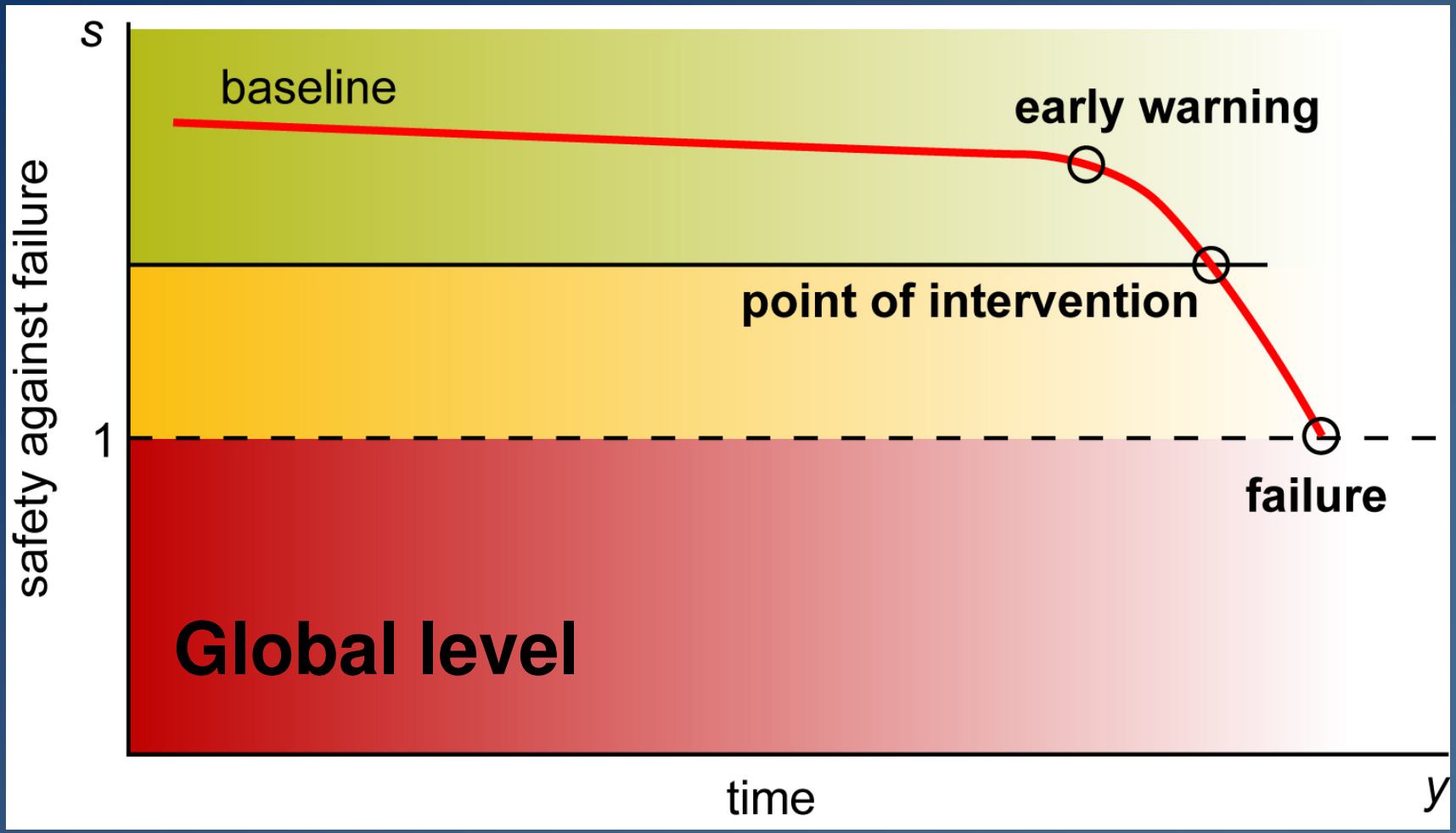
CSHM-2 Workshop

Taormina, 29.9.-1.10. 2008

On the necessary combination of SHM with WIM procedures

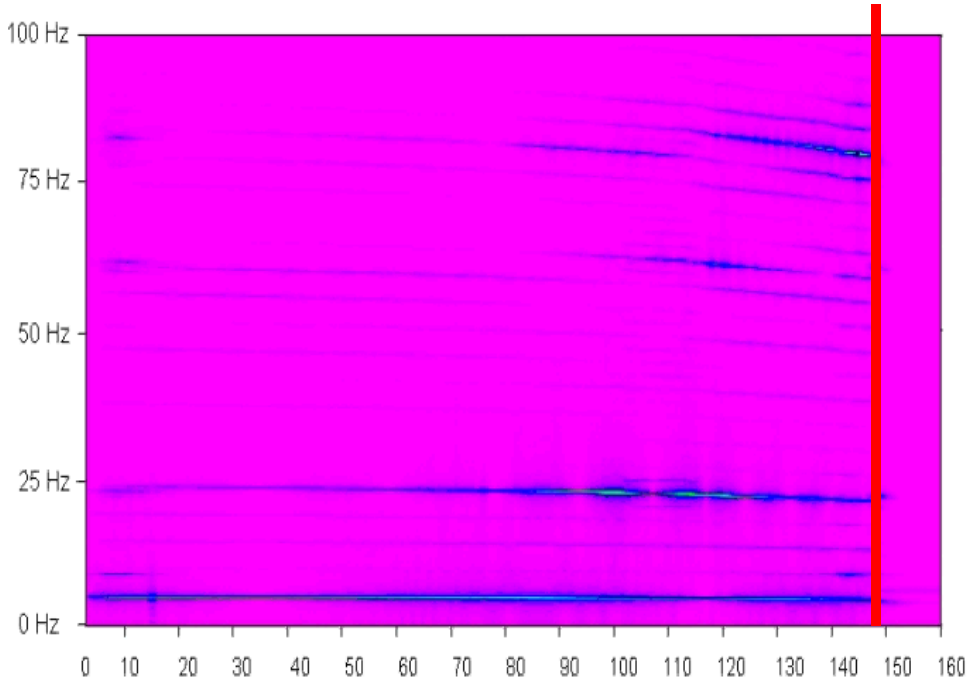
Helmut WENZEL



Typical Life Cycle of a Structure

vce

Failure



Results from accelerated Fatigue Test

Europabrücke

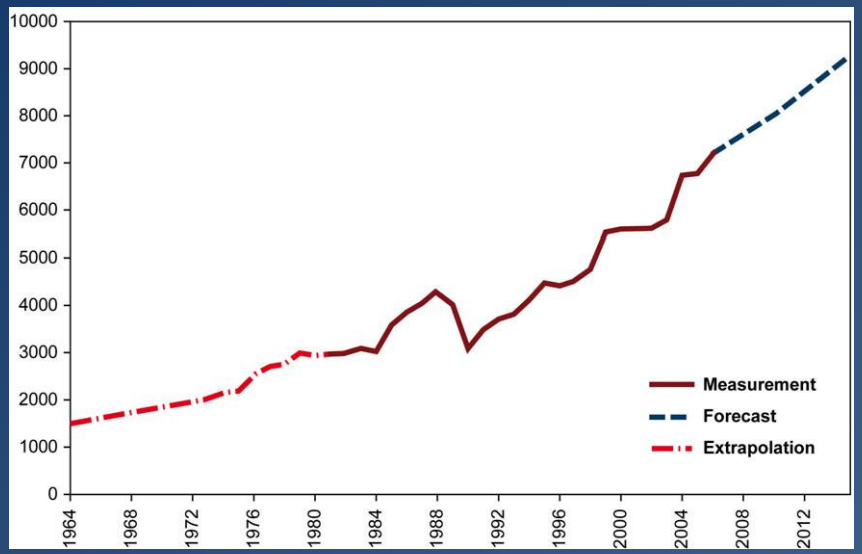
VCE

- Traffic loads and volume have changed dramatically over time (+500%).
- Despite known deficiencies we have to keep our infrastructure operating safely
- Any realistic assessment requires information from monitoring data
- Decision Support Systems help to do this properly

Scope

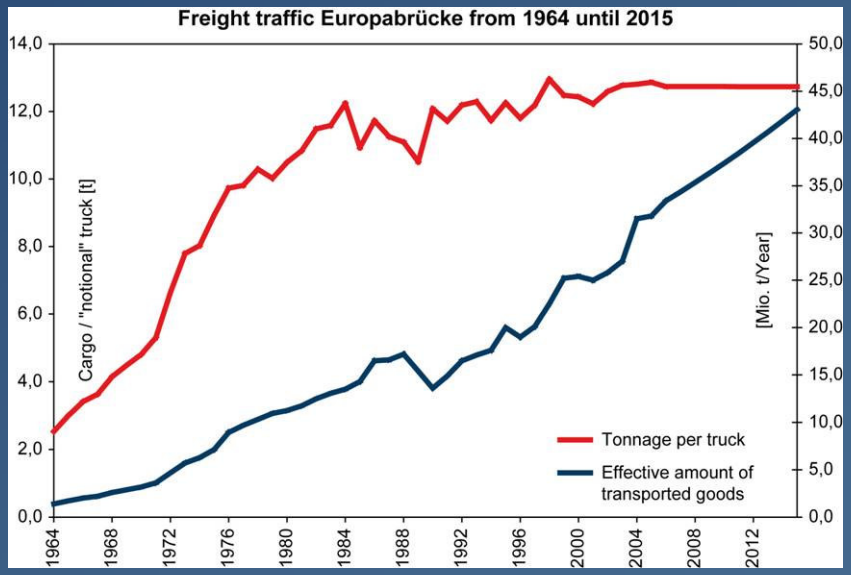
vce

Progression of freight traffic volume at the Europabrücke from 1964 until 2015 [trucks/day]



Traffic volume in 2006 increased to an amount of 472 % in relation to 1964 and is expected to grow 2.9% per year until 2015.

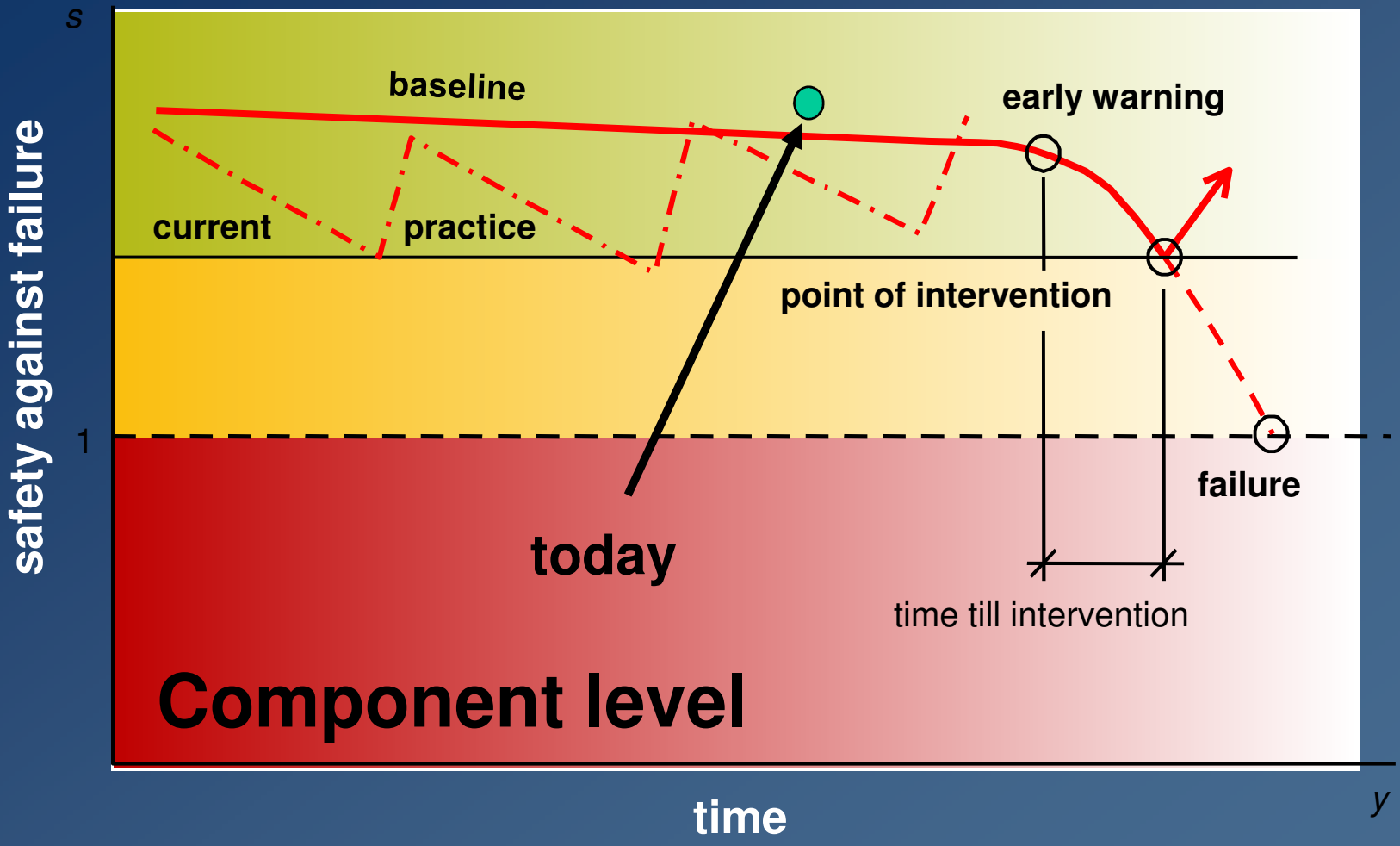
Effective amount of transported goods compared to a calculated cargo per notional truck



The truck utilisation in 2006 increased to an amount of 503 % in relation to 1964 and is assumed to have already reached a maximum.

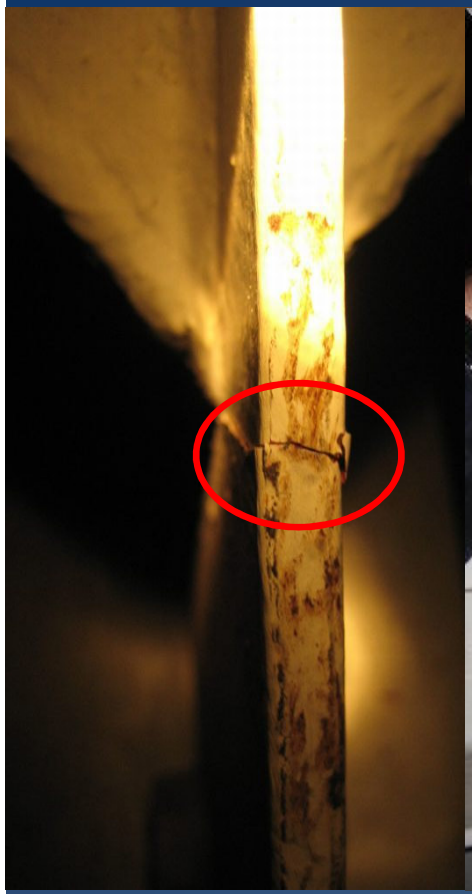
Freight Traffic - Situation

vce

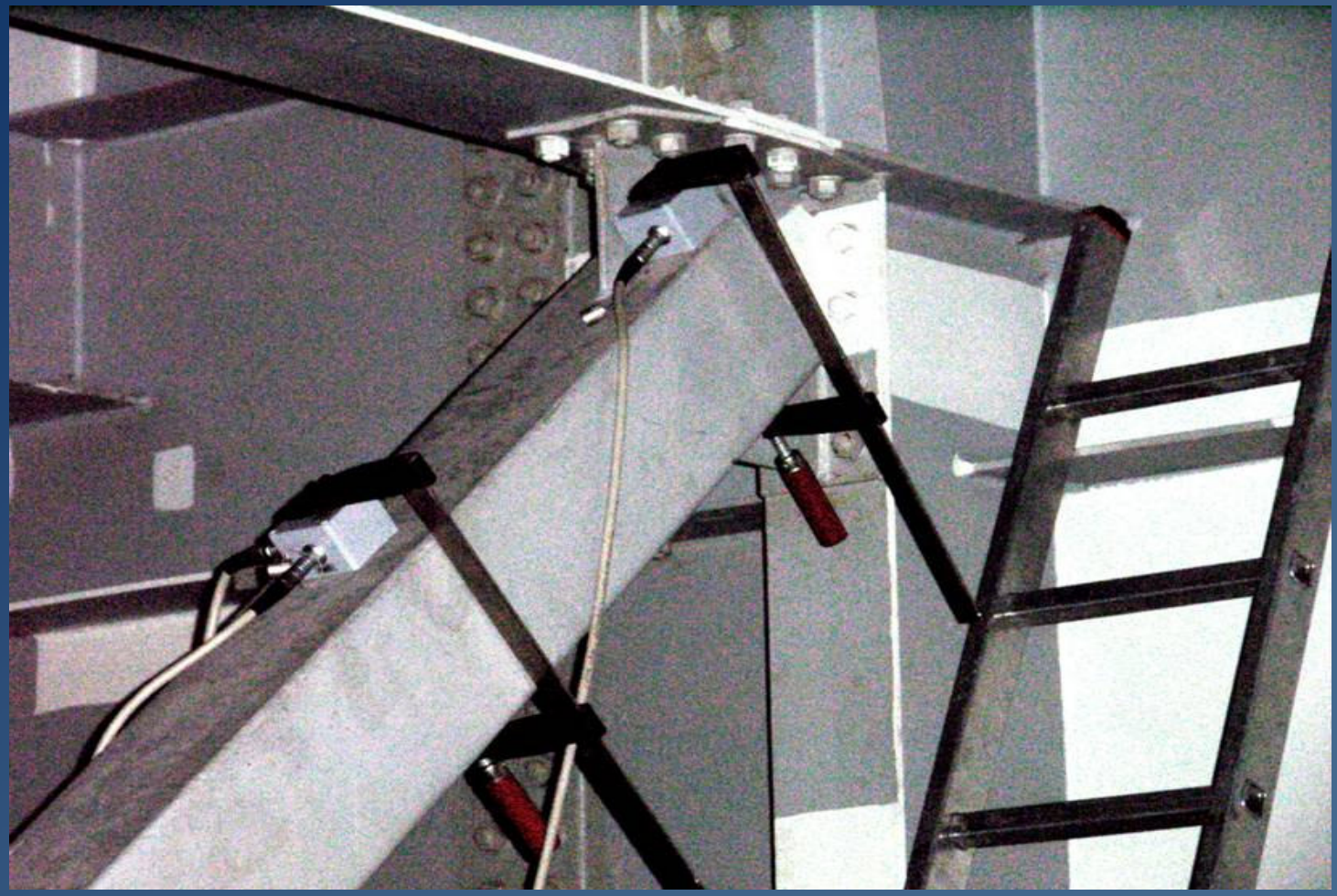


Early Warning, Point of Intervention

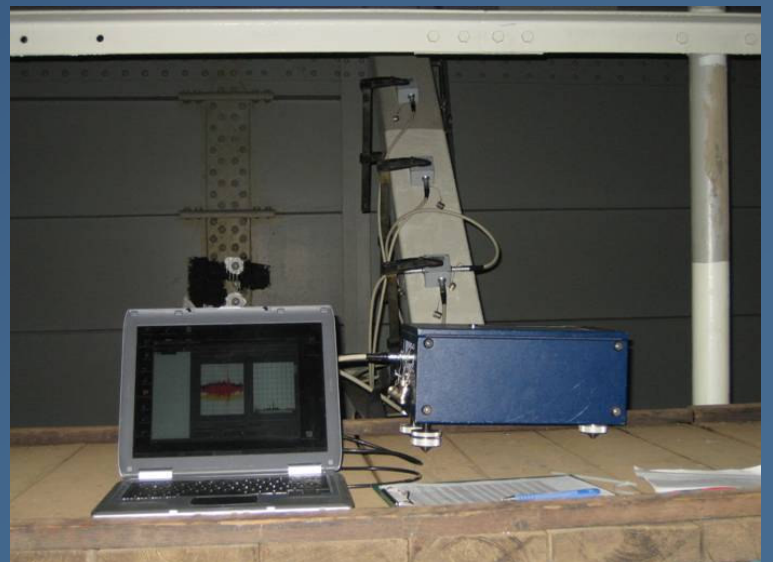
vce



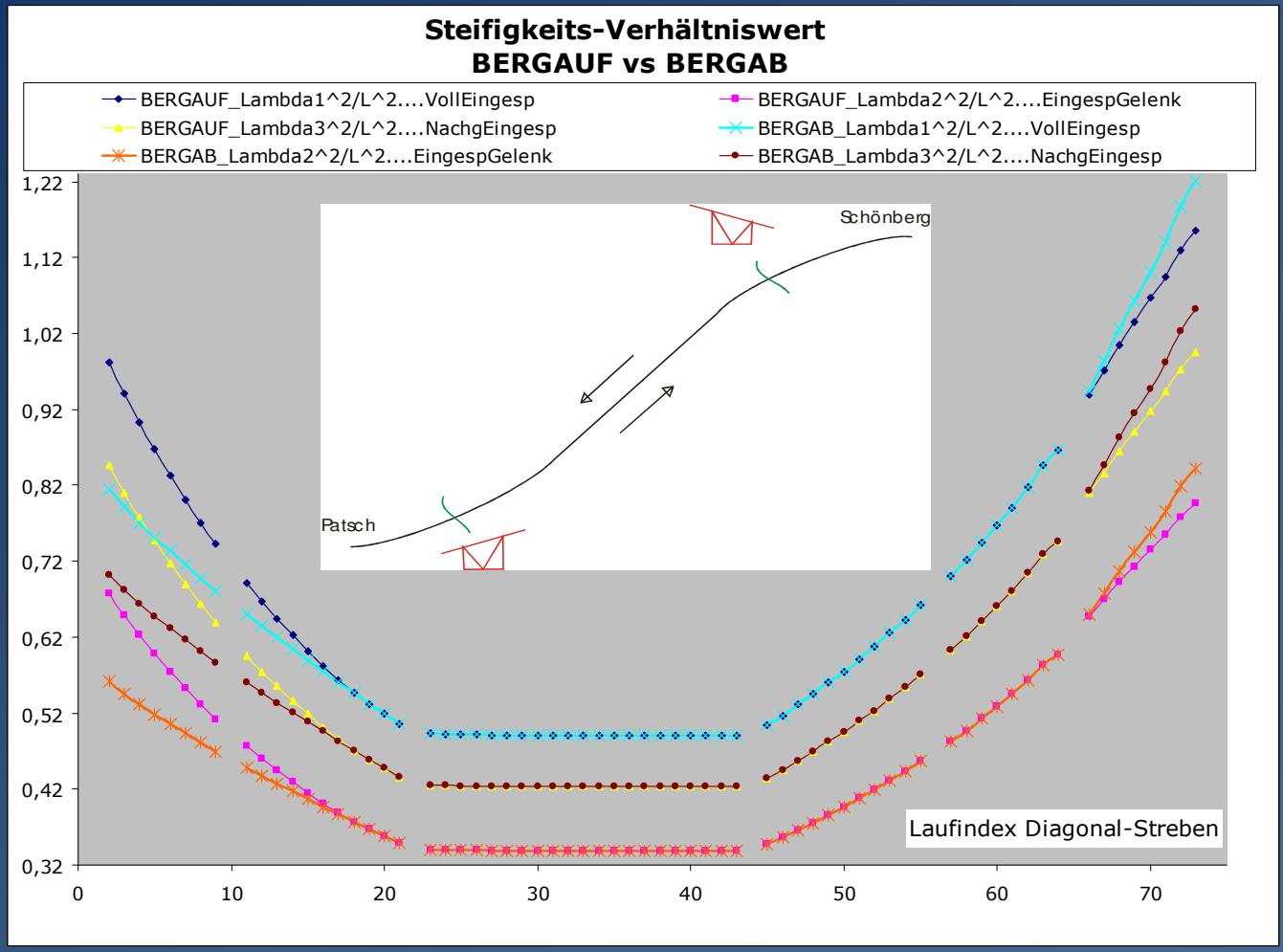
Cracks from Fatigue and Overload



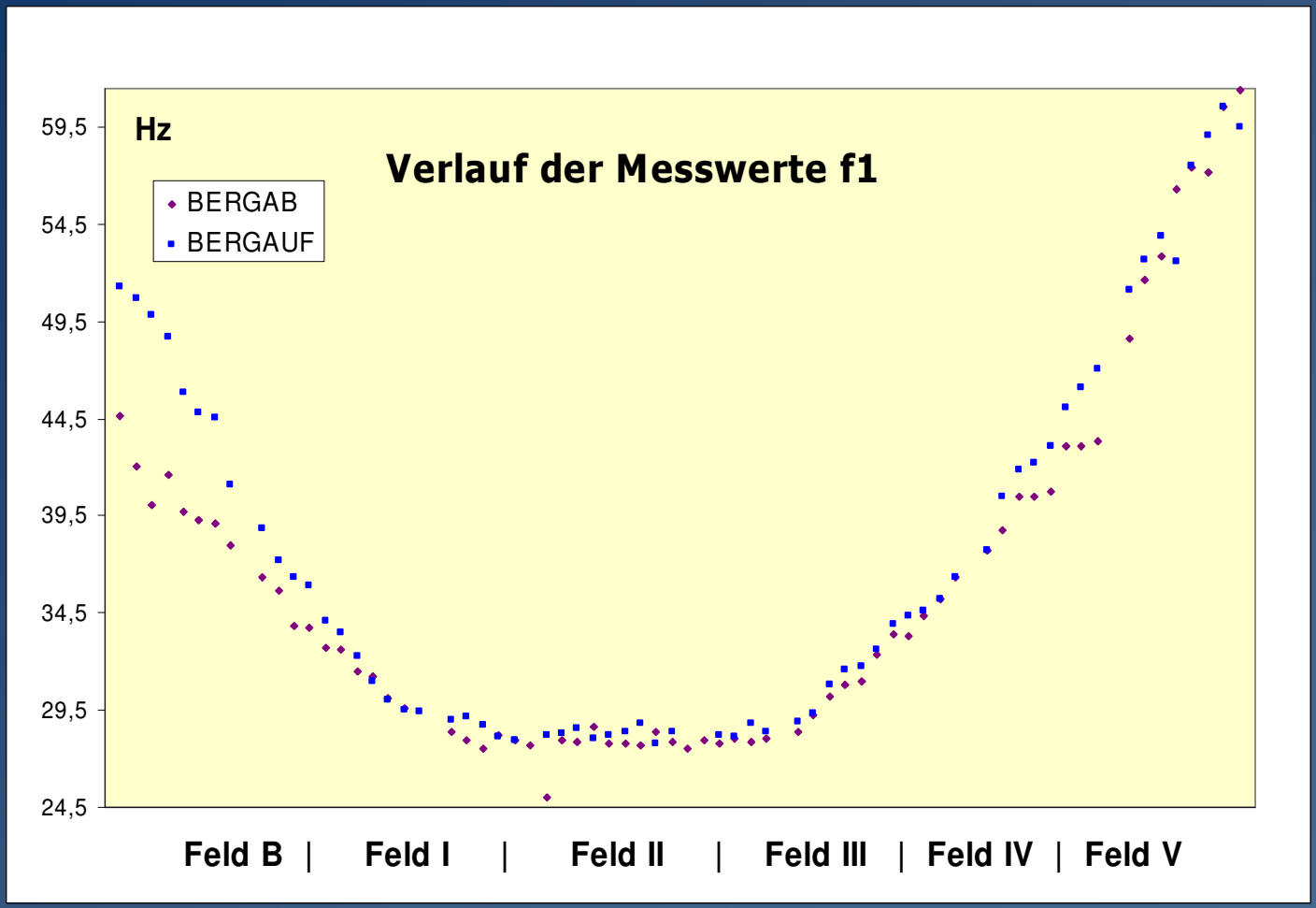
Weak Point Determination



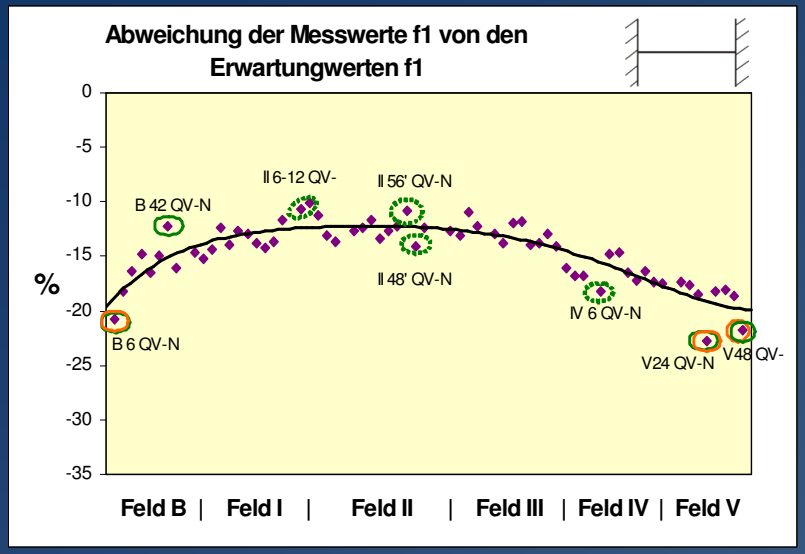
MONITORING CAMPAIGN

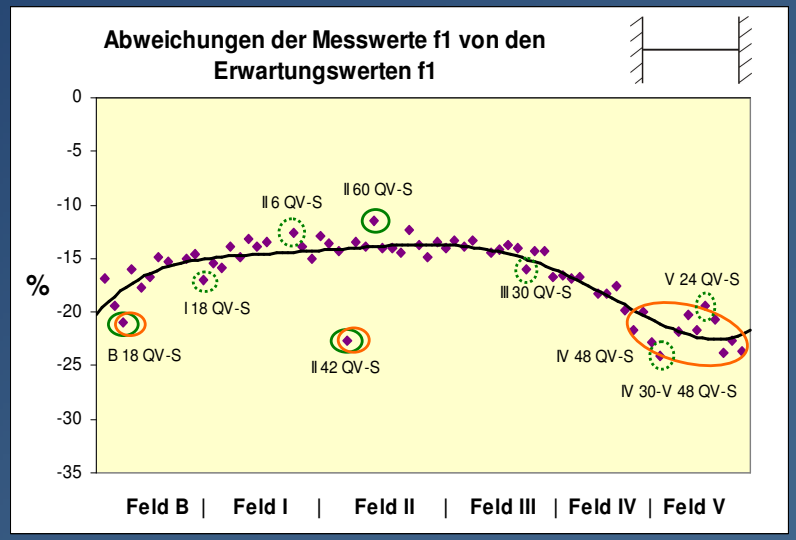


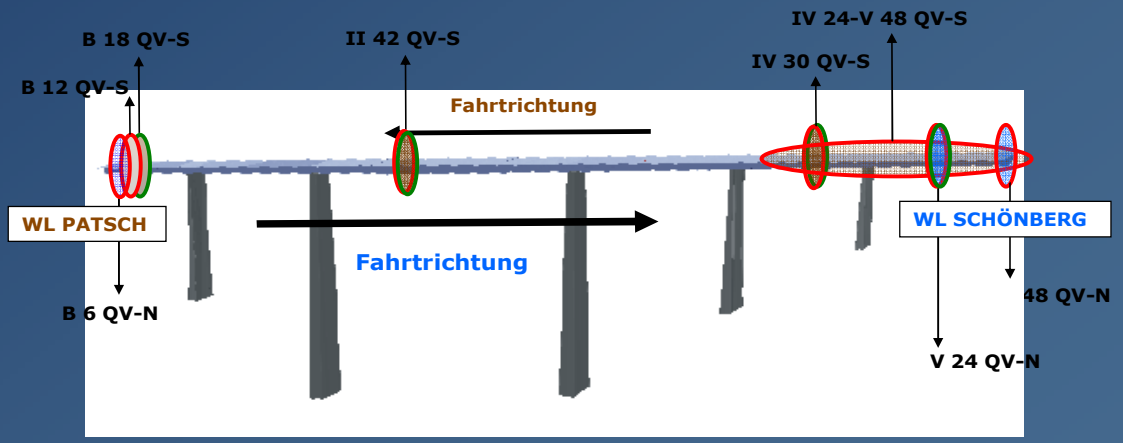
EXPECTED RESULTS FROM CALCULATION



RESULTS OF THE MEASUREMENTS







Weak Point Determination

ISHMII, Taorrmina, Sept. 2008

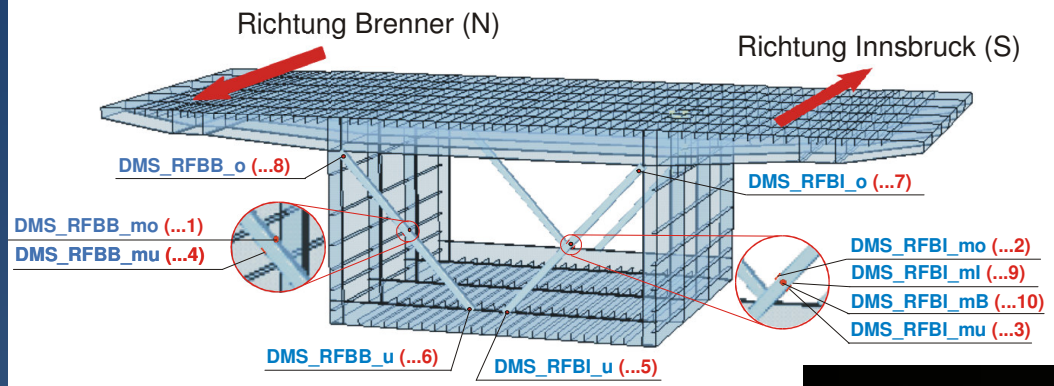
VERIFICATION by STRAIN GAGES

WIM

DMS - Profil (V30 QV-N und S)
Sondermessung Mai 2007

Sensor: Spider 8_1 CH...
Nummerierung nach Reihenfolge der Montage

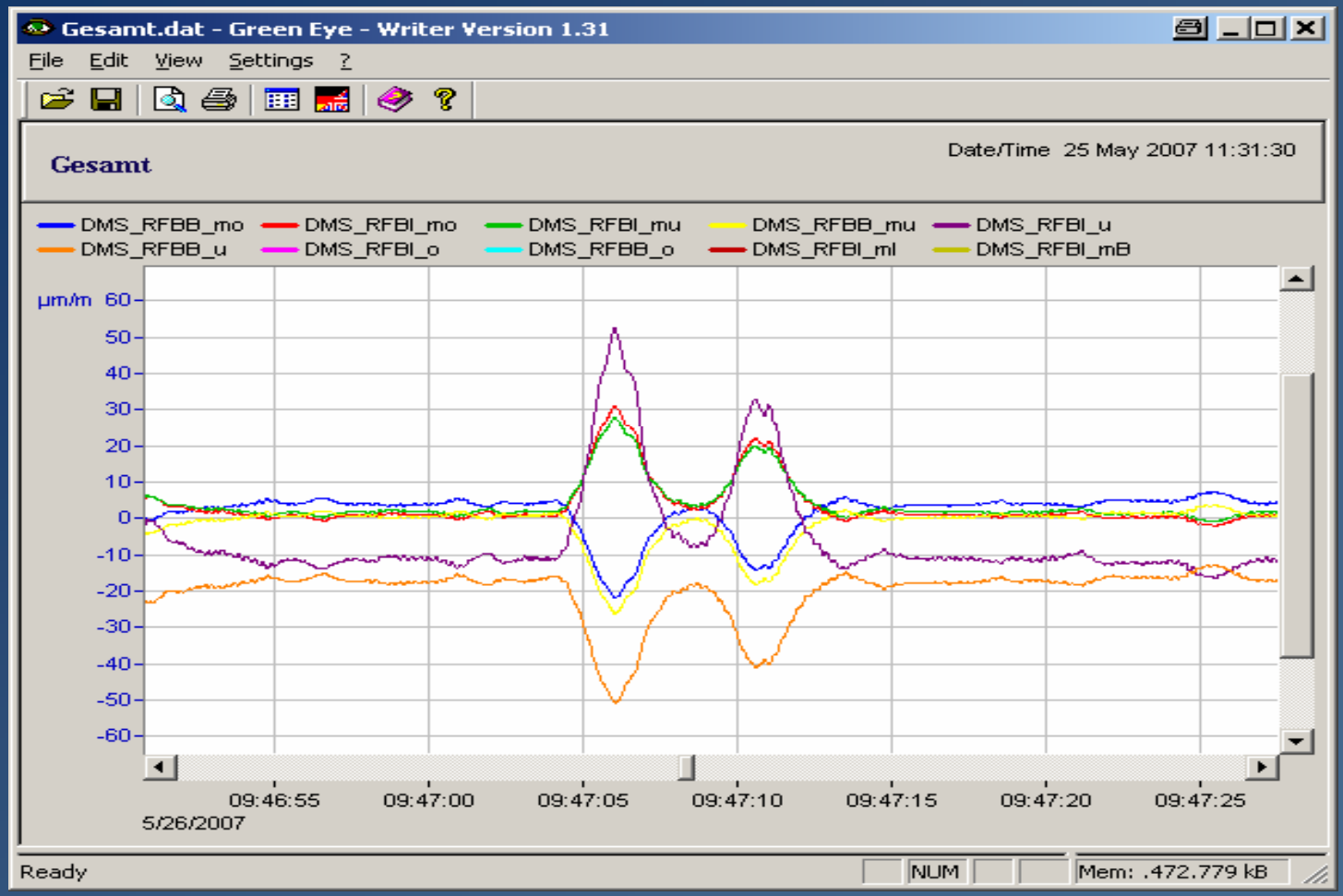
Stationierung des Profils: x = 621m (entspricht 36m von WL Schönberg)

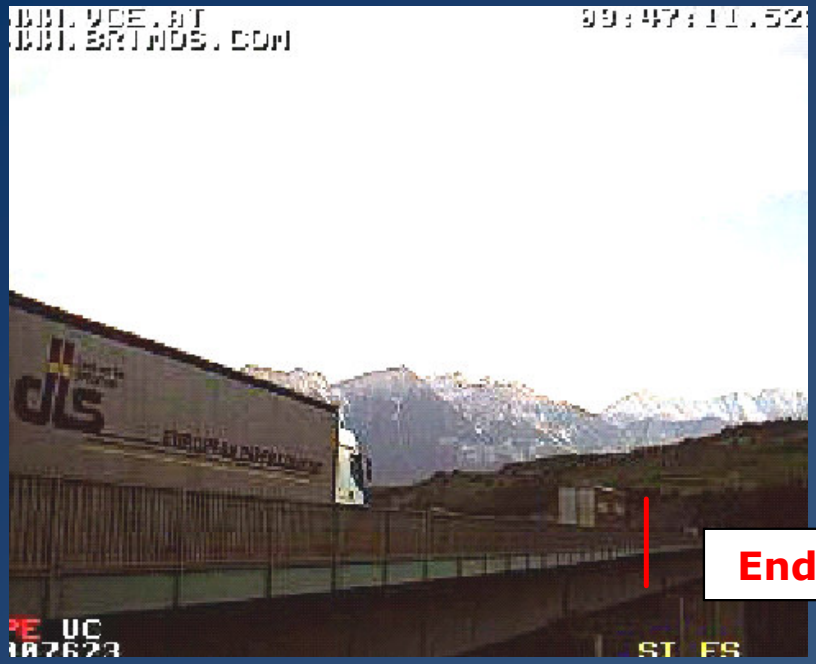


chluss

RFBI_o...Richtungsfahrbahn In
RFBI_mo...RFB Innsbruck, Stre
RFBI_mI...RFB Innsbruck, Stre
RFBI_mB...RFB Innsbruck, Stre
RFBI_mu...RFB Innsbruck, Stre
RFBI_u...RFB Innsbruck, unter

WIM


Gesamt.dat - Green Eye - Writer Version 1.31
File Edit View Settings ?
Gesamt
Date/Time 25 May 2007 11:31:30
DMS_RFBB_mo
DMS_RFBI_mo
DMS_RFBI_mu
DMS_RFBB_mu
DMS_RFBI_u
DMS_RFBB_u
DMS_RFBI_o
DMS_RFBB_o
DMS_RFBI_ml
DMS_RFBI_mB
µm/m
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
09:46:55
09:47:00
09:47:05
09:47:10
09:47:15
09:47:20
09:47:25
5/26/2007
Ready
NUM
Mem: .472.779 kB



ZWEI LKWs

Dyges-Zeit 09:40:25
Video-Zeit 09:47:11

v= 48,16 km/h; 44,93 km/h
Dyges = 5,9721 mm ; 4,0974 mm
=>
Scaling Factor = 0,749 ; 0,758

Dygeskal = 4,4731 mm ; 3,1058 mm

Entsp. 35 t
22 t

v-Klass 45-50 km/h; 40-45 km/h

WIM

Corresponding LOAD MODEL

- Truck load at time of design (1959) 25 ton
- Truck load changed to 44 tons
- Axle load increased from 8,5 to 11 tons
- Some structures cannot comply with the current codes (not this one)
- Nevertheless many of them remain in service (for various reasons)
- Can Monitoring help?

Changes in the Code

vce

- The actual global load model is determined by monitoring (local by separate unit)
- At Europabrücke the actual global load is in average 55% of the load model in EC
- The worst case recorded in 3 years is 60%
- Probabilistic models can be considerably improved by monitoring data
- The follow-up is made easier

WIM results in the Assessment

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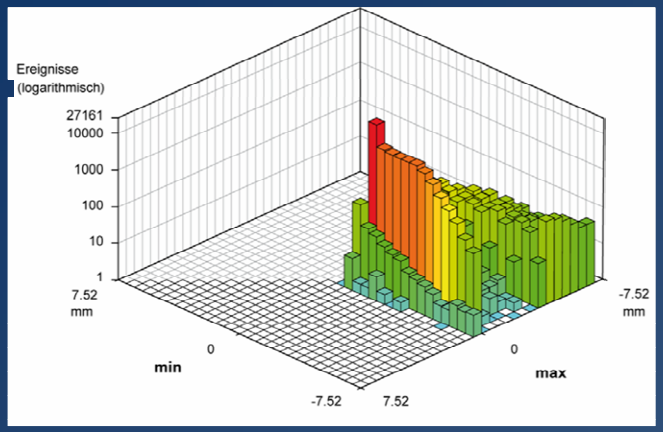
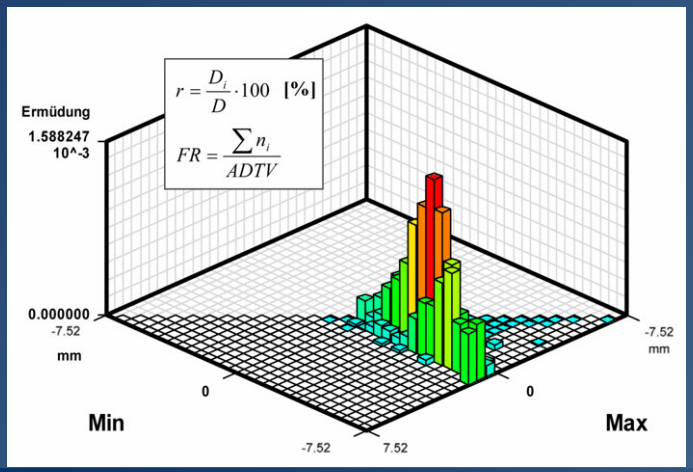
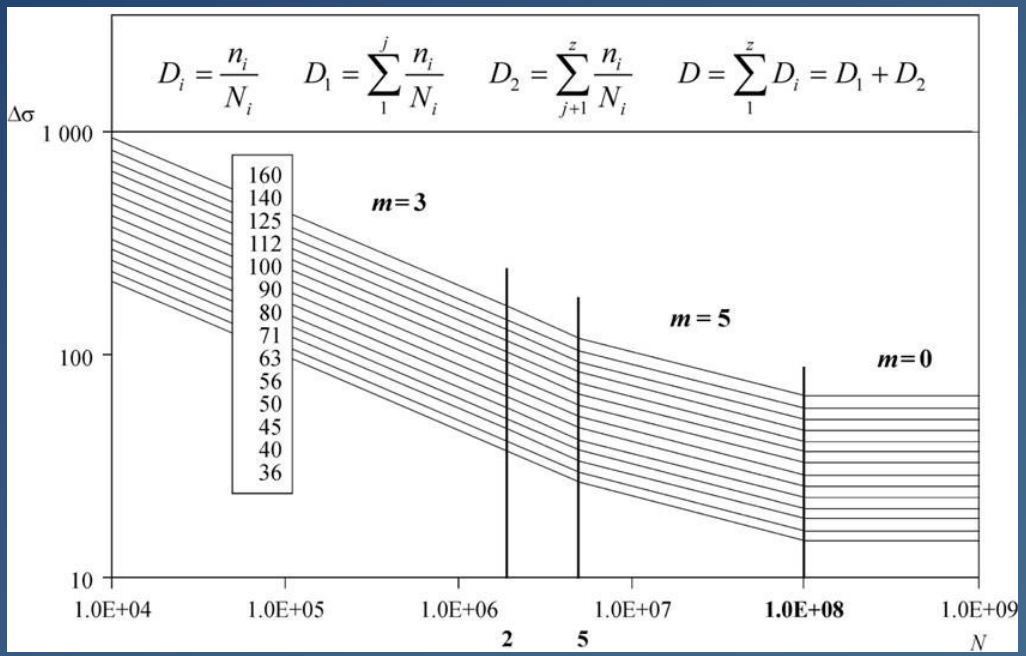
Rainflow Matrix



Damage Matrix

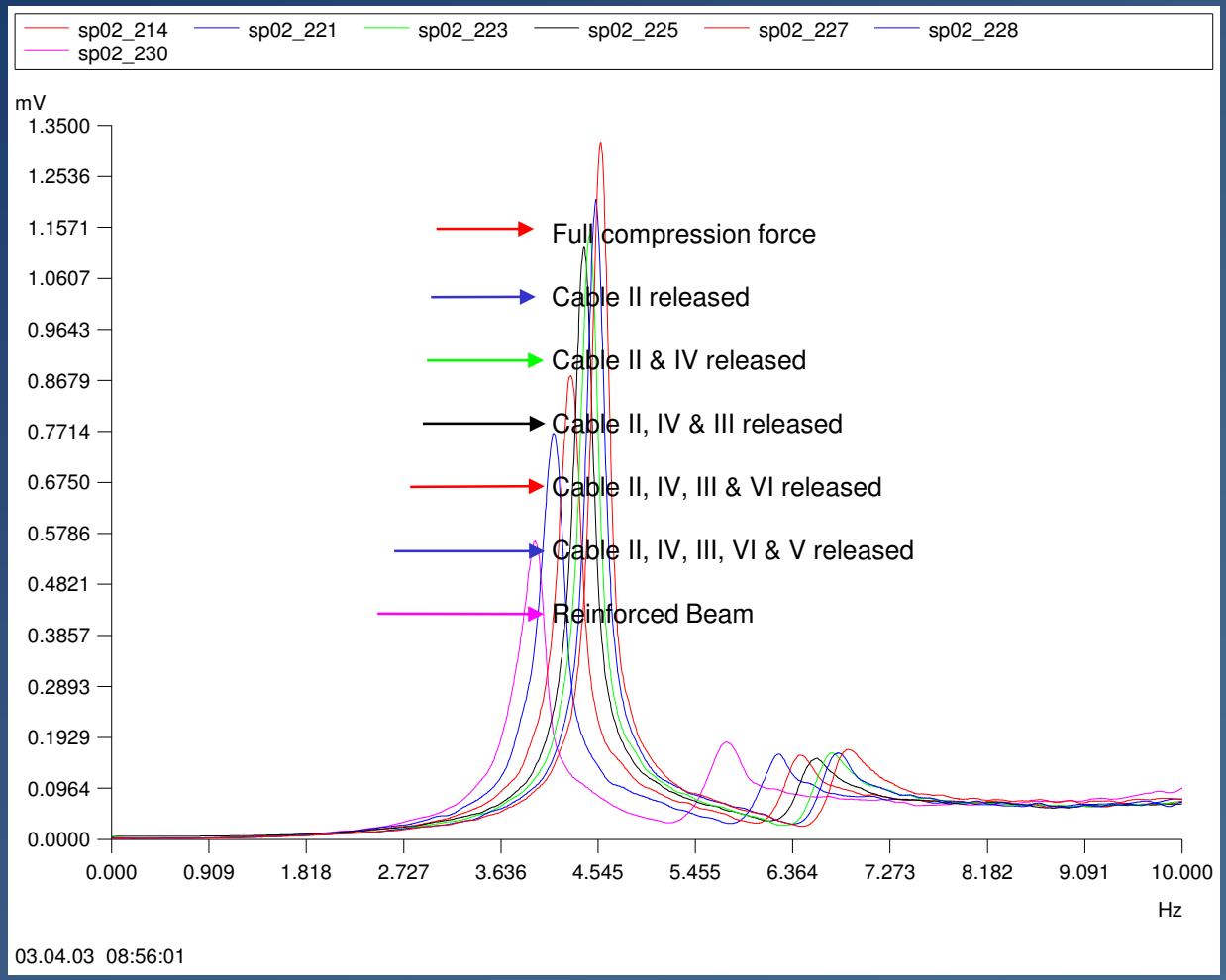




Remaining Lifetime : 32,2 Years

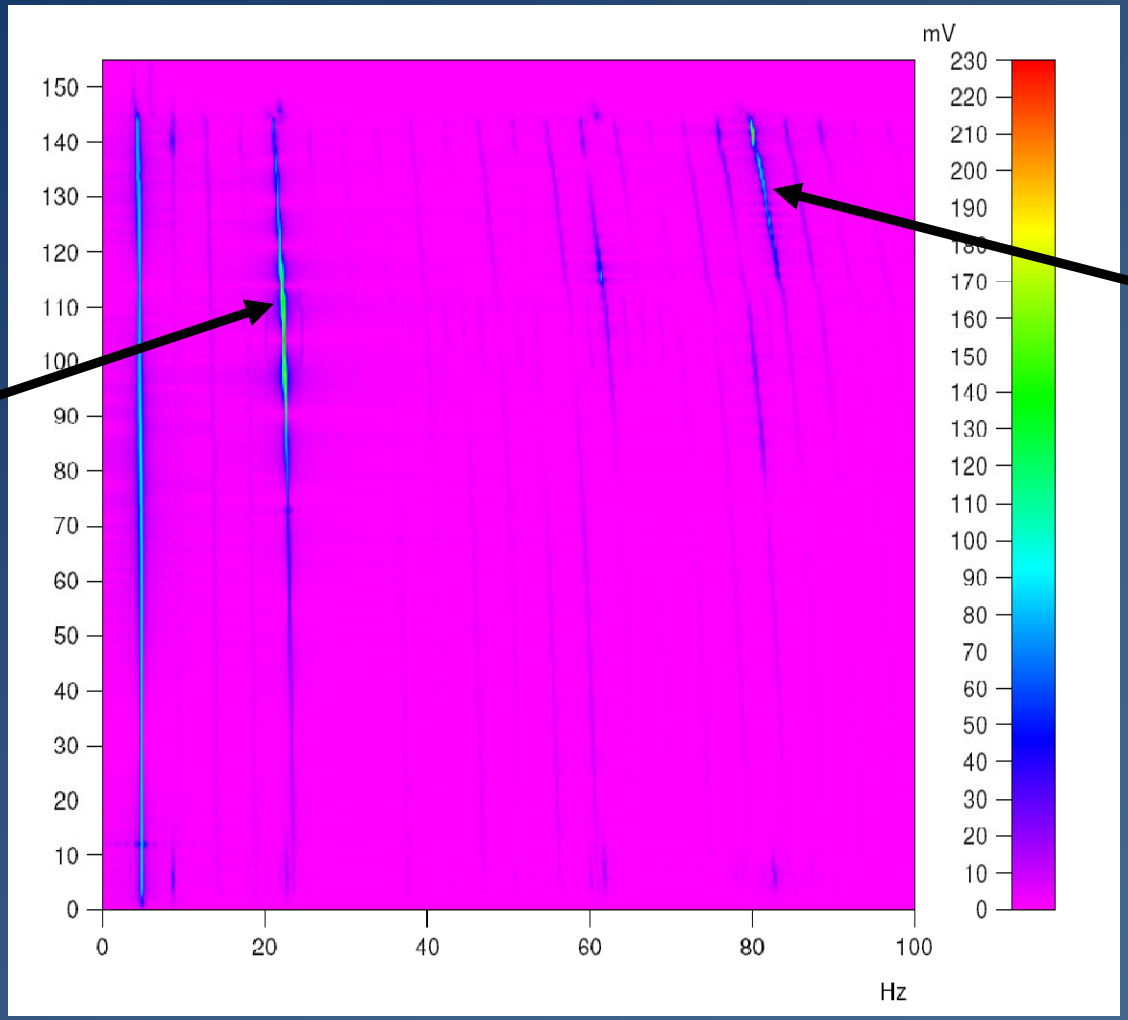
Performance Prediction

Reduction of frequencies and amplitudes



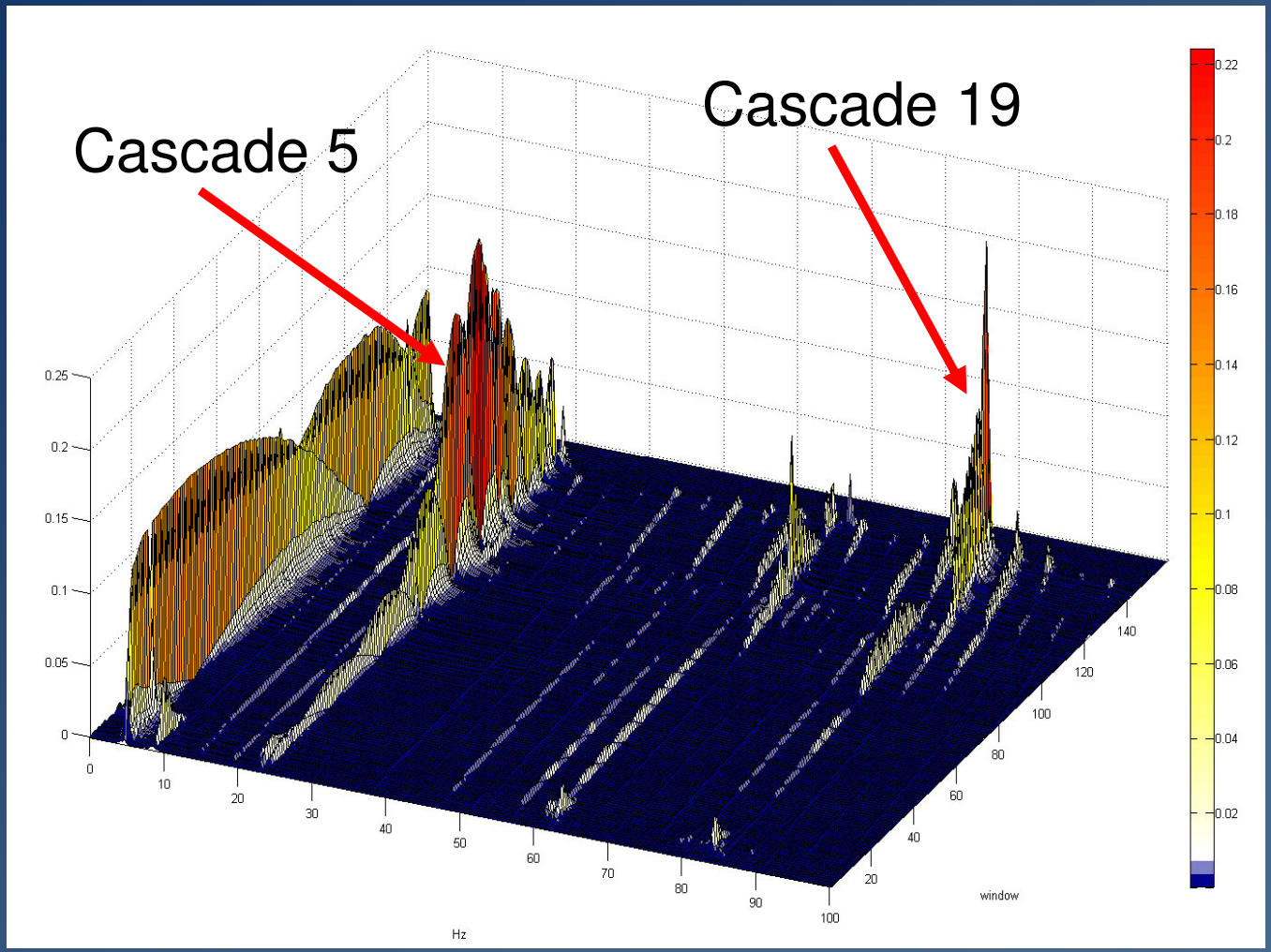
Frequency Development

Mode 5



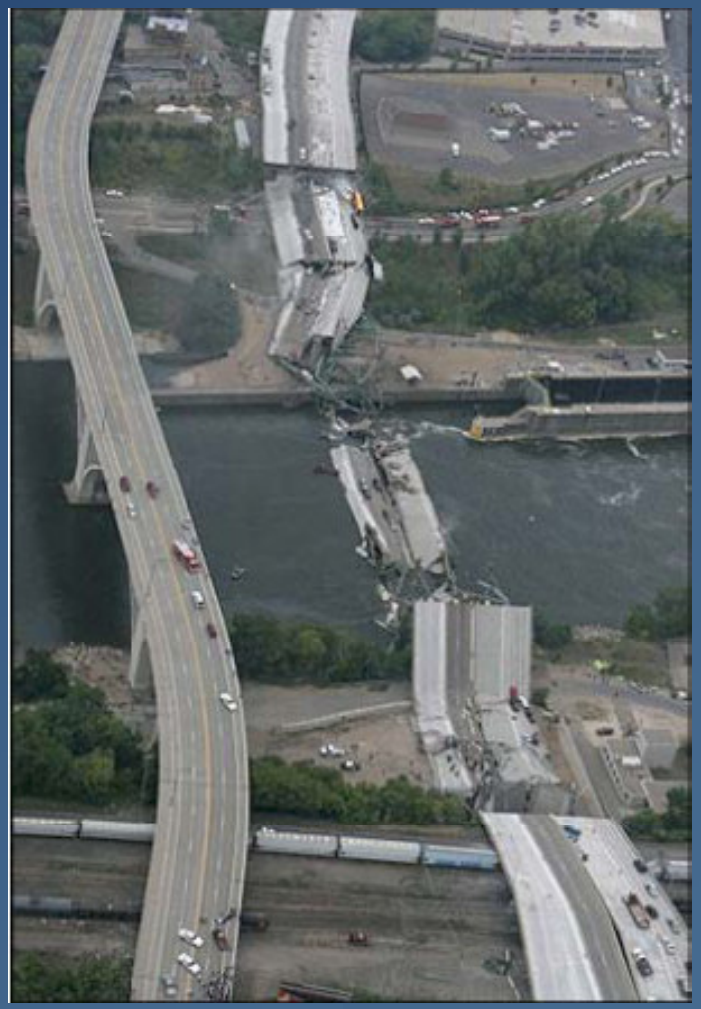
Mode 19

VCE Damage Detection



VCE Damage Detection

- Avoidable by Monitoring?



1. August 1976 -- Aug. 1st 2007

VCE

I-35 Motivation for Health Monitoring ?

VCE

- A gusset plate has been wrongly designed (1/2” instead of 1”)
- Dead Load has been increased by 20% over the 40 years of life
- During retrofit works a local pile of gravel (190 tons) has triggered the failure

- Could Monitoring have helped?

I-35 Collapse (FHWA view Sept. 2008)

vce

Monitoring retrofit works in Austria

vce

BRIMOS

VCDECIS

BRIMOS Rating Matrix

Evaluation		1 very good		2 good		3 fair		4 moderate		5 bad	
Impact		high	low	high	low	high	low	high	low	high	low
low	low	low									low
	high			low			low	significant			
slight	low		low	significant						significant	
	high					high					high
moderate	low				high		very high			very high	
	high		low			very high				extreme	
serious	low		significant					extreme			
	high					very high					
very serious	low										
	high	low	significant		high		extreme			extreme	

- A knowledge based approach has enabled better assessment results
- New promising methodologies are emerging and should be used
- There is still a gap in knowledge requiring further investigations and research
- The FP7 IRIS Project will bring progress
- Summer Academy and Tutorial Sept. 09

Conclusions

vce

ISHMII, Taorrmina, Sept. 2008

VCE

Thank you for your attention

IRIS

Integrated European Industrial Risk Reduction System

CP-IP 213968-2

IRIS Industrial Safety

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