



# Propulsion Engineering

## EPSRC Institutional Support Grant ATI Theme in Propulsion

# PERSEUS

Propulsion Engineering Revolutionary Systems EPSRC University Support

Professor Pericles Pilidis  
Vice-President ISABE & Director – Thermal Power MSc  
Head – Propulsion Engineering at Cranfield University

EPSRC Institutional Support Final Dissemination Event - 30 May 2017



# Propulsion Engineering

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**I will talk about**

**B O**



# Propulsion Engineering

## BO-1 Britain Outstanding

### 2015 UK Aerospace – Global N° 2

- £31b turnover - Exports £27b (~90%)
- Employs 128,000 (inc 26,000 in R&D and engineering)
- plus an additional 154,000 jobs

Source AGP

industry grows at 4.5% p.a.  
much faster than UK economy

2033: Double  
2054: x 5

Challenge: Invest to protect this employment, manufacturing and export success



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## BO-2 British Opportunity

### Disruptive Change – Hybrid Electric Propulsion (HEP)



Image Courtesy of Airbus Industrie

From

To



2030-50:  
2050:

Energy requirement reduced by 50% & 75%  
With fuel change - potential of ultra low emissions

Pros: Propulsive Efficiency  
Integration E&A&S

Cons: Weight  
Complexity

Need Appropriate Investment in Technology & Systems  
Route to Market & Infrastructure with High ROI



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## **BO-2 British Opportunity but.....Serious Threat**

International Market Dominated by Large Players in Large Blocs with a National Aero Res Organisations – To them we export extensively!

Except UK – ATI partially fills the gap

Strengthen ATI: Significant & sustained investment

Universities working together – aligned to UK strategy

- equivalent of Distributed National Aerospace Research Organisation
- HEP technology infrastructure and R&D in a decade
- Work closely with AGP - EPSRC - AIRC & Industry
- As TRL increases (1- 7) so does industrial element
- Help bring EPSRC and ATI to closer alignment



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## **BO-3 British Academia Organising Excerpt from EPSRC Letter of Award**

A further allocation of institutional sponsorship is being made available to those institutions which have a coordinating role in the research community related to the Aerospace sector, specifically around the four pillars of the Aerospace Technology Institute's Technology Strategy. Cranfield University is one such institution and EPSRC expects Professor Pericles Pilidis to take a leading role in working with the research community, EPSRC and the Aerospace Technology Institute on the Propulsion pillar of the ATI strategy.

- The UK does not have an Aerospace Research Organisation
- It does have a very strong, global reach, aerospace academic community
- Convert into equivalent 'Distributed Aerospace Research Organisation?

**EPSRC: 1<sup>st</sup> Step - Integrate UK Academic Propulsion Research Community**



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## BO-3 British Academia Organising

The outline plan

- Given Opportunity/Threat
- Hence Technology Field HEDP
- Alignment with ATI Outline Plan





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## BO-3 British Academia Organising

PERSEUS Pump Priming Work: 6-7 Workpackages

10 University Partners

Collaborating across 3 themes

Aircraft

Propulsion

Systems

Described in posters: Focus

=> Connectivity

Sharing Experts

Sharing Tools

Sharing Labs

Strategy Board WP7 – Legacy of Perseus > Working together

**NEW!**

Hybrid Electric Propulsion Group at Cranfield





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## BO-3 British Academia Organising Technical Work

Sharing Facilities

Two trials:

Electrical Operation

Gas Turbine Control

De-risking tests

Tool Synergy

Performance

Aircraft

Components

Diagnostics

No show stoppers



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## BO-3 British Academia Organising

### PERSEUS Logistics

Transparent Project Allocation  
Public Call > Call Workshop >  
Bids > Allocation Board >  
Contract negotiations >  
POs > Work > Invoices

EPSRC support doubled +  
by partners own  
Contributions

Workshops & Events



**The Royal Aeronautical Society Fedden Lecture**  
**Propulsion Technology –**  
**Is past performance a good indicator of the future?**



**Alan Newby**  
**Director of Aerospace Technology & Future**  
**Programmes - Rolls-Royce**

Wednesday 14 December 2016 - 6.45 pm  
Auditorium – Vincent Building (Building 52) - Cranfield  
Refreshments available from 6.15pm



# Propulsion Engineering

## BO-4 British Outlook - Academia

### Wide Range of Industry Requirements

Areas of interest

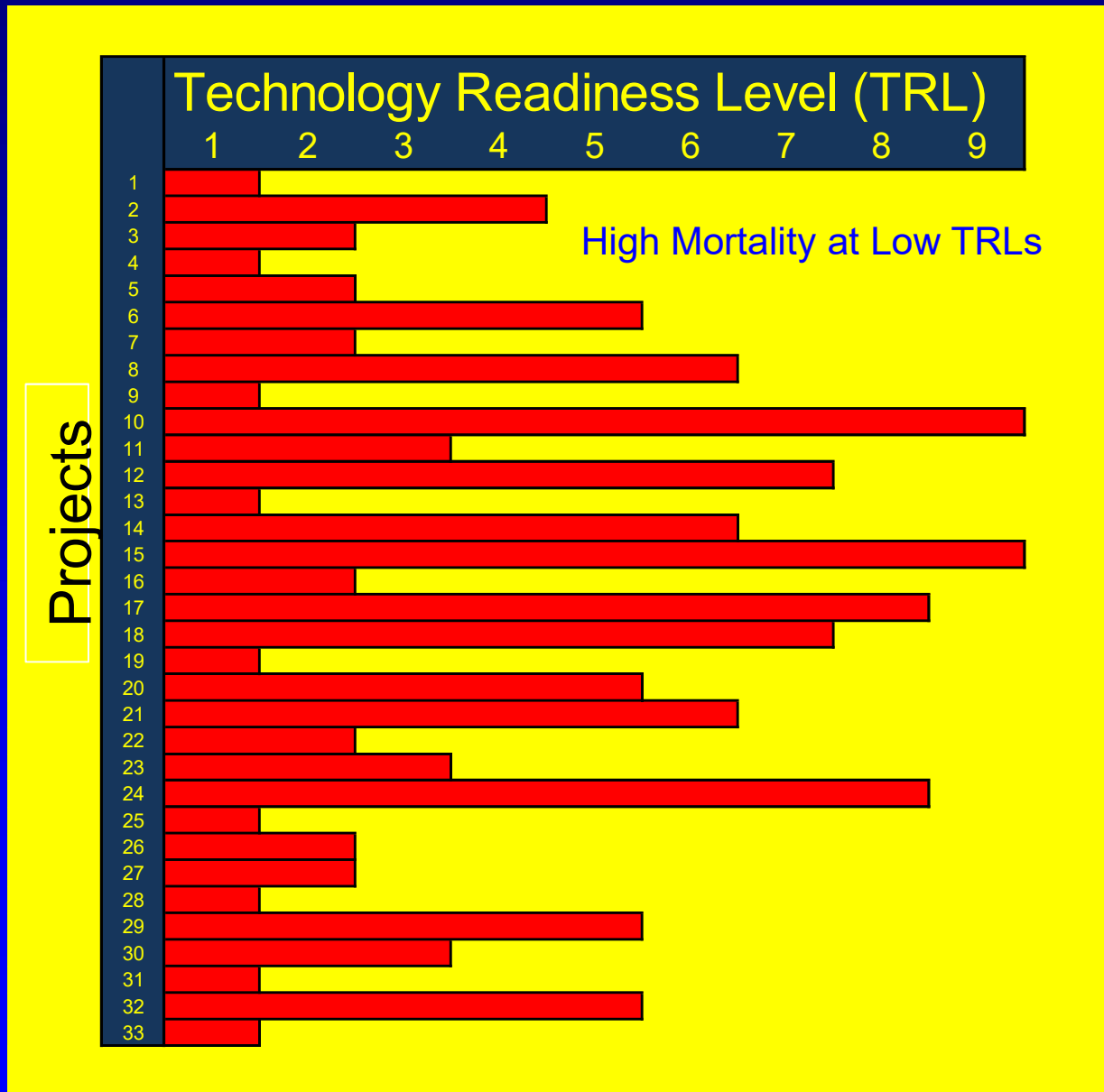
	Value to UK	Propulsion & Systems			
		Low power demand; hybrid electric;	Low power demand; all electric;	High power demand; hybrid electric;	High power demand; all electric;
General aviation	Low				
Rotorcraft*	Moderate				
Turboprop	Low				
Regional jet	Low				
Business jet	Moderate				
Narrow-body	High				
Wide-body	High				



# Propulsion Engineering

Many projects  
from wide range  
of requirements

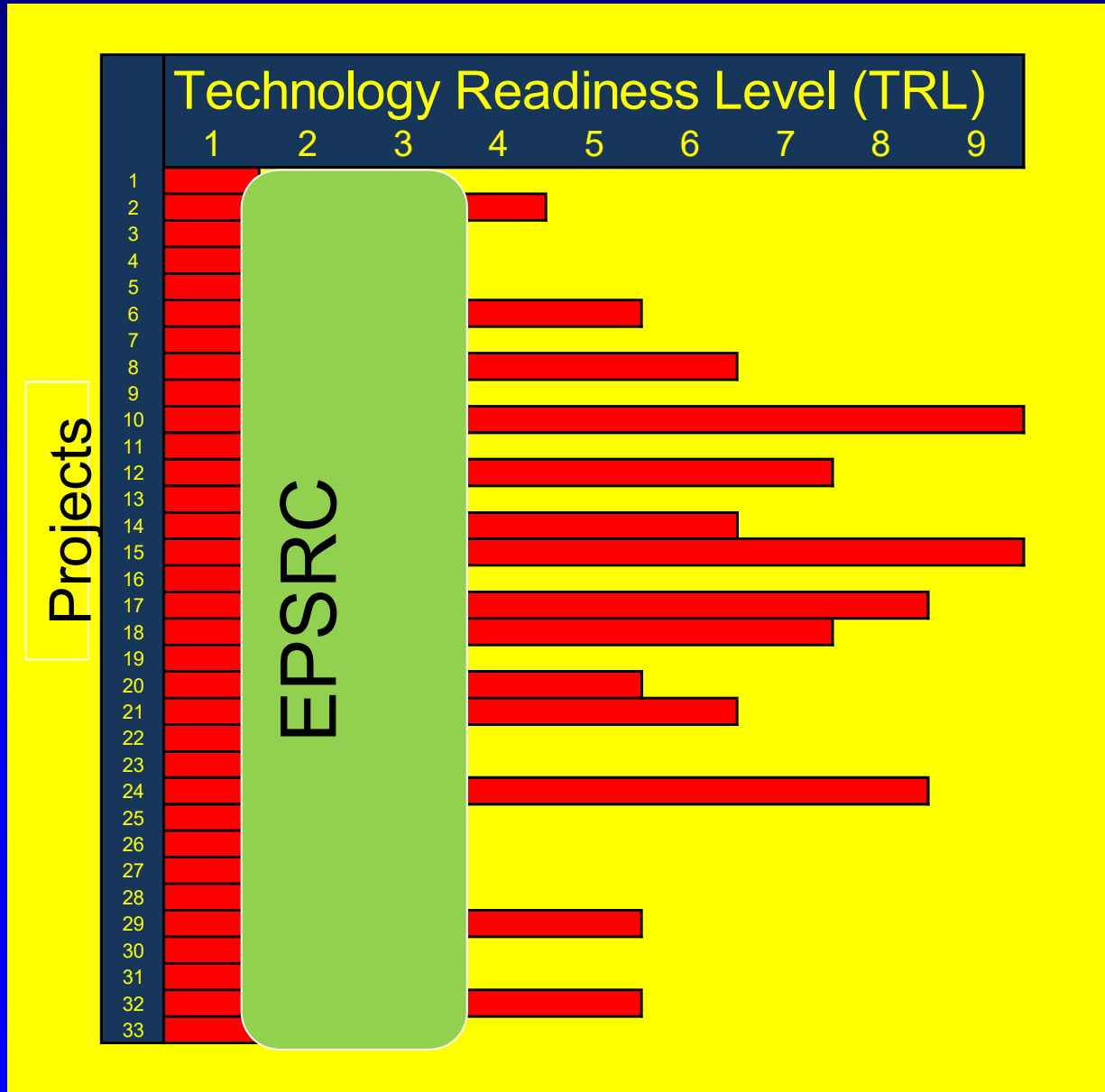
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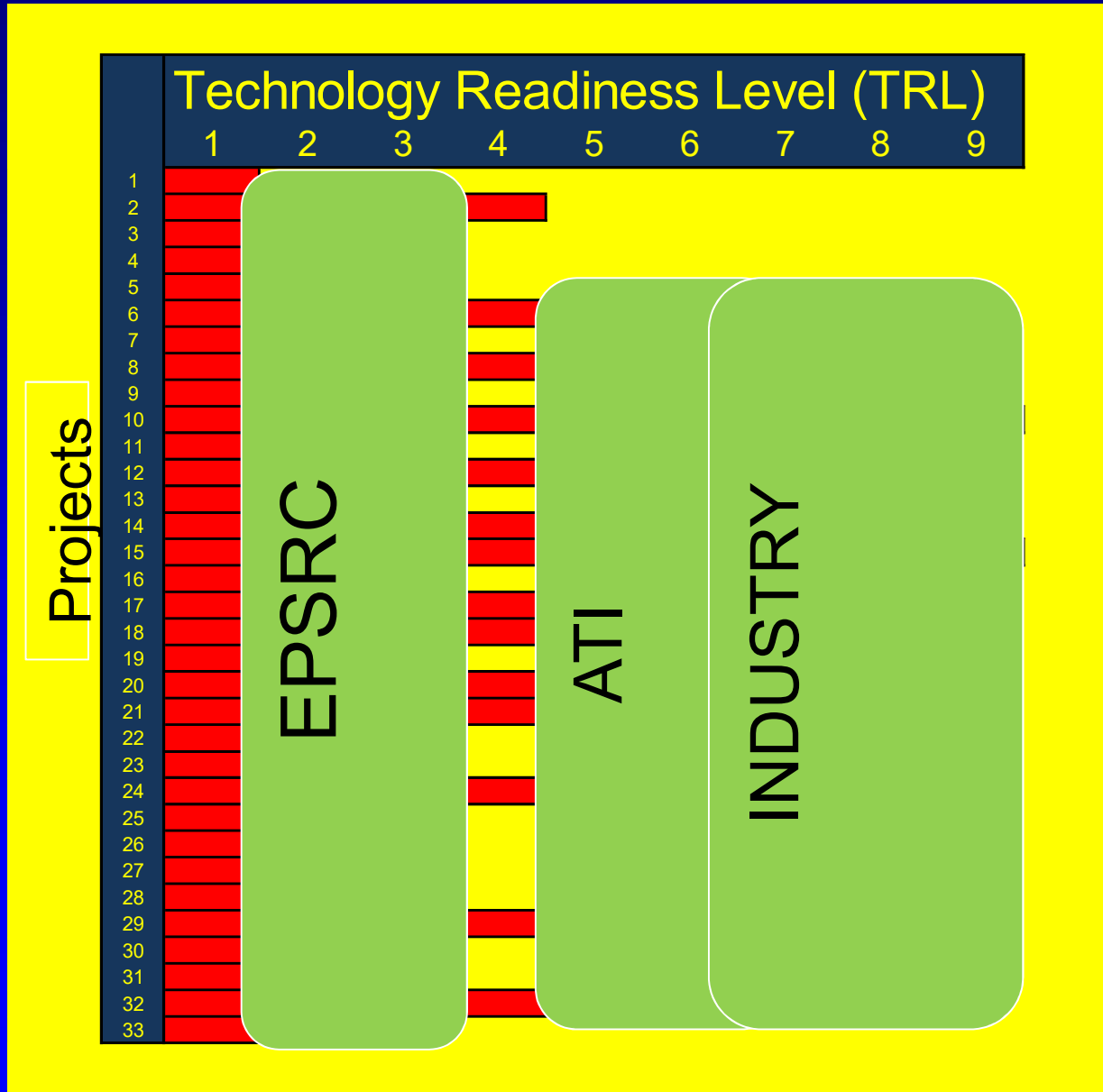


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Gaps?

Academia

Can Support







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## BO- 4 British Outlook - Academia

### Next Step – VISION (Not a promise!) Focus on HEP



**Project - 1**  
 TERA for low TRL concepts + Mid-High TRL Upgrades + Start Library of National Tools  
 Univ A, B, C....  
 SME N  
 Co M  
 Cons P  
 Other F

**Project - 2**  
 Remote Op & Control of Distant Labs for National Assets  
 Univ A, B, C....  
 SME N  
 Co M  
 Cons P  
 Other F

**Project - 3**  
 BeLief  
 BLI Demo  
 Univ A, B, C....  
 SME N  
 Co M  
 Cons P  
 Other F

**Project - 4**  
 Infrastructure + ATM ...  
 Univ A, B, C....  
 SME N  
 Co M  
 Cons P  
 Other F

**Project - n**

**Project – n+1**

**WIP**  
 Plan: Submit co-ordinated proposals by Dec 2017 with stakeholders advice





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## BO- 4 British Outlook - Academia

**PERSEUS** : Addressing the 4 EPSRC Prosperity Outcomes

**CONNECTED** in executing aerospace research on areas of national strength.

**PRODUCTIVE** on the basis of integrated development of new wealth generating ideas in an area of strength.

**RESILIENT** because of the multiplicity of members of the network.

**HEALTH** aspects arise from the long term environmental benefits of hydrogen fuelled distributed propulsion.



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## BO - 5 Yes We Can!

EPSRC £1m Experiment: Success

Academia can and must make a large contribution to UK wealth generation

Invitation: capitalise on this EPSRC £1m Investment

Formality & Funding



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**INVITATION:** Perseus, legendary founder of Mycenae, left a legacy that spanned centuries. We invite UK Aerospace plc to enable PERSEUS to deliver a meaningful legacy in our national aerospace industry.



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## HEDP Invitations

ISABE 2017 Manchester

NASA-Cranfield Day

**ISABE 2017 CONFERENCE**

3 - 8 SEPTEMBER 2017  
MANCHESTER, UK

*(the city where The Honourable Charles Rolls met Sir Henry Royce)*

Hosted by  
UK Organising Committee &  
**Rolls-Royce**

Co-Hosted by  
**Cranfield UNIVERSITY**

Supported by  
**MANCHESTER CITY COUNCIL**

**NASA Day- Hybrid Electric Propulsion**

**Cranfield University - 12 Sep 2017**

**Presentations from**

<b>Dr James D Heidmann</b> Manager Advanced Air Transport Technology Project NASA Glenn Research Centre	<b>Prof Riti Singh</b> Professor Emeritus Cranfield University
<b>Dr Nateri Madavan</b> Associate Project Manager for Technology Advanced Air Transport Technology Project NASA Ames Research Centre	<b>Prof Pericles Pilidis</b> Head - Propulsion Engineering Centre Cranfield University
<b>Mr James Felder</b> Aerospace Engineer NASA Glenn Research Centre	<b>Dr Panagiotis Laskaridis</b> Head - Hybrid-Electric Propulsion Group Cranfield University
<b>Ms Chana Goldberg</b> NASA Grant PhD Researcher	<b>Dr Devaiah Nalianda</b> Propulsion System Performance and Integration - Lead Cranfield University

**Abstract**

NASA has identified environmental responsibility as one of the key drivers that will change the aviation industry over the next 20 to 40 years. Global aerospace research is now focused in advancing technologies for significant improvements in efficiency, environmental performance and technologies for ground breaking Low-Carbon integrated propulsion system and airframe concepts.

Highly integrated electric/hybrid systems propulsion systems is one of the key areas and focus of global research. This necessarily entails a significant change in aerodynamic design and system integration aspects of the technology. Therefore, with an impetus on "clean green technology", great strides are today being made in the incorporation and adaptation of more distributed hybrid electric propulsion concepts.

NASA and Cranfield University are amongst the leading organizations involved in this field of research, and consequently, the Propulsion Engineering Centre at Cranfield University was awarded a 5 year International Grant from NASA to further research in this field. As the Grant comes to an end in 2017 and to mark the event the Propulsion Engineering Centre has invited colleagues from NASA- Dr James D Heidmann, Dr Nateri Madavan and Mr James Felder to the university for the final review of research and attend a NASA Day at Cranfield.

As part of the event, a series of prestige lectures are being organized to inform students of NASA initiatives towards a more sustainable aviation industry and future directions of research in aviation. The event will feature prestige lectures and talks from colleagues at NASA and Cranfield University.

*Dr Panagiotis Laskaridis - Head, Hybrid-Electric Propulsion Group*  
*Dr Devaiah Nalianda - Propulsion System Performance and Integration - Lead*



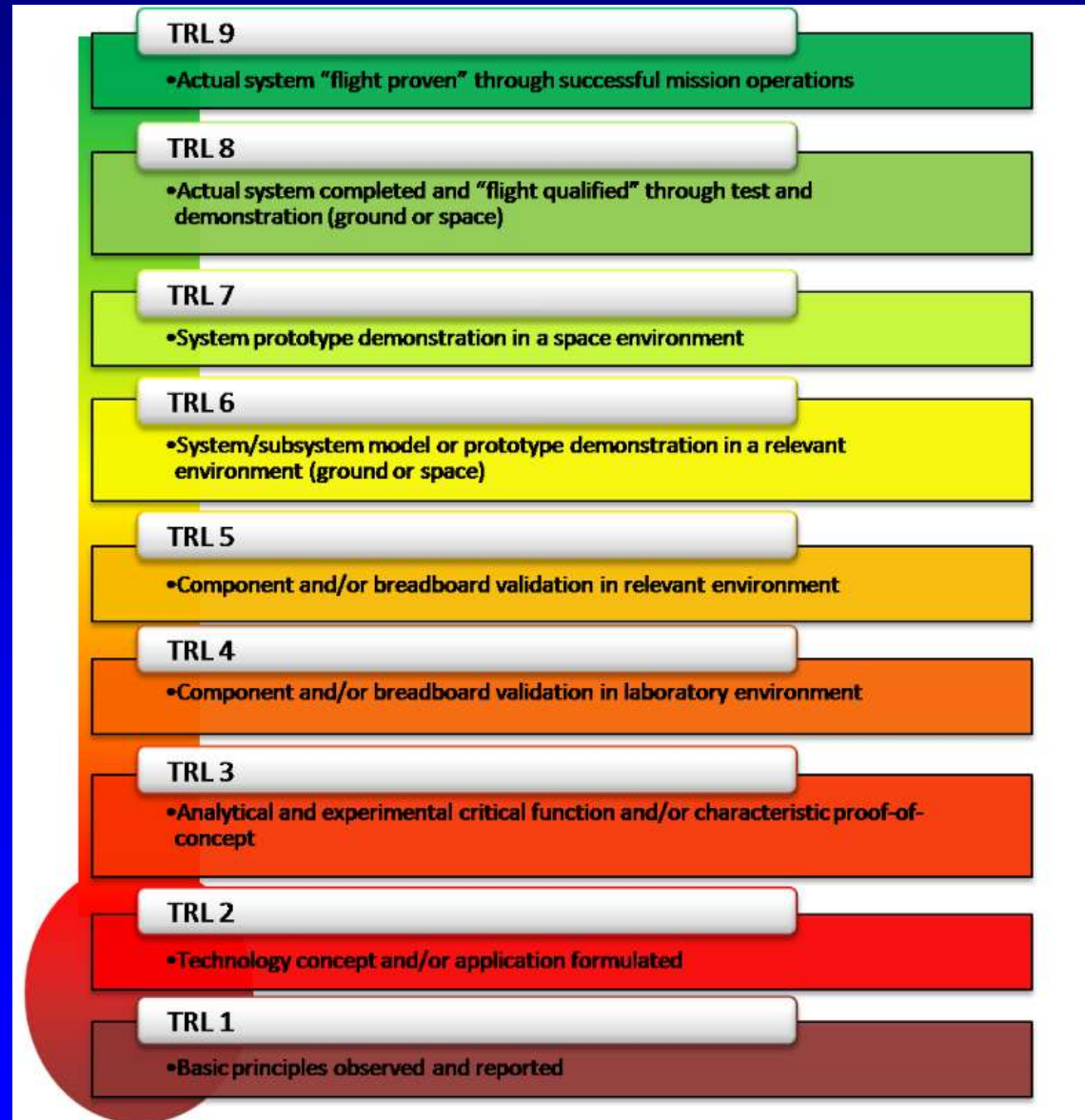
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## Additional Slides



# Propulsion Engineering





# Propulsion Engineering

## UK - ATI EPSRC Supporting Mission

Aircraft: A. Schafer – UCL

Structures: K. Potter - Bristol

Systems: B. Mecrow - Newcastle

Propulsion: P. Pilidis – Cranfield

Many Synergies – specially Systems & Propulsion



# Propulsion Engineering

Nat Assett 2  
TERA Mission assessment

Helicopter Flight  
Around Cranfield

TURBOMATCH / HECTOR /  
HEPHAESTUS



Total mission time	1.05 Hrs
Total mission range	168.5 Km
Total fuel burn	558Kg
Total CO2 emission	1779Kg
Total NOx emission	2 Kg
Total CO emission	3 Kg