



**QUEEN'S  
UNIVERSITY  
BELFAST**

SCHOOL OF  
MECHANICAL  
AND AEROSPACE  
ENGINEERING



# 'Reducing Product Development Lead Times Using Parametric Design'



**Dr Joe Butterfield**

Mechanical & Aerospace Engineering

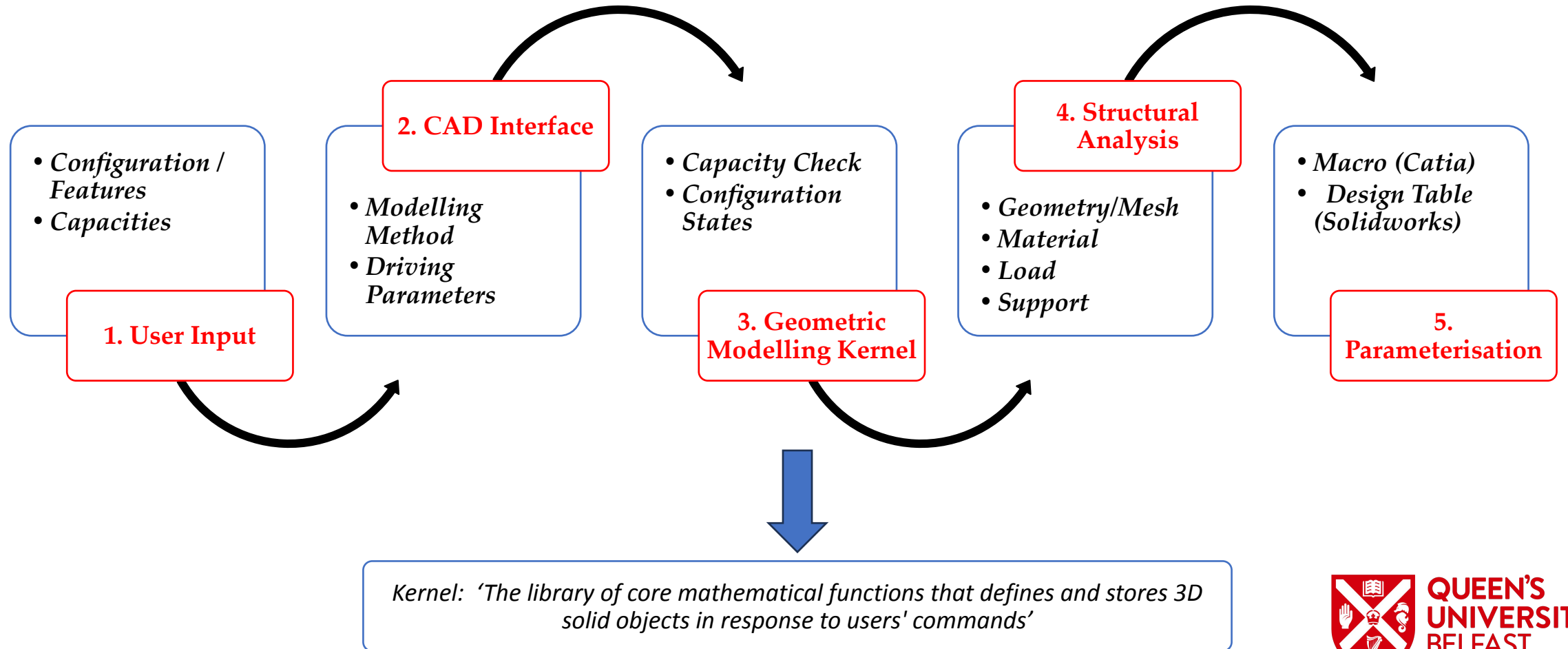
11<sup>th</sup> June 2026



## Overview

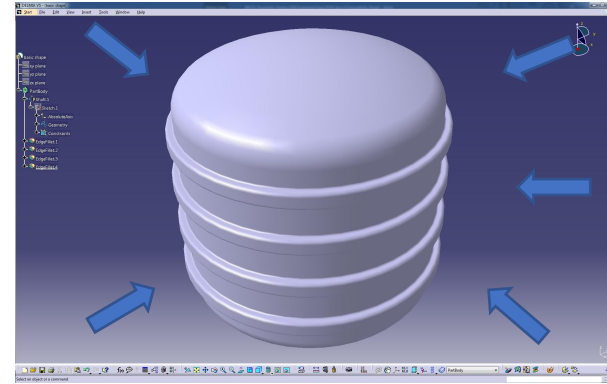
- Parametrics
  - CAD Kernel
- Vertical Tanks
  - Macros – CATIA
- Horizontal Tanks
  - Design Tables – Solidworks
- Products & Moulds

# The CAD Kernel

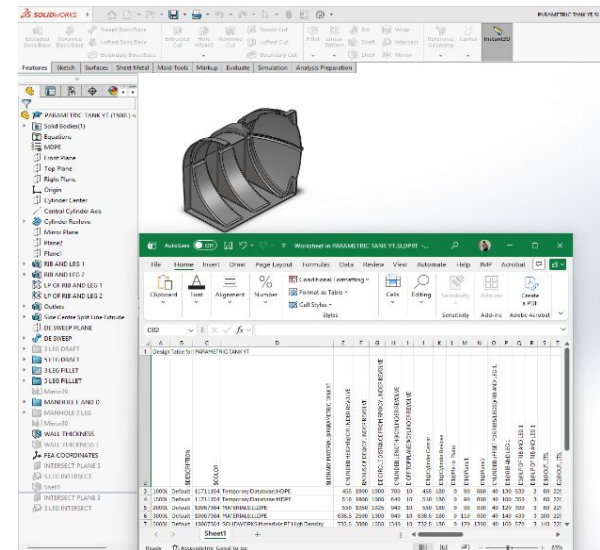


# Computer Aided Design

- 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

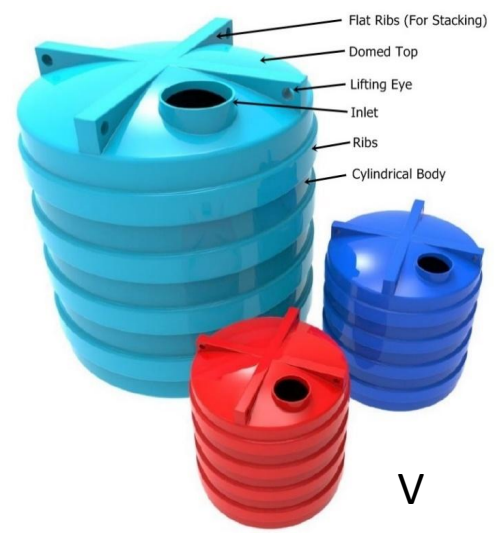
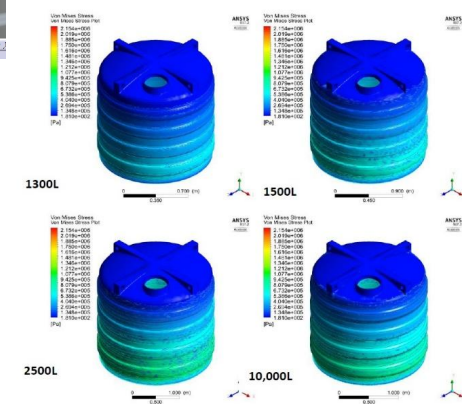
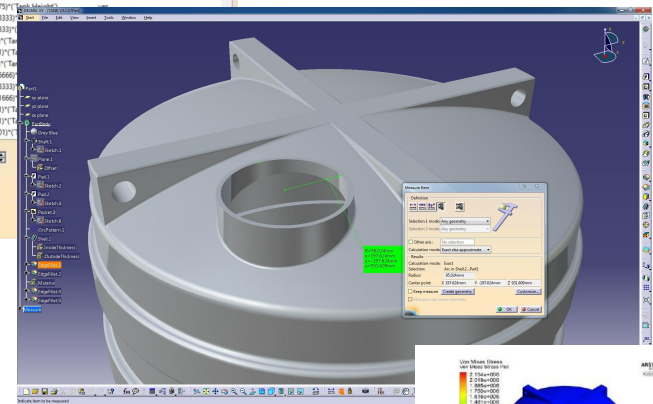
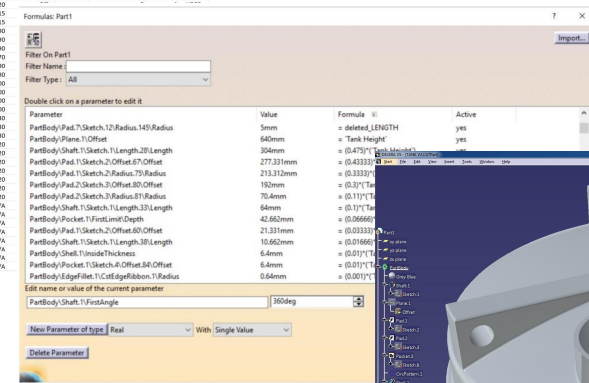


Solidworks

# 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

Manufacturer	Volume (l)	Height (mm)	Diameter (mm)	Height Diameter Ratio	Tank Opening Diameter (mm)	Tank Opening Location	No. Of Wall Ribs	Top Ribs	Material
Noboru	200	480	720	0.64	N/A	Central	2	4	MPOE
	500	1080	900	1.20	N/A	Central	4	4	MPOE
	1000	1380	1040	1.33	N/A	Central	4	4	MPOE
	1500	1590	1120	1.42	N/A	Central	8	4	MPOE
	2000	1640	1120	1.46	N/A	Central	8	4	MPOE
	3000	1770	1160	1.53	N/A	Central	10	4	MPOE
	5000	2470	1740	1.39	N/A	Central	10	4	MPOE
	10000	2440	2070	1.18	N/A	Central	12	6	MPOE
EnduraTank	800	1200	600	2.00	355	Central	0	0	HOPE
	500	1500	700	2.14	455	Central	0	0	HOPE
	1250	1300	1200	1.00	455	Central	2	2	HOPE
	2000	1900	1200	1.58	455	Central	4	2	HOPE
	3000	1800	1600	1.25	620	Central	2	2	HOPE
	10000	2300	2400	1.04	620	Central	2	2	HOPE
DESU Engineering	1500	1270	1100	1.15	415	Central	2	2	HOPE
	1500	1780	1100	1.62	415	Central	2	2	HOPE
	1675	1900	1410	1.35	390	Central	2	2	HOPE
	3050	1810	1700	1.06	390	Central	2	2	HOPE
	4250	2300	2130	1.08	390	Central	2	2	HOPE
10000	2700	2340	1.19	470	Central	2	2	HOPE	
Polylux Roto	200	410	750	0.83	290	Central	2	2	HOPE
	300	750	770	0.97	290	Central	2	2	HOPE
	500	890	930	0.96	400	Central	2	2	HOPE
	750	950	1020	0.93	400	Central	2	2	HOPE
	1000	1270	1070	1.19	400	Central	2	2	HOPE
	1500	1270	1100	1.15	400	Central	2	2	HOPE
	2000	1460	1185	0.98	530	Central	2	2	HOPE
	3000	1840	1300	1.11	530	Central	2	2	HOPE
	4000	1930	1560	0.99	530	Central	2	2	HOPE
	5000	1880	1700	1.11	530	Central	2	2	HOPE
	6000	1930	2030	0.96	530	Central	2	2	HOPE
	7000	2720	2030	1.35	520	Central	2	2	HOPE
	10000	3210	2180	1.47	520	Central	2	2	HOPE
	15000	4160	2180	2.00	520	Central	2	2	HOPE
	20000	4320	2450	1.76	520	Central	2	2	HOPE
	3000	2170	2030	1.06	520	Central	2	2	HOPE
BRS Plastik	1000	1270	1100	1.15	N/A	Central	2	2	HOPE
	1000	2400	780	3.08	N/A	Central	2	2	HOPE
	2000	4000	1050	4.51	N/A	Central	2	2	HOPE
	3000	2950	1900	1.58	N/A	Central	2	2	HOPE
	5000	1750	2300	0.76	N/A	Central	2	2	HOPE
	10000	2650	2400	1.15	N/A	Central	2	2	HOPE
	20000	4000	3000	1.33	N/A	Central	2	2	HOPE
	50000	5000	3000	1.67	N/A	Central	2	2	HOPE

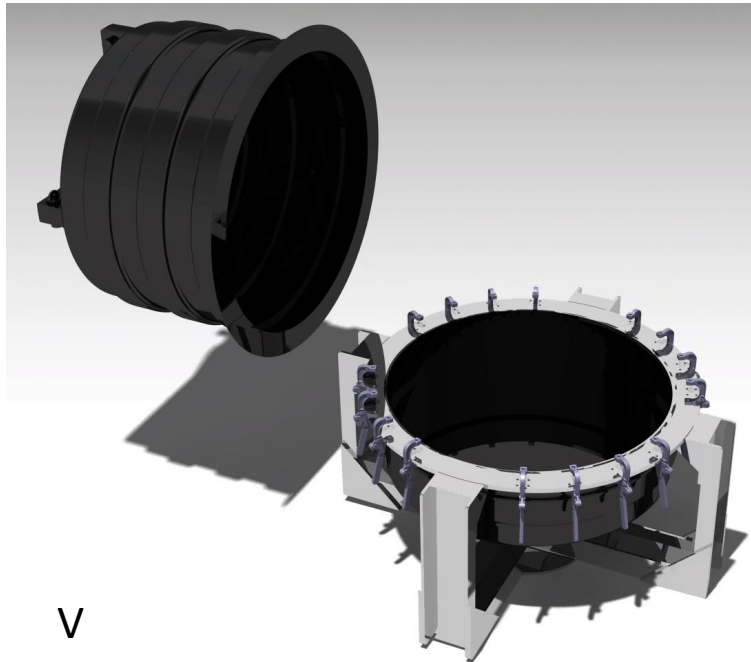
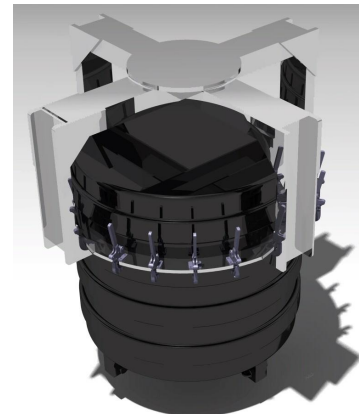
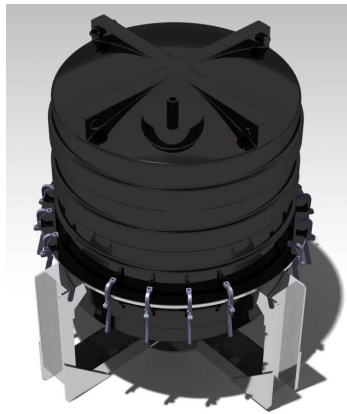


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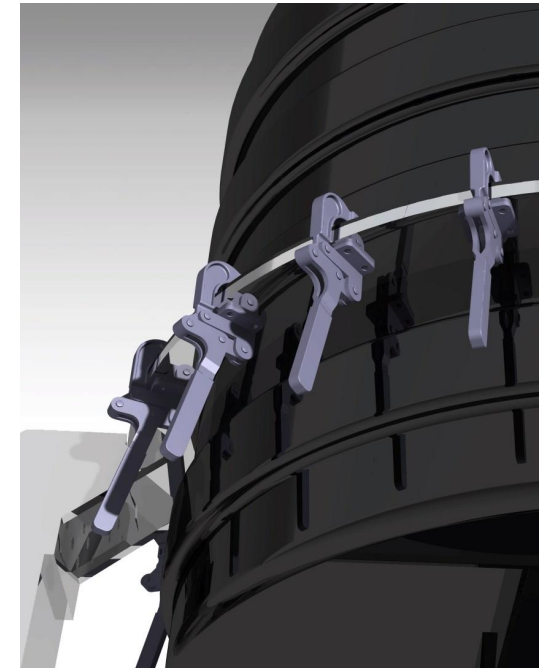
175 constraint5.Mode = catCstModeDrivingDimension
176 Dim length2 As Length
177 Set length2 = constraint5.Dimension
178 Set length2.Value = InputBox("Tank Height", "Enter Desired Tank Height:")
179
180 Dim reference10 As Reference
181 Set reference10 = part1.CreateReferenceFromObject(line2D5)
182
183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

# 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

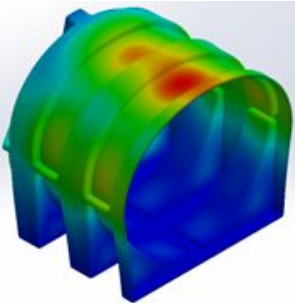
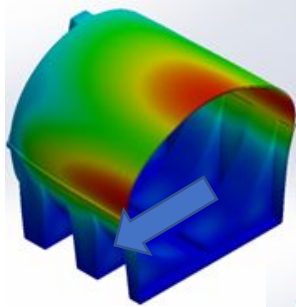
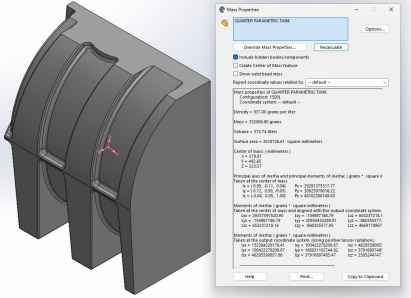
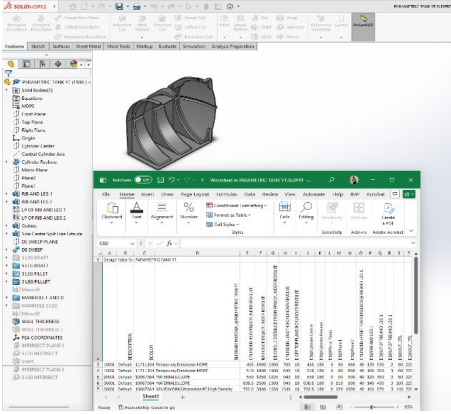


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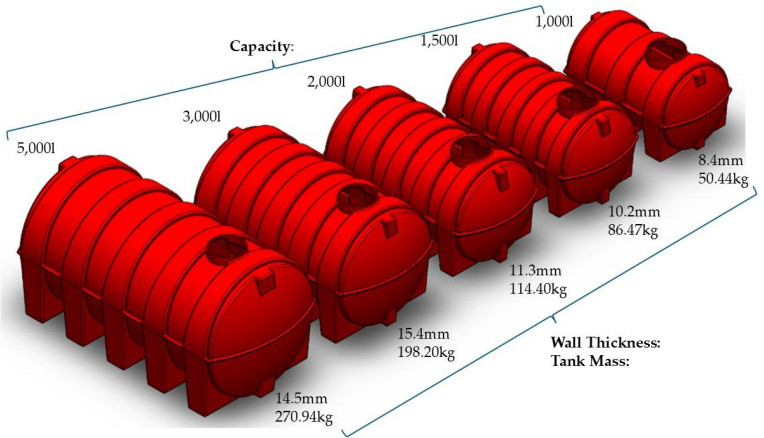
# Parametric Design: Solidworks

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



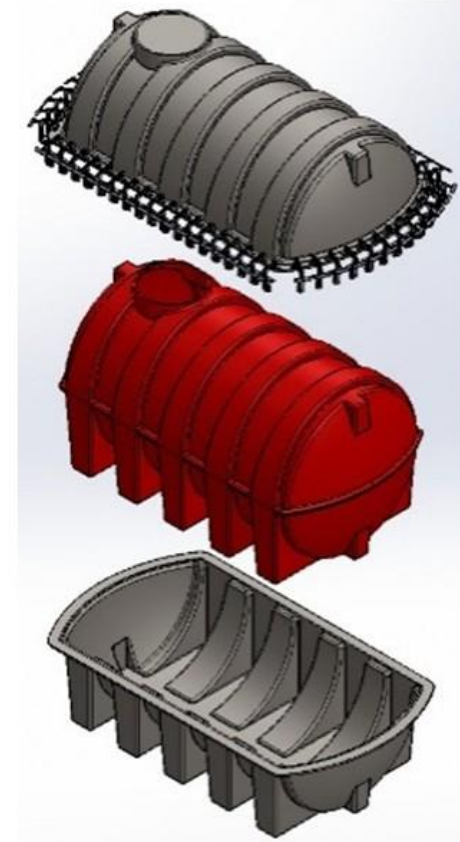
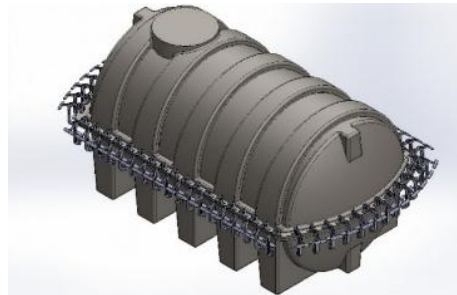
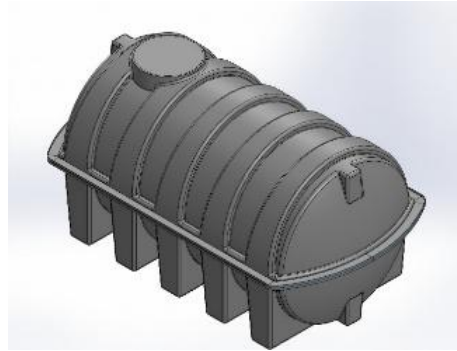
A screenshot of the 'Design Table' in SolidWorks. The table lists various design configurations for the tank, including parameters like 'Capacity', 'Wall Thickness', and 'Tank Mass'. The table is organized into columns for 'PARAMETER', 'UNIT', and 'VALUE'.

PARAMETER	UNIT	VALUE
Capacity	dm <sup>3</sup>	1,500
Capacity	dm <sup>3</sup>	2,000
Capacity	dm <sup>3</sup>	3,000
Capacity	dm <sup>3</sup>	5,000
Wall Thickness	mm	8.4
Wall Thickness	mm	10.2
Wall Thickness	mm	11.3
Wall Thickness	mm	15.4
Wall Thickness	mm	14.5
Tank Mass	kg	50.44
Tank Mass	kg	86.47
Tank Mass	kg	114.40
Tank Mass	kg	198.20
Tank Mass	kg	270.94



# Tool Design

- Conceptual design review
  - Tank proportions + shrinkage allowance
  - Additional features
    - Clamps
    - Flanges
      - High enough to retain full material charge
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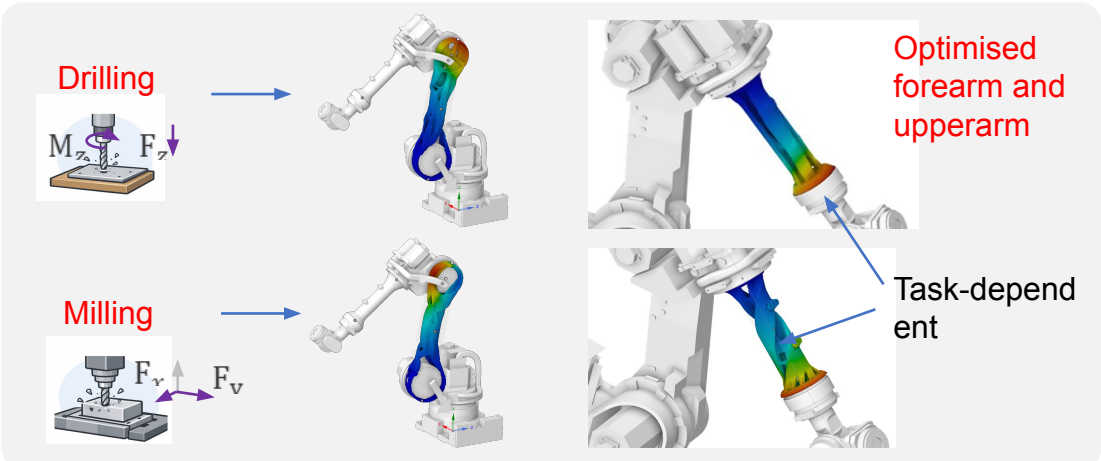
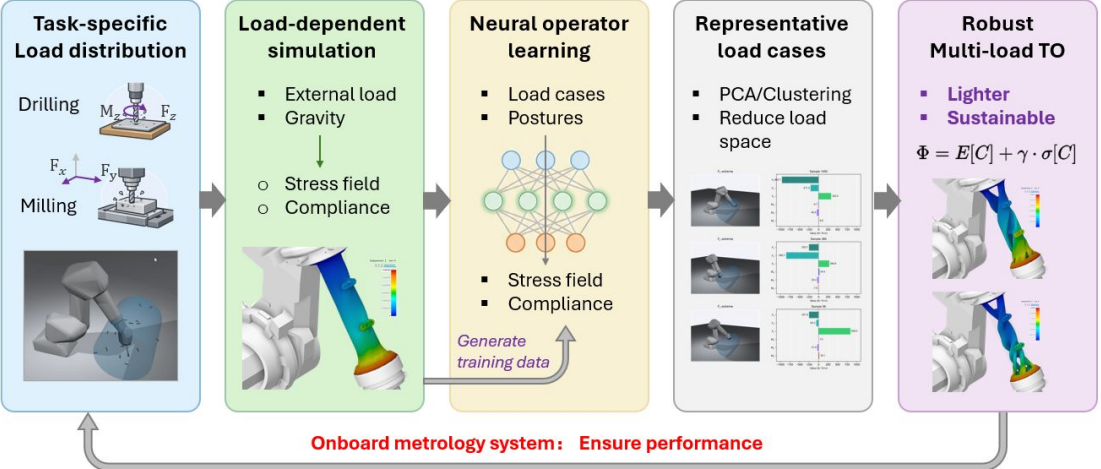
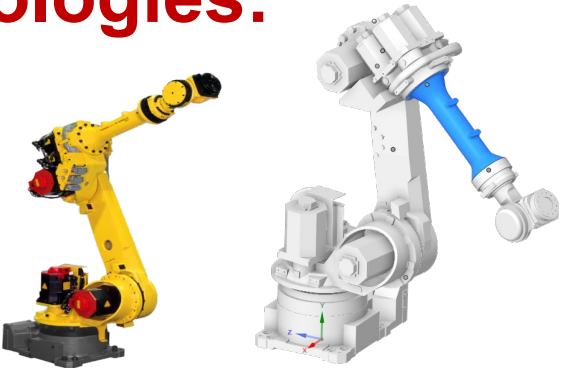
# Conclusions

- 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.

# Automated Technologies:

Fanuc  
R-1000iA/80F

- Lighter
- Sustainable

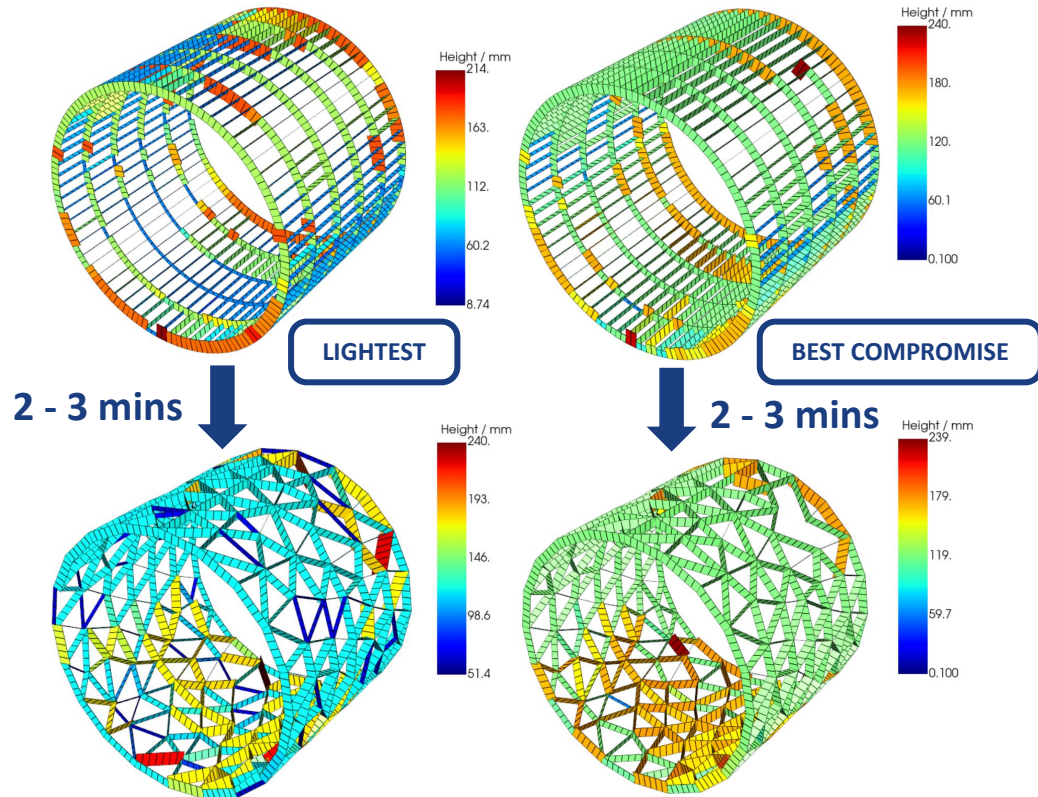


- Enhanced structural configurations for robot arms:
  - Topology optimisation:
    - *Determines optimal design for specific goal, given a set of constraints, loads, and boundary conditions, by adding or removing geometric features and adjusting their size.*
- Applications
  - Drilling:
    - Linear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

# 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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