Serialized Maintenance Data Collection Using DRILS

Capt. Greg Lindsey
Ogden Air Logistics Center

Kevin Berk
Total Quality Systems, Inc.

The Defense Repair Information Logistics System (DRILS) is a specialized Web-based application that collects, stores, and retrieves Air Force depot and field maintenance data. A Web browser is all that is needed to operate DRILS from any <.gov> or <.mil> Internet address to "carpe data" or, seize the data. One of the main goals of DRILS is to benefit those who enter the data. DRILS accomplishes this by providing streamlined and automated data entry that reduces maintenance documentation time while improving the data integrity. DRILS also provides historical analysis and other decision support tools that can be immediately used by the supervisor or technician.

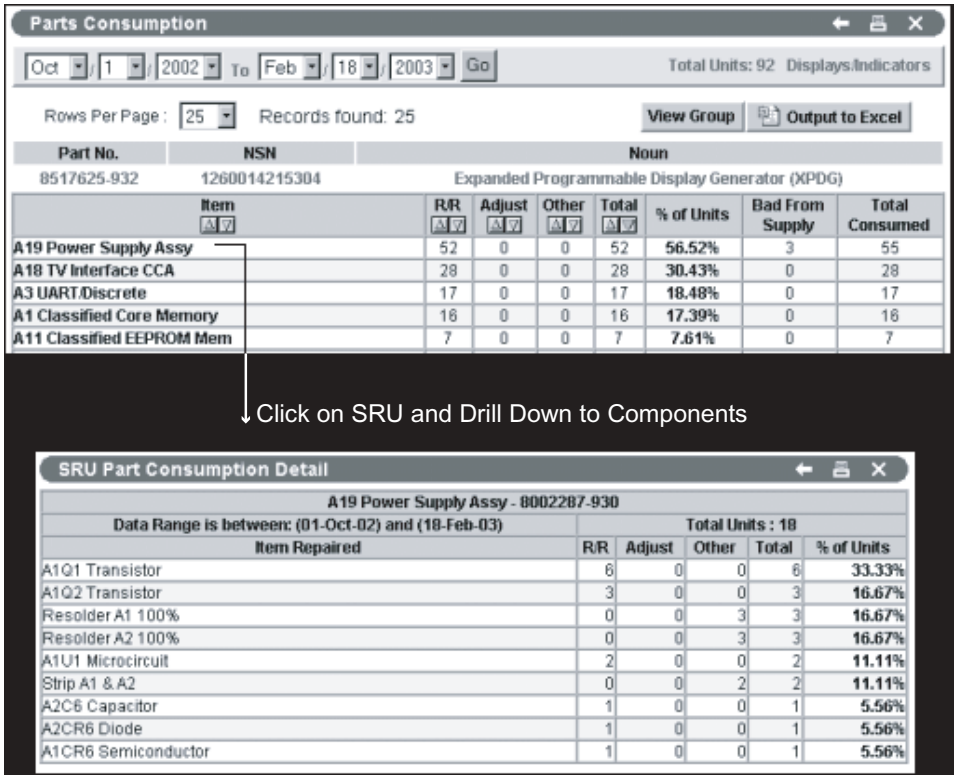
Supply chain managers (SCMs) work to continuously reduce the cost of sustaining their weapon systems through product and process improvements. The main cost-drivers must be prioritized to tackle the highest cost problems first, as not all problems can be solved simultaneously. To do that, the SCM must baseline the current repair activities using actual maintenance data collected at the point of maintenance by the repair technicians. The common repair technician complaint is that current U.S. Air Force legacy systems are too difficult to use for both inputting and retrieving data, and therefore, technicians do not regularly use them.

An F-16 SCM realized that he needed dependable and complete repair data to make and implement sound sustainable decisions. Manual data collection using spreadsheets started in a couple of avionics repair shops to quantify known problems. This effort grew to a Microsoft Access database that was updated every four months. The repair technicians and shop management found the Microsoft Access database useful and wanted a real-time system that provided instant feedback.

A Web-based database was initiated using rapid prototyping, focusing on the technician inputting the repair data at the depot and in the field. Tracking the items being repaired by serial number, the warfighter in the field has visibility into the depot repair activities on those items and vice versa.

The remainder of this article will detail the challenges and how the Defense Repair Information Logistics System (DRILS) team meets or is planning to meet these challenges.

Figure 1: *Repair Parts Consumption*



Supply Chain Management Challenges

The Air Force SCMs are currently in need of a single dependable source of depot repair data. This became evident when the F-16 SCM at Ogden Air Logistics Center initiated the F-16 Flexible Sustainment program, otherwise known as Falcon Flex. This system is designed to analyze and attack high repair-cost drivers and determine the root causes of failures. These analyses are then used to drive performance-based acquisitions for hardware, software, and test equipment.

The SCM sought out part repair history like that shown in Figure 1 in order to feed the Falcon Flex analyses. Figure 1 is an example of DRILS parts consumption in a part number family sorted on the most replaced part. Various legacy data systems were queried to extract enough detailed repair data to perform an accurate analysis. The results of this very labor-intensive process were less than desirable, and the authenticity of the depot data that was available was suspect. Individuals in SCM organizations typically work around this issue by developing personal knowledge bases that are stored only in the brains and spreadsheets of program managers, item managers, material managers, engineers, etc.

Further research led the SCM to the shop floor to research technicians' personal log books and any other source of repair data at the depot repair facilities. Manually documented maintenance actions were also found on the work control documents used by the technicians, but were only saved for one year. Data were entered into the legacy system if the technician was willing and the system was available. However, data were difficult to enter and to retrieve using the user interfaces.

For example, it is well known that each technician will document the same maintenance action in different ways

(e.g., R/R A2, R2 A2, Replaced A2, etc.). The SCM hired contractor labor to independently harvest these data and store them first in spreadsheets, then in a Microsoft Access database. These data were then *scrubbed* to group all similar maintenance actions together using a consistent notation and published quarterly to the SCM. This database was the precursor to the Web-based DRILS application.

Currently, DRILS data are being used by the F-16 SCM's Falcon Flex program to find high cost-drivers such as the Expanded Programmable Display Generator. The F-16 SCM has achieved $43 million in cost avoidance as of January 2003 and a projected $822 million in cost avoidance through 2020.

Depot Maintenance Data

Challenges to supply chain management's ability to reduce total ownership costs are largely caused by the lack of dependable repair data, which is largely driven by a general distrust of the current legacy maintenance data systems. Antiquated user interfaces increase repair costs by requiring more time to input and retrieve data.

Another challenge is that depot repair facilities are inundated with many different computer systems performing similar functions that do not often interface with each other. This often results in shop-floor technicians being required to log into multiple applications with multiple user identifications and passwords. These applications often require duplicate data entry and cause frustration and errors between systems. Also, the designs of these systems often do not match the business process of the repair facilities, thus requiring the technicians to adapt their processes to the system.

In one example, the system software prohibited the technician from performing work on multiple items simultaneously. This forced the technician into a less efficient mode of serial production in order to accommodate the required software. The technician sees data entry time as impeding his or her primary goal, which is to produce serviceable units. What the depot technician really needs and wants is a flexible, single-user interface to quickly and easily enter all data documentation about the repaired unit.

Several initiatives by Air Force leadership to deploy obsolete information technology requiring extensive manual data entry with no additional worker compensation have died quick deaths. Thus, maintenance data documentation is regarded as an expense that can be easily eliminated from depot repair costs. However, by declining to fund maintenance documentation as the repairs are being performed, SCMs are setting themselves up for a larger expense later when a study must be contracted to determine why the repair facility is having problems with certain parts. It is the old *pay now or pay later* lesson with the latter needlessly expending many more times the cost of continuous maintenance data documentation.

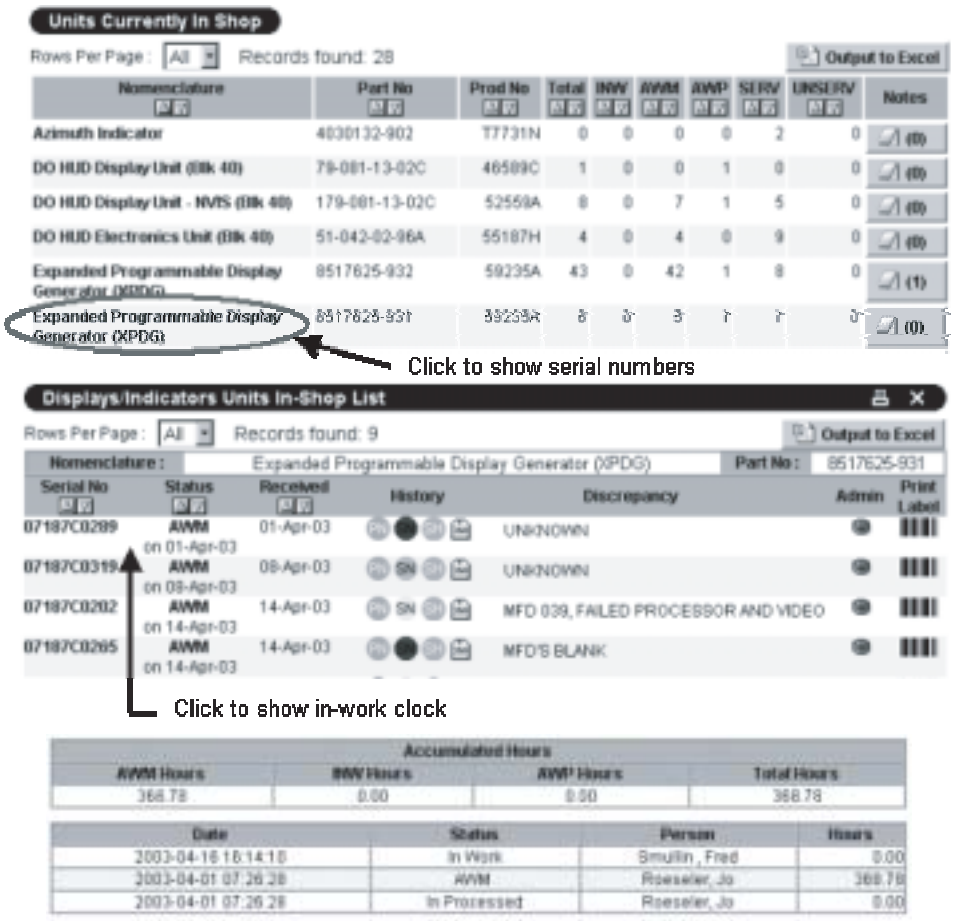


Figure 2: *Placing a Serial Number End Item in Work*

We live in a data-rich environment, yet we are information poor. Today's warfighting requirements are far different than they were 20 years ago when legacy data systems were initially designed and deployed. The fiscal year 1996-2001 "Defense Planning Guidance" states the following:

> In order to support increasing functional requirements for information while implementing overall reductions in the budget, the Department must accelerate the pace at which it selects and deploys migration systems, identifies standard data, and conducts business process re-engineering across all functions. [1]

DRILS provides a Web-based, streamlined, user-friendly maintenance data documentation application for technicians at the point of maintenance. An example of how a technician can place an item into work is shown in Figure 2. By using the computer mouse to *point and click*, the part number family is selected from the "Units Currently in Shop" screen, which displays all the items currently inducted into the shop. The technician then selects the serial number of the selected end item and it is automatically placed into work thus initiating the in-work time clock, which tracks the labor time expended on that particular serial number.

DRILS also facilitates the collection and reporting of serialized maintenance data to Air Force worldwide data consumers for decision support thus filling a gap in legacy systems. An example of repair history for a serially tracked Line Replaceable Unit (LRU) is shown in Figure 3 (see page 18).

Specifically, DRILS provides much needed information and decision support both at the point of maintenance and in the SCM's organization. The technician at the point of maintenance is the only source that we have of obtaining this data.

Figure 3: *Repair History of a Serial Numbered LRU*

Both shop technicians and managers can use the Shop Status features as demonstrated in Figure 4.

Warfighter Support

Today's warfighter does not have ready access to serialized depot repair data that could be used to diagnose faults in fielded weapon systems. The only option is to test the failed parts and then send them to the depot when they cannot be fixed locally. Once the parts are sent to the depot, the warfighter loses visibility of them and never receives feedback about the field diagnosis. This potentially results in wasted resources and an inability to investigate problems with training or equipment. The fighter wing's intermediate shops attempt to solve this problem by keeping detailed logs or local databases for trend analysis and bad actor identification.

To directly support the warfighter in the field, DRILS provides a fighter wing version of DRILS (using the same Web server as the depot version) as shown in Figure 5. Fighter wing intermediate shops can track items sent to the depot, and depot technicians can view the repair activities performed on the serialized item in the field. The entire repair history is available to both the fighter wing intermediate shop and depot personnel. The warfighter version is being used currently by the 388th and 419th Fighter Wings.

Legacy System Modernization

The military continues to attempt information system modernization with an emphasis on integrating commercial off-the-shelf (COTS) enterprise inventory and resource-scheduling products that promise shorter development and deployment time while improving supportability. However, the method in which the military performs and documents maintenance is quite different from anything currently in the commercial market. Thus, there are no readily available COTS solutions that can be employed without requiring massive changes to military maintenance documentation policy or to the COTS product.

Each previous attempt has failed because of the lack of focus to provide benefits to the technician. Each has attempted to *swallow the elephant whole* and provide a standardized, enterprise-wide solution where *one size fits all* yet the product satisfies no one. The repair activities vary from shop to shop, base to base, and between military services.

The length of time it takes to develop this type of solution is counter-productive to the overall military mission. A development life cycle from concept to enterprise deployment historically has taken 10 years or more, ensuring that the systems are obsolete when they are deployed. Potential users are required to forecast requirements 10 years out and *compete* their requirements with other enterprise users. The military cannot wait 10 or more years for new *big-bang* information technology solutions. It is also not practical to discard many years and dollars invested in current legacy information systems when they can still be utilized.

Current legacy systems that house maintenance data such as the Enterprise Data Warehouse perform a very valid function. Their primary mission is to provide the capacity and processing power to store terabytes of maintenance and other data collected from worldwide sources. Their secondary mission is to provide weapon systems and enterprise-level decision tools to data consumers. However, their breadth and scope of mission do not allow them to be very responsive to point-of-maintenance changes and technology advances.

DRILS Software Prototyping Process

As can be seen by the previous discussion, there are many challenges to collecting, storing, retrieving, and using maintenance data. To solve these challenges, DRILS used rapid joint application prototyping and evolutionary development techniques to elicit user interface requirements from shop-floor users and data consumers. The purpose of using this methodology was to field initial capabilities and quick refinements to all users faster than using traditional software engineering approaches.

The DRILS development team was able to learn and implement the users' likes, dislikes, and their processes, earning their trust early in the prototyping phase. The development team solicited requirements from users over several iterations of the software. Past mistakes such as developing a system without user involvement and *dumping* it on them, were avoided. The results of this prototyping are being used to complete a software requirements specification defining what is currently thought to be close to a *mature* application.

DRILS uses Macromedia's Cold Fusion MX as the front end while storing and retrieving data using Oracle. A Web-

Figure 4: *Shop Status*

based application was selected so that only the server software would need to be updated in one physical location. Since most people are familiar with Web-based applications and Web browsers, training time is focused on the work processes and maintenance data collection.

During user development and testing, defects were collected and the appropriate developer notified automatically by Cold Fusion as users exposed them. Defects that were discovered during testing prior to release were also collected and measured. The average time to fix a minor defect was about one hour.

Future DRILS Enhancements

Future development and expansion into a more widely used product will be done with tighter process controls. A configuration control board will also be organized to evaluate and prioritize new and changed requirements as well as major defect fixes to form block releases for implementation and deployment. Releases will be coordinated to occur as often as feasible depending on the number, size, and complexity of the changes.

The Software Engineering Institute's Team Software Process℠ (TSP℠) will be used to plan and track block upgrades and user-requested changes, and expansion to other organizations. Closer tracking of TSP software development metrics during future development phases and testing will provide more accurate estimates and on-time deliveries of more robust DRILS application releases.

Support costs are a concern of many users as DRILS is expanded into more shops. Computer-based training, online help, frequently-asked-question pages, DRILS usability feedback, and experimentation with training techniques are all being considered to help reduce the overall support costs without sacrificing data integrity and completeness.

Lessons Learned

The following are just a few of the lessons learned so far:

- You must work directly with customers to understand and implement their processes. Design and implement applications to actually help users satisfy the *what's in it for me* yearning.
- Rapid prototyping works well to determine exactly what works and how well. Interface screens were developed *overnight* to incorporate the process owners' ideas and improvements.
- When a prototype *works*, most people think of it as production quality and want all the *documentation* that a software product normally contains. DRILS software documentation was delayed in order to focus on core functionality and easy-to-use interfaces.
- Design applications so that they can be easily modified to conform to process improvements.
- Solve current problems while architecting to include future requirements.
- Data must be captured at the point of maintenance and not estimated or *sampled*.

℠ Team Software Process and TSP are service marks of Carnegie Mellon University.

Nomenclature	Part No	# Recvd	# NRTS	# Serv	# CND	% CND	# MICAP	# TCTO
Antenna (C/D,800)	758R800G01	3	3	0	0	0.00	0	0
AUDIO 1 (-3)	16F4419-3	1	0	1	0	0.00	0	0
Countermeasures Switching Unit	179250-0003	1	0	1	0	0.00	0	1
Data Transfer Unit (DTU)	7461000002	1	0	1	1	100.00	0	0
Data Transfer Unit (Night Vision)	7461000007	2	2	0	0	0.00	0	0
Digital Flight Control Computer (DFLCC)	3757528-1	8	3	5	4	50.00	1	0
DO HUD Display Unit (Blk 40)	79-081-13-02C	6	4	2	1	16.67	2	0
DO HUD Electronics Unit (Blk 40)	51-042-02-95A	2	0	2	1	50.00	0	1
DO HUD Electronics Unit (Blk 40)	51-042-02-96A	1	0	1	0	0.00	0	0
DO HUD Electronics Unit (Blk 40)	51-042-02-95B	2	0	2	1	50.00	1	1
Dual Mode Transmitter (DMT)	758R990G01	6	5	1	1	16.67	0	0
Enhanced Central Interface Unit (ECIU)	16E10080-827	1	0	1	0	0.00	0	0
Enhanced Central Interface Unit (ECIU)	16E10080-829	1	1	0	0	0.00	0	0
EXDEEU (-805)	16E10090-805	2	1	1	1	50.00	2	0
Expanded Programmable Display Generator (XPDG)	8517625-931	1	0	1	0	0.00	0	0

Figure 5: *Fighter Wing (Warfighter) View of DRILS*

Future Activities

Future activities include the following:

- Expand to 20th Fighter Wing Component Maintenance Squadron shop at Shaw Air Force Base.
- Participate in the U.S. Air Force serial number tracking effort.
- Continue to expand in Ogden-Air Logistics Center/avionics repair shops, Tobyhanna Army Depot, and Support Center Pacific.
- Expand to Ogden-Air Logistics Center airborne generator shop.
- Interface with Inventory Tracking System, Material Planning System, Core Automated Maintenance System, and Integrated Maintenance Data System.
- Participate in the Shop Service Center process improvement effort.

Conclusion

The warfighter, depot repair facility, and SCM all need dependable part consumption and serialized repair history data. They need an agile, easy-to-use, maintenance data documentation solution that will facilitate and not hinder the collection of dependable serialized repair data at the point of maintenance.

Repair technicians both in the field and at the depot need a solution that aids rather than impedes their daily tasks. The solution should be beneficial to the repair technicians and the organizations that need to access the data.

The SCM needs dependable part consumption data to accurately forecast future part needs as well as identify those areas where efforts are likely to provide the greatest return on investment. DRILS fulfills these *needs* and is a key enabler for future supply chain process and product improvements. DRILS is a government-owned maintenance documentation system that is being developed by Total Quality Systems, Inc. For more information about DRILS, please contact the authors.◆

Reference

1. Department of Defense. Defense Planning Guidance. Fiscal Year 1996-2001. Sec. III, Subsection F, Paragraph 4.

COMING EVENTS

November 2-5
Amplifying Your Effectiveness Conference
Phoenix, AZ
www.ayeconference.com

November 5-7
Association for Computing Machinery SenSys '03
Los Angeles, CA
www.cens.ucla.edu/sensys03

November 10-12
PDF Conference: Expanding the PDF Frontier
Anaheim, CA
www.pdfconference.com

November 15-21
Supercomputing Conference 2003
Igniting Innovation Conference
Phoenix, AZ
www.sc-conference.org/sc2003

November 17-20
4th Annual National Guard Bureau IT Conference
Las Vegas, NV
www.technologyforums.com/ngb

November 17-20
14th IEEE International Symposium on Software Reliability Engineering
ISSRE 2003
Denver, CO
http://salieri.cs.colostate.edu:8000/

November 17-21
2nd International Conference on Software Process Improvement
Washington, DC
www.icspi.com

March 30-31, 2004
3rd Annual Southeastern Software Engineering Conference
Huntsville, AL
www.ndia-tvc.org/SESEC

April 19-22, 2004
2004 Software Technology Conference

STC

Salt Lake City, UT
www.stc-online.org

About the Authors

Capt. Greg Lindsey is the Defense Repair Information Logistics System program manager and is currently stationed at Hill Air Force Base, Utah. He began his Air Force career as an F-4 Tactical Aircraft Maintenance technician and progressed to KC-135 Maintenance officer. He was selected to participate in the Operational Exchange Program and was assigned to Wright-Patterson Air Force Base, Ohio, where he led an Integrated Logistics Acquisition Team at the F-22 System Program Office. He is a graduate of the University of Central Florida.

OO-ALC/MAC
6090 Gum Lane
Hill AFB, UT 84056
Phone: (801) 586-6634
DSN: 586-6634
Fax: (801) 777-8159
E-mail greg.lindsey@hill.af.mil

Kevin Berk is the Defense Repair Information Logistics System program manager for Total Quality Systems, Inc., Ogden, Utah. He has a wide range of experience in program management, managing software development, and process improvement in both the public and private sectors. He has a Bachelor of Science in physics from the University of Central Florida, a Bachelor of Science in electrical engineering from Michigan State University, and a Master of Science in computer engineering from the Air Force Institute of Technology.

Total Quality Systems, Inc.
1990 West 2550 South
Ogden, UT 84401
Phone: (801) 731-2150
Fax: (801) 731-4457
E-mail: kberk@tqsinc.com

WEB SITES

American Society for Information Science and Technology
www.asis.org
Since 1937, the American Society for Information Science and Technology has been leading the search for new and better theories, techniques, and technologies to improve access to information. Membership includes some 4,000 information specialists from such fields as computer science, linguistics, management, librarianship, engineering, law, medicine, chemistry, and education.

The Data Management Association International
www.dama.org
The Data Management Association (DAMA) International is a not-for-profit, vendor-independent association of technical and business professionals dedicated to advancing the concepts and practices of information resource management and data resource management. DAMA International's primary purpose is to promote the understanding, development and practice of managing information and data as a key enterprise asset.

Boxes and Arrows
www.boxesandarrows.com
Boxes and Arrows is an online journal dedicated to understanding the design of the architecture and structure of digital spaces, and often features articles on the craft of information architecture. Boxes and Arrows is a peer-written journal featuring the sharing of exemplary technique, innovation, and informed opinion of this field. The journal strives to provoke thinking among peers, to push the limits of the accepted boundaries of these practices, and to challenge the status quo by teaching new or better techniques that translate into results.

DoD 5000 Series Resource Center
http://dod5000.dau.mil
The DoD 5000 Series Resource Center provides a complete package of information on the DoD 5000 Series documents, including the official directive, operation of the defense acquisition system, interim defense acquisition guidebook, terminology, a defense acquisition tutorial, frequently asked questions, and more.