Space based ADS B using NANOSATS

D. Alan Gardiner
BSc (Phys). MSc (Astron),MSc (Telecomms)
aerial-maritime.com

AERIAL MARITIME LTD

SATELLITE ATM SURVEILLANCE SERVICES

Space Based ADS B using NANOSATS.

- Space Based ADS B can provide complete coverage worldwide of terrestrial, oceanic, desert and mountainous terrain and deliver the wide area or specific area situation to the ACC.

- ADS B data from Low Earth Orbiting (LEO) satellites use existing Asterix Cat 21 and other Asterix Protocol messages to enable simple integration with existing or new ATM systems .

- Performance Parameters for Space Based ADS B have been proposed by EUROCAE and RTCA (ED 129-B)

- Aerial Maritime will be certified as a Surveillance Supplier by EASA

- While large satellite hosted Space Based ADS B has been in the forefront of the News for the last few years, our Nanosat based Space based ADS B solution has been quietly under development and has been operating in Space for over 6 years.

- Aerial Maritime plans to offer Space Based ADS B service in a cost effective way using their own NANOSATS from 2019 onwards.

Relationship to ABSU

- **Because Space Based ADS B is seamless and provides consistent situation awareness it has the potential to be a major contributor to the ASBU in 65% of the designated areas. Specifically***

- **Because of the Seamless nature of Space based ADS –B coverage the following ABSU Areas are supported and made more efficient**
  - **NOS,FRTO,FICE,OPFL,SNET,CDO,CCO,TBO,RPAS,NOPS**

- **Because of the extended and complete worldwide nature of surveillance with ADS B the following Areas are supported and made more efficient**
  - **ASUR,RATS,GADS**

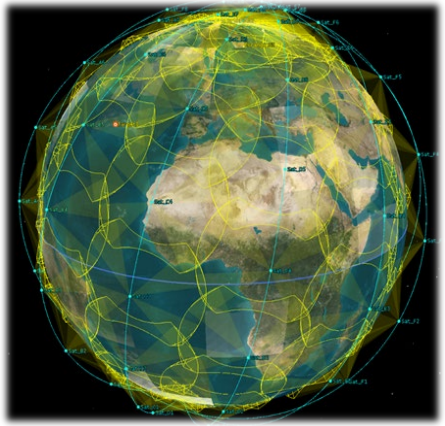
- **Space Based ADS B has now received its own designator within ABSU**
  - **ASUR-B1/1**

* ANSP Guidelines for Implementing ATS Surveillance Services Using Space-Based ADS-B CANSO 2016

Who Are We ?

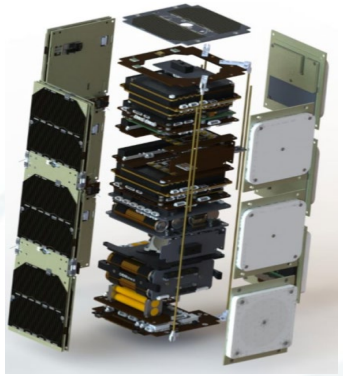
Aerial Maritime Ltd.

- **AM operates the Space and Ground Based ADS B segment for Aircraft and AIS for Ships**
- **Co owned by GomSpace group, Private Equity and Danish Government through their IFU (Investment Fund for Developing Countries)**
- **GomSpace are building the Nanosats for AM**
- **Ground Segment services will be provided by GomSpace.**



GomSpace

- **Major European Nano Satellite maker**
- **Wholly Owned by GomSpace Group**
- **Now building the NANOSATS for AM**
- **Has developed and space tested compact ADS B and AIS receivers**
- **Has produced thousands of components and many complete satellites for companies in Europe and world wide.**



GOM Space/AM
ADS B Nanosat Experience in Space since 2013

Mission	Objectives	Status/ results
GOMX-1 GATOSS	• **2U** platform • 1st gen. ADS-B receiver	• Launched in 2013 • Successful payload demonstration • Platform still in operation
GOMX-2 BY GOMSPACE	• **2U** platform, new avionics • Aero brake payload • Quantum mechanics payload	• *Launch failure in 2014*
GOMX-3 GOMSPACE	• **3U** platform • 2nd gen. ADS-B receiver • Software Defined Radio • 3MBit/s X-band downlink • Robust ADCS capability	• Launched in 2015 • All mission objectives successfully met • Payload functions extended through in-orbit upgrades • Entered in 2016 (12 month+ from ISS)
GOMX-4 BY GOMSPACE	• 2x **6U** platforms • AIS, ADS-B tracking • Visual & hyperspectral camera • Cross linking • Enhanced ADCS capability • Propulsion for station keeping	• Launched February 2018 • Successful mission demonstration of: • Interlink capability • Attitude control • ADS-B reception

GOMX-3 and GOMX-4B funded by ESA, GOMX4A by Danish Defence Authority

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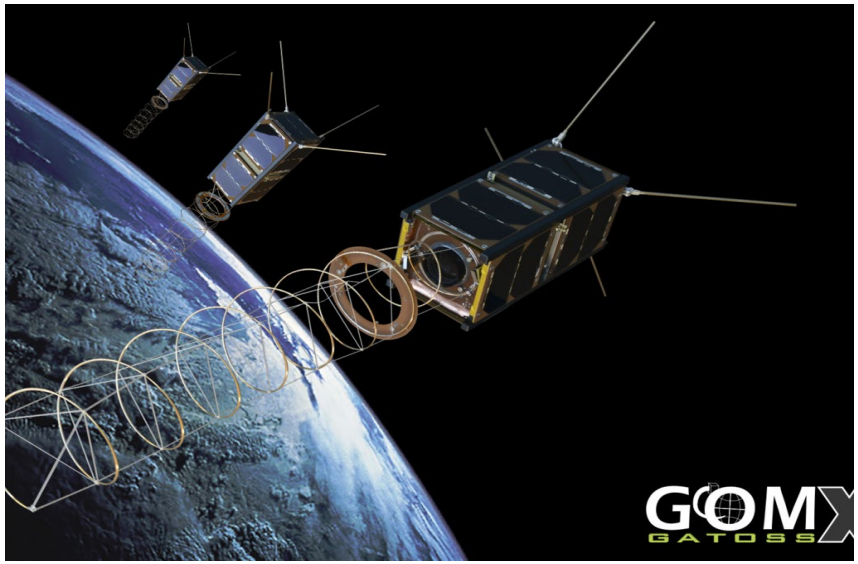
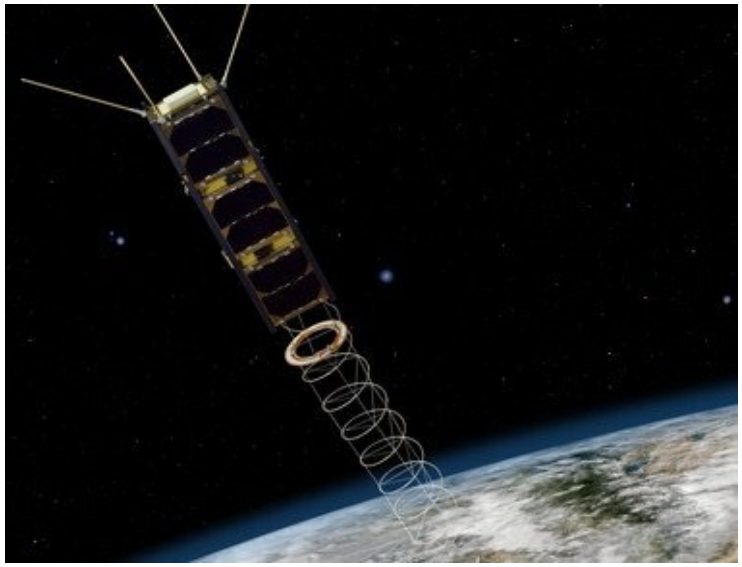


GOMX-1 2U (20x10x10 cm)



GOMX-3 3U (30x10x10 cm)

GOMX-4A and 4B, 6U (20x30x10cm)

Nanosat Deployment

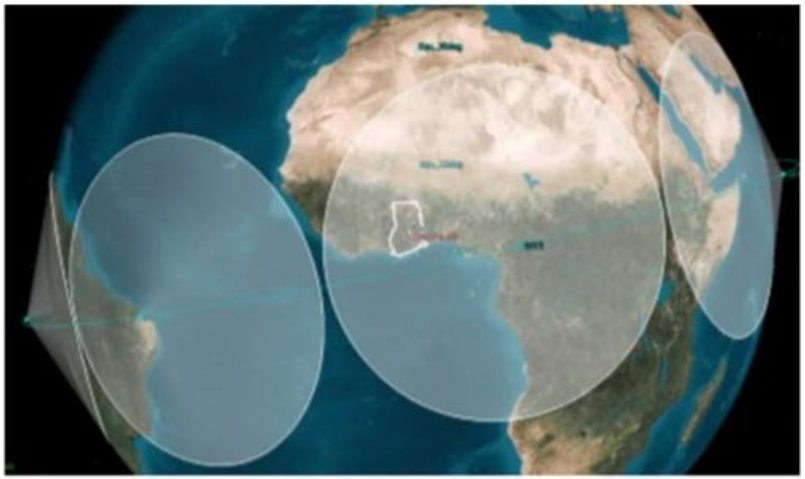
- AM is implementing ADS-B, GADDS 1 & 2 and AIS service capability from specially designed dedicated GOMspace Nano Satellites in Low Earth Orbit (400 to 500 kms) in 2 phases:

- **Phase 1; 8 Satellites in an Equatorial orbit. (2019)**
  Coverage, Equator +/- 20 degrees
  - Update frequency 12 minutes.
  - Primarily low density ADS B Oceanic FIR and Maritime Coverage
  - 4 Equatorial Ground Stations

- **Phase 2: 108 Satellites in Polar orbit. (2020-2021)**
  - 18 interlinked Satellites in 6 orbital planes
  - Complete Global coverage
    - Update Frequency ADS-B; max 8 sec. (ED 129B)
    - Latency ADS-B; max 1.5 sec (ED 129B)
    - Provides surveillance of complete global airspace in low, medium and high density environments
    - 2 Polar Ground Stations
    - Control Centre and Service Centre in Europe (Luxembourg)

Surveillance Data delivered over Secure network to Service Points in Asterix format same as ground based ADS -B

System coverage - Phase 1, 8x3U Sats 2019



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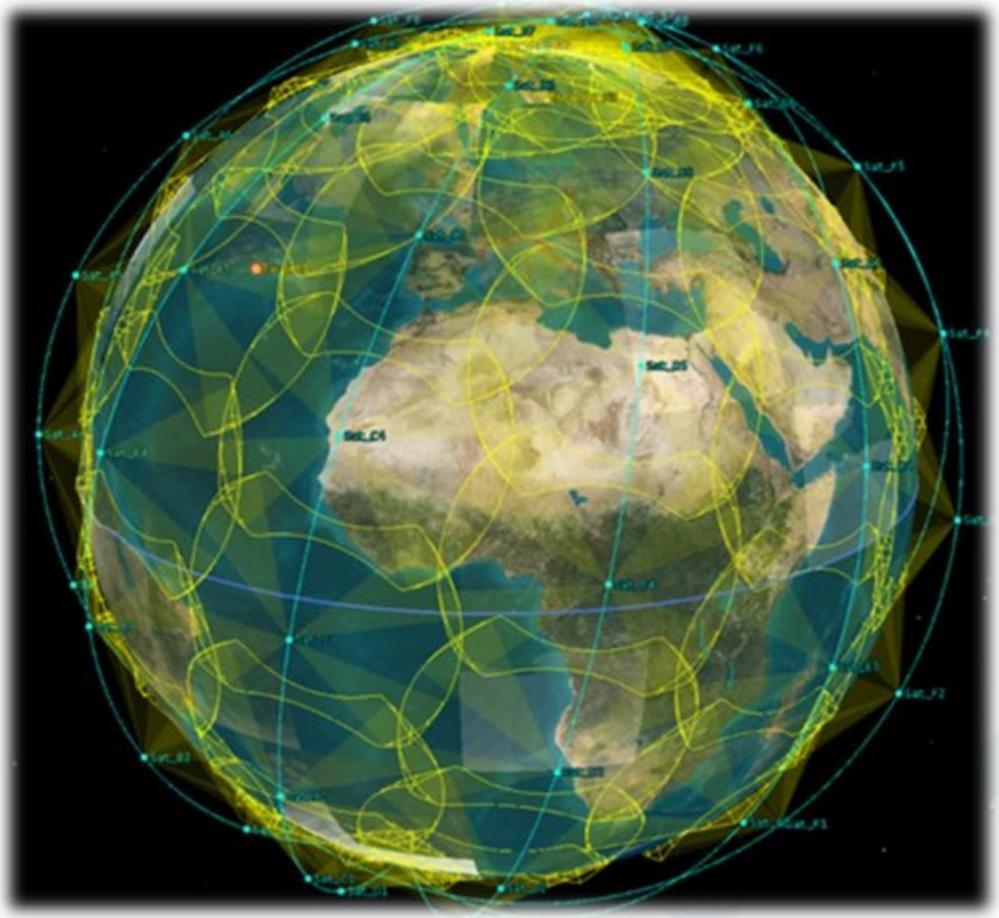
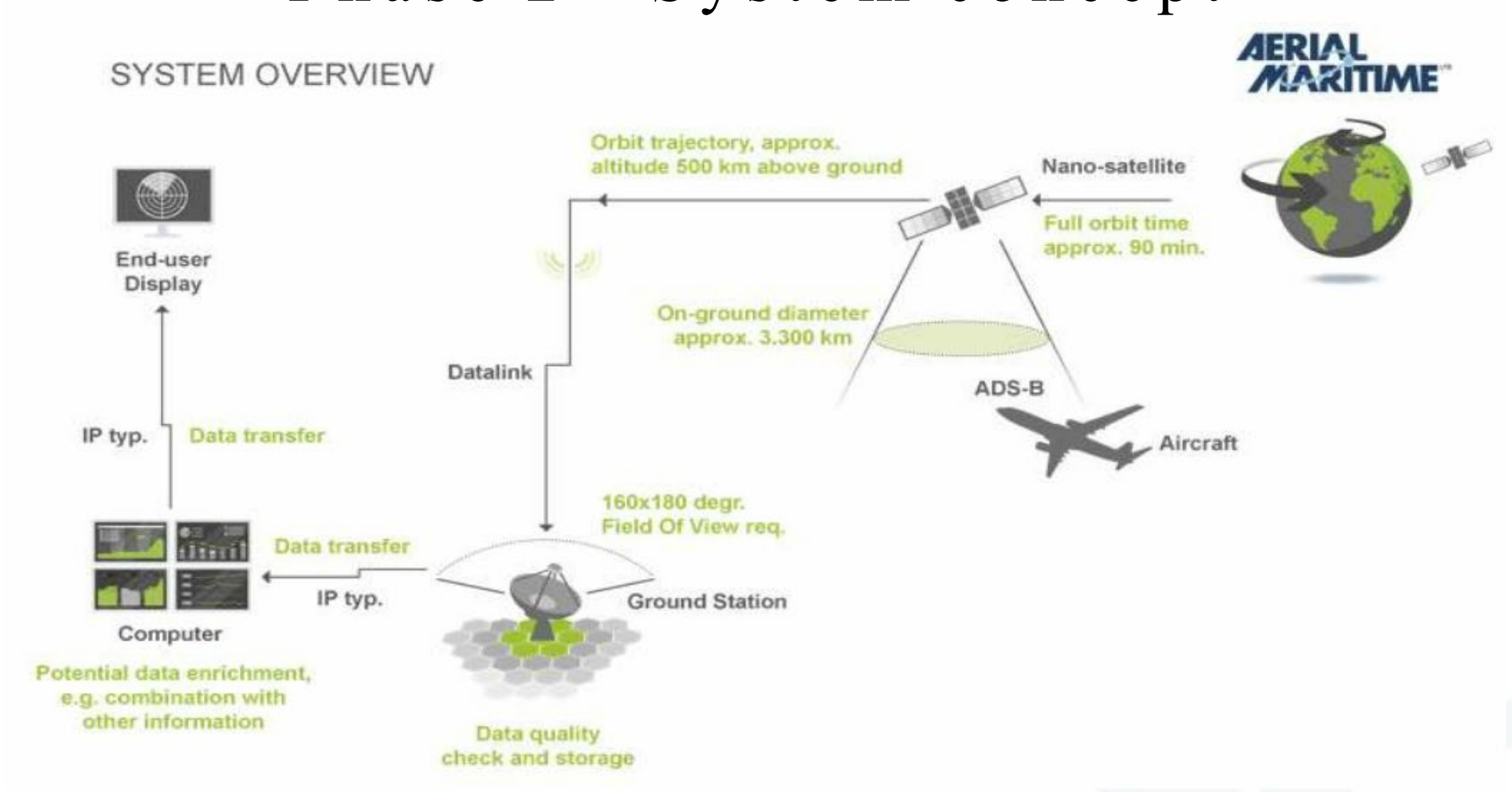
System coverage –Phase 2 108X6U Satellites
Launch 2020-2021, Service from 2022



Phase 2 - System concept

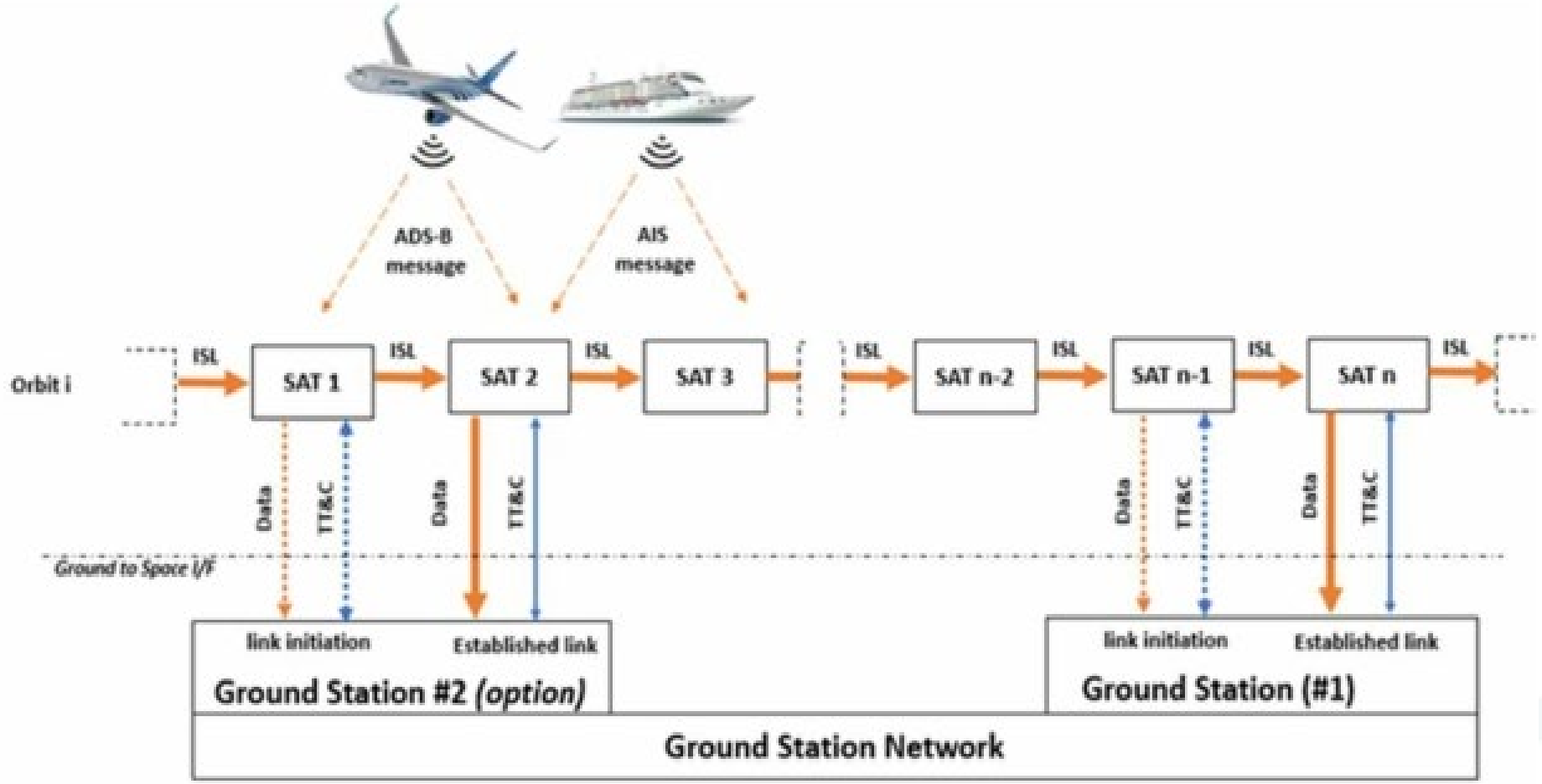


AM Constellation Control Centre and Service Centre is in Europe

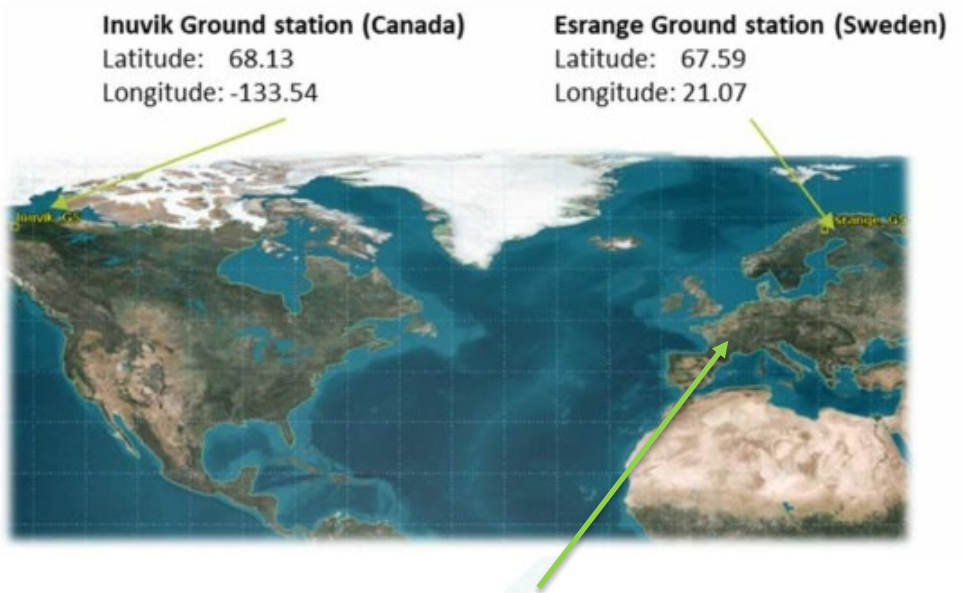
Phase 2 –ADS B Performance

- **Based on Aviation Regulatory requirements (EUEUROCAE/US-RTCA) ED 129-B.**

ED-129 B minimum standards	
Latency	Maximum 1.5 seconds to Automation Platform
Probability of update	• Maximum 8 seconds with **96%** probability in Low Density areas • Maximum 8 seconds with **97.5%** probability in Medium Density areas • Maximum 8 seconds with **98.5** % probability in High Density areas (best effort)



Ground Stations have multiple down link antennas and are in Sweden and Canada

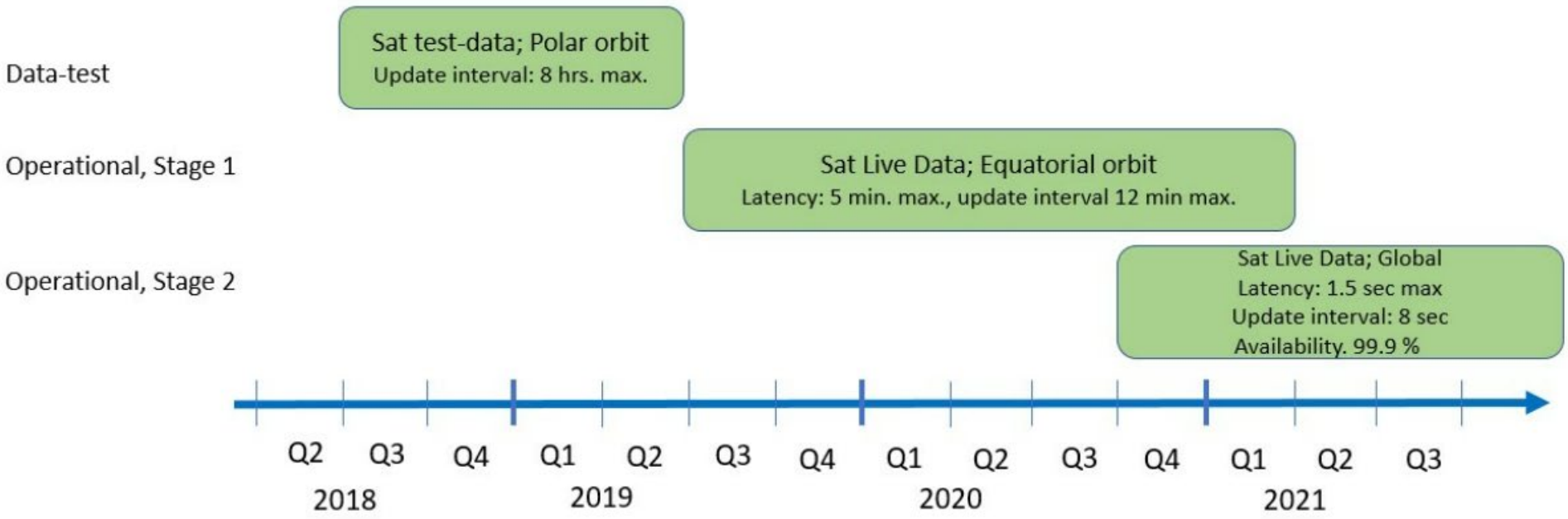


AM Control Centre Luxembourg
Telemetry, Orbit control
Service point for customers

AM Ground Environment

Multiple Nanosats Launched at one time
Low cost - 75% less than Large Satellite Launch

Phase 1 and 2 - Timeline



Increasing capability from 2019 to 2021


| GOMSPACE SATELLITES |
A GLIMPSE INSIDE
Telemetry Radio and Antenna
Fine Sun Sensor
Battery Pack
Propulsion Unit
Software Defined Radio
Advanced Reaction Wheels
S-band Patch Antenna
Modular System Design
High Efficiency Solar Cells

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Space Based ADS-B
Nanosat vs Large Satellite Approach

Nanosat Approach will provide all services to the same standards as implementations using large satellites.

- Meets all ICAO, RTCA and EUROCAE requirements.
- Will seek certification from EASA.
- Equivalent Quality of Service to Large Satellites.

Nanosat Approach has the potential to be more cost effective

- Technology based on proven Mobile Phone electronics and manufacturing.
- Lighter satellites <10kg vs 860kg
- Smaller satellite 600cubic cm vs 11 cubic meters. (1:6000)
- Single mission platform designed for ADS B/AIS only
- Lower Orbit 500km vs 800 km
- Low weight /low orbit means many can be launched at one time using low cost underwing method
- Plan for regular evolutionary HW and SW technology upgrades in space to follow ANSP and ICAO needs.

- **Nanosat Approach up to 50% Less expensive to launch and operate**

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CONTACT FOR MORE INFORMATION

Karsten Ingemann Pedersen, CEO
kip@aerial-maritime.com
Tel: +45 4080 0606

Peter Majgård Nørbjerg, Director
Air Traffic Solutions
pmn@aerial-maritime.com
Tel: +45 2324 9513

D. Alan Gardiner, Director Marketing
dag@aerial-maritime.com
Tel +66 966 594 796