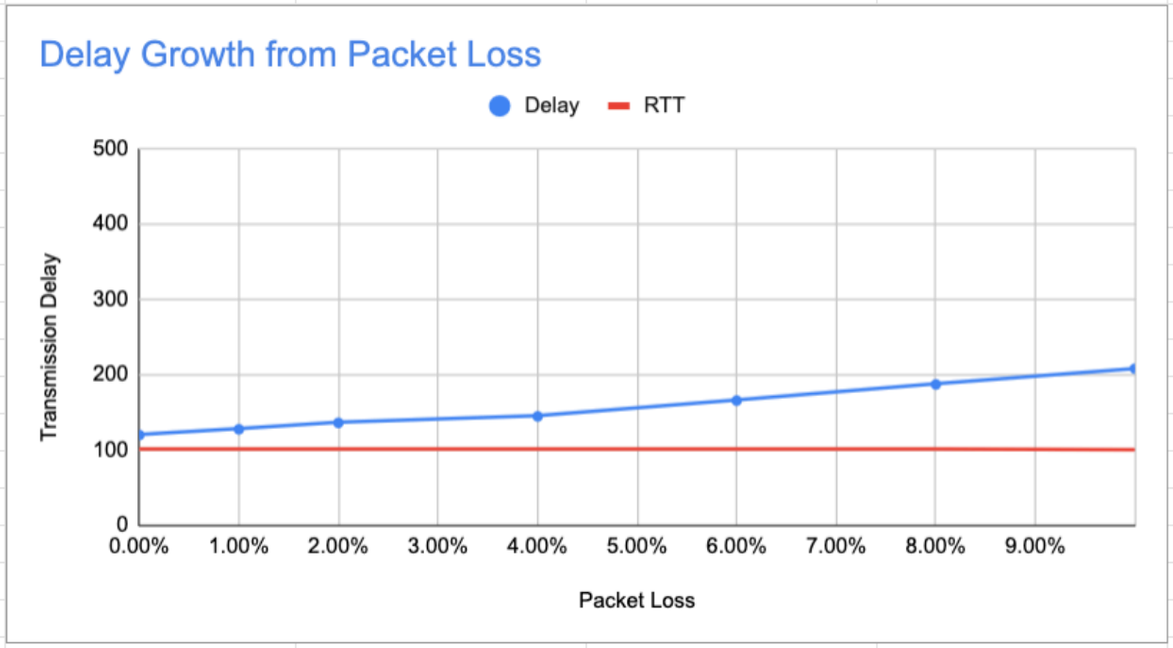
- Continous Measurement
- Temporal and Spatial bitrate adaptation
- Communicate Quality to Users

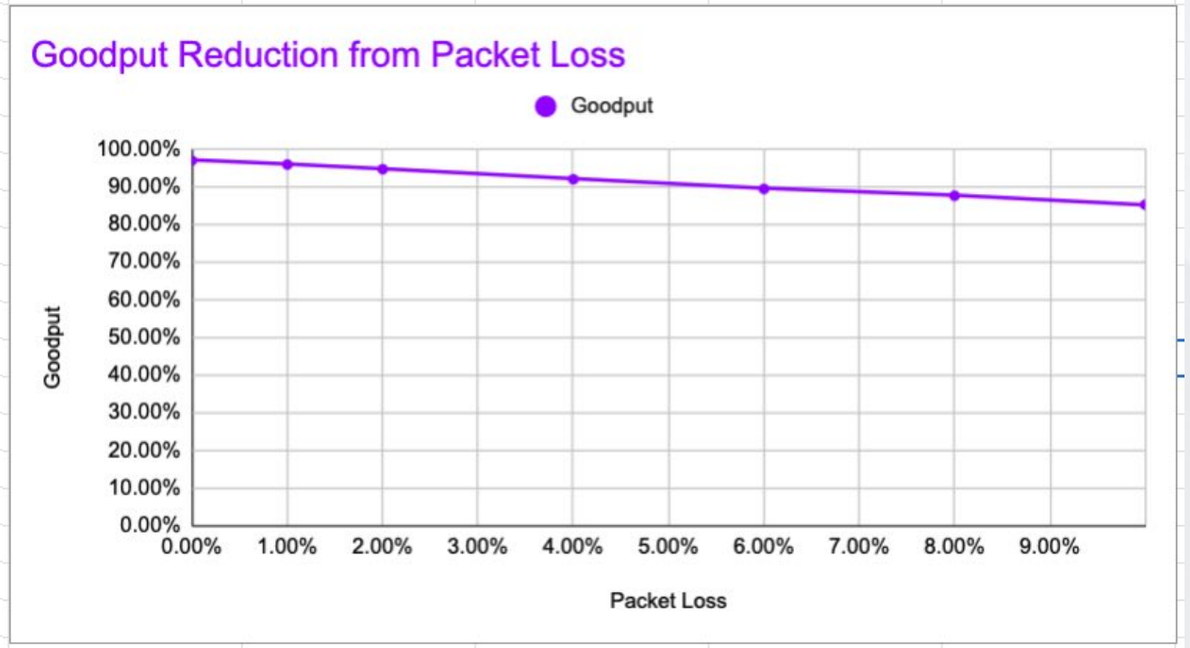
MEASUREMENTS

DISRUPTION RESILIENCE TEST - DTN

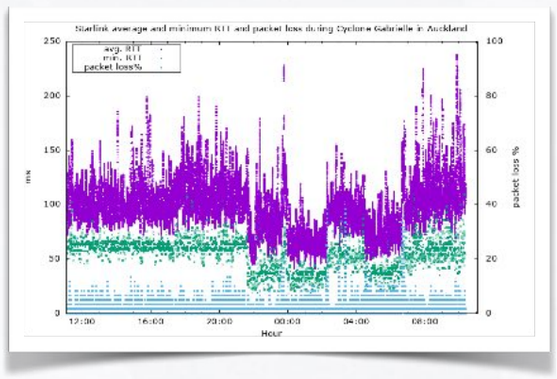
5G at **0.25%**, 4G at **0.5%**, Base Station Congestion **0.75%**, Satellite **1%**, Storm Satellite **10%**

RTT:	Packet Loss:	Average Delay:	99th Percentile:	Goodput:	Retransmissions:	Overhead:	Samples:	Sample Size:
100 ms	**0.00%**	119.59 ms	204.78 ms	96.98%	0.01%	3.01%	150	0.5 Mb
100 ms	**1.00%**	127.38 ms	493.17 ms	95.89%	1.11%	3.00%	150	0.5 Mb
100 ms	**2.00%**	135.94 ms	660.97 ms	94.63%	1.87%	3.50%	150	0.5 Mb
100 ms	**4.00%**	144.54 ms	740.32 ms	91.99%	4.12%	3.89%	150	0.5 Mb
100 ms	**6.00%**	165.45 ms	1124.59 ms	89.45%	6.39%	4.16%	150	0.5 Mb
100 ms	**8.00%**	186.95 ms	1380.04 ms	87.58%	8.05%	4.37%	150	0.5 Mb
100 ms	**10.00%**	208.08 ms	1543.32 ms	85.20%	9.97%	4.82%	150	0.5 Mb





10% packet loss condition is Starlink during storm



Reference from Auckland NZ Cyclone Gabrielle (Ulrich Speidel)

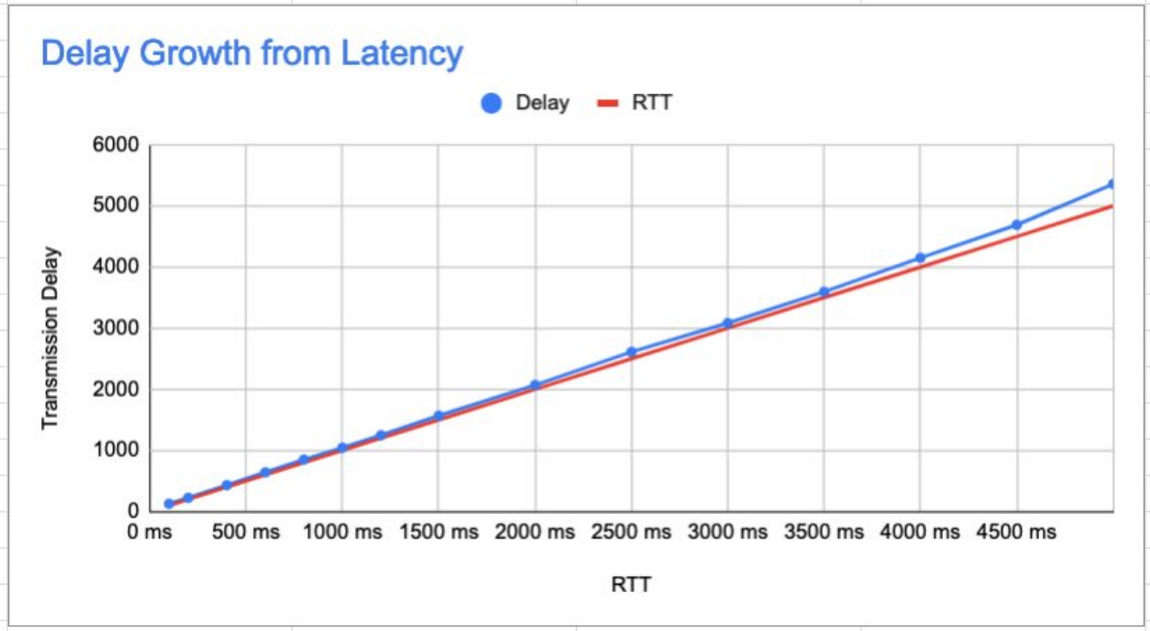
Inspiration:

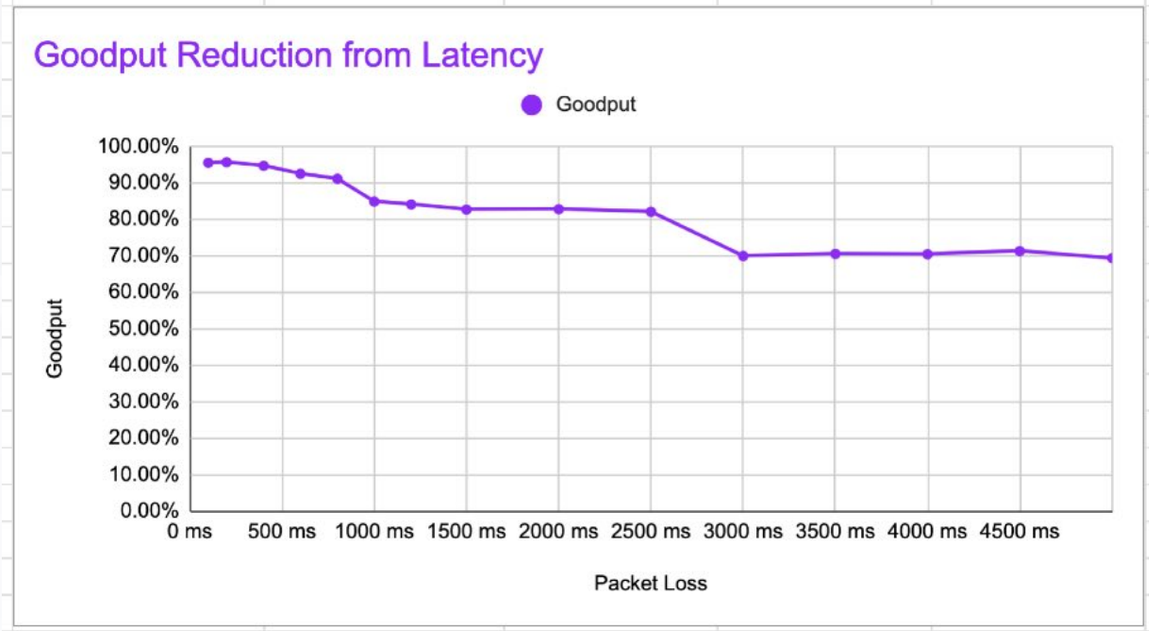
1. Licklider Transmission Protocol (LTP)-Based DTN for Long-Delay Cislunar Communications (Link)
2. Use of a Hybrid of DTN Convergence Layer Adapters (CLAs) in Interplanetary Internet (Link)

DELAY RESILIENCE TEST - DTN

Earth **200ms**, ISS **500ms**, Moon **1200ms** (Extreme **5000ms**)

RTT:	Packet Loss:	Average Delay:	99th Percentile:	Goodput:	Retransmissions:	Overhead:	Samples:	Sample Size:
100 ms	1.00%	126.35 ms	523.76 ms	95.49%	1.11%	3.40%	140	0.5 Mb
200 ms	1.00%	223.84 ms	772.32 ms	95.61%	1.01%	3.38%	140	0.5 Mb
400 ms	1.00%	430.86 ms	1240.97 ms	94.65%	0.86%	4.49%	140	0.5 Mb
600 ms	1.00%	640.87 ms	1781.66 ms	92.46%	0.87%	6.67%	140	0.5 Mb
800 ms	1.00%	849.21 ms	2055.72 ms	91.08%	1.07%	7.85%	140	0.5 Mb
1000 ms	1.00%	1044.19 ms	2534.43 ms	84.87%	6.08%	9.05%	140	0.5 Mb
1200 ms	1.00%	1247.39 ms	2910.18 ms	84.06%	10.78%	5.16%	140	0.5 Mb
1500 ms	1.00%	1567.88 ms	4057.77 ms	82.68%	8.10%	9.23%	140	0.5 Mb
2000 ms	1.00%	2070.03 ms	4310.00 ms	82.76%	7.71%	9.52%	140	0.5 Mb
2500 ms	1.00%	2611.44 ms	5771.04 ms	82.05%	7.23%	10.71%	140	0.5 Mb
3000 ms	1.00%	3083.55 ms	6405.83 ms	69.93%	23.37%	6.70%	140	0.5 Mb
3500 ms	1.00%	3595.17 ms	6828.15 ms	70.52%	22.87%	6.61%	140	0.5 Mb
4000 ms	1.00%	4150.57 ms	8637.32 ms	70.42%	22.89%	6.70%	140	0.5 Mb
4500 ms	1.00%	4691.15 ms	10872.70 ms	71.29%	21.22%	7.48%	140	0.5 Mb
5000 ms	1.00%	5359.38 ms	12801.08 ms	69.35%	22.53%	8.12%	140	0.5 Mb



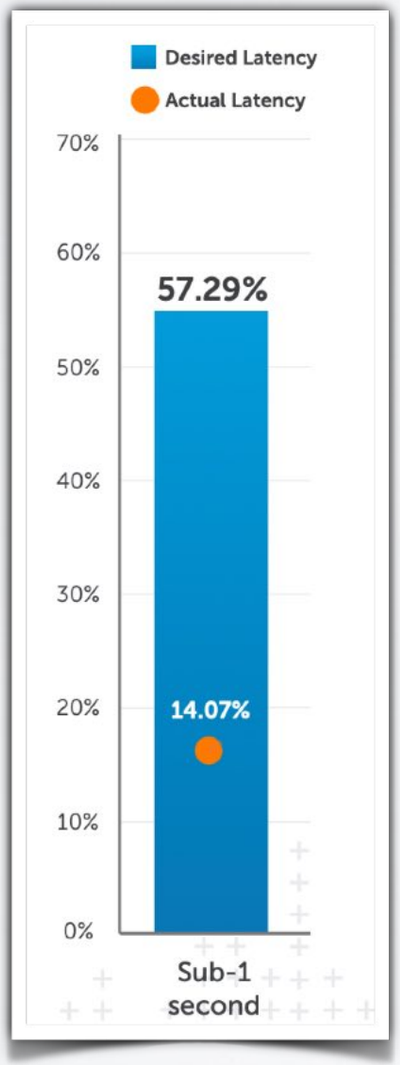


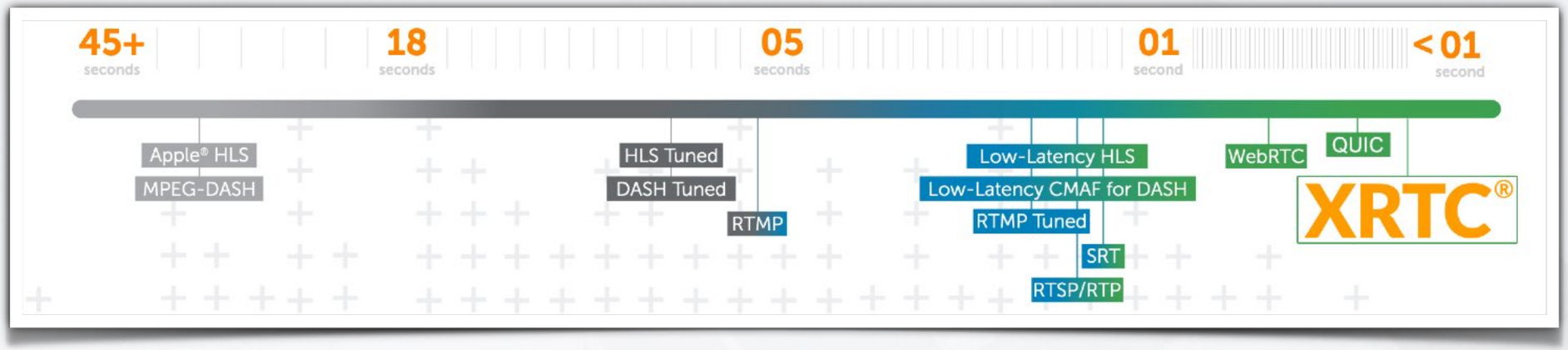
Inspiration:

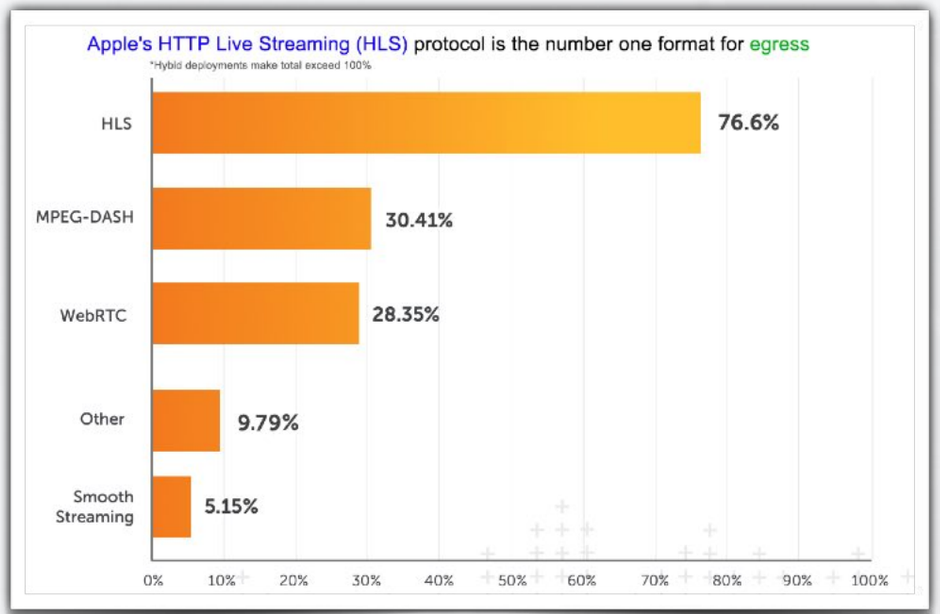
1. Licklider Transmission Protocol (LTP)-Based DTN for Long-Delay Cislunar Communications (Link)
2. Use of a Hybrid of DTN Convergence Layer Adapters (CLAs) in Interplanetary Internet (Link)

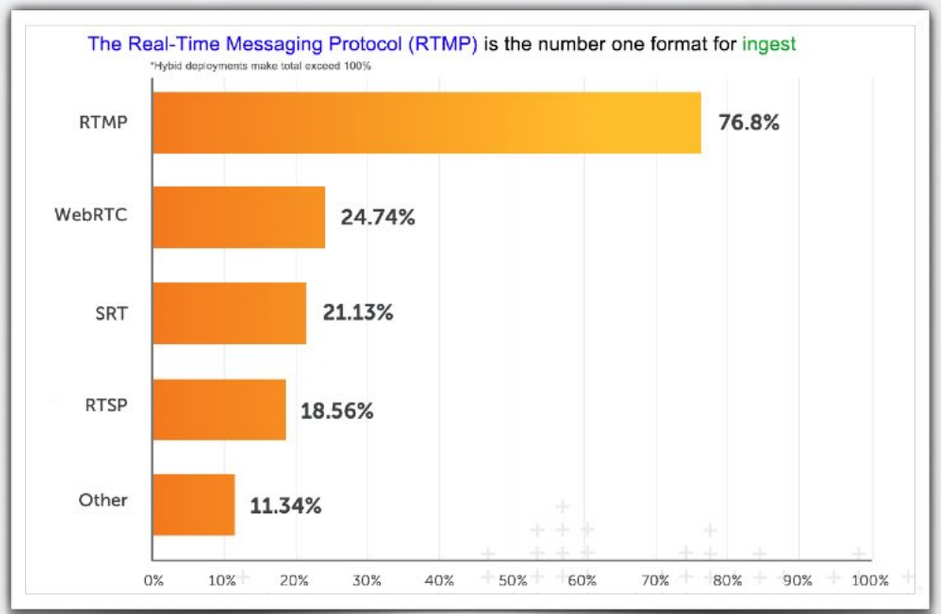
FUTURE

WOWZA REPORT









Only 14% of companies can utilize sub second latency
While 57% of companies wants / needs sub second latency

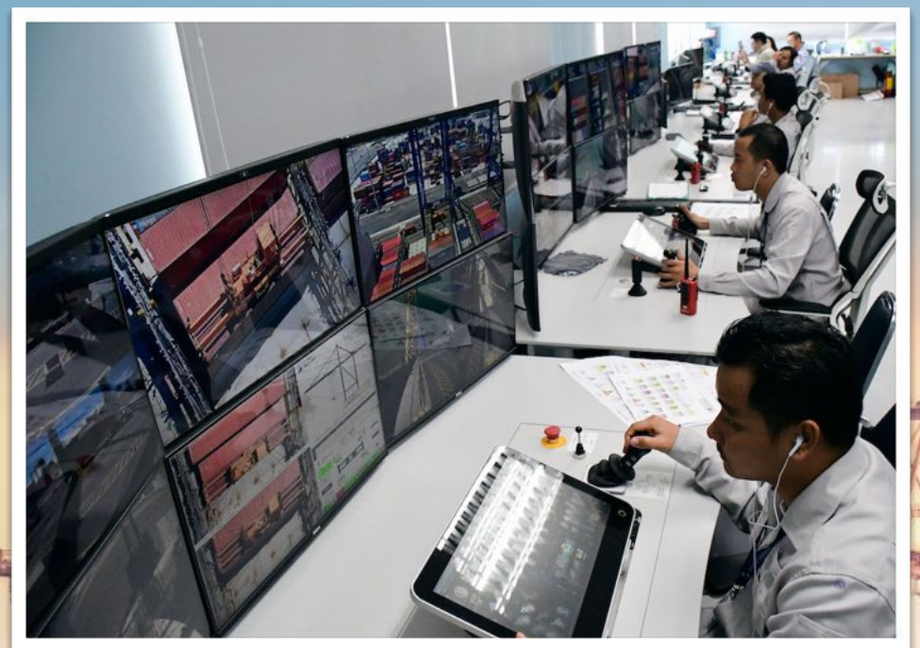
Example 1: Process monitoring and control

100 000 sensors, 2 updates / sec

Up to 1 Gbps up, 700ms on AWS

Resilience and latency constrained

Example 2: Machine assisted fleet control



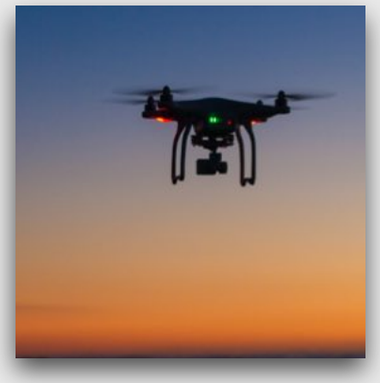
Cargo handling, logistics and transportation
Local as only big harbors have enough volume
Resilience and latency constrained

HIGH-RESILIENCE LOW-LATENCY STREAMING

$1.5 TRILLION MARKET (… AND MORE IN THE MAKING BY DTN WG!)

Autonomous driving and machine assisted operations

Mining, cargo, fleet management, auxilary services, edge compute part of control loop



UxV, rovers and roamers

Energy, grid, agriculture, Oil and gas, surveillance, search and resque, teleoperated robots

AR/VR telepresence, metaverse distributed experiences

Design and engineering, review, participatory work with stakeholders and customers

Smart factory, IIoT production, market control

Medical, food, chemicals, pulp & paper, distributed process monitoring and control

Remote onboarding, ticketing and offers field-services

Among 600 million field workers, remote mentoring, services and as built as serviced

DTN WG IS AT THE CORE OF ENABLING THIS MARKET

DTN WG
Delay / Disruption Tolerant Networking
IETF116 (Tokyo, 28.03.2023)

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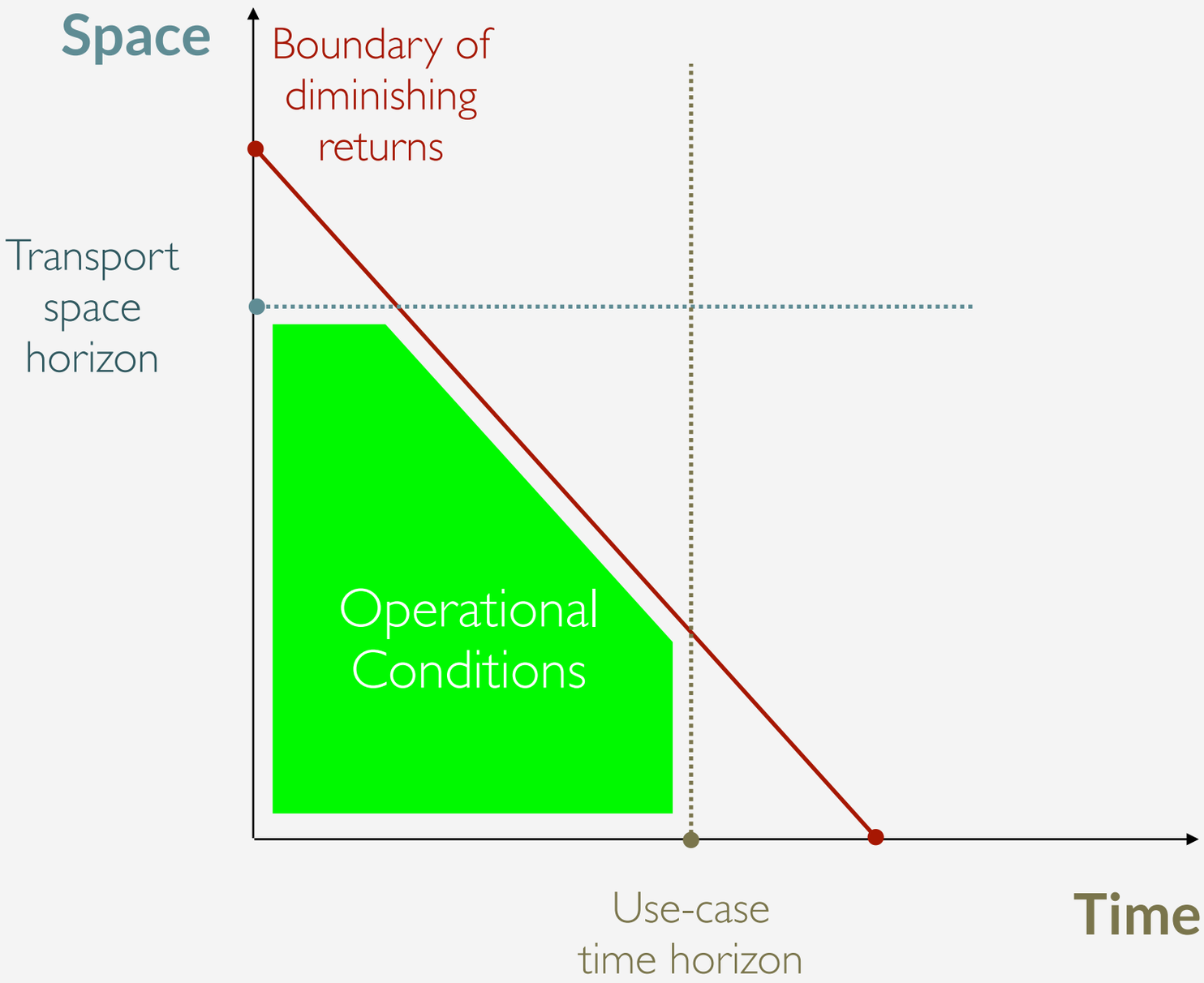
BIG O NOTATION AND COMPLEXITY

Resources required to get an desired output from a specific input conditions.

Space complexity, the amount of space needed for desired output O(m), the space complexity with a given input m.

Time complexity, the amount of time needed for desired output O(n), the time compexity with a given input n.



What are our options with packet loss?

- Loss of a packet is space complexity issue
- Increase of delay is time complexity issue