Commercial Space Transportation

QUARTERLY LAUNCH REPORT

Special Report:

Trends in Satellite Mass and Heavy Lift Launch Vehicles

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Trends in Satellite Mass and Heavy Lift Launch Vehicles

Growth Trends in Commercial Satellite Mass

The size of commercial GEO satellites has steadily grown as a result of the telecommunications market demanding more satellites with higher power and more transponders. Many analysts within the satellite manufacturing and launch industries see this trend continuing.

In 1996, the Commercial Space Transportation Advisory Committee (COMSTAC) was split among two possible scenarios for the growth in satellite mass over the next decade: either satellite mass growth would plateau or it would continue to rise.

By 1997, COMSTAC concluded that commercial GEO satellites would likely continue to grow in size and mass and that heavy commercial GEO satellites would comprise a larger proportion of the market than had initially been predicted. Satellites heavier than 9,000 pounds to GTO are expected to increase from about 10 percent of the market today to approximately 50 percent by 2010 (see Figure 1). This trend, according to COMSTAC, will result in a corresponding percentage reduction in the intermediate market segment (satellites weighing 4,000 to 9,000 pounds).

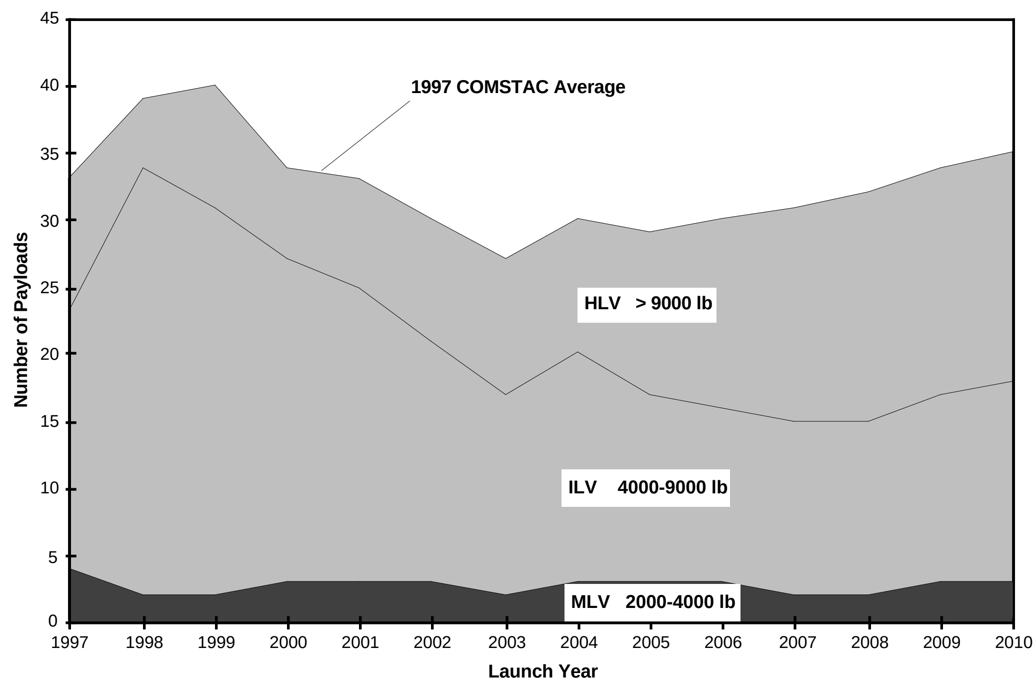

Figure 1. Forecast Trends in Annual GTO Payload Mass Distribution (1997 - 2010)[1]

[1] Commercial Space Transportation Advisory Committee, *Commercial Spacecraft Mission Model Update*, May 1997, p. 6.

The heaviest of the "heavy" commercial GEO satellites could weigh as much as 11,000 pounds from 1998-2000, and may exceed 15,000 pounds in the future.

In another analysis conducted by The Aerospace Corporation, the top 25 percent of satellites are projected to have GTO weights close to 10,000 pounds by the year 2000, and may reach 13,000 to 14,000 pounds by 2010 (see Figure 2). This represents a payload mass trend that is more or less consistent with historical growth rates.

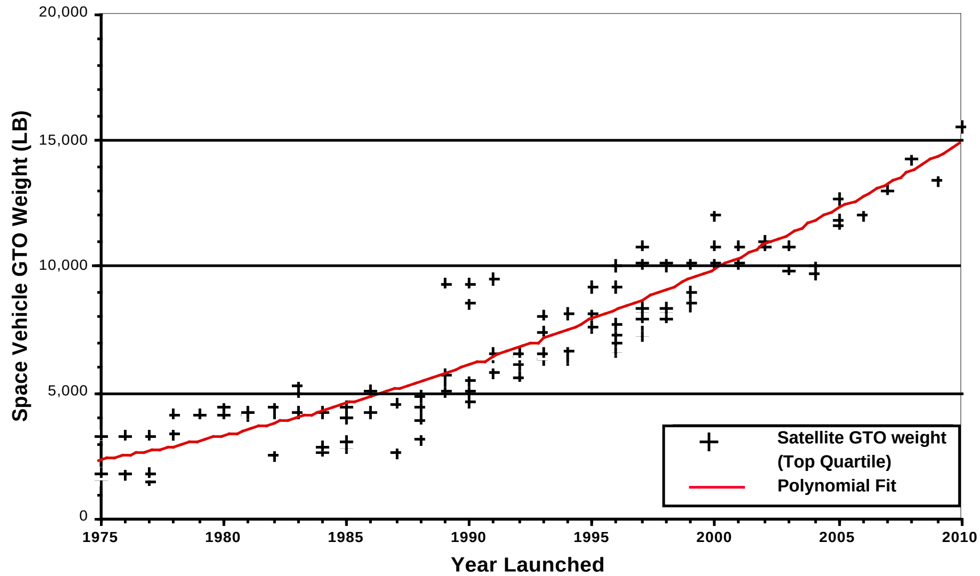

Figure 2. GTO Communications Satellite Weight Growth Trend[2]

There are a number of factors favoring continued mass growth. Satellites with larger numbers of transponders tend to be more cost effective. Also, increased power needed for multiple spot beams or phased array antennas increases the mass of batteries and other supporting systems. However, satellite growth may be constrained if satellite operators deem the risks associated with the premature loss of a high-cost satellite (due to a launch failure or in-orbit failure) to be too high. Another limiting factor is that satellite manufacturers typically compete to meet the customer requirements at the lowest cost, often with a smaller satellite mass.

Launch Service Providers Increasing Lift Capacity

The world's launch service providers are planning increased lift capacity into their range of services to enable the growth of the heavy-lift commercial market. However, as Table 1 shows (below), the majority of the proposed near term vehicle upgrades (particularly those of the United States) do not sufficiently address the full range of heavy satellite masses identified in this year's COMSTAC report.

In the long term, alternative technologies such as reusable orbital transfer vehicles may also be available to augment the performance of comparatively smaller launch vehicles by ferrying payloads from low earth orbit. The plans for adding capacity to the various GEO-capable launch systems are outlined below.

[2] The Aerospace Corporation, *Future Spacelift Requirements Study*, 1997

Atlas

Lockheed Martin's International Launch Services is planning increased capacity into its next upgrade of the Atlas launch vehicle, the Atlas 2AR. With a new first stage utilizing the Russian-designed RD-180 engine, Atlas 2AR will be able to lift close to 8,900 pounds. When strap-on solid boosters are added, the capacity increases to nearly 9,500 pounds. The capacity of the standard Atlas 2AR configuration represents an increase over the initial estimated capacity of just over 8,400 pounds, since capacity held in reserve for launch system components during the vehicle's early development stage was not needed.

The most powerful active version of the Atlas launch vehicle, the Atlas 2AS, can currently lift up to 7,950 pounds to GTO. Although the current and proposed Atlas vehicles may not be able to address all of the future heavy-class payloads discussed above, Lockheed Martin is planning a new family of launch vehicles for the Air Force's Evolved Expendable Launch Vehicle (EELV) competition. This vehicle, if developed, will also use the new RD-180 engine.

Delta

The decision to build the Delta 3 launch vehicle was initiated specifically to address the growing demand in the intermediate launch market, and

Table 1. GEO-Capable Launch Vehicles in Use and Under Development

Vehicle Family	Designation	Intro. Year	Maximum GTO Capacity (lbs.)
UNITED STATES			
Atlas 2	Atlas 2 AS	1993	7,950
Atlas 2	Atlas 2 AR	1998	8,900
Atlas 2	Atlas 2 ARS	2000	9,500
Lockheed Martin EELV	EELV (intermediate)	2003/2005	10,000*
Lockheed Martin EELV	EELV (heavy)	2003/2005	33,000*
Delta 2	Delta 2 7925	1990	4,060
Delta 3	Delta 3	1998	8,400
Delta 4/EELV	EELV (small)	2003/2005	4,800
Delta 4/EELV	EELV (intermediate)	2003/2005	10,000
Delta 4/EELV	EELV (heavy)	2003/2005	33,000
Shuttle		1981	13,000
Venturestar	Venturestar	2003/2004	14,850
EUROPE (ESA)			
Ariane 4	Ariane 44L	1989	9,965
Ariane 5	Ariane 5 (initial version)	1996	13,000
Ariane 5	Ariane 5 (planned 2005 upgrade)	2005	17,600
RUSSIA			
Proton	Proton/Block DM	1967	9,870
Proton	Proton M/Breeze	1998	12,125
UKRAINE			
Zenit	Zenit 3 (w/ Block DM)	1998	13,000
CHINA			
Long March	Long March 3	1984	3,100
Long March	Long March 2E	1990	7,430
Long March	Long March 3B	1996	9,900
JAPAN			
H 2	H 2	1994	8,800
H 2	H 2A (w/liquid booster strap-ons)	2001	13,200

* Estimated based on EELV requirements

will be capable of delivering about 8,400 pounds to GTO. This new Delta vehicle will effectively have twice the launch capacity of the Delta 2, already in operation.

Ariane

Arianespace is already planning upgrades to the Ariane 5 launch vehicle, which is designed to carry a total of 13,000 to GTO for dual payloads. A number of upgrades are planned to increase the capacity of the Ariane 5 so that it can still conduct dual payload launches with heavier satellites. Capabilities of about 15,400 pounds are planned for 2000, and 16,280 pounds by 2002. Arianespace has announced more recently that it plans capacities of up to 17,600 pounds for dual payloads by 2005.[3] By comparison, the most powerful version of the Ariane 4 currently available, the Ariane 44L, can deliver 9,965 pounds to GTO.

Proton

Russia's Proton launch vehicle is currently capable of delivering 9,870 pounds to GTO with its Block DM upper stage. The planned Proton M launch vehicle will be capable of delivering 12,125 pounds to GTO using the Breeze upper stage. The Proton M is scheduled to make its first flight in mid-1998, with commercial flights to follow.

Long March

The Chinese Long March family of vehicles are currently capable of delivering payloads of a variety of sizes into GTO. The largest booster, the Long March 3B, is designed to place 9,900 pounds into that orbit. As of late 1996, trade press reports indicated that China was considering an oxygen-hydrogen propulsion system for a new Ariane 5-class vehicle, as well as a kerosene-oxygen propulsion system based upon technology purchased from Russia. No timetable for these programs was available.[4]

H 2

Japan's H 2 launch vehicle is currently capable of delivering 8,800 pounds to GTO. The first upgrade to the H 2, the H 2A, will not add capacity but is, instead, intended to lower the cost of the booster and make it more commercially competitive. Further upgrades to the H 2A include a liquid strap-on booster system that would increase the GTO capacity to 13,200 pounds. The first H 2A is expected to launch in 2000, and the upgraded H 2A is expected around 2001.[5]

Sea Launch

The Boeing-led partnership to launch the Ukrainian built Zenit launcher from an off-shore platform is expected to enter into service in late 1998. From its equatorial launch site in the Pacific Ocean, the Zenit booster with the Block DM upper stage (also used on the Proton) will be able to loft 13,000 pounds to GTO.

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3 "Arianespace Looks Ahead," *Aviation Week & Space Technology*, August 25, 1997, p. 65.

4 "Chinese Manned Flight Set for 1999 Liftoff," *Aviation Week & Space Technology*, October 21, 1996, p. 22.

5 NASDA

Options for the Future

Old and New Boosters

In addition to the current family of launchers and their planned evolutions, there are still more alternatives for delivering payloads to geosynchronous orbit. While it is currently not authorized to carry commercial satellites, the Space Shuttle could, in principle, be used to launch commercial satellites, possibly as a privatized launch system during the next decade. The Shuttle is capable of deploying about 13,000 pounds to GTO. The X-33/Venturestar program plans to be able to launch roughly 14,850 pounds to GTO by 2003 or 2004.

Advanced Orbit Transfer Techniques

Another possible solution to the problem of getting large spacecraft into geosynchronous orbit would be to use a launcher only large enough to deliver the payload into low earth orbit and then rely on *reusable orbit transfer vehicles* to ferry payloads from low earth orbit into the higher geosynchronous orbit. The payload could then be launched into LEO on a small launch vehicle and for a lower cost.

Phillips Laboratory and NASA are developing solar thermal propulsion technologies which could lead to an operational orbital transfer vehicle. Solar thermal propulsion uses deployable mirrors which focus sunlight to heat the propellant, rather than using combustion. Other non-conventional orbit transfer techniques such as those involving tethers could be used. A system using a payload attached to a platform in low earth orbit by a tether could transfer momentum from the platform to the payload. A series of such devices could deliver a payload to GEO without having to use the payload’s onboard propellant. These systems have the potential to reduce the cost of GEO launches if they can be developed successfully and economically.