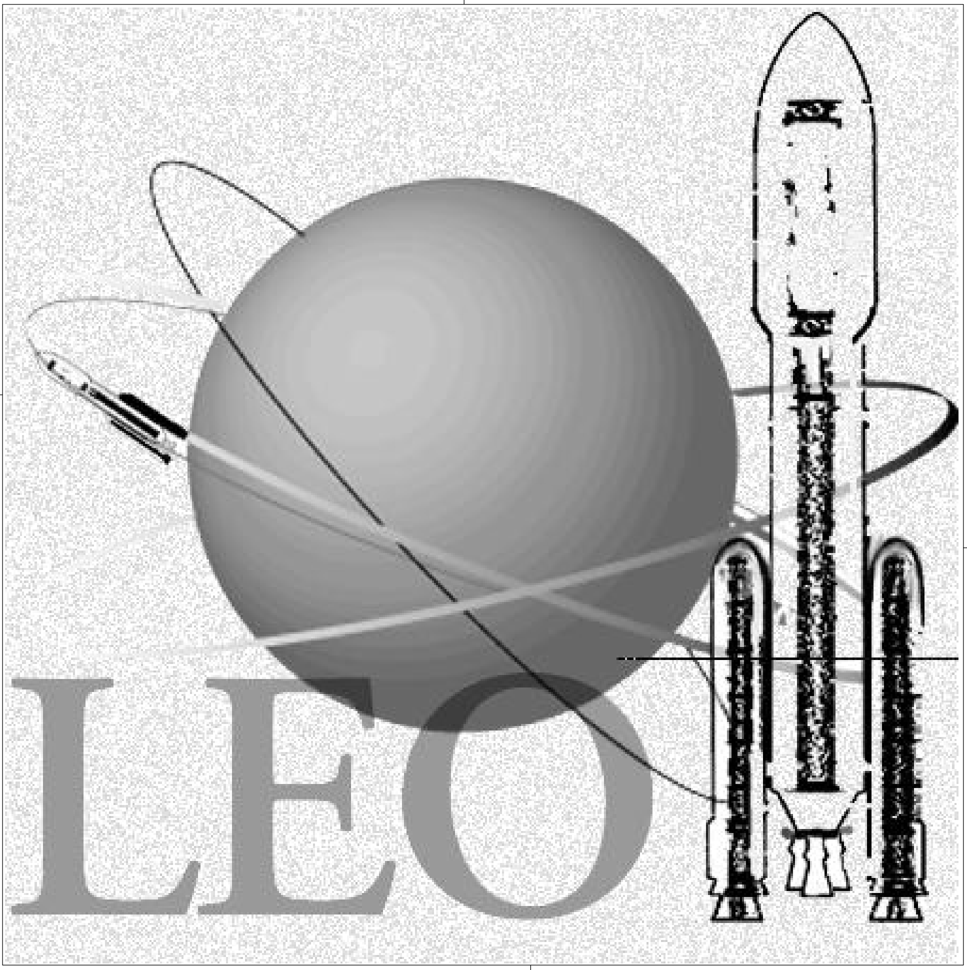
LEO Commercial Market Projections



Department of Transportation
Federal Aviation Administration
Office of the Associate Administrator
for Commercial Space Transportation

April 5, 1996

Executive Summary

I. Projected Satellite Demand

Based on the information provided in the attached report, OCST has again developed two possible scenarios for LEO satellite and launch services demand in the 1996-2005 time frame. With regard to a "modest growth" scenario, OCST projects that:

- *at least* three Big LEO (including MEO) and two Little LEO systems will be deployed in this period (the more optimistic scenario from the 1995 study).

By comparison, the more optimistic, "high growth" scenario projects that:

- four Big LEO systems and three of the larger Little LEO constellations could be deployed and potentially sustain operations in this time frame.

Both of these scenarios also assume that as many as two partial non-U.S. Little LEO systems will be deployed in the 1996-2005 time frame, while reflecting the fact that these systems represent a unique form of demand in several respects. As with the 1995 assessment, however, Mega LEO systems are not yet included in either scenario due to the unusual challenges involved in their development and financing, and to the current lack of contracts for satellite production and launches for such systems.

Finally, it appears that demand in the commercial remote sensing market will be capable of supporting several of the small, proposed ventures intending to provide commercial, high-resolution imagery (perhaps as many as four systems containing between one and four satellites). Thus, commercial remote sensing ventures could represent a significant source of demand for small LEO satellites and launch vehicles.

II. Projected Launch Demand

Based on these satellite demand projections, the resulting demand for commercial launches to LEO for this period should be:

- 5 to 10 medium-to-large launches per year *during deployment phase*s and 9 to 15 small vehicle launches per year throughout the 1996-2005 time frame, *depending on the specific scenario* (as discussed in the report).

III. Implications of Dramatic Growth

OCST also considered the implications of much more dramatic growth in this market than is currently anticipated. Based on current system plans, it seems likely that a significant increase in active (or sustained) launch capacity for medium-to-large vehicles would be required before such growth could be adequately supported.

LEO Commercial Market Projections

I. Introduction

The Office of the Associate Administrator for Commercial Space Transportation (OCST) of the Federal Aviation Administration (FAA) has prepared the attached projections of the Low Earth Orbit (LEO) commercial payload and launch markets for the period between 1996 and 2005. The information in the projections was developed on the basis of:

- responses to a February 1996 Federal Register Notice requesting data on the LEO commercial market;
- data obtained during a February 1996 public meeting (held by OCST) regarding the LEO market;
- publicly available information; and
- OCST research.

This latest assessment represents an update of prior studies of the LEO market that OCST conducted in March 1994 and May 1995 to facilitate a variety of Administration efforts, including Interagency Working Groups reviewing U.S. space transportation issues. Given the dynamic and somewhat uncertain nature of this market segment, further efforts will be made on an annual basis to update the projections and/or account for new activities as the market continues to develop.

The results presented in this study do not indicate FAA support or preference for any particular proposal or system. Rather, the information provided merely reflects an OCST assessment of overall trends in the mobile communications services and LEO commercial satellite markets, with the ultimate purpose of projecting future space transportation needs to LEO. The LEO system characteristics critical to making such projections (such as number of payloads and launch schedule) are representative of proposals currently under consideration in the industry.

II. Proposed LEO Communications Systems

To assess the size of the overall LEO commercial market, it is first necessary to understand the range of proposals existing world-wide for LEO communications satellite systems. Such systems will in all likelihood produce the highest level of demand for satellites and launch services in this market segment.

Accordingly, Figures 1 and 2 provide a listing of the various publicly announced proposals for LEO communications systems currently under development within the industry. Figure 1 summarizes the proposals for "Big" and "Mega" LEO constellations, while Figure 2 provides a listing of both U.S. and non-U.S. "Little" LEO constellations (differentiation among system types is done on the basis of system capabilities).[1] Among these three categories of systems, Little LEOs are intended to provide mobile data messaging and position determination services on a global level, while Big LEOs will add mobile voice and fax capabilities; Mega LEOs will provide wireless video, voice, and broadband, high-speed data services to small satellite dishes. For reference purposes, the orbit altitude and inclination for the various systems are provided in Figure 3.

With respect to non-U.S. proposals for LEO constellations (other than the ICO Global system), a great number of systems have been proposed on a conceptual level by various nations or non-U.S. firms in recent years, often with the stated intent of obtaining development assistance or financing before proceeding. Many of these proposals remain at comparatively early (and uncertain) stages of authorization, financing, and/or development, and have thus not been included in the attached figures. Nonetheless, some non-U.S. systems (particularly those in the Little LEO category) appear to have at least: 1) the domestic authorization necessary to proceed, 2) a potentially viable concept, and 3) the *potential* resources to place at least a small, partial system in orbit. Such systems are presented in either Figure 1 or 2, as appropriate, and are also discussed below in terms of potential market impact.

III. <u>Market Demand Scenarios</u>

Most of the systems listed in Figures 1 and 2 were under consideration by industry at the time of OCST's 1995 assessment. Nonetheless, given the uncertain status of many of the efforts and the apparent impact at that time of various market and regulatory factors, OCST determined that only two to three Big LEO systems and one to two Little LEO systems might ultimately be deployed (and sustain operations) in the 1995-2005 time frame (these potential outcomes were described in terms of two market scenarios). It should be noted that these projections represented some growth over the more conservative estimates of market size developed in 1994.

Over the course of the last year, however, significant progress has again been made by a number of *existing* LEO system proposers in terms of regulatory approval, technical development, contracting, and financing. At the same time, the overall prospective market for mobile, satellite-based communications services has continued to evolve in several notable ways. For example, continued progress has been made in the international allocation of spectrum for such services (at the 1995 World Radiocommunication Conference, or WRC-95), and several proposals have emerged for satellite systems in geosynchronous orbit (GEO) that

[1] For purposes of this assessment, Medium Earth Orbit, or MEO, systems providing global, mobile communications services have been listed as Big LEOs.

will *also* provide mobile satellite services (MSS) in specific global regions. These GEO systems will presumably compete to some degree with the LEO systems, at least in their respective regions, and thus potentially affect demand for LEO mobile communications services. For reference, currently operating or proposed GEO systems providing MSS (with firm satellite manufacturing contracts) include the American Mobile Satellite Corporation (AMSC) system; the Afro-Asian Satellite Communications system (known as Agrani); the Asia Cellular Satellite (ACeS) system; the Asia Pacific Mobile Telecommunications (APMT) system; and the Satphone International system.

Although less critical to an assessment of the overall LEO market, several existing remote sensing ventures also made progress over the course of last year, while other similar systems have recently been proposed for development in the 1996-2005 time frame.

<u>Assessment Criteria</u> Given such developments, OCST has again undertaken a review of potential commercial demand in the LEO market, utilizing certain assumptions and completed studies concerning:

- the projected customer demand for personal communications services (including MSS);
- the potential effect of various competing technologies (e.g., cellular phones, GEO-based mobile communications services) on that demand;
- potential limitations on the availability of capital for such projects;
- the government authorization/licensing process, and the availability of frequency spectrum necessary for the operation of LEO systems; and
- the status of contracting for satellite development/production and launches.

Although these factors apply more directly to the assessment of demand for LEO mobile communications services, similar criteria were utilized (as appropriate) in evaluating several proposed remote sensing ventures, as well as the overall remote sensing market.

<u>Discussion and Key Findings</u> Each of these factors is significant in determining the number of LEO systems that might be deployed, though to varying degrees depending on the *type* of LEO system in question. For example, capital availability and the size of the potential customer base are key considerations in assessing the viability of proposed Big LEO systems, given:

- the comparatively large amount of financing required for such systems;
- the number of users seemingly necessary to sustain such systems; and

- the recent emergence of several GEO-based MSS providers in critical market regions (as mentioned above).

By comparison, spectrum availability and "market timing" concerns (relative to alternative services) have emerged as critical issues facing the proposers of Little LEO systems (particularly in view of the WRC-95 decision not to allocate additional worldwide spectrum to such services). For several reasons, all of these factors remain important considerations in assessing Mega LEO providers, though it should be noted that 400 MHz of spectrum was allocated to such services at WRC-95 (alleviating some spectrum concerns for the time being).

To better understand the obviously fundamental issue of potential MSS demand, OCST staff reviewed several existing projections of the potential number of overall MSS subscribers, using both publicly available and proprietary sources. An effort was then made to assess the potential impact of GEO MSS providers on the demand for mobile services and to estimate the number of LEO systems that the remaining demand might be able to sustain. For similar purposes, extensive discussions were held with both industry and government officials to clarify the issues of spectrum availability and financing for LEO systems.[2]

Even after accounting for spectrum constraints and significant penetration of the potential MSS market by GEO-based providers, OCST determined that *at least* three Big LEO and two Little LEO systems would probably be deployed in the 1996-2005 time frame (the more optimistic scenario from the 1995 assessment), and that additional Big and Little LEO systems might also reach operational status. Although the data obtained by OCST staff were slightly less definitive or firm for other, more optimistic market scenarios (relative to the criteria discussed above), it also seemed possible that four Big LEO systems and three of the larger Little LEO constellations *could* be deployed and potentially sustain operations in this time frame.

With regard to non-U.S. LEO systems, it is quite likely that some of the proposed Little LEO systems listed in the attached charts will be deployed to at least a partial level in the 1996-2005 time frame. However, these systems generally differ from the larger Little LEO constellations (proposed primarily by U.S. firms) in certain important respects, and will thus have far different implications for satellite and launch demand. For example, these systems typically involve a small number of satellites that reportedly will be launched in a phased process over as long as a three-to-four year period. Furthermore, many of the non-U.S. system proposers have publicly stated their intention to launch their satellites as secondary (or "piggyback") payloads on larger vehicles (frequently from Russian launch providers, based on current information). As such, they will create a very different (more indirect) kind of launch demand than the Big LEO and larger Little LEO systems. Finally, many of the non-U.S. providers appear to be focussed more on niche markets, such as a particular segment of

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[2]The results from these assessments and discussions are not releasable in detailed form due to the proprietary nature of many of the inputs.

European users or even some government applications,[3] and do not seem to be positioning themselves for global competition with the larger Little LEOs providing services for truly hand-held communication devices. For such reasons, the smaller non-U.S. LEO systems are not specifically addressed in the overall findings discussed above, though two partial systems are reflected in the payload and launch demand charts discussed below.

As with the 1995 assessment, it is not yet clear whether Mega LEO systems will be deployed in this time frame due to the unusual challenges involved in their design, deployment, and financing, and to the current lack of contracts for satellite production and launches for such systems. However, OCST will continue to pay close attention to such proposals as the projections presented in this document are updated in coming months.

Finally, in terms of commercial remote sensing ventures, OCST reviewed both publicly available and proprietary sources of information to assess the status of the international remote sensing market. Based on these discussions, it appears that demand in this market will be capable of supporting several of the small, proposed ventures intending to provide commercial, high-resolution imagery (perhaps as many as four systems containing between one and four satellites). In addition, it seems reasonably likely that such ventures will sustain operations throughout the 1996-2005 time frame, and perhaps even grow in number of satellites if demand for such imagery increases substantially beyond current projections. Thus, commercial remote sensing ventures could represent a significant source of demand for small LEO satellites and launch vehicles, though certainly not at the levels projected for LEO constellations providing MSS.[4]

Market Scenarios   Accordingly, Figures 4 and 5 present OCST projections of small commercial satellite demand under two different scenarios, with three market segments identified for each scenario (Big LEO communications systems, Little LEO communications systems, and the more general segment of remote sensing, international scientific, and microgravity payloads). For clarity, the charts also contain separate projections of on-orbit failure replacement/Operations & Maintenance (O&M) payloads for both classes of LEO systems.

Consistent with the above discussion, Scenario 1 projects the deployment of three Big LEO systems and two Little LEO systems, while Scenario 2 (the high-end outcome) projects the deployment of four Big LEO systems and three Little LEO systems. Both scenarios assume that a few satellites will also be deployed in support of non-U.S. Little LEO systems, with the deployment taking place over a period of years in the form of secondary payload launches.

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[3]In fact, these proposed systems appear to have more direct financial support from their respective governments than is typically seen for proposed U.S. Little LEO systems.

[4]Further information on the commercial remote sensing market can be obtained from the Department of Commerce, Office of Air and Space Commercialization.

Such satellites are counted among the general segment, rather than the Little LEO segment, due to their unique nature.

More generally, OCST also assumes in both scenarios that all of the LEO systems deployed in this time frame will undergo a full block replacement at the end of system life, using the same number of satellites and a similar deployment scheme (hence the cyclical nature of the satellite demand projected over the 10-year period). Such an assumption is reasonable in that the market is still in an early stage of evolution, and it is difficult to know at this time what changes, if any, systems must undergo in the future to provide newly desired services or more effectively respond to competing technologies. In practice, however, second generation LEO systems may change fundamentally as a result of technology advancements or newly offered services, and out-year LEO satellite demand could be quite different from what is currently projected. Moreover, the market is clearly entering a phase of fierce competition among different forms of mobile communications services -- competition that will ultimately be resolved on the basis of price, quality and flexibility of service, market timing, and relative business strategies. Following this initial phase, it is certainly possible that consolidation will occur among deployed systems (regardless of the scenario), or that a second generation system will be reshaped to focus on a particular market niche, either of which could significantly alter current out-year demand projections.

Finally, as stated earlier, it should be noted that the projections and deployment schemes presented for Big and Little LEO systems in the two scenarios are representative of the characteristics described in various proposals currently under consideration by industry, and are not intended to signify OCST support for any individual system or proposal.

IV. Launch Demand

An assessment of the launch schemes for the various LEO constellations indicates that most Big LEO proposers currently plan to deploy the bulk of their satellites initially on medium-to-large commercial launch vehicles (capable of launching at least 10,000 to 20,000 pounds to LEO). However, Big LEO proposers apparently intend to conduct at least some portion of their failure replacement launches on small launch vehicles, usually in clusters of two or three satellites.

Little LEO proposers currently intend to conduct both initial deployment and failure replacement launches on small launch vehicles due to the relatively small size of these payloads.[5] Also, organizations planning remote sensing, international scientific, or microgravity payloads will most likely use single or dual-manifested small launch vehicles.

Based on these assumptions, the resulting Scenario 1 demand for commercial launches to LEO for the period between 1996 and 2005 should be:

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[5]The exception to this general rule is the non-U.S. proposers of smaller Little LEO systems, who seemingly plan to launch most of their satellites as secondary payloads on larger vehicles.

- 5 to 10 medium-to-large launches per year *during deployment phase*s (depending on the system and particular launch scheme), with the number of launches most likely falling in the high end of this range during the years 1996-1998 and 2002-2003, and at or *near* the low end of this range during the years 1999-2000 and 2004-2005; and

- 9 to 12 small vehicle launches per year (but with only five launches in 1996).

The resulting Scenario 2 demand for commercial LEO launches for the same period should be:

- 5 to 10 medium-to-large launches per year during deployment phases (now covering most of the ten-year period in some form), with the number of launches most likely falling in the high end of this range during the years 1996-2000 and 2002-2003, and at or *near* the low end of this range during the years 2001 and 2004-2005; and

- 10 to 15 small vehicle launches per year (but again with only five launches in 1996).

More specific estimates of LEO launch demand for the two market scenarios are provided in Figure 6 with respect to years and vehicle classes.

Based on available information, the competitions for these launches should in most cases be open to bids from all international commercial launch service providers.

V. <u>Implications of Dramatic Growth for Launch Capacity</u>

Of particular concern to the U.S. Government and the industry is the question of whether sufficient launch capacity and infrastructure exist to support a dramatic (very optimistic) growth in the number of satellite systems that will be deployed in the 1996-2005 time frame. Although the market scenarios described above clearly reflect *some* growth relative to the projections made in 1995, the numbers of LEO systems projected for deployment in this period are still markedly less than the overall numbers presented in Figures 1 and 2. Given this concern, OCST considered it potentially illuminating to assess the implications of significantly higher growth in demand for MSS than is currently anticipated, which would presumably result in the deployment of more LEO constellations (relative to the two baseline scenarios).

Accordingly, Figure 7 presents the potential satellite demand for two additional, "very-high-growth" scenarios:

- the deployment of six Big and five Little LEO systems (used merely as an example of a very-high-growth scenario); and

- the deployment of six Big and five Little LEO systems, along with Teledesic (currently the most developed proposal for a Mega LEO system).

Scenario 2 is also presented in the graph for comparison purposes. As can be seen from the data, the deployment of 11 total LEO systems results primarily in a "leveling" of demand at *approximately* 100 satellites per year, while the additional deployment of Teledesic increases that demand by a factor of six during the deployment phase (and 15 to 20 percent per year thereafter).

Similarly, Figures 8 and 9 provide the number of large and small vehicle launches resulting from the two additional scenarios. It can be seen that the deployment of 11 total LEO systems essentially doubles the number of large vehicle launches per year during deployment phases (relative to Scenario 2), while the addition of Teledesic increases the total number of large vehicle launches by nearly a factor of 10 per year during its deployment (again relative to Scenario 2). It also results in a slight increase per year thereafter as failed Teledesic satellites are replaced, primarily on medium-to-large vehicles. By comparison, the deployment of 11 total LEO systems increases the projected number of small vehicle launches per year by approximately 30 percent (relative to Scenario 2), while the addition of Teledesic does not substantially change the projected number of annual small vehicle launches.[6]

Given such evidence, it would appear that the increase in deployed LEO systems from seven in Scenario 2 to 11 in the first very-high-growth scenario results in a significant, though perhaps not fundamental, shift in demand for satellites and launch vehicles. The addition of Teledesic, however, would clearly represent a fundamental shift in the demand paradigm relative to Scenarios 1 and 2, particularly if the system were deployed in the manner shown in Figures 7 through 9. As such, it is likely that the world's commercial satellite and large launch vehicle manufacturing industries would require a significant increase in active capacity (relative to current or planned production and through-put levels) before being able to support such a system in the manner currently planned. This increase in capacity will be even more necessary (particularly for medium-to-large launch vehicles) if adequate margins are to be maintained in both production and operations to allow for potential failures or slowdowns.

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[6]Due to expected fairing volume constraints and other considerations, Teledesic reportedly does not expect to use small launch vehicles for failure replacement launches.

Figure 1

PROPOSED BIG LEO COMMUNICATIONS SATELLITE SYSTEMS[1]

TYPE	SYSTEM	OPERATOR	SATELLITE MANUFACTURER	OPERATIONAL SATELLITES[2]	SATELLITE MASS (lbs)	DEVELOPMENT COST ($B)	PROPOSED 1st LAUNCH[3]
"MEGA" LEO	Sativod[4]	Alcatel Espace	TBD	64	1540	3	2001
	Teledesic	Teledesic Corp.	TBD	840	1760	9	1999
BIG LEO	AMSC	AMSC Subsidiary Corp.	TBD	12	5000 - 5500	Unknown	1998 - 1999
	Constellation	Constellation Comm.	Lockheed Martin	46	1160	1.7	1999
	Ellipso System	Mobile Comm. Holdings	TBD	16	1430	0.9	1998 - 1999
	Globalstar	Loral Qualcomm	SS/Loral	48	990	1.9	1997
	ICO	ICO Global Comm.	Hughes	10	5500	2.6	1999
	Iridium	Motorola	Lockheed Martin	66	1500	3.4	1996
	Odyssey	TRW	TRW	12	4800	2.3	1999
	Signal[5]	KOSS Consortium	NPO Energia	48	680	0.6	1996 - 1997

1. Proposals for systems in intermediate circular or MEO orbits (such as AMSC, ICO, and Odyssey) have also been included in the study.
2. The proposals for Big LEO systems generally entail initial deployment in clusters on large vehicles. Failure replacement/O & M launches would, in most cases, utilize small launch vehicles. The systems generally assume a satellite failure rate of approximately 10%. (Most of the proposals involve the launch of spares in the initial deployment, which are not reflected in the table.)
3. The proposals typically call for deployment in 2 to 3 years.
4. Alcatel only recently proposed this potential Mega LEO system, which will likely change in configuration as the concept evolves. It is not yet clear whether the proposed service is truly equivalent to that proposed by Teledesic.
5. If deployed, this Russian LEO system would most likely be launched on Russian-built launch vehicles.

Figure 2

PROPOSED LITTLE LEO COMMUNICATIONS SATELLITE SYSTEMS

TYPE	SYSTEM	OPERATOR	SATELLITE MANUFACTURER	OPERATIONAL SATELLITES[1]	SATELLITE MASS (lbs)	DEVELOPMENT COST ($B)	PROPOSED 1st LAUNCH[2]
U.S.	E-Sat	E-Sat, Inc.	TBD	6	250	Unknown	1997 - 1998
	FAISAT	Final Analysis Comm.	Final Analysis, Inc.	26	220 - 250	0.14	1997 - 1998
	GE Americom	GE American Comm.	TBD	24	33	0.189	1997 - 1998
	GEMNET	CTA	CTA Space Sys.	38	99	0.10+	1997 - 1998
	Starsys	Starsys	TBA	24	165	0.25	1997
	Leo One USA	Leo One USA	TBD	48	274	0.2	1997 - 1998
	Orbcomm	Orbital Comm.	Orbital Sciences	36	95	0.22	1995
	Vitasat	VITA	Final Analysis	2	198	Unknown	1995
Non-U.S.[3]	Elekon	NPO-PM/Elbe Space (Russia/Germany)	NPO-PM	7	Unknown	Unknown	1996 - 1997
	Gonets	Smolsat (Russia)	NPO-PM	12-36	500-550	Unknown	1996
	IRIS	SAIT-Systems (Belgium)	OHB-System	2	Unknown	0.033	1997
	Leo One	Leo One Panamer. (Mexico)	CTA Space Sys.	12 - 24	330	Unknown	1997 - 1998
	SAFIR	OHB Teledata (Germany	OHB-System	6	132	Unknown	1997

1. As with Big LEOs, the systems generally assume a satellite failure rate of approximately 10%. Also, some of the proposals involve the launch of spares in the initial deployment, which are not reflected in the table.
2. The proposals typically call for deployment in 2 to 3 years. The launches of purely experimental satellites are not included in the launch date summary.
3. Some of these systems may not involve the use of truly "hand-held" receiving devices (at least in their current configurations). In addition, these systems will most likely be launched on non-U.S. launch vehicles, in many cases as secondary (or "piggyback") payloads (e.g., SAFIR and IRIS). Finally, several other non-U.S. LEO systems are under discussion, but are not listed due to their comparatively early (and uncertain) stage of authorization and development. The previously-listed TAOS system has reportedly been cancelled by CNES.

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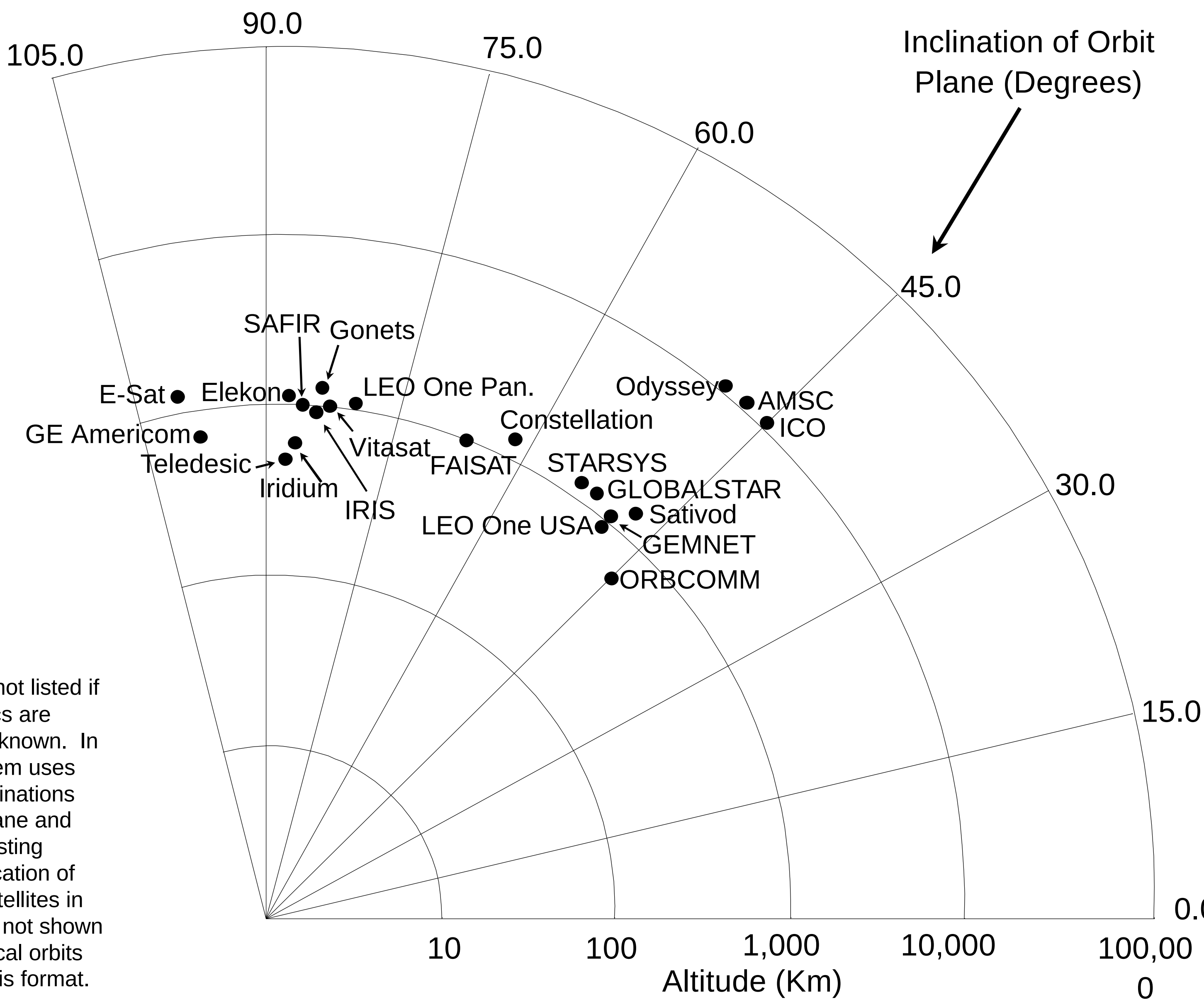
Figure 3

PROPOSED LEO SYSTEM ORBITS



NOTE: Systems are not listed if the orbit characteristics are either undefined or unknown. In cases where the system uses planes of different inclinations (e.g., an equatorial plane and inclined planes), the listing corresponds to the location of the majority of the satellites in the system. Ellipso is not shown because it uses elliptical orbits that do not apply to this format.

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Figure 4

LEO COMMERCIAL PAYLOAD PROJECTIONS (SCENARIO 1)[1]

MARKET SEGMENT	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Big LEO	24	69	36	6	6	0	43	30	24	32
Little LEO	0	30	16	12	0	0	24	24	12	0
Big/Little LEO[2] "O & M" Support	0	0	11	10	8	8	8	11	10	8
Remote[3] Sensing/ Int'l Scientific/ Microgravity	5	7	7	7	3	3	7	6	8	3
TOTAL:	29	106	70	35	17	11	82	71	54	43

1. Scenario 1 assumes that three Big LEO and two Little LEO systems will become operational. The projections and deployment schemes shown are representative of current proposals for LEO systems, and include the launch of spares.

2. Numbers are approximations based on estimates of satellite failure rates for the five systems.

3. Where appropriate, a 5-year on-orbit life cycle/system replacement phase was assumed for these classes of payloads. U.S. Government military and civil payloads have not been included.

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Figure 5

LEO COMMERCIAL PAYLOAD PROJECTIONS (SCENARIO 2)[1]

MARKET SEGMENT	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Big LEO(s)	24	69	36	8	13	3	43	30	24	32
Little LEO	0	30	32	34	0	0	24	40	34	0
Big/Little LEO[2] "O & M" Support	0	0	11	10	12	8	8	11	10	12
Remote[3] Sensing/ Int'l Scientific/ Microgravity	5	7	7	7	3	3	7	6	8	3
TOTAL:	29	106	86	59	28	14	82	87	76	47

1. Scenario 2 assumes that four Big LEO and three Little LEO systems will become operational. The projections and deployment schemes shown are representative of current proposals for LEO systems, and include the launch of spares.

2. Numbers are approximations based on estimates of satellite failure rates for the seven systems.

3. Where appropriate, a 5-year on-orbit life cycle/system replacement phase was assumed for these classes of payloads. U.S. Government military and civil payloads have not been included.

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Figure 6

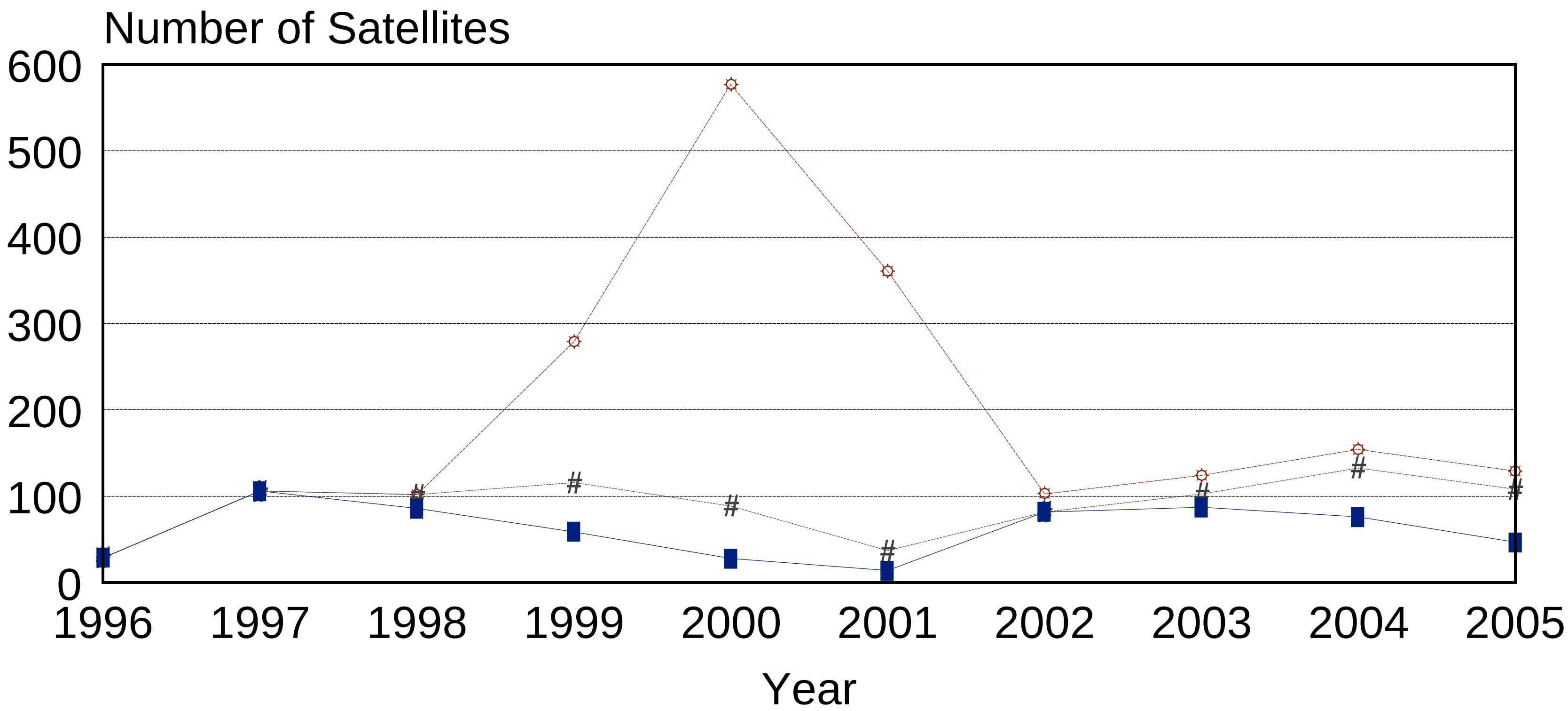
POTENTIAL LEO LAUNCH DEMAND FOR THE TWO MARKET SCENARIOS

VEHICLE SIZE	SCENARIO 1					SCENARIO 2				
	1996-98	1999-00	2001	2002-03	2004-05	1996-98	1999-00	2001	2002-03	2004-05
SMALL VEHICLE LAUNCHES	9-12/yr (5 in 1996)	9-12/yr	9-12/yr	9-12/yr	9-12/yr	10-15/yr (5 in 1996)	10-15/yr	10-15/yr	10-15/yr	10-15/yr
MED -TO- LARGE VEHICLE LAUNCHES	5-10/yr	3-6/yr	0	6-9/yr	4-6/yr	5-10/yr	6-9/yr	2-3/yr	6-9/yr	4-6/yr

NOTE: The launch ranges presented above are estimates only, and will in the end depend greatly on the particular system and launch scheme.

Figure 7

POTENTIAL SATELLITE DEMAND IF MORE SYSTEMS ARE DEPLOYED



1. The graph reflects the total number of satellites resulting from each scenario, including O&M satellites for constellations and satellites for remote sensing, microgravity, etc.
2. Scenario 2 demand, presented in detail on previous charts, is shown again for comparison purposes.
3. The two additional scenarios are presented only to demonstrate the implications of "higher" growth in the market (relative to Scenarios 1 and 2). The order of presentation is arbitrary.
4. The system characteristics and deployment schedules shown for the two additional scenarios reflect only the currently announced plans for each system. These plans are based on various assumptions concerning licensing dates, financing, and market approach, and may be subject to change as system concepts evolve.

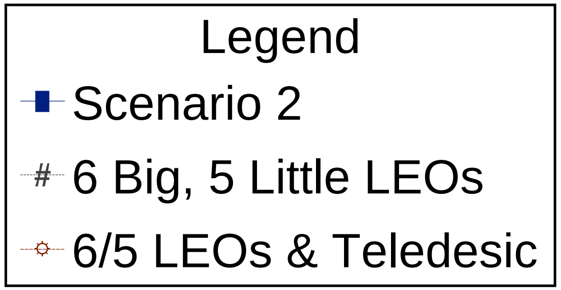
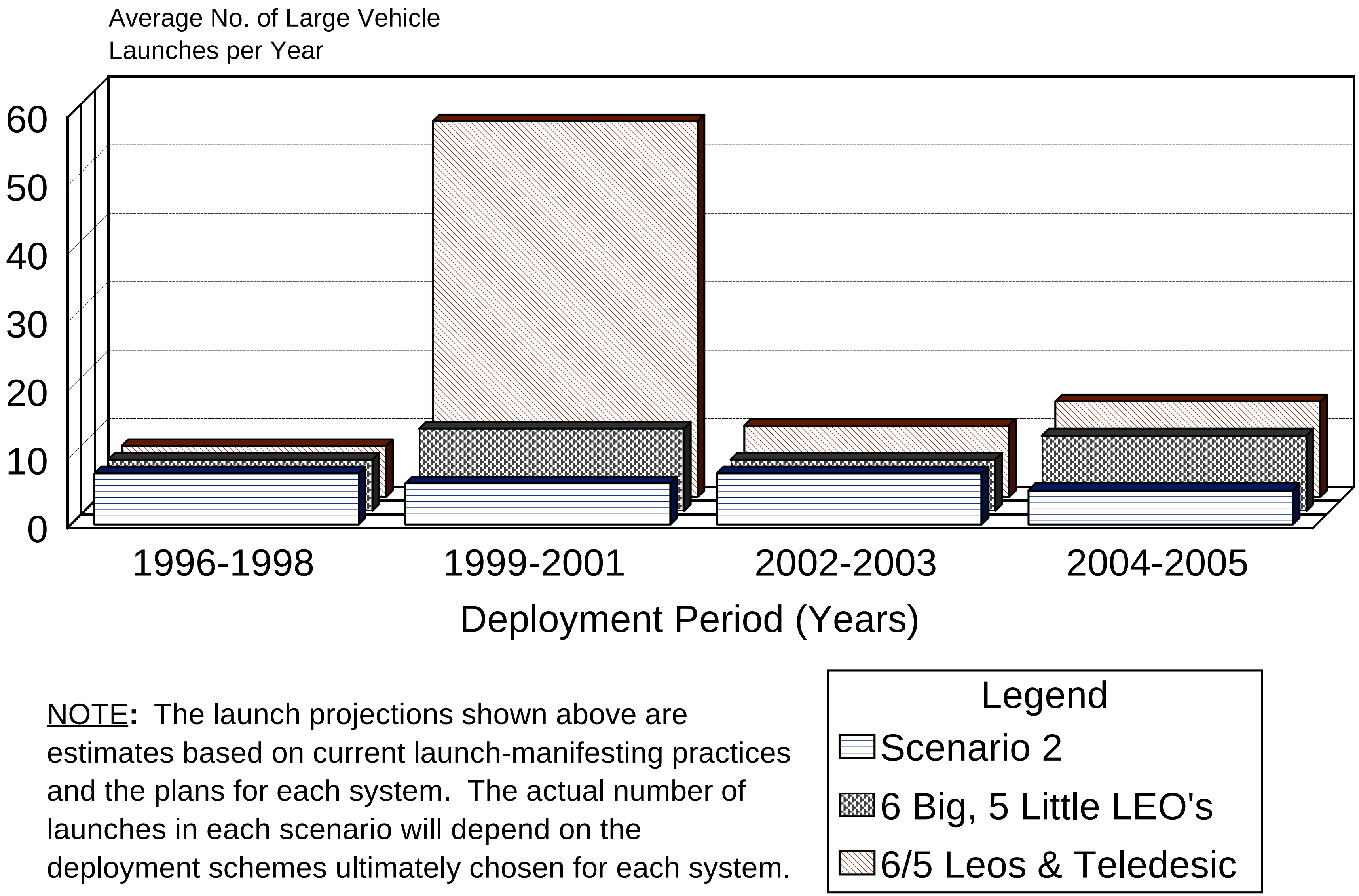


Figure 8

POTENTIAL LARGE LAUNCH VEHICLE DEMAND IF MORE SYSTEMS ARE DEPLOYED



NOTE**:** The launch projections shown above are estimates based on current launch-manifesting practices and the plans for each system. The actual number of launches in each scenario will depend on the deployment schemes ultimately chosen for each system.

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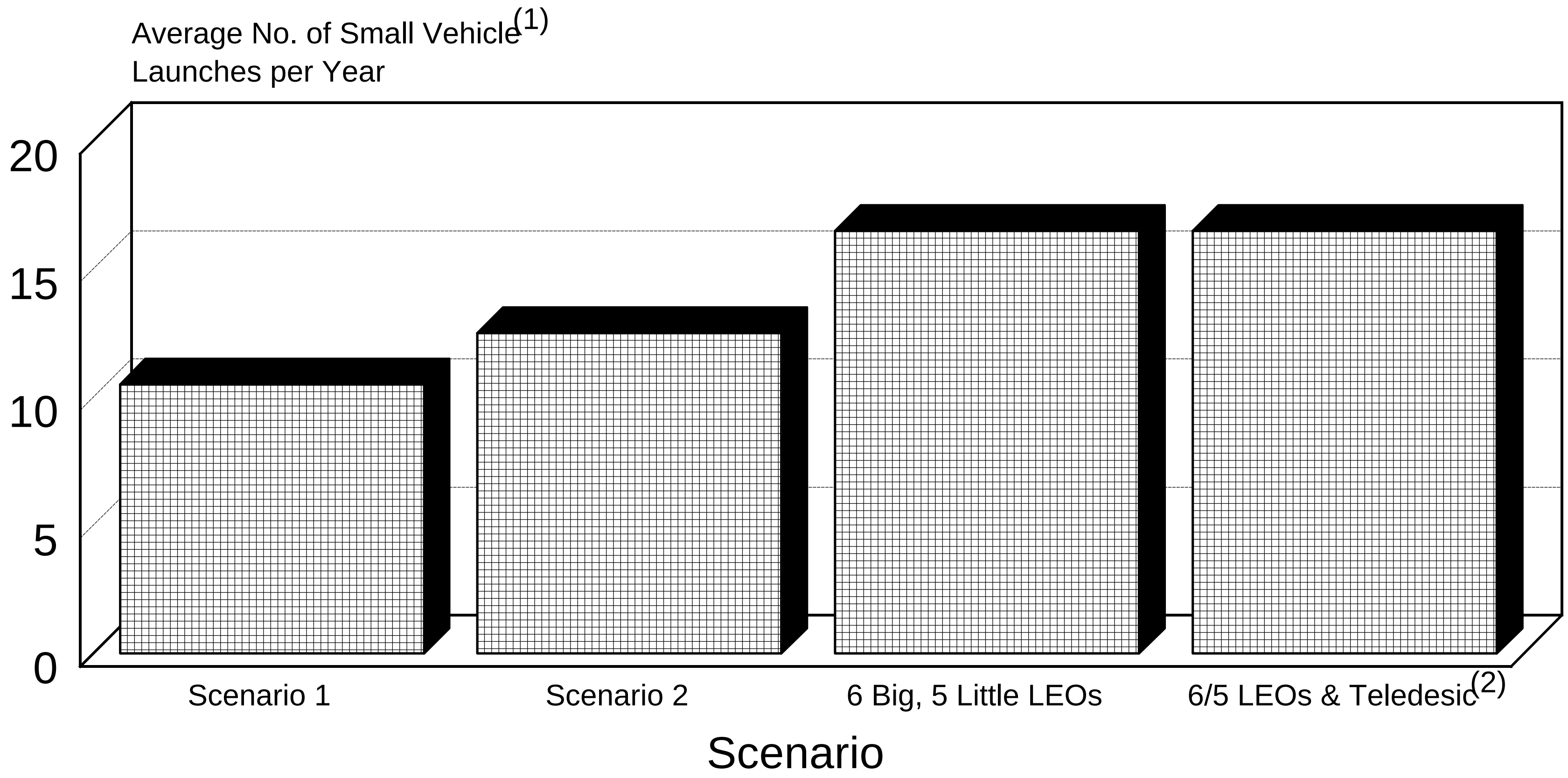
Figure 9

POTENTIAL SMALL LAUNCH VEHICLE DEMAND IF MORE SYSTEMS ARE DEPLOYED



1. The average annual numbers of launches shown are representative of a range of launches expected to occur per year *over the entire 10-year period*. The actual launch levels will, in the end, depend on the individual systems that are deployed and the launch/failure replacement schemes chosen for each system.

2. Due to expected fairing volume constraints and other considerations, Teledesic reportedly does not expect to utilize small launch vehicles for failure replacements.

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