R&D Advances
Impacting Parts Management and DMSMS

Parts Standardization and Management Committee Meeting
Tysons, Virginia
April 26-28, 2016
Outline

• Introduction
  • Enabling repairs not possible or cost prohibitive in past, longer lasting replacement items
  • Improving the cost effectiveness of reverse engineering, redesign, of MaSME items
  • Improving the cost effectiveness of reverse engineering and redesign of integrated circuits
  • Assisting internal manufacturing of DoD replacement parts
• Recommendations
• Backup: Dealing with software obsolescence and vulnerabilities
• Backup: Enabling better DMSMS management
Objective

- Inform PSMC of ongoing work of interest
- Obtain PSMC feedback

Disclaimer: This work is in process. Peer review comments have not been fully considered
Possible Relationship among Parts Management, DMSMS, and R&D Advances

- Parts management focuses on selecting the best parts at the design phase of an acquisition program under an overarching systems engineering umbrella.
- DMSMS management focuses on early identification and the cost effective resolution of issues associated with obsolescence or the loss of sources.
  - Part selection criteria include where the part is in its life cycle and open interfaces.
- Perhaps both could add greater weight to the selection of parts amenable to cost effective manufacturing with an advanced technology such that obsolescence issues could be more easily resolved.
R&D Advancement Impact Areas

• Implementation of resolutions that produce replacements for electronic items
  – These resolutions are often associated with low volume production

• Implementation of resolutions that produce replacements for materials and structural, mechanical, and electrical (MaSME) items
  – These resolutions are often associated with original producers who (1) are no longer in business or who (2) refuse to or cannot (because manufacturing details have been lost) make low volume runs of very old items

• Improvements to the DMSMS management processes
  – These improvements may be associated with new databases and information technology advances that can help DoD address obsolescence problems better
Organization

• Not an in-depth analysis of each advance
  – Description of advances
  – Potential impact
  – Organizations funding/working on advance
  – DMSMS/Parts Management application
• Designed to increase awareness
• Based on not for attribution interviews
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Additive Repair Advances

Description of Advances
• Laser cladding/welding/sintering deposits; Plasma deposition; Kinetic cold spray new techniques and capabilities

Potential Impact
• Advances enabling repairs not possible or cost prohibitive in the past
• Navy Undersea Warfare Center repairing parts at 10-15% of cost to manufacture new
• Improved wear and corrosion protection from coatings can yield longer lifespan repair than original

Organizations Funding/Working on the Advance
• Navy has been leader in additive repair technologies

DMSMS/Parts Management application
• Several of these new technologies for additive repair have been successfully applied to obsolescence and DMSMS/parts management problems
• Restoring damaged and corroded parts to original condition or better, without need for replacement parts.
Intermetallic Alloy Advances

Description of Advances
• New intermetallic alloys (aka “fine” ceramics) have properties between ceramics and metals

Potential Impact
• Have improved, higher temperature properties like ceramics, but metal alloy strength
• New intermetallic alloys such as titanium aluminum expected to offer expanded and improved repair opportunities for DoD
• Provide more options in replacing parts with more capable and longer lasting ones.

Organizations Funding/Using Technologies
• The interviews conducted for this effort did not identify any DoD organizations using or funding research on intermetallic alloys.

DMSMS/Parts Management application
• While these new alloys are primarily seen as an application for new, original production, their longer lifespan offers DMSMS/parts management opportunities, reducing need for replacements, but may create difficulties if the complex material is too difficult to repair
Ceramic Matrix Composite Advances

Description of Advances
• Ceramic matrix composites (CMCs) an advanced new category of materials, less likely to fracture under mechanical or thermo-mechanical stress due to cracks initiated by small defects or scratches (problem with conventional technical ceramics like alumina and silicon) due to embedding particles or fibers into the matrix

Potential Impact
• CMCs may be used as patch material for applications like Space Shuttle repair in space (inspired by Columbia disaster), surviving huge temperature swings
• CMCs can operate at temperatures exceeding the capability of current nickel alloys typically used in high-pressure turbine jet engines

Organizations Funding/Working on the Advances
• General Electric a leader in CMC development

DMSMS/Parts Management application
• While more capable CMCs primarily applicable to new production, there will be opportunities to aid in sustainment by replacing less capable materials with these longer lasting, stronger products
New Carbon Fiber and Carbon Fiber Nanotube Advances

Description of Advances

- Constant advances in high performance polyacrylonitrile-based carbon fibers (CF) yield better, faster and cheaper CFs, related intermediate materials and finished composite structures.
- New technology “carbon nanotubes” offer unique electrical, thermal and mechanical property improvements.

Potential Impact

- CFs offer unmatched strength and light weight advantages, vital for many DoD systems, especially in space and aerospace systems.
- Carbon nanotube impacts not predictable now.

Organizations Funding/Working on the Advances

- CF manufacturing firms.

DMSMS/Parts Management application

- Repairs where high strength to weight performance is desired and cost is less of a constraint.
Questions

• R&D Advances Enabling Repairs Not Possible or Cost Prohibitive in Past and Longer Lasting Replacement Parts
  – Additive Repair Advances
  – Intermetallic Alloy Advances
  – Ceramic Matrix Composite Advances
  – New Carbon Fiber and Carbon Fiber Nanotube Advances

Any suggestions on R&D advances to add? Who should we talk to about them? What’s going on in your organizations in these areas? Where do you see the most promise?
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Mechanical Reverse Engineering Advances

Description of Advances

- Improved Digital tomography for three-dimensional imaging of internal structures, new scanning and tolerancing tools to generate 3-D models of parts for computer aided design (CAD) models

Potential Impact

- Quicker, more accurate 3-D models of parts as input to CAD models
- Reverse engineered original equipment manufacturer (OEM) part libraries provide a less expensive alternative than the OEM or another company

Organizations Funding/Working on the Advances

- Services fund most of their reverse engineering R&D work, but some reverse engineering progress has enabled with Defense Advanced Research Projects Agency (DARPA) funding

DMSMS/Parts Management application

- Improvements in reverse engineering a key enabler of DMSMS resolutions
- When detailed production data on obsolete parts is not available (a frequent problem), DoD engineers must create the necessary documentation to produce or order equivalent parts
Description of Advances

• Integrated Computational Materials Engineering (ICME) is the “integration of materials information, captured in computational tools, with engineering product performance, analysis, and manufacturing-process simulation.”

Potential Impact

• ICME can reduce component design and process development costs and cycle times, lowering manufacturing costs, improving material and component life
• In contrast to trial-and-error-based approach that may take a decade, computational approaches based on physics-based material models can lead to much shorter development time and higher performance materials at lower cost
• Computational approaches predicted to reduce the development time by half using improved models and data
• Data needed for ICME generally not available now, but AF Systems Command and others “digital thread” improvements (addressed later) will enable ICME

Organizations Funding/Working on the Advances

• DOE’s Oak Ridge National Laboratory, General Electric, Air Force

DMSMS/Parts Management application

• Computational design of new alloys (e.g., very high strength new stainless steels) that DoD can use to replace aircraft landing gear with a higher performing new part that will not just perform better, but last longer, reducing DMSMS/parts management burdens; but repair difficulties may have the opposite effect
Qualification and Testing Advances

Description of Advances
• DARPA’s Open Manufacturing program is promoting rapid qualification technologies that comprehensively capture, analyze and control variability in the manufacturing process to predict the properties of resulting products

Potential Impact
• Qualification and testing, vital in DMSMS, very expensive and time consuming
• Prohibitive cost of qualification and testing new repair and replacement items often deters the switch to these potentially better options

Organization Funding/Using Technologies
• DARPA’s Open Manufacturing currently has three efforts—two focusing on metal additive processes and one on bonded composite structures
• Two Manufacturing Demonstration Facilities have been established, one at Penn State focused on additive manufacturing and the other at the Army Research Laboratory focused on bonded composites.

DMSMS/Parts Management application
• Navy SME noted that “qualification and testing cost is so expensive, that it can make redesign a more cost effective option than trying to validate a new source of supply that may be counterfeited”
• Additive Manufacturing (addressed later in detail) will require significant qualifications and testing to achieve its potential for DoD DMSMS/parts management benefit
Questions

- Advances Improving the Cost Effectiveness of Reverse Engineering and Redesign of Mechanical Parts
  - Mechanical Reverse Engineering Advances
  - Integrated Computational Materials Engineering Advances
  - Qualification and Testing Advances

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Electronic Reverse Engineering Advances

Description of Advances

• Advances in CAT scan use computer-processed combinations of X-ray images taken from different angles to produce cross-sectional (tomographic) images, continued improvements in 3D laser digitizing, improved capability to delayer and trace circuits and automate image recognition to identify gates, new tool called Derive that extracts details needed for reverse engineering by deriving encoding knowledge from the assembler for existing software.

Potential Impact

• Improved ability to recreate designs and develop Gerber files needed to reverse engineer microelectronics.

Organization Funding/Working on the Advances

• Companies, DARPA, DoE, Stanford University and University of Utah

DMSMS/Parts Management application

• Electronic reverse engineering often used in replacing circuit boards that are no longer produced.
Rapid Circuit Redesign Advances

Description of Advances
• Defense Microelectronics Activity (DMEA) continually improves its technology and tools for rapid circuit redesign

Potential Impact
• Continued improvements in rapid circuit redesign technologies enables faster, lower cost redesign of defense systems
• DMEA operates a sophisticated design, prototyping, and testing facility supported by over a hundred advanced technology specialists
• Continuous improvements to the technology and tools for rapid circuit redesign are made under the assumption that redesign of defense systems may generally be a better approach than replacing obsolete parts

Organization Funding/Working on the Advances
• DMEA, Companies like MacAulay-Brown Inc. which offers redesign services
DMSMS/Parts Management application
• Advances enable faster, lower cost redesign of DMSMS items
Emulation Technology Advances

Description of Advances

• Emulation is matching existing device performance, in a manner that is compatible with old software that can run on top of it
• Not many emulation technological advances on the horizon

Potential Impact

• Emulation advantages include the ability to consolidate some parts and achieve a "board level solution" so that no change is needed to documentation or test programs, and reduced or no need for redesign
• Emulation programs have saved Government hundreds of millions of dollars by avoiding costly circuit card assembly redesign efforts

Organizations Funding/Working on the Advances

• DLA’s Advanced Microcircuit Emulation (AME) Program

DMSMS/Parts Management application

• AME tracking/working on emulation technologies for DMSMS
• Few technologies coming that will make their work easier, while faster circuit technology change, quicker obsolescence, more rapid switches to new chips and technologies will keep making the obsolescence problems harder
• SMEs interviewed stressed that while DoD needs to stay on top of IC emulation advantages, far more important thing to plan for IC obsolescence and either procure all future demands up front or be sure of access to all necessary technical data
Field programmable Gate Array Advances

Description of Advances
• FPGAs are decades old, but now software programmable as well as hardware programmable, smaller, improvements in ability to program them to implement any logic and emulate most older electronics
• In the last twelve years, capacity has increased 50-fold and speed has increased 10-fold while price and power requirements have decreased by an order of magnitude

Potential Impact
• For low volume production, a programmable logic device is usually less expensive than a dedicated wafer ASIC run

Organizations Funding/Using Technologies
• Commercial industry
• Intel’s purchase of FPGA manufacturer Altera in 2015 may lead to some important DMSMS/parts management advances since aerospace and defense high performance embedded computing systems often paired Altera’s FPGAs with high-end Intel microprocessors

DMSMS/Parts Management application
• FPGA advances will help DoD system redesigns and emulation of replacement chips
Assembled Replacement Integrated Circuit Advances

Description of Advances

• Assembled Replacement Integrated Circuits (ARICs) are miniature printed circuit boards that combine FPGAs, Complex Programmable Logic Devices, and other components.

Potential Impact

• An ARIC replicates an obsolete or failed IC
• Using programmable devices and custom hardware description language code, these circuits are also more adaptable and sustainable; easier to upgrade and improve

Organizations Funding/Using Technologies

• NUWC, Keyport, Naval Sea Systems Command

DMSMS/Parts Management application

• ARICs can avoid more complex redesigns, often less expensive and less risky than a larger scale redesign
Interposer Advances

Description of Advances
• New Interposers, substrates used to attach components to the motherboard enabling adaptations to fix a legacy circuit board, provide better performance.

Potential Impact
• Silicon interposers are being used to stack chips side-by-side, allowing designers to put dies next to each other in a high-bandwidth, low-latency configuration
• Kyocera recently introduced "Advanced Package X" Interposers that provide fine pitch wiring and small size to support 2.5D interposer requirements, with smaller signal transmission loss compared to silicon interposers, low warpage, and lower cost than silicon or glass interposers.
• Interposer advances also supporting stacking chips side-by-side, allowing designers to put dies next to each other in high-bandwidth, low-latency configurations

Organizations Funding/Working on the Advances
• Outside of commercial industry, no DoD efforts have been identified

DMSMS/Parts Management application
• While not a leading technology development for industry, DoD leverages interposer advances to maintain very old electronic systems
Questions

• Advances Improving the Cost Effectiveness of Reverse Engineering and Redesign of Integrated Circuits
  – Electronic Reverse Engineering Advances
  – Rapid Circuit Redesign Advances
  – Emulation Technology Advances
  – Field Programmable Gate Array Advances
  – Assembled Replacement Integrated Circuit Advances
  – Interposer Advances

Any suggestions on R&D advances to add? Who should we talk to about them? What’s going on in your organizations in these areas? Where do you see the most promise?
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Additive Manufacturing Advances

Description of Advances
• Additive manufacturing (AM) most cited and touted new technology, growing rapidly in applications to manufacture wide variety of items

Potential Impact
• Enabling lower cost, low volume manufacturing for components not subject to great stress, avoiding many up-front production and overhead costs
• Faster prototyping being used by all Services
• Metal castings and forgings, with projected cost savings of 33-50%
• AM also has special abilities to produce a perfect custom product with complex internal shapes not producible via traditional, subtractive processes
• Metal AM has significant problems because the microstructure of the material can be very different from traditional manufacturing processes, far more variable.

Organizations Funding/Working on the Advances
• All Services, DLA, Commercial industry, Federal Government

DMSMS/Parts Management application
• Ideal for making obsolete parts in low quantities, quickly, and often in field
• Claim of deliberately abandoning large production runs and stockpiled inventories is not likely—it will still be cheaper to mass produce with traditional manufacturing and keep inventories for the vast majority of parts
High Speed Machining Advances

Description of Advances

• Continued improvements in high speed machining technologies and computer controlled machines

Potential Impact

• Despite emphasis on AM, improvements in traditional metal manufacturing and high speed machining (subtractive manufacturing) will be important, perhaps indefinitely given AM metal quality and reliability limitations

Organizations Funding/Working on the Advances

• Gradual advances are being pursued by private industry

DMSMS/Parts Management application

• Because of what may prove to be inherent problems with metal AM, may want to emphasize consideration of advanced high speed machining technologies

• Traditional, reliably manufactured metals and subtractive processing, the material strength and properties can be assured, and certification easier
Analog/Linear Microcircuit Emulation Production Advances

Description of Advances
- DLA’s AME and Generalized Emulation of Microcircuits (GEM) Programs continually adopt new technologies and advances
- Current area of emphasis is analog/linear microcircuit advances

Potential Impact
- Continual technology updates and improvements in GEM Program improve limited, trusted production capability (design, fabricate, package and test) for producing and repairing both legacy and new weapon systems
- As the electronics industry constantly pursues faster circuits with lower power, transistors have to be smaller and closer together, with smaller and smaller “wiring” and feature sizes, so AME and GEM Programs must follow suit (though with older technology)
- Will spend next 5-7 years implementing 0.5 micron into production capabilities while developing 0.35 micron technology
- First analog/linear capability will transition to production (GEM) in about 4 years

Organizations Funding/Working on the Advances
- DLA

DMSMS/Parts Management application
- Self-manufacture of chips that industry no longer produces essential to keep old DoD systems in operation
Die Extraction/Reassembly Advances

Description of Advances

• Die extraction/reassembly takes functional suitable commercial ICs not ruggedized or certified for military use (or questionable sourcing), extracts the die (circuit board), screens for counterfeit or Trojan components, then reassembles them into a rugged, ceramic package as a drop in replacement for military system

Potential Impact

• This process may save time and cost relative to redesign and test of replacement ICs

Organizations Funding/Working on the Advances

• AFRL, new company that works with a DLA certified laboratory, to have their remanufactured, Die Extraction, Reassembled IC tested and certified

DMSMS/Parts Management application

• In addition to reduce resolution time and cost, this approach can provide another source of supply for obsolete ICs
Multibeam Technology Advances

Description of Advances
• Multi beam technology involves the use of multiple electron beams, rather than a single electron beam, to produce chips; with no mask

Potential Impact
• Significant advantages to writing directly on the wafer (maskless production) for low volume fabrication
• Technology also well suited for another security enhancing application—adding chip identification and security keys.

Organizations Funding/Working on the Advances
• DARPA has supported such research in the past
• DTRA, AFRL, and the Space and Missile Systems Center have been working with and helping finance multibeam technology development

DMSMS/Parts Management application
• Can make low volume production more economically viable and therefore help mitigate the “manufacturing sources” aspect of DMSMS
Direct Write Laser Technology Advances

Description of Advances
• Direct write laser technology also writes directly to a disk, with no need for mask

Potential Impact
• By eliminating the need to prepare masks for integrated circuit fabrication, direct writing can save significant time and expense

Organizations Funding/Working on the Advances
• DARPA has funded in past; several companies have attempted

DMSMS/Parts Management application
• Particularly for low volume chip production, direct laser write could be a significant benefit for DMSMS
Questions

• Advances to Assist Organic Manufacturing of Replacement Parts
  – Additive Manufacturing Advances
  – High Speed Machining Advances
  – Analog/Linear Microcircuit Emulation Production Advances
  – Die Extraction/Reassembly Advances
  – Multi Beam Technology Advances
  – Direct Write Laser Technology Advances

Any suggestions on R&D advances to add?  
Who should we talk to about them?  
What's going on in your organizations in these areas?  
Where do you see the most promise?
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Recommendations (1 of 3)

1. Establish a DMSMS/Parts Management Technology Watch Capability

- Key DMSMS/parts management technology management issue is “when should government fundamentally support a new technology/product that may be very useful for DMSMS/parts management mitigation, but lacks sufficient commercial demand?”
- Need to understand likely commercial developments to judge whether promising new technology will get implemented without DoD support
- With no dedicated effort and responsible party to monitor and pass on information to the DMSMS/parts management community, we may miss opportunities to exploit or promote promising technological advances
- The DMSMS/parts management community might even consider making investments to acquire and develop expertise in some of these new technologies
2. Expand DMSMS/Parts Management Conference Role in Communicating R&D Information and Promoting Helpful R&D Advances

• Conference tracks could be designed to provide information on the latest developments, risk areas, and potential need for greater investment

• Consider outreach beyond defense industries to include more corporate commercial interest to expand scope of technological issues considered
3. Don’t allow R&D advances to substitute for applying best practices

• Design in a way that reduces future DMSMS/parts management issues
• Ensure contracts have effective DMSMS/parts management requirements
• Ensure complete item and system data owned or readily obtainable
• Conduct life-of-need buys when opportunities present themselves
• Anticipate and proactively prepare for new counterfeiting threats
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Software Obsolescence Prevention Advances

Description of Advances

• Advances in adaptive software systems to increase functional life of software

Potential Impact

• Software a large part of new, complex weapon systems
• Software also a somewhat neglected aspect of DMSMS
• Significant costs for maintaining, updating, qualification and testing any software update or issue, as well as the reprogramming costs
• DARPA’s “Building Resource Adaptive Software Systems (BRASS) project hopes to reduce time to make software more adaptive and self-updating
  – repair vulnerabilities and port useful functionality in complex systems from human time to machine time, allow various syntactic and semantic forms of adaptation to be applied over large code bases, reduce analytics and runtime monitoring overhead to enable adaptive solutions to be effective in continuously operational, deployed environments

Organizations Funding/Working on the Advances

• DARPA funding BRASS, Carnegie Mellon just awarded contract
• DLA’s GEM and AME programs address software obsolescence, collecting source code, software used and related details in the Technical Data Package for all ICs
• AF Systems Command supporting improvements in software change process

DMSMS/Parts Management application

• Too early to assess feasibility of BRASS, but a promising approach that DMSMS community needs to monitor and help support
DMSMS Cost Estimation Advances

Description of Advances
- New software and techniques to better forecast when DMSMS issues will occur, types of resolutions needed, and estimating cost of resolutions

Potential Impact
- Better tools to help forecast, better manage, and budget for obsolescence issues

Organizations Funding/Working on the Advances
- Small Business Innovation Research grant to Frontier Technology
- NUWC(Keyport), working with Univ of Washington

DMSMS/Parts Management application
- Advances in cost estimation techniques and tools can aid DMSMS management by enabling obsolescence to be more explicitly considered and rigorously modeled

Estimating Recurring Cost Impacts of Obsolescence

- If a child to a cost element that has computed the APUC, MTBF, MTTR, etc.:  
  - Click check boxes to inherit Cost of Repair Parts and MTBF from parent item
  - Click Get Defaults
  - Average Repair Cost and Number of Repair Events Per Year columns will be populated

- If not a child, manually enter Average Repair Cost and Number of Repair Events Per Year
- Manually enter Percent of Cost Subject to Obsolescence and Recurring Obsolescence Repair Cost Factor

TIP: Use Auto Fill feature by right-clicking on cell in table.
Designing for DMSMS Advances

Description of Advances

• Advances in designing for DMSMS are aimed at reducing DMSMS risk for new systems through improving the interface between DMSMS and Computer Aided Design tools to explicitly consider where part is in its life cycle, whether currently obsolete, and potential substitutes.

Potential Impact

• Addressing DMSMS issues in design/build process a proven way to avoid problems and reduce costs.

Organizations Funding/Working on the Advances

• AFRL SME described “designing for DMSMS” work that has been evolving for several years as a way to improve the interface between DMSMS and Computer Aided Design tools, helping to consider and, where possible, design in less DMSMS risks in new systems.

• ManTech leveraging a 3-year, $4M Manufacturing Process Driven Design project working with Georgia Tech University.

DMSMS/Parts Management application

• Need to use improved engineering methodologies and architecture and technology forecasting to design systems more resistant to obsolescence.
Data Capture and Integration Advances

Description of Advances

• Improved analytical techniques and algorithms for data management, transportability, exploration and interconnections

Potential Impact

• Reduce problems from not purchasing data or claiming the intellectual property rights to get data from OEMs despite acquisition requirements, plus problems from disparate data standards, and siloed, undiscoverable data

Organizations Funding/Working on the Advances

• Many DoD organizations and commercial companies
  – AFRL using “Spatial Information Management Programming Language” (SIMPL) programming environment that captures and manages a “digital history of data” and DREAM.3D software with data analysis tools easing data transport between collaborators, plus BlueQuartz Software tools that allow address the problem of disparate data standards, and siloed, undiscoverable data
  – AFRL’s data capture and integration strategy leveraging GE’s Predix, powerful new software platform that connects people, data and machines over the “Industrial Internet”
  – GE is also using Predix to predict when systems might fail

DMSMS/Parts Management application

• Help DoD obtain design and manufacturing data required to produce parts or source them commercially
Digital Thread Advances

Description of Advances
• Digital thread is weaving together all data across the firm in any area related to any aspect of the organization’s processes to avoid duplicative databases, data silos, enable updates to data anywhere to touch all places where data exists

Potential Impact
• The AFRL considers digital thread a “game-changing opportunity” for more rapid development and deployment of new systems
• Apple has digital thread system--if you change data in one place, it makes simultaneous change everywhere else, a huge integrated, perfect system
• “digital thread” also creates a vulnerability by making it easier for enemies to steal systems designs and may make it easier for counterfeiters to steal data

Organizations Funding/Working on the Advances
• When AF develops a new aircraft, “Aircraft Digital Twin” will be a complete data version of the system with the full details needed to produce and analyze the physical aircraft
• Navy working with NIST and others on data standard development, DoD pursuing data standardization via Semantic Web for Interoperable Specs and Standards

DMSMS/Parts Management application
• Advantage for DMSMS is achieving complete digital descriptions of systems to facilitate subsequent re-engineering or replacement part manufacture as needed
• Digital thread would be massive and extremely difficult for DoD to achieve
Database, Collaboration Tool, and Information Management Advances

Description of Advances

• Improvements in databases, tools, and information systems used to track parts, company product discontinuation and change notices, and counterfeit warnings
• Better functions to search for current and/or replacement parts, find best prices on replacements, manage cases, analyze Bills of Material (BOMs), and predict life cycles and obsolescence

Potential Impact

• These technologies enable robust DMSMS management

Organizations Funding/Working on the Advances

• All organizations involved in DMSMS management using these tools

DMSMS/Parts Management application

• These technologies enable robust DMSMS management
• As these technologies improve, more issues will be identified proactively rather than reactively
Questions

• Dealing with Software Obsolescence and Vulnerabilities and R&D Advances Enabling Improved DMSMS Management
  – Software Obsolescence Prevention Advances
  – DMSMS Cost Estimation Advances
  – Designing for DMSMS Advances
  – Data Capture and Integration Advances
  – Digital Thread Advances
  – Database, Collaboration Tool, and Information Management Advances

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