Eisenbahnfahrwerke 3 – EBFW3

Description and aims of the new project

ESIS TC24

Railway axles: Advances in Durability Analysis and Maintenance

01.-02.10.2014, Dipartimento di Meccanica, Politecnico di Milano

Andreas Deisl (Siemens)
Hans-Peter Gänser (Materials Center Leoben)
Sven Jenne (GHH Radsatz)
Reinhard Pippan (Erich Schmid Institute of Materials Science)

COMET Competence Centers for Excellent Technologies
virtual vehicle
TU Graz
Leichtbau
TU Clausthal IMAB
Fraunhofer IWM
MONTAN UNIVERSITÄT
ÖAW ESI
SIEMENS
ALSTOM
Bochumer Verein Verkehrstechnik GmbH · seit 1842
GHH-RADSATZ
VOITH
STADLER

Overview

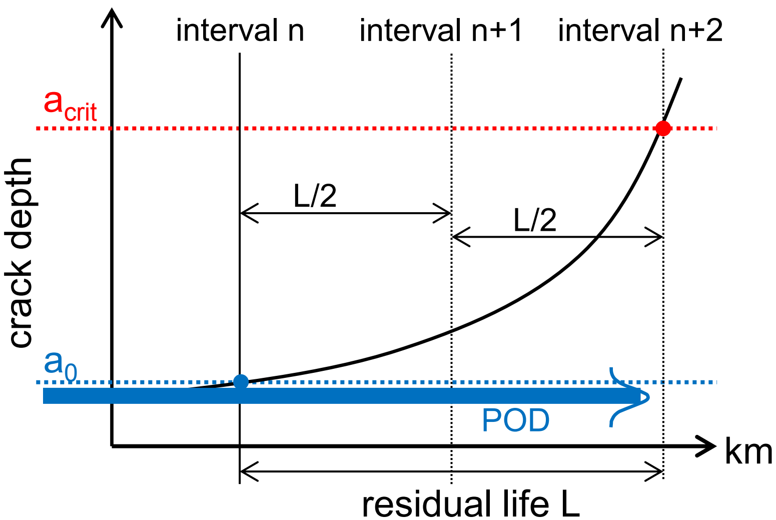
- Starting point
- Project history and goals
- Participants & project organization
- Work packages

Definition of NDT intervals for railway axles

a) from experience
b) by computation (→ EBFW3)
c) combined approach

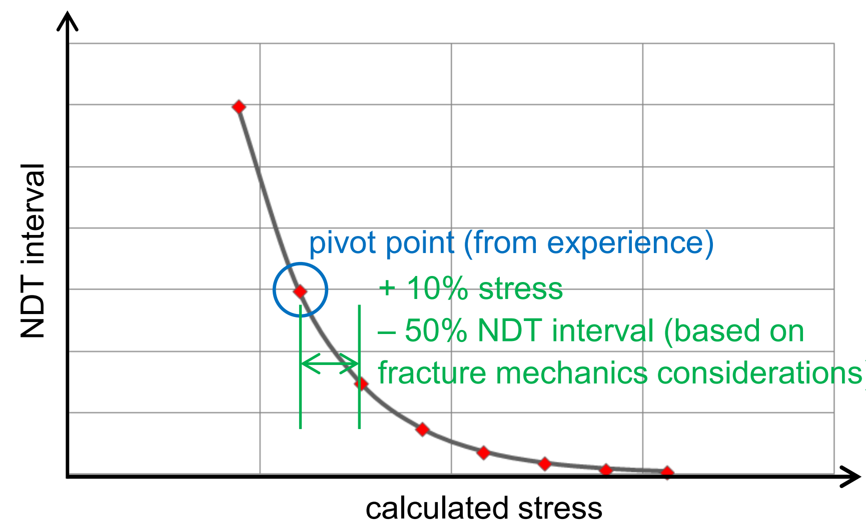
a) define NDT interval from previous operating experience

b) define NDT interval from crack growth computations (→ EBFW3)



Determination of residual life from
- component tests
- computation of crack growth

c) define NDT interval from a combination of experiance and computation → „curve method“ (under development)



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Project history

EBFW1 (2001 – 2004)

Contents:

- Determination of allowable stresses at the free surface and at the press fit of railway axles
- Measurement of load spectra (ICE 3)
- Development of a design and safety concept for railway axles (complementary to the design following standards EN 13103 / EN 13104)

EBFW2 (2005 – 2009)

Contents:

- Development of a computational method for determining the residual life and inspection intervals of railway axles by means of fracture mechanics
- Determination of fracture mechanics material parameters for axle materials
- Validation of the computational model by means of laboratory specimens and component tests on the scales 1:3 and 1:1
- Measurement of load spectra (locomotive and passenger car)
- Differences between computation and 1:1 test results showed the need for additional research → EBFW3

Project goals

Validated computational method for determining crack growth rate and inspection intervals

- Model for crack growth rate in railway axles from EA1N and EA4T shall allow residual lifetime prediction for
  - different designs (e.g. hollow axles),
  - different stress concentrations and
  - different load spectra

- Method for materials characterization for other materials
  long-term goal: 1:1 tests only for validation

- Method for determination of inspection intervals,
  with special attention to the enormous amount of existing knowledge
  („large-scale test: 150 years railway transportation“)

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Project participants

Industry Partners

Alstom

BVV

GHH

Siemens

Stadler

Voith

Scientific Board

Politecnico di Milano

TU Graz

Verband der deutschen Bahnindustrie e.V.

DB Systemtechnik GmbH

Scientific Partners

Virtuelles Fahrzeug

Materials Center Leoben

TU Graz

TU Clausthal

Fraunhofer IWM

Erich Schmid Institute

MU Leoben

Project and sub-projects – funding and participation

Funding

Volume ~ € 5 Mio.

K2 Comet Public Funding 1,8 Mio.

Industry [1) - 6)] Funding 3,14 Mio.

Project EBFW 3

Project Lead

Scientific Board [14) -17)]

Sub-projects

K2 Project MCL [7)]

K2 Project ViF [8)]

TU Graz [9)]

1:1 tests 35

TU Clausthal [10)]

Scientific partners in sub-projects.

MU Leoben [11)]

IWM Freiburg [12)]

ESI Leoben [13)]

Industry Partners

1) Alstom
2) BVV
3) GHH Radsatz
4) Siemens
5) Stadler
6) Voith Turbo

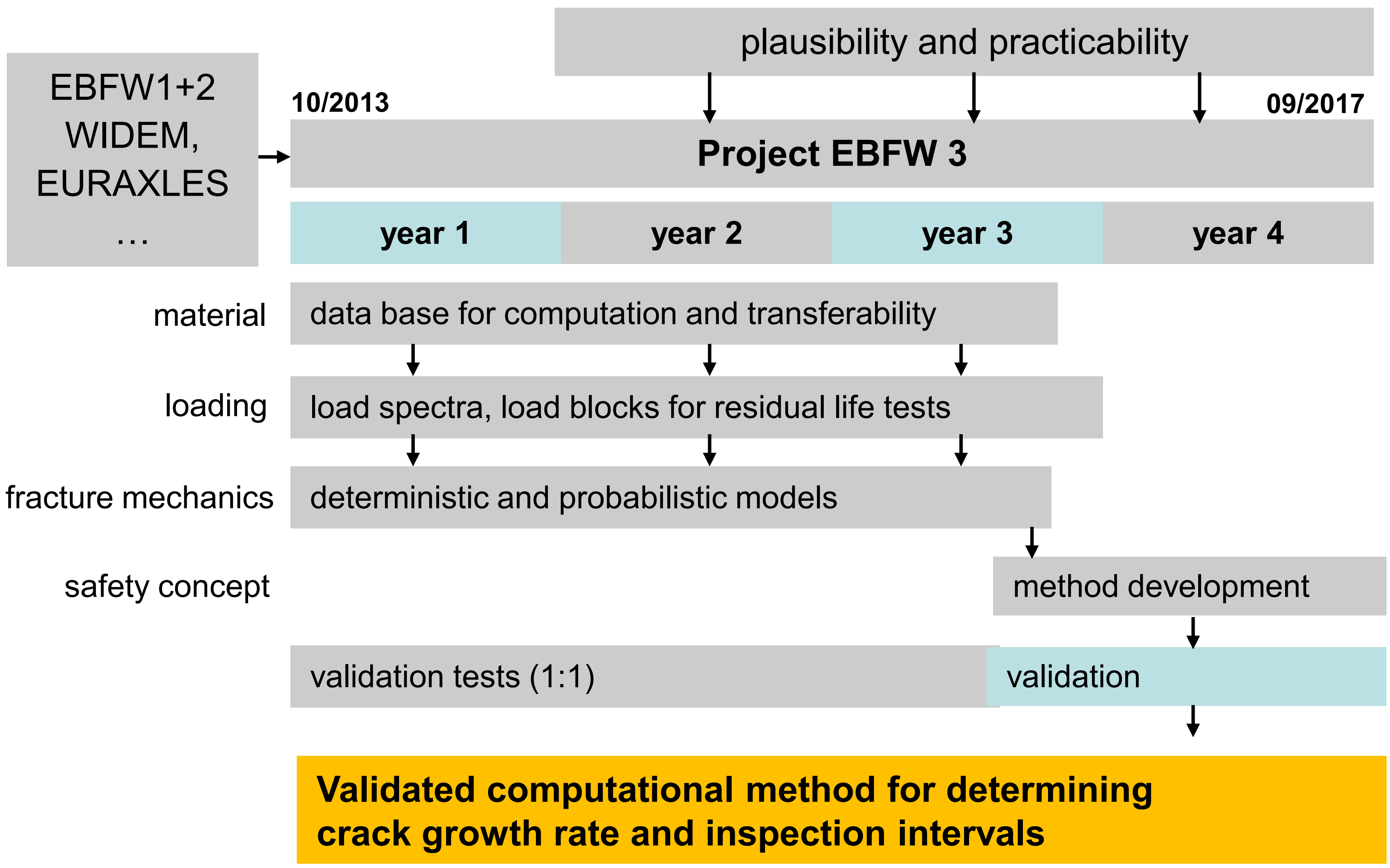
Scientific Partners

7) Materials Center Leoben (MCL)
8) Virtuelles Fahrzeug (ViF)
9) TU Graz, Institut für Leichtbau
10) TU Clausthal, IMAB
11) Montan Universität Leoben, AMB
12) Fraunhofer IWM Freiburg (IWM)
13) Erich Schmid Institut (ESI)

Scientific Board

14) Politecnico di Milano, DdM
15) TU Graz
16) Verband der Bahnindustrie in Deutschland e.V.
17) DB Systemtechnik GmbH

Timeline


plausibility and practicability
EBFW1+2
WIDEM,
EURAXLES
…
10/2013
09/2017
Project EBFW 3
year 1
year 2
year 3
year 4
material
data base for computation and transferability
loading
load spectra, load blocks for residual life tests
fracture mechanics
deterministic and probabilistic models
safety concept
method development
validation tests (1:1)
validation
Validated computational method for determining
crack growth rate and inspection intervals

Project organization

Scientific lead of WP
Industry lead of WP

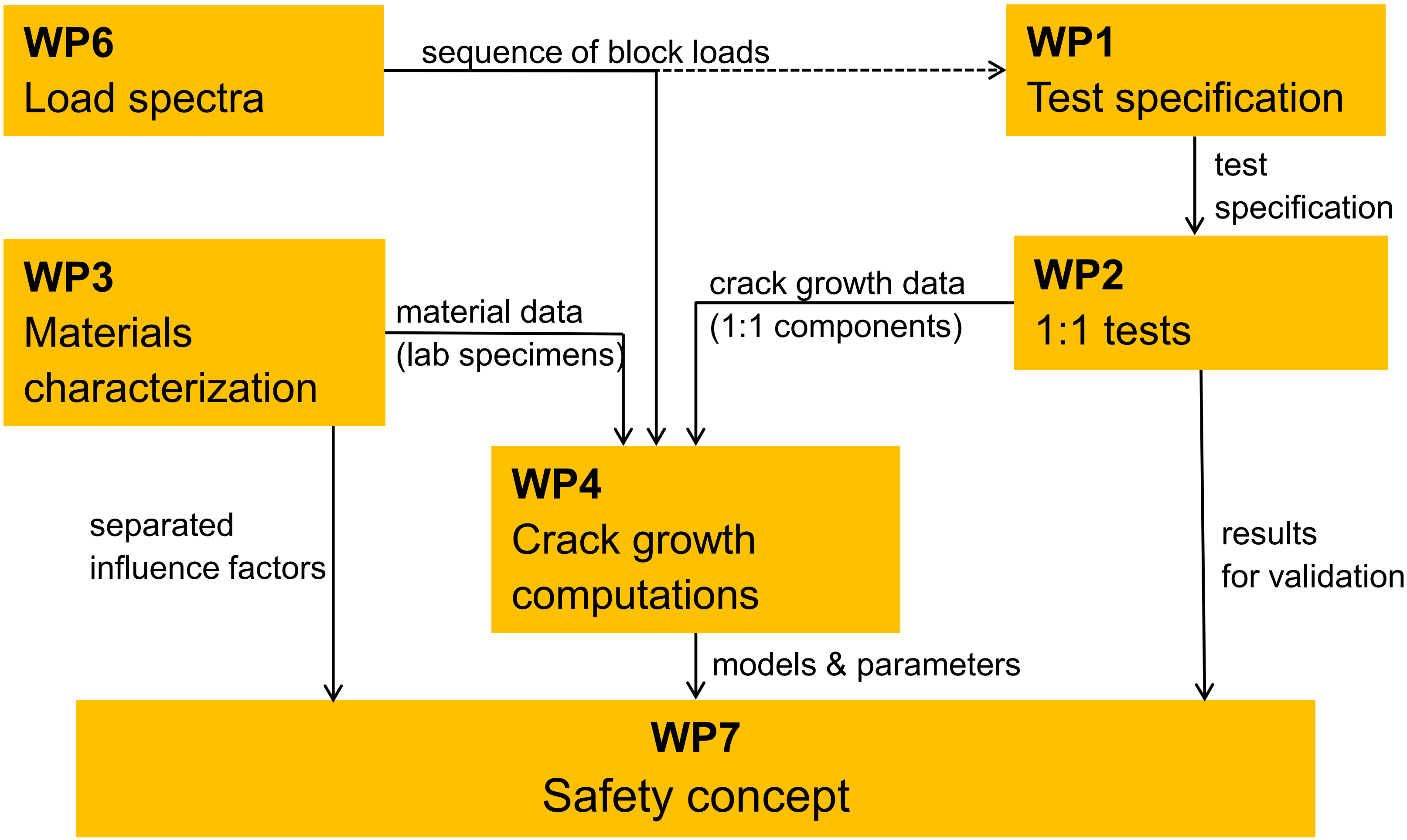
Project Lead
M. Koch
(A. Deisl)

Scientific Board
Prof. S. Beretta (POLIMI)
Prof. C. Sommitsch (TU Graz)
H.-P. Lang (DB)
W. Schwab (VDB)

WP1 Test specification	WP2 1:1 tests	WP3 Materials charact.	WP4 Crack growth comp.	WP6 Load spectra	WP7 Safety concept
TUG / IMAB Prof. C. Moser Prof. A. Esderts	TUG / IMAB Prof. C. Moser Prof. A. Esderts	MCL H.-P. Gänser	MCL R. Tichy	ViF K. Kunter	MCL H.-P. Gänser
BVV F. Murawa	Alstom K . Lütkepohl	Siemens G. Rüf	Alstom K. Lütkepohl	Stadler M. v. Borany	Siemens F.-J. Weber

ViF Virtual Vehicle
TUG TU Graz, Institute of Lightweight Structures
IMAB TU Clausthal, Institute of Plant Engineering and Fatigue Analysis
MCL Materials Center Leoben

Interaction of work packages



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Work packages

WP1 Test specification

Duration: 10/2013 – 06/2014

WP lead:
TU Clausthal / TU Graz, BVV

WP contents:

- development of a test concept
- preliminary tests for pre-cracking and measurement technology
- preliminary component tests
- substantiation of the concept by comparison of local stresses
- definition of test load spectra
- definition of test specification

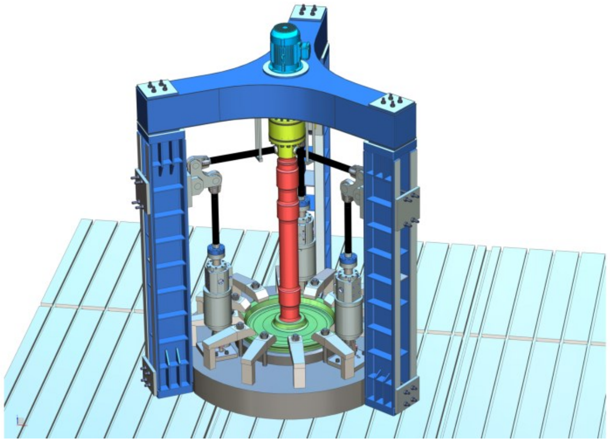
WP2 1:1 component tests

Duration: 10/2013 – 09/2016

WP lead:
TU Clausthal / TU Graz, Alstom

WP contents:

- definition and procurement of 1:1 test axles
- 1:1 component tests (35 pcs.) at TU Graz



Work packages

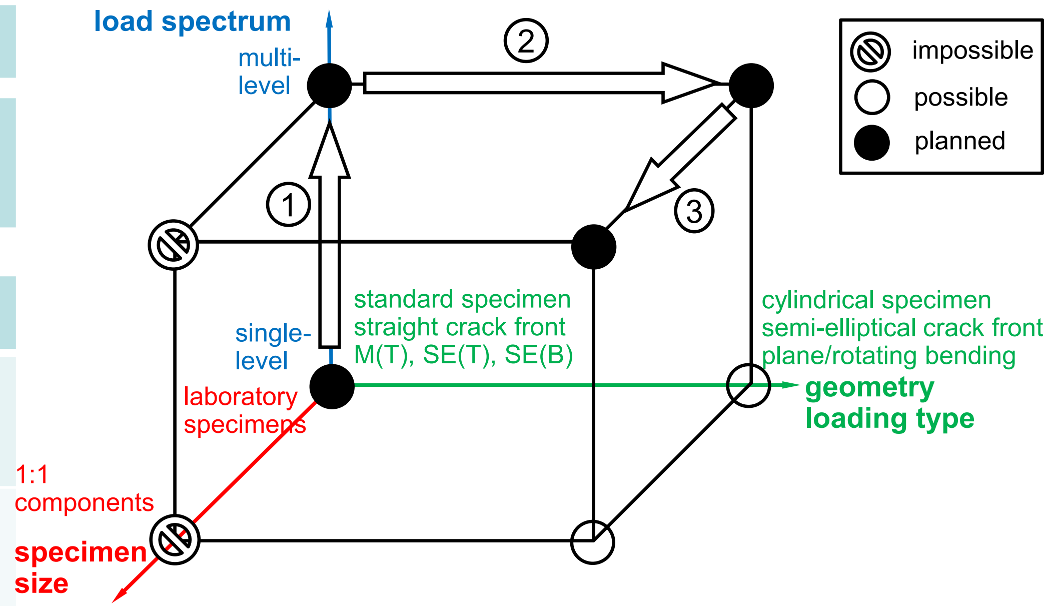
WP3 Materials characterization

Duration: 10/2013 – 06/2016

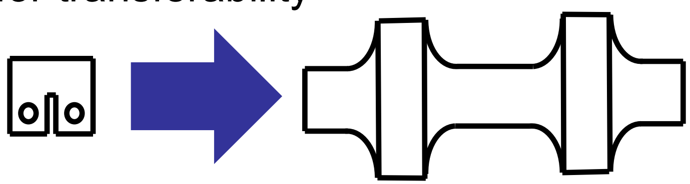
WP lead:
MCL, Siemens

WP contents:

- data base of current knowledge
- complementary experiments on laboratory specimens for:
  - constraint
  - batch influence
  - crack closure effects
  - load sequence effects
- deterministic modelling



separation of influence factors for transferability



- ~160 laboratory specimens
- 35 1:3 specimens
- 35 1:1 specimens

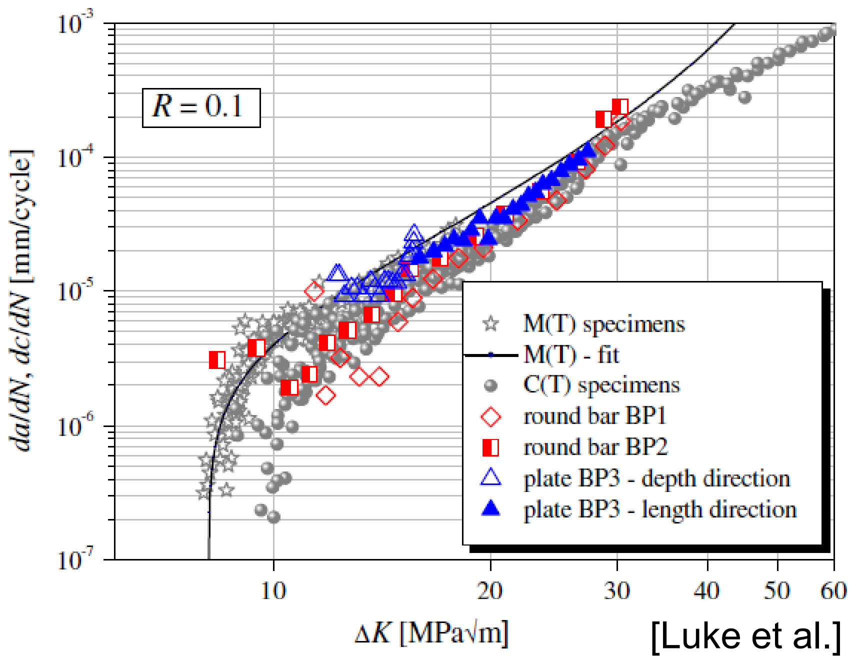
WP4 Crack crowth computations

Duration: 10/2013 – 06/2016

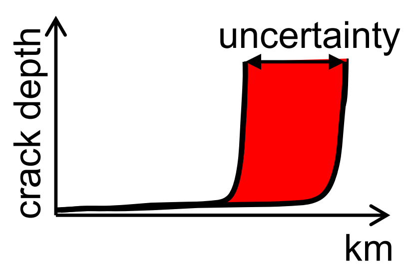
WP lead:
MCL, Alstom

WP contents:

- deduction of a generic crack shape and corresponding analytical SIF expression
- software implementation (INARA and ERWIN)
- FE simulation of test specimens
- simulation of 1:1 components (test rig / real operating conditions)
- probabilistic modelling
- determination of main influence parameters on local stresses etc.



[Luke et al.]



Partial safety factors for:
- stress
- initial crack size
- material parameters

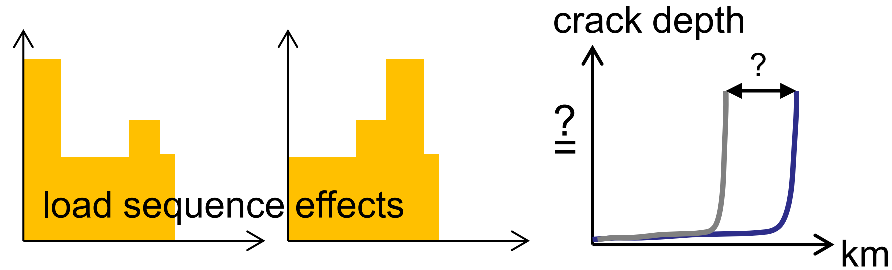
WP6 Load spectra

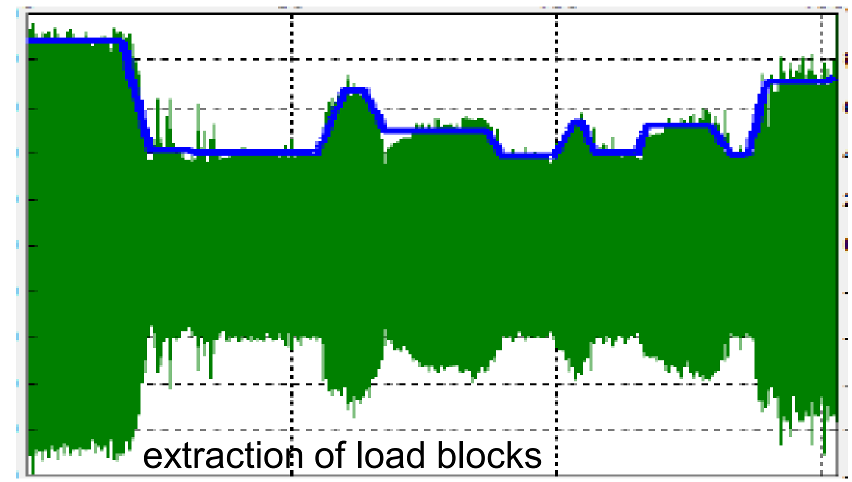
Duration: 10/2013 – 10/2016

WP lead:
ViF, Stadler

WP contents:

- extrapolation to load maxima
- investigation of load sequences
- derivation of load spectra for crack growth experiments
- investigation of the influence of the load discretization on crack growth predictions
- specification for the determination of load spectra for residual life assessment





WP7 Safety concept

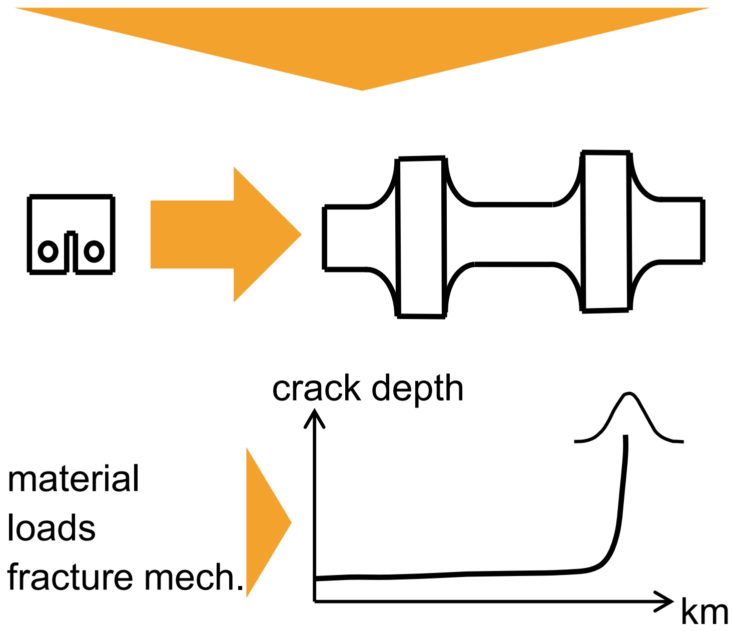
Duration: 07/2016 – 10/2017

WP lead:
MCL, Siemens

WP contents:

- finalization and implementation of assessment method
- verification
- analysis and assessment of project results
- preparation of standardization efforts

consolidation of WP results



validated computational method for determining crack growth rate and inspection intervals

Conclusion

„Industry and science collaborate in the development of a method for determining inspection intervals for railway axles"