



# **DSIAC TECHNICAL INQUIRY (TI) RESPONSE REPORT**

## **Weapon System Integration Cost Analysis**

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## ABOUT DSIAC

The Defense Systems Information Analysis Center (DSIAC) is a U.S. Department of Defense information analysis center sponsored by the Defense Technical Information Center. DSIAC is operated by SURVICE Engineering Company under contract FA8075-14-D-0001.

DSIAC serves as the national clearinghouse for worldwide scientific and technical information for weapon systems; survivability and vulnerability; reliability, maintainability, quality, supportability, and interoperability; advanced materials; military sensing; autonomous systems; energetics; directed energy; and non-lethal weapons. We collect, analyze, synthesize, and disseminate related technical information and data for each of these focus areas.

A chief service of DSIAC is free technical inquiry (TI) research, limited to 4 research hours per inquiry. This TI response report summarizes the research findings of one such inquiry. For more information about DSIAC and our TI service, please visit [www.DSIAC.org](http://www.DSIAC.org).

## ABSTRACT

The Defense Systems Information Analysis Center (DSIAC) was tasked with supplying data and analysis of typical platform integration costs for a missile/weapon system, to compare the potential cost of a new weapon versus that of an upgraded existing weapon. DSIAC noted that detailed weapon/platform integration costs are difficult to quantify, especially for various phases of a program (which may overlap). DSIAC also noted that leveraging ongoing efforts for previous phases may not be uniformly reported across various Armed Services and weapon system program offices, and/or they may not be reported uniformly from year to year. Instead, with concurrence from the requester, DSIAC researched U.S. Government reports detailing research, development, testing, and evaluation (RDT&E) and production costs for various major weapon systems and other cost estimating relationship (CER) studies; models for weapon system integration costs vs. weapon system complexity to developed notional RDT&E; and system integration cost curves vs. weapon system complexity. The reports were used as a simplified gauge to estimate similar costs for new system RDT&E and integration. Copies of the reports and studies were supplied to the inquirer. Additional reports that provided insight into the difficulties of and issues within cost estimating for major weapon systems were also provided.

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## 1.0 TI Request

### 1.1 INQUIRY

What are typical integration costs for new missile/weapon systems, and how do they compare to integration costs when upgrading existing systems?

### 1.2 DESCRIPTION

The inquirer requested data on missile/weapon integration costs. The inquirer was particularly interested in typical platform integration costs to compare new weapon costs versus pre-planned product improvement (P3I) upgrade costs to support future weapon system development efforts. The inquirer was interested in everything from aircraft to MK-41/ship integration costs.

## 2.0 TI Response

Defense Systems Information Analyses Center (DSIAC) staff with expertise relevant to the inquiry identified that detailed weapon/platform integration costs are difficult to quantify, especially for various phases of a program. These phases may overlap or leverage ongoing efforts for previous phases or other programs, which may not be uniformly reported across various Services and weapon system program offices or be reported uniformly from year to year. However, there are several yearly U.S. Government reports that attempt to provide a consolidated picture of the research, development, test, and evaluation (RDT&E) and production costs by major weapon systems. DSIAC staff provided sample information for weapon system RDT&E costs as the basis for a discussion to better understand what information would be helpful to make a proper analysis.

DSIAC staff also reviewed recent releases of reports from the Office of the Under Secretary of Defense Comptroller (OUSD(C)) on program acquisition costs by a weapon system developed as part of the yearly U.S. Department of Defense (DoD) fiscal year (FY) budget request [1–7]; the U.S. Government Accountability Office’s (GAO’s) annual report to Congressional Committees on assessment of DoD weapon system acquisitions during the years 2006–2015 [8–17]; and information on cost-estimating relationship (CER) models for weapon system integration costs used to help implement acquisition cost-reduction measures.

The author of this report, Scott Armistead, is Level III certified in DoD Acquisition and Test & Evaluation. He served for nearly 20 years as a U.S. Government Test Engineer, Program Engineer, Program Manager, and Technical Advisor for munitions developmental, operational, and Live-Fire testing organizations and Joint Program Offices developing programmatic, testing, and cost-estimating documentation for all phases of the weapon system acquisition life cycle. These systems included numerous Acquisition Category I, II, III, and IV Air Force, Army, and Navy programs.

### 2.1 OUSD REPORTS

Within the OUSD publications on program acquisition costs for weapon systems, one section is specifically devoted to missiles and munitions. For example, the FY2016 publication [7] covers the following weapon systems:

- Advanced Medium Range Air-to-Air Missile (AMRAAM).
- Air Intercept Missile-9X (AIM-9X).
- Joint Air-to-Surface Stand-off Missile (JASSM).
- Joint Direct Attack Munition (JDAM).
- Small Diameter Bomb (SDB).
- Hellfire.
- Javelin.

- Guided Multiple Launch Rocket System (GMLRS).
- Evolved Sea Sparrow Missile (ESSM).
- Rolling Airframe Missile (RAM).
- STANDARD missile family.
- Tactical Tomahawk.
- Trident II.
- Offensive Anti-Surface Weapon (OASuW).
- B61 Tail Kit Assembly (TKA).

Examples of the program acquisition costs and charts are shown in Figures 1 and 2. As seen in Figures 1 and 2, RDT&E costs can be broken out for the current and the past 2 years; however, these costs may be comingled funding for various phases of efforts and upgrades as funding is only for this specific period, not totaled to date or estimated to completion. Also, note the changes in the FY2014 and FY2015 cost and quantity numbers, shown in Figures 1 and 2. DSIAC would most likely have to go the OUSD and/or the Program Office for each weapon system to get a clear breakout of overall totals to date and estimation to completion. This type of detailed data would be regarded as highly sensitive by each organization, difficult to obtain, and would be beyond the scope of a standard TI. The OUSD reports on program acquisition cost by weapon system are available online [18].

	FY 2013		FY 2014						FY 2015	
	SM	Qty	Base Budget		OCO Budget		Total Enacted		SM	Qty
			SM	Qty	SM	Qty	SM	Qty		
<b>RDT&amp;E</b>										
Air Force	68.7	-	70.6	-	-	-	70.6	-	82.2	-
Navy	2.7	-	2.6	-	-	-	2.6	-	10.2	-
<b>Subtotal</b>	<b>71.4</b>	<b>-</b>	<b>73.2</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>73.2</b>	<b>-</b>	<b>92.4</b>	<b>-</b>
<b>Procurement</b>										
Air Force	201.4	113	323.0	183	-	-	323.0	183	329.6	200
Navy	86.9	67	82.5	44	-	-	82.5	44	32.2	-
<b>Subtotal</b>	<b>288.3</b>	<b>180</b>	<b>405.5</b>	<b>227</b>	<b>-</b>	<b>-</b>	<b>405.5</b>	<b>227</b>	<b>361.8</b>	<b>200</b>
<b>Spares</b>										
	1.4	-	2.1	-	-	-	2.1	-	3.7	-
<b>Total</b>	<b>361.1</b>	<b>180</b>	<b>480.8</b>	<b>227</b>	<b>-</b>	<b>-</b>	<b>480.8</b>	<b>227</b>	<b>457.9</b>	<b>200</b>

Figure 1: The 2015 program acquisition costs for the AMRAAM [6].



	FY 2014		FY 2015		FY 2016					
	\$M	Qty	\$M	Qty	Base Budget		OCO Budget		Total Request	
					\$M	Qty	\$M	Qty	\$M	Qty
<b>RDT&amp;E</b>										
Air Force	68.5	-	82.2	-	46.2	-	-	-	46.2	-
Navy	2.6	-	10.2	-	32.2	-	-	-	32.2	-
Subtotal	71.1	-	92.4	-	78.4	-	-	-	78.4	-
<b>Procurement</b>										
Air Force	318.4	183	329.6	200	390.1	262	-	-	390.1	262
Navy	82.5	54	2.2	-	192.9	167	-	-	192.9	167
Subtotal	400.9	237	331.8	200	583.0	429	-	-	583.0	429
<b>Spares</b>										
	1.4	-	2.9	-	4.2	-	-	-	4.2	-
<b>Total</b>	<b>473.4</b>	<b>237</b>	<b>427.1</b>	<b>200</b>	<b>665.6</b>	<b>429</b>	<b>-</b>	<b>-</b>	<b>665.6</b>	<b>429</b>

Figure 2: The 2016 program acquisition costs for the AMRAAM [7].

## 2.2 UNITED KINGDOM MINISTRY OF DEFENCE (UK MOD) CER MODELS OF WEAPON SYSTEMS

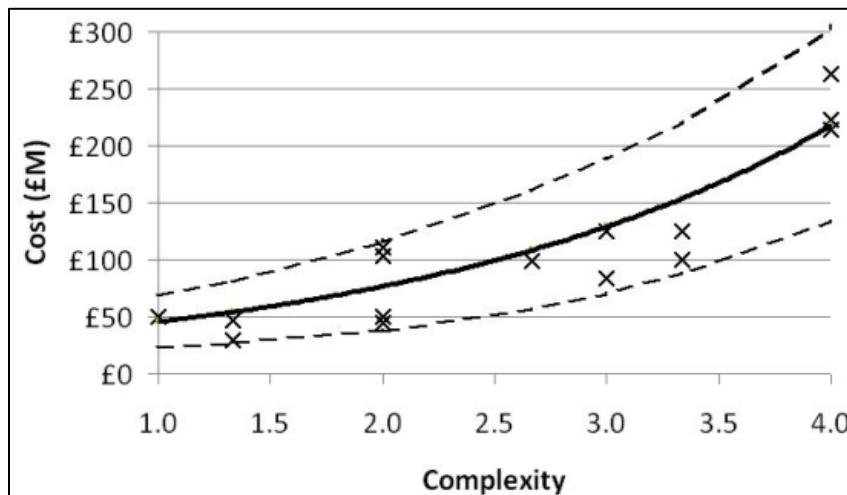
There have been significant efforts to quantify weapon system integration costs to create CER models to help implement acquisition cost-reduction measures. For instance, the UK MOD Defence Equipment and Support group has been working on developing CER models based on Paveway IV, Brimstone, Future Air-to-Surface Guided Weapon (FASGW), Storm Shadow, Advanced Short Range Air-to-Air Missile (ASRAAM), and AMRAAM (lower to greater complexity) integration on the Harrier, Wildcat, Tornado, Typhoon, and F-35 platforms (again, lower to greater complexity). Table 1 shows the complexity levels of these weapon systems as determined by CER models.

These weapon systems were designed in the 1980s and 1990s and entered production in the 1990s and 2000s (Paveway IV was the last of them to enter production in 2008), with the exception of the Future Anti-Surface Guided Weapon (Light) (FASGW(L)) or Lightweight Multi-role Missile, and FASGW (Heavy) (FASGW(H)) or Venom, which were scheduled to enter production in 2016 and 2020, respectively [19].

**Table 1: UK MOD CER Model Complexity Assessments of Weapon Systems [19]**

Platform	Weapon System	Complexity Level			
		Platform	Weapon	Environment	Average
Harrier	Paveway IV	1	1	1	1
Harrier	Brimstone	1	2	1	1.3
Wildcat	FASGW(H)	1	2	1	1.3
Wildcat	FASGW(L)	1	4	1	2
Tornado	Brimstone	2	2	2	2
Tornado	Stormshadow	2	2	2	2
Tornado	ASRAAM	2	2	2	2
Tornado	AMRAAM	2	4	2	2.7
Typhoon	Paveway IV	4	1	4	3
Typhoon	ASRAAM	4	2	4	3.3
Typhoon	Stormshadow	4	2	4	3.3
Typhoon	SPEAR C2	4	4	4	4
Typhoon	Meteor	4	4	4	4
Lightning (JCA)	Paveway IV	4	1	4	3
Lightning (JCA)	Meteor	4	4	4	4

A model with uncertainty bounds from the UK MOD’s 2013 brief on progress in quantifying weapon system integration costs to that time is shown in Figure 3. The complexity rating is a combined average of subject matter expert assessments for the relative complexity of the weapon system, integration platform, and environment [19].



**Figure 3: UK MOD CER model of integration costs (2007 £M) for various missile and bomb weapon systems onto various aircraft platforms [19].**

## 2.3 RAND STUDY ON HISTORICAL COST ESTIMATING RELATIONSHIPS AND COST REDUCTION INITIATIVES FOR MILITARY AIRCRAFT AND AIR-LAUNCHED GUIDED WEAPONS

In 2004, RAND performed a study like that of UK MOD’s for the purpose of improving the tools used to estimate the costs of future weapon systems. The study focused on recent technical, management and government policy changes affect cost by examining the effects of changes in the test and evaluation process used to evaluate military aircraft and air-launched guided weapons to include the AIM-9X, AMRAAM, JASSM, JDAM, Joint Standoff Weapon (JSOW), sensor fuzed weapon (SFW), Standoff Land-Attack Missile-Expanded Response (SLAM-ER), Tomahawk, and Wind-Corrected Munitions Dispenser (WCMD), which also provides some information on contractor system test and evaluation (ST&E) costs [20]. Portions of the study look at contractor ST&E costs and present a CER plot related to these costs to include Contractor ST&E total cost, ground testing cost, static and fatigue testing cost, flight testing cost, and other testing costs. The data and models used to support the RAND analysis would likely be useful in answering the question at hand; however, the openly available reports and briefings from the analysis tend to focus on development of the models and generally only contain samples of cost data used to develop the models. Acquiring the detailed data and approval for release would be beyond the scope of a standard TI response.

## 2.4 GAO REPORTS

The GAO published reports to Congress also provide an assessment of total RDT&E and production costs to date, as well as projected costs to completion (though not always for the latter). The report information is usually program block-/phase-specific. However, it may not be integration platform specific; data presented may be for integration onto multiple platforms (i.e., the JASSM onto F-15, F-16, and B-52 aircraft all rolled into single cost numbers). Though the data may not provide all the details and granularity desired, they are relatively easily obtained, and will be used as the basis for this response [8–17]. Figures 4 and 5 show examples from the GAO FY2014 and FY2015 assessments for the AIM-9X Block II missile, respectively.

<b>Program Essentials</b>	<b>Program Performance (fiscal year 2014 dollars in millions)</b>		
	<b>As of 12/2011</b>	<b>Latest 09/2013</b>	<b>Percent change</b>
Prime contractor: Raytheon Missile Systems			
Program office: Patuxent River, MD			
Funding needed to complete:			
R&D: \$113.2 million			
Procurement: \$4,167.0 million			
Total funding: \$4,280.2 million			
Procurement quantity: 5,321			
Research and development cost	\$178.8	\$224.5	25.6
Procurement cost	\$4,023.0	\$3,568.0	-11.3
Total program cost	\$4,201.8	\$3,792.5	-9.7%
Program unit cost	\$0.700	\$0.632	-9.7%
Total quantities	6,000	6,000	0.0
Acquisition cycle time (months)	39	TBD	TBD

Figure 4: GAO FY2014 program performance assessment for the AIM-9X Block II missile [16].

<b>Program Essentials</b>	<b>Program Performance (fiscal year 2015 dollars in millions)</b>			
Prime contractor: Raytheon Missile Systems	<b>As of 12/2011</b>	<b>Latest 08/2014</b>	<b>Percent change</b>	
Program office: Patuxent River, MD	Research and development cost	\$180.0	\$374.0	107.8
Funding needed to complete:	Procurement cost	\$4,051.3	\$3,248.8	-19.8
R&D: \$237.9 million	Total program cost	\$4,231.3	\$3,622.9	-14.4
Procurement: \$2,613.5 million	Program unit cost	\$.705	\$.604	-14.4
Total funding: \$2,851.4 million	Total quantities	6,000	6,000	0.0
Procurement quantity: 4,885	Acquisition cycle time (months)	39	45	15.4

**Figure 5: GAO FY2015 program performance assessment for the AIM-9X Block II missile [17].**

In Figures 4 and 5, note the large increase in projected funding needed to complete research and development. The FY2015 report cites a 65% increase due to program deficiencies. Year-over-year increases are common across all programs due to deficiencies, new capability requirements, software and hardware modifications, modernization, etc., further complicating the determination of true total RDT&E costs [17]. The GAO reports on assessment of selected weapon programs can be found on their website by searching for “defense acquisition assessment.” Additionally, the GAO report “Defense Acquisitions: Better Approach Needed to Account for Number, Cost, and Performance of Non-Major Programs” provides supplementary insight on the subject [21].

Table 2 provides data for consolidated RDT&E costs for weapon systems integrated onto aircraft platforms by date of reported costs from the FY2006 to FY2015 reports (the latest reported data are used). The comparison of weapon systems, such as the JASSM to JASSM-Extended Range (ER) and SDB I to SDB II, provides good insight into the spectrum of RDT&E costs for next increments/blocks, with JASSM-ER being similar to a P3I effort and SDB II being almost an entirely new development effort. JASSM-ER shares approximately 70% common hardware and 95% common software with the original JASSM, and its mission and capabilities remain relatively similar, except for providing additional range for launch outside the enemy’s air defenses. As expected, RDT&E costs for the incremental development (\$363 M) are significantly less than those for development of the original weapon system (\$1,422 M). Conversely, the SDB II provides greatly increased capabilities (global positioning system [GPS]/inertial navigation system [INS], a trimode radar/infrared/laser seeker, and airborne and ground data links to allow engagement of both fixed and mobile targets in adverse weather conditions) over the original SDB I (GPS/INS-only guidance). As expected in this case, the RDT&E costs for SDB II (\$2,209 M) are significantly more than those for the original SDB I (\$511.3 M) [8–17].

Tables 3 and 4 provide similar data for weapon systems integrated onto land and ship platforms and for Ballistic Missile Defense System (BMDS)-related weapon systems, respectively. Many times, the RDT&E costs for these systems may or may not be rolled up into the RDT&E cost numbers presented in the report because the systems include other sensors, command and control (C2), fire control, and other equipment. All costs are escalated to FY2015 dollars using U.S. Consumer Price Index (CPI) data as provided in the Appendix.

**Table 2: Estimated RDT&E Costs for Major Weapon Systems Integrated onto Aircraft Platforms [8–17]**

Weapon System	Integration Platform(s)	Weapon Qty	RDT&E to Date (\$M)	Est. RDT&E to Complete (\$M)	Est. RDT&E Total (\$M)	Est. RDT&E Total (FY15 \$M)	Est. RDT&E per Item (FY15 \$K)	As of Date
SDB Increment I (SDB I)	A-10, B-52, B-1B, B-2, B-52, AC-130W, F-15E, F-16, F-22A, F-35	23,842	384.2	51.2	435.4	511.3	21.4	Dec 04
JASSM*	F-15, F-16, B-52	5,006	1,317.2	TBD	1,317.2	1,422.7	284.2	Aug 09
AGM-88E Advanced Anti-Radiation Guided Missile (AARGM)†	F/A-18, EA-18G	1,767	722.2	0.0	722.2	747.9	423.3	Jun 11
OASuW Missile	F-18, B-1	110	—	1,189.6	1,189.6	1,189.6	10,814.5	Aug 14
Joint Air-to-Ground Missile (JAGM)‡	AH-64, AH-1Z, OH-58, MH-60H/S, MQ-1C	20,492	195.0	774.7	969.7	969.7	47.3	Aug 14
SDB Increment II (SDB II)	F-15E, F-16, F/A-18E/F, F-22A, F-35, B-1B, B-2, B-52, A-10, MQ-9	17,163	1,688.4	521.0	2,209.4	2,209.4	128.7	Aug 14
JASSM-ER§	F-15, F-16, B-52	2,877	298.2	65.2	363.4	363.4	126.3	Aug 14
AIM-9X Block II Air-to-Air Missile	F-15, F-16, F-18, F-22A, F-35	6,000	374.0	237.9	611.9	611.9	102.0	Aug 14

\* This is the last reported RDT&E amount when both JASSM and JASSM-ER were assessed together, as they had over 70% commonality in parts. RDT&E amounts for only JASSM were not provided in the GAO reports.

† Earlier procurement called for 1,842 items (a 4.1% decrease), which could have resulted in increased per item RDT&E costs.

‡ The program was restructured in early 2012. No RDT&E data prior to then were provided for accomplished prototyping efforts in an FY15 report [17], but an FY13 report [13] lists \$195M estimate for 2011–2013. The GAO 2010 report lists projected quantity at 33,853 [13] (the 2012 report suggests a decrease of 39.5% [14]).

§ Earlier procurement called for 2,507 items (a 14.8% increase). RDT&E costs for the ER version (JASSM-ER) may be lower than usual as JASSM-ER shared greater than 70% commonality of parts with JASSM, and much of the RDT&E costs could have occurred under that program.

**Table 3: Estimated RDT&E Costs for Major Weapon Systems Integrated onto Land and Ship Platforms [8–17]**

Weapon System	Integration Platform(s)	Weapon Qty	RDT&E to Date (\$M)	Est RDT&E to Complete (\$M)	Est RDT&E Total (\$M)	Est RDT&E Total (FY15 \$M)	Est RDT&E per Item (FY15 \$K)	As of Date
Extended Range Munition (ERM)	Modified Naval 5-inch gun	15,100	500.1	108.6	500.1	549.9	36.4	Aug 07
Intelligent Munitions System-Scorpion**	Land-based system	2,624	487.3	78.7	566.0	595.7	227.0	Nov 10
Standard Missile-6 (SM-6)	Aegis ships	1,200	996.5	0.0	996.5	1,017.1	847.6	Aug 12
Excalibur Precision 155mm Projectiles (Excalibur)**	Land/vehicle-based systems	7,474	1,143.7	0.0	1,143.7	1,143.7	153.0	Aug 14

\*\* Scorpion includes an integrated system of lethal and nonlethal munitions, sensors, software, and communications equipment.

†† Earlier procurement called for 76,677 items (a 90.3% decrease); there are multiple increments (Ia-1, Ia-2, Ib, Ib-S, Ib-N5, II, and III).

**Table 4: Estimated RDT&E Costs for Major BMDS Weapon Systems [8–17]**

Weapon System	Integration Platform(s)	Weapon Qty	RDT&E to Date (\$M)	Est RDT&E to Complete (\$M)	Est RDT&E Total (\$M)	Est RDT&E Total (FY15 \$M)	Est RDT&E per Item (FY15 \$K)	As of Date
BMDS: Kinetic Energy Interceptors (KEI) <sup>‡‡</sup>	Fixed installation and vehicle platforms.	NA	4,118.9	4,212.0	8,330.9	8,998.2	---	Sep 08
BMDS: Multiple Kill Vehicle (MKV) <sup>§§</sup>	Fixed installation and vehicle platforms.	NA	3,216.1	3,269.1	6,485.2	7,004.7	---	Nov 08
BMDS: Aegis Ballistic Missile Defense Standard Missile-3 Block IIA <sup>***</sup>	Fixed installation and vehicle platforms.	NA	2,521.8	TBD	---	---	---	May 11
BMDS: Ground-Based Midcourse Defense (GMD) <sup>†††</sup>	Fixed installation and vehicle platforms.	370	40,694.5	4,431.9	45,126.4	46,060.3	12,4487.2	Aug 12
BMDS: Aegis Ballistic Missile Defense Standard Missile-3 (SM-3) Block IB <sup>†††</sup>	Fixed installation and vehicle platforms.	367	944.7	112.6	1,057.3	1,079.2	2,940.5	Jan 13
BMDS: Terminal High-Altitude Area Defense (THAAD) <sup>§§§</sup>	Fixed installation and vehicle platforms.	NA	16,146.2	1,450.3	17,596.5	17,960.7	---	Mar 13

‡‡ The program was restructured in 2007 and now only includes development of the booster components of the system, so it is unknown if previous RDT&E costs were included.

§§ A modular payload for midcourse defense system interceptors including the ground-based and KEI.

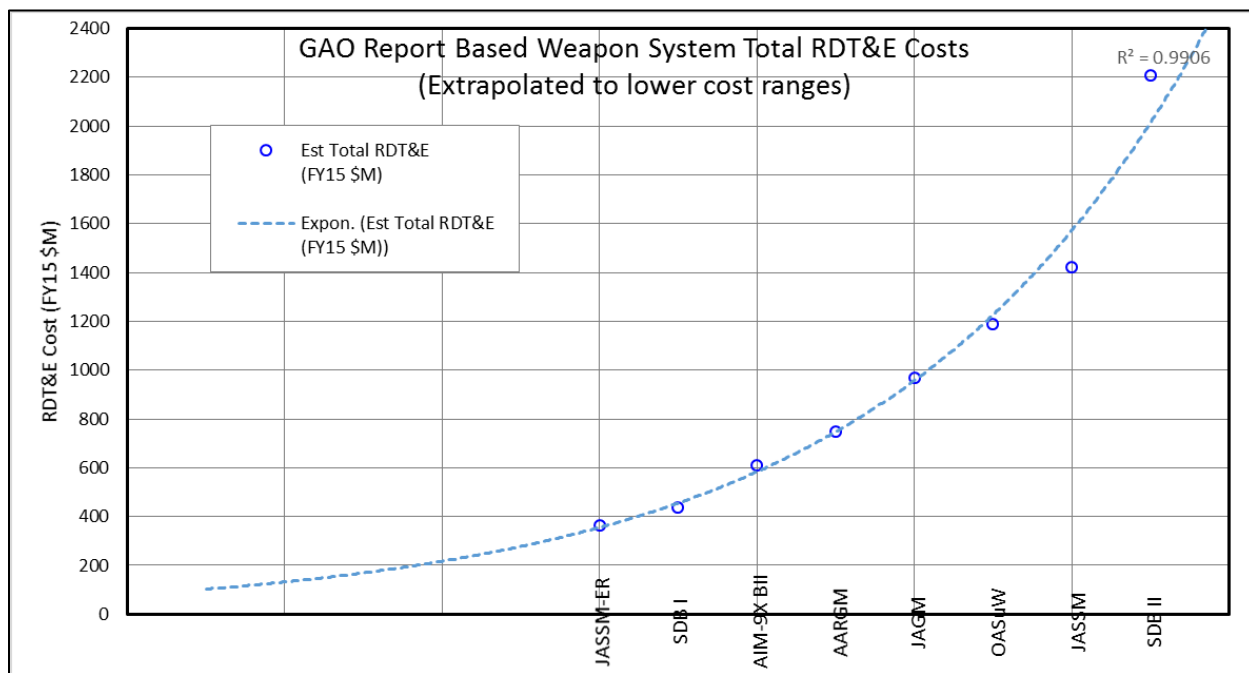
\*\*\* The 2009 GAO report stated that RDT&E costs were \$11,457M to date with an estimate of \$5,093M remaining for a total of \$16,550M [11].

††† The weapon system GMD includes an interceptor with three-stage booster, Capability Enhancement II (CE-II) configuration of the Exoatmospheric Kill Vehicle (EKV), and a fire control system.

††† The weapon system includes a radar, battle management and command and control systems, and SM-3 missiles.

§§§ The THAAD battery includes interceptors, launchers, X-band radar, a fire control radar/system, C2, and other equipment.

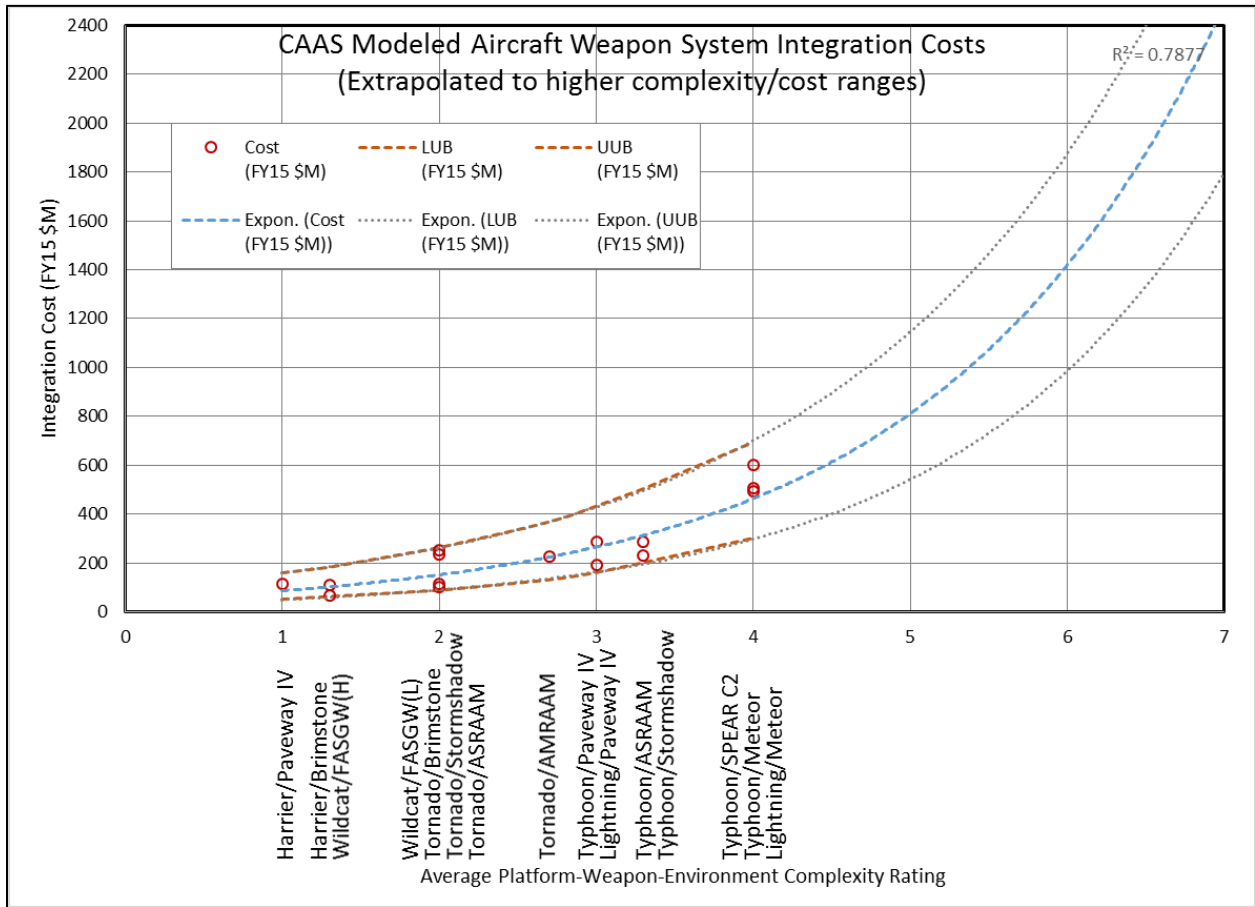
If it is assumed that the U.S. weapon system RDT&E costs given in Table 2 [8–17] bear a similar, direct relationship to complexity as that shown in the UK MOD CER model, and the differences in relative complexity from one system to the other are ignored (the relative complexity between each system is set to an equal value), a plot of the total RDT&E costs from lowest to highest values can be generated (Figure 6). In addition, the costs backwards and forwards can be extrapolated using a best-fitted curve (an exponential in this case). Although these assumptions are a gross oversimplification with many unknowns, the graph can still be useful by allowing a plot of a proposed weapon system to be drawn along the line in terms of its assessed relative complexity to the other weapon systems to get a rough order-of-magnitude (ROM) estimate of expected RDT&E costs.



**Figure 6: Notional extrapolation for estimated total RDT&E costs for U.S. weapon systems integrated onto aircraft platforms [1–17].**

Similarly, data from the UK MOD CER model (including the lower and upper uncertainty bounds) can be converted to FY2015 U.S. dollars using 2007 exchange rates (see the Appendix) and extrapolated “up” to the ranges covered by the U.S. weapon system estimated total FY2015 RDT&E costs in Table 2 using fitted exponential curves (Figure 7) [19].





LUB= Lower uncertainty bounds; UUB=Upper uncertainty bounds

**Figure 7: Notional extrapolation of UK MOD CER modeled integration costs and uncertainty bounds to higher complexity levels [19].**

Again, with some understanding of the relative complexity of a proposed weapon system, integration platform, and environment in relation to those used in the UK MOD CER model [19], it is possible to get a quick ROM estimate for expected platform-specific weapon system integration costs.

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## APPENDIX: Inflation and Currency Conversion Data

Inflation used to determine research, development, test, and evaluation (RDT&E) costs in fiscal year (FY)2015 dollars was calculated based on the year-over-year percentage change in average U.S. Consumer Price Index (CPI) [1] and is shown in Table A-1.

The conversion of the United Kingdom Ministry of Defence (UK MOD) cost-estimating relationship (CER) model data from 2007 UK Pounds (£) to 2015 U.S. Dollars (\$) was calculated based on the average exchange rate data [2] for 2007, as shown in Table A-1, and then escalated using the inflation rate data from Table A-2.

**Table A-1: U.S. Yearly CPI and Inflation Data [1]**

Year	CPI	Inflation (%)
2005	195.300	
2006	201.600	3.226%
2007	207.300	2.827%
2008	215.303	3.861%
2009	219.179	1.800%
2010	218.056	-0.512%
2011	224.939	3.157%
2012	229.594	2.069%
2013	232.957	1.465%
2014	236.736	1.622%
2015	237.017	0.119%

**Table A-2: 2007 UK Pounds to U.S. Dollars Exchange Rate [2]**

Month	Exchange Rate
Jan	1.957960
Feb	1.957967
Mar	1.947389
Apr	1.987469
May	1.983899
Jun	1.985594
Jul	2.032933
Aug	2.011641
Sep	2.019515
Oct	2.044439
Nov	2.069963
Dec	2.014625
<b>Average</b>	<b>2.001116</b>

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