Consideration in Planning to Use Commercial Ground Networks

GSAW
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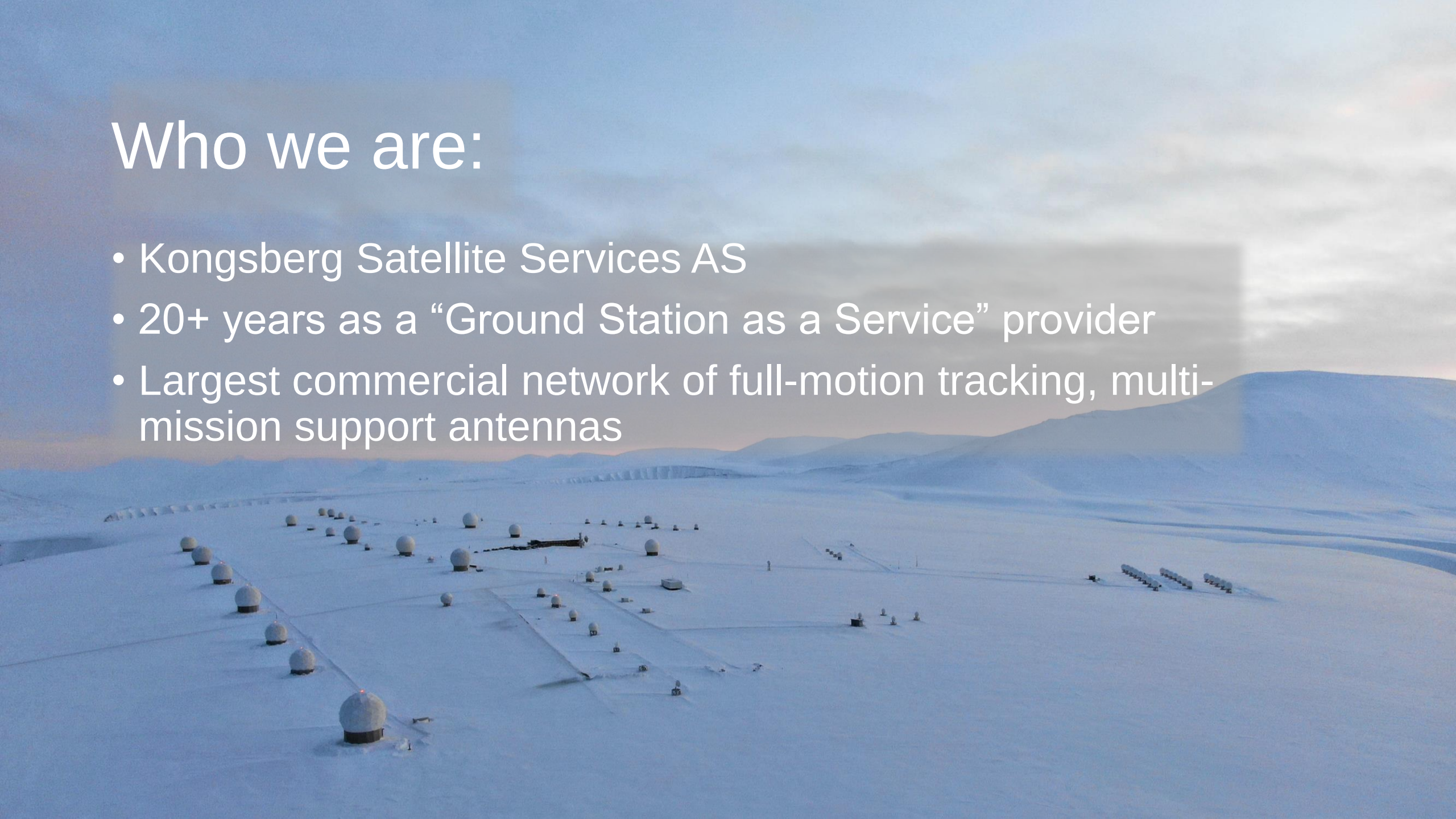
Who we are:

- Kongsberg Satellite Services AS
- 20+ years as a “Ground Station as a Service” provider
- Largest commercial network of full-motion tracking, multi-mission support antennas



Agenda

- Definition of Commercial Ground
- Benefits of Commercial Ground
- Programmatic Considerations
  - Ground Networks Fit to Need
  - Service models
  - SLAs
  - Operational support
- Technical Considerations
  - Waveform support
  - Interfaces
  - Security

Tutorial Goals

Our goal is to demystify commercial ground solutions

- Explain a little on what a commercial ground network is
- Highlight important areas to consider when developing your satellite-ground solution (Both technical and programmatic)

What’s Not Included:

- We won't be discussing specific technical or programmatic details of individual vendor offerings

What is Commercial Ground?

- Federated group of antennas/ ground stations integrated to a network
- Multi-user environment designed to optimize asset utilization for high-value / low cost
  - Commercial
  - Government / agency
  - International

How did we get here?

- Increasing volume of space-ground contacts
- Maturation of waveforms and standards
  - Leads to multi-mission capabilities
  - Leads to economies of scale
- Signal Processing Systems commonization
  - Modems / FEPs
  - Antenna assemblies
- Integrators and services providers
- Optimization and commercialization of space supply chains

Natural Progression

- Telecom & Mobile Networks
- SATCom & Broadcast Video Networks
- LEO / Earth Exploration Networks

Benefits of Commercial Ground Solutions

- Resiliency through proliferated networks
- Testable support functions
- Quicker time to market
- Scalable capacity
- Reduced non-recurring mission cost
- Pre-defined recurring mission operations costs
- Demonstrated capabilities with measurable performance

Preparing for Commercial Ground **Program Considerations**

Ground Station Locations and Network

- Ground Station Geographies: Location, Location, Location
- Supporting network and backhaul infrastructure

➢Which network supports your interests best: Coverage, Latency, Revisit Rates, etc.

➢Will you need to use more than one network?

Service Models

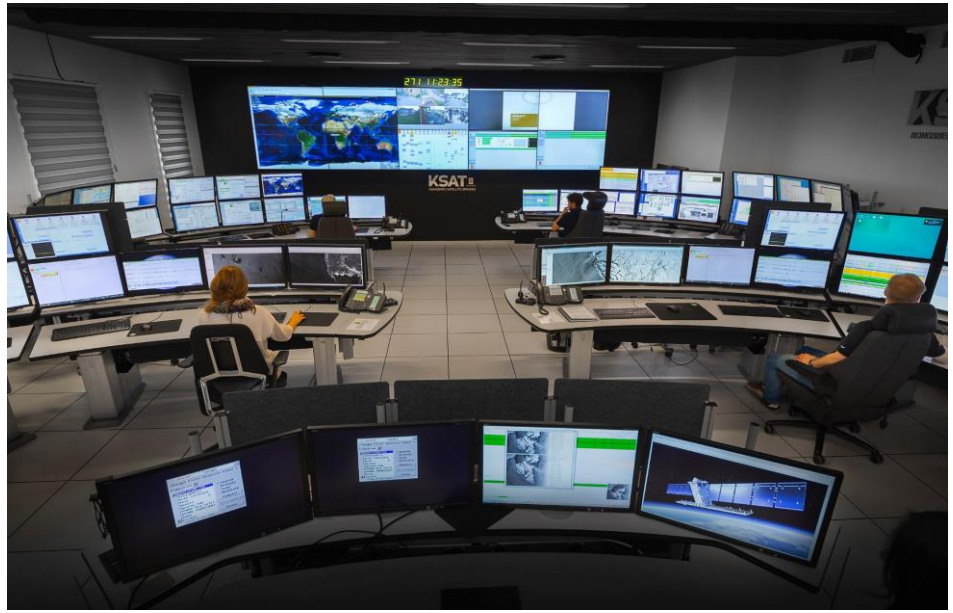
- Pricing – Recurring and Non-Recurring Costs
  - On-boarding and program management
  - RF and Network Compatibility testing
  - Per-pass/contact or per-minute charges
  - Network overhead
- Operations Approach
  - Scheduling
  - Commitment levels and contract durations
  - Antenna availability guarantees

Service Level Agreements

- Binding commitments to deliver to set Key Performance Indicators
  - Antenna Availability
  - Network Availability
  - Overall performance or proficiency
  - Equipment Maintenance
  - Service responses times in case of outages
  - Reporting structures
- Guarantees support levels through continued operations – confidence you’re getting what you signed up for

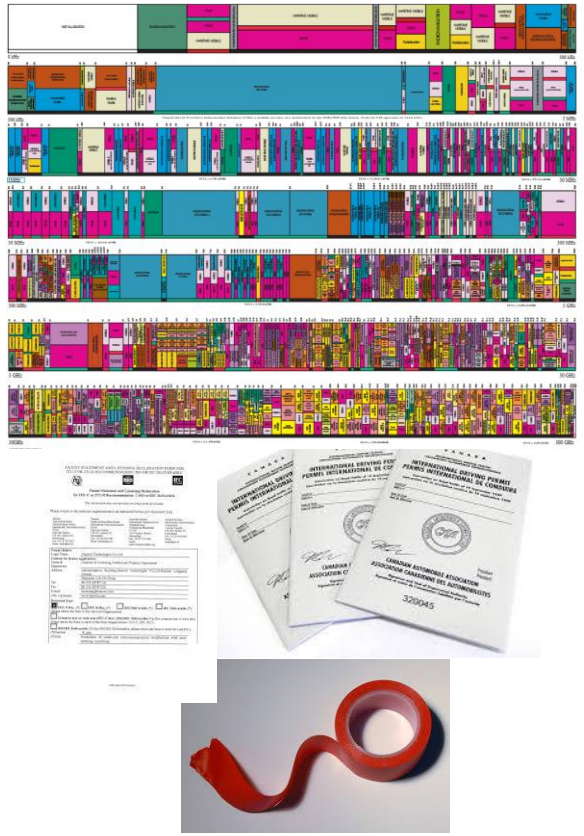
Operational Support

- Availability of engineering, operations, and program resources
- Pre-launch / operational testing and integration support
- Recurring operations on-call and as-needed engineering
- Critical anomaly and/or emergency response capability



RF Ground Licensing

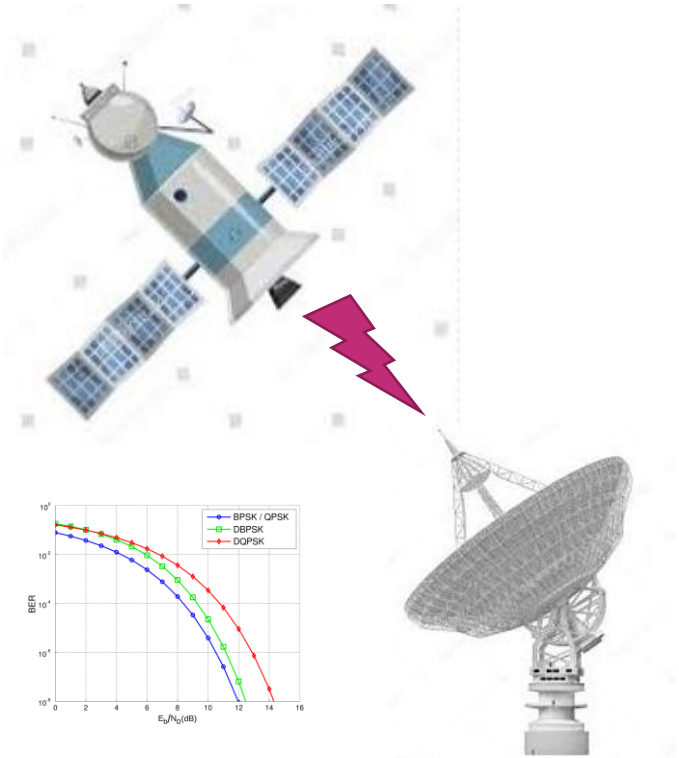
- Typically coordinated as part of the service
- Process and timeline may vary, largely governed by local site jurisdictions
  - Long-term providers have established process and relationships with licensing authorities
  - Some ground station locations may have burdensome cost and schedule constraints
- Spacecraft ITU registration significantly simplifies the process
- Restrictive data markings can create barriers



Preparing for Commercial Ground **Technical Considerations**

RF Technical Specifications

- Traditional due diligence still required
- Each mission must evaluate:
  - Link Budgets
  - Frequency Bands vs. Network Coverage
  - Bandwidth needs and network capabilities
  - Satcom vs LEO "Earth Exploration" applications

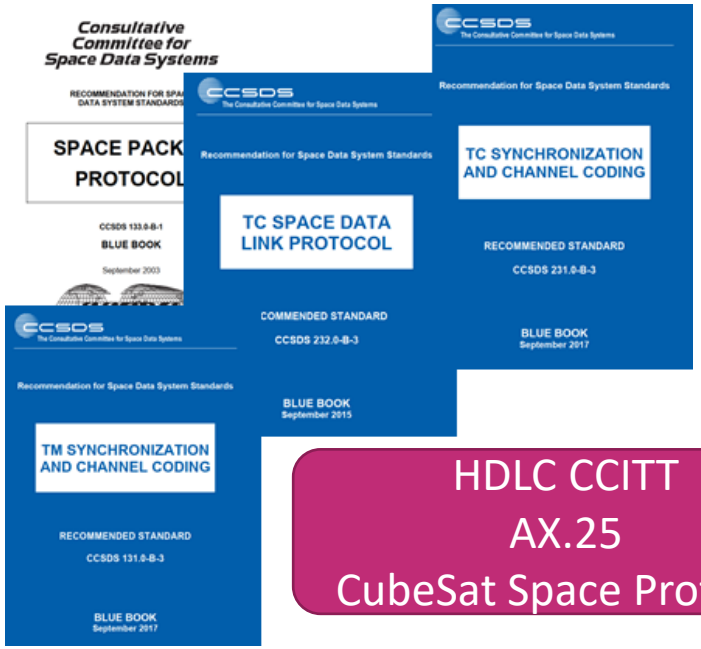


Waveform Compatibility

There's no «Easy Button»
but there is an «Easier Button»

Easiest path to work with commercial ground providers is to follow standards for Layer 1 & Layer 2

We still have to do our homework on space-ground compatibility testing

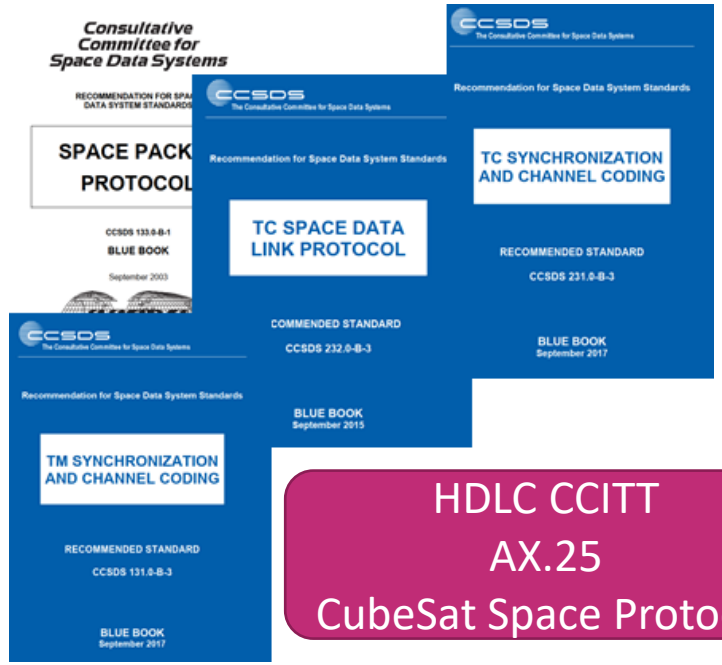


Some example standards (L1 & 2)

HDLC CCITT
AX.25
CubeSat Space Protocol

Layer 2 Processing

- Can be performed by the commercial ground station
  - Data filtering, framing
  - Multiple levels:
    - Space packets, TM, TC, CLTU, CADU
    - HDLC, AX.25
    - Etc...
    - Fill Insertion
- Typically need to work with the provider on their level of capability here



HDLC CCITT
AX.25
CubeSat Space Protocol

Once again, sticking to the standards will give you more flexibility in working with the commercial providers

Dataplane Interfaces Protocols

How do I format commands so the commercial ground station knows what to transmit them?

- Safety with the standards (but not as many standards here)
- Otherwise, typically aligned to signal processing vendor choices

ZODIAC DATA SYSTEMS
ZODIAC AEROSPACE

KRATOS
READY FOR WHAT'S NEXT

AMERGINT
TECHNOLOGIES

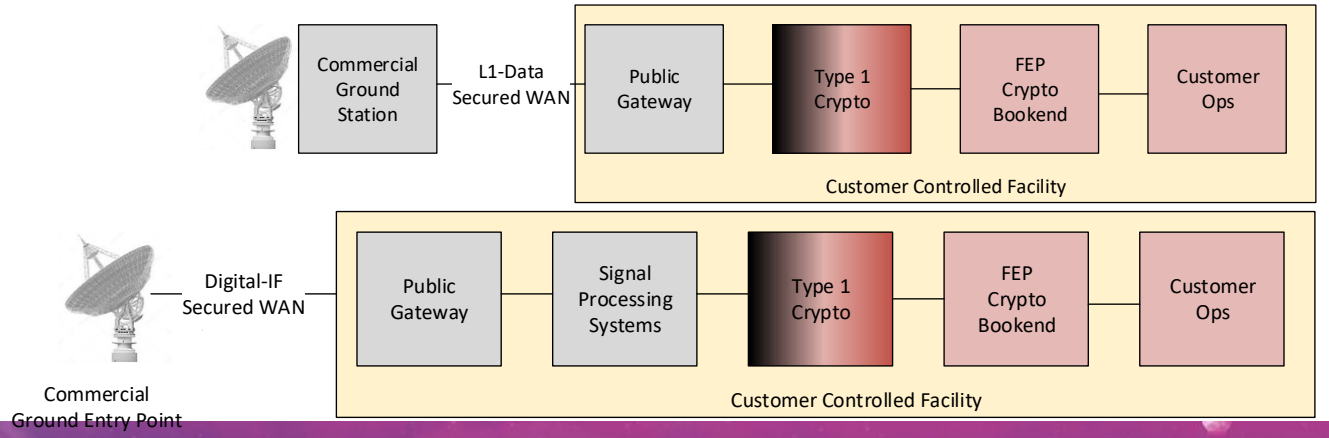
- Typically, an integration is required to link your Mission Control and Operations software to the providers data-plane APIs

Encryption

What if our system requires NSA Type 1 Crypto?

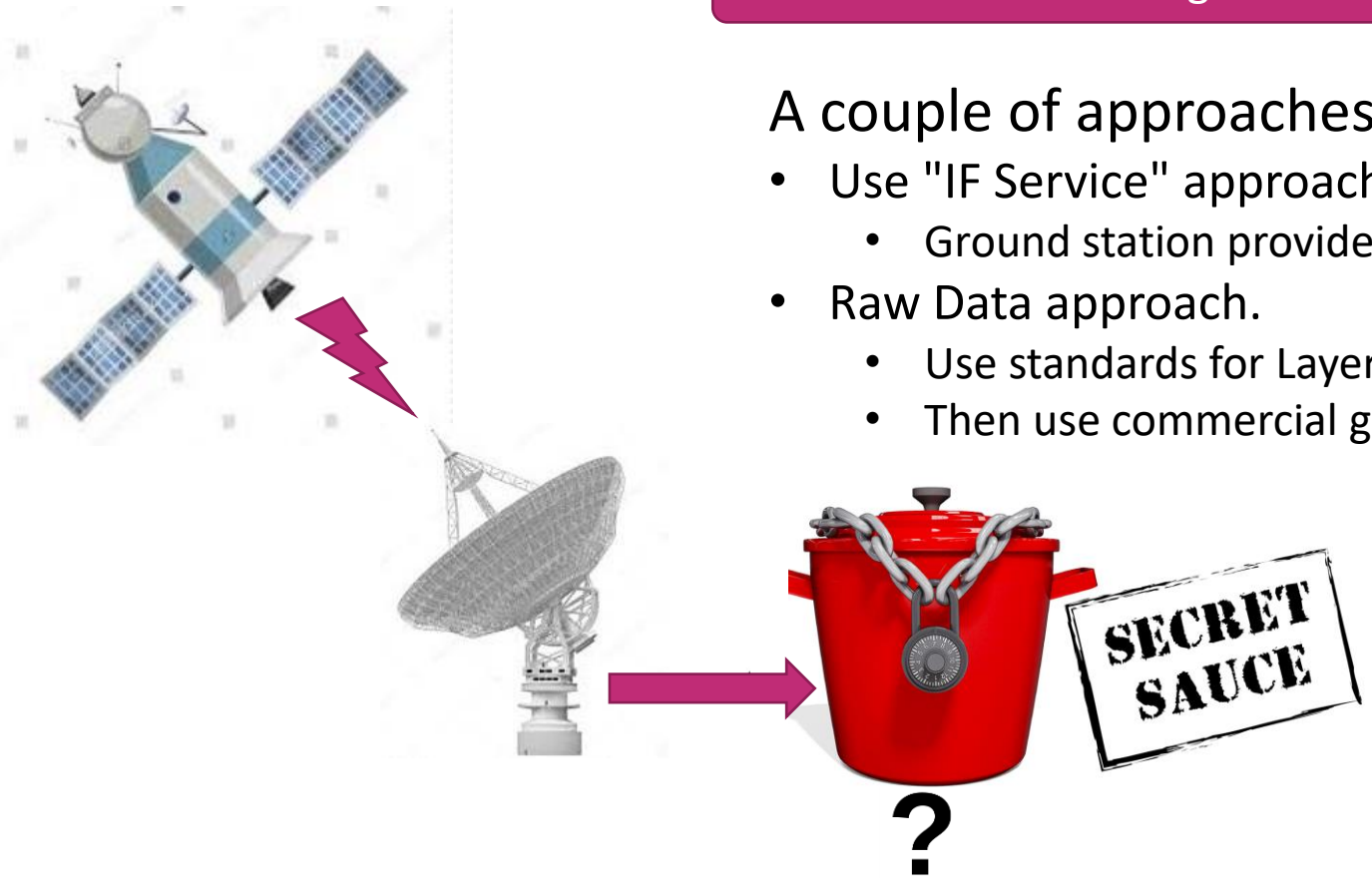
How can I use a commercial ground network?

- Architecture Options:
  - Use commercial ground station for Layer 1 processing
  - Encrypted data transfers to customer facility (Public Gateway)
- Alternatively transport Digital-IF data to customer facility
- Standard Security Enclave separation protocols



What if I need custom processing?

How can a commercial ground network support your secret sauce?



A couple of approaches:

- Use "IF Service" approach.
  - Ground station provides IF access to customer (Digital-IF)
- Raw Data approach.
  - Use standards for Layer 1 & (maybe) Layer 2.
  - Then use commercial ground station to just provide raw bits

Control Plane Interfaces

Scheduling passes on the network and watching your passes

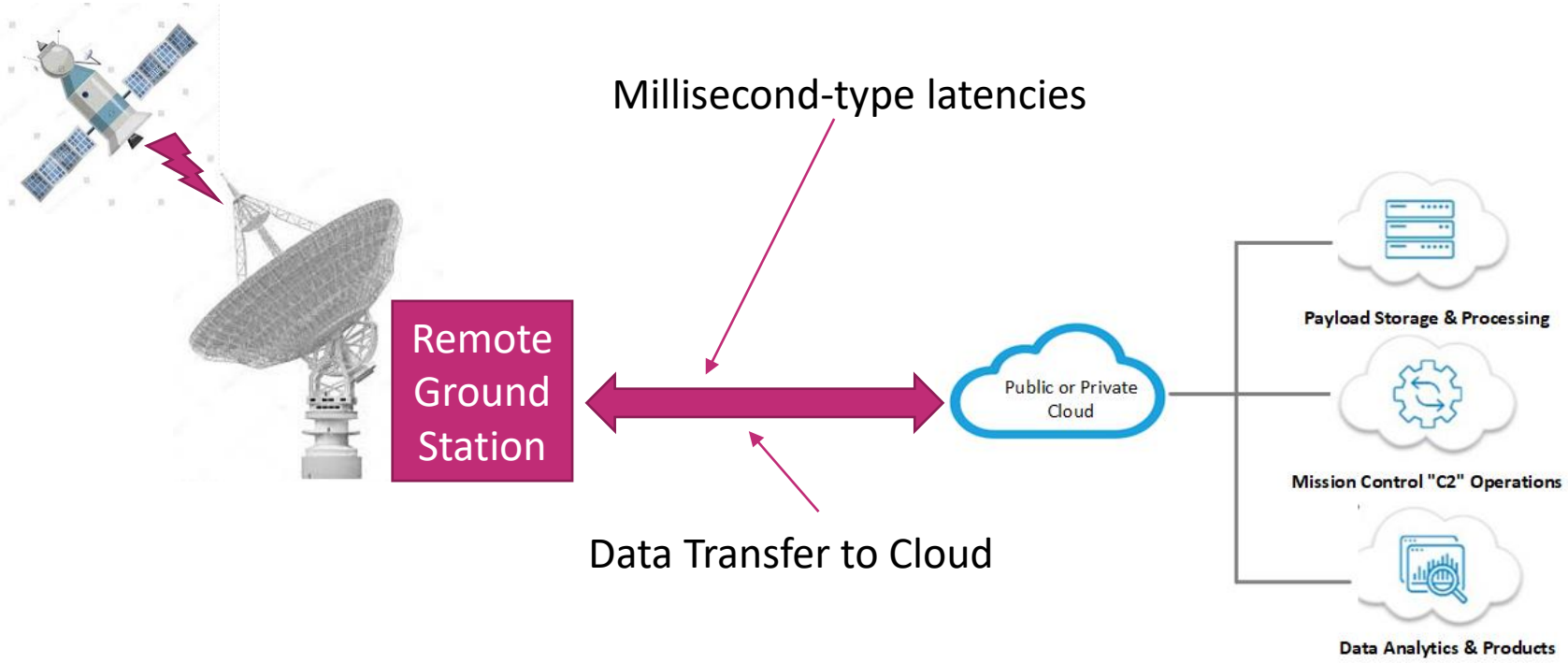
- Scheduling passes (by the minute, by the pass, automated)
  - Scheduling GUIs are available from some service providers
  - In reality: m-2-m scheduling APIs are what’s really used
  - Providers offer "by the minute" (time-based) and/or "by the pass" (contact-based)
  - Typically, an integration is required to link your Mission Control and Operations software to the providers scheduling API
- TLEs: Typically uploaded via service provider proprietary API
- Status Parameters:
  - Once again: APIs
  - Web Portal or similar "real-time" graphical status interface

Security

- Data Plane Security
  - Multiple options and layers here
  - Digital-IF Transport, DTLS / VPN connectivity, Public Cloud (e.g. ExpressRoute), Bulk Data Encryption (e.g. NSA Type 1)
- Data Trust Model
  - Authenticated and whitelisted user endpoint policies
- Physical Security
- Treaty / Jurisdictional issues
  - Some locations within networks have limitations types of data / customers
  - Not just military applications...can also be Satcom vs. Earth Exploration
- Certifications

Ops Center Location & Payload Processing

- Industry is seeing a transition to Cloud-Based Operations Centers
- GSaaS networks are generally transparent to this trend



Thank You!

Please feel free to reach out to Dan or John for more details on any of the topics covered here today