The Evolution of Satellites and their Role Supporting the Aviation Industry
Agenda

1. Communications Satellite Technology – History and future trends
2. Ground Equipment – The quest for cost and size reduction
3. End User Requirements – The need for speed
4. Satellites and Aviation – Communications, safety and navigation
5. Looking forward – Expected developments in various segments
Communications Satellite Technology – I

❖ In April 1965 the launch of Intelsat I marked the beginning of commercial satellite communications.
  o 150 kg launch mass & 40 W DC power;
  o Transparent repeater and analog communications techniques;
  o 240 voice channels or 1 TV Channel;
  o Mission duration ~ 3 years.

❖ Since then communications satellites continue to increase in mass and power and the technology continues to evolve.
  o >6,000 kg launch mass & ~20 kW DC power;
  o On-board processor and digital communications techniques;
  o >150 Gbps;
  o Mission duration >15 years.

❖ Equivalent to a 10 fold increase in capacity every 10 years!
❖ The improvements seen in other segments of the satellite industry have mirrored those in the communications satellites field.
Communications Satellite Technology – II

Intelsat I

HTS
Ground Equipment – I

✦ Back in 1965 satellites were used for trunk capacity links between large gateways.
  - Antenna apertures >30 m;
  - Transmitter power > 3 kW;
  - Cost >10 MUSD/gateway.

✦ Currently most satellite support mobility, broadcast and consumer applications, with links between one large gateway and a small terminal.
  - Apertures are mostly in the range 6m ~ 13 m for the gateways, and sub-meter for the user terminals.
  - Transmitter power mostly <500 W for the gateways and as low as 1 W for the user terminals.
  - User terminal prices depend heavily on the application, but are normally under 300 USD for consumer applications.
Ground Equipment – II

Ground Stations circa 1970

Aero Terminal
Initially, communications satellites were used almost exclusively for long haul trunk communications, carrying the standard communications services of the time, which comprised mostly voice and were virtually limited to fixed applications.

- This resulted in very simple point-to-point satellite networks, based mostly on proprietary systems.

User needs have expanded dramatically since then, and the evolution in fiber has seen a shift on the services supported by satellites, with trunk long haul communications now corresponding to a minimal part of it. Most of the capacity is now dedicated to TV broadcast, consumer broadband and mobility applications, like maritime and aeronautical.

- Satellite networks have grown very complex, and a lot of effort has been put into bringing them to the same standards of security and connectivity used on terrestrial networks.
End User Requirements – II

✦ The challenge for the communications satellite industry is to offer the same level of service experienced by users on the terrestrial networks.
  o That objective was simple back in 1965, as voice corresponded to well over 90% of the traffic.
  o The explosion of data communications has created an ever-increasing hunger for bandwidth, along with the expectation of a continuous reduction in the cost.
  o Cyber security is now a key requirement.
Arguably the provision of commercial communications satellite services for aircraft started with the launch of Inmarsat’s Aero-H service back in 1991.

- Supported voice at 4.8 kbps and Fax at 9.6 kbps;
- Airtime costs were around USD 10/min;
- Slow uptake and modest revenues.

That was followed by a continuous flow of new offers by different providers.

- Swift, Swift BB and GX by Inmarsat.
- Viasat Exede
- Panasonic

Live TV is now an important requirement for some airlines.

Aviation is the communications satellite segment currently experiencing the fastest growth.

- Throughput and price points still haven’t reached the expectations of consumers and industry.
Satellites and Aviation – Safety

✧ Satellites are transparent to the information been exchanged through them.
✧ The telemetry and command (TT&C) subsystems of modern satellites are protected by AES 256 equivalent or military grade encryption.
✧ Satellites have become increasingly more important in the provision of services that enhance the safety and security of the aviation industry.
✧ In addition to Navigation, a service on its own merit, those services include:
  o Automated Dependent Surveillance-Broadcast (ADS-B): ADS-B complements, or even replaces, radar as the primary means of tracking and monitoring aircraft;
  o Air Traffic Control (ATC) Communications: Enables air traffic controllers to stay in touch with the aircraft when out of range of traditional VHF/UHF radios;
  o Aircraft Communications Addressing and Reporting System (ACARS): Used for messages between aircraft and ground, including messages related to air traffic control and automatically generated messages on the aircraft’s systems.
  o Meteorology: Satellites are a key element to achieving accurate weather forecast.
Global Navigation Satellite Systems (GNSS), like the US Global Positioning System (GPS), are vital components for modern air navigation.

- GPS traces its origins to the 1970s as a military system, but over the years it was made available to the general public at no cost and with increased level of accuracy;
- Other GNSS include GLONASS (Russia), Galileo (Europe) and BeiDou (China) – the constellations for the latter two are still being completed.

GNSS is widely used in aviation today as a source of area navigation and almost every aircraft built today comes with a GNSS unit installed as standard equipment.

The accuracy of GNSS can be affected by a range of factors, including ionospheric conditions, clock errors, orbital errors and position errors.

- Satellite Based Augmentation Systems (SBAS) and Ground Based Augmentation Systems (GBAS) are key elements in ensuring higher accuracy.
The move to higher frequencies, like Ka and Q/V bands, the evolution in modulation and access standards like DVB-S2X and developments in the digital signal processing, have combined to enable High Throughput Satellites (HTS).

- Lower cost per bit.
- Higher capacity & Higher throughput per plane;
- Same level of service and security experienced on the ground;

New developments on the user terminal side, enabling lower profile solutions and lower costs.

Standardization on the ground network, facilitating seamless integration with the terrestrial network and the deployment of enhanced cyber security features, along the lines of the GVF’s Product Security Baseline, designed for organizations that develop and produce VSAT hardware and software.
Looking Forward – Safety

- New initiatives, like the EU’s SESAR and the FAA’s NextGen, are looking into solutions that integrate current satellite and ground based services into an integrated information management network, to improve the quality and enhance the capability of air traffic management services.

- The main areas being addressed by the new systems are:
  - Airport operations;
  - Network operations;
  - Air traffic services.

- The new systems will increase the capacity of the air traffic control system and improve safety, but could raise cybersecurity issues.

- To reduce risks, satellite systems must be designed with security in mind, including features like anti-jamming capabilities at satellite level, and secure ground networks.
SBAS are satellite based payloads, normally geo-stationary, that complements GNSS by improving the accuracy, integrity and availability of the system.

- SBAS utilize ground based reference stations, which calculate the error between the location derived from the GPS signal and the exact reference station location. The error information is then used to generate a correction signal, thereby allowing for more accurate positioning calculation.

Whilst SBAS solutions have been available for some time, the growth in the number of providers is continuously increasing the area covered by those systems, including:

- US: Wide Area Augmentation System (WAAS);
- Europe: European Geostationary Navigation Overlay Service (EGNOS);
- Japan: MTSAT Satellite Based Augmentation Navigation System (MSAS);
- Russia: System for Differential Corrections and Monitoring (SDCM).
Conclusion

Satellites are an essential component in ensuring the comfort and wellbeing of passengers, and are a key element in satisfying the growing need for personal connectivity.

- The satellite industry has evolved dramatically over the last 50 years, and can now offer good solutions to most of the needs of the aviation industry.

The role played by the various segments of the satellite industry in the safety of air travel, in areas like communications, tracking, navigation and weather forecast, will continue to increase.

Cyber security is a key element in the design of satellite systems, from TT&C subsystems to ground infrastructure.

- The satellite industry has a very good record and to date very few incidents have been registered, like an alleged possible attack on NOAA in 2014.
- The satellite industry needs closer cooperation with the aviation industry, to acquire better understanding of the aviation industry requirements and to ensure they are properly addressed.
Thank You!