Dear Colleagues and friends

I am very humbled to be asked to be in front of you and also replace a very important political figure, Mr. Chris Van Hollen, as I am sure the congressman is busy campaigning to be re-elected in about 2 weeks or so and he would have been a lot more interesting. These are big shoes to fill, especially (Peggy asked) when I was asked to talk about technical development in the satellite communications field and industry when some of the present audience here today were the driver behind many such technology developments in the past during their very distinguished careers.

I think that many of us, including myself, have been very fortunate to be in such industry, and moreover to be involved in it virtually as pioneers from the very beginning.

(Start with) Some Historical perspectives:

I joined Comsat Labs, in 1969, just out of school and very green. It was very exciting and extremely valuable experience for me that till today I rely on it. After spending close to 10 years at Comsat Labs, I joined

Intelsat where I spent another 29 years to learn many new things and gain more experience and then in 2008 I joined Asia Broadcast Satellite, a small start up satellite operator that was only founded in late 2006. At ABS, I also have learned many new things and have added to my experience (There are always new challenges regardless).

But it has not been only learning, I would like to think, that as the result of these years of experience, I also contributed to all of the entities who employed me (if any of my past bosses are here).

Although the nature of our business has evolved tremendously in these past forty and some years, it is still a very exacting business with different challenges, and more commercial than technical, compared to previous years.

In the past, we as (almost) pioneers, and partly due to the fact that a large majority of us worked for an IGO, placed emphasis mostly on obtaining and utilizing the best technologies available to us (without any undue risks), or could be obtained through further research and development for our business. This is mostly what

Comsat Labs, and later on Intelsat itself carried out and set the standards for many new comers to our field of business. Unfortunately, these days, very little and virtually no new R&D in our commercial field is carried out and most operators depend on the manufacturers to come up with new ideas and technologies and most prefer to procure off the shelf proven technologies mainly developed by the industry on their own (less risks, lower cost and delivery schedule).

As a technical person, one may not find this very rewarding, but from a business person and an operator perspective, this is actually a good thing that has happened, as it leads itself to a more reliable, more cost effective and more expeditious schedule solution which has also encouraged entry by many new operators, mainly regional, thereby creating more competition. Although recent consolidations of some operators has created some mega players where the top three to five out of about 36 satellite operators still dominant our business and are responsible for 57% to 70% of the more than US11.5B annual revenues, virtually all of them are the beneficiaries of the early work done and sponsored by Intelsat, either directly, or through Comsat Labs or other third party industries on a global basis (many third parties also benefitted from Intelsat early work). Even today, old Intelsat standards are still the reference and the bible of our industry (although the name is no longer as magical as in the past).

When I joined Comsat Labs, we were developing Intelsat-IV and IVA series of satellites. For the first time, these satellites had introduced the concept of the spot beams and frequency reuse in addition to the previously global beam only. They were an all C band only spacecraft with just 12 transponders for I-IV and 20 transponders for I-IVA. These satellites had to have two transmit antennas for the same coverage beam, one for the odd and one for the even channels as we did not know how to build contiguous band output multiplexers.

But technology of output multiplexers changed very drastically, thanks to work performed by three excellent Comsat Labs engineers sponsored by Intelsat (Bruno Blachier, Ali Atia and Albert Williams) which allowed the use of a single transmit antenna for all channels, hence saving one antenna and resulting in less spacecraft mass or the additional reflector could be used for generating additional beams, if so wished.

From Intelsat IV and IVA we moved to Intelsat-V series of satellites. There was a quantum and (large) evolutionary jump in capabilities of these series compared to the previous series. More efficient use of available spectrum through spatial and cross polarization was used for the first time allowing the use of the available spectrum two to four folds and for the first time new spectrum, namely Ku band was added to the traditional only C band spectrum (used in the previous series), giving the term of hybrid design to this series, meaning using more than one set of frequencies. Another major evolution for the Intelsat-V was the use of the three axis stabilized body for this series. Two major advantages of such design were: to have all of the utilized solar cells generating power for the payload, in contrast to half of the cells generating power in the case of a spinner design which was used in all of the previous series and to provide more real estate for the installation of more payload equipment.

This resulted in Intelsat-V series of satellites to have initially 21 C band and 4 Ku band transponders and later on to grow to 26 C band and 6 Ku band transponders as 15 of these satellites were built over a period of almost 7 years. It is interesting to note that although today the Ku band spectrum has become a very important spectrum on a global basis for the satellite use and its use (for instance) is the main staple for all of Eutelsat satellites, the third largest satellite operator, at the time of its introduction the Ku band was not considered that essential by Intelsat so that when it was decided to include a maritime L band package for Inmarsat on several of the Intelsat-V series of satellites (F-5 through F-9), we did not have adequate power to operate both the L band and the Ku band payloads simultaneously, so it was decided that we just shut the Ku band off and operate the L band payload for Inmarsat. Shows how much we knew, or did not know!

The technology evolution continued with the introduction of the Intelsat-VI series, followed by the Intelsat-VII, VIII and IX series simply by just having more number of transponders, more connectivity and flexibility and more importantly having additional power due mainly to large improvement in solar cell efficiency. This in turn also helped for the Ku band spectrum develop a rapid traction for DTH video services. Today, a very large majority of DTH video service delivery utilize Ku band spectrum, with very high performance to dishes as small as 45cm (18 inches) and a single satellite can deliver as many as several hundreds of HD video TV to such small dishes. Compare this to a satellite intended by Comsat in the 80s for the same DTH application, which could only deliver a maximum of 3 SD video channels. Needless to say, this business model failed and the satellites (2) ordered by Comsat were cancelled.

To be fair, a lot of progress also occurred on signal compression, thanks to the transition from analog to digital signals, so not all the credits should go to the satellite technology evolution.

So for a period of time, as satellite capabilities were increased, more of the same was included and packed in a single satellite. The only noteworthy technology introduced during the I-VI through I-IX was the introduction of the SS-TDMA and hence the inclusion of a

SS-TDMA switch on board the I-VI and I-X series of spacecraft, but this technology and access technique very quickly gave way to the introduction of the Internet and its packet switching characteristics. I don't believe that it was ever used in conjunction with I-9s.

However, with the last Intelsat series of satellite, namely I-X, another technology evolution occurred where the beam forming network for generating shaped foot prints for various beams of the Intelsat satellite, which included as many as 140 feeds, was replaced with a single feed due to the use of the shaped reflectors. This approach tremendously simplified the antenna design and implementation for virtually all of the satellites requiring shaped beams to match the coverage of the specific markets and allowed for satellites to be lighter, less costly and if required more capable by including additional beams, hence enhancing the marketability as well as future proofing the satellite design (and cost reduction). 2-3 frequencies from a single dish

In the meantime, the spacecraft buses also experienced technology advances, where better spacecraft thermal control was needed due to the higher payload power caused by increased solar cell efficiency, hence more thermal dissipation was occurring. Several technology evolutions included the introduction of heat pipes and radiation cooled high power amplifiers. This tremendously helped to pack even more payload equipment on board a single satellite, resulting in potentially enhanced revenues.

Another advance was in the area of propulsion. Traditionally, satellites carried a lot of liquid fuel for orbit raising as well as station keeping maneuvers. Carrying fuel to orbit is expensive but necessary (satellite life ends when it runs out of fuel and not because things ALL have failed. NASA rescue). With the introduction of the electrical propulsion, those who could afford it, could exchange the mass of the liquid fuel needed for station keeping maneuvers for a much smaller gas needed for the electrical propulsion and either gain savings in the spacecraft mass resulting in less costly launch, or add more payload for revenue enhancement (Terresatr).

In parallel with advances in the technology for the geo-stationary communications satellites mentioned above, many other service specific satellites with fairly advanced technologies were either proposed, or actually built and launched (Irridium, Teledesic, Astrolink, Spaceway, Skybridge, Wildblue, Globalstar, Aces, Thuraya and SkyTerra, Terrestar, just to name a few 11). Some never got off the drawing tables and some of those that were deployed were technical marvels and success but none were ever a commercial success (USD billions, Irridium). The deployed networks used very advanced technologies, such as on board processors, channelizers, active beam networks and multi spot beams configurations (mostly at Ka band). However as the targeted markets were mostly niche markets and the satellite configurations were application specific, they were not financially successful. In the foreseen future, the satellites which can address many markets and many types of traffic and applications over large geographical areas will rule.

I believe that the simple so called ~~net~~ bent pipe satellite configurations (just retransmitting the received signal) with shaped beams to cover desired markets will be around and very likely more successful for their owners for a foreseeable future compared to those utilizing more sophisticated, complex and very advanced technologies which are meant for specific applications.

not in business to experiment but earn revenues

While the satellite technology was evolving and advancing, as more payload capabilities were added, they also became heavier. So in parallel with the satellite design advances, the launch vehicle performance and lift capabilities also improved. However, the launch vehicle business is even more risky and more capital intensive than the satellite business, and although they have been some new entrants into this part of the business, their reliability and availability have been a bit spotty. As the result of this, launch costs have soared tremendously (compared to satellite costs), a lot faster than the cost of satellites. For large operators, or government sponsored operators, this cost is not very critical as large operators having established high earning revenue slots can justify these costs and the governments do not perform business cases to justify any cost anyway (government workers among us may disagree).

However for smaller operators and green field operators, it has become very difficult to close their business cases based on what it cost to launch a single transponder to orbit and what they can charge their customer these days. One way to reduce the cost of a transponder delivered to orbit, is to procure a very large satellite with many transponders and take advantage of the economy of scale (the larger the satellite, less cost per transponder). However for most small private operators this is not so easy and financially feasible.

This has recently resulted in another evolution in the satellite technology. As many recent satellites have used both electric and liquid propulsion systems, and liquid fuel is heavy, satellite manufacturers (currently only one) have come up with a new concept, namely an all electric propulsion system satellite configuration. This approach has resulted in about 10%-20% reduction in the spacecraft cost and more importantly as it has reduced the mass of the satellite by about 35%-40%, in turn has resulted in tremendous reduction in cost of launching such satellites.

This launch cost reduction can further be enhanced, if so desired, by launching two of such satellites on current launch vehicles (for the price of one compared to before), hence resulting further reduction in the cost of launching one satellite.

This is what we have done in the past year where I work today. By purchasing such lighter satellites, however still very capable, and launching two of them on a single rocket, we have managed to further reduce the cost of a single transponder delivered in orbit for a smaller satellite by as much as 20% when compared to a much larger satellite transponder cost (no need to buy larger satellite to gain more effective cost).

This idea may have been prompted by a recent launch failure and then successful orbit raising of a government AEHF satellite.

(Orbit raising ramifications replacement VS green field)