Supersonic Transport

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Presentation Outline

- Description of an SST
- SST development programs
- Technical, political, and economic challenges of SST flight
- Why are we so fascinated by SSTs?
- Conclusions and cross cutting themes

What is an SST?

- A supersonic transport (SST) is an aircraft that is designed to carry passengers faster than the speed of sound
  - Speed of sound or Mach 1 is 761 mph (at sea level and 15°C)
    - Speed decreases as temperature and pressure decreases
  - Average speed of current jet aircraft is .8 Mach
  - The Concorde flew at Mach 2.04
- There are currently no supersonic aircraft providing commercial service
  - The Russian Tu-144 was the only SST built in quantity (last flight June 1978)
  - The Concorde was the only SST to ever provide lasting passenger service (last flight November 26, 2003)

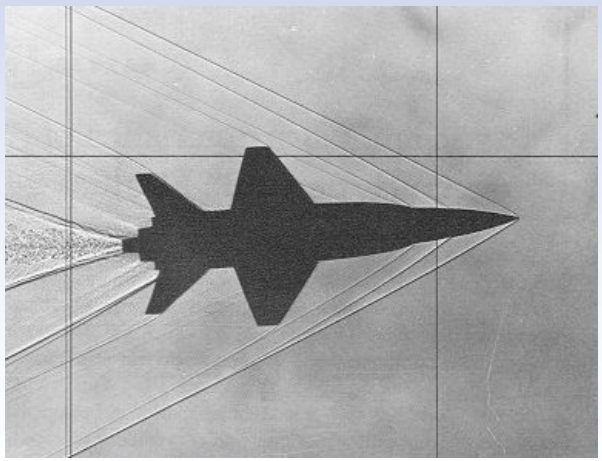
Concorde Technical

Two diagrams removed for copyright reasons.
Schematics of Concorde and its engine.

- 100 Seat Capacity
  - Height 1.96 meters (6’5”)
- Operational Weight: 78,700 kg
- Dimension
  - Length: 62.1 meters
  - Wing Span: 25.6 meters
  - Delta shaped wings
- Range: 6,230 km (3,870 miles)
- Service Ceiling: 1,525 meters (60,000 feet)
- Noise: 119.5 EPN dB
- Rolls-Royce Snecma 4 Olympus 593 Turbojets
  - 119,786 liters (31644 gallons) of fuel
  - .052 km/liter (.12 miles/gallon)

Challenges of Supersonic Flight

Courtesy of U.S. Navy (photo by Ensign John Gay).



Courtesy of NASA.

- Increased turbulence in the transonic regime
  - Increased drag and as a result fuel use
  - Increased skin temperature
  - Decreases lift
- Sonic Boom and Shock Waves
  - Different wing shapes are ideal for supersonic vs. subsonic flight
  - Engine casing that prevents shocks from forming inside turbojet are needed
- Very little sensation for passengers during supersonic

SST Technology Issues

- Noise and Emissions
  - Transition to supersonic speeds creates a loud sonic boom
  - The high altitude at which these aircraft fly means higher damage to the ozone layer
- Economics
  - Questionable economics of commercial operations

History

Breaking the Sound Barrier: Proving the Feasibility of Supersonic Flight

- 1940s NACA's (National Advisory Committee for Aeronautics) Langley Aeronautical Laboratory develops experimental supersonic aircraft to understand the transonic region
  - XS-1 (built by Bell Aircraft Company)
  - D-558 (build by Douglas Aircraft Company)
- October 14, 1947: test pilot Chuck Yeager broke the sound barrier by going at Mach 1.06 in the XS-1
- 1951 Whitcomb's transonic area rule allowed for a significant reduction of drag during the transonic regime
- November 1956: first flight of Convair B-58 Hustler (a Mach 2 capable bomber)
  - This aircraft was capable of achieving supersonic flight for only a short duration (minutes)

Cruising Along

- In 1956 Eggers developed the “supersonic wedge principle”
  - By placing the body of the aircraft entirely under the wing the shockwave produced by the body would create pressure on the bottom of the wing adding lift increasing aerodynamic efficiency at mach 3 by 20 to 30 percent (this would make cruising at supersonic speeds possible)
- 1956 the Air Force propulsion laboratory shows that blade cooling techniques could be safely applied to engines improving the supersonic efficiency
- October 1956 the Air Force redirects the WS-100 program toward sustained supersonic flight
  - 1957 Boeing and North American submit proposals for new supersonic aircraft

Excitement Mounts for a Commercial SST

- September 1952: Two Boeing Engineers publish a paper stating commercial SSTs are not feasible because of the increased costs (they recommended the idea be revisited in 30-40 years)
- 1956 Boeing starts a company funded project to study the development of a supersonic transport, and England soon followed with its own program
- By 1957 pressure to fund commercial SST research and development was mounting and a general belief that such a technology would be widely available within 10 to 15 years was spreading
  - One problem was the that project would need to be government funded since US manufacturers were hurting from producing the jet aircraft and did not have the resources for another large scale development project

The Need for Speed

- After the successful creation of supersonic military jets, the launch of Sputnik, and the burgeoning Cold War (all in the 1950s) the race to create a commercial version of the aircraft was on
- The United Kingdom, Soviet Union, France and the US all funded SST programs in the 1960s
  - In their view they were competing for continued balance of trade, technological parity or superiority, and national prestige
  - It was believed that a commercial SST would make the jet aircraft obsolete
- This development was conducted in a setting where increased speed was considered a virtue (good in its own right)
  - Cultural enthusiasm for technology (both pre- and postwar)
  - Faster transport and ways of doing business promised increased profits and a stronger economy
  - In aviation, progress came to be defined as higher speeds and altitudes

SST Timelines

- TU-144
  - Jun 1965: TU-144 model shown at Paris Air Show
  - Dec 1968: First prototype flies
  - Aug 1984: Aeroflot confirms it has ceased TU-144 service
- US SST
  - Jul 1961: SST steering group formed including FAA, NASA, DoD
  - Aug 1961: Congress approves $11m for FAA SST research
  - Mar 1971: House votes to delete all SST funds
- Concorde
  - Nov 1962: UK and French government sign agreement to produce an SST
  - 1969: First flight of prototypes; Shown at Paris Air Show in June
  - April 2003: British Airways and Air France announce retirement of Concorde
  - November 2003: Last flight

What Killed the US SST?

- Powerful detractors
  - Various groups and individuals spoke out against SST development from the early stages
  - The arguments against the SST were made primarily on economic grounds and some took issue with the amount of government support
- However, the main attack against the SST in the US came from the growing environmental movement
  - The movement was picking up speed at this time and targeting technology and industrial development as out of control and irresponsible
  - The SST singled out as symbolic of technology being put before environment
  - Educational campaigns as well as tests of sonic boom tolerance increased awareness of the noise issues associated with an SST
  - Questions regarding upper atmosphere emissions were also being discussed

Boeing Wanted the SST to Die

- While the political decision to cancel the SST program was highly motivated by the environmental outcry the SST program would have most likely died anyway
  - After the B747 was introduced the government began developing noise requirements for subsonic flights
  - It was decided that these standards needed to apply to the supersonic aircraft as well
  - This in turn meant that an new engine would have to be developed drastically increasing the costs of SST development and production

What Killed the Concorde

- High cost of operation
  - Round-trip flights could cost as much as $12,000
  - Small number of aircraft made volume profits impossible
  - Limited number of available airports (and limited fuel carrying capacity) reduced possible travel routes
- Environmental objections
  - Upper-atmospheric pollution became more of a public issue after ozone hole was discovered
  - Incredible noise pollution, which led also to. . .
- Political objections
  - Communities most affected by noise were barred from taking advantage of Concorde for economic reasons
  - Concorde was seen as another toy for the rich that negatively impacted the poor

What Killed the Concorde

- July 2000 crash
  - Shed light on safety concerns
  - Revealed questionable handling of safety problems in the past
    - A la the Columbia accident, very similar problems had occurred before with no accidents
  - Grounding of Concordes for more than a year cost British Airways and Air France vast sums of money
- September 11th
  - Return to flight announced on September 5th, 2001
  - General depression of commercial aviation industry made already difficult financial situation worse

Photo of Concorde taking off, trailing flames, removed for copyright reasons. Source: AP.

Recent SST Programs

- Late 1972 -1981: the National Aeronautics and Space Administration funded a much smaller program called the Supersonic Cruise Aircraft Research (SCAR)
- Upgraded Technology
  - Composite Fuselage
  - Latest in Thermodynamics
- 1989: NASA won approval of a third SST research program named High Speed Civil Transport (HSCT) cancelled in 1998
  - Mid-1990's Boeing forecasted that 800-1,200 SSTs could be used by 2020
  - Estimated cost of $30 billion
- Russian Tu-244
  - 300 seat M 2.05
  - Model shown at 1993 Paris Air Show

Recent SST Projects (cont.)

- Japanese SST
  - JAXA used 21% of its budget on SST
  - Working in conjunction with Russians and Australians
  - Recently launched test vehicle
- European Supersonic Commercial Transport
  - $20 billion in development and $6-$7 billion for engine
  - Engines at least 10% more efficient than Concorde's
  - In 2000 dollars, it is estimated that each aircraft would costs $350 million
  - Serve 524 routes

Two diagrams removed for copyright reasons.

Analysis

Decision

- Instead of focusing on a specific decision, we will discuss:
  - Why the SST was developed by some nations and not others
  - Why that development persisted even as costs and arguments against the programs mounted
  - The political and technical challenges confronting ongoing research in supersonic and now hypersonic flight

US vs. USSR

- SST: new territory for Cold War competition
- Focus on “getting there first”
- Soviets won the race
  - Flights continued for longer than US program existed
  - Impetuous for continuing civilian flights gradually disappeared
- In the US, circumstances were different
  - Belief that SST was the way of the future
  - Didn’t want to be left out of economy of future air travel
  - Government didn’t usually fund commercial aircraft development, and commercial developers became less enthusiastic about it
  - Open public discourse regarding environmental concerns was a significant impediment
  - When program was killed, President Nixon denounced decision

The Concorde

- British and French governments pump vast sums into SST program
  - Economic motivations included a desire to compete with aircraft production market then dominated by the US
  - Led eventually to Airbus Consortium
- First flight of Concorde prototype in 1969
- Contracts locked both French and British governments into SST program
  - Program was a *treaty* rather than a commercial contract
- Other countries were interested at first, but pulled out prior to completion of first commercial aircraft
- Commercial flights begin in1977

“Le SST”

- SST part of a French technological continuum
  - A variety of postwar technology programs emphasized French technological prowess and national pride
- A response to US/USSR Cold War brinksmanship
  - French resented US dominance of European continent
  - French mistrusted US political motivations and irresponsible behavior
  - Technological responses to political pressures
- From “Concord” to “Concorde”
  - Began with British spelling, ended with French spelling

Persistence

- Programs continued for a variety of reasons
  - Momentum
  - Lingering Cold War mentality
  - Culture of “progress”
  - Maintenance of competitive capabilities

Cross Cutting Themes

Cross Cutting Theme: 1

- Public perception of technology in decisions regarding massive development projects such as SST is key to the success or failure of these projects
  - Lack of focusing vision for SST inhibits public support
  - Apathetic attitude towards large-scale government projects
  - Political influence of interest groups over time (left-wing environmentalists when US SST program was killed in 1971 and right-wing, fiscally conservative groups today)
  - Imbalance of costs and benefits (both economic and social)

Cross Cutting Themes: 2

- National vision, political agendas, and social contexts drive and inhibit development of large-scale projects
  - Though another locus of Cold War competition, US and Soviet priorities diverged on SST
    - The success of the TU-144 program was less significant in the face of other, more intense technological competitions between the superpowers
  - Social interest groups in US gain influence as environmental and economic concerns become more prominent and well-defined
  - French national identity was strong during postwar period, and exploited by government in large-scale technological projects
  - Both France and Britain had political stakes in
    - maintaining technological independence from US
    - justifying public spending by continuing program

Cross Cutting Themes: 3

- SST case demonstrates the failure of technological determinism
  - Social, political and economic constraints outweighed whiz-bang nature of SST technology
  - Imbalance of costs and benefits with Concorde engendered resentment from people living in vicinity of airport
  - Rising environmental movement honed in on SST as an example of irresponsible technology development

Questions