Report Documentation Page			Form Approved OMB No. 0704-0188
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1. REPORT DATE **JAN 2014**	2. REPORT TYPE		3. DATES COVERED **00-00-2014 to 00-00-2014**
4. TITLE AND SUBTITLE **Investigation Into the Ratio of Operating and Support Costs to Life-Cycle Costs for DoD Weapon Systems**			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,9820 Belvoir Rd. Ste 3,Fort Belvoir,VA,22060-9910**			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)**	**24**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

Keywords: *Operating and Support (O&S), Life-Cycle Cost, Cost Analysis Improvement Group (CAIG), Cost Assessment and Program Evaluation (CAPE), Systems Acquisition*

Investigation into the Ratio of Operating and Support Costs to Life-Cycle Costs for DoD Weapon Systems

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Recent legislation, such as the Weapon Systems Acquisition Reform Act of 2009, requires a renewed emphasis on understanding operating and support (O&S) costs. Conventional wisdom within the acquisition community suggests a 70:30 cost ratio with respect to O&S and acquisition of an average weapon system. Using 37 Air Force and Navy programs, the authors estimate the mean overall ratio of O&S costs to acquisition costs to be closer to 55:45, although many weapon systems displayed significant deviation from this 55 percent average. Contributing factors such as life expectancy and acquisition strategy (i.e., new system or modification) affect this variance. Their research advises against using a single "one-size-fits-all" O&S/acquisition cost ratio for all major DoD weapon systems.

« Image designed by Diane Fleischer

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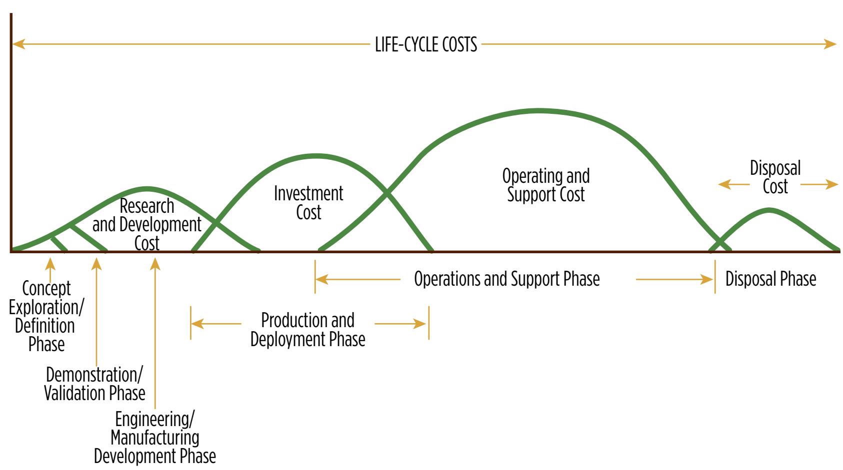
The Weapon Systems Acquisition Reform Act of 2009 and tightening Department of Defense (DoD) budgets have brought increased scrutiny to the life-cycle cost of major weapon systems acquisition. In a significant paradigm change, operating and support (O&S) costs are no longer relegated to the background for major acquisition decisions. For example, the DoD's 2013 budget plan considered mothballing the Block 30 variant of the Global Hawk to save money due to O&S costs, arguing that the venerable U-2 aircraft could meet theater commanders' needs for reconnaissance at less cost. As a result, it is imperative that we have an accurate understanding of the relative costs to operate and support DoD weapon systems.

FIGURE 1. NOTIONAL LIFE-CYCLE COSTS FOR A DOD WEAPON SYSTEM



Note. Figure 1 is illustrative versus quantitative. Adapted from *Operating and Support Cost-Estimating Guide*, published by the Office of the Secretary of Defense, Cost Analysis Improvement Group, 1992.

The cost profile of a typical DoD weapon system is shown in Figure 1 (Office of the Secretary of Defense Cost Analysis Improvement Group [OSD CAIG], 1992). The graph shows the four phases of a program's cost over its lifetime: research and development (R&D), procurement, O&S, and disposal, with O&S considered the most expensive of the four phases. The conventional wisdom of this 70:30 or "golden ratio" of O&S to acquisition cost (assuming negligible disposal cost) is that such a pattern holds for a majority of weapon systems. Therefore, Figure 1 has permeated the DoD literature and acquisition schoolhouse training material. As a result, many levels of acquisition leadership reinforce the idea to managers and analysts that a cost ratio exists among the various stages of a weapon system's life, namely 70 percent for O&S and 30 percent toward acquisition (Carter, 2011).

Several studies by the Government Accountability Office (GAO) cite this 70:30 ratio or display charts to reflect this pattern (General Accounting Office, 2000a, 2000b; GAO, 2010, 2012). This research looks to determine the origins and accuracy of this ratio using historical O&S cost data. If actual O&S data do *not* support this ratio, then the veracity of this rule is called into question and might have significant implications in portfolio analysis and affordability analysis decisions that affect the broader DoD budget.

Terms and Definitions

Throughout this article, we define O&S costs in the same manner as the OSD CAIG (2007), now the Cost Assessment and Program Evaluation (CAPE) system's O&S cost:

> Consists of sustainment costs incurred from the initial system deployment through the end of system operations. Includes all costs of operating, maintaining, and supporting a fielded system. Specifically, this consists of the costs (organic and contractor) of personnel, equipment, supplies, software, and services associated with operating, modifying, maintaining, supplying, training, and supporting a system in the DoD inventory. (p. 2-2)

For the definition of life-cycle cost (LCC), we turn to the *Defense Acquisition Guidebook* (DAG). The DAG, published by the Defense Acquisition University (DAU, 2012), defines LCC as follows:

> For a defense acquisition program, life-cycle cost consists of R&D costs, investment costs, operating and support costs, and disposal costs over the entire life cycle. These costs include not only the direct costs of the acquisition program, but also indirect costs that would be logically attributed to the program. In this way, all costs that are logically attributed to the program are included, regardless of funding source or management control. (p. 7)

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When dealing with the life of a weapon system, we discuss its service life and its life expectancy. According to the DAU online glossary, the service life describes the period of time "from first inception of the weapon until final phase-out" (DAU, 2012). Realistically, some costs incurred in the very early stages of a program, such as those before Milestone A, may not be fully captured due to the immaturity of the technology or divergence from some original concept. According to the 1992 and 2007 versions of the OSD CAIG (CAPE) *Operating and Support Cost-Estimating Guides*, life expectancy should include the phase-in period, a period of steady-state operations, and a phase-out or decommissioning period (OSD CAIG, 1992; 2007). The draft 2012 OSD CAPE *Operating and Support Cost-Estimating Guide* wasn't as clear, though it stated that "[t]he O&S estimate should extend over the full life expectancy of the system," alluding to the idea that life expectancy only pertains to the O&S phase. As we show in the next section, these terms appear to be used interchangeably even though they are clearly defined to be different in scope.

We make one last distinction before highlighting various studies that discussed acquisition cost to O&S cost ratio. In performing financial analyses, analysts and researchers need to account for inflation when comparing fiscal events that happened in different time periods. The Base Year (BY), or Constant Year, describes past and future costs as they would appear in a certain year of reference. Then Year (TY), or Current Year, describes costs as they would appear when costs are incurred or when purchases are made, usually taking into account the effects of inflation over time. In this research, we assume BY forms the basis for analysis in the literature reviewed, unless specifically noted.

Historical Research

To understand the origins of the 70:30 ratio, we conducted a literature search. What was remarkable about this review is how little empirical research appears to have been conducted on this topic, and how a recurring, authoritative set of assertions continues to propogate without independent evaluation or confirmation.

Two studies from the 1970s examined O&S cost ratios with respect to life-cycle costing. Fiorello (1975) states that the costs of ownership, "...in general make up over 50 percent of the LCC of aircraft weapon systems" (p. 5). Unfortunately, Fiorello provides no information on the derivation of this percentage. In October 1977, the Comptroller General of the United States gave a report to the U.S. Senate Committee on Appropriations about O&S costs of new systems compared to the systems they are replacing (General Accounting Office, 1977). In Appendix IV, Part 2, this report shows the most recent cost estimate for a fleet of 800 F-18s, and shows that 42.2 percent of this fleet's LCC can be attributed to O&S costs. This information was based on an estimate that used the actual performance and logistics of the F-14 as an analogy to the F-18, and used an estimated life span of 15 years.

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In 1981, the Comptroller General of the United States delivered a report to Congress on logistics planning for the M1 tank (General Accounting Office, 1981). The report was aimed at convincing Congress that more funding should be spent on R&D and initial procurement to reduce the O&S costs, arguing "the costs of operating and supporting a system, such as the M1, may be 70 to 90 percent of the system's life-cycle cost" (p. 18). Like previous studies, the authors do not elaborate or indicate the source of this ratio information.

With the release of the *Operating and Support Cost-Estimating Guide* in 1992, OSD CAIG gave more official guidance regarding O&S cost estimates (OSD CAIG, 1992). This guide does not designate any particular ratio of O&S costs to acquisition costs, but does portray the customary program cost pattern during the various acquisition phases. Figure 1 originated within this 1992 guide, and many training materials have reproduced or mimicked this graph. Since 1992, the OSD CAIG has issued one other *Operating and Support Cost-Estimating Guide* (2007) and had intended to officially release another in 2012. We reviewed

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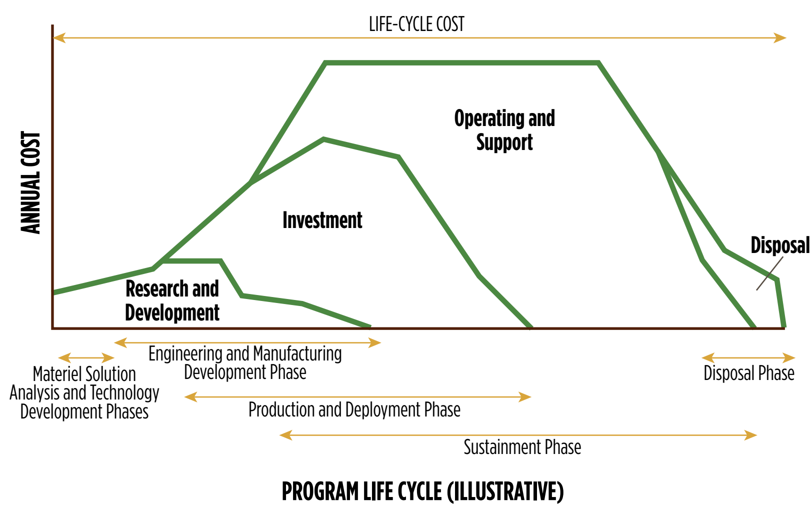
the 2012 draft version, but the OSD CAPE *Operating and Support Cost-Estimating Guide* delayed final publication due to the impending release of the revised DoD 5000.4-M-1, *Cost and Software Data Reporting (CSDR) Manual* (2007), to incorporate any policy changes therein. Figure 2, which first appears in the 2007 and also the 2012 draft OSD CAPE O&S Guide illustrates the slight change to Figure 1 from 1992. Neither of these versions of the guide includes any further information on cost ratios.

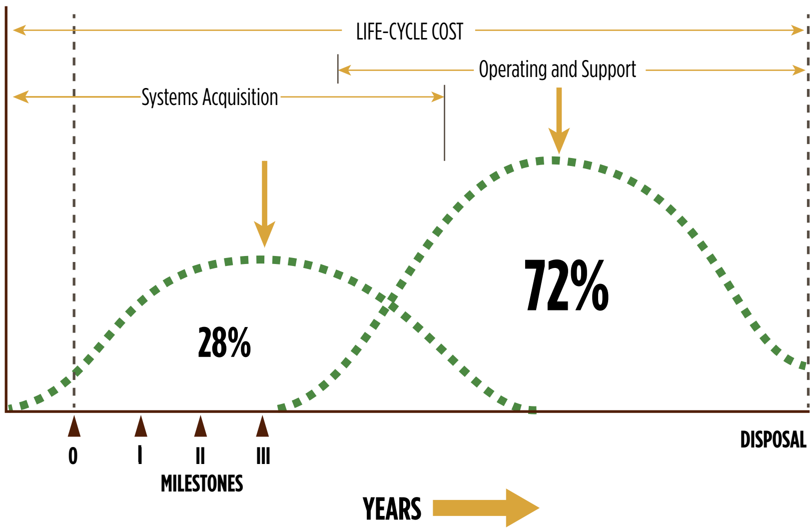
FIGURE 2. ILLUSTRATIVE SYSTEM LIFE CYCLE



Note. This figure depicts the ratio as nominal. Adapted from *Operating and Support Cost-Estimating Guide*, published by the Office of the Secretary of Defense, Cost Analysis Improvement Group, 1992.

In 1997, the Defense Systems Management College (DSMC) published its *Acquisition Logistics Guide*, in which it illustrates "the dominant role that logistics plays in system life-cycle cost" (DSMC, 1997), as portrayed in Figure 3. This is the first time a ratio with this level of specificity is provided (72 percent of life-cycle costs attributed to O&S). Unfortunately, the guide provides no details on how the percentages were obtained or derived. Figure 3 is replicated in four other sources: (a) a 2000 General Accounting Office report titled *Air Force Operating and Support Cost Reductions Need Higher Priority* (General Accounting Office, 2000a); (b) a 2003 General Accounting Office report on reducing Total Ownership Costs through setting requirements (General Accounting Office, 2003); (c) the American Institute of Aeronautics and Astronautics' *Management of Defense Acquisition Projects* (Rendon, Snider, & Allen, 2008); and (d) an acquisition research paper published by the Naval Postgraduate School entitled, *Total Ownership Cost—Tools and Discipline* (Naegle & Boudreau, 2011).

FIGURE 3. NOMINAL LIFE-CYCLE COSTS



Note. Adapted from Figure 13-1 of *Acquistion Logistics Guide* (3rd ed.), Defense Systems Management College, 1997, p. 13-6.

In 1999, the Institute for Defense Analyses (IDA) produced a seemingly influential document that covered a presentation by a panel of representatives from the OSD, Naval Center for Cost Analysis, Air Force Cost Analysis Agency, and the U.S. Army Cost and Economic Analysis Center during the 32nd Annual DoD Cost Analysis Symposium (IDA, 1999). In this document, weapon system types are split out and presented in terms of their R&D, procurement, and O&S costs, where the information is available. Table 1 summarizes the information presented, which is cited in the Life-Cycle Cost article from the DAU's ACQuipedia Web site (Life-Cycle Cost, 2008).

For most system types, the percentages reflect what was considered at the time to be "typical" percentages of life-cycle costs. The exceptions were in the Rotary Wing Aircraft category, where the percentages came from the Comanche estimate in the 1997 Selected Acquisition Report (SAR), and the Missiles and Surface Vehicles categories, which did not specifically state what the percentages represent. However, we assumed them to be "typical" since no other discussion led us to believe

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otherwise. The only two categories that come close to, or meet exactly, the 70:30 ratio are the Ships and Automated Information Systems (AIS) categories. The data from Table 1 appear to be the source for the *GAO Cost-Estimating and Assessment Guide* (GAO, 2009), and DAU's course material on BCF 106, Introduction to Cost Analysis (DAU, 2009).

TABLE 1. COST RATIOS BY WEAPON SYSTEM TYPE

System Type	R&D	Investment	O&S/Disposal
Space	18%	66%	16%
Fixed-Wing Aircraft	20%	39%	41%
Rotary-Wing Aircraft	15%	52%	33%
Missiles	27%	33%	39%
Electronics	22%	43%	35%
Ships[a]	1%	31%	68%
Surface Vehicles	9%	37%	54%
AIS[b]		30%	70%

Note. Data represent point estimates, without accompanying statistical data. No further information was obtainable. Adapted from *Status of DoD's Capability to Estimate the Costs of Weapon Systems: 1999 Update*, published by the Institute for Defense Analyses, 1999.
[a]Most ship design costs are included in production cost of lead ship of a class. [b]Available data preclude split of pre-O&S costs into R&D and Investment categories.

For the past 15 years or so, the GAO consistently cites or mentions this 70:30 ratio of acquisition cost to O&S cost (General Accounting Office, 2000a). Specifically:

> ...operating and support costs include those for fuel, repair parts, maintenance, and contract services, as well as the costs of all civilian and military personnel associated with a weapon system. History indicates that these costs can account for about 70 percent of a system's total life-cycle costs. (p. 3)

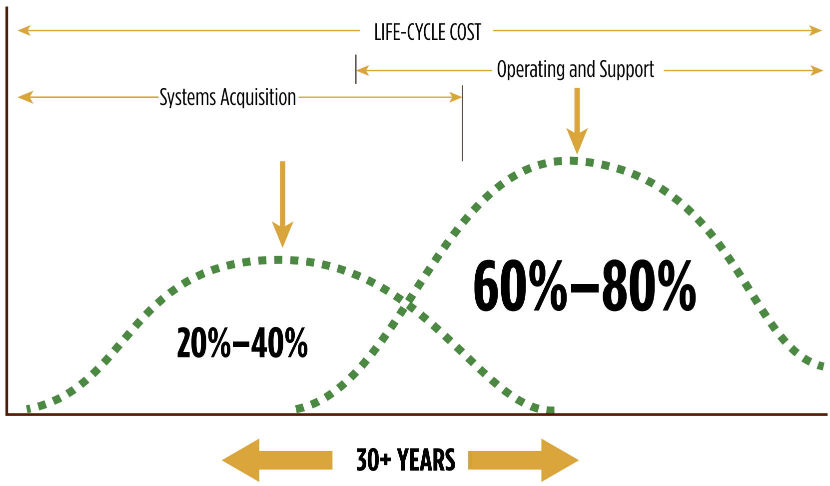
With respect to the Army (General Accounting Office, 2000b):

> While some attention has been given to the cost of operating and supporting a weapon system after it is fielded, responsibility for these functions after systems are fielded generally shifts to other Army agencies such as maintenance depots, software support facilities, and operating bases. DoD has long identified this division of responsibility as a key cause of higher weapon system

> operating and support costs, which are generally estimated to account for about 60 to 70 percent of a system's total life-cycle costs. (p. 7)

GAO is not the only recent source to focus on this particular ratio value. In an article in the *Defense AT&L* magazine on designing systems for supportability, Dallosta and Simcik (2012) state that, "...total ownership costs incurred during the operations and support phase may constitute 65 percent to 80 percent of total life-cycle cost." Figure 4 accompanies this quote within their article, but once again, no information is provided on how that figure was derived or percentages allocated.

FIGURE 4. NOMINAL LIFE-CYCLE COST DISTRIBUTION



Note. Adapted from *Designing for Supportability: Driving Reliability, Availability, and Maintainability In While Driving Costs Out,* by P. M. Dallosta and T. A. & Simcik, 2012, pp. 34–38.

The history of O&S cost ratios, as presented in the reports and studies discussed in this article and summarized in Table 2, often show the plausibility of 70 percent of a total weapon system's LCC representing O&S costs, especially in the more recent reports. In addition, relatively few of the O&S statistics cited in the Table 2 literature review appear to be grounded in historical O&S data. Instead, we find they are based on estimates of how long a weapon system will last and how costly it is to repair, replace, sustain, maintain, or operate. By extracting actual O&S cost data and accounting for the increased length of current weapon systems, serious researchers can readily determine what this true percentage should be.

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TABLE 2. SUMMARY OF FINDINGS FROM LITERATURE REVIEW

Source	O&S Portion of LCC
Fiorello, M., *Getting "Real" Data for Life-Cycle Costing,* 1975	50%
General Accounting Office, *O&S Costs of New Weapon Systems Compared with Their Predecessors,* 1977	42.2%
General Accounting Office, *Logistics Planning for the M1 Tank*, 1981	70–90%
OSD CAIG, *O&S Cost-Estimating Guide*, 1992	78%, 84%
DSMC, *Acquisition Logistics Guide*, 1997	60–80%, 72%
IDA, *Status of DoD's Capability to Estimate the Costs of Weapon Systems: 1999 Update*, 1999	Varies by Type
General Accounting Office, *Higher Priority Needed for Army O&S Cost Reduction Efforts*, 2000	60–70%
DoD, Weapon Systems Acquisition Reform Act of 2009	60–75%
General Accounting Office, *Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs,* 2009	Varies by Type
General Accounting Office, *Littoral Combat Ship: Actions Needed to Improve Operating Cost Estimates and Mitigate Risks in Implementing New Concepts,* 2010	70%
General Accounting Office, *Improvements Needed to Enhance Oversight of Estimated Long-Term Costs for Operating and Supporting Major Weapon Systems,* 2012	70%
Dallosta & Simcik, *Designing for Supportability: Driving Reliability, Availability, and Maintainability In While Driving Costs Out,* 2012	65–80%

Analysis and Results

To collect actual O&S expenditures, we utilized the Naval Visibility and Management of Operating and Support Costs (VAMOSC) system for the Navy, and the Air Force Total Operations Cost (AFTOC) system for the Air Force. We excluded Army programs from the analysis because the Army's Operating and Support Management Information System is currently unable to allocate major cost elements (including personnel and fuel) to individual systems. Acquisition costs were collected from SARs in the Defense Acquisition Management Information Retrieval system. The analysis was limited to Acquisition Category I (ACAT I) programs. [*Note*. These are programs that exceed $365 million (BY 2000) in Research, Development, Test, & Evaluation (RDT&E) funding or $2.19 billion (BY 2000) in Procurement funding, or have been designated by Congress or the DoD as an ACAT I program due to high visibility or interest.] Generally, costs associated with necessary additions or changes for each system were included in the SARs, mostly under the Military Construction appropriation. Infrastructure costs were not necessary for many systems since some new and many modification programs do not require new facilities or structures.

The data were screened using inclusion criteria for the research database. Each program had to have fielded operational units and have a stable period of O&S costs. This stability provided some assurance that the program was past the initial ramp-up in fielding and was able to produce a realistic estimate of recurring annual costs. Therefore, each program needed to have produced at least 10 percent of the planned procurement quantities. Early in production, contractors may run into difficulties that could change the production schedule or increase costs due to factors unknown when production commences. Until these issues are resolved, the acquisition is likely to have a greater risk of increasing significantly.

The final database consisted of 37 programs with operational data from 1989 through 2010. Table 3 lists all the programs analyzed, organized by the lead Service component. We grouped these programs into eight different categories: Missiles, Cargo/Tanker Aircraft, Fighter Aircraft, Helicopters, Ships, Electronic Equipment, Unmanned Aerial Vehicles, and Tilt-Rotor Aircraft. We determined these categories by similarities or unique capabilities from other weapon systems; for example, the tilt-rotor aircraft, which is a combination of helicopter and cargo aircraft.

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TABLE 3. FINAL DATABASE–LIST OF PROGRAMS ANALYZED

Ships	Service
AOE 6	Navy
CVN 68 (By 1974/1975)	Navy
CVN 68 (By 1976)	Navy
DDG 51	Navy
LHD 1	Navy
LPD 17	Navy
MHC 51	Navy
SSGN	Navy
SSN 21	Navy
SSN 774	Navy
STRATEGIC SEALIFT	Navy
T-AKE	Navy
T-AO 187	Navy

Fighters	Service
F-16 C/D	Air Force
F-22 (BY 2005)	Air Force
JPATS (BY 2002)	Air Force/Navy
AV-8B REMAN	Navy
EA-18G	Navy
F/A-18 E/F	Navy
F-14D	Navy
T-45TS (BY 1995)	Navy

Tilt-Rotor	Service
V-22 (BY 2005)	Navy

Cargo/Tanker	Service
C-130J	Air Force
C-17A (BY 1996)	Air Force
E-2C	Navy
JSTARS (BY 1998)	Air Force/Army
KC-135R	Air Force

Missiles	Service
AMRAAM	Air Force/Navy
JASSM	Air Force/Navy
AIM-9X	Navy/Air Force
JSOW (AGM-154)	Navy/Air Force

Helicopters	Service
C/MH-53E	Navy
MH-60R (BY 2006)	Navy
MH-60S	Navy

UVA	Service
GLOBAL HAWK	Air Force
PREDATOR	Air Force

Electronic Equipment	Service
NESP	Navy

From the information in the VAMOSC and AFTOC systems, we calculated an actual Annual Unitized O&S Cost (AUC) per program. This metric describes the cost to operate and sustain one unit (individual plane, ship, etc.) per year. Generally speaking, the AUC is calculated by dividing the total annual O&S cost for a system by the number of units operational in the year. [*Note*. For a more complete description of the AUC methodology, see Ryan, Jacques, Colombi, & Schubert (2012).] We approximated the total O&S cost of a particular program by multiplying the AUC by the number of units procured by the life expectancy of the system. It is important to note that some costs that can be logically attributable to programs, such as the maintenance of simulators and training devices, may or may not be included properly in the VAMOSC and AFTOC systems. This uncertainty has the potential for understating O&S costs.

TABLE 4. SUMMARY OF DIFFERENCES IN LIFE EXPECTANCY FROM VARIOUS VERSIONS OF THE OSD CAIG O&S COST-ESTIMATING GUIDE

	1992	2007	2012 (draft)
Cargo	25	25	30–40
Bomber	25	25	30–40
Tanker	25	25	30–40
Fighter	20	20	20–30
Helicopter	20	20	20–30
Small Missiles	15	15	10–20
Large Missiles	20	15	10–20
Electronic Equipment	10	10	10–30
Ships	20–40	20–40	20–40
Ground Combat Vehicles	20	20	20
Unmanned Aerial Vehicles	N/A	N/A	15–25

Table 4 shows how the life expectancies have changed over the years. As illustrated, life expectancy has increased for most systems, most notably for the Cargo/Bomber/Tanker and Electronic Equipment categories. Since one of the unknowns in this analysis is the expected life of each program, we used the draft 2012 OSD CAPE *Operating and Support Cost-Estimating Guide*, coupled with program-specific information

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found in SARs, to develop specific platform service life ranges. Table 5 shows these life expectancy ranges. From these estimates, we chose the highest and lowest expectancies to use as an upper and lower bound.

TABLE 5. LIFE EXPECTANCIES FOR VARIOUS WEAPON SYSTEMS

	High (yrs)	Low (Yrs)
Ships		
AOE 6	40	20
CVN 68 (BY 1974/1975)	50	20
CVN 68 (BY 1976)	50	20
DDG 51	40	20
LHD 1	40	20
LPD 17	40	20
MHC 51	40	20
SSGN	40	20
SSN 21	40	20
SSN 774	40	20
STRATEGIC SEALIFT	40	20
T-AKE	40	20
T-AO 187	40	20
Fighters		
F-16 C/D	30	20
F-22 (BY 2005)	30	20
JPATS (BY 2002)	30	20
AV-8B REMAN	30	20
EA-18G	30	20
F/A-18 E/F	30	20
F-14D	30	20
T-45TS (BY 1995)	30	20

	High (yrs)	Low (Yrs)
Cargo/Tanker		
C-130J	50	25
C-17A (BY 1996)	40	25
E-2C	40	20
JSTARS (BY 1998)	40	25
KC-135R	40	25
Missiles		
AMRAAM	40	10
JASSM	20	10
AIM-9X	33	10
JSOW (AGM-154)	30	10
Helicopters		
C/MH-53E	30	20
MH-60R (BY 2006)	30	20
MH-60S	35	20
UVA		
GLOBAL HAWK	34	15
PREDATOR	25	15
Electronic Equipment		
NESP	30	10
Tilt-Rotor		
V-22 (BY 2005)	43	30

Before performing any calculations, we standardized the annual cost data to Fiscal Year (FY) 2010 using OSD inflation indices. Once normalized to FY 2010, the costs per year were de-escalated back to the base year of the program. For certain programs that reported more than one baseline year due to changes or milestones in the program, for example, the V-22 Osprey, we used the most recent SAR report. Multiplying the actual AUC by the highest (or lowest) life expectancy for a program and by the number of units to be procured (as given by the last or most recent SAR) resulted in our estimate of O&S costs. To calculate the ratio of O&S to LCC, we divided the O&S cost estimate by the total of the O&S cost estimate and the acquisition actual cost. Table 6 provides the summary statistics for all weapon systems studied.

TABLE 6. SUMMARY STATISTICS FOR ALL PROGRAMS

	Mean	Median	Standard Deviation
High	55.92%	62.57%	22.74%
Low	43.85%	48.33%	21.96%
Average	49.88%	54.09%	23.02%

For all programs as a whole, we estimate an approximate range of 44–56 percent (mean) or 48–63 percent (median) for the proportion of life-cycle costs attributable to O&S. The "high" end of the range (using the upper estimate of life expectancy) went from 4.91 percent (Joint Standoff Weapon, or JSOW) to 88.79 percent (KC-135R), with a standard deviation of 22.48 percent. The "low" end (using the lower estimate of life expectancy) started at 1.69 percent (JSOW) and went through 83.19 percent (KC-135R), with a standard deviation of 21.56 percent. The large standard deviation associated with this overall range highlights vast differences among the weapon systems in terms of O&S costs and emphasizes the need to further reduce the set of programs into different types.

In Table 7, we segregate the weapon systems into eight categories, and then for the Ship and Cargo/Tanker groups we performed two additional analyses. The Ships category includes 13 ships, three of which consisted of submarines. Of these three, two fell outside two standard deviations from the mean—the SSN 21 and the SSN 774. The SSN 21 O&S proportion was estimated to fall within 11.65 percent and 20.87 percent, and the SSN 774 was estimated to fall between 12.65 percent and 22.46

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percent. Because these relatively low O&S percentages affected the mean value for the whole group, we reran the Ship group without the submarines and presented that information as well.

TABLE 7. SUMMARY OF O&S COST PERCENTAGES BY TYPE OF SYSTEM

Platform	Mean	Median	Standard Deviation
Ships	48.21%	51.12%	18.14%
Ships — No Submarines	53.26%	53.12%	13.13%
Fighter Aircraft	52.99%	51.46%	15.65%
Cargo/Tanker Aircraft	65.15%	61.73%	13.98%
Cargo/Tanker — No KC-135R	59.94%	59.55%	9.68%
Missiles	8.35%	6.56%	7.51%
Helicopters	70.73%	70.13%	5.70%
Unmanned Aerial Vehicles	71.56%	71.56%	9.39%
Electronic Equipment	15.53%	15.53%	9.60%
Tilt Rotor Aircraft	65.03%	65.03%	5.77%

For the Cargo/Tanker group, five airframes were included in this category—four Air Force and one Navy. One program stood out as anomalous in this group—the KC-135R. Overall, the ratios for this category were 59.19 percent–71.11 percent (mean); and 54.20 percent–70.30 percent (median). The KC-135R range was 83.19–88.79. Although the upper estimate for the KC-135 fell within two standard deviations of the mean and median, the estimate for the low end exceeded two standard deviations above both measures. As with the Ship category, we removed this outlier from the group and reran the analysis. Lastly, although we did determine a range of the expected O&S proportion of LCC for electronic systems, we cannot in good faith determine this range to be representative for other electronic systems given we only had one data point in this category.

Since the work performed on this database seemed to show a possible connection between high O&S proportions and variant/modification programs, an additional analysis was performed on all newly developed systems. This is presumably due to the fact that the initial acquisition cost of a plane, for instance, is included in the "new" estimate, but not included in the "modification" estimate since the aircraft has already been purchased. The resulting list included 22 systems. The ranges for O&S proportions for this group were 35.09 percent–47.00 percent (mean); and 36.97 percent–53.98 percent (median). The decreases in proportions from the larger group of systems, including variant and modification programs, seem to lend some credence to the notion that new systems will have more life-cycle costs devoted to acquisition than to sustainment. Table 8 summarizes the results.

TABLE 8. SUMMARY STATISTICS FOR NEW PROGRAMS

	Mean	Median	Standard Deviation
High	47.00%	53.98%	23.60%
Low	35.09%	36.97%	21.27%
Average	41.04%	45.84%	22.99%

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Discussion and Conclusions

To make informed decisions regarding the maintenance and lifetime cost of our nation's weapon systems, leaders and portfolio managers need to have the right information at the right time. The DoD has accumulated valuable information about its sustainment costs through systems like AFTOC and VAMOSC. By tapping into this historical information, analysts and decision makers can better understand what portion of a weapon system's LCC can be attributed to acquiring the weapon system and what portion can be attributed to operating and supporting it.

The notion of O&S costs being 70 percent of LCC has been circulating around the DoD acquisition community for more than 35 years, and has repeatedly been emphasized in several recent GAO reports. The origin of this 70:30 ratio comes from an amalgamation of *estimates* of the O&S weapon systems' costs given by program offices or other official sources, such as SARs. However, by analyzing the *actual* sustainment costs in VAMOSC and AFTOC, the 70 percent O&S to 30 percent Acquisition cost ratio for a "typical" DoD weapon system appears not to be valid. Our data suggest that O&S costs are quite varied, with a mean of 55 percent.

Not only does the conventional wisdom regarding this fundamental LCC ratio appear to be incorrect, but the tendency to reduce the life-cycle costs of all DoD weapon systems down to a single ratio with respect to acquisition cost is impractical and imprudent. Although the average percentage of O&S costs observed fell around 50–55 percent of LCC, we noticed significant deviations from this percentage. Not only did individual weapon system's ratios vary from this percentage, but also entire categories of systems. Both of these observations suggest a peanut butter spread of one ratio of acquisition to sustainment is too simplistic. The differences within certain categories or subcategories, such as Ships and Submarines, illustrate the need to further distill these groups into more meaningful and homogeneous types of systems before assigning a typical O&S/Acquisition cost ratio.

Another interesting item to come out of this research was the variable nature of life expectancies itself. As shown earlier in Table 4, many weapon systems categories have experienced an increase in their recommended life expectancies over the past two decades. Fighter platforms expected to be operational for 15 years, e.g., the F-15, are still around almost 30 years later. A look at the actual useful lives as well as the expected lives of our weapon systems has shown that not only are we capable of sustaining our weapon systems far beyond their intended lives, but we are able to extend the capabilities of existing naval vessels and airframes through modification. This can have a profound impact on the costs to sustain these systems for a longer duration. As these systems continue to age, additional research should be conducted to monitor actual O&S costs.

By illustrating the variability of life-cycle proportions among weapon systems categories, we have shown a more realistic picture of what program analysts and portfolio managers can expect in terms of sustainment costs. Although beyond the scope of our work, perhaps future studies can drill down to speculate or reason why different sorts of systems appear to have such different cost ratios. This research has begun to open a window into the real effects of acquisition strategy on life-cycle costs. In the face of looming budget cuts over the next decade, leaders across the DoD and Congress are struggling to make tough decisions regarding our nation's arsenal. Only with a full understanding of how our acquisition decisions affect our long-term sustainment costs can we make the right decisions on what capabilities are needed, how we will acquire those capabilities, and how we will maintain those capabilities.

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