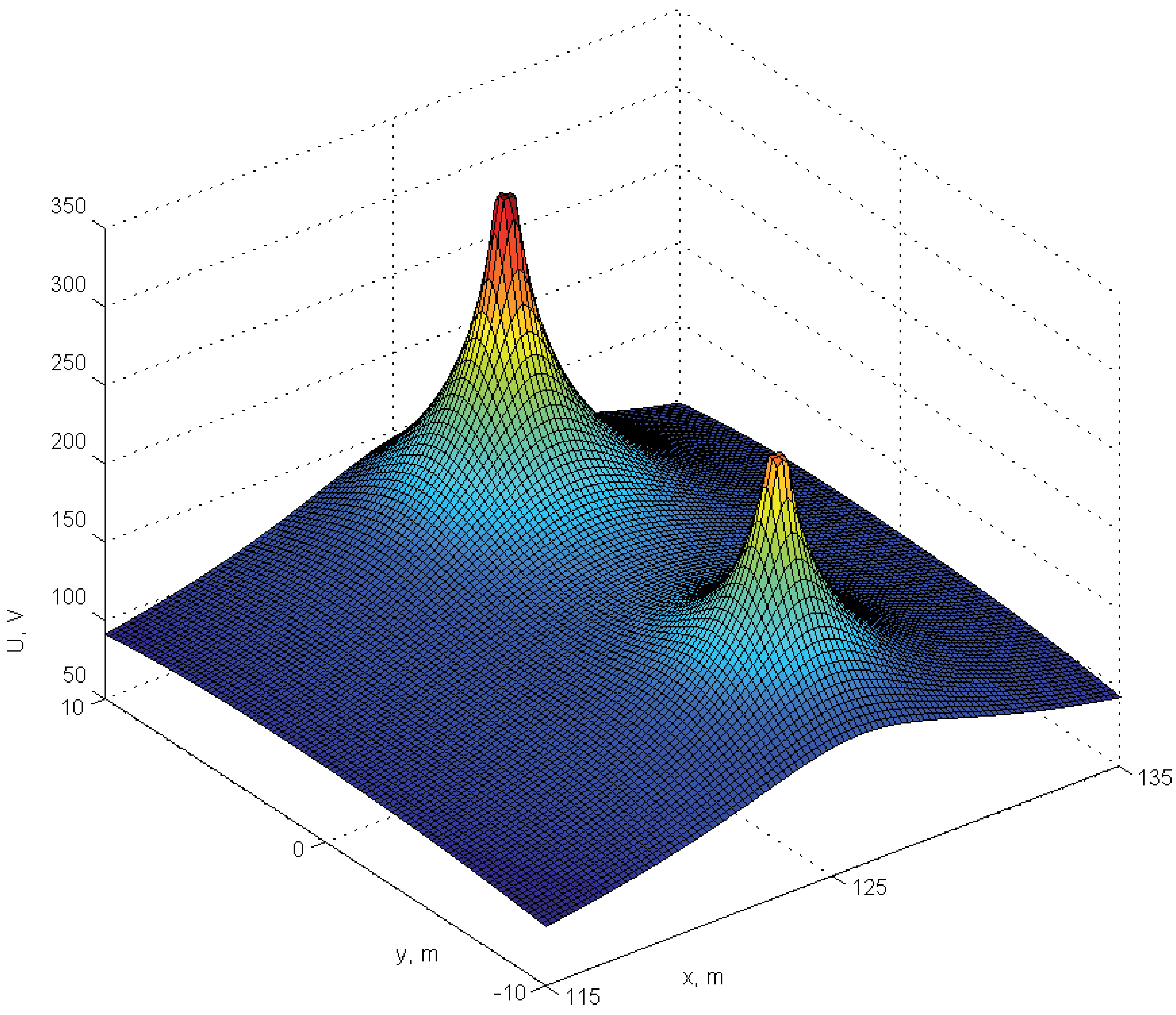
Made in Germany

# Systems Design



# Systems Design

## The key to tailor-made traction power supply systems

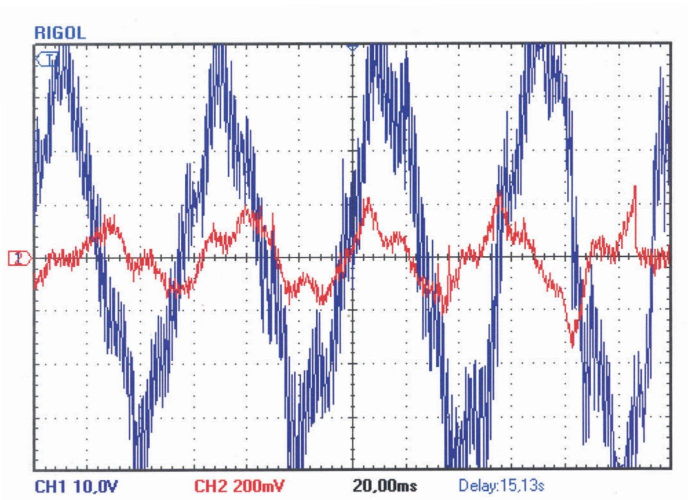
As an expert specialist for electrical railway infrastructure, Rail Power Systems plays a key role in providing infrastructure users with a type of mobility that is reliable and, first and foremost, safe. Decades of business experience gained on the world‘s most important markets, our use of state-of-the-art technology and a corporate philosophy that focuses on the customer set Rail Power Systems apart as one of the leading suppliers of electric traction power supply systems worldwide.

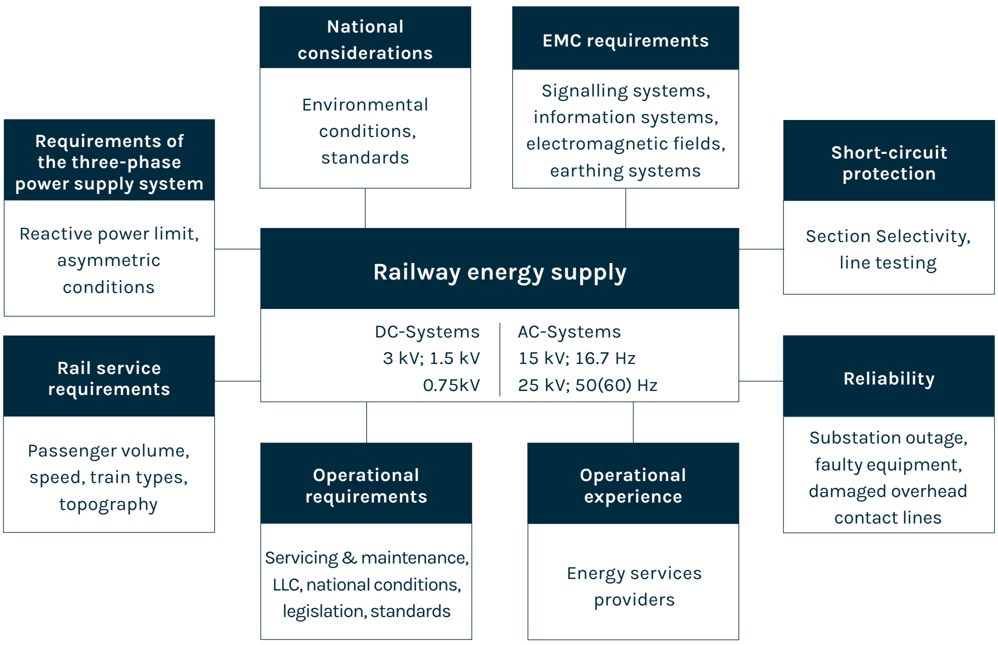
Efficiency and longevity are two of the decisive factors that will make or break the development of innovative railway infrastructures. The systems design department at Rail Power Systems lays the groundwork for solutions that are perfectly customised to the individual needs and specifications of the customer.

Our experienced specialist engineers apply their exceptional know-how along with the latest computer applications and simulation systems to analyse all relevant aspects affecting the system.

## The systems design department acts as an internal and external service provider for:

- Simulation of traction power supply systems
- RAMS analyses
- Consideration of EMC issues
- Subcontractor for the notified body for interoperability (Eisenbahn-Cert)
- TSI-compliant draft planning
- Calculation of dynamic behaviour of the pantograph / overhead contact line
- Safety features for protection against electric shocks




Requirements for an optimal development of traction power systems (applicable for direct and alternating current rail systems)

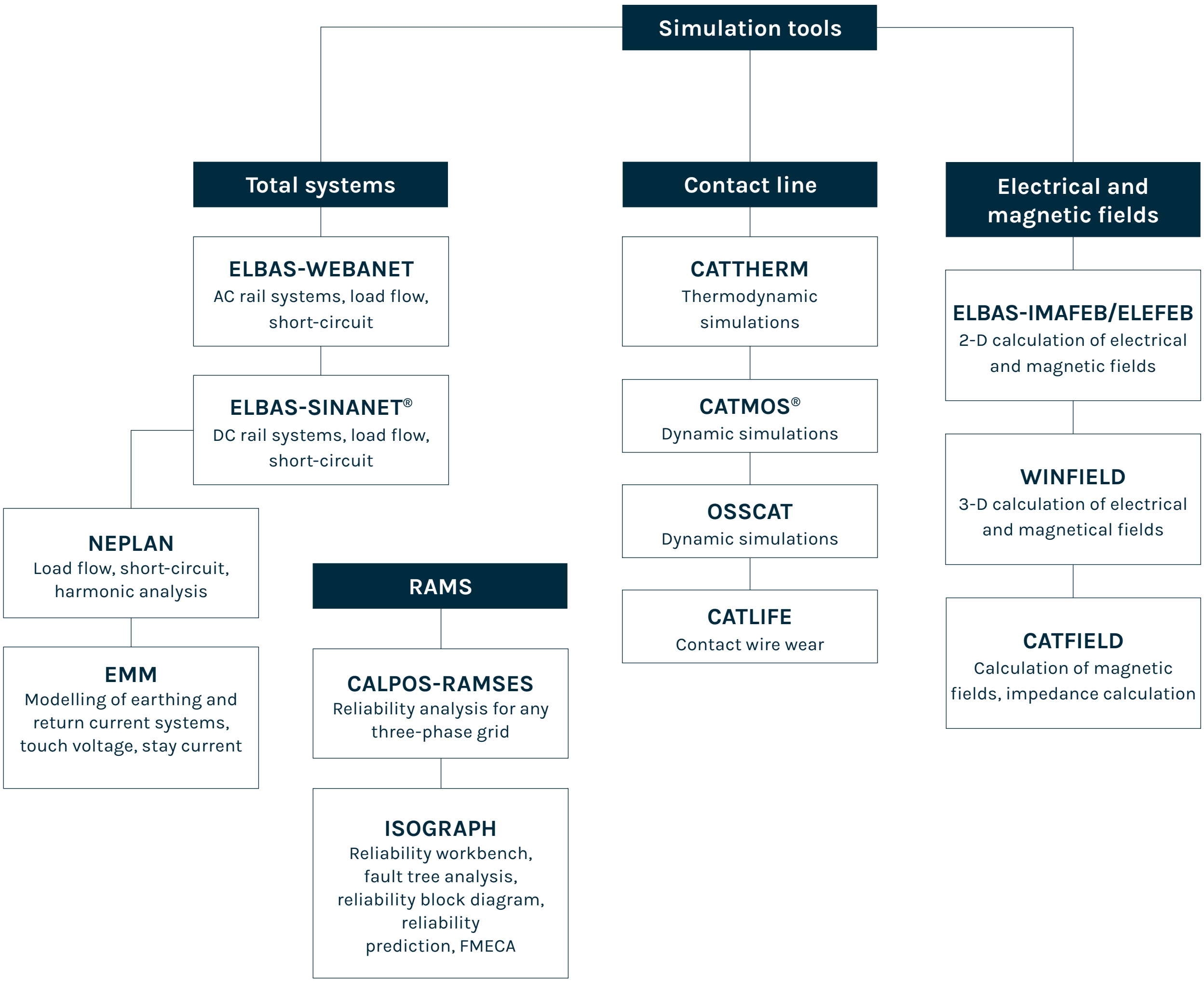
# Simulation tools

## Optimising the design of railway power supply systems

During the optimisation process, we prioritise the smooth and trouble-free interaction of the electrical and mechanical network for the vehicles that will be using the system, taking into account their behaviour under operational conditions. This is, ultimately, the only way to obtain reliable information during the design phase that can be subsequently incorporated in the traction power supply system. There are also a large number of other factors and requirements that need to be taken into consideration.

We utilise the findings of our systems design department and the resulting experiences gathered by our specialist engineers for the purposes of both project implementation and developing new systems or optimising systems that are already in place. Whatever the case may be, our goal is always to provide the best possible solution for the specific conditions.

- Design and optimisation of traction power supply systems
- Simulation tools for AC and DC rail systems
  - for system design and planning
  - on behalf of the client
  - for sales and project management
- EMC analyses
- Measurements and tests
- Economical analysis
- Life cycle costs/RAMS



# Systems design process

**Project specification**

- Route topology
- Transport operations

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**System specification**

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| Contact line system | Substation specifications | Operating data | Network layout |
|---|---|---|---|
| • Type/design<br>• Line feeding concept | • Transformer data<br>• Voltage level | • Schedule<br>• Vehicles, load conditions | • Single or double-side fed sections<br>• Substation locations |

↓

**Calculation**

- Substation load
- Voltage drops and losses
- Short-circuit currents
- Operating currents
- Track-earth voltage
- Stray currents

↓

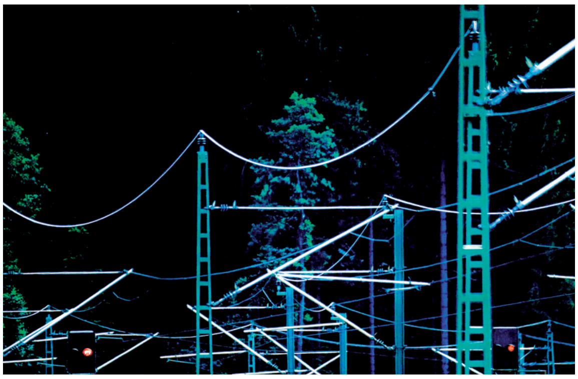
| Specification of traction power supply concept for project planning / tender | | | |
|---|---|---|---|
| **Substation configuration** | **Line configuration** | | |
| • Testing of protection system – adjustment<br>• Testing of load conditions – components, transformers, circuit breakers<br>• HV network disturbances<br>  • Asymmetric conditions<br>  • Harmonics<br>  • cos φ | • Contact line<br>• Current distribution<br>• Load conditions | • Earthing/return current<br>• Touch voltage | • Electromagnetic compatibility<br>• Electromagnetic fields<br>• Harmonics<br>• Interaction network/ traction vehicle |

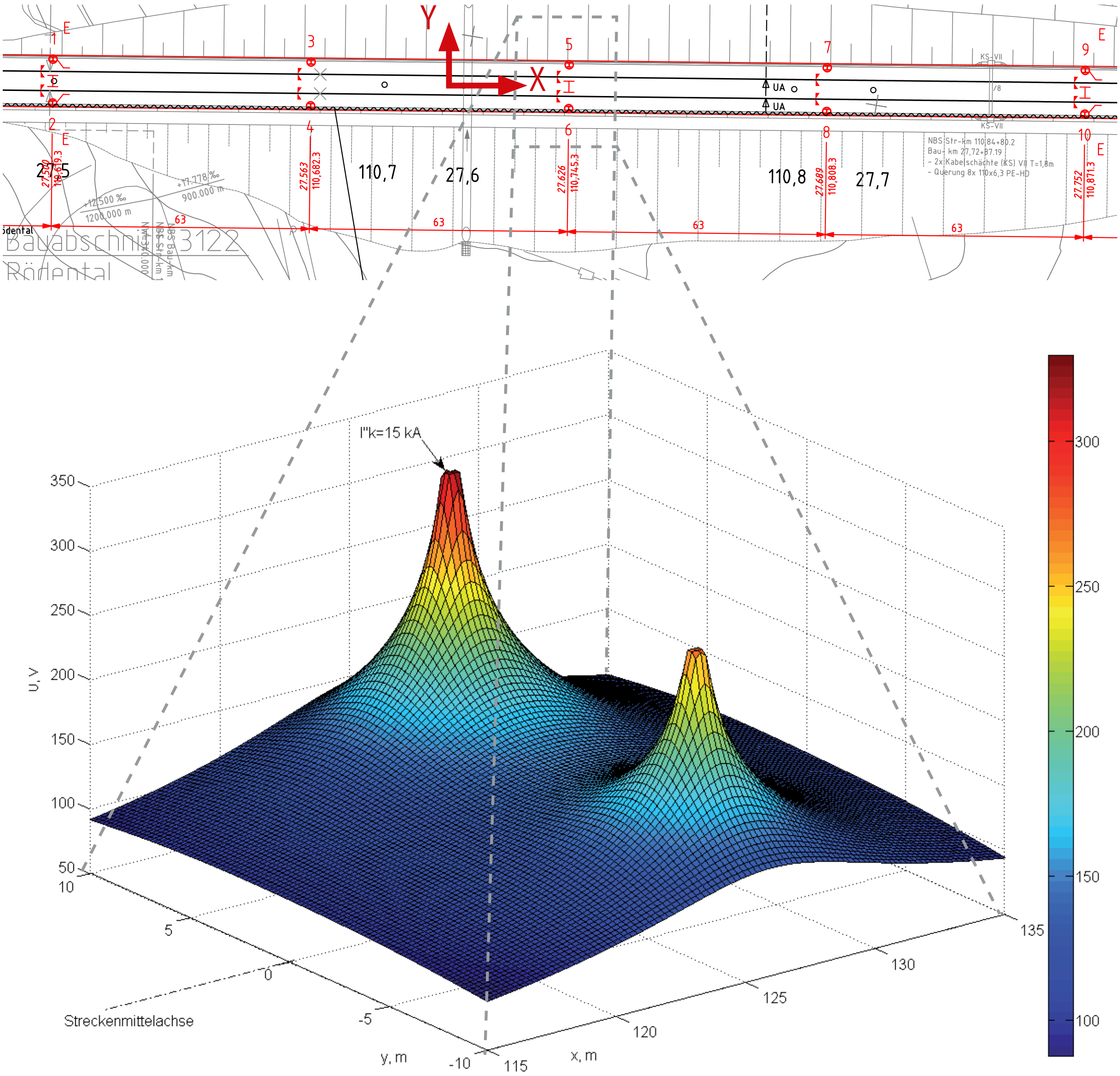
# Earthing Modelling Method (EMM)

## Calculations of potentials, determination of touch voltages and stray currents

For a safe and sustainable railway system it is essential to comply with the limits for body and touch voltages as well as stray current criteria according to EN 50122-1,2,3.

Modelling of earthing and return current systems of electric railways based on the Earthing Modelling Method (EMM) supports railway system design that complies with the applicable standards.






Earth surface potential in the event of a short-circuit due to flashover of an insulator on mast 5.

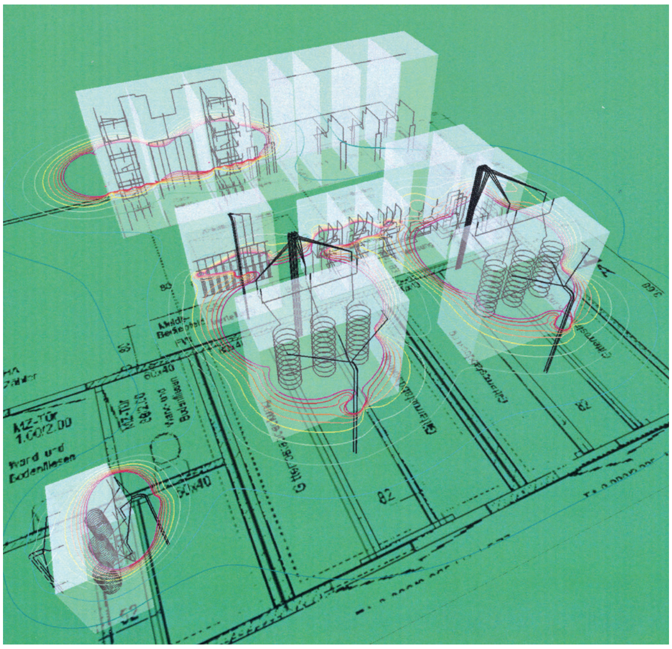
# Electromagnetic compatibility (EMC)

## The precondition for a safe and reliable traction power system

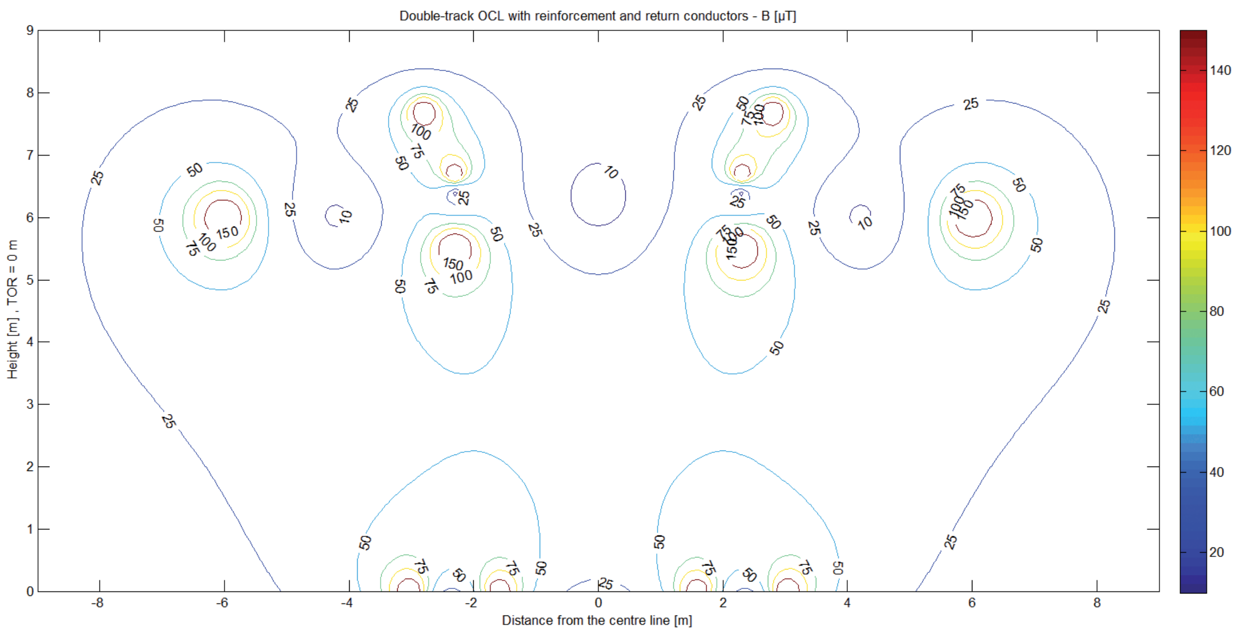
Electromagnetic fields can affect the operation of electrical devices and may place the health and safety of humans and animals at risk. It is vital, therefore, that mitigation measures be introduced to limit or avoid the generation of such electromagnetic fields. This will ensure the safe and reliable operation of equipment and, in particular, provide effective protection for people and animals. In order to achieve this goal uniformly throughout Europe, the Council of the European Communities adopted EMC Directive 2014/30/EC.

The widespread use of electronics makes it necessary to institute uniform guidelines for the analysis, evaluation and reduction of mutual electromagnetic interference. EMC plans for devices, systems and installations are prepared on the basis of measurements, calculations and experience. Those who address EMC issues early on will save substantial costs and will prevent performance restrictions occurring later.

Rail Power Systems has the expertise necessary to implement proper EMC planning and to monitor the measures invovled.



Sample field calculations
Top: substation
Bottom: overhead contact line



### Electromagnetic compatibility (EMC) is broken down into two aspects

1. Impact of electromagnetic fields on humans and animals (EMC-E)
2. Electromagnetic interference between electrical equipment (EMC)

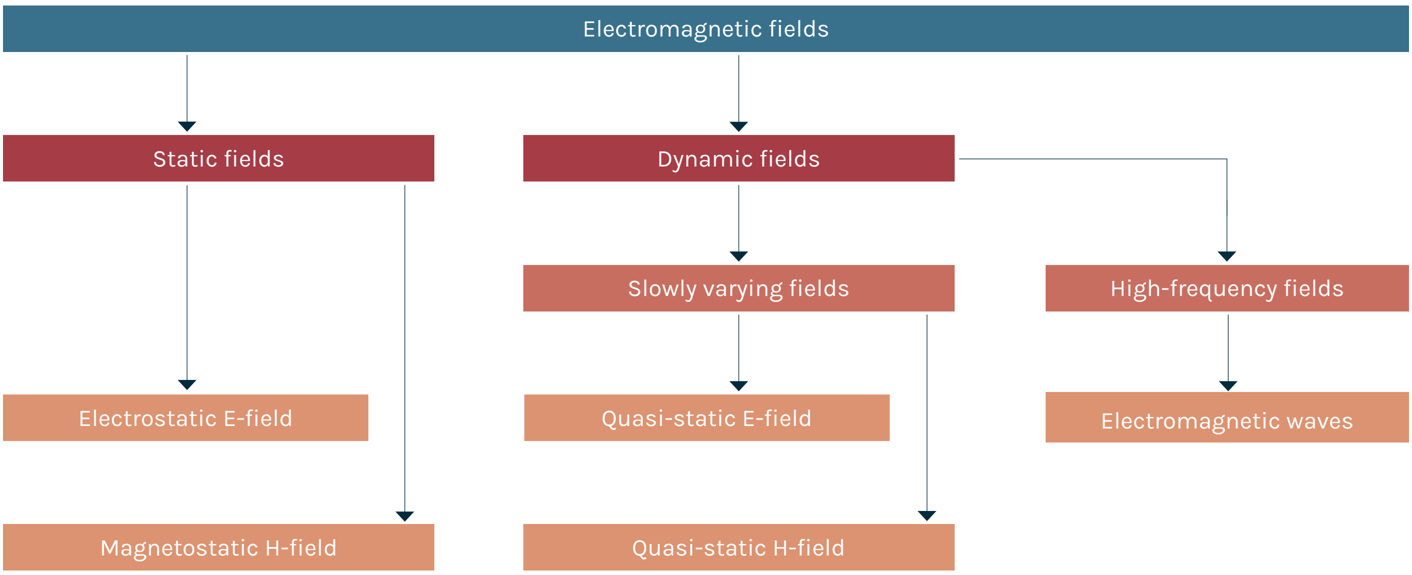
### Definition of the electromagnetic compatibility of biological systems (EMC-E)

EMC-E covers the impact of electrical and magnetic fields on humans.

### Definition of electromagnetic compatibility (EMC)

EMC is defined as the ability of electrical equipment, a component, a subsystem, a device or a complete system to function satisfactorily in its electromagnetic environment without affecting other equipment in this environment to an impermissible extent.

## Classification of field types



# RAMS

## Objectives of RAMS engineering

In addition to the scheduled technical implementation, the factors of reliability (R) and availability (A), maintainability (M) and safety (S) are becoming increasingly important as part of the construction, expansion and modernisation of traction power supply systems.

RAMS stands for:

### Reliability

The probability of a unit to fulfil the required function under preset conditions within a preset period of time.

### Availability

Availability is the ability of a product to be in a state or to perform a required function under given conditions at a given instant of time or over a given time interval assuming that the required external resources are provided.

### Maintainability

Maintainability is the probability that a given active maintenance action, for an item under given conditions of use, can be carried out within a stated time interval when the maintenance is performed under stated conditions using stated procedures and resources.

### Safety

Freedom from unacceptable risk to human health or the enviroment The primary objective in RAMS engineering is to use certain parameters in an effort to determine, evaluate and optimise the reliability and availability of the products and systems made by Rail Power Systems under the conditions given. This objective also comprises observing and illustrating the maintainability of the components and systems and the detection and avoidance of possible safety risks as early as the conceptual design stage of the systems.

An integral part of project management, RAMS engineering cmakes a sizeable contribution to ensuring that systems remain easy to use and service and operate without failure.

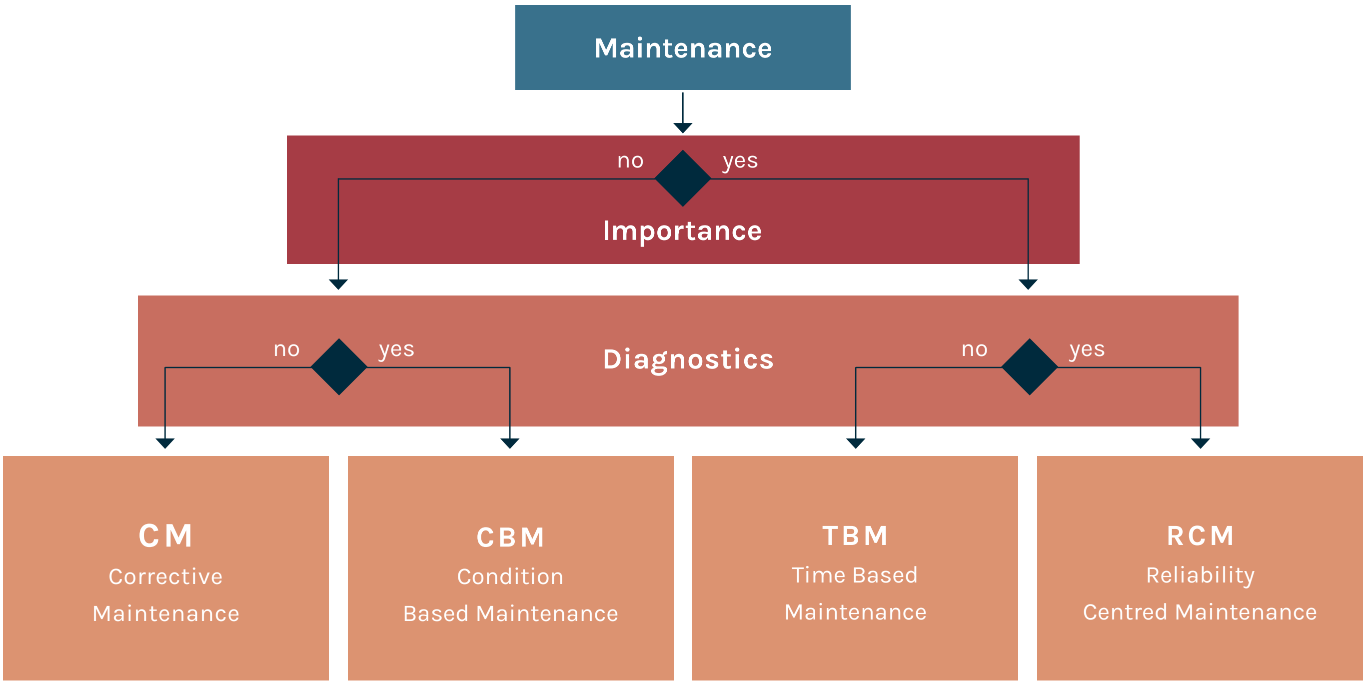
## The Process

All employees working in sales and project management are affected by RAMS engineering. Project managers are responsible for further development of AC and DC switchgears, contact line systems, as well as information and remote control systems. Having completed in-house and external training courses, all staff members entrusted with RAMS engineering tasks are experts in handling all matters concerning the subject.

The design of the system and the selection of the components to be used are based on the aspects of RAMS taken into consideration during the design phase.

For the customer this translates into a high degree of operational reliability and availability of their systems. We involve customers directly in this planning process by arranging meetings, requesting information, and including them in the decision-making process and seeking their approval for our designs.

Our failure strategy for overall systems plays a vital role in this regard. This is because it has an impact on the maintenance concept, maintenance costs and, consequently, the entire life cycle of the systems.



# TracFeed® OSSCAT

**A software tool for static and dynamic simulation of interaction between pantographs and overhead conductor rails (OCR) as well as other overhead contact line (OCL) designs and their transitions**

For at least two decades, simulations of dynamic interaction between overhead contact lines with catenary suspension and pantographs have been an established, generally accepted method for developing new designs for all operation speeds. Simulations are increasingly used for approval of overhead contact lines, pantographs and subsystems in the context of the Technical Specification for Interoperability (TSI), as well as for subsystem energy supplies and rolling stock.

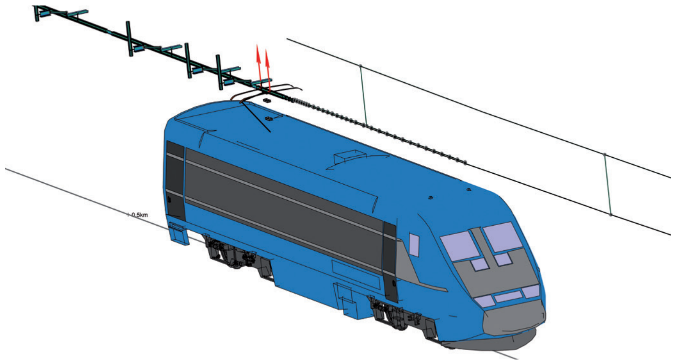
The new OSSCAT simulation software has been primarily designed for the development and simulation of Rail Power Systems' overhead conductor rail TracFeed® OSS. This software uses multi-body models to simulate pantograph dynamics as well as finite element method (FEM) to simulate several OCR arrangements.

### The most important features of OSSCAT are:

- Simulation of any OCR arrangements for the TracFeed® OSS using extruded profiles with a height of 80 mm, 110 mm and 130 mm, as well as extruded sections of other manufacturers
- Variable support distances and lengths of OCR profile sections
- Parallel arrangements of OCR for insulated overlaps
- Suspended supports and hinged supports, as well as user-defined supports
- User-defined OCR elements, e.g. dilatation and transition zones to OCL
- Up to 8 pantographs per train

Transition zones between OCR and OCL are critical, particularly for high speeds. Therefore, this special infrastructure requires an especially accurate design. The new OSSCAT simulation software can simulate several transition zones from OCR to OCL as well as any subsequent OCL sections. The OSSCAT software has been compared with dynamic test runs in the Leipzig City Tunnel and validated against the results. It is a universal tool for development and optimisation of the TracFeed® OCR and other overhead contact line systems.

The OSSCAT simulation software fulfils the requirements of European standard EN 50318, just like the previous simulation software CATMOS®. The evaluations stated in the aforementioned standard, along with various other detailed studies, can be carried out.



### Some examples of OSSCAT evaluations include:

- 2-D and 3-D representation of OCR and OCL arrangements
- Animation of pantograph interaction
- Statistical analysis of contact force
- Graphical representation of static assembly arrangement, contact force and vertical movements of the pantograph
- Graphical representation of vertical movements of selected catenary points
- Location and duration of arcs of any pantograph contact strip

### The OSSCAT simulation software provides the following applications:

- Optimisation/emulation of existing contact line systems
- Development of new overhead conductor rail/overhead contact line systems
- Development/optimisation of customised designs for special structures
- Increase in operation speed of existing catenary designs in interaction with new pantograph models
- Operation with multiple pantographs
- Certification of TSI conformity

# Earthing measurements

## Seminars

### Earthing measurements

To ensure the safety of persons in electric railway facilities, protective measures must be taken against the effects of the hazardous touch voltages and dangerous body currents that arise both in normal operation and in the event of earth faults. Earthing is generally employed as a protective measure. The installed earthing systems must be designed and laid out correctly and undergo regular condition checks to ensure a safe and reliable traction power supply system.

Earthing measurements allow for the acquisition of the specific types of information necessary for earthing provisions and for the assessment of the condition of installed earthing systems and related plant safety provisions.

Carrying out earthing measurements in substations (AC and DC), switching installations, 50 Hz systems and structures in the railway environment is another core task of systems design.

### Seminars

The rail industry is a highly complex, closely integrated area of the transport sector, with a great influence on public life. The demands on traction power supply systems continue to rise for electrically operated intercity rail traffic, and light rail in particular. Senior professionals offer participants expert guidance to help them prepare for future challenges in the traction power supply field. The discussion and evaluation of fascinating real project issues are an integral part of the training courses.

### Examples of course topics

#### Basics of AC and DC traction power supply

- Introduction to the traction power supply system
- Railway traction vehicle behaviour, energy
- requirements
- Structure of traction power supply systems and
- contact lines
- Designing traction power supply systems
- Configuring return circuit and earthing systems
- Electromagnetic compatibility, interferences, power quality impact

#### Designing AC and DC traction power systems

- Influencing parameters/essential sizing criteria
- Energy needs assessment for train runs
- Voltage drops, contact line impedances and current
- carrying capacity
- Influence of the contact line wiring
- Substation distances/loads
- Characteristics of the traction power simulation tool (SINAET, WEBANET)

#### Objectives of earthing and return current conduction in AC- and DC-powered railways

- Interferences in electric railways
- Galvanic interference
- Capacitive interference
- Inductive interference
- Return circuit system and its influencing parameters
- Return current distribution
- Rail potential and touch voltage
- Impedances of the track and other components
- Influence of return conductors on the return circuit
- system
- Earthing in AC-powered railways in accordance with signalling equipment

#### Traction power systems compared

- The traction power supply system and basic requirements
- Comparison of electric and diesel traction
- Historical overview of electric traction
- Comparison of traction power systems
  - Comparison of AC and DC; advantages and disadvantages
  - Comparison of 15 kV without separation sections and 25 kV with phase separation sections
  - Autotransformer systems
  - Basic feeding concepts for AC and DC railways
- Special features of traction power supply in comparison with the common energy supply

RPS/EN/144/0824



The specifications set out in this document apply to conventional applications. They do not represent performance limits. This means that divergent specifications may be attained in specific applications. The contractually agreed specifications alone shall apply. We reserve the right to effect technical modifications.

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