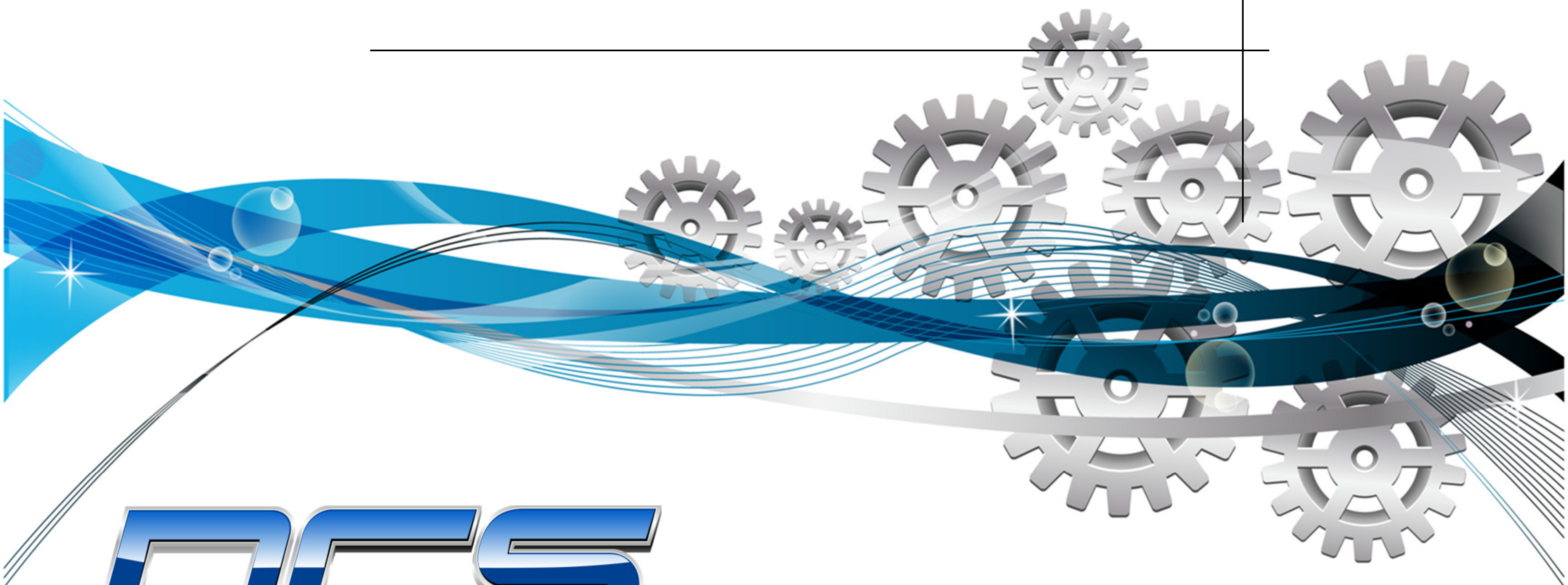
Do it right the first time…

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



DCS
ENGINEERING IN NEW DIMENSIONS

Prevention

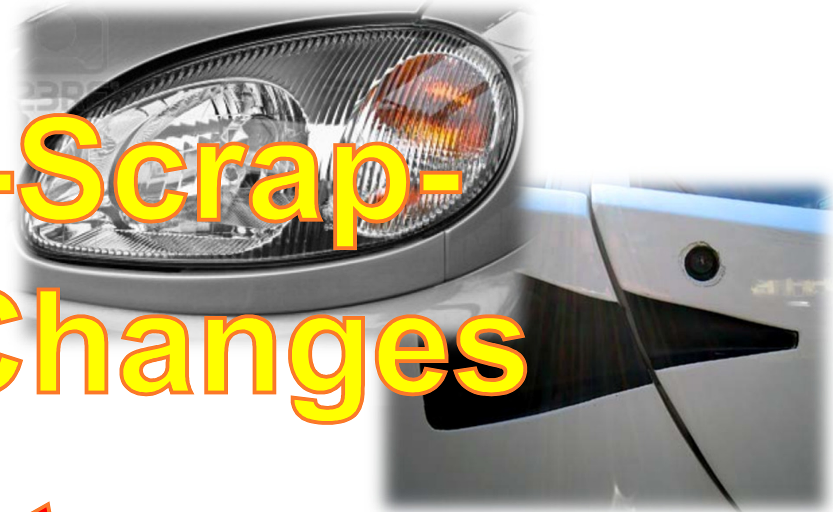
Deaths in Rhode Island from Smoking	
Adults who die each year from their own smoking	1,600
Kids now under 18 and alive in Rhode Island who will ultimately die prematurely from smoking	23,000

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…

Rework-Scrap-Tooling Changes

Process Inconsistency



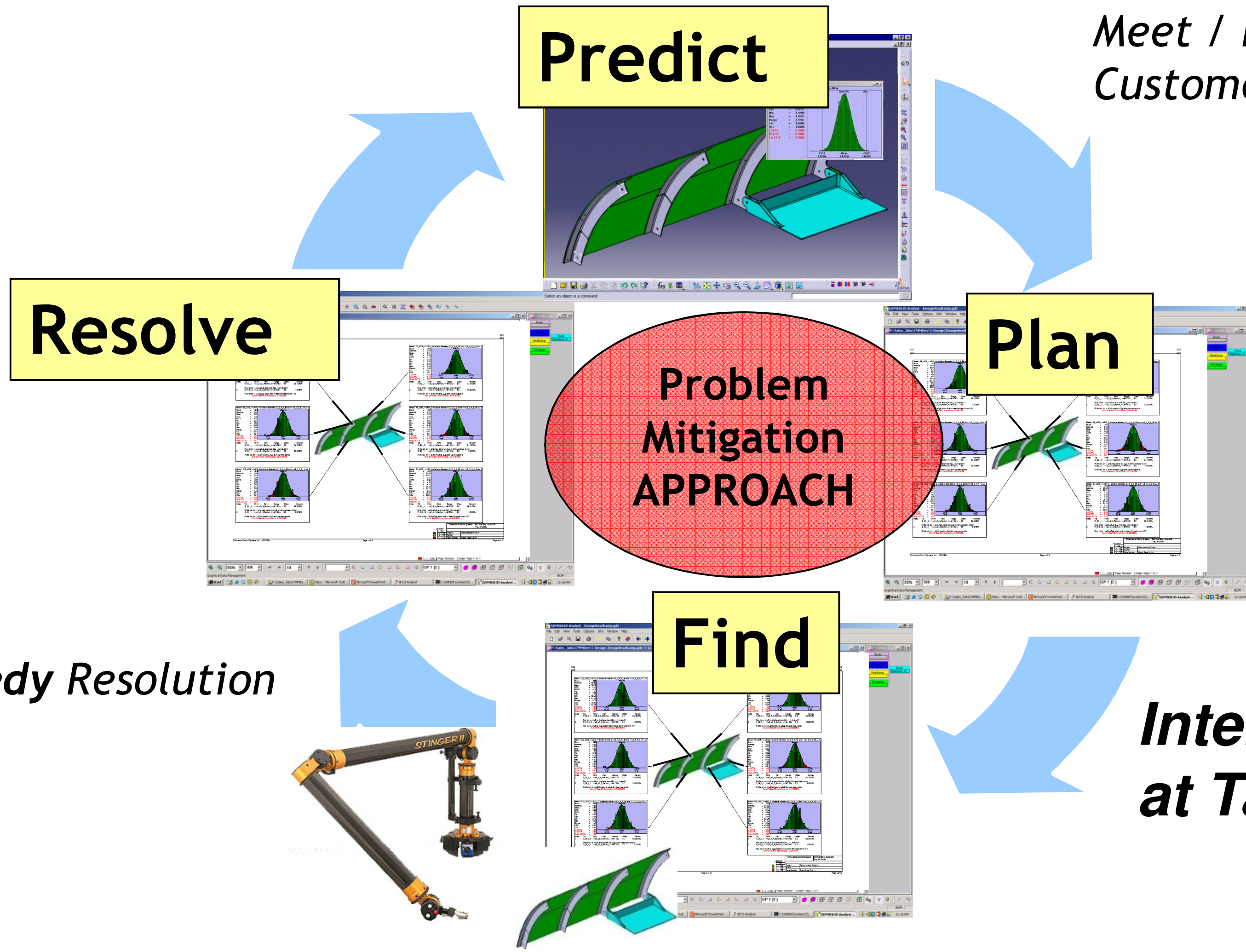
Product Non-Conformance

Warranty & Liability

Traceability Gaps

Closed-Loop Quality

DE Process that will Meet / Exceed Customer Expectations



Speedy *Resolution*

Intended Quality at Target Cost

Dimensional Engineering...

Applied Early and Throughout Product Lifecycle

Program Directives

Build Objectives

Build Strategies

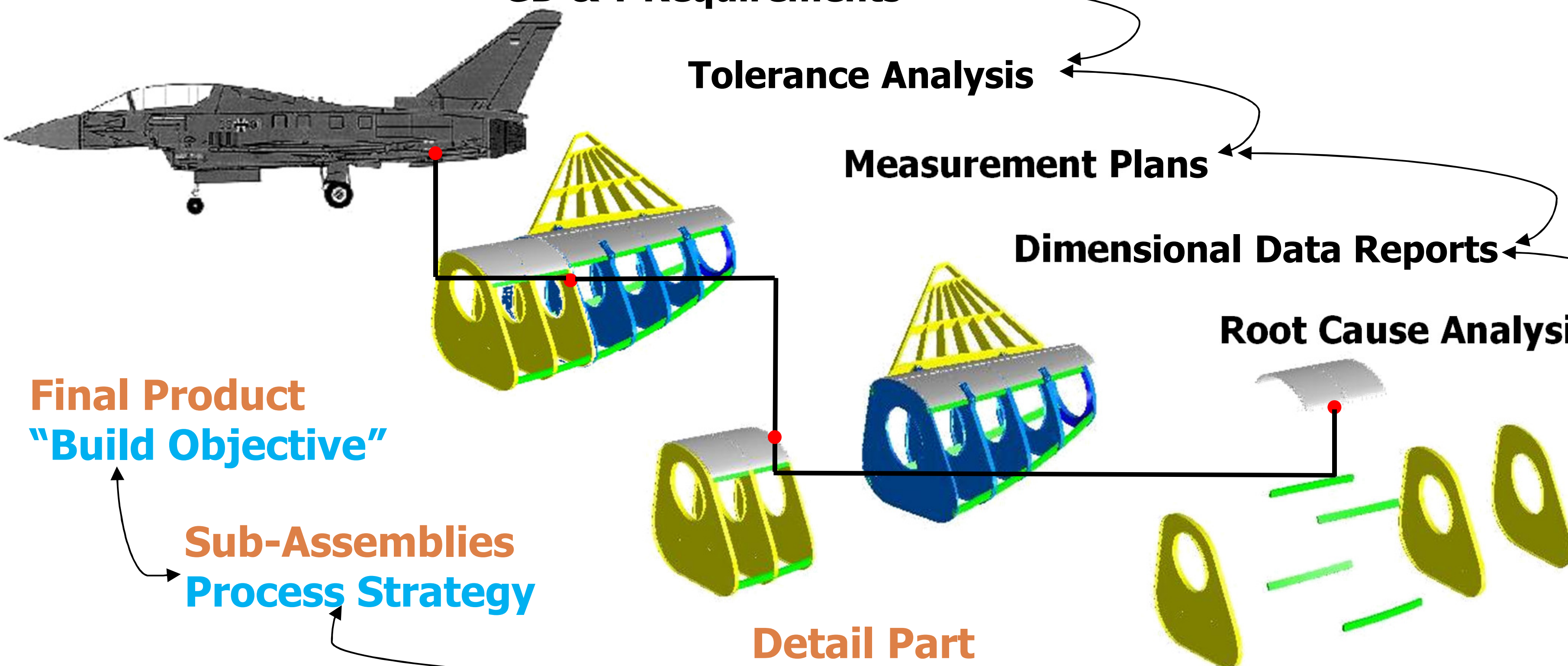
GD & T Requirements

Tolerance Analysis

Measurement Plans

Dimensional Data Reports

Root Cause Analysis

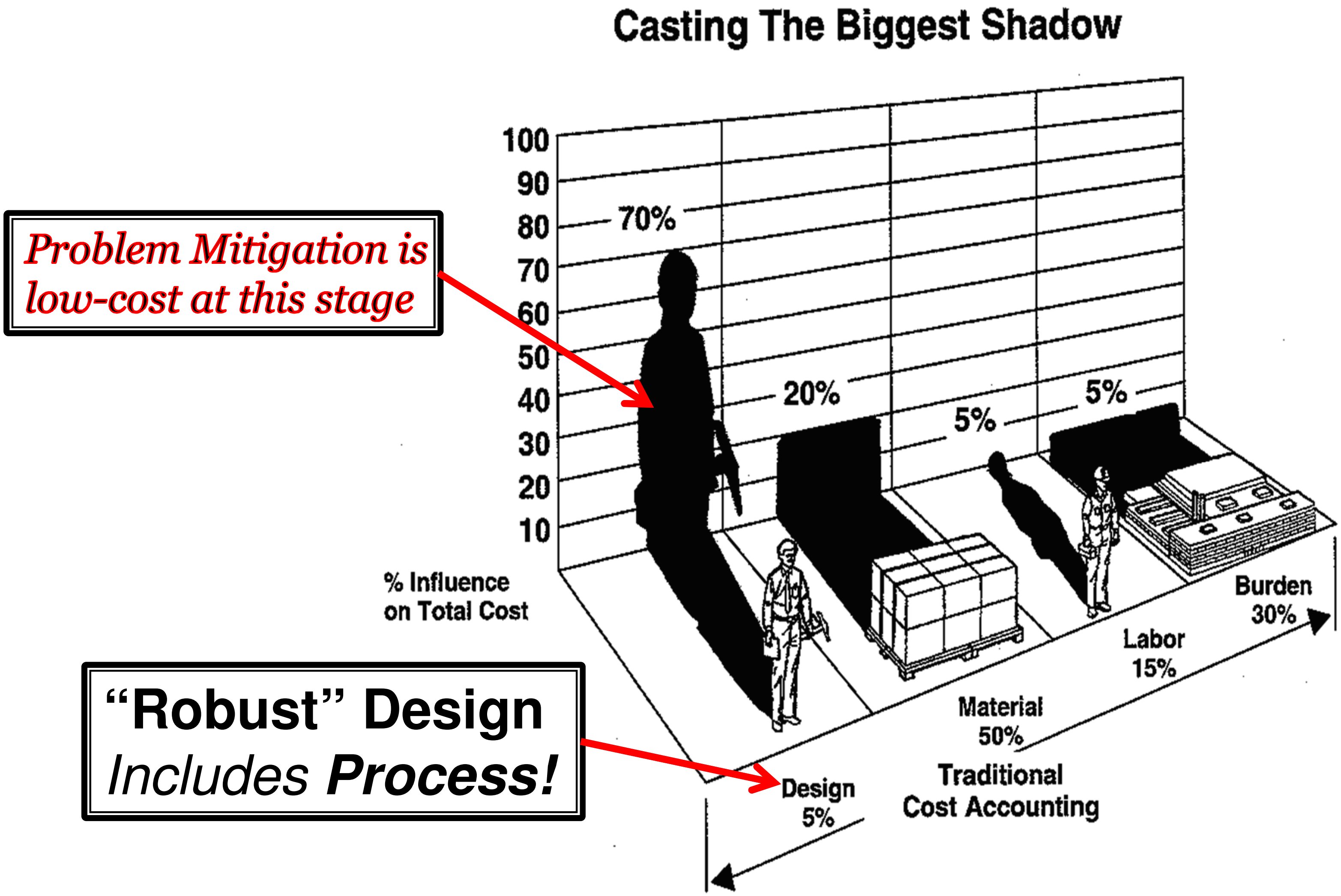


Final Product
"Build Objective"

Sub-Assemblies
Process Strategy

Detail Part
Dimensional Requirement

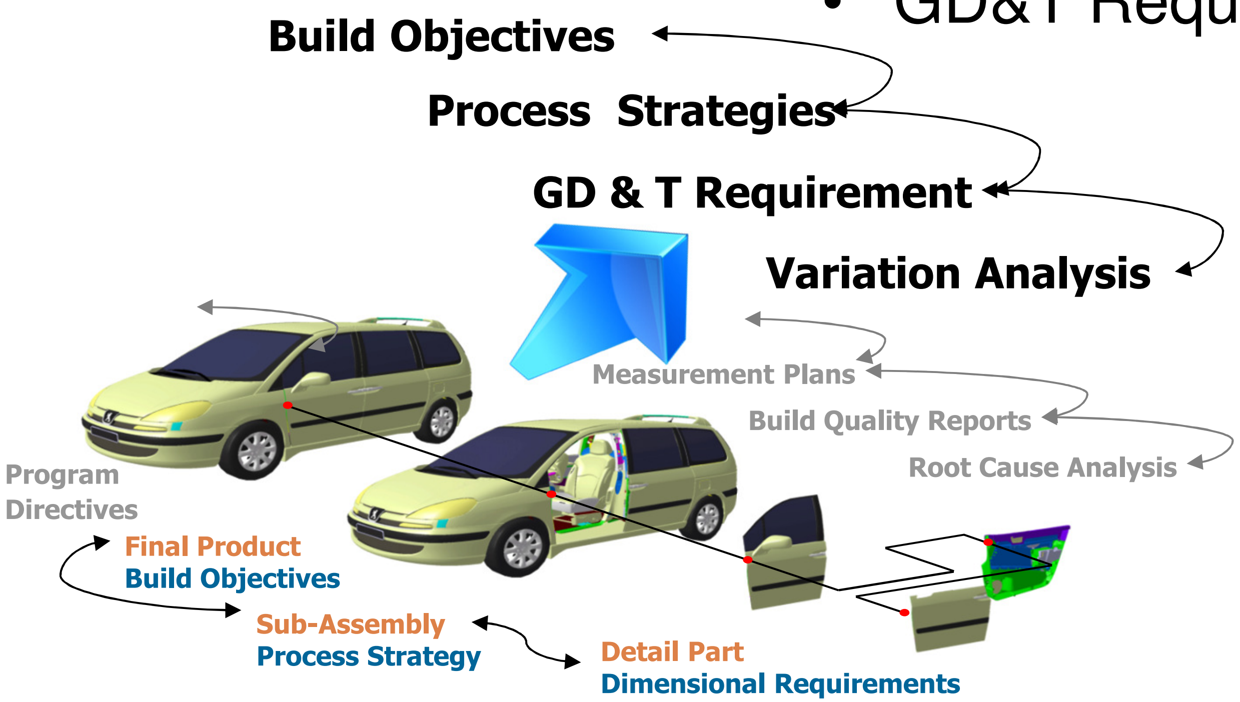
Why Dimensional Engineering?



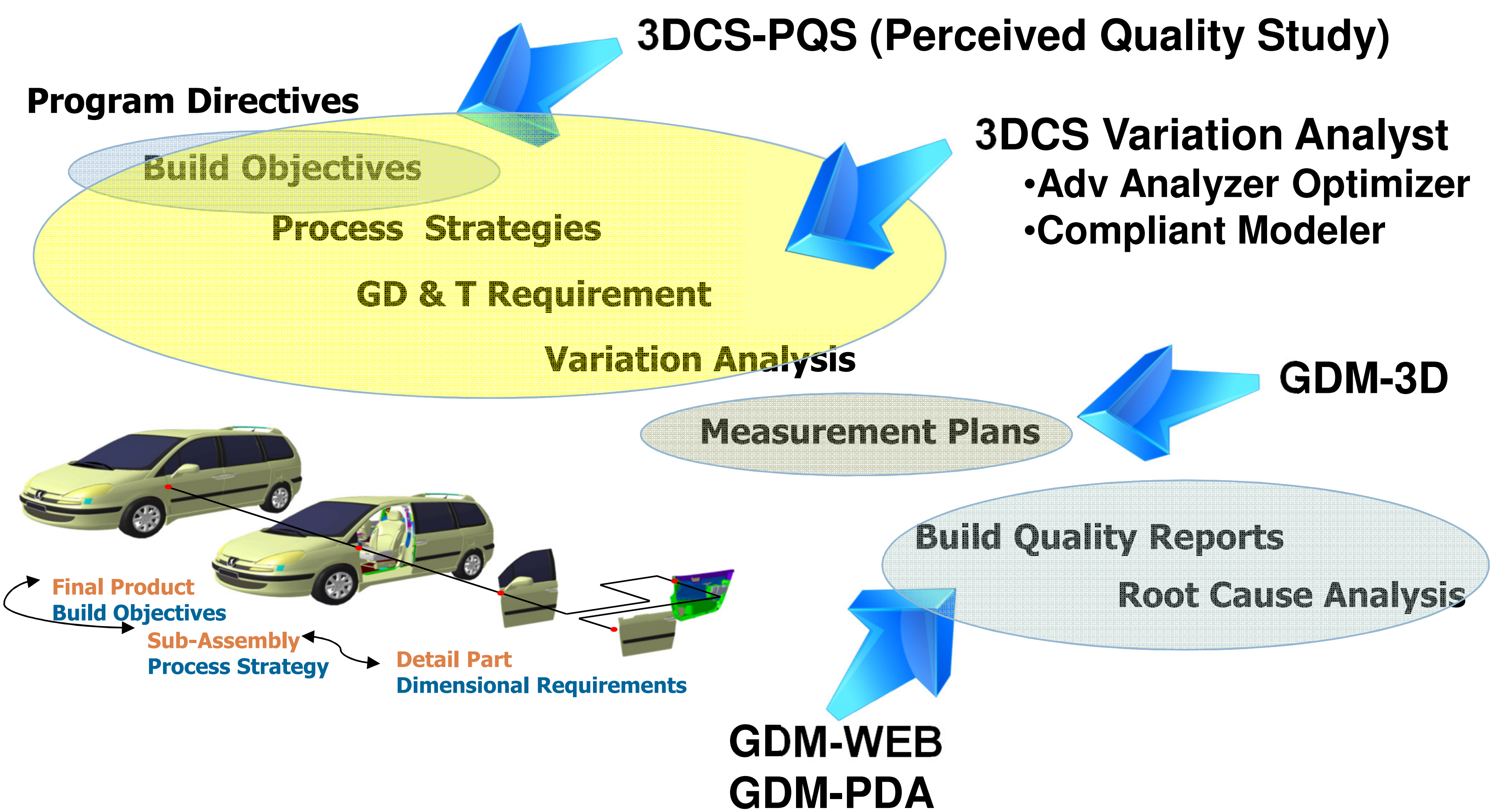
Key Elements of a Robust DE Process

Variation Analysis **Validates**:

- Build Objectives
- Process Strategies
- GD&T Requirements

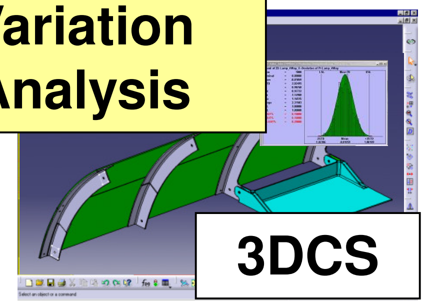


Tool Alignment to DE Process



DVA Process Alignment to PLM

Dimensional Variation Analysis



3DCS

Complete Process Support

For Engineering & Manufacturing Quality

Product Lifecycle

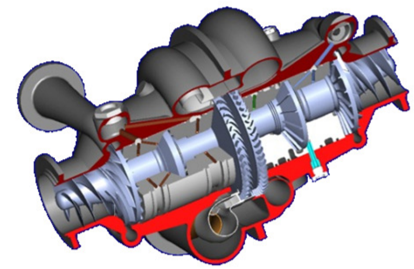
Stage: Concept → Design → Process → Manufacture → In-Service

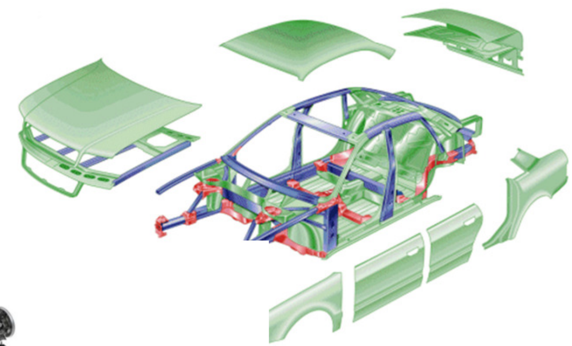
DVA Process:

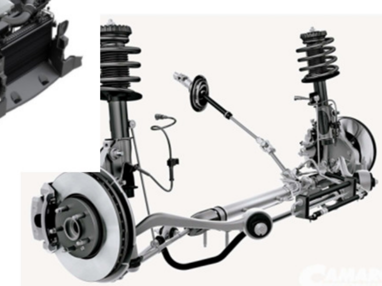
- Rigid Body Variation Analysis
- Perceived Quality | GD&T Optimization | As-Built Correlation
- Compliant Variation Analysis

DVA Application Domains…

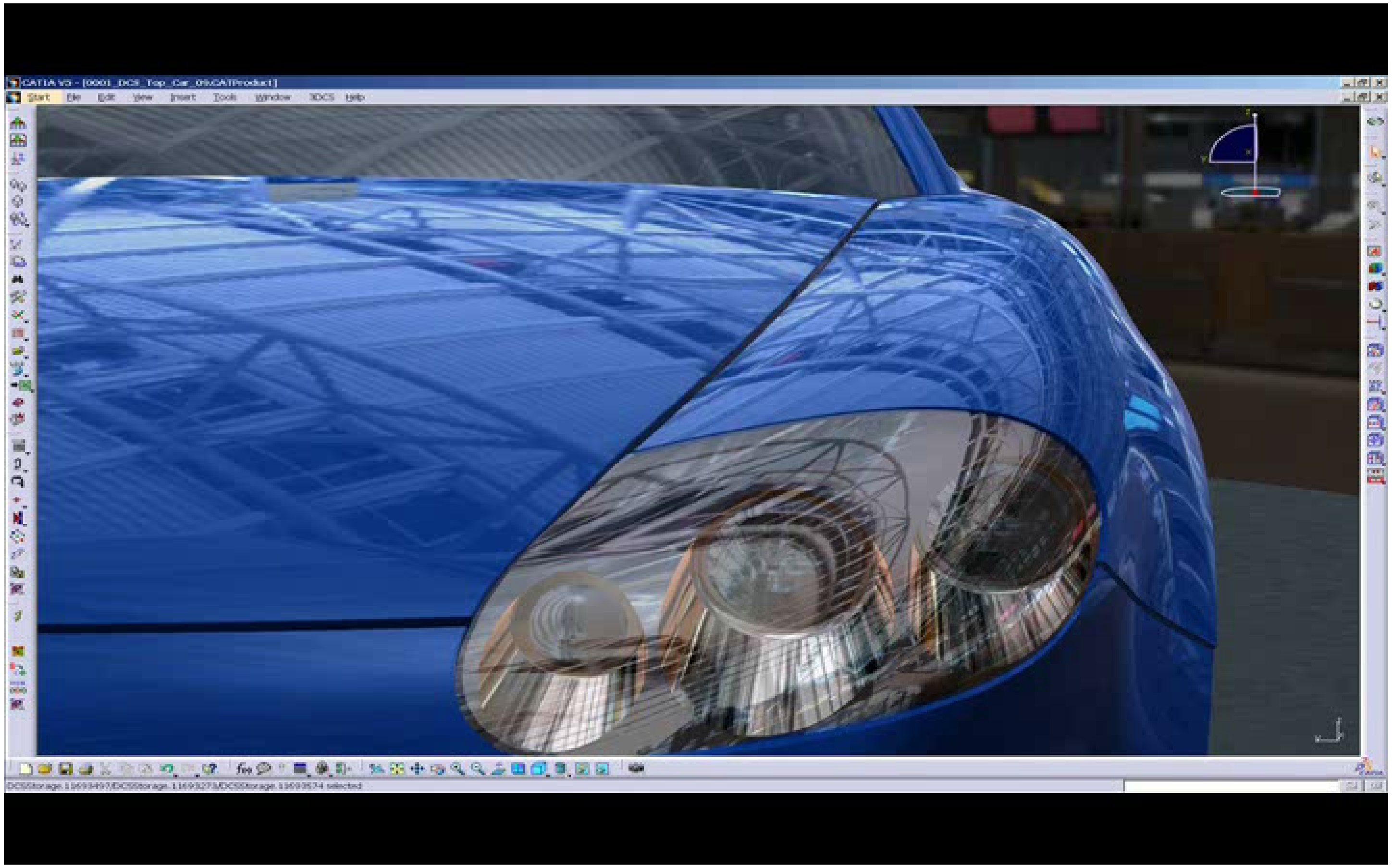
- Structures / Chassis
- Mechanisms
- Enclosures
- Aesthetic Fits
- Any Assembly







Visualize Variation Impact Early

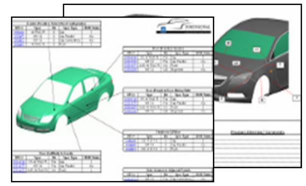


Perceived Quality Study

General Motors Results…

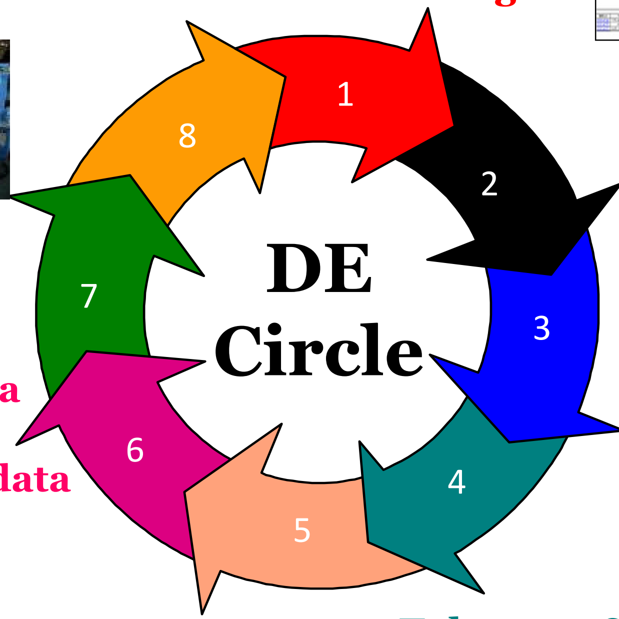
8. Verification
- Final DTS verification
- Lessons learned workshops

1. DTS
Define gap, flush and radii targets



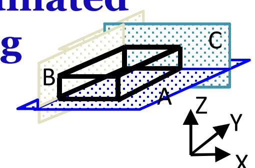
2. Concept Creation and Investigations
- Simulation of new concepts
- Digital visualization
- Benchmark of different concepts

7. Validation tools
- Vendor part gages
- Vendor part measurement devices



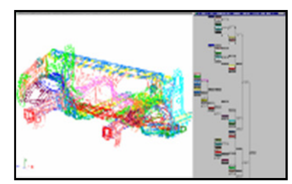
6. DTS / Drawing Review
- Check DTS against latest data
- Check and release drawings
- Check tolerance studies for data changes

3. CDLS
- Develop coordinated datum locating strategy
- MDM support



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…

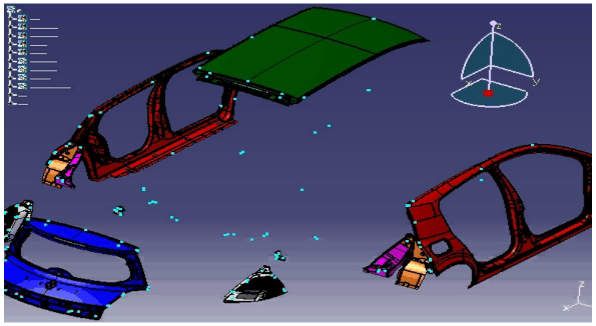
"Successful tolerance analysis product execution played a major role in our achievement of high quality across our product vehicle line.
The Chevrolet **Volt**, Chevrolet **Silverado**, Chevrolet **Malibu** and Cadillac **CTS** were all named **Car/Truck of the Year** winners."

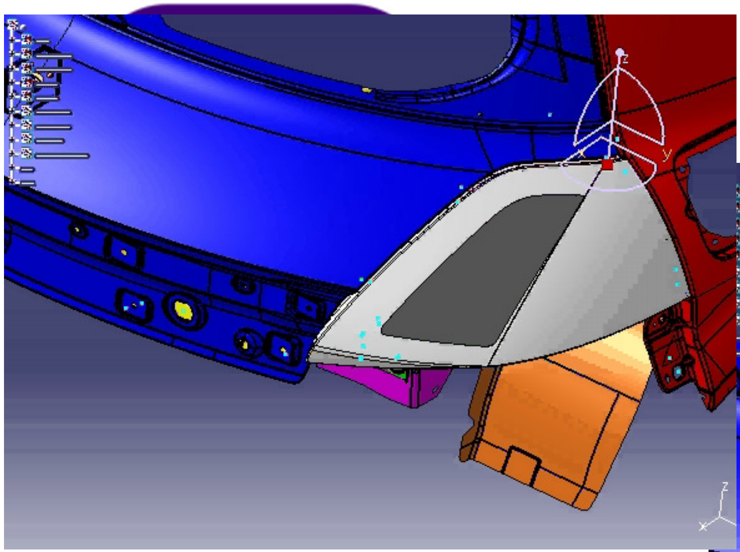
Richard Korynski
Body Tolerance Analysis Manager- General Motors

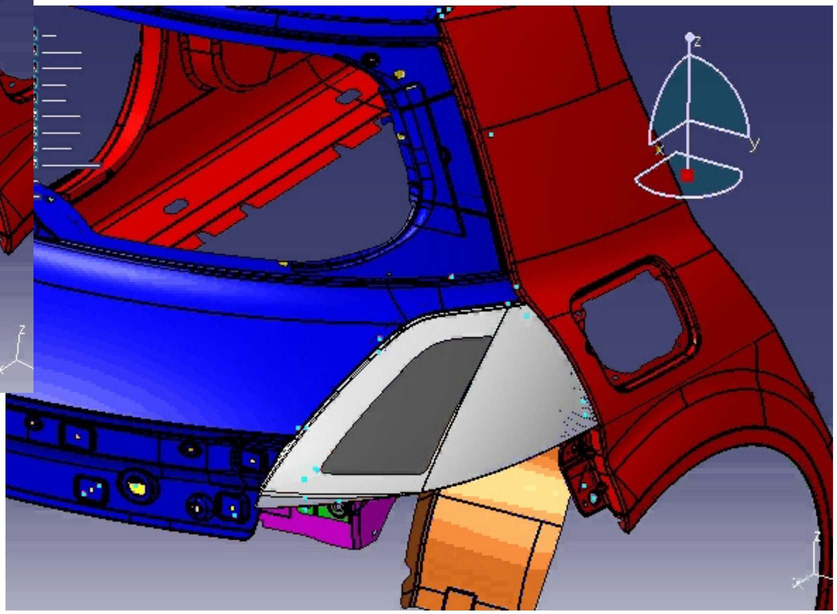
In-depth Tolerance Studies

Model Based

Dimensional Variation Analysis







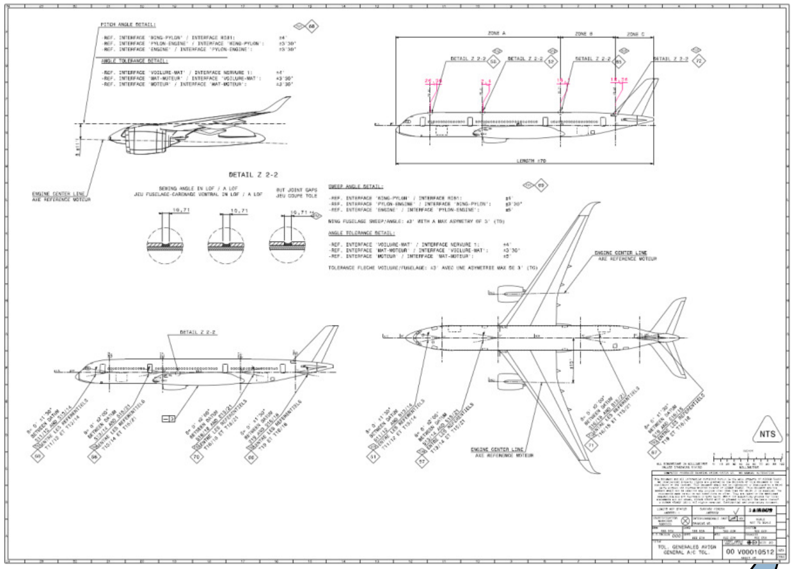
Simulate-

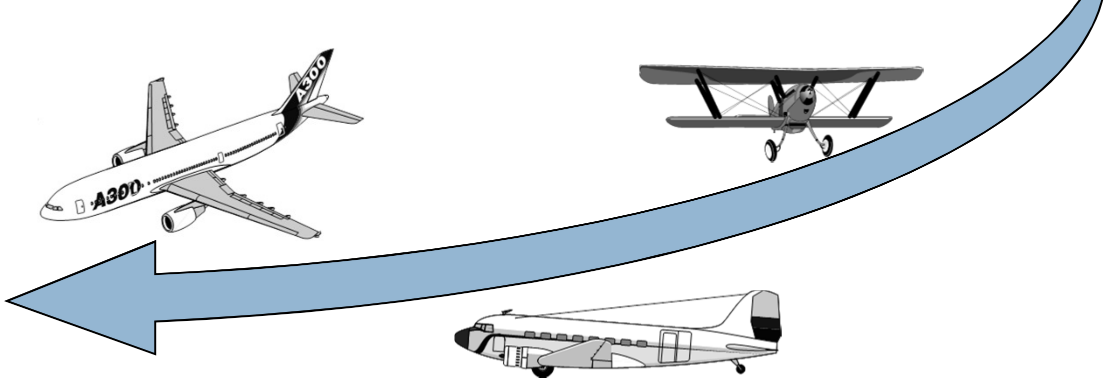
- Thousands of Assembly builds in Minutes

Airbus: Tolerance management during early concept phase

Evaluation of:

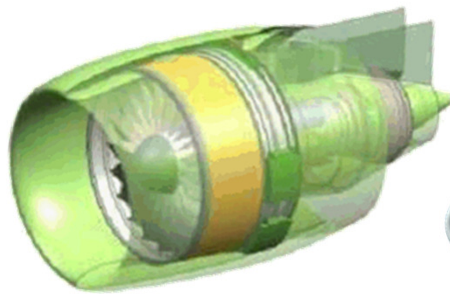
- assembly process regarding global aircraft requirements
- different assembly strategies
- new manufacturing technologies (CFRP, bonding, water-jet cutting, One-Shot-Single-Barrel)
- new assembly technologies (indoor-GPS, Laser-scanner/tracker)

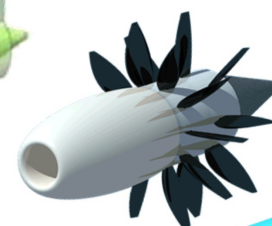




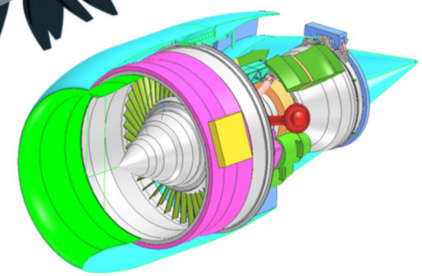
Tolerance management during early concept phase

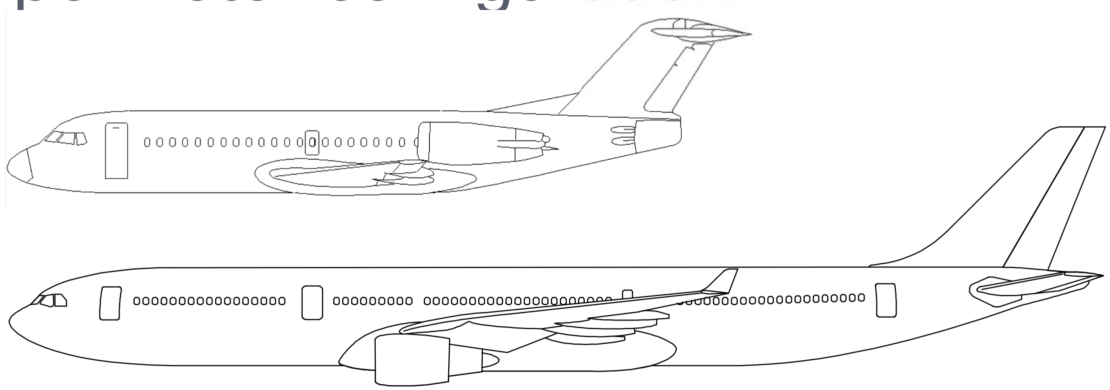
Analyse different engine concepts for aerodynamic efficiency

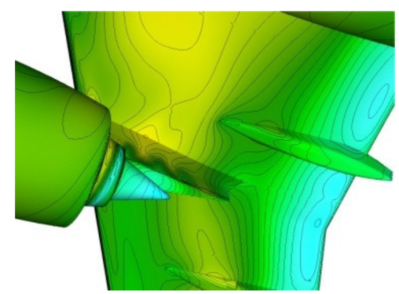




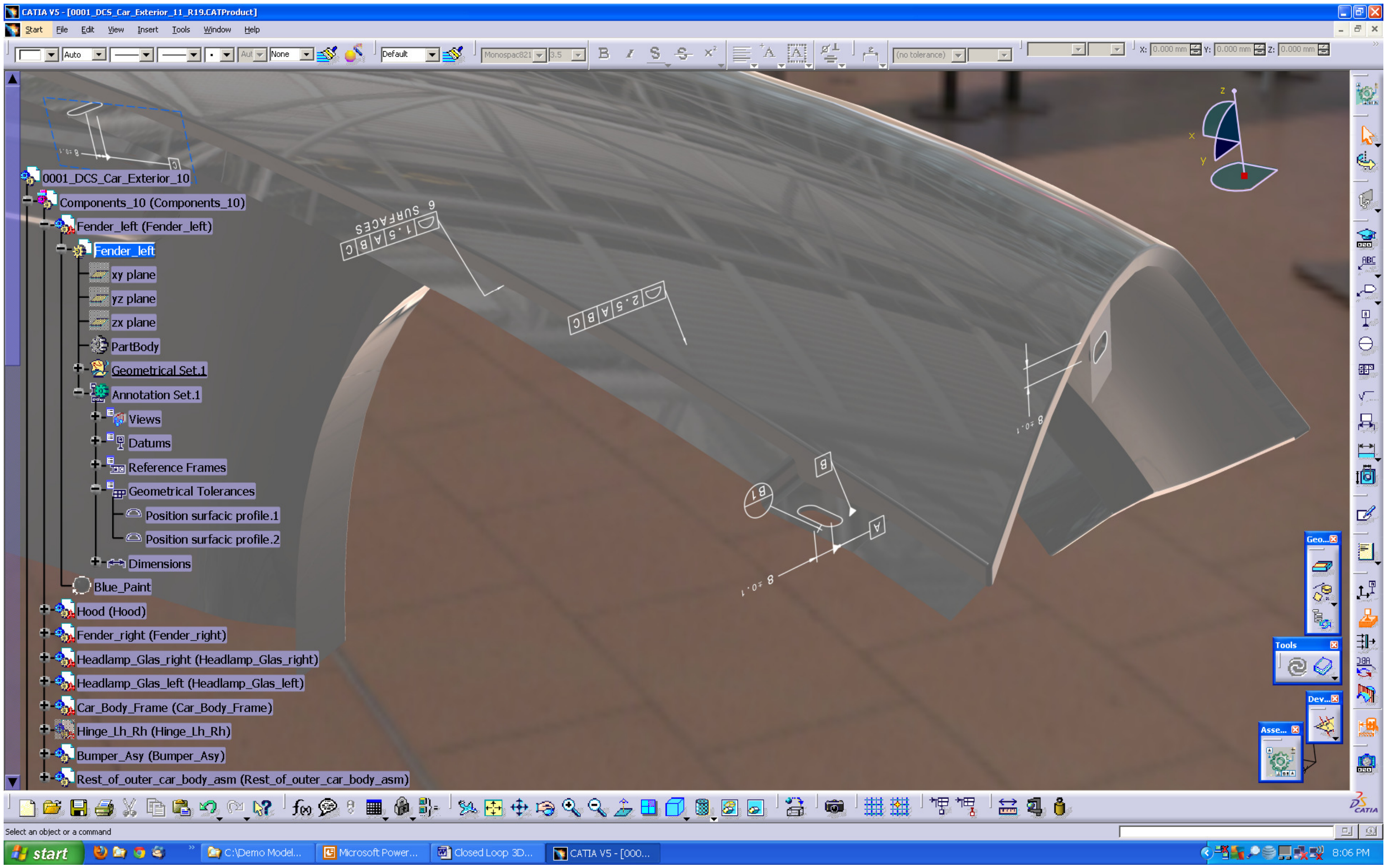
- Tail or wing mounted
- Geared turbo fan
- Open rotor configuration



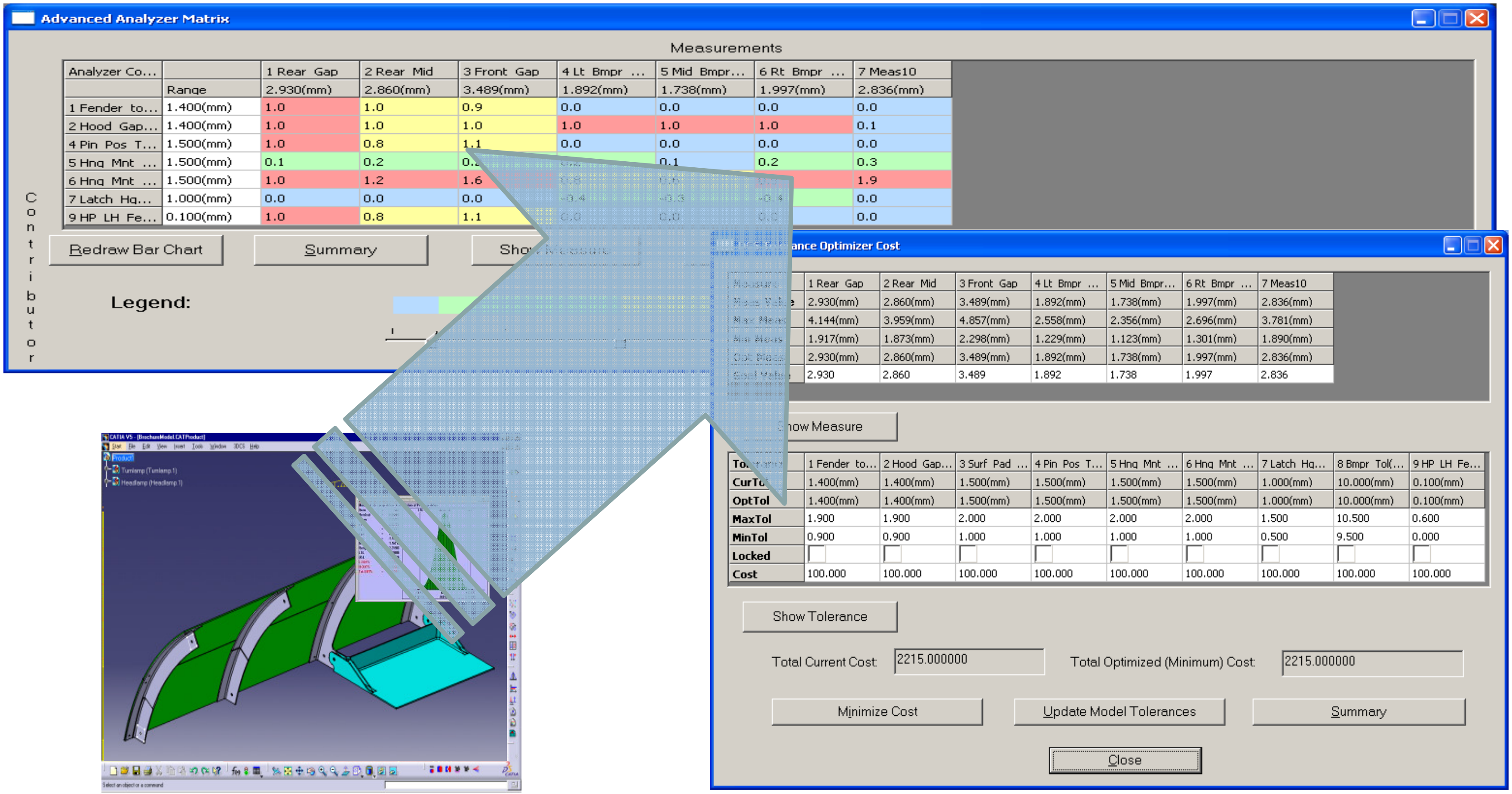




Associativity to CAD Model & GD&T



Tolerance Optimization to Cost Constraints



Advanced Analyzer/Optimizer

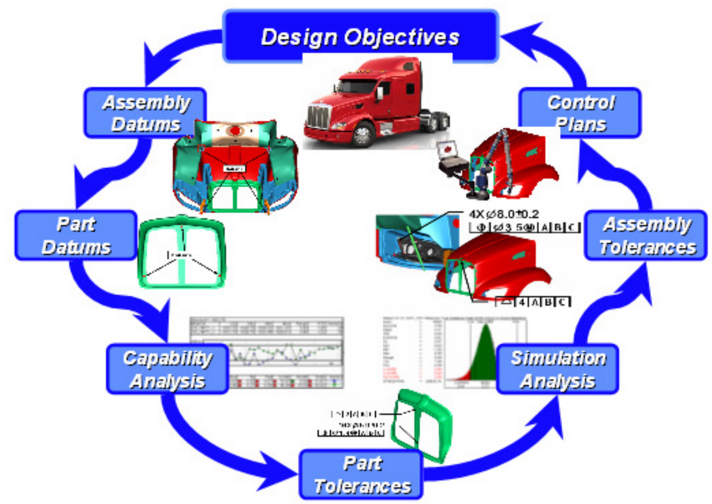
Peterbilt Results…

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

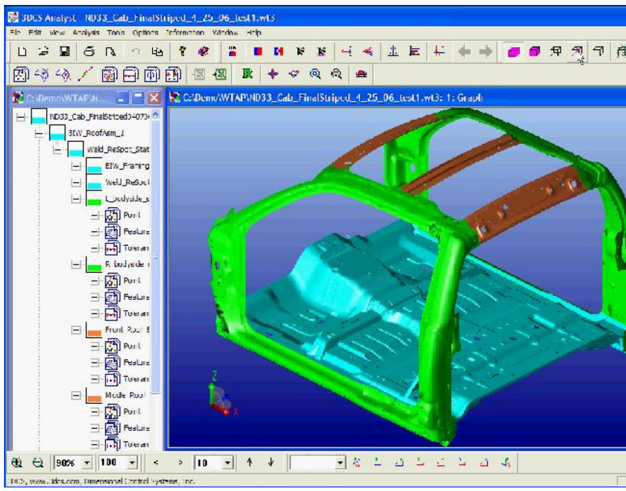
We have seen the fit & finish and overall quality of our products improve since the implementation of tolerance simulation / dimensional management.

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

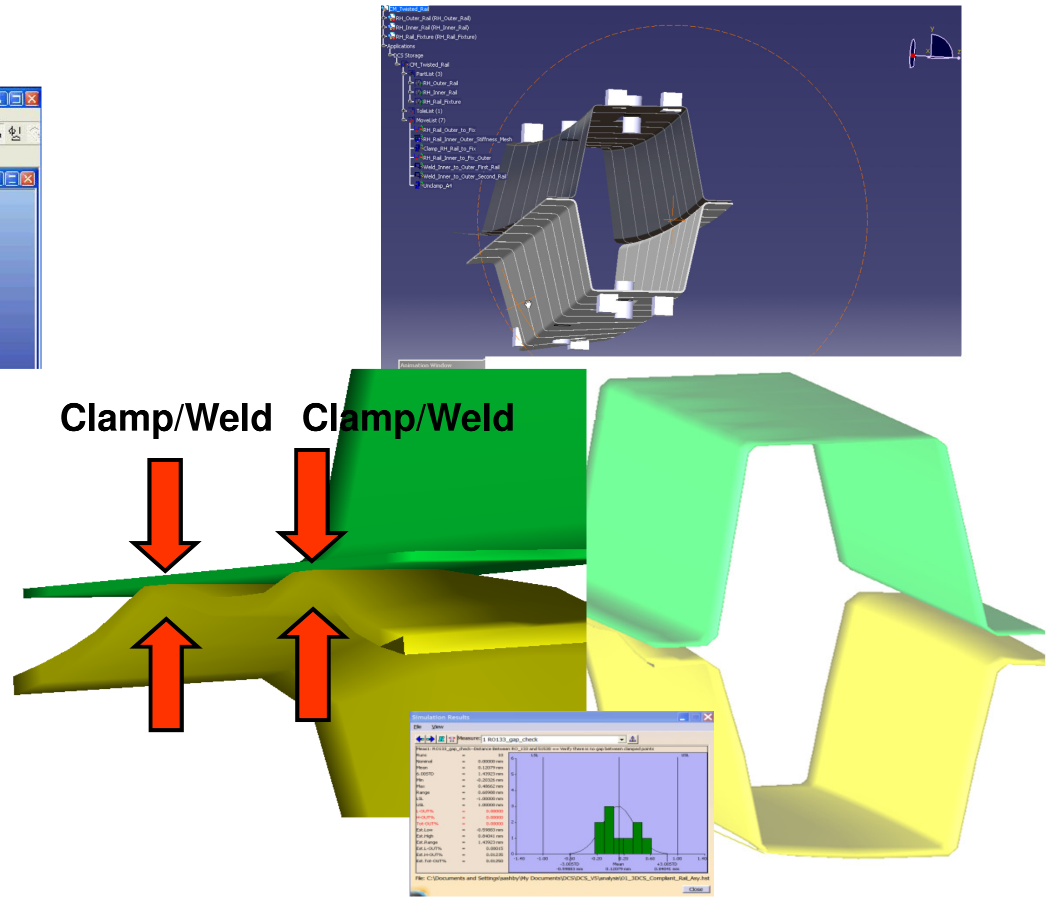


Compliant Variation Analysis



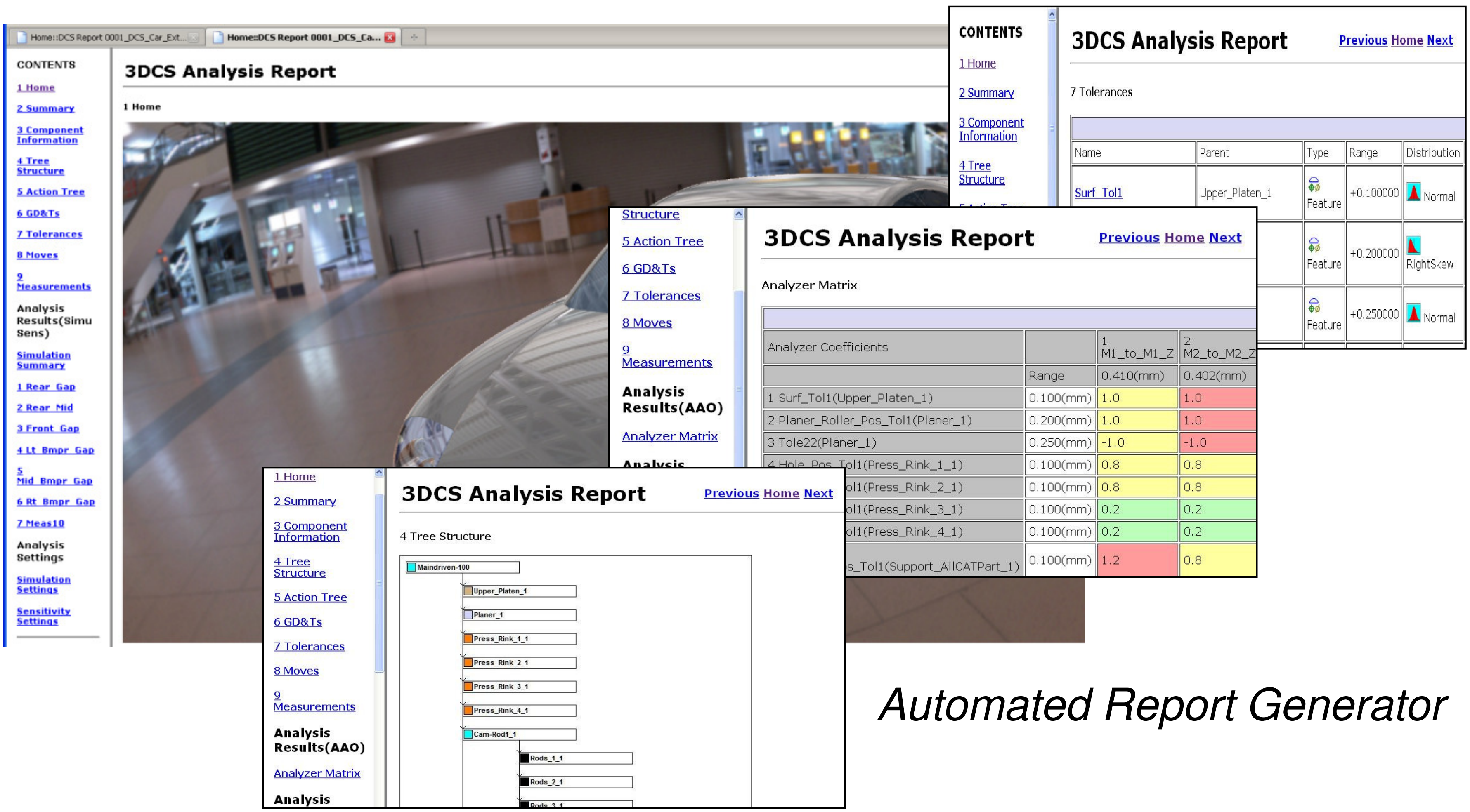
Consider Effects of:

- Force
- Gravity
- Thermal



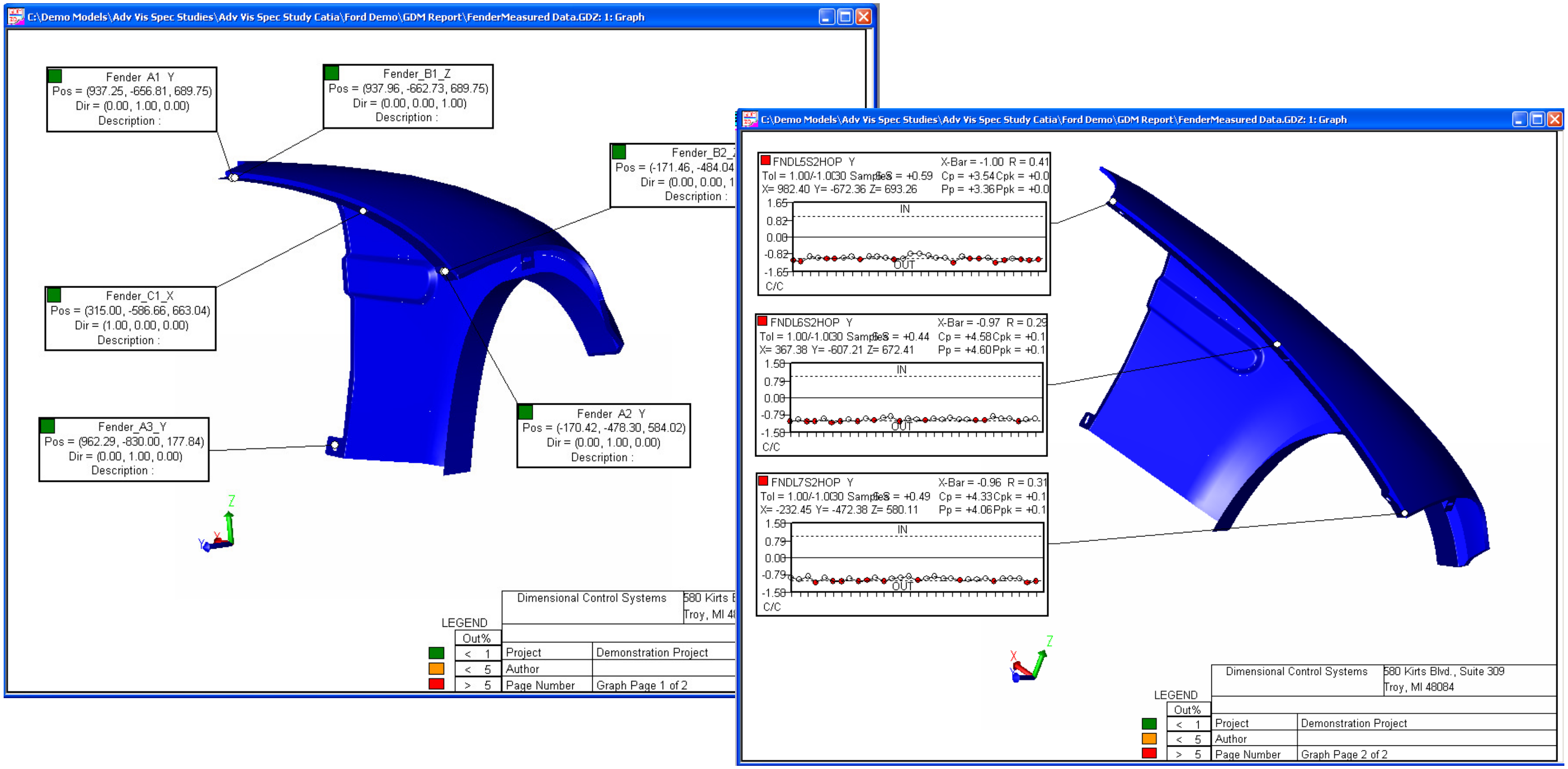
Compliant Modeler

Automated Reporting



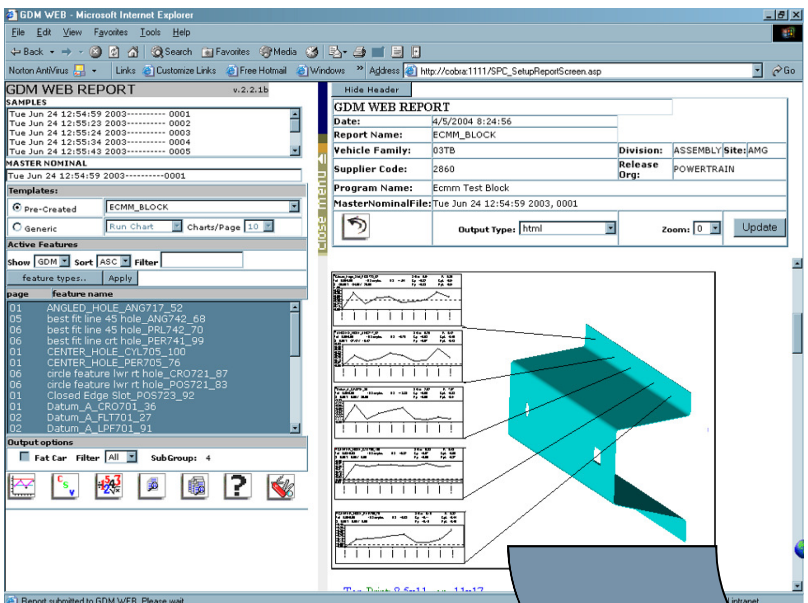
Automated Report Generator

Measurement Plan Authoring

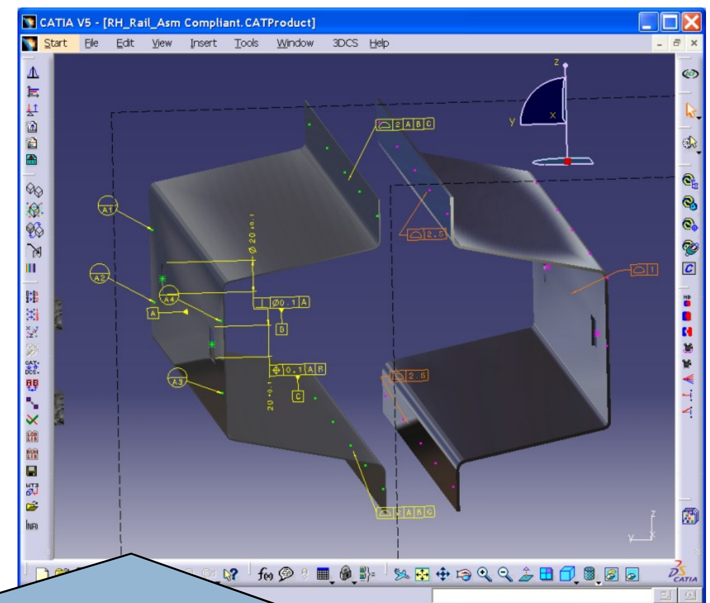


Leverage ***Analysis*** *within* ***QA Process***

As a powerful root-cause analysis toolset



GDM-Web
Quality Management System



3DCS-
Root Cause Analysis

Chrysler Results…

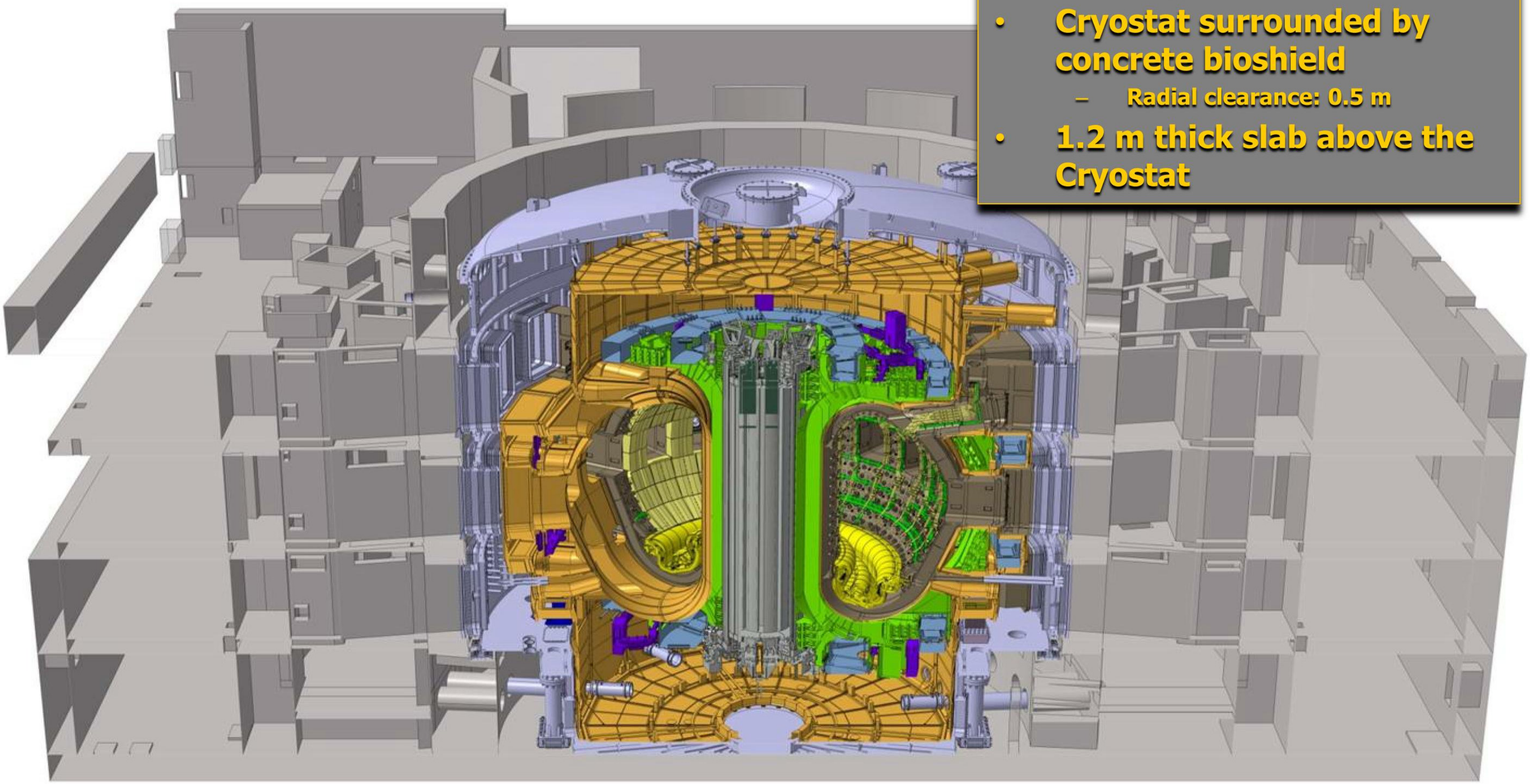
"Chrysler has realized significant cost savings over the years by using tolerance analysis as part of our overall dimensional engineering process.

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

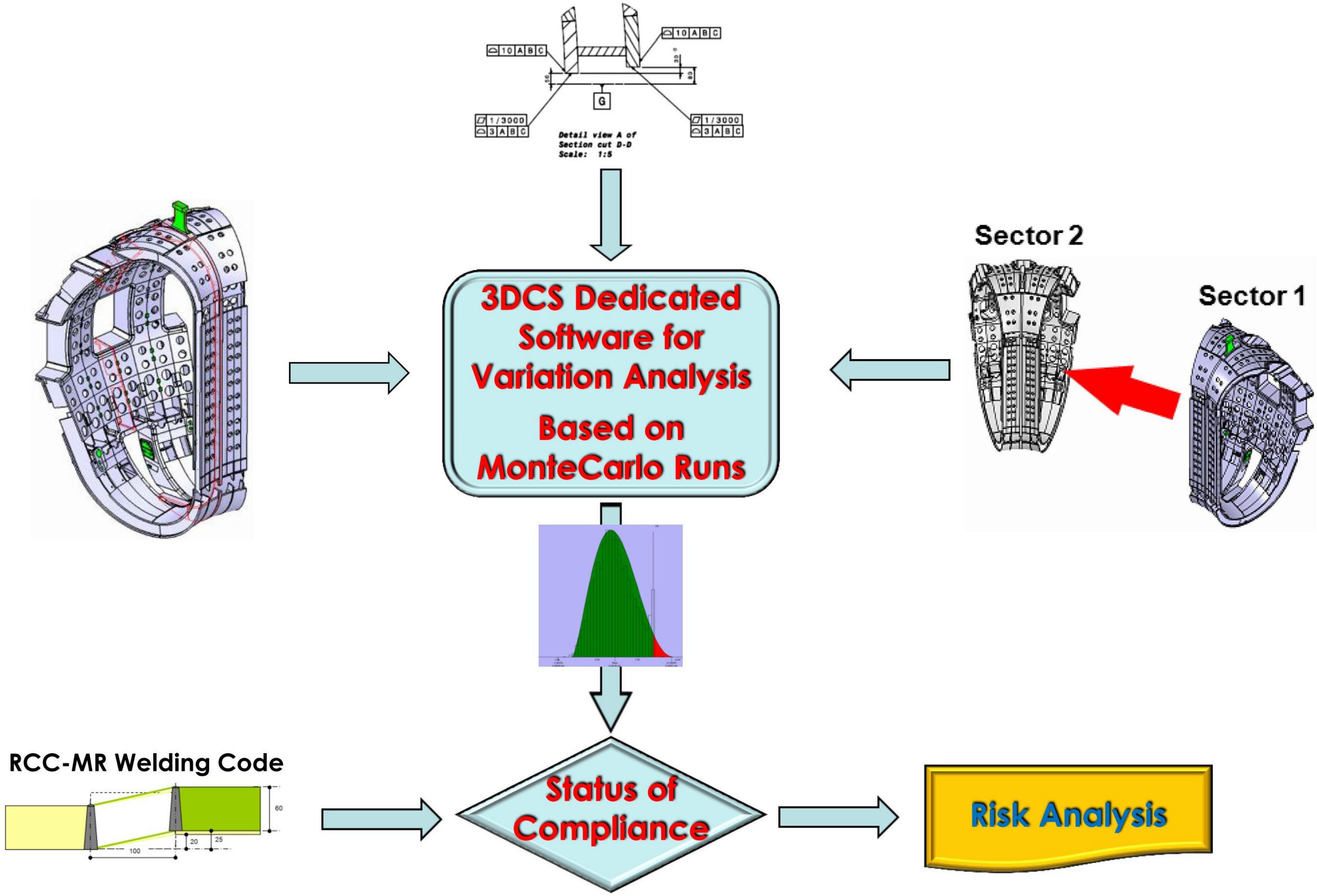
TOKAMAK Project



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

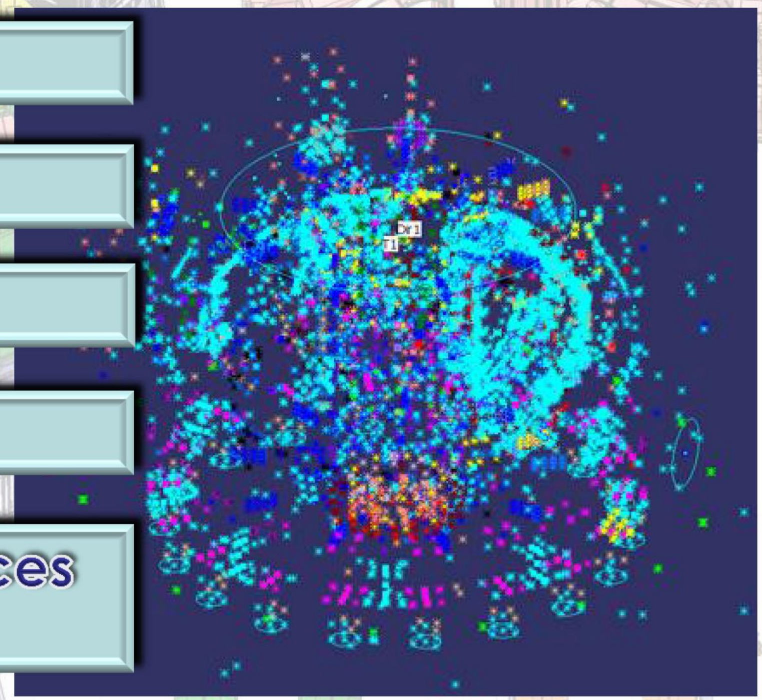
2200 Part Tolerances

760 Moves

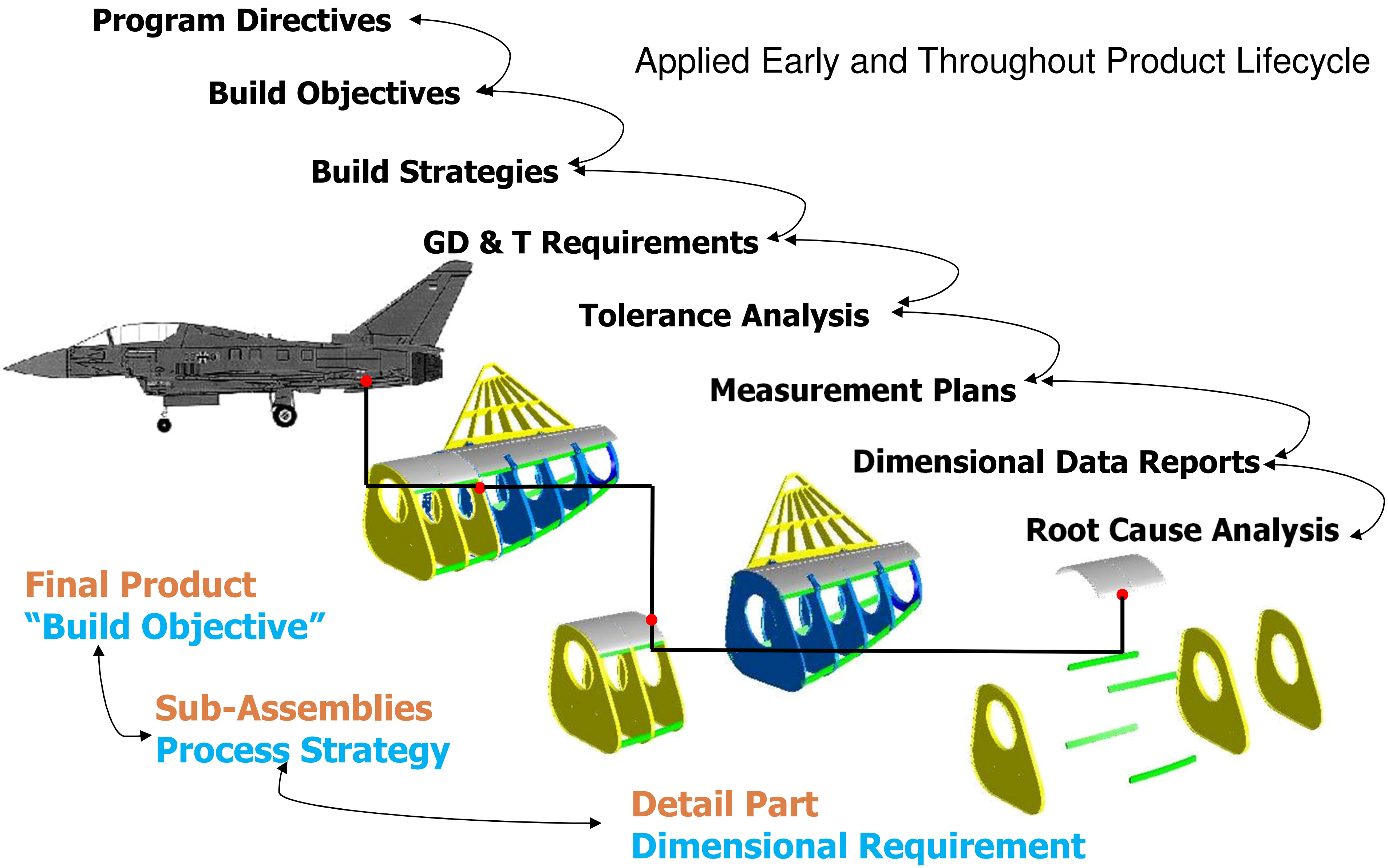
30 Functional/Assembly Requirements

6000 Measurements to verify Compliances and perform Impact Studies

15 min to run a 5000 Tokamaks analysis



Dimensional Engineering…



Questions???

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