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Subject	Release-notes for CONTACT version 22.2

Summary

These release-notes document the changes in CONTACT version 22.2 with respect to version 22.1. The main change is as follows.

- Added variable rail profiles for the simulation of contact in switches and crossings.

1 Simulation of switches and crossings

Background In recent years, there has been considerable interest in the simulation of vehicle track interaction in switches and crossings. A number of benchmark problems have been defined and run using different software codes [1, 2]. Details on the methods used are presented in the method statements [3] and subsequent scientific papers, e.g. [4].

Whereas the benchmark results show reliability and efficiency regarding vehicle dynamics, there is room for improvement regarding the detailed contact results, concerning the contact position, angle, contact patch size and pressure distribution. CONTACT is extended to fill this gap and deliver detailed results for the validation of fast computation approaches as shown in Figure 1.

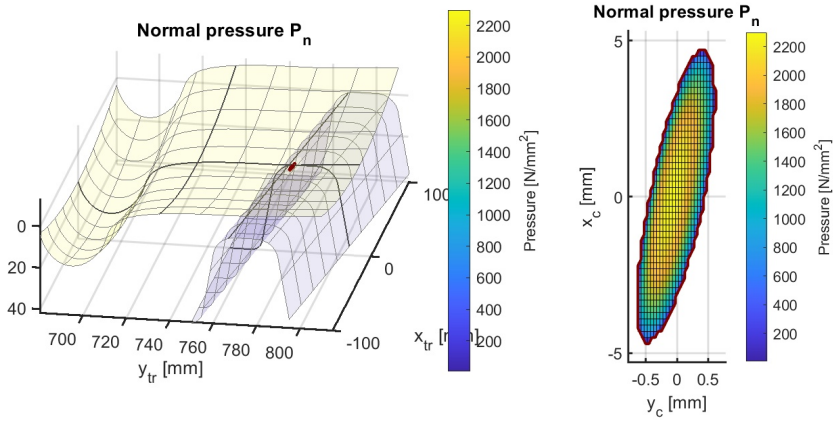

Figure 1: *Contact of a wheel with an artificial wing rail diverging at rate* $1:10$*, creating an effective angle of attack of* $-5.7°$.

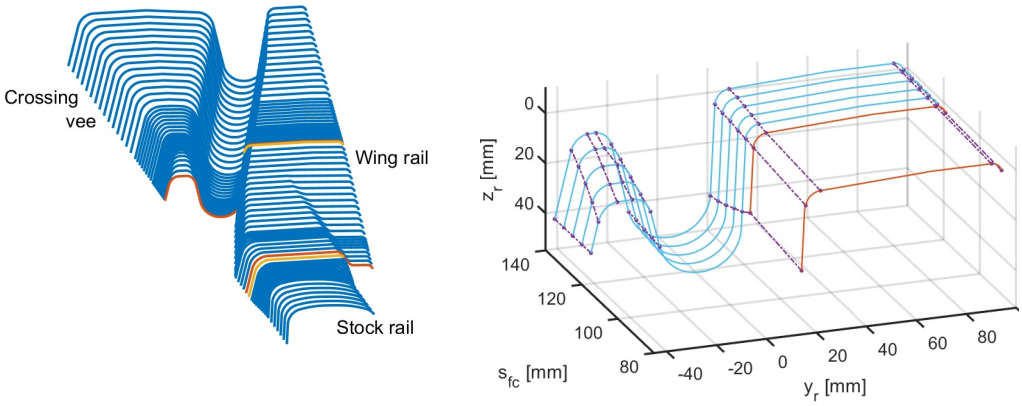

Figure 2: *Successive profile slices defining the geometry for a crossing, with geometrical features connected into 'interpolation paths'.*

Variable rail profiles The geometry of switches and crossings is characterized using a series of lateral cross-sections as illustrated in Figure 2. This entered in CONTACT through a so-called '*slices file*' (`.slcs`) with '*feature information*' as discussed in the User guide [5], Section 3.2.

Feature information is used to guide CONTACT in 2D spline construction and evaluation.

- Features are helpful to reduce spline overshoot and fluctuations at sudden changes in profile slope and curvature.
- Features are needed to indicate 'missing parts' on shorter slices and corresponding parts on longer slices.

3D contact search CONTACT uses a fully 3D contact search as discussed in [6], including the effects of yaw and the corresponding longitudinal shift of the contact position. This has been extended for rail profiles with longitudinal variation and the consequent effects on the contact position. Fully 3D surfaces are constructed and used in the contact search and undeformed distance computation.

Two different methods are provided using 'grid based' and 'contact locus' approaches. The contact locus method proves to be more delicate, sensitive to spline fluctuations. To make this work, this needs quite good information on profile features. More robustness is provided by the grid based method, at the expense of lower performance.

The contact locus method is selected using `D` = 2 and 4, for planar and conformal contact approaches. Setting `D` = 5 activates the grid based method, which is provided for planar contact only.

2 Resolved problems and general improvements

Several smaller extensions and improvements are made, the main ones being

- A new feature is introduced to improve the continuity of total forces for contact patches that lie close together. This is called the 'turning of the reference angle'. An optional input parameter `D_TURN` is introduced for this. For more information consult the User guide [5], Section 3.5.
- A new algorithm is implemented for solving cubic equations in spline computations, using Cardano's method. This leads to slight differences in the results for module 1.
- The automatic detection for mirroring of z-values is changed, improving the decision for a number of profiles found in switches and crossings.
- An option `scale_yz` is introduced in the Matlab script `read_profile.m`, e.g. to convert data from m to mm.

3 Compatibility w.r.t. previous versions

This version of CONTACT produces the same results as version 22.1 except for the improved accuracy in spline computations.

No changes are needed to user input files to upgrade from the previous release to the current one, and no changes are made to the output-file.

The format of the mat-file is changed with respect to the previous release, adding the nominal radius for the wheel and (optionally) roller. In the script `read_profile.m`, an optional argument `scale_yz` is added.

No changes are needed to user programs calling the CONTACT library version.

4 Known problems and restrictions

- Computations using variable rail profiles are rather slow, compared to computations with constant profiles.
- The contact locus method (`D` = 2) is not fully robust for variable rail profiles with rapid fluctuations, especially related to poor feature information. This may be circumvented using the grid based approach (`D` = 5).
- Subsurface stresses are computed using elastic influence functions, also when the problem uses the viscoelastic material model.

References

[1] Y. Bezin and B.A. Pålsson. Multibody simulation benchmark for dynamic vehicle-track interaction in switches and crossings: modelling description and simulation tasks. *Vehicle System Dynamics*, 2021.

[2] Y. Bezin, B.A. Pålsson, W. Kik, P. Schreiber, J. Clarke, V. Beuter, M. Sebes, I. Persson, H. Magalhaes, P. Wang, and P. Klauser. Multibody simulation benchmark for dynamic vehicle-track interaction in switches and crossings: results and method statements. *Vehicle System Dynamics*, 2021.

[3] Repository for participants' method statements. University of Huddersfield, 2021. https://doi-.org/10.34696/s60x-ay18.

[4] H. Magalhães, F. Marques, P. Antunes, P. Flores, J. Pombo, J. Ambrósio, A. Qazi, M. Sebes, H. Yin, and Y. Bezin. Wheel-rail contact models in the presence of switches and crossings. *Vehicle System Dynamics*, 2022. DOI: 10.1080/00423114.2022.2045026.

[5] E.A.H. Vollebregt. User guide for CONTACT, Rolling and sliding contact with friction. Technical Report TR20-01, version 22.2, Vtech CMCC, 2022. See `www.cmcc.nl/documentation`.

[6] E.A.H. Vollebregt. Detailed wheel/rail geometry processing using the planar contact approach. *Vehicle System Dynamics*, 60(4):1253–1291, 2022. Open access.