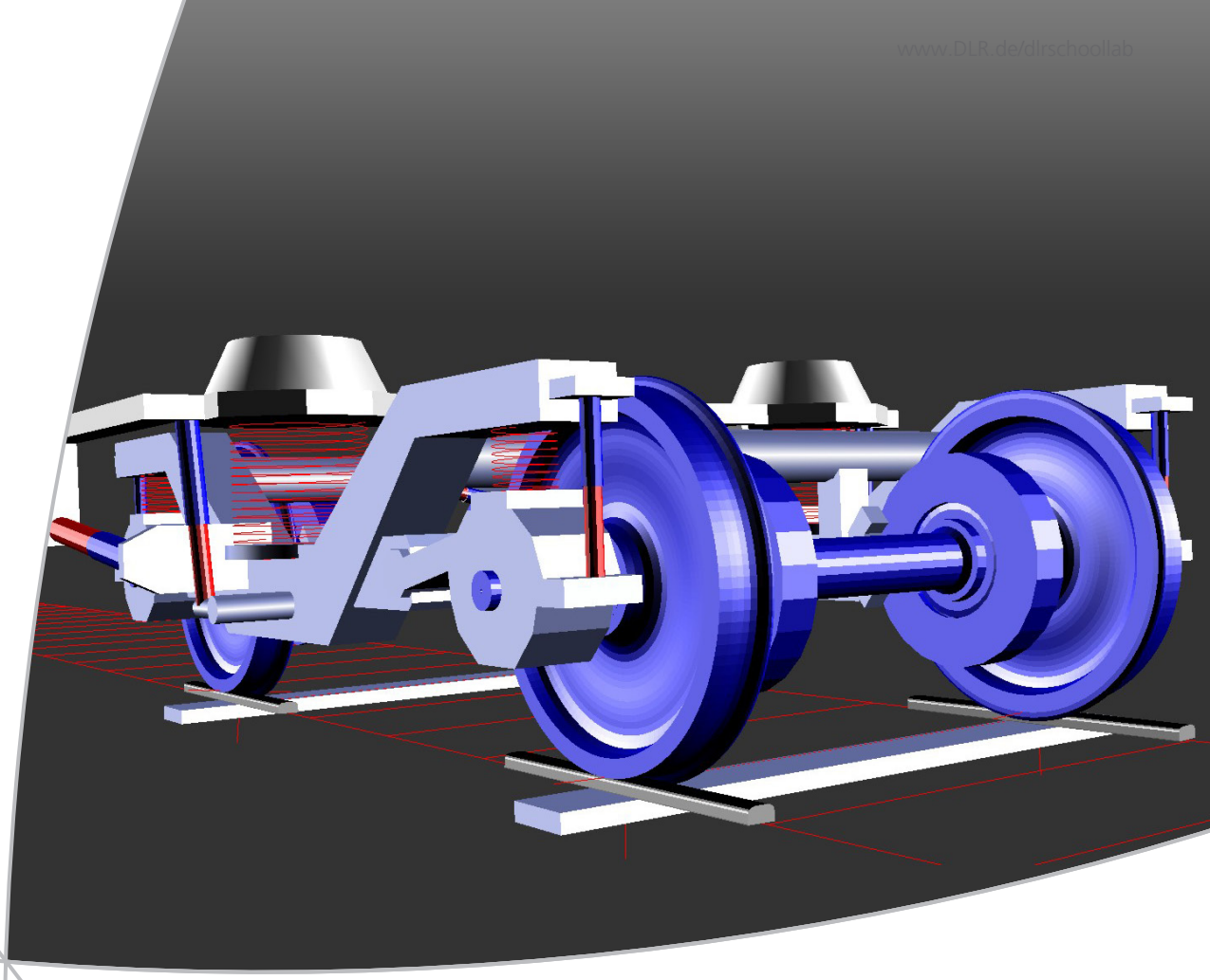
DLR



DLR_School_Lab

Oberpfaffenhofen

Virtual Mechanics

What happens if.... Or, being clever ahead of time

So that systems like automobiles, trains and aircraft function perfectly, they have to be designed properly, in other words, all their individual parts, down to the springs and shock absorbers, have to be carefully adjusted and attuned to each other. This cannot be done by instinct, and it has to be accomplished before the system is built. There are two main reasons: it can be very dangerous if a system does not function as desired, for example, if a train jumps its tracks, and secondly, tests with finished systems or subsequent reconstruction work cause substantial additional effort and high expense.

Simulation programs simplify this work. These programs take into account the required physical laws and mathematical methodologies. With their help it is possible to calculate safely, rapidly, and without great effort such consequences as how a system will behave and what forces will arise, so that the final system functions properly from the very beginning.

Virtual Mechanics

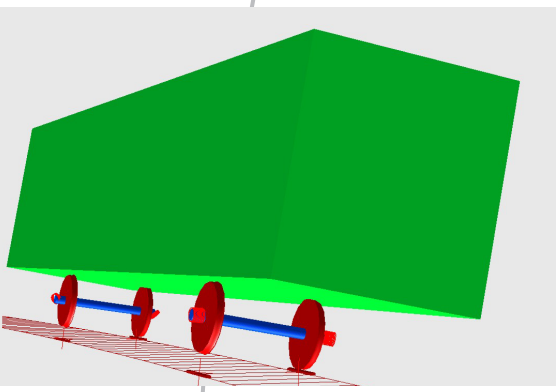


Fig. 1: Dangerous situations can be safely portrayed in a simulation

Multibody Systems

A multibody system is a concept related to a special type of modeling. An actual system like an automobile or a railroad car is reproduced by making use of a number of simple basic elements. These elements can be bodies (mass pieces), joints which enable the bodies to move, and elements of force such as springs or contacts. According to the law "force is the product of mass times acceleration" a body is accelerated or slowed down by the forces acting on it. On the other hand, the force exerted by the force elements depends on the movement of the bodies. For example, the force of a spring increases as it is stretched, which happens whenever the two bodies between which the spring is inserted move apart. The movement of the entire system is determined by such interactions.

This thinking leads to a model which behaves almost exactly like a real system. Logically, such a model can be extremely complicated. Fortunately, computer programs have been developed which can build such a model graphically, literally by "clicking." These programs can also automatically formulate the mathematical equations which describe the behavior of the system and solve them numerically. The results of such calculations can then be portrayed in computer animations to produce a vivid impression of how the system moves.

With the simulation it is possible to determine whether a system can actually function before it is constructed in reality. If it reveals that dangerous conditions would arise, the construction can be modified in good time. With this method a high degree of safety can be achieved, and also considerable time and money saved.

Rail Vehicles

Rail vehicles such as trains or trams are track guided. There is no steering involved, since the path is determined by the rails, which the vehicle is not supposed to leave.

Previously, only very simple formulas were available for designing a rail vehicle and much experience was required. Since the mid-1970s, how a vehicle will behave can be predicted much more precisely since one can model it as a multibody system. The forces between the wheel and the rail are especially important. If they are too high, the vehicle can damage the track or leave it. It is also possible to calculate in advance with relatively high precision what loads the individual components have to bear without breaking, and what vibrations act on the passengers.

Designing with the help of the multibody systems modeling concept has led to trains which today achieve velocities previously unimaginable, while they are at the same time very safe. But other technical systems, for example automobiles, have also highly benefitted from this type of simulation, which is reflected in their higher performance and safety.

Although multibody simulation programs are already very advanced today, research continues in order to make the simulation even more detailed and realistic. A current focus of research is on describing the deformation and vibration of bodies like railway wheel sets and the resulting loads. These affect the strength of wheel sets and the extent of wear and tear.

The Experiment

The multibody program SIMPACK was originally developed at DLR in Oberpfaffenhofen. It is a professional simulation program now being used in both industry and research.

After an introduction to acquaint you with SIMPACK, you can work with the program on your own. If you want to tackle a realistic problem you can construct your own model of a freight car. This way you can find out what data you need to describe this type of vehicle. You will also discover that in reality a train on a straight track does not itself move straight ahead, or why a train often leans when it enters a curve, and under what conditions it jumps its track.

Although SIMPACK is actually nothing but mathematics and mechanics, you do not have to struggle with formulas yourself: the program does all that for you. You only have to construct the model, whereby the graphical display helps you, and specify the parameters. So if you want to know what actual practical work is like in this field, are not afraid of computers, have some interest in technology, and can invest a bit of patience, then, "Have fun with virtual mechanics!"

Questions to think about

What parameters are important for other technical systems such as airplanes, bicycles, cableways, cranes or wind energy converters?

What does this sentence mean: "A good model is as simple as possible and as detailed as necessary?"

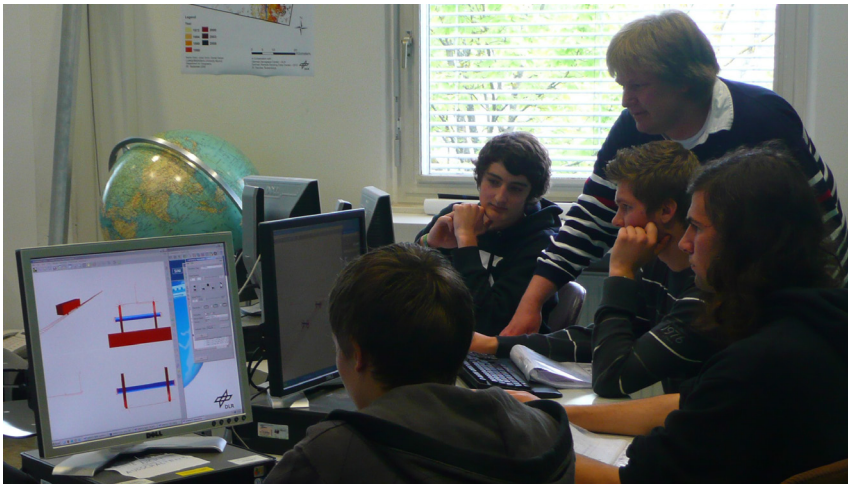


Fig. 2: Students creating a simulation

Glossary

Design
Harmonizing the parameters involved so that the system functions as intended.

Numerical solution
Many mathematical problems cannot be solved analytically, in other words by modifying a formula until an answer is obtained. Such problems are solved numerically: the numerical values of a likely solution are estimated and then improved step by step until they satisfy the equation. This procedure for discovering a solution is also called an algorithm. It consists of simple calculations that are repeated until the solution is precise enough.

Parameters
The physical quantities that determine the behavior of a system, for example, the hardness of a spring, the weight of a component , the speed of a vehicle or the radius of the curve through which the vehicle travels.

System
Practically any construct consisting of individual parts which influence each other is a system. Every machine, for example a train, automobile or airplane, is a technical system.

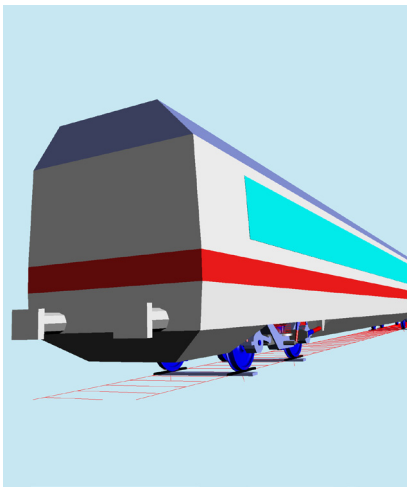


Fig. 3: A railroad car is tested virtually before it is put on actual tracks

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DLR at a Glance

DLR is Germany's national aeronautics and space research center. Its extensive research and development activities in the fields of aeronautics, space, transportation and energy are integrated in national and international cooperative ventures. In addition to this research, as Germany's space agency the federal government has given DLR the responsibility to plan and implement the German space program and to represent German interests internationally. DLR is also the umbrella organization for Germany's largest project management agencies.

Approximately 6,500 people are employed at DLR's 13 locations, which include Köln (headquarters), Berlin, Bonn, Braunschweig, Bremen, Göttingen, Hamburg, Lampoldshausen, Neustrelitz, Oberpfaffenhofen, Stuttgart, Trauen and Weilheim. DLR also operates offices in Brussels, Paris and Washington D.C.

DLR Oberpfaffenhofen

Aerospace, environment and transportation are DLR's primary fields of interest in Oberpfaffenhofen. Some 1,500 people work there in nine different institutes and facilities, making DLR Oberpfaffenhofen the largest DLR location.

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