DOWNLOAD PDF DESIGN AND TESTING OF LOW SONIC BOOM CONFIGURATIONS AND AN OBLIQUE ALL-WING SUPERSONIC TRANSPORT

Chapter 1 : Sonic boom - WikiVisually

nasa-cr mcat institute final report (nasa-cr) design and testing of low sonic bocm configurations and an oblique all-wing supersonic transport final.

Show Context Citation Context This method, that aims at reducing the sonic boom at ground via the configuration shaping, has been recently validated with in-flight test in the context of the DARPA shaped sonic bo An axisymmetric full Navier-Stokes computational fluid dynamics study is conducted to examine nozzle exhaust jet plume effects on the sonic boom signature of a supersonic aircraft. The computational fluid dynamics code is validated using available wind-tunnel sonic boom experimental data. The effects of grid size, spatial order of accuracy, grid type, and flow viscosity on the accuracy of the predicted sonic boom pressure signature are quantified. Grid lines parallel to the Mach wave direction are found to give the best results. Second-order accurate upwind methods are required as a minimum for accurate sonic boom simulations. The highly underexpanded nozzle flow is found to provide significantly more reduction in the tail shock strength in the sonic boom N-wave pressure signature than perfectly expanded and overexpanded nozzle flows. A tail shock train in the sonic boom signature is observed for the highly underexpanded nozzle flow. Axisymmetric computational fluid dynamics simulations show the flow physics inside the F nozzle to be nonisentropic and complex. Although the one-dimensional isentropic nozzle plume results look reasonable, they fail to capture the sonic boom shock train in the highly underexpanded nozzle flow. The modified F-5E aircraft of Northrop Grumman for sonic boom shaping, also known as the Shaped Sonic Boom Demonstrator is equipped with an optimized nose attachment for sonic boom mitigation. The geometry of the e The geometry of the extension is optimized for ground level sonic boom mitigation using Response Surface Methodology and Computational Fluid Dynamics. High fidelity non-linear prediction methods are used which include unstructured Euler near-field solution with grid adaptation and shock fitting and 2nd order non-linear full potential signal marching in entire cross-flow through mid-field. The modification strategy is based on reshaping the area distribution to obtain the optimum Whitham F-function distribution for sonic boom mitigation. The resultant aircraft prototype demonstrated a Nomenclature by Kenneth J. Rallabhandi, Wu Li " Practical aircraft design for sonic boom minimization is a complex process that needs significant manual iteration to obtain configurations that match the target signatures. The target signatures have traditionally been the result of application of classical sonic boom minimization theory. However, traditional target signatures are not ideal to the aircraft design problem for several reasons. Firstly, they are not flexible enough with respect to the trade-off between boom minimization and other performance measures. Additionally, they do not offer a mechanism to allow practical front and aft shaped ground signatures or control over the volume constraints in aircraft design. Feasible design practices call for a procedure wherein not only the aircraft geometry is modified to reach a target equivalent area distribution, but also the target distribution itself is modified while still resulting in a low boom signature on the ground. This paper proposes a generalized analytical F-function, extends the classical sonic boom minimization theory and demonstrates the equivalence of the optimal analytical formulation and the minimization theory in the generation of front and aft shaped profiles.

Chapter 2 : Supersonic civil airplane study and design: Performance and sonic boom - CORE

NASA Technical Reports Server (NTRS) Design and testing of low sonic boom configurations and an oblique all-wing supersonic transport.

Wing 14 has a highly swept supersonic wing design, specific to and with aerodynamic coefficients of efficiency for flight above Mach 3. Additionally, the highly swept wing 14 is such in its geometric planform for sustained flight, at or above Mach 3. This has always thought to be impossible due to reduced swept area drag and wave drag at high Mach numbers and not been done before or in a pragmatic sense, or has ever been achieved in flight surface design in practical flight vehicles, but is possible in the disclosed vehicle because of the novel geometry and planform of the V-tail or butterfly tail 20 aft of the main wing 14, which is set three wing chord root thicknesses above the centerline of the main wing The V-tail 20 is configured so that it is not just a control and stabilizing surface, but also serves as a major lifting surface of the aircraft 10 and provides the basis by which that the main wing WM, MAC, and WSA can be behind the center of gravity of the entire aircraft and that the root chord to tip chord can be above Mach 3. This configuration by mass weight, center of mass and wetted surface area of aircraft 10 provides a method by which the trim condition of the aircraft at Mach 3. Although wave drag may still exist, at the design cruise condition, it is eliminated in the present design. This is due, in part, to the QHESCT planform design based on wing position and size and as it relates to position of the V-tail, its position and size and as the V-tail 20 being active as a lifting dynamic surface. The highly swept wing 14 and V-tail 20 surfaces are sized to the specific surface area defined to maximize cruise efficiency at the design speed of Mach 3. Cruise efficiency is described as the ratio of lift to drag whereby lift is maximized in the design and drag is minimized. Typically lift to drag ratios are seen in the range of 7: This is configured successfully by the V-tail having a chord to tip ratio of below 3: Such ratio is one root chord to tip chord ratio below other traditional supersonic designs because of: The highly swept wing 14 is so configured geometrically that the parabolic leading edge is set at an average of 68 degrees aft sweep with trailing edge sweep set at 55 degrees sweep. The leading edge sweep varies from 74 degrees at the root to 66 degrees at the outer wing join approximately two-thirds out in distance from the root toward the tip of the wing. The angle of sweep is set by achieving a lifting pressure at the design Mach speed, and at the design altitude, which compensates and overcomes the weight of the aircraft fully loaded at the cruise condition the lifting pressure from the airfoil must exceed the negative weight of the aircraft at any given point in time. Also, the sweep angle is set so that the Mach cone angle, which is formed by the nose 22 of the aircraft penetrating the air at any given design cruise condition i. This is necessary so that a second shock cone or Mach angle which increases drag does not occur at the leading edge of the wing also. Hence, the Mach cone angle formed at the nose 22 creates the same aerodynamic condition skin friction and wave drag as is formed at the wing Additionally, the average sweep angle of the wing which is delineated by the leading edge, is noted to have a continuous curvature and is not straight, such design being novel and unique in supersonic civil transport design. The curvature is to prevent constant build up of pressure and shock waves at Mach 3. Subsequently, the curved leading edge of the highly swept wing prevents undue pressure build up which can contribute to the decay of the lift to drag coefficients required for the design cruise condition and the fuel burn constraints needed to achieve specific range requirements of the aircraft at Nautical Miles NM. In one embodiment, the aircraft has a center of mass location approximately Fuselage 12 is designed for high altitude operations. Main fuselage 12 defines a custom-luxury cabin and pilot deck, pressurized to 85, ft. The exterior of fuselage 12 may be implemented with structural sheet skins made of alloyed titanium 6. Doors may have aluminum structural cores covered with titanium skins. Aircraft empennage may be implemented with composite internal primary and secondary structure, high temperature composite skins, titanium alloyed leading edges. Windows of the aircraft 10 may comprise FAA conforming carbon-acrylic ceramic glass. The interior of fuselage 12 may be designed for any of custom super luxury for the VIP executive class, government officials and diplomats, cargo and accessory compartments, heavy cargo, medical supply and cryogenic refrigeration capable, and even specialty and luxury high worth transport items capable such as thoroughbred race horses, cabin sized for this accommodation. The aircraft 10 disclosed herein may have the performance as follows. The operational speed of air craft is believed to be up to Mach 3. Aircraft 10 may have a payload-range of 70, lb. Aircraft 10 may have a cruise altitude of 81, ceiling at 12 PSI cabin pressurization; a cruise speed of Mach 3. Aircraft 10 may have powerplant and fuel system, as follows. Engine and fuel control maybe digital and fiber optic full autonomous control and power systems hierarchical sensor systems architecture. Aircraft ignition may be electromagnetic superconducting pulse phase start and continuous pulse phase power in a ion plasma starter configuration. Engine indicating may be implemented with automated fiber optic control and display, flight deck sensor board and touch control indicating. Engine exhaust may be implemented with plasma accelerated control and thrust attenuation to supported electric supercruise at design Mach cruise conditions. Aircraft 10 utilizes magnetic levitation turbine engines, all electric aircraft and airframe, therefore reducing the need for oil on board the aircraft. Engine start up maybe achieved by ground start cart, conventional operating start conditions; airborne start capable upon necessity. Aircraft 10 utilizes a magnetic transmission and power transfer thereby eliminating the need for an accessory gearbox or main turbine shaft. Avionics suite may be implemented with: Aircraft lights may utilize standard and flight mode approach. Flight Controls may be implanted with quad-redundant all electric actuation and plasma actuator aerodynamic controls. Other systems within aircraft 10 may be implemented as follows. Air conditioning may utilize environmental health controls of passengers through internal channeling of air conditioned air. A fire protection system may be certified to extend beyond FAA certification using aerogel fire protection blanket systems between outer skins, inner hull liners and structural spars and stringers. Landing gear may be implemented with single double forward bogie on nose gear, swinging forward; triple axle, single bogie main gear rotating inward to central fuselage plane, all electric actuation. An onboard oxygen supply system may be implemented with on-board electric oxygenation generation generators, eight located above inner top hull lining covering air masses sufficient to cover 20 passengers and a crew of four. Numerical Methodology of QHESCT Wing Aerodynamics The curved, highly swept leading edge of the wing 14 also serves the purpose of supporting aerodynamic stability in low-speed high alpha flight, approach and landing speed conditions high-alpha is high, nose-high flight conditions, approaching stall , as well as being optimized for high mach number flight, but carries a washout condition distal to the wing join to induce laminar flow near stall and promote a high lift condition high lift to drag ratiosâ€"high lift, low drag at design Mach cruise conditions. In essence a hybrid aerodynamic condition exists where the performance and numerical analysis of the inner wing panel and geometric aerodynamics there perform in a low speed environment for a highly swept delta, and the aerodynamic condition of the inner wing delta functions in a higher speed airflow speed environment. Here, as it relates to the aircraft configuration, the third quantity defining the hybrid wing environment is the Reynolds number.

DOWNLOAD PDF DESIGN AND TESTING OF LOW SONIC BOOM CONFIGURATIONS AND AN OBLIQUE ALL-WING SUPERSONIC TRANSPORT

Chapter 3 : CiteSeerX â€" Citation Query Sonic Boom Minimization

This team developed two different configurations: a conventional wing-tail and a canard wing, in an effort to reduce the overpressure of shock waves and the accompanying noise which are projected to the ground from supersonic civil transport aircraft.

For supersonic flight, the planform is designed to achieve optimum aspect ratio, span, and sweep angle to minimize wave drag. This will allow the airplane to have high subsonic performance with short take-off and landing distance and low stall velocity due to low wing loading. The whole 3-D configuration is symmetric about the longitudinal and lateral planes. A flat pressure surface of the airfoil used as the isentropic compression surface is employed to cancel the downward shock and sonic boom. Diminished take off noise will be achieved by attaining a low stall velocity and mounting the engines on the upper part of the airplane in order to shield the jet noise. A novel LE radial air injection to delay LE stall is suggested to avoid using the conventional LE slats system, which is heavy and complicated. The rotation transitional time will be short enough not to lose lift and the acceleration is so small that no passenger discomfort will be created. This design has the mission requirements of a cruise f Mach 1. Introduction Supersonic civil transports have always been a topic of aircraft design engineers, scientists, and business professionals due to the potential to reduce inter-continental travel time. The Concorde, the first supersonic civil transport to carry passengers, ceased service in due to high operating costs. However, the dream of travelers to fly at supersonic speeds has never stopped. Supersonic transports SSTs have two major problems: The first factor that affects efficiency is the extra drag contribution during supersonic flight: Wave drag does not exist for subsonic airplanes and is not a serious problem for transonic flight due to the low supersonic Mach number. At take-off and landing, the low flight speed requires a high aspect ratio and low wing sweep angle. High-speed cruise however requires the opposite characteristics. Noise is an issue caused by the sonic boom that propagates to the ground from the shock waves created by the leading edges of a supersonic airplane and its components. A supersonic airplane cannot be economically and environmentally viable if the efficiency and noise problems are not resolved. The flying wing and blended wing body concepts eliminate the non-lifting fuselage component of the conventional tube and wing configuration, so efficiency during subsonic flight is improved. However, the flight of a supersonic flying wing or blended wing body configuration for civil transport has not appeared, and the full conceptual study of such configurations is rarely seen. The oblique flying wing OFW concept first proposed by Jones was intended for the development of supersonic flying wings. However, there are some difficulties with oblique flying wing or oblique all wing OAW concepts. First, the configuration of an OFW is asymmetric about flight direction. The asymmetry of the configuration may create serious problems for stability and control, in particular at a high sweep angle. All flying animals have symmetric bodies about the flight direction, which is an evolution of nature after millions of years. Second, to accommodate sufficient headroom for passengers, the airfoil thickness must be high and the OFW airplane size will be usually very large. This is because an OFW stacks the airfoil to align with the low speed flight direction and form a high aspect ratio elliptic planform. Hence, the airfoil chord is short. This is very different from the regular flying wing concept with the airfoil aligned with the flight direction and a long chord length. The high thickness airfoil of an OFW would not be favorable for supersonic Mach number flight due to the large wave drag. The large airplane size would also create airport operating difficulties. Interestingly, none of them adopted the OFW configuration. Instead, they used tube-wing configurations accompanied by the wings implemented by the oblique wing. The oblique wing designs of NASA12 and Boeing13,14 were for supersonic cruise, and the General Dynamics15 design was for high subsonic cruise at a Mach number of 0. The most promising potential advantages of oblique wings seem to be the improvement of aerodynamic efficiency with variable sweep angle and aspect ratio at different speeds. However, the oblique wing configuration does not have an inherent advantage in reducing sonic boom. Studies performed by scientists including Jones, Seebass, and George have concluded that by implementing bluntness at the tip of the aircraft, shock boom will be minimized. This is caused by a gradual loss in intensity as the shock wave travels from the aircraft to the ground. Unfortunately, this design also implements substantial drag. A sharp nose design on the other hand is aerodynamically efficient but produces a much stronger shock at mid-field and far-field distances from the aircraft. However, McLean found that the pressure signature that reaches the ground from a long slender aircraft with minimal weight change will not fully develop into the far-field N-wave form. However, this design is intended for a small civil transport carrying 8- 14 passengers. Use of this concept to achieve the goal of a larger civil transport with passengers is not feasible due to the much larger sonic boom that must be minimized. Previous efforts have focused on either reducing sonic boom or improving aerodynamic efficiency for the supersonic airplane system. So far, there is no viable aerodynamic system concept for supersonic airplanes that can achieve both high aerodynamic efficiency and low sonic boom. The SBiDir-FW concept is to combine the advantages of conventional symmetric airplane configurations for stability and variable sweep of oblique wing for high aerodynamic efficiency. In addition, the SBiDir- FW adopts an isentropic compression pressure surface configuration to cancel sonic boom and a leading edge LE injection flow control method to increase stall margin. First, the airplane is a symmetric flying wing with a thin airfoil stacked in the cruise flight direction to achieve high supersonic aerodynamic efficiency and sufficient volume. Second, the wave drag is minimized by the thin airfoil and the lifting load distribution along the long length of the flying wing. Third, the pressure surface of the flying wing is an isentropic compression furface, which minimizes the shock wave propagating downward and the resulting sonic boom. The flight planform direction is rotated by 90O to change from a high sweep angle at supersonic speed to a low sweep angle at subsonic speed and vice versa. Thus, a high aspect ratio will be achieved at low speed and a low aspect ratio at high speed. Fifth, a novel active flow control method using radial flow injection at leading edge is suggested to delay the leading edge stall due to the sharp leading edge. This report applies the SBiDir flying wing SBiDir-FW concept to the design of a supersonic civil transport that achieves supersonic cruise efficiency, low sonic boom, and high lift for take-off and landing. Geometry25,26,42,43 The conventional supersonic airplane always has the dilemma to favor supersonic performance and penalize the subsonic performance or vice versa. The reason is that at supersonic speeds a high sweep wing with small cross-sectional area is preferred to minimize the wave drag. However, at subsonic speeds, a small sweep with high aspect ratio is preferred to have large lifting surface, high dynamic pressure, and small induced drag. It can be observed that depending on the direction of flight, different aerodynamic characteristics are employed. For subsonic flight, a low sweep angle is present and a large span is available; for supersonic flight, the wing is highly swept and its span is short ensuring the aircraft will be completely inside the Mach cone and thus reducing wave drag further. For this design it was observed that a double-delta type of leading edge LE was favorable and that the use of sweep angles of 80O and 60O displayed proficient aerodynamic characteristics for supersonic cruise conditions. For simplicity, the point of change of sweep is located at one quarter the length of the aircraft as shown in Figure 1. The ability of SBiDir-FW to accommodate to the different flight conditions is due to the symmetry it exhibits for each flight direction; hence, it is required of this concept to be accompanied by an airfoil that is symmetric about its half-chord point. Because of the condition of symmetry, the maximum thickness must be at the half-chord point as well. The shape selected for this design was, for the suction surface, a circular arc, and for the pressure surface, a flat plate, as depicted in Figure 2. This airfoil is the one used along the span of the wing when flying supersonic; therefore the maximum thickness line is the lateral x axis in Figure 1 for supersonic flight, and inherently the longitudinal y axis for subsonic flight. Even with the boundary layer displacement thickness effect on the pressure surface, the Mach waves are expected to be diverged without coalescence. At non-zero AoA, an isentropic compression pressure surface needs to be designed using characteristic method. The sharp leading edge of the airfoil will further weaken any shock waves due to 3-D effect. The wave drag is expected to be significantly lower than that of the conventional tube-wing configuration and oblique wings that usually do not have a sharp LE and the conical shocks generated are full annulus. Therefore, by using the thin circular-arc airfoil section with a flat pressure surface, a low sonic boom and low wave drag can be expected. The geometry of the airfoil was selected mainly thinking on the cruise section of the mission since it is there where most of the fuel consumption occurs and where the sonic boom propagation is most critical. Therefore, although the planform geometry was designed with both subsonic and supersonic flights in mind, the airfoil section geometry for the subsonic mode of the aircraft will rather depend on the LE shape of the wing. The subsonic airfoil sections vary in shape and thickness across its span as shown in Figure 3. Figure 4 presents the thickness distribution for both supersonic and subsonic modes. At subsonic mode, the sharp LE may reduce the airplane stall margin. There are three ways to resolve this problem First, conventional airplane LE slats can be used to create the effect of a round LE. During supersonic cruise, the slat will be stored inside the airplane and extended outward during subsonic flight. The slat system requires moving parts, which introduces extra weight and system complications. The second method proposed is an innovative method of using radial air injection at the sharp LE as shown in Figure 5 a. The aerodynamic principle is that a uniform flow superimposed with a source flow will create a blunt body flow as shown in Figure 5 b. By adjusting the source strength, the effective LE radius R can be controlled. This will be a much simpler way to increase the LE effective radius in order to reduce LE stall. This technique can be used for all kinds of airfoils at subsonic and supersonic flight. However, it appears particularly useful for supersonic airfoils. Third, the sharp leading edge stall margin and lift enhancement may be achieved by using the delta wing detached leading edge vortices. The mesh is H-type and is inclined to measure the sonic boom two body-lengths below accurately with the angle depending on the cruise Mach number. For this design the Mach number is 1. The CFD analysis was only applied to the supersonic configuration. A future paper will present the CFD analysis for the subsonic configuration. Figure 8 shows the results for lift coefficient CL and pressure drag coefficient CDp for a range of angles of attack AoA. Figure 10 shows the isentropic Mach contours for the upper and lower surfaces at different AoA. A strong shock on the upper surface and a bottom surface that remains almost uniform is evident for every AoA analyzed. This demonstrates that the shock waves at the bottom of the circular-arc airfoil are not as strong as the ones at the top, which was expected from theory. Figure 11 further illustrates these findings with the distributions of pressure and flow Mach number around the aircraft. The implications of these phenomena towards sonic boom propagation are presented at a later section in this paper. Using the initial constraints, a preliminary estimate of the aircraft weight at different flight stages was made by using standard estimates of the weight of passengers and crew, luggage, cockpit, engines, and other components. Once weight was calculated, a selection of the overall length see Figure 1 was performed. The constraints that mostly affected the selection of the length were the maximum height of the aircraft reached by this length i.

Chapter 4 : aerodynamics - Could Mach be a better design point for SST? - Aviation Stack Exchange

Get this from a library! Design and testing of low sonic boom configurations and an oblique all-wing supersonic transport. [Christopher A Lee; United States. National Aeronautics and Space Administration.].

This, in turn, leads to penalties in the form of degraded vehicle performance at low speed and increased structural weight. As the cruise Mach number is increased, the optimal slenderness of the vehicle increases as well, creating even further disparity between the best cruise design and the best low-speed design. Another critical design conflict arises because the optimum engine bypass ratio decreases as Mach increases. Design compromises result in degraded subsonic performance and lower usable maximum lift during low-speed flight. As a result, almost 40 percent of the fuel carried at takeoff is devoted to low-speed flight and reserve fuel. Offsetting the difficulties associated with higher Mach numbers is the increased utilization distance flown per year that higher speeds make possible. Equation 2 is plotted in Figure , assuming that and have values of 0. The wave drag terms, , and the term containing ARl are set to 0 below Mach 1. Page 20 Share Cite Suggested Citation: The National Academies Press. As the cruise speed of a supersonic aircraft increases, specific fuel consumption also increases. However, this increase has not been demonstrated in operational engines. Furthermore, parametric design studies of supersonic airplanes show that designers have much less freedom to make necessary compromises than with subsonic aircraft. Most work to date has focused on the higher speeds to increase the benefit in terms of utilization. Based on more recent estimates of environmental constraints, however, a range of 1. As described in the preceding section, improved vehicle configuration designs are also likely to be a key part of reducing sonic boom to levels that might permit overland supersonic flight. State of the Art Research in supersonic aircraft aerodynamics, which has been ongoing for almost 50 years, has been marked by intermittent effortsâ€”first in the late s and early s when the Concorde was developed and a U. Although the estimates for the HSCT are somewhat optimistic, the improvements in cruise performance and particularly in subsonic performance are significant. For a design range of 5, NM and with an assumed engine efficiency of 45 percent and an empty weight fraction of 0. Several promising concepts, while immature, may become key features of a successful future commercial supersonic aircraft. Related Promising Technologies Supersonic aerodynamics could be revolutionized by successful technologies in any of four areas: Supersonic laminar flow has long been recognized as a potential breakthrough that might reduce skin friction drag by as much as 90 percent. But achieving extensive laminar flow has been an elusive goal. Substantial efforts are being made to achieve laminar flow for subsonic aircraft, but results have not been particularly encouraging. Research on suppressing the transition from laminar to turbulent flow using active flow control via suction, blowing, or time-dependent boundary-layer manipulation continues in many laboratories, but the prospect of developing an economically viable system of this sort remains remote. Perhaps more intriguing is the possibility that laminar flow may be more easily maintained at supersonic speeds than at lower speeds. A few related approaches involve the careful design of wing surfaces to achieve favorable streamwise pressure gradients and minimize cross-flow transition. These approaches range from those described by Tracy et al. The latter concept, while more sensitive to disturbances and aimed at achieving laminar flow over 25 percent of the wing surface, permits the use of substantial wing sweep. The more mildly swept natural laminar flow concept has demonstrated much larger extents of laminar flow in recent flight tests but may incur structural penalties because of the need for very thin wings. In addition, the short lifting length of the reference concept is difficult to reconcile with the requirement for shaped sonic boom signatures. Research on each of these concepts is in its infancy but, if successful, may have a dramatic effect on achievable supersonic aircraft performance. It appears feasible to extend these ideas with additional measures for cross-flow suppression. Active cooling or passive techniques for suppressing the initial cross-flow instability White and Saric, may permit additional sweep on the supersonic leading-edge natural laminar flow concept or more extensive laminarity for the subsonic concept. The second area of general interest for dramatic improvements in supersonic aerodynamics involves much more speculative approaches to the modification of the flow field. Active flow control, virtual shaping, and energy addition in various forms have been proposed for many years as a possible means for reducing wave drag or sonic boom amplitude. The committee does not believe that any of these approaches promise near-term breakthroughs in supersonic Page 21 Share Cite Suggested Citation: Indeed, some of them appear to have no reasonable physical basis, while others are either too complex to evaluate at this time or feature concepts whose practical implementation is hard to imagine see, for example, Rethorst and Kantner, ; Rising and Vadyak, ; and Soloviev et al. Future research programs should consider investigating such concepts, with the understanding that success, while unlikely, would be important. A third alternative is to investigate unconventional designs that attempt to address some of the fundamental problems encountered with supersonic aerodynamics. These range from nonplanar and multiple-surface configurations to asymmetric, oblique wings. Several of these ideas are based on fundamentally sound aerodynamics, but integrating them into practical aircraft designs has been difficult. In some cases, this is due to a basic limitation of the concept. For example, the oblique all-wing concept that accommodates passengers inside the wing structure appears to offer spectacular aerodynamic performance and great potential for reducing sonic boom, but it is difficult to configure as a passenger aircraft unless it is scaled up to accommodate passengers Jones, ; Seebass, In other cases, the complexity of the configuration may limit the applicability of simple analyses, and the associated risk and large amount of work required to develop appropriate analysis methodologies cannot be accommodated within the time and resource constraints of ongoing supersonic research programs. Immature vehicle configurations also have a hard time competing against vehicle configurations that have long histories of wind tunnel testing and computational design analyses. The solution to this dilemma may lie in the development of analytical methods that permit higher-fidelity analysis of new concepts early in the design cycle. High-fidelity analysis of unconventional vehicle configurations is just now becoming feasible and represents a true opportunity for breakthrough technology. Advances in computational algorithms for aerodynamic analysis and shape optimization, together with a revolution in computer hardware capabilities, now make it possible to consider a much wider range of design possibilities at a level of detail formerly restricted to a single baseline design. More mature flow solvers, improved representations of boundary layer turbulence, and methods for efficient calculation of flow field sensitivities to design changes make the evaluation of alternative design concepts feasible. Coupled with advances in techniques for multidisciplinary optimization, such capabilities hold out the promise that unconventional concepts can be transformed into practical breakthrough technologies. As an example, consider the concept of natural laminar flow. Until recently, the ability to predict transition of a three-dimensional boundary layer and use this prediction to design a wing with extensive laminar flow was a remote possibility. Indeed, tests on an F in the late s showed that limited laminar flow could be achieved, but tools were not available to analyze the results, let alone use them to design a wing. More recently, a specified wing design was analyzed to assess its potential for extensive natural laminar flow Agrawal and Powell, The conclusion was that despite the small sweep, little laminar flow would occur. Current computations including nonlinear computational fluid dynamics, three-dimensional boundary layer analysis, and stability calculations have made it possible to successfully optimize a wing for extensive laminar flow. Combining this capability with structural analysis and more comprehensive aircraft performance calculations would greatly advance the prospects for using natural laminar flow to significantly improve the performance of a commercial supersonic aircraft. Basic and Applied Aeronautics Research Future research programs that would support the development of the technologies described above should include the following: New supersonic wind tunnel capability may also be needed. These instabilities must be stabilized using high-authority, flight-critical feedback control Page 22 Share Cite Suggested Citation: Furthermore, owing to their size and shape, large commercial supersonic aircraft will also exhibit unusually low structural-vibration modal frequencies. For example, the 1- to 1. Either aerodynamic instability or structural flexibility considered separately would present significant technical challenges. Taken together, they create severe frequency coalescence between the rigid-body and structural modes that must be carefully examined before developing the flight-and structural-mode control systems. Hence, both phenomena are encompassed by the acronym APSE, which can refer to either aircraft-pilot servo-elastic or aero-propulsive servo-elastic phenomena. Although both APSE phenomena fundamentally depend on structural deformations, APSE is not an aeroelastic problem per se and it cannot be solved by methods used to counter classical aeroelastic flutter. Regarding the aircraft-pilot servo-elastic phenomenon, the excitation of the elastic modes of aircraft with structural modal frequencies below 2 Hz which is a natural consequence of turbulence and pilot control inputs will be orders of magnitudes greater than that encountered in other transport aircraft. If left unmitigated, these modal excitations would create unacceptable handling quality and ride quality. Configuration Design Implications Both forms of APSE phenomena are exacerbated by vehicle configurations with long and slender fuselages and thin or highly swept wings, by lightweight hence low stiffness structural design, and by increased aerodynamic instability, all of which are key factors in achieving high-performance, low-boom commercial supersonic aircraft. Thus, even though APSE effects are likely to be a major factor in defining the vehicle configuration for next-generation commercial supersonic aircraft, their importance in this regard is not generally recognized and they are rarely incorporated into the early stages of aircraft design. Consequently, research into APSE phenomena and their causes, along with new analysis and synthesis tools, is required. These tools include new active-control concepts, new control-system synthesis techniques, and aeroelastic modeling approaches that may be used in the vehicle configuration-design phase and integrated into multidisciplinary optimization techniques. Additional Research Required Low-frequency structural vibration modes will require active structural mode control systems that are highly integrated with the primary flight-control systems. Success in this effort will be particularly beneficial because solving the control problems associated with low-frequency structural vibration modes is one key to resolving both forms of APSE phenomena. New techniques must be developed and validated for designing affordable, certifiable, highly integrated, high-authority flight- and structural-mode control systems. Research in handling qualities is necessary to develop design criteria for aircraft control systems. Additionally, novel sensors and actuation devices, along with novel distributed control approaches, must be considered. Options include 1 multidisciplinary configuration optimization techniques that capture both types of APSE phenomena, 2 active or smart structures, and 3 viscoelectric or electrorheological materials. This is not an appropriate organizational structure for handling the issues associated with these APSE phenomena. As previously recommended by the NRC in an assessment of the HSR Program, interdisciplinary teams should be formed to fully address relevant aspects of the APSE problem, and the organizational distance between groups responsible for 1 guidance and control systems and 2 structural-mode control laws should be reduced or eliminated NRC, Experimental programs should be initiated as a first step in establishing better handling- and ride-quality requirements for highly unstable and highly flexible aircraft and associated flight control and structural-mode control systems. Real-time, manned simulations of the dynamics of these vehicles, however, would severely tax both fixed-base and inflight simulation facilities, limiting the ability to establish 4 Anna-Maria McGowan, NASA Langley Research Center, personal communication with David Schmidt, These time histories reveal an undamped oscillatory instability beginning at about 19 normalized time units. In the first power-spectra plot, on the left, calculated early in the time history, there is little correlation between the peak-power frequency of the stick input and the lateral accelerations. But in the power-spectra plot on the right, which is calculated from the traces in which the instability is evident, the peak power of the stick input shows a strong correlation with the peak power of the lateral acceleration. This indicates a feedback process is present between the cockpit accelerations and the stick input. These data further indicate that the instability is inadvertentâ€”the pilot could not avoid the instability despiteâ€”or because ofâ€”stick inputs intended to maintain stable flight. The ability of national simulation facilities to deliver high-fidelity manned simulations of highly flexible aircraft may need to be upgraded. For aircraft, the importance of integration increases with flight speed. Supersonic aircraft are much more sensitive to how components and disciplines are Page 24 Share Cite Suggested Citation: Stringent requirements for component performance with attendant development, manufacturing, cost, and operational issues , coupled with the economic and environmental challenges faced by commercial supersonic aircraft, leave little room for inefficiencies in the design of the airframe, engine, flight controls system, or other performance-critical systems. Design integration tools should allow design teams to interact in the design of complex systems where technical and other factors including cost can be appropriately traded; to compress the design cycle time by concurrently considering all critical constraints and disciplines; to adapt quickly to changes in design and manufacturing processes; to easily accept new and improved tools; and to provide databases with levels of complexity appropriate to each task. Fortunately, a substantial national investment has been made in tools for integrated design, including system engineering methods, multidisciplinary optimization methods, detailed discipline methods and interfaces, and design-integration frameworks. The aircraft design and manufacturing industry is heavily committed to improving such tools. Universities and the government also have critical roles in advancing the state of the art in many of these areas. Despite the progress that has been made, important work remains to be done. Existing tools cannot model some key technologies e. At the broad technical scale, it is extremely important to begin with a full understanding of the design objectives and constraints, such as payload, range, takeoff gross weight TOGW , noise, sonic boom, and cost, and to identify all the critical disciplines.

Chapter 5 : Aircraft Design Information Sources: Advanced Design/Unusual Concepts: Oblique Wing Conc

Abstract. From December to June , applied aerodynamic research support was given to the team working on Low Sonic Boom configurations in the RAC branch at NASA Ames Research Center.

Several designs for integrating and supporting a propulsion system with reduced transonic and supersonic drag are disclosed. A tail-braced wing configuration for supporting a propulsion system installation with minimum draft interference and reduced structural weight is provided. A method for designing an improved wing in the presence of a propulsion system supersonic pressure disturbance is also provided. The drag reducing features synergistically help in meeting a shaped sonic boom minimized lift and area distribution. The tail-braced wing design and other asymmetric area distribution features further reduce the shaped sonic boom minimum. For example, boom pressure at audible frequencies may be reduced 30 to times for business jets. Provisional Application Serial No. Field of the Invention [] The present invention relates to supersonic aircraft, joined-wing aircraft and sonic boom reduction, separately and in combination, for long range supersonic cruise aircraft with reduced sonic boom loudness. Description of Related Art [] A number of prior patents and technical reports have individually described technologies for joined-wings, low supersonic drag and sonic boom minimization. Further design studies and actual supersonic aircraft revealed shortcomings that reduced and eliminated the perceived advantages of such designs. Although tandem and connected wing designs have been proposed in prior patents, such designs are unfavorable because the wing downwash on the following wing and pitch stability were not taken into account. Downwash created by one wing reduced the lifting efficiency of any nearby or following wing, requiring a greater angle-of-attack to generate the same lift. This reduction in lifting efficiency increased induced drag and reduced pitch stability. Trailing wings carried very little lift or often a down load to trim an aircraft with the center-of-gravity far enough forward for positive pitch stability. Current artificial stability technology allows the trailing wing lift to be slightly increased, but also increases development cost. Downwash is the main reason why biplane and canard airplanes were abandoned and now serve only in applications not primarily based on efficiency. Box-wings and tip-connected joined-wings claim vortex drag reductions as their primary improvement. However, the contribution of vortex drag to total drag and the vortex drag benefit of interconnection diminish as speed increases supersonically. Another important requirement of supersonic applications is the need to keep cross-sectional area distributions as low as possible and minimize second derivative changes, also known as area ruling, to reduce wave drag. Blunt and unswept wings, blunt connecting elements and superimposed connections have rapid cross-sectional area changes that produce high wave drag supersonically. Supersonic surfaces and bodies need to be sharp or swept greater than the Mach cone angle and need low thickness-to-chord ratios. Unfortunately, reducing the sonic boom due to volume results in a sonic boom due to lift that is typically stronger than the combined lift and volume boom. This counter-intuitive result occurs because the lift is concentrated in a length shorter than the vehicle length and the typical area ruled volume superimposes an expansion where the lift is located, mitigating the lift. As for energy techniques, the energy in the boom pressures is equivalent to the entire propulsion system output that balances them, suggesting impractical power requirements. The wings are connected by vertical struts, which cannot provide joined-wing in-plane stiffening or box-wing vortex induced drag reduction. However, it is only suitable for low speed flight having its connections superimposed, no wing sweep and an excess of bracing struts and wires. This is recognized to form a truss arrangement, reducing wing loads. Multiple trailing wings have increasing drag due to increasing downwash. While there would be a vortex drag reduction, the wings are close causing high interference downwash and the vertical interconnecting structures cannot transfer loads in-plane for less strength and rigidity benefit. Further, both wings are highly sweptback, resulting in little torsional stiffness improvement leading to increased weight to resist flutter and aeroelastic elevon reversal. The interconnecting fins are also superimposed with the wings, creating increased area unsuited for compressible flow regimes. First, in having a rearwardly swept wing connected at the tip, by a vertical fin, to a forwardly swept wing, increased torsional stiffness eases aeroelastic problems. However, the box-wing is not claimed to resist lift loads in-plane, so it is more similar structurally to dual cantilevered wings. Second, reduced transonic and supersonic wave drag is attributed to the greater length over which the wing volume is spread. Unfortunately, this improvement is greatly reduced with practical longitudinal stability requirements. A stable box-wing as shown requires a download from the aft wing to trim and current artificial stability systems would only allow a small upload, so trim drag and flight control system impacts must be considered when assessing benefits. The design is suited to a low speed, ultralight-type aircraft stressing simple construction and rugged design at the expense of performance. The design is in particular claimed suited to flexible lifting portions made material such as canvas. The acute angle and wing superposition at the tip results in high interference and wave drag in compressible flow regimes. Further, the short distance between the control surfaces and the center-of-gravity results in a large trimmed loss of flap lift and increase in drag. Finally, the preferred embodiment describes that elimination of the wing tip vortex eliminates sonic boom. Current theory attributes the formation of sonic boom to the downward momentum imparted to the air to generate lift and the volume disturbance. As this design shows no area ruling and a relatively short vehicle length, the theory would indicate greater than average sonic boom at the ground. The wings do form an interconnected structure capable of carrying loads in-plane for lighter weight. The wings are superimposed at their tips and drawings indicate an attachment structure that reduces channel closure but add further tip volume, causing increased wave drag. The upper wing is swept more so that its trailing edge is positioned approximately over the leading edge of the lower wing. However, the tips are connected through a blunt leading edge plate that would have high stress. In addition above about Mach 1. The design is not suited for high speeds or altitudes requiring pressurization with a rectangular fuselage cross-section. As the lifting body is very low aspect ratio with very short end plates, induced drag would be very high for the lift developed on the fuselage. The wing tip connections are staggered and separated by a blending structure, reducing interference drag but resulting in high stresses in the blending structure. The sweptback wing is attached to the fuselage at a lower elevation than the sweptforward wing. All drawings show high aspect-ratio span divided by chord wings for subsonic applications. Large streamlined members are shown for staggered wing connections. These lighten the weight for load transfer but incur a friction area increase. The streamlined members are also shown with their maximum thickness aligned with the sweptback wing maximum thickness, and fin-wing connections are superimposed. Both superpositions reduce the drag divergence Mach number and increase transonic and supersonic wave drag. The claims further teach that the structural box should be strengthened in opposite corners whose diagonal is more out-of-plane with the connecting wing. However, the structure of the stiffening would need to be different for multi-spar wings with mid-span connections. Design Patent , to Legeti shows an aircraft very similar to patent U. The design is not suited for flight in compressible flow regimes. Design Patent , to Argondezzi shows a box-wing arrangement similar to patent U. While reducing interference drag of a superimposed wing tip connection, the instability and inability to efficiently lift from the aft wing and trim the aircraft eliminate much of the claimed advantages. Design Patent , to Ratony shows an arrangement similar to design patent , to Argondezzi except that the wing tips are joined in tandem to a common streamlined member with triple winglets. The unswept center wing and pusher props are not suited for flight in compressible flow regimes. It teaches improvements for short and vertical takeoff and landing designs for subsonic cruise speeds. The planer wings cannot provide bracing of lift loads. The control surface is used to regulate the strength of the boom minimized, triangular, nose pressure spike to match non-standard conditions or to eliminate the spike drag penalty during over water operation where somewhat louder boom has been accepted. The smaller vertical separation of the fuselage-mounted wings reduces the induced drag benefits and amplifies previous comments regarding stability reduction or increased trim drag. Since the wings are coplaner, structural bracing of lift load is not possible, and therefore, is carried like cantilevered wings. Joints show coplaner fairings that increase area at connections increasing transonic and supersonic drag. Design Patent , to Hartmann et al. These studies focused on configuring a joined-wing for optimum aerodynamic and structural tradeoffs, and determined that the weight savings of inboard joint locations outweighed the aerodynamic advantages of tip joint locations. They also found that a download on the aft wing or tail was needed to trim the aircraft percent statically stable. They further determined that their optimized joined-wing actually performed worse than the conventional design for this application. Supercruise applications typically have all of these characteristics. The high wing sweeps and resulting long structural load paths are poor at resisting aeroelastics and flutter. Moreover, propulsion nacelles cantilevered behind the maximum thickness increase flexure. The nacelle pressure drag may be recovered by altering the wing camber slope. Previous to this technique, flow calculations without nacelles were used to determine the wing camber slopes, or flexure, for a minimum drag, lift distribution. It was noticed that when nacelle pressures impinged on the wing, the lift distribution changed, and it was speculated that the wing should be, at least partially, reflexed to restore the original minimum drag, lift distribution. Nacelle pressure disturbance impingement calculations were made using an axisymmetric equivalent body and linearized theory. When the angle of the wing camber slopes was changed reflexed to restore the original lift distribution, the drag was improved, but the drag was reduced the most when only one-half to two-thirds of the slope change was used. In wind tunnel tests, recovering the nacelle pressure drag through wing reflexing often resulted in half or less of the improvement expected due to additional inaccuracies in calculation and manufacturing resolution. Wing reflexing diminished in importance as a design technique due to these marginally effective results. Shaping sonic boom is capable of loudness reductions of dB or higher, reductions with no additional energy requirement beyond that already needed for flight , and successful demonstrations beyond the near-field in wind tunnel tests. The key to understanding shaped sonic boom, using shaping to minimize loudness and applying the concept to practical aircraft designs, starts with understanding how aircraft pressure disturbances change as they propagate to the ground. No existing aircraft creates a shaped sonic boom that persists more than a fraction of the distance to the ground while flying at an efficient cruise altitude. Typical source pressure disturbances quickly coalesce into an N-wave, a shape with the largest shock magnitudes possible from a given disturbance. Since the front of a supersonic aircraft generates an increase in ambient pressure, and the rear generates a decrease in pressure, the variation in propagation speed causes aircraft pressure disturbances to stretch-out as they propagate to the ground. As the disturbances stretch-out they also tend to coalesce because shocks travel at halfway between the speed of the lower pressure ahead and higher pressure behind them. In general, to keep pressures from coalescing the pressures at the nose must have a large compression and the pressures at the tail must have an expansion, with the pressures in between constrained to weak compressions and expansions. This causes the ends of the signature to stretch out faster than the pressures between them, resulting in non N-wave sonic boom at the ground. Meaning that to achieve acceptable supersonic flight over land, the loudness of a sonic boom needs to be minimized. Shocks become quieter with decreasing magnitude and with increasing rise time of the pressure change. However, the shock rise time is inversely proportional to its magnitude although there is a large variability around this relationship in measurements. For example, two shocks of half the pressure of a single shock are about 6 dB quieter, and one shock of half the pressure is about 9 dB quieter. In summary, minimizing shock magnitude minimizes loudness. Sonic boom minimization methodology calculates the minimum shock strength possible subject to a compression slope input fraction below minimum coalescence slope, 0 for N-wave, 1 for flat-top signature for a given vehicle length and weight at the desired flight conditions.

DOWNLOAD PDF DESIGN AND TESTING OF LOW SONIC BOOM CONFIGURATIONS AND AN OBLIQUE ALL-WING SUPERSONIC TRANSPORT

Chapter 6 : Flying wing - Wikipedia

Since aircraft configuration plays an important role in aerodynamic performance and sonic boom shape, the configuration of the next generation supersonic civil transport has to be tailored to meet high aerodynamic performance and low sonic boom requirements.

Shock wave â€" In physics, a shock wave, or shock, is a type of propagating disturbance. When a wave moves faster than the speed of sound in a fluid it is a shock wave. In supersonic flows, expansion is achieved through an expansion fan also known as a Prandtl-Meyer expansion fan, unlike solitons, the energy of a shock wave dissipates relatively quickly with distance. Also, the accompanying expansion wave approaches and eventually merges with the shock wave, when a shock wave passes through matter, energy is preserved but entropy increases. Bow, Occurs upstream of the front of a blunt object when the flow velocity exceeds Mach 1. Some other terms Shock Front, The boundary over which the physical conditions undergo a change because of a shock wave. Contact Front, in a wave caused by a driver gas. The Contact Front trails the Shock Front, when an object moves faster than the information about it can propagate into the surrounding fluid, fluid near the disturbance cannot react or get out of the way before the disturbance arrives. In a shock wave the properties of the fluid change almost instantaneously, measurements of the thickness of shock waves in air have resulted in values around nm, which is on the same order of magnitude as the mean free gas molecule path. In reference to the continuum, this implies the shock wave can be treated as either a line or a plane if the field is two-dimensional or three-dimensional. Shock waves are formed when a pressure front moves at supersonic speeds, Shock waves are not conventional sound waves, a shock wave takes the form of a very sharp change in the gas properties. Shock waves in air are heard as a crack or snap noise. Over longer distances, a wave can change from a nonlinear wave into a linear wave, degenerating into a conventional sound wave as it heats the air. The sound wave is heard as the familiar thud or thump of a sonic boom, the shock wave is one of several different ways in which a gas in a supersonic flow can be compressed. Some other methods are isentropic compressions, including Prandtl-Meyer compressions, the method of compression of a gas results in different temperatures and densities for a given pressure ratio which can be analytically calculated for a non-reacting gas. A shock wave compression results in a loss of pressure, meaning that it is a less efficient method of compressing gases for some purposes. The appearance of pressure-drag on supersonic aircraft is due to the effect of shock compression on the flow 2. Vapor cone â€" When the localized air pressure around the object drops, so does the air temperature. If the temperature drops below the temperature a cloud forms. In the case of aircraft, the cloud is caused by supersonic expansion fans decreasing the air pressure, density, then pressure, density and temperature suddenly increase across the stern shock wave associated with a return to subsonic flow behind the aircraft. Since the local Mach number is not uniform over the aircraft, in addition to making the shock waves themselves visible, water condensation can also occur in the trough between two crests of the shock waves produced by the passing of the object. However, this effect does not necessarily coincide with the acceleration of an aircraft through the speed of sound or Mach 1 and these condensation clouds can often be seen appearing around space-bound rockets as they accelerate through the atmosphere. For example, they were seen during Space Shuttle launches, about 25 to 33 seconds after launch. Similar effects were visible in archival footage of some nuclear tests. Scientists observing the Operation Crossroads nuclear tests in named the transitory cloud a Wilson cloud for its similarity to the Wilson cloud chamber effect. In , Osborne Reynolds showed that noise interfered with laminar flow, as Mach I nears, the Doppler Effect increasingly concentrates aircraft sound intensity, with associated extreme increase in ultrasonic noise frequency. The intense high frequency noise of air in the anterior sound cone prevents laminar flow, with higher resistance to penetration by the leading edges. The high intensity anterior sound cone ultrasound field will heat the conical cloud disc, as Mach I is being exceeded, the sound barrier is breached as the aircraft slides into silent, low resistance, uncompressed laminar air. Proving highly adaptable, it was adopted by the U. Marine Corps and the U. The Phantom is a fighter with a top speed of over Mach 2. It can carry more than 18, pounds of weapons on nine hardpoints, including air-to-air missiles, air-to-ground missiles. The F-4, like other interceptors of its time, was designed without an internal cannon, later models incorporated an M61 Vulcan rotary cannon. Beginning in , it set 15 world records for performance, including an absolute speed record. The Phantom has the distinction of being the last U. It was also the aircraft used by both U. The F-4 was also operated by the forces of 11 other nations. Phantoms remain in front line service with five countries, Phantom production ran from to , with a total of 5, built, making it the most numerous American supersonic military aircraft. With no new aircraft competitions on the horizon, internal studies concluded the Navy had the greatest need for a new and different aircraft type, in , McDonnell Aircraft began work on revising its F3H Demon naval fighter, seeking expanded capabilities and better performance. The company developed several projects including a variant powered by a Wright J67 engine, the Jpowered version promised a top speed of Mach 1. On 26 May , four Navy officers arrived at the McDonnell offices and, within an hour, because the Navy already had the Douglas A-4 Skyhawk for ground attack and F-8 Crusader for dogfighting, the project now had to fulfill the need for an all-weather fleet defense interceptor 4. It was developed as a project from the Lockheed A reconnaissance aircraft in the s by Lockheed. American aerospace engineer Clarence Kelly Johnson was responsible for many of the innovative concepts. During aerial reconnaissance missions, the SR operated at high speeds, if a surface-to-air missile launch was detected, the standard evasive action was simply to accelerate and outfly the missile. Air Force from to A total of 32 aircraft were built,12 were lost in accidents, the SR has been given several nicknames, including Blackbird and Habu. It has held the record for the fastest air-breathing manned aircraft since Lockheeds previous reconnaissance aircraft was the relatively slow U-2, designed for the Central Intelligence Agency, in late , the CIA approached the defense contractor Lockheed to build an undetectable spy plane. The project, named Archangel, was led by Kelly Johnson, head of Lockheeds Skunk Works unit in Burbank, the work on project Archangel began in the second quarter of , with aim of flying higher and faster than the U Out of 11 successive designs drafted in a span of 10 months, despite this, however, its shape made it vulnerable to radar detection. Thirteen were built, two variants were developed, including three of the YF interceptor prototype, and two of the M drone carrier. The A flew missions over Vietnam and North Korea before its retirement in , the programs cancellation was announced on 28 December , due both to budget concerns and because of the forthcoming SR, a derivative of the A Originally named R by Lockheed, the Air Force version was longer and heavier than the A, with a longer fuselage to hold more fuel, Reconnaissance equipment included signals intelligence sensors, a side looking airborne radar and a photo camera. It had a speed over twice the speed of sound at Mach 2. First flown in , Concorde entered service in and continued flying for the next 27 years and it is one of only two supersonic transports to have been operated commercially, the other is the Soviet-built Tupolev Tu, which was operated for a much shorter period. Air France and British Airways were the airlines to purchase. The aircraft was used by wealthy passengers who could afford to pay a high price in exchange for Concordes speed. In the UK, any or all of the type are known simply as Concorde, the type was retired in after the crash of Air France Flight , in which all passengers and crew were killed. The general downturn in the aviation industry after the September 11 attacks in The group met for the first time in February and delivered their first report in April , at the time it was known that the drag at supersonic speeds was strongly related to the span of the wing. The team outlined a baseline configuration that looked like an enlarged Avro and this same short span produced very little lift at low speed, which resulted in extremely long take-off runs and frighteningly high landing speeds. In an SST design, this would have required enormous engine power to lift off from existing runways, based on this, the group considered the concept of an SST infeasible, and instead suggested continued low-level studies into supersonic aerodynamics. This effect had been noticed earlier, notably by Chuck Yeager in the Convair XF, Weber suggested that this was no mere curiosity, and the effect could be deliberately used to improve low speed performance. Although the delta had already used on aircraft prior to this point. Such a layout would still have good supersonic performance inherent to the span, while also offering reasonable take-off. It would also need to have landing gear to produce the required angle of attack while still on the runway. Lockheed F Starfighter â€" The Lockheed F Starfighter is a single-engine, supersonic interceptor aircraft which later became widely used as an attack aircraft. One of the Century Series of fighter aircraft, it was operated by the air forces of more than a dozen nations from to Its design team was led by Kelly Johnson, who went on to lead or contribute to the development of the Lockheed SR Blackbird, the F set numerous world records, including both airspeed and altitude records. The poor safety record of the Starfighter also brought the aircraft into the public eye, Fighter ace Erich Hartmann was forced to retire from the Luftwaffe due to his outspoken opposition to selection of the F The ultimate production version of the model was the FS, an all-weather interceptor designed by Aeritalia for the Italian Air Force. An advanced F with a wing, known as the CL Lancer, was considered. In a privately owned Starfighter is scheduled to launch a group of small cubesat satellites into low orbit by carrying the rocket aloft. At the time, the U. Armed with this information, Johnson immediately started the design of such an aircraft on his return to the United States. In March, his team was assembled, they studied several designs, ranging from small designs at 8, lb. The engine chosen was the new General Electric J79, an engine of dramatically improved performance in comparison with contemporary designs, the small L design powered by a single J79 remained essentially identical to the L Starfighter as eventually delivered. The design was presented to the Air Force in November , although all were interesting, Lockheed had an insurmountable lead, and was granted a development contract in March for two prototypes, these were given the designation XF Work progressed quickly, with a ready for inspection at the end of April. Meanwhile, the J79 engine was not ready, both prototypes were designed to use the Wright J65 engine, a licensed-built version of the Armstrong Siddeley Sapphire. The first prototype was completed by early and first flew on 4 March at Edwards AFB, the total time from contract to first flight was less than a year. Its official program name was Space Transportation System, taken from a plan for a system of reusable spacecraft of which it was the only item funded for development, the first of four orbital test flights occurred in , leading to operational flights beginning in Five complete Shuttle systems were built and used on a total of missions from to , the Shuttle fleets total mission time was days,19 hours,21 minutes and 23 seconds. Shuttle components included the Orbiter Vehicle, a pair of solid rocket boosters. The Shuttle was launched vertically, like a rocket, with the two SRBs operating in parallel with the OVs three main engines, which were fueled from the ET. The SRBs were jettisoned before the vehicle reached orbit, and the ET was jettisoned just before orbit insertion, at the conclusion of the mission, the orbiter fired its OMS to de-orbit and re-enter the atmosphere. The first orbiter, Enterprise, was built in for use in Approach, four fully operational orbiters were initially built, Columbia, Challenger, Discovery, and Atlantis. Of these, two were lost in accidents, Challenger in and Columbia in , with a total of fourteen astronauts killed. A fifth operational orbiter, Endeavour, was built in to replace Challenger, the Space Shuttle was retired from service upon the conclusion of Atlantiss final flight on July 21, The vehicle consisted of a spaceplane for orbit and re-entry, fueled by liquid hydrogen and liquid oxygen tanks. The first of four orbital test flights occurred in , leading to operational flights beginning in , all launched from the Kennedy Space Center, Florida. The system was retired from service in after missions, the program ended after Atlantis landed at the Kennedy Space Center on July 21, Major missions included launching numerous satellites and interplanetary probes, conducting space science experiments, the first orbiter vehicle, named Enterprise, was built for the initial Approach and Landing Tests phase and lacked engines, heat shielding, and other equipment necessary for orbital flight. Supersonic transport â€" A supersonic transport is a civilian supersonic aircraft designed to transport passengers at speeds greater than the speed of sound. Concordes last commercial flight was in October , with a November 26, ferry flight being its last airborne operation, following the permanent cessation of flying by Concorde, there are no remaining SSTs in commercial service. However, some aerial company aims at Supersonic business jet, which may bring supersonic transport back again, Supersonic airliners have been the objects of numerous recent and ongoing design studies. Drawbacks and design challenges are excessive noise generation, high development costs, expensive materials, great weight. Throughout the s an SST looked possible from a technical standpoint, lift is generated using different means at supersonic speeds, and these methods are considerably less efficient than subsonic methods, with approximately one-half the lift-to-drag ratio. This implies that for any given required amount of lift, the aircraft will have to supply about twice the thrust and this effect is pronounced at speeds close to the speed of sound, as the aircraft is using twice the thrust to travel at about the same speed.