SILOET II: P01 - Holistic Optimised Systems

Rolls-Royce (Lead), Rolls-Royce Control & Data Services (CDS), Raytheon UK and Sheffield University.

Project details:

The project aims to deliver optimised aero engine actuation sub-systems to TRL4 and TRL6 depending on the particular subsystem. The scope of work includes the requirements, design, modelling and build of the identified sub-systems so that it can be demonstrated on an appropriate test rig or engine demonstrator, as appropriate for the particular subsystem and TRL being achieved. The project does not include the development of any engine demonstrator itself.

The technologies will be developed by the identified partners but are also expected to engage and enable UK SMEs to stimulate the industrial and creativity bases, such as Covnetics, TTTech, Parker, Eaton and Triumph.

Increasing technology capability in micro-electronics, power electronics, electrical machines, sensors and actuators, through the Holistic Optimised Systems project, enables the development of smarter, optimised sub-systems. These systems can sense their condition, adapt their work rate and be tuned, by the overall system, to deliver optimal performance and predictability of operation.

Aero engines have a constant demand to improve performance in terms of fuel consumption, emissions and the increasing work load and utilisation placed on the aircraft demands perfect dispatch reliability and predictability in operation. These levels of performance are expected throughout the life of the engine (new to old) and in all modes of operation (long/short haul, calm/adverse weather).

Table 1: Summary of the project grant details

Project	Funding	No. of Partners	Partner Composition	Duration
110115 SILOET II P01	Total: £7.5m Grant: £3.7m	4	3 Large companies, 1 Academic	Jan 2013-Dec 2016

Table 2: Summary of the project focus areas

ATI Value Streams		ATI Enablers		ATI Attributes		Strategic Horizon	
Whole Aircraft		Aerodynamics		Safety		Secure	X
Structures		Manufacturing		Cost	X	Exploit	X
Propulsion	X	Materials		Environment		Position	
Systems	X	Infrastructure		Fuel Burn	X		
		Process and Tools	X	Operational Needs	X		
				Passenger Experience			

Technology Achievements:

The Holistic Optimised Systems project achieved significant advancement of gas turbine control and monitoring technologies at the system and sub-system/component levels. The development of the Multi-Design Assurance Level architecture is a key enabler for Rolls-Royce Control Systems to provide a low cost, high processing power control and monitoring system capable of hosting advanced, model-based algorithms that will deliver significant fuel burn (~2.0%) and component life savings.

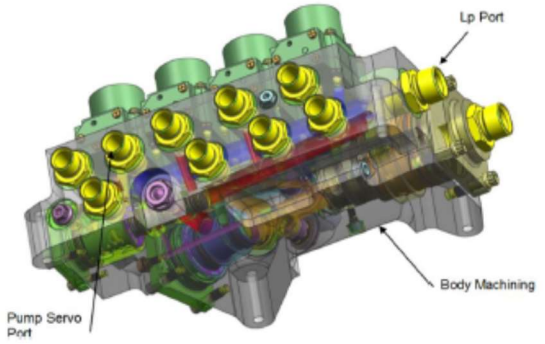
At the component level, the project has advanced the oil system modulation capability, power off-take (electrical machines and power converter units), electrically driven oil pumps, actuator control units, air system seals, air system vortex valves and wireless sensors to cope with the demanding requirements of future aerospace engines.

Two 'offshoot' opportunities to increase the capability of the project partners were identified during the course of the project: the work on wireless sensors led to Sheffield University developing thermal energy harvesting capability and associated management methodology for very low power wireless sensors. Furthermore, the development of fire resistant shielding for servo valves resulted in a UK environmental test supplier gaining the capability to perform kerosene-based fire tests.

Servovalve for oil system control

Seals measurement rig

Actuator Control Unit



Engine test of wireless sensor nodes

Table 3: Summary of the technology achievements

Project	Performance Improvements	TRL Progression
110115 SILOET II P01	Projected improvements once on in-service engine.	• Multi-Design Assurance Level Architecture TRL4 • Oil Modulation Valve unit TRL6 • Electrically driven oil pumping system TRL3 • Cap probe seal measurement TRL4 • Switched vortex valve TRL3

The first exploitation of the technologies developed by the Holistic Optimised Systems project will be in the UltraFan® demonstrator and future UltraFan® product programmes, with further utilisation across aerospace and wider gas turbine sectors being considered.

Roles of the collaborative partners:

Rolls-Royce Plc was lead partner and programme manager. Was technical lead on the delivery of the Control and Monitoring System Architecture, the Power Off-Take, the Modulated Air System and Engine Health Management.

Rolls-Royce CDS provided technical leadership for the Modulated Oil System and Fuel Management.

Raytheon Ltd provided the High Power Converter.

Sheffield University provided prognostic techniques, wireless sensor concepts, energy harvesting and management methods.

Economic Impact:

Engagement early in the program with Sheffield University allowed further development of this academic department's understanding of network based engine control and monitoring system architectures. With the selection of a network-based control and monitoring architecture being an output, following on programmes identified and worked with an SME supplier of real time networks.

The control and monitoring system architecture developed as part of this program ensures that the Rolls-Royce facilities in Birmingham remain at the cutting edge of gas turbine control and monitoring and will continue to be the choice to provide future Rolls-Royce products, potentially across an increased number of sectors: the results of this project therefore support the £15m investment that Rolls-Royce has made in the Derwent facility in Birmingham.

£700k worth of work was created at UK SMEs through 12 subcontracts during the course of the project, ranging from concept design studies at Oxford University, Covnetics and TTTech; prototype unit development by Parker, Eaton and Triumph; through to component fire-proof testing.

£3.9m was invested in the safe-guarding and skills improvement of an average of 29 employees over the duration of the project. Within Rolls-Royce, around ten people developed expertise in Model Based Systems Engineering, enhancing the company's skills in managing design complexities at the whole engine and platform levels; eight people improved their knowledge of power converters and electrical machine in the aerospace environment. Rolls-Royce and their suppliers developed their understanding of gas turbine oil and fuel systems and the possibilities for operating methods. The shared understanding of the design and challenges around oil filtration and kerosene fire testing have also had a positive impact on staff skill level.

Table 4: Summary of the economic impact

Project	Value created	Employment
110115 SILOET II P01	£4.6m of investment	Job Safeguarded: 29

Next Steps:

The Control and Monitoring system architecture will be developed to TRL6 under the ATI funded Powerplant Integration with Platform Systems (PIPS) programme between 2017 and early 2020. The first engine application is targeted for the UltraFan® variant available from 2025. Further exploitation of the architecture is planned across aerospace sectors. Specific control and monitoring features of distributed input/output and real time networking will be developed to support future engine architectures that have entry into of service of 2030 and beyond.

The power converter concept from SILOET II Project 1 will be further developed by Raytheon and Rolls-Royce under the ATI/InnovateUK funded Scalable MultiPlatform Power (SMPP) consortium. The power converter is an essential element towards a more electric powerplant solution with applications in the 2030+ timeframes.

The modulated oil valve technology is to be developed further through More Electric Engine Demonstration, Power Gearbox rig demonstrator and alternative engine architecture tests. The use of the electrically driven oil pumping solution is dependent on identifying a suitable supplier/partner to develop the solution further.

The fuel flow management components will be developed to TRL6 via the UltraFan® demonstrator in 2019/20 and planned to be deployed on the UltraFan® product from 2025. The ATI funded ENCASE programme will manufacture and assemble the Actuator Control Unit designed by SILOET II Project 1, and achieve TRL6 via the UltraFan® Demonstrator.

The switched vortex valves investigated by this project require demonstration on an engine vehicle. Currently an appropriate demonstrator vehicle is being identified.

The Cap probe seal measurement method will achieve TRL6 via engine demonstrator tests planned during 2018. The technology is then applicable for UltraFan® products and with possible benefits on Trent 1000, Trent 7000 and Trent XWB engines.

[ENDS]