View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by Embry-Riddle Aeronautical University

The Space Congress® Proceedings

2000 (37th) Space Means Business in the 21st Century

May 4th, 2:00 PM

Paper Session III-C - A Portable MBA Guide to the Commercialization of Space

Robert N. McGrath Ph.D.
Department of Business Administration, Embry-Riddle Aeronautical University

Follow this and additional works at: https://commons.erau.edu/space-congress-proceedings

Scholarly Commons Citation

McGrath, Robert N. Ph.D., "Paper Session III-C - A Portable MBA Guide to the Commercialization of Space" (2000). *The Space Congress® Proceedings*. 24.
https://commons.erau.edu/space-congress-proceedings/proceedings-2000-37th/May-4-2000/24

This Event is brought to you for free and open access by the Conferences at Scholarly Commons. It has been accepted for inclusion in The Space Congress® Proceedings by an authorized administrator of Scholarly Commons. For more information, please contact commons@erau.edu.

EMBRY-RIDDLE Aeronautical University
SCHOLARLY COMMONS

A Portable MBA Guide to the Commercialization of Space

Dr. Robert N. McGrath
Department of Business Administration, Embry-Riddle Aeronautical University
600 S. Clyde Morris Blvd., Daytona Beach, Florida 32114-3900
(904) 226-6703

for the

37th Space Congress:
"Space Means Business in the 21st Century"
Cape Canaveral, Florida
May, 2000

Submitted December, 1999

Abstract

This paper adopts reputable analytical techniques for identifying near and long term strategic success factors in the space telecommunications industry. Main conclusions of an industry analysis point to leverage attainable through moving quickly and massively, establishing large market share and production volumes, and getting unit costs down. However, limitations in the efficiency of launch vehicles, and the capacity of the global launch infrastructure, will continue to pace progress. It is then proffered that launch costs per pound might not be the best strategic metric of progress; rather, that more strategically important cost-reduction opportunities might lie in improving the overall characteristics of whole value chains viewed as systems, aimed at reducing the cost per service delivered over whole life cycles.

Introduction

Despite deregulation in the U.S., parts of the communications sector have characteristics of relatively mature industries [1]: production overcapacity, heavy concentration in a few dominant firms, fierce head-to-head competition, clearly defined market segments, etc. [2,3]. However, not all the world is industrialized and the nature of communications industries varies. In India, for example, less than 2% of the population has telephones, and two million others are on waiting lists [4]. In such places (and especially where industrialization is less advanced,) the communications industry has characteristics of emerging industries: lack of infrastructure, technological uncertainty, exploding growth, etc.

Rather than (or in addition to) extending land-based communications infrastructures, the best way to further develop and integrate global communications should (and will) involve further commercialization of outer space and associated technologies. Relatively nonexistent infrastructures in developing regions can be developed satellite-based about as easily as they can be developed by employing terrestrial technologies, for example, and the continued expansion of cellular telephony and the internet present a similar opportunity for continued growth in industrialized nations.

A quick look at related economic figures can lead to disparate speculations. According to the U.S. Federal Communications Commission, all sectors combined, telecommunications was a $550 billion industry in 1996, and will be a one-trillion dollar industry as soon as the year 2001. Yet of that, space-based telecommunications will command about $41 billion (4%) in 2001 [5]. One might assume from these numbers that the land-based incumbency has distinct first-mover advantages (in fact, that billions of dollars invested in establishing an enormous base over decades makes it an intractable incumbency.) Or, one might prefer to assume that space-oriented new entrants have an open frontier, and a golden opportunity to create rules of competition in their favor. This discussion will combine both perspectives, and space commerce in general will be viewed both as an emerging industry, and a competing, substitute industry.

Here, it is tempting to try to portray the commercial space industry plainly in terms of the most contemporary and newsworthy market segments, technologies, strategies, and so forth [1]. However, much uncertainty still exists and many unforeseeable changes are certain. As plain as the existence of some technology and market parameters may seem, the histories of the evolutionary patterns of many other industries teaches us to not assume that these parameters will prevail. Therefore, the author avoids the noted temptation, and chooses to not make speculations about specific firms, technologies, and markets. The author assumes that the intended audience of this paper is generally familiar with the major players, products, and goals of the major players, and feels that presenting a few macro-measures will suffice as a framework for the ensuing discussion.

According to the consulting firm Peat Marwick, all sectors of the space industry amounted to a $77 billion opportunity in 1996, and will grow to $121 billion in 2000 [6]. Of this, infrastructure and launch vehicles comprised $47 billion (61%) in 1996, and will comprise $60 billion (49%) in

2000. Telecommunications comprised $23 billion in 1996, and will comprise $46 billion in 2000. The figures for emerging applications are $4 and $12 billion, respectively. According to Merrill Lynch, in 1998 the market for satellites constituted about a $45 billion industry in 1998, and will grow to about $68 billion in 2001 and $155 billion in 2006 [7]. The largest and fastest growing niches will be mobile satellite services and multi-media, followed by direct-to-home television and fixed satellite services. Certainly, these numbers circumscribe a level of economic activity, and potential for profitability, that compels thorough inspection at all levels of analysis. Though being an arbitrary choice, the author feels that a focus on space telecom is nonetheless representative of space commerce in general. A brief industry-level analysis follows, based on a review of trade literature over a one-year period.

Industry Analysis

Industry analysis is a technique, anchored in Industrial Economics, developed to help firm-level strategists and industry policy makers to penetrate the inherent economic opportunities and threats that characterize an industry [1,8,9]. An industry is conceived to be the sum and structure of its economic forces, summarized by five factors: the intensity of rivalry, the threat of entry, the threat of substitution, the bargaining power of suppliers, and the bargaining power of buyers. Once an industry is dissected, profitability patterns clarify, and essential strategic actions often become apparent. As telecommunication satellites seem so important to leading the true commercialization of space, next is a cursory analysis of the space telecommunications spacecraft (satellite) manufacturing and operations industry. (The definition of this "industry," especially as it integrates satellite manufacturing and satellite communication operations, is strictly an interpretation of the author, guided by theoretical considerations of the problems determining the boundaries of any new, dynamic, and/or amorphous industry [10,11].)

Rivalry: First, the intensity of industry rivalry is indicated by the number of competitors and their size, although absolute and relative power are really the issue [1]. The major players in the space telecommunications industry are relatively few and clearly identifiable. However, when firms are reasonably well-positioned against each other in terms of their capabilities, it takes a surprisingly small number of firms to make an industry competitive. The prevalence and competitiveness of oligopolies exemplify this statement. On the whole, it can be seen that the most dominant firms participating in space telecom have corporate sponsors with a variety of strengths, fostering a multidimensional, heterogeneous but otherwise fairly high level of rivalry.

In contrast, the rapid growth rate of the telecommunications market implies that space telecom industry rivalry is not high, though the reasoning is a little obtuse. When a market's growth rate exceeds industry production capacity and capacity growth, it is often easier and more strategically prudent to avoid head-to-head competition and simply grasp for market share in unexplored and burgeoning market segments [1]. Rivalry in such a scenario might be thought of as occurring between individual firms and the clock, not among firms per se.

Next, the differentiability of a product/service plays an important role in determining rivalry. Differentiation refers to product/service attributes that are perceptible to consumers and valued enough to command a premium price [1]. (Here, differentiation should not be confused with segmentation. The former term is assumed to be a consumer-level phenomenon, while the latter is a consumer group-level phenomenon, a level of analysis avoided for reasons described earlier.) Or, conversely, when perceived attributes are roughly the same, price typically differentiates products. In space telecom, fine-grained consumer differentiation is difficult to yet assess (relative to what will occur as the industry develops,) and this is typical. But over a longer-term, bases of differentiation typically evolve in any industry, and change from performance-based differentiation to cost/price differentiation.

Furthermore, technology-defined industry boundaries, and market-defined industry boundaries, are not necessarily aligned with each other, especially in emerging industries [12]. So in addition to market segment phenomena, future industry structure will be shaped by the evolution of various technologies, a difficult area to forecast and beyond the scope of this paper [13,14]. What seems more plain is that space telecom has terrestrial rivals, so one clear basis for understanding near-term competition is to view one group of land-oriented firms as being positioned against another group of space-oriented firms. At an inter-industry level, these sets of providers seem differentiable from each other in terms of both performance and cost/price, though much of the argument is yet to come. But to preview an upcoming conclusion, profitability in space telecom will be affected to the extent that costs reach levels where space and terrestrial-based telecom are similarly priced for services that are perceived as very similar.

Switching costs also affect rivalry [1]. Switching costs are the costs borne by a consumer of changing a purchase decision, which can economically segment an industry which might be seamless in most other terms. For example, a consumer of a specific space telecom service might spend several thousand dollars to buy a unique type of telephone [15,16]. This is an obvious barrier to switching from land-based service. And to switch to another provider might necessitate the repetition of this investment. The presence of some switching costs does suggest some attenuation of rivalry. On the other hand, it is also typical for switching costs to become obviated over time by extensive standardization and convergent improvements in technologies [17,18]. Altogether, there are near-term switching costs in space-based telecom but they should decay over time.

Next, to the extent that fixed costs in an industry are high, rivalry tends to also be high [1]. High fixed costs imply high breakeven production volumes, intensifying the importance of achieving high levels of market share. Clearly, the fixed (and/or sunk) costs of participating in space telecom are very high. This infers tough rivalry as players compete for market share and production volumes, even during the early years of the industry, so as to establish first-mover advantages. However, the payback periods suggested in the popular media (to the extent that they are realistic) are short (especially considering the huge costs.) This implies that the kind of scale-based rivalry seen in other parts of aerospace like aircraft manufacturing (where payback periods are typically well over ten years) should not become the most compelling factor, but they could become a minimum requisite element for firm-level survival.

The perishability of a product/service also affects industry rivalry [1]. Perishability might sound irrelevant to the robust characteristics of satellite hardware and software, but it is the perishability of the service they provide that matters. As a microcosmic example, any discrete phone call made via terrestrial cable today is a phone call that will not be made via satellite; as a rule, services are infinitely perishable. Thus the scramble for volume can be quite mad (witness long-distance telephone service providers,) resulting in intense rivalry. On this account, and as it probably interacts with other factors, first-mover advantages in space telecom loom important.

The nature of added production capacity affects rivalry, and at present, space telecom capacity is basically being added one satellite *constellation* at a time. After constellations become operational, capacity might be better thought of as being added a few satellites at a time, but even individual satellites handle many thousands of customers, and each satellite capability costs many millions of dollars to establish. When industries are mature and markets are saturated, such a situation has the tendency to disrupt supply-demand equilibria and often triggers price wars. However, in the near term there looks to be plenty of unserved telecom market to accommodate foreseeable capacity additions, postponing significant impacts of this specific phenomenon.

Finally, exit barriers affect rivalr [1]. When for any reason -- psychological, economic, or otherwise -- it becomes difficult for players to exit an industry, industry overcapacity can result from the continued presence of many desperate, marginal players. In space telecom, for example, very significant debt and liability needs to be incurred just to enter the industry, making it difficult to exit before that debt and other obligations are serviced. Significant and sometimes unique investments must also be made in human and physical capital, making disinvestment difficult or costly. However, once again, the sheer munificence of the space telecom market should delay the issue, to the extent that unmistakable and abundant opportunities mask competitive weaknesses.

Threat of Entry. The threat of entry affects competition and industry profitability by placing a cap on average prices [1]. When economic factors impede entry and additional competition, prices rise to levels mitigated by other factors. First, the threat of entry is affected by inherent economies of scale. Especially if such economies are already being enjoyed by existing industry players, entry is made difficult by the amount of money and effort it would take to enter at a high capacity -- otherwise the new entrant would incur unit cost disadvantages. Economies of scale exist in space telecom in several forms, though the industry is probably still too youthful for any firm to yet have an unassailable advantage in them. But economies of scale are powerful phenomena, and must be exploited (along with high utilization rates) to help bring unit costs and unit prices down to levels that facilitate mass-market-like share volumes.

Likewise, to the extent that the amount of capital required to gain entry is high, the threat of entry is obviously low [1]. Given the billions of dollars it takes to compete in space telecom, the likelihood that many new entrants will invade is low. Thus some rivalry will be precluded.

In space telecom, as has been true of any industry, success can be limited by the availability of raw resources [1]. Here, the availability of technology does not seem to be as limited as the availability of more mundane resources [19,20]. Capital is a key and finite resource, and the inability to obtain financing will almost certainly continue to be one of the most severe impediments to entry [5].

Next, in much the same way that differentiation affects rivalry, it also affects the threat of entry [1]. A more specific concern here is differentiation affected by proprietary positions. To the extent that a defensible technology adds perceptible value to a product, economic returns are implied. However, the perception of value is key [8], and it is always consumers' perceptions that matter the most. In the simplest sense non-value adding technologies, even proprietary ones, bring unnecessary costs (unless, in contrast, their whole purpose is to reduce costs [21].) This is important because in space telecom, it is the standardization of many technologies, not their uniqueness, that will constitute the basis of an unfragmented industry. And fragmented industries, by definition, impede the full flowering of otherwise-inherent economies of scope and scale [1]. Ironically, much (not all, of course) of the hardware and software underpinning and continuously improving the commercial viability of space telecom will need to be commonly available, inexpensive, and reliable.

However, a "technology" is more than hardware and software and, for example, can lie tacitly in an organization's human capital, organizational processes and procedures, and so forth. Indeed, patents tend to be easily imitated, but organizational capabilities are often much more defensible and serve as ultimate sources of high economic returns [22]. Thus, it is argued, the threat of entry in space telecom is low not so much because of its hardware and software sophistication, but because establishing a constellation of satellites is a remarkable, rare, and difficult-to-imitate organizational capability.

Similarly, experience and learning curves affect the threat of entry [1]. Firms with profound levels of experience at space telecom services should have a lead over potential rivals with little or no experience. However, cumulative production volume, not time, is the basis of both experience and learning effects. Thus market and production volumes again surface as key objectives. Astute readers will have noticed the potential "Catch-22" in this situation. It is difficult to become efficient and lower costs without experience, and experience comes with production volume, but high production volumes of undifferentiated products/services are difficult to "move" unless prices are low, which are difficult to establish unless costs are already low.

The likelihood of entry is also affected by government policies. Here, entry is being made more opportune. First, the commercial use of space is becoming appreciated as an industry that is vital to national economic interest [23,24]. Second, it is apparent that a transition is underway between space R&D as an upstream business and the extensive operation of commercialized products, so time is of the essence [25]. Third, and as a result, governments are promoting the commercial use of space not only in spirit, but in law [26]. On balance the likelihood of new entry is increasing due to these trends and agendas.

Finally, access to distribution channels and the availability of favorable locations affect entry [1]. In space telecom, the availability of favorable locations would refer to the availability of orbits and bandwidths, both regulated by governments [24]. At present these resources seem to be reasonably available though again, they are not infinite and early entry might prove to be pre-emptively important.

But it is the access to distribution channels that seems to be one of the most imposing barriers to not only entry, but to expansion by existing players, and growth of the industry as a whole. Discussion of this factor will consume much of the remainder of this paper.

Bargaining power of suppliers and buyers. Defining the structure of an industry is always problematic [1]. It is arguable whether the providers of launch products and services are buyers, suppliers, or full partners to the space telecommunications industry. Furthermore, regardless of one's theoretical preferences, it is a fact that a very significant amount of backward, forward, and/or horizontal integration exists among the players [25]. The position taken here is that defining this industry's boundary is secondary to the common sense observation that physical satellite positioning, and therefore commercialization, can not happen without a launch service and launch vehicle manufacturing base, which altogether behaves like a value-adding outbound logistics infrastructure [8]. Hence the players will be considered to be logistics suppliers with the opportunity to bargain [27,28].

Virtually all major considerations point to a large amount of power held by launch service and vehicle providers. First, an estimated 1,000 commercial launches will be needed in the upcoming decade [29]. But there are very few launch pads in the world, creating a serious bottleneck which governments have both subsidized and monopolized for almost all of the space age to date. At present some of these facilities are being privatized [30] and new ones are under strictly-commercial development [31], but years will elapse until the launch infrastructure bottleneck is appreciably relieved. In the meantime launch costs should remain very high, and prices are likely to be value-based.

Second, launch vehicles have historically had significantly differentiated capabilities. There has been some overlap as to payload bulk, weight, operating envelopes, etc., but in the present sense commercially viable launchers have had relatively unique spectra of performance. Anyway, even if launchers were directly competitive in this simple sense, switching costs among satellite manufacturers and launch providers would still be significant, since seamless working relationships between a satellite manufacturer and a launch service provider can not be quickly or easily reconstituted. Fourth, and as stated, the boundaries among satellite manufacturers and launch service providers are unclear and there is significant integration among them [32]. Satellites are designed with launch vehicle capabilities taken carefully into consideration. Fifth, the importance of the quality of a rocket is extremely crucial and not entirely predictable. It is still not uncommon for launchers to explode during commercial operations, wiping out hundreds of millions of dollars of investment in a second [33,34]. This bodes well for the bargaining power of the most reliable launcher providers. As evidence, launch services are reported to be one of the three top cost categories of communication satellite system establishment, along with the cost of satellites themselves and the cost of insurance (which, obviously, is related to launcher reliability) [35].

Finally, other than a few choices among classic rocket designs, there are at present no real substitutes for them, collectively. If a firm wants to orbit a satellite, unmanned and non-recoverable rockets are practically the only viable launch option (other than the U.S. Space Shuttle.) Thus one sees that much of the inherent profitability of delivering satellite-based telecommunications services shifts to launch product and service providers. As evidence, launch cost per pound of payload is always targeted as a key, if not *the key* to the commercialization of space [5,35]. Consequently the pressure to lower unit launch costs is intense; nominal industry cost per pound in the late 1990s was about $10,000 per pound.

Threat of Substitution. The space telecom industry has been characterized as a collective substitute for similar terrestrial services. Here, much of the market in the industrialized nations is already being served, and space telecom will be successful to the extent that it provides performance/price ratios that rival its land-based competition [1]. On a truly global scale, much of the telecommunications market is rather poorly served via land or sky. Whichever sector expands to provide true global service first will have some advantages, but fast followship seems certain and ultimate performance/price will likely be a key competitive factor. So once more, it seems that across the industry, capable technologies are or will soon become available (except as pertains to launchers,) and that price, hence the overall structure of costs, may ultimately prevail as the leading predictor of strategic success [36,37].

To summarize, in the near-term, some amount of direct head-to-head rivalry should be postponed by the apparent size and growth rate of the market. The early availability of key technologies will provide quite high levels of service quality quite early, accelerating price towards becoming the more powerful differentiator. Likewise, switching costs will not be very high for very long. High investment and fixed costs, service perishability, the nature of capacity additions, economies of scale, experience and learning effects, and the finite number of prime "locations" and amount of investment capital all suggest critical advantages obtainable by moving early and massively. But enacting strategies aimed at these urgencies will continue to be braked by launch infrastructure (site, vehicle, and launch service) limitations, retarding growth and cost economies, and injuring price flexibility, revenue, and overall profitability. In the meantime terrestrial communications providers will continue to expand and some lost market share will be difficult to capture. This overall pattern is typical of the early stages of many industries' evolution, especially highly-capitalized and scale intense industries [1]. The biggest difference here seems to be that price will be an early differentiator, and that the mass-market will develop early.

As the industry transitions from relative infancy to rapid growth en route to eventual maturity, some product life cycle possibilities are as follows [38,39]. As service differentiation evolves quickly from performance to price, key organizational competencies will transition from engineering skills to marketing skills to production skills. A relatively amorphous set of industry "rules" of all kinds will eventually clarify and maybe rigidify, facilitating clearly defined market segments, dominant satellite designs, overall industry standards, etc. Along with the appearance of such structure will dissolve much of the opportunity to create or change the rules in any one firm's favor. The key to operations strategy will shift from design to manufacturing. The keys to rivalry will change from being inter-industry to intra-industry. Established percentages of the share of ever-sophisticated markets (including the mass-market) will become more jealously guarded. However, market saturation should not occur early, postponing the sometimes ruinous dynamics of industry overcapacity. Again the conclusion is that moving early and massively seems certain to convey latter-phase advantages, so sustaining mid-term growth, at least in absolute terms and preferably in share as well, may be essential. Along the way, economic opportunities of new proprietary technologies should be carefully assessed against the alternative benefits of universal standards and open architectures. But few firms will fully prosper until all links in the supply chain are established and rationalized. This means that bottlenecks and inefficiencies in the global launch infrastructure are poised to impede growth of space commerce into a true mega-industry. And due to the pressures described to this point, there are indications that the early players are falling somewhat into a classic trap, that being the tendency to suboptimize long-term value-chain cost structures in favor of resolving near-term marketing urgencies and the servicing of impatient debt.

Technological Evolution v. Revolution

While unit launch costs are an understandable obsession given the economics of the near-term situation, analyzing industry profitability beyond the foreseeable future should also take into account general multi-decade cost trends that are predictable in an abstract sense. Here, the author adopts a total system, total life cycle view. Metaphorically, if total industry demand could be described as a pie, the issue is not how big a slice of the pie the average firm might capture, but how to structurally enable the maximization of the size of the pie. It is not automatic that market demand will force the size of the pie to become as large as its potential; it will be much affected by strategic decisions made (or ignored!) at the level of the firm, and especially at the level of industry policy (i.e., public policy and investment.)

It has become axiomatic that in many aeronautical and aerospace systems, when the major costs of a system begin to accrue, it is often too late to do anything really serious about design features. Pressured by relatively short-term concerns, R&D, design, and even early manufacturing investments often seriously suboptimize total life cycle costs, which in the end are often driven by the costs of maintenance and logistic support [40,41]. Absent from most of the reviewed popular press, as it tracked the industry in question, was an abiding consideration of the long-term costs of satellite downtime, replacement, repair, and logistic support. This is an important observation, considering very large satellite R&D, production, and delivery costs -- the cost to launch a pound of payload, always cited as a very important parameter, may be a suboptimal metric from the most strategic view of total system cost, and long-term unit cost. Something like cost per unit of customer service over the entire life cycle of a constellation may be more correct, as an "objective function" for maximizing overall industry profitability. This may be a naive firm-level strategic goal, but there is still time for public policy-makers to shape, even subsidize, incentives for long-term socioeconomic optimization.

This shift in emphasis to maintenance and logistic support is not just hypothetical, even at the present stage of the "game" -- in addition to launch failures, in the constellations of communications satellites already being fielded, very costly failures have occurred [42-45]. Given existing industry structure and technologies, multi-million dollar satellites must be considered throwaway items, in the sense that if they fail, they are unrecoverable. It is the author's opinion that in the end, unit costs will be seen to be driven by total system reliability, where the entire industry value chain properly bounds "the system." From this point of view, there are two fundamental choices -- enhance the reliability of the system, or enhance the supportability of the system to accommodate reliability imperfections. As an obvious illustration, it is conceivable for spaceplanes to recover failed satellites, and space-based maintenance could prove cost-effective. Fortunately, reliability and supportability goals are not incompatible, but it is not certain that the structure of the present value chain properly incentivizes long-term system optimization.

As young as the industry may seem, it is nevertheless dominated by large, not-so-young corporations. This is not unusual for an emerging industry, but histories of other industries indicate that today's dominant players might not be the most influential in the long-term. It is often the case that radical improvements to technologies, architectures and infrastructures require paradigmatically different thinking [46,47]. The sources of radical innovation are often new start-ups, or "uncooperative" renegades from an existing industry, or invaders from other industries [48,49]. There is clear evidence that this may be happening in space launch concepts [32]. But to speculate which firms and technologies will eventually dominate would change the level of analysis maintained in this paper, and diverge from its purpose. The point is that first-mover advantages enjoyed by the industrial incumency, already discuseed as being a key to success in a realistic business sense, may block an evolution -- revolution, really -- towards the most technologically reliable cradle-to-grave value chain. This is not to suggest that the incumbency will fail society by pursuing a trjactory of incremental technological evolution; the argument for optimization is admittedly perfectionistic.

To summarize, the "systems" under present consideration might best be bounded broadly as satellite fleets, launch services, and launcher fleets together, considering all cost and effectiveness interactions and trade-offs from the moment a technology concept appears to the moment when the last discrete element of the system is retired. From the very strategic, life-cycle perspective, the best cost baseline for calculating unit costs is total R&D, production, operations, maintenance, logistic support, and retirement cost, unitized over total volumes and/or meaningful unit measures of service, delivered over the operational life cycle. A change in any major life cycle assumption -- changing the planned length of the operational life cycle, or changing the size of production runs, or even a change to financial discounting assumptions, has the degree of freedom to modify any per-unit metric very significantly. Ironically, sometimes cold, hard business realities, when placed into strategic context, make profound technological progress seem mundane in purpose and actually rather essential. It is for fundamental logistical purposes that some technological breakthroughs that foster the commercialization of space will be made in the next decades.

Summary and Conclusion

The market for communications services is enormous and exploding and presents munificent business opportunities, especially for first movers and early entrants. Strange for a contemporary industry however, is that technological innovation in principle products and services may not be the limiting factor faced by firms developing the space telecommunications sector. Technological innovations in the development of logistic infrastructures, especially launch vehicles, may be the limiting factor, along with an inadequate capacity of an inefficient launch infrastructure. A radical change in the present-day launch technology paradigm will probably be necessary to dissolve the seams between aeronautical and aerospace fleet operations, and literally push the sphere of seamless commerce out several hundred miles from the face of the earth. Unfortunately, the near-term urgency of meeting infinitely perishable demand may pull some technological trajectories towards suboptimal solutions. Despite the apparent potential for technologies like spaceplanes to bring payload costs down to levels that would allow explosive growth of space commerce, delivering large rents to some firms and efficiencies to society in the long run, the history of industrialization makes it seem very possible that near-term economic forces might lock in different, more costly choices. However, lost opportunities will always remain somewhat hypothetical and will not negate the very real socioeconomic gains destined to be otherwise achieved at these interesting frontiers.

References

[1.] M. E. Porter, *Competitive Strategy* (New York, Free Press, 1980).
[2.] 'At last, telecom unbound', *BusinessWeek*, July 6, 1998, pp. 24-31.
[3.] 'The new world order', *BusinessWeek*, October 13, 1997, pp. 26-35.
[4.] C. Covault, 'Asian economic crisis jolts pacific space sector', *Aviation Week and Space Technology*, October 5, 1988, pp. 22-3.
[5.] J. C. Anselmo & A. L. Velocci, 'Wall Street bulls chase SatCom boom', *Aviation Week and Space Technology*, June 15, 1988, pp. 56-58.
[6.] C. Covault, 'Global commercial space business sought for ISS', *Aviation Week and Space Technology*, May 11, 1988, pp. 26-7.
[7.] A. L. Velocci, 'Lockheed Martin angling for ComSat acquisition', *Aviation Week and Space Technology*, September 28, 1988, pp. 20-1.
[8.] M. E. Porter, *Competitive Advantage* (New York, Free Press, 1985).
[9.] M. E. Porter, *The Competitive Advantage of Nations* (New York, Free Press, 1990).
[10.] G. H. & C.K. Prahalad, *Competing for the Future* (Boston, Harvard Business School Press, 1992).
[11.] H. Mintzberg, *The Rise and Fall of Strategic Planning* (New York, Free Press, 1994).
[12.] C. Covault & J. C. Anselmo, 'Technology leaps signal dawn of new space era', *Aviation Week and Space Technology*, September 7, 1988, pp. 132-6.
[13.] M. Dodgson and R. Rothwell, *The Handbook of Industrial Innovation* (Cornwall, England, Edward Elgar Publishing Company, 1994).
[14.] M. L. Tushman and P. Anderson, *Managing Strategic Innovation and Change* (New York, Oxford University Press, 1997).
[15.] J. C. Anselmo, 'Investors eye Iridium as industry indicator', *Aviation Week and Space Technology*, June 15, 1988, p. 62.

[16.] B. A. Smith & J. C. Anselmo, 'Operational Iridium constellation in place', *Aviation Week and Space Technology*, May 25, 1988, pp. 26-7.

[17.] N. S. Levy, *Managing High technology and Innovation* (Upper Saddle River, New Jersey, Prentice-Hall, 1998).

[18.] A. Afuah, *Innovation Management: Strategies, Implementation, and Profits* (New York, Oxford University Press, 1998).

[19.] M. A. Taverma, 'Europe bets on small satellites', *Aviation Week and Space Technology*, September 7, 1988, pp. 136-7.

[20.] J. C. Anselmo, 'Faster, better, cheaper and a lot smaller', *Aviation Week and Space Technology*, September 7, 1988, p. 141.

[21.] E. von Hippel, *The Sources of Innovation*, (New York, Oxford University Press, 1988).

[22.] J. B. Barney, *Gaining and Sustaining Competitive Advantage* (Reading, Mass., Addison-Weseley, 1998).

[23.] A.L. Velocci, 'Space could launch new Calif. job market', *Aviation Week and Space Technology*, July 20, 1988, p. 55.

[24.] M. I. Hoffert & S. D. Potter, 'Beam it down', Technology Review, October, 1997, pp. 30-36.

[25.] E. D. Phillips, 'NASA turns to private sector', *Aviation Week and Space Technology*, October 5, 1988, p. 34.

[26.] J. D. Morrocco, 'Inmarsat poised for privatization,' *Aviation Week and Space Technology*, March 19, 1988, p. 78.

[27.] R. H. Handfield & E. L. Nichols, *Introduction to Supply Chain Management* (Upper Saddle River, New Jersey, Prentice-Hall, 1999).

[28.] P. Dornier, E. Ricardo, M. Fender & P. Kouvelis, *Global Operations and Logistics* (New York, Wiley, 1998).

[29.] J. C. Anselmo, 'Space ventures reach for new markets', *Aviation Week and Space Technology*, March 23, 1988, pp. 68-70.

[30.] J. C. Anselmo, 'NASA nears CSOC pick', *Aviation Week and Space Technology*, June 22, 1988, p. 33.

[31.] B. A. Smith, 'Sea launch prepares for demonstration in March', *Aviation Week and Space Technology*, October 12, 1988, p. 27.

[32.] C. Covault, 'Cape shortcomings threaten existing commercial launch ops', *Aviation Week and Space Technology*, March 2, 1988, pp. 30-1

[33.] C. Covault, 'Zenit destroys 12 Globalstars; Failure threatens Sea Launch', *Aviation Week and Space Technology*, September 14, 1988, p. 26.

[34.] C. Covault, 'Boeing Delta 3 explodes; Commercial debut ruined', *Aviation Week and Space Technology*, August 31, 1988, pp. 22-4.

[35.] A. L. Velocci, 'Commercial space basking in favorable insurance climate', *Aviation Week and Space Technology*, June 15, 1988, pp. 58-60.

[36.] M. Mecham, 'Industry learns to sell from satellite catalog', *Aviation Week and Space Technology*, March 23, 1988, pp. 73-74.

[37.] 'Life Cycle Costs', *Aerospace Engineering*, October 1997, p. 29.

[38.] J. A. Pearce and R. B. Robinson, *Strategic Management: Formulation, Implementation and Control* (Chicago, Irwin, 1997).

[39.] T. L. Wheelen and J. D. Hunger, *Strategic Management and Business Policy* (Reading, Addison-Weseley, 1998).

[40.] B. S. Blanchard, *Logistics Engineering and Management* (Englewood Cliffs, Prentice-Hall, 1992).

[41.] W. J. Fabrycky & B. S. Blanchard, *Life-Cycle Cost and Economic Analysis* (Englewood Cliffs, Prentice-Hall, 1991).

[42.] B. A. Smith, 'Delta 3 explosion rocks PanAmSat's schedule', *Aviation Week and Space Technology*, August 31, 1988, pp. 24-5.

[43.] E. Sekigawa, 'Japanese watchdog agency questions need for J-1', *Aviation Week and Space Technology*, May 11, 1988, pp. 41-2.
[44.] E. Sekigawa, 'Japanese H-2 failure ruins SatCom research mission', *Aviation Week and Space Technology*, March 2, 1988, p. 34.
[45.] C. Covault & E. Sekigawa, 'Atlas launches Intelsat pulled off Long March', *Aviation Week and Space Technology*, March 19, 1988, pp. 26-7.
[46.] J. M. Utterback, *Mastering the Dynamics of Innovation* (Boston, Harvard Business School Press, 1994).
[47.] R. A. Goodman & M. W. Lawless, *Technology and Strategy: Conceptual Models and Diagnostics* (New York, Oxford University Press, 1994).
[48.] C. M. Christensen, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail* (Boston, Harvard Business School Press, 1997).
[49.] S. P. Schnaars, *Managing Imitation Strategies: How Later Entrants Seize Markets from Pioneers* (New York, Free Press, 1994).