SatCom 101
“Connectivity for General Aviation”

Peter Lemme
Moderator
1:00 – 1:45
## Agenda

<table>
<thead>
<tr>
<th>Time</th>
<th>Topic</th>
<th>Presenter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:00</td>
<td>100 years of progress</td>
<td>Peter Lemme, Aircloud</td>
</tr>
<tr>
<td>1:15</td>
<td>Inmarsat Aero</td>
<td>Lars Ringertz, Inmarsat</td>
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<td>1:25</td>
<td>Iridium</td>
<td>Brian Pemberton, Iridium</td>
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<td>1:35</td>
<td>ViaSat Yonder</td>
<td>Charlie Gunderson, ViaSat</td>
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<td>1:40</td>
<td>Aircell Gogo Biz</td>
<td>Bill Darbe, Aircell</td>
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</table>
100 YEARS OF PROGRESS
AVIATION COMMUNICATION

Peter Lemme, Aircloud
(as best I can recall and as accurate as I can make it)
Ground to Air Communications (1910-1920)

• Visual cues
  – Fires lit a route through the night
  – Town names painted on rooftops
  – Canvas strips laid out in patterns
  – Light Signals

• Weather
  – wind

• Route navigation
  – IFRR
Air to Ground Communications

• 21 May 1927
  – Charles Lindbergh, after being airborne 27 hours, circles over a boat and yells,

  “Which way is Ireland?”

  No one answered!
Early Radio Communications

- 30 kHz - 3 MHz (HF)
- CW (Continuous Wave) Morse Code
- AM (Amplitude Modulation) Voice
- Aeronautical Radio (ARINC) formed in 1929 to manage US radio communication
- Long range communication
  600 - 3000 miles (1000 - 5000 km)
HF Communications

- Crystal controlled, vacuum tube
  - 1935 Collins *AUTOTUNE* switches between frequencies by pushing a button
    - Pilot control of 10 - 12 frequencies!

- Antenna requires a tuned coupler and significant size to optimize performance
  - Wavelength no less than 30 feet
Sky-to-Earth Phone Service Offered on Air Liner

Air hostess handing telephone to passenger for new sky-to-earth service

Latest convenience available to air-liner passengers is telephone service to the earth. The phones connect by radio with the air line's station, thence to a regular telephone exchange. The service is available on the Chicago-Seattle flight.
VHF Communications

• 1940s military found many uses
  – works on airplanes too!
• Frequency synthesis
  – flexible tuning
• Antenna installation much simplified
  – wavelength less than ten feet!
• 200 mile (300 km) air-ground range
• 600 mile (1000 km) air-air range
Line-of-Sight Aero Networks

• Magnastar
  – 1980s along with GTE AirFone
  – 2006 spectrum auction
  – 2009 Live TV Airfone takes over operation
  – 2012 Gogo purchases last slice of spectrum
Satellite Voice Communications

• Racal single channel prototype (1989)
• Inmarsat Aero-H (this is the classic!)
  – High Gain Antenna
  – Malaysia Airlines 747-400, September 1993
  – 6 Channel systems, 1993
  – Dual installations (11 channels), 1996
Line-of-Sight Aero Networks

• Claircom (1993)
  – AT&T (1994)
  – Discontinued (2002)
Line-of-Sight Aero Networks

- Aircell (1991)
- FCC Waiver (1998)
  - Cellular frequency re-use
- Gogo (2006)
  - Dedicated 3 MHz allocation
  - Additional 1 MHz allocation (2012)
  - Aircell Gogo Biz
Iridium

  - Al Gore makes the first call Nov 1, 1998
- Allied Signal engineering flight tests (1999)
- Bankruptcy (1999)
- Iridium Satellite LLC (2001)
- Seven spares (2002)
- Blue Sky Network C-1000 (2002)
Iridium 33 & Russian Kosmos 2251

http://www.celestrak.com/events/collision/Satellites.gif
first **accidental**, hypervelocity collision between two intact artificial satellites in Earth orbit.

http://www.celestrak.com/events/collision/RelativeVelocities.gif


http://www.celestrak.com/events/collision/RelativeVelocities.gif
Orbital Decay of Debris Field


Iridium 33 Russian Kosmos 2251

operational satellites green

Spares blue,
inactive satellites red.

Iridium 33 debris light blue

Cosmos 2251 debris orange

http://www.clestrak.com/events/collision/Current-Iridium.gif
ICO Global

- F-1 lost in launch
- F-2 in orbit (remaining 10 or so in storage)
- Bankrupt in 1999
- GEO large satellite G1 launched (2008)
- Bankrupt in 2009
- Dish acquisition of G1 (2012)
- ICO is a holding company for intellectual property (Pendrell Corporation)
Globalstar

• Launched 1999 – 2001
  48 + four spare
  degraded operation (2010)
• Bankrupt (2002)
• Restructured (2004)
• Replenishment eight satellites (2007)
• Second Generation launch of
  6 satellites (2010)
  12 satellites (2011)
  6 satellites (planned 2013)
• GSP-1700 Satellite Phone
  9.6 kbps
Connexion by Boeing

- United/Delta/American/Lufthansa (June 2001)
- Sep 11
- Four channels live TV
- Discontinued public services (2006)
- Boeing Broadband SatCom Network (BBSN)
  - Government services
Established Communication Providers

- Inmarsat (1990)
- Aircell (1998)
- ViaSat Yonder (2004)
- Iridium Satellite (2002)
Step 1: Choose Your Network
Inmarsat global satellite network

- 10 L-band satellites in GEO orbit
  - Inmarsat-2, 3 and 4 generations
  - Alphasat to be launched in 2013
  - Global L-band commercial life to beyond 2023
  - Inmarsat-6 2020+
- 3 Ka-band satellites under construction for launch 2013-14
  - Revolutionary GX service
  - Global Ka-band commercial life to beyond 2028
- Fully funded ($3B commitment to next generation networks)
Inmarsat Services

1991 Aero

1991 Classic
Aero, Aero H+
Flight Safety Services
Flight deck voice and data
Wired Cabin Phones

2008 SwiftBroadband
432 Kbps to 1.7 Mbps
Passenger Wireless Networks
Onboard Mobile Telephony System
Connected IFE
Crew and third party applications
Electronic Flight Bag

2013 Global Xpress
2015 GX Aviation
GX Aviation service launch

2013 GX Aviation
Passenger Wireless Networks
GXTV
Connected IFE
Crew and third party applications
Electronic Flight Bag

43 Mbps to the Aircraft

Satellite Communications
Swift 64 & Inmarsat Classic Services

- Aero H+, H, I and L
  - AOC data link (ACARS)
  - ICAO approved safety services including CPDLC, ADS-B, ADS-C, and FANS/ATN
  - Multi-channel voice and fax services using low, intermediate or high-gain antenna

- Swift 64
  - High-speed/High-quality voice and data services
  - Circuit-switched ISDN packet data from 64k to 256kbps.
  - Available with 1-4 channel
  - Provides simultaneous or stand-alone operation with Classic service through the same high gain antenna.
  - Available on the Inmarsat I-3 satellites
SwiftBroadband

- Consistent near global broadband service that provides simultaneous circuit-switched (voice/fax) and packet-switched (IP) connections
- Broadband speeds up to 432kbps/ channel.
- 1 – 4 channels using intermediate or high gain antenna
- Dedicated 8, 16, 32, 64, 128kbps streaming
- X-stream full channel 250kbps+ streaming
- Multivoice capability
- Provides simultaneous ICAO approved Classic safety services through the same avionics and high gain antenna
- Available on the Inmarsat I-4 satellites

High Gain Antenna (Class 6)

Intermediate Gain Antenna (Class 7)
SwiftBroadband 200

- Consistent near global service
  - above 15 degree elevation angle
- Simultaneous circuit-switched (voice/fax) and packet-switched (IP)
- Single channel connections speed
  - up to 200 kbps
- Dedicated streaming
  - 8 and 16 kbps
- Multi-channel voice capability
- Small low-gain antenna

Low Gain Antenna/
Enhanced Low Gain Antenna (Class 15/4)
## Inmarsat SwiftBroadband

<table>
<thead>
<tr>
<th>Installation Type</th>
<th>Type</th>
<th>Services</th>
<th>Data rate</th>
<th>Streaming</th>
<th>Channels/Installation</th>
<th>Coverage</th>
<th>Capacity mgmt</th>
<th>Safety Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>SwiftBroadband over High Gain Antenna</td>
<td>Packet based – Charge for volume of data *</td>
<td>Standard IP, Streaming IP, ISDN, Voice, Multivoice</td>
<td>Up to 432kbps/channel To aircraft</td>
<td>8, 16, 32, 64, 128kbps to a maximum of 192 kbps X-stream 218–250kbps &lt;700kbps **</td>
<td>Four</td>
<td>Global through narrow spot beams</td>
<td>Dynamic load balancing</td>
<td>Yes through the same antenna</td>
</tr>
<tr>
<td>SwiftBroadband over Intermediate Gain Antenna</td>
<td>Packet based – Charge for volume of data *</td>
<td>Standard IP, Streaming IP, Voice, Multivoice</td>
<td>Up to 332kbps/channel To aircraft</td>
<td>8, 16, 32, 64, 128kbps</td>
<td>Four</td>
<td>Global through narrow spot beams</td>
<td>Dynamic load balancing</td>
<td>Yes through the same antenna</td>
</tr>
<tr>
<td>SB200 (Low Gain Antenna)</td>
<td>Packet based – Charge for volume of data *</td>
<td>Standard IP, Streaming IP, Voice, Multivoice</td>
<td>Up to 200kbps/channel To aircraft</td>
<td>8 or 16kbps</td>
<td>Single</td>
<td>Above 15 degree through narrow spot beams</td>
<td>Dynamic load balancing</td>
<td>**</td>
</tr>
</tbody>
</table>

* Streaming charged by time connected  ** Network ready of 2013
SwiftBroadband Coverage
What can SwiftBroadband be used for?

Cockpit Applications
- Safety Services (Aero I, H+)
- Operational benefits
  - Efficient routing (fuel savings),
  - Applications (EFB)

Cabin Applications
- WiFi and wired Internet access
- An extension to the terrestrial network (Email, VPN)
- In flight mobile phone use (voice calls, text messaging, Tablets, Smart phones and Blackberry)
- An extension to the IFE system
- Ability to tailor own solutions to fit customers needs

Operational Applications
- Aircraft management
- Crew application
- Aircraft monitoring
SwiftBroadband evolution

Key portfolio milestones

- **High Gain Antenna (Class 6)**
- **Intermediate Gain Antenna (Class 7)**
- **Low Gain Antenna/Enhanced Low Gain Antenna (Class 15/4)**

- **Four SB channels**
- **Multi-voice**
- **Alphasat launch**
- **SwiftBroadband safety service network available**
- **Helicopter bearers**
- **High Data Rate Bearers /700kbps**
- **SB200 Evolution Class 4 in service**
- **SwiftBroadband safety service approved**
- **GX Aviation in service (global coverage)**

- **Q4 2011**
- **Q1 2012**
- **Q1 2013**
- **Q2 2013**
- **2014**
Inmarsat GX Aviation

- Designed for global mobile communication
- Initial Constellation is 3 Satellites
- Small Ka Band Spot Beams (2M km²)
- Single operator, seamless handoff, consistent service
- Commercially available Q1 2015
- Honeywell selected as master distributor for Business Aviation
  - With VAR’s to be announced
- Honeywell selected as Avionics partner
Iridium

- Provides global coverage for multi-channel voice, messaging, and data services
- ICAO approved safety services like CPDLC (FANS & ADS-C) and SATCOM Voice
- AOC data link (ACARS)
- Postpaid and credit card cabin voice
- Fax
- Low cost, low weight, and simple installation has Iridium the most popular aviation SATCOM communications solution
- Email and SMS applications are increasing popular along with EFB connectivity
## Iridium Satellite: Overview

<table>
<thead>
<tr>
<th>Applications</th>
<th>Cockpit and Cabin Voice &amp; Data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The Network</strong></td>
<td>66 satellites in low-earth orbit (Including in-orbit spares)</td>
</tr>
<tr>
<td><strong>Coverage</strong></td>
<td>Global, including the poles. In the air and on the ground.</td>
</tr>
<tr>
<td><strong>Inside Scoop</strong></td>
<td>Popular and proven with good voice quality and affordable service</td>
</tr>
</tbody>
</table>

### Key Features

- **Voice rates**: $1.00 - $1.60/min
- **Small antenna**
- **Global voice and data connectivity, in air and on the ground**
Iridium Satellite: Coverage

Reliable Coverage in the Air and on the Ground at All Altitudes and Latitudes. Even in Polar Regions.
Iridium Short Burst Data (SBD)

• Flexible, Universal Messaging Service
  – Third-party applications like weather

• Data Link Service Provider
  – ACARS/FANS
Iridium OpenPort Aero

• New broadband service that provides simultaneous voice and high-speed data connectivity
• Broadband speeds up to 128kbps with no per minute charges
  – Compressed data speeds in excess of 500Kbps
• Built-in compression, router and firewall functionality
• Optimal for Internet, VPN and EFB connectivity
• Requires high-gain fuselage or tail-mount antenna
Service Dependability

• The Iridium network is one of the most robust communications networks in the world
  – Consistently performs at 99.9%+ availability
  – Redundant network and satellite architecture
  – Only commercial satellite network with fully functional in-orbit spares

• Network performance demonstrated to be compliant with GOLD RCP240 specifications for ADS-C and FANS 1/A as part of a one year operational evaluation with the FAA
Iridium NEXT

- Fully replaces the current constellation of 66 LEO satellite
- Modernized ground earth stations with new features and capabilities
- Fully backward compatible for current users
- Significantly increased data speeds and network capacity
- Services scheduled to start coming on-line in 2016/2017
- Will begin announcing avionics and airtime partners in 2013
Service Continuity & Network Longevity

• Iridium is committed to supporting all current customers and services through the deployment and operation of Iridium NEXT
• Iridium NEXT is a fully financed program to fully replenish the satellite constellation
  – Extends constellation service life beyond 2030
  – Significantly increases network capacity and service capabilities
• Full backward compatibility eliminates technology migration risk, and cost, for customers and service providers
• Provides a baseline of services currently in operation and can be counted on well into the future
ViaSat Yonder Broadband Service

• Inflight connectivity
  – business jets
  – transport category VIP aircraft

• Network of commercial Ku-band satellites
  – seamless, near-worldwide coverage
  – ViaSat Network Operating Center
Yonder Provides A Great Internet Experience

1 – 2 Mbps to the aircraft

128 – 256 kbps from the aircraft

Speeds typical of those experienced by users sharing the network
Ku-Band Based Coverage
Next-Generation ViaSat Airborne Broadband Services

• “ultra high capacity” Ka-band satellites
  – ViaSat-1 (140 Gbps: world’s highest capacity satellite)
  – Eutelsat Ka-Sat
  – Yahsat Y1B
  – Exede® Internet for home and business launched January 2012

• Exede® In The Air
  – JetBlue fleet and United narrow body fleet
  – Service begins Q1 2013

• ViaSat hardware solutions

General aviation services will transition to Ka band when ultra-high capacity coverage is sufficiently built out
## Gogo Network: Overview

<table>
<thead>
<tr>
<th>Applications</th>
<th>High speed Internet, email, VPN &amp; more.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crystal clear voice expected soon.</td>
</tr>
<tr>
<td>The Network</td>
<td>A proprietary air-to-ground network using ground wireless towers</td>
</tr>
<tr>
<td>Coverage</td>
<td>Continental U.S. &amp; portions of Alaska</td>
</tr>
</tbody>
</table>

### Key Features
- Full mobile broadband – wired or wireless
- Based on 3G mobile technology
Gogo Network: Coverage

Continental US & Portions of Alaska Above 10,000ft AGL