CONDUCTING A STEP-BY-STEP DFA ANALYSIS

October 1, 2019

Bill Devenish – Global DFMA Leader and Producibility Engineer

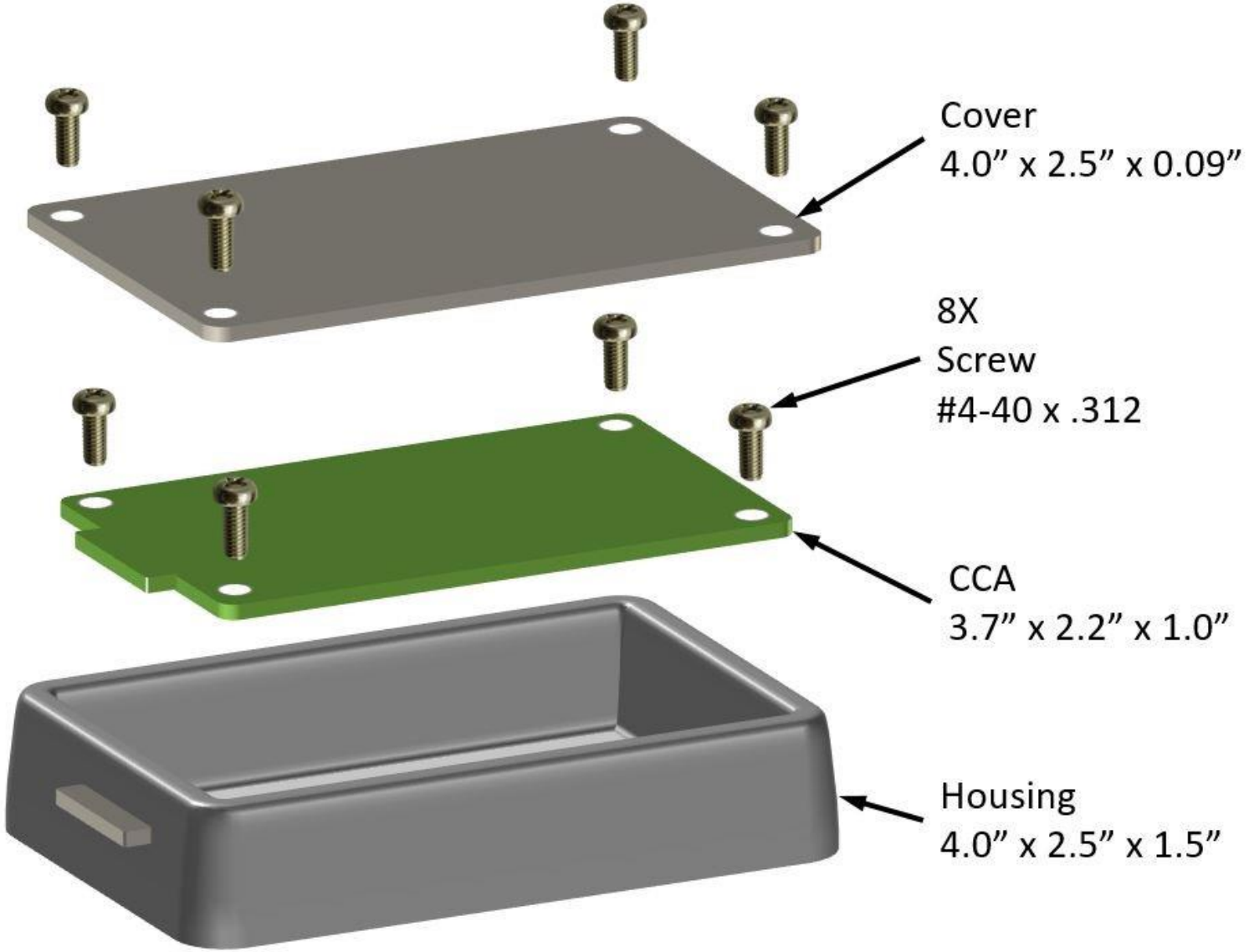
Eddie Rickenbacker (1890 – 1973)

Eddie Rickenbacker (1890 – 1973)

"Aviation is proof that given, the will, we have the capacity to achieve the impossible."

Example – Electronic Enclosure

PARTS LIST ELECTRONIC ENCLOSURE	
ITEM	**QTY**
Housing	1
CCA	1
Screw, 4-40x.312	4
Cover	1
Screw, 4-40x.312	4



DFA Overview

Create Product Structure (Parts List)

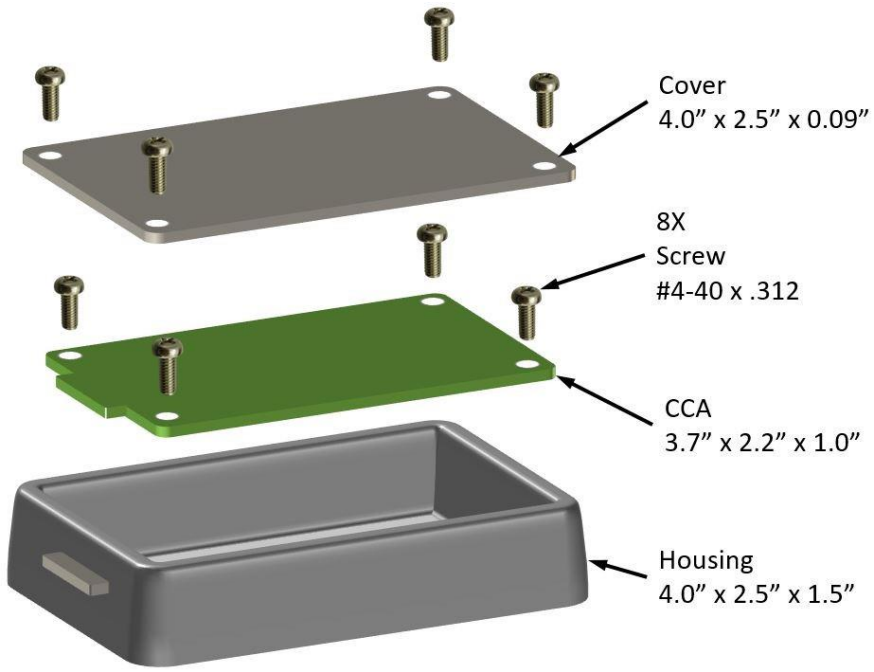
Answer DFA Questions

Review Results

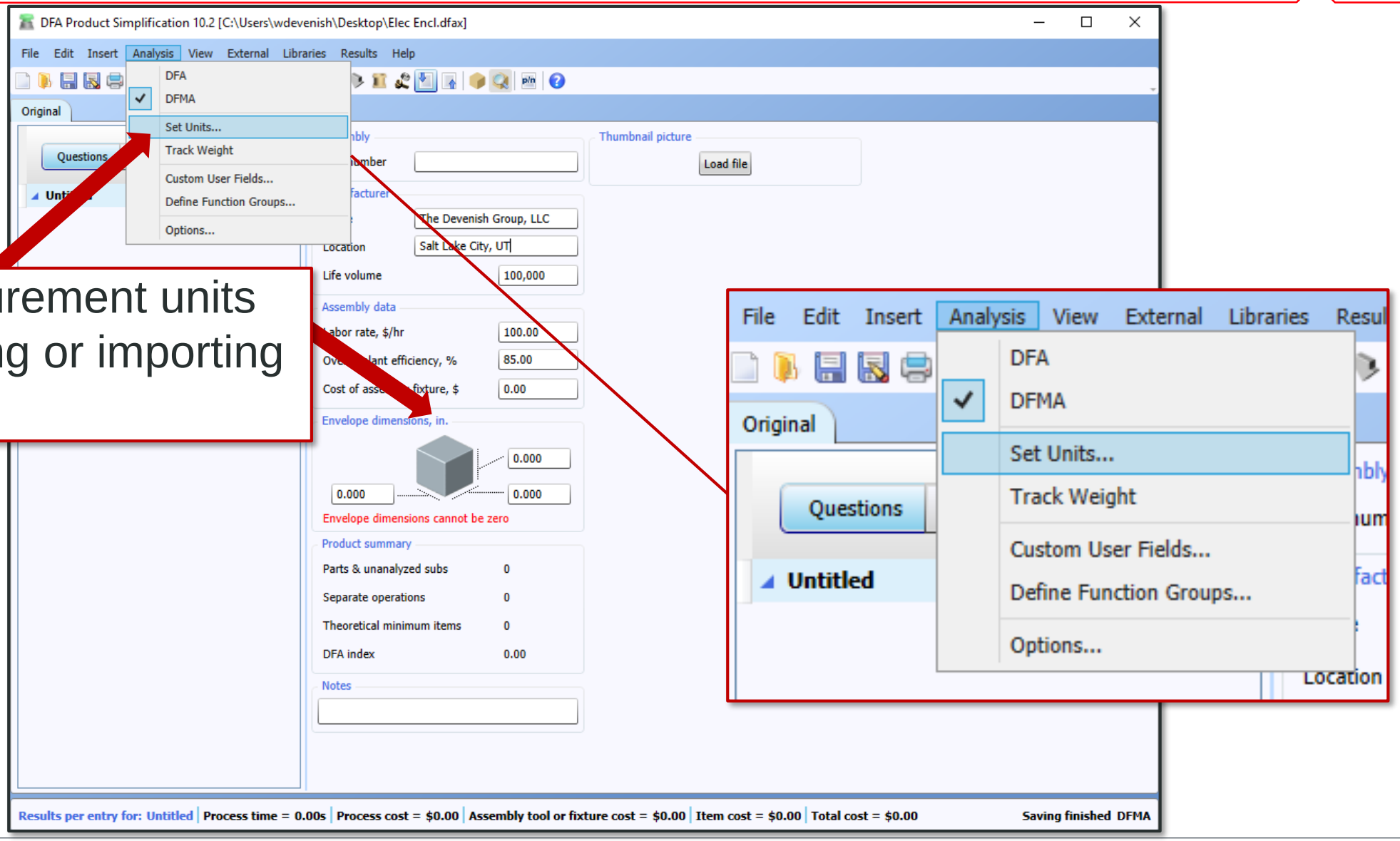
Brainstorm Redesign Ideas

Compare Redesign Concepts

Select Best Concept



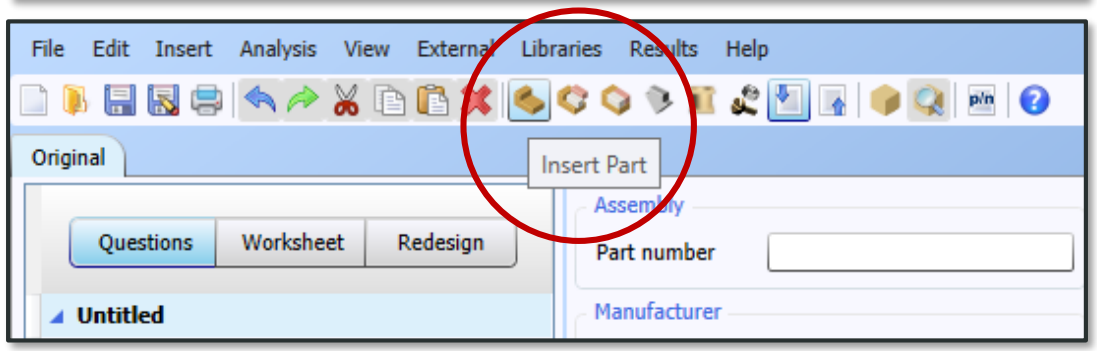
Verify Measurement Units



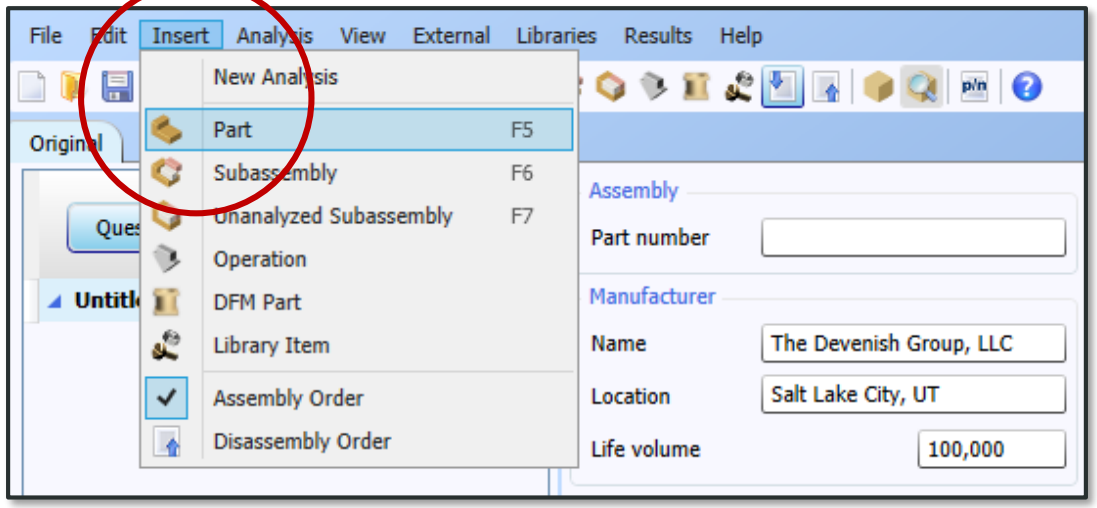
Check measurement units before creating or importing a Parts List

Three Different Methods for Inserting Parts

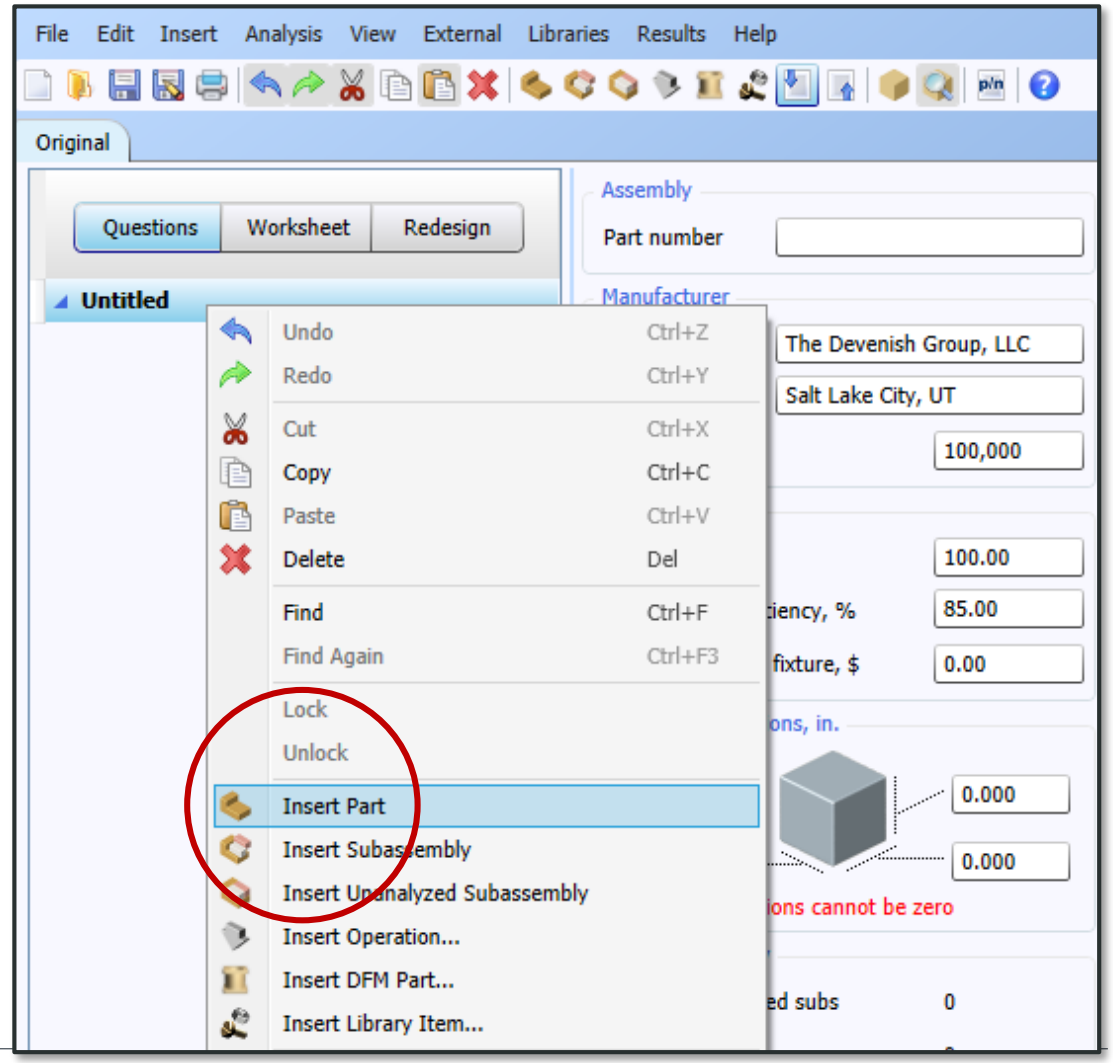
Select “Insert Part” Icon



Select “Insert Part” Menu Drop-down



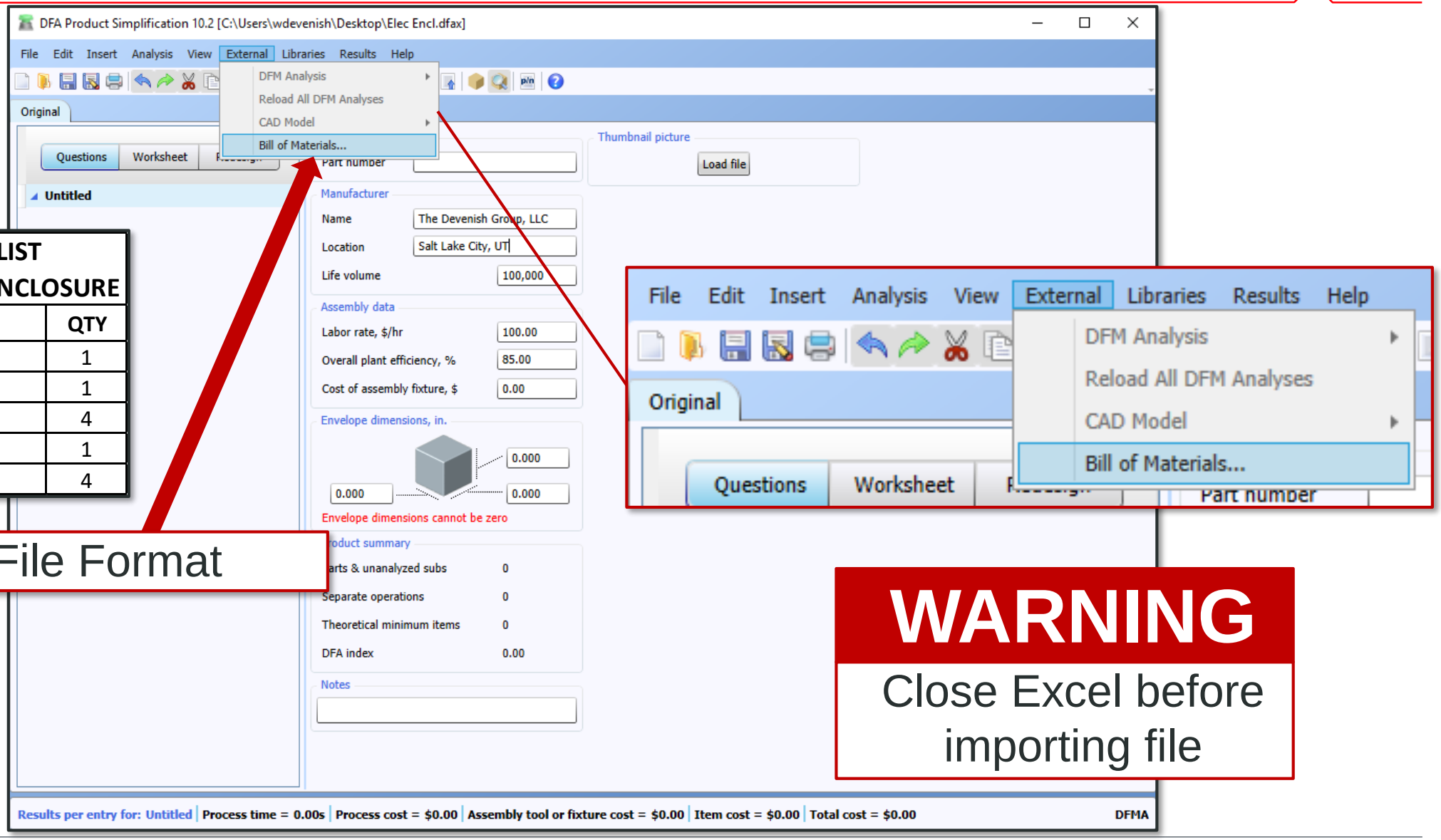
Right Click in Product Chart Area



Importing a Parts List

PARTS LIST ELECTRONIC ENCLOSURE	
ITEM	**QTY**
Housing	1
CCA	1
Screw, 4-40x.312	4
Cover	1
Screw, 4-40x.312	4

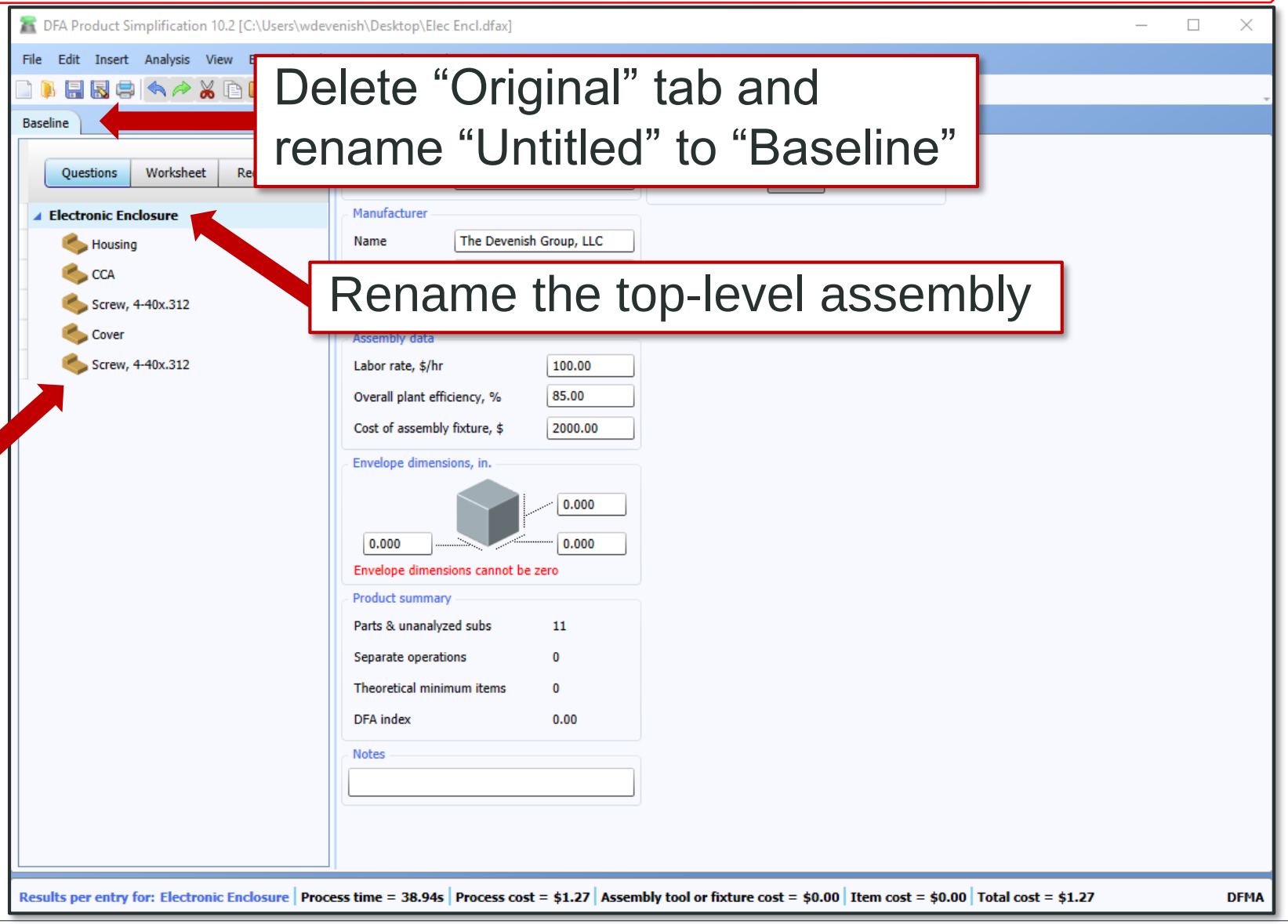
.TXT or .CSV File Format



WARNING

Close Excel before importing file

Establish the Baseline Tab

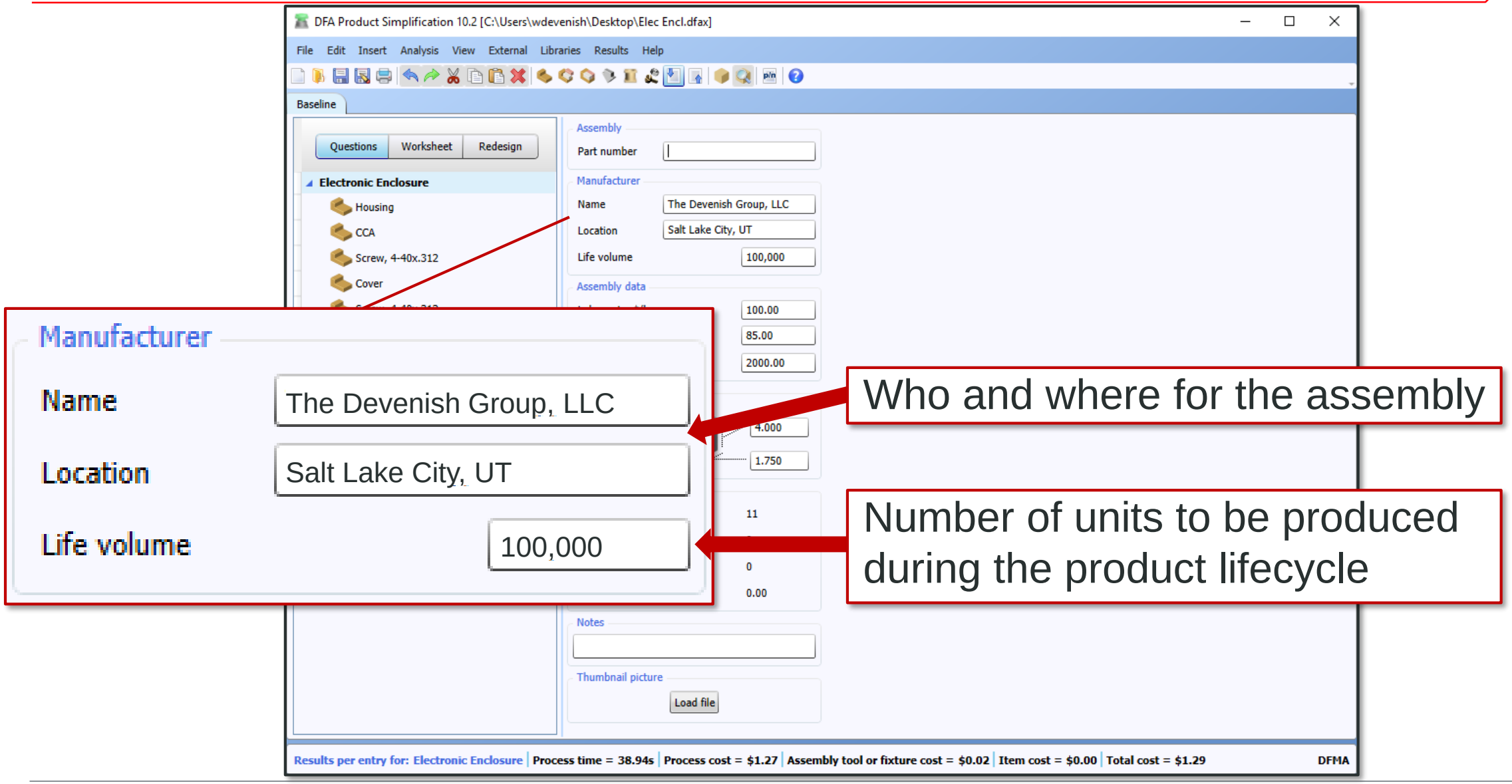


Delete “Original” tab and rename “Untitled” to “Baseline”

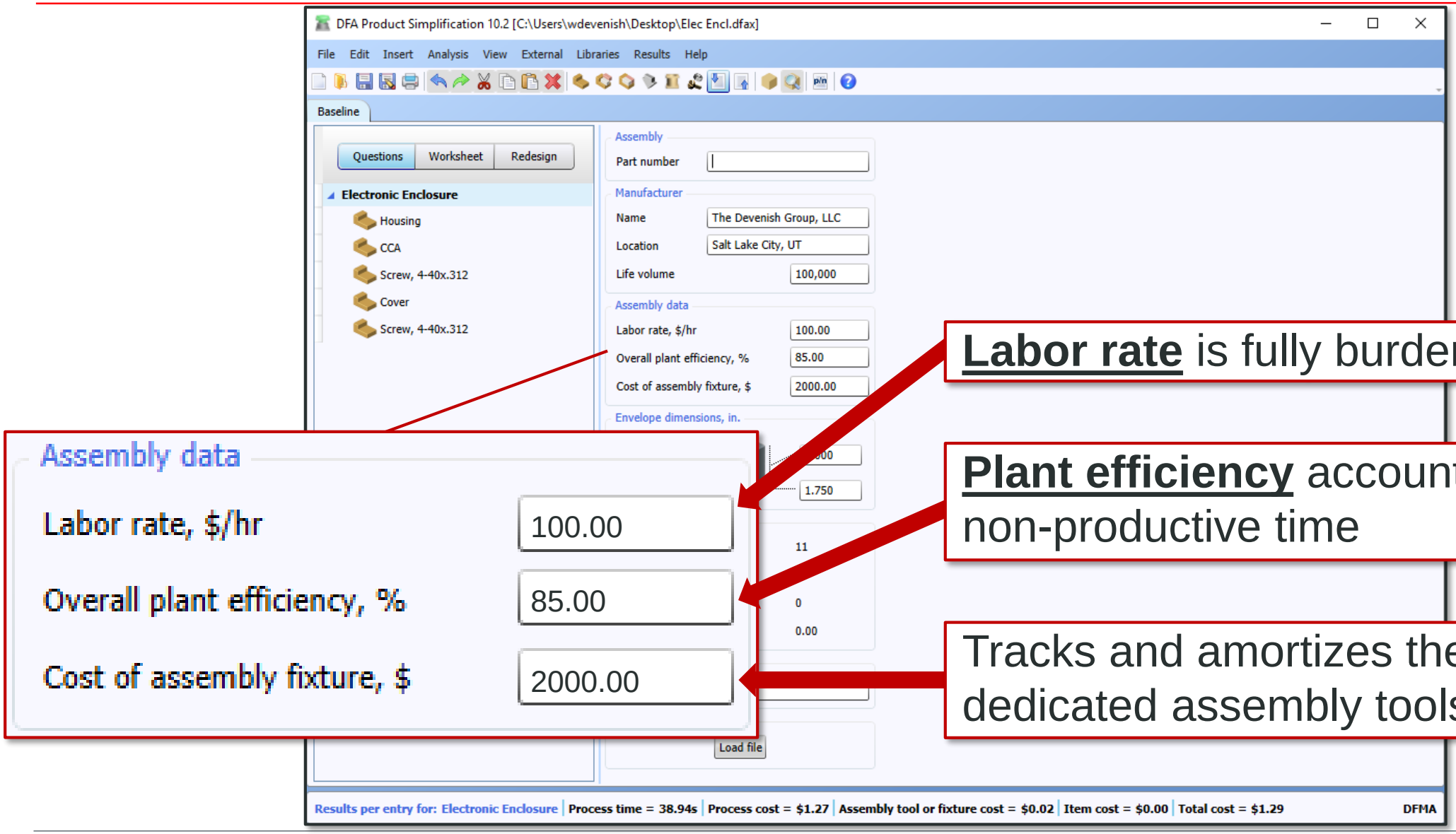
Rename the top-level assembly

Parts are listed in order of assembly

Main Product Page: Manufacturer Info



Main Product Page: Assembly Data

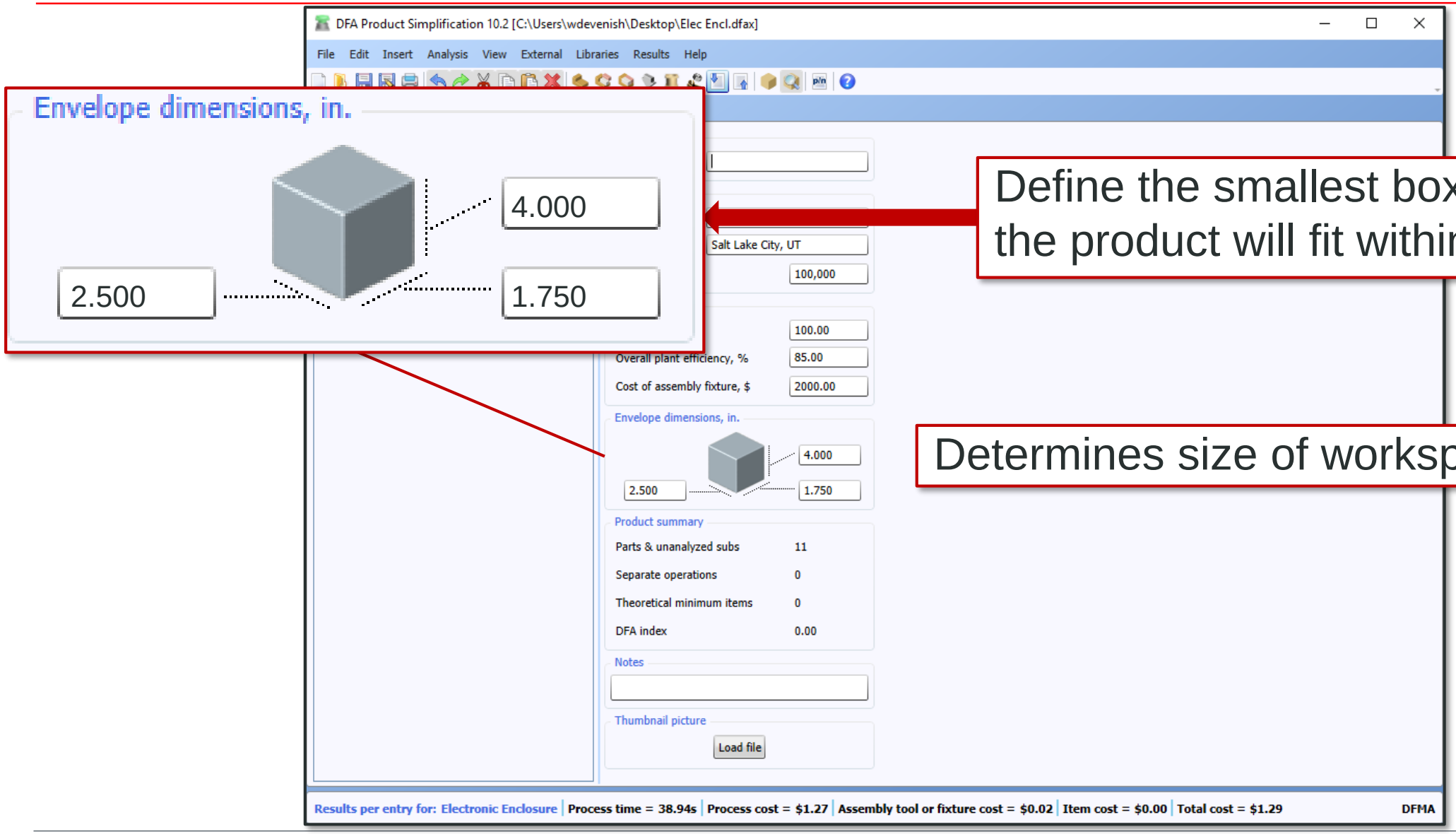


Labor rate is fully burdened

Plant efficiency accounts for non-productive time

Tracks and amortizes the cost of dedicated assembly tools

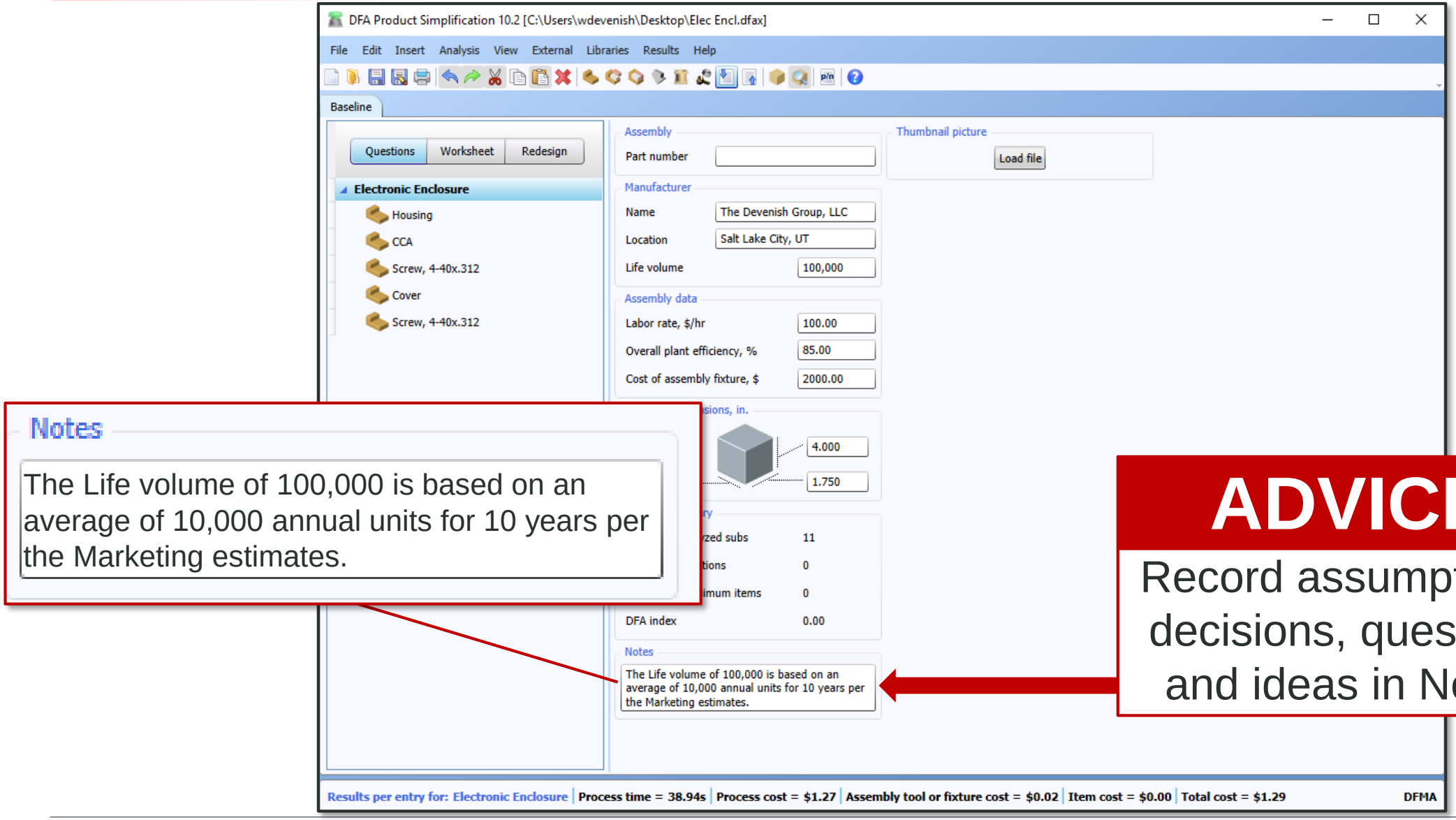
Main Product Page: Envelope Dimensions



Define the smallest box that the product will fit within

Determines size of workspace needed

Main Product Page: Use the “Notes” Field



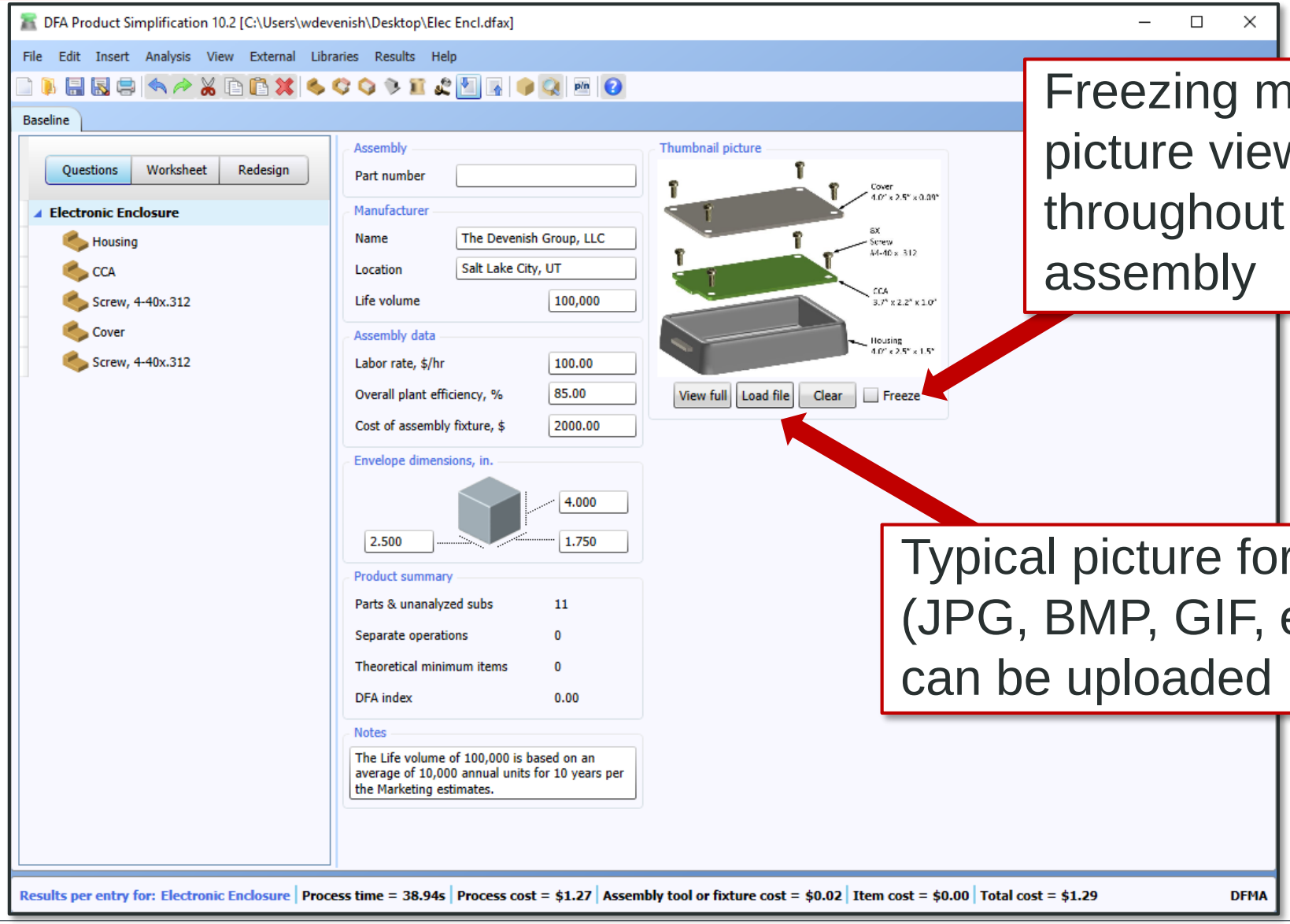
Notes

The Life volume of 100,000 is based on an average of 10,000 annual units for 10 years per the Marketing estimates.

ADVICE

Record assumptions, decisions, questions and ideas in Notes

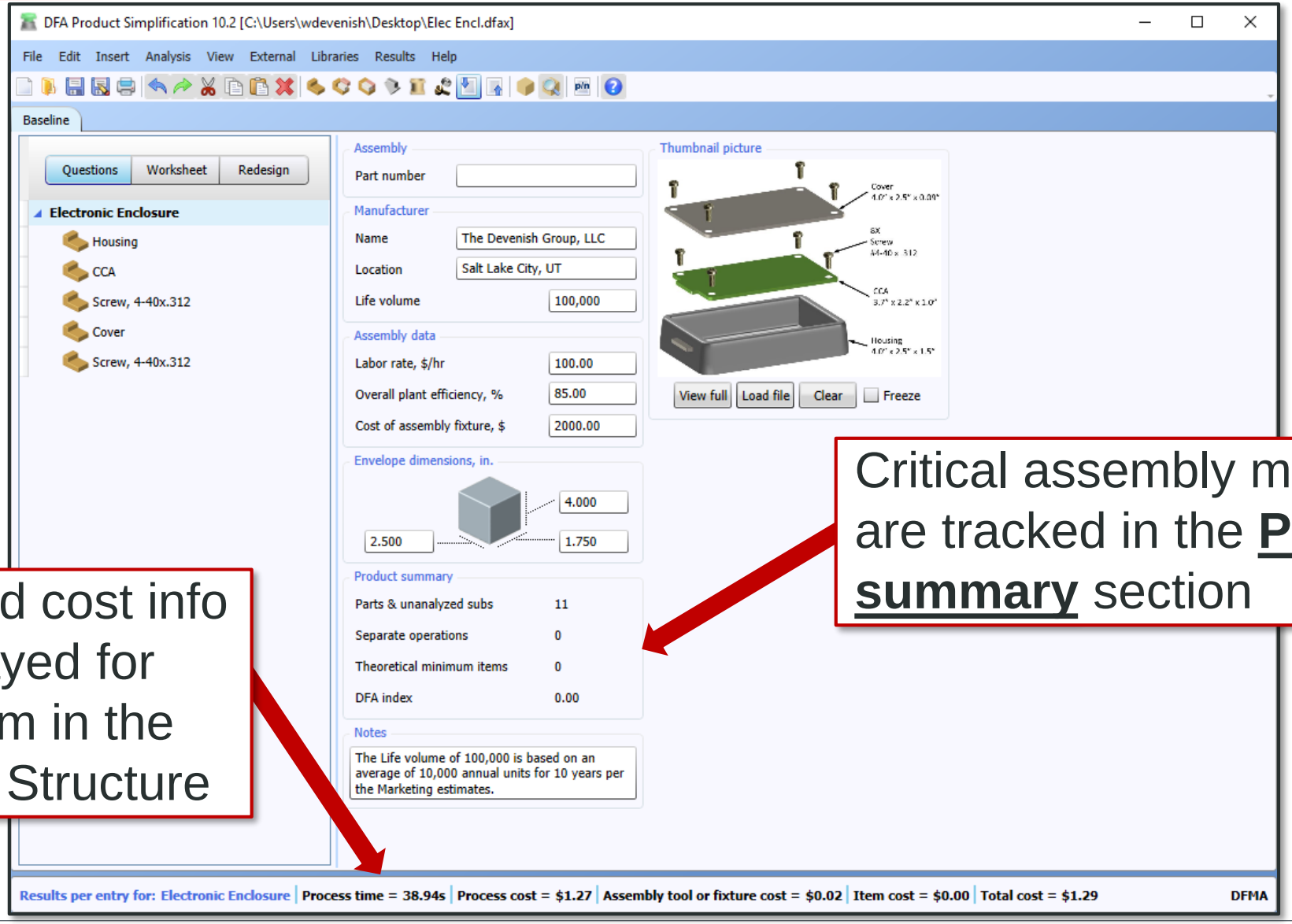
Main Product Page: Upload a Picture



Freezing makes the picture viewable throughout the entire assembly

Typical picture formats (JPG, BMP, GIF, etc.) can be uploaded

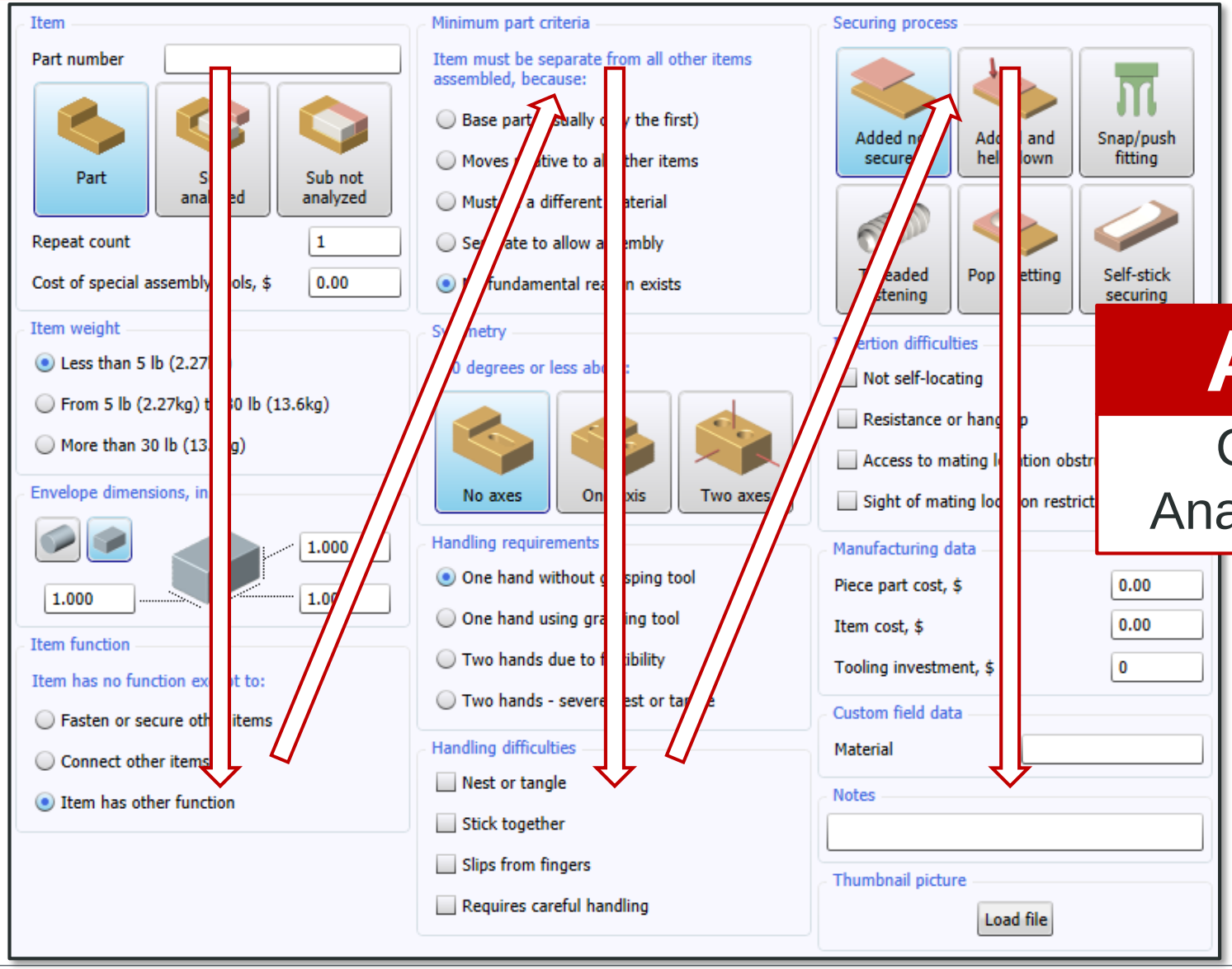
Main Product Page: Product Summary and Results



Critical assembly metrics are tracked in the **Product summary** section

Time and cost info is displayed for each item in the Product Structure

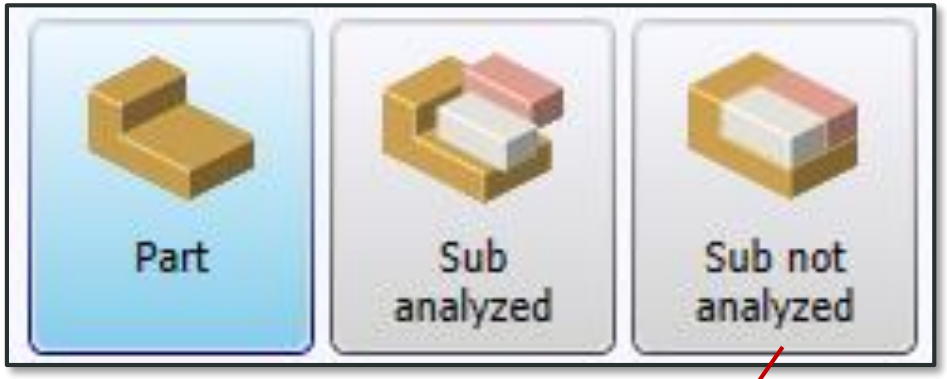
Answering Part Questions – The Meat of DFA Analysis



ADVICE

Conduct DFA Analysis as a team

Individual Part or Subassembly



- Motors
- Valves
- CCAs

A **Part** is a single component in the assembly, such as the Housing, Cover and Screws

A **Sub analyzed** is a subassembly of multiple parts assembled at a different workstation, adding time for the material transfer

A **Sub not analyzed** is a collection of multiple parts that are treated as a single part, such as the CCA

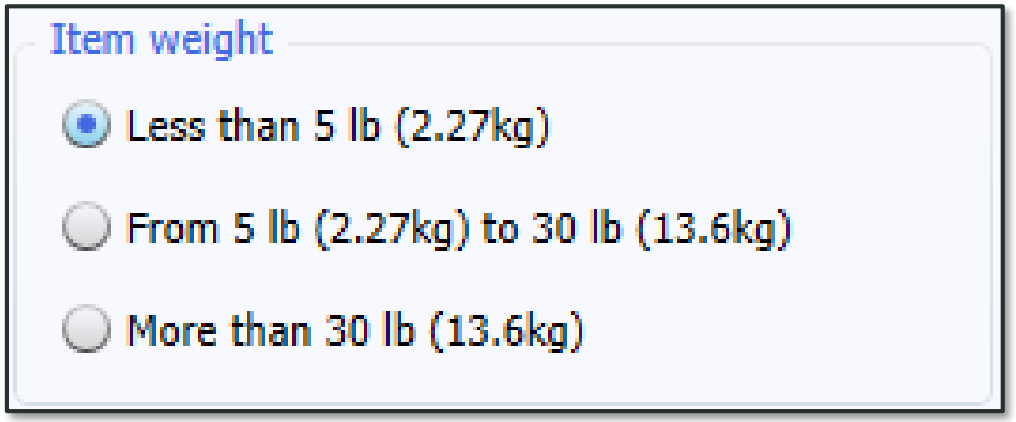
Repeat Count and Special Tool Cost

The **Repeat count** is the quantity of identical parts inserted at the specific assembly step

Repeat count	1
Cost of special assembly tools, $	0.00

The **Cost of special assembly tools** is the cost for any specialized tool required to assemble the part into the product, and is amortized across the estimated Life volume

Item Weight

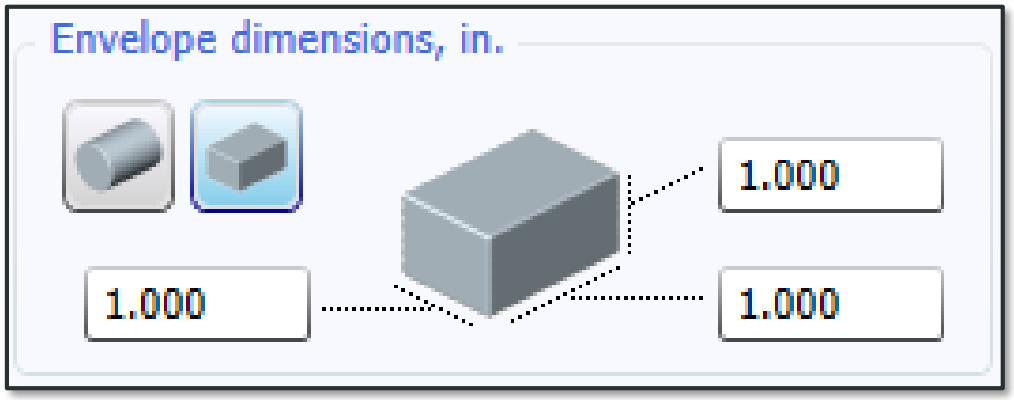


Three Weight Categories:

- Light
- Moderate
- Heavy

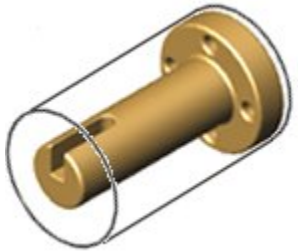
Used to determine which time standards apply to the part and what questions to ask

Envelope Dimensions & Shapes

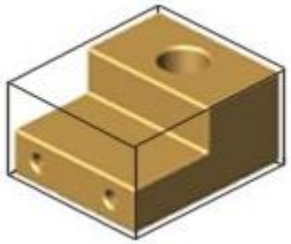


Two Shape Categories:

Cylindrical



Block

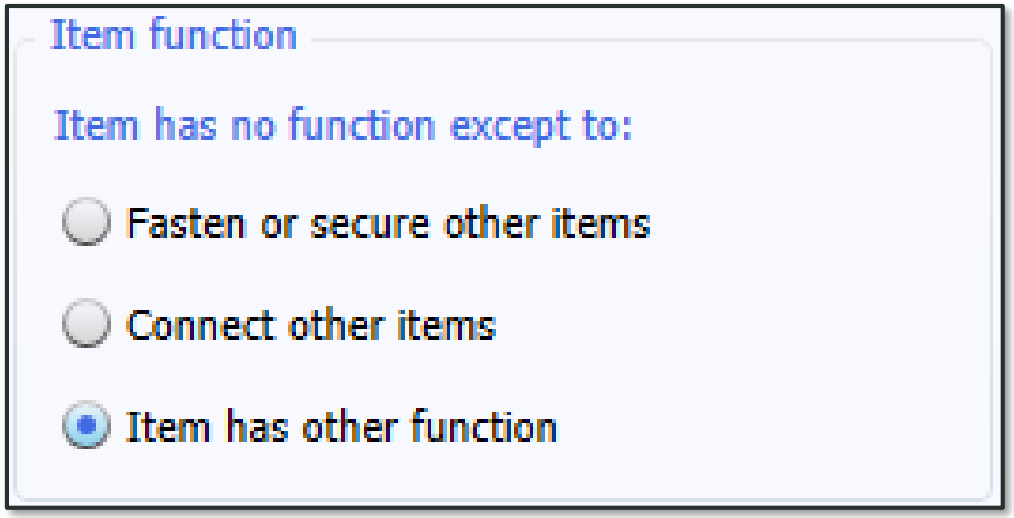


Used to determine which time standards apply to the part and what questions to ask

NOTE

Three place decimal dimensions are not necessary

Item Function



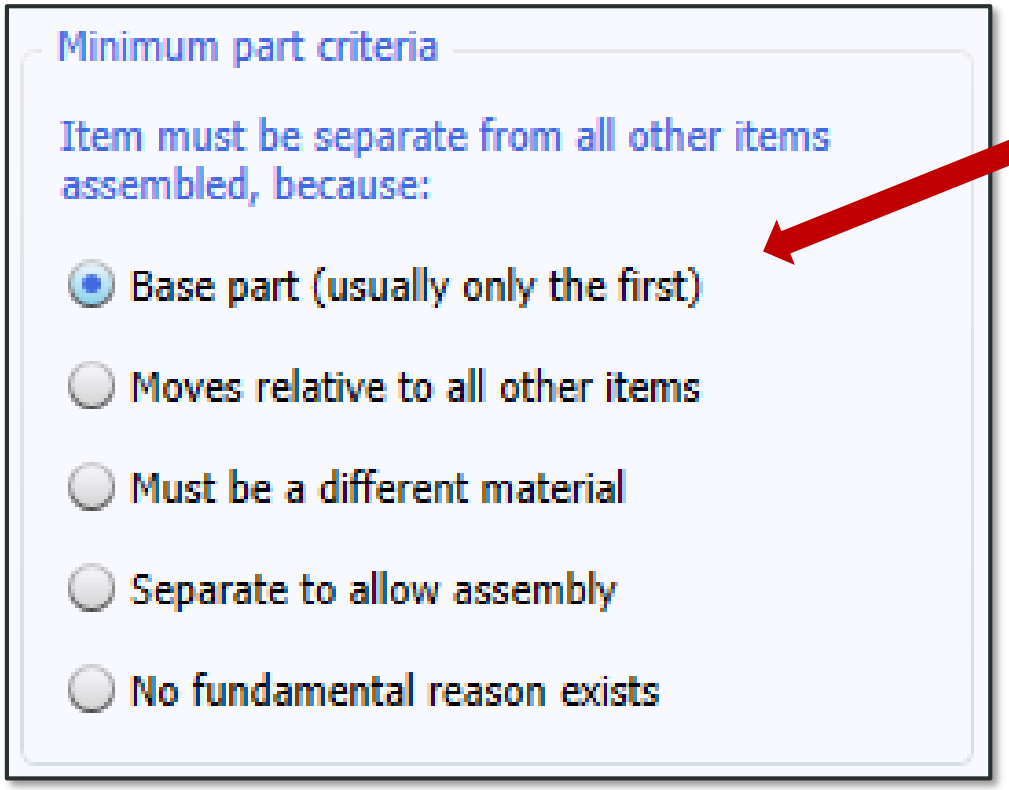
<u>Fasteners</u> secure two or more parts together:

- Screws, Nuts, Bolts, Pins, Rivets, etc.

<u>Connectors</u> join separate items that could theoretically be combined:

- Hoses, wires, cables, connectors, etc.

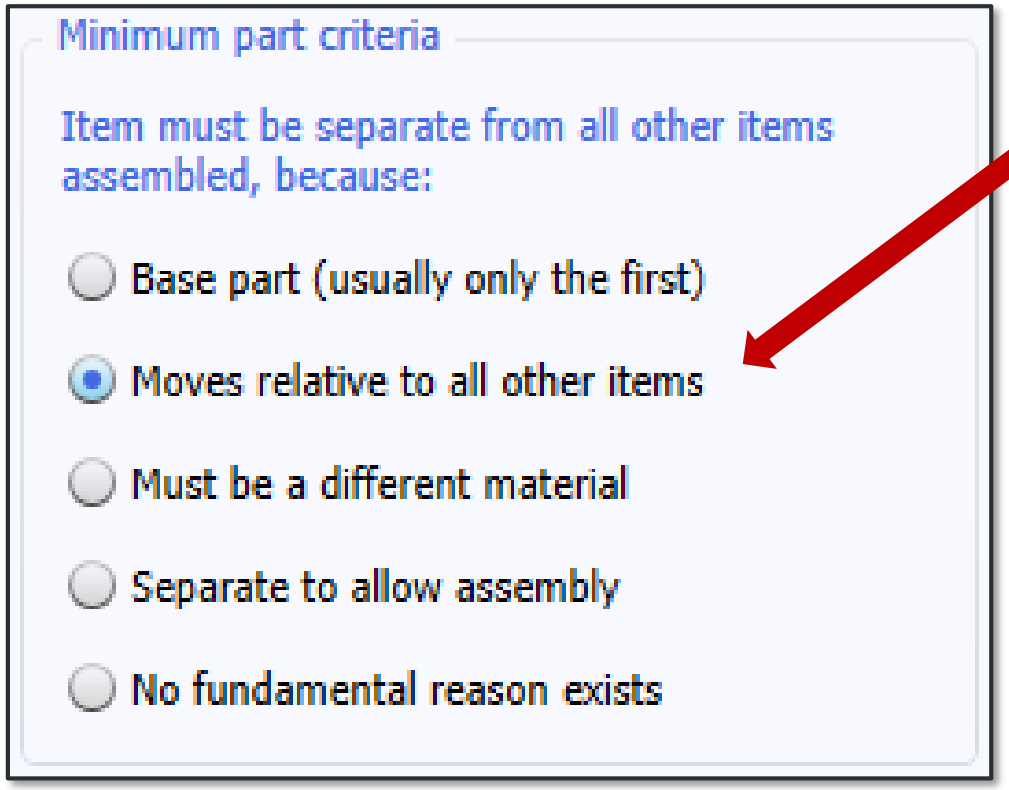
Minimum Part Criteria



Base Part (only one allowed per assembly):

- Housing
- Chassis
- Base
- Enclosure

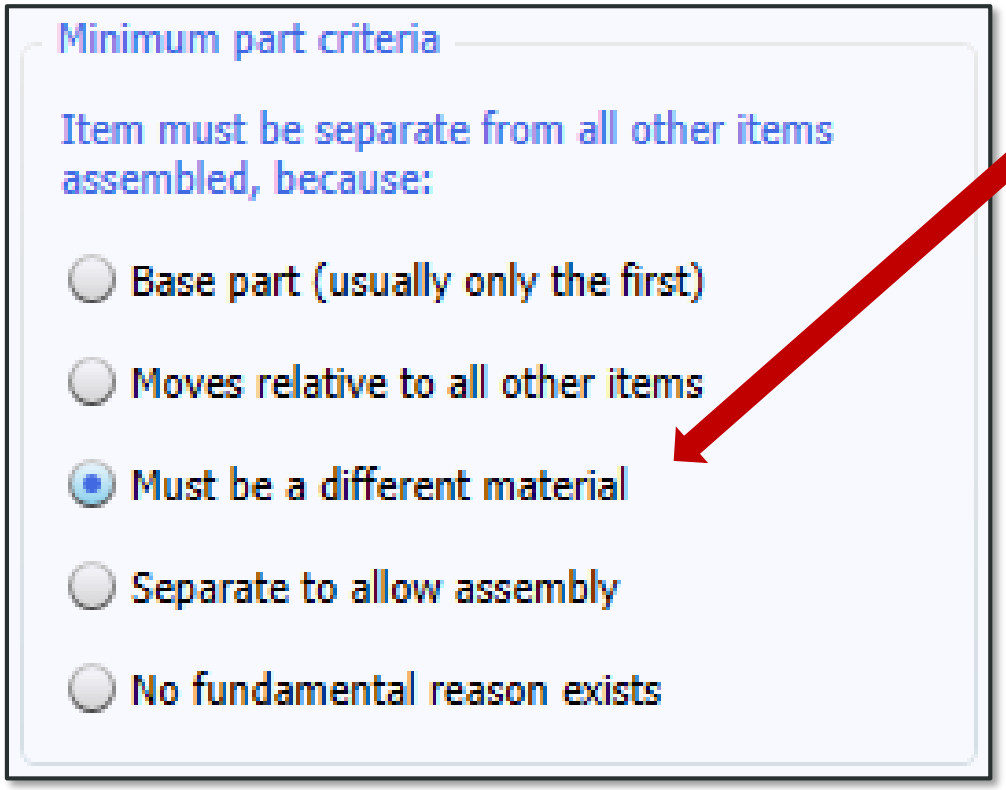
Minimum Part Criteria



<u>Movement</u> (entire part must move):

- Piston
- Faucet or Door Handle
- Wheel
- Propeller

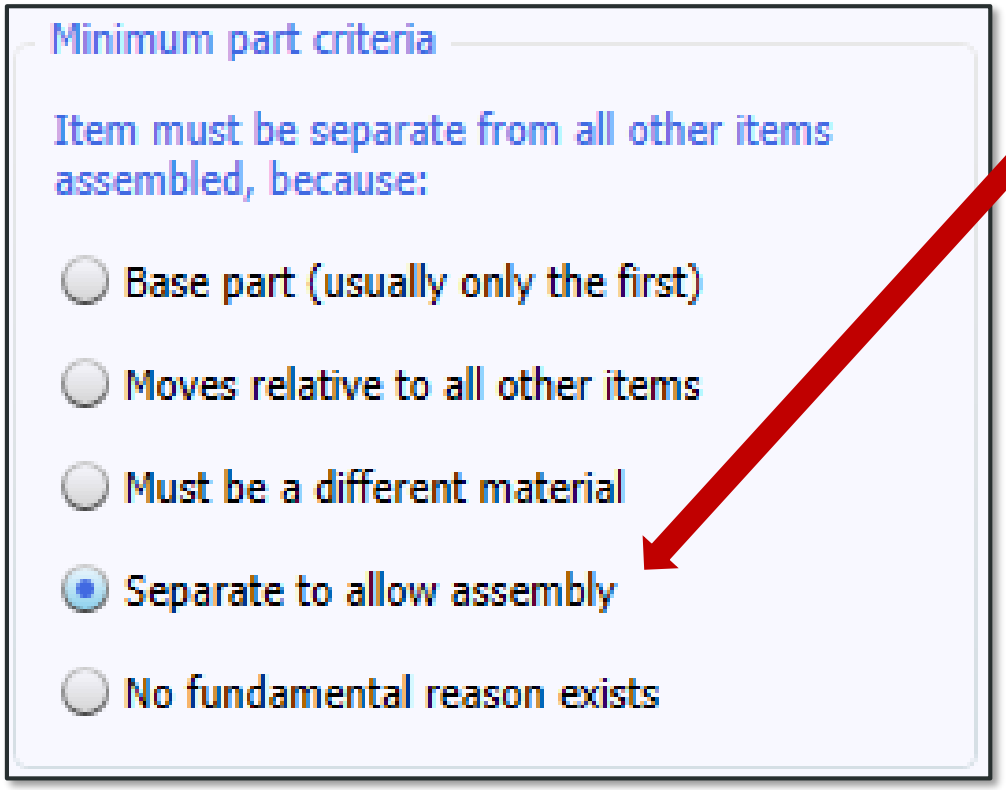
Minimum Part Criteria



Material (different fundamental properties):

- CCA (Circuit Card Assembly)
- Window
- Seal
- Insulator

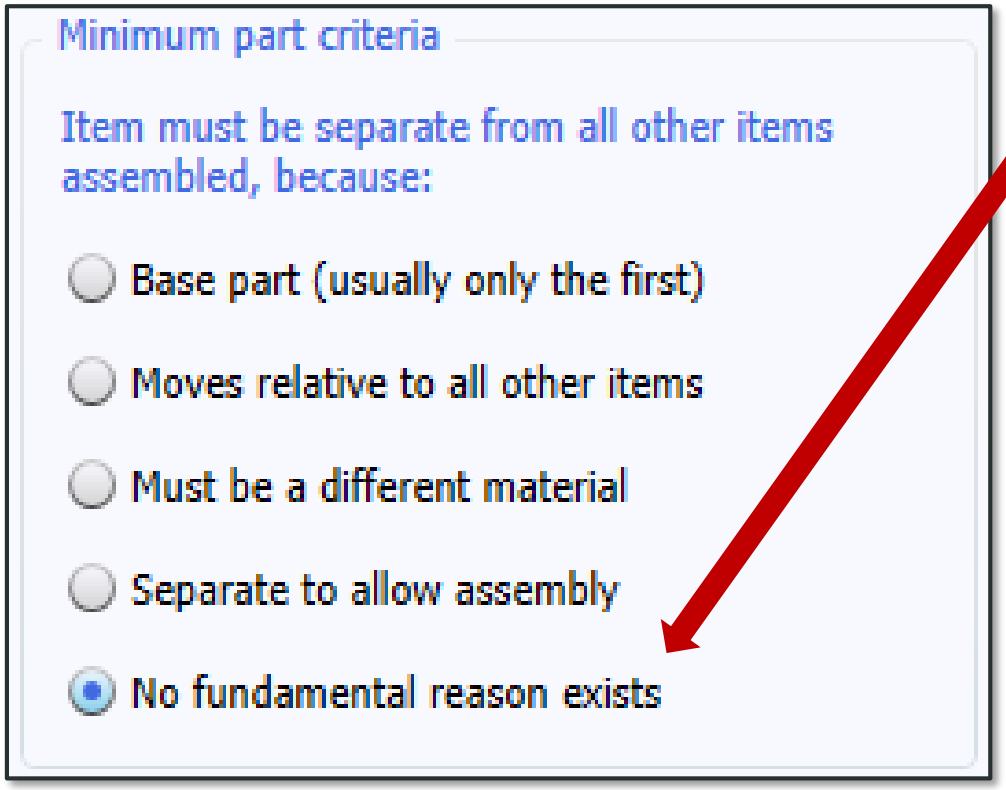
Minimum Part Criteria



Assembly (allow install of previous parts):

- Cover
- Lid
- Cap
- Shield

Minimum Part Criteria

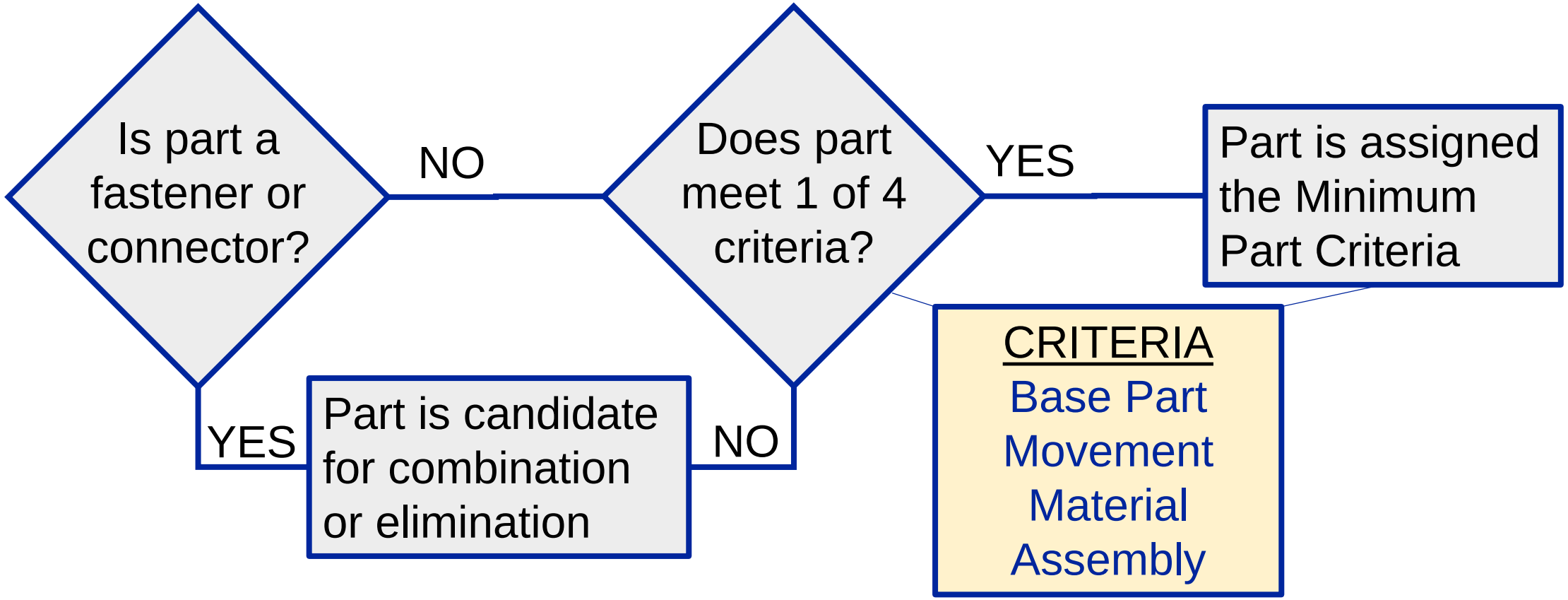


Alternate Definition:

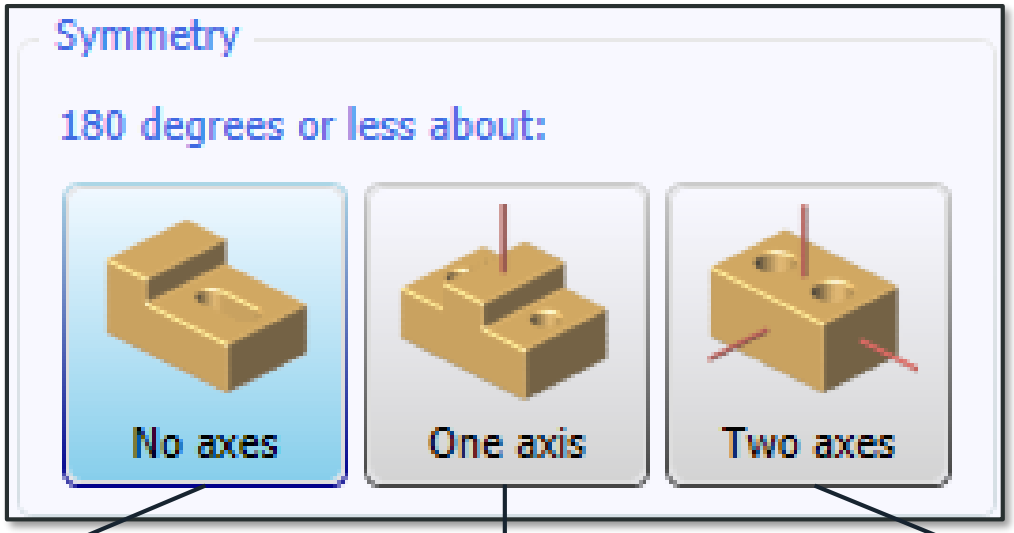
"Doesn't meet any of the criteria"

Minimum Part Criteria

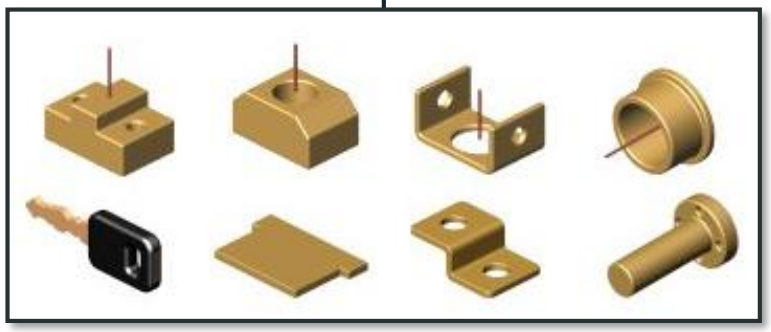
Minimum Part Criteria drives creativity and innovation

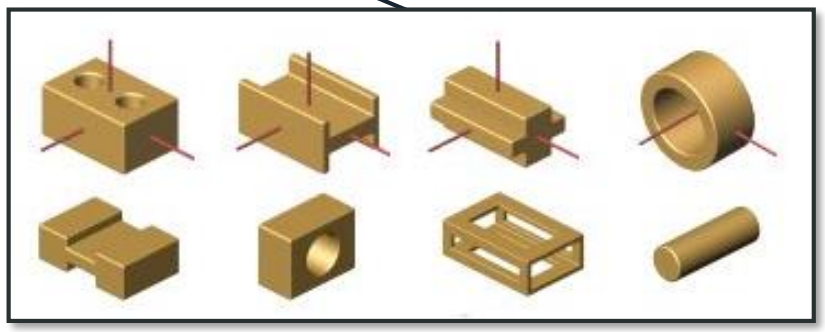


Symmetry



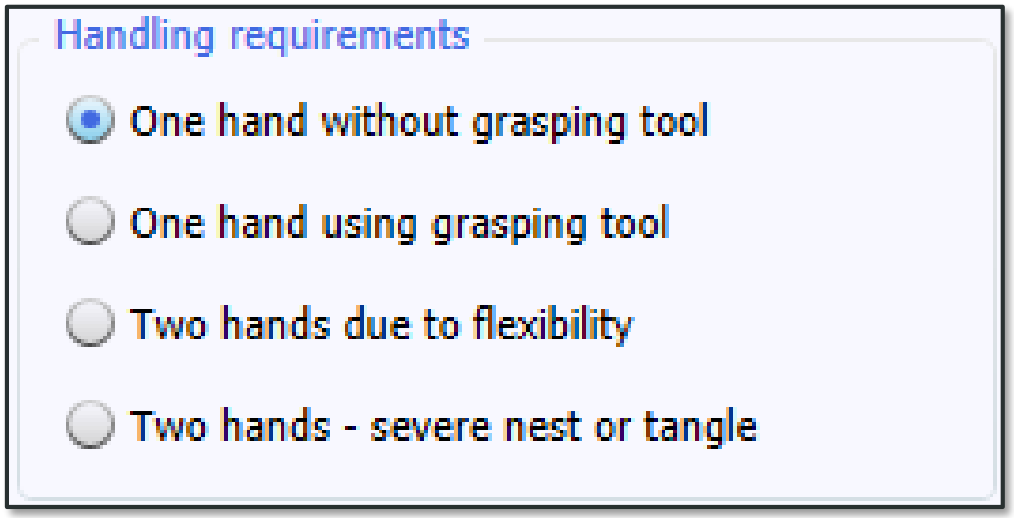
<u>Symmetry</u> applies to handling and insertion of part, not the symmetry of its design

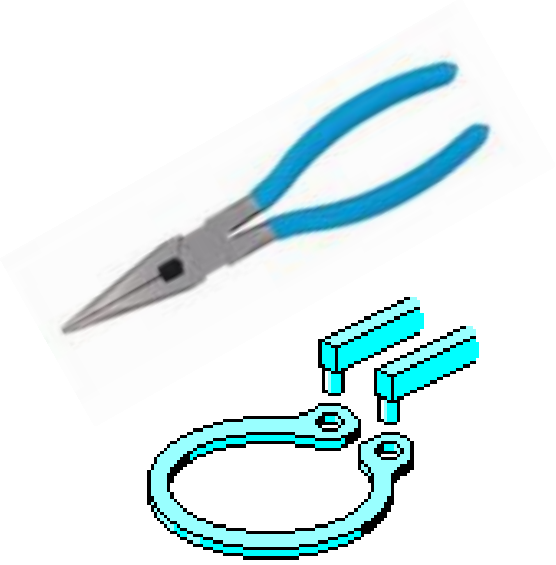




Handling Requirements

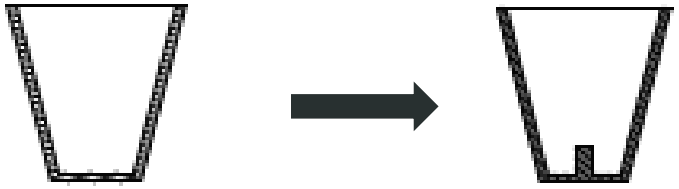
One Hand or Two Hands?





Grasping Tools

Flexible



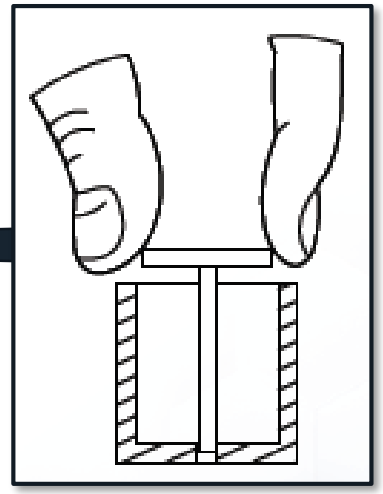
Will Nest Cannot Nest

Will Tangle Cannot Tangle

Handling and Insertion – Two Different Actions

Handling the part is the initial grasping of it

Inserting the part is placing it in the assembly

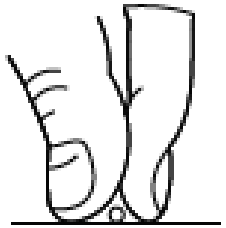


Handling Difficulties

Handling difficulties

- [ ] Nest or tangle
- [ ] Stick together
- [ ] Slips from fingers
- [ ] Requires careful handling

Stick Together



Very Small

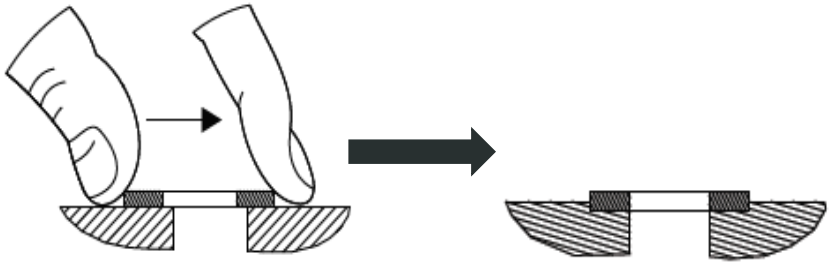
Slippery

Sharp

Insertion Difficulties

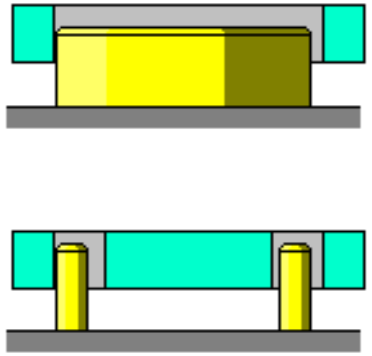
Insertion difficulties

- [ ] Not self-locating
- [ ] Resistance or hang-up
- [ ] Access to mating location obstructed
- [ ] Sight of mating location restricted



Alignment Required

Self-locating

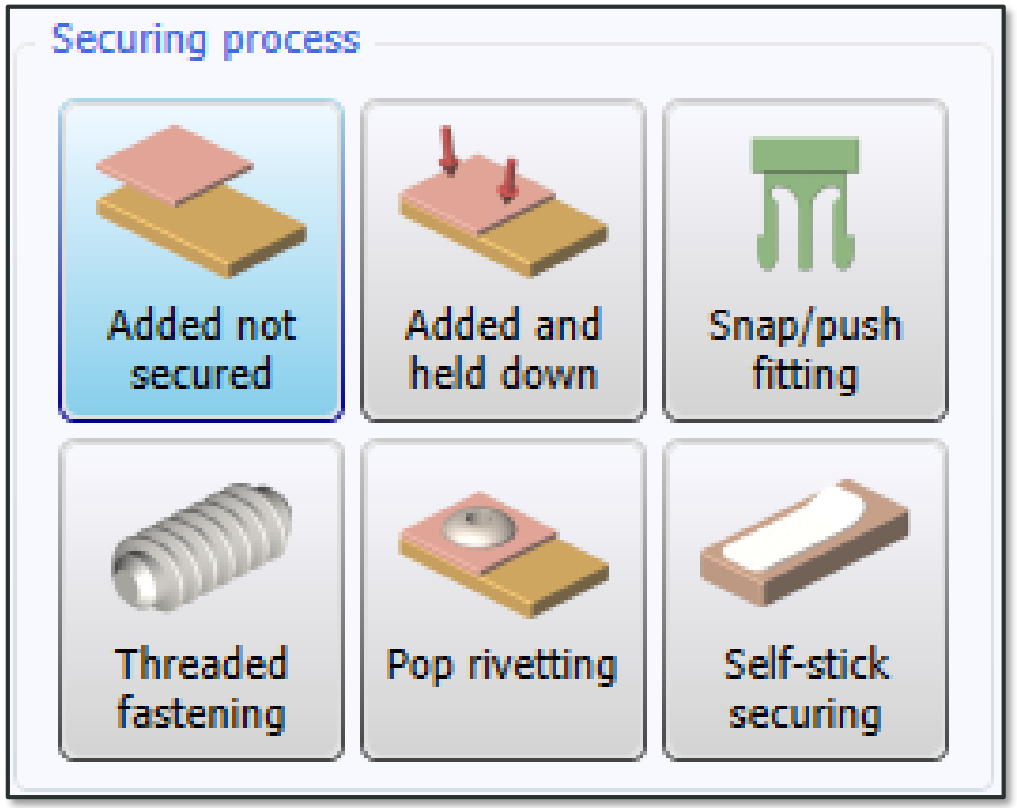


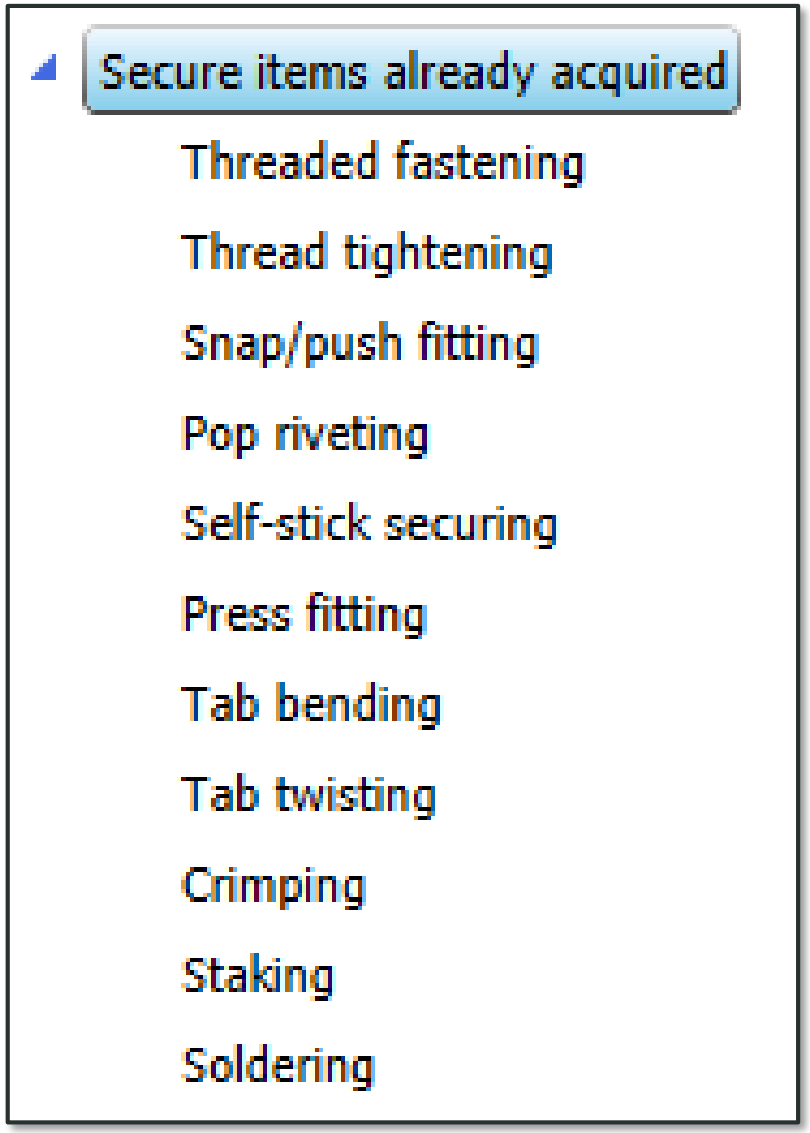
Resistance

Access Obstructed

Sight Restricted

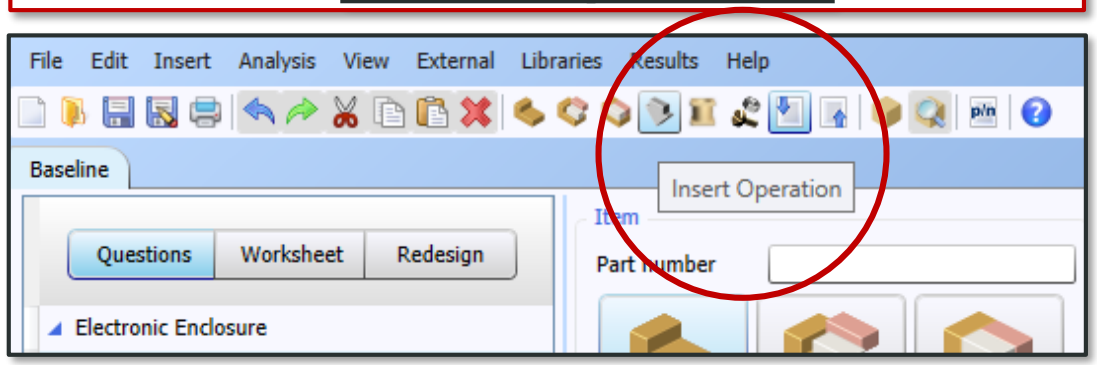
Securing Process



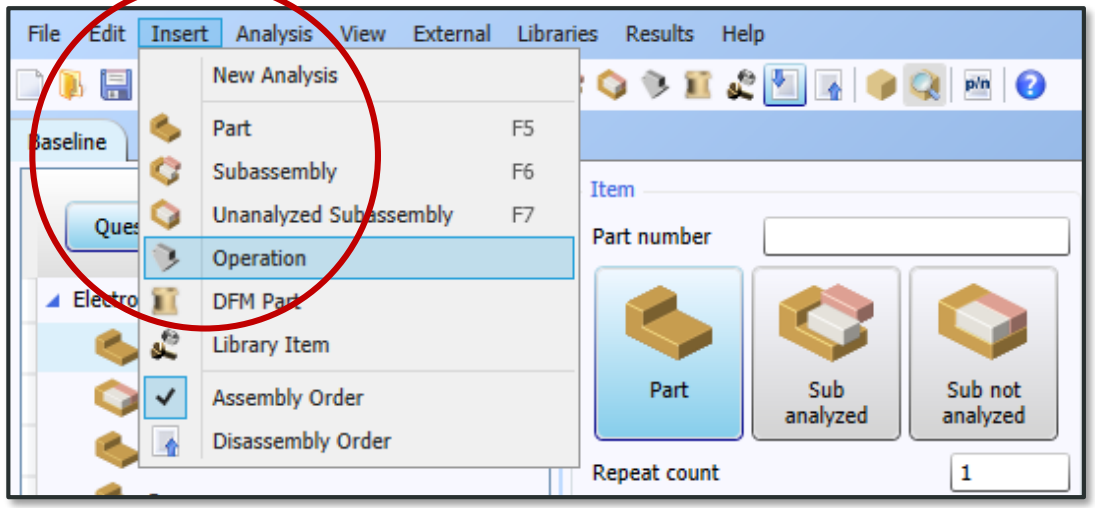


Three Different Methods for Inserting Operations

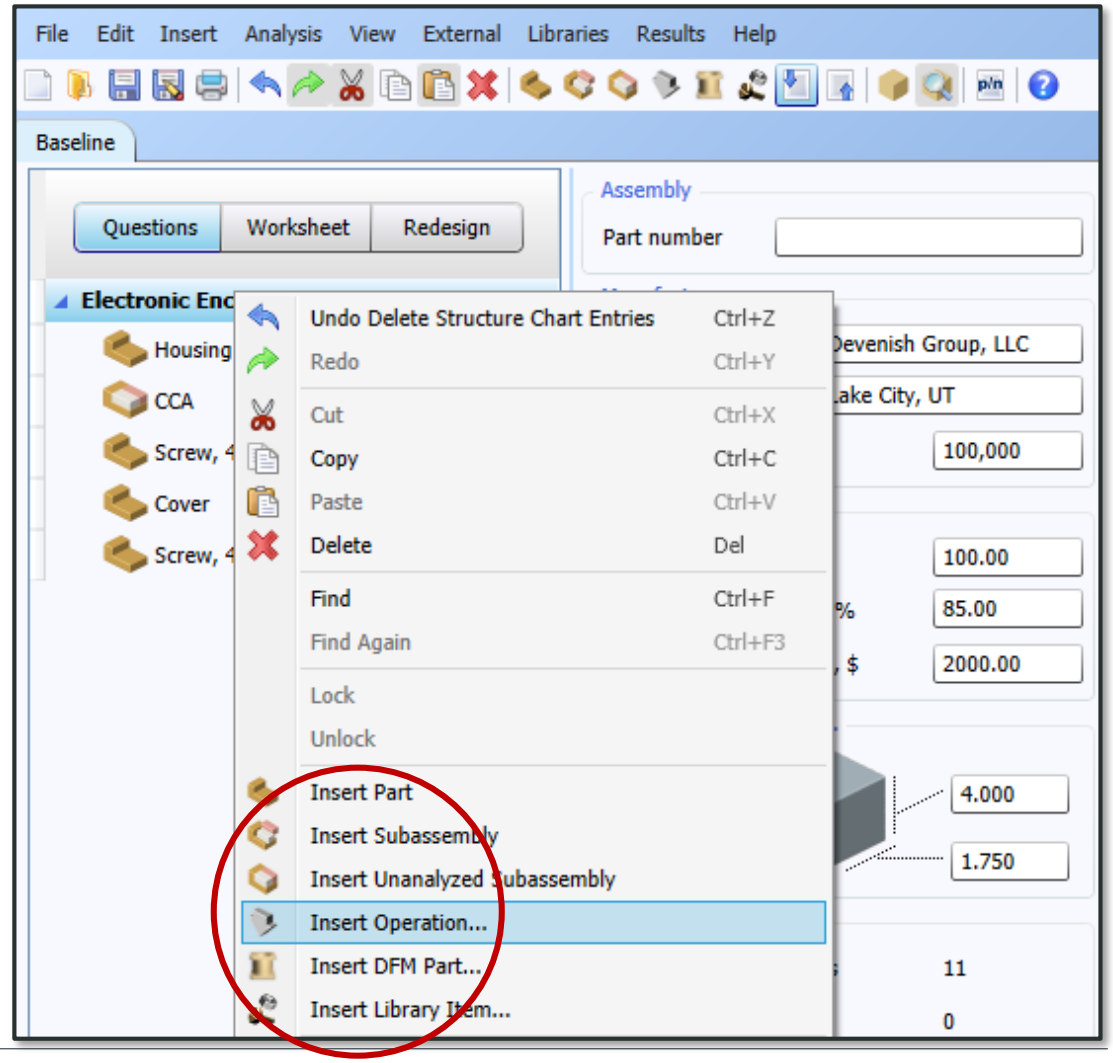
Select **Insert Operation** Icon



Select **Insert Operation** Menu



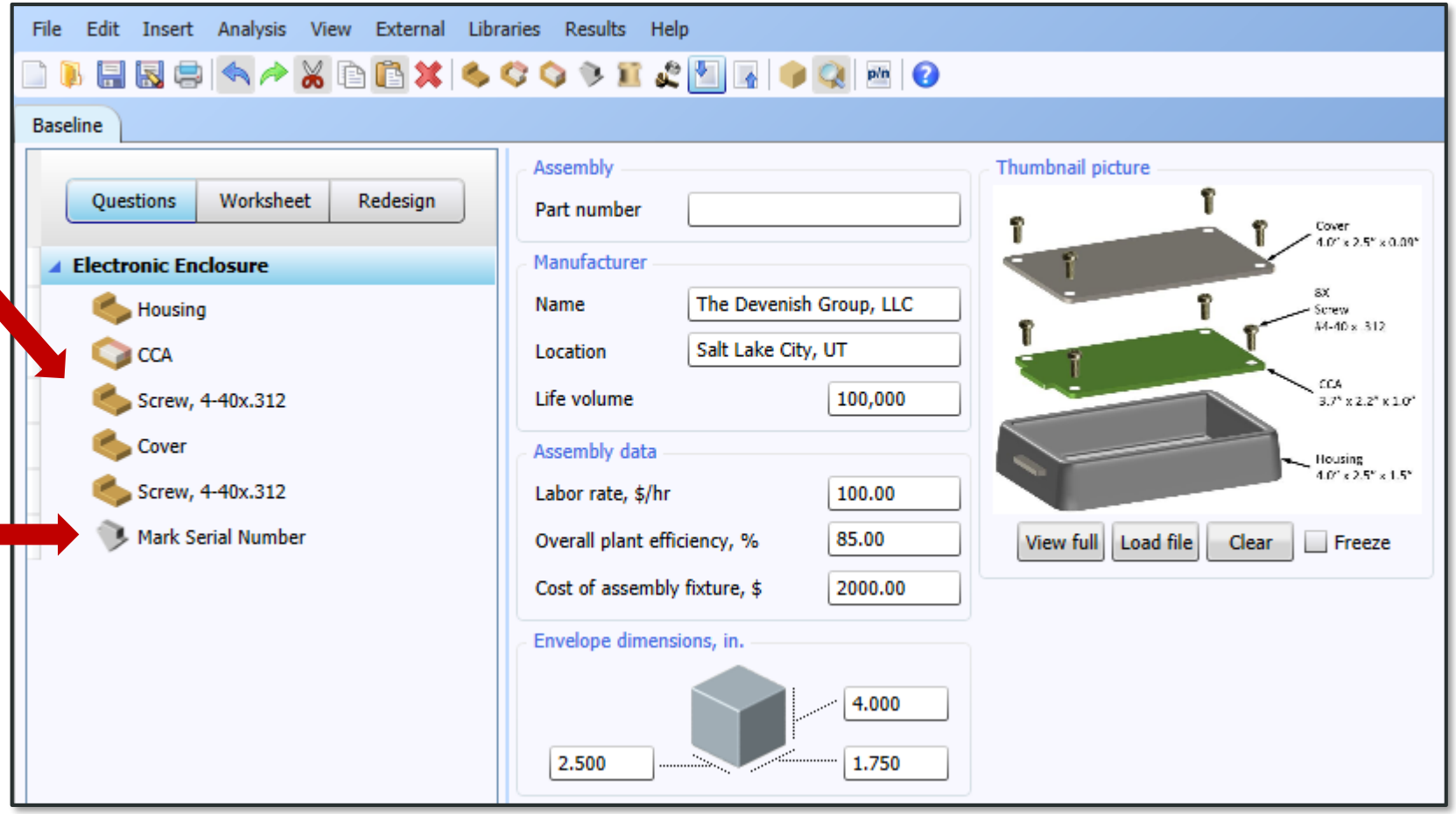
Right Click in Product Chart Area



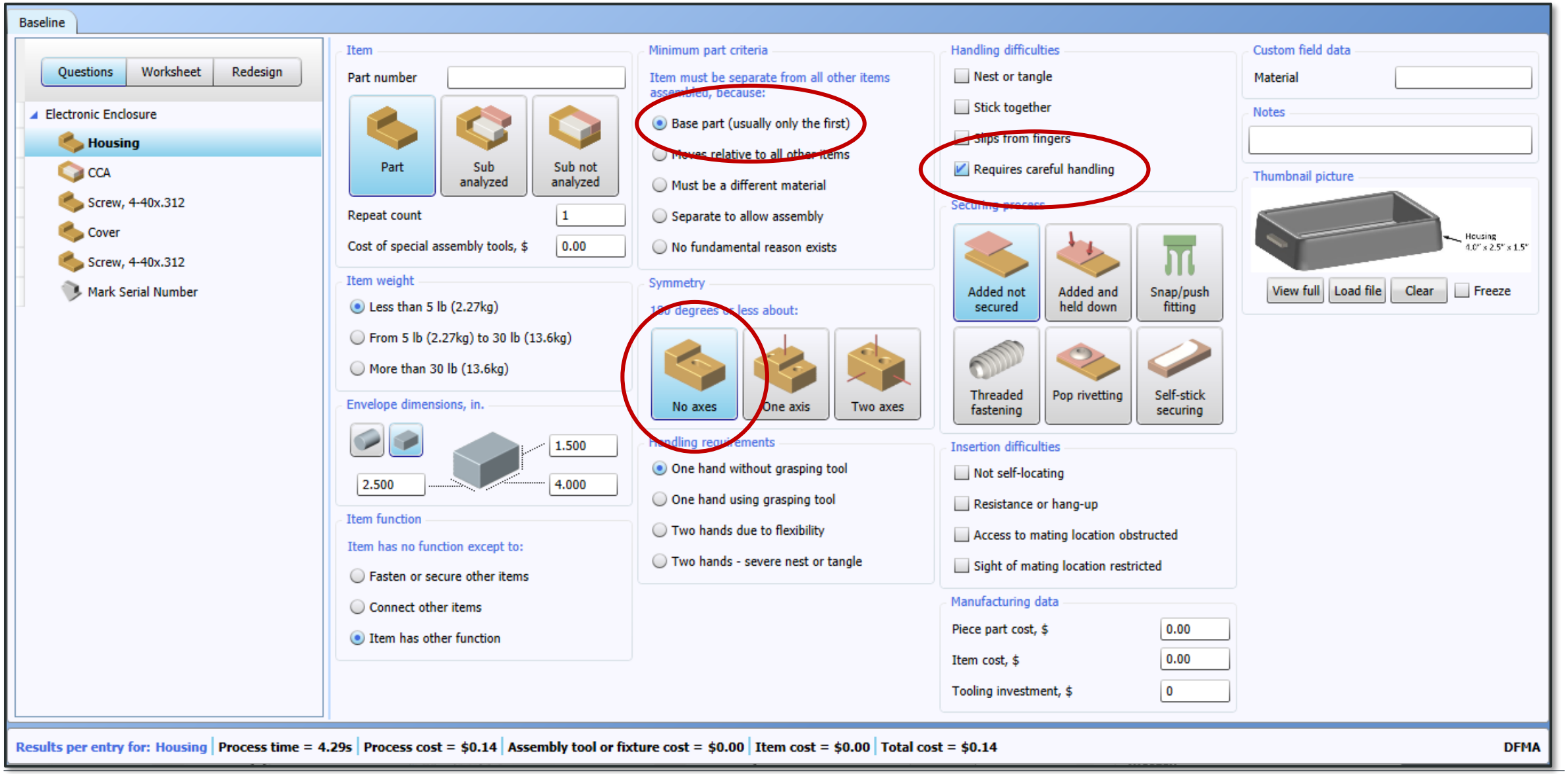
Electronic Enclosure Product Structure with Operation

Parts are listed in order of assembly

Marking operation added



DFA Questions: Housing



DFA Questions: CCA

Baseline

Questions | Worksheet | Redesign

- Electronic Enclosure
  - Housing
  - CCA
  - Screw, 4-40x.312
  - Cover
  - Screw, 4-40x.312
  - Mark Serial Number

Item

Part number

Part | Sub analyzed | Sub not analyzed

Repeat count: 1

Cost of special assembly tools, $: 0.00

Item weight

- Less than 5 lb (2.27kg)
- From 5 lb (2.27kg) to 30 lb (13.6kg)
- More than 30 lb (13.6kg)

Envelope dimensions, in.

1.000 | 2.200 | 3.700

Item function

Item has no function except to:

- Fasten or secure other items
- Connect other items
- Item has other function

Minimum part criteria

Item must be separate from all other items assembled, because:

- Base part (usually only the first)
- Moves relative to all other items
- Must be a different material
- Separate to allow assembly
- No fundamental reason exists

Symmetry

180 degrees or less about:

No axes | One axis | Two axes

Handling requirements

- One hand without grasping tool
- One hand using grasping tool
- Two hands due to flexibility
- Two hands - severe nest or tangle

Handling difficulties

- [ ] Nest or tangle
- [ ] Stick together
- [ ] Slips from fingers
- [x] Requires careful handling

Securing process

Added not secured | Added and held down | Snap/push fitting | Threaded fastening | Pop rivetting | Self-stick securing

Insertion difficulties

- [ ] Not self-locating
- [ ] Resistance or hang-up
- [ ] Access to mating location obstructed
- [ ] Sight of mating location restricted

Manufacturing data

Piece part cost, $: 0.00

Item cost, $: 0.00

Tooling investment, $: 0

Custom field data

Material

Notes

Thumbnail picture

View full | Load file | Clear | Freeze

Results per entry for: CCA | Process time = 4.29s | Process cost = $0.14 | Assembly tool or fixture cost = $0.00 | Item cost = $0.00 | Total cost = $0.14

DFMA

DFA Questions: Cover

Baseline

Questions | Worksheet | Redesign

- Electronic Enclosure
  - Housing
  - CCA
  - Screw, 4-40x.312
  - **Cover**
  - Screw, 4-40x.312
  - Mark Serial Number

Item

Part number

Part | Sub analyzed | Sub not analyzed

Repeat count: 1

Cost of special assembly tools, $: 0.00

Item weight

- Less than 5 lb (2.27kg)
- From 5 lb (2.27kg) to 30 lb (13.6kg)
- More than 30 lb (13.6kg)

Envelope dimensions, in.

2.500 | 0.090 | 4.000

Item function

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Manufacturing data

Piece part cost, $: 0.00

Item cost, $: 0.00

Tooling investment, $: 0

Custom field data

Material

Notes

- Include alignment features on the Cover, Hosuing, or both.

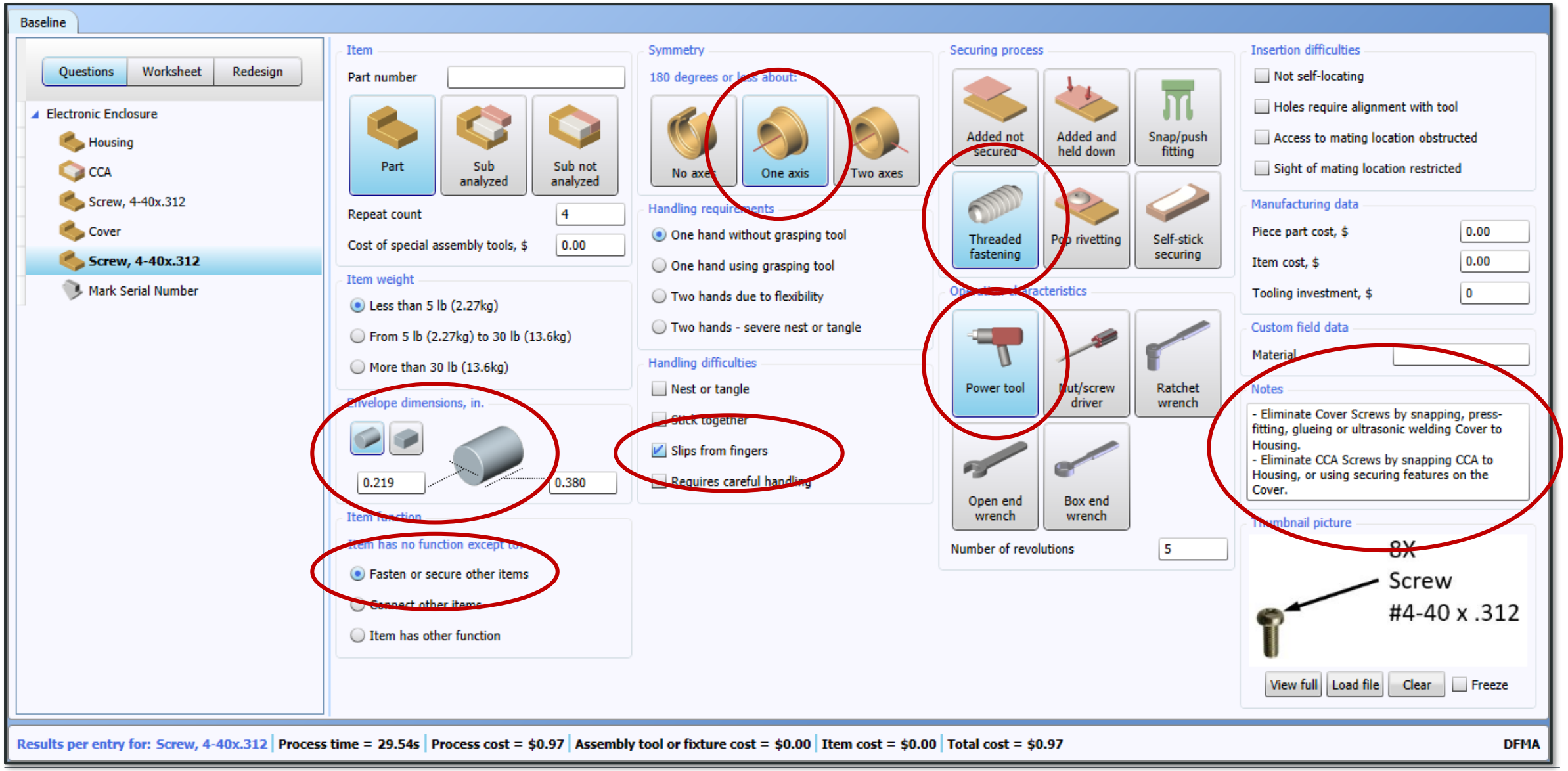
Thumbnail picture

View full | Load file | Clear | Freeze

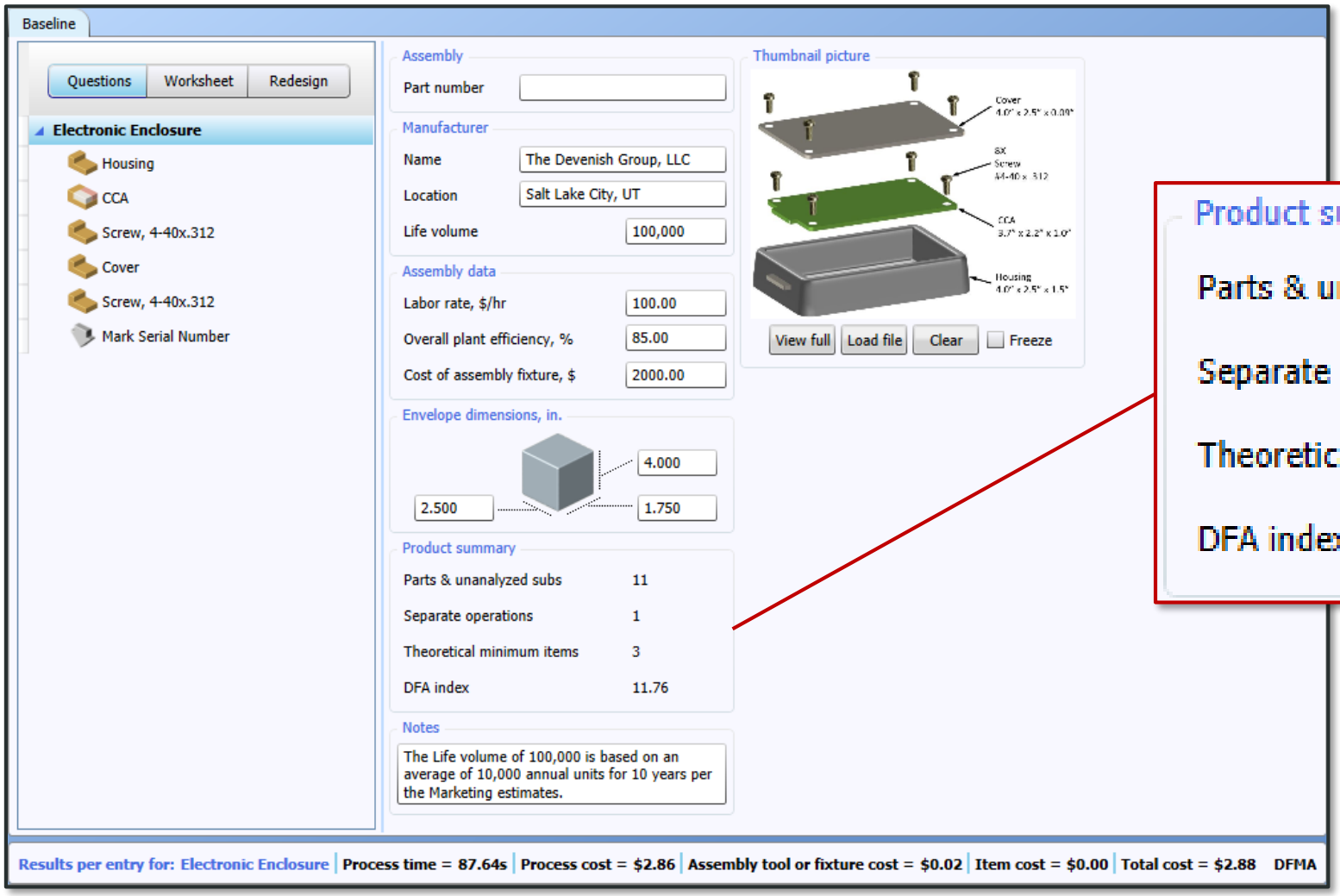
Results per entry for: Cover | Process time = 4.68s | Process cost = $0.15 | Assembly tool or fixture cost = $0.00 | Item cost = $0.00 | Total cost = $0.15

DFMA

DFA Questions: Screws



Product Summary & Results: Electronic Enclosure



Product summary

Parts & unanalyzed subs	11
Separate operations	1
Theoretical minimum items	3
DFA index	11.76

Process time = 87.64s | Process cost = $2.86 | Assembly tool or fixture cost = $0.02 | Item cost = $0.00 | Total cost = $2.88

DFA Index

- The DFA Index is a relative number identifying **“assembly efficiency”** of a proposed design
- **Two main factors** influence the DFA Index
  - Number of parts that meet and don’t meet the Minimum Part Criteria
  - Ease of handling, insertion and fastening the parts
- The DFA Index provides a comparative metric using a scale of 0-100

$$\text{DFA Index} = \frac{\text{Ideal Assy Time}}{\text{Actual Assy Time}} \times 100$$

Source: Product Design for Manufacture and Assembly (2002, p.93)

Redesign Ideas

File Edit Insert Analysis View External Libraries Results Help

Baseline

Questions | Worksheet | Redesign

Part number	Repeat count	Total count	Minimum items	Minimum part criteria	Process time per product, s	Notes
Electronic Enclosure		12	3		87.64	The Life volume of 100,000 is based on an average of 10,000 annual units for 10 years per the Marketing estimates.
Housing	1	1	1	Base part	4.29	
CCA	1	1	1	Different material	4.29	
Screw, 4-40x.312	4	4	0	Fastener	29.54	
Cover	1	1	1	Assembly	4.68	- Include alignment features on the Cover, Hosuing, or both.
Screw, 4-40x.312	4	4	0	Fastener	29.54	- Eliminate Cover Screws by snapping, press-fitting, glueing or ultrasonic welding Cover to Housing. - Eliminate CCA Screws by snapping CCA to Housing, or using securing features on the Cover.
Mark Serial Number	1	1			15.30	

Suggestions for redesign

Category 1

- (●) Candidates for elimination other than fasteners and connectors

Category 2

- ( ) Fasteners
- ( ) Connectors
- ( ) Separate operations

Category 3

- ( ) Handling or insertion difficulties

Try to eliminate the highlighted parts by combining parts or incorporating features into other parts that serve the required function. These suggestions will typically result in the largest improvements in your product design because any associated fasteners, connectors, and joining operations will be eliminated when the separate part is eliminated. These suggestions should have the highest priority and should always be considered before continuing on to Category 2 and 3 suggestions.

Product summary

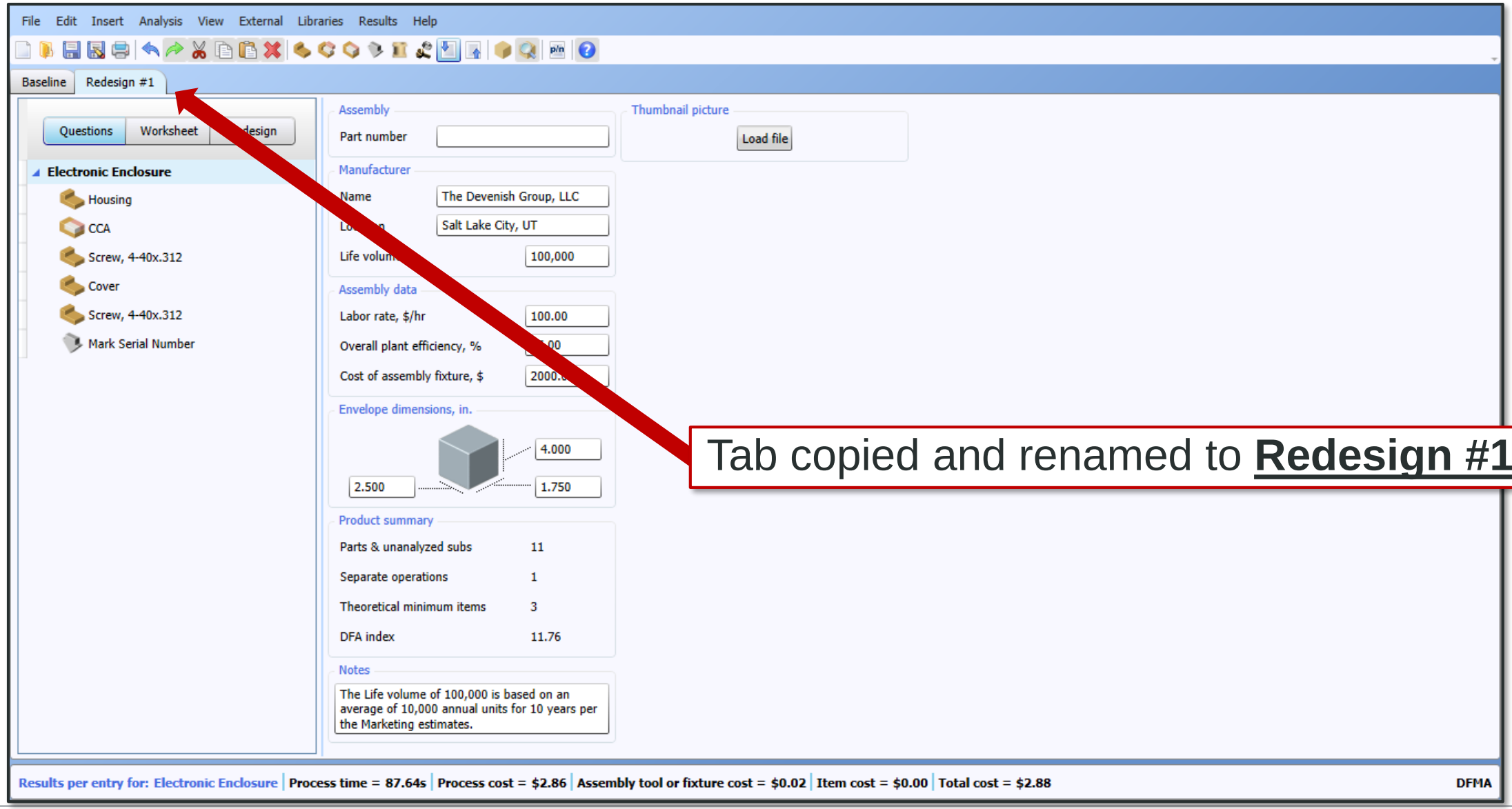
Parts & unanalyzed subs	11
Separate operations	1
Theoretical minimum items	3
DFA index	11.76

- Add alignment features to Cover, Housing, or both **(Redesign #1 & #2)**
- Eliminate Cover Screws by snapping, press-fitting, gluing or ultrasonic welding Cover to Housing **(Redesign #1)**
- Eliminate CCA Screws by snapping CCA to Housing, or using securing features on the Cover **(Redesign #2)**

Total process time per product for selected entries = 87.64s

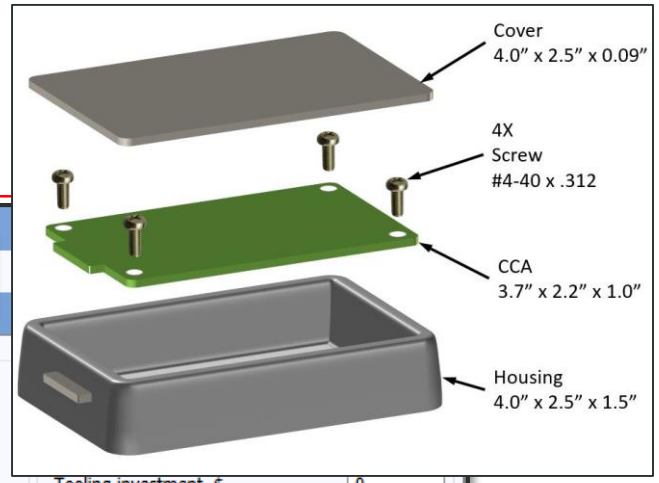
DFMA

Copy, Paste, and Rename New Analysis Tab



Tab copied and renamed to **Redesign #1**

Redesign #1 Changes



Cover changes

Deleted Cover Screws

Added notes about addition of alignment and snap features to the Cover

File Edit Insert Analysis View External Libraries Results Help

Baseline | Redesign #1

Questions | Worksheet | Redesign

Electronic Enclosure
- Housing
- CCA
- Screw, 4-40x.312
- Cover
- Mark Serial Number

Item
Part number
Part | Sub analyzed | Sub not analyzed
Repeat count 1
Cost of special assembly tools, $ 0.00

Item weight
- Less than 5 lb (2.27kg)
- From 5 lb (2.27kg) to 30 lb (13.6kg)
- More than 30 lb (13.6kg)

Envelope dimensions, in.
0.350
2.500
4.000

Item function
Item has no function except to:
- or secure other items
- ct other items
- Item has other function

Minimum part criteria
Item must be separate from other items assembled, because:
- Base part (usually on the first)
- Moves relative to other items
- Must be a different material
- Separate allow assembly
- No fundamental reason exists

Symmetry
180 degrees less about:
No axes | One axis | Two axes

Handling requirements
- One hand without grasping tool
- One hand using grasping tool
- Two hands due to flexibility
- Two hands - severe nest or tangle

Handling difficulties
- Nest or tangle
- Stick together
- Slips from fingers
- Requires careful handling

Securing procedure
Added not secured | Added and held down | Snap/push fitting
Threaded fastening | Pop rivetting | Self-stick securing

Operation characteristics
Number of snap/push fit sites 1

Insertion difficulties
- Not self-locating
- Access to mating location obstructed
- Sight of mating location

Tooling investment, $ 0

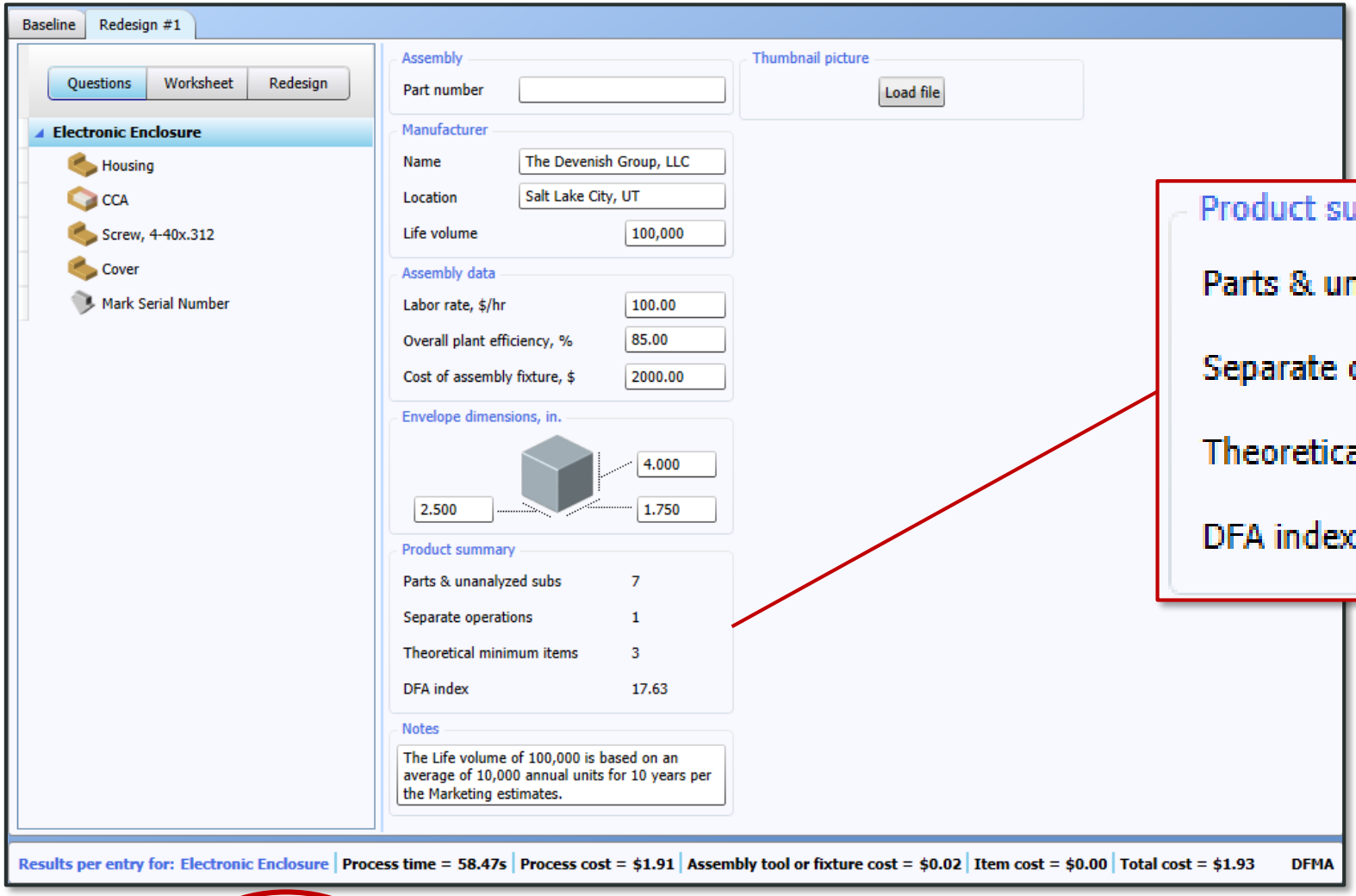
Custom field data
Material

Notes
- Include alignment features have been added to the Cover.
- Snaps have been added to the Cover, eliminating the Screws.

Thumbnail picture
View full | Load file | Clear | Freeze

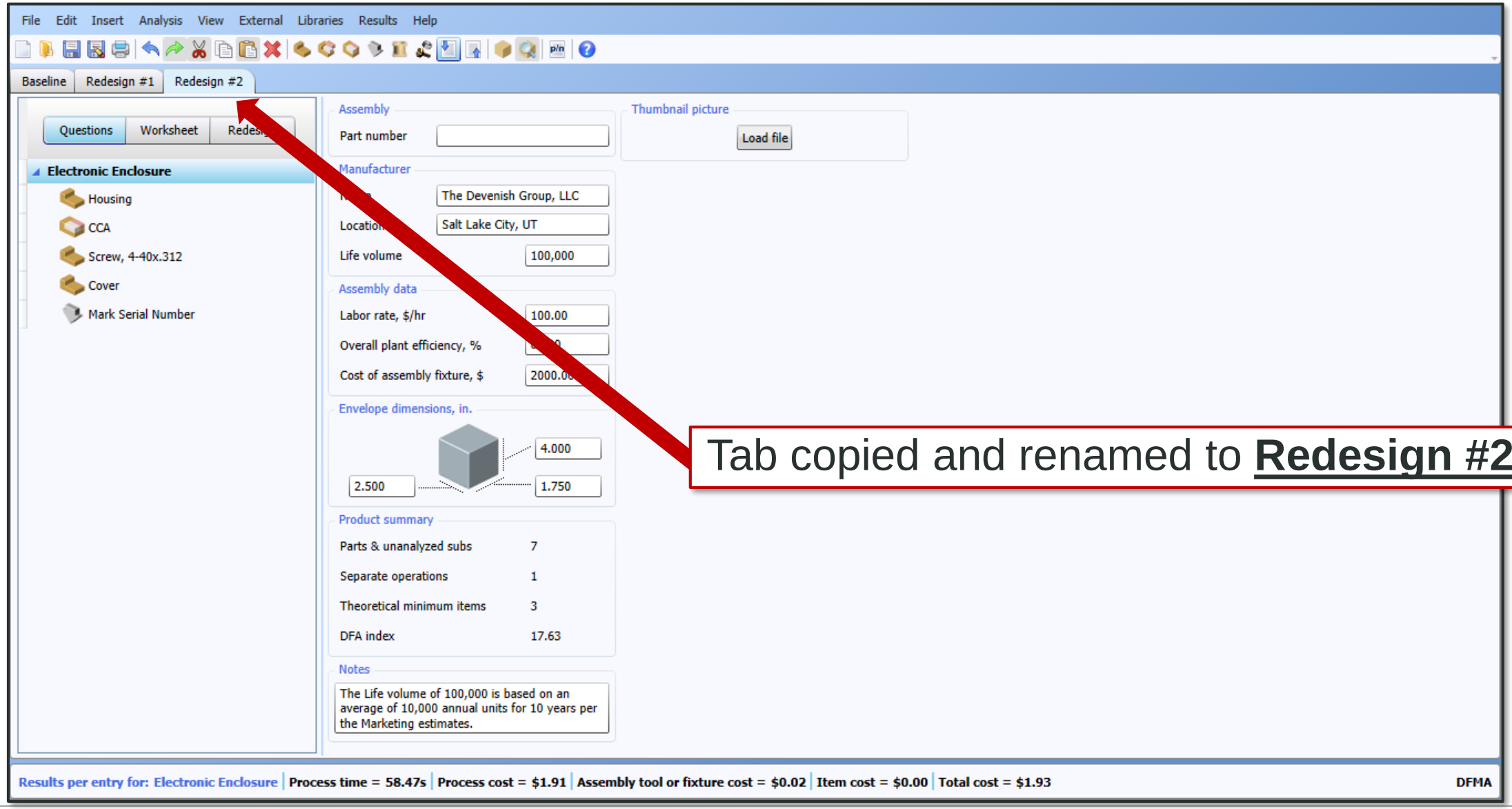
Results per entry for: Cover | Process time = 5.05s | Process cost = $0.17 | Assembly tool or fixture cost = $0.00 | Item cost = $0.00 | Total cost = $0.17

Product Summary & Results: Redesign #1



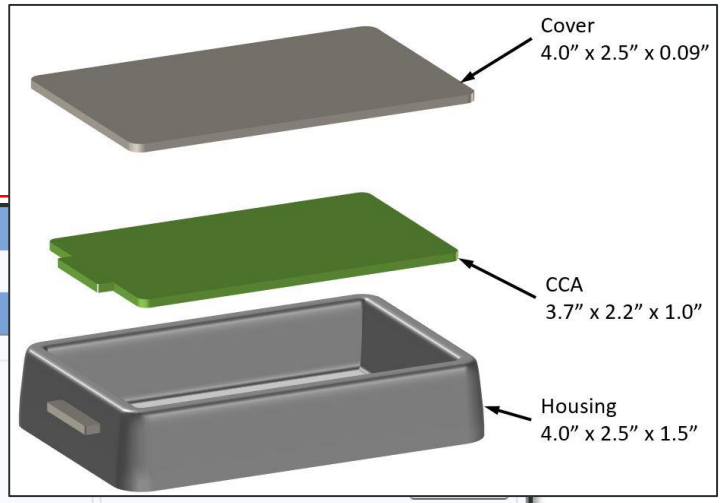
Process time = 58.47s | Process cost = $1.91 | Assembly tool or fixture cost = $0.02 | Item cost = $0.00 | Total cost = $1.93

Copy, Paste, and Rename Redesign #1 to Redesign #2



Tab copied and renamed to **Redesign #2**

Redesign #2 Changes



File Edit Insert Analysis View External Libraries Results Help

Baseline | Redesign #1 | Redesign #2

Questions | Worksheet | Redesign

- Electronic Enclosure
  - Housing
  - CCA
  - Cover
  - Mark Serial Number

Item

Part number

Part | Sub analyzed | Sub not analyzed

Repeat count: 1

Cost of special assembly tools, $: 0.00

Item weight

- Less than 5 lb (2.27kg)
- From 5 lb (2.27kg) to 30 lb (13.6kg)
- More than 30 lb (13.6kg)

Envelope dimensions, in.

1.000 | 2.500 | 4.000

Item function

Item has no function except to:

- ...ten or secure other items
- ...nect other items
- Item has other function

Minimum part criteria

Item must be separate from all other items assembled, because:

- Base part (usually only the first)
- Moves relative to all other items
- Must be a different material
- Separate to allow assembly
- No fundamental reason exists

Symmetry

180 degrees or less about:

No axes | One axis | Two axes

Handling requirements

- One hand without grasping tool
- One hand using grasping tool
- Two hands due to flexibility
- Two hands - severe nest or tangle

Handling difficulties

- Nest or tangle
- Stick together
- Slips from fingers
- Requires careful handling

Securing process

Added not secured | Added and held down | Snap/push fitting | Threaded fastening | Pop rivetting | Self-stick securing

Operation characteristics

Number of snap/push fit sites: 1

Insertion difficulties

- Not self-locating
- Access to mating location obstructed
- Sight of mating location restricted

Custom field data

Material

Notes

- Include alignment features have been added to the Cover.
- Snaps have been added to the Cover, eliminating the Screws.
- Features added to Cover to secure CCA.

Thumbnail picture

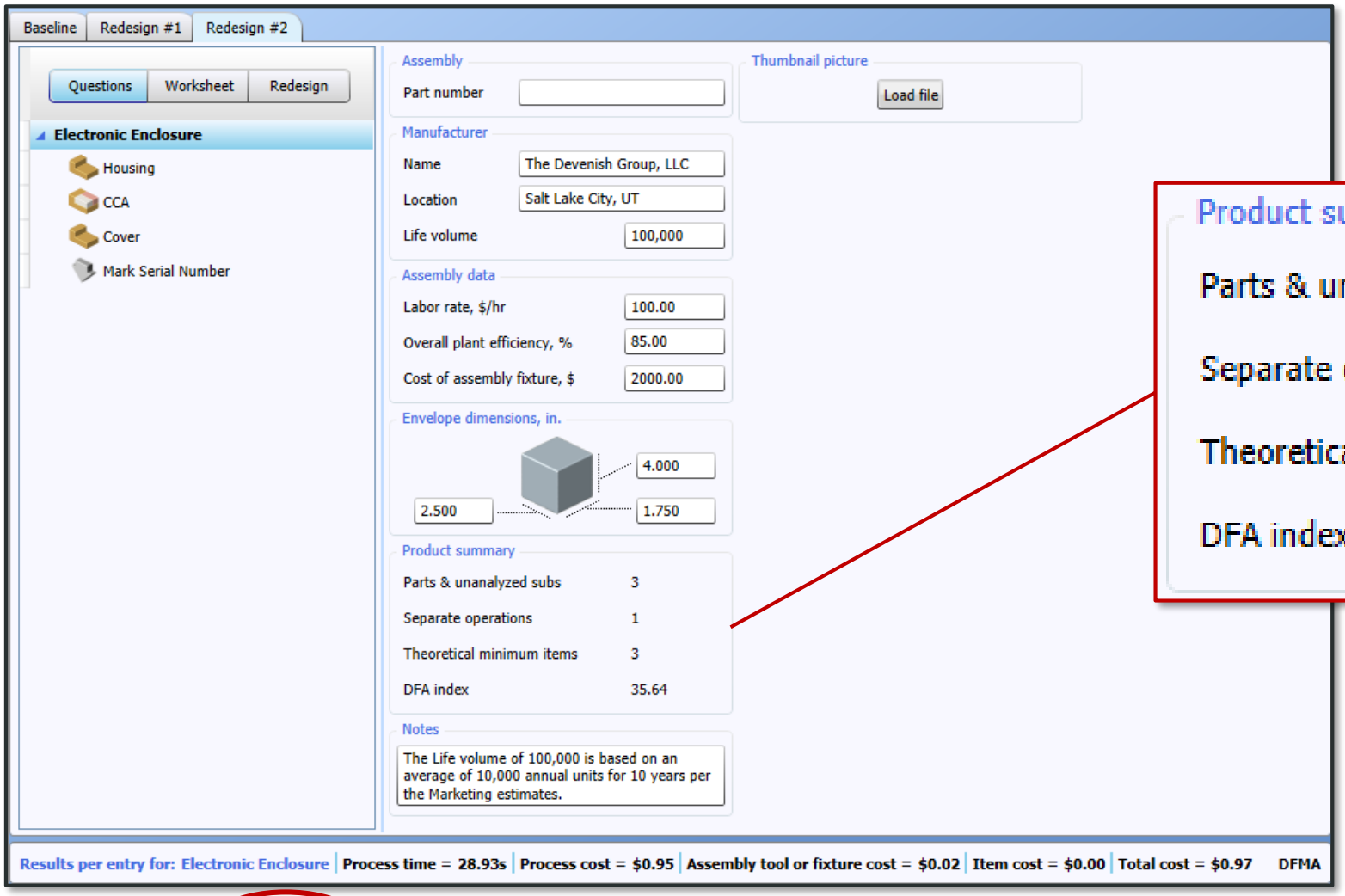
View full | Load | Clear | Freeze

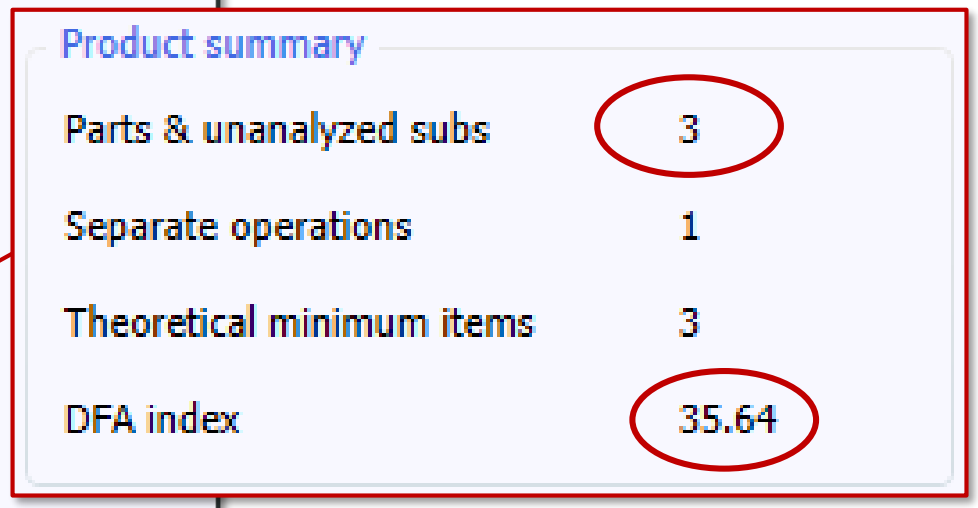
Results per entry for: Cover | Process time = 5.05s | Process cost = $0.17 | Assembly tool or fixture cost = $0.00 | Item cost = $0.00 | Total cost =

Deleted CCA Screws

Added note about CCA securing features added to Cover

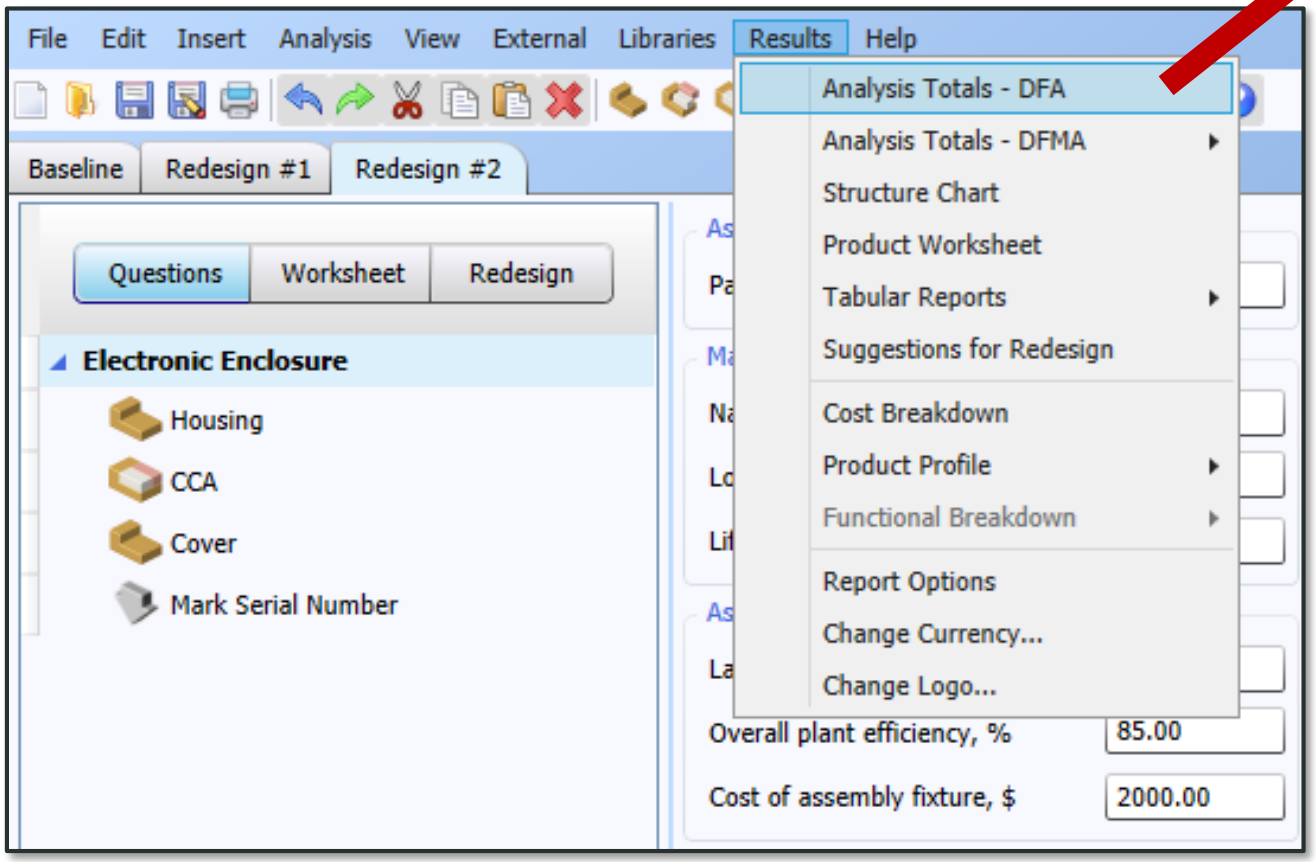
Product Summary & Results: Redesign #2

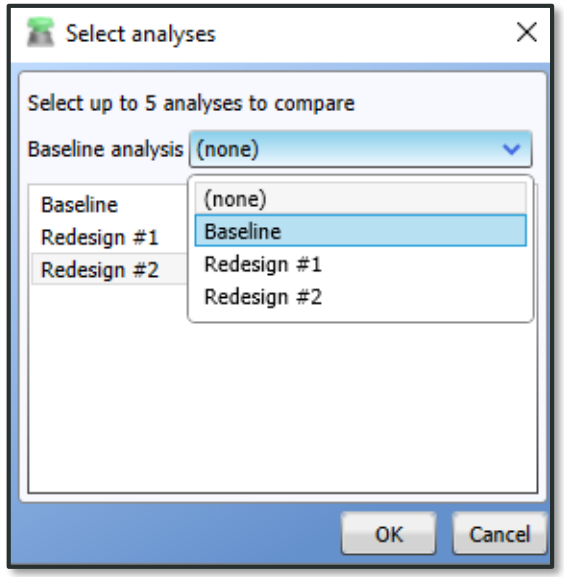


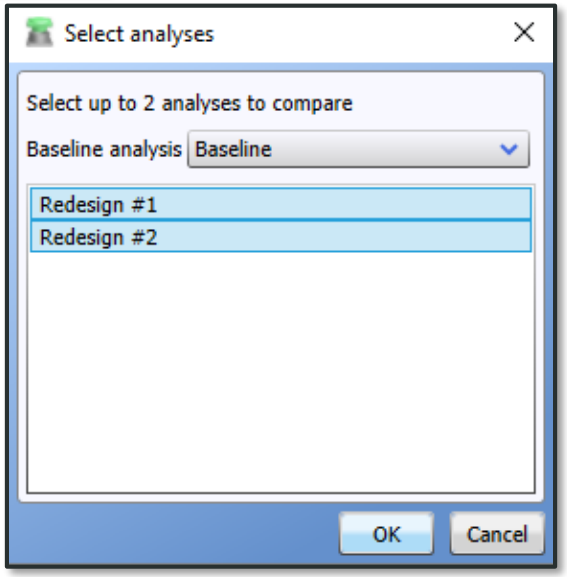


Process time = 28.93s | Process cost = $0.95 | Assembly tool or fixture cost = $0.02 | Item cost = $0.00 | Total cost = $0.97

Generating a DFA Report

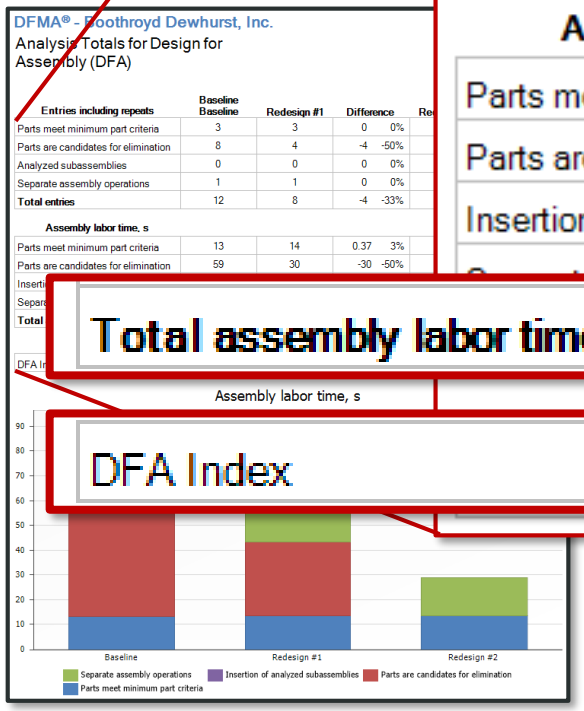






Comparing Results

Entries including repeats	Baseline Baseline	Redesign #1	Difference		Redesign #2	Difference	
Parts meet minimum part criteria	3	3	0	0%	3	0	0%
Analyzed subassemblies	0	0	0	0%	0	0	0%
Separate assembly operations	1	1	0	0%	1	0	0%
Total entries	12	8	-4	-33%	4	-8	-67%
Assembly labor time, s							
Parts meet minimum part criteria	13	14	0.37	3%	14	0.37	3%
Parts are candidates for elimination	59	30	-30	-50%	0	-59	-100%
Insertion of analyzed subassemblies	0	0	0	0%	0	0	0%
Total assembly labor time	88	58.47	-29.17	-33%	28.93	-58.71	-67%
DFA Index	11.76	17.63	6	50%	35.64	24	203%



Next Steps

Determine cost estimates by conducting DFM Concurrent Costing analysis on the alternative Housing and Cover designs

Identify pros, cons and risks for each concept

Estimate resource needs (personnel, equipment, etc.) for each concept

Review the data and select the concept that best meets expectations

Conclusion

With the DFA tool

"…we have the capacity to achieve the impossible."

Eddie Rickenbacker