



Modernizing Satellite Communications: Cloud-Native Infrastructure and AI/ML at Constellation Scale

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Agenda

- Modernization Challenges
- Cloud-Native Solutions
- AI/ML Applications
- WAVE Standard
- 5G NTN



High-Level Solutions Overview



GenAI & ML

Software development lifecycle
Natural language interaction
with complex data sets
RAG and Agents for Space
Satcom AI & ML



Modernization

Digital Satcom
5G NTN
Constellation Digital Twins
Distributed Processing
Digital Engineering

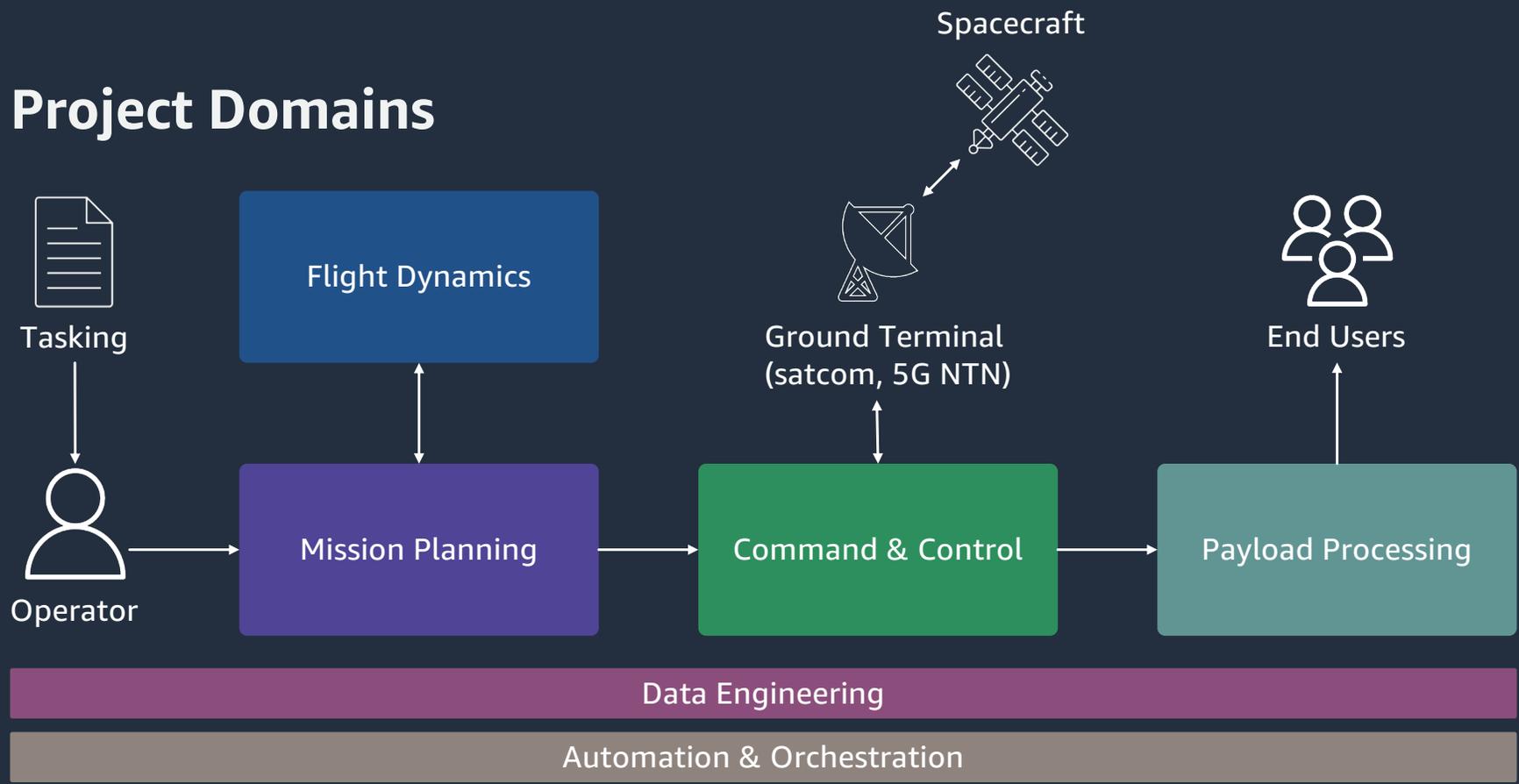


Data

Space data fabric
Real-time insights
Partner data integration

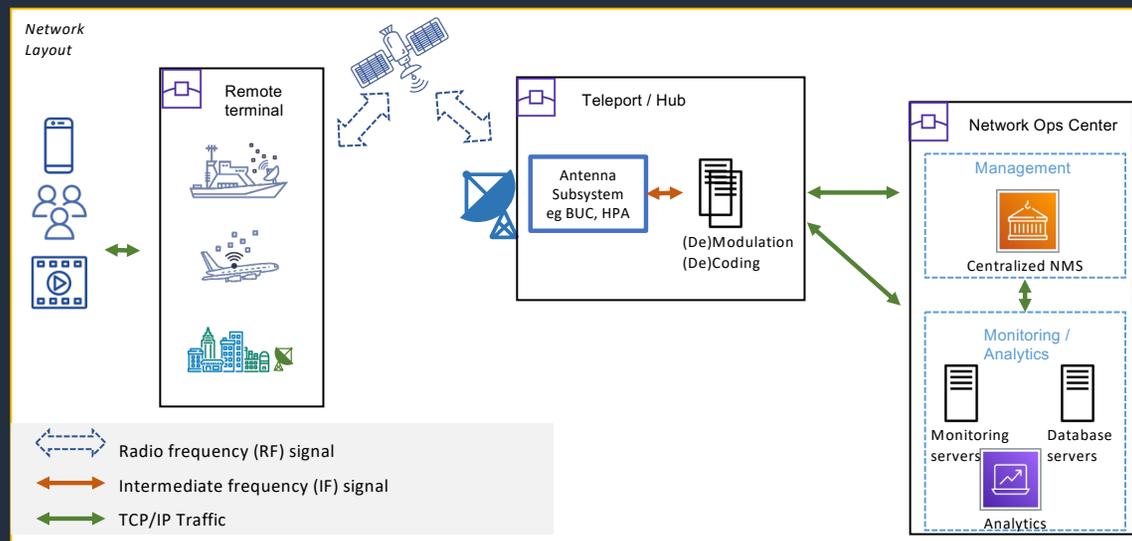


Project Domains



Background

Traditional Satellite communications : Fixed hardware at teleports and Network Operations Center

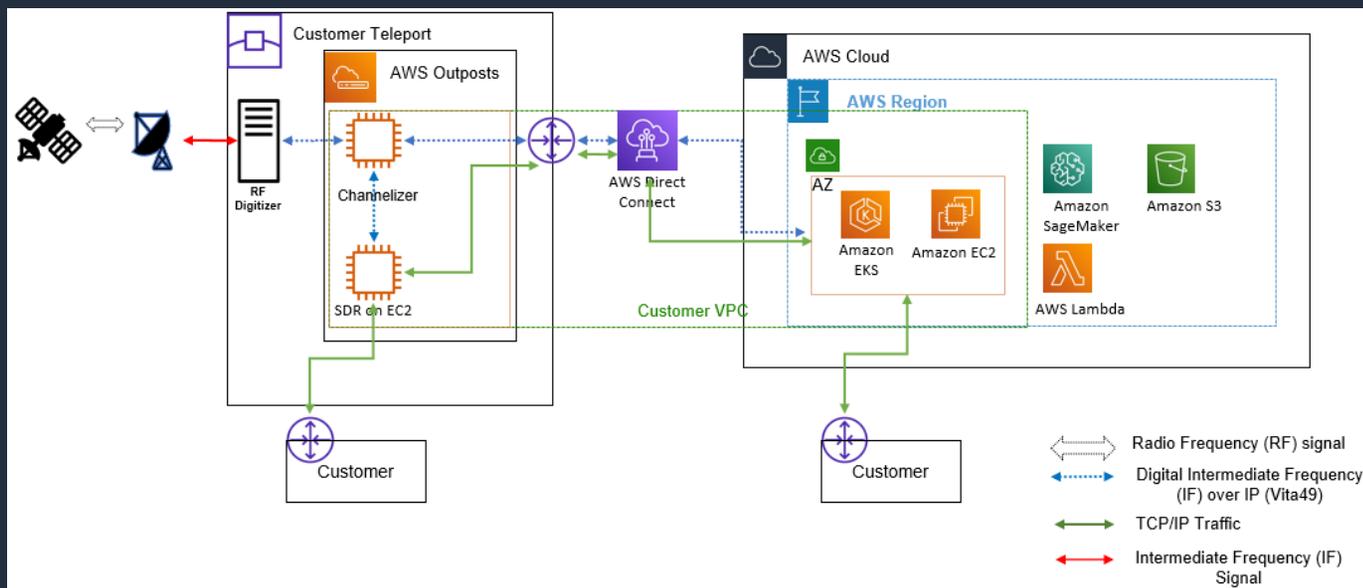


Disadvantages

- Inflexible – difficult to scale up/down
- Upfront capex – cost of modulators, demodulators
- Operations overhead – onsite maintenance at tens of teleports
- Large physical infrastructure footprint – cooling etc.
- Vendor lock
- Complex to upgrade

Agile satcom

New Satcom : Cloud-based modulation/demodulation (SDR), high-availability Network Management, AI/ML

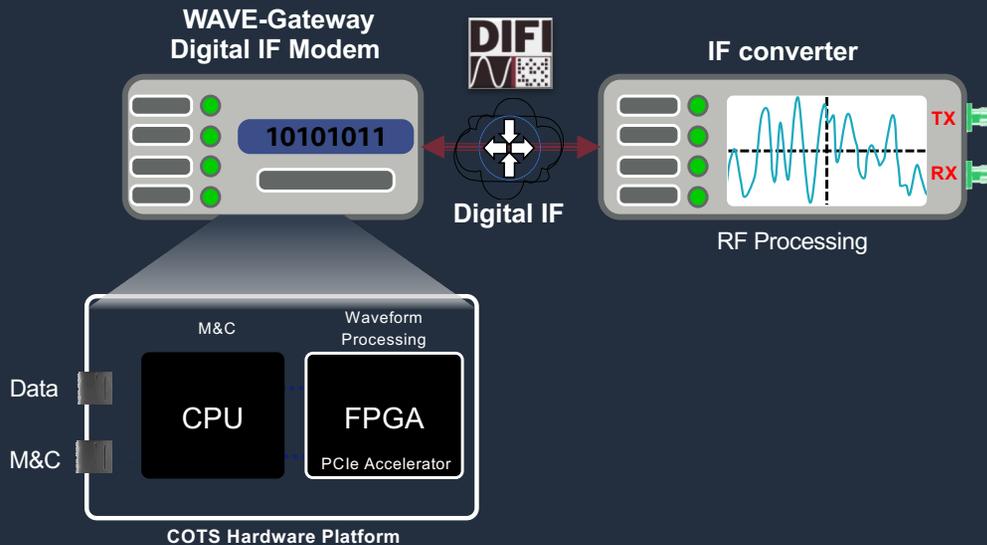


Transform ground-stations to open, virtualized architecture enabling scale, flexibility and simplified operations

WAVE – a new standard driving the Satcom industry

Waveform Architecture for Virtualized Ecosystems

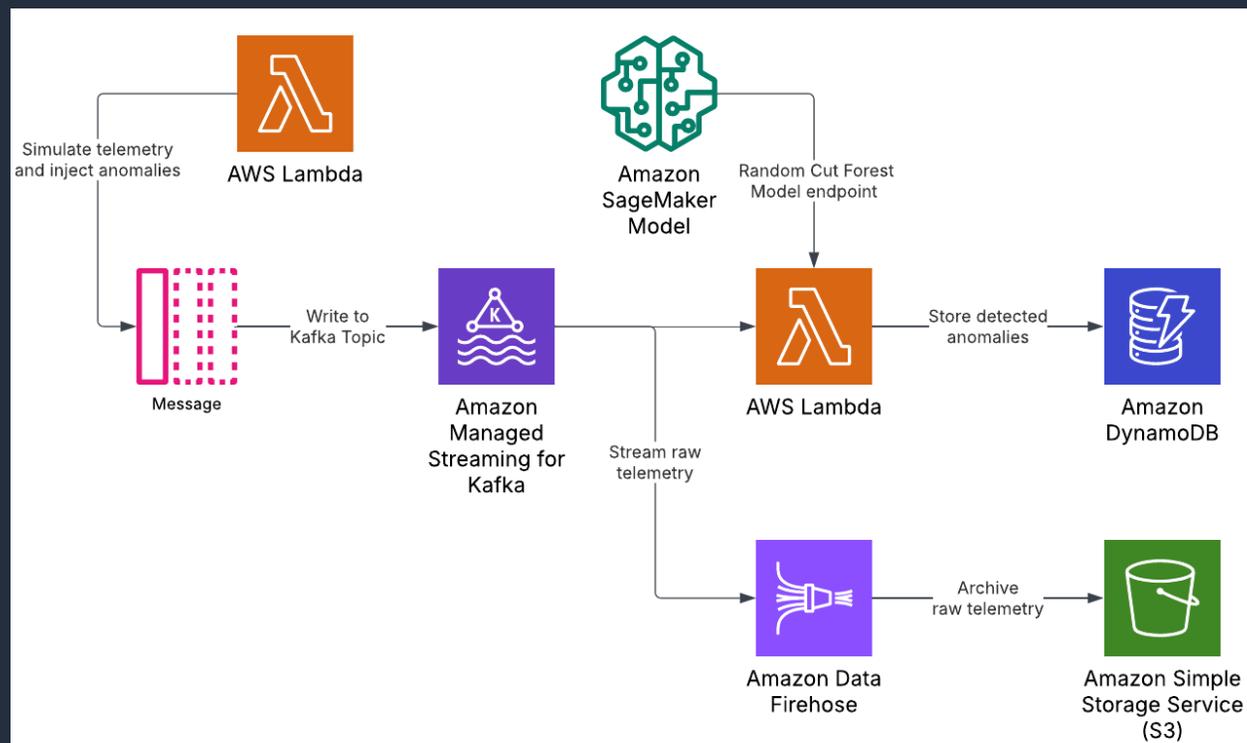
- The Telecommunications industry has had well established standards (3GPP) for >25 years.
- WAVE will help drive Satcom to an interoperable ecosystem with virtualized networks.



AWS is a founding member of the WAVE consortium



Payload/Telemetry Processing – Architecture Diagram



Payload/Telemetry Processing – Real-time Anomaly Detection

serverless-telemetry-msk Info

[Actions](#)

Cluster summary

[View client information](#)

Status Active	Cluster type Serverless	ARN arn:aws:kafka:us-east-1:909812796193:cluster/serverless-telemetry-msk/46ea8171-3075-4903-a971-cb82548e4838-s3	Creation time April 5, 2025 at 14:57 UTC
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[Metrics](#) | [Properties](#) | [Cluster operations](#) | [Tags \(0\)](#) | [Pipes](#) | [S3 delivery](#)

Amazon CloudWatch metrics Info

[Investigate with AI - new](#) | 3h | 1d | 1w | 12M | Local timezone | [Create CloudWatch alarm](#) | [Explore related](#)

Bytes per second received from clients

Time	BytesInPerSec
09:00	0
12:00	0
15:00	0
18:00	0
21:00	672
04/27	0

Bytes per second sent to clients

Time	BytesOutPerSec
09:00	0
12:00	0
15:00	0
18:00	0
21:00	746
04/27	0

Timestamp	Message
	There are older events to load. Load more.
2025-04-05T21:44:21.88...	Message latency (time since production): 255170.41 ms
2025-04-05T21:44:21.92...	Inference latency: 39.75 ms
2025-04-05T21:44:21.92...	Anomaly score for value 7.5: {'score': 2.2470949118}
2025-04-05T21:44:21.94...	Inference latency: 59.70 ms
2025-04-05T21:44:21.94...	Anomaly score for value 4.6: {'score': 1.1296331308}
2025-04-05T21:44:21.98...	Inference latency: 99.85 ms
2025-04-05T21:44:21.98...	Anomaly score for value 784.0: {'score': 4.555589707}
2025-04-05T21:44:22.02...	Inference latency: 139.70 ms
2025-04-05T21:44:22.02...	Anomaly score for value 4.0: {'score': 1.7266828134}
2025-04-05T21:44:22.02...	Message latency (time since production): 255165.41 ms
2025-04-05T21:44:22.04...	Inference latency: 19.72 ms
2025-04-05T21:44:22.04...	Anomaly score for value -173.7: {'score': 4.4448089461}
2025-04-05T21:44:22.08...	Inference latency: 60.30 ms
2025-04-05T21:44:22.08...	Anomaly score for value 4.8: {'score': 1.0683563243}
2025-04-05T21:44:22.10...	Inference latency: 79.74 ms



Detect telemetry anomalies in under 100 ms using ML

AI/ML - IQ Constellation interference detection

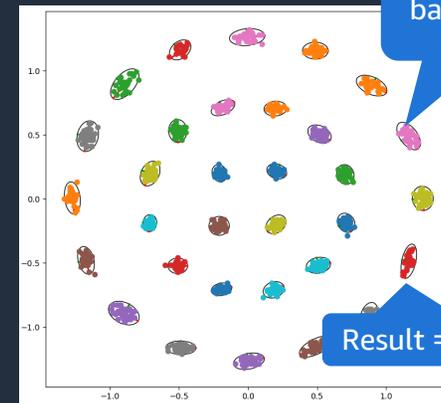
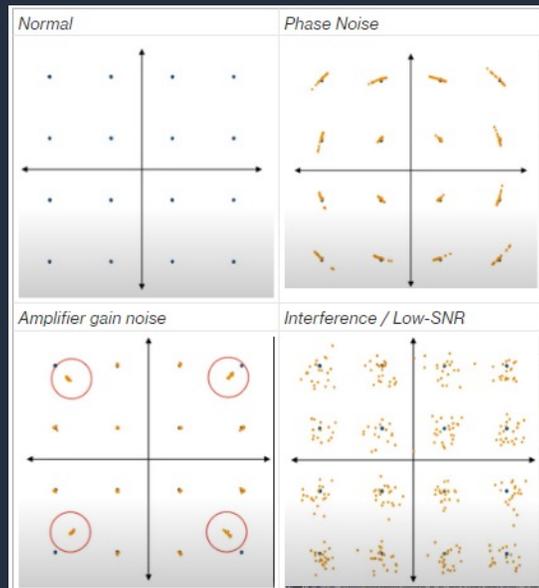
Detect interference and/or noise patterns in Digital IF data



Amazon SageMaker



Amazon Simple Storage Service (Amazon S3)



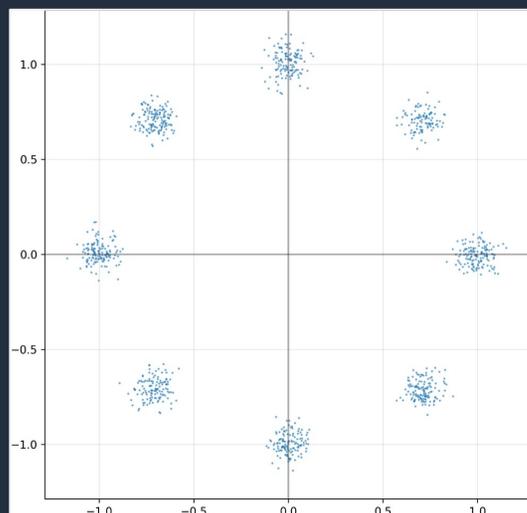
Result = Phase Noise

<input checked="" type="checkbox"/>	Name	Type	Last modified
<input checked="" type="checkbox"/>	sdr-report-2023-03-28-20-18-59.json	json	March 28, 2023, 16:19:00 (UTC-04:00)

Write summary report to S3



Generative AI - IQ Constellation interference detection



Alternate method to detect interference using GenAI

PROMPT

"You are an RF Analyst looking at IQ constellation diagrams. You need to determine the modulation type. You also need to determine if the constellation has noise present, and if so what type of noise or imbalance? Finally indicate typical causes of the noise."

ClaudeSonnet

Looking at this IQ constellation diagram, I can make the following analysis:

1. Modulation Type:

- This appears to be an 8-PSK (8-Phase Shift Keying) modulation

2. Noise Present:

- Yes, there is visible noise in the constellation
- The constellation points show spreading/scatter around their ideal positions
- The spread appears to be roughly Gaussian in nature

3. Typical Causes:

- Additive White Gaussian Noise (AWGN) is likely the primary contributor, caused by:
 - * Low signal-to-noise ratio (SNR)
 - * Channel interference
 - * Phase noise in the local oscillator
- There doesn't appear to be any significant amplitude or phase imbalance, as the constellation points are relatively symmetrical

Overall, while there is noticeable noise, the constellation points are still clearly distinguishable, suggesting this is still a functional communication link

What is 5G over NTN?

5G over Non-Terrestrial Networks is used to deliver wireless connectivity to remote locations through the deployment of satellites/HAPS/drones

Support for NTN formally introduced into 3GPP spec in release 17

Benefits:

- Global coverage, network resilience, new use-cases e.g. IoT

On the space side:

- **NGSO (LEO, MEO):** Lower latency
- **GSO (GEO):** Continuous coverage, critical services

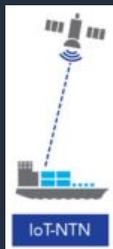


5G NTN – Use Cases

Narrowband IoT

<100 kbps, low power

- SOS messaging e.g. *Apple Emergency Text via Satellite*
- Asset tracking e.g. shipping containers



New Radio

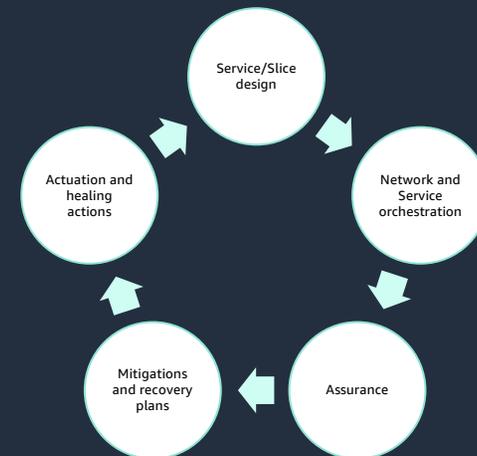
Up to 20 Gbps, large frequency bands in L, S-band & future Ka

- Mobility – ships, trains
- Network resilience – disaster relief



GenAI-powered telecom

- Network Genius – anomaly detection, service repair
- Small language models – edge inference



Repositories

HOW TO GET STARTED

Use case	Type	Title
Satcom AI/ML & GenAI	Github repo	Interference detection
Digital Satcom	Blog	Agile satellite communication ground systems with Amazon EC2 F2 FPGA solutions
5G NTN	Blog	Modernize 5G networks with second-generation AWS Outposts racks



Summary

- Transforming Legacy To Modern
- Key Enablers
- AI/ML Innovations
- Market Opportunities

Thank You

