The UltraFan© engine is an innovative geared turbofan engine demonstrator, as well as a major showcase within Clean Sky’s Engines programme. The demonstrator targets fuel-efficient and more environmentally-friendly engine performance and achieves this by incorporating a raft of technologies and innovative high-temperature materials, as well as new geared architecture (using a power gearbox introduced between the fan and intermediate pressure compressor) to ensure that the fan, compressors and turbines all continue to run at their optimum speed.

Operating at higher speeds means better fuel efficiency and fewer emissions, in line with the EU’s green ambitions and Clean Sky’s objectives.

‘The beauty of the UltraFan engine is its modular design, so you can cover a wide range of tasks from 25,000 to 100,000 pounds of thrust,’ explains Clean Sky Engines project officer Andrzej Podsadowski.

‘Clean Sky and Rolls-Royce are working together on the key enabling features for the UltraFan, such as different fans, solutions for transmission systems, solutions for bearings, and many other technologies, and these are progressing well,’ he adds. ‘The demonstrator programme encompasses over 30 different organisations across eight different countries via Clean Sky 2.’

Recent achievements

Despite the challenging environment, the UltraFan recently reached one of its major milestones, not just for the past year but for the whole programme.

‘We’ve started the formal build of the very first UltraFan demonstrator, so it’s a tremendously exciting time,’ says Charmaine Cordo, Rolls-Royce’s Chief Project Engineer, UltraFan Demonstrator.

‘Years of preparation and planning are coming together to create our first real working piece of equipment, the start of something that has the capability to transform into an entire family of UltraFan engines – with a power range from 25,000lb to more than 100,000lb, that can power both the narrowbody and widebody aircraft of the future.’

The build is taking place at Rolls-Royce’s DemoWorks facility in Derby, UK, and the company is creating all the build kits that are needed to get the demonstrator build up and running. Concurrently, a number of associated milestones are being reached on all the key technologies going into UltraFan, so all the large pieces of technology are now in the build phase.

These include the carbon composite blades that will make the demonstrator the largest in the world at 140 inches in diameter (encased in a composite fan-case that is big enough to drive a London tube train through) are already in production at Rolls-Royce’s new composites facility in Bristol, UK.

And meanwhile, the UF001 Power Gearbox, the most powerful in the aerospace industry capable of delivering 50MW, is now on build at the company’s facility in Dahlewitz, Germany.
‘It’s all coming together and it gives me a real sense of pride to know that this programme is about to deliver something tangible and something that will make a real difference in reducing emissions at a time when people are preparing to connect again, travel again and want to do so sustainably,’ says Cordo.

**Gearing up for sustainable aviation fuel**

Cordo points out that there are two ways UltraFan will help the drive to net zero. Firstly on the basis of technology with such innovations as Rolls-Royce’s Advance 3 core architecture and the ALECSys (Advanced Low Emissions Combustion System demonstrator, which received funding from Clean Sky 1’s Sustainable And Green Engine programme) lean burn technology, ‘making UltraFan 25 per cent more efficient than the first generation of Trent engine.’

And secondly, the UltraFan will be capable of running on 100% sustainable aviation fuel (SAF) right out of the box: ‘We’ve just announced that we are going to do our first run of the demonstrator on 100% SAF, which will provide the industry with further proof that gas turbines are capable of operating on this kind of fuel,’ she says.

‘That will be additional confirmation, as last November Rolls-Royce ran the ALECSys technology on 100% SAF. That covered 15 hours of engine running, 19 starts, 5 accelerations/decelerations, and 33 fuel dips to explore combustor extinction boundary and relight behaviours.’

Cordo confirms that no issues were found, nor anything that would be detrimental by incorporating 100 per cent SAF: ‘Our preliminary analysis found that NOx, CO and UHC (unburnt hydrocarbons) emissions were similar or slightly better than using Jet A-1 (regular jet engine fuel). Non-volatile particulates – previously measured as smoke – were much improved as expected due to lower aromatic content.’

**Product portfolio ambitions**

In terms of the company’s product portfolio UltraFan is crucial to Rolls-Royce’s future gas turbine strategy, with the benefit of being a scalable technology that can be applied to both the narrowbody and widebody market.

‘But it is also critical to our sustainability strategy, which will be hugely important to Rolls-Royce going forward,’ says Cordo, who notes that there are still opportunities to improve gas turbine performance which will be vital to aviation, ‘as we know that gas turbines will be the only viable solution to long-haul flight for many years to come, and every saving that can be made will be important in reducing emissions.’

Gas turbines will continue to be the bedrock of long-haul aviation for many years, and UltraFan’s efficiency will help improve the economics of an industry transition to more sustainable fuels, which are likely to be more expensive in the short-term than traditional jet fuel. The first test run of the engine will be conducted on 100% sustainable aviation fuel.

‘Advocacy for the use of 100% sustainable aviation fuel is the second element of our sustainability strategy and is obviously closely tied to UltraFan developments,’ Cordo says, which is why the ALECSys run on 100% SAF was important in terms of demonstrating its applicability to gas turbines. The same fuel has been tested on a Pearl business jet engine, which proved there is no requirement for a specialist lean burn combustion system.
Milestones ahead

For the immediate future, the programme’s next challenge is the completion of build by the end of 2021.

‘And that will be an incredible moment for everyone on the team,’ says Cordo. But other related milestones are crucial to UltraFan’s success, she notes – ‘one of the biggest will be the formal opening of Testbed 80 in Derby, our new £90 million facility where UltraFan will perform its test running.’

The state-of-the-art facility, the largest indoor testbed in the world capable of running engines up to 150 000 lb thrust, is also the smartest – capable of detecting vibrations at the rate of 200 000 samples per second.

‘So it will be quite a moment at the end of 2021 when we have a brand new engine demonstrator and a brand new testbed both ready to start the testing phase of the programme. It’s a real sign of the commitment the company is putting into this engine despite the huge impact COVID-19 has had on the aerospace industry,’ Cordo says.

Can’t beat the system

Rolls-Royce, Clean Sky and the expansive Clean Sky ecosystem of SMEs and universities have been instrumental in bringing the programme to this tangible state of progress.

‘UltraFan is a really collaborative programme for us, both in terms of the design of the engine and construction of the programme and supply-chain,’ says Simon Lukaszewski, Programme Manager Aerospace R&T, Rolls-Royce.

To deliver UltraFan, Rolls-Royce has research, design and hardware manufacture coming from its facilities and partners in the UK, Germany, Spain, France and Sweden, funded by Clean Sky 2, complemented by the company’s extensive research network of University Technology Centres and National Research Centres.

‘Clean Sky 2 then provides an even broader ecosystem in which not only is our existing network able to participate, but its open nature also facilitates collaboration with SMEs and universities that we would not have otherwise worked with,’ adds Lukaszewski.

He emphasises that ‘Clean Sky 2 is a great enabler for really driving the collaboration model and for working across the technology programme together with our partners, old and new.’

‘This,’ concludes Lukaszewski, ‘all helps us in developing a greater understanding of the underpinning technologies, and our engagement with European universities and research institutes will have contributed to the European skill base helping the company, and Europe more generally, to remain globally competitive.’