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# Current trends and developments in global rail, infrastructure and rolling stock

## WHITE PAPER

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# CONTENTS

- I. INTRODUCTION: BROAD INDUSTRY TRENDS
  - A. CURRENT TRENDS IN RAILWAY INFRASTRUCTURE
  - B. CURRENT TRENDS IN ROLLING STOCK
- II. NEXANS: GLOBAL EXPERT IN RAIL SOLUTIONS
  - A. WHAT DO THE INFRASTRUCTURE AND ROLLING STOCK INDUSTRIES EXPECT FROM A CABLE MANUFACTURER?
  - B. RAILWAY INFRASTRUCTURE SOLUTIONS
  - C. ROLLING STOCK SOLUTIONS

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## SYNOPSIS

This report offers a general overview of the global Railway Network market, and information on how Nexans continues to provide new products, solutions and services to serve that market.

First, we will describe a number of broader trends in the global Railway Industry and how this is affected by global transportation requirements, recent technical developments, energy cost, climate change, customer demand and geographical developments. Next, we take a closer look at specific developments in infrastructure and rolling stock, and what actions Nexans is taking to meet current and future demands.

Overall, the key drivers for new developments are population and urbanisation, digitalisation and innovation, sustainability and economic developments in specific geographies. These changes are affecting infrastructure and rolling stock in a variety of ways.

Finally, we will look at the familiar product ranges Nexans offers, including the latest additions and updates.

### About the authors



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## INTRODUCTION: BROAD INDUSTRY TRENDS

Research by the International Railway Research Board (IRRB) and International Union of Railways (IUR) shows that demand for long distance rail solutions and more energy-efficient systems for rolling stock and infrastructure will grow as a result of demographic evolutions and lifestyle changes.



According to independent consultancy company SCI Verkehr<sup>1</sup>, global freight, passenger and urban rail transport around has been growing since 2005. Rail continues to be widely seen as a reliable and efficient mode of transport and there is no reason to assume this will change in the foreseeable future. According to the Unife (Association of the European Rail Industry) World Market Study 2018<sup>2</sup> total track infrastructure has reached more than 1.6 m km of urban and interurban tracks. Growth has largely been in the urban and very high speed track segments. Some 40% of all track kilometres are electrified, which means there is significant market potential for further track electrification.

According to Unife World Market Study, intended spending on rail projects has been taking place since 2015 despite the economic downturn. The Study also states that the overall industry, with a current market volume of just above EUR 159 bn per year, will to grow further at 2.6 % CAGR 1 until 2021 during the next six years – an unprecedented high level. Highest growth rates were recorded in the rolling stock and rail control segments, at 5.8 % and 4.9 % respectively. The total market for rail supply is expected to maintain the 2.6% growth of recent years and should reach around EUR 185 bn per annum in 2019 – 2021. Services and rolling stock are expected to supply 68% of expected market growth. Looking at segments, metro showed the highest growth rate, relatively speaking. The report expects the largest demand to remain in the interurban segment. In coming years, the highest growth rates are expected in the urban market driven by growing populations along with expanding metropolitan areas.

## Global population expansion and urbanisation

Global population increase and urbanisation on an unprecedented scale are driving growth in the transport market. By 2050, there will be 9.8 billion people on the planet, which is already driving demand for efficient, innovative and clean mobility solutions<sup>3</sup>.

Today, some 54% of the global population lives in cities. By 2020, this is expected to reach 66%, according to the UN World Urbanization figures<sup>4</sup>. Europe and the USA are expected to have reached an even higher level of urbanization by then. By 2050 most people will be living in or near cities, a fact that impacts the movement of people and goods, especially in areas of high congestion. The need for urban mass transit solutions will rise significantly in coming years.



Around the world, rail lines are carrying 10 billion tons of freight and 21 billion people each year. Demand for rail is outpacing capacity and infrastructure creating bottlenecks and the efficiency of legacy systems. Passenger and freight rail need to change in order to meet current demands in the area of, mobility, sustainability and digitalisation.

## Digitalisation

The rail industry is adopting digital technology in order to improve customer journeys and planning with real time information and cross-platform tools, providing enhanced ticketing services and offering travellers a more streamlined experience. Infrastructure management is also being enhanced through digitalisation to reduce delays and predict potential problems. Combining Information Technology and Operational Technology with connectivity, Internet of Things and cloud functionality allows systems to autonomously exchange information and initiate actions.

Component-level sensors can provide early warnings when maintenance is required, avoiding breakdowns. According to McKinsey<sup>5</sup> advanced analytics will make condition-based maintenance “an attractive lever to increase maintenance efficiency.” Condition-based maintenance could save the global maintenance market around €7.5 billion per year by. A ‘must’ for regional and urban rail operators and cargo operators, says McKinsey, as these segments will be most affected by increased competition.

A few examples of sensor and ‘smartness’ applications in rail: Deutsche Bahn and Hyperloop Transportation Technologies (HTT) have developed augmented reality windows. In Seoul, smart cameras track passenger numbers and boarding speed and at central China’s Wuhan Railway Station, facial recognition assists boarding. Around the world, automated driverless passenger trains are being used to optimise the running times and Australian freight company Rio Tinto successfully introduced a fully autonomous freight train in October 2017.

The developing digital ecosystem is bringing new, digital services and business models that rely on connectivity and data. New control technologies, such as communications-based train control (CBTC) and autonomous trains are further improving helping maximize use of assets and controlling costs. Optical Fibre cable demand and the importance of cyber-security will increase along with the increasing importance of digitalisation.

## Sustainability

Efforts to decarbonise transport are progressing rapidly. The 2015 Paris Climate Summit (COP 21) saw a broad coalition agree to halt global warming at 2°C, or even 1.5°. 195 countries

committed themselves to limiting greenhouse gas emissions to less than 2% in coming years, in line with Intended Nationally Determined Contributions (INDCs).<sup>6</sup>

Unife comments that rail industry growth will support sustainable improvement of mobility in developed and developing countries, with rail as the backbone of an intermodal transport system that allows urbanisation to go hand in hand with sustainable development goals. Across the rail industry, innovations are being introduced to reduce the use of power and resources, such as freight transport through dedicated rail corridors.

Several alternatives to diesel trains are being developed around the world:

- Onboard fuel cells in trains that combine hydrogen and oxygen.<sup>7</sup>
- Liquefied natural gas (LNG) as an option for dual-fuel locomotives.
- Locomotives recharged by overhead wires, electrified tracks or at charging stations.<sup>8</sup>

## Geographical development

Various regional markets are expected to keep growing steadily. The highest growth rates are expected in Western Europe (3.1%) and Africa/Middle East (3.0%). In South America, a relatively large number of metro and train projects are currently under development. Unife reports that over the past two years the overall rail supply market has seen substantial growth at 3%, primarily driven by the Asian Pacific region, with large projects in India and China. According to SCI Verkehr, the degree of electrification in Asia has risen substantially in recent years, from 34% in 2013 to 47% in 2017. China's growth consists of new lines and electrification of diesel. Furthermore, Sub-Saharan Africa is currently an attractive region for rail suppliers with high growth rates, states Unife.

## Railway innovation

In China, several MAGLEV projects are in the pipeline, and key metro projects are being undertaken in big cities. Innovate UK, part of the Department of Transport's (DfT) wider Accelerating Innovation in Rail (AliR) scheme, is funding a wide variety of innovations to the tune of £7.9 m. Examples include carriages design that can quickly switch from passengers to goods transport, 'intelligent trains' beacons for visually impaired passengers and methods of guiding boarding passengers to empty seats.

In September 2017, Hyperloop One successfully completed its second test, in which a carriage passing through a near-vacuum test tunnel reached speeds in excess of 300 km/h. Adoption of this mode of transport on a wide scale could lead us to completely rethink travel distances and times and urbanization.

1 [https://www.sci.de/en/document/news/weltmarkt-fuer-bahnelektrifizierung-waechst-weiter-anhaltende-investitionen-in-europa-und-asien-sorge/?no\\_cache=1&tx\\_news\\_pi1%5Bcontroller%5D=News&tx\\_news\\_pi1%5Baction%5D=detail&cHash=697c4d9ea5137dba8ce8635895529415](https://www.sci.de/en/document/news/weltmarkt-fuer-bahnelektrifizierung-waechst-weiter-anhaltende-investitionen-in-europa-und-asien-sorge/?no_cache=1&tx_news_pi1%5Bcontroller%5D=News&tx_news_pi1%5Baction%5D=detail&cHash=697c4d9ea5137dba8ce8635895529415)

2 <http://unife.org/publication-press/wrms.html>

3 <https://esa.un.org/unpd/wup>

4 <https://www.un.org/development/desa/en/news/population/world-population-prospects-2017.html>

5 <https://www.mckinsey.com/industries/travel-transport-and-logistics/our-insights/the-rail-sectors-changing-maintenance-game>

6 <https://www.eia.gov/outlooks/ieo/emissions.php>

7 <https://www.railway-technology.com/features/featurehydrogen-fuel-cells-vs-batteries-how-to-power-the-trains-of-tomorrow-5692017/>

8 <https://www.railway-technology.com/features/featurehydrogen-fuel-cells-vs-batteries-how-to-power-the-trains-of-tomorrow-5692017/>

# CURRENT TRENDS IN RAILWAY INFRASTRUCTURE

According to a recent study by Transparency Market Research<sup>9</sup>, the key driver boosting the rail infrastructure market is increased demand for transportation as a result of rapid globalization. The study also points out that aging transport infrastructure is also a likely driver for the global rail infrastructure market. Dated urban transport can no longer meet today's requirements. Marketwatch<sup>10</sup> claims that the global Rail Infrastructure market, valued at 47000 million US\$ in 2017, will reach 61400 mn US\$ by the end of 2025, growing at a CAGR of 3.4% during 2018-2025.



## Interoperability

In Europe, each country has adopted different systems, specifications and standards for railways. This covers everything from component sizes, to track widths, signalling systems and IT standards. For the European Commission, a current key topic is realising interoperability, enabling, for example compatibility and communication between IT and signalling systems as well as cross-border trains. An important development aiming to enhance rail efficiency is increased interoperability and standardization. In Europe, significant progress is being made. The first Technical Specifications for Interoperability (TSI) related to railway infrastructure, energy, rolling stock, control-command and signalling, maintenance and operation from the European Association for Railway Interoperability (AEIF) was adopted in 2002 and revised in 2008. The Delegated decision (EU) 2017/1474 set out common and specific objectives of all TSIs to be developed or amended with a view to harmonising them and streamlining the EU railway legislation. In accordance with these, the Commission issued a mandate for drafting, adoption and review of TSIs in 2017. The EU's Fourth Railway Package aims to make the European rail system more efficient and better adapted to changing transport needs. The resulting harmonisation of European rail traffic should positively affect rail operators and suppliers.

The European Rail Traffic Management System (ERTMS) is the system of standards for management and interoperation of signalling for railways by the European Union (EU). Its main target is to promote interoperability of trains across the EU, enhancing rail safety, and efficiency and cross-border interoperability by replacing national signalling equipment and operational procedures with a unified pan- European train control and command standard.

ERTMS is conducted by the European Union Agency for Railways (ERA) and covers

- GSM-R (communication),
- European Train Control System (ETCS, signalling),
- European Train Management Layer (ETML, payload management)

ERTMS has three levels. ERTMS levels 2 and 1 are based on physical layer cable, whereas level 3 cable is mainly based on mobile information, satellite, wireless data and cloud.

In its Strategic Business Plan (SBP) 'Electrical equipment and systems for railways' the IEC TC 9 body is preparing international standards for railway which include rolling stock, fixed installations, management systems (including communication, signalling and processing systems) for railway operation, their interfaces and their ecological environment. The standards cover railway networks, metropolitan transport networks (including metros, tramways, trolleybuses and fully automated transport systems) and magnetic levitated transport systems. The standards relate to systems, components and software.

## Digitalisation

In rail infrastructure, digitalisation can be applied in different areas:

### 1. Asset management

Using collected data, an operator could make traffic management smarter, or better understand occupation and utilization levels at different times. Some power companies are already developing systems with IoT and sensors built in for emergency detection. It would be possible to create something similar for rail, which allows ongoing analysis of rail quality, potential damage and so on.

### 2. Mobility management



People are becoming increasingly mobile, traveling for work and pleasure. Digitalisation opens up new possibilities in customer service such as ticketing and trip planning. Taking this a step further, Digitization and system integration at multiple levels makes multimodal travel possible: the seamless combination of different transportation modalities, including related information and planning services. This requires the right infrastructure, supported by high-quality, real-time information systems that enable the connection of routes, schedules and fares and possibly allows travel using a single ticket. Furthermore, congestion and power consumption are significantly reduced.

The benefits are smooth, fast journey for the customer, who may be prompted to use routes or vehicles they may not be aware of, or which they might not normally use. They are also provided with up-to-date information, if necessary, across different devices if required. To make multimodal travel work, transportation systems need to be closely connected in both a virtual and physical sense.

Mobility management requires many different systems to work together seamlessly, for which certain networks will need to be upgraded. Also, IT platforms have to be capable of processing across different channels and understanding each other. In some countries, such as France, a single organization may provide rail services, whereas in the UK, for example, there are different operators. This, too, will require a significant degree of harmonisation.

### 3. Predictive and condition- based maintenance

Predictive maintenance is becoming an important topic for rail companies. With lines becoming denser and faster, any maintenance work needs to be predicted in advance. Currently, considerable effort is being put into investigating how maintenance can be carried out without interrupting traffic. Normally, a group of experts is sent to a site to gauge the quality of installations and schedule maintenance accordingly. If, for example, a cable requires closer inspection, the installation will need to be shut down. This brings considerable costs in the areas of time and money, especially because schedules are interrupted. Often, downtime is planned at night, which is also inconvenient. There is a need to predict when maintenance is required quickly and cost-effectively.

One option is to integrate sensors and some form of intelligence into cables, and combining this with data analysis and new installation models. Nexans is looking into these areas and building the required capabilities in our digital lab, as well as leveraging know-how from other parts of the company. The result: control and testing of large installation allowing very precisely scheduled maintenance to take place when and where required.

A 'data spine' is required across the entire network to allow infrastructure managers to introduce route-based maintenance management assessment that can model failure patterns and identify high and low risk components for whole-life asset management, especially for power supply equipment and line-side signal cabinets. This 'smart maintenance' concept which will shift from time-based to condition-based maintenance will require sophisticated information and communication technology based on a track-side cable systems which could even incorporate an Automatic Track Warning System (ATWS) to protect staff working on repairs.

### 4. Autonomous vehicles

Around the world, there are already many examples of driverless trains and shuttles, for example at airports. This fast-growing technology area strongly relies on structured cabling and component connectivity. This allows, for example, doors on a platform to open in exactly the right place at the right time.

### 5. Sensor applications

When building a long stretch of railway, which might easily be 100 kilometres, multiple cable drums need to be positioned at different spots along the trajectory. By integrating sensors, drums can be identified, located and delivered more easily. Tracking functionalities also prevent theft.

## 6. Fire safety: focus on CPR

On July 1, 2017, the Construction Product Regulation (CPR) applicable to cabling came into force. This new classification system is to be used wherever electrical systems are permanently installed across Europe. CPR covers all products incorporated into residential, commercial, or industrial buildings and other civil works. Its scope now also includes power and control cables of any rated voltage, as well as communication cables with metal and glass (optical fibre) conductors.



CPR provides a common technical language and a harmonised set of rules for assessment and performance testing of construction products in the EU. It extends responsibility to all of the parties in the supply chain and improves quality monitoring. Before a product reaches the market, manufacturers are obliged to draw up a Declaration of Performance (DoP). Independent product certification bodies and test laboratories identify each product, its intended use and its fire performance characteristics. The highest cable assessment criteria are extremely challenging, as these represent worst-case scenarios. CE-marked cables guarantee enhanced performances, transparency and reliability.

For tunnels longer than one kilometre, European regulations require definition of minimum category of cables in relation to fire performance. To make compliance with CPR easier, Nexans offers certified products, as well as experience, extended technical expertise, information and support. A full range of fire-resistant, asbestos free and RoHS (Restriction of Hazardous Substances) compliant cables is available.

Nexans is actively participating in CPR European technical committees, and our customers are being duly informed and updated on the evolution of the legislation. Nexans Tracker™ gives quick and easy access to the Declaration of Performance online, allowing direct consultation and download of Regulatory Information related to CPR. User can check compliance of products with the regulation and their performance classes immediately, anytime, anywhere.

Nexans is additionally providing advice and dedicated tools, from training and (online tutorials) to brochures and FAQs. Clear CE marking and consistent labelling, which clearly displays all useful information and is exactly the same for every Nexans product.

9 <https://www.transparencymarketresearch.com/rail-infrastructure-market.html>

10 <https://www.marketwatch.com/press-release/rail-infrastructure-market-2018-global-share-trend-segmentation-analysis-and-forecast-to-2025-2018-06-28>

# CURRENT TRENDS IN ROLLING STOCK

According to Unife, the market for rolling stock amounted to approximately 54 bn EUR per annum in the past two years. APAC accounted for the largest part of the total market with some 44 % market share followed by Western Europe (19%) and NAFTA (15%).

We are seeing three key trends rolling stock, driven by customer demand, technology developments and legislation.

- Fire safety
- Communication
- Power consumption



## Fire Safety

Increased passenger volumes, network density and regulations are all drivers for enhanced passenger safety. In general, rail infrastructure is difficult to evacuate and escape from, making this topic even more important. Operators, partly driven by customer demand, are looking to increase train safety. At Nexans, this has resulted in the development of a specific 'fire resistance' FLAMEX® product range. The goal is preventing fire from spreading through cable trays and ensuring the lowest possible emissions of smoke and toxic fumes, whilst guaranteeing that power and communications systems continue to work for as long as possible.

Fire resistance in buildings, or other sensitive industrial fields, has been a topic of discussion for years, but for rolling stock this is a relatively new area. In shipbuilding, for example, fire resistant cable has been standard for years, with fire resistant Power, Control and Instrumentation cables in place on board years ago. Nexans led this trend toward more safety on board of cruise liners with the renowned SHIPLINK® MPRXCX 331 or TCX 331 series. The learnings from maritime applications – subject to stringent regulation and often involving hundreds of kilometres of cabling – are being leveraged for rolling stock applications.

## Data Transmission and Communication

In rolling stock, there is a clear trend towards enhanced communication, monitoring and on-board system intelligence. There is marked interest in close monitoring of a wide variety of functions, which are closely linked to the train itself: speed, consumption of electricity or fuel, routes and so on. Operators are interested in introducing new features, such as the ability to book and change seats online. WiFi is also becoming increasingly common on trains. Increased data transmission rates are driving up cabling requirements from CAT 5 - the current standard - towards Cat 6A and 7.

Traditional on-board cabling is deployed with Ethernet CAT 5 with different cross-sections depending on the requirements of different rolling stock manufacturers. However, train operators are facing marked growth of on-board data traffic, resulting from enhanced WiFi systems, interactive technology for making seat reservations, intelligent door display systems, passenger information provided on high definition screens, and luggage monitoring. Furthermore, customers have higher expectations regarding mobile phone and internet access on board, as well as entertainment and multimedia access. This places more pressure on the train operators in terms

of customer service. In response to this trend, FLAMEX® CAT 6A to 7A cables with higher performance rates have been introduced to the railway market: the data transmission backbone is mainly designed with these cables whereas cable looms for local networks inside the coaches are locally designed with Ethernet CAT 5 quads that are faster to install, lighter and smaller for tight bending. To support rolling stock customers in this transition, Nexans is offering the latest generation of FLAMEX® CAT 7A cables alongside traditional CAT 5 cables. While data transmission speed of Ethernet CAT 5 cables is limited at 1 Gbps, Nexans FLAMEX® CAT 7 cables for rolling stock can support up to 10 Gbps, bringing customer experience to a whole new level. Nexans can also provide 7A for rail applications, although there are no dedicated rolling stock connectors for 7A yet.

### **Weight in relation to power consumption**

As we have seen in the automotive, aerospace and logistics sectors, weight reduction is essential in all transport segments. On a train, cables run everywhere, through doors, floors, the roof, the toilets... Every metre of train houses approximately 1km of cable. Reduction of cable weight on board has a significant impact on energy consumption, and also reduces wear and tear of the rolling stock equipment. What's more payments to rail authorities for track use are also lower when weight is decreased. To accommodate these requirements, Nexans has created thinner cable designs with high performance material. In a building, a larger diameter wouldn't be a problem, but on board there are space constraints and tight bending.

Nexans has developed family of cabling using material that operates at higher performance levels, so that power throughput – and cable volume - can be decreased. This is particularly the case with FLAMEX® Control EN 50306 and Power high temperature EN 50382 series. A specific flexible aluminium cable line was also created to tackle this challenge in the rolling stock industry. Nexans has been focusing on rethinking concepts and also introducing incremental improvements, improving designs, materials and more. This is largely done with our engineering departments at plants in France, Germany and China. All products are developed in-house, and our capabilities are fully utilised.

Development of new cable takes time and costs considerable engineering resources, which are already stretched by their involvement on existing projects. At corporate level, we are adding a competence centre that will support materials development, for example for insulation and sheathing material. Our INFIT™ technology for FLAMEX® Ethernet Fire resistant cables, for example, has been under development for more than ten years and has resulted in several patents which were used to create fire resistant Ethernet cable. We are also working closely with colleagues in the metallurgy department and business units such as Accessories, with whom we're developing full systems of aluminium or high voltage cables.

Nexans also has the ability to test and develop intercar cables. These can be single core power cables, but also more complex hybrid jumper cables, including control and communication along with power in a single jacket. Installation needs to be easy and the cables have to withstand the operational mechanical stresses of rail use. This has implications for cable design and requires millions of test cycles.

## WHAT DO THE INFRASTRUCTURE AND ROLLING STOCK INDUSTRIES EXPECT FROM A CABLE MANUFACTURER?

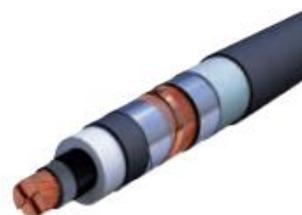
- A full range of power, signalling and communication cables and solutions to meet all current and future infrastructure needs, both trackside and at stations, control centres, etc.
- Because of the international nature of railway expansion worldwide, a regional supply base, with firm guarantees that a certain percentage of supply will be locally manufactured or easily available.
- Innovation to ensure faster and easier installation of key elements like axle counters, and, if required, full compliance of cables with national standards, and also the ability to evolve and adapt to changing infrastructures (including backward compatibility with existing networks).
- Solutions to problems like copper theft, and advanced safety assurances in terms of fire-resistance, not only for safety cables, but also for medium-voltage and telecom cables.
- New installation methods that can reduce time and cut costs.
- Optical fibre universality in the IP world, coupled with ruggedness in the field.
- Reduction of complexity in cable and system procurement, a simplification of references for buried cables, and a harmonization of specifications and designs.
- Advanced technical knowledge from a trusted supplier, since in many cases operators are losing their long-acquired expertise through generational attrition of their own in-house experts.
- Special services, such as inventory management and e-services.



# NEWANS RAILWAY INFRASTRUCTURE SOLUTIONS

## Traction-feeder cables

These cables are for MV and HV energy transmission to and from transformer substations and for powering catenaries and systems. The cables are installed along the tracks, and a new generation with non-hygroscopic characteristics can be directly buried.



## Power distribution cables and components

These standard cables handle 16.7/50/60 Hz current and can be installed as easily as traditional energy networks. A wide range of earthing cables is available with optional anti-theft markings or metal-hybrid constructions.

## Signalling cables

These energy and telecommunication copper cables provide LV power and bidirectional communications for trackside equipment and vital relay stations. They come in multi-conductor or multi-pair/quad versions.



## Axle counter cables

Armoured and unarmoured 90 kHz multi-conductor cables provide information on train position, circulation path, length, number of cars and train integrity.

## Optical-fibre cables

To handle data exchange for Automatic Train Control, these cables are available in LAN, MAN, and WAN versions with special protection in tunnels and against fire. New solutions are available using micro-bundles, which are compact and cost-effective.

## Radiating cables

Perforated coaxial cables function as antennas in confined areas, like tunnels, subway stations, and so on where traditional antennas do not work. These are vital for radio technologies.



## Optical IP switches

These are used to interconnect Ethernet-based track devices for communication and monitoring. The switches feature 3 fibre optic uplink ports and 8 copper ports and can supply IP cameras, phones, WLAN access point with Power over Ethernet (PoE).

## Innovative solutions for cost-effective upgrades and safety

### 1. All-in-one DuoTrack for easy electrification

In 2007, Nexans launched DuoTrack®, a breakthrough in-train control and communication network technology. By combining copper-based functions and fibre-optic transmission in a single rail-attached cable it gave non-electrified regional lines the same security guarantees as main lines in terms of signalling, train control, telecommunications and advanced ETCS and GSM-R.

This hybrid cable is clamped directly to the rail and allows operators to save 30-40% of cable installation time, while achieving cost savings of over 50% for their complete system. This innovation also discourages copper theft since stealing cable requires the painstaking removal of the clamps placed at short distances from each other: not feasible for thieves and quite dangerous.

DuoTrack® is a complete cabling system which includes cable, hybrid closures, custom-built clamps and branches and advanced laying equipment. It has been rigorously tested by Germany's Deutsche Bahn over a nine-year period on the main transit line between Germany and Scandinavia and is now approved by the German Federal Railway Authority (EBA).



### 2. Eurobalise cables for interoperability

These fully compliant ERTMS cables combine reliability, mechanical strength and electromagnetic compatibility for carrying HF signals for the overall traffic control system. Phased in with GPS, ERTMS will improve safety and efficiency, and promote standardization and interoperability.

Nexans originally developed halogen-free signalling cables for Level 1 ETCS Eurobalise applications to connect trackside signalling equipment to radio transmit vital data to the train's onboard computer. They are now fully operative on Level 2 installations as well.

Eurobalise cable has a low mutual capacity of around 42. 3nF / km, which is low enough to transfer data and energy over long distances (up to several kilometres) It is also designed to survive between and along the tracks.

### 3. Flame-retardant, fire-retardant, fire-resistant cables for protection

Three different cable categories have been developed by Nexans

- Flame-retardant cables that self-extinguish in case of a flame application to a single cable

- Fire-retardant cables that do not propagate the fire and with a low smoke and gas generation
- Fire-resistant cables which ensure the operation of vital equipment during a fire, such as keeping escape exit lights and exit signs lit, signalling information flowing, and fire-fighting equipment operating.

For these critical safety systems in substations or tunnels, Nexans has developed special fire-Resistant Medium-Voltage Cables, Optical Fibre cables, LV, signalling cables all in Fire resistant options.

In recent years, special projects have been deployed within Nexans to develop Flame or Fire-retardant cables complying with fire requirements of the new Construction Public Regulation (CPR), in particular cables meeting the required classification for cables installed in tunnels longer than 1 km, the Euroclass B2ca, s1a, a1.

#### 4. RheyRail® to discourage copper theft

Since copper reached record values, stealing copper cables along railway tracks has become a lucrative business for organized criminal gangs. Across Europe, hundreds of incidents occur both night and day, adding up to thousands of tons of lost conductors (primarily copper) and a replacement bill which runs into hundreds of millions of Euros.

Also, copper theft causes service disruptions that can greatly exceed the replacement costs of cables. Moreover, degradation of vital infrastructure is a threat to achieving the highest standards of public safety.

For surface-installed grounding wires (between power poles and rails) Nexans has developed RHEYRAIL®, a standard-sized copper-core conductor. This cable discourages copper theft through hard-to-cut, fine steel wire strands at the core and outer layer; integrated and insulated monitoring wires for fast detection; rugged steel-tape armouring to protect conductor and cable survey; and a heavy-duty polyurethane halogen-free sheath jacket to hamper sheath removal. Also, its conductor size and capacity fully comply with standard connectors, lugs and ampacity.

In addition to the cable, a monitoring system has been developed for detection of damage to RHEYRAIL cables, protection against theft and detection of manipulations for the purpose of cable theft. The damage caused by cable theft is considerable and exceeds the material value of the stolen cables by many times over.

Nexans new solution permanently monitors return line systems in such a way that defects are recognized as quickly as possible. When damage is detected, emergency forces should be alerted and directed to the location of the damage. Changes to the cable, as well as those affecting the monitoring wires, are identified and reported immediately. In the event of a fault, localisation can alternatively be carried out by measuring the resistance or the capacitance.

# NEXANS ROLLING STOCK SOLUTIONS

FLAMEX® cables for Rolling Stock are halogen-free, non-toxic, non-corrosive, low smoke, flame and fire-retardant. They comply with EN 45545-2, the European standard covering fire behaviour of materials and products in railway rolling stock. Besides complying with EN 45545-2, FLAMEX® solutions meet various international standards such as NFPA 130 and GOST-R 31565 and the IEC 61156-6 electrical requirement.



Nexans assures compliance to standards through rigorous testing in its research laboratories that are ISO 17025 certified. Robust and durable, the cables are tested for 20,000 hours of peak operation to ensure high levels of safety for passengers and equipment. The range is also asbestos free and RoHS (Restriction of Hazardous Substances) compliant.

To ensure easy installation, the cables are fully compatible with connectors designed for rolling stock projects, such as X-coded M12 connectors. Furthermore, the easy-to-strip insulation and sheath also make it possible to install and connect cables easier and faster.

## THIN TO ULTRA THIN CONTROL WIRES & CABLES

Energy concerns of operators have inspired development of smaller, lighter products. Single or multi-core, shielded or unshielded, for all command and surveillance functions, compliant with the performances and design requirements of the EN 50306 series: doors, lighting, converters / transformers.

## FLEXIBLE AND ROBUST POWER CABLES

### Rolling stock power cables

Nexans offers a wide range of flexible Power cables designed with stranded tinned copper wire according to European standard EN 50264-3. Their cross-linked insulation and/or outer sheath provides high resistance to chemicals, mechanical stress and extreme temperatures to face the various installation and working conditions. These products meet the highest hazard level class HL-3 from the EN 45545-2.



## High-temperature flexible power cables



To deal with extreme operating temperatures from -50° to 150° C, these power cables are designed for fixed installation or for inter-cars. The FLAMEX® EN 50382-2 silicone-based cables provide further weight savings compared to regular power cables, allowing higher working temperature. These cables are used to feed high-voltage machines, transformers, motors or generators, where high temperatures prevail, and flexibility is required.

## Roof line system solution

Tailor-made to carrying electricity from the pantograph to the locomotive's transformer, Nexans solutions cover flexible 26/45kV HV cables (FLAMEX® (N)TMCGCHXOE and FLAMEX® PANTO), bushings and T-connectors. These high voltage components can also be supplied with the required cable length as a pre-mounted, pre-tested cable assembly before the installation on board of the vehicles.

## HIGH RATE COMMUNICATION CABLES

### Ethernet, Databus or Coaxial cables

A pressing need for train management has led to significant advances in data cable designs. Nexans is extending the scope of Ethernet cables toward higher data transmission to keep supporting customers' challenges. Designed to cope with transmission rate up to 10 Gigabit, Ethernet cables will step by step replace the former communication protocols with Profibus, MVB, WTB for passenger video services/surveillance and the monitoring of vital equipment for the train operation. A braided shield ensures the cables can withstand heavy electromagnetic disturbances ensuring a reliable signal transmission. Its cross-linked outer sheath provides fire performance and high resistance to chemicals, mechanical stress and extreme temperatures required in rolling stock.

### Optical fiber cables

Instead of a copper-based twisted-pair bus cable, customised multimode optical fibre cable delivers high bandwidth for onboard services: video, interactive passenger information, WIFI and Internet. These solutions are designed for fixed installation or intercar links.

## FIRE RESISTANT CABLES

In the rail industry, tunnels and rail cars can quickly turn into potentially lethal enclosures if a fire breaks out. It is essential to maintain power and control system operation to ensure the train can continue to a safe place.

Safety is a key concern for Nexans and our customers, transit authorities and manufacturers. Addressing this concern is our top priority. Increasing safety demands are a driver for finding better ways to assure electrical circuit integrity and improve fire performance. A new product line is emerging with FLAMEX fire-resistant cables that ensure circuit integrity of key components per the EN 50200. Power, control and communication cables are of course compliant with EN 45545-2 meeting the highest hazard level class HL-3.



FLAMEX® cables are designed for a long service life and feature a braided shield and cable sheath for protection against EMC and harsh operating conditions such as heavy vibration and abrasion. They have a working temperature range of -40°C to +85°C. The FLAMEX® Fire Resistant range meets the most stringent regulations in the industry while maintaining performance, and therefore safety. To meet increasing demand for higher safety, Nexans designed a full range of fire-resistant cables to assure passenger exit or train movement to a safe zone.

### **Solutions for Communication networks**

FLAMEX® Ethernet FR product range ensures cable integrity keeping control of the critical emergency functions in the most demanding fire situations. FLAMEX® Ethernet FR can reach data transmission performances for Category 5 as described in the ISO/CEI 11801 showing no loss of data train and no drop of the transmission parameters when burnt. This performance is achievable thanks to Nexans unique technology for fire resistant cables known as INFIT™.

On top of the fire performances this technology makes easier and faster the preparation and the connection of the wires with rolling stock connectors compared to older taping technologies. Lastly this product line helps savings weight on board by getting rid of heavy mechanical protections and moving to updated communication systems.

### **Solutions for Power and Control networks**

FLAMEX® SI-FR product line meet fire resistance requirements laid out by EN 50200 or IEC 60331 standards. These cables enable the continuous flow of power needed for emergency systems to function reliably when needed most, providing improved safety for operators and fire response personnel. FLAMEX® SI-FR cables can withstand the harsh operating conditions on rolling stock. They are particularly suitable where high temperatures are required to save weight as the cables can operate at up to 170°C with a maximum operating voltage of 3 or 6 kV. As for other FLAMEX® types, these cables help limit the spread of potential fires and the release of harmful smoke.

### **CUSTOMIZED SOLUTIONS FOR JUMPERS**

To link cars/bogies/wheels, strong and flexible jumper cables carry information (through Ethernet, databus, coaxial components) and energy (for control and power) in an open, moving environment for millions of cycles. Nexans engineering teams work in partnership with its customers and the suppliers of components to take the right design decisions to deliver reliable jumper assemblies and minimize the potential risk of failure after years in operation.



## CUSTOMISED SERVICES FOR ROLLING STOCK

Innovation is no longer an option for industry. Digital transformations, a growing regulatory environment and profitability require rethinking traditional business and technology approaches to help sustainable performance.

This is why Nexans has developed a unique program of services to support the operational and financial performance for industrial operators.

A program based on engineering, digital, innovation, business and logistical expertise. A leading know how to cope with your future industrial challenges.

For rolling stock, Nexans can provide customized solutions from engineering to supply chain and to recycling. In each step of the rolling stock process Nexans engineers help performance of its partners.

We are offering dedicated services in three areas:

- **Supply Chain and Operations**
- **Engineering of electrical cabling**
- **Business Support**

Each of these areas, and the related services, are discussed below.

### **Rethinking Supply Chain and Operations**

Rolling stock players, in particular OEMs and their subcontractors, are seeking to reduce their total cost of ownership. Where electrical cable is concerned, Nexans uses analysis tools to carry out diagnostics and propose personalized solutions combining RFID technology and modern supply chain methodologies. The aim: reduction of costs in operation, improved cash flow, freeing up warehouse space and simplifying project management.

Your performance depends on perfect project execution, so you need to rely on solutions designed to increase supply chain reliability while minimizing your costs and working capital requirement.

### **Service 1: ADVANCED LOGISTICS**



In large projects, cable logistics come with specific demands and severe constraints. Storage space on the confined work site is usually non-existent, and there is always a real risk of cable theft. However, execution delays come with severe penalties.

Nexans offers an end-to-end cable logistics solution that takes into account the specific context of projects. This including storage, just-in-time delivery and project management tools tailored to your project environment and context

Our on-time execution combined with just-in-time delivery means a significant reduction of project site congestion as well as better control of budgets. This approach also guarantees securisation of materials and equipment right up to the last minute.

Benefits:

- 70% storage space reduction
- 20 to 50% cost savings on logistics
- Cable stock at customer disposal when required
- Cut-to-length if required
- Transportation to construction site
- Project management tools allowing traceability and ongoing updates on stock whereabouts and availability

### **Service 2: SMART INVENTORY MANAGEMENT**

An RFID-based solution allows reliable automatic stock replenishment, fast and easy physical stock counting and incoming good reception process. Our multi-supplier, multi-product solution is based on efficient demand-driven supply models and the usage of advanced RFID technology to easily monitor your stocks and manage your inventories in real-time. Your entire portfolio of supplies can be managed through one platform and a single system.

Benefits:

- Reliable demand driven automatic stock replenishment
- Lowest possible inventory levels
- 100% Material availability
- Simplification and acceleration of incoming goods reception process
- Fast and easy physical stock counting
- Transparency throughout the end-to-end value chain
- 40% inventory reduction

### **Service 3: CONNECTED DRUMS**

A digital geolocalization solution designed to optimize the management of cable drums and rotation cycles time and avoid cables loses and theft. No more lost or missing drums thanks to Nexans unique solution which allow you to accurately pinpoint the location of your drums at any moment.

Multi-sensor GPS tracking devices, with six-year battery life, are affixed to drums and dedicated ERP-ready web software (iOS/Android) allows mobile tracking anytime, anywhere. Nexans takes care of installation, maintenance and software upgrades. Nexans' approach is based on a combination of hardware, software, services and engineering expertise. Our experts are happy to explain how this can be adapted to your specific needs.

Benefits:

- Cable theft detection
- Customized dashboards
- Full fleet geolocalization
- Automatic delivery notification
- Management of residual length
- 25% shorter drum rotation cycle time

### **Service 4: CONNECTED PAYOFF**

Estimated cost of theft on construction sites adds up to anywhere between 4% and 7%. Nexans can offer 100% stock visibility, with accuracy down to one metre. Our easy SUP connect solution brings

easy handling, geolocalization, theft prevention and cable length measurement in a single, integrated package.

System hardware consists of a cable measurement tool, NGC locking system, connectivity and multisensory solutions, batteries and GPS. These are linked to a web platform and Android app that provides push alerts and NFC user identification. You can rest assured that you know who is doing what, and where, and which materials are being used, and match this with planning and authorization data.

Benefits:

- Cable theft detection
- Customized dashboards
- Full fleet geolocalization
- Automatic delivery notification
- Management of residual length
- 25% shorter drum rotation cycle time

### Rethinking electrical cabling engineering

The reliability of the cable backbone is the key factor for the train performance. Through digital simulations, Nexans consider multiple external parameters to assess and improve the long-term behaviour of the electrical cabling.

For major projects, on-site experts will also identify technical solutions and product alternatives to make cable purchases leaner with good enough products. All initiatives reduce the Total Cost of Ownership and make operations from purchasing to commissioning easier.

### Service 1: ELECTRICAL ARCHITECTURE DESIGN

Nexans is placing its considerable expertise and know-how at your fingertips so you can meet project requirements, delivery times and budgets, with cabling systems designed to ensure the best compromise between cost, reliability and power efficiency. We can help you redesign tin line with budgets, optimize cable routing, and use lifecycle and TCO design methodologies to maximize power efficiency.



You will be assigned a project manager who will liaise with Nexans Research Centre, Electrical Engineering Team and Plant Engineering. In addition to functional analysis all involved will provide peer design reviews and redesign to cost support. Tools include CAPEX/TCO oriented cable sizing, Electrical 2D/3D CAD, FEM simulation model, qualification laboratories, prototyping workshops and Data Management systems.

Benefits:

Complexity reduction: fewer items, product substitutions and industry runner switches  
Design optimization: cable routing optimization and BOM comparison  
'Good enough' product selection: analysis and selection of variants for cost optimisation

## Service 2: INTERCONNECT SYSTEMS

Nexans builds and delivers complete cable assemblies ready to be connected. These can be either custom designs or 'built-to-print' designs. In effect, this is a one-stop-shop for electrical wiring solutions, providing a complete electrical system that can be installed directly into your environment.

NEXANS can act your sole point of contact and supplier for the entire electrical wiring part of any installation. Our engineers take care of everything from industrialisation and certification, allowing you to stay focused on your core business. Our teams are ready to analyse your requirements and propose a solution for your specific project.

Services:

- **ENGINEERING**

- Project Management
- Custom Design
- Built-To-Print
- Technical Expertise

- **INDUSTRIALIZATION**

- Prototypes
- (Pre) Serial
- Testing

- **CERTIFICATION**

- ISO 9100
- ISO 13485
- IRIS
- and more...

## Service 3: ELECTRICAL ENGINEERING CONSULTING FOR SPECIFIC CHALLENGES

Benefit from Nexans engineering and research teams' scientific knowledge and state-of-the-art simulation and modelling tools to solve your technical issues. You can easily and rapidly address your specific technology challenges for industrial MV and LV applications. Either optimise cabling systems for new builds or analyse and redesign existing installations.

Services:

- Electro thermal simulation (computational fluid dynamics approach)
- Performance or TCO based current rating (static or transient profile)
- Cabling installations analysis (impedance, admittance, capacitance, short circuit limitations)

## Rethinking business support

Nexans can help you to limit the impact of the unexpected. Execution flaws, metal price fluctuations, project cancellations or delays can significantly impair your financial performance. Thinking ahead allows you to mitigate these risks, but also reduce your ecological footprint.

### Solution 1: RECYCLING & BUYBACK

One of the challenges our customers face is cable waste. In fact, 3% of cable value purchased ends up as scrap and 30,000 tons of scrap is recycled each year. By choosing Nexans recycling services you can receive money back in exchange for your leftover cables, while positively contributing to the environment. For over 35 years, Nexans as a recycling expert, has collected and recovered copper and aluminium cable waste from production plants and from cables at end-of-life through European countries.



Nexans can also re-sell products that remain unused once a project is completed. This offer can be extended to the 'obsolete' stock of cables that cannot be installed on new rolling stock equipment 5 years after the manufacturing date.

Following inspection, Nexans will issue a credit note for your obsolete and leftover cables and scrap at the fairest market value through its own controlled waste recovery channel. The buyback value of a product is a function of the frequency and volume of sales by Nexans as well as their current state and, possibly, its actual or anticipated obsolescence. Logistics and release of administrative certificates (ISO 9001, OHSAS 18001, ISO 14001, ICPE) are included.

Benefits:

- Reduced impact of losses associated with incorrect forecasts
- Nexans bears the metal risk (between redemption and eventual resale)
- Cash recovery at the end of construction
- Free storage space

$$\text{Buy value} = \text{Qty} (\text{LME}_{\text{Low}} - D) Y - T - L$$

*Qty : Cable scrap quantity (t)*

*LME Low : Official (Cu or Al) LME Lowest converted in Euros*

*D : Discount according of the quality of the granules*

*Y : Yield or metal content (% obtained after grinding)*

*T : Treatment (Process costs)*

*L : Logistics costs*

### Solution 2: HEDGING

The extremely volatile price of copper puts project profitability at risk. Nexans can help mitigate this through its power as one of the world's largest private copper traders (550,000 tons per year).

Our metal hedging platform enables securitisation of sourcing through long-term contracts with copper cathode suppliers, offering price stability up to 5 years and a competitive cost of service. Our metal management consulting service offers advices on options for hedging strategies and management of project evolutions (for example in timing and quantities).

## NEXANS: GLOBAL EXPERT IN RAIL SOLUTIONS

Nexans is a highly experienced, vertical market supplier that can manufacture the hundreds of specialty products necessary to outfit a complete train set. Nexans address the projects of OEMs, subcontractors, transit authorities, system suppliers, around the world from its European and Asian facilities

Nexans wants to be part of (or to take part in) current changes, by playing a role beyond cable. During its half-century of involvement in the rail industry, the company has gained valuable experience by working closely with rolling stock engineers and operators to find solutions which respect their many priorities, from concerns of cost, efficiency and safety, to wider issues of reducing CO<sub>2</sub> emissions.

With its customers, Nexans is anxious to see “sustainable mobility” achieved for main line high and ultra-high-speed lines, but also for revamping regional lines, as well. It also recognizes that rail transport has major advantages in the urban context. It has special experience in metros, tramways, light rail, and driverless people movers; and can contribute towards the development of intermodal urban mobility systems to meet the expectations of tomorrow’s citizens, especially in terms of today’s information-rich travel experience.

Nexans recognizes that expensive breakdowns, accidents, and short-lived cabling and equipment pose real threats to long-term viability and growth. That is why the products, technologies and systems that Nexans offers are intended to improve efficiency, prolong product life, and assure the highest standards of safety.

Nexans sees its role in the coming years as a “privileged supplier” to rolling stock, as it continues to demand a global procurement policy, integrating buying, standardization and interoperability. More than ever before, Nexans strategy is to go “beyond cable” to add value to products, do innovative research, and provide a host of relevant services, reducing the Total Cost of Ownership of the electrical function for its clients.

## ABOUT NEXANS

As a global leader in advanced cabling and connectivity solutions, Nexans brings energy to life through an extensive range of best-in-class products and innovative services. For over 120 years, innovation has been the company's hallmark, enabling Nexans to drive a safer, smarter and more efficient future together with its customers.

Today, the Nexans Group is committed to facilitating energy transition and supporting the exponential growth of data by empowering its customers in four main business areas: Building & Territories (including utilities, smart grids, e-mobility), High Voltage & Projects (covering offshore wind farms, submarine interconnections, land high voltage), Telecom & Data (covering data transmission, telecom networks, hyperscale data centres, LAN), and Industry & Solutions (including renewables, transportation, Oil & Gas, automation, and others).

Corporate Social Responsibility is a guiding principle of Nexans' business activities and internal practices. In 2013 Nexans became the first cable provider to create a Foundation supporting sustainable initiatives bringing access to energy to disadvantaged communities worldwide. The Group's commitment to developing ethical, sustainable and high-quality cables drives its active involvement within several leading industry associations, including Europacable, the National Electrical Manufacturers Association (NEMA), International Cablemakers Federation (ICF) or CIGRE to mention a few.

Nexans employs more than 26,000 people with an industrial footprint in 34 countries and commercial activities worldwide. In 2017, the Group generated 6.4 billion euros in sales. Nexans is listed on Euronext Paris, compartment A.

For more information, please visit: [www.nexans.com](http://www.nexans.com)

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