# 4.3.2 HSR High Lift Program and PCD2 Update


## High Lift ITD Team

Guy T. Kemmerly, Langley
Peter Coen, Langley
Paul Meredith, Boeing
Roger Clark, McDonnell Douglas
Dave Hahne, Langley
Brian Smith, Ames


February 25, 1997

Aero Performance Workshop

4.3.2 High Lift Technology

As a representative of the High Lift Integrated Technology Development team I am here to "kick-off" the high lift independent sessions with an overview - where we have been, where we are, and where we are headed.

I'll also describe some of the interfaces we have so everyone can see how we connect with the rest of the program.

# High Lift Mission

**4.3.2**

**The mission of High-Lift Technology is to develop technology allowing the design of practical high lift concepts for the High-Speed Civil Transport (HSCT) in order to:**

- **operate safely and efficiently**
- **reduce terminal control area and community noise.**

**In fulfilling this mission, close and continuous coordination will be maintained with other High-Speed Research (HSR) technology elements in order to support optimization of the overall airplane (rather than just the high lift system).**

4.3.2 High Lift Technology

This is the mission of the high lift team.

We will develop technologies for safe and quiet low-speed operations of a High Speed Civil Transport. That includes both high lift and stability-and-control technologies.

And, we will do so as an integrated part of the larger program.

The work is broken into four overlapping subelements.

# Technology Concept Assessment

**4.3.2.1**

**Develop an efficient high-lift system for the Technology Concept airplane (TCA) and provide an assessment of the low speed aerodynamic performance and stability and control characteristics.**

- TCA
  - 5% model for 14 X 22 and 12-Ft
  - AERO2S
  - CFL3D and TetrUSS
- Modified Ref H
  - 2.2% model for NTF
  - CFL3D modeling

4.3.2 High Lift Technology

First subelement: TCA Assessment for both high lift and S&C

As with the Ref H, low Re parametric studies will be conducted in the 14 X 22. Linear codes have been used to predict optimum flap settings and both structured and unstructured viscous codes have modeled the configuration in an attempt to define the limitations of those codes on this type of configuration. Status reports will be presented on the CFD efforts which, of course, have the ultimate goal of reducing risk and the design cycle time for high performance aircraft. In the 14 X 22, the low speed model will also be used to define powered ground effects on the aft body this summer.

Early in FY'98, that model will be tested in the 12-Ft Pressure Tunnel over a moderate Re range. That will be an unpowered test.

High Re estimates will be made from Re trends seen on the Ref H adjusted for planform and leading edge radius effects as measured in our most recent test in the NTF. Because of constraints created by a long, scheduled facility shut-down, the NTF testing was conducted on a heavily modified Ref H model. Viscous codes are being validated using that data and will hopefully give us an understanding of the Re effects and help "push" the data out to higher Re. I encourage you to attend the presentations on the results of that test.

# High Lift System Concept Design

**4.3.2.2**

**Design and evaluate refinements to the TCA high-lift system in order to identify and develop potential improvements required to meet performance targets established for the HSR Phase II High-Lift Technology program.**

- Arrow Wing
  - 4% model in 12-Ft
- Ref H
  - 6% model in 14 X 22
- Modified Ref H
  - 2.2% model in NTF
- Non-Linear CFD

4.3.2 High Lift Technology

Work is continuing in the more general category of high lift system development. This work will be used to refine the TCA high lift system at the end of this FY.

Again, the experimental work is being conducted in the same three facilities and is being accompanied at all levels of complexity computationally.

# Propulsion/Airframe Integration

**4.3.2.3**

**Evaluate the installation effects of the propulsion system on the low speed aerodynamic performance and stability and control characteristics both in and out of the influence of the ground.**

- Isolated Nozzle
- HEAT 1A
- TCA 2



A great deal of work has been conducted in the ARC 40X80 to define the powered effects and the nacelle installation effects on this type of vehicle. The test referred to as HEAT 1 (High-Lift/ Engine and Aeroacoustic Test 1) studied, among other things, the effects of a powered inboard nacelle on the configuration. A semispan model was used so ground-effect and sideslip testing were impractical or impossible.

A follow-on test will look at the effect of a powered outboard nacelle and both nacelles powered on the same semi-span model. A wind-on, isolated nozzle calibration will be performed first leading to that test which is refereed to as the HEAT 1A test. It will look at the effect of:

- the high lift leading edge flap configuration on the inlet flowfield
- the nacelle installation on the high lift system
- high lift wing on the performance of the nozzle.

Also, as stated earlier, the 5% TCA model will be used to define some of the powered ground effects on TCA.

# Tools and Methods Development

**4.3.2.4**

**Develop the tools and methods required for:**
**– accurate assessment full scale aerodynamic performance of HSCT configurations**
**– aerodynamic design of the HSCT high lift systems.**

- CFD Development and Validation
  - AERO2S, A502, DACVINE, ...
  - CFL3D and TetrUSS
- Support System Interference
- Re Scaling and Transition Detection
- Ground Effect Modeling
- "Real Airplane" Effects
- Ice Accretion

4.3.2 High Lift Technology

This subelement contains a number of different activities all aimed at successfully making the jump from model to full scale.

It is true that CFD is being used in our test planning, but our test results are also being used to build confidence in our CFD tools. Linear codes are still being widely used and CFL3D is still the most commonly used viscous code by those working in this area, but several exciting new CFD packages are now being evaluated which could dramatically reduce the time required to get a viscous solution. We are involved in some technique development work and in validation efforts on an unstructured NS package and in some rapid structured grid development efforts.

There are experimental and computational efforts ongoing to remove the support system interference effects from the wind tunnel data sets.

Much of our Re scaling and boundary-layer-transition detection work is for this subelement, as well.

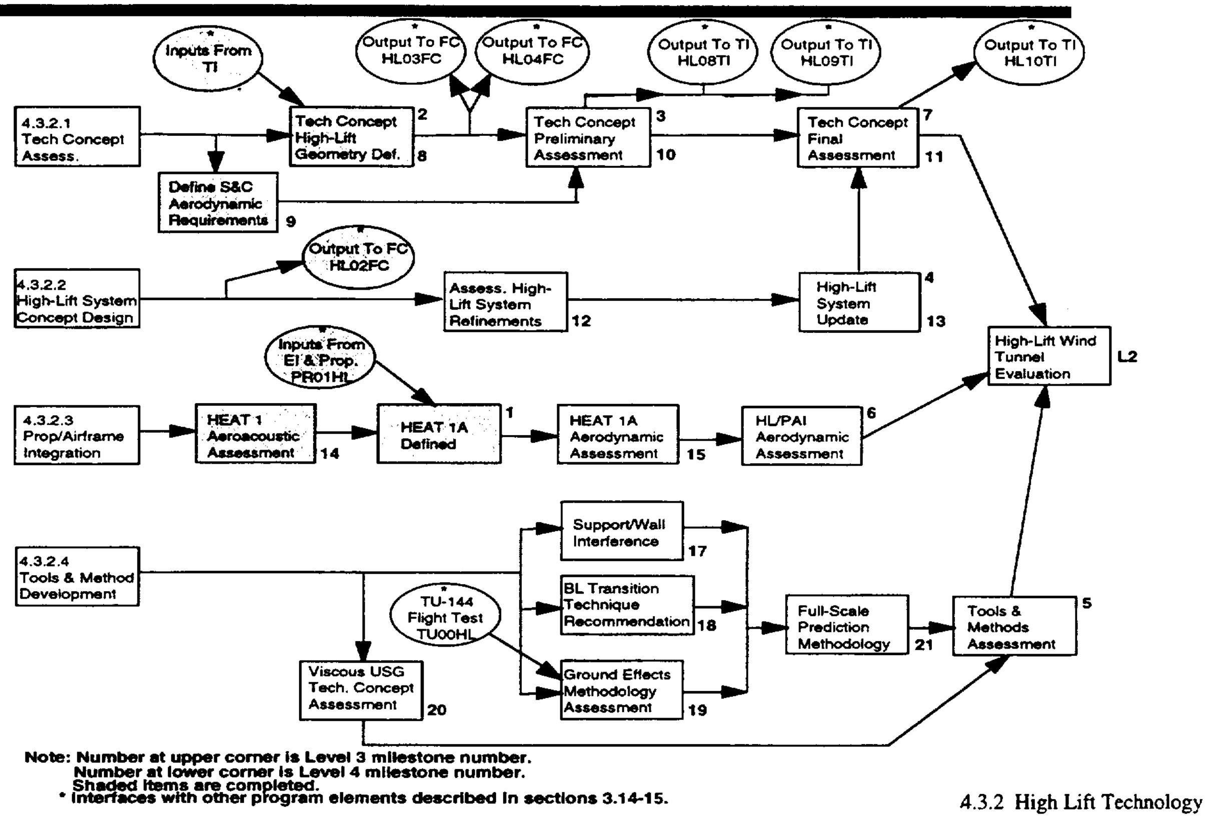
Another modeling issue being addressed involves the prediction of the ground effects that the vehicle will encounter. To date, the ground effects have been predicted based on testing that didn't model the sink rate that the aircraft will actually have on approach. Some work is being done in this element, both computationally and experimentally, to see if we think that modeling is giving us good predictions.

Also, a "piggy-back" activity is being considered for the HEAT 1A test which would look at the effect on high lift system performance of the messy aspects of real airplanes. These are the things that we experimentalists work hard to eliminate from our models like that gaps between leading edge flap segments and less-than-smooth hingelines.

Finally, we are using the LeRC Icing Research Tunnel to grow some representative ice shapes for testing.

Now lets look at the planned flow of the work in each of these subelements.

# Logic Network




This is a sketch of the flow of the work and of the interfaces with the outside world. The shaded activities are done.

In the TCA assessment you see that, based on TCA definition from Technology Integration and based on what we learned from Ref H, we have designed a TCA high lift system. We also have a set of S&C requirements for the vehicle which we will use to evaluate the performance measurements we will get from our testing. Our test results will be given to the Flight Controls element for simulator development. After a few tests of the TCA, a preliminary assessment will be done and forwarded to TI. Following some refinements and another year of testing, a final assessment will be done and again, the results will go to TI.

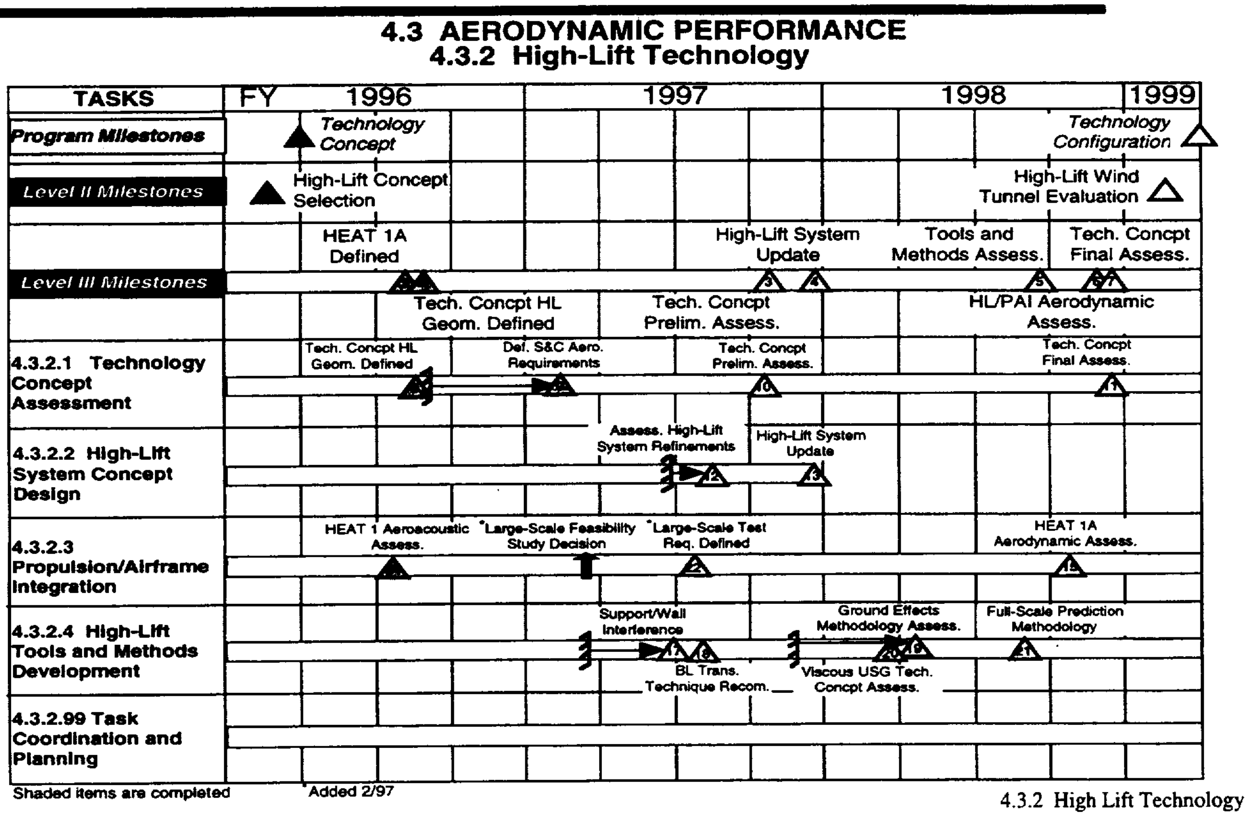
Interface HL02FC was the hand-off of ground effects data on the Ref H in high lift configuration to Flight Controls. The plan is to take what we have learned from the recent NTF test and the Arrow Wing test currently in the 12-Ft and develop a refined high lift system for the TCA. That will be evaluated on the TCA models and the results will impact the high lift system for the Technology Configuration.

As I said earlier, HEAT 1 is complete. That was a test with data for acoustics and propulsion as well as high lift. They made suggestions for the follow-on test, HEAT 1A, and the test has been defined. Following the test, the aerodynamic data will be studied and then combined with other HL/PAI data and CFD results to develop a generalized HL/PAI assessment of this type of aircraft.

As you saw on my last slide, this subelement contains a number of different activities. Following the first test of the TCA in 14 X 22, existing unstructured NS solutions will be compared to the data and that new code will be assessed. A number of wind tunnel testing methods are also being developed. These include removing support system and wall interference effects, detecting boundary layer transition at all Re, and measuring ground effects accurately. Data from the TU-144 flight test will help in the ground effects assessment. These will all roll up into a methodology for predicting full scale performance from sub-scale testing.

That's the work; here's how it lays out in time.

# Level III & IV Milestones




4.3.2 High Lift Technology

These are the milestones as they were defined at the start of PCD 2. Slips are indicated.

The definition of S&C requirements for TCA arrived later than planned, but still early enough to be used during the wind tunnel tests of the configuration.

Because the Arrow Wing entry in the ARC 12-Ft was delayed, refinements to the TCA high lift system will be defined a couple of months later than predicted, but this won't affect any downstream milestones.

Odd-looking data from our last test in the 14 X 22 has delayed our definition support-system interference effects in the data acquired in that facility, however it does appears that the CFD estimates are accurate.

And, the dynamic ground effects test in the 14 X 22 was pushed back to the end of this FY and we have added the evaluation of a time-marching Euler code to that milestone so we slid it into 1998. Again, the change has little impact on the larger program.

You can look at the other dates on your own.

# 1996 Major Technical Accomplishments

- All milestones, deliverables, and interfaces completed on schedule and within cost.
- Demonstrated viability of temperature sensitive paint technique for boundary layer state measurements at high Reynolds number conditions.
- Demonstrated 2% increase in suction parameter (15 counts drag reduction) on 6% Ref. H due to sealed slat concept on outboard leading edge.
- All wind tunnel test activities on schedule.
- Development of viscous unstructured grid capability progressing slowly, but initial results show promise.
- Supported initial assessment of "Earned Value" procedure within HSR.

4.3.2 High Lift Technology

Here are some of our accomplishments from last year. This slide was prepared for an end-of-the-year report to Wally Sawyer.

We are on schedule and resources were fine last year.

Check out the TSP talk and see the results of the transition detection tests at cryogenic temperatures. It is very promising.

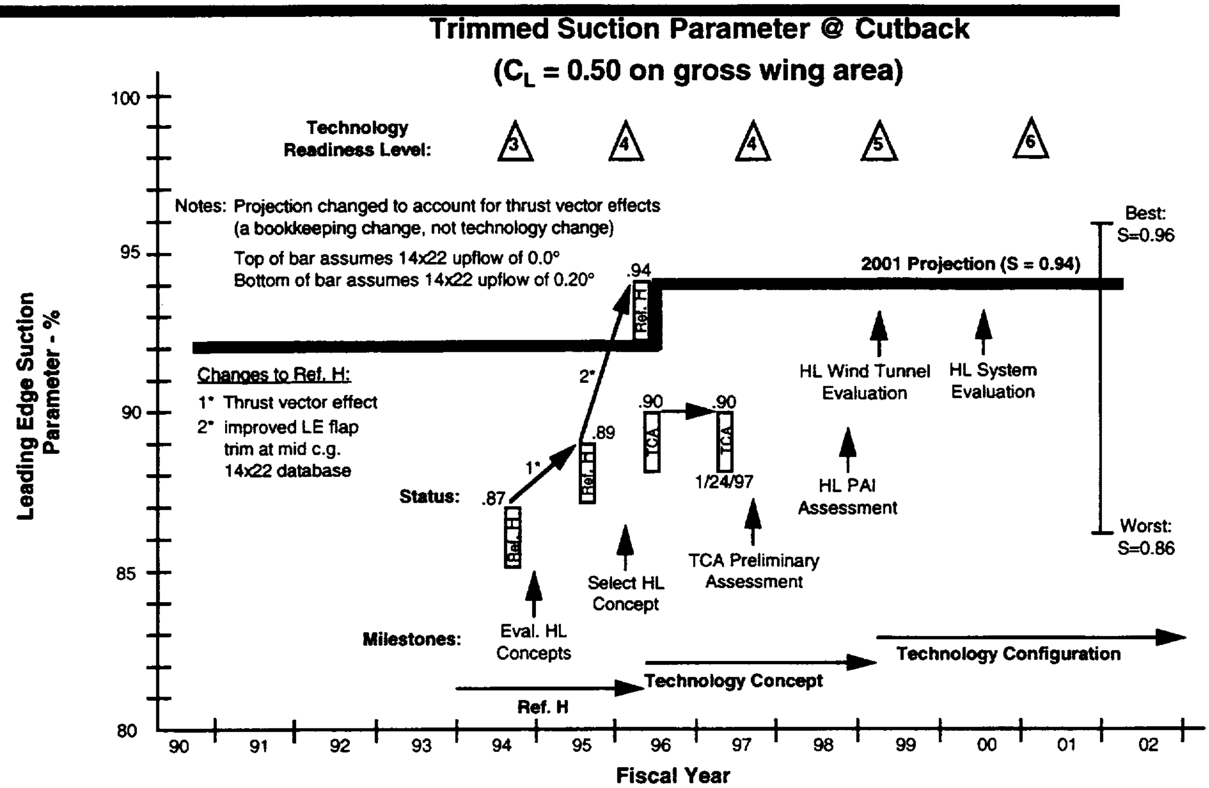
A new outboard l.e. slat has nudged us a little higher in our principal metric, suction parameter.

Our program's high priority within NASA has allowed the tests to be scheduled such that we get what we need when we need it.

Exciting progress has also been made in the area of unstructured NS codes. Catch that talk, too.

And finally, we supported the tracking of a new metric for management called "Earned Value."

# Technology Performance Metrics



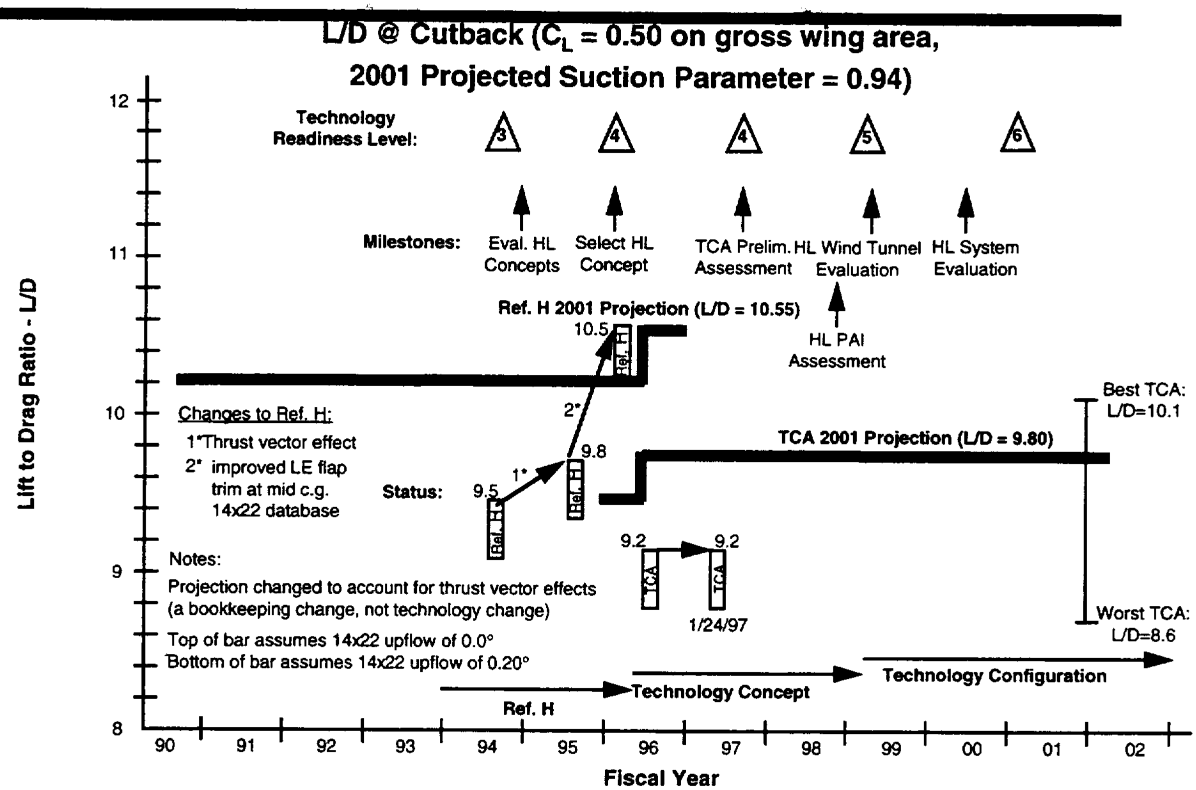

4.3.2 High Lift Technology

As I said earlier, Suction Parameter is our principal metric. Here's how we're doing.

Our goal is 94% and we were getting there with the Ref H. The length of the bar indicates the difference 0.2 degrees of flow angularity could mean to the conclusions drawn from he wind tunnel data.

Changing to the TCA we moved back some, but should be able to get back to 94%.

# Technology Performance Metrics (cont)




4.3.2 High Lift Technology

This is a similar slide for L/D.

As you can see, L/D is sensitive to the change in planform that happened between Ref H and TCA. As a result, the final projection is lower. That's the result of the lower aspect ratio.

## Issues, etc.

- Large uncertainty with schedule and availability of NASA wind tunnels.
- 14- X 22-FST upwash data uncertain.

4.3.2 High Lift Technology

There are some issues that could cause problems in the future if we don't address them.

The uncertain availability of the ARC tunnels and the backlog of tests at the 14 X 22 create a big unknown.

As I have said before, the data from the last 14 X 22 test looks funny. Without it, not only is the flow angularity in the facility unknown, but, if the cause is not identified, the data from upcoming tests will be questionable.

# Conclusions

- Excellent progress
- Future looks bright
  - Funding is solid
  - Support is strong
- Still challenges

4.3.2 High Lift Technology

For the most part, though, the High Lift element is making excellent progress.

The support is still strong for HSCT at NASA HQ and in congress. Resources are good.

But, there are still some issues and plenty of technical hurdles to keep us all challenged.

This page intentionally left blank.