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THE APPLICATION OF MODEL BASED SYSTEM ENGINEERING TO SIGNIFICANTLY IMPROVE TESTING AND QUALIFICATION OF AEA

March 2023

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WILL USING MBSE IMPROVE SAFETY WHILE SIMULTANEOUSLY BRINGING IMPROVED PRODUCTS TO MARKET FASTER AND AT LOWER COST?

- **Survitec *and our customers* are on a journey to digitise our systems and transform the approach to delivering AEA.**
- **Customers demanding rapid support of changing requirements and equipment needs.**
- **The development of a Model Based Systems Engineering(MBSE) tool set will enable safer equipment to be developed, qualified and delivered quicker than with traditional methodologies.**

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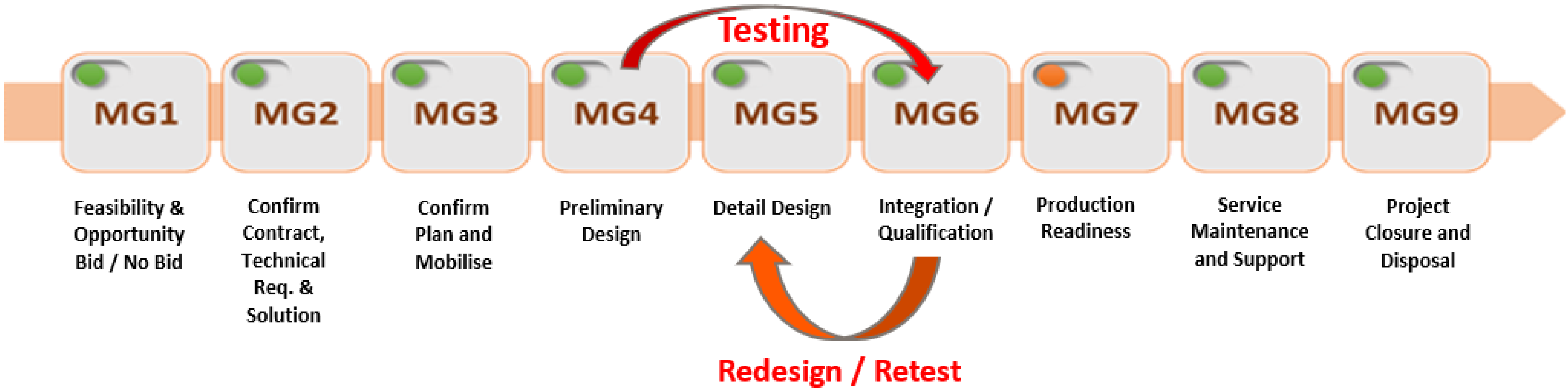
The Traditional Physical Approach To Test and Qualification Brings Inherent Program Risk.

- **Current design process relies on design, prototyping and physical test to qualify solutions.**
- **Material, component & sub-assemblies tested independently prior to system test – risk at system test.**
- **Test failures can generate "re-design loops" until the requirements are met.**

The Design Maturity Gate Stages



The Traditional Physical Approach To Test and Qualification Brings Inherent Program Risk.

- System level testing can be prohibitively expensive and usually at the end of the project.
- To de-risk projects, solutions can be over-engineered and design innovation can be curtailed in favour of adopting proven, lower risk solutions.

100% physical approach to Test and Qualification can lead to reduced optimisation of designs

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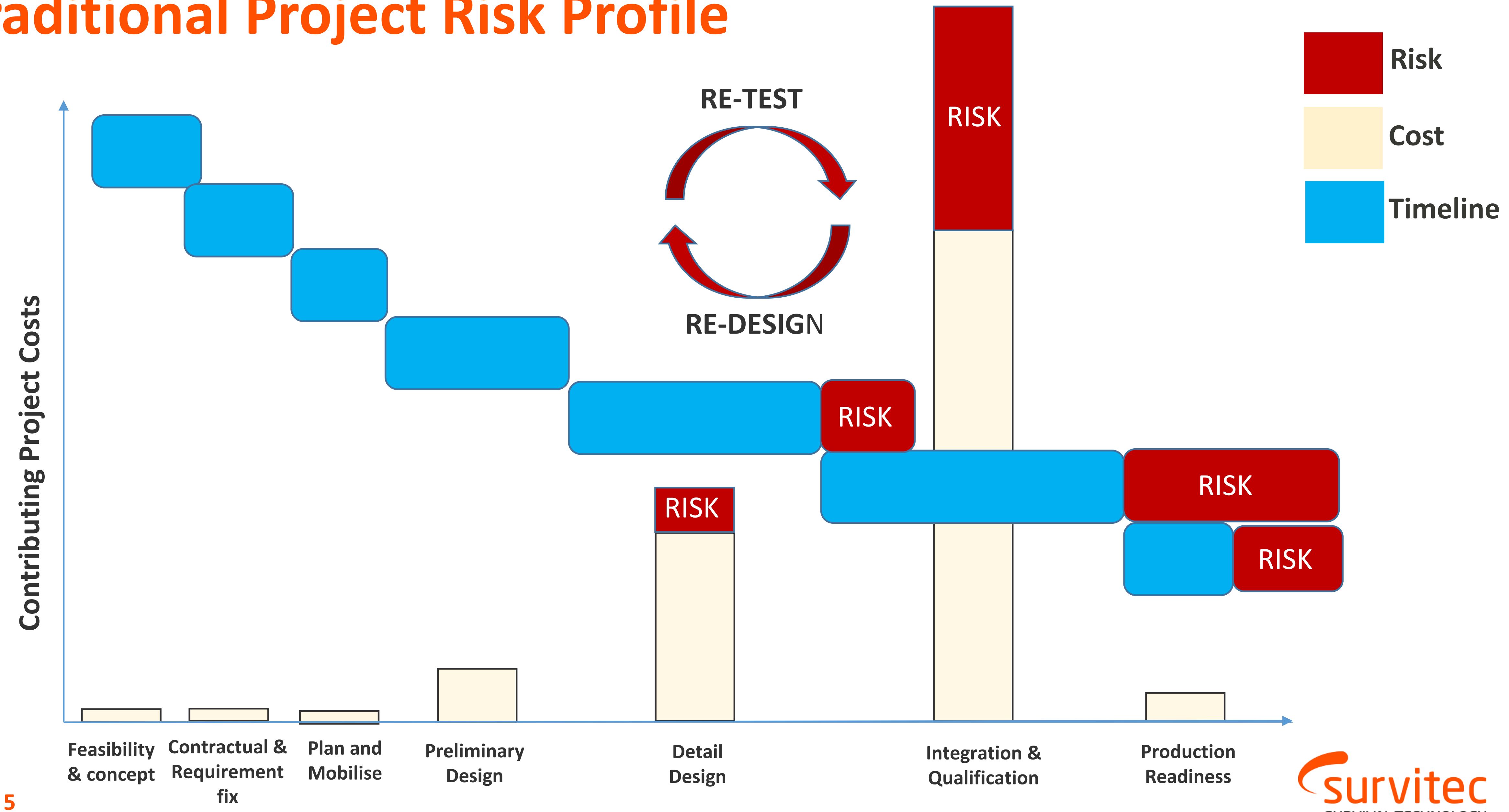
Traditional Project Risk Profile



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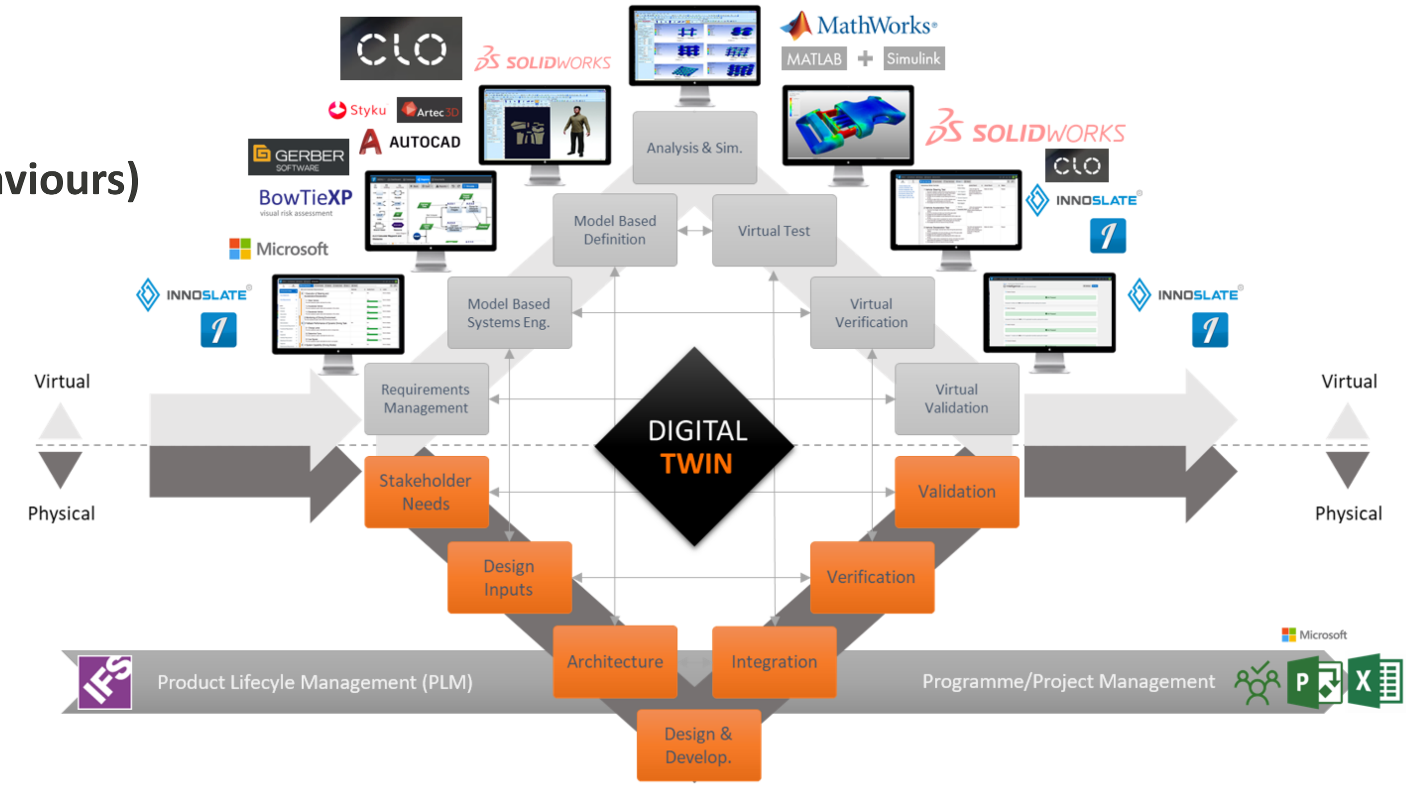
Current State – Hybrid Design Methodology

- Model the components in a digital world by utilising the decades of data and qualification evidence held by Survitec (Data harvesting)
- Optimise the models
- Validate the models (especially non-linear behaviours) against known qualification source data.
- Run the simulations
- Analyse the results
- Improve the designs
- Re-run the simulation
- Perform real time testing to validate (if required)
- Verify the component as well as system behaviour



Digital models optimised and validated by database of physical test results

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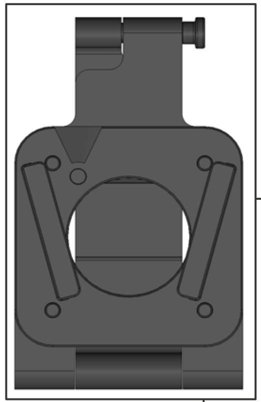
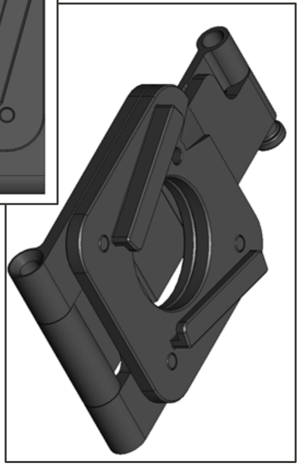
CASE STUDY – CRU60/P Flight Jacket Plate Development

- Existing attachment plate for the oxygen supply hose is configured for attachment to parachute harness.
- Modularity & adjustability significant design drivers, plate reconfigured for attachment to Flight Jacket.
- Requirement for minimal footprint, configurable on waistcoat, meet performance / safety requirements.

Existing Solution

New Solution





Opportunity to work with customer on first digital qualification of integrated component

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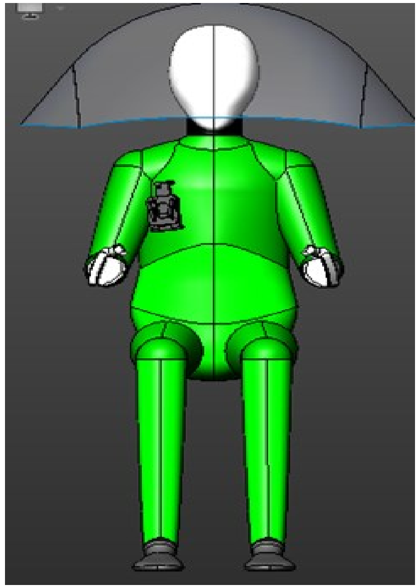
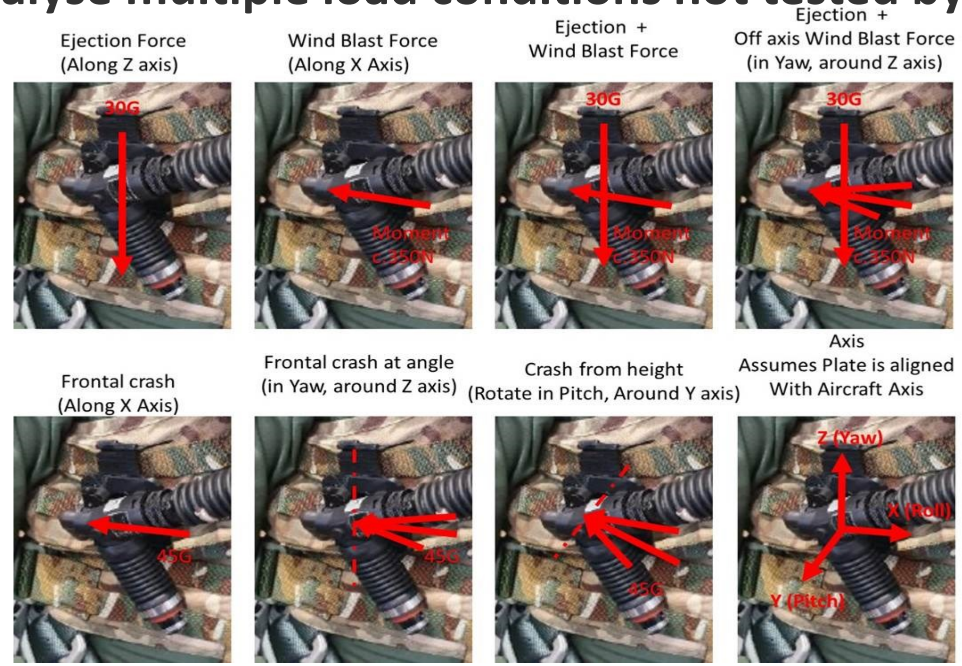
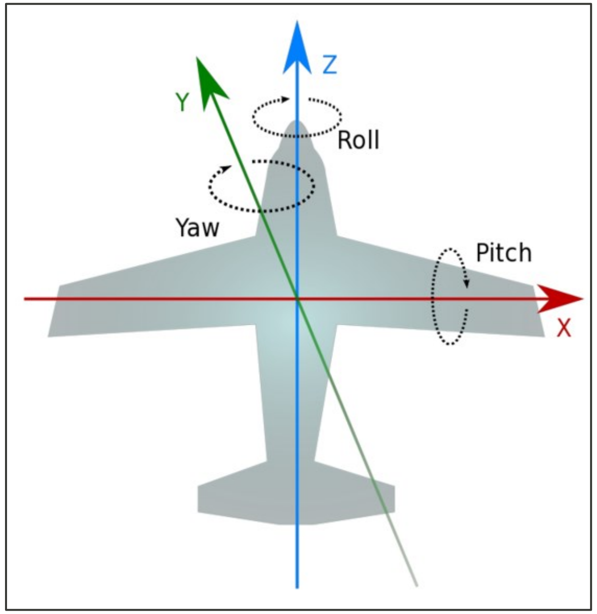
How Things Were Done Differently

- Traditional method would entail design, integration, test of the new plate including wind blast test
  - Customer desire for faster, lower cost approach.
- Employed a MBSE approach faster route to solution and delivering underpinning qualification data.
- Built model & analysed various loading conditions based on aircraft orientation and forces applied
  - Ejection or head on collision.
- Additional opportunity to analyse multiple load conditions not tested by wind blast.



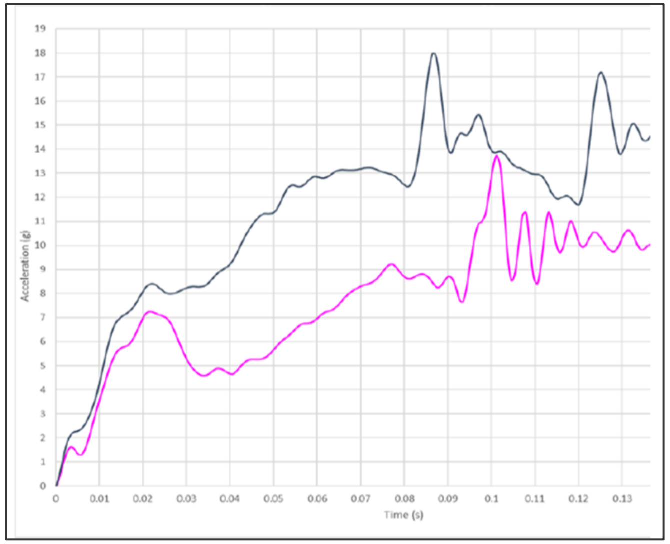




Optimised safer solution developed with reduced time and cost

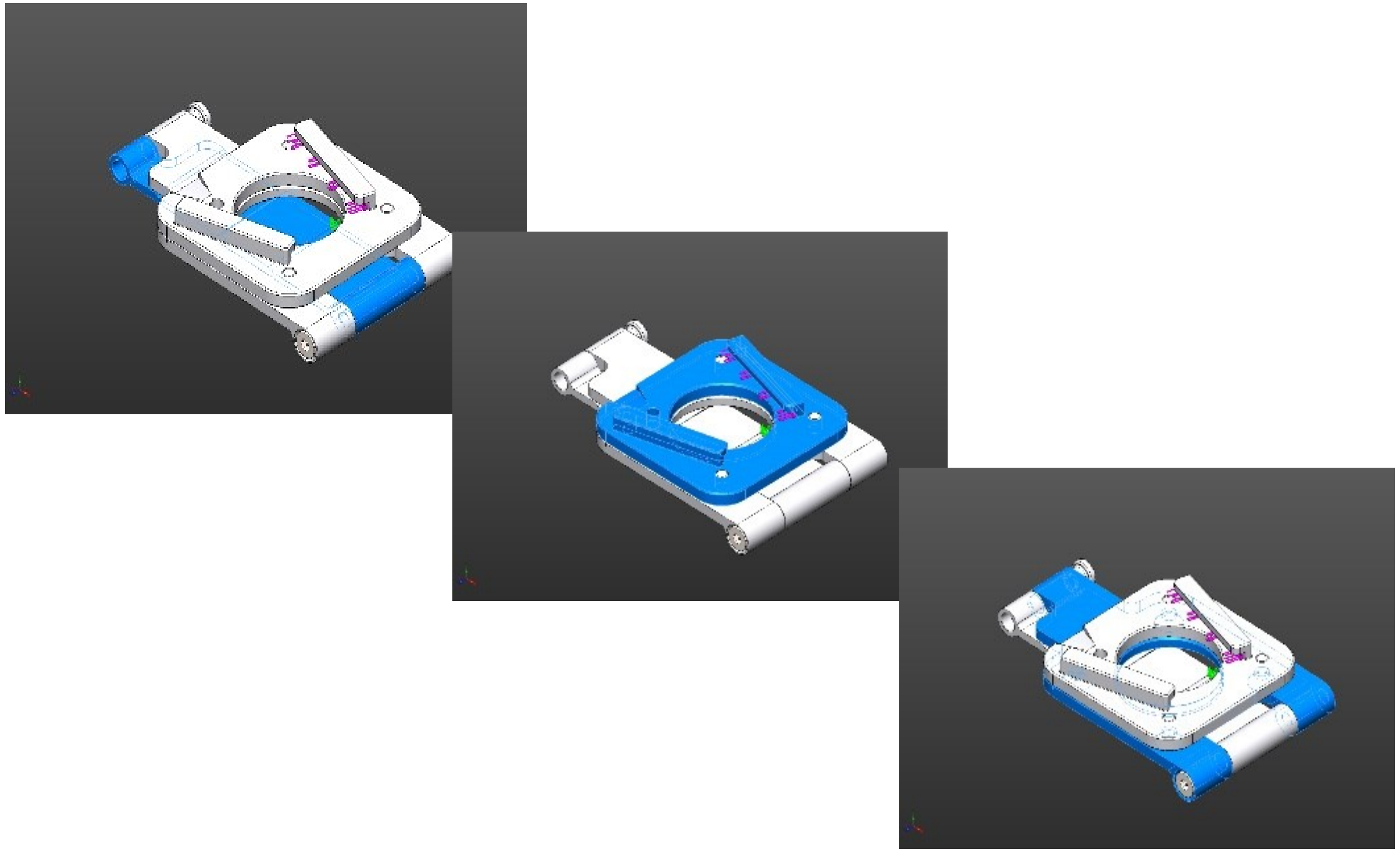
Derivation of Input Loads

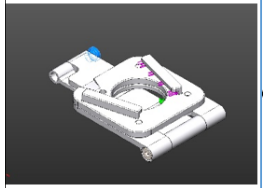
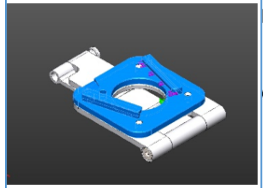
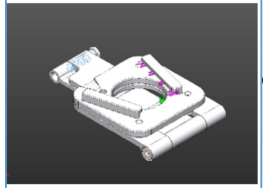
- **Compiling this data relied on a collaborative approach with OEM partners.**
- **Loads were derived based on real measured data from past Wind Blast & Ejection trials.**
- **Acceleration data was translated into specific forces acting on attachment plate in multiple directions.**



Material Optimisation

- **Model allowed varying materials and properties to be input for each detail so multiple simulations could be run to ensure best performance**

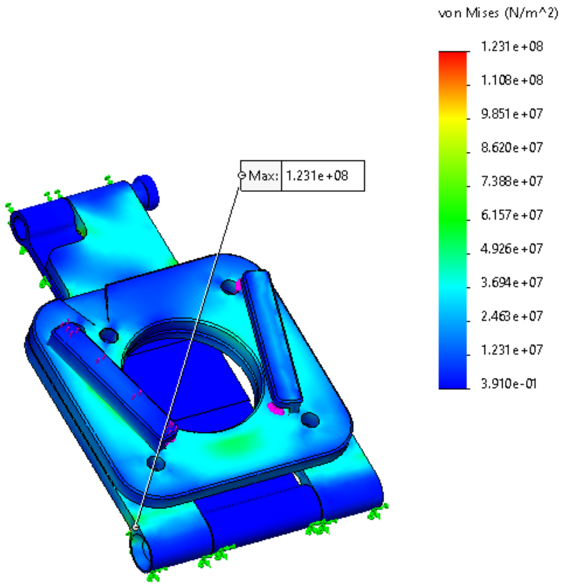


	D5114 – LOCKING PIN KNOB Mass:0.000539392 kg Volume:1.91954e-07 m^3 Density:2,810 kg/m^3 Weight:0.00528604 N	Name: 6082 (1) Model type: Linear Elastic Isotropic Default failure criterion: Unknown Yield strength: 5.05e+08 N/m^2 Tensile strength: 5.7e+08 N/m^2 Elastic modulus: 7.2e+10 N/m^2 Poisson's ratio: 0.33 Mass density: 2,810 kg/m^3 Shear modulus: 2.69e+10 N/m^2 Thermal expansion coefficient: 2.4e-05 /Kelvin
	D5116 – CRU MOUNTING PLATE Mass:0.0376612 kg Volume:1.34026e-05 m^3 Density:2,810 kg/m^3 Weight:0.36908 N	Name: 6082 (1) Model type: Linear Elastic Isotropic Default failure criterion: Unknown Yield strength: 5.05e+08 N/m^2 Tensile strength: 5.7e+08 N/m^2 Elastic modulus: 7.2e+10 N/m^2 Poisson's ratio: 0.33 Mass density: 2,810 kg/m^3 Shear modulus: 2.69e+10 N/m^2 Thermal expansion coefficient: 2.4e-05 /Kelvin
	D5126 – COMPRESSION SPRING Mass:0.000217438 kg Volume:2.78773e-08 m^3 Density:7,799.82 kg/m^3 Weight:0.00213089 N	Name: Stainless Steel (ferritic) Model type: Linear Elastic Isotropic Default failure criterion: Unknown Yield strength: 1.72339e+08 N/m^2 Tensile strength: 5.13613e+08 N/m^2 Elastic modulus: 2e+11 N/m^2 Poisson's ratio: 0.28 Mass density: 7,800 kg/m^3 Shear modulus: 7.7e+10 N/m^2 Thermal expansion coefficient: 1.1e-05 /Kelvin

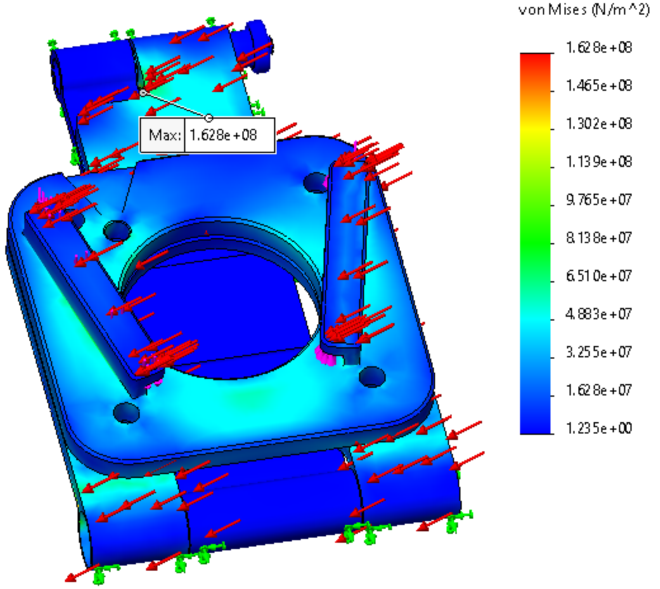
Solution optimisation without the additional time and cost of physical testing

Created Stress Plots for Different Scenarios

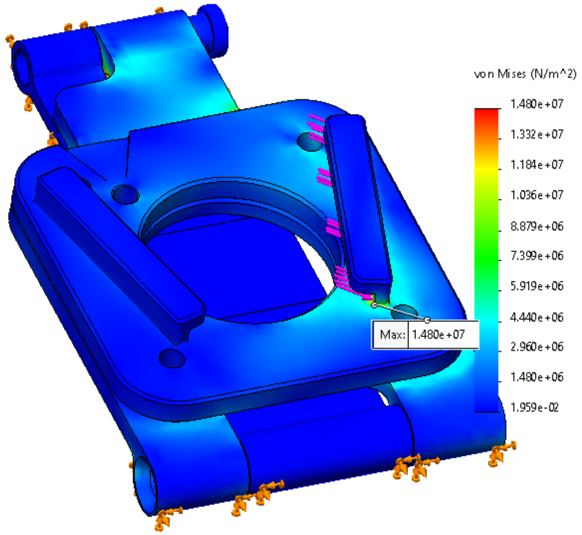
- **For each of the load conditions the meshed model was utilised to establish the loading on the plate and the safety factor of the design**



Simulated results of **Windblast** Forces in the G (+x) direction



Ejection and wind blast forces



Deceleration Force – Head-On Crash

Ability to digitally model scenarios not traditionally tested physically for component level change

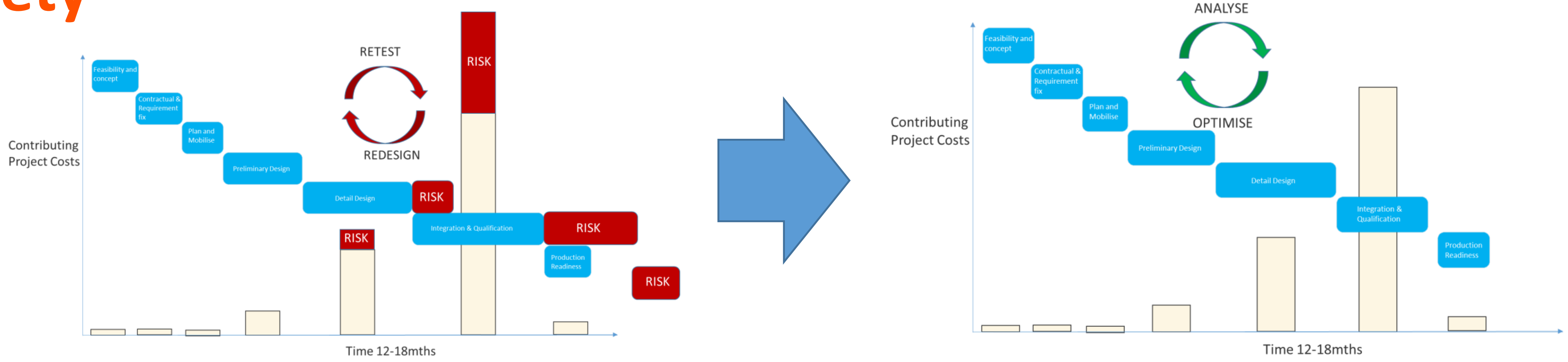
Case Study – Results and Conclusions

- Demonstrated Safety Factor of plate in relation to potential extreme events as further justification of quality of Mk42 LP
- MBSE approach allowed CRU60P plate to be qualified on the MACS Mk42 LP without need for any costly long lead-time testing
- With the fully developed model able to optimise design and improve safety
- Opportunity to further refine model and to optimise solutions using database of wind blast test results

CASE	Factor of Safety (FOS) min.
1	9.9
2	4.1
3.1	3.1
3.2	3.3
4.1	20.2
4.2	5.9
5.1	20.2
5.2	18.0
5.3	19.5
5.4	22.6
5.5	34.1

First customer acceptance of Model Based Testing as "Safe to Fly" qualification evidence in AEA!

MBSE Approach Reduces Time and Risk While Increasing Safety



- **Explore Alternatives & Learn Faster.**
  - **By modelling, analysing and optimising the component designs against system level requirements enables project to be de-risked in advance.**

- **Deliver better safer solutions.**
  - **Enables components of standard and new designs to be analysed in various configurations to rapidly offer improved capability, modularity and increased safety to end user.**

Significant reduction in time to fielding and increased surety in project time line

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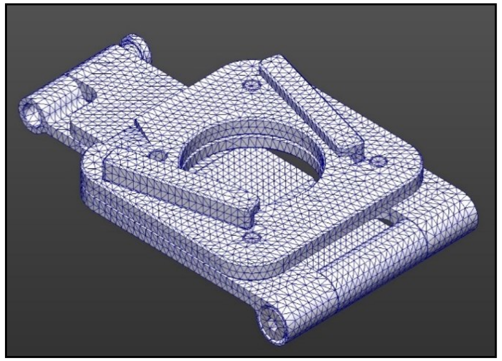
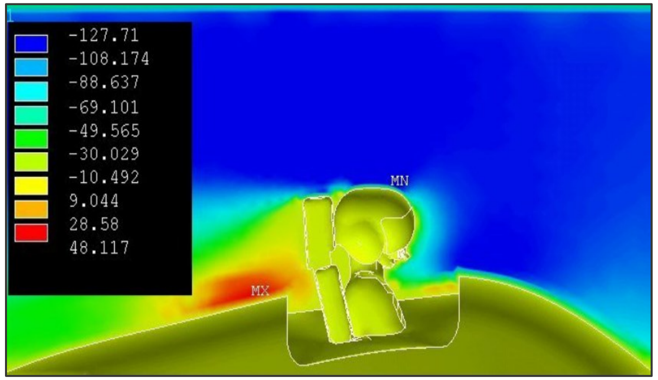
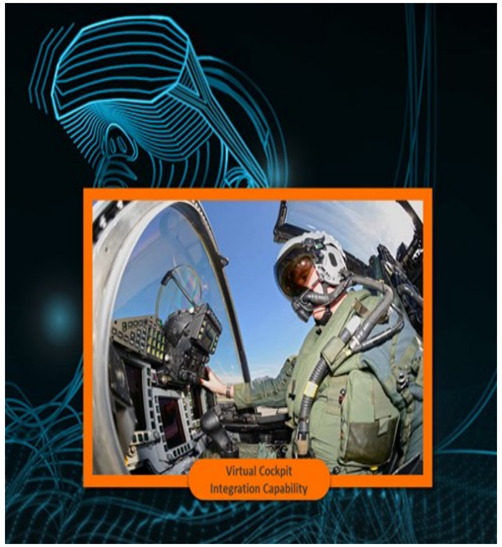
MBSE Capability - The Journey to date ....

Component in isolation → Environment simulation (operational scenarios) → System & Human models → Virtual cockpit integration and validation







Forces from instrumented mannequin trials

↓

FE analysis of rigid Flight Jacket components

Ability to analyse different environmental parameters

↓

CFD simulation techniques to represent windblast static pressures acting on Flight Jacket & its components

Design tools to represent fabric garments in 3D coupled with mobile Avatar mannequins

Virtual domain with digital representation - equipment, environment and human

Using MBSE improves safety while simultaneously bringing superior products into service faster and at lower cost

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