

# RCMS

## Automatic Ring Convergence Measurement System for tunnelling projects with segmental lining

- ▣ Ring convergence in view from the first minute
- ▣ Fast installation and removal due to reversible adhesion of the sensors
- ▣ Wireless, space-saving, cost-effective

## RCMS | Ring Convergence Measurement System for tunnelling projects with segmental lining

The automatic ring convergence Measurement system, RCMS, from VMT continuously and reliably determines the deformation of the rings resulting from environmental pressures. RCMS combines all the necessary hardware and software components and, unlike other comparable systems, is specially optimised for tunnelling projects with segmental lining. Due to its small sensors that are attached using releasable adhesive, and due to its wireless operation, RCMS is quickly installed and does not get in the way of anybody or anything.

### Why automatic convergence measurement?

Clients do not always request an automatic convergence measurement – but it is almost always sensible.

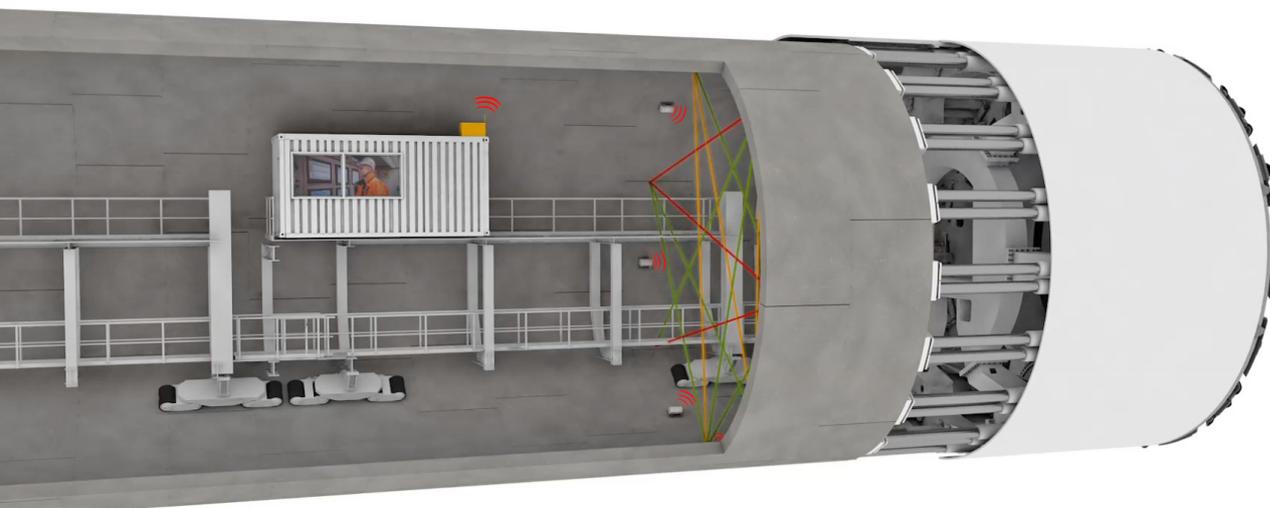
In a tunnelling project, strong forces act on the installed rings, which regularly leads to larger or smaller deformations of the rings. Convergence measurements make it possible to recognise and evaluate the extent of such deformations. The earlier that unexpectedly large deformations are recognised, the faster counter actions can be undertaken if necessary. On the other hand, if the convergences are lower than expected, certain measures and the associated costs might be able to be saved.

In contrast to manually operated measurements, the measurement intervals are significantly shorter with an automatic convergence measurement. You receive the data and their evaluation almost in real time. You can react accordingly quickly if necessary. If you have already taken measures, you can see their success or failure straight away and optimise them immediately where necessary.

### If manual measurements are not possible

At the position where the ring building is taking place, it is usually not possible to measure immediately. With RCMS, it is possible much earlier. With RCMS, you can already spot convergence after a ring leaves the protection of the tailskin and as soon as it is subject to the loads from earth pressure and the annular gap injection.

Also, with manual measurements, the measurement team can generally only determine the deformation for the first 10 to 20 metres behind the TBM. After that, the gantry of the TBM is in the way. If annular gap injection happens in the tailskin, this situation is usually not critical because the annular gap is then already filled and the actual construction process is already complete. However, if the injection occurs in the rings 5 to 20 metres behind the machine, ring deformation can often no longer be recorded manually. In this case, the only effective checking possibility at all is an automatic measurement.



*Due to the early installation of the RCMS, a complete documentation of occurring ring deformations is achieved*

### Operation of RCMS

In the first step, a small inclination sensor (inclinometer) is mounted in the rings to be monitored on each segment. A segment itself is assumed to be stable in shape, but the longitudinal joints between the segments act as a hinge joint. From the relative angle changes of the segments to each other, the underlying radial movement can be calculated and conclusions reached on the applied deformation of the ring. The displacements determined in the joint areas allow the calculation of all convergence distances that you are interested in observing. In addition to the convergences, relative deformations of a ring in particular can also be recognised and displayed in the form of movement vectors (displacements relative to the installation position).

The sensors transmit their data by radio to a central data logger. This saves the data and then relays it to the logging computer. The logging computer evaluates the data, visualises it and archives it.

As a rule, 2 to 3 rings are provided with sensors at a spacing of approximately 20 to 40 metres. After hardening of the grout and after the rock reaction has subsided, the sensors are removed and mounted again on new rings.

### Simply wireless

Cables are tedious: they not only have to be laid, taking a lot of time, and fed continually to moving objects – they tend to always be in the way and hinder other work.

RCMS needs no cables. All components communicate wirelessly. The sensors used do not even require an external current supply as they already have it on board.

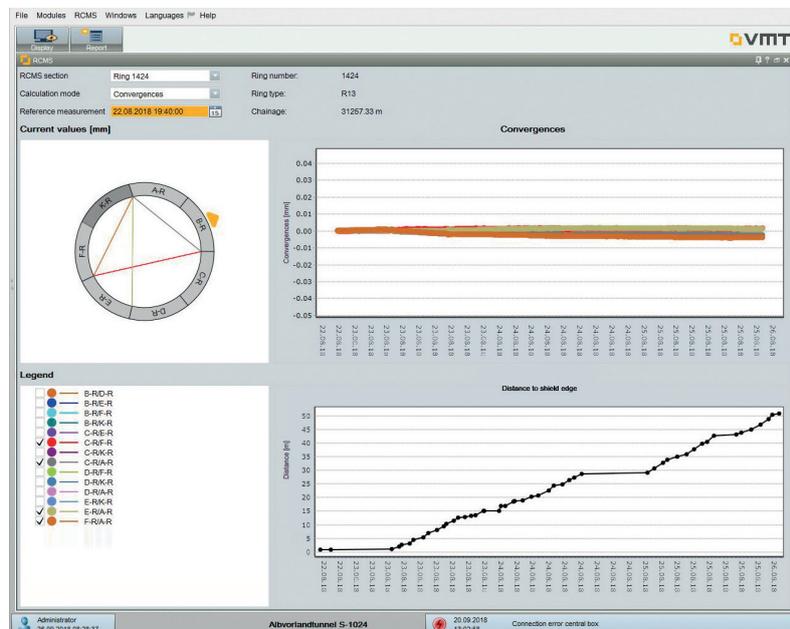
The RCMS sensors are also so small and light that they can be attached to the segment using an adhesive that can be released later. No time-wasting drilling and screwing, no damage to the segment surface.

A sensor is only just as big as a fist and thus is not an annoying obstacle.



### Benefits

- ▣ Measurement begins immediately after a ring is finished
- ▣ Timely availability of measurement results without delay between measurement and evaluation
- ▣ Minimisation of possible damage to the ring building by early recognition of deformation
- ▣ Continuous monitoring and documentation of ring convergence
- ▣ Minimal personnel expenses due to automatic data acquisition, monitoring, recording and archiving.
- ▣ Efficient fulfilment of contractual duties for convergence measurement and also documentation at small time intervals
- ▣ Minimal cost for installation and deinstallation due to wireless communication of system components and reversible adhesion of the sensors without drilling
- ▣ Minimal space requirement
- ▣ Cost-efficient, reusable sensors



*The software modules are fully integrated into TU/IS Navigation system and provide multiple functions for analysis and visualisation*

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## Feature Set / Functions

- ▣ Specially optimised for shield tunnelling with segmental lining
- ▣ Supply of all necessary hardware and software from one source
- ▣ Fast, wireless installation using wireless technology and reversible adhesion of the sensors
- ▣ Wireless data transmission using radio data transmission
- ▣ Space-saving sensors with integrated current supply
- ▣ Significant accuracy of  $\pm 1$  mm
- ▣ Recording both of convergences and relative deformations of a ring in the form of movement vectors
- ▣ Software with comprehensive evaluation and display options
- ▣ Automatic recording and archiving of the data
- ▣ PDF reports can be automatically generated for documentation
- ▣ Interfaces for data evaluation and archiving in external systems

### Not an island solution

Data are a valuable commodity and often develop a particular usefulness when they are combined with other data and evaluated accordingly.

RCMS was not conceived as an island solution but integrates seamlessly into the IT system at the jobsite: The collected and processed data can be transmitted to the TUNIS Navigation Office software for further analysis.

### Advice and competence from VMT

We don't leave you alone for the configuration, installation and operation of RCMS. On request, we offer you competent support against the background of our over 20 years' experience in more than 1,000 successful tunnelling projects.

Any questions? We are happy to help!

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