# INTEGRATION OF STAR-CD TO DAILY JEEP DESIGN PROCESS

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DaimlerChrysler

May 1, 2000

# Integration of Star-CD to Design Process

--- Catia is very powerful design tool

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--- Star-CD is user-friendly CFD tool

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a). Speed up design - simulation process.
b). Increase use of user environments.
c). And more.

# BENEFIT FROM CFD ANALYSIS

**First:** Significant time saving.

**Second:** Mockup cost saving.

**Third:** Lab testing facility and manpower saving.

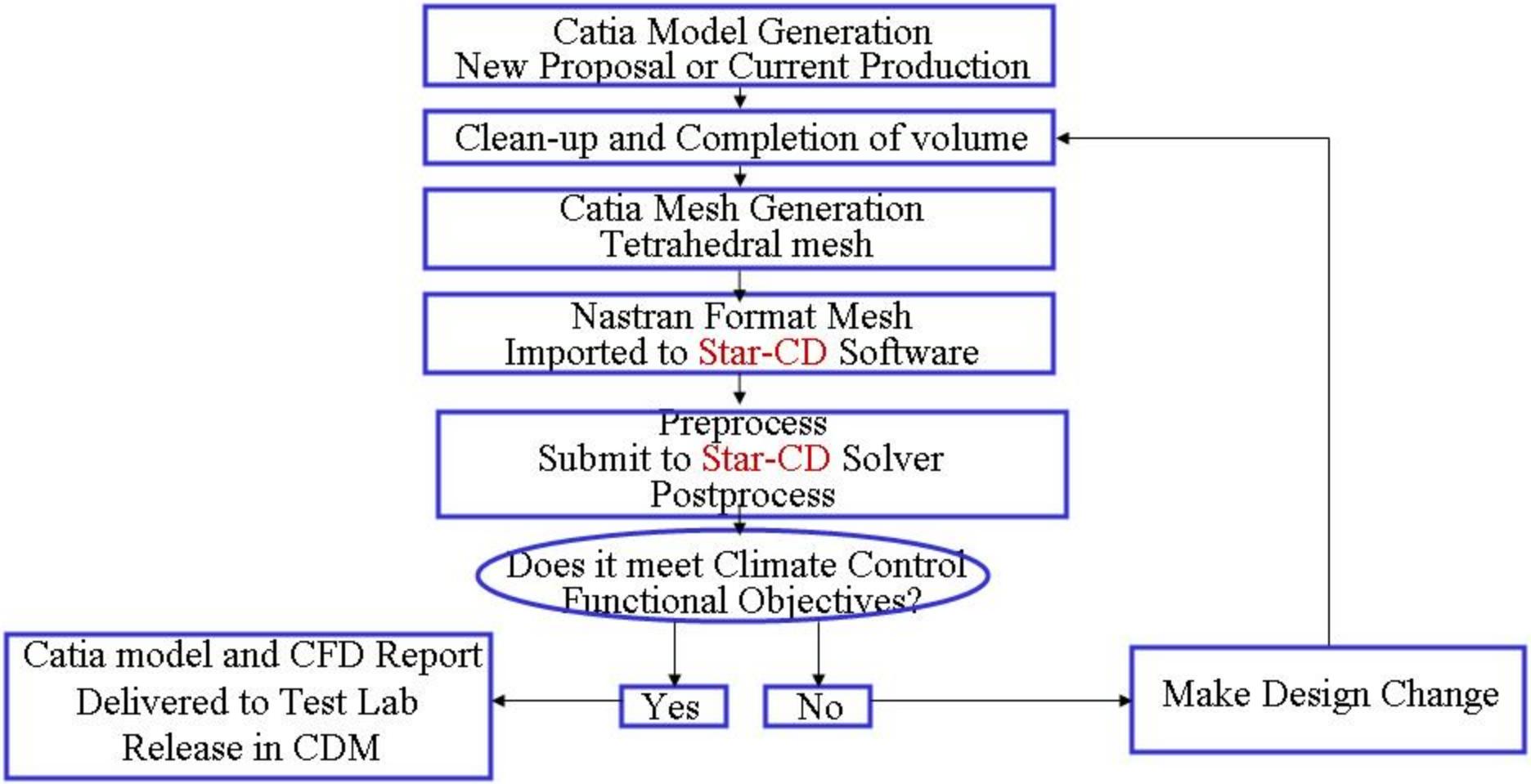
# BENEFIT FROM CFD ANALYSIS

**Example of Jeep plenum CFD study**:

To find the effect of filter screen size on plenum airflow

| | CFD | Lab Test |
|---|---|---|
| Time Saving | One week for two iteration CFD model | 14 weeks for 2 prototype tool, and 2 weeks for lab setup and testing |
| Mockup Cost Saving | ~ $0 | $10,600 for twice prototype tools |
| Lab Facility & Manpower Saving | $2,000 for labor and machine | $4,000 for two week labor, and $4,000 for two week Lab facility |

# Star-CD Integrated to Design Process
# JEEP CLIMATE CONTROL



# Star-CD SUPPORT
# JEEP CLIMATE CONTROL

*Project Studied for Jeep Program:*

- Plenum Design Optimization
- HVAC Unit Performance Study
- Defrost duct and grille study
- Demist duct and outlet grille study
- Panel duct airflow split study
- A/C outlet aiming study
- Floor Duct and Rear console
- Body Exhauster Size and Location
- Passenger Compartment Warm-up
- Passenger Compartment Cool-down
- Radio Cooling Study

# JEEP HVAC UNIT AIRFLOW STUDY
## AIRFLOW PATTERN ON EVAPORATOR

**OBJECTIVE:** -Study of different flow modes, door positions, and flow split,
-Evaluate the airflow pattern on evaporator surface for maximum use of evaporator's heat capacity,
-Evaluate the temperature stratification: airflow mixing

**MODEL SETUP:** CFD model is run in different modes.
The model includes whole hvac unit and ducting

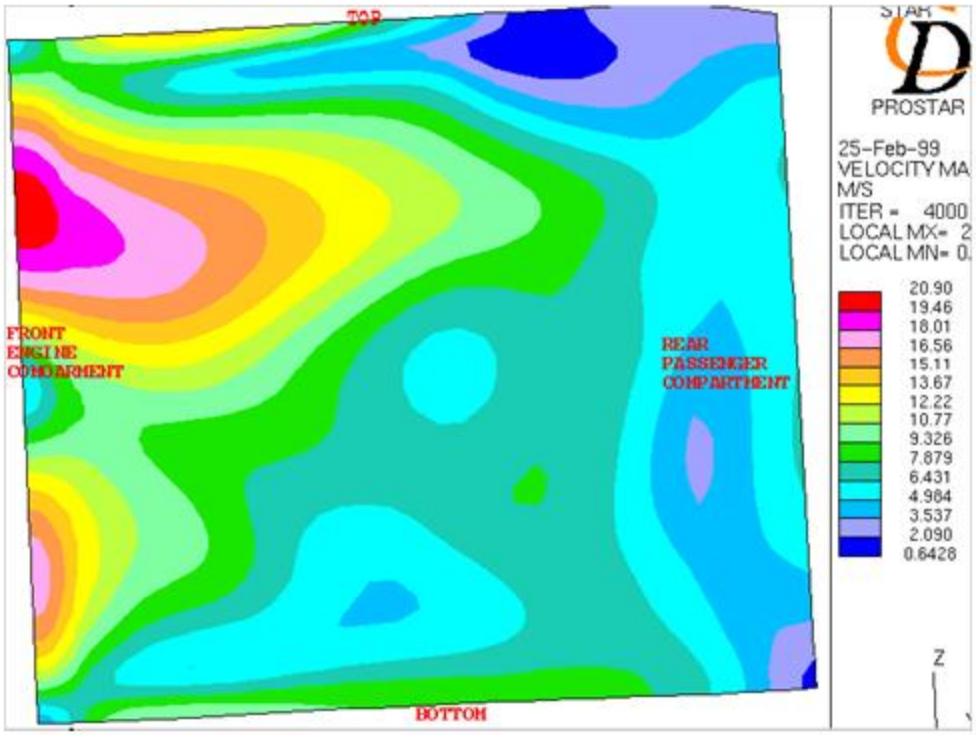
**CFD RESULTS:** Unbalanced airflow to evaporator face:
Analysis result shows that:
a). High velocity airflow is found in front center location.
b). At rear top and bottom area, very low velocity airflow pass evaporator, that causes inefficient use of heat capacity.

**RECOMMENDATION:**
Modify blower and housing design to deliver more uniform airflow to evaporator

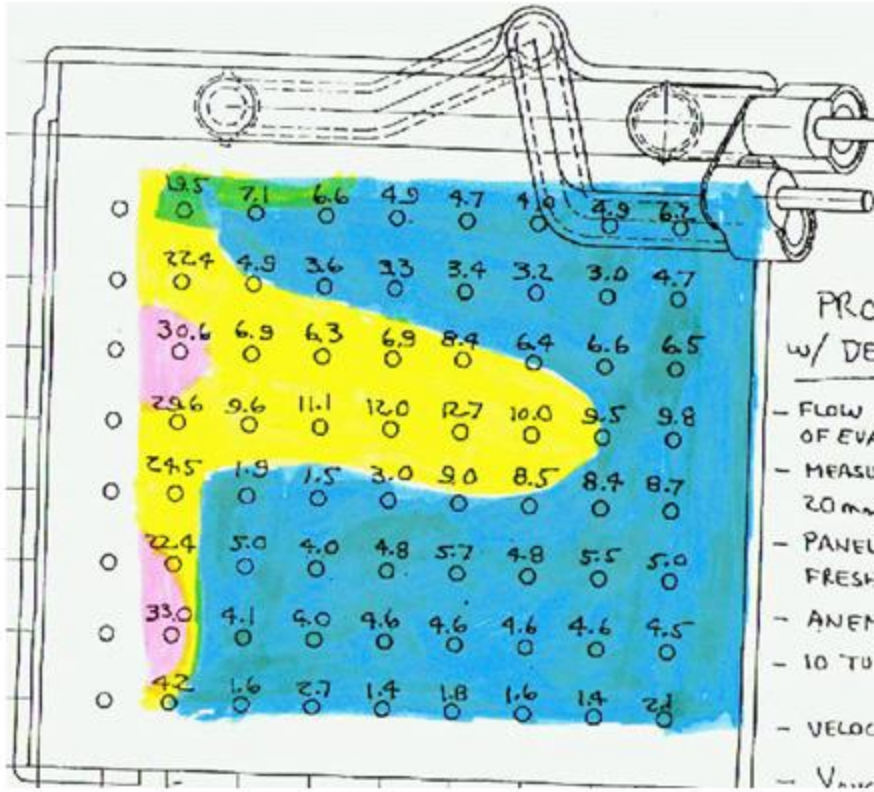
# JEEP HVAC UNIT AIRFLOW STUDY

## AIRFLOW PATTERN ON EVAPORATOR

### CFD




### TEST



# JEEP DEFROST DEVELOPMENT

***OBJECTIVE:*** **To study airflow and deicing pattern on windshield**

***CFD Model:*** ***HVAC unit, defrost duct, cabin***

**Deliverable Result:**

a). Good airflow pattern on windshield.

b). Deicing performance meets target.

C). Inside of duct: low noise, low pressure drop

**CFD result Compared with S0 vehicle:**

a). CFD and test are close on airflow and deicing pattern

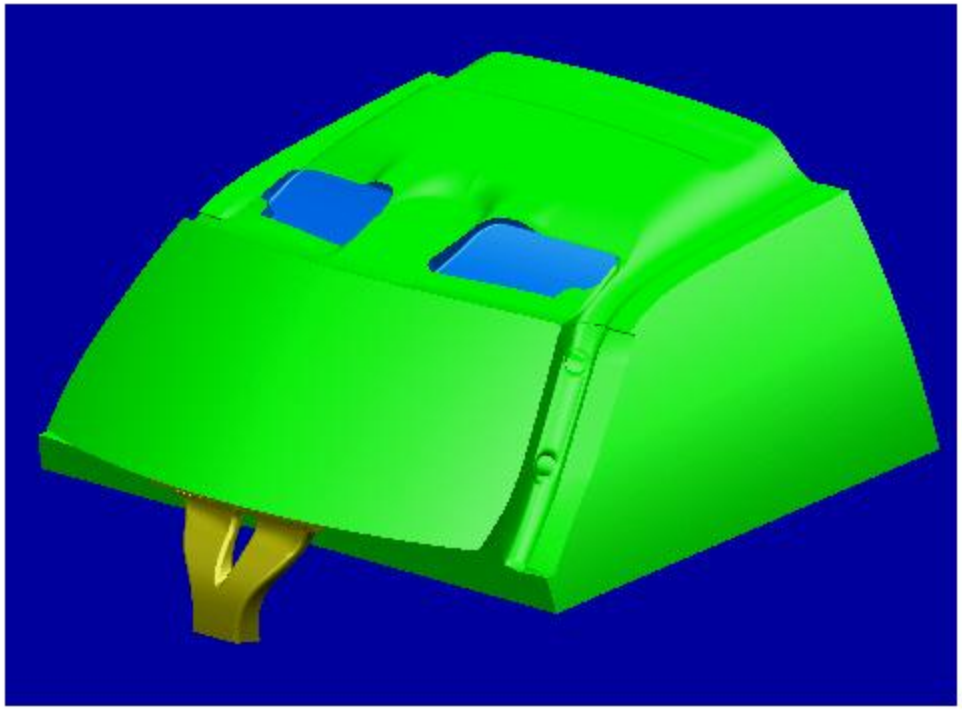
b). Deicing test meets KJ target.

**Total 10 CFD models were analyzed before S0 phase completion**

# JEEP DEFROST AIRFLOW STUDY

## WITH HEADLINER AND A-PILLAR

## CFD MODEL



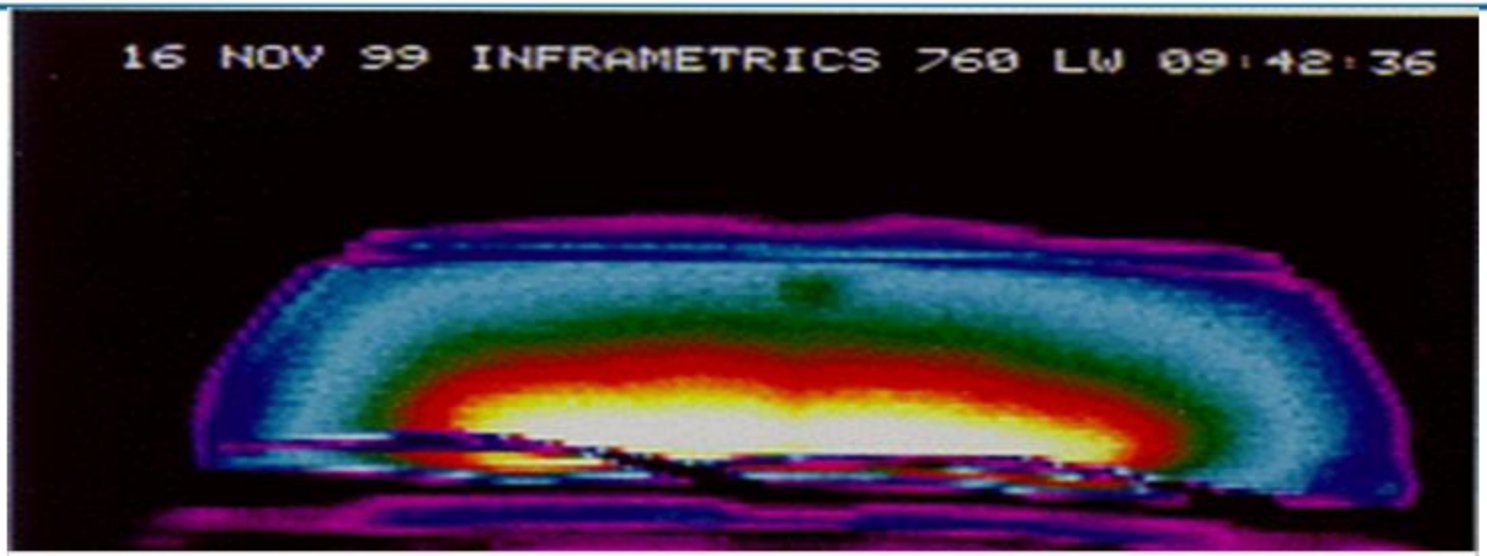
CATIA SOLUTIONS

Jeep Climate Control

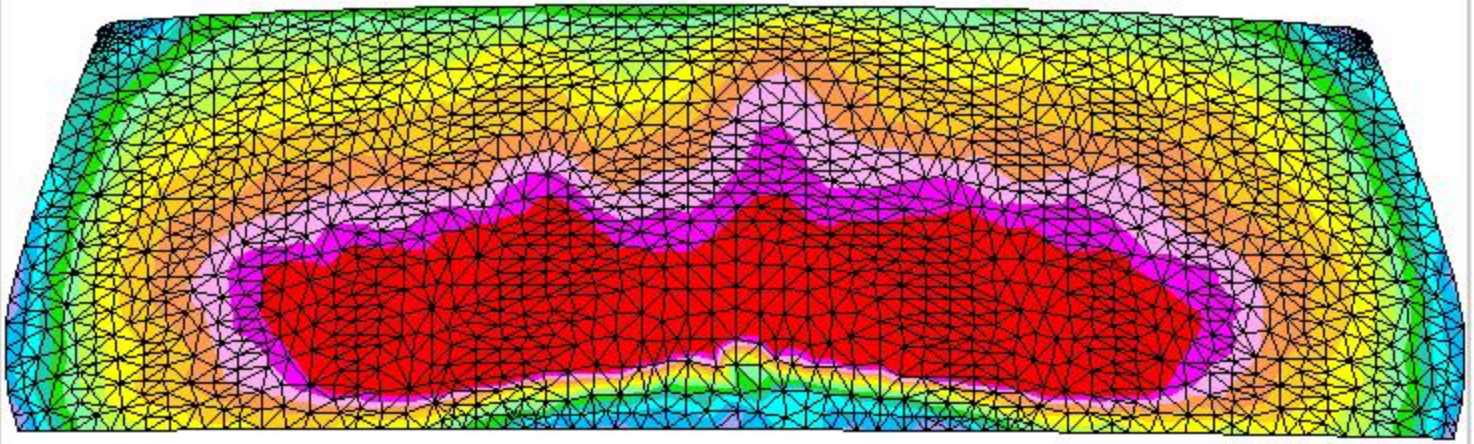
STAR PROSTAR 3.10

# JEEP WINDSHIELD AIRFLOW COMPARISON OF CFD WITH TEST

IR Camera




CFD



CATIA SOLUTIONS

Jeep Climate Control

STAR PROSTAR 3.10

# JEEP DEMIST STUDY

## *OBJECTIVE*

**To study airflow pattern on side glass through demist duct**

## *RESULTS OBTAINED*

**Flow distribution pattern on side glass**

## *IMPACT*

**Reduced the turn around time from 2-3 weeks to 3 days**

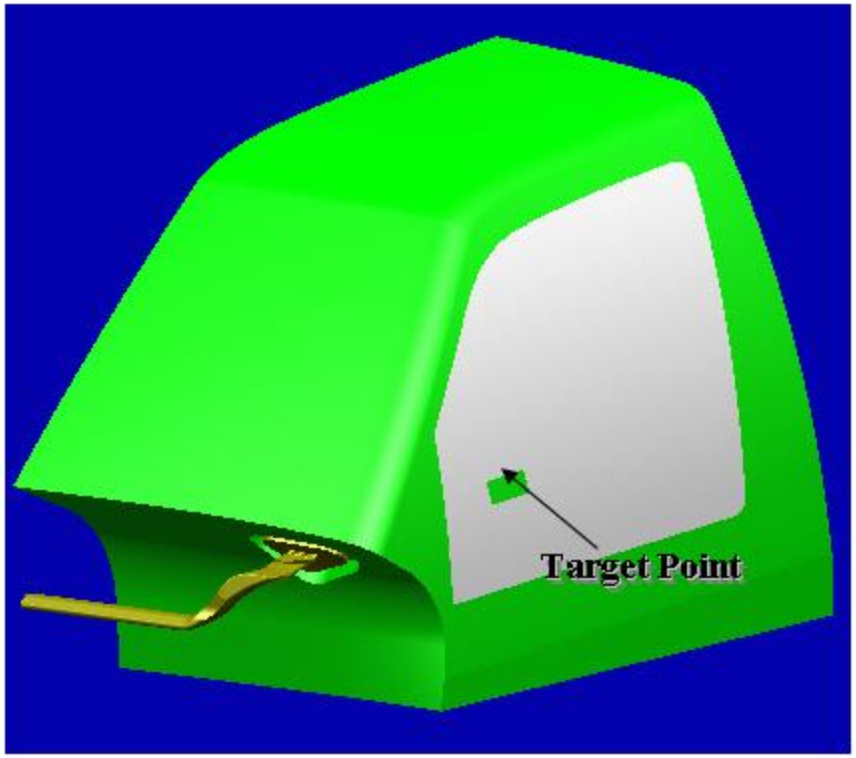
**by using CATIA solid modeling and CFD.**

## *NOTE:*

**Analysis included 6 design proposals and 8 model iterations**

**over a span of 13 months of product development.**

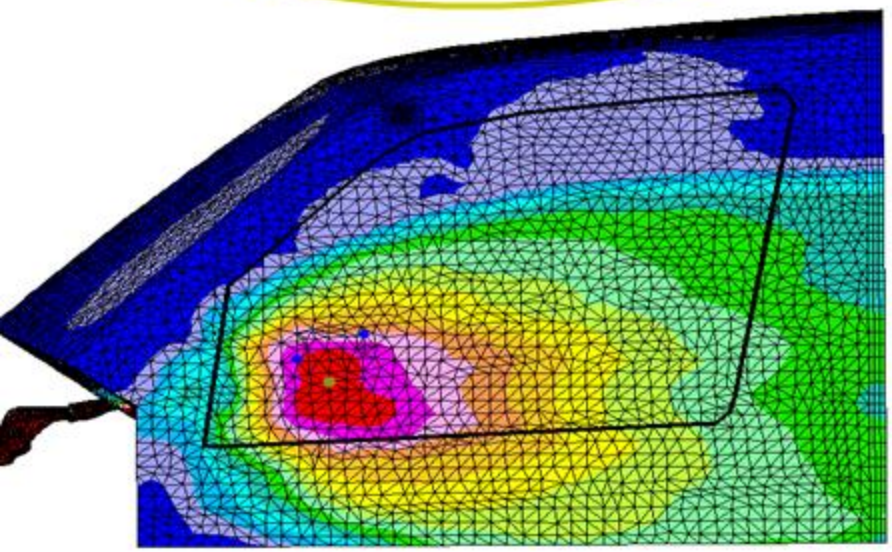
# JEEP DEMIST STUDY



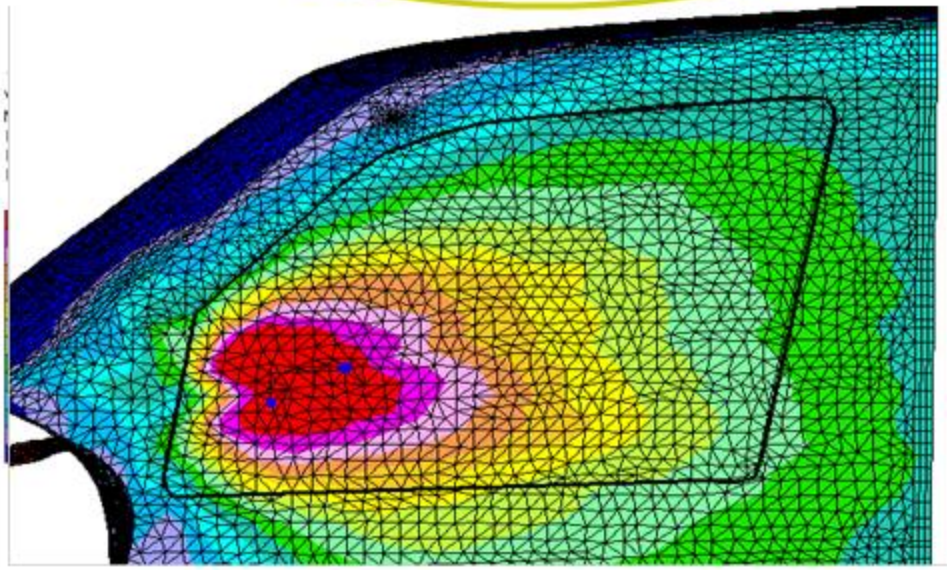

CFD MODEL

# JEEP DEMIST STUDY

Airflow pattern from first design proposal



Airflow pattern from CFD modified design



# A/C Outlet Airflow Aiming

## OBJECTIVE

To optimize A/C outlet aiming

## RESULTS OBTAINED

Flow pattern on driver face and “H” point.

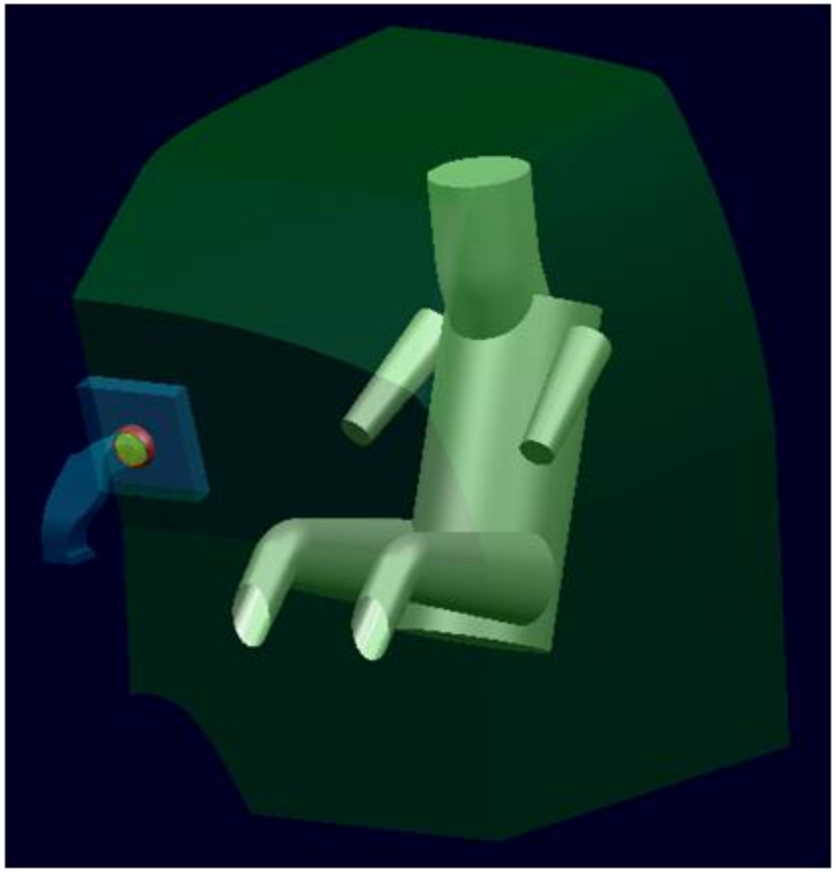
## IMPACT

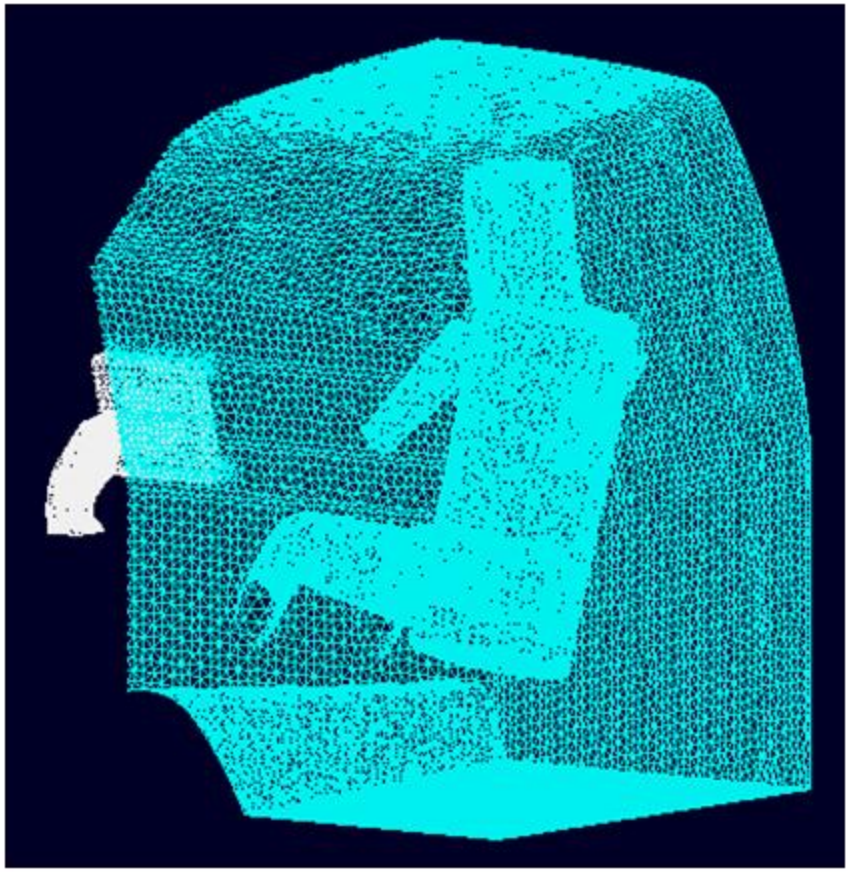
Reduced the turn around time from 4-5 weeks to three days

## NOTE:

Analysis included 22 design proposals and 45 model iterations over a span of 13 months of product development.

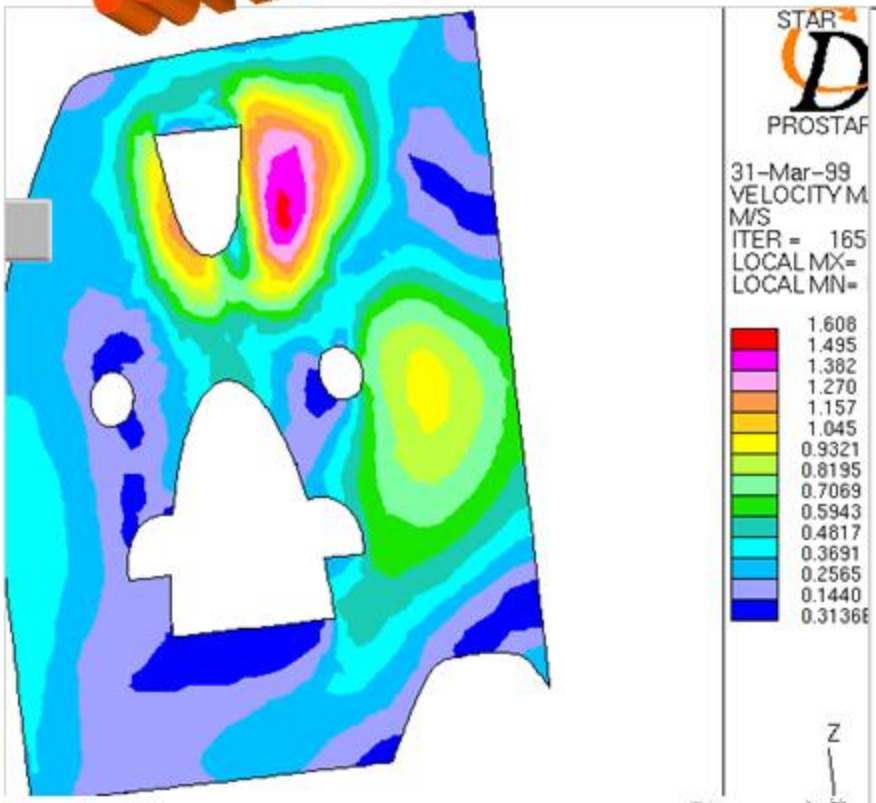
# A/C Outlet Airflow Aiming



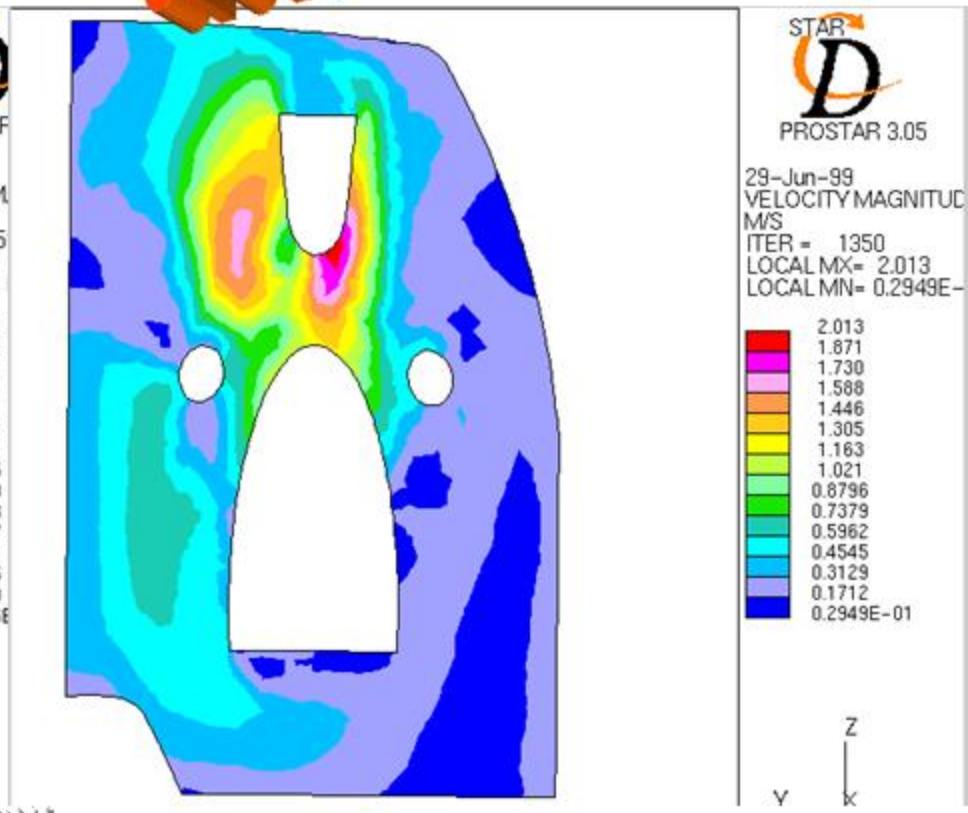


# A/C Outlet Airflow Aiming

## SO Phase Design

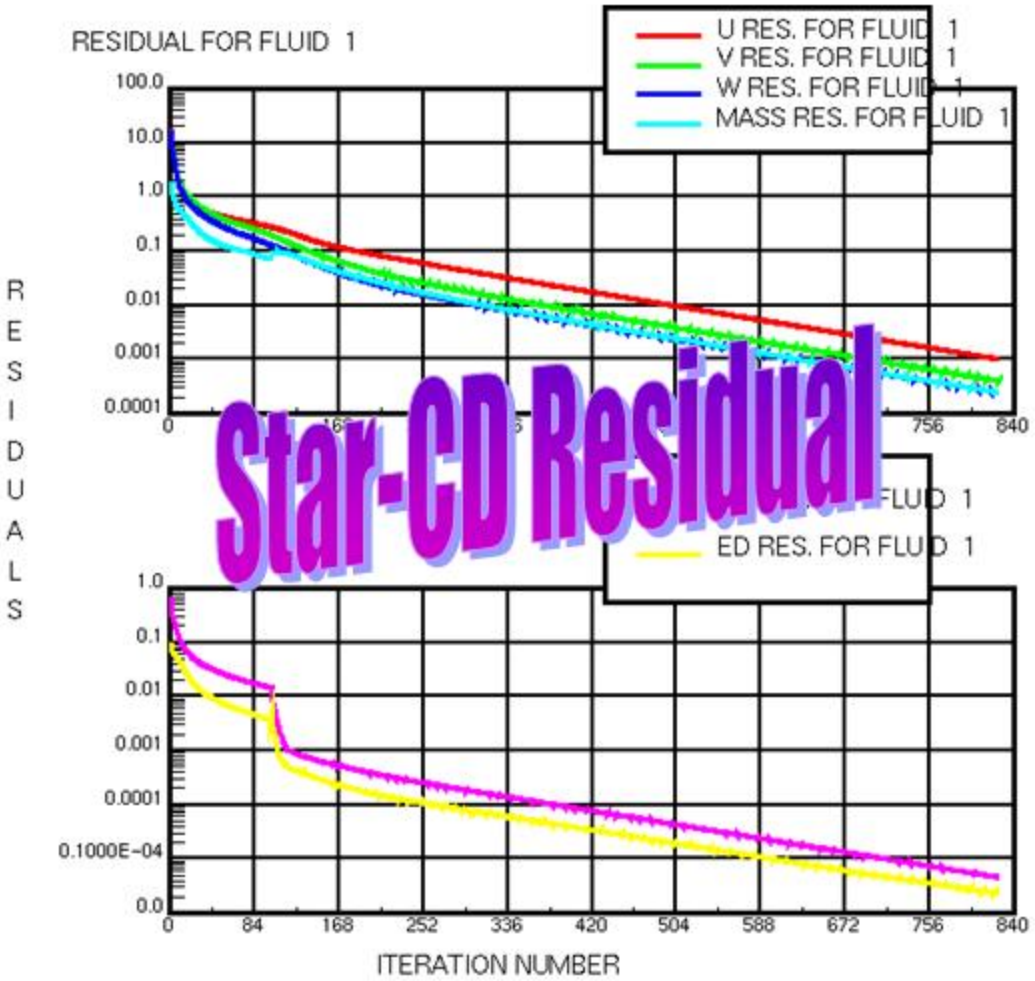



## STO Phase Design




Rear View

# A/C Outlet Airflow Aiming



# JEEP FLOOR DUCT AIMING STUDY

## *OBJECTIVE*

- To study airflow aiming on occupants feet

## *•RESULTS OBTAINED*

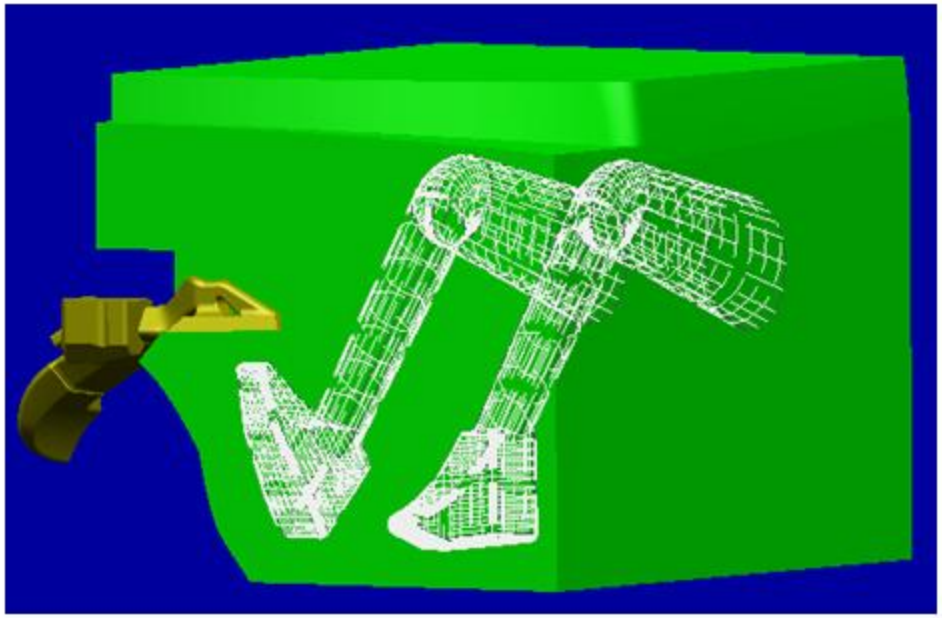
- Airflow distribution pattern
- Airflow split

## *IMPACT*

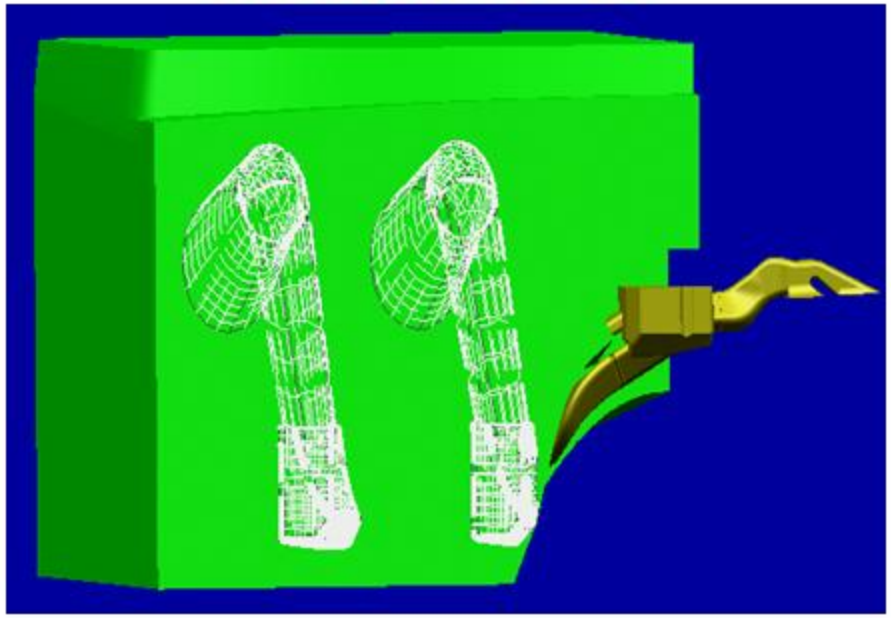
**Reduced the turn around time by 2 days**

# JEEP FLOOR DUCT AIMING STUDY

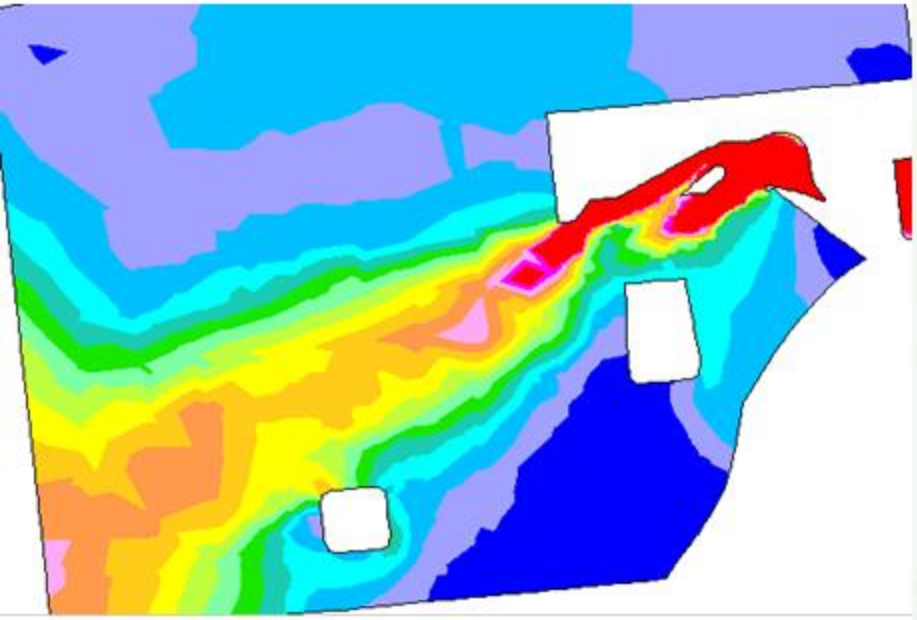
## DRIVER SIDE

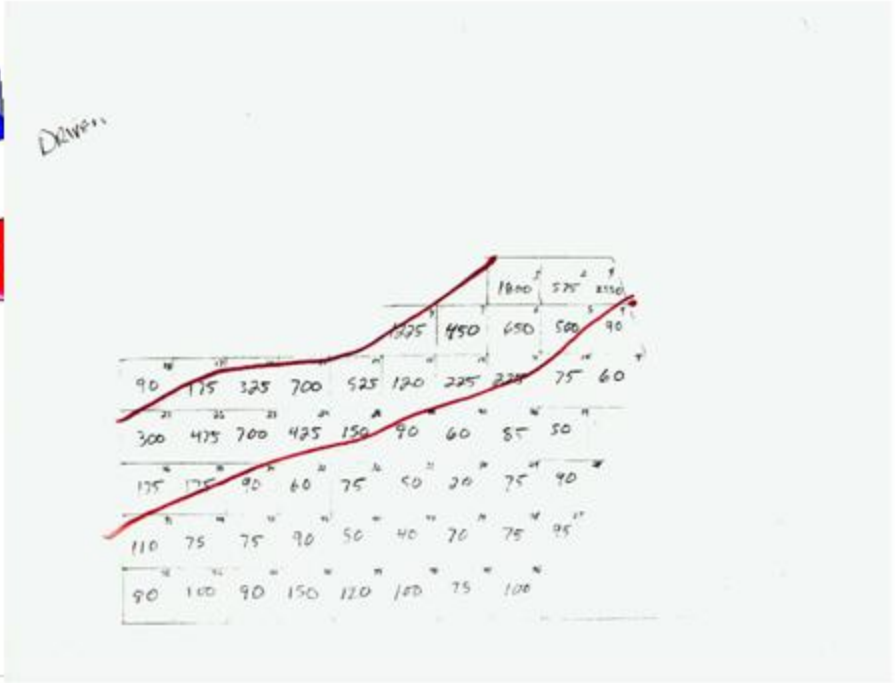


## PASSENGER SIDE



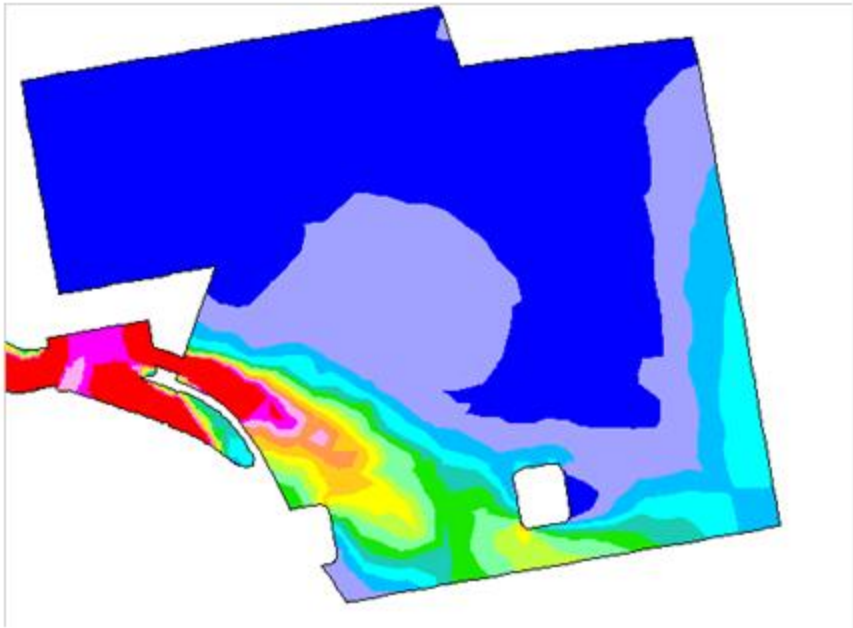
# JEEP FLOOR DUCT AIMING STUDY

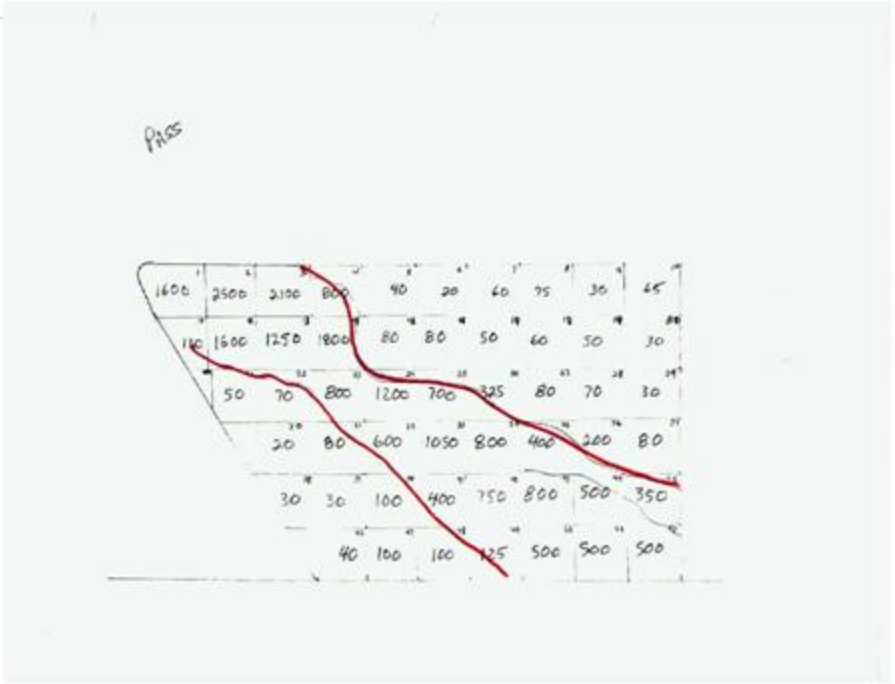





# DRIVER SIDE

# JEEP FLOOR DUCT AIMING STUDY






## PASSENGER SIDE

# Effect of Glass on Interior Temperature

## *OBJECTIVE*

To study effect of solar glass on interior temperature

## *RESULTS OBTAINED*

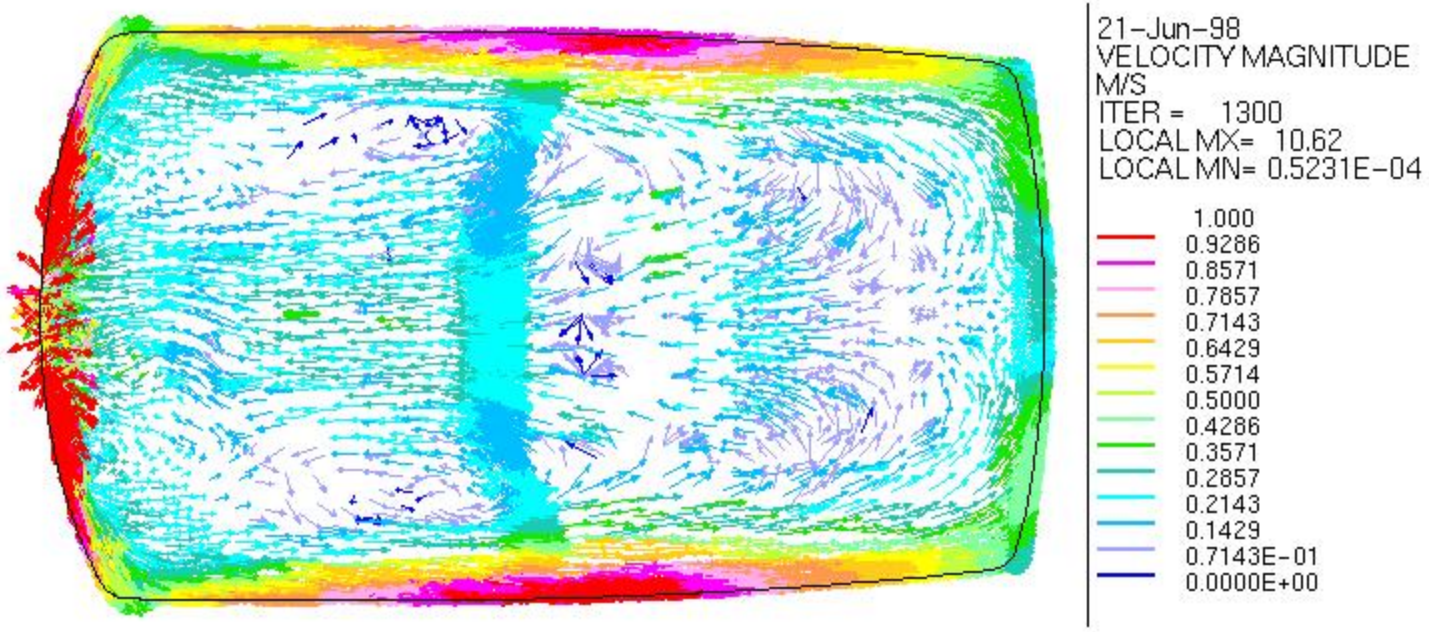
- Flow distribution pattern
- Temperature distribution.
- Pressure drop across the cabin.

## *IMPACT*

Reduced the turn around time from 4-5 weeks to 3 days

by using CATIA solid modeling and auto meshing techniques.

# JEEP BODY EXHUASTER CFD STUDY




PLAN VIEW @ HALF GLASS SECTION

# Effect of Glass on Interior Temperature

MODEL CONDITIONS:

a). Full Panel Mode (240 CFM air inlet @ 50 F);

b). 24 sq. in airflow outlet at front of passenger leg;

c). Full size car body with four occupants, front & rear seats;

d). Solar energy is considered: 1000 w/m*2, 45 degrees;

e). Outside surface of car body except glass is set as 110F;

f). The glass combinations are summarized in the table below:

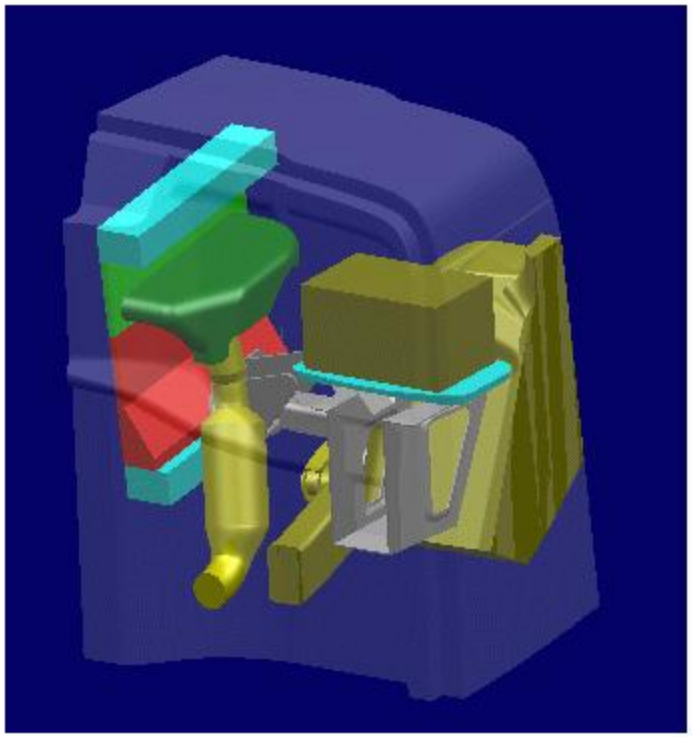
| Case # | Average Temperature (F) | | | Cost Increased In Dollars |
|---|---|---|---|---|
| | In front seats | In rear seats | On driver face | |
| 1 | 79.0 F | 76.0 F | 81.6 F | $0.00 |
| 2 | 73.7 F | 71.2 F | 75.8 F | $6.31 |
| 3 | 72.7 F | 70.9 F | 74.5 F | $10.00* |
| 4 | 78.5 F | 75.7 F | 80.6 F | N/A |

Conclusion:

The PrimaGaurd glass with solar windshield can reduce interior temperature 6 F compared with tint glass, cost is increased $10.00.

* This number is estimated based on case 2 cost.

# JEEP Exhaust System Temperature



- Find effect of engine-exhaust system on dash panel temperature.
- CFD model included engine, exhauster system, dash panel etc.
- CFD Analysis: 175 F on dash surface
  Test measurement: 190 F on dash surface
- Continuous work on effect of dash panel w/ fiber glass heat shield.

# JEEP PLENUM AIRFLOW STUDY
## WITH 4 MM BY 4 MM FILTER SCREEN

***OBJECTIVE***

•To study effect of filter screen size on plenum performance:

a). Pressure drop; b). Airflow distribution and direction.

***CFD MODEL:***

- Base model without screen,
- With screen 6.5mm X 6.5mm size, and
- With screen 4mm X 4mm size.

***RESULTS: Compared with base design:***

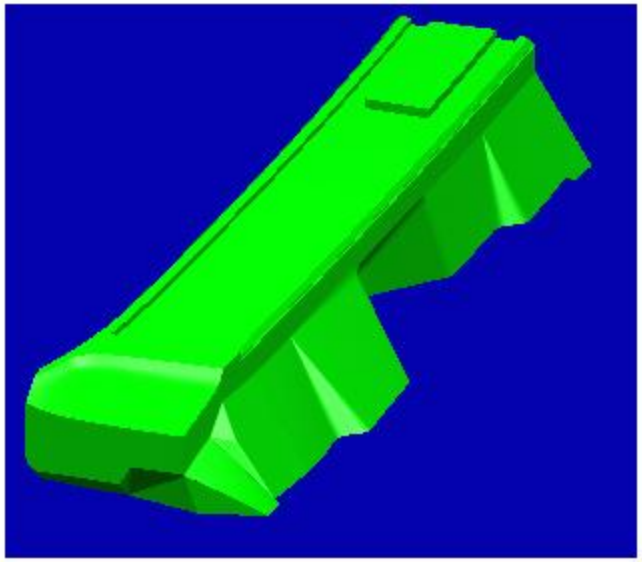
- 6.5mmX6.5mm screen: pressure drop 18 pa more,
- 4mmX4mm screen: pressure drop 37 pa more
- Airflow pattern for all three design are almost same at inlet area.

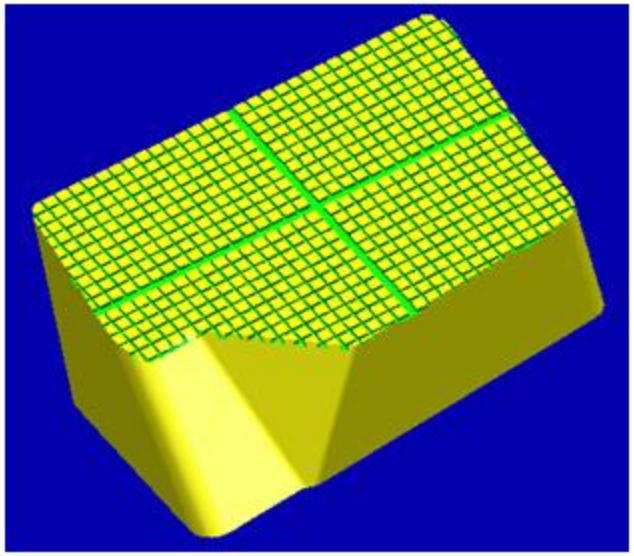
***CORELATION***

***CFD co-relation with laboratory testing is within 4.5 Pa difference.***

# JEEP PLENUM AIRFLOW STUDY
## WITH 4 MM BY 4 MM FILTER SCREEN

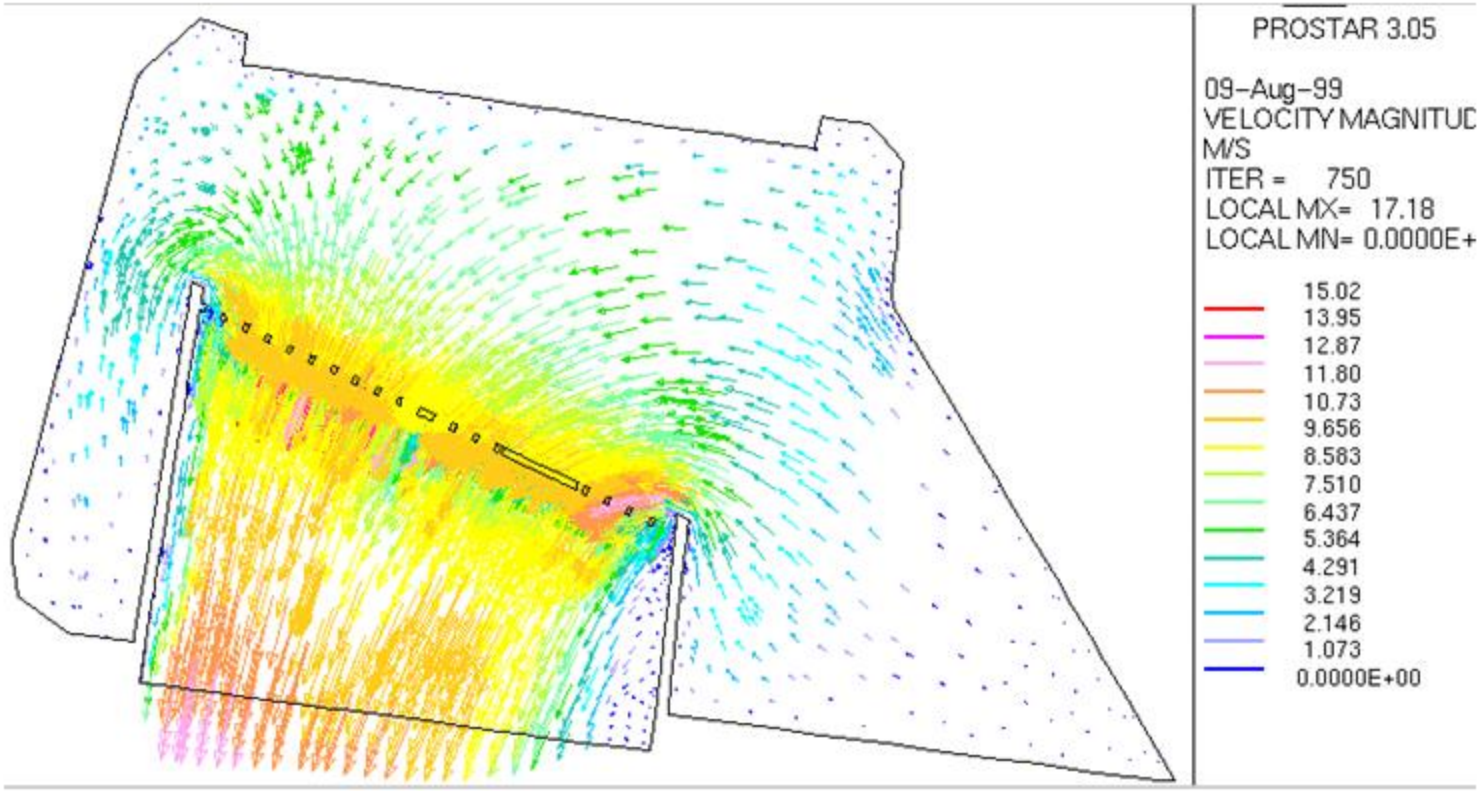
## CFD MODEL



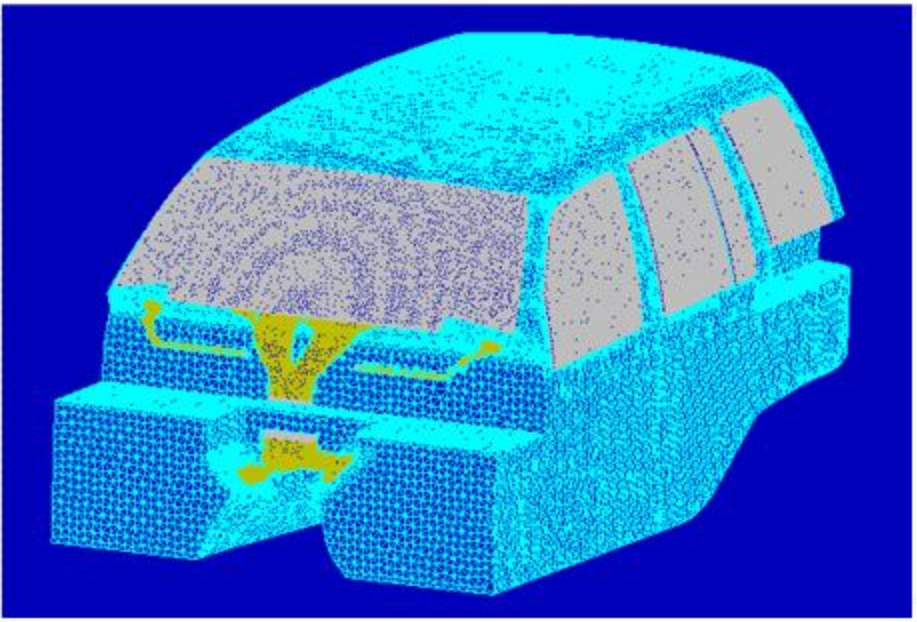


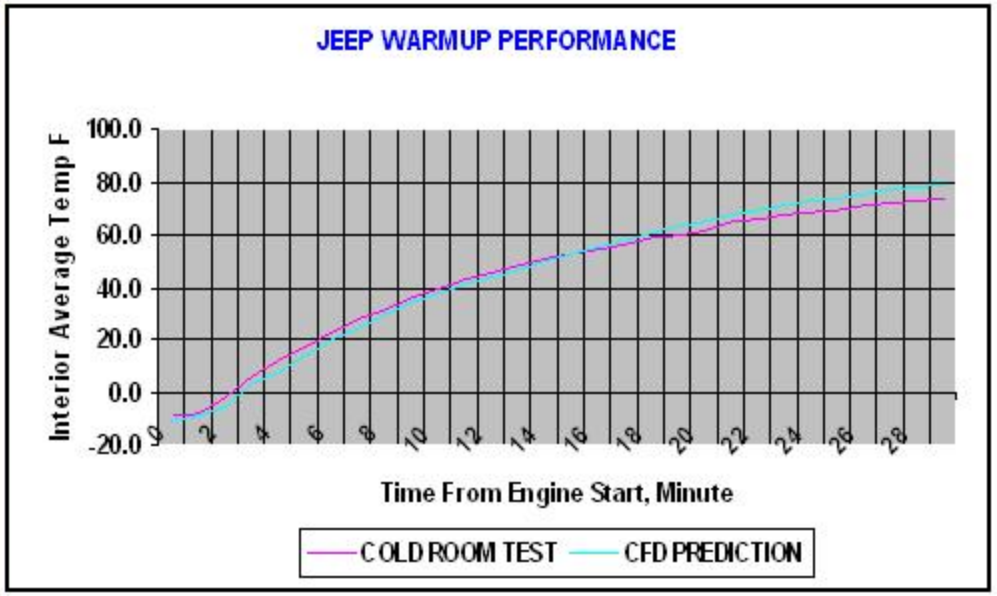
# JEEP PLENUM AIRFLOW STUDY

## WITH 4 MM BY 4 MM FILTER SCREEN



# JEEP WARMUP STUDY






**Remark:**

a). Cold room test starting temperature is -8 F, CFD model starts at -10 F. This makes the difference between prediction and testing in beginning of the test.

b). S0 bodies which are not very tight, would make the average vehicle temperature lower. CFD model assumes all air is exit from body exhauster. So prediction temperature is high than testing after engine start 15 minutes.

c). We are continuously working on correction.

# JEEP CLIMATE CONTROL/CFD TEAM

## KJ CLIMATE CONTROL

| | |
|---|---|
| Gary Baker | Supervisor |
| Kurt Houslander | Lead Engineer |
| Steve Hall | Engineer and Lead Designer |
| Chris Connolly | Core Designer |
| Jun Lu | CFDer and Coordinator |
| Zia Ullah | TCC Meshing Support |

## PROGRAM SPONSOR

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