Pushing the limits – Managing risk in a faster, taller, bigger world

Emerging Risk Initiative – Position Paper

November 2014

CRO FORUM

The CRO Forum's Emerging Risk Initiative

The Emerging Risk Initiative (ERI) was launched in 2005 to raise awareness of major emerging risks relevant to society and the re/insurance industry. The Initiative consists of representatives from Allianz, AXA, Hannover Re, Lloyd's, Munich Re, Prudential, RSA, SCOR, Swiss Re and Zurich. In 2014, Swiss Re is its chair.

The ERI pursues the following goals:
- Raising awareness and promoting stakeholder dialogue
- Developing best practice solutions
- Standardising disclosure and sharing knowledge of key emerging risks

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1. Executive summary

Faster bullet trains, taller skyscrapers, longer bridges – our world is moving into new technological dimensions at the beginning of the 21st century. This process is not limited to infrastructure: While nanotechnology is conquering the micro-world, high-speed trading is accelerating the stock exchange, and ships in ever-larger dimensions are ploughing the oceans.

Superlatives abound, generating a new environment for us to live in. A growing global population drives the development of this new world. The majority of people now live in cities. The challenge of delivering goods and services on an increasing scale to growing towns triggers the need for novel and innovative technologies. These bring not only new benefits; they can also entail new risks. Our world, therefore, not only surprises us every day with new records; it also changes the risk landscape in many ways.

When the world moves faster, we have less time to react to avoid accidents. When buildings become taller, they must be more stable. And when ships become bigger, more is lost when they sink. So technology is pushing our systems to new limits. The question that arises is – which safety margins will be able to accommodate these changes when we want to keep our current levels of safety? Especially in a world where human failure is the key driver for many losses? After all, developments in safety, technology and human behaviour are often not aligned with scientific advances. This opens up space for incidents. And given the increasing dimensions in the world we build, negative effects of failures can occur on unprecedented scales.

Some of these effects can be seen already in the case study highlights presented in this publication; others have not yet manifested themselves. While the upsides of new technologies become evident right away, experience shows that there is a time lag until the arrival of the first unintended negative effects.

Looking at the canvas of the world of the 21st century as it is laid out on the following pages, it is obvious that risk management must adapt to new realities. The key to this adaption is to collaboratively design flexible systems that are as safe as the ones we are currently used to. As margins of error are diminishing in our more interconnected, faster world, this is a challenging task.

To achieve this, it is crucial that risk management starts early in the process. Many failures have their root causes in the planning or inception phase, and getting active then can help to prevent losses from occurring in the first place. This makes economic sense for investors, project owners and society at large since preventing failures keeps business running and does not impact societal emergency services.

What we therefore need is for developers, risk experts, city planners, industry professional and many more to come together to identify new ways to keep our systems safe when the margins for system stability become smaller. Only as a group, can we come up with the ways and means to achieve the safety goals acceptable to society.

The insurance industry can support this process. It has already contributed know-how in the past by developing guidelines jointly with other industries. Examples are the "Tunnelling Code of Practice" or the "European Wind Turbine Committee Offshore Code of Practice". Collaborative projects like this between insurance and its industry partners have been successful in managing the risks inherent to new dimensions of technology, benefitting all parties in the process.

This publication aims to be an introduction to the changes happening now. It spotlights key developments based on recent examples of what is changing around us. It is also meant as an invitation to start collaborating on risk management for the 21st century with all stakeholders– to make tomorrow's world at least as safe as today's.

Construction work at the 32.5 km long Donghai Bridge, one of the longest cross-sea bridges in the world.

2. Faster, bigger, taller – the shrinking margins for error

At the start of the 20th century, less than two billion people lived on our planet[1]. Fast travel was by rail or ship, and the phone was the way for rapid communication. Cities were in the middle of constructing infrastructure for gas, water and sewage to address the issues of public health that became prevalent in the decades before.

Looking at our planet today, it is obvious that it has changed profoundly. We have passed the seven billion mark of people living on earth, and are expected to reach nine billion by 2050[2].

This growing population lives in ever-greater density in many parts of the globe. Since 2013, for the first time more people are living in cities than in rural areas. And this trend is set to continue. By 2050, the urban population will almost double, increasing from approximately 3.4 billion in 2009 to 6.4 billion[3].

Urbanisation changes the way we live and shifts the way we interact with our environment. Without the exchange of goods and services on a global scale, the transition from rural to city life is not possible. And given the growing and more concentrated population, the volume of this exchange is ever increasing, prompting an unprecedented level of interconnectivity.

Food, water, energy and daily supplies have to be transported in increasing amounts from the countryside to sprawling metropolitan areas, making new or improved infrastructure necessary. This infrastructure must handle larger volumes and an increased delivery frequency. Furthermore, the demand for energy, water, telecommunications, sewage, waste disposal and others services continuously grows in many parts of the world.

The developments described above have already changed deeply our environment in the past. For long distances, air travel has replaced ships and, partly also, rail. The internet is an integral part of our lives. And, while in the East new infrastructure is still being built, other countries struggle with maintaining facilities constructed 100 years ago.

Another effect of the higher concentration of humans and property in cities is that our towns are more vulnerable if earthquakes, floods, storms or pandemics strike. And the latter can travel the world faster than ever before on today's high-speed transport networks.

All trends combined signal that technological limits are being pushed everywhere – the examples discussed in this publication are only highlights of what we see.

This faster, taller and bigger world is based in no small part on new technologies. An obvious example is the internet, which we by now almost take for granted. Other technological breakthroughs like nanotechnology or genetic engineering are not immediately visible, but still have far-reaching consequences.

Prototype risk is one of the terms that are often quoted in the context of the developments we see. This raises the question as to whether the expertise we've gained from our past experiences will be enough to provide safety in operating the technologies of the future.

Prototype risk

The term prototype refers to a new technology, a new genre or a development from an existing technology[4]. It usually denotes something that has not existed before, a product which cannot be mass-produced or a process that does not easily lend itself to duplication. 'Unproven' equipment or processes that require modifications from one application to the next or where experience in use is limited are also considered to be prototypes.

In some industries, failure of prototypes is accepted and considered to be part of the development process. Skill, experience and a detailed understanding of the limitations of the prototype are necessary to ensure safe operation.

While computer modelling aims to identify the risks associated with prototype use, the human factor related to real-life implementation cannot be accurately modelled. A level of risk is therefore attributed to the use of prototype due to the limited experience in its use. The potential negative results if prototypes are used in real life can be property damage, business interruption and last but not least bodily injury or death.

While true prototypes may not use the final material or manufacturing designs, 'prototype risk' refers to the fact that design principles, materials and the manufacturing or implementation process have not been thoroughly tested in real life.

Projects which push the limits of current technologies give rise to prototype risks due to their very nature. They go beyond the proven and accepted methods, processes or technologies, and there are no standards available on which risk management practices could be built. Current knowledge and state of the art become irrelevant when many design elements are prototypical. This increases the inherent risk.

Key aspects of prototype risk are higher transmission speeds and increasing links between previously unrelated systems. Joining systems which have not been coupled before is a hallmark and challenge of the world in the 21st century. The supply chain disruptions during the floods in Thailand 2011 are only some of many examples which illustrate this.

This interconnectedness generates a new level of complexity, where unforeseeable system failures can happen on timescales that make timely intervention impossible. Concurrently, the inability to predict possible outcomes is eroding safety margins for system reliability.

As a result, the fall-out of a crash can reach previously unimaginable dimensions. The recent financial crisis, the tsunami in Japan, the SARS* crisis or the Arab Spring are examples of developments where local or regional events rapidly affected the whole globe.

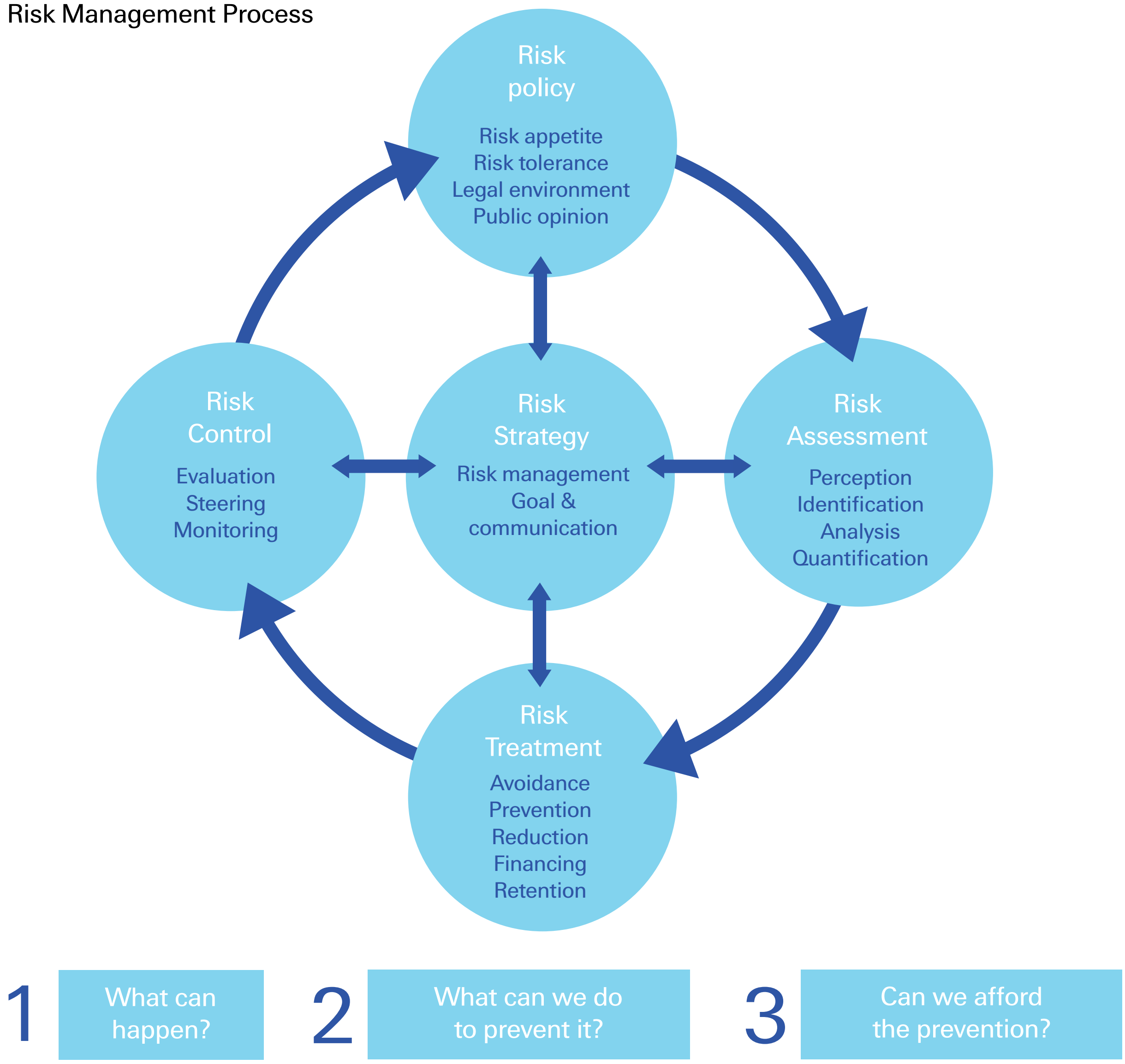
* Severe Acute Respiratory Syndrome

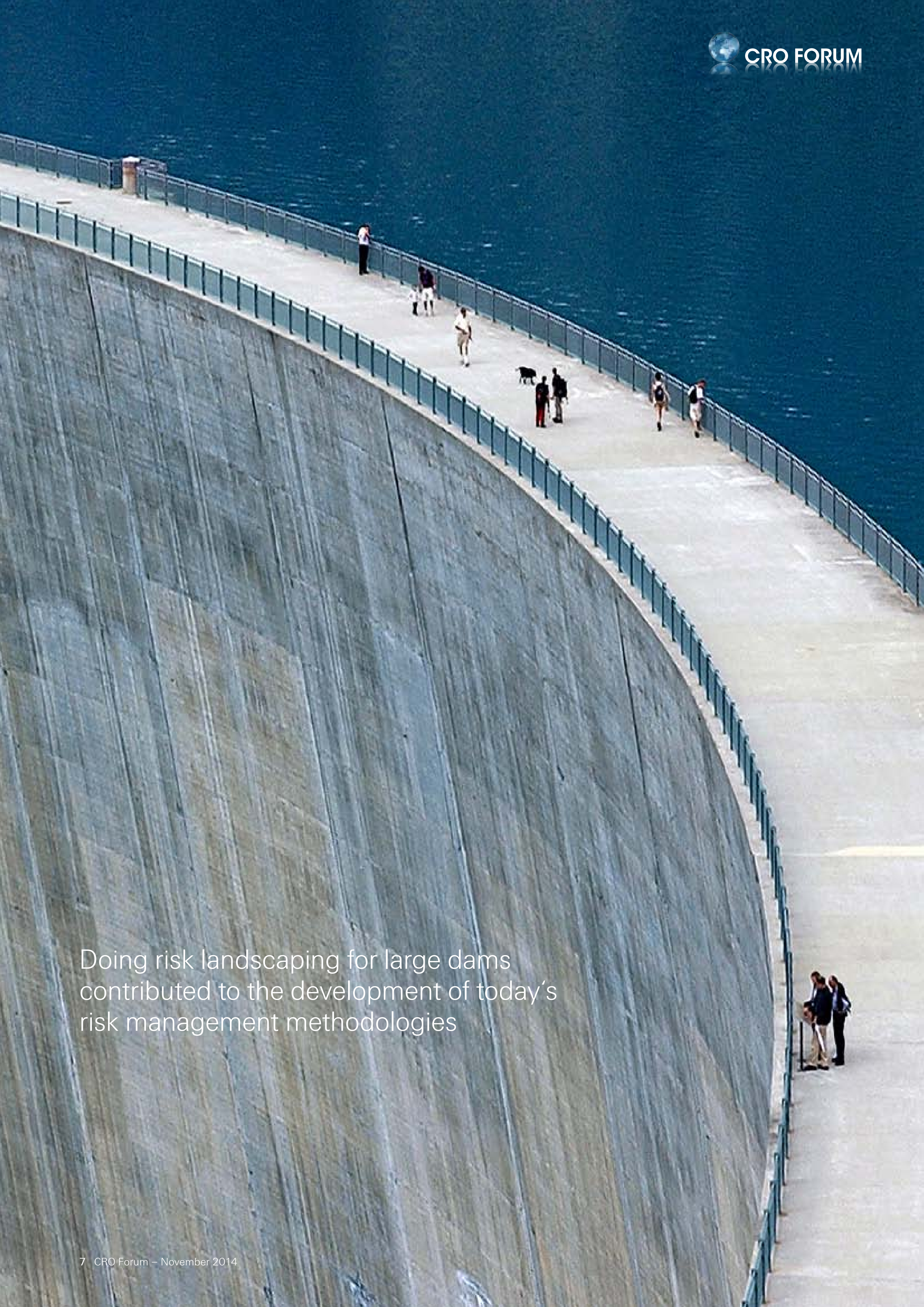
If the world is changing on such a scale and in so many aspects at the same time, risk management must change, too. We need a new paradigm of risk management that acknowledges the complexities technology generates today. One that takes into account that shorter time frames may not allow risk management to continue as usual. One that starts to identify and address new interfaces that otherwise become evident only over time. And one that considers that larger structures also means larger failures, and which plans accordingly for such events.

This new risk management paradigm needs to be based on many aspects: collaboration between fields of expertise, the willingness to learn from failures and the possibilities which new data technologies give us in identifying, assessing and quantifying previously impossible scenarios are all crucial.

But it will also be built on the foundations of our current risk management procedures, which include mapping potential failures, evaluating them by frequency and severity, looking for effective prevention and mitigation measures, and measuring success. On the following pages, we set out how existing risk management procedures can be updated for the risks of the 21st century, and why this process must start now.

Risk Management Process





Doing risk landscaping for large dams contributed to the development of today's risk management methodologies

3. New horizons and rapid changes

The increasing demand for raw materials essential to produce new goods to meet the necessities of a growing population puts pressure on the extraction of minerals, fossil fuels and the provision of food and water[5].

The last century exploited resources that were easy to reach. Since they have run out, increasingly remote or extreme environments come into focus to still the hunger for new resources. One example is the Arctic region, which climate change is opening up for exploration.

Colder temperatures, ice, storms and a long lasting polar night make the safe operation of installations in the Arctic a challenge not experienced before. Furthermore, to bridge the distance to processing facilities for raw materials extracted there, novel transportation infrastructure is needed in perilous seas.

The Arctic frontier

What's new?
Human ingenuity not only pushes technological limits, but also shifts geographical boundaries. One of the key areas coming into focus is the Arctic region.

Global trade routes are expected to shift more and more into Arctic waters as global warming makes these waterways more navigable. These routes are not yet well explored, and coastal infrastructure often does not exist or is inadequately developed. However, as Arctic routes are about 30% shorter than traditional waterways, the economic savings are tempting so increasing ship traffic is to be expected despite these obstacles.

Offshore energy exploration and production in Arctic waters will also become more prominent. There are already some fields in production north of the Arctic Circle (66° latitude) such as Snøhvit in the Barents Sea, Prirazlomnoye in the Pechora Sea and Nikaitchuq in the Beaufort Sea. And many more are foreseen as the area is expected to hold very significant reserves.

What are the implications?
These developments are sparking controversial discussions, especially with regard to environmental concerns. The technology to control and manage leakages of fluids in this region is still being developed and tested. Furthermore, mankind's experience operating under such extreme environmental conditions is limited, increasing the probability of something going wrong. In case of a disaster, rescue missions and salvaging ship wrecks will be much more difficult and costly than in other regions.

The Arctic is only one example of many extreme environments which are currently being newly explored. Another one the world turns to is even more unknown: the deep sea.

Oil exploitation started over a century ago on land and then moved to shallow off-shore areas. The Gulf of Mexico was the first frontier reached, and it was also the scene of the largest incident so far in the industry.

The Deepwater Horizon case

Deepwater Horizon was a drilling rig to drill the Macondo well about 41 miles off the Louisiana coast. When it exploded in April 2010 it caused what is considered to be the largest accidental marine oil spill ever. It was stopped in July 2010, only after approximately 5 million barrels of oil were discharged. This equals 318 Olympic size pools full of crude oil.

The spill and the adverse effects from clean-up activities caused massive damage, especially to the environment, fishing and tourism industries. Hundreds of miles of coastline were contaminated by the oil itself or by chemical oil dispersants used to avoid more oil from reaching the coast. According to investigations, the explosion was caused by a defective cementing job and the failure of the rig's blowout preventer.

The oil spill triggered a multitude of claims: pure economic losses by seafood- or tourism-related businesses, claims related to medical conditions by clean-up workers or persons living in the region, expenses for removal costs and securities claims by shareholders amongst others.

By 31 July 2013 more than USD 12 billion in compensation had been paid out[6].The USD 20 billion fund, originally set aside for compensating claims arising from the incident, is likely to be insufficient[7].

The stock market capitalisation of the companies involved also took a hit of up to 55%. For many the stock prices have not recovered to pre-event levels yet. In 2013 it was still 28% below for some companies.[8910]

Oil exploration has now reached the abyss of the world's oceans. What happened in the past in a few hundred metres of depth is now taking place kilometres away from the surface of the water. This brings colder temperatures, higher pressures and even more severe challenges for the energy industry if something goes wrong.

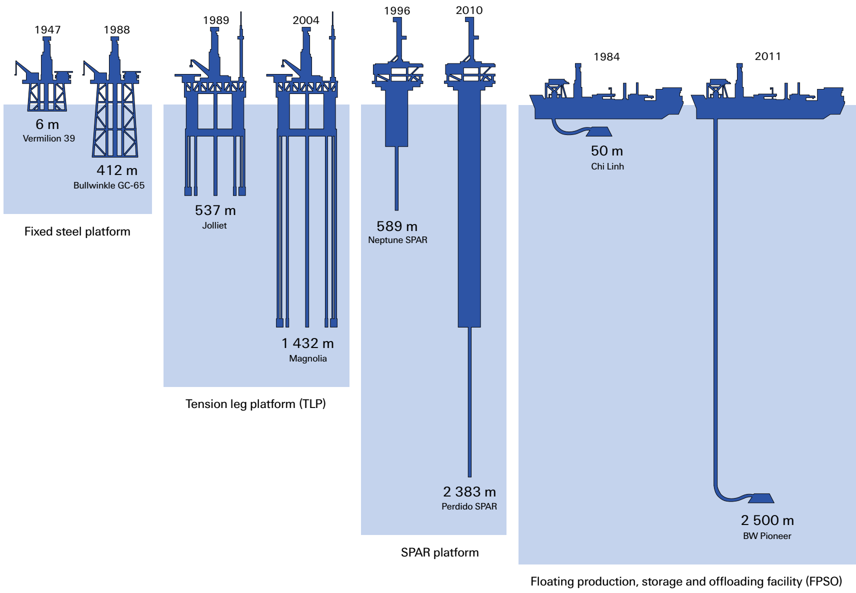
Offshore energy and minerals exploration

What's new?
Offshore energy operations have continuously moved into deeper waters, and installations have become ever larger. Conventional fixed platforms in waters up to 500 m deep are being replaced by floating installations in more than 2 000 m water depth. The introduction of production storage and offloading vessels (FPSOs) replaces the need for export pipelines. In the coming years, we will also see the installation of floating liquefied natural gas vessels (FLNGs).

Bigger size also means an increase in costs. Offshore field projects such as the Shah Deniz 2 project in the Caspian Sea may generate development costs of up to USD 10 billion, and a single FPSO vessel may be worth more than USD two billion. The biggest FLNG unit, which is currently under construction, will have a total value of more than USD six billion.

The growing importance of ultra-deep water drilling and production (in excess of 2 500 m water depth) requires an evolution of subsea technology. These brand new technologies come also with a price tag. In Brazil, for instance, the "Libra" oil field, which is currently being developed to produce oil from wells in about 3 500 m water depth, will require an investment of more than USD 200 billion.

Development of offshore installations over time



Despite the huge costs involved, the trend of moving more technology to the sea bottom will continue. Subsea compression and associated technologies will improve the economics and reserves of gas fields. Furthermore, the exploitation of methane hydrates may become an important aspect for offshore energy in the foreseeable future.

Due to the high oil price level, existing oil and gas fields will increasingly become targets for redevelopment as new technologies become available, and a number of the old platforms may receive an extension of their existence. In addition, new areas like Western Australia, East Africa, Northwest Africa and the Arctic region increasingly come into focus.

Far offshore, the race for deep-sea mineral mining has also started. Raw materials for mobile phones as well as gold, copper, zinc, manganese and other minerals are luring many nations to the deep sea. Currently, eight nations have been granted exploration licences by the International Seabed Authority, while, at the same time, investigations are still ongoing into the effects on the highly sensitive ecosystem in the deep sea[11 12].

What are the implications?

As offshore energy and minerals exploitation increasingly moves into new environments with novel and partly untested prototype technologies, exposures arise in areas where none have been before. New technologies may fail unexpectedly in the extreme conditions they have to operate in, adding to the inherent risk.

The success of offshore energy hinges on whether safety and protective systems can keep pace with the development of technology and its application in new areas to prevent future mega-disasters. A loss of a single asset with a value of USD 3-6 billion, plus significant additional costs, will have an extreme impact on the offshore industry. In addition, new scenarios of natural catastrophes may become decisive factors, and the human factor will remain crucial for the safety and success of offshore energy operations.

Not only is the sea a new frontier in raw material exploration; on land, new territories are being conquered, too. Areas that contain shale gas or oil sands are explored in many parts of the world. Technologies employing new chemicals and novel techniques have made it possible to tap into these resources to fulfil the ever increasing energy demands of today's way of life.

This exploitation is a much more dispersed process, either with many wells over a large range, as in the case of fracking, or with huge open pit mines for tar sands. These large-scale operations are often located in environmentally sensitive regions, making safe operating procedures even more essential.

Besides energy, demand for raw materials is also growing rapidly. More steel, aluminium, copper and other resources are necessary to meet the requirements of our modern world. Consequently, the building and consumption boom of the last decades has driven huge investments in bigger mines and equipment. As mine pits have become larger and underground operations have gone deeper, the tools to run them have also increased in dimension. Gigantic mechanical diggers, monster trucks and supersize freight trains are now a common sight on many exploration sites worldwide.

Both developments – more demanding locations and bigger equipment – trigger needs. While broken trucks were easily replaceable in the past, it may take much longer to get one of today's behemoths back on track. Mining sites must be planned and laid out differently to allow safe operation of the larger equipment. Operators must receive specialised training to ensure a safe working environment. In addition, human rights aspects must be considered in setting up new mines. Relocations of inhabitants or mines that generate no benefits for locals have frequently generated friction in the last two decades[13 14].

Mining

What's new?
The mining industry in the 'old world' is constantly shrinking as deposits are depleted, so attention has moved to other regions. However, countries with vast mineral deposits are few, and global demand is increasing. Many of the mineral deposits which are still available are located in inhospitable areas such as the Australian Outback, high up in the mountains, north of the Arctic Circle, deep in the tropical rainforest or in areas generally deemed as 'politically unsafe'.

To stay economically viable, both the mines themselves and the machinery employed there are becoming increasingly more sophisticated, bigger and faster. A heavy duty truck (HDT) – used to haul the raw ore from the face to the processing facilities – had a payload of 80 tonnes in the 1980s. Today, payloads have increased to 400 tonnes. Grinding mills have also increased in size. While grinding mills had up to 20 feet diameters in the 1980s, today's machines feature 44 feet.

Digital technology is now commonplace for mining operations. Some mines in Western Australia, for instance, are running their HDT fleets driverless, GPS-controlled. In South Africa, a diamond mine runs driverless front end loaders and HDTs in a mine, again, GPS-controlled.

Price fluctuations for minerals – especially if in short supply on global commodity markets – are a constant concern for mining operators. Since globally active mining houses, with their production and trading power, are able to influence the commodity markets enormously, single incidents can have drastic implications on prices. For instance, an incident at a major mine site in Indonesia ten years ago prompted the copper price at the London Metal Exchange (LME) to increase overnight by 10%.

What are the implications?
The growth of machinery and the sensitivity of markets to single incidents pose challenges for developing and running mining operations. Tailored super-large machinery may be difficult and costly to replace if something goes wrong, and inter-connected commodity markets may potentiate the financial impacts of an incident.

The 'new mining world' is not necessarily located where the highest demand for the mineral products is. This results in increased transportation needs and a growth in traffic that may also cross sensitive areas which is a challenge for the transport industry. Tailing dams, which retain partly toxic residues of mining operations, are another issue. A break of such dams, which are found more and more in environmentally sensitive areas, is a great concern.

Trains, trucks and ships which transport the mineral wealth to processing facilities have grown together with the mining operations. They are now longer, as exhibited by road trains and trains, or larger like the vessels ploughing our rivers, lakes and oceans.

Indeed, ships have become ever larger. At the same time, climate change is opening up the Northwest and Northeast Passages in the Arctic. Both developments bring increasingly big vessels and their partly hazardous freight to areas previously free from such exposure.

But it's not just goods that are moving in larger volumes across the sea. Given the popularity of cruise holidays, more people are on ships, too. As a result, more and larger cruise liner terminals are being built in many major ports for boats that hold several thousand passengers, as opposed to catering for just a few hundred people like in the past.

Loading capacities for container vessels have increased with the needs to ship goods across the globe.

Ships

What's new?
Vessels of all kinds are becoming larger and more sophisticated. Both size and cargo capacity of crude oil and gas tankers, bulk carriers and container ships is increasing further and further, with some vessels already exceeding the dimensions of crucial maritime bottlenecks such as the Suez or Panama Canal. Besides obvious benefits due to increased cargo capacity, larger vessels often are also more fuel efficient than smaller ones[15].

The trend towards ever larger vessels is not limited to cargo ships. Cruise liners are also becoming increasingly bigger, with some of them already exceeding 360m in length. While cruise ships have been able to proceed worldwide without limitation since the early 1990s, a new concept has emerged lately: ports have become less important, and the vessel is itself now the destination ("destination ships").

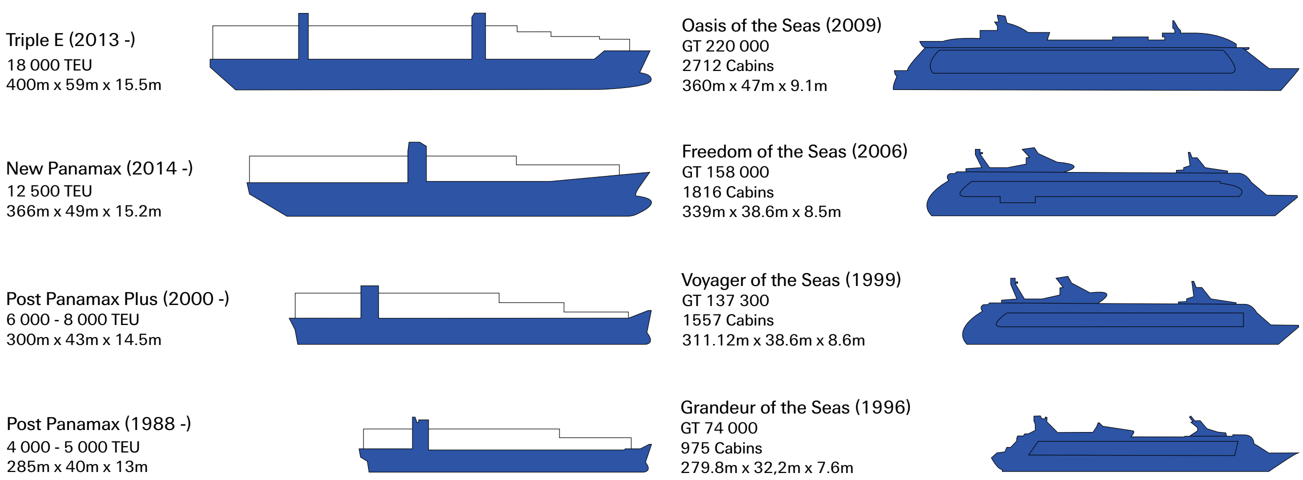
As fuel becomes more expensive, "green ships" increasingly come into focus. In the coming years, a lot of new technology will be tested to find ways to reduce our dependence on fossil fuels, for instance by improving propulsion. Furthermore, crewless autonomous cargo vessels may also become reality, thanks to technological advancements[16]. As new technology is a risk management factor, these developments are likely to change the marine risk landscape.

What are the implications?
While increasing size brings economic benefits, it also multiplies the risks. Larger ferries and cruise ships imply that the number of passengers affected if an accident strikes becomes larger. And the financial exposure associated with losing a transport vessel grows with increasing vessel size[17].

Due to the mounting sizes, the damage in case of a loss is much higher than in the past. When the container ship MOL Comfort sank in 2013, the freight was more valuable than the ship. Salvaging or wreck removal costs have also increased with larger ship sizes and the growing technological sophistication of these missions. In the case of the Costa Concordia, which capsized in January 2012, the wreck removal costs were bigger than the price tag for building the ship.

Bigger, more expensive and more sophisticated vessels also intensify the pressure on physical facilities, such as cargo handling, operational timetables, ancillary services and other operational infrastructure[18].

Development of container ships (left) and cruise ships (right) over time



The graphic on container ships was adapted from the Geography of Transport Systems, Jean-Paul Rodrigue.

It's not just the seas that are seeing more and more traffic nowadays; the skies are also becoming busier. Globalisation has generated the need to rapidly transport people and goods around the globe. The "just in time" delivery of products like computer chips or flowers, the need to travel more for business, pleasure or to meet family all contribute to a boom in air travel.

The number of flights and the volume of passengers reach new heights every year, as do the number and size of planes and airports in service.

Operating costs are a key driver for technological advancements in the airline industry. To stay competitive, airlines need to minimise fuel consumption, driving demand for new lighter aircraft materials. Many of these are composites, which have different ways of ageing and are difficult to monitor for fatigue. This is a challenge in the design and maintenance of planes.

In addition, to be productive, planes are spending more time in the air, cutting down on the time available for maintenance. Flight fleets are also more utilised than before. If a plane has to stay suddenly on the ground due to a malfunction replacements are often not available, disrupting schedules and delaying flights.

Aviation

What's new?
Air traffic is growing significantly across the globe and is expected to double in the next 15 years[19]. In Europe, it has increased by 70% between 1990 and 2003[20]. While approximately 500 million passengers were transported worldwide in 1973, in 2012 the figure was approximately 3 billion[21].

To cater for the growing demand, passenger planes are becoming larger. At present, the largest plane in operation can hold 850–1 000 passengers. In contrast, the original Boeing 707 as the first long range jet liner carried 179 passengers. Compared with the 1950s, the maximum number of passengers transported in a plane has increased by a factor of 5 to 10[22 23].

With regard to plane construction, there has been a gradual but incessant substitution of traditional materials with composites. Carbon-fibre-reinforced plastic is particularly popular as it is around 40% lighter than conventional aluminium elements. New technologies such as lithium-ion accumulators are also entering the aerospace industry.

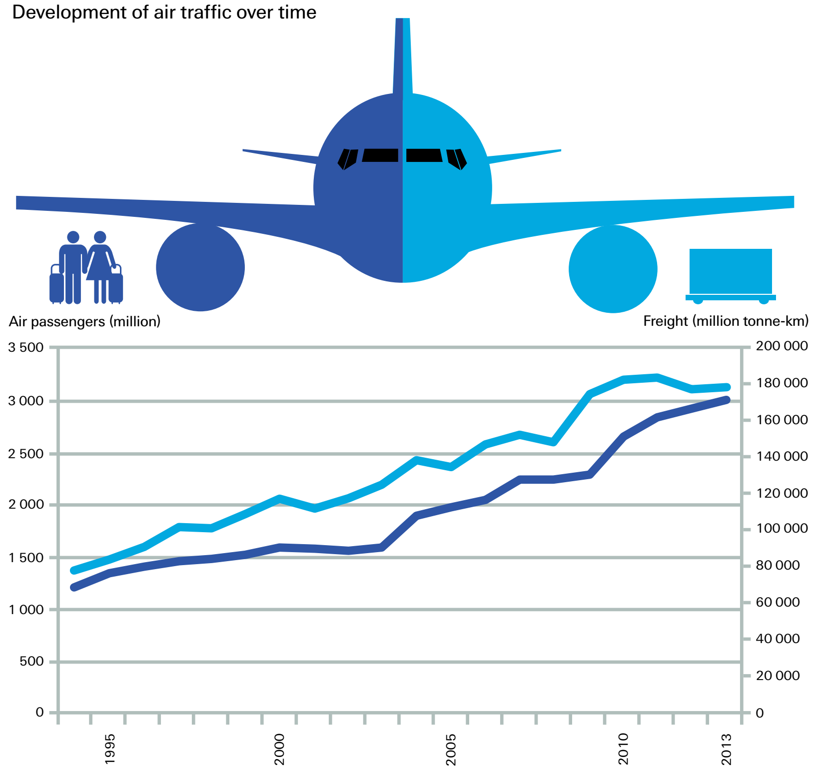
Hand in hand with the increase of the airplane since 1930 efforts were stepped up to build new international airports which are able to handle more and bigger planes[24 25].

What are the implications?
New materials and technologies, such as composites and lithium-ion accumulators, give rise to new risks and may have far-reaching consequences. This was illustrated by the grounding of the Boeing Dreamliner[26] due to self-igniting batteries.

While lithium-ion accumulators are valued for their high energy density and performance, they are also capable of spontaneous ignition under certain circumstances. In the past, this has caused the batteries of aircraft to auto-ignite or explode. The greatest losses to date have occurred during transportation of lithium batteries in air-freighters. After the batteries auto-ignited in the cargo hold, all the planes crashed within minutes. Five cargo planes crashed in the years 2006–2013[27 28], and there were 59 incidents involving lithium accumulators in the passenger holds of planes between 2007 and 2010[29].

Where composite materials are used in aircraft manufacturing, new construction principles are required which go beyond those applied to metallic materials. Aircraft models in which newly developed materials have replaced traditional ones reported material fatigue in the form of capillary fissures. Owing to the stresses that build up during flight, eg bending, tension/compression and torsion, and changing flight manoeuvres, the materials are exposed to vibrations, which cause this novel form of fatigue. Reports of these consequences mainly concern aircraft models in which newly developed materials have replaced traditional ones[30 31 32].

Development of air traffic over time

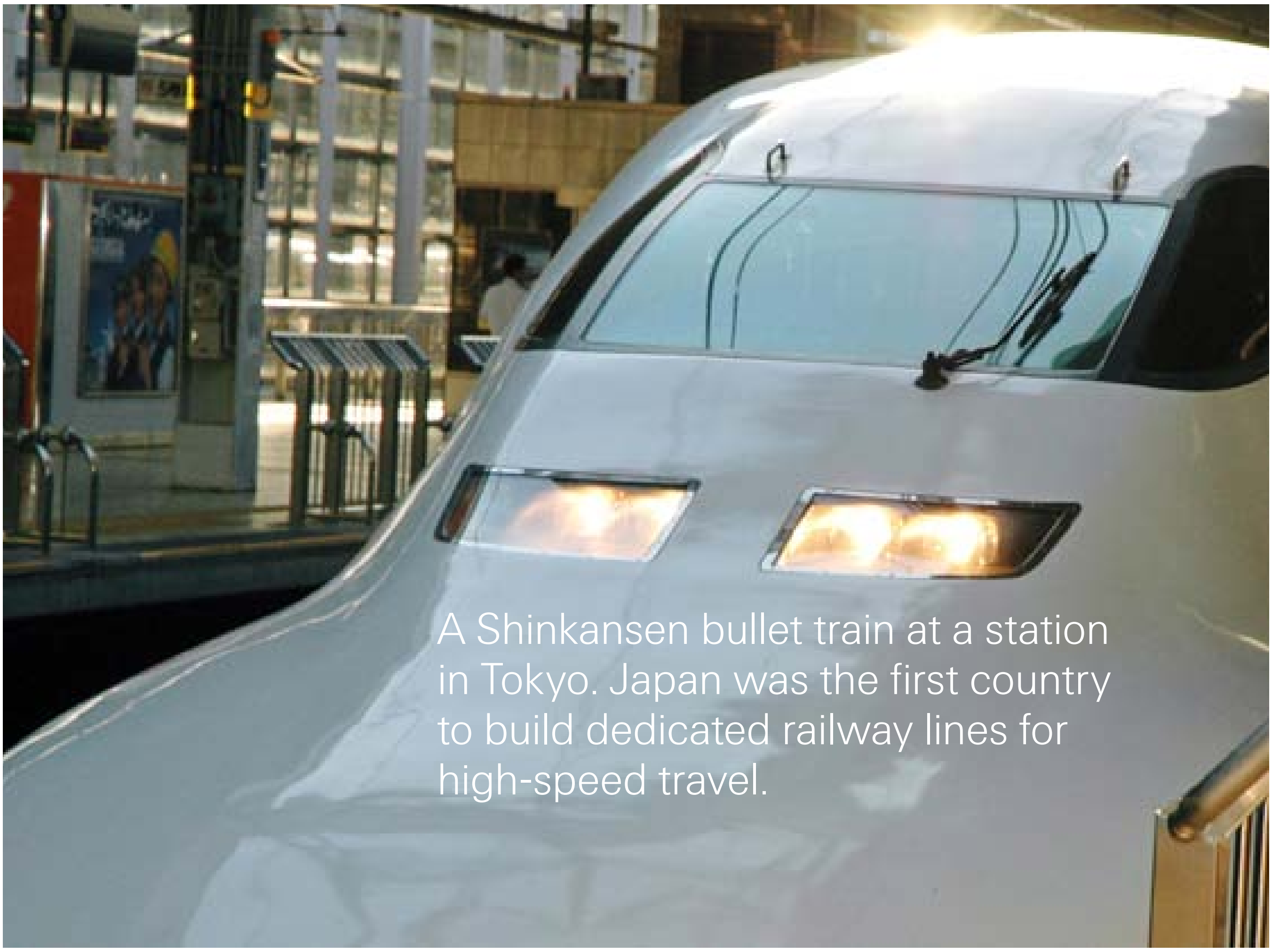


With the skies getting more crowded, other methods of fast transport have become popular for medium distances on the ground. High-speed train networks have developed in many parts of the world, and more are planned for the future.

The faster speed calls for new signalling and safety systems since humans are no longer able to react fast enough to events on the track. Thus IT has become more important in managing rail traffic, which, in turn, also brings new vulnerabilities. Power failure or cyber risks are new realities that must be addressed.

Besides IT, novel materials are also being used for high-speed trains. Similar to aviation, long-term experience hasn't yet been established with some of them, generating new challenges in the design and maintenance of the trains.

And the break-neck pace with which some of the new high-speed train networks are being developed is sparking a shortage of experienced construction workers and companies, high quality raw materials and other necessary supplies. This makes it challenging to safeguard the necessary quality standards for high-speed tracks.



A Shinkansen bullet train at a station in Tokyo. Japan was the first country to build dedicated railway lines for high-speed travel.

High-speed trains

What's new?
The number of high-speed trains – trains running at speeds of 200-300 km/h – is increasing steadily worldwide[33]. High-speed trains mainly run on new lines or on infrastructure that has been upgraded to take high-speed traffic, but also with reduced speed on sections of the conventional network.

The evolution of maximum operating speed on rails changed dramatically over the years, starting in the 1960s with exceeding the maximum speed of 200 km/h and reaching more than 350 km/h in 2012. Maximum speeds in tests have already approached 600 km/h[34].

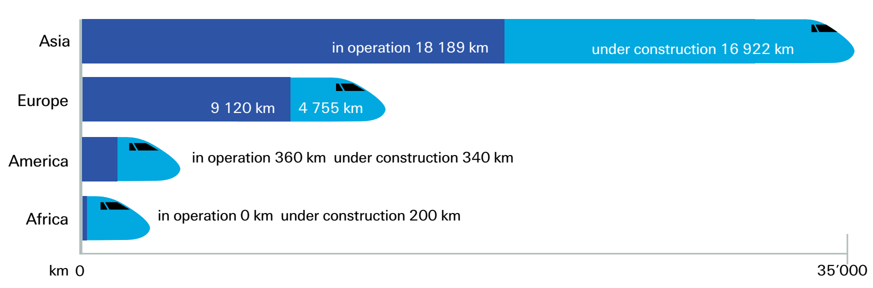
Not only speed is increasing, but also the number of passengers transported, the density of high-speed train traffic and the number of countries operating high-speed trains[35]. Global high-speed traffic has almost doubled from 2000 to 2010, from 130 billion passenger km to approximately 250 billion passenger km.

Approximately 28 000 km of high-speed train networks are currently in operation worldwide, and more than 22 000 km are under construction[36 37]. China has the largest network in operation and is planning to double it over the next decade. Spain operates the world's second largest high speed train system, followed by France and Germany. Overall, more and more countries are building up, increasing or renovating their high-speed networks.

What are the implications?
Given the rapid increase in high-speed train networks globally, the probability of a high-speed train accident is likely to increase. The risks of high-speed train traffic are essentially the same as for normal trains, but impacts are often more severe[38] – possibly due to the fact that active safety features for passengers inside high-speed trains common in other high velocity modes of transport are not yet prevalent at the moment (eg no air bags or seat belts). Experience from previous accidents indicates that approximately 35% of all passengers die and that 36-64% are badly injured in the case of an accident at speeds over 150 km/h[39 40 41].

While rail travel is changing, what we need to ask ourselves is whether safety features for passengers have to change, too, to sufficiently protect passengers. The current focus is more on avoiding accidents in the first place. So far, planning for an incident as such has not gained the same attention.

High-speed train networks by region



Equally impressive growth can be observed in road travel. More people can afford cars now, crowding the streets across the globe to get to or away from the growing urban areas[42].

The roads we travel on must cross mountains and rivers, or have to be stacked on top of each other in the cities to make efficient use of limited space. This is achieved via tunnels and bridges, which are used not only for roads, but also for rails, sewers, water pipes and other infrastructure. Accordingly, tunnels and bridges are being constructed in unprecedented numbers and in dimensions not seen before.

Longer than ever free spans are crossing valleys, rivers and bays. New materials and design concepts are employed to achieve this. Many of these new structures are also built in areas with a high potential for windstorms, floods and earthquakes, making design and construction a constant challenge.

The Millau Viaduct is the tallest bridge in the world. Its deck rises 270 m above the valley of the River Tarn near Millau in Southern France.

Long-span bridges

What's new?

Bridge span lengths are increasing continuously as material technologies improve, design principles are refined and new structural forms are invented. The Russky Bridge, which was built in 2012 in Vladivostok, currently is the longest stay cable bridge in the world, with a main span of 1 104 m[43]. The Akashi Kaikyo Bridge in Japan has held the record for the longest suspension bridge in the world since 1998, with a main span of 1 991 m[44].

With increasing confidence in skills, materials and tools, aesthetics have become as important as functionality, fulfilling a human need to build distinctive landmarks that serve as legacies for future generations. This is supported by developments in concrete and steel production technologies, which have generated light-weight materials with high strength that allow increased flexibility in design.

Computer modelling, which has been facilitated by the availability of increased desktop computing power, enables advanced mathematical modelling as well as wind and shaking tunnel tests. Such investigations allow better understanding of the bridge performance, especially since classical structural design codes do not apply to such special structures. Furthermore, advances in equipment such as travelling formworks for pylon concreting, cranes, etc. now can meet the challenges of constructing advanced bridge projects.

What are the implications?

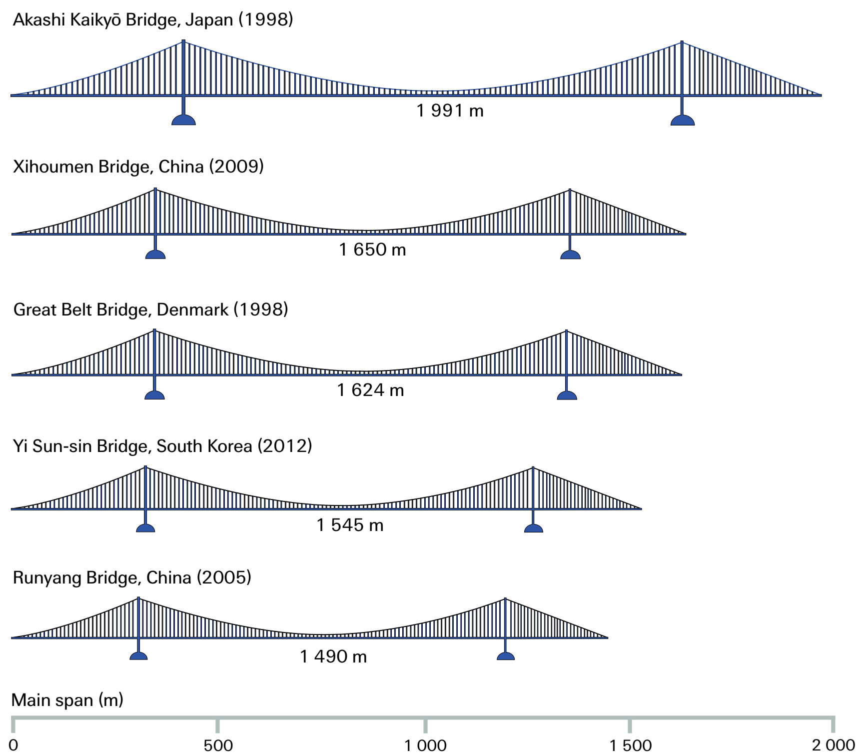
These developments are contributing to increased span length, reductions in construction time, manpower, resources onsite and an increase in the design life. However, they also give rise to new risks.

Almost every large-scale bridge project can be considered a prototype, as the opportunity to transfer experience and know-how from previous projects is limited. Carbon fibre materials, for instance, are used in limited cases and only for a few elements of a bridge, mainly due to cost restrictions, but also due to limited experience in their long-term performance.

The latter also poses a challenge in the area of maintenance, since new monitoring procedures must be developed and adjusted, based on the experiences made with them over time.

Other challenges arise from such aspects as the complexity of managing mega-projects or relate to issues like the environmental impact of long bridges, the availability of resources to build them or the instability of the financial markets, ultimately compromising ongoing project financing.

The world's longest suspension bridges



If there is not enough room above ground or mountains and wide water bodies need to be crossed, tunnels come into play. They are also becoming longer and are built deeper in the ground than ever before.

Deeper means higher forces pressure the rocks and warmer temperatures exist on the construction site. This makes the conditions for those building the tunnels harder, potentially giving rise to a higher rate of human failure.

When tunnels are constructed in populated areas, care must be taken not to damage the existing buildings above ground. In other areas, soft soils or the threats of groundwater and flooding make construction of tunnels difficult.

Given the increasing traffic in tunnels, emergency planning is also coming more and more into focus. Issues such as how to fight fires and to evacuate people in areas where there is no easy exit generate a host of new threat scenarios which must be addressed.

Tunnels

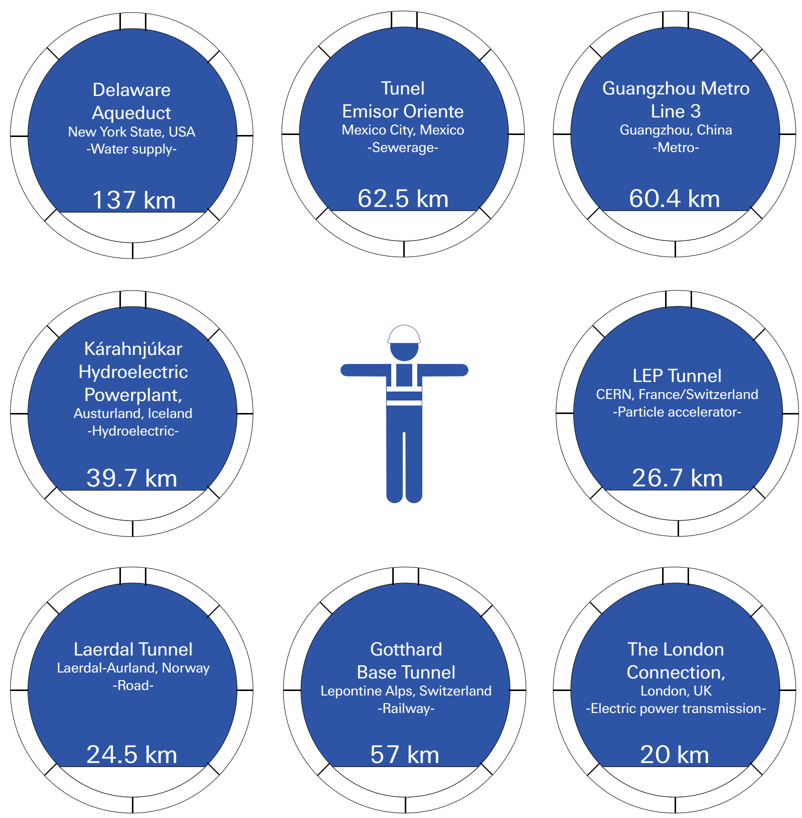
What's new?
The dimensions of tunnel projects are continuously increasing. The length of traffic tunnels is now exceeding 50 km, and many are located deeper underground than ever. The diameter of single bored tunnels is now reaching 20 metres, where before a few metres were standard. Many metro construction projects feature a multitude of individual tunnels or even see several entire lines being constructed under one project.

This trend is supported by an innovative construction industry, coming up with larger and more sophisticated tunnel boring machines, shaft sinking equipment and other machinery purpose-made for underground use.

Many tunnel projects are planned in a rush, with very little ground investigation and only a very basic design concept provided to tendering contractors. In addition, the envisaged construction periods are getting shorter so that the facilities can be available as quickly as possible.

What are the implications?
In view of the vast opportunities the tunnelling industry offers, many former general contractors without specialised tunnelling expertise are now moving into this industry segment. These developments foster increasing competition and consequently huge pressure on tender prices. Many large contracts are acquired at inadequate pricing levels.

The world's longest tunnels



As an effect of the 'tunnelling gold rush' the global tunnelling industry has been plagued by a sequence of serious accidents since the early 1990s that were mainly triggered by a lack of professional risk management standards. These accidents caused numerous fatalities on and off the construction sites, huge cost overruns and project delays.

All the goods and people ferried on the new traffic infrastructure require space once they arrive at their destination. And the need for space already starts on the footpath. Especially during rush hour, the capacity of pedestrian space can be exhausted, making crowd control in case of an emergency a new area that planners must consider.

Besides room for pedestrians, there is also the need for offices, homes, hotels, shops, recreation, schools, hospitals and much more. Since space is very limited in most cities, real estate costs are soaring. To make economics work, high-rise buildings have become the solution. And here again we are observing a trend towards more and higher buildings on a global scale in dimensions not seen before.

The 509 m high Taipei 101, which was completed in 2004, was the first building in the world to exceed the half kilometre mark in height.

High-rise buildings

What's new?
Urbanisation and increasing population density in many parts of the world forced developers to start building high-rise buildings. Both the number and height of buildings have increased significantly over the last decades. By the end of the 20th century, buildings such as the Petronas Tower in Kuala Lumpur, the Jin Mao Tower in Shanghai, and other tall buildings have elevated their cities and countries to a height of more than 500 m. Within 10 years, the maximum height increased to 828 m (Burj Khalifa, Dubai) and, by 2019, will be topped by the more than 1000 m high Kingdom Tower in Saudi Arabia.

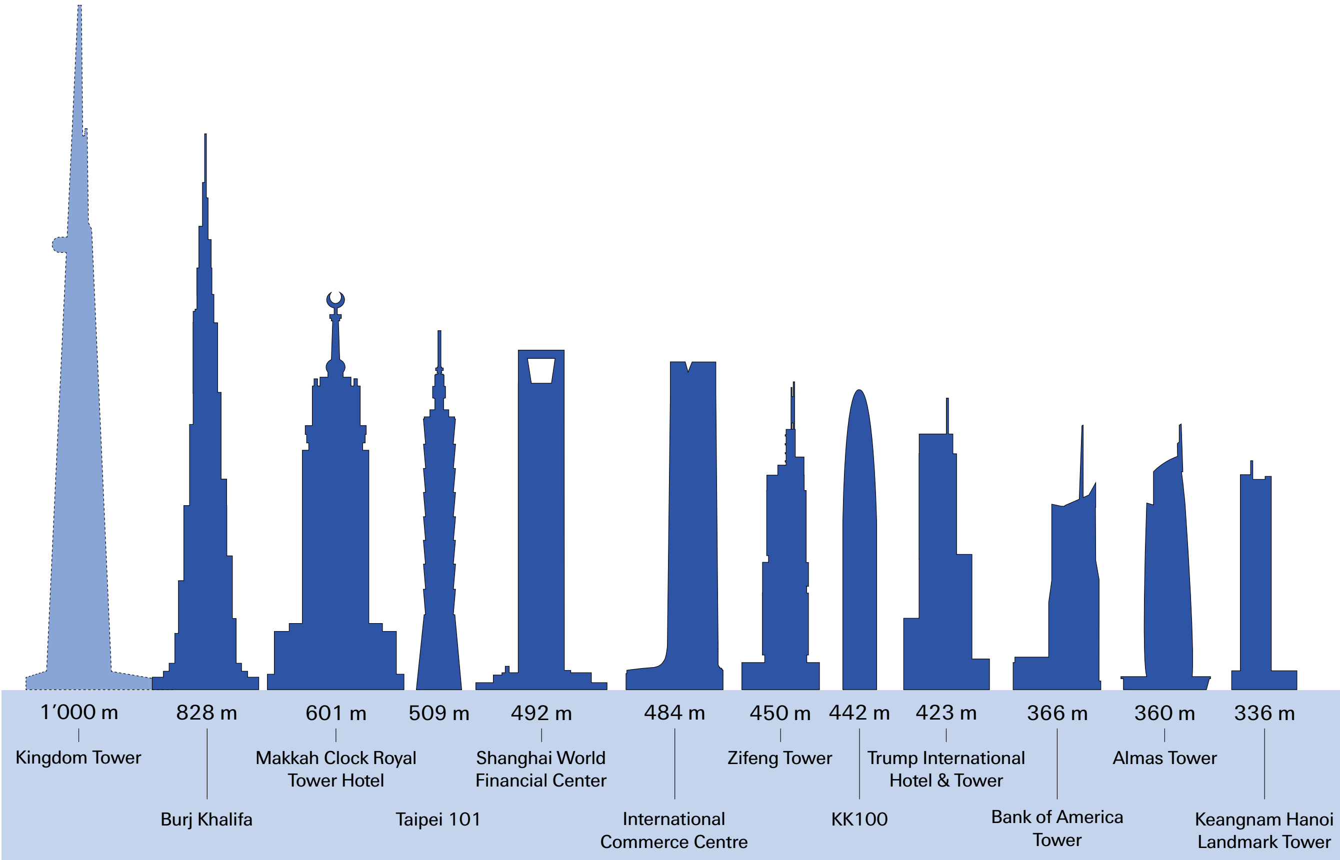
In 2014, the number of 200 m+ buildings will be in the range of 65 to 90 and, for 300 m+ buildings, in the range of 7 to 13, depending on how many will be finished in time. In 2015, the 632-metre Shanghai Tower will be the only mega-tall building constructed, but 8-15 others are anticipated to be 300 m+ high[45]. And project developers, architects and engineers continue to strive for even higher constructions. Ideas have already been brought forward for buildings of up to 4 km in height, for example the 800-floor high X-Seed 4000, which was designed in Japan.

According to experts, the maximum height currently achievable seems to be one mile. Curiously enough, limitations are not primarily determined by the construction of the building, but by the means for transporting the people who will use the building, ie by the efficiency and speed of elevators. Other limiting factors relate to materials, energy efficiency, damping systems and, most importantly, financing.

What are the implications?
Constructing ever taller buildings poses challenges for architects and engineers. Mega-tall buildings require those involved to go beyond proven and accepted methods, processes or technologies – both during the design and the construction phase. This increases the inherent risk.

Furthermore, fire hazard is an important risk factor for tall buildings, both during construction and occupation. Evacuation of multi-purpose buildings which house hotels, restaurants, residential areas, shopping centres and offices is crucial, especially considering the large number of people who need to be evacuated within a short time period. Thus an enormous focus lies on the design of sprinkler systems, escape rooms and fire resistant structures at an early stage of design.

The world's tallest buildings



The new buildings are not only taller, they are also more complex. This already comes into play during the construction phase when increasingly large projects put a strain on conventional project management approaches.

Managing complex projects

What's new?

Mega-projects – large-scale, complex ventures which typically cost at least USD 1 billion, take several years to complete, involve multiple stakeholders and affect large numbers of people – are increasingly used as the preferred delivery model across a range of businesses and sectors[46 47]. Recent examples include high-speed rail lines, air- and seaports or the construction of giant airplanes and ships, plus the development of information and communication technology infrastructure or mega sports events.

Such complex projects are pushing the limits of current project management procedures, both with regard to process and people management. Mega construction projects, for instance, may at peak times involve more than 10 000 people. If projects take place in remote areas, accommodation, infrastructure, health services and transportation must be provided for the workforce. Potential conflicts within the workforce as well as with local populations need to be considered. Logistics become a challenge, and organising and managing subcontractors and suppliers requires a dedicated and highly experienced team.

Furthermore, envisaged construction periods are getting increasingly shorter to have the facilities available as quickly as possible. To facilitate tight timelines and to give project owners a higher cost certainty, many projects are now awarded on a design and build, fixed price basis.

What are the implications?
The contracting strategy allocates most of the project risks to the contractors, leaving them with very little opportunity to claim for additional funds if the project encounters difficulties, eg unexpected ground conditions which require different working methods, or additional ground treatment to ensure safe working procedures.

To meet these challenges, joint ventures, clients, consultants, subcontractors and suppliers need to work closely together and act as a team. Project organisation increases in complexity with the various phases of a project from feasibility studies to design, to execution, operation, and maintenance. Higher levels of skill, different expertise and tools become necessary. This organisational complexity should be reflected in the contractual as well as the management structure of the project.

Once completed, today's buildings are expected to be energy- and resource-efficient. In addition they must be able to communicate with internal and external infrastructure. Sensors collect data on everything from room temperature to humidity, communicate with the heating or cooling system to keep it in a comfortable zone while, at the same time, minimise energy consumption.

Many future constructions will include alternative energy generation, making them not only energy consumers but also producers. This makes two-way communication with the external power grid necessary. And since this grid, in turn, may have many energy producing and consuming buildings in its network, a whole new power network structure is currently under development.

Complexity and interconnectivity are not only prevalent in mega structures, but are also increasingly part of our day-to-day life. Smart phones are now ubiquitous. Sensors and cameras in cars monitor the environment and react before the driver can. Automatic systems in planes avoid collisions, while other algorithms monitor the stock exchanges to avoid financial crashes.

Still, the more data is monitored and the more computers steer, the less clear it is from the outside how systems will behave, especially in extreme events. Our networks have developed a degree of complexity which humans can no longer understand. And this is likely to increase even further as the number of connected devices keeps soaring[48].

Connected devices

What's new?
Cell phones, cars, buildings, critical infrastructure – everything is more and more globally linked through the internet. And as people increasingly want digital support in their lives, the number of connected objects will continue to grow significantly in the future.

According to the International Data Corporation, the digital universe in the US is set to grow sevenfold between 2012 and 2020, and will generate 30 billion autonomously connected devices[49]. Cheaper technology will connect more people than ever, with a big share of this happening in emerging markets.

While in the beginning of the internet users created the majority of the data (text messages, photos, videos, posts, tweets, etc.), nowadays data is generated by the devices directly. Smart phone coordinates, temperature and speed measurements, burnt calories, hours slept – sensors can today register and transmit nearly everything. This exponentially increases the amount of available data.

Collecting, combining and analysing data will be crucial to businesses. In health care, for instance, evidence-based medicine using big-data sets and algorithms supports physicians' judgements. In connected cars, embedding telematics systems will bring new opportunities for drivers, eg through security and safety features that can respond faster to dangerous situations.

What are the implications?
The growing number of connected devices gives rise to "big data", which poses challenges to data security and privacy. Numerous security threats arise once connected devices monitor personal lives.

These risks increase further if data is stored and transmitted via the internet. A higher risk of unauthorised access, especially when using unprotected, ie public, wireless local area networks (WLAN) is just one aspect of data security. Unauthorised parties or hackers can easily capture data, alter records, instigate attacks on systems or interfere with the data transmission.

Results of such activities can be theft, fraud, damage to assets or extortion through espionage. Cyber attacks are nowadays quite common, as illustrated by almost daily reports in the media. Such attacks can bring down production facilities, causing business interruption or loss of data. Risks have increased even further with the introduction of cloud computing services, where the exact location of the data storage may no longer be known, leading, for example, to compliance uncertainties. Moreover, cloud computing services become more interconnected with each other, resulting in non-transparent dependencies and unmanageable chain reactions.

Cloud computing services are currently entering businesses dealing with sensitive data such as banking or health care. For the latter, the cost savings associated with centrally storing x-ray images, patient files, standard medication or immunisations make cloud computing services attractive to insurance and health care providers.

And not only is the storage of patient data on the horizon: Telemedicine – the use of telecommunication and information technologies to provide clinical health care at a distance – is expected to grow from USD 9.8 billion in 2010 to USD 23 billion in 2015[50].

Services here include everything from the above-mentioned cloud storage of data over remote monitoring of health conditions, to surgery with the help of robots over long distances.

All of these activities make data transmission and storage necessary which, in turn, creates new vulnerabilities. Tampering with stored data or the transmission of signals may thus even have life threatening consequences.

Robots have entered the operating theatre, assisting humans in healing patients.

Life sciences

What's new?
Against the backdrop of growing populations and rising life expectancy, demand for life science products and services is expected to increase steadily over the next decades. Products and services are becoming more and more sophisticated, thanks to substantial scientific progress. While research used to focus on the development of new, but "traditional" drugs and medical devices, scientists nowadays are looking for "intelligent" drugs, devices and computer systems and individualised therapies.

Robotic surgical systems enhance capabilities of surgeons and overcome the limitations of traditional minimal-invasive procedures. Instead of directly moving instruments, the surgeon works through computer control while robotic arms carry out the movement of the surgical instruments ("joystick surgery").

Expert computer systems such as computer-aided diagnosis (CADx) and clinical decision support systems (CDSS) assist medical doctors in diagnosis and therapy. CADx-systems are predominantly used in radiology, while CDSS are available in all areas of clinical medicine. Both use elements of artificial intelligence.

Active implants are inserted into the body via open surgery, minimal-invasive procedures or catheter guided via the vascular system. Once implanted, modern systems can be controlled and operated from outside the body, eg by providing readout programmes which allow the physician to modify the implant's functions by re-programming its software.

"Smart drugs" allow for target-specific delivery of pharmaceutical substances, as opposed to "traditional" drugs that affect more or less the whole body when ingested. Novel molecular drug-envelopes, for instance, control release and confine drug actions to targeted areas of the body such as diseased organs or cancer tissue.

What are the implications?
While such applications and technologies may improve diagnosis and treatment of patients, they also pose new risks. Concerns focus on technical complexity, patient safety and long-term benefits.

As applications get more and more complex, human error becomes a leading cause of losses. Even built-in error reduction systems may not prevent critical incidents, as human factors such as missing technical understanding and excessive demand are essential contributors to serious complications.

Knowledge about possible side effects, complications and long-term safety is often limited when new life science products are introduced to the market. Smart devices and tools such as active implants, robotic systems and others require thorough training and education of end-users, and this learning process is likely to take longer the more complex the technologies and applications are.

The informed consent process for patients has to reflect all patient-relevant aspects of these new risks. In particular if diagnosis and/or therapy have any experimental character, the special provisions and issues have to be discussed with the patient and need to be documented in detail.

While healthcare is revolutionised by new technolgies for the diagnosis and treatment of diseases other existing devices and services like smart phones and cloud computing have already profoundly changed our way of living. Pulse and sleep sensors are common today and more will come. All of these devices drive a change in human behaviour.

This is important from an insurance point of view because the vast majority of losses in today's insurance world are due to human failure[51]. Not adequately addressing the human factor in the risk management for the 21st century will thus definitely trigger new incidents.

The human factor

Research in a number of industrial sectors indicates that up to 80% of accident causes can be attributed to a breakdown in human interaction with the result of human error affecting the safety of used technology[52 53]. Recent examples are the "Costa Concordia" disaster[54] or the derailment of a Spanish high-speed train in Santiago de Compostela[55]. In both cases, basic safety rules or instructions were not observed.

Many of the new technologies and systems outlined in this publication feature a degree of complexity which is no longer comprehensible to the human mind. Some day-to-day objects we use today already are black boxes for us. That is, we confidently use them, but have no idea how they function. If our smart phone breaks down, for instance, we don't know how to fix it – although we will be painfully aware of how the break-down disrupts our daily life.

This "smart phone effect" can be even more disruptive in high risk systems which are already running on the edge. An external shock in an era of shrinking safety margins can thus rapidly have devastating consequences, especially when considering the growing dimensions of buildings, ships, planes and systems in general, as described in this publication.

One way to address human failure is to design systems so that they automatically default to a safe status in the case of an external shock. While this can be an option for external power supply – where batteries or generators may be installed to kick in automatically – it will not work for more complex areas such as health care, traffic control or running an oil refinery.

The best way to tackle the problem of human factor in complex systems is to train people to ensure they act appropriately when faced with challenging situations. This requires sufficient and well-rested staff. Time limits on operation, like we see it in aircraft already today, must become standard where staff has to monitor and possibly regulate high-risk systems. Furthermore, developing a loss prevention strategy which considers human reaction under stress can also be helpful, for instance by exploring how to prevent impulsive reactions to unexpected events.

The examples above are only highlights of the changes we experience around us. More could be added and even more are sure to come. The pace of change is fast, of great magnitude and ubiquitous, generating a new risk landscape in a very short time.

Still, over the long-time stretch of the industrial revolution, we became used to a certain level of safety and reliability. Will we be able to maintain this? And, if yes, which safeguards will be good enough to assure it?

4. Risk management in a more complex world

The level of safety we can achieve in the future will not only be determined by the way our environment changes with technologies and infrastructure; also instrumental are the changes in our natural environment.

Climate change is moving coastlines and affecting rainfall patterns, storm intensities and frequencies, and may shift the range of plant pests to some of the world's key growth areas. All of this will impact agriculture.

Droughts and floods are already significantly impacting food supplies[56]. Given that the dependency of urban areas on outside food supplies will increase with a growing population, this is a threat scenario that needs to be addressed.

Furthermore, climate change is expected to increase the exposure of cities to floods, windstorms and heatwaves, endangering the lives and livelihoods of city residents[57]. Since cities are often the nexus of whole economies, the ripple effects may be felt by many more people than those directly affected. In extreme cases, they may even be felt globally, for instance if a key supply chain element is knocked out.

All of this together means that we are not only reaching new horizons in the technologies we employ, our new world may also be exposed to environmental conditions we have never experienced before. This creates a double challenge since not only the technological, but also the natural goal posts are moving.

Consequently, the new safeguards we need must address not only the areas we actively change by introducing new technologies and larger structures; they must also deal with changes that are not within our direct control.

Safety – managing complexity in a highly interconnected world

Safety is a term with many meanings. The Encyclopaedia Britannica defines it as "activities that seek either to minimise or to eliminate hazardous conditions that can cause bodily injury"[58]. In the context of this publication, it has an additional meaning: "the incident-free and reliable operation of systems that minimises or eliminates negative impacts to people, property and the environment".

An expert meeting of the Swiss Federal Institute of Technology in 2013 discussed how to achieve safety in a world focused on managing complexity and interconnectivity[59]. It concluded that, while the standards of ISO 31 000[60] are still a good foundation, achieving safety today renders new solutions necessary and additional discussions are required about different values, cultures and the trade-offs between flexibility and standardisation.

A safe environment can be ensured by a combination of the right protocols, the right data, the right working conditions, appropriate risk assessment, learning from mistakes, rich face-to-face communication, and the integration of local cultural particularities.

Redundancies should no longer be considered as a cost block, but as an investment in reliability and safety. The same is true if outsourcing is considered. While it may appear cost efficient at the beginning, outsourcing generates new interfaces – and these have proven in the past to be the source of many major disasters. Pure economic considerations have shown themselves to be too limited to make adequate decisions on safety. Last but not least, having experienced staff is one of the best risk prevention measures. When human failure is behind the majority of losses, staff must be a focus of all risk management activities.

In times of tight cost management and efficiency gains across industries, risk management must lie within the CEO's responsibility as well as that of the Board. Regular safety updates belong on the agenda of top management. Companies need to ensure that funding for proactive investment in prevention and safety management planning is available.

Only by managing risks in this comprehensive manner can we ensure that companies, systems and societies run in a stable manner. And stability is, after all, the foundation to achieve economic growth and societal well-being.

So, how can we manage the risks in this new world? In the past, successful risk management models were developed, and the key components of these – setting safety goals, identifying risks, quantifying frequencies and severities, selecting risk management measures, implementing them, monitoring success and regularly reviewing the goals – must be kept[61].

We should also remember the lessons learned in the past since they hold valuable clues on cause, effect and risk mitigation. This is the expertise that must be brought to the table[62]. Early warning systems must also be maintained and further developed to enable timely reaction, wherever possible[63 64].

We can build on this foundation by enriching and further developing it to capture and adequately assess new interfaces and resulting effects. To do this, risk management and loss prevention must:

- be an integral part of enterprise philosophy
- feature tailored early warning systems which also employ new methods such as big data analysis
- be forward-looking by developing competitive intelligence and early warning systems which include information from research communities and scientific journals as well as regulators
- be pro-active and timely in assessing potential impacts of new projects by starting already in the design or inception stages rather than in the implementation phase
- be collaborative over fields of expertise in detecting emerging risks and new technologies
- be imaginative by developing unrealised scenarios and being open to various cultural and educational backgrounds

We, in the insurance industry, can support this process. Insurance is in its core about risk management, and our expertise in root-cause analysis to avoid or mitigate the extent of incidents, which is one of the base building blocks of the approach outlined above, comes long before the actuarial work sets in.

Besides actuaries insurance companies have engineers and technical experts for any economic activity taking place. In addition, they all speak the common language of risk management. This is an asset given the fact that experts who did not work together in the past now have to come together to make our new world a safer place.

By combining their expertise, insurance and industry experts can help to develop and implement risk mitigation policies and features early in the process. Good examples of this are the "Tunnelling Code of Practice" or the "European Wind Turbine Committee Offshore Code of Practice", which were jointly developed by the insurance industry and responsible industry bodies to ensure safe and reliable project delivery on time.

Since many failures have their root causes in the planning or inception phase, this is where the greatest leverage to avoid losses is. It also helps the insurance industry to meet the challenges of insuring new technologies. In the absence of applicable loss histories, technical understanding of what is new and how it impacts safety and reliability aspects are vital for insurability.

Such collaboration, ultimately, also helps investors and project sponsors since they can now benefit from the insurance sector's risk management expertise. This will contribute to safe and reliable project delivery and operation, and create economic benefits for project owners – because failure at a later stage is inevitably more expensive.

5. Conclusion – Insuring the 21st century

It is possible to make our new world a safe one, provided we design and implement a new approach for managing risk. Building on our past experience in managing risk in well-defined systems, we must consider how previously unrelated systems now interact with one other.

Scenario modelling can provide valuable insights for us in this regard. Scenarios help us to identify the interfaces that exist already, are being developed right now, or will become important in the future. Unmanaged interfaces are often the root cause for system and human failure; hence knowing them is a big step forward in risk management. Once identified, interfaces must be analysed in terms of their resilience against internal and external shocks.

Shrinking safety margins in sub-systems require special attention, since one system can bring down the whole complex network. Such margins are the hallmark of our new world. Faster systems and larger installations dominate our increasingly interconnected world. It is not easy to identify crucial nodes in an environment where all the goal posts are shifting.

Safety in this context may differ from what we had in the past. Discussing what constitutes safety in the future and defining the interfaces that must be addressed requires a continuous dialogue between different fields of expertise. While this has already happened in the past, it must be stepped up to reflect the new, complex world we are living in.

Collaboration is the paradigm for managing risk in the 21st century. As most losses stem from lapses in the planning or inception phase, teamwork must start early. The insurance industry is willing to do its part, not only by providing financial assurance for the residual risks remaining, but also by sharing its expertise to avoid losses from occurring in the first place.

In addition, this is in the interest of insurance buyers because keeping a business running is always more benefical than managing insurance payouts and the additional work along like minimizing reputational damage or keeping a customer base. Helping others to avoid losses also supports society at large, as big losses will always have side effects on many stakeholders – not only those involved in the insurance value chain.

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6. References

1 http://www.un.org/en/development/desa/population/
2 http://www.un.org/en/development/desa/population/
3 http://www.who.int/gho/urban_health/situation_trends/urban_population_growth_text/en/
4 London Engineering Group (2010), Prototypicality
5 Udo Bardi: „Extracted – The past, present and future of global mineral depletion" – A report to the Club of Rome. Chelsea Green Publishing 2013.
6 BP, Gulf of Mexico Oil Spill Claims Report 7/31/2013: www.bp.com/en/global/corporate/gulf-of-mexico-restoration/claims-information.html
7 http://www.reuters.com/article/2013/03/15/us-bp-spill-appeal-idUSBRE92E12Y20130315
8 http://www.telegraph.co.uk/finance/newsbysector/energy/oilandgas/7820915/BP-oil-spill-an-interactive-timeline-of-the-share-price.html
9 http://marketrealist.com/2014/09/bp-lost-55-shareholder-value-deepwater-horizon-incident/
10 Bloomberg BP ticker values 07/04/2010 and 31/07/2013
11 http://www.isa.org.jm/en/home
12 http://eu-midas.net/
13 http://www.thecroforum.org/esg-country-risk-management-a-new-horizon/
14 CRO Forum Publication Respecting human rights – The role of the insurance industry, to be published November 2014 http://www.thecroforum.org/publications
15 "Navigating recent development in marine and airline insurance", Swiss Re sigma No 4/2013
16 "Ghost ships", The Economist Technology Quarterly, March 8th 2014
17 "The challenges and implications of removing shipwrecks in the 21st century", Lloyd's 2013
18 "Navigating recent development in marine and airline insurance", Swiss Re sigma No 4/2013
19 http://www.airbus.com/company/market/forecast/
20 http://www.bmub.bund.de/themen/luft-laerm-verkehr/verkehr/flugverkehr/
21 http://data.worldbank.org/indicator/IS.AIR.PSGR?page=5
22 http://en.wikipedia.org/wiki/Lockheed_Constellation
23 http://en.wikipedia.org/wiki/Airbus_A380
24 http://de.wikipedia.org/wiki/Liste_der_gr%C3%B6%C3%9Ften_Verkehrsflugh%C3%A4fen
25 http://en.wikipedia.org/wiki/World's_busiest_airports_by_international_passenger_traffic
26 http://www.usatoday.com/story/news/nation/2014/05/22/ntsb-dreamliner-boeing-faa-lithium-ion-batteries-united-japan-all-nippon/9433841/
27 http://en.wikipedia.org/wiki/UPS_Airlines_Flight_6
28 http://online.wsj.com/news/articles/SB10001424127887324823804579012341263333198
29 http://www.faa.gov/about/office_org/headquarters_offices/ash/ash_programs/hazmat/aircarrier_info/media/battery_incident_chart.pdf
30 http://www.ladepeche.fr/article/2014/03/09/1835117-des-fissures-dans-les-787-dreamliner.html
31 http://articles.chicagotribune.com/2013-01-11/business/chi-dreamliner-problems-cracked-window-oil-leak-amon-latest-787-woes-20130111_1_dreamliners-japanese-carrier-orders-review
32 http://www.dailymail.co.uk/news/article-2089153/Airbus-A380-More-cracks-wings-worlds-biggest-jets.html
33 http://de.wikipedia.org/wiki/Hochgeschwindigkeitszug
34 http://www.uic.org/spip.php?article608
35 http://www.uic.org/spip.php?article608
36 http://en.wikipedia.org/wiki/High-speed_rail_by_country
37 Peterman, Frittelli & Mallett (2013): The Development of High Speed Rail in the United States: Issues and Recent Events. [fas.org/sgp/crs/misc/R42584.pdf]
38 Munich Re Analysis; not published
39 http://de.wikipedia.org/wiki/Eisenbahnunfall_von_Wenzhou
40 http://de.wikipedia.org/wiki/ICE-Unfall_von_Eschede
41 http://de.wikipedia.org/wiki/Eisenbahnunfall_von_Santiago_de_Compostela
42 http://media.swissre.com/documents/Swiss_Re_Mind_the_risk.pdf
43 http://www.roadtraffic-technology.com
44 http://www.kkr.mlit.go.jp
45 http://www.ctbuh.org CTBUH Journal 2013, Article: Kingdom Tower Jeddah, Website: CTBUH.ORG
46 Flyvbjerg, Bent (2014): What you should know about megaprojects and why: an overview. Project Management Journal 45(2): 6-19.
47 Managing complex risks successfully Munich Re Discussion Paper http://www.munichre.com/site/corporate/get/documents_E-1170441588/mr/assetpool.shared/Documents/0_Corporate%20Website/1_The%20Group/Focus/Emerging%20Risks/302-07873_en.pdf
48 http://media.swissre.com/documents/Cyber_security.pdf
49 http://www.emc.com/collateral/analyst-reports/idc-digital-universe-united-states.pdf
50 "Telemedicine: Opportunities for Medical and Electronic Providers", BBC Research
51 Mellert, Lars: Human Failure, organizational Change and Culture. http://www.geo.uzh.ch/en/units/economic-geography/studying/master-theses-completed
52 http://www.atrainability.co.uk/index.php?option=com_content&view=article&id=2&Itemid=2
53 Reducing error and influencing behaviour HSG48 – Health and... www.hseni.gov.uk/hsg_48_reducing_error_and_influencing_behaviour.pdf
54 Costa_Concordia_-_Full_Investigation_Report[1].pdf
55 Santiago de Compostella: IF240713200514CIAF[1].pdf
56 http://www.thecroforum.org/esg-country-risk-management-a-new-horizon/
57 http://www.swissre.com/rethinking/climate_and_natural_disaster_risk/Mind_the_risk.html
58 http://www.britannica.com/EBchecked/topic/516063/safety
59 http://media.cgd.swissre.com/documents/ZRH-13-02426-P1_CGD_Safety+management_Broschure_web_final.pdf
60 http://www.iso.org/iso/home/standards/iso31000.htm
61 http://www.iso.org/iso/catalogue_detail.htm?csnumber=43170
62 http://www.eea.europa.eu/publications/late-lessons-2
63 http://www.weforum.org/issues/global-risks
64 http://media.swissre.com/documents/SONAR_2014.pdf

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