THE EC-18B ARIA: AIRBORNE TELEMETRY AND REENTRY VEHICLE SCORING COMBINED

Keith W. Bubb, Capt, USAF
ARIA Programs Division
Directorate of Flight Test Engineering
4950th Test Wing
Wright-Patterson Air Force Base, Ohio

ABSTRACT

The 4950th Test Wing, at Wright-Patterson Air Force Base, Ohio, is converting four Boeing 707-320C aircraft into EC-18B Advanced Range Instrumentation Aircraft (ARIA). In addition to the antenna and electronic equipment required to collect telemetry data in support of NASA and DOD space and missile programs, the EC-18B will be equipped with a Sonobuoy Missile Impact Location System (SMILS), an optics system, and a meteorological sampling system.

Once these systems are added, the EC-18B ARIA will be the most versatile and capable airborne mobile instrumentation platform in the world. They will be able to collect telemetry data from various space and missile systems; acoustically determine the geodetic impact point of reentry vehicles at any location; obtain photographic and video data from reentry vehicles as they pass through the earth's atmosphere; and provide local atmospheric data in support of worldwide US ballistic missile tests through the year 2000 and beyond.

BACKGROUND - WHAT IS SMILS

DOT SMILS

The current sonobuoy missile impact location system in use consists of the following parts:

1. Deep Ocean Transponder (DOT) Array - This is a circular pattern of DOTs deployed by a range instrumentation ship, permanently fixed to the ocean floor. The geodetic location of each DOT is determined and recorded for use during data reduction.

2. Sonobuoy - A floating electro/acoustic buoy which telemeters buoy pings and acoustic data (including reentry vehicle [RV] splashes) to aircraft instrumentation. There are several buoy types required for SMILS missions. Of primary importance in DOT SMILS missions is the Air Deployed Interrogator (ADI) buoy, which is deployed by the SMILS aircraft to determine if the aircraft has correctly navigated to the DOT array. Once the DOT array has been properly located, the remaining sonobuoys are deployed.

3. Sonobuoy Array - This circular pattern of sonobuoys is deployed by the aircraft and centered over the DOT array. The surface buoys receive pings from the DOTs and then telemeter them to the aircraft for recording. Analysis of the ping times of arrivals provides the geodetic location of each (surface) sonobuoy since the DOT geodetic locations are known. The RV is targeted within this sonobuoy array, approximately 20-25 kilometers in diameter.

4. Aircraft Recording Equipment - This consists of receivers, tape recorders, and other electronic equipment required to receive, process, and record the buoy pings and RV splashes which are transmitted to the aircraft.

The EC-18B will replace Navy P-3 aircraft which are presently used to perform the SMILS mission. The P-3 will fly to the DOT array, deploy an ADI buoy to precisely determine the aircraft position, then deploy the remaining surface sonobuoys. The sonobuoys and DOTs ping and these pings are recorded on the aircraft. From this, the geodetic location of each sonobuoy can be determined. When the reentry vehicle impacts within the array, the splash is detected by the sonobuoys and these signals are immediately transmitted to the aircraft, where they are recorded. By analyzing the time of arrival of the splash noise at each sonobuoy, the impact location may be determined. The standard (DOT) SMILS concept is shown in Figure 1.

Global Positioning System (GPS) Based SMILS

GPS SMILS, which will be done by the EC-18B ARIA, is similar to DOT SMILS in most respects except that the geodetic location of the surface sonobuoys is determined using GPS satellite signals with no requirement for a DOT array. This can result in significant savings since a DOT array is expensive to implant and maintain. Several sonobuoys (GTD-GPS Transdigitized) which receive signals from the GPS satellites are initially deployed to determine the location of the sonobuoys and the precise aircraft location. Next, the remaining sonobuoys are deployed and their positions are determined relative to the GTD buoys. Once the sonobuoy array is “surveyed,” the reentry vehicle impact location can be determined in the same manner as described for the DOT SMILS. The GPS SMILS concept is shown in Figure 2.

The GPS SMILS concept provides more flexibility than DOT SMILS because it does not require a previously surveyed DOT array to be present. This is important in the event of inclement weather or the presence of a surface vessel in the anticipated impact area. With DOT SMILS, the test might need to be cancelled in this situation. Using GPS SMILS, the impact area could be changed and the test could go on with little or no change to the schedule.

PROGRAM HISTORY

As part of the 4950th Test Wing, ARIA Programs Division, Improvement and Modernization Program, four Boeing 707-320C aircraft were purchased from American Airlines in 1981 to be converted into EC-18B Advanced Range Instrumentation Aircraft (ARIA). One of the many advantages of this aircraft (over the EC-135 ARIA) is the extra space available to place additional equipment on board. The equipment to be added to the EC-18B includes the Global Positioning System-Deep Ocean Transponder Sonobuoy Missile Impact Location System (GPS-DOT SMILS), an Optics System (OPTICS), and a Meteorological Sampling System (MET). These systems will greatly increase the capability of the ARIA fleet.

The concept of placing a SMILS and OPTICS capability on the ARIA fleet was proposed as a means of reducing operating and maintenance costs involved in reentry vehicle scoring. Normally, reentry vehicle test support requires an ARIA (for telemetry collection) and a Navy P-3 (for impact scoring and optics collection). Placing SMILS and OPTICS on the ARIA would eliminate the need for the P-3 aircraft.

The Office of the Secretary of Defense directed the 4950th Test Wing to proceed with the SMILS program in October 1982. At the same time, the Western Space and Missile Center (WSMC) was working with the Applied Physics Laboratory (APL), in Laurel , Maryland, to develop a GPS SMILS capability. Using GPS SMILS would allow reentry vehicle impact testing worldwide, not just in the predetermined broad ocean area (BOA) locations. By combining the two efforts, the DOT arrays could eventually be eliminated and the cost of the range instrumentation ships could be avoided. It was decided to merge the two efforts and the ARIA/GPS-DOT SMILS program was initiated. A Memorandum of Agreement between the 4950th Test Wing and WSMC was signed in May 1983, which provided for WSMC to manage the SMILS instrumentation segment with APL while the 4950th Test Wing was to manage the aircraft modification and launch segment in conjunction with the EC-18B ARIA conversion program.

The 4950th Test Wing was also to incorporate an optics system into the EC-18B ARIA/SMILS program to provide optical validation of cloud penetration, failure diagnostics, and time of event correlation as well as atmospheric properties for impact accuracy determination. In addition, the Meteorological Sampling System is being developed to allow collection of valuable meteorological data to be used during analysis of test results.

PROJECTED CAPABILITIES - GPS-DOT SMILS

The ARIA SMILS aircraft will have the option of scoring reentry vehicle impacts using the surveyed DOT (ocean floor) arrays or using a GPS positioned (surface) array. This allows greater flexibility in choosing the impact location for the test since the GPS mode does not require any prior surveying.

It is anticipated that the RV impact location will be determinable to within 10-15 meters, the advertised accuracy of the GPS. The aircraft will provide limited accuracy impact location information on the order of several kilometers within minutes, while a Post Mission Processor (PMP), to be located at Wright-Patterson Air Force Base, Ohio, will later analyze the data to provide the 10-15 meter accuracy.

Figure 3 depicts the overall mission concept. As shown, either GPS or DOT mode may be used to collect the information on tape. These tapes will then be delivered to the PMP for processing.

GPS SMILS DETAILS

Several components of the ARIA/GPS-DOT SMILS will be similar to the DOT SMILS program currently used. Some of the main operating features of the ARIA/SMILS program are discussed below.

GPS Transdigitized (GTD) Sonobuoy

The GTD sonobuoy will receive GPS signals from up to four satellites. These signals will be down converted and one bit quantized. Only the clear access (C/A) component of the GPS signal will be used in real time. (The precision code signals will be recorded for later use.) The received acoustical signals will be digitized and a serial data stream generated. The digitized GPS and acoustic signals will then be quadraphase modulated on an RF carrier for transmission to the aircraft, which will be circling 50 miles downrange.

The GTD buoy will be equipped with a command receiver to allow on/off control of the signal translator to save battery life. The buoy receiver system will be able to handle an unlimited number of satellite signals, although only four satellites are expected to be used on a normal basis. The buoy position will be determined using differential ranging with doppler smoothing, a technique which relaxes the stability requirement on the buoy oscillator.

Once the GTD buoy positions are known, the positions of the other sonobuoys may be determined. At this point, there is a floating array of sonobuoys whose geodetic positions are known. This floating array may be placed anywhere worldwide (once the GPS network is completed).

Aircraft Equipment

The aircraft equipment consists of the sonobuoy launch tubes (and associated equipment) and the instrumentation equipment. The instrumentation will be capable of “navigating” the buoys, recording the buoy transmissions, and providing a “quick-look” impact location for the RV splash. The aircraft will be equipped with antennas to receive the sonobuoy transmissions and the signals directly from GPS satellites. It will also receive the acoustic data from Low Frequency Pinger (LFP) (surface) sonobuoys. The LFP sonobuoys will be modified to ping at a commanded rate, which will aid in data reduction. The signals from the GPS satellites and GTD sonobuoys will be recorded directly, while the LFP acoustic data will be multiplexed before recording.

The equipment will be able to determine the position of the aircraft, in real time, to aid in the buoy placement. It will also be able to monitor the position of the GTD buoys and determine the position of the other buoys by using acoustic data to locate the buoys relative to the GTD buoys. Verification of correct operation of all buoys is also possible. The approximate splash location of the RV is available on board the aircraft, while the final accuracy of 10-15 meters will be possible only after data reduction at the Post Mission Processor.

OPTICS DETAILS

The optics program requires that several types of documentation be available to the user. This requirement drove the selection of sensor and film types to be placed on the ARIA fleet. The system will be capable of providing the following information:

1. Documentation of catastrophic RV failures;

2. Verification of RV cloud penetration;

3. Verification of RV survival to impact;

4. Documentation of jacket separation;

5. Time correlation of above events to 10 milliseconds UTC;

6. Correlation of above data to the aircraft position; and

7. Documentation of terminal area cloud coverage.

As one can see, this will be a very capable system in and of itself. Figure 4 depicts the operation of the OPTICS program. One must remember, however, that this data collection will be going on while the telemetry and SMILS data is also being collected.

METEOROLOGICAL SAMPLING SYSTEM DETAILS

The general operational concept for the Meteorological Sampling System is shown in Figure 5. The sonde is the device used to measure the temperature, humidity, pressure, density, and wind velocity in the terminal area. The sonde will be dropped from a gravity launch tube in the EC-18B which is being installed as part of the SMILS program. As the sonde descends via parachute from the launch altitude (10,000 feet or less), a helium balloon is being inflated. A sea water sensor wire, approximately 50 feet long, hangs from the sonde and upon sensing the water, triggers the release of the balloon and sonde from the remaining hardware. The balloon will then carry the sonde to an altitude of 80,000-100,000 feet, transmitting meteorological data as it ascends.

This meteorological data is obtained and recorded prior to the test, so as not to interfere with the telemetry, SMILS and OPTICS portions of the ARIA collection requirements, since the meteorological data is received on the SMILS receivers and recorded on the SMILS mission recorders.

SUMMARY

The completion of these programs and their incorporation into the ARIA EC-18B fleet will indeed make the ARIA the most versatile and capable airborne mobile instrumentation platform in the world. Yet these programs are only some of the many improvements and modernizations underway at the 4950th Test Wing, ARIA Programs Division. Collectively, these programs will keep the ARIA fleet up-to-date and expand their capabilities. In so doing, the programs will continue the Division’s tradition of excellence and performance for many years.

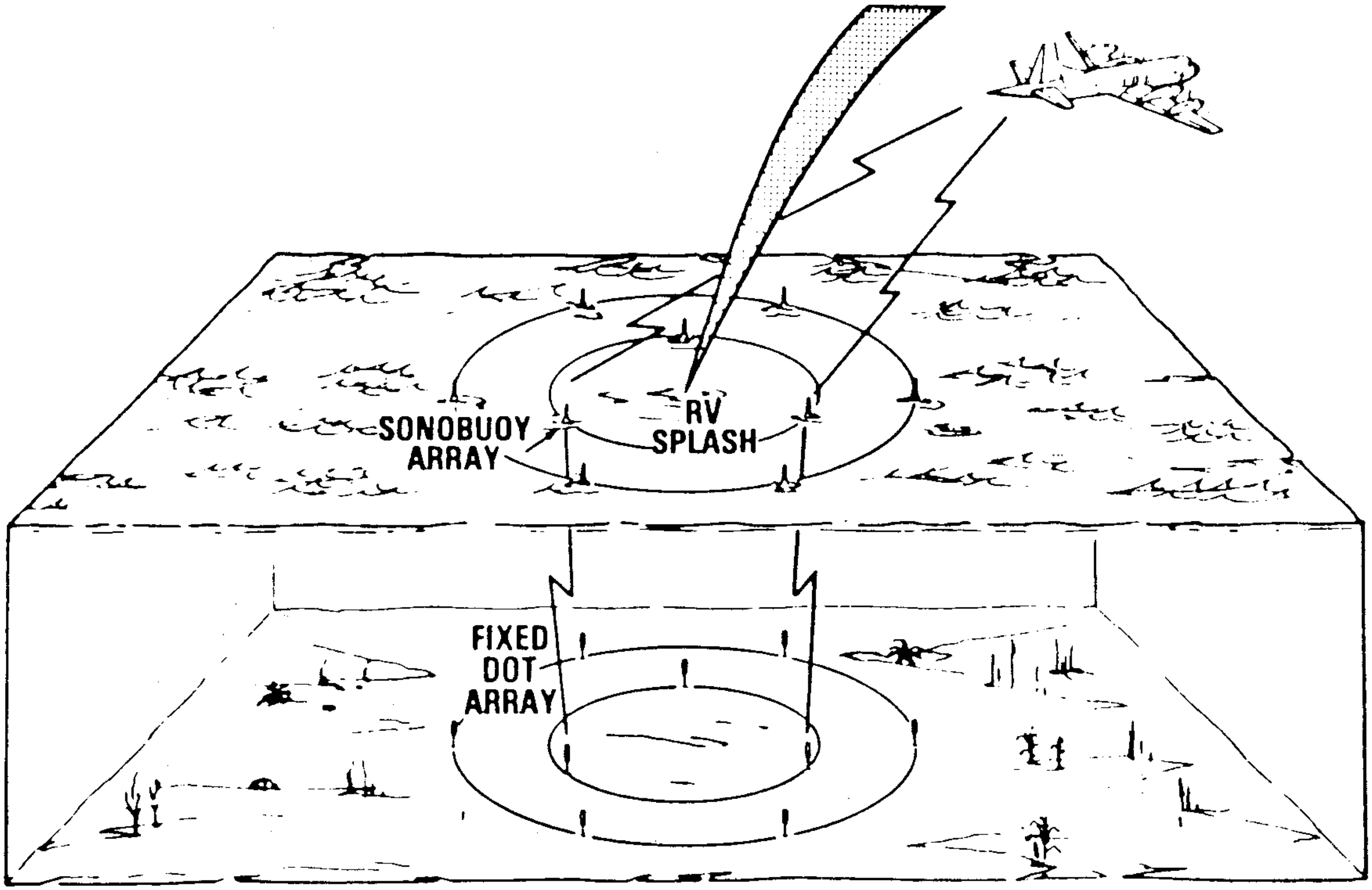

FIGURE 1 - DOT SMILS

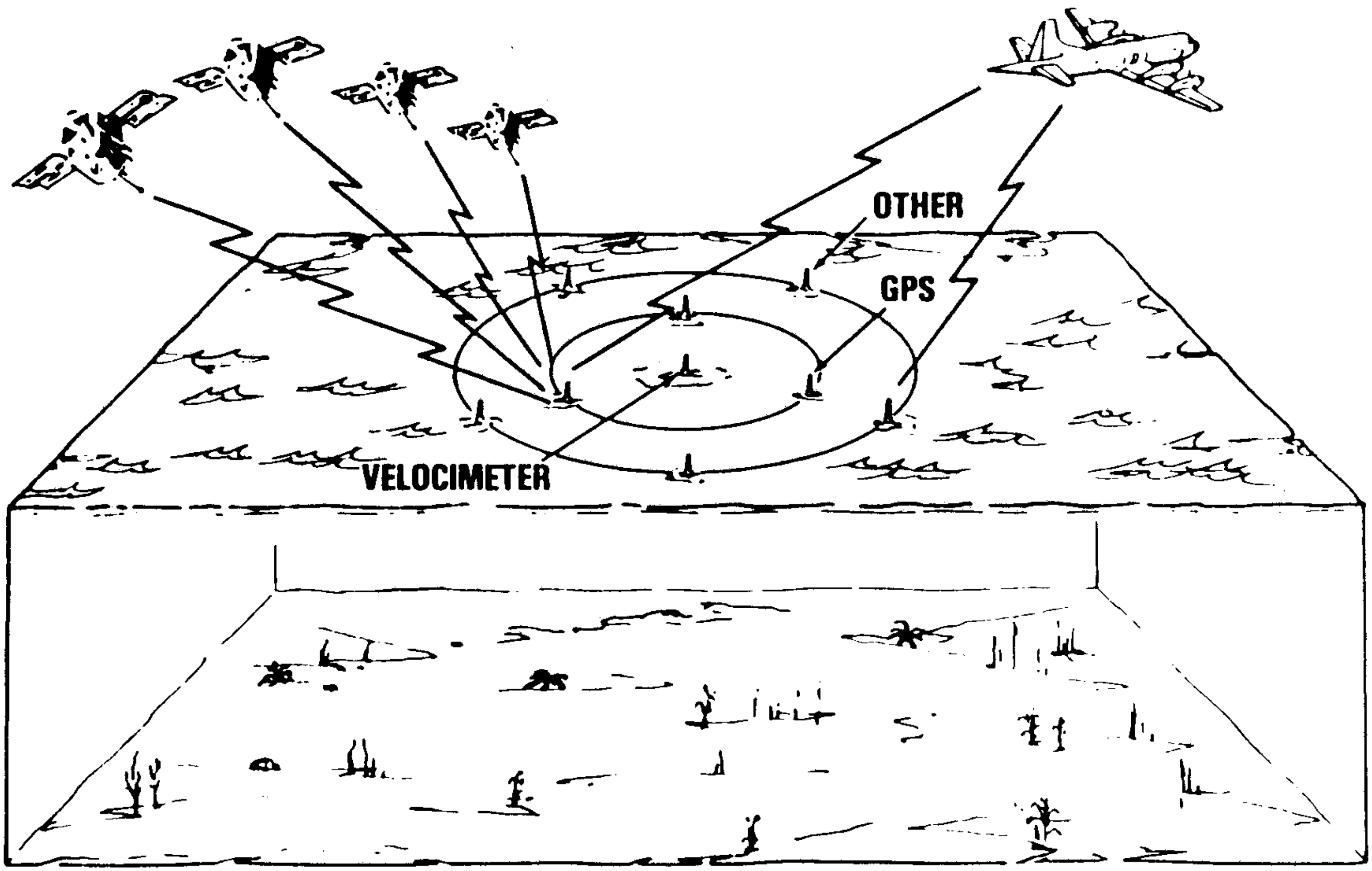

FIGURE 2 - GPS SMILS

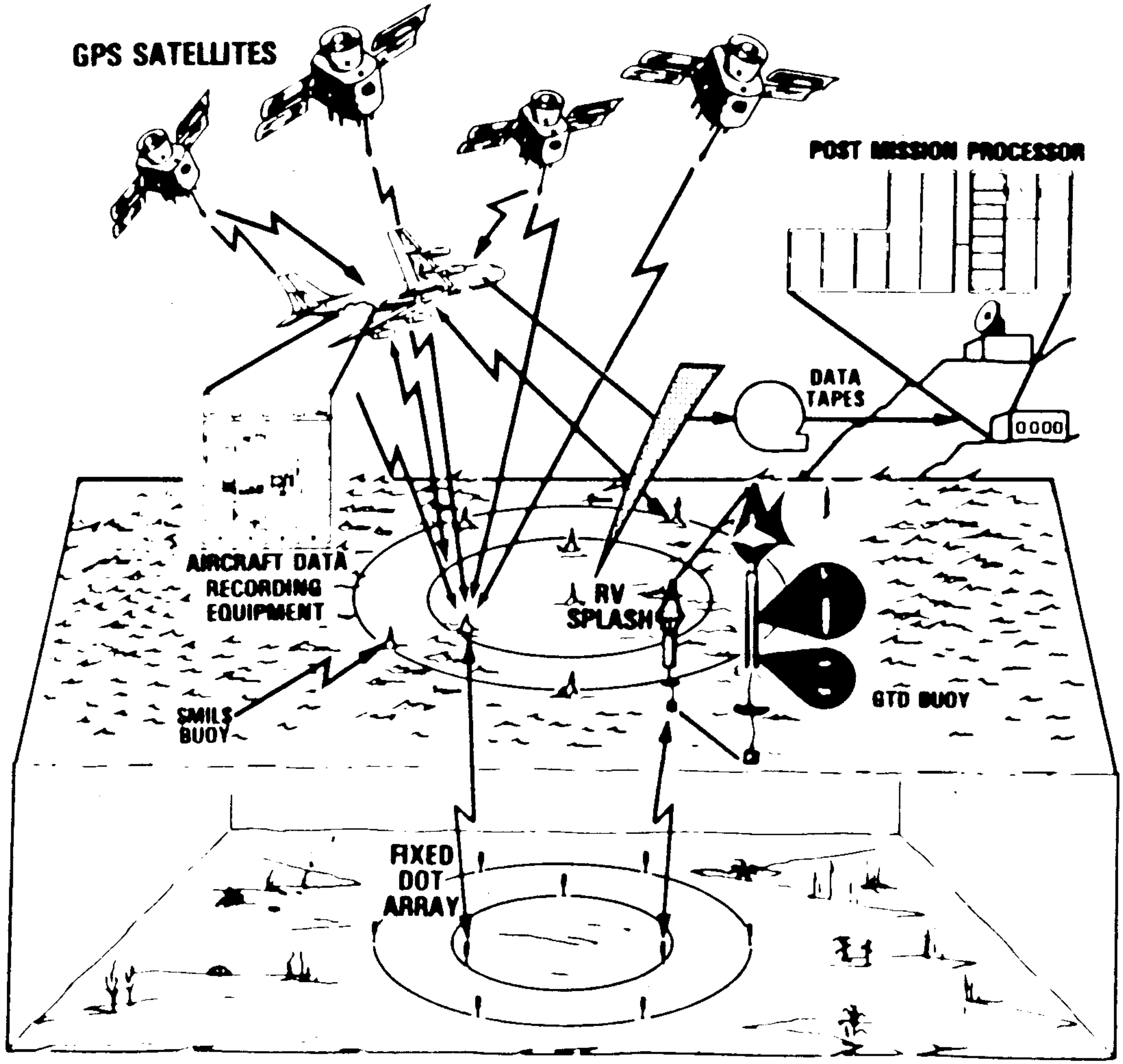

FIGURE 3 - ARIA/GPS - DOT SMILS SYSTEM CONCEPT

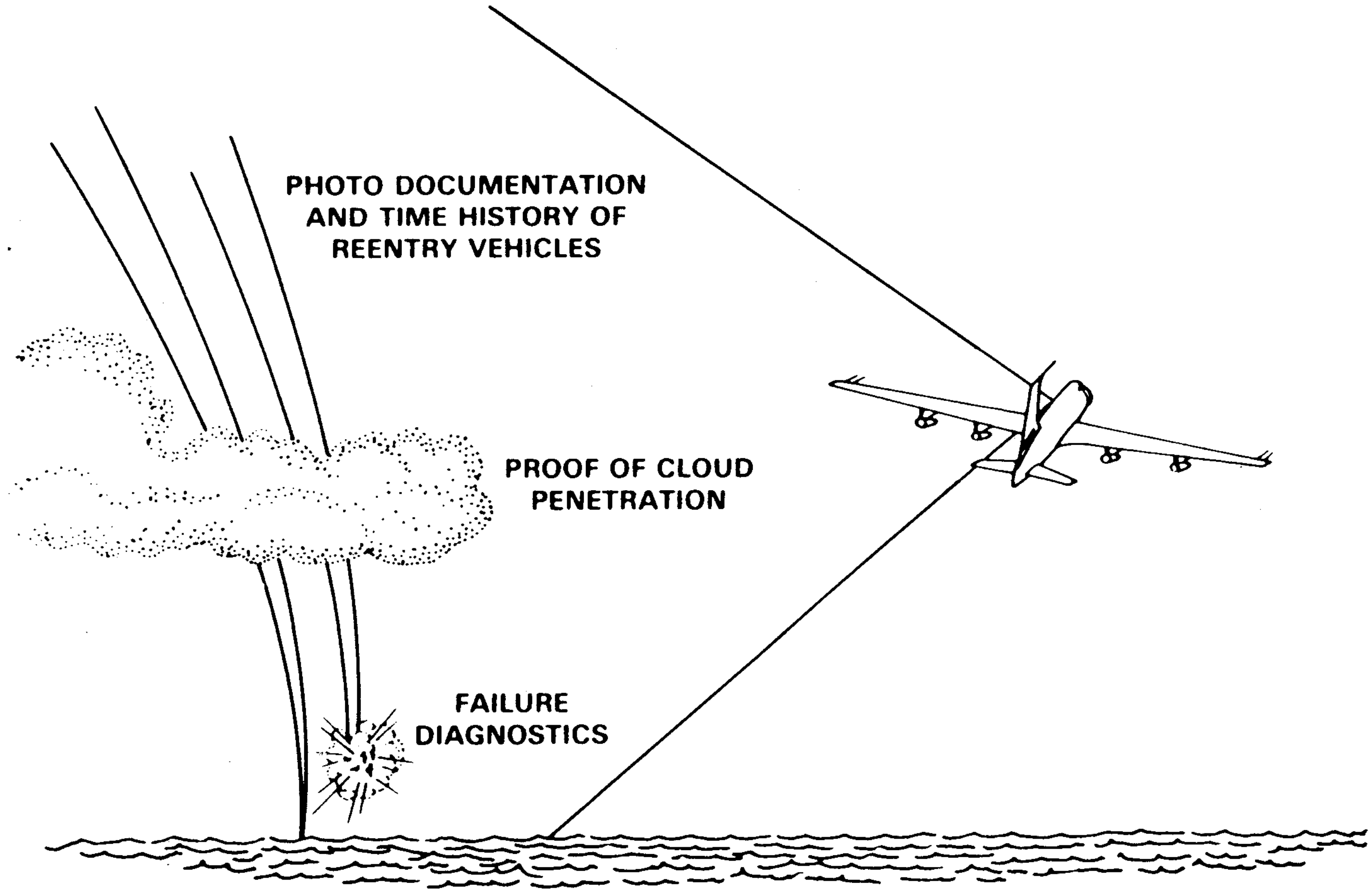

FIGURE 4 - ARIA OPTICAL SYSTEM

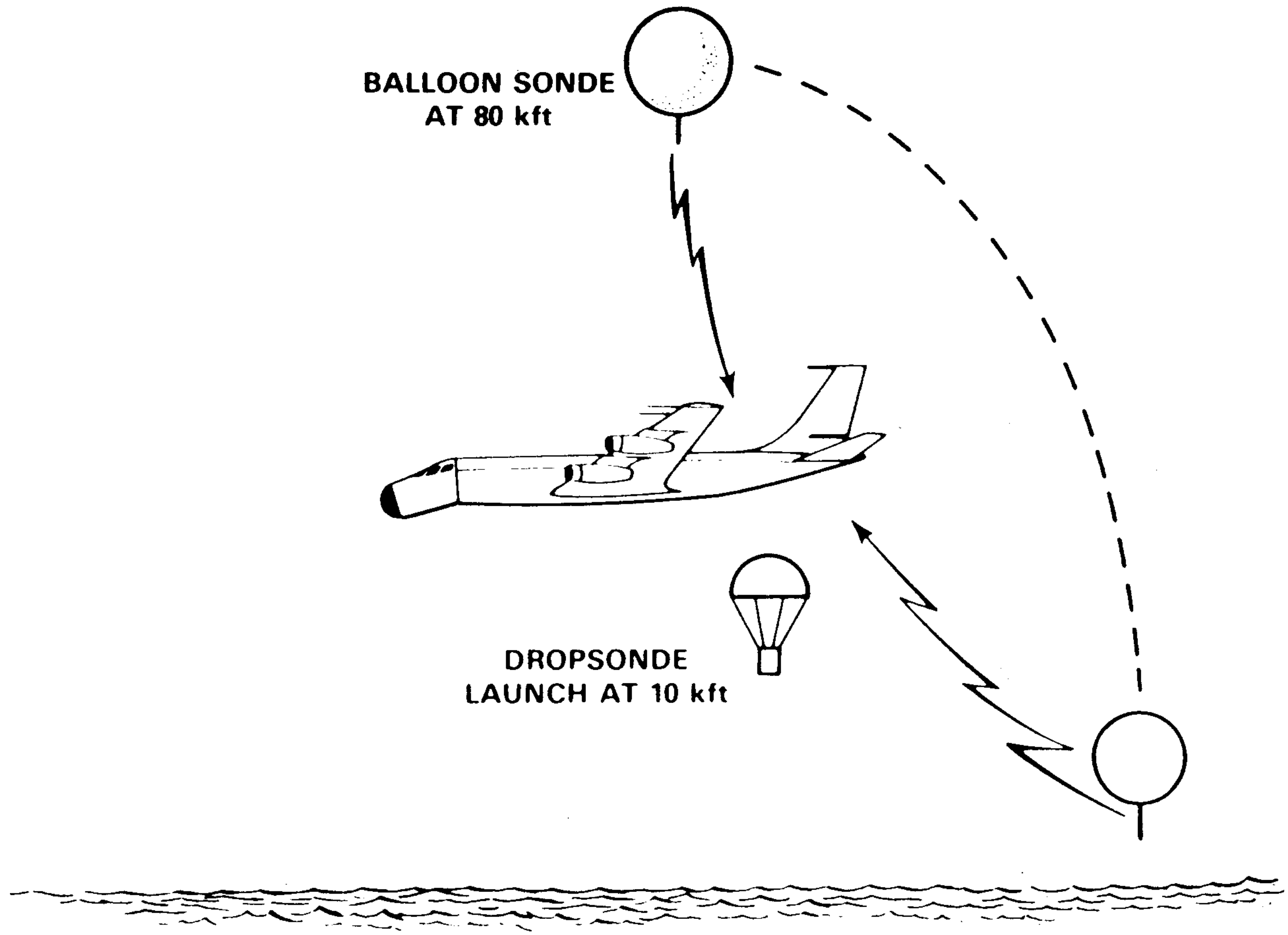

FIGURE 5- ARIA METEOROLOGICAL SAMPLING SYSTEM