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Automated data evaluation in the world's largest climatic wind tunnel

Today, engineers and technicians face the challenge of developing new products in ever shorter time while quality requirements keep rising. Increasing competitive pressure and stricter legal regulations require ever more extensive testing, whether for design validation in prototype testing or for quality assurance in production. But in non-industrial areas, too, such as climate monitoring or basic research, ever larger amounts of data are generated as the performance and capacity of modern measurement hardware increase.

Managing and efficiently using this data is an increasing challenge for companies and research institutions. In view of fierce international competition, it has become vital for companies and institutions to be able to access all archived data at any time and extract the currently required information from it without loss of time. If, for example, an engineer only has the data needed for important design decisions after a long search and extensive preparation, this inevitably leads to losses in efficiency and the associated competitive disadvantages.

More and more companies and research institutions are therefore relying on the consistent introduction of standard technologies and standard software. A broad user base ensures both low costs compared with in-house developments and reliability and future-proofing through continuous maintenance and further development.

The world's largest climatic wind tunnel has been in operation at RTA Rail Tec Arsenal Fahrzeugversuchsanlage GmbH in Vienna-Floridsdorf since 2003. In the high-tech facility, which cost 65 million euros, any weather on earth can be produced at the push of a button. Everything is possible, from arctic cold at minus 50 °C to tropical thunderstorms at plus 60 °C. The fan in the large climatic wind tunnel alone has a diameter of 6.3 meters and a connected load of 4.75 megawatts, the refrigeration system even 6.25 megawatts. A heat exchanger with a heat transfer surface of 7,707 m² – larger than a football pitch – transfers the heating or cooling power. In two climatic chambers, rail vehicles from all over the world, but also buses, trucks and cars, are tested under extreme weather conditions to make rail, bus and car travel safe and comfortable. While the headwind howls around the vehicle at up to 300 km/h and any weather is "brewed up" at the push of a button, the air conditioning system inside the vehicle shows what it can do. The operator's technicians check the performance of the heating, ventilation and air conditioning systems as well as the smooth functioning of important parts of the train such as doors, brakes and windscreen wipers.

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Fig. 1 Rail vehicle under extreme climatic conditions in the climatic wind tunnel (RTA)

Statements on thermal comfort play an important role in tests on rail vehicles in particular, since, in view of increasing traffic and climate problems, the aim is to make public transport more attractive, also by improving comfort. Since passengers can compare with their own air-conditioned cars, rail vehicles face tough competition here, which they can only withstand in the long run if they can match the demanding standards of the automotive industry.

Thermal comfort is given “when a person perceives the air temperature, humidity, air movement and thermal radiation of the surroundings as optimal and wishes for neither warmer nor colder, neither drier nor more humid room air”. Thermal comfort is influenced by personal factors such as activity level, clothing and length of stay, spatial factors such as radiant temperature and the temperature of the enclosing surfaces, and ventilation factors such as air temperature, air velocity and humidity. Since these factors act on the human heat balance in a complex way, a condition perceived as comfortable by as high a percentage of vehicle occupants as possible can only be achieved by taking all influencing variables into account.

Even though numerous other factors influence thermal comfort, essential statements about the probable acceptance of the vehicle climate by passengers can be made on the basis of a few standardized and easily measurable comfort parameters – air temperature, surface temperature, flow velocity, relative humidity, fresh air volume and overall heat transfer coefficient (U-value).

Given the sometimes considerable dimensions of the vehicles to be assessed and the many possible positions of the passengers, acquiring these quantities requires a large number of measuring points

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both in the interior, where every passenger should feel comfortable in their seat, and on the outer skin of the vehicle under test. But considerable amounts of data result not only from the sheer number of measurement signals; the relevant standards for local and long-distance transport and for the design of driver's cabs prescribe test durations that are sometimes considerable – at least three to eight days, depending on the desired statement.

However, the test results obtained with so much effort only become valuable for vehicle manufacturers and operators when they are adequately processed and documented. A test evaluation therefore includes, in addition to a detailed written presentation of the results, numerous calculations and, above all, diagrams that visualize the time histories of the acquired physical quantities.

Such evaluations typically take a great deal of time, since a large number of acquired quantities have to be reviewed, combined in calculations, displayed graphically in a suitable form and finally added to the test report. On the other hand, most evaluations are similar, since they relate to similar test objects and basically the same physical processes. And finally, the number of manufacturers of rail vehicles, buses or cars – and thus the circle of customers for such tests – is comparatively small. As a rule, the requirements for the evaluation are therefore at least similar. Based on this requirements profile, an in-house software solution was developed at RTA some time ago that made it possible to preconfigure typical evaluations and generate the necessary displays at the push of a button on the basis of these configurations.

With the company's growing success and the resulting increase in the number of tests, however, there was a lack of capacity for adapting and extending the system, and even for the necessary adaptations to new PC hardware and operating systems. The decision was therefore made to switch to a standard software platform that would ensure continuous further development with minimal effort. In addition to compatibility with the current operating systems, this software also had to be adaptable to the specifics at RTA, especially with regard to the self-defined data formats used. After extensive evaluation, the decision was made in favor of DIAdem®, the National Instruments data platform specifically optimized for the automated and interactive processing of a wide variety of data formats.

The DIAdem® application itself consists of two independent modules, one for creating configurations and one for the automated generation of graphical test evaluations. The two-part approach takes into account that configurations, once created, are rarely changed, whereas test evaluations are carried out more frequently, namely after the end of each test. Both sub-applications were written in Visual Basic Script, the automation language of DIAdem®, and use numerous standard functions of the software, such as the so-called DataPlugins (universal data import interfaces), an extensive library of mathematical functions and flexible report layouts.

A configuration contains more than 10,000 parameters, although not all of them always have to be specified. A fraction is sufficient for many applications. If, on the other hand, the full range of parameters is used, 10 sheets are created, each with up to 10 diagrams and a lot of additional information. An extension to 50 or 100 pages is possible at any time. Creating a configuration starts with general information about the test. Then the layout of the individual sheets is selected. After that, the quantities to be displayed are specified. For each diagram, curve pairs and their colors, scaling, axis labels and titles, axis texts and hatching are defined.

Both measured and calculated quantities can be displayed. The latter are generated at application runtime, with the calculation rules also specified in the configuration. The user can choose between predefined calculations, for which only source and result channels have to be specified, and free calculations, for which the calculation rule must also be specified. The predefined calculations include mean values, sums, differences and ranges, among others; a large number of mathematical functions can be used for free calculations. There is also a setpoint calculation function that allows channels with section-wise changing generation rules (constants, linear and measured functions) to be created, mainly for displaying limit values.

Once the configuration has been saved, a few steps are sufficient for the graphical test evaluation. After starting the corresponding sub-application, only the data set to be displayed and the configuration to be applied to it have to be selected. Then, as if by magic, sheets with diagrams and descriptive texts are created within a few seconds and can be included in test reports as PDF files or in any graphics format.

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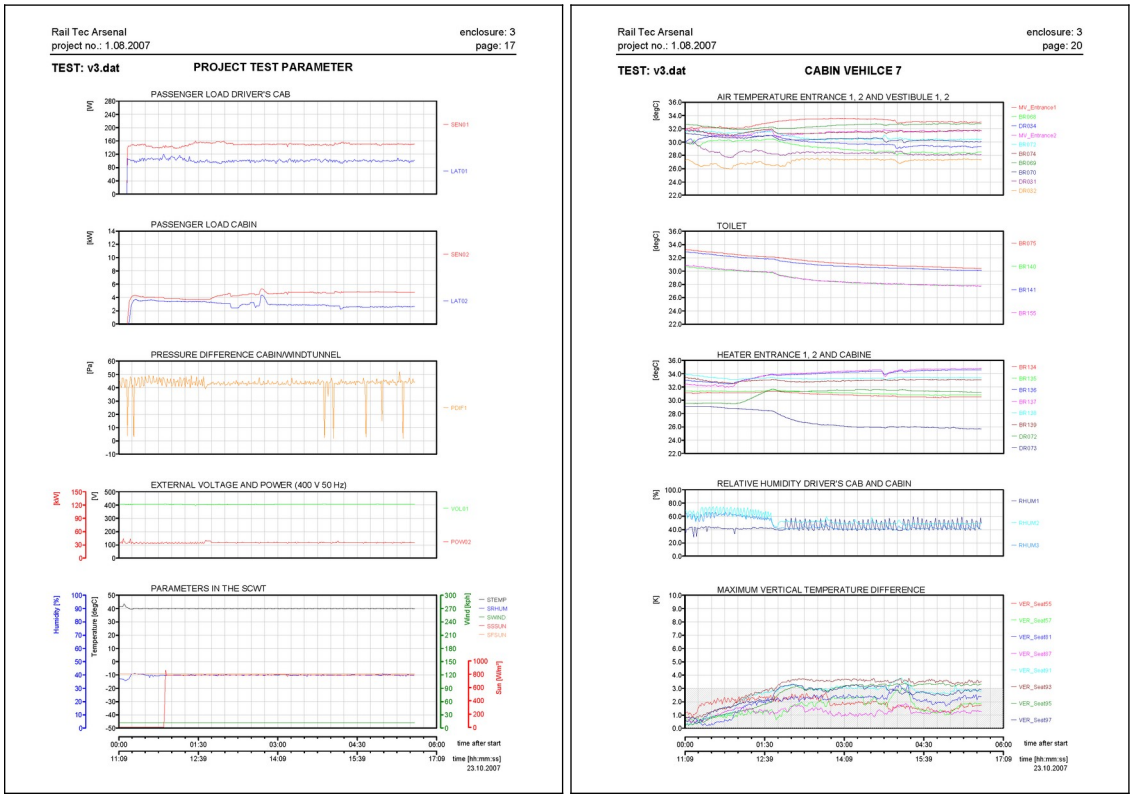


Fig. 2 Typical displays of the test results, created at the push of a button

Without further effort for the presentation, the test engineer can concentrate on evaluating the results and derive statements from the numerous curves, especially on thermal comfort. The application cannot – at least at present – take this part of the work off his hands. However, by reducing the time required for the formal presentation of the test results, the engineer has more time for this, his core task.

References:

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