Magnesium Elektron

SERVICE & INNOVATION IN MAGNESIUM

Development of a Lightweight Forged Magnesium Aircraft Seat Component

Eighth Triennial International Aircraft Fire and Cabin Safety Research Conference

27th October 2016

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Martin Kemp – Altair Product Design

LUXFER GROUP

ENVIRONMENTAL • HEALTHCARE • PROTECTION • SPECIALITY

Agenda

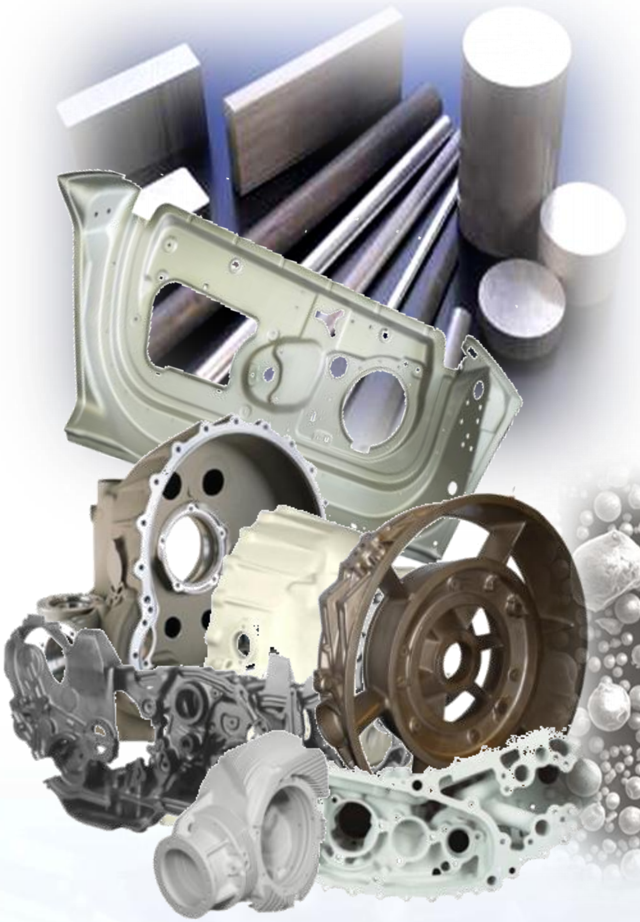
- Introduction
  - Magnesium Elektron
  - Magnesium in the aircraft cabin
- Development of lightweight forged aircraft seat components
  - Intro to Featherlite Aircraft Seat NATEP project
  - Data generation and properties
  - FEA simulation development
  - Forging – Buy to Fly ratio improvement
  - Machining – fast & efficient dry machining
  - Dynamic Testing – 16 G
- Summary

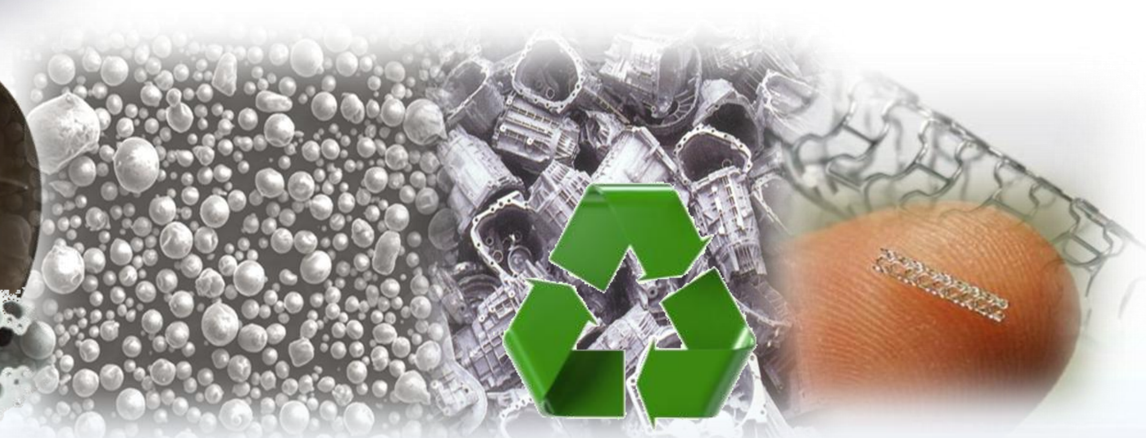
Magnesium Elektron
SERVICE & INNOVATION IN MAGNESIUM

A Luxfer Group Company

- Wrought Products
- Casting Alloys
- Powders
- Recycling
- Biomedical

- 9 manufacturing sites in the UK, Europe & North America
- 500 employees worldwide





- Aerospace, Automotive, Defence, Biomaterials, Graphic Arts, Oil & Gas, Speciality

Magnesium Elektron
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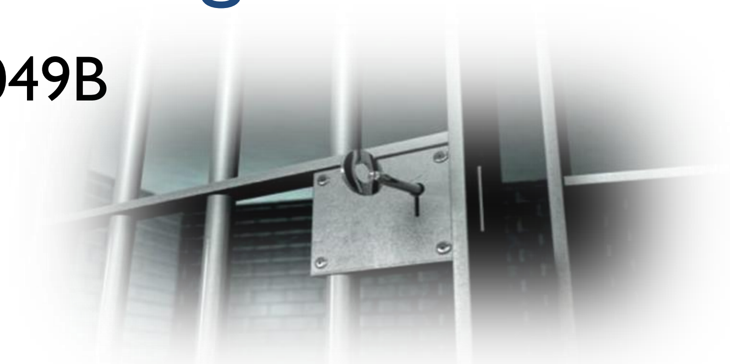
Magnesium – Aircraft Cabin Regulations

SAE International Aerospace Standard – AS8049B



Para 3.3.3 "Magnesium alloys shall not be used."

…. it appears that certain magnesium alloys may have flammability properties acceptable for use in aircraft seat structure ….

Example of no burning after melting (Elektron 43 & Elektron 21)

Example of burning after Melting (AZ31)

AS8049C: *"Magnesium alloys may be used in aircraft seat construction provided they are tested to and meet the flammability performance requirements in the FAA Fire Safety Branch document: Aircraft Materials Fire Test Handbook – DOT/FAA/AR-00/12, Chapter 25, Oil Burner Flammability Test for Magnesium Alloy Seat Structure."*

What is Elektron®43?

- Elektron® 43: The latest wrought magnesium aerospace alloy

- Elektron ®43: Available as plate, extrusion, forging stock.
  - AMS 4371 - Plate Precipitation Heat Treated
  - AMS 4485 - Extrusions Precipitation Heat Treated
  - MMPDS: Contains –A and –B basis statistical minima

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Magnesium Elektron
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Where are WE43 alloys used?

Eurocopter EC120

Bell Agusta 609

MD Helicopter: MD600N

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NATEP

Featherlite Aircraft Seat Project

- UK Government backed scheme - National Aerospace Technology Exploitation Program
- Lightweighting offers economic and environmental benefits
  - Reduced fuel burn and CO_2 emissions.
- Reduce barriers to aircraft interiors OEM's using UK sourced high performance magnesium alloys
- Develop forging and machining technology to ensure UK based supply chain is economically and technically capable of providing weight saving in the cabin
- Establish a UK based supply chain with a potential global end market not just be limited to seats

Partners and their roles in the Project

Magnesium Elektron
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- Lead partner with 80 years of magnesium alloy development experience.

Geven

- End User (non-funded) with 30 years aircraft interiors experience. European based passenger seat manufacturer for Aircraft OEMs.

Mettis Aerospace

- Leading global service provider of precision-forged and machined components in titanium, aluminium and special steels.

Kenard

- Specialist machinist - Aerospace, Defence, Oil & Gas and Communications - with 5 axis capability.

Altair ProductDesign

- A world leader in virtual design solutions with a 20 year track record in developing better products across industries including Auto, Aero, Defence and Consumer.

The University Of Sheffield.
Advanced Manufacturing Research Centre
BOEING

- Advanced Manufacturing Research Centre (AMRC) with Boeing is a world-class centre for advanced machining and materials research for aerospace and other high-value manufacturing sectors

Part Selection

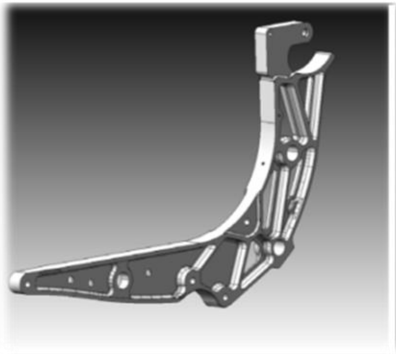
Figure 4 - Seat basic structure ISO front view

Figure 5 - Front Leg CAD view	Figure 6 - Central Spreader CAD view

Piuma EVO seat put forward for project by Geven

Geven

Project Innovation – Work packages



WP1
Component design
- FEA
- HSR Data

High strength
Mg alloy
Elektron® 43

WP2
Forging

WP7
Validation
and Testing

Lightweight
Aircraft Seat
components

WP3
Specification
- ASTM / AMS

WP6
Product costs

WP4
Machining

WP5
Recycling

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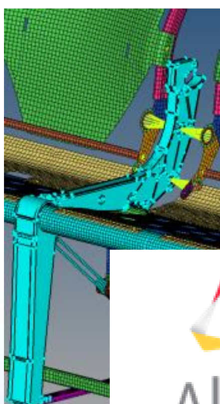
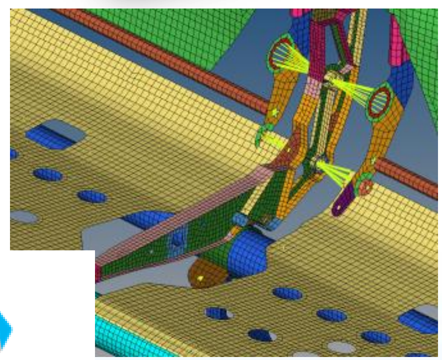
Project Innovation – Highlights WP1

WP1
Component design

Elektron®43
High specific strength & energy absorption @ HSR

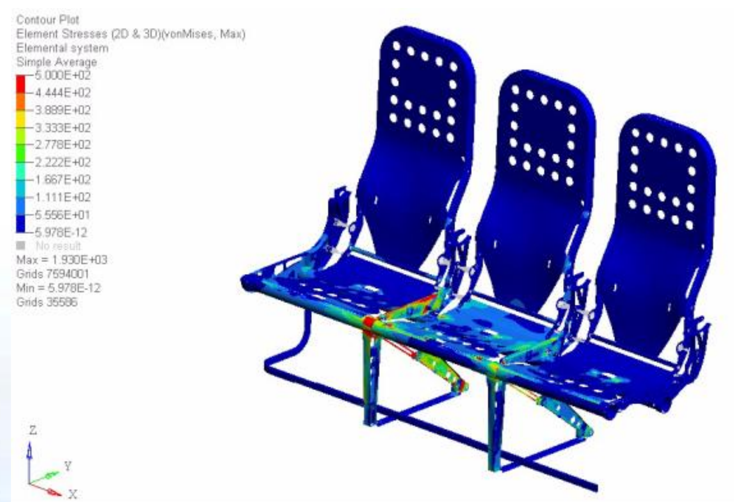
Genuine Design for Manufacture



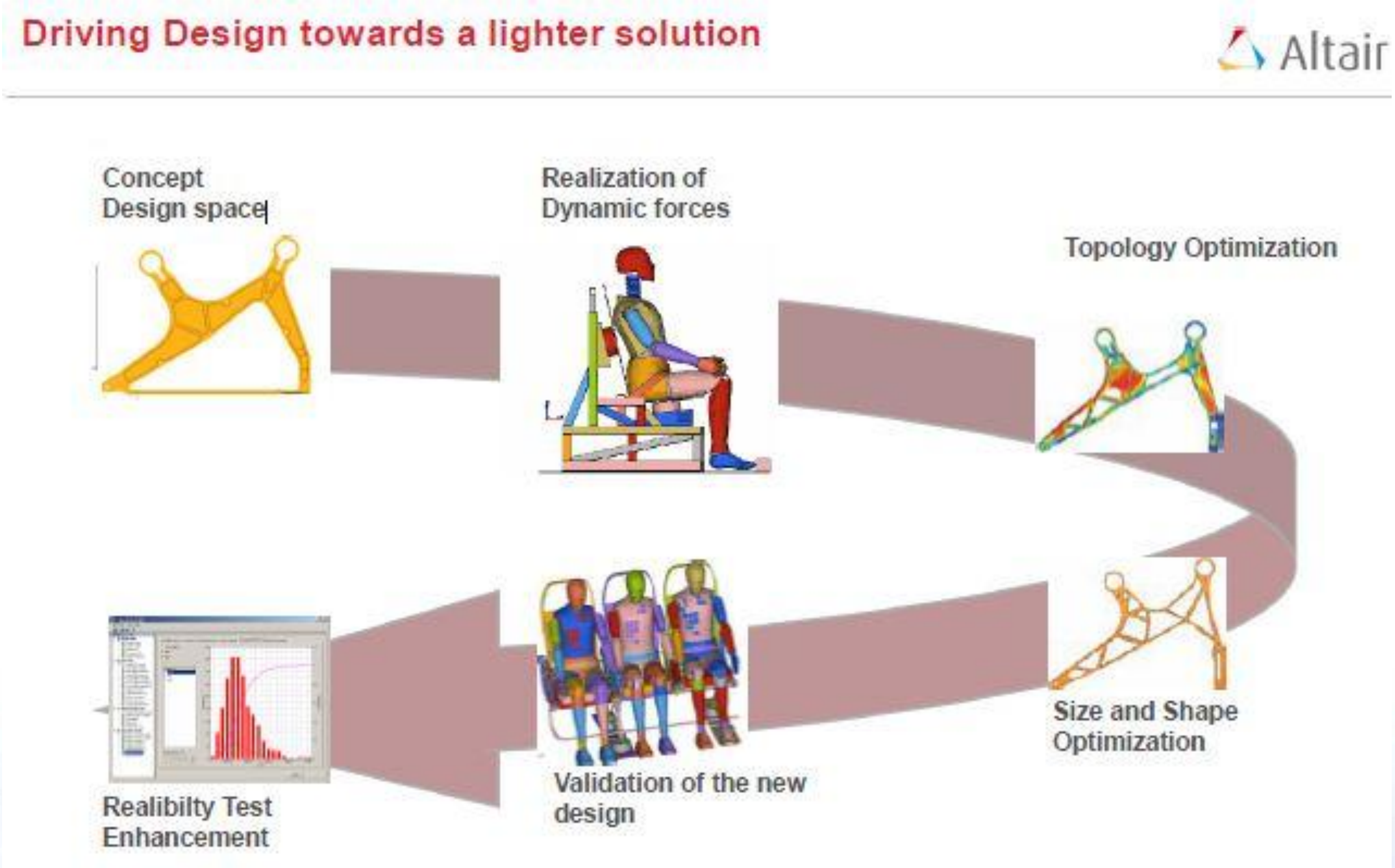


Altair
ProductDesign

External experts used when required



Altair Product Design Approach



NATEP FEA Design Development Process

Loads Development

- Develop equivalent static load cases

Topology Optimisation

- Use Topology (concept) optimisation to establish load paths.
- Interpret topology results into a new baseline designs.

Size and Shape Optimisation

- Develop and parameterise an FE model from the new baseline
- Run size and shape (refinement) optimisation to tune the design under static load conditions

Design Verification

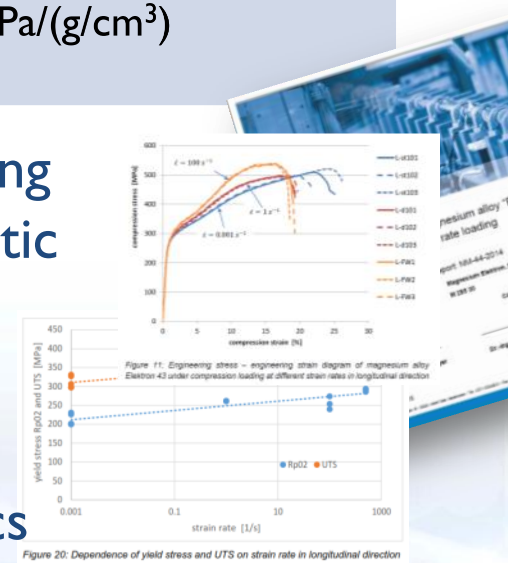
- Up to seven dynamic and static test simulations will be performed to verify the optimized design including forward, upward, downward and sideward cases

Development of FEM – Material Data

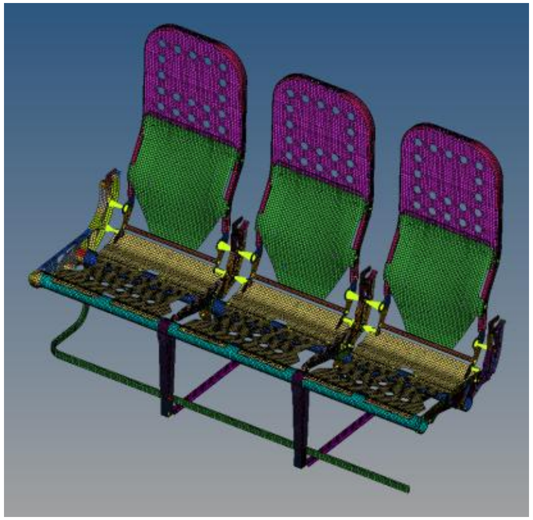
- Material Properties for Elektron® 43 vs Aluminium 2024 – T351

Property	Magnesium (Elektron® 43)	Aluminium 2024 T351
Youngs Modulus	44 GPa	73.1 GPa
Poissons Ratio	0.27	0.33
Density	1840 kg/m^3	2780 kg/m3
Yield Stress	240 MPa	324 MPa
UTS	350 MPa	469 MPa
Specific Strength	190 $MPa/(g/cm^3)$	170 $MPa/(g/cm^3)$
Elongation	12%	6%

- High quality data suitable for non-linear dynamic modelling
- Material model requires family of true stress vs true plastic strain curves for rate range
- Strain rate up to 500/s generated at specialist test house
- Elektron®43: High specific strength, high strain hardening behaviour and excellent energy absorption characteristics



Development of Finite Element Model



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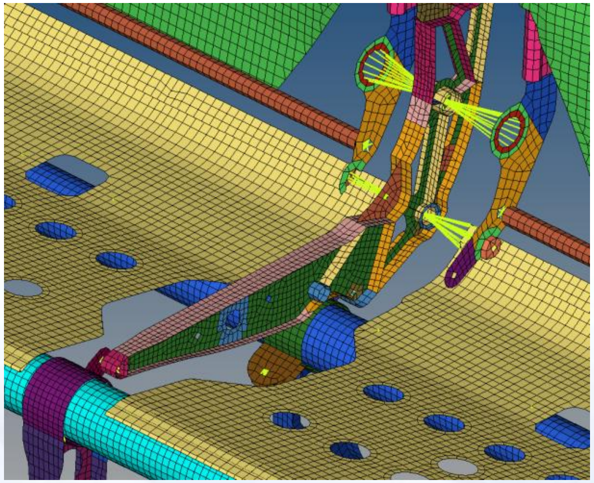
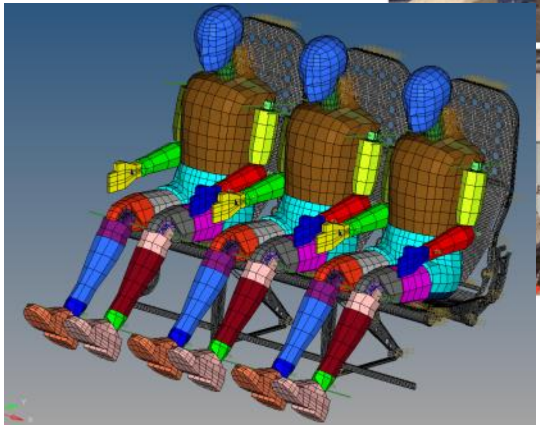
- Mid Surfaced Seat Assembly FE Model created in HyperMesh suitable for Dynamic and Static Assessment



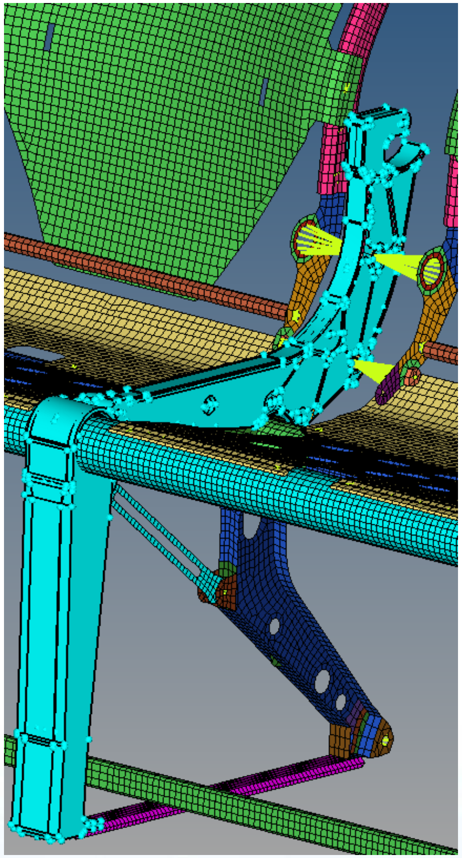
FE Modelling and Load Case Definition

- Equivalent Static Load Cases Defined for Design Purposes
  - 16g Forward
  - 14g Down
  - 16g Fwd -ATD Restraints
  - Static 12.0G FWD
  - Static 4.0G Sideward
  - Static 7.2G Upward
  - Static 11.5G Down
- Load cases are defined from peak test reaction forces
- Static analysis performed using OptiStruct and Dynamic analysis using RADIOSS



- Dynamic Loading to Represent Physical Test
  - Dynamic Model Developed using Hybrid III dummy models
  - Dynamic Simulations to be defined to represent test cases

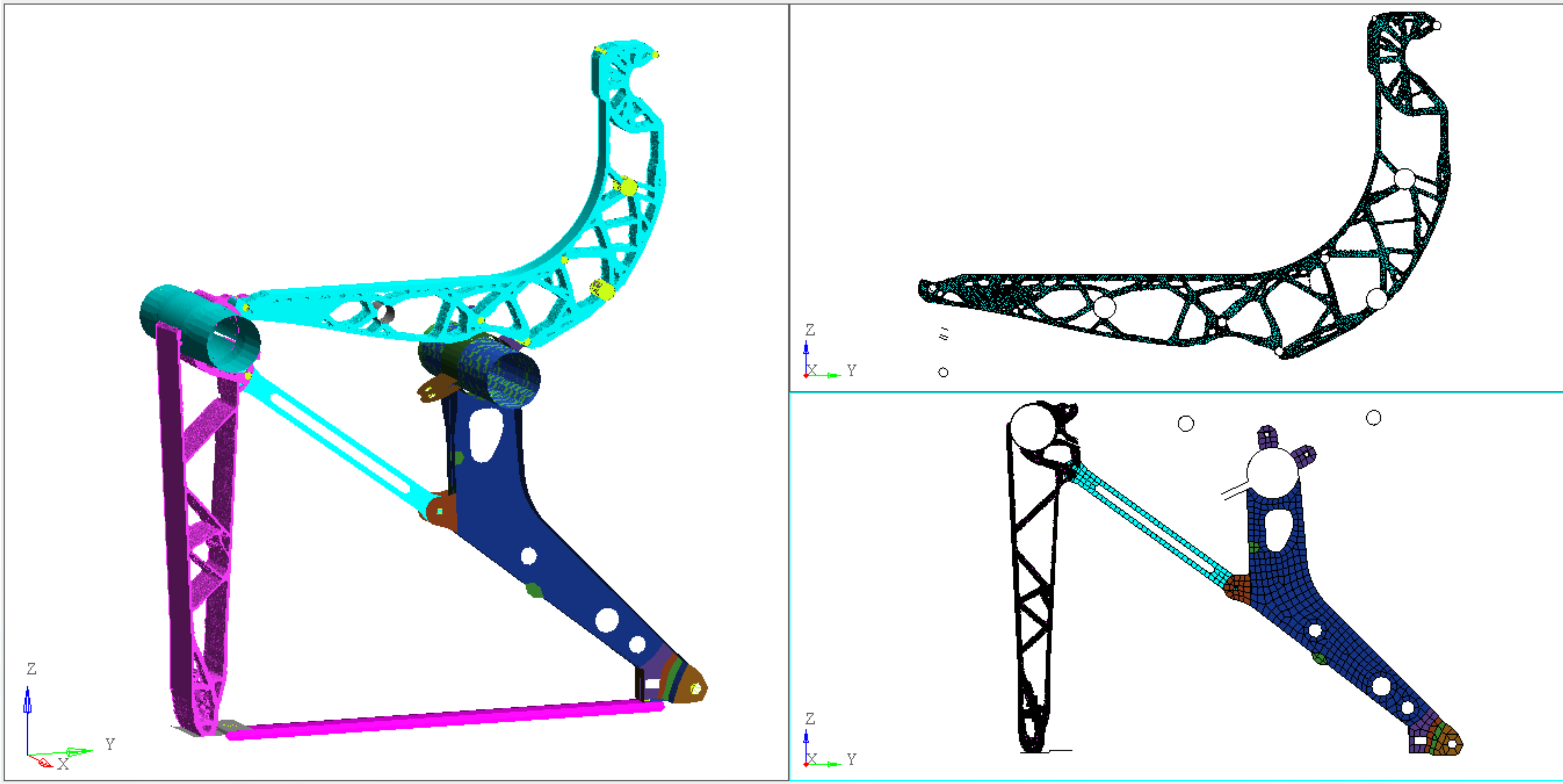
Design Space Definition



- Design Space geometry defined to encapsulate existing structure and to add additional space for new stiffening options
- Integrated with current seat structural model using similar modelling strategy to seat structure model
- Sub–Model created to focus on design space and capture boundary conditions

Topology Concept Definitions

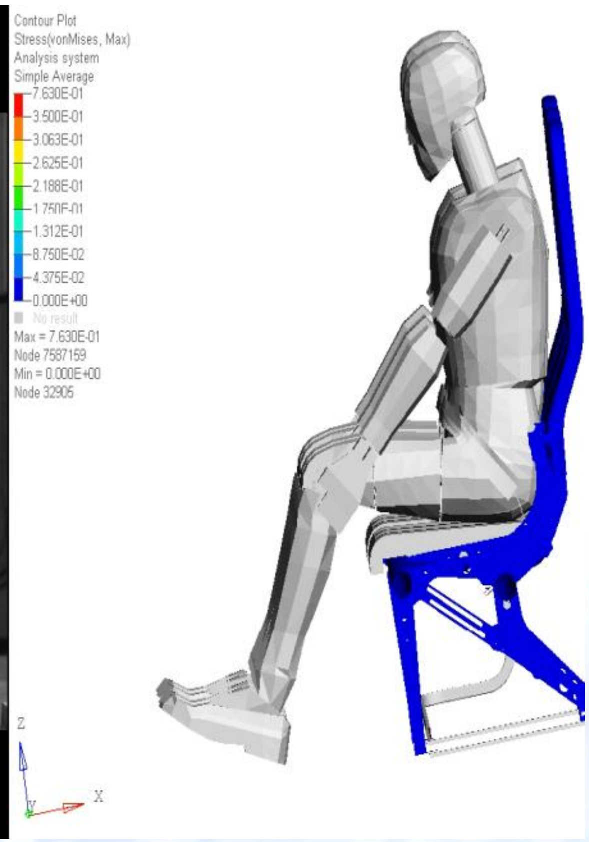
- OptiStruct topological optimisation to define architectures
- Simplified static load cases to represent key loading requirements



Example Analysis (based on 16g FWD reactions)

Model verification – preliminary testing

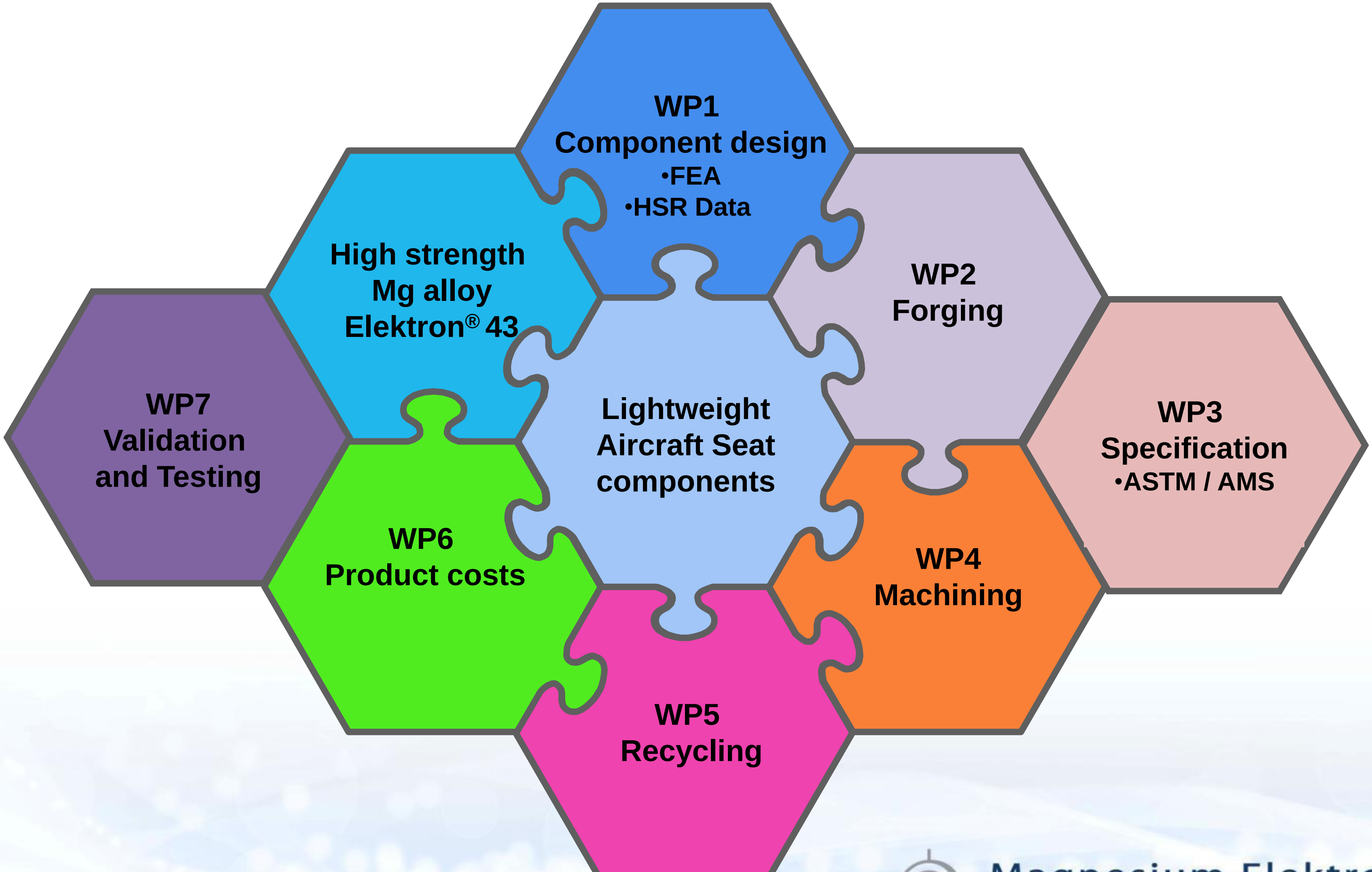
- Testing carried out on machined demo parts
- Material not forged, but used as early indicator of performance and potential success.



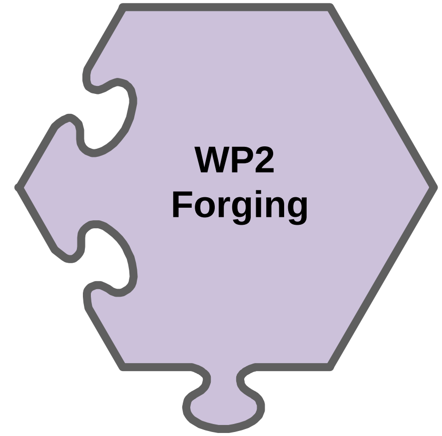
Final Design –
19% weight saving vs existing Al 2024 – T351

Material / Component	weight saving (%)
Aluminium 2024	
Spreader:	
Front Leg:	
Elektron 43 Mg Rev 3	
Spreader	21
Front Leg	21
Elektron 43 Mg Rev 4	
Spreader	19
Front Leg	19

Project Innovation – Work packages



WP2 – Forging Development

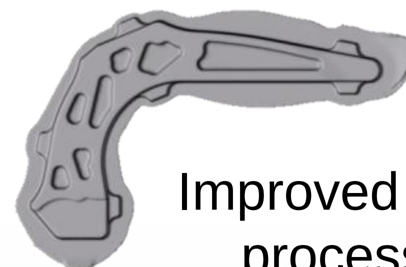


- Reducing Buy to Fly ratio through forge process

	Machining	Pre-NATEP	NATEP
Buy-to-Fly ratio	10 : 1	4.4 : 1	3.3 : 1
% yield (F2B)	10 %	22 %	31 %

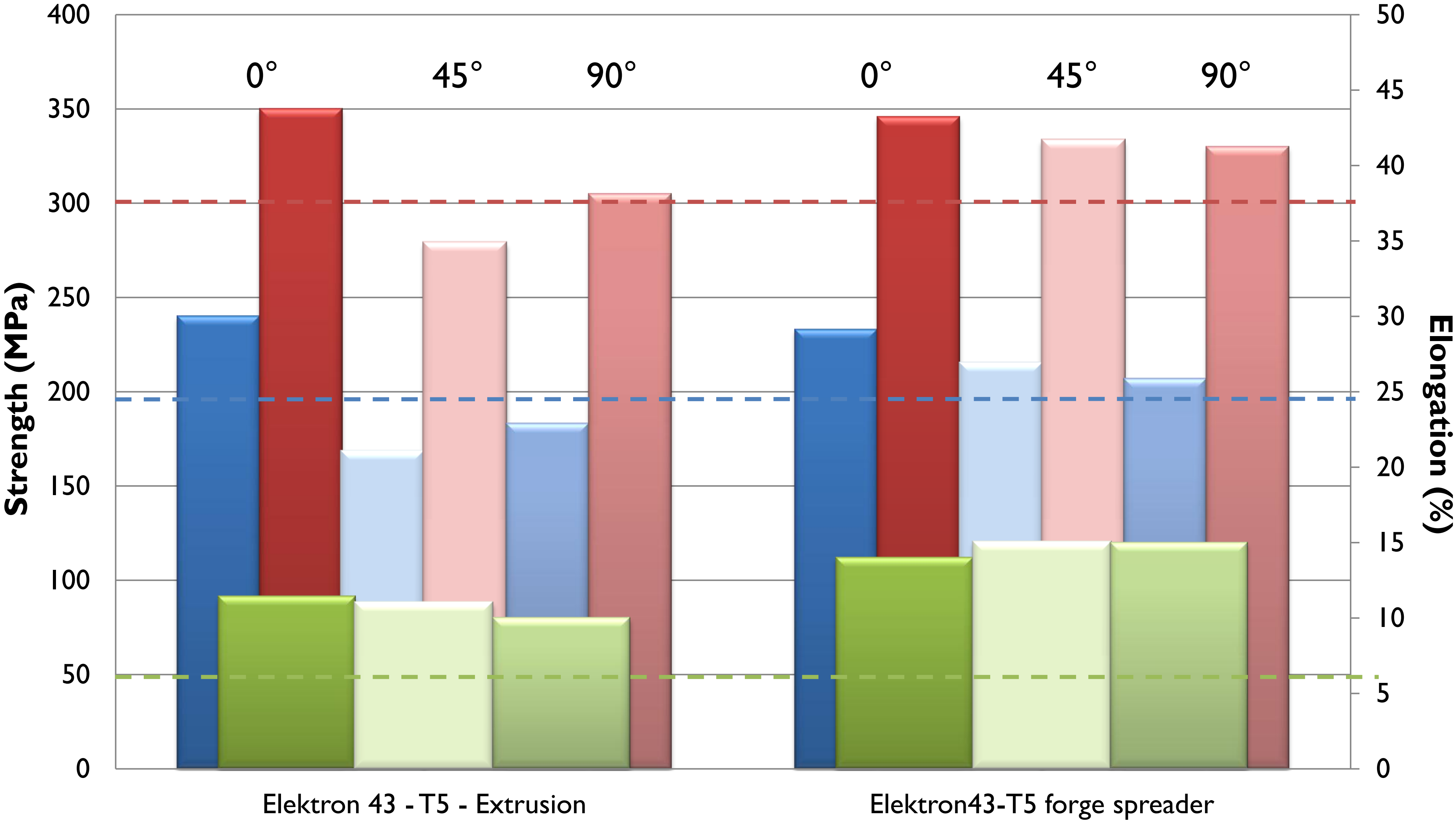
Extruded bar feedstock

Pre-NATEP – excess flash

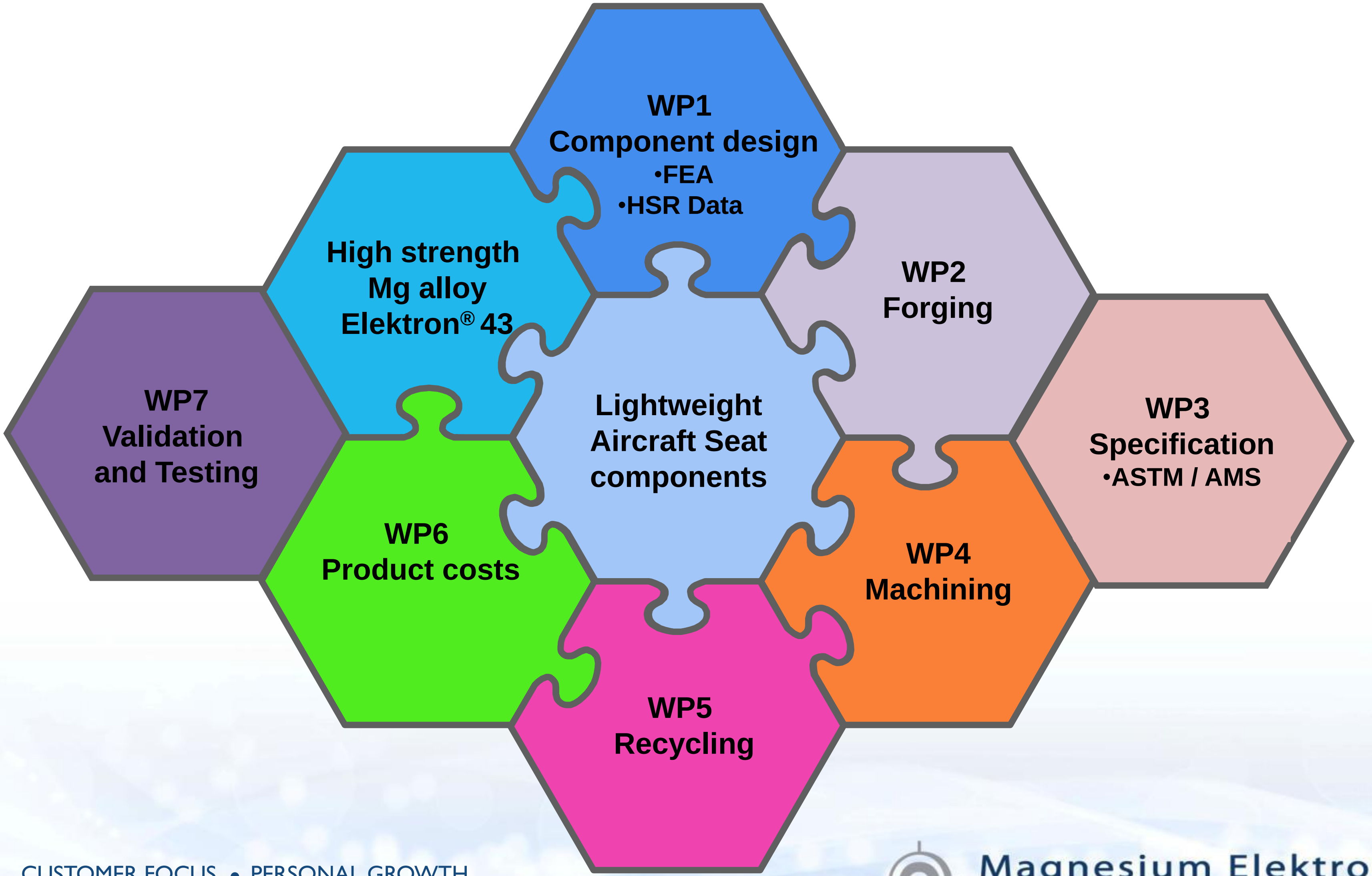


Improved forge process – reduced flash

Elektron ® 43 – Tensile Isotropy forge vs. ext.



Project Innovation – Work packages

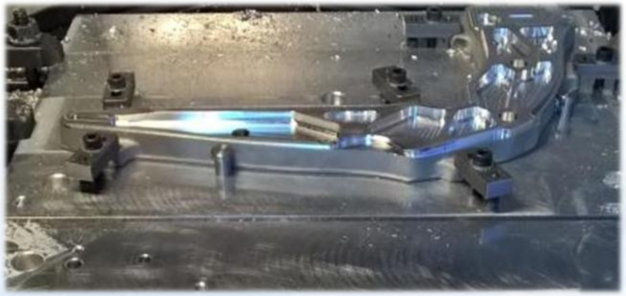


WP4 – Dry machining Elektron®43

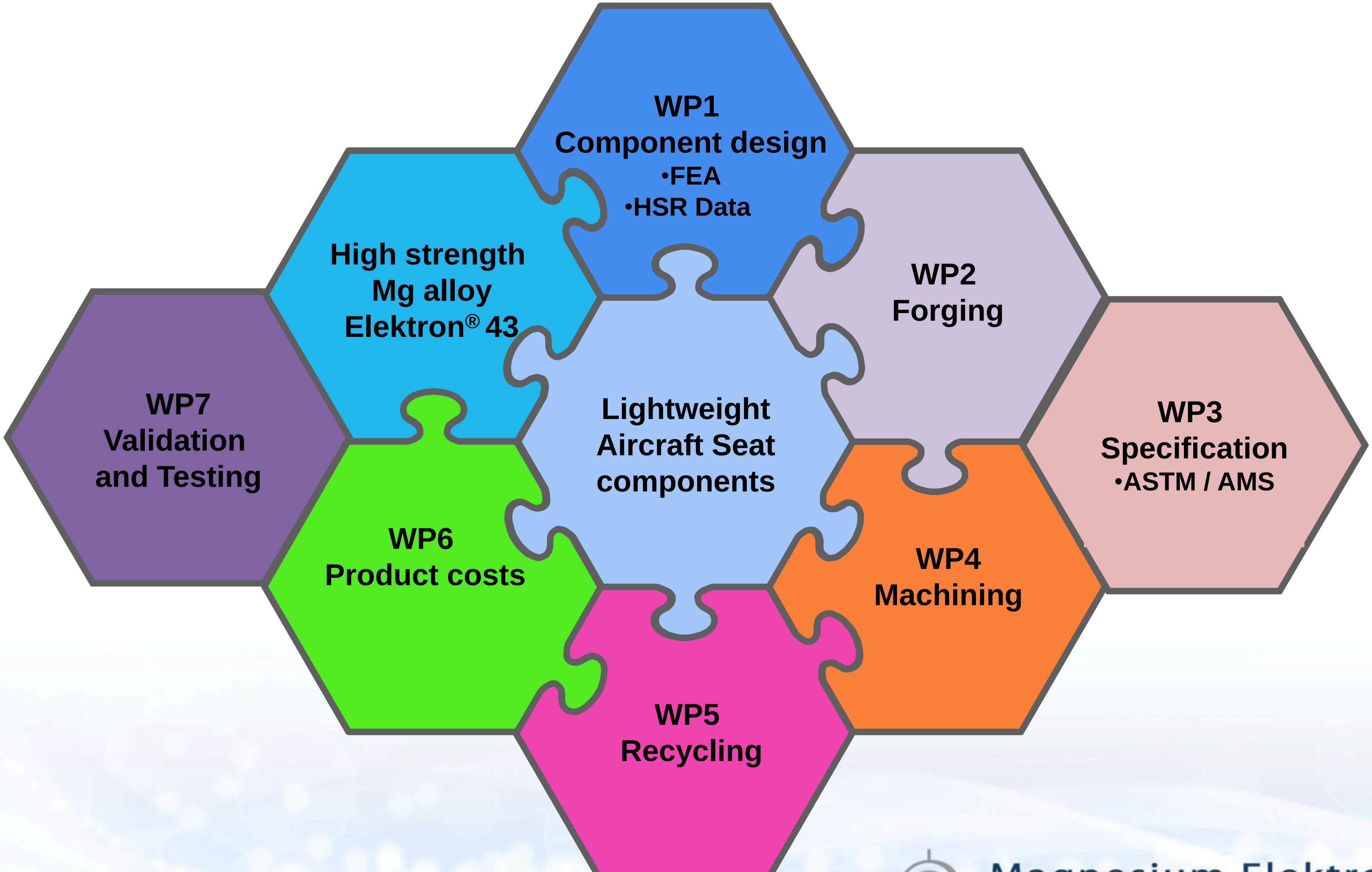
WP4 Machining

Kenard

- Baseline dry machining characteristics vs aluminium
  - Parts machined on Vertical Milling Centre.
  - Standard (Aluminium grade) tooling used
- Depth of cuts +35% compared to Aluminium.
- Feedrate +40% compared to Aluminium.
- Cycle time saving of approximately 35%.



Project Innovation – Work packages



Successful 16G Dynamic Test

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Summary

» Significant weight saving of Elektron®43 vs high strength aluminium alloy 2024
  - Successful 16g dynamic testing

» Capabilities developed in the forging of a magnesium alloy suitable for aerospace applications

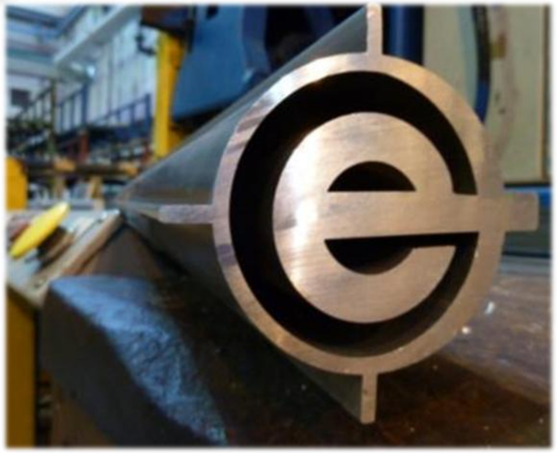
» Fast, efficient, dry machining of a magnesium alloy safely demonstrated.

» The aerospace industry: improved UK supply chain for downstream processing of magnesium alloys coming out of Magnesium Elektron

Thank you for listening...

A special thank you to all of the following people:

- Martin Kemp and the Altair Product Design team – UK
- Pete Bishop and Xenofon Gogouvitis – Mettis Aerospace
- Pasquale Rapullini and Bonaventura Vitolo – Geven
- Martyn Alderman and Steve Montisci – MEUK
- Steve Batsford and Richard Elvins – Kenard
- Nacho Blanco, Erdem Ozturk and Omer Ozkirimli - AMRC
- Rohima Begum, Rory Barker, Phil Rogers and many others in the technical department at MEUK



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