A Rich Heritage, a Blossoming Future
The Power of Partnership

www.toraytac.com
Reinforcing Our Composites Market Position

TenCate Advanced Composites blossoms into a new era at JEC World 2019, officially becoming Toray Advanced Composites.

As we look to the future, it is important to recognize our legacy as part of the 315-year-old Dutch textile company Koninklijke (Royal) TenCate. TenCate revolutionized the adoption of thermoplastic composites in the aerospace industry with its Cetex® portfolio, itself in its 30th year. Cetex® is responsible for numerous global firsts that revolutionized the industry and continue today with the world’s first thermoplastic rear pressure bulkhead, manufactured by Premium AEROTEC for the Airbus A320i family of aircraft.

We highlight TenCate’s legacy in this edition, sharing a range of articles published over the years in TenCate’s corporate magazine textures. These stories not only demonstrate the rich heritage TenCate brings to the Toray family as Toray Advanced Composites, but also the necessity of partnership and support to advance technology for our customers’ success.

Toray Advanced Composites continues to offer a portfolio of industry-leading resin and prepreg technologies, now with the global scale to drive these technologies into new segments. The leading supplier of carbon fiber and composite materials in the world, Toray brings vertical integration and scale to Toray Advanced Composites, along with a strong commercial channel to drive these products into the right applications at a competitive price.

Toray Advanced Composites will bring a robust portfolio of products to our customers, leveraging our combined companies’ strength. We will continue to work as partners with our key resin and reinforcement suppliers to support the programs that are important to us all. And as always, we will be transparent, honest, and committed to working as partners with our customers. After all, our goal is your success. When you succeed, we succeed.

On behalf of Toray Advanced Composites management and employees, I thank you all sincerely for the support you have shown us over the years. We look forward to expanding our partnership with you in the future as Toray Advanced Composites.

Mr. Keisuke Ishii,
Chief Executive Officer
Toray Advanced Composites

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TenCate revenues from the aerospace industry declined in 2012 and the first half of 2013 as a result of delays in deliveries for the Airbus A380 and A350 and the Boeing 787. After this period, however, revenues and profitability increased the TenCate Advanced Composites market group recorded a 16 percent increase in revenues in 2013. The market for aerospace composites showed strong growth, and good progress was made in the latest generation of aircraft. The order book for the Boeing 787, which is important to TenCate, has more than 900 aircraft listed in it. The order book at Airbus for the A350 is also well filled, containing over 800 aircraft.

**Radomes**

Increasing opportunities for communication during passenger flights, especially in the United States, have led to a great demand for radomes. These are made of thermoset composite material and often involve the nose of the aircraft, which houses the radar equipment. These materials are subject to stringent requirements for impact tolerance. They must be made in an extremely clean environment (a clean room), so they do not become contaminated with conductive particles, which may lead to safety problems and communication malfunctions. TenCate Advanced Composites produces these materials in its facility at Morgan Hill (California).

**Aircraft seats**

It is more interesting for passengers to know among which TenCate materials they are traveling (see box) and whether they will be comfortable during the journey. This is in part determined by the cabin pressure and humidity and whether one is sitting comfortably. TenCate Advanced Composites USA currently supplies many composite materials to both US and European aircraft seat manufacturers. One of these customers is Geven, an Italian company manufacturing aircraft seats and interiors. The American company Cutting Dynamics has used TenCate composite to make a lightweight, slim seat frame with high crashworthiness (up to 16G).

The French company Explioplast has made an aircraft seat weighing a mere 4 kilograms, based on a combination of titanium and TenCate composite. This provides a saving on fuel of up to €370,000 a year for each A320 or B737. It is the lightest aircraft seat ever to have withstood the crash test. Meanwhile, a contract has been signed for the delivery of these seats to a European aircraft manufacturer. BE Aerospace, also a major seat manufacturer, uses TenCate Cetex® laminate for the structure that joins the seat to the floor. If it is the buyer of the aircraft who determines which interior will be used in the aircraft, this is known as buyer-furnished equipment. If the aircraft manufacturer sees to this, then it is known as supplier-furnished equipment.

TenCate Advanced Composites supplies the aerospace industry with thermoset and thermoplastic composite. The major end-users in the aerospace industry are Airbus and Boeing. The proportion of composites in new generations of aircraft is increasing. This applies to parts for the fuselage and wings as well as for the interior. In 2014, the market group is expected to increase its revenues and result due to increasing production for aircraft for which qualifications have been received.

TenCate received Boeing Silver Performance Excellence Awards in 2013 and 2017. This is an annual award presented by The Boeing Company to suppliers who have put in a superior performance.

In 2013, TenCate was one of only 459 suppliers to have received this award at Silver level. There are in total approximately 23,000 Boeing suppliers. This award is particularly important because TenCate, a compression-molded parts for the military V-22 Osprey helicopter program (photo) provides a reduction in both cost and weight. TenCate also supplies similar parts for the F-35 program and for the Boeing 737, 747, and 787.
New seats are one thing, but the replacement or retrofit market is also important. Aircraft operators like to replace old seats with new ones, as nowadays these are lighter, smaller, and look more attractive. Not only do they save weight, but also space, which is then used to place one or two additional rows of seats.

In the kitchen
Composites are also used in the galleys: the aircraft kitchen. The galleys of the Boeing 737s of SouthWest Airlines are made of TenCate materials. Southwest is the largest low-cost carrier in the US and, measured by the number of passengers transported, the largest aerospace company in the world. The materials for kitchens and other interior applications must satisfy very strict fire safety requirements. Interior materials from TenCate also score well on their self-extinguishing capability and requirements relating to fire smoke toxicity. This, moreover, also makes them suitable for ships and trains, which have longer evacuation times.

Aerospace armor
TenCate Advanced Armor is a technology-driven, tier 1 company in specific ballistic protection, particularly for military helicopter and aircraft projects. It thus supplies directly to the OEMs. After a cautious start in 2013, deliveries to Airbus Helicopter (formerly Eurocopter) recovered somewhat. In November, TenCate was selected by the Brazilian aircraft manufacturer Embraer to design the ballistic protection for the Embraer A-29 Super Tucano. The design and the prototypes of the ballistic protection for this military aircraft program are in the final stages. TenCate is also the technical and industrial partner and supplier of materials and special processes for the Embraer KC-390 project. The market group is currently in the qualification phase for delivery to Airbus of the protection of the cockpit door and walls in passenger aircraft. In this market there have as yet been only a few cases of retrofit applications.

Structural demand
TenCate Advanced Composites is well positioned to benefit from the structural demand for weight-saving materials in the aerospace industry. In 2014, revenue and results are expected to rise due to increasing production for aircraft for which qualifications have been received. A key factor in this growth forecast is, as mentioned above, the increase in production for the Airbus A350 and the Boeing 787. The further increase in the use of thermoplastic composite material for the aerospace industry, and in particular for Airbus, is also highlighted by the recent expansion of the TAPAS consortium (see page 12).

The acquisition of Amber Composites (UK) at the beginning of 2013 has given TenCate a leading position in the automotive industry, and in particular for cars. The European Commission has determined that by 2020 CO2 emission standards will have to be reduced by 40%, vis-à-vis the level of 2007. This will force car manufacturers (OEMs) to look for weight savings. Compared with traditional materials, composite is 30 to 50 percent lighter and thus eminently suited to help achieve this weight savings. TenCate has occupied a leading position in thermoplastic composite technology for well over 30 years. This material is increasingly being used in the aerospace industry, the automotive market is much greater and more diverse. Thermoplastic composite is ideal for use in series production, but it does require adaptation of the production chain from structural parts. This is because OEMs are not yet geared to the processing of this type of advanced material.

Solutions for mass production
Thermoset is ideal for low-volume production. When it comes to large numbers, thermoplastic composite is the obvious material. In alliance with BASF and Owens Corning, TenCate is developing optimal solutions in thermoplastic composite for mass production in the automotive industry. Tooling prepregs are supplied for large thermoset.
parts; thermoplastics will mainly be processed using metal molds.

Together with Kringlan Composites, TenCate is engaged in providing solutions for the automated manufacture of parts based on thermoplastic composite technology. The most significant development at this time is a fully carbon-reinforced composite wheel for cars in the upper segment. This wheel has a strong weight-saving effect and reduces the unsprung mass of the vehicle. Tests show that in terms of material stress, the demonstrator of the wheel meets extremely high safety and integrity requirements. The market release is expected this year and limited series production will be possible about twelve months later. A prototype of a composite bottom plate has been made jointly with Voestalpine Polynorm. A traditional steel plate weighs 22 kilos; when produced in composite, this weighs less than 10 kilos.

Tooling – fast-growing market segment

TenCate Advanced Composites UK produces mainly tooling and structural prepregs (resin-pre-impregnated fibers) and honeycomb cores. As a result of the increasing use of composite material, the molds will also be made of composite. The company in Langley Mill (Derbyshire, UK) is already a major supplier to the Formula 1 market. One of the developments in this market is that, as a result of the use of lighter turbo engines, temperature requirements will increase. For TenCate, this increase in temperature requirements is not unfavorable. The expected growth of the facility will mainly come from the automotive sector (Alfa Romeo 4C). The growth of tooling applications is more evident.

Alfa Romeo 4C

TenCate and the Adler Group (Naples, Italy) have recently signed an agreement for the exclusive supply of TenCate E700 carbon-fiber prepreg for the Alfa Romeo 4C platform. This material from TenCate Advanced Composites UK is used for the production of the entire monocoque: the passenger compartment. This reduces its weight and gives the vehicle an extremely stiff and safe basic structure. TenCate has been supplying the Adler Group with this material for the production of this car for some time. For logistical reasons, the intention is for material production to be carried out locally. For TenCate, this agreement represents its first OEM project of this size in the automotive industry. Up to three thousand cars of this type are expected to be manufactured annually.

• Thermoplastic composite is eminently suited to series production, but does require adaptation of the production chain of (structural) parts
• Thermoset is ideal for low-volume production; for large numbers, thermoplastic composite is the obvious material
• TenCate composite materials will be used for the production of the passenger compartment of the Alfa Romeo 4C
TenCate Advanced Composites supplies thermoplastic composite material to Fokker Aerostructures in Hoogeveen. The material is processed there into parts for the aircraft and helicopters of Airbus, Boeing, Gulfstream, Dassault, AgustaWestland, and others. TenCate and Fokker Aerostructures form a natural and reliable combination in their value chain.

TenCate is involved in various development projects and consortia for the aerospace industry, including TAPAS (with Airbus) and TPAC (with Boeing). One of the partners in these partnership alliances is Fokker Aerosystems, which specializes in the design, development, and production of lightweight parts for the aerospace industry. The materials that are processed are metals such as aluminum and titanium, thermoset composite, and relatively new materials, such as Glare®, a thermoplastic composite material from TenCate. The company supplies complete tailplanes and moving wing parts for commercial and military aircraft for customers such as Boeing, Airbus, and Lockheed Martin. These are delivered in part directly and in part to Tier 1 companies, which are the suppliers of systems to OEMs.

Material processing
The material from TenCate Advanced Composites undergoes a variety of different treatments in Hoogeveen. Single-layer semipellet material is used to laminate large parts, such as the skin and the spars of the leading-edges of wings, and rudders. The supporting tension box in the tail of a helicopter is fused in a single process step. Cetex®, a thermoplastic composite material from TenCate, is used by Fokker to make tens of thousands of press-formed ribs each year. All these individual parts are then welded together to form the leading-edges of wings for Airbus A380 airliners and the rudders for Gulfstream and Dassault business jets.

Panels
Each year, thousands of floor panels are also made from TenCate Cetex® for a variety of types of Gulfstream aircraft. In this process they are press-formed, bonded, thermofolded, and induction welded. The new Airbus A400M is fitted with ice-protection panels from Fokker Aerosystems, based on TenCate Cetex® TCI 1100 PPS/glass. Fokker Aerosystems also designed the horizontal tailplane for the AgustaWestland AW169.

Needless to say, all the processes and products have to satisfy the stringent quality requirements set by the aerospace industry in general and the OEMs in particular. This involves accuracies to tenths of a millimeter. It is specialist work, into which a great deal of development has gone.

"An exceptional proposition"
According to Arnt Offringa, director of R&D at Fokker Aerosystems, in the partnership with TenCate there has been "a natural match for several decades. Together we strive to achieve the same goal: light, affordable aircraft parts using thermoplastic composite technology. By jointly distinguishing ourselves on the market with an exceptional proposition, we acquire orders. It’s like a marriage: you need each other to reach the goal you’ve set. Together you are stronger and you provide your customers with a better product." He mentioned in particular as the strong point of TenCate its focus on thermoplastic composite as a material and their joint approach to the market. "This has enabled us to secure our current position."

Smart factories
Fokker Aerosystems and TenCate are also two of the companies in East Netherlands that are involved in the Region of Smart Factories. Together with multinationals such as IBM and Philips, SME companies, knowledge institutes, and universities, they aim to develop new techniques to substantially improve or even double productivity in the manufacturing industry. Existing principles like automation and lean manufacturing are no longer sufficient. Smart factories provide new opportunities for increasing productivity.

Smart factories constantly think for themselves and correct and improve themselves. Such a factory requires areas of high-calibre expertise, like advanced sensor systems and the processing of data streams. Sensor systems allow one to fathom complex industrial processes. Knowledge of the control of large data streams is necessary to make processes self-learning. The first Smart Factory project has just been completed at Fokker in Hoogeveen. In this project, the logistic system behind part of the composites line has been optimized using advanced techniques. The partners will in the years ahead exchange expertise on smart factories, acquire new knowledge, and conduct pilot projects.

Vision for the future
Aerodynamic draughts at aircraft manufacturers have been focusing on the aircraft of the future, creating animations of planes with remarkable shapes—aircraft that moves like birds with a slow wingbeat. Arnt Offringa believes that the increasing scarcity of fossil fuels and global warming will ensure there will continue to be a great demand for economical and thus lightweight means of transport.

For the aerospace industry, this means an ongoing need for affordable, lightweight aircraft. TenCate and Fokker Aerosystems are extremely well placed in this respect, with unique thermoplastic composite technology from TenCate Advanced Composites. Material, production techniques, and design expertise all come together here. "When it comes to engines, significant development is taking place: at a stroke they have become 20 percent more economical, which is a revolution in aircraft manufacturing." As an example, he mentions the new Airbus A320neo (New Engine Option) narrow body, which is fitted with these new engines. "These engines do, however, make the aircraft heavier, so its weight must be reduced. Herein lies a task for both of us."

- Fokker Aerosystems processes composite materials from TenCate to make parts for aircraft and helicopters
- Both companies are co-initiators of the Region of Smart Factories, which aims to increase or even double productivity in the manufacturing industry
- Now, more economical engines in the aerospace industry demand further weight reduction
On Monday January 20 2014, the CEOs of Airbus, Fokker Aerostructures, and TenCate put their signatures to the contract for the next stage of the Thermoplastic Affordable Primary Aircraft Structure (TAPAS) program to run until the end of 2017. This innovation program, a highly successful tool for project-based innovative partnership, has thus entered the next stage.

The TAPAS consortium consists of companies and knowledge institutes in the Dutch aerospace industry working together with Airbus on the further development of thermoplastic composite applications in aircraft fuselages, wings, and tail sections. The target is to further increase the proportion of thermoplastic composites in current aircraft as well as in new generations. The partners of TenCate Advanced Composites are Airborne Composites, CODET, DTC, KE-Works, Technobis Fiber Technologies, the National Aerospace Laboratory, the Technical University of Delft, and the University of Twente. The Dutch aerospace industry enjoys a good reputation worldwide in the field of lightweight materials. This is due in part to its excellent knowledge infrastructure, materials, and processes. In terms of size, the Netherlands has the sixth-largest aerospace industry in Europe.

**Tail section**
A demonstrator of a tail section made entirely of thermoplastic composite material is being developed as part of TAPAS 2. Other aircraft components too, such as the wings and fuel tanks, are being studied. A wing can be compared to the tailplane, but it is “a fairly complex part,” explains TenCate manager of engineering, Winand Kok. It has conflicting requirements: “It must be light and strong, conductive, the fuel has to be stored in it and it must be able to lift the aircraft off the ground.” During a flight, lightning may strike and static electricity cause sparks, which is not desirable in the vicinity of fuel tanks. While traditional wings are made of metal, which is a good conductor, composite is far less conductive. “You have to develop a specific solution for thermoplastics to overcome this, with each application making its own demands. In the aerospace industry everything is put under the magnifying glass.”

**Impact-resistance**
In the event of impact, a dent will be visible in a metal aircraft fuselage. If the wall is made of a composite (layers of material), nothing can be seen, but damage may well have occurred inside. That is why an aircraft with composites is designed “thinner,” also due to its scale. The walls of smaller aircraft are thinner and their impact-resistance is greater. “Our thermoplastics are tougher and can possibly be designed ‘thinner’, so that the aircraft becomes lighter. Yet the nose and fuselage must be able to withstand hailstorms, with hailstones measuring as much as 8 centimeters in diameter. These are extreme scenarios, but you do have to take them into account. The important thing is to be able to fly safely from A to B. This can be translated into material characteristics, which are what we make in our processes. It is a part of the safety that is reflected in the care that we exercise in our manufacturing processes. Our customers expect us always to do the same thing and deliver exactly the same product.”

www.tapasproject.nl
Moreover, the use of composite enables production volumes to be adapted fairly flexibly, as was indicated in the presentation “Global Challenges, Dutch Composites.”

Inspiring presentation
Robert Lenferink, director of business development thermoplastic composites at TenCate Advanced Composites, was present at the Hannover Messe and gave an inspiring presentation. “With our great knowledge and experience of composite gained in the aerospace industry, the transition to the car industry is opening up an entirely new market. TenCate aims to reach out from small (racing) car producers to large car manufacturers with countless - thermoset or thermoplastic - composite components or materials for the large-scale production of cars.” To this end, the company is collaborating with a number of strategic partners. At the fair, TenCate prominently displayed the chassis of the Alfa Romeo 4C.

TenCate operates at the very heart of society and makes a genuine contribution to continuing improvements in sustainability. With its innovative products, systems, and technological developments, TenCate often leads the way. This is one of the main conclusions that can be drawn from the presence of TenCate at the Hannover Messe, the world’s largest industrial trade fair, which was held April 7–11, 2014.

The fair, which was opened by the German chancellor, Angela Merkel, together with Dutch prime minister, Mark Rutte, was inspired by the theme “The Fourth Industrial Revolution.” This year, the Netherlands was the partner country. There were 270 Dutch companies present and TenCate, which was presenting its products here for the first time, attracted a great deal of attention.

Reaching out to the German car industry
For TenCate, the Hannover Messe was a great success in various respects. The company took advantage of the fair in part to reach out to the large German-car industry, which is also increasingly focusing on improving sustainability. This means lighter cars that use less energy. This is an irreversible trend, as a result of European regulations, which oblige even cars to reduce their CO2 emissions. This offers a golden opportunity for composite. It is not only much lighter and more sustainable, but also far stronger than steel and thus safer. And safety is also of great importance on roads that are becoming ever more congested.

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produced by Adler in Italy, with thermoset composite from TenCate. Producer voestalpine Polymerm from Burschtien (NL) is our partner for undertakings, as is Kringle and Saico for wheel rims, which have already been certified. Weight savings of no less than 50 to 70 percent have been achieved on these car components. 

Aviation industry continues strong growth
TenCate has for many years had a prominent presence in the aviation industry with its thermoplastic composites. Thermoset composite from TenCate is widely used in the space industry. During his presentation, “Global Challenges, Dutch Composites,” Arnt Offringa, director of R&D of Fokker Aerostructures, indicated a number of interesting long-term trends. These are partly the result of the increasing use of composites in aircraft. “Since 2000 the aviation industry has grown by some 50 percent, whereas fuel consumption has increased by only 3 percent,” Arnt Offringa stated. “In addition to much more fuel-efficient engines, an important factor is the incorporated more and more into the interior. So it’s a case of green being combined with growth.”

Increasing need for composite
“In view of the expected growth in the number of daily flights from 84,000 in 2011 to 170,000 in 2020, the need for composite will only increase,” he continued. “Such an increase can also be attributed to other advantages of composite: they suffer less corrosion and material fatigue than traditional aluminum aircraft structures. This means that a large-scale revision will need to take place only once every 13 years, instead of every six, which will make a considerable difference in costs. Moreover, it will make it possible to construct larger windows and the pressure and thus the moisture level in the aircraft can be higher. This will all contribute to a greater degree of comfort for the traveler,” claimed the R&D director of Fokker Aerostructures.

Opportunities and potential
Harald Heinrich, general manager of the leading global ThermPlastic composites Research Center (TPRC) in Enschede, also placed great emphasis in Hanover on the opportunities for the material and its potential. “Thermoplastic composite is inherently suitable for use in efficient high-volume production, such as that in the car industry,” he said enthusiastically. “It makes very fast processing cycles possible. Moreover, it has greater toughness, and offers the possibility to yield components using a variety of technologies, in addition to higher chemical resistance to corrosion and solvents. It is also, relatively speaking, a very safe material in the event of fire and also in relation to the development of smoke and poisonous gas. And, last but not least, there is the possibility of recycling and reusing the material, thus also making the composite sustainable.”

At the Hannover Messe, TenCate was reaching out to the German car industry, which is increasingly focusing on greater sustainability.

• The use of composite in aerospace means less corrosion and material fatigue, less revision, and makes it possible to construct larger windows and it contributes to greater passenger comfort.

• A relatively limited number of smaller producers of composite means thin supply chains between chemical companies and companies in the aviation, aerospace, and automobile industries.

Far, Far Away

From its production locations in Morgan Hill and Fairfield, CA, in the United States, TenCate supplies a wide range of composite materials for communication, military, and research satellites, as well as for launch vehicles.

Satellites utilize high-modulus (high-stiffness) carbon fibers combined with tailored resin systems for the production of structures on the satellite, including solar arrays, booms/trusses, reflectors, and bus structures. Solar arrays are used to provide power to the satellite while it is in space; booms/trusses hold equipment and solar arrays to the main structure of the satellite; and reflectors are the communication dishes that are used to upload and download satellite communications that enable data transmission with mobile phones; the internet, HD television, military communications, and analytical instruments. Satellites

Communication satellites enable internet, television, and mobile phone communications. The need and the desire for mobile phones, digital television, and internet connectivity are all driving the demand for communication satellites. Military satellites provide Earth observation, secure communication, GPS location/navigation, early warning, and weather information. A new trend that has begun is the development of microsatellites, which are to be deployed in large numbers to allow internet access in far regions. Research satellites serve a variety of specialized purposes. For example, they may be used to measure atmospheric changes, weather, and climate change.

AstroMesh®

On January 31, 2015, NASA launched its Soil Moisture Active Passive (SMAP) satellite. TenCate Advanced Composites provided Astro Aerospace with TenCate Cetex® thermoplastic composites for the AstroMesh® reflector on this spacecraft. The SMAP spacecraft will provide global measurements of soil moisture and indicate whether it is frozen or thawed. The data will be used to understand the processes that link Earth’s water, energy, and carbon cycles and improve weather and climate prediction models. The 6-meter-long AstroMesh® reflector, which will spin atop the spacecraft at nearly 15 revolutions per minute, provides for total global mapping every 2 to 3 days. The reflector uses TenCate Cetex® thermoplastic composites to achieve the strength, durability, and weight savings needed. Astro Aerospace is a business unit of Northrop Grumman, a North American defense, aviation, and aerospace company. “TenCate Cetex® thermoplastics are integral to the structure of our mesh reflectors,” states Daniel Ochoa, product development manager at Northrop Grumman’s Astro Aerospace. “They help to create the parabolic shape of the antenna. The material has been extensively tested as part of the unit prior to flight, and is durable and stiff, which is critical to the functioning of the antenna.”

Launch vehicles: weight and cost reduction
Launch vehicles (rockets) use standard- and intermediate-modulus (moderate-stiffness) fibers. These fibers are impregnated with thermostoy-based resin systems (prepreg) to create the rocket structure. The structures on launch vehicles are typically large and can be very heavy as a result. So the lightweight composite materials from TenCate are used to replace metals such as aluminum and titanium for weight savings. Since the cost to launch a satellite is driven primarily by the weight of the payload, reducing the weight is critical for cost savings. Additionally, TenCate materials are valued since they may be cured in large
ovens under low pressure, which is a very valuable characteristic, as curing the parts in large pressurised ovens (autoclaves) would be very expensive due to the size of the autoclave needed. One of TenCate’s newest customers for composite materials is SpaceX.

Orion space capsule
In 2010, a heat-resistant composite resin was developed by TenCate and provided for the heat shield (with a 5-meter diameter) and the backshell structure of NASA’s Orion crew vehicle. Lockheed Martin Space Systems Orion thermal protection group worked closely with TenCate Advanced Composites in North America on the 5-year development and qualification effort for a range of materials used in this extreme application. This Lockheed Martin spacecraft was successfully launched as a trial at the end of 2014. The TenCate materials in this space capsule replaced the traditional titanium solution for entry and splashdown requirements, while saving weight and cost. The composites from TenCate used on the heat shield design allow very large composite structures to be fabricated out-of-autoclave.

Making a difference
Customers and end-users in both the aerostructures and the space markets, like Thales, Boeing, Northrop-Grumman, Space Systems Loral, and SpaceX, turn to TenCate for both technical reasons (such as product characteristics) and for customer support reasons. First and foremost, TenCate has perhaps the largest suite of materials, well-documented flight history, and an enormous range of technical data on its materials for satellite and launch structure materials. Unique data such as radiation resistance, thermocycling and microcrack resistance, and low outgassing are required for our customers to successfully apply our materials to their application. We also provide industry-leading response times and on-site technical support for our customers, which further helps to differentiate TenCate from our competition.

Rapid change
The space and satellite market is an area of extreme innovation and rapid change. Launch vehicles are now being developed that are either reusable or very low cost. Rather than spending over $100 million on a single launch, satellite operators will be able to put satellites in orbit for dramatically lower cost. On top of lower costs, satellite manufacturers are shifting toward more rapidly deployable architectures (designs), and will be putting hundreds of lower cost satellites into orbit. This is creating a need for materials with similar properties to the traditional satellite materials from TenCate, but that can be produced faster and at a lower cost. The space market is experiencing rapid innovation, expansion, technology adoption, and change. TenCate is paying very close attention to these trends so we can maintain our leadership role in the market as it evolves.

TenCate Advanced Composites provided Astro Aerospace with TenCate Cetex® thermoplastic composites for the AstroMesh® reflector

INFO@TCAC-USA.COM

TenCate materials have traveled > 4 billion miles from Earth on NASA’s New Horizon spacecraft

With a view to weight savings, metals such as aluminum and titanium for launch vehicles are replaced by the lightweight composite materials from TenCate

Launch vehicles are now being developed that are either reusable or very low cost

and satellite manufacturers are shifting to more rapidly deployable architectures

- A satellite structure experiences very intense loads during the actual launch of the satellite into orbit, and in space is exposed to extreme temperatures
D²RAGON: Aerospace Cluster in China

The Netherlands has comprehensive knowledge infrastructure and expertise in aerospace. This makes our country an attractive partner for the rapidly growing Chinese aircraft industry. In April 2014, the government and a number of companies, including TenCate, signed a covenant for cooperation in this field: D²RAGON. Within its Asia strategy, TenCate is already working jointly with players in Chinese aerospace.

The two programs in this twin-track approach can strengthen each other.

Partners for International Business (PIB) is a public-private program for groups of Dutch companies and knowledge institutes that have the joint aim of entering a foreign market in one of the top sectors. One of these sectors is High Tech Materials & Systems, such as composites. Part of PIB is D²RAGON. This includes research and development in aerospace with the support of a network organized by the government (Dutch Development and Research in Aeronautics supported by Government Organized Network). The contribution of TenCate consists of technological knowledge and materials.

Networks and partnerships
TenCate Advanced Composites and Fokker Technologies are two companies within D²RAGON that are already operating in the Chinese aviation market. As part of its Asia strategy, TenCate has concluded agreements for cooperation with major players in the Asian aviation industry. Networks and partnerships are being established and expanded. Fokker Aerostructures incorporates composite materials from TenCate into lightweight parts for aircraft and helicopters. The company, which has a production site in China for aircraft wiring, has had contacts with aircraft manufacturer COMAC (Commercial Aircraft Corporation of China) for quite some time. Just as the D²RAGON partners, it sees the potential for growth in the field of composites for aircraft designed and produced by China.

G2G and K2K
D²RAGON focuses on establishing a good and stable market position for the Dutch aerospace cluster in China. Its short-term objectives include entering into an agreement between the Dutch and Chinese governments (G2G) for technological, industrial, and academic cooperation, the development of commercial activities and involvement in the “concept definition phase” of the 929-wide body of COMAC. In the medium term, they intend to conclude at least two contracts with COMAC for development and design. The goal in the long term is to generate a minimum of €50 million in revenues annually.

K2K (exchange of knowledge) is also a part of the program. Chinese aircraft manufacturers can make use of Dutch knowledge and expertise in the field of aerospace. The aim is to increase the number of Chinese students at Dutch colleges and universities that provide courses in aeronautical engineering, which will benefit long-term cooperation.

Involved with D²RAGON
The contacts for D²RAGON on behalf of TenCate are Raoul Starmans (business development manager, TenCate for Greater China) and Harm Albers (sales manager, TenCate Advanced Composites). Raoul Starmans organizes the local representation of TenCate in Greater China and is responsible for the development of new business opportunities. He is supported by a team of experts from TenCate.

Continued on page 22
TenCate composite technologies for the next generation of Chinese commercial aircraft. Raoul Starmans was co-signatory to the D²RAGON covenant.

What are the advantages of this program? “The cluster offers a wide range of technologies. You enter the Chinese market together and can thus strengthen each other. The government bears part of the costs and helps to raise the awareness of companies at trade fairs and seminars and by making high-level contacts with Chinese company and government officials. Companies like Fokker already have local production and their presence is an advantage for us. Thermoplastic composites for aviation applications are relatively new for China and knowledge of them is still very limited. Fokker can make high-grade components from our composites, and it leads the way here in terms of thermoplastic technology. The combination of TenCate (material development) and Fokker (part manufacturing) works well. COMAC is favorably disposed to an open business model in which close cooperation with suppliers plays an ever more central role.”

What does the PFI program mean for TenCate? “This year, there are G2G and K2K activities on the program. Together with the PFI consortium we are taking part in trade fairs and promotional activities, and there are airshows in China and Europe. Furthermore, TenCate was welcoming a combined company visit from a Chinese delegation to TenCate Advanced Composites, Fokker Aerostructures, and other members of the consortium.”

In what extent can D²RAGON and the TenCate Asia strategy strengthen each other? “The two strategies run parallel and strengthen each other. This is a twin-track approach: the one is a collective effort by the Dutch aerospace cluster. You can see it as a trailblazer. The other is more sales-oriented. The PFI aims at strengthening the image and the reputation of Dutch industry. They support the valuable contacts that the Dutch government has made for us in China and from which we can benefit. The TenCate Asia strategy is more ‘work on the ground,’ with a strategy focused on the sale of our materials. Our products will not be used until they have been qualified. We must continue to be very alert in our operations so as to enable new aerospace applications to be found for our materials. This requires close cooperation with partners in the supply chain.”

What opportunities are there in China for TenCate composites? “China is a world power with excellent growth potential in commercial aviation, therefore we are already having talks with other players, including COMAC. There are also opportunities for other applications, such as satellites, but these may not legally be exported and, of course, we respect that. So we shall deal only with commercial aviation and with composites for the automotive industry.”

How can you prevent knowledge ending up with third parties as a result of cooperation? “You see that a particular need arises, for which our materials are certified and that there is a local need for technical people who could take this on. China has a significant amount of catching up to do in the field of thermoplastics, but they are working on this at two research institutes. These are low-grade thermoplastics for consumer electronics, for example. On the high-tech side, we have a headstart, based on a twenty-year learning curve and this we of course want to hold on to as far as possible. Would this completely block local production in China? It seems possible in set up clear frameworks for this and to deal extremely cautiously with acquired intellectual property and its protection. Let’s not forget that the Chinese market will develop anyway. It is quite conceivable that assembly will take place there.”

Amber Composites Celebrates Anniversary with New Name

On Wednesday, October 2, 2014, Amber Composites Limited, based in Langley Mill (Nottingham, UK), celebrated its 25th anniversary, marking this special occasion with an identity change to TenCate Advanced Composites. Sixty invited guests (customers, suppliers, associates, and other business partners) gathered together to celebrate the anniversary and the change in name.

The TenCate Advanced Composites group manufactures both thermoplastic and thermoset composite materials. The thermoset activities were formally concentrated in Morgan Hill (United States) and focused mainly on the space and aerospace sector (satellites and communication). The main product lines at the Langley Mill (UK) site are composite tooling prepreg (TenCate AmberTool®), structural component prepreg, and various honeycomb cores. The honeycomb cross-range includes aluminum, Nomex®, and Kevlar®. These products are used in Formula 1 and high-performance automotive, as well as for commercial aviation, marine, and other industries.

Formula 1 – highly demanding market
The market for Formula 1, sports, and luxury cars
is relatively new to TenCate. It is an innovative and highly demanding market noted for rapid developments. A racing car is made up of more than 5,000 components, and after each race up to 20% of these are replaced or upgraded. Thermoset composite materials have been used in this industry for many years. New material innovation or a new technology can quickly prove itself here—unlike in the aviation industry, where new product introduction can take many years to certification approval to fly. The United Kingdom is at the heart of Formula 1 racing, with no less than eight of the eleven F1 teams being based within a 40 mile radius of the Silverstone race circuit. The former Amber Composites is an important supplier of prepreg systems and materials to this market. For example, the TenCate E745 resin system is used in high-impact structures. From the start of 2014, this will be the only material qualified and specified for use in side impact structures of all Formula 1 cars. The Langley Mill business is dedicated to this industry and is keen to develop materials for all aspects of the vehicle.

**Strengthening activities**

Through the acquisition of Amber Composites, TenCate Advanced Composites can also strengthen its thermoset activities within the European communication and satellite industry. TenCate continues to invest in the development and production of prepregs, as well as in the necessary technical support in test equipment and manpower to support substantial growth. For the domestic UK market, this means competitive materials, supplied more quickly and efficiently. The Langley Mill facility (formerly Amber Composites location) is now the center of excellence when it comes to the production of thermoset prepregs for Europe. Working together with their USA colleagues, markets will be developed where the strengths of its materials development can really benefit the industry and customer base. "The rebranding day was an excellent opportunity to explain to customers and other stakeholders just what our plans with the company actually are," says Frank Meurs (group director, TenCate Advanced Composites EMEA). "Besides the new, modern production site, we presented TenCate as company. And the feedback we received from our guests, including some Formula 1 teams, was very positive."

**TenCate AmberTool®**

In September 2014, TenCate Advanced Composites launched a rebranded series of prepregs for composite tooling under the name TenCate AmberTool®. This portfolio incorporates the original heritage of the former Amber Composites’ tooling range with tooling prepregs available from TenCate Advanced Composites USA, and use is made of the 3M nanosilica fortified-resin technology. New opportunities for application can be found within the motor racing, aviation, marine, and prosthesis industries.

- TenCate Advanced Composites is an important supplier of prepreg systems and materials to the Formula 1 market
- In cooperation with their USA colleagues, markets will be developed where the strengths of its materials development can benefit the industry and customer base
- The TenCate AmberTool® portfolio incorporates the former Amber Composites’ tooling range with tooling prepregs available from TenCate Advanced Composites USA

www.tencatecomposites.com/tooling

tcacsales@tencate.com
TOOLING REINVENTED

The increased use of composites materials is driving the need for more advanced composite tooling solutions. Part manufacturers are demanding tools with longer life and tighter tolerances while pushing for more efficient production methods. The market demands a trusted technology partner that can provide world-class innovation, manufacturing, and service.

With more than 20 years of pedigree in demanding tooling applications, the TenCate AmberTool® collection of prepregs comprised of the HX, HXR, and TC series, is sold globally by a proven team of tooling experts. Our comprehensive range of prepregs for aerospace applications cure from 50°C (122°F) while delivering Tg properties up to 213°C (415°F). These materials are available on a wide range of reinforcements, allowing our customers to have complete tool design freedom and flexibility.

COMPLETE TOOL DESIGN FREEDOM

TenCate AmberTool® composite tooling prepregs allow high precision for molded and machined tooling applications with a superior degree of accuracy. We support our products globally, offering customers a complete technical support service including tailored training courses.

INDUSTRY-LEADING COMPOSITE TOOLING EXPERIENCE

Master and surface coat application
- Compatible with high-performance epoxy paste and block master patterns
- Specialized sealing and release agent recommendations
- Excellent surface finish generation

Experienced technical support
- Proven processing procedures and full tooling processing guide available
- Tailored training courses offered
- Specialized tooling knowledge on surface treatments and advanced experience in mold heating applications
- Mold life-cycle maintenance solutions
- New materials research, assuring health and safety compliance

TEN CATE AMBERTOOL® COMPOSITE TOOLING PREPREGS

Product Overview

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<tr>
<th>RESIN</th>
<th>Tg (ONSET)*1</th>
<th>MIN CURE TEMP</th>
<th>TYPICAL CURE TIME AND TEMPERATURE*2</th>
<th>TACK LIFE</th>
<th>KEY PRODUCT CHARACTERISTICS</th>
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<tr>
<td>HX21*1</td>
<td>Epoxy</td>
<td>162°C (323°F)</td>
<td>65°C (149°F)</td>
<td>12 hours at 70°C (158°F)</td>
<td>30 days</td>
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<tr>
<td>HXR56*</td>
<td>Epoxy</td>
<td>185°C (365°F)</td>
<td>40°C (104°F)</td>
<td>8.5 hours at 50°C (122°F)</td>
<td>50 hours</td>
</tr>
<tr>
<td>HX50*</td>
<td>Epoxy</td>
<td>190°C (374°F)</td>
<td>40°C (104°F)</td>
<td>8.5 hours at 50°C (122°F)</td>
<td>50 hours</td>
</tr>
<tr>
<td>HX42</td>
<td>Epoxy</td>
<td>200°C (392°F)</td>
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<td>8 hours at 60°C (140°F)</td>
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<tr>
<td>HX40</td>
<td>Epoxy</td>
<td>203°C (397°F)</td>
<td>50°C (122°F)</td>
<td>12 hours at 65°C (149°F)</td>
<td>8 days</td>
</tr>
<tr>
<td>TC40*</td>
<td>BMI 213°C (415°F)</td>
<td>182°C (360°F)</td>
<td>5 hours at 182°C (360°F)</td>
<td>14 days</td>
<td>High service temperature</td>
</tr>
</tbody>
</table>

*1 after post cure | *2 followed by post cure | | Sourced from: *3 Europe | *4 North America

FULL TOOLING DELIVERY SOLUTIONS

- Custom cutting solutions within Europe
- Fast delivery solutions for standard materials
- Wide range of carbon and glass reinforcements with curing temperatures as low as 40°C (104°F) and Tg's up to 213°C (415°F) (after post cure)
- Surface machinable for final accuracy
- Carbon and glass backing structures

NEW PRODUCTS

TenCate AmberTool® HXR56 is the latest innovation from our heritage range of composite tooling prepregs. The new TenCate AmberTool® HXR series is a multi-axial format, specifically designed for when complexity and speed are required, ultimately reducing overall tooling costs.

Example of HXR lay-up:

For more product information, please refer to our app, our website www.tencatecomposites.com/tooling, and our online resource center for processing information, also available in print copy.
Airbus Defence and Space Netherlands, Airborne Aerospace, and TenCate Advanced Composites have developed and qualified the next-generation, state-of-the-art substrate panel technology for satellite solar arrays. The panel design, materials, processes, and tooling were improved from previous panels with the main goals being increased process robustness, product performance, and cost efficiency.

The Strength of Partnership

Airborne will utilize composite materials supplied by TenCate Advanced Composites to create the substrate panels of the Advanced Rigid Array (ARA) Mk4 solar array system for satellites. The ARA Mk4 technology, developed by Airbus Defence and Space Netherlands in close cooperation with Airborne, will be deployed on solar arrays for European Space Agency (ESA) missions. The development and qualification of this new panel technology was supported by the European Space Agency (ESA) and the Netherlands Space Office (NSO).

The assembled solar array is designed by Airbus Defence and Space Netherlands to be low in mass with high stiffness in stowed configuration (in order to survive the launcher loads and frequencies), as well as in deployed wing configuration. The titanium inserts in the panel are the hold-down interfacing toward the spacecraft sidewalls (stowed) and the edge-members connect to the hinge mechanisms for wing deployment in space.

Material Solution

The substrate panel features the next generation of space prepregs developed by TenCate Advanced Composites on areas including the facesheets, edge-members, and patches. TenCate R36N, an epoxy-based thermostet prepreg for structural composite applications, was selected as the material solution.

Cost-effective, space qualified

Exceptionally tough to resist microcracking

High glass transition temperature (Tg)

Low coefficient of moisture expansion (CME)

Low coefficient of thermal expansion (CTE)

Low outgassing

In May 2017, TenCate and Airborne signed a long-term agreement for the supply of these materials, in uni-directional and fabric prepreg format from TenCate’s European Centre of Excellence for thermoset systems in Langley Mill (Nottingham, UK).

Next Generation Space Exploration

The first solar array with ARA Mk4 technology will be launched in 2018, on ESA’s European Data Relay System (EDRS-C) satellite. EDRS is an independent, European satellite system designed to reduce time delays in the transmission of large quantities of data. The solar array for EDRS consists of two wings, each with a length of approx. 7 meters.

Future deployments of the ARA Mk technology include the Juice (JUpiter ICy moons Explorer) mission, planned for launch in 2022, which features the largest solar array ever flown on an interplanetary mission, covering a total surface area of nearly 100 m², and the MetOp-G, which carries the objective to provide operational observations and measurements from polar orbit for weather prediction and climate modeling and monitoring.

TenCate materials are used in a variety of applications in aerostructures, ranging from commercial aircraft to helicopters to general aviation. TenCate manufactures composites in two distinctly different resin forms, thermoplastic composites and thermoset composites. The current market is largely thermoset based, with typical resins being epoxy. However, thermoplastics are now in the area where the most growth is expected, primarily because of the benefits associated with thermoplastic composites.

In general, composites provide weight reduction and high strength. The use of composites provides weight reduction, which results in less fuel being consumed, and the weight reduction in structure allows more passengers or freight to be carried.

Some of the newer commercial aircraft today such as the Boeing 787 and the Airbus A350 XWB use composites for the fuselage. The use of composites in this application allows for greater passenger comfort since the interior can be pressurised higher, resulting in a more comfortable environment. Also unlike metals, composites do not corrode so this means less maintenance for the airlines.

Depending upon the aircraft, TenCate materials are used for the flight structures (wings, fuselage, flight control surfaces). The thermostet composites from TenCate are typically epoxy with either fiberglass or carbon fiber reinforcement, depending on the application. Fiberglass epoxies are used for fuselages and flight control surfaces on general aviation aircraft or UAVs, while carbon fiber epoxy is used for highly loaded structural parts, like wings, spars, and control surfaces. TenCate Cetex® thermoplastic materials are typically used in interior applications (seats, galleys, floors, clips). On commercial aircraft such as the Airbus A380, thermoplastic composites are used on leading edges and in the fuselage frame for structural clips and brackets.

Thousands of clips

The Airbus A350 XWB is of great strategic importance, in view of the amount of thermoplastic composite material that is used in each aircraft. TenCate supplies TenCate Cetex® thermoplastics for the robotic production of thousands of clips that connect the carbon fiber-reinforced composite fuselage shell to the interior composite rib structures. The Airbus order book contains some 700 aircraft of this type. TenCate Advanced Composites works with leading customers in the aviation industry involved in the production of structural, semi-structural, and interior applications in Airbus aircraft programs, such as the A350 XWB and the A380.
Communication options through radomes

In a more recent application for TenCate composites, TenCate materials are used to develop the structure (radomes) around communication and navigation antennas. As a result of increasing communication options during passenger flights, the demand for in-flight internet access is growing. These are made of thermoset resins with either a glass- or quartz-based composite fabric. Radomes are typically part of the aircraft structure; they are used to cover antenna and other radio transmission devices. The radome protects the antennas and electrical systems while still allowing signals to pass through. TenCate materials are used on the nose radome of the Boeing 787, which houses navigation and weather radar equipment, as well as on satellite communication (“satcom”) radomes, which bring Internet and Wi-Fi connectivity to the passengers on board. In North America, TenCate supports the market for commercial and regional jets with radome materials. These unique radome materials are also used on the radomes of military aircraft and unmanned aerial vehicles.

Strict requirements on radomes

Strict requirements are in force for these materials; for example, they must not become contaminated with conductive particles during production. Any contamination, no matter how small, from carbon fibers or metal particles would create hot spots and result in damage to the radome and reduced radar efficiency. For that reason, TenCate Advanced Composites makes these materials in its clean rooms in Morgan Hill (California) and Langley Mill (Nottingham). Materials from TenCate are valued, since they are electrically pure and contain no carbon contamination. This ensures high-powered radar signals to be transmitted through the radome without interference. The fabrics that TenCate uses for military radomes are made primarily of quartz, which is 99.9% pure glass. This material allows the radar to electrically use through it, much like an electronic window. TenCate materials are also used on shipboard radar for the same reasons.

Interior applications

TenCate materials are used for diverse parts of the aircraft interior. Examples include flooring, ducting, overhead bin structures, trolleys, aircraft seats, and galleys, such as those on the Boeing 737s of Southwest Airlines. The materials for interior applications meet strict fire-safety requirements. TenCate Advanced Composites USA and the Netherlands supply composite materials to US and European manufacturers of aircraft seats. Using a combination of titanium and TenCate composite, the French company Expliseat manufactured the Titanium Seat: an aircraft seat weighing only 4 kilos—the lightest ever to have withstood the crash test. At JEC Composites 2014 in Paris (France), the makers of the seat were presented with the JEC 2014 Aircraft Interiors Innovation Award.

Airbus A350 XWB is of great strategic importance in view of the amount of thermoplastic composite material used for the production of thousands of clips.

Demand for radomes is growing as a result of increasing communication options during passenger flights.

Materials for interior applications such as floors, ducting, seats, and galleys have to satisfy strict fire-safety requirements.

www.tencatecomposites.com/radomes
Small, Convenient, and Comfortable

The proportion of composites in aircraft is steadily growing, and this applies not only to massive passenger aeroplanes such as those of Boeing and Airbus, but equally to small business jets or private planes of Cirrus and Gulfstream. The use of composites not only makes aircraft lighter and extends their life span, but also enables air pressure and atmospheric humidity to be increased, enhancing passenger comfort. Furthermore, no material fatigue whatsoever occurs in composites, unlike in aluminium.

Thermoset composites are primarily used for wings, fuselages, flight control surfaces, and radomes, while thermoplastic composites are used in general aviation for interior applications such as panels and flooring. “TenCate has years of experience in this market,” says Michael Cichon, director of product marketing of TenCate Advanced Composites in the US. “Our in-depth material databases and our high service levels are greatly valued by aircraft manufacturers. This segment is therefore one of high value with continuing growing opportunities. Thermoset epoxy-based composites from TenCate, such as BT250E-1, TC250, and TC275-1, are the products used most often in general aviation.”

Cirrus Aircraft
In February 2014, a multi-year contract was signed with Cirrus Aircraft for the supply of advanced composites for the Cirrus Aircraft SR series of turboprop Kestrel K-350. Composites offer considerable design freedom, more room, and interior comfort. The materials for these applications are produced at the facilities of TenCate Advanced Composites in Morgan Hill and Fairfield (United States).
epoxy prepreg system, which is capable of out-of-autoclave processing. This processing reduces not only the costs of composites but also investment in their processing. More than 95% Cirrus Vision SF50 personal jets have been ordered to date.

Innovative aeroplanes

When it comes to small aircraft, Cirrus Aircraft is an acknowledged leader with its all-composite series of private aeroplanes. These are characterized by high performance and leading safety technologies, and much else besides.

According to Rick Hollander, director of operations of Cirrus Aircraft, the partnership between his company and TenCate Advanced Composites combines "the proven advanced composites in strategic terms with the most innovative aircraft in the world." In his view, the best available materials are found in these aeroplanes. In 2014, Cirrus Aircraft was acquired by China Aviation Industry General Aircraft Co., Ltd. (CAIGA). The Chinese company wants to make Cirrus and similar aircraft for its domestic market. This offers TenCate the opportunity to leverage its successful history with Cirrus within China's general aviation industry.

ICON Aircraft

The new star in the aviation world is the ICON A5 of ICON Aircraft, a manufacturer of sport aircraft. TenCate Advanced Composites supplies ICON Aircraft with out-of-autoclave epoxy composites for this amphibious sport aircraft. The ICON A5 can take off and land on both water and land. The plane is a two-seater, has a cruising speed of 194 km/h, and a range of approximately 550 kilometers. The first official plane, with Engineering Serial Number 1 (ESN-1), made its maiden flight on July 7, 2014. A second prototype is now being built: the ESN-2. This will be ready by fall 2015.

After certification by the FAA, series production can get underway and a start made on delivery to customers. In this respect, ICON Aircraft is building a new factory in the north of the state of California, with a production capacity of 500 planes a year. The company has already received more than 1,400 orders for the A5 from the market. The plane has won several of the world’s most prestigious design awards and has inspired many worldwide.

Matthew Green, director of engineering and chief technology officer of ICON, “can’t wait until our customers have experienced the end product.”

Kestrel Aircraft

At the end of 2014, a long-term supply agreement was signed with Kestrel Aircraft of Superior (Wisconsin, USA) for the Kestrel K-350. This is a new composite single-engine turboprop aeroplane. It can carry a maximum of eight passengers on high-speed flights over long distances to destinations inaccessible to large aeroplanes. Thanks to the use of advanced composites in its construction, the plane boasts a slim aerodynamic design and has a large pressurised cabin. Composites invariably offer a great deal of design freedom.

TenCate Advanced Composites is a leading supplier of advanced composites and resin systems for the radome industry. TenCate’s cyanate ester and epoxy-based prepregs, liquid resin systems, adhesives, and syntactic foams feature low dielectric constant, low loss tangent and low moisture absorption properties. This capability coupled with TenCate’s segregated manufacturing facilities allows total isolation of conductive graphite from nonconductive (dielectric) materials, thus assuring superior quality and electrically pure products.

The General Dynamics LiveTV radome is a technologically advanced composite satcom radome. Designed to transmit data across three bandwidths (K, Ku, and Ka), the radome achieves enhanced levels of speed and connectivity for inflight Wi-Fi and two-way communications.

TenCate Advanced Composites worked in partnership with General Dynamics, the radome designer and manufacturer, in providing a material solution that would allow the enclosed antennas to transmit and receive radio frequency signals across a broader range of bandwidths. Other design considerations included consistency in signal transmission across all parts, longevity, and also cost-effectiveness.

TenCate TC250 is an epoxy-based thermoset prepreg that offers an excellent balance of toughness, low dielectrics, mechanical property translation, and hot/wet performance. Combined with a quartz fabric, this advanced composite material solution provided excellent mechanical performance whilst maintaining cost-effectiveness.

TenCate Advanced Composites for Radomes

Technologically Advanced Triband Satcom Radome

ULTRA-PURE ADVANCED COMPOSITES FOR RADOMES

TenCate Advanced Composites is a leading supplier of advanced composites and resin systems for the radome industry. TenCate’s cyanate ester and epoxy-based prepregs, liquid resin systems, adhesives, and syntactic foams feature low dielectric constant, low loss tangent and low moisture absorption properties. This capability coupled with TenCate’s segregated manufacturing facilities allows total isolation of conductive graphite from nonconductive (dielectric) materials, thus assuring superior quality and electrically pure products.

The General Dynamics LiveTV radome is a technologically advanced composite satcom radome. Designed to transmit data across three bandwidths (K, Ku, and Ka), the radome achieves enhanced levels of speed and connectivity for inflight Wi-Fi and two-way communications.

TenCate Advanced Composites worked in partnership with General Dynamics, the radome designer and manufacturer, in providing a material solution that would allow the enclosed antennas to transmit and receive radio frequency signals across a broader range of bandwidths. Other design considerations included consistency in signal transmission across all parts, longevity, and also cost-effectiveness.

TenCate TC250 is an epoxy-based thermoset prepreg that offers an excellent balance of toughness, low dielectrics, mechanical property translation, and hot/wet performance. Combined with a quartz fabric, this advanced composite material solution provided excellent mechanical performance whilst maintaining cost-effectiveness.

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TenCate Advanced Composites is the composite technology partner of the Aston Martin Valkyrie program, supplying advanced composite materials for a broad range of end-use applications throughout the car, including structural, cosmetic, and high temperature components.

TenCate’s Expert Services team worked closely with Aston Martin to ensure the best possible composite material solution for the program, developing custom material forms where needed to best meet the unique application demands.

The Aston Martin Valkyrie is built around a lightweight carbon fiber structure, boasting truly radical aerodynamics for unprecedented levels of downforce in a road-legal car.

The Aston Martin Valkyrie door assembly delivers structural performance, together with a visual quality appearance. A selection of TenCate Advanced Composites prepregs with Toray high- and intermediate-modulus fibers were utilized in the part prior to assembly by Multimatic. The design weight for the full carbon fiber construction is 4.9 kg.

The Valkyrie door assembly features a 2-piece inner panel with separate cold-bonded A-pillar and B-pillar reinforcements. The A-pillar section proved challenging to ensure occupant viewing angles met regulations yet delivered the strength and support required. The lower segment of the door has been developed to maximize energy absorption during a crash, increasing driver safety. Additionally the door panel vents the cabin directly.

### ASTON MARTIN VALKYRIE DOOR ASSEMBLY

The Power of Partnership

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The ThermoPlastic composite Research Center (TPRC) in Enschede was the result of an initiative by TenCate in 2007 with aircraft manufacturer Boeing, Fokker Technologies (manufacturer of aircraft parts), and the University of Twente as partners. TPRC is an open innovation center that focuses on thermoplastic composites for the aircraft industry and on secondary high-grade applications in transport, industry, energy, and healthcare. Interest in thermoplastic composites and their potential applications is increasing steadily as customers seek materials that are lighter, more cost-efficient, and more environment friendly. These composites are light, strong, stiff, sustainable, and recyclable. Fuel consumption is a major factor in the price of the flight. Boeing aims to speed up the development of thermoplastic composite technologies and to make the production of thermoplastic composite products both faster and more efficient. This will require the value chain to grow and mature.

Growth in human resources, knowledge, and customers

TPRC has grown rapidly in the past few years. Students from the University of Twente, the Saxion and Windesheim universities of applied sciences, the universities of applied sciences in Arnhem and Nijmegen (HAN) and in Amsterdam, as well as from foreign educational institutions, can regularly be found in the research and test areas. There has also been an increase in knowledge of thermoplastics and of their processing and potential applications. “As a result of the specific knowledge that has been acquired and the support we have provided in the making of several products, other companies now know where to find us,” general manager Harald Heerink and former business developer Bert Rietman told us. “It is important to understand the process and to strengthen our position. And this will reverberate. The world of thermoplastics is still small, but we have been able to attract ever more customers. The Netherlands is a major player in thermoplastics, particularly through TenCate and through branding TenCate Cetex®, and helping to market it.”

Automotive

TPRC is also now focusing on the automotive industry. Composites in the form of fiber-reinforced thermosets are already being used in more expensive cars and in Formula 1 racing cars, which are produced in small numbers. This material is, however, less suitable for mass production. “The automotive industry can in principle expand the use of thermoplastic composites more rapidly. This is because its requirements are less strict when it comes for example to knowledge of long-term behavior, such as fatigue, creep, and degradation.”

Expertise in Thermoplastics

Since it was set up in 2009, TPRC has been showing steady growth in terms of knowledge acquisition, employees, and customers. Initially, attention was focused on the development of thermoplastics for the aerospace industry; recently, however, sights have also been turned to the automobile industry. And this is to the satisfaction of the aircraft manufacturer involved as the automotive industry has faster development processes, of which the aerospace industry can take advantage.
Recently, a major step was taken: with ever-improving technology, Rietman is now also working on bilateral projects—primarily to develop the roadmap research for paying TPRC members, they are now also working on bilateral projects—primarily to develop the roadmap research for paying TPRC members, they are now also working on bilateral projects—primarily to develop the roadmap research for paying TPRC members, they are now also working on bilateral projects. Thanks to our structure we have the opportunity to fundamentally study these materials and processes in the longer term.”

**Learning from developments**

Boeing has welcomed the switch to the automotive industry, said Harald Heerink. “The reason behind this is that when volume becomes high, the price can be reduced. All the OEMs in the automotive industry make demands as regards lightweight and that are based on European emission requirements. Low weight is one of the ways to achieve lower emissions, just like the drive system and aerodynamics. There is a wide range of options when it comes to materials. Thermoplastics are relatively new, so there is still some hesitation about this new technology. We expect thermoplastics to make a breakthrough, even though there will always be a mix with materials like high-strength steel. Aerospace can learn from the developments in the automotive industry, such as automation, production processes, and overmolding.

This is the shaping of thermoplastics in combination with injection molding for extra finishing and functionalities. However, our focus on the automotive industry must not divert us from our core research program. We must continue to keep up the momentum, as it is the basis of our success. That is also the reason why we intend to integrate automotive partners into the TPRC, such as a tier 1 and material producer, so as to bring the value chain into alignment with them. However, the automotive industry has not yet advanced that far.”

**Results**

TPRC has already achieved results: an increase in knowledge and a lightweight car seat, which, they both believe, is “a critical part.” “A double curvature is especially difficult, they explain, also in a car seat. By placing the fibers this way and that in the mold, it can be made without folds and with predictable characteristics. We are going to continue to optimize this process, in which we lead the way. Our customer is now offering this seat to OEMs. The seat can be made in ninety seconds, and in our world of traditional processing that is a significant breakthrough.”

“Customer knowledge, development of the software, and understanding of the production process are all increasing. The same applies to the material and processing. Boeing can then take decisions about their use in future aircraft. OEMs focus rather more on the ‘shorter’ term for their own R&D departments. Thanks to our structure we have the opportunity to fundamentally study these materials and processes in the longer term.”
The Swiss manufacturer, Kopter Group (formerly Marenco Swisshelicopter), selected TenCate’s advanced composite materials as a result of its database, technical support, and performance. Additionally, the resin system that was selected is capable of being processed under vacuum bag processing typically called “out-of-autoclave.” The ability to process this material in lower cost ovens versus high pressure autoclaves reduces production and capital costs.

Excellence in thermosets

The resin system selected by Kopter Group for use and qualification on the SH09 is currently produced by TenCate Advanced Composites in the US and will be initially supplied from the US. As Kopter Group’s production rates increase, TenCate will be in a position to shift composite production to Langley Mill in the UK. TenCate Advanced Composites in the UK will eventually become one of TenCate’s centers of excellence for thermoset resins. The Langley Mill (Derbyshire, UK) location currently provides composites to Formula 1, automotive, tooling, and industrial markets. Over time, TenCate Advanced Composites in the US will transfer production for aerospace products to Langley Mill to supply European-based customers in the satellite, radome, and general aviation segments.

The young, fast-growing Kopter Group will be a strategic partner for TenCate Advanced Composites in the years ahead. According to Martin Stucki, the founder and CEO of Kopter Group, TenCate will “not only bring innovation, but also expertise in a variety of fields.”

Civil purposes

The SH09 is a single-engine helicopter used for civil purposes, including transporting passengers, surveillance, firefighting support, and search and rescue operations. It is a “new generation,” as the helicopter is made entirely of composites: both the structure and the main and tail rotor blades are of composite. The rotor is the rotating wing of a helicopter. Through the cabin, which is made partly of glass, both pilots have an unobstructed view of the condition of the terrain beneath them. This helicopter can operate for longer in higher or thinner air: the air ambulance version for example exploring the top of the Matterhorn (4,478 m high). The helicopter can reach a speed of 270 km/hour and has a range of 800 kilometers. The helicopter is already in production, starting with five units this year. Work is also underway on a second prototype.

Other applications

Composite materials from TenCate Advanced Armor are already in use in several helicopter platforms, including the Airbus Helicopter NH 90, the Boeing V-22 Osprey, and the Erickson S-64 Air Crane. On the Airbus Helicopter NH 90, TenCate’s composite material represents add-on armor for aircraft that are deployed in war zones and crisis situations. These anti-ballistic inserts protect the crew and passengers from small-arms fire and are supplied in Airbus Helicopter as anti-ballistic inserts.

On the Boeing V-22 Osprey, TenCate provides compression-molded parts that are fabricated from chopped carbon fiber and epoxy resin. These composite parts replace metal and composite parts for both weight and cost savings. The V-22 is multipurpose: the helicopter combines attack and transport options with a high forward speed and the potential to hover and to descend and rise vertically during the flight or above a target.

On the Erickson S-64 Air Crane, TenCate composites were chosen for the composite helicopter blade. The Erickson S-64 Air Crane (or Sikorsky S-644 Skycrane) is a large twin-engined transport helicopter (“flying crane”) that was specially designed to transport heavy loads.

www.tencatecomposites.com
The Fifth Mode of Transportation

At the end of January 2016, a team from Delft University of Technology gained a highly creditable second place in the Hyperloop competition organised by Elon Musk, top executive of SpaceX and Tesla. Furthermore, the Delft team collected first prize for the most innovative design. They will soon be able to test their design for a futuristic transportation system in the final in California. TenCate Advanced Composites UK provided the team with thermoset carbon prepggs, adhesive film, and Nomex® honeycomb core material.

SUSTAINABILITY

The Hyperloop is an innovative concept for a future transport and transit system with capsules (pods) in a system of air pressure tubes. The concept is the brainchild of Elon Musk, CEO and chief designer of the aerospace firm SpaceX. In 2015, this company instigated the Hyperloop Pod Competition in order to stimulate the development of a working prototype. He challenged student teams and companies throughout the world to design, build, and test their own Hyperloop pod. The team gave a digital presentation of a detailed concept version at the University of Texas. And with a successful outcome: second place in the design & build category meant a place in the final. Furthermore, the Delft team received the Pod Innovation Award, the prize for the most innovative design. Together with 21 other teams, Delft Hyperloop can now actually build and test its design for a superfast sustainable transport system.

Rapid and reliable

Delft Hyperloop is working on a safe, rapid, reliable, and inexpensive pod. The transport pod must reach a speed of more than 1,000 kilometers an hour and be able to carry both passengers and freight. So the Hyperloop will transport passengers from Amsterdam to Paris or Berlin within half an hour, whereas currently the Thalys takes 3.5 hours to reach the French capital. Megabus needs 8 hours to cover the route from Los Angeles to San Francisco, but this too will be cut to 30 minutes.

Continued on page 46
Low air drag
Unlike pneumatic despatch, the transport system does not work with overpressure. The low pressure in the tubes means the air drag is so low that traveling speed can almost reach the speed of sound. Delft Hyperloop has selected a design for a carbon-fiber pod weighing only 149 kg, with an aerodynamic shape and electrodynamic suspension. Permanent magnets have been chosen to allow the pod to glide in the tunnel. This minimizes both energy consumption and the construction costs of the track.

Custom-made
Tim Houter captains the Delft team. In Texas, he had the opportunity to exchange ideas with Elon Musk. “We brainstormed on our approach, the realisation of the Hyperloop, whether it should be an underground or overground system and I also explained the design and its scalability.” At the beginning of February 2016, back in the Netherlands, the team started building the prototype for the final. Now it’s a question of producing and assembling the components. No easy task: each component is custom-made and will have to be turned and milled, just like the molds. “ Afterwards, we will make a large-scale test model, with rotating discs to simulate the speed of the test track.”

Test tube
The end game will take place in the summer of 2016, near the headquarters of SpaceX in Hawthorne (California). The Hyperloop pods will race through a specially-constructed test tube (enclosed track 1.6 kilometers long and 1.8 meters in diameter). Building will start this spring. The design and performance of each pod will be assessed by experts from Tesla Motors and SpaceX and several associated professors.

A passion for technology
Tim Houter describes himself and the other team members as “engineers with a passion for technology in general and for mobility in particular” with environmental friendliness as a guideline. He says that the transport sector is one of the biggest consumers of energy in the world. “Mobility has always been a complex issue. It is high time for innovation. After the boat, car, train, and aeroplane, the Hyperloop is the new form of transport.” In his opinion, the car is more economical for shorter distances, up to one hundred kilometers. “For longer distances, from a thousand kilometers, the aeroplane will be more efficient. But when it comes to those journeys between a hundred and a thousand kilometers, the Hyperloop technology has great potential.”

Material supplier
A number of companies have now committed themselves as partners to the team. One of these is TenCate Advanced Composites UK (Langley Mill). For the Formula 1 market, the company produces epoxy resin systems for impact structures (reinforcement against impact) and for application in the suspension, brake lines, gearboxes, bedplates, and monocoque. The plant is an important material supplier for the team from Delft, providing it with thermoset carbon prepregs (fabric and UD tape), adhesive film, and a Nomex® honeycomb core for the pod floor.

“The desired curve”
“We’ve already gained experience in the processing of composites and how to make panels with the desired curve,” continues Tim Houter. “Because we used the carbon prepregs from TenCate, not only did the production of our test panels run extremely smoothly, but we also acquired a good deal of knowledge along the way. By looking at the different resin systems together with TenCate, we were ultimately able to select a resin system that seamlessly fitted the capsule requirements. For example, the chosen resin system has a low flexible curing temperature, which minimizes the costs of the mold and auxiliary materials. Through utilizing the materials from TenCate Advanced Composites, we are capable of creating environmentally friendly transportation for the future!”

• The Delft Hyperloop team have opted for a carbon-fiber pod, with permanent magnets enabling the pod to glide through the tunnel
• The concept minimizes energy consumption, construction costs, and track maintenance
• TenCate Advanced Composites UK supplies the team with thermoset carbon prepregs and technical advice

www.delfthyperloop.nl
Expansión y actualización de la instalación de TenCate Advanced Composites en el Reino Unido

Los empleados de TenCate Advanced Composites en el Reino Unido recogieron recientemente frente a las nuevas instalaciones de Langley Mill para posar con la Alfa Romeo 4C. TenCate propone al Grupo Adler (Nápoles, Italia) confecciones de fibra de carbono para el marco de la Alfa Romeo 4C. El material de TenCate Advanced Composites se utiliza para la producción de todo el monocoque: el compartimiento de pasajeros. Esto reduce su peso y proporciona al vehículo una estructura básica rígida y segura.

Langley Mill: la cima en termoset

Desde el principio de 2016, TenCate Advanced Composites en el Reino Unido ha estado disfrutando de su nuevo aspecto en un espacio más espacioso. La instalación ha sido completamente actualizada de acuerdo con las exigentes demandas de mercados como el aviación y el aerospatial. De hecho, la instalación en Langley Mill (Nottingham, Reino Unido) se completó en mediados de enero de 2016. La zona de producción se ha ampliado y la capacidad para confecciones de termoset se ha aumentado considerablemente. Aplicaciones son el mercado de la medicina, el Fórmula 1, la industria automotriz y el mercado europeo de aviación, satélites y radomes, y el mercado de la aviación –cada uno de ellos.
Thermoplastic Composites: Success and Growth

In December 2015, the Airbus Group and TenCate Advanced Composites extended their supply contract relating to thermoplastic composites. This contract was recently confirmed. The Airbus Group and TenCate also both focus on product and process innovation. “Our thermoplastic composite solutions highlight the innovation-driven approach taken by TenCate.”

On Friday, March 11, 2016, Loek de Vries (formerly President and CEO of TenCate), Frank Meurs (group director, TenCate Advanced Composites EMEA), and representatives of the Airbus Group confirmed the extension of their supply contract relating to thermoplastic composites. The official event took place during the 2-day Dutch economic mission in France. Also in attendance were King Willem-Alexander and Queen Máxima. The fact that Airbus Group and TenCate Advanced Composites were able to highlight here the importance of the proportion of thermoplastic composites on Airbus Group aircraft was “fantastic exposure” for both parties, said Marlie Koekenberg (sector sales manager, aerospace EMEA).

Continuous improvement

The proportion of composites, and notably of thermoplastic composites, on the Airbus Group fleet has grown rapidly in recent years. The Airbus Group together with such companies as TenCate is committed to further expansion of the thermoplastic composites footprint on Airbus Group aircraft. “There are several applications on our commercial aircraft made of thermoplastic composite materials, such as clips and engine pylon covers,” said Mark Walker (Vice President Procurement, Airbus Composites & Paints). “The ambition of the Airbus Group is to make aviation efficient and sustainable, and thermoplastic composites can play a role in this.”

TenCate materials from Nijverdal are used in such aircraft as the A320, the A380, and in particular in the A350XWB.
A working group, composed of both parties, is focusing on continuous improvement: ensuring that thermoplastic composites remain competitive with other material solutions, with a view to reducing overall life-cycle costs for users and end customers.

**Innovation-driven approach**

Airbus Group and TenCate are also jointly developing new thermoplastic composite products and processes. The working relationship with the Airbus Group is based on the pursuit of operational excellence, cost savings, and innovative solutions that provide added value. TenCate thermoplastic composite solutions highlight the company’s innovation-driven approach. The meeting with the king and queen marked the culmination of all this.

**Secondary and interior applications**

The Airbus Group and TenCate have maintained a close relationship for many years. Through tier 1 companies, TenCate Advanced Composites provides the Airbus Group with thermoplastic composite materials for secondary structures and interior applications in its aviation and aerospace programs. A tier 1 supplier supplies systems and parts directly to the aircraft manufacturer. TenCate Advanced Composites is among the tier 1 suppliers of parts and components. In this way, TenCate materials from Nijverdal are on the A320, A330, the A380, and in particular the A350XWB. Fifty-three percent of the A350XWB consists of composites, such as trusses for the fuselage skin. Each A350XWB incorporates several thousand parts made of TenCate Cetex® thermoplastic composites. And TenCate composite material is also fitted on the inside of the engines of the A320 and the A380. This helps to absorb the vibration of the engines and thus increase passenger comfort. The Airbus Group A400M is fitted with ice protection panels based on TenCate Cetex®. A smaller quantity of materials from Nijverdal is used in aircraft of Boeing, Gulfstream, Bombardier, and Embraer.

Expansion of Nijverdal and Morgan Hill

Production at TenCate Advanced Composites in Nijverdal was expanded several years ago and configured to be able to meet increased production levels at Airbus. In the next 3 years, further upscaling of production will take place, thus ensuring that the aircraft manufacturer and its tier 1 partners receive a stable and continuous supply.

The facility of the market group in Morgan Hill (California, USA) has also recently undergone expansion. This relates in particular to the production of thermoplastic UD tape. TenCate Advanced Composites USA currently supplies composite material for aircraft including the Boeing 787 Dreamliner (for the nacelle and the mounting for the hydraulic and fuel lines), the Boeing 737 and 747, the F/A18 Hornet, and the Boeing V-22 Osprey helicopter. Here too, their ambition is to further expand this success story and to increase the proportion of thermoplastic composites in aircraft.

**Safety and reliability**

TenCate Advanced Composites is renowned in the market for affordability, on-time delivery, high quality, and innovation. “When it comes to service, we easily outperform the rest,” Marlie Koekenberg says.

In the aviation and aerospace industry, safety and reliability are sacrosanct. “The greater the range of an aircraft, the more important the reduction in weight and CO\(_2\) emissions. The overall costs over its entire lifespan also play an increasingly important role in decisions taken by the end customer. Thermoplastic composites fully meet these needs,” explained Frank Meurs in Paris. “The advantages of these materials are their processability into molded parts and assembly, their high strength/weight/impact ratio, excellent fire, smoke and toxic liquid retardance, as well as their recyclability. They can in this way contribute to low overall life-cycle costs.”

Lightweighting by using TenCate Cetex® thermoplastic composites has saved 2.4 million tons of CO\(_2\) emissions every year since 2006.
The market for small satellites is booming and the demand for launches has grown substantially in recent years. Increasingly, smaller satellites are being built and are also becoming progressively cheaper. The company Rocket Lab (Los Angeles, California) has set itself the task of overcoming the obstacles confronting commercial aerospace by facilitating affordable and high-frequency rocket launches. According to the team surrounding founder Peter Beck, small payloads require dedicated launch vehicles and flexibility—something not currently offered by traditional rocket systems. The company has now developed a series of rocket systems and technologies for fast affordable payload deployment. Rocket Lab utilizes innovations in rocket technology and rapid development cycles to accelerate not only deployment but also cost reduction.

Limited impact

On Kaitorete Spit, a deserted promontory to the south of Christchurch (New Zealand), Rocket Lab is building a launch base from where a sounding rocket or satellites with a small launch rocket can be delivered into orbit. A small launching pad, a mobile transport vehicle, and an assembly hall have been built on the site. Thanks to the modest site dimensions, the impact on the environment is limited. Rocket Lab selected this area because of the absence of nearby towns, heavy air traffic, and busy shipping routes. Furthermore, to send its own small satellites into orbit 500 km above Earth's surface, Rocket Lab has developed the Electron, a 20-meter-long two-stage rocket made completely of carbon composite. Uni-directional tape and thermoset prepregs from TenCate Advanced Composites USA have been used in this respect.

Thermoset composite

The production plants of TenCate Advanced Composites in Morgan Hill and Fairfield (California, USA) are designed for the development and production of thermoset composite materials for aerospace (rockets, satellites, and reconnaissance vehicles). Customers include major aerospace companies including Boeing, Lockheed Martin, NASA, Airbus, and nearly every satellite and rocket manufacturer in the US and Europe. By selecting these composite materials from TenCate, Rocket Lab is able to deliver the lowest mass fraction for a rocket of this size. The rocket is capable of a launch payload of 150 kg, while protection during assembly and flight is also improved. Through utilizing carbon fiber for the parts and the rocket motor battery technology, as well as a 3D printer for producing crucial rocket components, production is significantly faster than the building of conventional rockets. Consequently, the cost price of one Electron is $5 million—a fraction of the $30 million commanded by the cheapest launch rocket on the market. Furthermore, fuel consumption during rocket launch is less than a Boeing 737 uses during the flight from San Francisco to Los Angeles. Such choices also enable Rocket Lab to profile itself as an environmentally friendly aerospace company.

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TenCate thermoset prepregs have characteristics suitable for space: they are thermally stable, exceptionally strong, durable, lightweight and micro-crack resistant.
Underbody Panel for the Jaguar F-TYPE

TenCate Advanced Composites recently partnered with POLYTEC GROUP in the development of a serial production, high-performance thermoplastic composite underbody panel for the new Jaguar F-TYPE. The targeted application of thermoplastic composites from TenCate demonstrates an innovative approach to the use of thermoplastic materials within the automotive industry.

Continued on page 58
TenCate Advanced Composites have a market-leading range of UD and fabric thermoset prepregs for use within aerospace applications including aerostructures, wings, rotor blades, and control surfaces.

The next-generation multipurpose lightweight Kopter Group SH09 helicopter features a full composite fuselage and tail rotor as well as all-composite main and tail rotor blades, made using TenCate TC275-1 and BT250E-6 epoxy resin systems. Kopter Group selected this advanced composite solution of TenCate because of their excellent mechanical properties coupled with TenCate’s experience in supporting new emerging programs.

Designed to stand out from the competition, the Kopter SH09 helicopter offers exceptional hot and high performance with a low noise signature. The lightweight composite materials from TenCate provide an excellent balance of toughness, mechanical property translation, and hot/wet performance.

GLOBAL PARTNER FOR AEROSPACE COMPOSITES
TenCate Advanced Composites signed in March 2016, a multiyear supply agreement with Kopter Group (formerly Marenco Swiss helicopters) for the SH09 program. TenCate will supply Kopter Group globally from facilities in the United States and the newly expanded Langley Mill plant in the United Kingdom.

TC725-1 is available in UD tape or woven prepreg format, and is out-of-autoclave processable making it ideal for large systems. A new longer out time version, TC275-1E, is now available.

BT250E-6 is a high-modulus resin system for rotor blade usage, out-of-autoclave processible, and FAA-conformed database.

POLYTEC COMPOSITES NL—automotive parts designer and manufacturer and part of the POLYTEC GROUP—developed a lightweight underbody panel for the Jaguar F-TYPE AWD Drive. The basis of this solution is the combination of a targeted placement of TenCate Cetex® lightweight reinforced thermoplastic, providing localized reinforcement where most needed, with glass mat thermoplastic to achieve the required rigidity. These were both pressed in a single production step, thus improving processing efficiencies and overall quality of the part.

Since October 2015, some 500 of these underbody covers have been coming off the production line at the POLYTEC COMPOSITES plant in Roosendaal every month. This adds up to a yearly total of 6,000 pieces, which is soon to be tripled, as Jaguar Land Rover has also commissioned POLYTEC to equip the standard version of the rear-wheel-driven F-TYPE with this underbody solution.

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The Jaguar F-TYPE

The part with the underbody panel for the Jaguar F-TYPE

The place where the relevant part is fitted
In the Center of the High-Tech Composites Industry

Thermoplastic composites for the aircraft industry, automotive and industrial applications played a central role at Experience Composites and ITHEC. Held in Germany in 2016, these two trade fairs plus conferences featured the development, characteristics, and applicability of these materials. TenCate Advanced Composites was present with a team and an exhibition stand. Germany is a major player in the aerospace and automotive markets.
The share of thermoplastic composite materials is growing in the aircraft programs of Airbus, Boeing, and other OEMs. Thanks to rapid processing speeds, thermoplastics make low production costs possible. They are suitable for high-volume production, are characterized by high-strength-to-weight ratios, and are fire retardant. They contribute to a high strength-to-weight ratio, are easy to recycle and are fire resistant. They are suitable for high-volume production, are characterized by low production costs possible. They are suitable for high-volume production, are characterized by high-strength-to-weight ratios, and are fire retardant. They contribute to a high strength-to-weight ratio, are easy to recycle and are fire resistant.

**North and South Germany**

Experience Composites took place in Augsburg (South Germany) in September 2016, and Experience Composites in Bremen (North Germany) in October 2016. No random choice of location! The German aviation industry is also showing increasing interest. The market potential is based chiefly on the need for substantially lower vehicle CO2 emissions. That’s why the automotive industry is also showing increasing interest. The market potential is based chiefly on the need for substantially lower vehicle CO2 emissions. That’s why the automotive industry is also showing increasing interest.

**Aircraft programs**

“For us, it’s a case of putting composites for the German aviation and automotive industries even more firmly on the map,” says Marie Koekemamp (formerly sector sales manager, aerospace & marine). “The focus in aviation is on thermoplastics. Many R&D initiatives and innovation efforts are taking place around the line Stuttgart-Augsburg-München. We want to use the German Aeronautics and Space Center (DLR) to gain better access to major aircraft programs. DLR conducts materials assessment, designs aircraft parts, and investigates the producibility of a part. That’s interesting information for customers.”

**Opportunities in the automotive industry**

“Currently, the share of thermoset composites in the automotive industry is substantially larger,” says Michael Versteegen (former account manager, Industrial Central Europe of TenCate Advanced Composites). “That’s because there are many small programs. There are many more opportunities for thermoplastics precisely because of their characteristics.” At the moment, the obstacle is still the end customer. He has learnt from experience that car manufacturers want to use thermoplastics but they expect the supplier to have sufficient production capacity and only decide at the last moment whether or not to opt for application. First, the production processes will have to change. “That is indeed the direction in the middle term. New programs are becoming increasingly specific. If we can further optimize the price comparative to that of metal, then it is only a question of time.” TenCate Advanced Composites is distinguished by its years of know-how. There are many producers of composites and prepregs, but relatively little knowledge to be found among suppliers and customers.”

**The German aviation industry**

The German aviation industry is concentrated in North and South Germany; the majority of the car manufacturers are found in the southern region.

**The focus in aviation is on thermoplastics**

**Car manufacturers are expected to use thermoplastics, but first the production processes will have to change**

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A Royal Company

On Thursday, September 15, 2016, TenCate became a private company. This is laid down in a deed of conversion and an amendment to the articles of association. As a limited company, the company has known many investors, both private and institutional, since 1872. With the takeover by Gilde Buy Out Partners, the number of shareholders has been reduced to one.

The roots of the company date back to the end of the 17th century, when members of the Ten Cate family based in Almelo were already operating in the textile trade. The firm of H. Ten Cate was established in 1766. In Nijverdal, Godfried Salomonson received the predicate “Royal” in 1852 for the steam weaving mill (KSW) set up a year earlier with his brother Hein. In 1872–144 years ago—the KSW became a limited company. Both the legal form and the royal predicate were retained after the merger in 1917 with H. ten Cate Hzn. & Co, which led to the birth of the NV Textielfabrieken Ten Cate/KSW. Over the years, there were name changes via Koninklijke Textielfabrieken Nijverdal-Ten Cate nv, Koninklijke Nijverdal-Ten Cate nv, to Ten Cate nv, Koninklijke Nijverdal-Ten Cate nv, to Ten Cate nv, Koninklijke Nijverdal-Ten Cate B.V. The listing of TenCate on NYSE Euronext (AMX) dating back 62 years came to an end on March 17, 2016.

Companies
A company is a form of organization where the primary aim is to realize profit for the continuity of the company. In the case of a public limited company, the registered capital is divided into shares that in principle are freely and publicly transferable. The public “partners” are relatively anonymous. They do not usually know one another, nor are they aware of one another’s investment purposes. In the case of a private limited company, the registered capital is divided into shares that are not freely transferable: they are registered to names. To date, Gilde holds 100% of the shares of TenCate. Gilde focuses on companies “with superior business models, strong and often leading market positions, growth potential, and a predictably positive cash flow.”

Executive and Supervisory Boards
The Executive Board is composed of Jan Albers and Frank Spaan. Jan Albers is member and chairman of the Executive Board, with the functional title of chief executive officer (CEO). Frank Spaan is member of the Executive Board, with the functional title of chief financial officer (CFO). The members of the Supervisory Board of Royal Ten Cate are Broodewijn Mihinaar (chairman), Jan Hovers, Fred van Houten, Loek de Vries, and Erik-Jan Westerink.

Aerospace Composites
Go Underground

Replacing the present train doors of the London Underground with alternatives based on TenCate Cetex® thermoplastic composites means a shorter time between stops and greater capacity. These are just two of the benefits that such a replacement would provide. One train is currently being monitored to validate the potential savings.

The London Underground, the umbrella organization of the capital’s tube system and the world’s first underground network, transports over 1.2 billion passengers a year. The trains travel more than 75 million kilometers a year. The Central line is the busiest and most intensively used section of the London Underground. It serves 49 stations and, with its 73.5 kilometers, is also the longest line of the network. The Central line has 85 eight-carriage trains, each carriage having four doors on each side. This line alone has 7,820 train doors, and 280 million passengers pass through these doors each year.

Expanding capacity
London currently has 10 million inhabitants—a figure expected to reach 13 million in 2020. Reason enough for Transport for London to embark on exploring the possibilities for expanding capacity 2.5 years ago. Transport for London (TfL) is a governmental organization that is responsible for the traffic and public transport in the London conurbation. Running more trains on the present network is not an option; adaptation is. Replacing the present metal-coated doors with doors based on thermoplastic composites means they would be lighter. Thanks to these weight savings, the time involved in opening and closing the doors can be reduced by 0.7 of a second, and TfL calculates that this equates to running 2.5 more trains on the circuit each day.

Faster actuation times
“The lower weight of the doors will achieve faster actuation times,” says John Darlington, head of product management for TenCate Advanced Composites UK. “This leads to a shorter time between stops and increased capacity due to faster passenger throughput. Transport for London has also calculated that the 25–30% weight savings achievable with the new composite doors would mean that the trains will be around one ton lighter overall, resulting in less wear on the tracks. The doors will also be more durable and corrosion-resistant than the metal and honeycomb core construction currently used.”

Net benefit
TfL has estimated that the net benefit of replacing a total of 12,000 current doors with composite alternatives based on TenCate Cetex®, at a replacement cost of €25 to €29 million, would be approximately €178 million over their lifetime. TenCate Cetex® thermoplastic composites are valued for their toughness and impact resistance. Furthermore, they are fire retardant, as well as resistant to moisture and solvents.

“Trains for the London Underground must last for 40 years. After 20 years, major maintenance and refurbishment are carried out. As far as the Central line is concerned, it’s a question of 300 to 400 new doors for trains destined to replace those scheduled to be taken out of service. TfL will be replacing approximately one hundred of these doors in 2017, and this represents not only a replacement cost of €116 million over their lifetime, but also savings achievable with the new composite doors would mean that the trains will be around one ton lighter overall, resulting in less wear on the tracks. The doors will also be more durable and corrosion-resistant than the metal and honeycomb core construction currently used.”

Continued on page 66

> Entrance to the Nijverdal North location

> Leyton Station (ITV News/PA)
a huge opportunity but also a challenge to the train builders and the British composites industry.”

**Railways, a worldwide market**

“Rail is a global market with ever-expanding fleets in major cities, where better vehicles with lower maintenance are required,” continues John Darlington. “That’s where we really see the potential. The underground system of Greater London serves as a kind of flagship for metropolises such as New York, Tokyo, and Shanghai. Because of the worldwide potential for underground trains, TenCate wants to be involved in the project. There is a long qualification period in this industry but TenCate has the stomach to ride that wave. When we first entered the aerospace industry with TenCate Cetex®, there was a 7-year qualification period—and then we had to wait a further 2 years before the introduction of the first parts. The railway market is similar to the aerospace market: high standards are demanded of the materials; high performance is the goal. The fire safety requirements are also similar, and our performance in aerospace has gained the confidence of the railway sector. Our interest lies in helping the suppliers who want to be part of this opportunity.”

**Supply chain**

John Darlington refers to the supply chain required to provide train builders with parts at the relevant scale. “Currently, the supply chain is still based on 90–95% metal fabrication and small volumes of thermoset composite.” From the Langley Mill plant (Nottingham, UK), TenCate Advanced Composites has begun to develop a supply chain for the delivery of these parts at the necessary scale. John Darlington is in discussion with customers concerning the processing of composites—both thermoset and thermoplastic—and the benefits for the railway market. Choice of material depends on the intended application. Not all rail vehicles are manufactured for the same purpose, and different requirements and performance criteria apply, for example, to light city trains, commuter trains, high-speed (intercity) trains, and underground vehicles. “The ability to deliver at a competitive whole-life price is the key to the success of composite materials in the rail industry.”

**Door with sensors**

To fully validate potential savings, a composite door equipped with a range of sensors has been mounted on a London Underground train and is currently undergoing a test program. These sensors measure the vibrations, acoustics, and material fatigue. The door was developed by a consortium composed of Atkins (engineering & design consultancy), Wabtec (manufacturer of locomotives and components for trains), University College London, and the National Composites Center (NCC). TenCate Advanced Composites UK is a member of the NCC. “A composite door requires less maintenance, and its reduced weight delivers time and energy savings. Over the coming 20 years, it would be possible to run 1 or even 2.5 extra trains a day, with weight savings of one ton per vehicle. When it comes to maintenance of doors in service, time savings are expected to amount to £100 million ($127 million).”

**Owner or franchisee**

John Darlington points out a possible obstacle to the immediate wide-scale adoption of such composites on the British market. Unlike TfL, British railway companies don’t own their tracks but operate on a 7- to 10-year franchise basis. “So for them longer-term reinvestment is difficult to justify. They have neither the same long-term vision in respect of line wear nor the same capacity restrictions as TfL, and as a result they push upgrading plans to the back of their schedules.” Nevertheless, he expects thermoplastic composites to become increasingly accepted by the railway industry over time. “If you look at the composite fuselage of a modern plane, there’s no reason why the roof of a train couldn’t be made from exactly the same materials—with all the advantages that would bring.”

• Replacing metal doors with composite doors means savings in maintenance and faster actuation times, which would enable 2.5 extra trains to run each day
• TenCate Advanced Composites intends to develop a supply chain so that the relevant parts can delivered at sufficient scale
• It is expected that thermoplastic composites will be increasingly accepted by the railway industry over time

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Over the next 20 years, Transport for London should be able to run 1 to 2.5 extra trains a day (PriestmanGoode)
Support without the Weight

Composite materials and systems from the Advanced Composites group of TenCate are used particularly in the aerospace and automotive industries. Other areas of application are the medical, sports, and electronics sectors. Toray PMC, formerly TenCate Performance Composites, has specialized in these for many years. “Visitors and customers are positively surprised when they see how streamlined, vertically integrated, and efficient we are.”

TenCate Performance Composites started operating in 1986 in Camarillo as Performance Materials Corporation (PMC)–initially for podiatry inserts and gradually for branded footwear for athletics. Just over a decade later, the company was already producing a million items a month for these applications. In 2016, the varied product range has been extended and TenCate Performance Composites now produces over 10 million items a year.

Water jet cutting
Previously, TenCate Performance Composites had three sites: Performance Materials Corporation in Camarillo (California, United States), Baycomp Company in Burlington (Ontario, Canada), and PMC Guangzhou (Guangzhou, China). The basic products are lightweight TenCate CRIT™ (continuous fiber reinforced thermoplastic) fabrics, and uni-directional tape. One of the technologies used is water jet cutting whereby a jet of water under extremely high pressure is used to cut shapes from various sheet materials. The water jet is so powerful that it can also cut composites and plastics. The cut is of constant, high quality. No heat is applied to the material, so its characteristics remain unchanged.

Vertically integrated
These are three vertically integrated businesses. Both materials and parts are produced. Camarillo, where the high-volume production takes place, produces laminates and components, while Burlington produced uni-directional (UD) tape before production was transferred to Morgan Hill. In Guangzhou, the employees use these materials to make mainly components and assembled products. These include small parts that are used in the soles of sports and other special shoes of brands such as Nike, Reebok, and Adidas.

Asia is by far the biggest sales market for recreational and sports goods, with the home market of the US a close second. Footwear with these materials is used by participants in professional sports: from long-distance runners and basketball players to mountaineers. The products can be found in hundreds of millions of pairs of shoes and under the feet of over 5 million chiropody patients. They are also used for orthopaedic correction and for skating. They are lightweight and increase the wearing comfort and stability of the shoe.

Lighter and more comfortable
In addition to the recreation and medical sectors, Toray PMC, formerly TenCate Performance Composites, serves the high-performance industrial market. Consumer electronics is a key market segment. In Guangzhou, employees produce tablet bodies to replace the heavier metal back. That is already the case for Acer laptops and these parts are now being manufactured for HP laptops. Portable devices such as tablets, smartphones, and laptops are used increasingly when traveling. A large volume of shoe production is also based in China.

Advanced composites have a good strength-to-thickness ratio and are impact- and scratch-resistant, smooth, and light. Composite material strengthens helmets; it makes them lighter in weight and more comfortable to wear, partly because it replaces foam. Another application is backpacks, for example for military personnel. The use of composites limits the weight of the backpack, actually making it pleasant to carry. Finally, another less well-known use is in car seat backs.

“Positively surprised”
Whatever else may have changed since the business started, production efficiency, accuracy, and quality have remained as high as ever. “Visitors and customers are amazed and positively surprised when they see how streamlined and vertically integrated we are and how efficient our high-volume production is,” says Laurie Calligaris (Director of Sales). “That’s also clear from audits carried out by Nike for example, which has investigated working conditions. We stand out in that regard, just as we do with our production...”
Braces for Ossur

Components for skates and running shoes

Components for skates and running shoes

Components are also incorporated into car seat backs

Recyclability and durability
TenCate Performance Composites can also make the difference in terms of recyclability—“that's increasingly an issue”—and durability. “Our products score highly. The sole of a shoe crumbles in your hand after an average of 40 years. After that time, our sole is still completely intact.”

TenCate Performance Composites is vertically integrated: both materials and parts are produced
Asia is by far the biggest sales market for recreational and sports goods, with the home market of the US a close second
“We stand out with our streamlined, efficient production process and our granulate.”

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Continuous fiber reinforced thermoplastics were first used more than 30 years ago on commercial aircraft structures for fabricating small clips and brackets. Fast forward to today — a revolution in aircraft design is motion. Engineers are now using these innovative thermoplastic materials to fabricate large, complex, flight-critical structures using fully automated processes with no fasteners, enabling manufacturers to meet higher aircraft production rates in less time, and at a lower cost, than ever before possible.

Who knew what started so small would lead to something so big?

Small parts. Big ideas.

Providing our customers with innovative products and industry-leading service, now with the strength of the world leader in carbon fiber technology behind us. TenCate Advanced Composites blossoms in a new era as part of the Toray Family.

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Toray Group