# Validation of operation of a hydraulic bascule bridge

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Ronald Kett, FLUIDON GmbH

# What is a bascule bridge?

- A bascule bridge (sometimes referred to as a drawbridge) is a moveable bridge with a counterweight that continuously balances a span, or "leaf", throughout its upward swing to provide clearance for boat traffic
- It may be single or double leafed

# What has FLUIDON to do with a Bascule Bridge?

- The operation of bascule bridges is a safety-critical application
- All parts (mechanics, hydraulics, control, …) have to be checked for function, operability, and safety
- Although the movement is very slow, there might be high dynamic forces e.g. in case of an emergency stop
- During design of the bridge a review of the hydraulic system by simulation is often prescribed

- That's where FLUIDON comes into play:
  - FLUIDON has large expertise in verification and optimization of hydraulic systems
  - FLUIDON is an engineering service provider specialized in the field of fluid power systems and simulation of fluid power
  - The simulation software DSHplus is a product of FLUIDON

- Task: Validation of operation of the hydraulic system of the new Rethe bridge in Hamburg

# Some Impressions

## Best known bascule bridge

# Some facts

## New construction of Rethe bridge in Hamburg

- Span length: 104 m
- Width: ~ 25 m
- 4 leaves with a length of 50 m each
- Separation of road and rail traffic
- largest bascule bridge of Europe
- replaces a vertical-lift bridge

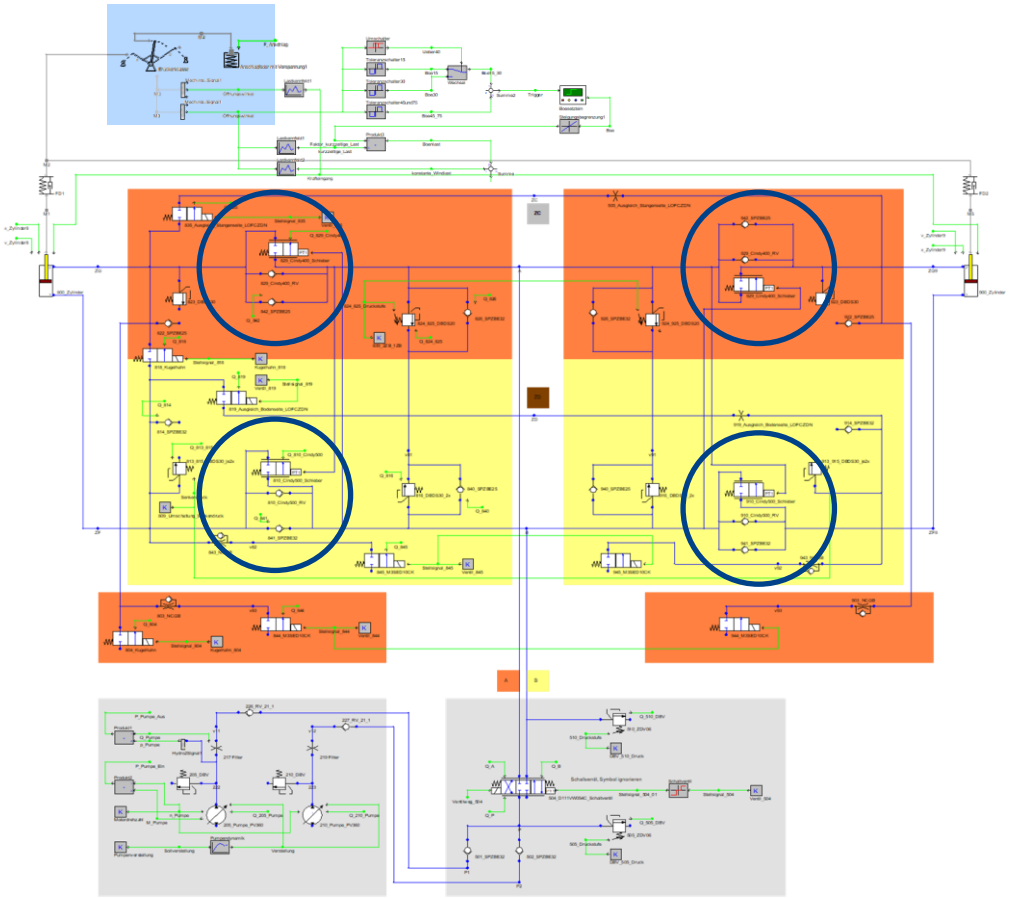
- Utilization:
  - more than 7.000 trucks and passenger cars per day
  - about 30 freight trains per day
  - about 40 ships per day

- 8 hydraulic cylinders with a length of 6.500 mm and a diameter of 560 mm
- 8 hydraulic cylinders with a length of 600 mm and a diameter of 250 mm for locking

# Simulation Model

## Overview

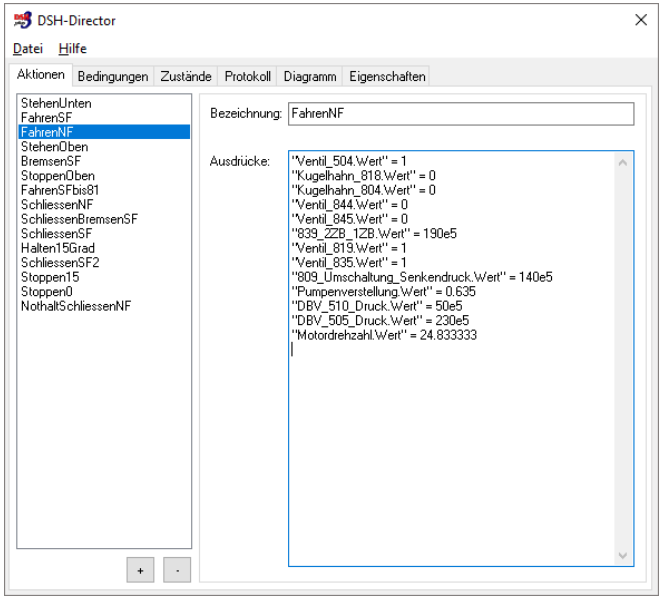
- independent hydraulic circuits for each span
- therefore simulation of a quarter of the whole system (2 pumps, 2 cylinders)
- mechanical model for one span with inertia, friction and static loads
- additional model for wind load
- central safety elements are counter balance valves mounted directly to each cylinder port
  - secure cylinders against moving under load or their own weight without actuation
  - need a pilot pressure for opening
  - for stable function the damping has to be fitted



# Simulation Model

## Control of Motion by DSH-Director

- Realization of movement profile using a finite state machine
- Inside DSHplus is represented by DSH-Director




- Representation for 9 different load cases for regular operation and also for operation with just one cylinder per span



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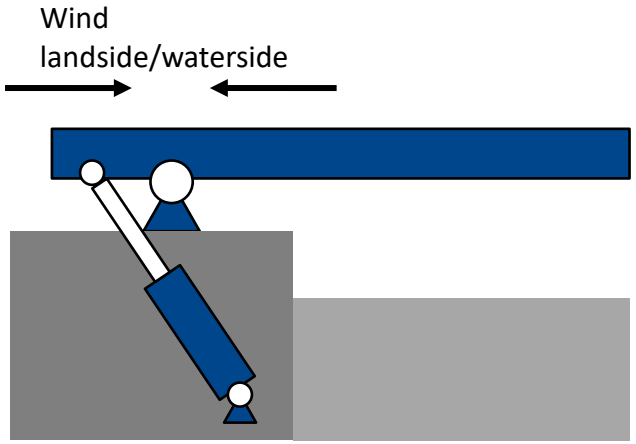
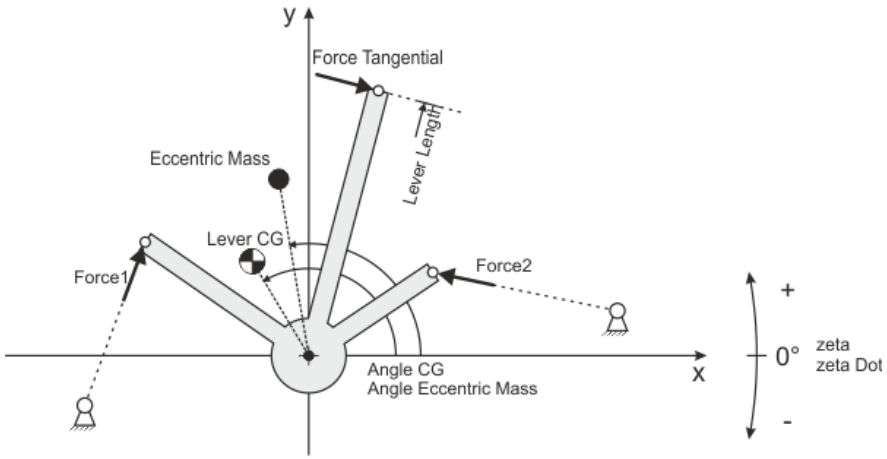
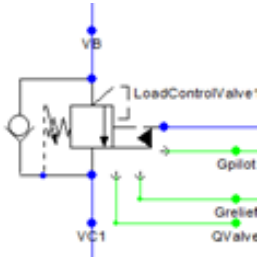
# Some detailed Solutions

## Span and cylinder linkage / counter balance valve

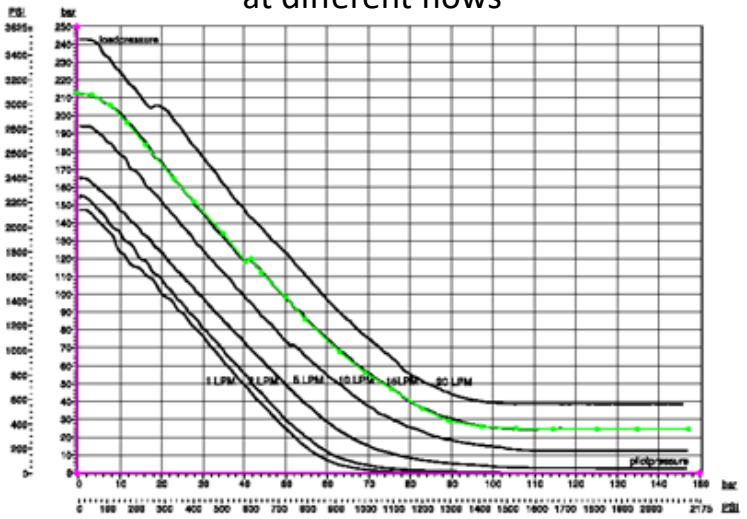



Counter Balance Valve




System pressure versus pilot pressure at different flows





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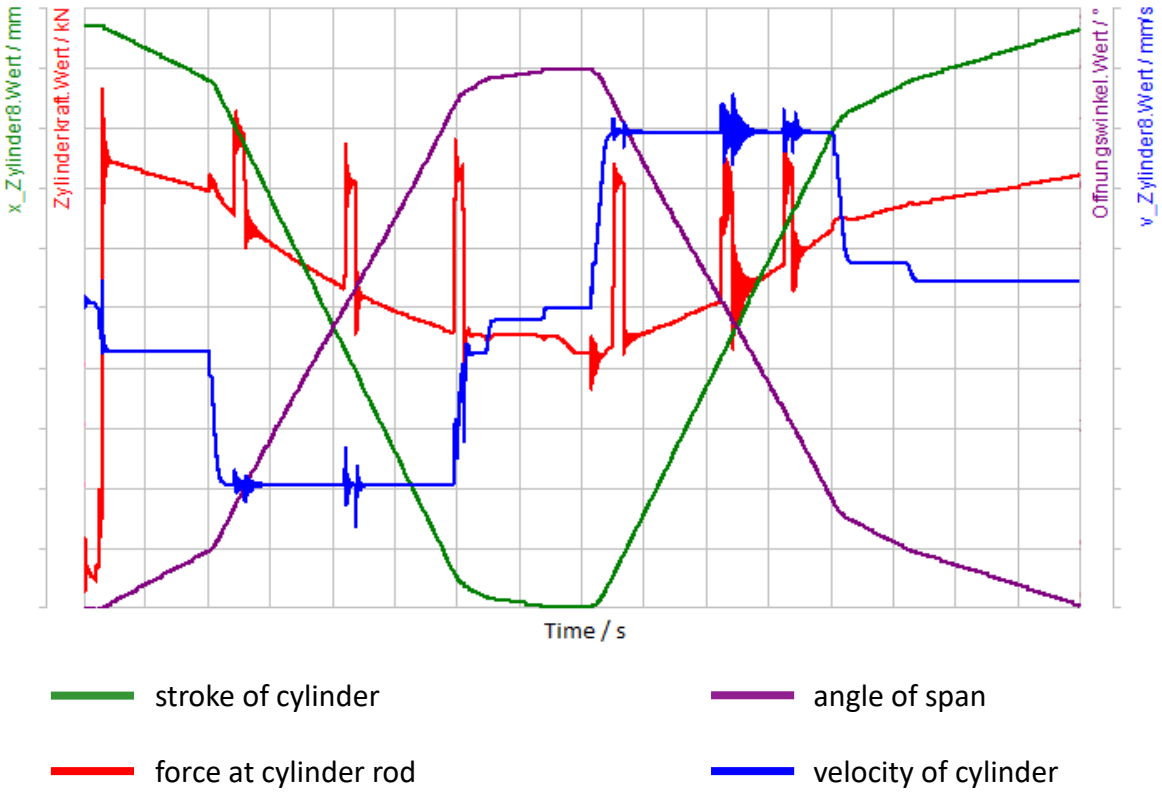
# Results

## Example of movement with gusty wind



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# Results

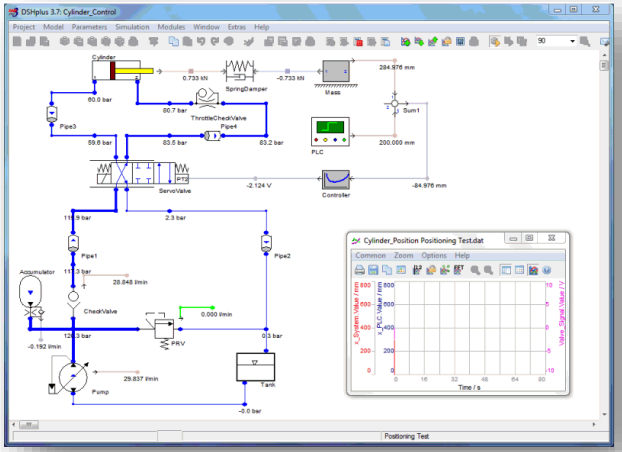
## Is it safe?

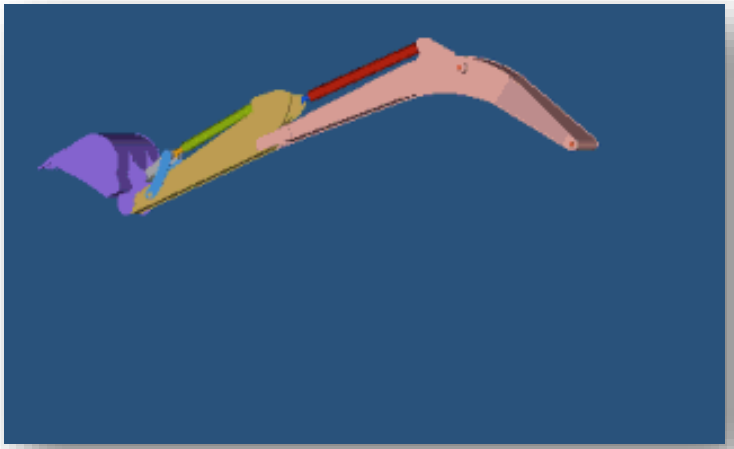
- The design of the hydraulic system and the control is very robust and fulfills the safety demands
- Only two points had to be reviewed or changed:
  - Due to simulated dynamic forces in addition to static forces the steel structure had to be rechecked
  - The damping of counter balance valves had to be adopted to achieve a smoother force progression in case of an emergency stop
- After a long building phase the bridge now is authorized for full road traffic (2016)
- Train traffic is in test phase
- Next step is to remove the old bridge

# Extension of Application

## Improvement of mechanical model by co-simulation

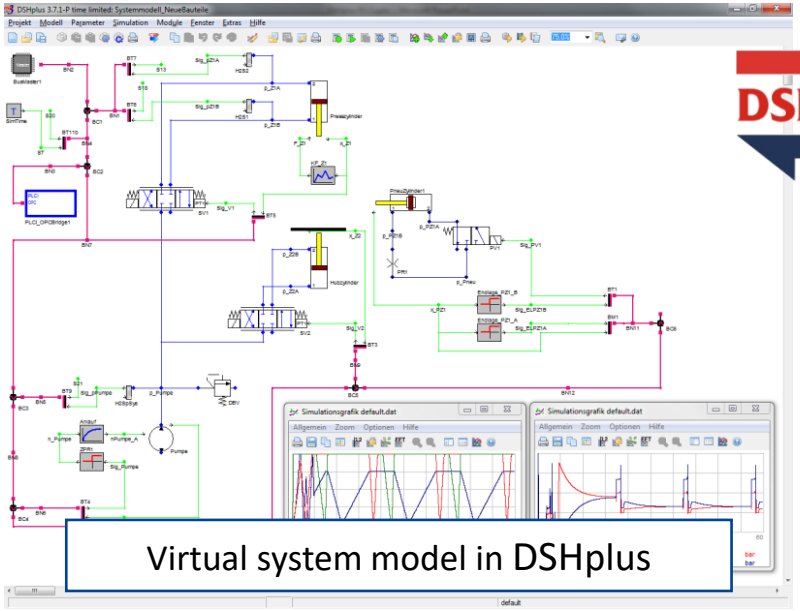
- DSHplus has a limitation in modelling of more complex mechanical structures
- Different interfaces help improving this part of the simulation model
- Within Altair Partner Alliance DSHplus can co-simulate with Motion Solve, solidThinking Activate and others
- Used technics are
  - user modules for Motion Solve created automatically by DSHplus
  - FMUs (Functional Mockup Units) for solidThinking Activate and others





# Extension of Application

## Replacement of internal control by real PLC

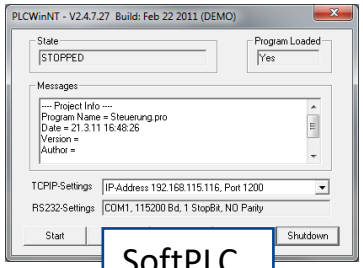


Virtual system model in DSHplus

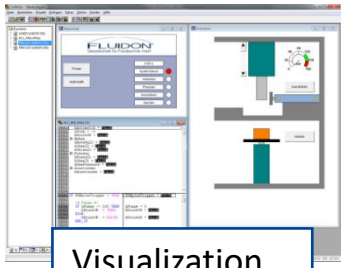
DSHplus-PLCI

OPC FOUNDATION

Server




SoftPLC

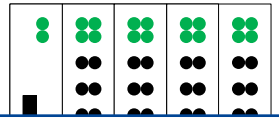


Visualization

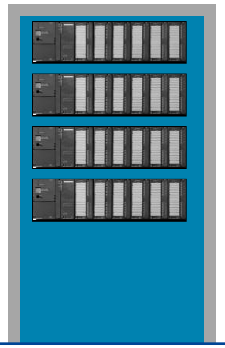
DSHplus-PLCI

PROFIBUS PROCESS FIELD BUS

Hardware Interface



I/O-field bus node



Control cabinet



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Thank you for your attention.

DSHplus

More than 20 years experience in simulation of fluid power systems