

The AGE PAGE GAZETTE

Aging Aircraft Integrated Product Team



Improving Fleet readiness & reducing ownership costs by attacking the effects of age

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Arc Fault breaker dances through first test -- no trips!

The arc fault circuit breaker, technology being developed jointly by the Navy, the FAA and industry to protect aging aircraft from wire-related problems, passed its first ground test at Naval Station Norfolk, VA, Oct. 23-26.

The breaker, which is designed to detect arcing electrical faults in aircraft wiring, was ground tested using a Navy C-9, similar to a civilian McDonnell-Douglas DC-9 or MD-80, provided by Fleet Logistics Support Squadron 56 and put through a series of normal electrical loads.

This first test, using an actual aircraft, was designed to check the breaker's resistance to "nuisance" or false trips under normal conditions, explained Chuck Saye, engineer with the Naval Air System Command's C-9 engineering team. The tests included a variety of power configurations.

"We connected the prototype arc fault circuit breaker in the circuits under test and conducted normal ground operations," he said. "We had external power on the aircraft and ran 50 different systems – they didn't create any nuisance trips."

Following the ground power tests, the team then conducted tests using the aircraft's onboard auxiliary power unit and engines.

"We did several transitions between APU and



No arcs, no sparks -- Chuck Saye, an engineer with the Naval Air System Command's C-9 engineering team, monitors a C-9 circuit breaker panel during recent ground testing of the arc fault circuit breaker.

engines and the breakers performed satisfactorily," Saye added.

Saye noted the importance of this first major milestone test of the prototype breaker in an aircraft.

"We have commercial derivative aircraft," he explained, "and this gives us the opportunity to be on the leading edge of technology that will improve safety and reduce life cycle costs for all operators. We have a pretty good maintenance program and this [breaker development] will continue our good safety record."

Arc fault circuit breakers are designed to detect and prevent electrical arcing caused by breaks in wire insulation before that arcing can lead to a fire or other catastrophe. Such faults are prone to occur where microscopic cracks, abrasions or breaks in the wire's insulation result as the wire ages, or is improperly installed or maintained.

Thermal circuit breakers currently used in most military and civilian aircraft only detect classic "bolted" short circuits.

Once development is completed, the new breakers can be used in both military and civilian aircraft to lessen the risk posed by aging wiring, according to Bob Ernst, head of the Navy's Aging Aircraft Integrated Product Team.

But more testing must be done before the new breakers go into production – no simple task when it comes to taking technology originally developed for residential use and qualifying it for use in aircraft where transient electronic "signatures" are more varied and complex.

"For example," Ernst said, "If your wingman turns on his radar or you cycle generators, you don't want all your circuit breakers to pop because they interpreted those signals as arc faults."

"This isn't simple," he continued. "That's why it isn't getting done overnight. The Navy, FAA,

Air Force, Air Line Pilots' Association, NASA and industry are working together to develop a common specification. It's better to spend a little extra time up front to make sure we get it right."

The agencies jointly developing the specification agree that if the arc fault circuit breaker has too many false alarms, it won't be used.

"If the breaker is always popping for false alarms because we didn't get the programming right," said Ernst, "then maintainers out in the

field are going to pull them, set them aside and put the old breakers back in. Then what will we have accomplished? You can't just throw something out there with a high false alarm rate."

"We know the urgency of the issue and we are all working as fast as we can, but we have to get it right," Ernst added.

Chuck Singer, the NAVAIR electrical engineer leading the development effort, projects flying a prototype breaker soon, though.

"We should be flying a prototype breaker in October 2001 in a Navy C-9 and transition to procurement beginning in 2002," he stated.

'This gives us the opportunity to be on the leading edge of technology that will improve safety and reduce life cycle costs for all operators.'

**Chuck Saye
C-9 Engineer**

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Dept. of the Navy stands up Aging Aircraft Team



Wire dogs -- Aging Aircraft team members Greg Kennedy (L) and John Milliman (R) evaluate an aircraft wiring diagnostic tool.

Recognizing rising operating and ownership costs associated with an aging aircraft fleet, the Naval Air Systems Command last year chartered an Aging Aircraft Integrated Product Team to tackle issues associated with aging Navy and Marine Corps aircraft.

Since then, the team has aggressively faced some of the biggest challenges to operating an aging fleet. Under the leadership of NAVAIR's Bob Ernst, an engineer with extensive background in two of the Navy's oldest platforms -- the F-14 *Tomcat* and the S-3 *Viking* -- the team successfully changed the way the Navy thinks about age from a purely structures focus to a comprehensive systems engineering approach.

Ernst's team faces a big challenge with equally big ramifications -- Aging aircraft issues have a cascading effect on readiness and modernization.

"Clearly, we must keep our equipment in good repair to maintain readiness," testified Dr. Jacques Gansler, then Under Secretary of Defense for Acquisition and Technology, before the Military Procurement Subcommittee of the House Armed Services Committee in October, 1999.

"However, it drains resources - resources we should be applying to modernization or replacement of existing systems as they become increasingly obsolete and to the development and deployment of new systems to counter the anticipated asymmetrical threats of the early 21st century."

Significant challenges

Like the other services, the Navy and Marine Corps have a significant age-related challenge.

"The average age of our aircraft is increasing greatly," Ernst explained. "For instance, the average age of our in-flight refueling and maritime surveillance aircraft is about 28 years. If they were cars in Maryland, many could qualify for historic license plates."

"And current procurement rates will increase the percentage of aircraft older than 15 years to about 65 percent by 2008," Ernst added.

The problem isn't merely one of age in and of itself, Ernst explained. The problem is with the *effects* of age. The problem is compounded because aircraft are dynamic platforms with vibration, impacts and pressure changes.

The problem may not be all that apparent yet, according to HASC Military Procurement Subcommittee chair, Rep. Duncan Hunter (R, CA). Because the services have adopted a more conservative approach to using older equipment, mishap rates are down and possibly masking the problem.

"So the problem with aging equipment doesn't manifest itself until we have a conflict in which we've got to fly all this stuff," Hunter said.

Team accomplishments

Since being formed more than a year ago, Ernst's team has chalked up some impressive accomplishments in support of NAVAIR programs. Because of its multidisciplinary approach and ability to share information across various communication channels, team members are quickly tackling and overcoming age challenges throughout Naval aviation:

* Team member Chuck Singer, a NAVAIR electrical engineer, is working closely with the Office of Naval Research and the Federal Aviation Administration to develop a new circuit breaker technology that will help prevent tragic mishaps like that believed to have caused the TWA 800 explosion. The arc fault circuit interrupter recently passed its first ground test.

* Aerospace engineer Dave Kayser recently designed a new oxygen system controller spring for the F-14 *Tomcat* to replace the original one that was about to ground the entire *Tomcat* fleet.

* Electrical engineers Sean Field, Wayne Boblitt and Pall Arnason are developing "Smart Wire" technology that could render age-related wiring woes in aircraft a thing of the past.



Ernst

The team charter:

To improve fleet readiness and reduce life cycle cost by aggressively attacking and countering the effects of aging aircraft.

- * **Identify problems - Quantify risk**
- * **Provide information to Program Teams**
 - Available funding sources
 - Other IPT solutions
 - Industry/Other services' solutions
- * **Advocate for enabling technologies**
- * **Provide standard risk and cost evaluation tools**
- * **Focus attention on Aging Aircraft issues**

"We're rather unique in that we're taking a systems approach to the issue and looking at all aspects," Ernst explained. Previous aging aircraft groups focused on only one aspect of the issue like structures.

"For example, the structures group developed a - number of good initiatives in the area of fatigue and corrosion," said Ernst.

"But the weapon system is only as strong as its weakest link," he added.

"We want to look at all the issues and develop a catalogue of tools to help our customers.

"We recognize that there are multiple solutions for the many age-related problems and what works in one case might not in another." ■

From Russia with love titanium nitride -- Technology developed to prevent turbine blade erosion in Mi-24 Hind helicopters in Afghanistan will help aging Navy and Marine Corps CH-53E Super Stallion heavy lift helicopters (below).

Russian coating to prevent turbine engine blade wear

--Expected savings to top \$1.6 million annually



A Soviet-era technology under evaluation by Naval Air Systems Command engineers is promising impressive life span and power improvements for some aging aircraft engines.

“Many [people] think advanced technology is for new systems only,” said Dave Pauling, NAVAIR’s department head for Propulsion and Power Systems. “But this team showed us how advanced technology can be applied to legacy systems — today’s fleet — as well.”

The program itself involved evaluating a Russian process that coats turbine engine compressor blades with a thin layer of titanium nitride. These compressor blades, especially those used in the CH-53E *Super Stallion*’s T-64 engine, were experiencing dramatically shortened life spans due to erosion.

“We had a problem with sand erosion taking the compressor in the T-64 engine down to 1/20th of its design life,” explained Greg Kilchenstein, a NAVAIR Propulsion and Power Systems engineer and member of the integrated product team evaluating the new coating process. “That trickled down to other problems like compressor stalls.”

Ultimately, eroding compressor blades affected performance to the point Leathernecks operating the *Super Stallion* in Southwest Asia during Operation Desert Shield and Desert Storm were having difficulty making

heavy lifts.

“They had to call on Army CH-47 *Chinooks* to make heavy lifts,” he said.

Obviously, something needed to be done.

Although the CH-53E, like many other platforms, is fitted with a particle separator to filter out larger particles before they are ingested by the engine, the *Super Stallion*’s Engine Air Particle Separator is designed to catch particles larger than 10 microns, according to Kilchenstein. That equates to a very fine dust getting “blown” through the engine at very hot temperatures and high speeds, and scouring engine components in its path like a sand blaster.

“In the T-64 engine compressor, the blades in the first 10 stages are titanium,” said Kilchenstein. “Titanium is lightweight, strong and a good candidate for building rotating components, but it’s not good at handling hard-particle erosion.”

A search for help led them ultimately to technology used in the Soviet-era Mil Mi-24 *Hind* attack

helicopter.

“The Russians had the same experience in Afghanistan that we did in SWA with engines,” Kilchenstein said. “They were scrapping about 80 percent of their rotor blades. This coating technology helped them reduce that rate to about three percent.”

The coating process had been developed by the Ural Works of Civil Aviation (or PRAD by its Russian initials) in Ekaterinburg, Russia, according to Chris Georgiou, a NAVAIR aerospace engineer responsible for advanced propulsion programs (AIR 4.4T). It has been successfully protecting TV2 and TV3 engines used in the Mi-24 and Mi-48 helicopters, as well as most of the Russian military fleet.

A sales visit by the Montreal-based MDS Aero Support Corporation led to the Canadian engineers asking about the gold-colored turbine blades from the helicopter engines being rebuilt at the PRAD plant. That in turn led to the creation of the joint Russian-Canadian venture, MDS-PRAD Technologies Corporation, to market the process.

“To prove a good ROI on coated blades that cost 1.3 times as much as uncoated blades, we would need them to last at least twice as long,” Kilchenstein said. “We found the coated blades lasted five times as long as the uncoated blades.”

‘Many [people] think advanced technology is for new systems only. ...It can be applied to legacy systems -- today’s fleet -- as well.’

**Dave Pauling
AIR 4.4**



Fleet maintainers find ...

The pen *is* mightier than the gun



Spot paint applicators minimize waste, HAZMAT costs

Fleet maintainers are quickly discovering that the pen *is* mightier than the gun – especially if that gun shoots spray paint.

Naval Air Systems Command chemical engineers, working with industry and the Aging Aircraft IPT, have developed a unique kit to speed spot paint repairs of aircraft while reducing overall procurement and disposal costs.

The SemPen, made by PRC-DeSoto of Glendale, CA, is designed to store, mix and apply small quantities of two-component paints and primers, according to Dave Pulley, a chemical engineer with the Naval Air Systems Command's Organic Coatings Lab here.

"It really boils down to ease of operation in the Fleet," Pulley said. "Maintainers are used to dealing with odd ratios. Now they can just stick a couple of SemPens in their pockets, go out and fix the airplane."

Even aircraft down for spot repairs require extensive, time-consuming preparation using current repair techniques.

An aircraft brought in the hangar for corrosion maintenance must be roped off to keep people from breathing the toxic fumes associated with aerosols and spray paint components. And no one can come near it without wearing proper protection, according to Tom Doughty, engineering technician and Fleet support representative for NAVAIR's

Organic Coatings Lab. That containment, needed for both health and safety reasons, makes it nearly impossible to do anything else to the aircraft while it is down.

"Using the SemPen eliminates that need," said Doughty. "Using it for aircraft only needing spot repairs allows Maintenance Control to schedule other needed maintenance at the same time. Thus, after they finish the spot painting and roll the aircraft back out to the line, it has fewer outstanding awaiting maintenance gripes because more shops had an opportunity to work on it."

"The SemPens are awesome," said AMCS Rick Robinson, airframes coordinator for maintenance with Patrol Reconnaissance Wing 10 at NAS Whidbey Island. "We're able to get other maintenance done at the same time.

"The [maintainers] don't have to use forced-air respirators," he added. "The whole process is 10 times faster than mixing paint and all that."

Overall, according to Pulley, the SemPen's greatest cost savings are found doing small, spot repairs where current repair methods typically are wasteful and then require hazmat disposal.

"The SemPen is ideal for nicks, scratches and fasteners – places that only need a spot touch up," he said.

"We like 'em because they're quick and easy," explained Robinson. "You hit the corrosion and about 20 minutes later, you're



A new way to fly -- PRC-DeSoto's SemPens are helping Fleet maintainers speed spot touchups and reduce HAZMAT costs.

putting on primer. About 40 minutes after that, you topcoat. And then, you're done. The SemPen cuts the whole process down."

With such small repairs, maintainers will also end up with better looking airplanes that they won't be tempted to repaint because of a spotty appearance.

Maintainers and supply officers desiring to reduce maintenance/HAZMAT costs and turnaround times on aircraft will be able to find the GSA stock numbers for the SemPens in the new Corrosion Control Manual, NAVAIR 01-1A-509. To receive a fact sheet on the SemPen, contact Tom Doughty at the NAVAIR Organic Coatings Lab: doughty@navair.navy.mil or (301)342-8052. 

\$8 spring keeps aging Tomcat

On the prowl



A seemingly small fix, researched and developed quickly by NAVAIR Aging Aircraft Integrated Product Team members, is preventing a fleet wide grounding of the F-14 and netting a cost avoidance of more than \$5 million over the next 15 years.

In short, a redesign and procurement of an \$8 part is preventing a need to redesign and procure of a \$30,000 safety of flight component, according to Dave Kayser, an engineer with the AAIPT.

Over an 18-month period (Dec '98 – Sept '00), The F-14 Backup Oxygen System controller required 268 maintenance actions, requiring a total 468 maintenance man hours at a cost of \$526,700 for an MFHBF of 71. Per year, this equates to 312 direct maintenance man-hours and \$351,000 annually.

Also, units coming out of the supply system with an RFI status are failing on initial installation. Some squadrons experience as many as 3 failed BOS controllers before they

find one that works.

As a result of this high failure rate, the number of BOS controllers going into the maintenance/supply cycle is quickly exceeding the available spares quantity.

This condition is shorting fleet needs such that there is an insufficient quantity available for each F-14. The problem is such that the supply of usable BOS controllers will be exhausted by June 2001. Without a working BOS, the F-14 is not authorized for flight.

Within the BOS controller there are two servo valve assemblies that change the flow of air going to the aircrew from the On-Board Oxygen Generating System to the BOS should a failure of the OBOGS occur. As part of a study of the problem, four valve assemblies, marked Ready For Installation,



Kayser

were sent to Kayser for testing – all four valves failed intermittently (>35% failure).

The BOS controller servo valves (see inset above) were found to be improperly seating due to a poorly designed internal spring slipping into the piston working area. This interference caused the oxygen system to leak, expend numerous BOS bottles prematurely and become a safety issue.

Kayser redesigned the spring in the servo assembly so that it would not slip off its seat and jam the valve piston. We're now procuring these redesigned springs for \$8 each. The new spring eliminates the failure mode previously experienced and raises the BOS controller MMHBF rate to 1,420 hours from 71.

Should this spring have not worked, the cost of replacement servos could have exceeded \$3,000 each with a lead-time of approximately one year. 

Navy engineers find technology to help aging/defective control surfaces

Engineers working with the Aging Aircraft team are testing new technology that will prevent inflight failures of aircraft control surfaces.

The new technology being tested involves treating the aluminum honeycomb material to a phosphoric anodization process during construction.

Flight control surfaces (i.e., rudders, ailerons, flaps) on most of Navy and Marine Corps aircraft are constructed using an aluminum honeycomb core which, while being structurally efficient and inexpensive to make, is prone to several corrosion-related types of failure.

The most common failures include core material corrosion, corrosion-assisted fatigue of the hinge and buffeting fatigue of the skin. These failures can be so extensive that the parts have to be scrapped rather than repaired. And if the failure occurs in flight, loss of control can result.

To combat this problem, NAVAIR engineers are working with industry to implement a new process where the aluminum honeycomb

cores are anodized with phosphoric acid to improve corrosion resistance.

This process is expected to yield a cost avoidance over the next 10 years of more than \$34 million.

In addition, follow-on technology will help eliminate problems associated with corrosion altogether. These new technologies include creating new honeycomb material, making control surface hinges out of titanium and fabricating control surfaces and hinges from all-composite materials. 



Gone with the wind -- An F/A-18 rudder shows extensive damage after honeycomb core rot caused an inflight failure.

AAIPT Meetings

Get the gouge -- Programs, other IPTs and interested individuals are encouraged to attend the Aging Aircraft IPT bi-weekly meetings. Meetings are scheduled for the first and third Tuesdays of each month. Location varies, but generally one of the large conference rooms in Bldg. 2185 are used. For more information or to get on the agenda, please contact Greg Olson at olsongp@navair.navy.mil or 301-342-2265.

Meeting Schedule:

AAIPT Meeting	3 & 17 April	Bldg 2185, Room 3150
APMSE Training	19 April	Frank Knox, Room 120
NAVAIR SBIR Expo	6 June	Bldg 2272
Aging Aircraft Conference	10-13 Sept.	Orlando, FL
Digital Avionics Systems Conference	14-18 Oct.	Daytona, FL



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