Technology Integration Overview

53/02

Presented at the HSR
Configuration Aerodynamics Workshop
February 27, 1996
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Presentation Outline

- Technology Concept Airplane Description
- LCAP Overview
- ACE Overview

Purposes of HSR Technology Concept Airplane

Trade Studies and Sensitivities:

- Common base for technology assessment, analysis and testing
- Platform for assessing technology sensitivities, for example, Off-design performance, environmental, operational
- Common base for integrated system level trade studies

Technical Consistency:

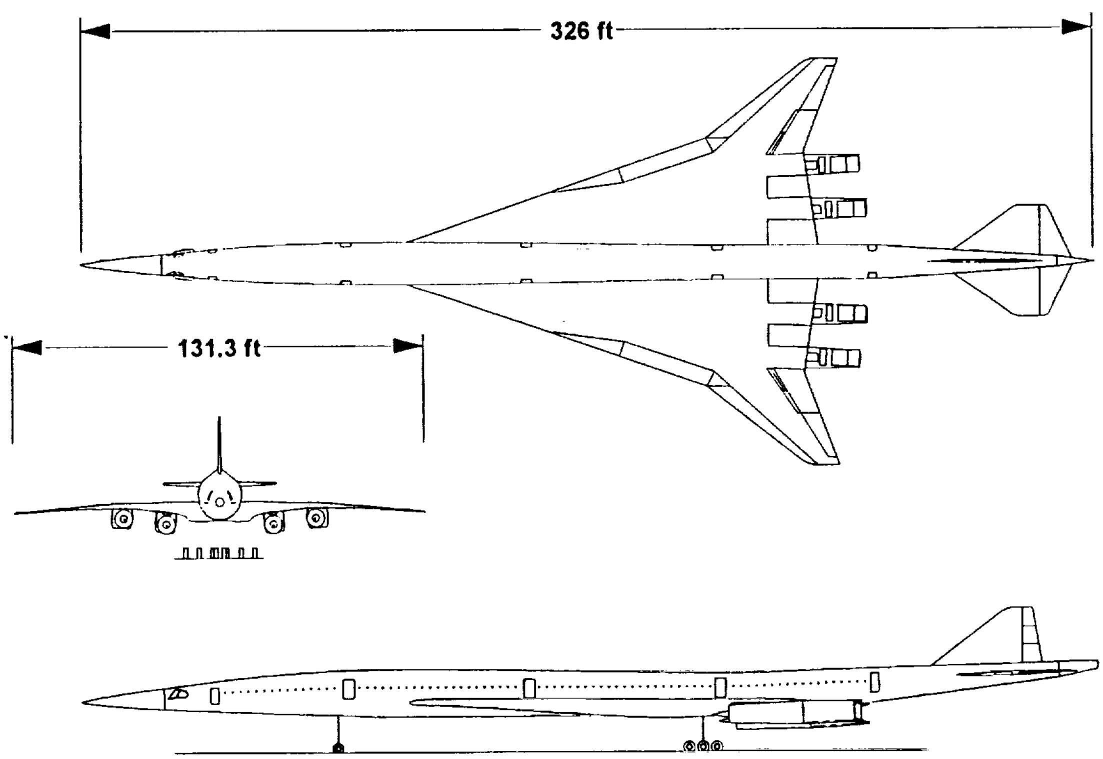
- Technology integration
- Technology cost/benefit analysis (prioritization)
- Vehicle level tracking

HSR Technology Baselines should be close enough to Industry baselines to ensure technology application

The HSR Technology Concept is:

- Not the latest industry baseline
- Not the vehicle for program economic assessments
- Updated only as required for technology development focus
- Not the EXCLUSIVE vehicle for technology downselects

HSR Technology Concept Airplane

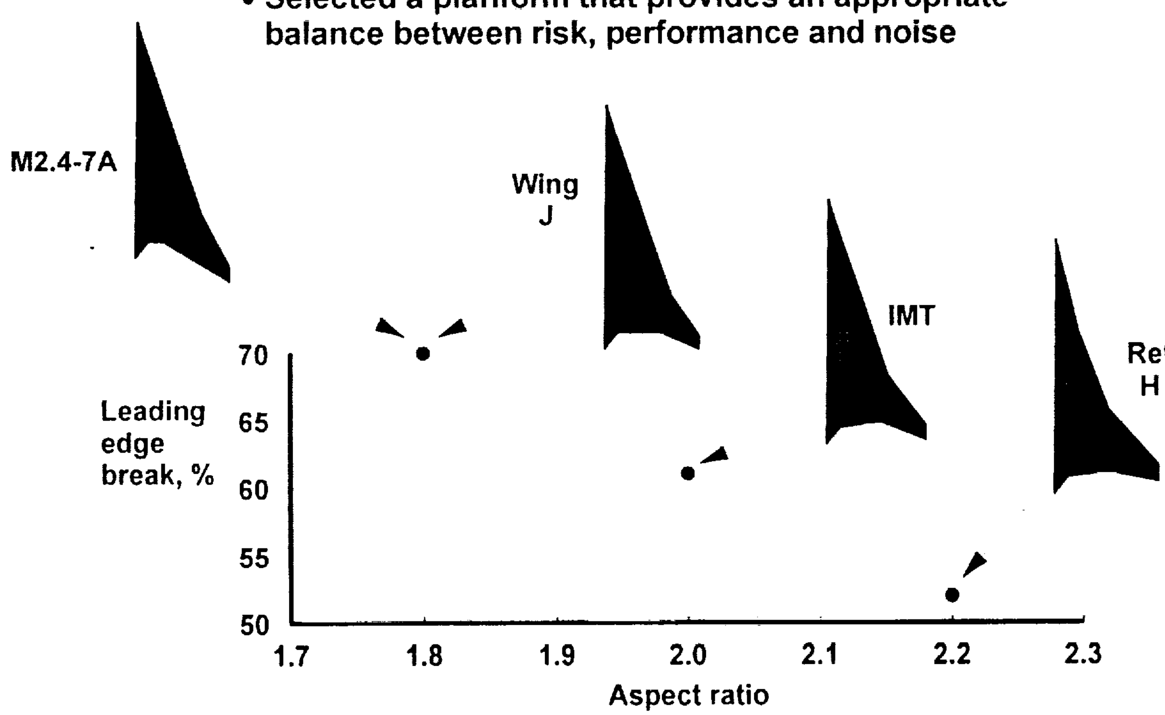


Design Assumptions

- Picked planform from planform studies conducted at Boeing and MDC
- Jointly developed a new fuselage based on MDC and Boeing best practices
- Defined a gear bay that will allow either MDC or Boeing gear concept to fit
- Switch to M3570.80 FCN MFTF
- Use "generic axi-inlet"
- Follow recommendation of Config Aero, Materials & Structures, Flight Deck, Propulsion and Environmental Impact teams

Picked Planform from Planform Studies Jointly Conducted at Boeing & MDC

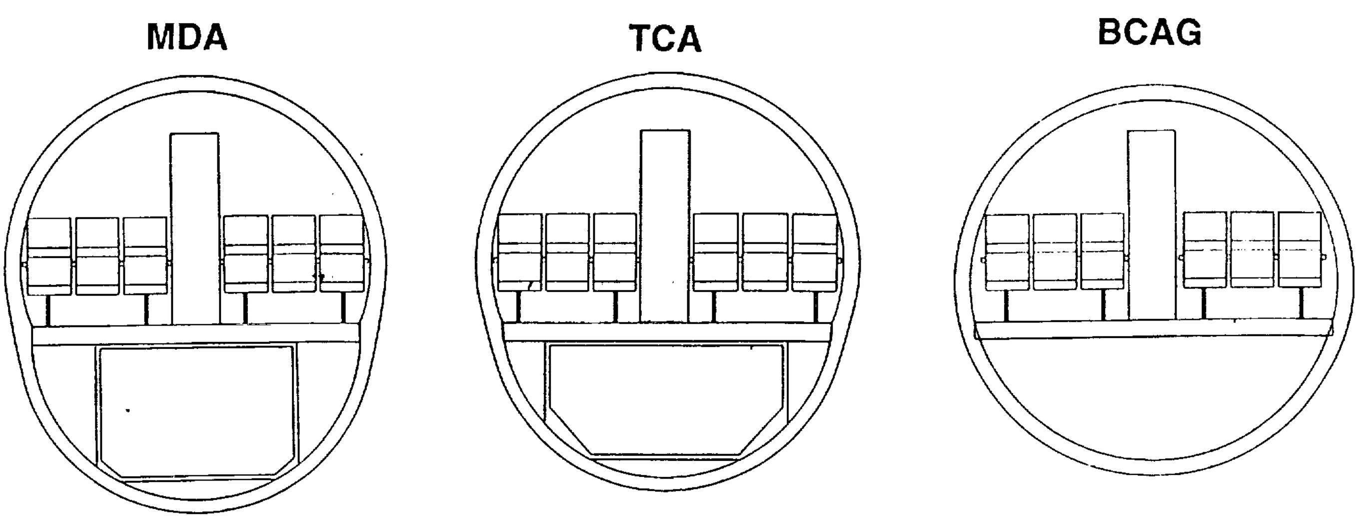
- Confirmed a relatively flat design space
- Selected a planform that provides an appropriate balance between risk, performance and noise



High Lift Concept

- Plain Flap
  - Leading edge flap covers 50% inboard panel and complete outer panel
  - Trailing edge flap covers entire wing span excluding engine cutouts
  - Three outboard trailing edge segments for high lift and control

TCA Cross-Section Reflects Best Practices

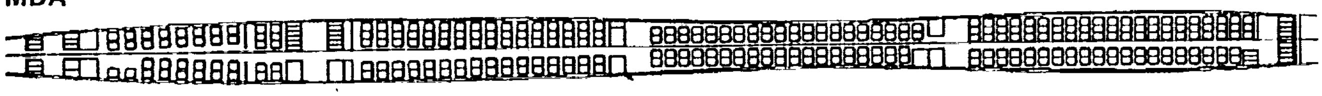


MDA	TCA	BCAG
Area: 162.5 sq ft	Area: 153.5 sq ft	Area: 153.5 sq ft
Baggage: 6 ft^3/Pass.	Baggage: 5 ft^3/Pass.	Baggage: 4.5 ft^3/Pass.
Ovalized	Ovalized	Circular

Interior Comparison

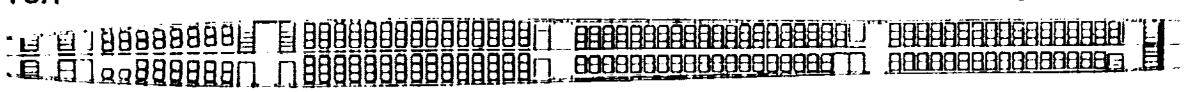
MDA

Body Length = 334 ft



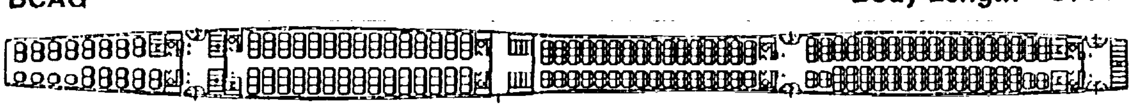
TCA

Body Length = 326 ft

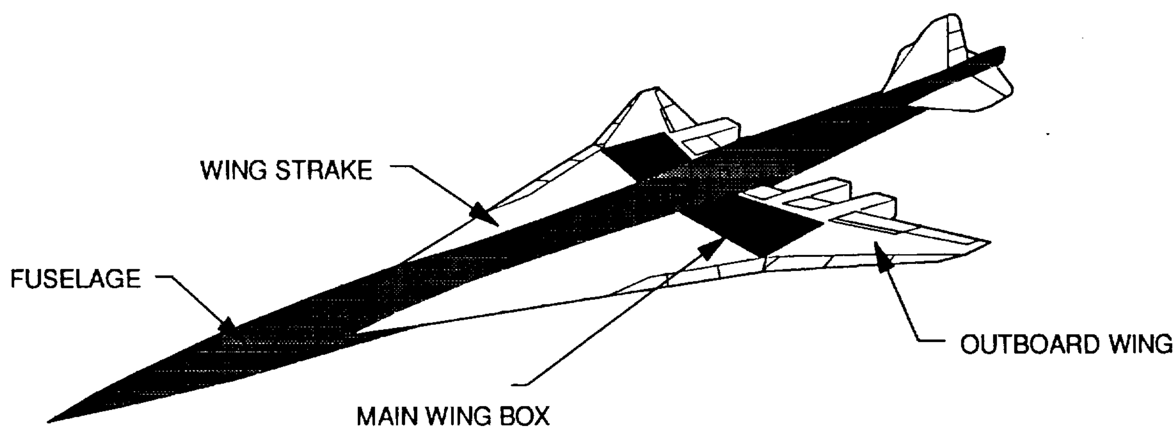


BCAG

Body Length = 314 ft



Structural Choices Made by Materials & Structures



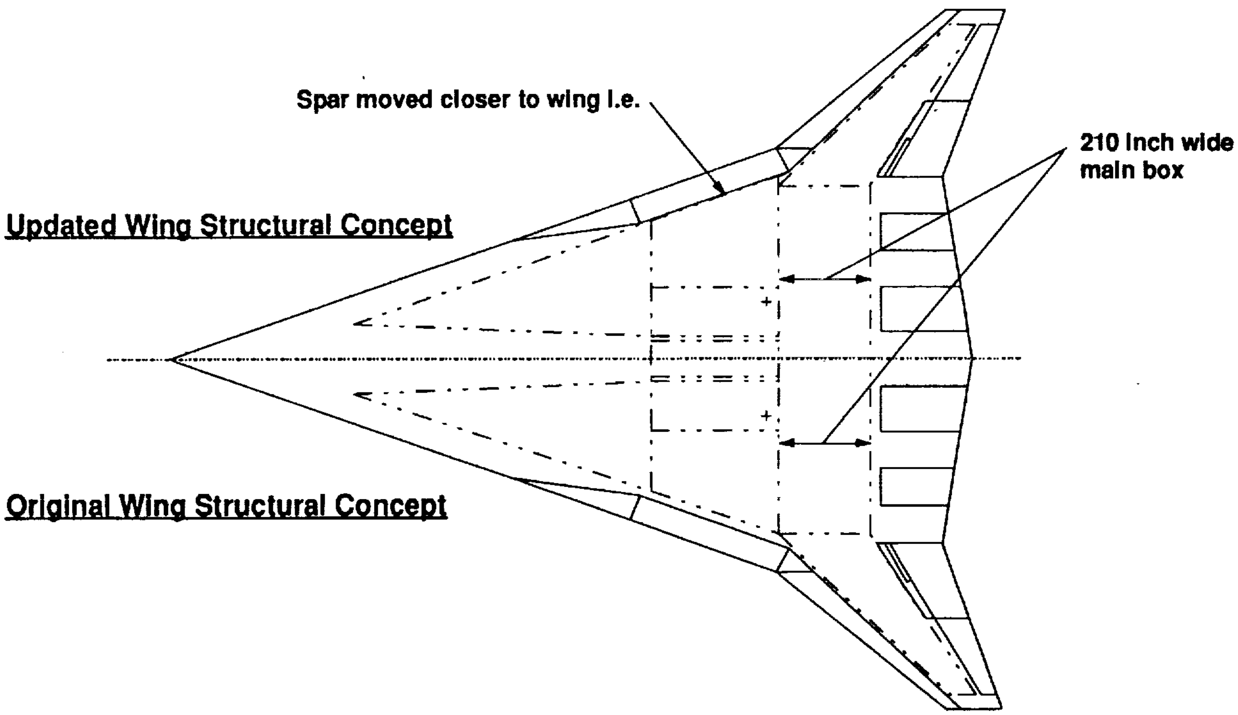
Used for TCA

	PRIMARY	ALTERNATE
FUSELAGE	PMC S/S	PMC, TI-PMC and TI SAND
MAIN WING BOX	TI SAND	PMC and SPF/DB SAND
OUTBOARD WING	PMC SAND	
WING STRAKE	PMC and TI-PMC SAND	

Materials & Structures recommendations based on meeting the HSCT weight goal

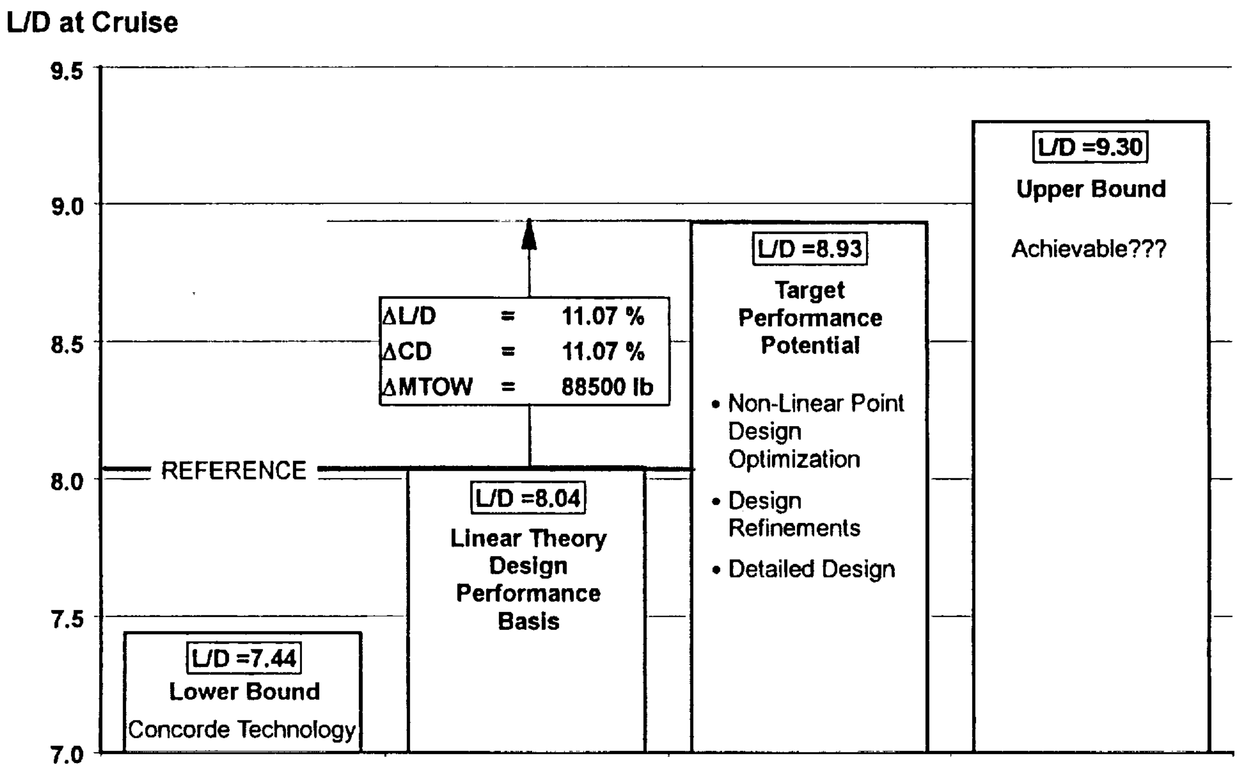
Materials and Structures will continue research on both primary and alternate

Resolved Wing Structural Concept with Design Integration Trade Study (DITS)

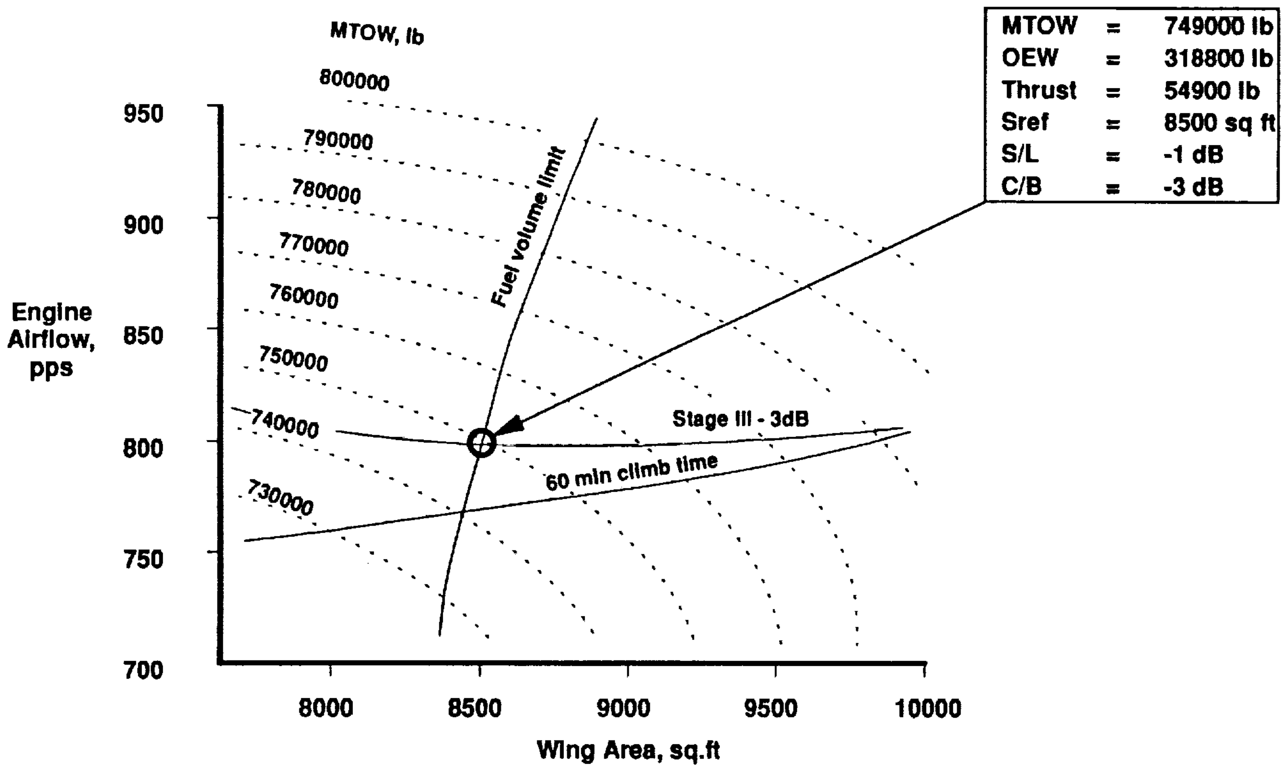


TCA Cruise L/D Projections

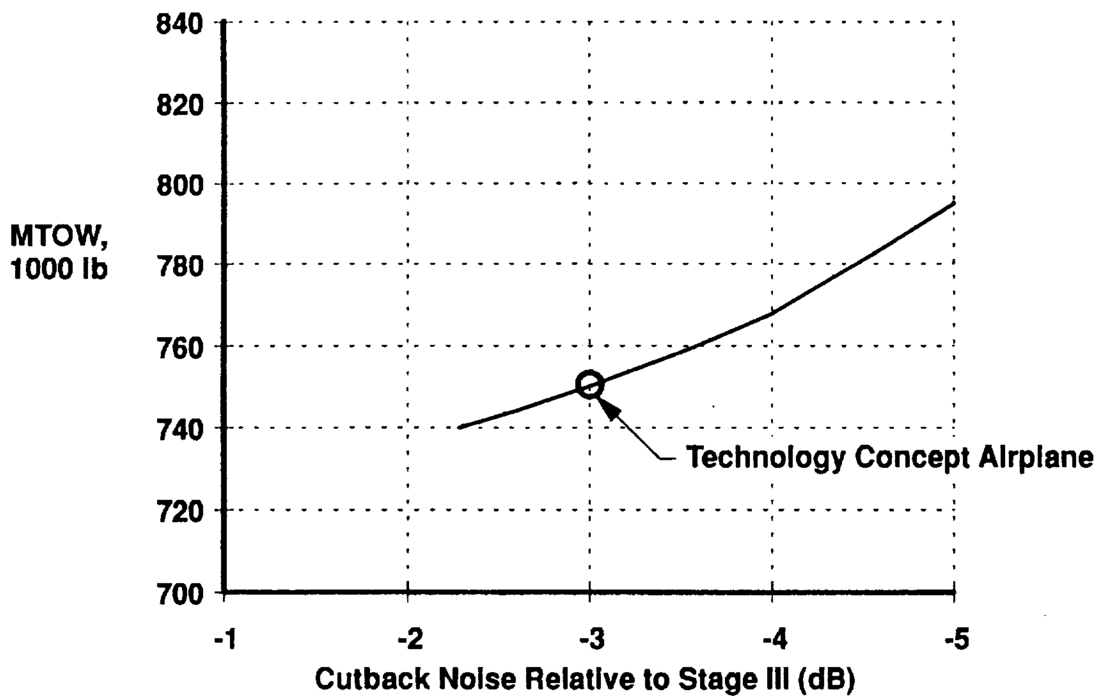
M = 2.4



TCA Sizing Chart



Cutback Noise Sensitivity



HSR Technology Concept Airplane

OEW Changes Relative to Interim Technology Baseline

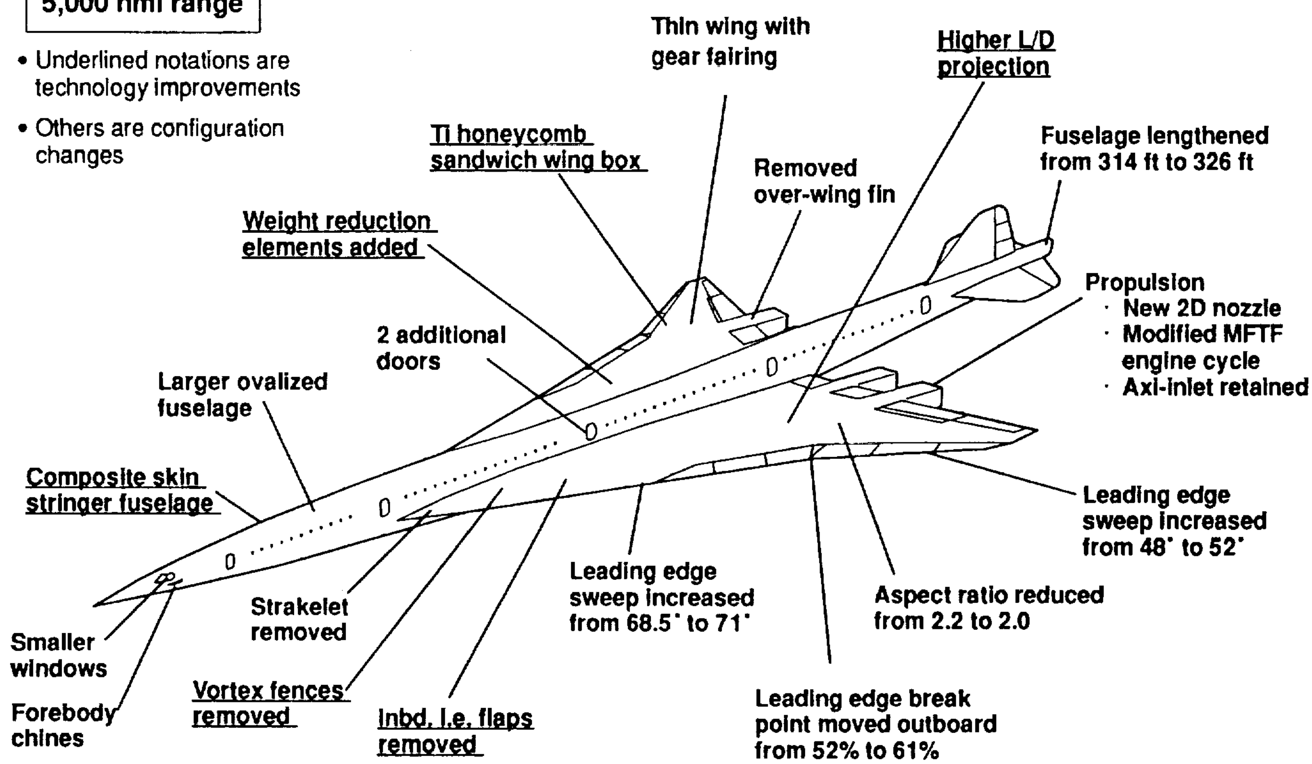
Interim Technology Baseline (sized)		**302600 lb**
CONFIGURATION CHANGES	+ 7500 lb	
• Wing Planform and t/c distibution		
• Body length and cross-section		
TMT RECOMMENDATIONS	+ 13500 lb	
• Structural material allowables and techniques		
• Engine cycle and nozzle type		
METHODS ADJUSTMENT	- 4500 lb	
• Common weight accounting		
• Common weight methodology		
Technology Concept Airplane (sized)		**319100 lb**

HSR Technology Concept Airplane

Changes Relative to Interim Technology Baseline

300 Passengers
5,000 nmi range

- Underlined notations are technology improvements
- Others are configuration changes



Near Term Plans

- Define OML (Outer Mold Line) by March 1, 1996
- Publish configuration document and data base by April 1, 1996

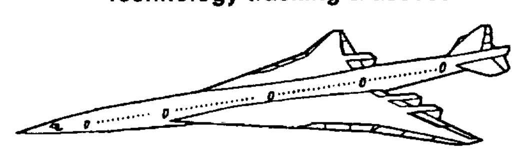
Longer Term Plans

The TCA will be used to support:

Aerodynamics
- CFD analysis/optimization
- Wind tunnel testing

Materials & Structures
- Finite element analysis
- Materials trade studies

Technology Integration
- Trade studies
- Technology tracking & assessment



LCAP Overview

- **Objective**
  - **Consistent evaluation of aft-tail, canard and three surface concepts to determine potential advantages for longitudinal control**
  - **Focus on elastic behavior**
    - Structural sizing with elastic loads and flutter
    - Handling and ride qualities
    - Relative MTOW
  - **Configuration recommendation for continued analysis**
- **Approach**
  - **Parallel studies**
    - Reference H based study by NASA with Boeing support
    - Arrow wing based study by McDonnell Douglas

Project Elements

- **Boeing cônfiguration data**
  - External geometry based on 1080-892
  - Structural model (FEM) based on 892STR
  - Weight and mass data (updated during sizing process)
  - Pre - HSR mission ground rules
- **NASA detailed analysis**
  - Rigid and aeroelastic loads
    - linear and nonlinear data
  - Subsonic and supersonic flutter analysis
  - Optimization based structural sizing with strength and flutter constraints
  - Rigid and flexible stability and control derivatives
  - Handling and ride qualities analysis
  - Assessment of control requirements
  - Vehicle performance and sizing

Project Constraints

- **Fixed Configuration**
  - No recamber, rebalance, tail sizing or area rule
- **Longitudinal characteristics only**
- **Limited experimental data for S&C**
  - Little transonic and supersonic with tail
  - Practically no data for canard and 3 surface
- **Assess Control Requirements only**
  - No rigorous control system design
  - Simple control laws applied to facilitate analysis
- **No propulsion-aerodynamic interactions**
- **No operational considerations**
  - ground servicing, LOPA, etc.

Aerodynamic Loads

Linear aerodynamics - USSAERO

- **Potential Flow method**
  - Compressibility, local Mach effect
  - Wing, body and control surface analysis
- **Vortex Wake shed downstream in plane of trailing edge**
  - No wake rollup
- **Pressures limited to stagnation and suction extremes**

Nonlinear aerodynamics - USM3D

- **Unstructured Euler method**
  - Finite volume, cell centered tetrahedra
- **Special boundary conditions for**
  - Base areas created by flap, control surface porting

Good agreement with analysis and experiment

Nonlinear Loads Correction

- Euler solutions obtained at known α, δ for all load cases
- Linear solutions obtained at α, δ to match total load from Euler solutions
- Δ loads calculated on the linear solution grid
- Load redistribution applied in aeroelastic trim process

LCAP Load Cases

ID	MACH	Alt (ft)	C.G	n (g's)	L.E. Flap	T.E. Flap	C_L
LX79	2.40	60900	aft	1.0	0	0	.121
LX42	.95	29000	aft	-1.0	10	0	-.219
LX43	.95	20700	aft	2.5	10	0	.382
LX45	.95	37500	aft	2.5	10	0	.816
LX52	1.20	34500	aft	-1.0	10	3	-.177
LX55	1.20	40500	aft	2.5	10	3	.590
LX56	1.20	52000	aft	-1.0	10	3	-.409
LZ25	.50	14000	aft	2.5	26	8	1.051
LZ26	.50	27000	aft	-1.0	40	13	-.725
LZ2X	.50	14000	forward	2.5	26	4	1.051
Lz2Y	.50	27000	forward	-1.0	40	8	-.725

Current Status

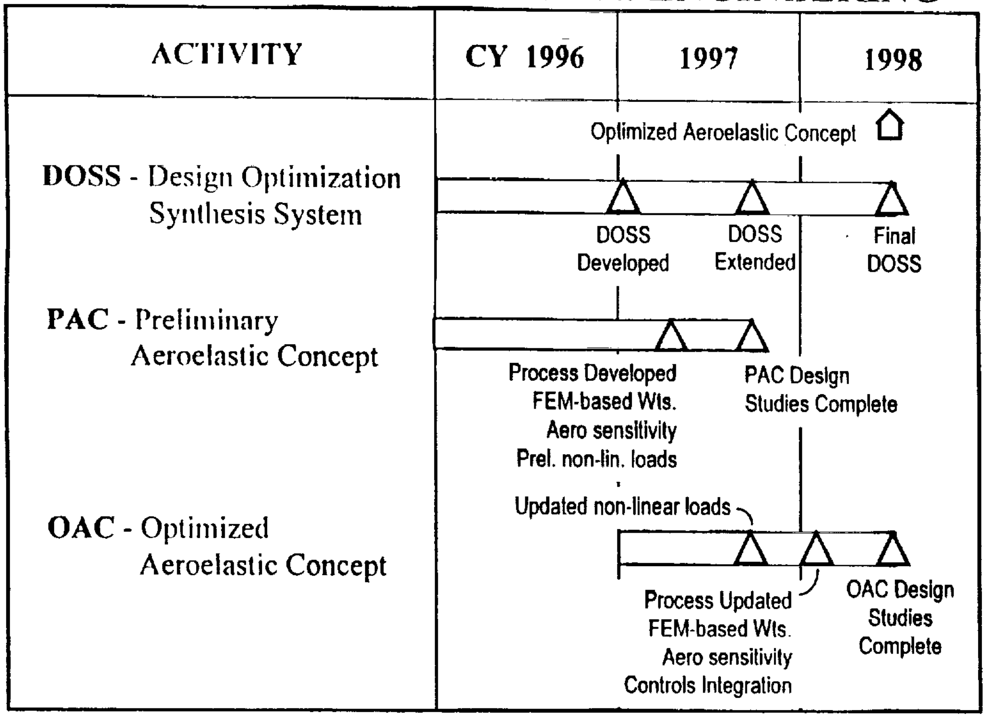
- **Activity scheduled to finish in March**
- **Aft tail configuration**
  - Completed all analysis
- **Three surface configuration**
  - Completed structural sizing with linear loads
  - Completed three cycles of sizing with nonlinear loads
  - Handling and ride qualities analysis in progress
- **Canard configuration**
  - Completed structural sizing with linear loads
  - Completed three cycles of sizing with nonlinear loads
  - Stability and control data ready

Aeroelastic Concept Engineering (ACE) Team Charter

Refine the Technology Concept Airplane (TCA) utilizing integration of aerodynamics, structures, propulsion, controls and aircraft sizing disciplines employing detailed CFD/FEM design tools and selective use of optimization techniques.

- Develop and validate processes/methods/tools to integrate the advanced technology being developed in the key individual disciplines into the aircraft design procedure
  - ensure all key interdisciplinary interactions are accounted for in the design
  - include optimization whenever/wherever feasible
  - leverage, not duplicate, work done in other elements of HSR
- Implement the new process to develop a new design - Optimized Aeroelastic Concept Airplane (6/98, Level II milestone)
- Use the new process to help guide the definition of the HSR Technology Configuration (12/98, Level I milestone)

HSR AEROELASTIC CONCEPT ENGINEERING



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Features of ACE Team Optimization Strategy

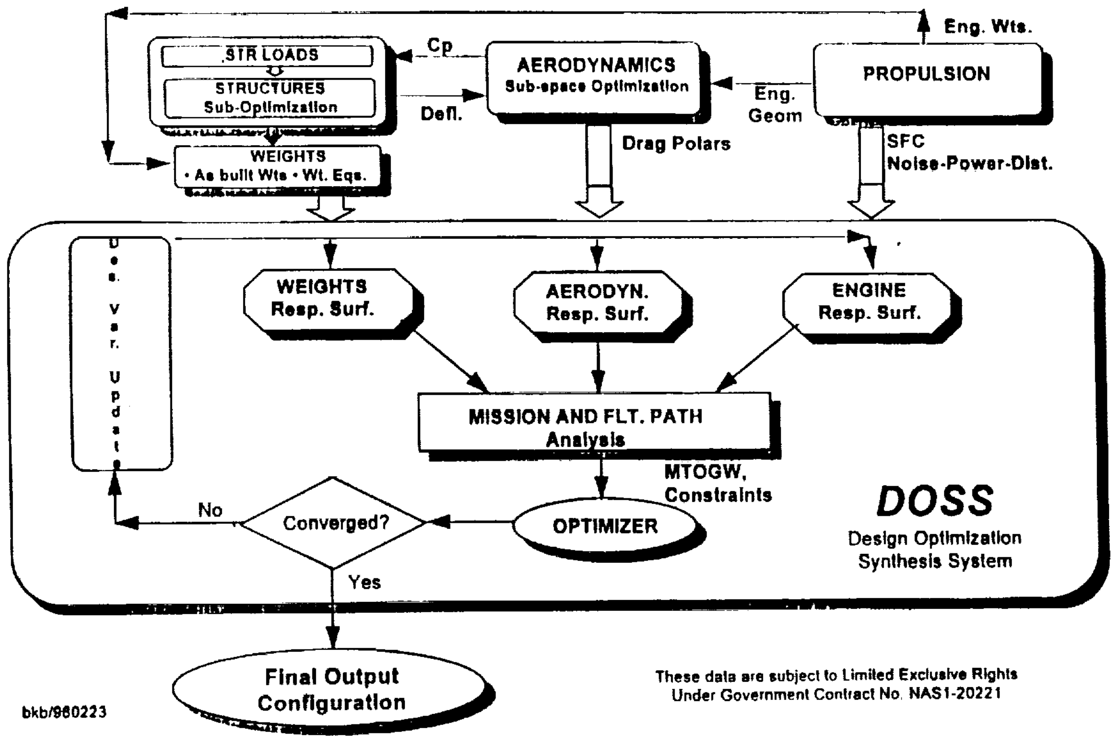
Overall Goals:

- Process accounts for all realistic airplane design constraints, and minimizes TOGW
- Process is practical and reliable
- Process is applicable at the conceptual/advanced design stage as well as at the preliminary design phase
- Process can be modified and augmented to suit specific needs of participating organizations in HSR
- It should be possible to maintain the autonomy of individual contributing disciplines

Strategy Adopted:

- The design process is split into individual contributing discipline groups
- Overall design process is based on exchanging data from the contributing discipline groups
- Individual disciplines work concurrently and maintain autonomy in prescribing procedures and processes to generate data for the design
- At the top level, the system will deal only with global variables - those design variables that have strong interdisciplinary coupling and/or significant impact on the airplane configuration
- Convergence for weakly interacting (local) design variables and the outputs achieved through multi-level iterative process
- Design system will be set up to handle realistic set of constraints

OVERALL ACE PROCESS



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Major Deliverables from ACE Team

DOSS - Design Optimization Synthesis System

- Basic system that integrates data from different disciplines contributing to the airplane design (12/96) - uses "advanced design" level of data in 1996
  - configuration optimization for a fixed flight path (9/96)
  - configuration optimization with optimized flight path (12/96)
  - use system for trade studies during 1997 and 1998
- Enhancements to integrate additional variables and FEM & CFD data (in 97 and 98)

PAC - Preliminary Aeroelastic Concept (9/97)

- Process for FEM-based wts, non-linear CFD Aero Performance, non-linear Aero loads
- Design recommendations from optimization of wing thickness/camber/twist distributions starting from TCA FY 96

OAC - Optimized Aeroelastic Concept (6/98)

- Process to include wing-box and planform variables, and aeroservoelasticity (controls effects) using FEM-based wts, non-linear CFD Aero Performance, non-linear Aero loads
- Design recommendations from optimization of wing thickness/camber/twist, planform parameters, engine parameters, and controls parameters starting from TCA FY 96

ACE Team Activities Within HSR

(Funded by WBS 2.1.3)

ACE TO DEVELOP / PERFORM

- Develop DOSS to integrate several disciplines
- Define global design variables
- Develop process to compute sensitivity of drag polars to global variables
- Perform multidisciplinary design studies for PAC and OAC

ACE TO UTILIZE

- Lessons learned from Acrodynamics work (CA & HL) related to the following
  - CFD code accuracy, robustness, efficiency
  - corrections to analysis data from WT tests
  - efficient procedures to incorporate nacelle-diverter effects

ACE / TI TO PROVIDE

- Recommendations on optimum thickness, camber and twist distributions from PAC design studies
- Recommendations on opt. planform parameters, spar locations and engine size from OAC design studies

ACE WOULD LIKE TO COORDINATE

- With Configuration Acrodynamics on multi-point design studies

ACE's Perception of Aero Activities Within HSR

AERO TO DEVELOP / PERFORM

- Procedures to perform aerodynamic contour design optimization for given planform and constraints on spar depth and locations, etc.. Aero methods/processes will be developed for such things as - generating exact airfoil shapes for best L/D, nacelle-diverter integration for minimizing drag, leading edge shaping, high lift system definition, fuselage shaping (?)
- Develop WT database and Calibrate / improve analysis codes

AERO TO PROVIDE

- Guidance / expertise on Aerodynamics issues to support ACE funded work
  - codes to use and/or modify for computing sensitivity derivatives
  - corrections to CFD data based on WT results
  - procedure to handle nacelle-diverter effects
  - realistic low speed drag polars
- Experts to work on generating sensitivity derivatives (for ACE funded activity)

AERO TO UTILIZE / COORDINATE

- Design constraints on global variables from ACE and TI (from baseline updates)
- Coordination with ACE on multi-point design strategy and approach