Developments in Satellite Ground Systems

by Dr. Gerhard Franz and Dr. Andrea Franz

The term "Satellite Earth Station" or "Ground Station" evokes the memory of the massive 30-meter antennas of the early 1970s. However the technology has advanced over the years to the point that today we find sophisticated electronic installations in a typical "large" ground station needing antennas from the very large (13-19 meters) to VSAT (Very Small Aperture Terminal) systems with 1-2 meter antennas. The goal is still to receive the weak signal from the satellite and then to provide sufficient uplink power for the satellite to receive a signal, many times supported by automatic uplink power control systems.

On the transmit side, the baseband (whether it is video, voice, or data) signal passes through a modulator. This modulated signal at intermediate frequency (IF) is then converted to the transmit frequency using an up-converter, it passes through an amplifier and is finally coupled to the antenna waveguide for transmission through the antenna to the satellite.

On the receive side, the satellite signal is coupled from the antenna receive waveguide to a low noise amplifier (LNA), translated to IF by a down-converter, and then de-modulated to the receive baseband signal.

Frequently, equipment is used that is capable of several, or even all, of the above processes. For example, a modem takes care of modulation on the uplink and de-modulation on the downlink. A block up-converter (BUC) does up-conversion as well as amplifies the signal sufficiently for transmission through the antenna. A transceiver takes care of modulation, up-conversion, down-conversion, and de-modulation.

Services

Services of a satellite ground station can be split into two groups – those that support the operation of the satellites (including launch support, early orbit and on-station or in-orbit control), and those that use the satellite for telecommunication purposes (including the transmission of video, voice and data for broadcasters, news gathering and direct-to-the-home television). Obviously the latter group represents the vast majority of services and is subject of ever more expansion. Many more teleports focus their business on these telecommunication services.

Technical Challenges

Over the last 10-15 years the teleport industry has seen significant consolidation, in part as a reaction to the consolidation of satellite operators into a small number of companies operating satellite fleets spanning the globe. Naturally this has led to a decrease in investment in new facilities and hence a slowing of technical innovation. Furthermore, RF technology which is at the heart of the teleport equipment has always been moving slowly because of the inherently small market as compared to digital technology.

Satellites continue to provide worldwide connectivity service for video, voice and data. Particularly video transmissions have seen a continuous growth in bandwidth demand with the ever expanding use of HD programming and now the emerging 3-D technology. As more countries switch over to digital TV services this trend will continue. While initially the introduction of digital TV lead to a reduction in bandwidth this has been more than compensated by the vastly higher data rates required for HD. A typical SD program encoded in MPEG2 will require between 3-5 Mbps depending on the content (fast moving sports events versus static talking head newscasts). In comparison, an MPEG2 encoded HD video will need at least 15 Mbps.

The advent of more efficient encoding technologies, mainly MPEG4/H.264 AVC has helped by reducing the bandwidth needs for HD video by a factor of two. Besides the increased bandwidth that a teleport operator has to accommodate there is also the significant cost associated with the newer encoding equipment that typically amounts to 2-4 times as much as the MPEG2 equivalent. Teleport operators who want to maintain their business are augmenting their installations with new equipment to provide encoding/decoding services.

Another challenge for teleport operators is the continuing move to IP within the video processing industry. The dominant connectivity solution for MPEG-based video has been ASI for many years. This point-to-point protocol is working well for streaming video. However, it requires expensive drivers in each device and connecting multiple devices is difficult. An IP based signal distribution solves all these issues: interface circuits are ubiquitous and inexpensive, point-to-multipoint distribution is simple through the use of multicasting and powerful IP switches. The impact of this technological development on teleport equipment is significant. Over the next few years the percentage of IP connected teleport equipment will grow dramatically and it is safe to say that the ASI technology will slowly disappear through the next decade. Together with the upgrade to IP based systems there is also a move towards fiber optic installations since they are much more robust, space optimized and cost-effective than the conventional cables.

The use of IP is not limited to the transport of video streams. It is also pervasive in the management of the teleport itself. IP networks enable the use of SNMP (Simple Network Management Protocol) to manage devices connected to the network. This simplifies greatly the network management of the various pieces of equipment present in teleports. Most new equipment today has SNMP agents implemented allowing the network management system to monitor and configure each device on the network. Thus, the teleport now has two parallel IP-based networks installed: one for the routing of video and data (the transport network) and a second one for the management of the equipment (the control network). This creates another challenge for the operator: while it is theoretically possible to run both data (video) and control on the same network a careful design of the network architecture is required to avoid unintended traffic collisions, particularly for the real-time streaming video. This requires an in-depth knowledge of the IP protocol and technology that may not be available at a certain teleport operation. Thus, the technical challenge translates into a staffing challenge in a way familiar in other high-tech niches where long-time experienced personnel needs to be supported by a growing number of digital network engineers who in turn may not know much about satellite technology or the intricacies of RF design leading to potential priority conflicts in the day-to-day operation of the teleport.

Finally, teleport operators need to keep up with the increasing complexity and integration of the equipment they use in their facilities. Equipment vendors are integrating increasing functionality into their devices in order to gain higher packaging densities which allow the reduction of rack space for electronic equipment giving operators the room required to install more customer equipment or add more functionality. Examples are the integration of test loop translators into BUCs for monitoring of the transmission signals, integration of web-based control interfaces in lieu of front panel buttons and dials, or the integration of fiber-optic equipment for the inter-facility links. Together with the use of IP networking these developments are enabling a much higher concentration of functionality into a standard rack unit.

Summary and Outlook:

Teleport operators face a number of technical challenges in today's rapidly growing video transport environment. Consolidation has reduced the number of active teleports but at the same time has made their operation much more complex. The increasing use of HD video has led to a dramatic increase in bandwidth. This is partially being neutralized by the growing utilization of IP network technology for the interfacility transport of data and video streams. While IP networks offer tremendous benefits to the teleport operator the challenge of proper design and maintenance of these networks cannot be underestimated. Finally, ever increasing complexity and integration on the individual equipment level is an opportunity for operators to provide more services to their clients without costly expansion of their physical facilities.

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