Mixed-Use Business Park Developments in Space: A Real-Estate Paradigm

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Standard terrestrial business-park development practice is proffered as a realistic organizational model for expanding human activity in Earth orbit. The histories, methods and biases of the modern real-estate development and aerospace industries are contrasted. Profit driven decision making can allow the real estate paradigm to succeed where other approaches have failed: space-based industries are produced as a by-product of money making, rather than the reverse. Preconditions for viable investment in orbital real estate development projects are explained, including return-on investment bounds, privatization of transportation support, legal requirements and the pivotal role of government-funded proof projects like space stations. Consolidated provision of standardized services to a variety of orbital users is detailed, analyzed for compatibility, and proposed as the best approach to keep development costs acceptable. The organizational scheme proven successful in large-scale terrestrial projects is summarized.

Introduction

As the twentieth century draws to a close, the visionary goal of self-sustaining spacefaring activity remains unachieved and elusive. Worldwide, the government development business base is contracting, partly because benefits of investing in the technology of space remain hard to quantify. So far, only robotic systems have yielded viable markets, and then really only for terrestrial communications. In response, the aerospace industry is currently struggling to find "new ways of doing business", including total quality deployment, government procurement reform, business overhead streamlining, core-competency realignment, and "smaller, faster, cheaper" projects.

This paper is *not* about new ways of doing business for the aerospace industry; rather it is about the aerospace industry taking part in a *completely new business*: the extension of traditional real estate development practices into space as a way of making money for investors. The scale, scope and complexity of large real estate development projects are analogous to what is required for space infrastructure development; one notable difference is that real estate projects are more often actually realized. Terrestrial business park developments manage budgets of up to billions of dollars contributed by many investors and lenders, over periods as long as decades, and coordinate the activities of hundreds of diverse suppliers to generate wealth and, along the way, physical infrastructure.

If developed using this proven approach, expansionary and diversifying space-based industries would be by-products of successful investment, rather than the reverse as typically pursued by the aerospace industry. Traditional aerospace goals, such as high performance and technology innovation, would be secondary to generating profit, since without significant assurance of profit potential investors would simply look elsewhere and such goals would forever remain moot measures of unrealized projects.

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The paper first compares the maturation of the real estate and aerospace industries we know today, highlighting key differences. We then characterize terrestrial mixed-use business parks (the most applicable model for potential large scale, space-based profit-making enterprises) and describe the way they are actually developed on Earth now. Next, we apply this model directly to the development of research, production and leisure facilities in LEO. We list and discuss the infrastructure services to be made available to these industries in space, and specify the enabling financial arrangements. Finally we cover organizational requirements for developing such mixed-use LEO business parks.

Comparison of the Aerospace and Real Estate Industries

Before reviewing the specifics of how the mixed-use business park real estate model applies to the development of large scale facilities in low Earth orbit, a brief comparison of the differences between how the aerospace industry and other large manufacturers do business and how the real estate industry does business is needed.

The aerospace industry as we know it today can be traced back directly to pre-World War II. Improvements in engine technology and the widespread adaptation of aluminum as a structural material were the direct result of close collaboration between government and industry during the 1930's. This collaboration carried on almost without interruption as cold war defense spending built up through the 1950's and into the Viet Nam era, and picked up again during the Reagan years.

The manufacturing technologies developed during the World War II and the cold war fueled the growth of civilian air travel. Post-war economic growth in the 50's and 60's raised the demand for air travel and facilitated the growth of the airline companies that are the major customers of today's aerospace manufacturers. The major players in the aerospace industry today are with few exceptions WW II era manufacturing companies or their successors, loosely organized in what would be called an oligopoly in Keynesian economic terms.

The real estate industry as we know it today also is a child of World War II, but for different reasons. The rapid growth of the automobile industry after the war and the concurrent development of the interstate highway system (called a defense project at the time), together with consumer pressures of the baby boom generation, led to the largely un-planned result of suburban growth, shopping centers, and tract housing development.

Since there was little or no active government involvement in this process, and no major firms dominating the industry nationally, the way was clear for thousands of small entrepreneurial builders and developers to sense the market demand in specific locales and bring projects to market. While not all projects and developers were successful during the building of suburbia, most people who entered the field during the 50's and 60's were able to make a good living, and consolidation of the industry into a few national players did not occur.

The economies of scale needed to control costs are generated at the component supplier level in the real estate development industry. Manufacturers of heating, ventilation, and air conditioning (HVAC) systems, electrical equipment, lumber, structural steel, elevators, windows, and the like have developed lines of standardized building components useful in a wide variety of buildings and locations. Creativity in the real estate development industry is in how the standardized parts are integrated into unique (or not so unique) designs intended to meet specific market demands and price targets.

The first principal difference between the aerospace and real estate industries is the highly fragmented business organization within the practice of real estate development when compared to

aerospace. While the aerospace industry may have a half dozen principal manufacturers and a dozen principal customers accounting for over 80% of total market, the real estate industry has dozens of large players, hundreds of mid-size players, and thousands of small players involved as principals in real estate deals. These firms in turn rely on thousands of small design, engineering, brokerage, and financial services firms which all contribute to making deals happen.

The second principal difference between the two industries is in the fundamental premise of doing business. The aerospace industry, and in fact most manufacturing companies, operate with a more or less consistent level of business activity. The airlines will always need a certain percentage of the fleet replaced in any given year, more so when markets are growing or increased fuel or operational efficiency can enhance operating margins. The aircraft and engine manufacturers can count on some level of continued new orders and service work on the existing fleet even during lean economic times, and the entire industry benefits from reducing costs and servicing an expanding market.

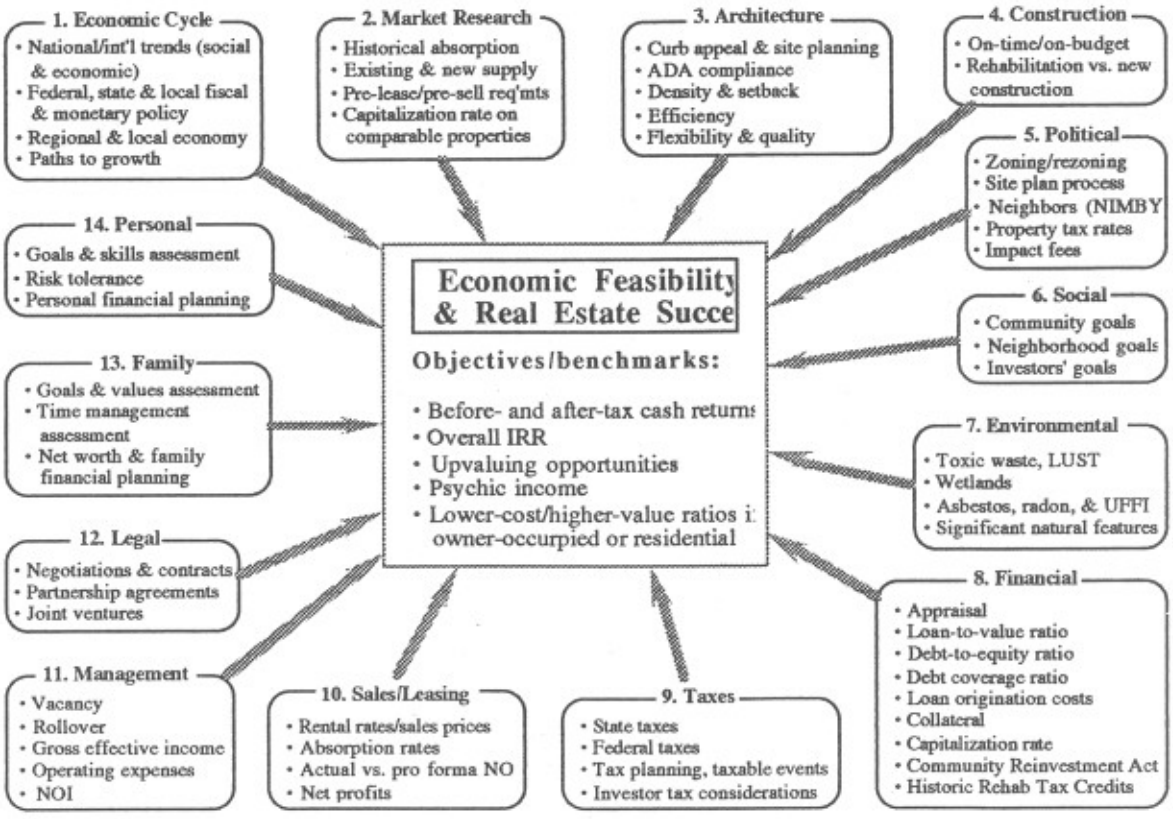

Figure 1: Economic Feasibility & Real Estate Success (Peter T. Allen © 1992)

The real estate development business operates in a different manner, because projects start and stop due to events beyond control of the developers. Figure 1 illustrates the risk factors affecting the success or failure of any particular real estate deal. Any single risk factor within the diagram has the capability of effectively killing a development, regardless of whether it is small or large, and regardless of whether the dozens of other factors are all favorable. For example, an office tower may have significant pre-leasing, cost and design advantages, financing commitments, and a top level development and management team, but if the neighbors protest the proposed zoning and prevail in a referendum, the project does not happen. Political, environmental, and financial factors affecting a particular project are largely indifferent to whether the project happens or not, and the benefit of the doubt seldom falls in favor of a project proceeding.

Finally, the corporate cultures of the two industries are widely disparate. In aerospace, both the manufacturers and their customers are large corporations or governments with tens to hundreds of thousands of employees sharing a consensus to continue to do business. In this work environment, individual performance is typically measured in terms of teamwork and efficiency of function within the system. In contrast, in real estate development all sites and projects are to some extent unique and are the responsibility of a relatively small number of people. Individual personality characteristics such as drive, imagination, salesmanship, and financial sense are much more important in being successful due to the inherent difficulties of making any project happen.

Given the many differences between the two industries, an analysis of the comparative cost efficiencies between manufacturing and real estate reveals some surprising relationships. Figure 2 graphs the cost per pound and cost per cubic foot of product for airliners, heavy construction equipment, and cars and trucks as representative manufactured products against single family homes, office buildings, cruise ships and oil platforms as representative real estate projects.

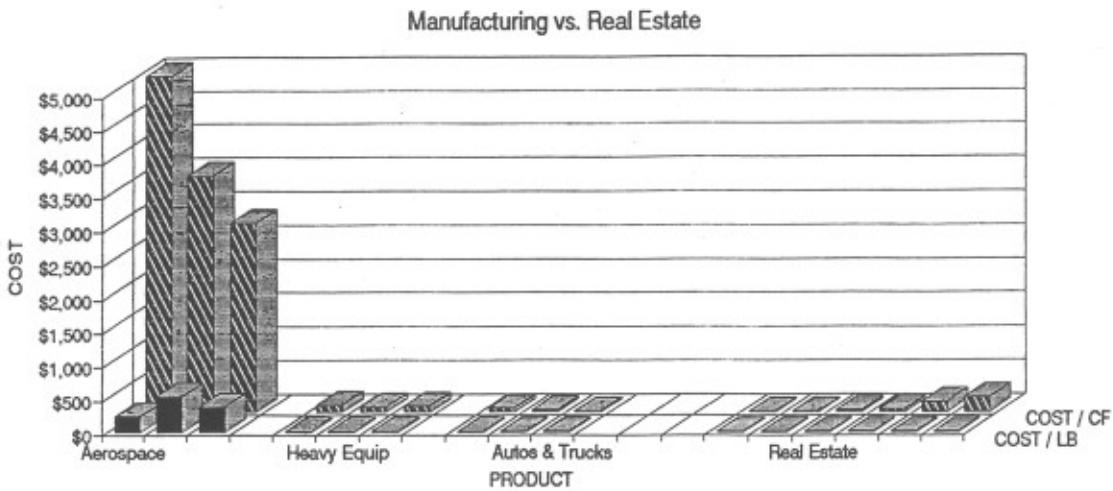

Figure 2: Comparing Cost Efficiencies

It is interesting to note that real estate products remain relatively flat in cost per pound and cost per cubic foot over projects ranging in size by four orders of magnitude. In contrast, manufactured products vary widely from industry to industry, with aerospace products two orders of magnitude more expensive than any of the other products.

Terrestrial Mixed-Use Business Parks

Mixed-use real estate development projects are among the most difficult of all types of projects to develop, due to the large scale of the investment and the political, design and market positioning complexities of the various uses. Mixed-use projects are typically done on the largest available parcels in a given market in order to minimize absorption (selling) time and spread the cost of common infrastructure over as wide a revenue base as possible. In addition, political considerations will often dictate some degree of mixed use development where a single use such as office or industrial may be the preference of the developer.

Business parks can range in size from 100 acres to 10,000 acres. The largest developments, such as the Irvine Ranch and Columbia, MD are more closely related to British New Town projects than traditional US developments. Total investment in land, infrastructure, buildings, and amenities can range from $50 million to over $2 billion, depending on size and location. The period of active development and construction can range from 5 years to 20 years, with ownership and

management of rental properties within a development continuing for another 10 to 20 years after completion of construction. Ultimately, rental properties are sold, syndicated, or re-financed to return the original equity investment and generate "back-end" profits.

Business park uses typically include land for sale for owner-occupied office research, and light manufacturing buildings; single and multi-tenant rental buildings for the same uses; a hotel or some type of transient or short-stay housing; varying degrees of commercial and retail space; and recreational amenities. Larger projects will also generally include single family and multi-family residential neighborhoods, with both rental and ownership units, child care facilities, and in the largest projects schools and medical facilities.

When a developer is planning out and doing the financial analysis on such projects, there is little or no idea of who the actual users will be or what the specific building projects will look like. However, the requirements for the core infrastructure do not require specific users, only general market targets. Road systems, sewer, water, and utility service, site amenities, preservation of significant natural features, political realities of maximum allowable density, municipal impact fees, upgrading of sewer and water treatment plants when needed, local tax incentives for new business attraction, and similar issues are all considered when large scale mixed-use projects are designed and developed.

Once the overall project design and market mix are established, one of the key factors in financial success lies in the phasing plan for the infrastructure development. Ideally, the initial pre-sales will cover the costs of the first phase of the infrastructure development , and the amount of negative cash flow required to bring the project to market will be minimized. Subsequent phases of development are financed through "recycling" of the same investment used to open the project, so the amount of additional cash required to finish the project is kept to a minimum. The true profit from the development activities does not actually begin to show until the project is at least 80% complete, although fee and management income to the developer is usually available throughout the life of a project.

Application of the Real Estate Development Model to LEO Projects

Commercial users can capitalize on the space-based environment when it is available on a regular and controlled basis. They will pay for and profit from ready access to: vacuum, variable gravity levels ranging from micro to hyper, extreme temperature ranges, direct sunlight, and clear views of Earth and space. In addition, isolation and extraterritoriality are available in orbit. Considerable research (and follow-on commercial exploitation) will focus on the effects of gravity variation. The control of gravity will open new windows into biology, chemistry, materials science and operational capabilities. In addition to micro-gravity effects, it will be possible to vary the levels of gravity providing insight and knowledge previously unobtainable.

Figure 3 details how the inherent characteristics of LEO space (several of which are typically regarded as operational problems) may in fact be marketed to business-park tenants as resources. Figure 4 expands this picture, by indicating which of these "controlled environment" and other services are required by, desirable to, or incompatible with various classes of potential users. Arranging and managing the provision of this array of services is the development and operation of the business park.

On-orbit facilities would offer a core of basic services regardless of the usage. These basic services could be offered by business park management directly, or made available by franchise or outside service contracting. Operational services include those typical at most Earth based business parks, such as: power, delivered utilities, waste removal, structure, administrative/financial

Features	Description	Explanation	Benefits to User
Vacuum	~10E-6 to 10E-15 torr	Easy access to vacuum several orders of magnitude harder than economical/ feasible in Earth laboratories	Ultra-cleanliness; rapid outgassing; high-precision analysis & fabrication; vacuum-dependent processes (atomic/molecular deposition, sputtering, etc.)
Gravity	Variable, µg to hyper	Tethered/rotating facilities decouple weight from mass, allowing variable control of fundamental physical "constant"	Cancellation or emphasis of buoyancy, convection; containerless processing; dominance or suppression of diffusion, surface tension, film behavior; novel kinetics (micro & macro); macro-structures
Temperature	-100 - 170°F (passive) Source (sun) 5780K Sink (dark sky) 3K	Wide range using passive techniques; hard vacuum facilitates achieving/using extreme temps (cryogenic, high-temp with solar or nuclear)	Uses benefitting from exclusively radiative transfer; longterm thermal stability; superconductivity; IR observation; thermal processing
Sunlight	1470 W/cmE2	Unattenuated solar spectrum; can be virtually constant	Non-depletable energy source for direct thermal use or reliable electrical power; UV source; export to space and Earth users
Radiation	MeV - GeV particles, weak-flux trans-UV photons	Geomagnetically trapped e- and P, episodic solar proton events (high or pols orbits); cosmic rays; controllable with collimated shielding, filters	Irradiation-mediated chemical/biological sample processing;
Atomic oxygen ram flux	@ 300 km: v ~8km/sec ~10E19 mE-2secE-1	Extremely erosive to oxidation-susceptible materials	Chemical milling, etching & sputtering processes
View	Optically unimpeded; everchanging Earthview	Orbit-geometry-dependent; map-like overview of Earth geology, meteorology, ecology, sociology, technology; best astronomical clarity, full-spectrum observ	Astronomy; longrange optical monitoring; Earth sciences; security; entertainment imagery; new, unique type of tourism
Isolation	Infinite room; proximity controllable, costly, detectable	No ecology-based environmental contamination restrictions; extremely limited opportunities for information leaks, espionage, oversight, interference	Hazardous chem/bio processing; nuclear activities (orbit-dependent); greater freedom for all activities
Extraterritoriality	Orbits inherently trans-national	Affiliation selectable; choice of regulatory regimes and legal precedents/statutes; opportunity for novel arrangements	Flexibility to design conducive business address
Materials	Unlimited variety & quantity	Not immediately available; asteroidal/ luner sources; retrieval requires extensive, interplanetary operations infrastructure	Heavy manufacturing; material export (incl. Pt-group); space settlement; eventual autonomy from Earth

Figure 3: LEO Business Park Resources

services, telecommunications, computing, security, and maintenance. An important aspect of security includes maintaining the confidentiality of proprietary intellectual property. Available operational services, unique to the space environment include: stationkeeping, thermal rejection management, radiation shielding, debris armor, and, as necessary, pressurized volume, automation and robotics, and EVA support.

The business park would provide services for supporting on-orbit staffs and visitors, including: lodging, food services, medical clinic and recreational opportunities. Businesses, universities and governmental agencies could send their own researchers or purchase the services of bonded research staff stationed on-orbit by the business park or third party providers.

An early and highly elastic market segment is tourism. Tourists will be eager to experience the absence of gravity, the extraordinary views offered of Earth and space, the frequent and unique sunsets and sunrises and other recreational opportunities. The earliest mixed-use business parks could offer tourist accommodations modeled on Bed & Breakfast operations, or on the pay-to-help EarthWatch lay-research assistant scheme. As space operations increase and transportation costs are reduced facilities dedicated to tourism can evolve to offer resort-class hotels, with name entertainment, traditional resort recreation and novel forms of culture.

The prime decision in any real estate project is selecting the location. Users will have different preferred orbits and launch sites to maximize their return (and it should be noted that a launch site cannot launch to an orbit lower than their latitude). Manufacturing users, especially those processing large amounts of material would require orbits selected based on maximum payload lift capability from their launch site(s). Tourists will likely choose travelling to orbits with a higher inclination (or polar orbit) over a lower inclination orbit, so that they can observe more of the Earth's surface. Many observation users will find sun-synchronous orbits better suited or

Requirements
- ● Essential
- ⊕ Optional
- ○ Not Needed

	Controlled Environment							Operations Support																Material Handling					Transportation Support						Accommodations			
	Vacuum	Gravity Level (μ - hyper-g)	Extreme temperatures	Controlled Sunlight	View	Isolation	Environmental Stability	Station-keeping	Power	Thermal Rejection	Delivered Utilities	Waste Removal	Radiation Shielding	Debris Armor	Structure	Pressurized Volume	Admin/Financial Services	Telecommunication	Computing	Automation & Robotics	Security	EVA Support	Maintenance	Construction	Handling	Storage	Moving	Warehousing	Docking	Launch	Shipping	Traffic Control	Servicing	Maintenance	Life Support	Food	Lodging	Recreation
Research																																						
Biological	○	●	○	⊕	○	●	○	●	●	●	●	●	●	●	●	●	⊕	⊕	●	⊕	⊕	○	●	●	⊕	⊕	○	⊕	○	●	●	○	⊕	⊕	●	●	●	⊕
Materials	●	●	●	⊕	○	⊕	○	●	●	●	●	●	●	●	●	●	⊕	⊕	●	⊕	⊕	⊕	●	●	●	⊕	⊕	⊕	○	●	●	○	⊕	⊕	●	●	●	⊕
Systems	⊕	⊕	⊕	⊕	○	○	○	●	●	●	●	●	●	●	●	●	⊕	●	●	●	⊕	●	●	●	●	●	○	⊕	○	●	●	○	⊕	⊕	●	●	●	⊕
Medicine																																						
Basic Research	○	●	⊕	⊕	○	●	○	●	●	●	●	●	●	●	●	●	⊕	●	●	●	⊕	○	●	●	○	⊕	○	○	○	●	●	○	⊕	⊕	●	●	●	⊕
Clinical Treatment	○	●	○	⊕	⊕	⊕	⊕	●	●	●	●	●	●	●	●	●	⊕	●	●	⊕	⊕	○	●	●	○	⊕	○	○	○	●	●	⊕	⊕	⊕	●	●	●	●
Infirmary	○	⊕	○	⊕	⊕	⊕	○	●	●	●	●	●	●	●	●	●	⊕	●	●	○	○	○	●	●	○	⊕	○	○	○	●	●	○	⊕	⊕	●	●	●	⊕
Earth Observation																																						
News	○	○	○	○	●	○	⊕	●	●	⊕	●	⊕	●	●	●	⊕	⊕	●	●	⊕	⊕	⊕	●	●	○	○	○	○	○	●	○	○	⊕	⊕	⊕	⊕	⊕	○
Disaster Support	○	○	○	○	●	○	○	●	●	⊕	●	⊕	●	●	●	⊕	⊕	●	●	⊕	⊕	⊕	●	●	○	○	○	○	○	●	○	○	⊕	⊕	⊕	⊕	⊕	○
Weather/Climate	○	○	○	○	●	○	○	●	●	⊕	●	⊕	●	●	●	⊕	⊕	●	●	⊕	⊕	⊕	●	●	○	○	○	○	○	●	○	○	⊕	⊕	⊕	⊕	⊕	○
Resource Exploration	○	○	○	○	●	○	⊕	●	●	⊕	●	⊕	●	●	●	⊕	⊕	●	●	⊕	⊕	⊕	●	●	○	○	○	○	○	●	○	○	⊕	⊕	⊕	⊕	⊕	○
Resource Management	○	○	○	○	●	○	⊕	●	●	⊕	●	⊕	●	●	●	⊕	⊕	●	●	⊕	⊕	⊕	●	●	○	○	○	○	○	●	○	○	⊕	⊕	⊕	⊕	⊕	○
Security	○	○	○	○	●	⊕	⊕	●	●	⊕	●	⊕	●	●	●	⊕	⊕	●	●	⊕	⊕	⊕	●	●	○	○	○	○	○	●	○	○	⊕	⊕	⊕	⊕	⊕	○
Astronomy	●	⊕	●	●	●	●	○	●	●	●	●	⊕	●	●	●	⊕	○	●	●	●	⊕	●	●	●	⊕	⊕	○	○	○	●	○	⊕	●	●	⊕	⊕	⊕	○
Light Manufacturing																																						
Pharmaceuticals	⊕	●	●	●	○	●	⊕	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	⊕	●	●	●	●	●	●	●	●	●	●	⊕
Electronics	●	●	●	●	○	●	⊕	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	⊕
High $/kg materials	●	●	●	●	○	●	⊕	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	⊕
Heavy Industry																																						
Structures	●	●	●	●	○	●	⊕	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	⊕
Bulk Materials	●	●	●	●	○	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	⊕
Exported Power																																						
Space Users	●	●	●	●	●	●	⊕	●	●	●	●	⊕	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	⊕	●	●	○	●	●	●	●	●	●	⊕
Earth	●	●	●	●	●	●	⊕	●	●	●	●	⊕	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	⊕	●	●	○	●	●	●	●	●	●	⊕
Exported Entertainment																																						
Imagery	⊕	●	○	●	●	○	○	●	●	⊕	●	⊕	●	●	●	⊕	●	●	●	⊕	⊕	⊕	⊕	●	○	⊕	○	○	○	●	○	⊕	⊕	⊕	●	●	●	●
Sporting events	⊕	●	○	●	●	○	⊕	●	●	⊕	●	⊕	●	●	●	●	●	●	●	⊕	⊕	⊕	⊕	●	○	⊕	○	○	○	●	○	⊕	⊕	⊕	●	●	●	●
Fine Arts	○	●	⊕	●	●	○	○	●	●	⊕	●	⊕	●	●	●	●	●	●	●	⊕	⊕	⊕	⊕	●	○	⊕	○	○	○	●	○	⊕	⊕	⊕	●	●	●	●
Tourism																																						
Tours	⊕	⊕	○	●	●	○	⊕	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	⊕	●	●	●	●	●	●	●	●	●	●	●
Hotel	⊕	●	○	●	●	○	⊕	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	⊕	●	●	●	●	●	●	●	●	●	●	●
Resort	○	○	○	○	○	○	⊕	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	⊕	●	●	●	●	●	●	●	●	●	●	●
Information Processing																																						
Messaging	●	○	○	○	○	⊕	⊕	●	●	●	●	○	⊕	●	●	⊕	⊕	●	●	●	●	●	●	●	○	○	○	○	⊕	●	○	⊕	⊕	⊕	⊕	⊕	⊕	○
Financial Services	○	⊕	○	○	○	○	●	●	●	⊕	●	●	●	●	●	●	●	●	●	⊕	●	○	●	●	○	⊕	○	○	○	●	⊕	⊕	⊕	⊕	●	●	●	⊕
Business Services	○	⊕	○	○	○	○	⊕	●	●	⊕	●	●	●	●	●	●	●	●	●	⊕	●	○	●	●	○	⊕	○	○	○	●	●	⊕	⊕	⊕	●	●	●	⊕
Transportation																																						
People	○	⊕	○	⊕	●	○	○	○	●	●	⊕	⊕	●	●	●	●	⊕	●	●	⊕	⊕	⊕	●	●	●	●	⊕	⊕	●	●	●	●	●	●	●	●	⊕	⊕
Cargo	⊕	○	⊕	○	○	⊕	○	○	●	●	⊕	⊕	●	●	●	⊕	⊕	●	●	●	⊕	⊕	●	●	●	⊕	●	●	●	●	●	●	●	●	⊕	⊕	⊕	○

Figure 4: Space Business Park Uses vs. Services

required to accomplish their missions. Research users may not care what inclination is used. Any large scale projects in LEO will attract users from around the world, and will of necessity be financed multi-nationally. The business mix and ground location of the users will influence the selection of orbits and launch sites. Today each of the spacefaring nations operates launch facilities at a different latitude; new launch systems may not have such restrictive demands.

The LEO equivalent of raw land cost is the launch cost per pound to a given altitude and inclination. Since large projects require large tracts of land, it makes sense to buy in bulk using long-term contracts rather than buying an acre of land at a time. The raw land for virtually all large scale real estate projects is acquired in this manner. In orbit, the actual parking space is free (at least for the near term), so the nearest terrestrial analogy is a trucking contract for fill dirt. The structural mass for any significant LEO commercial facilities would be at least half a million pounds, and may grow to several million pounds. A purchasing agent buying a million pound trucking contract would be indifferent to whether the trucks were Peterbilt or Kenworth, or whether the loads came in 20 ton or 50 ton increments, as long as the total cost is as low as possible and delivery is as fast as possible.

The current catch phrase used to describe the real estate industry is "market driven". Practically speaking, this means that a project must be largely pre-leased or pre-sold before significant debt and/or equity financing can be procured. Users of space (either rental or sale) are courted and induced to sign "soft" letters or letters of intent which are then used to finalize designs and procure political and financial approvals. For larger users of office or research space, the process of evaluating locations and size requirements can take several years before any binding agreements are executed, with implementations taking several more years.

Assuming that LEO projects will be as (or more) difficult to finance as other large scale real estate projects, the pre-selling process is that much more important. Referring back to Figure 4, a matrix of possible LEO Business Park users and the menu of possible services to support these users is illustrated. Every node in this matrix represents a discrete selling opportunity. As many of these nodes as possible would need letters of intent or contingent lease/purchase contracts in order for initial equity investors to become convinced of the viability of the market.

For example, hotels and tourism need established chains to provide name recognition, experienced operating staff, and market credibility. A selling strategy for this node would be to play off Hilton's pledge to be the first hotel in space against other large players such as Radisson, Resorts International, and Sheraton. The goal would be to execute a contingent management contract with the operating chain and include their input in the design and development process, hopefully with some seed money contributions on top. In addition, two to three week package tour itineraries need to be developed, including ground time in the tour plan and all transportation costs. This package could then be marketed through exotic and high-end travel agencies, with refundable reservations going into a growth mutual fund and converted to down payments on excursion packages when delivery dates become finalized.

Pay-per-view and video entertainment events can generate tens to hundreds of millions of dollars in a relatively short period of time. A selling strategy for this node might be to approach all the world's great ballet companies for the rights to produce the first zero-g ballet.

All of the applied research and light manufacturing nodes would be sold exactly as Earth-based real estate is practiced. Growing companies in targeted industries are identified and contacted to "make them aware of the tremendous opportunities" of the project. The goal would be to get the prospects' creative minds working on what could be done with a given volume of space with appropriate utility connections and gravity levels, and how much money could be made from the endeavor.

Transportation services nodes would be sold to the current players in the industry, with design and operations inputs similar to those used in the development of commercial jet liners, like the Boeing 777.

Business park life cycles will be based not only on initial opportunities, but on the outcomes of research or successful business ventures. Many applications will be space-based, but others could provide better understanding and improvement of ground-based processes and products.

Management of the financing requirements for multi-billion dollar projects in LEO would be very similar to that for terrestrial projects of similar size. Large projects are first broken down into smaller units of $10 to $100 million each when possible. Divisions are made by the smallest unit that can have a discrete legal description and mortgage. The largest projects, such as casinos and resorts, where separated mortgages are impractical, are syndicated among multiple lenders with the loan consortium holding an undivided security interest in the property.

The financial model used for virtually all real estate projects is the discounted cash flow model. Costs and income are placed in the analysis at their actual projected values factoring in inflation. Rents and expenses are typically assumed to rise at or slightly below the CPI inflation rate, although in a LEO development one of the largest expenses (launch cost) would be expected to decline over time. Depreciation expenses, marginal tax rates, capital gains, and loan amortization are all calculated in the analysis, with the time value of the money being factored in at the end of the analysis. This discounting of the value of the money earned in future years results in a total yield calculation called an Internal Rate of Return (IRR). This yield would have to be between 25% and 30% in order to attract the initial investors.

As more of a business history is built for LEO real estate operations, IRR yields could fall into the 18% to 24% range. One of the largest ways of boosting IRR's is to compress the time from when the equity money is spent to when the cash flow from sales and rentals begins. As shown in Figure 5, the discounting curves show a significant reduction after 5 years, so a ten year schedule for construction and launch would need about twice the undiscounted return of a five year schedule in order to maintain the same IRR.

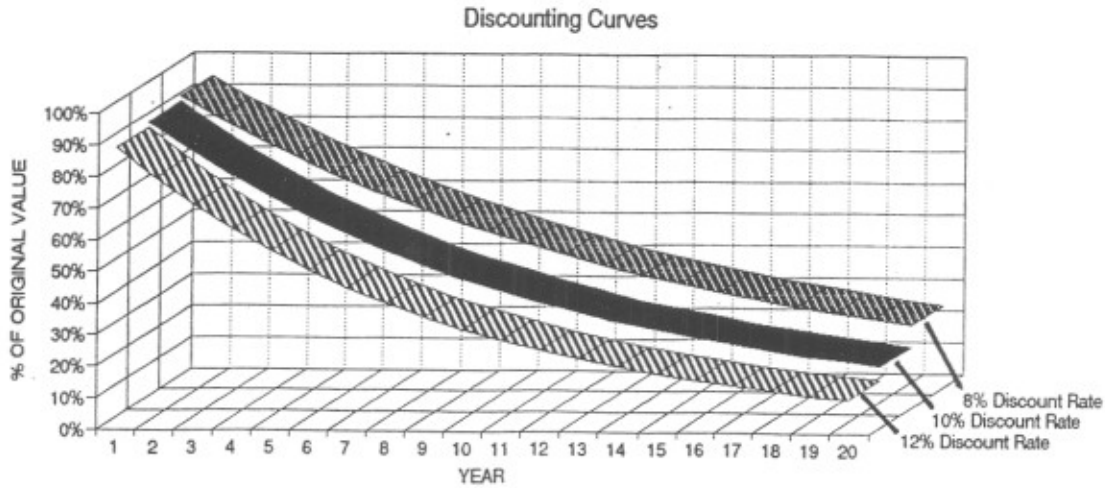

Figure 5: Net Present Values

Historically, pension funds and insurance companies have been the long term lenders for income producing property. Due to the financing excess of the 1980's and the continuing drag on commercial real estate markets by Resolution Trust Corporation inventories, long-term lending by these institutions has been significantly reduced. However, pension funds with vested interest in particular locations or industries (construction and municipal unions) often make loans when

other financing is impossible to obtain. Aerospace unions would have a vested interest in seeing large scale LEO construction happen, so their pension funds might be possible lenders for such a project. Pre-selling would give the loan underwriters for the pension funds the necessary degree of comfort to make load commitments, subject to verification of construction cost, launch cost, and operating cost.

Real Estate Investment Trusts (REITS) have become much more active in the last few years as traditional lending has become less available. These publicly traded stocks acquire and hold real estate assets, and are sold on the yields generated from rental income after all expenses. Currently, REITS offer yeilds of from 7% to 12%, plus whatever returns are generated from the appreciated value of the stock. Future profits from sale or refinancing of individual real estate assets are considered as part of the overall investment decision, but are not as heavily weighted as current yield. Once an operating history in LEO is established, REITS could be excellent long-term financing sources for LEO development if initial returns are high enough and stablized returns hold at or above casino/resort returns (13% to 16%).

It should be clearly understood that all investment decisions are made strictly or at least primarily on the total returns offered and the perceived degree of risk. Lenders, investors, and underwriters are generally not "vision" people, and must be convinced (sold) on any investment decision available among the myriad of investment choices in the market today.

Organizational Requirements for Implementing LEO Real Estate Operations

Operating expenses for LEO rental space, whether used for research, light manufacturing, or tourism, need to be closely studied and defined. Government funded space stations provide a crucial step in quantifying these costs and providing the operating experience needed for larger facilities, without which the projected profit margins from LEO commercial facilities would not be believed by investment underwriters. Staffing requirements, replenishment of consumables, recycling/on-orbit food production, and long term launch costs all need to be defined with a relatively high degree of confidence. The vast majority of commercial users prefer to deal with a service oriented private entity instead of a government bureaucracy. Government service providers have no need to meet demanding schedules, since they have no competition. In addition they are subject to the whims of politics and users have little legal recourse when the services are arbitrarily changed or dropped completely.

One of the largest operating expenses in terrestrial real estate is property taxes. Multi-billion dollar development at LEO will be impossible to finance until a clear determination is made as to the jurisdiction and tax status of the investment. This determination would likely take the form of a treaty, with consent of all of the spacefaring nations and probably the United Nations.

One of the standard clauses in all U. S. real estate contracts is a statement saying "This contract shall be governed by the laws of the State of _____." For a LEO business address, this statement has both positive and negative implications for business considerations, such as the tax status of income earned in orbit, banking and securities regulations, gambling and vice laws, building code requirements, and security positions for the mortgage lenders which will be financing the infrastructure development.

An orbital equivalent of a County Register of Deeds will be needed in order to provide a mechanism for recording mortgages and Uniform Commercial Code (UCC) filings for personal property financing. Any title insurance company requested to insure a lender's mortgage position would need all of these jurisdictional issues resolved before they would be in a position to insure a mortgage loan.

Cost control objectives in any large scale construction project in low Earth orbit would provide the impetus for sharing common infrastructure among as many users and revenue sources as possible. Financing structures for this type of project are much more closely related to the real estate capital markets than the airline capital markets, in that projects are built, held, and financed over much longer periods of time.

The complexity of the tasks and the political and financial uncertainty inherent in large scale orbital construction are comparable in scope to the largest terrestrial real estate projects, such as Disney World or Research Triangle Park in North Carolina, so the organizational models used for such projects would seem to be an appropriate model for LEO development.

All real estate projects, regardless of size, have at their core an entrepreneurial team of fewer than a dozen key design, marketing, construction, and finance people who coordinate the development process through all of the risk factors shown in Figure 1. For LEO mixed-use business park developments to become a reality, these teams need to be assembled and a minimum level of seed money needs to be spent to bring in the various users. "Soft" commitments from the user groups are essential to design and develop facilities which will be well received in the market place and provide the returns on investment necessary to validate the concept of long-term commercial activities in space.

References

Peter T. Allen (313)769-2700 for photocopy permission
American Demographics (8/93)
Arnold, Alvin L., Charles H. Wurtzebach, Mike E. Miles, "Modern Real Estate", 1981, Warren, Gorham & Lamont, Pub.
Boeing Commercial Airplane Marketing, Thomas Deckwitz, personal communication
Carnival Cruise Lines 1992 Annual Report
Crain Publication Wheels '94 Car & Truck Survey
Michigan Caterpillar Sales Office
Offshore Data Services
Royal Carribbean Cruises 1993 S & P Stock Report
University of Michigan College of Architecture & Urban Planning
1993 Wards Automotive Weekly Annual Survey