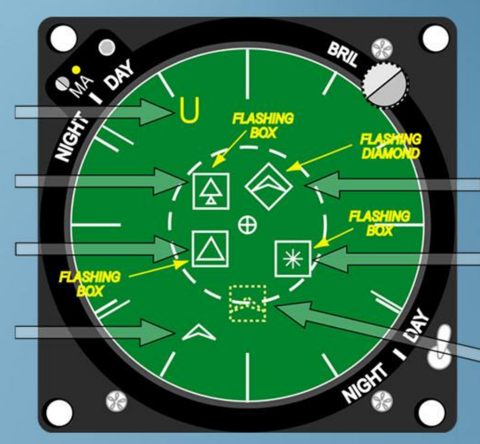
The Radar Warning Story



THE RADAR WARNING STORY

IN THE BEGINNING
YEAR: 1965

In July 1965, an American F-4 Phantom II was shot down over North Vietnam. This loss represented the first American aircraft to be downed by an SA-2 Surface-to-Air Missile (SAM) in the Southeast Asian conflict. This event heralded the beginning of a serious and lethal new challenge to American air superiority.

In the succeeding months of the war, American aircraft would attempt to penetrate major targets in the North, and they would fly their missions into the teeth of the most sophisticated air defense network ever deployed in history.

The North Vietnam air defense system, as it evolved in the mid to late 1960s, consisted of Anti-Aircraft Artillery (AAA), SAMs and MIG fighter aircraft, all closely coordinated through the use of communications and radar. The need to counter this lethal new threat was painfully obvious as losses of aircraft and crew grew to unacceptable levels.

Brigadier General K.C. Dempster, then Director of Operational Requirements and Development Plans, U.S. Air Force Headquarters, was selected to head a Blue Ribbon Air Staff Task Force to investigate methods of countering these lethal weapon systems in an effort to provide warning and protection to U.S. air crews against this new threat.

The need for aircraft self-protection assets was the driving force behind a seminar held in August 1965, and led to a recommendation for the development of aircraft avionics systems capable of detecting and destroying the controlling radars in these defense networks. The concept was appropriately named Wild Weasel, an animal known to hunt vermin.

Almost in disastrous parallel, a Navy RA-5C reconnaissance aircraft was lost over Dienbienphu. Again, the culprit was the SA-2. A $5.5 million aircraft was lost, causing considerable comment that the aircraft was too expensive to introduce into combat. Soviet-built SAM technology was threatening to destroy a much needed intelligence capability that had been developed and deployed at a cost of several hundred million dollars.

In parallel with the Dempster panel, DDR&E convened a committee to evaluate options and make selections for the development of a warning and jamming equipment suite. It was decided that of all the proposals received, a concept called Vector IV offered the best potential solution to the warning problem. As a result of this decision, a then-small company based in Northern California rocketed into national focus. The Vector IV concept was proposed by Applied Technology, Inc.

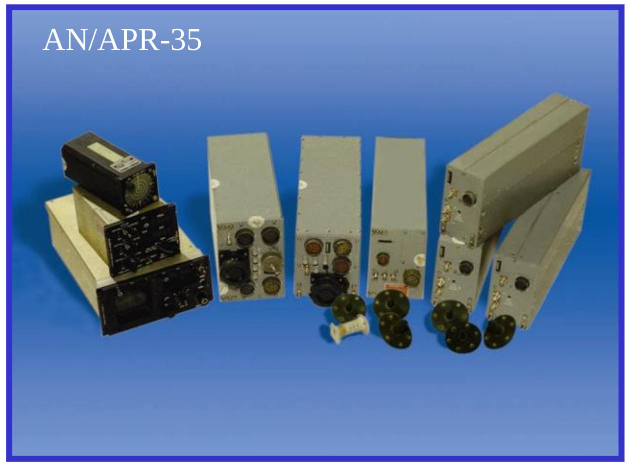
AN/APR-25

In November 1965, the USAF Sacramento Air Material Area awarded Applied Technology a contract for 500 AN/APR-25s, the system nomenclature for the Vector IV concept. The system was based on the use of crystal-video detection techniques in the threat bands only, where the hostile equipment's relative direction was resolved by a CRT display using vectorial inputs from four antenna patterns. Thus, the initial concept name, Vector IV.

Until this time, Applied Technology had been primarily involved in strategic reconnaissance and intelligence technology programs where a large production run consisted of 10 systems. The impact of the AN/APR-25 award was huge. Further, the U.S. Navy awarded Applied Technology a production order to outfit its aircraft with this critical new protective asset.

Very little was known about the threat in those early days, and the design philosophies of warning systems were based upon gathering as much signal information as available. Later this philosophy would change as the need for sorting analysis and prioritization of lethal pulses became semi-automatic.

On a Friday the 13th in 1966, Applied Technology's AN/APR-26 radar warning receiver performed successfully in a combat mission and added yet another success for the growing company. In the 1966 – 1967 time frame, Applied Technology was shipping radar homing and warning systems at a rate of 250 per month. Employment levels approached 1,400, a seven-fold increase in just two years.



AN/APR-35

The AN/APR-36 and AN/APR-37 were updates to U.S. Air Force AN/APR-25/26 systems. Continually pressing the edge of technology for new ways to protect aircraft and crews, Applied Technology developed and added features such as automatic time/video correlation circuits. At the same time, the company developed a superheterodyne analysis receiver in the form of the AN/APR-35 system.

This second generation system was quickly fitted into all Wild Weasel aircraft. The new equipment provided the Electronic Warfare Operators (EWO) with improved capability to discretely assess the threat.

It was during their support of strike missions into North Vietnam that the Wild Weasels won their motto of "first in and last out." The Weasels flew well in advance of strike aircraft and actually baited hostile SAMs to clear a safe corridor for the follower aircraft to enter and reach the target. The Weasels rolled back the SAM sites through bait or attack of the sites. As they detected SAMs along the strike route, they also provided warning to strike aircraft when they detected a SAM launch. This provided an instant alert and maximum reaction time for evasive action. U.S. Air Force B-52s were never sent into North Vietnam, or any other areas within possible range of SAMs, without a Wild Weasel escort.

New technology had been deployed at the scene of the battle, and the use of Applied Technology's radar homing and warning equipment played a key role in the success of the engagements.

The action taken to interface this new technology with needs of a pilot and an EWO required unprecedented military and industry teamwork. Tense pilots, busy flying their aircraft with full knowledge of their illumination by a SAM, did not have the time to work with a potentiometer or a confusing jumble of strobes. The action to address this issue was is one of the most critical successes of the Wild Weasel program. Teamwork between the pilot and EWO developed to a point where communications were instantaneous, with the EWO making quick interpretations from displays and providing instructions to the pilot as to "which way to duck." When a SAM was fired at a Weasel aircraft, there was no time for discussion as survival demanded speed. The improvements made in operator interface began to pay off in lifesaving dividends.

At the same time, new information continued to surface about the subtleties of the various threats. After analysis, new logic and techniques were consistently incorporated in true Quick Reaction Capability (QRC) fashion in operational systems on board strike aircraft. When a new requirement originated in Da Nang, in some cases, only 72 hours passed before an Applied Technology representative was performing installation changes.

TIMES CHANGE

In 1969, the hostile chess game assumed new proportions with the fielding of more lethal SAMs and AAAs. The U.S. Navy, upon perception of the Mediterranean Threat impact, initiated action that resulted in the next generation warning systems for Naval attack aircraft, the AN/ALR-45. It was the first digital system which incorporated hybrid

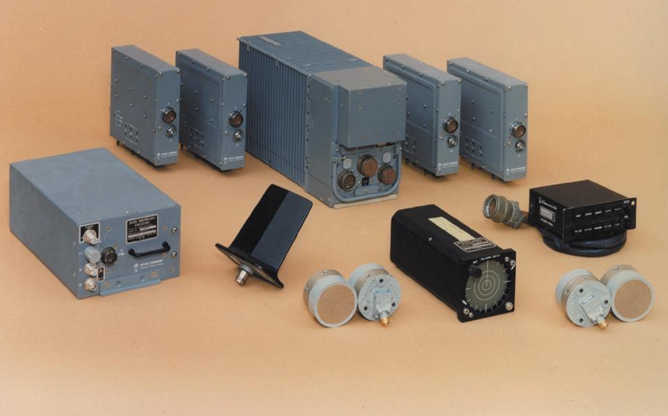
AN/ALR-45

microcircuits using digital logic and clock drivers. From 1970 – 1974, the AN/ALR-45 was introduced to the Fleet.

As the threat scenario continued to proliferate into a lethal array of densely deployed weapons of varying types, frequencies and modulation methods, a new realization emerged. Previous design philosophies were based on obtaining as much signal data as possible. Now, it became necessary to start discarding non-lethal threat information. Prioritization of threats and emitter tagging became critical. Only computational power could solve this increasingly complex technical problem. Unambiguous warning, coupled with ease of use, heralded the end of analog control in the aircraft warning function.

The U.S. Air Force, as part of its ALR-46 program, was the first to field a digital, software-controlled radar warning receiver.

ALR-46



In late 1971, a fundamental change took place at Applied Technology. In its continual quest to lead technology innovations, the company was changed from an analog circuit design house to a computer sciences house. Cost was a major motive in this change.

In mid-1972, Applied Technology was in the midst of purchasing a militarized computer with an architecture similar to that of a standard avionics computer. Management review of the situation noted an indelible trend of the future need for more costly computer systems. The determination that a circuit board improvement to the ALR-45 could be duplicated by low cost memory, if the CPU was fast enough, provided a more attractive option. The solution resulted in an effective application of another new technology, the Vector V warning concept, and a next generation Applied Technology system.

Based on a processing concept that was built around a variable programmer-alarmer idea, software routines were created so that probability statements on frequency/PRI, PRF, Pulse Width, Pulse Coding, etc., could be constantly analyzed.

The initial study resulted in the idea that conditional probability statements with determinant pairs of frequency and PRI represented an effective, processing technique. Creating a computer capable of handling large volumes of data was the over-riding philosophy, but dramatic technological change had begun.

In late 1972, Applied Technology established a goal to develop the world's first computer specifically designed for electronic warfare applications. The system would occupy 100 cubic inches in volume, consume 80 watts in power and realize a 250K words per second I/O rate. Also, the computer would deinterleave pulse trains and be capable of squadron-level reprogramming using flight line equipment.

Results were impressive. In July 1973, the Applied Technology Advanced Computer (ATAC) was implemented. Cost was well within targeted goals, volume was only 96 cubic inches, power consumption was 45 watts instead of 80 watts and the I/O rate was 1.25 megawords per second, representing a five-fold improvement over the initial design goals.

The new ATAC computer was subsequently injected into the Vector V program and resulted in a third generation system which incorporated all advancements in microprocessor and microcode technology.


AN/ALR-68

The Vector V signal data converter formed the basis of the AN/ALR-68(V), as well as the nucleus of the Enhanced Radar Warning Equipment used on the MRCA Tornado.

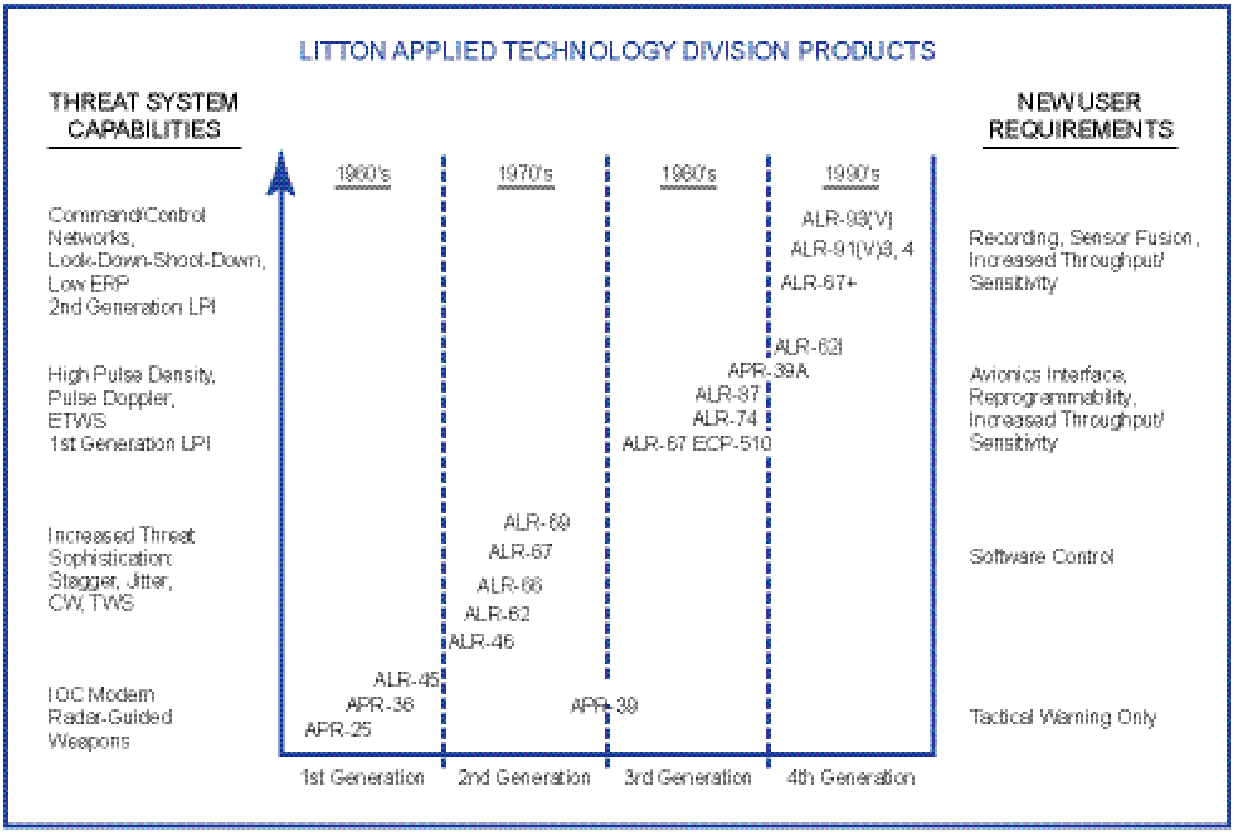
The concept of computer managed power allocation of jamming assets began gathering favor. An aircraft flying into the forward edge of a battle area, facing SAM and AAA weapons, which are all controlled by a variety of radars, needed to intelligently use its radiative power. The jammers were used to spoof, or otherwise blot out the return to the hostile radar receiver. Integrated power management systems, using state-of-the-art computer processing, collected and analyzed multiple threats and provided real-time data for optimum jamming capabilities.

The typical power management suite implied a “look through” time for the radar warning receiver. The implicit need for speed and prioritized threat warning information passed to jammers pushed technology to yet another frontier.

Recognizing the need for coordinated use of electronic warfare assets, the U.S. Navy initiated the development of its third generation warning receiver for the EA-6B Prowler electronic warfare aircraft, called the CWCS program. In 1974, intense competition surrounded this coveted program solicitation, as an entire fleet retrofit and new aircraft inventory programs were on the horizon.

In 1975, Applied Technology was awarded the CWCS program, now called the AN/ALR-67 countermeasures warning and control system.

At the same time, the U.S. Air Force also had other major programs underway, the ALR-46 and the AN/ALR-69.



THREE DECADES LATER

Litton Applied Technology's reputation for providing products with exceptional performance records in combat was reinforced again during Desert Storm. Litton threat warning systems were flown onboard 80% of the 1,000 U.S. fixed wing aircraft, and 100% of Canadian and Kuwait combat aircraft. Litton Applied Technology systems flown included the: ALR-69 on F-16, A-10 and MC/AC-130 aircraft; ALR-46 on B-52, RF-4C and MC/AC-130 aircraft and ALR-67 on F/A-18, A-6, F-14A and AV-8B aircraft. Coalition forces equipped with Litton threat warning systems achieved nearly perfect survivability rates. Installed EW systems and operational tactics were flown in more than 2000 combat sorties the first 48 hours of the war. Although many SAMs were fired, only one aircraft was lost to missile fire. This one loss amounts to an almost unbelievable low attrition rate of 0.05%. Standard attrition percentages used by Military Air Planners are 0.3% for the first 24 hours of combat operations.

During the 42 days of Desert Storm operations, USN/USMC pilots flew 28,000 sorties with a total of 7 aircraft combat losses for an attrition rate of 0.025%. Combat pilots repeatedly praised the unambiguous threat identification and timely warning of Litton radar warning systems even in the presence of jammers, numerous hostile threat systems and large numbers of friendly radars.

Since the beginning of the electronic warfare environment, Litton's Applied Technology division has designed and produced threat warning systems to meet the most severe tests. Not since the first threat warning system, the APR-25, was exposed to combat in the skies over Viet Nam, has the company's products been so critically tested. Pilots who flew in Viet Nam found the Iraqi air defenses as tough or more difficult than anything they had ever flown against. A member of the U.S. House of Representatives' Intelligence Committee was quoted as saying, "next to Moscow, Baghdad is the most heavily defended target we might ever have planned to go against." Threats faced and survived by coalition air forces included the SA-2, SA-3, SA-7, SA-8, SA-9 SA-14, Improved Hawk, Roland, Crotale, ZSU-23, multiple AAAs and various Soviet and French-made Iraqi aircraft.

Air Force and Navy pilots reported that flack from AAA and SAM missiles was so heavy over target areas that without effective threat warning and coordinated countermeasures, many more aircraft would have been lost.

Litton's ALR-67, ALR-69 and ALR-74(V) series threat warning systems were designed to defeat the best Soviet and other nations weapons technology. Operation Desert Storm was a real world demonstration of the superiority of the technology and knowledge embodied in the Litton systems.

WHAT THE FUTURE HOLDS

Litton Applied Technology systems are meeting the needs of worldwide militaries in over 30 nations. representing 80% of all threat warning systems produced.

As the proliferation of new threats and world conflicts continue to arise, the threat environment becomes more complex. This continuing proliferation of advanced weapons systems and missiles will drive the requirement for advanced, integrated and automated self-protection systems.

There are very few defense equipment suppliers that have consistently delivered leading edge combat systems that operate effectively against present and emerging threats anywhere in the world. Litton Applied Technology is the leader of those few.

Tomorrow's changing requirements for self-protection and surveillance systems will continue to press the limits of technology. Leading the way with practical cost-effective solutions, Litton Applied Technology has designed and developed upgrade kits for installed systems, as well as new systems and self-protection suites.

NEW TECHNOLOGY BREAKTHROUGHS

<u>ALR-66B(V) Surveillance and Targeting System</u>

The ALR-66B(V)2 Surveillance and Targeting System provides precision direction finding for over-the-horizon capabilities for operators of maritime patrol aircraft through the


ALR-66B(V)3

detection, identification and location of radars in the C-J frequency range.

The ALR-66B(V) system uses advanced signal processing techniques to achieve instantaneous, positive emitter identification in high-density environments. Integrated with the aircraft's radar antenna, the system provides ultra-high system sensitivity and precision DF accuracy with no penalty to radar performance. Simultaneous operation of the radar, surveillance and direction finding functions is allowed.

Advanced system capabilities include:

- Automatic measurement of emitter parameters
- Integration with other aircraft sensors and systems via an expandable processor interface structure
- Advanced signal processing concepts cou pled with expanded data memory

ALR-62I Threat Warning System

The ALR-62I represents major changes to the previously fielded ALR-62, providing improved situational awareness, survivability and mission accomplishment capabilities. The ALR-62I incorporates the latest in technology advancements including:

- Frequency Sorting Techniques
- Multiple Preprocessors and Processors
- Gate Arrays
- Integrated Instantaneous Frequency Measurement Receiver, Superheterodyne Receiver, Crystal Video Receiver and YIG-controlled receiver
- Capability to integrate with jammers, chaff and flare dispensers and missile warning systems and to provide Forward Looking Precision


ALR-62I

The ALR-62I addresses CW, On/Off Keyed CW, Electronically Scanning emitters, Pulse Doppler, Pulse emitters (RF stable/hopper/agile and PRI stable/jitter/stagger/agile/wide-random) in the RF range of 0.5 to 18 GHz.

A higher density environment capability was added to identify state-of-the-art threats, and to provide faster processing time with lower false alarm rates. Flight-line reprogrammable with a comprehensive diagnostic BIT, other ALR-62 improvements include 1553B interfaces with onboard avionics and increased MTBF rates.

This advanced technology system upgrade includes fast bipolar CVRs, a wide-band IFM receiver, dual bandwidth SHR, multiple CW/PD input protection devices consisting of two-band reject YIG filters, variable attenuator, software adaptive threshold, frequency and AOA screens. Also, a computer network consisting of dual CPUs with EEROM memory and 7 microcontrollers, dual pipeline video processors, dynamic input scheduling, new self test oscillators and new software algorithms are included.

ALR-67 and the ECP-510/Follow-On Upgrade

The basic ALR-67 threat warning system is installed on F-14, F/A-18, A-6 and AV-8B tactical aircraft for improved situational awareness. The ALR-67 ECP-510 upgrade for fielded ALR-67 systems is a card-for-card upgrade that provides a significant increase in system sensitivity in the presence of strong signals, and a sizeable increase in computer pulse processing capability using the latest in technology.

Litton has made a significant investment in a follow-on upgrade to the ALR-67 ECP-510 system. Upgrade features include wide band passive ranging and the capability to detect and/or exploit low frequency signals for improved tactical awareness.

ALR-91(V) Series Threat Warning Systems

The principle technology breakthrough provided by the ALR-91(V) Series threat warning systems is the capability to continuously collect and analyze radar signals over the full 0.5 to 18.0 GHz frequency range. Prior and current generation systems are constrained in that collection and analysis capabilities of radar signal data are limited to a portion of the frequency range. Typically, other systems are of “band sampling” type; that is they collect and analyze signal data of one band at a time. Three or four bands are usually required to cover the full frequency range. Detection of radar signals on other bands is not possible when a band sampling is underway. The ALR-91(V) Series does not require band sampling, as all bands are collected at the same time. This new capability allows detection of all tactical radars as soon as aircraft tracking begins.

The capability to continuously collect and analyze radar signals over the full frequency range is made possible because of recent breakthroughs in the design of Very Large Scale Integration (VLSI) Application Specific Integrated Circuits (ASIC). A set of these VLSI ASIC chips was developed by Litton to enable the ALR-91(V) Series to rapidly detect and provide warning of the growing number of phased array radars. Software programmable, these chips automatically:

- Collect radar signal pulse data;
- Sort each pulse by frequency, angle and amplitude;
- Store the sorted pulses in separate memory areas;
- Store only the desired number of pulses from each radar signal, and
- Remove redundant pulses.

The ALR-91(V) Series threat warning systems detect, analyze and identify all known types of tactical threat radars in less than two seconds. The systems have been successfully tested against the full range of standard and modern radar types.

ALR-93(V) Series Threat Warning and ESM System

The ALR-93(V) Threat Warning and ESM System is a lightweight, high-sensitivity, C through J band system, designed to operate in dense, complex emitter environments with a high probability of intercept capability. Its unique architecture, combined with advanced technology and sophisticated packaging concepts, resulted in a high-performance, small footprint system which weighs less than 55 pounds, and meets the critical requirements needed for today's fighter aircraft.

The principle technology breakthrough provided by the ALR-93(V) Series Threat Warning and ESM systems is continuous collection and analysis of radar signals in complex environments.

The ALR-93(V) is an effective asset to use against these modern threats including:

- Lethal radars that operate in CW, wide pulse widths and/or high duty cycle (Pulse Doppler);
- Lethal scanning radars (track-while-scan);
- High duty cycle emitters capable of masking the detection of other radars; and
- Simultaneous agility in PRI and RF parameters.

The ALR-93(V)'s unique receiver configuration contributes to its effective operation. Baseband receivers and a wide acquisition bandwidth Instantaneous Frequency Measurement (IFM) receiver cover the entire frequency spectrum in continuous bands while maintaining a high probability of intercept. This capability minimizes the time required to cover the entire RF spectrum and provides pulse-to-pulse frequency measurement of even the most frequency agile radars. The IFM provides the key discriminator to the emitter analysis process, and significantly contributes to its ability to operate in high density environments.

The ALR-93 incorporates a superhet receiver for high sensitivity and high selectivity with narrowband frequency search modes. The SHR scanning capability further contributes to the elimination of ambiguities by resolving and/or looking around multiple high duty cycle Pulse Doppler and CW emissions radiating at closely spaced frequencies and bearings.

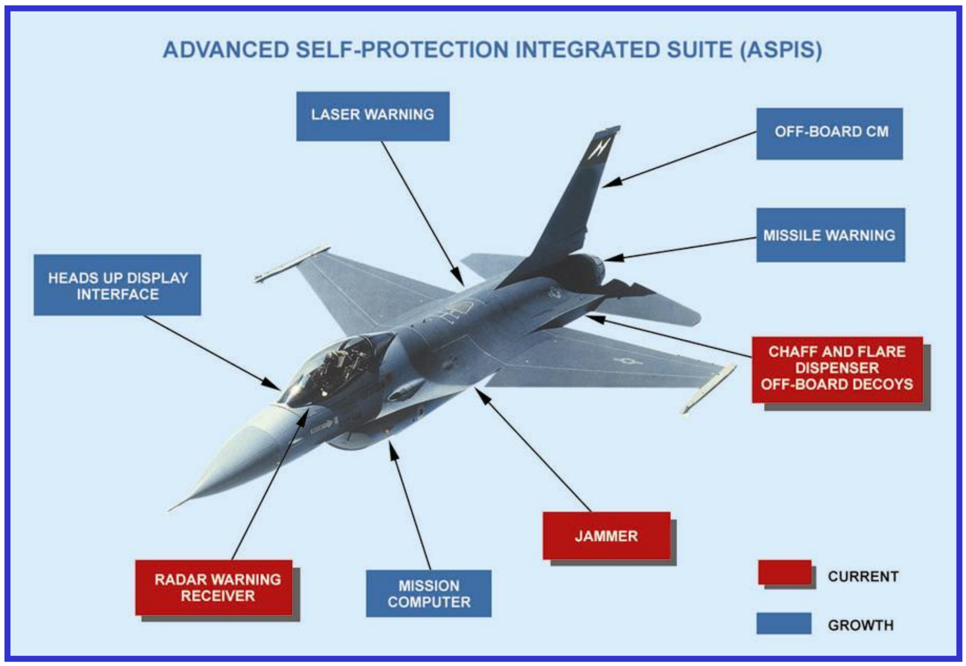
The ALR-93(V) Series contains hardware and software tools which function automatically and without degradation in high density environments, and addresses the problem of high duty cycle signal corruption and the acquisition of pulsed emissions in the presence of these signals. This includes environment filtering at RF and video, narrowband SHR search and preprocessing.

Advanced Self-Protection Integrated Suite (ASPIS)

One of the ways Litton Applied Technology is improving situational awareness capabilities for tactical aircraft is through an Advanced Self-Protection Integrated Suite or ASPIS. Strategically aligned, Litton Applied Technology, Raytheon's Electromagnetic Systems Division and Tracor Aerospace have integrated what is clearly the survivability system for the 21st century.

The ASPIS consists of threat warning/ESM systems, provided by Litton, electronic countermeasures systems (jammers) provided by Raytheon, and chaff and flare countermeasures dispenser systems provided by Tracor.

The customer is able to purchase a system tailored to his unique needs using off-the-shelf and proven electronic warfare systems which have been pre-integrated and demonstrated. The diversity of this unrivaled approach allows ASPIS to be installed



as an original system or as an upgrade to existing systems. Phased upgrades of capabilities are available to meet the user's schedule and budget.

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Defensive Systems Division