THE TOMAHAWK CONSOLIDATED DATA BASE

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ABSTRACT

As today's weapon systems grow increasingly complex, more and more often groups of contractors work together to fulfill hardware procurement requirements. The use of dual source programs by the Department of Defense to increase competitiveness adds to the number of contracts which must be monitored by the government. Test and performance data generated by each of these contractors during development and production, as well as government supplied deployment data, must be analyzed to ensure the reliability and availability of fielded units. If the amount of data becomes too large to handle manually, it must be automated for efficient management. A consolidated data base was developed for the Tomahawk Cruise Missiles Project to store and automatically retrieve data from numerous production contractors, field activities, and repair facilities. This paper addresses as a case study the design and implementation of the CDB.

INTRODUCTION

The Tomahawk cruise missile is a long term weapon system whose performance must be constantly tested to ensure its reliability and continued availability. The results of production, field, and depot testing must all be considered when assessing the system. The task of consolidating the data from these numerous sources has historically been performed manually, consuming valuable resources. To efficiently manage the data, an automated data base serving as the central collection and dissemination point was developed.

The initial development of the Tomahawk consolidated data base (CDB) was completed over a period of 8 months and an initial operating capability (IOC) was demonstrated. At that time, the data base system design was completed, software applications programs for data entry and retrieval were operational, and data summary reports were being provided upon request to government and contractor representatives. Full operational capability of the CDB was achieved 6 months later, with several remote government and contractor users trained in system operation, data collection and entry more complete, and the CDB being used in a day-to-day fashion.

Data collection efforts have continued during the entire development process and the CDB now includes over 20000 test records. Over 30 tracked components of each Tomahawk missile are followed through production, deployment, depot return, and redeployment. The number of missiles tracked continually increases as new missiles are produced. The system will continue to grow for some time, since only one quarter of the planned total procurement has been completed so far. As the in-service length of fielded missiles increases, the contractor-run depot activity has also been increasing. Numerous contract deliverable reports, government and contractor internal reports, and specialized data bases are queried and data is extracted from them and entered into the CDB. One of the immediate outcomes of the CDB has been a recognition of the need to properly capture necessary data, and as a result more detailed data requirements are being placed into new production and depot contracts. Future contracts will include the requirement for all deliverable data to be provided to the government in magnetic media format.

BACKGROUND

The cruise missile, essentially a small, unmanned aircraft, has been developed to complement and supplement manned aircraft in the performance of strategic and tactical missions. It is a singular major element in the ability of the U.S. to deter large-scale conventional and nuclear war. The Cruise Missiles Program was initiated in 1973 with the decision to develop a long range strategic air launched weapon system. The success of the air launched cruise missile (ALCM) and the inherent flexibility of the cruise missile concept led to the development of other variants to satisfy a widening range of operating conditions and mission goals.

The Tomahawk cruise missile system is a joint program of the Navy and the Air Force, combining both sea-launched and ground-launched cruise missiles (SLCM and GLCM). The same basic structural and propulsion systems are used in both variants, with navigational and ordnance configurations adapting to fit the specific mission requirements. SLCMs can be launched from the surface or undersea, while GLCMs are ground-launched only. The joint development of the Tomahawk provided for maximum interchangeability of hardware between land, sea, and undersea forces, resulting in an extremely versatile and capable weapon system.

PROBLEM ADDRESSED

The initial production of the Tomahawk began in 1980 using a multi-tiered hardware procurement arrangement. A single prime contractor was responsible for the design of the structural system and assembly of the complete missile, or All-Up-Round (AUR). Subassembly contracts were directly awarded by the Cruise Missiles Project Office (CMPO) for design and production of major missile subassemblies, i.e., the guidance set and propulsion assembly. These subassemblies were accepted by the government from the subassembly manufacturer and provided as government-furnished-equipment (GFE) to the missile level contractor. Design and production of major subassembly components were also contracted directly by the CMPO. These components were then provided as GFE to the subassembly manufacturers. When the assembly of the AUR was complete, it was accepted by the government and deployed. After the normal field rotation period, or for unscheduled maintenance actions, the AUR was returned to a contractor-run depot and essentially "bought back" from the government. Any GFE subassembly or component that failed during depot AUR testing, or that needed scheduled maintenance, was returned to its GFE maker for failure analysis, repair, or refurbishment. After missile maintenance was complete, it went through a thorough set of acceptance tests. The government then accepted the missile after depot work and it was redeployed. A schematic of the production, deployment, depot, and redeployment cycle is shown in Figure 1. This cycle of deployment and depot work is repeated several times during the missile's lifetime.

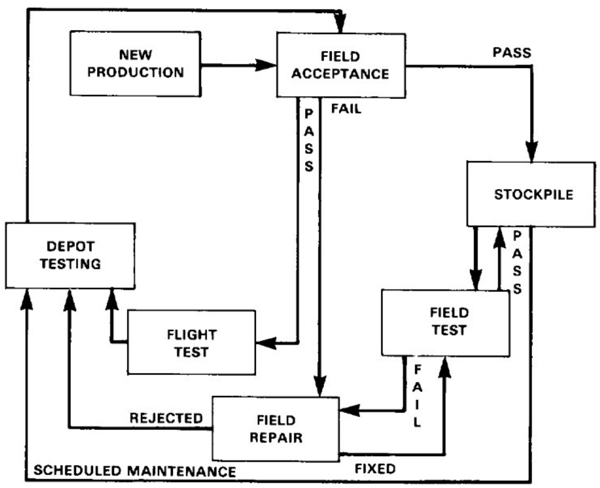

Figure 1. Tomahawk Missile Hardware Life Cycle Flow

In response to the Department of Defense's requirement to increase competition, as well as to increase capability of supply in case of need, a dual source procurement program was introduced on most GFE equipment. The contractor-run depots were also included in the dual source program. This resulted in two AUR manufacturers, four GFE subassembly manufacturers, seven GFE component manufacturers, and two depot contractors being managed directly by the CMPO. These contracts were each awarded yearly.

Each contractor (both production and depot) was required by contract to submit regular reports providing details of testing and failure analysis. Field activities were also required to submit regular reports on field performance. These reports were delivered to CMPO in hardcopy, all with differing formats, reporting periods, and data requirements. When a comprehensive overview of the program was required, it generally involved a lengthy manual search of all data sources. Most of this information was contained in the delivered reports, but some was located in other places such as logbooks, specialized contractor and government data bases, and briefing notes, or uncovered through telephone calls. Correlation and analysis of this large amount of data was a difficult, inefficient task. The complexity of the acquisition program using multi-tiered dual sources, combined with numerous field activities and separate production and depot contracts, provided an enormous challenge in program management and assessment.

PROBLEM SOLVED

The Cruise Missiles Product Assurance Office, recognizing the need for a single, automated source of product assurance data covering both the factory and field performance, initiated development of the CDB. This data base was intended to be the central repository for data, holding the most current, validated information available. There were several major objectives to be accomplished in the development of the CDB, as shown below:

- Provide an automated, central system available to the entire cruise community
- Contain field history and test, failure, failure analysis, and corrective action data on the missile and major components
- Collate data from numerous different sources to provide a single source of validated data
- Be user friendly for ease of operation
- Be least disruptive to existing data collection systems
- Have ability to interface with other systems.

Work on the CDB began in February 1986 with the development of an initial list of data elements and hardware items to be tracked. Preliminary studies estimated that 100 megabytes (MB) of data would be generated from production, field testing, depot evaluation, and failure analysis. Efforts in hardware selection, software design and programming, and data collection were accomplished in parallel to get the system on line as quickly as possible.

The data in the CDB was categorized into four main modules: identification, location, testing, and failure. These modules contained a total of 11 files as shown in Figure 2. The identification module holds basic inventory data such as part and serial numbers, government acceptance dates, and field configuration. Location data on the AUR allows the CMPO to evaluate the effects of storage and operational environments on

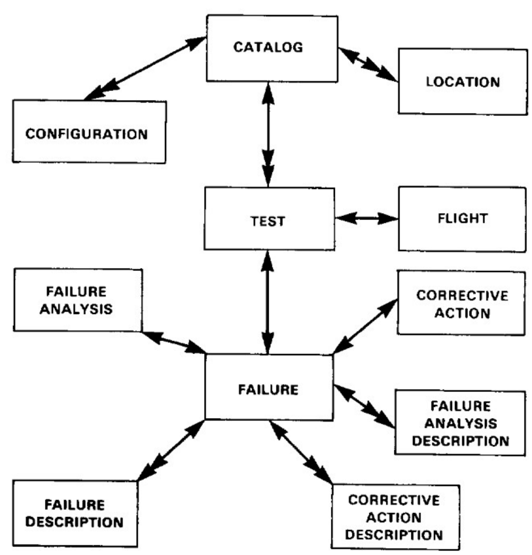

Figure 2. Tomahawk CDB File Structure

missile performance. The test module holds records on performance testing for the AUR, subassemblies, and components. The data includes test dates and environments, amount of power on time, and test result. Both pass and fail tests are recorded. The failure module contains the identity of the subassemblies and components that caused the failure. Narrative descriptions of the failure, failure analysis results, and corrective actions are also captured. The data base contains over 100 datafields and will support a complete assessment of the Tomahawk missile and its components. The interactions between these different files are maintained internally by the data base management system.

The data base was developed on a VAX 11/785 minicomputer using a commercially available data base management system (DBMS) called INFO. There were several appealing aspects of this hardware and software configuration. INFO runs on many hardware systems, including personal computers (PC). This allows for data to be downloaded from the VAX to a PC and then manipulated offline. Applications programs and data can be transferred with no change in programming or format. In addition, it provides the future capability for direct data transfer between the major data sources (i.e., manufacturer data bases) and the CDB. INFO utilizes an ASCII datafile format for data storage, allowing it to exchange data with many commercially available statistics and graphics packages.

The VAX is capable of handling telephone communications so that several users can access the system at once over a phone line. Access at the user's end is accomplished with a PC or a VT-100 terminal. Anticipated users are located throughout the United States and Canada. The system is capable of supporting up to 24 users at one time. Additional users can be added as the demand increases.

The INFO programming language was used to develop a completely menu-driven system for ease of operation. Several predefined, standard reports were developed that could be run directly from the menus. The reports extracted data from the various files and produced concise listings giving the following types of information:

- Failure trending analyses
- Test yield assessments
- Storage and flight assessments
- Failure summaries giving narrative descriptions
- Failure status and closeout assessments.

Data can be provided for a specific subassembly or for all subassemblies in a particular missile. In addition to providing standard reports, the data base allows users to perform ad hoc queries to answer specific questions. The data base design allows users to leave the menu driven system and access the INFO interactive query language. Users can then perform their specific analyses, such as field reliability and availability assessments, spares predictions, identification of suspect fielded hardware, etc, that have not had menu driven applications programs developed. This is a very powerful aspect of the CDB, because virtually any question on performance and reliability can be answered using the data. Standard report and ad hoc query outputs can be shown either directly at the terminal screen in real time or printed out in a batch mode.

Data collection and normalization began as the hardware and software requirements were being developed. AUR data, consisting of production, depot, and flight test performance, was used as the initial baseline. A date of January 1, 1984 was used as the cutoff date for the first phase of data collection, as the majority data prior to that was archived. AUR contractor reports

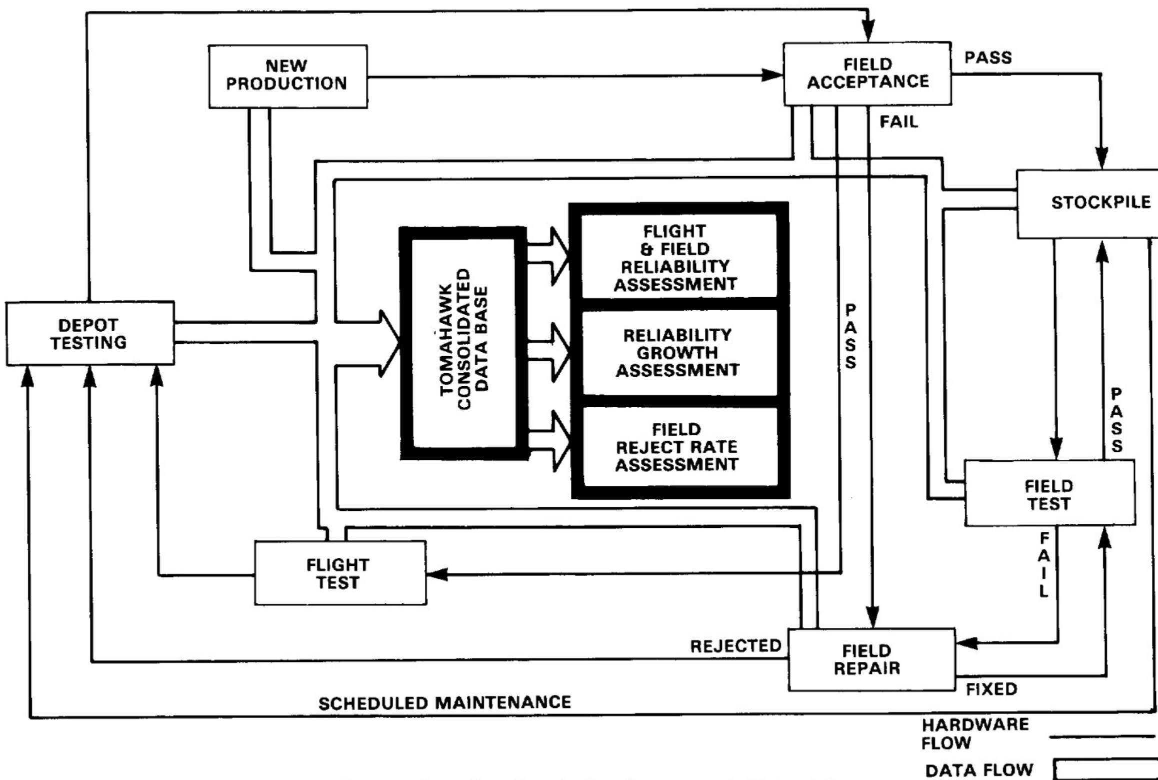

Figure 3. Tomahawk Hardware and Data Flow

provided missile level test results, and failure analysis results for contractor furnished equipment (CFE). The GFE subassembly and component failure analysis results had to be found from GFE reports. GFE manufacturer failure analysis results were summarized and used to update the failure records from the missile level failure. In this manner, a complete history of a failure, from first failure indication, through removal and retesting at one or two levels of GFE manufacturer locations, to the results of piece part failure analysis, could be found in one place. Once the AUR data collection was up to date, production performance data was collected on the GFE and CFE subassemblies. Following this, GFE and CFE component production data was gathered.

The data was supplemented from any available, validated source. All data was normalized and combined, then input into an event-oriented system. The input was subjected to numerous edit checks to ensure standardization and quality. As new information became available, the data base was updated to provide the most current data possible. Data collection and entry is continuing daily.

The CDB now plays a central role in the information loop, receiving data from the numerous production, field, and depot sources and making it available to support various product assurance related evaluations and assessments. A schematic of the system, showing both the cruise missile hardware and data flow, is presented in Figure 3. The CDB has provided a means of efficiently managing the huge amounts of data that are generated during the life cycle of the Tomahawk weapon system.

CONCLUSION

The CDB has become the best single source of accurate information available to the cruise missile community. Previous manual program assessments had caused hours or days of work in collecting, collating, and analyzing the data, whereas the CDB can provide an assessment or the data to support an analysis in a matter of minutes. This frees the engineers to perform higher level work, letting the computer search the mass of data for relevant information. In addition, the ready availability of the data base has allowed for easier tracking and identification of problem areas within the Tomahawk cruise missile. The CDB has become one of the main tools for managing the product assurance aspects of one of the complex weapon systems typical in today's Armed Forces.

BIOGRAPHIES

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