What Exactly is Space Logistics?

James C. Breidenbach

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **JAN 2011**	2. REPORT TYPE	3. DATES COVERED **00-00-2011 to 00-00-2011**

4. TITLE AND SUBTITLE **What Exactly is Space Logistics?**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Defense Acquisition University,Defense AT&L,9820 Belvoir Road,Fort Belvoir,VA,22060-5565**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

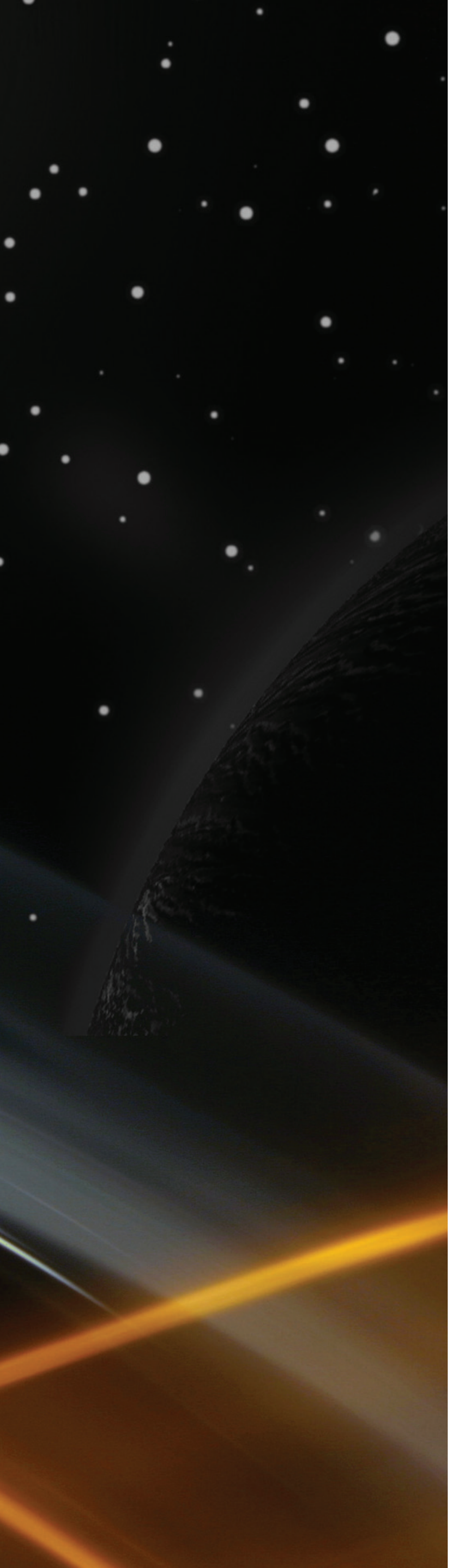
12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	



The realm of space has been dramatized and glamorized in popular books, television series, movies, and video games. Such phrases as "the final frontier" (from the opening lines of *Star Trek*) or "the ultimate high ground" (from Department of Defense and Air Force space doctrine documents) appeal to the adventurous side of our human spirit. On the other hand, the word "logistics" usually brings to mind very unglamorous and perhaps mundane aspects of our lives: miles-long trains of coal-filled hopper cars on our nation's railway system, semi-trailer trucks hauling freight on the interstate highway system, or ships carrying containers of goods across the oceans. It might even include the service department of your auto dealer, if maintenance and repair are part of your concept of logistics.

You may have seen information on the space shuttle in the news and have inferred by now that resupply missions to the International Space Station, Hubble Space Telescope repair missions, and satellite deployment missions are space logistics—and you would be technically correct. The science of logistics as applied to our military space systems, however, is simultaneously very much like, and very different from, the examples of logistics given in the previous paragraph.

The Ultimate High Ground

Our national military space systems consist of satellites orbiting the earth (the space segment); ground-based systems to monitor and command the satellites (the control segment); various types of equipment to employ the capabilities of the satellites in orbit (the terminal, or user, segment); launch vehicles that carry satellites to orbit (the launch segment); and extensive launch-range systems to support those critical minutes that make the difference between success and failure—a failure that could result in years of effort and billions of tax dollars ending up as junk on the sea floor instead of a valuable asset orbiting the earth. These space systems—the satellites, their control systems, and the terminals/user equipment—provide unique and critical capabilities to our country's leadership and military forces in the form of navigational data and time references, global communications, weather data and forecasts, and surveillance information. Logistics planning is crucial during system design and development to ensure that each system can be supported throughout its operational life. Logistics activities following launch/deployment and operational acceptance—also referred to as product support activities and sustainment—are critical efforts carried out to preserve the significant taxpayer investment in these national assets (hundreds of millions of dollars to over $1 billion per satellite), and assure worldwide warfighter

Logistics—The science of planning and carrying out the movement and maintenance of forces. In its most comprehensive sense, those aspects of military operations that deal with:

a. design and development, acquisition, storage, movement, distribution, maintenance, evacuation, and disposition of materiel;
b. movement, evacuation, and hospitalization of personnel;
c. acquisition or construction, maintenance, operation, and disposition of facilities; and
d. acquisition or furnishing of services.

Joint Publication 1-02, *Department of Defense Dictionary of Military and Associated Terms*, April 12, 2001 (as amended through June 13, 2007).

access to the essential information and capabilities provided from "the ultimate high ground."

The Logistics of Space

Logistics planning and product support take very different forms for each segment of a space system. We'll start with the space segment, which is composed of the satellites that are out of reach after launch and can be "touched" only by sending commands and receiving telemetry data via radio frequency signals. Satellites operate in the vacuum of space in temperatures ranging from minus 150 degrees Celsius to more than 120 degrees Celsius (minus 240 degrees Fahrenheit to more than 250 degrees Fahrenheit). They must be extremely reliable; and they must carry lifetime "spares" in the form of redundant components that can be switched to replace failed components, either automatically or upon command from the ground. They must also carry on board their lifetime fuel to perform maneuvers necessary to move from one orbital location to another and to avoid colliding with other satellites or debris. Satellites must generate their own electrical power (typically using solar panels) in order to provide power to the satellite subsystems as well as to the payload that provides the warfighter capability.

Satellites are seldom built in a true production-line manner, so there may be significant configuration differences from one satellite to the next, even if they are functionally equivalent. From a vantage point in space hundreds to thousands of miles above the Earth, a single satellite can "see" 20 to 30 percent of the Earth's surface, so a small number of satellites typically covers the entire Earth. A relatively large satellite system, such as the Global Positioning System, has 25 to 30 operational satellites at any given time; while a smaller satellite system, such as the Wideband Global Satellite Communications System, can provide worldwide coverage (except for the polar regions) with as few as five satellites.

During the development of a space segment, logistics activities focus on design reliability and other factors that contribute directly to the highest levels of mission capability and the shortest periods of downtime. The primary satellite sustainment efforts are technical in nature: engineering analyses of telemetry data to assess and forecast satellite health; software and data adaptations to compensate for satellite component aging, failures, and mission changes; and maintenance/upgrade of the ground-based satellite simulation environment to support analysis efforts and to provide a significant risk-reducing test and verification capability. Most military systems experience 70 to 80 percent of the life cycle cost during sustainment. For satellites, however, the inverse is frequently true: 70 to 80 percent of the life cycle cost is required just to build the satellites and launch them into orbit.

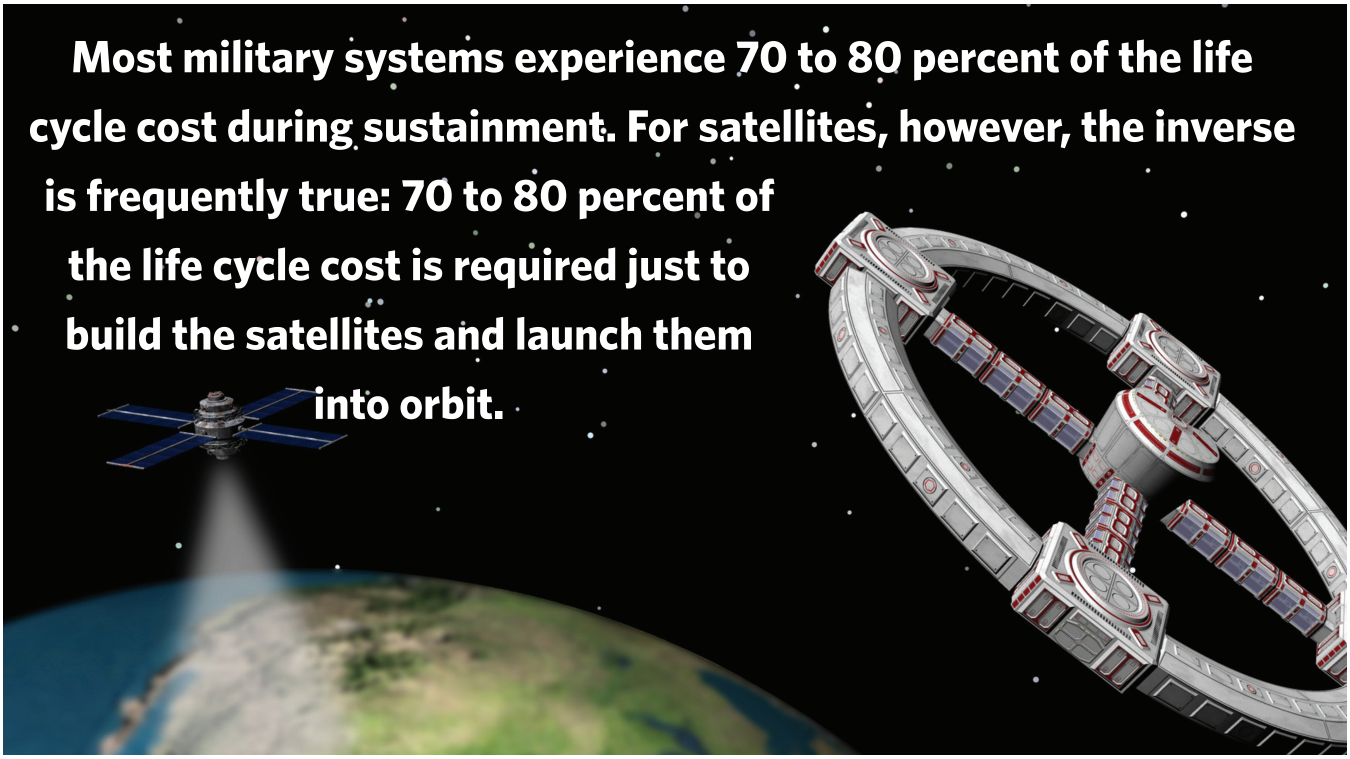
The Logistics of Control

The control segment consists of commercial off-the-shelf (COTS) computer workstations, specialized equipment to format satellite command codes and translate satellite telemetry, and a worldwide networked family of tracking stations (the Air Force Satellite Control Network, or AFSCN) with large dish antennas and radio frequency equipment to communicate with satellites in orbit. Some space systems also have a second control system to allow command and control of the satellite payload separately from the "flying" of the satellite, or to facilitate mobile command and control outside the fixed AFSCN infrastructure.

Satellite command and control activities are typically grouped together at one or two specific nodes of the AFSCN, and each satellite system may have only six to 20 strings of equipment located at a site. Logistics activities during development focus on reliability but also pay attention to security and maintainability as well as design factors intended to minimize the impacts of COTS obsolescence on life cycle cost. The primary control segment sustainment efforts are, like those for the space segment, predominantly technical in nature. The original equipment manufacturer support life cycle of COTS software is a primary driver of effort and cost, typically rendering the highly reliable COTS hardware obsolete long before it fails; and requiring significant integration, test, and verification efforts every three to five years to follow the commercial baseline, thereby maintaining system certification and accreditation. The control segment life cycle cost is typically split roughly 50-50 between development and sustainment.

The Logistics of Terminals

The terminal or user segment consists of various types of equipment to employ the capabilities of the satellite payloads on orbit. There is radio frequency equipment to receive signals from the payload, and sometimes a transmitter to send signals to or through the payload to another receiver. There is also, typically, processing and display equipment (most often COTS



computer workstations), and there may be additional equipment to send processed payload information to other users or to link other users into a satellite terminal. Most terminal and user equipment is located with warfighters (both in garrison and deployed); is produced in larger quantities (hundreds to thousands of units); and has characteristics similar to other communications-electronics equipment.

Logistics activities during development focus on the traditional reliability-maintainability-supportability factors applied to other communications-electronics items. The primary sustainment efforts are likewise more oriented to maintenance and repair than with the space or control segments. The life cycle cost of most operational terminal and user equipment is closer to that of other military systems: approximately 20 to 30 percent for design, development, and production; and the remaining 70 to 80 percent for sustainment. Because of the increasing use of COTS software and hardware, however, the commercial life cycle is becoming a more dominant factor in cost distribution throughout the life cycle. Larger production quantities and schedules result in fielding some equipment that is commercially obsolete as a result of the three- to five-year commercial obsolescence cycle, or drive the requirement for a software rehost/operating system update concurrent with production and fielding. The resultant effect on life cycle cost distribution is not well quantified at this time.

The Logistics of Launch

The launch segment consists of the rocket vehicles that carry satellites from the Earth's surface into orbit. The launch vehicles are highly complex systems that must demonstrate extremely high reliability during their relatively short (minutes to hours) operational life. The Saturn launch vehicle used to transport astronauts to the moon in the late 1960s and early 1970s had to exhibit more than a 99.9 percent reliability—a 1 percent failure rate would have meant that approximately 1,000 components had failed, dooming a mission and imperiling the lives of the astronauts. Logistics activities during development focus on reliability, redundancy (where required), and safety. Launch vehicles are not typically stored or sustained in a conventional sense. When storage and reactivation are required, a specialized engineering activity is applied, involving significant non-destructive inspection and exhaustive testing to provide the needed mission assurance and safety.

Extensive launch range systems support critical satellite launch activities, primarily from Cape Canaveral, Fla., and Vandenberg Air Force Base, Calif. The launch range systems are loosely integrated, highly coupled collections of one-of-a-kind radar and optical tracking systems, safety and destruct systems, voice and data communications systems, and weather systems. The systems are necessary to manage the critical minutes when thousands of discrete factors must be monitored, measured, assessed, and reported to support split-second decisions that could successfully place a billion-dollar satellite in orbit, send it to the sea floor as useless junk, or leave it in a useless orbit where it will become a collision hazard to other satellites.

The current systems came into being and evolved over the last 50-plus years as NASA, DoD, and commercial space launch customers brought individual requirements to the table; there was no single, focused development program for those systems of systems. The two ranges in Florida and California differ significantly in overall configuration as well as in the component systems that provide specific capabilities. The primary sustainment efforts are split between reverse engineering and remanufacturing failed one-of-a-kind assemblies, subsystems, and components; analyzing security issues at all levels and re-engineering/modifying systems as required to support certification and accreditation; and struggling to balance maintenance and repair requirements with modernization efforts—all competing for the same scarce budget dollars.

Assuring Bang for Our Buck

The United States' military space systems, with the exception of terminals and user equipment, are low-density, high-demand systems. The subsystems and components are rarely produced in production quantities, and are frequently one-of-a-kind configurations. Logistics planning and product support activities tend to be more technically focused, with systems and software engineering dominating more traditional maintenance and repair. Even with these differences, however, the fundamental logistics planning and product support processes continue to be both relevant and necessary to assure that our space systems are reliable and supportable, meet the needs of our national leaders and warfighters on the battlefield, and return the best bang for the taxpayers' buck—the ultimate measures of all logistics.

Breidenbach *is the chief of logistics and systems sustainment manager of the Air Force military satellite communications portfolio of 20 ACAT and sustainment programs. A former Air Force officer, he is DAWIA level III certified in both life cycle logistics and systems planning, research, development and engineering (SPRDE). The author welcomes comments and questions and can be contacted at* **james.breidenbach@peterson.af.mil**.