QUEEN'S UNIVERSITY BELFAST

SCHOOL OF MECHANICAL AND AEROSPACE ENGINEERING

‘Reducing Product Development Lead Times Using Parametric Design’

Dr Joe Butterfield

Mechanical & Aerospace Engineering

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Overview

- Parametrics
  - CAD Kernel
- Vertical Tanks
  - Macros – CATIA
- Horizontal Tanks
  - Design Tables – Solidworks
- Products & Moulds

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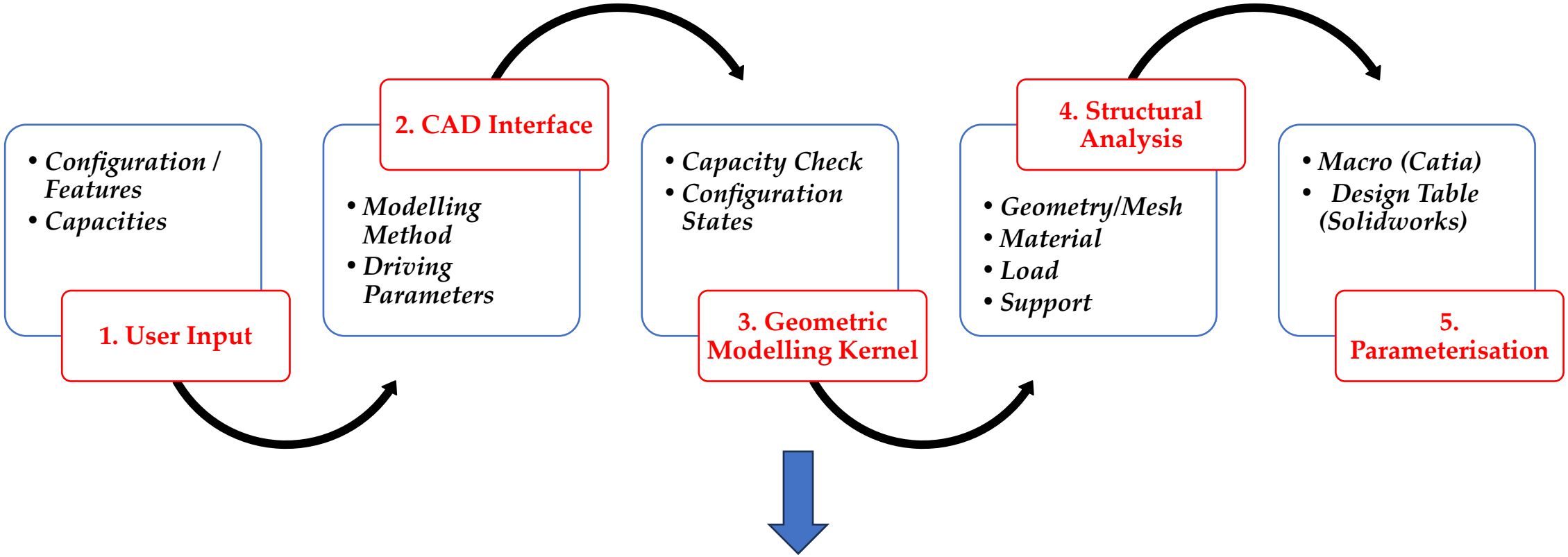
The CAD Kernel



Kernel: 'The library of core mathematical functions that defines and stores 3D solid objects in response to users' commands'

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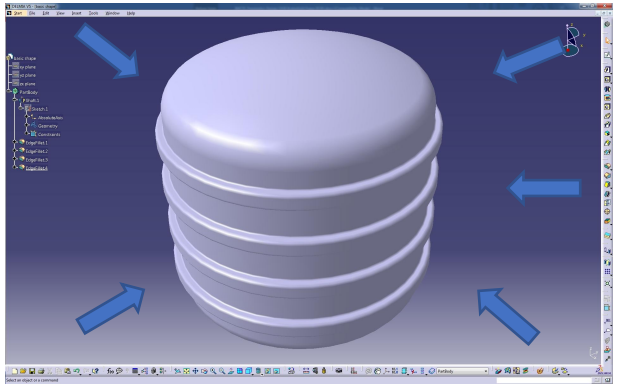
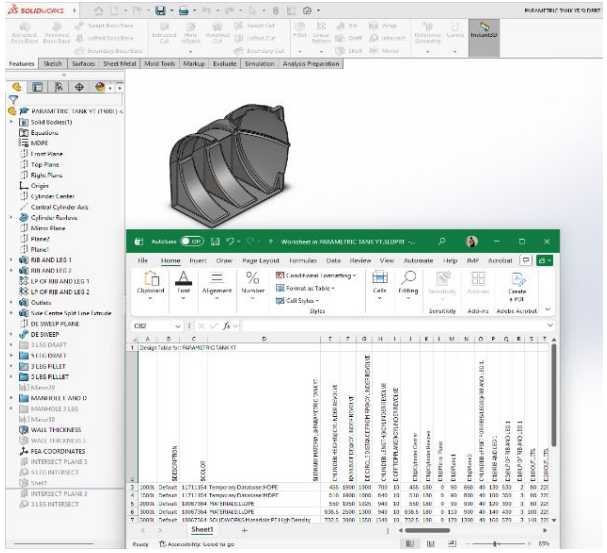
Computer Aided Design

- Graphical user interface (GUI)
  - Model construction
    - Sketch, Extrude, Revolve etc.
  - Feature tree
    - Model parameters based on user inputs
    - Plots / visualises model evolution
    - Model changes automatically if parameters are changed and appropriate constraints are in place.
- Macros (CATIA) / Design Table (Solidworks)
  - Drafted from scratch or
  - Recorded based on interaction with GUI
  - Parameters can be replaced with variables to allow generation of multiple solutions from one model.



CATIA



Solidworks

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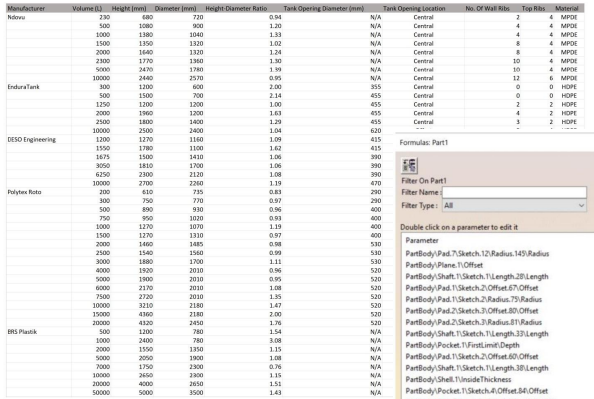
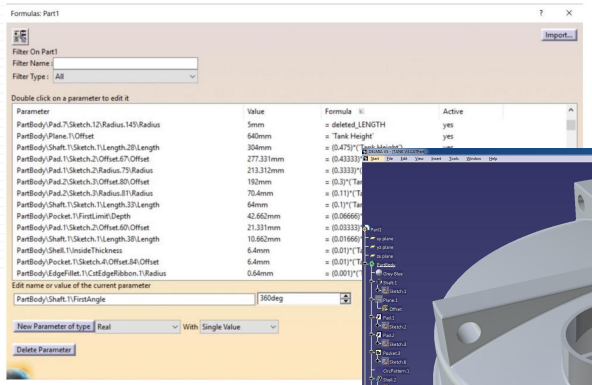
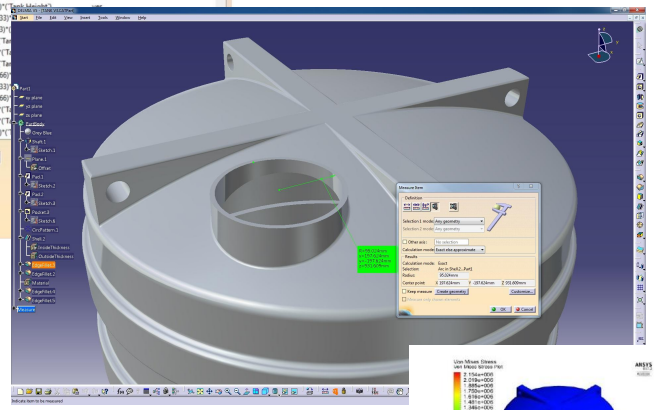
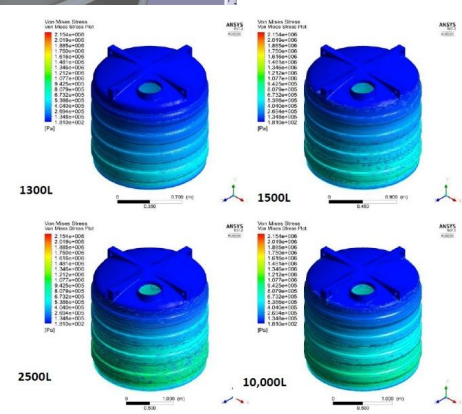
Parametric Design: CATIA

- Conceptual design review
  - Tank Proportions
  - Key Features
  - Design Principles
- Tank configuration defined & capacity checked
- Configuration validated using FEA
- Macro recorded & Edited
- Alternative sizes generated

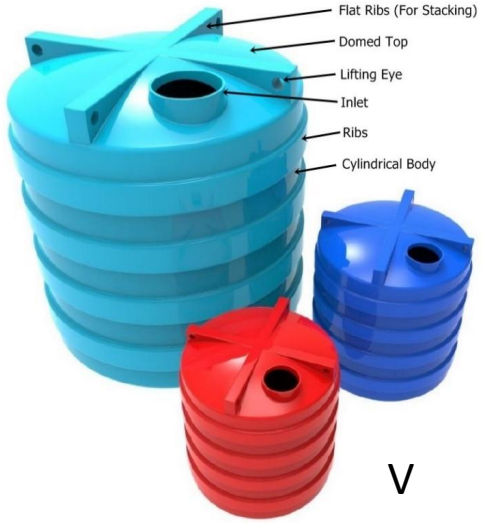









```
175  constraint5.Mode = catCstModeDrivingDimension
176
177  Dim length2 As Length
178  Set length2 = constraint5.Dimension
179
180  length2.Value = InputBox("Tank Height", "Enter Desired Tank Height:")
181
182  Dim reference10 As Reference
183  Set reference10 = part1.CreateReferenceFromObject(line2D5)
184
185  Dim constraint6 As Constraint
186  Set constraint6 = constraints1.AddMonoEltCst(catCstTypeLength, reference10)
187
188  constraint6.Mode = catCstModeDrivingDimension
189
```



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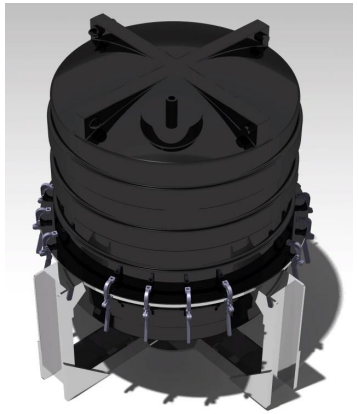
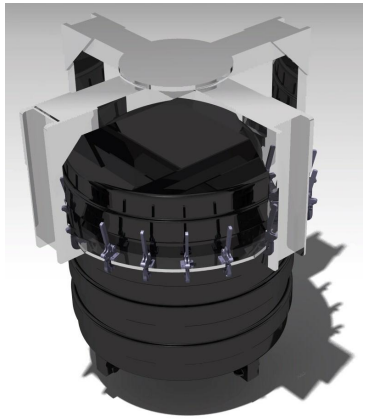
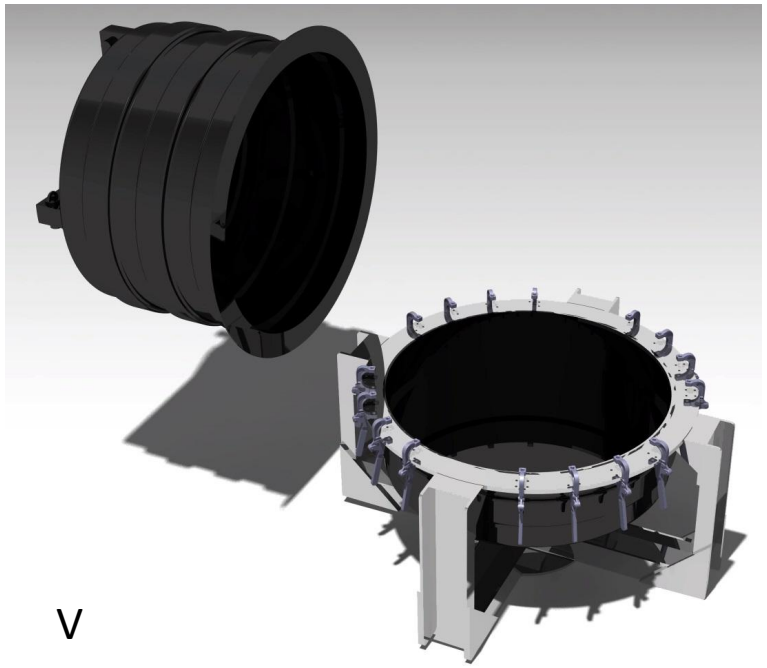
Tool Design

- Conceptual design review
  - Tank proportions + shrinkage allowance
  - Additional features
    - Breather
    - Clamps
    - Frame
    - Inserts (Lifting points)
    - Flanges
      - High enough to retain full material charge
      - Located for minimal visual impact







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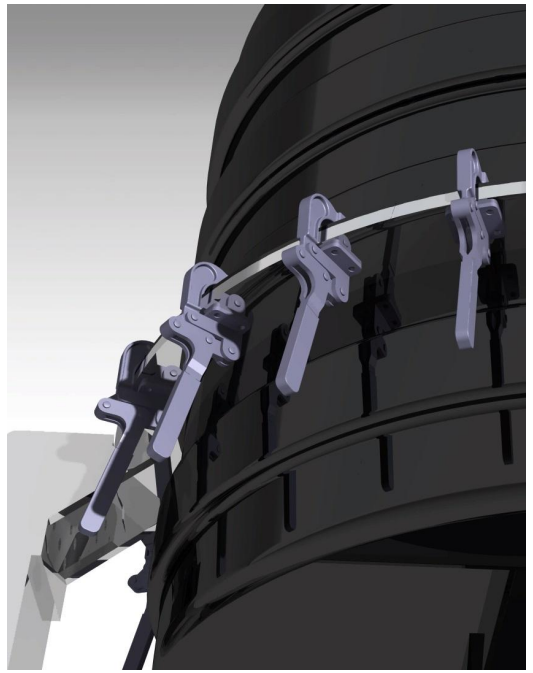

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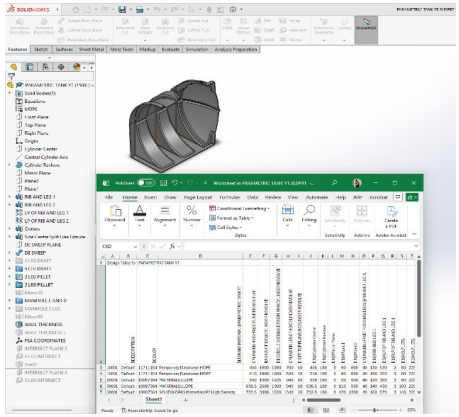
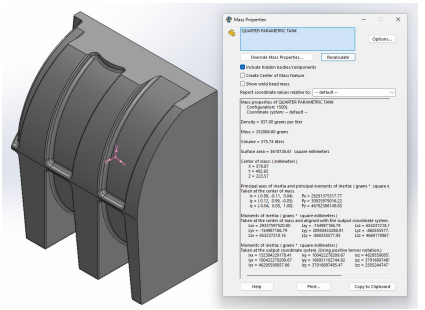
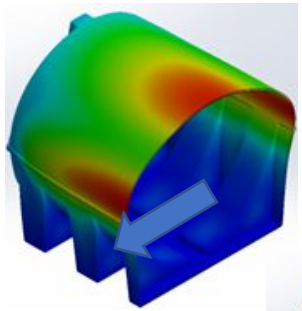
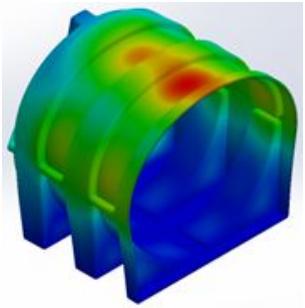
Parametric Design: Solidworks

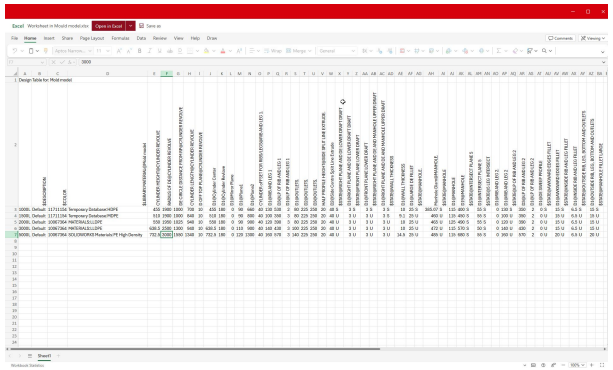
- Conceptual design review
  - Tank Proportions
  - Key Features
  - Design Principles
- Tank configuration defined & capacity checked
- Configuration validated using FEA
- Design table edited
- Alternative sizes generated

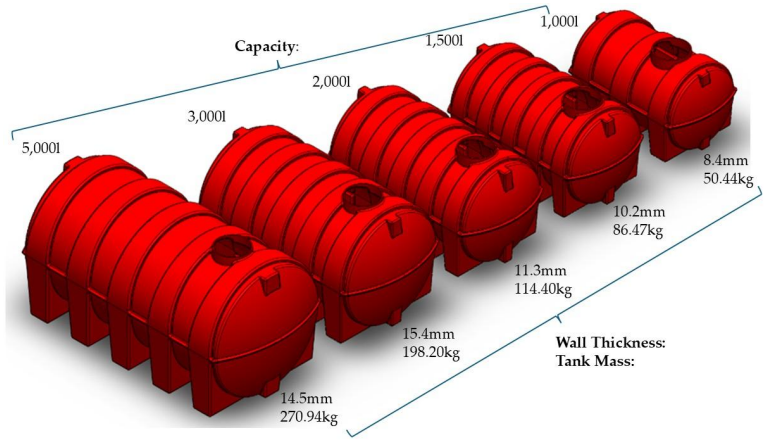












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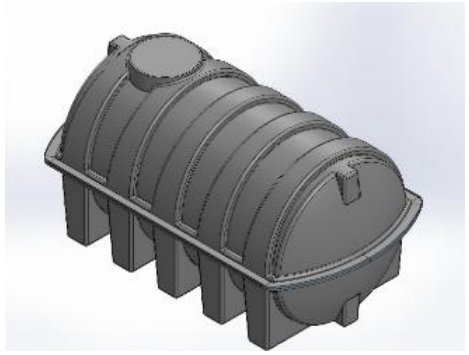
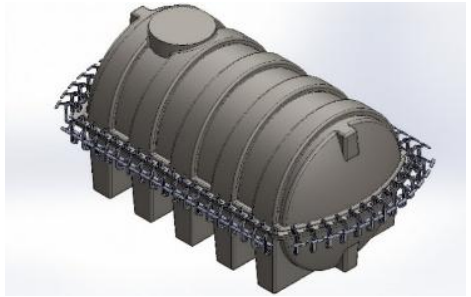
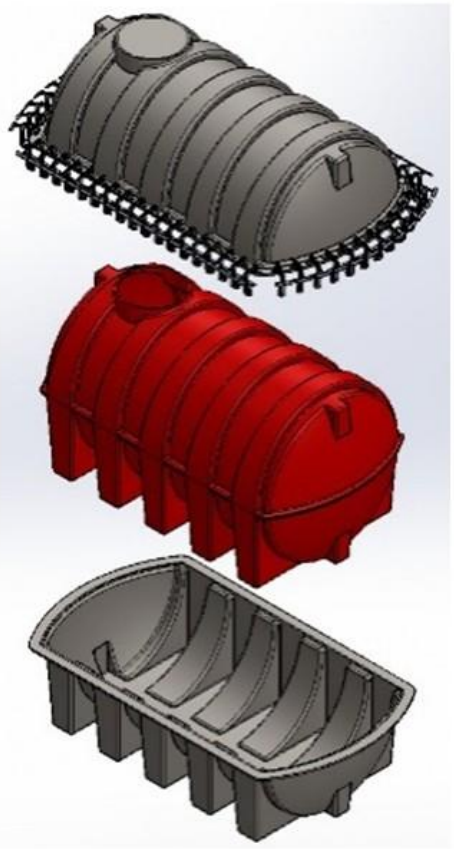
Tool Design

- Conceptual design review
  - Tank proportions + shrinkage allowance
  - Additional features
    - Clamps
    - Flanges
      - High enough to retain full material charge
      - Located for minimal visual impact







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Conclusions

- Parameterised models created for suite of vertical tanks and their tools – strategy around creation & management of parameters is critical.
- Parametric Methods applicable to multiple product versions BUT not efficient for
  - ‘one offs’
  - product versions with significant geometrical variation
- Development lead times reduced from hours / days to minutes / seconds AFTER macros / code is in place
- Added benefits in knowledge capture / retention / exploitation
- Method automates geometry creation but is still heavily reliant on decisions from the designer resulting on an iterative approach.

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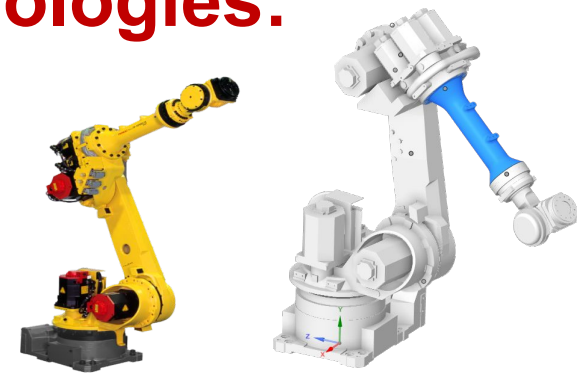
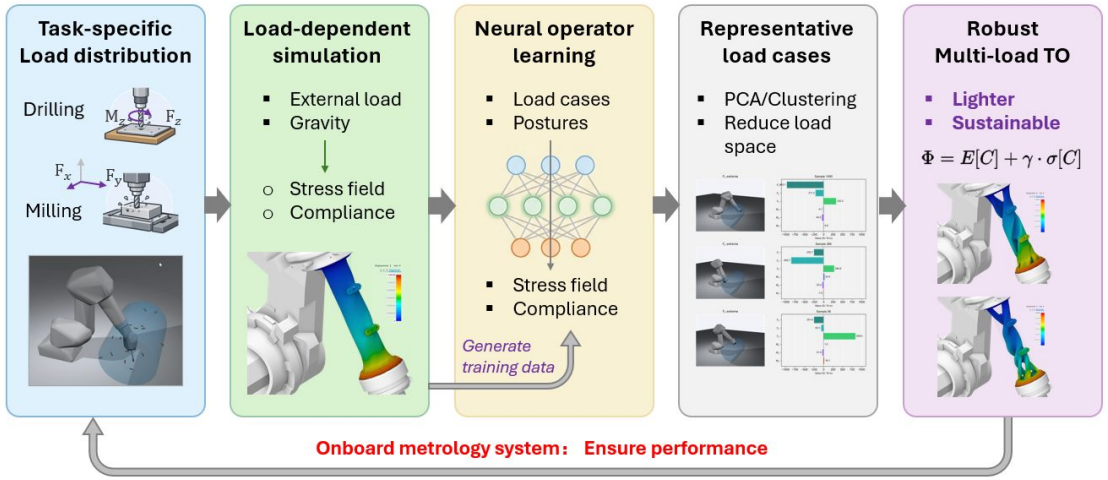
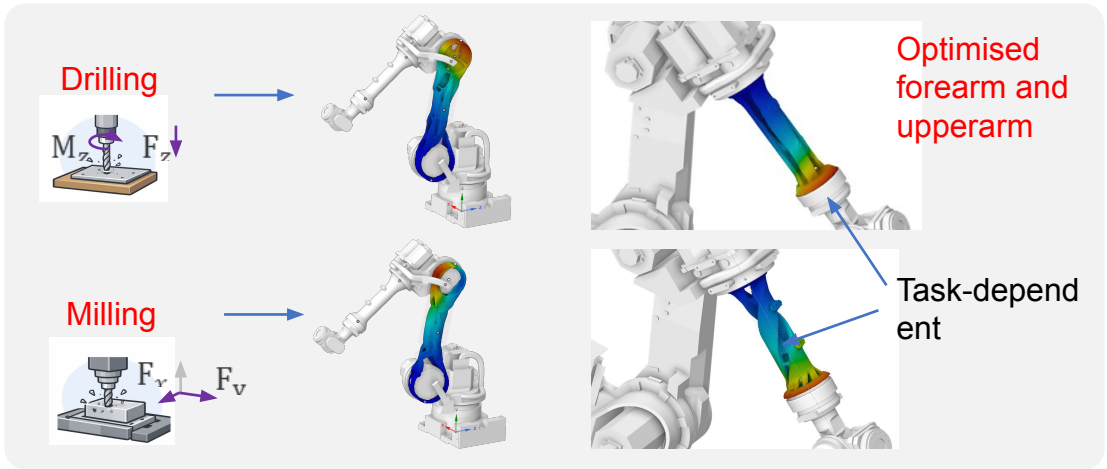
Automated Technologies:

Fanuc R-1000iA/80F

- Lighter
- Sustainable







- Enhanced structural configurations for robot arms:
  - Topology optimisation:
    - *Determines optimal design for specific goal, given a set of constraints, loads, and boundary conditions, by adding or removing geometric features and adjusting their size.*
  - Applications
    - Drilling:
      - Linear features to react drilling load
    - Milling:
      - Helical features to react milling load
  - Challenge:
    - Manufacturability of solutions.

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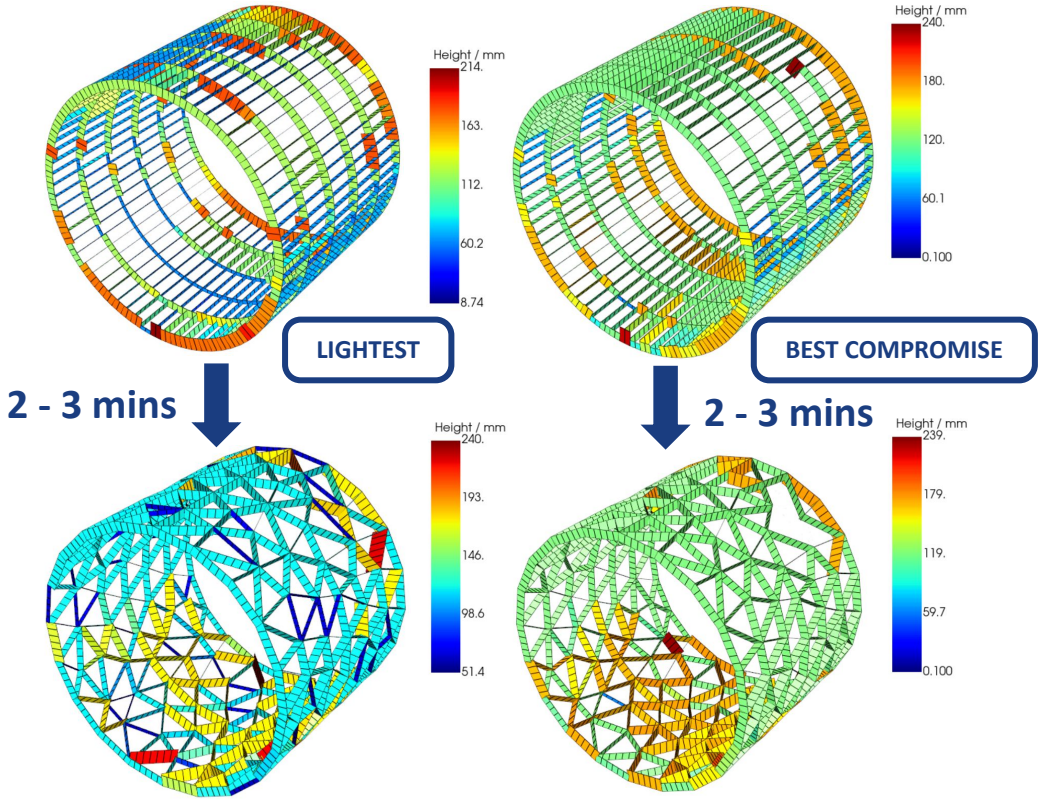
Automated Technologies:



- Novel structures for hydrogen propulsion systems:
  - RIED:
    - ***Using nature and biological evolution as a framework to build smarter, lighter, and more adaptable structural designs.***
  - Application
    - Novel fuselage structures for the accommodation of hydrogen storage solutions
  - Challenge:
    - Manufacturability of solutions.

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