LEVEL II

1

ADVANCED IR IMAGING SEEKER PROGRAM

11 20 May 1980

by

10 R. A. Aguilera

12 8

Presented to

AIAA Strategic/Tactical Systems and Space Sciences Meeting

8-10 September 1980

San Diego, California

15 DAAK40-77-C-0129
V DARPA Order-3239

ROCKWELL INTERNATIONAL

Advanced IR Imaging Seeker Program

R. A. Aguilera

Rockwell International
Anaheim, California

Abstract

Rockwell has developed under a U.S. Army contract an advanced IR Imaging Seeker System which is compatible with the Hellfire Missile System mission. A technical overview of this program and current status will be presented. The IR imaging seeker was tested during late 1979 and early 1980. This seeker utilizes a Rockwell-developed 1024-element InAsSb/silicon hybrid focal plane array (FPA) operating at 77°K and IR sensitive in the 3.4-4.0 micrometer wavelength region. A multimode tracker provides improved tracking capability for operation against targets in a high clutter background.

The payoff for the technology being developed on this program is the ultimate realization of reduced IR seeker cost at equivalent or increased performance to present-day IR Imaging seeker designs.

Technical Discussion

This paper will report upon the final results of government Contract DAAK40-77-C-0129, which was funded by the Defense Advanced Research Projects Agency under DARPA Order 3739. The contracting agency was MICOM, and the program was monitored by both MICOM and the Night Vision and Electro-Optics Laboratory.

The objective of this program, as ennumerated in Figure 1, was to evolve a fire-and-forget IR imaging guidance approach with multi-functional application, exhibiting performance significantly better than 1st-generation approaches, and meeting low-life-cycle-cost objectives that make it affordable to the government. The Advanced IR Imaging Seeker is multi-functional because it is adaptable to both a lock-on before launch and a lock-on after launch scenario. It will have high performance because (1) it will ultimately use > 1000 detectors providing high resolution and sensitivity, (2) it will ultimately be capable of 2-color operation, and (3) it utilizes an advanced microprocessor-based multimode tracker. It will be low cost because of the simple design afforded by the solid-state FPA, because of the microprocessor-based signal processing, and because of its modular design.

This contract was awarded in June of 1977, and completed in February 1980. Major outputs of the program were:

(1) Seeker hardware ready for captive flight test, utilizing a 32x32 hybrid focal plane array and a microprocessor-based multimode tracker.
(2) A 64x64 hybrid focal plane array design.
(3) Seeker configuration studies addressing the ultimate packaging of the hardware in an operational configuration.

A functional block diagram of the seeker is shown in Figure 2. IR energy enters the seeker through a dome and is focused upon the hybrid focal plane array (FPA) via a 2-element cassegrain optical system. The FPA consists of a sandwich of InAsSb detectors with a silicon CCD multiplexer. The output of the 32 x 32 FPA proceeds to an analog and digital signal processor which performs the function of dc non-uniformity (background suppression) and ac non-uniformity (automatic responsivity control) response compensation. Corrected video then proceeds to (1) a scan converter for presentation on a 525-line TV display during captive flight tests, and (2) a microprocessor-based multimode tracker.

The seeker hardware developed under this program has been configured to be compatible with the air-to-ground anti-armor scenario of the Hellfire Modular Missile System (Figure 3). Target acquisition takes place using a high-performance FLIR aboard the AAH. A boresight correlator provides for automatic handoff of the target to the IR Imaging Seeker. Once the missile is launched, the seeker continues to track the target via the imaging FPA and the multimode tracking algorithms. For terminal homing, the multimode tracker allows reliable target centroid tracking via internal target gradients operated upon by a correlation tracking algorithm.

The multimode microprocessor-based tracker has been configured to allow via software modification, an autonomous lock-on capability, as shown in Figure 4. This capability would allow the launch platform (the AAH for the Hellfire System) considerably improved survivability since exposure to air defenses would be minimized. Thus, missile launch would take place while the platform was masked from air defenses by terrain or trees. The missile would fly a pop-up trajectory, immediately initiating a pre-programmed search sequence. Potential targets would be prioritized via target classification algorithms, and final lock-on would take place via pre-programmed logic. Terminal guidance would utilize the multimode tracking algorithms developed for the lock-on before launch scenario.

The seeker system is configured as shown in Figure 5. The sensor head contains the FPA, optics, gimbal, and signal processing electronics which must be in close proximity to the FPA. Cables interconnect the sensor head to an equipment rack containing the seeker control electronics, the seeker electronics unit, the multimode tracker, and the character generator (for TV display). A 9825 computer in conjunction with a temperature reference source is used in the calibration sequence required to remove the ac and dc non-uniformities inherent in the FPA.

Figure 6 summarizes the overall characteristics for the Advanced IR Imaging Seeker. As mentioned in a previous chart, the seeker has been designed to be compatible with the Hellfire air-to-ground mission, and thus many of the characteristics are derived from those mission requirements.

Figure 7 is a photograph of a 32x32 InAsSb/Silicon Hybrid FPA of the same design as that incorporated into the AI^{2}S hardware.

The 32x32 FPA has been packaged in a glass dewar for integration into the AI^{2}S sensor. Figure 8 is a photograph of an early unit which has been used for preliminary tests.

Figure 9 shows the sensor platform before integration with the seeker gimbal. Visible are the optics, gyros, and dewar/cryostat assembly.

The AI^{2}S is being configured in a modular fashion as depicted in Figure 10, to permit improved performance as technology advances permit. Technology improvements will allow (1) larger focal plane arrays of up to 128x128 to be addressed, (2) a lock-on-after launch capability to be incorporated, (3) thermo-electric cooling to be substituted for cryostat cooling, and (4) a two-color focal plane capability to be incorporated all within the next several years.

In summary, an Advanced IR Imaging Seeker is being developed which will simultaneously exhibit high performance and low cost, and will initially address a lock-on-before launch scenario, with growth to lock-on-after launch capability also being addressed. This AI^{2}S concept will have widespread application to all DoD IR guidance applications, including IRIS for Hellfire, Dragon replacements, Advanced Harpoon, etc. The AI^{2}S guidance concept has been validated during tests conducted in late 1979 and early 1980. Technology to address a 64x64 FPA is on-going and will be demonstrated in mid-1980.

- **MULTIFUNCTIONAL EVOLUTION**
  - DIRECT FIRE (DEMO CY 79)
    - LOCK-ON BEFORE LAUNCH
    - FIRE AND FORGET
  - INDIRECT FIRE (DEMO CY 80)
    - LOCK-ON AFTER LAUNCH
    - FIRE AND FORGET
- **HIGH PERFORMANCE**
  - >10,000 DETECTORS
  - 2-COLOR
    - 3 TO 5 μM
    - 8 TO 12 μM
  - RESOLUTION
    - MISSION DEPENDENT
  - HIGH SENSITIVITY
    - ACQUISITION RANGE
  - MULTIMODE TRACKER
- **LOW COST**
  - SOLID-STATE FOCAL PLANE
  - μPROCESSOR BASED SIGNAL PROCESSING
  - MODULAR DESIGN

Figure 1. Advanced IR imaging seeker development objectives.

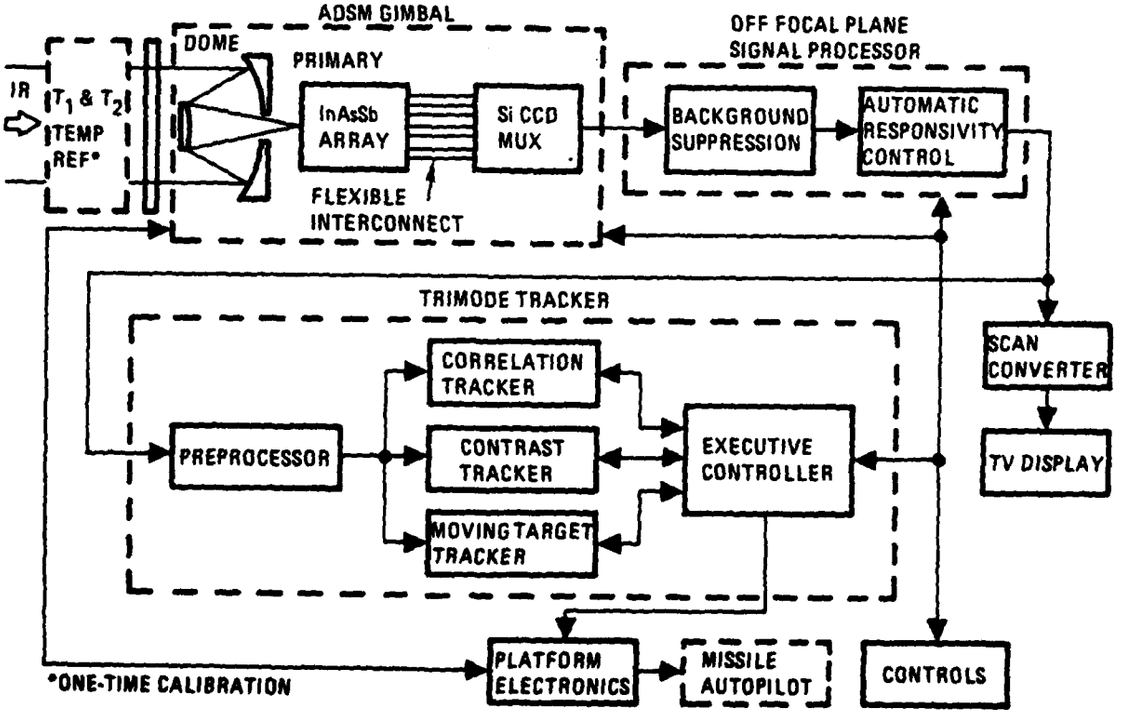

Figure 2. Advanced IR imaging seeker functional diagram.

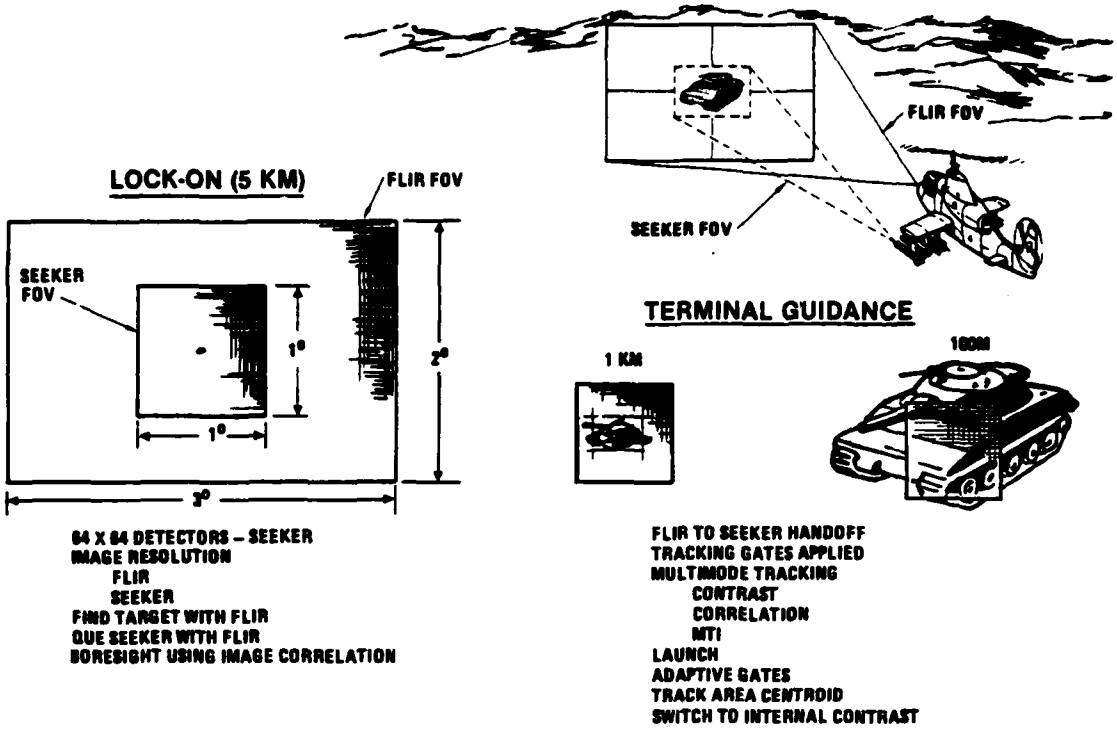

Figure 3. Imaging IR lock-on before launch.

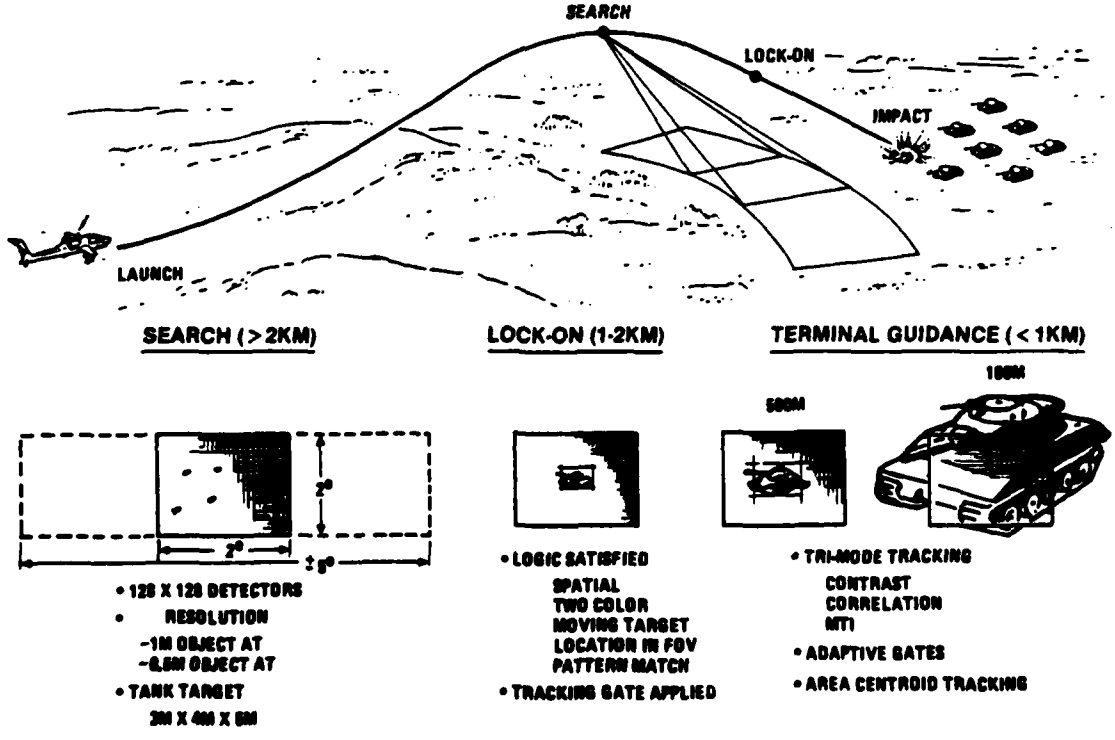

Figure 4. Imaging IR lock-on after launch.

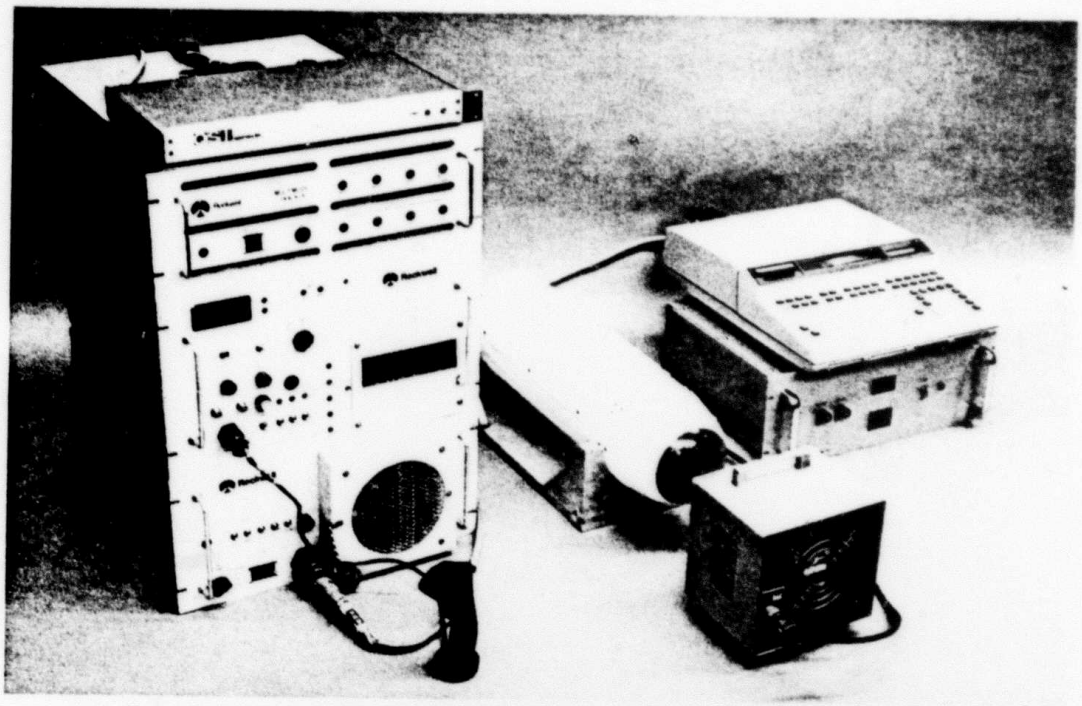

Figure 5. AI^{2}s major assemblies.

PARAMETER	VALUE
SEEKER DIAMETER	7 INCHES
TYPE GIMBAL/STABILIZATION	EL-AZ RATE GYRO STABILIZED (ADSM)
GIMBAL ANGLES	± 20 DEG (EL-AZ)
OPTICAL APERTURE	3.5 IN.
TOTAL FOV	
NO. DETECTORS	1024 (32 X 32)
DETECTOR IFOV	
SENSITIVITY	
TRACKER TYPE	MULTIMODE • CONTRAST • CORRELATION • MOVING TARGET
TRACKING RATE	10 DEG/SEC MAX
INTERFACE	
• POWER	+ 28 VDC
• CYROGEN	J-T CRYOSTAT WITH HIGH PRESSURE N_2

Figure 6. AI^{2}s characteristics.

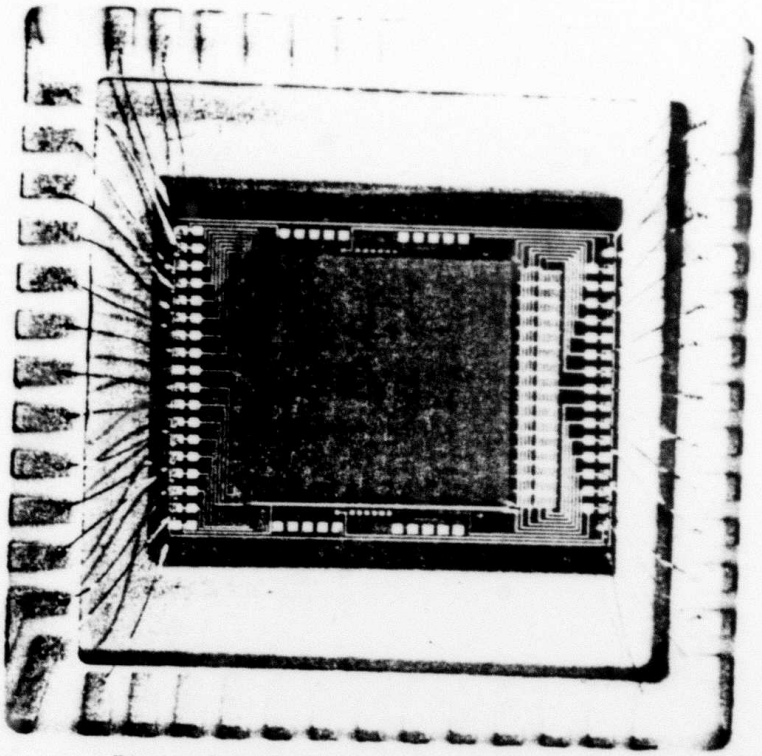

Figure 7. 32 x 32 InAsSb hybrid array.

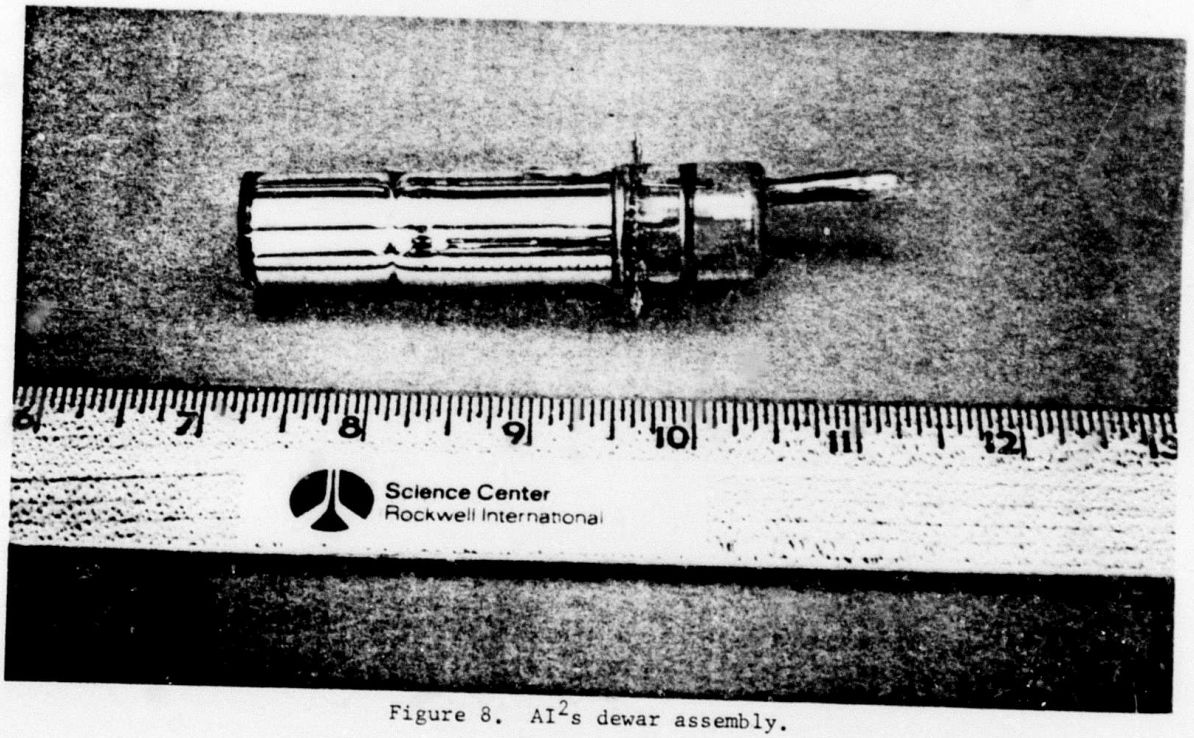

Figure 8. AI^{2}s dewar assembly.

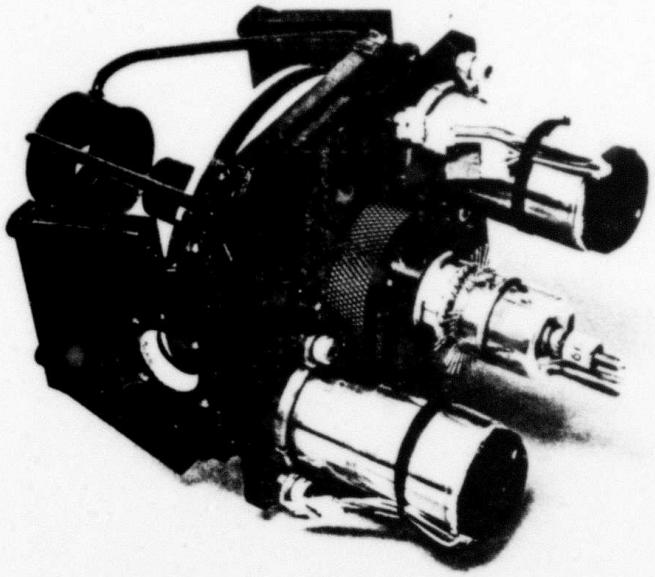

Figure 9. AI^{2}s platform.

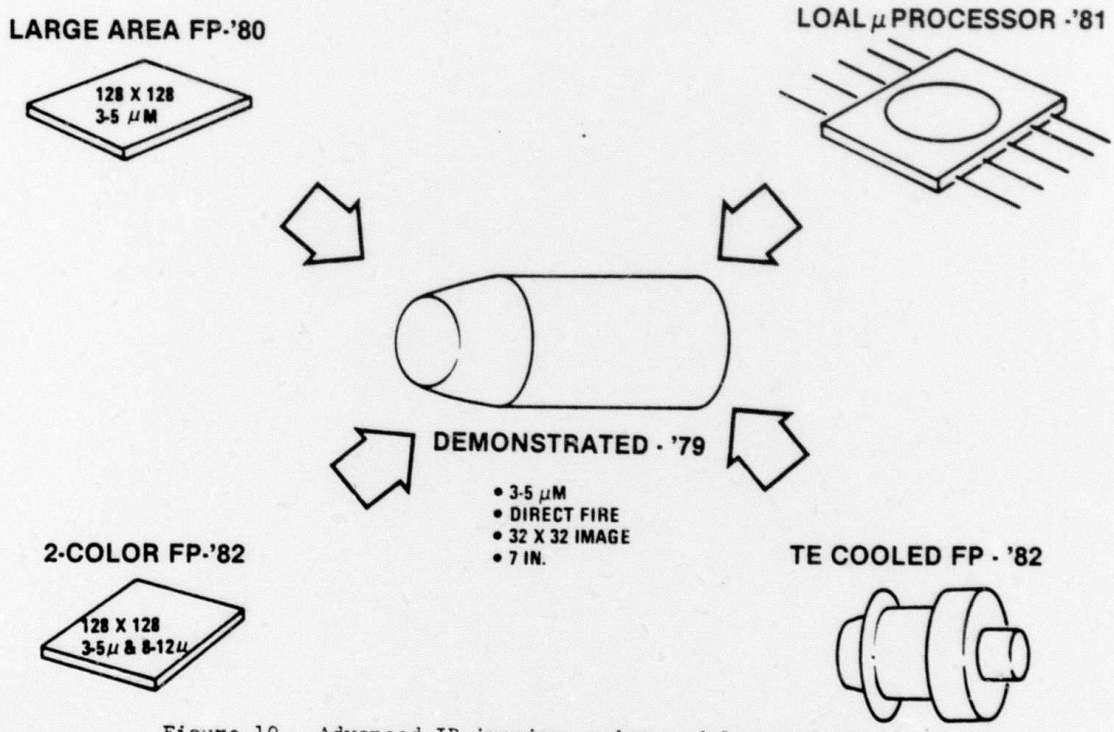

Figure 10. Advanced IR imaging seeker modular evolution