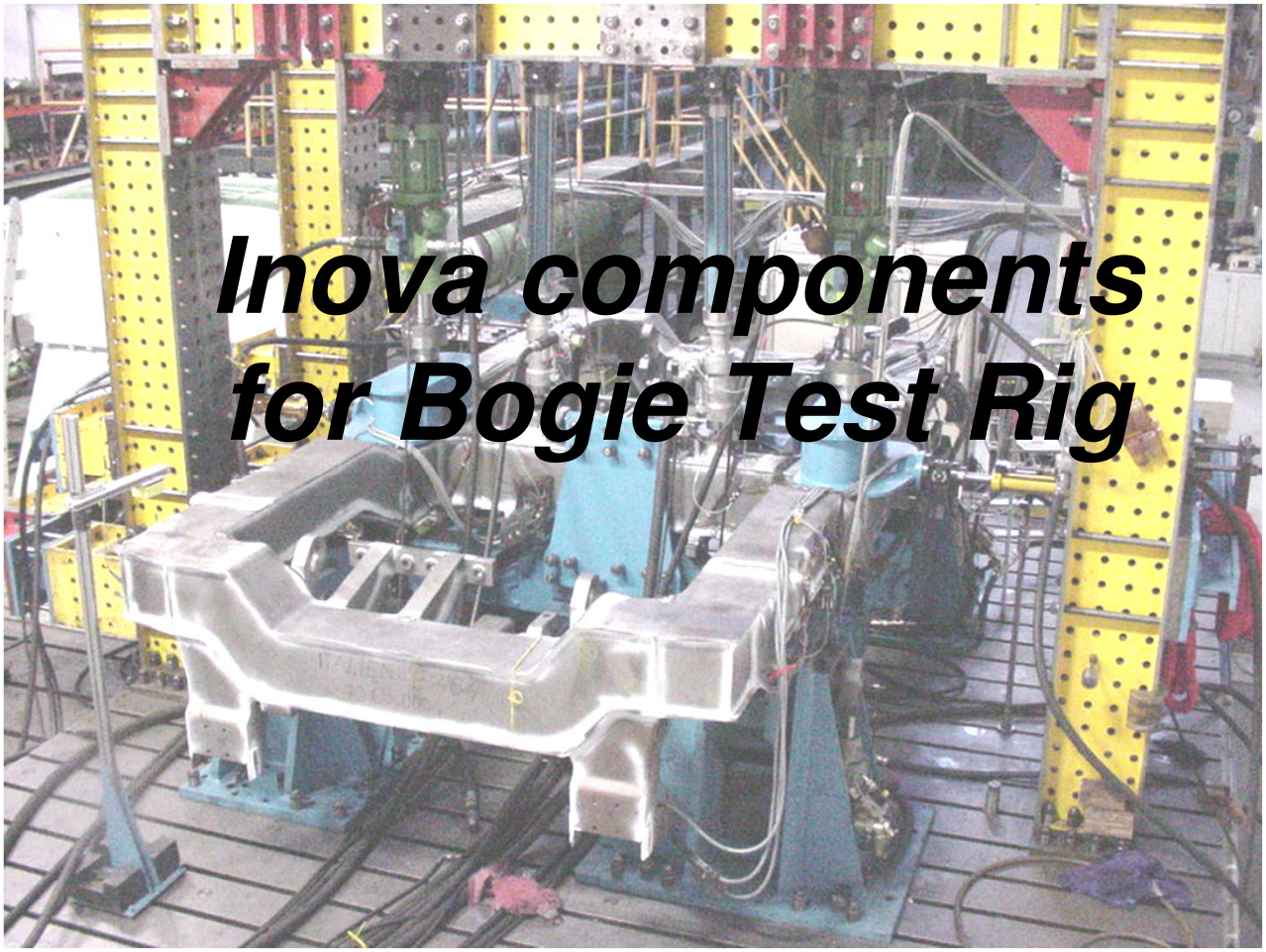
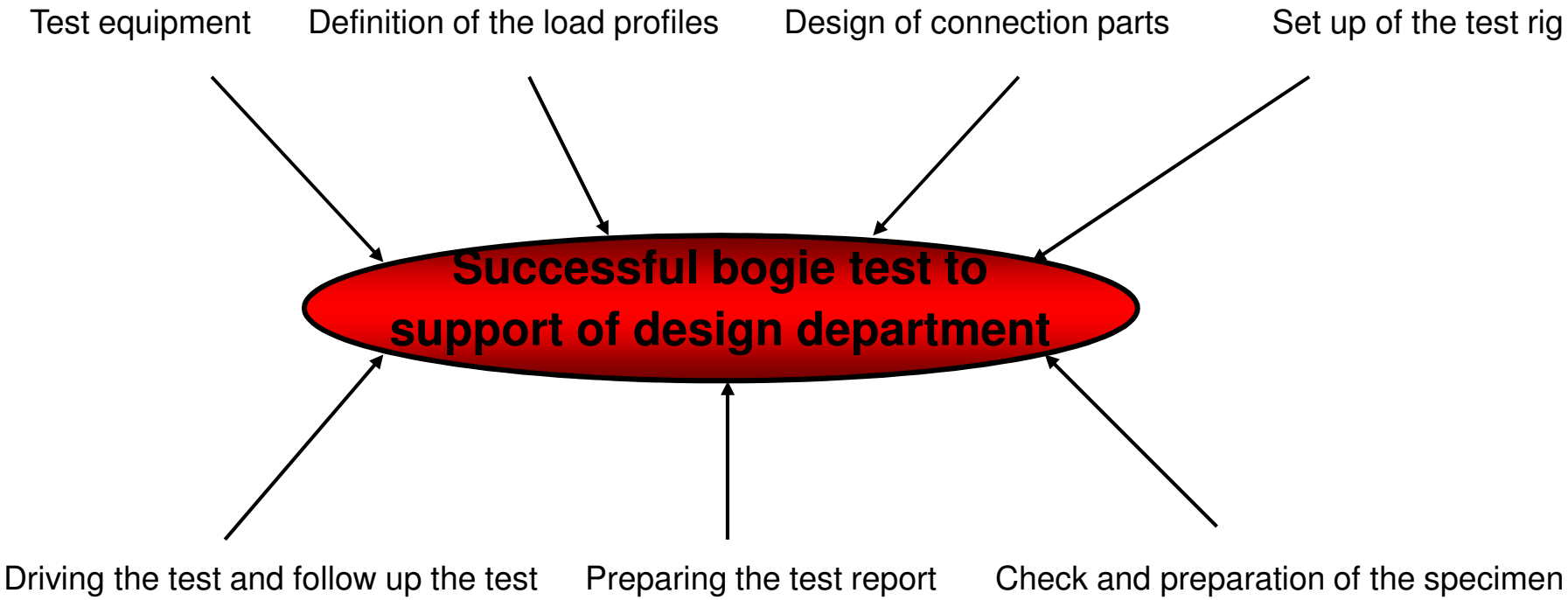
Servohydraulic Testing Systems



Target for bogie test



Principal test program

There are four groups of tests which have to realise:

1) exceptional loads - static

here the purpose is to proof, that the bogie frame will not permanent deformed as a result of the superposition all maxima of operational loads

2) in service loads - static

with that tests will proofed, if there are in superposition of forces (vertical, longitudinal and effects of track deformation) tiredness cracks will be expected

3) particularly operational loads - static

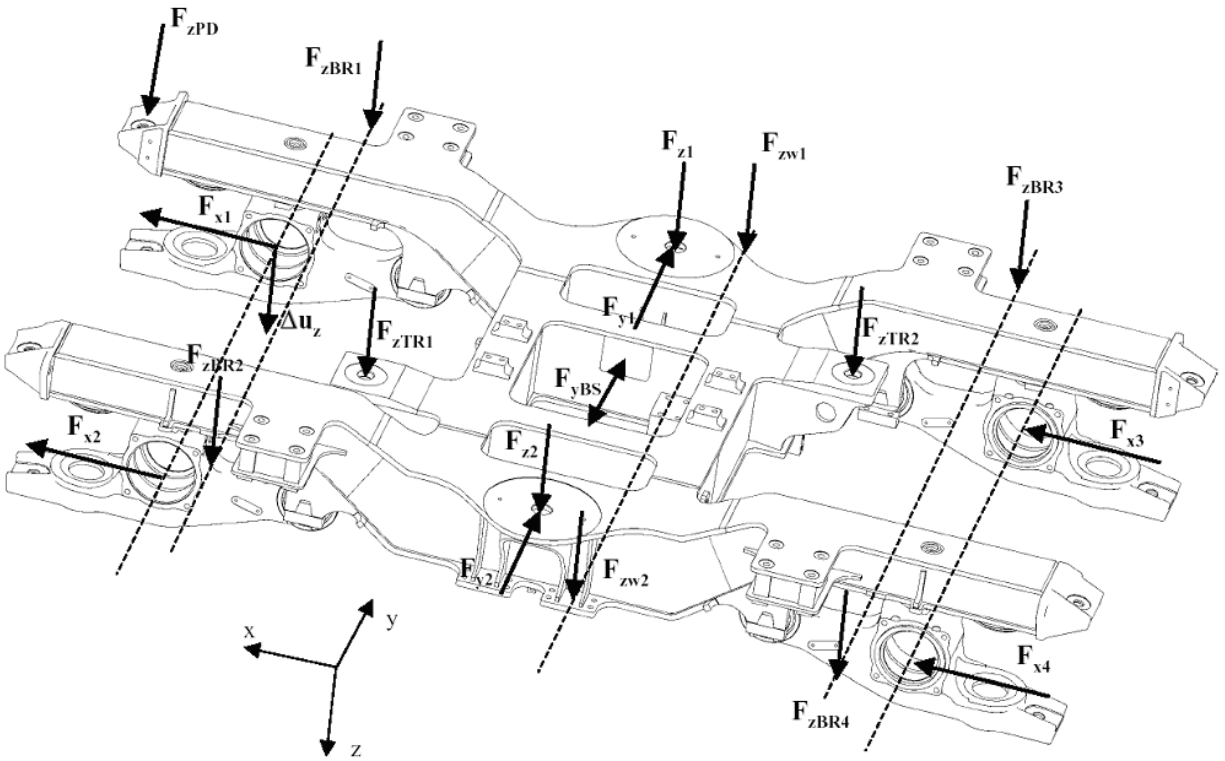
to proof that there are no local defects or cracks as result of repeated introduction of forces from components of the bogie (like engine, brake, damper, etc.)

4) Fatigue tests - dynamic

Proof of fatigue strength for the bogie frame. Investigation factors of safety
Looking for possible weak points, which could not found by static tests

Description of the test

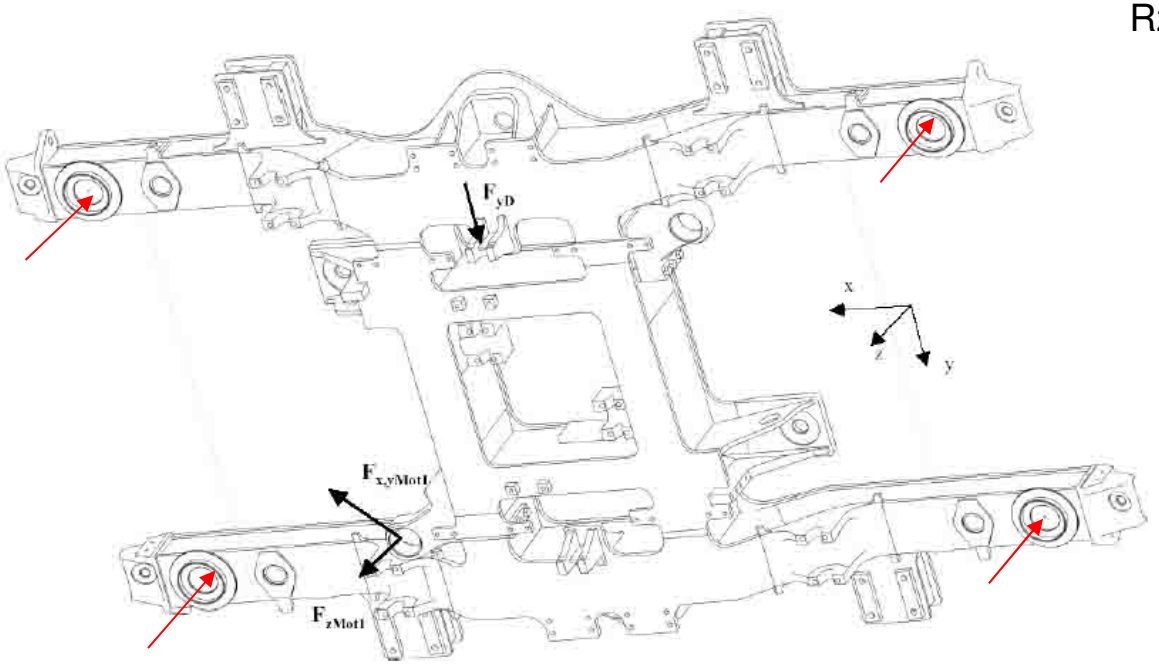
Arrangement of the forces



Description of the test

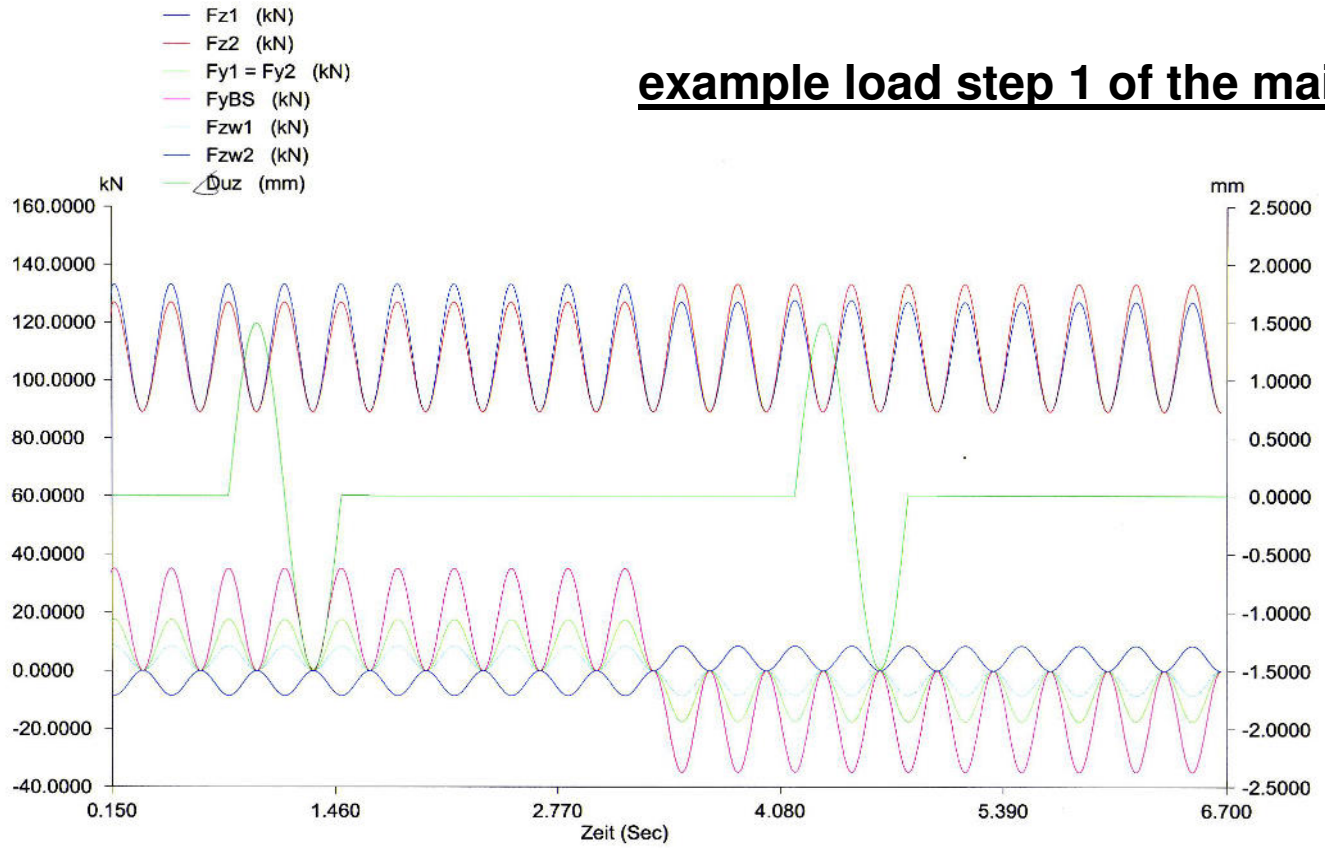
Arrangement of the forces

Rz 1..4: Reaction forces



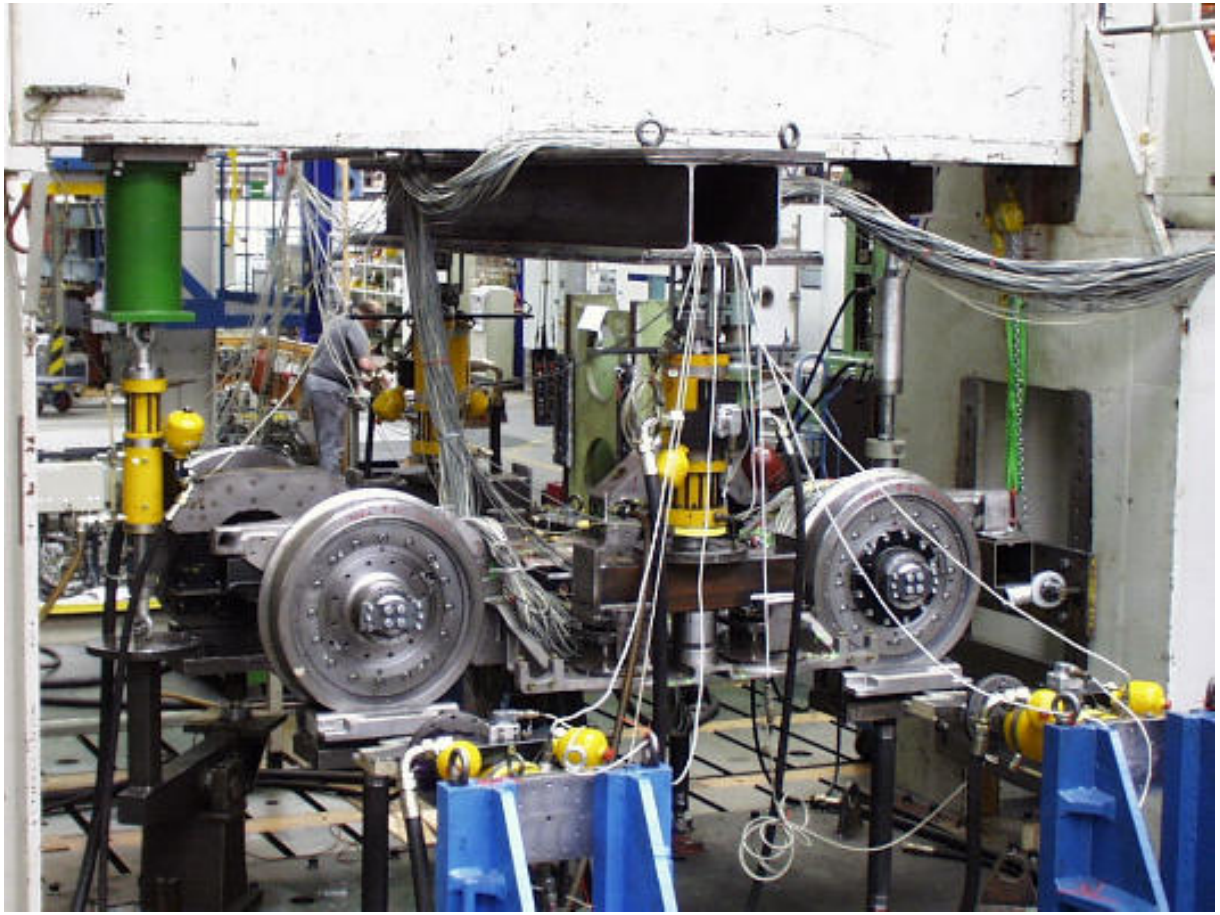
load courses

example load step 1 of the main loads



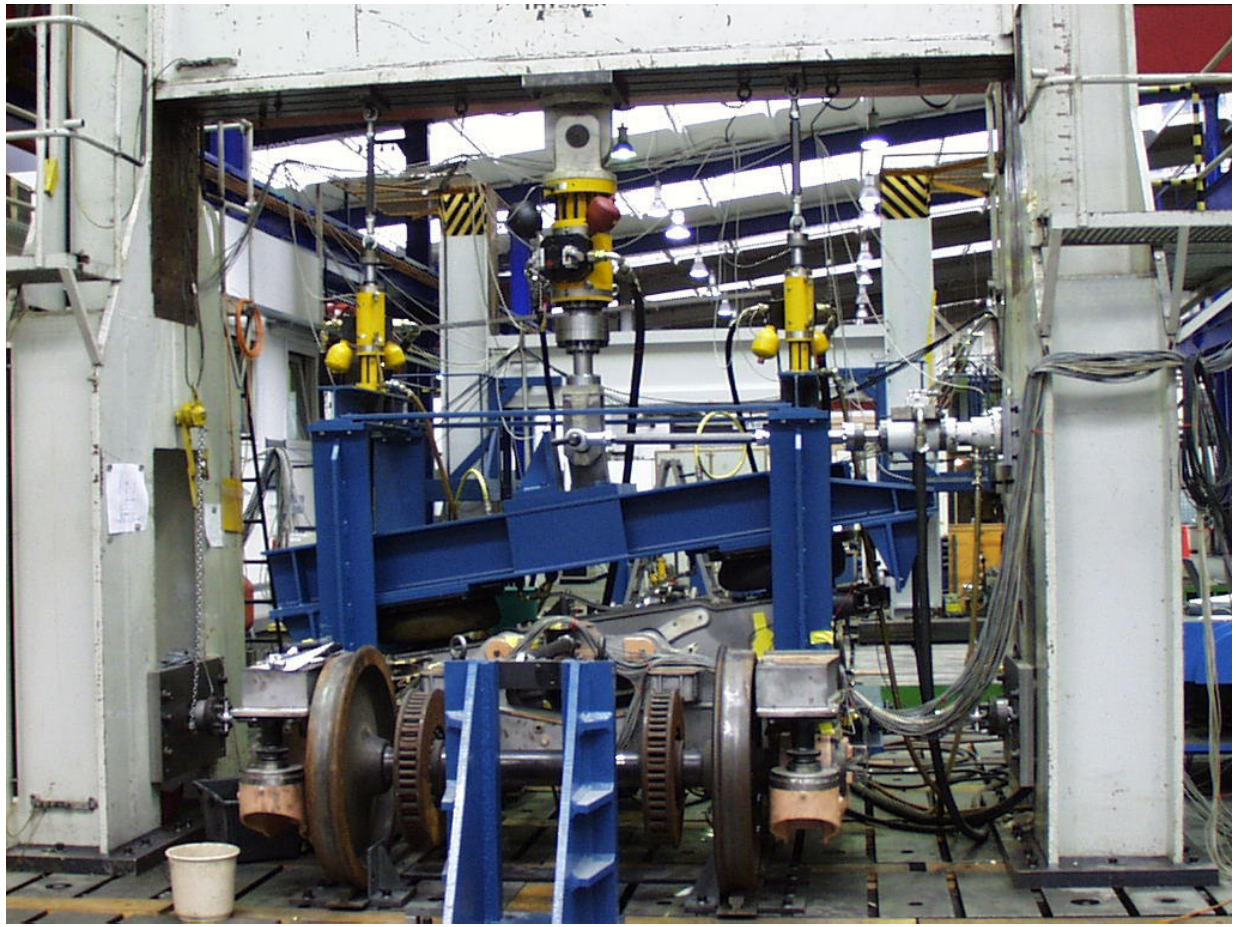
Examples of Bogie test rigs

Thyssen Transrapid at Kassel



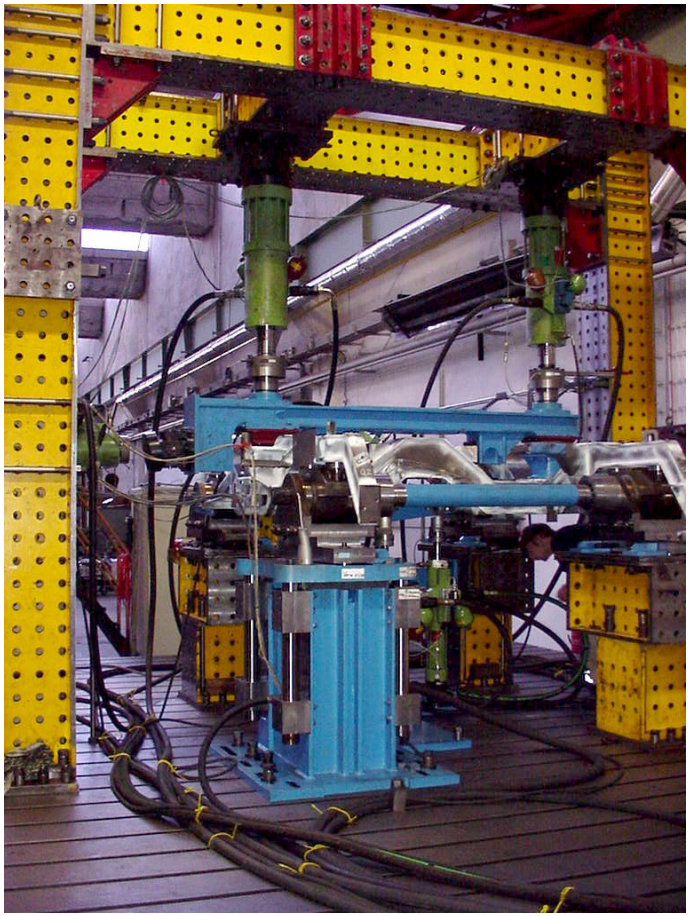
Examples of Bogie test rigs

Thyssen Transrapid at Kassel



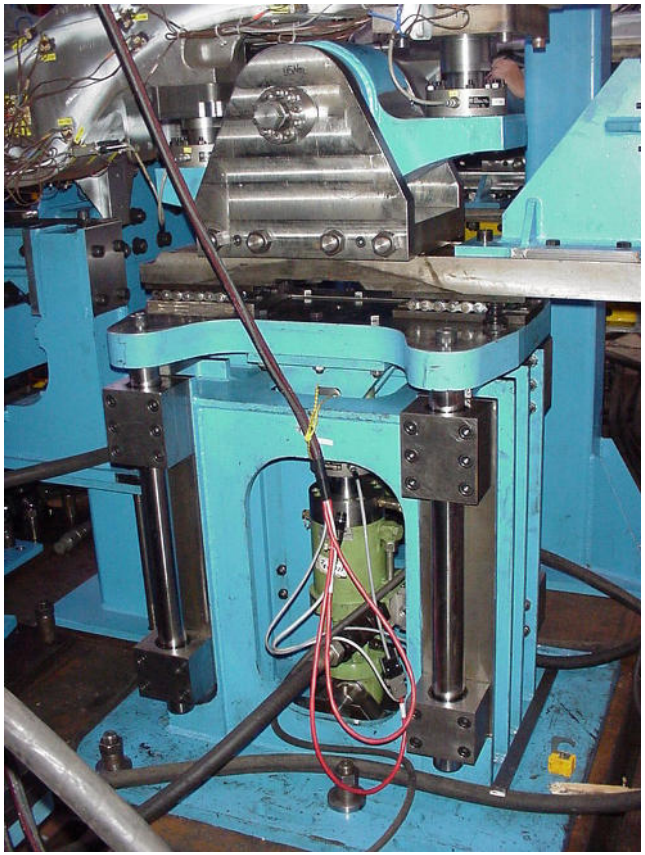
Examples of Bogie test rigs

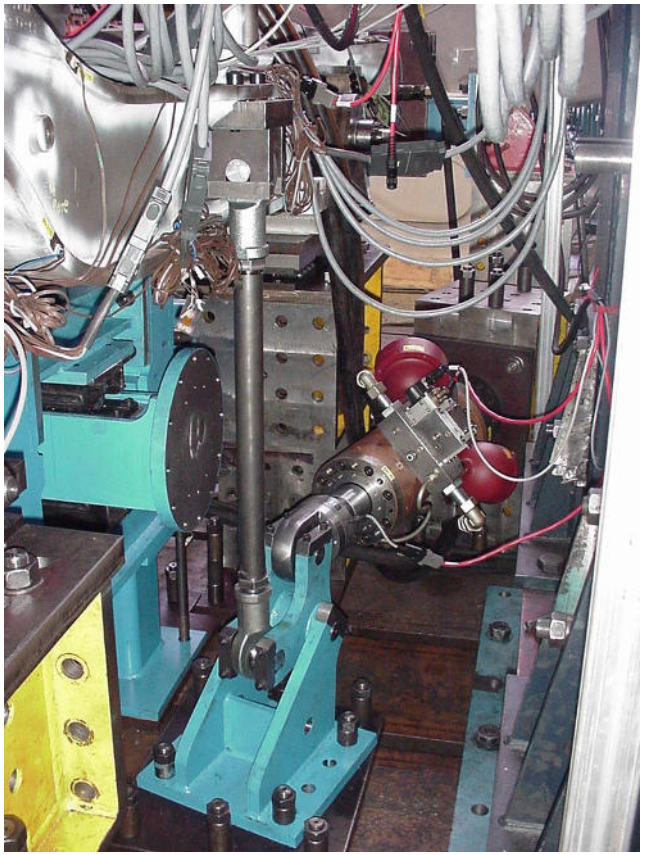
DWA / IFS / Bombardier / RST at Berlin



Examples of Bogie test rigs

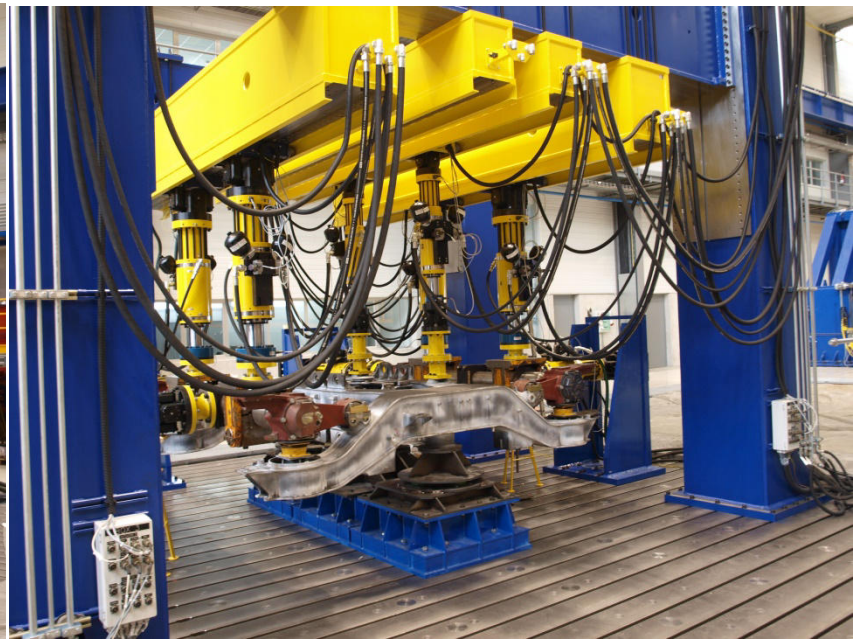
DWA / IFS / Bombardier / RST at Berlin





Examples of Bogie test rigs

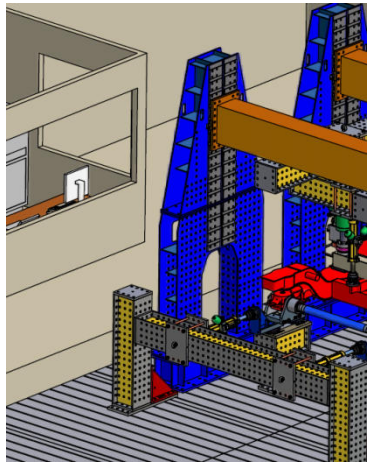
CETEST spain

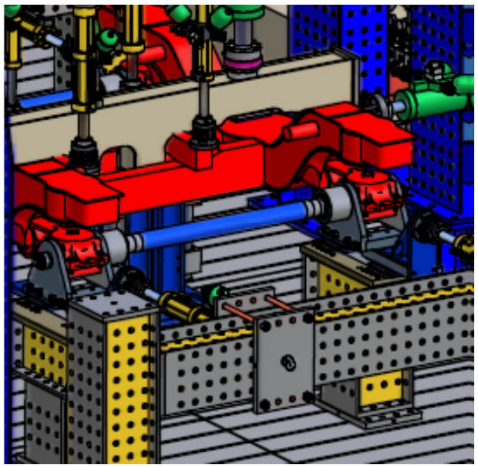


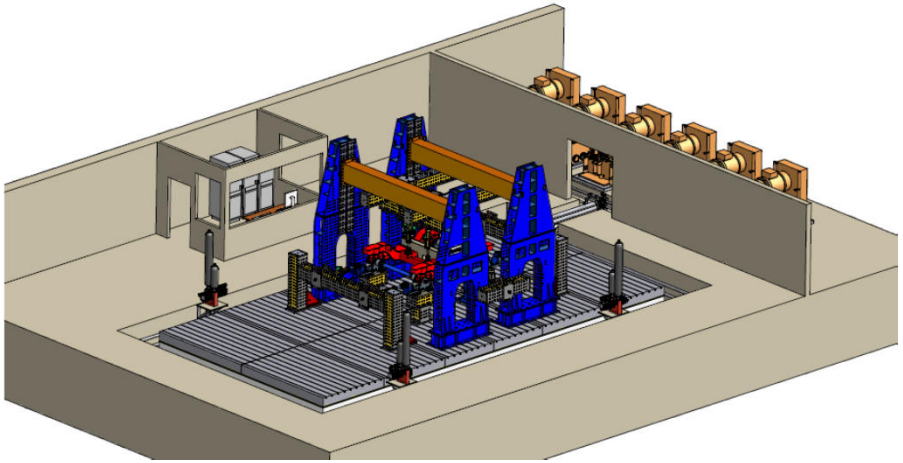
Examples of Bogie test rigs

CSR Sifang Loco Qingdao

Principle of Bogie test rigs







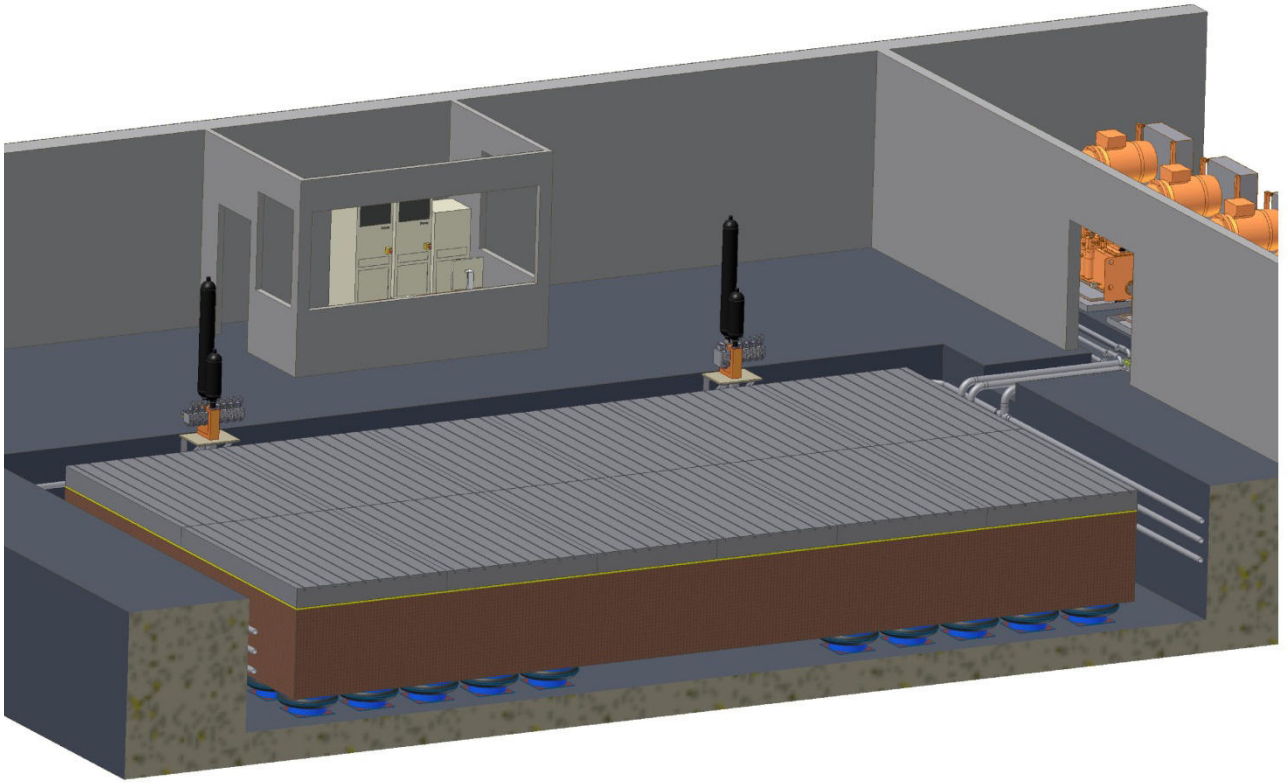
Main parts which could be done by Customer

- Civil engineer work
- Power supply
- Seismic mass
- T-slot table
- Portal frame with crossbeam
- Mounting brackets
- Attachment between bogie and rig

Main parts must be done by Inova

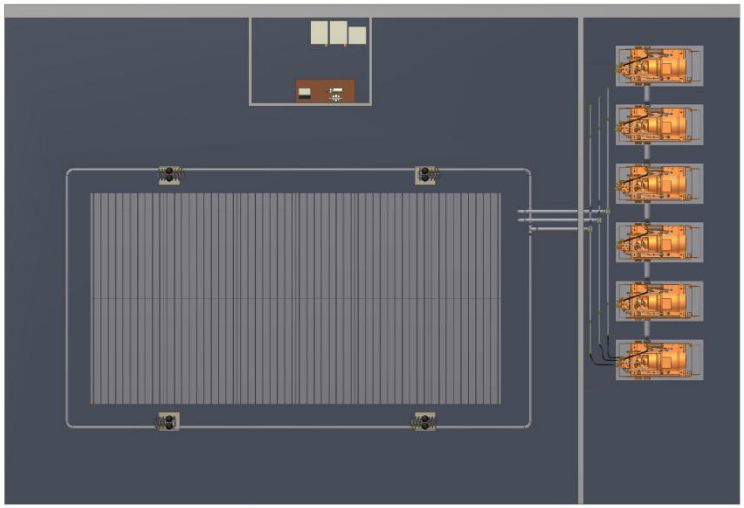
- Linear actuators with accessory
- Hydraulic power pack system
- Hydraulic Distribution System
- Hydraulic Control Stations
- Digital measuring an control system
- Project design and management
- Installation and training

Principle of Bogie test rigs

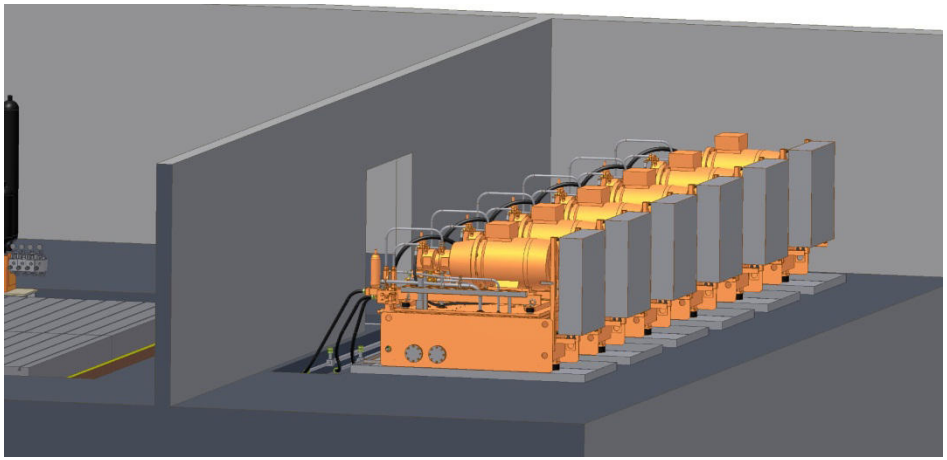


The picture shows a cross cut with a view to the air spring suspension system

Principle of Bogie test rigs



The left picture shows the top view from test area

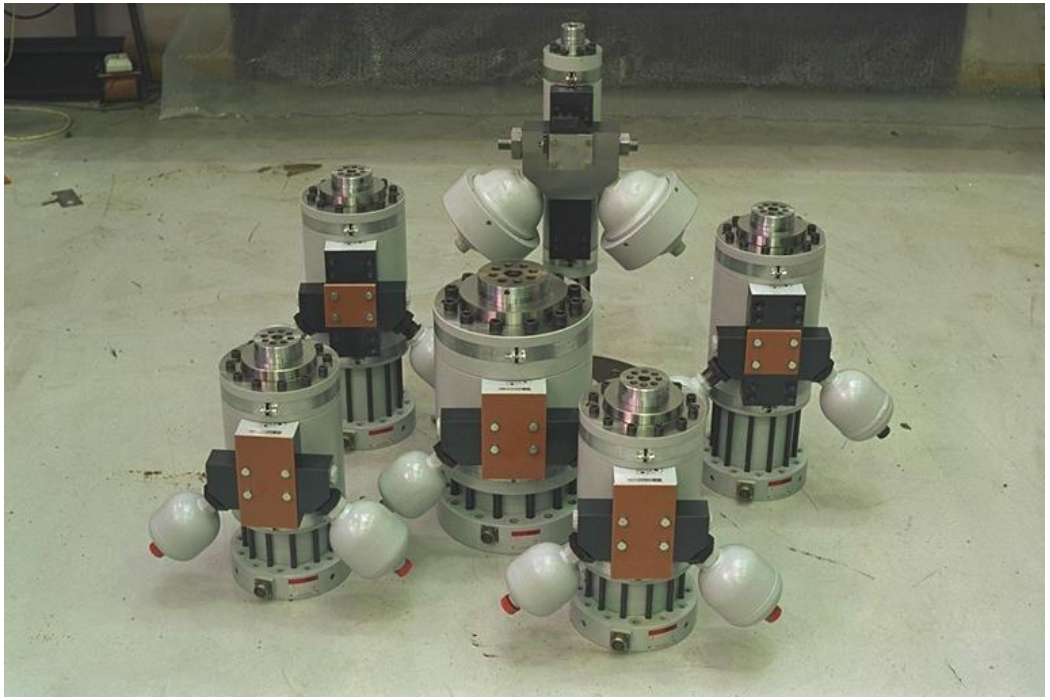


The right picture shows the power pack station with a nominal flow of 1500 l/min

Recommended components

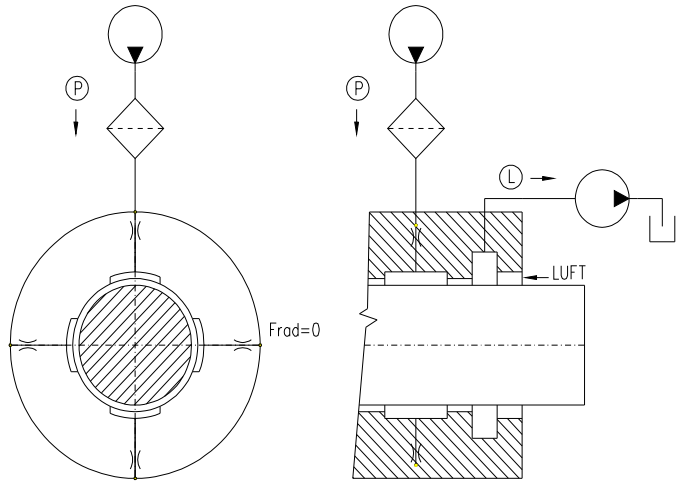
- First of all - skilled engineers
- hydraulic actuators with high accuracy load cells
- backlash free joins
- adequate oil supply
- adequate tube system
- adequate t-slot table
- adequate Portal frame with crossbeam
- flexible Control Electronic with Test and evaluation software
- powerful data acquisition system
- Attachment between bogie and rig

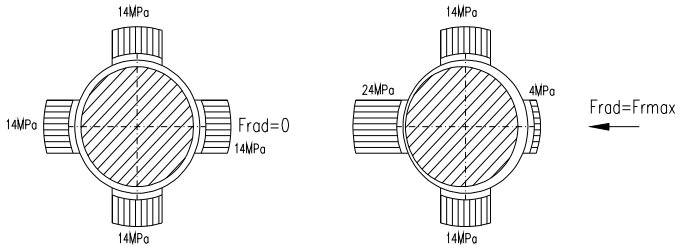
Linear actuator



- Hydrostatic bearing linear actuators series AH
- Nom. Load from 3kN up to 2500 kN
- Nom. stroke:
  20 mm up to 400 mm

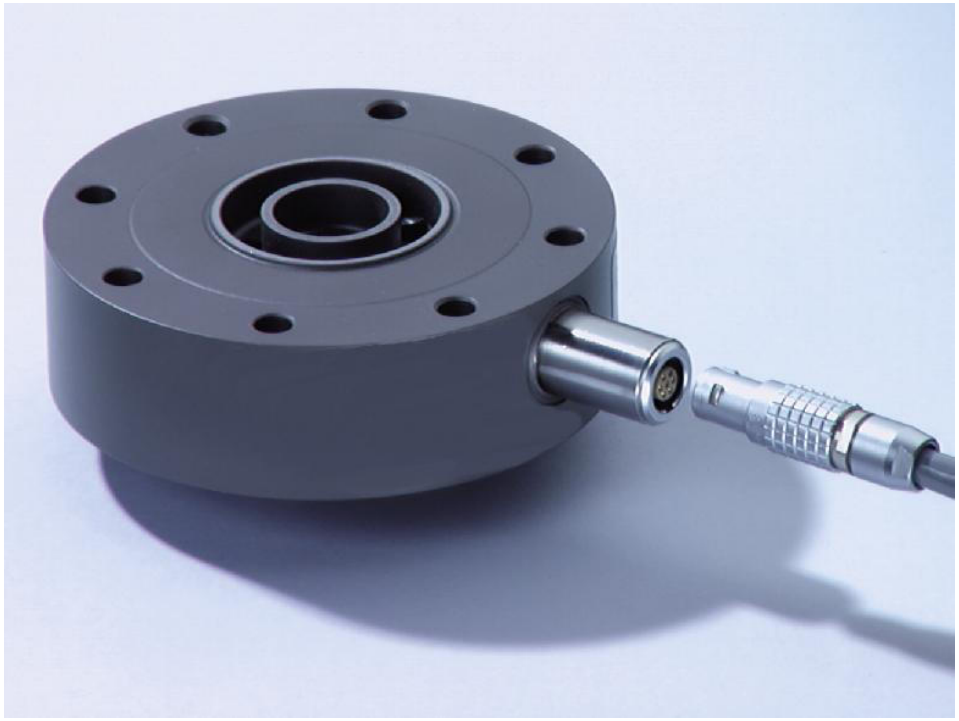
hydrostatic bearing





- wear and tear free
- friction free operation
- optimal control property
- high side load capacity
- suitable with permanent high speed
- maintenance free

Load cell series KA



- high accuracy class 0,1
- low influence of the side load to the measured signal (< 0.02% at Fq=0.1*Fnom)
- high stiffness
- high own frequency
- easy mounting

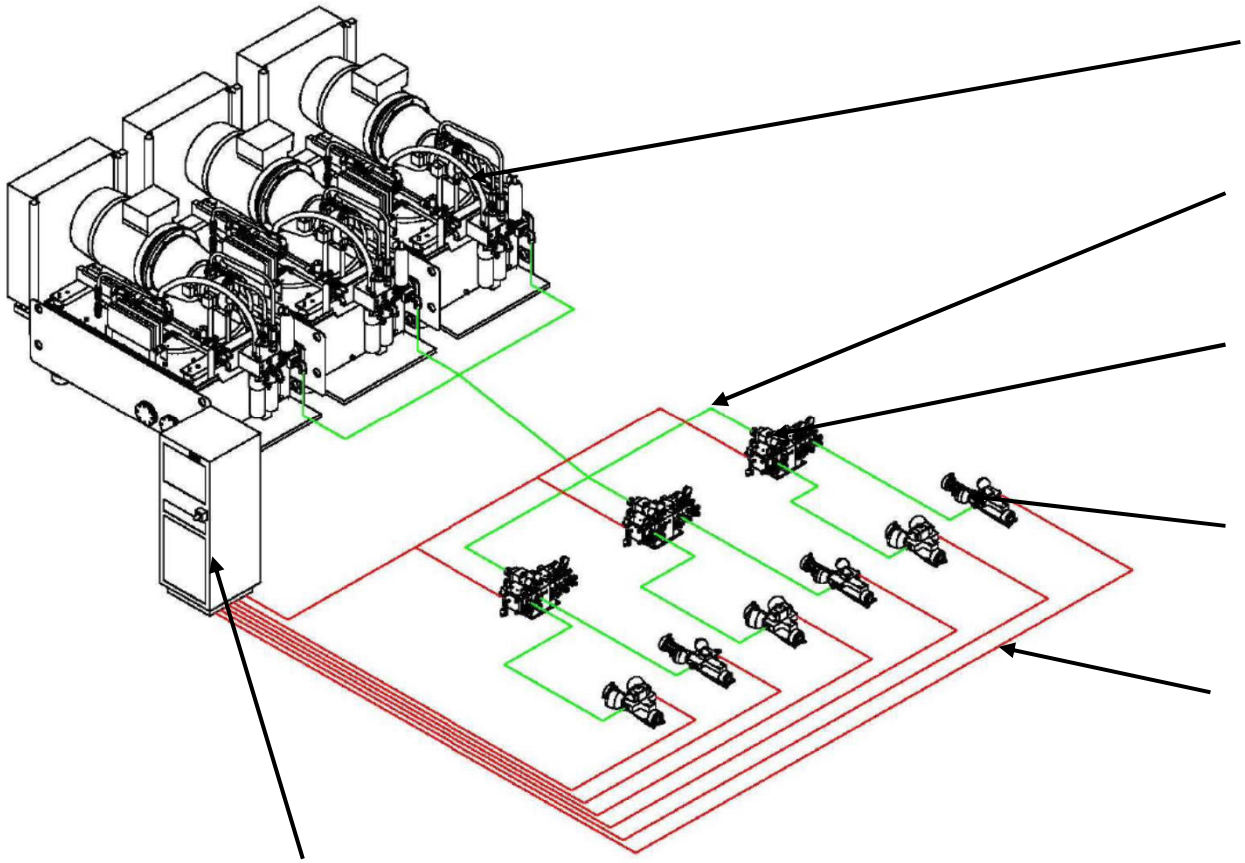
Ball Joints JB

- Free from backlash, adjustable ball joints series JB
- Angle: +/- 20°
- Nom. load from 5 kN up to 630 kN
- Lowest friction
- Long service life

Cardan Joints Series JC

- free from backlash
- working angle +/- 8°
- low friction
- less maintenance work (only smear)
- long live time

Principle electric and hydraulic connection



Power pack station

Hydraulic connection, hard piping and hoses

Hydraulic manifold with start stop valve

Hydraulic actuator

Electrical connection, Servo valve, position transducer, Load cell, hydraulic manifold

Control electronic and software

Hydraulic Power Packs Series HU

- hydraulic Power Packs Series HU
- adjustable pressure (nominal pressure 280 bar)
- usage of controlled pumps
- expandable flow by connection of several power packs
- several types of power pack remote control
- long life time
- flow rate from 6.3 up to 345 l/min

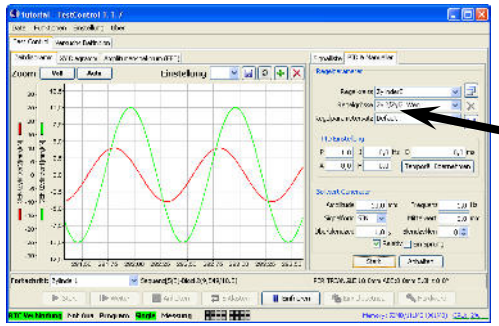
Safety Start-Stop Valves Series PB

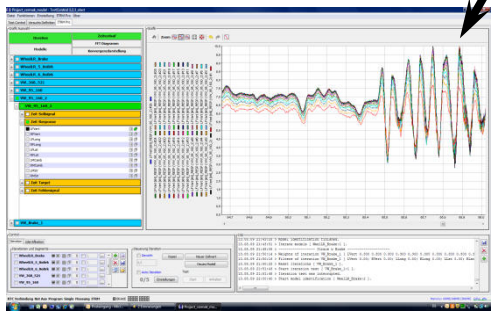
- safety Start-Stop Valves Series PB
- high pressure mode up to 315 bar
- low pressure mode 10 up to 100 bar
- restricted flow between 2l/min and 25 l/min in low pressure mode
- modular concept with flow rates of: 63, 130, 250 and 630 l/min

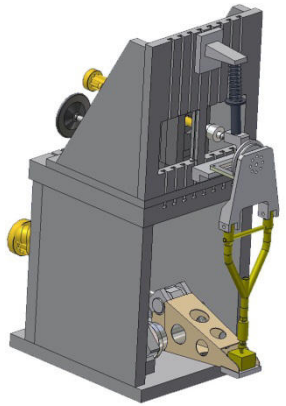
Digital Controller EU3000-RTC

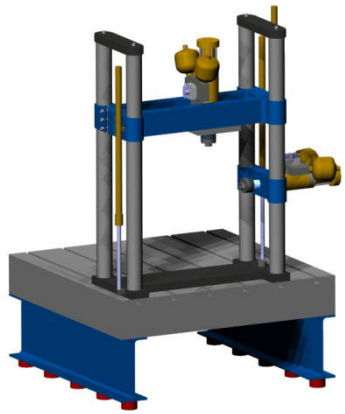
- Digital control and measure system
- Flexible configuration from one up to n.. channels
- Multi channel, multi station concept
- No limitation of number of control channels
- No limitation of numbers of amplifiers
- test frequency up to 1000 Hz
- Sample rate 10 kHz net (100 kHz brut) for each measurement channel
- Resolution 24 bit AD/DA (net)
- Loop update rate 10 kHz
- control algorithm – PID, PIDF, cascade
- Control accuracy static < 0,1%, dynamic < 1%
- Phase difference accuracy
- low frequency (typical 0-5 Hz) < 3°
- middle frequency (typical 5-10 Hz) < 5°
- Digital filtration
- integrated UPS
- Pilz emergency stop system
- Big quantity of available software modules

•Digital Controller EU3000-RTC



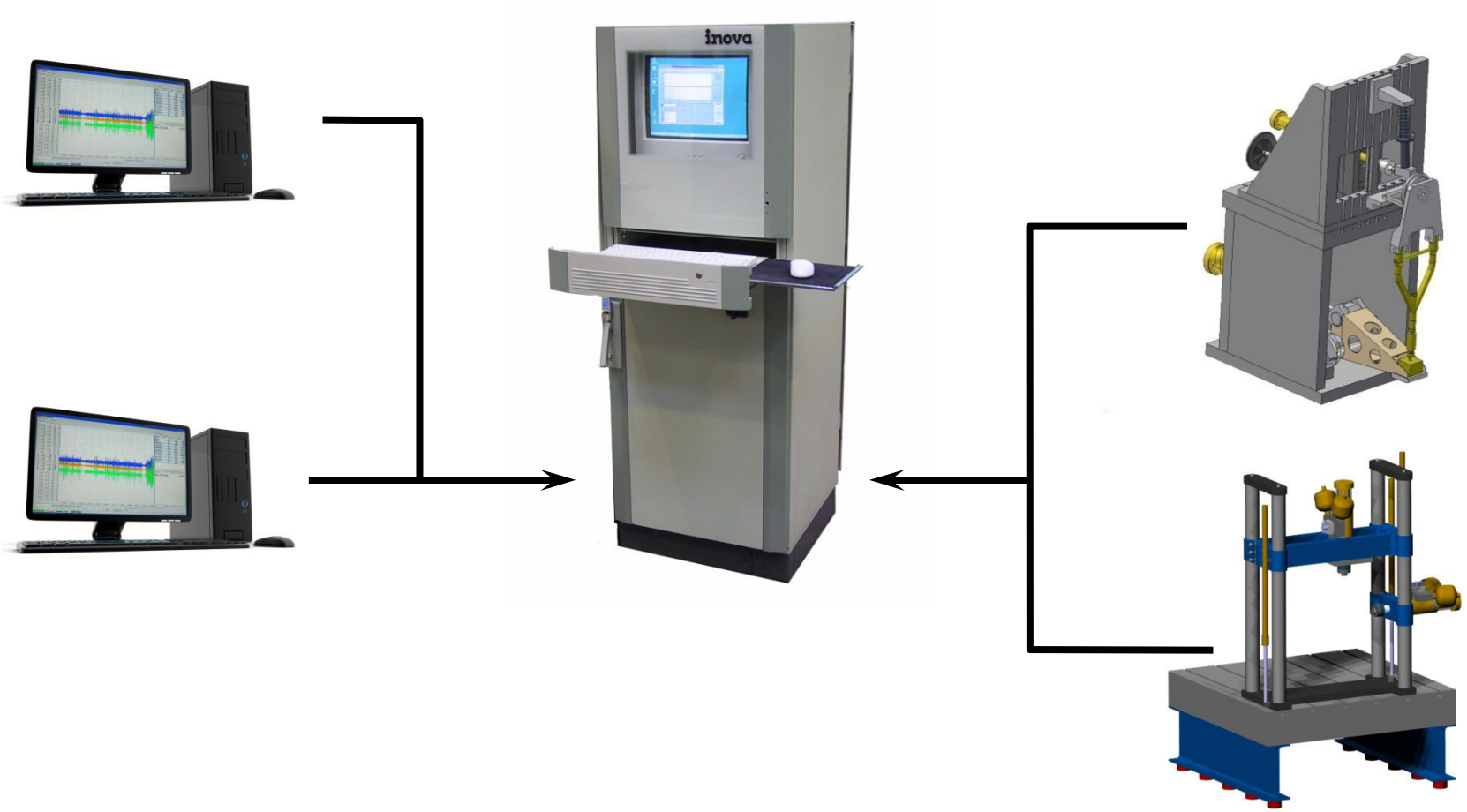






•Multichannel / Multistation

•Multistation Multiuser

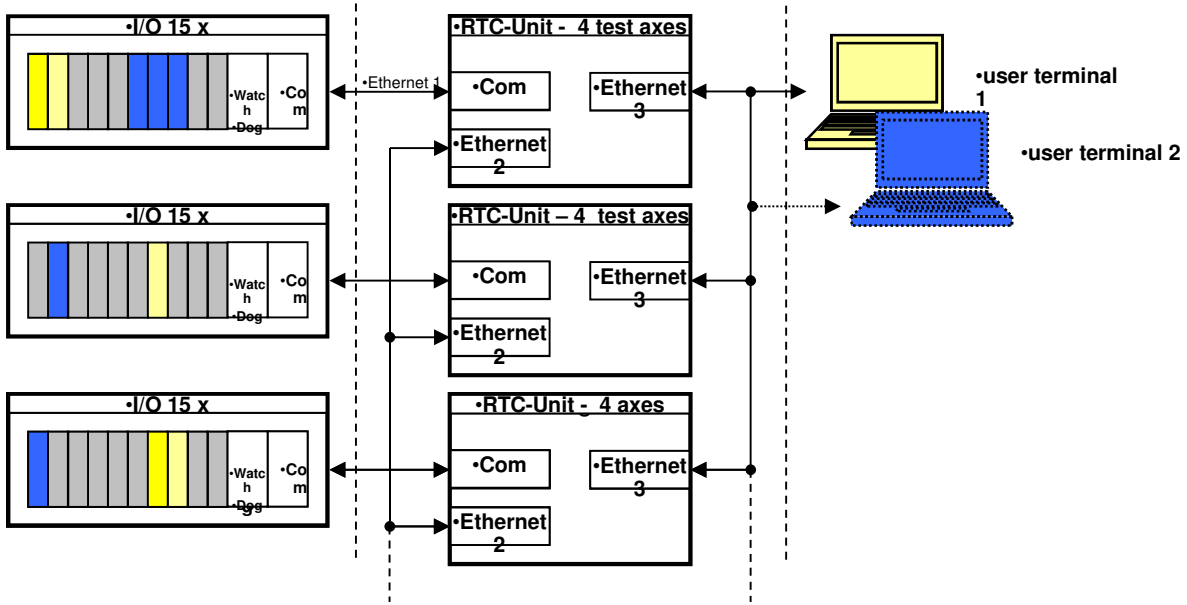


Structure EU 3000 - RTC

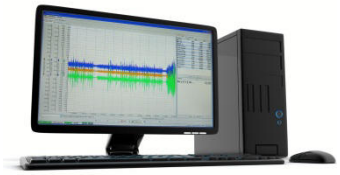
- **I/O Layer**
- Signal conditioning
- Anti alaising Filtering
- AD/DA Conversion
- Hard Security functions

- **Realtime Layer**
- Closed Loop Control
- Geometric Compensation
- Mode Control Calculations
- Filtering
- Data Acquisition
- Realtime Iteration
- Peak Control

- **Operation Layer**
- Configuration
- Operation
- Visualization
- Test programming
- Iteration
- Evaluation, Analysis



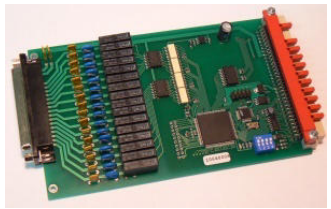
Scaling of EU 3000 - RTC



•**Unser terminal PC**

•**RTC** Real Time Controller

•**I/O frame**
•with 15 slots



•**I/O moduls**
- actuator interface (AI)
- signal conditioner AC/DC)
- analogue I/O (Ana I/A)
- digital I/O (Digi I/A)

	Min. stage of extension	Max. Stage of extension	Typical 12 DOF axle test rig
PC	1	Depends on demands	1
RTC	1	4	2
I/O frame	1	4*4 **=16**	2
I/O Modul	2 (1 x AI + 1 x AC/DC-2)	16*15 **=240**	30 12 x AI 12 x AC/DC-2 2 x Digi I/A 4 x Ana I/A

available I/O cards

DC double amplifier, fully adjustable by software

- *module provides 2 independent signal conditioner*
- *full bridge, halfbridge, quarterbridge DMS, potentiometric input, voltage input*
- *sensitivity 0,5 to 1000 mV/V*
- *supply voltage 2,5 to 10V*
- *24 bit ADC*

AC double amplifier module, fully adjustable by software

- *module provides 2 independent signal conditioner*
- *LVDT, or half bridge input, full bridge - 50 up to 5000 Ohm independent carrier frequency generators*
- *sensitivity 0,5 mV/V to 500 mV/V*
- *supply voltage 1, 2, 5 V eff - max 50 mA*
- *phase compensation*
- *24 bit ADC*

AU universal double amplifier, fully adjustable by software

- *module provides 2 independent signal conditioner*
- *full bridge, half bridge – 50 up to 5000 Ohm*
- *sensitivity 0,5 to 1000 mV/V*
- *independent carrier frequency generators 1-10KHz*
- *excitation voltage 0,5 to 10Vef – max 50 mA*
- *18 bit ADC with oversampling (640kHz)*
- *24 bit internal/ external resolution*
- *phase compensation*

Analog input module

- *Provides 4 independent analog inputs for general use*
- *free software assignment*
- *general assignment as external amplifier ADC or external analog command*
- *Resolution 24 bit DAC*
- *10 kHz internal sampling rate, 5 kHz hardware filtering*

Analog output module

- *provides 8 independent analog outputs for general use or as analog outputs for amplifiers.*
- *free software assignment*
- *Resolution 16 bit DAC*
- *2,5 kHz internal sampling rate*
- *software adjustable filters*
- *connection directly or via BNC input/output panel*

SV-PB module - Servovalve and manifold control

- *voltage to curent amplifier for servovalve exciting*
- *manifold and multivalve driving*
- *1,2,4 servovlaves Moog G 761 or equal types*
- *1,2,4 servovalves Moog 765 or equivalent (electric feedback) (Two or more valves paralell needs additional current from power supply unit)*
- *1 or 2 servovalves Moog 792 or equivalent (three stage)) (Two valves paralell needs additional current from power supply unit)*
- *max . three solenoids 24 V DC/ 1,5A at manifold and one solenoid 24 V DC/1,5A at multiventil*

available I/O cards

Digital output module

- *Module provides 16 independent digital outputs for general use ang general assignment*
- *free software assignment*
- *rating 24 V DC/1,5 A per contact*
- *4 kV isolating voltage*
- *2A regenerative fuses*

Digital input module

- *Module provides 16 independent digital inputs for general use and general assignment*
- *4 kV isolating voltage*
- *24 V DC support voltage from isolated supply or from internal 24 V DC*

Digital input / output module

- *Module provides 4 independent digital outputs*
- *24 V DC (0,3A) support voltage from isolated internal supply or external 24 V DC max 1,5A (regenerative fuses 2A)*
- *Module provides 12 independent digital inputs*
- *both for general use and general assignment*
- *rating 24 V DC*
- *free software assignment*
- *4 kV isolating voltage*

IRC double Encoder , fully adjustable by software

- *module provides 2 independent counter modules*
- *ABC signals, RS 422 or TTL signals*
- *Max. 500 kHz counting rate*
- *5V or 24 V DC sensors supply*
- *up to 2 x 300 mA sensor supply current*
- *32 bit up/down counters*
- *support for ultranoise transducers Balluff BTL and Stegman H Pomux*

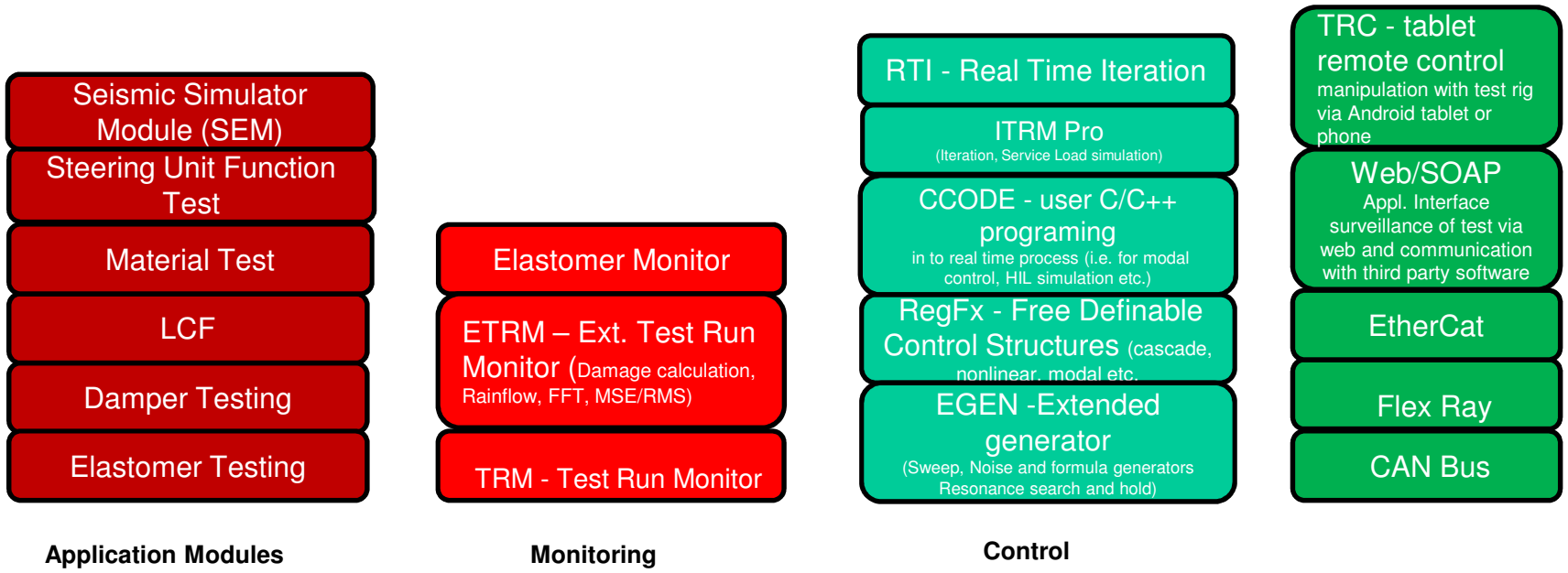
RES resolver amplifiers, fully adjustable by software

- *module provides 2 independent signal conditioner*
- *sensitivity 3,2 V+-20% (resolver transfer 0,5-1)*
- *excitation voltage 1 to 20Vpp*
- *independent carrier frequency generators 1-10KHz*
- *16 bit resolution*

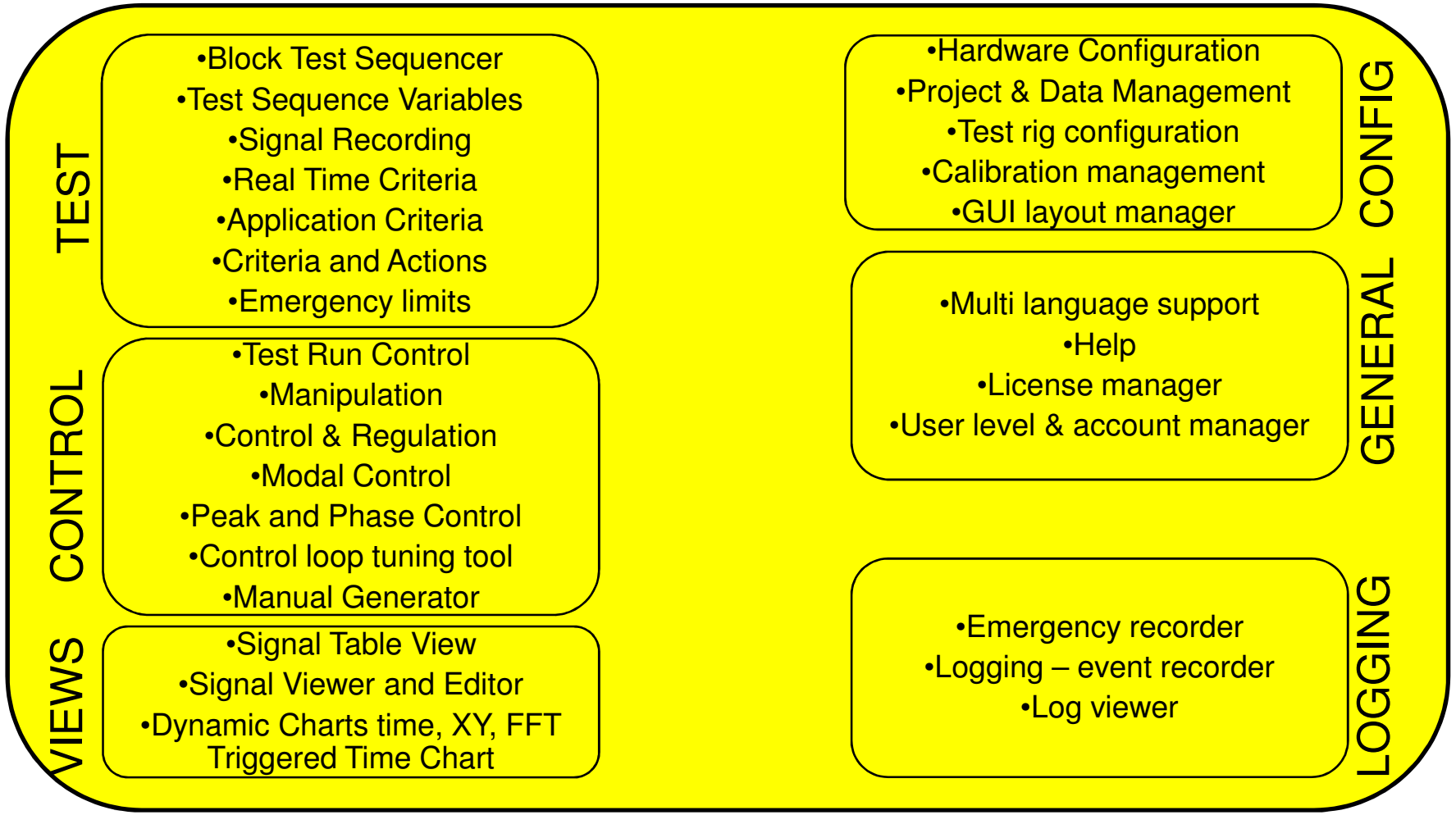
ICP double amplifier, fully adjustable by software

- *module provides 2 independent ICP inputs*
- *isolated constant current , adjustable 1-5 mA*
- *adjustable gain*
- *high pass filter 1 Hz or 0,2 Hz*
- *lowpass filter 5 kHz*
- *integration or double integration possible in RTC*

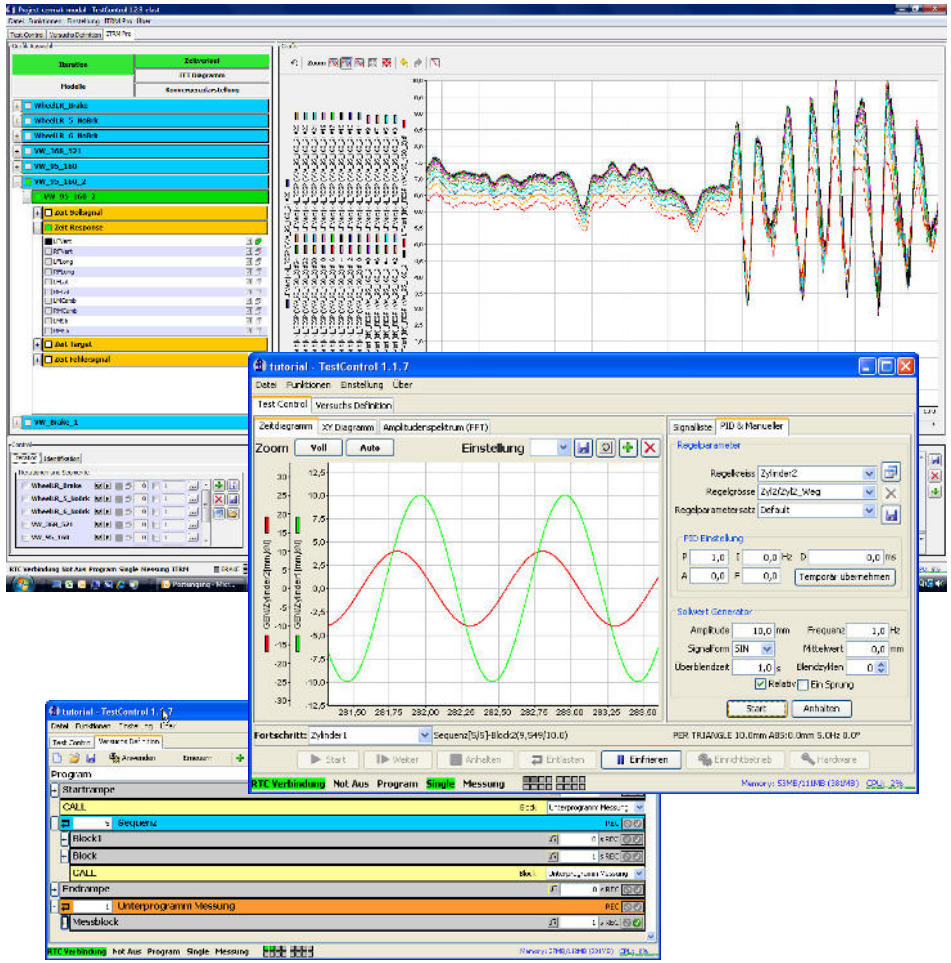
Software Modules



TestControl
Base Software

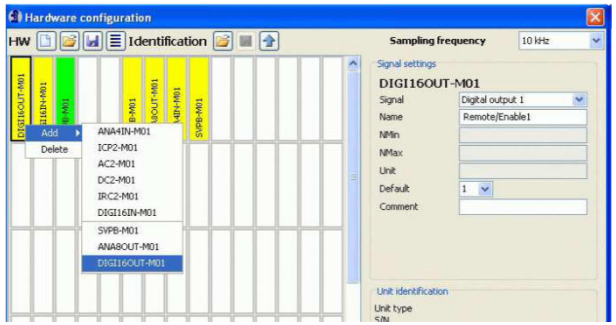


Software TestControl



The Software Test Control serves as the user Interface to the digital control System EU3000RTC. TestControl allows to configure the test rig, set up the loading sequence, monitors the progress of your test, handles the data acquisition and finally gives you the result of your tests. TestControl is very easy to handle. The unique user interface allows to configure test station and set up a test in minutes. The support of multi station operation allows you to run several independent tests from one PC. TestControl run on standard windows PC without special hardware requirements. TestControl itself will fulfill the most tasks in daily testing. Even replay of time histories, advanced peak control, criteria triggered test run control and comprehensive data acquisition is integrated. TestControl is extensible by plug in Modules for extended functions or special test procedures like Damper or Elastomer Testing or service load simulation with iterative transfer function compensation.

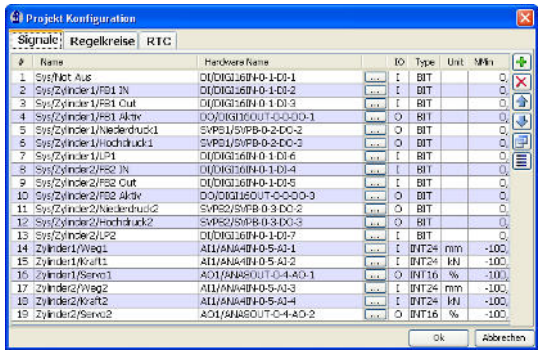
Software TestControl



Hardware Configuration

TestControl comes with a easy to use tool to set up you're the installed Hardware. All I/O cards will be shown with its name, type and at the right position in the control rack.

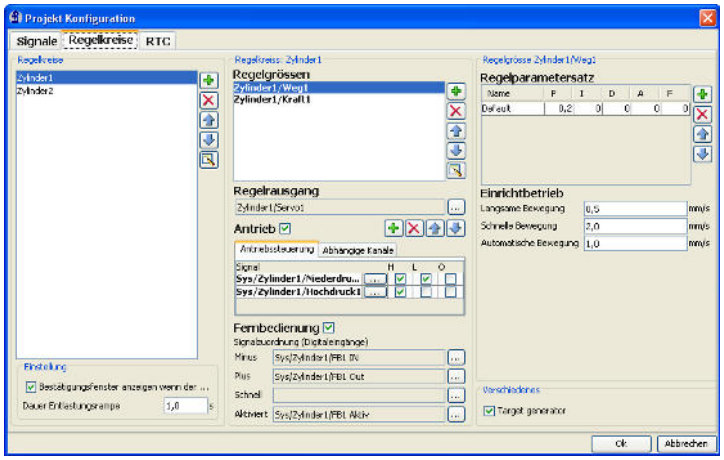
Different hardware configuration settings can be managed. A click on the Module symbol allows to change its parameters.



Test Station Set up

TestControl comes with a easy to use tool to set up your test station.

Just choose the Hardware out of a list what is available. Use the default names or rename the signals as you want. Finally combine your in- and output signals to Control loops.



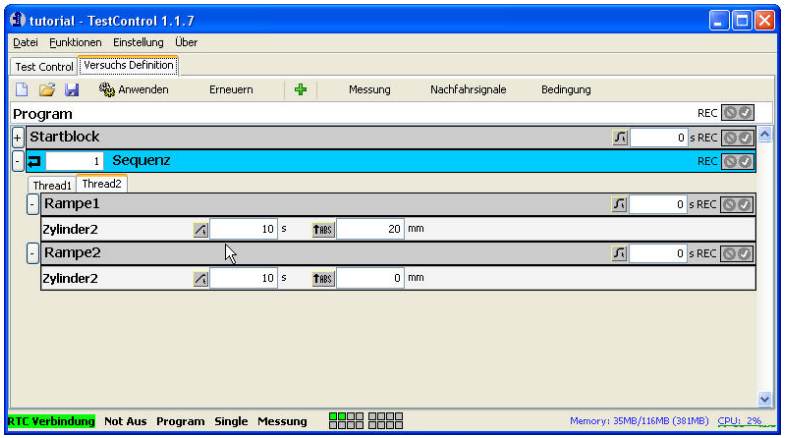
Controller Set up

In the controller set up dialog the configured inputs and outputs are combined to control loops. All signals in the system can be used to set up a controller

Software TestControl

Manual Operation

In manual operation it is easy and save to operate the test rig for specimen assembly.

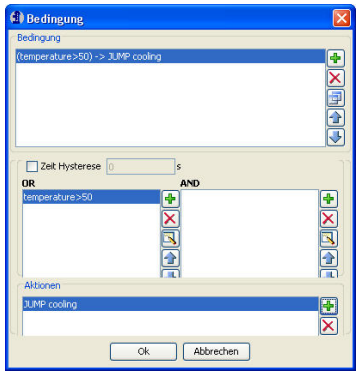


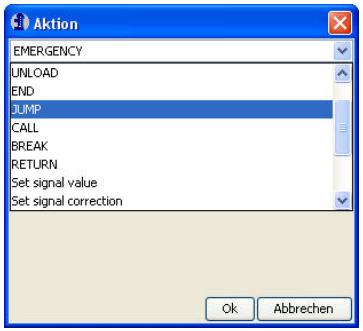
Block Programming

The unique block programmer or test sequencer is one of key elements of TestControl. It allows to set up complex, multi channel multithreaded test sequences within a graphical editor. The multithreading technology allows to set up e.g. a long term temperature profile for temperature chamber together with multiple blocks for the loading in a asynchrony overall synchronized testing sequence
A delay time of 1 sample (0.1ms) between 2 blocks allows to generate each arbitrary wave form out of ramp and sine segments.

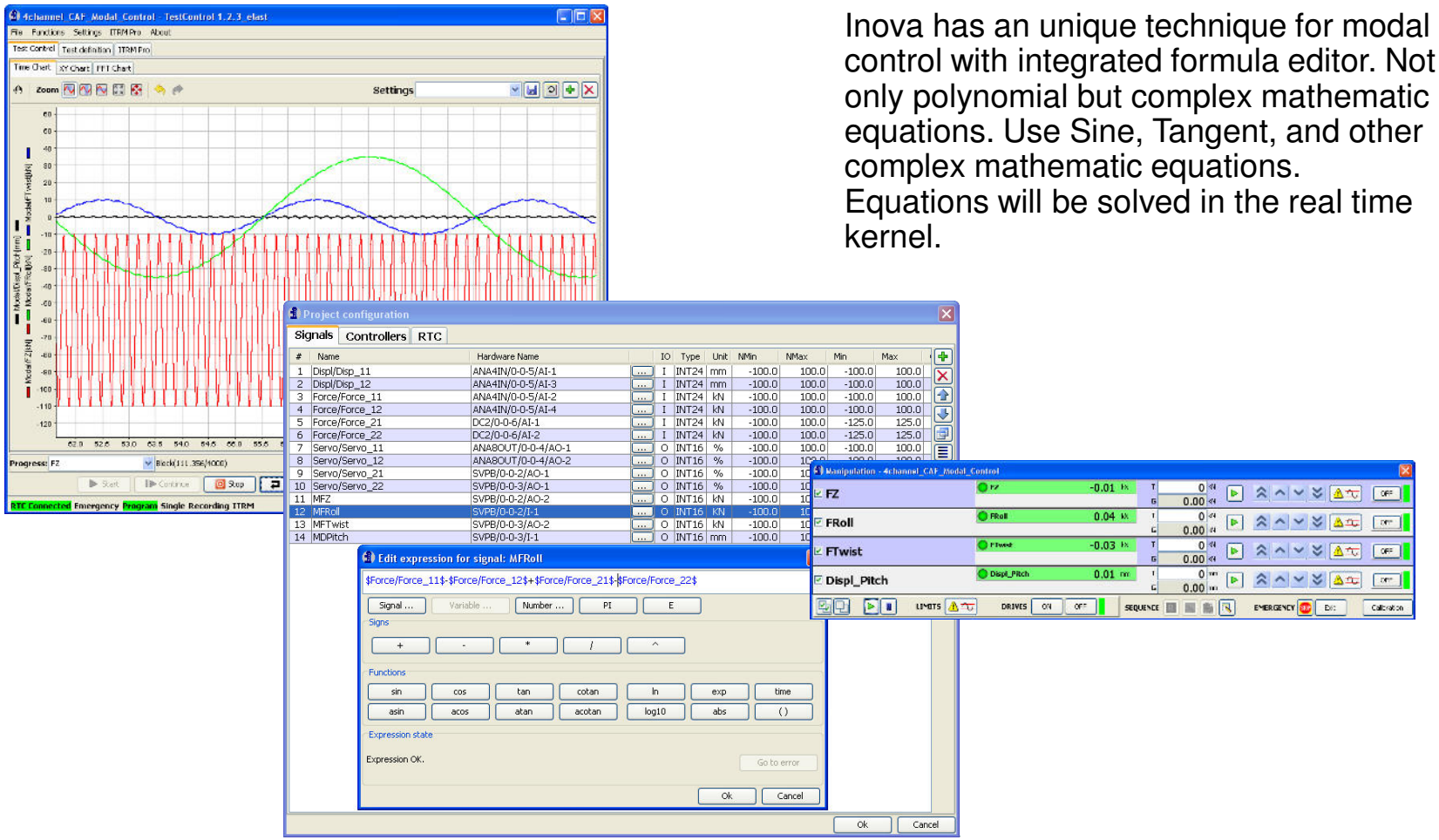
Criteria's

So called criteria's allows a event triggered run of the test with this criteria's it is possible to run a ramp in position control an stop if a defined load is reached or jump to cooling sequence if temperature of a specimen rises a certain level.
Criteria's can be combined by OR and AND function.



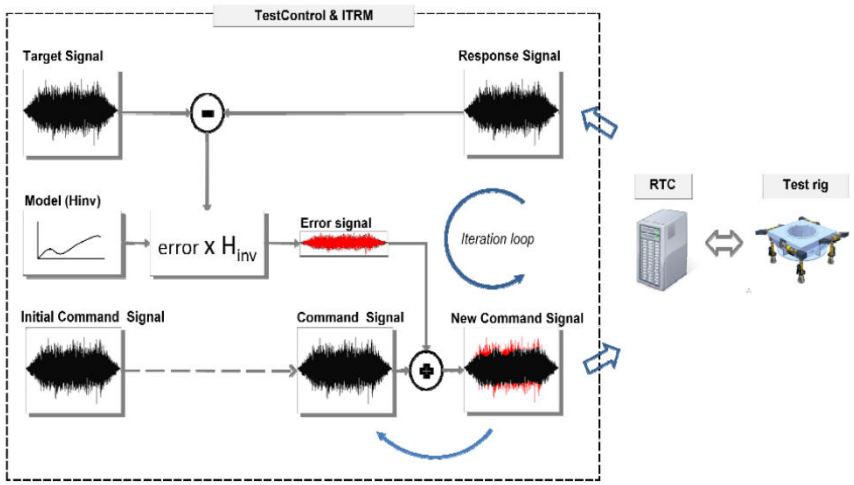


Modal control



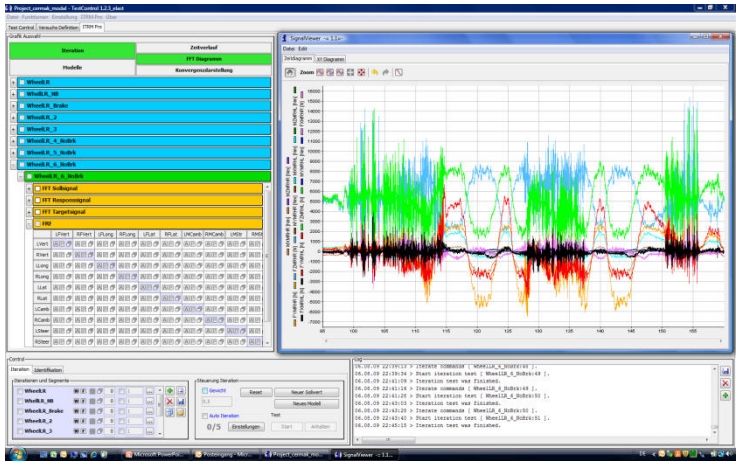
Inova has an unique technique for modal control with integrated formula editor. Not only polynomial but complex mathematic equations. Use Sine, Tangent, and other complex mathematic equations. Equations will be solved in the real time kernel.

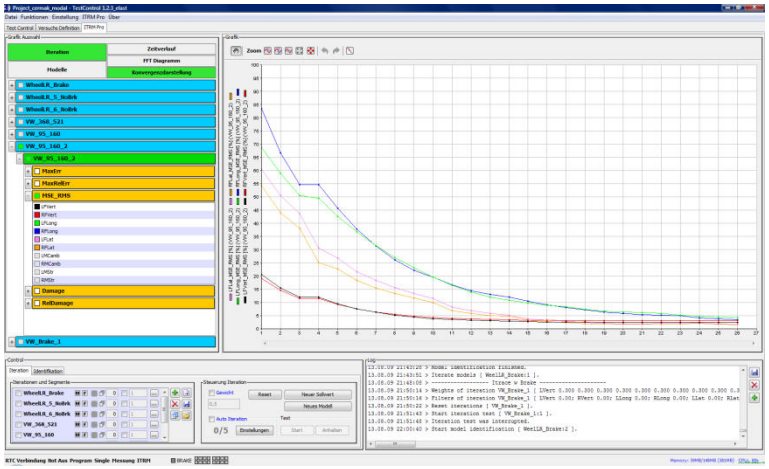
Software ITRM Pro



ITRM-Pro is the Inova frequency domain iteration Software. It is fully integrated in the TestControl package

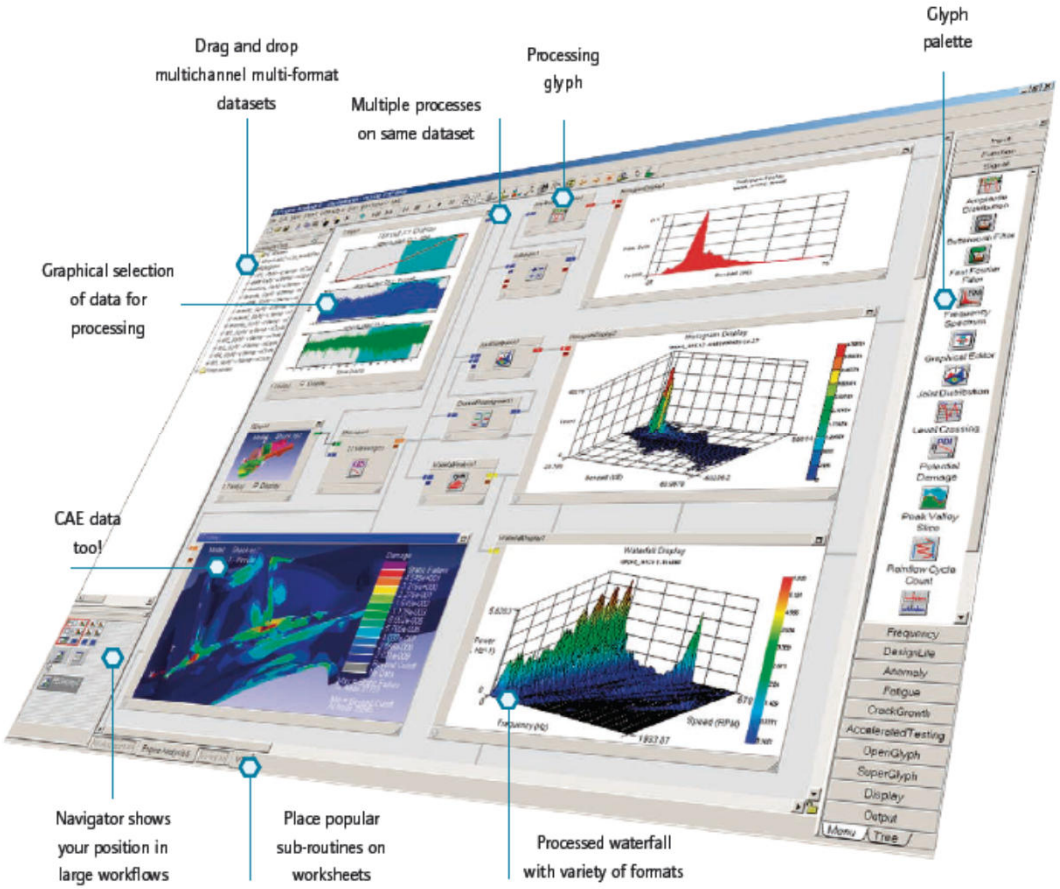
It Easy to Operate It runs fine with the default parameters. For difficult test rigs it has a lot of functions to tune the iteration process





Extended Data processing and fatigue analysis software

(third party software as ad on module)



Fatigue Analysis

(third party software as ad on module)

SN and EN Fatigue analysis

GlyphWorks provides the industry-leading technology you need to calculate fatigue-life from measured data.

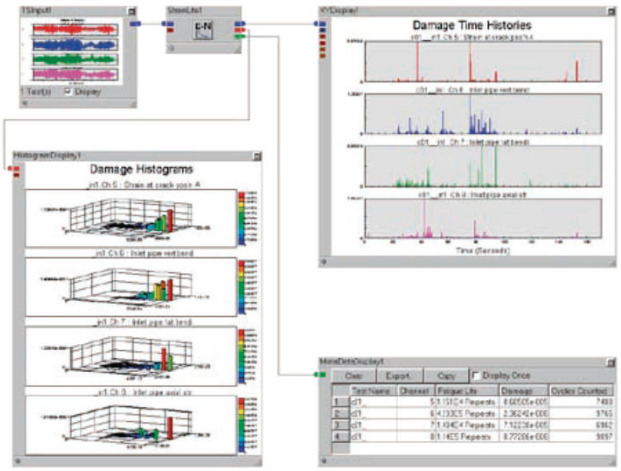
The Stress-Life (SN) method uses a nominal stress approach for high-cycle conditions or non-metallic applications; while the Strain-Life (EN) method is more appropriate for more severe loading conditions (low-cycle fatigue) – where plasticity is significant.

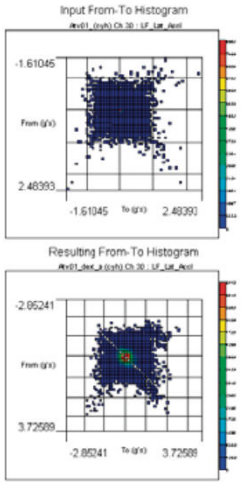
You can correct for mean stress and surface finish effects, even back calculate from each data channel to determine a scale or fatigue concentration factor required to achieve a target life. You could then review damage histograms to determine which load cycles were most damaging, even output damage time histories to show exactly when the damage occurred.

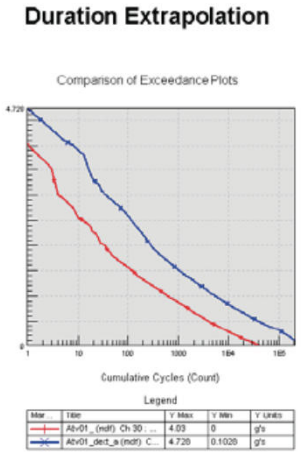
Rainflow manipulation

A suite of advanced rainflow matrix manipulation and analysis tools will help you to combine, edit and extrapolate matrices.

Complete schedules of rainflow matrices to be combined into a single rainflow matrix – effectively creating the same result as driving around different sections of a proving ground. There are also statistical methods to extrapolate new matrices from existing data, either for the effect of duration (e.g. more repeats) or percentile extrapolation from given samples. The effect is more realistic than just multiplying a given matrix by a given factor, as it takes into account the likelihood of statistical variance between different runs or drivers.



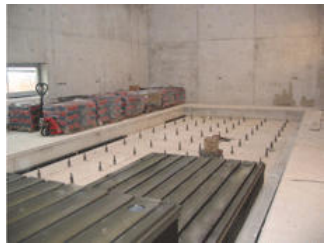




Technical support

Inova provides:

- Layout and design of individual test rig solution
- Design review meetings
- Manufacturing of all essential parts
- Approval and training trips to our plant
- Installation and commissioning of test equipment
- Component and system Training
- Calibration of load and position sensors
- Technical support for customer during the test
- Maintenance



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