



#### Virtualized Ground Station

#### Wideband Signal Processing

DIFI WORKSHOP



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## Introductions

## Who is KSAT?

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## **Kongsberg Satellite Services (KSAT)**

#### World's largest LEO Satellite Ground Station Network 350+ Groundstations over 25+ locations





Svalbard (78° North)



Tromsø Norway - KSAT-HQ (69° North)



Troll Antarctica (72° South)

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## A few facts about KSAT

- 1.7M+ satellite contacts per year across the network
  - 99.5% Proficiency
  - 99.9% Availability

- Approx 35% of Groundstations have been virtualized
- API service (Ground Station aaS model)
- All services are automated & M2M

- Svalsat (150+ Apertures)
- Multiple Bands & Sizes
  - UHF/S/X/Ku/Ka
  - 3m 13m LEO Apertures
  - 20+m Lunar Apertures
  - 50cm Optical-1550nm



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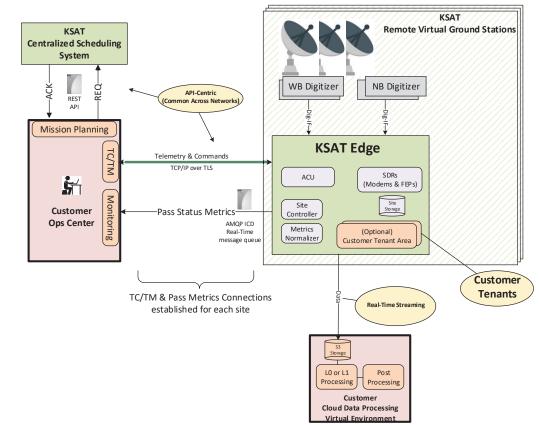
# Virtualized Ground Station

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## **KSAT's Virtual Ground Station**

- Foundational Components
  - Digital-IF (DIFI standard)
  - Cloud Compute Solution (Edge or Public)
  - SDRs
- Performance
  - S & X-band (up to 400MHz bandwidth)
    - Direct S-Band Digitization (sampling)
  - 2Gbps throughput (dual-pole)
    - Limitations of Bandwidth & SDRs
  - 1min setup time (limited by mechanical)



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## Wideband Signal Processing

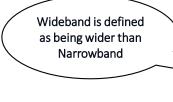
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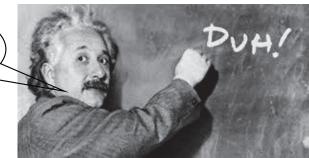


## What is Wideband?

«Wideband» varies by application, band & decade:

- Deep Space vs. LEO vs. HTS vs. Relay
- Optical vs. RF
- 1990s vs 2000s vs 2010s





KSAT's Definition:

- Payload (or X-band) services
- Typically greater than 20MHz Bandwidth
- Large range of BW's: 20MHz 1500MHz

For Virtualized Ground Stations: The Digital-IF network BW is now a defining factor for Wideband

Digital-IF BW > 1Gbps (approx 40MHz)

Digital-IF Bandwidth is the number one challenge for our virtualized architecture

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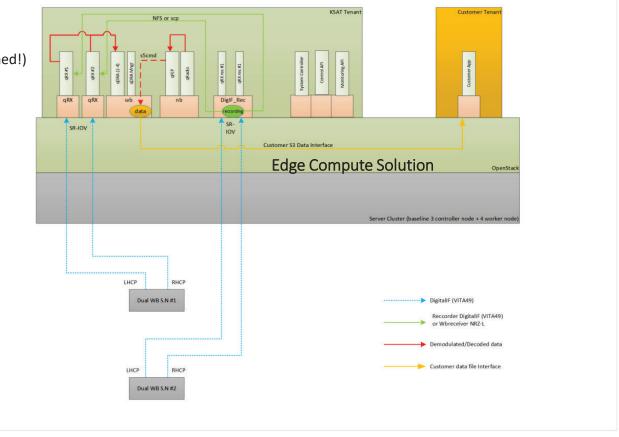
## **Processing Solution**

Stressing Wideband Use Case:

- 400MHz Bandwidth
- Digitizer: 475Msps (Digital-IF BW: 7.6Gbps sustained!)

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- 516Mbps Datarate
- 8PSK + R/S
- Challenges
  - Digital-IF Packet Loss
  - CPU Interrupt Servicing
  - Memory Access
  - CPU type & quantity





### **Biggest Challenge: Packet Loss!**

#### Initial Implemention (50% Packet Loss Rate)

• Standard ENET Frames (650k packets / sec)

#### Intermediate Implementation (5% packet loss)

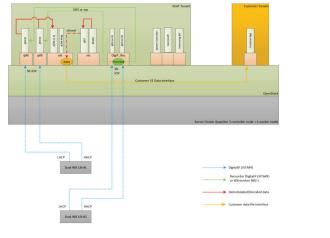
- Jumbo Frames (100k packets / sec)
- NUMA Node with CPU Pinning
- Optimized LXC Container on VM

#### Final Implementation (Lossless)

- SR-IOV
- Use NICs with dedicated PCIe to CPU
- Increased Network Buffers and queue length

#### Solving Packet Loss has allowed for virtualization of X-Band









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## Where do we go next?

Chasing Moore's Law

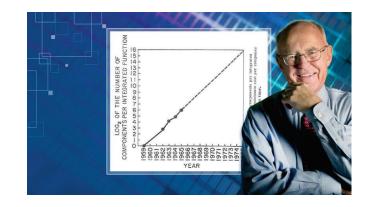
Use Cases which remain untapped or just beyond the horizon

#### Ka-Band (1500MHz spectrum)

• 4x what we can do today

#### **Digital-IF long haul transfer**

- Public Cloud processing
- Sensitive / Restricted Processing solutions







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## **KSAT Perspective / Thoughts**

Virtualized Ground Station Architecture has brought significant efficiencies

- Reduced bespoke «boxes» and simplified/standardized supply chains
- Simplified and expedited remote site setup
- Quicker / More Flexible waveform adaptation

#### Overcoming Challenges / Lessons Learned

- (Cloud and Network Engineers) vs. (Traditional RF & Infrastructure Engineers)
- Packet Loss is an architectural killer for Digital-IF (Virtualized) architectures