ROLLING STOCK

IMIA Working Group Paper 102(17)
IMIA Annual Conference 2017 - Munich

Sponsor: Guido Benz, Swiss Re

Christoph Guntersweiler (Chair)	christoph.guntersweiler@helvetia.ch	Helvetia
Heiko Hammacher	heiko.hammacher@helvetia.ch	Helvetia
Eric Bentz	ERICBEN@mapfre.com	Mapfre
Ho Kun Hong	KHO@scor.com	SCOR
Ed Chan	ed.chan@uk.rsagroup.com	RSA insurance Group
Brendan Reed	bmr@codan.dk	Codan
Thomas Gebert	thomas.gebert@axa.de	AXA
Denis Kocan	Denis_Kocan@swissre.com	Swiss Re
Darren Smart	Darren.Smart@LibertyGlobalGroup.com	Liberty
Bruno Ternisien	bruno.ternisien@naudet.fr	Naudet
Colin Hamling	Colin.hamling@hs2.org.uk	High Speed 2, UK
Richard Day	richlach96@gmail.com	Arup
Raik Wittowski	olive66@gmx.ch	-

1 EXECUTIVE SUMMARY

Rolling Stock is a broad term which defines everything which travels on rails and is rolling.

This paper gives an overview about the different topics about Rolling Stock in the insurance industry. The goal of this overview is, that an engineering line underwriter, risk engineer or claim manager get helpful support and information about different kinds of Rolling Stock. In the paper, there are the following areas:

- Definition and values

- Rolling Stock in Engineering insurances
  There is some information about the market players, technology, maintenance, standardizations and regulations. It gives the reader an understanding about this market and its technology.

- Loss Examples
  There are a number of loss examples. They give a real feeling to the reader of potential implications of product failure and property exposures.

- Insurance thoughts
  The insurance thoughts are divided into 3 sections: The underwriting, PML and pricing considerations. These contain advice about what the underwriter and risk engineer should consider to cover such risks.

Depending on the whole development of the transportation market and its importance, this paper should give an accessible aide memoire for Rolling Stock.

2 INTRODUCTION

2.1 Goal

This paper should be of interest to engineering and technical line underwriters, risk engineers, claims managers and brokers who have to work on Rolling Stock.

The paper should give support and impression about the Rolling Stock market overall (size, technology, and so on), claims and covers. It is not the intention of this paper to describe every detail but it shall give any Reader a good overview about risks and insurability of Rolling Stock.

2.2 Scope of paper

The scope of this paper is focused towards Rolling Stock. It means everything which is on rails and rolling is in scope. Any infrastructure like tunnels, bridges, rails or something else is out of scope and there are no topics about this. There are some other IMIA-papers (https://www.imia.com/knowledge-base) which have been written about infrastructure topics (e.g. CECR, Bridges, Tunnel Projects).

If there is any important information or thoughts about claims, covers or questions about the interaction between Rolling Stocks and such other properties (as an example like rails and speed), then there are some explanations about such later on in this paper.

2.3 Field of observations

There are different field of observations, which are important for Rolling Stock. One field is the project (design, manufacturing, assembling, testing and so on) and the other field is operational (including maintenance and so on). Where some of the topics are related to both projects and operational others only relate to one of the fields.

Mainly the paper is focused on property and not liability. In the field of Underwriting Considerations, there is a short explanation about liability.

3 DEFINITION

What do we understand by «Rolling Stock»?

3.1 In scope / out of scope

3.1.1 History

One early definition of Rolling Stock is „Locomotives, carriages, wagons, or other vehicles used on a railway“. The first railway was documented as being in the first century AD in Greece – rather a „wagon way“ made of limestone paths which have grooves cut into them so that the wheels of the wooden carts (pulled by men or horse) that could only travel along the grooves. In the 1500s wagon ways developed from wooden rails to cast iron rails, and the wheeled wagons could be connected together carrying much more goods or people along longer routes. In the 1800s the first steam locomotives was invented[1] which could tow many more passenger carriages or wagons in series. The steam locomotive like today's locomotives or „driver trains“ are at the front of freight wagons or passenger carriages, where the onboard train operator throws coal into the combustion system and applies the brakes as the Rolling Stock approaches a station. This steam locomotive and series of carriages and wagons would be our first ever mechanised Rolling Stock.

https://de.wikipedia.org/wiki/Dampflokom

https://de.wikipedia.org/wiki/Heizer

3.1.2 Today

Today Rolling Stock takes many forms of driver trains and carriage configurations, and usually associated with the mass transportation of people or goods within cities or continents on a much developed rail network infrastructure. In this paper we consider Rolling Stock that travels on dual rails with a minimum of 4 wheels per carriage (ski lift, cable cars, monorail are not considered herein) for passenger or cargo transportation. We do not specifically cover specialty propulsion such as magnetic trains or speciality Rolling Stock subcategories such as grinding machines.

[1] https://en.wikipedia.org/wiki/History_of_rail_transport

3.1.3 **Categorization**

We have found that the categorisation of Rolling Stock is driven by the propulsion, territory, use, speed or even technology: [2]

- Propulsion by fuel source
  - diesel engines[3],
  - electricity where the power comes through the overhead power line or separate power rail adjacent to the rail track,
  - Combination or hybrid systems (in areas with no electricity the diesel engine is used, or „batteries“ can be used as a backup resource.

- Transported goods
  Can include cattle wagons, coal wagons, oil or gas tanker wagons. The locomotive is a fairly rugged unit to consider the terrain source of power and the type of load on the wagons being towed, but the wagons themselves need to be easy to load or unload the goods. Volatile goods such as petrochemical products are required by regulation to be transported in enclosed vessels with various bypass systems and certain instrumentation to prevent any health and safety incidents.

- High speed trains
  Are most often associated with the breakthrough of the „bullet train“ in Japan for long distance travel at speeds often exceeding 220km/hr along certain stretches[4]. High speed Rolling Stock must be efficient at speed and involves costly design considerations for the procurement of materials, design of aerodynamic shape and any other requirement set by relevant safety protocols.

http://www.mckinsey.com/industries/automotive-and-assembly/our-insights/how-rolling-stock-manufacturers-can-lay-track-for-profitable-growth

[2] Taken from McKinsey & Company “Huge value pool shifts ahead – how Rolling Stock manufacturers can lay track for profitable growth” Advanced Industries September 2016

http://www.mckinsey.com/industries/automotive-and-assembly/our-insights/how-rolling-stock-manufacturers-can-lay-track-for-profitable-growth

[3] http://www.railway-technical.com/diesel.shtml

[4] http://www.uic.org/highspeed#What-is-High-Speed-Rail

- Metro systems
  The rail network is often underground but can be above ground, using specifically designed locomotives and carriages to convey people within a small area such as a city or town. Normally we can assume electricity as a source of power. Whilst metros have the benefit of a separate rail networks within large cities the space is limited and stops are frequent. For example the London Underground network is 274 km long with a mix of underground and above ground sections. It travels at 33mph but on certain stretches travel can be 60 mph. The locomotives themselves are distinct in that the driver sits in a separate compartment within the locomotive so that passengers can also board the locomotive section[5].

- Trams
  Are similar to Metro systems in terms of citywide transportation with similar configurations of driver carriage. Trams are often powered by overhead lines. Given the above ground nature often sharing routes with bike lines and roads. Their speed is often limited and designed to accommodate left and right turns, at points or interchanges, due to design considerations.

- Other specialties
  - Driverless technology: the central control room can send signals to the train's onboard control system propulsion and braking system. This network has to be supported by CCTV (see "Appendix 1 – Glossary") and also an onboard ticket collector who controls the door opening and closing actions.
  - Tilting trains – if the rail network has many turnings or uneven terrain, tilting trains are programmed to travel a route and at known points activate hydraulics to tilt the train bogeys. Speed is often slowed and the mechanics of the tilt required are generally not controlled by the driver.

[5] http://metro.co.uk/2013/01/09/london-underground-turns-150-top-10-tube-facts-3344227/

4 VALUES OF ROLLING STOCKS

4.1 Costs

We have mentioned many types of Rolling Stock each operating on certain infrastructure, certain capacity and certain technologies. The average modern Rolling Stock on:

- metro and Intercity cost around £1.25m - £1.5m per carriage/vehicle
- high speed up to £2.5m-£3m per carriage/vehicle

With considerable variation between individual territories, as greater interoperability, these average figures cannot be blindly applied or be benchmarked against for example Rolling Stock in Europe. For instance we have seen specifically designed passenger Rolling Stock where 1 set will have 2 driver cars and 10 carriages are initially estimated at £ 50m per set.

Between each of the different types of Rolling Stock, there are some key design and components to consider, which can increase the cost of unit construction:

- Metro
  - regenerative braking
  - multiple doors per side
  - high standing capacity
  - variety of signaling- from historic absolute block to cab-based
- Intercity
  - Conventional
  - Lower number of doors- speed up to 200kph- many similarities to above in technology
- High Speed
  - End doors – required for high structural integrity and crashworthiness (e.g. Grayrigg 2007 - 10 vehicles derailed, 1 fatality)
  - Cab based and GPS signaling
- And overall
  - adjustment to Rolling Stock so that it meets Infrastructure it will run on
  - compliance with interoperability regulations
  - Passenger capacity per carriage
  - any technological features onboard with respect to performance or comfort
  - Design considerations for maintenance and operation factored in.

4.2 Annual Costs of the rail industry

Rolling Stock construction and maintenance of existing Rolling Stock accounts stands for a significant proportion of the annual spend on rail industry. For example the rail industry in the United Kingdom spent £ 12.92bn in 2009/2010, 4% of this was new Rolling Stock, 12% on leasing and maintaining Rolling Stock (operations) and the residual amounts on infrastructure and financing. Reviewing the overall spend on Rolling Stock over the duration of its operational life surprisingly only 31% of it is on the initial purchase, 44% is spent on ongoing maintenance and the residual 25% is spent on operational costs.

Rolling Stock operators are consistently looking to find a balance between high specification vehicles that are fit for purpose, cost efficient to build but also convenient and cost effective to run and maintain in the long run[6].

[6] Rolling Stock whole life costs - Arup, March 2011
http://orr.gov.uk/__data/assets/pdf_file/0011/2711/rvfm-arup-rolling-stock-mar2011.pdf

5 Rolling Stock in Engineering Insurance

5.1 Key Statistics

5.1.1 Rolling Stock Industry

The whole market volume of Rolling Stock Industry varies substantially by region. According to the latest SCI-Study "The Worldwide Market for Railway Industries 2016"[7] the biggest market is Asia:

5.1.2 Rail Transport Market

The Rail Transport Market can be divided into three sectors Freight, Passenger and Urban Rail (see the extract from the SCI-Study "Rail Transport Markets – Global Market Trends 2016-2025")[8]:

[7] THE WORLDWIDE MARKET FOR RAILWAY INDUSTRIES 2016
http://www.sci.de/download/documents.html

[8] http://www.sci.de/uploads/tx_edocuments/Flyer_Rail_Transport_Markets.pdf

In the latest years, the market has been growing and the expectation is still positive for growth for all 3 sectors

The performance of regional transportation markets differ substantially between passenger and freight, see pictures below:

The Asian market of the operators is driven by passenger transports (biggest) in which the North America passenger market is very small. On the other hand the North America freight market is, together with Asia, the biggest market.

5.2 Market Overview about Suppliers / Manufacturers

The global rail industry has in the last fifty years become dominated by a handful of manufacturers and suppliers. This is due in part due to the choices of some countries to pursue a policy of rail transport investment and thus bringing growth of domestic vendors, and in part owing to the high levels of initial investment required to enter this market – it is the level of early capital expenditure which is a bar to all but the largest and most experienced established production centres. Globally the vendor market has been and continues to be dominated by Europe, Japan and China. The United States has largely ignored high speed passenger rail investment in favour of road and air travel, although it remains a key market for freight business.

Most rail systems themselves are at least in part nationalised i.e. government-controlled, and retain autonomy and control to dictate or at least influence the manufacturers in what they produce. Rolling Stock is manufactured for particular projects in a PPP (see "Appendix 1 – Glossary") format for particular clients as per their requirements.

As governments look to reduce carbon emissions over the long term, and also look to service the transport needs of increasing numbers of people in large urban environments, there is significant demand upon these major manufacturers to supply both high speed services and urban metro or light rail systems.

The powerhouses of Europe are dominant in their own region and have also enjoyed significant success globally where free competition is permitted. The long term commitment across Europe to high speed rail and reliable inter-city rail travel has consolidated the upper tier positions of Alstom, Siemens, Stadler, CAF, Talgo and also Bombardier whom – whilst of Canadian ownership – run their Transportation business from Germany.

Across to Asia, the Japanese market is largely self-sufficient, with Kawasaki and Hitachi having the largest international footprint with awards in United States and the United Kingdom.

The China market place is dominated by CRRC[9], which was formed from the merger of CNR and CSR. Whilst primarily focussed upon domestic contracts, CRRC has a growing

[9] http://www.crrcgc.cc/en/g6782.aspx

international order book too. The global footprint of CRRC (graphic below) is a demonstration of the broader Rolling Stock industry as introduced within this overview.

5.2.1 The Top-10 Suppliers / Manufacturers

Related to the extract of the SCI-Study "Worldwide Rolling Stock Manufacturers 2016"[10], the 10 most important Rolling Stock manufacturers generate a combined new vehicles revenue of around EUR 39 billion, more than 75% of the global market for new vehicles in 2015.

[10] http://www.sci.de/produkte/scimulticlient-studien/suchergebnis/studie/hersteller-schienenfahrzeuge-weltweit.html

5.3 Market overview rail transport

In each country there are different railway operating structures. In the past where most railways were owned by one company, all infrastructure and all the services to freight and passenger customers were provided by only one company[11].

Nowadays, in the markets are different models which mean:

- service is provided by franchise operators whilst the rail infrastructure is still operated and maintained by the railway owner, or
- service and infrastructure are operated by a public company, or
- Infrastructure is operated by a private company and the service is provided by public or private companies.

The operation model can have an influence on the competition between the providers in a market. If there are many providers of the same service, in a competitive market, the rates for transport will decrease.

5.3.1 The Top10 Rail Operators

As mentioned in chapter 5.1.2, the Rail Transport Market differs depending on the region and country. Where in some regions, the passenger is much bigger than the freight market others are the opposite of it or in a similar size. Based on a data-base from the UIC[12] following are the 10 biggest Rail-Operators (related to the passenger and tons kilometer):

[11]Recent Developments in Rail Transportation Services 2013
http://www.oecd.org/daf/competition/Rail-transportation-Services-2013.pdf

[12]Railway Statistic 2015, synopsis
http://www.uic.org/statistics

5.4 Technology and its development

There are a variety of technologies used in the Railway Industry. The chapter below describes some of the current technology and gives also an outlook to future developments.

5.4.1 Present Day

5.4.1.1 Bi-Mode or Dual Mode (Power) Vehicles

A number of suppliers provide vehicles where traction power is developed from both diesel and electric sources. This should not be confused with diesel-electric vehicles or hybrid vehicles. The term diesel-electric vehicles are used to describe the solution where the diesel engine drives and electrical generator or an alternator the output of which is fed to the electric traction motors. Hybrid vehicles are discussed below.

Bi-mode powered vehicles are almost always implemented to overcome discontinuation of service or transfers on an existing (or combination of existing) routes where electrification has not been completed over the entirety. As such, the provision is found in markets where the railway sector is developed and for existing main line rail because:

- Developing rail markets will generally be new build with the traction and permanent way provided under the same project as Rolling Stock procurement
- Metros and light rails are almost always electrified and in any case it is more efficient and economic even in the short term to electrify shorter routes rather than procure specialist mixed traction package vehicles.

Examples of this vehicle are Hitachi for the IEP and the AT300 five-car electro-diesel multiple units for Hull trains.

5.4.1.2 Gauge Changing

Rolling Stock vehicles with an ability to change gauge i.e. the lateral spacing between wheels are not common but necessary for some long distance routes usually between countries/regions but also on Japan's Shinkansen. The benefit is the removal of the need to de-train/re-train passengers and freight at the border between the different gauges and the risk, obviously is that the change is not achieved properly with the consequence of derailment.

Some of the earliest examples of this example involved lifting the train sets and changing the wheelset or bogies for instance between France and the Iberian network. Then in the late 1960's, extendable axles were fitted to passenger cars with the change implemented by running through a purpose made gauge changer although this required de-coupling the locomotive from the trailing stock.

5.4.1.3 Energy Storage Systems

Light Rail Systems are increasingly becoming available with vehicles that can store electrical energy and this can be in 2 forms, either batteries or, more recently, ultra capacitors

The rapid advancement of battery and electric charge storage technology has enabled a spread over from low current portable hand held devices, principally smartphones, to high current, high load applications. Storage capacity is all important in this field dictating the usage in normal and emergency situations.

Super capacitors such as the "rapid charge accumulator" in operation on CAF's vehicles on the Seville and Zaragoza tram lines, require a much shorter charging time – down to around 20 seconds – which can be achieved during station stops. They also allow storage of energy produced during regenerative braking.

5.4.1.4 Hybrid Vehicles

Hybrid trains use an onboard rechargeable battery system to store electric power derived an alternator driven by the diesel engine. Diesel and electric b-mode vehicles can also be hybrid type if they are fitted with battery storage between the electrical source and traction motor.

This technology is not new with rail applications being around as early as the 1900s. Development of this type of traction package can be expected for higher load, capacity and distance applications not suitable for battery or super capacitor storage. Energy efficiency is increased as the battery pack is able to store energy retrieved using regenerative braking.

Development will be seen in terms of usage in high speed rails systems and increasing power demand applications such as the “New Tube for London” (NTfL) where air conditioning is being reduced

5.4.1.5 **“Catenary Free” Light Rail**

For safety reasons, the city centre locations of trams have necessitated that the electrified supply be made inaccessible to the public usually by locating it at high level i.e. on a catenary system with vehicles fitted with pantographs. Solutions with power supplied at low level were developed in the early 2000’s with only the section occupied by the vehicle being powered live but these proved unpopular due to lingering concerns over safety and a reputation for unreliability.

Some suppliers claim that both batteries and super capacitors offer the possibility of a catenary free system however the reality for most of these is that short sections of catenary are required at stations and, in some cases, intermediate stopping points for charging facilities. There is also a number of limiting factors that currently restrict the applications of vehicles with these technologies.

The first is distance between charging points, and hence stations, which needs to be kept relatively short (400m is not uncommon). Gradients of 5-8% are generally about as much as can be accommodated and obviously the loading is lower than for continuously energised vehicles. This reduced loading and the possibility of unforeseen events means that only above ground applications are currently considered suitable for vehicles fitted with these technologies. Finally, in order to ensure that the energy stored is not expended before the next charging point due to unforeseen events such as breakdown of the vehicle in front, the guideway needs to be dedicated to light rail vehicles only.

Developments in storage technology and inductive charging (where the charging is achieved without direct between direct contact between live parts on the wayside and vehicle respectively) have allowed a number of suppliers to offer “catenary free” light rail options. Bombardier’s Primove System transmits power using induction loops.

5.4.1.6 **Driverless and Unattended Train Operation (UTO)**

Improvement of safety by eliminating human error and increasing capacity on existing infrastructure are key drivers for the introduction of advanced technology on Rolling Stock. The requirement for the highest levels of system reliability and availability have also been key considerations and implementation of technologically advanced systems has increased the opportunities where failures can be addressed by moving to a degraded mode rather than stopping the service altogether.

There are a number of rail systems around the world which are either operated in a driverless or unattended mode. The move from driverless to unattended (where there is no operations staff on board the train in any capacity) is significant as unattended operation presents challenges for both the system supplier and the system operator. The Rolling Stock supplier has to consider failures and recovery solutions in much more detail with no possibility of placing a driver in the cab.

The capability within the Rolling Stock is achieved primarily via onboard mounted train control systems equipment which interfaces with the traction, brake and door systems on the train. Therefore the considerations from a Rolling Stock point of view centre on the ability of those packages to interface with the train control system and the system design must include assessment of the performance characteristics of each of these.

The implementation of unattended systems also has an impact on the requirements for on board passenger means of communication with the outside world, the monitoring of the situation within the train (CCTV, see "Appendix 1 – Glossary") and the means of escape.

This means that the availability of the communication link between the wayside and the train is of utmost importance and even in degraded mode must be able to support full functioning of sub-systems critical to safety, preferably including normal train operation.

The Rolling Stock needs to be provided with a 2-way passenger communication system, this could be for communication with remote locations (such as the nearest station, control centre) or, for non-UTO systems only, by a member of staff (who will need a means of communication to stations/control centres) on the train or both. This member of operating staff could be either at the front of the train in a “driving” capacity or as a “train captain” positioned somewhere in the passenger accommodation.

Means of escape from a passenger vehicle should be determined at the concept design stage as it has a significant impact on not only the Rolling Stock but the civil structure too – particularly in the case of underground tunnels and high level viaducts. Escape can be achieved either on to a walkway at train floor height throughout the alignment via the side doors in the passenger compartment or directly onto the tracked using a dedicated walkway at either end of the train. In this latter case, factors affect the design to be considered include the type of escape method (steps or ramp) and its deployment as these affect the rate of detrainment. Generally speaking, ramps are easier to accommodate where there is no provision for constant attendance of an operator at the end of the train and controls can therefore be pushed to one side and locked away under covers thus increasing the width available for escape and the imposition of a door to an operator’s cab.

5.4.2 **Technological Developments**

Similar to other areas of engineering for business, the Internet of Things and more specifically the Industrial Internet of Things is a topic being discussed within the railway industry. Judging by feedback from Operators and what is shared with the professional media, the highest level of interest is in the operation and maintenance space – not surprisingly with a view to improving availability / reducing failure on demand by increasing predictive and reducing unplanned maintenance activities respectively. The most successful of these developments are most likely to be those that avoid an “alarms for everything” approach but combine information from several measuring points and over a prolonged period to indicate the most appropriate time for maintenance/replacement. This would be when the component or assembly has provided as much useful service life as it can but not yet failed. Identifying maintenance / failure trends both from a local system and across geographically spread locations where a component / assembly has been deployed are also applications that could be manipulated to the operators’ benefit.

Energy reduction is an ever present target in designing new Rolling Stock and associated with this is a reduction in weight, principally with the introduction of more efficient traction packages and lighter yet stronger materials. These trends are likely to continue particularly in light of the goal to bridge the gap between power demand and onboard energy storage systems.

The demand for information by passengers has never been greater and continues to increase. Advances in display screen technology have seen the introduction of fixed displays with illumination of routes / station stops and it is reasonable to expect that this demand will lead to the introduction of more dynamic screens with changing screens and detailed information including, of course with the operator’s revenue in mind, advertising. The demand for personalised information via data (wifi) connections is also becoming considered as an essential hence the spread of connectivity, already available on some underground metro systems, can be expected to continue over into long distance and high speed rail systems. Applications on freight services are less obvious but continuous tracking of individual consignments via GPS could be developed if there was a demand.

5.5 Maintenance of Rolling Stock

The Maintenance of Rolling Stock is fundamental for the availability of the train and consequent cost reduction and security.

5.5.1 Maintenance in general

Locomotives and cars are equipped with mechanical, electrical and pneumatic systems which have to be monitored for an appropriate preventive maintenance.

In most countries Code of Practices are applied and fix the periodicity of control of these systems and the following procedure to be applied according to the findings.

The maintenance process should include:

- Lubrication of all the moving parts
- The regular control of
  - wheels
  - brakes and couplings
  - bogies
  - cardan axles
  - motor brushes
  - the fuel injection
  - the turbo charger

5.5.2 Maintenance of wheels

One of the most demanding sources of maintenance is the control of wheels. It is required for regular measurement of steel wheel in respect of shape (roundness) and profile (to fit with Rail).

https://www.atsb.gov.au/media/5770652/rid43-picture-6.jpg

The wheels can be damaged due to thermal effect or contact rolling fatigue, or by skidding

5.5.2.1 Thermal cracks

Thermal cracks are the result of alternate heating and cooling of the wheel tread and rim area, and originate from metallurgical changes in the wheel material. Thermal cracks are the most severe form of wheel defect.

The heating of brake pads during braking often produces a fine network of lines on the tread of the wheel.

Thermal cracks are usually transverse, across the wheel tread, and if allowed to grow without corrective action can develop to the point where the wheel will fracture.

Many shallow thermal cracks can be removed by machining but extra care must be used to ensure that the crack has been completely eliminated in the operation.

If thermal cracks are found on a wheel, then the vehicle's brake system should be checked for evidence of dragging brakes. Depending on the thermal cracks class restriction has to be applied on the car or the whole train like speed limitation or removal of circulation of the defective car.

Fractured wheel caused by thermal effect

5.5.2.2 **Rolling contact fatigue**

Rolling contact fatigue cracks are caused by repeated contact stress during the rolling motion. This type of defect can lead to spalling.

Depending on the type of fatigue, a restriction may have to be applied to the car or the whole train such as speed limitation or removal from circulation of the defective car.

5.5.2.3 **Skidded wheels effect**

Skids occur when a wheel "locks up" while the vehicle is moving. All skids eventually lead to further wheel damage such as spalling or flats can reduce the life of bogie components such as bearings. Impact forces produced by a skid are also detrimental to the track structure.

The damaged wheels can then be reshaped or re-turned in a wheel lathe.

This operation has to be applied on the whole wheels of the car or locomotive to keep the balance of the whole vehicle.

The inspection of wheels is visual in a first stage and identifies the degree of damage. Deeper investigation is made further according to the type and degree of damage.

5.5.3 New maintenance tools and maintenance subcontracted to manufacturers

As an example of these new maintenance tools Deutsche Bahn and Siemens have launched a pilot application for the predictive servicing and maintenance of the high-speed Velaro D (Series 407 ICE 3) trains. Impending faults and malfunctions as well as the sources of these problems are identified at an early point by means of digitalized data analysis, and recommendations for vehicle maintenance then derived from this data.

5.6 Testing

Testing and Commissioning (T&C) is a very important phase in the construction of a rail system before it can be safely opened for commercial operation. Like in any other industry, T&C demonstrates that all technical and project requirements, as developed during the concept and design stages, are met. It ensures that interfaces between different systems that can include existing and third party systems are systematically closed and integrated. T&C confirms that the equipment is ready to be taken over by the employer and/or the operator.

T&C needs proper coordination between the various parties involved in a railway project:

- Employer – the infrastructure owner / organisation awarding the main contract or the set of contracts;
- Contractor – the main contractor along with the sub-contractors who build the equipment;
- Manufacturer – all contractors and sub-contractors who supply equipment, Rolling Stock, etc.
- Operator – the railway operator (may differ for Infrastructure and Rolling Stock)
- Third party – any organisation or system outside the main contract (Control Body, other infrastructure owners and operators…)

Usually, the employer provides a basic framework for the T&C process during the project concept phase and identifies who should be responsible for it. This framework sets out the fundamental criteria and requirements for testing a system. Based on this, the contractor(s) develop and use a detailed and overall T&C Plan, which defines the contractor’s systems, the interfaces between those systems and the resulting tests. This plan can be specific for a system too, such as for trackwork, traction substations etc.

5.6.1 Testing and commissioning stages

The testing and commissioning process can be sub-divided into the following phases[13]:

- Factory Acceptance/Inspection Test (FAT)

  The FAT stage is the testing of equipment and equipment components during production in the factory or in similar conditions. This initial stage of the T&C process confirms that the supply of individual components and equipment is according to the design and the overall project requirements. This stage gives the proof that all the components and equipment meet the specifications. FATs normally take place at the manufacturer's premises but can also take place at the contractor's premises for certain equipment. The FAT stage may also include some integration tests at the manufacturer's factory, which are performed to test the integration of the components that make equipment.

  Specific sub-systems or equipment can be tested using developed test benches to simulate inputs and outputs. This also allows as much integration testing as possible, thereby reducing the overall integration risks to equipment at later stages.

- Site Installation Test (SIT)

  The SIT stage is the testing stage following the installation of equipment and sub-system on site. The goal of the SITs is to demonstrate that all the equipment or sub-systems are correctly installed and wired, are checked and are suitable for operation. SITs can be carried out on a site by site basis and in phases as the railway line sections get built and equipped. SITs for train on-board equipment are normally performed on the train and therefore can be completed at the Rolling Stock manufacturer's factory, but can also be repeated at the employer's site.

- Site Acceptance Test (SAT)

  The SAT stage is the stage when all installed equipment and sub-systems are tested. This stage shows that all the various equipments and sub-systems can functionally operate, thus fulfilling all the performance requirements. In systems which are densely integrated, like those on any railway, it is these integration tests that need special attention because of the inherent complexity of the interfaces between the systems. Usually, SAT tests can be quite comprehensive and can include a range of tests, which can be divided into internal SATs (within the respective sub-system e.g. power supply, track, Rolling Stock) and

[13] Testing and Commissioning Process for a light rail project
R. Sharma, Ove Arup & Partners Ltd, Infrastructure and Planning Midlands (Rail), Blythe Valley Park, Solihull (West Midlands), B90 8AE, United Kingdom

external SATs (including interfaces to other or third party systems e.g. Rolling Stock to track, Rolling Stock to power supply).

- Overall Site Acceptance/Performance Test (SATOV)

  Overall testing (SATOV) can be defined as set of activities that prove that the overall system will operate satisfactorily in actual service. SATOV stage requires the operation of substantial amounts of systems on a coordinated basis, in a manner which is similar to the operation of systems in commercial service. This would involve performing all functional tests on all equipment and systems with operator involvement. SATOV-Line is a trial run period that commences after SATOV-Equipment and hand-over. All the equipment is placed under operation with actual train running.

While the above general classification applies for the railway system, there are some specific things to be mentioned in case of testing of the railway infrastructure or the Rolling Stock.

5.6.2 Testing and Commissioning of railway infrastructure (railway line)

Below list shows some of the most important Site Acceptance tests for the railway infrastructure involving specialized Rolling Stock:

- Ultrasonic Test of Rails (Rail Welding)
- Geometric Track set test (various Parameters)
- Geometric rail profile measurement (conicity)
- Testing of Control and Safety equipment (level measurement GSM-R, ETCS)
- Dynamic Measurement of Contact Force Pantograph - Feeding Cable, Catenary
- Dynamic Running Test (measurement of contact forces rail / wheel, and accelerations), normally with min. 110% of planed operating speed (normally no train control available)

Most of these tests involve special test trains, who are equipped with various monitoring and measurement equipment.

From an exposure point of view most relevant are the dynamic running tests, since here the trains run with high speeds, which even exceed the normal operational speed of the later regular train service. Further to that these test rides are normally conducted without the full control and safety equipment being operational.

After the completed railway infrastructure has passed all tests an integrated test with the designated Rolling Stock is normally carried out (SATOV). These test runs normally cover the full operational Scheme.

5.6.3 Testing and Commissioning of new Rolling Stock

Before a unit of Rolling Stock is accepted by the customer, there will be many formal tests to be performed. Each piece of equipment will be tested, before assembly into the train, first at the particular subcontractor's plant. This Factory Acceptance Tests will involve an inspector comparing the specification and drawings to the actual product in front of him. In the majority of cases, the piece of equipment will receive some form of dynamic test. This, for instance, could involve operating a gearbox on a test rig to verify it works correctly or maintains the correct temperature for the oil. If it is an electrical/electronic item, tests for continuity or breaker tripping and so on will be performed.[14]

Once all the FAT tests have been completed and passed as satisfactory on a particular item, the equipment can be sent to the vehicle builder for installation. When the Rolling Stock has been assembled, series of tests (SIT) will verify that the equipment functions as intended. There are again both dynamic and static tests. Some tests will seem mundane and will just be proving that lights work or the windshield wipers are working. Others have a more important function and will ensure that the wiring is correct through the vehicle or trainset,

[14] http://www.railway-technical.com/Manufacturing.shtml

called train line testing. Every piece of equipment will be tested on each piece of Rolling Stock and witnessed and approved by an Inspector appointed by the customer, before the Rolling Stock moves onto the next segment of the acceptance cycle, which is commissioning.

Commissioning, which involves (Overall) Site Acceptance Tests usually takes place on the customer's property. If it is a new piece of Rolling Stock or a trainset there will be a set of tests required called a performance evaluation. These tests will be used by the supplier to prove to the customer that what he is getting is, in fact, what he ordered. When the order was first placed, probably the first one or two items of Rolling Stock (or trainsets) would have been designated as prototypes or pre-production units. The intent here is to prove everything is in order before the supplier commences production of the remainder of the fleet.

Dynamic tests will be used to prove the acceleration and deceleration tests meet the specification performance criteria. Some contracts include an endurance or "burn-in" test when the vehicle will be tested and required to achieve a number of kilometres without a failure.

5.7 Security Equipment

5.7.1 Communication system between the railway and the Rolling Stock

5.7.1.1 Wheel to Rail Shunting system

When a single railway is used for traffic in both directions the need to control traffic is obvious. In the early days of railways watchmen were employed to inform train drivers about the presence of other trains using hand signs.

With the invention of the telegraph and the telephone it became possible to achieve a better traffic organisation.

Nowadays lines are equipped with Track Circuit. The line is divided into sections of length not shorter than the stopping distance. The Track Circuit consists in a block section defined at each edge by insulated joints on the rails. These joints provide electrical insulation between a track circuit and the adjacent track. A signal source is connected to the rails at one edge of the block section while the receiver is connected to the other edge. The presence of a train is detected by the electrical connection between the rails provided by the wheels and the axles of the train: Wheel to Rail Shunting system. The proper functioning of this Wheel to Rail Shunting system may depend on the design of the train and its maintenance.

5.7.1.2 Railway and Locomotive Communications-System (ERTMS)

ERTMS is the European Rail Traffic Management System is a computer based signaling system which improves interoperability and train control. Train speed depends on its design, and it also protects infrastructure access.

5.7.2 Brakes

The speed and length (and then the load) of a train is limited by its braking capacity. Indeed these two factors increase the length to stop the train. Over the years braking systems have been improved to optimise performances.

In addition to the pneumatic brake the systems are completed by technologies like electricity, electronic or electro-magnetic devices.

The main features of a breaking system are to be:

- Continuous along the cars
  A braking system is continuous if it allows the possibility of stopping all the cars at the same time by one single brake application.
- Automatic braking system
  The braking system is automatic if it operates as soon as there is a failure along the braking system (coupling of cars, leakage in the pneumatic circuit) without human operation.
- Endless braking system
  The braking system is endless if it can operate with the same nominal efficiency every times.
  Basically the air tanks close to the brakes will always immediately be refuelled, the wear parts of the brakes will be monitored.

In addition the braking system should be designed in a way to bring some comfort to the travellers by smooth braking. Each car is fitted with a special brake when parking.

5.7.3 Coupling of cars and other connections between wagons

The coupling system function is to connect the cars one to each other and to the locomotive to let it to draw the whole train. Beyond the mechanical connection the coupling system connects the continuous pneumatic braking system, electricity, and communication system.

Considering the relative position of the cars and imperfection of the railway track this mechanical connection needs to be flexible.

The maximum length of a train is regulated from countries to others. In EU it is about 1km for instance. The cargo weight, type and the maximum gradient of the track will limit that length. In this respect the management of the arrangement of the train is key. Some locomotives can be added in key position along the train.

The resistance of the coupling system can be affected by speed variation. For this reason drivers have to comply with strict speed rules especially on heavy cargo trains.

There are several types of coupling systems like the chains and buffers coupling, Janney, and Scharfenberg system. But there are much more, see below[15].

[15] https://en.wikipedia.org/wiki/Railway_coupling_by_country

- Chains and buffers coupler
  The traditional manual connecting system

https://en.wikipedia.org/wiki/Buffers_and_chain_coupler

- JANNEY system
  Automatic locking system for high tension (heavy load), predominantly used in the US.

https://en.wikipedia.org/wiki/Janney_coupler

- SCHARFENBERG system
  Fast electrical coupling system which doesn't need manual operations. The connecting operation is quick and soft. Most of the metro, tramway and high speed train are fitted with such coupling system.

  The benefit of such system is to provide comfort to passenger and the possibility to couple train with passenger present on board without security problems.

https://de.wikipedia.org/wiki/Scharfenbe

- Tightlock system[16]
  Tightlock coupler is a Janney automatic coupler used in North America passenger cars. This system reduces slack action, improves safety and remains compatible with other Janney couplers.

- Dellner system
  Dellner couplers are pneumatic and electronic coupling systems. It allows coupling at speeds of up to 15 km/hr without damages and up to 36 km/hr with deformation but with the vehicles remaining on track.

5.7.4 Closing of the doors

The doors are an important security device of passenger trains as they should not injure people when closing in case of obstruction. They have to allow the possibility to be opened mechanically if electricity or pneumatic systems are out of order.

5.8 Standardisation and Regulation of the market

5.8.1 Standardisation

Historically the development of railway systems and networks took place within regional or national limits. With growing networks the industrialized countries were setting their own standards and to some extend developing their own technologies.

The upcoming of international cargo rail traffic urged the necessity of trans-national lines and regional standards. The fostering of this process was one of the main objectives for setting up the International Railway Association (UIC, http://www.uic.org/) founded in 1922.

For the early rather simple cargo- and first passenger trains the standardisation processes was focusing on track geometry and rail profile (e.g. gauge), clearance profile, maximum weight, signaling systems and - after the beginning of electrification of lines - on adequate power supply and overhead lines. Nevertheless the differences across Europe could only be standardized to a certain extent.

Standard Gauge across the world[17]

[16] https://en.wikipedia.org/wiki/Tightlock_coupling

[17] https://en.wikipedia.org/wiki/Standard_gauge

The "revival" of Railway Systems was fostered by the development of highspeed trains starting in the 1970s first in Japan and France, later in Germany, Spain and Italy and finally in China, resulted in a new level of complexity. Every one of the pioneering highspeed railway nations set its own industry standards which included e.g. train technology, power supply, overhead lines, tracksystem, train control or information systems. In a long process all the complex interfaces were managed and functioning and robust integrated systems having been developed. Due to this situation a mixing of components from different developed standards represents an increased exposure.

In order to enable a more efficient railway traffic across Europe and increase competition amongst the various market actors in the railway industry (e.g. railway operators, Rolling Stock manufacturers, track system manufacturers, control, safety and signaling equipment manufacturers) the European Union introduced the Technical Specification for Interoperability (TSI). These specifications were drafted by the European Railway Agency and have been adopted in a Decision by the European Commission in 2002.

The interoperability issues apply to defined lines (corridors) within the Trans-European Rail network and are related to:

- infrastructure,
- energy,
- Rolling Stock,
- control-command and signalling,
- maintenance and operation

One prominent result of the introduced TSI is the development of the European Train Control System (ETCS). ETCS is a signalling, control and train protection system, designed to replace the many incompatible safety systems currently used by European railways, especially on high-speed lines. ETCS requires standard trackside equipment and a standard controller within the train cab. In its final form, all lineside information is passed to the driver electronically, removing the need for lineside signals that, at high speed, could be almost impossible to see or assimilate. Even many networks outside the EU have adopted ETCS, generally for high-speed rail projects.

Despite the fact that more than 15 years have passed since the introduction of the TSI the homogenization process is still at an early stage. Considering the large infrastructure spread across thousands of kilometers and a slow pace of changes due to set licensing and testing processes it might take more decades to reach the desired state.

5.8.2 **Regulation**

It is important to identify that high value manufacture may be subject to complex contractual liabilities between manufacturer and employer, which may not always follow common law, and is subject, depending on territory, to both National and Regional regulation which may impose additional standards. As a positive, these together produce a very safe environment for this industry, although underwriters should never be complacent, as unpredictable product failures do happen, as at Eschede (below).

As an example, the EU regulates Railways throughout the community via the medium of the European Union Agency for Railways (http://www.era.europa.eu).

The mission of the European Union Agency for Railways is: “Making the railway system work better for society.”To achieve this, the Agency contributes, on technical matters, to the implementation of the European Union legislation aiming at improving the competitive position of the railway sector by:

- enhancing the level of interoperability of rail systems;
- developing a common approach to safety on the European railway system;
- contributing to creating a Single European Railway Area without frontiers guaranteeing a high level of safety.

And supports the Railway Safety Directive 2004/49/EC, and the newer Interoperability Regulations (DIRECTIVE 2008/57/EC).

5.8.2.1 **Translation into local law (UK)**

These are translated into local law throughout the EU, and in the case of the UK, have been applied as:

- The Railways and Other Guided Transport Systems (Safety) Regulations 2006 (http://www.rail-reg.gov.uk/server/show/nav.1511). These transpose the European Railway Safety Directive into UK law. ROGS came into force on 1 October 2006 and place a duty on railway undertakings (RU) and infrastructure managers (IM) to:
  - Develop safety management systems that must meet certain requirements
  - Have a safety certificate (for RUs) or a safety authorisation (for IMs)
  - Show that they have procedures in place to introduce new or altered vehicles or infrastructure safely
  - Carry out risk assessments and put in place the measures they have identified as necessary to make sure that the transport system is run safely
  - Work together to make sure the transport system is run safely (ROGS regulation 22)
- The ROGS (Miscellaneous Amendments) Regulations 2013 (http://www.legislation.gov.uk/uksi/2013/950/contents/made), came into force on 21 May 2013. The 2013 amendments include:
  - The requirement for entities in charge of maintenance (ECM) of freight wagons to have an ECM certificate
  - The removal of the requirement for mainline operators to carry out safety verification under ROGS (this requirement has been superseded by the equivalent requirement in the common safety method for risk evaluation and assessment, Commission Regulation (EC) 352/2009)
  - The requirement for controllers of safety critical work to have **suitable and sufficient** monitoring arrangements in place
- The Railways (Interoperability) Regulations 2011 (RIR 2011) (http://www.legislation.gov.uk/uksi/2011/3066/made), transpose the Railway Interoperability Directive 2008/57/EC ('the Directive') into UK law. RIR 2011 came into force on 16 January 2012, superseding the earlier Railways (Interoperability) Regulations 2006. RIR 2011 require new, upgraded, or renewed structural subsystems or vehicles to be authorised to be placed in service, before they can be put into use on mainline railway network in the UK (that is, before they are 'used on or as part of the rail system in the United Kingdom for the transportation of passengers or freight or for the purpose for which it was designed').
  New, upgraded, or renewed structural subsystems or vehicles must comply with the relevant Technical Specifications for Interoperability (TSIs) (https://www.rssb.co.uk/standards-and-the-rail-industry/standards-explained/technical-specifications-for-interoperability)in order to demonstrate they meet the 'essential requirements'. The essential requirements can be summarised as safety, reliability and availability, health, environmental protection, technical compatibility and accessibility.
- The Railways (Interoperability) (Amendment) Regulations 2013 (http://www.legislation.gov.uk/uksi/2013/3023/made), came into force on 1 January 2014. The Amendment Regulations:
  - Amend the definition of 'the Directive' to incorporate amendments to the Railway Interoperability Directive (2008/57/EC)
  - Amend the essential requirements to include 'accessibility to persons with disabilities and persons with reduced mobility'.

The UK RSSB (Railway Safety Standards Board) also holds responsibility for implementing:

- Common Safety Methods

  The Railway Safety Directive 2004/49/EC required ‘Common Safety Methods’ (CSMs) to be drafted by the European Rail Agency, working to a mandate from the European Commission. The CSMs are defined as 'the methods to be developed to describe how safety levels and achievement of safety targets and compliance with other safety requirements are assessed'. Currently, there are six CSMs:
  - CSM for assessment of achievement of safety targets
  - CSM for assessing conformity with the requirements for obtaining a railway safety authorisation
  - CSM for assessing conformity with the requirements for obtaining railway safety certificates
  - CSM for supervision by national safety authorities
  - CSM for monitoring to be applied by railway undertakings, infrastructure managers and entities in charge of maintenance
  - CSM for risk evaluation and assessment (CSM REA)
- Common Safety Targets

  (CSTs) are European-wide safety targets. They are set by the European Railway Agency (ERA), and are designed for member states to achieve at their level, rather than at the level of the individual transport operator.

5.8.2.2 **In Case of a major incident (UK)**

In addition to this, and again using the UK as a model, the individual territory will have its own standards- in the UK these are Group Standards, administered by the UK RSSB.

In the event of a major incident, especially fatal, there are at least 3 levels of investigation. In Britain these are (and there will be similar overlaps in all developed territories):

1. Police- the accident site/ cause will be regarded as a potential scene of crime, and the police will work with
2. HMRI- the Railway Inspectorate- is the British organisation responsible for overseeing safety on Britain's railways and tramways, and
3. The RAIB- Railway Accidents Investigation Board, which independently investigates accidents to improve railway safety, and inform the industry and the public.

Remember that whilst an accident site in the hands of one or more of these it is difficult for the insurer/ loss adjuster to get inside the cordon, and claim investigation may take considerable time, and liability may be dependent on the official post-incident reports, which may take years to produce.

6 LOSS EXAMPLES

6.1 Data

Below there is some data about losses in Europe. This data gives examples about types of risks and causes of accidents. It might be possible to extrapolate this data for other regions. Most accidents involve personnel, although the focus in this paper is on material damage.

The data are from 2010-2014 (Europe)[18]:

[18] http://appsso.eurostat.ec.europa.eu/nui/setupDownloads.do

6.2 Assembly, Testing & Storage

6.2.1 **2015 Eckwersheim Derailment – Testing/Speeding/Human Failure**[19]

On 14 November 2015, a TGV train derailed in Eckwersheim, Alsace, France, **while performing commissioning trials**. The train was carrying 53 persons, including four children, ages 10-15, who were not officially authorized to be aboard. The derailment resulted in 11 deaths and 42 injured. According to investigators, **late braking**, which led to the train **entering the curve at excessive speed**, was the immediate cause of the accident.

Tests scheduled for 11 and 14 November 2015 were to traverse each of the two tracks, in both directions of travel and at a test speed 10% above the speed limit when the line is in commercial service. The train reached a maximum speed of 352 km/h on sections where the speed limit will be 320 km/h. It should have slowed from 352 to 176 km/h before reaching Kilometer Point (KP) 403.809, where the speed limit for commercial service will be 160 km/h. The lead power car separated from the rest of the train, and the rear of the lead power car struck the concrete parapet on the abutment to a bridge over the Marne-Rhine Canal.

Three investigations have been opened. The French Land Transport Accident Investigation Bureau (BEA-TT, Bureau d'Enquêtes sur les Accidents de Transport Terrestre), which is responsible for investigating rail accidents in France, opened a non-judicial technical investigation that is ongoing as of December 2016. A criminal investigation and internal investigation by French national rail operator SNCF have also been opened.

On 19 November 2016, SNCF announced the initial findings of their investigation. The train's event recorder indicated that the train entered the curve at 265 km/h and was travelling at 243 km/h at the moment it derailed, which investigators have determined to be a **result of centrifugal forces**. The speed at the moment of derailment was 67 km/h above the train's assigned operating speed on the curve. According to the SNCF, the "immediate cause" of the accident was "a late braking sequence"; the braking should have begun at least 1 km or 12 seconds earlier. The investigation has found no fault for the accident in the infrastructure, train, or member of the technical team.

SNCF suspended all test trials at high speeds until the lessons learned from the investigation can be integrated into testing processes. The scheduled opening of the second phase of the LGV Est for commercial service was delayed by three months, from 3 April to 3 July 2016.

[19] https://en.wikipedia.org/wiki/Eckwersheim_derailment

6.2.2 **2001 Mersin, Turkey - Offsite Storage – NatCAT**

The project in question consists of a light rail system including trackwork, electrification, signal works, control systems and the delivery of Rolling Stock.

When the Rolling Stock was delivered (just in time as per the original time schedule) it could not be delivered to the depot directly, and testing and commissioning could not start, since the project experienced substantial delay in respect of trackworks and depot construction.

In order to store the Rolling Stock, an old railway yard was rented from the state railway company. The yard has been out of use for some years but the tracks still in place were in an acceptable condition for temporary storage.

Some 100 units were stored at the yard. The yard area was slightly sloping from the city (north) towards the sea (south) so that the height difference between the highest track and the lowest track was approximately 1m. The southern boundary of the yard was a rail track on a 2,5m high embankment.

During the time of storage the area experienced a torrential rain/thunderstorm which led to wide-spread flooding in the city, overloading of the rainwater drainage system. As a consequence, run-off water entered the railway yard from the city and started accumulating at the railway yard. As it was discovered later, a syphon that was originally installed under the railway embankment with the purpose to drain the yard, was clocked with mud and detritus. The drainage system of the yard was not checked when it was used as a temporary storage.

As a consequence the yard started to fill with water, inundating the Rolling Stock to varying levels, depending on whether they were closer or further away from the embankment. One unit was not flooded at all, as it was on the highest ground. This proved very helpful in the claim adjustment.

The construction of the units was such that all the electrical and electronic cubicals were beneath the floor, meaning they were flooded to varying levels and durations. Also numerous couplings and bogies were partially under water.

The overall period of inundation was only a couple of hours. It is also important to point out, that the water was fresh water and not brackish. Nevertheless, after the water receded, some mud deposits were noticeable in most electrical/electronical cubicles.

The original supplier engaged a loss adjuster as his adviser and requested to completely abandon the delivery as all inundated elements (brakes, electronics etc.) were safety-relevant and therefore repair inacceptable and no warranty would be given. Discussions ensued and insurers involved a restoration company. Nevertheless, it was necessary to separate the bogies from the units and ship them to a nearby railway repair yard to check the brakes, axles and bogies as a whole. In respect of the under-floor cubicles the supplier put up extreme resistance in respect to reparability and a categorical unwillingness even to consider repair as an option.

The fortunate circumstance that one unit was entirely undamaged allowed the restoration company to make a daring proposal: "If we can restore the unit that was deepest and for the longest time under water to the same state of performance and integrity as the undamaged unit - then there will be no grounds on which to reject the repair option." The two units were dismantled and shipped to the original manufacturing factory. The restoration works were executed by Belfor personnel under supervision of the original manufacturer. All tests showed positive results and consequently the repair option was taken on for all cubicles.

The loss was ultimately settled at 10% of the original reserve, much faster than a new order of the Rolling Stock would have been delivered, and to the satisfaction of all parties involved.

It shows that offsite storage can carry unknown exposures which are sometimes difficult to identify. Repair options, whilst often rejected by the manufacturer on grounds that no warranty will be given on repaired items, is sometimes the better and fully adequate option.

6.2.3 **2012 Norway Derailment – Testing/Speeding**[20]

In Norway, a Flirt train from Stadler Rail derailed during test drives.

On Wednesday, February 15th 2012 the 250 ton train bounced on a test ride against rock wall. The five on-board staff of Stadler Rail and the Norwegian National Railways (NSB) survived the accident, but were seriously injured. The accident occurred on a difficult-to-reach section of the Oslo-Sandefjord IC route, some 100 kilometers south of the Oslo capital.

A report from the Norwegian Commission has shown that no flaws have been found on the Flirt trains. The accident was due to excessive speed. The train drove too fast into a curve and jumped at 135 km/h from the tracks - on a track that allowed 70 km/h. **The train driver accelerated the test train in a straight section lying immediately ahead of a curve and was no longer able to brake it.**

In August 2008, Stadler received the 640 million Swiss Franc order to deliver 50 Flirt trains to Norway. Flirt stands for «flinker leichter innovativer Regional-Triebzug / nimble light innovative regional trainset». By November 2011 Stadler Rail sold 707 vehicles to Germany, Italy, Hungary, Finland, Poland, Algeria and others. Depending on the design, the trains have a maximum speed of 120 to 200 km/h and are a further development of the basic version designed for the climatic conditions in Norway.

20 http://www.tagesanzeiger.ch/panorama/vermischtes/StadlerZug-in-Norwegen-entgleist--5-Verletzte/story/30735993
http://www.tagesanzeiger.ch/wirtschaft/unternehmen-und-konjunktur/StadlerZuege-in-Norwegen-wieder-auf-Testfahrt/story/26399787

6.3 Operational

6.3.1 **2016 Hoboken Train Crash - Human Failure**[21]

On September 29, 2016, a commuter train crashed at Hoboken Terminal in Hoboken, New Jersey. The accident occurred during the morning rush hour at one of the busiest transportation hubs in the New York metropolitan area. The events leading up to the crash remain unclear, but are being investigated. One person died and 114 others were injured.

One witness reported that the train "never slowed down" as it entered the station. The train involved in the crash reportedly did not have an automatic brake system using positive train control (PTC), which is used to slow the train in case the engineer does not apply the brake in time. It is unclear whether PTC would have prevented the crash.

The train engineer said he had no memory of the crash and was lying on the cab floor when he woke up after the impact. The investigation is **considering sleep apnea as a possible cause of the crash**.

Following the train crash, New Jersey Transit issued new regulations requiring that engineers must be accompanied by at least one other crew member as they pull a train into Hoboken Station. In addition NJ Transit also mandated a reduction in the approaching speed limit into the train station from 10 miles per hour to 5 miles per hour.

[21] https://en.wikipedia.org/wiki/2016_Hoboken_train_crash

6.3.2 **2016 Bad Aibling Train Crash - Human Failure**[22]

On 9 February 2016, two Meridian-branded passenger trains were involved in a head-on collision at Bad Aibling in southeastern Germany. Of approximately 150 people on board the two trains, 12 people died and 85 were injured, including 24 seriously.

There were considerably fewer passengers on board the two trains than usual because of Carnival Holidays. The accident occurred just after 06:47 CET on the single-track Mangfall Valley Railway. Each train was travelling at about 100 kilometres per hour at the time.

The site of the accident was difficult to reach because it lies between the Stuckenholz forest and the canalised Mangfall River (Mangfallkanal). This made rescue work considerably more difficult, meaning rescue workers had to be transported by boat and casualty extraction supported by air ambulance.

The trains were equipped with a total of three train event recorders. The line and both trains were equipped with a train protection system, which was designed to reinforce line-side signaling and prevent drivers from accidentally passing signals at danger.

The local prosecutor (Staatsanwalt) identified "**human error**" as the cause of the crash. A train dispatcher at the signaling centre had given a wrong instruction. German investigators said they found no evidence of mechanical failure or technical defects that would have caused the crash.

It was revealed that **the dispatcher had been playing a game on his mobile phone at the time**. After realizing he had made an error, allowing both trains to proceed, he dialed an incorrect number when trying to issue an emergency call. He was subsequently jailed for 3½ years.

[22] https://en.wikipedia.org/wiki/Bad_Aibling_rail_accident

6.3.3 **1998 Eschede Derailment – Fatigue Crack**[23]

The Eschede derailment occurred on 3 June 1998, near the village of Eschede, Germany, when a high-speed train derailed and crashed into a road bridge at a speed of 200 km/h. 101 people died and around 100 were injured. **The cause was a single fatigue crack in one wheel.**

The ICE 1 trains were originally equipped with single-cast wheelsets, known as Monobloc wheels. Once in service it soon became apparent that this design could, as a result of metal fatigue and out-of-round conditions, result in resonance and vibration at cruising speed.

In response engineers decided that to solve the problem, the suspension of ICE cars could be improved with the use of a rubber damping ring between the rail-contacting steel tire and the steel wheel body. A similar design had been employed successfully in trams at significantly lower speeds. The new design was not tested at high speed before it was made operational. Nevertheless, over a period of years the wheels proved themselves apparently reliable and, until the accident, had not caused any major problems.

The Fraunhofer Institute for Structural Durability and System Reliability (LBF) in Darmstadt was charged with the task of determining the cause of the accident. It was soon apparent that dynamic repetitive forces had not been accounted for in the statistical failure modelling done during the design phase, and the resulting design lacked an adequate margin of safety. Within weeks, all wheels of similar design were replaced with monobloc wheels.

Further, rescue workers at the crash site experienced considerable difficulties in cutting their way through the train to gain access to the victims. Both the aluminium framework and the pressure-proof windows offered unexpected resistance to rescue equipment. As a result, all trains were refitted with windows that have predetermined breaking seams.

[23] https://en.wikipedia.org/wiki/Eschede_derailment

6.3.4 **2014 Tiefencastel Derailment - Landslide**[24]

The Tiefencastel derailment occurred near the municipality of Tiefencastel, Graubünden, Switzerland, on 13 August 2014 when a Rhaetian Railway passenger train travelling on the Albula Railway **was struck by a landslide** and derailed. Of 140 passengers on the train eleven people were injured, five seriously.

The train was travelling from St. Moritz to Chur and hauled by Ge 4/4 III-class locomotive No. 651 (top left picture). Of the seven-coach train, one carriage was left almost at right angles to the track down an embankment, and two others were derailed. Trees prevented the carriage from ending up in the Albula River. In one of the derailed carriages, passengers moved to one side of the carriage in a bid to prevent it from plunging into a ravine. Four helicopters and eight ambulances assisted in the rescue operations. All the passengers had been evacuated within three hours of the accident. The railway reopened on 16 August.

In a twelve-hour period before the accident, rainfall was recorded at a 50-60 litres per square meter, about half the average rainfall for the month of August in the area, according to a statement by MeteoSwiss. The Swiss Accident Investigation Board opened an investigation into the accident. A separate investigation was opened by the Canton of Graubünden.

[24] https://en.wikipedia.org/wiki/Tiefencastel_derailment

6.3.5 **2013 Lac-Mégantic Rail Disaster – Poor Maintenance**[25]

The Lac-Mégantic rail disaster occurred in the town of Lac-Mégantic, in the Canadian province of Quebec, on July 6, 2013, when an unattended 74-car freight train carrying crude oil rolled down a 1.2% grade and derailed, resulting in the fire and explosion of multiple tank cars. Forty-two people were confirmed dead, with five more missing and presumed dead. More than 30 buildings in the town's centre were destroyed, and 36 to be demolished due to contamination.

Eight months before the derailment the lead locomotive was sent to repair shop following an engine failure. Because of the time and cost for a standard repair and the pressure to return the locomotive to service, the engine was repaired with an epoxy-like material that lacked the required strength and durability. This material failed in service, leading to engine surges and excessive black and white smoke. Eventually, oil began to accumulate in the body of the turbocharger, where it overheated and caught fire on the night of the derailment.

Shortly before the derailment the engineer parked the train on the main line by setting the brakes and followed standard procedure by shutting down four of the five locomotives. He left the lead locomotive running to keep air pressure supplied to the train's air brakes and also applied a number of hand brakes. However, he set hand brakes on just the five locomotive engines, a buffer car, and a car housing the remote control apparatus. The Transportation Safety Board of Canada (TSB) concluded that a minimum of 17 and possibly as many as 26 hand brakes would have been needed to secure the train, depending on the amount of force with which they had been applied.

After the engineer had departed, the Nantes Fire Department responded to a 911 call from a citizen who reported a fire on the first locomotive; according to Nantes Fire Chief, "We shut down the engine before fighting the fire. Our protocol calls for us to shut down an engine because it is the only way to stop the fuel from circulating into the fire." The fire department extinguished the blaze and notified the Montreal, Maine and Atlantic Railway's rail traffic controller. The Nantes firefighters left the scene as the MMA employees confirmed that the train was safe.

With all the locomotives shut down, the air compressor no longer supplied air to the air brake system. As air leaked from the brake system, the main air reservoirs were slowly depleted, gradually reducing the effectiveness of the locomotive air brakes. As soon as air pressure had dropped to a point at which the combination of locomotive air brakes and hand brakes could no longer hold the train, it began to roll downhill toward Lac-Mégantic.

Gathering momentum on the long downhill slope, the train entered the town at high speed. The TSB's final report concluded that the train was travelling at 105 kilometres per hour.

TSB launched an investigation into the accident. It identified 18 distinct causes and contributing factors, which included leaving the train unattended on a main line, failure to set enough hand brakes, the lack of a backup safety mechanism, **poor maintenance** on the locomotive and several failures of training and oversight.

[25] https://en.wikipedia.org/wiki/Lac-M%C3%A9gantic_rail_disaster

6.3.6 **2002 Dresden – Flood**[26]

This is an unusual loss example for mobile machinery – nevertheless it happened.

In August 2002 a flood caused by over a week of continuous heavy rains ravaged Europe, killing dozens, dispossessing thousands, and causing damage of billions of Euros in the Czech Republic, Austria, Germany, Slovakia, Poland, Hungary, Romania and Croatia. The flood was of a magnitude expected to occur roughly once a century.

Dresden (Germany) received significant damage when the Elbe River reached an all-time high of 9.4 meters. More than 30,000 people were evacuated from various neighborhoods throughout the city and some of the city's cultural landmarks were considered to be at risk.

Obviously, the flood came too fast for some of the trains too.

[26] https://en.wikipedia.org/wiki/2002_European_floods

6.3.7 **2008 Channel Tunnel – Fire**[27]

Hydrodemolition of the spalled concrete of the precast concrete segments following the September 2008 Channel Tunnel fire

Image caused by the 1996 freight shuttle train fire

The 2008 Channel Tunnel fire involved a France-bound Eurotunnel Shuttle carrying heavy goods vehicles (HGVs). The fire lasted for sixteen hours and reached temperatures of up to 1000 °C. Of the thirty-two people on board the train, fourteen people suffered minor injuries, including smoke inhalation.

The fire was reported on 11 September 2008, 11 kilometers from the French entrance in the North Tunnel. The shuttle train was carrying 27 vehicles. The blaze spread to other trucks, destroying six carriages and one locomotive.

About 650 m of tunnel was damaged by the fire. Eurotunnel replaced over one thousand bolts holding the concrete tunnel lining. The damaged concrete was removed with high pressure water jets, damage to the reinforcing steel mesh repaired and a new concrete lining applied by a shotcreting process. Tunnel equipment was repaired and replaced as necessary. Repair works were estimated at about €60 million.

When the fire was reported, the tunnel was immediately shut to all services except emergency traffic. The undamaged south tunnel was reopened 13 September. Service levels were reduced, costing Eurotunnel an estimated £185 million in lost revenue. Full service resumed on 9 February 2009.

As it took 75 minutes before the fire services started to tackle the blaze and the ventilation was on during this time, fanning the fire and increasing the damage, Eurotunnel built four "fire-fighting stations" in the tunnel. When a fire is detected on a train, it continues to the next station, passengers and crew are evacuated into the service tunnel and an automatic system puts the fire out with water mist. These were operational in autumn 2011.

This fire was the third to close the tunnel since it opened in 1994, the first being the 1996 Channel Tunnel fire. In August 2006, the tunnel was closed for several hours after fire broke out on a truck loaded onto a HGV Shuttle.

[27] https://en.wikipedia.org/wiki/2008_Channel_Tunnel_fire

6.3.8 **2017 South Tyrolia Train Accident – Break Failure**[28]

The train accident on the Brenner route at Brixen in South Tyrol could have been triggered by a **technical failure of the braking system**, according to the Bolzano State Attorney's Office. The prosecution authority commissioned a technical report to clarify the cause of the accident.

Two people had died during the disaster in the night of Wednesday, April 26th 2017 and three others were seriously injured. A construction train with about 20 workers had set in motion at 11:45 pm from unknown cause.

The train loaded with concrete railroad ties of about 1500 tonnes could no longer be braked and hit another construction machine, which was also on the line. Several workers were trapped.

For two of them, every help came too late, three were recovered with the most severe injuries. In addition, many workers suffered minor injuries. The two death victims were on the second construction vehicle, which was rammed with great force.

The Brenner route remained closed for two days. A bus service was installed for regional rail traffic. The ÖBB also implemented a rail replacement service between Innsbruck and Bolzano. The freight traffic was handled by means of detours.

[28] http://www.blick.ch/news/ausland/zugunglueck-zugunglueck-in-suedtirol-moeglicherweise-durch-bremsversagen-ausgeloest-id6590053.html

6.4 Lessons learned from the losses

Often, the losses are a not only the result of one single root cause, but rather a chain of causes started by a human failure. For example:

- poor maintenance resulting in brake failure and derailment of the Rolling Stock,
- overspeeding during testing caused by human failure.
- It is also important to consider the implications of major stock accumulations for example awaiting delivery. Following on from a flood, it is possible the warranties would be voided and new or almost new Rolling Stock might have to be scrapped.

This is why a high level of education and training is needed for a safe operation. This should be an important information during the underwriting and risk assessment of Rolling Stock accounts.

7 UNDERWRITING CONSIDERATIONS

7.1 Project (Assembling & Testing)

7.1.1 Insurable Interests

This largely depends on the Insured Parties that are named on the Insurance Policy. One main party to the contract could be the relevant Department for Transport within the government, who are committed to building more passenger or freight trains. Train operators subject to enough financial motivation can also consider building replacement fleets of trains. It is worth noting that a train operator often can be a train maintenance company, who in turn are part of a larger train manufacturing company – and all 3 of these parties are financially reliant on the EAR but not all necessarily be able to say that they have an insurable interest on a given insurance policy. Lenders and other investors may also be involved and have a financial interest in the project, and ensure they can recoup any monies in the event of an indemnified loss and that they should wish to cancel the loan. Third parties might also be able to claim under any relevant Public Liability sections. Owners of any existing Property or any other property i.e. railtracks or other infrastructure which the trains are in physical contact with, might also have an Insurable Interest if the policy affords indemnity. There are many parties to consider and often during the early stages of announcing a project there are many consultants involved to discuss the degree of Insurable interests allowed onto the main policy.

Another aspect to consider is as described above the whole manufacturing process of Rolling Stock can include sub supplier or manufacturers of components, who have their own insurances. We briefly mentioned that train operators can be the manufacturer but sometimes 2 or more train manufacturers can be asked to form a joint venture (as required in the US) and therefore this is strictly a different entity from the respective holding company.

For the purposes of this particular section we will introduce the scenario whereby the government makes a commitment to build more passenger freight trains and tenders the project. The government being the franchisor and potentially franchisee require a policy in which if there is damage or loss to the passenger or freights during construction, testing, delivery or for a longer initial operational period that they receive indemnity.

The contractor in the contract the risk allocation between the two parties (contractor and employee) is being defined and additionally the insurance requirements. The contractor bears the risk for accidental loss until final handover to the employer. Accordingly he is liable to deliver the trains as agreed apart from circumstances which are mentioned in the contract e.g. ‘force majeure’. The force majeure can include natural perils or non-damage delays.

The values per train can up be up to a two digit million amount and in addition there is the risk of accumulation e.g. in the rail yard before hand-over. Accordingly the manufacturer needs the possibility of a risk transfer for damages to the insured property due to accidental losses for the period from unloading of items at the manufactures’ facility until handover of the trains.

7.1.2 Insurance Solutions

There are different Insurance Solutions to cover the project-phases. It is important to remember, that the concept of cover has to be adapted to the requests of the general contract.

7.1.2.1 **Erection Policies**

The wording is comparable to an EAR policy (all risk basis).

Sub-contractors can be insured as well and the period includes all project phases such as design, assembly and testing. Defects Liability after the project phase expiry can be covered under Extended/Guarantee Maintenance endorsements.

In addition train manufacturers are not just producing trains but also perform works on trains which are already in operation such as:

- Repair;
- Maintenance;
- Modernization;
- Retrofit;

The premium for the insurance of such works is based on the value of the contract but the insurers' liability includes a first loss amount for the train which is under 'care, custody and control' of the manufacturer during performance of such activities.

7.1.2.2 **Erection Policies Annual Open Covers**

Most of the policies for train production are on an annual open cover basis. That simplifies the procedure for the insured as they need to inform the insurer about the turnover for the different works only once per year. Beside the production of new trains, works on trains which are already in operation can be covered as under an annual program as well. The disadvantage for the manufacturer is that the limits are normally not higher than a total loss of a single train. Additionally very large contracts are mostly being awarded to consortiums or joint ventures and accordingly there is no cover under the annual open cover policies for the other stakeholder with insurable interest. In addition in very large procurement contracts there can be provision that the assembly of the trains must be performed locally. The reason are subsidies and the government wants to ensure that part of the funds are being reinvested and spend locally in order to build up infrastructure, train/qualify workers, create jobs and generate sustainable economic growth.

7.1.2.3 **One-Off Policies for Train Manufacturing**

The procurement of a single project specific policy is often necessary because of (all points below are depending on the contract and have to be discussed during the underwriting process):

- Insured values
  Cost of individual components, cost of built train; how many sets are stored at any one point. Do all parties understand that with the mass production and storage of train sets being a moving target, that with any change in the bar chart, what their new exposures are at any one point? Are these being monitored? Are the values being intertwined with old Rolling Stock in which case replacement values are required?
- Project duration
  With trains being manufactured and handed over in phases, with overlapping manufacturing periods, testing of subsequent train sets and storage, when does the Defects Liability begin?
- Requested limits
  Are these limits in excess of any other valid insurances, and why they are being requested? If so, are they necessary and does the project insurer need to consider any additional information to take on this exposure
- Necessary extensions
  Additional Cost of Increased Working to cover Rolling Stock, infrastructure, suppliers separately?
- Consortium/Joint Ventures
  What is the experience of the parties involved and who are the likely individual project managers with the requisite experience who will be overseeing the project of this size

and technology. An example of previous projects and an understanding of any novel features being introduced is important.

- Owners/Lenders interest
  Financiers have a huge leverage including lender's clauses. For many projects of public importance, government institutions could be working with other institutions and it would be important to understand their role and demands on the policy before including them.
- Location of the production
  Do we understand the risks of the main manufacturing or component manufacturing locations? Are there any natural catastrophe perils that increase the risk? Are there any surveys or loss data?
- Third party liability cover especially for the testing
  Where does the testing take place and what is the likelihood of injury or damage to third parties or existing property? It is worth noting that an individual manufacturer must be fully involved with the specifics of running a track on different countries rail infrastructure. Does the third party infrastructure provider (rail operator) have any specific requirements for business interruption and how onerous are the obligations in the contract?
- Operational cover
  In the event of a loss during operation of the trains, is there any enough quality assurance information at certificate of completion/acceptance stage to suggest that any losses covered whilst trains sets are in use, that this was "operator error" or "during defects" or other factor? ETCS was previously a large issue in this arena.

The contract can include hundreds of new trains which could be built over a period of up to 10 years. The handover is normally after successful testing.

The EAR cover is normally requested without loss limit, although the full contract value is at no point of time exposed due to the serial production and consequential handover. The highest loss exposure is normally in case the railroad operator doesn't takes the trains over on time and the manufacturer would still bear the risk for a large number of trains stored in a rail yard which could be destroyed by a fire.

It is important to understand that the manufacturing process[29] does not drastically change between each type of Rolling Stock (for example metro or high speed). The main point to understand is that components are not manufactured at one location, they can come from numerous specialist suppliers who in turn procure them from other sub-suppliers internationally. The Insureds want to understand that their construction insurances will cover all of these activities in various locations under their policy. One way to deal with this is using both the project description and definition of Rolling Stock in the slip and policy.

[29] http://www.railway-technical.com/Manufacturing.shtml

7.1.3 **Definitions of Rolling Stock in insurance policies**

Considering the above there are a myriad of differing Project Descriptions and Rolling Stock definitions in our insurances (below, see some examples):

1) Project has the meaning given to it in the _____ Agreement. The Project shall mean _ sets of train carriages and _ locomotives.
   A carriage shall mean: body and shell, furnishings, HVDC, windows, connections, direct control, communication, tilting system, and the bogie including…all as per the Contract.

2) Car shall mean a single item of Rolling Stock delivered under the Purchase Agreement dated_____between_____ and _____. New Trains shall mean finally delivered items to _____ and accepted.

3) All work relating to design engineer, procure fabrication, construction, erection, installation, testing, commission, including trial and defects maintenance, in connection with the final contract of work including any associated activities related to that whatsoever.

4) Contract between Authority, Project Company being the Manufacturer, Maintenance, loanees, consultants and any subcontractors whatsoever for the Project. The project is fully described in _____ and any associated documents with the Project.

5) Contract relating to Rolling Stock PPP (see "Appendix 1 – Glossary") in repsect of design supply delivery testing commissioning and maintenance of ____ and _____as more particularly defined in the scope of works in the Project Contract Conditions and its Schedules including variations thereto.

6) Insured Property includes Project Works relating to the Cars and Simulators Rolling Stock Manufacturers Production line, temporary or permanent works, and all materials necessary for the project brought by the _____ to the Project Site.

7) Components for the Rolling Stock include
   a. Traction
   b. Brakes
   c. Suspension…

8) **Rolling Stock** – the … fleet of new ….. Trains designed, built and maintained pursuant to the Contracts, to operate at …km/h [plus the necessary spares; tools; jigs; diagnostic and other associated equipment; software, systems or sub-systems supplied for the purposes of any integration laboratory; training, operation and maintenance manuals; simulators and the provision of driver training]**.**

9) The Units and Equipment, and any other property, including property of the Purchaser, the Manufacturer, and the directors, employees, officers, servants or agents of any of them, for incorporation in or use in connection with the construction, integration, commissioning, testing and completion of the Units and Equipment, such cover shall include testing on mainline metals (including testing in tunnel and in depot) in respect of each Unit before operational handover which shall be on the date of Provisional Acceptance in respect of each Unit.

10) Rolling Stock is defined as the new fleet of _____ as per contract, to extend the existing fleet of _____

Some statements to the Definitions:

- Definition 1)
  is the simplest provided the Project Description is clear and the scope of works is entirely understood by both parties. This also includes components.

- Definition 3)
  includes finance through to design and initial operation and other relevant sub documentation that was agreed between contracting parties.

- Definition 4)
  makes it clear that consultants (often for the government or lender) have a say in this process, and any additional requirements they have may or may not be binding. This is not to say that Insurers are party to this contract, but any tortious liability could still arise.

- Other definitions specify the types or model numbers of Rolling Stock but also pre-production vehicles or prototypes or simulators.

- Definition 9)
  includes suitability testing, perhaps with the differing alloys of the wheelsets and the track, there is additional testing as a precursor to meeting the rail authority requirements. If the first set does not meet these requirements, the Rolling Stock is not deemed to be considered so by the authority, but it is still an insured value for Insurers.

7.2 Transfer Delivery and Storage

An important point to consider is also the Transfer delivery and Storage of Rolling Stock, these points are also depending on the contract.

7.2.1 **Transfer or delivery**

The cover-requirements of the Transfer-period depend on:

- location of production
- by sea or rail or road
- testing location of Rolling Stock

If the production of Rolling Stock is in the same location as the operator is, it might be possible to cover the transfer within the Project Policy. Where larger distances are required, including shipping, then the underwriter should consider a marine-based-cover, to bring in all the knowledge of the marine underwriters to find a helpful solution, rather than reliance upon the transit extension within a traditional project / EAR policy.

7.2.2 **Storage**

During the Project duration, there is an important question about storage of the produced Rolling Stocks and components as part of the supply chain. The Underwriter should consider what the agreement about taking over the Rolling Stock from the manufacturer to the operator is. If there is a possible need to store the Rolling Stock between testing and final delivery, then the project cover needs to be adapted to include this.

It is worth understanding what the FLEXA (Fire, Lightning, Explosion, Aircraft) and natural perils exposures are at the many locations involved and taking this into account when adapting the cover to include this. A property survey might assist in this matter, the major exposures will include NatCat, arson and malicious damage or fire.

7.3 Operational

7.3.1 Insured subject matter

In most of the cases the operator will be the insured party. However, the underwriter should be aware that under a number of significant contracts the manufacturer retains the property risk on the Rolling Stock when they take it back for routine maintenance in the depot.

As already mentioned in 3.1.3, there are different categories of Rolling Stock. It depends on the specific field of activities of the operator, which kind of Rolling Stock needs to be insured.

7.3.2 Potential covers for Rolling Stock

Generally, material damages and business interruption covers may be required. It depends on the whole concept, if there is an all-risks or just a named perils cover for Rolling Stock.

7.3.3 Insurable Interests

As opposed to the construction policy, provided the Rolling Stock has achieved practical completion and can be handed over to the eventual operator, then the Rolling Stock should be covered under an operational policy. The Insured might be able to have Business Interruption cover but potentially some machinery breakdown. It is worth mentioning that the manufacturer of the Rolling Stock could potentially also be the maintenance provider for up to 25 years and be required to insure the Rolling Stock while it is in the depot for maintenance.

Parties with insurable interests could be:

- Operator
- Leasing Company as Owner
- Schedule of Financiers
- Manufacturer
- Maintenance Provider

It is rare on the majority of Western European networks for Rolling Stock to be owned outright, most is leased on a variety of terms and thus the policy should offer cover to all interested parties using the Multiple Insureds clauses.

7.3.4 Insurance Solutions

There are different insurance solutions for operational Rolling Stock covers. It is possible to get a solution from a marine-, engineering or property department.

7.3.4.1 Marine Insurance

Depending on requirements Rolling Stock can be covered under a Marine insurance. As a hull insurance which cover damages as a consequence of the following events, but not the inner damage (machinery breakdown) of the machinery.

- Derailment,
- Collision,
- Fire,
- NatCat.

7.3.4.2 **Engineering Lines Insurance**

The Rolling Stocks can be covered under an All Risk cover. There are different wordings for Rolling Stock insurance available.

It is important to define in the policy the maximum indemnification in case of a total loss. As there is no second hand market a lost train can normally not be replaced by an equal (type, age) one. Furthermore the procurement of a new train is often not possible as they are not being produced anymore and for a different type is no operating permit available. To which extend that issue exist must be checked during the underwriting process. However it can be assumed that it is more critical for high speed trains rather than freight trains.

A standard solution to limit the indemnification is the implementation of a depreciation clause, which allows the insurer to indemnify less than the new replacement value for used vehicles which is standard in Engineering Lines business. In case that the policy is based on new replacement values there should be a cap as it is unclear during the underwriting process how much the replacement of a single vehicle can cost. This may be imposed as a standard set of terms by the financier or the leasing company and each territory may have a different standard. It is important for the underwriter to investigate the individual contracts.

The leasing contract may also carry the requirement for a sets clause. This recognises the inability to operate complete sets of units where one unit is damaged or destroyed, and where the leasing company would expect indemnity for the value of the entire set.

7.3.4.3 **CECR (Civil Engineering Completed Risks) Insurance**[30]

In some territories it is common to insure the Rolling Stock together with the infrastructure within a CECR-policy.

CECR is a form of property insurance and predominantly covers operational infrastructure. The fundamental purpose of the CECR insurance is to protect the property insured against unforeseen and sudden physical damage. Natural catastrophe events are generally considered to be the main risks, rather than fire, but fire can still have high exposure for some risks. It is for operational risks and is normally renewable annually.

7.4 Third party liability

Third Party risks are an important element of the Rolling Stock programme. As a minimum the underwriter should consider:

- Premises liabilities, including surrounding third parties, public/ third party access, pollution and contamination, fire and explosion, and property of third parties within the premises.
- Product Liability- including both the unit manufacture and suppliers insurance, and requirements for Professional Indemnities depending on the legal framework of the territory involved, and the contract jurisdiction.
- Testing and Commissioning
- Operational Liabilities
- Professional (design) liabilities

There are different market practices about third party liability covers. Sometimes, some of the liability covers are included in a project policy. In some markets, the liability cover is stand alone cover, one for the manufacturer and one for the operator.

[30] IMIA CECR-Paper

7.4.1 Contractual issues (common areas of contract limitation)

It is also important to identify that high value manufacture may be subject to complex contractual liabilities between manufacturer and employer, which may not always follow common law, and to understand the liabilities and limitations of the relevant contractual regime. For example, a UK employer may impose Professional Indemnity (PI) requirements where the manufacturer's home market may view insurability of this in a different light, or define PI differently. There may be specific duties which apply in a particular jurisdiction, and so it is essential to view the contract document against the jurisdiction in which the insurance is to be procured.

The contractual framework extends to liability for the consequences of breaching an operating regime. Again using the UK as an example, a manufacturer whose product failed and interrupted the network would be liable via the operator for the charges levied by the infrastructure provider. These are charged via Schedules 4 and 8 of the ORR's operating regime, and although they appear as liquidated damages, UK court rulings have determined that they represent a reasonable approximation of the likely lost revenue or additional costs of working for the infrastructure. Again, each territory may have a different approach and the underwriter should be aware of the financial consequences of product failure during operation.

7.4.2 Premises Risks

These are of a class which is generally not unique to railway manufacturing industries, and are similar to any high quality large manufactory. The main/ most common catastrophe level public liability exposures may include:

- Spreading Fire/ Explosion - causing death/ bodily injury to visitors/ third parties and major damage to/ destruction of surrounding third party property. This may also extend to loss of or damage to third party Rolling Stock on the premises either awaiting delivery or repair- responsibility for which depends on the liability clauses within the contract conditions.
- Pollution, or escape of toxins, noxious substances- both sudden/ accidental or gradual contamination
- Noise/ fumes/ dust/ light emissions, or other nuisance issues

7.4.3 Product Liability

The train itself may be manufactured at a point in time, but the individual components may have a long service life. Some of these may be safety critical, and the risk manager should be able to identify the manufacturer's recommendations to end user on maintenance provisions, product service life and maintenance requirements, and previous experience showing product failure statistics, and consequences if these result in accident rather than just unit failure to operate. Depending on territory (limitation provisions etc.), the potential liability from product failure may remain active for many years after hand over of the operational units. The risk should be underwritten and risk managed by liability rather than contract works underwriters/ risk managers.

7.4.4 Testing and Commissioning

The apportionment of risk between manufacturer and client will depend upon the contract- again important for the underwriter to obtain and read the relevant contracts before taking underwriting action. The build contract may impose liability on the manufacturer for all incidents before defined operational handover. Testing and commissioning may be done at the manufacturer's own premises (e.g. Siemens), on a normal operational rail network with interface with passenger carrying or freight trains, or on a dedicated private test track e.g. Old Dalby/ Melton Mowbray, or High Marnham (UK) or Velim (Czech Republic), or Rail Tec Arsenal (Vienna).

All of these may have specific contractual limits or exclusions and need to be read in conjunction with the proposed policy wording. The EAR policy may also have limits on the scope of testing and commissioning, e.g. on operational metals, or may exclude damage to Rolling Stock after nominal handover / provisional acceptance.

7.4.5 Operational Liabilities

These probably fall outside the scope of this paper, but are, at least in Western Europe, the primary cause of fatal incidents. The **majority** of operational incidents arise from operational causes- human factors such as distraction, tiredness, overwork at peak times, or from infrastructure failures (e.g. Grayrigg https://www.gov.uk/raib-reports/derailment-at-grayrigg) but may as at Eschede arise from mechanical failure, which **is** within the scope of this paper.

7.4.6 Professional (design) liabilities

These will normally have a contractual rather than a tortuous basis. The contract may contain specific warranties regarding fitness for purpose, or other liability arising out of failure to exercise reasonable skill and care, which entail a contractual remedy for financial losses- e.g. delay, remediation, non-serviceability, inability to meet service requirements. This must be viewed in relation to the jurisdiction of the end client/ user, as not all jurisdictions have identical legal boundaries on professional duties. Not all manufacturers purchase PI (Professional indemnity insurance) as routine, so may have to go to market to meet the requirements of a specific contract. It is particularly important for the underwriter/ risk manager to review the contract terms, particularly if the contract requires the manufacturer to provide a service and/or performance pattern rather than simply tender for a specified number of trains. It is also important to assess the impact of a mid-manufacturing period catastrophe on the manufacturing location (NatCat or fire) which may extend the delivery period and incur penalties or Liquidated Damages under the contract. At times, manufacturers have been too eager to enter into a contract for their own commercial reasons without considering the LD downside.

7.5 Risk Management

The risk management of the Transport Manufacturing sector has perforce to look at process management, as well as a backward look at the past experience of the operating rail industry in terms of accidents and near misses. We learn from the latter, and use the questioning of our risk managers to ensure that lessons have indeed been learned by the industry; we use the general process experience of our insurance industry risk managers to ensure adherence with industry regulation and technical standards, and that testing and research capability reflects the requirements of regional and individual territory regulation. In other words, we ensure that our prospective clients do what they claim to do, and that which is required as minimum standards by the territory's standards. This is all the more important in a high-output industry where the intention is to provide highly reliable products but where any small failure may result in catastrophic results.

As with any project, the risk manager should start with the ERM (see "Appendix 1 – Glossary") approach of the parent organisation. Does the board have sight of the risks that affect the continuity of the business, which in the case of transport manufactory will include

catastrophic product failure, including concurrent reputational risk. The risk manager should be able to trace down both the acceptance of risk by the board, and its mitigations/ elimination where possible. There should be an identifiable continuous cycle of assessment and assurance, to which the insurance intervention is another, independent step in ensuring the business not only has minimized its relevant risks, but maintains scrutiny of maintaining standards.

As a first step, the insurer risk manager should have a working knowledge of the Rolling Stock manufacturing sector. In whichever territory the risk manager works, there should be a well-documented history of both railway products and operational incidents, often investigated in a learning and blame free environment independent of any criminal investigation.

Fortunately, given the high profile of transport in most economies, any meaningful accident will both be reported in the press, and will be the subject of industry and regulator investigation. This will give the risk manager an overview of the cause of accidents as a first source of material, and followed by the regulators reports into causation and recommendations for change. Each developed territory will have a regulatory body and an accident investigation team, who publish reports on incidents and on change within standards.

Secondly, the risk manager should make himself acquainted with the structure of design and safety standards within each individual territory and region. Examples include:

- Germany- Eisenbahn Bundesamt
- France- Etablissement Publique de securite Ferroviare (EPSF)
- United Kingdom- Rail Safety Standards Board (RSSB)

These in most first world developed territories will encompass either specific components‘design or service life, or will set wider standards on overall safety systems. The risk manager will be dealing with no more than a dozen leading international or regional manufacturers, with both central component sourcing, and local territory assembly sites. The modern supply contract for (esp. Passenger) Rolling Stock will normally involve the manufacturer in both manufacture supply (including testing and commissioning) and a lengthy maintenance obligation for up to 25 or 30 years following handover to the operator. Some modern contracts may involve the manufacturer in providing equipment in sufficient volume to maintain a laid down service pattern rather than a given number of vehicles, so there will be additional risk scrutiny in terms of planned reliability of the equipment.

7.6 Risk Assessment

There is specific information needed if the underwriter needs to understand the extent of perils associated with Rolling Stock. Risk assessment is essential before considering any terms and conditions of the policy including pricing.

Suggested underwriting information includes:

- Information about manufacturing areas, assembling locations and so on
- Parties of the contract/project
- Terms of the Contract
- Every information about warranties, maintenance and so on
- Time schedule including peak values at risk
- Detailed information about testing and handover
- Year of Manufacturing
- List of maintenance services and schedules
- Potential for technical upgrading (which modules)
- New replacement value (often only actual cash values are being provided)
- Production Line and lifetime
- Identify long term potential for replacement vehicles (important if a Business Interruption coverage is required)
- Spare Parts and supply chain
- Loss ratio of the last 5 - 10 years
- List of the 5 largest losses during the last 5 – 10 years
- Manufacturer Warranty
- Security systems
- Vehicle Type
- Number of Vehicles
- Manufacturer
- Expensive special painting (e.g. created by an artist)
- Insurance of the fire risk and NatCat – Are the trains in the rail yard covered by a separate Property insurance?
- Area of operation (freight traffic, passenger transportation)
- Categorization (propulsion by fuel source, transported goods, kind of passenger vehicles, special vehicles)
- Prototype or not, experience with the technology (Manufacturer, Operator)

There are some important thoughts about risk assessment concerning damage and business interruption:

- Spare Parts
  It is generally expected that the insured will have some stock of spare parts available for their day to day operations and maintenance. Consideration should be given by a claims handler to discuss these options with the insured and should the insured not carry the particular part in stock to look into the possibilities of leasing a part from another rail company while the part is re-produced by the manufacturer.
- Indemnification
  In the case of older stock that cannot be replaced or parts are not available anymore there are some options to be considered 1) Have a fixed repair rate in the policy 2) Include a clause in the policy that limits any claims payment to the equivalent cost of a similar repair where the part is available 3) In some case post accident there are specialist companies that can re-produce an obsolete part or have a stock of redundant part.
- Serial losses
  Like any mass produced machinery, the Rolling Stock can be prone to serial losses by the manufacturer. In many cases this fault would be realized while the asset is still

within the warranty period – but this cannot be guaranteed and the policy would still incur the effect of any Business Interruption costs. In some cases an underwriter could mitigate this risk by applying a serial loss clause to the policy and limit the exposure, however, the underwriter should note that the clause does not apply to the BI section sometimes. In the event of a loss it is most favorable to work very closely with the insured to enable an accurate assessment of the issue and then provide guidance on how to overcome the matter. It is common in serial loss cases that the repair or solution to the part in question is not immediately critical to the insureds operations – but would be if ignored. To limit liability in these cases the insured could monitor the performance of the parts and replace the part prior to any critical loss but in a more economic planned repair regime.

- Freight business
  It seems important to know, that repairs often can only handled by a approved company and the repairs has to be conform to the standards of the operator and cannot be controlled from the insurer. Business interruption can be an issue, because the costs by a BI can be 400 Euro / wagon / month. For a Locomotive it could be approximately 30'000 Euro/Month.
  Also, the competition to reduce tare has leaded wagons manufacturers to reduce steel thickness. Nowadays, new wagons are not easily repairable and are replaced. Main issue for insurers is that it is not possible to buy a freight wagon with a competitive price for only one or 2 pieces.
- Passenger business
  For passengers often, they are handled by big companies and covered by major contracts (as it is the case for DB or SNCF). The park is big but when insurers are involved, it is a main issue.
  Big issues often mean long legal process. Big companies place big orders to key market players (in Europe: Siemens, Bombardier, Alstom, and now Hitachi for which rail headquarters have moved to United Kingdom). When the train can be repaired, costs are limited to a few million Euros. When it cannot be economically repaired, 2 main factors are committing:
  - obsolescence: train life is 30 years and are not produced anymore, second hand market doesn't really exist: how to evaluate the same material?
  - Trains are bought in fleet on major contracts (for instance, yesterday urban trains for Paris region is more than 3 billions €): it is impossible to order one single train.
  - Claim implications
    It is important to identify skilled loss adjusters with experience in the rail transport sector. There are issues over total loss of individual units, either freight or passenger, where production lines have closed and it is not economical to replace individual units. The experienced adjuster may work with either operator or leasing companies to identify the most appropriate short term work-arounds. These may address material damage issues and mitigation of revenue losses.

7.7 Risk Appetite

How many Rolling Stock policies an insurer is willing to sign is a question of the risk appetite.

It's depending on the capacities of an insurer and how much he likes to exposure his portfolio. The Values of Rolling Stock are quite big and an accident (also a small one) costs often more than one million Euro.

Normally the deductible for such a cover is high enough to scope with a frequency of smaller losses. The regulations / standardization brings the business to a good quality of risk. This is the reason, why many insurers are interested to cover such risks.

7.8 Wording / concept of cover

As mentioned before, there are some different insurance solutions for both, project and operational. In the following chapters are some thoughts about possible and common covers.

7.8.1 Project: Scope of Cover

The wording for a project (design, construction, manufacture, erection, testing and commissioning of trains) insured varies only partially from normal erection project policies (all risk basis).

The policy can be on an annual open cover or single project basis. The main difference in respect of the scope of cover is that single risk policies for large projects may include the construction of either the manufacturing site or a new maintenance depot, or both.

7.8.1.1 Material Damage Cover during Construction

The scope of cover is usually to indemnify the Insured for physical loss or damage to the property insured arising out of the performance of the project occurring during the period if insurance for:

- activities on the manufacturing site;
- any kind of inland transit including operation of the trains for testing purposes.

The Defect exclusion can be on LEG 2 or LEG 3 (see Appendix 2) basis. Furthermore a serial damage clause is recommended, in order to manage the concerns related to defects in multiple units.

Often the contracts include a Property insured in use extension: In case that the property insured is handed over to the Owner, cover shall continue until the expiry date of the policy, subject to cessation at practical handover.

Other than the above mentioned the usual extensions for projects are being provided such as:

- Expediting Expenses
- 72 Hours Clause
- Escalation Clause
- Preventive Measures Clause
- Debris Removal
- Repeat Tests
- Reinstatement of Sum Insured
- 50/50 Clause
- Off Site Storage
- Extended Maintenance

For some of the mentioned clauses, find detailed information about the clauses and the defect exclusions in Appendix 2.

7.8.1.2 Third Party Liability for the construction period

To indemnify the insured in respect of their legal liability for death of injury to any person not related to the project performance or loss of or damage to property directly arising out of or in the course of the project works performance and occurring during the period of insurance.

7.8.1.3 **Operational All Risks Insurance as part of the project insurance**

This cover would need to be provided by a specific extension with underwriting information based upon the individual risk circumstances. It would be more likely that operational risks would fall back to the operators or manufacturers' annual material damage covers. All material property fixed, mobile or in transit (excluding air and sea transport) but mainly the operation of the newly created manufacturing facility including all extensions such as:

- Buildings
- Content of buildings
- Machinery
- Plants
- Raw materials
- Fuels
- Computer Equipment
- Documents

7.8.1.4 **Loss of Profit (DSU / ALoP)**

There could be damage to completed Rolling Stock which could may then impact the delivery time. It depends on the responsibilities placed upon the manufacturer in the contract. It is possible to cover the Loss of Profit (Delay in Start-Up (DSU) / Advanced Loss of Profit (ALoP) caused by a covered risk (and peril).

7.8.2 **Operational: Scope of Cover**

There is a very large market for operational Rolling Stock covers. In North America the Rolling Stock is mostly insured together with the infrastructure. Accordingly the main exposures are NatCat events or fire in tunnels and railyards. Neither the underwriting nor the scope of cover for such accounts is comparable to Rolling Stock stand-alone policies to which the following refers.

7.8.2.1 **All Risk cover**

Example of perils covered:

- Machinery Breakdown (inner damage of the locomotive, car…)
- Derailment
- Collision
- Natural Disasters
    - Flood
    - Storm
    - Landslide
    - Snowfall
    - Hail
- Fire
- Explosion
- Unlawful activities of third parties

Available Extensions:

- Business interruption
- Buildings, machinery and other equipment
- Expediting expenses
- Firefighting expenses
- Debris Removal
- New replacement value insured

Potential Exclusions/cover limitations:

- Damages to the insured object upon its use outside the insurance territory
- Damages caused by faults in designing or producing the insured object
- Non-purposive or incorrect use of the insured object
- Serial damages
- Damages directly caused by wear and tear
- Terrorism
- War, civil war…
- Radioactive or nuclear contamination
- Depreciation Clause

For some of the mentioned clauses, find detailed information about the clauses in Appendix 2 .

8 PML CONSIDERATIONS

For the purpose of this paper the Probable Maximum Loss (PML) follows the definition of IMIA:

"The Probable Maximum Loss is an estimate of the maximum loss which could be sustained by the insurers as a result of any one occurrence considered by the underwriter to be within the realms of probability. This ignores such coincidences and catastrophes which are remote possibilities, but which remain highly improbable."

Probable Maximum Loss (PML) assessment is critical to assess the risk exposure arising from Rolling Stocks. It should take into consideration the most extreme hazards (e.g. NatCat event, impact, collision and fire) which can result in maximum probable damage. With new information and also change in environmental conditions throughout the world, PML should be a regular and focus topic that the industry reviews on a regular basis.

8.1 Information required for a proper PML assessment

As with other types of risk assessment, underwriting information must be available in order to ensure satisfactory risk assessment and particularly to determine a reliable PML scenario and estimation. A large part of the risk exposure of Rolling Stock deals with widespread risks (e.g. roads, railways) with individual exposures and require adequate information. The following information should be available for assessment:

- Geographical situation
- Overall plan of the project
- Plans and sections of key structures of the project
- Technical key figures
- Construction costs per major elements and in total
- Internal and external exposures

Information collected must contain adequate quality and accurate details of the risk in order for a risk assessment and loss estimation to be completed meaningfully. The collected information should then be checked against risk exposure (property and natural catastrophe) documents published by established and acceptable agencies (both locally and internationally) to ascertain the expected loss scenario events to be considered in the loss estimates. The following risk exposures are common loss events and should be considered as part of the PML assessment.

8.2 Risk Exposures

- Earthquake
- Tsunami
- Flood
- Wind – Tornado, Hurricane, etc.
- Landslide / Rock Fall
- Sabotage
- Train machinery/component failure resulting in fire/explosion
- Train on-board storage fire resulting in fire/explosion
- Train collision or derailment resulting in first or third-party property damage
- Idling stocks in depots and yards (locomotive servicing and repair shops, switching yards, freight classification yards and transit equipment storage yards)
- Control system failure

8.3 Loss Estimate Scenarios

Types of risk, areas and locations can influence the loss scenario and the quantum of loss. Undoubtedly for Rolling Stock insurances, the concentration of values will be the most critical element, as events occurring to single trains / units are unlikely to present a significant physical damage loss amount. In all considerations, all possible and probable loss scenarios should be included in the assessment. It should also be noted that existing risks present at the subject location can change over time with new available information and data and the adopted loss scenarios should therefore be viewed as on-going work.

Loss scenarios may be different for construction and operational risks. For a construction project site, the probable maximum loss commonly increases in tandem with the construction phases with the maximum loss expected during commissioning and testing phase where equipment is fully in place already. For an operational site, the probable maximum loss remains largely the same but the cost of replacement for the affected property including equipment will vary over time.

The type of loss can arise from one or multiple of the following:

- **Loss at Storage or Maintenance Depot**
  Completed units either in storage or undergoing maintenance will present the largest accumulation of values, and hence should be a major consideration in assessment of PML. The key concerns will relate to a fire across the depot, or a flood event inundating the storage location (see 8.4 Worst Case Scenario).

- **Fire**
  Fire on trains remains a subject of some concern to the travelling public, although statistical analysis shows that it is a relatively rare phenomenon and that in comparison to other hazards in this topic the risk associated with fire is small.

  The use of electricity-powered trains compared to trains in the past where diesel or coal was used and also the use of non-combustible type materials on trains especially those for passengers, contributed tremendously to restrict fire development and spread.

- **Natural Catastrophe**
  Earthquakes can have serious effects on the state of high-speed rail structures and embankments. Under a seismic event, the tracks can get out of imposed geometrical limits, which can lead to train derailment. Besides the adoption of improved design rules, immediate (automatic) action triggered by earthquake motions is seen as a necessity by some countries. Other NatCat events such as tsunami and windstorm can also have significant impact on construction projects and also operational properties especially those situated near to coastlines and low-lying areas.

  NatCat events in recent years such as those in Japan, China, USA, etc. resulted in large scale damage to properties including railway structure and Rolling Stocks disrupting power, services and buildings.

- **Equipment Failures**
  Equipment failures such as those mentioned above in this section can result in single component/service failure to cascading failures of multiple component and connected services depending on the nature and cause of failures. Equipment concentration should also be considered when establishing PML. For Rolling Stocks, such situation is likely at depots (servicing and repair) and storage yards for trains which can also include trains kept in holding areas or terminals.

  A concentration of equipment is most vulnerable to loss by fire, explosion, flood, tsunami or earthquake. Storage areas located in low-lying areas may be subject to flooding resulting in equipment damage. Storage areas located adjacent to hills are exposed to landslide and bush/forest fires.

- **Train Collision and Derailment**
  Train collision and derailment can occur and has happened in many instances around the world. Many loss incident data attributes the main cause to a combination of natural events and human failure with direct loss to the trains involved and damage to in-house and third-party properties.

  Loss statistics show that collision and derailment happens much more frequent compared to NatCat events but the loss/damage in monetary terms is much lower than from NatCat events. Such loss is usually limited to 1 or 2 trains and may also involve damage to other parts of the rail/station depending on the location of impact along the rail.

- **Business Interruption (BI) and Contingent Business Interruption (CBI)**
  Depending on the type of damage, interruption to operations can be expected leading to business interruption at the location and even in another location (upstream or downstream).

  The extent and duration of business interruption should be assessed taking into consideration all relevant construction and operational data, redundancy of service utilities especially power, rail connectivity, train load, etc.

8.4 Worst-case Scenario

Considering the advancement in train construction technology and the limited combustibility of materials used in modern train and railway, the worst-case scenario considered is a natural catastrophe occurring at a Rolling Stock storage yard resulting in total loss of the property and equipment therein.

Depending on the cover, 100% business interruption should also be taken in consideration unless reliable information is available to suggest otherwise.

9 PRICING CONSIDERATIONS

Rating tools (there are some common tools in the market) and guidelines will differ from company to company. However, some of the main pricing considerations are outlined below.

9.1 Project (Assembly Testing)

- Policy Duration and Values at Risk at various phases:
  - Fabrication of individual components
  - Assembly work
  - Testing and validation
- Maintenance period
- Concept of Cover, type of wording (endorsements and exclusions)
  - TPL (third party liability required)
  - DSU/ALoP required (indemnity period, e.g. 12 months, 24 months, time deductible e.g. 30, 60 days)
  - Type of maintenance required (visits, extended, guarantee)
  - Design coverage (LEG 2, LEG 3)
  - Cover for serial losses
- Natural Perils exposures at all locations, including fabrication, assembly, storage depots.
- Deductibles
- Insured (owner, contractor, sub-contractor), allocation of risk
- Sublimits

9.2 Operational

- Level of maintenance, modernization, retrofit cover
- Is the asset still covered by manufacturer's warranty?
- TPL (third party liability required)?
- BI required (indemnity period, e.g. 12 months, 24 months, time deductible e.g. 30, 60 days)
- Sum insured
- Deductibles
- Concept of Cover, type of wording (endorsements and exclusions)
- Insured (owner or operator)
- Insured object
- Information from the risk assessment (signaling systems, security systems, density of traffic)
- Location(s)
- Sublimits
- Categorization of Rolling Stock
- What is the quality of the assets? (Modern/ Obsolete/ 1st Generation and are any assets reliant on being fixed at a location distant from the operational region)
- Is the line use dedicated to high speed traffic or is it mixed between low/ medium and high speed
- the Static Depot Risk – if there is only one maintenance location
- Redundancy of fleet, meaning if there is other assets that could be utilised to replace any that are not operating

10 CONCLUSIONS

This has been a wide-ranging paper which has attempted to highlight the varied challenges presented to underwriters of Rolling Stock assets, notably those projects for the supply of new Rolling Stock and the operational covers which follow.

We have seen that Operators and Regulators may impose contract conditions on the Rolling Stock providers which should be assessed by potential underwriters.

We have also seen through the Loss Examples section that losses are not uncommon and can be catastrophic in nature. It is highlighted in several circumstances that human error is a key point of failure, and should be the subject of increased technological oversight / intervention where possible to ensure a safe Rail system.

Finally we have explored the underwriter's common information requirements, and the key loss scenarios which might affect allocation of capacity.

Rail as a reliable form of transport for urban and intercity locations continues to grow at a positive rate, and the incorporation of new technologies, lighter weights and higher speeds will further increase the complexity of the challenges faced by Insurers in this industry.

Appendix 1 – Glossary

Term	Explanation
CCTV	Closed Circuit Television Example: http://www.moxa.com/Solutions/Railway/Solution/CCTV.htm
Contracting Parties	Contracting Parties usually consist of the Rail Operating Company, Rolling Stock Manufacturer (and Maintenance company) as a minimum.
PPP	Public Private Partnership
ERM	Enterprise Risk Management
ETCS	European Train Control System

Appendix 2 – Clauses

Description or Examples.

LEG 2	Model "Consequences" Defects Wording "The Insurer(s) shall not be liable for All costs rendered necessary by defects of material workmanship design plan specification and should damage occur to any portion of the Insured Property containing any of the said defects the cost of replacement or rectification which is hereby excluded is that cost which would have been incurred if replacement or rectification of the Insured Property had been put in hand immediately prior to the said damage. For the purpose of this policy and not merely this exclusion it is understood and agreed that any portion of the Insured Property shall not be regarded as damaged solely by virtue of the existence of any defect of material workmanship design plan or specification http://www.londonengineeringgroup.com/#/leg-clauses/4576465682
LEG 3	Model "Improvement" Defects Wording "The Insurer(s) shall not be liable for All costs rendered necessary by defects of material workmanship design plan or specification and should damage (which for the purposes of this exclusion shall include any patent detrimental change in the physical condition of the Insured Property) occur to any portion of the Insured Property containing any of the said defects the cost of replacement or rectification which is hereby excluded is that cost incurred to improve the original material workmanship design plan or specification. For the purpose of the policy and not merely this exclusion it is understood and agreed that any portion of the Insured Property shall not be regarded as damaged solely by virtue of the existence of any defect of material workmanship design plan or specification". http://www.londonengineeringgroup.com/#/leg-clauses/4576465682
Expediting Expenses	In the event of loss or damage to the Property Insured or any part thereof the cost of any repair replacement or rectification admitted under this Policy shall include the additional cost 25% above the normal cost or overtime weekend and shift working bonus payment plant hire charges express delivery (including airfreight) and the like necessarily and reasonable incurred in expediting such repair replacement or rectification but excluding any such cost solely to expedite have been obtained had no such loss or damage occurred. http://ahliasuransi.com/expediting-expenses-clause/
72 Hours Clause	Any loss of or damage to the insured property arising during any one period of 72 consecutive hours, caused by storm, flood, typhoon, tsunami or earthquake shall be deemed as a single event and therefore to constitute one occurrence with regard to the deductibles and limits provided for herein. For the purpose of the foregoing the commencement of any such 72 hour period shall be decided at the discretion of the Insured it being understood and agreed, however, that there shall be no overlapping in any two or more such 72 hour periods in the event of damage occurring over a more extended period of time

Escalation Clause	It will be in order for Insurers to allow automatic regular increase in the Sum Insured throughout the period of the policy in return for an additional premium to be paid in advance. The terms and conditions for this extension shall be as follows:- a. The selected percentage increase shall not exceed 25% of the Sum Insured. b. The additional premium, payable in advance, will be at 50% of the full rate, to be charged on the selected percentage increase. c. The Sum Insured at any point of time would be assessed after application of the Escalation Clause. d. Escalation Clause will apply Building, Machinery and Accessories only and will not apply to stock. e. Policy Condition of Average will continue to apply as usual. f. The automatic increase operates from the date of inception up to the date of operation of any of the Insured Perils.
Preventive Measure Clause	It is agreed that in the event of actual damage (or imminent damage) to the Insured Property , the Insurer will pay the reasonably costs necessary in preventing, minimising or reducing damage to the Insured Property, which the Insured can prove were necessarily incurred immediately and urgently in an emergency. http://ahliasuransi.com/preventive-measure-clause/
Debris Removal	Coverage for the cost of removal of debris of covered property damaged by an insured peril. This coverage is included in most commercial property insurance policies.
Repeat Tests	In case of Damage recoverable under this Policy and in consequence thereof it is necessary to repeat any test or trial, the Insurers shall also pay the expenses of such repeated test or trial.
Reinstatement of Sum Insured	In consideration of the Insured undertaking to pay any premium at the agreed rate on the amount of loss on a prorata basis from the date of such loss to expiry of the current period of insurance , it is agreed in the event of loss the insurance hereunder shall in force for full sum insured
50/50 Clause	In the event of loss or damage to interest due to a peril insured against being discovered after the risk has terminated under the Marine Insurance and if after proper investigation it is not possible to ascertain whether the cause of such loss or damage happened prior to termination of the marine venture or subsequently it is understood and agreed that the Insurers hereon shall contribute 50% of the property adjusted claim provided the Insurer of the Marine Insurance also agree to contribute 50% such contributions to the without prejudice to subsequent final apportionment of the claim as may be agreed between the Insurers hereon and the Corporation of the marine Insurance. It is further agreed that in the event of the excess under this policy being different from the excess under the Marine Policy , in settling claims as described above each Insurer shall deduct 50% of Its appropriate excess from its 50% share of the adjusted claim. It is further agreed that immediately after arrival of all cargo at this point of destination proper investigations are made to ascertain visible damage and record thereon is made available to the Insurers. http://www.akademiasuransi.org/2013/04/5050-clause.html

Off Site Storage	It is agreed and understood that, notwithstanding the terms, exclusions, provisions and conditions of the Policy or any Endorsements agreed upon and subject to the Insured having paid the agreed extra premium, Section 1 of the Policy shall be extended to cover loss of or damage to property insured (except property being manufactured, processed or stored at the manufacturer's, distributor's or supplier's premises) in off-site storage within the territorial limits as stated below. The Insurers shall not indemnify the Insured for loss or damage caused by the failure to take generally accepted loss prevention measures for warehouses or storage units. Such measures shall include, in particular: – ensuring that the storage area is enclosed (either a building or at least fenced in),guarded, protected against fire, as appropriate for the particular location or type of property stored; – separating the storage units by fire-proof walls or by a distance of at least 50 meters; – positioning and designing the storage units in such a way as to prevent damage by accumulating water or flooding due to rainfall or by a flood with a statistical return period of less than 20 years; – limiting the value per storage unit.
Extended Maintenance	It is agreed and understood that otherwise subject to the terms, exclusions, provisions and conditions contained in the Policy or endorsed thereon and subject to the Insured having paid the agreed extra premium, this insurance shall be extended for the maintenance period specified hereunder to cover loss or damage to the contract works - caused by the insured contractor(s) in the course of the operations carried out for the purpose of complying with the obligations under the maintenance provisions of the contract, - occurring during the maintenance period provided such loss or damage was caused on the site during the erection period before the certificate of completion for the lost or damaged section was issued.
Firefighting Expenses	It is hereby understood and agreed that in the event or fire or series of fires arising directly or indirectly from the same occurrence following earthquake, including fire threatening to involve the property insured, The Insured shall be entitled to recover: • The actual cost of materials used and /or damage in extinguishing or controlling or attempting to extinguish or control any such fire • The cost of all clothing and/or personal effects damaged in extinguish or control such fire unless more specifically insured • All other actual expenses (including wages, and the like paid for fighting, extinguishing or controlling or attempting to fight, extinguish or control such fire and / or localizing such fire)

Appendix 3 – References and Weblinks

(Please be aware that links might get outdated, up-dated, changed or taken from the Internet)

Description/Topic	Link
IMIA, Knowledge base	https://www.imia.com/knowledge-base
History of Rail Transport	https://en.wikipedia.org/wiki/History_of_rail_transport
Railway technic	http://www.railway-technical.com http://www.railway-technical.com/Manufacturing.shtml http://www.railtechnologymagazine.com/Home http://www.railmagazine.com/trains/new-trains/rise-of-the-smart-train/page/2
UIC, the worldwide railway organisation	http://www.uic.org http://www.uic.org/highspeed#What-is-High-Speed-Rail http://www.uic.org/statistics
SCI SCI Verkehr is an independent consulting firm that is specialized on traffic economy and traffic engineering	http://www.sci.de
European Union Agency for Railways	http://www.era.europa.eu
Regulators	www.rssb.co.uk
London engineering group	http://www.londonengineeringgroup.com
Database about clauses	http://ahliasuransi.com