High-tech made by MTU
MTU Aero Engines is Germany’s leading engine manufacturer and a firmly established player in the industry. The company, whose roots reach back to the dawn of aviation, designs, develops, manufactures, markets and supports commercial and military aircraft engines as well as stationary industrial gas turbines. Its predecessor companies provided the engines for the first powered airplanes as early as at the beginning of the 20th century. Today, the company has carved out leading positions in essential engine technologies: High-pressure compressors, low-pressure turbines, manufacturing and repair technologies made by MTU are among the finest to be found in the global marketplace.

With its comprehensive and well-balanced product portfolio MTU has content in all thrust and power classes and in all essential components and sub-assemblies that make up an engine. As a renowned partner, MTU closely cooperates with all of the big engine manufacturers and actively drives the development of the industry. It plays a role in all important national and international technology programs. With its partners from industry, research and academe MTU has for years been developing novel technologies to make engines quieter, fuel-thriftier and cleaner. The propulsion system of the future is the geared turbofan (GTF) engine which excels by its very high efficiency and low noise levels. The engine is developed and built jointly by Pratt & Whitney and MTU.

One of the core competences of the company is the maintenance of commercial engines. Its maintenance segment is the world’s leading independent provider of commercial engine maintenance services. In the military arena, MTU is Germany’s industrial lead company for practically all engines flown by the German Armed Forces. European military programs in which MTU has a leading role include the TP400-D6 for the A400M military transport, the EJ200 for the Eurofighter/Typhoon, and the MTR390 for the French-German Tiger attack helicopter.

MTU Aero Engines’ headquarters are in Munich. It is from there that the German and non-German affiliates and most of the companies research and development activities are controlled. The Munich location is also home to the company’s military engine business.
Based on the geared turbofan technology, Germany’s leading engine manufacturer has developed its forward-looking Claire (Clean Air Engine) technology program. It aims at reducing fuel consumption and hence carbon dioxide emissions in three stages by up to 30 percent by the year 2035. Furthermore, the perceived noise level will be halved. A compelling advantage of Claire is that all of the key technologies to be folded into the project already exist or that at least their feasibility has been demonstrated.

With its Claire project, MTU has identified an approach to addressing the challenges facing the aviation industry in the future: The aircraft manufacturers will build thriftier, cleaner and quieter aircraft, and MTU will supply the engines to power them.
High-tech made by MTU

Innovation is the moving force behind MTU Aero Engines and forms one of the company’s five strategic pillars. With over 100 patent applications a year, MTU secures its technological leadership position in its core competencies in the fields of low-pressure turbines, high-pressure compressors, engine control, monitoring and diagnosis units, as well as high-tech manufacturing and repair techniques.

Its technology portfolio includes some 100 projects that are firmly focused on the company’s objectives and pursued in accordance with strict product development rules. Close meshing with industrial partners, academe and research institutions is the sine qua non of success in the development of new technologies.

Tomorrow’s engines call for innovative ideas. The growing mobility needs of billions of people, limited raw materials and acerbating ecological problems leave little doubt that new engine solutions must go beyond existing concepts.

Current projections assume that air traffic will keep growing at a rate of four to five percent a year, practically doubling within 15 years. The industry’s challenges are growing accordingly, because tomorrow’s aircraft must be fuel-thriftier, quieter and cleaner.

The European aerospace industry has set specific goals for itself. In 2002, ACARE, the Advisory Council for Aeronautics Research in Europe, issued its Strategic Research Agenda: By the year 2020, aircraft are to burn 50 percent less fuel, emit 50 percent less carbon dioxide (CO₂) and 80 percent less oxides of nitrogen (NOₓ). Moreover, the perceived noise level is to be halved. A substantial contribution will have to come from the engines of the next generation: 20 percent less CO₂, up to 80 percent less NOₓ and 50 percent less noise (-10 ENPdB). But that’s not the end of it: Under the Flightpath 2050 initiative, the industry has set itself even more ambitious goals: 75 percent less CO₂ emissions and 90 percent NOₓ emissions as compared with 2000 values. Noise is to be reduced by 65 percent.

In addition to environmental objectives, ACARE also defined precise goals in terms of quality, cost, safety and system efficiency.

MTU has already developed solutions to achieve the ambitious targets for the future: Under its Claire technology initiative, the company combines key technologies that already exist or whose feasibility has been demonstrated to build a highly advanced engine that will burn 30 percent less fuel, emit less carbon dioxide and produce half the perceived noise. Plans are to achieve these targets by 2035. The new concept revolves around the geared turbofan which will be further optimized.

15 percent, 20 percent, 30 percent less carbon dioxide are the staged goals the company has set for itself. This roadmap was developed by MTU experts in partnership with the futurologists of Bauhaus Luftfahrt. The geared turbofan engine alone already provides a reduction in carbon dioxide emissions by up to 15 percent. In the next stage, further improvements are aimed at generating thrust more efficiently, by enhancing individual components or by the use of a shrouded counter-rotating propfan. In the third and last stage, the focus will be on improving the efficiency of the core engine, for example, with the aid of a heat exchanger.

With Claire, MTU once again lives up to its reputation as a technology leader: MTU’s Claire initiative is not about lofty visions but bases on existing and well-tried key technologies.

MTU technologies are on board also on Boeing’s next-generation wide-body aircraft, the 787 Dreamliner.

The PurePower® PW1000G engine is setting new standards worldwide in terms of fuel consumption, CO₂ emissions and noise.
Pilot concepts describe the engines of future generations. Individual pilot concepts outline potential engine architectures for a certain application category believed to satisfy future market requirements. Pilot concepts specify the general direction technology development is supposed to take. MTU develops pilot concepts for all applications forming part of its strategic product portfolio. In the commercial domain, these are engine concepts for business and regional jets, short-, medium and long-haul aircraft.

**Advanced turbofan engine**

Today, the turbofan engine has found a home on practically all jet-propelled aircraft. However, the ambitious emission goals of the ACARE Vision 2020 cannot be fully met with the turbofan concept. Any significant reduction in fuel consumption and noise can be achieved most effectively using a high bypass ratio. Further developments of turbofan engines are aimed at increasing the bypass ratio to a little above ten and optimizing individual components for better aerodynamic efficiency and lower weight.

**Geared turbofan engine**

The geared turbofan (GTF) is the engine concept of the future. MTU is partnering with Pratt & Whitney on demonstrator and development programs for this new engine generation. Unlike conventional turbofans, where fan and low-pressure turbine rotate on a common shaft and at the same speed, the two components are decoupled by a gearbox arranged between them. Accordingly, the large fan operates at a slower and the low-pressure turbine at a faster speed, which improves their respective efficiencies, lowers the noise level and about halves the number of stages in the turbine. Bypass ratios of 12 and beyond become a possibility and fuel burn can be considerably reduced.

Orders from Mitsubishi, Bombardier and Irkut, who are going to use the geared turbofan engine on their emerging regional jets and short- and medium-haul aircraft, have paved the way for the successful placement of the product on the market. In late 2010, Airbus selected the GTF as one of the two engine options for its upgraded A320neo.
Future developments
The propulsive efficiency can be further boosted only with a higher bypass ratio. A major step forward is the further development of the GTF into the second-generation GTF. At the same time, alternative solutions are being investigated, such as the counter rotating integrated shrouded propfan, or Crisp for short. In this derivative of the geared turbofan, two counter-rotating fan rotors are arranged one behind the other. The shroud is intended to reduce noise emissions.

The technical foundations of this concept had been laid already back in the mid-1980s, when also its general feasibility had been demonstrated. The low fuel prices at the time, however, prevented the concept from going into production.

Intercooled recuperated engine
In the quest for higher efficiencies advanced thermodynamic cycles are also being investigated. Among others, the recuperated propfan appears to be a promising concept which helps further enhance the thermal efficiency of engines. It is designed to take the last hurdle on the route to 30 percent carbon dioxide reduction. This concept, too, bases on the geared turbofan with a high-speed low-pressure turbine.

The efficiency of an engine can be optimized by the use of downstream recuperators.

In addition, it features an intercooler between the compressors and a recuperator in the exhaust gas stream. Intercooling and recuperating energy from the exhaust gas stream markedly increase the engine’s thermal efficiency.

Considering that intercooler and recuperator involve weight and cost penalties, the integration of these components poses new technological challenges for the overall system.
In MTU’s military product portfolio, the spectrum of pilot concepts is delineated by various applications. On the one hand, they include the conventional low-bypass turbofan engine to power combat aircraft, which is currently being tailored to suit the peculiarities of unmanned applications, and pilot concepts for advanced turboshaft engines to power turboprop airplanes and helicopters on the other.

**UAV engines**

In the EU, engines for unmanned aerial vehicles (UAV) are presently taking center stage in military technology development. For long-range cruise applications, they need to be fuel-thrifty, but for low-level operations also should generate substantial thrust.

To achieve compactness, innovative solutions are needed, because the engine will have to be entirely integrated into the airframe to suppress its radar and infrared signature. Since the intention is to fly the aircraft unmanned, engine control and operational reliability requirements are immense. Here, MTU brings its comprehensive experience in the military business to the table and is a reliable partner in national and international research projects, such as the European Technology Acquisition Programme (ETAP).

**Variable cycle engines**

A combat aircraft system is designed for maximum performance in extreme situations. For cruising, a smaller engine would be fully sufficient. The variable cycle engine concept therefore uses so-called active systems to individually adapt the engine to suit changing operating modes. What needs to be developed for such engines are variable modules (bypass duct, fan or exhaust nozzle) or variable components (stator vanes). The technical challenge here is to reliably integrate these systems into the engine mechanically and electronically.

**Helicopter engines**

For helicopter engines, the rules are basically the same as for turbofan engines, the challenge being to boost performance while reducing weight and fuel consumption. Much like the geared turbofan, the turboshaft engine has a high-speed low-pressure turbine. The transfer of technologies from existing large commercial and military engines is subject to particular constraints. Helicopter engines need to be rather compact, which necessitates very high speeds and involves enormous mechanical stresses.

**Heavy-duty turboprop engines**

Heavy-duty turboprop engines are typically found on large airlifters like the Airbus A400M. They burn less fuel than a turbofan and behave better during extreme flight maneuvers which are frequently encountered during military missions. The engine architecture is basically comparable to that of a helicopter engine, except that much more power is needed. The propeller is normally driven by a separate power turbine, the power being provided by a gas generator.

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The GE38 powering the CH53-K heavy-lift helicopter would be a suitable candidate also for a European helicopter.
Technology fields

The name MTU Aero Engines stands for leading-edge military and commercial engine technologies and superior quality. The company has established itself as a worldwide technology leader in the industry and intends to remain at the forefront of innovation, the aim being to maintain and strengthen its leadership position.

High-pressure compressors and low-pressure turbines made by MTU rank among the most advanced in their class. Apart from these, MTU’s product spectrum also encompasses combined engine control and monitoring units. The company is building on long experience in the military field here. These three product development domains are complemented by manufacturing and repair technology fields. The objective is to maintain the company’s technical, operational and logistics competitiveness in the manufacturing and maintenance areas. MTU’s technology portfolio presently includes about 100 projects.

Compressors

With its top-notch technological capabilities MTU Aero Engines aims to be the preferred partner for high-pressure compressors for commercial applications. The company comes recommended by its earlier performance in the field of advanced low-pressure and innovative high-pressure compressors. Current flagship products developed by MTU’s experts are the compressors for the EJ200 powering the Eurofighter/Typhoon and the TP400-D6 for the new A400M military airlifter.

The high-pressure compressor currently being developed in partnership with Pratt & Whitney constitutes the centerpiece of a new family of geared turbofan engines targeted at regional and business jets and short- to medium-haul airliners. Development here focuses on improvements in efficiency and weight reductions. Both factors directly affect fuel consumption and hence also the emission of carbon dioxide and nitrogen oxides. Further cost reductions, too, are on the wish list.

The latest generation of MTU’s high-pressure compressors boasts active control features.
Turbines
Low-pressure turbines are a core competency of MTU. The technological band-width is enormous, extending from conventional low-pressure turbines for engines to power business jets, power turbines for heavy-lift helicopters, large conventional low-pressure turbines with high-efficiencies all the way to high-speed low-pressure turbines for the powerful geared turbofan.

The company hopes to consolidate its technology leadership long-term through technological preparations for the successor generations of current engines. The objective of technology development remains unchanged regardless of concept: it is to strike a reasonable balance between efficiency, weight, noise level, cost and life.

Overall system
Optimum engine control and monitoring units and flawless accessories are essential for the safety of aircraft. MTU has a broad background of experience in this field. Its line of products encompasses the overall control and monitoring system as well as the integration of subsystems and equipment including associated software. The company’s competencies extend from equipment, software and system development all the way to system validation, production support and maintenance.

Manufacturing and maintenance
Engines are high-tech products the manufacture of which involves innovative techniques. With their aid, just about any product can be manufactured today, except that to be saleable, it also needs to be affordable. Apart from making the necessary technical preparations for a new component or material MTU’s manufacturing shops have to organize the entire process chain in a manner that secures the Munich site’s international competitiveness. In the area of manufacturing technology, the company is therefore pursuing activities extending across the entire bandwidth of manufacturing technology from the initial development of manufacturing processes, testing and measuring methods all the way to automation and factory planning.
Award-winning compressors

High-pressure compressors made by MTU have been among the best worldwide for decades. For more than 30 years the German company has been developing, manufacturing, repairing and overhauling this component, the core of the engine. The technologies are being continuously refined and adapted to suit the particular requirements of each engine type. Over the next years, the compressor’s efficiency will be enhanced to further lower the specific fuel consumption.

Because approximately one third of the total flow losses are caused by leakage, the design of the transitional zones between rotor and stator stages must be given particular attention. Brush seals here permit technical solutions that would not be possible with conventional labyrinth seals. Moreover, innovative technologies have been developed that influence the action of the flow, for example the so-called casing treatment that involves structural modifications to the rotor casing inner surfaces for increased aerodynamic loading of the compressor. Active systems, too, will play an increasingly important role. These involve component assemblies that respond to variations in operating conditions, for instance by minimizing clearances or injecting air to improve stability.

Integral constructions and novel materials are key to significant weight reductions. The concept applying to the blisk, where disk and blades form an integral part, should equally be applicable also to whole successive stages in line. Tandem configurations of the type open up opportunities to reduce overall length and hence compressor weight.

Highly advanced aerodynamic computation methods are used in the design of MTU's compressors which excel by an extremely high stage pressure ratio.

Comparable saving potentials are offered by novel disk and blisk materials in titanium and nickel-base alloys. They outperform prior materials by their greater specific strength that makes for "leaner" component designs.

To protect the high-value components, such as compressor blisks, against erosion by sand and dirt particles, MTU has developed a novel multilayer coating: Dubbed ERCOat®, this coating combines the hardness of ceramic layers with the high ductility of metallic layers. The layer is thin enough to be deposited on components also subsequently and without interfering with their aerodynamic or structural-mechanical properties.
Efficient turbines

The low-pressure turbine contributes significantly to engine cost. Depending on engine size and concept, its cost share amounts to 15 to 20 percent. In component development, MTU is exploring novel constructions to reduce complexity and concurrently looking at more cost-effective materials for use at elevated temperatures. Under its “High Lift Blading” project, for instance, the company is developing an innovative blading concept to reduce the blade count in the low-pressure turbine without appreciably reducing its efficiency. A welcome by-product in that endeavor is the potential reduction of module weight.

Novel light-weight materials hold promise of saving up to ten percent of the overall turbine weight. While they are just as strong, rotor blades in titanium aluminum weigh only half as much as blades in conventional nickel alloys. This provides a tremendous weight-saving potential for low-pressure turbine blades for use at operating temperatures of up to 800 degrees centigrade. Before one material can be exchanged for the other, numerous questions need to be answered. It is important to know, for instance, how the material holds up under operating conditions or what manufacturing process would be best to use.

Intentions over the next five years are to enhance the turbine efficiencies by reducing flow losses by as much as 15 percent, no mean feat when considering the high degree of efficiency already attained. This is hoped to reduce an aircraft’s fuel consumption by 1.1 percent. For an A380 flying the route from Frankfurt to New York about 600 times a year this would translate into a reduction of fuel consumption of approximately 757,000 liters. The availability of more computing power and new design programs will in the years ahead permit the three-dimensional design of the blade ducts, including side walls and fillet radii. In the process, numerical aerodynamic design optimization methods are used. For operation at the high altitudes commonly associated with long-haul airliners and business jets, improved airfoil designs and measures to selectively influence the boundary layer will be explored.

In air traffic, flight noise is a limiting factor. Individual flight movements have indeed become less noisy over the past several years, but in all, their growing incidence is eating away at the improvement. The primary sources of flight noise are engines, undercarriage and the air enveloping the aircraft. In accordance with ACARE targets, next-generation engines should provide a ten ENPdB improvement over current engines. That is a notable figure, considering that a ten dB or so difference halves the perceived noise.

To keep the noise low that the low-pressure turbine contributes to engine noise under certain operating conditions, such as approach, a number of noise abatement measures, such as the 3D contouring of turbine blades, are being explored using an experimental turbine specifically set up for the purpose.
Overall system

More Electric Engine
On the next generation of aircraft, experts anticipate electric power requirements to quintuple, not least because the air conditioning system, for example, will no longer operate on engine air but on electricity. On the engine proper, too, mechanical and hydraulic components will advantageously be replaced with electrical units because these are smaller and lighter in weight, more flexible to accommodate and smarter. An electric fuel pump, for instance, would reduce fuel consumption since it would permit fuel to be fed only in the amounts actually needed, obviating the present need for scavenging excess fuel back into the tank.

The More Electric Engine of the future will come with a plurality of sensors, electric motors and control elements, posing new power management, control engineering and engine monitoring challenges.

Control unit
Becoming increasingly apparent is the need to closely link the engine control system with the flight control system and the supply systems. Current control units are central devices featuring a direct, analog connection to every component in the engine. Each additional component requires a separate physical connection including a line and connector. Unless the concept is changed, a control box would in the future be characterized by a plurality of connections, although its interior would require only a fraction of the space.

MTU is pushing the notion of a distributed control system in which every electrical component has its own control logic and is driven by a central unit via data bus.

Monitoring and diagnosis
For the Eurofighter’s EJ200 engine, MTU has developed a new generation of control units that control the engine and concurrently monitor it. Their primary task is to immediately alert to defects, while its number two job is to prevent defects through earliest possible detection of deviations. These technological capabilities are gradually being transitioned also to other engines.

An engine trend monitoring system, for instance, has been developed for use by MTU’s maintenance shops that captures essential operating data such as pressure, temperature and vibrations through the onboard computer and radios or emails it to a ground-based network for continuous comparison with ideal engine data. When deviations from nominal are noted, appropriate repairs can be made to prevent major consequential damage and costly repairs.

Power management
The airborne power generation station, that is, the engine, will need to produce quintuple the present amount of electric current for the aircraft. At the magnitudes involved, the conventional approach of using a generator to tap electric power at the high-pressure shaft is no longer practicable.

A highly promising solution seems to be to connect an additional generator to the low-pressure shaft. The additional space required by a further accessory is a penalty that can be offset by integrating the generator into the low-pressure turbine. That concept promises to afford a weight advantage of up to 30 percent, compared to a conventionally attached generator.
Manufacturing and maintenance

Manufacturing processes
An excellent example of MTU’s capabilities is the manufacture of compressors in blisk design, where disk and blades come as one piece. One of the techniques used in the manufacture of these high-tech components is linear friction welding, a process that reduces the consumption of raw material while at the same time ensuring a high-strength welded joint between the precision-forged airfoils and the disk body. The patented linear friction welding technique has been developed by MTU in Munich. Other processes used in blisk manufacturing are high-speed milling and electro-chemical machining, which have also been developed or matured for this particular application by MTU. The individual blisk stages are joined by inertia friction welding. MTU’s Munich location boasts a highly advanced inertia welding machine. It is 20 meters long and produces upsetting forces of up to 1,000 metric tons. It joins components together to tolerances of ten hundredths of a millimeter.

Inspection engineering and metrology
Products used in aviation must be flawless. To make sure they are, MTU is continuously improving its inspection methods along the entire supply and manufacturing chain. It uses highly advanced computer tomography and ultrasonic inspection to reveal flaws in cast materials of sizes 30 percent smaller than detectable otherwise.

While it helps to detect flaws, it is even more desirable to prevent them. This is where online in-process inspection takes center stage. On critical components, quality-relevant manufacturing process data is captured digitally to immediately and reliably alert engineers to process deviations.

Maintenance
Whether airline or leasing company, customers are all pursuing the same objective of minimizing engine maintenance costs without violating specified safety standards. The largest single item in maintenance is material cost. It amounts to as much as 70 percent of the layout for a shop visit.

MTU’s strategy is that “repair beats replacement”. In the development of new repair techniques, MTU can draw on its unique expertise derived in the development and production of numerous engine programs. Typical examples are the patch repair technique for blisk airfoils, or blade tip repair by laser powder cladding. Thus, the company achieves levels of restoration that are unique worldwide.
In engine development programs plagued by time and cost pressures, there is little room for experiments. Innovations must be developed, tested and matured for production in advance. For the purpose, technology projects are launched to build concept engines to demonstrate the feasibility and capability of new technologies. These are normally funded under cooperative or sponsored programs. MTU participates in all major European aviation research programs and has launched its own long-term technology initiative, dubbed Claire (Clean Air Engine).

Claire
MTU experts, in partnership with futurologists of Bauhaus Luftfahrt, have defined the long-term goals for aircraft engine technology development. 15 percent, 20 percent, 30 percent less carbon dioxide are the staged goals the company has set for itself to achieve by 2035. The Claire program revolves around a novel engine concept, the geared turbofan. That engine alone already provides a reduction in carbon dioxide emission by fully 15 percent. Concurrently, plans are to reduce oxides of nitrogen and noise.

JTDP
Between Pratt & Whitney and MTU Aero Engines, a successful partnership has existed for decades. Their cooperative development effort bases on a Joint Technology Demonstrator Program (JTDP) stipulating the joint exploitation of demonstrators to test new technologies. An outstanding result of their joint activities is the geared turbofan demonstrator that has successfully completed several test flights on the wing of a Boeing 747 and an Airbus A340. Used as a demonstrator so far has been a PW6000 engine, to which MTU contributed the high-pressure compressor and the high-speed low-pressure turbine the company developed for the geared turbofan.

At present, the partners are focusing on the development of the high-pressure compressor for a new engine generation.

Newac/Vital/Lemcotec
After several years of research, the Newac (New Aero Engine Core Concepts) and Vital (Environmentally friendly Aero Engine) technology projects, which were sponsored by the European Union under its 6th Research Framework Program, have now been successfully completed.

Under the Newac and Vital technology programs, promising new technologies were identified and validated in rig tests. Taken together, these technologies make a substantial contribution towards achieving the ambitious ACARE targets of cutting CO₂ emissions by 20 percent and NOₓ emissions by as much as 80 percent. The research work will be continued under the successor project Lemcotec (Low Emissions Core-Engine Technologies).

The MTU-led Newac project was aimed at improving the core engine. 41 partners—Rolls-Royce, Snecma and Avio being the largest
among them—worked together to develop smart compressors, optimize the combustion chamber and integrate heat exchangers for novel, highly efficient core engine concepts. Under the project, MTU focused on exploring options to economize fuel by actively controlling the high-pressure compressor.

The successor project of Newac is dubbed Lemcotec. MTU also plays a major role in this, the most recent technology project of the European Union, which is aimed at further reducing engine emissions. The work under the project, which will run until 2015, focuses on exploring options to increase the overall pressure ratio (OPR) to further enhance the thermal efficiency of future engines. MTU is responsible for two work packages involving the design, construction and testing of a new high-pressure compressor with an unprecedented pressure ratio, which will feature lighter materials capable of withstanding very high temperatures and an advanced secondary air system.

Dream
Dream (Validation of Radical Engine Architecture Systems) is a further technology program sponsored by the European Union. It was launched in spring 2008 to develop new engine concepts and implement the ACARE 2020 goals. Under this initiative, Rolls-Royce and Snecma are exploring the open propfan. MTU is cooperating with a dozen other partners on innovative systems to further improve the geared turbofan.

Clean Sky
Clean Sky is the EU technology program the European aviation industry hopes will help achieve the ambitious ACARE standards. It forms part of the Joint Technology Initiative of the European Union’s Seventh Research Framework Program. Clean Sky encompasses six so-called Integrated Technology Demonstrators (ITDs) and one Technology Evaluator.

From the very beginning, the project drew a large number of participants from the European aviation industry and from science and research. Further partners for specific activities under the Clean Sky program can be invited to join in through calls for proposals. With an overall budget of 1.6 billion euros, half of which is funded by the EU, Clean Sky is the biggest research program ever undertaken by the European Union.

Within the SAGE (Sustainable and Green Engine) ITD of Clean Sky five engine demonstrators in different thrust classes and for different market segments will be built and tested by 2015. One of the sub-projects (SAGE-4) is led by MTU. It is pursued with the aim to further develop the geared turbofan technology, in particular the low-pressure section, in cooperation with other European partners, and test and validate it in 2014. The new generation of geared turbofan engines is targeted at future regional jets as well as short- and medium-haul airliners. The project was officially launched in 2008 and will run through to 2017.

The most advanced high-pressure compressors can be validated on MTU’s compressor test rig.

The “noise footprint” of an aircraft powered by geared turbofan engines is 70 percent smaller than that of today’s aircraft.
MTU Aero Engines has for many years been closely cooperating with research institutions and universities. Pursued are long-term, cross-system engine development activities in a concerted win-win effort, where the institutes’ more or less fundamental research propensity takes on a more practically oriented tilt and MTU, in turn, draws on the scientists’ excellent expertise.

MTU’s network strategy relies on the three pillars of trend analysis and development of visionary engine concepts at Bauhaus Luftfahrt, concentration of basic research at just a few top-notch institutions and universities, and regular exchange of experience with experts within and outside the aviation industry.

Bauhaus Luftfahrt
An internationally oriented think tank, Bauhaus Luftfahrt aims to develop innovative approaches for future air transport systems. Within the framework of the research activities pursued by Bauhaus, the complex system of air transport is reviewed from various aspects: First and foremost, the Bauhaus researchers aim to develop visionary aircraft concepts, taking ecological aspects, such as alternative fuels, revolutionary technologies, and socio-political factors into account. Key in the Bauhaus roadmap to success is the interaction between its in-house disciplines and cooperation with industry and research in a global network.

Bauhaus Luftfahrt was founded in November 2005 by four partners—EADS, Liebherr-Aerospace, MTU Aero Engines and the State of Bavaria.

Centers of competence (CoC)
Cooperation with universities and research institutions forms an essential part of MTU’s research and development work. Strategic alliances with world-class research partners are hoped to secure MTU’s innovation capabilities long-term and foster the meshing between academia and industry. Getting students in touch with industrial reality early in their academic careers, MTU hopes to produce a continuous pool of young talent. Jointly with leading German universities, MTU has launched six different centers of competence (CoC) to perform specific research tasks. Selection criteria for its partners were outstanding technical qualification and long experience.

Expert working groups
Expert working groups convene regularly. Specialists in a particular technical discipline meet two or three times a year to trade insights gained into new trends and developments. Discussed are specific technical issues for which likely solutions are sought and hopefully found. These working groups benefit from the broad, cross-industry networking of experts from science and industry.