



# Solutions

Solutions for Rolling Stock



LogoMotive dimensions  
the TOTAL SYSTEM



Andreas Straßer  
Managing Director



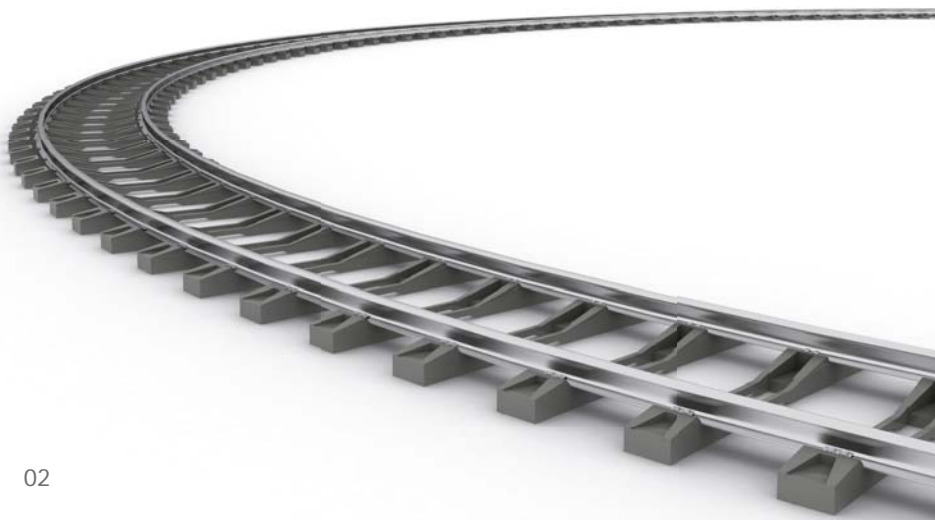
With best professional expertise  
and expert knowledge – we focus  
fully on each single work step of the  
total system.

Thomas Endres  
Managing Director



Our customers worldwide – vehicle and component manufacturers, transportation system operators as well as national safety authorities – are convinced of LogoMotive's capabilities.

Thomas Benker  
Managing Director



## With us, it's your turn!

As the experts for mechanical vehicle engineering we concentrate our efforts in all aspects related to rolling stock – from single components up to large projects.

Our customers benefit from the know-how, which we have collected in numerous domestic and international projects and we are continuously increasing. You get an independent and neutral consultancy as well as an overall competent and personal partner. LogoMotive dimensions the mechanical total system of the vehicle and optimizes the single components. We analyze the vehicle behaviour in the transportation system taking into consideration the interaction between vehicle and track. We prepare documented evidences considering the safety of the transportation system and investigate its risk as well as the reliability. Our team of experts is eager to meet you!

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Ronaldo Gorsten  
Director Marketing  
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CTO & Sales



Thilo Weigel  
Director Marketing  
& Sales



TOTAL SYSTEM

# Control centre in railway transportation? LogoMotive!

We are your partner for all issues related to vehicle systems, from A like acoustics through Z like crash deformation zone. We develop, plan, consult, conceive, check, design, simulate, calculate, coordinate – in short: We take full charge of all mechanical vehicle systems! And comply with the customer's detailed requirements. We handle the complete range of rolling stock: regional mass transportation and long distance intercity traffic, passenger and freight transportation as well as track construction and maintenance machines. Each detail receives our full attention, a single component as well as an overall system, a domestic as well as an international project, a consultancy service as well as a completely new vehicle development.





# Development of Complete Vehicles

## intelligent solutions, cost saving when in operation

We are professionals when we are talking about the interfaces of the “vehicle system” and its interaction with the infrastructure as well as the operational requirements. The combination of test results, up to date requirements derived from norms and rules and the evaluation of documents clearly define the project related necessities. Combining the previous with the high competences of our engineering team leads to interdisciplinary solutions when developing the complete vehicle, which are surprisingly simple and highly cost efficient when in operation.

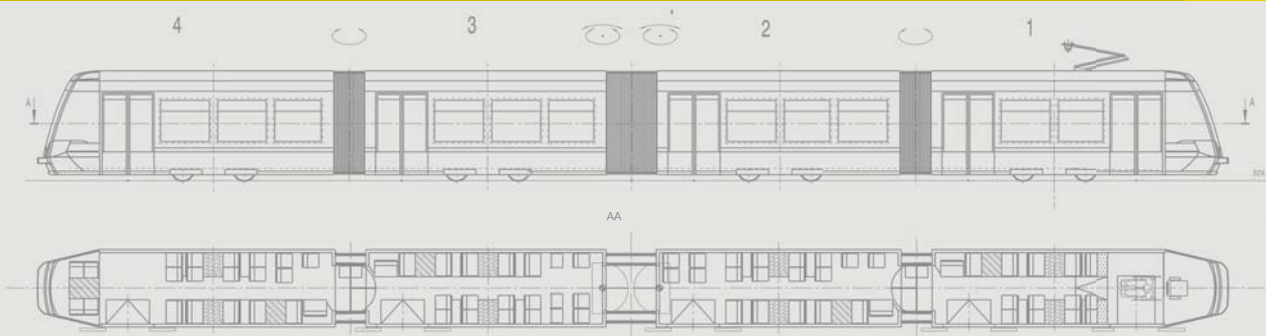
We optimize the interaction of components among each other and the interaction between the vehicle and the infrastructure by profound research. This way we reduce the stress and strain of the vehicle, components and the track as far as possible and by this minimizing the costs of service and repair. As a final step our experts deliver a documentation, which will lead to a fast and efficient homologation process together with the authorities in charge.

- **CONFIGURATION** of the vehicle defining the function of the articulation and positioning the articulation and the bogie
- **ANALYSIS OF THE INFRASTRUCTURE AND THE OPERATIONAL PARAMETERS** and definition of the environmental conditions and requirements for the development
- **WEIGHT MANAGEMENT** to optimize the masses and distribution
- **BRAKES AND DRIVE TRAIN** to define the concerned sub systems
- **VEHICLE LAYOUT AND OVERVIEW DRAWINGS** for the seat arrangement and standing space as well as the main dimensions
- **PRELIMINARY SELECTION OF SUPPLIERS** for minimizing the necessary effort for synchronized component development
- **RAMS / LCC** to optimize the related values
- **DEFINITION AND OPTIMIZATION OF INTERFACES** by considering the necessities of the „Other Side“

### Vehicle development of a low floor tram or a low floor electrical multiple unit.

LogoMotive prepared the overall vehicle concept taking into account the boundary conditions and customer requirements, followed by the interdisciplinary development work (design, simulations, verifications). Furthermore we defined the interfaces, components and loadings. The output included the 3D CAD models, the drawings, the purchase and the test specifications – and the evidence documents for dynamics, strength and crashworthiness.

**REFERENCE  
PROJECT**





# Vehicle Body Development

## innovative and compliant to norms and rules

When developing a vehicle body our focus lies on innovative approaches, which we combine with up to date and norm compliant approval methodology. In this way we assure, that new and up to date requirements are taken into consideration – as we have shown in numerous accomplished projects: starting with conventional vehicle bodies for metros, long distance and high speed trains all the way to low floor vehicle bodies for multi body trams and regional train sets.

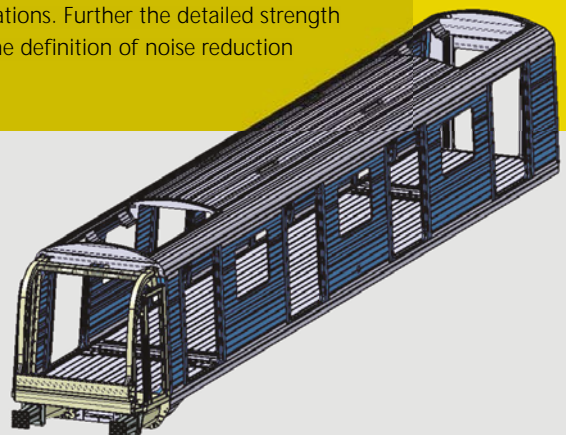
The diverse materials or material combinations, out of which vehicle bodies are produced, have specific characteristics and therefore ask for individual solutions within the structure, the used production technology and the implemented joining technics. Due to the great number of projects we have accomplished our profound experience and know-how in all of the before mentioned topics help us to improve constantly our approach to tasks within the services we offer. This leads to advantages in products we develop for the benefit of our customers.

- **GENERAL PRECONDITIONS AND REQUIREMENTS** to be collected, prepared and fixed: What are the furthest reaching solution approaches, which are acceptable?
- **CONCEPT** for realization: final definition of the basic structure
- **DETAILED MECHANICAL ENGINEERING IN 3D CAD** for the realization of the virtual product
- **DRAWINGS** to be derived as technical drawings from the 3D CAD model
- **STRENGTH ANALYSIS OF THE VEHICLE BODY:** Will the structure withstand all load cases over the whole life time?
- **STRENGTH ANALYSIS OF THE CONSOLES, COMPONENTS, HIGH DUTY BOLTED JOINTS:** Will it be possible to include all units without unbearable risks?
- **CRASH ANALYSIS:** Will all crash loads be absorbed and will the entire survival space remain in place?
- **CHECK OF THE STRENGTH ANALYSIS OF SUB SUPPLIERS** to minimize safety and availability risks caused by components with insufficient properties
- **REVIEW OF DRAWINGS:** Is all necessary information and technical data available to start the production process?

### Car body shell development for a metro train.

The entire scope of work comprised the complete design, the interface clarification and the 3D CAD modeling up to the preparation of drawings with bill of materials and purchase specifications. Further the detailed strength and crash analysis was performed as well as acoustic calculations including the definition of noise reduction measures.

**REFERENCE PROJECT**



# Bogies

## maximum safety, minimum wear and tear

Bogies have to withstand diverse and in part contradicting requirements. Not only the vehicle type needs to be considered, but also the influences of the infrastructure as well as operational requirements.

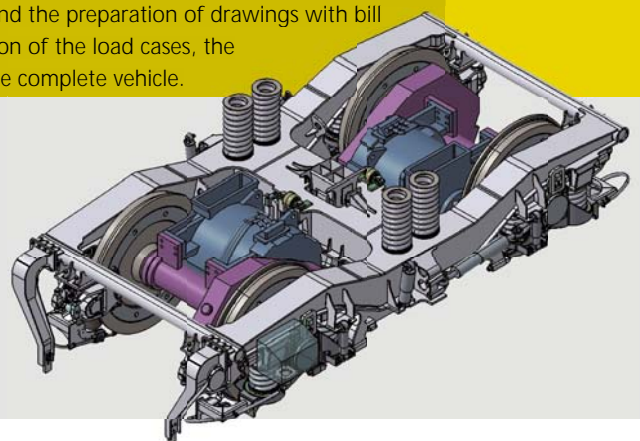
The bogies we develop ensure the highest safety against derailment and running stability within the given boundary conditions. At the same time the bogies offer a high riding comfort and low wear and tear, because all components are developed on the basis of precisely defined load cases. The result is an engineering solution with optimized distribution of forces, which combines light weight mechanical engineering and force flow optimization to achieve an extension of the life cycle. At LogoMotive all necessary competences and methods are available under one roof. Our highly specialized engineers are able to develop above mentioned optimized solutions by an interdisciplinary approach. Finally the approach is transformed into a solution engineered for series production.

- **BOUNDARY CONDITIONS AND REQUIREMENTS:** Where and how will the bogie be used? What impact has the infrastructure?
- **CONFIGURATION CONCEPT:** First overview of the possible arrangement of the components, adjusted to the basic vehicle concept and the further requirements
- **CONCEPT DEVELOPMENT / INTERFACE DEFINITION:** Will there be enough mounting space for all functionally necessary components?
- **FINAL DESIGN IN 3D CAD:** Computer aided modeling of the bogie frame matching all specifications
- **CREATION OF TECHNICAL DRAWINGS** for the preparation of the production
- **STRENGTH ANALYSIS** of the bogie frame. Will the frame withstand all long term appearing load cases?
- **STRENGTH ANALYSIS OF BRACKETS, COMPONENTS, HIGH DUTY BOLTED JOINTS:** Determination whether all units to be integrated can be mounted without remaining risks
- **CHECK OF STRENGTH ANALYSIS PERFORMED BY SUPPLIERS:** Were all specifications met or are there residual risks?
- **FATIGUE TEST** of the first frame to verify the strength analysis
- **REVIEW OF TECHNICAL DRAWINGS** to secure that all information and all sets of data are available for the realization process

### Bogie development for a four axle electrical locomotive.

The concept design up to the detailed design work of the bogie development was part of the entire work scope as well as the interface specification, the 3D CAD modeling of the bogie frame including all brackets and the assembled components, the dimensioning of all structures in terms of strength and the preparation of drawings with bill of materials and purchase specifications. Further services were the evaluation of the load cases, the specification of the bogie frame fatigue test and dynamic simulations of the complete vehicle.

#### REFERENCE PROJECT





## Power Packages optimized vibration behaviour

The components of the drive train of a diesel-multiple-unit (DMU) are integrated into a subsystem, which among others comprises the motor, the generator, the cooling system, the control unit and the mounting frame. The development of the power packages we will handle for you, adjusted to your needs and specifications and in close cooperation with the component suppliers.

In general the control of the vibrational behaviour of this subsystem is a great challenge. In case of necessity we will perform thorough vibrational analysis at the start of the project with the goal to optimize the vibrational behaviour of the drive train. With a group of highly qualified dynamics specialists unmatched in Germany we tackle this topic to live up to the importance of this issue for DMU's.

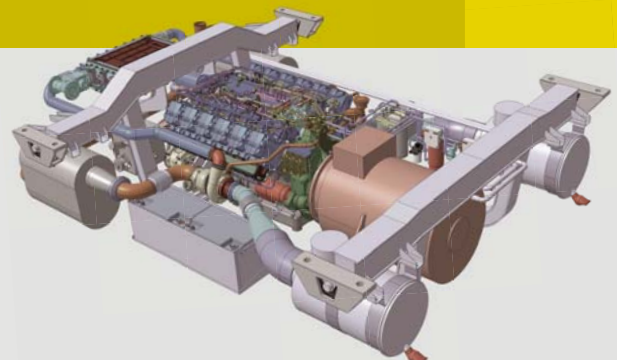
As a final step for a power package project you receive a complete documentation including all analysis reports all the way through to the documents necessary to start the production of the drive train.

- **COMPONENT INTEGRATION** to fix the arrangement, the mounting space and the interfaces of all components
- **MECHANICAL ENGINEERING** of the frame to convert the concept into a mechanical solution
- **STRENGTH ANALYSIS** to check the stability of the frame
- **STRENGTH ANALYSIS OF BRACKETS, COMPONENTS, HIGH DUTY BOLTED JOINTS** to ensure that all load cases will be born
- **DYNAMIC ANALYSIS** to assess the vibrational behaviour of the whole power package and the components included into the system
- **ACOUSTIC ANALYSIS** to achieve a low noise emission to match the requirements
- **FATIGUE TEST** of the first produced frame to verify the strength analysis

### Concept of power package for the use in diesel-electric commuter trains

Our task was the development of a concept for a power package frame with the integration of the system components as well as the definition and the positioning of the spring / damper elements. In addition we set up a dynamic model to be able to analyze the vibrations.

#### REFERENCE PROJECT





## Articulation Systems strong and safe

To connect the single cars of a train set the use of force transmitting and safe articulation systems is mandatory. By the use of such articulations the single cars are connected safely but still are able to move in an ideal way relative to each other.

In close coordination with the single component suppliers we develop these articulation systems. Dependent on the vehicle concept and the requirements, we determine the most suitable articulation system with respect to the number of degrees of freedom, interfaces with the bogie and the bearable loads. Since the structure of the vehicle body is soft compared to the articulation brackets they are designed in a way that within the adjacent vehicle body structure an optimized flow of forces and the least possible strength gap is achieved.

In addition the articulation system is analysed and optimized according to the requirements of different crash scenarios.

- **BOUNDARY CONDITIONS AND REQUIREMENTS:** Which forces are to be transmitted and which degree of freedom must be made possible for the articulation system?
- **CONCEPT PHASE:** Which parts are possible to be used and how do we have to arrange them?
- **FINAL DESIGN IN 3D CAD** by modeling of a virtual CAD model matching the requirements
- **TECHNICAL DRAWINGS** for the preparation of the production
- **STRENGTH ANALYSIS** to check the strength of the articulation system and the strength transition to the vehicle bodies

## Interior / Exterior Finishing not only fire resistant

We also support you with the interior and exterior finishing of your vehicle including the seating, covers, holding bars, doors and many more. When working on these numerous tasks you have substantial benefit out of our know-how within the aspects of mechanical engineering, structural mechanics and ergonomics as well as the knowledge on norms and rules particularly concerning fire protection.

To meet the requirements we choose modern and innovative materials in close consultation with you. We deal with fixing all components inside and outside the vehicle and put focus on safety, maintainability and the resistance against vandalism. To accomplish these challenges a close cooperation between numerous partners is necessary. The interfaces are defined together with experts for topics such as the electric installation, the climate system or the industrial designers.

Above that, we have gathered substantial experience in the modernization of vehicles. The main task lies in upgrading the vehicle body to withstand additional loads such as a refurbished climate system. For a given engineering concept of the vehicle body with the ability to take certain load cases we develop modification solutions, which guarantee the safe operation of the refurbished vehicle.

- **BOUNDARY CONDITIONS AND REQUIREMENTS:** which are the preconditions setting the frame for the solution approach
- **INTEGRATION OF COMPONENTS** from the mechanical point of view by considering the requirements of ergonomics, industrial design and fire protection
- **CLARIFICATION AND DEFINITION OF INTERFACES** of all components connected to the vehicle body and amongst each other
- **CONCEPT DESIGN** for setting the basic structure
- **FINAL DESIGN** of the interior and exterior finish
- **TECHNICAL DRAWINGS** for the production preparation
- **STRENGTH ANALYSIS OF BRACKETS, COMPONENTS, HIGH DUTY BOLTED JOINTS:** Will all load cases be born?
- **REVIEW OF STRENGTH ANALYSIS OF SUPPLIERS:** were all requirements obeyed?
- **REVIEW AND APPROVAL OF TECHNICAL DRAWINGS:** are all information and all sets of data available for the realization process?



# Your connection to the future.

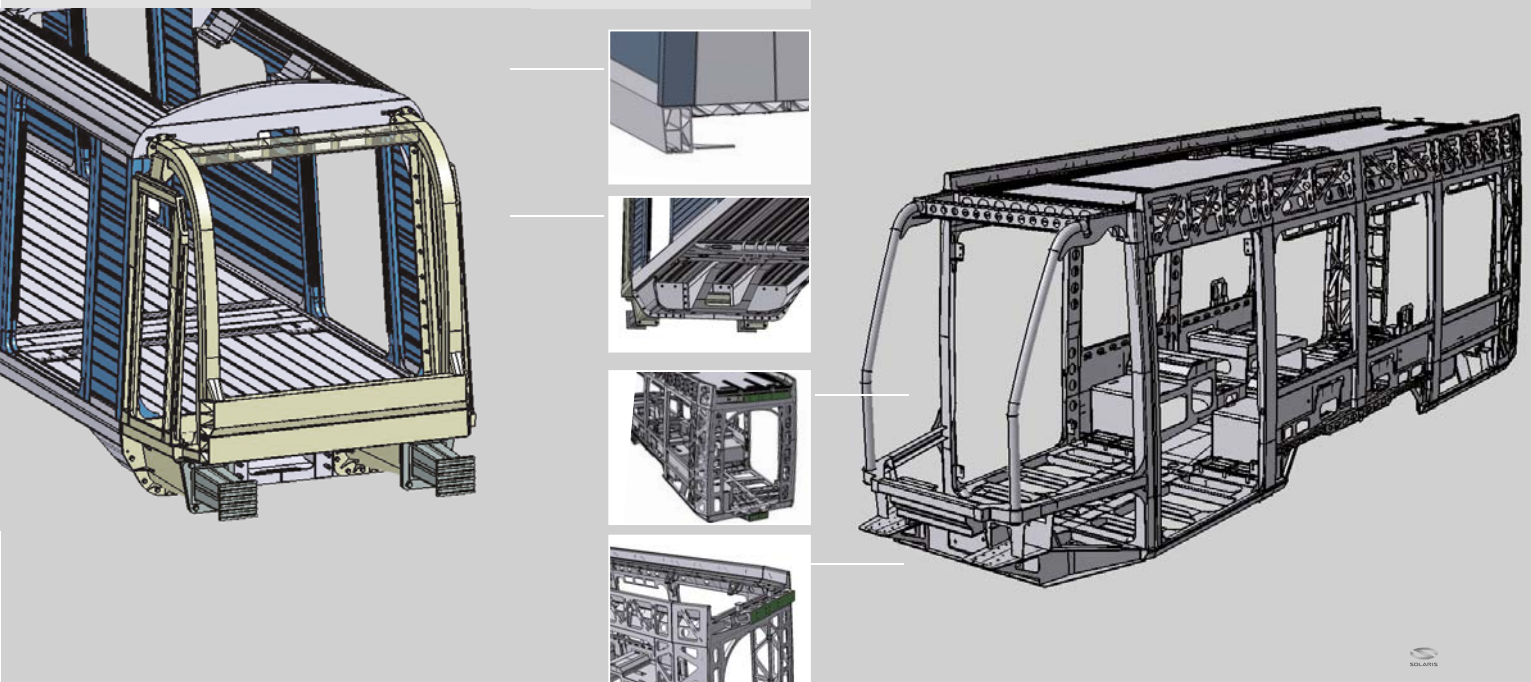
The integration of components and subsystems as well as the management of interfaces are considered by us in an integral and practical experience based manner. In order to optimize the customer communication, we harmonize the development processes as well as the software tools. Together with our customers we make the future of railway transportation systems within and between cities.

- **CONCEPTION** of complete vehicles and single components
- **DRAFT** of first sketches up to 3D models for feasibility studies and variations
- **DESIGN** of the complete (sub)system up to all details, such as car body shell, bogie, components
- **INTEGRATION STUDIES** of the components into the total system considering all relevant conditions such as design space, interface functionality and boundary conditions given by the vehicle
- **DETERMINATION** of the joining and manufacturing technologies like welding, bonding, riveting, bolting as well as casting, milling, bending and others
- **PREPARATION** of 3D CAD models, assembly and single part drawings, welding and mounting drawings, measuring sheets and manufacturing instructions, purchase and test specifications
- **DOCUMENTATION** of the complete system and the single components
- **COACHING** of component suppliers and vehicle manufacturers during the manufacturing

## Reference projects:

Car body shell made of steel for a tram and made of aluminium for a metro train.

The development work comprised the concept design and 3D modeling, preparing the drawings in a close cooperation with the strength, crashworthiness and dynamic experts taking into account all customer requirements, the requirements of the interiors and the electrical units as well as the manufacturing requirements.





# Travel by train? This sounds good!

Passengers in the train and everybody living nearby the track demand low noise emissions and low vibrations emitting from the railway transportation system. Our experts analyse the complex system with its interactions, identifying the noise emitting devices and finally develop noise reduction measures.

- **CALCULATION** of noise levels, air-borne and structure-borne noise inside and outside of the vehicle, using the FE-/SEA-models as well as LogoMotive's own developed software system
- **MEASUREMENTS** including the set-up of the test specification, the execution of assembly tests, component tests, identification of noise sources and noise paths, speech intelligibility (RASTI, STIPA)
- **OPTIMISATION** of noise reduction concepts for vehicle, bogie, traction chain, ventilation and cooling systems, acoustic insulation and others
- **CONSULTANCY** in acoustics to answer questions from our customers
- **EXECUTION** of R&D projects

## Reference project:

Acoustic management of high speed locomotive.

Our analysis of the status, the definition of measures to meet the vehicle noise requirements, our noise prediction calculations as well as our acoustic component specifications, led together with our homologation support to the successful homologation.







# We load the train. Not you.

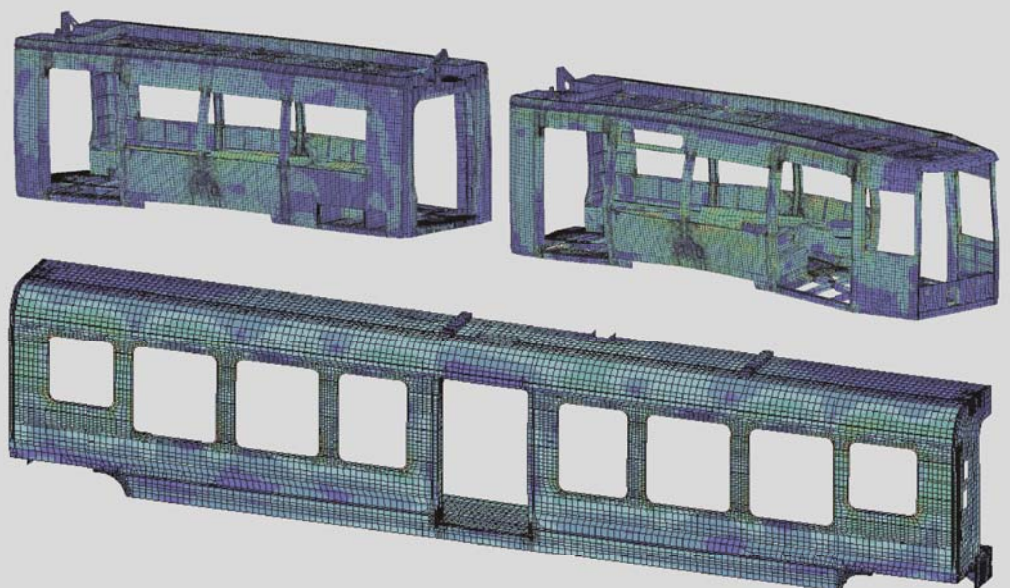
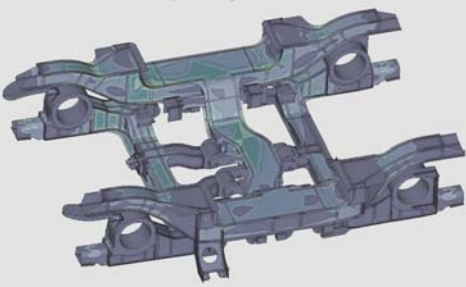
We define the specific load cases considering the requirements. We take into account the standards as well as the dynamic behaviour of the vehicle and components. Thereby we prepare the evidence load cases and execute the strength evidence. Structural reinforcements are done with experience and strength proven solutions, first discussed in the team, are implemented into the vehicle development.

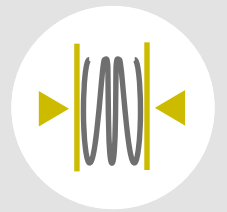
- **STRENGTH EVIDENCE CALCULATIONS** of the complete system and components such as car body shells, bogies, wheel set axles, wheels considering the relevant standards and guidelines
- **FATIGUE EVIDENCE** of relevant load collectives including the output of the component's life time or utilization ratio, optimisation of components
- **STIFFNESS AND STABILITY ANALYSIS** of the deformation behaviour, linear and non linear buckling and folding investigations
- **STRUCTURAL DYNAMIC ANALYSIS** including the eigenvalue analysis, analysis of the car body vibration behaviour under time variable excitation, optimisation of the structure vibration behaviour
- **COMPONENT OPTIMISATION** including weight reduction based on specific load conditions and the consideration of the applicable manufacturing technology
- **COMPONENT REFURBISHMENT** by development of repair concepts, reduction of component stress, evaluation of inspection intervals based on fracture mechanic studies
- **STRENGTH TESTS** are specified and executed, e.g. static load and compression test of car body shells and fatigue tests of bogie frames and components.

## Reference project:

Bogie of a low floor tram in welded design.

We prepared the load assumptions based on standards and the results of the multi-body-simulation. Thereby we compiled the evidence document of the bogie structure including the evaluation of the welding requirements and joining bolts.





# Preferably strong, but remaining elastic.

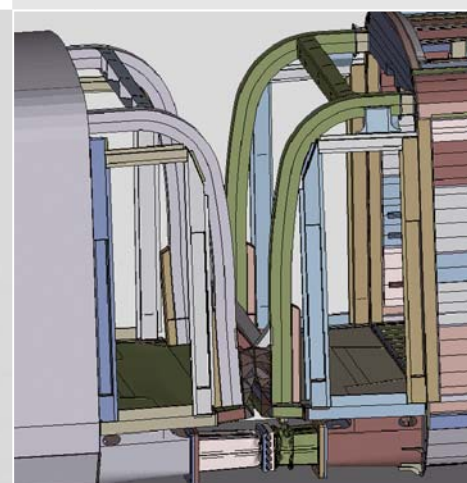
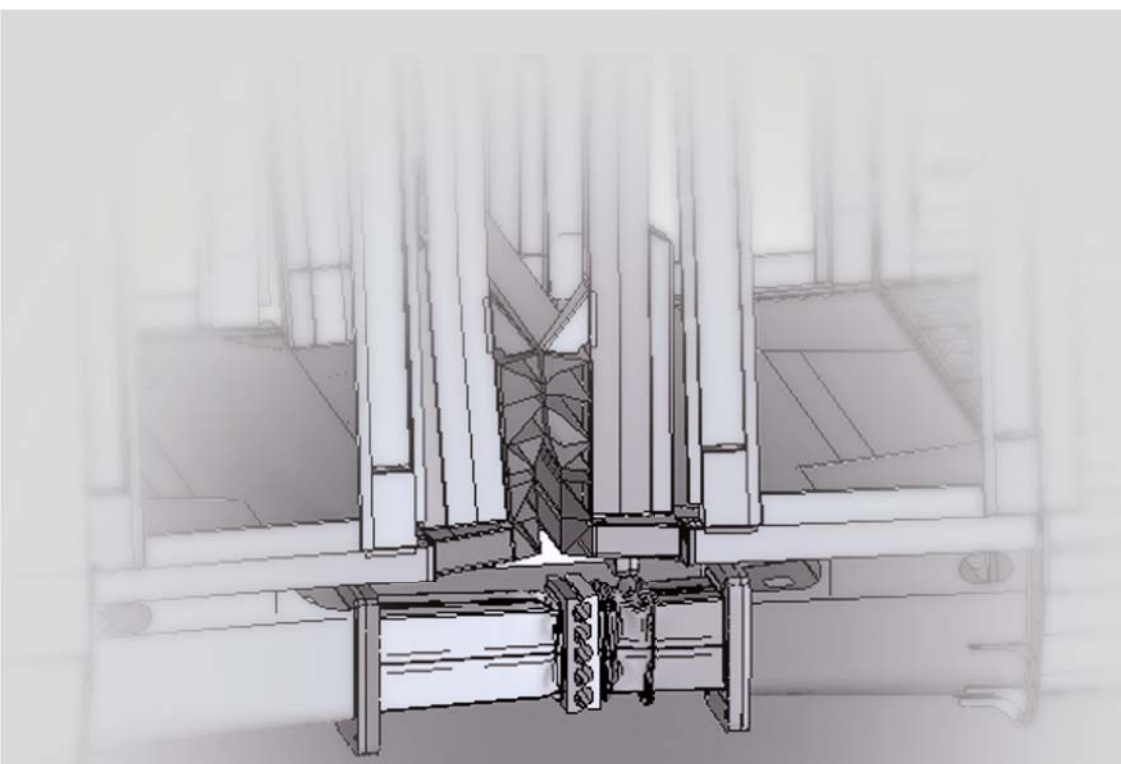
Crash structures absorb energy occurring in crash incidents to ensure the survival space for passengers and driver. And to provide a controlled deformation of the vehicle structure. The strength and the collision safety needs are partially opposed: a conflict! Our optimised solutions are implemented into the vehicle during the development process.

- **STUDIES** are performed for passive safety, driver and passenger safety, damage minimisation in case of a collision, minimization of repair costs, e.g. by simple exchange of damaged sections leading to a fast availability of the vehicle after a collision
- **ANALYSES** of the complete vehicle system, such as locomotives, trams, passenger coaches and subsystems, focussing on e.g. the driver's cab and the crash elements
- **MONITORING** of the vehicle homologation process
- **PREPARATION** of test specifications and support for approval tests
- **CONSULTANCY** for the preparation of customer specific requirements related to collision risks, which aren't defined in normative specifications
- **DETERMINATION/VALIDATION** of parameters for materials such as GRP and failure models for welded and bonded joints. The determination of material data is done with renowned institutes
- **SIMULATION** of ramp collision scenarios, e.g. for tank wagons, taking into account the sloshing behaviour of the liquid content
- **TESTS** e.g. virtual drop and impact tests for container and tanks

## Reference project:

Crashworthiness dimensioning of a metro train with aluminium car body shell design

Our in house experts prepared the crashworthiness concept for the train, the design of the crash elements as well as the modelling, the crash simulation and the evaluation of the complete vehicle. The technical details were discussed and decided together with the component suppliers as well as the vehicle manufacturing specialists.





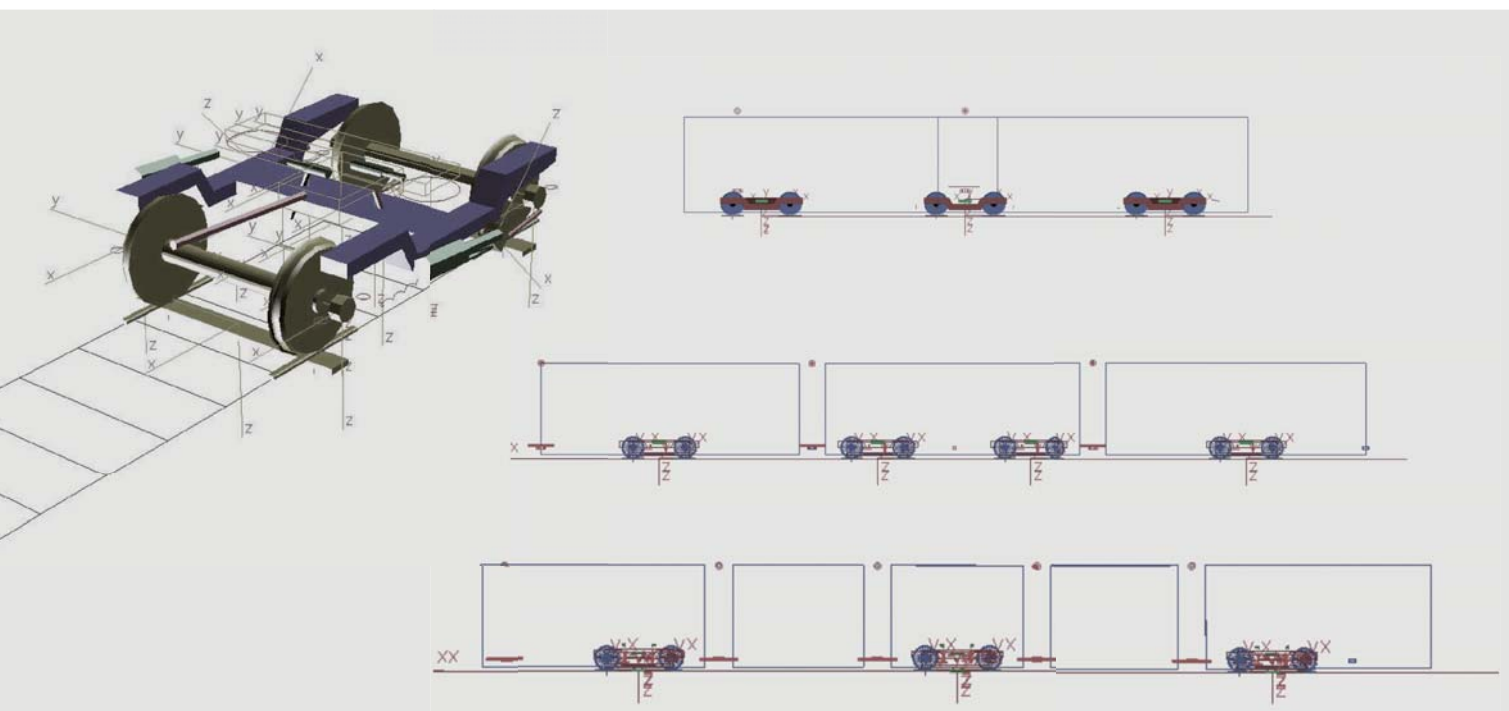
# Your dynamic is our drive.

Dynamic simulations represent the running tests in the computer and show the complete relevant vehicle system's interaction with the track. LogoMotive optimizes the vehicle layout for existing and future networks and prepares all evidence documentation.

## Reference project: Vehicle dynamics for dimensioning the vehicle and the train set.

On the basis of the operator's requirements we dimensioned the vehicle regarding the system behaviour, the vehicle gauge requirements as well as the loads and optimised on one hand the vehicle and on the other hand the requirements. Further we investigated the drive and gearbox layout so as to reduce the drive vibrations.

- **OPERATOR'S BOUNDARY CONDITIONS** are assessed, such as the analysis of alignment, the track layout, the superstructure, the wheel/rail profiles and the operation conditions
- **INTERACTIONS** between vehicle and track considering the operational boundary conditions are optimised
- **VEHICLE RUNNING DYNAMICS** are performed for the design of bogies and vehicles, like articulated trains, tilting trains, high speed trains, multi-articulated trains, track construction and maintenance vehicles
- **TORSIONAL VIBRATIONS** in traction systems are analysed and optimized considering the interaction between wheel and rail
- **VEHICLE GAUGE REQUIREMENT** are determined, limitation calculations are performed and the evidence is documented
- **LONGITUDINAL TRAIN-SET FORCES** and their influence on the behaviour of the system are investigated such as the safety against derailment
- **LONGITUDINAL VIBRATIONS** are analysed and optimised, e. g. vibration comfort
- **COMPONENT LOADS** (load cases for the strength analysis) based on the system behaviour and the requirements are investigated and minimised
- **TRACK/WHEEL COMPATIBILITY** is investigated and the parameters are optimised
- **STRUCTURAL DYNAMICS** are focussed on the analysis and reduction of elastic eigenvibrations and their excitations







# More value than simply a test.

We execute measurement tasks for validating our simulation models as well as the test result based analysis of the system behaviour. We use an extensive preparation of the measurement specification, the measuring equipment and its calibration. We test and occasionally improve our own developments and those of third parties.

- **WHEEL/RAIL PROFILES** are investigated by contour copying of wheel and rail, measuring the gauge and the wheel back to back distance, measuring the wheel roundness, evaluating and assessing the results
- **RUNNING TESTS** are prepared and organised, the measurement equipment installed, measurements executed and results evaluated. The mobile measuring equipment with more than 200 channels is used to record the accelerations, distances, forces, pressure and elongations. Measurements on rotating parts can be done as well by using the wireless data transmission
- **SPECIAL MEASUREMENT SOLUTIONS** are developed to record non directly measurable variables (e.g. special articulation device for articulated trains)
- **STATIC TESTS** are planned and executed, e. g. lateral compression tests, torsion and twist tests
- **COMPONENT TESTS** are realised such as the recording of the characteristics of elastic and damping components
- **RECORDING AND EVALUATION METHODS** are used, e. g. rainflow counting methods, data filtering/ data smoothing methods and special filters with online monitoring of the measured signals on screen and analogue data plotter

## Reference project: Analysis of operator's boundary conditions.

With our measuring concept, which has been applied on an existing vehicle, we determined the requirements for new, still not existing vehicles in that network. The installation of measuring devices, the execution of the measurements in the network and the evaluation of results were the basis for merging the relevant scenarios as input for the vehicle simulation. The analysis results including a lot of variations with our recommendations were provided for decision making to our customer.





TOTAL SYSTEM



DEVELOPMENT & DESIGN



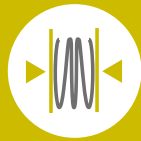
ACOUSTICS



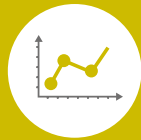
DYNAMICS



STRENGTH



CRASHWORTHINESS



TESTING



CERTIFICATION \*

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