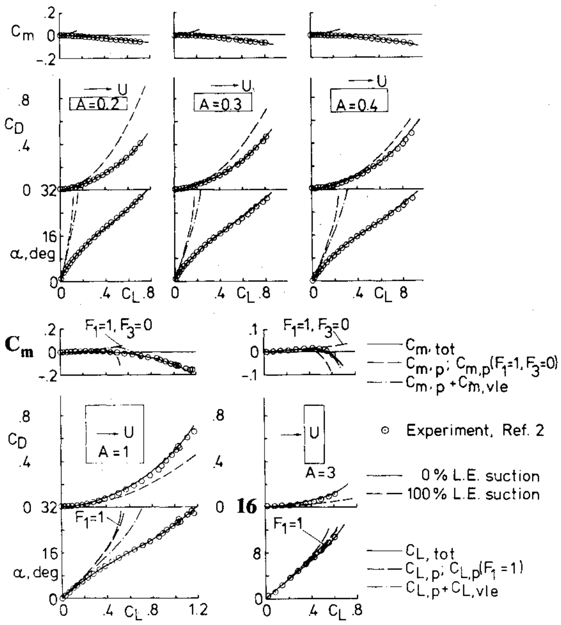

Fig. 3 $C_L(\alpha)$, $C_D(C_L)$, and $C_m(C_L)$ on sharp-edged rectangular wings of aspect ratios $A=0.2$, 0.3, 0.4, 1, and 3 at $M=0.2$ [experiments according to Ref. 2 compared with present semiempirical formulas, Eqs. (1-12)].

however, be implicitly hidden. A small positive quantity would most probably be a better approximation of $\xi_{v,\mathrm{le}}$ than Eq. (8).

The empirical F factors [Eqs. (10-12)] are subjective compositions with the only merits of being simple and fulfilling their intended tasks, namely: to correct for the losses in potential lift [F_1] due to losses in circulation; to correct for the corresponding wandering of the center of pressure of the potential flow pressure distribution [F_3]; and to give a higher order correction term [F_2] to the side-edge suction force coefficient $\bar{K}_{v,\mathrm{se}}$ at high angles of attack. The factor F_2 could be recognized as the contribution from the secondary vortices and can be neglected for $\alpha<10$-15 deg. The correction factors are plotted in Fig. 2, where it can be seen that for $A \leq -0.4$, F_1 is negligible in the actual angle-of-attack interval, $\alpha < |32|$ deg, and that F_3 can be neglected for $\alpha < |25|$ deg. As A increases from $A=0.4$, F_1 first decreases quite slowly for increasing α up to $A=1$, and thereafter decreases faster with increasing A. The factor F_3 shows a corresponding but opposite trend for increasing A with a rapid increase from $A=0.4$.

Results

The numerical results are compared with experiments[2] at the subsonic Mach number, $M=0.2$, on sharp-edged rectangular wings having the aspect ratios $A=0.2$, 0.3, 0.4, 1, and 3. Evaluating the set of Eqs. (1-12) and observing that the arguments of the correction factors F_1 and F_3 [Eqs. (10) and (12)] are not allowed to take a negative sign, the solid-line curves in Fig. 3 are obtained for the total coefficients. Curves for the attached flow (potential flow) characteristics and for the sum of potential flow and leading-edge separated flow characteristics are also shown. The potential flow curves with $F_1=1, F_3=0$ completely cover Lamar's[2] potential flow result. The correlation between the set of equations [Eqs. (1-12)] and experiments is, from an engineering point of view, quite satisfactory.

Conclusions

Improved correlation with experiments in incompressible flow, up to moderately high angles of attack (depending on the aspect ratio), is obtained by using an $\alpha^{5/3}$ dependence of the side-edge singularity of sharp-edged rectangular wings.

Empirical correction factors have been developed which make it possible to obtain good correlation with experimental results on sharp-edged rectangular wings up to high angles of attack, where flow separation effects have already built up.

Acknowledgment

This work has been supported by the Materiel Administration of the Armed Forces, Air Materiel Department, Missiles Directorate, Sweden.

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AIAA 81-2368R

Advanced-Range Instrumentation Aircraft Improvement and Modernization Program

James S. Nash*
Wright-Patterson Air Force Base, Ohio

Background

THE advanced-range instrumentation aircraft (ARIA) are seven EC-135 aircraft equipped with telemetry acquisition systems and are used to support: 1) satellite launches from Cape Canaveral Air Force Station, Fla., and Vandenberg Air Force Base, Calif.; 2) telemetry coverage of instrumented re-entry vehicles in the terminal area during ballistic missile testing; and 3) telemetry relay and command/destruct capabilities during air-launched cruise missile testing.

Exterior modifications to the C-135 airframe were required to provide the telemetry support capability. These modifications include the addition of a 7 ft dish antenna to the aircraft nose, two high-frequency (HF) wing probe antennas, a 125 ft HF trailing wire antenna, three ultrahigh-

Presented as Paper 81-2368 at the AIAA/SETP/SFTE/SAE/ITEA/IEEE 1st Flight Testing Conference, Las Vegas, Nev., Nov. 11-13, 1981; submitted Nov. 16, 1981; revision received Feb. 8, 1982.

*Chief, Systems Engineering Branch, 4950th Test Wing.

frequency (UHF) satellite antennas on the top of the fuselage, and a S-band (2200-2300 MHz) data dump antenna on the bottom of the fuselage.

The equipment within the ARIA is divided into six main systems: 1) a UHF telemetry antenna, 2) the data separation console, 3) telemetry receivers, 4) an antenna control system, 5) HF and UHF communication systems, and 6) the record/timing system. The changes to each of these systems currently in progress are described below.

Requirements for ARIA support of ballistic missile and cruise missile testing are expected to continue through the turn of the century. During this period, the ARIA capabilities will be expanded to include additional functions. Plans are being developed to utilize ARIA in the launch area near Vandenberg Air Force Base, Calif., during developmental flight tests of the MX missile. ARIA will be utilized in a range safety capacity relaying telemetry data from the MX to the ground and relaying command/destruct data from the ground to the MX. Due to the high cost of utilizing range instrumentation ships and the limited availability of P-3 aircraft for ballistic missile testing, studies are being conducted to equip the ARIA with sonobuoy missile impact location systems (SMILS).

To maintain the current ARIA capability as well as supporting new user requirements, each of the six major ARIA systems are being replaced or extensively modified. The ARIA equipped with J-57 engines are to be replaced with used Boeing 707 C/CF airframes over the next several years. This will significantly enhance the operational capability as well as the productivity of the ARIA. Further improvements in productivity will result from replacing the current parabolic dish antenna with a phased-array system capable of multiple-object tracking and data acquisition.

UHF Telemetry Antenna

Recent modifications to the UHF telemetry antenna have improved the performance and reliability of the system. New feeds are currently being installed that increase the ARIA system G/T by approximately 0.5 dB. The original feeds resulted in a system G/T of 1.5 dB. Preliminary testing indicates the new feeds will increase this to near 2.0 dB.

A pseudomonopulse tracking system has replaced the original monopulse tracking system. Major improvements have been realized during re-entry tests. The system is much less susceptible to locking onto antenna pattern sidelobes when re-entry vehicles emerge from blackout conditions. The pseudomonopulse tracking system is also much less vulnerable to locking onto multipath signals.

Data Separation Console

The data separation console (DSC) is a three-bay rack used to evaluate incoming data in real time during satellite launches. Missile and spacecraft parameters are monitored and the parameter changes are reported via HF radio to the user at Cape Canaveral or Vandenberg. The data can also be routed to UHF radios for real-time satellite retransmission or to HF radios for relay to the users. For cruise missile testing, the DSC system monitors cruise missile ephemeris data obtained from the telemetry bit stream and compares it with the aircraft's inertial navigation system to give range and range rate measurements from the ARIA to the cruise missile.

The DSC system is currently being modified to enable simultaneous evaluation of two data links. As a result, both the third-stage booster as well as spacecraft telemetry can be evaluated in real time. A pulse code modulation (PCM) simulator is being added to the DSC system that will enable telemetry data and synchronization codes to be simulated during premission calibration procedures.

Telemetry Receiver System

The telemetry receiver system consists of telemetry tracking and data receivers and associated test equipment. Five data receivers and four tracking receivers are normally used. For special applications, two additional data receivers may be employed. This provides redundancy and increases flexibility as three data and two tracking links are the maximum number usually encountered during a launch.

The receivers currently used are out of production and are being replaced with new receivers of the same size that will combine the data and tracking functions. Wider bandwidths (20 vs 3.3 MHz) will be available and the new receivers will provide binary-phase shift-keyed (BPSK) demodulation capability that is unavailable on the current receivers. The current receivers utilize plug-in modules for the intermediate frequency (i.f.) filter and demodulator functions. With the new receivers, all i.f. filters and demodulators are built into the receiver.

Antenna Control

The antenna control system (ACS) is used to control the 7 ft parabolic dish antenna. Used with the pseudomonopulse tracking system, the ACS uses one of several modes to track S-band telemetry signals. In addition to manual handwheel control of the antenna, automatic modes are employed, depending on the type of missile being tracked. The rate memory mode, used during orbital launches, drives the antenna during signal dropouts at the same rate as the previous 15-20 s of strong signal reception. The acceleration memory mode, used during re-entry tests, drives the antenna during blackout conditions at the rate before occurrence of blackout biased by the missile's theoretical trajectory. A punched paper tape containing antenna pointing angles based upon aircraft position and missile trajectory is provided to the aircrew prior to departure from Wright-Patterson Air Force Base. The trajectory bias is required due to the rapid deceleration of re-entry vehicles during the blackout period. The current ACS is being replaced with a newer, more sophisticated system. The new system employs a floppy disk containing the missile's theoretical trajectory. The new system is coupled to the ARIA's carousel IV-E inertial navigation system and automatically points the antenna from any aircraft location. This is particularly important when the aircraft's test support location must be changed due to weather. Each of the antenna tracking modes discussed above are available on the new system for weak signal conditions. In addition, the reliability of the ACS will be improved with the elimination of many electromechanical components.

Satellite Data Relay

The ARIA relay data via UHF communication satellites during launches from Cape Canaveral and Vandenberg. The ARIA utilize 1000 W Collins AN/ARC-146 radios. Recently they have been modified to operate through the Air Force Satellite Communication System (AFSATCOM). The ARIA previously utilized Lincoln Experimental Satellite No. 9 (LES-9) and the UHF transponders on the Marisat satellites. This update to include AFSATCOM utilization significantly increases the ARIA operational capability.

Recorders

Although data are relayed through satellites to range users, all data are recorded on 14 track recorders for post-test data analysis. The presently used recorders are out of production, are limited in bandwidth to 1.5 MHz, and are extremely temperature sensitive. New recorders are being installed on the ARIA (Bell and Howell USH-30 2.0 MHz recorders). The new recorders have greater reliability; also, the setup and calibration of the new recorders are facilitated using a microprocessor controller.

Boeing 707 Replacement Aircraft

The fiscal 1981 Department of Defense supplemental appropriations bill included provisions for purchasing used

Boeing 707-320C/CF series aircraft from the air carriers. Six of these aircraft will be used for ARIA. The equipment from current ARIA EC-135Ns equipped with J-57 engines will be transferred to the used Boeing 707 aircraft. The 707s are 153 ft long vs 135 ft for the current ARIA and have a wingspan of 147 ft vs 132 ft for the EC-135Ns. The increased size plus the more economical and powerful JT-3D engines will result in significant improvements in the ARIA operational capability. Runways, such as Kwajalein, that are inaccessible to the current ARIA could be used by a 707 ARIA.

The conversion of an EC-135N ARIA into a Boeing 707 ARIA requires approximately a year. As a result, two of the EC-135Ns scheduled for the final conversions will be equipped with JT-3D engines from currently grounded Boeing 707s. Studies are in progress to assess the practicality of utilizing the increased capability of the 707s to add a sonobuoy missile impact locator system if it were deemed more cost effective than current systems on P-3 aircraft.

ARIA Phased-Array Telemetry System

For ballistic missile testing, one ARIA is required for each instrumented re-entry vehicle. This requires up to four ARIA to support a given mission as up to four instrumented re-entry vehicles may re-enter the atmosphere simultaneously during a test. To alleviate this problem, studies are in progress with three contractors to determine the feasibility of placing a phased-array antenna on the side of the ARIA that would be capable of tracking and acquiring data from four instrumented re-entry vehicles simultaneously. This would save operating costs, improve the aircraft's technical capability, and provide for increased aircraft availability.

Summary

The ARIA improvement and modernization program is designed to support ballistic missile, cruise missile, and expendable booster satellite launches through the turn of the century. All of the major telemetry systems on the ARIA are being replaced or extensively updated. Larger and more capable airframes are replacing the currently used EC-135 aircraft. New concepts such as utilization of phased-array antennas in place of parabolic reflectors will enhance the technical capability as well as improve the productivity of the ARIA.