Sustainable and Green Engine (SAGE) ITD

Annual Implementation Plan 2012

2012 will be a key year for the SAGE ITD, when critical decisions will be made and projects will start to come to fruition and deliver engine demonstrations. The focus up to this mid-year in the programme has been largely expended in preparing for demonstrations: defining technology demonstration requirements and validation strategies, managing the risk to engine demonstrations by raising the Technology Readiness Level of selected technologies through sub-system rig testing, developing engine test component designs and enabling manufacturing technologies and reviewing the demonstrator plans. Key decisions and significant commitments will be made in 2012 that will freeze the demonstrator configurations and finalise the technological designs. Components will be manufactured and demonstrators assembled and delivered for test, with the first engine demonstrations in projects SAGE3 and SAGE5 scheduled to be completed before the end of the year. A Lean Burn Demonstrator was introduced into a new SAGE called SAGE 6.

SAGE 1 will continue to develop Geared Open Rotor Technology and a demonstrator engine for ground and flight testing, now planned outside the Clean Sky timeframe, based on the work performed under SAGE1 and SFWA. The CROR technology acquisition effort under SAGE1 proceeds in parallel to the Lean Burn demonstration, to be able to assist outstanding SFWA CROR key decisions in 2012, including support to the rule making process and definition of key technologies to be demonstrated and to enable CROR demonstration after the current Clean Sky The significant technologies to be developed and finally demonstrated are the open rotor assembly including the counter rotating blades, the blade pitch control and the transmission systems. The initial programme of work is focussing on the R&T necessary to develop the TRL of the fundamental enabling technologies and assess the feasibility of the open rotor concept for full demonstration. This will be achieved by both ongoing design studies, methods and tool development and validation and engine component rig test programmes. Additional rig testing at aircraft level will be carried out in the Smart Fixed Wing Aircraft ITD, in 2012 and 2013/2014.

For **SAGE 2**, the 2011 activities were dedicated to feasibility studies of the Geared Open Rotor configuration. A Preliminary Concept Review took place in December 2011. The SAGE 2 project will hold two reviews in 2012 to consider the feasibility and configuration of the open rotor demonstrator: a Concept Review mid 2012 and a Preliminary Design Review end 2012. Configuration and installation feasibility studies will be performed in the period leading up to the reviews, together with gas generator development and open rotor propulsor design studies. These studies will encompass the composite propeller, pitch control, power gearbox, power turbine, rotating nacelle and structures, lubrication and cooling and control sub-systems and the integration of the sub-systems into a full engine system. A conceptual design phase is scheduled to close mid-2012 with the CoR (Concept Review). During this period, detailed design studies will be made at system level to consider sub-system interactions and establish a coherent overall demonstrator concept that is consistent with the configuration and installation conclusions reached by the SFWA ITD. Low speed component tests of two propeller configurations are scheduled in the first semester of 2012. Combined with high speed tests performed in 2011, they will enable aerodynamic and acoustic design tools calibration. After the CoR, the project will enter the preliminary design phase that is planned to last until end 2012 and to close with the PDR end 2012. The demonstrator architecture, modules interfaces and propeller blades design will be frozen at the PDR. Low and high speed wind tunnel tests of demonstrator propeller are scheduled for the second semester of 2012.

The **SAGE 3** project demonstrates technologies for large 3-shaft turbofan engines and is scheduled to deliver its first engine demonstration during 2012 and to complete a large proportion of the preparation for the second engine build. The first technology for engine demonstration is the advanced dressings, which will be demonstrated in two phases, through trial builds and subsequently through indoor engine testing. The second engine test, to demonstrate the composite fan, is

scheduled to commence in early 2013 and work in 2012 will focus on manufacturing components and completing associated rig tests. Technologies to support higher temperature capability and lower weight intercase structures are being demonstrated through a series of rig tests and this programme will reach a conclusion during 2012. Demonstration of low pressure turbine technologies commenced through rig testing in 2011 and tests will continue in 2012, both in preparation for the engine tests and to provide validation data. Detail design of the LP turbine module for engine demonstration will be completed in 2012, procurement will be launched and manufacturing of components progressed in preparation for assembly of the turbine in 2013.

SAGE 4, the Geared Fan Demonstrator Project, will complete most of the procurement activities during 2012 to ensure its readiness for the engine demonstrator test starting in the last quarter of 2013. Having established the demonstrator concept design and having defined the technologies for demonstration in the first half of 2011, the concept optimization of the demonstrator design will progress throughout the remainder of 2011, being the demonstrator design frozen at Critical Design Review in the first quarter of 2012. A key aspect of the concept optimization phase is that the complete description of the planned demonstrator engine will be carried out, and this will be the engine configuration which will be detailed during the following project phase. Preliminary engine design and detailed design work will follow up and will be completed by the end of 2012 and beginning 2013. Component manufacturing, procurement activities and coordination of the contributions of the various project participants, will proceed through the year towards final parts being delivered at the end of 2012 and beginning 2013.

Project **SAGE 5** will deliver its first engine demonstration during 2012, having completed design activities and launched manufacturing and procurement in 2011. Final parts for the first build are scheduled for delivery in first quarter of 2012, following which the engine will be assembled and delivered for test in mid-year. The test plan will be performed in the third quarter, to be followed by data analysis and preparation of test reports, which are due by mid-2013. Preparations for the second engine build incorporating hot section technologies will continue with final detail design activities being completed and manufacturing of components for the second build being launched during 2012, although final delivery of parts is not due until 2013.

The aim of the **SAGE 6** lean burn project is to demonstrate a lean burn whole engine system to a TRL6 maturity level, suitable for incorporation into civil aerospace applications in the 30,000lb to 100,000+ thrust classes. Lean burn combustion is a vital technology acquisition for the European aerospace industry to remain competitive in the world marketplace and comply with future CAEP & ACARE emissions legislation. Significant technologies that will be developed during this programme in 2012 will consist of, but are not limited to, Combustion, hydromechanical fuel control, control laws and associated sensing devices, whole engine thermal management, acoustic attenuation, turbomachinery thermo-mechanical integration and system health monitoring and maintenance functions. To increase current TRL levels of subsystems from typically TRL 3-4 to TRL 6 by full system demonstration a proposal has been made to develop a new demonstrator vehicle based on a Rolls-Royce Trent 1000 engine for ground test and suitable for installation on a flying test bed.