Deloitte.

Program management in aerospace and defense

Still late and over budget

Contents

Executive summary

In our 2009 study **"Can we afford our own future? Why A&D programs are late and over budget—and what can be done to fix the problem,"** we predicted that if significant changes were not made to address the root causes of program management, cost overruns and schedule delays would continue to accentuate. In line with our prediction, total cost of the US Department of Defense's (DoD) 2015 Major Defense Acquisition Program (MDAP) portfolio grew at 48.3 percent with an average schedule delay of 29.5 months[1] over original baseline estimates. The combined cost overrun for the MDAP portfolio in 2015 was US$468 billion, up from US$295 billion in 2008.[2] Similarly, in the commercial aerospace market, aircraft manufacturers have continued to experience significant schedule delays and cost overruns in their new aircraft developments.

Looking ahead, our research indicates that although cost overruns and schedule delays are expected to continue through 2020, the magnitude of increase is likely to be gradual. In addition, this study has observed:

01

Total cost overruns have risen from 28 percent to 48 percent, from 2007 through 2015 and we forecast this will rise to 51 percent by 2020.[3]

02

Rate of increase of program costs has significantly declined from 51 percent year-over-year (YoY) increases between 2008 and 2012, to 5 percent increases from 2012 through 2015.[4]

03

80 percent of the growth in program cost occurred five years ago or prior to 2011.[5]

04

Number of programs in the current DoD portfolio and their total cost is at the lowest level since 2004, and reached its peak in 2009.[6]

05

Since 2008, only 14 major programs have entered the DoD program portfolio, which stands at 79 in 2015, compared to 95 in 2007 and 102 in 2009, respectively.[7]

06

72 percent of programs in the current portfolio kept their cost growth below 10 percent over the past five years, a substantial improvement compared to the 2011 portfolio, when only 47 percent of the programs met this metric.[8]

07

Programs in the current portfolio are either very new or very mature, with older programs already having experienced issues and now stabilized.

08

New programs in the portfolio have not yet reached those milestones when programs have historically experienced cost overruns.

09

Programs with the largest cost growth have resulted from quantity increases, process inefficiencies, design and technical modifications, and major restructuring such as combining programs and changing the mix of items purchased.

10

Some programs experienced cost reductions as a result of decreased quantities or program restructuring, which mainly combined or eliminated portions of the program.

High pressure on cost versus value drives proposal strategies that try to optimize cost by bidding the minimum acceptable technical solution and then anticipating subsequent changes. This in turn fuels cost and schedule overruns.

Improving program management processes and avoiding continued schedule delays and costly overruns entails, among other solutions:

- Identifying requirements early on and avoiding including additional requirements later in the process. Maintaining requirements from the start of a project keeps cost down and offers a more realistic estimate of how long a project takes to complete.
- Having realistic and feasible project cost estimates at the beginning of a program to help prevent them from rising steeply over the course of the program lifecycle.
- Using the knowledge-based approach recommended by the US Government Accountability Office (GAO) more extensively than what current adoption indicates.
- Providing proper incentives and empowering program managers, while also holding them accountable to solve problems and reduce risks by effectively addressing issues early.


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Introduction

It has been seven years since we published our study on cost overruns and schedule delays in the aerospace and defense (A&D) sector. There was at that time, and there continues to be, significant activity to try and address the systemic cost and schedule overruns that erode the buying power of A&D companies. These efforts included changes to the product development lifecycles, changes to the acquisition processes of MDAPs, and use of ever more sophisticated program development tools.

As we approach this year's election and the installation of a new administration, it is timely to look at the progress over the past seven years. And, as appropriate, again make recommendations on what can be done to abate this long term problem as it has become an ever more critical issue. While the focus of this study is the DoD and defense side of the A&D sector, manufacturers of commercial aircraft are also grappling with the same issues and therefore, our conclusions and recommendations are applicable for the commercial aerospace sub-sector as well.

Although a number of programs improved their buying power by finding efficiencies in development or production and requirements changes, cost and schedule growth remain significant. Specifically, companies competing for defense contracts face challenges of extensive and ever-changing regulations, increased costs, and instability of funding caused by sequestration, continuing resolutions, and lapses in appropriations. More importantly, with the advent of the Budget Control Act and the resultant effects of sequestration, there are even less acquisition dollars available and we now have the smallest number of MDAPs in the defense portfolio since 2003.

In the commercial aerospace market, increased aircraft demand due to increasing passenger miles drives the need to hold and shorten the development schedules of new models. However, recent evidence indicates the opposite. Publicly available data on commercial aircraft development indicates large budget overruns and schedule delays are common.[9]

Multiple major studies were commissioned by US presidents, secretaries of defense, Congress, government agencies, and universities on this topic. The GAO has also published numerous studies with recommendations for changes. However, schedule and cost slippages as well as shortfalls in technical performance, especially on defense acquisition programs, continue to persist.

To gain a deeper understanding of the issues associated with cost and schedule overruns for the A&D programs, we conducted interviews of multiple senior program managers from both government and commercial A&D organizations, performed extensive research from publicly available information of commercial A&D programs, and also analyzed MDAPs using the cost and schedule data published in the Department of Defense's "Selected Acquisition Reports."

This study looks at the progress that has been made since our 2009 assessment, explores the root causes seen today with respect to the key challenges associated with the continued trends of cost and schedule growth, and provides recommendations for sustainable and long-term improvement.

Cost overruns and schedule delays continue to grow, although at a slower pace

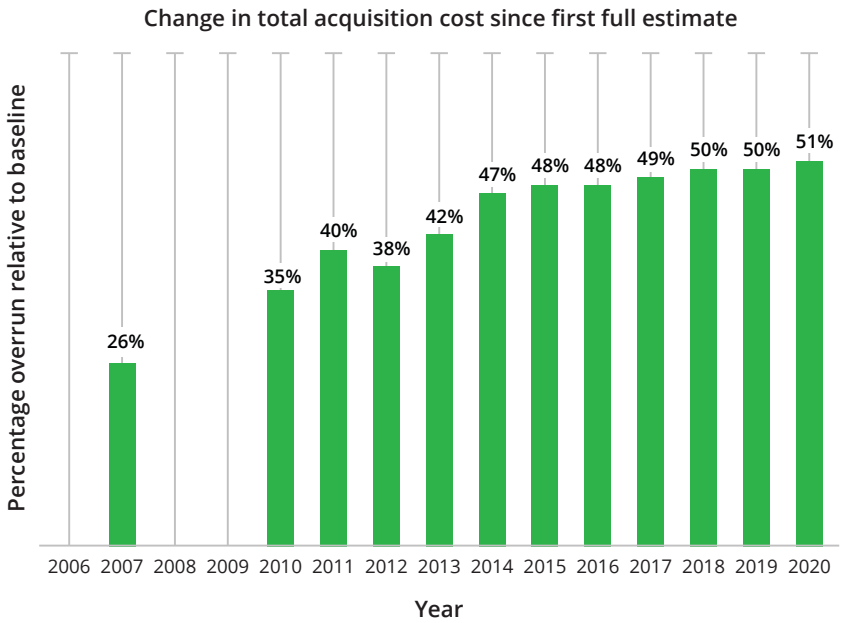
Our research indicates that over the past seven years, despite significant attention, the problem has persisted, albeit at a gradual rate.

Major weapons acquisition programs have continued their trend of cost growth and schedule delays. Total cost growth of today's MDAP portfolio over the original baseline estimates is 48.3 percent and an average delay of 29.5 months. In dollar terms, the combined cost overrun for all programs in 2015 was US$468 billion, up from US$295 billion from a similar study eight years ago.[10]

MDAP portfolio growth of only US$96 billion was seen in the last five years, providing some optimism that recent programs are doing better. Further, the number of programs in the current portfolio and their total cost are at their lowest level since 2004, when the DoD's portfolio of major acquisition programs reached its peak in terms of numbers of programs and cost in 2009.[11] This could likely be a result of relative maturity of the programs. Specifically, programs in the current portfolio are either very new or very mature, with older programs already having experienced issues and have now stabilized. The set of new programs in the portfolio have not yet reached the milestones where programs have historically experienced overruns.

When looking at the defense programs with the largest growth or largest declines, we find that those with the largest growth result from quantity increases, process inefficiencies, design/technical modifications, and major restructuring such as combining programs and changing the mix of items purchased. Programs that experienced cost reductions were a result of decreased quantities or program restructuring, which mainly combined or eliminated portions of the program.

Figure 1. Cost overruns are likely to continue, though at a slower rate



Source: Deloitte analysis based on data from GAO and on real baseline dollars.

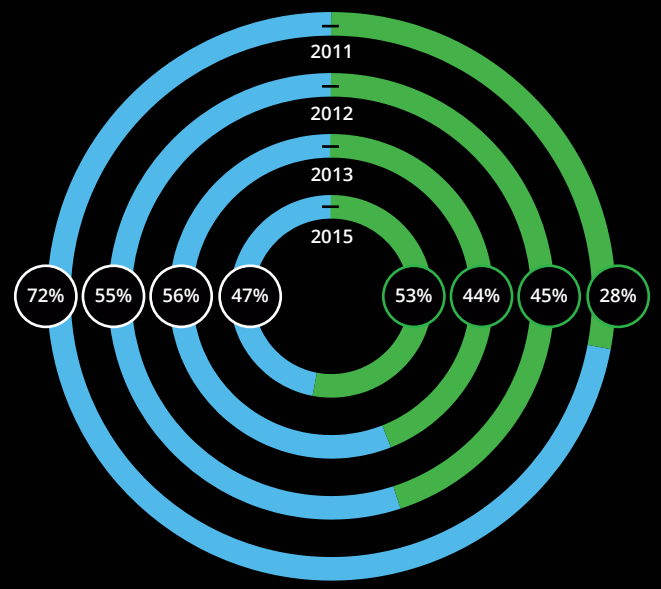
Data for 2006, 2008, and 2009 not published by GAO.

GAO, Office of Management and Budget (OMB), and the DoD measure cost performance of the programs using a set of metrics. According to these metrics, programs with less than 10 percent cost growth in the last five years and less than 15 percent cost growth from its first full estimate meet the metric. We observed from the GAO reports that 72 percent of programs in the 2015 program portfolio managed to keep their cost growth below 10 percent over the past five years, a substantial improvement compared to the 2011 portfolio, when only 47 percent of the programs met this metric.[13]

"In September 2010, Secretary Gates and I issued guidance to our acquisition workforce, entitled "Better Buying Power," which identified the principal changes we felt were necessary to improve the way the Department of Defense does business. These reforms would be important to apply in any budget environment, but they take on added significance given the defense budget cuts we face. The days when ever-rising budgets could cover poor program management are gone. These changes are already showing results in such big-ticket programs as the KC-46 Tanker (where an unprotested contract award ended a many-year drama and obtained a great deal for the Air Force), and our largest tactical aircraft, shipbuilding, and satellite programs."[12]

- Ash Carter
United States Secretary of Defense

Figure 2. Comparison of cost performance: 2011-2015



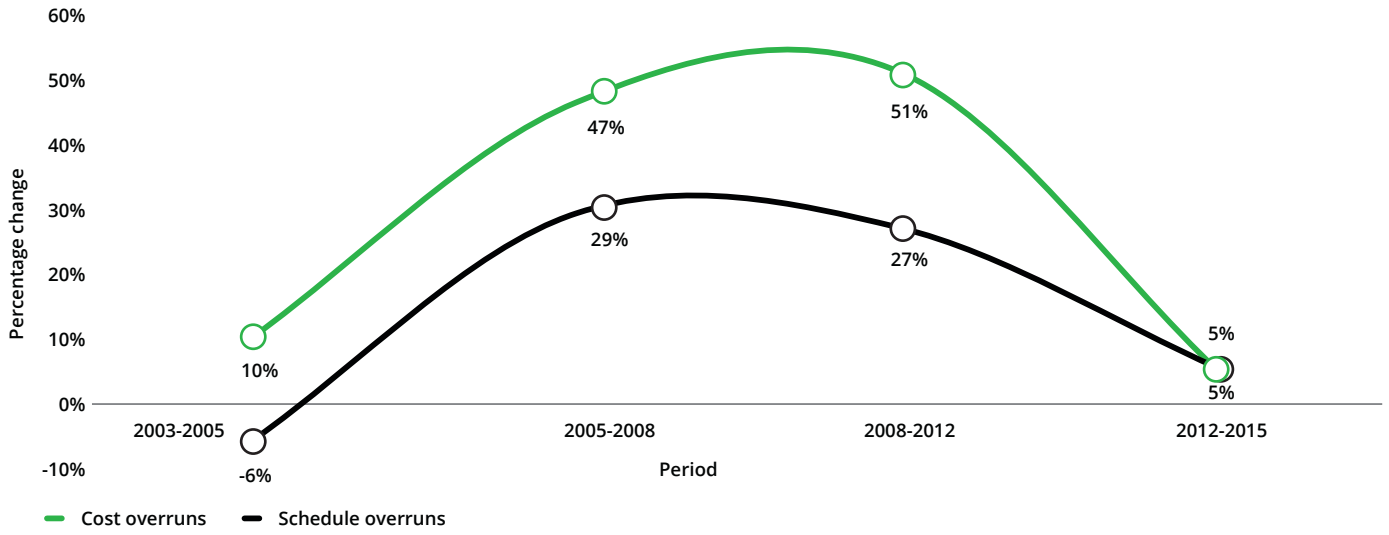
There is an evidence that the cost growth could be slowing as the cumulative cost growth of the 2015 MDAP portfolio over the 2010 to 2015 period was only 7.1 percent. There is also evidence that this is a result of a mature MDAP portfolio, specifically, the remaining programs are very mature by historical standards. Since 2008, only 14 major programs have entered the portfolio.[14]

- Percentage of programs that do not meet the metric
- Percentage of programs that meet the metric

Source: Deloitte analysis based on data from GAO

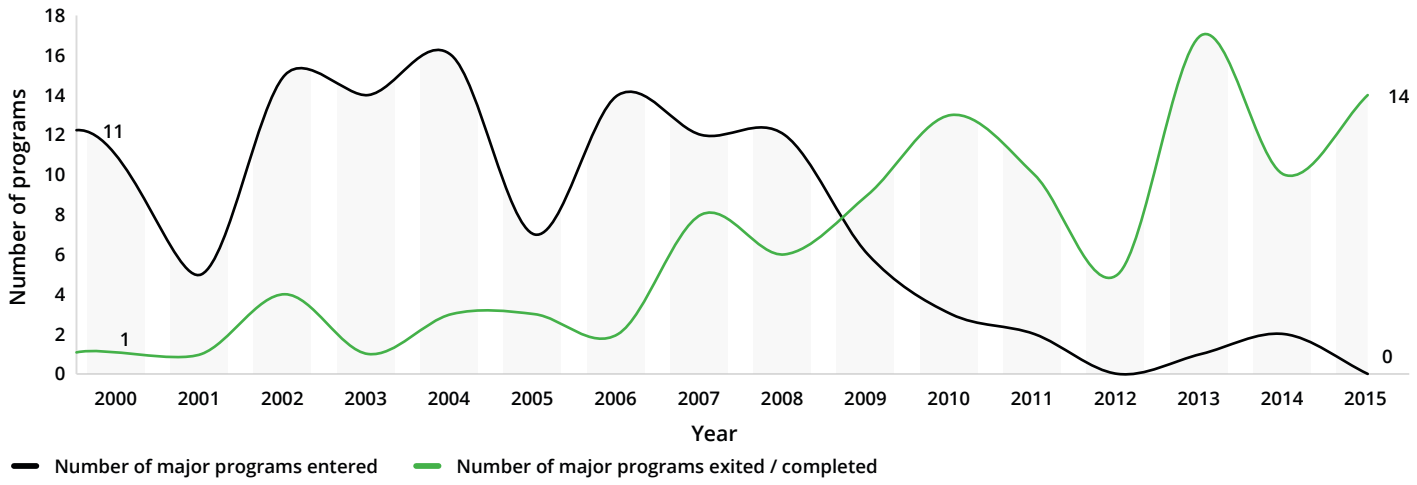
Note: For 2014, GAO did not calculate a 5-year comparison as there was no data published for December 2008

Figure 3. Increase in cost and schedule overruns of MDAP portfolio (2003-2015)



Source: Deloitte analysis based on data from GAO

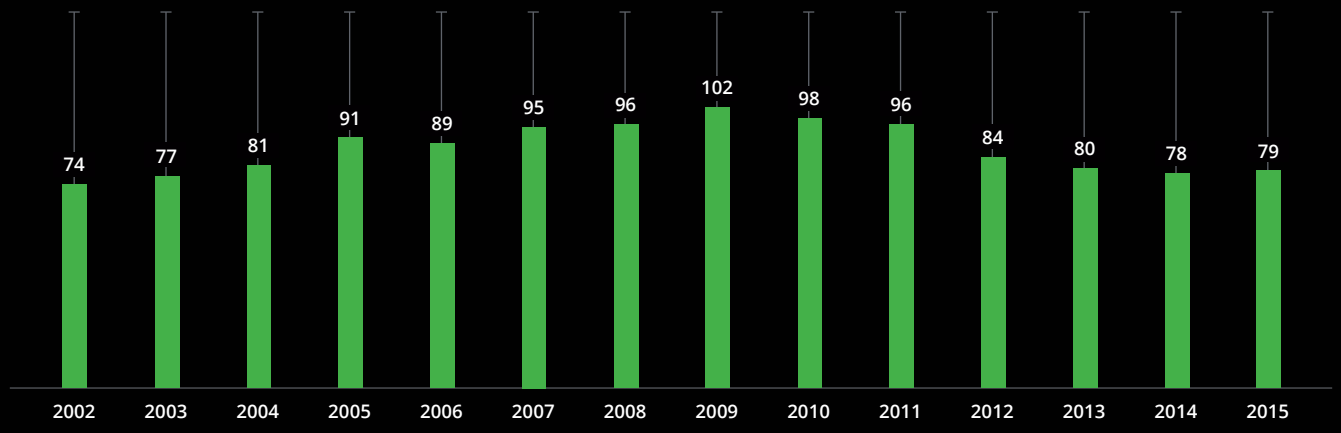
Figure 4. Number of major programs that entered and exited DoD portfolio (2000-2015)



Source: Deloitte analysis based on data from GAO

Moreover, the DoD's program portfolio stands at 79 at the end of 2015 as compared to 102 in 2009 and 95 in 2007.[15]

Figure 5. Number of major programs in DoD's portfolio (2002-2015)



Source: Deloitte analysis based on data from GAO

However, unless effective program acquisition reform is agreed upon and implemented, project cost and schedule overruns are likely to continue to increase through 2020, resulting in additional expenses and project delays for the Pentagon.

Even in the commercial aerospace market, aircraft manufacturers have continued to experience significant schedule delays and cost overruns in their new aircraft developments at all levels in the market, from the largest passenger aircraft to the mid-range executive jets. We have witnessed schedule delays ranging from 2 to 4 years and associated program cost growth of US$6 to 8 billion, and as much as US$26 billion for one of the major programs.[16]

Commercial aircraft manufacturers are under pressure to ramp up production to reduce their backlogs and in turn, the lead times to fulfill current orders have been reduced with increase in production rates. Consequently, it has become increasingly important that major development programs are managed efficiently and effectively as schedule delays may lead to OEMs losing aircraft orders to their competitors. For example, in July 2016, Qatar Airways stated that it is in discussions with Boeing to buy up to 30 narrowbody planes after it canceled the delivery of its first Airbus A320neo due to schedule delays.[17]

Environmental concerns, supply chain strategies, concentration of OEMs in a single region, and dependence on outsourcing have all contributed to delivery delays. Specifically, increased focus on addressing environmental concerns, has led to changes in manufacturing processes by aircraft makers. Furthermore, commercial aircraft manufacturers' inefficient supply chain strategies are impacting the entire value chain, with pressure of discounts and concessions on the suppliers. Major OEMs' engineering footprint were mostly outdated as majority of them had their commercial engineering unionized and heavily concentrated in a single region instead of being globalized. High dependence on outsourcing, including outsourcing of critical components, has been often resulting in integration issues.

"A350 program was in a big crisis earlier in 2016 due to serious supply chain delays. We have to put in place the foundations of this program now. It will be rolled out over the coming years and applied to all commercial programs."[18]

- Didier Evrard
Head of Programmes at Airbus

Understanding the root causes of the problem: Issues persist across the typical program lifecycle

As we looked at the information we gathered from our research, executive interviews, and DoD studies, we decided to report our findings in the context of a large program/platform development lifecycle to illustrate where in the lifecycle the issues exist and to offer solutions in that context.

Figure 6. Major program lifecycle phases

	Initial capability requirements	Technology and risk evaluation	Development	Production
Activities during key phases	• Overall need defined/ market gap to fill • Analysis of alternatives • Lifecycle cost analysis	• Affordability of program and available resources • Evaluation of likelihood of program success	• Capability development • Full system integration • Completion of manufacturing process • Test and evaluation	• Limited production • Full production • Operational deployment begins
Key issues	• Lack of understanding requirements in the early stages • Under-estimation/ improper planning	• Managing technological changes • Setting achievable and testable requirements	• Increasing regulatory requirements • Technical complexity	• Supply chain issues • Coordination between prime and suppliers • Production processes not under control

Source: Deloitte analysis

Initial capability requirements

A lack of understanding, early in the program, of what it is going to take to deliver the platform has resulted in the "appearance" of cost and schedule increases in both the commercial aircraft and defense markets. We believe this is most likely the result of optimistic planning.

Some of the examples of issues due to the initial capability requirements include:

- Use of composite materials requiring more testing to demonstrate performance and reliability
- Innovative and adaptive wing designs requiring more flight certification testing
- Integrating dissimilar materials
- Ineffective cost estimates and baseline schedule assessments

None of these actually failed, however, it required additional time and money to prove as compared to their traditional counterparts.

For instance, C919 faced program delays of four years due to its inexperience and its vigilant approach to ensure no safety issues cropped up. Also, the company had planned 20 percent of composite usage which was later cut to 10 percent to avoid complexity and likely delays.[21] Similarly, the MC-21 program experienced delays due to the company's attempt to use a new weight-saving composite technology.[22]

The Global 7000/8000 program's wing design to provide both short-field and long-range performance led to the delivery delay as meeting the dual requirements required redesign.[23]

It is important to make sure the initial capability requirements are not over-estimated and are reviewed continually in order to avoid any changes at a later stage.

If we heard one factor more frequently than any other, it was around requirement stability. Defining the requirements fully early in the program and then managing the changes with a strict program management discipline is important.

This phase primarily focuses on program affordability, availability of resources, and estimating the prospect of success of the program.

"18 percent of cost growth during product development is due to initial errors in cost estimation. A continuous cycle of reform, review and revision is required in the defense acquisition process."[19]

- Todd Harrison
Director of Defense Budget Analysis, Center for Strategic and International Studies (CSIS)

"Sometimes people do know that it's going to cost a lot more than they're actually fessing up to. Facing up to the truth in what we're seeking to develop, how much it's going to cost, what the risk is involved and the price tag of the risk, allows for an honest analysis of project pricing and outcome."[20]

- Tina Jonas
Former Comptroller for the DoD

Technology and risk evaluation

A few programs that faced issues during this phase resulting in cost and schedule overruns include:

- The DDG 51 *Arleigh Burke* class guided missile destroyers required substantial design modification, to incorporate the new Air and Missile Defense Radar (AMDR). With those changes and associated increases in the ships' displacement, the average cost per ship over the entire production run increased to US$1.9 billion in 2015 dollars, or approximately 15 percent more than the Navy's estimate of US$1.7 billion.[24]
- Also, the Standard Missile 6 program experienced cost overruns as it was decided at a later stage to modify it into an anti-ship missile, rather than just a ballistic missile defense weapon.

Technical complexity and the desire for technological innovations to be incorporated into today's sophisticated programs are contributing to the cost and schedule overruns we are seeing in large development programs. While A&D programs, weapon systems in particular, are more complex and sophisticated now, acquisition systems are not nimble enough for these programs that rely heavily on rapidly changing technologies. Increasing complexity of systems (for example, in F-35 combat aircraft) is one of the principal reasons that development times have increased significantly in the past few decades.

"Setting achievable and testable requirements is probably the most important part of the acquisition process, because if you get the requirements wrong at the beginning, it will eventually derail a whole program."[25]

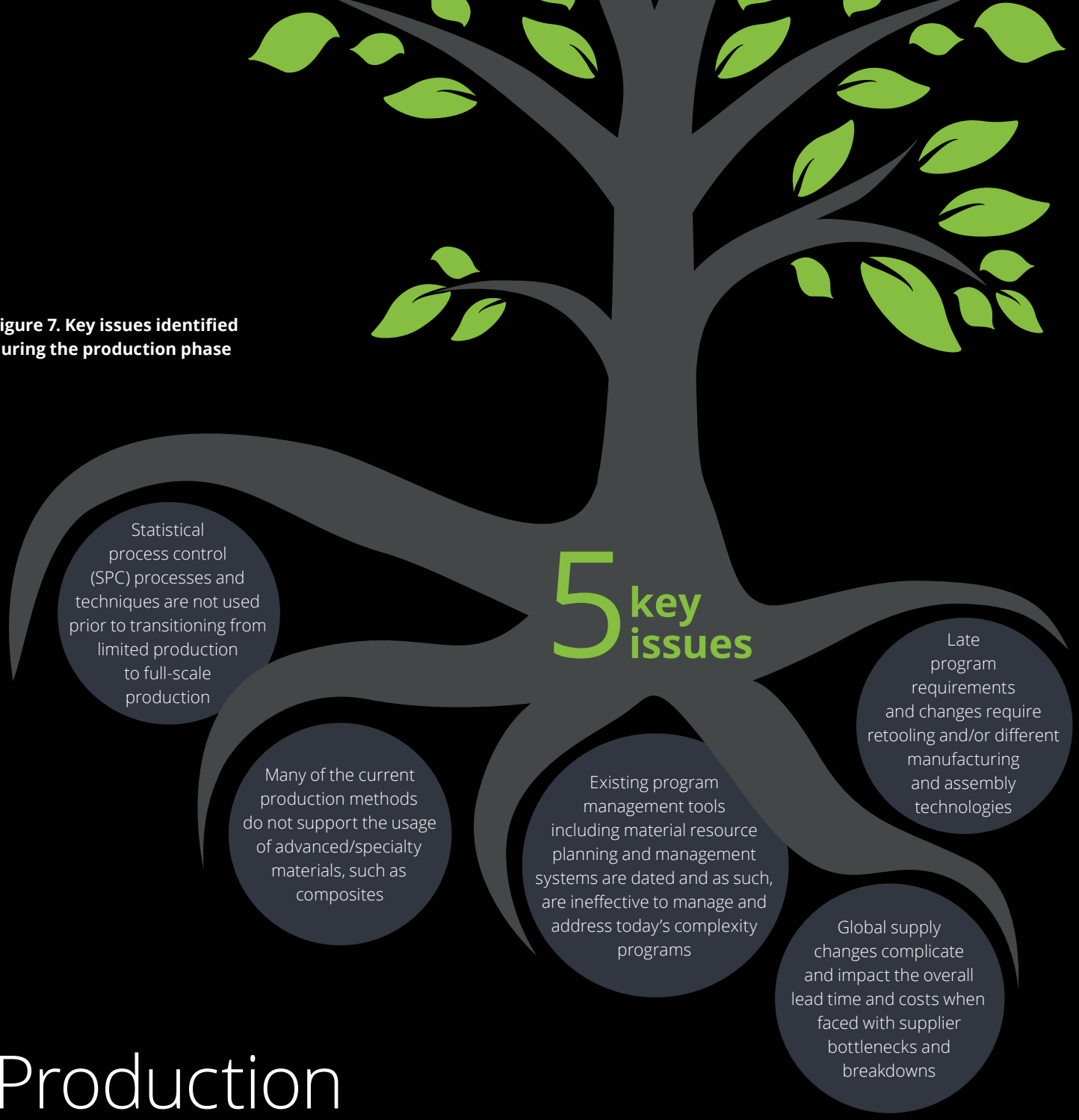
- Todd Harrison
Director of Defense Budget Analysis, Center for Strategic and International Studies (CSIS)

Development

We see the effects of this during the development phase of the program when we begin to try and integrate the myriad of elements and begin to test their performance:

- Increasing and changing regulatory requirements, such as environmental factors, have driven development requirements (such as carbon emission and noise limits) that require rework late in the lifecycle, contributing to cost and schedule increases.
- In the 787 Dreamliner program, the key composite structured elements failed during testing, which resulted in significant redesign and reviews causing US$26 billion in cost growth.[26]
- Both LHA 6 *America* class amphibious assault ship and Joint Direct Attack Munition programs experienced schedule delays and budget overruns due to the incorporation of technological advancements.

Figure 7. Key issues identified during the production phase



Production

The production phase includes commencement of production and operational deployment. There has to be effective coordination between the DoD and contractors during this phase in order to ensure a smooth flow of production without facing any hurdles. Lengthy purchase cycles lead to technology becoming obsolete during the phase of the acquisition process, weapon system and the technology being acquired becomes obsolete due to the prolonged purchase cycle. In various instances, this has resulted in modifications and subsequent costs as well as schedule delays. Such issues are more prevalent in new technologies and emerging threats such as cyber.

Cross-cutting contributing issues

Issues of cost and schedule overruns are cutting across all or some of these program phases:

- **Engagement between OEMs and suppliers/contractors.** There have been various instances where contractors have failed to understand OEMs' requirements to develop and deliver the best possible product in a timely fashion. Over the past many years, contractors have put in enormous efforts and spent huge time to convince the OEMs to buy the equipment manufactured by them in order to avoid losses.
- **Lengthy lifecycle.** Length of the program lifecycle of today's programs cause further issues such as changing technology, obsolescence, and frequent requirement changes.
- **Discipline.** It's often seen that proper discipline is not followed across the phases of a program, such as lack of scoping in the initial capability requirements. Time and again, special processes and procedures are based on only a few problems faced in the past, which are not likely to recur.
- **Communication.** There are excessive lines of communication and layers within the DoD acquisition domain. These involve program managers, deputy executive officers, executive officers, and then the higher ranks of the DoD acquisition, technology, and logistics office.
- **Program management tools.** There was a schedule delay for four years with huge cost overruns for the 787 Dreamliner program. One of the causes for the delay included the failure of Exostar, a web-based communications tool for suppliers to input information. In another instance, A380 Jumbo Jet program experienced a two-year schedule delay, where one of the reasons for the delay was the design inconsistencies due to different Computer Aided Design (CAD) software used by the OEM.
- **Culture.** Program managers have been working in an operating environment where the culture does not encourage prioritizing programs, making hard decisions, conducting tough analysis, and increasing focus on costs. Also, they have lesser authority and lack the ability to say no, i.e., they are not empowered to focus on building critical military capabilities while working to reduce non-core workforce and associated costs.
- **The widening skills gap.** US manufacturers, including those in the A&D sector, continue to report a sizeable gap between the science and engineering talent they need to keep growing their businesses and the talent they can actually find. According to Deloitte and the Manufacturing Institute's The Skills Gap in US Manufacturing study, six out of 10 manufacturing positions currently remain unfilled due to the talent shortage. Additionally, it takes an average of 94 days to recruit employees in the engineering field and an average of 70 days to recruit skilled production workers. The effects of the talent shortage are being felt in functions throughout the A&D companies. Specifically, the greatest impact of the skills shortage has been in maintaining or increasing production levels in line with customer demand and implementing new technologies while achieving productivity targets. The issue is growing and is exacerbated by a number of factors including baby boomer retirements, loss of embedded knowledge due to movement of experienced workers, a negative image of the manufacturing industry among younger generations, and lack of STEM (science, technology, engineering and mathematics) skills among workers.

> Ash Carter suggested that reducing number of people involved in acquisition process, which will include evaluating, "and where appropriate reducing" members of the Defense Acquisition Board, which currently is composed of 35 principals and advisers. "Reducing these layers will both free up staff time and focus decision-making energy on overcoming real obstacles to program success rather than bureaucratic hurdles," Carter said.[27]
>
> **- Ash Carter**
> United States Secretary of Defense

Recommendations: How can the A&D sector address program management issues?

01. Have realistic cost and schedule estimates.
To address cost estimation and other technical issues, contractors and program managers should be realistic about their expectations of their programs' accomplishments concerning timelines and budgets. Since implementing change and assessing the effects of major policy changes is a time consuming process, program managers and DoD leaders should be educated and encouraged to have patience. Anxiety by program managers to have and see on-ground improvements quickly could result in further new changes being made even before the reforms lead to a positive effect.

Follow a knowledge-based acquisition approach.
A&D sector will likely gain from leveraging a knowledge-based acquisition approach, where product developers ensure significant knowledge is attained during key development stages. As suggested by GAO in its "Assessments of Selected Weapon Programs" report published in March 2016,[28] key action areas include ensuring:

- technology, schedule, cost, and other resources are in line with customer's expectations
- design stability that meets performance expectations
- production is in line with cost, schedule, and quality objectives

02. Empower program managers and make them accountable.
Give program managers more responsibility and make them accountable throughout the project lifecycle. No-go decisions should be taken by program managers in cases where there are substantial changes that may result in the project being unviable or delayed unreasonably.

03. Leverage an advanced risk-based approach to managing acquisition programs.
The issue of a complex operating environment can be overcome by developing an advanced risk-based approach to managing acquisition programs. This can be done by considering the exclusive features of the weapon systems being acquired and the circumstances (funding, geopolitical climate, etc.) in which these procurements are being executed. Program managers should analyze past data to identify and increase focus on those programs or phases of programs, which are likely to experience challenges in the future, based on empirical data.

04. Follow engineering change discipline.
A discipline in terms of engineering changes should be followed strictly in order to restrict program management challenges. Implications of any changes once the critical design review is complete should be communicated clearly as such changes lead to both cost and schedule delays. Project requirements should be identified at an early stage and adding additional requirements later in the process should be avoided. Maintaining the requirements from the initial phase of the project can ensure low costs and can also provide a more accurate estimate of the project duration.

05. Ensure smooth cross-functional communication.

Program managers should ensure there is an effective and smooth cross-functional communication between teams. For instance, different engineering departments should clearly communicate with each other before committing any timelines to management. Lack of communication may lead to delays or budget overruns as inputs from some teams may be missing at the time of decision making.

Align R&D efforts with DoD's future needs.

Defense contractors' Internal Research and Development's (IRAD) spending decisions should be made keeping in mind the DoD's future needs as well as to avoid significant spending on developing weapons and equipment that the military does not actually need. For instance, to ensure Boeing's UCLASS drone fighter is equipped for long-range strike, intelligence, surveillance and reconnaissance missions, Pentagon decided to pause the program, which was a significant IRAD investment for the OEM.[29] So, it is highly recommended for the industry to align their internal R&D spending with what the DoD requires.

06. Engage with innovative niche players.

Large companies could benefit from improving engagement with small, innovative companies to harness their expertise to develop products and systems that are needed in a cost-effective and timely manner. Increased efforts should be made to engage with niche and innovative players, specifically startups from the technology hubs across the country, offering advanced solutions at a cheaper cost and faster pace. For example, Thales announced their xPlor innovation platform as they are seeking to engage a wider set of start-ups and an academic ecosystem to share ideas.

07. Work towards creating a supply of workers with strong skills.

Skilled engineers and production workers will be critical to the future competitiveness of A&D companies and the sector as a whole. A&D companies therefore, should take the lead in managing the talent crisis by designing strategies that not only optimize talent acquisition, and deployment, but also contribute to developing manufacturing and engineering skills in their communities. Fresh approaches in areas such as employer branding can generate big results when pursued in tandem with more traditional approaches. Similarly, many manufacturers are using a number of the same tactics to talent development that were being employed a decade ago. New performance tools and formal processes should be playing a larger role in any A&D manufacturer's talent management plan.

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Summary: Holding the line and staying on target

The A&D sector has been struggling with program management for decades. Major A&D programs, both commercial aerospace and defense systems are increasingly becoming more complex and sophisticated, leading to a significant increase in schedule delays and development costs. However, there have been improvements implemented, programs restructured, and decline in cost and schedule growth at the DoD during the past five years. This progress more likely is due to maturing programs and a significant decline in new program starts, although serious efforts by the acquisition community appear to be taking hold. However, as new DoD programs are introduced, cost and schedule challenges experienced previously could reappear without significant reforms and additional investments in acquisition and program management initiatives.

Significant and long-lasting improvements to program management in the A&D sector is possible by addressing the problem at the grass roots level. Key focus areas, among others, should include having realistic cost and schedule estimates, empowering program managers and making them accountable, and following a knowledge-based acquisition approach to programs.

Appendix

Figure 8: Key defense programs that witnessed significant cost variation
Amounts in US$ millions

Program	Current total acquisition cost	Cost estimate T-5	5 year change	5 year change (%)	Reasons for cost increase / decrease
Evolved Expendable Launch Vehicle	$60,497	$18,643	$41,854	224.5%	Causes for this cost growth include extension of the program life-cycle from 2020 to 2030, procurement of 60 additional launch vehicles, unstable nature of the demand for launch services. Also, according to DoD officials, the inefficient buying practice of purchasing one vehicle at a time also contributed to the increase in costs.
F-35 Joint Strike Fighter	$339,997	$308,807	$31,190	10.1%	A restructuring was initiated in early 2010 when the program's unit cost estimates exceeded critical thresholds established by statute. DoD commenced efforts to significantly restructure the program and establish a new acquisition program baseline. These restructuring efforts continued through 2011 and into 2012, during which time the department increased the program's cost estimates, extended its testing and delivery schedules, and reduced near-term aircraft procurement quantities.
DDG 51 *Arleigh Burke* class Guided Missile Destroyer	$115,169	$102,738	$12,431	12.1%	Substantially modify the design, which would incorporate the new Air and Missile Defense Radar (AMDR), now under development, which will be larger and more capable than the radar on current DDG 51 destroyers. With those changes and associated increases in the ships' displacement, the average cost per ship over the entire production run would be $1.9 billion in 2015 dollars, or about 15 percent more than the Navy's estimate of $1.7 billion.
Warfighter Information Network-Tactical Increment 2	$10,433	$5,165	$5,268	102.0%	Changes in the relative mix of items being procured include a higher percentage of more expensive items. Also, the WIN-T Increment 2 procurement schedule was extended by 10 years. According to program officials, future unit cost growth remains an ongoing concern and the program could be at risk of an additional unit cost breach if there are significant quantity changes in the future.
Handheld, Manpack, and Small Form Fit Radios	$9,130	$5,211	$3,919	75.2%	Issues faced in the testing phases, where the Manpack did not meet reliability requirements twice, leading to schedule delays and cost overruns. However, redesigning efforts have been able to resolve these problems.

Source: GAO, DoD, Deloitte analysis

Figure 8: Key defense programs that witnessed significant cost variation(contd.)
Amounts in US$ millions

Program	Current total acquisition cost	Cost estimate T-5	5 year change	5 year change (%)	Reasons for cost increase / decrease
LHA 6 *America* class amphibious assault ship	$9,971	$6,958	$3,013	43.3%	Witnessed increase in costs due to design changes and technological advancements.
EA-18G Growler aircraft	$15,305	$12,628	$2,677	21.2%	Increase in costs primarily attributed to increase in quantity.
AH-64E Apache Remanufacture	$13,992	$11,516	$2,476	21.5%	Cost increase due to upgradation efforts.
Standard Missile 6	$8,963	$6,679	$2,284	34.2%	Increase in cost as it is being modified to be an anti-ship missile, rather than just a ballistic missile defense weapon.
Joint Direct Attack Munition	$9,205	$6,947	$2,258	32.5%	Cost increased due to quantity increases and technological advancements.
Patriot Advanced Capability-3 Missile Segment Enhancement	$6,354	$8,361	($2,007)	-24.0%	Cost decrease primarily due to decrease in quantities from 1,528 units to 1,093 units and also due to due to the acceleration of the procurement buy profile.
KC-46 Tanker modernization program	$43,532	$47,011	($3,479)	-7.4%	Cost reduction led by a competitive award of an Aircrew Training Systems (ATS) contract in May 2013 as well as due to overall program risk reductions given the program's assessment, continued stability in execution and no engineering change orders. Other reasons include reduced MILCON costs based on site surveys and knowledge gained since contract award.
RQ-4A/B Global Hawk unmanned aircraft system	$10,039	$14,785	($4,746)	-32.1%	Mainly led by decrease in quantity.
Airborne and Maritime/Fixed Station Joint Tactical Radio System	$3,590	$8,953	($5,363)	-59.9%	Program went through a major restructuring; program previously planned to also acquire the Small Airborne Link 16 Terminal (SALT) radio, but, in August 2015, the Army directed program officials to close-out the SALT sub-program.

Source: GAO, DoD, Deloitte analysis

Figure 8: Key defense programs that witnessed significant cost variation (contd.)
Amounts in US$ millions

Program	Current total acquisition cost	Cost estimate T-5	5 year change	5 year change (%)	Reasons for cost increase / decrease
Warfighter Information Network-Tactical Increment 3	$2,025	$14,781	($12,756)	-86.3%	Went through a major restructuring which eliminated the requirements for hardware but retained the software development efforts. Restructuring of the WIN-T program was due to fiscal constraints that forced the Army to adjust its funding priorities and requirements.

Source: GAO, DoD, Deloitte analysis

Figure 9: Commercial aircraft programs that witnessed cost and schedule overruns

Program	Reasons for cost and schedule overruns
787 Dreamliner	Witnessed a schedule delay of 4 years with massive cost overruns, primarily due to complexity in the global supply chain, use of structural elements made of composites, and lack of supply chain and risk management experts
747-8	The program witnessed a two-year delay in the 747-8 led by limited availability of engineering resources within the company, changes in design, and factory worker's strike.
A380	Witnessed a two-year delay in schedule and a US$6.1 billion in cost overruns due to technical complexity of the aircraft - the aircraft's composite fuselage, high efficiency, and adaptive wings required extensive testing to prove consistency prior to entering into service.
A350-900	Witnessed delay and cost overruns as a certifying technology for the composite fuselage frames for the aircraft structure was absent initially. Also, A350-900 used advanced production techniques with over 1,000 lightweight 3D-printed resin parts in the initial production aircraft leading to delays.
C Series	Cost and schedule delays were led by issues from suppliers, longer than expected system integration processes, difficulties with certification flight testing, engine failure in one of the four test aircrafts, as well as order cancellations.
Global 7000/8000	The Global 7000/8000 program's wing design to provide both short-field and long-range performance led to the delivery delay as meeting the dual requirements required redesign.
C919	C919 faced program delays of 4 years due to its inexperience and its vigilant approach to ensure no safety issues crop up. Also, the company had planned 20 percent of composite usage initially, which was later cut to 10 percent to avoid complexity and likely delays.
Mitsubishi Regional Jet	MRJ program was delayed by 4 years as there were delays in the procurement of engines and other components, which delayed flight testing. The program also had aircraft weight issues.

Source: Airbus, Boeing, Bombardier, Deloitte analysis

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