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ARMY SCIENCE BOARD

AIR FORCE SCIENTIFIC ADVISORY BOARD

JOINT SUMMER STUDY 1978

U.S. AIR FORCE ACADEMY

COLORADO SPRINGS, CO

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FINAL REPORT

Classified by Exec Sec'y SAB
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Schedule of Executive Order 11652
Automatically Downgraded at Two Year
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UNCLASSIFIED

ARMY SCIENCE BOARD/
AIR FORCE SCIENTIFIC ADVISORY BOARD

JOINT SUMMER STUDY

U.S. AIR FORCE ACADEMY

JULY 1978

(S) "TACTICAL BATTLEFIELD SYSTEMS" (U)

Classified by Exec Secy, SAB
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Intervals, Declassified on
31 December 1990.

UNCLASSIFIED

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(S) EXECUTIVE SUMMARY (U)

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(S) EXECUTIVE SUMMARY (U)

(U) The Joint Summer Study of the Army Science Board and the Air Force Scientific Advisory Board prepared this report during their working session at the Air Force Academy in Colorado Springs from July 17 through July 28, 1978. This study, the first combined effort of the two Boards, addressed four topics that were identified by TAC and TRADOC as high-priority items for combined Air Force/Army attention:

- Reliable IFF of aircraft by ground-based AD systems
- Improved capability to provide supporting firepower by systems of either Service, using target acquisition means of either Service
- Effective capability to interdict enemy command and control
- Accurate location and reliable classification by type, or identification by specific unit, of enemy AD systems

(See Annex C for more detailed initial task statements.) All topics were addressed in the NATO Central European context and included assessments of their C^3 implications.

The classification of the principal report is SECRET, but several important conclusions from the study areas are contained in a smaller set of separate appendices of a special classification.

(C) The topics studied have the common elements that they require closely coordinated actions by ground and air forces, that they are of great importance, in some cases of critical importance, to a successful defense of NATO, and that major deficiencies exist in current operational capability. The Task Groups considered both technological and procedural aspects of the problems, and provided recommendations for action that would provide improved operational capabilities in two time frames: near-term i.e., from now through 1983; and longer-term, after 1983.

(U) The study was conducted by four Task Groups composed of members of both Boards and full-time Service participants, with guidance from the summer study steering group including a general officer participant from each Service. (See Annex A for a list of participants.) Preparation before the study session at the Air Force Academy included briefings and discussions at a general meeting of all Task Group participants, plus a number of separate meetings of the individual Task Groups from May through early July, and a visit to major U.S. defense headquarters in Europe by a small subset of the participants in late June. (See Annex B for list and topics of pre-study meetings.) Findings and recommendations were briefed to members of the Department of the Army staff, Department of the Air Force staff, and general officers of the Army and Air Force on July 28 at the Academy. (See Annex D for schedule, agenda, and names of principal attendees at the July 28 briefing.)

(U) In overview, the summer study developed four major themes:

- o Identification of potential joint Air Force/Army program initiatives
- o Emphasis on "short-loop" systems
- o Classification of recommendations by timeliness of operational utility
- o Definition of impact on NATO C^2/C^3 requirements

(S) The emphasis on joint programs was aimed at highlighting aspects of combined arms operational capability where TAC and TRADOC need to combine their efforts to gain synergism from their efforts. The "short loop" concept was intended to focus attention on relatively simple, highly productive "fixes", where a close tie between, e.g., a sensor and a weapon, would minimize response times, communications load, vulnerability, etc., as contrasted to "big system" approaches with massive central data bases. Examples of short loop concepts considered include direct EIFF at the HAWK battery; in-theatre reprogramming of EW assets; integration of PLSS and AGTELIS; and a PLSS-TACFIRE loop for artillery targeting.

(U) Each of the Task Groups considered their analysis and recommendations in two distinct time frames. Near-term items were those which could provide some enhanced capability before the end of 1983; longer-term fixes would be operational after that date. Substantial emphasis was placed on the near-term category, where innovative use of existing or programmed assets could minimize the cost of added capability.

(U) Although not directly identified as a separate task area, command and control was one of the common themes for the study. Although definition of the associated C^3 system architectures and implementations was beyond the scope of the Task Groups' efforts, each group made an attempt to scope the implication of their recommendations on the European C^3 system of the future. In this area, several common perceptions were held by all of the Task Groups:

(S) 1. That the NATO (and U.S.) C^3 system is extremely marginal, especially the communications dimension, and will largely fail under realistic wartime stresses, particularly REC by the WP.

(S) 2. That major improvements are urgently needed before any more load can be added to the system or any higher reliability expected. Examples include:

- Higher mobility of assets
- Shortened response times
- Data orientation
- Reduction of bandwidth requirements
  - o Discipline
  - o Preplanning (e.g. Creek Braille)
- AJ on all major links
- Fail-safe network geometries
- Acceleration of DSCS III

NATO IMPLICATIONS

(U) All of the Task Groups addressed their topics in the context of Allied operations within the NATO Central area. It was recognized that in any of the areas studied -- aircraft identification, supporting firepower, $C\text{-}C^3$, or countering enemy ADs -- a U.S. only capability would be of limited value.

(U) The NATO-wide implications of the problem of aircraft identification are self-evident. Multi-national, multi-Service aircraft operations in offense and defense, along with multi-national surface-based defenses clearly demand a theater-wide identification system, and the findings and recommendation of Task Group I are presented in this light.

(U) In the area of supporting firepower for friendly forces, the most obvious basis for the requirement for NATO-wide solutions to current deficiencies pertains to CAS. NATO tactical airpower in the central region operates under the central control of AAFCE and aircraft of any NATO country in the region may be assigned to close support targets in support of any country's troops. Artillery and attack helicopters have relatively shorter ranges than CAS aircraft and are organic assets of ground units rather than being centrally controlled. However, even these shorter-range firepower assets may be applied in support of a neighboring Division and that Division may well belong to another nation. Thus, inter-Allied systems interoperability and procedural interoperability are important across the whole spectrum of fire support.

(S) The subject areas of Task Groups III and IV are somewhat different from the other two subject areas with respect to NATO implications in that both tend to depend more heavily on compartmented information. Nevertheless, operations to counter enemy C^3 and to negate enemy defenses must be viewed on an Alliance-wide basis. During peacetime, the U.S. can assist the Alliance by leading in the development of concepts, doctrine, and tactics for these operations. During wartime, some security restrictions on disclosure of the sources of targeting and order-of-battle information may be relaxed. Even if this is not the case, target nominations for C-C^3, counter AD operations may be exchanged among Allies without compromising sources. New sensor systems coming into the U.S. inventory, such as PLSS, AGTELIS, SOTAS, etc., can provide a basis for specifying sourees of information at collateral security levels.

(U) The consensus of the participants in the joint summer study was that the DoD should actively pursue implementation of pertinent recommendations with the NATO Allies, and that the most effective way to do so would be to bring the Allies early into the discussion and implementation process.

OBSERVATION ON THE JOINT STUDY

(U) In the view of participants and reviewers, significant benefits have accrued from the combined activity among Army and Air Force scientific advisors, military staff, and Department staffs.

(U) The principal findings and recommendations of the four Task Groups are presented in the following pages.

TASK GROUP I: IDENTIFICATION OF AIRCRAFT IN THE NATO AIR DEFENSE ENVIRONMENT

(U) Task Group I addressed the problem of reliable identification of aircraft in the NATO AD environment with the main emphasis on identification of aircraft by surface-based defenses. Two classes of identification were considered: direct identification at the point of fire, i.e., identification by the AD gunner or missile operator; and indirect identification, i.e., identification performed elsewhere than at the point of fire and communicated to the firing unit. In addition to considering the technological aspects of identification, the Task Group undertook a review of some major aspects of the operational procedures and rules of engagement pertaining to aircraft identification.

(U) The key operational needs in aircraft identification by surface-based defense are that identification must be timely and highly reliable, and must not significantly compromise the engagement opportunities or engagement range of the defenses. Reliability is of critical importance not only to increase the probability of successful engagement to enemy aircraft but to avoid fire against friendly (or conceivably in some contexts, neutral) aircraft.

(S) The study found that a number of critical deficiencies currently exist in the identification capability of the NATO AD system. These may be summarized as follows:

- The MK X/MK XII cooperative, direct IFF system has a variety of widely known weaknesses, including susceptibility to jamming, exploitation, spoofing, saturation, and equipment failure

- Visual direct identification, the only method available for many AD fire units, is severely range-limited, provides relatively low confidence, is subject to significant variability depending on operator skill and training level, and is strongly dependent on cueing

- The AD ground environment does not provide for adequate transfer of tracks and related identities; does not realize the potential to be gained through netting of appropriate AD radars and lacks adequate secure, reliable data links for operation in an environment of heavy battle damage and EW

- Current procedures and rules of engagement are not compatible with the capability of equipments, are not well accepted by aircrews, and in wartime are likely to lead to unacceptable levels of fratricide and/or to inadequate defense

(S) The study explored a number of approaches to improving aircraft identification in the NATO environment. The following actions are recommended as being of the highest priority:

- Implementation in Europe of effective communications and data processing for parallel and redundant exploitation of AWACS data for indirect identification

- Development of a data-link for coupling DAD weapons to the HAWK C^3 system

- Implementation in Europe of a capability for exploiting certain SIGINT information for aircraft identification

- Consideration of a JTIDS-like system as the basis for the future NATO direct target identification system

- Initiation of advanced development of a millimeter-wave coded retro-reflector identification system for short-range applications

- Advanced development and test of TDOA systems as adjuncts to radar detection and tracking systems

- A concept definition study of widespread radar netting for identification purposes

(S) Also recommended, but of somewhat lower priority are:

- Addition of JEM equipment to the HAWK CW acquisition radar

- Implementation of Mode 5 of the MK XII IFF system

- Study of the feasibility and cost-effectiveness of a passive identification system for use with short-range and man-portable AD weapons

- Addition of EIFF equipment to HAWK

(U) Technology initiatives in the 6.1, 6.2 and 6.3 program areas were also recommended, as discussed in the Task Group report.

TASK GROUP II: SUPPORTING FIRE FOR FRIENDLY FORCES

(U) Task Group II investigated potential improvements in procedure, systems and interface equipment to enhance the timely application of firepower from artillery, fixed-wing aircraft and attack helicopters.

Particular emphasis was given to improving the capability of Air Force ground-attack assets in support of the ground commander's mission. Improved use of either Service's weapon systems with either Service's target acquisition or cueing systems was another major topic.

(U) Key operational needs identified by the Task Group were the need to provide an effective and timely means for allocating ground attack assets and assigning them against specific targets; the need for effective target cueing and target hand-off; and the need for fast, accurate and survivable communications and position location for coordination of Army and Air Force firepower.

(C) Critical deficiencies now exist in the capability for providing supporting firepower. The Task Group singled out the following for emphasis:

- OAS capability is quite limited at night, in reduced visibility and in heavy defenses

- Current procedures for allocation of sorties to OAS are too cumbersome for high-intensity, fluid operations

- An adequate common or interchangeable coordinate system is not available for coordinated application of Army/Air Force firepower

- The Army and Air Force do not fully exploit each other's target acquisition sensors

- Army/Air Force target handoff techniques need to be improved to provide successful fire-pass mission accomplishment by ground attack aircraft at low altitude and in poor visibility

- New equipment is not introduced early enough in the development cycle of the equipment to meet the needs for joint and combined testing and training

- The A-10 lacks equipment for navigation under IFR conditions and for effective weapon delivery at night

(C) After considering a menu of approaches to improved capability for coordinated fire support in joint Army/Air Force operations, the Task Group recommended the following actions:

- The process for allocation of sorties to OAS missions and for assignment of these sorties against specific targets should be streamlined and clarified. The system should emphasize a "push" process of allocating OAS sorties to Corps and below in lieu of the current "pull" system for preplanned and immediate requests

- High priority should be placed on creating and fielding a common Army/Air Force position-locating and digital communication system; a common digital targeting language system should be provided

- New equipment, including prototypes, should be introduced early into joint Army/Air Force OAS training and testing programs to obtain early feedback between development of tactics and procedures and development of equipment

- To improve target handoff, the following systems are needed:

  - o a common coordinate based-cueing system
  - o improved-accuracy beacon bombing
  - o burst digital communications
  - o improved sensors for acquisition of targets at night by air-crews and ground observers

- To improve joint target acquisition, data exchange should be provided from PLSS to TACFIRE; between AGTELIS and TPQ-37 and PLSS; and from SOTAS to ground attack aircraft

- An inertial navigation system, a FLIR, and a radar altimeter should be added to the A-10; a JTIDS or PLRS terminal should be added to the A-10 when available; a forward-firing cannister weapon should be provided for the A-10

TASK GROUP III: INTERDICTION OF ENEMY COMMAND/CONTROL.

(C) Task Group III treated the topic of the utility of and capability for NATO detection, identification location, and neutralization of WP C^3 assets in a European war environment. Capability assessments were made for existing assets and both technological and program initiatives recommended.

(S) The principal finding in this task area is that the WP has a much stronger capability to interdict NATO C^3 than NATO has to interdict the WP's C^3. In addition to substantial numerical superiority in types and fielding equipments, WP doctrine integrates $C\text{-}C^3$ into their overall offensive warfare plan. Both physical attack and REC are not only called for in doctrine, but are also supported by dedicated organizations trained in these disciplines. This potent advantage over NATO is also enhanced by the WP probably having the attack initiative in any first battle, with the obvious advantage of being able to fight from "fixed" plans for some period. On the other hand, both historical trends and observations of current training WP exercises indicate a substantial disinclination toward initiative actions without higher chain-of-command authorization; which implies a potentially substantial benefit to be obtained from disruption of this chain.

(S) The study indicated that NATO needs to critically assess possibilities and priorities for $C\text{-}C^3$ separately for pre-war and for active wartime phases; and WP REC assets/capabilities were identified as potentially very high yield targets in terms of retained NATO effectiveness. Attacking these targets was assessed as much less costly than fully "jam-proofing" and otherwise protecting our own C^3 assets. The Soviet SVOD Navigation System was also identified as another extremely attractive target.

(S) A major study ground rule was that recommended $C-C^3$ asset requirements not represent a major percentage of total assets - from development through fielded sensors and deliverable weapons - available to NATO. Analysis based on this concept indicated that this is a feasible approach because C^3 targets are generally "softer" than the weapon systems they support; and frequently may be effectively neutralized by harassment tactics requiring an order of magnitude less assets - location accuracy; number, size, and accuracy of weapons, etc. - than outright destruction.

(S) Some of the major current NATO $C-C^3$ deficiencies included:

- Failure to treat $C-C^3$ as the important element of combined arms warfare it is
- Failure to extract and process $C-C^3$ information from data regularly collected by National assets
- Failure to focus development priority on $C-C^3$ systems or equipment
- Failure to develop the important ability to perform C&D actions
- Extreme non-survivability of the sparse assets available for $C-C^3$ activities

(S) Near-term (pre-1983) approaches for improved $C-C^3$ capability included:

- Provision of focused organization responsibility for $C-C^3$, supported by appropriate strengthening of the associated doctrine

- Development of a joint Air Force/Army C-C[3] intelligence screening activity

- Influencing of current developments (PLSS, BETA, ASAC, TIPI-II, etc.) and National Systems to force provision of functional C-C[3] capabilities

- Development of specific C&D activities for NATO

- Careful evaluation of existing sensors and weapons and future systems such as RPV's as to their applicability to C-C[3] activities

(S) Recommendations for longer term (post-1983) improvement of capability included:

- Initiation of C-C[3] anti-radiation weapon development

- Implementation of EW fingerprinting to enhance C[3] location/identification

- Incorporation of EW capability into PLSS

- Fielding of RPV-borne sensors for C-C[3] and specific C-C[3] weapons

(C) Additional, detailed recommendations may be found in the Task Group report; including some of major significance in an appendix of special classification.

(S) Overall, the crucial recommendation from this study is for the establishment of strong doctrinal and specific organization responsibility for making C-C[3] a major element of our combined force warfare concepts. This must also lead to the evolution of systems architecture, tactical doctrine, and identified assets for survivable C-C[3] implementation.

TASK GROUP IV: TEMPLATING AND COUNTERING SOVIET AIR DEFENSE ON THE BATTLEFIELD

(S) Task Group IV addressed the ability of NATO to detect, locate, classify and target WP AD units in a European war scenario. The principal current deficiencies in this regard were analyzed and proposed solutions were developed for the near (pre-1983) and longer (post-1983) term operational introduction. Two major topical areas were considered - AD battlefield "templating" and AD countermeasures.

(S) In reviewing NATO operational needs for locating and C-AD, the key items were identified as:

- Numbering (+20%) and correct classification (90%) of AD weapon systems in the FEBA +10 kilometer zone

- Location of AD units (including uncommitted assets) with a few kilometer accuracy and determination of their affiliation to Army echelons for battlefield management purposes

- Short-term (few minutes) location to 50 meters CEP for strike direction

- Capability for physical and electronic attack of critical AD system elements, including radar and communication links

- Rapid and accurate detection and analysis of WP AD emission changes to support appropriate on-site reprogramming of NATO self-defense systems such as radar warning receivers, ARM's, etc

(S) Assessment of NATO ability to meet these requirements indicated critical deficiencies when exposed to realistic wartime threats. In the location aspect, NATO is currently relatively unable to determine which AD assets, observed at different times, are new versus re-observed units. Further, current NATO assets would rapidly saturate in the expected target-rich wartime environment. NATO ability for C-AD is similarly limited, particularly because it does not attack the AD system, but generally concentrates on spot self defense actions against limited targets. Further, many of NATO's potential C-AD assets are woefully out of date, and are effective only against relatively unsophisticated, immobile (e.g., SA-2, SA-3) threats.

(S) The overall recommendations of this study may be generally summarized:

- NATO must consider systematic attrition and jamming of the enemy's AD system by the use of our EW arsenal as a system to broaden the applicability of our "area" EW systems

- It is necessary to configure NATO's EW support system to accept in theatre reprogramming of equipments based on inputs from survivable collection system which can rapidly observe the surprises which the WP has in store

- Specific recommendations for the pre-1983 time include:

  - o Development of special purpose collection systems and processor for AD data links

  - o Emphasis on developing "off-line" FMOP processing for use against known threat radar

  - o Development of a precise PRI data base on WP AD radar

  - o Provision of in theatre reprogramming of critical EW assets - RWR, jammers, etc

- o Modification of ALQ-131 pod to attack Flat Face

- o Rapid development of techniques to defeat "scan with compensation" technique for AJ

- Recommendations for longer range (post 1983 introduction) capability actions include:

  - o Urgent determination of integrated modes for PLSS and AGTELIS by a joint Air Force/Army team

  - o Addition of an AD data link capability to PLSS and AGTELIS

  - o Phase out work on Quick Look II and TEREC in favor of AGTELIS and PLSS; and evaluate adding airborne AGTELIS

- Numerous other recommendations are contained in the Task Group report; and some particularly important ones are contained in the specially classified appendix to that report

REPORT OF TASK GROUP I

(S) IDENTIFICATION OF AIRCRAFT IN THE NATO AIR DEFENSE ENVIRONMENT (U)

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ABSTRACT

(U) This report addresses the problem of identification of air vehicles in a NATO combined AD environment. Special emphasis is placed on the identification of targets for surface-to-air AD operations. The operational needs for aircraft identification are reviewed, the present/programmed capabilities are assessed and the critical deficiencies are identified. A number of near-term (available by 1983) and longer-term concepts and approaches for improving the aircraft identification capabilities and reducing or eliminating the known deficiencies are identified, together with a number of recommendations for technology initiatives.

Contents, Report of Task Group I

(S) I. SUMMARY (U)

(U) A. DESCRIPTION OF TOPIC

(U) This Task Group addressed the problem of reliable identification of air vehicles in a NATO combined AD environment. The emphasis of the Task Group was focused on the joint Army/Air Force aspects of the topic (in consonance with the joint nature of the summer study). As a result, the primary effort was devoted to the identification of targets for surface-to-air AD operations. Air-to-air defense operations received only secondary emphasis. Extension and/or possible fallout applicable to identification of ground vehicles was not considered because of lack of time.

(U) The Task Group investigated both potential short-term (1978-1983) and potential longer-term (1983 and beyond) improvements in air vehicle identification technology, concepts, and systems. Based on this investigation, the Task Group identified and recommended those potential improvements which were deemed to represent doable, effective, and affordable contributions to solution of the problem of achieving reliable identification of air vehicles. Finally, the first-order impact of the recommended improvements in technology, concepts, and systems on operational procedures and rules of engagement was explored by the combined scientific and military representatives in the Task Group.

(C) B. KEY OPERATIONAL NEEDS (U)

(C) In order to maximize AD system effectiveness and minimize fratricide in a combined AD environment, it is essential that the combined AD forces have equipment, operational procedures, and rules-of-engagement which assure very high confidence of proper identification of all air vehicles which can be potentially engaged by the individual fire units/interceptors. This identification has to be made available, either directly or indirectly, to the individual fire units/interceptors in a timely manner that does not significantly compromise their capability and effectiveness (e.g., range capability, engagement opportunities).

(C) For maximum operational flexibility, it is desirable to be able to accomplish the identification of the air vehicles at the point-of-fire (i.e., by the gunner). Under circumstances in which this is not possible with the necessary confidence, it is essential to have complementary high-confidence identity information available elsewhere and to be able to reliably communicate it to the point-of-fire in a useful form and in a timely fashion. (These two previous sentences "define" what are called direct and indirect identification, respectively.) In this context, it is implied that the necessary communications must be effective in a severe EW environment, must degrade gracefully under battle damage, and must operate effectively throughout the NATO theater. Finally, it is essential to have simple, easily understood procedures and rules-of-engagement which accommodate the limitations of the identification system(s) and which minimally compromise the effectiveness of the AD weapons systems.

(S) C. CRITICAL DEFICIENCIES (U)

(C) The current "overall identification system" operational in the NATO theatre involves appropriate combined use of several subsystems. These consist of the MK X/MK XII, cooperative, direct system; visual, largely noncooperative, direct identification; an ADGE system with indirect identification capability; and a set of procedures and rules-of-engagement compatible with NATO airspace control doctrine. Each of these subsystems has critical deficiencies as outlined below:

(S) Critical deficiencies in the MK X/MK XII systems are:

- Jamming susceptibility
- Exploitation susceptibility
- Spoofing susceptibility
- Saturation susceptibility
- Low equipment reliability

- o Anomalous interrogation/reply blackout
- o Lack of proper training, exercises and data for quantitative evaluation of performance
- o Operational use limitations

(S) Critical deficiencies in visual direct identification are:

- o Fair weather, daylight only
- o Severely range limited and subject to terrain masking; hence, not compatible with new beyond-visual-range weapons
- o Relatively low confidence and subject to significant training variability (overflight of many separate AD firing units leads to low overall probability of all identifications being correct)
- o Results strongly dependent on cueing for MANPADS

(S) Critical deficiencies in the ADGE are:

- o Does not provide for adequate redundancy or alternate routing of essential traffic message
- o Does not provide for adequate transfer of tracks and related identity to AAD firing units
- o Does not permit ground units to take full advantage of the low altitude surveillance and track history capability of the AWACS with its strongly synergistic effect on maintaining <u>track and identity</u>
- o Does not realize the potential to be gained from netting of the appropriate AD radars (both airborne and ground-based) as regards track/identity continuity

- Inadequate secure, reliable communication links for proper netting in a severe EW and heavy battle damage environment

(S) Critical deficiencies in current procedures and rules-of-engagement are:

- Procedures not compatible with the equipment capability
- Safe passage procedures (including use of MK X/MK XII) not well accepted by pilots
- Complexity and variability of procedures throughout NATO region which reflect IFF and related equipment variability
- Unsatisfactory wartime rules-of-engagement which will likely lead to either unacceptable levels of fratricide or an inadequate defense

(S) D. PROPOSED APPROACHES FOR IMPROVING CAPABILITY (U)

(U) Proposed approaches for eliminating air vehicle identification deficiencies and improving capability are listed and briefly described in this section. They are divided into near-term (1978-1983) approaches which could lead to improved operational capability prior to 1983 and longer-term approaches (1983 and beyond) which could not lead to improved operational capability until after 1983.

(S) 1. Proposed Approaches for Near-Term Improvements (U)

(U) a. Direct Identification Approaches. Proposed near-term approaches which have potential for improvement of direct identification capability are:

(S) (1) The addition of JEM classification capability to the HAWK ICWAR acquisition radar. This would provide an added, non-cooperative direct identification capability which is complementary to the current MK X/MK XII cooperative, direct, interrogation-reply capability. Such an added capability would also provide identification in case of MK X/MK XII failure or anomalous blackout, could provide identification in the near-FEBA area where it might be dangerous to use MK X/MK XII, and could be used synergistically if the short-term radar netting recommendation is implemented. The range of JEM on HAWK is reasonably compatible with the HAWK missile range, and, since the proposed installation is limited to HAWK, it should not be too expensive (on the order of $2-3M acquisition costs for all HAWKS in NATO).

(S) (2) Elimination of the vulnerability of the MK XII to direct exploitation by the enemy through addition of Mode 5 which uses very rapid time synchronized interrogator code changes. This would allow more confident use of the MK XII in the far forward areas where our air vehicles are engageable by the enemy's ground-based AD weapons and possibly some of his interceptors. However, even if the exploitation possibility were removed, the enemy could still render the MK X/MK XII ineffective by direct jamming and this still might be a better tactic for him.

(S) (3) Incorporation of a passive point of fire system identification system for SHORADS and MANPADS weapons. Many types of aircraft operating at low altitudes in the ground attack role radiate electro-magnetic signals while performing their mission. Examples of such signals are those from terrain following radars, radar altimeters, attack radars, doppler navigation systems, etc. These emissions can be detected with relatively simple detectors and relatively small antennas. Since most such systems are modulated at audio frequencies, the simplest concept would be to envelop-detect the signal and feed the detected audio signal directly to the operator via earphone. Preliminary calculations suggest that detection of a 16 GHz signal from a terrain following radar using a 4-inch antenna could produce a practical system design. The features of this technique are:

- Passive
- Simple, compact and inexpensive
- Many different friendly and enemy aircraft are distinguishable by their RF signatures

(S) (4) Addition of equipment to the HAWK batteries which is capable of exploiting the enemy's IFF system. Equipment for the active tactical exploitation of EIFF has been developed and installed on the F-15 and on some F-4E aircraft. Since the interrogation code for the Soviet transponder SRO-2 is well known, the present U.S. systems can readily interrogate and receive a coded reply from the SRO-2. There is reason to believe that the wartime modes of Soviet IFF may change. Nevertheless, addition of flexible EIFF capabilities to the HAWK radar merits consideration if it is believed that the enemy will use his IFF when in the range of HAWK batteries. The maximum HAWK engagement range extends 35 kilometers beyond the FEBA and the active EIFF exploitation systems can operate at longer ranges. It appears that the cost of the EIFF addition to HAWK may be relatively low.

(S) b. Indirect Identification Approaches. Proposed near-term approaches (which have potential for improving indirect identification capability) are:

(S) (1) Downlinking appropriate track reports from AWACS to all three MPCs for redistribution to firing units. When the E-3A AWACS is introduced in the European theater, this system will be extremely effective in eliminating low-altitude gaps in radar coverage, thereby maintaining track continuity on both friendly and hostile aircraft. Under current planning the utility of AWACS for indirect target identification will be limited by two factors. One is that on-board track processor is able to process a maximum of 100 aircraft tracks generated by its own radar. The second limitation is imposed by the traffic handling capacity of the links between the AWACS and the CRCs in the AD net.

Interim improvements are available by downlinking in parallel the appropriate radar data from AWACS to all three MPCs. From there it could be simultaneously relayed to the four CRCs in the 4th ATAF and to the four AAD groups. Under this arrangement the Master CRC at Boerfink, as long as it was operable, would direct the AD battle using AWACS data for overall force management. If Boerfink became inoperable the remaining CRCs could take over autonomous command of the AD battle in their area with the AWACS data still available to them. Finally, if the CRCs were rendered inoperable, the surface-based AD could operate autonomously.

(S) (2) Coupling of DAD firing units to the HAWK batteries. The kill potential of the new DAD weapons, STINGER, ROLAND and DIVAD Gun makes it imperative that coupling of these weapons to the overall AD C^3 system be improved as soon as possible. The technology to support such an interim capability is available. The Marines have developed a WDU to link the SHORAD and MANPAD weapon teams to the IHADP. The WDU employed a digital data link compatible with military VHF/FM radios to transfer alerting and pointing information from IHADP to the SHORAD and MANPAD weapons. Tests showed increased detections and launches by the MANPAD teams at increased average detection ranges. The WDU development has continued, and this work appears directly applicable to the DAD C^3 problem.

(S) (3) Exploitation of SIGINT data for identification purposes. There are a number of different types of SIGINT data (COMINT and ELINT) which could be useful as aids for identification of hostile aircraft. Soviet and WP aircraft carry emitting avionics equipment which can be exploited to yield aircraft identity and location information. It appears that the exploitation of a particular SIGINT source would be very useful and could be implemented in Europe in the near term. An exploitation system for this source could be assembled with the proper intercept receiver, collection platforms, data links, processing centers (all straight-forward hardware requirements) and with the establishment of procedures for timely dissemination of the intelligence data to the various users. For adequate coverage of the AFCENT region, one ground processor and three to six aircraft could provide a quick-reaction capability. This system could provide identification and track data on WP aircraft of sufficient accuracy for AD battle management and weapon allocation purposes and for most weapon cueing purposes.

(S) 2. Proposed Approaches for Longer Term Improvements (U)

(S) a. Direct Identification Approaches. The Task Group proposes two longer-term approaches which appear to be able to jointly solve the direct identification problem.

(S) (1) Use of Advanced JTIDS type system. Advanced JTIDS type systems have three complementary modes of operation which could be used for identification purposes:

- A direct interrogation mode referred to as the RTT where a synchronous reply is sent immediately in response to an interrogation
- A position and identity mode whereby the users in the system issue identification and position in their time slots which is independent of interrogators or of radars which might desire to use such information
- A data link mode for secure transfer of position and identity data for indirect identification

Preliminary calculations suggest that by proper design of the RTT mode, by power control, and by multiple interrogation coupled to the frequency hopping and spread spectrum features already designed into JTIDS type systems, an identification system using an advanced JTIDS system could be designed which has a sufficiently LPI[1] that it can be turned on in the crucial combat zone. Specifically, such a system could be designed to have direct interrogation times of 0.1 seconds minimum with an LPI capability of 40 dB. A tradeoff between LPI and interrogation time exists with reduced interrogation times being available at reduced LPI. The AJ capability of such a system would be with an appropriate communication signal level. It could operate up to a range of 450 kilometers at reduced LPI and it would have the flexibility of solid state transmitter power control. Finally, position accuracies of the order of 70 meters would be obtainable at ranges of 120 kilometers.

With regard to the suitability of such a (modified) advanced JTIDS for the direct identification part of the NATO FIS, it is noted that such a system would (if properly designed):

- Meet all interrogation time requirements stated by NATO except the short range (500 meters) air-to-air requirement of 0.01 seconds, which is an overly severe requirement whose validity and utility is highly questionable
- Exceed the stated LPI requirement
- Provide substantial AJ (20 dB)
- Be ideally suited for use in any NATO FIS indirect subsystem

(U) [1] An LPI communication system uses a variety of techniques - particularly spread spectrum - to reduce the signal perceived by the enemy to a level below the noise level, receivers recover the signal to intercept. Friendly receivers recover the signal out of the noise using special processing techniques.

- Provide much needed multi-function non-identity related capability without the necessity of using separate black boxes for these functions

- Meet all interrogation range requirements stated by NATO except the 850 kilometers AEW identification range requirement, which is also an overly severe requirement whose validity and utility is also highly questionable considering the AWACS capability

(C) (2) Use of a Millimeter wave direct IFF system for short range (MANPADS/SHORADS). Millimeter wavelength direct IFF applications systems have a number of advantages for short range applications. These include:

- Narrow interrogation beamwidths with small antennas

- Reasonable all-weather short range performance

- Difficult to exploit from a distance because of atmospheric attenuation

The concept proposed is to interrogate a passive retro-reflector antenna on the aircraft. The antenna reflects the energy back towards the interrogator, instead of broadcasting it in all directions. In addition, the reflection can be modulated with a suitably encrypted code if required. It is expected that current technology developments in the 90 GHz region could support a reasonable, short-range IFF system of this type for SHORADS/MANPADS weapons.

(S) b. <u>Indirect Identification Approaches</u> (U)

(S) (1) Use of TDOA systems for identification. Since all aircraft radiate in the communications and radar bands at some time, detection of these radiations could be used an an identification aid. In order for these radar or communications systems to be useful for aircraft target identification, TDOA or the radar/communications used must produce location accuracy good enough to positively associate a particular identification achieved through parameter association with a radar track. TDOA systems such as PLSS, AGTELIS and ELS have a potential for emitter location accuracies of 50 meters or so and are ideal for this purpose.

The specific concept proposed would make use of PLSS/AGTELIS data from moving radar emitters which is normally discarded. This data would be processed in a separate processor to obtain emitter identification and location information on friendly and enemy air vehicle radar emitters. This information would then be used to generate air vehicle identity and track association data of great value to AD units for target identification. The same approach would be used on friendly and enemy air vehicle communications, using ELS-like intercept systems.

(S) (2) Development and use of a highly netted radar/TDOA complex to maintain continuity of track and identity. Recent progress in advanced signal processing has now made possible automatic acquisition and tracking of all aircraft within a surveillance radar's field of view. The addition of low sidelobe antennas of inexpensive construction greatly reduces susceptibility to jamming. These advances make it practical to net together many radars with partially overlapping coverages into an overall system capable of maintaining very large area coverage, continuity of tracks and continuity of identification. These new techniques and the netting proposed would provide the following important advantages:

- Lessened vulnerability to enemy actions

- o Network less fragile to loss of individual radars
- o Individual radars less costly to replace
- o Good geometry to counter main-lobe jamming
- o Jammer location using DF and TOA
- o Emission control without loss of coverage (e.g., blinking against ARMs sector jamming burn-through)
- o Improved low-altitude coverage
- o Height finding using two or more radars
- o Incorporation of AWACS in the net to provide low altitude coverage and continuity
- o Maintenance of track and, hence, continuity once identification established

(S) E. RECOMMENDED ACTIONS (U)

(S) 1. Based on these proposed approaches for near-term and longer-term improvements in the current direct and indirect target identification capabilities of the NATO AD system, the following actions are recommended as being of the highest priority:

- o The implementation in Europe of a more effective and extensive communications and data processing architecture for the parallel and redundant exploitation of AWACS data for indirect target identification as proposed

- The immediate development of a data-link system

  - based on the technology base established in the Marine's WDU and TST/IDT programs -

  for coupling the DAD weapons (SHORADS and MANPADS) to the HAWK C^3 system

- The implementation in Europe of the capability for the exploitation of a certain specific SIGINT source for aircraft target identification

- A reconsideration by the DoD of its position relative to the direct element of the NATO FIS and the adoption of a multi-function (communications, navigation, identification) JTIDS/TDMA-like system as the basis for the future direct target identification instead of the current approach of a separate black box for identification

- The initiation of advanced development of a millimeter wave, coded retro-reflector IFF system for short range applications such as DAD

- The initiation of an advanced development and test program - using existing PLSS and AGTELIS advanced development hardware - to demonstrate the feasibility of using TDOA systems as identification adjuncts to radar detection and tracking systems

- The initiation of a concept definition study of the use of nearly complete radar netting to maintain track continuity and eliminate need for frequent identification. The study should define appropriate new multifunction radars to be netted, the proper signal processing for effective and efficient passing of tracks and for incorporation of TDOA - derived identity with the tracks and the communication links required to complete the netting process

(S) 2. Also recommended, but of somewhat lower priority are the following:

- o The addition of JEM equipment to the HAWK CW acquisition radar
- o The implementation of Mode 5 on the MK XII IFF system
- o The conduct of a feasibility and cost effectiveness study of the use of a passive point-of-fire system with the SHORADS and MANPADS weapons. If the study results are favorable, the initiation of an advanced development program for such a system should be undertaken
- o The addition of EIFF equipment to the HAWK system

(C) 3. The following technology initiatives are also recommended:

(C) a. Basic Research (6.1) (U)

(C) (1) Continuation of research on computerized spatial pattern recognition and identification of two-dimensional target images in the plane normal to the viewing axis of visible, infrared and millimeter wave imaging sensors.

(C) (2) Initiation of research on computerized recognition and identification of targets observed by FLIR's.

(C) (3) Initiation of measurements and research on absorption bands in the ultraviolet, infrared and millimeter wave regions for use in the design of controllable short-range identification systems using such frequencies and which will not be observable or jammable at longer ranges.

(C) b. Exploratory Development (6.2) (U)

(C) (1) Continuation of advanced development of systems to perform identification using target range profiles using HRR radar data.

(C) (2) Continuation of advanced development of systems to perform identification using target range profiles using MFR data.

(C) (3) Initiation of development work to adapt for ground-to-air use and demonstrate feasibility for identification of a laser three-dimensional sensor coupled with a spatial pattern recognition computer which has been demonstrated in air-to-ground identity applications.

(C) (4) Initiation of developmental work on a system to perform helicopter identification using doppler-shifted radar returns from rotor blades. Belief in the practicality of this proposed technique is based on demonstrated recognition of helicopters by analysis of target acoustic signals from rotors which, however, is too short in range because of acoustic propagation.

(S) II. DISCUSSION (U)

(S) A. ANALYSIS OF OPERATIONAL AND FUNCTIONAL NEEDS (U)

(U) 1. General.

(U) a. The enormous challenge of providing effective identification of air vehicles operating in the Central Region during wartime has been stated by NATO as one of its most pressing problems. The current identification system employed in the Central Region (which consists of a combination of the direct interrogation reply system, direct visual identification, MK X/MK XII, various situation dependent operational procedures and rules of engagement) is clearly inadequate to satisfy operational requirements. The inadequacies of this system have been well-documented in DALFA Study 1-77.

(U) b. To overcome the deficiencies of the present system effective technological solutions are needed. These solutions must be highly reliable, real-time responsive, jam and exploitation resistant and most important, immediately available to the AD weapon system at the point of fire. The following discussion establishes the major operational needs which any effective solution to the NATO identification problem must meet.

(S) 2. Operational Needs. (U)

(U) a. Reliability. Ideally, both direct and indirect ID systems would function correctly 100% of the time. However, from a practical viewpoint, only some level of performance below 100% is achievable. Nevertheless, military commanders will operate with the best equipment available and compensate for deficient equipment performance by structuring rules of engagement and operational procedures most appropriate to the combat situation.

The consequences of incorrect ID are most immediate and severe at the point of fire. Reliable direct ID at the point of fire can serve as a final check or validation for indirect ID information. Therefore, some measure of error passed through the indirect ID channels can be corrected where it really counts- at the point of fire. It is most critical then that direct point-of-fire ID systems have a very high degree of reliability and it is not inappropriate to state the operational need as very close to 100% (e.g., 9.99 to .999). It is possible to accept somewhat lower reliability in the indirect ID system as long as the point-of-fire system is highly reliable. The amount of ID error permissible in the total AD C^3 system is not quantified in this study, but levels of ID error which would seriously impede the threat prioritization and allocation process would be unacceptable.

(S) b. Responsiveness. Because of the nature of the air interception problem, time is a critical factor in any ID process. If the ID process uses a direct electronic interrogation reply system, some small increment of time must exist between interrogation and reply. Because of high closing rates and high maneuverability, an air vehicle target may escape the engagement envelope in a fraction of a second. NATO has expressed an operational need for ID elapsed times no greater than 10 milliseconds. The 10 millisecond requirement apparently is driven by a stated need for air-to-air identification at an initial range of 500 meters. It does not appear reasonable to the Task Group to insist on this very special, and probably unlikely, case as an overall system requirement. It is especially inapplicable for surface-to-air IFF.

The flow of ID information through the C^3 system is through many channels and it is used for many purposes, e.g., alerting, advising, directing, etc. The necessary speed of transmission obviously varies with the purpose. When the purpose is authorizing engagement the speed of transmission requirements are as stringent as the point-of-fire interrogation-reply time requirement stated above -- 0.1 seconds.

However, when ID information is passed for other purposes, it is sufficient that the user receive the information in sufficient time to take appropriate action.

(U) c. Security. In a general sense, it is important to deny the enemy any information which he could exploit. Certainly there is an operational requirement to deny the enemy the panoramic view of the air battle as it exists in our C^3 system. Thus, there is a valid operational requirement for an airborne or ground-based weapons system to receive ID information and instructions over secure communications channels. Security aspects of the ID process as it applies to airborne systems conducting interceptions are more complex. If the ID process is active, it may alert the target vehicle, whether the process is secure or not. It may also highlight the presence of the interrogating aircraft and be susceptible to exploitation by enemy defensive systems. This leads to the need for LPI active ID systems. If the airborne ID process is passive, it is automatically secure. While the relative advantages of a passive system over an active system for airborne interceptors are apparent when the interceptor is operating in enemy airspace, there are disadvantages to such a system when the interceptor is operating in his own airspace. Thus, there appears to be an operational need for both active and passive ID capabilities in interceptor aircraft. Much the same rationale can be used to support the inclusion of both active and passive ID capabilities in ground-based systems where location by the enemy increases the probability of destruction by enemy firepower.

(S) d. Discrimination. The current and proposed WP air attack capabilities will sorely tax NATO's limited AD resources. NATO will have to operate at a high level of efficiency to keep air attack damage to acceptable levels. Thus, there is an operational need to identify enemy air vehicles by type at ranges where engagement choices are open.

NATO air defenders could then concentrate their resources on the highest priority targets among the attacking enemy air vehicles. JEM systems are representative of the type of technology pertinent to this operational need.

(U) e. Range-Continuity of Tracks. "Birth-to-death" tracking is approaching feasibility as demonstrated by AWACS technology and new technology for use in radar netting. The point of origin of an aircraft is a positive ID cue and may well contribute also to type classification of the target. Moreover, continuous tracking reduces the magnitude of the ID problem, since there would be no or few air vehicle tracks which would have to be reidentified. Thus, there appears to be an operational need for birth-to-death tracking of air vehicles in the forward area, and, if feasible, for birth-to-death tracking of air vehicles in the Western Military Districts of the Soviet Union.

(U) f. Communications/Interoperability. The integration, correlation, and identification of radar data from multiple sources such as the E-3A, ground radars, and TDOA systems, must occur in real time. To meet this need, standard message formats such as established under the TACS/TADS program must be developed within NATO. The transmission media must be secure, jam resistant, and possess a suitably high data flow rate with multiple redundant path options. These considerations lead directly to requirements for the AD C^3 system.

(C) g. Capacity. The AD C^3 system and its ID subsystem must have a high volume capacity if it is to function effectively in the Central European theater. The total system track/ID loads could be as high as several thousand in a peak activity hour. Subsystem track loads will vary from sector to sector, but system capacities and range should accommodate anticipated loads when adjacent subsystems are not operational. These considerations lead to operational needs regarding track capacity and for redundancy and survivability of the overall C^3 system.

(U) h. Environmental Compatibility. The AD C^3 system and the weapons systems it controls not only have to satisfy the operational needs cited earlier in a benign environment, they also must satisfy those needs in the anticipated theater wartime environment. Thus, there is an operational need for the system, and its ID subsystem, to function day or night, in all weather and in an intense EW environment. The system must also continue to operate despite anticipated combat damage, and it must interoperate effectively with various national subsystems.

(S) B. ASSESSMENT OF PRESENT CAPABILITIES AND DEFICIENCIES (U)

(U) 1. General. There are two fundamental ways in which aircraft target identification can be carried out: directly, by means of interrogator-transponder or non-cooperative IFF techniques carried out at the point-of-fire; or indirectly, by means of target identification data generated by sensors located elsewhere in the battle area and relayed to the fire unit via the AD C^3 system. Neither of these approaches, direct target identification or indirect target identification, can be relied on to do the entire aircraft target identification job by itself under the wide variety of circumstances that may be encountered on the NATO battlefield. Rather, a judicious combination of direct and indirect techniques must be employed, which hopefully will produce an overall target identification system with viable, useful performance over the wide range of expected combat situations. This section addresses the indirect component of this overall system.

(S) 2. Current Indirect ID Capabilities and Deficiencies. (U)

(C) a. There are a number of potentially useful sources of indirect target ID data which currently exist in the 4th ATAF area. These include:

- Radar tracking data generated by 412L radars, 407L radars, the air surveillance radars at the AAD BOC, the Hercules and HAWK radars, and the FAAR.
- Flight plans and in-flight updates for Blue Air, for both the AD aircraft and the strike and CAS aircraft.
- Air space control procedures.
- SIGINT data.
- MK X/MK XII identifications generated by the IFF interrogations collocated with the various air surveillance and AD radars.

(C) b. There are a number of different elements of the overall AD C^3 system which could exploit some or all of these data sources for indirect target identification. These elements include the Air Force CRC, the AAH GOC and BOC, the Hercules and HAWK batteries, the Chaparral/Vulcan fire units, and the REDEYE teams. Figure I-2-1 presents a wiring diagram showing the way that these elements, plus a number of others that are only indirectly involved in AD, are interconnected in the current 4th ATAF C^3 system. Figure I-2-2 shows which of these elements, as a result of these interconnections, get which of the classes of indirect target identification data.

(S) c. Insofar as indirect target identification is concerned, there are several problems or limitations with the current C^3 system. The principal ones appear to be:

(S) (1) Sensor Limitations. Against low flying aircraft, the current radars provide rather incomplete coverage, with major gaps being commonplace. Because of this, it is

(S) 4TH ATAF C^3 SYSTEM (U)

SECRET

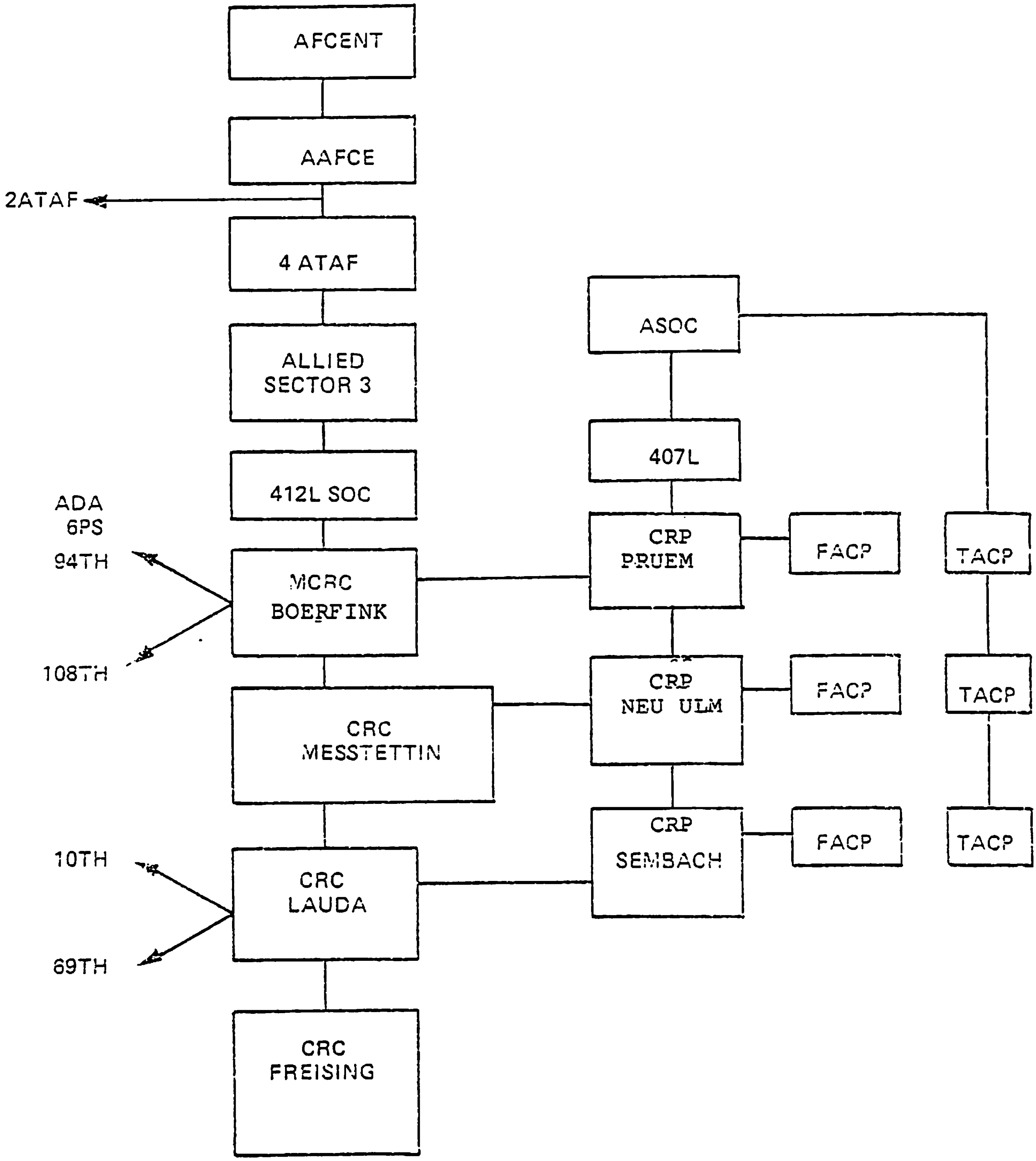

FIGURE I-2-1

(S) Data Availability Matrix (U)

FIGURE I-2-2

Data Types/Sources → Air Defense System Elements ↓	Radar Tracks & Mark 10/12 Interrogations						Flight Plans & In Flight Updates		Air Space Control Procedures	SIGINT
	412L Radars	407L Radars	BOC Radars	Hercules	Hawk	FAAR	Air Defense A/C	Strike & CAS A/C		
CRC	X	X Salty Net			(X)		X	X	X	
GOC/BOC	X	X	X		(X)				X	
Hercules	X	X	X	X					X	
Hawk	X	X	X		X				X	
Chaparral/Vulcan			Limited		Limited	X	Limited	Limited	Limited	
Redeye						X				

(X) ⟹ Data availability that will be present when TSQ-73 is operational impossible to maintain track continuity on low altitude air vehicles, which leads to loss of ID and the subsequent need for reidentification when the air vehicles again come into the radar's field of view. So, not only is there loss of coverage which limits the performance of the C^3 system, there is also loss of the ID which leads to further loss of performance of the C^3 system.

(S) (2) Traffic Handling Capacity Limitations. The various nodal elements in the AD C^3 system have limited target handling capacity. Specifically, their capacities at the present time are:

412 L System--------------100 tracks per CRC
407 L System--------------256 tracks per CRP
TSQ-73--------------------256 tracks per TSQ-73

In the 1982-1984 time period, the current 412 L system will be replaced by the GEADGE system. This new system will have an improved track capacity of 400 tracks per GRC.

On the other hand, during a NATO/PACT conflict there may be more than a thousand aircraft plus large numbers of helicopters operating at the same time in the 4th ATAF air space. This number of air vehicles will certainly produce local traffic saturations of the AD C^3 system, and may also produce saturation across the entire 4th ATAF region. In such a situation, the various nodal points of the AD C^3 system will be unable to process and disseminate all of the friendly/hostile air vehicles tracking and identity information presented to them. They will instead attempt to disseminate aggregate data on groups of air vehicles, and, under current 4th ATAF/32nd ADCOM procedures, will probably cease the downward dissemination of most data on friendly air vehicles. As a result, in such a saturated environment the AD C^3 system will have only a very limited capability for indirect identification of enemy aircraft and essentially no capability for indirect identification of friendly aircraft.

(S) (3) Limitations in the Coupling of DAD Firing Units to AD C^3 Systems. Currently, the DAD weapons -- Chaparral, Vulcan, and REDEYE -- are almost completely uncoupled from the rest of the AD C^3 system. Their only tie-in is a VHF single channel voice link from the BOC in the Division area to the Chaparral/Vulcan Battalion CP. Considering the large number of friendly/enemy air vehicles which may be operating in the Division area at one time -- scenario studies have shown average loads of 40 to 60 and peak loads of 150 -- this voice link will be totally inadequate for the transmission of air vehicle tracking and identity data which the AD C^3 system may possess to the DAD firing units.

In this situation, the only source of air vehicle tracking and identity data available to the DAD weapons will be that from the FAAR relayed via the TADDS. Because of the manual operation of the FAAR radar, the manual interface between the radar and the TADDS digital data link and the gross nature of the aircraft position data that is relayed (± 2.5 kilometers), the aircraft location and identity data passed to the Chaparral, Vulcan and REDEYE fire units via the FAAR/TADDS system are of only marginal utility.

This situation -- the lack of adequate coupling of the DAD weapons to the AD C^3 system -- will become critical in the early 1980's, as a series of new weapons, Stinger, Roland and DIVAD gun, are added to the Division inventory. These new weapons have greatly increased performance. Their potential for shooting down enemy aircraft (on purpose) or friendly aircraft (by mistake) is considerably greater than that of the weapons they replace and much more effective ID capability will be essential for DAD firing units.

(S) (4) Limitations in the Exploitation of SIGINT Data. There are a variety of types of SIGINT data -- radar emissions from enemy aircraft, GCI communications, etc. -- which may be potentially useful as an identification and tracking aid for hostile aircraft. Currently, the 4th ATAF AD C^3 system makes no use of these data for indirect target identification. They are retained at a high level within the command system -- the master CRC at Boerfink -- and used only for indications-and-warning purposes.

(S) 3. Current Direct ID Capabilities and Deficiencies. Current direct ID capabilities are limited to the MK X/MK XII systems plus visual ID. The capabilities and deficiencies of these techniques are discussed below.

(U) a. Capabilities of the Current MK X/MK XII system. The MK X/SIF system is widely used throughout the U.S. and NATO for normal peacetime air traffic control. The MK XII system, which consists of the MK X plus the Mode 4 crypto-secure interrogation link, is widely used in current NATO-based U.S. and Canadian military aircraft and in all U.S. and German 4-ATAF Nike and HAWK units and one Netherlands Nike unit. It will be implemented also in all German aircraft in the near future. However, the UK and Belgium have not adopted the MK XII system, principally because of its many limitations.

Chart I-2-1 briefly outlines some of the important system characteristics of the MK X/MK XII systems. In most normal installations, the MK XII will operate at ranges substantially in excess of the ranges of the radars with which it is associated.

The basic MK X/MK XII system incorporates technology and techniques that are 15 to 20 years old, and it has been estimated that a total of $2-4 billion has been spent over the years in its development and fielding. There have been sporadic attempts to update the system and a number of different equipments are now in the field. As a result, the system suffers from a variety of equipment reliability and field maintenance problems, as well as a few interoperability problems.

CHART I-2-1

(C) CURRENT MKX/XII CHARACTERISTICS (Ref 1,2) (U)

(Interrogate 1030 ± 0.2 MHz; reply 1090 ± 3 MHz; vert. polar.)

			MODE	CHARACTERISTICS
"MK XII IMPROVEMENT"	MK XII	MK X (SIF)	1	Double-pulse interrogation, 0.8 ± 0.1μ s pulses, 3 ± 0.1 μs spacing. 32 reply codes changed at 30 ± min. intervals 0.45 ± 0.1 μs pulses a/c mission reply
			2	Double-pulse interrogation, 0.8 ± 0.1 μs pulses, 5 ± 0.2 μs spacing. 4096 reply codes set on ground, changed when required. 0.45 ± 0.1 μs pulse. Tail No. reply (in formations only lead a/c replies).
			3A*	Double-pulse interrogation, 0.8 ± 0.1 μs pulses, 8 ± 0.2 μs spacing. 4096 reply codes changed at 30 ± 1 min. intervals. 0.45 + 0.1 μs pulses. Military function and special ID reply.
			C*	Double-pulse interrogation, 0.8 ± 0.1 μs pulses, 21 ± 0.2 μs spacing. 1278 reply codes. 0.45 ± 0.1 μs pulses. Altitude reply.
			4	Multiple-pulse interrogation, 0.5 ± 0.1 μs pulses, 32 pulse positions spaced 2μs, randomly occupied under crypto control. Three-pulse reply, 0.45 + 0.1 μs pulses, 1.8 + 0.2 μs spacings. 16 possible time delays, 4 μs spacings, crypto selected.
			5	Improvements, such as rapid code changes, improved decoders and decision logic, diversity and monopulse antennas, to reduce vulnerability to exploitation, jamming, saturation, and spoofing.

*Extensively used by the FAA for air traffic control

In addition, present MK XII systems have a variety of widely-known weaknesses such as relatively easy exploitation and jamming and spoofing susceptibility. These weaknesses could prove disastrous, or, at best, make the system useless in a sophisticated ECM environment.

Extensive studies of the various deficiencies of MK XII have been undertaken and a variety of improvements have been proposed for many of these. It is clear that the operational impact of these various deficiencies is highly scenario dependent - but the Task Group has restricted its considerations to those of greatest concern in the NATO AD environment. The following pages discuss deficiencies of the MK XII system; a somewhat expanded discussion is presented in Appendix A.

(S) b. Deficiencies of MK XII, Mode 4: Reliability. Three forms of reliability will be distinguished:

(C) (1) Equipment Reliability. Serious equipment reliability problems have been cited which not only impair operational utility, but reduce operator confidence in the system. No complete quick-check field equipment appears to have been developed to satisfy this need. The interrogators, in particular, appear to be a weak link in the system due to some highly stressed components in the transmitter.

It must be noted that this problem is being addressed by the MK XII Technical Improvement Program at Warner Robins Air Force Base and the MK XII Improvement Program at the Naval Research Laboratory.

It should also be noted that a greater commonality among the equipments fielded by the various users could lead to improved reliability, improve interoperability and probably reduced costs and logistic problems.

(S) (2) Interrogation Reliability. In addition to equipment reliability, the MK XII system has problems with the reliability of a single interrogate/reply round trip, called "round-reliability." Round-reliability is a function of a great many variables including scenario-dependent factors such as multi-path propagation, range, numbers of interrogators and transponders, ECM environment, etc.; as well as equipment characteristics such as antenna sizes and locations, decision logic, etc. It should be noted that "round-reliability" is not to be confused with the reliability of a complete interrogation sequence, which usually consists of a number of rounds, depending on equipment design and decision logic. This is often called "interrogation reliability."

Inadequate transponder antenna installations on aircraft have been credited with causing wide variations in interrogation reliability. The F-4 aircraft is noted to be particularly vulnerable in this area. The problem of adequate system testing (as opposed to testing of interrogators or transponders separately) needs further attention in order to pinpoint system problems and/or improve user confidence.

There is serious concern that even if the interrogation reliability, or probability of correct ID is fairly high (> 0.95), there is still a good probability that in an environment of dense AD weapons, at least one ground weapon will not correctly identify and will engage a friendly aircraft.

(C) (3) Operator Reliability. In addition to the hardware reliability and interrogation reliability problems mentioned above, there are reliability problems associated with human operators. For instance, the crypto codes in some transponders can be zeroed (destroyed) by shocks such as those associated with rough landings unless a "hold" switch is activated. The operator is also required to see that the proper codes are set into the equipment before takeoff and that the MK XII is switched to the proper code for that day. (Typically, two sets of codes, or two days of operation, can be sustained without inserting new codes on the ground.)

These problems are severely aggravated by the fact that operators only rarely have a chance to train and exercise with the MK XII, Mode 4 equipment. As a secondary result of the lack of controlled exercises, there is also a paucity of data on the effectiveness of the complete system in realistic environments.

(S) c. Deficiencies of MK XII, Mode 4: Exploitation. (U)

(C) (1) It is felt that possible exploitation of the MK XII Mode 4 is one of its chief weaknesses in a sophisticated ECM environment. This exploitation can be done in several ways, either passive or active. Obviously the enemy can passively DF and track a squawking transponder or interrogator. In addition, the enemy can record one or many valid interrogations that can be used to trigger any of our MK XII, Mode 4 transponders, enabling him to interrogate and thus identify and track his targets. This interrogation is useful for up to 24 hours, although one of the fixes proposed for Mode 5 is to change codes so rapidly that this form of exploitation could be negated, unless the enemy almost continuously monitored and repeated our interrogations. It is noted that it would be relatively easy for the enemy to receive AWACS interrogations from well behind the FEBA.

(C) (2) Even without recording one of our interrogations, if the enemy understands the system, he can guess at our interrogation code with a probability of guessing correctly in 1 of 256 tries. Once found, this code would be correct for up to 24 hours. Again, techniques have been developed, such as that described above, to limit the utility of this form of exploitation.

(S) (3) Several WP countries are now known to have a ground TDOA system similar to AGTELIS which is used in their AD system. It has been known for some time that the Czechs have had systems deployed and, more recently, it has been established that the Hungarian AD have at least one system. The Soviets have two models deployed in the Baltic. In addition, the Romanians are known to have a system under development. With this established trend, it is easily concluded that the entire WP will be so equipped and will be able to TDOA on the current MK XII IFF system.

(C) d. Deficiencies of MK XII, Mode 4: Jamming. (U)

(C) (1) Although either the interrogator or transponder receivers can be degraded or inactivated by the enemy by any form of jamming, CW and AM- or FM-modulated CW jamming requires the most assets, pulse-width and amplitude noise jamming is easier and intelligent jamming is easiest of all.

(C) (2) For instance, a series of pulse triplets could be sent to the interrogators appearing as a series of synchronous or invalid replies (fruit). This would overload the system and reduce the probability that friendlies will be properly identified. In addition, the instantaneous side-lobe suppression circuitry in the transponder can be inhibited by suitable pulse sequences, also reducing the time available for or preventing valid interrogations.

(C) (3) Another form of intelligent jamming simply over-interrogates Modes 1 to 3 (SIF). Although the transponder will not reply to these modes when set on Mode 4, it forces the receiver to separate these interrogations from valid Mode 4 interrogations. This, too, can load up the system and the design of this decoder directly affects round-reliability.

(U) (4) Even in a friendly environment, over-interrogation, caused by a multiplicity of over-active interrogators and/or transponders (garble), can be considered a form of self-jamming, reducing receiver sensitivities (hence range) and reducing round-reliabilities.

(C) e. Deficiencies of MK XII, Mode 4: Spoofing. (U)

(C) (1) Spoofing, or pretending to be what you are not, appears to be one of the least likely threats in the NATO environment. For instance, since the reply code is fixed and well known (3 equally spaced pulses), and only the time delay is coded, an enemy aircraft could guess at the time delay associated with each round and be correct 1 time in 16. In fact, he would be correct on the average 1 time in 16 with a fixed time delay. However, if a given reply evaluator logic requires n correct replies, then the probability of guessing all of them is only 1 in 16^n. Such logic is incorporated into the MK XII system specifically to eliminate such spoofing.

(C) (2) A more likely tactic is for the enemy to repeat the reply of a nearby MK XII transponder and appear as a "friend" to the interrogator. Since the enemy can measure the time difference between the interrogation and the reply from a nearby transponder, he can determine the appropriately delayed response to that interrogation. A fix to this called "Wooden Duck" has been implemented for the AN/APX-103 interrogator for AWACS. In this case, an incorrect interrogation and reply are transmitted by the interrogator; the enemy repeats, the friend does not.

(C) (3) Another possible form of spoofing repeats interrogations so that a nearby MK XII transponder is triggered to reply properly. If the timing and geometry are correct, the reply arrives at the friendly interrogator in time to make the enemy appear as a friend.

(C) f. Visual Identification. Visual identification is used instead of MK XII for DAD firing units and in certain other situations, but it is not a very satisfactory technique. High performance aircraft operating in the very low altitude regimes expose themselves for a period of time far too short for reliable identification. Furthermore, training under realistic conditions is almost impossible. Thus, despite best efforts, a significant percentage of misidentifications do occur using visual identification. Further, it does not possess the night/all weather capability of the new radar directed DAD weapon such as Roland and DIVAD guns.

(S) 4. NATO Considerations (U)

(S) a. Aircrew/AD Operators Perspectives. Aircrew comments on deficiencies in current safe passage and recovery procedures are grouped into two categories:

(S) (1) IFF/SIF Equipment and Procedures:

(a) Not all aircraft, as stated previously, are MK XII Mode 4 equipped. British and Belgian aircraft and U.S. LORAN-equipped F-4Ds are examples of aircraft without a Mode 4 capability.

(b) In a high ECM environment, aircrews question the likelihood of ground-based interrogators being able to properly interrogate airborne transponders.

(c) Verification that the aircraft's transponder is working properly is impossible without extensive communications with a ground-based interrogator.

(d) The tactical soundness of operating the IFF/SIF transponder in the vicinity of the FLOT is questionable. The IFF turn-on lines, 10 NM and 30 NM, on the enemy sides of the FLOT, for low and high altitude, for homebound aircraft respectively, is of real concern to aircrew members because of enemy exploitation.

(S) (2) SFL Procedures:

(a) The present SFL bands are 10,000-15,000 feet and 40,000-45,000 feet. In order to use sanctuary altitudes, aircraft are required to climb over enemy territory in order to cross the FLOT at 5000 feet. Aircrews are concerned that this places the aircraft in a very vulnerable position in respect to enemy forward AD.

(b) SFL bands do not allow recovering aircraft to operate at altitudes optimum for fuel conservation. Returning from a mission with sufficient fuel for a safe recovery is always a concern for the aircrew. Fuel used to climb and fuel flow figures, extracted from the performance data section of the F-4 Flight Manual, show that after nine minutes of cruise at 12,000 feet total fuel used is greater than if the aircraft had climbed and cruised at 25,000 feet.

(c) Aircrews question the validity of their information on the location of the FLOT. Considerable time elapses from the time Army ground position is transmitted to the wing, the aircrew is briefed for the mission and then the mission is actually flown. In a highly fluid situation, it is possible that the FLOT may have moved considerably during this timeframe. Secondly, the FLOT is not a well defined line on the ground or a map.

(S) b. AD operators' comments have been addressed to three areas of concern:

(S) (1) Engagement Restrictions: Current plans require HAWK units to deploy "as far forward as possible" and to engage hostile aircraft "at maximum effective range." Many of the HAWK positions provide engagement capability east of the FLOT. However, HAWK units are not allowed to engage aircraft east of the FLOT. The reason given for this restriction is to allow a weatbound aircraft to show a friendly maneuver west of the FLOT. This restriction is reinforced by the forward edge of the LOMEZ. A HAWK fire unit, without an operational IFF/SIF is not allowed to fire unless target identification is provided by a controlling agency or an adjacent fire unit.

(S) (2) SFL System: (U)

(a) The sanctuary flight bands are too thin. Each flight level band is only 5000 feet. This allows only six possible SFL combinations. An aircraft flying at a random altitude between 8000 and 17,000 feet is at a friendly sanctuary altitude 44% of the time. Between 10,000 and 15,000 feet the aircraft is at a friendly sanctuary altitude 60% of the time. Thus, the probability that a foe can successfully use the sanctuary altitude ranges to avoid being engaged is too high.

(b) Both the HAWK and NIKE systems must lock-on and track a target to determine altitude and speed. Each fire unit has only one tracking radar; hence, another target cannot be engaged while determining altitude on the first aircradt. Additionally, neither the NIKE nor HAWK systems display height with the accuracy required by the SFL procedures.

(S) (3) FLOT. Dissemination and the plotting of FLOT information is a time consuming process that is vulnerable to error. The FLOT is not a well defined line but rather a zone. For these reasons, the FSCL has been proposed as a better alternative for use in NATO.

(S) c. Studies and Initiatives (U)

(S) (1) Several studies in the past have highlighted the shortcomings in the Central Region procedures to insure passage at minimum risk through AD. As early as 1975, a tri-nation (GE, UK and US) combined working group identified several deficiencies with the SFL procedures. This study proposed a minimum risk routing system as an alternative to the SFL procedures. In addition to this study there have been numerous initiatives brought forth in an attempt to resolve the problem of minimum risk passage. The following is a discussion of the more pertinent of these initiatives.

Feasibility of the Sanctuary Flight Level System, 22 July 1977. This is an AAFCE study which looked at the validity of the SFL procedures.

Draft Central Region Airspace Control Plan, 16 June 1977. Primary objective of the plan is to provide an airspace control system composed of a minimum number of procedures which will guarantee, as much as possible, the free use of the airspace by all users under all combat conditions.

2D BN 62D ADA Aircraft Recovery Study, 25 May 1977. This study was conducted in early 1977 to examine the recovery procedures in effect in the Eifel Region.

Safe Recovery of Homebound Aircraft Penetrating the Battlefield and Rear Combat Zone, 23 May 1977. This 2D ATAF paper, after discussing the disadvantages of the current procedures, attempts to answer the question "Is there any way of identifying our own aircraft that does not rely on vulnerable equipment and communications and which does not force those aircraft to adopt tactically unsound profiles?"

Effect of SAM Hold Fire for HAWK Units Within Low-Level Transit Routes (LLTR), 3 August 1977. This study was conducted in mid-1977 by 4th ATAF. The study addressed the impact on HAWK units of the weapon control order SAM Hold Fire for LLTR.

AAFCE Routing and Recognition Work Group. This work group is endeavoring to bring together in a single document the pertinent information needed by the various users of the Central Region airspace.

Airspace Control in the Combat Zone Minimum Risk Procedural Control System, 12 October 1977. This document is a draft of procedures for the BALTAP (Baltic Approaches) area developed by Headquarters, Tactical Air Command Denmark. Its purpose is to prescribe procedures for minimum risk to friendly aircraft operating in the BALTAP area while maximizing freedom to AD weapons systems, even during heavy jamming conditions (radar/IFF/SIF) and including situations of no communication to controlling agencies.

(S) (2) These initiatives concluded that the use of the SFL system for minimum risk passage depends on the ability of the defensive radars to accurately measure and display the altitude of aircraft flying at a SFL. Tests conducted in 2D and 4th ATAF show that defensive radars are incapable of displaying aircraft altitude with sufficient accuracy (plus or minus 2000 feet) for the effective use of the current SFL system as a minimum risk passage procedure.

(S) (3) The Central Region Airspace Control Plan was developed in an effort to provide safe passage of friendly aircraft without impeding AD employment. LLTR and Transit Corridors are prescribed in the Central Region Airspace Control Plan as the primary procedures for insuring minimum risk passage. The joint Task Group analyzed the LLTR and Transit Corridor procedures as contained in the Central Region Airspace Control Plan. These procedures were determined not to be the solution to the minimum risk problem for the following reasons:

(a) The LLTR procedure as written does not provide minimum risk passage of aircraft between the FLOT and the FSCL.

(b) Forward SHORAD is overly restricted by the 10 kilometer wide funnel on the eastern end of each LLTR.

(c) LLTR by their design seriously impair the effectiveness of Improved HAWK in the Central Region.

(d) A 5 kilometer wide LLTR overly restricts aircrews during adverse conditions.

(e) Recovery routing is constrained by the procedures.

(f) The procedures do not compensate for AD spatial display inaccuracies.

(S) (4) A more recent effort, DALFA Project 1-77, Safe Passage in Air Defense, sought to determine "How do friendly aircraft operate in the NATO AD environment at minimum risk while allowing the AD system maximum effectiveness to engage hostile aircraft?" The joint Task Group concluded:

(a) Present procedures used in the Central Region for safe passage through friendly AD are inadequate.

(b) Total reliance on IFF/SIF procedures for safe passage is not feasible.

(c) Procedures for optimum offensive and defensive operations are not compatible; therefore, any procedures developed will restrict both offensive and defensive systems.

(d) The minimum risk passage problem is most acute in the forward combat zone.

(e) Minimum risk passage procedures must accommodate equipment capabilities.

(f) The FSCL is a better reference line than the FLOT for operations involving air and land forces.

(g) The Travel Route concept is the most advantageous of the minimum risk passage concepts analyzed.

(S) C. ASSESSMENT OF PROGRAMMED CAPABILITIES AND DEFICIENCIES. (U)

(C) 1. In the near term, four systems will be introduced in the 4th ATAF area which offer capability improvement and enhancement of identification process. These are AWACS, AN/TSQ-73, GEADGE and F-15 JEM which are discussed below:

(S) a. AWACS (U)

(C) (1) With the introduction of the E3A into the European theater, a powerful tool will be available for eliminating the current large, low altitude gaps in the NATO radar coverage. AWACS has the potential of enhancing ADA operations by providing:

- o Continuity of early warning information
- o More reliable identification, since the E3A has a continuous track of low altitude targets versus the intermittent tracks from ground radars which have to be reidentified
- o Faster and more effective reactions due to the longer time available for decision making by the CRC and ADA group
- o A form of radar netting to pass identified tracks, resulting in fewer interrogation by ground units

(S) (2) Under current planning, however, the utility of AWACS for indirect target identification to ADA will be significantly limited by three factors:

- Track data will be processed only on board each E3A aircraft and each of the E3A will only be able to process a maxirum of 100 to 200 aircraft tracks generated by its own radar. When larger numbers of aircraft are in the radar field of view, maintaining track continuity on individual aircraft will be impossible. (This is a limitation of the on-board track processor, not a limitation of the radar.)

- E3A information will be available to ADA units only by means of the "Salty Net" interface, i.e., E3A to MPC to 412 L CRC to Group AN/TSQ-73. Use of the E3A data by ADA units will be denied should the vulnerable 412 L CRC become non-operational.

- The number of tactical radio links that can be established from the E3A may restrict the extent and effectiveness with which the E3A can interoperate with other systems as prescribed by deployment concepts.

(S) b. AN/TSQ-73 (U)

(S) (1) The AN/TSQ-73 Missile Minder ADA Command and Control System will replace the obsolescent AN/MSG-4 equipment in Europe during the 1978-1979 timeframe. The AN/TSQ-73 will be deployed at the ADA Group and Battalion levels. It is a highly mobile, automated system capable of maintaining data on 256 aircraft. The Group level system maintains data on aircraft provided by its subordinate Battalions and the CRC. The Group level system is not colocated with an acquisition radar and therefore does not generate local data.

(S) (2) The Battalion system will be associated with either NIKE Hercules or Improved HAWK Batteries. It is capable of maintaining data on 128 targets received from the Group AN/TSQ-73 and two remote radars. The remote radar capability is not exploitable at this time due to the lack of an Army program to procure required remote radar processing equipment. The Battalion system has the capability to automatically acquire 64 targets from its local radar and to automatically track up to 128 targets simultaneously. Its ability to exploit this capability is determined by the type of acquisition radar with which it is colocated. Radars currently available in the ADA inventory are the AN/MPQ-43 (HIPAR), AN/MPQ-50 (IPAR) and the obsolescent AN/GSS-1/7 radars. The AN/GSS-1/7 radar is a variant of the AN/TPS-1D which was developed in the late 1940s. It has no ECCM capability and was designed against 10 square meter targets.

(S) (3) Current plans are to colocate the Hercules Battalion AN/TSQ-73 with Batteries so that it can utilize the AN/MPQ-43 as the Battalion sensor in lieu of the AN/GSS-1/7. This will allow exploitation of AN/TSQ-73 processing capability in support of NIKE Hercules operations. Colocation with the Hercules Battery has minimal tactical impact due to the relative immobility of the Hercules system.

(S) (4) However, the colocation of the HAWK Battalion AN/TSQ-73 with a HAWK Battery to permit interface with the Battery AN/MPQ-50, is considered to be inadvisable due to the limited range of this radar. The ability to exploit the AN/TSQ-73 processing capabilities when employed with HAWK will be limited due to the lack of a suitable mobile radar. The Army has initiated action to procure an "off the shelf" three-dimensional radar to overcome this deficiency in the near term.

(S) c. GEADGE. The 412 L command and control system will be replaced by the GEADGE system. While each 412 L CRC has a local track capacity of

100 tracks, a GEADGE CRC local track capacity will be 400 tracks. It is anticipated that it will incorporate message standards which are incompatible with those utilized by AWACS, 407 L, MPC and AN/TSQ-73. Message processing incompatibility will require the employment of translative devices, i.e., buffers, to permit data exchange.

(S) d. F-15 JEM Non-Cooperative Target Recognition. The F-15 employs a DMR method of identifying aircraft by means of its JEM. It has the potential of positively identifying all friendly aircraft and a fraction of enemy aircraft. It is capable of identifying aircraft within ± 45° in the head-on aspect and within ± 35° in the tail-on aspect. It is effective at 50-70% of maximum tracking range of the radar (approximately 50 miles).

(S) 2. Summary. AWACS provides an order of magnitude improvement over the current ground environment systems due to its capability to provide continuity of identified air tracks in an ECM environment particularly in the low altitude spectrum.

The AN/TSQ-73 by its capability to automatically track and report targets detected forward of the ground environment radars provides a valuable source of track identification and update as the C^2 network is degraded due to battle damage. This capability also represents an order of magnitude improvement in comparison to the obsolescent AN/MSG-4.

GEADGE provides a general evaluationary improvement to the 4th ATAF ground environment system by increasing its track handling capacity and capability to correlate information provided by other sources, e.g., ADA units. This capability may be degraded due to the lack of definition of interfaces to 407 L, AWACS, AN/TSQ-73, etc.

F-15 JEM provides a non-cooperative means of positively identifying hostile aircraft when engaged in air-to-air operations.

However, in spite of these programmed improvements, serious, perhaps total discussion in air vehicle identification will continue to exist in NATO.

(S) D. PROPOSED NEW CONCEPTS (U)

(U) 1. A number of system concepts have been identified which, if implemented, could serve to alleviate the deficiencies identified above and improve the overall target identification capability in NATO to an acceptable level. These system concepts are discussed below. For easy discussion, they are divided into near-term and longer-term categories which are further subdivided into direct and indirect target identification concepts.

(U) 2. The near-term concepts are additions and/or modifications to the current AD system which, if implemented, could provide relatively quick improvements to the system's capability for target identification. A key, and very limiting, criteria in their selection was their operational availability in Europe by 1983. In many cases, the items in this near-term category are quick fixes, intended to provide NATO with an improved interim capability to be used until a more permanent and more effective system is available.

(U) 3. The longer-term concepts discussed are systems which, when used in a complementary way, could solve the NATO target identification problem, but which could not be available until after 1983.

(S) a. Near Term, Direct Concepts. (U)

(S) (1) Adding JEM to the HAWK Acquisition Radar. Identification of aircraft by JEM of radar signals was described in "Report of the Army Scientific Advisory Panel Ad Hoc Group on Non-Cooperative IFF" (Confidential), February 1975 and in "Defense Science Board Task Force on Identification Friend, Foe or Neutral (IFFN)" (Secret) Final Report, 31 March 1976. This identification and classification by type scheme is based on the doppler spectrum of the radar return from an aircraft which consists of the airframe doppler return plus intermodulation lines and doppler returns from compressors and turbines. The latter are related to the number of blades and the shaft speed and can serve to help classify aircraft by type according to the engines they use.

Three different processing and classification schemes have been considered for extracting ID: (1) TRISAT; (2) DMR; and (3) SPECS. The last exists only as a computer software package with no dedicated hardware having been implemented, so it will not be considered further.

The DMR uses Fourier analysis to derive the blade counts of the first and second compressor or turbine stages, the symmetry of and the shaft rotation rate. These derived values are correlated with stored values of known engines to extract ID. This method requires less storage capacity than does TRISAT and exhibits good ID performance in regions approximately 40° to 45° around both nose and tail aspects. As compared with TRISAT, however, DMR (which is an Air Force sponsored development) is not in as advanced state of adaptation to the HAWK radar. However, DMR is being implemented on the F-15.

TRISAT has been under development by the Naval Electronic Center Lab Center at San Diego for over a decade and has been operated experimentally in conjunction with the Improved HAWK High Power Illuminator Radar with very high probability of correct ID against a number of aircraft. TRISAT correlates the direct doppler returns with stored returns from known engines and thus requires more memory capacity than does DMR. Furthermore, TRISAT functions only in a region of 40° to 45° around nose aspect. However, it is judged that TRISAT is sufficiently advanced in development and field testing that it could confidently be fielded with the HAWK system in the immediate near term. The Army has a program at the level of $500K per year to produce a fieldable model of TRISAT for use with the HAWK radar to be available in FY 1979 or FY 1980. This program should be accelerated.

The TRISAT should provide HAWK with an important supporting ID mechanism usable around nose aspect out to ranges of 50% to 60% of the radar detection range. Identification capability degrades proportionate to detection range in the presence of jamming. TRISAT gives a non-cooperative, day, night, all weather, relatively long range capability which can be made available in the near term.

The above recommendation to implement the TRISAT version of JEM on the HAWK radar is based on information presently available to the Task Group; particularly the fact that TRISAT has been operated with the HAWK radar. The Task Group does not have information regarding the degree of difficulty in adapting DMR to the HAWK radar. However, since the addition of tail aspect capability would be valuable, the Task Group recommends that the Army study this question. If it should be found the time and costs do not differ significantly, the Task Group recommends that DMR, rather than TRISAT, be implemented with the HAWK radars.

(U) (2) MK XII Mode 5. The term Mode 5 loosely includes a variety of improvements to the MK XII system that are being developed in several government laboratories and under contract. In addition to equipment reliability problems and the lack of training required to operate the equipment, the MK XII Mode 4 system can be readily exploited, jammed or spoofed. It is felt that the exploitation problem is the most serious of these and contributes significantly to its lack of use in Europe, as well as the reluctance of the UK (and others) to adopt the system.

Therefore, the techniques that have been proposed to rapidly and synchronously change encryption codes, a technique that would significantly reduce the possibility for enemy exploitation, should be implemented. This assumes that the development of a FIS is in reality many years off.

It may well be that in the course of implementing the above, several other improvements can be made at minimal additional cost. These are improvements that could reduce susceptibility to jamming, simplify coding procedures and improve greater equipment reliability. (See Appendix A for more details.)

(S) (3) Passive Point-of-Fire System for SHOPADS and MANPADS Weapons. Virtually all aircraft operating at low altitudes in close support of ground operations must radiate electromagnetic signals in order to successfully accomplish their missions. Examples of such would be terrain following radars, radar altimeters, attack or bombing radars, doppler navigation radars and voice or digital communications. At the relatively close ranges needed for SHOPADS and MANPADS weapons (> 10 kilometers), these emissions can be detected with relatively simple receivers and with relatively small antennas. Since most such systems are pulse modulated at audio frequencies, the simplest concept would be to envelope-detect the signal and to amplify and feed the detected audio signal directly to the operator via earphones. Even without encoding the radar pulse repetition frequency, it is anticipated that different radars will have distinctly different audio signatures.

To be attractive, such a system must be able to operate with a relatively small antenna. As an example, consider a small, 4-inch square receiving antenna used to sense the approach of the terrain-following radar on an F-111. This is a 16 GHz, 30 kilowatt radar with a prf of 4045 Hz. The power received from the radar, Pr, can be approximated by

$$P_r = P_t \qquad \frac{g_t A_r}{4 \quad R^2}$$

where

P_t = peak transmitted power

g_t = directivity of transmitting antenna in the direction of the receiver

A_r = area of receiving antenna (pointed in direction of radar)

R = range

The beamwidth from a 4-inch receiving antenna at this wavelength is about 10° and it is easy to point manually in the direction of a moving target. The power received by this small antenna can be estimated from the above equation to be -36 dB at 10 kilometer range at the $g_t = 1$ or unity gain level, which is often far out in the side-lobe region of radar antennas. Closer to the main lobe the signals would be even stronger. This is to be compared to the -55 dB minimum detectable signal that is typical of simple crystal-video detectors. It can be seen that such a radar might be detectable to ranges as great as 100 kilometers under favorable conditions.

If the signatures of friendly and enemy radars were not sufficiently distinct, it should be possible to apply very small amounts of jitter to the radar's prf and pass this through a suitable audio filter or a very simple spectrum analyzer to distinguish the superimposed modulation. It is anticipated that very little sophistication will be required in the spectral filtering, although it is certainly possible; in any case, the human brain is remarkably good at sorting out what it wants to hear in a cluttered environment (the cocktail party syndrome).

The attractive features of this technique include the facts that it:

- is passive (i.e., cannot be detected; requires no significant power)
- is simple, compact and inexpensive
- can distinguish many different friendly and enemy aircraft radars by their audio prf signatures and antenna scan rates or sort them by wavelength bands
- requires no additions or modifications to the aircraft, but capitalizes on existing mission-related radiations

- is difficult to jam because of directivity of receiving antennas and proximity to source

- has all weather, day or night, capability

- is compatible with many of our air vehicles. Many of our current aircraft (F-111, RF-4, A7D) have terrain following radars and/or attack, multimode, weapon delivery or navigation radars in the 16-17 GHz band with distinctive prf's and antenna scan rates in the audio range. Others (F-15, F-16, F-4) have similar X-band systems in the 8.7-10 GHz band.[1] The laser doppler navigation system on the AAH is an FM/CW system operating in the 13.25 to 13.40 GHz band

- is perhaps useful for simple search or cueing, since the radars can probably be seen at much greater ranges than visual range, and in all weather

(S-NFD) (4) EIFF on HAWK.(U)

(S-NFD) (a) Equipment for the active tactical exploitation of EIFF has been developed and installed on the F-15 (AN/ALQ-128) and on some F-4E aircraft (AN/APX-81A). Similar equipment has also been developed for Naval use (AN/ALQ-91) and was considered for possible use on AWACS (AN/ALQ-108).

(S-NFD) (b) Since the interrogation code for the Soviet SRO-2 transponder is well known (a pulse triplet at 668 MHz or a single pulse coincident with the radar pulse), these systems can readily interrogate SRO-2 transponders and receive a coded reply at the same frequency.

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[1] R.F. Lemon, Jr., "Current Airborne Radar Systems Handbook," TR-PTE-77-102, AFALD/PTE Wright-Patterson AFB, OH 45433 (1 July 1977 SECRET/NOFORN).

(S-NFD) (c) These systems can also operate in the receive only mode for the SRO-2 transponder replies, as well as for the SOD-57M (730, 740 or 750 MHz) air traffic control beacon replies, giving approximate bearings to any targets emitting such signals.

(S-NFD) (d) There are reasons to believe that the wartime modes of the Soviet IFF may be different and they are kept under tight security restrictions. Several possible changes of mode have been suggested (Reference 1, Chapter VI and Appendix B) which could negate the use of the EIFF equipments on U.S. aircraft unless provision is made in the equipment to rapidly change to new interrogation codes.

(S-NFD) (e) Nevertheless, the addition of these capabilities to HAWK radars merits serious consideration if it is believed that the enemy will not turn off his IFF when in range of HAWK batteries. Based on available intelligence data, including Soviet/WP practices during penetration and AD exercises in East Germany and the procedures employed by the Syrian Air Force (Soviet equipped and trained) during the 1973 war, there appears to be a substantial possibility that this will indeed be the case: i.e., the enemy will not turn off his IFF. Given this possibility, together with the fact that the EIFF hardware is already developed, it would appear that the addition of EIFF to HAWK is a relatively low cost add-on which could provide enemy air vehicle identification in some tactical situations of interest.

(S-NFD) (f) Furthermore, the active EIFF exploitation (i.e., active interrogation and response) can operate at longer ranges than the HAWK radar itself. For the AN/APX-81A, SRO-2 transponders have been detected at ranges of 150-180 miles, although more usual performance is "in excess of 100 miles." This is well in excess of the normal HAWK acquisition range and could represent an additional, useful augmentation of the HAWK capability.

(S) b. Near-Term, Indirect Concepts. (U)

(S) (1) Exploitation of AWACS Data. With the introduction of AWACS into the European theater, a powerful tool will be available for eliminating the low altitude gaps in radar coverage and for maintaining track continuity on both friendly and hostile aircraft. Under current planning, however, the utility of the AWACS for indirect target identification will be significantly limited by two factors:

(S) (a) Track data will be processed only on board each E3A aircraft and each of the E3As will only be able to process a maximum of 100 to 200 aircraft tracks generated by its own radar. When larger numbers of aircraft are in the radar field of view, maintaining track continuity on individual aircraft will be impossible. (This is a limitation of the on-board track processor, not a limitation of the radar.)

(S) (b) AWACS tracking data will be downlinked to the MPC collocated with the CRP at Pruem and will be relayed from there to the MCRC at Boerfink. It will be relayed from there to the other CRCs and to the ADA Groups. Because of the finite traffic capacity of the Boerfink CRC, it may act as a bottleneck in dense air vehicle environments on the transfer of AWACS tracking data to the ADA Groups where it could be of value for indirect target identification. Furthermore, if Boerfink and/or its communications were knocked out by enemy action, the various ADA Groups and their HAWK and Hercules fire units would be completely decoupled from this valuable AWACS data.

Interim fixes are available to eliminate both of these limitations. The on-board track processing bottleneck can be eliminated by downlinking the appropriate radar data and doing the track processing on the ground where a much greater processing capability could be made available. The Boerfink "bottleneck" can be eliminated if the AWACS data are downlinked to several locations in parallel. If these locations are judiciously chosen, the result would be an AWACS data exploitation system with significantly greater traffic handling capacity and one that would degrade much more gracefully as key nodes are knocked out.

As one illustrative example, the AWACS data could be downlinked in parallel to all three of the 4th ATAF MPCs (Pruem, Neu Ulm and Sembach) where the ground-based track processing would be performed. From there it could be simultaneously relayed to the MCRC at Boerfink, to the three other 4th ATAF CRCs at Lauda, Messtetin and Freising and to the four ADA Groups at either their peacetime locations (Kaiserslautern/Bonn for the 94th and 108th Groups, Darmstadt for the 10th Group and Wurzburg for the 69th Group) or their wartime, tactical locations. Under this arrangement, as long as the MCRC was operable, it would direct the AD battle, using the AWACS data for overall force management. In this non-degraded mode of operation the other CRCs and the ADA Groups would execute the AD decisions determined by Boerfink using the AWACS data for their sectors to assist in detailed target identification and weapon assignment decisions. When Boerfink became inoperable, for whatever reason, the remaining CRCs could take over autonomous command of the AD battle in their areas and they would still have AWACS data available to them. Finally, if all of the CRCs were rendered inoperable, the ADA Groups could operate autonomously using the AWACS data from the MPC closest to their sectors to assist in target identification and weapon assignment within those sectors.

In order for AWACS data to be used in this fashion and, in particular, for it to be useful to the AAD units deployed in the field, the current position uncertainty with which AWACS tracking data is supplied to tactical users must be reduced. This position uncertainty -- usually quoted as two nautical miles -- is not a result of the basic tracking accuracy of the AWACS radar since the 75 meter range resolution and 0.1 degree angular resolution of the radar should lead to a basic tracking accuracy of 0.3 nautical miles or better. Rather it appears to be the result of uncertainties in determining/reporting the E3A aircraft position. This position uncertainty could be eliminated by careful use of LCPAN or ground beacons and errors introduced during the various coordinate conversions that are carried out could be eliminated by more careful numerical procedures.

(S) (2) Improved Coupling of DAD Weapons to the Overall AD C^3 System. In view of the increased aircraft kill potential of the new weapons -- Stinger (IOC 1980), Roland (IOC 1983), DIVAD Gun (IOC 1983) -- being introduced into the DAD inventory, it is imperative that the coupling of these weapons to the overall AD C^3 system be improved as soon as possible. Ultimately, a PLRS plus JTIDS type system as envisaged in the ADDS program is probably the best solution to this problem. However, such a system could not be available in Europe until the mid 1980s at the earliest. Thus, it would be very useful -- if not essential -- to deploy a quick fix solution to this problem to provide an interim DAD C^3 capability to be used until more permanent and effective solutions are available.

The technology to support such an interim capability is almost certainly available. During the 1974-1976 time period, the Marines developed a WDU designed to link the SHORAD and MANPAD weapon teams to the IHADP. The WDU employed a 1200 bit/second digital data link compatible with standard military single-channel VHF/FM radios to transfer alerting and pointing information from the IHADP to the SHORAD and MANPAD weapons. In 1976 the Marines field tested the developmental hardware using an Improved HAWK and two MANPAD weapon sites. These tests indicated that the WDU provided warning and pointing information, increased the percentage of detections and launches achieved by the MANPAD teams and increased their average detection range.

Since 1976 the Marines have continued work in this area, developing a TST to process HAWK track data messages and reformat them for transmission to the MANPAD teams and a hand-held IDT to serve as an improved data read-out device for the MANPAD teams. The IDT weighs 3.6 pounds, uses a light-emitting-diode display to present aircraft warning, pointing (range, azimuth and altitude) and identification data and -- like the WDU -- uses a digital link compatible with standard military single-channel VHF/FM radios for connection to the TST. During 1978 field testing of the IDT and TST, it was determined that: (a) the IDT adequately demonstrated the feasibility of operating as an early warning, pointing and identification device for the MANPAD teams, (b) the HAWK unit currently provides the AD data most effective for the MANPAD early warning, pointing and identification needs, but that (c) a number of minor deficiencies exist in the TST for which further design effort is required.

Obviously, further refinement of the TST/IDT equipment design is possible and an extended development program could be structured which would ultimately -- in the mid to late 1980s -- provide the DAD fire units with a superior C^3 system. However, it would appear that the Marines WDU and TST/IDT programs have substantially developed the technology base and engineering designs required to provide the Army with an interim, near-term, quick-response solution to their DAD C^3 problem. (Such a quick response solution could incorporate minor, but not major, changes to the existing IDT and TST designs.) One advantage of the TST/IDT approach is that it uses existing military single-channel VHF/FM radio equipment of the type already employed by the maneuver units and AD fire units. New channel assignments may be required, but a new communication system is not required. This means that once the TST/IDT hardware is developed and produced, it can be quickly introduced into the operational units as a supplement or, more probably, a replacement for the TADDS equipment. (AAD personnel have often referred to this TST/IDT system as the TADDS update.)

(S) (3) Exploitation of SIGINT Data. There are a number of different types of SIGINT data, both COMINT and ELINT, which could be useful as an aid for the identification and tracking of hostile aircraft. In particular, Soviet and WP aircraft carry certain types of avionics equipment which can be exploited to yield aircraft identity and location information. The details of this equipment and the nature of the exploitation are discussed in a specially classified appendix.

It appears that the exploitation of this particular SIGINT source could be implemented in Europe in the near term, since the detailed analysis of the source has already been completed. All that is required now is the assembling of the proper intercept receivers, collection platforms, data links and processing centers and the establishment of procedures for timely dissemination of the intelligence product to the various users.

The requirements for intercept receivers, collection platforms, data links and processing centers are outlined in the specially classified appendix. Suffice it to say here that these requirements are not particularly pressing. The receiver requirements are straightforward. An airborne collection platform is preferred for wide area coverage. A number of existing airborne collection platforms could be adapted for this mission but they would require new receivers, etc. If this proves to be inconvenient, or causes conflicts with other SIGINT collection missions, additional airborne platforms would have to be obtained. These could be either RF-4C, RC-135 or U-2R; the selection would be on operational grounds, not technical collection considerations. The requirements for the data link from the collection platform to the processing center are also straightforward; a number of existing data links could be adapted for this purpose. A new, special purpose processing center would be required but this is a development which is well within the state-of-the-art.

Since all of these hardware requirements are straightforward and since only a limited number of units need be procured for adequate coverage of the AFCENT region -- three to six aircraft and one ground processing center would provide a minimum capability-- it should be possible to deploy a quick-response system to Europe within about three years. This would provide an interim, near-term capability which could be augmented later by additional collection platforms and processing centers.

When deployed to Europe, this system will provide identification and tracking data on WP aircraft with an accuracy sufficient for all AD battle management and weapon allocation purposes and most AD hostile target identification and weapon cueing purposes. The establishment of procedures for the timely dissemination of this data to the various AD users, with the appropriate sanitization, is a key requirement for the realization of full military utility of this data source.

This sanitization and dissemination process can take many forms. Two examples, chosen from current SIGINT practices in Europe, are illustrative of the range of dissemination architectures available:

(a) In AAFCE the dissemination of SIGINT and other compartmented intelligence data is limited to the USAFE TFC in the Boerfink bunker. This information, in sanitized form, is used as an assist in updating the current peacetime WP air order of battle, as well as in the conduct of AD exercises and other exercises. In sanitized form this data can be discriminated throughout the 4th ATAF/17th Air Force/32nd ADCOM AD net and used as an additional source of information on enemy activity.

(b) In USAREUR each of the U.S. Corps and Division has peacetime access to SIGINT and other compartmented intelligence data. There are special intelligence sections -- sometimes called All Source Intelligence Centers or ASAC - in each U.S. Corps and Division headquarters, both in garrison and in the field and a significant number of the commanders and G-2/G-3 staff have access to the unsanitized data. The Divisions and Corps each have organic SIGINT collection assets. They are all interconnected with special intelligence-secure communication channels and they are connected via the Corps with the NSOC. This system is used in peacetime training and exercises -- during REFORGER '77 for example, commanders as low as Brigade level made tactical decisions based on real SIGINT data -- and it is intended that it operate in wartime exactly the same as it functions in peacetime exercises. When new collection systems such as TACELIS and AGTELIS are deployed to Europe they will be coupled directly into this Corps/Division tactical SIGINT system.

The proper architecture and procedures for the dissemination of data from the particular SIGINT source under discussion here is obviously a complex question. On the one hand the desire for protection of the source leads one to a highly centralized system with extremely limited peacetime dissemination, little or no use, in either real or simulated form, in training or exercises. On the other hand, the desire for efficient tactical utilization of the data during wartime, in a manner which degrades gracefully with enemy attrition of the U.S. C^3 system, leads one to a somewhat decentralized system with parallel dissemination to more than one command element and with peacetime utilization in at least simulated form in training and exercises. A judicious combination of these approaches must be selected in order to maximize the tactical utility of the data, commensurate with protection of the source and the various multi-national NATO constraints.

(S) c. Far Term Direct Concepts. (U)

(S) (1) NATO FIS and JTIDS/PLRS Plus. Some NATO nations will not adopt the MK XII system because its signal can be exploited and jammed. Indeed, the WP nations are gradually deploying a ground TDOA system which is now capable of accurately tracking many signals including our IFF replies, whether these replies are enemy-induced or are valid replies to valid friendly interrogations (see Appendix A).

(S) (a) NATO FIS. In order to combat the enemy exploitation of our identification systems, the NATO nations have published a STANAG dealing with a FIS which is called "NATO FIS." It was published by the UK on 3 February 1978.

While the specifications for the NATO FIS are still being refined, it is fairly certain the direct interrogate-replay element in the system will rely on a spread-spectrum signal both to defeat jamming and to reduce the radiated spectral density below noise level at expected intercept ranges. The specification is based on the hope that a 33 dB processing gain can be achieved through spread spectrum techniques.

(S) (b) The Dynamic Range Problem in LPI Signals. In order to achieve a low probability that hostile forces will be able to intercept our signals we must be sure that the spectral power density of our signals is below the noise at expected enemy interrupt equipment ranges. The power of our signals at the receiver can be made smaller by reducing the radiated power. However, power cannot be reduced to such an extent that we cannot receive a useable signal and if no processing gain were used, the power required would be such that the hostile forces would be able to receive and use the same information as we do.

Unfortunately, we would like to receive our signals when our aircraft are at a great distance and where an interceptor may be close by. Also, to read the contents of a message requires about 10 dB more signal to noise ratio than to detect it with some reasonably useful probability of detection like 0.5.

To illustrate the above, assume we had a communication system with 30 dB processing gain. Subtracting the 10 dB more we need to read the contents than the hostile does to detect it leaves a 20 dB margin. This means that if the transmitter power is adjusted so that we can just read the reply message, the enemy can detect our reply when he is one tenth the distance away from the transmitter as we are. (Ten times in range is a 20 dB signal level decrease.)

However, we may want to interrogate out to 100 miles. In this instance, the enemy could intercept when ten miles from the transmitter. While this may be satisfactory most of the time, we certainly would like more margin than 20 dB margin.

From the foregoing we see that the NATO FIS specified processing gain of 33 dB would be quite useful, it probably would not assure us the degree of protection against enemy exploitation we want or need.

(S) (c) Separate Communication, Navigation and Identification System versus an Integrated System like JTIDS/PLRS. The NATO FIS system is directed toward achieving a new interrogating reply identification system-one that has LPI, excellent jam resistance and is not exploitable nor spoofable. These four "security" attributes, LPI, AJ, anti-exploit and anti-spoof are also desired for position location systems and communication systems. To achieve these "security" attributes requires sophisticated signal processing. To benefit from these attributes for the three functions separately--CNI -- would require a triplication of these sophisticated signal processors if three separate systems were installed. This certainly would be an expensive and space consuming course to pursue.

Not only would three separate black boxes entail triplication of signal processing, but they would probably entail triplication of antennas, receivers, transmitters and power supplies if they were developed independently. In an integrated system which furnished all three functions, it would be possible to avoid the triplication of signal processing and by adding minimum redundancy in power supplies (the receivers and transmitters are now multiple units) to achieve a very reliable three-function CNI system.

An important cost often forgotten by engineers is the cost of installation. Installing three boxes may cost from two to three times as much as single-box installation. Space limitation in the aircraft, along with training and maintenance requirements also tend to argue for a single, integrated multi-function system.

(S) (d) Using Advanced JTIDS for Identification. Advanced JTIDS has a good likelihood of being adopted as a DoD standard for communication and position location. While the Army plans to use a different system called PLRS, it is possible to have interface boxes and make slight modifications to PLRS to make it quite compatible with Advanced JTIDS.

Advanced JTIDS has three possible modes of operation for identification purposes:

- Indirect Mode. Each aircraft's position message is determined by AWACS or netted ground radars and the advanced JTIDS communication capability is used to transmit the identity information to JTIDS-equipped interceptor aircraft and ground-based fire units

- Direct Mode in a Net. In this mode, Advanced JTIDS issues identification and position reports asynchronously. Its report is not related to a radar or an interrogation. The position is then processed through a co-ordinate transformation at the fire unit site to provide useful identity and location information

- RTT Mode. The JTIDS sends out a reply to an interrogation in a separate net. This reply is synchronous with an interrogator. The RTT Mode is the mode emphasized in the proposed use of our Advanced JTIDS system for the direct element of the NATO FIS

While JTIDS has about 30 dB of processing gain, in general, it would not create a sufficiently LPI signal to prevent enemy exploitation as discussed above. This occurs because the normal transmitter power is much larger than that required to assure an adequate signal-to-noise ratio at 300 miles range whereas identification in the combat zone may only require 30 miles range or less.

One possibility to enable use of reduced power is to control the transmitter power as a function of the range. The home radar station desiring identification of a given radar return could send a power control signal based on the air vehicle (transponder's) known radar range and actual measured signal quality.

An Advanced JTIDS system can provide secure-jam resistant identity directly in two distinct manners. One utilizes its position-determining capability called its relative navigation. In the other, identity is obtained by using the RTT transponding capability of the JTIDS system.

Relative navigation is the ability of a JTIDS family of users to navigate relative to an arbitrary navigation grid designated by a navigation master. In this scheme, primary and secondary navigation references are used. The primary navigation references are users whose terminals contain high quality clocks. All navigation references and users periodically transmit their identification, position and velocity using a position (P) message. Pseudo-range measurements to users radiating these P messages enable the computation of a terminal's own position relative to the navigation grid designated by the master. An aircraft surveillance radar in the same relative navigation grid as JTIDS will correlate all active users with its own radar tracks. All active users are friendly; consequently, all tracks which are friendly can be so labeled.

RTT in JTIDS is utilized to transfer system time. RTT is a transponder mode whereby a user transmits a unique interrogation message. The recipient replies in the same time slot in which the interrogation was transmitted. The reply message contains the TOA of the received signal, the serial number of the interrogator and the serial number of the transponder. The interrogator thus performs a two-way range measurement. A typical interrogate and respond RTT message format is illustrated in Figure I-2-3.

INTERROGATOR	SYNC	TIME REFINE	HEADER	INTERROGATOR SERIAL NUMBER	ADDRESS IN TRANSPONDER (used in addressed RTT	
TRANSPONDER	SYNC	TIME REFINE	HEADER	INTERROGATOR SERIAL NUMBER	TRANSPONDER SERIAL NUMBER	TIME OF ARRIVAL

FIGURE I-2-3

(S) RTT MESSAGE FORMAT (U)

RTT transponding is performed utilizing a choice of two message types. These are the "all-call" message and the addressed message. The all-call is used when little is known about other users in the area. An interrogator using the all-call will accept the first transponded signal to be received. For identity the interrogator will range gate the receiver to synchronize the reply of the target with the range measurement of the radar. Large numbers of targets can either be isolated and identified one at a time based upon a single message reply or multiple acceptor circuits can be incorporated so that multiple interrogations can be used and the multiple replies can be integrated to build up the system.

The addressed RTT is normally used to measure distance to users with known high quality clocks. The surveillance radar will also use the addressed RTT to identify expected friendlies with known flight plans. If no reply is transponded, then the all-call RTT is used.

The only modification required to Advanced JTIDS receivers is the addition of range gating to the RTT replies in the interrogator so to enable the sorting out of many unknown friendlies. This situation of many unknown friendlies will probably be a very rare occurrence with an Advanced JTIDS.

Relative navigation will provide essentially 100 percent of the identity function unless the users are in radio silence. A suggested change to the terminal is the addition of a warning indication that alerts the pilot to interrogations. Once alerted, he could switch to the RTT low power mode to be described later.

The turn-around time of the RTT interrogation by the transponder is approximately two milliseconds. The message error rate of RTT interrogations and replies is 1 out of 400 at a J/S of 20 dB without range gating. Other JTIDS messages have a message error rate of 1 out of 100 at the same J/S. The addition of range gating could also permit improvement in performance by changing correlator detection threshholds.

The use of range gating reduces the cumulative probability of false alarm, thus enabling adequate RTT detection probability at higher jamming powers. This added performance due to incorporation of range gating could be utilized to advantage by controlling and reducing the aircraft transmitter power to the bare minimum. By transmitting with the minimum power which allows the friendly interrogator to decode a reply, a typical enemy interceptor, without the Advanced JTIDS processing gain would receive a signal below his noise level. If necessary, many simultaneous replies could be recovered with additional receivers in the interrogator. The use of range gating does not preclude reception of such other replies. Also, each reply could be tagged if the one expected is not received.

(S) (e) LPI Considerations. In Advanced JTIDS, the processing gain of the preamble matched filter (having 32 pulses) is 11 dB above the processing gain of a single pulse, after implementation losses are subtracted. Theoretically, the processing gain of a single pulse is 15 dB. The 15 dB is reduced by 2 dB due to correlator side lobe losses. The total realizable processing gain of the matched filter is thus 24 dB. Increasing the processing gain for a special identity response can be achieved by adding more pulses to the preamble. This approach is feasible without changing the basic matched filter because the associated radar requesting identity furnishes range and thus permits the updating of frequency and code every 13 microseconds. Each doubling of the sync preamble provides a 2.2 dB increase in processing gain because binary addition is used. Thus, a single 128 pulse identity pulse train provides a processing gain of 28.4 dB. Repetitive transmissions of this response to additional interrogations provide further improvements of 2.2 dB for each doubling factor. Thus, 32 replies provide an additional 11 dB of processing gain resulting in 39.4 dB after all implementation losses are subtracted.

The identity response for high processing gain and therefore LPI is achieved by randomly using all 51

JTIDS frequencies. The transmitted power of the identity response will be under control of the surveillance radar. The interrogation signal will command the transponder to reduce power so that the received response is at the minimum discernable level. The objective of this technique is to minimize the probability of intercept receivers detecting the replies to the interrogations. Additional improvements are feasible in multiples of 2.2 dB by doubling the number of pulses if necessary. The maximum number of pulses in a response is 600 in one time slot. Therefore, a 512 pulse response will provide an additional 4.4 dB of processing gain over a 128 pulse response bringing the total to 43.8 dB. However, the 128 pulse response is probably adequate. It is important to note that hardware in the transponder is not affected by the use of more pulses. The incorporation of power control, however, would represent a change. Also, the detection logic in the interrogator would have to be changed to measure the preamble matched filter output over a longer pulse sequence and with multiple detections.

(S) (f) TDOA on JTIDS LPI Signal. Just as hostile forces can perform a TDOA correlation on the proposed NATO FIS, so can they perform such an operation on a JTIDS LPI pulse. To make TDOA measurement, the hostile TDOA sensor must have an adequate signal-to-noise. Our discussion so far has emphasized the reduction of signal strength to minimize intercept and effective use of enemy TDOA systems. A similar effect could be achieved by an increase in the general noise background.

In the case where an Advanced JTIDS system were used to perform the direct identity function, an increase of noise background would be present as a consequence of system design and loading. If there are multiple users in an Advanced JTIDS system normal signals tend to begin to look like interference noise, especially if the number of simultaneous users and messages are large. Also, some JTIDS users will be operating in the friendly zone. They would not need LPI and would have full power. Thus, they also would add to the background noise but in such a way that it would not affect the terminals with the proper codes. In this connection, it appears that DTDMA or HTDMA may have an advantage over ATDMA in that the random dispersal of the pulses in time, frequency and code space may lead to a noise-like background at a lower density than with ATDMA.

This gratuitous background noise results from the multiple-function capability of JTIDS. When transmitting data, or position reports or voice, it adds to the background entropy. A separate identification system would not have this natural background noise cover which is inherent in a multifunction system.

(S) (g) JTIDS RTT Antenna Gain. In the RTT Mode, a directional antenna would be planned for use on the interrogation and reply mode. The directional antenna would be made to lock in the same direction as the radar which it serves. For LPI purposes, this directional antenna need not have high gain on interrogation. However, high gain would be needed for AJ purposes.

At L band a gain of about 23 dB in the azimuthal direction and about 18 dB in the elevation is feasible. These would be the gains from a 2° pencil beam which is agile in elevation. Since it is to be agile in receive only, the antenna should be a significant cost contributor. Moreover, radar and JTIDS position and altitude reports would yield the data necessary to steer the beam used to receive the identification replies.

It should be noted that this antenna gain is available to the friendly side and not to the hostile TDOA system. The NATO FIS system could also have antenna gain but it would need position and altitude information to be able to steer in elevation. It is important to note that increasing the antenna gain (decreasing antenna beamwidth) reduces the number of pulses which would be available for integration so that increasing gain in LPI by increasing antenna gain does not help the LPI problem. However, it does help in the AJ mode.

(S) (h) JTIDS RTT Traffic Handling Considerations. It might be noted that a good deal of the gain in LPI performance comes from a long message. The proposed message length is long enough so that the return from multiple aircraft will overlap. However, this is not a serious situation. The interrogator must have multiple receivers and tracking loops. The overlapping replies would then look like multiple nets and the degree of interference would be minimal.

(S) (i) JTIDS Visibility and Detection Vulnerability. One of the questions which has not been resolved is the exposure of the normal non-RTT TDMA mode to enemy exploitation. All the previous discussions considered the RTT in the LPI mode. In the TDMA mode, it has been feared by some people that the regular occurrence of the synch and the discrete occupation of a slot by a single user enables a hostile TDOA system to easily track every user. DTDMA should not be so vulnerable. This should be investigated in depth. If the vulnerability to enemy TDOA is significantly different, then use of DTDMA would be preferable.

(S) (j) Reliability. The identity function in JTIDS can have a high MTBF. Identity in JTIDS is performed mainly in the RF and signal processing elements of the terminal. Both the transmitter and receivers utilize redundancy. For example, a high AJ JTIDS fighter terminal utilizes eight receivers and a transmitter containing sixteen transitor power modules. Failures of receivers and transitor power modules cause graceful degradation in performance. The power supply in JTIDS, however, is common and its failure will disable the terminal. Power supply backup via multiple power supplies is feasible. For example, half of the transmitter power modules and half of the receivers could be split and powered by two separate power supplies. Since the signal processor consumes only a small fraction of the total power, each power supply could furnish the power for the processor. The reliability of the signal processing elements is high and redundancy here should not be necessary.

JTIDS uses solid state technology throughout. Its basic reliability should exceed 600 hours MTBF. By providing redundancy, the users should have an identity box they can trust. The MK XII reliability is considered by users not to be great enough for confidence in positive identification. A JTIDS-based system with its basic high reliability and minimum redundancy should be able to furnish the needed confidence.

In summary, it appears that by proper design of the RTT mode, by power control, by multiple message integration and by use of the frequency hopping and spread spectrum capability already designed into Advanced JTIDS, an Advanced JTIDS system should be able to accomplish the direct identity function for the NATO FIS with sufficiently low LPI that pilots could keep turned on in the crucial combat zone.

However, we do not believe that LPI operation is possible for aircraft engaged in deep interdiction. They will have to shut off their JTIDS box and rely on AWACS tracking (which should be feasible) and only turn their JTIDS box on as they near the firing envelope of friendly fire units. When they do that, all the LPI advantages of the JTIDS structure should be exploitable.

The use of JTIDS for identity is preferable to a new FIS being considered by a NATO study group because:

- it can be available sooner
- it can evolve from present assets
- it can perform other functions
- some NATO nations are interested in an integrated CNI system; the former system is much like JTIDS

(C) (2) Short-Range, Millimeter-Wavelength, Coded Retro-reflector 10 System for Short Range DAD Use. Retro-reflectors can have very large radar cross-sections if they are many wavelengths in size. In addition, they reflect incident energy directly back to the source, instead of broadcasting it in all directions. In order to capitalize on these properties to develop a short range direct ID system and still keep the physical size reasonably small, it is necessary to go to short wavelengths. However, in order to maintain reasonable all-weather capability for the newer weapons systems, it is necessary to utilize millimeter-wavelengths as opposed to optical wavelengths. Millimeter wavelengths allow narrow antenna beamwidths with small antennas. In a direct IP system, this also results in good spatial discrimination of multiple targets. Such a system should be very difficult to exploit from a distance because of the significant atmospheric absortpion at millimeter-wavelengths, especially if the system operated on the skirts of the transmission windows. The region around 90 GHz is seeing considerable developmental activity for a variety of applications. Hence, components for a millimeter-wavelength direct ID system should become readily available in the longer-term which suggest 90 GHz as a good frequency for such systems.

For a diffraction-limited system and neglecting atmospheric absorption, the round-trip loss from interrogators to retro-reflector and back can be approximated by:

$$\frac{P_r}{P_t} \quad \frac{P_{rec}}{P_{tr}} < \frac{A_i^{2} \quad A_t^{2}}{{}^{4} \, R^{4}}$$

Where P_r = received power

P_t = transmitted power

A_i = aperture of interrogator antenna

A_t = aperture of retro-reflector at transponder

For a baseline system at a wavelength of $\lambda = 3.2$ millimeter (94 GHz) and 4" x 4" antennas, the minimum round-trip loss is 128 dB at a range of 5 kilometers (it is 116 dB with 8" x 8" antennas).

Kilowatt peak powers are available at 94 GHz (25% duty cycle), using coupled-cavity travelling wave tubes and mixers with $\sim$ 10 dB noise figures are also available. If -80 dBm (-110 dBw) can be detected, the system should have enough margin to operate satisfactorily.

On the aircraft, it would be highly desirable to develop flat, flush-mounted retro-reflectors, rather than deep antennas, such as corner-cubes and Luneburg lenses. It is conceivable that printed-circuit versions of the Van Atta array could be developed for this purpose. Such arrays could also be rapidly modulated with diode switches along the feed-through lines behind the radiating elements.

(S) d. Far Term - Indirect Concepts. (U)

(S) (1) Use of TDOA Systems as Identification Adjuncts. Since all aircraft radiate in the communications and radar bands at some time, detection of these radiations could be used as a very effective means for identification of both friendly and enemy air vehicles. For example, a particular type of radar could be identified as friendly because of its frequency (or frequency agility pattern), pulse width, pulse repetition rate, scan characteristics and the like. We could also positively identify enemy radars using similar signatures. Likewise voice communications could also be used as immediate identification aid.

In order for these radar or communications signatures to be useful for air vehicle target identification, the radar/communications intercept system being used must have emitter location accuracy good enough to positively associate a particular identification achieved through parameter association with a radar (or visual) track. Generally speaking, DF systems will have inadequate accuracy for this purpose. TDOA systems such as PLSS, AGTELIS and ELS however have potential emitter location accuracies of 50 meters (ELS) against targets moving at typical tactical air vehicle velocities and should be ideal for this purpose.

At present, the PLSS system -- an airborne TDOA system for theater-wide coverage of enemy radar emitters -- and the AGTELIS system -- a ground-based system to be deployed in the Corps/Division areas for local coverage of enemy radar emitters -- are intended to be employed exclusively against fixed emitters (SAM radars, etc.). Intercepts on moving radar emitters will not be processed.

In the concept proposed here, these moving-emitter intercepts would not be discarded. Rather, they would be exploited to provide air vehicle identification (from the radar parameter association) and radar track association (from the PLSS/AGTELIS emitter location) on friendly and enemy air vehicles.

The PLSS system has already demonstrated its ability to track aircraft in simulation tests. In the particular simulation used, five aircraft targets were simultaneously tracked. Clearly, maintaining PLSS track on the much larger number of friendly and enemy aircraft to be expected in a NATO/WP air war will be a considerably greater data processing problem and will undoubtedly require an augmentation to the PLSS processing capability. This is even more true since currently the PLSS system throws away all of the moving targets it sees and devotes its entire processing capacity to the fixed emitters.

When employed in this fashion, the PLSS system -- being airborne with a theater-wide coverage area -- has the potential capability, assuming adequate augmentation of its processing capacity, to obtain identity and track association data on essentially all friendly and enemy air vehicles in the 2nd ATAF/4th ATAF region who have their radars turned on. This has the advantage of providing theater-wide aircraft target identification. It has the disadvantage of having to cope with extremely large numbers of aircraft targets.

AGTELIS, employed in the same emitter-identification/track-association mode, would provide very useful and complementary capability to the PLSS system. The AGTELIS system, being ground-based with its intercept receivers located in the forward area, would provide detailed coverage and aircraft target identification, over a much more limited area of the battlefield. Since the AGTELIS coverage area is approximately the same as the HAWK coverage area, the aircraft identifications, emitter locations and track associations, provided by AGTELIS could be of direct utility to the HAWK batteries.

This same approach could be used with communications intercept systems which have TDOA correlation systems (e.g., ELS) attached. The language of the intercepted communications will provide a rapid indication of target identification. The TDOA correlation processing of the modulated CW communications signal will provide the location of the moving emitter. The principal difference, compared to the PLSS/AGTELIS case, is that the correlation processing takes a much longer time (of the order of 1 second per emitter) than did the pulsed emitter processing (of the order of 10^{-3} seconds per emitter). This has two effects: fewer targets can be processed and tracked by a given data processing capacity and larger location errors are introduced due to target motion during the correlation processing. (For a Mach 1 aircraft and a 1 second correlation time, this error would be about 300 meters.)

In summary then, this proposed concept is to use PLSS/AGTELIS, with suitably augmented data processing capability, to obtain emitter identification and location information of friendly and enemy aircraft which have their radars turned on. This information would then be communicated to appropriate AD units where it would be used to generate aircraft identity and track association of value to AD units for target identification. The same approach could be used on friendly and enemy aircraft communications, using ELS-like intercept systems.

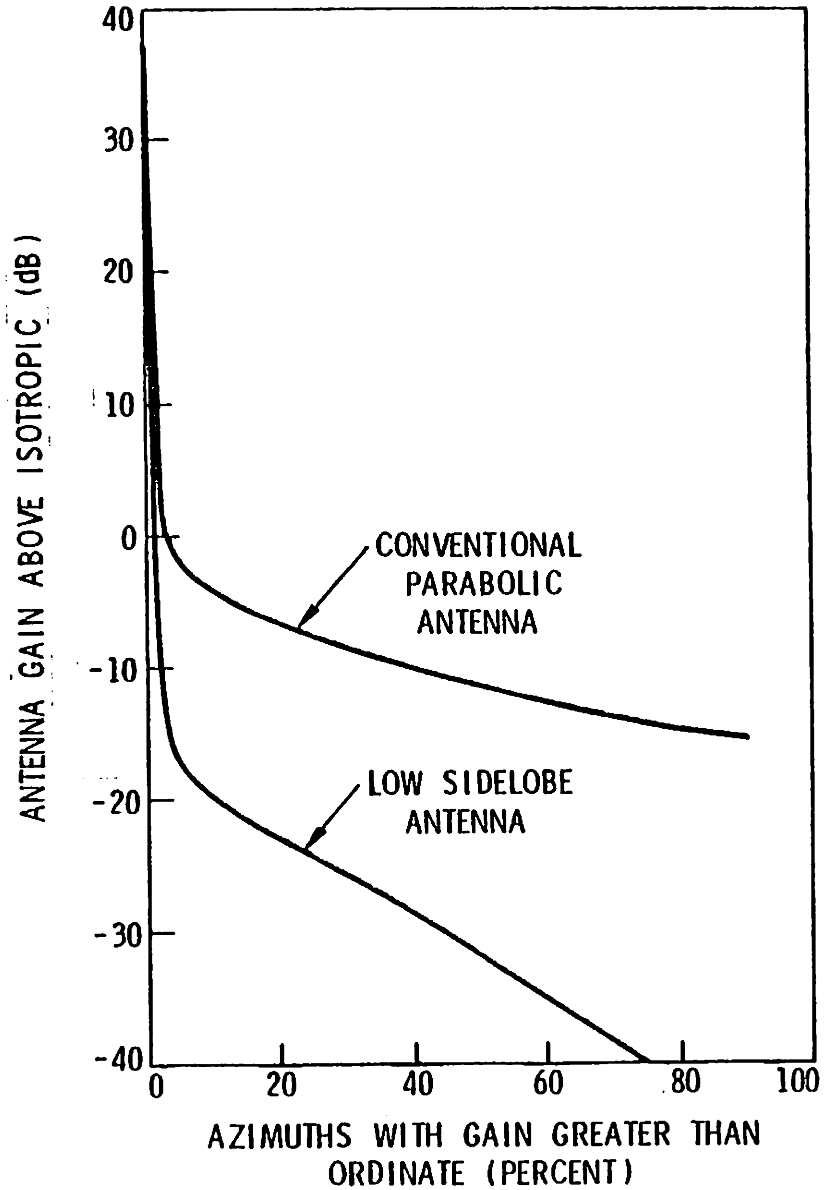
(S) (2) Netting of Radars and TDOA Systems. Recent progress in advanced digital signal processors has now made possible the automatic acquisition and tracking of all aircraft within a surveillance radar's antenna field of coverage. Tests of the Lincoln Laboratory Moving Target Detector Radar in an environment of moderate jamming and heavy chaff show only a small degradation in the sidelobe region and complete visibility through passive chaff.

The addition of a low sidelobe antenna and modern digital signal processing greatly decreases the utility of sidelobe jamming. This is illustrated by Figures I-2-4 and 5. Figure I-2-4 shows the cumulative distribution of a normal parabolic antenna sidelobes and that of a low sidelobe antenna such as AWACS. Figure I-2-5 shows the required jamming power for two levels of jamming against such a radar. Notice that a stand-off jammer at 50 nmi range requires about 107 watts ERP to be effective against such a radar. This is an impractical amount for an airborne jammer.

The above results led to a radar-anti radar technique study which concluded that sidelobe jamming and other deception techniques can be easily countered so that the enemy will eventually have to resort to mainlobe jamming using either large numbers of distributed jammers (e.g., small parachute or balloon-borne jammers with 1 to 10 watts of power) or noise illuminated chaff (see Figure I-2-6). About the only sensible counter to a distributed jamming threat is a distributed network of radars.

Figure I-2-7 shows one possible network. Several advantages are given in Figure I-2-7 and stressed in Figure I-2-8. In addition to the many advantages against possible enemy action, the network and radar parameters were chosen to give good low-altitude coverage. Studies show that a typical range against low flying aircraft is only about 35 kilometers due to shielding by undulating terrain.

(U) ANTENNA GAIN DISTRIBUTION FOR VARIOUS RADAR ANTENNAS



(S) SIDELOBE JAMMER EFFECTIVENESS (U)

Figure I-2-5

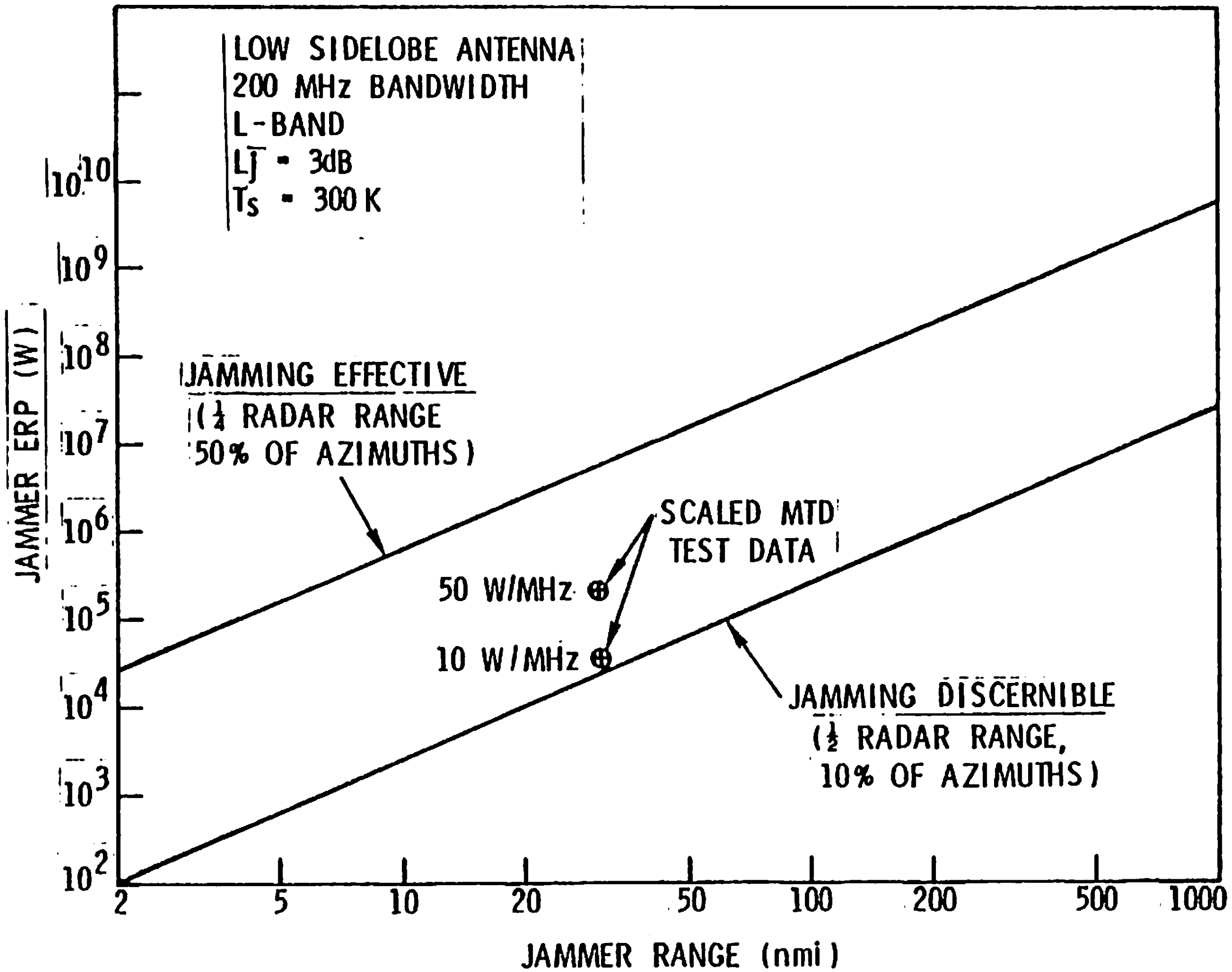


Figure 1-2-6

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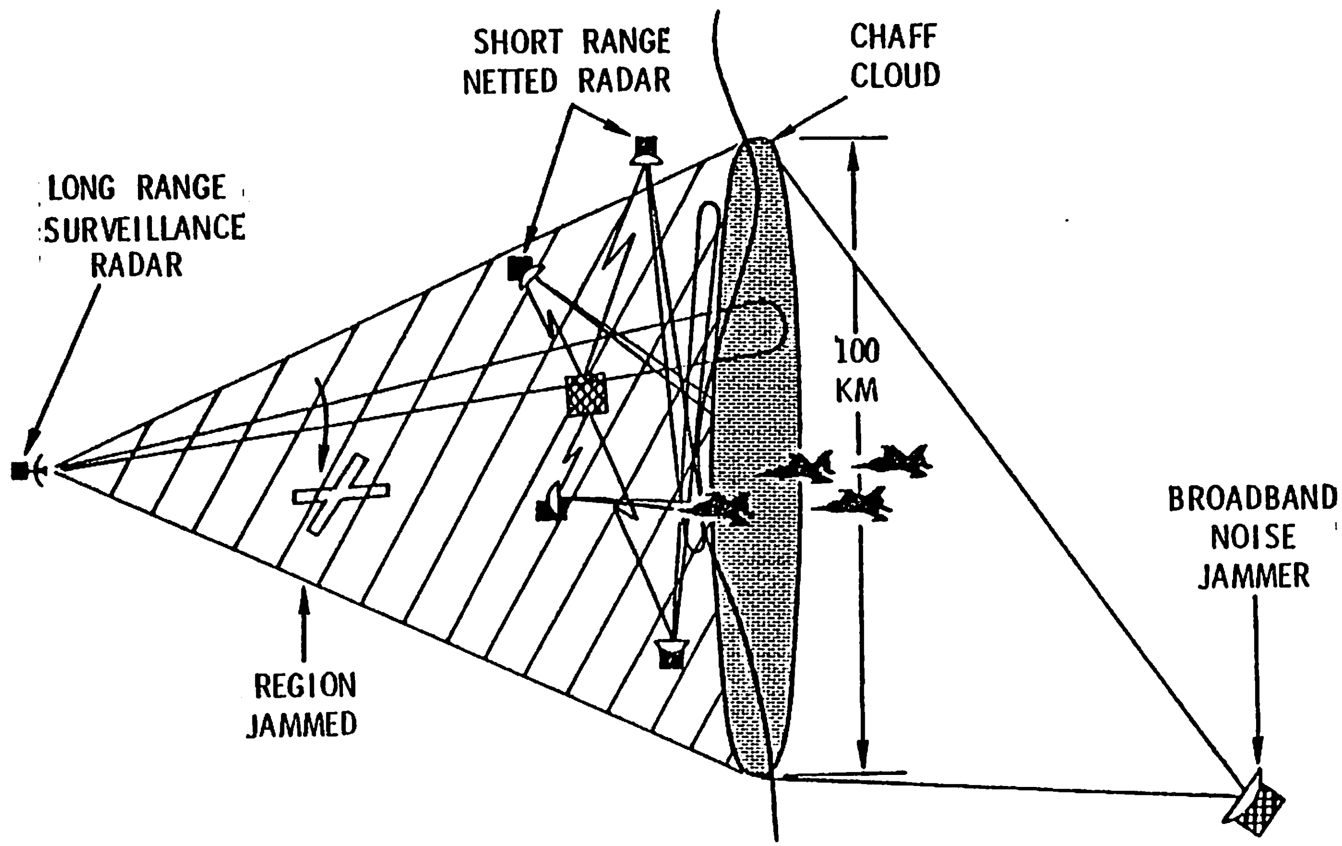
(S) NOISE ILLUMINATED CHAFF (U)



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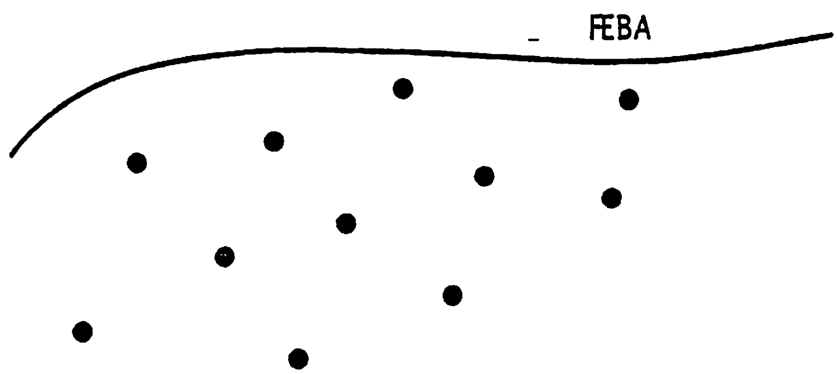
UNCLASSIFIED

Figure I-2-7

(U) RADAR NETWORK



AVERAGE SPACING: 30-60 KM

SPACING NEEDED FOR:

- LOW ALTITUDE COVERAGE (AIRCRAFT AND HELICOPTERS)
- ANGLE DIVERSITY AGAINST JAMMERS
- PASSIVE DF AND TOA ON JAMMERS
- REDUNDANT COVERAGE

UNCLASSIFIED

FIGURE I-2-8

ADVANTAGES OF NETTED RADARS

LESSENED VULNERABILITY TO ENEMY COUNTERACTIONS

- NETWORK LESS FRAGILE (self-healing)
- LOW-COST RADAR REPLACEMENT
- GOOD GEOMETRY TO COUNTER MAIN LOBE JAMMING
- JAMMER LOCATION USING DF AND TOA
- EMISSION CONTROL WITHOUT LOSS OF COVERAGE (e.g., blinking against ARMs, Sector Jammer burnthrough)

GEOMETRY

- IMPROVED LOW-ALTITUDE COVERAGE
- HEIGHT FINDING USING TWO OR MORE RADARS

A completely developed radar network should include the output of as many radars as possible. A great diversity of radars and radar types is to be encouraged because enemy action will usually be selective. Specific radars (e.g., AWACS) will probably receive a lot of attention by the enemy. They will be subject to physical and electronic attack. Some radars suggested for inclusion in the network are AWACS, TPS-43s, HAWK PARS, PATRIOT Radars, FAAR, Roland's surveillance radar. Many of these will require improvement to be able to automatically acquire and track all aircraft. Few presently have that capability, but the technology is here.

The importance of automatic acquisition and tracking cannot be stressed enough. When faced with the ID problem in a hostile environment, the netted system can maintain track and identification and pass on track data information that any particular air vehicle is a friend or foe. The enemy will make a great effort to jam everything on the battlefield including radar, communications and possible ID systems. The output of any equipment which is still effective must be carefully gathered and distributed. Thus once an aircraft is identified in a netted radar system, its track can be maintained and does not have to be reidentified when it reappears at any given radar. In addition, the use of radar netting to pass identified tracks results in fewer interrogations by ground units.

In conclusion, a properly designated set of multifunctional radars uses the outputs of a multiplicity of sensors, each of which may be fragile on the battlefield. However, the network can be employed to maintain and make maximum use of any information which is available. AD systems should consist of netted multi-function radars for which identification can be considered a major function in addition to surveillance and tracking. The maintenance of continuous tracks due to effective netting of the radars and TDOA systems provides a major contribution to indirect identification capability.

(C) e. Proposed Technology Initiatives. In this section some techniques which the Task Group feels are promising for research at the 6.1, 6.2 and 6.3 levels are briefly discussed. The techniques discussed are those for which the Task Group sees some specific use and hope of success. Other directions of research may also be worth pursuing but are not mentioned because they have not come to the attention of the Task Group or fall outside the competence of the Task Group members. Therefore, just because a technique or area of research is not mentioned, it should not be concluded that the Task Group feels it should not be pursued. Also, some obvious technologies of potential future use to ID operations, such as two dimensional infrared detector arrays and very large scale integrated circuit chip technology, are of such importance in many other applications that their primary justifications were assumed to come from the other applications.

(C) (1) 6.1 Technology Programs. There exist two computerized shape recognition techniques which appear sufficiently promising to be deserving of continued support at the basic research (6.1) level. They are as follows:

o Computerized Visible Spectrum Shape Recognition.

The Electrical Engineering Department at the Ohio State University under AFOSR support has demonstrated some success at computerized shape recognition of aircraft silhouettes in a plane normal to the optical axis of an electro-optical sensor such as TISEO. The results evidenced a misclassification rate equal to or slightly better than that of trained human observers. Performance of the computerized system is independent of the training and skills of the human operator. This technique appears to be applicable to short range vehicle mounted, fair-to-good visibility weapons such as Vulcan and Chaparral.

o <u>Computer Shape Recognition from FLIR Data.</u>

Work at the U.S. Army Night Vision Laboratory (NVL) has demonstrated some success at identification of aircraft silhouettes by human observers from FLIR images. The successes in computer identification of visible images suggests that the technique should be tried with FLIR images. If successful it would be applicable to short range, vehicle-mounted, daylight, fair-to-good visibility weapons such as Chaparral and Vulcan and extend their utility to night, fair-to-good visibility conditions. A FLIR is presently being developed for Chaparral.

o <u>Optical and Millimeter Wave Absorption Band Structure and Effects.</u>

By operating in the wings of an atmospheric absorption band, attentuations much greater than 1/range^2 can be obtained. This permits operation at some short ranges with high immunity to detection, exploitation and jamming at longer ranges and with a relatively short transition between the two regions. The range at which the transition occurs is adjustable by selection of how far into the wing of the absorption band operation is positioned. Such absorption bands occur in the ultraviolet, the infrared and the millimeter regions. Operation of identification devices in these regions can deny an enemy the ability to detect, exploit and interfere. At the basic research (6.1) level, where needed, measurements should be made of the characteristics of these bands and analyses should be made of the performance achievable by operating in the wings of these bands, i.e., the ranges at which operation can be had, the position and width of the cut-off region and the degree of protection obtainable in the beyond-cut-off region.

o <u>Radar Identification of Helicopter Rotor Doppler.</u>

In the early 1970s the Environmental Research Institute of Michigan (ERIM) (then called the Willow Run Laboratories (WRL) of the University of Michigan) under DARPA support built and demonstrated a system which identified helicopters from their acoustic signals. In the presence of a CH47 helicopter and two propeller drive aircraft good recognition was obtained on UH 1 and OH 6 helicopters. At one kilometer range 100% recognition of UH 1 and OH 6 helicopters was demonstrated with no false alarms. At 2 kilometer range 85% recognition was obtained with no false alarms. At 7 kilometer range occasional recognition was obtained with no false alarms.

The same rotor motions causing the acoustic signals will certainly cause doppler shifts in reflected radar signals. It seems probable that these doppler shifted signals can be analyzed to produce identification. If successful, this technique should be applicable to many of the existing doppler radars. It is recommended that this technique be investigated at the exploratory development, feasibility measurements (6.2) level. It may provide identification capability for helicopters for which there exists no present alternative other than visual methods.

(C) (2) 6.2 Program. (U)

o <u>Optical Spectral ID for Use with Optically-Sighted Weapons.</u>

Optical identification methods are not all-weather devices, but do match the regimes of applicability of optically-sighted weapons such as Stinger and REDEYE. Work has been done on using distinctive spectral signatures in jet engine plumes due either to naturally occurring trace constituents or to deliberate additives as a basis for identification. All the methods known suffer from marginal available spectral power to work with. For purposes of optical spectral identification, it would seem always preferable to mount on the aircraft narrow-band active optical sources such as lasers, flash lamps, etc. These have the advantages of adequate spectral power density and being capable of modulation or coding. As individual components, all elements required for such a system exist such as sources, receivers and modulation or coding mechanisms. The receivers are inherently small enough to be carried by Stinger and REDEYE operators and the sources are small and lightweight enough to be mounted on aircraft and helicopters without undue difficulty. It is recommended that a 6.2 level design and developmental effort for such an identification device should be initiated for a small, lightweight identification capability matched to the range and regime of operation of Stinger and REDEYE type weapons. Because of their inherent short-range and narrow bandwidths, they have reduced vulnerability to enemy interference. They are self-contained at the point of fire and can be turned off over enemy territory to avoid exploitation. No such program is presently known to exist.

(C) (3) 6.3 Programs. (U)

o Range Profiles by HRR. The Naval Electronics Laboratory Center at San Diego has demonstrated some success in aircraft identification by analyzing range profiles of the aircraft using high range resolution (high bandwidth) radars. If successful, the technique would be long range, all weather, day and night in operation. The technique appears very promising and may be competitive to TRISAT/DMR with the advantage that performance would extend more nearly to the full detection range of the radar.

o Range Profiles by MFR. The Ohio State University under AFOSR support has shown that aircraft range profiles can be derived from analysis of radar returns at several different frequencies. This is a multiple frequency analog of the HRR technique described immediately above. It would be long range, all weather, day and night in operation. The multiple frequency requirement is not compatible with most existing radars. However, the multiple frequency aspect may be of advantage in multiple-aspect signature sorting identification processing and jam resistance.

o Three-Dimensional Laser Imaging. Within the last two years ERIM under Air Force and DARPA sponsorship has demonstrated a three-dimensional laser sensor coupled with a new shape recognition computer and associated shape recognition algorithms which can identify ground targets from aircraft platforms in real time. This technique should be explored for the ground-to-air identification problem. It would be applicable to short range, fair-to-good visibility, daytime weapons such as Chaparral and Vulcan and, when cued, could possibly extend operation to night, fair-to-good visibility conditions.

(U) f. Impact of Proposed Improvements on Procedures. Current procedures within the Central Region are driven by the lack of an effective technologic solution to the identification problem and to the lack of position control over the SHORAD system. Although some procedures will always be required, major breakthroughs in technology for both direct and indirect identification systems such as those proposed above will significantly overcome procedural dependence.

In working toward this overall objective, there will be a number of programs which could be introduced to improve current operations. Such programs as JEM and EIFF added to SAM systems are examples which could improve immediate point of fire capability.

As a result of these anticipated short-term technological innovations, including command and control, procedures will be in a continual dynamic state of change. In developing these procedures, it is essential that provisions be included for allowing immediate fire by the weapon system upon identification.

With the advent of a truly effective identification system in the late 1980s to early 1990s, it is likely that current, cumbersome safe passage and sanctuary procedures could be eliminated altogether. Improvements in the area of point-of-fire identification reliability, automated data exchange and processing and communications will permit this important shift away from dependence on the current unrealistic and cumbersome procedures used and rules-of-engagement used to achieve the best compromise between AD systems effectiveness against enemy air vehicles and fratercide using the current systems with their serious deficiencies.

(S) III. APPENDICES. (U)

(S) APPENDIX A. (U)

(S) A. CURRENT MK X/MK XII CAPABILITIES. (U)

(U) The IFF MK X SIF system is widely used throughout the U.S. and NATO for air traffic control. The MK XII system, consisting of the MK X plus the Mode 4 crypto-secure interrogation link, is widely used in current U.S. and Canadian military aircraft and will be implemented in German aircraft in the near future. However, the remainder of NATO has not adopted the MI XII system, principally because of its many limitations.

(U) Chart I-A-1 briefly outlines some of the important system characteristics. In most normal installations, the MK XII will operate at ranges substantially in excess of the ranges of the radars with which they are associated.

(U) The basic MK X/MK XII system incorporates technology and techniques that are 15 to 20 years old and it has been estimated that a total of approximately $2 billion has been spent over the years in its development and fielding. There have been sporadic attempts to update the system and a number of different equipments are now in the field. As a result, the system suffers from a variety of equipment reliability and field maintenance problems, as well as a few interoperability problems.

(S) In addition, present MK XII systems have a variety of widely-known weaknesses such as relatively easy exploitation, jamming and spoofing; weaknesses that potentially could prove disastrous or, at best, make the system useless in a sophisticated ECM environment.

(U) However, because of limited funding, the need for continued peacetime air traffic control and the probability that many years may elapse before a new system could be deployed, it is important that a

CHART I-A-1

(C) CURRENT MKX/XII CHARACTERISTICS (Ref 1,2) (U)

(Interrogate 1030 $\pm$ 0.2 MHz; reply 1090 $\pm$ 3 MHz; vert. polar.)

	MODE	CHARACTERISTICS
"MK XII IMPROVEMENT" / MK XII / MK X (SIF)	1	Double-pulse interrogation, 0.8 $\pm$ 0.1 µs pulses, 3 $\pm$ 0.1 µs spacing. 32 reply codes changed at 30 $\pm$ min. intervals 0.45 $\pm$ 0.1 µs pulses a/c mission reply
"MK XII IMPROVEMENT" / MK XII / MK X (SIF)	2	Double-pulse interrogation, 0.8 $\pm$ 0.1 µs pulses, 5 $\pm$ 0.2 µs spacing. 4096 reply codes set on ground, changed when required. 0.45 $\pm$ 0.1 µs pulse. Tail No. reply (in formations only lead a/c replies).
"MK XII IMPROVEMENT" / MK XII / MK X (SIF)	3A*	Double-pulse interrogation, 0.8 $\pm$ 0.1 µs pulses, 8 $\pm$ 0.2 µs spacing. 4096 reply codes changed at 30 $\pm$ 1 min. intervals. 0.45 + 0.1 µs pulses. Military function and special ID reply.
"MK XII IMPROVEMENT" / MK XII / MK X (SIF)	C*	Double-pulse interrogation, 0.8 $\pm$ 0.1 µs pulses, 21 $\pm$ 0.2 µs spacing. 1278 reply codes. 0.45 $\pm$ 0.1 µs pulses. Altitude reply.
"MK XII IMPROVEMENT" / MK XII	4	Multiple-pulse interrogation, 0.5 $\pm$ 0.1 µs pulses, 32 pulse positions spaced 2 µs, randomly occupied under crypto control. Three-pulse reply, 0.45 + 0.1 µs pulses, 1.8 $\pm$ 0.2 µs spacings. 16 possible time delays, 4 µs spacings, crypto selected.
"MK XII IMPROVEMENT"	5	Improvements, such as rapid code changes, improved decoders and decision logic, diversity and monopulse antennas, to reduce vulnerability to exploitation, jamming, saturation, and spoofing.

*Extensively used by the FAA for air traffic control hard look be given to the possibilities for gracefully upgrading the present MK XII system so that it will remain downward compatible with existing systems and control facilities.

(S) B. DEFICIENCIES OF MK XII, MODE 4. (U)

(U) 1. Introduction. Extensive studies of the various deficiencies of MK XII have been undertaken and a variety of improvements have been proposed for many of these. It is clear that the operational impact of these various deficiencies is highly scenario-dependent - but the Task Group has restricted its consideration to those of greatest concern in the NATO AD environment. Many of these deficiencies are being tackled by the Tri-Service/NSA MK XII Technical Improvement Program begun less than a year ago and coordinated out of the AIMS Systems Program Office.[4]

(S) 2. Reliability. Three forms of reliability will be distinguished:

(C) a. Equipment or Hardware Reliability. (U)

(U) (1) Equipment reliability questions have been raised which not only impair operational utility but reduce operator confidence in the system. No complete quick check-field equipment appears to have been developed to satisfy this need. The interrogators, in particular, appear to be a weak link in the system due to some highly stressed components in the transmitter.

(C) (2) It must be noted that this problem is being addressed by at least two groups:

(a) MI XII TIP at Robins AFB:

- failure statistics
- replacement of hi-failure module (contractor: Hazeltine)
- development of a new LWI

(b) MK XII Improvement Program at the Naval Research Laboratory:

- developmental E.B.S. solid-state power amplifier (contractor: Watkins-Johnson)

(U) (3) It should be noted that a greater commonality among the equipments fielded by the various users could improve reliability, improve interoperability and probably reduce costs and logistic problems.

(S) b. Interrogation Reliability. (U)

(U) (1) In addition to equipment reliability, the MK XII system has problems with the reliability of a single interrogate/reply round trip called "round-reliability." Round-reliability is a function of a great many variables including scenario-dependent factors such as multipath propagation, range, numbers of interrogators and transponders, ECM environment, etc., as well as equipment characteristics such as antenna sizes and locations, decision logic, etc. It should be noted that round-reliability is not to be confused with the reliability of a complete interrogation sequence, which usually consists of a number of rounds, depending on equipment design and decision logic. This is often called "interrogation reliability."

(S) (2) To obtain a better insight into the effect of round-reliability on interrogation-reliability, it is interesting to quote from Reference 11, Volume I, page 43, regarding the HAWK interrogator: "To obtain a friend-acceptance probability of 99%, E_T (round-reliability) must be higher than 70%. Although the figure of 99% friend acceptance probability appears high, it does mean that an average one out of each 100 friends will be attacked by each HAWK missile they approach." Typically, friend-acceptance reliability drops rapidly when round-reliability drops below 70 or 75%.

(C) 3. Exploitation. (U)

(C) a. It is felt that possible exploitation of the MK XII, Mode 4, is one of its chief weaknesses in a sophisticated ECM environment. This exploitation can be done in several ways, either passive or active. Obviously the enemy can passively DF and track a squawking transponder or interrogator. In addition, the enemy can record one or many valid interrogations that can be used to trigger any of our MK XII, Mode 4 transponders enabling him to identify and track his targets. This interrogation is useful for up to 24 hours, although one of the fixes proposed for Mode 5 would change codes so rapidly that this form of exploitation could be negated unless the enemy almost continuously monitored and repeated our interrogations. It would be relatively easy for him to receive AWACS interrogations from well behind the FEBA.

(C) b. Even without recording one of our interrogations if the enemy understands the system he can guess at our interrogation code with a probability of guessing correctly one in 256 tries. But once found, this code would be correct for up to 24 hours. Again, techniques have been developed, such as that above, to limit the utility of this form of exploitation.

(C) 4. Jamming. (U)

(C) a. Although either the interrogator or transponder receivers can be degraded or inactivated by the enemy by any form of jamming, CW and AM or FM modulated CW jamming requires the most assets, pulse width and amplitude noise jamming is easier and intelligent jamming is easiest of all.

(C) b. For instance, a series of pulse triplets can be sent to the interrogators appearing as a series of asynchronous or invalid replies (fruit), overloading the system and reducing the probability that friendlies will be properly identified. In addition, the instantaneous sidelobe suppression circuitry in the transponder can be inhibited by suitable pulse sequences, also reducing the time available for or preventing valid interrogations.

(C) c. Another form of intelligent jamming simply over-interrogates Modes 1 to 3 (SIF). Although the transponder will not reply to these modes when set on Mode 4, it forces the receiver to separate these interrogations from valid Mode 4 interrogations. This, too, can load up the system and the design of this decoder directly effects round reliability.

(U) d. Even in a friendly environment, over-interrogation, caused by a multiplicity of over-active interrogators and/or transponders (garble), can be considered a form of self-jamming, reducing receiver sensitivities (hence range) and reducing round reliabilities.

(C) e. The design requirements specify an interrogation rate control on the transponder for Mode 4, adjustable from 1500 to 3000 interrogations per second above which the sensitivity is gradually reduced. It is noted that in NATO, STANAG 5017 recommends that this ACC be set at 1200 replies/second.[11] These rates are rarely exceeded in estimates of the NATO environment without ECM.[11]

(C) 5. Spoofing. (U)

(C) a. Spoofing, or pretending to be what you are not, appears to be one of the least likely threats in the NATO environment. For instance, since the reply code is fixed and well known (3 equally spaced pulses) and only the time delay is coded, an enemy aircraft could guess at the time delay associated with each round and be correct 1 time in 16. In fact, he would be correct on the average 1 time in 16 with a fixed time delay. However, if a given reply evaluator requires n correct replies, then the probability of guessing all of them is only 1 in 16^n.

(C) b. A more likely tactic is for the enemy to repeat the reply of a nearby MK XII transponder and appear as a "friend" of the interrogator. Since the enemy can measure the time difference between the interrogation and the reply from a nearby transponder, he can measure the appropriately delayed response to that interrogation. A fix to this called "Wooden Duck" has been implemented for the AN/APX-103 interrogator for AWACS. In this case an incorrect interrogation and reply are transmitted by the interrogator; the enemy repeats, the friend does not.

(C) c. Another possible form of spoofing repeast interrogations so that a nearby MK XII transponder is triggered to reply properly. If the timing and geometry are correct, the reply arrives at the friendly interrogator in time to make the enemy appear as a friend.

(S) C. <u>PROBLEMS OF THE NEAR-TERM FIX TO MK XII IFF</u>. (U)

(S) 1. While the fixes to the MK XII IFF can deny replies to unfriendly interrogators and thus deny their exploitation of our MK XII signals, it will not prevent other than "interrogation-type" exploitation.

(S) 2. A "non-interrogation-type" exploitation occurs when hostile forces track our MK XII signals by passive means. One such means is by a direction finder. In a not too dense environment this would be sufficient. In a dense environment, TDOA techniques can be used. If hostile forces use TDOA techniques every signal radiated by our aircraft will be tracked and tracked accurately.

(S) 3. Our intelligence informs us the Czechs have had an AD TDOA system for two years. The Soviets are believed to have two mobile systems in the Baltic area. We know its Soviet nomenclature. The Hungarian AD has one system just completed. The romanians are believed to be starting one system. Certainly in five years we can expect to see widespread deployment of the TDOA system.

(S) 4. When the deployment of the TDOA system is completed, the MK XII signal will be exploitable, with or without the proposed fixes tentatively called Mode 5. The value of the MK XII fixes which appear to have only limited life is thus questionable.

(U) D. RECOMMENDED ACTIONS.

1. If technical improvements of MK XII are not deemed worthwhile, it is still necessary to overcome the hardware and operator reliability problems associated with the peacetime use of present equipment. Therefore, it is recommended that more complete statistical studies of failure modes be undertaken and appropriate corrective measures begun. It is also recommended that greater equipment standardization among the various users be strongly encouraged. Furthermore, it is recommended that greater testing of the complete system be undertaken and present deficiencies such as those associated with inadequate antenna installations corrected if they significantly affect operational capabilities. Some of these may already be in progress under the MK XII Technical Improvement Program.[4]

2. Greater system testing is compatible with a recommendation that substantially more training and exercise with the MK XII, Mode 4, be undertaken to increase operator familiarity with the equipment, both its capabilities as well as its limitations. Only in this way can the capabilities, limited though they may be, be used to maximum benefit in the event of war. If distrust and unfamiliarity are allowed to persist, the equipment will never be utilized.

3. If technical improvements to the MK XII are deemed worthwhile, then, in addition to the reliability improvement program recommended above, it is recommended that the following efforts be accelerated:

a. Anti-exploitation techniques:

- rapid, synchronized code changes

- reexamination of coding strategy, (perhaps negating the need for code changes)

b. AJ and spoofing techniques, if they can be done at minimal cost and in connection with circuit modernization and/or miniaturization efforts for future systems.

(S) APPENDIX B. (U)

(S) A. AIR DEFENSE IN THE 4th ATAF. (U)

(U) 1. Introduction.

a. The purpose of this paper is to provide background information on the execution of AD in NATO as it is today with emphasis on wartime identification of friend from foe. The NATO Central Region further delineated to the 4th ATAF area was selected due to its importance and location of major U.S. forces.

b. AD in the Central Region is based upon the principle of total integration of Allied Air Defense Forces. Operational control of these forces has been delegated by Commander AAFCE from his location at Boerfink Bunker to Commanders, 2nd ATAF at Maastricht, The Netherlands and the 4th ATAF at Kindsbach, Germany. Organized structure as in Figure I-B-1. The functional responsibilities of the 4th ATAF Air Defense Command and Control Agencies is at Attachment 1.

(S) 2. Mission. Commander, 4th ATAF AD mission is:

(S) a. In Peacetime. (U)

(S) (1) To preserve airspace integrity by conducting AD operations against un unauthorized intrusion, within the scope of higher NATO headquarters' directives.

(S) (2) To assess and provide early warning of attack.

(S) (3) To direct a state of readiness of 4th ATAF command forces commensurate with the development of the air situation and which will ensure an immediate and effective reaction.

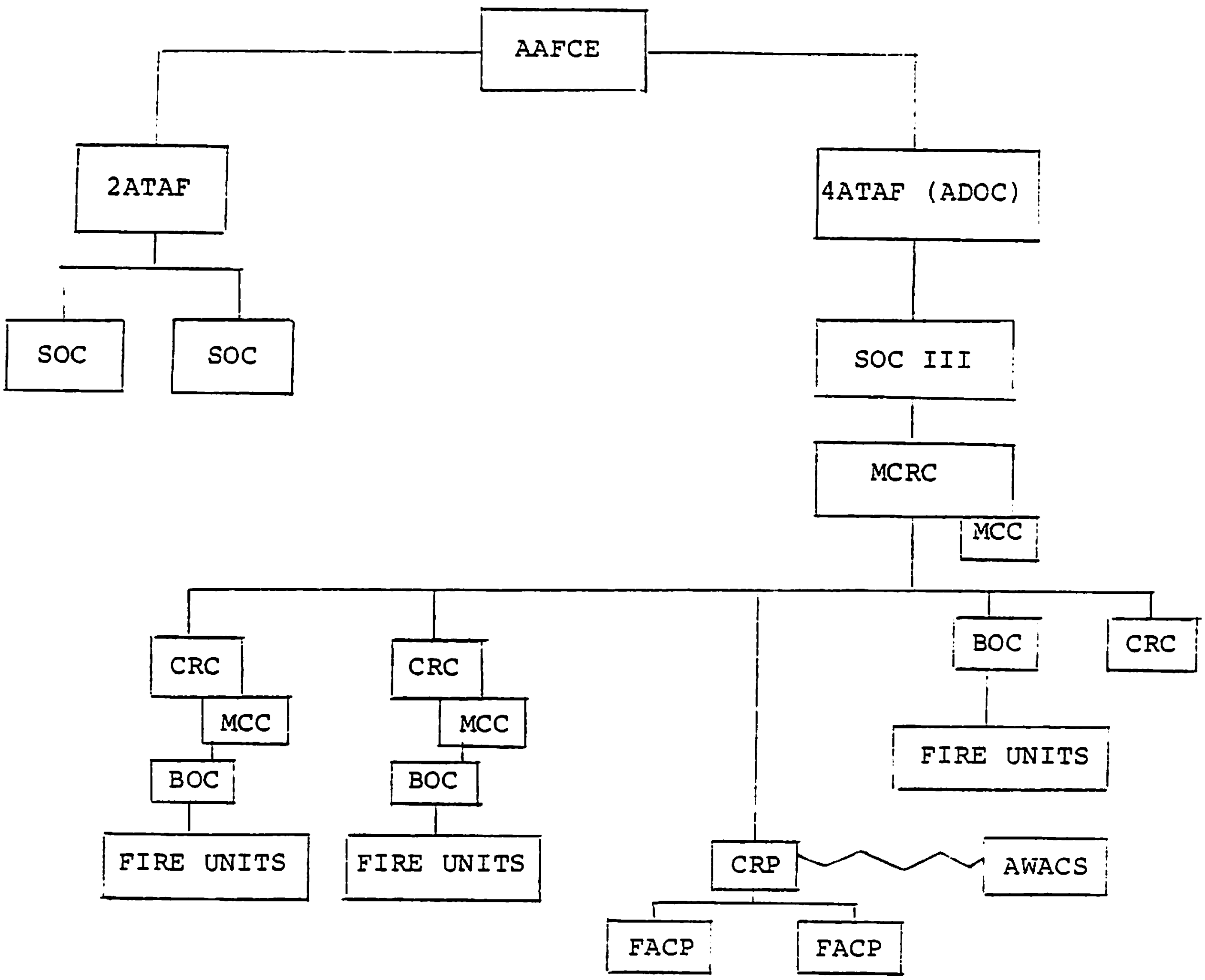


Figure I-B-1

Figure 1

(S) b. In Wartime. (U)

(S) (1) To defend the 4th ATAF area against air attacks with the first priority given to protect the nuclear counter offensive forces and installations.

(S) (2) To impose the maximum attrition on enemy air.

(S) (3) To provide a favorable air situation to designated times in specified areas.

(S) 3. Command and Control. The command and control of 4th ATAF are vested in ATAF Modes of Control which establish the level at which the authority to order engagement of AD weapons exists. The mode of control will be declared by Commander, 4th ATAF, the Sector Commander, or by the highest authority retaining communications with subordinate formations in the event of communications loss. These modes of control have the purpose of retaining control of AD operations at the highest level.

(S) a. ATAF Mode of Control may be designated at any time by Commander 4th ATAF for the purpose of retaining tactical control of all AD forces. Commander, 4th ATAF will direct tactical operations from the 4th ATAF ADOC. This mode may be implemented to cope with specific political or military complications which may escalate to a limited action and, subsequently, to general war.

(S) b. SOC Mode of Control is the normal mode of control. The SOC Commander exercises tactical control of AD operations from the primary or alternate SOC locations. This mode will be maintained as long as possible in peace and war. This is the normal operational mode for HAWK and NIKE forces during Phase "A" and "B". See Attachment 2, SACEUR's Rules of Engagement.

(S) c. MCRC Mode of Control will maintain centralized management of forces and defensive weapons. It will be in effect when SOC mode of control is not possible from the SOC or its alternate, or when directed by the SOC Commander, or when communications are lost to the SOC. The Commander of the MCRC or alternate MCRC will be the battle commander and will exercise tactical control over the assigned/available AD forces within Allied Sector Three. During Phase "B" and wartime, when MCRC mode of control is implemented because of loss of all communications to higher authority, Commander 4th ATAF automatically authorizes the MCRC battle commander to direct engagement within the 4th ATAF area.

(S) d. CRC Mode of Control is the highest decentralized mode of control. It will be implemented when directed by the Sector Commander or when MCRC mode of control can no longer be maintained or when communications are lost with higher authority. The purpose is to retain as much control as possible over AD forces under degraded conditions. When implemented, the Master Controller of each CRC will become the AD Controller responsible for AD operations within his area of responsibility. All AD forces under the control of a CRC will be responsive to the AD Controller. During Phase "B" and wartime, when CRC mode of control is implemented because of loss of all communications to higher authority, Commander 4th ATAF automatically authorized the CRC AD Controller to direct engagements in his area of responsibility.

(S) e. Wing/Squadron, Battalion/Battery Mode of Control. In the event no control of AD forces can be maintained above unit level, the local unit commander may assume control of AD operations. The Battalion or Battery commander, as appropriate, exercises control over SAM engagements. The following procedures apply:

(S) (1) Communications with higher NATO authority exists. The Battalion/Battery commander will:

(a) Take necessary tactical action to employ forces under his control in accordance with the effective WEZ and weapons/warhead control order established by the higher NATO authority.

(b) Order engagement of hostile aircraft in accordance with the applicable Rules of Engagement.

(c) Request permission from the controlling NATO authority to establish the Battery mode of control when deemed necessary. (Applicable to Battalion mode only.)

(S) (2) All communications with higher NATO authority are lost. The Battalion/Battery commander or highest authority retaining communications with these levels of command will:

(a) Establish appropriate WEZs.

(b) Declare appropriate DEFREPs.

(c) Issue appropriate weapons/warhead control orders.

(d) Order engagement of hostile aircraft in accordance with the applicable Rules of Engagement. It is emphasized that so long as SACEUR's Rules of Engagement are in effect (i.e., until General Alert or Cancellation of SACEUR's Rules of Engagement) Battalion/Battery commander will order engagement only in self-defense.

(S) 4. Identification. (U)

(S) a. IFF/SIF (MK X or MK XII) is the primary means of identification of friendly aircraft within the Central Region. Any aircraft not possessing an operational IFF/SIF set should avoid overflying the Central Region unless accompanied by an aircraft which does have operational equipment. Within the Central Region a mixed IFF/SIF MK X/MK XII environment will exist until such time as a common NATO-wide identification system has been fully implemented. During this time, units must challenge on MK X (SIF) and, if fitted, Mode 4. The IFF MK XII equipment is a crypto secure identification system. It consists of IFF MK X (SIF) and cryptographic mode of operation, Mode 4. Mode 4 may be employed by itself in a designated area or it may be employed in conjunction with Mode 1, 2 or 3 in a mixed environment. The aircrew has complete control over the Mode 4 operation and may select it individually or in conjunction with any of the other available codes.

(S) b. Procedures have been developed for implementation to help ensure safe passage of returning friendly forces crossing the FLOT to include MK X IFF/SIF, Minimum Risk and Sanctuary Levels.

(S) (1) MK X IFF/SIF Procedures. All IFF/ISF (MK X) equipped friendly aircraft are to reply the allocated code to Mode 3 interrogation whenever electronic identification is required.

(a) Allocation Tables. IFF/SIF MK X Mode/Code selection is to be changed every 30 minutes in accordance with NATO allocation tables. At each change-over time there is one minute tolerance before and one minute tolerance after this time. During the 2 minutes tolerance period the old and the new setting is correct.

(b) Implementation. IFF/SIF operational procedures will be in force automatically at the declaration of REINFORCED ALERT or STATE ORANGE.

(S) (2) Minimum risk procedures for friendly aircraft during times of alert and war become effective throughout Central Region upon declaration of REINFORCED ALERT or STATE ORANGE or declaration of the individual measure ROI. They are to be deactivated automatically with the cancellation of the state/stage or individual measure. The common reference line from the minimum risk procedures of combat aircraft is the FLOT which indicates the most forward positions of friendly forces in any kind of military operation at a specific time (see Figure I-B-2).

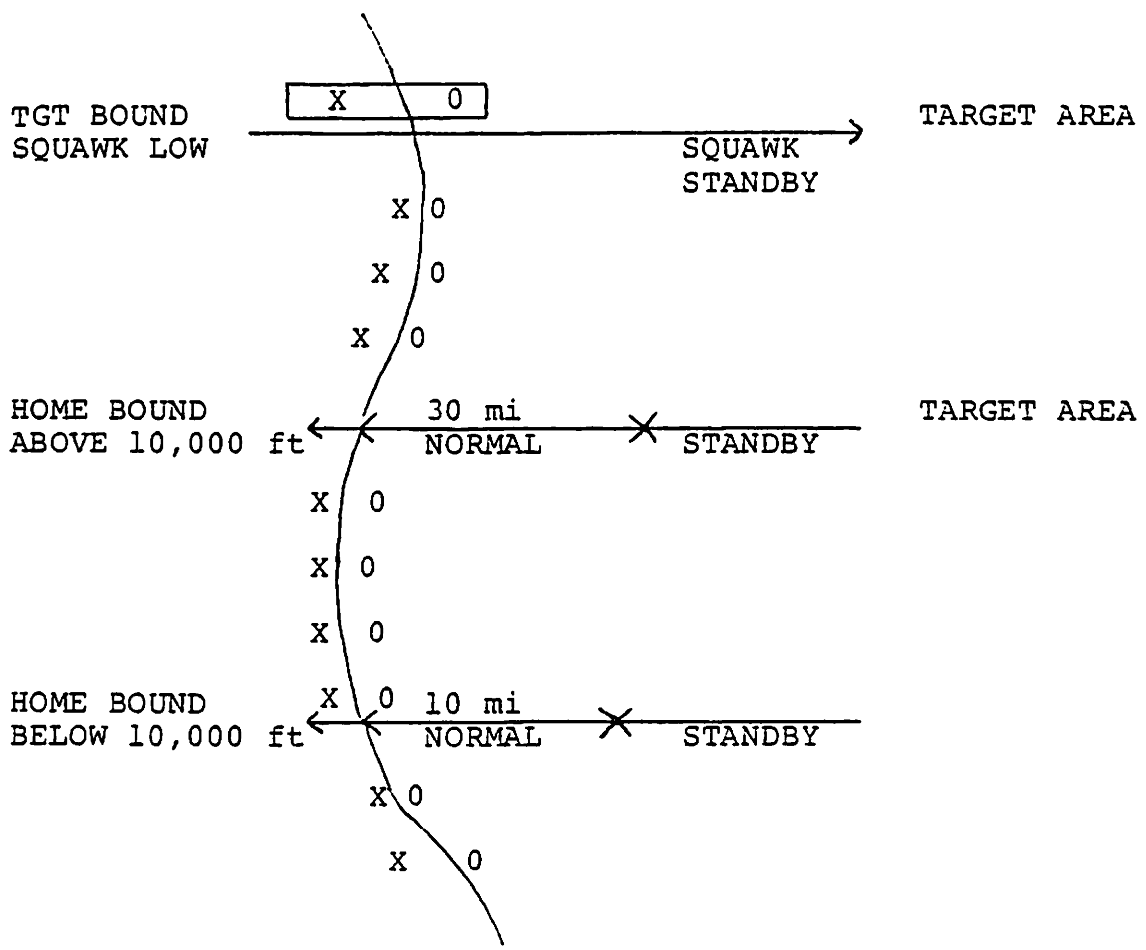


Figure I-B-2
Minimum Risk Procedures (U)
Figure 2

(a) Target Bound Aircraft. Target bound aircraft are defined as friendly aircraft which will be crossing the FLOT into hostile territory. They will squawk "LOW" from the start of the mission until they cross the FLOT. Transponders will be set on "STANDBY" when passing the FLOT.

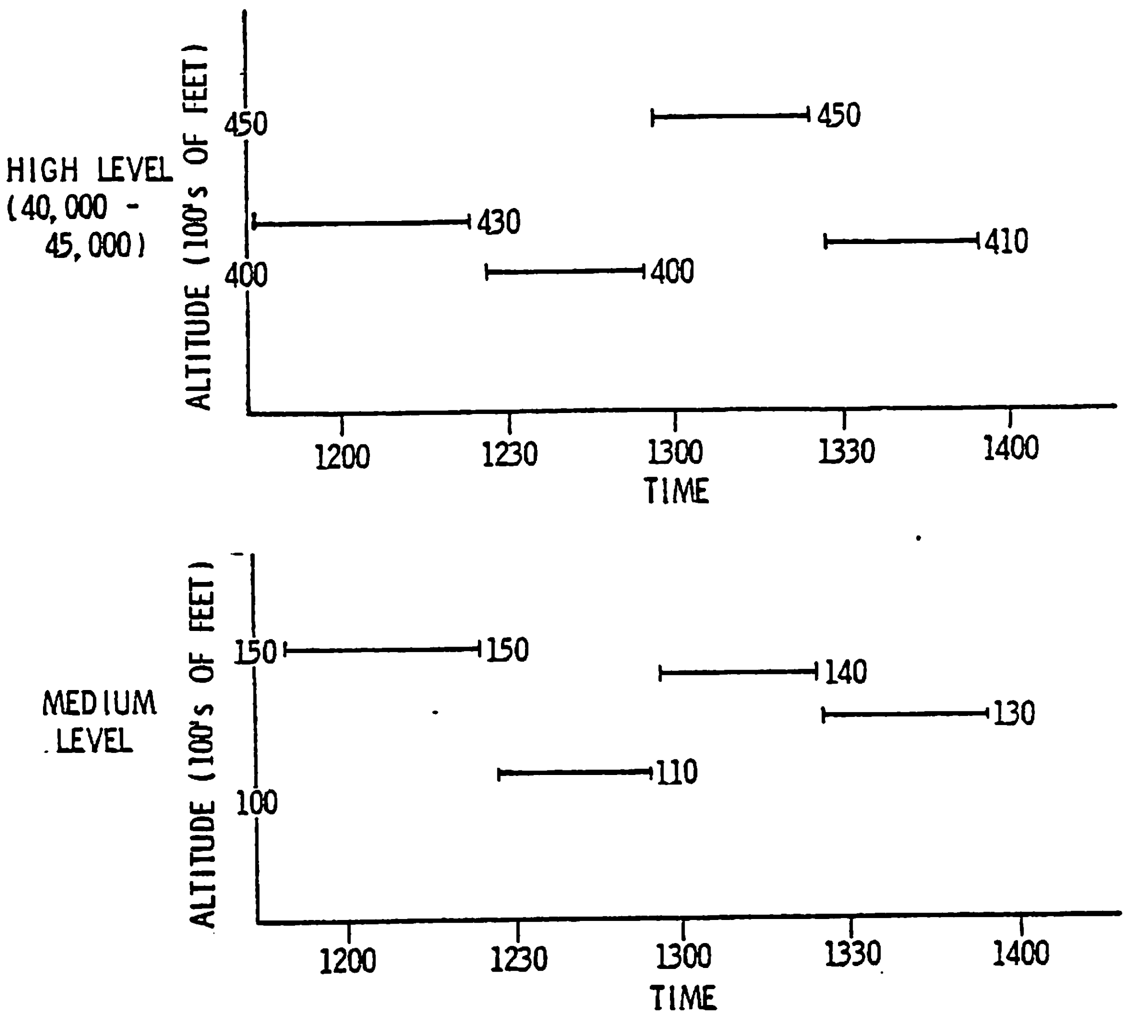
(b) Home Bound Aircraft. Home bound aircraft are defined as friendly aircraft returning from a mission over enemy territory. Aircraft returning at medium or high altitudes (10,000 feet and above) will display the appropriate IFF/SIF codes at least 30 NM prior to crossing the FLOT and will cross the FLOT at the appropriate sanctuary level unless there is evidence that the IFF/SIF is working properly. Aircrews returning at altitudes below 10,000 feet will turn their IFF/SIF to the required codes 10 NM prior to crossing the FLOT and will cross the FLOT at or above 5,000 feet. Provided that the IFF/SIF is functioning properly aircrews may proceed at any altitude above 5,000 feet mean sea level until they have reached their let-down point or crossed the western boundary of the HIMEZ. Aircrews will avoid flying below 5,000 feet mean sea level to prevent inadvertent engagement by friendly SHORAD weapons.

(S) (3) SLP. It is very probable that many friendly aircraft will be returning during periods of intense ECM activity when radar and missile sites will be unable to interrogate the airborne IFF/SIF equipment. Sanctuary levels will provide an additional capability for ground environment facilities to identify home bound friendly aircraft and preclude inadvertent engagement. These procedures will also assist aircrews returning without an operating transponder to over-fly missile defended areas. (See Figure I-B-3.)

Definition. A sanctuary level is a flight level at which an aircraft will not be subject to engagement unless positively identified "HOSTILE" by other means.

Figure I-B-3

(S) SANCTUARY LEVEL PROCEDURES (U)



(a) Sanctuary levels are activated automatically with all other minimum risk procedures at REINFORCED ALERT/STATE ORANGE or declaration of the individual measure ROI. They are to be deactivated automatically with the cancellation of the state/stage or individual measure. However, during the time minimum risk procedures are in force, a situation may arise that SFL procedures may not be desirable for the Central Region.

(b) Aircrew procedures.

1. Aircrews returning at low level, i.e., below 10,000 feet, with the exception of CAS missions and Army aviation, will cross the FLOT above 5,000 feet. If a sanctuary level must be used for protection, a second climb will be initiated so that the sanctuary level is reached 10 NM west of the FLOT. This behavior will be recognized as friendly by missile units.

2. Aircrews returning at high level, i.e., above 10,000 feet will fly at the appropriate sanctuary level when crossing the FLOT unless they rely on IFF/SIF for identification.

(c) HAWK and NIKE Execution.

1. Units will consider and subsequently designate as friendly all aircraft flying on a westerly heading at an activated sanctuary level including buffer of plus and minus 2,000 feet, except when there is evident misuse of sanctuary levels.

2. Sanctuary levels are valid for the same half-hour time periods as IFF/SIF Codes and will be changed concurrent with SIF codes for Mode 3 outlined in ACP 160, NATO SUPPLEMENT 2(A).

(S) 5. <u>AD Weapons Systems Employment</u>. (U)

(S) a. Weapons Systems. In the 4th ATAF area, the AD weapons systems include:

(S) (1) Interceptor aircraft.

(S) (2) SAM systems.

(S) (3) SHORAD weapon systems.

(S) b. Weapons Employment. The weapons systems will be employed as follows:

(S) (1) SAM units are deployed to provide defense of the battle area against enemy aircraft from low to high altitudes and to complement the defense provided by aircraft and SHORAD weapons in the engagement of targets at all effective altitudes.

(a) HAWK units, in conjunction with interceptor aircraft, will be employed in an area termed the FMDZ close to the NATO WP boundary, sometimes called "the belt." When considering redeployments of units for defense of 4th ATAF rear areas, the need to preserve the integrity of the FMDZ must be realized.

(b) Selected HAWK units, together with interceptor aircraft and SHORAD weapons systems, will primarily protect strike bases and other vital areas.

(c) NIKE units, in conjunction with interceptor aircraft, will be employed above the forward SAM and SHORAD weapons systems to engage the enemy at medium and high altitudes.

(S) (2) Interceptor aircraft will be employed in conjunction with SAM forces to provide a flexible weapon system for continuous active AD. The interceptors will normally be employed utilizing CAP patterns located above and west of the FMDZ forming a strong defensive barrier as dictated by the tactical situation. When accomplishing the peacetime air policing tasks, AD fighters are the only weapons that can be used for interrogation/intervention. In wartime, when engagement has been authorized, interceptor aircraft will normally be employed to destroy enemy aircraft that penetrate through the forward SAM defenses. In addition, they will be utilized to defend areas no longer defended by SAM forces due to destruction by enemy action, denial actions or redeployment of units. Whenever the tactical situation warrants, defensive fighters may be employed in any of the SAM WEZs, in the airspace of WP and neutral countries after border crossing authority has been granted by SACEUR or General Alert has been declared and in the airspace of adjacent sectors after coordination has been effected.

(S) (3) SHORAD weapons will normally be deployed to defend priority point targets, small vital areas and forward divisional areas.

(S) c. WEZs. (U)

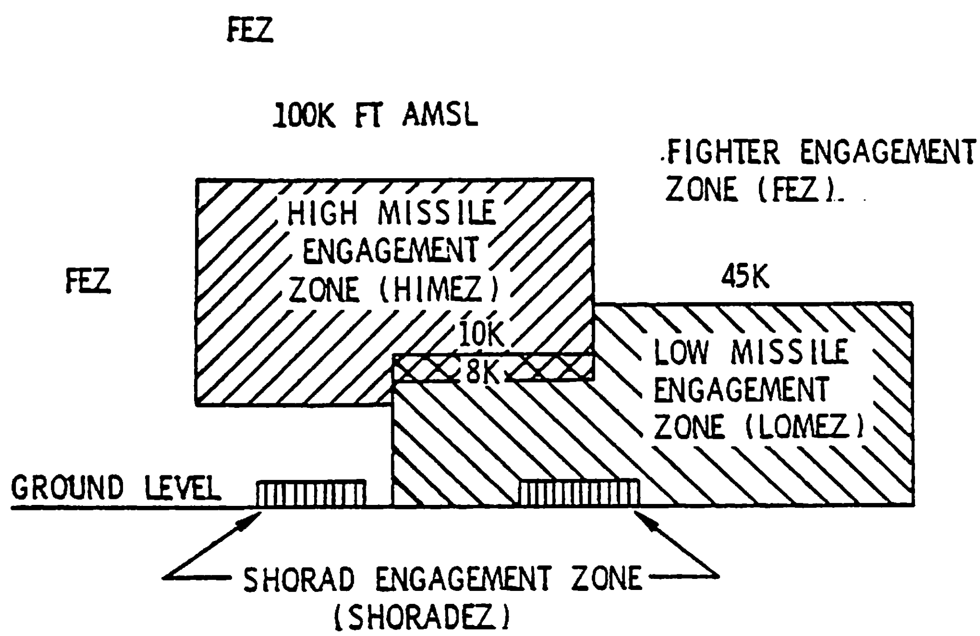
(S) (1) Employment of the AD weapon systems is to ensure that maximum attrition of enemy aircraft is achieved as far from the defended area as practicable and that maximum benefit is obtained from the mixed weapons inventory. As one valuable method of weapons control, each type of weapon system will normally have a predesignated WEZ. (See Figure I-B-4.)

(S) (2) The WEZs provide the AD commander with an orderly and flexible means of coordinating airspace and controlling engagements while a centralized method of operation is in effect. When decentralized or autonomous methods of operation are effective, these zones help to ensure a system within which the weapons can continue engagements in an effective manner.

(S) (3) When a weapons system is assigned a designated WEZ, that weapon has priority of engagement in that zone. Engagements outside the designated WEZ are authorized only under the following circumstances:

Figure I-B-4

(S) TYPICAL WEAPONS ENGAGEMENT ZONES (WEZ) (U)



(a) AD fighter aircraft may engage as directed by the responsible AD commander.

(b) SAM may engage under SAM DISCRETE FIRE.

(S) (4) Commander 4th ATAF or Commander, Allied Sector Three, may activate or modify WEZs for the 4th ATAF area.

(S) d. Simultaneous Engagements. In a centralized method of operation simultaneous target engagements by SAM and interceptor aircraft are normally not authorized. If the situation dictates, the AD commander may, however, specifically direct simultaneous target engagement. In this case, SAM units will insure positive identification of the hostile aircraft prior to engagement.

(S) 6. Interceptor Control Classes. Interceptor control classes advise interceptor aircrews that their operational objectives will be governed by close, loose, broadcast or no control. Interceptor classes are class 4, class 5, class 6 and class 7.

NOTE 1: Classes 1, 2 and 3 are intentionally not used to prevent any misunderstanding with SAM Weapons Control Order Case I, II and III.

NOTE 2: In any of the following control classes, airborne interceptors (especially the F-15) may provide significant assistance to the ground environment system by providing advisories on radar contacts not seen by ground-based radars.

(S) a. Class 4. All intercepts will be accomplished under Close Control, which is defined as an interception in which the interceptor is continuously controlled to a position from which the target is within visual range or airborne radar contact. It is the normal control class and need not be identified as class 4 except when a ground radar unit has been temporarily operating in class 5 or 6 and has returned to class 4.

(S) b. Class 5. All control of interceptors will be conducted by Loose Control, which is defined as a control method in which interceptor aircrews are given information on their allocated target and required to effect their own interceptions with only limited further control. It will be implemented when Close Control is not possible. Constant radio contact will be maintained between aircrews and ground intercept controllers.

(S) c. Class 6. All control of interceptors will be conducted by Broadcast Control, which is defined as a control method in which interceptor aircrews are given information about target movements, enabling them to effect their own interceptions without further control. It will be implemented when Close or Loose Control is not possible. Target information will be broadcasted in the blind giving the following details:

(S) (1) Position of target (raid) in GEOREF.

(S) (2) Heading of target (raid).

(S) (3) Altitude in thousands of feet.

(S) (4) Speed.

(S) (5) Number of targets, if possible.

(S) (6) Any other relevant information.

The acknowledgement of receipt of broadcast control information will be that interceptors move toward the broadcasted targets. This does not preclude the ground radar sites from requesting acknowledgement of broadcast information by a radio response, IFF/SIF FLASH squawk or by an identification maneuver.

(S) d. Class 7. When ground radar sites are unable to provide any control of interceptors, class 7 will be implemented. It requires aircrews to conduct preplanned independent actions within preallocated lanes. If no radio contact can be established with a ground radar site, aircrews will attempt contact with their units and operate in Wing/Squadron mode of control. F-15 aircrews may provide assistance to F-4 and F-104 interceptors in HCAPs and LCAPs by broadcasting any raid information observed on their airborne radar.

(S) 7. Control of HAWK and NIKE Weapons. (U)

(S) a. General. Weapons employment is controlled by establishment of modes of control (paragraph 3 above), weapons control orders, warhead control orders, fire control orders and WEZs (paragraph 5c above).

(S) b. Weapons Control Orders. Weapons Control Orders are used to establish or modify the responsibility for engagement limitations. Definitions of Weapons Control Orders are as follows:

(S) (1) SAM Discrete Fire. Units will only engage those targets allocated by the authority authorized to order engagements. This order is not applicable to the Battery Mode of Control. Units will assist in target detection. As an exception to the Discrete Fire restrictions, improved HAWK fire units initially detecting ADP designated Category I targets within 20 kilometers of the unit location may immediately engage such targets without further reference to higher control authority. This exception is authorized only when the following conditions exist:

(a) General Alert has been declared or SACEUR's Rules of Engagement have been cancelled.

(b) No restrictive Fire Control Order has been imposed for the area wherein the engagement is to occur.

(c) The target is approaching the unit from an easterly direction.

(S) (2) SAM Normal Fire. Units will engage all aircraft which are within the applicable activated missile engagement zone and which have been designated hostile by higher echelons or positively identified by the unit as being hostile (SACEUR's Rules of Engagement prior to General Alert or SACEUR's Rules of Routing and Recognition subsequent to General Alert). Ordinarily, SAM Normal Fire will be used in conjunction with the Battery Mode of Control. Higher tactical control facilities will monitor engagements while capable of doing so. Targets allocated by higher echelons (SOC/CRC/MCC/BOC) subsequent to SAM Normal Fire will take engagement priority.

<u>NOTE</u>: It is reemphasized that so long as SACEUR's Rules of Engagement are in effect (i.e., until General Alert or Cancellation of SACEUR's Rules of Engagement), on loss of communications, Battalion/Battery commanders can only order engagement in self-defense.

(S) (3) Implementation of Weapons Control Orders. Fire control of HAWK and NIKE will be retained by the highest tactical control authority capable of exercising centralized direction of engagements. As long as communications exist, only the Sector Commander or his duly authorized representative is authorized to issue weapons control orders. When communications are lost, weapons control orders will be implemented and/or modified as indicated below:

(a) If the weapons control order previously issued was for a prescribed time period, it will remain in effect for the time period specified. At the end of the specified time period, the highest commander who has communications and is authorized to order engagement (MCRC/CRC/MCC/Battalion/Battery) will issue the appropriate weapons control orders until communications are restored.

(b) If a weapons control order was not issued or was issued without fire limitations, the highest commander who has communications and is authorized to order engagement (MCRC/CRC/MCC/Battalion/Battery) will issue the appropriate weapons control order until communications are restored.

(c) Warhead Control Orders. Warhead Control Orders control the use of NIKE nuclear warheads in the AD role and are discussed at Attachment 3.

(d) Fire Control Orders. These orders are used to direct or inhibit fire and/or to exercise constraints during tactical activity. Fire Control Orders normally apply to engagements on a case-by-case basis and are implemented by ADL and/or telephonically. Definitions of these orders are as follows:

1. Engage. An order issued to a unit by a higher controlling agency directing it to engage/reengage a specific target.

2. SAM hold Fire. An emergency order issued to prevent engagement of a specific target (friendly or otherwise). When received, the following actions will be taken:

- If a missile has been fired, do not fire and cease tracking.
- If a missile has been fired, destroy the missile immediately, without causing a nuclear burst and cease tracking.

NOTE: Under exceptional circumstances a SAM HOLD FIRE may be applied to a number/variety of AD weapons systems in a specified area for a specified time.

3. SAM Cease Fire. An order directing units to disengage a particular target to preclude simultaneous engagement by

interceptors and HAWK and NIKE, or by two or more HAWK/NIKE units or to prepare for engagement of another target of higher priority. When received, the following actions will be taken:

- If a missile has been fired, permit it to continue to intercept; continue to track the target; do not fire an additional missile; stand by for a subsequent fire control order.

- If a missile has not been fired, do not fire; continue tracking the target; stand by for a subsequent fire control order.

- If the target has to be reengaged, an engage order will be issued; if the target has to be abandoned for engagement of a target of a higher priority, "Hold Fire" will be orderd.

(S) 8. SHORAD. SHORAD weapons include all light anti-aircraft artillery and light surface-to-air missile systems employed in the AD role. Specifically excluded are HAWK and NIKE weapons systems.

(S) a. General Employment.

(S) (1) SHORAD weapons have two principal roles:

(a) To protect the commander's priorities as identified in his concept of operations.

(b) To close the low to very low altitude corridors which are masked to NIKE and HAWK defense because of terrain relief.

(S) (2) SHORAD weapons will, where applicable, be employed in a SHORADEZ when specific ground forces, areas or vital installations of particular importance have to be protected, the criticality of the area warrants so and the possibility exists that other AD means will not be adequate to avoid unacceptable levels of damage to the defended asset. A SHORADEZ is a designated part of the airspace which should be avoided by all friendly air traffic unless sufficient coordination with the local SHORAD commander has been effected.

(S) (3) SHORAD weapons will normally be granted "Weapons Free" against air targets flying inside an active SHORADEZ. However, the SHORAD commander may amend the weapons control orders locally to meet specific coordination requirements of friendly aircraft exceptionally cleared into a SHORADEZ.

(S) (4) Some basic considerations concerning SHORAD employment are as follows:

(a) To receive benefit from the increased effectiveness of modern SHORAD weapons, maximum freedom of action must be permitted them.

(b) Positive identification is of the utmost importance. Therefore, every effort must be made to ensure friendly aircraft are not erroneously engaged.

(c) The primary means of identification in Central Region is IFF/SIF. As most SHORAD weapons systems currently do not have an adequate IFF/SIF capability and radar, visual recognition will remain as essential means of identification.

(d) SHORAD rules of engagement and implementation of SHORAD weapons control orders take into account the fact that currently most SHORAD weapons do not have adequate IFF/SIF.

(e) Establishment of zonal measures and permissive and restrictive weapons control orders will be based primarily on friendly air activity in the given area. Due consideration will be given to employing SHORAD weapons system at maximum efficiency.

(f) When the presence of friendly aircraft in a given area cannot be determined due to lack of effective communications, "Weapons Free" will not normally be authorized.

(S) (5) SHORAD weapons systems will be employed in the SHORAD mode of control utilizing pre-established hostile criteria, weapons control orders and engagement procedures.

(S) (6) SHORAD weapons have been categorized in terms of their capabilities.

(a) CATEGORY 1. This category includes those blindfire capable weapons that fulfill all requirements listed below.

1. Equipped with operational IFF/SIF which enables correlation of all individual targets with IFF/SIF responses received.

2. Have an intercept capability in the height band between 5,000 feet/ 1,500 meters and 10,000 feet/3,000 meters above mean sea level.

3. Can measure target heights below 10,000 feet/3,000 meters above mean sea level.

4. Have effective communications with a command and control agency (SOC, CRC, BOC, ATOC, DASC/ASOC) able to receive and disseminate directives and information on the air situation in the area of concern.

(b) CATEGORY 2. This category includes SHORAD weapons (including self-defense) which through design or loss of capability do not fulfill all the requirements of Category 1 weapons.

(S) (7) SHORAD weapons systems currently employed in 4th ATAF or programmed for future employment in 4th ATAF are indicated below by category:

TYPE	USER	CAT 1	CAT 2
Gepard	Ger	X	
Roland	Ger	X	
40mm L60	Ger		X
40mm L70	Ger		X
40mm Boffin	Cdn		X
Chaparral			
Vulcan	USA		X
20mm Twin-Barrel Gun	Ger		X
20mm Single-Barrel Gun	Ger		X
REDEYE	USA) Ger)		X
Blowpipe	Cdn		X
Machine-Gun of any calibre	USA) Ger) Cdn)		X

(S) (8) All SHORAD units are encouraged to establish communications/liaison with any integrated AD unit able to disseminate necessary information on the air situation.

(S) b. SHORAD Weapons Control Orders. SHORAD weapons control orders are issued to direct or inhibit the fires of SHORAD weapons systems. Inherent in each weapons control order are the constraints which apply to SHORADEZ and weapons systems.

(S) (1) Weapons Free. An order used to indicate that SHORAD weapons will engage all of the specified types of targets within the designated airspace, other than those identified as friendly.

(S) (2) Weapons Tight. An order used to indicate that SHORAD weapons will engage those specified types of targets in the designated airspace which are identified as hostile, or which commit a hostile act.

(S) (3) Weapons Hold Fire. An order used to indicate that SHORAD weapons will terminate or withhold fire, except in self-defense against a direct attack.

(S) c. General Applications and Restrictions. (U)

(S) (1) To allow for the flexible use of the different weapons control orders, engagement ceilings have been introduced for SHORAD fires. Their application is explained elsewhere in this paragraph.

(S) (2) Whenever practicable, fire restrictions will be minimized on those aircraft with a westerly component (181 to 359 degrees) and maximized on those aircraft with an easterly component (0 to 180 degrees).

(S) (3) "Weapons Free" may either be applied to a specific category of targets (jet aircraft, helicopters, etc.) or to an airspace designated by the NATO AD Commander (SOC-3 or higher). The following prerequisites must be met:

(a) General Alert must have been declared.

(b) "Weapons Free" must be valid for a specific time period.

(c) No friendly air activity in the airspace or specified area during the specific time period "Weapons Free" is in effect.

(d) Operational communications from the engaging unit to a command control agency (organic or external) which has the capability to receive air activity information from knowledgeable authorities (DASC/ASOC, CRC or higher) and disseminate appropriate weapons control orders.

SHORAD units/weapons operating under "Weapons Free" will immediately revert to "Weapons Tight" after loss of communication with its command and control agency.

(S) (4) "Weapons Tight" will be implemented prior to and after declaration of General Alert for all aircraft whenever:

(a) Communications are not available which enable the command and control agency to receive information on the air situation and disseminate directives and necessary information to its SHORAD units/weapons.

(b) Warranted by the employment of friendly aircraft within range of friendly SHORAD.

(S) (5) "Weapons Hold Fire" may be issued by any friendly element which has an identification capability. This order is normally applied to specific aircraft. In an emergency, it may be applied to an airspace.

(S) (6) Category 1 SHORAD weapons will normally be permitted to operate under "Weapons Free" if conditions specified in Attachments 1 and 2 are met.

(S) (7) Category 2 SHORAD weapons will normally operate under "Weapons Tight." Exceptionally, Category 2 weapons may operate under "Weapons Free" in designated areas, against certain target types and directions, for specific periods of time, when authorized by Commander 4th ATAF.

(S) (8) SHORAD/self-defense units weapons deployed with the field army without operational IFF/SIF and lacking two-way communications to the NATO Integrated AD, but having two-way communications to the OAS organization (ASOC, ATOC) may, after ascertaining that communications are operational and that no friendly OAS mission is due, go to "Weapons Free" within a specified area and for a limited time period under Standard Friendly Criteria and the following restrictions:

(a) In an area extending till 10 NM west of the FEBA.

(b) On westbound aircraft (181 to 359 degrees).

(c) On high-speed jet aircraft (more than 300 kts) or armed helicopters visually identified as hostile.

(d) Below 5,000 feet above mean sea level.

(S) (9) SHORAD self-defense units/ weapons without operational IFF/SIF but having communications to the NATO Integrated AD will be responsive to weapons control orders issued by the NATO AD Commander. The SOC Commander will issue "Weapons Free" any time the air situation permits to maximize effective employment of SHORAD weapons.

(S) (10) Whenever the air situation or the availability of SHORAD units/weapons with operational IFF/SIF permits the implementation of the weapons control order "Weapons Free," the Commander, Allied Sector Three, will issue this order.

<u>NOTE</u>: Regardless of the status of communications, Commander 4th ATAF can authorize "Weapons Free" for SHORAD/self-defense units/weapons without operational IFF/SIF.

(S) d. Friendly/Hostile Criteria for SHORAD. (U)

(S) (1) The weapons control order "Weapons Free" indicates that SHORAD will fire on all aircraft other than those identified as friendly. An aircraft will be considered friendly if one or more of the Standard Friendly Criteria for SHORAD listed below apply.

(a) Complying with Safe Passage Procedures.

(b) Visually recognized as friendly.

(e) Any aircraft conforming to safe passage procedures but detected committing a hostile act.

(f) Any aircraft being engaged by neighboring friendly organic SHORAD weapons in case communications are operational between the two units or in conjunction with another hostile criterion.

NOTE: An aircraft which is visually recognized by configuration or markings as a friendly aircraft will nullify hostile criteria (c) and (d).

(S) (3) The hostile criteria listed above will be applicable after declaration of General Alert or after cancellation of SACEUR's Rules of Engagement. The fundamental right of a unit to self-defense against any aircraft making a direct attack against the unit remains.

(S) (4) The Commander, Allied Sector Three, may extend hostile criteria with respect to areas and/or times.

(S) e. Safe Passage Procedures. (U)

(S) (1) Basic Means of Identification. It is of the utmost importance to ensure that home-bound friendly aircraft can transit safely through engagement zones of SHORAD weapons. Rapid, reliable and secure means of identification are a desirable objective. To this effect, Safe Passage Procedures have been established consisting of:

(a) IFF/SIF Procedures.

(b) SFL

(S) (2) Information of Friendly Air Activity. All agencies possessing information concerning friendly air activity over the Forward Combat Zone will provide pertinent data to SHORAD commanders. To avoid inadvertent engagement of friendly aircraft, the appropriate SHORAD commander authorized to issue the weapons control order "Weapons Free" will establish communications/liaison and cooperate closely with those agencies controlling or having information concerning friendly offensive and defensive air activity. Agencies which have this information are CRCs, HAWK BOCs, DASC/ASOCs, TACPs, HLT/ADOLTs, CPs of the LLRS and the Army aviation air traffic control element.

(S) (3) Aircraft Recovery. To facilitate safe recovery and departure of friendly aircraft to SHORAD-defended airbases, standardized procedures will be established by Commander 4th ATAF for his area of responsibility. Each base commander will be responsible for the coordination of the base AD and the recovery of aircraft with the SHORAD commanders. Where several air bases are defended as one vital point, the SHORAD commander will ensure that organizational means for recognition are coordinated for the vital point as a whole. The dimensions of the SHORADEZ as well as approach and departure corridors will be detailed. If the situation so requires, the base commander has the authority to order "Weapons Hold Fire" or "Weapons Tight" in order to safeguard friendly aircraft.

(U) 9. Summary of AD Engagement Controls. (See Figure I-B-5.)

(S) 10. Communications. Communications to interceptor aircraft are, with few exceptions, by voice via UHF radios. Communications from the CRC through the Group level and Battalion level operating centers to HAWK and NIKE fire units are digital and voice via point-to-point, multichannel, UHF radios. All SHORAD C^3 are via voice, although SHORAD units can receive limited alerting data via a one-way digital link from forward area alerting radar.

(U) 11. Conclusions.

a. Current control concepts and procedures are generally adequate within the constraints imposed by existing equipments. Current weapon system abilities to accept and implement currently available control procedures

Figure 1-B-5

SECRET

(S) NATO (4ATAF) AIR DEFENSE ENGAGEMENT CONTROLS (U)

INTERCEPTORS	SAM (HAWK, NIKE)	SHORAD
MODE OF CONTROL: WHO HAS ENGAGEMENT AUTHORITY		SHORAD MODE OF CONTROL
WEZ: FEZ	HIMEZ, LOMEZ	SHORADEZ
INTERCEPTOR CONTROL CLASSES: CLASS 4, CLOSE CONTROL CLASS 5, LOOSE CONTROL CLASS 6, BROADCAST CONTROL CLASS 7, AUTONOMOUS	WEAPON CONTROL ORDERS: DISCRETE, VERY CENTRALIZED NORMAL, ENGAGE HOSTILES IN WEZ FIRE CONTROL ORDERS: ENGAGE HOLD FIRE, TO PROTECT FRIENDLIES CEASE FIRE, TO PREVENT SIMULTANEOUS ENGAGEMENTS	WEAPONS CONTROL ORDERS: WEAPONS FREE, ENGAGE NONFRIENDLIES WEAPONS TIGHT, ENGAGE HOSTILES WEAPONS HOLD, ENGAGE ONLY IN SELF DEFENSE

SECRET

are marginal in some areas. Although current procedures can be changed or modified to degrees, they approach maximum potential to enhance integrated employment of AD weapon systems. Equipment improvements are required to achieve further enhancement.

b. Future equipment improvements in the areas of point-of-fire identification reliability, automated data exchange and processing, displays suitable for correlating data with ongoing air activity and communications, would permit a shift in procedural philosophy from avoidance of conflicts between weapons types to enhancement of mutually supporting tactics.

ATTACHMENT 1

(S) FUNCTIONAL RESPONSIBILITIES OF 4th ATAF COMMAND, CONTROL AND REPORTING AGENCIES. (U)

(S) a. 4th ATAF ADOC. The ADOC is the agency through which Commander, 4th ATAF exercises operational control over 4th ATAF AD forces. The ADOC will be manned by 4th ATAF ODO personnel on a full-time basis when the 4th ATAF SWHQ is operational during times of tension and hostilities. When the 4th ATAF SWHQ is not fully manned, SOC-3 personnel will perform the following ADOC functions:

1. Assessing the air threat in the 4th ATAF area.

2. Maintaining appropriate displays of the current AD situation, status of all AD forces, states/stages of alert, DEFREFs and Air Raid Warnings.

3. Evaluation and dissemination of Early Warning information in accordance with SHAPE and AFCENT directives. (This function is performed by SOC-3 at all times.)

4. Ensuring Headquarters 4th ATAF ODO, AFCENT/AAFCE SWHQ and SHOC are informed of possible violations and incidents as outlined in appropriate NATO documents.

5. Execution of other tasks as required by other directives and instructions.

(S) b. SOC-3. AD tactical operations will be conducted from the designated SOC at Kindsbach or the alternate SOC facility at Boerfink. The Commander, Allied Sector Three, is appointed on 4th ATAF General Orders and responsible for allied tasks as listed below. He and other U.S. General Officers have been designated by CINCUSAFE to make Phase "A" tactical decisions. The authority for these decisions in the 4th ATAF area is charged to

CINCUSAFE under MC 66/1 in conjunction with the technical arrangements for the application of SACEUR's Rules of Engagement. The SOC is responsible for:

1. Commander, 4th ATAF's executive agent for AD and is charged with the tactical employment of 4th ATAF AD forces.

2. Exercising tactical control of all AD forces under the operational control of Commander 4th ATAF and fire control of non-assigned SAM and SHORAD units.

3. Exercising tactical control of augmenting AD units in the Sector.

4. Exercising tactical control over French forces may be made available.

5. Coordinating AD activities with Commanders of the adjacent Allied Sectors and the French Zone Air Defense Northeast as necessary to support principles of integrated AD.

6. Disseminate to subordinate units the release of nuclear weapons, alert states/stages, air raid warnings, DEFREP's and other information.

7. Declare, disseminate and display air raid warnings, DEFREPs, modes of control and SAM engagement orders for the 4th ATAF area in accordance with existing instructions.

(S) c. MCRC. The MCRC manages the ground environment system, employs AD weapons and implements tactical actions under the supervision of the Sector Controller. The MCRC will:

1. Manage all ground environment units in the 4th ATAF area.

2. Ensure the ground environment system presents an accurate and complete air picture through the use of scheduled maintenance and judicious use of alternate cross-tell data line routings or manual tell operations.

3. Initiate and implement tactical actions in accordance with applicable directives with final approval granted by the Sector Controller.

4. Notify the SOC of emergency maintenance outages as they occur.

5. Correctly apply and efficiently manage the radar system surveillance, detection, tracking, identification and display resources including SAM units and LLRS inputs.

ATTACHMENT 2

(S) SACEUR'S RULES OF ENGAGEMENT. (U)

(S) a. SACEUR's Rules of Engagement are based on MC 66/1, "Rules of Interrogation, Intervention and Engagement for Air Defense Forces in Allied Europe in Peacetime," and are applicable throughout SACEUR's area of AD responsibility.

1. Within the Integrated Air Defense of NATO Europe, the Regional Commanders, i.e., COMAAFCE for the Central Region, are responsible for the application of SACEUR's Rules of Engagement within their areas of responsibility. However, this responsibility is limited by particular political implications in the Central Region.

2. In the Central Region, the application of these rules over the territory of the FRG by Allied AD Commanders is subject to modifications posed by special political provisions of the Bonn Convention. Under these provisions the three powers (France, UK and U.S.) retain the right to control Soviet aircraft utilizing West German airspace. Following the withdrawal of French armed forces from ACE, France has stated her intention not to use her forces for safeguarding FRG airspace, but has reserved the right to do so.

3. In order to comply with the Bonn Convention and at the same time to safeguard effectively the integrity of the airspace over Central Europe, since France had decided not to participate in the air policing of FRG, the responsibility to apply SACEUR's Rules of Engagement will be vested in normal peacetime in the national Air Force Commanders of the UK and US, stationed in the FRG. However, in time of imminent emergency, provisions have to be made to use all AD forces placed under the operational command or control of the Allied AD Commanders responsible for AD of Western Germany.

(S) b. In accordance with MNC's Alert System, there are three peace to war phases for AD operations. These phases and the associated application of SACEUR's Rules of Engagement are as follows:

1. Phase "A". Normal peacetime defined as up to and including SIMPLE ORANGE. SACEUR's Rules of Engagement apply (MC 54/1).

2. Phase "B". Imminent emergency defined as beginning with the declaration of REINFORCED ALERT and/or STATE SCARLET. SACEUR's Rules of Engagement apply and are expanded for this phase (MC 54/1).

3. Wartime Phase. Effective on declaration of General Alert, SACEUR's Rules of Engagement are automatically cancelled.

(S) c. SACEUR's Rules of Engagement are based on the following principles:

1. Defensive actions taken must be in consonance with international law and the sovereign right to take action in self-defense.

2. Allied defensive reactions should neither prove nor result in a more dangerous situation than it attempts to safeguard.

3. Every action must be taken to avoid mistaken, unwarranted or unnecessary destruction of any aircraft.

4. Action to engage and destroy other aircraft can be justified only:

(a) If the present action or previous similar actions provide sufficient indication of intent to commit a hostile act and then only after taking into account all the prevailing circumstances, including the behavior of the aircraft probable origin, their position and pattern and any failure to respond to clear signals given by our defense forces; or

(b) If they commit a hostile act.

5. Rules and signals contained herein do not apply to naval forces operating over or in international waters; however, these rules and signals do not apply to such forces when operating in European NATO airspace.

6. Declaration of an aircraft as hostile must be tempered with judgment and discretion. There may be circumstances in which the destruction of Communist Bloc aircraft would be contrary to Allied interests. Any available intelligence of such circumstances must be considered in determining the action to be taken.

7. However, in times of imminent attack, defined for this purpose as after the declaration of REINFORCED ALERT or STATE SCARLET, the application of these rules will be more rigid in accordance with the prevailing situation than in Normal Peacetime, defined as prior to the declaration of "Simple Alert" or STATE ORANGE.

8. In consonance with the strategic concept for defense (MC 14/3) the application of the Rules of Engagement must be flexible to deal with all forms of aggression. Consequently, when multiple hostile acts have been committed in 4th ATAF area after declaration of REINFORCED ALERT or STATE SCARLET, Commander 4th ATAF through COMAAFCE, may request SACEUR for authority to cancel all or part of the Rules of Engagement for ACE AD Forces to meet a particular situation in Central Europe or in 4th ATAF area.

9. On declaration of General Alert the rules and signals will be cancelled automatically and 4th ATAF Wartime Operational Procedures will be applied.

(S) d. Hostile Act is committed when:

1. One aircraft:

(a) fires on an intercepting aircraft or clearly and persistently maneuvers into position to attack; or

(b) in European NATO Airspace and without proper clearance releases or is unmistakably preparing to release bombs or fires missiles, rockets or guns other than on a recognized range; or

(c) conducts minelaying operations in the territorial waters of an European NATO nation; or

(d) attacks friendly forces.

2. Two or more aircraft:

(a) individually or collectively commit a hostile act as defined in subparagraph 1(a) above; or

(b) in European NATO airspace and without proper clearance drop paratroopers or land troops; or

(c) penetrate European NATO airspace at speeds above 200 knots and an altitude below 10,000 feet in direct flight from Soviet or Soviet Satellite territory without proper clearance. This action will only be considered a hostile act after the declaration of REINFORCED ALERT or STATE SCARLET.

NOTE: Reconnaissance as such is not included in the definition of a hostile act in MC 66/1. However, if one or more unidentified aircraft indicates beyond a reasonable doubt that routine or recurring reconnaissance is being conducted, it may be declared hostile by Commander 4th ATAF or higher authority.

(S) e. Wartime AD Operations. The wartime phase is effective on declaration of General Alert and SACEUR Rules of Engagement are automatically cancelled. The 4th ATAF OPLAN 34001 in its entirety is implemented and Commander 4th ATAF is responsible for all AD operations in the 4th ATAF area.

1. Procedures for identification and engagement will be in accordance with ACP 160 and 4th ATAF Routing and Recognition instructions as contained in 4th ATAF SUPPLAN 34001 T.

2. 4th ATAF Hostile Criteria are implemented. They are expanded to include:

(a) All hostile criteria as listed in paragraph c.1. above.

(b) One or more aircraft observed flying at a ground speed greater than 250 knots and not complying with IFF, SIF or SLP.

(c) One or more aircraft observed emitting ECM and not complying with IFF/SIF or SLP, regardless of speed.

3. Commander 4th ATAF may declare all targets hostile in a specific area where hostile aircraft cannot be separated from friendly aircraft.

(S) f. During Phase "A" the responsibility to apply SACEUR's Rules of Engagement in Central Region will be subdivided with regard to:

1. The airspace over West German territory and

2. The airspace over Central Region Integrated AD area outside West German territory.

(a) Airspace over the FRG. During this phase, it is the responsibility of the UK and U.S. to safeguard the integrity of West German airspace. Therefore, by delegation by their national governments, Commander-in-Chief, RAF Germany and Commander-in-Chief, USAFE, will be responsible for the application of SACEUR's Rules of Engagement in Western Germany. These commanders will use for this purpose the active AD forces of the UK and U.S. but will technically be assisted by the Allied Ground Environment of Central Region. They will closely coordinate their activities, based on their geographical areas of responsibilities as Allied AD Commanders. German AD controllers may be used for directing interceptors or other active AD units of NATO forces stationed in Germany if the decision for initiating operational AD missions which may lead to opening fire and for the fire order itself, is taken by the responsible U.S. or U.S. AD Commander in Germany or, on his behalf, by the appropriate Sector Commander or a Sector Controller of U.S. or UK nationality.

(b) Airspace of the Integrated Air Defense Area of Central Region Outside Western Germany. During Phase "A", it is SACEUR's responsibility to safeguard the integrity of the airspace of the Integrated Central European Air Defense area outside Western Germany. Therefore, by delegation through allied channels to COMTWOATAF and COMFOURATAF these commanders are responsible for the application of SACEUR's Rules of Engagement within their areas of responsibility as Allied AD Commanders outside the FRG.

(S) g. Phase "B". (U)

1. As soon as REINFORCED ALERT or STATE SCARLET has been declared by competent Allied authorities, COMAAFCE will, by delegation from SACEUR, be responsible for the application of SACEUR's Rules of Engagement throughout Central Region Integrated Air Defense Area.

2. COMTWOATAF and COMFOURATAF will assume their responsibility for application of SACEUR's Rules of Engagement within their respective AD area. They will use, for this purpose, all appropriate AD forces and facilities available to them in accordance with the prevailing air situation to safeguard effectively the integrity of the AD responsibility.

ATTACHMENT 3

(S) WARHEAD CONTROL ORDERS. (U)

(S) a. Warhead Control Orders are prescribed to conduct employment of AD nuclear and high explosive warheads in the surface-to-air role. Warhead Control Orders Case Codes are defined as follows:

1. CASE ONE. Use of nuclear warheads against targets above the MNBA for the nuclear warhead specific is authorized.

2. CASE TWO. Use of nuclear warheads against targets at all altitudes is authorized (authority to declare/order is retained by Commander 4th ATAF).

3. CASE THREE. Use HE warheads only. Nuclear warheads are not to be used.

NOTE: Combination Warhead Control Orders. A Warhead Control Order of CASE ONE and TWO could be issued with the letters "BXS" or "BXL" added to indicate to which warhead the order applies. For example: The order "CASE ONE - BXL or BXS", "CASE TWO - BXS" would mean that nuclear warheads can be used, but that only "BXS" would be used below MNBA. In addition, warhead control orders in force may be related to specific areas, thus providing flexibility to adjust fire distribution for varying tactical situation.

(S) b. As long as communications exist, the Commander, Allied Sector Three is authorized to implement CASE THREE at any time. He may also implement CASE ONE after receipt of selective or general release (R-Hour). Commander 4th ATAF retains sole authority to implement CASE TWO after receipt of selection of general release and after the lifting of SACEUR's constraints pertaining to MNBA.

(S) c. Five minutes after loss of communications with higher authority, the highest commander who has communications and is authorized to order engagement (MCRC/CRC/MCC/Battalion/Battery) may implement CASE ONE provided that general release had been received, but not yet implemented by the Commander Allied Sector Three prior to the communications loss and provided the tactical situation is so critical as to warrant CASE ONE.

ATTACHMENT 4

(S) WALK THROUGH EXAMPLE OF AIR DEFENSE IN 4ATAF (U)

- Wartime Rules of Engagement in effect

- Aircraft detected in 4ATAF Air Defense area of responsibility

- Identification officer at MCRC attempts to identify TRACK

  -- MK X/MK XII Interrogation

  -- MK X IFF/SIF procedures

  -- Minimum risk procedures

  -- SLP

- Aircraft identified hostile

  -- Weapons Assignment Office at MCRC allocates to

    --- Fighters - in fighter engagement zones

    --- SAMS - in missile engagement zones - Hi or Low

- Aircraft not detected by RADAR Ground Environment System and/or System degraded to antonomous operations

  -- SAM Operations

    --- Battery mode of control

    --- Weapons fire control orders

    --- Weapons warhead control orders

    --- Identification procedures if capable

      ---- MK X/MK XII Interrogation

      ---- MK X IFF/SIF Procedures

---- Minimum risk procedures

---- SLP

-- SHORAD Operations

--- No minute-to-minute control

--- Preplanned weapons control orders

--- With communication - weapons control orders from SOC III

--- Identification procedures

---- Apply safe passage procedures if capable

---- Visual recognition

ATTACHMENT 5

(S) 4ATAF AIR DEFENSE RESOURCES (U)

TFS BITBURG 3 SQ = 72 F-15
RAMSTEIN 1 SQ = 18 F-4E
NEUBURG 2 SQ = 30 F-4F

MCRC/MCC BOERFINK

5 NIKE BATTALION
1 NIKE BATTALION
2 C/V BATTALION (US)

CRC/ALT MCRC MESSTETTEN

CRC/MCC FREISING

3 HAWK BATTALION

CRC/MCC LAUDA & MCC DARMSTADT

7 HAWK BATTALION

RP - DOEBRABERG
RP - WASSERKUPPE
EWRP - BURGLENGENFELD

TACS CRP PRUEM, NEU-VLM, SEMBACH
FACP PRUEM, WIESBADEN, WUERZBURG, GRAFENWOEHR, ALZEY, BAD KREUZNACH

LLRS = LAUDA, NAILA, ULM, ROTHENBURG/F.

(U) APPENDIX C.

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Warner Robins ALC/MMIME
Robins AFB, GA 31098
ATTN: Joseph Smith, Autovon 468-2994

5. Naval Research Laboratory
Washington, D.C.
ATTN: Walter Bishop/Carlyle V. Parker, (202) 767-3396/AV 297-3396

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REPORT OF TASK GROUP II

(C) SUPPORTING FIRE FOR FRIENDLY FORCES (U)

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Dr. David Fried, Vice Chairman	ASB
Dr. John Blair	ASB
Dr. Philip E. DePoy	ASB
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Maj Roger Hegstrom	AFTEC
Maj Jack May	TAC

(C) ABSTRACT (U)

(U) This section treats the subject of coordination of supporting fire. The principal problem areas and areas of opportunity for improvement are identified, discussed in some detail, and proposed solutions are presented. The areas identified concern:

(1) the procedure for allocation and assignment of CAS sorties,

(2) the need for an electronically-based common position location system,

(3) the need for a digital message capability for targeting,

(4) the need for improvement interplay in the development of new tactics, training, and new equipment,

(5) the need for improved target handoff with reduced exposure for both the strike element and the unit designating/handing-off the target, and

(6) the need to be able to handoff targets acquired with one Service's electronic sensors for rapid servicing by the other Service's strike assets.

(C) Among the principal recommendations are the following four:

(1) CAS sorties should be allocated downward, with full authority to assign the strike to a target retained at the allocated level.

(2) The move to a PLRS/JTIDS system be given high priority, as it can provide both the common electronic coordinate system and the digital targeting message capability.

(3) Laser designator/FLIR and upgraded avionics/ visionics should be deployed, and special tactics/ procedures be established, as described, to facilitate target handoff and reduce exposure.

(4) Joint training and tactics development exercises for coordination of supporting fire should be conducted, with prototypes of equipment still in development, to establish feedback between equipment development and development of tactics.

Contents, Report of Task Group II

(C) I. SUMMARY (U)

(U) A. DESCRIPTION OF TOPIC

(U) The topic for Task Group II was fire support for friendly forces. The Task Group investigated potential improvements in procedures, systems, or interface equipment to enhance the timely application of firepower, from artillery, fixed-wing aircraft, and attack helicopters, on enemy maneuver units. The combat missions involved are concerned primarily with weapon allocations, communications and target standoff. Particular emphasis was given to improving the capability of Air Force strike assets in support of the ground commander's mission. The improved utilization of either Service's weapon system with either Service's target acquisition or cueing procedures for some battlefield applications was another major topic.

(U) B. DEFINITIONS

(U) Terms commonly used for offensive and CAS are defined in Appendix A.

(C) C. KEY OPERATIONAL NEEDS (U)

(U) Three key operational needs were identified by the Task Group. The need to provide the ground commander with timely and effective means to assign ground and air weapons to specific targets, including the assignment of fixed-wing strike aircraft in support of the land-air battle, and provide the information and flexibility at higher headquarters so that these can be allocated effectively as the developing battle requires.

(U) The need to provide for target handoff and cueing capability which will assure a high probability of successful target engagement by either Service's fire-strike system from either Service's target acquisition/location process.

(C) The need to provide fast, accurate, survivable communication and common position location means to all appropriate elements in the combined-arms loop to coordinate Air Force/Army firepower within the total target development and engagement cycle.

(C) D. CRITICAL DEFICIENCIES (U)

(C) The existing OAS capability is quite limited at night, in reduced visibility and in heavy defenses--particularly in an intensive reactive situation.

(C) Current procedures for allocation of sorties to OAS missions, which are based primarily on requests from the bottom up for "pre-planned" and "immediate" scheduling, are too cumbersome and time-consuming for high intensity, fluid operations. They place a high demand on Army/Air Force communications; they stress the decision-making process (particularly at the DASC); and they have a high likelihood of breakdown during critical times.

(C) Effective joint operations are totally dependent on secure, reliable, prompt, flexible, interoperable communications. Existing communications rely heavily on voice and are both slow and vulnerable to enemy counter-actions. Interoperability between Army and Air Force elements is poor and security is lacking.

(C) The effective coordinated employment of Army and Air Force firepower assets is not achievable until a common or interchangeable coordinate system is established for targeting missions involving joint assets.

(C) The Army and the Air Force do not fully exploit each other's target acquisition sensors. For example, the effectiveness of Army fire or emitters, especially in the suppression of enemy AD weapons by artillery and rotary wing aircraft, could be improved by more direct coupling with Air Force's PLSS for targets within the zone of interest.

(C) Because of heavy enemy air defenses, attacking aircraft on OAS missions must fly low and accomplish their missions on their first pass. Low altitude greatly complicates the problem of seeing the target even under good conditions and there is little time for search during pop-up. For this reason, Army/Air Force hand-off techniques need substantial improvement especially in conditions of poor visibility.

(U) New equipment is not introduced early enough in the development cycle of the equipment to meet the needs for joint and combined testing and training.

(C) E. PROPOSED CONCEPTS (U)

(C) 1. Streamline and Clarify OAS Allocation Process

(C) Approach. The Joint Force Commander should make a master apportionment of sorties for the OAS mission for a particular time period. A portion of these sorties should then be allocated to Corps Commanders, who may then, as they see fit, suballocate to subordinate units. These allocations may be changed as the situation requires, normally over time intervals of hours, rather than minutes or days. All the sorties that are allocated to Corps (or suballocated below Corps) will be on an "on-call" basis. As targets develop or are identified by ground elements on the scene, requests for the assignment of allocated sorties to specific targets and the execution of the mission will then be made by the requisite ground commander. There is no comparable allocation problem with Army's attack helicopter, since the battle commander has control of those assets as part of his maneuver forces.

(C) Expected Accomplishments. The above procedure will simplify both the allocation process and the engagement process, but more importantly it will facilitate the availability of Air Force strike support to the Corps Commander. Within allocated sorties, this approach will allow for assignment of sorties to targets by the commander, without recourse to higher headquarters. Furthermore, adoption of this concept will reduce the congestion of messages and decisions (particularly at the DASC) during critical times, since it will replace much of the "pre-planned" or "immediate" requests. In addition, the simplified allocation procedures will reduce the communication required by coordinating elements of the Army and the Air Force. Such a concept is particularly appealing in an environment where: (1) there may be more targets appropriate for strike by CAS than there will be OAS sorties; (2) there is apt to be confusion exacerbated by the rapid dynamics of a Soviet attack, and (3) the enemy will be placing a major emphasis on preventing meaningful communications--either by attacking or jamming our communications elements.

(C) 2. Improve Joint Capabilities for OAS (U)

(C) Approach. The Task Group's view of OAS is shown in simplified form in Figure II-1-1. It was evident to the Task Group that flexibility and rapid response are of utmost importance, especially in high-intensity, defensive war in which we are reacting to enemy actions, and therefore, precisely where the times and places in which fire support must be applied will not be predictable. The Task Group saw the problem in terms of closed-loop feedback systems where system response time is critical to success. The process, therefore, is viewed not as a single loop but as several loops corresponding to several different time scales--allocation assignment, execution.

(C) Expected Accomplishments. Continued emphasis on joint tactics, procedures and training will evolve a more effective OAS capability so that all elements of these feedback systems work well and are properly integrated into a real capability. Sensors must detect, locate, and identify the targets at night and in adverse visibility and weather conditions if OAS is to work under such conditions. Communications must be able to deliver the needed information. Command and control posts with data processing and display aids must be available to the decision-makers. Weapons must be able to navigate, survive, see the target directly or indirectly, and communicate immediately and rapidly. All must operate in common, accurate position coordinates. Munitions must have high probability of kill over wide areas. All must continue to operate in the presence of intensive enemy defenses. No one of these features is enough by itself, no matter how good it might be. When all of these contributing functions work well together, and our tactics and training have been developed to the point where they make full use of the equipment's capability, and work around the equipment's deficiencies and weaknesses, then will it be possible to achieve a probability of target kills in accordance with needs of the ground commander's mission.

(C) 3. Improve C^3 and Target Handoff for Army/ Air Force Supporting Fires (U)

(C) Approach. The Task Group believes that the most critical deficiency of the OAS capability lies in its C^3. Therefore, the structure of OAS should be thought out to define the sensory and communication

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(C) TASK FORCE VIEW OF OAS (U)

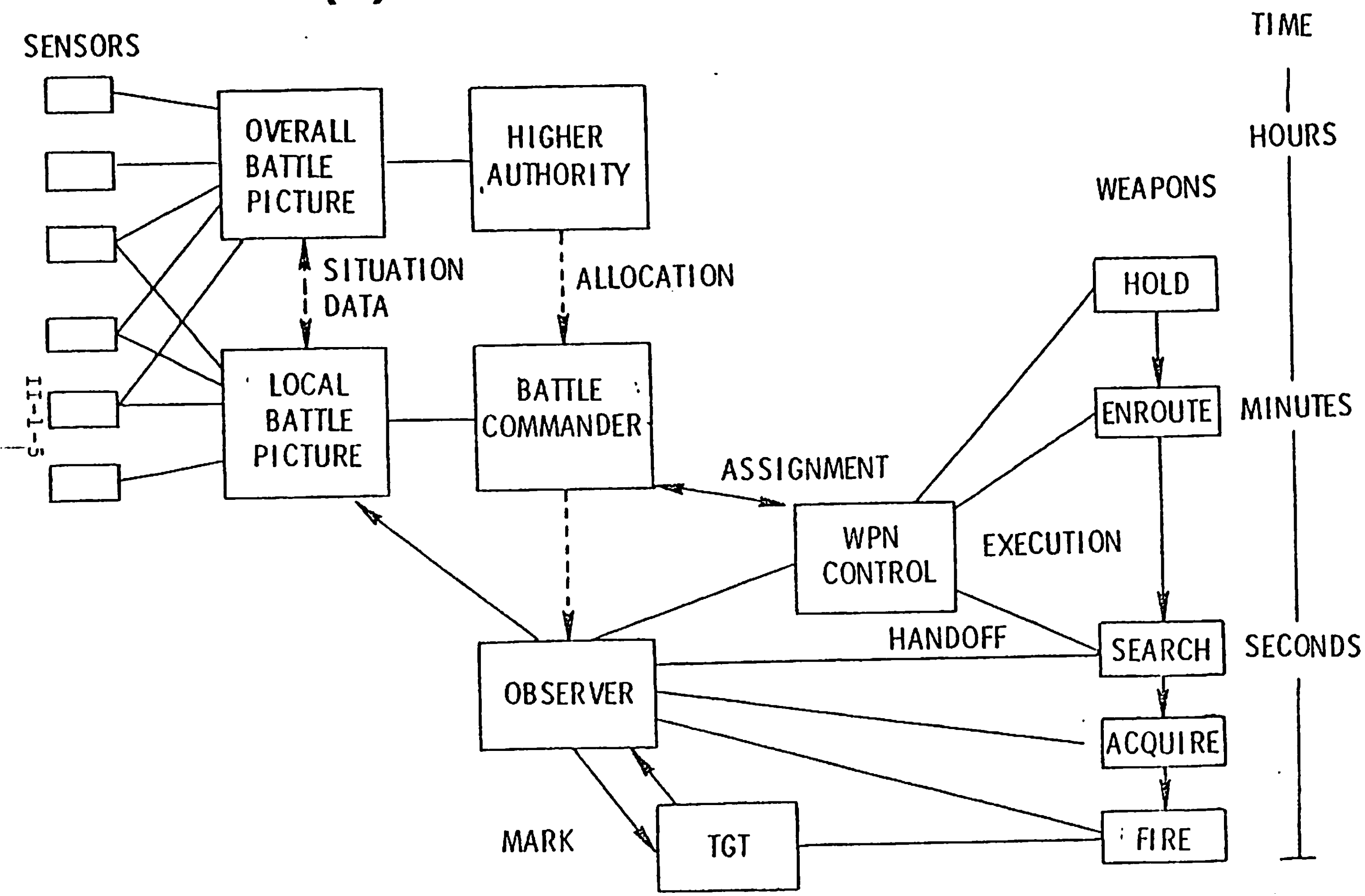

Figure II-1-1

II-1-5

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needs to provide the kinds of information and response times needed to make OAS effective in fluid situations. The concepts of allocation as previously discussed, and as being developed in Europe, are encouraging first steps in this direction. All possible emphasis should then be placed on providing a common or interoperable digital communications and position-location system of the PLRS/JTIDS-type as a basis for evolving a joint/ combined capability.

(C) The target hand-off process for strike aircraft and helicopters must be improved in timeliness and accuracy. The availability of digital, secure communication and common grid systems is essential for this mission. Furthermore, the capability must be enhanced for target acquisition and cueing at night and in reduced visibility. More opportunities should be exploited to provide for joint target acquisition to enable each Service to apply its weapons to important targets located by the other Services.

(C) Expected Accomplishments. These approaches would enhance the probability of a successful engagement while reducing the exposure time of weapons platforms and the man on the ground. Implementation of the proposed approaches will collectively contribute to significant improvements for hand-off procedures, including those which depend on target acquisition by eye, marking rounds, ground reference points, target offset techniques and laser cueing. Because of the improved C^3 responsiveness and overall increased effectiveness of the target engagement phase which will result, the ground commander would be afforded a more realistic choice of the appropriate ground/air weapons system in the combined arms battlefield. The above approaches would further enhance the capability of the AAH and minimize time on station; without these approaches the joint Service CAS mission would be of limited utility under all but good visibility conditions.

(C) F. RECOMMENDED ACTIONS (U)

(C) 1. Sortie Allocation and Execution (U)

(C) The current 24-hour preplan/immediate FRAG cycle for OAS is inadequate for high intensity warfare. The preplan and immediate request system is a "pull system" from the lowest level (Battalion) to the highest level (Corps).

(C) The Task Group sees the requirement to emphasize the improvements now underway in some elements of NATO to create a "push system" of allocating OAS sorties to Corps and below in specified time blocks to allow real-time fire support decisions at all echelons. With current intelligence/reconnaissance systems and automated fusion centers, Corps has a better view of the overall battle and fire support assets than do lower echelons. Scarce OAS assets must be provided to commanders (suballocated) in specific time blocks to reduce the air request communications requirements, increase the confidence of OAS availability to subordinate commanders, reduce the time for execution of OAS missions, and enhance the flexibility of OAS assets.

(C) Within these allocated OAS sorties the commander should be allowed to assign sorties to targets, without recourse to higher headquarters. The commander doing the assignment must have directly available the near-real-time sensor data from systems such as SOTAS in his area of interest.

(C) 2. Common Position Location and Digital Communication (U)

(C) Expedite the creation and fielding of an integrated joint digital communications and common-grid positioning system based on the use of PLRS for the Army and JTIDS for the Air Force. If one of the systems is delayed or not implemented, the other should be used by both services for OAS. The Task Group also urged development of a common digital targeting language for joint Army/Air Force use. This language should have enough flexibility to accommodate later NATO standardization, but such standardization must not be allowed to delay joint development.

(C) 3. Joint Training and Testing (U)

(C) The Task Group recommends the introduction of new equipment (even prototype) early into joint Army/Air Force OAS training and testing programs to obtain early feedback between the development of tactics and procedures and development of equipment. Start now! Use existing equipment such as PLRS terminals, JTIDS in pods, SOTAS, lasers, and ground beacons in promising combinations to support an overall OAS capability. The NATO nations should also be invited to participate.

(C) 4. Improved Handoff (U)

(C) In order to enhance the probability of engagement and reduce exposure of strike aircraft, attack helicopters, and the man on the ground; develop a common coordinate-based cueing system which will:

- generate target coordinates (periodically)
- enter classification of target
- route (transmit) data to weapons platform
- cue the pilot through his head-up display.

(C) To improve the effectiveness of ground beacons, provide attack aircraft with accurate ($\sim$100 ft CEP) range and bearing from beacon to target. To reduce the probability of detection, screen the beacon from the enemy (e.g., by using a directional antenna).

(C) Burst digital transmission is required to reduce vulnerability to jamming and to enhance the reliability of communications. The Services should provide--"tomorrow"--ancillary devices for digital burst entry into existing tactical radios (such as an IDT-like system).

(C) Improved sensors are required to enhance the acquisition of targets by pilots and ground observers at night and in reduced visibility. Accelerate the provision of FLIR for the ground-mounted laser locator device (GLLD) and hand-held laser target designator (LTD). Expedite the development of long-wavelength infrared lasers and seekers for designation and weapons guidance. Accelerate exploration of millimeter wavelength technology (6.2) for target acquisition, designation, and homing.

(C) 5. Joint Target Acquisition (U)

(C) In order for each Service to be able to apply its unique strike assets to high priority targets located by the other Service, provide direct two-way data links for transmitting PLSS located targets to TACFIRE for possible strike by artillery, and for transmitting target locations determined by AGTELIS and FIRE FINDER (TPQ-37) to PLSS for possible guidance of aerial ordnance. Provide a means for direct input and use of SOTAS data and other near-real-time data at the levels in either Service's C^3 hierarchy that need the information for allocation, assignment, or control.

(C) 6. Improved Strike Assets (U)

(C) Present aircraft and helicopters have a limited capability to conduct OAS at night or in adverse weather. This situation must be improved. The AAH development program is well underway, but the A-10 requires provision of an inertial navigation system (INS), FLIR, and a radar altimeter in the near term and JTIDS or PLRS terminals in the future. A forward firing canister weapon for delivery of area munitions is also required. (The only modification to the A-10 needed in order to employ this weapon is a laser ranger.) Finally, the Services should accelerate the decisions regarding the development of night/adverse weather OAS capabilities in high threat scenarios.

(C) 7. Weapons/Munitions (U)

(C) Considerable improvement in weapons/munitions is both possible and needed. This subject deserves an in-depth study in its own right.

(U) A summary of above recommendations is shown in Figure II-1-2.

(C) SUMMARY OF RECOMMENDATIONS (U)

RECOMMENDATION		TIME SCALE
I.	FURTHER STREAMLINE/CLARIFY ALLOCATION	NOW
II.	"COMMON" POSITION LOCATION AND DIGITAL COMMUNICATIONS	NEAR/MID TERM
III.	JOINT TRAINING AND TESTING	NOW
IV.	IMPROVE HANDOFF	
	A. COMMON COORDINATE CUEING AND WEAPON DELIVERY	MID TERM
	B. GROUND BEACONS	NEAR TERM
	C. BURST DIGITAL TRANSMISSION	NOW
	D. IMPROVED SENSORS	
	1. FLIR FOR GLLD AND LTD	NEAR TERM
	2. LWIR LASERS AND SEEKERS	FAR TERM
	3. MILLIMETER WAVELENGTH TECHNOLOGY	FAR TERM
V.	JOINT TARGET ACQUISITION	NEAR TERM
VI.	IMPROVED STRIKE ASSETS	NEAR TERM

FIGURE II-1-2

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(C) II. DISCUSSION (U)

(C) A. INTRODUCTION (U)

(C) Ground forces in high-intensity conflicts require responsive, coordinated, intense, and effective fire support against many types of targets, including personnel, vehicles, weapons, facilities, C^3, etc. Both the Army and the Air Force are equipped to provide such fire; the Army by artillery, cannons, rockets, and missiles, attack helicopters; the Air Force with the A-10, F-4, A-7, F-16, and to some extent, with the F-111 and F-15. For some missions, tactical air can be thought of as a kind of artillery, of which the total firepower is not large compared to the total Army assets but with the advantages of the ability to concentrate fire both in space and time (i.e., to provide very high rates and densities of fire in limited critical areas) and the ability to reach beyond Army firepower into the back areas of the enemy.

(U) It is evident that such a scarce but flexible asset should not be frittered away as a simple adjunct to artillery but must be skillfully applied to the points of greatest leverage in support of the ground battle. Close coordination between ground and air forces is of the highest importance.

(C) Conversely, Army firepower can help in overcoming the enemy AD, which are the greatest problem for the tactical air forces. The combined use of Air Force and Army assets for best effect is an important but difficult problem.

(U) This problem of the integration of these various forms of firepower in a NATO environment is the issue with which this Task Group was concerned; specifically, to examine what potential improvements in procedures, systems, or equipment might enhance the timely application of firepower on enemy maneuver units. Particular emphasis was given to improving the capability for the weapons systems of either Service to use the target acquisition and cueing assets of either Service.

The Task Group did not examine in detail the performance of individual weapons and delivery systems, with the exception that tactics of individual systems often had to be considered in order to understand the problems of handoff and coordination.

(C) The Task Group considered that the Soviets will attempt breakthroughs which will be countered initially by Army covering forces (including tanks, mechanized infantry, field artillery, and attack helicopters), and engaged later by our main force at times and places that afford us every possible advantage. During the cover force and main battle area fighting, the Air Force provides the ground forces with CAS, attacking targets such as armored vehicles, artillery, troops, command posts, and air defense units to contain the first echelon enemy forces. At the same time, the Air Force will engage in battlefield air interdiction (BAI) missions to impede, blunt, and destroy the second echelon Soviet forces so that they cannot exploit any potential breakthroughs by the first echelon forces. CAS missions are differentiated from BAI missions on the basis of location of the targets, as illustrated in Figure II-2-1.

(U) For purposes of this study, the application of firepower was divided into three parts corresponding to three very different time scales. The first part involves the allocation of OAS sorties by higher authority (Theater, Corps, etc.) to subordinate elements which actually fight the battle. It is assumed that the higher authority has an accurate picture of the overall battle provided by an ASAC, and thus can make an appropriate allocation of resources. The allocation process is considered to be dynamic, but is made and altered in times on the order of hours. The allocation procedures and recommendations for their improvement are discussed in Section IIB.

(U) The second part of firepower application is the assignment by the Battle Commander of his allocated weapons to the available targets. In this process, times are on the order of minutes. The assignment includes the communication of the necessary targeting

(U) BATTLEFIELD DEFINITIONS

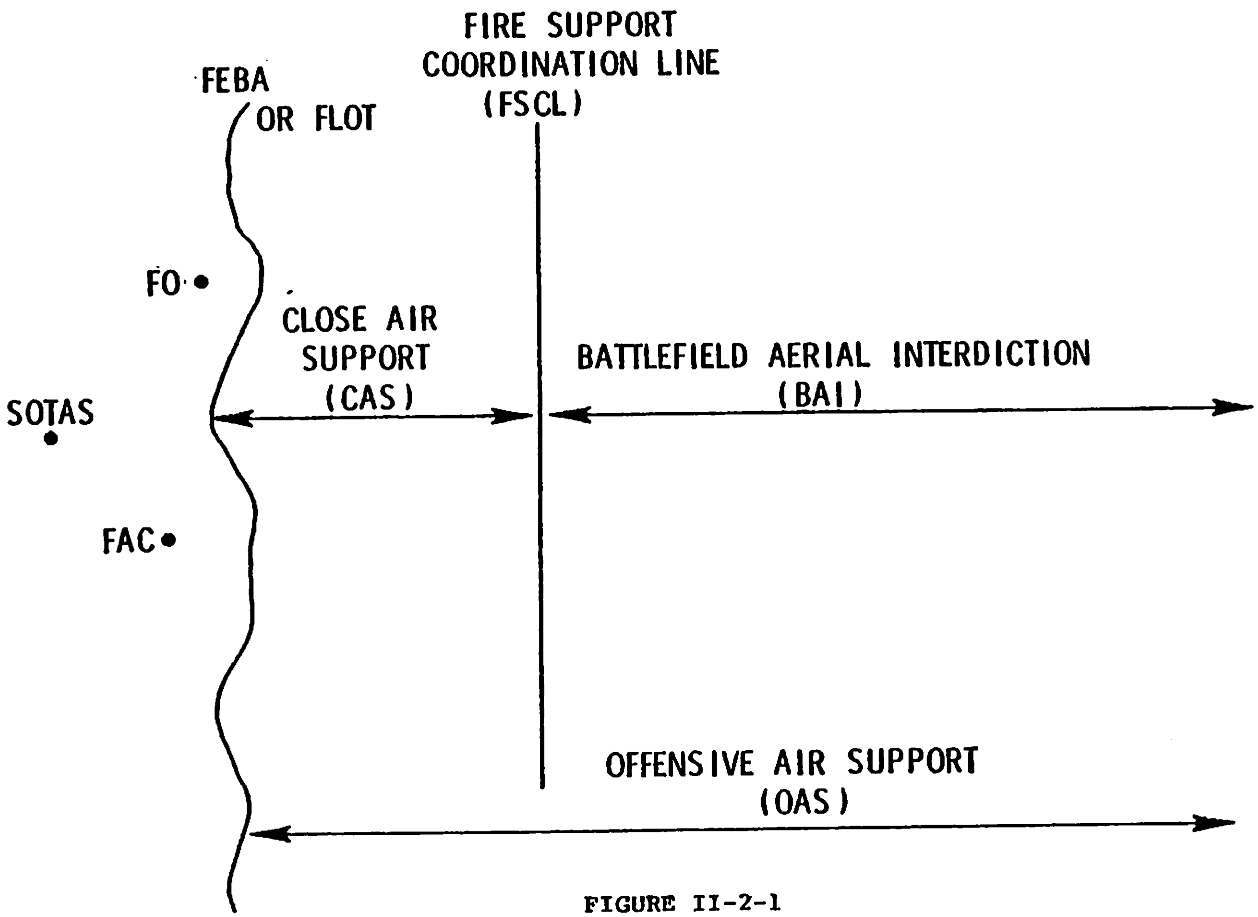

FIGURE II-2-1

information (target type, location, etc.) to the attack systems (artillery, helicopters, or fixed-wing aircraft). Recommendations for improvement of the very critical problems of battlefield communications and position location are proposed in Section IIC. Potential improvements in joint Service training and testing are discussed in Section IIC, and some recommendations for improving the transfer of target information between Services are presented in Section IIF.

(C) The third part of firepower application is the engagement, i.e., the process of delivering fire to the target. In most instances, the target is handed off from a forward observer (FO) or forward air controller (FAC) to the attack system. Critical times of this process are on the order of seconds. The handoff may involve only the communication of targeting information, or it may require active participation of the observer or controller such as laser illumination of the target. Recommendations for the improvement of some types of handoff are discussed in Section IIE.

(U) In order to have an effective fire support capability, a large number of individual elements must survive, work well, and be fully integrated. Sensors, C^3, and weapons systems must be highly survivable and reliable, and must function in night and adverse weather conditions (a shortcoming of OAS in this regard is discussed in Section IIF). Handoff systems must be reliable and as undetectable as possible.

(U) The Task Group is painfully aware that one of the very critical elements of fire support is the effectiveness of the munitions. Time has not permitted an adequate examination of this subject in this effort. However, there is general agreement that considerable improvement is both possible and needed. It is felt, therefore, that this element deserves a full-scale study by itself.

(C) <u>B. ALLOCATION OF OAS SORTIES</u> (U)

(C) <u>1. The Problem</u> (U)

(C) There is a need to simplify the OAS allocation process and make it more responsive to the battlefield commanders. In a war of high tempo the OAS process needs, as never before, centralized management of the advance allocation of OAS sorties to ground commanders, coupled with an essential flexibility achievable only through decentralization of execution. With the advent of the ASAC based on the BETA concept, higher level commanders will have a better picture of the battle area. These new developments thus both support and demand a greatly improved and streamlined management of the allocation of OAS sorties in support of the battle.

(C) 2. Discussion (U)

(U) Success in countering a massive Soviet attack in the Central Front in Europe will require joint Army/Air Force procedures for OAS allocation that assure the delivery of firepower in a rapid and responsive manner.

(C) There is presently a program underway to provide the commanders of Tactical Air Forces and Army Corps and Divisions with the "big picture" of what is happening on the battlefield. The BETA project has been inititated to demonstrate the techniques and equipment to underwrite the ASAC, which will be responsible for providing this picture. The ASAC concept is to "fuse" the streams of information from many sensors and sensor platforms--TEREC, GUARDRAIL, RF-4Cs, AWACS, SOTAS, unattended ground sensors, ground observers, UPD-X (when available), and so on. The output of the ASAC will provide information on the disposition of various enemy units, where they came from, and a forecast of their future movements and actions. The principal areas of enemy activity will be identified.

(C) Based on information and assessments from the ASAC, commanders at Corps and Air Tactical Operations Centers (ATOCs) will allocate OAS assets to be available to attack these enemy maneuver units within some specified time intervals and specified geographic areas. In the vernacular, this constitutes part of "battlefield management." This management involves the allocations of certain strike assets to particular ground units for a particular span of time.

(U) The engagement phase extends from the time a specific aircraft is assigned a specific target until the strike asset has delivered its weapon(s) on target and, in the case of strike aircraft, has exited the area.

(U) The current OAS allocation process is difficult to define accurately since it has been found that the process, as practiced, is different than the one described in current documentation. In many instances, the approach being recommended by this Task Group already has been accepted, or at least advocated, by some planning elements of both the Army and Air Force. Therefore, rather than describe the present process, the approach herein is to propose an improved OAS allocation process which, in our opinion, further streamlines and clarifies the current allocation process.

(C) The proposed process is: first, the Joint Force Commander makes an apportionment of sorties to: (1) counter air, (2) interdiction, and (3) OAS. Then, Tactical Air Force (TAF) and Army Group Commanders allocate their OAS sorties to particular Corps for time blocks in the planning horizon. It is important to note that allocation of sorties is dynamic and is an integral part of battlefield management. The time interval between changes is expected to be hours--not minutes or days.

(C) A portion of the OAS sorties is retained at TAC level for BAI mission. Those OAS sorties allocated to the Corps can be used by the Corps Commander for BAI targets that the Corps has nominated, with the remainder of the OAS sorties being used for CAS. The distinction between BAI and CAS is that CAS is defined as attacks upon targets in the area between the FLOT and the FSCL, while BAI applies to attacks beyond the FSCL. The Corps Commanders may suballocate OAS sorties to Division and perhaps down to Brigade. The important point here is that the OAS sorties allocated to Corps for a particular time period belong to the Corps, and in turn, sorties are utilized as the Corps Commander deems necessary.

(C) The apportionment/allocation process among these missions is, of course, based ultimately on the success of containing the enemy thrust. It is important to note that the decision to apply OAS assets in BAI and CAS must be based on a choice of disrupting enemy forces prior to the time they pose an immediate threat to our front line ground units and of support in these front line units when the enemy is an immediate threat. This perception is at times at odds with the concept of placing emphasis on responding to requests for CAS by beleagured commanders.

(C) OAS sorties will be allocated to a ground unit for use during a specified period of time. Those OAS sorties allocated to the Corps and subordinate divisions will be on call to the unit which received the allocation. The strike aircraft for these on-call missions will be loaded with appropriate munitions and placed in an appropriate alert condition and committed when requested by the unit to be supported, within the specified time period. A unit commander will commit sorties and assign these sorties to strike particular targets at particular times when these targets and times have been identified. In such a concept, the process of "immediate requests" becomes moot. There will be no purpose in generating such requests and having them processed for approval; Corps has already made tentative allocations of on-call missions in anticipation of enemy actions and where they plan to engage the enemy. Authority to finally commit strike aircraft (either from strip alert or air alert) would be delegated, for instance, to the Brigade Commander who exercises that authority through the airborne FAC-A.

(C) The above concept does not make the distinction between "pre-planned" and "immediate" requests with respect to OAS sorties. It would seem that such a distinction with regard to requests is somewhat beside the point and only leads to the requirement for additional decisions and congestion of message traffic at critical times. Typically, most of the so-called "pre-planned" missions are changed (diverted) to "immediate" requests. What should be pre-planned is the allocation and (suballocation) for specific periods of time of OAS sorties to ground commanders at different echelons. Targets are attacked as they develop and are identified. The timing of when specific aircraft are "committed" and assigned specific targets is determined by the ground commander on the scene; but presumably these attacks would be executed as soon as possible--once the target has been identified.

(C) The proposed approach will simplify both the allocation and the execution process and facilitate the availability of strike support to the Corps commander. This concept will reduce the congestion of messages and decisions during critical times; it will also significantly reduce the required communication by Army/Air Force elements. Such a concept is particularly appealing in an environment where there will be OAS sorties; there is apt to be much confusion exacerbated by the rapid dynamics of a Soviet attack; and the enemy will be placing a major emphasis on preventing meaningful communications--either by attacking or jamming our communications elements.

(U) The proposed concepts are complementary to the Air Fire Support System. The FSS permits all nominated targets to be analyzed as to the appropriate means of engaging the target, be it OAS, artillery, or attack helicopter.

(C) The planned Army attack helicopter employment as a separate maneuver force complements the combined arms engagement in that the attack helicopters are constantly engaged in the battle, while OAS is required at critical times and places where victory or defeat may hang in the balance. Thus, the allocation process is not applicable to the attack helicopter as it is employed as a maneuver unit already committed to the battlefield.

(C) 3. Proposed Solution (U)

(C) The following approach and concept appear to be a better process of allocation of OAS sorties in support of ground commanders.

(1) The Joint Force Commander makes a master apportionment of sorties for the OAS mission for a particular time period. A portion of these OAS sorties

are then allocated to Corps commanders by the Air Force and Army component commanders. Corps commanders may then, as they see fit, suballocate to subordinate units. The allocations and suballocations are "for planning purposes" and may be changed as the battlefield dynamics dictate. The time interval between changes is expected to be hours--not minutes or days. Inherent in the OAS allocation is a specified time period in which the sorties are to be executed. When that time period arrives, the allocated OAS sorties are on an "on-call" to the ground commander. As targets are identified by ground elements on the scene, the OAS sorties are executed with no recourse to higher levels of command.

(2) The execution of attacks within the limits of the on-call sorties allocated may be arranged by the FAC-A via direct communication to the air units that are on-call--either on strip alert or air alert.

(3) No distinction is to be made between "immediate" requests and "pre-planned" requests. The allocation and to a large extent the suballocations are planned; execution of attack by those sorties allocated will generally be "immediate" when battlefield targets are identified by ground elements on the scene.

(C) 4. Recommendation (U)

(C) Establish a process for the allocation of OAS sorties in a fluid, highly intensive environment along the following guidelines:

Top-down for allocation--higher authorities must have timely information for battlefield management; ASAC is a large step in this direction.

Simplified (with respect to both decisions and communications).

TAF/Army makes the allocation of sorties between

- sorties allocated to a particular Corps for each time block in the planning horizon

- sorties retained by the ATAF level.

Corps commander may suballocate sorties to the Division and perhaps down to the Brigade levels.

Allocation of OAS sorties is dynamic and is an integral part of battlefield management.

Centralize allocation of sorties to commanders--decentralize assignment of sorties to targets.

(C) C. COMMON POSITION LOCATION AND COMMUNICATIONS (U)

(C) 1. The Problem (U)

(C) The specification of target location in a NATO battle environment is very difficult due to the use of many different coordinate systems by the different NATO countries and the several Services. Delays and errors are introduced when coordinates must be transferred from one frame of reference to another. Furthermore, there is a great deal of reliance on voice communications links in the battlefield. These voice links can be jammed and intercepted, and are too vulnerable for reliable command and control. To solve these problems, it is necessary that a system be provided for secure, jam-free communications and position reporting using interoperable coordinate systems for all maneuver units, including air.

(C) 2. Discussion (U)

(C) There are currently under consideration two developments that could meet the need for a common position location and communications system: (1) The JTIDS under development by the Air Force; and (2) The PLRS, in engineering development by the Army. Both of these systems offer position location capability together with secure (Incrypted) digital, AJ, burst communications. This dual capability would greatly facilitate the OAS process--especially navigation, target location, handoff from forward observers, etc.--and promises significant simplifications in the C^3 process associated with the OAS mission.