Lessons From Satellite Industry

&

The joy of Teaching

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I came to the US in 1978 to manage the technology programs for the then international consortium, INTELSAT. Prior to that, I was invited in 1967 by Vikram Sarabhai to join a system study for a domestic satellite system for India with Hughes in LA. The Hughes team was led by Harold Rosen who had launched the very first GSO satellites a few years earlier.

After a few years of managing technology programs for INTELSAT, my responsibility was expanded to include planning, industrial contracts and launches of newer programs. By the time I retired from full time jobs in year 2000, the consumer-based systems were emerging and I was keen to share my experiences and the generic methodologies which made more and more sense to me. As a vehicle of interaction, I formed a consulting company and few lucky breaks got me started quite well. I took active part in conferences including as a Moderator for Broadband for many years at the premier annual conference, Satellite 19xx in Washington DC. I also had the honor to collaborate with several senior executives from the industry for two books on successes as well as visions for the industry[[1]](#footnote-1),[[2]](#footnote-2). All this experience has taught me valuable lessons, some of which I share in this narrative.

Lookng back now, the most rewarding was my experience of teaching at GMU during 2000 and 2020 in parallel with consulting work above. It almost happened by accident. Soon after my retirement from full time career in 2000, I gave a call to Dr Allnutt to say hello to my long-term colleague at INTELSAT who was then at GMU. At the end of the call, he invited me to visit him at GMU. When I reached his office, after exchanging news about our other colleagues at INTELSAT, he invited me for lunch in another building. When we got there, two other colleagues of Jeremy were already at the table. They asked quite a few probing questions about my experience in India and the US. I guessed it was pre-arranged when they said that I should teach at GMU. I told them that I had no teaching experience, they persisted said, they would like me to share my experience in the real world with graduate-level class under the TCOM program that Jeremy was heading. I was honored to accept.

In my first two classes, I almost lost my students. A few of the students m came over after the second class to say that they could not follow anything; besides why use satellites? They are going bankrupt. The first issue I could be corrected quickly as I had over-prepared as if I was in a conference; the second was harder as three mobile LEO systems had indeed failed due to the entry of terrestrial mobile.

With these improvements, I could slowly bring most of the class to take active interest. By the time of my last class in fall 2020, not only the satellite boom was in full swing but successive classes’ had helped me improve the overall model to be applied to any other communication technology, s captured in the following flow chart

With this brief introduction, I will first summarize in Part I, the lessons I learnt through my career in this industry. In Part II, I will summarize the joy, professional satisfaction and addition of the knowledge stimulated by 20 years of teaching a GMU.

 **Part I LESSONS**

After years of System Development and deliberations with peers and students, the Flow Chart shown below was developed. An earlier version of this chart was presented in Reference 3.[[3]](#footnote-3)

In the class, I used to break this into individual phases spread over 4 or 5 classes. However, now I prefer the integrated flow chart as it enables me to give an overview first and then go in details as needed. Notable and surprising benefit is that it has found application in different systems.

Let us begin from the left and go step by step all the way, capturing key lessons. A notable new feature is the emphasis that ideally until the preparation of the business plan, the activities should keep the selection of the final technology open as far as possible. This puts emphasis on the team being able to defend the preferred technology in front of those who will finance the system.



**Strategy Development Process**

The first step in all types of projects is to carefully define the Mission. It is quite common, at least in our industry, that new ventures are started by visionaries who are quite passionate about their views and convictions. If they have a technical background, they often have a specific architecture in mind. Sometimes it all works out well; however there is a risk of their solutions not being optimum in the marketplace.

Ideally, the Mission Statement should limit itself to the objectives in terms of service, geographical areas to be served, cost ceilings and perhaps time frame.

***The Mission Statement should only define the requirements and NOT the technology.***

The Strategy Development Process starts with the Mission Statement and ends with the choice of the best Strategic option. The first step is to review the Strengths & Weaknesses of the management team at the start. The strength could be in the form of intellectual property of the current staff; however this should not drive the final choice. Instead this could play a role in attracting financing. If the management does not contain personnel that cover all likely bases, efforts should be mounted to have relevant experts on consulting basis.

The first major activity is the determination of market share. It could be a brand new service or one or more of the current services that leave room for a new entrant with better quality or lower costs. A common mistake that is often made is to count all of those who do not have service as potential customers. Recent COVID has demonstrated the risk here. Several families could not help their children to join virtual classes because they could not afford modern computers and the interface equipment to connect to Internet! In short, it is not adequate to cover a potential user. Your service should also be affordable.

That brings us to the most important factor and that is the potential costs to the consumer. In this regard , at least two factors are critical and should not be glossed over. While the propagation loss for LEO satellites is much lower, for the same coverage area, their scan angle is much larger, thus reducing the antenna gain which has to be compensated with higher power. Second, small antennas for GEO satellites are much simpler than those for LEO systems which require phase array antennas in order to switch quickly from one satellite to the next. The second factor is still not yet fully resolved and it is not yet certain that the final designs will meet the cost targets.

 ***Proper assessment of market share is key to eventual success. It should not be assumed that all the unmet demand will be met with your system unless you have confirmed the consumer equipment cost for the candidate systems. At this stage, the likely market share should be captured through a series of graphs with likely consumer costs as a parameter.***

With market data in hand, the next step is to identify viable strategic options for the full system. This effort could be a major one and requires expertise in:

1. Applicable regulations, both national and international
2. System design for both space and ground segments
3. Engineering cost estimates for each of the options.

The above estimates are not required with high certainty, but should be accurate enough to distinguish one option from the other on the basis of estimated capacity, user equipment complexity and costs and time frames. This is the stage when a tentative decision could be made with regard to orbit, viz GEO, LEO and MEO. If it becomes absolutely necessary, industry could be consulted. In the context of current environment, it is important to make key decisions objectively and not to go with the flow necessarily. The final step is to narrow the choices to a maximum of three options These selected options should be narrowed further by a risk analysis—technical, engineering and financial. Hopefully, one option will stand out and take the team to the next step of developing a Business Plan.

***Risk analysis of the selected options is a critical step before Business Plan development***

**Business Plan**

The Business Plan is often described as a brief life history of the project, past present and future for the company. The last item is of course presented through the selected strategic option and the accompanying financial calculated on the expected costs and revenues.

The second crucial factor is the quality of management; in particular they often look for indicators that demonstrate signs of flexibility and ability to make midcourse adjustments objectively rather than with rigidity.

 ***Business Plan document ad its discussions thereof should aim at convincing the financial experts that a sound management is in place and is capable of handling their responsibilities with confidence and have the ability to handle any crises n with a dispassionate confidence, using the right expertise needed.***

**System Engineering**

Once the funding is in place and the staff with necessary expertise has moved in, this group, sometimes also known as Project Engineering, becomes the fulcrum of most activities. The first major activity is to optimize the overall system design to get optimum consumer cost and the desired capacity. Once there is consensus on the system, the teams develop what are called the “interface parameters” for the major procurement items. These would typically include:

* Spacecraft
* Consumer equipment
* Ground network
* Interface to satellite control system, typically leased.

It is inevitable that during the development cycles, some adjustment to interface or other internal parameters becomes necessary. Such adjustments should not be done arbitrarily but rather through use of system link budget. A common mistake managements make is to assume that link budget is only for the junior engineers. Rather it is an important management tool.

 ***System link budget is not just for working level engineers; it is a MUST for management when you are making decisions regarding relative investments between various segments, notably the space segment and the ground segment.***

**Consumer equipment Engineering Model**

This second iteration is to positively confirm with the Consumer industry the best set of interface parameters that can be ensured in quantity production and within the consumer cost ceiling selected. While engineering models are adequate, the importance of this step cannot be overstated as these parameters can determine the design and cost of the space segment and hence the extent of success in the marketplace.

As the industry substantially increased recently the use of NGSO orbits, this activity was not always given adequate importance. In particular, users on the ground have periodic handovers from one spacecraft to another, the rate of such handovers being determined largely by orbital height. Even more critical is the speed of these handovers and their orbital range. The related active phase array technology is still in evolution while in some cases at least part of satellites were already launched. The complexity of these antennas, both in terms of range in degrees and transmit-power has been under-estimated to the extent that the number of spacecraft in orbit had to be increased (largely to reduce the handover range). Recent efforts have begun to give commendable results; however this issue could turn out be a much costlier lesson.

 ***Develop engineering models of the consumer equipment for the selected strategic option with the likely vendors to determine the range of performance parameters within the competitive cost limit.***

**Space Segment Programs**

We will first recall the GEO spacecraft program elements. This will be followed by a summary of the factors that could change for non-GSO programs.

 The traditional approach has been to contract out the spacecraft through a rigorous and detailed contractual specifications. There are some exceptions where the entire or part of the activity is carried out inhouse. In such cases, each program can be unique.

The starting point is to draft a detailed specification document. From my experience here, here are some lessons I have learnt:

***The specification document should include all performance ,lifetime and environment requirements***

***1.*** *All clauses should be performance based. In simple words, refrain from telling the contractor how to achieve a particular performance. On the contrary, even an indirect hint on how to build or what devices to use, can sometimes come back to haunt the customer in case of any disputes down the road.*

*2. Do not dictate a particular subcontractor. Prime contractors like to call competitive bids for subcontracts.*

*3. Specify at least two choices of launch vehicles; this is important for the design process to include the shock and vibration requirements.*

**Differences in program management for NGSO spacecraft.**

 ***The answer is still evolving:***

*1. With large number of satellites involved, there could be temptation to relax the reliability requirements since the impact of failure of a single spacecraft can be often compensated; however, this should be done smartly and carefully.*

 *2. The debris disposal requirements are much more stringent for LEO*

 *3. NGSO systems providing multiple network services need a matching network on the ground. Its role and requirements should be established early and not after the space segment is finalized.*

**Part II: The Joy of Teaching**

As mentioned before, I had real fear of failure after my first two classes since I was teaching for the first time. However, once I reoriented my lectures, I began to see smiles on many young faces and I began to enjoy my classes. Listed below are a few self-standing memories of twenty years of teaching, mostly three semesters per year:

* Most classes in the beginning were between 30 to 40 students. This number began to drop halfway through my association. Part of the reason was that most full time foreign students who were going into IT careers.
* There was keen interest in international telecommunication quality standards extracted in my lectures but this also began to drop with digital techniques permeating everywhere.
* I began to encourage questions, particularly those I could not answer them straightaway. They made me research for the answers, thus expanding my knowledge-base. Instead of feeling embarrassed, I began to feel elated that I was getting the benefit of fresh minds asking new questions. This was and remains today my main joy of teaching.
* A few times, we had a discussion that the satellites we study could become obsolete in a few years. I welcomed this discussion as it took me back in time when I was an employer. My Finance Director probed me a bit and asked me why do I pay higher to PhD and Masters candidates than graduates. I thought it over an my reply was roughly on these lines. The graduate-level classes (more so for Ph D)encourage you to look for answers carefully and systematically. Once in a way the answers could lead to new inventions. It is that rationale that led me to emphasize my whole class to say Why and How rather than simply memorize known acts and write them in the exams. The flow chart here is more generic and cold well be applied to new systems of tomorrow.
* I went one step further. In their team projects, I encouraged them to ask me questions—any questions. If I could not get fully satisfactory answers, I encouraged them to include them in their slides for future reference. Perhaps some of them could lead to future research projects.
* One question I will never forget. The student was proposing a non-GSO solution but could not find a way of instantly switching the ground antenna to the next satellite. When I suggested cell towers do it all the time, She politely answered, “Sir, at cellular frequencies, the beamwidth is much wider but we can do that at higher frequencies. Ironically, the industry never answered it fully but jumped into LEO systems at higher frequencies. Today, Large sums are being spent to develop phase-array antennas to solve this issue.
* Recently, when COVID forced most universities to go to virtual classes, there was also a proposal to ask all foreign students to return home if they were attending only virtual lasses. Two of my students were crying on the phone to me that they cannot go home without a degree; their fathers had spent all their money on them already. Even though I had no definite answer, I consoled them this will never happen since most universities depend upon full fees of foreign students. They did not quite believe me but that is what happened a week later due to pressure from large universities. It was a great see them smile through half-dry tears.

Lastly, once I had to go to my TA’s apartment to pick up answer papers after a test. As I walked down the corridor, I could smell different aromas of food from all over the world. It turned out that apt. building was occupied manly by GMU students who slept on mattresses to accommodate more of their friends, preferably who liked the same cuisine!

1. Sachdev, D.K. (Editor): “Success Stories in Satellite System” AIAA (2009).ISBN 978-1-56347-966-3 (Ref 1) [↑](#footnote-ref-1)
2. Sachdev, D.K. (Editor; “Recent Successful Satellite Systems: Visions for the Future” AIAA (2017) ISBN 9781624040246 {Ref 2) [↑](#footnote-ref-2)
3. Sachdev, D.K, “ Business Strategies for Satellite Systems”, Horizon House, 2004. [↑](#footnote-ref-3)