Starling
Advanced Communications

THE AIRBORNE BROADBAND DREAM – IS IT JUST ANOTHER BUBBLE?

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The Inflight Entertainment (IFE) and communications market is quite familiar with service offerings that promise much and yet deliver little.

One of the newer offerings currently in the spotlight is Broadband connectivity, and as with many previous offerings it can be difficult to separate the hype from the reality.

In order to address this issue we need to understand what is really meant by Broadband and what services it can provide.

Starling Advanced Communications (Starling) is relatively new to IFE. However, Starling draws on extensive experience in the use of Broadband technology within the aerospace and communications sectors - we are therefore able to examine this issue from a unique perspective.

Broadband can be defined as the data transmission capability, or bit-rate, that can support the following services and activities: TV, Internet, Video, E-mail and VPN access. In quantitative terms, this means about 1 to 2 Mbps of data transmission to a typical wide-body aircraft.

There are two fundamental factors that will determine success or failure for Broadband. These are:

- The existence of a technical solution that can deliver the required service.
- The ability of the technology to support a service that makes economic sense.

The objective of this brief paper is to examine these two factors in detail. To do this we must address the following issues:

- What are the current capabilities?
- What are the limitations?
- What can be delivered, where and when?
- What applications can be supported?
- What is in store for the future?

The options

Today there are a number of possible solutions to the next generation of inflight connectivity:

- Ka
- L-band
- S-band
- KU-band

1. **Ka– Band:**

Ka-band has been "the promised land" for many years now. The reality is that due to technical and economic factors, none of the Ka projects to date has been deployed with any significant impact. The near future indicates no Ka availability. Even if there is to be Ka in the future, the design is for "pencil beams" which will not be relevant to airborne use. Therefore, Ka-band will not be discussed in detail within the context of this paper.

2. L-Band

L-band, is the only current global solution for aeronautical use. L-band satellites were designed to provide voice and very limited data on a global basis to serve the maritime users, remote areas and for search & rescue.

Technical Considerations - L-band has limited capacity as far as multi-users are concerned. The L-band satellites are limited to 34Mhz (bandwidth) by authority allocation to MSS (Mobile Satellite Service). Total bit rate capacity is a combination of: bandwidth, antenna beam forming and power as well as modulation techniques. Today, the total capacity is limited to approximately 30Mbps (as is the single channel). Even as the technology advances towards an advanced level of L-band, such as Inmarsat 3 and 4, where the total capacity will still be limited to around 100Mbps for all users – land, sea and airborne. Assuming all of the bandwidth in this future system is allocated to aerospace (which today accounts for a fraction of the L-band business), in a 500 aircraft environment the bit rate per aircraft will be only about 200Kbps.

Economic Considerations – The cost of operation of the L-band network remains more or less constant, meaning that the cost per Mbit or Kbit will not change dramatically from the current expensive rates, even if bit rates are higher. The reason is because the **total capacity** and operational costs are constant, so it does not matter if you deliver it in "narrow pipes" or "wide pipes". Therefore, the price varies little with the amount of total capacity used.

3. **S–Band:**

To start, a misconception about S-Band should be clarified.
Under the above definition of Broadband S-band does not qualify as Broadband. Rather, in a multi-aircraft environment, it has more in common with **Narrowband.**

Technical Considerations- S-band is quite similar to L–band. Hence, the total throughput is limited. Every satellite can deliver about 80Mbps. This is fine for TV where the same transmission can be broadcasted to all users. However if S-band is divided, for example, 40Mbps for TV and 40Mbps for all other services, then the capability becomes almost exactly the same as the L-band.

Economic Considerations- S-band presents even more economic hurdles than L-band. To build the needed satellite constellation (satellites, ground stations, service, etc.) the costs are greater than $1billion. The annual recurring cost of operating the ground stations is estimated at an additional 10%. Also there are significant content costs to consider.
Given that direct-to-home satellite service providers with tens of millions of users are struggling without the complexities of technical and legal issues specific to aerospace, launching a new satellite constellation to service the aerospace niche market presents a great economic challenge. Moreover, doing a simple calculation, even under optimistic assumptions, shows that the average bit rate in a 250 - 500 aircraft environment will be approx 160 - 80Kbps per aircraft. This presents a dilemma - in order to have a reasonable revenue stream to compensate for the very high non-recurring costs (launching the satellites) and recurring costs (network operation, content, marketing, etc.) millions of users are needed, translating to a very slow service. For broadband service only a few aircraft would benefit, a fact that presents a difficult business case.

4. **Ku-band**

Ku-band is the most commonly used band today for fixed satellite services (FSS).

Technical and Economic Considerations – The capacity of a single Ku transponder can be between 36 – 72Mbps. A single satellite can provide an average of 1- 2Gbps. This means that in a 250 - 500 aircraft environment the bit rate will be approx 2 - 8Mbit per aircraft. Moreover, the bit rate and cost can change according to system performance and demand by simply adding or reducing the number of transponders used. The clear message is that Ku is the only viable possibility for airborne connectivity.

Ku advantages include:

- The capability to deliver the needed bit rate.
- The use of mature technology, and existing standards.
- Satellites and ground stations already exists.
- New satellites are launched on a regular basis.
- It is flexible.
- It is a competitive market – not a monopoly.

Simple? Not quite. Even Ku has certain issues that need to be addressed.

Technical Challenges:

Given that the satellites, the airborne network and the ground infrastructure already exist, the technical challenges lie within the antenna and the communication protocol system. The existing Ku SATCOM systems were designed for terrestrial use, where the end user and the energy level is fixed, the service is usually regional and there are no limitations on the antenna size.

Coverage –Ku coverage will grow, as demand for airborne broadband becomes a reality. Since Ku is a competitive market, the current Ku coverage (which already covers most routes) will become global and will provide adequate service to all routes.

Providing coverage and developing airborne equipment presents great business challenges since the satellite segment cost (leasing transponders) and the onboard equipment could significantly affect the economics of the entire business case.
More specifically, the main challenges are in the following:

1. Antenna:
   - Physical dimensions of the antenna.
   - Reliability
   - Cost Effectiveness.
   - Performance to support high bit rate.
   - Low elevation scan to enable global performance.
   - Directivity – the ability to have a directed and narrow beam that will be able to receive/transmit the energy.

2. SATCOM:
   - Dynamically allocate the resource in a multi-aircraft environment.
   - Optimize bit rate according to link budget.
   - Prevent adjacent satellites interference (when receiving) that can lower bit rate or prevent signal reception.
   - Maintain spectral density according to fixed satellite service standards.
   - Prevent interference to adjacent satellite when transmitting.

Current systems developed according to fixed satellite service standards or for other applications **will not meet the need** for global coverage or provide cost effective solutions. However there are technologies that can tackle these challenges. These technologies, most of them developed for military use, can provide effective solutions to the above-mentioned challenges. Using these technologies will support high performance at a reasonable price.

Conclusion:

1. S and L-band are **narrowband** in **performance** and are **economically** prohibitive.
2. Ku-band is the only potentially suitable frequency range for true Broadband.
3. Ku-band has many technical issues that have to be (and can be) solved in order to:
    - Be able to deliver the needed bit rate.
    - Support a solid business case for all participating parties.

Broadband connectivity in air travel is inevitable, however, it is critical to select the right system that will make economic sense and meet customers' expectations.

About the Author

Dr. David Mansour, *CTO of Starling Advanced Communications*

Dr. Mansour brings more than three decades of leadership in research and development of communication systems. Most recently he was Senior VP for Technology at Ibiquity Digital, where a new standard for AM and FM digital radio is being developed, also designed and developed the audio coding for Sirius satellite radio service. Previous to Ibiquity, Dr. Mansour served as CTO of Geotek Communications - developing state-of-the-art cellular systems, specifically designed for fleet management, including dispatch, telephony and data services. Prior to Geotek, Dr. Mansour was Co-Founder of RDC

Communications, where one of the first wireless LAN systems was developed in less than 18 months. Prior to RDC, Dr. Mansour spent two decades at RAFAEL in research and development of state-of-the-art communication and satellite communication systems, specializing in a number of communication disciplines - like adaptive antenna arrays, spread spectrum modems, etc. Dr. Mansour's career at RAFAEL covered all the managerial levels, up to the Director of the Communication and Intelligence Directorate. Dr. Mansour holds a B.Sc. and M.Sc. degrees in electrical engineering from the Technion Israel Institute of Technology, and a Ph.D. in computer and electrical engineering from the University of California, Santa Barbara.