The international trade in launch services : the effects of U.S. laws, policies and practices on its development

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CHAPTER 1

The global satellite launch market and the launch companies

1.1 The global satellite launch market

The trade in launch services is part of a booming, multi-billion dollar industry.

An authoritative report published in 1997 estimates that global space industry revenues in 1996 totalled about USD 77 billion, and are expected to exceed USD 121 billion annually by the year 2000.
The two largest sectors of the industry are infrastructure and telecommunications. Infrastructure, which in the above report includes satellite-manufacturing, ground installations and operations, spaceports, launch vehicles, the space station, and related science and R&D represented 61 percent or USD 47 billion in 1996, and will increase to USD 59 billion, representing 49 percent of global space revenues, in 2000.
Telecommunications services provided by/through satellites will surge from USD 23 billion in 1996 (30%) to USD 46 billion annually by the year 2000 (38%).[1]

The manufacture, launch and use of communications satellites is 'big business' indeed.

1. See *State of the space industry - 1997 outlook*, published by Space Vest, KPMG Peat Marwick, Space Publications and Centre for Wireless Communications, hereinafter referred to as State of the space industry, at 9. The report distinguishes four categories of activities or sectors: infrastructure, telecommunications, support services (engineering, technical support, business consulting, financial and legal services, and space insurance) and emerging applications (remote sensing, geographical information services, global positioning systems and services, and materials processing). Support services totalled $3 billion (4%) in 1996 and will remain at the same level in 2000 (2%), whereas emerging applications will grow from $4 billion (5%) in 1996 to $13 billion (11%) in the year 2000. The report also observes that commercial utilization of space hardware in 1996 represented approximately 53% of the industry, the first year on record that commercial revenues surpassed government expenditures. This percentage is likely to increase as, according to the report (and supported by developments in 1997 and 1998), the industry is continuing its evolution from a government-driven, project-defined industry to one in which the government plays a lesser role and commercial forces predominantly dictate growth, see *id.*, at 10.

A distinction can be made between the Geostationary Earth Orbit (GEO) market on the one hand and the combined Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) markets on the other hand.

A 1997 market overview forecasts that, from 1997 through the year 2006, a total of *273* commercial communications satellites will be launched into GEO orbit, with a total value of about *USD 37.8 billion* (excluding launch cost).[2]

The same market overview forecasts that over the same period a total of *1,062* commercial communications satellites will be launched into either LEO or MEO orbits, with a total value of just under *USD 11.2 billion* (excluding launch cost).[3]

A more recent study, produced by the U.S. FAA's Associate Administrator for Commercial Space Transportation, forecasts the following global demand for commercial launch services for the period 1999-2010 (in average number of launches per year):

GEO satellites:	25 launches of medium-to-heavy launch vehicles
LEO/MEO/elliptical satellites:	15 launches of medium-to-heavy launch vehicles
LEO satellites:	11 launches of small launch vehicles
Total launches per year:	51 (+40%)
Total launches in 12 years period:	610, for a total of 1369 satellites.[3a]

2. See *World space systems briefing*, Teal Group Corporation (1997), hereinafter referred to as 1997 Teal Group briefing. The GEO/LEO/MEO market development data which follow are derived from this market study, unless indicated otherwise. Though, in its 1998 update, the aerospace and defense analysis group scaled back its assessment of the world market for commercial satellites for the years 1999 to 2008 in view of both the Asian economic crisis and recent launch failures which affect the start-up/completion dates of a number of satellite constellations, it continues to forecast a bright commercial and financial future for, in particular, space-based communications (notwithstanding these 'short-term' setbacks), and is joined in this positive long-term view by Merrill Lynch analysts of the industry, see 2 (16) International Space Industry Report (Sep 28, 1998), hereinafter referred to as ISIR, at 1, 4.
3. Another figure, provided in the State of the space industry, *supra* note 1, at 24, quoting Via Satellite, puts total sales of all GEO/LEO commercial communications satellites in the period 1996-2000 at USD 54 billion. Other figures in the same report show a rather stable international government (gov) demand for satellites, and an increasing commercial (com) market: (in approx. $billions) 1996: gov 6, com 3; 1997: gov 6, com 4; 1998: gov 6, com 5; 1999: gov 6, com 6,5;2000: gov 6, com 8,5, see *id.*, at 25.

3.a See *1999 Commercial space transportation forecasts*, FAA's Associate Administrator for Commercial Space Transportation (AST) and the Commercial Space Transportation Advisory Committee (COMSTAC) (May 1999).

A private market research firm gives the following forecast for the years 1999-2008, a 10-year period, including an approximate total value of the satellites concerned:

commercial communications satellites:	1.017 (value: USD 49.8 billion)
commercial earth imaging satellites:	40-50 (value: USD 3.5 billion)
military satellites:	305 (value: USD 35.1 billion)[3b]

GEO market

In the GEO market, the customers, *i.e.* the buyers and users of the satellites, consist of government agencies, private telecommunications entities and companies, international global and regional organizations, who use the satellites and satellite systems for such programs as telecommunications/tv broadcasting, direct-to-home tv, broadband multimedia and mobile communications.

- The U.S. customers, such as PanAmSat, Loralsat, Lockheed Martin's Astrolink and Hughes Communications' Spaceway, are expected to buy 101 satellites, for some 26 of the above programs. Together with a small number of Canadian orders, this represents about USD 17.3 billion and 39 percent of the worldmarket of GEO satellites launched;
- Asia and the Pacific Rim will buy 78 satellites at approximately USD 10.3 billion;
- Nine European countries and the European Telecommunications Satellite Organization (Eutelsat) will together obtain 32 satellites with a value of approximately USD 5.1 billion;
- Africa and the Middle East, made up of four customer countries and the Arab Satellite Communications Organization (Arabsat) will spend approximately USD 1.3 billion for 8 satellites;
- Intelsat and Inmarsat, the two global communications organizations will buy 12 and 6 satellites respectively at a total value of close to USD 1.9 billion;
- Latin America and the Caribbean account for 10 satellites at approximately USD 1.1 billion, with Brazil dominating that regional market with 6 satellites; and, finally,
- Russia is expected to acquire 20 GEO satellites for close to USD 1 billion.

3.b See *Satcom market buffeted by economic uncertainties*, Marco Antonio Caceres, Teal Group Corp. (January 11, 1999), Aviation Week & Space Technology Online <http://www.aviationweek.com/aviation/sourcebook/99satel.htm> The military forecast is based on an estimated 15 satellites per year launched by the Russians, and 10-11 per year launched by the U.S, with Europe, China and some other countries responsible for the remainder.

The *satellite manufacturers* most likely to produce the large majority of the above satellites are three U.S. and two French companies, namely:
Hughes Space and Communications (48 satellites (sats) at USD 8.4 billion),
Lockheed Martin Telecommunications (36 sats, at USD 5.2 billion),
Space Systems/Loral (27 sats at USD 3.6 billion),
Matra Marconi (13 sats at USD 2.1 billion), and
Aerospatiale (14 sats at USD 1.6 billion).[4]

LEO/MEO market

A plethora of satellite programs for at least three different applications will make use of LEO/MEO satellites: systems will be dedicated to broadband multimedia (fixed, high-powered digital voice, data and video services), mobile (hand-held) voice and data communications (faxing, paging, messaging and positioning), and mobile data communications (regional or global data relay, faxing, etc.)
Broadband multimedia systems, such as the U.S. Teledesic and M-Star and the French Skybridge will use a total of *458* 0.6 to 4 ton satellites, with a start of launches in 2001. A shortage of sufficient launchers could delay the entry into service of these systems by a few years. An estimated 5 mobile voice and data systems, among which Globalstar, ICO, Iridium and Odyssey will consist of *374* satellites, with the LEO systems (Globalstar and Iridium) using small satellites of less than 1 ton, and the MEO programs using satellites of 2 to 3 tons in weight. Finally, mobile data systems such as Orbcomm and Starsys will need some 230 small to very small (less than 100 kilo) satellites.

Even more so than in the GEO market, U.S. customers will dominate this market, with 85 percent of the satellites destined for U.S. systems, such as Globalstar, Iridium, Orbcomm and Teledesic. They are followed by European programs such as Alcatel's Skybridge, Belgian IRIS and Matra Marconi's WEST, taking 10.5 percent of the satellites. ICO owned by Global Communications, a subsidiary of Inmarsat, and two Russian systems will also operate in this market segment.

The satellite manufacturers which will produce and sell the great majority of these satellites will be:
Motorola, which early in 1998 replaced Boeing Defense and Space as designer and builder of about 325 Teledesic satellites (at almost USD 3.3 billion),

4. Via Satellite gives the following market shares of communications satellites in orbit as of January 1997: Hughes 36%, Lockheed Martin 17%, Space Systems/Loral 13%, Matra Marconi 8%, Aerospatiale 8%, other 18%. For communications satellites under construction, the following market shares are given: Hughes 29%, Space Systems/Loral 18%, Lockheed Martin 17%, Aerospatiale 14%, Matra Marconi 10%, Alcatel 4%, other 8%, as quoted in State of the space industry, *supra* note 1, at 26, 27.

Lockheed Martin Missiles and Space (168 Iridium satellites for USD 1 billion), Space Systems/Loral (116 Globalstar satellites at USD 290 million), Alcatel Espace (112 satellites for Skybridge and Starsys at approximately USD 784 million), and Orbital Sciences which will build 92 satellites for its own Orbcomm system (USD 132 million).

The above commercial communications satellites represent approximately 70 percent of the total of all payloads to be launched. The remaining 30 percent cover such other categories as civil and military government satellites, earth imaging and meteorological satellites, scientific and technology development satellites. Civil satellites, *i.e.* all government satellites which are not military, make up about 13 percent (scientific, earth observation, meteorological, communications and technology development satellites), while military satellites (*inter alia* communications, reconnaissance and surveillance, meteorological satellites) are expected to account for approximately 9 percent of worldwide payloads to be launched in the years to come.
One may conclude that the space industry in general and the satellite manufacturing industry in particular (and the U.S. companies concerned) are extremely healthy, poised for further growth and, as a consequence, employing an increasing number of people around the globe.[5]

5. Worldwide, some 800,000 people are actively employed in the space industry. The commercial sector is creating over 70,000 new jobs per year, see State of the space industry, *supra* note 1, at 10. According to William A. Reinsch, U.S. Under Secretary for Export Administration, Dept of Commerce, "U.S. [satellite manufacturing] industry revenues last year were $23.1 billion, a 15% increase from the previous year. Employment in 1997 was over 100,000, a 10% increase from the previous year.", see *The adequacy of Commerce Department satellite export controls*, testimony before the Subcommittee on international security, proliferation and federal services (Jun 18, 1998) <http://www.bxa.doc.gov/press/98/sattest.htm>; also Gary R. Bachula, Acting Under Secretary for Technology, Dept of Commerce: "[t]he Satellite Industry Association estimates that the worldwide commercial satellite industry already represents a $44 billion industry, providing over 150,000 high-wage, high-tech jobs. Roughly half of those revenues and jobs are in the United States. Annual growth in this area was over 14% in 1997, and is projected to remain strong as the global demand for satellite services expands,", see *Remarks on commercial space transportation*, Science, Technology, and Space Subcommittee, Commerce, Science, and Transportation Committee, U.S. Senate (Sep 23, 1998) <http://www.ogc.doc.gov/ogc/legreg/testimon/commerce.052/bach0923.htm>

1.2 The launch companies and the spaceports

1.2.1 The launch companies

A report of the U.S. FAA Associate Administrator for Commercial Space Transportation covering 1997 worldwide launch activity, listed a total of 89 orbital launches involving 150 payloads (satellites) performed in that year for commercial, civil and military purposes.[6]
Of these 89 launches worldwide, 35 were considered *commercial, i.e.* launches which were in principle open to international competition.
The launch companies concerned had revenues exceeding *USD 2.4 billion*. The U.S. launch companies in the same year earned a total revenue (for commercial launches) of close to USD 1.0 billion. Arianespace, with sales of FF 6.6 billion (about USD 1.1 billion), earned slightly more.[7]
Those amounts will grow substantially in the coming years thanks to the explosive expansion of satellite systems, particularly in Low Earth Orbit (LEO). On the other hand, the international government launch market, though still the largest in overall revenues, is not expected to show any substantial growth in the next few years. A 1997 study of historic and forecasted launch revenues produced the following picture:[8]

Launch Vehicle Revenues ($ Millions)

	1995	1996	1997 (F)	1998 (F)	1999 (F)	2000 (F)	Compound Growth
Expendable Launch Vehicles - Commercial	1325	1811	2214	2400	2594	2700	49%
Expendable Launch Vehicles - Government	3101	3143	3143	3220	3215	3205	2%
Total	4426	4954	5348	5620	5809	5905	19%

Where the actual worldwide commercial launch revenues as reported *c.q.* forecasted by the FAA for the years 1997 and 1998, *i.e.* USD 2.4 and 3.0 billion respectively, are higher than the above figures, the difference in growth

6. See *Commercial Space Transportation: 1997 Year in review*, Department of Transportation (DOT), Federal Aviation Administration (FAA), Associate Administrator for Commercial Space Transportation (AST) (Jan 1998) hereinafter referred to as AST Report 1997, at 3.
7. See Arianespace - Espace Newsletter No.134 (Jul/Aug 1998) hereinafter referred to as Espace newsletter 134 <http://www.arianespace.com/english/news_letter.html>.
8. See State of the space industry, *supra* note 1, at 34.

percentages becomes only bigger and the gap between the two markets smaller.[9]

Only 4 'launching states', (groups of) countries whose companies perform these launches, were involved in the above commercial launches: U.S (14), Russia (7), Europe (11) and China (3).
The launch providers of these states also performed non-commercial, mostly government-launches, and were, in those latter activities, joined by 3 other states, Japan (2), India (1) and Brazil (1).

The U.S., Russia, Europe and China are the main players, which dominate the international commercial launch market. Of these, only the U.S. and Russia also have a sizable non-commercial, *i.e.* mainly government (civil and military), launch manifest: in 1997, the U.S. performed 24 such launches, and Russia 22.

The list of active launch companies *per country* is not a very long one as yet: In the **U.S.**, 2 major companies and one smaller enterprise performed the commercial launches in 1997:
- *Lockheed Martin*, operating the Atlas family of launchers and a new small launch vehicle, the Athena 1, launched once in 1997.
- *Boeing*, operating the (formerly McDonnell Douglas) Delta, and
- *Orbital Sciences*, operating the small, air-launched Pegasus.

The three companies use and plan to employ additional launch vehicles, either developed within the company or through arrangements with other launch companies (see below).

(The U.S. government also makes use of the above companies for its launch needs, and has, in addition, NASA's Space Shuttle and the Air Force's Titan IV, for its various civil and military government missions. The latter two do not operate in the commercial market)

Russia employs a wide range of launch vehicles, and increasingly offers its launch services with those vehicles through a number of (semi-) governmental companies on the international market.
In 1997, it was primarily the *Proton* heavy-lift vehicle which was used for commercial launches. The commercial debut of the small *Start* vehicle, a refurbished missile, also occurred in 1997. Other launch vehicles, sofar only used for domestic (government-) missions are the Cosmos, Cyclone (Tsyklon),

9. The 1998 figure is mentioned in Commercial Space Transportation, 3rd Quarter 1998, DOT, FAA, AST (Jul 31, 1998), hereinafter referred to as AST Report 1998 (3d Q), at 12. Proton and Delta 3 failures kept launchers on the ground resulting in fewer 1998 launches than originally foreseen actually taking place and in 1998 total launch revenues reaching an estimated USD 2.1 billion, see *infra*.

Molniya, Soyuz and Zenit, some of which form the subject of international cooperation with European and American companies (see below).

China's Great Wall Industry Corporation (CGWIC) employs and sells the *Long March* family of launchers. Of its 6 launches in 1997, 3 were commercial, the other 3 non-commercial.

The **European Space Agency** (ESA) financed the development of the *Ariane* launch vehicle, successfully sold by Arianespace on the international commercial launch market. (Until 1997, Arianespace traditionally performed the majority of the world's commercial launches, but a record number of U.S. launches for LEO satellite constellations in 1997 reduced the European share to 31 percent, lower, for the first time in close to a decade, than the U.S. (40 percent). This trend will continue in 1998.
Arianespace performed only one launch of a non-commercial nature, a second test flight of the new Ariane 5. ESA, in the light of the stormy LEO developments, also sees the need for a small European-built launch vehicle.

Japan's first indigenously built launch vehicle, the H2, was first launched in 1994. This was followed in 1997 by the M5, a much smaller vehicle carrying a scientific satellite. In 1997 each of the vehicles was launched once, both for non-commercial purposes. The hopes of Japan's (future) international launch clients with large satellites are pinned on a heavier-lift version of the H2, the H2A, which is not yet operational.

India is one of the most experienced new entrants into the exclusive club of commercial launching states. In 1980 it performed its first successful launch with an indigenous launch vehicle, thus becoming the seventh launch nation. Though the launch capability now provided by its Polar Satellite Launch Vehicle (PSLV), first successfully launched in October 1994, is primarily used for domestic needs, such as the launch of Indian Remote-sensing Satellites (IRS), the PSLV is also marketed for commercial launches. The one launch performed in September 1997 was a non-commercial one. The next launch will take place in late 1998 and will carry both an IRS and a small Korean scientific satellite, the latter under a commercial contract. The Indian Space Research Organization (ISRO) proposes to build 5 more PSLV's in the next 5 years to carry IRS spacecraft.[10] In July 1998, Antrix Corporation, the commercial wing of India's Department of Space, signed on behalf of ISRO its third commercial contract for the launch of a Belgian microsatellite; the satellite will share space with an IRS on the PSLV.[11]

10. See Space News Online (Jun 8, 1998) at 1 ("India increases space funding by 52 percent/largest budget hike ever targets communications, launch vehicles") <http://www.spacenews...members/sarch/sarch98/sn0608q.htm>, hereinafter referred to as India space funding).
11. See Space News Online (Jul 13, 1998) at 38

Israel, though it did not perform any launch in 1997, should be introduced here, because, in 1988, it became the eighth member of the space launch club with the launch of the small Shavit launch vehicle. It has not yet made a commercial launch but an upgraded version called LK-1/*Next* is being developed for commercial use, in close cooperation with a U.S. and a French aerospace firm (see below). Israel's special handicap is its small territory surrounded by less than launch-friendly neighbours, which severely limits trajectories available for launches. For that reason, a determined effort is being made to get U.S. government permission for launches from U.S. bases.

Brazil has been working for some years on the development of the Veiculo Lancador de Satellites (VLS), designed to place small satellites into equatorial low earth orbit. So far the test flights, including one in 1997, have not been successful. Nevertheless, Brazil has the ambition to market the VLS commercially once it is operational.

Ukraine, not included in the above FAA report because it did not perform any commercial launches in 1997, needs to be mentioned here nonetheless as the manufacturer of the well-proven Tsyklon (Cyclone) and Zenit launchers. In its ambition to commercialize these vehicles, its space industry has concluded an agreement with Boeing for the sale of an advanced version of the Zenit, and the government has entered into a launch trade agreement with the U.S. which makes commercial Zenit launches of Western satellites possible.

1998 developments

FAA reports on 1998 worldwide launch events show little change in the above picture of launch service providers and launch vehicles:

In the first two quarters of the year, the launch companies of the U.S., Europe, Russia, China, Japan and Israel performed together 39 launches (through the launch companies and with the launch vehicles mentioned above), 20 of which were commercial ones.[12]
New were the launch of U.S.' Orbital Sciences other small vehicle, the Taurus and Lockheed Martin's successful launch of another version of the Athena, the Athena 2.

<http://www.spacenews ...members/sarch/sarch98/sn0713j.htm>.

12. The U.S. was responsible for a total of 20 launches, 13 of which were of a commercial nature, Europe took care of 4 launches (3 commercial), Russia 11 (3 commercial), China 3 (2 commercial), and Japan's H2 and Israel's Shavit were each launched once (both were non-commercial and failed), see AST Report 1998 (3d Q) *supra* note 9, at 3, 8 and similar report for the second Quarter (Apr 27, 1998) hereinafter referred to as AST Report 1998 (2d Q), at 3, 8.

In July 1998, the Russian Shtil rocket entered the commercial launch market. The Shtil, which carried two small Tubsat satellites of the Technical University of Berlin into low Earth orbit, is a converted missile launched from a submarine located about 30 meters beneath the sea surface. With Russia's impressive missile inventory now in principle available for commercial purposes, the small satellite owners have an additional low-cost launch option for their missions.[13]

Later in 1998, Ukraine's entry into the international commercial launch market, based on a 1995 contract with Globalstar to perform three Zenit launches carrying 12 satellites each, was dealt a serious blow with the failure of the first launch on September 10, 1998, which destroyed the 12 Globalstar satellites and resulted in the remaining two Zenit launches being cancelled.[14] Apart from affecting the reputation of the Zenit (and increasing insurance cost for the launcher), it was not immediately clear to what extent this failure would affect the U.S.-Ukrainian Sea Launch project, which uses a more powerful version of the vehicle (See *infra*).

Finally, in October 1998, the third and final testflight of the Ariane 5 heavy-lift European launcher took place. The new vehicle performed as planned, thus paving the way for commercial operations starting in 1999.

The worldwide totals for 1998 as reported by the FAA were as follows:[14a]

13. See Space News Online (Sep 21, 1998) hereinafter referred to as Space News Online 0921, at 1 ("Small satellite makers seek first-class rides into space"), <http://www.spacenews...members/sarch/sarch98/sn0921m.htm>)

14. Loral Space and Communications in the mean time used existing options on the Russian Soyuz vehicle and the U.S. Delta 2 to carry the satellites - with a costly delay - into orbit, see Space News Online (Sep 14, 1998) at 1 ("Globalstar shifts launchers after failure of Zenit/Mishap will cost $100 million"). <http://www.spacenews...members/sarch/sarch98/sn0914bg.htm>

14.a *See Commercial space transportation: 1998 Year in review*, FAA Associate Administrator for Commercial Space Transportation (AST) (Jan 1999) hereinafter referred to as AST Report 1998, at 3, 4. For purposes of this report, a "commercial launch" is defined as a launch that is internationally competed, *i.e.* available in principle to international launch providers, or whose primary payload is commercial in nature. U.S Government launches procured commercially are considered to be government launches. The term "commercial payload"refers to a spacecraft which serves a commercial function or is operated by a commercial entity, without regard to how it was launched. For this report, communications satellites launched for international consortia such as Intelsat are considered commercial, see *id.*, notes 1 and 3.

launches performed:

	commercial launches	non-commercial launches	total
U.S.	17	19	36
Russia	5	19	24
Europe	9	2	11
China	4	2	6
Japan	0	2	2
Ukraine	1	0	1
Israel	0	1	1
North Korea	0	1	1
TOTAL	36	46	82

payloads (spacecraft) launched:

	commercial payloads	non-commercial payloads	total
U.S.	59	21	80
Russia	12	33	45
Europe	13	3	16
China	8	2	10
Ukraine	12	0	12
Japan	0	2	2
Israel	0	1	1
North Korea	0	1	1
TOTAL	104	63	167

The above report notes that, out of the above 104 commercial payloads, 78 were spacecraft destined for the Iridium, Globalstar and Orbcomm LEO telecommunications constellations alone, which continued a trend started in 1997. European Arianespace did not participate in the LEO launches, but launched 13 telecommunications satellites into GEO orbit.

Launch failures at the end of 1997 and in 1998 and the resulting temporary grounding of the respective launch vehicles led to a lower number of launches than originally foreseen and lower revenues than previously predicted. According to the FAA report, revenues from the 36 commercial launches conducted globally reached an estimated USD 2.1 billion, with the U.S. companies earning USD 911 million, followed by Europe (763), Russia (313), China (90) and Ukraine (35).[14b]

14.b *Ibid.*

International launch ventures

The Sea Launch project is a joint venture of Boeing Commercial Space Company, KB Yuzhnoye/PO Yuzhmash of Ukraine, RSC Energia of Russia and Kvaerner Maritime a.s. of Norway. The partners will operate the Ukrainian Zenit launch vehicle from a self-propelled, semi-submersible launch platform, the *Odyssey*, a former North Sea oil-drilling rig, with Boeing operating the Sea Launch Home Port at Long Beach, California and acting as overall project manager. The Russian firm will contribute the Block DM-SL upper stage and be responsible for Sea Launch vehicle integration, launch operations and range services, and Kvaerner, which modified the platform and was responsible for the design and manufacture of the Assembly and Command Ship, the Sea Launch Commander, a floating mission control centre and rocket-assembly plant.[15]
Sea Launch will offer (geographically) flexible launch services and, thanks to its possibility to move the launch platform to near the equator, will be able to put heavy satellites into geostationary orbit, and has thus the potential to become a formidable competitor for both Arianespace and another international venture, *International Launch Services.*[16]
Sea Launch's first commercial customer is Hughes Space and Communications, whose Galaxy XI communications satellite is slated for launch from the Pacific Ocean in August 1999. (Sea Launch in the meantime acquired a package of 13 firm launch orders from Hughes and 5 from Loral Space and Communications), and performed a successful inaugural flight on March 27, 1999 (without commercial payload).

A second international venture, *International Launch Services* (ILS), preceded Sea Launch. It was formed in 1995 when Lockheed Martin Commercial Launch Services and Lockheed Khrunichev Energia International (LKEI) joined forces to market two launch vehicles, the U.S. Atlas and the Russian-built Proton. (LKEI itself was formed in 1992, when Lockheed, a major U.S. defense company without a launch vehicle of its own, concluded a joint marketing agreement with the two Russian manufacturers of the Proton, Khrunichev Enterprise and NPO Energia of Kaliningrad, and created a new company LKE International, headquartered in California, to sell the Proton launcher internationally). The merger of Lockheed with Martin Marietta (builder of the Titan and - since 1994 - owner of General Dynamics, the manufacturer of the Atlas) brought the international sale of the Proton and the

15. See Sea Launch, <http://www.boeing.com/defense-space/space/sealaunch/>. The shares in Sea Launch are distributed as follows: Boeing 40%, Energia 25%, Kvaerner 20%, Yuzhnoye 15%.
16. On the U.S.-Ukrainian bilateral launch trade agreement, by virtue of which Ukraine, both independently and through Sea Launch, offers its launch services on the international market, see *infra*, Chapter 3.3.

Atlas launch vehicles into one hand, to the benefit of both the U.S. and Russian partners.[17]

The above U.S.-led joint ventures give the two U.S. aerospace giants powerful additional tools to compete with Arianespace and CGWIC in the market of medium to heavy payload launches. To partially answer that competitive challenge, Arianespace, together with the French aerospace company Aerospatiale, in August 1996, teamed up with the Russian Space Agency (RKA) and the Russian Samara Space Centre to form *Starsem*, a company which is to sell commercial launch services using the Soyuz launch vehicle family (which includes the four-stage Molniya launcher) for low and medium Earth orbit missions. Where the Ariane 5, once operational, will easily accommodate 10 LEO satellites at one time, the Soyuz will take care of smaller numbers (at lower prices). By 1996, Starsem had signed three contracts with Loral Space and Communications for the launch of 12 Globalstar constellation satellites, and is scheduled in 2000 to launch ESA's four scientific Cluster satellites, two per Soyuz.[18]

Arianespace took another step to cater for the (very) small satellite launch market, by signing an agreement with Antrix Corporation, the commercial wing of India's Department of Space/ISRO to jointly market the Indian Polar Satellite Launch Vehicle and Arianespace's Ariane 5 for the launch of auxiliary payloads in the weight class of up to 100 kilograms.[19]
This may be only the beginning of an important 'alliance' between an established launch provider and a newcomer in the international commercial launch market.

In 1995, German DASA (Daimler-Benz Aerospace) and Russian Khrunichev jointly created a company, *Eurockot* Launch Services GmbH of Bremen, with the aim to market refurbished Russian SS-19 ICBM's ("Rockots") for small LEO satellite launches. In September 1998, Eurockot was reported to be close to signing firm contracts for two commercial launches of the Rockot in late

17. See *e.g.* Lockheed Martin Today - August 1998 ('Progressive partners - cooperative ventures with Russia grow business and build cultural bridges'). <http://www.lmco.com/files3/lmtoday/9808/progressive.html>
18. See Loral Press Release (Dec 5, 1996) ("Space Systems/Loral signs an agreement with Starsem to launch 12 Globalstar satellites") <http://www.loral.com/starsemagreement.html>. As we saw earlier, the September 1998 Zenit failure resulted in Globalstar's affirming the Starsem launch contract reservations. The first such launch - of 4 Globalstars - took place on Feb 8, 1999. The shares in Starsem, which is led by a French chairman and CEO and a Russian COO, are distributed as follows: Aerospatiale 35%, Arianespace 15%, RKA and Samara 25% each. For further info on Starsem, see Starsem brochure (1997) and Espace newsletter 134, *supra* note 7, at 4-6.
19. See Arianespace News & Information (Jun 10, 1998) ("ISRO and Arianespace to jointly market launch services for small satellites"). <http://www.arianespace.com/english/news_news.html>

1999. These contracts would come on top of the 10 launches U.S. communications company Motorola has booked for future replenishment of the Iridium LEO constellation and of 2 E-sat messaging satellite launches. In addition, Eurockot has also collected reservations from undisclosed customers for 12 more flights.[20]

Cosmos International OHB-System GmbH of Bremen is mentioned in the trade press as the Western company marketing the small Russian Cosmos launcher. The company is reported to have three firm contracts for the launch of small satellites (up to 1,300 kg) into LEO.[21]
The Russian-U.S. company Cosmos USA, a joint venture of AKO Polyot of Omsk, Russia and the American company Assured Space Access has also been promoting the Cosmos for launching small satellites.[22]

In the small launch services market at least one other international venture will compete with OSC's Pegasus and Lockheed Martin's Athena, *i.e.*, the *LeoLink* Consortium, set up by Israel Aircraft Industries (IAI) with Coleman Research Corporation (CRC) of Florida. CRC attempts to sell the *LK-1*, a launcher developed on the basis of the design of the Israeli Shavit, but with sufficient U.S. content to qualify for U.S. government launch contracts.[23]

20. Space News (Jan 25, 1999) reports, at 8, that Eurockot had signed a contract for the launch of 2 Iridium satellites in Dec 1999. "The contract also includes an option for 12 more launches of Iridium satellites". Eurockot will operate from the Plesetsk Cosmodrome, but may also use Baikonur, Russia's main launch base in Kazakhstan.
See also Space News (Feb 20, 1995) at 3: Khrunichev is shareholder in the Iridium venture, whereas DASA has purchased a stake in the Loral-led Globalstar network; both are LEO constellations, for which Eurockot offers its launch capabilities. Eurockot 's first demonstration launch is now scheduled for October 1999, see Space News Online 0921, *supra* note 13. Also, see ISIR *supra* note 2, at 1, 17 ("Eurockot prepares for first flight with launch commitments"). DASA was also reported to be working on an arrangement with the Yuzhnoye Design Bureau of Dnieprpetrovsk, Ukraine, to operate the latter's Cyclone rocket from the Guyana Space Centre in Kourou, French Guyana).
21. See Space News Online (Mar 9), 1998, at 10 ("Russian rockets factor heavily in strategy"), hereinafter referred to as Space News Russian rockets, <http://www.spacenews...members/sarch/sarch98/sn03091.html>
22. See Liudmila Bzhilianskaya, *Russian launch vehicles on the world market: a case study of international joint ventures*, 13 (4) Space Policy 323-338 (1997) hereinafter referred to as Bzhilianskaya, at 332-333. Prominent advertising by Cosmos USA (Assured Space Access Inc.) appears to show Western competition in exercising sales rights pertaining to the same Russian launcher, see State of the space industry, *supra* note 1, at 35 (ad), 36.
23. For that purpose, the main stages have to be US-built. In Oct 1998, NASA did select the launcher as one of the two candiates for contracts under its Small Expendable Launch Vehicle Services 2 (SELVS 2) program of 16 small payload launches, valued at about USD 400 million, see Space News (Nov 2, 1998) at 1. Matra Marconi of France, the third partner, provides *i.a.* the fourth stage, see ISIR, *supra* note 2, at 16; on the 'fly US' policy, see Chapter 3.4.4 *infra*. On CRC's efforts to be selected by NASA for government launches under the SELVS 2 program, see Space News Online (Jul 27, 1998) at 6 ("Unproven launcher in running for NASA payloads").

(Other) launch vehicle development plans and projects

Where in the past the size of commercial satellites was limited by the capability of the available launchers which had been designed and built for government payloads, this trend has now reversed. Commercial requirements increasingly determine the design and development of the launchers.
As a consequence, both the existing launch companies and new enterprises are developing more powerful and increasingly sophisticated upgrades of current vehicles. New launchers are also being designed to cater to the expanding satellite launch market and meet specific demands of their customers, the satellite manufacturers and satellite owners/operators, with respect to capacity, flexibility, reliability and cost. (Noteworthy in this connection is that the large (GEO) satellites become larger and the small (LEO) satellites become smaller.)

U.S. projects

Boeing
The Delta II, Boeing's reliable 'workhorse' which has been in operation since 1989, launching medium weight satellites (with a maximum of 4,120 lb/1,860 kg) into GTO, has been joined by the Delta III, developed by Boeing to compete with the Ariane and Proton heavy lift launchers, with a GTO capability of 8,400 lb/3,810 kg, *i.e.* twice the payload of the Delta II.
Delta III's maiden flight took place on August 26, 1998, but one minute after ignition the vehicle lost control and had to be destroyed. The payload, a Galaxy 10 communications satellite owned by PanAmSat, was destroyed as well, bringing the total loss of vehicle and payload (including insurance) to USD 225 million.[24]
Notwithstanding this loss, Boeing will forge ahead with the Delta III and is expected to have this new and powerful launch vehicle in operation for the commercial launches it is committed to. In June 1998, Boeing reported to have contracts for 18 launches, 13 for Hughes and 5 for Space Systems/Loral.[25]

Lockheed Martin
Like Boeing, Lockheed Martin in 1995 initiated a new program to be able to carry the larger satellites being developed by Hughes and other satellite

<http://www.spacenews...members/sarch/sarch98/sn0727as.htm>

24. See NYT (Aug 26, 1998) at 1; also "Boeing begins investigation into rocket failure", Boeing (Aug 27, 1998) <http:/www.boeing.com/defense-space/space/delta/delta3/d3invest.htm> and Boeing, Delta III inaugural flight (Aug 28, 1998) ("Boeing rocket investigation focuses on control system") <http://www.boeing.com/news/feature/delta3webcast/>.

25. See Boeing Space systems, Delta expendable launch vehicles, <http:/www.boeing.com/defense-space/space/delta/deltahome.htm>

manufacturing companies. The Atlas 2AR, and its larger 'cousin', Atlas 2ARC, recently renamed Atlas 3A and Atlas 3B respectively, and both powered by Russian-designed RD-180 first-stage engines, will have a slightly larger capacity than the Delta III: the Atlas 3A, expected to have its maiden flight with a commercial payload around June 1999, will be capable of launching 4,055 kg satellites into GTO, whereas the Atlas 3B, offered for launches in mid-2000, can lift 4,500 kg. (this is not sufficient capacity to accommodate the latest Hughes HS 702 communications satellites of up to 5,200 kg/11,464 lb in weight).

A U.S. government initiated launch vehicle modernization plan called *EELV* (evolved expendable launch vehicle) will, in the years to come, result in a new generation of medium to heavy-lift launchers. Built by the two above companies, it will be used for both government (USAF) and commercial launches, thus strengthening the competitive position of the U.S. launch industry.
For an initial investment of about USD 2 billion, the goal of the EELV system is to reduce the costs for the government of launching its satellites into space by at least 25 percent compared to using the existing vehicles, Delta, Atlas and Titan. The current vehicles, which are acquired by DOD, are used for a variety of national security and civil government missions. Not only do they operate at or near their maximum performance capability, but they (in particular the Titan IV) are also considered by DOD and congressional sources to be very costly to produce and launch. Since 1987, the government has made various efforts to develop a new, more efficient and less costly launch vehicle system, but none of these projects got off the ground, either because of funding issues, changing requirements, or controversy regarding the best way to meet these requirements. In 1994, DOD was directed by Congress to develop a launch vehicle modernization plan, which led to the present EELV system program. Fierce competition for the contract between Lockheed Martin and McDonnell Douglas (later Boeing) was resolved in November 1997, when the Air Force, in stead of choosing for one specific company's rocket, decided that the two companies would share the contract. The USAF's change in plans came after a six month review of the commercial launch market which confirmed that that market was growing much faster than originally forecast.[26] Instead of giving one company an unchallengeable lead over the other as far as governmental launches are concerned, the two companies would both profit from this government investment in upgraded technology and would both enjoy an enhanced competitive position in the international commercial launch market. They would produce more launchers for the commercial market also, resulting in recurring cost reductions by virtue of a significantly larger

26. See News release, USAF (Nov 6, 1997) ("New acquisition strategy for evolved expendable launch vehicle") hereinafter referred to as USAF News release <http://www.laafb.af.mil/SMC/PA/Releases/eelvchng.htm>

customer base (government and commercial). DOD has a clear interest in seeing that EELV is used for commercial purposes in order to lower the cost per launch (particularly if the companies, in view of these important commercial spin-offs, also make private investments in the EELV development).[27] The shared contract approach was reported to help USAF to save between USD 5 and 10 billion in program costs through the year 2020.[28]
EELV is intended to be the federal government's only medium-, intermediate and heavy-lift expendable space transportation capability for several years after the beginning of the 21st century. It is supposed to take care of - in early 1997 estimates - 193 government launches for fiscal years 2002 through 2020, 177 for defense and intelligence purposes and 16 for NASA.[29] To prepare for their EELV launch activities, both Lockheed Martin and Boeing in the meantime announced plans to upgrade/build new launch facilities at Cape Canaveral, in Florida, and at Vandenberg AFB in California.

The U.S. government sponsors another program of new launch vehicles, that of the *reusable launch vehicles* or RLV's. The only RLV now in operation is the space shuttle, which is managed, for NASA, by the United Space Alliance (USA), a joint venture of - again - Boeing and Lockheed Martin.[30] The space shuttle is, as a rule, not available for the commercial satellite launch market. One of NASA's goals is that of providing, and *in casu* assisting in the development of, low-cost reliable access to space.[31] Its 1993 "Access-to-space" study concluded that the best opportunity to reduce launch costs, and improve safety and reliability, was to develop a fully reusable single-stage-to-orbit vehicle capable of delivering 25,000 lb to the International Space Station. This required a focused technology development program and, since NASA

27. See GAO's report *Access to Space: Issues associated with DOD's evolved expendable launch vehicle program*, Letter report, GAO/NSIAD-97-130 (Jun 24, 1997) <http://www.access.gpo/cgi-bin/getdoc.cgi?dbname=gao&docid=f:ns97130.txt>
28. See Boeing, Lockheed to share EELV contract, Florida today space online (Nov 7, 1997) <http://www.flatoday.com/space/explore/stories/1997b/110797f.htm>; also USAF News release, *supra* note 26: "Pentagon and Air Force officials see this as an opportunity to partner with industry, and develop a national launch system supporting both government and commercial requirements. This will reduce the Government's overall launch costs by more than 25 percent. This also supports the Air Force goal of saving between $5 billion and $10 billion in program life-cycle costs through the year 2020."
29. More recent estimates are lower, about 165 in total, and involving smaller military satellites which reduces the USAF need for the EELV successor of the heavy-lift Titan IV and thus also results in substantially smaller cost savings from using that EELV successor.
30. In Sep 1996, USA and NASA signed the Space Flight Operations Contract, which designated USA as the prime contractor for Space Shuttle operations and gave USA authority to proceed with full operation of the contract effective Oct 1, 1996.
31. See, also for the informations which follows, Powell, Lockwood and Cook, NASA, *The road from the NASA Access-to-space study to a reusable launch vehicle*, IAF-98-V.4.02, 49th International Astronautical Congress (Sep 28-Oct 2, 1998), Melbourne, Australia, hereinafter referred to as IAF Melbourne Congress.

would henceforth purchase future launch services in stead of operate the space shuttle, a commercial entity which would develop and market the new vehicle. As NASA realized that no private U.S. company would commit to the costly and highly complicated development, it decided to aid in the maturation of the required technologies and, to that end, NASA entered into a cooperative agreement with Lockheed Martin to develop the X-33, a half-scale demonstrator of a single-stage-to-orbit, all rocket-powered vehicle. The development of the X-33, together with some other related NASA test programs and design studies, will provide the necessary information to determine, by the year 2000, the viability of a commercially developed launch vehicle. The project should result in airplane-like operations at significantly lower cost: the goal is to reduce the cost to deliver payload to low earth orbit from the current estimated USD 10,000 per pound to USD 1,000 per pound. Lockheed Martin calls its commercial X-33 based RLV system, which should be operational and on the market by 2005, *VentureStar*.[32]

Independent from the above NASA-sponsored RLV project, a private U.S. company, Kistler Aerospace Corporation, is building its own RLV, the K-1, "the world's first fully reusable aerospace vehicle".[33]
Kistler plans to build a fleet of K-1 vehicles with a capacity of 100 flights per year (at USD 17 million per flight). It aims particularly at the growing LEO communications satellite constellations market. By late 1999, Kistler plans to start commercial operations from the Woomera launch site in South Australia, but will also (later) use launch facilities in southern Nevada, U.S. The use of two launch sites and a fleet of 5 vehicles will, in Kistler's view provide a unique launch scheduling flexibility for its customers. Kistler has in the

32. See on the VentureStar project, Sumrall (NASA), Lane and Cusic (Lockheed Martin Skunk Works), *VentureStar-Reaping the benefits of the X-33 program*, IAF-98-V.3.03, IAF Melbourne Congress. Another part of NASA's efforts to reduce the cost of access to space is the X-34 program. The X-34 is a reusable suborbital rocketplane, which, like the Pegasus, is carried by a Lockheed L-1011 aircraft to a specific height in airspace before 'taking off' as a launch vehicle. The X-34 program's general goals are two-fold: to provide a testbed vehicle capable of demonstrating key RLV technologies as well as operational systems and techniques that will enable a dramatic reduction in the cost of space access, and to provide a testbed vehicle capable of carrying a variety of experiments supporting the needs of the aeronautical sciences community. Orbital Sciences Corporation (OSC), contracted by NASA on Aug 23, 1996 to develop the X-34, sees the vehicle as a precursor for the development of a fully reusable, liquid propellant replacement for its Pegasus expendable launch vehicle. The first flight is scheduled for 1999, see London III and Lyles (NASA), *X-34 program status*, IAF-98-V.4.04, IAF Melbourne Congress, *supra* note 31.
33. The above and following information on the K-1 is based on two papers presented at the IAF Melbourne Congress by Kistler Aerospace Corporation officials, Mueller, Brandenstein, Cuzzupolli and Kohrs, *The K-1 commercial reusable aerospace vehicle*, IAF-98-V.1.01, and Wang, Mueller, Brandenstein, Lepore, *The K-1 reusable aerospace vehicle: Meeting the demand for LEO satellite delivery services*, IAA-98-IAA.1.2.03. The two articles also provide detailed vehicle designs and market forecasts,

meantime entered into a contract with Space Systems/Loral for 10 K-1 launches.

Other private RLV manufacturers, poised to bring their own launch vehicles on the promising LEO satellite launch market are Kelly Space & Technology, which is developing the air-launched, piloted *Eclipse Astroliner* (and has already signed a launch services contract with Motorola for 10 flights to carry 20 Iridium satellites into LEO), Rotary Rocket Co., which is testing its vertical-lift, vertical-landing *Roton space helicopter*, and Pioneer Rocketplane, developing the piloted, partially reusable *Pathfinder spaceplane*. All companies concerned are in various stages of raising the capital required to get their vehicles 'of the ground', but, given Wall Street's interest, spurred by the successful financing of the commercial satellite constellations such as Iridium, PanAmSat and Globalstar and (forecasts of) a booming satellite market, financing appears to be quite feasible for the most promising of these new transportation companies.[34]

The U.S. government shows a keen interest in promoting research and development (R&D) in the small launcher (technology) field, witness a NASA program, *Bantam*, originally aimed at funding the development of low-cost launchers for light-weight scientific satellites built by universities, and a more recent USAF small launcher procurement program, which, through a competitive bidding process aimed at small launcher companies such as Orbital Sciences and Kelly Space & Technology, should result in new, low-cost launchers becoming available for USAF needs.[35]

34. See Space News Online (Jan 19, 1998) at 6 ("Rlv firms scramble to finance systems") <http://www.spacenews.com/spacenews/members/sarch/sarch98/sn0119cr.htm> and Space News Online (Mar 23, 1998) at 16 ("Wall Street warms up to new rocket firms") <http://www.spacenews...members/sarch/sarch98/sn0323p.htm>.

35. See Space News Online (Jan 19, 1998) at 10 ("Bantam under fire by commercial launch firms") <http://www.spacenews...members/sarch/sarch98/sn01119dg.htm> and Space News Online (Jul 20, 1998) at 6 ("Usaf to open small launcher competition") <http://www.spacenews...members/sarch/sarch98/sn0720x.htm>. In the latter article, OSC's Pegasus and Taurus and Lockheed Martin's Athena are mentioned as the only proven launchers in the size class sought by the Air Force. Apart from these programs, OSC has a contract with USAF to develop a small launcher based on the Minuteman 2 ballistic missile and including Pegasus components, dubbed the Minotaur, which will be capable of launching small payloads for 30% less than the air-launched Pegasus. The same article reports that, after complaints from the private industry ("the government should buy launch services rather than fund selected rocket development efforts"), NASA recently restructured the Bantam program to focus on generic rocket technology development.

European projects

With the successful third and final qualification flight of the Ariane 5 on October 21, 1998 this new heavy-lift launch vehicle is now ready for commercial service. The first commercial flight is scheduled for July 1999, and will possibly be followed by 3 more in the same year. Compared with the Ariane 4, capacity has increased considerably: Where Ariane 4 has the power to lift a satellite of approximately 4,900 kg (9,965 lb) into GTO, thereby surpassing all its foreign commercial competitors except for the Proton (12,100 lb), the Ariane 5 offers a capacity of 6,700 kg (15,000 lb) for a single launch and 5,970 kg (13,134 lb) for a dual launch (*i.e.* two spacecraft on the same launch), thereby exceeding not only the Proton's performance, but also the capacity of the (non-commercial) space shuttle (13,000 lb), and thus trailing only the U.S. military Titan 4 (19,000 lb).

For the period 2000-2010, the launch service market, as forecast by Arianespace, presents two major characteristics, (1) a further increase in the mass of geostationary satellites, which should still represent the majority of launches (an estimated 30-35 satellites per year), and (2) a diversification of space applications, with particular focus on the LEO satellite constellation market segment. Arianespace therefore sees the need for higher performance GEO/GTO launch vehicles and is in the process of further upgrading the Ariane 5 to that end (more than 9,000 kg/19,800 lb in 2001 up to a GTO capacity of more than 11,000 kg/24,200 lb by 2005-2006!); flexibility should also be increased to cater to LEO missions with diverse orbital characteristics.[36]

At its June 23-24, 1998 meeting in Brussels, the ESA Council approved funding for initial studies for the *Vega* small launch vehicle, an Italian-backed development project that should produce a commercially usable small launcher (in 2002) designed for launching small (700-1,000 kg) scientific, Earth-observation and military satellites into low Earth orbit. Available ESA documents estimate a market of six launches per year; whether the ESA Council of Ministers, meeting in 1999, will give a go-ahead to the program, is a matter of debate.[37]

36. See Espace Newsletter 134, *supra* note 7. Also, Astorg, Ruault (CNES), Durand (ESA), Bartholomey (Arianespace) and Dutheil (DASA), *The Ariane 5 launcher and its future*, IAF-98-V.1.03, IAF Melbourne Congress, *supra* note 31. The latter base the Ariane 5 capacity requirements on the following satellite mass predictions: "[t]oday, the average communication satellite mass is around 3000 kg. In 2002 - according to the most recent market analysis - 60% of the satellites will have a mass between 3000 and 5000 kg, and in 2005 around 50% will have a mass over 4000 kg." With a preference for dual launches this translates into the capacities as given in the text.

37. See Space News Online (Jun 22, 1998) at 3

Japanese projects

With the H-2, operational since early 1994,[38] both too expensive for the market and with insufficient lift (approximately 4,000 kg/8,800 lb) for the larger GEO satellites now being built and planned, NASDA, the National Space Development Agency of Japan, is developing a new family of launchers under the name H-2A. Considerable cost reductions have been obtained through the use of American solid-rocket motors and fuel tanks. The H-2A will come in three models: the H-2A-202 (standard version) with about the same capacity as the H-2, which is expected to fly in mid-2000, an augmented version, the H-2A-212, planned to be available a few years later (maiden flight in 2002?), with a capacity of up to 7,500 kg, and a possible future version that could reach a capacity of 9,500 kg. Rocket System Corporation, the private company selling Japanese launch services worldwide, in 1996, concluded contracts with both Hughes Space and Communications and Space Systems/Loral for 10 H-2A launches each.[39]
NASDA has also developed the smaller J-1 launcher, capable of putting about 1,000 kg into low Earth orbit; its first test flight in 1996 was a success, and will be followed by a second flight in 2001. The J-1 is primarily built for domestic (NASDA) requirements (which does not exclude commercial uses at a later stage).
For scientific research experiments and programs, including planetary missions and astronomical research, the Institute of Space and Astronautical Science (ISAS), an interuniversity research organization falling under the Japanese ministry of Education, science, sports and culture, has developed its own M-series of launchers. An enhanced version, the M-5 performed its first launch in July 1998, putting a scientific satellite into an elliptical orbit.
Finally, NASDA's plans include a step-by-step development of reusable launch vehicles, a project which has a 2000-2030 timeframe.[40]

<http://spacenews...members/sarch/sarch98/sn0622g.htm> and Space News Online (Jun 29, 1998) at 1 <http://www.spacenews...members/sarch/sarch98/sn0629ak.htm>

38. The maiden flight of the H-2 took place in february 1994. Since then, the vehicle has been launched six times, five of which were successful. The sixth flight, on Feb 21, 1998 failed. Altogether eight spacecraft have been launched, but with an excessive price tag of USD 140-160 million, the H-2 had no chance to compete in the international market.
39. See, on the H-2A program, Watanabe and Hirata (NSDA), *H2-H2A redesign for more efficient and active space development - enhanced capability and reduced launch cost*, IAA-98-IAA.1.1.01, IAF Melbourne Congress, *supra* note 31.
40. For further info on these programs, see Shigeaki Nomura (NASDA), *Japanese activities for future space transportation system*, IAF-98-V.3.01, *id.*

Chinese projects

The growing size and weight of satellites also forces China to upgrade its launch vehicles to meet its customers' needs. The two launch vehicles presently employed by Great Wall Industries, the Long March 2E (LM-2E) and the 3B version (LM-3B), will both be upgraded, resulting in a payload capacity of the new LM-2E(A) of 5,000-6,000 kg available for the market in the year 2000. And, if the same performance measures are applied to the LM-3B, the latter's capacity, now 4,500 kg/9,900 lb, could be raised to close to 7,000 kg/15,400 lb.[41]

Russian projects

Russia's 'workhorse' the Proton-K/Block DM, the most powerful commercial launcher until the advent of the Ariane 5, with a lift of between 4,800-5,500 kg (10,560-12,100 lb), will be upgraded through the replacement of the Energia Block DM fourth stage with a newly developed Khrunichev "Breeze" upper stage. This new Proton-M will ultimately be capable of launching up to 7,800 kg/17,160 lb to GTO. Further plans involve the capability of launching heavy dual payloads like the upgraded Ariane-5.[42]

Indian projects

In the years to come, India plans to enhance the capability and reliability of the PSLV for mainly domestic payloads.

One of the more ambitious projects undertaken by ISRO, however, is the development of a launch vehicle for geostationary launches, the Geostationary Satellite Launch Vehicle (GSLV-Mk1), which uses a Russian cryogenic upper stage. With tests having progressed in 1997, a first flight is being planned for early 1999. Though this launch vehicle is primarily developed for India's own 'independent access to space', with one flight per year in the coming five years for domestic (communications) satellite launch needs, commercialization, on a limited scale, is not excluded.[43]

Between mid-1998 and 2003, 11 indigenous launch vehicle missions are planned, further enhancing India's experience in this field.[44]

41. See Hatfield and Middleton, *Implications for Asia Pacific launchers of the global GEO launch market after 2000*, IAA-98-IAA.1.2.07, *id.*
42. See *ibid.*
43. See Space News Online (Jan 26, 1998) at 22 ("Krisnaswamy Kasturirangan/Chairman, Indian Space Research Organization")<http://www.spacenews...members/sarch/sarch98/sn0126ae.htm>.
44. See India space funding, *supra* note 10.

Over the horizon is the Indian AVATAR project to build a miniature, reusable, single-stage-to-orbit, hydrogen-fueled space plane, for small satellite launches into LEO. India's own substantial aerospace technology expertise will, however, have to be supplemented by that of other countries to turn this 10-year plan into a reality.[45]

Though the above review of present and prospective launch providers and launch vehicles may not do justice to plans and projects of all countries or companies aspiring to become involved in the (commercial) launch trade, it is suggested that it nevertheless gives a fair picture of the relatively limited number and the type of 'players' most active in the field. In the following chapters, other (former/would-be) launch participants may be reviewed in the context of specific issues dealt with therein.

1.2.2 The spaceports

United States spaceports

Since the 1950's, the U.S. government has built, operated and maintained a space launch infrastructure for its military and civil launches. The most frequently used of these government-operated launch sites were, and still are, Cape Canaveral Air Station in Florida, and Vandenberg Air Force Base in California.
Since the early 1980's, these ranges have increasingly also accommodated commercial launch activities. Gradually, the launch infrastructure has followed the launch services industry in commercializing its activities. This has led to Federal government agencies paying more attention to meeting commercial launch needs through modernization and upgrading of the launch ranges. Pressure of commercial users has also resulted in a move towards commercially operated, non-governmental launch sites or spaceports catering in particular to private launch companies' requirements.

The following is a brief description of the main federal and 'private' launch sites now actively wooing (commercial) customers among the above present and prospective launch providers.[46]

45. See Space News Online (May 18, 1998) at 15 ("India sees bright skies for space plane") <http://www.spacenews...members/sarch/sarch98/sn0518u.htm>
46. See *e.g. Six states in contention for launches - investing in spaceports seen as way to attract spinoff businesses, jobs*, Florida Today (Dec 1997) <http://www.flatoday.com/space/explore/spacial/floridasfuture/pg08.htm> The information on spaceports which follows is to a large extent derived from *An overview of the U.S. commercial space launch infrastructure*, Special Report, AST Report 1998 (3d Q), *supra* note 9, SR-1-14).

Federal

- Cape Canaveral Air Station (CCAS) in Florida, in operation since 1950; operated by the USAF; launch complexes 17 and 36, available for Delta and Atlas launches respectively. Also supports launches of Athena, Titan and Pegasus vehicles and, in the future, EELV's and RLV's (all orbits);
- Vandenberg Air Force Base (VAFB) in California, in operation since 1958; operated by the USAF; available for LEO launches by all types of launch vehicles;
- Kennedy Space Centre (adjacent to CCAS) in Florida, in operation since 1964; operated by NASA; originally created for the Apollo program, it is now exclusively used for space shuttle launches (to all orbits);
- Wallops Flight Facility, Virginia, in operation since 1945; operated by NASA; used for Pegasus LEO launches and, in the future, for converted Minuteman missile launches.

Other Federal (mostly military) launch sites offering their services for commercial launches, include Barking Sands (Hawaii), operated by the U.S. Navy, White Sands Missile Range (New Mexico), operated by DOD, Edwards Air Force Base (California), the U.S. Army's Kwajalein Missile Range (Marshall Islands, near the Equator), Poker Flat Research Range (Alaska), operated by NASA and the Department of Energy's Nevada Test Site.
The latter has in principle been made available to Kistler for the launch of its K-1 reusable launch vehicle (Kistler awaits FAA-AST approval for its operations).

Commercial

- California Spaceport, at VAFB, operated by Spaceport Systems International (SSI), a private company; not in use yet, but available for LEO launchers such as Athena, Taurus, Minotaur and various RLV's. SSI was the first private operator to be granted a commercial launch site operator's license by DOT's Office of Commercial Space Transportation (FAA-AST), in September 19, 1996;
- Spaceport Florida, at CCAS, Launch Complex 46, operated by the Florida Spaceport Authority, a public transportation authority; in use by Athena and available for all orbital launches; the second operator to receive a licence, on May 22, 1997;
- Virginia Space Flight Centre, on Wallops Island, operated by Virginia Commercial Space Flight Authority (VCSFA), a public organization, which was awarded a commercial launch site operator's license by FAA-AST on December 19, 1997. Also in 1997, the VCSFA signed an agreement with NASA to use the latter's facilities at Wallops on a cost reimbursement basis; to be used for LEO launches by Athena, Taurus, and various RLV's.
- Kodiak Launch Complex (Alaska), operated by the Alaska Aerospace

Development Corporation (AADC), a public corporation founded by the Alaska State government; for suborbital and LEO launches (Athena, Taurus, various RLV's). AADC obtained its launch site operator's license on September 24, 1998. The first commercial launch, for the USAF, took place in early 1999. In April 1999 NASA awarded a contract to Lockheed Martin for the Athena 1 launch of a scientific satellite; this will be the first LEO launch from the Alaska facility.

In addition, proposals to develop commercial spaceports involve at least one additional candidate:

- Southwest Regional Spaceport, adjacent to White Sands Missile Range (New Mexico), to be operated by the New Mexico Office of Space Commercialization, State of Mexico; for various RLV's.

Two U.S. launch systems are special in this connection, Sea Launch and Orbital Sciences' Pegasus. The Sea Launch partners perform launches from their own mobile, floating launch platform in the Pacific Ocean, along the equator, about 1,400 miles from Hawaii.
The Pegasus is air-launched from underneath an aircraft (L-1011), which can take off from any launch site/spaceport fit for aircraft operations: one such launch started from a base on the Spanish Canary Islands.

Europe

Both Norway and Sweden have sounding rocket ranges (Andoya Rocket Range and Esrange respectively), both in operation since the 1960's and used by ESA and ESA member states for suborbital launches.
Additionally, Italy owns and operates the San Marco launch platform, located 4,8 km off the coast of Kenya. The facility, situated conveniently close to the equator, has been used between 1967 and 1988 for (U.S.-built) Scout launches. Italy's sponsorship of the, yet to be developed, European small launcher Vega, based on an upgraded San Marco Scout launcher, may bring new operations to the platform.

The launch base for all Ariane launches is the Guyana Space Centre, at Kourou, French Guyana. The centre has been operational since 1968. On the basis of a contract between ESA and the French Space Agency, CNES, the latter manages the Centre. It has two launch pads, ELA-2 and now ELA-3, built more recently for the Ariane 5. The Centre's ideal (near-equatorial) geographic location translates into substantial fuel and - thus - cost savings for launches with a GEO destination.[47] Some consideration has been given to

47. Compared to launches from Cape Canaveral, those from Kourou require approximately 15-17% less fuel to deploy a payload into GEO, see 1997 Teal Group briefing, *supra* note 2.

making the facility available for use by non-European launch vehicles. One would assume that, for competitive reasons, this would only make sense if done within the framework of a strategic alliance with the launch provider concerned.

Russia

Baikonur is Russia's prime 'cosmodrome', until 1991 the site of some 40 to 50 - mostly military - launches per year. The demise of the Soviet Union and the economic problems that have since plagued Russia, including its space programs, has reduced the number to some 28 per year. All Russian manned space flights (on Soyuz vehicles), Zenit and Proton launches take place from this spaceport. The launch site is based in the former Soviet republic Kazakhstan and Russia rents the site for USD 115 million per year. Though the income derived from commercial launches with the Proton (acquired through ILS) is of vital importance to Russia, government (military and civil) launches continue to have priority use of the launch vehicle. The Ministry of Defense's control of the launch site is reported to be transferred to the Russian Space Agency by the year 2000.[48]

The Plesetsk cosmodrome, located near Archangelsk in Rusia, is the country's second spaceport, with a rich history of Soviet launches for also mainly military purposes. Eurockot's Rockot launch vehicle will use this launch base, and probably also the Start and Cosmos launchers.

A third launch site, currently unused, is Svobodny, a military base, close to the Russian-Chinese border in Khabarovsk, formerly used for ballistic missile launches.

By virtue of a Presidential decree of December 1997, the control over the above spaceports will be transferred from the Russian Ministry of Defense to the Russian Space Agency by the year 2000 (which will presumably also bring the revenues earned by the use of the facilities into civil rather than military hands).

China

CGWIC uses three satellite launch centers for operating the various Long March launch vehicles:

- Xichang, in the southwest China Sichuan province, primarily for the heavy-lift LM-3B;

48. For this and other information on Baikonur and the other Russian launch sites, see *e.g.* Space News Online (Feb 23, 1998) at 10, (Aug 3, 1998) at 4, and (Sep 7, 1998) at 6, <http://www.spacenews..members/sarch/sarch98/sn0223bx.htm, /sn0803bo.htm and /sn0907x.htm> repectively.

- Taiyuan, in the Shanxi province, for the medium-lift LM-2C and -4 launch vehicles, and
- Jiuquan, 1,600 km west of Beijing, in the Kansu province, also for the medium-lift LM 2C and 2D. At the latter site, a new launch pad is being constructed.

Japan

Both the H-2 and the J-1 make use of the Tanegashima Space Centre on Tanegashima Island in the South of Japan. The Centre is operated by NASDA. A new launch pad is being constructed for the H-2A. Until 1997, an agreement with the local fishing community limited launchings to two 45-day periods per year, which made it in practice impossible to have more than two launches per year. A new agreement reached in June 1997 expanded this allotment to 190 days per year, which, depending on the amount of reduction in preparation time at the launch pad, may result in 4 to 8 launches per year.[49] The M-5 was launched from the Kagoshima launch site.

Brazil

The Instituto de Aeronautica e Espaco is responsible for operations at the Alcantara Launch Centre, located on the Atlantic coast near the equator. The Centre is available for the indigenous VLS launches.
In 1994, the Centre's launch pads were used by NASA for sounding rocket launches. And a number of other foreign launch providers, including the Chinese, Russians and Ukranians, have in the meantime shown interest in using Alcantara for GEO launches.[50]

India

Sriharikota, India's spaceport, located on an island on the east coast, provides launch services for ISRO's Rohini sounding rockets and the PSLV, and is being modified for the first launch of the GSLV in 1999.

49. The Teal Group anticipates Tanegashima will start averaging about 4-5 launches annually early in the next decade (for both H-2 and J-1 launches), see 1997 Teal Group briefing, *supra* note 2; a NASDA official more recently stated that, as a result of the new agreement, "NASDA can at maximum launch eight H-IIA launch vehicles annually if it can cut down preparation period at the launch pad from 90 days to 20 days.", see Masahiko Sato, *The Japanese legal framework: third party liability resulting from NASDA launch activities*, IISL-98-IISL.2.05, IAF Melbourne Congress, *supra* note 31.
50. See 1997 Teal Group briefing, *supra* note 2.

Australia

The Woomera Prohibited Area, north of Adelaide, was originally a missile test facility. In the 1960-70s, the facilities were used extensively for sounding rocket launches by Europe, the U.S. and other countries. The Australian government now offers Woomera as a space launch centre to commercial users. As a result, agreements have been concluded with a number of countries, reportedly including the Russians and the Japanese, to develop space launch service facilities in the area.[51]
Kistler Australia has also concluded an agreement for the use of Woomera, for operations of its K-1 RLV.

1.3 Factors affecting the development of the (free) trade in launch services

The international commercial launch market is - at present - essentially dominated by the U.S. firms Boeing and Lockheed Martin and the European firm Arianespace. Although China, Russia and Ukraine have considerable capabilities in this field, with a long-time experience in domestic government launch activities, in practice they have yet to establish themselves as full-fledged members of the club of international launch service providers. In the meantime, Russia and Ukraine sell their services primarily through joint ventures with Western companies, and the three launch providers concerned have the relative luxury of eager (GEO and LEO) satellite manufacturers and operators clamouring for launch vehicles: it is, and is expected to remain for years to come, a seller's market.
Japan is late in entering the commercial launch market, and India will not make a competitive impact for years to come.

Altogether, there are only a few serious players in the market, and innovation, in the sense of new companies with new products, appear to be almost all of American nationality.
Obviously, there are some serious handicaps and barriers which prevent other countries and their companies from joining the 'club' of launching states.

A number of practical barriers for these launch 'have-nots' are obvious:

Technology

The manufacture of indigenous launch vehicles is a high tech activity requiring extremely sophisticated expertise which either has to be developed from scratch

51. *Ibid.*

or borrowed from a full-fledged domestic military missile industry (which uses virtually identical technologies). For example, Japan, with little or no missile expertise to speak of, has been building sounding rockets since the mid-1950s and, since approximately 1969, developing launchers on the basis of imported U.S. Delta hardware and technology. Its decision to build its own, 100% Japanese, launcher started a 10 year effort which NASDA describes as follows:

"The H-II rocket was entirely different to the H-I rocket, developed in a completely different way. The new [first stage] engine, LE-7, was extremely difficult to develop and it failed at test firing several times. In an effort to reduce weight and thus improve efficiency, and to increase tolerance to vibration, noise and high temperatures, developers encountered numerous difficulties. But developers' enthusiasm helped them to overcome these difficulties and in February 1994 - two years later than originally planned - the first rocket made entirely in Japan was launched. The successful launch represented the culmination of 10 years o[f] gruelling effort".[52]

And it took the collective European expertise in and knowledge of rocketry (primarily available in France, U.K and Germany) 7 years, from decision in 1972 to first launch in 1979, to get the first Ariane successfully into space.

The Ariane 5 took some 10 years of development before the first flight could take place.

Proof that this is indeed a 'high tech, high risk' industrial activity may also - and even more conclusively - be found in launch failures suffered by both established and new launch service providers. For example, in 1996, a Chinese Long March 3 and a 3b, a European Ariane 5 and a Russian Soyuz malfunctioned; in 1997, a U.S. Delta 2, a Russian Proton and a Brazilian VLS failed, followed in 1998 by a Japanese H-2, an Israeli Shavit, a U.S. Titan 4 and Delta 3, and a Ukrainian Zenit 2. In the first half of 1999, the U.S. experienced four launch failures, two Titan 4, one Delta 3 and one Athena 2. A private industry database on all spaceflights performed shows 60 significant launch failures since 1990.[53]

52. See - *H-II - an entirely Japanese-made rocket, History of Japanese rocket development* (5), Online space notes/launch vehicles <http://spaceboy.nasda.go.jp/note/Rocket/E/roc105_his5_e.html>

53. U.S.-based Aerospace Corporation, as quoted in NYT (May 12, 1999) at 1 ("Series of rocket failures unnerves U.S. space launching industry"). In the same article a U.S. space program expert, John Pike, is quoted: "[s]pace launch vehicles are inherently unreliable and people should understand that is still a risky business".

Development cost and commercial prospects

Building a launch vehicle, including the necessary infrastructure, from scratch is a costly affair: The Ariane 5 development price tag up to mid-1996 had reached USD 8.5 billion.
The cost of upgrading existing (families of) launch vehicles also gives an indication.
The partners in Arianespace, for example, will spend some USD 1,3 billion to give the Ariane 5 its two satellites/11,000 kg lift capacity by the year 2006. Close to that same figure will be spent in USAF funding on the EELV program of Atlas, Titan and Delta modernization and upgrading. But the companies at the receiving end will also have to invest several hundreds of millions USD, before the upgraded products actually become available.
The price per launch also illustrates (to some extent) the amounts involved in the manufacture of the respective vehicle. The FAA gives the following approximate 1998 figures (in USD millions) for a number of medium-to-heavy lift GEO/GTO launchers:[54]

- Ariane 5: 115-143; Ariane 4 (depending on the 'intermediate' version used): 75-110
- Long March 3B: 60-70, the medium-lift versions 2C and 4: 20-30
- Titan 4: 240-270, the medium-lift Titan2: 41-47
- Proton: 50-70
- Sea Launch (Zenit 3): 90-100
- Zenit 2: 25-40

In the same "intermediate" class of launchers as the Ariane 4, the Atlas 2A will command a price of USD 65-80 million with its stronger version, the Atlas 2AS is worth USD 90-100 million, and its colleague, the Delta 3 USD 55-60 million.
The "medium" class Delta 2 costs USD 45-50 million per launch, and the Japanese M-5 USD 41-47 million.

The above '10 years gruelling effort' to build the Japanese H-2 brought the launch price of that indigenous heavy-lift vehicle to a hefty USD 182-201 million.[55]

The development cost of the smaller launch vehicles is understandably lower, partly because of the technology base already available through the earlier manufacture of the above larger launchers, partly because of other power, endurance and material parameters and requirements.
One recent example is the Italian-French Vega, with a projected development cost of approximately USD 360 million and a tentative launch price of USD

54. See: AST Report 1998 (3d Q), *supra* note 9 at B-1-2 ("Characteristics of cited vehicles").
55. See AST Report 1998 (2nd Q), *supra* note 12, at B-2.

20 million. The Vega will compete with the following small LEO launchers (price in USD millions):

- Athena 1: 14-16
- Athena 2: 19-21
- Pegasus XL: 12-14
- Taurus 1: 18-20
- Start 1: 5-10
- Rockot: 5-8
- Shavit: 12-18[56]

Of course the above cost, even for the heavy lift launchers, is far from insurmountable for both Western and Asian industrialized countries. But the question will then be two-fold: how much time and (high tech) energy will it take to build a new indigenous launcher and will it be worth the effort.

It is difficult to ascertain whether all present launch operators consistently make a profit in the business they are in. But more important from the newcomers' perspective is the fact that the 'incumbents' are there, that the U.S. government and, since the early to mid-1980s, the U.S. and European companies have been dominating the market, and that the above launch companies and their colleagues, individually and collectively, through various development and modernization plans and (joint) projects, seem determined to keep, or increase their grip on all segments of the market. Various forms of direct and indirect subsidization and support on the part of the governments concerned have helped to turn the established launch providers into formidable competitors, now and in the future, with the financial, technological and sales power to meet any newcomer head-on, in whatever segment or niche of the market the latter would wish to start doing business. Not a very attractive prospect!

And then, the long term development of the satellite launch market is not one that can be easily predicted or foreseen: by the time the launch vehicle is operational and the development money has been spent, a 'dip' in the market combined with an oversupply of competitors' proven launch vehicles may be the end of the new entrant's dream of capturing a part of the market that appeared promising many years earlier.

But a country may have other than commercial reasons to enter the launch market, either internal (high tech spin-off's (new industries), national economy, jobs etc.) or external (international cooperation, enhanced position in international, space-related organizations, regional dominance, prestige, etc). Or the commercial aspect may be only the by-product of what is essentially

56. See *ibid*.

the geopolitical or national development-inspired need for independent access to space.

The fact is that some countries, irrespective of the above practical barriers, want to 'join the club' anyhow. So they simply *buy* the launch vehicles, have somebody build a launch site, hire the engineers, technicians, managers and salesmen, and start the business of providing launch services for domestic and foreign clients? They do not. Because they can not.

Regulatory impediments

This is where other impediments come into the picture, namely those of a *regulatory* nature: barriers which have proven to be rather effective in preventing or discouraging the acquisition of these launch vehicles and the related technology by countries with space launch aspirations.

Not only the 'have-nots' are faced with barriers. The countries which possess a missile and/or launch industry and have the ability to provide launch services for domestic and international purposes, *i.e.* the 'haves', also have encountered difficulties in entering the market.

China and the (former) Soviet Union/Russia are prime examples of this category. For many years these countries, with of course the Soviet Union as the most successful and prominent performer since the dawn of spaceflight, launched domestic military and civil satellites and showed they had all the operational capabilities for making an impact on the international commercial launch market.
Of course they had certain handicaps of a practical nature, one of which being the secrecy with which their launch industries had been operating for many years (a fact which inspired little confidence on the part of their commercial satellite clients and the space insurance community).
Other problems were related to their non-market economy status and limited marketing expertise in this new and sophisticated business.
No handicaps or problems, however, that cannot be addressed and overcome.

Still, it took the Chinese until 1988 before they were able to conclude their first launch contract with a Western customer, and Russia followed in 1992. And, although in the mean time their presence in the commercial market has become a fact of which the satellite manufacturers and owners are well aware, their actual impact on the market, in the sense of actual launches performed and contracts signed, lags considerably behind their Western competitors.

As in the case of the launch 'have-nots', (other) regulatory barriers prove to be the main stumbling blocks for market entry and, additionally, for full access to the market.

As most of these barriers had (and have) their origin in *c.q.* are based on U.S. laws, policies and practices, particularly in the field of national security and foreign policy, these will be reviewed and analyzed in the following Chapters, and their impact on the international trade in launch services will be determined.

The U.S. government's attitude towards, and its role in the emergence of, the U.S. private launch industry is the most suitable starting point for what is essentially a critical assessment of the U.S. government's behaviour vis-à-vis its industry's foreign competitors (*in statu nascendi*).