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Supersonic Cruise Military Aircraft Research - An Annotated Bibliography

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Supersonic Cruise Military Aircraft Research - An Annotated Bibliography

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INTRODUCTION

During the 1970's, as a result of the NASA Supersonic Cruise Research (SCR) program, significant progress was made in the design of second-generation supersonic civil aircraft and in the development of the advanced technologies which are needed for such aircraft. This work, in turn, has sparked renewed interest in a supersonic cruise fighter/penetrator/interceptor airplane. This bibliography is addressed to those interested in such aircraft.

Two publications (items 32 and 62) which list work published, to date, under the SCR program are included. In addition, a publication (item 66) which summarizes many of the military aircraft contributions made by the NASA Langley Research Center is also provided.

The items selected for inclusion in this bibliography are arranged chronologically by dates of publication. An author index is included at the end of the listings.

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1 *Robins, A. Warner; *Morris, Odell A.; and *Harris, Roy V., Jr.: **Recent Research Results in the Aerodynamics of Supersonic Vehicles.** AIAA/RAeS/JSASS Design and Technology Meeting, Los Angeles, Calif., Nov. 15–18, 1965. AIAA Paper 65-717. Also: Journal of Aircraft, Vol. 3, No. 6, pp. 573–577, Nov.–Dec. 1966. (A67-12914#).

The continuing aerodynamic-research effort aimed at improving the design of supersonic-cruise vehicles has recently produced some significant results. Research by both government and industry has provided, in addition to a better understanding of the design problem itself, some new and very useful design tools and concepts. Some of the advantages of these methods in the treatment of wave drag and drag due to lift are briefly discussed. Also presented are some new considerations of aerodynamic interference and its effect on the aerodynamic efficiency of the trimmed vehicle. An illustrative example of the application of these design tools and concepts to the aerodynamic design of a supersonic-cruise vehicle (SCAT 15-F) is made. A parallel analytic and experimental buildup of the vehicle is presented, including treatment of the symmetric (flat camber-plane), the warped, and the warped-and-reflexed versions of the configuration. The potential of the new techniques is demonstrated by the good agreement between experiment and theory and by the high level of vehicle performance. (Fighter-type to transport vehicles are studied in this paper.)

*NASA, Langley Research Center, Hampton, VA 23665

2 *Redin, P. C.; and *Schweikhard, W. G.: **Altimetry, Performance, and Propulsion Problems of High Altitude Supersonic Cruise Aircraft.** In: "NASA Aircraft Safety and Operating Problems," Vol. 2, 1971, X71-10673, pp. 7–24. Available to U.S. Gov't. Agencies and their Contractors Only. Unclassified document. (X71-10675#).

*NASA, Dryden Flight Research Center, Edwards, CA 93523

3 *Berry, D. T.: **Some Handling Qualities Problems of High Altitude Supersonic Cruise Aircraft.** In: "NASA Aircraft Safety and Operating Problems," Vol. 2, 1971, X71-10673, pp. 25–38. Unclassified document. Available to U.S. Gov't. Agencies and their Contractors Only. (X71-10676#).

*NASA, Dryden Flight Research Center, Edwards, CA 93523

4 *Matranga, G. J.: **Materials, Systems, and Maintenance Problems of High Altitude Supersonic Cruise Aircraft.** In: "NASA Aircraft Safety and Operating Problems," Vol. 2, 1971, X71-10673, pp. 39–48. Unclassified document. Available to U.S. Gov't. Agencies and their Contractors Only. (X71-10677#).

*NASA, Dryden Flight Research Center, Edwards, CA 93523

5 *Newsom, William A., Jr.; and *Grafton, Sue B.: **Free-Flight Investigation of a 1/17-Scale Model of the B-1 Airplane at High Angles of Attack. (U). NASA TM SX-2744, April 1973. CONFIDENTIAL document.**

*NASA-Langley Research Center, Hampton, VA 23665

6 *Berry, D. T.; and *Gilyard, G. B.: **Some Stability and Control Aspects of Airframe/Propulsion System Interactions on the YF-12 Airplane.** ASME, Winter Annual Meeting, Detroit, Mich., Nov. 11–15, 1973. ASME Paper 73-WA/AERO-4, 7 pp. (A74-13246#).

Airframe/propulsion system interactions can strongly affect the stability and control of supersonic cruise aircraft. These interactions generate forces and moments similar in magnitude to those produced by the aerodynamic controls, and can cause significant changes in vehicle damping and static stability. This in turn can lead to large aircraft excursions or high pilot workload, or both. For optimum integration of an airframe and its jet propulsion system, these phenomena may have to be taken into account.

*NASA, Dryden Flight Research Center, Edwards, CA 93523

7 *Dahlem, Valentine, III; *Johnson, David T.; and *Wilbanks, Hugh, III: **Experimental and Analytical Study of Two Advanced Manned Interceptor Configurations from Mach 0.2 to 6.0. (U). Final Report, Sept. 1971–Mar. 1973.** Rep. No. AFFDL-TR-74-14, April 1974, 192 pp. CONFIDENTIAL document. Available to U.S. Gov't. Agencies Only. (AD-530785L). (X74-77577#).

*Air Force Flight Dynamics Lab (FXG), Wright-Patterson AFB, OH 45433

Contract No. AF Proj. 1366

8 *Schweikhard, W. G.; and *Berry, D. T.: **Cooperative Airframe/Propulsion Control for Supersonic Cruise Aircraft.** SAE, Air Transportation Meeting, Dallas, Texas, Apr. 30–May 2, 1974. SAE Paper 740478, April 1974, 8 pp. (A74-34998).

Interactions between propulsion systems and flight controls have emerged as a major control problem on supersonic cruise aircraft. This paper describes the nature and causes of these interactions and the approaches to predicting and solving the problem. Integration of propulsion and flight control systems appears to be the most promising solution if the interaction effects can be adequately predicted early in the vehicle design. Significant performance, stability, and control improvements may be realized from a cooperative control system.

*NASA-Dryden Flight Research Center, Edwards, CA 93523

9 *Berry, D. T.; and *Schweikhard, W. G.: **Potential Benefits of Propulsion and Flight Control Integration for Supersonic Cruise Vehicles.** In: "Advanced Control Technology, and its Potential for Future Transport Aircraft," July 1974, 20 pp., X74-10214. Unclassified document. Available to U.S. Gov't. Agencies and their Contractors Only. (X74-10231).

*NASA, Dryden Flight Research Center, Edwards, CA 93523

10 *Dollyhigh, Samuel M.: **Subsonic and Supersonic Longitudinal Stability and Control Characteristics of an Aft Tail Fighter Configuration with Cambered and Uncambered**

Wings and Uncambered Fuselage. NASA-TM-X-3078, Aug. 1974, 96 pp. (N74-31419, Available NTIS).

An investigation has been made in the Mach number range from 0.20 to 2.16 to determine the longitudinal aerodynamic characteristics of a fighter airplane concept. The configuration concept employs a single fixed geometry inlet, a 50° leading-edge-angle clipped-arrow wing, a single large vertical tail, and low horizontal tails. The wing camber surface was optimized in drag due to lift and was designed to be self-trimming at Mach 1.40 and at a lift coefficient of 0.20. An uncambered or flat wing of the same planform and thickness ratio was also tested. However, for the present investigation, the fuselage was not cambered. Further tests should be made on a cambered fuselage version, which attempts to preserve the optimum wing loading on that part of the theoretical wing enclosed by the fuselage.

*NASA, Langley Research Center, Hampton, VA 23665

11 *Hill, G. C.; and *Waters, M. H.: **Conceptual Design of a Lift Fan Plus Lift/Cruise Fighter Aircraft.** AIAA Aircraft Design, Flight Test and Operations Meeting, 6th, Los Angeles, Calif., Aug. 12–14, 1974. AIAA Paper 74-969, 8 pp. (A74-38734#).

Results of a design synthesis and mission analysis of a supersonic VTOL fighter aircraft are presented. Propulsive lift is provided by a single turbotip-driven lift fan and deflected thrust from a high performance turbofan cruise engine fitted with an afterburner for supersonic flight. The inlet and thrust diverter in the main engine tail-pipe are seen to be the principal design problems. V/STOL and supersonic design tradeoffs are addressed in lift fan sizing and placement, reaction, and aerodynamic control sizing, fuselage volume requirements, and area ruling. Range and turn rate are used as figures of merit.

*NASA—Ames Research Center, Moffett Field, CA 94035

12 Lockheed's Lone Ranger—Reconnoitring at Mach 3—SR-71/YF-12 Production. Air International, Vol. 7, Oct. 1974, pp. 159–166, 203. (A75-21018).

A description is given of the program that produced the SR-71 and its forerunner, the YF-12, in response to performance requirements involving sustained supersonic cruise faster than Mach 3.0 and a sustained altitude capability above 24,400 m. Questions of aerodynamic and thermodynamic design are considered along with details regarding the turbo-ramjet powerplants. Attention is given to flight procedures and the use of the aircraft in NASA studies.

13 *Child, R. D.: **Design and Analysis of a Supersonic Penetration Maneuvering Fighter.** NASA-CR-132633, Apr. 1975, 182 pp. (N75-23558#, Available NTIS).

The design of three candidate air combat fighters which would cruise effectively at freestream Mach numbers of 1.6, 2.0, and 2.5 while maintaining good transonic maneuvering capability, is considered. These fighters were designed to deliver aerodynamically controlled dogfight missiles at the design Mach numbers. Studies performed by Rockwell International in May 1974 and guidance from NASA determined the shape and size of these missiles. The principal objective of this study is the aerodynamic design of the vehicles; however, configurations are sized to have realistic structures, mass properties, and propulsion systems. The results of this study show that air combat fighters in the 15,000 to 23,000 pound class would cruise supersonically on dry power and still maintain good transonic maneuvering performance.

*Rockwell International Corp., Los Angeles, CA
Contract No. NAS1-13496

14 *Krebs, J. N.: **Advanced Supersonic Technology Study: Engine Program Summary. Supersonic Propulsion: 1971–1976**, 1976, 18 pp. In NASA Proc. of the SCAR Conference Part I, pp. 353–370 of N77-17996. (N77-18013#, Available NTIS).

Sustained supersonic cruise propulsion systems for military applications are studied. The J79-5 in the Mach 2 B-58: YJ93 in the Mach 3.0 B-70 and the current F101 in the B-1, are all examples of military propulsion systems and airplanes operated at sustained supersonic cruise speeds. The Mach 2.7 B2707 transport powered by GE4 turbojet engines was the only non-military, sustained supersonic cruise vehicle intended for commercial passenger service.

*General Electric Co., Philadelphia, PA

15 *Campbell, James F.; *Gloss, Blair B.; and *Lamar, John E.: **Vortex Maneuver Lift for Super-Cruise Configurations.** NASA-TM-X-72836, Feb. 1976, 23 pp. (N76-21161#, Available NTIS). (This was also presented as a paper in Design Conference Proceedings—Technology for Supersonic Cruise Military Aircraft, Vol. I, AFFDL TR-77-85, U.S. Air Force, Feb. 1976. See No. 16-j in this bibliography).

Research is being conducted to determine the vortex maneuver-lift characteristics for high performance fighter aircraft. The generation of vortex lift for maneuver of super-cruise aircraft may be particularly important if this supersonic aircraft is to have maneuver performance similar to current subsonic-transonic fighters. This paper reviews some of the theoretical and experimental research conducted at the NASA Langley Research Center to investigate the subsonic vortex-lift producing capabilities for two classes of Super-Cruise designs: a close-coupled wing-canard arrangement and a slender wing configuration. In addition, several analytical methods are discussed for estimating critical structural design loads for thin, highly swept wings having separated leading-edge vortex flows.

*NASA, Langley Research Center, Hampton, VA 23665

16 *Riccioni, E. E.; and *Draper, A. C. (Conference Chairmen): **Design Conference Proceedings: Technology for Supersonic Cruise Military Aircraft, Vol. I. (U).** Colorado Springs, Colo., Feb. 17–20, 1976. AFFDL-TR-77-85, Vol. 1, April 1976, 1154 pp. Unclassified document. Available to U.S. Gov't. Agencies Only. (AD-B025253L). (X78-74382#).

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l. Trade Studies on a Long Range Mach 2.7 Supercruiser (Also published as NASA-TM-78811, Dec. 1978, N79-15906#, which is No. 45 in this bibliography.) — Russell B. Sorrells, Willard E. Foss, NASA/Langley

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18 Studies of a Multicycle Supersonic Technology Demonstration Airplane Concept. Preliminary Design. Final Report. *Boeing Rept. No. D6-75772; NASA-CR-144904, May 1976, 237 pp. UNCLASSIFIED document. Available to U.S. Gov't. Agencies and their Contractors Only. (X76-10735#).

*Boeing Commercial Airplane Co., Seattle, WA 98124

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19 *Grantham, William D.; *Deal, Perry L.; and *Libbey, Charles E.: **Piloted Simulator Study of the Stability and Control Characteristics of the B-1 Airplane at High Angles of Attack.** (U). NASA TM SX-3381, June 1976, 80 pp. CONFIDENTIAL document. Available to U.S. Gov't. Agencies Only. (X76-77228).

*NASA-Langley Research Center, Hampton, VA 23665

20 *Nelson, B. D.; *Middleton, W. D.; *Baullinger, N.; *Sterbeck, P.; and *Alberts, L.: **Light Experimental Supercruise Conceptual Design. Final Report, June 1975—Mar. 1976.** Boeing Rep. No. D180-19115-5; AFFDL-TR-76-76, July 1976. 319 pp. Unclassified document. Available to U.S. Gov't. Agencies Only. (AD-B022011L). (X78-70042#).

*Boeing Aerospace Co., Seattle, WA 98124
Boeing Military Airplane Development

Contract No. F33615-75-C-3150

21 *Riccioni, E. E.: **Technical Applications for an Experimental Supersonic Cruise Aircraft.** AIAA Aircraft Systems and Technology Meeting, Dallas, Texas, Sept. 27—29, 1976. AIAA Paper 76-892, 7 pp. (A76-47680#).

In order to decide on the feasibility of an efficient supersonic cruise fighter (supercruiser), the technical requirements for integrating aircraft technologies are analyzed. Current characteristics of supersonic airplanes, such as radius of action, energy maneuverability, and 'G' capabilities are examined. Special attention is paid to the performance disparity between fighters designed for supersonic cruise and those for transonic maneuvering. In particular, the problem of the combat engagement time (persistence), i.e., the disparity between attained maximal speeds (up to M 2.5 in F-101, F-104, F-106, and F-111 models) and the cruise (combat) speeds of these fighters is analyzed. A cost evaluation is presented as well as recommendations regarding further research, and an optimistic conclusion is reached as to the possibility of realization for the supersonic cruise fighters and their potential.

*Air Force Flight Dynamics Laboratory (FX), Wright-Patterson AFB, OH 45433

22 *Berrier, B. L.: **A Review of Several Propulsion Integration Features Applicable to Supersonic-Cruise Fighter**

Aircraft. NASA-TM-X-73991, Dec. 1976, 58 pp. (N77-15039#, Available NTIS).

A brief review has been made of the propulsion integration features which may impact the design of a supersonic cruise fighter type aircraft. The data used for this study were obtained from several investigations conducted in the Langley 16-foot transonic and 4 by 4 foot supersonic pressure wind tunnels. Results of this study show: (1) that for conventional nozzle installations, contradictory design guidelines exist between subsonic and supersonic flight condition, (2) that substantial drag penalties can be incurred by use of dry power nozzles during supersonic cruise; and (3) that a new and unique concept, the nonaxisymmetric nozzle, offers the potential for solving many of the current propulsion installation problems.

*NASA, Langley Research Center, Hampton, VA 23665

23 *Chuprun, John, Jr.; and *O'Connor, Wayne M. (Compilers): **Proceedings of the Conference on the Operational Utility of Supersonic Cruise.** May 1977. Conference held at Wright-Patterson Air Force Base, 12–14 April, 1977. SECRET documents.

*Aeronautical Systems Division, Wright-Patterson AFB, OH 45433

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Deputy for Development Planning (ASD/XR)
Aeronautical Systems Division
Wright-Patterson AFB, OH 45433

24 *Ciminera, V. R.; *Giesler, W.; and *Schwartz, P. M.: **Advanced Technology Emphasis for a 1985 Tactical Supersonic Cruise Airplane.** Soc. of Allied Weight Engineers. Paper presented at the 36th Annual Conference, San Diego, Calif., May 9-12, 1977, 18 pp. (A78-17879).

A procedure is developed for determining optimum aerodynamics, materials, and propulsion techniques for a proposed 1985 weapons system. The procedure consists of: (1) the determination of mission and point performance criteria for a 1985 supercruise weapons system, (2) a computerized initial sizing estimate program applicable to a baseline airplane with 1975 state-of-the-art technology, and (3) establishment of figures-of-merit for evaluating technology payoffs (including takeoff gross weight, life cycle costs, and cost effectiveness).

*Grumman Aerospace Corp., Bethpage, NY

25 *Graham, A. B.: **Experimental and Analytical Investigations to Improve Low-Speed Performance and Stability and Control Characteristics of Supersonic Cruise Fighter Vehicles: Final Report.** NASA-CR-154122, June 1977, 5 pp. (N77-28136#). (Available NTIS).

Small- and large-scale models of supersonic cruise fighter vehicles were used to determine the effectiveness of airframe/propulsion integration concepts for improved low-speed performance and stability and control characteristics. Computer programs were used for engine/airframe sizing studies to yield optimum vehicle performance.

*Old Dominion Univ. Research Foundation, Norfolk, VA
Grant No. NSG-1309

26 *Thomas, J. L.; *Paulson, J. W,; and *Yip, L. P.: **Effects of Deflected Thrust on the Stability and Performance Characteristics of a Close-Coupled Canard Fighter Configuration.** 13th AIAA and SAE Propulsion Conference, Orlando, Fla., July 11–13, 1977. AIAA Paper 77-887, 8 pp. (A77-38576#).

The effects of deflected thrust on the stability and performance of a close-coupled canard fighter configuration are presented. These results were obtained at low speeds in the Langley V/STOL tunnel. Transonic as well as low-speed results are also presented for an unpowered close-coupled canard and a "supercruiser" configuration. The V/STOL tunnel data indicate an increase in maximum lift and reductions in drag due to lift with the addition of two-dimensional vectored thrust at the wing inboard trailing edge. The longitudinal pitchup associated with the unpowered configuration at higher angles of attack was significantly reduced with power.

*NASA, Langley Research Center, Hampton, VA 23665

27 *Morris, Odell A.: **Subsonic and Supersonic Aerodynamic Characteristics of a Supersonic Cruise Fighter**

Model With a Twisted and Cambered Wing With 74° Sweep. NASA-TM-X-3530, August 1977, 63 pp. (N77-29102#, Available NTIS).

A wind-tunnel investigation has been conducted in the Mach number range from 0.60 to 2.96 at a Reynolds number of 6.56×10^6 per meter to determine the longitudinal and lateral aerodynamic characteristics of a model of a supersonic cruise fighter configuration with a design Mach number of 2.60. The configuration is characterized by a highly swept arrow wing twisted and cambered to minimize supersonic drag due to lift, twin wing-mounted vertical tails, and an aft-mounted integral underslung dual-engine pod. The investigation also included tests of the configuration with larger outboard vertical tails and with small nose strakes. Results of the investigation showed that the maximum values of lift drag ratio for the complete basic configuration varied from about 7.5 at subsonic speeds to about 6.3 at the design Mach number of 2.60. The complete configuration had sufficient positive zero-lift pitching moment so that for conditions of neutral subsonic stability, trimmed supersonic cruise flight could be maintained with little or no trim drag. Only the configuration with the large vertical and ventral tails indicated positive levels of directional stability for lift coefficients up to 0.1 at a Mach number of 2.60. The addition of nose strakes to the model also provided small improvements in directional stability at the higher lift coefficients.

*NASA, Langley Research Center, Hampton, VA 23665

28 *Dollyhigh, Samuel M.: **Subsonic and Supersonic Longitudinal Stability and Control Characteristics of an Aft-Tail Fighter Configuration with Cambered and Uncambered Wings and Cambered Fuselage.** NASA-TN-D-8472. Sept. 1977, 77 pp. (N77-31093#, Available NTIS).

An investigation has been conducted over a Mach number range from 0.50 to 2.16 to determine the longitudinal aerodynamic characteristics of a fighter airplane concept. The configuration incorporates a cambered fuselage with a single external-compression horizontal-ramp inlet, a clipped arrow wing, twin horizontal tails, and a single vertical tail. The wing camber surface was optimized in drag due to lift and was designed to be self-trimming at Mach 1.40 and at a lift coefficient of 0.20. The fuselage was cambered to preserve the design wing loadings on the part of the theoretical wing enclosed by the fuselage. An uncambered or flat wing of the same planform and thickness ratio distribution was also tested.

*NASA, Langley Research Center, Hampton, VA 23665

29 *Shrout, B. L.: **Aerodynamic Characteristics at Mach Numbers from 0.6 to 2.16 of a Supersonic Cruise Fighter Configuration with a Design Mach Number of 1.8.** NASA-TM-X-3559, Sept. 1977, 79 pp. (N77-32081#, Available NTIS).

An investigation has been made in the Langley 8-foot transonic pressure tunnel at Mach numbers from 0.6 to 1.2 and in the Langley Unitary Plan wind tunnel at Mach numbers of 1.6, 1.8, and 2.16 to determine the static longitudinal and lateral aerodynamic characteristics of a model of a supersonic-cruise fighter, number four in a series of Langley configurations. This configuration is a twin-engine tailless arrow-wing concept with a single rectangular inlet beneath the fuselage. It has outboard vertical tails and ventral fins and is designed for efficient cruise performance at a Mach number of 1.8. Three inlet-diverter combinations were tested. The results of the investigation show untrimmed values of lift-drag ratio ranging from 10 at subsonic speeds to 6.4 at the design Mach number. The elevons were not very effective as pitch control devices at supersonic speeds. The configuration was statically stable both longitudinally and laterally.

*NASA, Langley Research Center, Hampton, VA 23665

30 *Miller, L. E.; and *Dahlem, V., III: **Supercruiser Fighter Analysis.** June 1978, 16 pp. In AGARD Fighter Aircraft Design, N78-30099. (Paper presented at Multi-Panel Symp. on Fighter Aircraft Design, Scuola di Guerra Aerea, Florence, Italy, 3–6 Oct. 1977). (N78-30107#, Available NTIS).

A fighter aircraft that cruises efficiently at supersonic speeds and is effective in air to air combat is considered. Supersonic cruise performance and transonic maneuvering requirements are emphasized. Speed advantage, ability to engage or disengage at will, maintaining control over the combat arena, and target acquisition are among the factors analyzed. From differential game technology, supercruiser maneuvering requirements are determined as a function of the threat's maneuvering capability. Wind tunnel results indicate that a small single aircraft can be configured to produce the level of efficiency necessary for supersonic cruise.

*Air Force Flight Dynamics Lab., Wright-Patterson AFB, OH 45433

31 *Rettie, T. H.; and *Sutton, R. C.: **The Impact of Emerging Technologies on Tactical V/STOL Airplane Design and Utility.** SAE, Aerospace Meeting, Los Angeles, Calif., Nov. 14–17, 1977. SAE Paper 770985, 11 pp. (A78-23824).

A new look at tactical combat V/STOL design and utility as affected by emerging technology and mission concepts is given in this paper. History has shown that a certain level of useful load fraction must be attained before an airplane system can be considered operationally successful. Technology trends reviewed in this paper suggest that the time is here or at least near for V/STOL tactical aircraft to achieve a truly viable useful load fraction. Propulsion, structure, and controls technologies will contribute to the success of the tactical V/STOL system. In addition, aerodynamic technology as related to interference effects in hover and transition, and as required for efficient supersonic cruise and combat, significantly impacts the design solution. A unique approach to system design risk assessment is described with results giving technology leverage as a function of design options.

*Boeing Co., Seattle, WA 98124

32 *Hoffman, Sherwood: **Bibliography of Supersonic Cruise Aircraft Research (SCAR) Program From 1972 to Mid-1977.** NASA-RP-1003, Nov. 1977, 102 pp. (N78-12895#, Available NTIS).

This bibliography documents publications of the Supersonic Cruise Aircraft Research (SCAR) Program that were generated during the first 5 years of effort. The reports are arranged according to Systems Studies and five SCAR disciplines: Propulsion, Stratospheric Emissions Impact, Structures and Materials, Aerodynamic Performance, and Stability and Control. The specific objectives of each discipline are summarized. Annotation is included for all NASA inhouse and low-number contractor reports. There are 444 papers and articles included.

*NASA, Langley Research Center, Hampton, VA 23665

33 *Dollyhigh, S. M.; *Monta, W. J.; and *Sangiorgio, G.: **Longitudinal Aerodynamic Characteristics at Mach 0.60 to 2.86 of a Fighter Configuration With Strut Braced Wing.** NASA-TP-1102, Dec. 1977, 149 pp. (N78-16000#, Available NTIS).

An investigation was made to determine the effects on longitudinal aerodynamic characteristics of utilizing struts to brace the wing to allow the wing thickness reduction on the LFAX-8 fighter configuration. Structural and load analysis indicated that the maximum airfoil thickness could be reduced from 4.5 to 3.1 percent with the strut brace concept. Wave drag theory indicated that reducing the wing maximum thickness from 4.5 percent to 3.1 percent would yield a significant reduction in zero-lift wave drag of about 28 percent at the design Mach number of 1.60. Strut arrangements designed and tested included a single straight strut, a single swept strut, and a set of tandem straight struts. In addition, a wire of approximately the same cross sectional area replaced the single straight strut on one series of runs. The original LFAX-8 with the 4.5-percent-thick wing was retested to serve as a base line for this investigation.

*NASA, Langley Research Center, Hampton, VA 23665

34 *Lamar, John E.: **Subsonic Vortex-Flow Design Study for Slender Wings.** AIAA 16th Aerospace Sciences Meeting, Huntsville, Ala., Jan. 16–18, 1978. AIAA Paper 78-154. Also: Journal of Aircraft, vol. 15, No. 9, Sept. 1978, pp. 611–617. (A78-20708).

A theoretical study describing the effects of spanwise camber on the lift dependent drag of slender delta wings having leading-edge-vortex-flow is presented. The earlier work by Barsby, using conical flow, indicated that drag levels similar to those in attached flow could be obtained. This is reexamined and then extended to the more practical case of nonconical flow by application of the vortex-lattice method coupled with the suction-analogy and the recently developed Boeing free-vortex-sheet method. Lastly, a design code is introduced which employs the suction analogy in an attempt to define 'optimum' camber surfaces for minimum lift dependent drag for vortex flow conditions.

*NASA, Langley Research Center, Hampton, VA 23665

35 *Meyer, R. C.; and **Fields, W. D.: **Configuration Development of a Supersonic Cruise Strike-Fighter.** AIAA 16th Aerospace Sciences Meeting, Huntsville, Ala., Jan. 16–18, 1978, AIAA Paper 78–148, 9 pp. (A78-22587#).

Tactical requirements for extended supersonic cruise and a high level of air combat maneuverability lead to a unique set of configuration tradeoffs. Recent studies show that the cruise-maneuver design conflict can be resolved with advanced wing technology. The critical design requirement is to achieve extremely low zero lift drag to improve cruise L/D and avoid A/B operation. Plans for a supersonic aircraft with both advanced cruise and air combat capabilities are discussed with attention to air-frame design. The aircraft is intended to be operational in the 1985+ time period and will use either side inlets or pods in its engine configuration, with the engines based on today's technology. The capabilities forseen, e.g., air combat maneuverability of 3.5–4.0 G at Mach 0.9 at 10,000 meters, cruise speed of Mach 2, and SRAM payload of 5000 pounds, call for high lift/drag and thrust/weight ratios. To achieve these goals, aircraft configuration features include: twin nacelle arrangement, two-dimensional wedge nozzles, variable geometry inlet, fully submerged tandem stores, variable attitude cockpit-canopy, control configured canard arrangement, variable twist/variable camber wing. The paper reviews the technical background for the conclusions and traces the configuration development of a supersonic cruise strike-fighter from conception to final design and early wind tunnel testing.

*Grumman Aerospace Corp., Bethpage, NY
**Flight Dynamics Lab, Wright-Patterson AFB, OH 45433

36 *Yoshihara, H.: **Computational Fluid Dynamics (CFD): Future Role and Requirements as Viewed by an Applied Aerodynamicist---Computer Systems Design.** NASA, Ames Research Center's "Future Computer Requirements for Computational Aerodynamics," N78-19778, pp. 132–142. Feb. 1978. (N78-19789#, Available NTIS).

The problem of designing the wing-fuselage configuration of an advanced transonic commercial airliner and the optimization of a "supercruiser" fighter are sketched, pointing out the essential fluid mechanical phenomena that play an important role. Such problems suggest that for a numerical method to be useful, it must be able to treat highly three dimensional turbulent separations, flows with jet engine exhausts, and complex vehicle configurations. Weaknesses of the two principal tools of the aerodynamicist, the wind tunnel and the computer, suggest a complementing combined use of these tools, which is illustrated by the case of the transonic wing-fuselage design. The anticipated difficulties in developing an adequate turbulent transport model suggest that such an approach may have to suffice for an extended period. On a longer term, experimentation of turbulent transport in meaningful cases must be intensified to provide a data base for both modeling and theory validation purposes.

*Boeing Co., Seattle, WA 98124

37 *Elwell, R. E.: **Documentation of a Wind Tunnel Test on the AFFDL Conceptual Supersonic Cruise Aircraft at Transonic Mach Numbers. Final Report.** AEDC-TSR-78-P19, July 1978, 44 pp. Unclassified document. Available to U.S. Gov't. Agencies Only. (AD-B030263L). (X79-70970#).

*ARO, Inc., Arnold Air Force Station, TN

38 *Hahn, D. W.; *Genzlinger, D. D.; *Stutz, A. L.; *Bambrick, R. W.; *Osterbeck, P. G.: **Military Utility of the Boeing Model 733-606-19 Supercruiser. Volume 1: Configuration Development. Final Report, 1 Sept. 1977–1**

May 1978. Boeing Rep. No. D180-24640-1; AFFDL-TR-78-80 Vol. 1, 183 pp. July 1978. Unclassified document. Available to U.S. Gov't. Agencies Only. (AD-B034200L). (X79-74088#).

*Boeing Aerospace Co., Boeing Military Airplane Development Organization, Seattle, WA 98124

39 *Hahn, D. W.; and *Genzlinger, D. P.: **Military Utility of the Boeing Model 733-606-19 Supercruiser. Volume 2: Penetration Analysis (U), Final Report, 1 Sept. 1977–1 May 1978.** Boeing Rep. No. D180-24640-2; AFFDL-TR-78-80 Vol. 2, July 1978, 128 pp. SECRET document. Available to U.S. Gov't. Agencies Only. (AD-C016683L). (X79-75777#).

*Boeing Aerospace Co., Boeing Military Airplane Development Organization, Seattle, WA 98124

40 *Genzlinger, D. D.; *Stutz, A. L.; *Bambrick, R. W.; *Osterbeck, P. G.; and *Friebel, G. O.: **Military Utility of the Boeing Model 733-606-19 Supercruiser. Vol. 3: Threat Description. (U) Final Report, 1 Sept. 1977–1 May 1978.** Boeing Report No. D180-24640-3; AFFDL-TR-78-80-Vol. 3, 70 pp. July 1978. SECRET document. Available to U.S. Gov't. Agencies Only. (AD-C01684L) (X79-75776#).

*Boeing Aerospace Co., Boeing Military Airplane Development Organization, Seattle, WA 98124

41 *Hendrickson, R. H.; *Grossman, R. L.; and *Sclafani, A. S.: **Design Evolution of a Supersonic Cruise Strike-Fighter.** AIAA Aircraft Systems and Technology Conference, Los Angeles, Calif. Aug. 21–23, 1978. AIAA Paper 78-1452, 13 pp. (A78-49783#).

The present paper reviews the preliminary design of an advanced supersonic cruise strike-fighter configuration and compares early wind tunnel data with pre-test predictions and ultimate technology goals. The paper goes on to describe how these results and continued configuration studies were factored into the aircraft design evolution for improved performance. Specific material covered will include: baseline configuration selection, packaging, and supersonic area-ruling; variable twist/variable camber wing design using 2D and 3D transonic computer codes and comparison with wind tunnel force, moment, and pressure data; propulsion-airframe integration effects for several inlet and nozzle configurations; and an appraisal of the maneuvering performance compared to current state-of-the-art capabilities.

*Grumman Aerospace Corp., Bethpage, NY

42 *Kulfan, R. M.: **Applications of Hypersonic Favorable Aerodynamic Interference Concepts to Supersonic Aircraft.** AIAA Aircraft Systems and Technology Conference, Los Angeles, Calif., Aug. 21–23, 1978. AIAA Paper 78-1458, 27 pp. (A78-52042#).

A study was made to identify hypersonic favorable aerodynamic interference concepts for application to supersonic aircraft. Preliminary aerodynamic analysis defined key design parameters, and scoped potential aerodynamic efficiency improvements. The study included supersonic biplanes, ring wings, parasol wings, wave rider concepts, and flat-top wing/body arrangements. Results indicate the parasol wing concept offers the greatest potential aerodynamic benefits for the study conditions. However, the best aerodynamic concept is very dependent on the design Mach number, and on the airplane component size relationships. It is shown that existing aerodynamic design/analysis methods can be used for parasol wing aerodynamics studies.

*Boeing Commercial Airplane Co., Seattle, WA 98124

43 *Presley, L. L.: **High Angle of Incidence Implications Upon Air Intake Design and Location for Supersonic Cruise Aircraft and Highly Maneuverable Transonic Aircraft.** NASA-TM-78530, Sept. 1978, 13 pp. (N78-32044#, Available NTIS). Also see AGARD-CP-247, "High Angle of Attack Aerodynamics," Jan. 1979, N79-21996, Paper No. 31, 11 pp. (N79-22026#, Available NTIS).

Computational results which show the effects of angle of attack on supersonic mixed compression inlet performance at four different locations about a hypothetical forebody were obtained. These results demonstrate the power of the computational method to predict optimum inlet location, orientation, and centerbody control schedule for design and off design performance. The effects of inlet location and a forward canard on the angle-of-attack performance of a normal shock inlet at transonic speeds were studied. The data show that proper integration of inlet location and a forward canard can enhance the angle-of-attack performance of a normal shock inlet. Two lower lip treatments for improving the angle-of-attack performance of rectangular inlets at transonic speeds are discussed.

*NASA, Ames Research Center, Moffett Field, CA 94035

44 Vinh, N. X.: **Optimum Cruise Performance, Final Technical Report. June–Aug. 1977.** AFFDL-TR-78-131, Nov. 1978, 130 pp. (AD-A062607). (N79-20107#, Available NTIS).

This report considers the cruise performance of a jet-propelled aircraft at high speed. The two problems of cruise with maximum range and with maximum endurance are analyzed. In each problem, for any given aircraft aerodynamics and engine characteristics, the equation for determining the optimum Mach number for cruise is derived. For maximum range, there exists an optimum cruise altitude. For the maximum endurance problem, the effect of the altitude on performance is negligible. It is shown that in both problems, constant Mach number cruise is a satisfactory flying technique. In the true optimum solution the optimum Mach number slowly decreases along the flight path. In this case, the singular thrust control is obtained explicitly as a function of the Mach number.

*Air Force Flight Dynamics Lab., Wright-Patterson AFB, OH 45433

45 *Foss, Willard E., Jr.; and *Sorrells, Russell, B., III: **Trade Studies Relating to a Long Range Mach 2.6 Supercruiser.** NASA-TM-78811, Dec. 1978, 19 pp. (N79-15906, Available NTIS). (This was also given as a paper in X68-74382, Design Conference Proceedings – Technology for Supersonic Cruise Military Aircraft, Volume I, AFFDL TR-77-85, U.S. Air Force, Feb. 1976, which is No. 16-I in this bibliography).

A systems study has been conducted on an aircraft concept, representative of a supersonic-cruise military aircraft (supercruiser). The study results indicate that supersonic ranges in excess of 7.5 Mm (4000 n.mi.) at a Mach number of 2.62 are possible with a 222 kN (5000 lbf) class aircraft. Trade studies, to determine the sensitivity of supersonic range to parameters which would improve maneuverability, indicate that thrust-weight ratios of as much as 0.5 can be used without significantly decreasing supersonic range; however, increasing the thrust-weight ratio to 1.0 decreases the range capability by about 2.0 Mm (1100 n.mi.). The range penalty for increasing the aircraft limit load-factor from 4.0 to 9.0 is about 0.93 Mm (500 n.mi.). The increased fuel volume of several configurations improved the subsonic range capability by about 2.2 Mm (1200 n.mi.); but, due to associated losses in supersonic L/D, had an insignificant effect on the range at a Mach number of 2.62.

*NASA, Langley Research Center, Hampton, VA 23665

46 *Miller, David S.; and **Schemensky, Roy T.: **Design Study Results of a Supersonic Cruise Fighter Wing.** AIAA 17th Aerospace Sciences Meeting, New Orleans, La., Jan. 15–17, 1979, AIAA Paper 79-0062, 9pp. (A79-19512).

A study has been conducted to explore the use of existing aerodynamic techniques to design a new supersonic cruise wing for an existing fighter wind-tunnel model. In addition to the usual wing design constraints of lift, pitching moment, and minimum drag, a ground rule was imposed that the wing had to fit on the existing fuselage. Experimental wind-tunnel results were obtained for a camber design and a reference flat wing. The flat wing was also fitted with leading-edge flaps which approximate the cruise camber design. The experimental results indicate that significant improvements in supersonic cruise capability can be obtained by a new wing designed using existing supersonic aerodynamic techniques.

*NASA, Langley Research Center, Hampton, VA 23665
**General Dynamics Corp., Fort Worth, TX

47 *Hinz, Werner W.; and *Miller, Eugene H.: **Propulsion Integration of a Supersonic Cruise Strike-Fighter.** AIAA 17th Aerospace Sciences Meeting, New Orleans, La., Jan. 15–17, 1979. AIAA Paper 79-0100, 10 pp. (A79-23531#).

Requirements for efficient supersonic cruise in future strike-fighter aircraft place increased emphasis on the integration of the propulsion system. The current paper reviews the propulsion considerations that contributed to an attractive aircraft design, and reports the results of a wind tunnel test program that examined a matrix of inlet, nacelle, and exhaust nozzle configurations. These propulsion components were incorporated into a complete aircraft model, insuring proper geometric simulation of aircraft/propulsion interference effects, and tested at Mach 1.5 and 2.0. Included in the propulsion package were rectangular and semi-circular inlet configurations. Nozzles examined included the wedge, ALBEN, 2-D C-D, and current and advanced axisymmetric configurations. The external drag data acquired during these tests and supporting inlet/nozzle internal performance and weight data were subsequently combined to determine the overall propulsion system impact on mission and aircraft takeoff gross weight.

*Grumman Aerospace Corp., Bethpage, NY

48 *Krieger, Robert J.; *Gregoire, Joseph E.; and *Hood, Richard F.: **Unconstrained Supersonic Cruise and Maneuvering Configuration Concepts.** AIAA 17th Aerospace Sciences Meeting, New Orleans, La., Jan. 15–17, 1979. AIAA Paper 79-0220, 8 pp. (A79-19606#).

Configuration concepts are presented which have high lift-to-drag ratios and maneuverability achievable by relieving constraints due to carriage, propulsion and subsystem integration. Noncircular body, lifting body, blended wing-body, wing-body and favorable interference concepts are developed using aerodynamic design criteria derived for climb-cruise-intercept missions. The Hypersonic Arbitrary Body Program (HABP) is evaluated for predicting aerodynamic characteristics. Comparisons of wind tunnel data and predictions are presented. Major features such as a spatular nose, flat bottom, high fineness ratio, ramped nose, planar shape, high wing, end plated wing, and interference channel are shown to enhance aerodynamic characteristics.

*McDonnell Douglas Astronautics Co., St. Louis, MO

49 *Tinoco, E. N.; and *Yoshihara, H.: **Subcritical Drag Minimization for Highly Swept Wings with Leading Edge Vortices.** AGARD-CP-247, (N79-21996), "High Angle of Attack Aerodynamics", Jan. 1979, Paper No. 26, 9 pp. (N79-22021#, Available NTIS).

A method is sought to improve the subsonic lift to drag ratio of supercruiser type wings at sufficiently large lifts for which flow separation cannot be avoided. In the presence of the resulting leading edge vortex, minimum drag due to lift is no longer dictated by spanwise load distribution alone but is also a function of the chordwise loading. For the resulting nonlinear problem a higher order panel method utilizing a vortex sheet model is used to search for an "optimal" design. A brief outline of the computational method is given followed by examples validating the procedures. Results of the search for an "optimal" camber are discussed.

*Boeing Aerospace Co., P.O. Box 3999, Seattle, WA 98124

50 *Shrout, Barrett L.; and *Fournier, Roger H.: **Aerodynamic Characteristics of a Supersonic Cruise Airplane Configuration at Mach Numbers of 2.30, 2.96, and 3.30.** NASA-TM-78792, Jan. 1979, 141 pp. (N79-14025#, Available NTIS).

An investigation was made in the Langley Unitary Plan wind tunnel at Mach numbers of 2.30, 2.96, and 3.30 to determine the static longitudinal and lateral aerodynamic characteristics of a model of a supersonic cruise airplane. The configuration, with a design Mach number of 3.0, has a highly swept arrow wing with tip panels of lesser sweep, a fuselage chine, outboard vertical tails, and outboard engines mounted in nacelles beneath the wings. For wind-tunnel test conditions, a trimmed value above 6.0 of the maximum lift-drag ratio was obtained at the design Mach number. The configuration was statically stable, both longitudinally and laterally. Data are presented for variations of vertical-tail roll-out and toe-in and for various combinations of components. Some roll-control data are shown as are data for the various sand grit sizes used in fixing the boundary-layer transition location.

*NASA, Langley Research Center, Hampton, VA 23665

51 *Dollyhigh, Samuel M.: **Experimental Aerodynamic Characteristics at Mach Numbers from 0.60 to 2.70 of Two Supersonic Cruise Fighter Configurations.** NASA-TM-78764, Feb. 1979, 190 pp. (N79-20062#, Available NTIS).

Two 0.085-scale full span wind-tunnel models of a Mach 1.60 design supercruiser configuration were tested at Mach numbers from 0.60 to 2.70. One model incorporated a varying dihedral (swept-up) wing to obtain the desired lateral-directional characteristics; the other incorporated more conventional twin vertical tails. The data from the wind-tunnel tests are presented in this report without analysis.

*NASA, Langley Research Center, Hampton, VA 23665

52 *Lind, G. W.; and *Ervolina, T. S.: **Future Tactical Fighter Requirements – A Propulsion Technology Update.** ASME, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif. Mar. 12–15, 1979. ASME Paper 79-GT-46, 9 pp. (A79-30523#).

A survey is presented of the progress and activities undertaken in pursuit of efficient supersonic cruise within the constraints of future tactical roles. The developing roles of future tactical fighters are outlined from the basic supersonic penetration mission to design alternatives such as STOL capability. In each case the predominant effect on the candidate propulsion design process is to establish the configuration which best resolves a solution in terms of the advanced technology projections. Each role, whether directed toward high Mach number cruise or high transonic maneuvering suggests a supersonic cruise requirement. Sufficient wind tunnel tests are conducted to indicate that propulsion technology, when integrated properly, can meet this challenge. Stealth implications are part of the overall propulsion/weapon system tradeoffs.

*Grumman Aerospace Corp., Bethpage, NY

53 *Kehrer, William T.: **Flight Control and Configuration Design Considerations for Highly Maneuverable Aircraft.** AGARD-CP-262, "Aerodynamic Characteristics of Controls" Paper #5. Conference held in Pozzuloi, Italy, May 14–17, 1979.

Advanced supersonic cruise tactical aircraft designs are trending towards high wing loading and high wing sweep combined with wing variable geometry to achieve design goals for efficient supersonic cruise and good maneuverability. Active control systems replace inherent aerodynamic stability to provide substantial weight and lift/drag (L/D) improvements and to achieve advanced mission performance capabilities. Working within wing geometry and other design constraints, the controllable limits of instability and the maneuver capabilities of various design approaches are investigated. Preliminary studies conducted to evaluate competitive configuration arrangements indicate that an aft-tail controller concept will be superior to canard and tailless delta configurations. The latter configurations suffer controllability limitations that compromise the ability to achieve design goals for maneuverability and efficient supersonic cruise. Thrust vectoring is explored as a means of improving maneuver load factor capability. An additional fundamental design requirement for future tactical aircraft is the provision of good roll control for high-angle-of-attack maneuvering. The ability to achieve and sustain high maneuver load factor must be complemented by the ability to reverse heading quickly while at high load factor through rapid bank-to-opposite-bank maneuvers. Effective controls must be developed to achieve this roll control capability.

*Boeing Aerospace Co., Boeing Military Airplane Development, Seattle, WA 98124

54 *Shrout, Barrett L.; *Corlett, William A.; and *Collins, Ida K.: **Surface Pressure Data for a Supersonic – Cruise Airplane Configuration at Mach Numbers of 2.30, 2.96, and 3.30.** NASA-TM-80061, May 1979, 54 pp. (N79-22051#, Available NTIS).

The tabulated results of surface pressure tests conducted on the wing and fuselage of an airplane model in the Langley Unitary Plan wind tunnel are presented without analysis. The model tested was that of a supersonic-cruise airplane with a highly swept arrow-wing planform, two engine nacelles mounted beneath the wing, and outboard vertical tails. Data were obtained at Mach numbers of 2.30, 2.96, and 3.30 for angles of attack from -4° to 12°. The Reynolds number for these tests was 6.56×10^6 per meter (2.0×10^6 per foot).

*NASA, Langley Research Center, Hampton, VA 23665

55 Supercruise Requirements. (U) ***Northrop Report No. NOR-79-54, June 28, 1979, 307 p. SECRET, NF document.**

*Northrop Corp., Aircraft Division, 3901 West Broadway, Hawthorne, CA 90250

56 *Miller, L. E.: **Approximate Trajectory Solutions for Fighter Aircraft.** In "Atmospheric Flight Mechanics Conference for Future Space Systems", Boulder, Colo., Aug. 6–8, 1979. Collection of Technical Papers (A79-45302) New York, AIAA, Inc., 1979, pp. 13–20. AIAA Paper 79-1623, 8 pp. (A79-45305#).

Approximate solutions to the segments of typical fighter trajectory profiles are obtained. The specific problems addressed are subsonic cruise, supersonic cruise, initial climb, and supersonic acceleration and climb. Closed form solutions for the initial climb problem are in good agreement with the results obtained from the integration of the differential equations of state. The agreement is not as good for the supersonic acceleration and climb. Theoretical subsonic cruise range factor performance results agree quite well with the actual optimum results. For the supersonic cruise problem, it is demonstrated that universal distributions between fuel flow and thrust could be developed that are independent of altitude. Thus minimum fuel flow or maximum range factor can be easily determined. The utility of the solutions is that relationships between performance and system characteristics are developed. The solutions do not depend upon the details of the variation in the parameters along the path but only on the conditions at the ends of the path or average values.

*USAF, Flight Dynamics Lab., Wright-Patterson AFB, OH 45433

57 *Miller, Eugene H.; *Protopapas, John; **Obye, Roger; and ***Wooten, William: **Nozzle Design and**

Integration in an Advanced Supersonic Fighter. AIAA Aircraft Systems and Technology Meeting, Aug. 20–22, 1979, New York, NY. AIAA Paper 79-1813, 11 pp. (A79-51707#).

Numerous studies aimed at evaluating the key advances in vehicle design have highlighted the importance of propulsion integration in the aircraft. This paper describes the design and integration of advanced nozzles in a future supersonic fighter. The requirements for such a nozzle include operation at high area ratio during supersonic cruise, vectoring for STOL field performance and maneuvering, use of thrust reversers for combat and basing, good airframe integration, and high thrust performance with minimal thrust cooling losses. Such a nozzle configuration must also have favorable stealth characteristics in providing a low IR and RCS signature. The advanced nozzles, their mechanisms, and their performance are described. Takeoff gross weight studies were performed and thrust reverser and vectoring performance were analyzed in terms of takeoff and landing distances. The effects of thrust vectoring on maneuverability were also examined.

*Grumman Aerospace Corp., Bethpage, NY
**Pratt & Whitney Aircraft, East Hartford, CT
***General Electric Co., Fairfield, CT

58 *Robins, A. W.; and *Carlson, H. W.: **High-Performance Wings with Significant Leading-Edge Thrust at Supersonic Speeds.** AIAA, Aircraft Systems and Technology Meeting, New York, NY, Aug. 20–22, 1979. AIAA Paper 79-1871, 6 pp. (A79-47924#).

A new class of curved-leading-edge wings with which significant levels of leading-edge thrust may be achieved at moderate supersonic speeds is suggested. A recent analysis of the factors limiting such leading-edge thrust has led to a new method for the prediction of attainable leading-edge thrust from subsonic through supersonic speeds for wings of arbitrary planform. Recent supersonic tests of a new wing shape, which largely meets design criteria given by the new prediction method, give evidence of significant levels of leading-edge thrust. The consequent unusually high levels of aerodynamic performance should renew interest in supersonic-cruise vehicle design in general and in cruise-speed selection in particular.

*NASA, Langley Research Center, Hampton, VA 23665

59 *Yip, Long P.: **Low-Speed Wind-Tunnel Tests of a 1/10-Scale Model of an Advanced Arrow-Wing Supersonic Cruise Configuration Designed for Cruise at Mach 2.2.** NASA-TM-80152, Aug. 1979, 265 pp. (N80-10135#, Available NTIS).

The low-speed longitudinal and lateral-directional characteristics of a scale model of an advanced arrow-wing supersonic cruise configuration were investigated in tests conducted at a Reynolds number of 4.19×10^6 based on the mean aerodynamic chord, with an angle of attack range from -6 deg to 23 deg and sideslip angle range from -15 deg to 20 deg. The effects of segmented leading-edge flaps, slotted trailing-edge flaps, horizontal and vertical tails, and ailerons and spoilers were determined. Extensive pressure data and flow visualization pictures with non-intrusive fluorescent mini-tufts were obtained.

*NASA, Langley Research Center, Hampton, VA 23665

60 *Cronvich, L. L.; and *Liepman, H. P.: **Advanced Missile Technology. A Review of Technology Improvement Areas for Cruise Missiles, Final Report.** NASA-CR-3187, Oct. 1979, 66 pp. (N80-10103#, Available NTIS).

Technology assessments in the areas of aerodynamics, propulsion, and structures and materials for cruise missile systems are discussed. The cruise missiles considered cover the full speed, altitude, and target range. The penetrativity, range, and maneuverability of the cruise missiles are examined and evaluated for performance improvements.

*Johns Hopkins Univ., Laurel, MD

61 *MacDonald, I. A.; and *Smith, E. A.: **Supersonic Cruise Fighter Technologies Assessment Studies.** Northrop Corp. Rep. NOR-79-120, Nov. 1979, 442 pp. Available to Selected U.S. Gov't. Agencies Only. Northrop proprietary.

*Northrop Corp., Aircraft Division, 3901 West Broadway, Hawthorne, CA 90250

62 *Hoffman, S.: **Supersonic Cruise Research (SCR) Program Publications for FY 1977 Through FY 1979 – Preliminary Bibliography.** NASA TM-80184, Nov. 1979, 42 pp. (N80-11029#, available NTIS).

This bibliography was prepared for the November 13–16, 1979 SCR Conference at the Langley Research Center and is a preliminary report. It covers the time period from FY 1977 through FY 1979. A previous bibliography, NASA RP-1003, covers the first five years of the program, 1972 to mid 1977. The present report also includes a few publications that were omitted in the first bibliography and several non SCR papers, which support the program, for completeness. The bibliography is arranged according to System Studies and the five SCR disciplines, as follows: Propulsion, Stratospheric Emissions Impact, Materials and Structures, Aerodynamic Performance, and Stability and Control.

*NASA, Langley Research Center, Hampton, VA 23665

63 *Daugherty, James: **Wind-Tunnel/Flight Correlation Study of Aerodynamic Characteristics of a Large Flexible Supersonic Cruise Airplane CXB-70-1. I: Wind Tunnel Tests of a 0.03-Scale Model at Mach Numbers From 0.6 to 2.53.** NASA-TP-1514, Nov. 1979, 222 pp. (N80-11068#, Available NTIS).

(See Nos. 68 & 69 in this bibliography for Parts II & III.)

The longitudinal and lateral forces and moments for a 0.03 scale deformed rigid, static force model of the XB-70-1 airplane were determined. Control effectiveness was determined for the elevon in pitch and roll, for the canard, and for the rudders. Component effects of the canard, deflected with tips, variable position canopy, bypass doors, and bleed dump fairing were measured. The effects of small variations in inlet mass flow ratio and small amounts of asymmetric deflection of the wing tips were assessed.

*NASA, Ames Research Center, Moffett Field, CA 94035

64 *Lamar, John E.; **Schemensky, Roy T.; and ***Reddy, C. Subba: **Development of a Vortex-Lift-Design Method and Application to a Slender Maneuver-Wing Configuration.** AIAA 18th Aerospace Sciences Meeting, Pasadena, Calif., Jan. 14–16, 1980. AIAA Paper 80-0327.

There has been much interest recently in a supersonic-cruise-fighter aircraft. In concept this aircraft would not only perform the cruise mission at supersonic speeds, but it would also provide transonic maneuver capabilities similar to the current light-weight fighters. Since this aircraft will most likely be slender in order to provide supersonic efficiency, the transonic-maneuver lift needed will probably be provided by vortex flow. The probable use of vortex lift stems from the fact that maintaining completely attached flow for transonic-high-lift conditions on wings with highly-swept leading-edges is a rather remote possibility. Therefore, the concept of combining vortex lift with a cambered leading-edge to develop high lift while recovering some leading-edge thrust and inducing reattached flow in the knee region is an attractive alternative. The problem, of course, is to define the optimum combination of camber shape and vortex strength to minimize the lift-dependent drag. A method has been developed to optimize the mean camber surface of a cranked slender wing having leading-edge vortex flow at transonic-maneuver conditions using the suction analogy. This type of flow was assumed because it was anticipated that the slenderness of the wing would preclude attached flow at the required lift coefficient. A constraint was imposed in that the camber deflections were to be restricted by a realistic structural-box requirement. The resulting application yielded mean-camber shapes which produced effective suction levels equivalent to 77 percent of the full-planar leading-edge value at the design lift coefficient.

*NASA, Langley Research Center, Hampton, VA 23665
**General Dynamics Corp., Fort Worth, TX
***Old Dominion Univ., Norfolk, VA

65 *Carlson, H. W.; and *Mack, R. J.: **Studies of Leading-Edge Thrust Phenomena.** 18th AIAA Aerospace Sciences Meeting, Pasadena, Calif., Jan. 14–16, 1980, 10 pp. AIAA Paper 80-0325.

A study of practical limitations on achievement of theoretical leading-edge thrust has been made and an empirical method for estimation of attainable thrust has been developed. The method is based on a theoretical analysis of a set of two-dimensional airfoils to define thrust dependence on airfoil geometric characteristics and arbitrarily defined limiting pressures, an examination of two-dimensional airfoil experimental data to provide an estimate of limiting pressure dependence on local Mach number and Reynolds number, and employment of simple sweep theory to adapt the method to three-dimensional wings. Because the method takes into account the spanwise variation of airfoil section characteristics, an opportunity is afforded for design by iteration to maximize the attainable thrust and the attendant performance benefits. The applicability of the method was demonstrated by comparisons of theoretical and experimental aerodynamic characteristics for a series of wing-body configurations. Generally, good predictions of the attainable thrust and its influence on lift and drag characteristics were obtained over a range of Mach numbers from 0.24 to 2.0.

*NASA, Langley Research Center, Hampton, VA 23665

66 *Maddalon, Dal V.: **Military Aircraft and Missile Technology at the Langley Research Center – A Selected Bibliography.** NASA-TM-80204, Jan. 1980, 41 pp. (Available NTIS).

A compilation of reference material is presented on the Langley Research Center's efforts in developing advanced military aircraft and missile technology over the past twenty years. Reference material includes research made in aerodynamics, performance, stability, control, stall-spin, propulsion integration, flutter, materials, and structures.

*NASA, Langley Research Center, Hampton, VA 23665

67 *Tinoco, E. N.; *Johnson, F. T.; and **Freeman, L. M.: **Application of a Higher Order Panel Method to Realistic Supersonic Configurations.** AIAA 17th Aerospace Sciences Meeting, New Orleans, La., Jan. 15–17, 1979. AIAA Paper 79-0274. (A80-17696#). Also: Journal of Aircraft, Vol. 17, Jan. 1980, pp. 38–44. 21 refs.

A higher-order panel method has been developed for the analysis of linearized subsonic and supersonic flow over configurations of general shape. This method overcomes many of the slender body limitations of present day programs in the analysis of supersonic configurations. The capabilities of this method are demonstrated through its application to the analysis of realistic supersonic cruise configurations. Comparisons are shown with experimental data and with results from other methods in current use. These comparisons demonstrate the unique capabilities of a major new software system called PAN AIR soon to be available as a general boundary value problem solver.

*Boeing Aerospace Co., Seattle, WA 98124
**Mississippi State Univ., University, MS

68 *Peterson, John B. Jr.; *Mann, Michael J.; *Sorrells, Russell B. III; *Sawyer, Wallace C.; and *Fuller, Dennis E.: **Wind-Tunnel/Flight Correlation Study of Aerodynamic Characteristics of a Large Flexible Supersonic Cruise Airplane (XB-70-1). II-Extrapolation of Wind-Tunnel Data to Full-Scale Conditions.** NASA-TP-1515, Feb. 1980, 77 pp.

(For Part I, see No. 63 in this bibliography, Part III follows.)

This report contains the results of calculations necessary to extrapolate performance data on an XB-70-1 wind-tunnel model to full scale at Mach numbers from 0.76 to 2.53. The extrapolation was part of a joint program between the NASA Ames, Langley, and Dryden Flight Research Centers to evaluate present-day performance prediction techniques for large flexible supersonic airplanes similar to a supersonic transport. The extrapolation procedure included: Interpolation of the wind-tunnel data at the specific conditions of the flight test points; determination of the drag increments to be applied to the wind-tunnel data, such as spillage drag, boundary-layer trip drag, and skin-friction increments; and estimates of the drag items not represented on the wind-tunnel model, such as bypass doors, roughness, protuberances, and leakage drag. In addition, estimates of the effects of flexibility of the airplane were determined.

*NASA, Langley Research Center, Hampton, VA 23665

69 *Arnaiz, Henry H.; **Peterson, John B. Jr.; and ***Daugherty, James C.: **Wind-Tunnel/Flight Correlation Study of Aerodynamic Characteristics of a Large Flexible Supersonic Cruise Airplane (XB-70-1). III–A Comparison**

Between Characteristics Predicted From Wind-Tunnel Measurements and Those Measured in Flight. NASA-TP-1516, Mar. 1980, 56 pp.

A program was undertaken by NASA to evaluate the accuracy of a method for predicting the aerodynamic characteristics of large supersonic cruise airplanes. This program compared predicted and flight-measured lift, drag, angle of attack, and control surface deflection for the XB-70-1 airplane for 14 flight conditions with a Mach number range from 0.76 to 2.56. The predictions were derived from the wind-tunnel test data of a 0.03-scale model of the XB-70-1 airplane fabricated to represent the aeroelastically deformed shape at a 2.5 Mach number cruise condition. Corrections for shape variations at the other Mach numbers were included in the prediction. For most cases, differences between predicted and measured values were within the accuracy of the comparison. However, there were significant differences at transonic Mach numbers. At a Mach number of 1.06 differences were as large as 27 percent in the drag coefficients and 12° in the elevator deflections. A brief analysis indicated that a significant part of the difference between drag coefficients was due to the incorrect prediction of the control surface deflection required to trim the airplane.

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16. Abstract

This bibliography, with abstracts, consists of 69 publications arranged in chronological order. The material may be useful to those interested in supersonic cruise fighter/penetrator/interceptor airplanes. Two pertinent conferences on military supercruise aircraft are considered as single items; one contains 37 papers and the other 29 papers. In addition, several related bibliographies are included which cover supersonic civil aircraft and military aircraft studies at the Langley Research Center. There is also an author index.

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