# Commercial-off-the-Shelf (COTS) Obsolescence: Identification of Strategies for Minimizing its Negative Impacts to Company XYZ

by

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## Abstract

This study identifies strategic solutions to the problems Commercial-off-the-shelf (COTS) product obsolescence creates for defense contractors and the programs they support. COTS products allow defense contractors to design systems at much lower initial costs by leveraging COTS products created for a larger consumer market, but Total Ownership Costs (TOC) can end up being much larger than expected if careful lifecycle obsolescence planning does not take place (Enslen & Doray, 2002). COTS obsolescence is a significant problem for defense contractors as most COTS products have two to three year life spans while defense programs have significantly longer life spans of 20-30 years (Edwards, 2009). While there is no one solve-all solution to this problem, there are several strategies defense contractors, such as Company XYZ, can take advantage of to minimize the negative impacts of COTS obsolescence to cost and schedule. In this study,

several strategies will be collected through reviewed literature involving the topic of COTS obsolescence. The Company XYZ common procedure titled "Lifecycle Obsolescence Management" (2009) will be analyzed to determine if the strategies collected through the other literature reviewed are included in the common procedure. The ultimate goal is to identify possible strategies missing from the Company XYZ "Lifecycle Obsolescence Management" common procedure that should be further investigated for possible future inclusion.

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# Chapter I: Introduction

It is not likely that the average user of electronics is very concerned about obsolescence in the same way defense contractors need to be. Obsolescence to an average user of electronics means it's simply time to replace a device with a newer and likely better one. Unfortunately, for the defense industry, the answer isn't always so simple. With complex software interfaces developed, weapon system certification issues, custom shock isolated mounting kits, and an extensive sustainment trail, obsolescence to key Commercial Off-The Shelf (COTS) electronic components can be detrimental to a defense program's cost and schedule when there is a scramble to replace a product that has gone End-of- Life (EOL), in other words, the product is not sold or supported any longer. It is not always as simple as choosing a replacement product with similar function. In many cases, a replacement product with the exact same form, fit, and function cannot be found. The custom mounting kits could require updates, along with control software. It could even require re-design in part or full of the system architecture affecting more than just the obsolete component in order to continue to meet system requirements (Francis, 2006). While COTS components can provide lower cost solutions than using legacy components or developing of new components, the lifecycle cost (LC) can end up being higher. COTS products have much shorter lifecycles and can present significant surprises affecting cost and schedule of defense programs (Adams, 2005). While COTS obsolescence presents a significant problem for the defense industry, it also provides an opportunity for defense programs to lower TOC and improve schedules through improved COTS product management involving the use of several strategies for dealing with COTS obsolescence.

*Purpose/Goal of the Study*

The purpose of this study is to identify through a literature review what strategies exist to defense contractors to deal with the problem of COTS product obsolescence. The study will further determine if the strategies found in the literature review are being covered in the Company XYZ, common procedure titled "Lifecycle Obsolescence Management." The researcher is an engineer with a technological background but hopes learning more about other factors like lifecycle support for obsolescence issues will help provide him with a big picture view of defense program lifecycles. While the researcher believes gaining this big picture view will help him to make better future contributions to strategy planning around COTS obsolescence, the researcher also hopes this study will create a contribution to Company XYZ by identifying which strategies identified throughout the literature review could be considered for addition or expansion to the Company XYZ common procedure titled "Lifecycle Obsolescence Management." The ultimate goal of identifying any missing strategy areas is to bring to the awareness possible opportunities for improvement to the Company XYZ common procedure, "Lifecycle Obsolescence Management."

*Background and Significance*

The defense industry once provided a significant market for the electronics industry but now it constitutes less than 1% of the commercial market (*Aging Avionics*, 2001). It is estimated that 60% of semiconductor chips made are for personal computers or cellular phones alone (Edwards, 2009). The increase in consumer electronics demand and production has lead to new innovations and lower costs. State-of-the-art electronics components are virtually all commercial now, that is, available to the average consumer (Adams, 2005). The military with the help of its defense contractors has been taking advantage of the cutting edge technology and lower up-front costs that Commercial Off-The Shelf (COTS) products have to offer. While using COTS products avoids development headaches and costs of supporting legacy products or designing custom products, it also introduces problems of its own (Ames, 2004).

According to Ames (2004), "The obsolescence problem may be the thorniest…as systems take longer to design than the lifetime of the products inside them" (p. 3). Consumer electronics are made and supported for 2-3 years while 20-30 year life spans are common on defense programs. Military customers are faced with problem of buying COTS products after suppliers have lost interest in making them. The volumes are typically very low on military programs, so the influence on most manufacturers to accommodate the program by continuing to make the component is negligible. This is a very significant change. Thirty years ago, the defense industry practically owned the electronics industry (Edwards, 2009).

While up-front costs for COTS components are typically far less than legacy components and drastically less than designing a custom component for the same purpose, programs which do not manage COTS obsolescence properly in too many cases are experiencing total ownerships costs (TOCs) which are soaring out of control. In some cases, this requires systems to be prematurely taken out of service (Enslen & Doray, 2002). The Navy, alone, estimates that COTS obsolescence costs $750 million per year and hopes to reduce figure by about half. In 2005, the Department of Defense (DoD) called for a unified approach to obsolescence management (Adams, 2005).

The "Diminishing Manufacturing Sources and Material Shortages (DMSMS) Management Plan Guidance" was published by the Office of the Assistant Secretary of the Navy in April of 2005. Obsolescence is referred to as a DMSMS issue by the DoD. DMSMS includes COTS Obsolescence issues ("Diminishing Manufacturing," 2005). This study focuses on tackling the unique obsolescence problems characterized by the use of COTS products by defense programs. With that said, the "DMSMS Management Plan Guidance" does provide assistance to programs for developing a plan that encompasses the best practices for COTS Obsolescence Management ("Diminishing Manufacturing," 2005).

Despite the problem of COTS obsolescence, there are still advantages to using COTS. In the pre-COTS days, military customers got stuck on single supplier driving up costs and lowering quality (Ames, 2004). While defense contractors had much more influence over what products were made and how long they were in production, the influence just about stopped there as many times they were limited to working with one supplier which prevented competition. COTS products have a lot to offer the defense programs and are not going anywhere. Neither are their obsolescence issues. There is no one simple answer to this complex problem. Defense contractors must continue to battle this problem from many angles, both proactive and reactive, to reap the full benefits of COTS by lowering Total Ownership Cost (TOC) growth that results from unplanned obsolescence (Cavill, 2000).

If Company XYZ does not have some or all of the known strategies in place for dealing with COTS obsolescence, there is opportunity for growth by Company XYZ.

*Assumptions of the study*

There are some assumptions made in this study. The first assumption are that strategies covered in a relevant book or peer reviewed academic journal are assumed to be existent and plausible strategies. It is also assumed that defense programs supported by Company XYZ follow the documented common procedure titled "Lifecycle Obsolescence Management" and therefore the common procedures followed are the same as those documented. In reality, since no two programs are exactly alike, a common procedure cannot be followed verbatim by all programs. Since the primary intent of this study is to identify possible improvement areas to the common procedure through suggested improvements to the documented Company XYZ common procedure for lifecycle obsolescence management, it is assumed for the purposes of this study that all programs follow the documented procedure.

*Definition of terms*

Blade Chassis – A chassis which holds multiple blade servers, including support for new technology insertion ("IBM Solutions," 2010)

Bridge Buy - A limited quantity of parts that is procured to satisfy near-term requirements until a long term solution is achieved. ("Lifecycle Obsolescence," 2009)

Contingency Plan – a plan that is developed and ready for execution in the event that mitigation efforts fail and a risk occurs (Heldman, 2005)

Commercial Off-The Shelf (COTS) - An item developed by a supplier for multiple customers whose design and configuration is controlled by the supplier's or an industry specification. ("Lifecycle Obsolescence", 2009)

Contractual Lifetime Support (CLS) – non-obsolescence agreements contracted through suppliers where the supplier agrees to provide form, fit, function equivalent products throughout lifetime of the program (Francis, 2006)

Diminishing Manufacturing Sources and Material Shortages (DMSMS) – The loss or impending loss of manufacturers of items or suppliers of items or raw materials may cause material shortages that endanger a weapon system's or equipment's development, production, or post-production support capability ("Diminishing Manufacturing," 2005)

End-of-Life ( EOL) – when a product is no longer sold and/or supported ("Lifecycle Obsolescence," 2009)

Form, Fit, and Function (3F) - Physical, functional, and performance characteristics or specifications that uniquely identify a component or device and determine its interchangeability in a system ("Form-fit-function", 2010)

Lifecycle Cost (LC) – The costs associated with the entire lifecycle including program kick-off, through sustainment, and even through conclusion (Adams, 2005)

Lifetime Buy - The purchase of a sufficient quantity of a part to support total demands of that part for the projected service life of the system/equipment. ("Lifecycle Obsolescence," 2009)

Open Architecture – Development efforts which involve decoupling the hardware and software elements of a system (Bradley, 2007)

Technology Insertion – A change that incorporates the next generation product or product upgrade to an existing technology or component that improves overall system functionality. A technology insertion may require redesign of the next higher assembly, and re-certification. ("Diminished Manufacturing," 2005)

Technology Refresh – A change that incorporates a new product to avoid product end of life or product obsolescence or to correct a problem based on customer feedback. The refreshment may or may not have the same Form, Fit, and Function (3F), and can occur at anytime in the life cycle. Re-certification or certification will be required. ("Diminished Manufacturing," 2005)

Technology Roadmapping - Technique for technology planning which identifies technology advances and trends to help programs make better technology investment decisions. ("Lifecycle Obsolescence," 2009)

Total Ownership Cost (TOC) – Synonymous with Lifecycle Cost

VME – Virtual Machine Environment (Kirk, 2008)

## Chapter II: Literature Review

This chapter discusses literature reviewed related to the background of COTS obsolescence and strategies for managing its negative impacts. The literature review will discuss strategies for coping with the problem of COTS obsolescence. Fortunately, several common process strategies to minimize the negative impact that COTS obsolescence can have on a defense program's cost, schedule, and performance were found in the literature reviewed. This literature review will identify what strategies are being used in the defense industry and similar industries so the strategies can later be determined if they are being covered by the Company XYZ common procedure "Lifecycle Obsolescence Management."

While there was no one answer found in the literature review to deal with all the problems associated with COTS obsolescence, there were several strategies identified in the literature reviewed to help minimize the negative impacts of COTS obsolescence. The strategies found were organized into key strategy points which will be covered in this chapter and include:

1) Consider Obsolescence during Design Phase/Component Selection
2) Vendor Selection/Relations
3) Technology Roadmapping/Component Obsolescence Monitoring
4) Use of Open Architecture
5) Lifetime or Bridge Buys
6) Contingency Plans
7) Adopted COTS Obsolescence/Lifecycle Management Plan

*Consider Obsolescence during Design Phase/Component Selection*

Considering COTS obsolescence during design phase and component selection was the most heavily referenced strategy in all the academic journals and best practice strategy guides reviewed for this study. According to Francis (2007), "The first necessity is to nip problems in the bud by preventing obsolescence problems in the first place" (p. 24). According to the Company XYZ common procedure "Lifecycle Obsolescence Management" (2009), "Studies have shown that 60 to 80 percent of total operating costs (TOC) is committed during the early stages of the design" (p. 1). By proactively addressing obsolescence issues early on during the design phase, system and component designers have more options open to them to design the system in a way that minimizes life cycle costs (Enslen & Doray, 2002).

Impacts of early design decisions on lifecycle costs need to be closely probed. System and component designers need to be well-trained to implement good obsolescence avoidance techniques throughout the complete design process. It is imperative that lifecycle costs associated with obsolescence are considered in conjunction with technical performance. A design that meets performance objectives, even if it has lowest up-front costs for COTS hardware, does not mean it will be the best design in terms of life cycle costs and obsolescence avoidance. Frequently, in acquisition programs, the Department of Defense (DoD) underfunds logistics and cuts too deeply into supportability-related tasks. As a result of today's tight budgets and schedules, acquisition program managers are forced to steer away from activities not directly related to design. Frequently the attitude is that since funds are barely able to support design and built activities, the lifecycle obsolescence issues can just be worried about later. Unfortunately, later is too late. The program is a great success when the end item is fielded under budget as program sponsors are promoted. Everything is fine until five to ten years later when the aircraft or other systems start piling up on the tarmac (Enslen & Doray, 2002).

According to Enslen and Doray (2002), "A comparatively small increase in acquisition cost to embrace early obsolescence program will reap the benefits of greater TOC avoidance [lower lifecycle costs] and increased readiness [throughout the lifecycle of the program]." With adequate funding to involve lifecycle logistics support in the early design phases and additional funding made available for selection of components with less obsolescence issues or components which allow for easy insertion of new technologies, total ownership cost can actually end up being lower. According to Edwards (2009), "To help manage the situation at design time – and avoid incorporating parts that are likely to disappear quickly – the bigger defense contractors have built databases to help score components in terms of their obsolescence risk" (p. 41). Since these tools are available to company XYZ, a program can involve lifecycle logistics support in the early design activities to help combat obsolescence costs, helping to select components that are more likely to have longer life spans. Taking this step to avoid COTS obsolescence costs is still only a partial solution. Recall from Chapter 1, according to Edwards (2009), "The problem is that few consumer electronic products are made and supported for more than two or three years, let alone the 20 or 30 years that the military programs need" (p. 40). There is still a clear gap to meet the need of the programs that cannot be solved strictly through selecting components with lower obsolescence risks.

Another strategy found in the literature review to minimize lifecycle costs associated with COTS obsolescence is to plan for new technology insertion at design time. According to Phil Angelotti, Director of Defense and Aerospace Sales at Corfin Industries LLC in Salem, N.H., as quoted in article authored by Ames (2004):

> Changing the hardware itself is a three to seven-year timeframe, so it will always be a problem to use newer technologies. There's no way around it, designers can plan for that obsolescence by building each system with the assumption they will soon have to take it apart to replace old parts. (p. 4)

According to Frank Willis, Vice President of SBS Technologies in Albuquerque N.M., as quoted in article authored by Ames (2004), "Being a COTS supplier, I know that the problem will not go away. Customers are looking for 30-year boxes with three-year electronics, so we need to design them ready for technology refit and insertion" (p. 4). It is clear to see that some COTS vendors, while they are not interested in providing the same parts for 30-years, are willing to provide solutions that minimize impacts of COTS obsolescence by designing systems that are more accommodating to new technology insertion. This planning also requires another strategy found in the researcher's literature review involving supportive vendor relationships that will also be covered in this chapter.

According to Gareth Williams, director of Plextek's digital engineering group, as quoted in article authored by Edwards (2009), "It is a constant worry for them. And because their volumes are so low they are always going to struggle" (p. 40). Recall from Chapter 1, the defense market's share in the electronics industry has been severely dwarfed by consumer electronics and the industry is generally not interested in providing the same exact products for the life span needed by military programs. This reinforces the point that few components are going to be available for the life span needed and this obsolescence must be planned for at design time.

One option available to defense programs that can be considered in the early design phases and has been very successful in handling obsolescence and technology insertion are Virtual Machine Environment (VME) Chassis. Steve Cecil was employed by NAVSEA Crane for over 13 years and assisted the Department of Defense in adopting commercial technologies. According to Cecil (2002), "VMEbus boards and systems in general are performing better than expected." In a memo, he discussed a system where 90 VMEbus single-board computers, all with the same part number, providing 30 different functions in the system. The company selling the boards informed them that one of the boards had a component obsolescence issue and did extraordinary efforts to make the replacement form, fit, and function compatible (Cecil, 2002). VME Chassis allow for the VME boards to be easily changed out without affecting the chassis mounting whatsoever. VME Chassis, as an open architecture, is a prime candidate for a design that allows for easy insertion of new technologies (Kirk, 2008).

There are other similar options on the market where a chassis with a comparatively longer lifespan can be chosen to hold boards with shorter life spans. These boards can typically be replaced with reverse compatible newer versions of the boards when obsolescence occurs. One example is a blade chassis that holds blade servers which function exactly as regular computer servers from the same family of processors as Intel-based desktop or laptop PCs. New servers can be installed without affecting rack-mounting whatsoever. Also, the chassis typically allows for reverse compatibility for a variety of CPU architectures ("IBM Solutions," 2010).

All of the authors in the various works of literature reviewed surrounding COTS obsolescence mitigation strategies agreed that a strategy to coping with COTS obsolescence is planning for it at design time. The two most noted approaches were choosing COTS components based on obsolescence risks and choosing components that allow for easy insertion of new technology. Several authors agree that both approaches need to be taken in parallel and should be included as a part of any design decision planning or modeling. Also, all of the literature reviewed agreed that COTS obsolescence planning must be considered throughout the lifecycle of the program, therefore the strategies involving just the design phase that have been presented thus far are not the only ones that need to be considered.

*Vendor Selection/Relations*

Another common strategy that was a recurring trend throughout the works reviewed in the literature review for this study was the importance of choosing the appropriate vendors and keeping good relations. Several of the works pointed out that there are vendors out there willing to work with defense contractors unique COTS obsolescence issues and help plan for technology insertion. According to Steve Cecil (2002) of NAVSEA Crane, in reference to an obsolescence issue with his VMEbus vendor supporting a system of 90 boards he states, "They bent over backwards to make it [the replacement product] form, fit, and function compatible with the previous version of the product." The importance of choosing appropriate suppliers was emphasized at a recent conference (Bradley 2007).

At Asia Pacific Engineering Conference – Aleaide 2007, according to Maureen Bradley (2007), "small suppliers may specifically cater to the military market." In addition, small suppliers, according to Bradley (2007), "May be more willing to modify, enhance or develop a product for a specific contractor application, manufacture and support a product for a protracted time-frame, work with contractors on changes to components and firmware, and accept contractual conditions." There are also several risks among small suppliers that must be considered. Among these are, according to Bradley (2007) "May be less able to weather military market fluctuations; Generally more likely to merge or be procured; Smaller number of personnel with knowledge of product; Product less-likely to be mainstream."

At the conference the benefits and risks of large suppliers were also discussed. The benefits of large suppliers, according to Bradley (2007), "Generally more financially stable than smaller suppliers; offer solutions that are more mainstream; less expensive if a mainstream product is used; technical support for current products is generally robust." Among the risks cited around using larger suppliers according to Bradley (2007):

> Typically, [large suppliers] do not cater to the military/defense sector – limited influence in modifications, enhancements or new designs; may be unwilling to work with contractors to maintain configuration control, change parts without notice – but keep the part number the same; may change firmware without notice; limited technical support for products no longer manufactured; limited contracting flexibility.

The risks and benefits of small and large suppliers need to be carefully considered around the needs of the specific program.

Another strategy for handling vendor relations are contractual lifetime support (CLS) plans. According to an author for the IET Electronics Systems and Software journal, Lloyd Francis (2007):

> Many component manufacturers are beginning to offer contractual lifetime support (CLS) plans or non-obsolescence policies to eliminate the problem altogether. However it is worth noting that, valuable though these can be, they cannot be accepted at face value. Purchasing and engineering professionals need to work together to ensure that such guarantees are technically achievable. (p. 24)

While it is fortunate that such contracts are offered by component vendors creating a useful tool for defense contractors, a piece of paper obviously does not take the place of COTS obsolescence management. One cannot forget that the vendors offering the contracts and the vendors of their subcomponents are all part of an aggressive and volatile market and could go out of business leaving the CLS useless. These contracts can be useful tools in vendor relations but can never be taken at face value without investigation into technical feasibility. This investigation still requires effective COTS obsolescence management and affirms that this is just one of many strategies that can be used to mitigate risks associated with COTS obsolescence (Francis, 2007).

When all proactive measures to prevent COTS obsolescence have failed and obsolete components must still be procured, End of Life (EOL) suppliers fortunately exist as an option. According to the editor-in-chief of COTS Journal, Jeff Child (2009), "Fortunately, there's a well-established infrastructure of companies and government organizations in the business of addressing the obsolescence." The COTS Journal includes an Annual End-of-Life Supplier directory which lists companies and government organizations that can help acquire components that are obsolete.

Based on all of the literature reviewed it is clear to see that there are some vendors who are more willing to work with defense contractors to help solve their COTS obsolescence issues. The authors agreed that vendors must be carefully selected based on the needs of the program. Since there is a still a large gap in the lifespan of commercial electronics and defense programs, choosing good vendors and keeping good vendor relations alone will not mitigate all the risks associated with COTS obsolescence.

*Technology Roadmapping /Component Obsolescence Monitoring*

Technology roadmapping is a strategy cited by many of the authors in the literature reviewed as going hand-in-hand with vendor relations. It was found that defense contractors need to manage their vendors and product selections carefully through technology roadmapping. Robert Phaal belongs to the Centre for Technology Management at University of Cambridge. According to Phaal (n.d.):

> The technology roadmapping method is used widely in industry to support technology and strategy planning. The approach was originally developed by Motorola more than 25 years ago, to support integrated product-technology planning. Since then the technique has been adapted and applied in a wide variety of industrial contexts, at the company and sector levels. Technology roadmaps can take many forms, but generally comprise multi-layered time-based graphical charts that enable technology developments to be aligned with market trends and drivers. (p. 1)

Since technology roadmapping has became such a commonplace tool in the electronics industry, the defense contractors can greatly benefit from following vendor and product technology roadmaps and creating technology roadmaps of their own for the program.

In a Logistics Spectrum journal article, the first key concept listed that should be part of any COTS implementation program is, according to Enslen and Doray (2002), "Technology management by means of market research, including surveillance of leading edge technologies, investigation of promising commercial products and assessing technology trends." One of the key concepts Maureen Bradley (2007) noted at the Asia Pacific System Engineering Conference – Adelaide, was the importance of observing the marketplace. She notes that it is important to monitor suppliers market share and viability. She also pointed out that it is important to ask questions such as, "How often does the technology endure? How long does a product line within the technology last? How long will a specific board last?" (Bradley, 2007). Having this information will help programs make better decisions to help minimize the negative impacts of COTS obsolescence.

The components in a design must continue to be monitored carefully for supply health after it is selected for a design. Lloyd Francis is a writer for IET Electronics Systems and Software journal. According to Francis (2006):

> Component engineering professionals must begin to monitor the health of supply of devices as soon as they are added to the design parts list. This stricture may sound overly cautious but, with military and aerospace design cycles routinely lasting from five to eight years, it is likely that a good proportion of COTS components on the design parts list will not just suffer supply problems, but will become obsolete altogether before production even begins. (p. 23)

This volatility makes it clear for the need of defense programs to have a plan in place to carefully monitor the marketplace, technology trends, and component health.

The *FAA COTS Risk Mitigation Guide: Practical Methods for Effective COTS Acquistion and Lifecycle Support* lists a key mitigation strategy to working with COTS as performing continuous COTS product market research. According to the guide authored by Shaffer and Mcpherson (2002),

> Market research allows the acquiring activity to:
>
> - Proactively anticipate obsolescence situations due to rapid and asynchronous product changes
> - Plan and budget using a broader range of product obsolescence management options rather than incur higher life cycle costs due to more limited and costly reactive solutions
> - Maintain insight into technology trends as well as internal product changes by the manufacturer to be able to test the effects of those changes to the system if necessary
> - Assess the quality of a manufacturer, the impact of the product change to a system, its suitability for the user, its information security characteristics and its supportability
> - Determine the project manufacturer support period and inventories for a particular product (p.17)

These benefits emphasize the point that technology roadmapping is a powerful tool that needs to be a part of a successful COTS obsolescence mitigation plan.

The *FAA COTS Risk Mitigation Guide: Practical Methods for Effective COTS Acquisition and Life Cycle Support* also discussed when and how to implement COTS product market research. The guide emphasizes that market research needs to occur in all of the system's life cycle phases. Ongoing market research needs to occur through Mission and Investment Analysis. It even continues after design to focus on system product obsolescence projections and the availability of alternate form, fit, and function compatible substitute products. The guide indicates this market surveillance can be done using several methods including internet searches, attending trade shows, technology publications, hiring consultants, screening information requests (SIRSs) to prospective manufacturers/suppliers, manufacturer supplier visits, and product demonstrations. The guide further states that ignoring this strategy will lead to a greater likeliness of subpar product and technology selections. It will also lead to the inability to predict and mitigate COTS product obsolescence impacts. The FAA guide concludes that market surveillance is the most important strategy for both new start or fielded systems (Shaffer & McPherson, 2002).

Technology roadmapping and component health monitoring strategies appeared heavily throughout all the literature reviewed around mitigation strategies. The fact that these strategies are important is backed up by the FAA stating that market surveillance is the most important risk mitigation strategy that any successful COTS Lifecycle or Obsolescence Management plan needs to involve these strategies (Shaffer & McPherson, 2002).

*Use of Open Architecture*

Another common trend strategy found in the literature review is combating risks associated with COTS obsolescence through the use of open architecture. By using open architecture (OA), software is able to be run on a variety of hardware platforms. Since the software is less dependent on the specific hardware, it will allow hardware changes due to COTS obsolescence or technology insertion to not impact the software design, thus mitigating risks associated with the cost of redesigning software each time the hardware needs to change due to obsolescence. While open architecture should be considered for new systems, it is going to take several years to retro-fit OA. There will also still be mechanical and technology changes that need to be managed (Bradley, 2007).

*Lifetime or Bridge Buys*

Lifetime and bridge buys can be used as strategies but all of the authors in the literature reviewed around this subject cautioned that they need to be carefully considered and programs need to heed many warnings when considering them. A lifetime buy is when enough of a component is purchased to support the predicted number of spares needed throughout the lifespan of the program. A bridge buy is when enough of a component is purchased to support the predicted number of spares needed until the next planned technology refresh for the program (Tomczykowski, 2003).

A technology insertion is when the system is re-designed to not include components that have become obsolete and to include components with newer technologies. It differs slightly from a technology refresh in that technology refresh usually refers to a simple replacement of a component, such as a VME board, with a newer, more robust board that still has similar form, fit, and function and are generally reverse compatible ("Diminishing Manufacturing," 2005).

According to Lloyd Francis (2006), "Many manufacturers now buy sufficient components up-front to satisfy the predicted needs of the whole life of the product, including after-sales service. This not only secures against obsolescence, but brings the cost benefits of bulk-buying" (p. 24). While a lifetime buy can eliminate obsolescence issues with some components, it is very often difficult to get the funding necessary to make such buys. In a journal article for *Military & Aerospace Electronics* regarding the Radstone redesign of the U.S. Army Firefinder to fight obsolescence, John Mchale (2001) wrote, "Lifetime buys were impossible on the Firefinder program. In some instances lifetime buys would cost 10 times that of the original product" (p. 7). While lifetime buys can be considered as a strategy, it is sometimes simply not an option because the funding is not available. Defense contractors can, although, present predictive lifecycle cost data to the DoD customer if the upfront investment indicates a major lifecycle cost savings. Aside from the procurement cost, there are still many other warnings around lifetime buys cited.

For example, additional costs beyond the purchase of the components need to be considered like storage. In reference to storage of lifetime buys, Francis (2006) states:

> This means not only storage in properly designed and dedicated facilities with electrostatic discharge protection and controlled humidity and temperature, together with a sound incoming-test system. Watchdog samples must also periodically be taken from storage for testing to assess any ongoing degradation. (p. 24)

Another thing that must be carefully considered is inventory tracking. Extreme care must be taken to ensure warehouse locations are carefully tracked, this data is not lost, and the components are not accidently used for another build, program, or customer (Francis, 2006).

In a study conducted by Walter J. Tomczykowski from ARINC in Annapolis, it was found that due to the many problems surrounding lifetime buys, bridge buys are usually preferred. Lifetime buys seldom procure the correct amount of spares especially if the life of the program gets extended. Bridge buys allow for the support of the near term requirements while a longer term solution is found for the next technology refresh (Tomczykowski 2003).

*Contingency Planning*

When all strategies to mitigate a risk fail, having a contingency plan in place will be extremely helpful (Heldman, 2005). Recall that the COTS marketplace is very unpredictable. Frequently vendors will announce product discontinuances with a last time buy opportunity. This sometimes does not give the DoD enough time to respond to the request for the funding (Edwards, 2009). For this reason, it is very important when dealing with COTS to plan for the worst and have a back-up plan. While the decision to carry out a contingency plan is a reactive response to COTS obsolescence when it occurs, contingency planning can be a very proactive activity. Part of being proactive is having carefully thought out contingency plans, so the program can react quicker if mitigation efforts fail and a risk becomes a reality (Heldman, 2005).

The simplest solution when a component becomes obsolete is to replace it with a direct form, fit function replacement. The new component duplicates the performance of the legacy instrument. With a direct form, fit, function replacement, you simply swap out the old component and carry on as before. The simplest solution to an obsolescence problem that has already occurred is a form, fit, function replacement. Therefore, identifying these form, fit, function replacements or possible alternatives would make sense to be a key part of every contingency plan for COTS obsolescence risk contingency planning (Lecklider, 2008).

Unfortunately, sometimes same form, fit, and function replacements are not always available for every product. When proactive measures have failed to prevent obsolescence, many vendors offer last-time buy opportunities. Experienced purchasers can also take advantage of grey-market sources if approached with caution (Francis, 2007).

When all other proactive and reactive strategies to cope with a COTS obsolescence problem have failed, it may be required to reverse engineer the obsolete part. A specialist laboratory with tools to analyze the components exact function is needed to determine how a device can be developed to emulate the obsolete device (Francis 2007).

*Adopted COTS Obsolescence/Lifecycle Management Plan*

This last strategy found to be common in the literature is actually a combination of all the strategies above but involves having a documented and executed program plan in place for juggling several strategies throughout the lifecycle of the program. In response to the many challenges faced using COTS products on programs with longer lifecycles, Radstone Technologies developed a new program called Whole Program Life COTS to mitigate the effects of component obsolescence. There is no one-solve-all solution to dealing with the problem of

COTS obsolescence. The fundamental strategy is the strategic balance of various strategies to address issues of long-term support (Cavill, 2000).

The "Diminishing Manufacturing Sources Material Shortages Management Plan Guidance" provides guidance for programs to develop a proactive plan that addresses component obsolescence issues. It requires acquisition managers to develop a formal obsolescence management plan that covers all phases of the lifecycle including program kick-off, through sustainment, and even through conclusion. While many strategies exist for COTS obsolescence, it was clear to see there is no one-size fits-all approach and each program needs to proactively plan the use of multiple strategies throughout the entire program lifecycle (Adams, 2005).

*Literature Review Conclusion*

Throughout all of the literature reviewed, there was not one single strategy identified by any of the authors as being a complete solution to the challenges with COTS obsolescence that defense contractors or similar industries face. There were, although, several strategies suggested by the authors and having a lifecycle obsolescence plan to harness several of these strategies in a balanced, simultaneous approach at the appropriate times throughout the lifecycle of the program appears to be the closest thing to a one-solve-all solution. This could be the best approach for dealing with COTS obsolescence by minimizing its negative impacts, but it does not make the problem disappear. Company XYZ and other contractors in similar industries in order to stay competitive must continue to improve their lifecycle obsolescence management plans by embracing and improving upon several strategies. The Company XYZ "Lifecycle Obsolescence Management" common procedure included several of the strategies found in the other works of literature reviewed, but it does not cover all of them. This indicates there is a possibility that the common procedure might be able to be improved by considering the incorporation of the strategies not included.

# Chapter III: Research Methodology

*Overview of Research Methodology*

The researcher will create a checklist of the strategies for mitigating COTS obsolescence risks that were identified in the literature review. The researcher will review the Company XYZ common procedure titled "Lifecycle Obsolescence Management" to determine if all strategies found in the literature review are covered by the common procedure. The checklist will consist of overall strategies and key strategy points which were cited in the literature review.

According to Atul Gawande, in his book *Checklist Manifesto*, we have all accumulated stupendous amounts of know-how and many times the volume and complexity of what we know exceeds our individual ability to deliver. There is a simple to solution to being sure things aren't missed and this and it's called a checklist (Gawande, p13, 2009).

As mentioned in Chapter I under the assumptions of the study, any strategies found in the literature reviewed involving COTS obsolescence mitigation and planning are assumed to be existent strategies with merit. A checklist of the key strategies and their sub-points covered in the literature reviewed is created with a check box for each key strategy and its sub-points. The checklist will help the researcher verify if key strategies and their sub-points covered in the various works of literature reviewed are also covered in Company XYZ common procedure titled the "Lifecycle Obsolescence Management."

After completion of the procedure review, the checklist entries with empty boxes will indicate which, if any, strategies are possible candidates for further investigation into the possibility of being added to the Company XYZ common procedure "Lifecycle Obsolescence Management." Page numbers in the "Lifecycle Obsolescence Management" common procedure document supporting the strategy checklist point inclusions, if any, will be recorded as well. If there are any strategies that are only partially covered, the strategy will not be checked off as being included but page numbers supporting its partial inclusion will be recorded in a supplemental matrix. The supplemental matrix will include the strategy numbers used to identify each strategy in the checklist along the y-axis and common procedure page numbers along the x-axis. At the intersection in the matrix, the page number will be checked off if it supports the strategy.

The Company XYZ "Lifecycle Obsolescence Management" common procedure is a Company XYZ internal document and is not included as an appendix in the academic copy but will be included as an appendix in the internal version provided to Company XYZ.

The following checklist will be completed by the researcher by reviewing the Company XYZ "Lifecycle Obsolescence Management" common procedure for inclusion of the strategies. Meanwhile page numbers in the procedure which support the strategies' inclusions will be recorded. These page numbers will later be used to create the supplemental matrix previously described in this chapter.

*Strategy Checklist for Company XYZ "Lifecycle Obsolescence Management"*

1 Consider Obsolescence during Design Phase/Component Selection

- 1.1 Prevent obsolescence before it happens
- 1.2 Utilize component and system designers that are well-trained in implementing good obsolescence avoidance techniques
- 1.3 Utilize this well-trained staff throughout the complete design process
- 1.4 Lifecycle costs associated with obsolescence are considered in conjunction with technical performance
- 1.5 Adequately fund logistics support throughout lifecycle of project
- 1.6 Embrace early obsolescence program to reap benefits of lower lifecycle costs
- 1.7 Embrace early obsolescence program to reap benefits of increased system

readiness

1.8 During design process, avoid incorporating parts that are likely to disappear quickly

1.9 Use component databases to help score components in terms of obsolescence risk

1.10 Designers should plan for obsolescence by building each system with assumption they will soon have to take it apart to replace old parts

1.11 Design systems with components ready for technology refit and insertion

1.12 Designs can utilize technologies, such as, VME Chassis or Blade Chassis where the chassis keeps the same form, fit, function, but blade servers can be updated with reverse compatible newer models

2 Vendor Selection/Relations

2.1 Find vendors more willing to work with programs on obsolescence problems

2.2 Keep good relations with this vendors through open communication and technology roadmaps.

2.3 Being Aware of Benefits and Cautions of Utilizing Small Suppliers

2.4 Being Aware of Benefits and Cautions of Utilizing Large Suppliers

2.5 Being aware and the Benefits and Cautions of Contractual Lifetime Support (CLS) plans or non-obsolescence policies

2.5.1 May help eliminate problem obsolescence issues for some components altogether

2.5.2 Cannot be accepted at face value; purchasing and engineering professionals need to work together to ensure such guarantees are technically achievable

2.6 Utilize EOL suppliers when proactive measures to prevent obsolescence fail

3 Technology Roadmapping/Component Obsolescence Monitoring

3.1 Use technology roadmapping to guide strategy planning

3.2 Awareness that technology roadmaps can take many forms

3.3 Awareness that technology roadmaps generally comprise multi-layered time-based graphical charts that enable technology developments to be aligned with market trends and drivers

3.4 Technology management by means of market research, including surveillance of leading-edge technologies

3.5 Investigation of promising commercial products

3.6 Assessing technological trends

3.7 Observe the marketplace

3.8 Monitor suppliers market share and viability

3.9 Continued monitoring of component supply health as soon as part is added to design parts list

3.10 Market Research allowing the acquiring activity to:

3.10.1 Proactively anticipate obsolescence situations due to rapid or asynchronous product changes

3.10.2 Plan and budget using a broader range of product obsolescence management options rather than incur higher life cycle costs from more limited, costly, reactive solutions

3.10.3 Maintain insight into technology trends as well as internal product changes

3.10.4 Assess the quality of the manufacturer, the impact of product change to a system, its suitability for the user, its information security characteristics and its supportability

3.10.5 Determine project manufacturer support period and inventories for a particular product

3.11 Market research should occur throughout the entire system's life cycle

3.12 Use of market research to project product obsolescence

3.13 Use of market research to determine availability of alternate form, fit, function replacements

3.14 Market surveillance can be done with several methods:

3.14.1 Internet searches

3.14.2 Attending trade shows

3.14.3 Technology publications

3.14.4 Hiring consultants

3.14.5 Screening information requests (SIRS) to prospective manufacturers/suppliers

3.14.6 Manufacturer/Supplier visits

3.14.7 Product Demonstrations

4 Use of Open Architecture

4.1 Utilize open architecture so software can run on multiple hardware platforms

4.2 Utilize open architecture to allow hardware changes due to COTS obsolescence or new technology insertion to not impact (or limit impact to) software design

5 Lifetime and Bridge Buys

5.1 Use careful consideration and heed many warnings when making lifetime or bridge buys

5.2 Consider planned technology refreshes as an option when determining if a lifetime or bridge buy is advantageous to a program

5.3 Utilizing lifetime or bride buys to secure obsolescence and benefit from bulk-buying

5.4 Be aware that funding is sometimes simply not there for lifetime or bridge buys and contractor may need to present benefits to customer to request this funding

5.5 Consider proper storage for lifetime or bridge buys and its associated costs

5.5.1 Utilize properly designed facilities that are ESD and environmentally controlled

5.5.2 Take watch-dog samples periodically to assess any ongoing degradation

5.5.3 Careful inventory tracking (both electronically with database and physically)

5.5.3.1 Use care to ensure components are kept for specific program and not accidently fielded for something else

5.6 Awareness that bridge buys are usually preferred over lifetime buys for below reasons:

5.6.1 Bridge buys can be utilized to allow for support of near term requirements while longer term solution is found for next tech refresh

5.6.2 Bridge buys are also preferred because lifetime buys seldom procure correct number of spares, especially when life of program is extended

6 Contingency Planning

6.1 Carefully thought out contingency plans will allow program to react quicker when obsolescence occurs

6.2 Awareness of last time buy opportunities often announced with product discontinuances

6.3 Replace obsolete components with direct form, fit, function replacements whenever possible

6.4 Utilize experienced purchasers to take advantage of grey-market sources to procure obsolete components when absolutely necessary

6.5 Reverse engineering as a last resort, utilizing specialist laboratories with tools to analyze components exact function is needed to develop a new component to emulate its functions

7 Adopted COTS Obsolescence/Lifecycle Management Plan

7.1 Development of a program plan which plans the appropriate utilization of several strategies throughout the lifecycle of the program

7.2 Requirement for acquisition managers to develop formal obsolescence management plan covering all phases of lifecycle

*Data Collection Methodology*

The researcher will review the Company XYZ "Lifecycle Obsolescence Management" common procedure for each strategy in the checklist above checking off each strategy included and recording page numbers from the common procedure that researcher concludes to support coverage of the strategy. In addition to completing the checklist above, the researcher will provide a supplemental matrix outlining which strategy checklist points are supported by which pages of the Company XYZ "Lifecycle Obsolescence Management" common procedure. The strategy checklist points are numbered in the above checklist and make up the y-axis on the matrix while the page numbers of the common procedure make up the x-axis. Rows for strategy checklist points inadequately covered by the common procedure will be highlighted black. Rows for strategy checklist points only partially covered by the common procedure will be highlighted grey, and lastly, rows that are covered completely by the common procedure will be highlighted white. The recorded results matrix will provide a visual representation of the strategy checklist points covered. It will also provide reference page numbers, if any, from the "Lifecycle Obsolescence Management" common procedure, which support the inclusion of the strategy checklist points.

# Chapter IV: Results

While COTS obsolescence appears to be a problem with no one answer through all the strategies reviewed in this study, many strategies were identified in the literature review which were compared against Company XYZ "Lifecycle Obsolescence Management" common procedure for inclusion. As described in Chapter III, a strategy checklist was created from the strategies found in the literature review. The researcher reviewed the Company XYZ "Lifecycle Management Obsolescence Management" common procedure and determined if the strategies were covered by the common procedure. The checklist presented in Chapter III was completed and supporting page numbers within the common procedure which supported strategy inclusions were recorded for presentation of an additional supplemental matrix.

*Data Presentation*

The following data presented is the completed strategy checklist and supplemental matrix. The researcher determined if each strategy checklist point from the strategy checklist presented in Chapter III is currently being referenced in the Company XYZ "Lifecycle Obsolescence Management" common procedure by reviewing its latest release closely and noting page numbers that support each strategy's inclusion. The supplemental matrix includes a visual representation of each strategy checklist point by its indentifying number in the checklist on the y-axis with page numbers of the Company XYZ "Lifecycle Obsolescence Management" common procedure covering each strategy on the x-axis.

*Completed Strategy Checklist for Company XYZ "Lifecycle Obsolescence Management"*

The researcher carefully reviewed the Company XYZ "Lifecycle Obsolescence Management" common procedure for inclusion of the strategies in the checklist. Each strategy checklist point that was adequately covered in the Company XYZ "Lifecycle Obsolescence

Management" common procedure based on the researcher's review is indicated with a check mark in the check boxes below:

☑ 1 Consider Obsolescence during Design Phase/Component Selection

- ☑ 1.1 Prevent obsolescence before it happens
- 1.2 Utilize component and system designers that are well-trained in implementing good obsolescence avoidance techniques
- 1.3 Utilize this well-trained staff throughout the complete design process
- ☑ 1.4 Lifecycle costs associated with obsolescence are considered in conjunction with technical performance
- ☑ 1.5 Adequately fund logistics support throughout lifecycle of project
- ☑ 1.6 Embrace early obsolescence program to reap benefits of lower lifecycle costs
- ☑ 1.7 Embrace early obsolescence program to reap benefits of increased system readiness
- ☑ 1.8 During design process, avoid incorporating parts that are likely to disappear quickly
- ☑ 1.9 Use component databases to help score components in terms of obsolescence risk
- ☑ 1.10 Designers should plan for obsolescence by building each system with assumption they will soon have to take it apart to replace old parts
- ☑ 1.11 Design systems with components ready for technology refit and insertion
- 1.12 Designs can utilize technologies, such as, VME Chassis or Blade Chassis where the chassis keeps the same form, fit, function, but blade servers can be updated with reverse compatible newer models

☑ 2 Vendor Selection/Relations

- ☑ 2.1 Find vendors more willing to work with programs on obsolescence problems

- ☑ 2.2 Keep good relations with this vendors through open communication and technology roadmaps
- 2.3 Being Aware of Benefits and Cautions of Utilizing Small Suppliers
- 2.4 Being Aware of Benefits and Cautions of Utilizing Large Suppliers
- 2.5 Being aware and the Benefits and Cautions of Contractual Lifetime Support (CLS) plans or non-obsolescence policies
  - 2.5.1 May help eliminate problem obsolescence issues for some components altogether
  - 2.5.2 Cannot be accepted at face value; purchasing and engineering professionals need to work together to ensure such guarantees are technically achievable
- ☑ 2.6 Utilize EOL suppliers when proactive measures to prevent obsolescence fail

☑ 3 Technology Roadmapping/Component Obsolescence Monitoring

- ☑ 3.1 Use technology roadmapping to guide strategy planning
- ☑ 3.2 Awareness that technology roadmaps can take many forms
- ☑ 3.3 Awareness that technology roadmaps generally comprise multi-layered time-based graphical charts that enable technology developments to be aligned with market trends and drivers
- ☑ 3.4 Technology management by means of market research, including surveillance of leading-edge technologies
- ☑ 3.5 Investigation of promising commercial products
- ☑ 3.6 Assessing technological trends
- ☑ 3.7 Observe the marketplace
- ☑ 3.8 Monitor suppliers market share and viability

- ☑ 3.9 Continued monitoring of component supply health as soon as part is added to design parts list
- ☑ 3.10 Market Research allowing the acquiring activity to:
  - ☑ 3.10.1 Proactively anticipate obsolecense situations due to rapid or asynchronous product changes
  - ☑ 3.10.2 Plan and budget using a broader range of product obsolescence management options rather than incur higher life cycle costs from more limited, costly, reactive solutions
  - ☑ 3.10.3 Maintain insight into technology trends as well as internal product changes
  - ☑ 3.10.4 Assess the quality of the manufacturer, the impact of product change to a system, its suitability for the user, its information security characteristics and its supportability
  - ☑ 3.10.5 Determine project manufacturer support period and inventories for a particular product
- ☑ 3.11 Market research should occur throughout the entire system's life cycle
- ☑ 3.12 Use of market research to project product obsolescence
- ☑ 3.13 Use of market research to determine availability of alternate form, fit, function replacements
- ☑ 3.14 Market surveillance can be done with several methods:
  - ☑ 3.14.1 Internet searches
  - 3.14.2 Attending trade shows
  - ☑ 3.14.3 Technology publications
  - 3.14.4 Hiring consultants

☑ 3.14.5 Screening information requests (SIRS) to prospective manufacturers/suppliers

☑ 3.14.6 Manufacturer/Supplier visits

3.14.7 Product Demonstrations

4 Use of Open Architecture

4.1 Utilize open architecture so software can run on multiple hardware platforms

4.2 Utilize open architecture to allow hardware changes due to COTS obsolescence or new technology insertion to not impact (or limit impact to) software design

☑ 5 Lifetime and Bridge Buys

☑ 5.1 Use careful consideration and heed many warnings when making lifetime or bridge buys

☑ 5.2 Consider planned technology refreshes as an option when determining if a lifetime or bridge buy is advantageous to a program

☑ 5.3 Utilizing lifetime or bride buys to secure obsolescence and benefit from bulk-buying

☑ 5.4 Be aware that funding is sometimes simply not there for lifetime or bridge buys and contractor may need to present benefits to customer to request this funding

☑ 5.5 Consider proper storage for lifetime or bridge buys and its associated costs

5.5.1 Utilize properly designed facilities that are ESD and environmentally controlled

5.5.2 Take watch-dog samples periodically to assess any ongoing degradation

☑ 5.5.3 Careful inventory tracking (both electronically with database and physically)

- ☑ 5.5.3.1 Use care to ensure components are kept for specific program and not accidently fielded for something else

5.6 Awareness that bridge buys are usually preferred over lifetime buys for below reasons:

- ☑ 5.6.1 Bridge buys can be utilized to allow for support of near term requirements while longer term solution is found for next tech refresh
- 5.6.2 Bridge buys are also preferred because lifetime buys seldom procure correct number of spares, especially when life of program is extended

☑ 6 Contingency Planning

- ☑ 6.1 Carefully thought out contingency plans will allow program to react quicker when obsolescence occurs
- ☑ 6.2 Awareness of last time buy opportunities often announced with product discontinuances
- 6.3 Replace obsolete components with direct form, fit, function replacements whenever possible
- ☑ 6.4 Utilize experienced purchasers to take advantage of grey-market sources to procure obsolete components when absolutely necessary
- ☑ 6.5 Reverse engineering as a last resort, utilizing specialist laboratories with tools to analyze components exact function is needed to develop a new component to emulate its functions

☑ 7 Adopted COTS Obsolescence/Lifecycle Management Plan

- ☑ 7.1 Development of a program plan which plans the appropriate utilization of several strategies throughout the lifecycle of the program

☑ 7.2 Requirement for acquisition managers to develop formal obsolescence management plan covering all phases of lifecycle

*Supplemental Results Matrix*

The following is a supplemental results matrix indicating which strategies were found in the Company XYZ "Lifecycle Obsolescence Management" common procedure and supporting page numbers within the procedure. The matrix includes each strategy number identifier from the checklist previously presented along the y-axis and the page numbers of the Company XYZ Lifecycle Obsolescence Management common procedure along the x-axis. The page numbers supporting each strategy, if any, are indicated with an "X" in the appropriate cell. Rows in the matrix for strategies which are adequately covered by the Company XYZ "Lifecycle Obsolescence Management" common procedure are highlighted white. Strategies which are partially covered show page numbers where the partial coverage of the strategy is indicated in the common procedure, but the row is highlighted in grey instead. Lastly, strategies which were not covered if full or part are highlighted black.

| Strategy Checklist Identifiers | Company XYZ "Lifecycle Obscolecense Management Plan" Page Numbers | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ☐ | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 1 | ☑ | X | X | X | X | X | | X | X | | X | | | | X | X | X | X | | | X | | | | X | X |
| 1.1 | ☑ | X | X | X | X | | | | X | | | | | | X | X | X | X | | | | | | | | |
| 1.2 | ☐ | | | | | | | | X | | | | | | | | | | | | | | | | | |
| 1.3 | ☐ | | | | | | | | | | | X | | | | | | | | | | | | | | |
| 1.4 | ☑ | | X | | | | | | | | | | | | X | X | | | | | | | | | | |
| 1.5 | ☑ | X | | | | | | | | | | | | | | | | | | | X | | | | | |
| 1.6 | ☑ | X | | | | | | | | | | | | | X | | X | | | | | | | | | |
| 1.7 | ☑ | X | X | | | | | | | | | | | | X | | X | | | | | | | | | |
| 1.8 | ☑ | | | | | X | | X | | | X | | | | | | X | | | | | | | | | |
| 1.9 | ☑ | | | | | | | | | X | X | | | | | | | | | | | | | | X | X |
| 1.10 | ☑ | | | | | | | | | | | | | | | X | X | | | | | | | | | |
| 1.11 | ☑ | | | | | | | | | | | | | | | X | X | | | | | | | | | |
| 1.12 | ☐ | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | ☑ | | | | | | | | X | X | X | | X | | | X | X | X | | | | | | | | |
| 2.1 | ☑ | | | | | | | | X | X | X | | | | | | | | | | | | | | | |
| 2.2 | ☑ | | | | | | | | X | X | X | | | | | X | X | X | | | | | | | | |
| 2.3 | ☐ | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.4 | ☐ | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.5 | ☐ | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.5.1 | ☐ | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.5.2 | ☐ | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.6 | ☑ | | | | | | | | | | | | X | | | | | | | | | | | X | | |

| | ☐ | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | ☑ | X | X | X | X | X | X | X | X | X | X | | | X | | X | X | X | | X | X | X | | X | X | X |
| 3.1 | ☑ | X | X | X | X | X | X | X | X | X | X | | | X | | X | X | X | | X | X | X | | X | X | X |
| 3.2 | ☑ | | | | | | | | | | | | | | | | X | | | | | | | | | |
| 3.3 | ☑ | | | | | | | | | | | | | | | | X | | | | | | | | | X |
| 3.4 | ☑ | | X | | X | | X | | X | X | X | | | | | | | | | X | | | | X | X | |
| 3.5 | ☑ | | | | | | | | | | X | | | | | | | | | | | | | | | |
| 3.6 | ☑ | | | | | | | | | | X | | | | | X | X | | | | | | | | X | |
| 3.7 | ☑ | | X | | X | | X | X | X | X | | | | | | | | | | X | | | | | X | |
| 3.8 | ☑ | | | | | | | | | | | | | | | | X | | | | | | | | | |
| 3.9 | ☑ | | | | | | | | | | X | | | | | | | | | | | | | | | |
| 3.10 | ☑ | | | X | | | | X | X | X | X | | | | X | X | X | X | | X | | | | | X | X |
| 3.10.1 | ☑ | | | | | | | | | X | | | | | X | | | | | | | | | | | X |
| 3.10.2 | ☑ | | | | | | | | | | | | | | X | | X | | | | | | | | | |
| 3.10.3 | ☑ | | | | | | | | | | X | | | | | X | X | | | | | | | | X | |
| 3.10.4 | ☑ | | | X | | | | | X | | | | | | | X | | X | | | | | | | | |
| 3.10.5 | ☑ | | | | | | | X | | | | | | | | | | | | X | | | | | | |
| 3.11 | ☑ | | | | X | | | | | | | | | | | | | | | | | | | | | |
| 3.12 | ☑ | | X | | X | | X | | X | X | X | | | | | | | | | X | | | | | X | |
| 3.13 | ☑ | | | | | X | X | X | | | X | | | | | | | | | | | | | | | X |
| 3.14 | ☑ | | | | | | | | | | | | | | | | X | | | | | | | | | |
| 3.14.1 | ☑ | | | | | | | | | | | | | | | | X | | | | | | | | | |
| 3.14.2 | ☐ | [redacted] | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.14.3 | ☑ | | | | | | | | | | | | | | | | X | | | | | | | | | |
| 3.14.4 | ☐ | [redacted] | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.14.5 | ☐ | | | | | | | | | | X | | | | | | | | | | | | | | | |
| 3.14.6 | ☑ | | | | | | | | | | | | | | | | X | | | | | | | | | |
| 3.14.7 | ☐ | [redacted] | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | ☐ | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4.1 | ☐ | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4.2 | ☐ | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | ☑ | | | X | | | | | | | | | X | | | | | | | | | | | X | | |
| 5.1 | ☑ | | | | | | | | | | | | X | | | | | | | | | | | | | |
| 5.2 | ☑ | | | | | | | | | | | | X | | | | | | | | | | | | | |
| 5.3 | ☑ | | | X | | | | | | | | | X | | | | | | | | | | | X | | |
| 5.4 | ☑ | | | | | | | | | | | | X | | | | | | | | | | | | | |
| 5.5 | ☑ | | | X | | | | | | | | | | | | | | | | | | | | | | |
| 5.5.1 | ☐ | [redacted] | | | | | | | | | | | | | | | | | | | | | | | | |
| 5.5.2 | ☐ | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5.5.3 | ☑ | | | X | | | | | | | | | | | | | | | | | | | | | | |
| 5.5.3.1 | ☑ | | | X | | | | | | | | | | | | | | | | | | | | | | |
| 5.6 | ☐ | [redacted] | | | | | | | | | | | | | | | | | | | | | | | | |
| 5.6.1 | ☑ | | | | | | | | | | | | X | | | | | | | | | | | | | |
| 5.6.2 | ☐ | [redacted] | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | ☑ | | | X | X | | X | X | X | | | | X | X | X | X | X | X | X | X | X | | | X | X | X |
| 6.1 | ☑ | | | | | | | | | | | | | X | X | | | | | | | | | | | |
| 6.2 | ☑ | | | | | | | | | | | | | | X | | | | | X | | | | | | |
| 6.3 | ☐ | | | | | | X | | | | | | | | | | | | | | | | | | | X |
| 6.4 | ☑ | | | | | | | | | | | | X | | | | | | | | | | | | | |
| 6.5 | ☑ | | | | | | | | | | | | X | | | | | | | | | | | | X | |
| 7 | ☑ | X | X | X | X | X | | | | | | | | | X | X | X | X | X | X | X | | | | | |
| 7.1 | ☑ | X | X | X | X | X | | | | | | | | | X | X | X | X | X | X | X | | | | | |
| 7.2 | ☑ | | | | | | | | | | | | | | X | X | | | | | | | | | | |

*Discussion*

The Company XYZ "COTS Lifecycle Management" common procedure included the majority of the strategies the researcher found in the literature review. It was found the 54 out of the 74 strategies in the checklist of strategies compiled in the literature review were covered adequately in the Company XYZ "COTS Lifecycle Management" common procedure. Since approximately 73% of the strategies found in the literature review are being covered by the procedure, this indicates that the Company XYZ "Lifecycle Obsolescence Management" common procedure encompasses a wide variety of strategies found helpful to industry in mitigating risks associated with COTS obsolescence and minimizing its negative impacts to defense programs.

While the Company XYZ procedure covers 73% of the strategies in the checklist, 4 out of the 74 are only partially covered and 16 out of the 74 are not covered at all. Strategies in the above completed checklist with empty boxes indicate strategies which were found in the literature review but were not covered Company XYZ "Lifecycle Obsolescence Management" common procedure. Since 27% of the strategies in the checklist were not found in the Company XYZ "Lifecycle Obsolescence Management" common procedure, this indicates there are a significant number of strategies for mitigating COTS obsolescence and minimizing its negatives impacts to defense programs that are not included in the Company XYZ "Lifecycle Obsolescence Management" common procedure. This could indicate there are possible opportunities for improvements to the common procedure by encompassing these missing strategies.

## Chapter V: Recommendations

Since twenty strategies for mitigating COTS obsolescence and minimizing its negative impacts to defense programs were found in the literature reviewed but not in the Company XYZ "Lifecycle Obsolescence Management" common procedure, this indicates that there might be additional strategies that Company XYZ should add to their "Lifecycle Obsolescence Management" common procedure. Recall, the assumption of this study is that if a strategy existed in the literature reviewed, the strategy was assumed to be existent and have merit as a beneficial strategy. Additional research is recommended to investigate each of the strategies missing from the Company XYZ "Lifecycle Obsolescence Management" common procedure to determine their viability and potential benefits to the defense programs handled by Company XYZ. If additional research confirms benefits to these strategies, they should be added to the common procedure.

There is no one answer to make the problem of COTS obsolescence to defense programs go away, but an effective plan which encompasses a wide-array of strategies can help mitigate the associated risks and minimize its negative impacts. The Company XYZ "Lifecycle Obsolescence Management" common procedure was determined to be very effective in covering a wide-array of strategies. It covers 73% of the strategies found in literature reviewed around the subject matter. This study does, although, indicate there is a possibility for improvements to the common procedure. The fact that twenty strategies were not found indicates that there might be opportunity to make the common procedure more effective by encompassing the missing strategies. It is highly recommended that the strategies that were not included are investigated further for possible inclusion into the Company XYZ "Lifecycle Obsolescence Management" common procedure.

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