NAVY WORKSHOP AIMS TO CUT COSTS

This article summarizes the results of a Navy-industry-academia workshop focused on accelerating the implementation of new cost-saving technologies into the U.S. Navy's manufacturing and maintenance environment.

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An F/A-18 Hornet performs a touch and go landing aboard the Nimitz-class aircraft carrier USS Theodore Roosevelt (CVN 71). U.S. Navy photo by Mass Communication Specialist 3rd Class Jonathan Snyder.

Two important and interrelated topics that affect the Navy's ability to sustain long-term operations and prosecute the war on global terrorism were addressed at a recent Navy-industry-academia workshop: reducing the cost and turnaround time of maintenance, repair, overhaul, and manufacturing; and increasing the rate of technology insertion.

Both the technical and the non-technical challenges associated with the research, development, and implementation of cost and time saving technologies were examined. Participants were challenged to identify means of achieving a 30% reduction in cost and a 30% increase in throughput, by accelerating the insertion of current and emerging materials and manufacturing technologies. Workshop participants identified and prioritized high-value technologies for insertion, as well as non-technical barriers such as policies, qualification, and processes.

Workshop purpose

The principal goal was to identify potential approaches that reduce cost and accelerate maintenance operations. Workshop participants were divided into five working groups addressing four technology areas: Green Manufacturing, Modeling and Simulation, Rapid Prototyping, and Repair Technologies. Non-technical areas associated with the introduction of new technologies were also addressed. The workshop provided a forum for 97 national and international experts from the National Academy of Engineering, the Dept. of Defense, industry, and academia to share their views and recommendations (Fig. 1).

The workshop organizers identified the goals and objectives for each of the four technology areas and the non-technical area. Participants were divided into working groups and asked to validate the objectives, identify the challenges, and formulate viable approaches to achieving the objectives. The working group modified and validated the organizer's objectives, and then assessed the viability of various technology solutions and their potential for implementation in the near term (1 to 5 years), mid-term (5 to 10 years), and far-term (10 years +).

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•Air Force •ARMY •DARPA •JSF •NIST •OSD •ONR •PEO(A) • NAVAIR •FRC	•3M Aerospace •ALCOA Defense •Battelle Memorial Institute •Bell Helicopter •Boeing •Carpenter Technology •CTC •Dynamics Research Corp •GE Aviation •JENTEK •KBSI •Lockheed Martin •METBLAST	•NanoTechLabs •NAVMAR •Navy Metalworking Center •Northrop Grumman •Spatial Integrated Systems •Sikorsky •Stratasys •TRI •Maven Group •Connecticut Center for Advanced Technology	•Craven Community College •Georgia Institute of Technology •Institute for Maintenance Science & Technology , NC State Univ. •North Carolina State University •Penn State University •Purdue University •University of Virginia

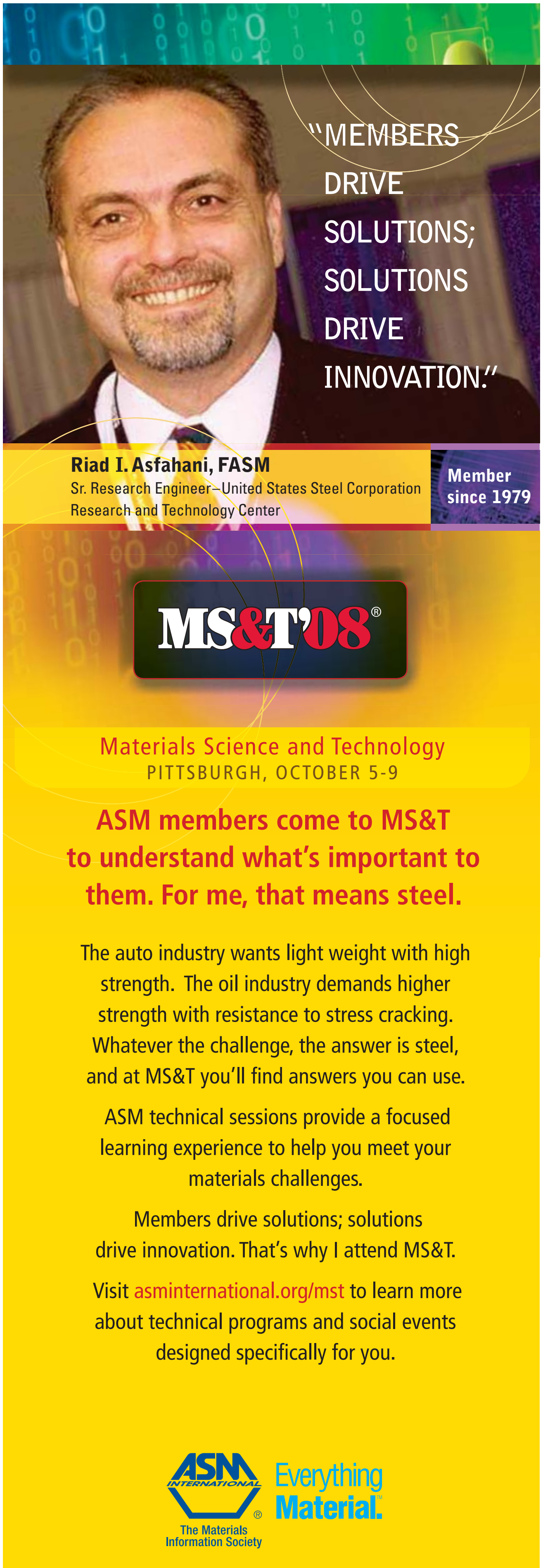
Fig. 1 — Participating organizations.

Maintenance challenges

Prosecuting the war on terrorism has not only increased aircraft utilization, but also has placed these assets in harsh and diverse operational environments. To increase the number of assets available, repair loops must be faster, and in-theater repair and maintenance capabilities must be improved.

The cost of maintaining DoD weapon systems

**Fellow of ASM International*



has also been escalating: from $40 billion in FY-01 to $87 billion in FY-06. The maintenance budget has risen 25% from FY-01 to FY-08 (in constant FY-08 dollars). Indeed, the cost of maintenance as a percentage of the DoD budget has been rising, and in FY-06 represented 16% of the DoD budget. It is therefore not surprising that sustaining combat readiness at the right cost is a priority for the Chief of Naval Operations and the Naval Aviation Enterprise (NAE).

Green manufacturing

The objectives for green manufacturing are to increase the paint application rate by 50% over the current baseline and reduce the personal protection equipment costs by a minimum of 30%; and to speed the rate of paint removal by 25% over the existing baseline rate, while reducing costs associated with Navy aircraft de-painting by 50%. Another goal is to reduce defects by 95% for metal finishing while reducing personal protection equipment costs by a minimum of 30%.

Several important technology areas were identified as critical to achieving these objectives. These include the development of non-chrome primers, environmentally friendly chemical strippers, rapid-cure polyurethane paint, powder coating and de-coating technologies, and alternatives to hard-chrome plating.

The elimination of chromates in primers is of high importance, because hexavalent chromium is both toxic and carcinogenic. The challenge is that the current non-chrome primers provide inferior corrosion protection, and the test standards that evaluate chromium-containing primers are not suitable for alternative systems.

High-velocity oxygen fuel (HVOF) coatings are being developed and implemented as a means of providing a hard, wear-resistant alternative to hard-chrome plated steel components. These HVOF coatings provide reasonable corrosion resistance. However, strain incompatibility between the coating and the steel substrate, which can result in excessive spalling, has limited their application to moderately loaded components.

Polyurethane paint systems can provide good environmental resistance. The challenge is that polyurethane paints can take up to seven days to fully cure. Further, the pot life for these paints is too short. One possibility of decreasing the time required to paint a weapon system and reduce the quantity of volatile organic compounds is through powder coating. However, these coatings must be applied at high temperatures (350 to 400°F), which can cause damage to the substrate. Further, the coatings are tenacious and are not easily removed with chemical strippers alone.

Modeling and simulation tools

This effort focused specifically on work content estimation, planning, and execution via material-process modeling. One major goal is to reduce the time and cost associated with the development of work content/profile estimates for manufacturing and repair processes by 75%, while increasing the accuracy of initial estimates by 25%. Other goals include reducing production line work in progress by 50%, and increasing throughput by 25% over the baseline process. The time required to plan capital facilities for manufacturing, repair, or warehousing should be reduced by 50%, while increasing the confidence in facility capacity planning by 100%.

Technology areas identified as critical to achieving these objectives include the automatic generation of simulation models from standard data formats; the development of methods to assess the impact of platform condition and history on repair work content; and the semi-automatic regeneration of repair instructions (Fig. 2).

To improve part availability, maintainable tools are needed for developing on-demand, richer work instruction content. Other tools are needed to analyze existing and historical usage data and lead-time data. Data mining and statistical analysis tools are needed for the creation of process models.

Repair technologies

Structural repair technologies that increase throughput by 100% need to be developed. Technology is also needed to improve/achieve material state awareness at an annual cost savings of 50%; and corrosion control technologies that double the time between required maintenance intervals and reduce maintenance cost by 50%.

Technology areas identified as critical to achieving these objectives include additive materials restoration (cold spray, digital direct manufacturing); damage assessment technologies; state of health technologies (condition-based maintenance, integrated mechanical diagnostics system); and alternative coating systems (Fig. 3).

Cold spray was specifically cited for its potential to repair corrosion-damaged magnesium castings, which are ubiquitous in Navy rotorcraft and are a high cost maintenance item. Less expensive, more environmentally friendly alternative coating systems as compared to hard chrome and cadmium are also required. HVOF and alternative cladding methods were recommended for further research.

The working group identified corrosion and fatigue damage assessment technologies as an important area for R&D. Specifically, smart coating systems capable of detecting corrosion and fatigue damage need further research.

To reduce unnecessary aircraft maintenance while concomitantly maintaining safety and performance, state-of-health determination technologies need to be developed. Implementation requires a better physics-based understanding of how materials and components fail, the R&D of sensor technologies, energy harvesting systems, damage assessment models, and data collection and analysis systems.

Rapid manufacturing

The goals for rapid manufacturing were to cut fabrication time by 50% with no sacrifice in accuracy, and to identify five components for repair by solid free-form processing that will reduce replacement cost by 60% (Fig. 4). Another goal is to increase by a factor of three the number of aerospace components produced via rapid manufacturing through the development of general qualification procedures for all aerospace structural and propulsion components that are suitable candidates.

Important technology areas include Direct Digital Manufacturing (DDM) of metallic materials, DDM of nonmetallic components, the development of a government-industry specification, a joint services qualification standard, improvement to the quality and reliability of DDM equipment, and NDE technology to ensure product quality. Compared to conventional manufacturing processes, the DDM of new parts has its greatest return on investment for the production of low volume, high value components. Examples of DDM processes include

- Selective Laser Sintering (SLS): A high power laser fuses small particles of plastic, metal, or ceramic powders into components.
- Laser Engineered Net Shaping (LENS): Metal powder is injected into a molten pool created by a focused, high-powered laser beam.
- Solid freeform fabrication (SFF): Energy and/or material is sequentially delivered to specified points

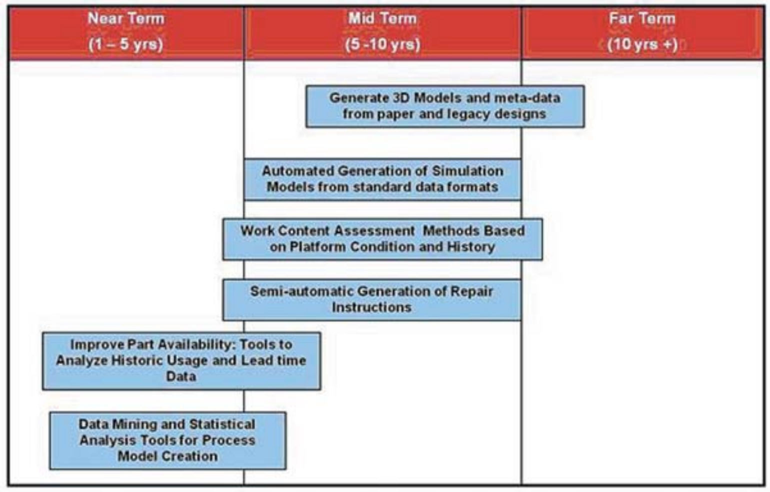


Fig. 2 — Modeling and simulation roadmap.

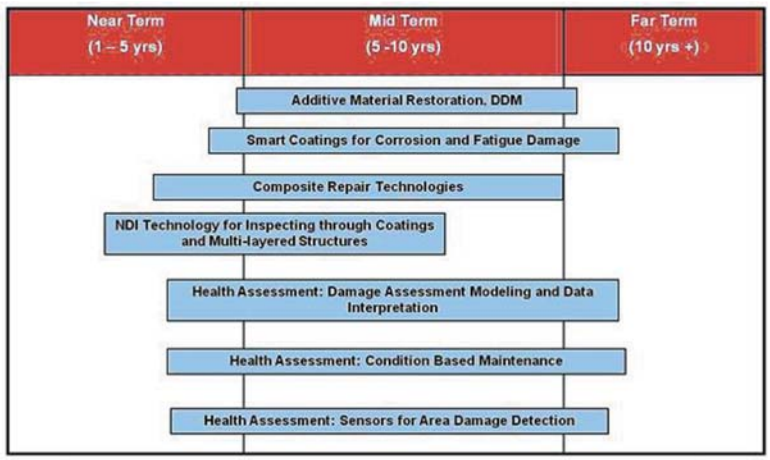


Fig. 3 — Repair technology roadmap.

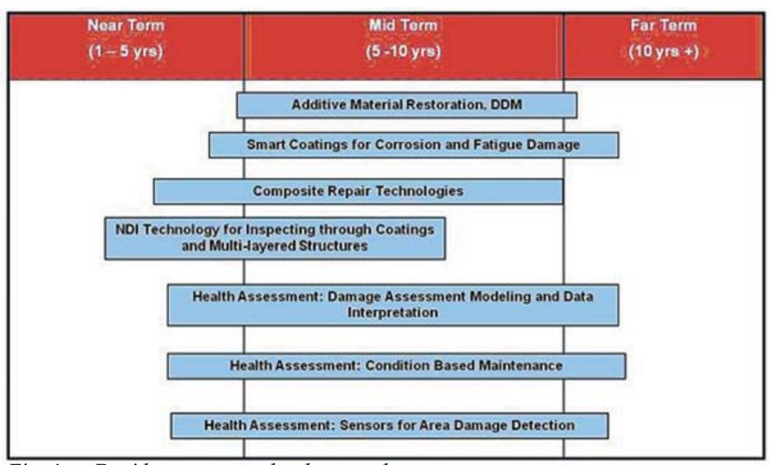


Fig. 4 — Rapid prototype technology roadmap.

in space to produce that solid.

• Electron Beam Melting (EBM): Metal powders are melted layer by layer with an electron beam in a high vacuum.

Transition hurdles

To significantly decrease the non-technical hurdles to technology insertion, the objectives are to identify five business processes which, if improved, could reduce the time of technology insertion by 50%. Other goals are to assure that 100% of the efforts needed to insert technologies are properly resourced; and to reduce the time associated with the qualification, certification, and insertion of new technologies by 80%.

To achieve these goals, the Navy should optimize and fully integrate its aviation maintenance, science, and technology insertion processes. This would facilitate work across organizational, competency, and site lines.

It should also establish a single organization (a program office) responsible for facilitating and tracking maintenance technology insertion. The process of qualification and certification of new maintenance technologies should be optimized and integrated into the overarching technology insertion process.

The Working Group recommended the initiation of two lean-six sigma projects. One project would focus on optimizing the process of technology insertion across organizational and site boundaries; the second would address the streamlining of the qualification and certification process.

Plenary speakers

Richard Gilpin, NAVAIR AIR-4.3 Director, Air Vehicle Engineering Department
John Johns, Deputy Commander Fleet Readiness Centers
Thomas Laux, Program Executive Officer Air, ASW, Assault and Special Mission Programs
Todd Mellon, NAVAIR AIR-6.7 Director, Industrial & Logistics Maintenance Planning / Sustainment
Col. David Smith, Commanding Officer FRC East
Greg Kilchenstein, Senior Sustainment Technology Policy Analyst, OSD(AT&L)
John Carney, Director, Navy ManTech Program, Office of Naval Research

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Acknowledgments

Mr. Timothy D. Bair[1], Mr. George Blasiole[4] , Dr. Tom Donnellan[1], Mr. Jose Jimenez[5], Mr. Robert Kestler[2], Dr. Eui Lee[2], Mr. Ray Paulson[5] Ms. Denise Piastrelli[4], Ms. Michele Pok[2], Brian Riso[2], Mr. Irv Shaffer[3], Mr. Mark Traband[1], Dr. Jeff Waldman[3] , and Dr. Daniel Winterscheidt,[4] representing 1. ARL Penn State, 2. NAVAIR, 3. Navmar, 4. the Navy Metalworking Center, and 5. the Fleet Readiness Center South West.

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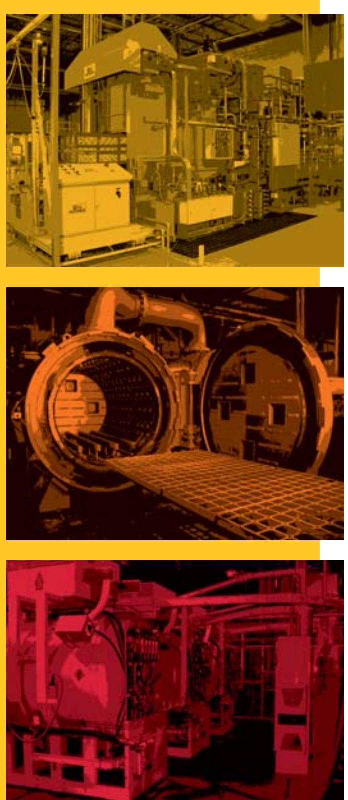

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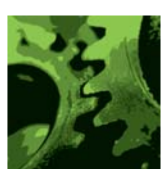

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