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NASA Technical Memorandum 109089

The Evolution of the High-Speed Civil Transport

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(NASA-TM-109089) THE EVOLUTION OF THE HIGH-SPEED CIVIL TRANSPORT (NASA) 48 p

N94-26155

Unclas

G3/99 0208992

February 1994

National Aeronautics and
Space Administration
Langley Research Center
Hampton, Virginia 23681-0001

THE EVOLUTION OF THE HIGH-SPEED CIVIL TRANSPORT

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Summary

Current research directed toward the technology requirements for a high-speed civil transport (HSCT) airplane is an outgrowth of many years of activity related to air transportation. A review has been made of some of the events that have provided the background upon which current research programs are built. The review includes the subsonic era of transport aircraft and some events of the supersonic era that are related to the development of commercial supersonic transport aircraft. The events include the early research of the National Advisory Committee for Aeronautics (NACA); the continued research of the National Aeronautics and Space Administration (NASA); industry evaluations; the United States Supersonic Transport (SST) Program; the follow-on NASA supersonic cruise research programs; and the issuance of the National Aeronautical Research and Development (R&D) goals. Some of the factors, both technical and nontechnical, that have had an impact on HSCT studies are mentioned.

Introduction

Man has consistently pursued means of transporting greater loads over longer distances at higher speeds. Insofar as air travel is concerned, evolutionary advances in flight technology have been made through researchers with innovative ideas and with the ability to build on the work of others. Some of these advances in flight technology, with special emphasis on high-speed civil transportation, will be discussed herein. While it is recognized that thorough coverage of all related activity would be an almost insurmountable task, it is hoped that many of the major events to be included will provide an appreciation for the magnitude of the transport airplane research and development efforts.

Discussion

The Subsonic Era

Getting Started. The subsonic era of commercial aviation in the United States is outlined in figure 1. The early experiments of the Wright brothers and other pioneers paved the way for flight in the United States prior to World War I. Advances in civil aviation were delayed for several years because of the war, however, and air service in the United States did not begin until the mid-1920's. Some airplanes used in early airline operations included the Douglas M-2 single-engine biplane with open cockpits that required the passengers to wear flying suits, helmets, goggles, and parachutes; the Ford all-metal trimotor with enclosed cabin; the Boeing Model 40 single-engine biplane with an open cockpit for the pilot but a small enclosed cabin for the passengers; the Boeing Model 80 trimotor biplane with an enclosed cabin; and the Curtiss Condor with sleeping accommodations.

New Technology and New Airplanes

The 1920's and 1930's. In this period many advances in technology were made that would impact transport aircraft. Among the airplanes developed with the advanced technologies were the Boeing Model 200 and 221 Monomail; the Boeing 247; and the Douglas DC-1, DC-2, and DC-3. These airplanes featured such advances as all-metal construction, cowled engines, low cantilever monoplane wings, retractable landing gear, and variable-pitch propellers.

Flying boat activity was significant during the 1930's and into the early 1940's primarily to support the oceanic routes of Pan American Airways. These airplanes included the Sikorsky S-38, S-40, and S-42; the Martin M-130; and the Boeing 314. The flying boat concept was subsequently replaced by land-based airplanes when land-based airplanes that met the range and payload requirements became available.

The 1940's and 1950's. Transport airplanes began to appear in this time period that provided increases in speed, range, and payload as a result of continuing advances in research and technology particularly in engines, propellers, structures and materials, airfoils and flaps. Airplanes utilizing these improvements included the Douglas DC-4, a four-engine enlarged outgrowth of the DC-3 and predecessor of further improved designs in the DC-6 and DC-7; the Lockheed Constellation and Starliner; the Boeing 307 Stratoliner, a four-engine transport that, for the first time, used a pressurized fuselage; and the Boeing 377 Stratocruiser that featured a twin-lobe, two-level cabin.

The Coming of the Jets. Among the new technologies emerging after World War II were turboprop propulsion, turbojet propulsion, and wing sweep. These features introduced the possibilities of substantial increases in speed and the potential for increased productivity. These possibilities led to advanced research in airfoils, wing twist and camber, interference flow fields, high-lift devices, boundary layers, structures and materials, and manufacturing techniques. Among the new airplanes that appeared was the Lockheed Electra, a long-range four engine turboprop transport that was the only large civil turboprop airplane ever built in the United States.

The first jet transport built in the United States was the Boeing 707 which flew in July 1954. The four-jet, swept-wing design was a private venture of Boeing based on their experience with the B-47 and B-52 swept wing jet bombers. The second jet transport built in the United States was the Douglas DC-8 which was also a four-engine swept-wing design intended to compete with the Boeing 707. The third four-jet swept-wing transport built in the United States, the Convair CV-880/990, made use of area ruling and speed bumps and was credited with being faster than the 707 and the DC-8. However, the speed advantage was not sufficient to produce sales and production was limited since Boeing and Douglas had taken the market. The Boeing 727, second in the Boeing jet transport family, was a tri-jet swept-wing design with the engines mounted on the afterbody to provide a clean wing with an array of high-lift devices. The second Douglas jet transport , the DC-9, was a twin-engine swept-wing design with engines mounted on the afterbody to permit a clean wing. The Boeing 737, a competitor for the short-to-medium range market, had twin jets mounted beneath a swept wing.

The Wide Bodies. Having achieved increased productivity with the high subsonic speeds of the swept-wing jet transport, the possibility of still further increases in productivity might be expected from an increase in payload or from a further increase in speed. Insofar as increased speed was concerned, research into the supersonic realm was underway by the NACA in the mid-1940's. NASA research applicable to supersonic transports began in the mid-1950's. However, during the same time period, the aircraft industry and the airlines were planning the introduction of `jumbo' subsonic jets as a follow-on for highly productive long-range transports. The first commercial jumbo jet, the Boeing 747, was based, in part, on Boeing's experience gained in the C-5 military transport competition which was won by Lockheed. The 747 retained the four-engine swept wing design of the 707 but more than tripled the productivity through increased size. The 747 was announced in 1966, first flew in 1969, and entered service in 1970. The second wide-body concept was the McDonnell-Douglas DC-10, a trijet swept wing design that was slightly smaller than the 747 and was intended for carrying a large load of passengers from smaller fields and over short-to-medium ranges. Lockheed, having been involved with the C-5 military transport program , later entered the wide-body civil transport field with the trijet L.1011. The L.1011 was the first civil transport built by Lockheed since the Electra turboprop.

The Supersonic Era

Supersonic Research. A chronology of events of the supersonic era having an influence on the development of a high-speed civil transport are presented in figure 2. Theoretical and experimental research in supersonics began in NACA laboratories in the mid-1940's. The Bell X-1 research airplane achieved supersonic flight (M=1.05) in October 1947. A conference on supersonic aerodynamics, including some of the findings applicable to the X-1, was held at NACA-Ames in August 1948 (ref.1). Among those attending was Capt. Charles Yeager who had flown the X-1. The latest results were presented on subjects such as lifting surfaces, stability and control, bodies and wing-body interference, heat transfer and boundary layers, and inlets and diffusers. Referred to in this conference were the early theoretical studies of highly swept arrow and delta wings at supersonic speeds by researchers including Robert T. Jones of Ames and Clinton E. Brown of Langley. Also referred to was the early experimental work done in the Langley 9-Inch Supersonic Tunnel by Macon C. Ellis, Jr. and Lowell E. Hasel and in the Ames 1-by 3-Foot Supersonic Tunnel by Robert T.

Madden. The fundamental research reported in this conference had broad application including the development of high-speed civil transports. A significant expansion in the research related to high-speed civil transports was well underway in the 1950's when larger supersonic tunnels were operational.

The research was given an added impetus in the mid-1950's when John Stack of NACA-Langley returned from Great Britian with details of a British design by Barnes Wallis for a variable-wing-sweep supersonic transport known as the Swallow. The concept, shown in figure 3 as I, spawned several other variations. such as those shown in figure 3 with the designations II, III and IV. The basic concept of a variable geometry design to provide good aerodynamic efficiency at subsonic and supersonic speeds had application both for civil and military use. Other forms of variable geometry that were under consideration are shown in figure 4. Studies of these concepts together with the research effort that had already been employed in the development of the B-58, B-70 and SR-71 supersonic airplanes became major factors in a commercial supersonic transport research program by the late 1950's.

Federal Aviation Agency Involvement. Representatives of the Federal Aviation Agency (FAA), in the course of a review of the prospects for a supersonic commercial air transport, visited the Langley Research Center of NASA on November 15,1959. As a result of the visit, the FAA requested that a summary of the NASA material related to high-speed civil transports be presented to the principal executives and technical staff members of the FAA. Such a briefing was presented by NASA to the FAA on December 11,1959. A formal NASA paper on the technical summary presented to FAA was published in April 1960 (ref.2). Following this presentation, the FAA published a Commercial Supersonic Transport Aircraft Report in December 1960 (ref.3) in which the FAA administrator, E.R.Quesada, recommended that the Executive and Legislative Branches of our government give prompt and careful attention to the immediate establishment of a national program for the development of a commercial supersonic transport aircraft. Some research concepts depicted in this document show a variety of design concepts (fig.5).

The FAA published a Commercial Supersonic Transport Report in June 1961 (ref.4) in which it was stated that the Department of Defense (DoD), the National Aeronautics and Space Administration (NASA), and the FAA were the appropriate government agencies to jointly organize and undertake a vigorous effort to define a national program for the development of a commercial supersonic transport aircraft. The report was signed by Robert S. McNamara for DoD, James E.Webb for NASA, and N.E.Halaby for FAA.

NASA Involvement. NASA Headquarters established a Supersonic Transport Research Committee on November 4,1960. This committee, appointed by Ira H. Abbott, Director of Advanced Research Programs, was responsible for the technical leadership and research support for the commercial supersonic transport aircraft program. The committee members, with representatves from each of the NASA Research Centers, are shown in figure 6. In June 1961, a supersonic transport research team was formed at NASA-Langley under the direction of John Stack. The organization of this team is shown in figure 7.

Industry Interest. Major airframers were interested in the studies related to the development of a commercial supersonic transport. Some of the concepts that had appeared by the early 1960's, as suggested by Douglas, Lockheed, North American, Convair, and Boeing are shown in figures 8 through 12. Of the various concepts, only Boeing proposed the use of variable wing sweep.

Executive and Legislative Branches Involvement. In 1961, the U.S., under the direction of Vice President Lyndon B.Johnson, initiated an extensive investigation of the technical and economic feasibility of the commercial supersonic transport. The FAA was funded for the program beginning in Fiscal Year 1962, and the research program was officially underway.

Supersonic Transport Research Studies

The SCAT Program. The NASA research program on the supersonic commercial air transport (SCAT) began in 1959 and over a period of about seven years included 19 designated concepts (SCAT-1 through SCAT-19) which,with perturbations, yielded a total of about 40 concepts. These concepts, 25 of which are shown in figure 13, included a variety of geometric types such as variable wing sweep, arrow wings, delta wings, trapezoidal wings, an M-wing, canard surfaces, aft tails, outboard tails and three-surface arrangements.

The investigations included low-speed, transonic, and supersonic speeds although all concepts were not tested at all speeds. SCAT 16 and SCAT 15 models mounted in the test section of the Langley Unitary Plan Wind Tunnel are shown in figures 14 and 15, respectively. The results of the SCAT program are summarized in reference 5.

In February 1963, four of the concept's - SCAT 4, 15, 16, and 17 (shown in figures 16 to 19) - were selected by NASA for more detailed study under contracts with Boeing and Lockheed. The results of the study (ref.6) indicated that SCAT 16 and 17 were technically feasible but were somewhat larger and heavier than subsonic transports. SCAT 4 and 15 were considered to be impractical at the time because of stability and weight problems. The study indicated the need for advanced propulsion systems, major weight reductions, and lower sonic boom levels. Following the feasibility study, NASA continued research on SCAT 15, 16, 17, 18 and 19.

The National SST Program. In June 1963, President John F. Kennedy announced the commitment of the United States to develop a commercial supersonic transport under the direction of the FAA. In August 1963, the FAA issued a Request for Proposal (RFP) for the development of a commercial supersonic transport. Respondents were Boeing, Lockheed, North American, General Electric, Pratt and Whitney and Curtiss Wright. North American and Curtiss Wright were eliminated. The proposals of Boeing, Lockheed, General Electric, and Pratt and Whitney were accepted. The Lockheed proposal was a fixed delta-wing design somewhat similar to SCAT 17 (fig.20). The Boeing proposal was a variable-wing-sweep design somewhat similar to SCAT 16 (fig.21). Evaluations of these proposals, including wind-tunnel testing at NASA Langley, were conducted by NASA, FAA, and DoD personnel over a period extending from January 1964 to October 1966. On December 31,1966, the FAA announced the selection of Boeing/General Electric to develop the first U.S. supersonic transport. The Boeing concept was selected over Lockheed primarily because of the belief that the use of variable sweep offered more growth potential than the fixed wing delta. In the ensuing years, the Boeing design suffered from various problems of weight and stability and the configuration was changed until an arrangement with engines mounted on a large fixed aft surface was conceived. This concept, the Boeing 2707-200, is shown in figure 22.

However, weight and stability problems continued to plague the concept and in October 1968 Boeing announced that the variable-sweep wing was to be abandoned in favor of a more conventional fixed-wing aft-tail design. The Boeing redesign - the 2707-300 - is shown in figure 23.

The U.S. SST program continued to meet with technical, economical, political and ecological problems. In December 1970, Congress reduced the funding, and in March 1971 the U.S. SST program was cancelled. Some factors that led to the cancellation included the following:

- o Environmental, including sonic boom, community noise, engine emissions, and radiation exposure.
- o Aerodynamic, in particular; the need for a more efficient lift-to-drag ratio for both subsonic and supersonic flight.
- o Propulsion needed to provide sufficient thrust at both supersonic and subsonic speeds along with low noise and efficient fuel consumption.
- o Structures and materials to provide greater strength with less weight.
- o A need for systems integration techniques to combine the separate disciplines of aerodynamics, propulsion, structures, and other subsytems into an efficient airplane.
- o Others such as fuel usage, cost, economics, air-traffic control, and safety.

Further Research

The SCAR Program. Following the cancellation of the National SST program, the technology studies related to supersonic transports were continued with a NASA program begun in 1972 called Advanced Supersonic Technology (AST). Critics of the SST read the acronym to mean "advanced supersonic transport" so the program was renamed Supersonic Cruise Aircraft Research (SCAR) in 1974. Progress made during the first 4 years of this program was reported in a conference at the Langley Research Center in November 1976 (ref.7).

In addition to designs like the Boeing 2707-300, other concepts were proposed by McDonnell-Douglas and Lockheed during the AST and SCAR studies. Some of these concepts are shown in figures 24 through 27. A SCAR demonstrator was also proposed as a means of obtaining flight test data for various types of advanced technology. Such a demonstrator is illustrated in figures 28 and 29.

The SCR and VCE Programs. Following the 1976 conference, the name of the program was changed to Supersonic Cruise Research (SCR) in order to clearly indicate that the program was a research program and not an aircraft program. The research was focused on a variety of disciplines including aerodynamics, propulsion, stability and control, structures and materials, economics, environmental factors, and systems integration. Because of the multi-disciplinary nature of the program, a systems integration approach was adopted as a means of assessing design concepts. In the propulsion studies, a focused program called the Variable Cycle Engine (VCE) was started in 1976.

The SCR and VCE programs included participation by the Langley, Lewis, and Ames Research Centers as well as by the airframe and engine industries. Significant achievments were made in analytical techniques and design procedures, and the data base was expanded. These results were reported in a conference at the Langley Research Center in November 1979 (ref.8). It was anticipated that the supersonic cruise technology programs would continuue under SCR and VCE. However, as a combined result of budget reductions and other priorities, NASA cancelled the SCR and VCE programs in 1982. The government and industry research groups were somewhat disarrayed but a small basic research effort continued to pursue supersonic cruise technology. A more detailed account of the activities related to supersonic cruise technology up to 1982 may be found in reference 9.

Renewed Goals

National Aeronautical R&D Goals. In November 1982, an interagency group under the direction of the White House Office of Science and Technology Policy (OSTP) made a study concerning the state of aeronautical research and the role of the Federal Government in supporting that research. Among the conclusions was that monumental advances in aircraft performance are possible and that industry and the Federal Government must work together to realize the potential benefits. A committee composed of government, industry, and academic experts reviewed the study and, in March 1985, specified three goals (ref.10), one of which was the Supersonic Goal: To Attain Long-Distance Efficiency. It was noted that from a strategic and economic perspective, the Pacific area is constrained by distance, a factor adding significance to the supersonic goal. In February

1987, OSTP reinforced the supersonic goals by adding an emphasis on environmental issues and proposed an eight-point plan to achieve the goals (ref.11). This plan is currently being pursued by the High-Speed Research Project Office at NASA-Langley.

The SST Timeline

Programs related to the development of a high-speed civil transport airplane have been underway since the mid-1950's. An itemized timeline of major events in this development is shown in figure 30. Program timeframes for the U.S. SST effort are shown in figure 31. A supersonic perspective leading to the HSCT is presented in figure 32. Shown on this figure are typical values of take-off gross weight, range and number of passengers as envisioned from the 1960's through the 1980's.

A Short Look at a Long History

The history of civil air transportation, now in it's eighth decade, has been quite spectacular although sometimes tedious. Technology has been reasonably progressive but often in the face of some skepticism. Thus from the time of the Wright brother's flight at Kitty Hawk, it was almost a quarter of a century before commercial air transportation became a reality in the United States in the mid-1920's. Then about 10 years elapsed before the first generation of transports was replaced by more streamlined, all-metal, cantilever-wing, retractable-gear, twin-engine designs in the mid-1930's. In the mid-1940's, larger four-engine propeller-driven transports began service. In the mid-1950's, jet-propelled, swept-wing transports were being developed. This radical departure from convention gave rise to a number of new concerns: the jet engine was not fuel-efficient; would require frequent overhaul; would have a short operational life; the jet exhaust would burn up runways and buildings; cabin decompression was a danger; the jet engine noise was unacceptable; airport accommodations were scarce; ground crews would be exposed to added dangers; the ticket price would increase, and so on. However, the jet transport became a reality and is still a standard today. In the late 1960's, the development of wide-body jumbo jets was begun and these entered service in the early 1970's and continue to be the workhorses of the long-range commercial transport airlines today. In this same time period of the 1960's and early 1970's, the U.S. SST program was in progress but the time was not right and the program was cancelled. This, regardless of the thoughts given in a Boeing publication of 1964 (ref.12), in which it was stated that the next step in air transportation was the SST because it was within technical reach; was as safe as current airplanes; was a logical step and not a radical departure; would be a practical airplane and publicly acceptable; and would payoff for the nation, for the traveling public, and for the airlines.

Other countries did proceed with supersonic transports in the late 1960's. In the Soviet Union, the TU-144 was claimed to be the world's first SST when it flew in December 1969. However, the TU-144 saw only limited airline service. The British-French Concorde first flew in March 1969, entered service in 1976, and is still in service today. These airplanes are shown in figure 33 in comparison to the B-2707-300.

Now, as we move into the 1990's, the development of a supersonic, long-range, efficient civil transport is continuing in the United States under the NASA High-Speed Research Project Office. Many advances have been made in technology and in design study methods in recent years, and these advances are being applied in the HSCT program.

Epilogue

Some observations relative to the research and development of civil air transports are:

- The technology required to increase the speed, range, and payload capacity of civil transports has progressed throughout this century.

- Technology readiness is an absolute neccessity for the advancement of new commercial transports. However, the advancement will not become a reality unless the market need exists, and the environmental concerns can be reconciled.

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Mid-1920's Commercial civil air service begins

Douglas M-2, Boeing 40 and 80, Ford trimotor, Curtiss Condor

1920's - 1930's New technology appears

Boeing Monomail, Boeing 247, Douglas DC-1, DC-2, DC-3
Flying boats by Sikorsky, Boeing and Martin

1940's - 1950's Increases in speed, range and payload

Douglas DC-4, DC-6, DC-7, Lockheed Constellation, Boeing Stratoliner and Stratocruiser, Lockheed Electra

1950's - 1960's The coming of the jets

Boeing 707, Douglas DC-8, Convair 880/990, Boeing 727, Douglas DC-9, Boeing 737

1960's - 1970's   The jumbo jets

Boeing 747, McDonnell-Douglas DC-10, Lockheed L-1011

Figure 1.- The subsonic era.

1940's - Early theoretical and experimental studies.

Oct.1947- Bell X-1 exceeds M=1.

Nov.1956 - XB-58 flew.

1959-1961- NASA, FAA, Industry SST study begins.

1959-1966- NASA SCAT program.

June 1963- National SST program started.

1964 - XB-70, SR-71 fly.

Dec.1968- TU-144 flew.

Mar.1969- Concorde flew, entered service 1976.

Mar.1971- National SST program cancelled.

1972-1982- NASA AST, SCAR, SCR, VCE programs under ASD.

1982-85-87- National Aeronautical R&D Goals issued by OSTP.

Figure 2.- The supersonic era.

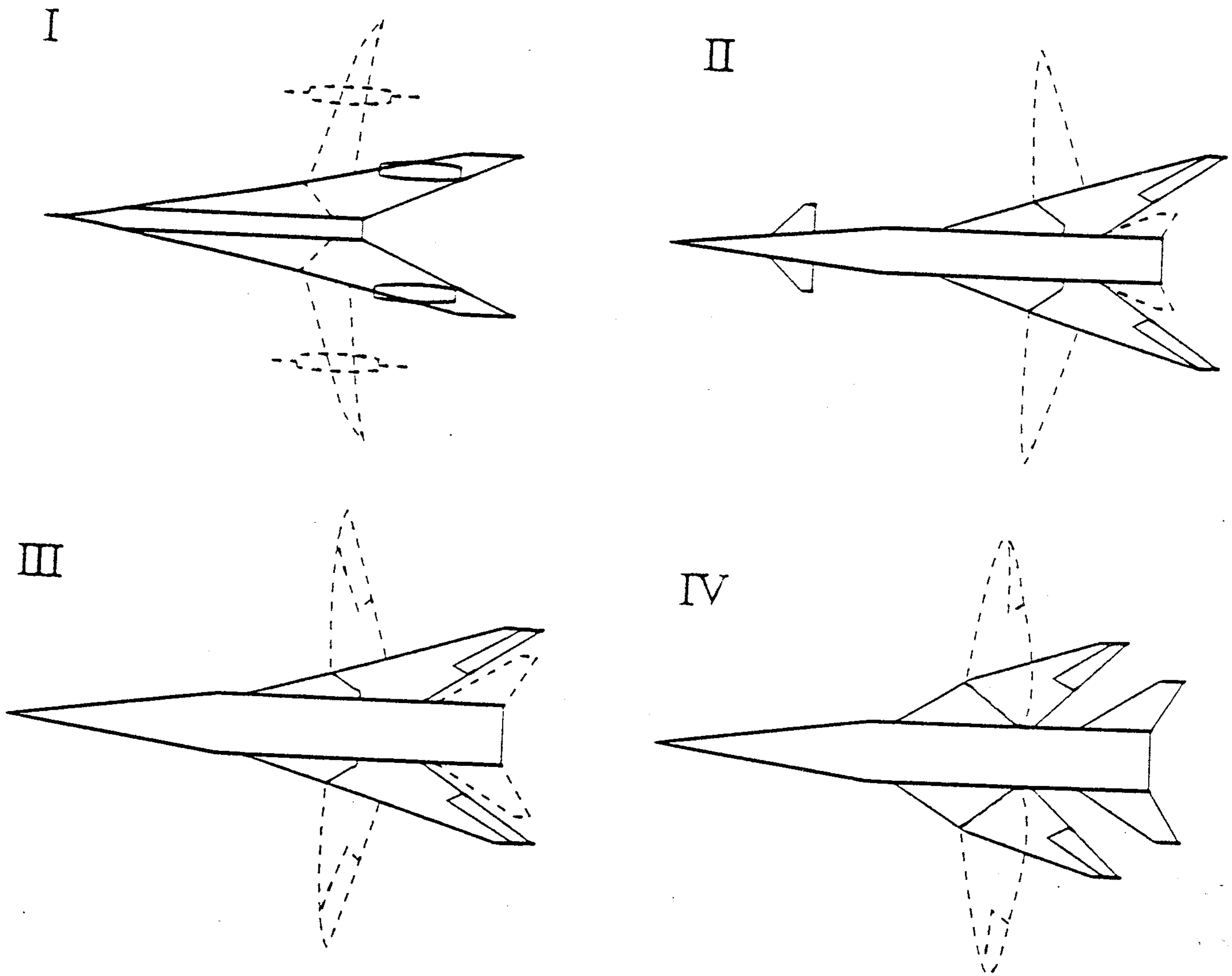

Figure 3.- Early variable-sweep concepts, 1959.

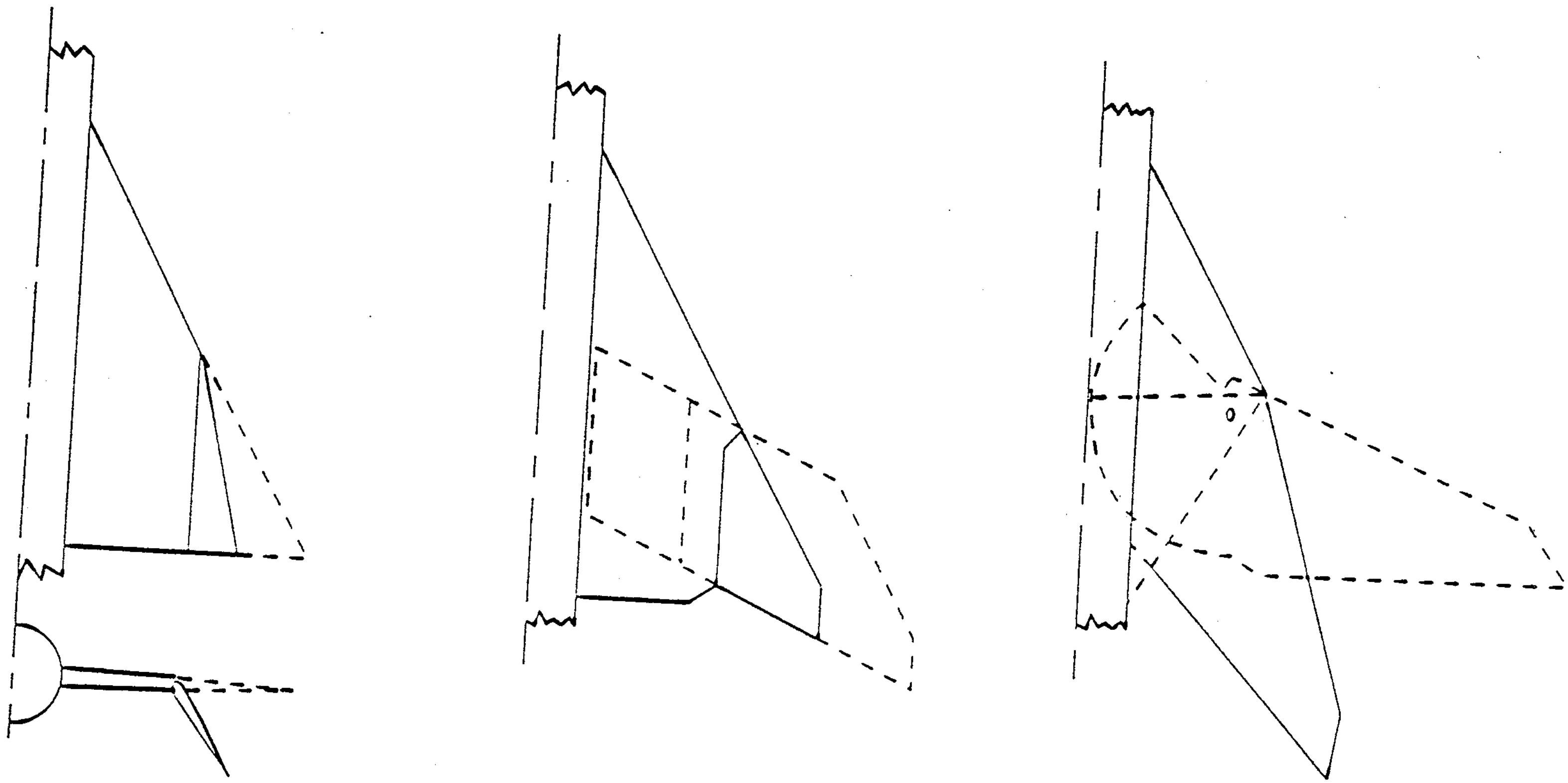

Figure 4.- Variable-geometry concepts, 1959.

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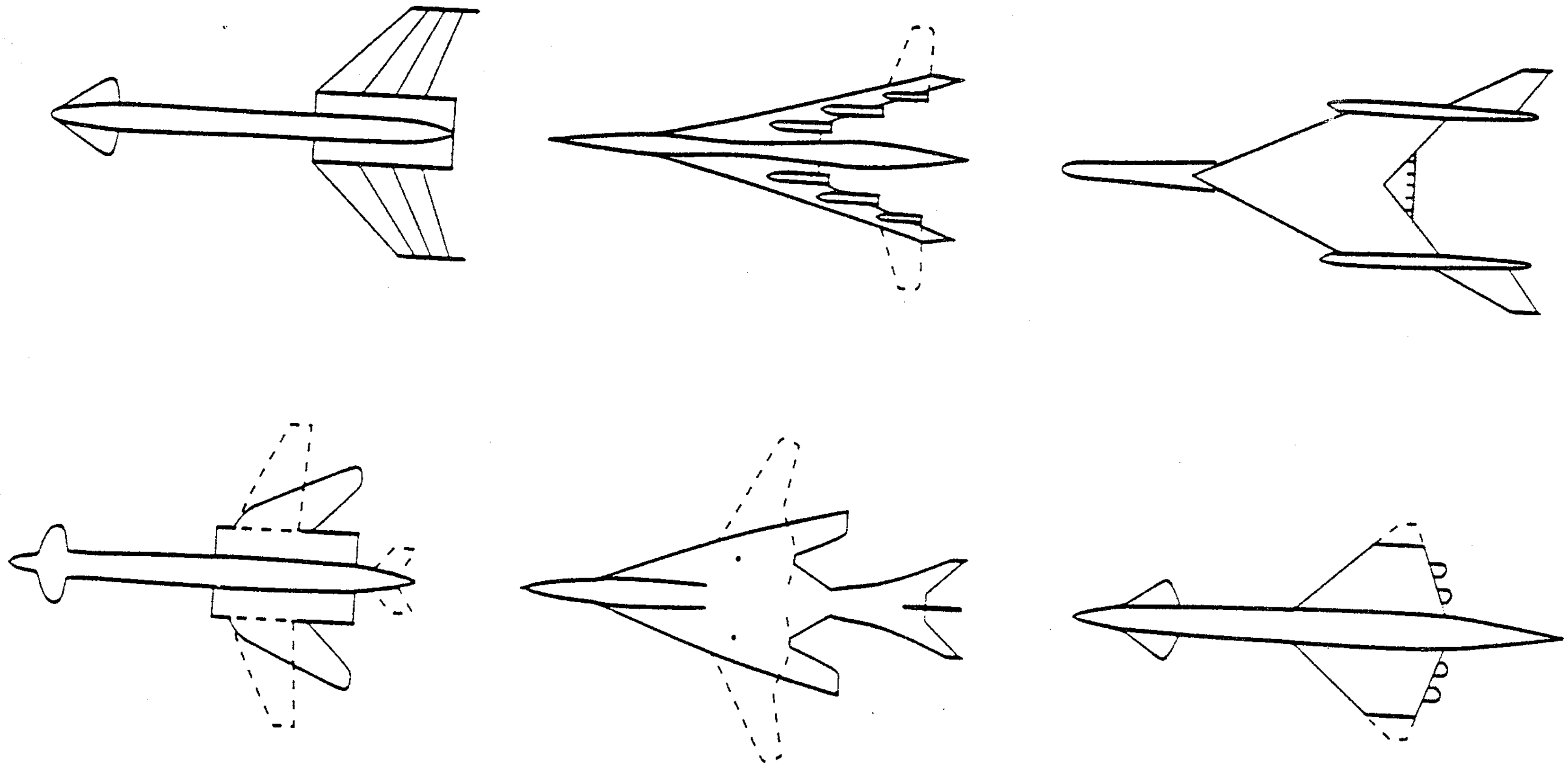

Figure 5.- Transport research configurations, 1960.

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Richard V.Rhode	NASA Headquarters, Chairman
John Stack	Langley, Vice Chairman
Donald D.Baals	Langley Research Center
D.E.Beeler	Flight Research Center
William Brown	Lewis Research Center
Charles W.Harper	Ames Research Center
Harry Press	NASA Headquarters, Structures and Operating Problems
William W.Woodward	NASA Headquarters, Propulsion
Albert J.Evans	NASA Headquarters, Aerodynamics and Secretary

Appointed by Ira H.Abbott, Director of Advanced Research Programs, NASA Headquarters

Figure 6.- NASA Headquarters supersonic transport research committee, Nov.4, 1960.

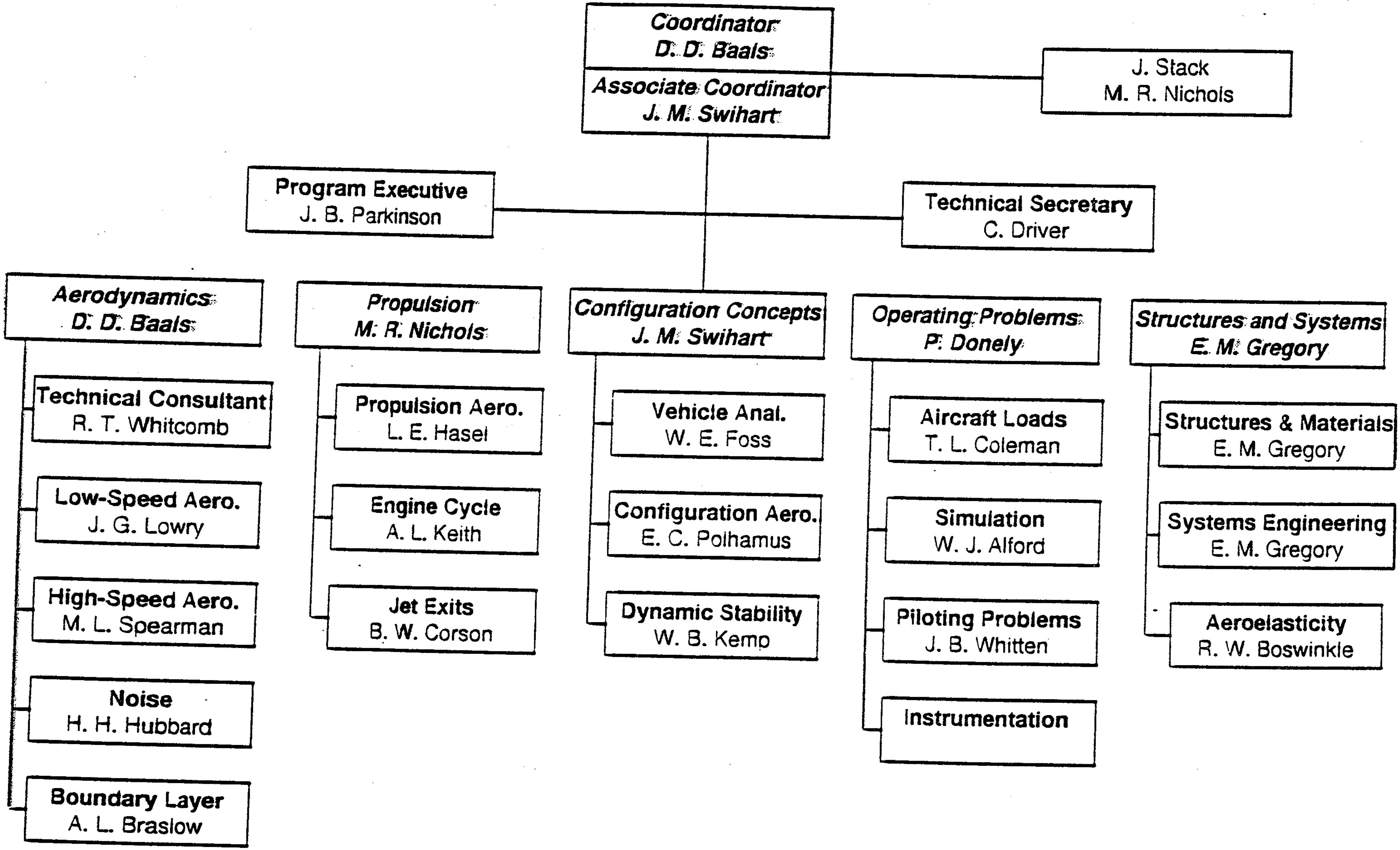

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Figure 7.- Langley supersonic transport research team, June 1961.

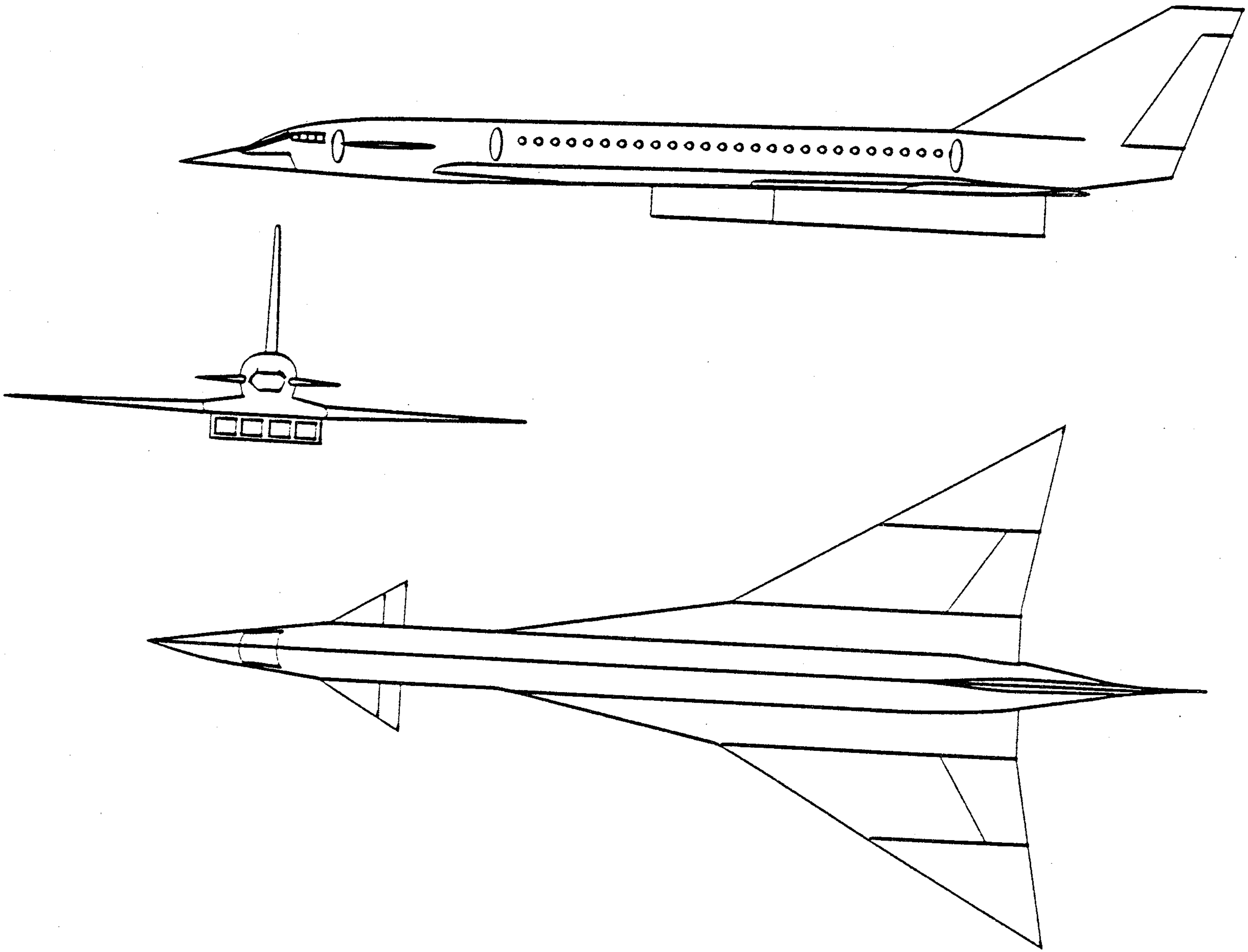

Figure 8.- Douglas configuration, 1961.

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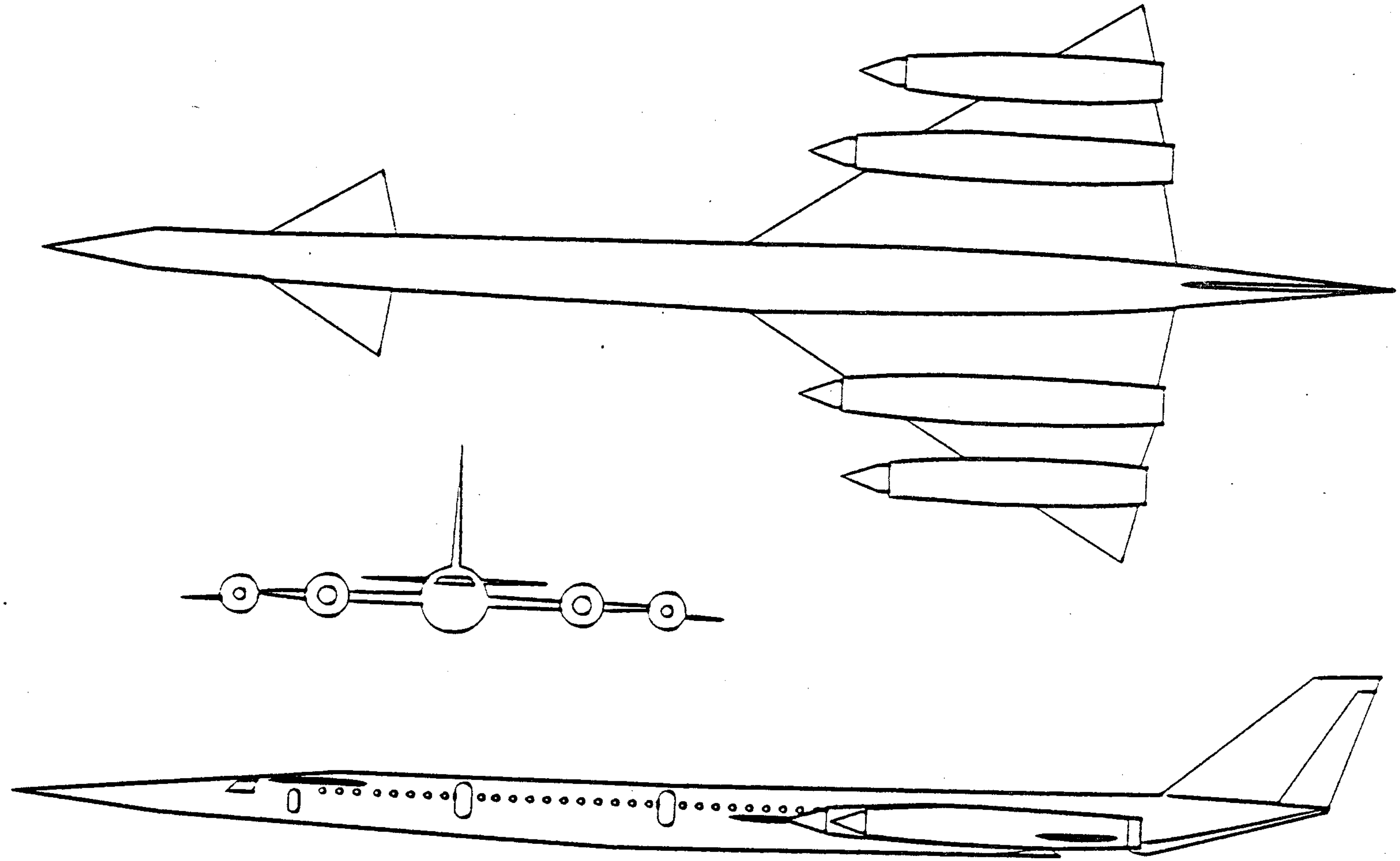

Figure 9.- Lockheed configuration, 1961.

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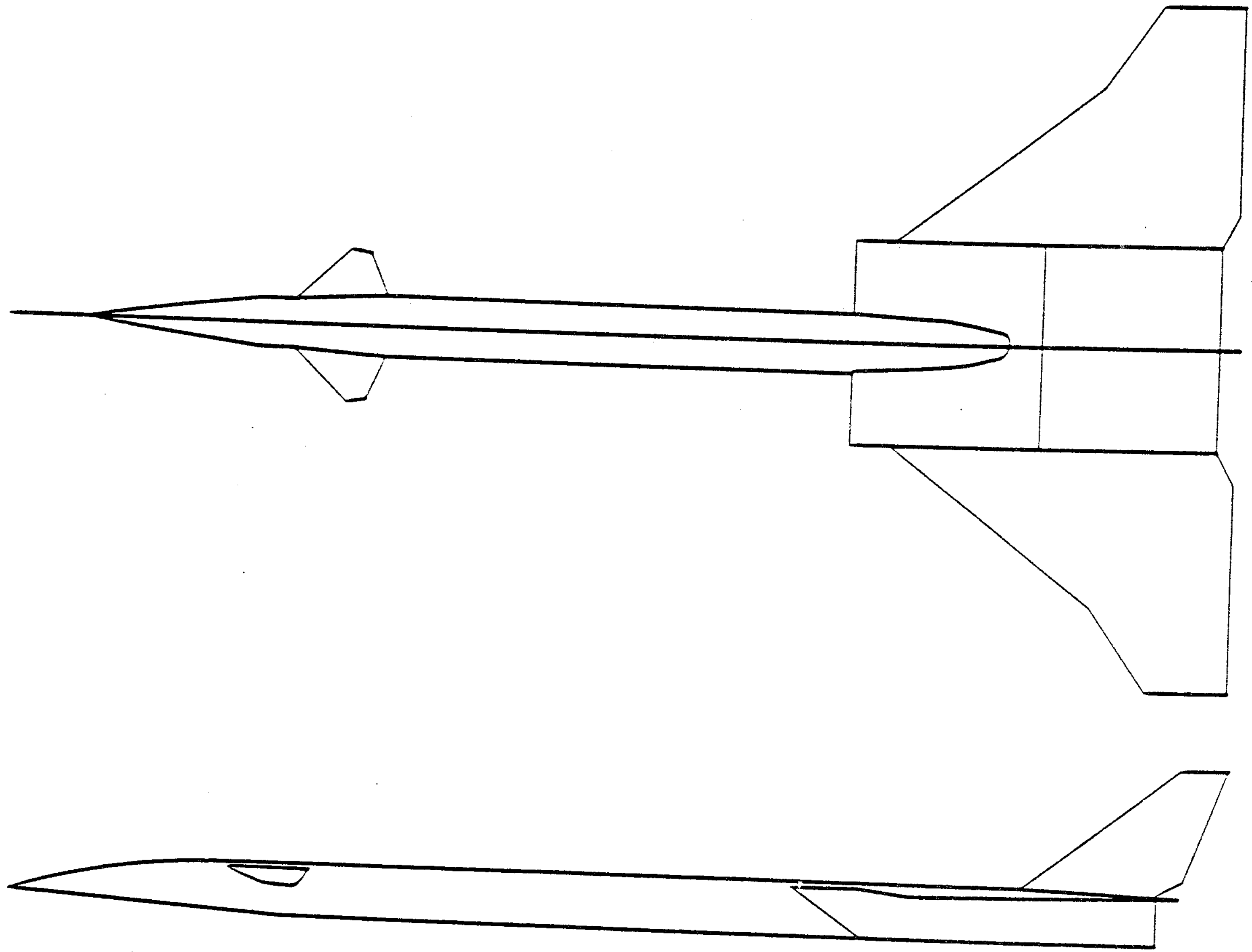

Figure 10.- North American configuration, 1961.

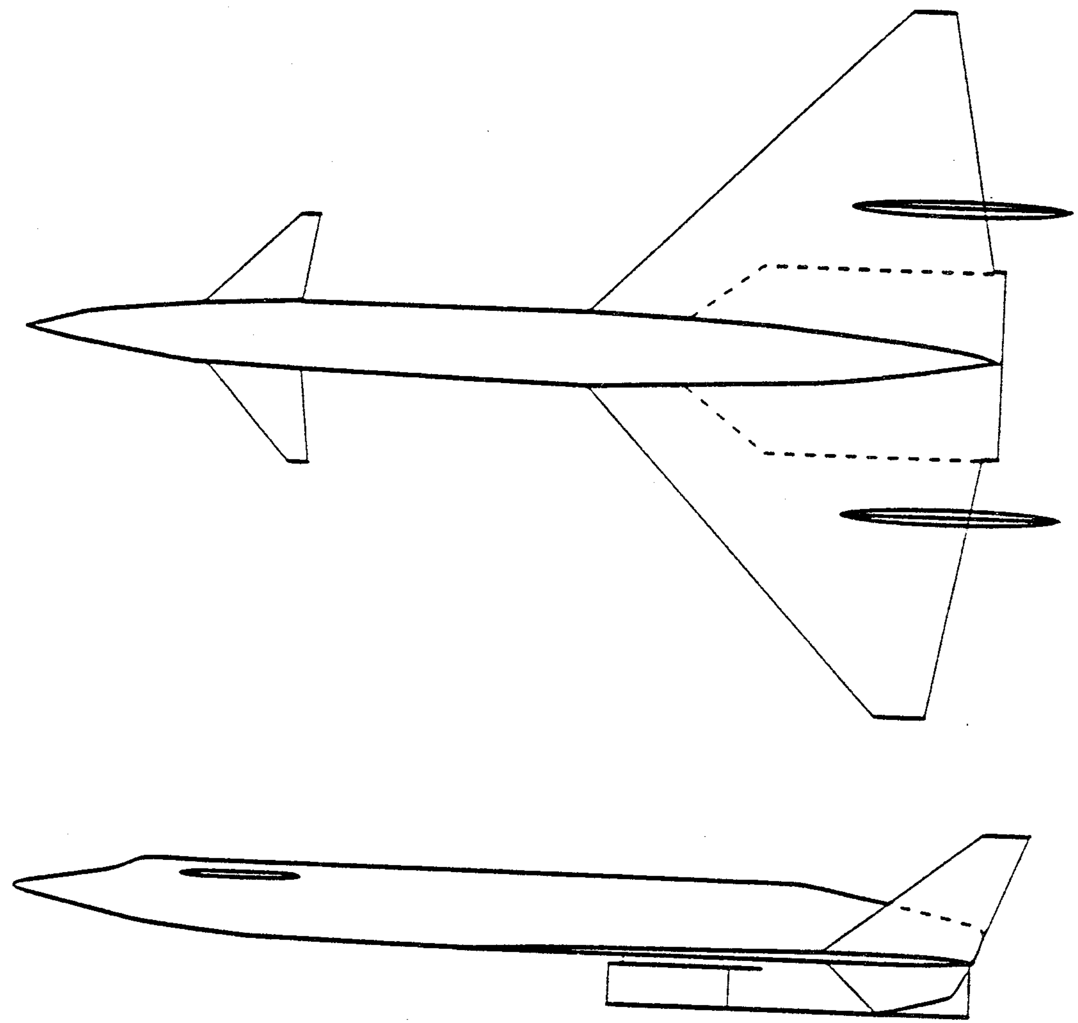

Figure 11.- Convair configuration, 1961.

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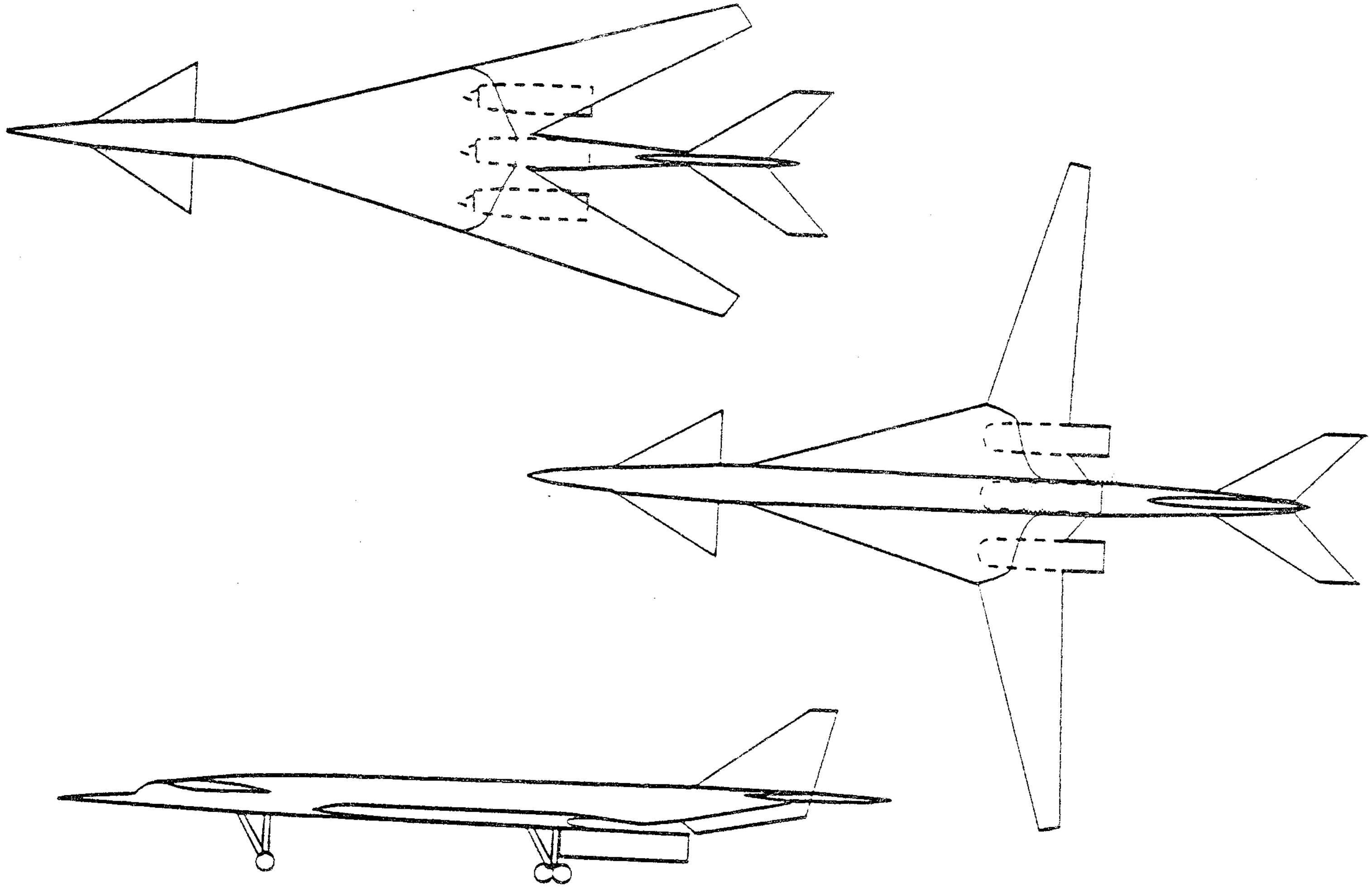

Figure 12.- Boeing configuration, 1961.

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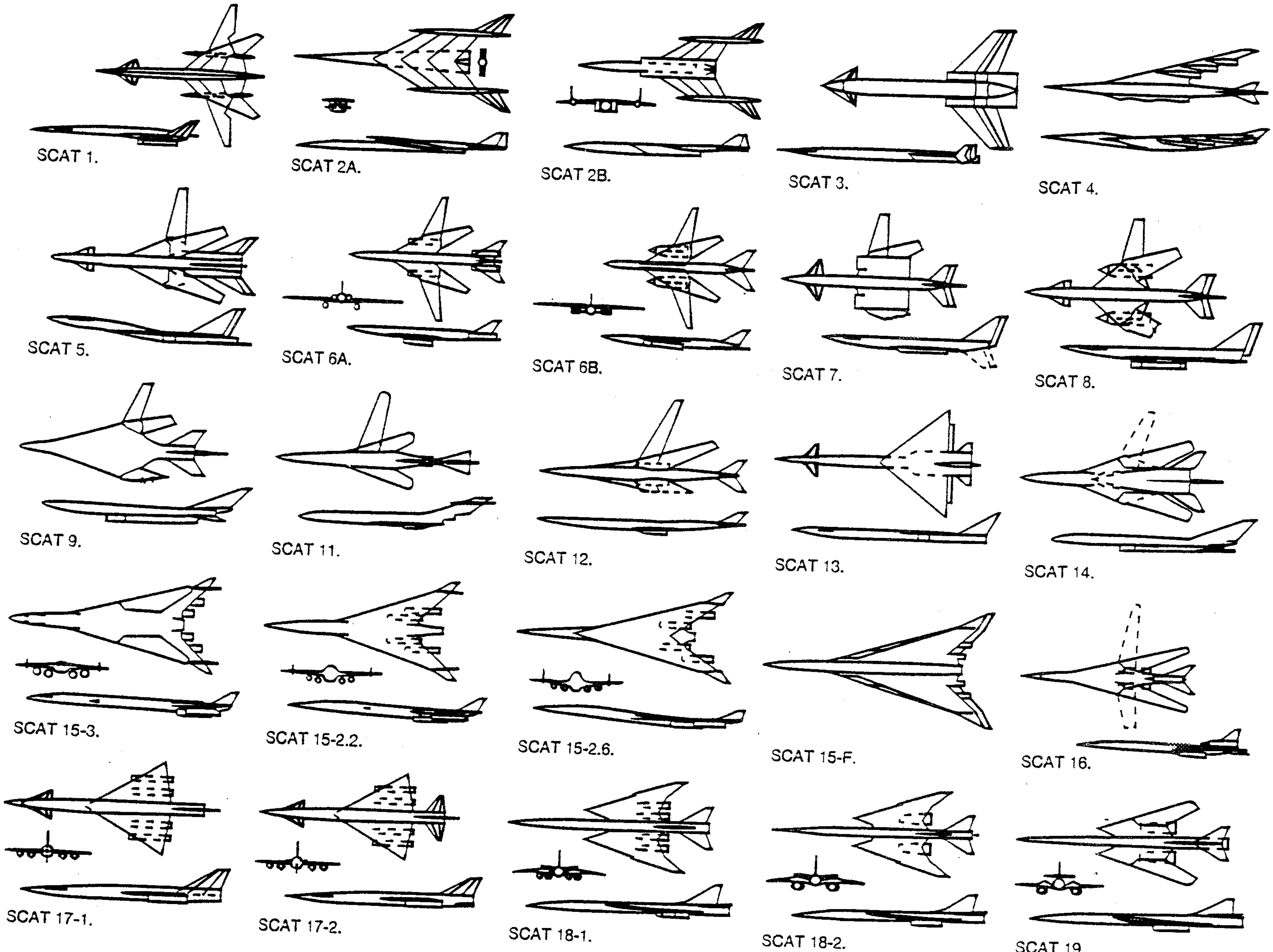

Figure 13.- SCAT configurations, 1959 -1966.

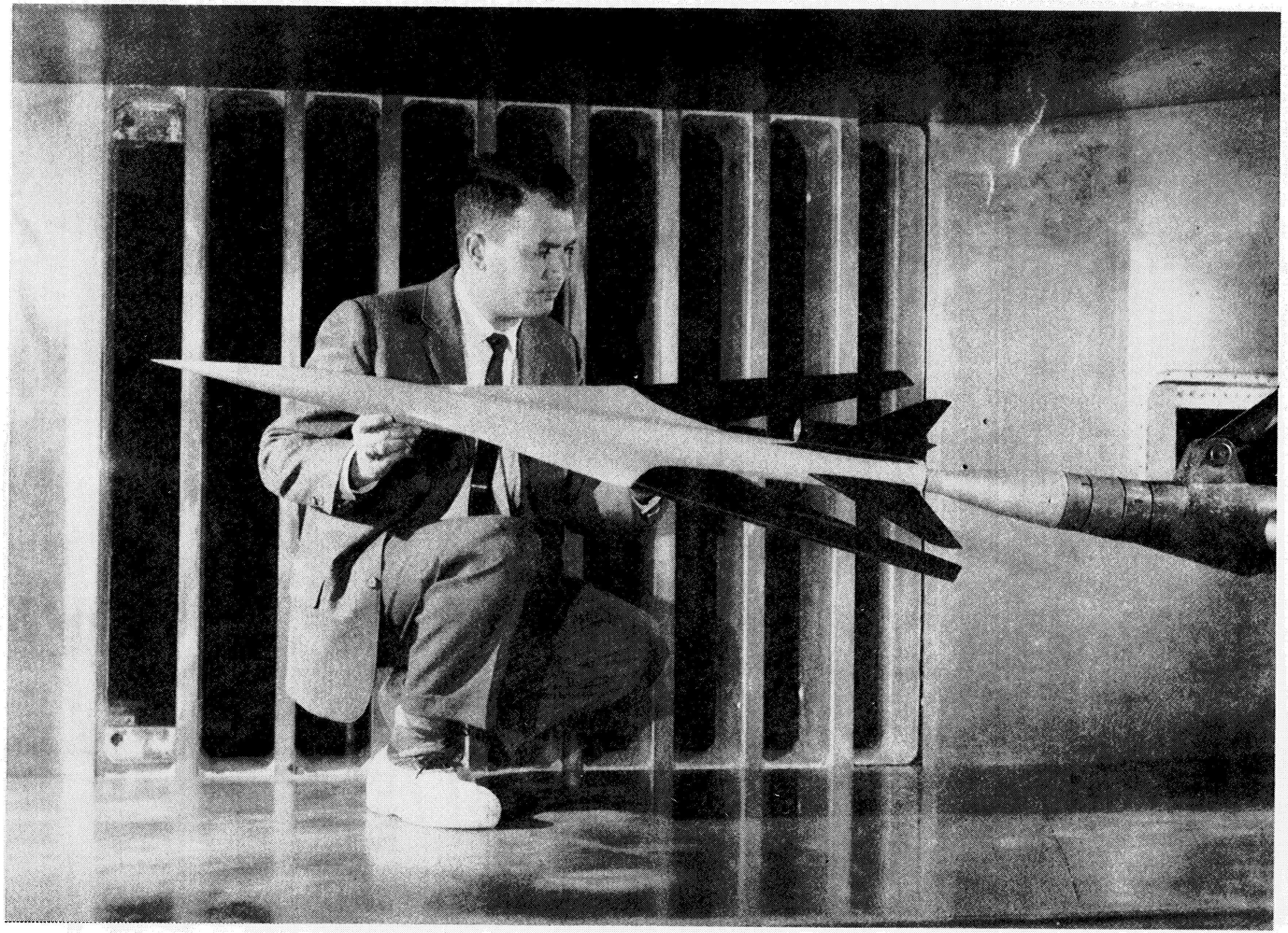

Figure 14.-SCAT 16 model in Langley Unitary Plan Wind Tunnel

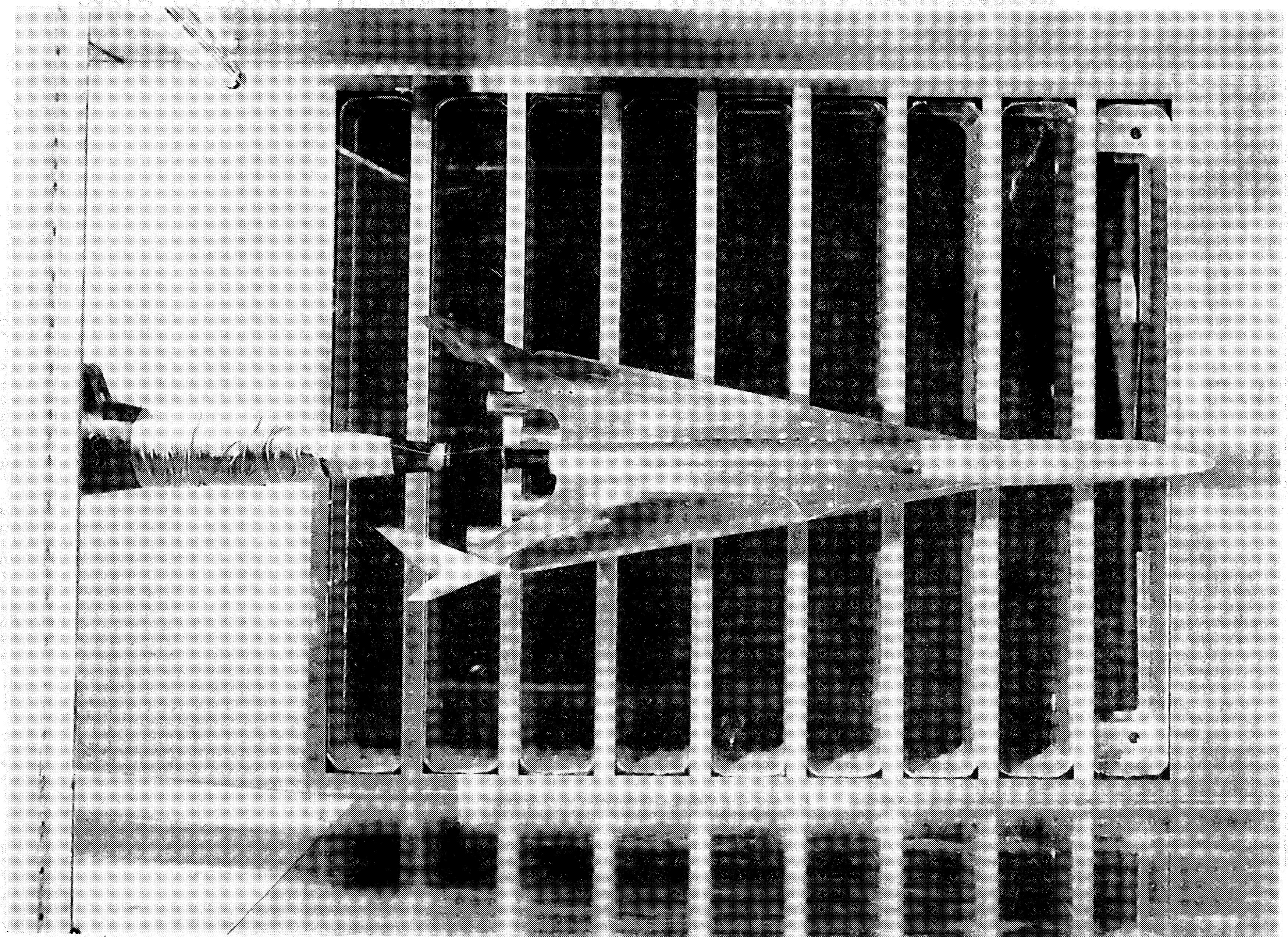

Figure 15.-SCAT 15 model in Langley Unitary Plan Wind Tunnel

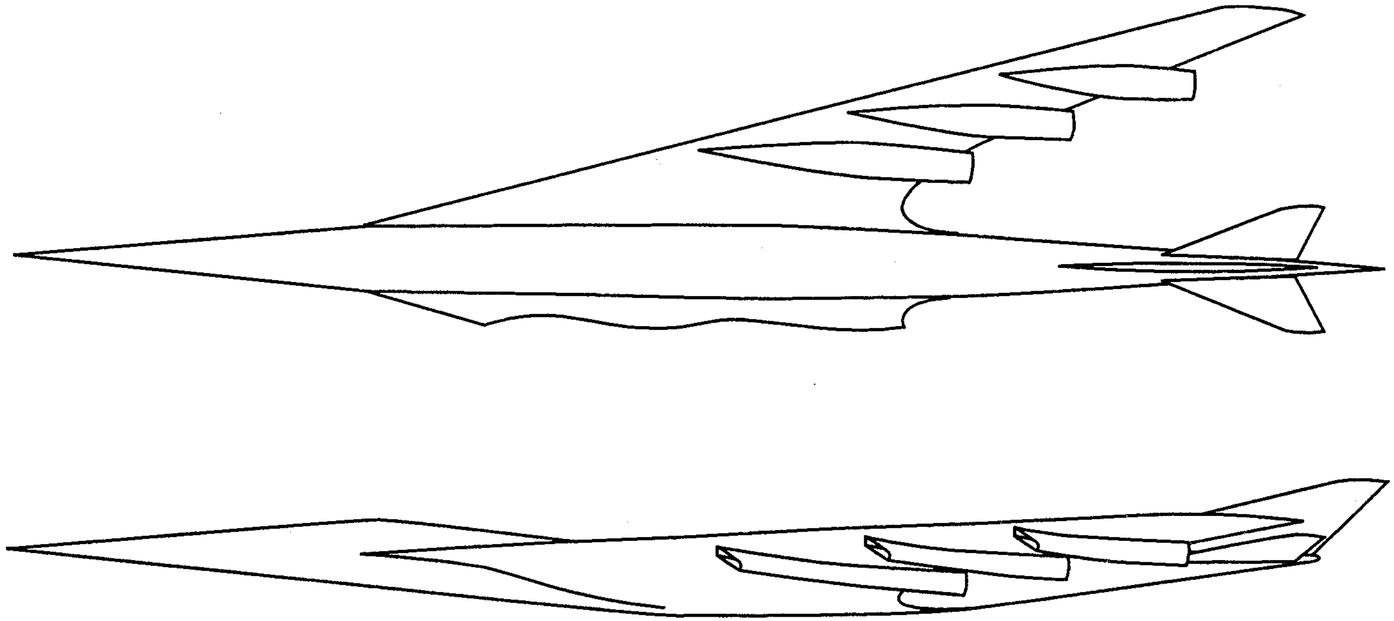

Figure 16. - SCAT 4.

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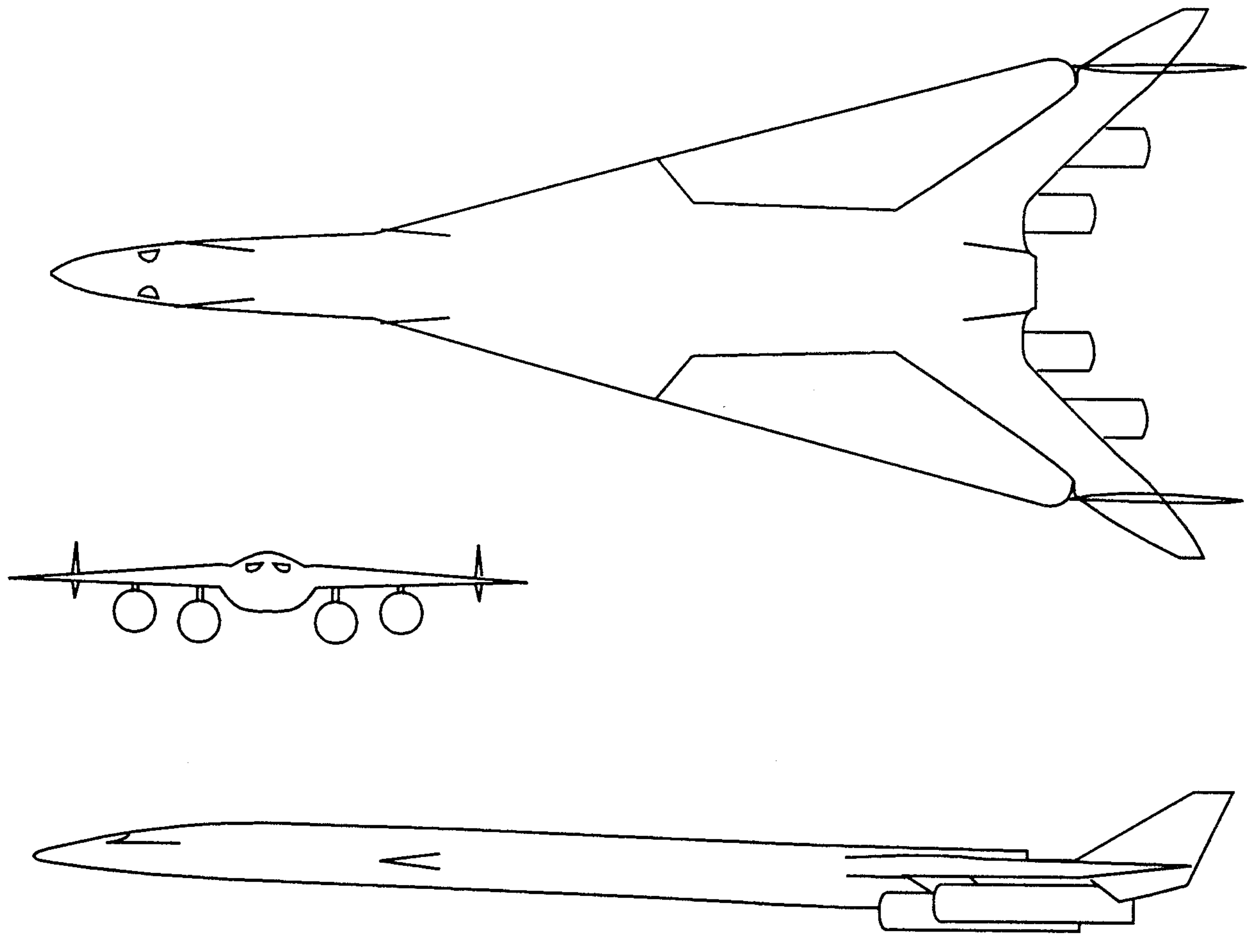

Figure 17. - SCAT 15-3.

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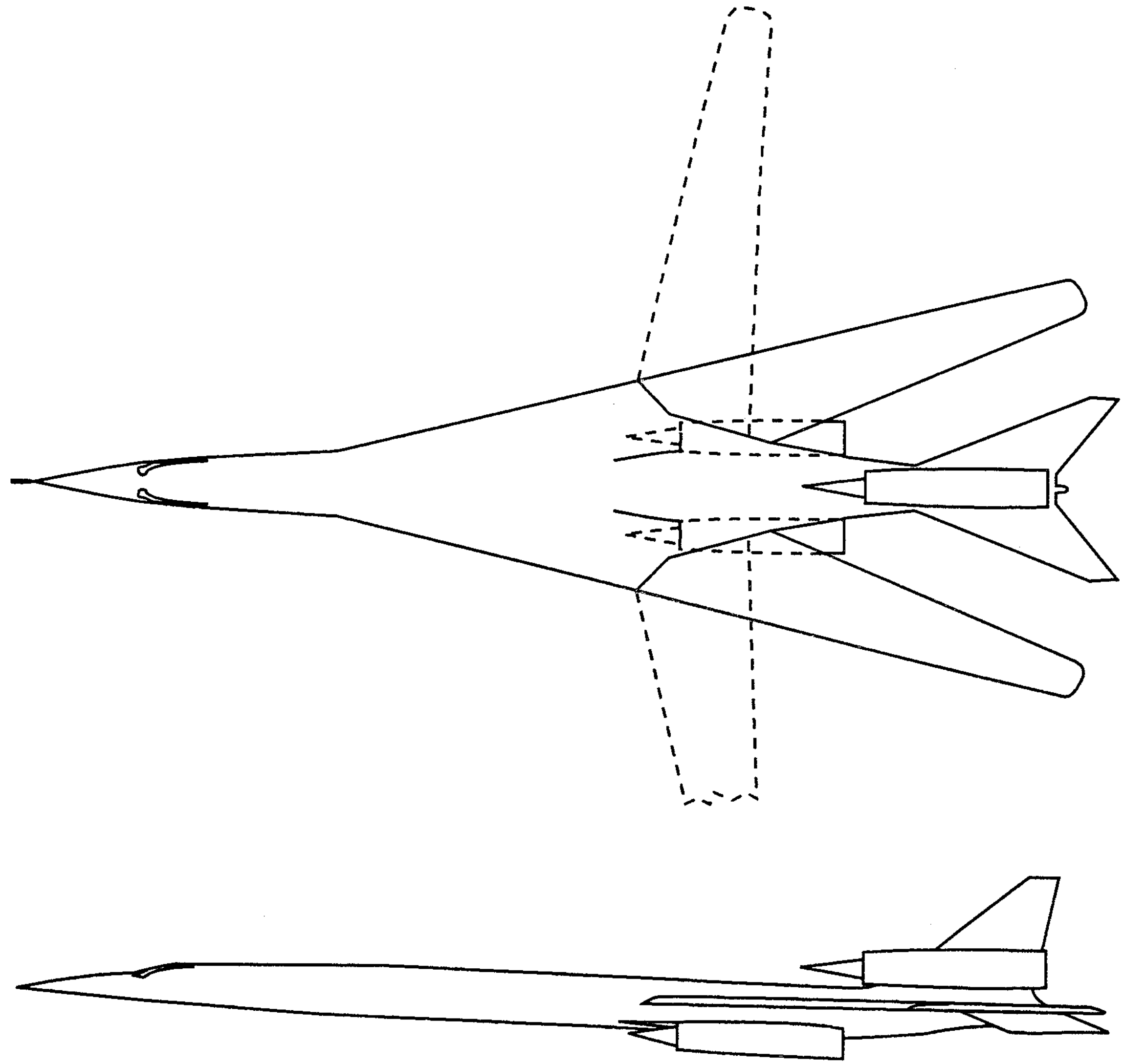

Figure 18 . - SCAT 16.

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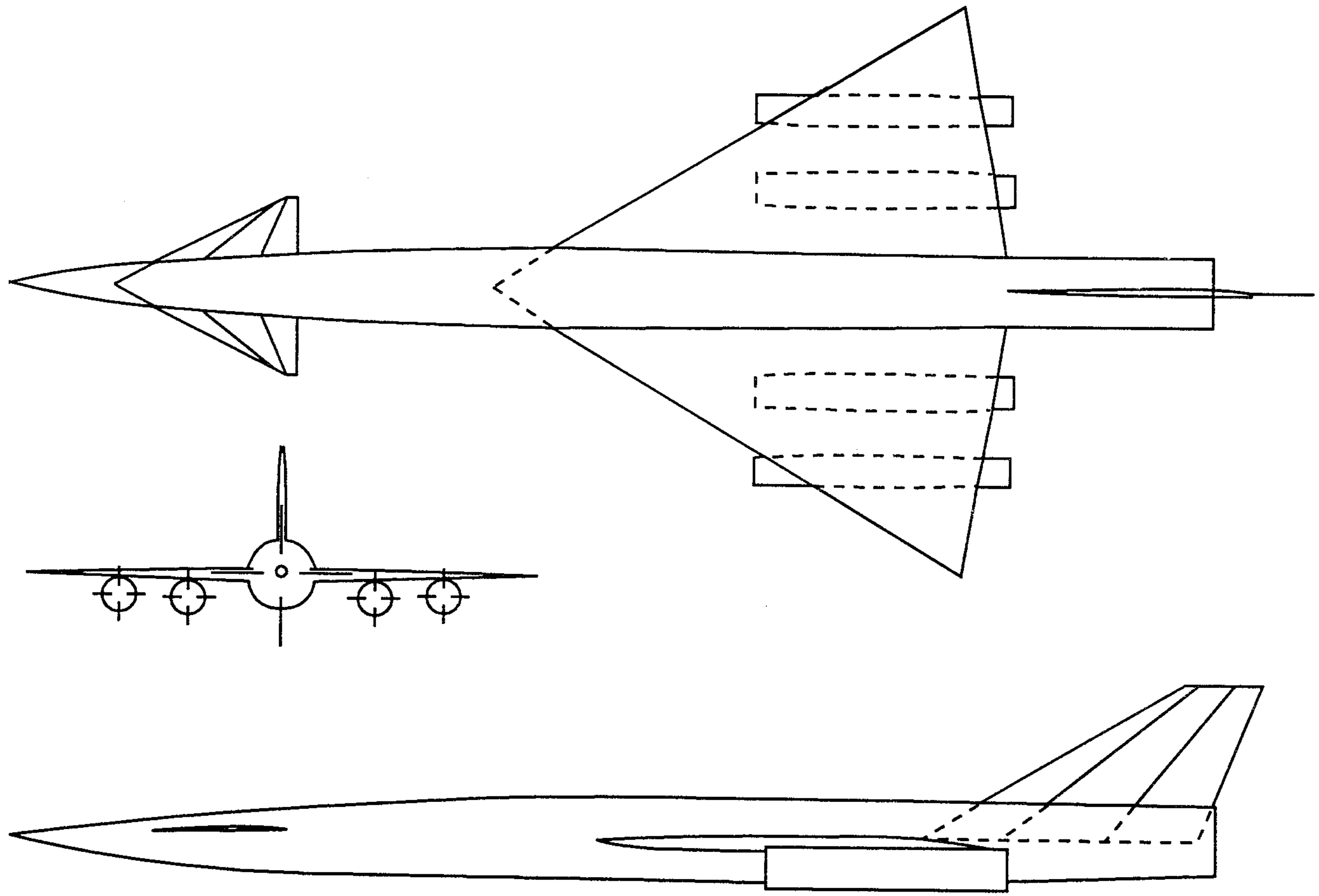

Figure 19. - SCAT 17

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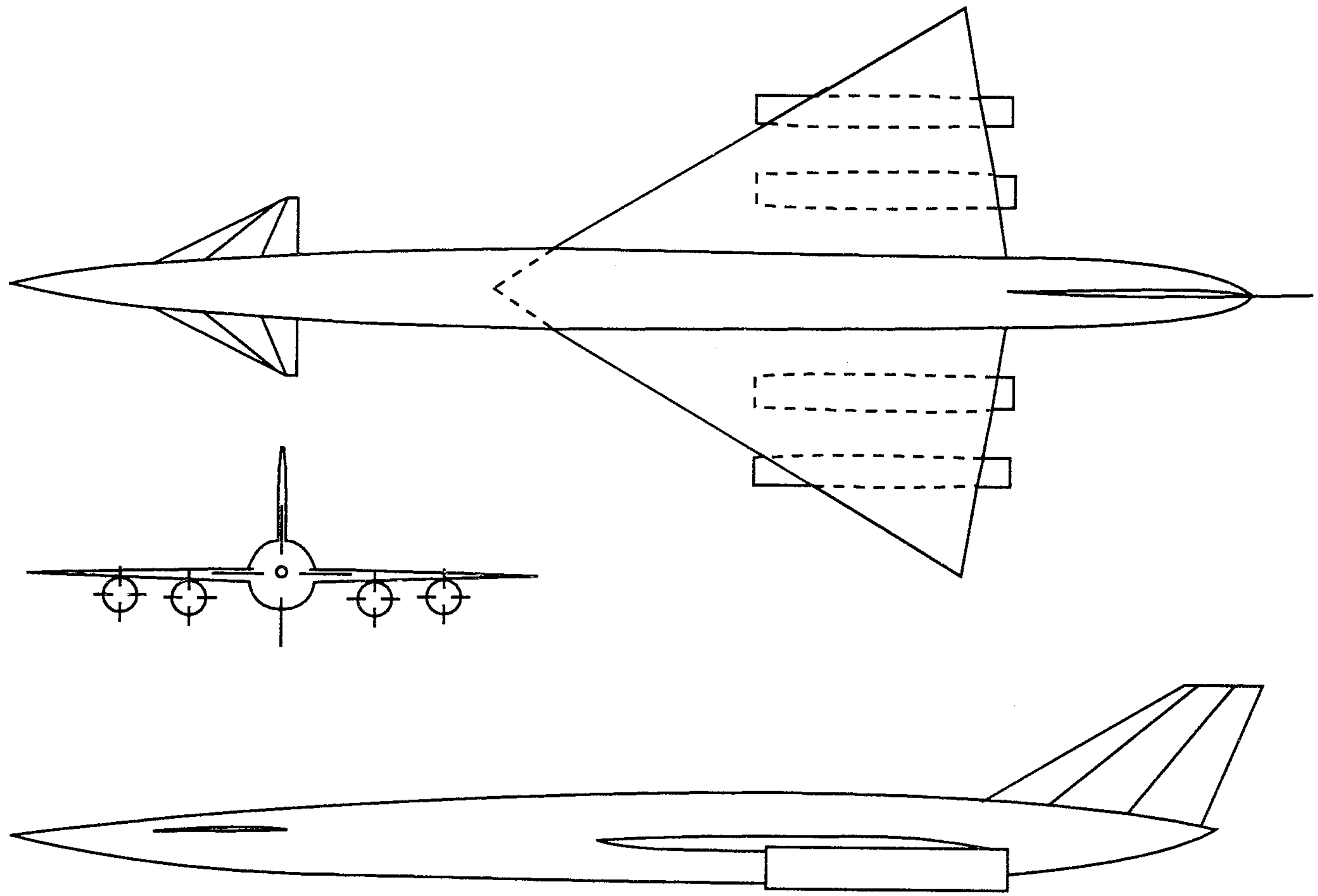

Figure 20 - Lockheed proposal-1964.

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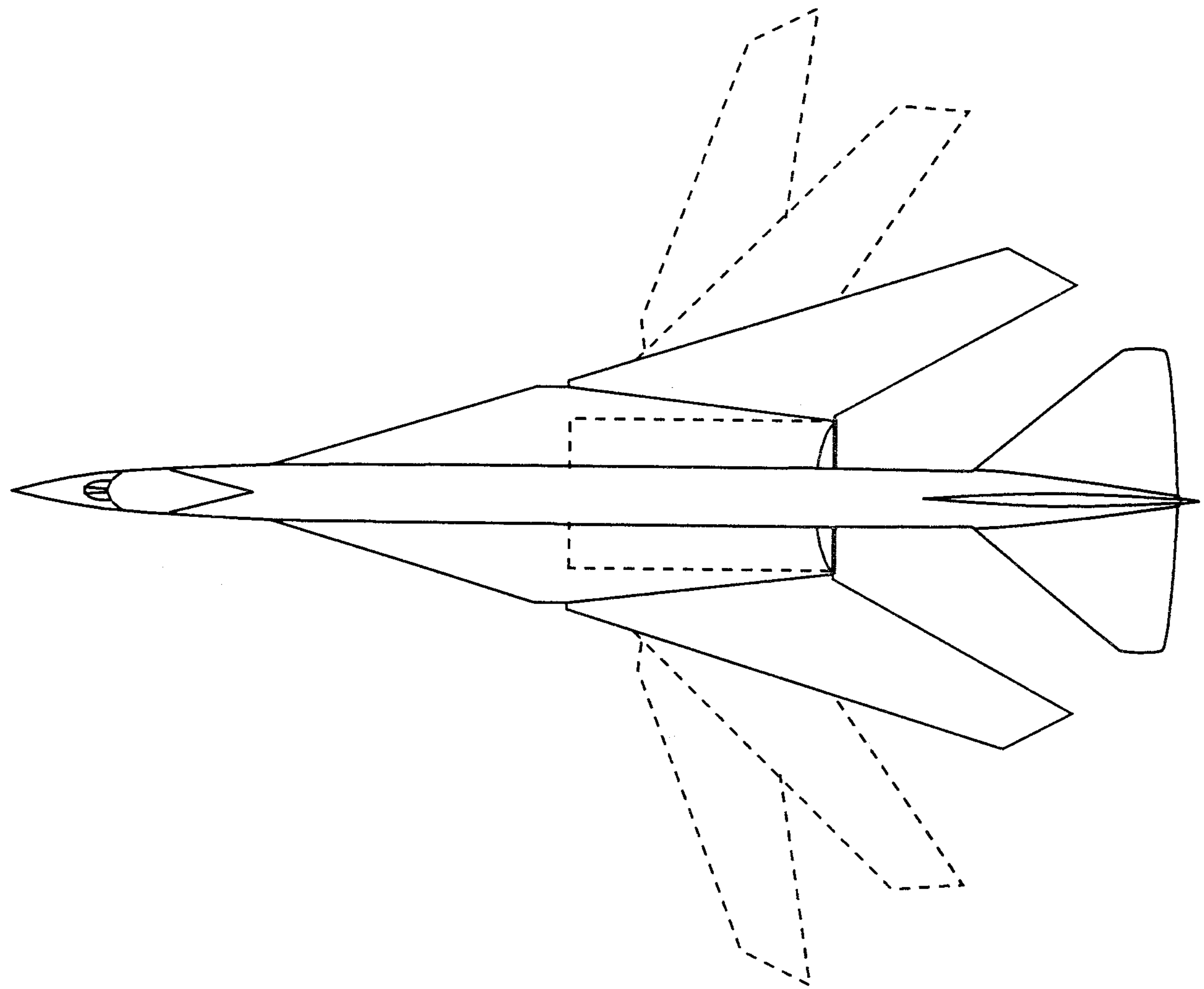

Figure 21. - Boeing proposal - 1964.

G2/41Boeing'64I93-925

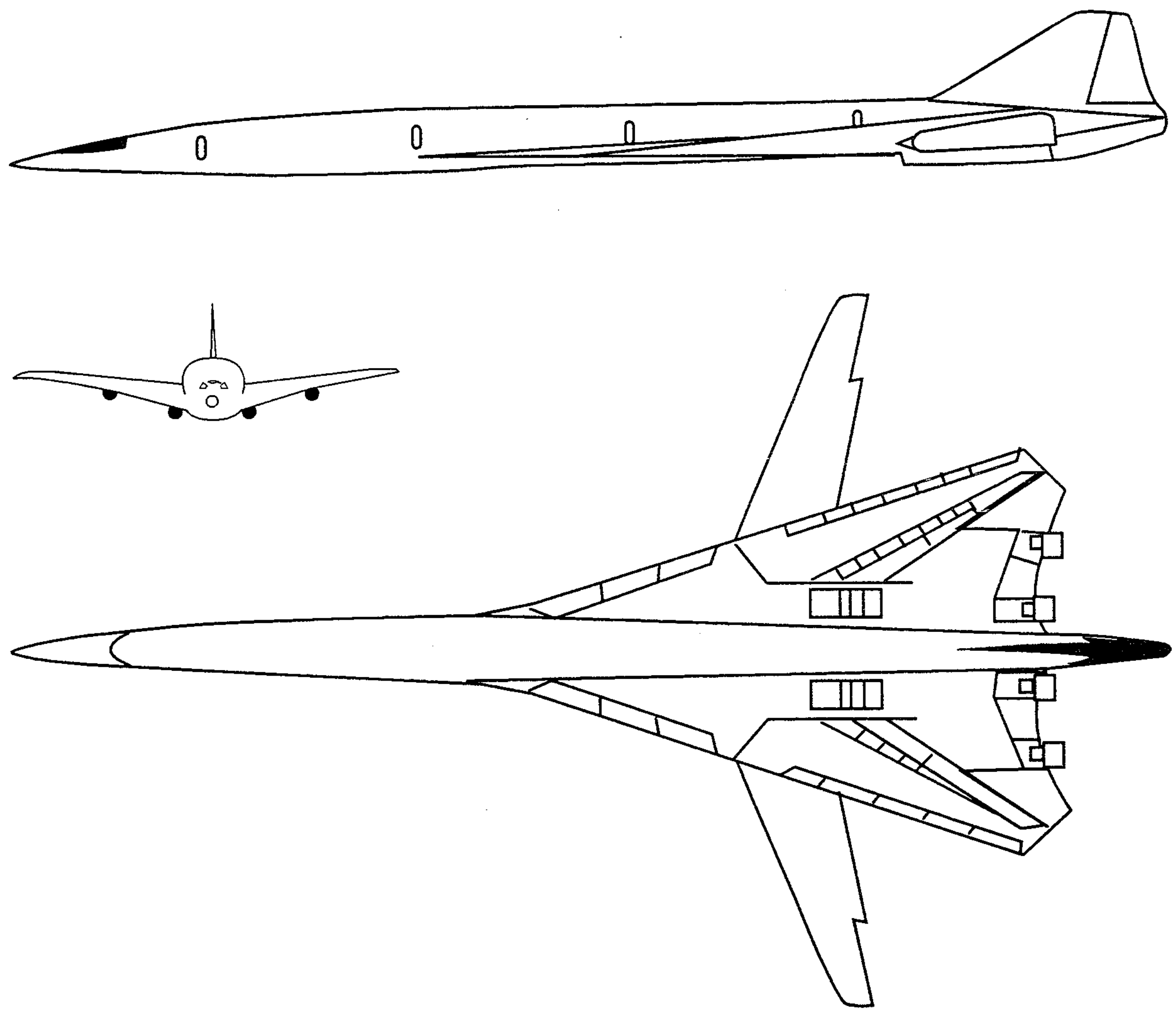

Figure 22.-Boeing 2707-200, 1966.

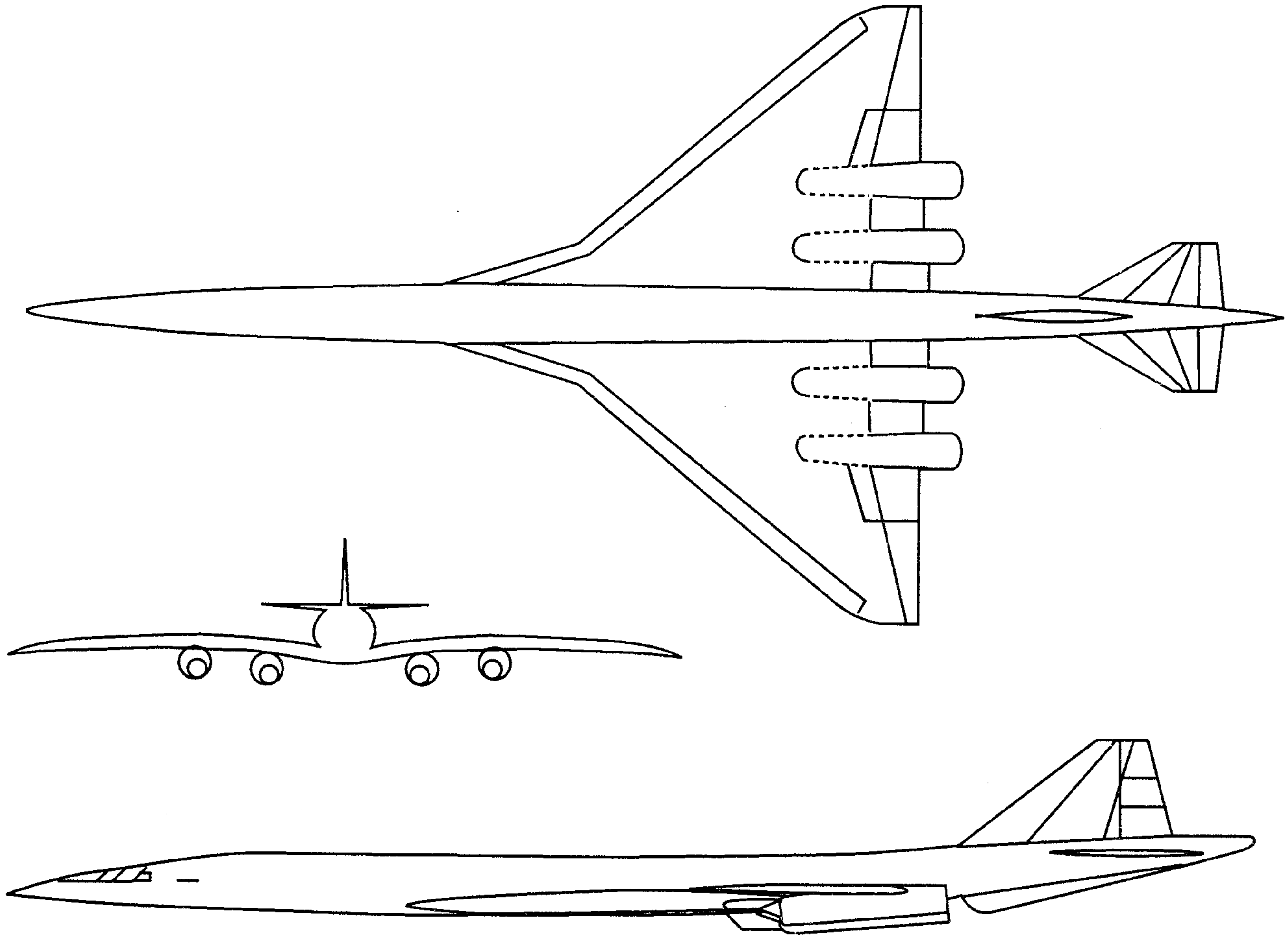

Figure 23.- Boeing 2707-300, 1971.

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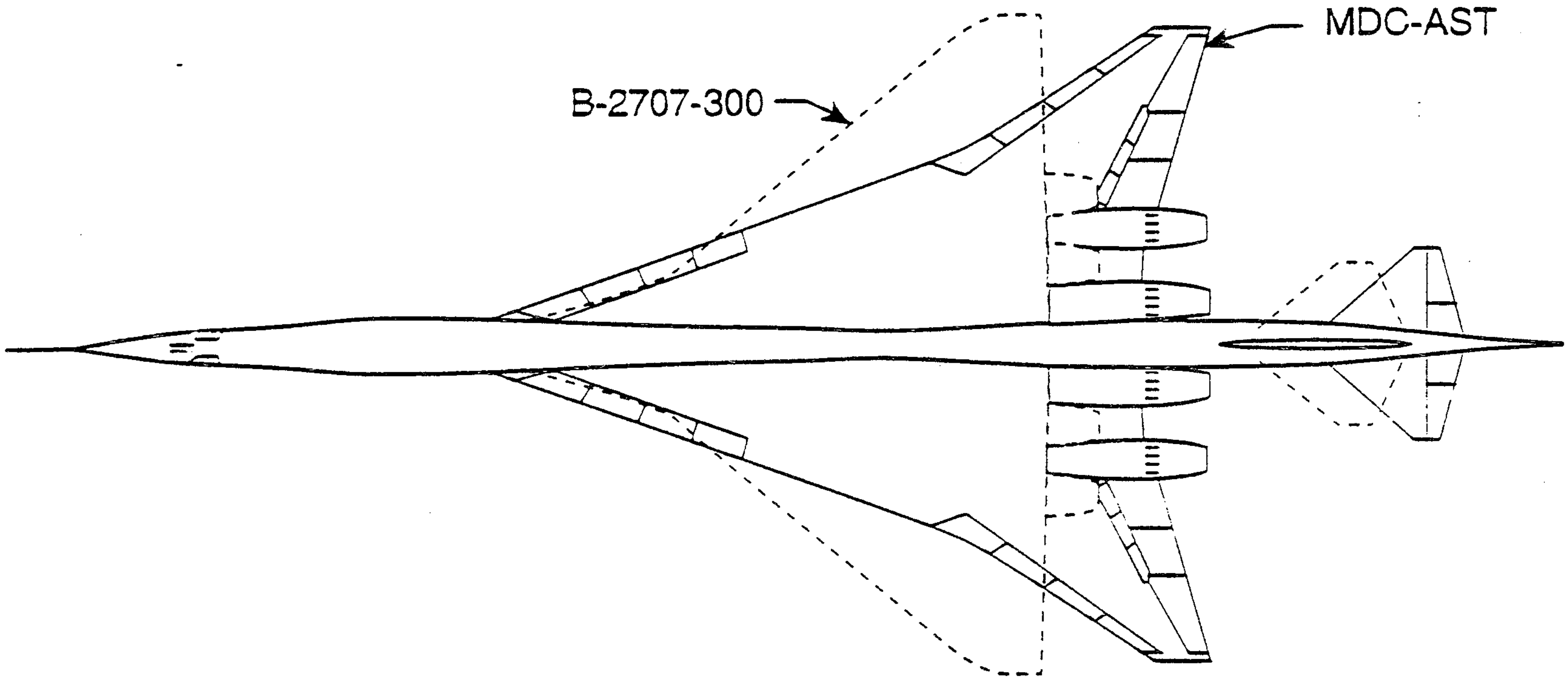

Figure 24.- McDonnell-Douglas AST compared to B-2707-300, 1975.

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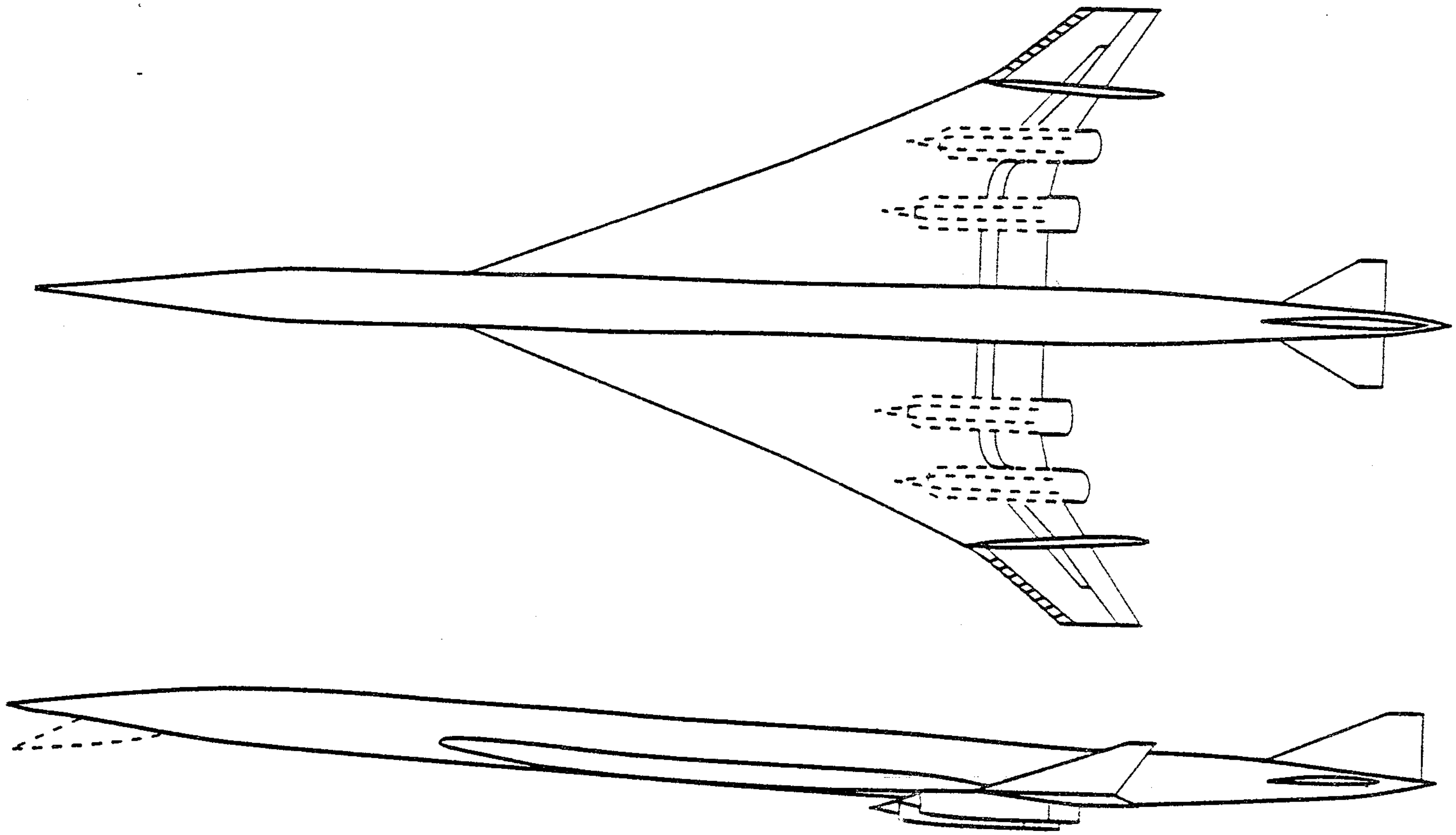

Figure 25.- Lockheed Mach 2.2 AST, 1975.

G2/35Lkhd2.2193-92

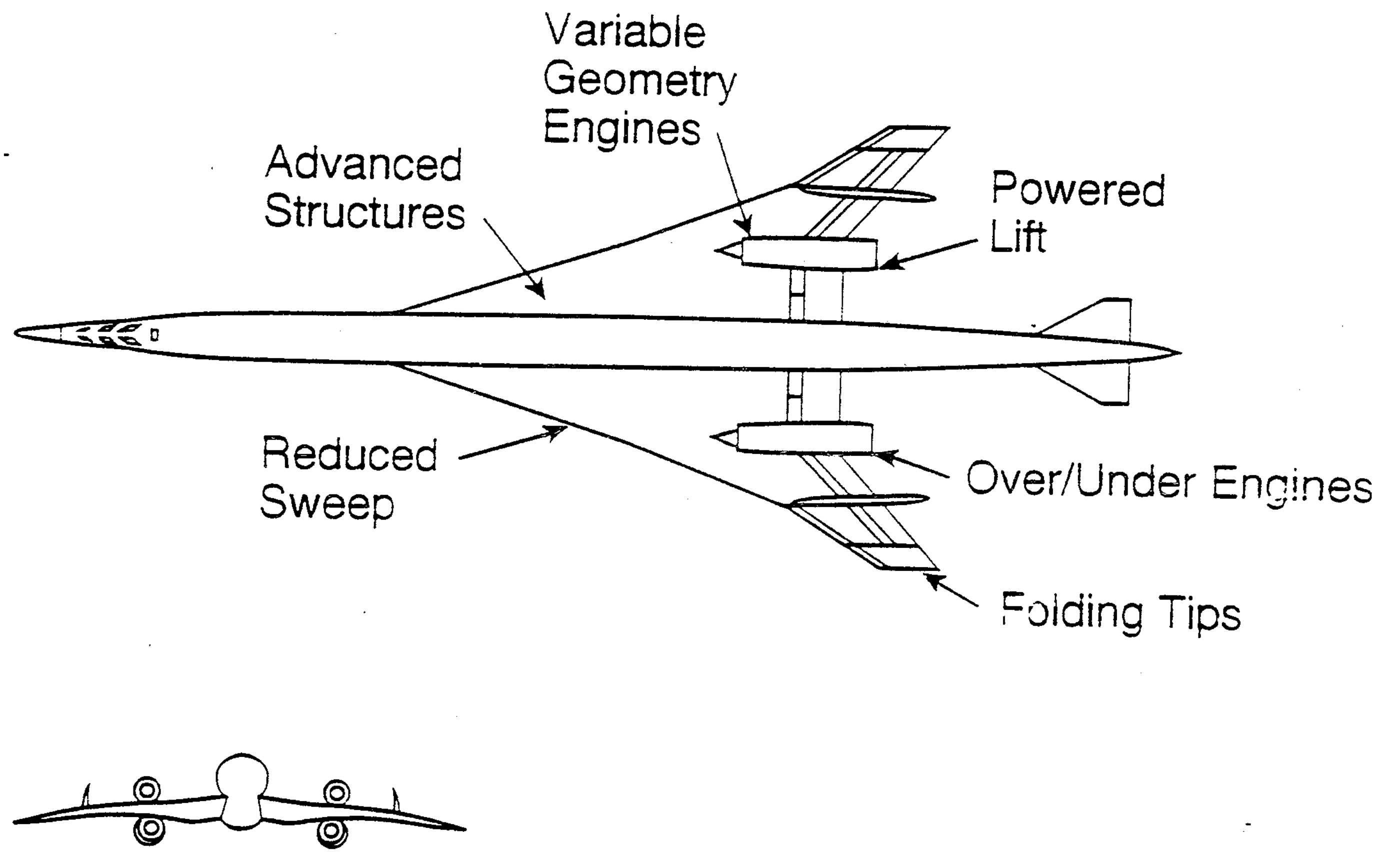

Figure 26.- Lockheed Mach 2.55 revised AST, 1975.

G2/36Lkhd2.55!9

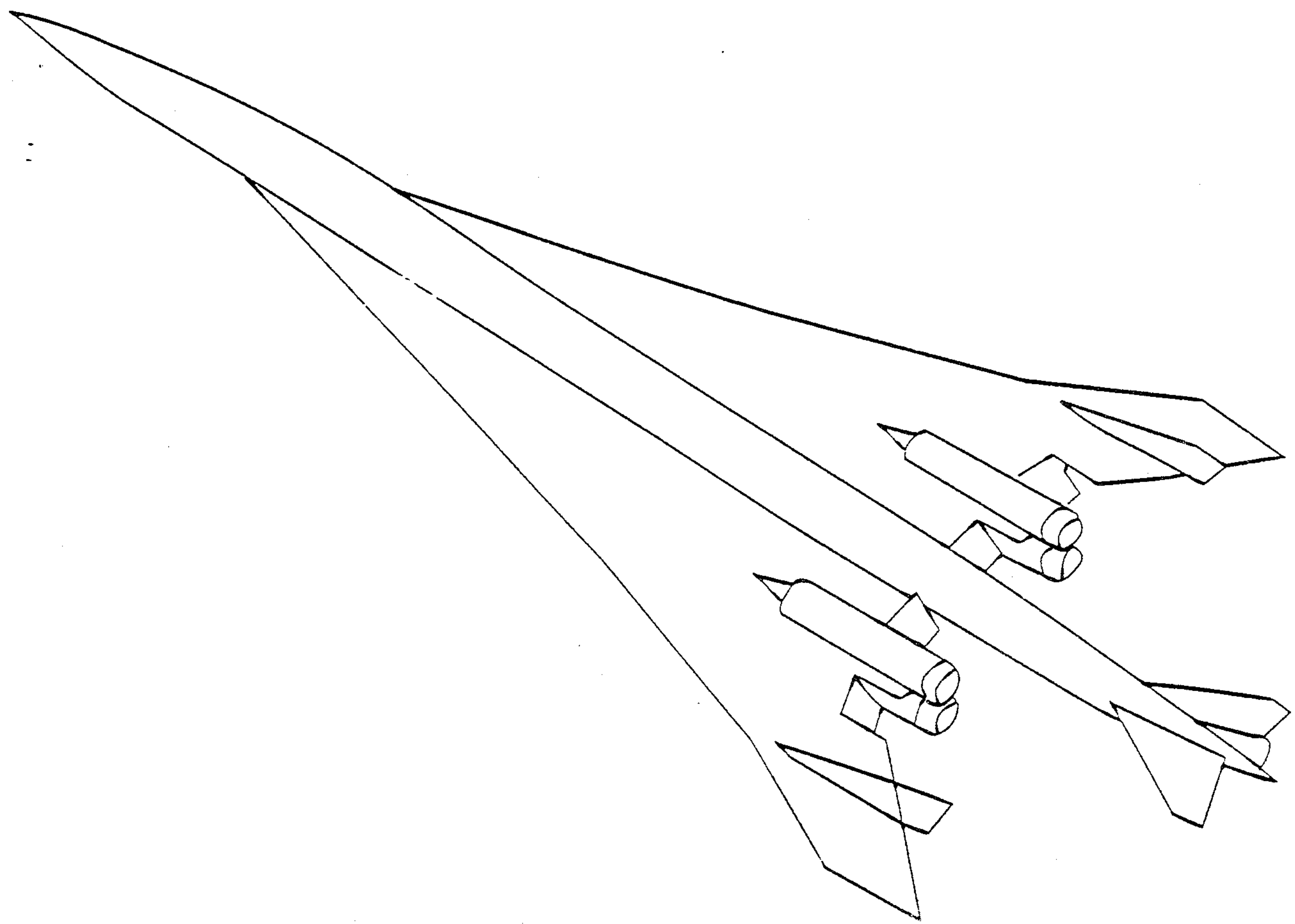

Figure 27.- Lockheed over/under arrangement, 1975.

G2/37LkndO/U193-9

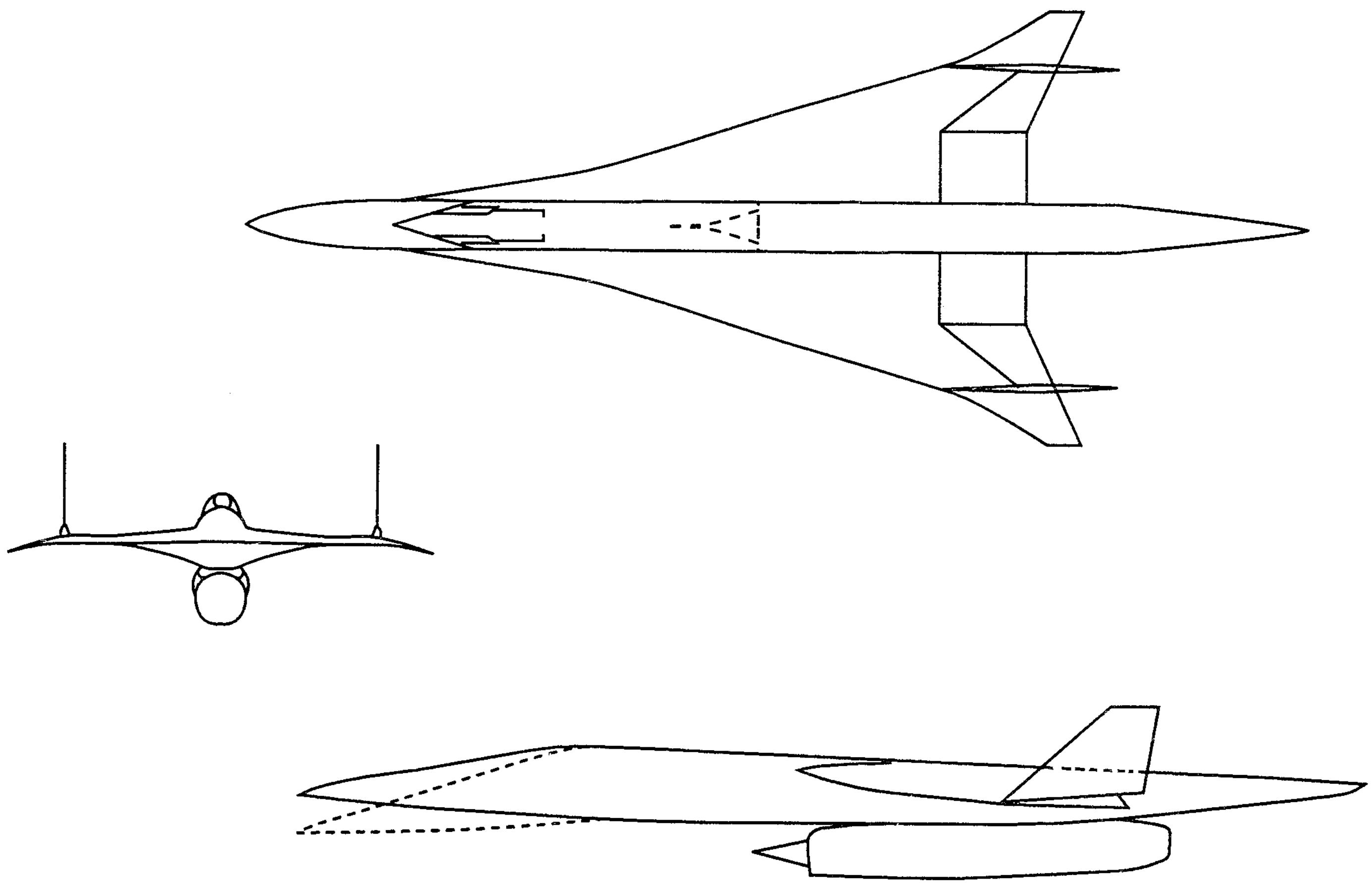

Figure 28.-A single-engined SCAR Demonstrator.

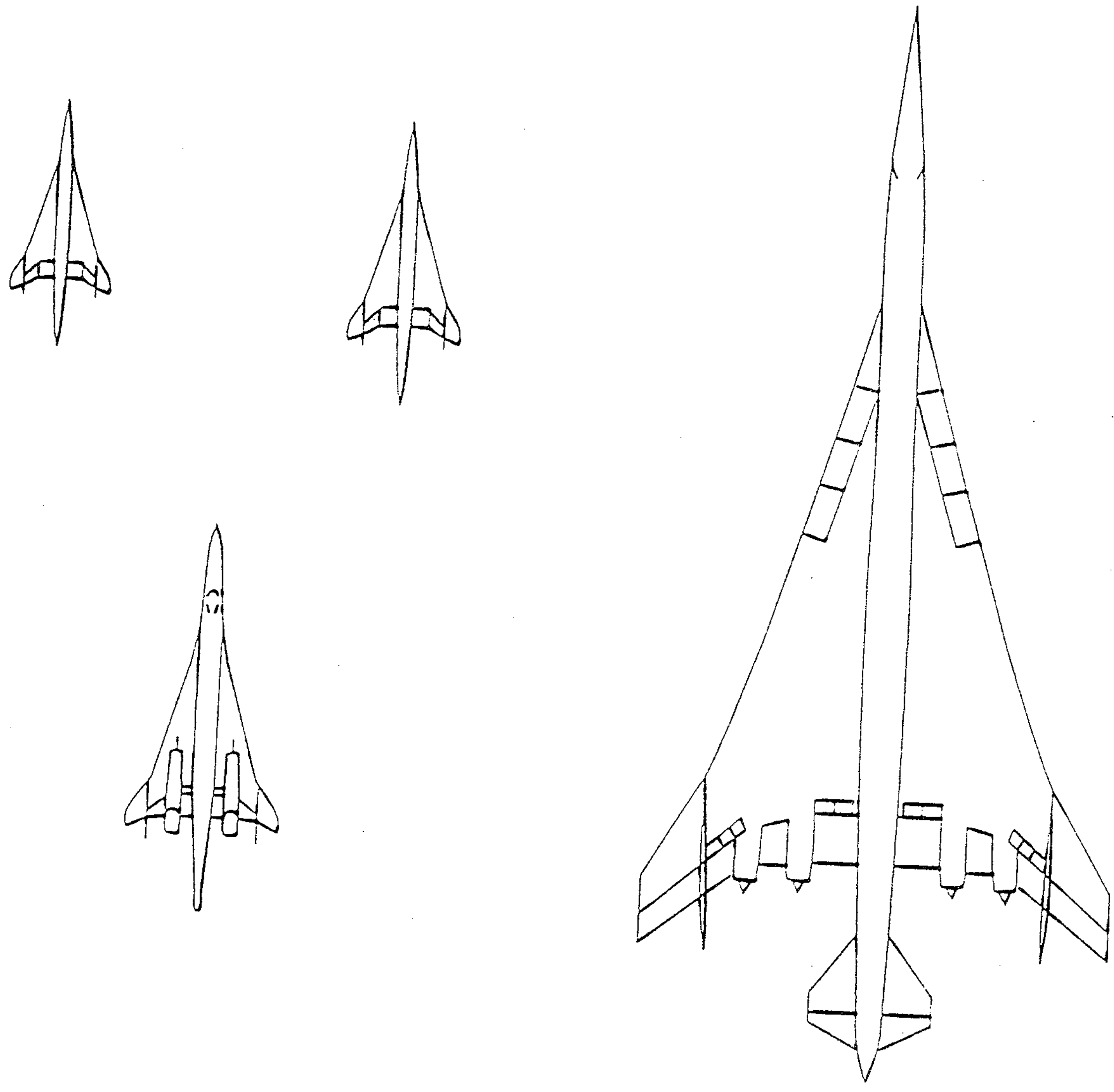

Figure 29.- SCAR demonstrators and an AST.

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Mid-1950's	Research applicable to the SST begun.
1959 -	SCAT program begun.
Nov.15,1959	FAA representatives visit NASA-LaRC for SST review.
Dec.11,1959	NASA-LaRC personnel brief FAA officials and staff.
Nov. 4,1960	NASA Hdqts. appoints Supersonic Transport Research Committee.
Nov. 1960	FAA recommends a national supersonic transport (SST) program.
June 26,1961	NASA-LaRC appoints Supersonic Transport Research Team.
June 28,1961	FAA recommends a national SST program under DoD, NASA and FAA.
June 1963	President Kennedy commits U.S. to SST development.
Aug. 1963	FAA Request for Proposal (RFP). Respondents were Boeing, Lockheed, North American,General Electric, Pratt & Whitney and Curtiss Wright.
Jan.1964-Oct.1966	Evaluations underway.
Dec.31,1966	FAA announces selection of Boeing / General Electric for U.S. SST.
March 1971	U.S. SST program cancelled by Congress.
1972-1982	NASA supersonic-cruise and variable-cycle engine research programs.
1982-85-87	Aeronautical R&D goals set by OSTP.

Figure 30.- The SST timeline.

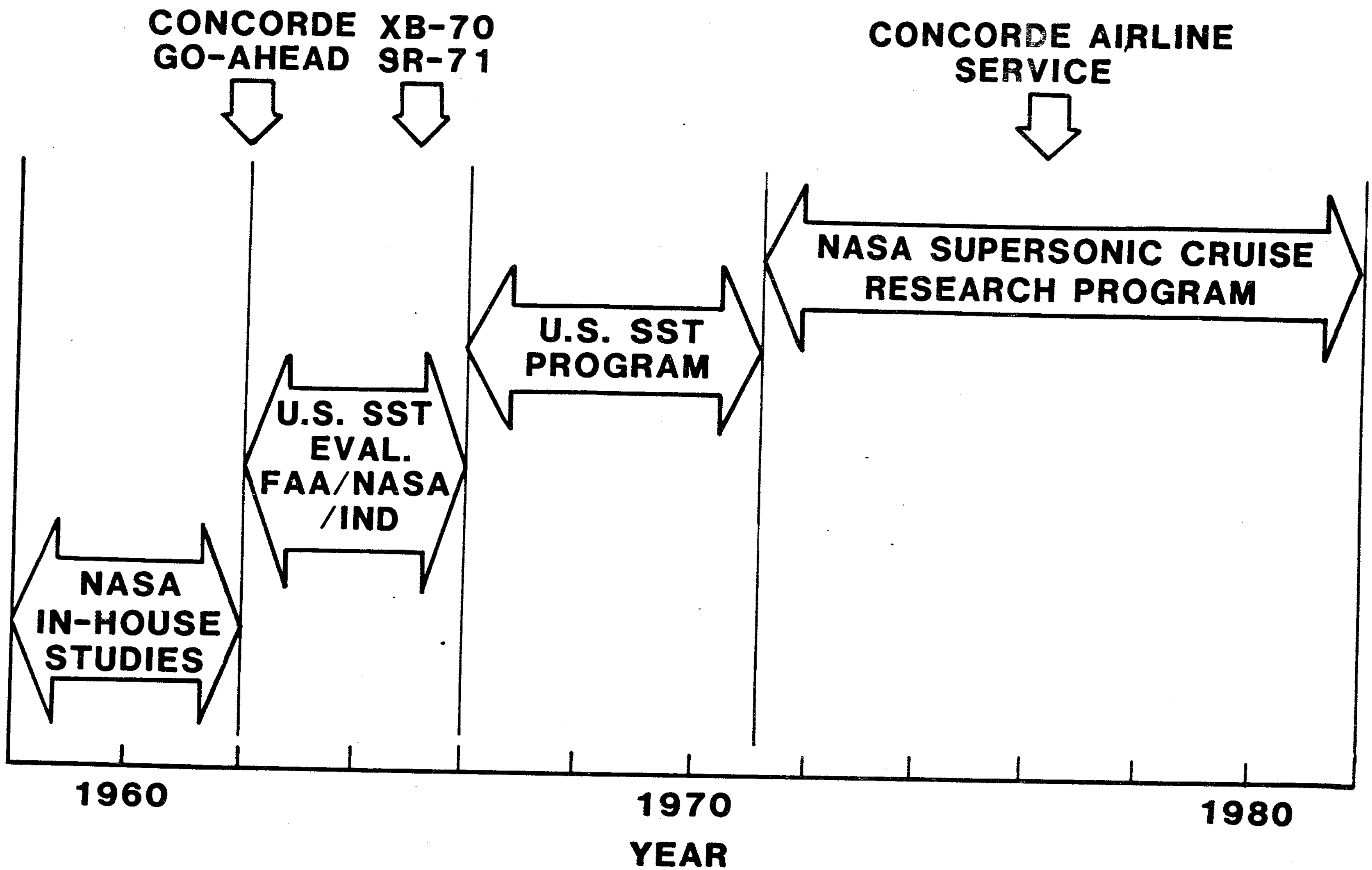

Figure 31. - Program timeframes for the U.S. SST effort.

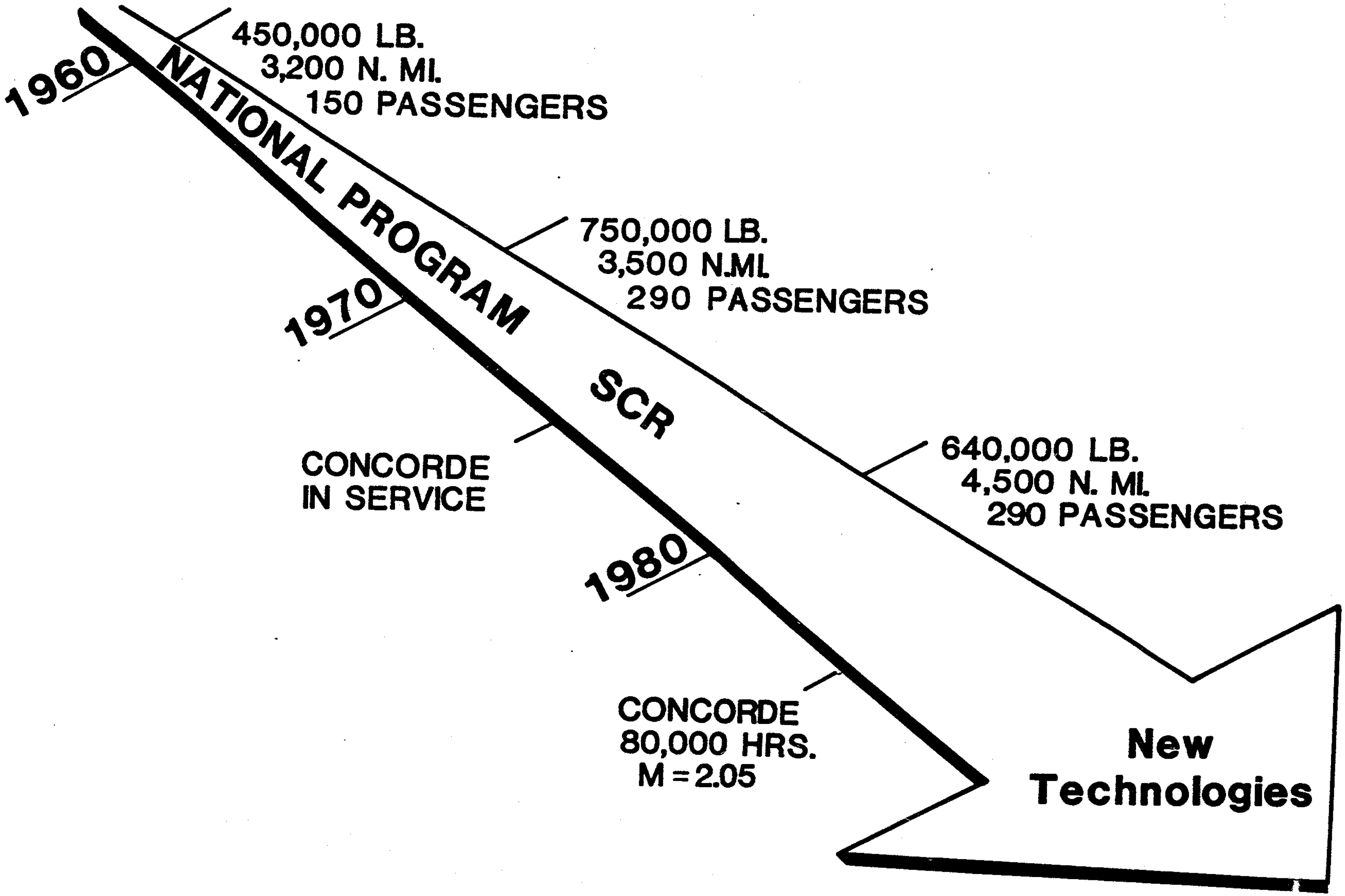

Figure 32. - A supersonic perspective leading to the HSCT.

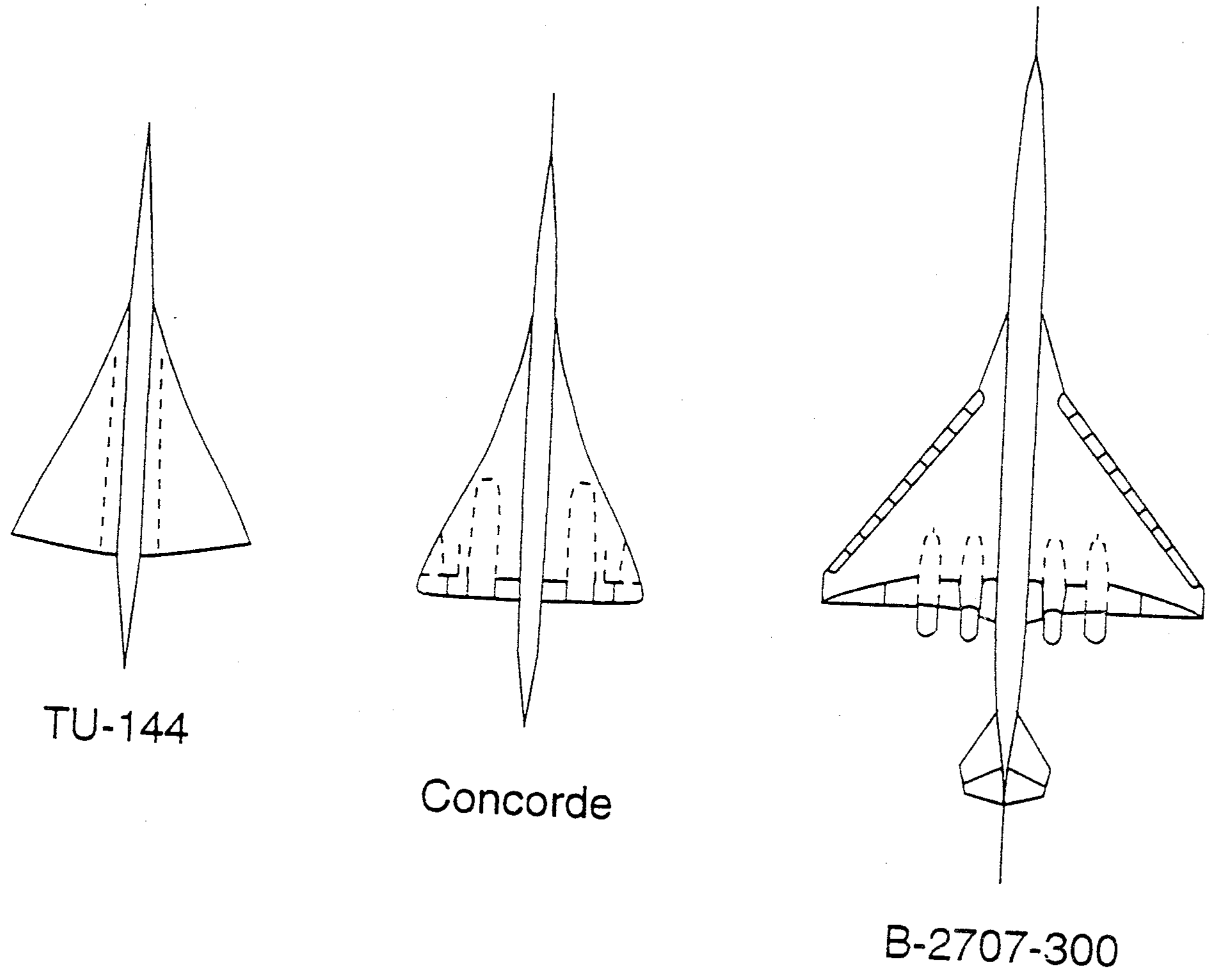

Figure 33.- The TU-144 and the Concorde compared to the B-2707-300.

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
February 1994

3. REPORT TYPE AND DATES COVERED
Technical Memorandum

4. TITLE AND SUBTITLE
The Evolution of the High-Speed Civil Transport

5. FUNDING NUMBERS
WU 505-69-20-01

6. AUTHOR(S)
M. Leroy Spearman

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
NASA Langley Research Center
Hampton, VA 23681-0001

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Aeronautics and Space Administration
Washington, DC 20546-0001

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
NASA TM-109089

11. SUPPLEMENTARY NOTES
Presented at the AIAA Aircraft Design, Systems and Operations Meeting
August 11-13, 1993, Monterey, CA

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Unclassified - Unlimited
Subject Category 99

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
Current research directed toward the technology requirements for a high-speed civil transport (HSCT) airplane is an outgrowth of many years of activity related to air transportation. It will be the purpose of this paper to review some of the events that have provided the background upon which current research programs are built. The review will include the subsonic era of transport aircraft and some events of the supersonic era that are related to the development of commercial supersonic transport aircraft. These events include the early NASA in-house studies and industry evaluations, the U.S. Supersonic Transport (SST) Program, the follow-on NASA supersonic cruise research programs and the issuance of the National Aeronautical Research and Development (R&D) goals. Observations will be made concerning some of the factors, both technical and nontechnical, that have had an impact on HSCT studies.

14. SUBJECT TERMS
Civil air transport
Commercial supersonic transport

15. NUMBER OF PAGES
47

16. PRICE CODE
A03

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	