# FEET Description Updates

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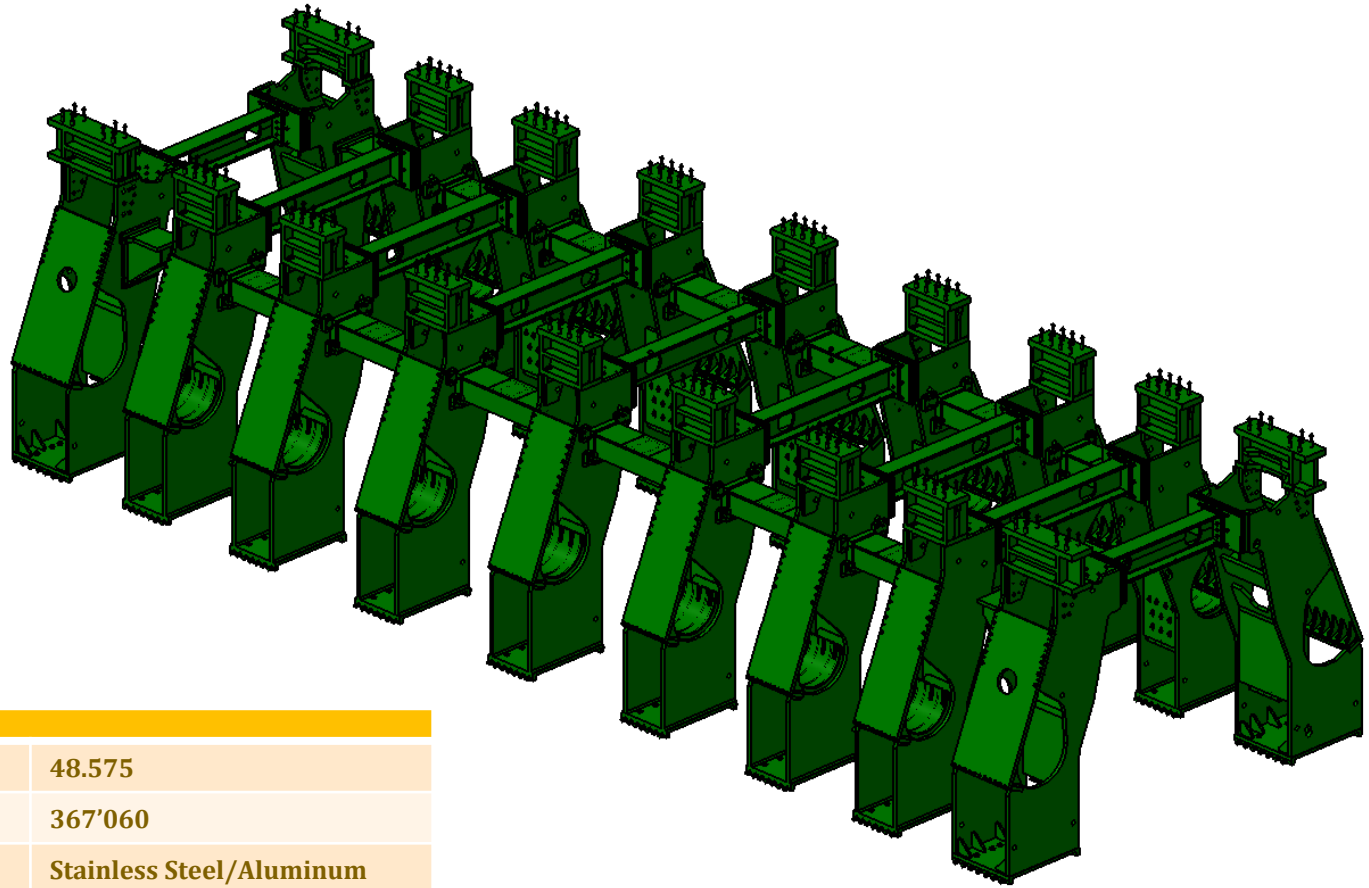
# Phase I.

## Reproduction of Detailed Geometry in CATIA

# Reproduction of Geometry



- 18 CATIA models were downloaded from SmarTeam Engineering database:
  - ST0190539_01
  - ST0195590_01
  - ST0197801_01
  - ST0200626_01
  - ST0203166_01
  - ST0203339_01
  - ST0208364_01
  - ST0208923_01
  - ST0209056_01
  - ST0209745_01
  - ST0204081_01
  - ST0205416_01
  - ST0199450_01
  - ST0193315_01
  - ST0193081_01
  - ST0192829_01
  - ST0191237_01
  - ST0204924_01



| | |
|---|---|
| Volume ($m^3$) | 48.575 |
| Mass (kg) | 367'060 |
| Material | Stainless Steel/Aluminum |
| Density ($kg/m^3$) | 8'000/2'700 |

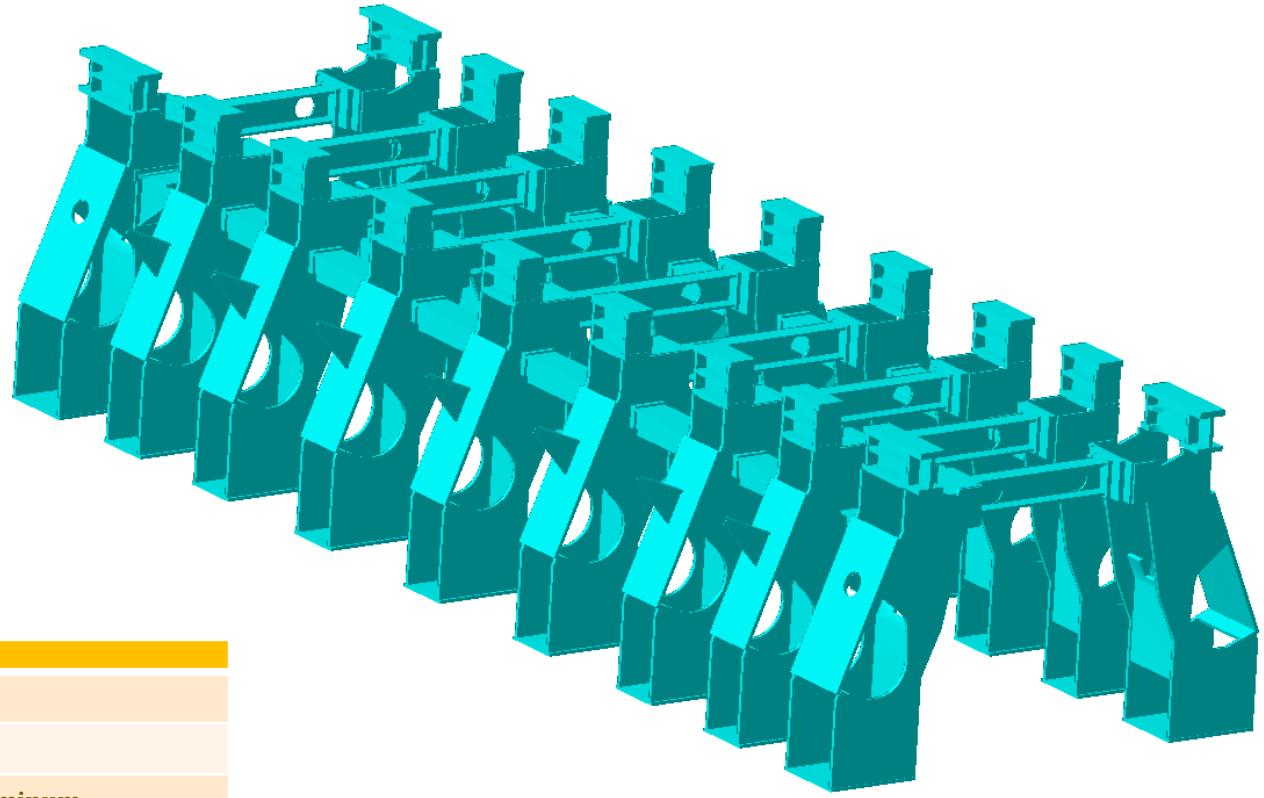
- 63 CDD drawings where added to downloaded geometry

# Phase II.

Compare Analyses of 2 geometries: CATIA vs Geant

# Compare Analyses

- Geant model where migrated from *gdml* to CATIA



499 Volumes

| | |
|---|---|
| Volume ($m^3$) | 43.457 |
| Mass (kg) | 331'307 |
| Material | Iron/Aluminum |
| Density ($kg/m^3$) | 7'870/2700 |

# Compare Analyses



- Whole Geant geometry split into 10 sub volumes for Analyses:

1. Standard Foot
2. Extremity Foot
3. Rail Support
4. Extremity Rail Support
5. Girder
6. Extremity Girder
7. FEET_Standard Strut
8. FEET_Extremity Strut
9. Bolts
10. Slanted ConnPlate Bracket

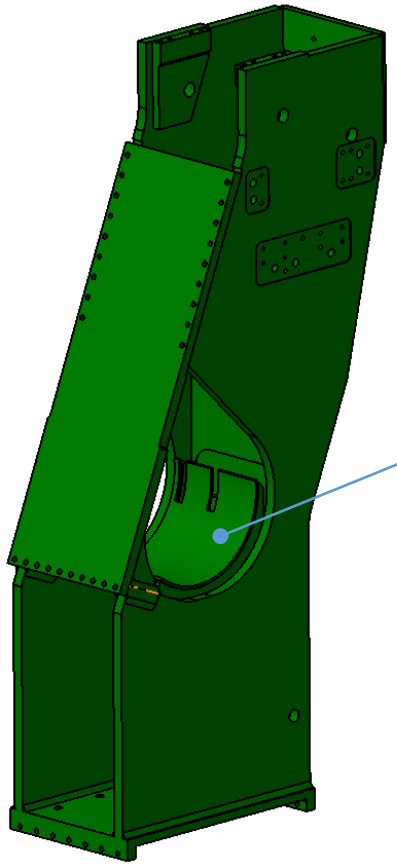
# CATIA vs GEANT: Standard Foot



Inner Part is missing in Geant

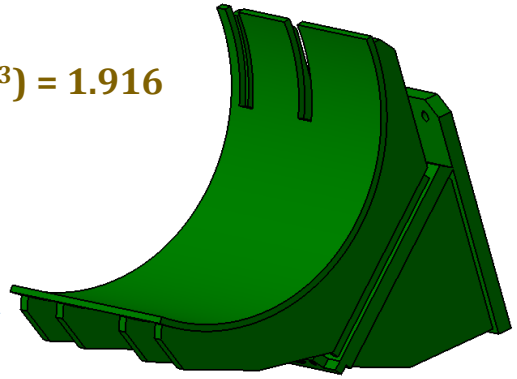
CATIA

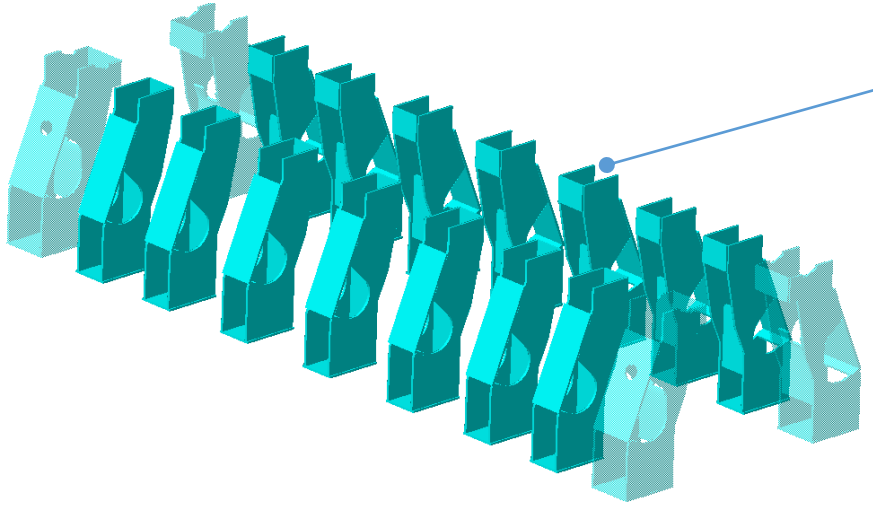
14x



| | |
|---|---|
| Volume ($m^3$) | 26.656 |
| Mass (kg) | 213'248 |
| Material | Stainless Steel |
| Density ($kg/m^3$) | 8'000 |

Vol. ($m^3$) = 1.916

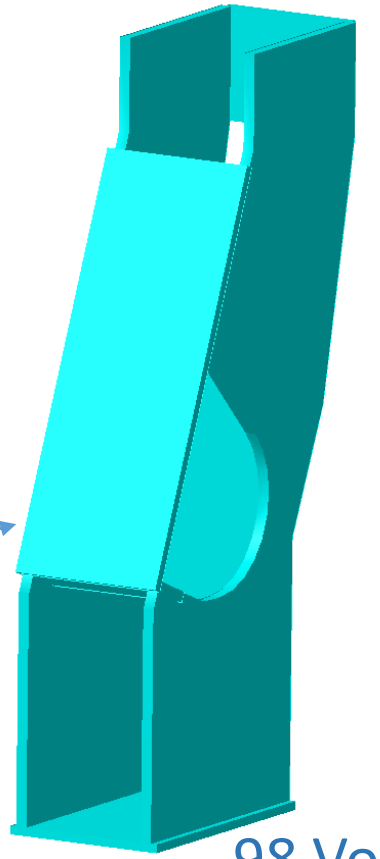




Diff: -26'847 Kg

GEANT

14x



98 Volumes

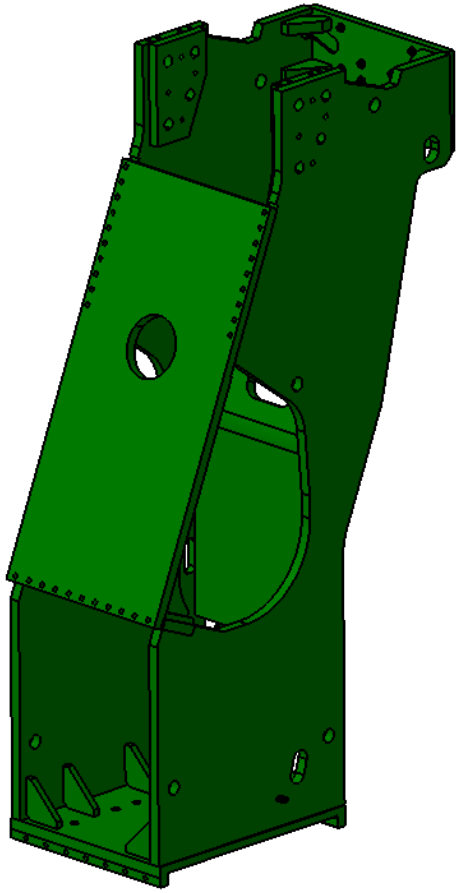
| | |
|---|---|
| Volume ($m^3$) | 23.685 |
| Mass (kg) | 186'401 |
| Material | Iron |
| Density ($kg/m^3$) | 7'870 |

# CATIA vs GEANT: Extremity Foot

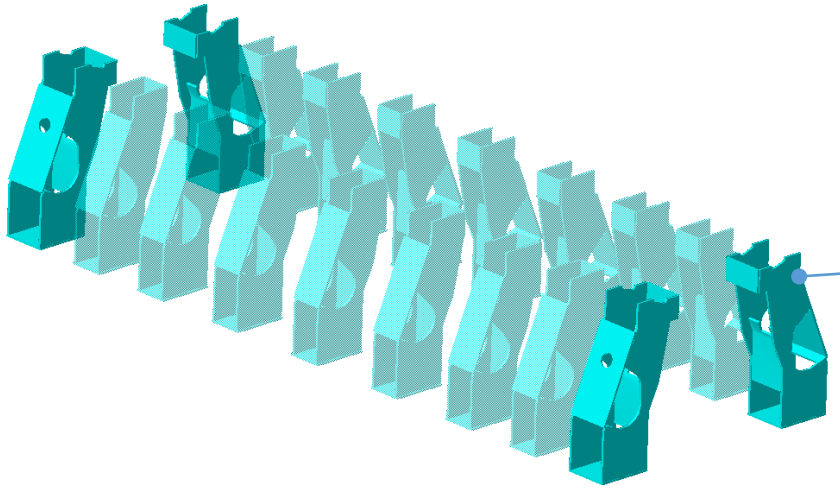


CATIA

4x



| | |
|---|---|
| Volume ($m^3$) | 8.358 |
| Mass (kg) | 66'864 |
| Material | Stainless Steel |
| Density ($kg/m^3$) | 8'000 |

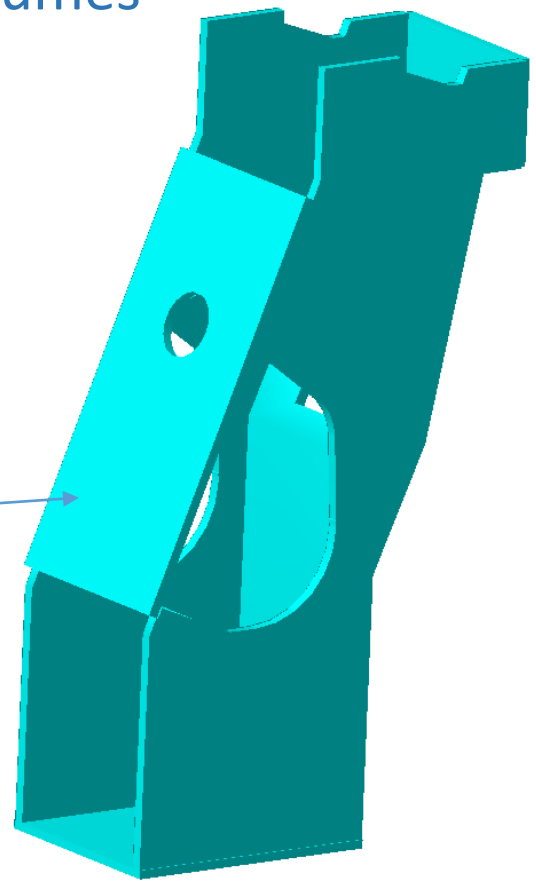


**Diff: -8'217 Kg**

GEANT

28 Volumes

4x

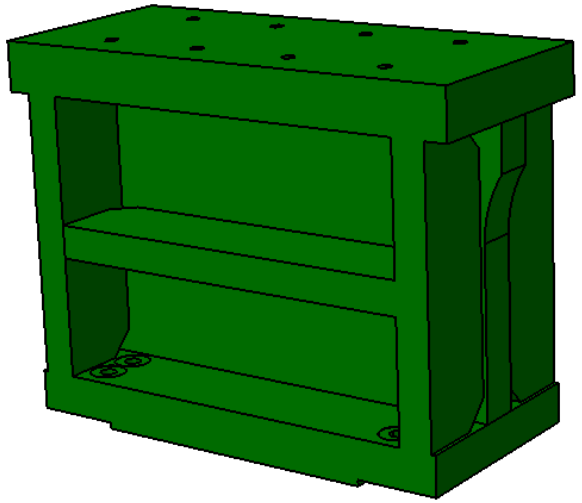


| | |
|---|---|
| Volume ($m^3$) | 7.452 |
| Mass (kg) | 58'647 |
| Material | Iron |
| Density ($kg/m^3$) | 7'870 |

# CATIA vs GEANT: Rail Support

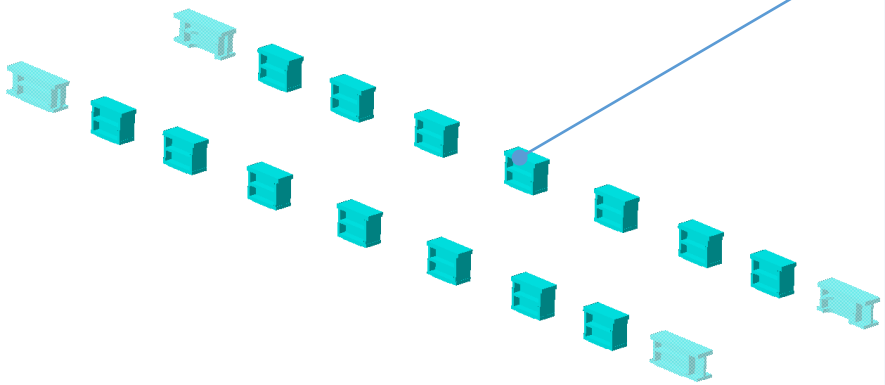


CATIA



14x

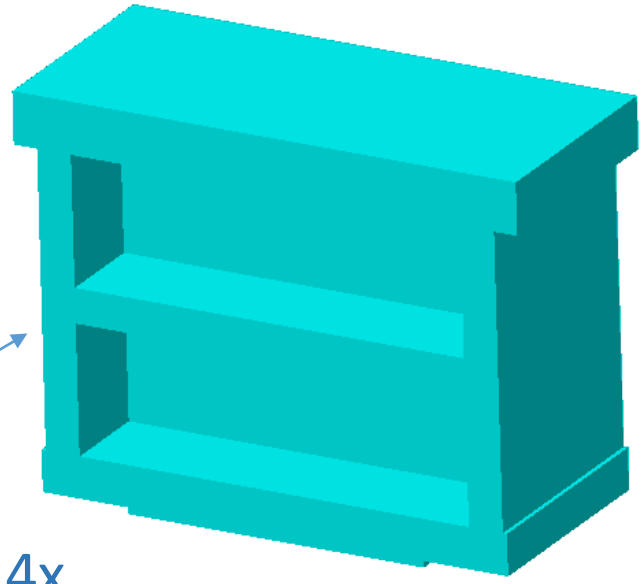
| | |
|---|---|
| Volume ($m^3$) | 3.993 |
| Mass (kg) | 31'944 |
| Material | Stainless Steel |
| Density ($kg/m^3$) | 8'000 |



**Diff: -496 Kg**

14 Volumes

GEANT



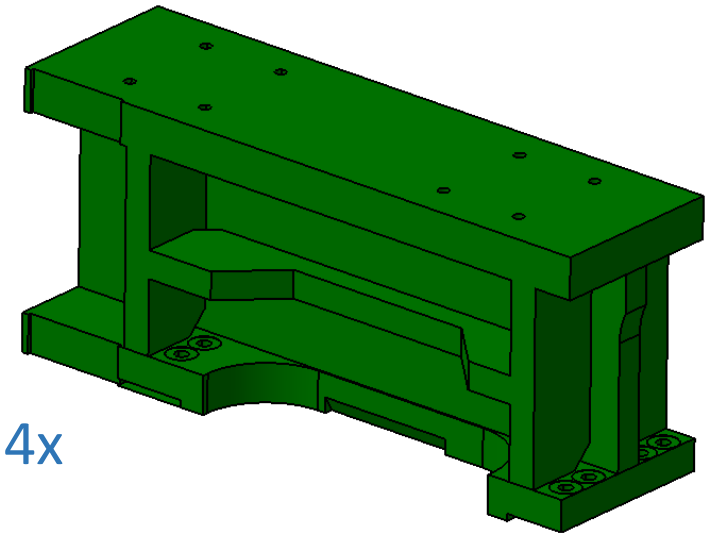
14x

| | |
|---|---|
| Volume ($m^3$) | 3.996 |
| Mass (kg) | 31'448 |
| Material | Iron |
| Density ($kg/m^3$) | 7'870 |

# CATIA vs GEANT: Extremity Rail Support

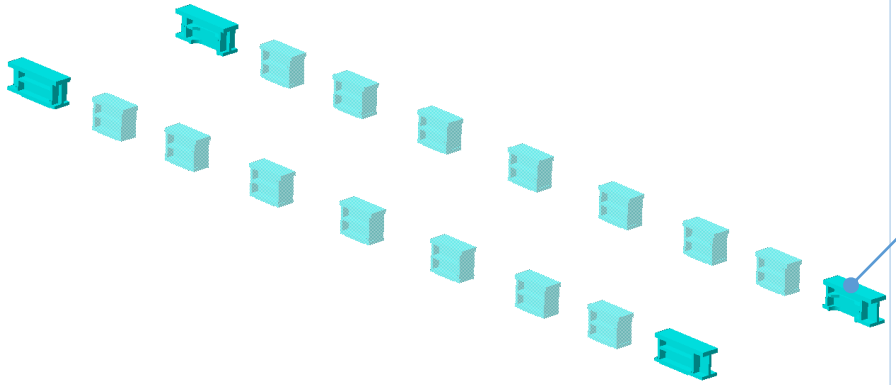


CATIA



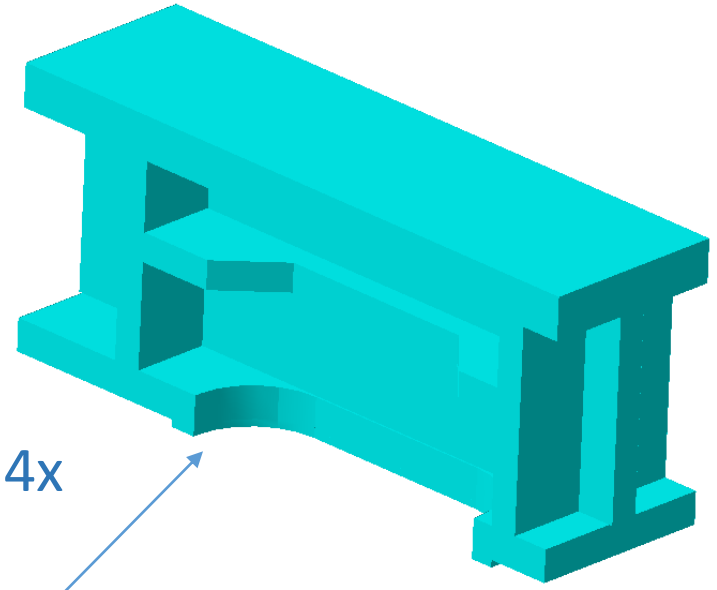
4x

| | |
|---|---|
| Volume ($m^3$) | 1.38 |
| Mass (kg) | 11’040 |
| Material | Stainless Steel |
| Density ($kg/m^3$) | 8’000 |



**Diff: -140 Kg**

GEANT



4x

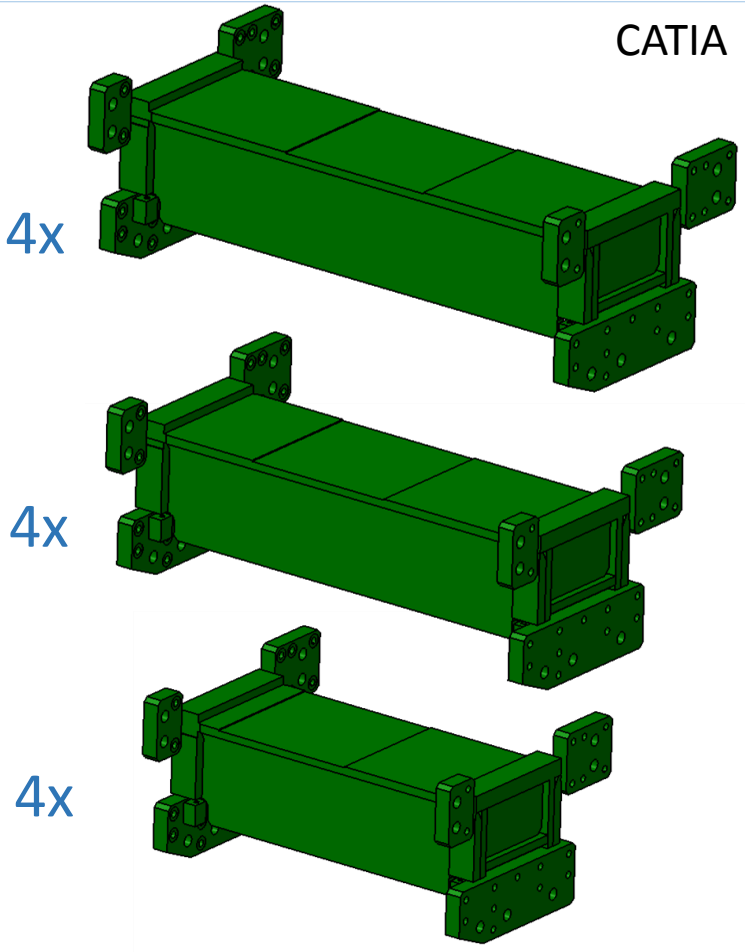
28 Volumes

| | |
|---|---|
| Volume ($m^3$) | 1.385 |
| Mass (kg) | 10’900 |
| Material | Iron |
| Density ($kg/m^3$) | 7’870 |

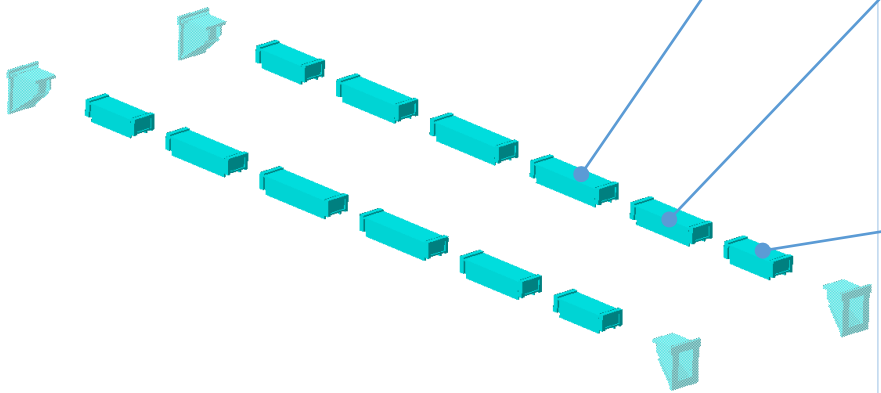
# CATIA vs GEANT: Girder



CATIA



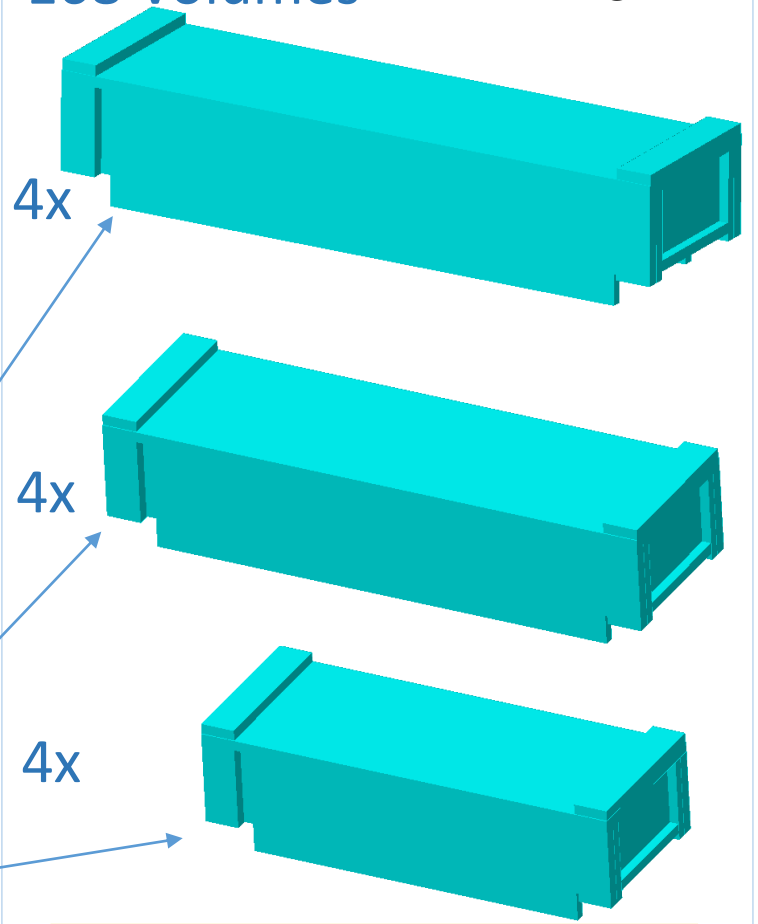

| | |
|---|---|
| Volume ($m^3$) | 3.012 |
| Mass (kg) | 24'096 |
| Material | Stainless Steel |
| Density ($kg/m^3$) | 8'000 |



**Diff: -5'791 Kg**

168 Volumes

GEANT



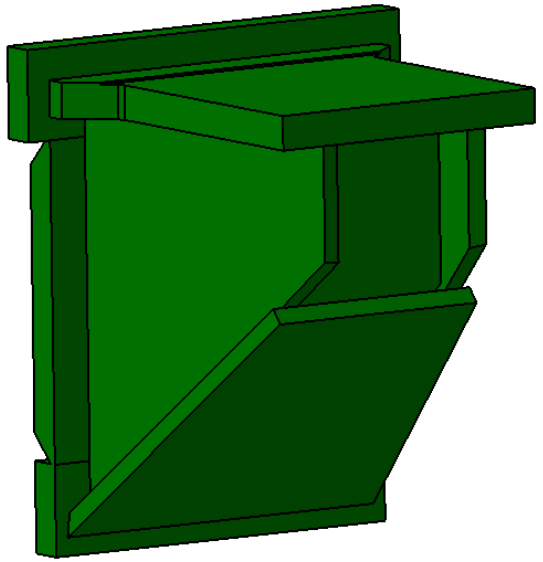

| | |
|---|---|
| Volume ($m^3$) | 2.326 |
| Mass (kg) | 18'305 |
| Material | Iron |
| Density ($kg/m^3$) | 7'870 |

# CATIA vs GEANT: Extremity Girder

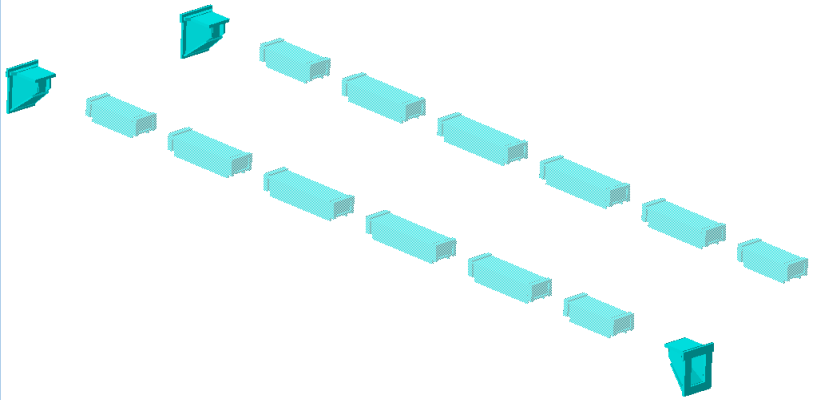


CATIA

4x



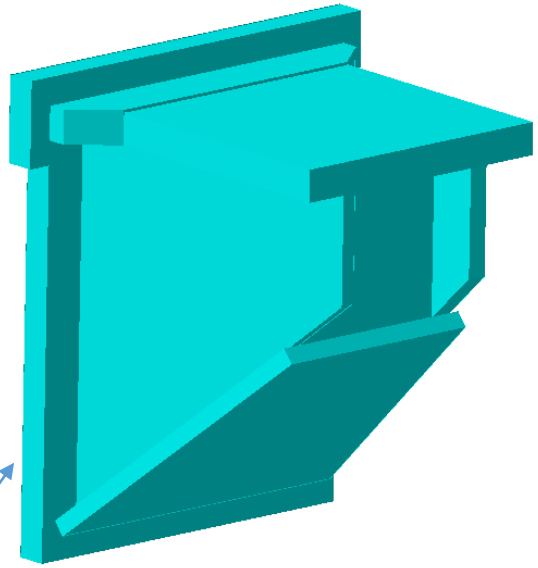
| | |
|---|---|
| Volume ($m^3$) | 0.572 |
| Mass (kg) | 4'576 |
| Material | Stainless Steel |
| Density ($kg/m^3$) | 8'000 |



**Diff: -146 Kg**

GEANT

4x



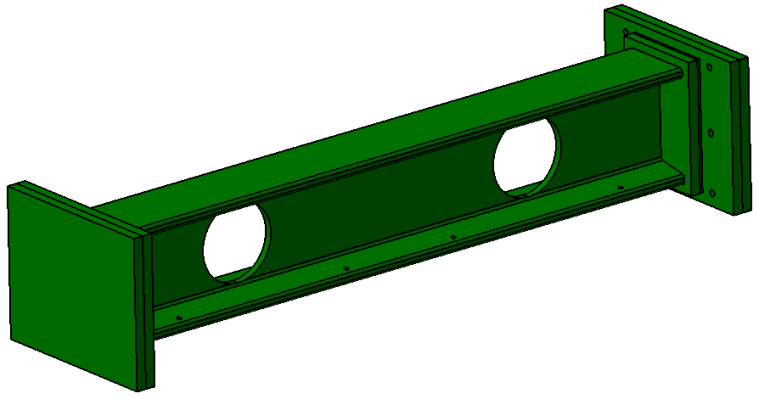
40 Volumes

| | |
|---|---|
| Volume ($m^3$) | 0.563 |
| Mass (kg) | 4'430 |
| Material | Iron |
| Density ($kg/m^3$) | 7'870 |

# CATIA vs GEANT: Standard Strut

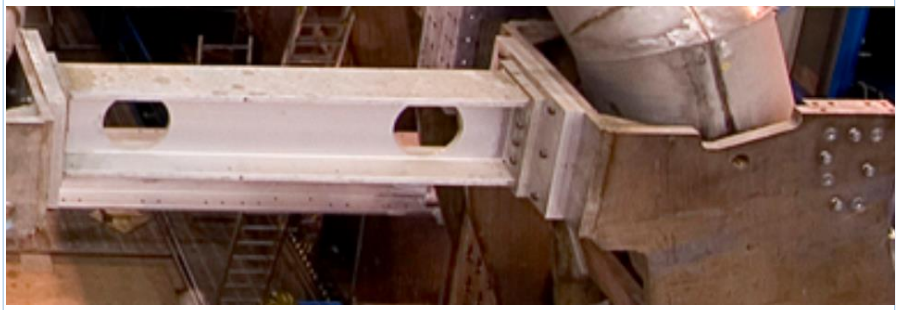


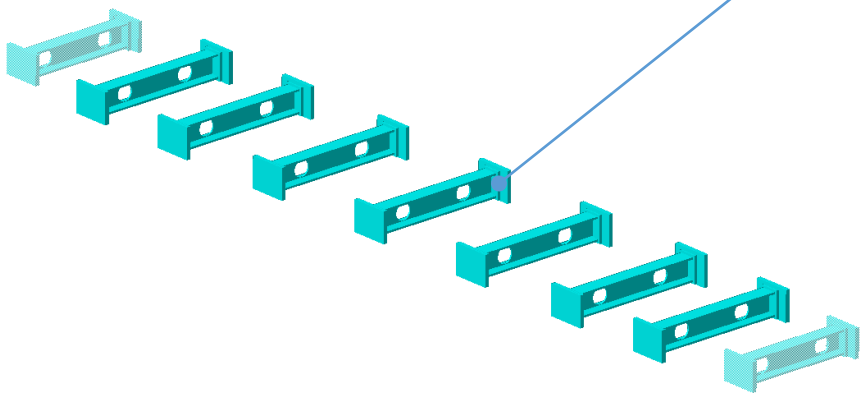
CATIA



7x

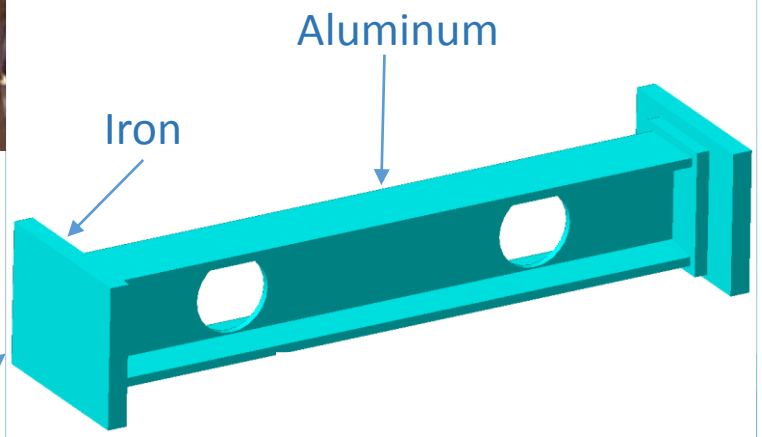
| | |
|---|---|
| Volume ($m^3$) | 3.157 |
| Mass (kg) | 8'523.9 |
| Material | Aluminum |
| Density ($kg/m^3$) | 2700 |





**Diff: +8'087 Kg**

GEANT




7x

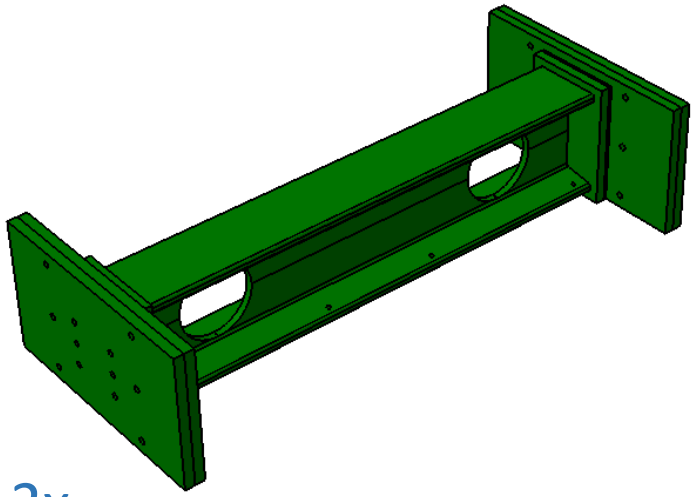
63 Volumes

| | |
|---|---|
| Volume ($m^3$) | 1.643 / 1.547 |
| Mass (kg) | 4'436 / 12'175 |
| Material | Aluminum/Iron |
| Density ($kg/m^3$) | 2700 / 7'870 |

# CATIA vs GEANT: Extremity Strut

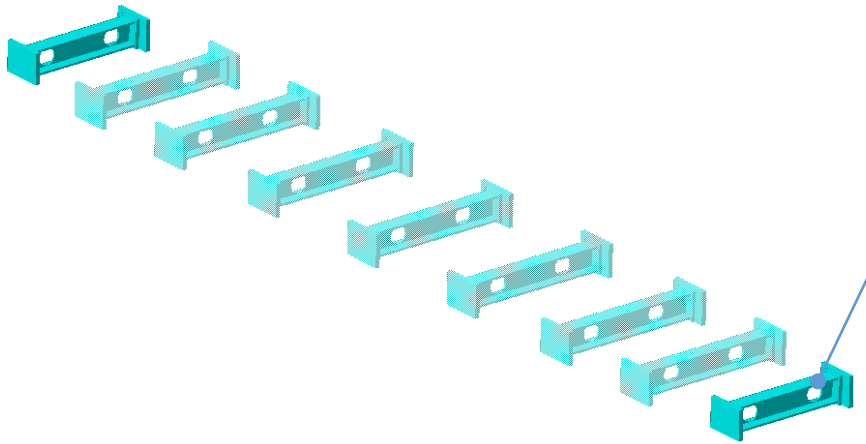


CATIA



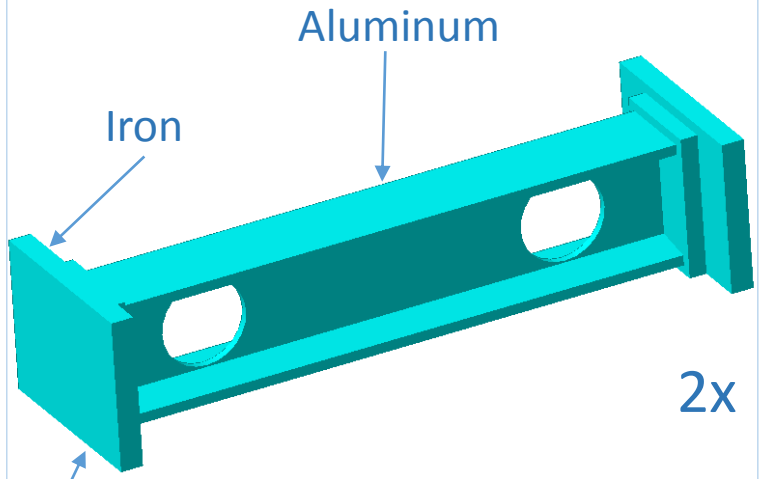
2x

| | |
|---|---|
| Volume ($m^3$) | 0.907 |
| Mass (kg) | 2448.9 |
| Material | Aluminum |
| Density ($kg/m^3$) | 2700 |



**Diff: +1’978 Kg**

GEANT




2x

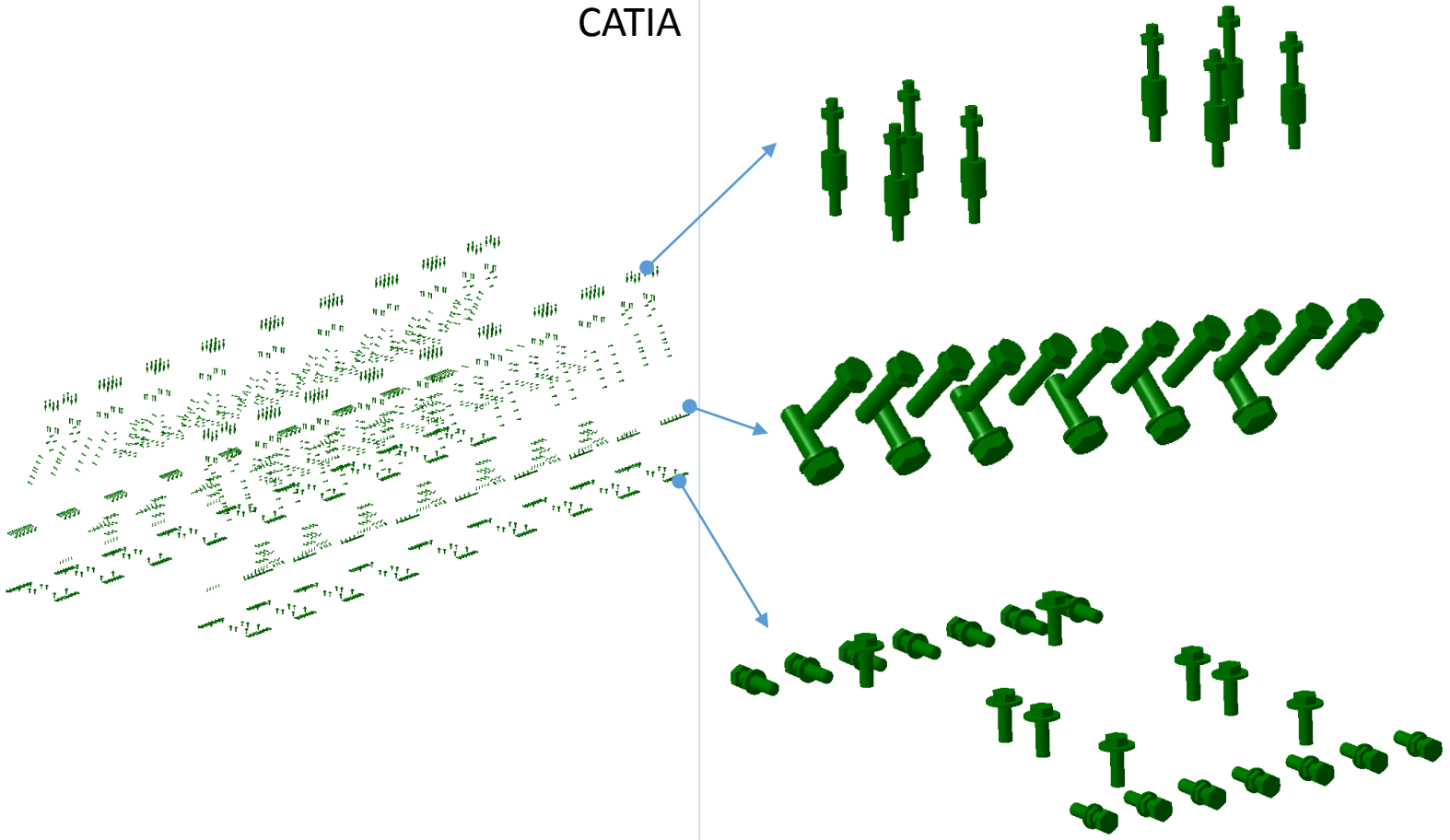
18 Volumes

| | |
|---|---|
| Volume ($m^3$) | 0.375 / 0.434 |
| Mass (kg) | 1012.5/ 3’415 |
| Material | Aluminum/Iron |
| Density ($kg/m^3$) | 2700/7’870 |

# CATIA vs GEANT: Bolts



CATIA



GEANT

Bolts are missing in Geant4

| | |
|---|---|
| Volume ($m^3$) | 0.54 |
| Mass (kg) | 4'320 |
| Material | Stainless Steel |
| Density ($kg/m^3$) | 8'000 |

**Diff: -4'320 Kg**

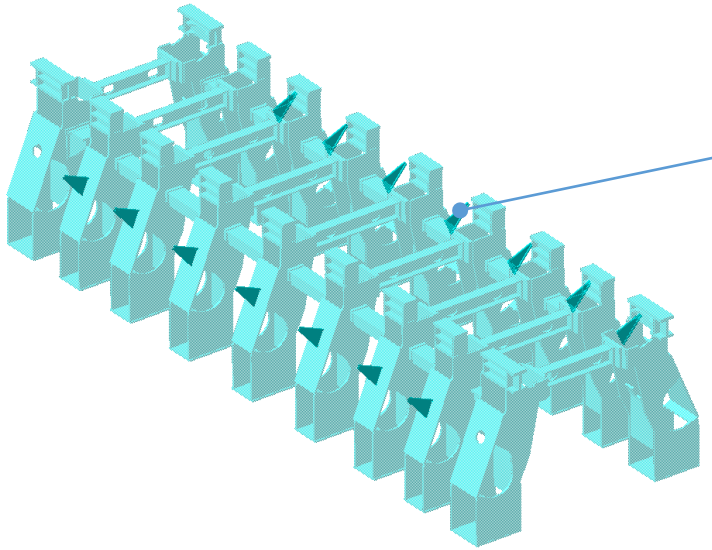
| | |
|---|---|
| Volume ($m^3$) | |
| Mass (kg) | |
| Material | |
| Density ($kg/m^3$) | |

# CATIA vs GEANT: Slanted ConnPlate Bracket



CATIA

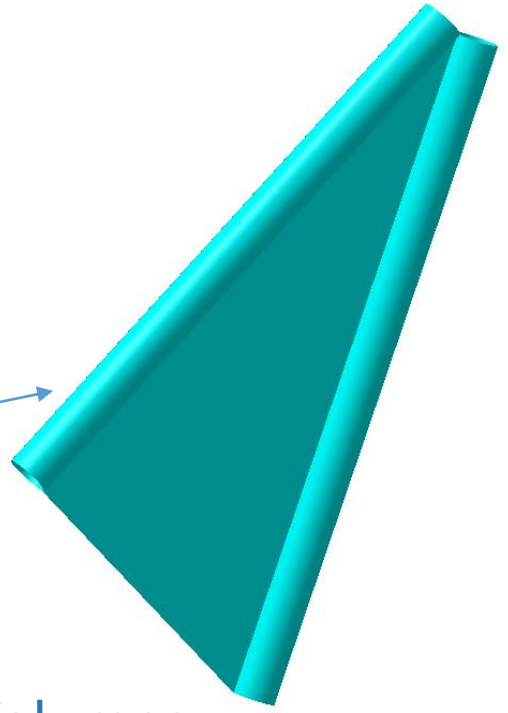
***This is*** not part of FEET



| | |
|---|---|
| Volume ($m^3$) | |
| Mass (kg) | |
| Material | |
| Density ($kg/m^3$) | |

**Diff: +138 Kg**

GEANT



14x

42 Volumes

| | |
|---|---|
| Volume ($m^3$) | 0.0512 |
| Mass (kg) | 138 |
| Material | Aluminum |
| Density ($kg/m^3$) | 2700 |

# CATIA vs GEANT

- CATIA vs GEANT comparison final results:

| | | CATIA | Geant4 | Difference |
|---|---|---|---|---|
| 1 | Standard Foot | 213’248 kgs | 186’401 kgs | -12.6 % |
| 2 | Extremity Foot | 66’864 kgs | 58’647 kgs | -12.3 % |
| | | | | |
| 3 | Rail Support | 31’944 kgs | 31’448 kgs | -1.6 % |
| 4 | Extremity Rail Support | 11’040 kgs | 10’900 kgs | -1.3 % |
| | | | | |
| 5 | Girder | 24’096 kgs | 18’305 kgs | -24 % |
| 6 | Extremity Girder | 4’576 kgs | 4’430 kgs | -3.2 % |
| | | | | |
| 7 | FEET_Standard Strut | 8’523.9 kgs | 16’611 kgs | +48.7 % |
| 8 | FEET_Extremity Strut | 24’48.9 kgs | 4’427.5 kgs | +44.7 % |
| | | | | |
| 9 | Bolts | 4’320 kgs | - kgs | - 100 % |
| | | | | |
| 10 | Slanted ConnPlate Bracket | - kgs | 138 kgs | + 100 % |
| | Total | **367’060 kgs** | **331’307 kgs** | **34.84 %** |

# Phase III.

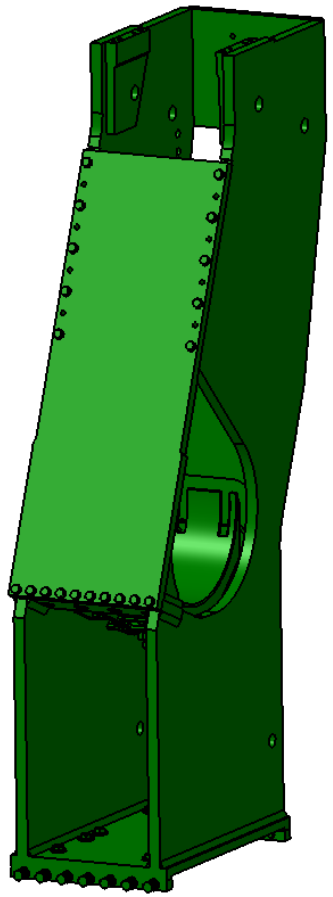
Simplification of CATIA detailed geometry

# Simplification: Standard Foot



Detailed

14x



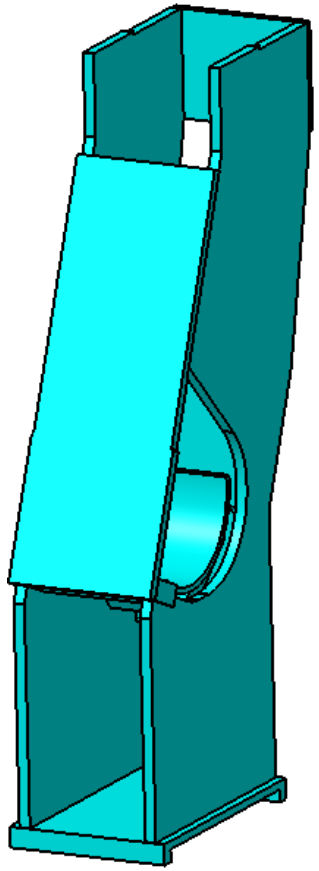
| | |
|---|---|
| Volume ($m^3$) | 26.95 |
| Mass (kg) | 215'600 |
| Material | Stainless Steel |
| Density ($kg/m^3$) | 8'000 |

**Diff: 0 Kg**

Simplified

14x

140 Volumes



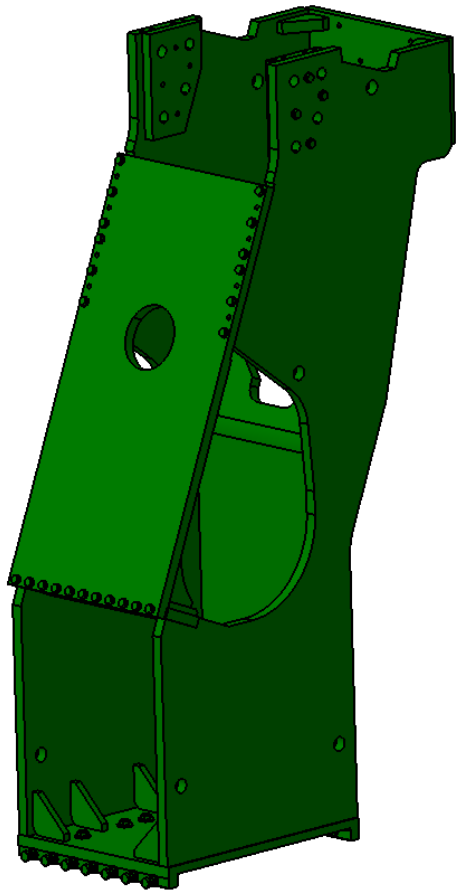
| | |
|---|---|
| Volume ($m^3$) | 26.95 |
| Mass (kg) | 215'600 |
| Material | Stainless Steel |
| Density ($kg/m^3$) | 8'000 |

# Simplification: Extremity Foot



Detailed

4x



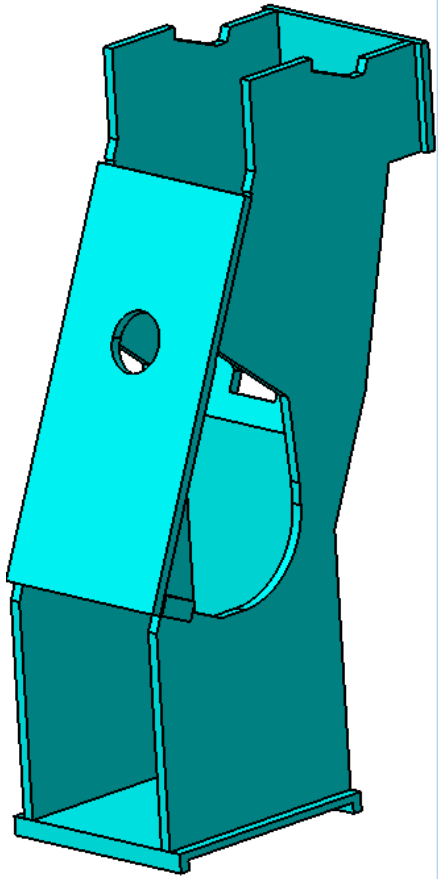
| | |
|---|---|
| Volume ($m^3$) | 8.436 |
| Mass (kg) | 67'488 |
| Material | Stainless Steel |
| Density ($kg/m^3$) | 8'000 |

Diff: -8 Kg

Simplified

4x

32 Volumes



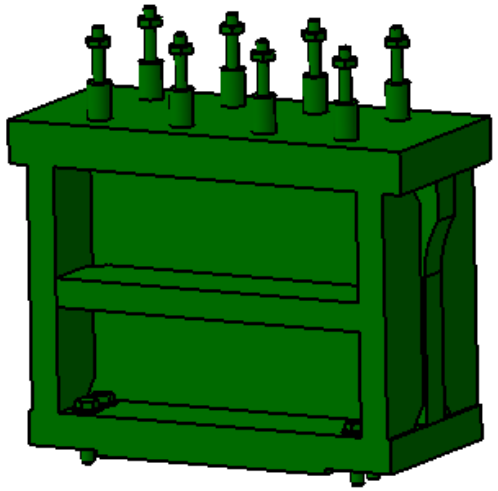
| | |
|---|---|
| Volume ($m^3$) | 8.435 |
| Mass (kg) | 67'480 |
| Material | Stainless Steel |
| Density ($kg/m^3$) | 8'000 |

# Simplification: Rail Support



Detailed

14x

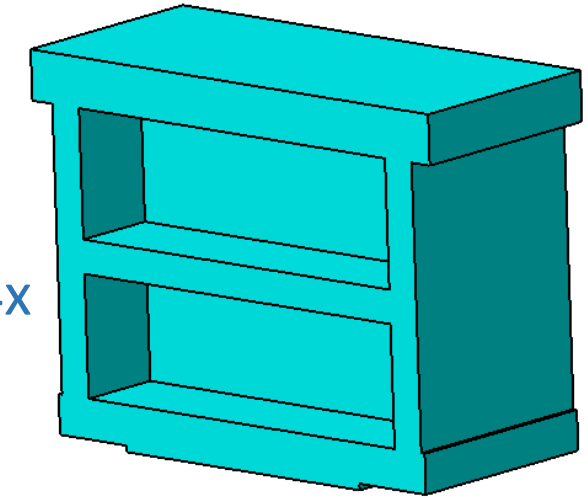


| | |
|---|---|
| Volume ($m^3$) | 4.084 |
| Mass (kg) | 32'672 |
| Material | Stainless Steel |
| Density ($kg/m^3$) | 8'000 |

**Diff: 0 Kg**

Simplified

14x



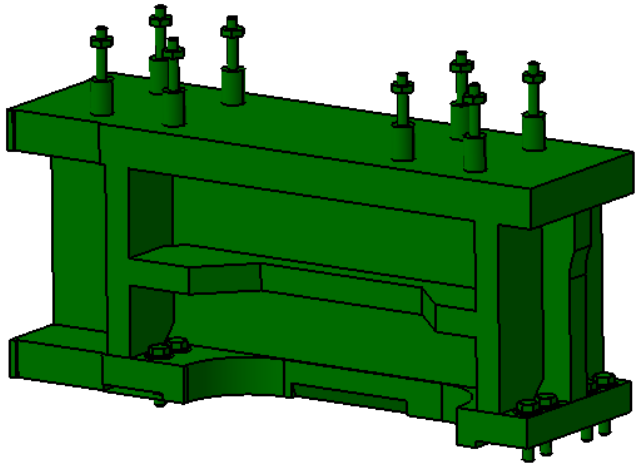
14 Volumes

| | |
|---|---|
| Volume ($m^3$) | 4.084 |
| Mass (kg) | 32'672 |
| Material | Stainless Steel |
| Density ($kg/m^3$) | 8'000 |

# Simplification: Extremity Rail Support



Detailed

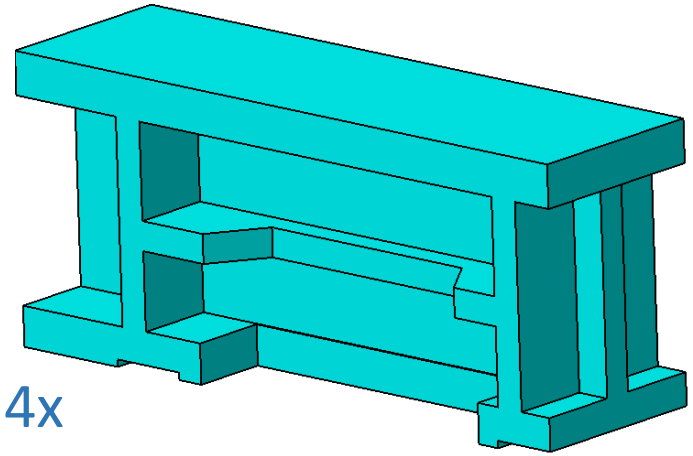


4x

| | |
|---|---|
| Volume ($m^3$) | 1.406 |
| Mass (kg) | 11'248 |
| Material | Stainless Steel |
| Density ($kg/m^3$) | 8'000 |

**Diff: 0 Kg**

Simplified



4x

20 Volumes

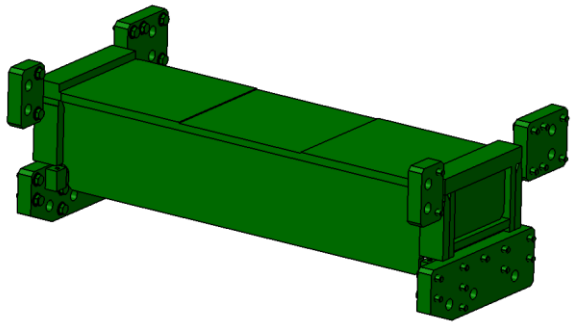
| | |
|---|---|
| Volume ($m^3$) | 1.406 |
| Mass (kg) | 11'248 |
| Material | Stainless Steel |
| Density ($kg/m^3$) | 8'000 |

# Simplification: Girder

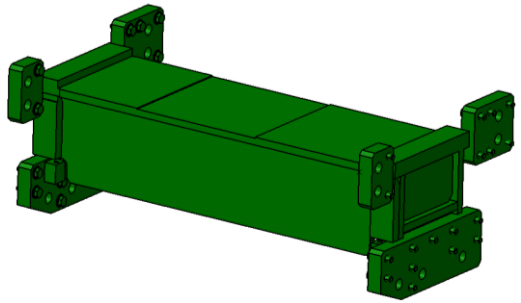


Detailed

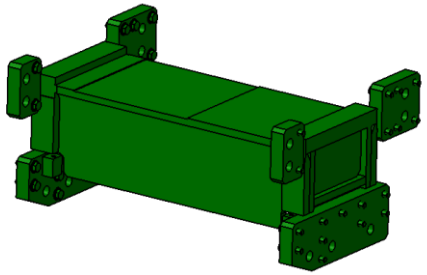
4x



4x



4x

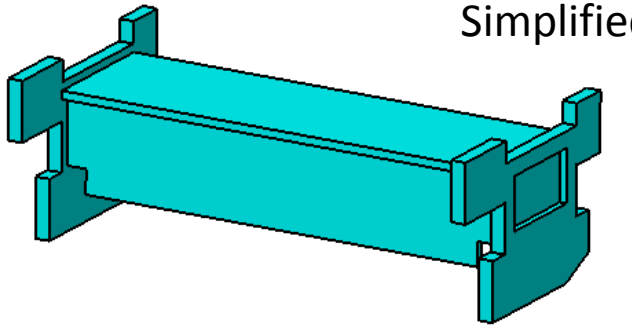


| | |
|---|---|
| Volume ($m^3$) | 3.0622 |
| Mass (kg) | 24'497.6 |
| Material | Stainless Steel |
| Density ($kg/m^3$) | 8'000 |

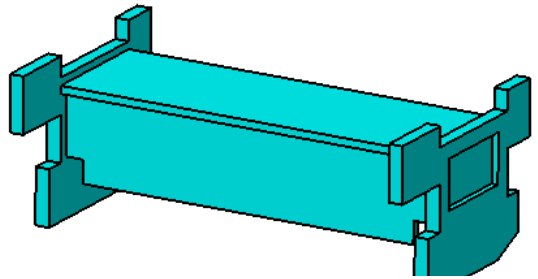
**Diff: +3.2 Kg**

Simplified

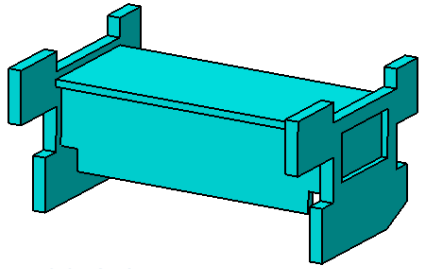
4x



4x



4x



96 Volumes

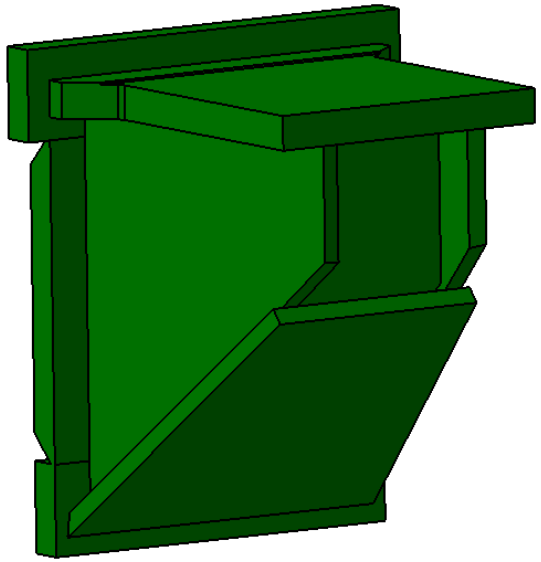
| | |
|---|---|
| Volume ($m^3$) | 3.0626 |
| Mass (kg) | 24'500.8 |
| Material | Stainless Steel |
| Density ($kg/m^3$) | 8'000 |

# Simplification: Extremity Girder



Detailed

4x

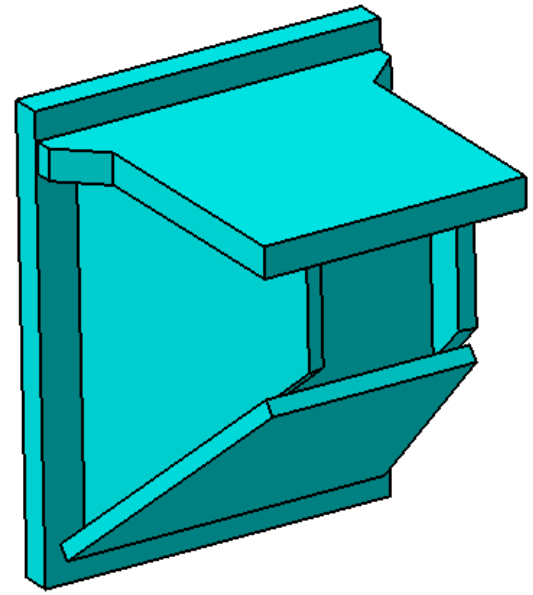


| | |
|---|---|
| Volume ($m^3$) | 0.572 |
| Mass (kg) | 4'576 |
| Material | Stainless Steel |
| Density ($kg/m^3$) | 8'000 |

**Diff: 0 Kg**

Simplified

4x



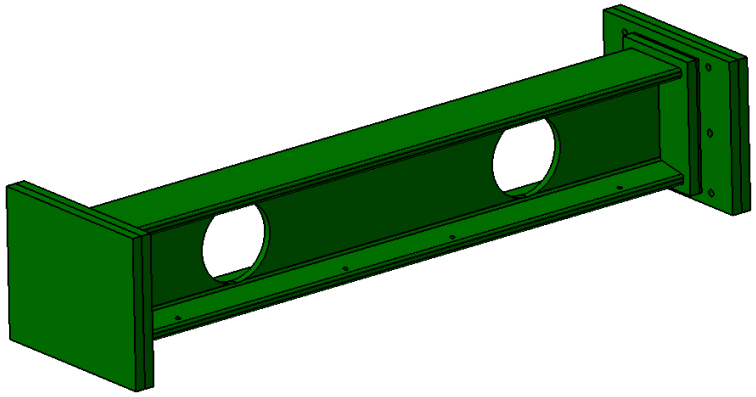
24 Volumes

| | |
|---|---|
| Volume ($m^3$) | 0.572 |
| Mass (kg) | 4'576 |
| Material | Stainless Steel |
| Density ($kg/m^3$) | 8'000 |

# Simplification: Standard Strut



Detailed

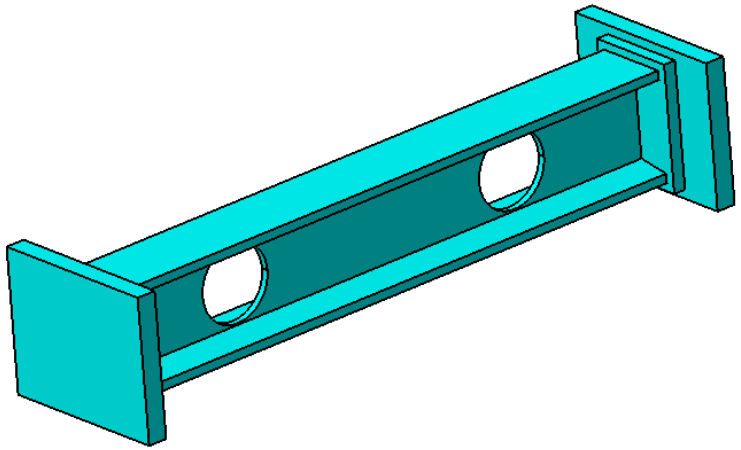


7x

| | |
|---|---|
| Volume ($m^3$) | 3.157 |
| Mass (kg) | 8'523.9 |
| Material | Aluminum |
| Density ($kg/m^3$) | 2700 |

**Diff: +1.4 Kg**

Simplified



7x

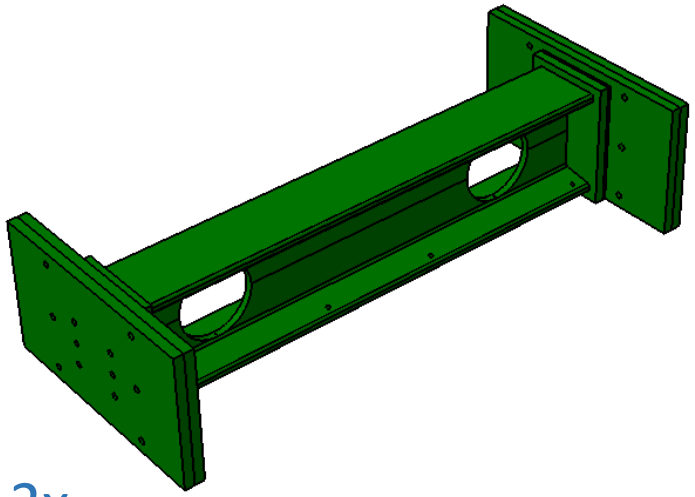
35 Volumes

| | |
|---|---|
| Volume ($m^3$) | 3.1575 |
| Mass (kg) | 8'525.3 |
| Material | 2700 |
| Density ($kg/m^3$) | Aluminum |

# Simplification: Extremity Strut



Detailed

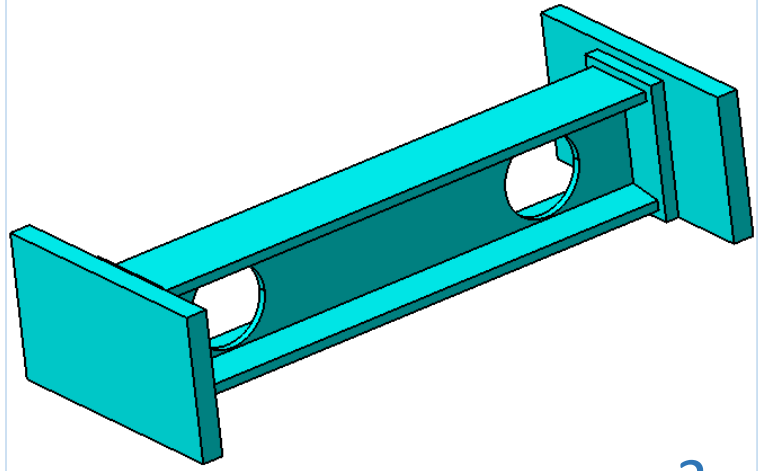


2x

| | |
|---|---|
| Volume ($m^3$) | 0.907 |
| Mass (kg) | 2'448.9 |
| Material | Aluminum |
| Density ($kg/m^3$) | 2700 |

**Diff: 0 Kg**

Simplified



2x

10 Volumes

| | |
|---|---|
| Volume ($m^3$) | 0.907 |
| Mass (kg) | 2'448.9 |
| Material | Aluminum |
| Density ($kg/m^3$) | 2700 |

# Simplification

- Final results of Simplification

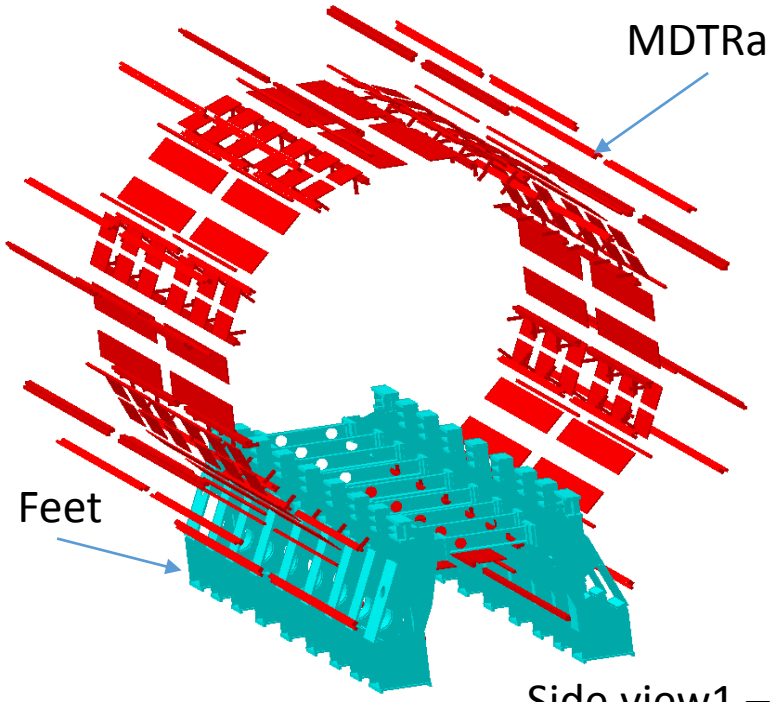
| | | Detailed | Simplified | Difference |
|---|---|---|---|---|
| 1 | Standard Foot | 215’600 kgs | 215’600 kgs | 0 kgs |
| 2 | Extremity Foot | 67’488 kgs | 67’480 kgs | -8 kgs |
| | | | | |
| 3 | Rail Support | 32’672 kgs | 32’672 kgs | 0 kgs |
| 4 | Extremity Rail Support | 11’248 kgs | 11’248 kgs | 0 kgs |
| | | | | |
| 5 | Girder | 24’497.6 kgs | 24’500.8 kgs | +3.2 kgs |
| 6 | Extremity Girder | 4’576 kgs | 4’576 kgs | 0 kgs |
| | | | | |
| 7 | FEET_Standard Strut | 8’523.9 kgs | 8’525.3 kgs | +1.4 kgs |
| 8 | FEET_Extremity Strut | 2’448.9 kgs | 2’448.9 kgs | 0 kgs |
| | | | | |
| | | | | |
| | | | | |
| | Total | **367’054 kgs** | **367’051 kgs** | **-3 kgs** |

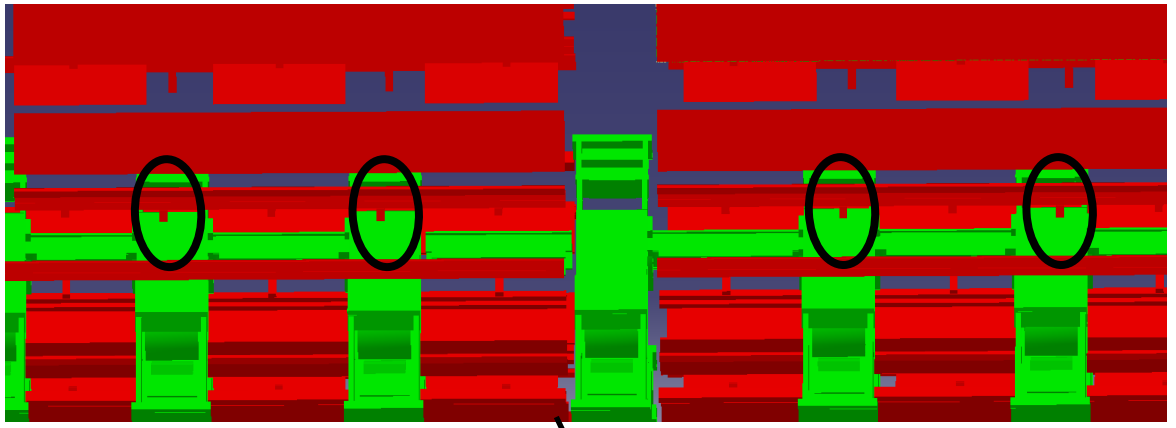
# Phase IV.

## Integration Conflicts Checking

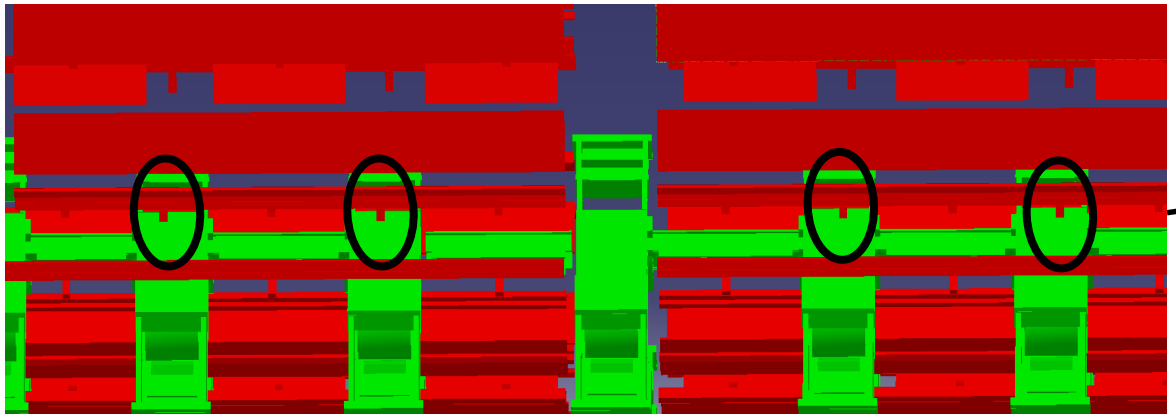
# Integration Conflicts Checking

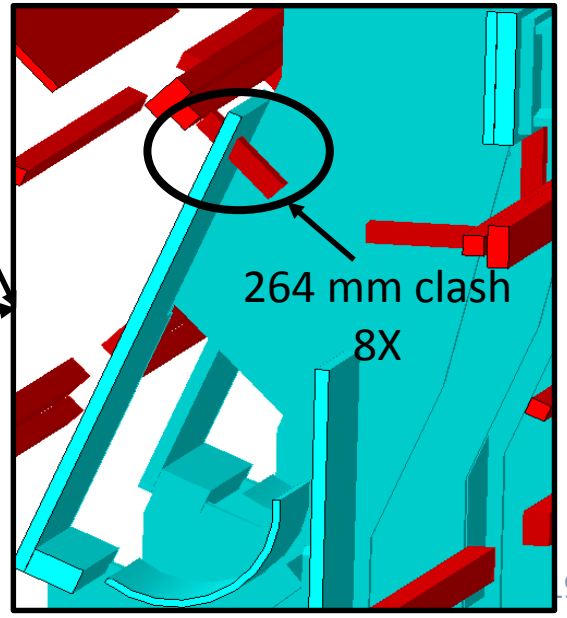
- Overlap #01: Feet vs MDT Rails



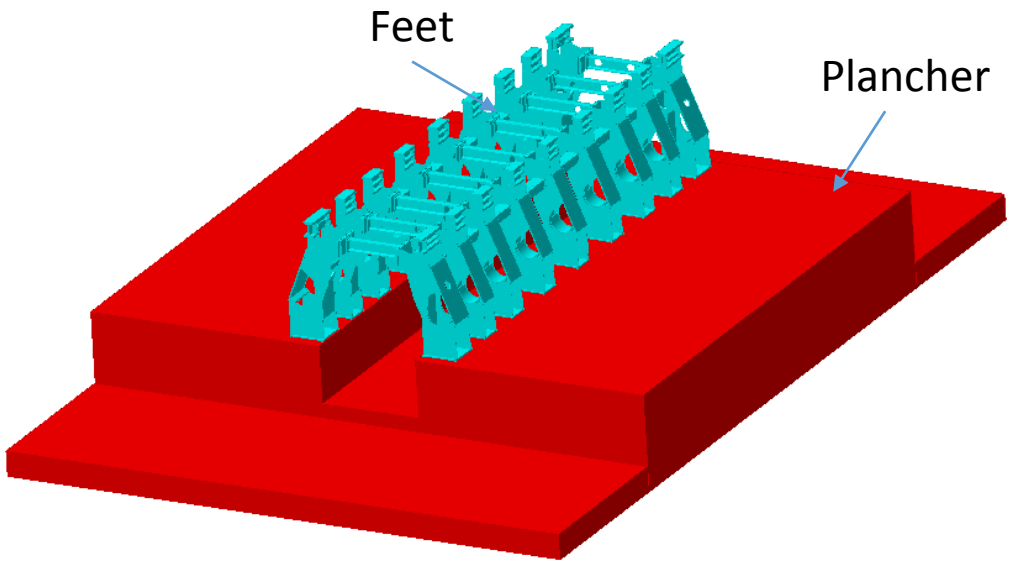
Side view1 – 4X Clashes

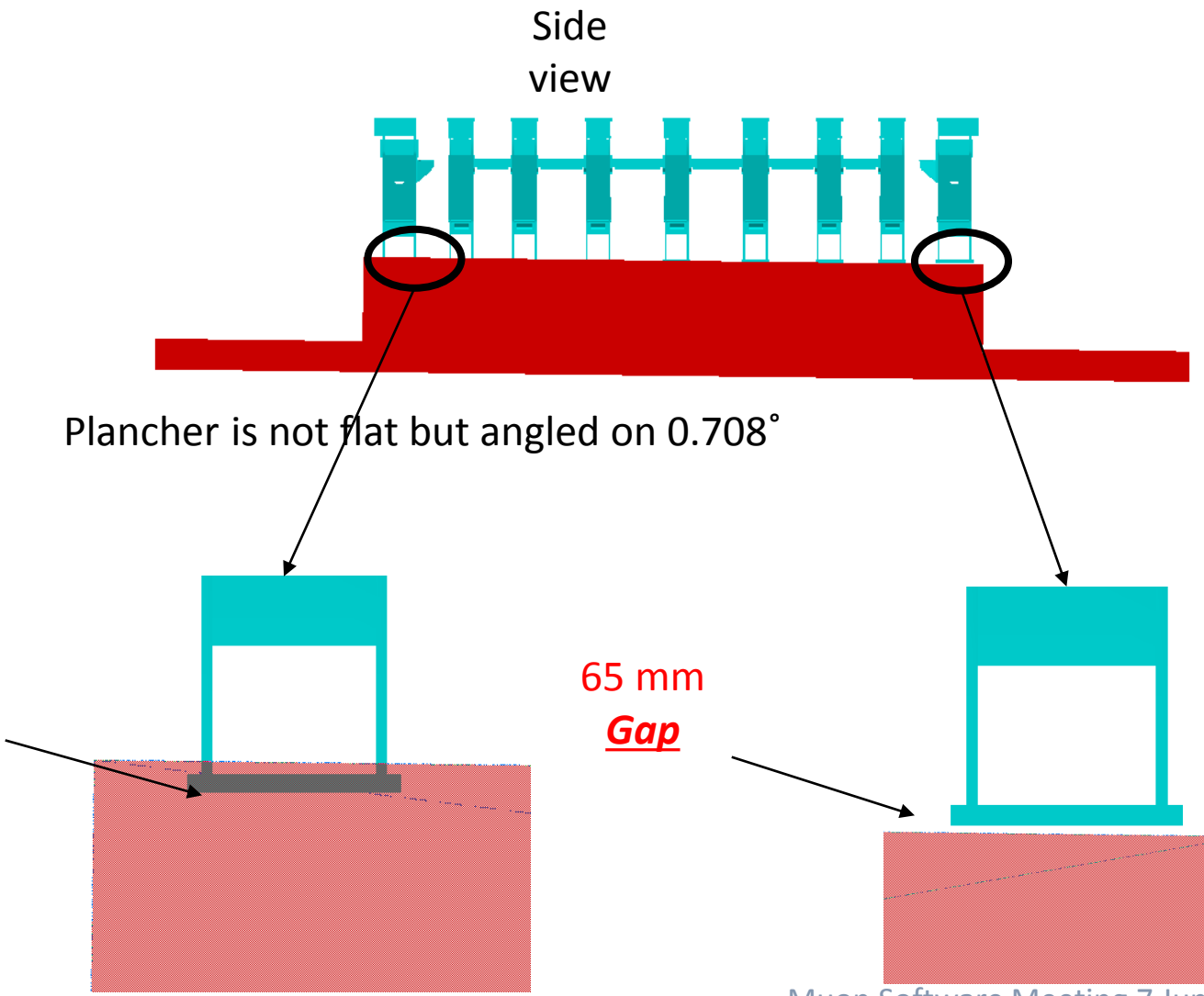




# Integration Conflicts Checking

- Overlap #02: Feet vs Plancher



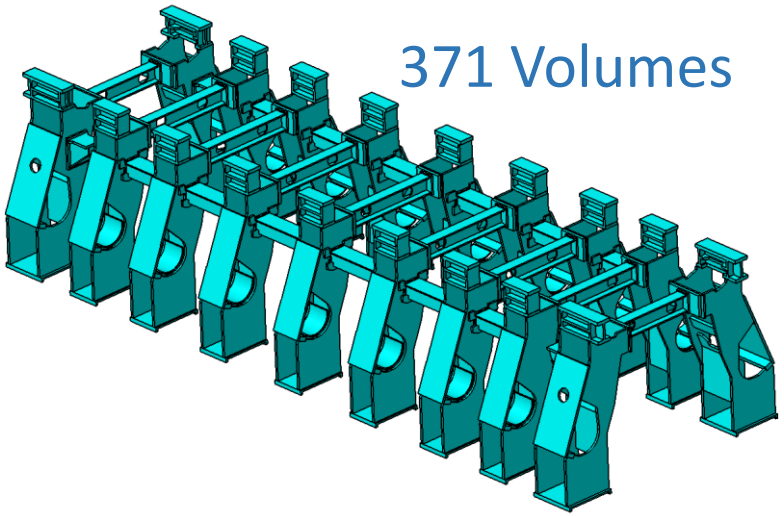
# Phase V.

XML coding

# XML Coding

- 371 volumes where separated for amdb structure which is less then baseline geometry volumes number – 499. So FEET new description will perform faster

371 Volumes

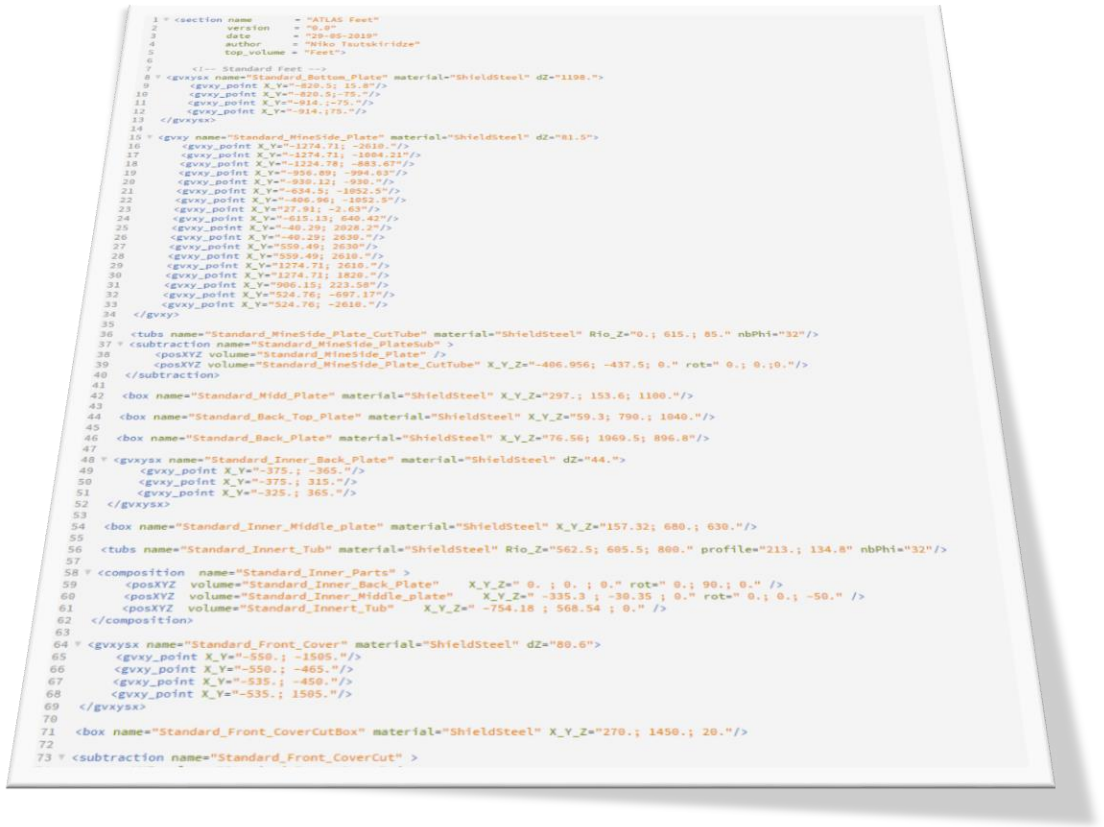


VS

499 Volumes

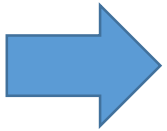
# XML Coding

- XML code produced and Merge Request generated on Gitlab



```
<section name    = "ATLAS Feet"
         version = "0.0"
         date    = "29-05-2019"
         author  = "Niko Tsutskiridze"
         top_volume = "Feet">

    <!-- Standard Feet -->
  <gvxysx name="Standard_Bottom_Plate" material="ShieldSteel" dZ="1198.">
      <gvxy_point X_Y="-820.5; 15.8"/>
      <gvxy_point X_Y="-820.5;-75."/>
      <gvxy_point X_Y="-914.;-75."/>
      <gvxy_point X_Y="-914.;75."/>
  </gvxysx>

  <gvxy name="Standard_MineSide_Plate" material="ShieldSteel" dZ="81.5">
      <gvxy_point X_Y="-1274.71; -2610."/>
      <gvxy_point X_Y="-1274.71; -1004.21"/>
      <gvxy_point X_Y="-1224.78; -885.67"/>
      <gvxy_point X_Y="-956.89; -994.63"/>
      <gvxy_point X_Y="-930.12; -930."/>
      <gvxy_point X_Y="-634.5; -1052.5"/>
      <gvxy_point X_Y="-406.96; -1052.5"/>
      <gvxy_point X_Y="27.91; -2.63"/>
      <gvxy_point X_Y="-615.13; 640.42"/>
      <gvxy_point X_Y="-40.29; 2028.2"/>
      <gvxy_point X_Y="-40.29; 2630."/>
      <gvxy_point X_Y="559.49; 2630"/>
      <gvxy_point X_Y="559.49; 2610."/>
      <gvxy_point X_Y="1274.71; 2610."/>
      <gvxy_point X_Y="1274.71; 1820."/>
      <gvxy_point X_Y="906.15; 223.58"/>
      <gvxy_point X_Y="524.76; -697.17"/>
      <gvxy_point X_Y="524.76; -2610."/>
  </gvxy>

  <tubs name="Standard_MineSide_Plate_CutTube" material="ShieldSteel" Rio_Z="0.; 615.; 85." nbPhi="32"/>
  <subtraction name="Standard_MineSide_PlateSub" >
      <posXYZ volume="Standard_MineSide_Plate" />
      <posXYZ volume="Standard_MineSide_Plate_CutTube" X_Y_Z="-406.956; -437.5; 0." rot=" 0.; 0.;0."/>
  </subtraction>

  <box name="Standard_Midd_Plate" material="ShieldSteel" X_Y_Z="297.; 153.6; 1100."/>

  <box name="Standard_Back_Top_Plate" material="ShieldSteel" X_Y_Z="59.3; 790.; 1040."/>

  <box name="Standard_Back_Plate" material="ShieldSteel" X_Y_Z="76.56; 1969.5; 896.8"/>

  <gvxysx name="Standard_Inner_Back_Plate" material="ShieldSteel" dZ="44.">
      <gvxy_point X_Y="-375.; -365."/>
      <gvxy_point X_Y="-375.; 315."/>
      <gvxy_point X_Y="-325.; 365."/>
  </gvxysx>

  <box name="Standard_Inner_Middle_plate" material="ShieldSteel" X_Y_Z="157.32; 680.; 630."/>

  <tubs name="Standard_Innert_Tub" material="ShieldSteel" Rio_Z="562.5; 605.5; 800." profile="213.; 134.8" nbPhi="32"/>

  <composition  name="Standard_Inner_Parts" >
      <posXYZ  volume="Standard_Inner_Back_Plate"    X_Y_Z=" 0. ; 0. ; 0." rot=" 0.; 90.; 0." />
      <posXYZ  volume="Standard_Inner_Middle_plate"    X_Y_Z=" -335.3 ; -30.35 ; 0." rot=" 0.; 0.; -50." />
      <posXYZ  volume="Standard_Innert_Tub"    X_Y_Z=" -754.18 ; 568.54 ; 0." />
  </composition>

  <gvxysx name="Standard_Front_Cover" material="ShieldSteel" dZ="80.6">
      <gvxy_point X_Y="-550.; -1505."/>
      <gvxy_point X_Y="-550.; -465."/>
      <gvxy_point X_Y="-535.; -450."/>
      <gvxy_point X_Y="-535.; 1505."/>
  </gvxysx>

  <box name="Standard_Front_CoverCutBox" material="ShieldSteel" X_Y_Z="270.; 1450.; 20."/>

  <subtraction name="Standard_Front_CoverCut" >
```

365 lines



atlas g4-xml

# Conclusions



1. We reproduced existing description of Feet in Smarteam DB by adding 65 CDD drawings
2. Compare analyses shows big difference between Geant-4 description of feet and as-built geometry - 35% overall difference
3. Decision for generation of new description + XML has been made
4. We received good result of simplification of detailed CATIA description – lose just 3 Kg
5. We have discovered 2 overlaps between Feet and other volumes. They are existed for both new and baseline geometries of Feet
6. For Overlap-#01 we propose to remove wrong parts from MDT Rails – modification in baseline Geant-4 description will needed
7. For Overlap-#02 we propose to change position of “Plancher” and make it flat (no $0.708^{O}$)– modification in baseline Geant-4 description will needed

# Project Summary



1. Started 1st of March, 2019 and finished 5th of June, 2019. So duration of project was >3 months
2. 1.5FTE involved
3. 16 working tasks were executed
4. 63 CDD drawings converted into 3D geometry and added to existing geometry on Smarteam in order to reproduce as-built CATIA geometry

Comments are welcome,

Thanks