Future Aircraft Propulsion Technologies
by Richard (Ric) Parker, Rolls-Royce Technical Director

The Rolls-Royce company was founded in 1906. Its charter stated that it intended to develop power sources for land, sea and air and that remains true right up to the present day. The company's first major involvement with aircraft engines was during WW1. The first aero-engine, the Eagle, was tested and flew 100 years ago this year. Over the years Rolls-Royce has acquired a number of other companies resulting in today's Worldwide company. Currently approximately 60% of its products are for use in aircraft whilst the remaining 40% are for land and sea purposes.

Ric's lecture concentrated on civil aircraft engine developments. In the recent past these have been concentrated almost entirely on Rolls-Royce's Trent series of jet engines which together provide power sources for the entire spectrum of present day civil aircraft. Today, jet aircraft contribute 2-3% of the World's CO_2 emissions. The overall aim by 2050 is to get CO_2 emissions down to 50% of their year 2000 levels despite an anticipated expansion in air travel. It is also important to reduce oxides of nitrogen (NO_x) emissions and aircraft noise. Already there have been significant advances since the Trent 800 of the year 2000. Maintaining these advances will demand the use of new technologies such as lean burn technology which reduces the fuel to air ratio and hence the NO_X emissions and revised fan designs to reduce air flow speeds and hence engine noise.

Rolls-Royce works with 31 university groups throughout the World to develop the new technologies. Advanced manufacturing centres have also been set up with universities to develop new manufacturing techniques.

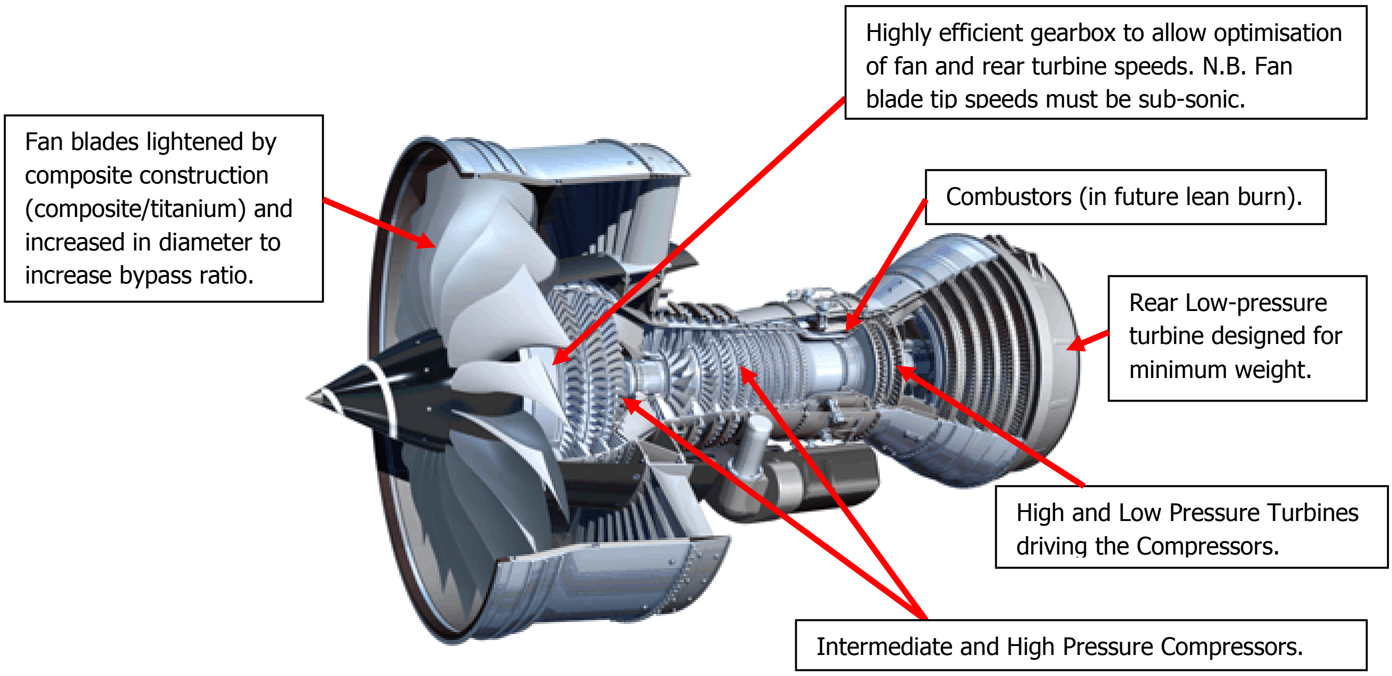

Fig. 1 – Future Jet Engine developed from Rolls-Royce's the highly successful Trent series of engines.

Fig 1 above shows the evolutionary approach which is being adopted based on the Trent engine series. The fan has been increased in diameter to increase the bypass ratio to in excess of 11:1. This will necessitate the use of composite fan blades. It will also be necessary to reduce the fan speed in order to keep the fan blade tips to a subsonic speed. This will in turn necessitate the use of a gearbox immediately behind the fan to ensure that the rear low-pressure turbine, which drives the fan, can still be operated at its optimum speed. The massive amount of power handled by this gearbox means that it must operate at a very high efficiency level – even 1% power absorbed by the gearbox is not acceptable. The design of this gearbox is currently being researched by one of the university research groups in Germany. The pressure ratio between the outside air pressure and the output of the high pressure turbine will also be increased from 50:1 to 60:1.

Pratt and Witney have already found it necessary to use a geared turbofan. This is because they use a two-shaft architecture whereas Rolls-Royce uses a three-shaft architecture. The latter allows Rolls-Royce to have separate high and low pressure spools thereby allowing the intermediate pressure compressor and low pressure turbine combination to operate at different speed from the high pressure and high pressure turbine combination, i.e. they can both operate at their optimum speeds. Thus the tipping point before a gearbox becomes a necessity is different between Pratt and Witney and Rolls-Royce. It should also be noted that the use of a gearbox has a significant weight disadvantage.

Other technologies to be used in the new breed of engines include 3-D printing which now includes the building up of metal structures using a variant of electron beam welding and direct laser deposition. Some of this technology is being researched at Loughborough University and developed at the Ansty research facility. Importantly, 3-D printing will allow the manufacture of shapes which cannot be manufactured by any other means.

The future beyond Trent engine developments may well see a further investigation of open rotor designs. Existing propeller driven aircraft suffer from both height and speed constraints. These constraints can be overcome by using a multi-bladed contra-rotating design as shown in Fig. 2 below. There is no heavy outer casing and the fan blades can become very large leading to a bypass ratio in the region of 50:1. The only problem will be that of noise as any noise produced by the blades will radiate immediately to the ground below. However testing carried out to date suggests that such an engine can be as quiet as current enclosed fan engines and thereby conform to current noise regulations although it will never be as quiet as the next generation of enclosed fan engines. This means that the choice of future engines will be more of a political rather than a commercial decision – efficiency and fuel economy v. quietness.

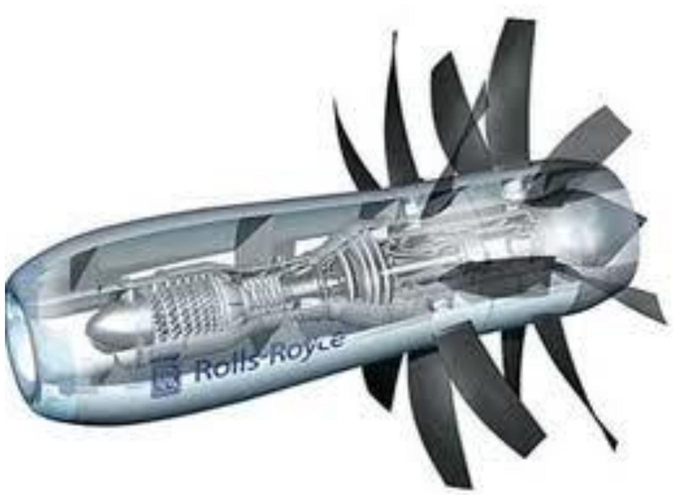

Fig .2 – Future Open Rotor Design with rear mounted contra-rotating fans.

Beyond the engine developments described above the future is likely to lie with more physical integration between the aircraft engines and the aircraft body thereby reducing overall drag and allowing the engines to be used in various lift enhancing roles. There is also likely to be increased use of hybrid technology allowing the engines to provide electrical power to drive majority of on-board systems.

The lecture was also attended by Bill Tyack, RAeS President and his wife together with Scott Phillips, RAeS Membership Services Manager. Ric's (Richard's) obvious comprehensive understanding and enthusiasm for his subject was rewarded by many questions at the end of his lecture. Following a vote of thanks given by Goff Tearle, the audience of about 160 people rewarded Ric with an enthusiastic endorsement of the lecture.

Lecture notes by Colin Moss