OVERVIEW OF NASA HSR HIGH-LIFT PROGRAM

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First Annual High-Speed Research Workshop
May 14-16, 1991

INTRODUCTION

The NASA High-Speed Research Program is being conducted to develop the technologies essential for the successful U.S. development of a commercial supersonic air transport in the 2005 timeframe. The HSR program is being conducted in two phases, with the first phase stressing technology to ensure environmental acceptability and the second phase stressing technology to make the vehicle economically viable (in contrast to the current Concorde design). During Phase I of the program, a key element of the environmental emphasis is minimization of community noise through effective engine nozzle noise suppression technology and through improving the performance of high-lift systems.

This presentation presents an overview of the current Phase I High-Lift Program which is directed at technology for community noise reduction. The total target for takeoff engine noise reduction to meet expected regulations is believed to be about 20 EPNdB As noted in Figure 1, the high-lift research is stressing the exploration of innovative high-lift concepts and advanced flight operations procedures to achieve a substantial (approximately 6 EPNdB) reduction in community noise to supplement the reductions expected from engine nozzle noise suppression concepts; primary concern is focused on the takeoff and climbout operations where very high engine power settings are used. Significant reductions in aerodynamic drag in this regime will allow substantial reductions in the required engine thrust levels and therefore reductions in the noise generated.

HIGH-LIFT REDUCES COMMUNITY NOISE

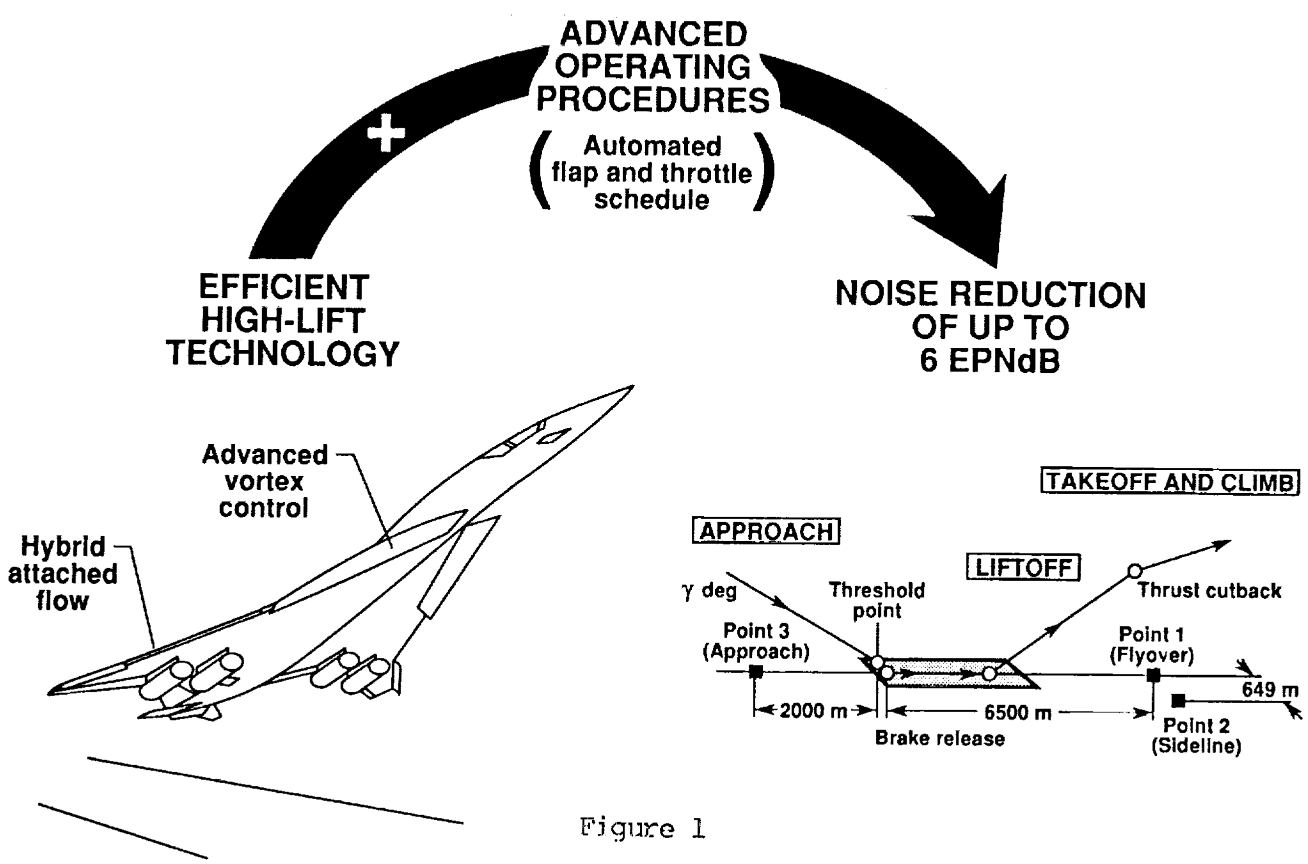

Figure 1

AERODYNAMIC POTENTIAL (Takeoff and Climb)

To achieve the objective of lower thrust (and therefore noise), the high-lift work is examining not only obtaining high values of useful lift but also getting these levels with the best possible aerodynamic efficiency (L/D). As illustrated in figure 2, the desired speeds for takeoff and climb place a highly swept-wing airplane like a supersonic transport in the lift coefficient range near and above the maximum values of L/D. In this regime, extensive flow separation is inevitable and both attached flow and seperated flow high-lift concepts must be explored to successfully address the strong separated and vortical flows.

However, as noted in figure 2, there exists substantial room for improving L/D if one considers the difference in performance from a basic untreated swept wing to that ideally possible with fully attached flow. The goal in this program is to achieve levels of leading edge suction in the 80 to 85 percent range; this will produce the subtantial improvements sought in L/D.

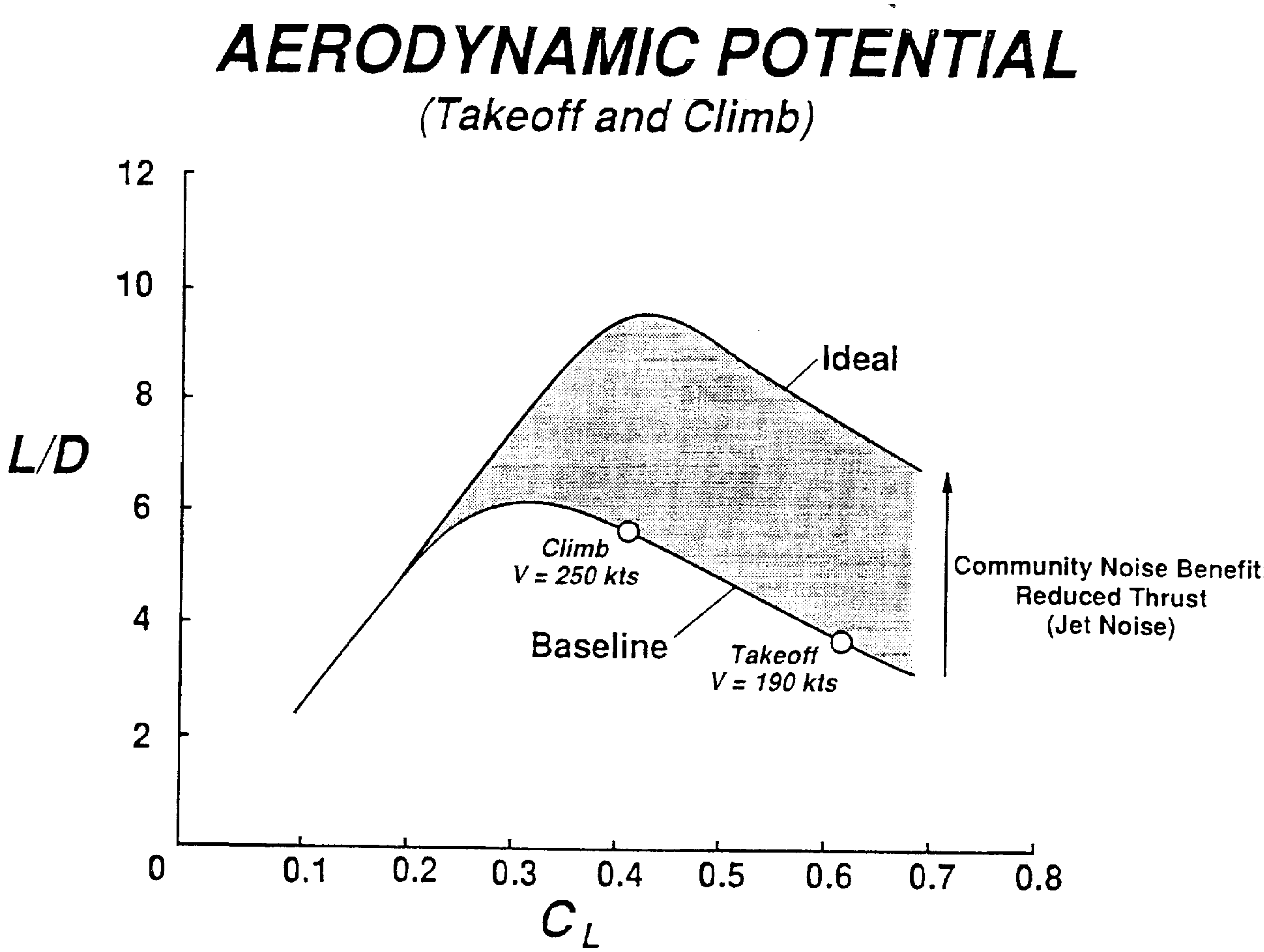

Figure 2

OBJECTIVES

The objectives of the HSR High-Lift research are outlined in figure 3 for both Phase I and Phase II. As already noted, in Phase I the principal emphasis of the high-lift work is to reduce the community noise. This effort involves exploration of high-lift concepts for both attached and separated flow control for both the leading edge and the trailing edge of the wing. During this research, the experimental and analytical efforts will be closely integrated to ensure good analyses codes are available to the designer for use in conducting the design trades during configuration integration. In addition, a key objective in Phase I is to quantify the possible gains in noise reduction from not only the aerodynamic concepts, but also the combination of these with new automated flight management procedures during landing, takeoff, and climbout.

Phase two objectives begin to shift the program focus to more detailed configuration integration efforts and toward extended concept validation tests involving large-scale testing and flight tests.

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OBJECTIVES

PHASE I - NOISE REDUCTION

- Concept exploration
- Method development & validation
- Payoff of specific concepts

PHASE II - PERFORMANCE

- Configuration integration trades
- Flight verification
  - methods
  - concepts

Figure 3

VORTEX FLAP FLIGHT EXPERIMENT

Completion of the recent vortex flap flight experiment on the F-106 airplane (shown in figure 4 below) at Langley has greatly increased confidence in the potential aerodynamic performance gains possible on higly swept wings operating at high values of lift. Gains predicted for this experiment were realized and correlated well with experiment and theory; much was learned during the indepth flight studies about the wing loading and flow field which was not evident from the earlier ground tests. The challenge now is to extend this type of technology to the more highly-swept, cranked planforms expected for the next generation of high-speed civil transports.

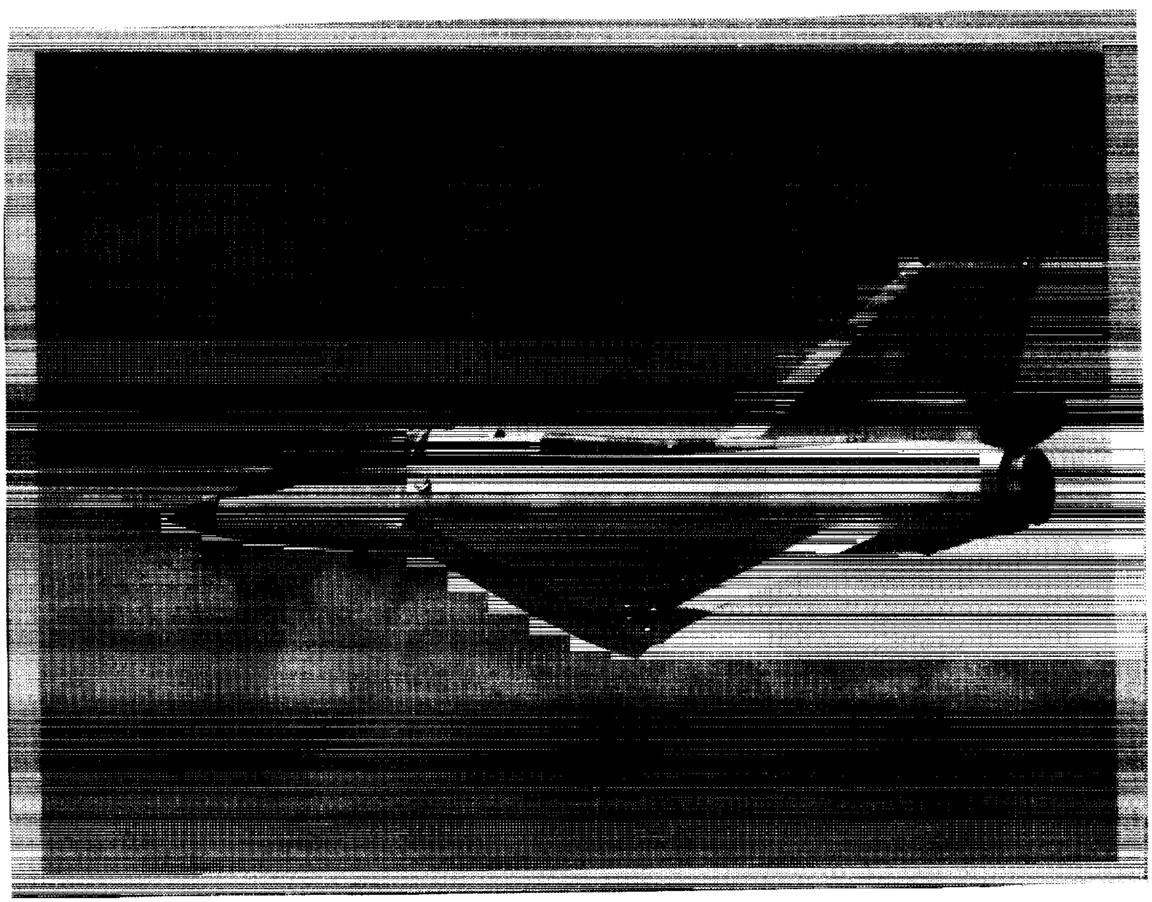

Figure 4

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F-16XL MODIFICATIONS FOR HIGH-LIFT RESEARCH

The range of high-lift concepts being studied in the current program is illustrated in the sketch shown in figure 5. The F-16XL will be used as a testbed in Phase II of the program to provide flight validation of both concepts and key aerodynamic prediction methods.

F-16XL MODIFICATIONS FOR
HIGH-LIFT RESEARCH

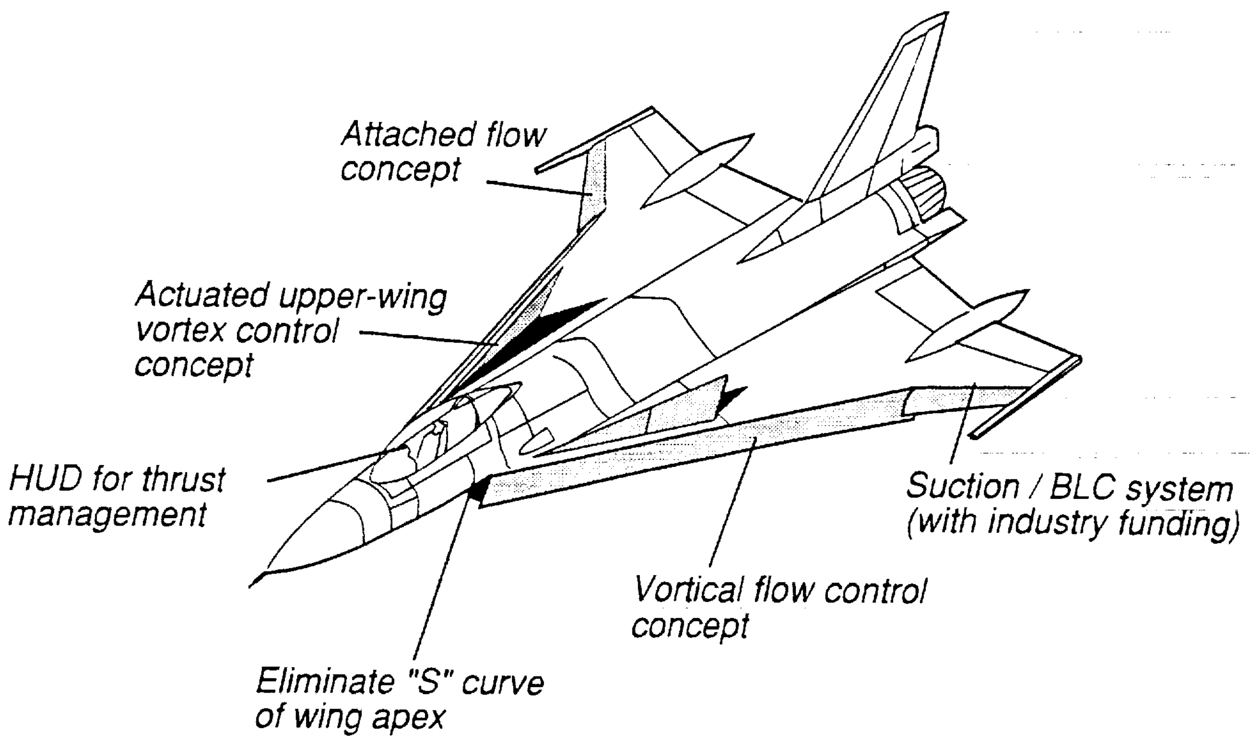

Figure 5

PROGRAM SCOPE AND APPROACH (FIGURE 6)

The NASA High-Speed Research (HSR), High-Lift Program scope ranges from CFD (Computational Fluid Dynamics) code development and application to High-Speed Civil Transport (HSCT) concepts, through extensive experimental investigations in wind-tunnels (and possibly flight tests), and to comprehensive piloted simulations to integrate aerodynamic gains with advanced flight procedures. The approach is to take maximum advantage of the extensive experience gained in the NASA Supersonic Cruise Aircraft Research (SCAR) program in selecting the high-lift concepts to explore and refine. This time around, we have much more powerful research tools in the CFD area and in wind tunnels (with facilities such as NTF).

A prime element in the approach for this program is the careful coordinated development of both promising high-lift concepts and the analysis and prediction methods needed for application of these concepts to various HSCT designs.

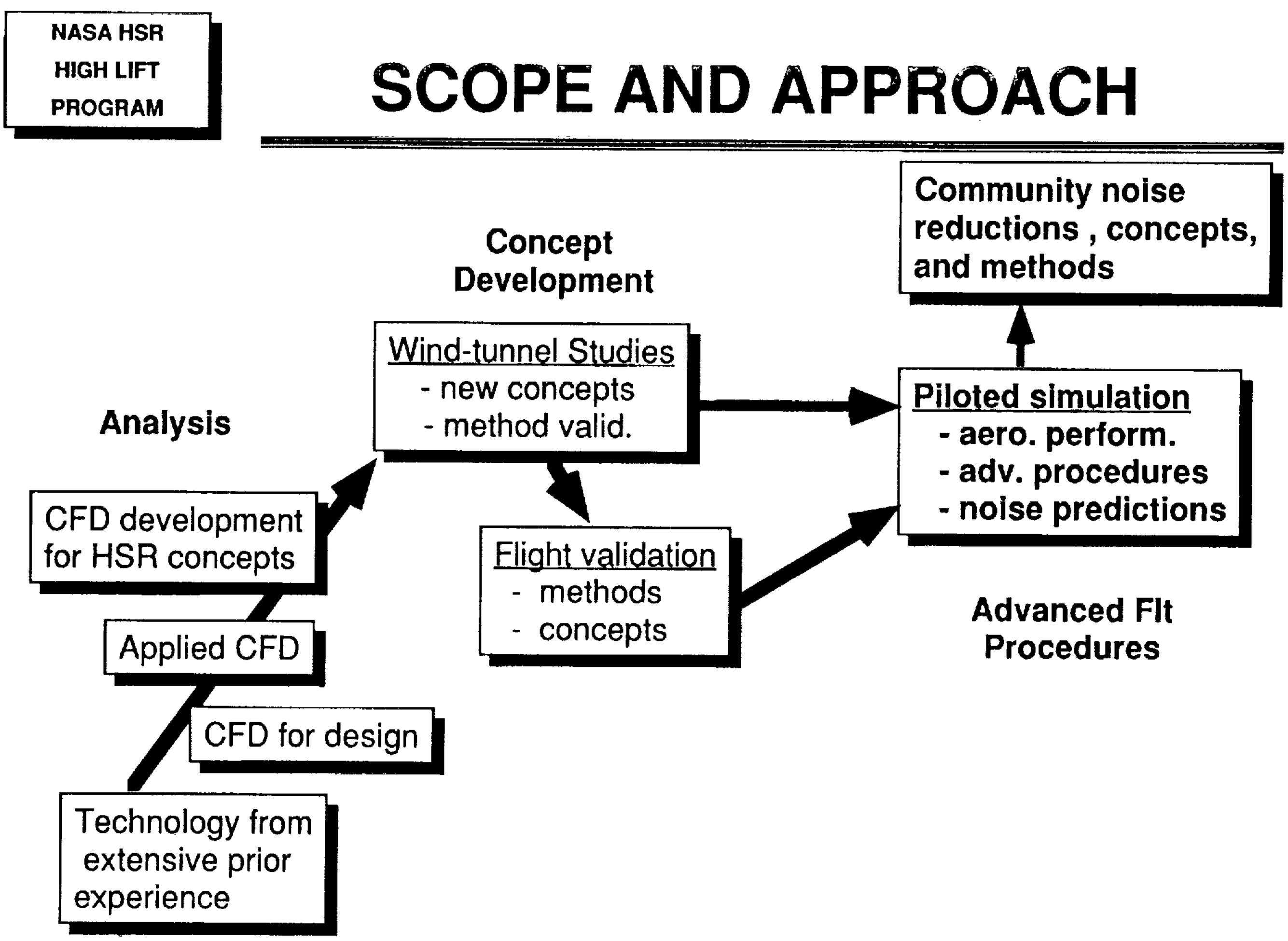

Figure 6

MODIFIED SCAR MODEL

As shown in figure 7, maximum advantage is being taken of the numerous wind-tunnel models available from the previous SCAR program. These models have been modified to refine concepts identified in the prior program and to explore new ideas. Shown in figure 7 is a NASA free-flight model developed during the SCAR effort.

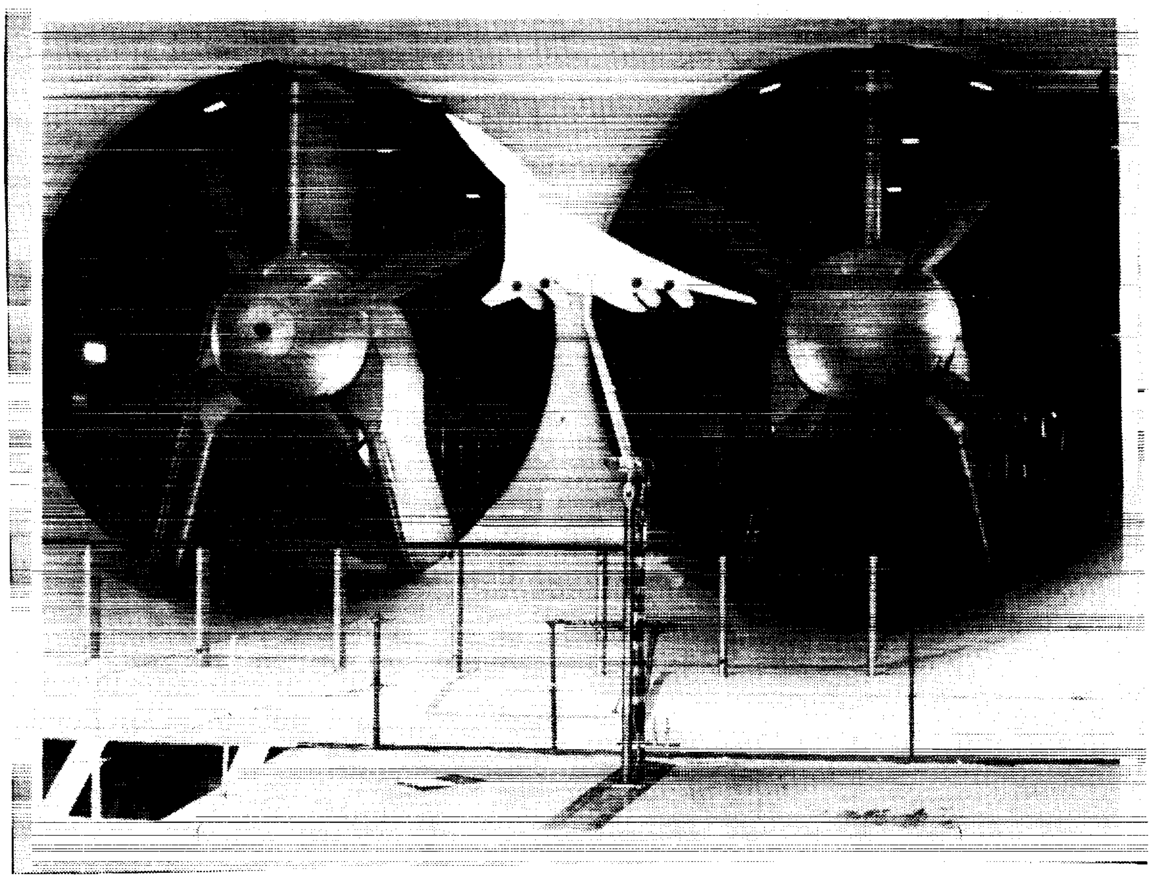

Figure 7

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PARTICIPANTS & ROLES

The organizations participating in the current HSR high-lift research are outlined in figure 8. The HSR high-lift program manager is located in NASA Headquarters (Office of Aeronautics, Exploration and Technology) in the Aerodynamics Division where he reports to the HSR program manager in the Office of Aeronautics. Both the Langley and Ames research centers are conducting high-lift research for the HSR program. Both centers are addressing CFD and experimental aerodynamics testing. The work at Langley also includes flight dynamics piloted simulation, and the prediction of community noise reductions provided by improved high-lift concepts. The teams at the two centers are working in a cooperative fashion to ensure the best high-lift concepts are identified, properly understood, and refined for effective application to realistic HSCT concepts. A concerted effort is being made at both centers to maintain a high level of cooperative work with industry.

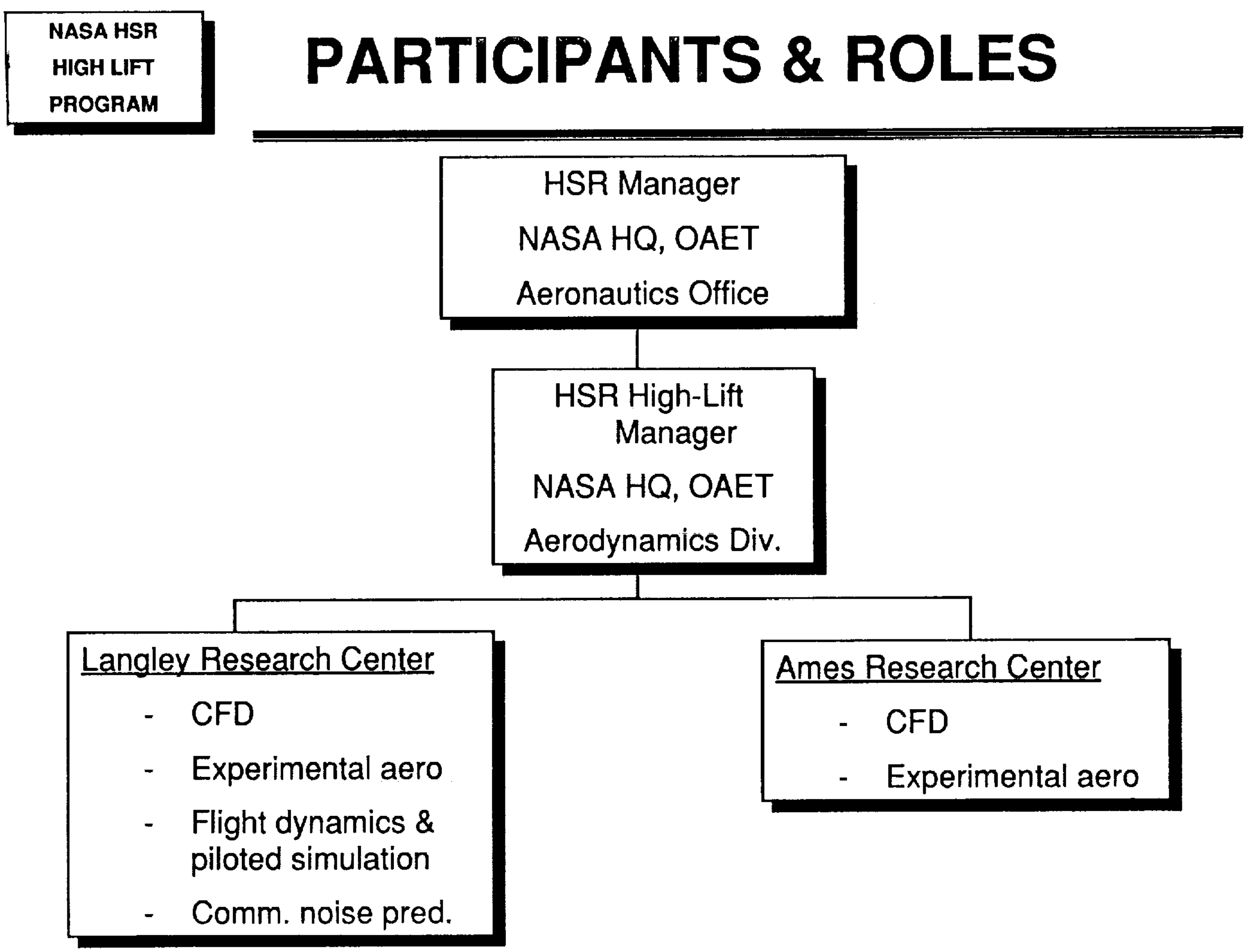

Figure 8

PHASE 1 SCHEDULE

The approximate timing for the research efforts in Phase I is shown in figure 9 for each of the three primary thrusts: simulation and analysis, supporting experiments (wind-tunnel studies), and concept verification (large-scale, high Reynolds number confirmation of most promising concepts). Also shown is the planned funding for this program phase.

The schedule is characterized by broad exploratory work early in the program and by increased focus on the most promising concepts and methods toward the end of the program.

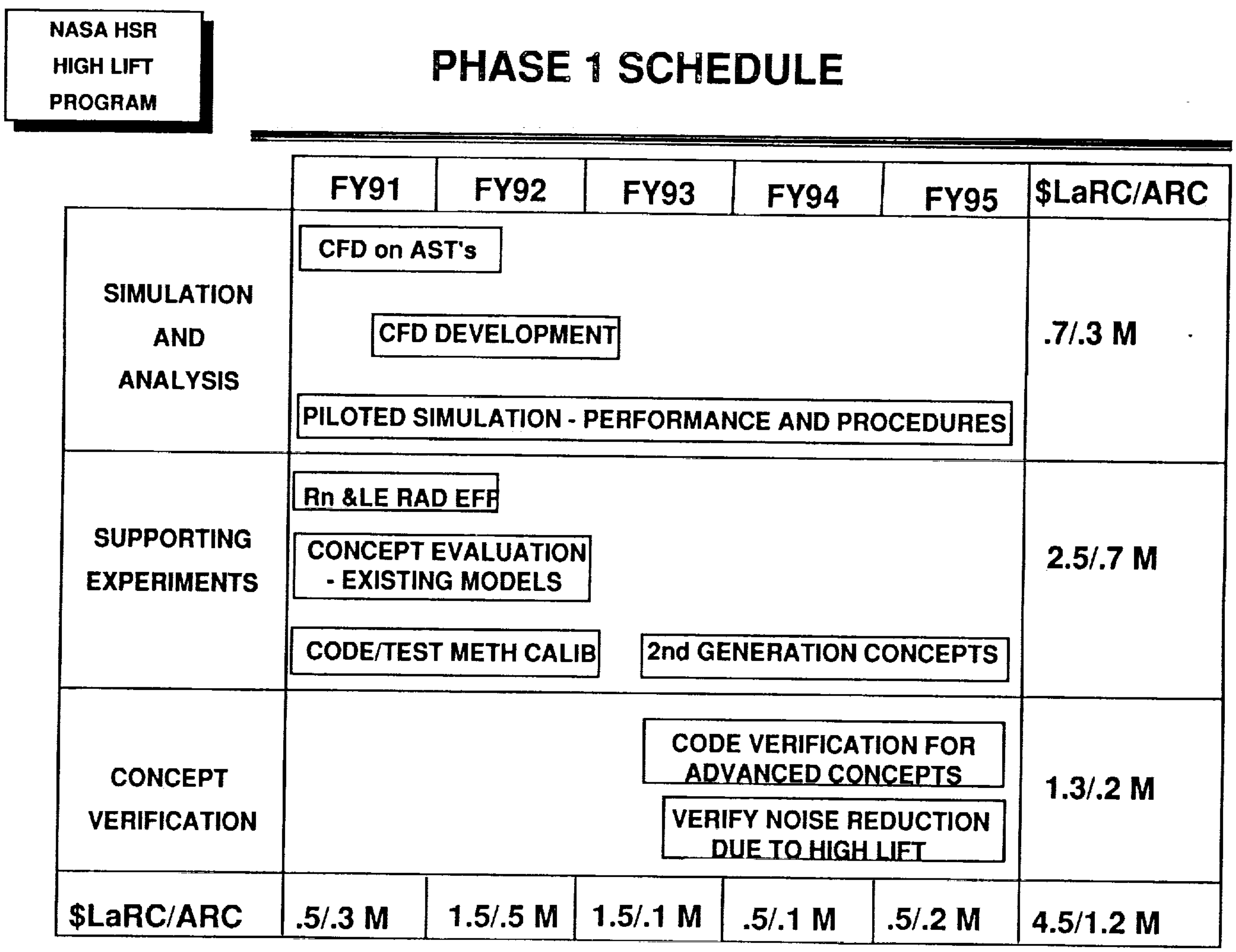

Figure 9

PHASE 1 MILESTONES

Key milestones for the Phase I effort are summarized in figure 10 in each of the three primary thrusts. Essential milestones will include proof of effective high-lift concepts, validation of the experimental and CFD methods capable of predicting the performance of these concepts, and prediction of the community noise benefits expected from these concepts.

An important message in this figure is that our program will begin developing a new series of HSCT wind-tunnel models in FY 1992 to carry the most promising ideas into more refined studies or representative wing platforms.

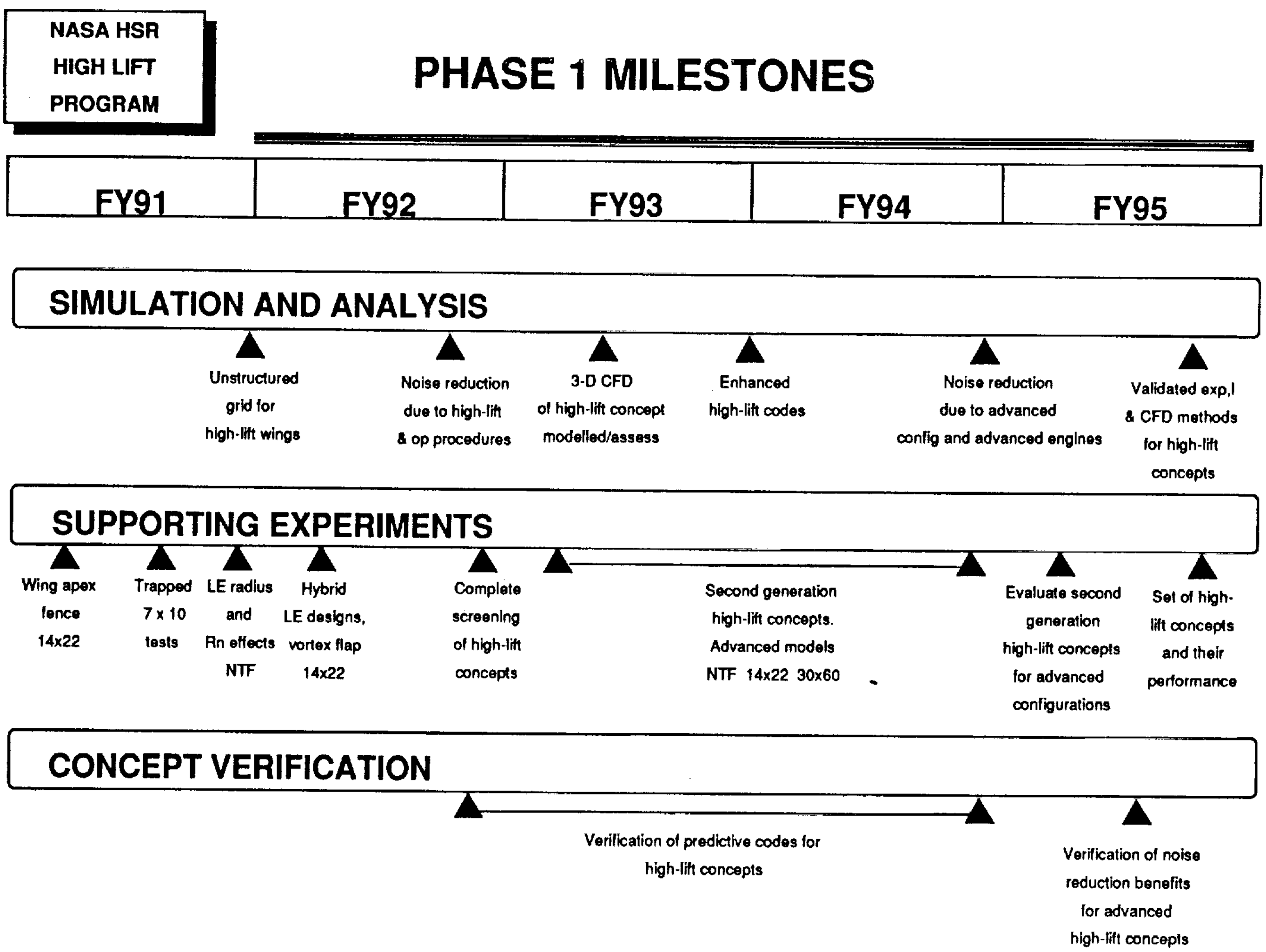

Figure 10

WORKSHOP OBJECTIVES
(FIGURE 11)

The present workshop for the high-lift research is intended to give the U.S. technical community a good update on NASA plans for Phase I, NASA progress to date, and industry perspectives and priority technology need. A principal purpose of the workshop is to achieve a good interaction of key technologists to ensure the current program plan is relevant, and the results are apparent to those who need them. All workshop participants should feel free to make constructive criticisms and suggestions for improving the ongoing program.

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WORKSHOP OBJECTIVES

- Provide HSR community an update on
  - NASA plans and progress with emphasis on Phase I
  - Industry plans, progress, and priority needs
- Provide forum for interaction of key techologists and sharing of ideas
- Accomplish constructive critique of high-lift program to improve value and timeliness for industry

Figure 11

AGENDA

The agenda for the high-lift workshop is shown in figure 12. After my overview, the session will first hear about the NASA efforts at Langley and Ames. Our industry colleagues will then brief Boeing and Douglas elements of our workshop.

We will close the workshop with a discussion period led by my Ames colleague, Dr. Jim Ross. I strongly encourage all attendees to give this session your best effort, and please share your concerns and ideas.

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AGENDA

8:30 - 8:45	Overview	Gilbert
8:45 - 9:15	Langley experimental results & plans	Coe
9:15 - 9:45	Langley computational results & plans	Waggoner
9:45 - 10:30	Ames results and plans	Ross/Rossow
10:30 - 10:40	Break	
10:40 - 11:05	Boeing status	Paulson
11:05 - 11:30	Douglas status	Antani/Morgenstern
11:30 - 12:00	Discussion	Ross/Gilbert

Figure 12

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