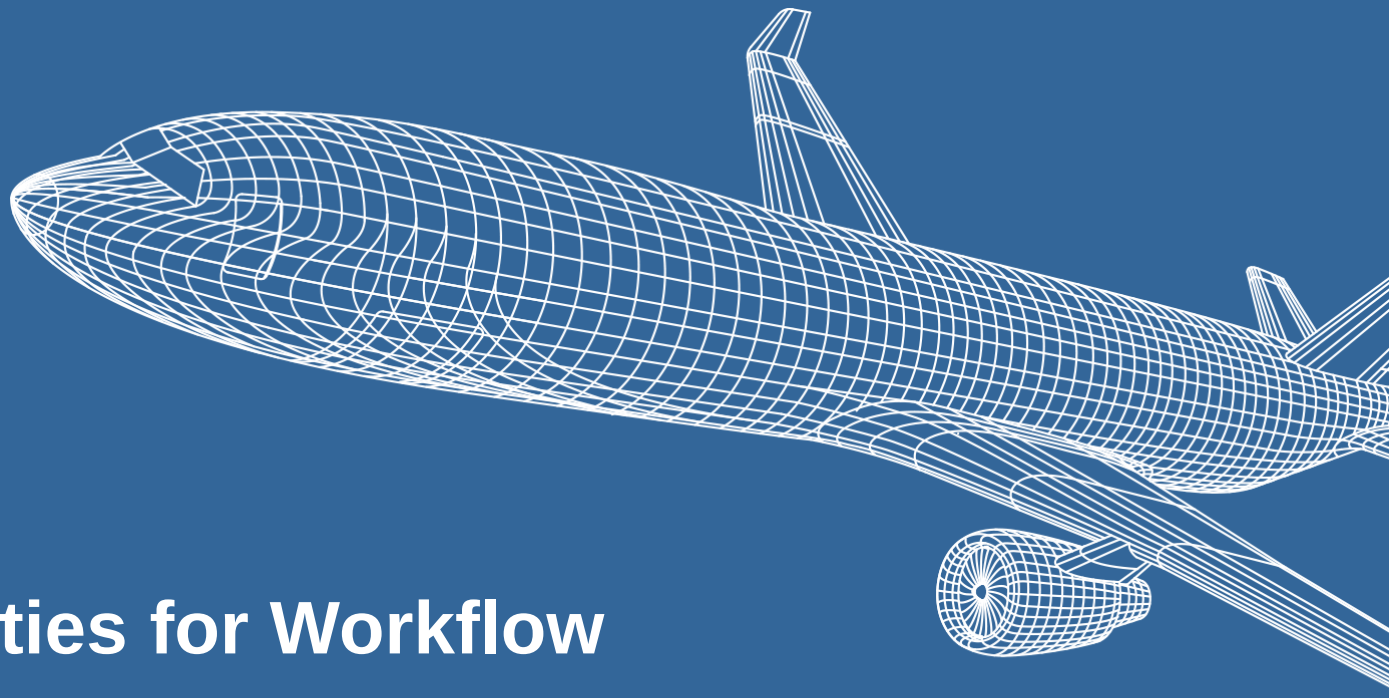


Opportunities for Workflow Automation in an Engineering Environment

Max Markestein
Manager Stress Engineering

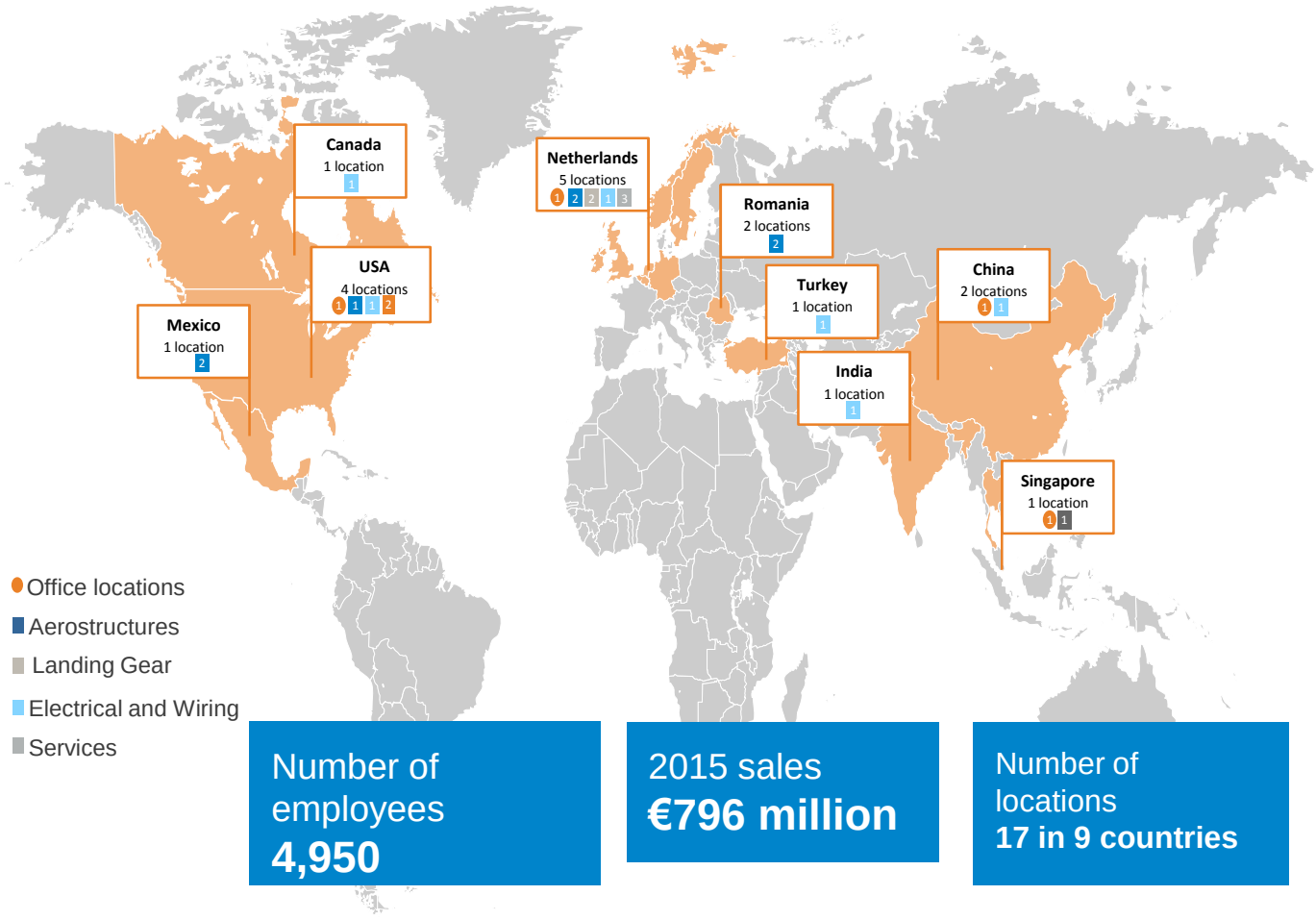
Contents

- GKN – Fokker Technologies - Fokker Aerostructures
- Opportunities in an engineering environment
- Workflow automation
- Democratized CAE
- Increase design maturity

Fokker Technologies

Founded in 1919, acquired by GKN Aerospace in 2015

Fokker Technologies
Leading multi-technology specialist



Number of employees
4,950

2015 sales
€796 million

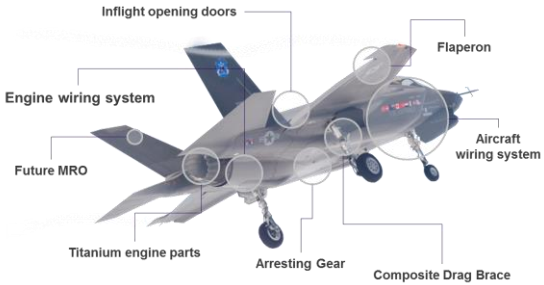
Number of locations
17 in 9 countries

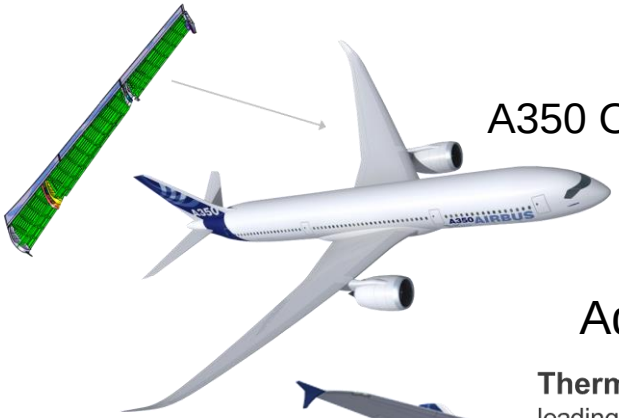
Fokker Aerostructures
Example products

Floorboards

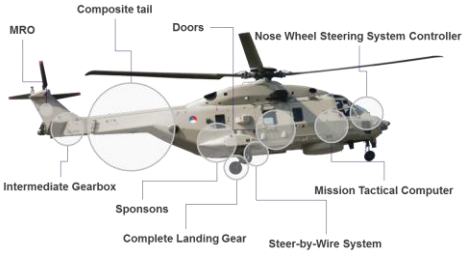
Empenage

Military





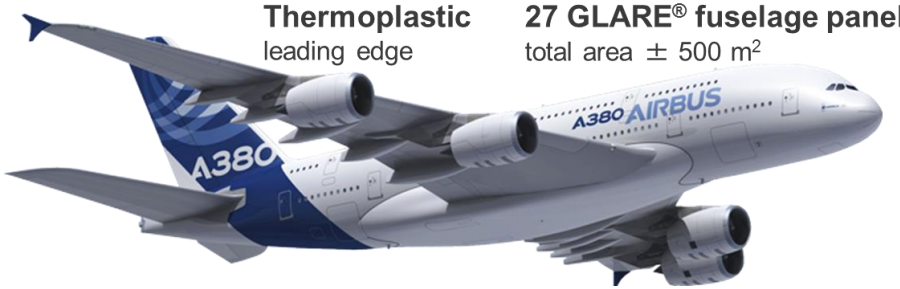
A350 OTB Flaps



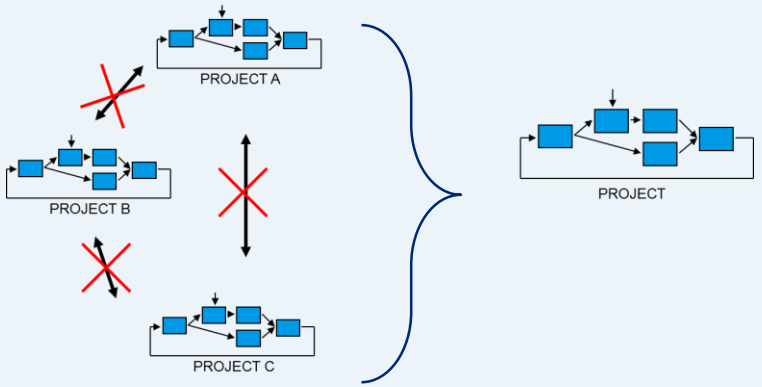
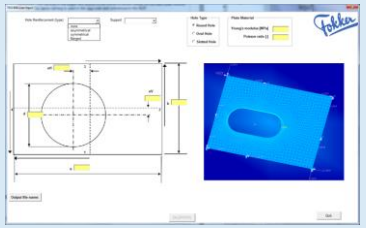
Advanced Technologies: FML & TP-welding

Thermoplastic leading edge

27 GLARE® fuselage panels total area ± 500 m²

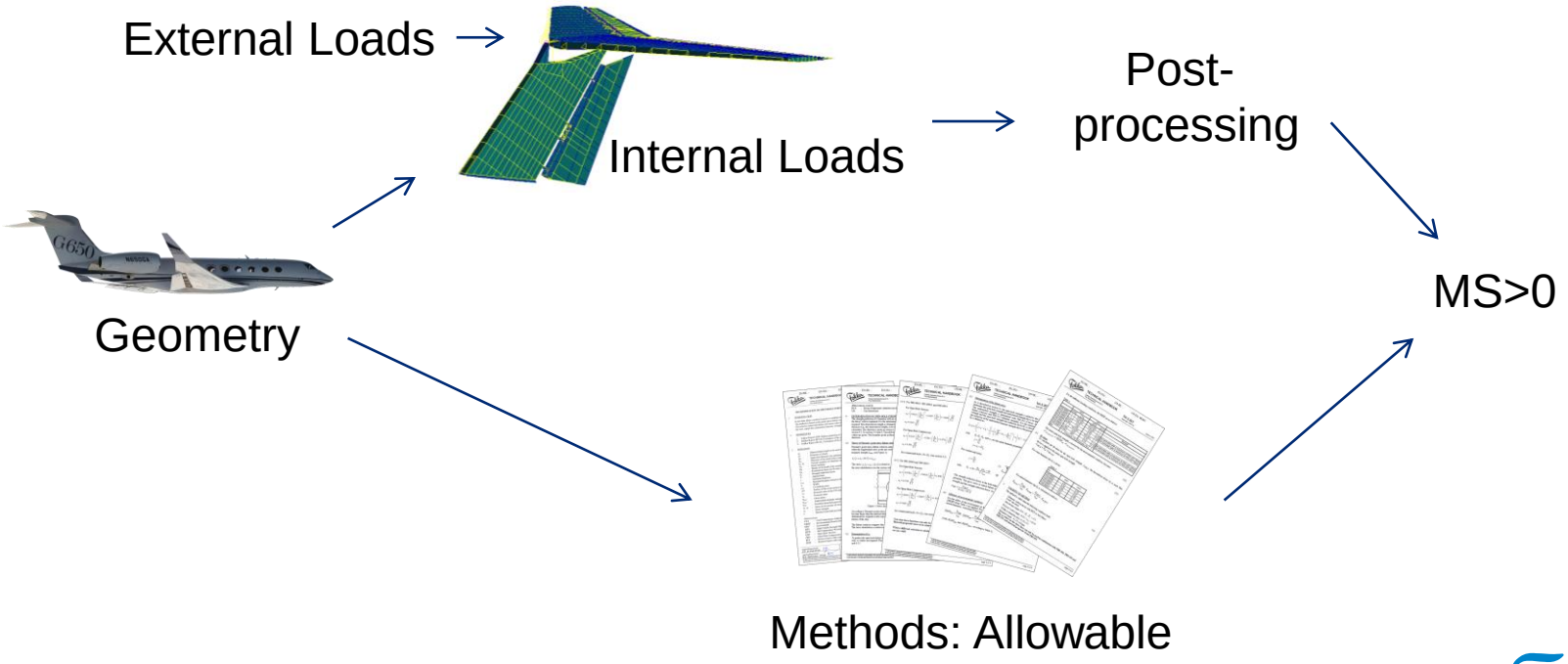


Opportunities

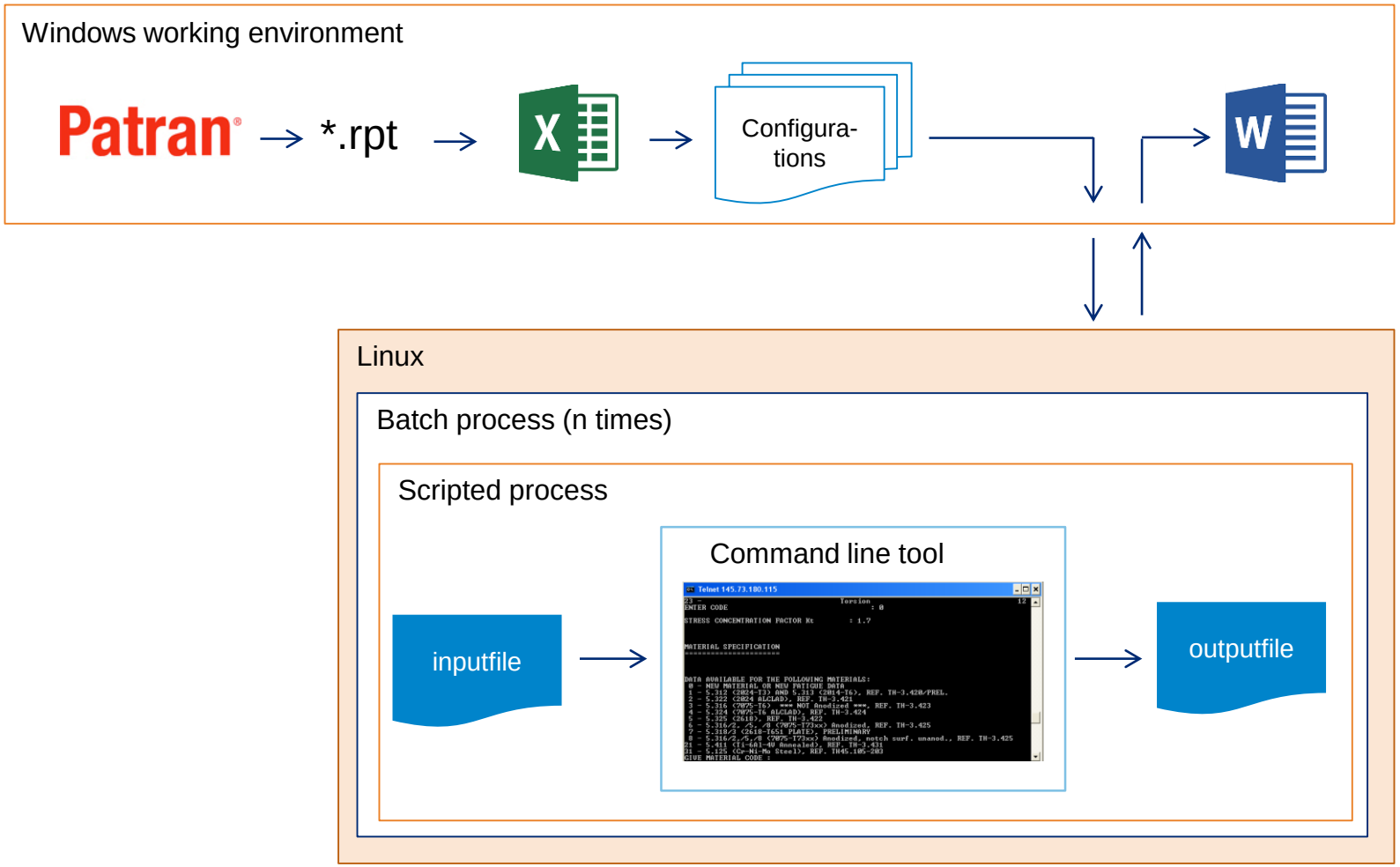
Reduce non-value added work: e.g. data handling	Process integration
Offer standardization to multisite projects and varying teams see the same challenges	
Offer more complex CAE assisted analyses	
Increased design maturity in all stages of the project	DOE, Optimization, Frontloading

The workflow automation opportunity
Typical process

- The structural analysis in the aerospace is characterized by the use of validated toolsets and methods, sometimes with a long legacy and old fashioned way of use.



The workflow automation opportunity
Typical data handling problem

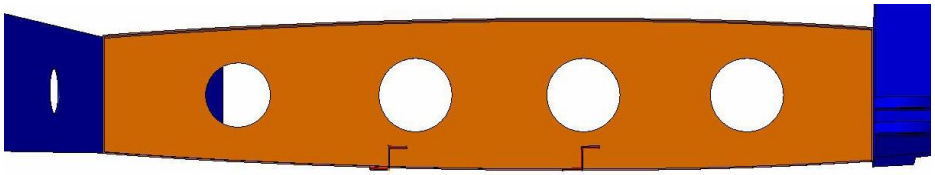


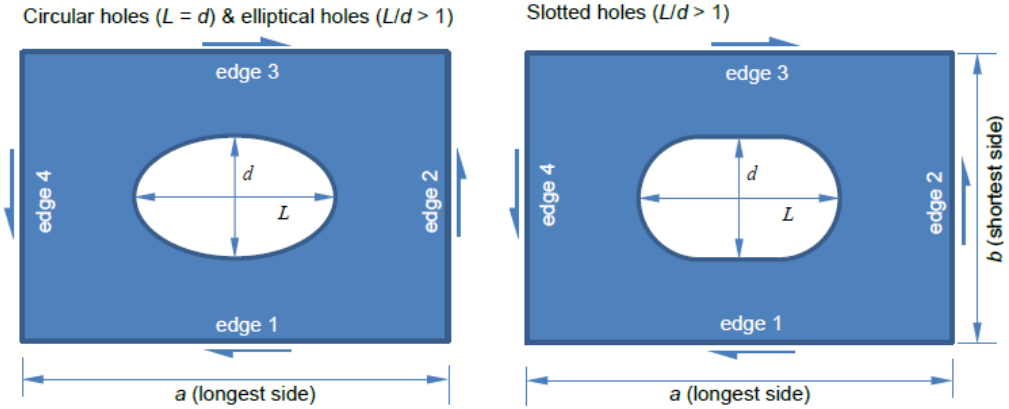
The workflow automation opportunity
Examples of deployed tools

Tool name	Tool description
A.1.1.001 Composite skin	Calculate composite skin strength and stability
A.2.1.002 Metallic Ribs Webs	Calculate metallic rib webs strength and stability
A.3.1.005 Metallic Ribs stiffeners	Calculate metallic rib longitudinal and transverse stiffener strength and stability
A.4.1.002 Metallic Ribs flanges	Calculate metallic rib flanges connection to skin and beams
A.9.4.002 Diesel to FATDAC_SPRAC	Convert Gulfstream Diesel output into FATDAC/SPRAC input
A.9.4.002 Diesel to FATDAC_SPRAC Batch	Convert Gulfstream Diesel output into FATDAC/SPRAC input
A_101 Joint strength and bearing	This application can be used to calculated the inplane MS of a joint (composite sandwich skin to metal substructure)
A_102 Panel+facing stability	This application can be used to calculated the stability MS of a composite sandwich panel and its facings
A_103 Facing strain cutoff	This application can be used to calculated the facing strain cut-off MS of a composite sandwich panel
A_104 Core strength	This application can be used to calculated the core strength MS of a composite sandwich panel
A.302 Submit Isami stand alone analysis	Submit Isami stand alone analysis with Excel- or text file template
A.16.1.001 Rainflow counting (SMS)	Rainflow count the 28 Fatdac input files from Fatigue wizard and create one spectrum file and run fatdac
A.16.1.001 Rainflow counting Batch (SMS)	Rainflow count the 28 Fatdac input files from Fatigue wizard and create one spectrum file and run fatdac
TH3.906	Calculate initial shear buckling stress of rectangular flat isotropic plates with one hole
run Nastran batch	Run all Nastran bdf files in a directory

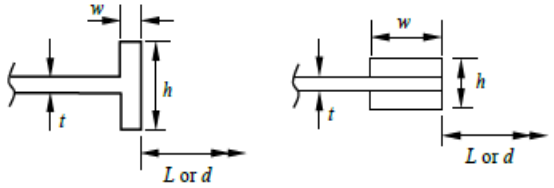
Offer more complex CAE assisted analyses
"Democratized CAE"

- Stability of reinforced holes in ribs or spars

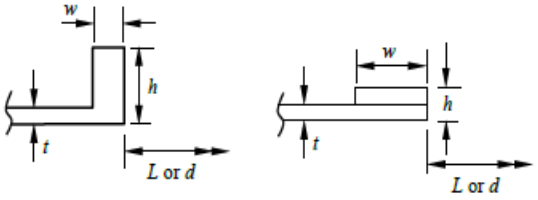




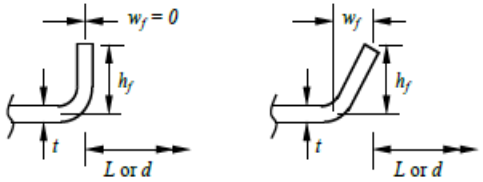
(1) Hole with a symmetrical reinforcement:



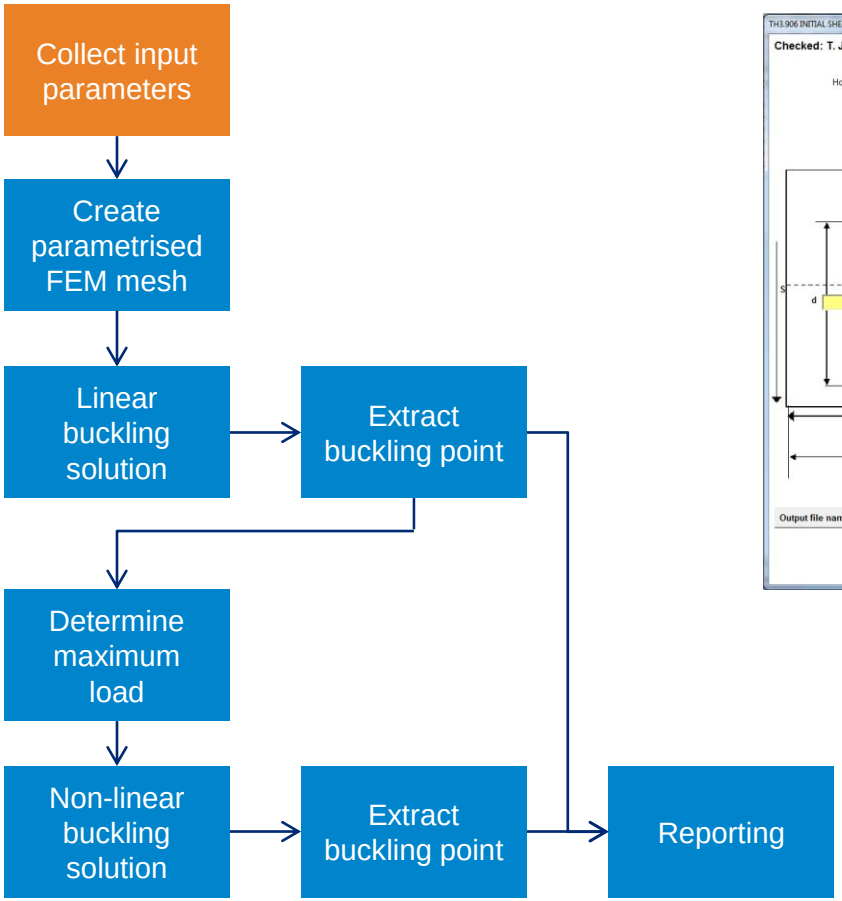
(2) Hole with an asymmetrical reinforcement:

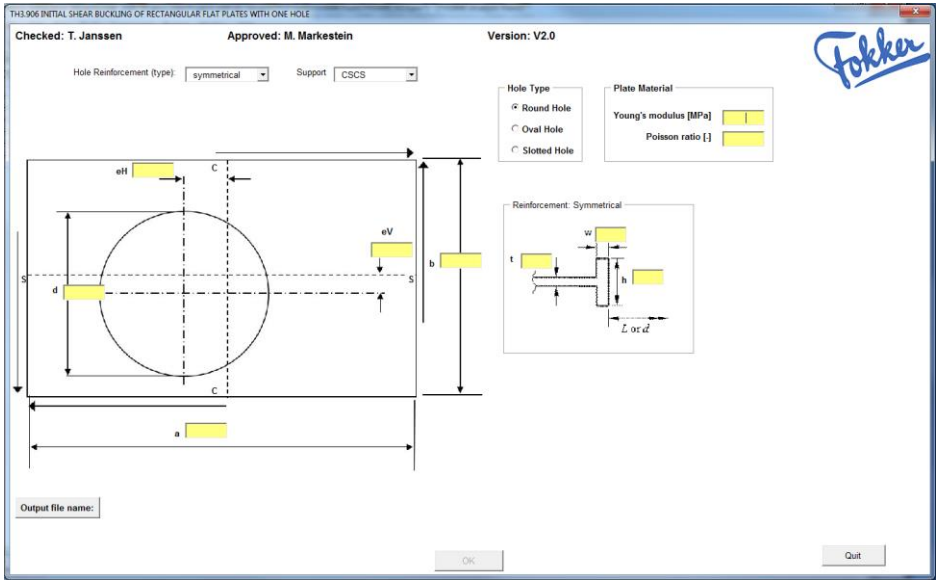


(3) Hole with a flanged reinforcement (sheet metal only):



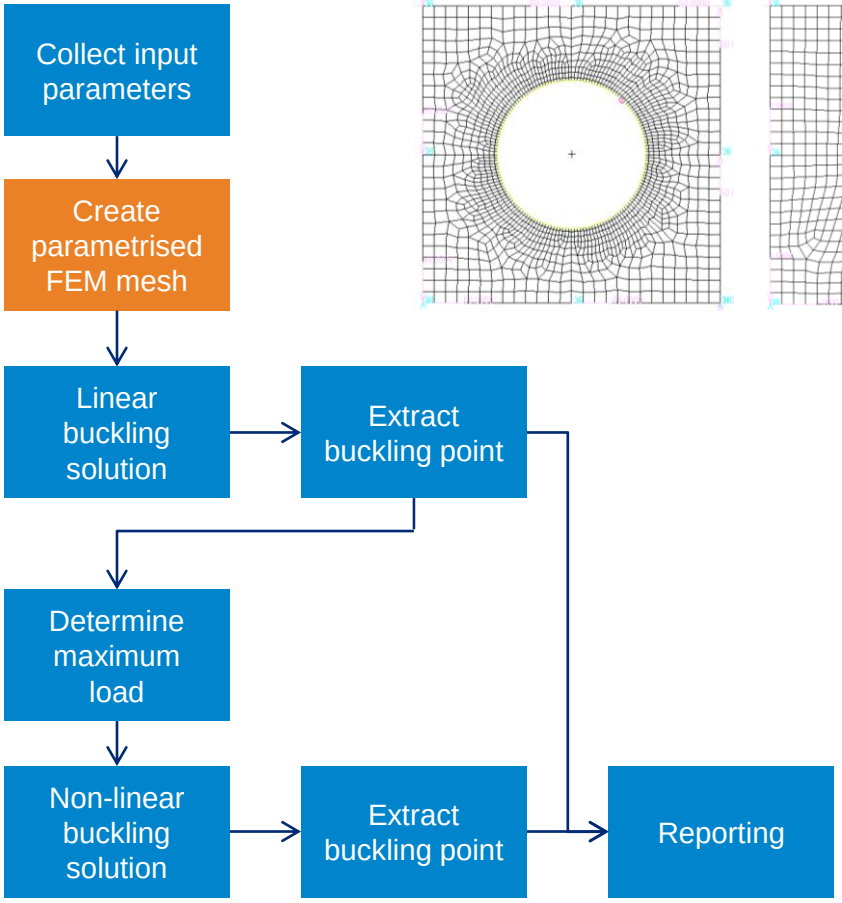
Offer more complex CAE assisted analyses
Gui

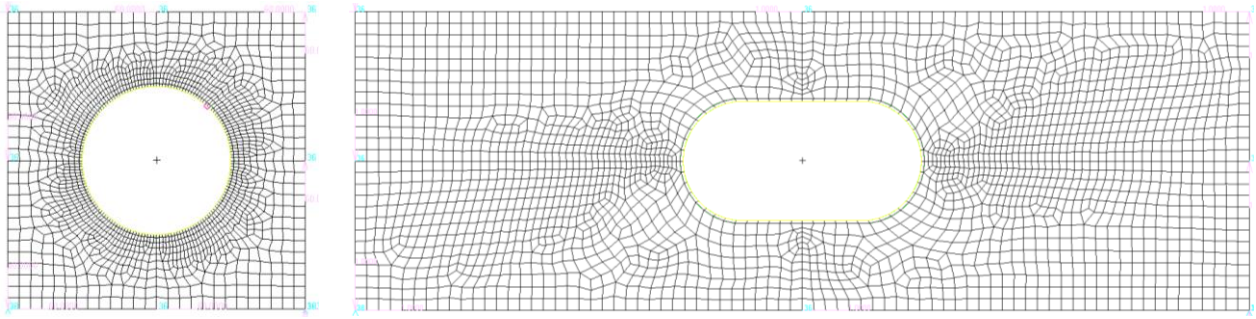


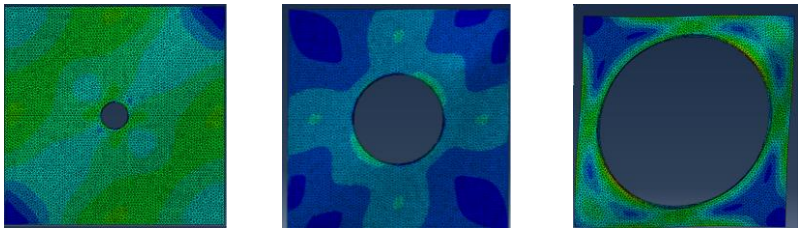


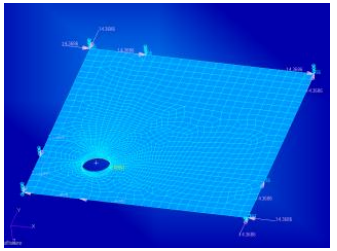
- All workflows tend to get complex rather quick → offer a user interface to the user
- Check consistency of input and validity ranges

Offer more complex CAE assisted analyses
Robustness in mesh creation



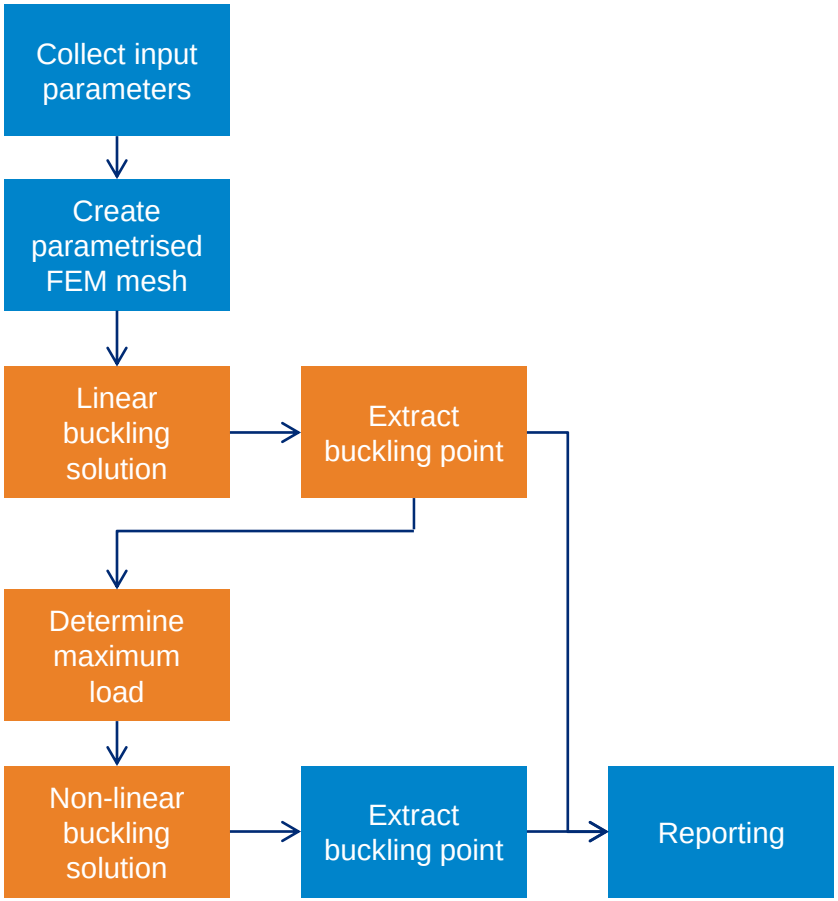




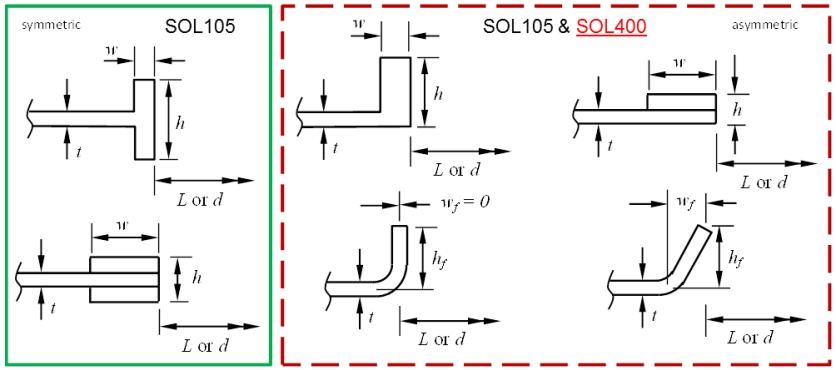


→Mesh suitable in all cases, validity?

Offer more complex CAE assisted analyses
Non-linear settings



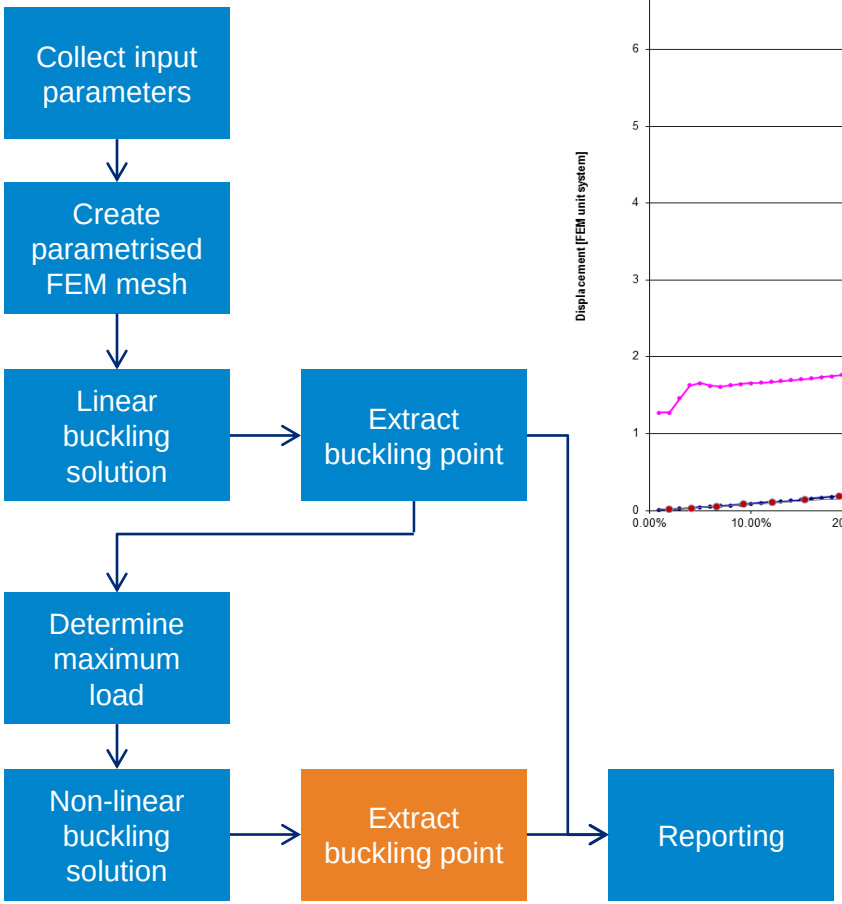
- Non-linear analyses done for all asymmetric and flanged reinforcements
- Typical sequence: first run SOL105 for load estimate
  Then run SOL400 with SOL105 load as 100%

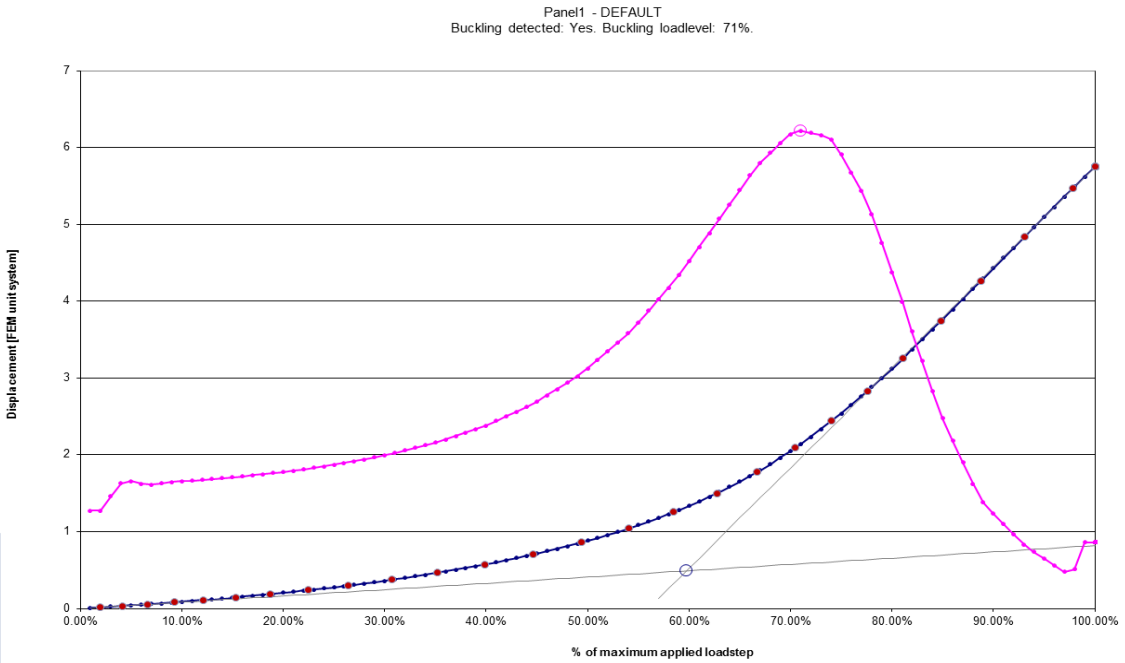


- Problem 1: NL settings should work for all possible geometry variations within validity range of tool
- Problem 2: finding optimum NL settings for required accuracy and minimized runtime is a time consuming process!

Offer more complex CAE assisted analyses

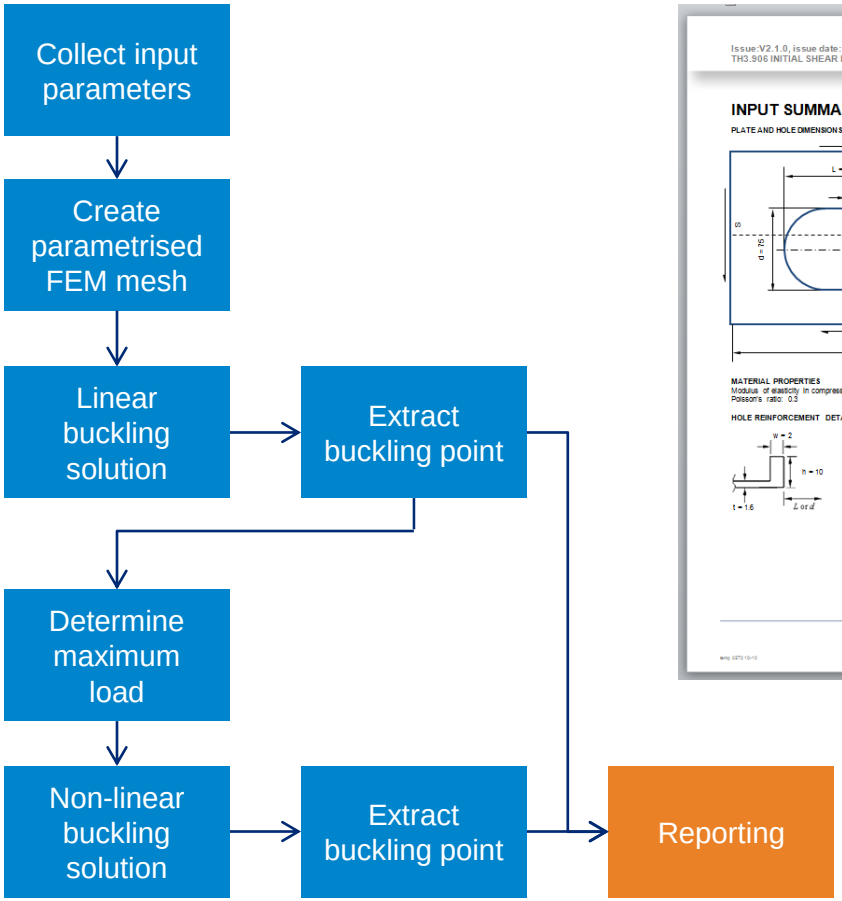
What is buckling?

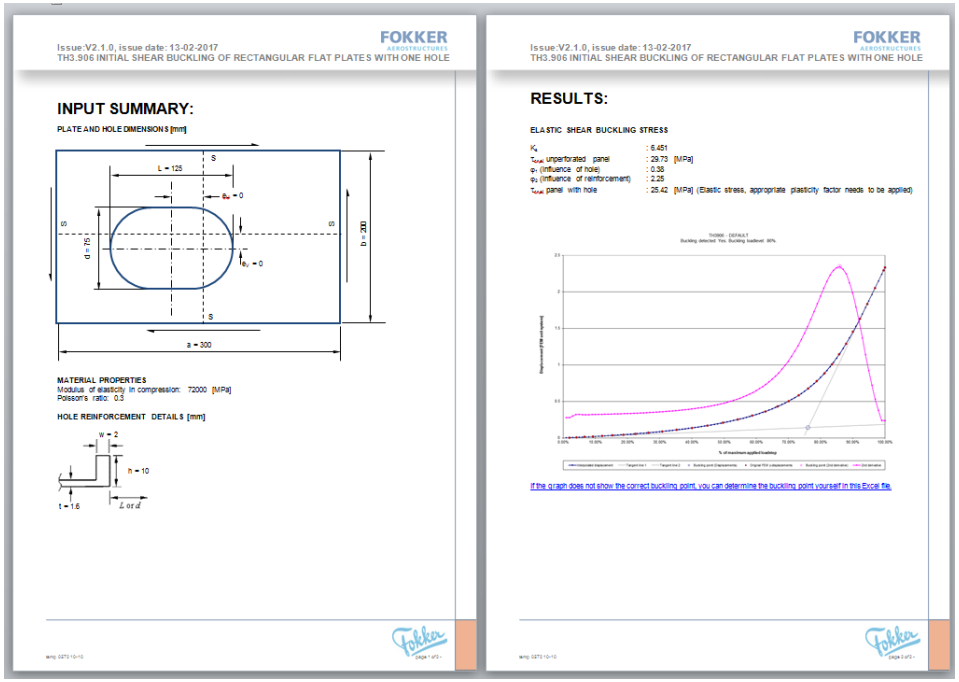




- FEM load steps: red dots
- Cubic spline function fitted: z-displ at each 1% load increment
- 2nd derivative from interpolated values: magenta line
- Peak = “buckling”

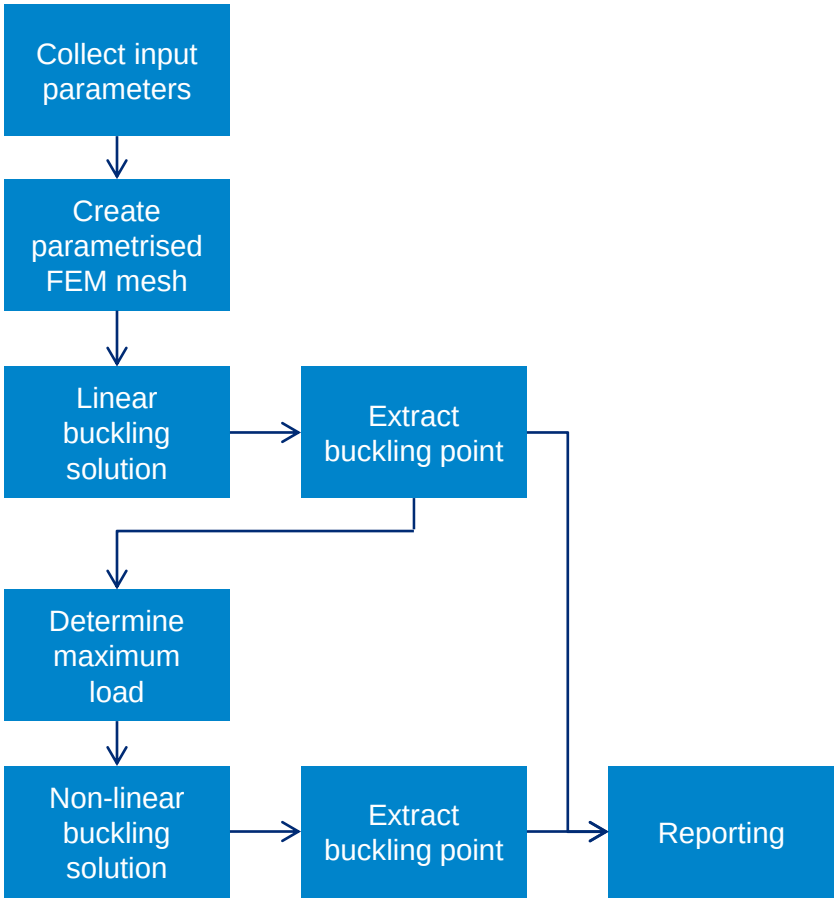
Offer more complex CAE assisted analyses
Feedback to the user

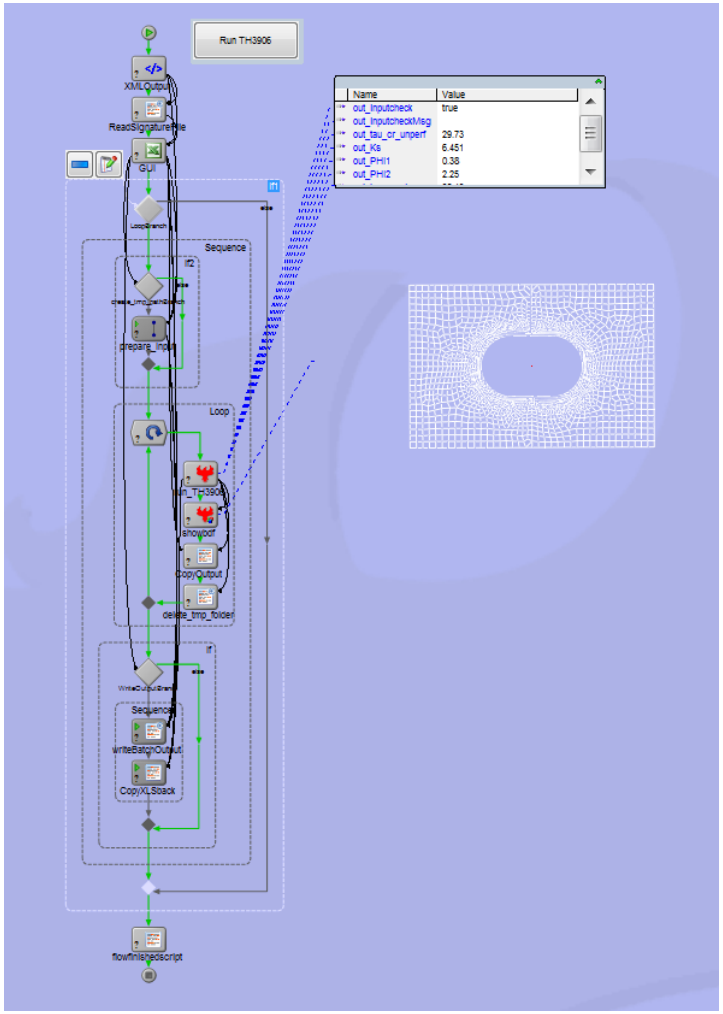




Offer more complex CAE assisted analyses

Modelcenter workflow



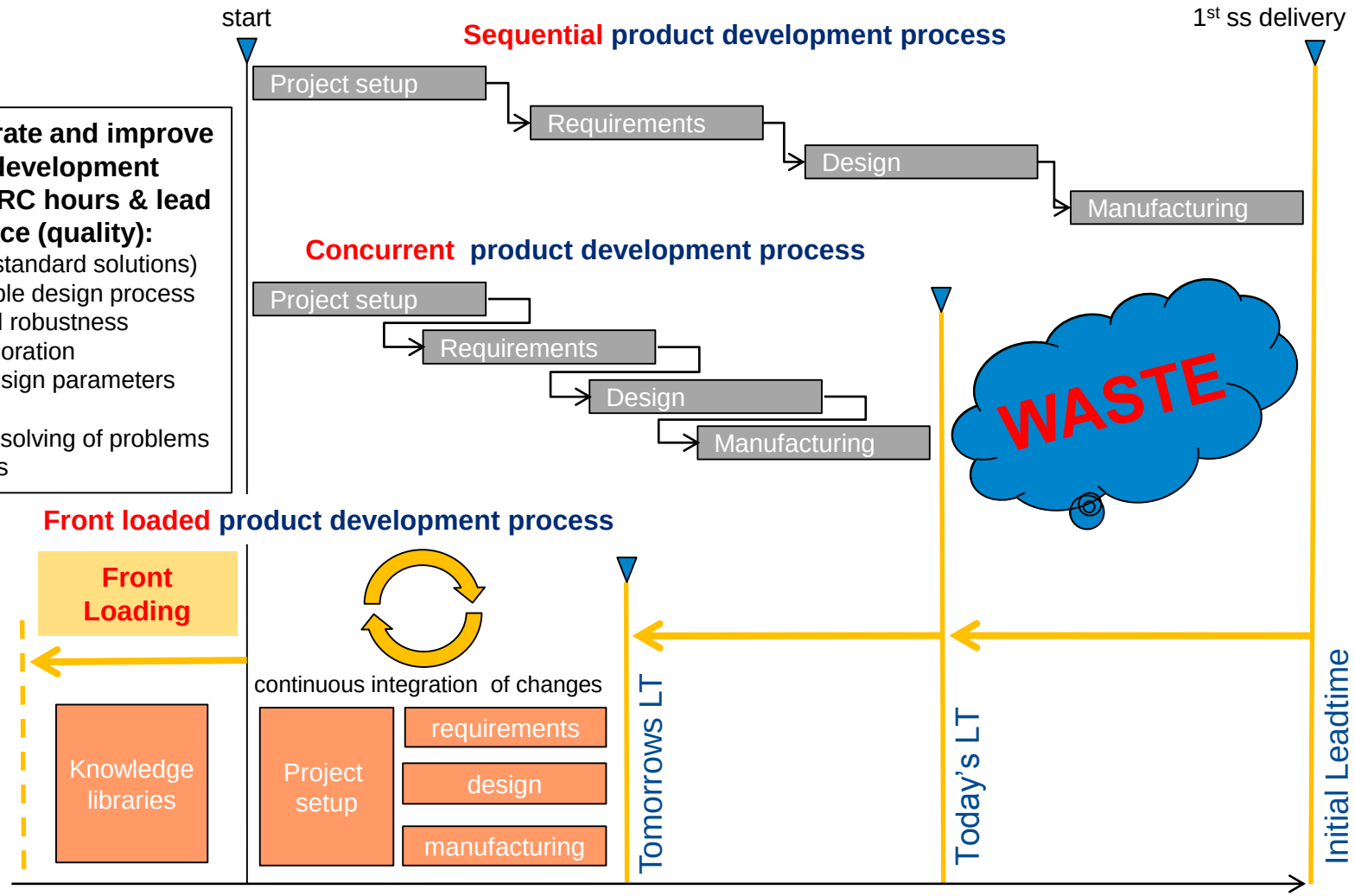


Increase design maturity in all stages of a project

Past, Present, Future

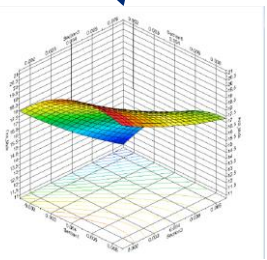
A strategy to accelerate and improve the overall product development execution (reduce NRC hours & lead time) and performance (quality):

- Re-use of knowledge (standard solutions)
- Standardized, predictable design process
- Evaluate sensitivity and robustness
  - Design Space Exploration
  - Knowing driving design parameters
- Fast design maturity
- Early identification and solving of problems
- Quickly absorb changes

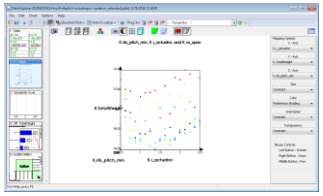


Increase design maturity
The principle

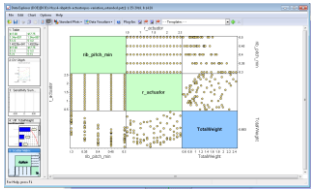
analysis model → DOE → chosen design variables + experiments → RSM → RSM model → global MOO → area of optimum + analysis model → local MOO → optimum → robustness analysis



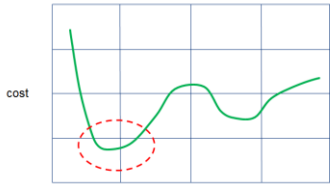
approximation of behaviour to enhance performance



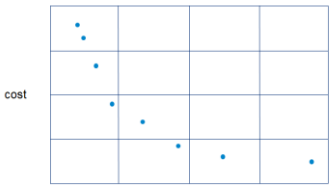
explore boundaries



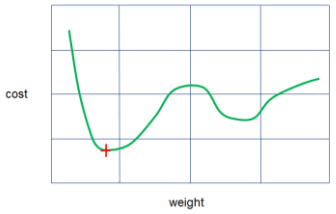
determine driving parameters



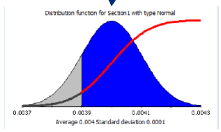
find area of global optimum



Pareto front



find optimum



check robustness w.r.t. variance in input

Increase design maturity in all stages of a project

Toolset development

1. Master Geometry Model:
   - Defines location of all conceptual structural items (skins, spars, ribs) and collects all (external) interfaces

2. CAD2FEM
   - The CAD to FEM process contains all process steps to go from MGM design geometry (CAD) to a finite element model (FEM) that can be run by a solver

3. Stress Analysis:
   - Post-processing of FEM results and performing stress analysis:
     - Buckling / Stability, Material strength, Joint strength

4. Detailed CAD models:
   - Creation of CATIA solid models for use in mock-up
   - Hinges, Rear Spar and Ribs implemented