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How Long Does It Take to Develop and Launch Government Satellite Systems?

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Abstract

This report is aimed at providing insight into government satellite acquisition processes to potentially identify focus areas to reduce satellite development timelines. There seems to be a perception that it takes 10 years or more to develop and launch a government satellite system. This perception may be due in part to the government acquisition process, which includes a fairly lengthy Pre Milestone A and B phase to develop and mature the concept and requirements, and to achieve the funding and advocacy for new systems that adds to the ultimate time to market, particularly for first of a kind systems.

Both the initial, first-of-a-kind, development durations of government satellite systems as well as the production durations of subsequent builds were considered. Although there are examples of government satellites taking 10 years or more to develop and launch, the data reflects that, on average, it takes 7½ years to develop and launch a first vehicle, and just over 3 years to assemble and launch subsequent vehicles. This is comparable to the 2 to 3 year duration of a typical commercial satellite program. The data suggests that a contributing factor to longer government timelines, particularly for first vehicles, is the degree of technology development at program start. Commercial manufacturers typically perform technology development prior to making a product available to customers. The examples provided show that when the appropriate comparisons are made, i.e. start of development to launch or start of assembly to launch, the durations are similar between government satellite programs and commercial satellite programs.

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1. Introduction

This report is aimed at providing insight into government satellite acquisition processes to potentially identify focus areas to reduce satellite development timelines. The government acquisition process includes a fairly lengthy Pre Milestone B phase to develop and mature the concept and requirements, and achieve the funding and advocacy for new systems that adds to the ultimate time to market, particularly for first of a kind systems [1]. This study considers both the initial, first-of-a-kind, development durations of government satellite systems as well as the production durations of subsequent builds, beginning with Milestone B, Approval to Proceed for the initial satellite and with prime contractor start assembly for subsequent vehicles.

A review of 24 Air Force and Navy space vehicle (SV) development programs found that on average it took 7.5 years from contract start to launch [2]. In this study, the development vehicle was defined as the first vehicle of a satellite program to begin assembly in the factory. Furthermore, once the initial development issues are resolved, production of subsequent vehicles takes only 3.3 years on average to proceed from start assembly to launch. This is similar to commercial satellite programs, which typically take 2 to 3 years from contract start to launch [3].

Typically for government satellite programs, technology is still being developed at program start. The first few years after contract award often include significant design and development efforts. This is the primary reason for the 7.5 years in duration to launch for the first vehicle. According to a study by the U.S. Government Accountability Office (GAO), the Department of Defense (DOD) typically starts a program in the program definition and risk reduction phase. This is much earlier than the start of a program at leading commercial firms [4].

Commercial satellite manufacturers typically complete the development of new technology prior to bringing the product to market. There is little design and development at program start. We propose that the start of a commercial satellite program is more comparable to the start of assembly of the second and subsequent vehicles produced in a government program. Several examples of new technology development approaches of commercial manufacturers are given to support this claim. Data is provided to show that the duration from start of assembly to launch for government production satellites is similar to contract start to launch durations for commercial satellites.

2. Space Vehicle Development Timelines

The first phase of the study considered initial development of DOD SVs of 500 kg dry mass or more, with contract start, i.e. authorization to proceed (ATP), of 1980 or later [2]. In this study, the development vehicle was defined as the first vehicle of a satellite program to begin assembly in the factory. In some cases, this vehicle was not the first vehicle launched, due to technical or other issues. In calculating the development time, storage time was subtracted from development durations whenever possible and schedule delays due to unforeseen factors external to the program, such as those resulting from the 1986 space shuttle Challenger accident, were removed from development durations.

The average ATP to launch duration for the programs in this study is 7½ years, ranging from a low of 3½ years to a high of 14½ years (Figure 1).

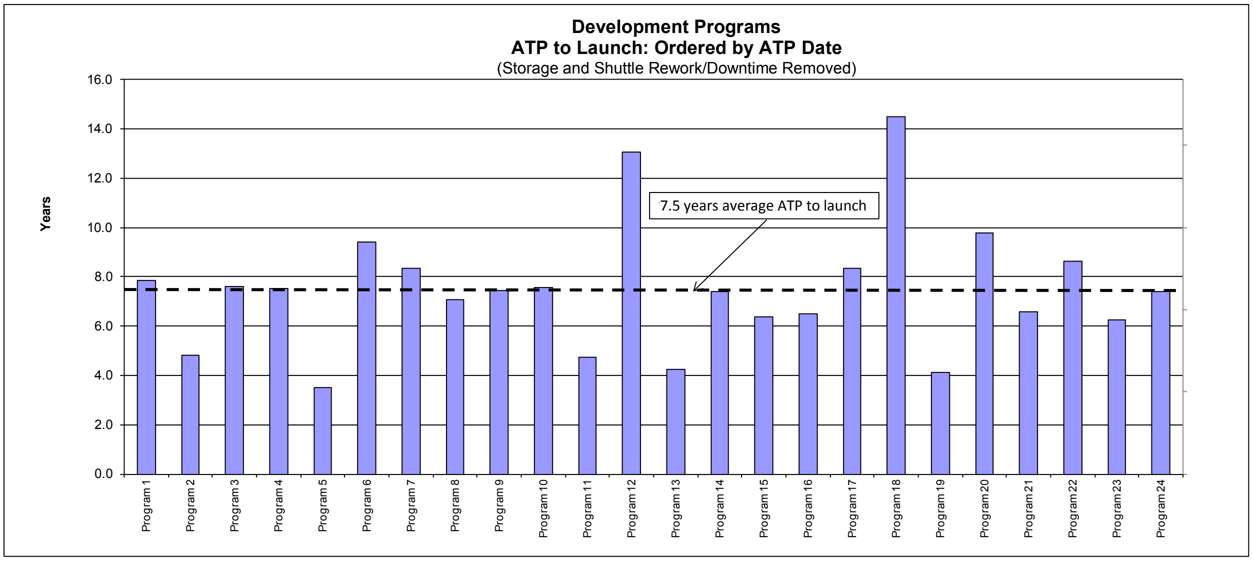

Figure 1. Development programs: authority to proceed to launch.

3. Commercial Satellite Program Development Approach

The examples here are provided to demonstrate that commercial satellite manufactures typically perform new technology development prior to bringing their product to market.

3.1 Boeing 702

An example of a commercial approach to satellite development would be the Hughes HS-702. The Boeing Company has since acquired Hughes and the satellite model is now referred to as the Boeing 702.

According to the GAO [4]:

> In the early 1980s, Hughes Space and Communications began developing dual junction solar cell technology that had the potential of greatly increasing the electrical power on satellites. By 1985, a Hughes laboratory had demonstrated the technology by ground testing prototypes, a TRL [Technology Readiness Level] 6, which is considered an acceptable level of demonstration for space-based technology. Nonetheless, Hughes was not satisfied that the supporting infrastructure (materials, reactors, and test equipment) was mature enough to sustain development and production of the new technology on a satellite. The infrastructure was seen as critical to meeting the cost and schedule requirements of a product. As a result, Hughes did not hand off the technology to a product. Instead, the firm kept it in a research environment, away from cost and schedule pressures.
>
> In the early 1990s, Hughes established requirements for a new satellite—the HS-702—that would use the solar cell technology to leapfrog the competition. After a laboratory demonstration in 1993, Hughes successfully used the new technology on a high-powered version of its existing HS-601 satellite before it began product development on the HS-702 satellite. By 1994, it had determined that the business base was available to sustain development and production of the HS-702 satellite. In all, the firm waited 10 years for the demonstrated technology to meet the requirements.

The report goes on to say, "Thus, the approach was not to accelerate technology development but to shorten product development by maturing the technology first."

Boeing cites the modular design of the 702 as a contributor to the short production time. In their Boeing 702 product line description [4], they state the following:

> After the payload is tailored to customer specification, the payload module mounts to the common bus module at only four locations. First, nonrecurring program costs are reduced, because the bus does not need to be changed for every payload, and payloads can be freely tailored without affecting the bus. Second, the design permits significantly faster parallel bus and payload processing. This leads to the third advantage; a short production schedule.

The Boeing 702 was first announced in October 1995. PanAmSat Corporation was the first customer for the Boeing 702. Galaxy XI was ordered in May 1997 and was launched in December 1999 [5].

It was only 2 years from the first Boeing 702 order (1997) to launch (1999). However, the time from start of HS-702 development (1994) to the first launch was 5 years. And that was 10 years after the start of development of the necessary solar cell technology.

3.2 Space Systems/Loral (SSL) 1300 Series Satellite

Another example of a commercial development approach is the SSL "evolutionary enhancement approach." SSL says that their 1300 series bus capabilities are enhanced based mostly on extension or improvement of heritage designs: e.g. larger equipment mounting panels, larger propellant tanks, etc. New technology is inserted only after the risks of development and qualification have been retired [6].

An example of insertion of new technology in the SSL 1300 bus is the Li-ion battery. Planning and source evaluation for the Li-ion battery development began in 1997. Cell development began in 1998. Qualification continued into 2001, and life testing continued into 2002. The heritage nickel-hydrogen system was maintained as a backup [6].

Qualification and extensive end-to-end ground testing was implemented before the technology was offered for use on an SSL spacecraft. SSL's first use of Li-ion batteries was on Thaicom-4 [7]. Thaicom-4 was awarded to SSL in 2000 and launched in 2005 [8].

Thaicom-4 was launched approximately 5 years after contact award. However, it was launched approximately 8 years after the start of the Li-ion battery development.

3.3 Lockheed Martin A2100 Platform

In 2013 Lockheed Martin (LM) announced upgrades to its A2100 satellite platform. According to the LM news release, "The new A2100 technical update addresses design architecture and manufacturing processes, offering satellite operators catalog-to-order solutions that leverage common parts, subsystems and components to meet specific customer and mission needs." [9]

In a June 2014 interview with *Aviation Week* [9] Mike Hamel, vice president and general manager of Commercial Space at Lockheed Martin, acknowledged that in recent years Lockheed Martin's attention has been focused on its government programs and customers, and that they had lost some of their market leadership in the commercial satellite business. Hamel says "So two years ago LMSS Co. and the corporation said we need to go through a complete refresh of that product line and redouble our efforts to establish a strong leadership position in the commercial satellite business."

Hamel refers to the upgrades as a "technical refresh" and told *Aviation Week* at the time that they were about half to 60% of the way through. The update includes all the underlying technology and subsystems of the A2100 platform, including the propulsion system, electrical power system, structures, payloads, avionics, flight software, antennas, and other payload elements [10].

LM plans to perform the technology development of this upgrade prior to making it available to customers [10]:

> We really have committed on this, not only the breadth of the tech refresh but we are taking this all the way through the design, development, test and qualification, so that instead of going out and trying to secure customers on the promise that if they will [pay] … we will build, instead we are actually fully flight qualifying all the subsystems and in fact going all the way up to the entire spacecraft level with full CDR [Critical Design Review] and the like so we will have proven technology and subsystems when we go to market.

There is not yet any data available for time to launch of LM's first satellite with the upgrades. However, based on the plan that they have presented, there is likely to be little development performed after contract award.

4. DOD Programs Achieve Shorter Timelines Once Initial Development Issues Are Resolved

The design and development activities on DOD programs are significantly reduced once a program has moved into the production phase. Many of the new technology development challenges are worked through on the first vehicle and the following SVs tend to have much shorter production times.

Data was gathered for a selection of recent DOD satellite programs. The durations from start of spacecraft assembly to launch were documented. What defines the start of assembly varies from manufacturer to manufacturer and from program to program for the same manufacturer. Generally, we used the first activities involving integration of bus components on to the bus structural panels (start of bus integration) or integrating payload components on to the payload structural panels (start of payload integration) as the start of assembly. Activities prior to this are considered component and structure fabrication (Figure 2).

Although start of assembly is not a direct comparison to the start of a commercial program, it is not an unreasonable comparison. In a commercial satellite program, the bus may be common for a particular satellite model, as with the examples discussed previously. As a result, at program start, there is little to no development activity for the bus, and sometimes little for the payload as well, with only tailoring to customer specifications.

The DOD satellite programs included in this study had contract award dates within the last 15 years, dry masses of greater than 1000 kg, and have launched two or more satellites to date. The data is for the second SV of the program to begin the SV assembly phase, and all following vehicles. Note that the second SV to start assembly may not be the second one launched due to a variety of factors.

All known storage or delays unrelated to the space vehicle production have been subtracted from the durations. Any launch site delays have not been subtracted.

On average, it took 3.3 years for the space vehicles in this study to go from start of assembly to launch, with the durations ranging from a high of approximately 6 years to a low of 1.5 years (Figure 3).

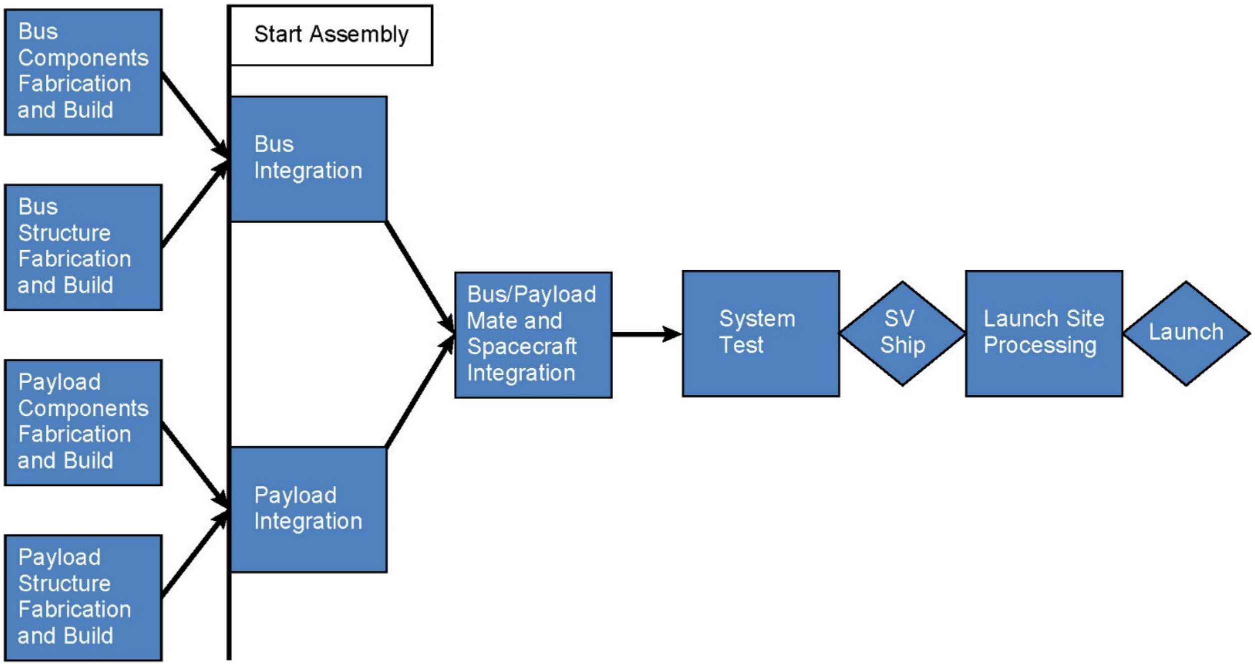

Figure 2. Typical space vehicle production flow.

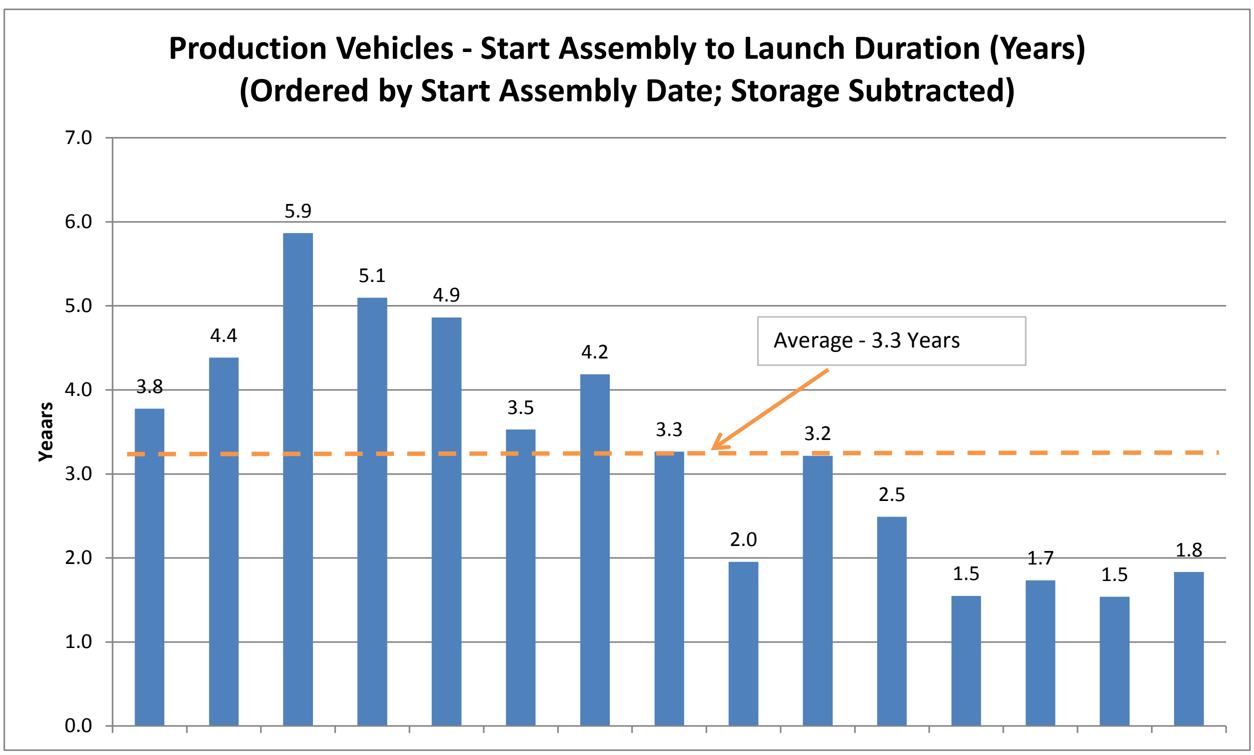

Figure 3. Production duration.

These durations are comparable to those of commercial satellite production durations. Figure 4 compares the government vehicle production durations with those of commercial vehicles, as reported by Futron [3].

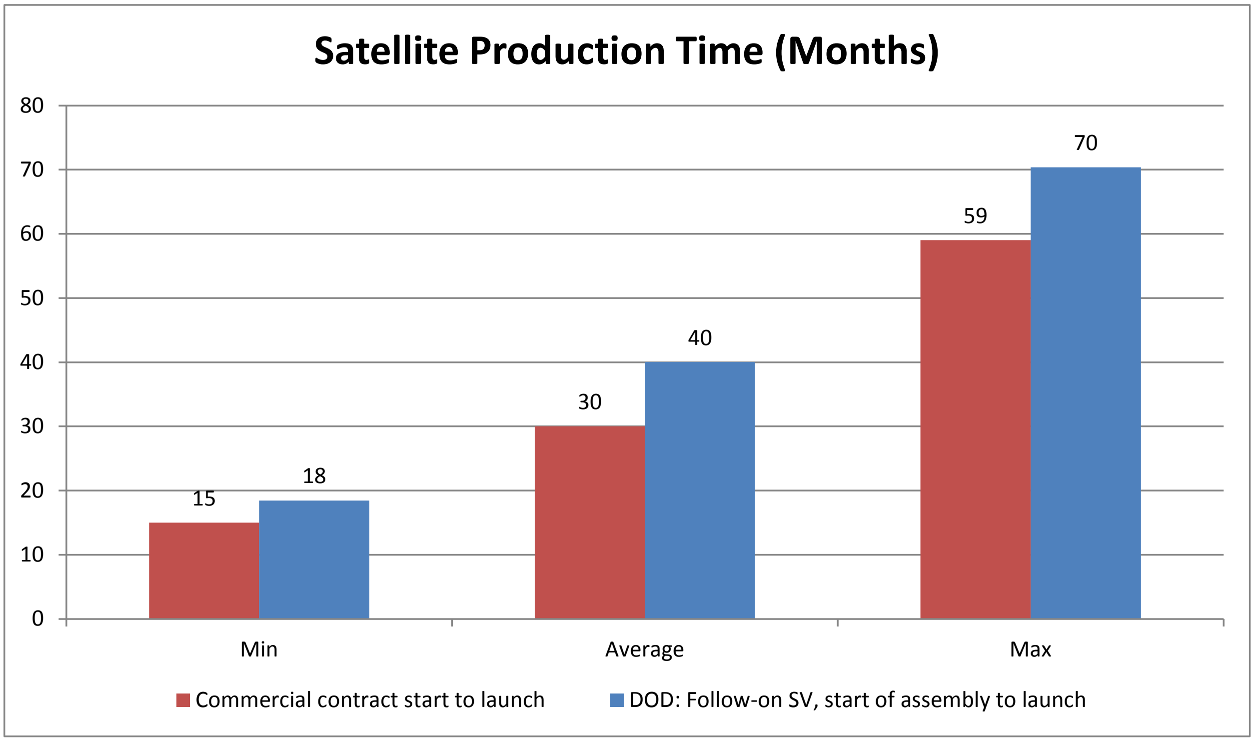

Figure 4. Satellite production time.

The shortest duration of the DOD vehicle production is only a few months longer than the shortest commercial vehicle production duration. The average and maximum DOD durations are within a year of the commercial durations.

5. Conclusion

Although there are examples of government satellites taking 10 years or more to develop and launch, the data shows that, on average, it takes 7½ years to develop and launch a first vehicle and just over 3 years to assemble and launch subsequent vehicles. The production timeline of subsequent vehicles is comparable to the 2 to 3 year duration of a typical commercial satellite program. The data and examples of commercial satellite development approaches suggest that a contributing factor to longer government timelines, particularly for first vehicles, is the degree of technology development at program start. Commercial manufacturers typically perform technology development prior to making a product available to customers. The examples provided show that when the appropriate comparisons are made, i.e. start of development to launch or start of assembly to launch, the durations are similar between government satellite programs and commercial satellite programs.

Future work may include a study of the Pre Milestone B phase in the government acquisition process and how that adds to the ultimate time to market for first-of-a-kind systems.

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