DATE: 31 January 1979

TO: Dr. Joseph H. Yang, Executive Director, Army Science Board

FROM: ASB Ad Hoc Committee on Precision Guided Munitions Technology

SUBJECT: Report of Findings

REFERENCES: Letters from P. W. Kruse to J. H. Yang, dated 27 November 1978 and 20 December 1978

BACKGROUND:

The ASB Ad Hoc Committee on Precision Guided Munitions Technology was organized at your request on 13 November 1978 to address technology, schedule, and cost issues regarding Assault Breaker terminal homing payloads (TGSM), Fire and Forget infrared guidance for HELLFIRE, and technology transfer issues regarding STINGER POST. This report of the Ad Hoc Committee is concerned with Assault Breaker payloads and Fire and Forget guidance for HELLFIRE. STINGER POST is addressed separately.

Members of the Ad Hoc Committee included Paul W. Kruse, Chairman, David L. Fried, Richard Honey, Khalil Seyrafi, and Joseph Sternberg. Dr. Seyrafi was unable to continue with the Ad Hoc Committee. Although Dr. Honey was absent when this report was prepared, it does reflect the views he had previously communicated to us.

The Ad Hoc Committee met three times. At our first meeting on 12 and 13 December 1978 in the Washington area we reviewed our understanding of the problem with you. We received a briefing from Dr. James Tegnelia of DARPA on Assault Breaker including the system concept and payload technology, and on staring sensor focal plane array technology for Fire and Forget. We were briefed by Mr. Joseph Martino, Mr. Edward Hutcheson, and Mr. John Daniels of NVEOL on staring focal plane array technology for Fire and Forget. At our second meeting at MIRADCOM on 10 and 11 January 1979 we were briefed by Dr. Donald McDaniel, Mr. Dale Holter, and others on Assault Breaker payloads and HELLFIRE infrared seeker technology including IRIS, scanning matrix array, and staring focal plane array technology. At our third meeting, in the Pentagon, 29-31 January 1979, Mr. Dale Holter of MIRADCOM replied to some questions we had posed concerning TGSM during our 10-11 January 1979 visit to MIRADCOM. Our 31 January 1979 briefing to you presents our findings.

Listed below are our findings regarding Assault Breaker TGSM technology and IR seeker technology for HELLFIRE. They are organized so as to address the specific issues which you raised, namely:

- o Is the program technically sound?
- o Is the IOC estimate realistic?
- o Is the cost estimate realistic?
- o Are there other technical approaches which would provide higher performance, earlier IOC, or lower cost?

ASSAULT BREAKER

The TGSM will be dispensed from a missile bus above a tank target array. Acquisition search will start at 500 m altitude and is designed to look for a target in a 200 m diameter circular region on the ground. Target acquisition and tracking ~~will~~ may be by means of an infrared sensor. Because the target is viewed from above, the infrared signature will be considerably greater than that available when viewed from nearly horizontally, as for the TADS or the TOW Night Sight FLIR. Attacked from above, the target's armor is also much less effective. In the target acquisition phase the TGSM's sensor faces the special problem that not only must it have sufficient sensitivity, in the sense of background shot noise and of detector/preamplifier thermal noise, to be able to detect the target intensity, but it must also be able to select the real target from among the various other thermal emitters (false targets) which may also be located in the seeker's field-of-view. System effectiveness analysis has shown that the density of credible false targets must be less than one per seeker field-of-view if the Assault Breaker system is to show overall effectiveness.

Is the Program Technically Sound?

The Committee has reviewed the design principles of the two leading contenders for the TGSM seeker, has been briefed on test results conducted at Redstone Arsenal and at Eglin AFB, and has conducted some independent analysis of the effect of background clutter on false target acquisition. Based on this we have arrived at the following findings concerning the ability of the two TGSM infrared sensor designs to acquire tank type targets and avoid acquisition of false targets:

- o Captive flight tests have been conducted with seekers whose search rates were matched to a slow descent rate. System considerations may require a faster descent rate, therefore a higher scan rate. It will be necessary to reevaluate seeker sensitivity in that event.
- o In a uniform background, the inherent seeker sensitivity is adequate to detect tanks with their engines running. The sensitivity may not be sufficient in the presence of rain (which reduces tank signature) or atmospheric effects (such as smoke, fog and low clouds).

- o Seeker performance against a non-uniform background will be limited by false target acquisition due to the background clutter pattern.

- o The present seeker designs will perform adequately against unsuppressed and moderately suppressed tank target infrared signatures (engines running) in the kind of background clutter found at Redstone Arsenal, but there is no great performance margin. Depending on the background type, the RMS clutter noise can be three times (for desert, mountains) to ten times (for an urban area), as great as that at Redstone.

- o The tank target signature suppression effort associated with the TGSM seeker tests performed to date was limited in scope. It should be possible to obtain much more effective suppression of the target's infrared signature than has been demonstrated so far.

- o The present seeker designs will probably not be able to demonstrate adequate target acquisition against targets with a moderately suppressed infrared signature in a strong clutter type of background representing battlefield conditions.

- o The present sensor designs have been put together without sufficient target and background infrared signature data. An understanding of the effects of background clutter and of the ways that sensor design could reduce RMS clutter leakage through to the target detection circuitry is needed. There has been limited sensor analysis leading to an estimate of the expected magnitude of the RMS clutter leakage. Program orientation in regard to background clutter has been largely focused upon field testing to see how the sensor performed.

- o With careful attention to the background clutter problem it should be possible to design a seeker that can reliably acquire tank type targets (engines running but with a reasonable level of infrared signature suppression) in a highly cluttered background. However, a major seeker redesign may be required.

Is the IOC Realistic?

There is no DA program for Engineering Development of Assault Breaker. The present schedule originates with DARPA, and calls for DSARC II and start of Engineering Development in 1981, with IOC in 1984. Such an IOC would correspond to an unusually short time span between ED and IOC, and would require circumventing the normal materiel acquisition cycle. The FY 80 Army budget contains $3M to perform concept studies and analysis.

Is the Cost Estimate Realistic?

The cost estimates for ED of Assault Breaker have been prepared by DARPA. MIRADCOM is not prepared to take any responsibility for them.

They are currently conducting a TGSM technical feasibility program with DARPA money to be concluded by 1981. The tests as planned can be completed within budget and schedule. However, we have doubts about the technical performance of the TGSM that will be demonstrated within this program, and whether what is demonstrated will be sufficient to justify the Assault Breaker program.

FIRE AND FORGET TECHNOLOGY FOR HELLFIRE

Three alternative technologies for HELLFIRE are under investigation, namely, the IRIS (Infrared Imaging Seeker), the mechanically scanned matrix array, also known as the TDI (Time Delay and Integration) seeker, and the staring matrix focal plane array seeker. IRIS is an adaptation of today's FLIR technology to a seeker, either in the form of a repackage of the common modular FLIR or a redesign of the Imaging Infrared (I^2R) seeker for MAVERICK. IRIS development for HELLFIRE has been underway for several years and captive flight tests have been made.

TDI is a proposed modification to IRIS in which a 60 X 8 element array replaces the standard 60 element array. Staring matrix focal plane array is an entirely new seeker concept under development by MIRADCOM with some DARPA funds in which the detector array views the entire field of view at once, rather than being mechanically scanned across it as in IRIS and TDI. However, it is not a strapdown system.

In considering the technical capabilities of IRIS it is necessary to include also the TADS (Target Acquisition and Designation System) aboard the AAH. IRIS cannot acquire the target by itself. Instead, target acquisition is performed by the TV camera on TADS during daytime, and the FLIR on TADS at night or day. Target handoff from TADS to IRIS is then required.

Is the IRIS Program Technically Sound?

The technology for building the IRIS seeker as designed is relatively mature and there is a good prospect that the missile design will perform according to the missile specifications. The real issue is whether the missile can be effectively employed on the AAH helicopter. Effective employment requires:

(a) Automatic target transfer from the TADS acquisition system to HELLFIRE.

(b) HELLFIRE target tracking through the launch transient to the target.

Because of the constrained missile size, the missile image resolution is only 1/3 that of TADS, and the missile field-of-view is only 2°. These constraints introduce significant problems in target transfer and target tracking, particularly at longer ranges.

Fire and Forget HELLFIRE offers two potential operational advantages:

(a) Operation when heavy battlefield obscuration may prevent the use of laser HELLFIRE while the TADS can acquire targets.

(b) Elimination of the need to remain exposed during autonomous designation for laser HELLFIRE.

There are very limited test data demonstrating the availability of these advantages; no tests in smoke and no demonstration of automatic handover and tracking. Both are under current investigation.

IRIS has demonstrated lock-on and track of tank targets under favorable conditions up to 6 km. However, if, as is assumed, the TADS FLIR requires 12 resolution elements across a target (tank) for identification, then the acquisition range would be 2.5 km. The necessity for 12 resolution elements is an estimate since no tests have been run with TADS in the field. Longer acquisition ranges are possible in principle during daylight if the TADS TV system is used, or if identification is not required (free fire zone).

Under the most favorable conditions, the engagement range is compatible with the 6 km range of HELLFIRE in direct fire, but shorter than the 8 km indirect fire range. Under "practical" conditions the range will be, say, 4 km, which is similar to that of laser HELLFIRE under those conditions.

Because the AAH will be unmasked during target acquisition and handoff, exposure time must be minimized. To do so requires development of automatic handoff from the TADS FLIR to IRIS. There is at present no demonstrated handoff capability, although efforts have begun. MIRADCOM believes that automatic handoff via scene correlation will not be a major problem. We believe achievement of automatic handoff is critical to AAH survivability, and it is not receiving sufficient attention.

Is the IRIS IOC Estimate Realistic?

The scheduled IOC is presently 3Q85. MIRADCOM believes it may slip 3 months. We believe the MIRADCOM estimate to be realistic.

Is the Cost Estimate Realistic?

The estimated cost of IRIS HELLFIRE is about $16K, which is about $6K more than laser HELLFIRE. Due to the complexity of the IRIS we believe this to be optimistic. However, we can find no obvious fault in the MIRADCOM method of estimating costs based upon common modular FLIR experience.

Are There Other Technical Approaches Which Would Provide Higher Performance, Sooner IOC, or Lower Cost?

Two alternate approaches are under consideration, namely, the 60 X 8 TDI array and the 64 X 64 staring matrix focal plane array. Neither could have an earlier IOC than IRIS. TDI is an intermediate approach which would retain all of IRIS except the present detector array, and would offer increased performance (1.7 times greater range) due to its greater sensitivity with moderate cost increase (3%) and an IOC estimated to be 3Q86. It can be introduced into the present IRIS design without entire redesign. Staring matrix focal place array is an entirely new seeker design which should offer reduced cost, and the MIRADCOM estimate is 10% less. Specific comments regarding TDI and staring FPA are listed below:

TDI - TDI can be developed sooner than staring matrix focal plane array because its complexity is less and because it retains most of IRIS. We agree that an IOC of 3Q86 can be met if a strong commitment is made to it.

We agree with a cost estimate only slightly greater than IRIS. However, we believe the IRIS unit cost estimate is low.

Staring Matrix Focal Plane Array - Both 3-5 and 8-12 μm staring matrix arrays are in Exploratory Development but the 3-5 μm is 2 years ahead. The use of 3-5 μm has advantages (higher resolution) and disadvantages (obscuration by smoke, lack of wavelength compatibility with TADS) with respect to 8-12 μm. MIRADCOM believes 8-12 μm to be the better choice. They estimate that the development is 4 1/2 years behind IRIS, i.e., IOC of 1989. We believe that it may be possible to shorten the development cycle by 1-2 years by a strong commitment and highly organized approach.

We agree that the MIRADCOM cost estimate for a staring matrix focal plane array seeker is reasonable. If there were to be a large commitment to 8-12 μm matrix focal plane arrays for FLIR's, which will eventually occur, there will be a cost advantage to using the same array in the seeker.

/s/ Paul W. Kruse	/s/ Richard C. Honey	/s/ David L. Fried	/s/ Joseph Sternberg
PAUL W. KRUSE	RICHARD C. HONEY	DAVID L. FRIED	JOSEPH STERNBERG
Chairman			

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DEPARTMENT OF THE ARMY
ARMY SCIENCE BOARD
OFFICE OF THE ASSISTANT SECRETARY
WASHINGTON, D.C. 20310

23 March 1979

Dr. Paul W. Kruse, Jr.
Principal Staff Scientist
Honeywell Corporate Technical Center
Bloomington, MN 55420

Dear Dr. Kruse,

Attached are comments on the findings of your review group as pertains to Fire and Forget, HELLFIRE. Dr. Yang has tasked Colonel Zugschwert to provide a status report on actions taken by 1 May 1979. That report will be forwarded to you.

Sincerely,

Helen Pipon
Staff Assistant
Army Science Board

Inclosures
As stated

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DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
WASHINGTON, D.C. 20310

5 February 1979

MEMORANDUM FOR BG BROWNE, PM, AAH

COL FEIST, PM, HELLFIRE

SUBJECT: Army Science Board Report of Findings Relative to Fire and Forget, Hellfire

The subject report is inclosed. Would appreciate your comments at your convenience.

JOHN F. ZUGSCHWERT
Colonel, GS
Deputy for Aviation

1 Incl
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CF:
BG McNair

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DEPARTMENT OF THE ARMY
UNITED STATES ARMY MISSILE RESEARCH AND DEVELOPMENT COMMAND
REDSTONE ARSENAL, ALABAMA 35809

DRCPM-HF

13 MAR 1979

Pls make sure the "appropriate emphasis" is translated into actions taken rather than papers filed. Would like to receive a status report on this by 1 May.
J.J.

Colonel John F. Zugschwert
Deputy for Aviation
Office of the Assistant Secretary
Department of the Army
The Pentagon
Washington, D.C. 20310

Dear Colonel John Zugschwert:

As requested by your memorandum of 5 February 1979, I have reviewed the Army Science Board's findings relative to Fire and Forget, HELLFIRE. I am in general agreement with their findings.

The Army Science Board identified target transfer from the TADS to the missile and target tracking through the launch transient as key issues. I agree that these are important issues and our development plans are structured to see that they receive appropriate emphasis.

The issue of target handoff deserves additional comment. There are two methods of target handoff, manual and automatic. The technology required for each method is in hand and the problems are mainly of an engineering nature. Uncertainties associated with target handoff are related to how fast it can be done rather than to how can it be done. With either the manual or automatic target handoff mode, exposure time for the AAH is projected to significantly decrease, when compared to operation with autonomous laser HELLFIRE, with handoff times for the manual mode being 3-6 times longer than for the automatic mode. Both handoff methods will be developed with the objective being to achieve minimum handoff time in each case. Lastly, exposure time related to target handoff needs to be kept in perspective. While it is expected that the Fire and Forget missile will significantly reduce exposure time of the AAH when engaged in autonomous operations, the total exposure time for the AAH consists of target acquisition/recognition time plus target transfer and missile launch time, with the majority of the exposure time attributable to target acquisition/recognition for most scenarios.

RCPM-HF

13 MAR 1979

Colonel John F. Zugschwert

Comments related to specific statements in the Army Science Board's findings are at Inclosure 1.

Sincerely,

ROBERT J. FEIST
COL ADA
HELLFIRE Project Manager

Specific Comments
Army Science Board's Findings
Fire and Forget Technology for HELLFIRE

Paragraph 1, second sentence: "IRIS is an adaptation of today's FLIR technology to a seeker, either in the form of a repackage of the common modular FLIR or a redesign of the Imaging Infrared (I^2R) seeker for Maverick."

Comment: The differences between the IRIS, the common module FLIR, and the Maverick Imaging Infrared seeker are significant enough that the words "repackage" and "redesign" suggest less differences than those actually existent. The following wording is suggested: "Two concepts have been pursued to date with one concept sharing technology with the common module night sight program and the other concept sharing technology with the Air Force Imaging IR Program."

Paragraph 2, first sentence: "TDI is a proposed modification to common modular FLIR IRIS in which a 60 X 9 element array replaces the standard 60 element array."

Comment: Texas Instrument's approach to the TDI modification is identified at present as a 60 X 9 element array as stated. However, Hughes concept is not known and approaches other than a 60 X 9 element array could be used.

Paragraph 3, second sentence: "IRIS cannot acquire the target by itself."

Comment: IRIS can be used for target acquisition. However, the Army's concept for the AAH is to use the TADS for target acquisition and transfer the target to the IRIS. For the AAH, this is considered to be the most operationally effective method of target acquisition and subsequent missile launch. For other applications, targets could be acquired via the IRIS; the effectiveness would be less than that expected to be achieved for the AAH but could be adequate for a specific application.

PM's comments are trivial. J.F.

Incl 1

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DEPARTMENT OF THE ARMY
PROGRAM MANAGER, ADVANCED ATTACK HELICOPTER
PO BOX 209, ST. LOUIS, MO 63166

Life. Hellfire F+F
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24 FEB 1979

DRCPM-AAH-TM-S

Colonel John F. Zugschwert
Deputy for Aviation
Office of the Assistant Secretary
Department of the Army
The Pentagon
Washington DC 20310

Dear Colonel Zugschwert:

I have reviewed the Army Science Board's findings relative to the HELLFIRE Fire and Forget problem as requested in your memorandum of 5 February 1979. I am in general agreement with their findings.

The Army Science Board did an outstanding job in surfacing some key issues and putting the real problems of a Fire and Forget system capability into perspective. This perspective needs to be sharpened to prepare for the ASARC/DSARC decision process.

Some of the issues surfaced by the Army Science Board require amplification. Up to this point most of the visibility has been on the choice of detector technology for the seeker. However, as pointed out, there is a more fundamental problem; namely, given any of these competing seeker technologies (IRIS, TDI, FPA)) "The real issue is whether the missile can be effectively employed on the AAH helicopter." Of the two issues raised, breaklock during the launch transient and target handoff, only the latter falls directly under my responsibility.

The principle potential benefits offered by a Fire and Forget weapon lie in the possibilities for significantly reducing aircraft exposure times and increasing rates of fire relative to the laser. It is also anticipated that the capability of the imaging infrared seeker will more closely match the TADS acquisition capability in degraded atmospheric environments. However, as a prerequisite to capitalizing on the obscurant gains it will first be necessary to solve the exposure time problem, since most of the engagements under degraded environments will be driven to shorter ranges due to increased atmospheric transmission losses. Without sufficiently short exposure times, helicopter losses might preclude effective use of the system in degraded environments. For these reasons, I view the key to the Fire and Forget missile for the Attack Helicopter to lie in a highly responsive fire control system which can produce quantum improvements in exposure times and rates of fire.

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24 FEB 1979

DRCPM-AAH-TM-S
Colonel John F. Zugschwert

As pointed out by the Army Science Board, a high degree of fire control automation will be necessary and this area has not received adequate attention. I agree with this finding and feel it is the area where we are most vulnerable at ASARC/DSARC. Our limited data indicates the automatic scene correlator will be a practical necessity. Correlator hardware is not a major problem, but considerable work needs to be done to optimize and prove out the correlation software. Additionally, the crew management of both laser and Fire and Forget ordnance introduces new workload problems which are expected to require increased dependence on crew station automation to achieve the desired gains in weapon system responsiveness. I have already taken steps to insure that these aircraft integration issues are properly addressed in the evolving ROC and covered in the Fire and Forget budgeting line.

I am especially concerned by the late IOC projected for the IRIS seeker (3Q 85). If the aircraft integration effort parallels the seeker development cycle, then a large portion of the AAH fleet will have been fielded without a Fire and Forget capability. Retrofitting will add to costs and reduce the availability of aircraft in operational units.

There is an alternative to an earlier IOC, not considered by the Army Science Board, which could avoid this problem. The projected IOC for the I^2R MAVERICK missile is at least two years ahead of the IRIS HELLFIRE missile. Since the fire control system for the two missiles would be quite similar, the aircraft integration could be accelerated and the Fire and Forget capability deployed with the first production aircraft. Additionally, the MAVERICK would provide a heavier firepower option to complement the HELLFIRE missile.

Preliminary investigations have not revealed any major obstacles to integrating MAVERICK on the AAH. The current single rail launcher appears to require, at most, minor modifications. Motor blast and temperature levels appear tolerable. Although further study is required to establish feasibility, I believe that the advantages offered by an earlier Fire and Forget integration warrant that the Army Science Board be tasked to study this alternative. One side benefit to the Army from an early MAVERICK integration might be to forego development of the IRIS seeker and proceed directly into development of the TDI imaging infrared seeker for the HELLFIRE missile.

Sincerely,

EDWARD M. BROWNE
Brigadier General, USA
Advanced Attack Helicopter
Program Manager

CF:
COL Feist, PM-HELLFIRE

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DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
WASHINGTON, D.C. 20310

FEB 9 1979

MEMORANDUM FOR DEPUTY CHIEF OF STAFF, RESEARCH, DEVELOPMENT AND ACQUISITION

SUBJECT: Army Science Board Ad Hoc Committee on Precision Guided Munitions

The Army Science Board Ad Hoc Committee on Precision Guided Munitions has reviewed the Assault Breaker and the Fire and Forget seeker for HELLFIRE programs and submitted the inclosed final report. The Ad Hoc Committee will also brief the Army Science Board, 20-21 February on its conclusions.

This report will be used by Dr. Pierre as support for his Congressional testimony on these programs. I am sending a copy to you for use as you deem appropriate.

(signed) Joseph H. Yang

Joseph H. Yang
Deputy Assistant Secretary of the Army
(Research and Development)

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DEPARTMENT OF THE ARMY
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FEB 9 1979

MEMORANDUM FOR DEPUTY CHIEF OF STAFF FOR OPERATIONS AND PLANS

SUBJECT: Army Science Board Ad Hoc Committee on Precision Guided Munitions

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