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NASA PARTICIPATION IN THE AMST PROGRAM

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INTRODUCTION

During the past 10 to 15 years, NASA research programs related to propulsive-lift aircraft technology have been directed toward expanding the technology data base which the aircraft industry designers may use for application to short-haul transport aircraft designs (ref. 1). These NASA research programs have resulted in development of such propulsive-lift concepts as the augmentor wing, externally blown flap, and upper-surface blown flap, which can produce more than twice the amount of usable aircraft lift coefficient for landing compared with the more conventional, non-powered-lift aircraft configurations (refs. 2 to 4). The improved take-off and landing performance inherent in these propulsive-lift aircraft concepts has been stated as a national asset, since short-haul transports employing these concepts will be able to operate from short runways with highly maneuverable, steep, and curved flight paths that could satisfy domestic and foreign market needs and, at the same time, could result in reduced community noise exposure (refs. 5 and 6).

With the advent of the U.S. Air Force Advanced Medium STOL Transport (AMST) Prototype Program early in 1973, the upper-surface blown flap concept was selected by The Boeing Company (ref. 7) to be applied to their YC-14 AMST prototype (fig. 1), while the externally blown flap concept was selected by the Douglas Aircraft Company (ref. 8) to be applied to their YC-15 AMST prototype (fig. 2). The Air Force AMST Program marks the first industrial application of several NASA propulsive-lift concepts to full-scale, mission-oriented transport aircraft (fig. 3). The AMST Program also provides the opportunity for full-scale flight validation of the propulsive-lift research which has been accomplished over the years through relatively small-scale experimental programs and through analytical techniques by NASA and the aerospace industry.

When it became apparent that NASA participation with the Air Force in the AMST Prototype Program could satisfy a number of the NASA objectives relative to civil short-haul transport technology needs, a Memorandum of Understanding was constituted in February 1973 by the Air Force and NASA. This Memorandum provides for NASA to conduct flight research experiments concurrent with the Air Force on noninterference or complementary bases during the Prototype Flight Test and Evaluation Program. The Memorandum further states that NASA will provide technical and facility support to the Air Force as needed, and that one or more of the prototype aircraft could possibly be made available to NASA subsequently for continued flight research.

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To structure and conduct an integrated NASA AMST Experiments Program, representatives from NASA Ames, Dryden, Langley, and Lewis Research Centers; NASA Headquarters; FAA; and the Air Force Flight Dynamics Laboratory have been meeting periodically to develop the set of flight experiments currently implemented and being conducted during the Air Force Flight Test and Evaluation Program on the YC-14 and YC-15. These representatives are also developing another set of follow-on flight experiments which are proposed to be implemented and conducted subsequently. The NASA AMST Experiments Program is intended to be a cooperative program between NASA and other government participants and the aircraft industry.

This paper discusses the objectives of the NASA AMST Experiments Program and describes several of the NASA experiments as they are currently being implemented and conducted on the YC-14 and YC-15 prototype aircraft. A brief description of the proposed future NASA AMST Experiments Program is included. This discussion is confined to those NASA experiments related to powered-lift aerodynamics and acoustics.

SCHEDULE OF EXPERIMENTS

Agreement in the USAF/NASA Memorandum of Understanding and the USAF AMST Program schedule has resulted in the following general NASA schedule of experiments involving AMST:

	AIRCRAFT	TEST PERIOD	USAF PROGRAM	NASA PROGRAM
CURRENT	DOUGLAS YC-15	AUG. 1975 - AUG. 1976	PROTOTYPE FLIGHT TEST AND EVALUATION	NONINTERFERENCE EXPERIMENTS
CURRENT	BOEING YC-14	AUG. 1976 - AUG. 1977	PROTOTYPE FLIGHT TEST AND EVALUATION	NONINTERFERENCE EXPERIMENTS
FUTURE	COMPETITION WINNER: YC-14 OR YC-15	OCT. 1977 - 1981	FULL-SCALE DEVELOPMENT	LIMITED NONINTERFERENCE EXPERIMENTS
FUTURE	COMPETITION LOSER: YC-14 OR YC-15	OCT. 1977 - OCT. 1982	POSSIBLE COEXPERIMENTERS WITH NASA	MAJOR EXPERIMENTS PROGRAM

Both current and future NASA AMST experiments are shown. Current experiments include

(1) YC-15 flight experiments over the period August 1975 to August 1976.

(2) YC-14 flight experiments over the period August 1976 to August 1977.

Future experiments utilize either or both YC-14 and YC-15 aircraft over the period October 1977 through October 1982. These two time periods encompass the period of the Air Force AMST Prototype Flight Test and Evaluation Program (August 1975 to August 1977) and the Air Force AMST Full-Scale Development Program scheduled to begin October 1977. During this latter Air Force Program period of full-scale development, NASA expects to conduct many of the major candidate experiments requiring at least one and possibly two dedicated AMST prototype aircraft to be made available by the Air Force. Additional minor experiments on a noninterference basis are planned to be conducted on the full-scale development prototype aircraft selected by the Air Force.

NASA AMST EXPERIMENT OBJECTIVES

The NASA AMST experiment objectives in the areas of powered-lift aerodynamics and acoustics are

(1) The full-scale flight validation of predictive methods based on small-scale experimental investigations and analytical techniques

(2) Development through flight research of a better understanding of aerodynamic and/or acoustic characteristics in areas where predictive methods don't exist or the phenomena have been too complex to model

(3) Full-scale proof-of-concept through flight research of methods for improving aerodynamic efficiency and reducing the effects of the acoustic environment

Several conference papers (refs. 9 to 12) are authored by NASA or NASA-sponsored AMST experimenters who have proposed flight and ground experiments to be conducted on both the YC-14 and the YC-15. These experiments will satisfy some of the NASA AMST objectives just described. The current (ongoing) AMST experiments fall into three broad experiment categories:

(1) Aeroacoustic and thermal load environments

(2) Noise sources affecting exterior fuselage structure, interior fuselage noise, and far-field noise environments

(3) Propulsive-lift aerodynamics

These experiments are intended to satisfy as many of the NASA experiment objectives as could be reasonably accommodated by the flight hardware and flight test time available in keeping with the USAF/NASA Memorandum of Understanding.

Specifically, small-scale experimental data have been obtained which indicate that jet propulsive-lift systems produce local flows which can subject wing, flap, and fuselage structures to severe environments involving aeroacoustic and thermal loads. These propulsive-lift environments are expected to be more severe in magnitude than currently experienced in conventional jet-powered transports and must be understood if efficient aircraft structural designs are to be realized. Further, there is a need to understand the mechanisms by which noise is generated in propulsive-lift systems, the propagation of this noise into the fuselage interior and the exterior far field, and methods by which noise can be attenuated. Finally, full-scale propulsive-lift aerodynamic characteristics in the dynamic flight environment must be examined to validate predictive methods based on wind tunnels, static test rigs, and analytical models.

KEY TECHNOLOGY AREAS

Experiments in the current Prototype Program are very similar for both the AMST YC-14 and YC-15 because

(1) Both the upper-surface blown flap and the externally blown flap propulsive-lift concepts encompass key technology areas which generally tend to be quite common.

(2) Experiments which tend to develop data in key technology areas generally had to be performed equally on both the YC-14 and YC-15 because of the competitive nature of the AMST program. This was necessary to avoid NASA-generated data that might unbalance the competition.

The key technology areas that are being addressed in these experiments are as follows:

- Structures and materials subjected to loads in the extreme aero-thermal-acoustic-vibration jet STOL environment
- External and internal acoustics
- Noise source identification
- Flow turning efficiency of engine effluence
- High-lift ground-effects aerodynamics
- Powered-lift configuration aerodynamics

The experimental investigations into these technology areas can generally be summed up by three broad experiment categories: (1) internal/external noise experiments, (2) flap loads/acoustics/inlet experiments, and (3) special or opportunity-type experiments.

Commonality to both the YC-14 and YC-15 exists for the first two stated experiment categories as shown in the following:

Common to YC-14 and YC-15:

Internal/external acoustics

Flap and inlet aerothermodynamic loads and acoustics

Unique to individual aircraft:

Targets of opportunity (e.g., ground crew noise)

Special tests identified during flight test program (e.g., ground effects)

Since the NASA YC-15 flight experiments have been completed, a brief discussion of only the NASA YC-15 flight experiments in these categories is included. However, similar NASA flight experiments are essentially planned for the YC-14 for the fall of 1976. The YC-14 static ground-test experiment completed in February 1976 for NASA to support the YC-14 flight tests is discussed briefly here and in detail in reference 9.

YC-15 Experiments

Internal and external noise environment measurements were conducted on the YC-15. Transducer locations on the YC-15 fuselage for the interior/exterior acoustics experiments are shown in figure 4. There were 8 accelerometers and 21 microphones in this installation. The ground and flight tests for this experiment were conducted in March 1976.

Flap loads/acoustics/inlet investigation experiments were conducted during early May 1976. The instrumentation on the starboard flap area was primarily for sensing aeroacoustic loads and for measuring the thermal environment. Flap instrumentation locations are shown in figure 5. Instrumentation for the engine inlet acoustics in the right inboard nacelle (engine 3) consisted of three static pressure transducers and five dynamic pressure transducers (microphones), as shown in figure 6, along with one exterior fuselage microphone.

As mentioned before, both the exterior/interior noise experiment and the flap loads/acoustics/inlet experiment will essentially be repeated with the YC-14 aircraft in the early fall of 1976.

Special or opportunity experiments have been planned for both the YC-14 and YC-15. In some cases these experiments have been implemented on the YC-15. Examples of this type of experiment include

(1) Engine noise investigations in the vicinity of the ground crew. Microphone positions for investigating engine noise in the vicinity of the ground crew are shown in figure 7.

(2) Flyover (far-field) noise measurements performed by the USAF Aerospace Medical Research Laboratory (AMRL).

(3) Ground-effects tests. The profile of a typical ground-effects test is shown in figure 8.

(4) NASA pilot evaluations (10 hours maximum).

YC-14 Experiments

The YC-14 experiments include integrated flight and static ground-test experiments wherein NASA was able to piggyback experiments on a planned test by Boeing of actual aircraft propulsive-lift hardware at their static test facility at Tulalip, Washington. The Tulalip ground test was a special set of experiments conducted with full-scale YC-14 hardware prior to flight tests. Figure 9 indicates the full-scale hardware tested at Tulalip. Since the Tulalip tests are discussed in detail in reference 9, only the following brief summary is presented.

The Tulalip tests permitted NASA to achieve the following objectives:

(1) To provide full-scale static measurements that could be compared with 1/4-scale static measurements of an identical configuration made by members of Langley Research Center

(2) To provide the data base required to correlate static measurements with flight measurements to assess the effects of the flight environment

(3) To assess the adequacy and location of research instrumentation to be installed in the flight vehicle

Future Experiments

There have been about 50 experiments of varying degrees of complexity proposed for the AMST. These proposed experiments have been compiled into a list, which is considered a "living list," since experiments will be modified, deleted, and added with time and as the AMST program unfolds. Examples of proposed future NASA experiments for the AMST program are as follows:

<u>Ames Research Center</u>

Prediction of the performance, stability, and control characteristics of STOL aircraft

Investigation of powered-lift STOL wake turbulence

Military/civil commonality in avionics design for short-haul air transportation

Validation of tentative airworthiness criteria for certification of powered-lift transports

Certification of powered-lift transports incorporating advanced guidance and augmentation devices

Langley Research Center

Acoustic loading and fatigue for STOL aircraft structure

Ride quality - vibration and noise measurements in the AMST

Lewis Research Center

Measurement of upwash angles at engine inlet

Forward velocity effects on fan and jet/flap interaction noise

Forward velocity effects on thrust reverser noise

Instrumentation, dedicated flight time, and aircraft modification requirements for the proposed experiments range from simple to extensive. An example of an experiment requiring extensive aircraft modifications is the possible flight testing of the Quiet Clean Short-Haul Experimental Engine (QCSEE) on the AMST.

CONCLUDING REMARKS

As discussed in this paper, the major element of NASA participation in the Air Force AMST Prototype Program is the conduct of flight research experiments on the AMST prototype aircraft, the Boeing YC-14 and Douglas YC-15. These experiments cover the broad range of technical disciplines that includes aerodynamics, propulsion, acoustics (including community noise and human factors), structures (including structural environment), stability and control, avionics and flight control systems, handling qualities, operating systems, and certification criteria. This paper has been limited to a discussion of the categories propulsive-lift aerodynamics and acoustics of flight experiments. As many NASA flight experiments as can be accomplished without interference to the basic Air Force AMST Prototype Program Objectives are currently being pursued by the NASA experimenters. Follow-on NASA flight experiments are being defined to be implemented subsequently, when one or more of the AMST prototype aircraft should be available for additional NASA flight research.

It is anticipated that the results of these flight experiments will provide the aircraft industry with additional needed technology that contributes to economical, safe, efficient STOL transport aircraft for both civil and military missions.

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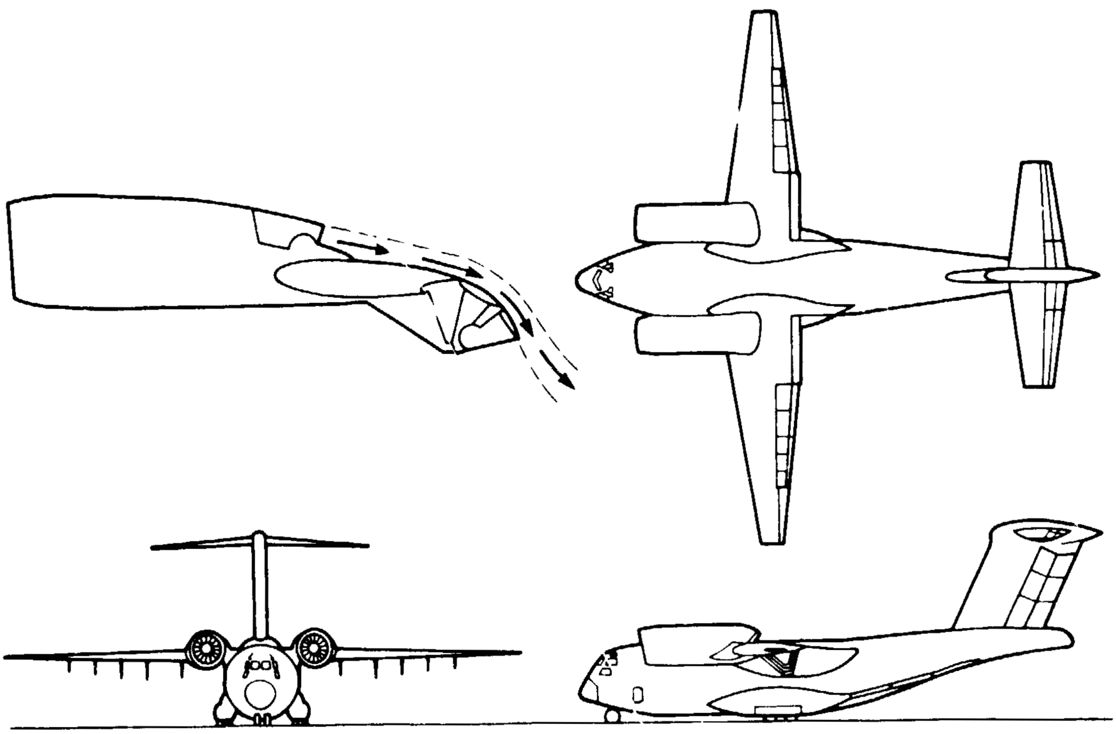
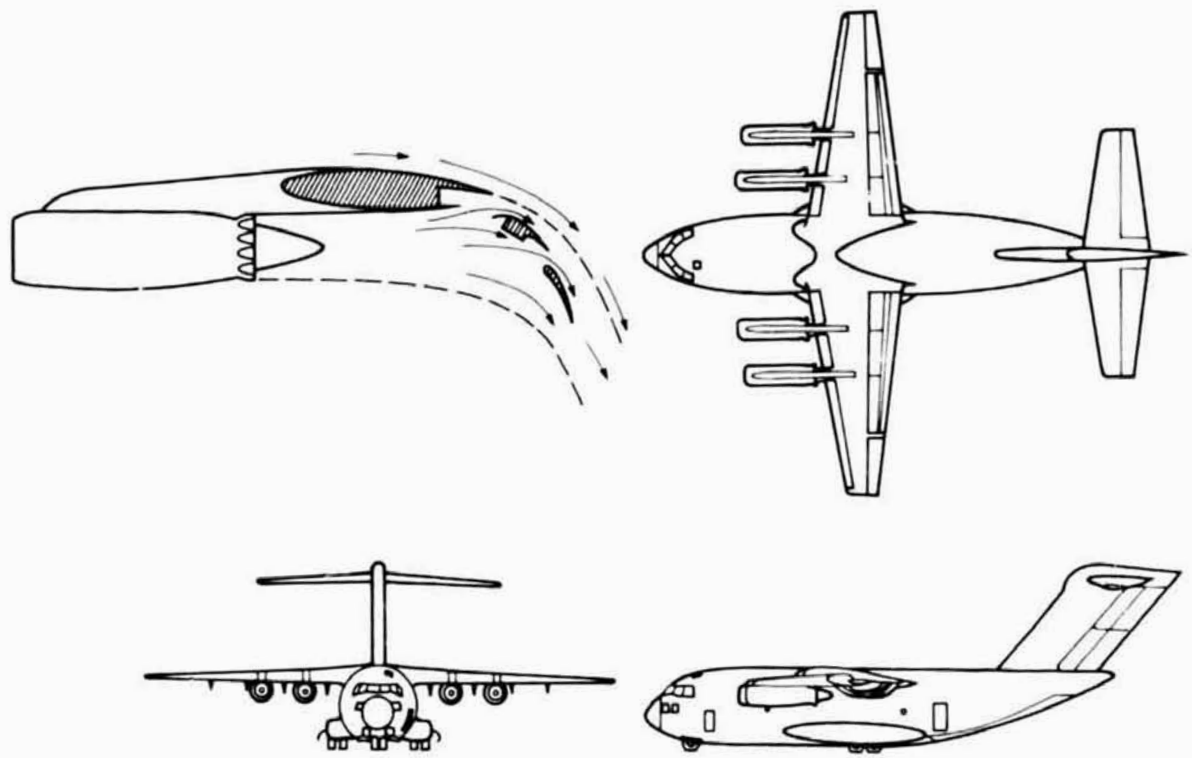


Figure 1.- USAF/Boeing YC-14 AMST prototype — upper-surface blown flap.



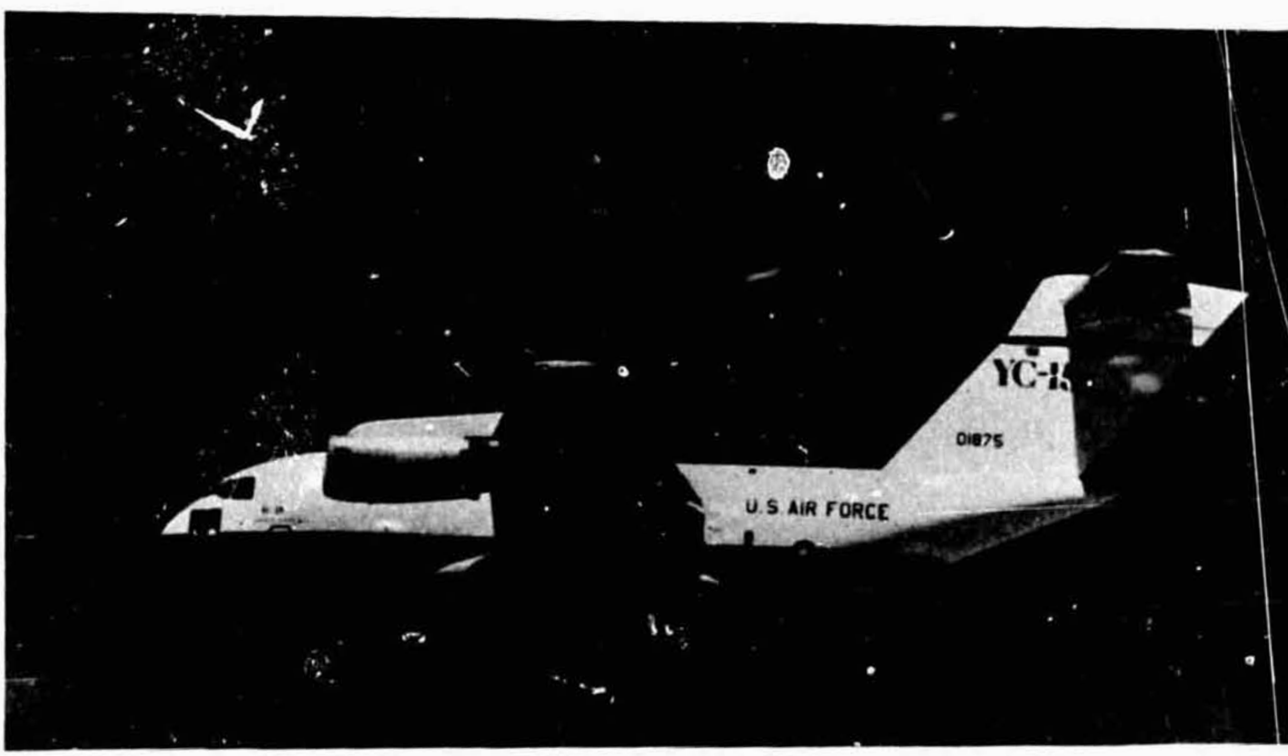


Figure 2.- USAF/Douglas YC-15 AMST prototype — propulsive-lift externally blown flap.

CAPABILITY: TAKEOFF AND LAND FROM 6096 m (2000 ft) RUNWAY WITH 12 247 kg (27 000 lb) PAYLOAD

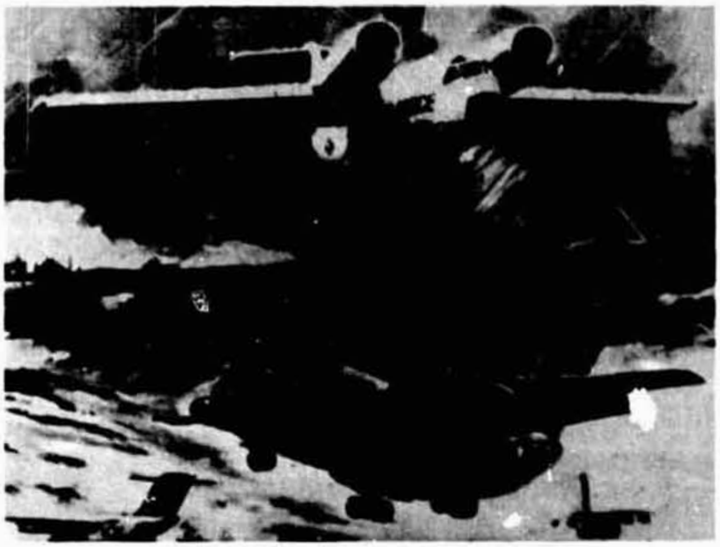


Figure 3.- USAF advanced medium STOL transport (AMST) aircraft.

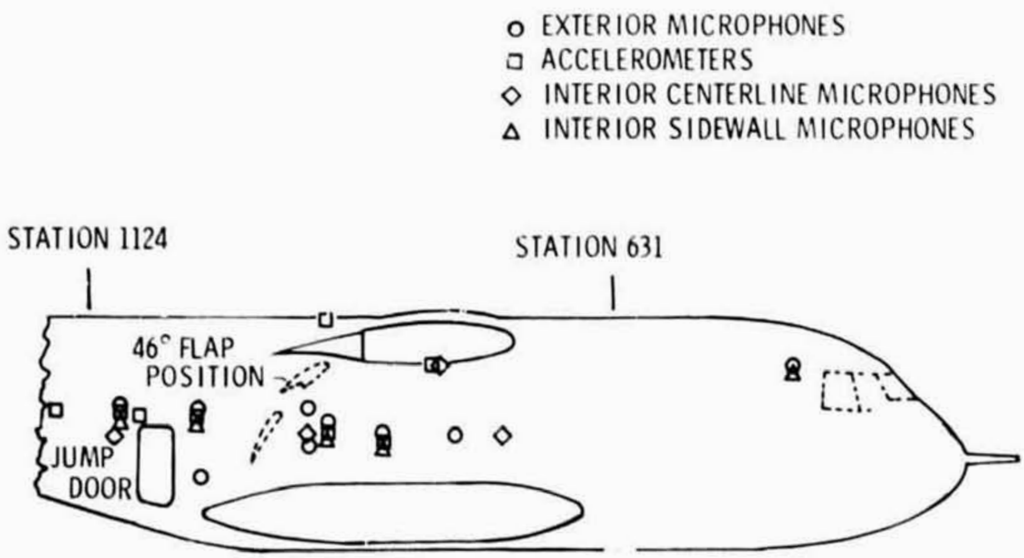


Figure 4.- Transducer locations on YC-15 fuselage.

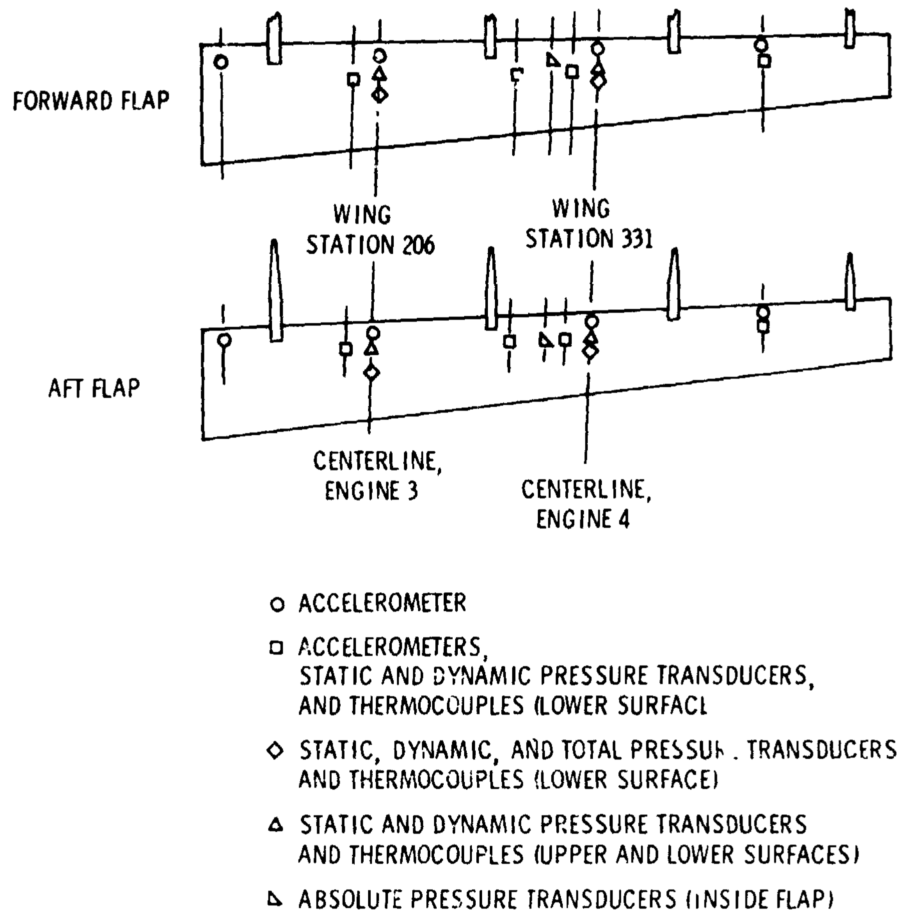


Figure 5.- Flap instrumentation locations.

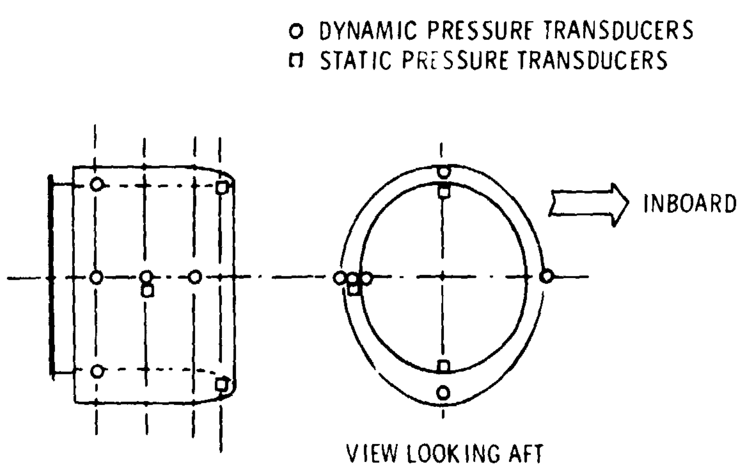
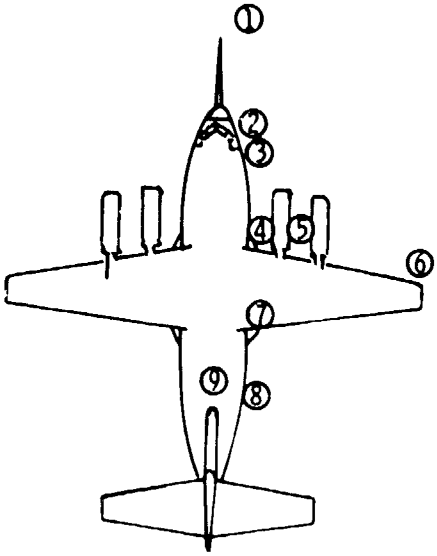


Figure 6.- Engine inlet instrumentation.



MICRO-PHONE	HEIGHT, cm	HEIGHT, in.	POSITION
1	163	64	6.1 m (20 ft) FORWARD OF NOSE
2	163	64	FORWARD DOOR
3	76	30	FORWARD LANDING GEAR
4	163	64	INBOARD ENGINES
5	163	64	BETWEEN ENGINES
6	163	64	OUTBOARD OF WING
7	76	30	MAIN LANDING GEAR
8	163	64	AFT CREW DOOR
9	163	64	INSIDE AIRCRAFT ON CENTERLINE

Figure 7.- Microphone positions for investigating engine noise in vicinity of ground crew.

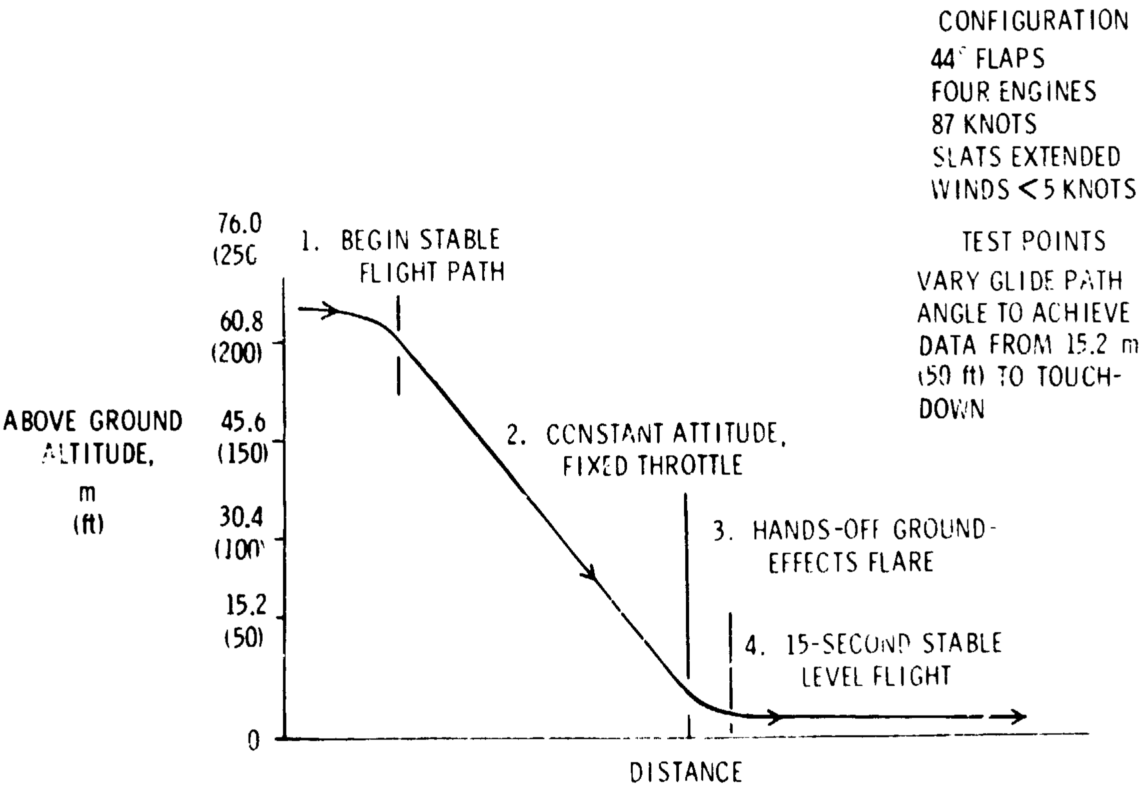


Figure 8.- Typical YC-15 ground-effects test.

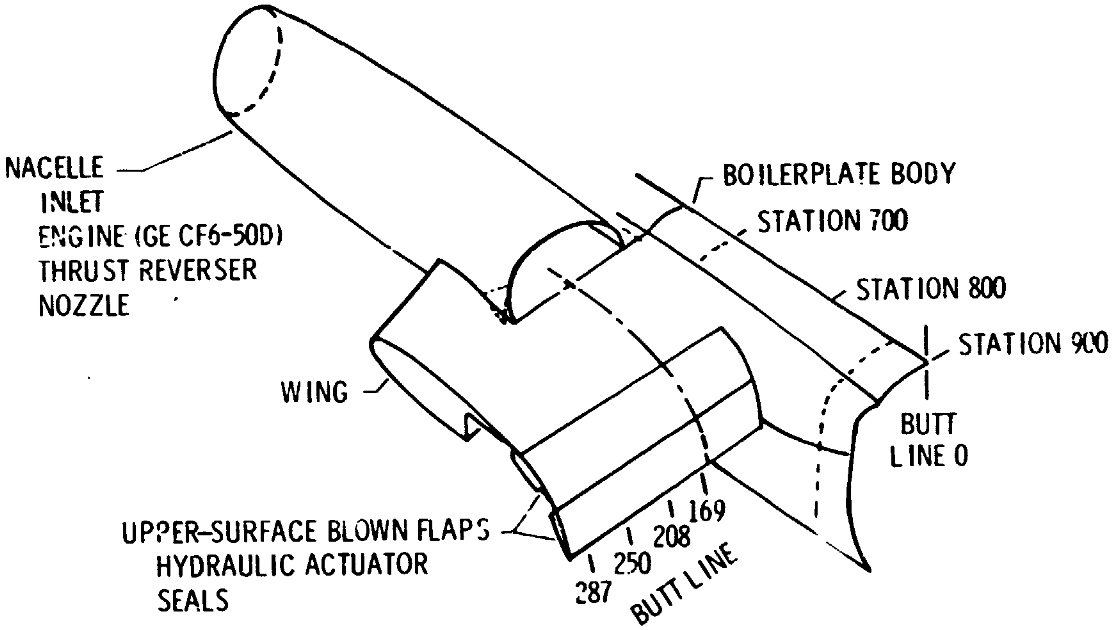


Figure 9.- Full-scale YC-14 hardware used in Tulalip ground test.