# REACH Compliant Hexavalent Chrome Replacement for Corrosion Protection (HITEA)


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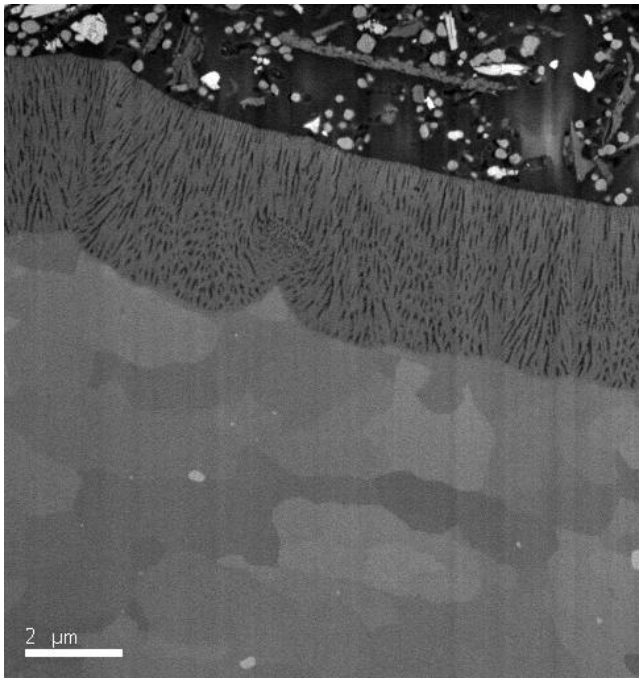
Rolls-Royce plc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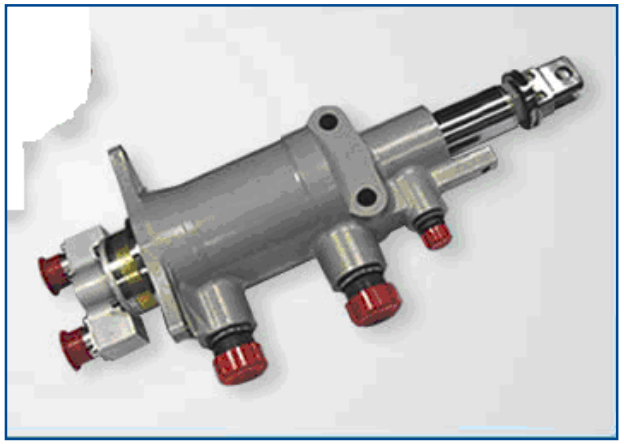
# The Need



- On the 1st June 2007 the European Union enacted REACH – Registration, Evaluation, Authorisation and Restriction of Chemicals – legislation.
- Hexavalent chrome compounds are classified as substances of very high concern (SVHC) because they are Carcinogenic, Mutagenic or Toxic for Reproduction (CMR).
- The stringent regulation of these compounds means that suitable alternatives must be investigated and implemented to ensure that product performance and business continuity is maintained.
- The sunset date for hexavalent chrome compounds is September 2017.

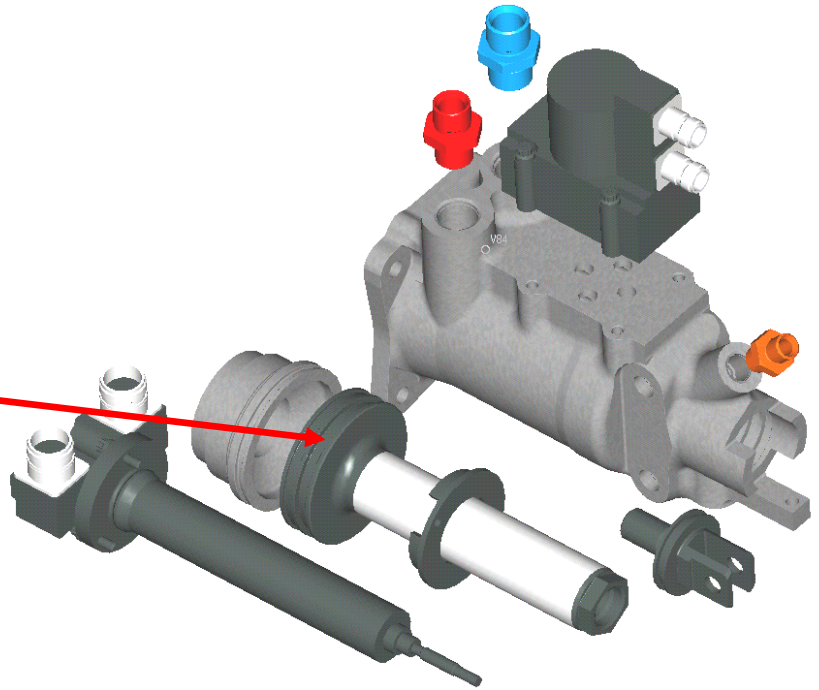
# Engine Guide Vane Actuator





**Aluminium Housing**
- Forged / Make from Solid
- Chromic acid anodised (CAA) externally.

**Aluminium Piston**
- Chromic Acid Anodised Head
- Hard Chrome Plated Stem
- Chromate Conversion Coating (CCC)



Images courtesy of Rolls-Royce Controls & Data Services Ltd.

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# The Role of the AAD and Materials KTNs



- A joint AAD and Materials KTN workshop in 2011 resulted in:
  - Definition of the hexavalent chromium replacement problem
  - Outline of a possible research strategy
  - Potential partnerships to address the problem
- The KTNs influenced the TSB collaborative R&D competitions to ensure REACH was a priority theme.
- Created the opportunity for the UK to position itself as the leading exponent of REACH-compliant materials science.
- The resulting programmes were seen to be essential to maintain the competitiveness of the UK aerospace industry.

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# The HITEA Programme



- Planned to identify and evaluate suitable alternative systems with progression through to TRL 4.
- Two main work packages are being pursued:
  - Chromic acid anodising (CAA), chromate conversion coatings (CCC) and chromate containing paints.
  - Electrolytic hard chrome replacement.
- The project is co-funded by Innovate UK (formerly known as Technology Strategy Board) and has a duration of 2.5 years
- The 17 member consortium* is made up of industrial aerospace end-users, suppliers, paint applicator companies and UK universities.
- The project also included an effective material information management system based on the GRANTA MI ™.
- The project benefits from an Advisory Board.

*Rolls-Royce (Lead Partner), AgustaWestland, Ashton & Moore, BAE Systems, Bombardier, GE Aviation Services, Granta Design, Indestructible Paint, Meggitt, Messier-Dowty, Monitor Coatings, Poeton, UTC Aerospace Systems, Rolls-Royce Controls & Data Services, Loughborough University, Manchester University, Southampton University

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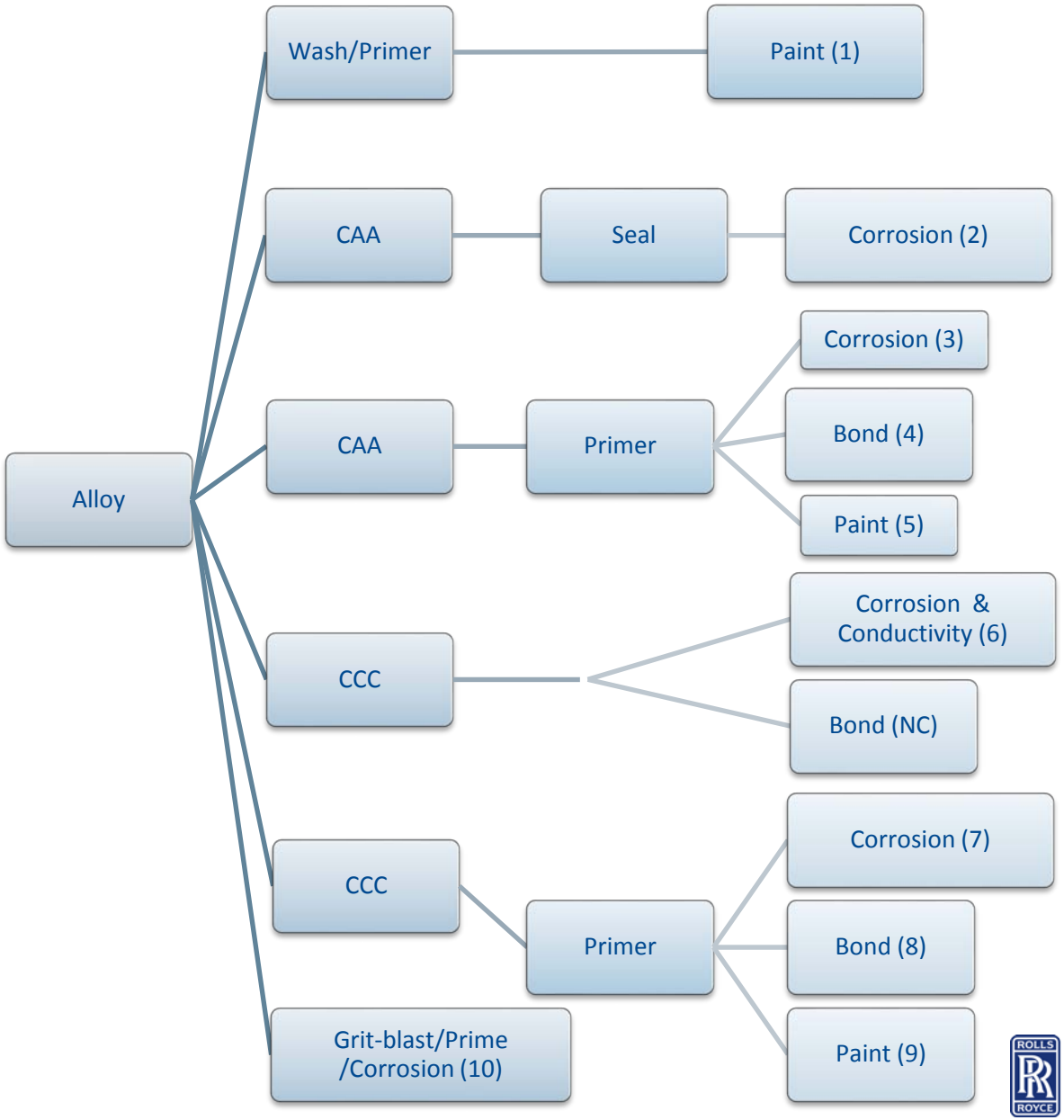
# WP 1



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# WP 1 systems being tested



Al 2024 (T3) was chosen as the substrate for WP1

CAA Alternatives:

- SAA, TFSAA, PAA, BSAA, PSAA

A number of alternative commercially available $Cr^{6+}$ free primers, paints and conversion coatings being tested.

Tests include:

B117, G85

Dry and wet film adhesion

Fatigue testing

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# WP 2



| | Low alloy steel | 15%Cr Stainless steel | 19% Cr Stainless steel | Ti64 | Al Alloy | Nimonic alloy |
|---|---|---|---|---|---|---|
| Hard chrome plating | x | x | | | x | |
| TiN | x | x | | | | |
| CrN | x | x | | | | |
| DLC | x | | | | | |
| WC/C | x | x | | | x | |
| PEO | | | | x | x | |
| Co-P | x | x | x | x | x | x |
| Trivalent Cr | x | x | x | x | x | x |
| Filled ENP | x | | | | x | |

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# WP2 testing



Testing includes:

Hardness

Increasing load scratch testing (to determine relative bond strength)

Wear testing

Salt Spray

Fatigue testing (on selected samples)

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# Technical Aims



- Provision of a performance database and standardised wear and corrosion methodologies to validate the reliability of new REACH-compliant coatings, whilst ensuring that the next generation material systems are sustainable in the long term.
- The consortium aims to establish a fast, inexpensive and robust testing methodology for selecting the most promising chromium-free alternatives.
- Creation of a centralised data management system which takes data from a number of sources from within the consortium to support decision making in the specification and use of alternative coating systems enabled by efficient consortium-wide access over the internet.

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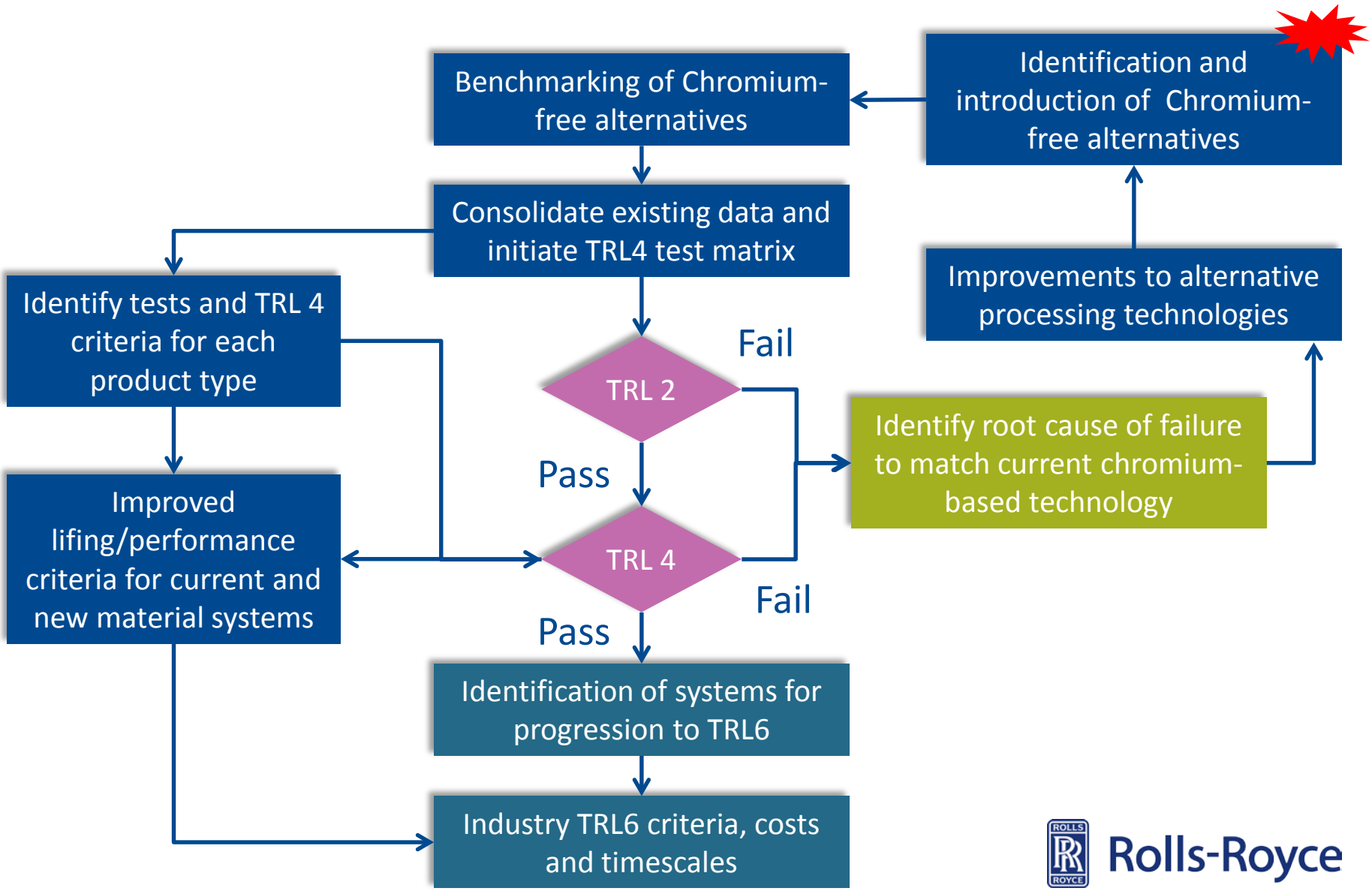
# The Technical Approach



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# Improved Corrosion Testing



- Within the scope of the HITEA project it was key to identify an advanced corrosion testing method which:
  - Improved the predictive capability of accelerated testing.
  - Retained the capability of obtaining fundamental information linked to the corrosion process.
- Electrochemical noise analysis (ENA), Linear polarisation (LPR) and electrochemical impedance testing (EIS) have been utilised to provide a practical tool for corrosion testing.
- These techniques allows the consortium to rapidly optimise and assess the performance of a new family of chromium-free, environmentally friendly treatments.

# Corrosion Performance of Chromium-free anodising using an ENA technique.


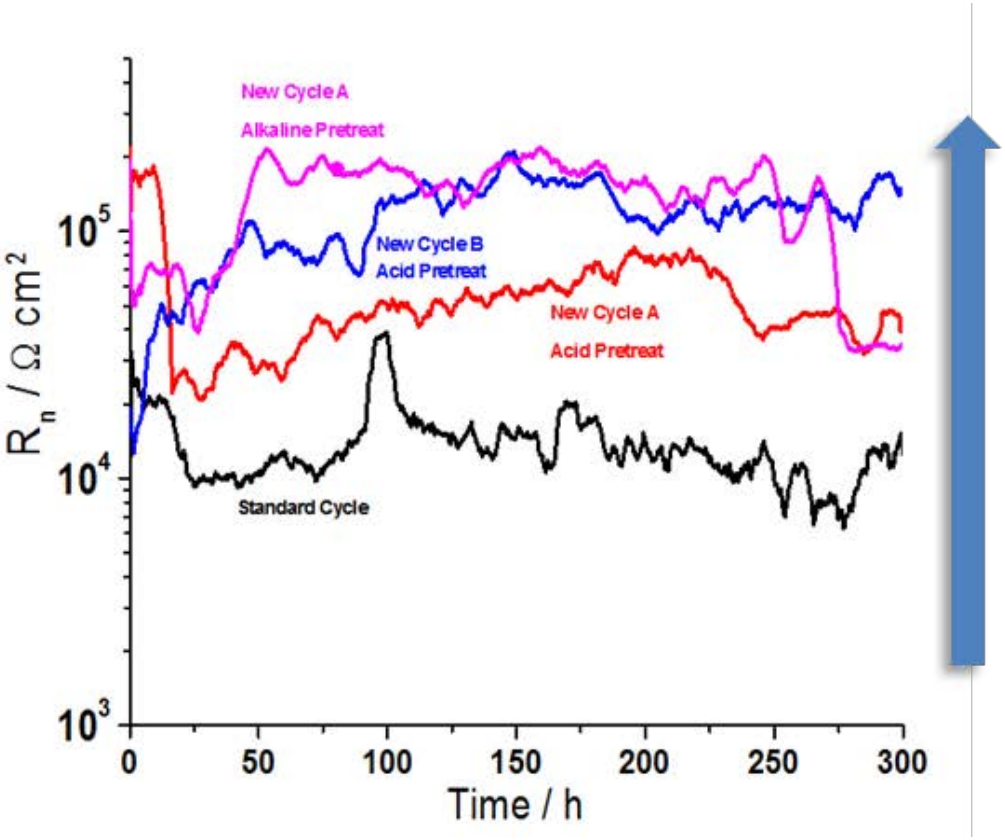


Image courtesy of Manchester University

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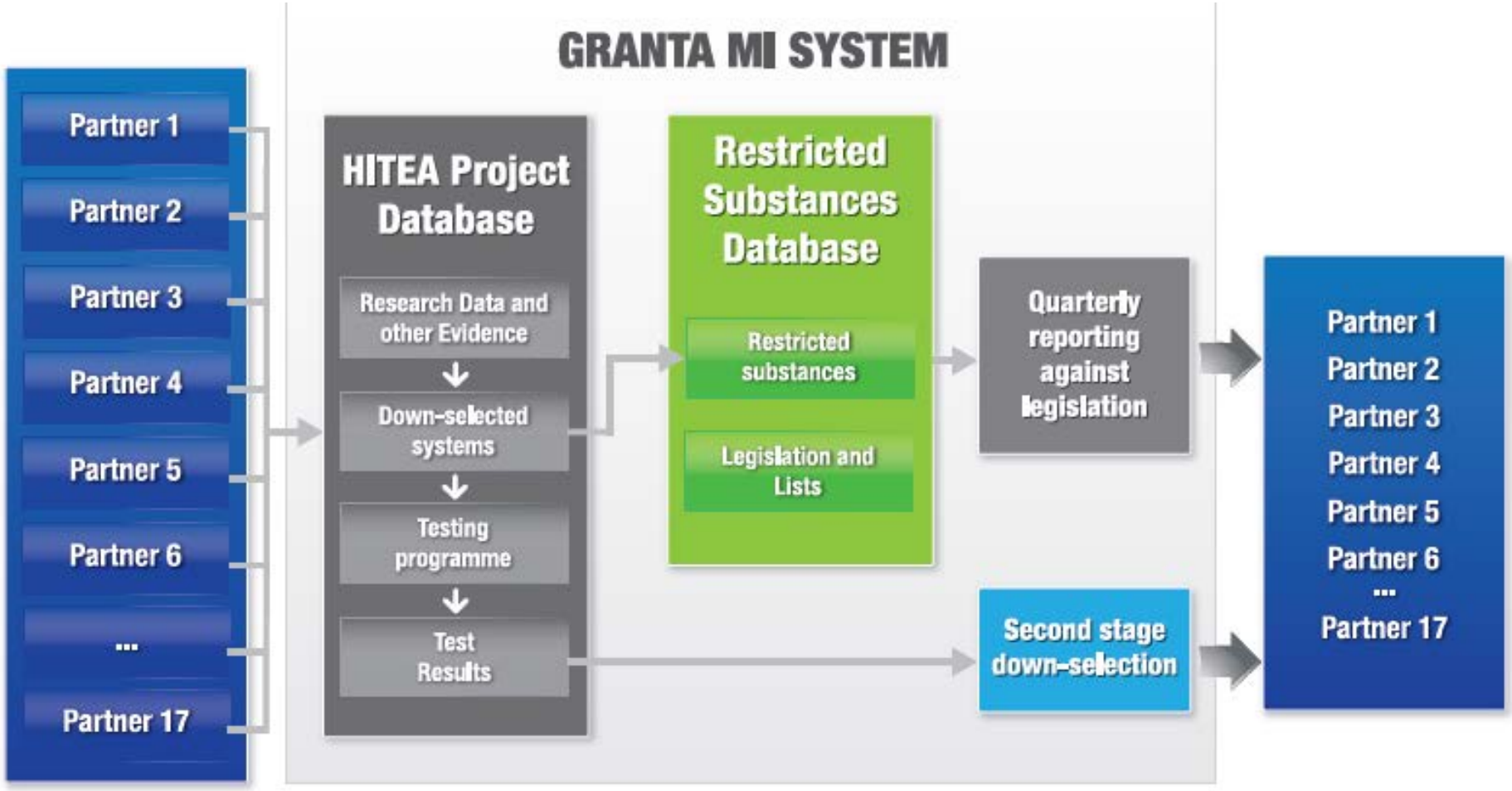
# Centralised Data Management



- The data structure designed for the HITEA project defines and organises the relevant types of data, their attributes and dependencies.
- 500 records added to the knowledge repository for current CAA and CCC alone.
- The consortium is in the process of testing a range of REACH-compliant alternatives identified at a two-day workshop with a wide range of paint suppliers and coating companies.
- This TRL2 phase of testing will generate in excess of 1000 data sets for consortium members to access via a single, searchable database.

# Database Schema for the HITEA Project



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# Replacement of Hard Chrome Plating



- The HITEA project has identified a number of alternative processes which are currently being assessed via a range of tribological tests which are designed to down select the most viable systems to TRL4.
- It was recognised that a “systems approach” would be required to achieve all of the customer requirements when identifying replacement technologies. For example, applying a hard face coating from a high velocity oxy-fuel (HVOF) applied tungsten carbide family of cermet coatings combined with a seal coat with an inorganic thermo-chemical material.
- Alternative processes capable of coating the inner bore of components are also under investigation.

# Potential Replacement for Electrolytic Hard Chrome Plating



Hard Chrome Rotor at end of life



Images courtesy of Monitor Coatings

Mud motor rotor up to two orders of magnitude life improvement by using a systems-design approach

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# Continuing Need for Collaboration



- REACH is a phased approach to substance regulation and therefore there was a requirement within the HITEA project to ensure that the next generation material systems are sustainable in the long term.
- The REACH process is quite transparent and it is clear that a number of substances currently in use within the aerospace sector will require phase-out.
- The HITEA project is an example of excellent cooperation and demonstrates that by securing access to a broad range of complementary skills then it is possible for a successful outcome to these complex engineering change projects.

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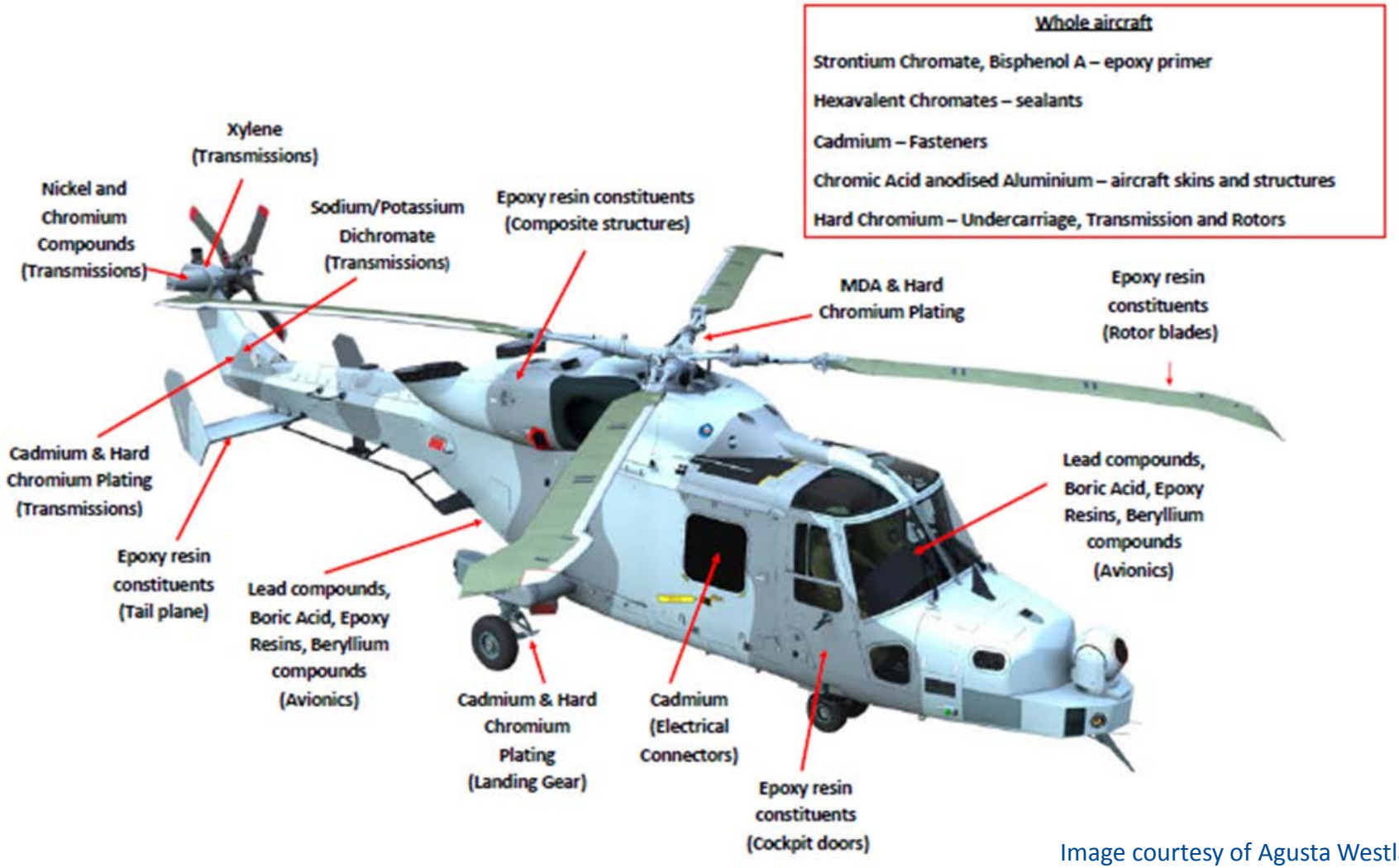
# REACH implications on aerospace products



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