Designed to Su

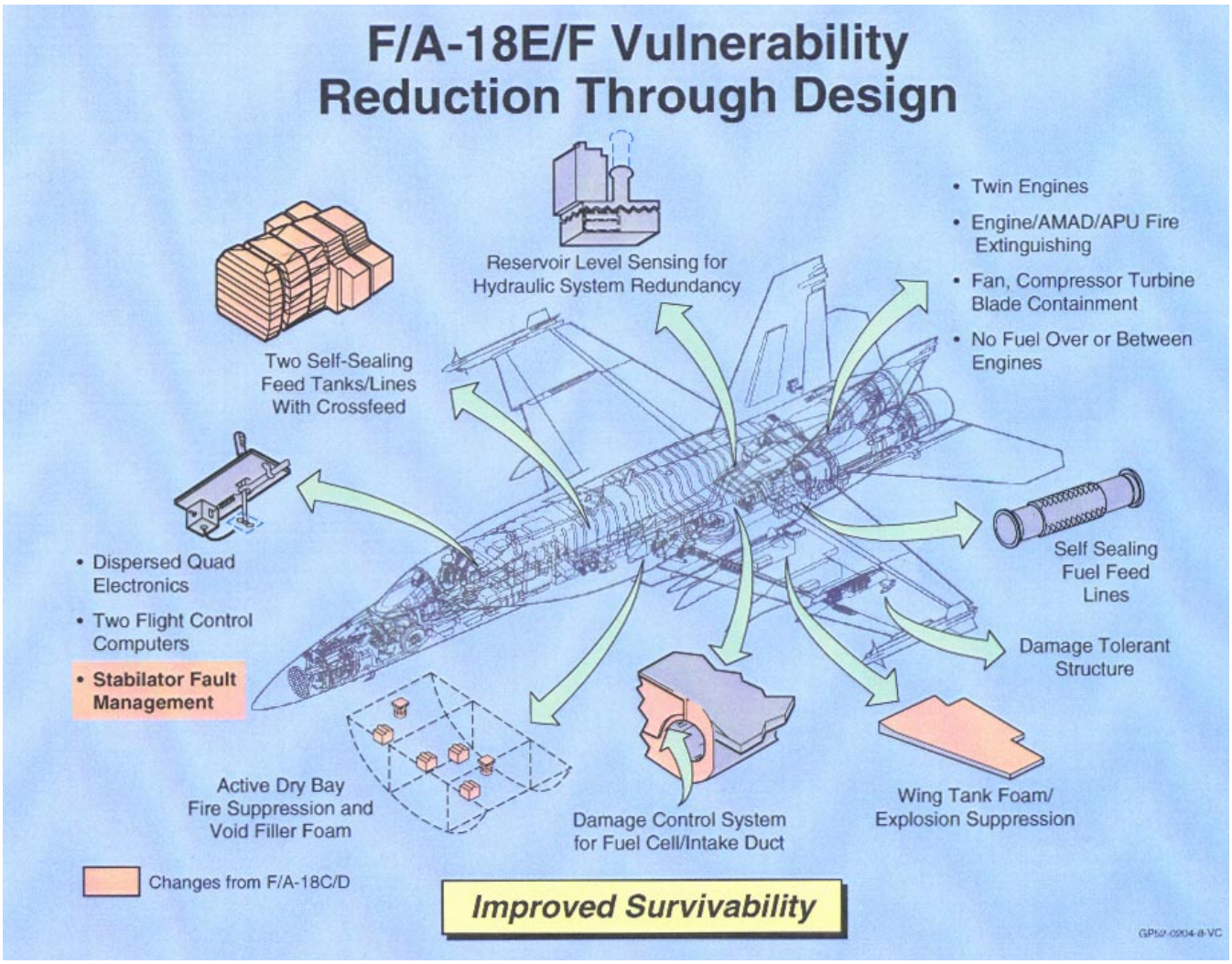
rvive

By Professor Robert E. Ball

Stories of an aircraft sustaining what should have been fatal damage during combat, surviving and returning to home base are legion, but such stories from WW II, Korea and even Vietnam owe their happy endings largely to happenstance. Today, Navy planners are less willing to trust the fate of their aviators and fighting machines to simple luck. Instead, today's aircraft are designed to survive in combat so they and their aircrews live to fly another day.

Combat survivability can be achieved in two ways. First, avoid being detected, engaged and hit by the enemy's weapons—referred to as susceptibility reduction. This can be accomplished by carrying threat-warning equipment that provides situational awareness data to the aircrew; employing electronic countermeasures equipment; and designing the aircraft to have low signatures in the radar, infrared and visual electromagnetic bands, and the aural signature. Other elements that can reduce susceptibility include nonlethal and lethal suppression of the enemy's air defenses; the use of lethal stand-off weapons or weapons delivered from high altitude; and mission planning

Opposite, the smile on Marine Captain Bill Berg's face is courtesy of the inherently rugged design of the F4U *Corsair* he flew during the Korean War. Today, designing aircraft to survive enhances an aircraft's capability to return to base with combat damage (below left) and also provides a significant safety margin for noncombat damage. Below, an F/A-18 *Hornet* returns to base after a midair collision during a training mission.



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systems that plot routes around the major air defense sites.

The second aspect of combat survivability is vulnerabilty reduction, which enables the aircraft to withstand a hit and continue to fly and fight. Critical components on the aircraft—such as those involving structural integrity or lift, thrust or control—must be designed to continue to function after the aircraft is hit. Design features must also address minimizing the impact of damage to subsystems, which would cause loss of power to the flight control actuators, fuel starvation, and/or a fire or explosion inside a fuel tank or in adjacent dry bays. In the event that aircraft damage is fatal, the aircraft's design must allow a gradual degradation of system capabilities, giving the aircrew a chance to get out of enemy territory before departing the aircraft.

The F/A-18A *Hornet* was the Navy's first aircraft in which combat survivability considerations played a major role in the design. Studies determined the payoffs and costs associated with each enhancement feature proposed, and those with the best benefit-to-cost ratio were incorporated. The F/A-18 proved itself to be a survivable aircraft in Desert Storm, during which four *Hornets* withstood hits by infrared-guided surface-to-air missiles. The design of the aircraft's newest version, the E/F *Super Hornet,* incorporates even more survivability features.

Today's operational and developmental aircraft undergo extensive live-fire testing to enhance their future survivability. The Joint Live Fire test program, initiated in the early 1980s, has tested the vulnerability of many operational platforms to both nonexplosive and explosive ballistic projectiles. In FY 1987 Congress passed the Live Fire Test law for aircraft in development, which requires realistic vulnerability tests on complete aircraft, including combustibles, against weapons likely to be encountered in combat. These initiatives encourage vulnerability testing of components and subsystems early in the development cycle in order to identify vulnerabilities and eliminate them without major weight or cost penalties.

The U.S. military's experience over the past five decades with aircraft in combat has led to the evolution of survivability as a distinct design discipline. Designing aircraft to avoid enemy weapons and to bet-

ter survive when hit increases the odds of today's aircrews and their high-tech weapon systems returning home.

Distinguished Professor Ball was on the Department of Aeronautics and Astronautics faculty at the Naval Postgraduate School, Monterey, Calif., until his retirement on 1 November.

If you would like to learn more about the aircraft combat survivability discipline, visit the survivability education web site: http://www.aircraft-survivability.com.

Above, V-22 aircraft #6 is prepared for testing to support the requirements of the Live Fire Test law passed by Congress in 1987. Left and below, F/A-18 state-of-the-art fire detection and extinguishing systems undergo testing under in-flight airflow conditions.

Photos this page courtesy of Danny Zurn, Management Assistance Corporation of America.