A METRIC TO EVALUATE MOBILE SATELLITE SYSTEMS

Elizabeth L. Young
Consultant to JPL
162 Wilton Creek Road
Hartfield, VA 23071
Phone: 804-776-9436 FAX: 801-776-7220
RRLOVELL@postoffice.worldnet.att.net

ABSTRACT

The concept of a "cost per billable minute" methodology to analyze mobile satellite systems is reviewed. Certain assumptions, notably those about the marketplace and regulatory policies, may need to be revisited, Fading and power control assumptions need to be tested, Overall, the metric would seem to have value in the design phase of a system and for comparisons between and among alternative systems.

INTRODUCTION

In early 1995, a class of advanced graduate students at MIT, under the instruction of the Jerome Clarke Hunsacker Professor of Aeronautical Engineering, Robert R. Lovell, tackled the problem of how systems engineers could establish a useful method of evaluating different systems architectures during the design process for satellites intended to support mobile communications. They were aided by guest lecturers from several leading aerospace companies and mobile system providers. Their work led them to postulate that: "The primary metric used to evaluate the design is the system cost per useful virtual circuit minute. " [1] The short-hand for this metric became "cost per billable minute" to produce a defined level of profitability or internal rate of return (IRR), which the study targeted as 30%.[2] One half of this equation was the number of billable minutes any system could address; the other half represented the matching satellite system life cycle costs, which included development, deployment, ground infrastructure, insurance and operations. [3] A "virtual circuit"" was defined as a full duplex voice connection, of predetermined quality, between two users. "Useful" in the primary metric included consideration of the network capacity, individual spacecraft capacity, and customer or user geographical distribution.

The students used the "cost per billable minute" metric to compare and contrast certain proposed and theoretical mobile satellite systems and to design a hypothetical system. (While they examined the probable dimensions, performance and costs/prices of handheld units, they did not include any assumptions about variations in handhelds that would influence the "cost per billable minute" metric.) Their conclusion was that several different types of mobile systems could be successful, provided that assumptions about the worldwide market were correct. The class study, which was published, also became the basis for two masters' theses and an AIAA paper. The purpose of the present article is to revisit certain of the assumptions that were imbedded in the MIT work and to speculate on variables that were not within the scope of the study but which could affect system choices and ultimate profitability of mobile satellite systems.

MARKET ASSUMPTIONS REVISITED

A key finding of the study was that the single most important variable in assessing likely success is market share, rather than, e.g., selection of orbit, access scheme, or complexity of the space or ground systems.[4] This assumption itself could, of course, be challenged, but even if it is correct, the underlying assumptions about the nature of the

present and future market for mobile satellite services become critical.

One such assumption was that by the year 2013, the addressable market would be 6.5 billion minutes. [5] Another was that growth would be capped in areas of the world where cellular was likely to be dominant; therefore, the greatest growth for satellite services was predicted to be in China. the CIS and Russia. other areas of the Far East and Latin America. (It was further assumed that only 10°/0 of the users would be in an urban environment, while at least 40% would be in suburban and 50 % in rural areas.) Some consideration was taken of business users in the maritime and aeronautical environments.

One could challenge any one or more of these assumptions, but a few key questions emerge. First, will the absolute appetite for mobile communications continue to grow worldwide? We have some evidence that it will. Inmarsat, the first and oldest mobile satellite system, continues to increase its minutes and revenues even as other new mobile systems, e.g., MSAT and OPTUS, have come on line. On the cellular front, (he Strategis Group predicts that "by 2002 there will be over 500 million cellular and PCS subscribers worldwide, more than tripling the end-year 1996 cellular and P('S subscriber base of nearly 1-IO million". [6]

However. the fact that cellular and PCS systems ARE growing, leaves a very real question about whether the size of the addressable market for satellites may have been overestimated. Obviously, issues such as quality. ease of use and prices of satellite services will dictate to a great extent how well they will compete with non-satellite services. Interestingly, the MIT study concluded that even with as many as five mobile satellite systems addressing the worldwide market all can be cost effective. but that as any system falls below 31% of the market toward 10%, its prices will likely approach $10.00 or more a minute retail. which may not be competitive with other satellite systems or with cellular and PCS, Another conclusion derived from the study was that "room for multiple [mobile satellite] systems exists since the initial systems will be unable to meet the full market demand". [7]

As a corollary question. have markets been underestimated, e.g.. by not including the full complement of possible aeronautical. maritime and industrial users. and by not assuming satellite technology will be deemed superior to terrestrially based systems in some settings? Also. should projected mobile satellite user minutes be capped at 125 million in more populated markets (as was assumed in the MIT study) or should correlative cellular/PCS and satellite minute growth be assumed? There are a few of the questions amenable to further research With h new, non-geo mobile satellite systems coming on line in the near future, we also have no absolute way of knowing whether their availability will release a pint-up demand.

The MIT study assumed that mobile satellite users' behavior would mirror that of fixed communications users, i.e., with peak use occurring between 9 a. m. to noon and 2 p, m. to 5 p.m. on weekdays. However, if mobile users are content with voice mail reception for a large percentage of their calls and if data transmissions begin to substitute for voice, it is at least possible that peaks may be redefined, allowing more efficient use of circuits -- and lower prices to users.

Additional assumptions about critical user requirements included: ubiquitous coverage: 90°/0 availability of any system (meaning a call could be placed and completed about 90°/0 of the time); 95% reliability (the call will not be dropped more than 5% of the time): call duration (an average of 5 minutes for a voice call or 20 minutes for a data transmission): voice quality on a par with cellular. and price (customers would expect competitive pricing but would also expect to pay more for satellite-based connections than for PSTN or local cellular calls) [8] As more customers have experience with both cellular and satellite sm'lees. these assumptions need to be retested. especially those concerning quality -- is, for example, mere voice recognition enough in many casts" Is call duration as predicted" And most important. what is the price elasticity"

TECHNICAL ASSUMPTIONS REVISITED

It is beyond the scope of this paper to examine in detail all the technical assumptions that led the MIT students to conclude that most planned (or hypothetical) mobile satellite systems could be profitable given sufficient market share. However, a few of the key assumptions that entered the calculations of "life cycle" cost would need to bc reviewed before making any rigorous applicati n of the MIT methodology to real systems. These assumptions arc discussed below

Satellite construction and replacement costs dominated cost estimates, followed by launch service and insurance costs. Gateway costs were assumed not to bc a significant variable between and among systems, even for LEO systems. A spacecraft recurring dry mass cost of $'77,000 per kilogram was assumed, Varying ratios of non-recurring to recurring costs were assumed, based on differences between and among possible systems, e.g., GEO, LEO, MEO. None of these assumptions appears to violate industry experience, although what is learned in building the new generation of satellites may provide a new dry mass cost average number.

Greater elevation angles were assumed to provide a higher quality of service (absent any other considerations) since signal fading and blockage are especially dependent on the elevation angle. [9] Actual practice will reveal how significant this assumption is. Higher link margins and multiple satellites may serve to overcome problems of potential signal fading and blocking Indeed, Violet notes. in commenting on the study, "the major assumption in the system capacity simulations that could most significantly change the cost per billable minutes results include the fading and power control assumptions." [10] The power control assumption made was that mobile satellite systems of any type could provide power control within 2 dBW to any user Atmospheric variations, multi-path effects and uncertainty of antenna gain in an omni-directional hand-held make accurate power control difficult at best

Subject/verb agreement?

ISSUES BEYOND THE MIT STUDY

The "cost per billable minute" metric contains implicitly embedded assumptions that may or may not prove accurate in the real world. Onc of the most potentially troubling of these is the nature of regulatory constraints. It is assumed that regulation will not significantly hinder deployment and operation of systems. thus leaving all market predictions dependent only on user behavior and the technical capabilities of th,. system. In fact. regulatory policies (or the lack thereof) can operate in several ways. As we saw in North America before the ultimate 1 icensing of MS AT, the regulators handled competition by forcing applicants to undergo a long series of negotiations before any system cool.! ultimately be designed. built and brought to market. Ifa satellite system comes on line many years after the initial system builders estimate costs and profitability, it is likely the early estimates will be wrong.

Today, the LEO, MEO and HEO systems are, by definition global (or quasi-global). Therefore, they need permission to operate wherever they plan to service users, Individual countries may deny licenses for unspecified periods of time, having a devastating effect on the "billable minutes" part of the equation, Also, as spectrum becomes scarce, there may be policy decisions restricting or denying assignment of certain bands to mobile satellites, with these decisions coming either at the global (ITU), regional or national levels. And perhaps the most significant restriction may prove to be the forced sharing and coordination of scare spectrum. since sharing may take considerable time to negotiate and may result in restrictions in service for onc or more sv stems

"scarce"

Another variable that could force different considerations in building the "cost" part of the model is the availability and cost of launch vehicles. If we encounter a period during which there are failures of several different launchers. significant delays and price increases may result The MIT study assumed competition in the launch vehicle field If and when competition decreases (although, today, there

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seem to be more countries trying to enter this business), then these costs and associated risks may also rise.

While the MIT evaluation of the mobile satellite marketplace did take into consideration competition from cellular and PCS. no dramatic changes in any technology -- whether ground or space based -- were assumed If we should see a breakthrough in how mobile users can be served. resulting in dramatically lower prices in equipment and service but with no loss of quality and reliability, market assumptions may need to be revised further.

A FINAL LOOK AT THE METRIC

As we have seen, while matching system costs against probable billable minutes seems to be a valid and intrinsically sound methodology. certain key variables require continuous review. Most notable among these are the size and probable behavior of the market. As a corollary, one could add the likely behavior of regulators and the results of regulatory policies, '1'ethnical assumptions will doubtless become modified with experience, and, of course, such assumptions will further need to be modified if user behavior differs from what is predicted (e. g , if users are willing to put up with certain types of gaps in service or service quality). Also. if dramatic changes ensue in the next few yea rs -- whether in mobile technology, the launch vehicle market. or the world economy -- all of what seem sound assumptions in estimating costs and profitability may be in need of drastic revision

The "cost per billable minute" metric has much to commend it as a [001 to evaluate different sy stem designs, Even with the assistance of such a tool. we cannot http but note that the creation of mobile satellite systems is a difficult and risky business! It is extremely challenging to design complex sy stems that may take anyw here from seven to ten years from conception to deploy ment and that hav e a design life-time of 12 or more years (w hich period may encompass tw o complete successiv e generations of a giv en LE O system, for example) Nonetheless. we are clearly entering an era when the demand for mobile communications is grow ing. and w ith that growth is coming a proliferation of systems to serve the demand, In the last one hundred years, it has been more common to underestimate telecommunications demand than to overestimate it. While this does not mean that everyone entering the market will be profitable, it does at least paint a scenario with room for competing sy stems. of differing designs. entering the market at different times -- w hich is exactly what the MIT study predicted,

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