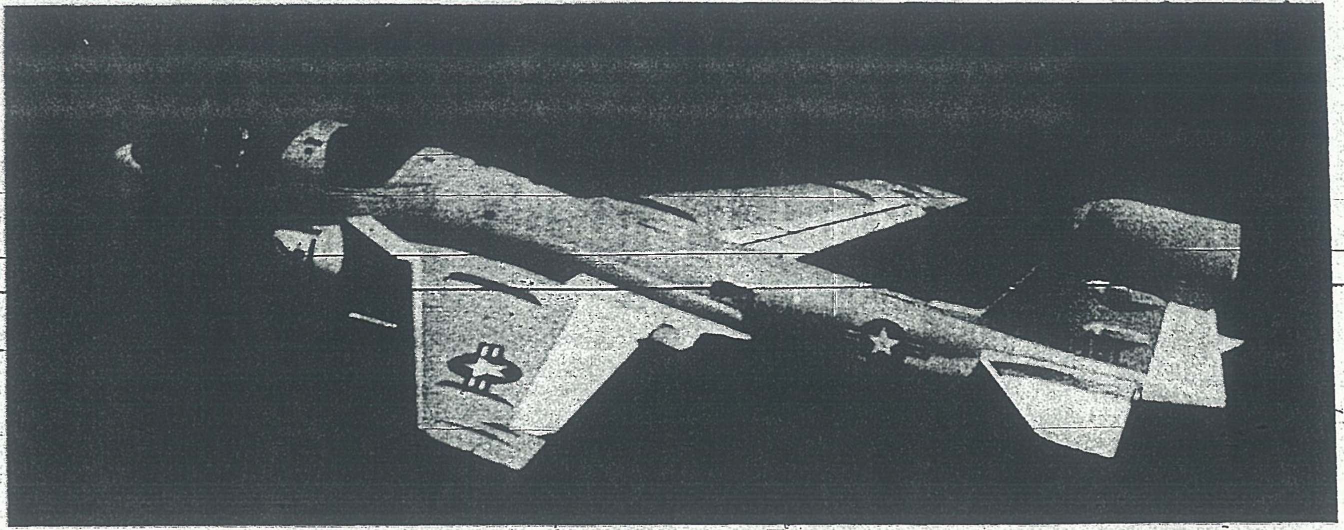


Large bubble dome fairing on vertical stabilizer of Navy/Grumman EA-6B contains receivers and six antennas for ALQ-99 tactical jamming system. Fairings visible on vertical stabilizer below the large dome contain low frequency band ECM receiving antennas. Antenna for ALQ-100 deception ECM system is visible protruding from left outboard pylon.

ECM designers got their wish for choice aircraft location by having the passive detection system antenna housed in the E-2C's elongated nose, with the aircraft's radar housed in a rotating dome above the fuselage. The E-2C has no self-defense ECM because it will not operate in a terminal area.

Amecom's system is believed to use the company's binary beam broad band direction measuring concept that offers high direction-finding accuracy with the electrical equivalent of a binary-coded shaft angle encoder.

■ **EP-3E Collection**—Seven Lockheed P-3A and two P-3B ASW patrol aircraft are being modified by Lockheed Aircraft into electronic surveillance vehicles, replacing Navy/Lockheed EC-121M surveillance aircraft, for world-wide shadowing of the Soviet fleet and signal intelligence (sigint) collection. The aircraft's engines are replaced by Allison T-56-A-14 turbo props used in the P-3C, its wings beefed up, its fuselage modified and a new landing gear installed. Gross takeoff weight is increased to 142,000 lb. from 127,500 lb. A tail cone antenna replaces its characteristic magnetic anomaly detector boom. Main external features are a retractable elliptical radome containing a high-power radar transmitting through a 17- by 4-ft. orange-peel parabolic antenna. Its upper and lower canoes, fitted to the fuselage, contain receiving antennas. A high-frequency (HF) dog-leg antenna stretches from the forward fuselage to the vertical stabilizer, thereby achieving good isolation. Inside, the crew station remains untouched with places for the crew of pilot, copilot, flight engineer, radio operator and navigator. There is a mission crew of 15 men for operating consoles, monitoring and recording signal intercepts, plus capacity for a relief crew of another 15 men, an increase of 13 men over full P-3A load.

■ **TASES**—Navy is expected to start a long-anticipated competition this month for its tactical airborne signal exploitation system (TASES) to supplant carrier-borne McDonnell Douglas EA-3B and land-based Lockheed EC-121M or its interim EP-3E replacement. The TASES system will perform highly accurate, long-range elint missions, supplying precision direction finding, automatic signal sorting and precision pulse repetition and frequency identification. Advanced signal acquisition and direction finding techniques developed in Navy's Big Look Improvement program, which employs a United Technology Laboratory elint receiving system and a Sperry Rand Univac computer in a Lockheed EC-121, may be applied to TASES. Aircraft competitors for the TASES role are likely to include the Lockheed S-3A and Grumman E-2, or its proposed counterpart to the S-3A, the VCX.

Army belatedly is getting started in ECM both for aircraft self-protection and such other functions as detection by aircraft of AAA acquisition radars for artillery direction. The Mohawk OV-1D surveillance aircraft carries the older Hallicrafters ALQ-80 radar jamming pod and the GTE Sylvania ALQ-67 fuze jammer on its outer wing stations. Antennas characteristic of the Itek APR-25 radar warning receivers are visible on the aircraft's wing tips and tail, presumably for SA-2 missile warning.

Two Quick Look 1 aircraft, Mohawk OV-1C carrying 800 lb. of United Technology APQ-142 elint receiving system, including two long pods on outboard wing stations and 10-ft. long wing antennas, are in Europe. Like the OV-1 side-looking radar missions, the Quick Look activity involves flights by the OV-1 along the western edges of Warsaw Pact borders, keeping tabs on radar activity. The elint system probably monitors from the UHF region up to J-band. It can detect Soviet Squat Eye AAA acquisition radars at ranges of perhaps 25 mi. with modest accuracy using direction-of-arrival techniques. Army now is considering a Quick Look 2 program to use a lighter weight elint receiving system and to sharpen accuracy of emitting target location. Quick Look 2 would use the later Mohawk OV-1D, taking advantage of the improved accuracy its Litton ASN-86 inertial navigator gives the aircraft. In Quick Look, collected data can be processed in the air or relayed via real-time wideband data link to the ground, in a manner analogous to the sequence on side-looking radar missions. The mission concepts are also analogous; side-looking radar missions locate tanks; Quick Look identifies AAA radars protecting or acquiring targets for tanks and AAA self-propelled weapons carriers.

Failure of the Army to implement this kind of activity sooner and more vigorously may be attributable in part to a conflict in mission between the regular Army and the Army Security Agency which traditionally had responsibility for strategic sigint missions. With the growth of tactical radar threats facing Army helicopters and ground troops, Army commands need elint data quickly as well as ECM protection for aircraft, but lack depth of electronic warfare experience and channels for rapid acquisition of hostile emitter data.

In Vietnam, Army helicopters relied on warning and evasive maneuvers to escape radar-directed weapons, but in a European environment that may not be sufficient. Helicopters may need jammers to crowd into the narrow beam tracking radars to jam them. Also, Squat Eyes and other acquisition sensors will have to be detected, located, jammed or destroyed if they are to be prevented from providing acquisition data to the highly lethal Soviet Gun Dish-directed, quadruple 23-mm. AAA guns employed by Warsaw Pact armies. The Army Security Agency Beech RU-21s serve well for signal collections and for communications jamming, but they may not be the appropriate choice for tactical radar jamming.

Techniques are under investigation for denying an enemy valid fuze information for radar directed weapons, as a final terminal electronic countermeasure. GTE Sylvania has flight tested at Eglin AFB an SA-2 Guideline fuze jammer, the QRC-400, for which USAF sought $2.8 million to build 45 units this year. Since Guideline uses a pair of CW F-band transmitters which radiate conical patterns the distance of the missile's lethal range, the Sylvania jammer presumably senses these signals beyond their proximity range and generates false returns for prematurely causing warhead ignition. ITL Research, Northridge, Calif., has developed a 30-lb., 0.5-cu. ft. fuze jammer with CW capability that is adaptive. It accepts the received signal and spreads it with Gaussian noise in the designed bandwidth.

U. S. research and development is probing countermeasures against the entire gamut of SAM sensors and aids, ranging from early warning and acquisition radars, through tracking radars, where much previous work was done, guidance links and fuzes. In the future, as expense permits, ECM may be employed in parallel against multiple sensing devices a defense employs, rather than concentrating so heavily on tracking radars.

General Electric, GTE Sylvania and Westinghouse are investigating techniques for deceiving Soviet airborne warning and control (SUAWACS) radar for the Air Force. Westinghouse also is exploring countermeasures against terminal threats under USAF contract.

The services are apt to step up emphasis on the ultimate countermeasure—actual radar destruction, as density of Soviet radars continues to ascend. This accounts for accelerated work on anti-radiation seekers for missiles and unpowered ordnance and their adaptation to anti-air, as well as air-to-ground roles. SUAWACS and Foxbat MiG-23's Jay Bird radar are initial airborne targets.

Efficient Use

To make more efficient use of limited aircraft jamming power, USAF is preparing to test "power management" concepts employing a digital analyzer or processor to analyze threats detected by a receiver and direct appropriate jamming response. This is a move toward the truly adaptive ECM system. Companies at work on analyzers or their applications include Bunker-Ramo, Dalmo-Victor, Loral and Philco-Ford.

In one power management activity USAF has parallel efforts to evaluate power management techniques with a Westinghouse QRC-335 jammer. In QRC-527-1, Loral will use a modified QRC-449 receiver to locate a threat. It will program into a field programmable core-memory computer the best techniques for use against given radars at certain conditions or whether jamming will be necessary. The jammer will be instructed on the appropriate modulation technique, the receiver and processor will assess the effects of jamming and determine what further action, if any, is necessary.

In QRC-527-2, Dalmo-Victor will marry a small, company-developed, moderate speed semiconductor memory processor with its APS-109 receiving system, built for the General Dynamics F-111. As in the Loral case, the analyzer will examine threats and set the jammer for the correct response. Air Force will evaluate the two efforts in its electronic environment simulator at Wright-Patterson AFB and in the General Dynamics electronic warfare environmental simulator at Ft. Worth, then pick one for flight evaluation.

Long-Range Implications

Dalmo-Victor also is working under tri-service QRC-7206 to analyze the applicability of the processor to all radar homing and warning systems in military inventory. The long-range implications for power management concepts, as well as completely-computer controlled systems could undermine the prominent place the electronic warfare operator has traditionally held, particularly as signal environments become more dense and the time to respond shrinks.

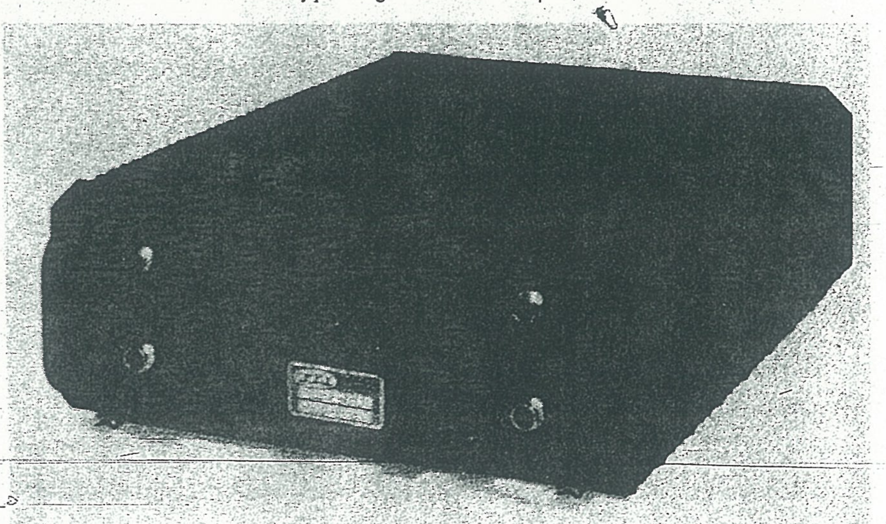
The power management concept could find application in USAF's latest tactical pod ECM set, the QRC-559, now in competition among Hughes Aircraft, Westinghouse, General Electric, Raytheon and Sanders Associates. In this instance, the processor would be housed in the pod, using warning receivers already installed on the aircraft, but bypassing the aircraft's onboard analog threat processing. For aircraft not now equipped with radar homing and warning systems, the receiving antennas, receivers and analyzer might be pod housed, even at a sacrifice in some threat coverage due to shadowing from the airframe.

As new threats were uncovered, the services found and are likely to continue to find the pod system the most convenient way of countering them without extensive aircraft modification. The more threat insensitive new systems may lessen the pod role somewhat, but where known threats are anticipated, extra dedicated pods are expected to continue to fill an important gap.

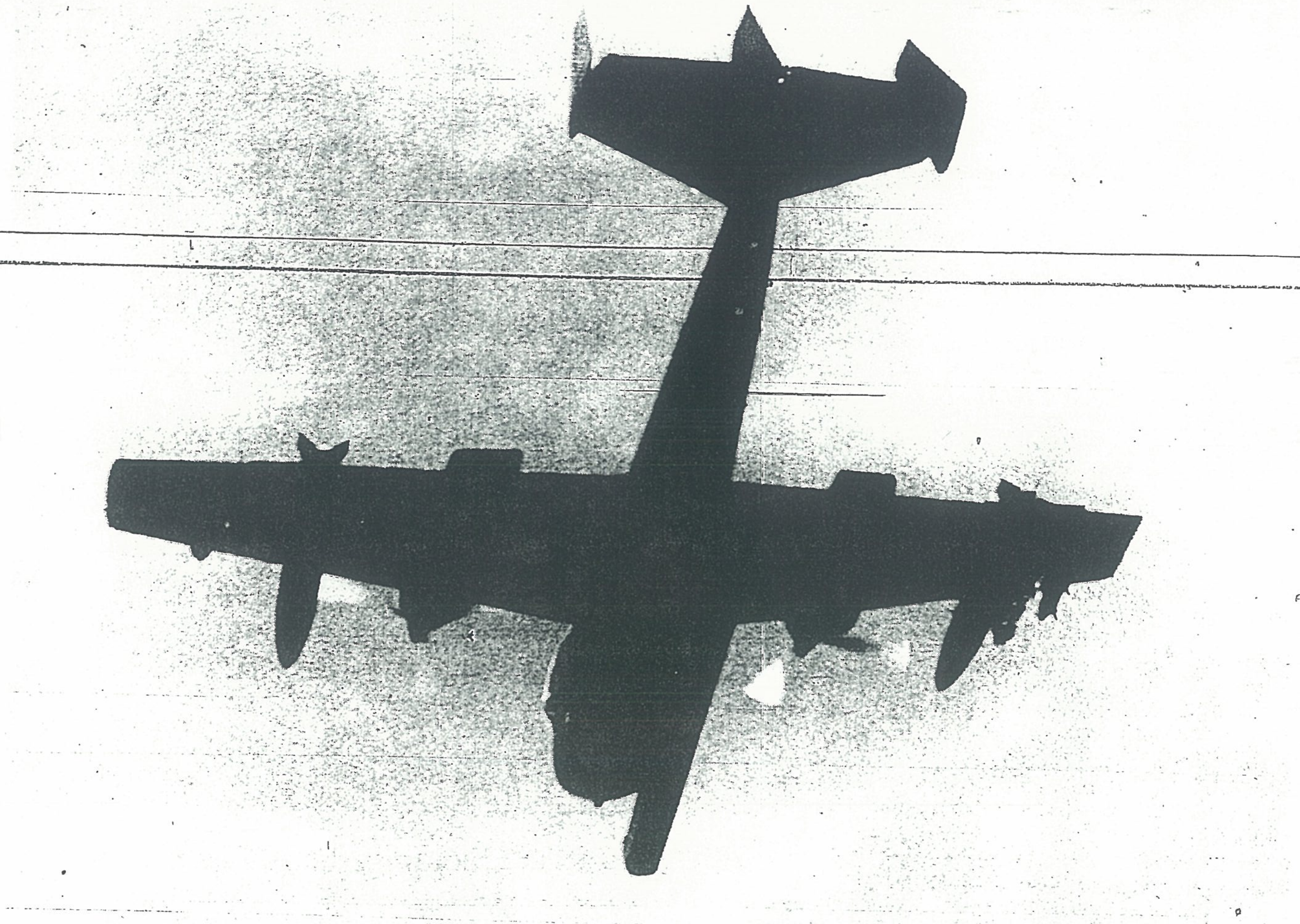
Air Force expects the quick reaction programs to remain with ECM for the indefinite future, as long as threats change or react to ECM. For tactical aircraft, this invests the pod with special prominence. How much shifting occurs is evident with USAF's main jamming pod system, the Westinghouse QRC-335 series.

The original QRC-335A contained a single, aft-facing S/C straddle band jammer. It was followed by the QRC-335-3 with fore and aft straddle band jammers, followed by the dash four version, which Air Force says added an X-band jammer. Newer versions include the QRC-335 dash 6, dash 8 and now dash 10. The QRC-335-8 upgrades the series so it is equivalent to the QRC-522 jamming system Westinghouse is now producing under contracts in excess of $50 million. The QRC-522 covers three "bands" and has a single driver with dual outputs in one or two bands to provide a modest dual mode, noise and deception output.

Newer jamming systems are no longer noise or deception varieties, but combine elements of both by having noise plus repeater chains. Modulated noise introduces what is called "smart" noise and modulated noise appropriately narrowed in frequency is sometimes referred to as "smart-smart noise."



Adaptive fuze jammer developed by ITL Research for the Air Force weighs 30 lb., occupies 0.5 cu. ft. of space. It accepts the received signal and spreads it with Gaussian noise.



Grumman OV-1D Mohawk, one of the few Army aircraft currently equipped with self-protective ECM countermeasures, has GTE Sylvania ALQ-67 fuze jammer (A) and Hallicrafters radar noise jammer (B), both directed against Soviet SA-2 surface-to-air missiles. The aircraft also has an Itek APR-25 radar warning system, with antennas on tail (C) and wing tips. Other visible equipment includes cigar-shaped Motorola side-looking radar and a photoflash pod near the radar jammer for use with belly-mounted pan camera.

originally planned as a joint single pod Sanders-EOS microwave/infrared countermeasures system.

■ Field tests by the Army of Avco Systems Div.'s ALQ-107 active infrared countermeasures set, designed for helicopter protection. All of the ALQ-107's electronics are housed within the helicopter, while the modulated cesium infrared source is in a fairing beneath the vehicle. An earlier pod-mounted Avco system, the ALQ-104, was evaluated by the Army and is being tested by the Navy and Air Force. It is intended for the Grumman OV-1, McDonnell Douglas F-4 and LTV Aerospace A-7.

While infrared countermeasures systems have progressed to the prototype hardware stage, visual countermeasures (V-CM) appear to be several years behind. A V-CM demonstration pod believed to contain a flashing Xenon arc lamp for protecting an aircraft, might briefly blind or deceive gunners peering at the vehicle when operated at certain known rates, thereby degrading accuracy of visually-aimed weapons. The pod was developed by Electro-Optical Systems for the Air Force which is conducting its V-CM optical countermeasures effort in the Compass Ghost program. Managed from Wright-Patterson AFB, Compass Ghost embraces the entire gamut of optical countermeasures phenomena, simulation and hardware verification. Other organizations believed to be working in V-CM include Chicago Aerial, Systems Research, Avco, and Holobeam, Inc. The latter, specializing in infrared and visual light sources such as pulsed alkali vapor lamps, has had two Air Force efforts for protecting aircraft from infrared seeking missiles and optically-aided tracking devices. Hughes Aircraft also is under contract for IRCM to the Air Force. Brassboard developments of a high intensity, pulsed V-CM set are expected from USAF's Avionics Laboratory, with Avco, Electro-Optical and Holobeam as possible competitive participants.

Navy has a nascent effort in infrared countermeasures for protecting its ships against cruise missiles which employ infrared seekers as one means of guidance. These range from firing infrared decoys to changing the infrared signature of a ship under attack by drenching it with salt water from the wash system originally intended to cleanse the vessels of nuclear debris. Virginia Research Inc. is doing conceptual work on airborne infrared electronic warfare systems.

Air Force is exploring a widening spectrum of countermeasures techniques against visual and infrared threats. It is looking into countermeasures against:

■ Laser fuzes which USAF deployed in the Hughes AIM-4H infrared-guided air-to-air missiles to enhance combat effectiveness during severe maneuvers. These early fuzes employ gallium arsenide proximity devices.

■ Next generation of infrared missiles.

■ Multi-color or multiple-line infrared seekers.

To counter anticipated Soviet deployment of laser-aided weapons, Air Force and Army are investigating countermeasures against laser designation weapon systems, as well as counter-countermeasures. GTE Sylvania is in the

Army Electronic Warfare Activities

Activity	Nature	Contractors	Status	Vehicle	Comments
Quick Look 1	Border surveillance of radar-directed AAA by Elint	United Technology Laboratory, HRB Singer	Test Demonstration	OV-1C	Deployed in Europe
Quick Look 2	Improved accuracy Quick Look 1	HRB Singer	Study	OV-1D	
Quick Fix	Communications intelligence collection	United Technology Laboratory	Test	Helicopter	
Cefirm Leader	Direction finding and communications jamming	McDonnell Douglas Electronics Co.	Test	RU-21	
Cefirm Scavenger	Communications code breaking		Study	RU-21	
AGTELIS	Emitter location and direction finding	Bunker-Ramo	Design		Automatic ground transportable emitter location and direction finding

midst of a year-long theoretical study for the Army of the vulnerability to ECM of its laser target designation system. The company is doing a similar study for laser rangefinders.

Martin Marietta is studying for USAF techniques for detecting and warning of laser ranging. Elsewhere, a technique for detecting narrow laser beams without actually having a sensor directly intercept the main beam has been demonstrated. USAF's laser countermeasures interest spans the finite laser optical spectrum, covering visual beams, such as red ruby laser rangefinders, to the infrared 1.06 micron neodymium (designators/rangefinders) and 10.6 carbon dioxide. Lasers may be susceptible to detection at appreciable ranges by passive microwave techniques because of impulses emitted by their pumping devices.

There is belief that more effective infrared countermeasures against passive seekers may await substitution of coherent laser sources for incoherent lamps, until now a primary active source in infrared countermeasures systems. The higher output energy and greater energy density, if properly aimed, might saturate or burn out optical sensors. TRW Systems hopes to probe into countermeasures against infrared seekers. It plans to run tests for the Navy to determine susceptibility of electro-optical devices to techniques using laser sources, possibly high-power chemical lasers which it has begun to develop separately. The chemically-pumped hydrogen fluoride laser radiates light at 2.3 to 3 microns, the region of peak response for certain widely used infrared detectors, like lead sulfide.

Countering first-generation laser designators and rangefinders may not be too difficult. An enemy's choice of operating frequency, or wavelength, is far more constrained than it is in the RF range. If a defense knows it is within acquisition range and field of view of a warhead with a known laser acquisition device, it could direct higher powered laser light against a harmless target to decoy the warhead's seeker. The first counter-countermeasure to this technique, which USAF is exploring (AW&ST May 3, 1971, p. 48) with its Pave Penny program, is to synchronize the seeker with a timed pulse, perhaps a coded pulse train. If the seeker misses the code, it might be programed to continue flight on the same course. Army also plans to code its standard laser rangefinder/designator slated for armed helicopters.

Rangefinders might be especially vulnerable to repeater deception. If an airborne rangefinder uses a last pulse return logic, to preclude false target indications from cloud returns, the deception repeater could transmit late pulses. Because range is determined simply from the two-way pulse transit time, the laser rangefinder would report greater than actual distance.

If the laser system transmits repetitive pulses, ranging, for instance, on the fifth pulse, and designating targets on all pulses, it may be possible to determine the rhythm of an enemy's system and set a transponder to anticipate the ranging pulse. In this manner, a transponder could transmit a deceptive range pulse back toward the enemy's laser rangefinder/designator, deceiving the laser device into reporting a short, false range, delaying weapon release if there are short range limits. If the enemy is at long range and gets a short range indication, he might fire prematurely his seeking weapon outside the actual weapon range.

To protect itself against laser directed weapons, a target probably would have to be covered with wide field of view sensors, akin to RF warning antennas appearing in staggering numbers on tactical/strategic aircraft. Its transponder could be a wide angle receiver with a 2π steradian beam.

For simple, usually more difficult to deceive systems, concentrating large amounts of optical energy to burn out an enemy's imaging devices or temporarily overloading his preamplifiers might be the appropriate recourse. The more sophisticated and complex systems, with extensive automatic features, would be more subject to deception.

Carbon dioxide laser thermal weapons in which the beam itself is a weapon, not simply a target pointing mechanism or measuring tool, pose a different magnitude of problem. As protection against radiation weapons, an obvious but paradoxical stratagem is use of highly reflecting surfaces on a target. Yet in a military environment it is difficult to avoid corrosion of reflecting surfaces from dust and sand on a tank, for example, or pollutants, dust, gravel, etc., on an aircraft surface.

Furthermore, a well-protected, poor radiation weapon target would be a good radar target and vice versa. For instance, an aircraft with shining metal surface would be an excellent conductor, hence have a high radar signature, a characteristic ECM planners have long sought to