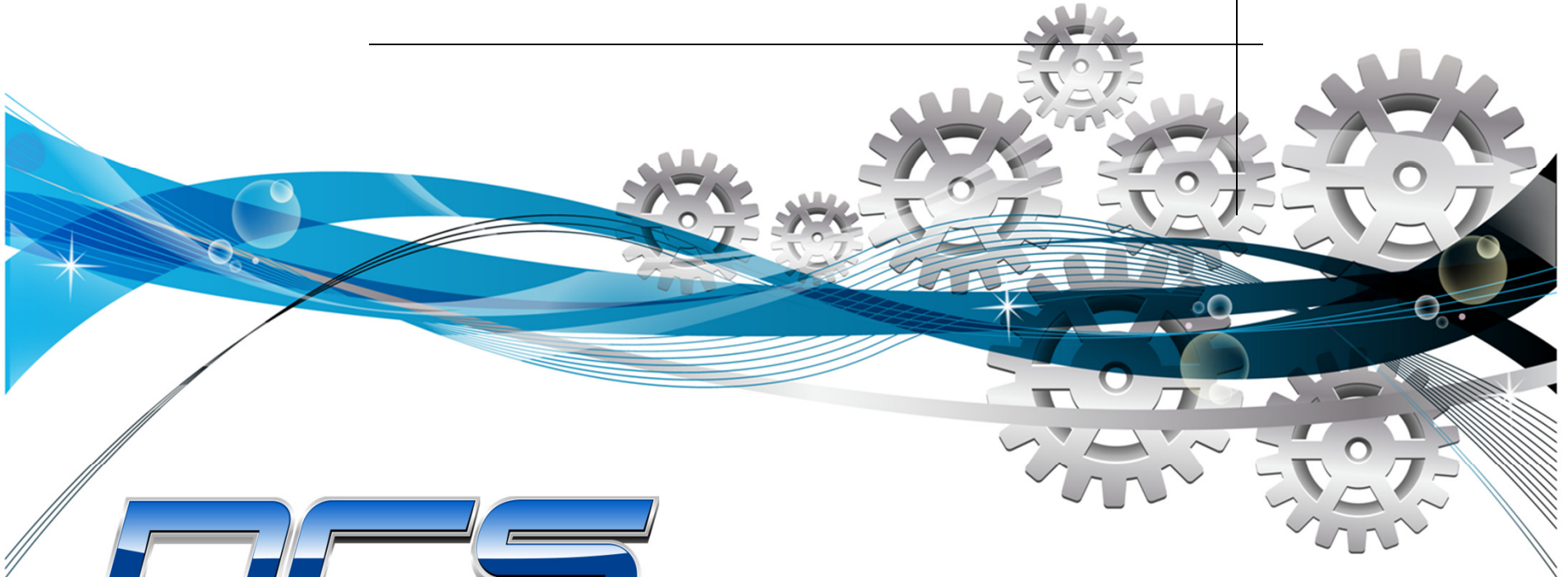


***Do it right the first time...***

***A Dimensional Engineering approach  
to Closed-Loop Quality Management***



***DCS***  
***ENGINEERING IN NEW DIMENSIONS***

# Prevention

## Deaths in Rhode Island from Smoking

Adults who die each year from their own smoking **1,600**

Kids now under 18 and alive in Rhode Island who will ultimately die prematurely from smoking **23,000**

**Smoking kills more** people than **alcohol, AIDS, car crashes, illegal drugs, murders, and suicides combined** — and thousands more die from other tobacco-related causes — such as fires caused by smoking (more than 1,000 deaths/year nationwide) and smokeless tobacco use.

# Problems to Mitigate...



**Process Inconsistency**

**Product Non-Conformance**

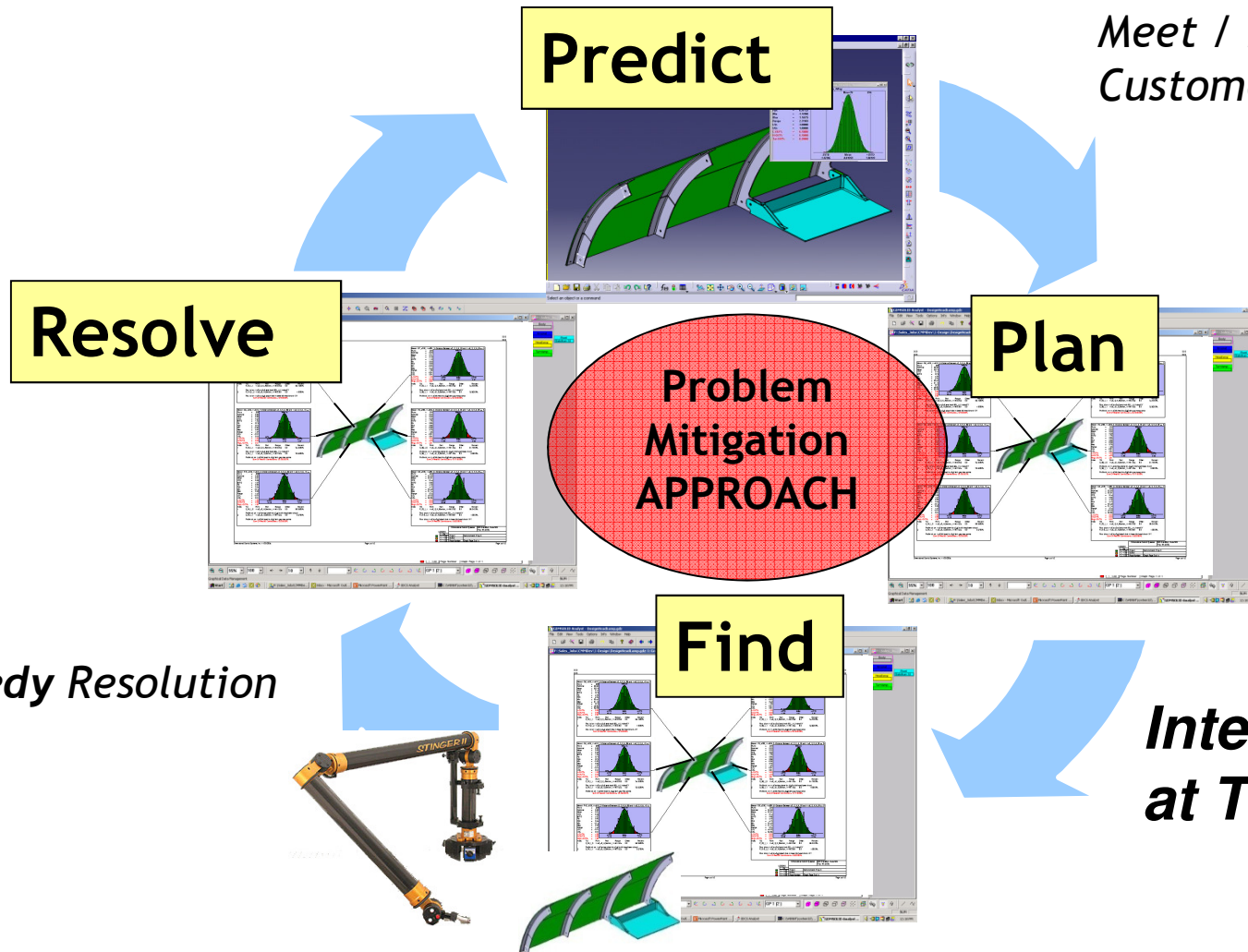
**Warranty  
& Liability**

**Traceability Gaps**



# Closed-Loop Quality

*DE Process that will Meet / Exceed Customer Expectations*

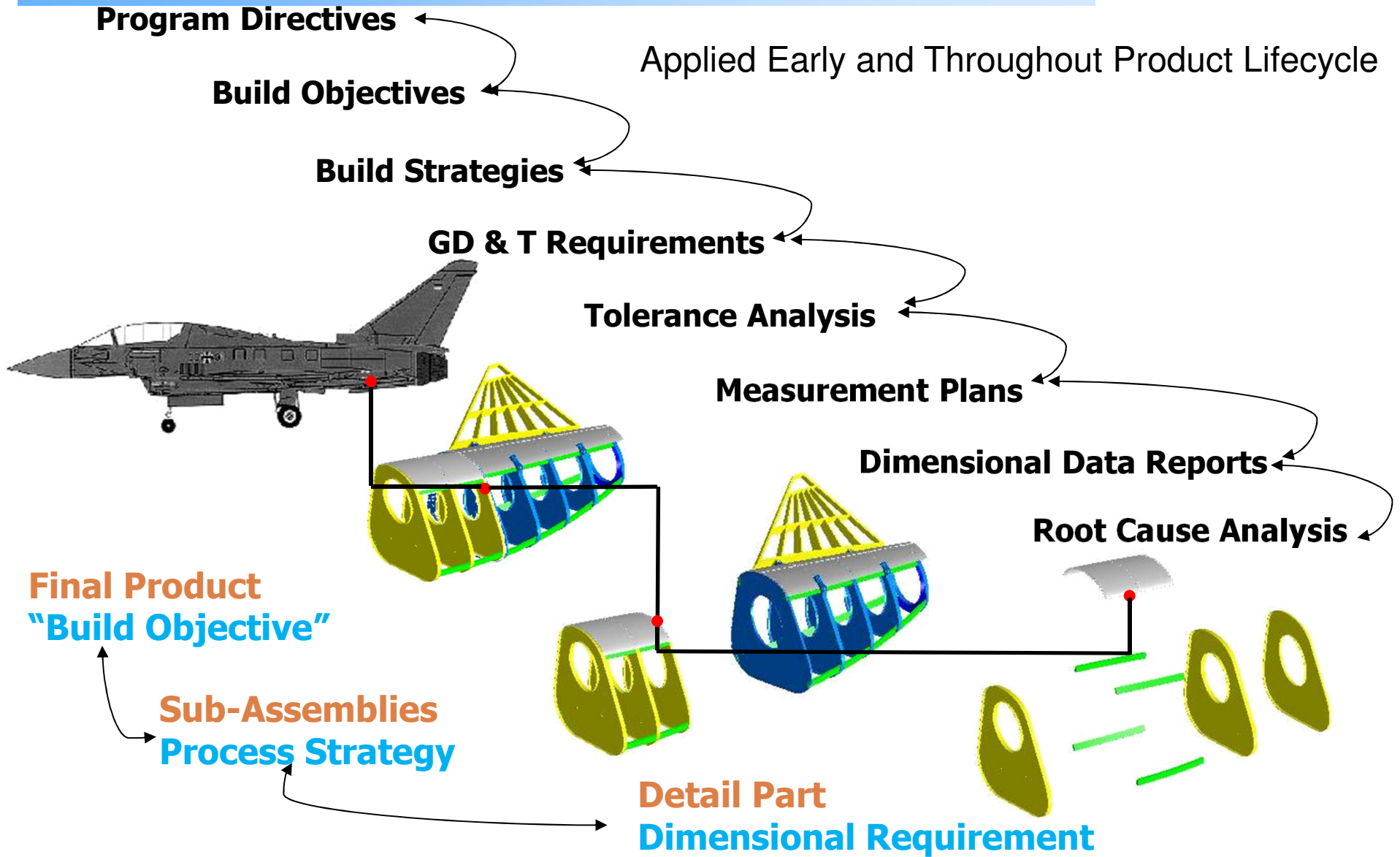




# Dimensional Engineering...

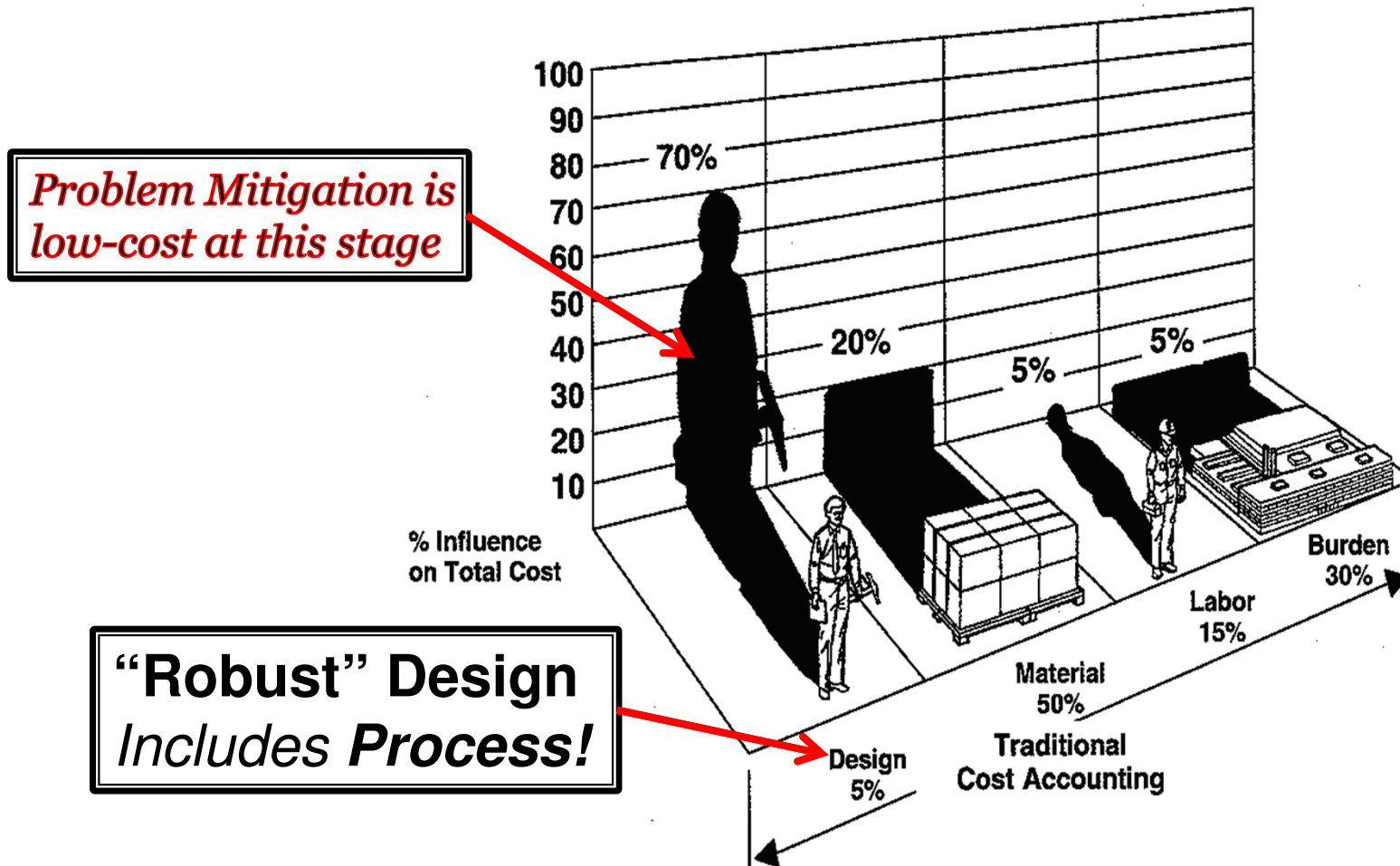


Applied Early and Throughout Product Lifecycle



# Why Dimensional Engineering?

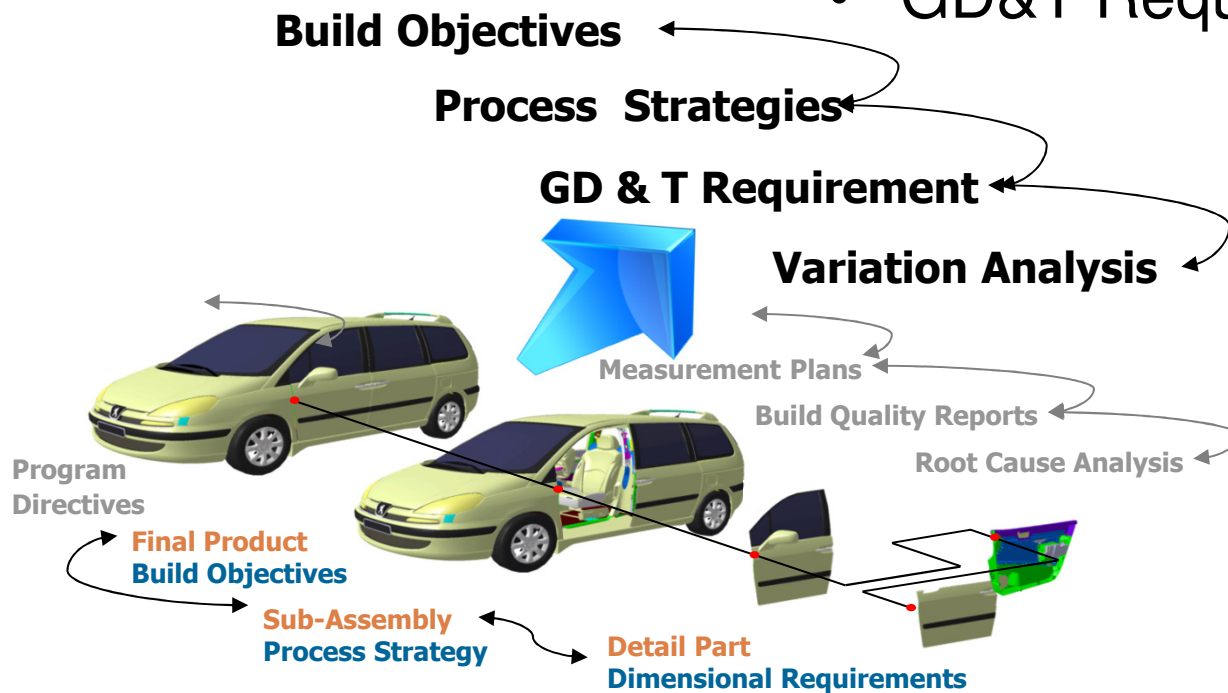
## Casting The Biggest Shadow



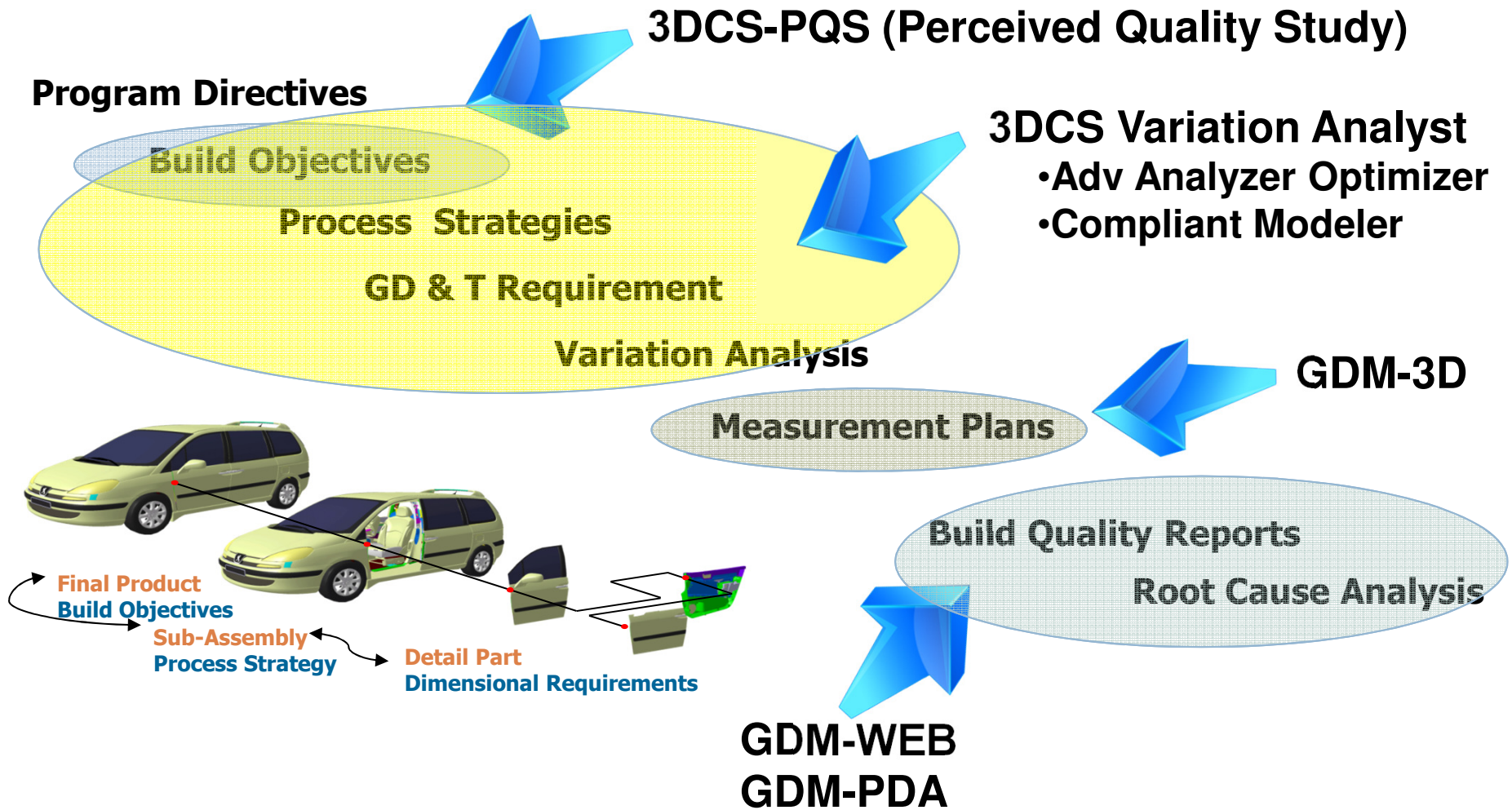
# Key Elements of a Robust DE Process

## Variation Analysis **Validates:**

- Build Objectives
- Process Strategies
- GD&T Requirements



# Tool Alignment to DE Process

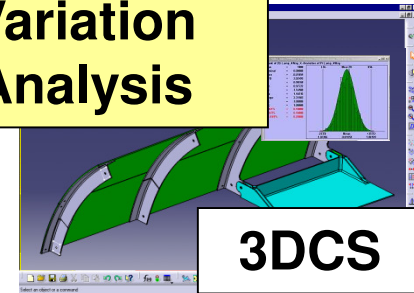


# DVA Process Alignment to PLM



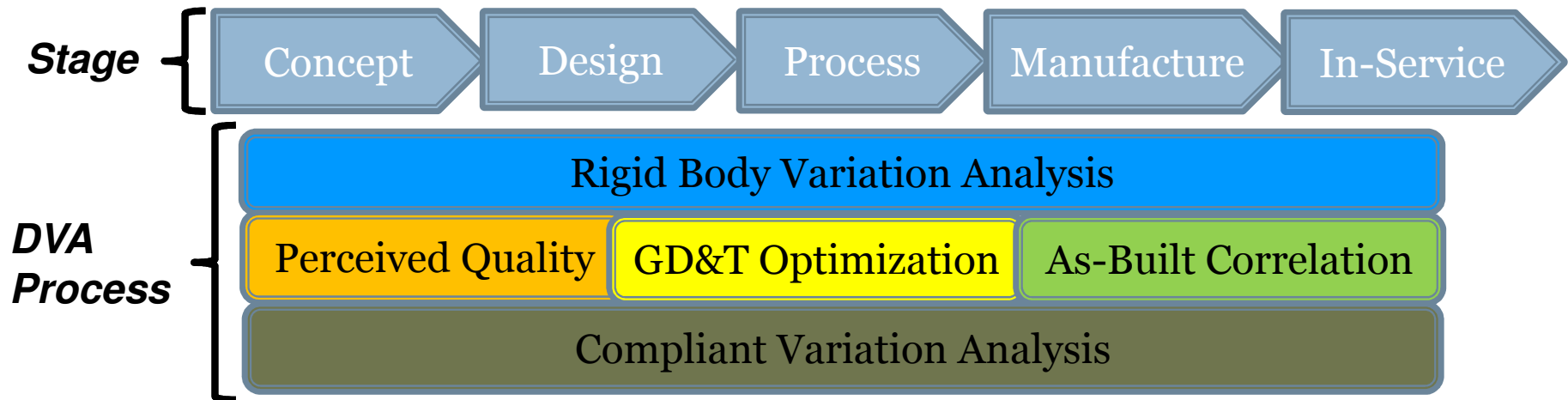
**Complete Process Support**  
For Engineering & Manufacturing Quality

**Dimensional  
Variation  
Analysis**



**3DCS**

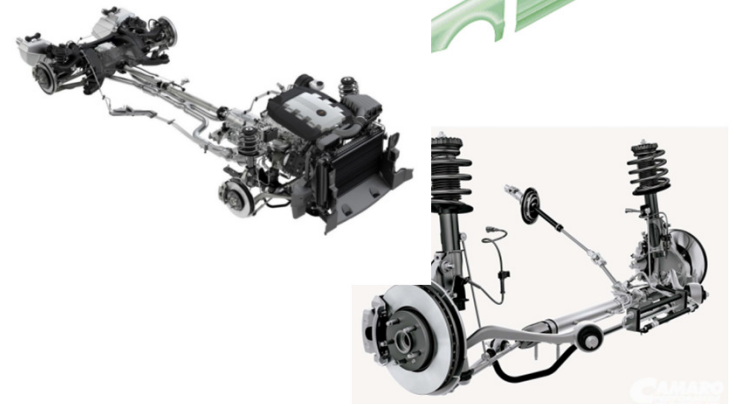
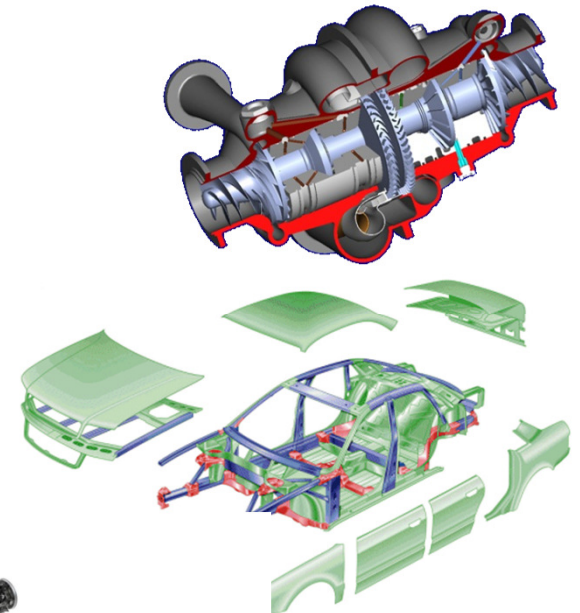
*Product Lifecycle*





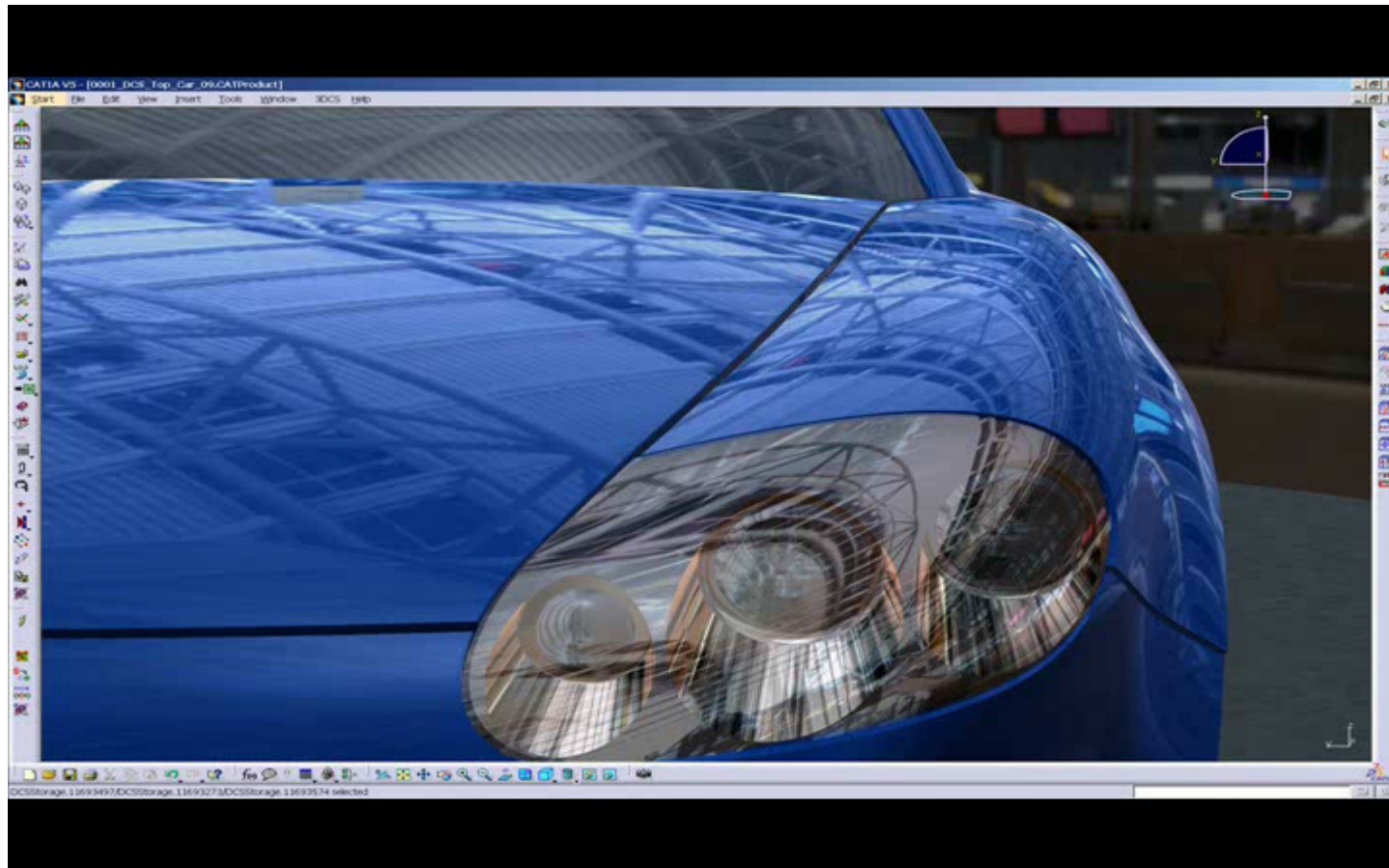
# DVA Application Domains...

- Structures / Chassis
- Mechanisms
- Enclosures
- Aesthetic Fits
- Any Assembly



# Visualize Variation Impact Early

---



*Perceived Quality Study*

---

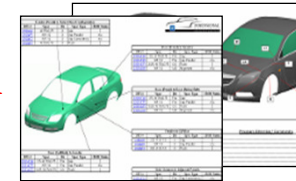
# General Motors Results...

## 8. Verification

- Final DTS verification
- Lessons learned workshops



## 1. DTS Define gap, flush and radii targets



## 2. Concept Creation and Investigations

- Simulation of new concepts
- Digital visualization
- Benchmark of different concepts



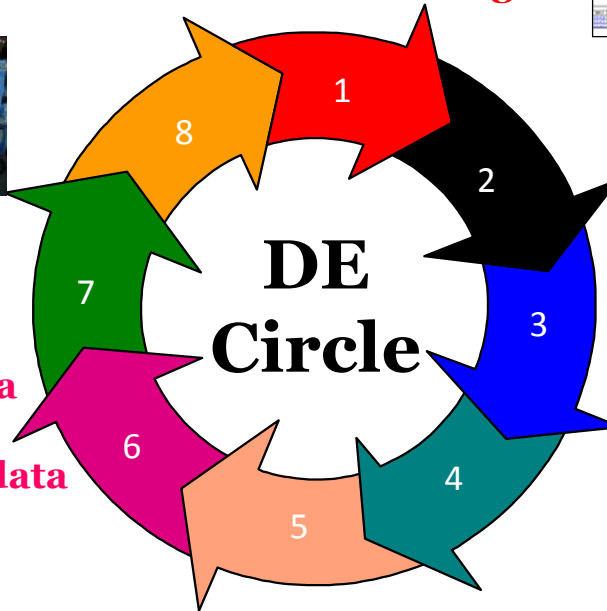
## 7. Validation tools

- Vendor part gages
- Vendor part measurement devices



## 6. DTS / Drawing Review

- Check DTS against latest data
- Check and release drawings
- Check tolerance studies for data changes



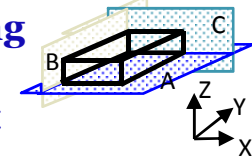
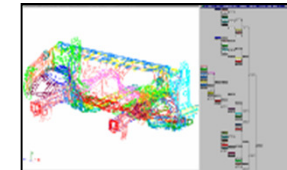
## 5. GD&T

- CFTs for all drawings related items like dimensions, tolerances and DTS requirements



## 4. Tolerance Studies

- Review design & evaluate quality achievement.
- Virtual validation of DTS requirements.





# General Motors Results...



"Successful tolerance analysis product execution played a major role in our achievement of high quality across our product vehicle line.

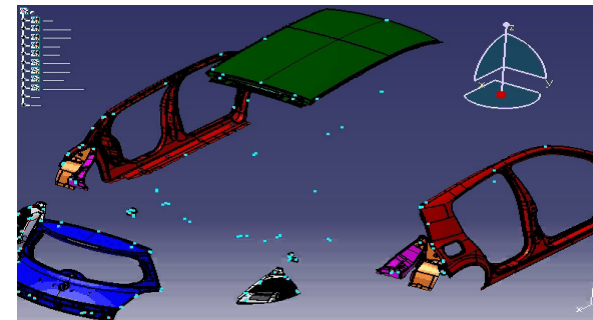
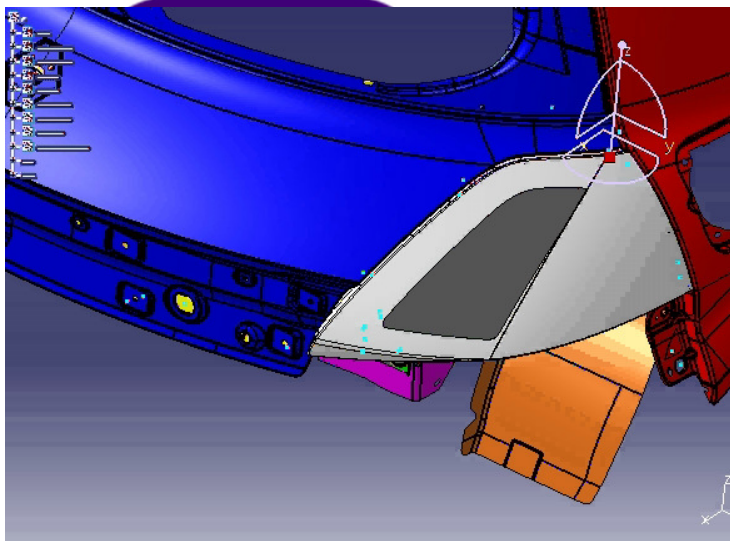
The Chevrolet **Volt**, Chevrolet **Silverado**, Chevrolet **Malibu** and Cadillac **CTS** were all named **Car/Truck of the Year** winners."

Richard Korynski

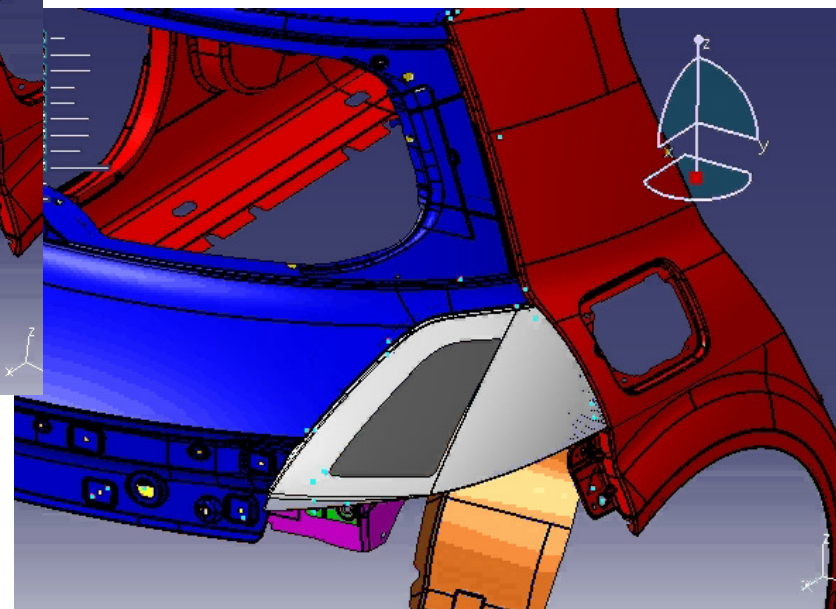
Body Tolerance Analysis Manager-  
General Motors

# In-depth Tolerance Studies

## Model Based *Dimensional Variation Analysis*



**Simulate-**  
*- Thousands of Assembly  
builds in Minutes*

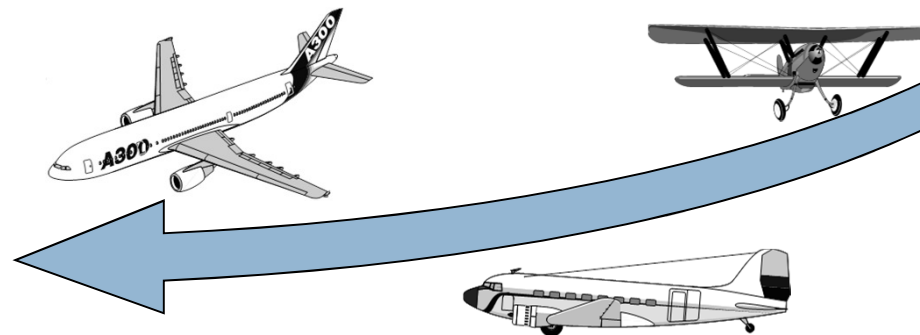
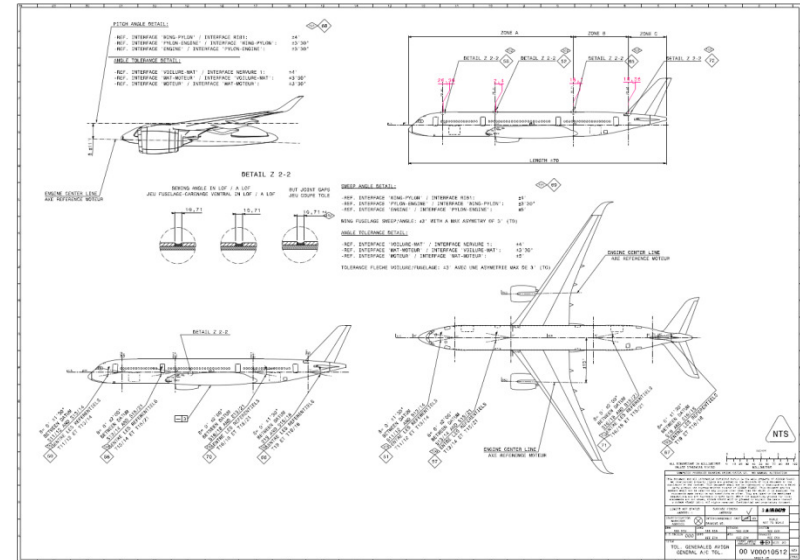




# Airbus: Tolerance management during early concept phase

Evaluation of:

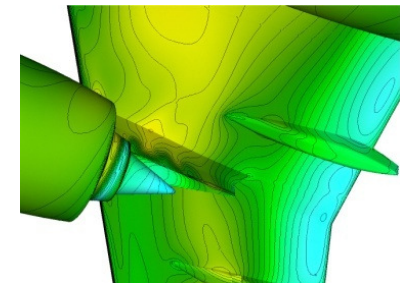
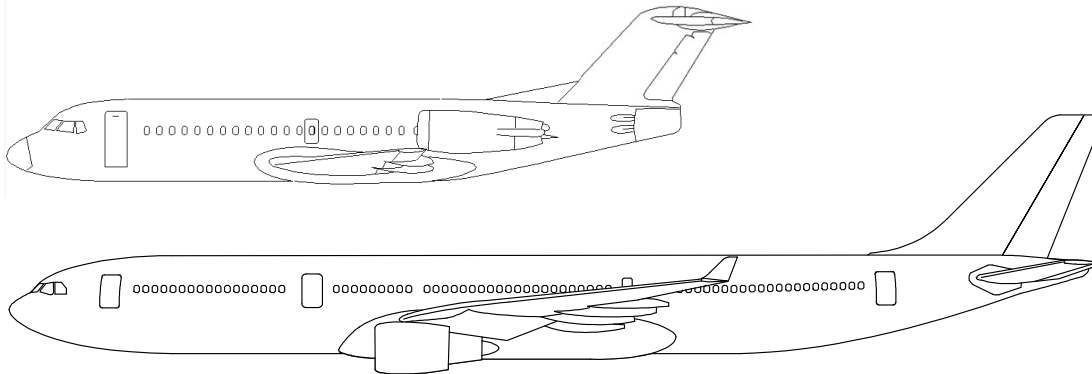
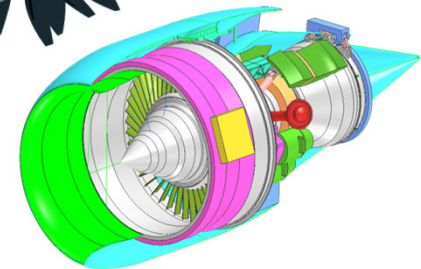
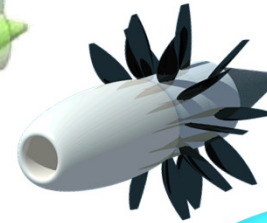
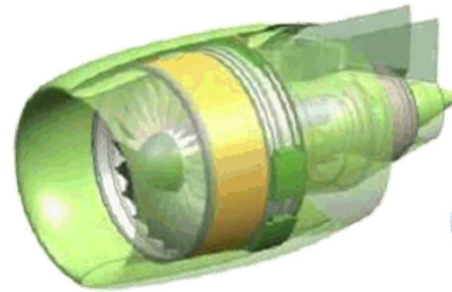
- ▶ assembly process regarding global aircraft requirements
- ▶ different assembly strategies
- ▶ new manufacturing technologies (CFRP, bonding, water-jet cutting, One-Shot-Single-Barrel)
- ▶ new assembly technologies (indoor-GPS, Laser-scanner/tracker)



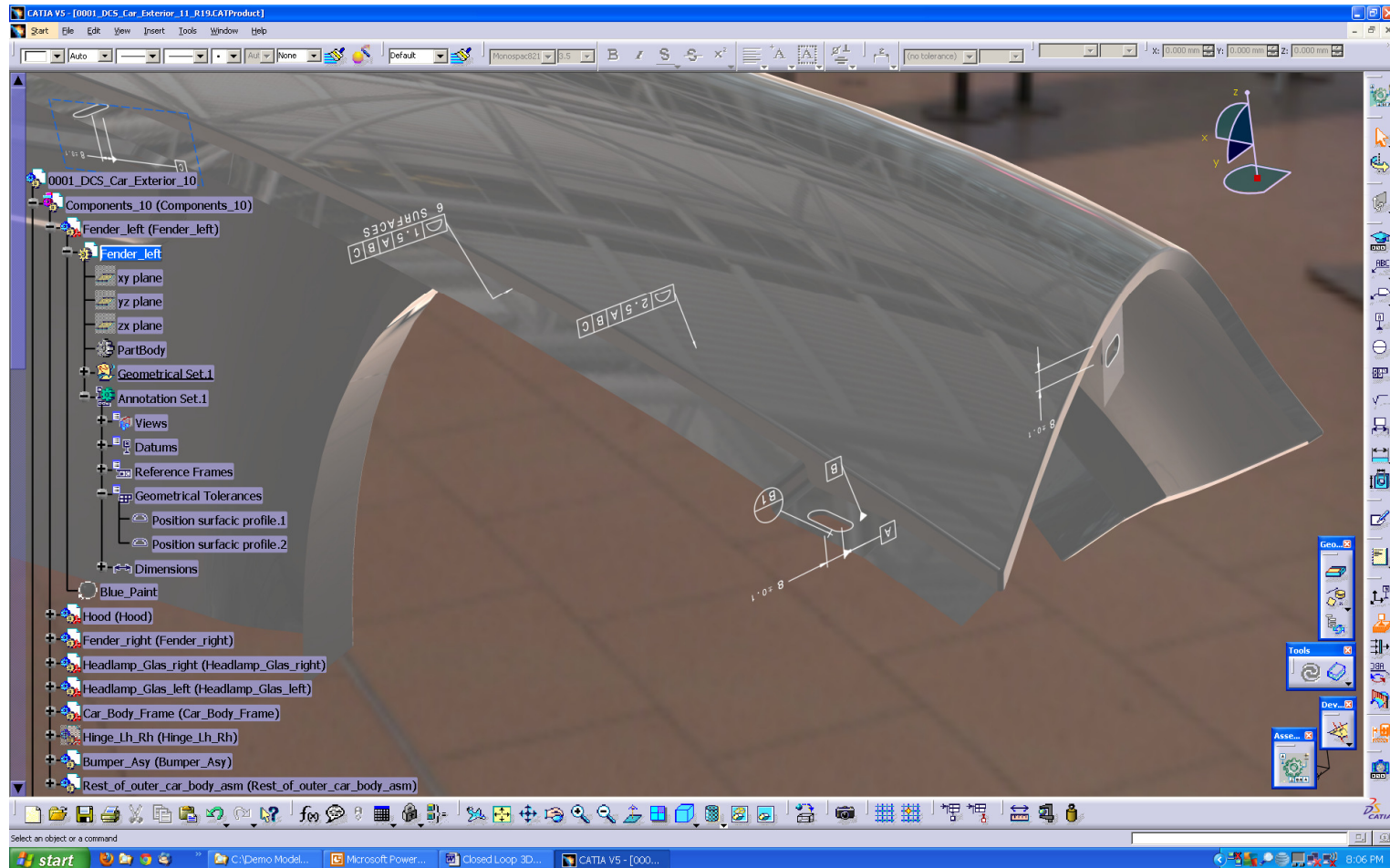
# Tolerance management during early concept phase

Analyse different engine concepts for aerodynamic efficiency

- ▶ Tail or wing mounted
- ▶ Geared turbo fan
- ▶ Open rotor configuration



# Associativity to CAD Model & GD&T



# Tolerance Optimization to Cost Constraints



**Advanced Analyzer Matrix**

Analyzer Co...	1 Rear Gap	2 Rear Mid	3 Front Gap	4 Lt Bmpr ...	5 Mid Bmpr...	6 Rt Bmpr ...	7 Meas10
Range	2.930(mm)	2.860(mm)	3.489(mm)	1.892(mm)	1.738(mm)	1.997(mm)	2.836(mm)
1 Fender to...	1.400(mm)	1.0	0.9	0.0	0.0	0.0	0.0
2 Hood Gap...	1.400(mm)	1.0	1.0	1.0	1.0	1.0	0.1
4 Pin Pos T...	1.500(mm)	1.0	0.8	1.1	0.0	0.0	0.0
5 Hng Mnt ...	1.500(mm)	0.1	0.2	0.2	0.1	0.2	0.3
6 Hng Mnt ...	1.500(mm)	1.0	1.2	1.6	0.3	0.6	1.9
7 Latch Hq...	1.000(mm)	0.0	0.0	0.0	-0.4	-0.3	0.0
9 HP LH Fe...	0.100(mm)	1.0	0.8	1.1	0.2	0.0	0.0

Legend:

**Advanced Optimizer Cost**

Measure	1 Rear Gap	2 Rear Mid	3 Front Gap	4 Lt Bmpr ...	5 Mid Bmpr...	6 Rt Bmpr ...	7 Meas10
Meas Value	2.930(mm)	2.860(mm)	3.489(mm)	1.892(mm)	1.738(mm)	1.997(mm)	2.836(mm)
Max Meas	4.144(mm)	3.959(mm)	4.857(mm)	2.558(mm)	2.356(mm)	2.696(mm)	3.781(mm)
Min Meas	1.917(mm)	1.873(mm)	2.298(mm)	1.229(mm)	1.123(mm)	1.301(mm)	1.890(mm)
Opt Meas	2.930(mm)	2.860(mm)	3.489(mm)	1.892(mm)	1.738(mm)	1.997(mm)	2.836(mm)
Goal Value	2.930	2.860	3.489	1.892	1.738	1.997	2.836

**Advanced Optimizer Matrix**

Measure	1 Fender to...	2 Hood Gap...	3 Surf Pad ...	4 Pin Pos T...	5 Hng Mnt ...	6 Hng Mnt ...	7 Latch Hq...	8 Bmpr Tol(...	9 HP LH Fe...
Cur Tol	1.400(mm)	1.400(mm)	1.500(mm)	1.500(mm)	1.500(mm)	1.500(mm)	1.000(mm)	10.000(mm)	0.100(mm)
Opt Tol	1.400(mm)	1.400(mm)	1.500(mm)	1.500(mm)	1.500(mm)	1.500(mm)	1.000(mm)	10.000(mm)	0.100(mm)
Max Tol	1.900	1.900	2.000	2.000	2.000	2.000	1.500	10.500	0.600
Min Tol	0.900	0.900	1.000	1.000	1.000	1.000	0.500	9.500	0.000
Locked	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cost	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000

Total Current Cost: 2215.000000      Total Optimized (Minimum) Cost: 2215.000000

Buttons: Minimize Cost, Update Model Tolerances, Summary, Close

Advanced Analyzer/Optimizer



# Peterbilt Results...

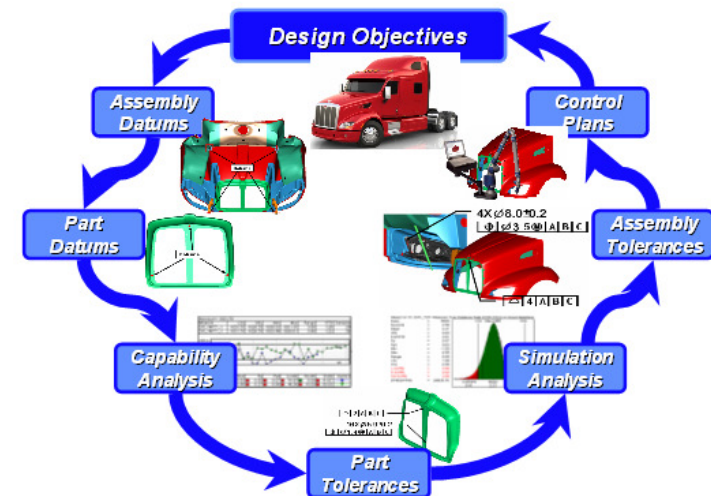


***"3D tolerance analysis has provided the foundation for our dimensional management process here at Peterbilt as well as throughout the PACCAR organization.***

***We have seen the fit & finish and overall quality of our products improve since the implementation of tolerance simulation / dimensional management.***

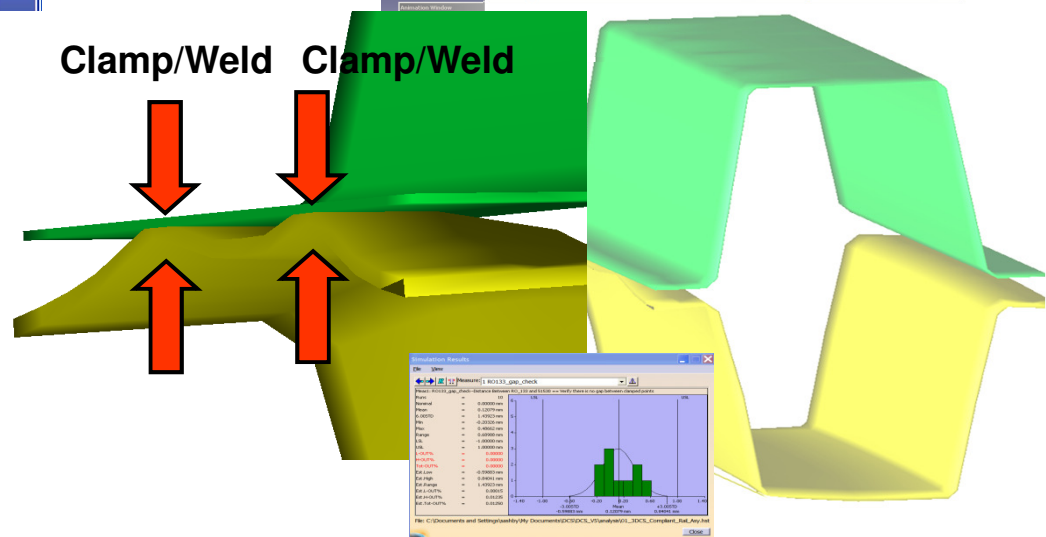
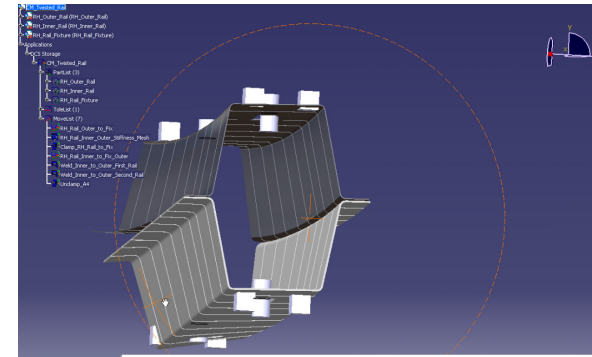
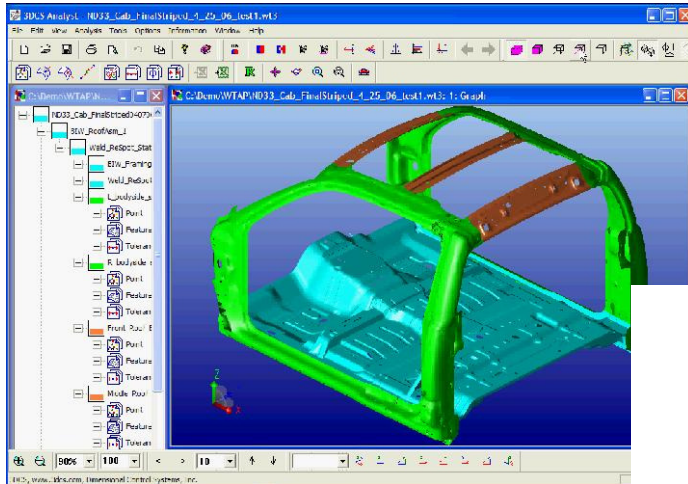
***We rely on tolerance analysis to help manage design quality and support our objective to be best in class.***

**- Jacob Conley  
Dimensional Management  
Group Leader**





# Compliant Variation Analysis



Consider Effects of:

- Force
- Gravity
- Thermal

*Compliant Modeler*

# Automated Reporting

The screenshot displays the 3DCS Analysis Report software interface. It features a main window with a navigation pane on the left and a central content area. The content area is divided into several overlapping panels:

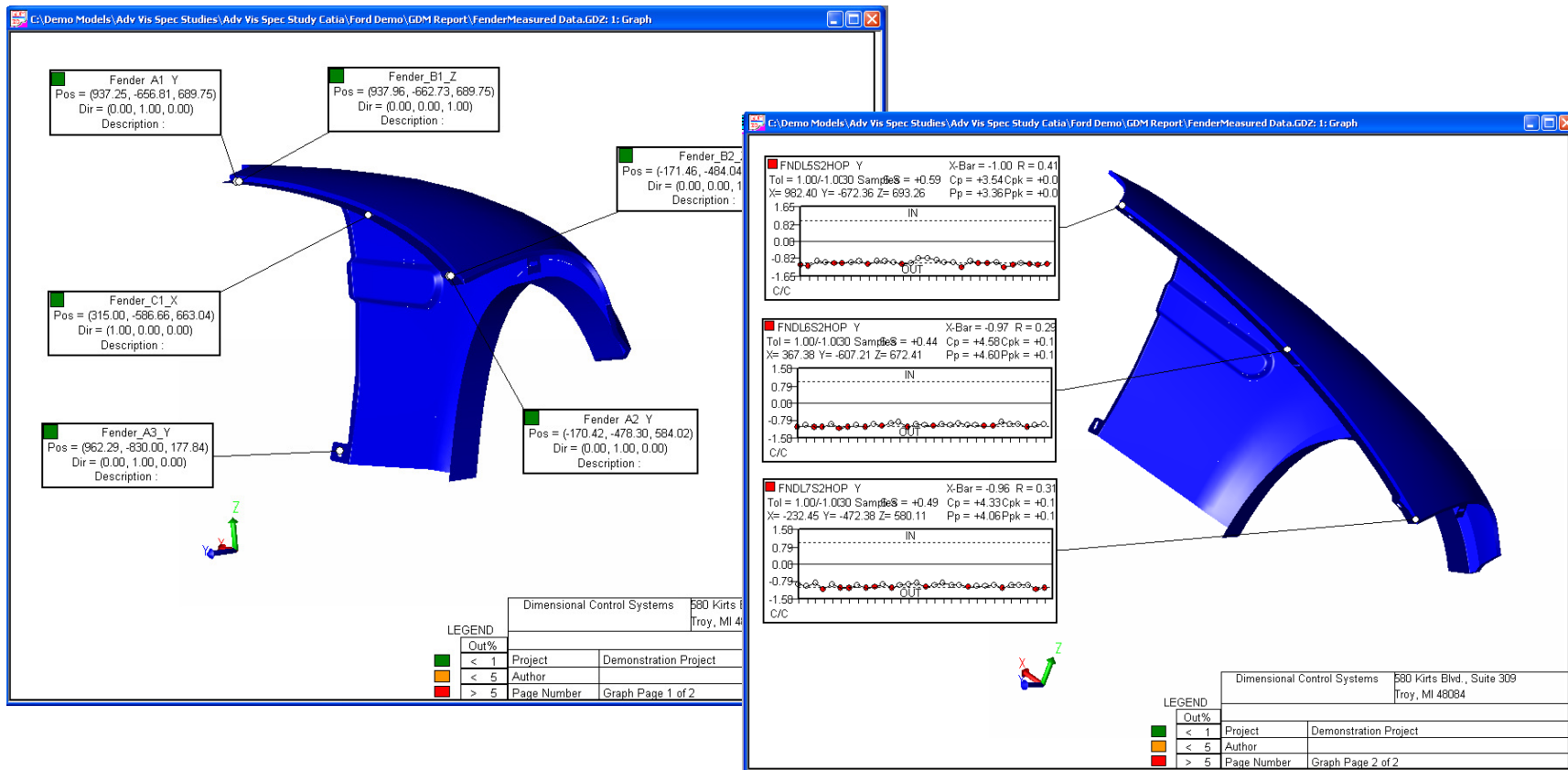
- Top Panel:** Shows the report title "3DCS Analysis Report" and a "CONTENTS" sidebar with links for Home, Summary, Component Information, Tree Structure, Action Tree, GD&Ts, Moves, Measurements, Analysis Results (AAO), Analyzer Matrix, and Analysis.
- Image Panel:** Displays a 3D model of a car's front end in a virtual environment.
- Table Panel (Tolerances):** A table listing tolerances for various features.
 

Name	Parent	Type	Range	Distribution
Surf_Tol1	Upper_Platen_1	Feature	+0.100000	Normal
		Feature	+0.200000	RightSkew
		Feature	+0.250000	Normal
- Table Panel (Analyzer Matrix):** A table showing the Analyzer Matrix for various features.
 

Analyzer Coefficients	Range	1 M1_to_M1_Z	2 M2_to_M2_Z
1 Surf_Tol1(Upper_Platen_1)	0.100(mm)	1.0	1.0
2 Planer_Roller_Pos_Tol1(Planer_1)	0.200(mm)	1.0	1.0
3 Tole22(Planer_1)	0.250(mm)	-1.0	-1.0
4 Hole_Pos_Tol1(Press_Rink_1_1)	0.100(mm)	0.8	0.8
o11(Press_Rink_2_1)	0.100(mm)	0.8	0.8
o11(Press_Rink_3_1)	0.100(mm)	0.2	0.2
o11(Press_Rink_4_1)	0.100(mm)	0.2	0.2
s_Tol1(Support_AllCATPart_1)	0.100(mm)	1.2	0.8
- Tree Structure Panel:** A hierarchical tree diagram showing the assembly structure, including Maindriven-100, Upper\_Platen\_1, Planer\_1, Press\_Rink\_1\_1, Press\_Rink\_2\_1, Press\_Rink\_3\_1, Press\_Rink\_4\_1, Cam-Rod1\_1, Rods\_1\_1, Rods\_2\_1, and Rods\_3\_4.

Automated Report Generator

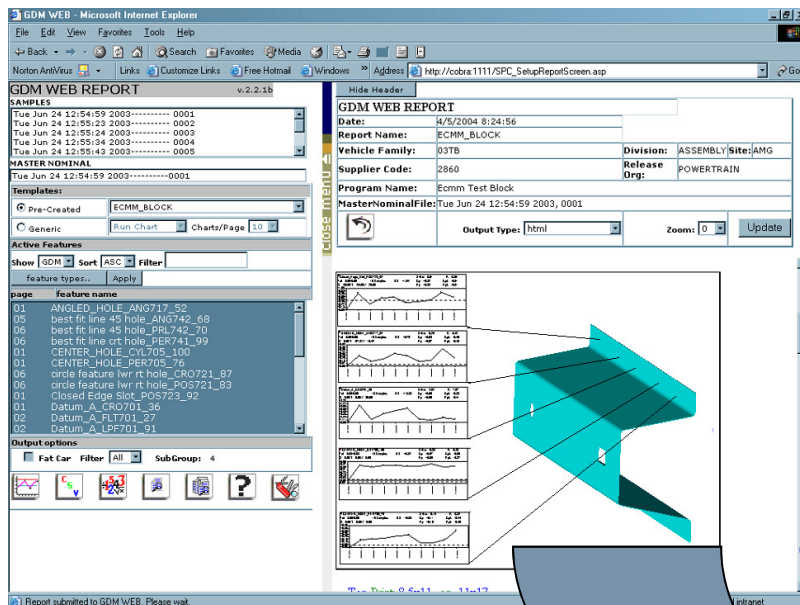
# Measurement Plan Authoring



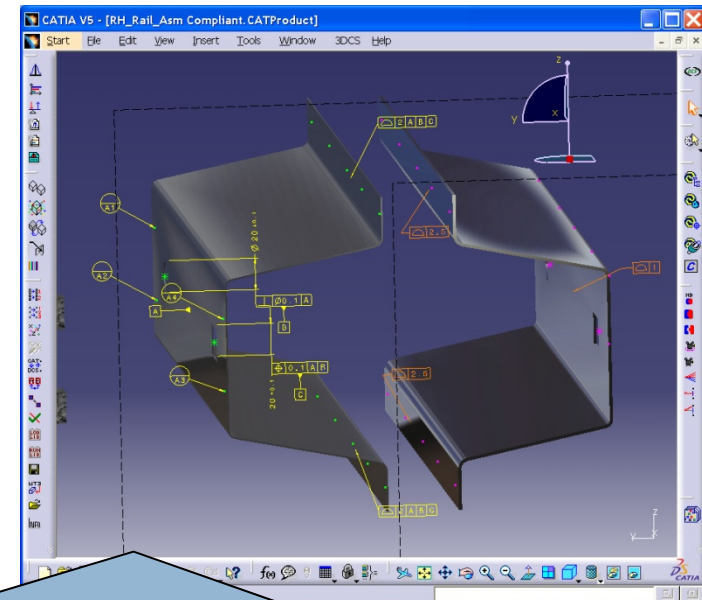
# Leverage Analysis within QA Process



*As a powerful root-cause analysis toolset*



**GDM-Web**  
Quality Management System



**3DCS-**  
Root Cause Analysis

# Chrysler Results...

---



*“Chrysler has realized significant cost savings over the years by using tolerance analysis as part of our overall dimensional engineering process.*

*We've applied tolerance analysis in the early design stages of our programs in order to identify potential build issues early in the product lifecycle.*

*This has enabled us to reduce physical prototypes, minimize costly gage & tooling changes, and avoid quality issues during production.”*

- Greg Medler  
Chrysler Tolerance Analysis Manager

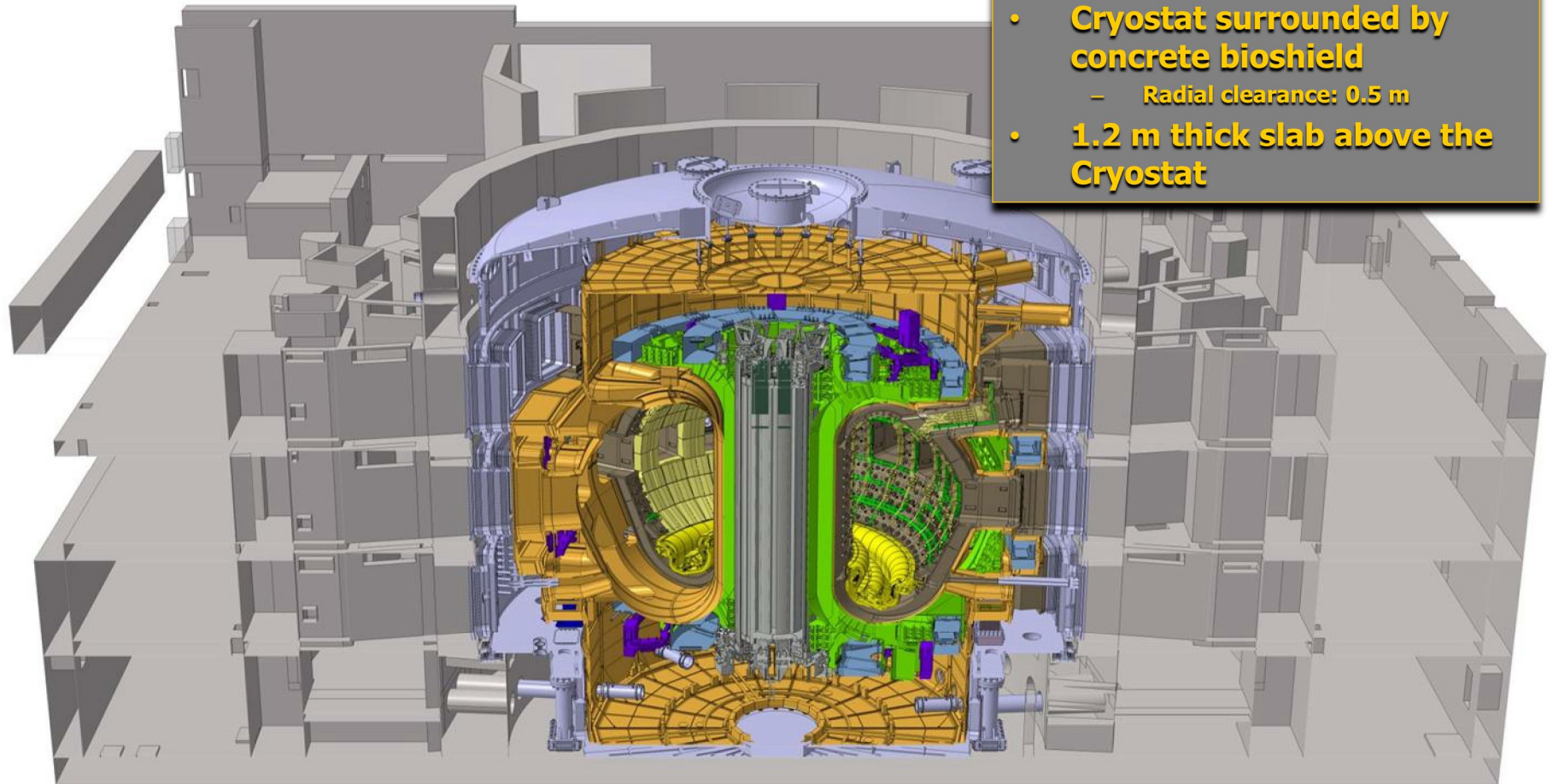




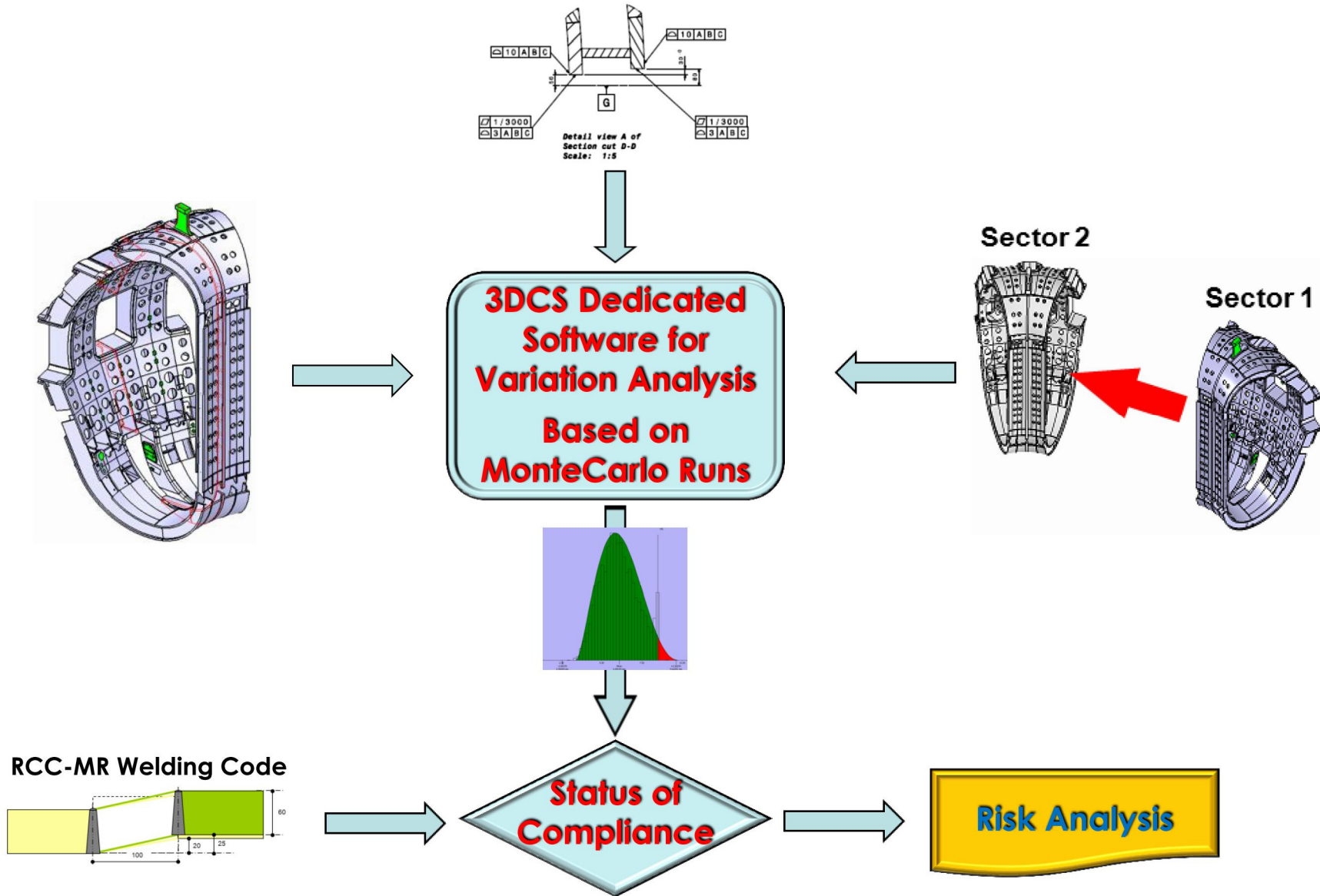


## TOKAMAK BUILDING

- Columns attached to building floor
- Cryostat surrounded by concrete bioshield
  - Radial clearance: 0.5 m
- 1.2 m thick slab above the Cryostat



# Tolerance Model Description





# Tokamak Tolerance Model Status

8 Systems level 1 / 23 Systems level 2

600 Single Parts

15000 Points

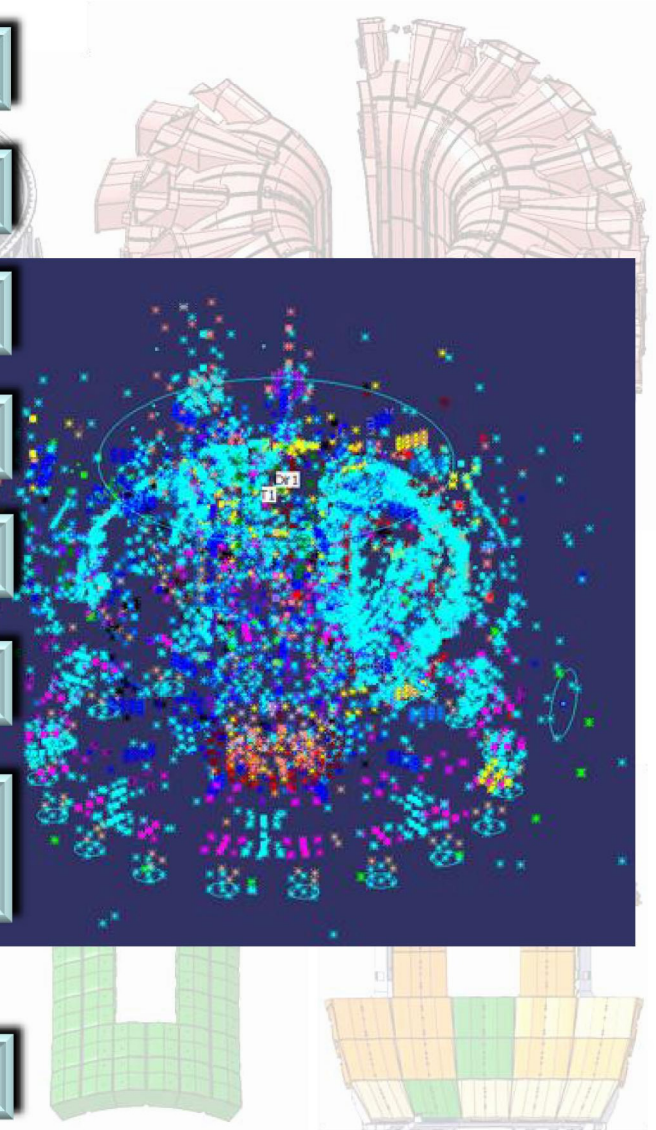
2200 Part Tolerances

760 Moves

30 Functional/Assembly Requirements

6000 Measurements to verify Compliances  
and perform Impact Studies

15 min to run a 5000 Tokamaks analysis



# Dimensional Engineering...



Applied Early and Throughout Product Lifecycle

Program Directives

Build Objectives

Build Strategies

GD & T Requirements

Tolerance Analysis

Measurement Plans

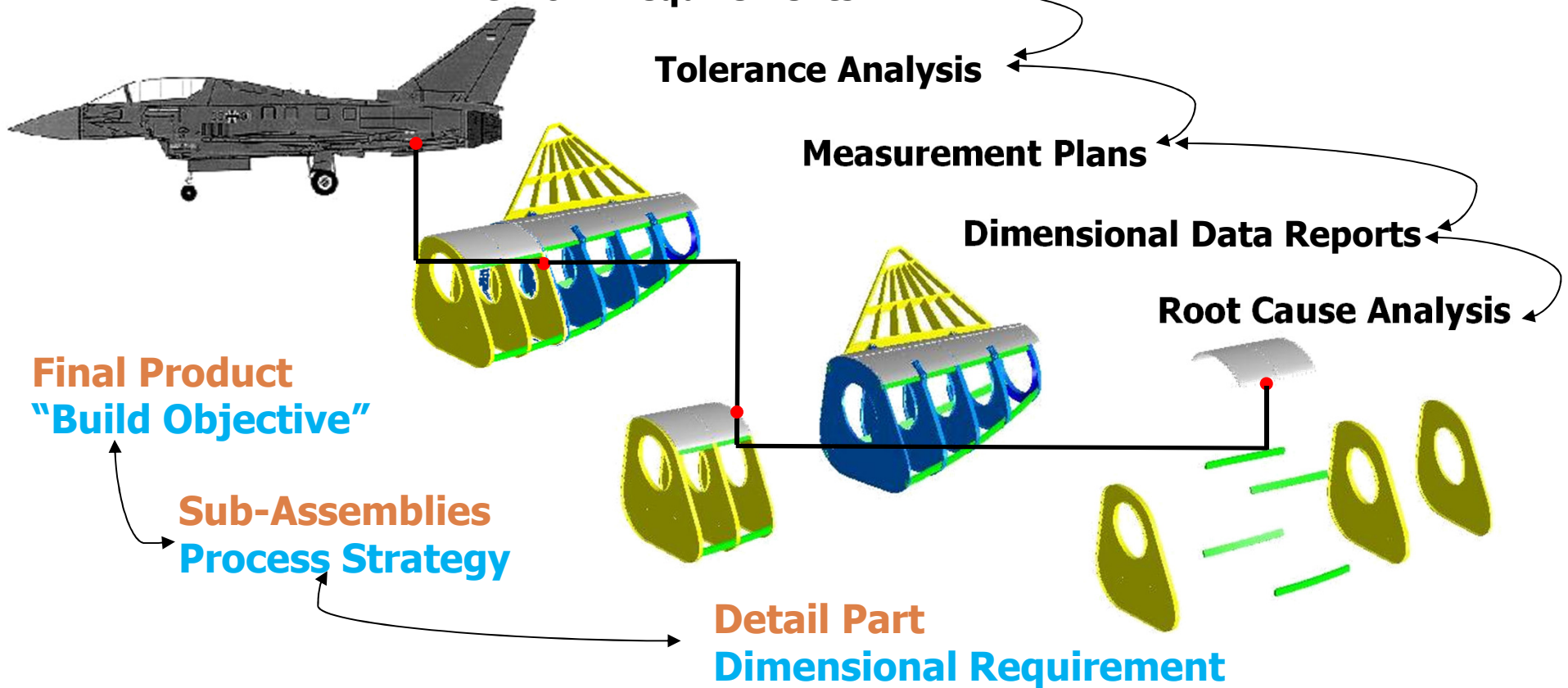
Dimensional Data Reports

Root Cause Analysis

Final Product  
"Build Objective"

Sub-Assemblies  
Process Strategy

Detail Part  
Dimensional Requirement



# Questions???

**Don Jasurda**  
**248-321-1378**  
**djasurda@3dcs.com**

**[www.3dcs.com](http://www.3dcs.com)**