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   The paper and supporting presentation will identify specific CI/NDI lessons learned and current risk mitigating efforts that have proven to be successful in reducing program and fleet operation risk from concept through operational life. Examples and discussion provided focus on Combat/Weapon System applications which require special consideration based on specific operational use and tactical interoperability requirements, however these subjects are generally applicable to all shipboard systems.

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SHIPBOARD SYSTEMS AND COMMERCIAL ITEMS, APPLYING LESSONS LEARNED

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INTRODUCTION

This paper addresses the application of Commercial Items/Non-Development Items (CI/NDI) hardware and software in Shipboard Systems development and life cycle support. The use of CI/NDI hardware and software has specific benefits, which will be summarized. This paper primarily focuses on the current challenges in using commercial products for shipboard military applications. It provides considerations, recommendations and mitigating strategies that will minimize acquisition and life cycle support risk when applying a commercial item solution in "New Start" and "Legacy " programs encompassing partial or full use of commercial hardware and software.

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The key to successful commercial item use is in understanding proven practices and tailoring those practices to fit a specific application. In leveraging research compiled by various DOD services and commercial industrial activities, a framework of pitfalls and risk mitigation recommendations are provided for educating military and industry personnel. Various techniques and processes have been developed to ensure that the delivery of commercial hardware and software meet Weapon/Combat system and shipboard operational needs. This paper is not intended to encompass every nuance of the "CI/NDI equation". It will be a reference source which can be built upon in order for activities to share "lessons learned" and "best practices". The authors intent is to, over time, expand this library of CI/NDI information and make it readily accessible via the DOD and Naval Sea Systems Command Web sites.

Definitions

The official definitions provide below are from the Federal Acquisition Regulation (FAR 2.101) and Department of Defense Regulations (DoD) 5000.2R:

Commercial Item: "A commercial item is defined as any item, other than real property, that is of a type customarily used for non-governmental purposes and that: (1) has been sold, leased licensed to the general public; or, (2) has been offered for sale, lease, or license to the general public; or any item that evolved through advances in technology or performance and that is not yet available in the commercial marketplace, but will be available in the commercial marketplace in time to satisfy the delivery requirements under a Government solicitation."

Modified Commercial Item: "A modified commercial item is any item with modifications of a type customarily available in the commercial marketplace or minor modifications of a type not customarily available in the commercial marketplace made to meet Federal Government requirements. Such modifications are considered minor if the change does not significantly alter the non-government function or essential physical characteristics of an item or component, change the purpose of the process."

Non Development Item (NDI): "A non-developmental item is: (1) any previously developed item of supply used exclusively for governmental purposes by a federal agency, a state or local government, or a foreign government with which the united states has a mutual defense cooperation agreement; (2) any item described in (1) that requires only minor modification or modifications of the type customarily available in the commercial marketplace in order to meet the requirements of the procuring department or agency; or (3) any item described in (1) or (2) solely because the item is not yet in use (far 2.101)."
Note: For use in this paper, the term Commercial Item will be used synonymously with Commercial Item/Non Development Item unless specified otherwise.

Technology Refresh/Insertion:
"Technology refresh" is the systems engineering and logistics process for replacing obsolete system components with newer commercially equivalent technology into a military system to sustain a system's baseline.

"Technology insertion" involves functional improvements to the military system with the integration of newer or enhanced capabilities that increase functionality. Either solution can be planned to occur in conjunction with announced or anticipated obsolescence of a single product or group of commercial products. These processes allow the Program Manager the opportunity to systematically plan the removal of obsolete equipment and components, to maintain operational requirements, and/or meet new requirements.

CI/NDI BENEFITS/OBJECTIVES

In reviewing benefits and objectives across DOD services, the following information is provided as common threads between services and rationale for use of commercial hardware and software:
- Reduce system acquisition costs by reducing development costs and taking advantage of the large, cost competitive, commercial marketplace.
- Provides accessibility to "State of the Art" technology.
- Reduce the time required to field new military systems by reducing development time.
- Capitalize on commercial research and development to field state-of-the-art systems more quickly.
- Maximize use of commercial infrastructure.
- Perceived reduction in Navy Total Ownership Cost (TOC).
- Will work as intended in their designated environment.
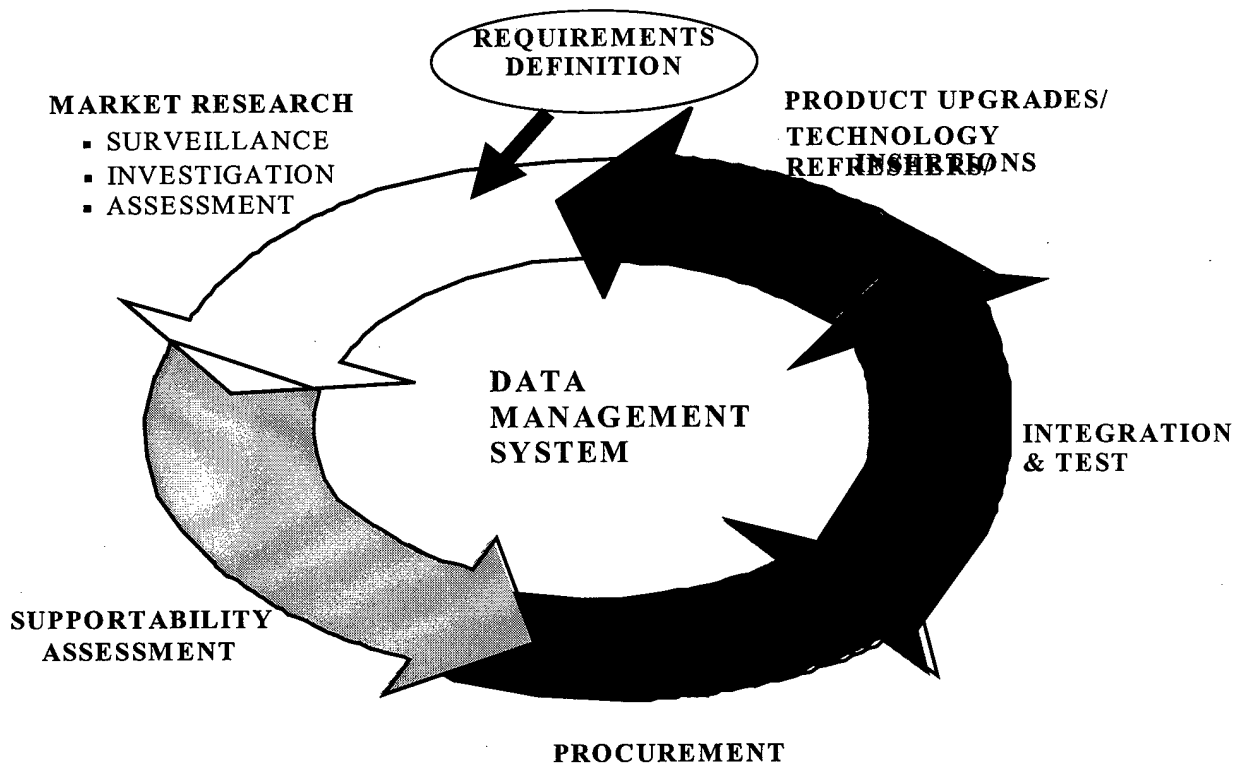- Will not adversely impact mission.

KEYS TO SUCCESS
As this paper provides lessons learned and recommendations on corrective action that can be taken, much of the risks associated with commercial item procurements can be mitigated by developing an acquisition concept. This acquisition concept consists of a comprehensive implementation program consisting of:

- Early establishment of a program CI/NDI Integrated Product Team (IPT) or equivalent.

- Research CI/NDI Web sites available in both Government and Industry –"Know the risk areas"

- Market research, including surveillance of leading edge technologies, investigation of promising commercial products, and the assessment of technology trends.

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- Supportability assessment of the preferred CI/NDI products.

- Ensure Vendors understand clearly your requirements.

- Procurement of the selected products.

- Integration and system testing of the CI/NDI items.

- Planning for technology refresh and technology insertion.

- Use of a Data Management System

Figure 1 illustrates not only the iterative and integrated application of the systems engineering processes involved in CI/NDI acquisition and insertion, but also the inherent interdependencies. A Data Management System will ensure that these processes are effectively linked and integrated.

REQUIREMENTS
DEFINITION

MARKET RESEARCH
- SURVEILLANCE
- INVESTIGATION
- ASSESSMENT

PRODUCT UPGRADES/
TECHNOLOGY
REFRESHERS/INSERTIONS

DATA
MANAGEMENT
SYSTEM

INTEGRATION
& TEST

SUPPORTABILITY
ASSESSMENT

PROCUREMENT

FIGURE 1. CI/NDI Systems Engineering Process

LESSONS LEARNED AND RISK MITIGATION

This area of the paper has been scoped down to comply with paper length submittal restrictions. This section will address the major significant lessons learned impacting the success of a program to meet schedule, operational requirements and maintain a reasonable life cycle cost when employing commercial items. Many more lessons learned are available, and will be provided by the author in future papers and articles.

Note: Many of the lessons learned are not specifically identified to a program, there is no attempt to identify who made mistakes but to focus on prevention and not repeating those mistakes. In respect of those offices and agencies which have provided "lessons learned" or "best practices" the parent organization may or may not be identified. Specific program identification is provided only when program source has authorized.

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Commercial Market Dynamcis

The commercial market moves to new technologies or product lines at a very rapid pace. This quick changeover in the commercial market is a primary concern with using CI/NDI.

Issue: Public consumers deem technology change as better than old, this is due to the increasing capability provided by technology advancements and cost reduction. Competition between commercial entities for latest technology and market share is fierce. In some cases, there is reluctance of the commercial entities to notify consumers that product line migration is planned, thereby keeping current inventories in demand and reducing the competition's ability to react to such change (seen in "state of the art" product lines). In other cases, the commercial entity does not maintain a product line notification system, therefore notification of product line change and/or support infrastructure is not forthcoming causing crisis management.

Recommendation #1: With assistance from the IPT, develop predictions on market stability in the commercial line by questioning and monitoring after market supplier's capabilities. Such as, if new technology is planned, will the new technology be interchangeable with the prior purchased interfacing commercial items? Will support for repair and parts stay in place for the life of the military application?

Recommendation #2: Develop a Data Management System to address regular posting of commercial notices and trends on market changes and specific key commercial components which would impact planned acquisition/support period. This Data Management System should not be managed by a commercial market supplier, it is best supported by a System Integrator whether it be a contractor or government agency.

Issue: Piece part obsolescence.

Recommendation: Diminishing Manufacturing Sources (DMS) in conjunction with a System Health Model database can assist a program in managing obsolescence. This approach leverages DoD and industry partner shortages in a common data base. Program Executive Office (PEO)/Theater Surface Combatants (TSC) has a health model which can predict piece part obsolescence of selected items by bouncing commercial part numbers against the notifications and predictions provided by commercial entities. This concept is being expanded to address assemblies and eventually repairable parts. Note: Proprietary rights may prevent after market parts support at higher indenture levels due to a "black box" approach maintained by many vendors.

Summary: These issues necessitate that the Program Manager constantly track the market and deal with fairly rapid product obsolescence. Formulating a support plan for a system impacted by the rapidly changing market requires substantial up front program planning. This requires continuous interdependent and complementary engineering and product support processes.

Integration And Interoperability

The integration and interoperability of commercial items at the equipment, system, platform, and battle group and joint operations level are significant challenges. The ability of two or more systems to exchange information and utilize the information exchanged is a key issue with CI/NDI products.

Issue: Many new or replacement commercial products are not designed or are misrepresented in their ability to interface with other operating systems and equipment. Discovering at installation that hardware and software are not compatible across a myriad of applications can cause costly rework and "bridging" (software/hardware).

Recommendation: Early program planning for additional integration time and testing is a must. Not only must individual hardware and software testing occur at a subsystem level, but additional testing will be required to ensure interoperability at the system level. Many commercial vendor's testing is limited to applications in the commercial market place, while this testing is useable and should be leveraged, it will not, in most cases truly ensure operational suitability. Additional independent testing is highly recommended to address the environment of multi-systems interface in a sea-going environment. General commercial predictions on interoperability of interfacing hardware/software must be tested to the extent of operational need. Program planning will be required to allow time and resources for thorough testing. If a system is a stand alone system, less testing will be required to mitigate operational risks, however testing is recommended as hardware and software performance may vary from marketed specification.

Issue: Components and systems acquired to commercial standards that should be compatible and interoperable with one another do not

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operate together or require "bridging" to facilitate operation.

Recommendation: Again, testing and integration time is required in the acquisition phase to insure interoperability. Commercial Standards, as in Military Standards, are not perfect. Testing individual components and software may meet their individual operational requirement, however, testing at the system level is required as the combination of hardware and software at a system level may be unacceptable to meet system level operational needs (timing/functionality restrictions).

Issue: System hardware or software changes which interface with other systems are driving unplanned alterations and upgrades in order for interfacing systems to remain interoperable with the changing system hardware and software. These unplanned upgrades are difficult to plan and budget in the near term. In many aspects, programs are forced to chase technology as interfacing systems replace legacy hardware and/or software with the latest technology. These changes cause a ripple effect of alterations in interdependent systems hardware and/or software.

Recommendation: As more systems require interoperability and interface with other systems, the need to have an overall management plan is required. The ability to manage configurations of dependent and interfacing systems reduces the exponential potential affect of unplanned individual system on other and/or larger system. Overall management planning additionally ensures that required resources and schedules are integrated to optimize the "Total Systems Approach".

Summary: As more joint and interfacing systems are developed in support of ship, battle group and battle area joint operations, the ability to ensure how systems hardware and software will interact becomes a major challenge for the Navy of today and the future. Additional program planning is required to encompass this area to ensure acquisitions meet the needs of interfacing systems and maintain interoperability requirements.

POM/Budgeting

The Program Objective Memorandum (POM) and budgeting processes have served the military well in Development Item acquisitions, however it is not currently tailored to accommodate rapidly changing CI/NDI applications. Because of the nature of the commercial market and rapid technology changes, both hardware and software life are significantly shorter than the life span of Military Specifications (MIL-SPEC) items. Program Managers will be challenged to develop timelines for CI/NDI insertions and upgrades, and to develop budget justifications in a timely manner to meet program requirements.

Issue: Forecasting future technology refresh and insertion requirements within the current FYDP budget process is difficult when predictability is not as refined as in a development item (MIL-SPEC build to print) system.

Recommendation: Because of the nature of the commercial market and rapid technology changes, both hardware and software life are significantly shorter than the life span of MIL-SPEC items. Therefore, CI/NDI out year budgets should anticipate periodic re-procurements, support engineering, and logistic efforts to replace items that are no longer supportable with next generation technology. Program Managers will be challenged to develop sensible timelines for item upgrades and to justify requests to accomplish these upgrades. Market surveys must be conducted and relationships established with commercial item suppliers to ascertain their plans for future support.

In preparing program budget forecasts, the Program Manager should determine which equipment and systems are most susceptible to changes resulting from technology advancements and define a succession of block upgrades that incorporate the then current technology. These forecasts should be based on industry growth trends in each of several areas including processors and computing technology, signal processors, storage technology, communications and networking, and packaging. The information required for these forecasts is a direct output of the market surveillance process. The results should be grouped into projected change packages and analyzed for life cycle cost impacts. This process should result in a reasonably predictable budget projection for the life of the program. Modeling techniques to assist in budget justifications are available and should be researched prior to creating a unique model.

Summary: As discussed above, the support budget for systems using commercial products can be difficult to project. Commercial product cycles are short in comparison to MIL-SPEC product cycles. Figure 2 illustrates a conceptual comparison between a typical military system (or build-to-print system) versus a system based

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on commercial items. The support expenditures for a military based system will have a limited number of major peaks resulting from large upgrades performed during the system life. The commercial based system will tend to have many smaller upgrades, reflecting the dynamic nature of commercial products.
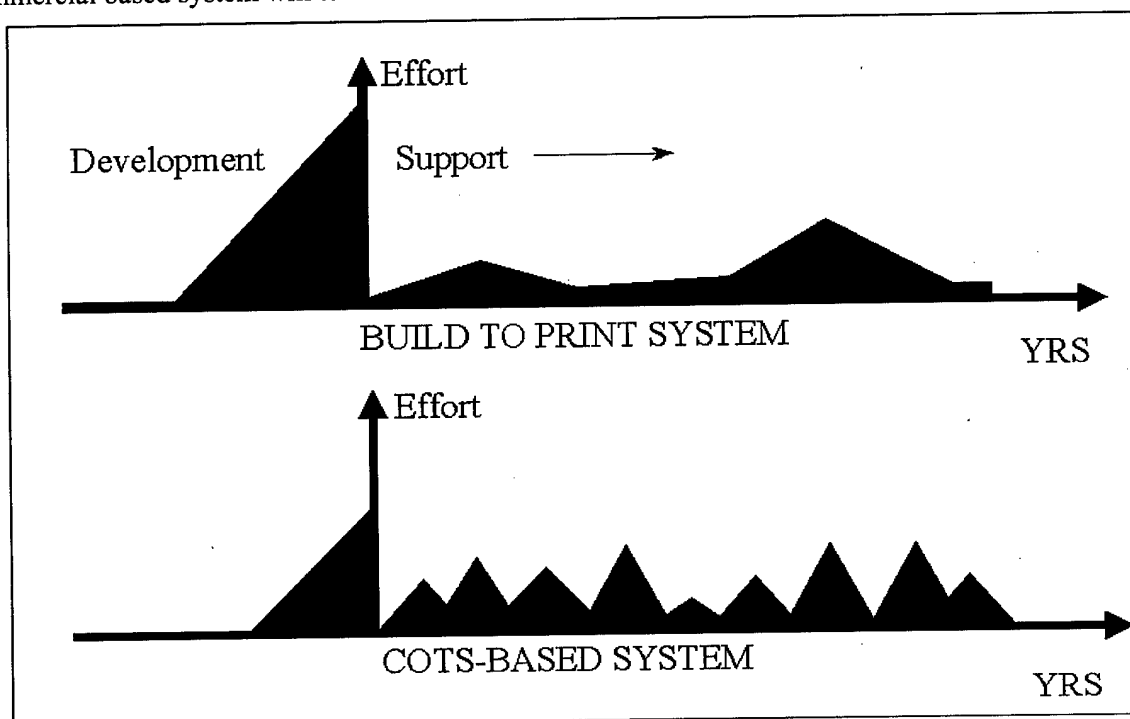

FIGURE 2. Conceptual Build-to-Print versus CI/NDI based System

Configuration Management

Configuration Management (CM) is applicable to hardware, software, firmware, middle-ware, and related technical documentation. CM is an integral part of life cycle management. CM helps ensure that all data relating to product characteristics (form, fit, and function - including interfaces) are accurately established, maintained and made readily available to support the engineering, logistic support, and acquisition aspects of a program. For CM to achieve this goal, it must integrate with the other program functions (budgeting, systems engineering, test and evaluation, ILS, etc.) throughout the life of the program. For effective management of all aspects of CM, four CM elements are commonly established:

- Configuration Identification
- Configuration Change Management
- Configuration Status Accounting
- Configuration Verification and Audit

Issue: Commercial products CM practices vary greatly and are costly. The determination of whether to utilize existing OEM CM practices or augmenting with other government processes is a difficult decision.

Recommendation: These CM disciplines should be applied to all CI/NDI items as well as any developmental items. However, as each of these disciplines are applied, the range and depth of its application should be tailored. In the past, the types (range) and amount (depth) of information NAVSEA contracted for was substantial. In depth documentation was required to support our MIL-SPEC equipment at all prescribed levels of support. This support requirement remains even as the development of new equipment shifts to a heavy infusion of CI/NDI. What is changing is the type and level of detail required in that documentation. Configuration Items may be replaced at a higher assembly level than before, requiring a lesser level of detailed life cycle documentation.

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The Program Manager is responsible for establishing the necessary processes for managing the Configuration Item baseline throughout its life cycle. Because the government is a low volume buyer (in the overall commercial marketplace) **baselines that include CI/NDI must be managed rather than controlled.** Baselines containing rapidly changing CI/NDI equipment should be established at a lesser level of detail, therefore reducing the cost to maintain them. However, it is important that once established, a defined process be used to maintain the baseline's integrity. The baseline must ensure that the Configuration Item's identity is not lost. Any departures from an established baseline should require the submission, for Government approval, of an Engineering Change Proposal (ECP) or a request for a deviation/waiver.

The major impact to the configuration change management program lies in the total control by the supplier over the timing and content of changes made to their products. To maintain its systems in an operational mode, the Government or its agent must stay abreast of changes in the commercial marketplace. This should be accomplished by conducting vendor surveys and/or establishing CM agreements with commercial market suppliers. These processes enable the Government to: (1) receive advance notification of supplier changes that affect product performance or interfaces; (2) receive advance notice of intended product obsolescence; (3) receive advance notice of intent to cease support of a product; and (4) receive advance notice of intended changes to licensing agreements or warranty provisions. The costs and risks associated with relying on vendors to provide change notification shall be considered as a major factor in establishing the change management program.

Logistics Support Planning

Selecting a commercial or non-developmental item does not imply that any of the elements of logistics support can be ignored. The support elements of CI/NDI candidates must be thoroughly assessed during the market investigation because logistics support remains a critical factor in the decision as to whether a CI/NDI selection is even feasible. In arriving at a decision regarding support, remember that departure from traditional methods of getting logistics support may be required or even desired. Consider the complete range of possible support methods available, from full reliance on contractor logistics support, to full use of traditional organic support.

Issue: A system was acquired and fielded on schedule and within budget, however the logistics support does not seem adequate to maintain readiness requirements.

Recommendation: One of the primary goals of the logistics support program for a CI/NDI product is to influence the selection of the item based on logistics considerations and best value to the Navy. The decision to use CI/NDI based systems requires the early and concurrent involvement of the ILS community. It is vital that logistics considerations become a part of the commercial item selection process. Operating and support costs for CI/NDI systems can and will escalate if not effectively managed in the early stages of the program. Programs using CI/NDI systems or equipment should maximize the use of the existing (commercial) logistics support capabilities and data. Development of new (organic) logistics products for CI/NDI should be limited to meeting a critical mission need or achieving cost savings.

The unique support considerations of CI/NDI must be evaluated within the context of traditional logistics support elements.

Issue: To what depth or degree do the logistics elements apply to commercial item acquisitions? When and how much logistics support should be procured from the vendor vice using traditional government processes and techniques.

Recommendation: In order to evaluate this area, each element must be reviewed with specific areas to be considered that mitigate program support risks. The following are minimum considerations by the logistics element. The support infrastructure for logistics is determined by early and thorough market investigation by the Program Commercial Item IPT.

Maintenance Planning

Factors for consideration when establishing the maintenance concept include:

- The degree to which manufacturers, other military services, or other sources already provide maintenance support to existing customers.

- The responsiveness of any such support activity to meet military requirements in peacetime and wartime.

- The degree to which the military service will be able to provide organic maintenance support, and the need for support facilities

or a training and sea-shore rotational base for service technical personnel.

- The Level of Built-In Test (BIT) and Fault Diagnostics/Fault Identification (FD/FI) capability of the CI/NDI.

Supply Support

Some possible alternatives for supply support that will need to be investigated are:
- Traditional Naval supply system support.
- Direct Vendor Delivery (DVD) - manufacturers or vendors store and distribute spares and repair parts as needed (also referred to as "Just-in-Time" support).
- Organic Direct Vendor Delivery (ODVD) - same as DVD but an organic activity stores and distributes the parts.
- Prime system contractors or integrators provide supply support.
- Replacement end items are purchased as needed (discard upon failure).

Support and Test Equipment (S&TE)

S&TE is used to verify operational status and restore the systems/equipment to operational status during planned and corrective maintenance.. Use of standard government test equipment (which may be commercial) instead of unique test equipment recommended by the manufacturer is preferred, but in some cases will not be feasible for a specific commercial item. The need for new calibration standards and procedures to support the required test equipment must also be determined. Dependent on the commercial item supported, the S&TE cost can be a significant unplanned program cost driver. These requirements should be an integral part of the CI/NDI selection criteria. Again, to provide effective support for S&TE, make a thorough review of the market investigation data.

Factors for consideration when establishing the S&TE concept include:
- Determine if there is a requirement for any S&TE capability (e.g., General Purpose Electronic Test Equipment (GPETE), Special Purpose Electronic Test Equipment (SPETE), special tools, adapters, etc.).
- Determine if existing or modified S&TE provides the required support.
- Conduct an analysis with the assistance of coordinating agencies to minimize/prevent the introduction of new test equipment.
- The level of BIT and FD/FI capability of the CI/NDI.

- The affect of CI/NDI on system availability as specified in the Operational Requirements Document (ORD).

Technical Data

Technical data includes specifications, drawings, technical manuals, calibration procedures, software documentation, and other data required to test and inspect, perform preventive and corrective maintenance, operate, and repair the item or its parts. Where suppliers claim proprietary rights to data, as is normally the case for commercial items, the logistics manager should validate the supplier's claim and carefully review the data requirements to avoid buying unnecessary and expensive data rights.

The Navy does not own rights to design or manufacturing data for CI/NDI products used in a system. The government should seek to negate the need for excessive CI/NDI product data by avoiding the use of single source products or product features that are unique to a single manufacturer. If deemed appropriate, government negotiated rights to vendor data (hardware and software) prior to the vendor going out of production may need to be considered as part of the acquisition strategy/analysis up front, and included in the cost analysis used in CI/NDI selection. This analysis includes software rights and operating systems.

In most cases there is no longer a requirement to develop Navy unique technical manuals for commercial equipment. The manufacturer of the equipment may supply the commercial technical manuals along with the equipment. However, the commercially supplied technical manuals may not meet all of the Navy's requirements. Commercial technical manuals may need to be supplemented with government unique requirements such as safety issues and interface requirements. The government should avoid modifying or duplicating information in commercially supplied technical manuals.

The supportability analysis should include a detailed review of technical data requirements and options for long term support of Navy requirements. Data rights information should be a key consideration of CI/NDI product manufacturers regarding product data disclosure vary among manufacturers from complete prohibition of disclosure to full disclosure. If it is impossible to avoid the use of a product for which data rights may become an issue, the cost and availability of the data should be considered during the supportability

analysis, and compared with other options in the event the need for the data arises. Identify whether there are provisions for the vendor to notify the government of CI/NDI documentation changes. Contracts should mandate notification when organic support, part numbers, or designs change.

Technical data considerations during the supportability analysis include:
- Availability of commercial technical manuals and drawings.
- Adaptability of commercial technical manuals to Navy end user requirements. Consider whether requirements such as safety, installation, operation, and maintenance of the CI/NDI in its operational environment are available in sufficient detail to support the system maintenance concept.
- Identification of hazardous material and disposal methodology.
- Technical Data reproducibility rights. Technical Data disclosure rights should vendor no longer produce or support.

Training and Training Support
In developing the training requirements, consideration should be given to the impact of CI/NDI on traditional training concepts. The short life cycle of CI/NDI may preclude use of extensive shore based training. Training based on functional principles vice specific hardware attributes can take advantage of open systems modularity by reducing data requirements and shortening the training pipeline. The government should consider developing training materials for use in electronic classrooms or on board trainers that are integrated with the CI/NDI system.

Training experts should be involved in the supportability analysis to consider training program support options for systems employing CI/NDI. Significant interface with Fleet Training Commands is necessary to ensure the Navy training infrastructure is part of the decision making process for establishing training concepts. The following issues should be considered when reviewing options for training plans:

- The requirement for a new or revised Navy Training Plan (NTP).
- Changes to the training requirements contained in Crew Scheduling and Phasing Plans (CSPPs) for new construction ships.
- Impact of CI/NDI training concept to Navy Enlisted Classifications (NECs).

- Availability and cost of vendor provided Computer Based Training (CBT), factory training, or on-the-job training for the CI/NDI products.
- Availability and cost of vendor furnished training and technical documentation to support the maintenance concept.

Manpower and Personnel (M&P)
In some programs, application of commercial equipment has made it possible to reduce shipboard manpower requirements by reducing time required to conduct preventive and corrective maintenance. The supportability analysis should include a consideration of the potential impact of use of CI/NDI to Manpower and Personnel. CI/NDI that results in an increase in either shipboard or shore based M&P requirements should be avoided. The training supportability assessment should address the proper support requirement in accordance with the CI/NDI concept. To provide effective manpower and personnel requirements for the CI/NDI, review the market investigation data for support options. The following issues should be considered during the supportability analysis:
- Minimum manning requirements imposed by higher authority may override CI/NDI induced crew reductions.
- Effect of insertion of CI/NDI on reliability, maintainability, and supportability and associated maintenance requirements.
- Impact of CI/NDI on the number and type of personnel required for systems maintenance.
- Effect of CI/NDI on Human-Machine Interface (HMI) including display management features and operator requirements.
- Use of embedded training or CD-ROM based training may reduce the number of shore based instructors and support personnel.

Facilities
The use of CI/NDI has the potential to significantly alter the requirements for specialized facilities to support the equipment or system. In traditional Navy developmental programs, the Navy often established and maintained specialized integration, test, support, and training facilities. Use of commercial vendors may negate the need for some or all of these specialized facilities.

Life Cycle Cost analysis and tradeoff studies help determine the most cost effective approach to satisfying facility requirements. The process

for determining facility requirements for test and integration, training, software maintenance, compliance testing, etc. will be unique for each program based on funding, end item quantities, installation and support schedules. Three approaches are commonly used:

- Using existing or modified government owned facilities
- Relying on existing commercial facility infrastructure
- Sub-contracting for use of contractor owned facilities

The supportability analysis must include a complete review of facility requirements. This is especially important for systems utilizing CI/NDI, since the government may be able to rely partially or fully on the commercial facility infrastructure to meet its requirements. Determining the adequacy of contractor owned facilities for CI/NDI systems requires a thorough review of the market investigation data. The following facility issues should be considered during the supportability analysis:

- The need for a system test bed capable of testing repaired and/or replacement parts prior to designating them as "Ready For Issue."
- The need for a system test bed to test computer program modifications and upgrades before Fleet introduction.
- Requirements for a system test bed to test technology/product refresh and next generation technology systems prior to Fleet introduction.
- Utilization of government or contractor facilities to conduct operator and maintenance training.
- Rapid technology change can result in multiple system configurations installed on similar platforms. Any integration/test facility will need to be able to maintain some capability for backward compatibility.

Test And Evaluation

Commercial item and non-developmental item acquisitions need to be supported by a tailored test and evaluation program. The extent of the testing depends on the type of item, similarity of the item's commercial use to the intended military environment, performance history of the proposed system or item, and the amount and quality of test data available from the original system development or from the commercial producer.

Issue: From a program management position, is commercial testing adequate, believable, or is a separate government testing program required to validate commercial testing?

Recommendation: The general guidance for CI/NDI acquisitions is to conduct testing only when existing vendor data (contractor or other) is insufficient. To avoid redundant testing, the IPT must understand to what standards commercial or other product developers tested their equipments/systems and be open to accepting their test results in lieu of conducting military testing. It is important to obtain assistance from developmental testing experts at an early point. Early participation by Operational Test and Evaluation Force (OPTEVFOR) is equally important. Together these testing experts can verify existing test data and plan for additional tests if required. CI/NDI test and integration planning should consider both development and support phase testing requirements. For a CI/NDI based system development, the developer's test plans should address requirements and facilities for CI/NDI evaluation and conformance testing, as part of the system integration and test plans. During the support phase, the Program Manager should allocate resources for conformance and compatibility testing of fielded systems that will regularly undergo CI/NDI product upgrades. The testing performed should support the following objectives:

- Ensure item meets operational requirements.
- Satisfy legal requirements, such as mandatory testing and reporting requirements for milestone decisions.
- Maximize the inherent advantages of using a commercial or NDI approach, such as user experience and test and performance history.
- Validate safety in the intended military environment.

Additional testing is required at specific levels to ensure all testing requirements are met. The following are the various testing levels that will be required dependent on the commercial item application as stand alone, integrated into a system, or interfacing with other systems.

Initial Test and Certification

System certification is contingent upon accomplishment of a complete Test & Evaluation (T&E) Program to ensure the system meets specified mission, performance, functional, and safety requirements. Certification is granted based upon the results of numerous levels of testing and detailed analyses into documented system performance parameters to ensure the overall ship mission is

accomplished. In addition, practical strategies are required to ensure that system certification is not compromised by rapid technology changes associated with commercial items.

Test and evaluation requirements should be thoroughly addressed during the commercial item market investigation process. The developers, users, and independent operational test community should be involved early in the development process. If the market investigation supports a CI/NDI solution, the IPT should determine and document all remaining test and evaluation requirements in the test and evaluation plan. The plan should also include a summary of previous testing and results. Developers, users, and independent operational testers should work together to tailor test requirements and execution strategy. Specific tests required will vary with each individual acquisition. Testing should vary with the type and application of the item. The IPT should determine which of the following four situations applies, and document test requirements accordingly:

- **CI/NDI intended to be used in the same environment and under the same conditions for which it was designed.** Development testing is normally not required before production qualification testing. Operational testing is required when organic maintenance is a necessity.
- **CI/NDI intended to be used in an environment different from that for which it was designed**. Early qualification testing will probably be required in the operational and maintenance environment. Pre-production qualification testing will be required if early qualification testing leads to modification of the original item. Production qualification testing as well as operational testing will be required.
- **CI/NDI intended for integration into a larger system.** Feasibility testing to qualify a test sample should be conducted before the item is integrated into the system. Pre-production testing of the complete system is required. Hardware and software integration testing will be necessary.
- **CI/NDI that has been modified.** Testing focuses on the modification to ensure it meets the operational requirement and does not negatively impact overall operation. A frequently used approach to early qualification assessment is to purchase a few candidate items and put them in the hands of the users to determine if they will work in the operational environment.

Unit Testing -
Unit (or component) testing is performed on the individual system components which include application modules, peripheral devices, processor boards, etc. Once all components have been individually verified, the assembled components are ready for integration testing.

Some strategies for certifying CI/NDI components appear below. Sufficient resources and facilities need to be established to support CI/NDI component testing activities.

- **Conduct compliance tests** – Many component performance specifications require adherence to various industry standards. Compliance tests can demonstrate how successfully the component design meets the standards.
- **Leverage market "burn-in"** – If the CI/NDI component supports a non-mission critical function, the certification requirements may be less stringent. In such cases, it may be acceptable to forego unit testing if the component has accumulated a track record of reliable performance in widespread industry use. Even if unit testing is still required, the use of reputable commercial products increases the level of product assurance.
- **Conduct black box tests** – Functional testing of a component involves stimulating the component with all possible inputs and verifying that the outputs satisfy the performance requirements. These tests can provide the same degree of assurance achieved for developmental items. However, this approach requires adequate specification of the component's performance requirements and thorough test procedures that anticipate all potential system inputs and outputs.

Integration Testing -
Integration testing involves the examination of system performance at the element, subsystem, and system levels. This examination focuses on requirements contained in the performance specifications and the interface design specifications. CI/NDI test procedures are usually "black box" oriented in that the system is stimulated with a specific set of inputs (which may consist of operator actions, sensor data, inputs from other systems or subsystems, etc.) and the output or results are observed and analyzed for correctness. Limited analysis of the application software is often included in the integration test evolution by using embedded

breakpoints or data recording features. Such tests may be conducted at land based test sites with a mix of live and simulated interfaces or aboard ship using live interfaces. Integration testing often requires extensive resources both in terms of manpower and facilities.

Early test and evaluation of CI/NDI components is important during system development. Quality vendor support of the commercial product is also important during system test and integration phases to provide commercial product troubleshooting assistance or other product information not readily available in standard commercial manuals and documentation.

CI/NDI software products should meet known interface standards. Using controlled, standardized interfaces will facilitate future changes and upgrades without impacting the entire system. Interoperability, or the ability of two or more systems to exchange information and utilize the information exchanged, is a key issue with CI/NDI products. Therefore, the Program Manager should plan for and allocate additional integrator time and resources to resolve CI/NDI interface and performance problems during system development and test. As part of the CI/NDI selection process, the integrator should communicate with the vendors to determine the product's interoperability with other CI/NDI products to be utilized in the system under development. For CI/NDI products with no positive interoperability records, the integrator should either find another product with interoperability data or flag the product as a risk item. For those critical CI/NDI products, the integrator should consider prototyping as a means to identify interoperability issues early in the development. The Program Manager should plan for possible cost and schedule impact during the integration and test phases resulting from integration and interoperability problems associated with CI/NDI products.

Maintaining System Certification Upon Modification -
Testing and verification of a system's individual components and functions form the basis for unit level certification. The initial certification extends only to the specific configuration tested. As such, subsequent changes to the system configuration usually require a repeat of some level of component or system certification. This may become very complex with CI/NDI, because multiple system configurations may exist on similar Navy platforms. For

commercial based systems which change frequently, give special consideration to ensure system certification can be maintained at a reasonable cost as each system's configuration evolves. The recommended approach is to establish a documented component certification process that is capable of determining potential system impacts and that ensures component changes are transparent to the rest of the system.

SUMMARY
Many things must come together to make the application of CI/NDI work, including implementation of significant changes in the way systems are acquired and supported. A summary of some of the high level areas which have significant impact on the ability to acquire, deliver and support commercial items over equipment and system life cycle are:

- Requirements should be defined (both hardware and software) in performance/functional terms, that enable and encourage the use of CI/NDI.
- To gain the advantages presented by the commercial marketplace, neither the integrator nor the government should impose restrictions or requirements outside the norm of the commercial marketplace, while still meeting mission requirements. Doing so would erode the cost and performance advantages inherent within the CI/NDI concept.
- The foundation of a successful CI/NDI application is to design hardware and software architectures that will withstand insertion of new technology, for whatever reason, without impacting their use in the system. This requires the use of Open System Architecture, with strict adherence to commercial interface standards for hardware and software.
- Major emphasis in the systems engineering process should be on the selection of new technology through market research rather than from Navy sponsored product development.
- Testing should be focused on system performance, operational effectiveness, operational suitability for the application, and integration of commercial and development items. Leverage commercial testing to the greatest extent possible.
- There is increased risk to the deployed system whenever products are acquired and installed in a fielded system without thoroughly testing them in the planned system configuration. Provision should be made for adequate test facilities at an

integrator or at a Navy facility, before a commercial item is deployed to the ship.

- Contractors supplying CI/NDI products should be allowed to use their existing support structure and existing data without change whenever possible. The modifications of these support structures are costly.
- The innovative use of contractor incentives can affect TOC. The commercial supplier or integrator will seek ways to reduce costs when presented with the appropriate incentive.

Obtaining Knowledge On Commercial Item Management

Much of the material provided is available through research on the DoD and Naval Sea System Command Web sites and links. Data is available via these web sites addressing the following areas which were not discussed in this paper:

- Shipboard Environment
  - Power Stability
  - Shock and Vibration
  - Temperature/Humidity
  - Electromagnetic Interface (EMI)
  - Corrosion and Fungus Control
- Information Security
- Contract Management
- Warranty and Licensing
- Cost Models
- Proprietary Data
- Information Technology Standards
- Databases
- Product Assurance
- Quality Assurance
- Reliability and Maintainability
- Contract Incentives
- Total Ownership Cost (TOC).

CONCLUSION

This paper has not addressed every aspect of the use of commercial items in shipboard applications, it is, but a starting point to build upon in creating a library of "lessons learned" and "best practices". There is no "cook book" approach to the management and use of commercial items. Individual program variables in funding, operational requirement, support period, interoperability, life cycle etc. all effect the commercial item selection or non-selection.

REFERENCES

This paper was developed from accessing various DoD Web Sites that provided links to multiple related Web sites. The primary Web sites are:

Defense Acquisition Deskbook
http://www.deskbook.osd.mil/
DoD Product and Technology Surveillance Website
http://pats.crane.navy.mil/
DoD Commercial Item Military Market Research Information Center
http://cmmr.crane.navy.mil/
Navy Acquisition Reform Homepage
http://www.ace.navy.mil
NAVSEA Total Ownership Cost Website
http://www.navsea.navy.mil/sea017/tocmodex.htm/
NAVSEA Open Systems Acquisition Website
http://www.navsea.navy.mil/acquisition-reform/open.htm/
NAVSEA COTS Steering Board Homepage
http://cots.crane.navy.mil/
NAVSEA COTS Website (under construction)
http://cots.navsea.navy.mil/

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