Top-down Design using Control Models

A systematic way of controlling inter-part associativities!
Bottom-up versus Top-down

• Recall that **bottom-up** design is creating individual part **solid models first**, then adding them to assemblies and constraining them.

• Top-down design is creating the **top level assembly first**, then adding components as empty part or sub-assembly files. The part solid models are created last. They are designed “in context”.
Bottom-Up vs. Top-Down Design

**Bottom Up**

1. 

2. 

3. 

**Top Down**

1. 

2. 

3.
Design in Place

- Also known as “Design in Context.”
- Solid Models are created such that the part and assembly coordinate systems line up in the assembly.
- Neighboring part can be used as reference.
Bottom-up Design Limitations

- Making a design change may require manually changing many interacting parts.
- Associative copy & assembly equations can be used between parts, but:
  - It is often done in an ad-hoc, untracked way
  - Parts may change unexpectedly, in unexpected ways.
  - Circular dependencies can be created.
- Top-down design can be done in a way that avoids these problems.
Top-down Design using Control Models

• We will use the Control Structure concept to do systematic, parametric top-down design.

• The key to the Control Structure concept is that one or more control models are used to control the actual parts in the assembly.
  – A control model is not an actual part that is manufactured.
  – It is only a conceptual part, containing a sketch or general shape of the overall design and important design parameters.
  – It acts as a template or skeleton for the entire design.

• This design concept relies heavily on associative copy and inter-part expressions.
Associative Inter-part Copy

• Associative inter-part copy creates a copy of geometry from one part in another. The copy is associative, so that if the original changes, the copy will also change.

• To create an associative copy in SolidWorks:
  1. Open the assembly containing the source and destination parts.
  2. Hide all components except the source and destination parts.
  3. Make the destination part to be the work part. (Right-click on the destination part and select “Edit Part”.)
  4. Identify and use modeling operations that can replicate the source geometry. E.g.:
     • Copy a reference plane by creating a reference plane coincident with it.
     • Copy sketch curves by creating a sketch and using “Convert Entities”.
     • Copy faces by using an offset surface operation, with an offset distance of ‘0’.
Associative Inter-part Copy

• An alternative way of creating an associative copy in SolidWorks is to:
  1. Open the destination file by itself.
  2. Select “Insert” → “Part…”
  3. Select the type of objects to copy (“transfer”). All instances of this type of object will copied.
  4. Click on “OK” without clicking in the graphics window. (Clicking in the graphics window will put the copy in the wrong place.)

• A third alternative (to copy solids) is to:
  1. Open the source file by itself.
  2. Select “Insert” → “Features” → “Split”
  3. Split off different parts of a solid to different (new) files.
Associative Inter-part Copy

• Changing & Exchanging Files
  – Associate Copy keeps track of the file name and the feature for the original. Changing either of these outside of SolidWorks will cause the link to become broken and the copied feature will not update properly.
  – To **change the name** of a source file:
    1. Open the destination file, the assembly file, and the source file
    2. Use “File” → “Save As…” to save the source file to a new part name.
    3. Resave the destination and assembly files.
  – To **change a feature** in a source file:
    1. Open the source file, make the change, and save the file.
    2. If they are not already open, open the destination and assembly files.
    3. Resave the destination and assembly files.

• Note that feature changes that cause geometry (faces, edges, etc.) to be created or destroyed will result in problems that need to be rectified in the destination file the same as if the feature dependency occurred in the same file (Persistent Naming problem).
Associative Inter-part Copy

• Identifying Broken Links
  1. Open the destination part and look at the Feature Manager.
  2. If a feature has “->”, right-click on the feature and select “List External Refs…” to see which file is the source file.
  3. If a feature has “-> ?”, the source file needs to be opened.
  4. If a feature and its part display a warning (⚠️) the link needs to be repaired.

• Fixing Broken Links – source file name changed
  1. Open the assembly file and select the correct source file when prompted.
  2. Open the destination file.
  3. Save the assembly and destination files.

• Fixing Broken Links – source geometry changed
  1. Open destination part in context of assembly, with source part also showing.
  2. Edit the feature showing the warning.
  3. Reselect geometry the geometry to be copied.
Inter-part Expressions

- Variables in the Equations table can be expressed in terms of variables from other part files.
- To use inter-part expressions in SolidWorks:
  1. In the “Value/Equation” column of the “Equations, Global Variables, and Dimensions” window for the destination file, reference the variable from the source file using syntax such as "myvariable@source<1>.Part@Assem.Assembly" (I have not gotten this to work myself.)
  2. Alternatively, in the “Equations, Global Variables, and Dimensions” windows:
     1. For the source file, check “Link to external file:” and select “Create new file” in the “Link Equations” window and click on “Link” (and then “OK”).
     2. For the destination file, check “Link to external file:” and select the text file created from the source file.
     3. Update the text file manually, then click on “Import…” to update values in both the source and destination files.
Top-Down Design Procedure

1. **Pick a “Team Leader.”**
   Team leader does Steps 2-7 with help from team.

2. **Create a “master sketch” or “master part.”**
   Use the term “master” or “control” in the name of the part.
   E.g., “master_layout”, “shape_master”, or “control_sketch”.
   It must contain all important **design geometry** and **variables**.

3. **Create an “assembly file.”**

4. **Insert “master part” into “assembly file.”**

5. **Create empty components.**
   Create empty part files (1 thru n) and add to “assembly file.”
   These may represent individual parts or sub-assemblies.
Top-Down Design Procedure

• In the Assembly Manager, the parts show up as:

  - Assembly part file
  - Component parts
  - Control part
6. Associatively copy geometry from the “master sketch” to “Parts 1 thru n.”
   Use Associate Copy and inter-part expressions to copy geometry and variables from the control part to component parts, as required.

7. “Team leader” gives “Parts 2 thru n” to “Person 2, Person 3, … Person n.”

8. “Team leader” models “Part 1,”
   “Person 2” models “Part 2,”
   “Person 3” models “Part 3,”
   …
Top-Down Design Procedure

Team leader

Person 2

Person 3

“Persons 2 thru n” should not have the “Assembly file” or the “Master part”!!!
Top-Down Design Procedure

9. When “Parts 1 thru n” are fully modeled:
   1) “Person 2 thru n” give “Parts 2 thru n” to “Team leader.”
   2) “Team leader” copies files from “Person 2 thru n” to folder with assembly. Operating system will ask if you want to replace original files. Say “Yes.”

10. Open “Assembly File” and check that it is correct.
Top-down Design Rules

1. What geometry should be in the Control Part?
   - If you were to create a sketch of your design on paper, what would be in that sketch? Probably, whatever is in that sketch should be in the Control Part.
   - It should include geometry and parameters for the whole, overall design.
   - The Control Part should contain geometry and parameters that are important to more than one part.
Top-down Design Rules

2. Top-down and bottom-up techniques can be used in the **same** product design.

3. These parts SHOULD be controlled from the Control Part:
   - part contains geometry that is related to geometry in another part (E.g., automobile door and fender shape must match a master shape.)

4. These parts SHOULD NOT be controlled from the Control Part:
   - part is “off-the-shelf”
   - part appears in other assemblies
   - part appears in other products
Top-down Design Rules

5. **ALL** associative copy and inter-part expression relationships **must be** directed from Control Part to other part.

6. Parts that are created using associative copy *usually* should not be constrained in the assembly. (They do not need to be, since they are designed in place.)