1.0 INTRODUCTION

1.1 Background

1.1.1 The History Behind the Emphasis on COTS

In a report developed by the Guidance and Control Information Analysis Center (GACIAC)[1] for the Defense Technical Information Center, it was noted that:

> In 1972, recommendations of the Commission on Government Procurement first emphasized the shift in fundamental philosophy toward commercial product acquisition. The impetus for the shift was the high cost of developing products to meet detailed or unique Government specifications . . . . The new philosophy envisioned greater reliance on privately-developed, off-the-shelf products . . . .

Although the commission's recommendations became policy in 1976, the use of commercial off-the-shelf (COTS) products did not become widespread or commonplace. Ten years later, the President's Blue Ribbon Commission on Defense Management sounded another call for greater use of off-the-shelf products (components, systems, and services). It was not until 1994, however, that a clear and direct policy concerning the use of COTS and non-developmental items (NDI)[2] was issued. In what many consider to be a landmark decision, then Secretary of Defense William Perry changed the way that the DoD does business. In his June 29, 1994 memorandum, titled "Specifications & Standards - A New Way of Doing Business," he clearly stated the importance of leveraging commercial technology:

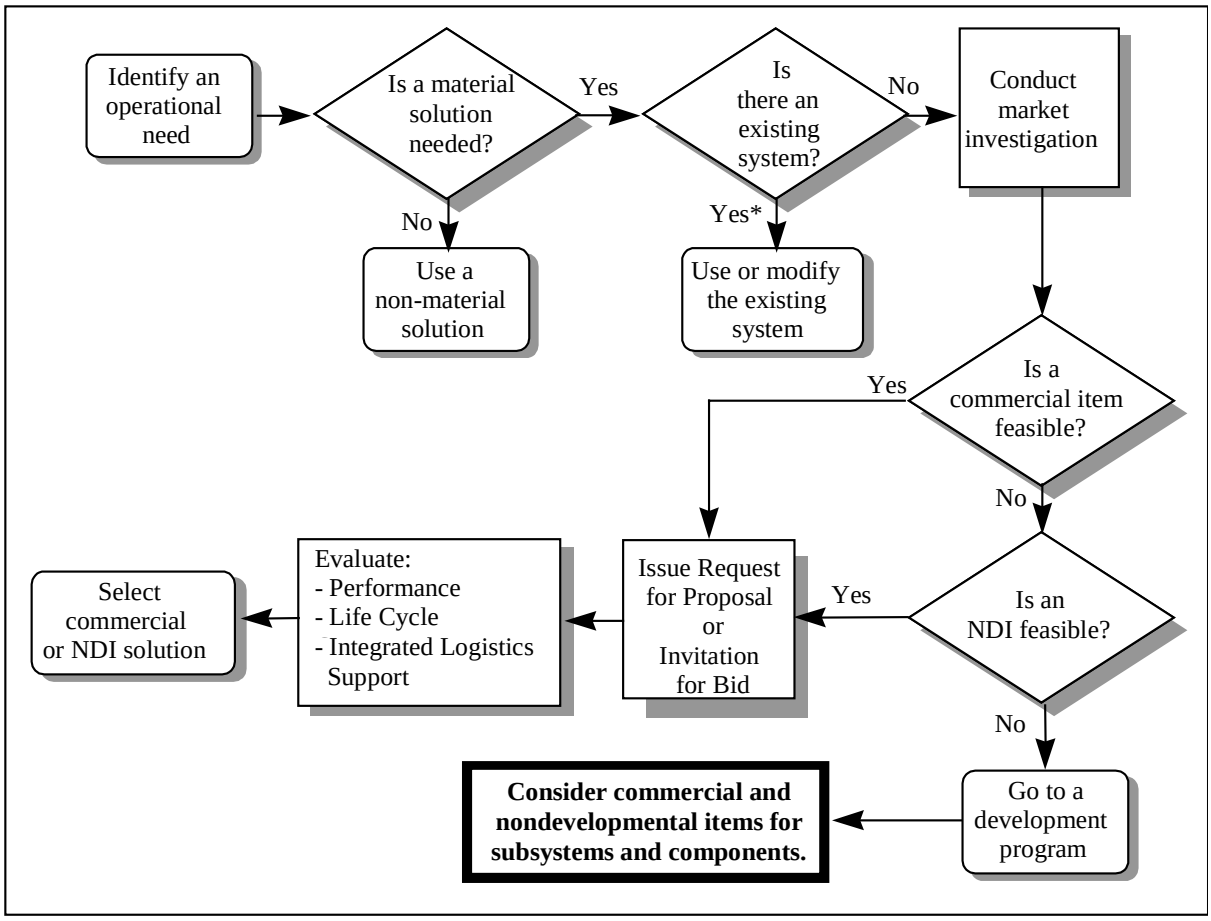
> To meet future needs, the Department of Defense must increase access to commercial state-of-the-art technology and must facilitate the adoption by its suppliers of business processes characteristic of world class suppliers. In addition, integration of commercial and military development and manufacturing facilitates the development of dual-use processes and products and contributes to an expanded industrial base that is capable of meeting defense needs at lower costs. . . . Performance specifications shall be used when purchasing new systems, major modifications, upgrades to current systems, and non-developmental and commercial items, for programs in any acquisition category. . . . The Under Secretary of Defense (Acquisition and Technology) shall . . . encourage contractors to propose non-Government standards and industry-wide practices that meet the intent of the military specifications and standards.

Subsequent policy memoranda and guidance documents from DoD specifically identified a clear preference for COTS products whenever practical. Today, the use of commercial items in military systems is no longer a question of "yes or no" but a question of to what degree" and a formal decision process for considering COTS has been established (see Figure 1-1). In the

[1] GACIAC is a DoD information analysis center sponsored by the Defense Technical Information Center and operated by IIT Research Institute.

[2] The need to use an NDI approach to software components was recognized by the 1987 Defense Science Board. In the NDI Preference Act of 1987, the DoD was required to state requirements in terms of functions, performance, and essential physical characteristics so that NDI could be procured to meet them.

Federal Acquisition Streamlining Act of 1994, Congress broadened the preference for acquisition of commercial items to a preference for the acquisition of non-developmental items (NDI). NDI is any previously developed item used exclusively for Government purposes by "federal agency, a state or local Government or a foreign Government with which the US has a mutual defense cooperation agreement." COTS are items available in a domestic or foreign commercial marketplace.[3] The focus of the remaining discussion is COTS.



*In preparation for the market investigation establish objectives and thresholds for cost, schedule, and performance based on the users' operational and readiness requirements.

Figure 1-1. The Commercial/NDI Decision Process (Taken from SD-2)[3]

Historically, commercial companies have routinely used commercial items (versus items made specifically for one or two companies) in building new products. Underlying the relatively new emphasis by DoD on commercial products and practices are four realities. First, the defense budget continues to shrink. Second, the decrease in military spending over the last decade has eroded the industrial base that existed to support development of weapon systems. Third, the DoD is no longer the technology driver. Fourth, many technologies (e.g., electronics, information, communications, etc.) are advancing at such a rapid pace that the Government can no longer

[3] SD-2, Buying Commercial and Nondevelopmental Items: A Handbook, Office of the Assistant Secretary of Defense for Production and Logistics, April 1996.

afford an acquisition process that has traditionally required years to develop, test, and field even the simplest of systems.

1.1.2 Benefits and Objectives of Using COTS

The primary objective of using COTS is to capitalize on proven designs, thereby reducing the development time and risk associated with a new product. In contrast to designing a completely new product, a proven product is used or proven components and subsystems are incorporated in a new product. Whether it is the Government or a commercial company, using COTS can potentially reduce costs, risks, and acquisition time. However, some compromises in the required functional performance (including reliability) of the product may be necessary to use a COTS item without modification[4], and other issues, such as logistics support, must also be considered. The decision to use COTS must be based on a thorough evaluation of its ability to perform the required function in the intended environment and to be operated and supported over the planned life of the product.

The use of COTS offers the following benefits:

- Lower life-cycle cost
- More rapid deployment
- Proven capability
- Increased competition
- Broader industrial base
- Access to state-of-the-art technology

1.1.3 Challenges of Using COTS

A product that is new in every aspect of its design carries with it cost, schedule, and performance risks. These risks are usually high for such a product because of all the unknowns surrounding a totally new design. Buying and using COTS reduces these risks, but presents new challenges to the defense acquisition community. For COTS, these challenges include ensuring that a design intended for one environment can perform as required in a different, often more demanding environment. Another challenge in using COTS is providing logistics support for an item for which the Government had no role in its design, most likely has no configuration control, and probably has limited or no data rights.

COTS items may constitute the entire product (e.g., a desktop computer) or they may be components or subsystems within the product (e.g., displays, power supplies, etc., used within a control system). The advantages and disadvantages of using COTS are summarized in Table 1-1.

[4] **NOTE**: A COTS product, once modified, is no longer COTS. Recognition of this fact is critical. It means that the solution to reliability problems cannot be a simple modification to the COTS product. So the subject of the reliability of COTS products and efforts to address reliability shortcomings in a military application will, with a few exceptions, be approached with the understanding that COTS products must remain COTS.

Table 1-1. Advantages and Disadvantages of COTS

Area of Comparison	Advantages	Disadvantages
Technical, Schedule, and Financial Risk	Decreased technical, financial, and schedule risks due to less new design of components and subsystems. Ideally no research and development costs are incurred.	When used as the components and subsystems of a product, integration of those items into the product can be difficult, expensive, and time-consuming.
Performance	There is increased confidence due to established product performance and the use of proven components and subsystems.	Performance trade-offs may be needed to realize advantages. Integration may be difficult.
Environmental Suitability	In similar applications, proven ability to operate under environmental conditions.	In new applications, may require modifications external to the equipment to operate.
Leverage	Ability to capitalize on economies of scale, state-of-the-art technology, and products with established quality.	There may not be a perfect match between requirements and available products.
Responsiveness	Quick response to an operational need is possible because new development is eliminated or minimized.	Integration problems may reduce the time saved.
Manufacturing	If already in production, processes are probably established and proven.	Configuration or process may be changed with no advance notice.
Resupply	There is no need for large inventory of spares because they can be ordered from supplier.	The long-term availability of the item(s) may be questionable.
Logistics Support	No organic support may be required (probably not possible). Repair procedures and rates are established.	Supplier support or innovative integrated logistics support strategies may be needed to support the product.

1.1.4 The Emphasis on Reliability

One reason COTS has become a subject of intense interest is the ever-shrinking military budget. Not only has the total budget dramatically declined since the fall of the Berlin Wall, but the portion needed for operation and support (O&S) of existing forces has remained at or near 60% or more. As a result, fewer dollars are available for modernization at a time when many of our front-line weapon systems are aging or nearing the end of their design life (driving the O&S costs even higher). Consequently, the military services have been searching for ways to decrease the percent of total budget required for O&S. Lean logistics, focused logistics, velocity management, just-in-time logistics, and flexible logistics are just some of the service initiatives created to reduce O&S costs. Time and time again, one specific product characteristic is cited as critical to efforts to reduce O&S costs -- reliability.

Reliability is often thought of as a mission, or functional, performance parameter. It is that, but it is also one of the key factors driving O&S costs. Failures drive the need for spares, for repair or replacement, for maintenance personnel, and for the underlying support infrastructure. In an ideal world with no failures, support would be essentially reduced to servicing (with petroleum, oil, and lubricants), washing and preservation, corrosion control (although some might argue with some merit that corrosion is a materials reliability problem), and calibration. Unfortunately, failures are a fact of life. Despite the best efforts of product and process designers, failures do occur. So, the goal is not to seek perfection but to achieve or exceed a required level of reliability while remaining within prescribed cost and schedule constraints.

1.2 Purpose of this Guidebook

Since reliability is of such importance to the Department of Defense (and the private sector, for that matter), it is imperative that COTS products selected for a specific program meet the reliability requirements. Yet, how can the acquiring agency, often without any detailed design and manufacturing data on the product, determine if the reliability is satisfactory? How can the acquiring agency write reliability requirements so that bidders will be encouraged to consider COTS products? How can COTS be evaluated fairly from a reliability perspective without compromising performance for short-term costs savings?

The purpose of the Guidebook is to provide answers to these and other questions on COTS reliability that program managers and technical staff members must address. In discussing COTS, the focus will be on line replaceable units (LRUs) or weapon replaceable assemblies (WRAs) rather than on piece parts. However, it is recognized that the use of COTS piece parts, especially microcircuits used in updating legacy systems, is an important subject. Consequently, Appendix A discusses some of the reliability issues specifically related to commercial parts.

1.3 Definitions

1.3.1 Commercial Item

The Federal Acquisition Regulation defines a commercial item in the following ways:

a. Any item, other than real property, that is of a type customarily used for non-Governmental purposes and that has been sold, leased, or licensed to the general public, or has been offered for sale, lease, or license to the general public. Possible indications that an item is commercial—customarily used by the general public—are a commercial sales history, listing in catalogs or brochures, an established price, distributors, and availability to the general public. However, a new offering, with no sales history, is also considered a commercial item if it is offered for sale to the general public. Examples of commercial items that DoD buys include transport aircraft, computers, medicine, and fuel. The commercial market is global; commercial items are not limited to the domestic commercial market.

b. Any item that evolved from an item described in a), through advances in technology or performance, that is not yet available in the commercial market, but will be available in the commercial market in time to meet the delivery requirements of the solicitation. Commercial items that evolve from advances in technology or performance include product updates, model changes, and product improvements. For example, new versions of software fall into this category.

c. Any item that, but for modifications of a type customarily available in the commercial market or minor modifications made to meet DoD requirements, would satisfy the criteria in a) or b). "Minor modifications" do not significantly alter the non-Governmental function or essential physical characteristics of an item or component, or change the purpose of a process. In determining whether a modification is minor consider the value and size of the modification and the comparative value and size of the final product. Dollar values and percentages may be guideposts, but are not necessarily

conclusive evidence that a modification is minor. Commercial items with standard commercial modifications are items that are similarly customized for commercial customers. For example, car and airplane manufacturers offer a standard set of options and routinely customize products for their commercial customers. Use these guidelines in making your technical judgment whether an item is still a commercial item.

d. Any combination of items meeting the requirements of a), b), or c), or e), following, that are of a type customarily combined and sold in combination to the general public. A commercial item can be the product of integrating commercial subsystems and components into a unique system. For example, a computer system composed of commercial subsystems integrated into a system would be considered a commercial item. A piece of industrial plant equipment that combines commercial components into a unique item based on customer needs is another example.

e. Installation services, maintenance services, repair services, training services, and other services if such services are procured for support of an item referred to in paragraphs a), b), c), or d), if the sources of such services:

   (1) offer such services to the general public and the Federal Government simultaneously and under similar terms and conditions, and
   (2) offer to use the same work force for providing the Federal Government with such services as the source used for providing such services to the general public

Item installation, maintenance, repair, training, and other services related to item support are examples.

f. Services of a type offered and sold competitively, in substantial quantities, in the commercial marketplace based on established catalog or market prices for specific tasks performed and under standard commercial terms and conditions. Construction, research and development services, warehousing, garbage collection, and transportation of household goods are examples of services that meet the provisions of the statute.

g. Any item, combination of items or service referred to in a) through f), notwithstanding the fact that the item, combination of items, or service is transferred between or among separate divisions, subsidiaries, or affiliates of a contractor. For example, a commercial item transferred to a defense contractor from its commercial division or subsidiary for incorporation as a component in a defense system is a commercial item.

h. A nondevelopmental item, if the procuring agency determines the item was developed exclusively at private expense and sold in substantial quantities, on a competitive basis, to multiple State and local Governments. Examples are protective vests used by police departments and rescue equipment used by fire and rescue units. Items developed for state and local Governments at private expense are considered commercial items.

1.3.2 Reliability

Reliability is usually and formally defined as follows:

(1) The duration or probability of failure-free performance under stated conditions

(2) The probability that an item can perform its intended function for a specified interval under stated conditions

As already alluded to, reliability affects both mission accomplishment and operating and support (O&S) costs. When discussed in light of its effect on O&S costs, we refer to **logistics** or **basic** reliability, and in referring to its effect on the mission, **mission** reliability. In the formal definition, definition (2) is equivalent to definition (1) for non-redundant items, and is logistics reliability. For redundant items, definition (2) is equivalent to mission reliability. Table 1-2 explains the differences between these two aspects of reliability.

Table 1-2. Logistics (Basic) and Mission Reliability Characteristics

Logistics (Basic) Reliability	Mission Reliability
• Measure of product's ability to operate without logistics support • Recognizes effects of all occurrences that will demand support even if no immediate effect on mission • Degraded by redundancy • Usually equal to or lower than mission reliability	• Measure of product's ability to complete mission • Considers only failures that cause mission abort • Improved by redundancy • Usually higher than logistics reliability (but never lower)

1.3.3 Availability

Availability is a function of an item's reliability and how long it takes to restore the item to an operable state when it does fail. Reliability is often stated as the mean time between failures (MTBF). The time to restore the item to an operable state after failure is often stated as the mean time to repair (MTTR). Inherent availability is then defined by Equation 1.

$$\text{Inherent Availability} = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}} \qquad \text{Equation 1}$$

Another way of thinking of availability is uptime divided by total time (uptime plus downtime). Downtime usually includes time other than actual repair, and MTBF usually includes only failures due to design or manufacturing flaws (i.e., other causes for repair or removal are excluded). For these reasons, availability as defined by Equation 1 is usually referred to as *inherent availability*, A_i. Availability, when defined by total uptime (i.e., the mean time between all causes for removal or repair) divided by total time is usually referred to as *operational availability*, A_o.

1.4 Organization of this Guidebook

In this section, some background information has been presented to help the reader understand why the DoD is emphasizing the use of COTS. Also, information has been presented to explain the importance of reliability. In the next section of this guidebook, the reliability issues related to COTS will be explored. Then, procedures for evaluating COTS products from a reliability perspective will be presented. In Section 4, approaches for minimizing reliability risk in using COTS will be discussed. Contracting for reliable COTS is addressed in Section 5. Section 6 presents some case studies that show the problems in using COTS and the solutions used to ensure that COTS reliability was adequate. A list of references is provided in Section 7. Section 8 is a glossary of terms used in this guidebook. Commercial piece parts and associated reliability issues are discussed in Appendix A. Appendix B is a list of questions related to COTS reliability that should be addressed as a part of market research. Appendix C provides information on design criteria for temperature, shock, noise, and electromagnetic interference used for COTS items. Appendix D lists some potential sources of reliability data for COTS items.