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# ESSENTIAL

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FREUDENBERG SEALING TECHNOLOGIES  
THE MAGAZINE – ISSUE #1 2016



## AROUND THE WORLD

Transcontinental relationships and partnerships –  
from Marco Polo to TTIP.

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### TRANSFORMATION IN QUICK TIME

South Korea's phenomenal transformation from an  
agrarian society to a leading industrial nation.

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### CALIFORNIA DREAMING

A pioneer in environmental protection for 50 years:  
California's journey to the energy transition.

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### NEW FROM THE WIZARD'S CALDRON

Smart materials and "relationship coaching"  
for lubricants and seals.



THE MAGAZINE online:  
<http://essential.fst.com>





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## FROM "AIRMAIL" TO "SNAIL MAIL"

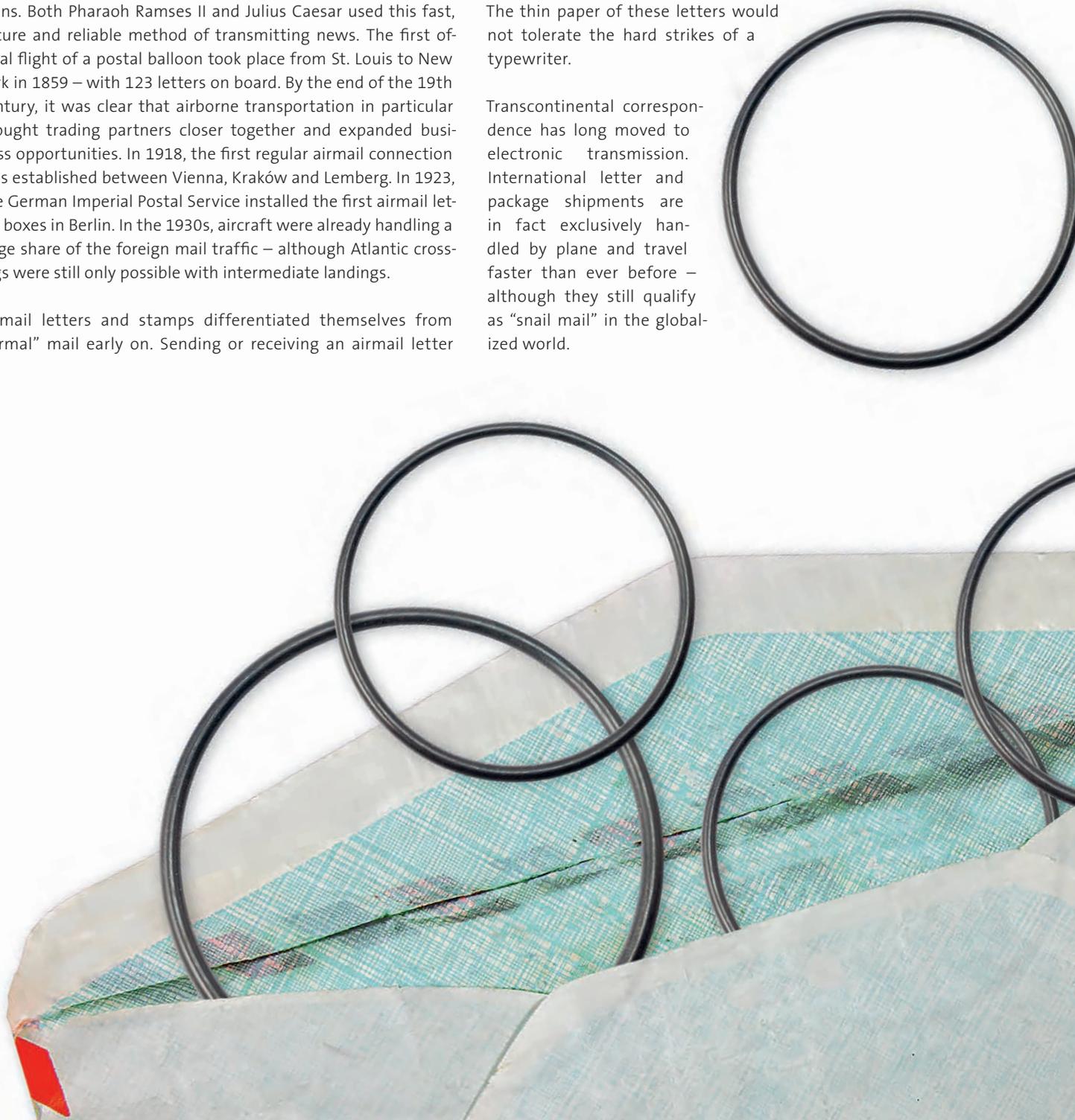
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In the ancient world, carrier pigeons were used to transport written messages, bringing up-to-date information from remote regions. Both Pharaoh Ramses II and Julius Caesar used this fast, secure and reliable method of transmitting news. The first official flight of a postal balloon took place from St. Louis to New York in 1859 – with 123 letters on board. By the end of the 19th century, it was clear that airborne transportation in particular brought trading partners closer together and expanded business opportunities. In 1918, the first regular airmail connection was established between Vienna, Kraków and Lemberg. In 1923, the German Imperial Postal Service installed the first airmail letter boxes in Berlin. In the 1930s, aircraft were already handling a large share of the foreign mail traffic – although Atlantic crossings were still only possible with intermediate landings.

Airmail letters and stamps differentiated themselves from "normal" mail early on. Sending or receiving an airmail letter

was something special well into the 1980s – in part because they were mostly handwritten. The thin paper of these letters would not tolerate the hard strikes of a typewriter.

Transcontinental correspondence has long moved to electronic transmission. International letter and package shipments are in fact exclusively handled by plane and travel faster than ever before – although they still qualify as "snail mail" in the globalized world.





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## TRADE THROUGH RAPPROCHEMENT

From Marco Polo to the TTIP – The basis of mutually beneficial long-term trade relationships has barely altered over the centuries.



## ACROSS ALL BORDERS

Joint projects and decades-long cooperation are a tradition at Freudenberg Sealing Technologies – extending far beyond continental and cultural borders.



## A STORY OF CONTINUOUS IMPROVEMENT

Freudenberg-NOK has been present on the American market since 1989 as a joint venture between Freudenberg Sealing Technologies and NOK. A portrait of a success story.



## UP IN THE SKY

The aerospace industry is booming and is on the brink of a structural transformation – especially in the U.S. A portrait of an industry where taking-off is part of the business.



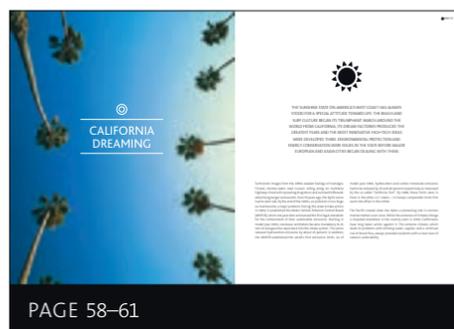
## HIGH-SPEED TRANSFORMATION

From agricultural country to leading industrial nation: The small nation of South Korea is among the leaders in practically every field of technology.



## GEARS AND MUCH MORE

ZF has just turned 100 and, with its acquisition of TRW, has grown considerably. A portrait of a company that has been a partner of Freudenberg Sealing Technologies for more than 80 years.



## CALIFORNIA DREAMING

The sunshine state has become one of the global pioneers in the field of environmental protection – and has been the avant-garde of the U.S. states for 50 years.



## SHORTCUT OF THE CENTURY

The opening of the new Gotthard base tunnel – the world's longest – is imminent. Seals from Freudenberg Sealing Technologies helped make this massive project a reality.



## INNOVATIONS

Seals are increasingly becoming specialists in multi-tasking, and proving themselves as technology enablers for renewable energy. We take a peek into the development labs.

#1

Good connections are important. In fact, in the age of digital communication and applications that access algorithms in the cloud, they are often vital. At home or in your car, wireless networks such as Bluetooth are increasingly replacing cables for the transmission of speech, music or data. Ever fewer phone receivers are hardwired to the network. But if really large data quantities are to be transmitted reliably, there is virtually no alternative to cable.

# DIGITAL LIFELINES

#2

Glass-fiber cables are the lifelines that connect continents today. The TAT-14 (Transatlantic Telecommunications Cable no. 14) connects North America with Europe and is part of an extensive network of undersea cables. The 15,000-kilometer cable consists of four glass-fiber pairs. They are arranged as a closed ring in which the north and south strands are laid several hundred kilometers apart. This means that a break in a cable, perhaps triggered by a tectonic movement, would certainly lead to a reduction in capacity but not to an outage. The performance of the digital "lifelines" is impressive. With a diameter of a mere 15 mm, the maximum transmission rate comes to 160 gigabytes per second.

Cyrus W. Field had the idea for an intercontinental cable on the floor of the Atlantic back in 1854. Fascinated by the invention of the telegraph, the American businessman dedicated everything to this idea. Two attempts failed. Although the cable had been successfully laid by July 1858, the connection broke down shortly before a message from Queen Victoria was supposed to be transmitted. A further attempt was not initiated until seven years later – and, as of 1866, it was finally possible for someone in New York to keep pace with day-to-day events in London.

# CHART of the SUBMARINE ATLANTIC TELEGRAPH

Compiled from the Journal of *CYRUS W. FIELD Esq.*

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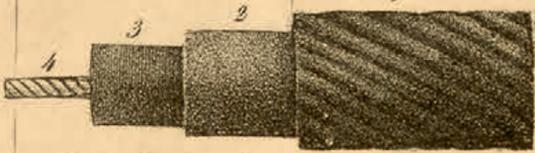
No 22 N<sup>th</sup> 6<sup>th</sup> St. Philadelphia Pa.



CYRUS W. FIELD Esq.



End view of Cable.



Side view of Atlantic Cable, with the covering laid bare, Natural size. 1. Coating of 18 wires 7 strands each 2 Rope & yarn soaked in Tar. 3. Gutta Percha 3 coats. 4. Telegraph wire Tin number.

Dist. from Fayal to Royal 1000 naut. Miles

Dist. from New York to Fayal 1800 naut. Miles

Halifax to Cape Race 463 M.

Boston to C. Race 820 M.

New York to C. Race 1010 M.

Distance to Tel. Station Trinity Bay 882 naut. Miles

Distance to Valencia harbour 813 naut. Miles

Cape Race to Inisbowhall 1770 and to Liverpool 1970 Miles Great Circle

Cape Race to Clear Hill and to Liverpool 2003 Miles Great Circle



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# MASS-PRODUCED GIANTS

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#6

A total of 135 ships can be launched annually from the shipyards of Hyundai Heavy Industries and Hyundai Mipo Dockyard in Ulsan and Gunsan. When it comes to rates of shipbuilding, this is mass production at a high level. The market share of South Korean shipyards still stands at about 30 percent.

#7

The output of South Korean shipyards tripled between the years 2000 and 2011. But the effects of the economic crisis have been noticeable since 2008. In 2014, the average cargo rate of 27,178 dollars a day still came to less than half of the six-year average before the recession. About 170,000 South Koreans continue to be directly employed in shipbuilding – about 0.7 percent of the workforce.

#4

Oceans and mountains alike impede the exchange of goods and services. In Europe, the Alps mark the geographical separation between north and south. But by 1881, the Gotthard Tunnel enabled railroad traffic between Switzerland and Italy. Eleven hundred meters above sea level, the tunnel became one of the most ambitious projects of the 19th century.



## THROUGH THE ALPS WITH SISSI

#5

A new era of transalpine transportation will begin with the opening of the new Gotthard base tunnel on June 1, 2016. Measuring 9.5 meters (31 ft. 2 in.) in diameter, the gigantic tube will greatly relieve traffic on the old railroad track through the Reuss Valley. Since 1999, the four gigantic tunnel boring machines, “Gabi I and II”, “Heidi” and “Sissi”, have been digging through the mountain at an average of 18 meters per day. The drill’s large bearings are equipped with special seals – 4.3 meters in diameter – from Freudenberg Sealing Technologies. And it’s highly possible that they will soon be getting more work. On February 28, 2016, the Swiss voted in a referendum in favor of building a second tunnel for road traffic at the Gotthard Tunnel.

5  
QUESTIONS  
for

MATT PORTU

President of  
Freudenberg-NOK Sealing Technologies



MATTHEW L. PORTU HAS BEEN PRESIDENT OF FREUDENBERG-NOK SEALING TECHNOLOGIES SINCE THE START OF THE YEAR AND IS ALSO RESPONSIBLE FOR GLOBAL PURCHASING FOR FREUDENBERG SEALING TECHNOLOGIES. PORTU, A BUSINESS EXECUTIVE AND ECONOMIST, HAS BEEN AT FREUDENBERG NOK FOR 11 YEARS AND HAS EXTENSIVE EXPERIENCE WITH AUTO SUPPLIERS AS WELL AS RAW MATERIALS AND SPECIALTY CHEMICALS. IN THE INTERVIEW, HE TALKS ABOUT HIS NEW JOB, OUR COMPANY AND ITS PARTNERS, AND FUTURE TRENDS.

**1** WHAT EMPHASES ARE YOU SETTING FOR THE COMING YEAR? This year, the name of the game is maintaining the course. We have many customers who are active worldwide, and that is why we have to think and operate globally, too. For example, we have made good progress over the past three years with the standardization of technologies, processes and procedures. We are a very diversified company globally, and part of our culture is “togetherness”, meaning reliable partnerships with various stakeholders across all business activities and regions.

global trends early. We bring the strengths of different cultures together. In many cases, German engineering is still at the forefront, and many of the best ideas and new developments come from there. Combined with the Japanese approach to continuous quality improvement and lean manufacturing, we have a unique competitive advantage.

**3** FREUDENBERG-NOK SEALING TECHNOLOGIES IS A JOINT VENTURE IN NORTH AND SOUTH AMERICA BETWEEN THE FREUDENBERG GROUP AND NOK. WHAT ADVANTAGES DOES THE JOINT VENTURE OFFER? With partners from various regions, we have an unmatched view of the markets. At the same time, the structure of the joint venture leads us to deal more effectively with problems and difficulties and to invariably develop approaches from a global perspective. Our decisions are better thought-through and less frequently reversed. Our longtime, strong and stable relationship is our foundation. Both partners are happy with the way it is functioning. Freudenberg and NOK enjoy very good mutual trust.

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## “WE CAN KEEP OUR FINGER ON THE PULSE OF GLOBAL MARKETS”

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I would also like to intensify our strong partnership with NOK. Cultural diversification is one of our greatest advantages in the market, and in the future we would like to exploit it to its fullest extent.

Another emphasis is strengthening our brand in the U.S. This is a basic requirement for positive business development and sustained growth. With our commitment to first-class performance – in technology, innovation and the quality of our products, processes and services – we make our customers successful, today and in the future.

**2** WHAT STRATEGIC ADVANTAGES DOES FREUDENBERG HAVE IN THE MARKET? I would especially like to highlight four advantages because they are closely tied to our Guiding Principles: cultural diversity, a long-term orientation, the capacity to innovate and entrepreneurial thinking.

As a German-Japanese joint venture in North and South America and as a global operation with enormous cultural diversity, we can keep our finger on the pulse of global markets and recognize

**4** IN YOUR VIEW, WHAT TRENDS ARE AFFECTING THE BUSINESS IN NORTH AND SOUTH AMERICA? The trends are less regional than global since our customers are also global. We are focusing on meeting the requirements for seals for alternative fuels. Products for different types of powertrain are an important field of expertise for us, whether we are dealing with diesel, electric or hydrogen powertrains. We have to take into account the very demanding environmental conditions where our products are used. For example, we need to have materials available that withstand high temperatures, are friction resistant and offer great media compatibility. This is not really new, but the world is moving faster and development times are becoming shorter.

**5** IN YOUR NEW POSITION, WHAT MESSAGE DO YOU HAVE FOR YOUR CUSTOMERS? One really clear message: We continue to feel obligated to understand your needs and to meet your expectations. We will be a reliable support for your success in the future as well, with innovations and a clear focus on the details. Our new slogan “Innovating Together” doesn’t just refer to the close cooperation of our business groups; it is also a reference to finding the best solution together with our customers. ©



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# TRADE THROUGH RAPPROCHEMENT

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LONG BEFORE GOVERNMENTS, MONARCHS OR RELIGIOUS LEADERS, TRADERS UNDERSTOOD THAT COOPERATION CAN WORK EVEN ACROSS GREAT DISTANCES AND CULTURAL DIVIDES – AND CAN ALSO BE PROFITABLE FOR ALL SIDES. TODAY, COMPANIES THAT COOPERATE SUCCESSFULLY ON AN INTERNATIONAL BASIS ARE PAR FOR THE COURSE. FUNCTIONING COMMUNITIES OF NATIONS THAT COMMIT TO A COMMON GOAL AND ACT ACCORDINGLY ARE OFTEN THE EXCEPTION – AND NOT JUST SINCE THE REFUGEE CRISIS. NONETHELESS, OUR GLOBALIZED WORLD WOULD NOT BE FUNCTIONAL WITHOUT INTERNATIONAL TRADE COOPERATIONS, WITH THE MOST IMPORTANT FACTOR BEING MUTUAL TRUST.

Time-consuming intercontinental business trips are part of the everyday routine for many executives, engineers and other business people. But one business trip lasting 24 years was an unusual occurrence – all the more since practically no contact with the office back home was possible at the time. When the seventeen-year-old Marco Polo left Venice in 1271 with his father and uncle on a journey to China, he didn't yet know that he would not return until 1295. His father Niccolò and uncle Matteo, both jewelry dealers, had already made the trip eastward to Beijing between 1260 and 1269, with a message to the pope from Kublai Khan in their bags on the return trip. In it, the grandson of Genghis Khan asked that the Venetians bring back holy oil from the grave of Jesus in Jerusalem on their second journey to China.<sup>1</sup>

To meet their trade partner's request, the Polos agreed to a detour through Palestine, where the pope was embroiled in the Crusades. Gregory X needed support and commissioned the trade delegation to convert the Great Khan to Christianity to win over Mongolian horsemen as partners in an alliance against Islam. The Flemish monk William of Rubruk had failed at this very task 20 years earlier. As the emissary of the French monarch, he

was in fact well received by Mongke Khan in 1254. But the ruler, who was tolerant of foreign religions and cultures, had no interest in meddling in disputes in the Holy Land.<sup>2</sup>

From the papal capital in Acre, north of Jerusalem, it took the three travelers nearly three years by horse and camel to reach Shangdu, Kublai Khan's summer residence, finally arriving with their valuable gift in 1274. On the way, the youngest Polo was impressed by bazaars, the production of silk, blacksmiths with artistic steel creations, and ports, where spices, precious stones, pearls and ivory were traded. Under the protection of the Great Khan, who then ruled a territory extending from China to today's Iraq and as far as Russia in the north, the Polos took up residence in the country. Kublai Khan was taken with the barely twenty-year-old Marco, quickly appointing him as a prefect and enabling him to take extended trips throughout China. In his writings, Marco Polo reported on the city of Dali, where the inhabitants ate raw pork with garlic and soy sauce, and identified the city of Quinsai (today: Hangzhou), with a population of millions, as his favorite place.<sup>3</sup> The city and its lagoons reminded him of Venice.

<sup>1</sup> Die Erkundung der Welt, D. Lohmann und N. Podbregar, Springer-Verlag 2012.

<sup>2</sup> Der Bericht des Franziskaners Wilhelm von Rubruk über seine Reise in das Innere Asiens in den Jahren 1253/1255, Wilhelm von Rubruk (Hermann Herbst, Hrsg.), Griffel-Verlag, Leipzig 1925.

The return trip began in the port city of Quanzhou; a fleet of 14 junks departed with 600 passengers, of whom only 17 were still alive four years later when the journey ended back in Venice. And wares were lost as well. Officials in the empire of Trebizond alone seized 500 kg of raw silk.<sup>4</sup> Nonetheless, the importance of the journey cannot be overestimated. It opened up a new view of trade far beyond the horizons of the Euro-



#### HANSE-KOGGE

A fleet of trading vessels was the basis for a lively exchange of goods.

pean experience: Traveling traders were still benefiting from Marco Polo's reports centuries later. The trip also showed the importance of the reliable transport of goods. In particular, it became clear that trade never thrives without mutual trust. The Venetians did not arrive as conquerors. They adapted to the manners and customs that they found – and integrated into foreign cultures.

The stronghold of Acre fell in 1291 during Marco Polo's return trip. It had been the last bastion of the crusaders. This ended the Crusades after more than 200 years. Hundreds of thousands of people had been forced to abandon their lives, European cities had been impoverished due to high taxes, and deep divisions between religions emerged that continue to this day. It would be hard to find a more impressive demonstration of the superiority of trade to armed conflict.

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## FIRST TRADE PARTNERSHIP: THE HANSEATIC LEAGUE

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Marco Polo cannot be considered the inventor of international trade, however. The beginnings of the German Hanse, or Hanseatic League, emerged as far back as the 12th century – initially as a consortium of North Sea and Baltic Sea merchants. They wanted the group's protection during dangerous journeys and believed they could better represent their interests at the destinations through an association. The trade primarily involved goods from areas of northern Russia that were rich in raw materials (grain, wood, wax, hides, furs) in exchange for finished products from Western European lands (cloth, wine). By the mid-14th century, the merchants' Hanse had turned into the cities' Hanse. In its heyday, nearly 300 towns along the coast and in the interior of northern Europe were members of the consortium – with branches ranging from London to Novgorod. The League's white and red colors can still be found today in the official crests of many Hanseatic cities.

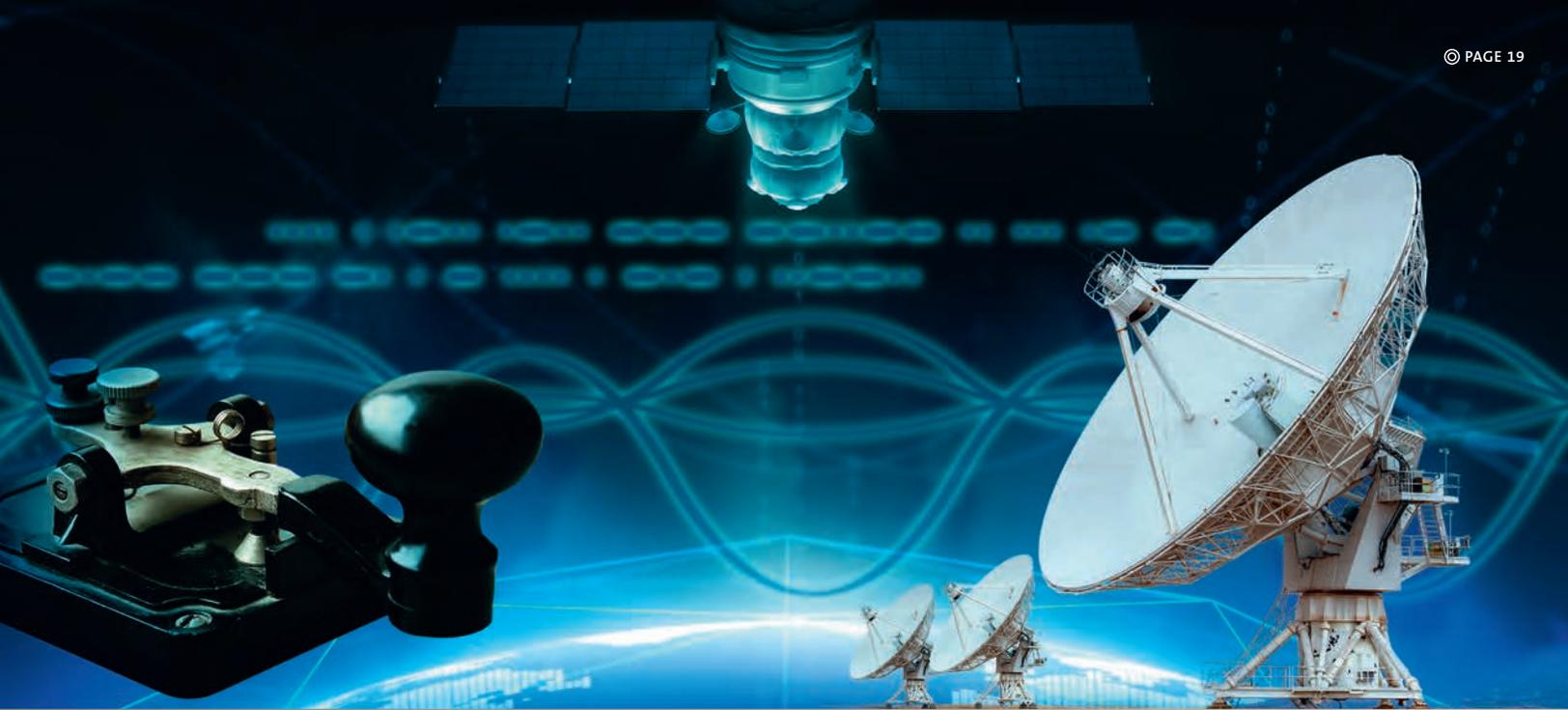
The goals of the Hanseatic League were to develop transportation and promote free trade. Through their membership, many cities developed great wealth, as evidenced by the numerous impressive buildings of the era that can still be seen today. For the first time, prosperous citizens formed a counterweight to the ruling nobility. The League was above all a gateway to the world. Along with money and goods, traveling merchants delivered much useful information to these cities, whose residents knew little of life beyond their own walls. In the commodity markets and the inns, commercial agents shared knowledge and experiences that were gathered on their great trade journeys. Thus, 15th century merchants benefited from the same



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SYMBOL OF PROSPERITY DOWN TO THE PRESENT  
The old warehouse district in Hamburg still hints at the prosperity of the Hanseatic League

<sup>3,4</sup> [https://de.wikipedia.org/wiki/Marco\\_Polo](https://de.wikipedia.org/wiki/Marco_Polo)



intercultural expertise provided by expat programs and internships abroad: If you are actually there, you gain a better understanding of people and can better assess the market.

But as with Marco Polo, the success of the Hanseatic League was not just based on distribution and logistics. It relied above all on a network of finely meshed, robust and trusting relationships. All the more because the trade law of the old world was law without attorneys. Questions regarding disasters or shipwrecks could not be clarified by referring to a trading law book or the Geneva Conventions on the Law of the Sea. Merchants instead turned to the *Lex Mercatoria*, an unwritten common law, which was sustained largely by trust in individual trading partners. If you had a good name, you offered your counterpart fair terms and then relied on good patronage in return – even if the actual heads of the commercial houses had never dealt with each other face-to-face. They worked in different corners of the world. And news was often weeks or months in transit – not to mention the goods themselves.

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### COMMUNICATION EXCHANGE: FROM MONTHS TO REAL-TIME

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The speedy gain the advantage. It is something that American entrepreneur Cyrus W. Field experienced again and again in his business life. Wire-based telegraphy had been around since 1833 and had made a breakthrough with the invention of written telegraphy. A dense network existed between major European and Amer-

ican trade centers, allowing the rapid exchange of information. The first sea cable was laid between Dover and Calais in 1850.

But Cyrus W. Field dreamed of something greater: The 38 year-old wanted to link Europe and America with a telegraph cable – to bring the Old World and the New World closer together and shorten the time needed for the transmission of news from months to weeks. He acquired the “*Great Eastern*”, the largest ship in the world, to accommodate 4,500 km of cable on gigantic drums in its cargo hold. In 1857, the first cable was successfully laid between Valentia, Ireland, and Heart’s Content, Newfoundland. Transmissions failed after just a few days – the cable was defective. In 1858, a second attempt was made – with the same result. Wide-ranging tests suggested that a lower transmission voltage might work better. In 1865, the third expedition was launched, but the cable was lost in the depths of the Atlantic. In 1866, an attempt finally succeeded with low-voltage cable – and the signal remained stable over days and weeks. Suddenly, agreements could be reached between the two continents in double-quick time. In 1871, another cable connection, this time to China and Japan through Hawaii, was laid through the Pacific Ocean – and in 1883, a 2,643-meter mountain in the Canadian Rockies was named Mount Field for the cable pioneer. Field’s contribution to stronger international relations was recognized early on.

Telephony followed telegraphy. Telephone calls could be made between Paris and Berlin as of August 6, 1900. Calls between continents only became possible in 1927 – the conductivity resistance of transatlantic cable was too great and the connection required a long-wave wireless link between Rugby (Warwickshire)

and Houlton (Maine) instead. There were only 2,000 telephone calls per year – no surprise at the cost of nine British pounds for three minutes.

The rapid exchange of information was one thing. But personal contact offered another dimension. Even in the 19th century, long-distance travel was beginning to take just weeks, not years. European companies started business in the U.S., trade delegations traveled on the steamships of the early 20th century so they could handle business matters on-site overseas in a matter of weeks. European companies bought American licenses and exported to the U.S., while American firms such as Ford and General Motors established subsidiaries on European soil.

As important as direct contact and fast information channels may have been, they were still not a sufficient basis for transatlantic trade based on mutual benefit. More than material achievements, the Hanseatic ethos of the “honorable merchant” laid the foundation for industrialization in 19th-century

Germany and still applies to the economy today. Entrepreneurs such as Robert Bosch and Carl Freudenberg were its ideal heirs because they cultivated business integrity and operated their businesses in accordance with Hanseatic principles. Openness to the world, reliability and social responsibility were established as entrepreneurial virtues and are still found in the CSR guidelines of many medium-sized and family-owned companies. Only the vocabulary has changed: “Honorable” has become “sustainable”.

Principled trade has proven to be a haven in unsettled times – at the collapse of the Middle Ages and the dawn of the modern age, just as it did during the 19th century with its expeditions and empire-building. Kings come and go, states rise and fall, but merchant honor remains untouched by it all. And as Europe lay in ruins and ashes after the Second World War, it was precisely this thinking that brought people back together again.



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## COAL AND STEEL COMMUNITY

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During the Western Allies’ “London Conference” in May 1950, French President Robert Schuman submitted a proposal to his colleagues from entrepreneur Jean Monnet, a brandy dealer and heir to an old French merchant dynasty. French and German coal and steel production should be placed under the oversight of a joint authority, which could also involve other

countries. German Chancellor Konrad Adenauer agreed and shortly thereafter the decision was made to form the “European Coal and Steel Community”. The idea was as simple as it was impressive: People who trade with one another do not make war. The coal and steel community was the foundation for the European Union and created the basis for European states to deal with the United States, the great victorious power, on an equal footing.

The European relationship with America is a special one: Common historical democratic traditions, the broad consensus on human-rights issues and comprehensive trade relations make the United States the EU's most important partner. The trade volume of the EU and the U.S. alone came to about 516 billion euros in 2014; together, the two regions generate nearly half of the world's economic output.

With such a tight interweaving of the transatlantic economy, it is no surprise that these players are also trying to close ranks on a formal basis. The Transatlantic Trade and Investment Partnership – in short, TTIP – is a free trade and investment protection agreement that the European Union and United States have been negotiating since 2013. The goal is the reduction of trade barriers that result from different standards and regulations. More jobs and greater prosperity are expected to result for both sides, along with a

greater diversity of products and services with simultaneously falling prices. When TTIP goes into effect, the result will be an economic zone of more than 800 million people.

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## TRADE ON AN EQUAL FOOTING

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The negotiations are accompanied by a lively debate at nearly all levels of society: Standards are discussed, benefits examined and the motives of each side in the negotiations are sounded out. Critics complain about a lack of transparency and the loss of political sovereignty. Advocates stress the expected prosperity and economic advantages. The discussion above all deals with different moral values: social and environmental standards, the exercise of influence by various parties, and generally the question as to whether the two economic systems are still compatible with one another. The advocates are ready to take the leap of faith, while opponents are unable to summon up the trust.



How little things have changed. Trust in a business partner is as valuable, important and essential as it was 800 years ago, in an era when 64 x 10 Gbit/s can be transmitted over cables in dense transatlantic networks and flying times between continents have been cut to a few hours. In times of globalization, when states relinquish more and more room for maneuver to international companies, the issue of a Lex Mercatoria arises just as it did during the times of the Hanseatic League: globalized trade

diplomacy on an equal footing that, in addition to laws and regulations, is also dependent on trust and personal integrity. ©



# ACROSS ALL BOUNDARIES

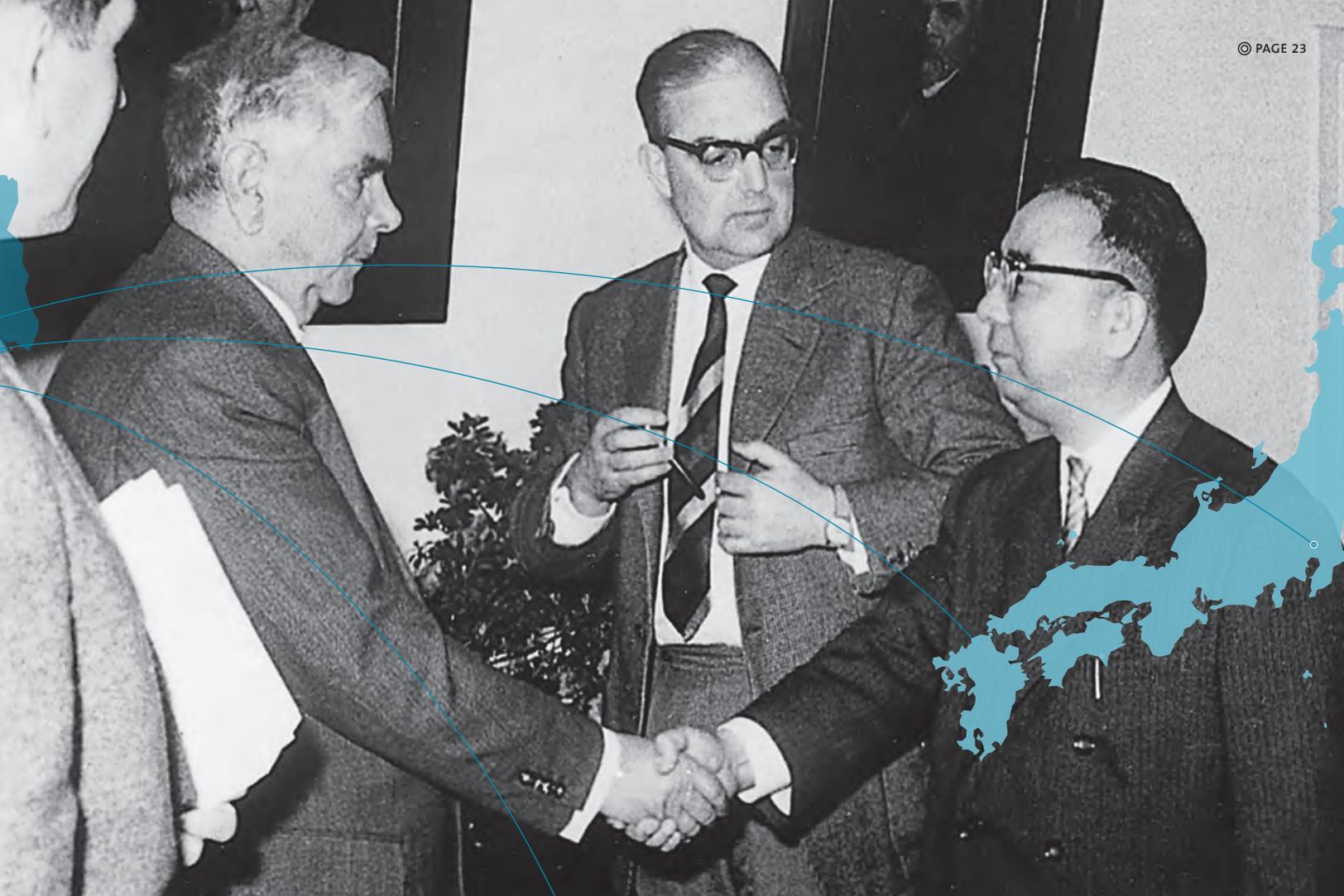
JOINT VENTURES AND CLOSE TRADE RELATIONSHIPS HAVE A LONG TRADITION AT FREUDENBERG SEALING TECHNOLOGIES. THE CARL FREUDENBERG TANNERY WAS ALREADY LOOKING FAR BEYOND NATIONAL BORDERS NEARLY 170 YEARS AGO. WHAT HAS ALWAYS REMAINED IMPORTANT TO THE COMPANY IS TRUST AND THE VALUES OF LONG-TERM COOPERATION – PRINCIPLES THAT STILL APPLY TO THIS DAY.

“If I can make it there I’ll make it anywhere” – whether what Frank Sinatra sang in 1979 also applied to Carl Johann Freudenberg 130 years earlier has not been handed down to us. But in 1849, New York was the destination of choice for many Europeans for whom the old continent with its small states and monarchical capriciousness had become too constricting. This was the year the 30 year-old Weinheim merchant formed the firm **Heintze & Freudenberg** with his significantly older partner Heinrich Christian Heintze – finding the first customers for its fine calf leather in the city on the Hudson that very same year. Its high-quality production in 75 separate steps impressed people everywhere: In 1851, the German company was awarded the bronze medal for fine leather at the “Great Exhibition of the Works of Industry of All Nations” in London.

And the company’s sales reach extended to more than just the other side of the Atlantic. From the Liverpool sales office of Leopold Heintze, son of the co-owner, Freudenberg leather was delivered throughout the British Empire – even as far as the British Crown colony of Hong Kong. Starting in 1923, even the Chinese Empire was buying the coveted product.

This far-sighted approach not only opened up new markets, but expanded opportunities as well. In his own tests between 1900 and 1904, Hermann Ernst Freudenberg, son of Carl Johann Freudenberg, developed a chrome tanning process – a technique already used in the United States – that saved an enormous amount of time and achieved better quality. By World War I, it had given Freudenberg a competitive edge in Europe that drove up sales – with an export share of more than 70 percent.

Foreign markets fell away with the onset of war – and could only be rebuilt with difficulty after 1918. In the 1920s, the company turned to these markets not just to supply customers, but also to establish its own branches. This made it possible to absorb currency fluctuations – which had become a familiar phenomenon after the hyperinflation of 1919-1923. Consequently, Freudenberg acquired the **Western Hide & Skin Corporation** in 1926 as a purchasing company for raw materials. In 1929, an American sales company was added at the other end of the value chain in the shape of **Carl Freudenberg Inc. Boston**.



FROM WEINHEIM INTO THE WORLD.  
The Carl Freudenberg tannery already had an export  
share of about 70 percent back in the 19th century



## WESTERN HIDE & SKIN CORPORATION

## CORTE E COSSO



HEINTZE & FREUDENBERG

CARL FREUDENBERG  
INC. BOSTON

GEORGE ANGUS  
& CO. LTD.

Other cooperative ventures emerged – like the one with the Italian firm Corte e Cosso. The Piedmontese company had been manufacturing parts for cars since the 1920s. Freudenberg – which had been a seal manufacturer as well as a tanner since 1929 – agreed to form a collaborative venture with **Corte e Cosso** in 1936 for the production of Simmerrings. This ultimately led to the incorporation of the company into Freudenberg Sealing Technologies in 2008. For the United Kingdom, the company entered a licensed-production agreement with **George Angus & Co. Ltd** in Newcastle. This British firm became part of the Freudenberg Group in 1989.

after the end of the Second World War, the focus was back on the U.S. In 1950, capital participation by German companies was still prohibited in this country, but Freudenberg used its friendly relationships with its American business partners to form the **Pellon Corporation** in Lowell, Massachusetts, for the production of interlining material. The cooperation with **Greer Hydraulics** began in 1955; Freudenberg later acquired it in its entirety. Starting in 1957, the company produced formed and hydraulic parts made of polyurethane in the U.S., operating under the name **Disogrin**.

As of 1938, nonwovens rounded out the Freudenberg Group’s broad portfolio. By the end of the 1950s, Japanese companies were also taking note of the products from Weinheim. At this



### HEADQUARTERS IN PLYMOUTH, MICHIGAN

The flags of the company’s partners in harmony with the “Star Spangled Banner”: Freudenberg and NOK have been working together as Joint Venture Partners in the U.S. since 1989.

**Carl Freudenberg Inc. Boston** was dissolved in 1935 due to pressure from the National Socialist government. But just a few years



**JOINT PRESENCE**  
Beginnings of the partnership: first brochure with joint product offerings in the U.S. from Freudenberg Sealing Technologies and NOK.

point, Japan was not yet an industrial power. Still, Hans-Erich Freudenberg’s interest was aroused. Over several weeks in 1959, he traveled around the Far East to sound out the market. Kurt Brasch, who sold leather in Japan, was on hand to accompany him. The son of a Japanese mother and a German professor, Brasch grew up in Kyoto and knew the country and its customs. He arranged a meeting with Shogo Tsuru, whose father had founded **Nippon Oil Seals Corporation (NOK)** and was the company’s president. Above all, it was the chemistry between Richard Freudenberg – spokesman for the company management – and Tsuru that made the difference. In 1960, the two firms signed a far-reaching cooperation agreement, to

PELLON  
CORPORATIONGREER  
HYDRAULICSFREUDENBERG-NOK  
GENERAL PARTNERSHIPNIPPON OIL SEALS  
CORPORATION (NOK)

SIGMA FREUDENBERG NOK

NOK FREUDENBERG  
GROUP CHINA

which the NOK president added a wish in Japanese characters: **“May this agreement endure forever”**.

The collaboration proved crucially important to the U.S. business in particular. Freudenberg and NOK have been strengthening their cooperation in the U.S. since the 1960s. Twenty years later, it resulted in the idea of a joint company in the Americas. On July 1, 1989, the **Freudenberg NOK General Partnership (FNGP)** was formed with its headquarters in Plymouth, Michigan, into which all the American enterprises of the two partners in the fields of sealing and vibration control technologies were consolidated.

In 1968, the two companies decided to work closely together on all their activities in China – quite an audacious prospect at the time. In 1980, they affirmed their intention to tackle joint-venture projects in China together. By 1983, NOK had finally managed to secure its first contacts with Chinese firms. But it was only in 1993 that the decision was made to form the **Changchun NOK-Freudenberg Oil Seal Co., Ltd.**, followed by **Wuxi NOK-Freudenberg Oil Seal Co. Ltd.** in September

1996. Today the **NOK-Freudenberg Group China (NFGC)** has three production facilities with a total of 3,000 employees, manufacturing primarily for the Chinese market.

The more than 50 years of close cooperation between Freudenberg and NOK – also in the form of joint companies – is an expression of an attitude that company founder Carl Johann Freudenberg once described thus: **“Even at the risk of being taken in, it is better to trust 100 times than to distrust unjustly just once.”**

Long-term cooperation is thus part of the company’s DNA – and currently the tool of choice for developing new markets and ensuring company success. Together with NOK, Freudenberg initiated a joint venture in India in 2000, teaming up with family-owned company **Sigma**. The first plant emerged in 2003, and the venture now has two facilities. It was not new territory for Freudenberg, which was already supplying leather to India back in 1867, and purchasing raw materials from there since the 1920s. ©





# A STORY OF CONTINUOUS IMPROVEMENT

FREUDENBERG AND NOK HAVE A LONG HISTORY TOGETHER, WHICH DATES AS FAR BACK AS THE 1960s. IT WAS THEN THAT FREUDENBERG FIRST JOINED FORCES WITH NOK TO MANUFACTURE SEALS IN THE U.S. THIS LED TO THE ESTABLISHMENT IN 1989 OF THE FREUDENBERG NOK GENERAL PARTNERSHIP (FNGP) IN THE U.S. SINCE THEN, FREUDENBERG-NOK HAS CONTINUED TO STRENGTHEN ITS PARTNERSHIP AND EXPAND ITS PRESENCE IN THE U.S. THANKS TO AN EYE FOR QUALITY AND CONTINUOUS IMPROVEMENT OF ITS PROCESSES, FREUDENBERG-NOK SEALING TECHNOLOGIES HAS POSITIONED ITSELF AS THE SEALING LEADER IN THE AMERICAS.



In the sealing industry, Freudenberg Sealing Technologies is a well-known name all around the world. The same holds true in the Americas, where a longstanding and productive partnership with the Japanese company NOK Corp. (Japan's first oil-seal manufacturer) has changed the name slightly to Freudenberg-NOK Sealing Technologies.

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### A THRIVING PARTNERSHIP

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Thanks to this mutually beneficial partnership, Freudenberg and NOK have flourished together over the years and are now, as one unit, the leader in the Americas when it comes to elastomeric seals and precision molded products. This success did not come overnight – it started in the 1960s, when Freudenberg and NOK decided to become allies in the important U.S. market. In 1989, the Freudenberg-NOK General Partnership (FNGP) was established in the U.S. (with headquarters

in Plymouth, Michigan) and from there has continued to grow into the entity it is today.

Freudenberg-NOK Sealing Technologies now supports most of the leading industries in the world. Automotive and commercial truck and bus sealing products comprise about 60 percent of its business, with about half of it falling into the “classical” powertrain segment (engine, transmission and driveline applications) for companies such as GM, Ford, Chrysler, Toyota, Honda and Nissan along with many of their suppliers. The other 40 percent of the U.S. business falls into the general industry category; more specifically seals for the aerospace, fluid power, agricultural, energy, steelmaking, food and beverage, construction, recreational and chemical industries, to name a few. Specializing in oil seals, O-rings, gaskets, boots, integrated molded components, thermoplastic seals and more, Freudenberg-NOK Sealing Technologies produces seals for myriad uses – a very broad product portfolio.

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## FREUDENBERG-NOK SEALING TECHNOLOGIES IN THE USA

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### LEAD CENTER

- Cleveland, Georgia
- Necedah, Wisconsin
- Findlay, Ohio
- Bristol, New Hampshire
- Manchester, New Hampshire
- Bamberg, South Carolina
- Tillsonburg, Ontario (Canada)

### COMPETENCY CENTERS

- Morristown, Indiana
- Shelbyville, Indiana
- LaGrange, Georgia
- Santa Ana, California
- Troy, Ohio
- Milan, Ohio
- Northfield, New Hampshire
- Ashland, New Hampshire
- Diadema, Brazil
- Querétaro, Mexico
- Cuautla, Mexico



A strong network of Competency and Lead Centers is behind this extensive product base. With six Lead Centers (facilities which direct operations for a specific industry) in the U.S. and one in Canada, Freudenberg-NOK can tap a wide employee base for expertise in specialized areas – like hydraulic accumulators, for example. In this case, Freudenberg Sealing Technologies recently acquired Tobul Accumulator in Bamberg, South Carolina and it is now the Lead Center for this particular industry. Competency Centers support the Lead Centers in the Americas as well as throughout the world, and there are eight located in the U.S. All told, Freudenberg-NOK employs about 5,000 people across North and South America at 20 different facilities.

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## A GLOBAL TALENT POOL

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This diversity in both resources and personnel has been one of Freudenberg-NOK's greatest advantages. Not only does the joint venture benefit from varied resources and a talent pool that hails from around the world; it can also utilize the best qualities of its German parent and Japanese partner. According to Matt Portu, President of Freudenberg-NOK Sealing Technologies since January 1st of this year, the cultural diversity stemming from the partnership is one of Freudenberg-NOK's greatest strengths. "When we combine the precise, progressive engineering that comes out of Germany with the relentless desire for perfect quality that our Japanese colleagues bring to the table, it becomes a pretty powerful tool for us," said Portu. "It also allows us to see global trends very quickly – our Japanese partners see things that are happening

in Asia; our German counterparts are aware of trends in Europe and we can share those very quickly. It's rare that we find ourselves surprised by what's happening. I believe it's an enormous advantage to us."

One major trend that Freudenberg-NOK Sealing Technologies has identified and focused on is the shift in the automotive industry towards producing more environmentally friendly products. Reducing emissions, increasing fuel economy, and developing and supporting technologies like hybrids, battery vehicles and fuel cells have been topics of increasing importance over the last few years, with the key driver in the U.S. being the CAFE (corporate average fuel economy) legislation. A fuel consumption goal of 54.5 miles per gallon by 2025 in the U.S. is similar to that of Europe's, but the overseas target is even tougher and will be implemented earlier. Therefore the motto "LESS is more" has been adapted. LESS stands for "Low Emission Sealing Solutions" and it demonstrates the sealing specialist's expertise and commitment to the environmentally sustainable mobility of tomorrow. In adhering to this motto, Freudenberg-NOK Sealing Technologies will assist the auto industry in achieving its development goals and secure future sales markets.

A recent example of the LESS motto in practice is the rollout of the new Levitex crankshaft seal. Developed in Europe, this near-frictionless automotive seal keeps oil from seeping out of an engine block from where the crankshaft emerges. Crankshaft seals have been around for decades, but the revolutionary design of Levitex utilizes an air cushion to separate the seal's sliding surfaces during operation instead of the traditional elastomeric lip seal. Less con-



tact means less friction, which translates to less wear, lower CO<sub>2</sub> emissions and reduced fuel consumption – thereby helping auto-makers meet increasingly stringent fuel economy targets.

So how will Freudenberg-NOK Sealing Technologies make use of this technology? It will gradually make its way to the U.S., where it will be adapted to other uses within the automotive sector and then to a broader range of industries, all while further refining quality. According to Portu, one of the company's goals is to leverage resources across as many different business segments as possible. A product that works well in the automotive sector may be applied to general industry or vice versa. And along those lines, the company has sought to expand its business beyond its primary focus of core powertrain products. These segments include steering, suspension, fuel systems, safety systems, climate and e-mobility.

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## INVESTING IN THE FUTURE

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Demonstrating this commitment, over the last year, Freudenberg-NOK Sealing Technologies has invested over 30 million dollars in two of its U.S. plants: one in Findlay, Ohio and the other in Morristown, Indiana. The Findlay facilities include a PTFE (polytetrafluoroethylene) manufacturing plant as well as Freudenberg-NOK's newest test laboratory in the U.S. With this investment, the company aims to bolster its already strong advantage when it comes to developing new and improved seals from an ever-increasing array of composites and polymers.

Strong material competency and a broad product portfolio along with the aforementioned cultural qualities give Freudenberg-NOK Sealing Technologies the benefit of a strong market position. But like any other successful company, it is under constant pressure to stay ahead of its competitors. This requires continuous improvement in all areas of operations – increasing product quality and investment in research and development are always top goals, but improvements developed through kaizen (Japanese model of continuous improvement) activities or other measures to improve efficiency come in close second.

“Everything can always be improved upon,” said Portu. “When I think about the way we operate, we as a company are known as experts in lean, Six Sigma and kaizen activities. This constant improvement, this constant ability to get a little bit better, every day, it's really part of our DNA to try and do that.”

The company is also streamlining and standardizing the way it approaches both its customers and suppliers in terms of computing interfaces. This involves the implementation of an entirely new enterprise resource planning (ERP) system throughout the Americas, which is being developed by the German software giant SAP.

Despite the advantages Freudenberg-NOK Sealing Technologies seems to be enjoying at the moment, Portu is careful not to underestimate the competition: “At the end of the day, I think it's dangerous to think that we are significantly different from our competitors,” he elaborates. “They are not standing still. We know who they are and these are smart people working day and night. We need to use our powerful resources to stay a step ahead.” ©



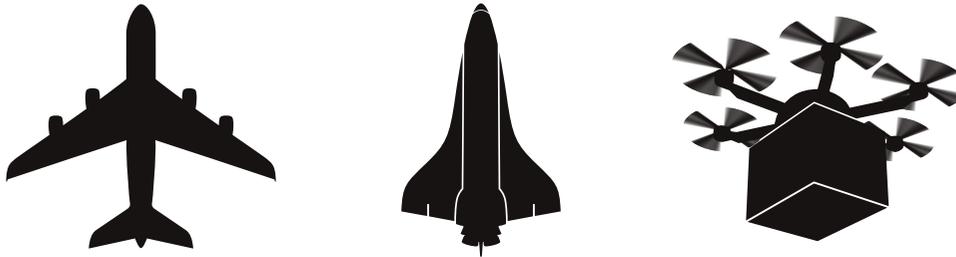
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# UP IN THE SKY

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THE U.S. AEROSPACE INDUSTRY IS ALIVE AND WELL



THE U.S. AEROSPACE INDUSTRY HAS UNDERGONE NOTHING SHORT OF MASSIVE CHANGES OVER THE LAST FEW YEARS, YET IT IS AS STRONG AS EVER AND GROWING THANKS TO A HIGH DEMAND FOR COMMERCIAL AIRCRAFT. WHILE THIS TREND IS NOT ESPECIALLY SURPRISING, THE SHIFT OF SPACE EXPLORATION FROM GOVERNMENT-LED INITIATIVES TO PRIVATE ENTERPRISE IS QUITE REMARKABLE AND FEW COULD HAVE PREDICTED THIS CHANGE MORE THAN 10 YEARS AGO. THEN THERE'S THE PROLIFERATION OF UNMANNED AIRCRAFT – THE LEAST REGULATED OF ALL SEGMENTS, BUT QUITE POSSIBLY THE ONE POISED TO GROW MOST.

With oil prices lower than they have been in over a decade, there has been a great deal of speculation about how this steep drop could negatively affect the U.S. economy. But while economic growth as a whole slowed in the last quarter of 2015, the U.S. aerospace industry stands mostly to benefit from this trend. According to the International Trade Administration, part of the U.S. Department of Commerce, there has been a steady increase in the value of total U.S. aerospace exports every year since 2010. What's more – 2015 was the best year ever, with 144 billion dollars worth of aerospace products exported to other countries. So it stands to reason that cheaper fuel will result in more

people traveling by air and subsequently increase demand for new airplanes.

And that's exactly what seems to be happening – while the latest figures for air travel have not yet been released, the U.S. Department of Transportation reports that through the third quarter of 2015, fares had fallen steadily for a year up to that point. And that translates directly into more trips being taken. This is not just a U.S. trend; it's global. Since the U.S. aerospace companies sell their products to almost every country in the world, this increase will mean increased exports and a stronger industry.



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## A SURGE IN DEMAND

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China is perhaps the biggest driver of this growth. Since 2012, the most populous nation in the world has been the biggest purchaser of U.S. aerospace products. A continuously growing economy with many Chinese citizens gaining increased spending power has resulted in a surge of air travel – and high demand for planes. With the U.S. being home to one of the largest jet manufacturers in the world (Illinois-based Boeing, which merged with McDonnell Douglas in 1997), this demand stands to benefit the already-strong domestic industry. Boeing currently supplies about 48% of the world's commercial airplanes, while the European Airbus Group has just a slightly smaller share. Canada's Bombardier, Brazil's Embraer, Japan's Mitsubishi Heavy Industries and China's Comac compete for the remaining 13% of the market.

This continuous increase in demand over the last several years has led to the development and deployment of several new commercial aircraft. Since its launch only five years ago, Boeing has sold over 1,000 units of its 787 Dreamliner. Concurrently, it developed the new 737 MAX, which will be available for delivery in 2017. This is not to say that U.S. manufacturers will face less competition in the coming years – the A320neo by Airbus (neo standing for new engine option, which delivers a fuel saving of 15% compared to the previous A320) has become the fastest-selling commercial aircraft to-date. As of January 2016, a total of 4,508 units have been ordered by over 70 airlines, and it only entered service on January 25th of this year. China's Comac is also stepping up its game, launching the new C919 in the narrow-body (or single-aisle) category.



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## AN EMERGING SEGMENT

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Another aerospace segment that is experiencing high growth is that of unmanned aircraft. While the proliferation and use of drones in the military has been widely publicized (and also debated) in the media, civilian applications are quietly being developed. The U.S. Federal Aviation Administration recently enacted regulations requiring the registration of all drones weighing more than .55 pounds and less than 55 pounds; this will apply to mostly hobbyists. For commercial use, the FAA is still working out regulations which should be in place by the summer of 2016. Companies in industries such as energy, agriculture, mining, construction, news media, film production and more are waiting for these regulations to be enacted. Their hope is that they will be able to use drones in operations previously completed by manned aircraft, namely helicopters. Corporations such as Amazon and Google or the delivery giant UPS are all looking into ways that drones could

streamline their businesses – as in delivering packages via drones. This application alone could be a major boon to aerospace.

In fact, one of the only segments of the U.S. aerospace industry that has not seen an uptick in production as of late is that of helicopters. Due to the sharp decrease in the price of crude oil (and quite possibly the expected proliferation of drones) the demand for helicopters has fallen drastically. This can be attributed mostly to a sharp decrease in the expenditures put into oil exploration. With a healthy surplus of oil and low demand there has been little incentive for oil companies to look for new sources, and helicopters have been their traditional means of doing so.

Undiscovered oil fields still abound but they lie in remote areas – areas which can now more easily be explored by drones.



### Which way is up?

With a surge of remote-controlled hobby aircraft being bought and operated by the general public, the FAA must develop guidelines to regulate this ever-growing segment.

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## THE LANDSCAPE IS CHANGING

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The one other sector of the U.S. aerospace industry that has seen a slight decline is military aviation. Funding across the globe has plateaued and has even been declining as reduction in military activity in areas like Afghanistan and Iraq have decreased demand for military aircraft. But that's not to say that U.S. companies – like Lockheed Martin and Northrop Grumman, two of the largest global air defense suppliers – are losing out. Countries such as India, Russia, South Korea, Japan and again China are spending more than ever before on defense aircraft and this segment still remains strong. But the U.S. still has the world's biggest military budget and thus the two biggest consumers of aerospace technology and products are the Department of Defense and... NASA.

Yes, NASA – the National Aeronautics and Space Administration. This distinctly civilian government agency is very much alive and well despite the clear shift of all space exploration activities from the public to the private sector. In fact, what was once the only name in space exploration currently has no launch capability. All lie in the hands of companies such as Orbital Sciences Corporation, SpaceX – led by Elon Musk, also the CEO of the electric car manufacturer Tesla – and Blue Origin, run by Amazon CEO Jeff Bezos. Then there are operations such as Virgin Galactic, helmed by none other than Sir Richard Branson (entrepreneur behind successful multi-million-dollar companies like Virgin Records and Virgin Airlines), who plans to offer suborbital space flights for a quarter of a million U.S. dollars sometime in the next few years.

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## TO THE MOON AND BACK

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So how does NASA fit in? To the casual observer it may seem as though its role is diminishing. Just last year the agency announced plans to stop supporting the International Space Station (which it operated jointly with Russia) by 2020. But in reality, NASA is very much alive and well and is in the midst of planning several large-scale projects in addition to heavy support of private space launches. Future plans include developing an asteroid defense system via the new Planetary Defense Coordination Office (PDCO), the launch of the Wide Field Infrared Survey Telescope (WFIRST) space telescope in the mid-2020s, the manned capture and exploration of an asteroid and, of course, sending astronauts to the planet Mars in the 2030s. To fund all this, the operating budget for the agency is expected to increase

over the next few years to a projected 19.66 billion dollars in 2020 (up from 18 billion dollars last year).

While the facets of the U.S. aerospace industry are quite varied and complex – evaluated either separately or as a whole – a rather good outlook is evident. Demand and production in most sub-sectors is higher than ever and, both in the U.S. and globally, this bodes well for the countless companies and entities that support the industry. Not only is this success a boon for the economy but it will also drive technological advancement, which in turn will allow for some very interesting developments to come about in the next decade and beyond. In this case, the saying “the sky is the limit” no longer applies...



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[www.fst.com/markets/mobility/aerospace](http://www.fst.com/markets/mobility/aerospace)



## SUPPLYING AN INDUSTRY: THE ROLE OF FREUDENBERG SEALING TECHNOLOGIES IN AEROSPACE

The growth experienced by the U.S. and European aerospace industries over the last five years has kept the companies that supply aircraft and spacecraft parts quite busy. With the rollout of several new planes over this time period, Freudenberg Sealing Technologies has worked closely with many component and assembly suppliers to provide seals for Boeing (737 MAX and 787 Dreamliner), Airbus (the A320neo, A350 XWB and A380), Bombardier with its new C-Series, and Comac's future C919. Fire-resistant/fireproof seals (providing up to 15 minutes of sealing at temperatures over 1000 degrees Celsius,) O-rings, plate seals, diaphragms and self-fusing silicone tape are a number of Freudenberg's products that can be found on these new planes. And although Freudenberg manufactures many different types of seals found throughout the commercial aerospace industry (as one of Freudenberg's guiding principles, it does not supply to military or defense operations) its expertise is not limited to Earth: Freudenberg Sealing Technologies also works with many of the

new private space transport services companies that are ushering in the next chapter of space flight.

With a lead center in Tillsonburg, Ontario and competency centers in Santa Ana, California, Ashland, New Hampshire and Morristown, Indiana, Freudenberg Sealing Technologies has a strong network from which the aerospace industry can benefit. Sean Morgan, Global Segment Director of Aerospace at Freudenberg Sealing Technologies, attributes his employer's success not only to this network, but also to an extensive history of materials and design expertise as well. "With the continual push for increased efficiency and safety in the industry, Freudenberg excels by using its materials and design expertise to partner with our customers on innovations that allow aircraft to fly hotter, higher, longer and more safely – that's what it's all about," said Morgan. "Innovating together – this is what makes our customers, and therefore Freudenberg Sealing Technologies, successful." ©



### REVENUE LEADING AIRCRAFT MANUFACTURERS 2014:

<b>Boeing</b>	\$90.762 billion
<b>Airbus</b>	\$74.264 billion
<b>Lockheed Martin</b>	\$45.600 billion

### GLOBAL AEROSPACE MARKET REVENUE:

2015 \$262 billion    2023 \$352.5 billion (expected)

### AIRCRAFT DELIVERED BY BOEING IN 2015:

Boeing 737	495
Boeing 787	135
Boeing 777	98
Boeing 747	18
Boeing 767	16
<b>Total</b>	<b>762</b>

### OLDEST CONTINUOUSLY OPERATING WORLD AIRLINES:

<b>October 7, 1919</b>	KLM, Netherlands
<b>November 16, 1920</b>	Qantas, Australia
<b>February 9, 1923</b>	Aeroflot, Russia
<b>October 6, 1923</b>	CSA Czech Airlines, Czech Republic
<b>November 1, 1923</b>	Finnair, Finland
<b>May 30, 1924</b>	Delta Airlines, United States

### TOP DOMESTIC ROUTES IN THE U.S., DEC 2014 – NOV 2015: (MILLION PASSENGERS)

1. Chicago – New York	4.16 million
2. Los Angeles – San Francisco	3.69 million
3. Los Angeles – New York	3.41 million
4. Chicago – Los Angeles	3.13 million
5. Miami – New York	2.87 million

### PASSENGERS IN THE U.S. IN 2015 – ALL CARRIERS AND ALL AIRPORTS:

**DOMESTIC** 638,312,519                      **INTERNATIONAL** 181,479,056                      **TOTAL** 819,791,575



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# HIGH-SPEED TRANSFORMATION

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IN OCTOBER 2015, THE WORLD BANK HONORED SOUTH KOREA AS THE FOURTH-BEST LOCATION FOR BUSINESS ACTIVITIES WORLDWIDE – AFTER SINGAPORE, NEW ZEALAND AND DENMARK. FOR NOW, THIS ASSESSMENT MARKS THE HIGH POINT OF THE GROWTH THAT HAS LED THE COUNTRY FROM BEING ONE OF THE POOREST IN THE WORLD TO THE FOREFRONT OF INDUSTRIAL NATIONS WITHIN 60 YEARS. ESSENTIAL LOOKS AT A COUNTRY THAT SELDOM GETS THE ATTENTION ATTRACTED BY CHINA OR JAPAN – BUT OFFERS MANY OPPORTUNITIES FOLLOWING A UNIQUE TRANSFORMATION.

1957 was the low point: The Korean War, which was fought between 1950 and 1953, led to the division of the peninsula. Its domestic industry was decimated, and the country's traditionally agricultural south was plunged into poverty. Its democratically elected government under Rhee Syngman had neither its industrialization nor its agriculture under control. South Korea became dependent on food shipments from its former wartime ally, the U.S., and was economically in the same straits as newly independent Ghana.

In 1961, the military under Park Chung-hee took power in a coup d'état. Although accompanied by severe human rights violations, the economy achieved a rapid rise starting in the mid-60s. The recipe for success was the renunciation of aid deliveries from rich industrial countries in favor of loans, which allowed the country to finance an export-oriented economy based on low-wage products. Although the nation increasingly invested in research and education, the World Bank and the International Monetary Fund recommended that South Korea focus instead on rice cultivation during its first recession at

the start of the 1970s – the rationale was that the country had expertise in this area that could not easily be matched. South Korea ignored the advice, betting again on industrial growth, and overcame the crisis.

1990 saw a change in the constitution, introducing a parliamentary democracy. Due to its newly formed unions and social improvements, South Korea initially lost its edge as an investment location – foreign companies migrated to neighboring states with purportedly more favorable business conditions. But social and individual freedoms made it possible for the country to reach the next level: Instead of low wages, South Korea banked on modern industry that was independent of foreign investment. The establishment of universities, the opening of international trade and political stability intensified growth. The result was that, in 1996, South Korea became the 29th member of the Organization for Economic Cooperation and Development (OECD) and overcame the Asian economic crisis in 1997. Today South Korea is ranked 13th for gross domestic product.



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## FREE TRADE SOUTH KOREA

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“Taegeukgi” is the name of the South Korean flag. The term is derived from Taegeuk which is the Korean name for the Taiji principle, a school of philosophy from the Chinese culture.

The flag was introduced in 1950. Its white background color symbolizes purity and peacefulness. The red-blue “Eum and Yang” symbol is closely related to the Chinese symbol for Yin and Yang. It embodies the opposites contained within the universe such as fire and water, day and night, dark and light, the masculine and the feminine as well as heat and cold.

The symbol is framed by four black signs from the I-Ging scriptures (Book of Changes). Their meanings are (clockwise from top left): heaven, water, earth and fire.

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## KOREAN INDUSTRY: FROM ENORMOUS TO TINY

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The Chaebols – conglomerates serving a vast multitude of segments – have long been characteristic of South Korea. The Lotte Group, with 56,000 employees, is typical. It operates amusement parks, but is also active in the chemical industry and agriculture, along with the confectionery industry. Incidentally, the name “Lotte” is derived from the enthusiasm of founder Shin Kyuk-ho for Johann Wolfgang von Goethe and his novel “The Sorrows of Young Werther”.

Korea plays in the major leagues in many important industrial fields. Only China currently launches more ships than the Korean shipbuilding industry, which continues to be extremely important to the country: The sector’s share of overall exports comes to about 10 percent. Steel is needed wherever ships are built, and two Korean steel producers, POSCO and Hyundai Steel, rank among the top fifteen. South Korea occupies fifth place worldwide behind China, Japan, the U.S. and India.

Korea can handle the very small as well as the very large. The country is in first place worldwide in display production. The same is true in semiconductor manufacturing, where it has a global market share of 11 percent. Entertainment electronics are one of the peninsula’s absolute export hits. Their flat-screen TVs, satellite and cable receivers, LED lighting, smartphones and navigation devices have become much more popular than their counterparts from Japan.

Korea is especially strong in batteries for hybrid and electric vehicles. The largest Korean supplier in the field, LG Chem, ranks fourth in the global battery sector and supplies VW, Audi, Ford and General Motors. Samsung SDI is also active in the battery market. For years, the company has supplied batteries for the BMW i3 and i8. As of this year, the 3 Series plug-in hybrid will get Samsung SDI batteries. Analysts assume that Korean firms will be providing up to 40 percent of the global volume of lithium-ion batteries in 2018.






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## STRONG BRANDS

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Korea's era as an "extended workbench" is long past. Korean brands are popular throughout the world. For example, Samsung, which was founded in 1969, is proud to be able to call 13 of its products world market leaders in their segments. In the "Best Global Brands 2014" ranking, Samsung rose to seventh place – ahead of McDonald's, BMW or Mercedes. The market share of Samsung and Hynix, the two leading Korean companies for flash memory devices and DRAM (dynamic random access memory), is more than 50 percent.

Education and science are the foundation of the country's technological competence. Relative to its economic performance, no other country spends more money on research, and it is mostly large companies that make the investments. According to the OECD, research accounts for 4.4 percent of gross domestic product (GDP), while the G20 nations invest an average of 1.6 percent. Each year, more than 100,000 university students complete their studies in various scientific disciplines, and Korea ranks fourth worldwide for patent applications.




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## HIGH AFFINITY FOR IT

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A leading technology nation needs an outstanding domestic IT infrastructure. A full 98.5 percent of all Korean households have an Internet connection – in the International Telecommunications Union (ITU) ranking, South Korea is in second place, trailing only Denmark. The Koreans don't have long load times either: With an average of 50 megabits (Mb) per second, they enjoy the fastest Internet in the world; in the U.S., the figure is just 10 Mb per second. Korea is far ahead in mobile Internet technology, too. The introduction of a 5G network is in full swing. After all, 80 percent of all Koreans own a smartphone. In the U.S., the share is just 40 percent. Koreans between the ages of 20 and 29 use their smartphone an average of 281 minutes a day – that's more than 4.5 hours!

So it's no surprise that South Korea is considered the third largest market for apps. This has made successes such as Kakao Talk possible: The free Instant Messenger app was programmed in 2010 and now has 140 million users and is installed on 93 percent of all Korean smartphones.

Koreans' strong affinity for the use of IT has important consequences for purchasing behavior. Since 2014, revenues in online commerce have exceeded those in traditional retail. The purchases don't merely take place from home PCs, with more than 60 percent of all Koreans regularly shopping via smartphone.

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## COMMERCIAL FREEDOM WITH LITTLE BUREAUCRACY

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More and more Koreans are taking advantage of the opportunity to buy goods from abroad online. The country's many free trade agreements, or FTAs, have favored this, lifting trade barriers over the past ten years. In May 2015, this Asian industrialized nation completed its 15th agreement – this time with Vietnam. South Korea is one of the few countries to have assembled the three large trade blocs – the EU, the U.S. and China – in its “FTA portfolio”.

This commercial freedom is also creating a favorable investment climate. In 2015, the World Bank came to the conclusion that, out of the 189 countries examined, South Korea was the fourth-best suited for investments and commercial operations, trailing only Singapore, New Zealand and Denmark. The country's lean bureaucracy was an advantage: On average, a company can be formed within nine days – instead of the 22-day average in the G20.

With Korean payments of 6.5 billion dollars in 2012, the United States was the most important source of foreign technologies – followed by Japan (1.1 billion dollars) and Germany (456 million dollars). South Korea primarily bought German technology in a number of sectors: the vehicle industry, electronics and telecommunications, the chemical industry, and machine tools. For example, Korean companies manufacture ship engines under license from MAN Diesel & Turbo, and LG Chem produces LCD glass with technologies from Schott. German-Korean joint ventures in the vehicle industry and other sectors bring German technology to South Korea – companies such as BASF, Bayer, Merck and Henkel operate development laboratories, and research entities such as the Max Planck Institute, the Fraunhofer Society and the Helmholtz Association are active here as well.

The seniority principle, which is widespread in Asia, creates opportunities for young Koreans. That's because subsidiaries of international companies pay for performance and offer significantly better terms for their first years of employment. Joining these companies is appealing, since higher pay levels do not need to be earned mainly through decades of loyalty, as is the case with the Chaebols.

Foreigners can even launch startups in South Korea – with the help of a “startup visa”. State-supported technology hubs like Seoul's G-Valley provide an excellent infrastructure, but South Korea has to catch up when it comes to foreign language competency. The country ranks just 24th on the English Proficiency Index. So it's no wonder that “Flitto”, a crowd-sourcing translation app, is one of the country's most popular applications.

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## INTO THE FUTURE: CREATIVE, SAFE AND CLEAN

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As much as Korean consumers may celebrate their strong won – it rose nearly 40 percent against the yen between 2012 and 2014 – it has weighed down exports. President Park Geun-hye, in office since February 2013, has called for a “creative economy” to unleash new economic forces. Since the start of 2015, twelve “Centers for Creative Economy and Innovation” have been formed to support startups in a variety of fields, such as content creation, the Internet of Things and film productions, with 3.7 billion dollars in funding. The president sees the cultural sector as the “essence of future growth”: Music, fashion and online games are supposed to contribute increasingly to the country's economic performance. The global public was given a surprising glimpse into South Korea's cultural scene in 2012. Rapper PSY, a representative of K-Pop, rocked the charts with his “Gangnam Style”. In late May 2014, the video reached 2 billion hits and is to-date the most viewed video in the history of YouTube. Korean culture may soon be just as popular as Korean cars. By the end of 2017, a “Pop Cultural Complex” is to be established in Gyeonggi-do Province at a cost of 911 million dollars, and includes plans for tourist facilities and production studios.

Safety, energy efficiency and environmental protection are also on the agenda. The quality of buildings – especially window glass and sealing – is at a low level. The will to complete everything as quickly as possible – also known as the “balli balli” (quickly, quickly) mentality – has its consequences. For example, Korea's safety shortcomings include “sinkholes,” pits that open up suddenly due to subterranean construction work, or the leak in a 5,200-ton aquarium. The current insecurities are giving foreign companies especially good openings on highly sensitive projects such as construction plans, the nuclear sector and healthcare.

To reduce electrical and natural gas costs, there is a drive to lower the energy needs of new-builds by 60 percent. Starting in 2025, only zero-energy buildings will receive construction permits, and the comprehensive refitting of buildings constructed in the 1980s is pending. The focus is also on air quality: By 2018, the number of electric vehicles is expected to have climbed from 3,000 to 55,000, and 575 charging stations are being built in the Seoul metropolitan area to accommodate them.




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## THE HIGH PRICE OF A FAST CLIMB

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How have Koreans handled their rapid transformation from a poor agricultural country to a low-wage center and onward to a high-tech nation? Rural areas suffer from high migration to cities because industrial growth is exclusively taking place there. The response to the exodus from the countryside has been the construction of numerous anonymous “overspill” and residential towns. Most are planned and built by the government. Sudogwon, on the outskirts of Seoul, is the world’s second-largest urban concentration. Nearly half of all South Koreans live here. The steep drop in births since the 1990s has led the proportion of elderly to climb rapidly, which is posing even greater demographic problems for South Korea than for Western European countries.

On the other hand, the living standard in South Korea has greatly improved: Since 1990, average wages have grown 7.6 percent each year, and now stand at about 2,300 euros a month. In Asia, only the Japanese earn higher wages than Koreans. The legal minimum wage is four euros per hour – which puts the country in 14th place among the 25 OECD nations.

But Korean society has to deal with its work-life balance. Koreans work the second-most hours – a total of 2,163 – of all OECD countries. Employees can only go home at the close of business when the boss calls it a day. The pressure to perform leads to the greatest number of visits to doctor’s offices of all the OECD countries. It also contributes to the fact that just 37 percent of Koreans characterize their health as “good”. Korea is the sad front runner in the suicide statistics, and “gwarosa” is the well-recognized term for death from overwork. The Korean government has recognized the problem. Since 2008, it has certified and promoted family-friendly companies. From just 14 companies the first year, their number had climbed to nearly 1,000 by 2015.

Korea has an edge over other Asian countries in that it has had its eye on new markets from the beginning and has never focused on its home market. It has also avoided a split between society’s winners and losers in its economic ascent. Furthermore, it has no latent problems with ethnic or religious minorities. So the still explosive conflict with North Korea is the primary risk factor, though this could prove to be another huge opportunity if its neighbor ever opens up to the world. ©



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# CARS FOR THE WORLD

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IT WASN'T UNTIL THE 1960s THAT THE FIRST CAR PRODUCED IN SOUTH KOREA CAME OFF THE LINE – A LICENSED REPRODUCTION OF A JAPANESE DATSUN, THE BLUEBIRD. TODAY KOREA IS THE WORLD'S FIFTH-LARGEST CAR PRODUCER, AND KOREAN CARS ARE IMPOSSIBLE TO MISS ON THE STREETS OF EVERY CONTINENT. TO MEET THE TASTES OF INTERNATIONAL MARKETS, SUCCESSFUL KOREAN AUTOMAKERS WERE AMONG THE FIRST TO TURN TO EXTERNAL EXPERTISE AND DEVELOPMENT CENTERS IN THEIR TARGET MARKETS.



Chung Ju-yung was extremely business-minded from an early age. As a youth, he had to flee from North Korea to Seoul, where he began selling rice from a bicycle. Born the son of a rice farmer, Chung knew all about that, but technology fascinated him more. In 1940, he opened a car service shop bearing the name of what would later become his global company: “Hyundai”. The name means “modern” in Korean. Chung pursued a strict

regimen in his workshop. He demanded his workers complete repairs within six hours, while others were scheduling six days. Never one for standing still, Chung then founded a construction company in 1947, with most of its orders coming from post-war reconstruction work. In the 1960s, he enjoyed the support of the dictator Park and was able to build Hyundai into an international conglomerate (Chaebol).

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## STARTING OUT WITH LICENSED PRODUCTS

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By the mid-1960s, Chung Ju-yung had decided to become an automaker. The first cars were already being assembled in Korea ten years earlier. The Ha Dong-hwan Motor Workshop had been producing military jeeps for the U.S. Army under license since 1954. The Japanese Datsun Bluebird PL310, the first passenger car assembled under license, finally came off the line in 1962 at Saenara Motors, which was formed specifically for the project.

What was missing was development know-how. So Chung negotiated with Ford Motor Company for licensed products from

the automaker’s global product portfolio. The Korean version of the British Ford Cortina was the first model to come off the newly constructed assembly line, closely followed by the Korean edition of the Ford 20 M P7, which had originated in Cologne. Its successor, the Granada, was destined to come off the Hyundai assembly lines from 1972 to 1985. Other Chaebols wanted to add automobiles to their portfolio and began manufacturing licensed products. The Kia Brise, which appeared in 1974, is considered the first Korean passenger car, but was a replica of the Mazda Familia.



### Hyundai Pony:

The Pony – the first car manufactured entirely in Korea – marks the start of Hyundai’s meteoric rise as an export brand in the mid 1970s.

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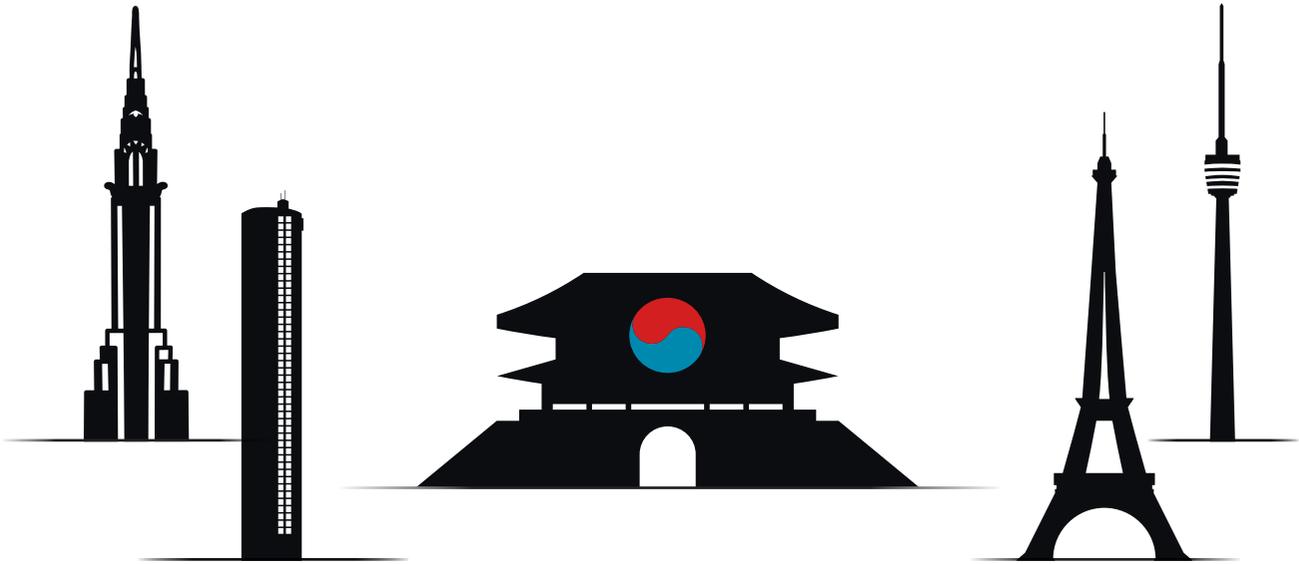
## EXPERTISE FROM OVERSEAS

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Know-how can be bought – also in the form of staff. In the early 1970s, Hyundai engineers dared to develop their own cars under the direction of a five-man British engineering team led by George Turnbull, the former director of British Leyland. With engines and transmissions from Mitsubishi and some components from the Ford Cortina, the Hyundai Pony was developed on the technical basis of the Morris Marina. Famous design studio, ItalDesign, created the fastback body. The result debuted in 1974 at the 55th Turin Motor Show. The Pony had a successful start – and not just

in the domestic market. Exports to Europe began in 1978, initially to the Benelux countries and later to Spain and Greece.

In 1983, the Pony II was also exported to Central America and Canada. In Canada, it exceeded forecasts tenfold and was the country’s bestselling car in 1984 at 50,000 units. U.S. citizens could only begin buying Korean cars in February 1986. The Hyundai Excel set a record by selling 168,882 vehicles the first year. No brand had ever had a better launch in the American market.




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## DIFFERENT STRATEGIES: COOPERATION VERSUS EXPANSION

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© Hyundai Motor America

All engineering activities for the North American market are pooled in the Hyundai American Technical Center (HATCI).

At an early date, to overcome its technological lag behind established automakers as quickly as possible – and not just sell on price – Hyundai turned to a strategy that was to prove extremely successful: developing cars in the classic auto-producing countries as well as at home. The Hyundai America Technical Center (HATCI) was established in Superior Township, Michigan, with the goal of bundling all Hyundai engineering activities in North America. The Hyundai Design Center in Fountain Valley, California followed in 1990. Today, the HATCI headquarters are in Ann Arbor, Michigan, with offices, laboratories and studios spread over 20,000 square meters. Kia has been designing its cars for the American market in Irvine, California since 2008.

By contrast, other Korean manufacturers turned to cooperative ventures with established automakers:

- For example, Shinjin Motors was allied with Toyota until 1972, before General Motors came on board as a new partner in 1976. In 1983, the company became Daewoo Motors Co. – which does business today as GM Korea.
- Samsung entered auto manufacturing much later: Samsung CEO Lee Kun-hee’s actual plan was to take over the battered automaker Kia, but it fell through in the early 1990s. So Lee founded Samsung Motors Inc. (SMI) in 1994. However, it fell victim to the Asian economic crisis. As a consequence, takeover negotiations began with Renault in 1998. Two years later, the French manufacturer took an initial 70 percent stake in SMI at a value of 560 million dollars.
- SsangYong Motors, which has been producing Jeep reproductions like the “Korando”, since 1984, sold shares to Mercedes-Benz and sourced engines and other components from the automaker. One result of the collaboration was the 1997 “Chairman” – a luxury sedan available exclusively in South Korea and based on the Mercedes E-Class. After six years, the connection was dissolved. SsangYong was part of the Daewoo Group until 2000. Since 2011, SsangYong, Korea’s fourth-largest automaker, has been majority-owned by Indian company Mahindra & Mahindra Limited and sells its eight different models in 115 countries.

Thanks to its strong export orientation, Hyundai survived the Asian economic crisis virtually unscathed, and even with a degree of growth. It acquired Kia Motors in 2000 – no. two in the Korean market but under insolvency administration at the time. After the death of the 85 year-old patriarch Chung Ju-yung in March 2001, the corporate conglomerate was divided into independent subgroups. Since 2003, the automotive division has been called Hyundai Kia Automotive Group.

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## FROM BUDGET BRAND TO QUALITY PROVIDER

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The internationally networked approach to development has paid off: With the introduction of its new model generations, Hyundai began achieving a significantly better level of quality in 2001, expressed in warranty periods that were unusually long for the industry. Safety in particular saw a quantum leap. Disastrous evaluations in crash tests were replaced by four and five-star ratings.

A crucial step was the formation of a European development center. In 2003, 300 engineers and designers began work at the Hyundai Motor Europe Technical Center GmbH (HMETC) in Rüsselsheim, Germany. They ensure that every Hyundai and Kia sold in Europe fulfills customer expectations and can be adapted appropriately. The best example is common rail diesel engines with variable turbocharger vane geometry, developed in Rüsselsheim for the European market with an investment in the billions.

To ensure that its designs and technology are up to date, Kia secured the services of the then-Volkswagen design chief Peter Schreyer in September 2006. Within a few years, the designer gave the brand an original face with a high recognition value with the “tiger nose”. In early 2013, Schreyer was the first non-Korean named as one of Kia’s three presidents. He was simultaneously awarded responsibility for the design offices of the entire Hyundai Kia Automotive Group. Schreyer is no anomaly. Numerous former top executives from established automotive companies are now working for Hyundai or Kia.

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## THREE QUESTIONS FOR CLAUS MÖHLENKAMP

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CLAUS MÖHLENKAMP, CHIEF EXECUTIVE OFFICER  
OF FREUDENBERG SEALING TECHNOLOGIES

**1** WHAT ROLE DOES SOUTH KOREA PLAY IN THE GLOBAL AUTOMOTIVE INDUSTRY? After China, South Korea holds the strongest position by far in the Asian region and also plays an extremely important role in a global context. With nearly nine million vehicles produced each year, the Hyundai Kia Automotive Group is among the top three players.

**2** WHAT POTENTIAL HAS THE SOUTH KOREAN MARKET FOR AUTO SUPPLIERS? The South Korean market has many similarities with the Japanese market. Market access is difficult for Western suppliers. There are very close, long-standing connections between the Korean supplier industry and the OEMs. Thus, a local presence is extremely important in the long run.

In addition to Hyundai Kia, General Motors, Renault and Mahindra also manufacture in South Korea. With production of 4.5 million vehicles per year, the country plays an even greater role than South America. China is the second biggest sales market for Hyundai after Korea. Furthermore, about six million engines and transmissions are manufactured in South Korea. This shows how intensively Hyundai is exporting to the rest of the world from its home market. If we want to be successful with Hyundai on a global basis, we must exploit this potential directly within South Korea.

**3** WHAT POTENTIAL DO YOU SEE FOR FREUDENBERG SEALING TECHNOLOGIES? We currently generate revenue of about 4.5 million euros with our customers in South Korea, which equates to just one euro per vehicle produced. Or, to put it another way, our market share is less than two percent. Globally, we are currently achieving an average revenue per vehicle of more than 20 euros. So there are still substantial opportunities for FST.



© Hyundai Motor Europe

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## TEST CENTERS ON THREE CONTINENTS

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The Korean test centers in Namyang and Hwasung have been supplemented with facilities in the export markets. The Hyundai America Technical Center was inaugurated back in 2004. In the middle of the Mojave Desert, prototypes undergo testing on 17 square kilometers and race around a roughly ten-kilometer high-speed oval. The European center is located in an entirely different climatic region. Since October 2013, engineers have been testing durability as well as steering and chassis tuning 16 weeks a year directly on the legendary Nürburgring Nordschleife, the world's most important test track for high-speed vehicles. The time difference between Korea and Germany even turns out to be an advantage: Errors discovered

during the day can be corrected overnight in Korea so a modification can be tested the next day. In all, the company has 13 R&D centers in six countries.

The globalization of design, development and production has paid off: More than two-thirds of all Kia and Hyundai models are now sold outside Korea. China is the most important foreign market, followed by the U.S., the Middle East/Africa and the EU. Unlike other companies, the Korean automaker does not put up with weakness in any key market. Instead, it is similarly strong everywhere.

GM Korea and RSM (Renault Samsung Motors) are also successful automakers

today. GM Korea has five production facilities and builds vehicles that are sold in more than 150 markets. With nearly two million units, approximately one in three Chevrolets worldwide comes from a South Korean production facility – and is developed there as well. Since 2010, GM Korea has tried to establish an automotive brand for the upper-middle-class with its “Alpheon” brand, which is intended to breathe “Corean Heritage”. RSM, owned 80-percent by Renault, built about 80,000 vehicles in 2015 – which are sold only in Korea as the Renault Samsung. No one gets by the “top dogs” Hyundai and Kia with their more than 75 percent market share.




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## THE NEXT LEVEL: ALTERNATIVE DRIVES AND THE ATTACK ON THE PREMIUM SEGMENT

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With eight million units in 2015, the Hyundai Kia Automotive Group has not only become the world's third largest car manufacturer, it has also been able to double its sales and market share (currently about 10 percent worldwide). The company is also assuming a pioneering technical role. With its luxury brand "Genesis", the Koreans, who start-

ed out with licensed production less than 50 years ago, are also demonstrating their competency in the premium sector. And the company developed a completely new platform for the world's first car that can be delivered as either a hybrid, an electric car or a conventionally powered vehicle. Hyundai is also displaying its self-confidence in its home

country. In the fall of 2014, the company purchased an 80,000 square-meter property in Gangnam, Seoul's trendy district, for a new company headquarters. The 571-meter skyscraper is due to house offices and conference rooms – surrounded by a hotel, a conference center and an automotive experience park on the model of Autostadt in Wolfsburg. ©

For further information, please visit:  
[www.fst.com/markets/automotive](http://www.fst.com/markets/automotive)



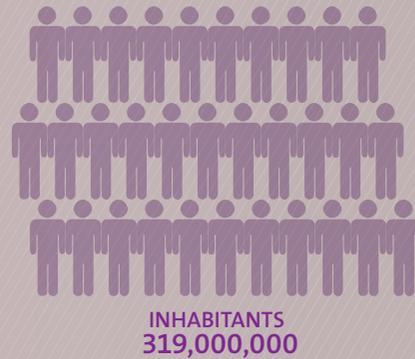
**THE HIGH-SPEED OVAL IN THE MOJAVE DESERT** provides engineers with a permanent test facility – regardless of season. Inside the oval are the handling course and other testing facilities where the prototypes are put through their paces.

# FACTS & FIGURES

## BETWEEN TWO WORLDS

South Korea's land boundary is only 238 km long – but its importance more than makes up for its modest length. In 1943, the allies announced their plan to grant Korea its independence after the war. What actually ensued was the formation of American and Russian military governments north and south of the 38th parallel, which were supposed to administer the country until national elections. The Cold War prevented unification and cemented the division. Thus far, there has still been no happy ending, and the border is considered the least penetrable barrier in the world.

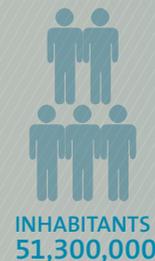
USA



GERMANY



SOUTH KOREA

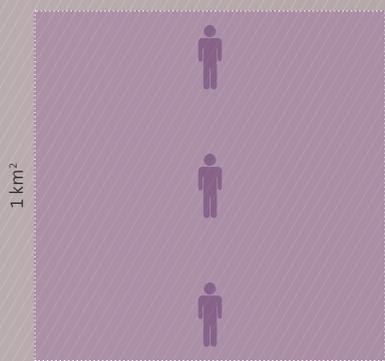


## Demographics/Geography

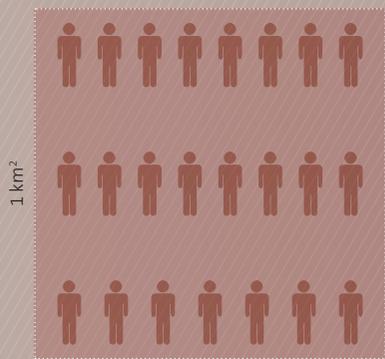
## OLYMPIC GAMES IN THE HIGHLANDS

At 1,950 meters above sea level, the Hallasan would not stand out in either the Rocky Mountains or the Alps. Rising from the water on the island of Jeju-do, Korea's highest mountain is visible from a great distance. But the 2018 Olympic Winter Games are taking place on the peninsula itself – at the

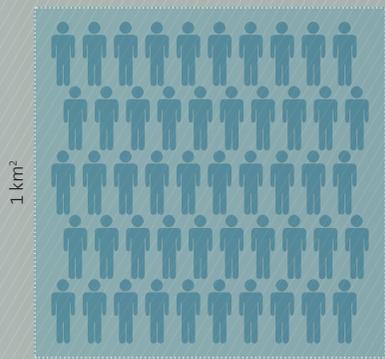
modest elevation of 700 meters in Pyeongchang, a location certain to have snow. From there it is only 30 minutes to the Jeongseon Alpine Centre, where the Olympic men's downhill run, ranging between 440 and 1370 meters above sea level, debuted in February of this year.



**POPULATION DENSITY**  
32.5 per km<sup>2</sup>



**POPULATION DENSITY**  
229.2 per km<sup>2</sup>



**POPULATION DENSITY**  
511.3 per km<sup>2</sup>



# FACTS & FIGURES

## IRON DISCIPLINE

South Korea has not quite reached the per capita gross domestic product of the United States or Germany. But the Asians are displaying their typical discipline in domestic matters. Measured against GDP, government indebtedness is only half what it is in the U.S. or Germany. And those who save during the good times ... South Korea's currency reserves are nearly double those of Germany and nearly three times those of the U.S.

USA



GDP  
\$20,050,000,000,000



GDP/CAPITA  
\$48,338



STATE INDEBTEDNESS  
71.2% OF GDP



CURRENCY RESERVES  
\$130,100,000,000

GERMANY



GDP  
\$2,915,000,000,000



GDP/CAPITA  
\$47,774



STATE INDEBTEDNESS  
74.7% OF GDP



CURRENCY RESERVES  
\$192,800,000,000

SOUTH KOREA



GDP  
\$1,410,000,000,000



GDP/CAPITA  
\$28,180



STATE INDEBTEDNESS  
37.2% OF GDP



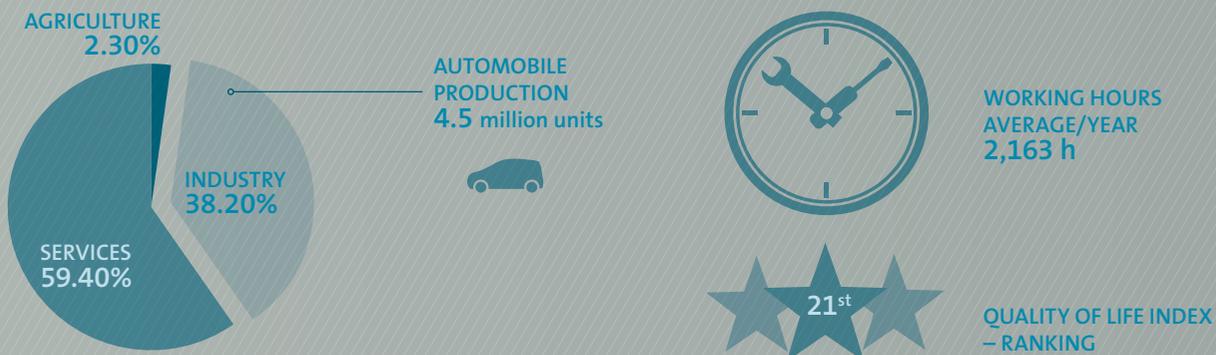
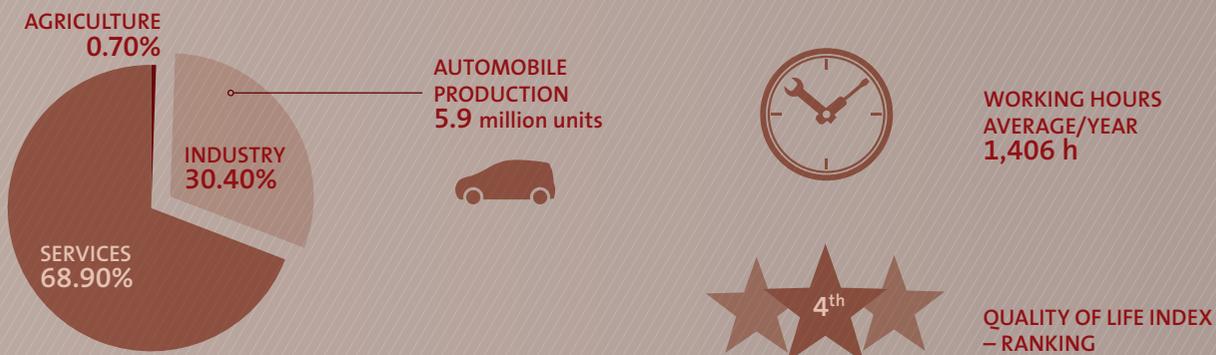
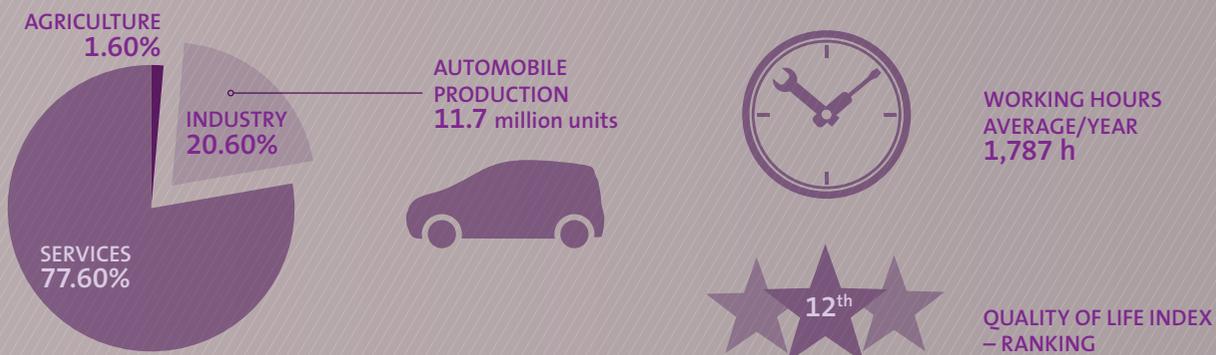
CURRENCY RESERVES  
\$363,600,000,000

## Finances

## HARD WORK

Industry accounts for a significantly larger share of the South Korean economy than in the U.S. or Germany. And Koreans have to work considerably longer for their prosperity – 50 percent more than German employees and a third more than the aver-

age American. The work-life balance is still skewed on the peninsula, which is visible in the service sector’s modest share of the economy. As a result, South Korea ranks only 21st on the “Quality of Life” scale.



Economy

Work/Life



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# GEARS AND MUCH MORE

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ZF – THESE TWO LETTERS REPRESENT A COMPANY HISTORY GOING BACK MORE THAN 100 YEARS, EXPERTISE IN POWERTRAIN AND CHASSIS TECHNOLOGY AND – SINCE THE ACQUISITION OF TRW – ONE OF THE WORLD’S THREE LARGEST AUTOMOTIVE SUPPLIERS. ZF HAS HAD MORE THAN 80 YEARS OF INTENSIVE COOPERATION WITH FREUDENBERG SEALING TECHNOLOGIES. ESSENTIAL PRESENTS THE GLOBAL COMPANY HEADQUARTERED AT LAKE CONSTANCE IN GERMANY.



Graf Zeppelin airships were the starting point for the company's unprecedented history. The German Luftschiffbau Zeppelin GmbH had always faced a nearly insurmountable problem in the development and construction of its silvery giants: The noise of the propeller drive in the gondola was almost unbearably loud. A patent filed by Swiss engineer Max Maag, who succeeded in manufacturing mathematically precise gears for the first time, offered the first remedy. The acquisition of the exclusive license for the sale of these quiet-running gears in August 1915 suggests their use beyond the

modest airship market. Zahnradfabrik GmbH – which today would be called a “spinoff” – was registered September 9, 1915 at the Tettng District Court and based in Friedrichshafen on Lake Constance in Germany. Its trademark “ZF” would soon be a synonym for the company. Luftschiffbau Zeppelin GmbH held a majority stake in the enterprise, whose business purpose was recorded as “the production of gears and gearboxes for aircraft, motor cars and motor boats”.

Just a few years after the company was founded, ZF began supplying the still

young auto industry in Germany with gearboxes. Its own expertise and the acquisition of licenses expanded its range of products: Starting in 1925 at its new Berlin location, gears for transmissions with helical gearing were ground for series production for the first time – based on a license from Belgian company Minerva Motors S.A. The new technology greatly improved noise levels – loud gearboxes became a thing of the past. The young company was extremely well-positioned with transmissions based on the Maag or Minerva principles.

## FROM LAKE CONSTANCE TO A GLOBAL PLAYER

A century later, the Friedrichshafen-based company has become a global player. Its collaborations with companies in Europe and the United States and its use of licenses showed global thinking early on. In 1958, ZF expanded to other continents. The first of many production facilities outside Germany was erected in Brazil, and

others followed in Spain (1973), Argentina (1979), the U.S. (1979) and China (1993). ZF products now come off the line in a total of 30 countries on every continent. The group generated 18.4 billion euros in revenue in 2014 with its 113 manufacturing units, currently organized into four divisions: Car Powertrain Technology, Car

Chassis Technology, Commercial Vehicle Technology and Industrial Technology. Its close cooperation with Freudenberg Sealing Technologies affects all of ZF's business areas. ZF sources about 150 million individual parts per year from 45 facilities worldwide – from hydraulic seals to diaphragms.





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## AUTOMOTIVE CORE WITH A LONG TRADITION

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ZF has been supplying car transmissions since 1919. Today, its **Car Powertrain Technology** Division is the largest of the company's four divisions, providing automatic transmissions, manual and dual-clutch transmissions, differentials and drive modules.

Its ongoing, close cooperation with Freudenberg began in the early 1930s and has continued through to the present. Europe's largest tannery has been using its expertise in leather for the production of seals since 1929. The Simmerring has been available



for sealing rotating shafts since 1932. The patented radial shaft seal prevents clutch slippage and continual oil loss. This solves a crucial problem with transmission technology.

In 1934, ZF introduced the first-ever fully synchronized four-speed transmission for cars. The especially compact construction was impressive – and allowed room for a planetary design, permitting an additional “autobahn overdrive”. This facilitated extremely economical driving in fifth gear on the new autobahns at reduced noise levels.

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## AUTOMATIC TRANSMISSION: TURNING THREE INTO NINE

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1965 was a milestone. The transmission specialist presented its first torque-converter automatic transmission – the 3HP12 – with sealing technology from Freudenberg. The sporty BMW 2000 CS had to manage with 100 instead of 120 hp and three gears – its sales figures remained modest. But the people in Friedrichshafen were galvanized by the automatic shift system. At the Frankfurt Motor Show (IAA) in 1969, they introduced a torque-converter transmission activated by an electronic control system for the first time. However, the company stuck with hydraulic control for series production until well into the 1980s. In 1999, ZF surprised the experts with a prototype of the first six-gear automatic transmission. Production began two years later – and helped the automatic transmission reach its ultimate breakthrough. Sixteen automakers chose either the first or second generation of

the 6HP. Up to 4,500 units came off the line daily in a three-shift operation in Saarbrücken – tallying more than seven million units by end-of-production in summer 2014.

ZF's product portfolio grew significantly in 2001. With its acquisition of the German **Mannesmann Sachs AG**, it began delivering clutches and torque converters for automatic transmissions – an ideal complement to its business. In 2009, ZF launched the 8HP. With the world's first eight-gear automatic transmission for cars, the technology company was offering a timely product, tailor-made for automakers and their ongoing efforts to further reduce fuel consumption. Based on a flexible modular system, it accommodates hybrid and all-wheel-drive variants, saves weight, is the first transmission of its kind to be suitable for start-stop systems and achieves fuel

savings of up to 11 percent compared to the second-generation 6HP.

In June 2011, ZF presented the 9HP, its first torque-converter automatic transmission with control electronics developed in-house. The unit, designed for front-transverse mounting and thus compact cars, entered production in 2013. Nearly 50 years after its first torque-converter automatic transmission, ZF established itself as a technological leader, installing more than just Simmerrings from Freudenberg Sealing Technologies. For the 8HP and 9HP product lines, Freudenberg Sealing Technologies also supplies composite pistons as well as rubberized plate springs, for which the two companies have a joint patent.

Every year, nearly 12 million clutches are produced at ZF and nearly 3 million automatic transmissions.

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## FROM TRANSMISSIONS TO CHASSIS – WITH KNOW-HOW FROM THE U.S.

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But ZF was about “more than just transmissions” from the early days. Steering systems for cars and commercial vehicles began rounding out the portfolio in the 1930s and formed the first building blocks of the company’s current chassis expertise. The steering system know-how initially came from the **Ross Gear and Tool Company**. Based in Lafayette, Indiana, the U.S. firm developed a one-pin steering system that was easy to build, yet smooth-running, precise and vibration-free. The **Wanderer-Werke** in Germany was its first customer.

The steering systems based on the Ross approach became less important

in the 1950s. To stay current, ZF cooperated with Detroit company **Gemmer Manufacturing**. Its worm-and-roller steering gear was more robust and offered a greater maximum steering angle. It was produced at ZF’s Schwäbisch Gmünd facility in Germany and firmly established steering systems within the company’s product portfolio.

With the acquisition of the German **Lemförder Gruppe** in 1984, ZF entered global business with chassis components and systems. The company had special expertise in connecting rods, tie rod ends and complete chassis systems –

safety-relevant components that require in-depth material and production expertise. Sealing bellows ensure the excellent sealing of sensitive joints; they seal reliably and do not restrict movement of the ball end – another result of the long development partnership with Freudenberg Sealing Technologies.

The collaboration proved itself at the end of the 1990s when the “Moose Test” suddenly moved active hydraulic roll stabilization to center stage. A universal joint seal from Freudenberg Sealing Technologies helped to minimize rolling movements and improve steering behavior.




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## SACHS: DAMPERS, CLUTCHES AND MOTORSPORT

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In 2001, the Sachs acquisition expanded the portfolio with the addition of shock absorbers, for which Freudenberg Sealing Technologies was already supplying seals, pistons and bellows. Electronics made their way into the company here, too. The adaptive damping system CDC (for continuous damping control) set new standards in 2004 in terms of driving safety, dynamics and comfort.

The venerable Sachs brand can look back on an extremely successful history in motorsports. The legendary Mercedes Silver Arrows of the 1930s and 1950s were already relying on Sachs frictional dampers and clutches. In 1993, Sachs re-entered Formula One with the Sauber Mercedes team, and was crowned with its first world championship six years later. From 1999 to 2004, Michael Schumacher won the world driver championship with Ferrari five times – always with Sachs shock absorbers. Since entering Formula One racing, ZF’s partners have brought home 132 victories, nine manufacturer titles and more than 6,000 world championship points.

Today, ZF is represented in all categories of international motorsports. In 2015, the official FIA world titles in the WEC and WRC were won with ZF products. In addition, the winners of the 24 Hours of Le Mans and the legendary Dakar Rally relied on the technology of ZF Race Engineering.

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## ZF TRANSMISSION: FORMULA ONE CHAMPION BACK IN 1963

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The Friedrichshafen company has already been a world champion. In September 1963, for example, employees gathered in awe around a green Lotus 25 in the ZF maintenance area. A few days earlier, Briton Jim Clark had won the Formula One world championship for the first time in Monza. The mo-

noposto, weighing just 450 kg and featuring the first monocoque chassis in Formula One racing, sent power to its rear wheels via a ZF-5DS10 transmission. Over the next three years, Lotus race cars with ZF transmissions would win more than 50 races – including the Lotus 38 in the Indy 500 in 1965.

Today the development and production of chassis and racing transmissions are a focus of motorsport activities – including a racing adaptation of the tried-and-tested 8HP automatic transmission with extremely short shifting times.



ZF's eight-speed plug-in hybrid transmission contains a powerful and compact electric motor instead of a torque converter and has the potential to reduce average fuel consumption by up to 70 percent.

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## ROBUST, RELIABLE AND ECONOMICAL: TRANSMISSIONS FOR COMMERCIAL VEHICLES

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The requirements for motorsports transmissions and clutches are low weight and the ability to withstand high engine revving. Transmissions for trucks and buses are at the other end of the spectrum, but have had a firm position in the product range from the outset. Today, ZF delivers more than 400,000 commercial vehicle transmissions per year.

Truck drivers of the 1930s were already benefiting from the quiet operation

of ZF transmissions, which made their workplace more tolerable. The fact that they can make an enormous contribution to reducing fuel consumption has been important since at least the oil crisis of 1973. ZF presented its Ecosplit transmission for commercial vehicles in 1979. It achieved significant savings and was impressive for its superior reliability. A further milestone came in 1997 with the AS Tronic. In the first fully automatic truck transmission, an electronics sys-

tem ensured, independently of the driver, selection of the best possible gear for any given operating situation.

Low-friction seals today play a crucial role in the search for greater efficiency in the commercial vehicle sector. And cassette seals from Freudenberg Sealing Technologies ensure that sensitive transmissions are not impaired by the penetration of dirt particles or moisture in harsh everyday commercial vehicle use.

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## OFF-ROAD TRANSMISSION TECHNOLOGY

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ZF transmissions have also established themselves off-road. In 1937, ZF engineers designed a tractor unit that combined a manual transmission and rear-wheel drive in a single component. The A 12 universal transmission for engine output up to 22 hp was the initial product of an entire generation of tractor drive units. Today, ZF builds high-performance continuously variable transmissions for tractors with up to 650 hp.

Wind turbines also need transmissions. In November 2011, ZF acquired Belgian specialist Hansen Transmissions International NV and, with its factories in China and India, advanced to number three in the world. Its first in-house development appeared in 2014. It was the “Atlas 1” transmission for Danish global market leader Vesta. The “Atlas 1” is equipped with sealing technology from Freudenberg Sealing Technologies.

Claus Möhlenkamp, Chief Executive Officer of Freudenberg Sealing Technologies, considers the cooperation with ZF to be a model for other companies. “What joins our two companies is that both are innovation-driven and especially customer-oriented. ZF is one of our top five customers, and we see ourselves as one of the major strategic suppliers to the company.”

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## 2015: 100 YEARS AND THE START OF A NEW ERA

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Its importance could continue to grow. During its anniversary year 2015, ZF expanded its technological foundation with the integration of TRW as a new ZF division called “Active & Passive Safety Technology”. With the “POWER OF 2” as its theme, ZF made clear that the move involved two champions who were uniting their strengths. The two companies are both market leaders: ZF with solutions for powertrain and chassis tech-

nology; TRW contributes safety, steering and braking technology as well as experience with driver assistance systems.

The figures relating to the new ZF Group are impressive: 138,000 employees work at 230 facilities in 40 countries and generate about 30 billion euros in revenue.

For Dr. Stefan Sommer, CEO of ZF Friedrichshafen AG, a new era is beginning:

“By merging our strengths through integration, we will be much more as a whole than just the sum of the two individual parts. This is enabling us to create unique opportunities for growth. We want to be leaders in the intelligent networking of mechanical components.” ZF’s diversified portfolio includes the right solutions for the megatrends of mobility: autonomous driving, more safety and greater efficiency.

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## ZF TRW: AUTOMOTIVE EXPERTISE WITH A 110-YEAR TRADITION

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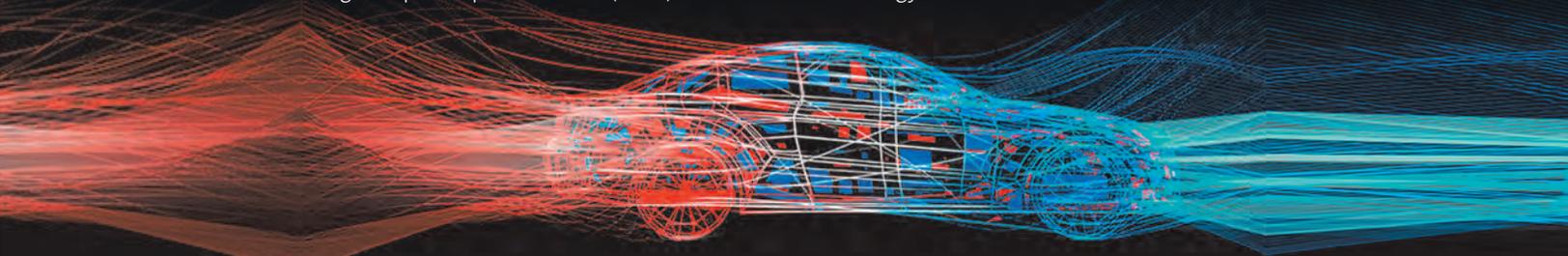
TRW Automotive can look back on a proud history of more than 110 years in the vehicle industry. In its early years, TRW developed the first two-part engine valve as well as wooden wheels for Henry Ford’s Model T. Its milestones of automotive development were the first hydraulic brake system (1939), the first power brake system (1946), the first power steering (1952), and the first disc brakes (1957). In 1968, TRW introduced the first electronically controlled antilock braking system.

Two of its developments are important steps on the way to autonomous driving: adaptive speed control (2002) and the

first lane-keeping assistant with an integrated camera and electrical steering technology (2008).

Along with regenerative braking systems for braking stability in hybrid vehicles (2006) and ESC-R regenerative braking technology for hybrid vehicles (2007), alternative powertrains are also high on the agenda.

Today, ZF TRW stands at the pinnacle of the development of an array of systems, including vehicle dynamics, driver assistance, service brakes, inflatable restraint systems, safety belt technology, and electronics and software innovations. ©

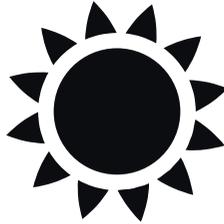




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# CALIFORNIA DREAMING

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THE SUNSHINE STATE ON AMERICA'S WEST COAST HAS ALWAYS STOOD FOR A SPECIAL ATTITUDE TOWARD LIFE. THE BEACH AND SURF CULTURE BEGAN ITS TRIUMPHANT MARCH AROUND THE WORLD FROM CALIFORNIA, ITS DREAM FACTORIES PRODUCED THE GREATEST FILMS AND THE MOST INNOVATIVE HIGH-TECH IDEAS WERE DEVELOPED THERE. ENVIRONMENTAL PROTECTION AND ENERGY CONSERVATION WERE ISSUES IN THE STATE BEFORE MAJOR EUROPEAN AND ASIAN CITIES BEGAN DEALING WITH THEM.

Technicolor images from the 1950s awaken feelings of nostalgia: Finned, chrome-laden road cruisers rolling along on multilane highways lined with sprawling drugstores and oversized billboards advertising burger restaurants. Even 55 years ago, the idyllic scene had its dark side. By the end of the 1950s, air pollution in Los Angeles had become a major problem, forcing the state to take action. In 1960, it established the Motor Vehicle Pollution Control Board (MVPCB), which one year later announced the first legal standards for the containment of toxic automobile emissions. Starting in model year 1963, crankcase ventilation became mandatory to direct oil and gasoline vapor back into the intake system. This alone reduced hydrocarbon emissions by about 25 percent. In addition, the MVPCB established the world's first emissions limits. As of

model year 1966, hydrocarbon and carbon monoxide emissions had to be reduced by 25 and 40 percent respectively as measured by the so-called "California Test". By 1968, these limits were in force in the other U.S. states – in Europe, comparable limits first went into effect in the 1970s.

The Pacific coastal state has taken a pioneering role in environmental matters ever since. While the existence of climate change is disputed elsewhere in the country even in 2016, Californians have long taken action against it. The extreme climate, which leads to problems with drinking water supplies and a continual risk of forest fires, always provided residents with a clear view of nature's vulnerability.



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## “CHANGE” AFTER THE OIL CRISIS

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Early on, after the oil crisis of 1973, the state created two commissions to work out opportunities for saving energy. The California Public Utilities Commission (CPUC) ordered that production volumes and profits be separated from one another. Accordingly, energy companies in California could not earn more than they required for operations and a fair disbursement of profits. It was a unique intervention in corporate autonomy that has proven effective. According to Pacific Gas & Electric in San Francisco, its customers have saved more than 20 billion dollars over the last 30 years and have released 120 million fewer tons of CO<sub>2</sub> into the atmosphere.

Founded in 1974, the California Energy Commission (CEC) was a crucial step in this direction. Requirements for reductions in the energy consumption of home appliances and buildings made the construction of new power plants unnecessary. The savings since then have been put at 700 billion dollars – and the “Rosenfeld Curve” has impressively shown the ever-widening gap between California and other states in energy consumption. Since 1970, per capita energy consumption has fallen 18 percent, and for every dollar earned, half as much CO<sub>2</sub> is emitted as in the rest of the U.S. – today, energy efficiency in California is two-thirds better than the U.S. average. No conventional power plant has gone on-line since 1989, and the energy company SMUD even shut down a nuclear power plant voluntarily.

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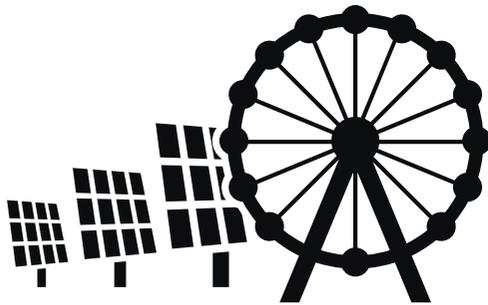
## PIONEER IN CLIMATE PROTECTION

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This attitude has transcended the usual party lines. For example, the agenda of Arnold Schwarzenegger – who served as California’s Republican governor from 2003 to 2011 – included a focus on environmental policy. He could not run again after two terms in office, but he supported Democrat Jerry Brown in the November 2010 elections. And he had harsh words for the “Proposition 23” party, whose goal was to overturn climate legislation. “Greedy Texan oil companies are fighting our environmental legislation. They just want profits – and to pollute the world.”

In 2005, Schwarzenegger signed a groundbreaking environmental law, the “Global Warming Solutions Act”, which was designed to reduce California’s greenhouse gas emissions to 1990 levels by 2020 – and by another 20 percent by 2050. It was ten years later that the U.S. government agreed to make a national commitment at the UN Climate Conference in Paris. Starting April 22, 2016, each UNFCCC<sup>1</sup> signatory can sign the Paris Climate Agreement. The agreement goes into effect 30 days after the day when at least 55 of the signatories that collectively represent at least 55 percent of global greenhouse gas emissions have submitted their ratification, acceptance, approval or accession certificate to the UN Secretary General in New York.

<sup>1</sup> United Nations Framework Convention on Climate Change.




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## ECONOMIC DRIVER "GREEN TECHNOLOGY"

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"Green industry" has meanwhile become one of California's most important economic sectors. During his first period in office between 1975 and 1983, Gov. Brown was already having wind farms built. Since 1980, California has created 1.5 million jobs through energy conservation alone. Today, the sunshine state has become a stronghold of the solar energy industry and wants to cover 50 percent of its energy needs from renewable sources by the year 2030. The fuel consumption of trucks and cars is to be halved and the energy efficiency of buildings doubled.

60 percent of the venture capital invested in the U.S. migrates into California's environmental sector. And the West Coast state accounts for about 40 percent of the world's clean technology investments. The efforts are visible everywhere. The prison island of Alcatraz in San Francisco can only be reached by hybrid ferry. The first Ferris wheel powered completely by solar energy revolves in Santa Monica and electric shuttle buses move passengers through downtown Santa Barbara. Hotels advertise their exemplary insulation, furnishings made from recycled materials and their waste separation.

The greater Los Angeles area – with 13 million residents, one of the largest metropolitan areas in the world – has still not become a green utopia. But the traffic on the eight-lane freeways radiating from its center would be even heavier without the expansion of its subway system, its buses fueled by natural gas and the carpool lanes reserved for vehicles with multiple occupants. And the air quality would be much worse. Today, greater Los Angeles produces about the same volume of emissions as Sweden – which, at just 9.5 million inhabitants, has a much smaller population. ©



In Santa Monica's "Pacific Park", the world's only solar-powered big wheel offers an unparalleled view of the Californian coast from a height of 40 meters.



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## GEARING UP FOR WEIGHT LOSS

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America is putting its heavy pickups and SUVs on a strict diet. By 2025, U.S. authorities want to reduce the fuel consumption of these heavyweights to a maximum of 7.8 liters per 100 km (30 miles per gallon). Advanced nine- and ten-gear automatic transmissions are considered the ideal appetite suppressor for the popular gas-guzzlers. Sealing technology from Freudenberg Sealing Technologies is ensuring that more gears don't simply translate into more weight.

Bigger is better. In the U.S., extra-large pickups are the blockbusters of the automotive market. In 2015, three trucks even stood at the top of the registration statistics – a trend fueled by low gasoline prices. But automakers are facing the task of substantially improving the fuel efficiency of their bestsellers so they can meet future fuel consumption limits. Along with aluminum bodies, innovative automatic transmissions are playing a key role in pursuing the required 30 miles per gallon limit (7.8 liters per 100 km). State-of-the-art power transmission systems were among the highlights at the 2016 Detroit Auto Show.

Although the number of gears is climbing as high as ten, the dimensions and weight of the transmissions are hardly growing at all. Freudenberg Sealing Technologies is contributing to this with a fluoro rubber seal for oil pans. Used in the aerospace industry, the material withstands temperatures up to 140°C. This is necessary because less and less oil is being used in today's transmissions, and to ensure the associated temperature rise is not at the expense of durability, seals must be especially heat-resistant.

Lighter-weight materials are also boosting the efficiency of the new generation of transmissions. Here, Freudenberg Sealing Technologies has developed a process to produce a transmission cover and its seal in a single process step. The new component, made of heat-resistant plastic, comes in at just half the weight of a conventional metal cover.

Hybrid powertrains offer further potential for fuel savings. Freudenberg Sealing Technologies has developed a solution here as well: Its electrically conductive transmission seal separates the electrical section of the assembly from the power transmission. It basically works like a lightning rod. Electric current is selectively guided from the housing to the shaft through a conductive nonwoven attached to the seal, preventing a buildup of electric charge. Experts at Freudenberg Performance Materials provided valuable help in the specification of the fabric. The solution, which is now ready for series production, means the necessary potential equalization can be achieved without additional expensive elements such as wear-prone carbon brushes. It is suited to both plug-in hybrid vehicles and the more simply constructed transmissions of battery-powered vehicles.

In all, Freudenberg-NOK supplies 30 seals for the ten-speed automatic transmission, sourced from eight different plants in the U.S. and Mexico. The company has invested 8.6 million dollars into its Findlay, Ohio facility, so it can manufacture more than 18 million transmission seals annually. "We are well prepared to help our customers meet demanding CO<sub>2</sub> and fuel consumption goals," said Claus Möhlenkamp, Chief Executive Officer of Freudenberg Sealing Technologies.



## NEW LEADERSHIP

Freudenberg Sealing Technologies has expanded its Board of Management: Dr. Theodore Duclos, the new Chief Technology Officer (CTO), is now responsible for technology, quality, occupational safety, health and environmental protection, as well as components, based out of company headquarters in Weinheim. Matthew L. Portu was named to his previous position as President, North America of Freudenberg-NOK Sealing Technologies (FNST).

With the appointment of Dr. Theodore Duclos, the Board of Management of Freudenberg Sealing Technologies consists of four members: Claus Möhlenkamp (Chief Executive Officer), Dieter Schäfer (Chief Operating Officer), Ludger Neuwinger-Heimes (Chief Financial Officer) and Dr. Theodore Duclos (Chief Technology Officer).

Duclos earned his doctorate from Duke University in Durham, North Carolina, and has three decades of experience in research and development as well as management. He joined the Freudenberg Group as Corporate Director Technology in September 1996. In 2002, he was appointed CTO of FNST. After serving as Vice President, Operations and Technology, he took over the management of the Radial Shaft Seal Ring Division, which produces sealing products for the auto industry and other industrial sectors. His next position, as head of the Fluid Power Division, followed in 2011. In addition to this role, he became President North America of FNST in June 2014.

Matthew L. Portu graduated with a bachelor's degree in economics and an MBA from the University of Wisconsin. He joined FNST in 2005 and has been Senior Vice President, Global Purchasing, since July 2013. He previously held various executive positions in the FNST purchasing area. Earlier, starting in 1994, he held a number of purchasing positions at Ford Motor Co. and at its Visteon unit when it spun off several years later. He was ultimately named associate director of purchasing at Visteon.



## LEAK-TIGHT EVEN IN THE COLD

Shock absorbers have to function flawlessly even in cold conditions. But sometimes even a short, intense period of freezing weather is enough to ruin them. With a new high-performance material, Freudenberg Sealing Technologies is ensuring that its shock absorber seals do not become brittle even in Arctic temperatures as low as  $-40^{\circ}\text{C}$ . At the same time, the new mixture is much more wear-resistant than conventional materials. Series production begins this spring.

Shock absorber seals have an important task: They seal an oil-filled cylinder in which a valve piston moves up and down. The shock absorber keeps the car's four wheels on the road. But driving safety is no longer ensured if there is a loss of oil – as occurs in extreme cold. Rubber loses its elastic qualities starting at  $-20^{\circ}\text{C}$  and becomes as brittle as glass.

The sealing of monotube shock absorbers is especially challenging, as they are primarily used in sports cars and SUVs. Here a gas, usually nitrogen, applies pressure to the oil. The two substances are separated by an additional piston. The pressure on the seal can reach 100 bar or more.

Special low-temperature polymers cross-bonded with peroxides are used to increase the seal's resistance to cold. Normally, elastomers produced in this way show increased wear. But with fundamental development work, Freudenberg Sealing Technologies has found a way to combine the conflicting material characteristics in a new mixture. Another advantage is that the friction is nearly the same at all temperatures, which means the vehicle's handling characteristics remains identical under all conditions.

The use of the new technology in large-volume production is already on the way. A European automaker is using the seals with the new material mixture from Freudenberg Sealing Technologies in its SUVs. Since the greater cold resistance is solely due to improved material qualities, no design changes in the shock absorber are necessary. This means the switch to the new seals can also be carried out on current vehicle models.



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# SHORTCUT OF THE CENTURY

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© AlpTransit Gotthard AG

A TOTAL OF 57 KM LONG AND 2,300 METERS UNDER ROCK: 17 YEARS AFTER THE START OF CONSTRUCTION, ONE OF EUROPE'S MOST IMPORTANT TRANSPORTATION PROJECTS IS ALMOST COMPLETE. THE LATEST TUNNEL IN THE ALPTRANSIT PROJECT RUNS THROUGH THE HEART OF THE GOTTHARD MASSIF, CONNECTING NORTHERN AND SOUTHERN EUROPE, SHORTENING THE TRAVEL TIME BETWEEN ZÜRICH AND LUGANO BY 45 MINUTES, AND UNBURDENING PEOPLE AND NATURE. SEALS FROM FREUDENBERG SEALING TECHNOLOGIES KEPT THE HUGE TUNNEL BORING MACHINES RUNNING AS THEY DEVoured THEIR WAY METER BY METER THROUGH THE STONE OF THE MASSIF.

In 1947, Carl Eduard Gruner, engineer, transportation planner and visionary from Basel, was far ahead of his time when he sketched out the first designs of a new tunnel through the Saint-Gotthard Massif, far below the rail tunnel that was opened in the 19th century. What Gruner could not foresee 68 years ago was the dramatic rise in the traffic across the Alps. Today, more than 1 million trucks cross the Alps each year. The results have been traffic jams as well as noise and environmental pollution along the main arteries.

As a result, 65 percent of the Swiss electorate voted in 1998 in favor of the tunnel, which is designed to ease traffic in their Alpine country. And they were prepared to dig deep to pay for it. The "shortcut" will cost more than twelve billion Swiss francs. The new Gotthard Base Tunnel is the heart of the AlpTransit

project to relieve traffic in the Alpine region. It consists of two single-track bores, each 57 km long, and covers more than 152 km with all its connectors and access tunnels. It has thus replaced the 60 km Subway Line 3 in Guangzhou, China as the longest railway tunnel in the world. The symbolic start of construction was in November 1999, with the first kilometer of the tunnel bored nearly two years later.

People, material and equipment reach the gigantic construction site via specially positioned access tunnels. In some cases, workers travel kilometers underground to reach their unusual workplace. At times, more than 2,400 workers have simultaneously been on the job. Up to 2,000 meters of rock – another world record – tower above the new AlpTransit line, which connects the north portal in Erstfeld with the south portal in Bodio.



“Train stations” have been set up throughout the tunnel construction site to handle planned maintenance work and parts replacement in the event of breakdowns. The gigantic boring machines “Gabi I + II”, “Heidi” and “Sissi” are the heart of this ambitious project. Each is about as long as four football fields laid end-to-end. The drill head peels away the stone, and a bucket wheel and conveyor belt carry it all away. In all, about 26 million metric tons of debris have been transported. Dirt, high load pressures and vibrations place extreme operational stresses on the tunnel boring machines. The “worst-case scenario” is a breakdown in the middle of

the tunnel. The reliable sealing of the sensitive large bearings – which are extremely expensive and difficult to repair if damaged in use – is a key competency for efficient tunnel construction. It is exactly the right challenge for the specialists at Freudenberg Sealing Technologies.

Individually produced shaft seal rings with a diameter of 4.3 meters protect multicomponent roller bearings against the intrusion of stone, mud and water and prevent transmission oil leaks in ambient temperatures of up to 50°C. Despite their massive diameters, they have no joints – a testament



to years of experience in seal development for tunnel boring machines. The unique technology reliably ensures maximum functional security and withstands extremely high stresses. As a result, the colossal “mole” can relentlessly devour its way meter by meter through the rock. The East Tunnel’s breakthrough was celebrated in October 2010. With Swiss precision, its path was off by just a few centimeters, despite its massive dimensions.

The Swiss are thrilled with their “Gottardo” and can hardly wait for the official opening on June 1, 2016. A countdown clock

at [gottardo2016.ch](http://gottardo2016.ch) tallies the days, hours and seconds until the opening. Anyone wanting to be the first to travel through tunnel will have to be lucky. The highly coveted tickets for the maiden trip are being raffled off. So if you aren’t lucky, you’ll have to wait. More than 3,000 test runs are being carried out before regular train operation begins in December 2016. ©





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# INNOVATIONS

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MORE AND MORE SEALS ARE BEING DEVELOPED INTO MULTITASKING “SPECIALISTS” AND ARE IMPORTANT ENABLERS IN REALIZING THE TECHNOLOGIES OF THE ENERGY TRANSITION. SIMULATIONS HAVE AN EVER GREATER ROLE IN MATERIAL DEVELOPMENT AND DESIGN — AND PLAY OUT THE INTERACTION BETWEEN MATERIALS AND MEDIA. A QUICK GLANCE INTO THE LABS OF FREUDENBERG SEALING TECHNOLOGIES.





## SEAL, FEEL, ACT

SEALS CAN DO MORE THAN MANY PEOPLE BELIEVE. EQUIPPED WITH ELECTRICAL CONDUCTIVITY, THEY TAKE OVER ADDITIONAL FUNCTIONS. THEY CAN MONITOR THEIR OWN WEAR, MEASURE FORCES AND CARRY OUT FUNCTIONS. BUT WHERE EXACTLY IS THIS HEADED?

A seal with sensory perception? Sounds like science fiction – for good reason. Seals are made of elastomers, commonly called rubber, and in its pure form, rubber cannot process a signal. That function is reserved for metals and semiconductors because they have a high proportion of free electrons. And elastomers? Well, it would make sense to use them since seals are often right on the frontline of the action. And, in fact, there are various ways to use seals as sensors or even actuators. But a little help is called for – without ever losing sight of the actual sealing task.

“The main function of a seal continues to be the prevention of material transfer,” said Dr. Boris Traber, who works on intelligent sealing systems in Advanced Material Development at Freudenberg Sealing Technologies. “Still, you can design seals so they perform additional functions.” For example, integrating a sensor or a microchip into the seal can equip it with intelligence, but there are also limitations. That’s because the component incorporated into the seal is a foreign body and must not impair its function.

Developers at Freudenberg Sealing Technologies are therefore focusing on approaches in which the intelligence comes from the material itself. Here the elastomer can use its functional characteristics as a sensor and an actuator. “This will certainly involve additional costs. But within the context of the overall value chain, the advantages from the added functions can quickly outweigh them,” Traber said. That’s what happens when the seal recognizes its own wear, for example. This self-monitoring, known as “condition monitoring”, is possible if the elastomer is electrically conductive. To achieve this, electrically conductive filler is introduced directly into the elastomer mixture. It is important for the filler to combine good conductivity with good setting behavior and heat resistance, and very good cold flexibility to ensure the actual sealing function is not impaired.

In one possible application, a conductive elastomer base material is combined with an insulating outer layer during the manufacture of a rod seal. This insulating outer layer forms the seal lip. If the rod or the housing wall is connected with an electrical circuit, the current can become a sensor value. As the rod seal moves back and forth in its position, the outer (insulating) layer wears away and the conductive base material comes to the surface. This produces an electrical connection across the seal between the rod and the housing, which a suitable sensor (an LED, in the simplest case) will indicate as soon as the seal lip is worn out. “Operating costs can be optimized with such relatively simple solutions,” Traber said. “In this way, you can use a seal over its entire operating life, and not replace it too early. On the other hand, you avoid the damage and follow-up costs from leaks if replacement comes too late.” Automated maintenance support is also a key requirement in networked Industry 4.0 facilities.

But other functions can also be achieved with smart seals, and they can go beyond pure self-monitoring. For example, Freudenberg Sealing Technologies is investigating various dynamic seal elements such as diaphragms, which can serve as motion or force sensors for monitoring things like absolute position. This is possible with so-called dielectric elastomers. The diaphragm is constructed like a sandwich, with the two outer layers consisting of an electrically conductive elastomer. By contrast, the inner layer is made of an electrically insulating elastomer. If the diaphragm moves during use, the dielectric field strength (in physical terms, the capacitance) changes. This makes it possible to measure the force applied to the diaphragm.

If you actively apply voltage to dielectric elastomers, you can not only use the sealing elements as sensors – they could also become actuators. By applying electrical voltage, it is



possible to compress the elastomer. If you use an entire multilayered stack made up of numerous layers – and not just a “sandwich” – your elastomer structure could take over a valve function. When the current is activated, the entire stack is compressed and the valve opens. If there is no current, then the elastomer layers “relax” and the valve closes. This kind of valve could be continuously adjustable. Moreover, the energy needs are low since current is only required to execute the function. This is surely some way away from series application, but with its in-depth elastomer expertise, Freudenberg Sealing Technologies nonetheless believes it is well positioned for the further development of such materials.

The application potential for intelligent seals is extensive. At the same time, a key premise is that they can be used in any conceivable media because the base material is geared to the particular use. After all, the fundamental principle is that the seal should still perform its core function. Thermochromic coatings for temperature measurement can function exactly at the point where a seal is thermally stressed – inside an engine, for instance. This is particularly advantageous in areas where it is impossible to use a sensor. Conversely, electrical conductivity can expand the basic functionality of the elastomer by, say, heating a seal with poor cold tolerance so it can be used in cold climates. Even if many of the approaches at Freudenberg Sealing Technologies are still in the research phase, they are far from being science fiction.



## SIMULATION AT ITS MOST PRECISE

AS A GENERAL RULE, ROD SEALS SHOULD NOT LEAK. BUT A STABLE LUBRICATING FILM BETWEEN THE SEAL AND ITS COUNTER FACE IS INDISPENSABLE FOR LONG-TERM FUNCTIONALITY. INJECTORS NEED A PRECISELY ADJUSTED LUBRICATING FILM BETWEEN THE SEAL AND THE PUMP PISTON – TO PREVENT LEAKAGE AND GUARANTEE LUBRICATION. AT FREUDENBERG SEALING TECHNOLOGIES A NEW SIMULATION TOOL HAS RELIEVED DEVELOPERS OF THE NEED FOR ELABORATE, COMPLEX INVESTIGATIONS.

Absolute leak-tightness is not desirable in a number of applications. For example, rod seals need a certain amount of leakage as lubrication. But too much oil in the sealing gap is a disadvantage as well – it leads to environmental contamination and, among other things, shortens the operating life of a shock absorber due to continual oil losses. Dr. Fabian Kaiser, Advanced Product Technology at Freudenberg Sealing Technologies, was dissatisfied with earlier methods of calculating the precise lubrication for an application. “We were only able to ar-

rive at a viable prediction in experimental trials”, he explains. “That took time and led to high costs.” But the existing simulation models were too simple and inaccurate in their predictions and were unsuitable for use by quality-oriented development engineers.

Working with three Freudenberg Sealing Technologies production facilities and the Technical University Kaiserslautern in Germany, the engineer developed a simulation model as part of his dissertation. He was able to demonstrate its

suitability for practical use with trials on a test stand. The system is based on complex algorithms. For the user, however, its incorporation into the configuration of a seal is comparatively easy. This fast, precise tool is available to developers of rod seals at Freudenberg Sealing Technologies. It allows an exact determination of the right lubricating film thickness for the seal contact with the hydraulic cylinder as well as the dimensions of the seal that arise from the calculation. All this happens faster than ever before.





## CELL FRAME GASKETS: COST-EFFECTIVE ENERGY STORAGE FOR STABLE GRIDS

WITH A RISING SHARE OF WIND AND SOLAR POWER, THEY COULD MAKE A CRUCIAL CONTRIBUTION TO THE RELIABILITY OF THE ENERGY SUPPLY: REDOX FLOW BATTERIES STORE ELECTRICAL ENERGY IN SALT SOLUTIONS. FREUDENBERG SEALING TECHNOLOGIES IS DEVELOPING THE RIGHT ANSWERS FOR THIS RAPIDLY GROWING MARKET OF THE FUTURE.

Grid stability will be the ultimate challenge of the energy transition if the share of wind and solar power continues to grow – as is intended worldwide. That’s because electric power must be available when it is needed, even when clouds block the sun or a dead calm prevails. Large energy storage systems are an important tool for balancing output and demand. Redox flow batteries (RFB) are an especially interesting approach for this.

Energy storage systems consist of tanks, pumps and galvanic cells. Two electrolytes with different charges circulate in separate circuits. In the galvanic cell, electrons are released from the charged media as usable electricity and come into contact with the opposing electrode. The charge equalization of the system occurs via ion transport through a conductive membrane. This sophisticated technology – developed in the 1960s at Technical University Braunschweig in Germany – has a decisive advantage; it facilitates a system price of less than 100 dollars per kilowatt hour and is thus competitive with pumped storage and compressed-air storage plants. It is especially the use of conventional metals instead of rare earths that makes the redox flow battery so appealing. The technology is also scalable at nearly every level – from a few hundred watts to several megawatts – and the efficiency across a charging and discharging cycle is 75 to 80 percent. Other pluses are little self-discharge, extremely low maintenance and a long service life. The salts used are non-toxic, unlike the lead salts in lead acid batteries.

Demonstration facilities like those of Sumitomo/Japan with one megawatt of output and five megawatts of storage capacity have eight battery units. 16 battery stacks are housed in each unit, each with 1,000 cells. 25 tanks each hold 12.5 cubic meters

of electrolytic solution, and each tank has a centrifugal pump. The facility contains several hundred meters of pipework with countless connectors.

The sealing of more than 100,000 cells between 0.5 and two square meters in size is a challenge technically. Freudenberg Sealing Technologies has developed, specifically for this application, a cell frame gasket (CFG) made of EPDM, which enables reliable sealing of the stack. The long-term embedding of an electrically conductive nonwoven-carbon electrode in the stack could prove interesting. Customers could take delivery of a component consisting of a frame, a seal and an electrode unit, which would facilitate more rapid assembly of the systems. This combination – with products from other group companies in the spirit of “Innovating Together” – puts Freudenberg in a unique competitive position.

The seal is designed for a service life of ten years and must withstand 10,000 charge/discharge cycles without impairment. There are currently six products in development at Freudenberg Sealing Technologies for the overall RFB technology – from O-rings to the Usit ring.

The prospects are promising: For example, the California Storage Mandate specifies that a total of 1.3 gigawatts of storage capacity be installed within this U.S. state by 2020. The EU program Horizon 2020 is pursuing similar goals. In 2013, about 90 percent of the approximately 300 RFB facilities worldwide were in Asia and Europe. By 2017, one facility in three is expected to be in the U.S. – the annual growth rate of the technology is estimated at more than 200 percent.





## LUBE & SEAL: A HARMONIOUS RELATIONSHIP

SEALS AND LUBRICANTS ARE ALWAYS ENTERING INTO RELATIONSHIPS WITH ONE ANOTHER.

BUT AS IN REAL LIFE, IT IS NOT ALWAYS WELL-BALANCED. WHILE THERE ARE TEST STANDARDS FOR EVALUATING THE HARMONY BETWEEN THE SEALING MATERIAL AND THE LUBRICANT, DIFFERENT TEST PROCEDURES LEAD TO DIFFERENT RESULTS. IN THEIR “LUBE & SEAL” PROJECT, SEALING EXPERTS FROM FREUDENBERG SEALING TECHNOLOGIES ARE WORKING CLOSELY WITH THEIR CORPORATE COLLEAGUES FROM KLÜBER LUBRICATION TO ENSURE A HARMONIOUS RELATIONSHIP EVEN IN DIFFICULT COMBINATIONS.

Like any relationship, one between a sealing material and a lubricant is not immune to crises. Both are part of a tribological system, and mutual compatibility is essential for their proper functioning. Test procedures certainly exist based on Europe’s ISO (International Organization for Standardization) and America’s ASTM (American Society for Testing and Materials) standards, and developers can use them to test the compatibility of elastomers and lubricants. But the two standards differ from one another in their test requirements and can lead to different results. For example, the American standard prescribes a smaller quantity of oil and higher temperatures.

The result is that many lubricant and elastomer combinations from the EU – having demonstrated trouble-free interaction to European standards over many years of unity – can score differently in ASTM studies. In any case, it is virtually impos-

sible to recreate all operating conditions in standardized testing, particularly in special applications. For example, transmission seals in a conveyor system must be able to complete more than 20,000 operating hours without a failure – four times the operating life of a car.

The Freudenberg Sealing Technologies slogan, “Often invisible – always essential”, proves itself here, too. While the seals’ share of the overall cost of an industrial transmission is well below one percent, a seal failure can bring the whole system to a very costly halt in an extremely short time.

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### ACTIVELY “CULTIVATING RELATIONSHIPS”

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In the Lube & Seal project, Freudenberg Sealing Technologies and its corporate sib-

lings Klüber Lubrication and Freudenberg Corporate Research & Development have actively “cultivated relationships” for several years. They find the ideal combination of lubricant and sealing material for the respective requirement, both experimentally in the lab and on the test stand.

The transmissions of ZAE-AntriebsSysteme show how this can work. The Hamburg-based transmission manufacturer was initially unable to guarantee a customer’s durability requirements. Seal failures occurred again and again in a conveyor system before reaching the required 20,000 operating hours. By integrating ZAE into the Lube & Seal project, it was shown in simulations that the required lubricant was aspirated away from the seal edges. Practical tests on a test stand confirmed the finding. Excessive temperatures were developing at the edges – the cause of the wear was found. Thanks to the wear-resistant

elastomer compound 75 FKM 170055, it was possible to meet the customer's requirement for 20,000 operating hours. There have been no breakdowns due to a seal failure since then.

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### COMBINED PACKAGE OF MEASURES

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An ideal combination can be found with the help of joint, ongoing research on the seal ring material and the lubricant being used, with the enormous material know-how of Klüber and Freudenberg Sealing Technologies proving hugely beneficial. "We would not have been able to go into such depth with an external lubricant manufacturer," said Dr. Julia Kubasch, Freudenberg Corporate Research & Development. "Our major advantages with Lube & Seal are long-standing, trusting cooperation and the opportunity to leverage both elements – the oil and the seal." Just like a healthy and functional relationship!

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### GREAT DEMAND DUE TO INCREASING REQUIREMENTS

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Klüber Lubrication sees a growing need for joint Lube & Seal projects. "The demands on powertrain technologies are continually climbing," said Dr. Michael Hochmann. "For example, the use of 'environmentally acceptable lubricants' (EAL) in U.S. waters is required due to new legal standards in the marine sector. The use of these lubricants is placing additional demands on compatibility with the seals used in the marine field." As a result, a tribological system had to be worked out for ship powertrain systems that guaranteed flawless sealing function also in combination with Klüberbio EG 2-150, an EAL from Klüber Lubrication. A one-year field test on a Rhine ferry produced a clear result: The oil seals looked like new.

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### LUBE & SEAL IN THE U.S. AS WELL

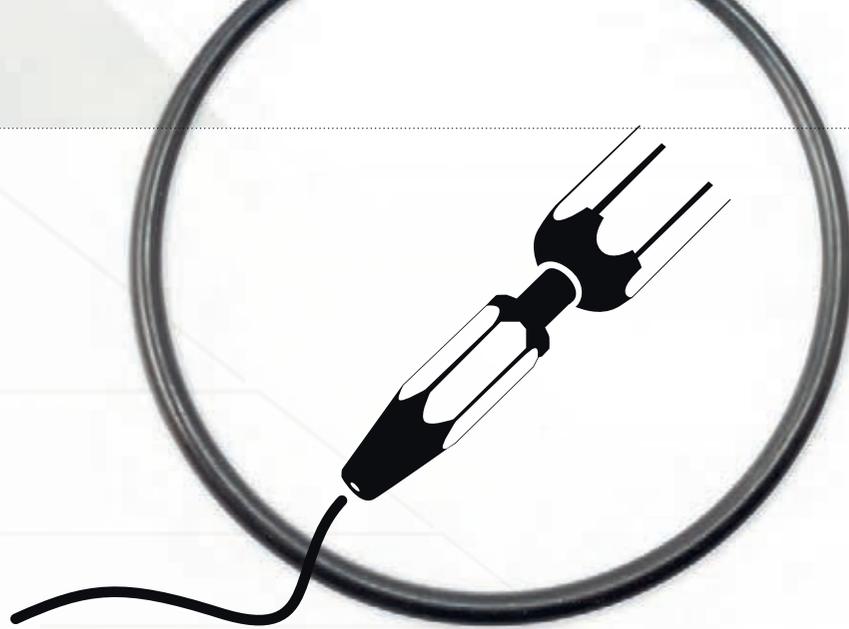
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As of this year, customers in the U.S. market can also benefit from this joint know-how – despite the country's different standards. "This way, we are giving our customers the certainty that their products will not only meet the appropriate standards, but also above all that a system failure can no longer result from a problematic combination of sealing material and lubricant," said Erich Prem, Freudenberg Sealing Technologies.

The excellent relationship between Freudenberg Sealing Technologies and Klüber Lubrication ensures that a harmonious coexistence of the elastomer and the lubricant continues even in critical situations. A performance ranking showing appropriate combinations of lubricants and elastomer materials based on the particular requirement provides orientation.

The experts at Freudenberg Sealing Technologies and Klüber Lubrication are ready to help with demanding and especially difficult cases of problem relationships and find the right solution. ©





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## MANUFACTURING MORE SUSTAINABLY

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**Analyzing large quantities of data and delivering precise information: A new IT tool in goods management systems reduces the need for materials in production. It's a promising approach that conserves resources and protects the environment.**

On average, the material in a seal accounts for 40 percent of its cost, making it all the more important not to waste any of it. "We need reliable data for the efficient use of materials," said Volker Schroiff, Head of Technology Management. "So we need to know whether compounds are destroyed because they haven't been retrieved at the right time and their maximum storage period has been exceeded. How much material do we waste during product changeovers when the equipment is flushed, and what losses are caused during forming by a particular production process?" A master's thesis, initiated and supported by Schroiff, has helped to clarify these issues. With O-ring and Simmerring production as an example, it was possible to determine with outstanding precision how much material "went missing" in which process steps. At the same time, the study clarified what proportions the different types of losses represent and where the data can be found in the SAP system.

Since O-rings are exclusively made of elastomers, they make especially good reference objects. Weinheim's Simmerring production, on the other hand, involves metallic support rings or springs. This makes it more difficult to determine compound loss accurately. "But our goal is to develop a uniform process in the SAP system that can be transferred to all the Freudenberg Sealing Technologies facilities and production processes," Schroiff said. To accomplish this, the new tool has to use and consolidate more data sources for Simmerrings than for less complex products. Facts in the form of concrete improvements can be derived from the data. This is a sustainable approach that lowers costs as well as the consumption of resources long-term – and thus spares the environment as well.

A workshop was held in March of this year to lay the foundation for the programming. The potential held by resource-sparing production methods is clearly shown by a novel net-shape process whereby the elastomer is sprayed directly into the mold via a nozzle. The sprue screen previously used has now been eliminated, significantly reducing raw-material usage and scrap.




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## A LONG LIFE - HIGH-PERFORMING SEALS FOR WIND TURBINES

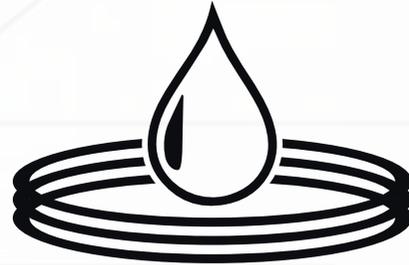
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Ever larger installations and increasingly extreme locations are creating high demands on seals for wind turbines. Freudenberg Sealing Technologies developed its “Ventoguard” material family to reliably seal the bearings of these massive electricity producers. Ventoguard seals help keep laborious maintenance work to a minimum during the equipment’s required twenty-year operating life, especially on the high seas.

The main bearings of wind turbines reach diameters of up to four meters. The maintenance work is correspondingly arduous: The replacement of a seal at a height of 100 meters takes several days. As a result, durability is of special interest to the operator.

But the demands on the seals are enormous, since they are exposed to extreme stresses. Depending on the location and the time of year, temperatures vary from  $-40^{\circ}\text{C}$  to well in excess of  $+40^{\circ}\text{C}$ . That is why the Ventoguard family developed by Freudenberg Sealing Technologies offers various solutions for a broad range of applications.

Freudenberg Sealing Technologies has developed a computer program that defines material characteristics, seal geometries and lubricants. The objective is to identify the best solution for a particular installation design and for on-site requirements, while achieving high wear resistance and optimal stability in the face of aging and media. With the help of lubricants from Klüber, lubrication specialist and another Freudenberg Group company, this ensures that the main bearing in wind turbines can do its job over a twenty-year period.




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## NEW SEALING MATERIAL FOR SYNTHETIC LUBRICANTS

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**Synthetic transmission oils based on esters and polyglycols have many advantages. They are more environmentally friendly than mineral oils, have applications in a wide range of temperatures, and have better oxidation resistance. But so far, they have had a negative effect on elastomer seals. With the new seal material FKM 260466, Freudenberg Sealing Technologies has solved this problem.**

The marriage of elastomers and lubricating oil has not been especially harmonious to this point. Additives that are exposed to the oil as well as the sealing material are often similar in their chemical composition. This results in chemical and physical effects: Both the frictional torque and the volume increase can change – which has an impact on the material’s rubber-elastic qualities. The loss of righting moment also leads to lower radial force – the main parameter for secure sealing in Simmerrings in transmissions, for example.

By developing a special sealing material, Freudenberg Sealing Technologies is acknowledging the greater use of synthetic transmission oils today – a trend relating to environmental issues as well as the limits of mineral oils’ effectiveness. This especially wear-resistant material made of fluoro rubber (75 FKM 260466) guarantees a longer service life even in combination with esters and polyglycols. The approach is easy on the environment: The share of renewable material in these bio lubricants is at least 25 percent, they are non-toxic and at least 60 percent biodegradable. Thanks to the new material, sealing problems no longer stand in the way of their use, even with the high stresses in transmissions.



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# OFTEN INVISIBLE ALWAYS ESSENTIAL



## KEEP ON RUNNING

You won't get far without them... Even though seals from Freudenberg Sealing Technologies may sometimes be taken for granted, their functions are vital. They must work around the clock and over thousands of miles – despite extreme conditions such as cold,

heat, dust and moisture. In the most literal sense, failure is not an option. Because going for a spin without a dependable vehicle is no fun at all.

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