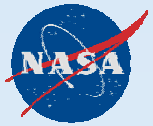

TFAWS 2005

Techniques for Preparing Pro/Engineer Models for CFdesign Fluid Flow and Convective Heat Transfer Analysis

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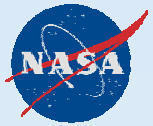
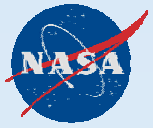
Outline

I. Introduction
II. Simplifying model geometry
III. Creating fluid volumes
IV. Utilizing Mechanica Volume Regions



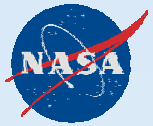
Background

- ISS Avionics Box (Engineering Model)
  - Tasked with conducting thermal analysis
  - Needed more than “back of the envelope”
  - Pro/E model set up for design and manufacturing, not analysis
  - Model complexity surpassed that of previous CFdesign analyses
  - Result: Many lessons learned regarding simplifying complex models and constructing models w/ analysis in mind
  - Currently supporting redesign for flight
- Techniques emphasize flow/convection

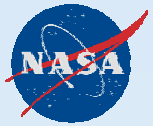


Benefits of Coupling Pro/Engineer With CFdesign

- Geometry not lost or skewed by approximation
  - Analysis utilizes the model by which the hardware will be constructed
- True associative relationship between design and analysis
  - Time and accuracy not sacrificed for rebuilding or updating analysis model
- Greater fidelity in preliminary design stage
  - Design engineer can do much better than “back of the envelope” without employing a CFD PhD

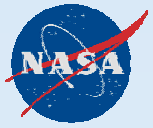


Simplifying Model Geometry



Simplifying Model Geometry

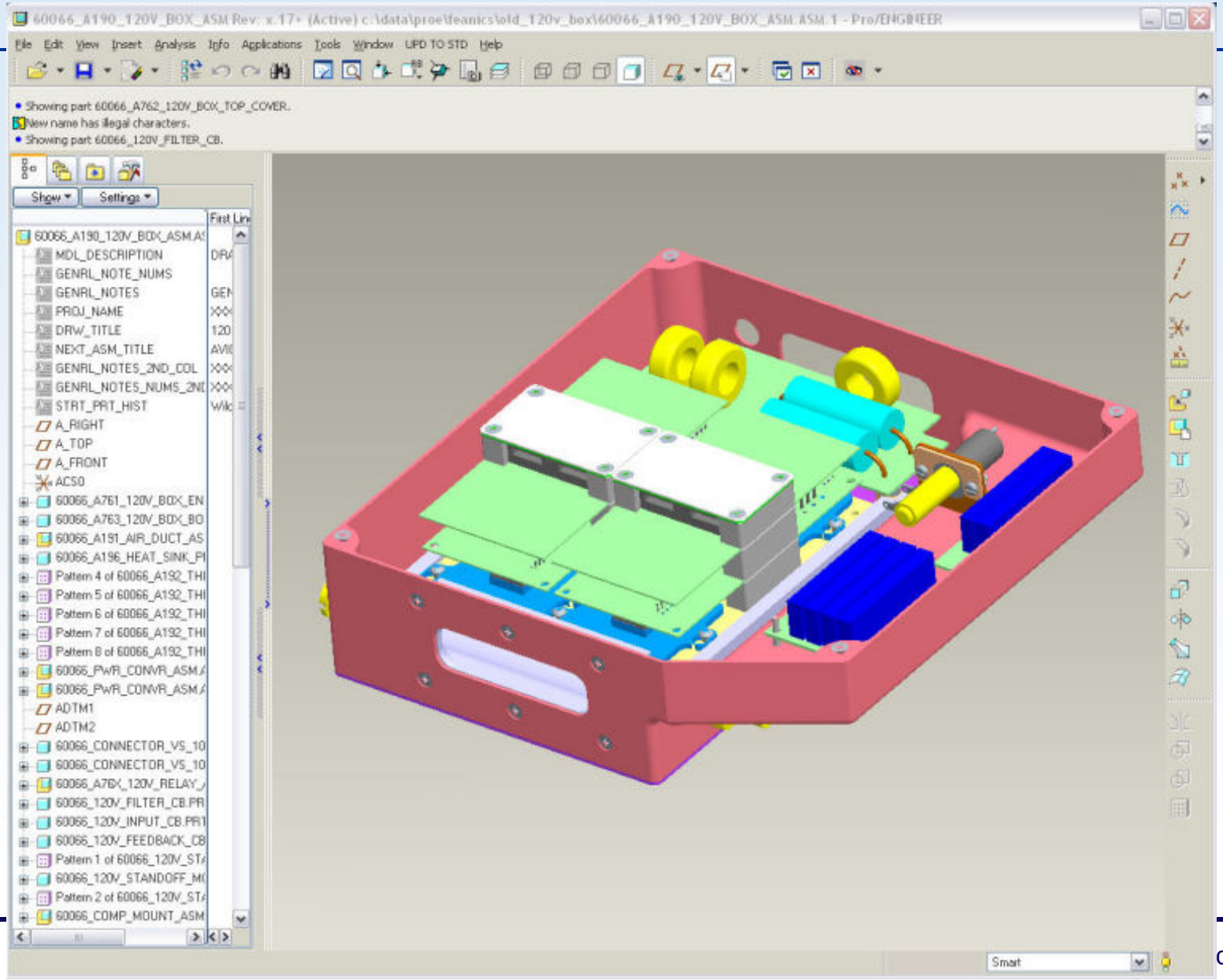
- Simplifying complex assemblies
  - Reduces unnecessary computational overhead
  - Promotes analysis convergence
  - Minimizes geometry/volume interferences
- Geometry analyzed by CFdesign needs only to be *displayed* in Pro/E environment
  - Avoids undesirable effects due to suppressing or deleting components not needed for analysis (even when “stepping”)



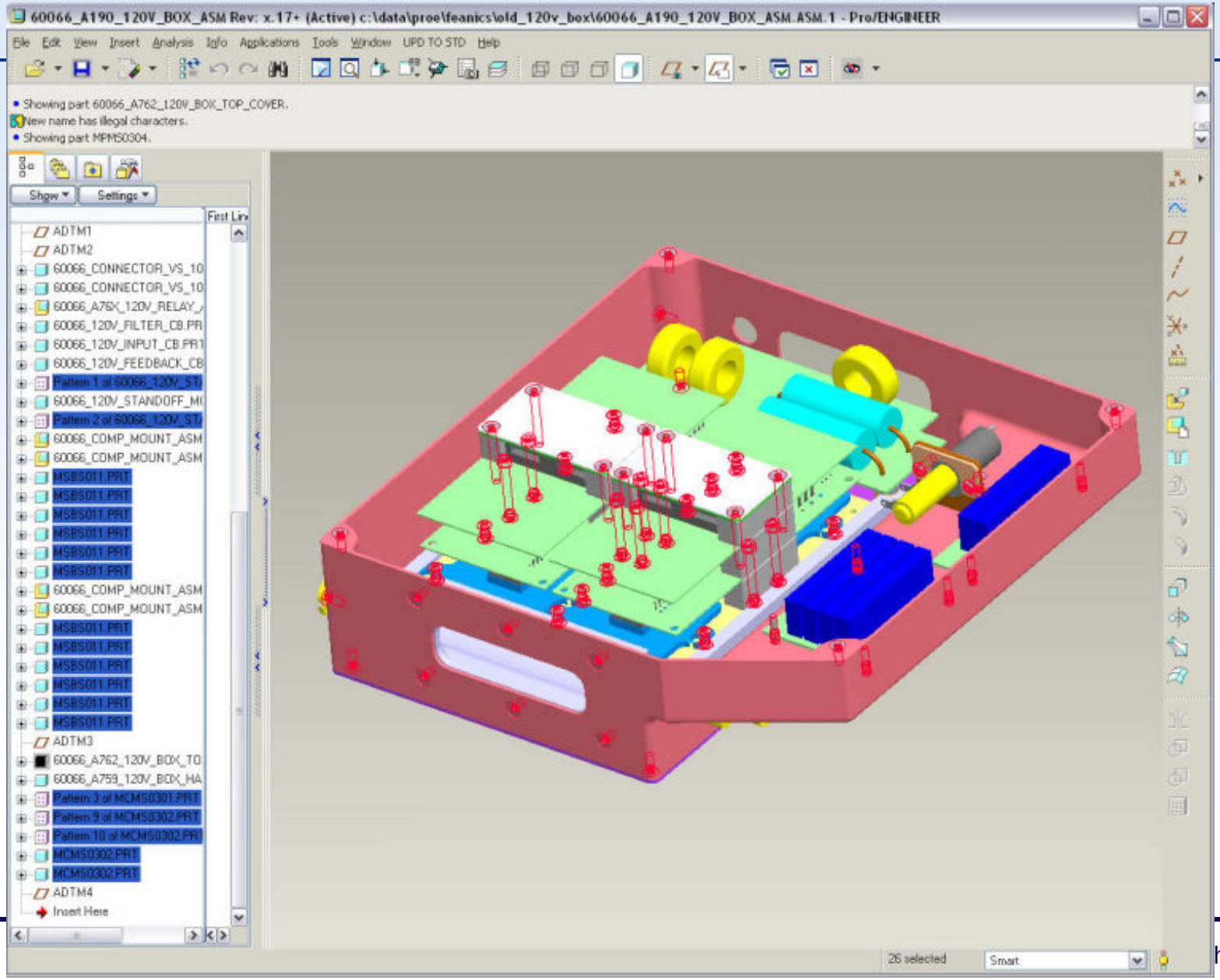
Simplifying Model Geometry

- Using ‘Simplified Reps’ in Pro/Engineer
  - Selected components are contained in single group which can be quickly hidden/redrawn
  - Reverting to previous configuration is 100% accurate
  - Multiple Simplified Reps are easily created and managed
  - View-based; no effect on actual model geometry
- Simplified Rep Creation (Wildfire 2.0)
  1. Select components to be removed from view
  2. Pick “View-Representation-Exclude”
  3. Run the View Manager, pick “Simp Rep”, and enter a name for new rep

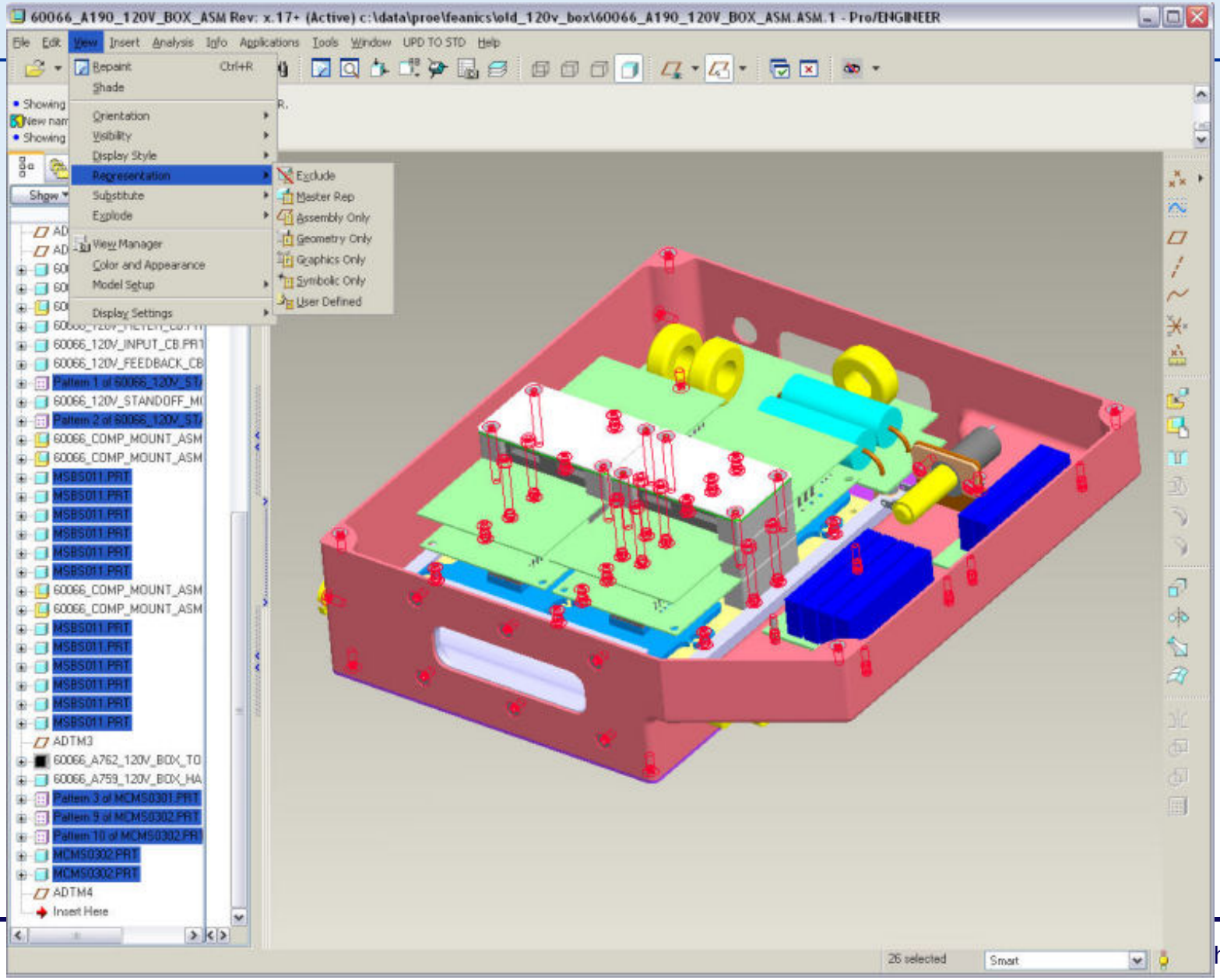
Creating a Simplified Rep



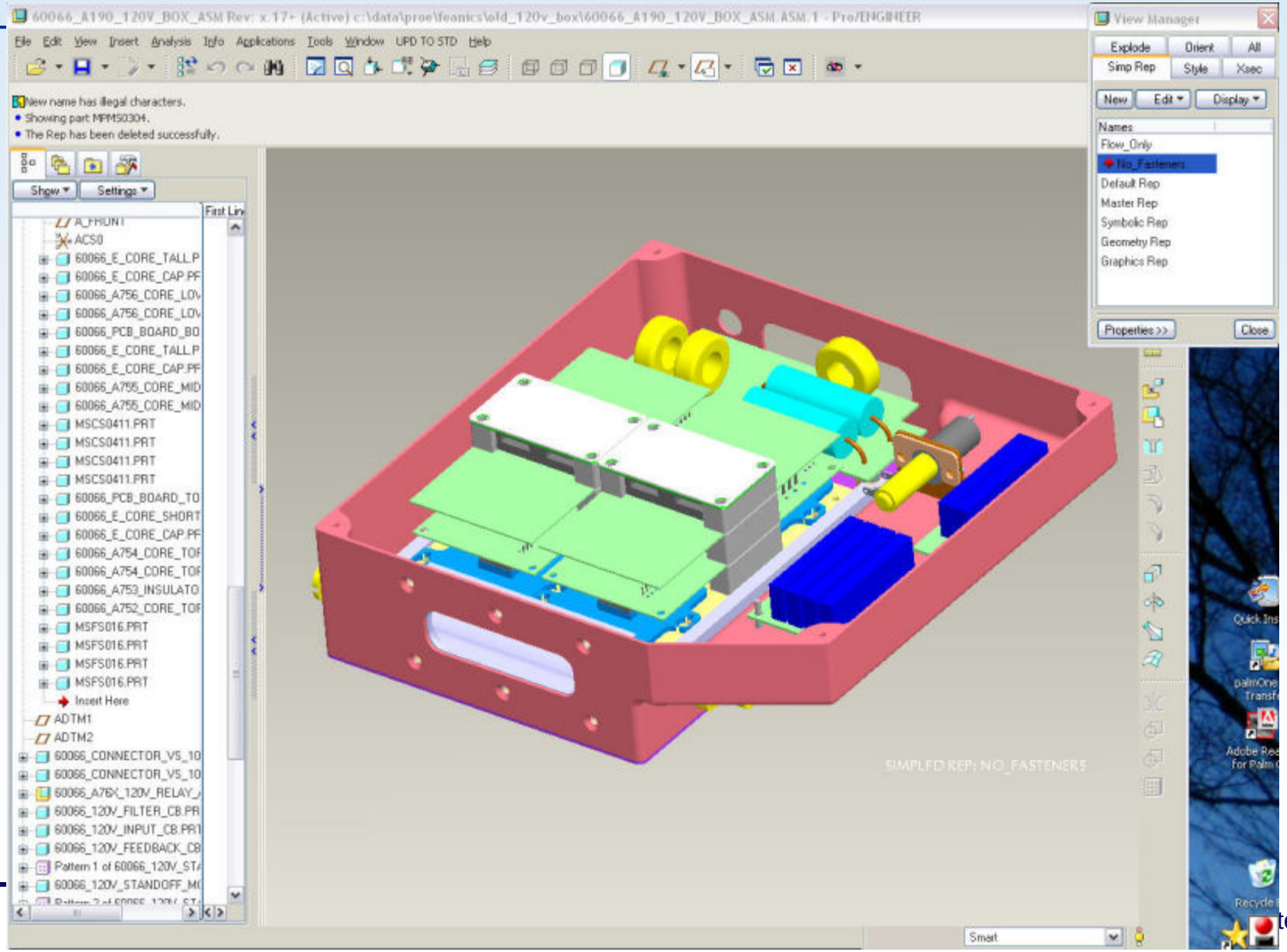
1. Select components to be removed from view

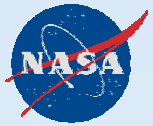


2. Pick “View-Representation-Exclude”



3. Run the View Manager, pick “Simp Rep”, and enter a name





Simplifying Model Geometry

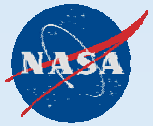
Reiterating benefits of ‘Simplified Reps’:

- Selected components are contained in single group which can be quickly hidden/redrawn
- Reverting to previous configuration is 100% accurate
- Multiple Simplified Reps are easily created and managed
- View-based; no effect on actual model geometry

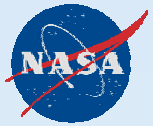
Simplifying Model Geometry

Checking for remaining geometric interferences:

1. “Analysis - Model Analysis”
2. “Type” = Global Interference
3. Leave defaults → “Compute”
4. “Info” will produce full text
5. Exclude components from simplified rep on case-by-case basis (ugh)

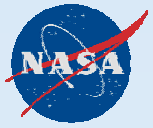


Creating Fluid Volumes



Creating Fluid Volumes

- Automatic ("void filling")
  - Preferred method
  - Advantages: Simple, fast, associative
  - Disadvantages: can be problematic w/ complex assemblies and/or flow paths
- Manual
  - Limited utility
  - Advantages: Full control over fluid geometry; can import fluid volume only
  - Disadvantages: No associativity, time intensive, human factors, process not trivial!

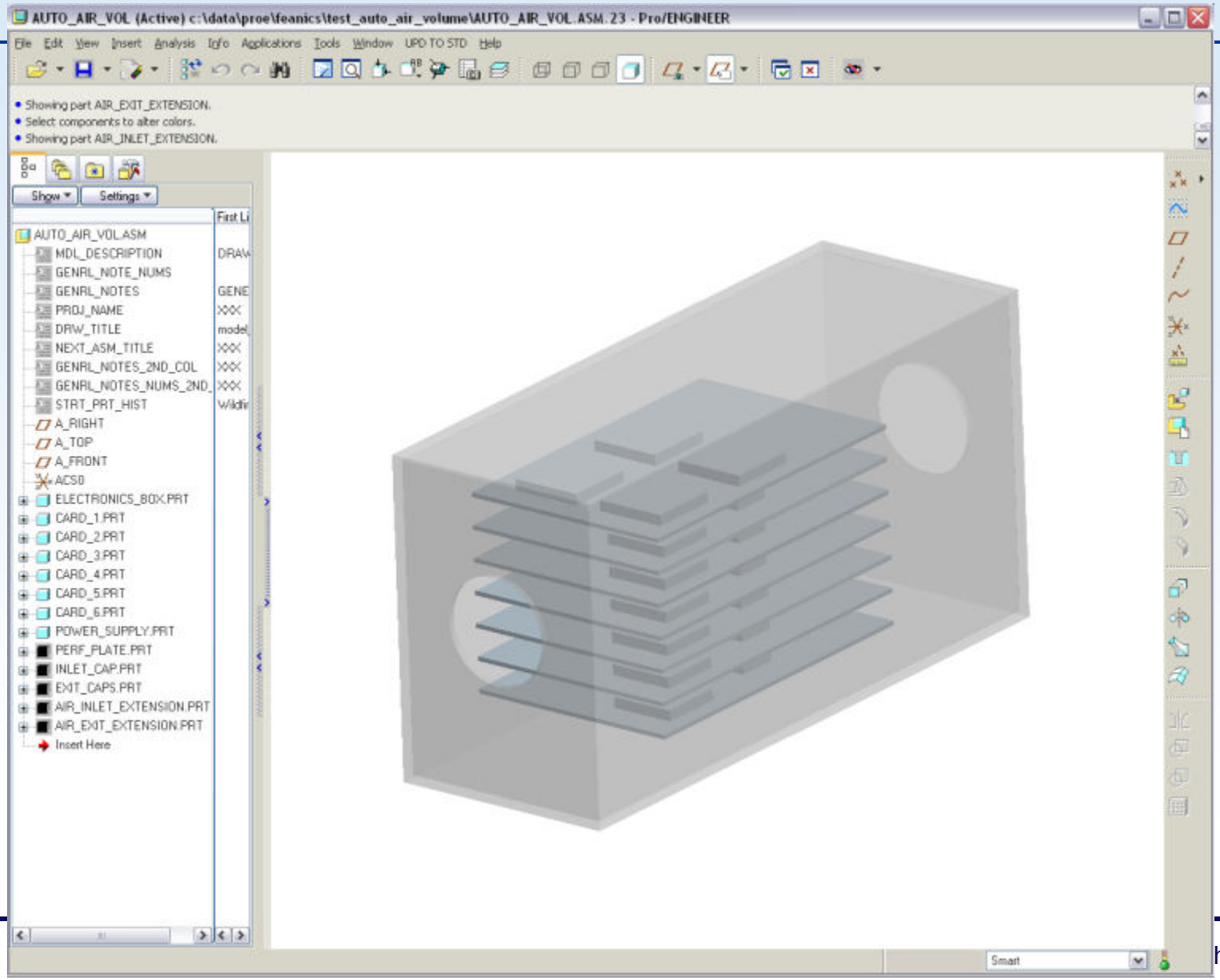


Creating Fluid Volumes: Automatic

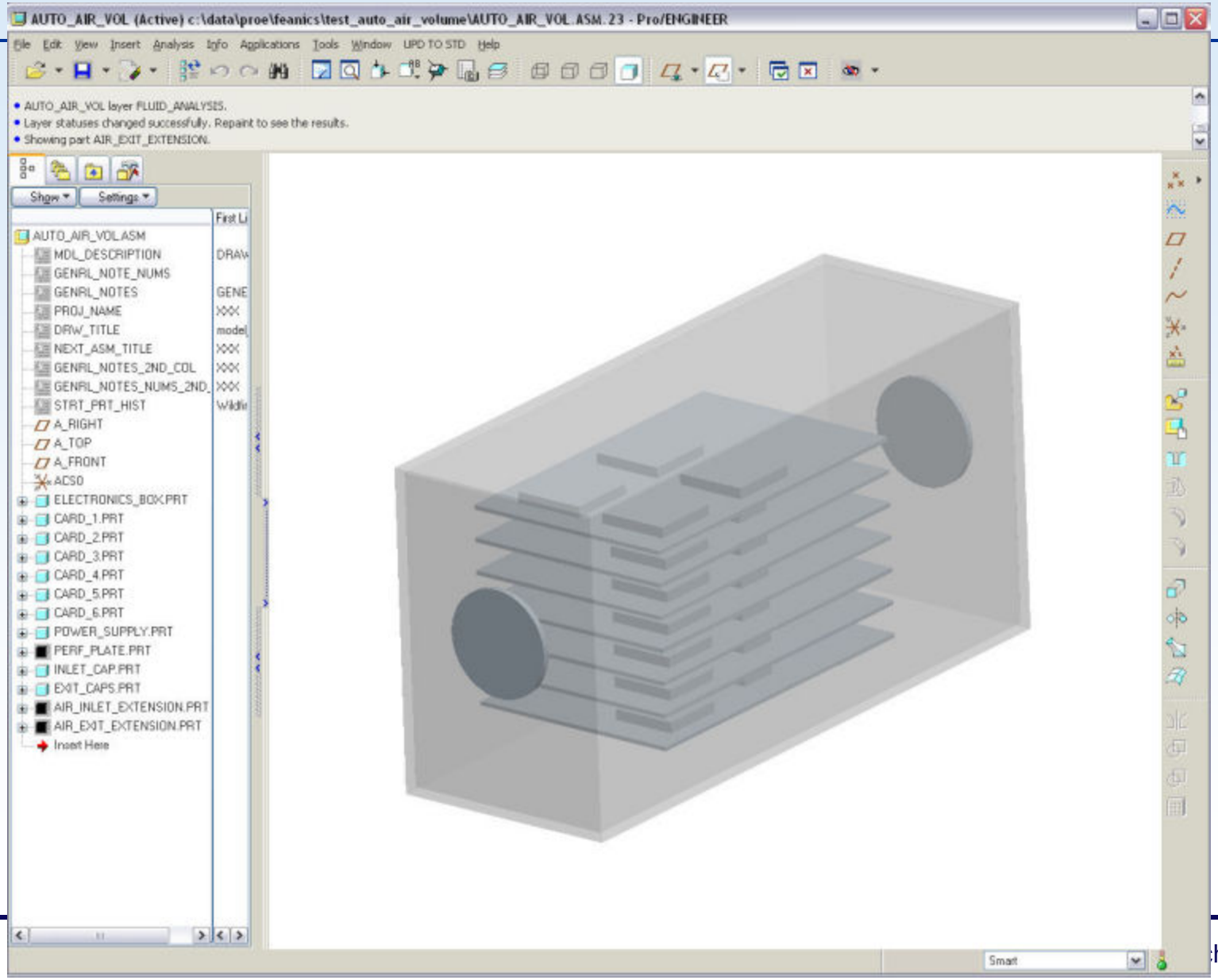
Process:

1. Create “caps” for all fluid inlets and exits
   a) No internal components can protrude into caps
   b) Caps must be flush with existing solid geometry
2. Create flow extensions for inlets and exits
   a) Promotes analysis convergence (CFdesign assumes fully-developed flow)
   b) Exit is mandatory; inlet is optional
   c) Extrude directly from caps when practical
3. Create ‘Fluid Analysis’ component layer and transfer recently-created components
   a) Isolates solid geometry not part of actual hardware

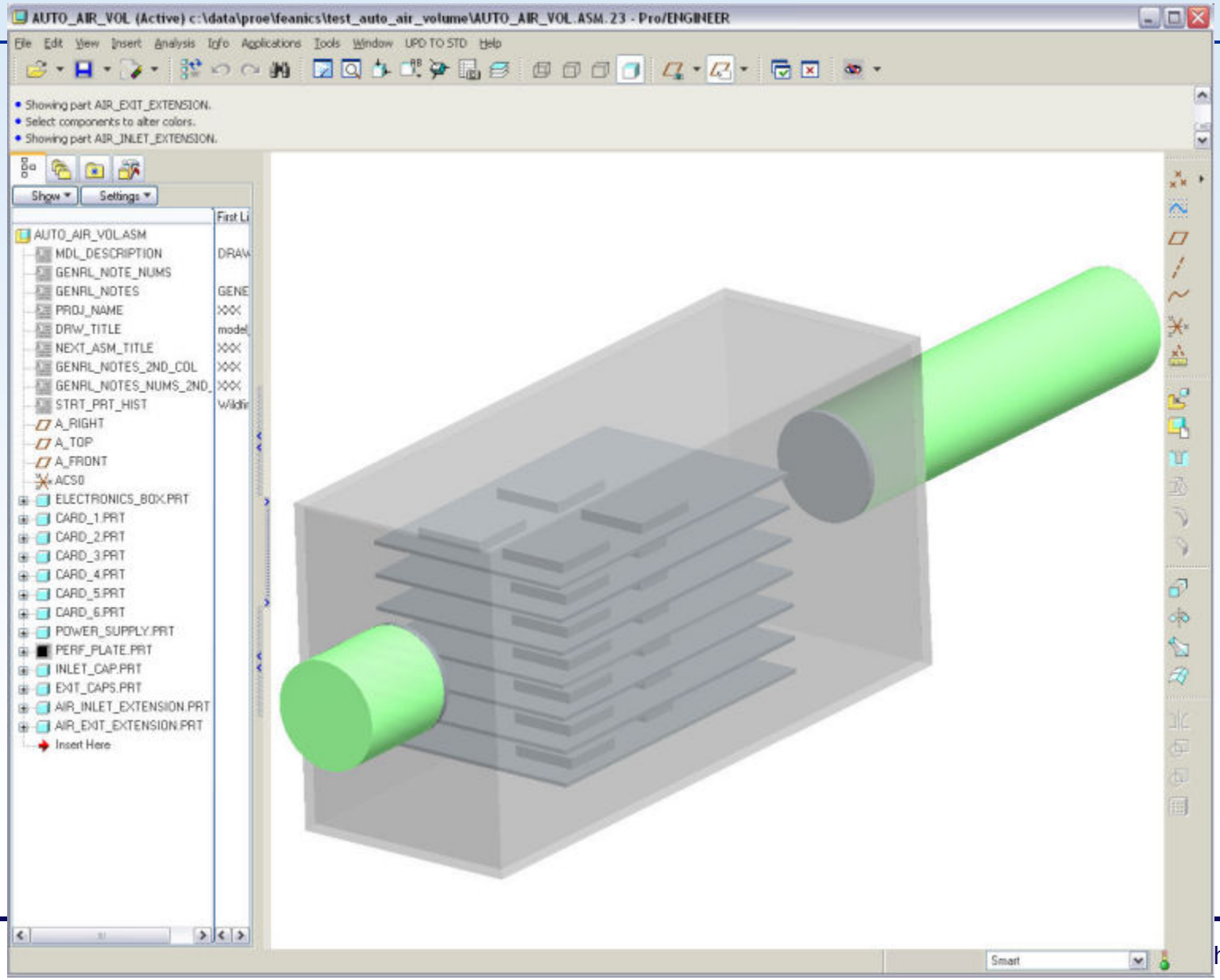
Generic Electronics Box



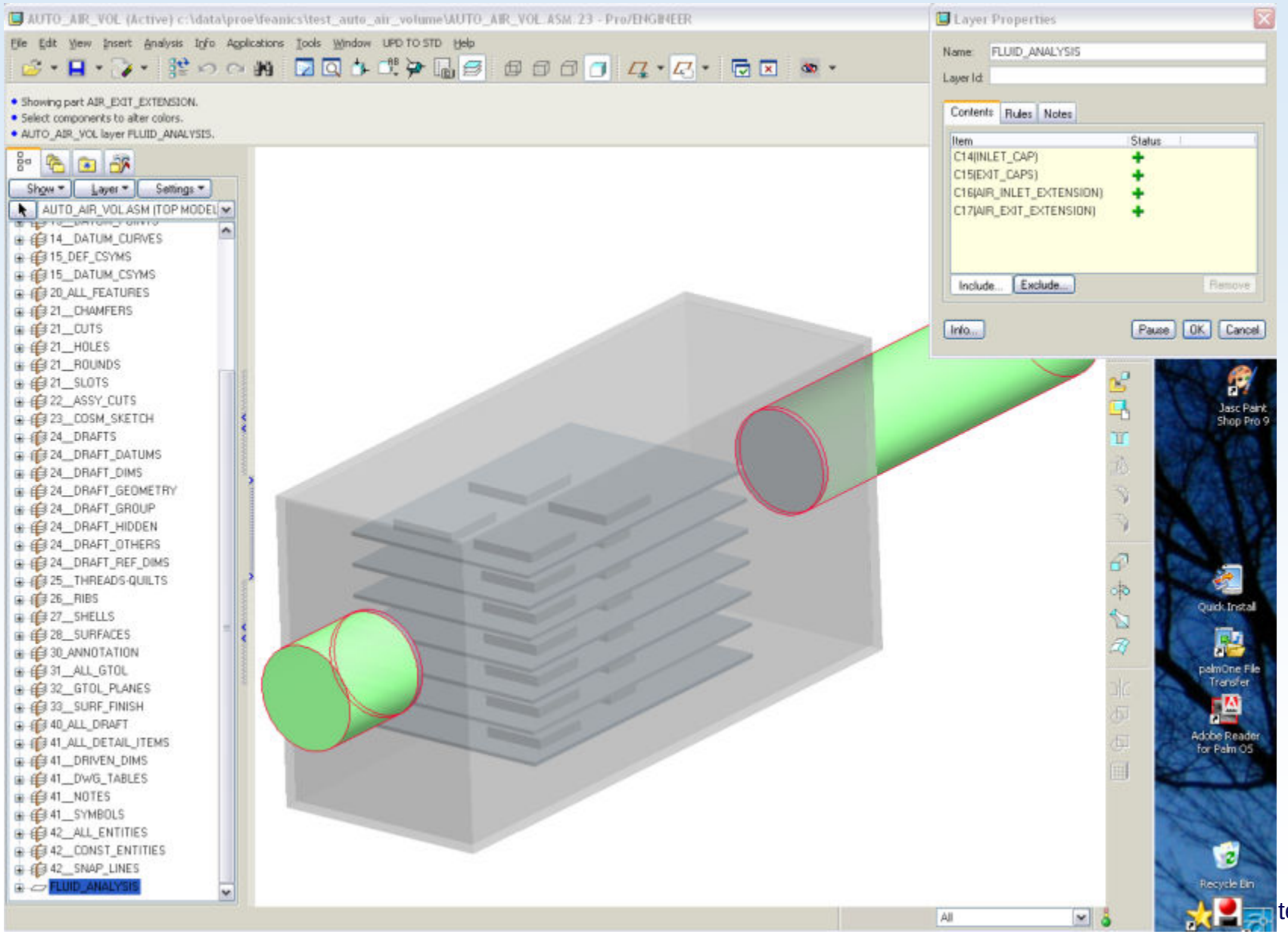
1. Create “caps” for all fluid inlets and exits

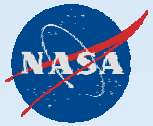


2. Create flow extensions for inlets and exits



3. Create ‘Fluid Analysis’ component layer



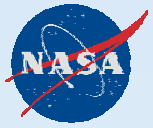


Creating Fluid Volumes: Automatic

4. Ready for import into CFdesign

A couple tips:

- "PROTOOL FILLVOIDS 1" must be set in cfdesign_flags.txt
- Be aware of effects on model properties, such as overall mass and BOM



Creating Fluid Volumes: Manual

In a nutshell:

1. Create a “bulk” fluid volume
2. “Cut out” flow paths using existing components

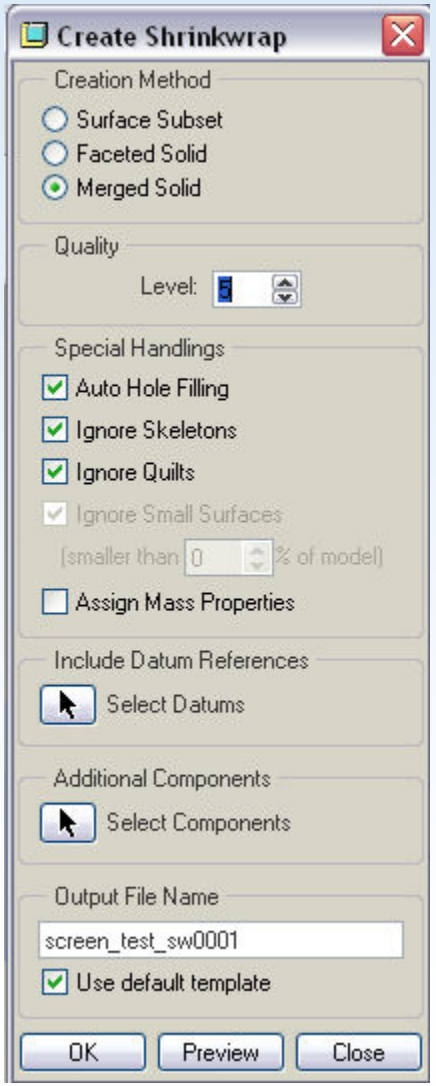
Specifically:

1. Create simplified reps of all sub-assemblies
2. Create geometric “Shrinkwrap” of each simplified rep
3. Assemble shrinkwrapped components into a new assembly for making “cut-outs”
4. Create a bulk fluid volume (in above assembly)
5. Cut to final shape using “Adv.Util – Cut Out”

Creating Fluid Volumes: Manual

Creating geometric “Shrinkwraps” in Pro/E:

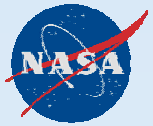
1. Open the sub-assembly and switch to the simplified rep created in Step 1
2. “Save A Copy” and select “Shrinkwrap” as Type
3. Select the “Merged Solid” option
4. “Quality”: Start w/ 5 and increase if necessary
5. Use “Auto Hole Fill” option with discretion
6. Select “Preview” and check # components selected (this tells you if Quality level is sufficient)
7. “Create”



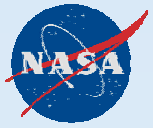
Creating Fluid Volumes: Manual

"Advanced Utility - Cut Out": Removing material from one component using the geometry of another

1. Under the "Edit" menu, select "Component Operations"
2. Choose "Cut Out" from the menu that appears
3. First select the part *to be cut* (fluid volume)
4. Then select the cutting part (shrinkwrap component)
5. "Done"



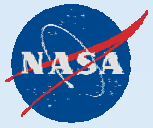
Utilizing Mechanica Volume Regions



Utilizing Mechanica Volume Regions

Uses for Volume Regions in CFdesign:

- Segregating complex volumes to allow for more discrete assignment of:
  - Boundary and initial conditions
  - Thermal, fluid, and other material properties
- Modeling and analyzing screens/meshes/flow resistances
  - Simplifies solid model, thus reducing overhead
  - Improves analysis accuracy and promotes analysis convergence
  - Allows efficient trade studies regarding FAR's using CFdesign's 'Design Center'
- Note: In order for CFdesign to recognize the volume regions, they can neither overlap nor share a surface

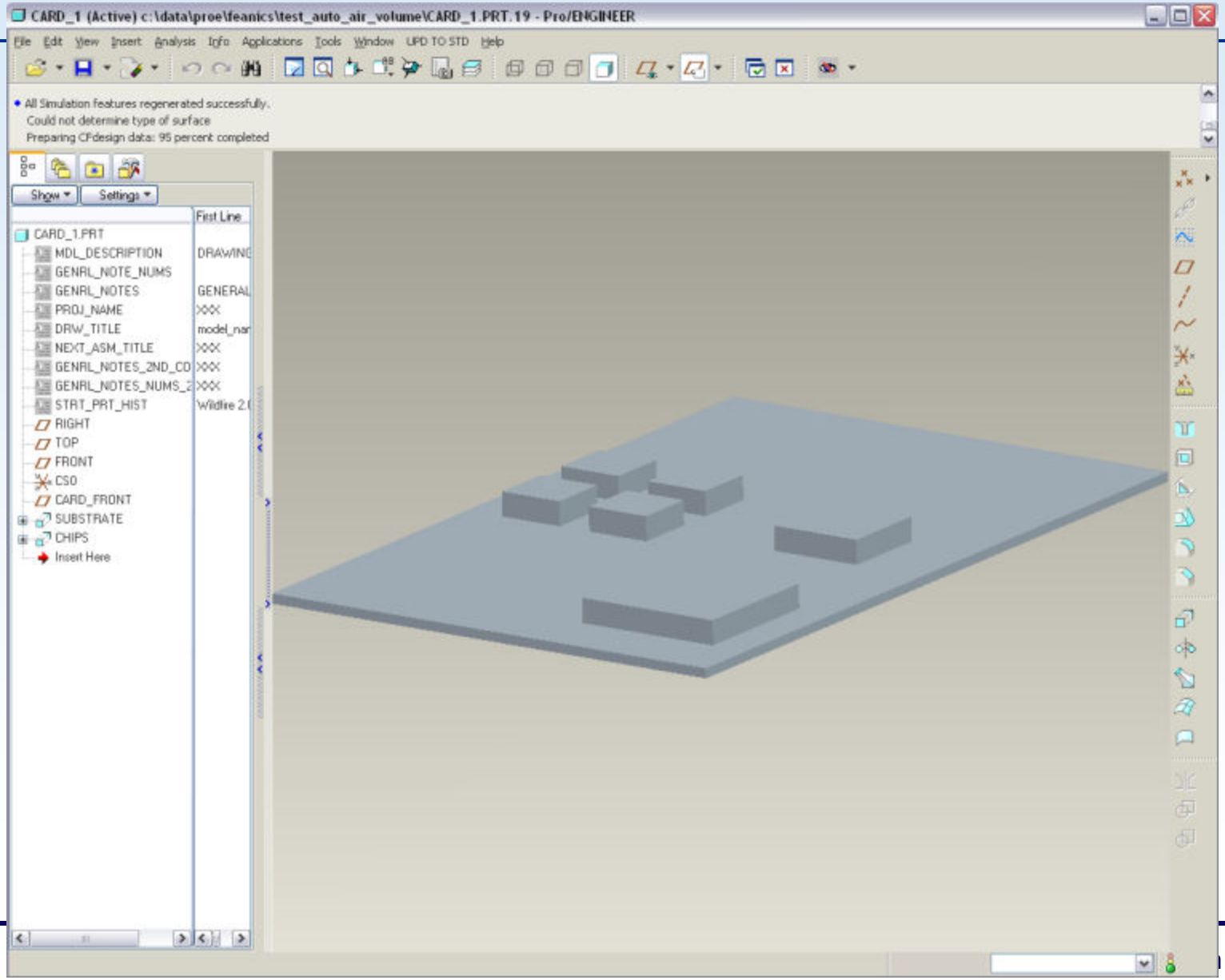


Utilizing Mechanica Volume Regions

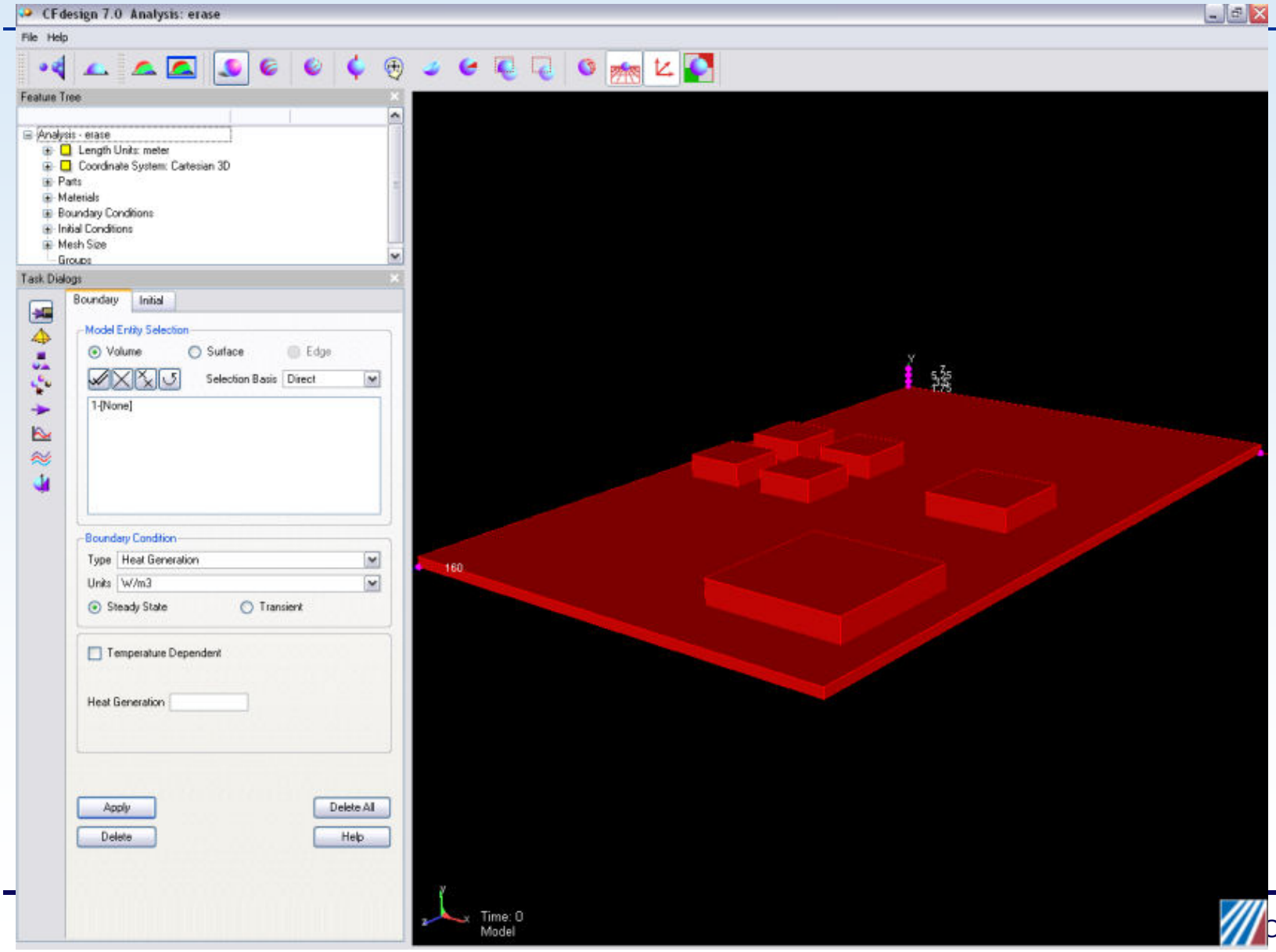
Creating Volume Regions:

1. Start ‘Mechanica’ Application
2. “Insert – Volume Region”
3. Choose feature creation method (extrude, sweep, etc)
   a) Note: Unfortunately you cannot use existing geometry
4. Select a surface to sketch upon and create geometry following normal Pro/E protocols
5. The new volume region shows up under Simulation Features and is recognized discretely when imported into CFdesign

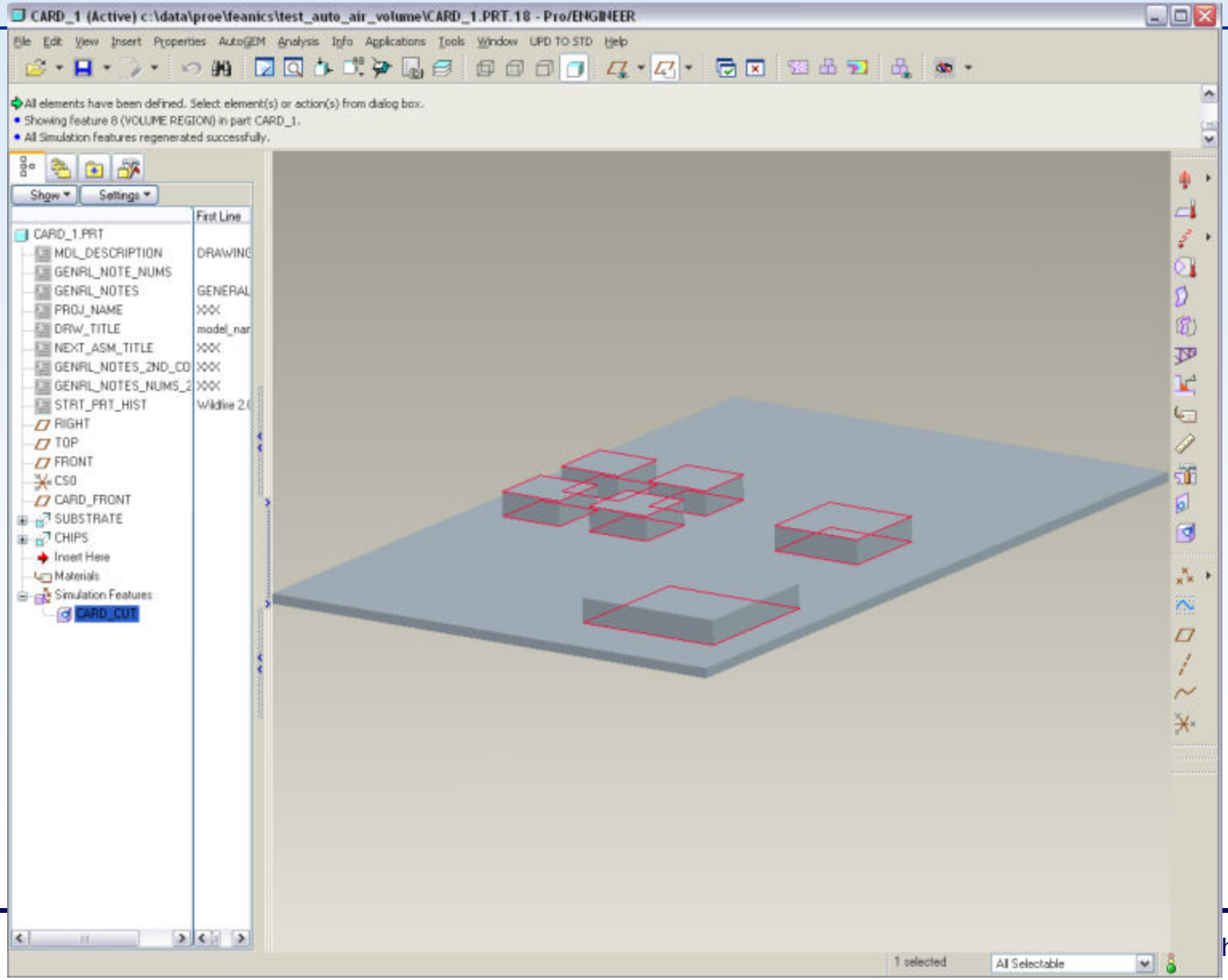
Volume Region Example: Circuit Board



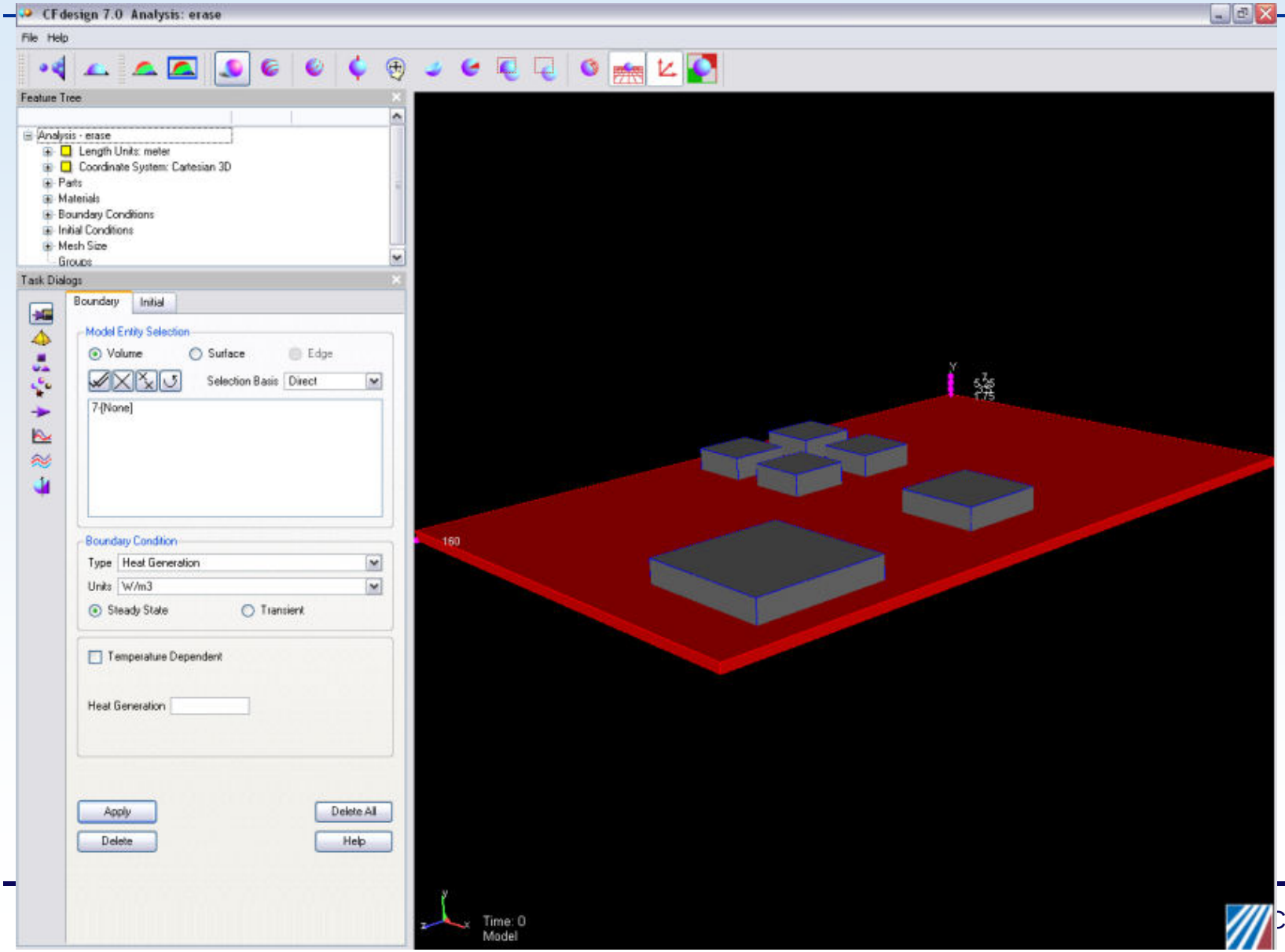
CFdesign – Before Volume Region

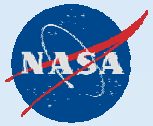


Isolate Components With Volume Region



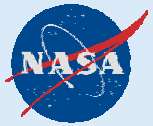
CFdesign – After Volume Region





Acknowledgements

- Bryan Fraser, NASA, Glenn Research Center
  - Puts the ‘Engineer’ in Pro/E
  - Instrumental in manual fluid volume creation method



Questions?