



# DESIGN AND PRODUCTION OF HIGH-TECH COMPONENTS OF CABLEWAY VEHICLES

Claudio Tonetta

# INTRODUCTION

## Vehicles

European Directive 2000/9 CE

- Risk analysis

Safety components according EN 13796

- Structural verification
- Quality requirements for material and welding process
- Traceability



MM PisaMover, IT



GD10 Castelir Le Fassane, IT







GD10 Genting Highlands, MY



CD8C Enzian, Racines, IT

# 3S EISGRATBAHN – STUBAIER GLETSCHER

## TD32 Eisgratbahn I - II

-  4686 m
-  1188 m
-  3014 p/h
-  997 kW
-  48
-  7



Neustift (Stubai) / AT

2016

# DESIGN

---

## 3S Vehicle – Safety components



3S Vehicle

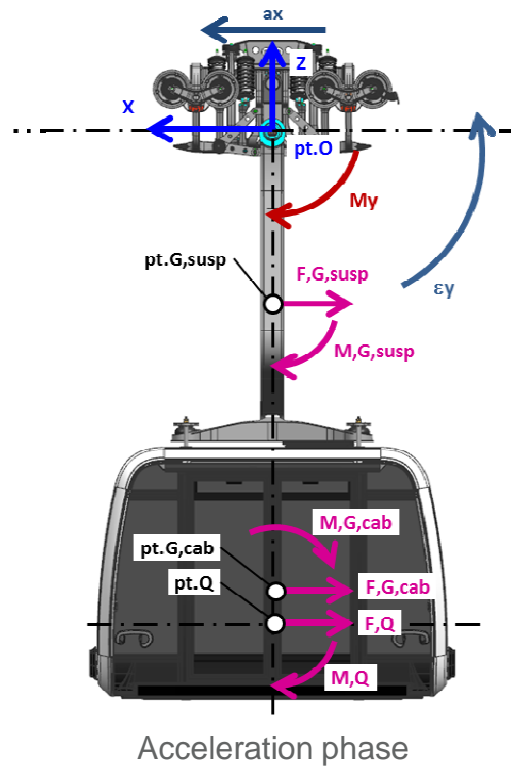
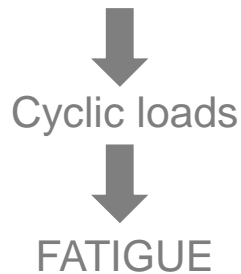
# DESIGN

## Load assessment and project life

Loads:

- Gravity loads
  - Self-weight
  - Pay load
- Dynamic loads
  - Passages on Towers
  - Acceleration
  - Deceleration
- Environmental loads
  - Wind

The load cases repeat at each travel of the vehicle



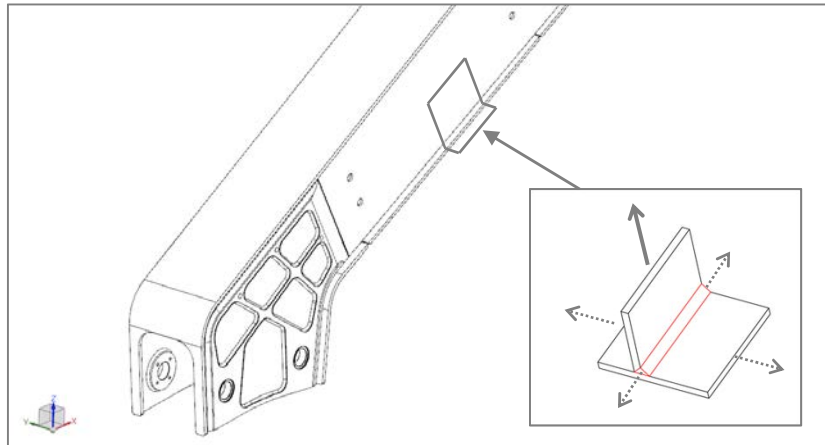
## 3S Eisgratbahn

Operation mode	
Operating days:	310 d/y
Operating hours at day:	12 h/d
Operating hours at year:	3720 h/y
Design length of the line:	4100 m
Operational speed:	7 m/s
Travel time:	586 s
Time into stations	150 s
Number of travel for hour:	4.89 travel/h
Total travels at year	18203 travel/y
Fatigue design life	
Operational year:	40 y
Total travels:	728.11E+3 travel
Total number of event	
Event:	Ni
acceleration	1.5E+6
braking	1.5E+6
entering station	436.9E+3
tower	6.6E+6
deviation	1.5E+6
boarding	728.1E+3

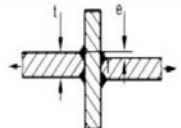
## Resistance criteria and local FEM model

Resistance criteria:

- Use of classes FAT IIW-FKM for welded details



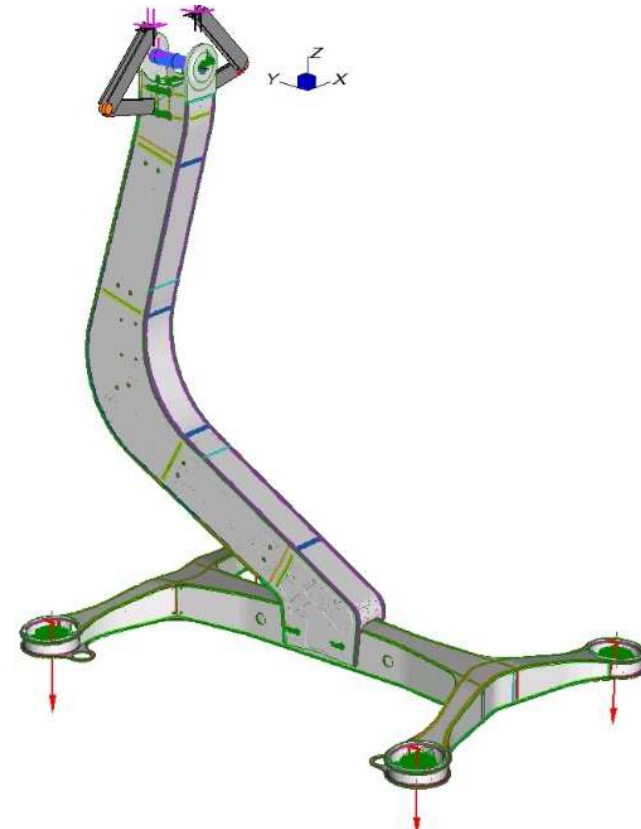
### Structural detail identification

No.	Structural Detail	Description (St. = steel; Al. = aluminium)	FAT St.
412		Cruciform joint or T-joint, K-butt welds, full penetration, potential failure from weld toe Single sided T-joints	71 80

Detail reference  
A.F. Hobbacher – IIW-2259-15

Stress calculation:

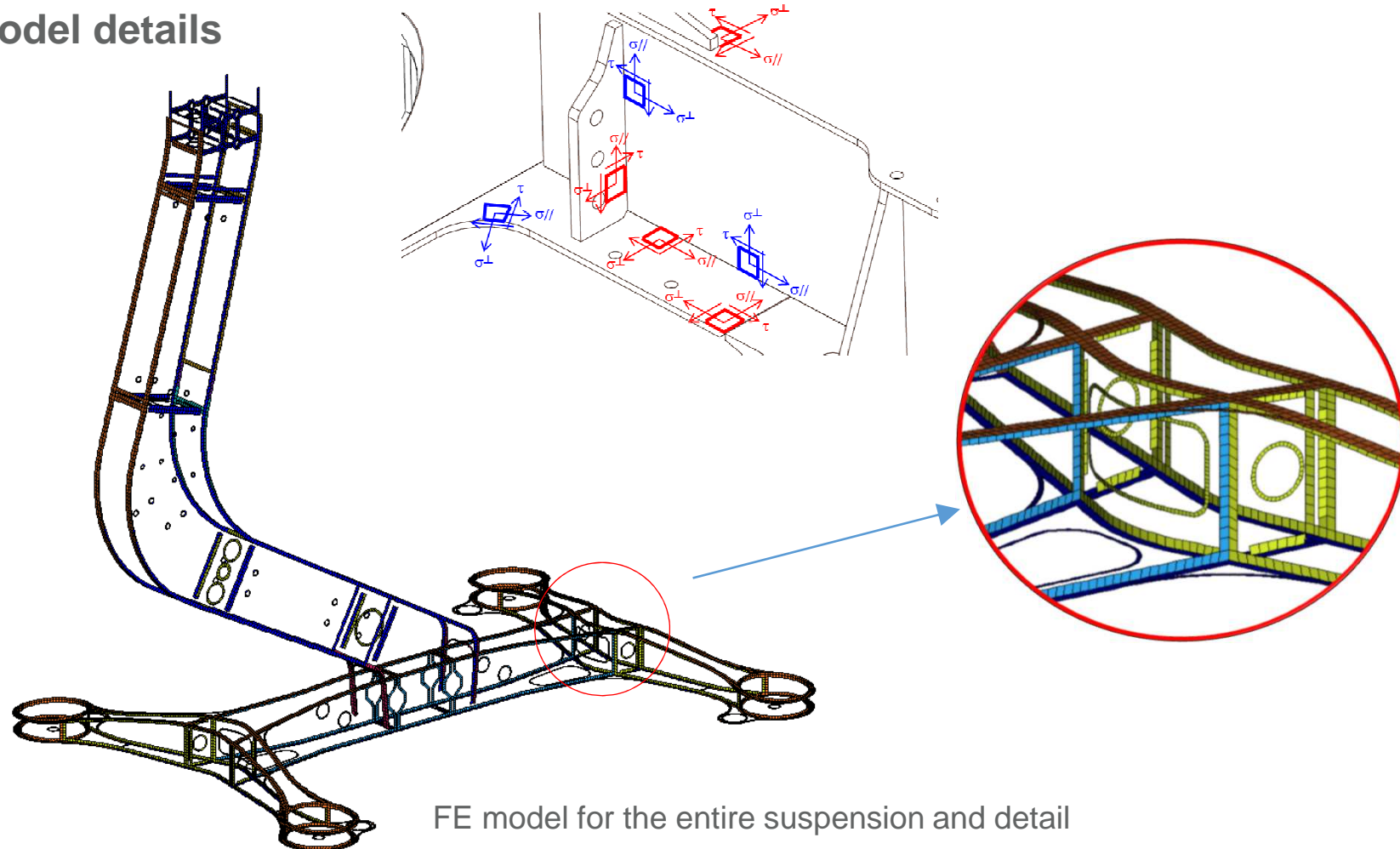
- «Nominal» local stress
- Shell-brick FE model



FE model for the entire suspension

# DESIGN

## FE model details



FE model for the entire suspension and detail

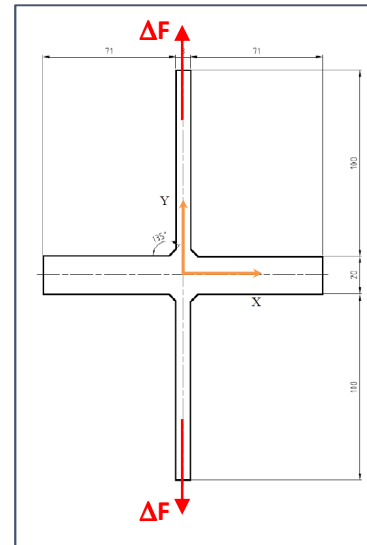
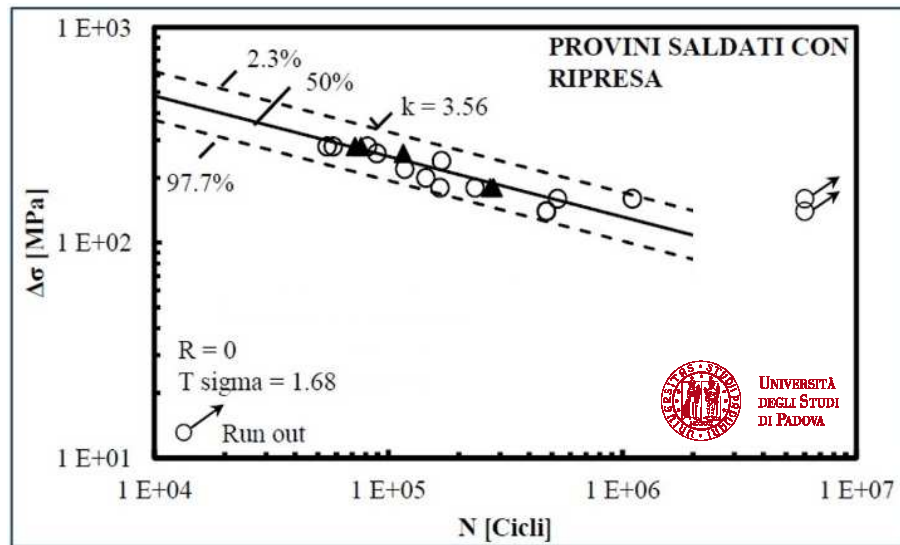
# DESIGN – Experimental evaluation of resistance category

Evaluation of design FAT class:

- FAT class IIW-FKM
- Correlation between FAT class and quality level (B, C, D) secondo ISO 5817
- Experimental evaluation



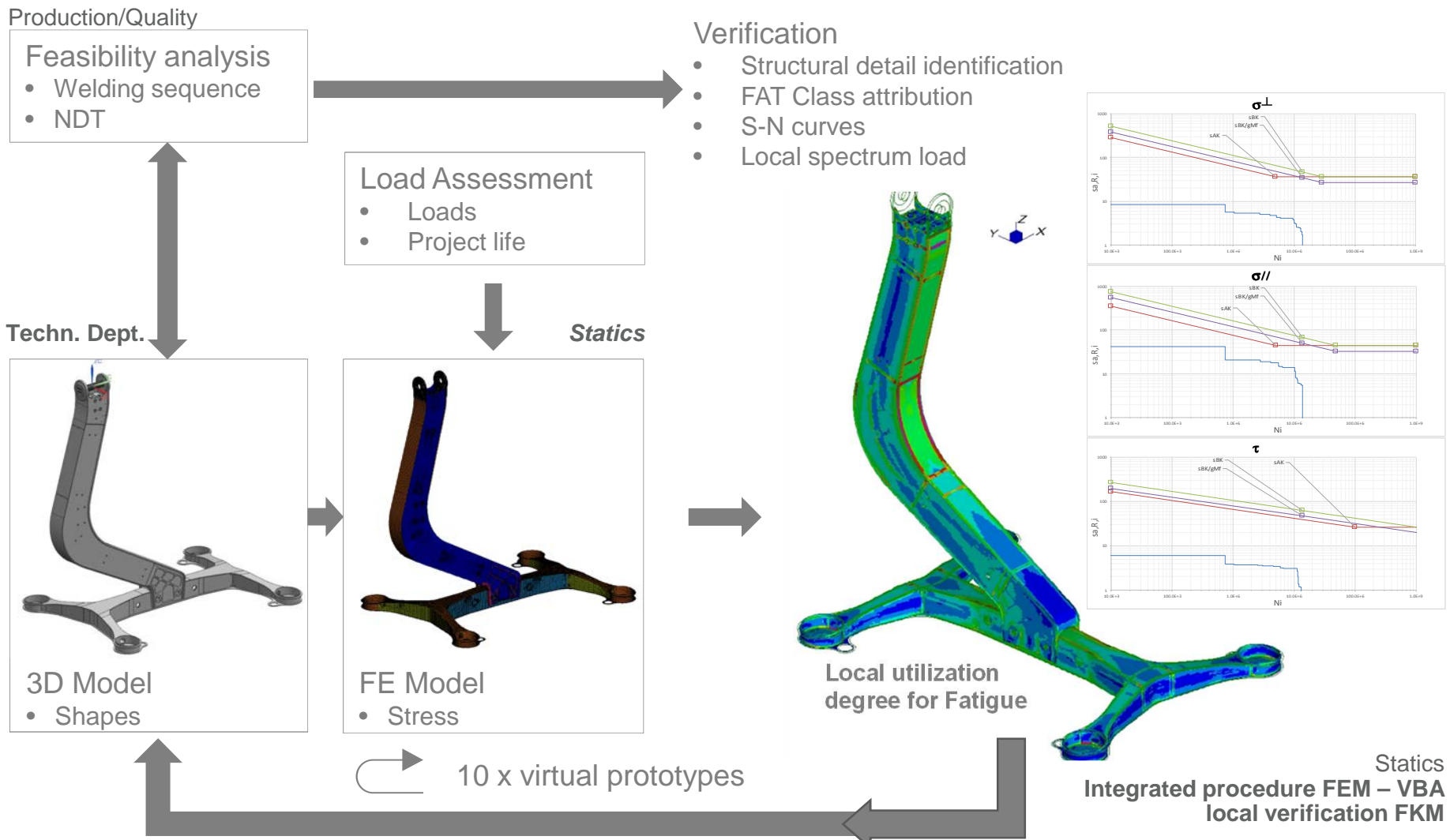
- A. Hobbacher and M. Kassner (2012)  
On relation between fatigue properties of welded joints vs. quality criteria and groups in ISO 5817  
IIW doc. XIII-2323r1-10. Weld World 11–12
- A. Hobbacher (2016)  
Raccomandazioni for fatigue design of welded joints and components – Second edition  
IIW doc. IIW-2259-15



L. Pierobon - Determinazione delle classi di resistenza di dettagli strutturali con approcci locali e prove sperimentali a fatica - Tesi di Laurea Magistrale – Università degli Studi di Padova

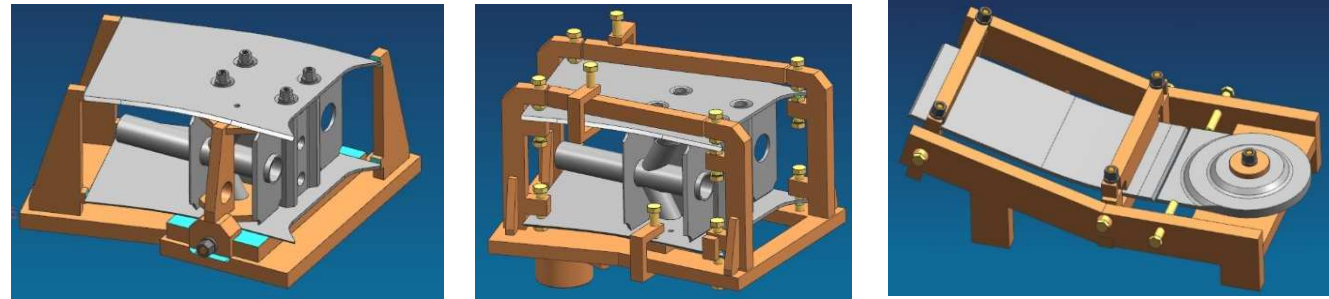


# DESIGN – CAE design and optimization



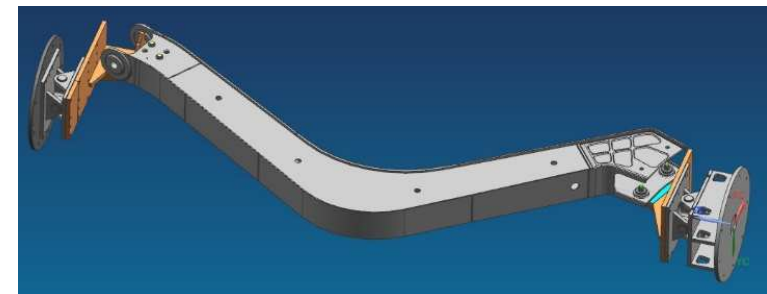
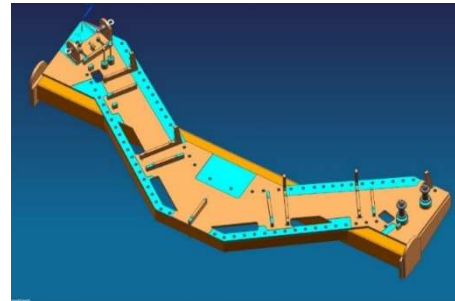
# PRODUCTION

## Welding



Respect of dimensional tolerances:

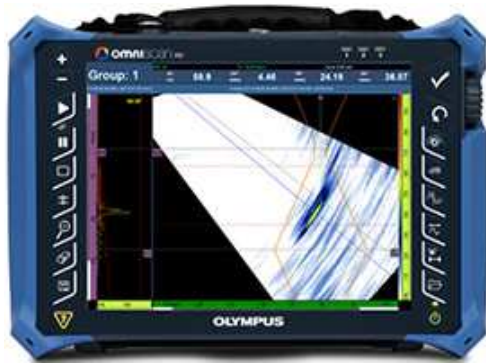
- Welding deformation control
- Jig for intermediate assembly
- Jig for manual welding
- Jig for automatic welding
- Stress-relieved heat treatment



# NDT

---

## Used devices



Phased Array Ultrasonic Testing



Conventional Ultrasonic Testing

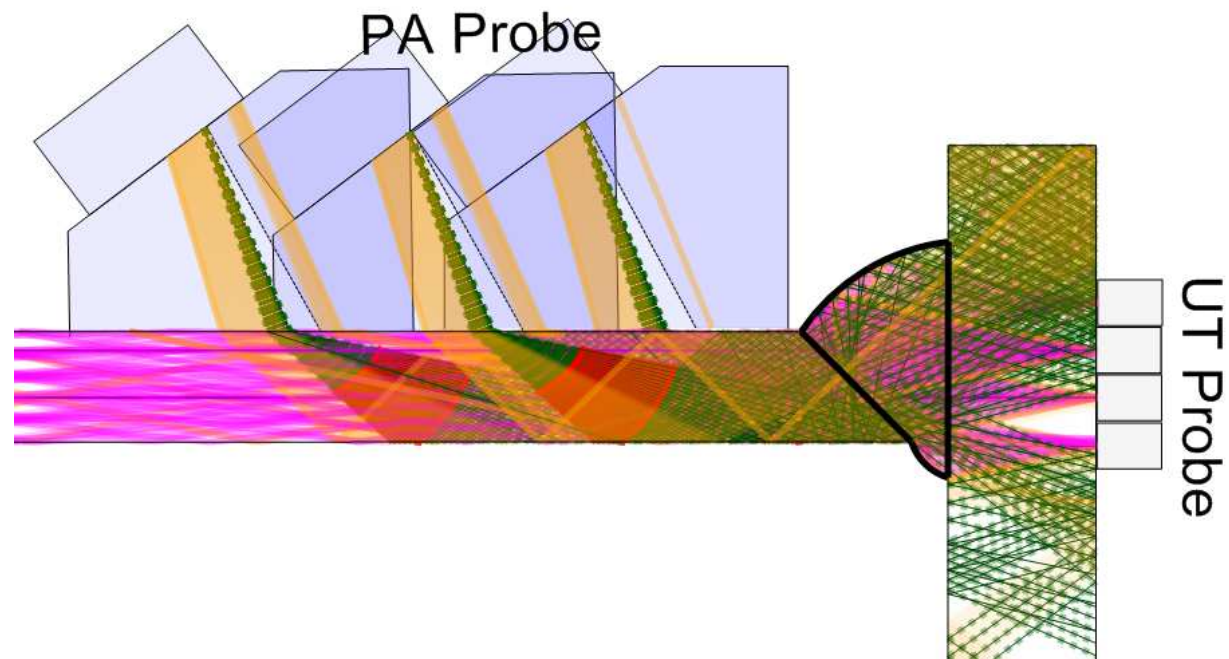


Magnetic Particle Testing



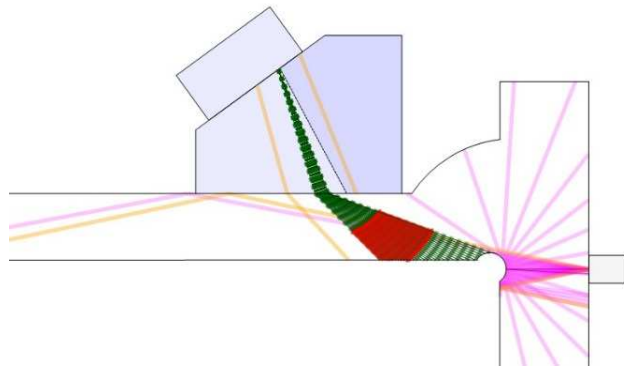
Remote Visual Inspection

Detail PAUT / UT

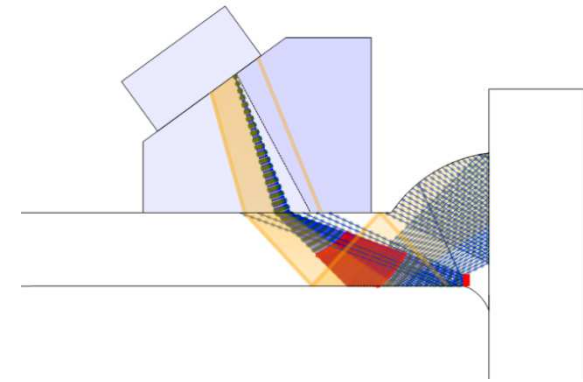


Probe path for one detail joint examination

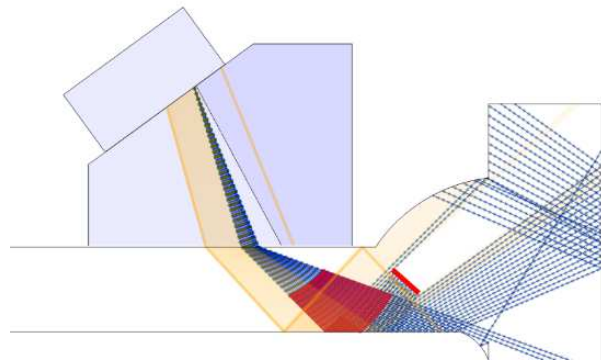
## Defects investigation according ISO 58



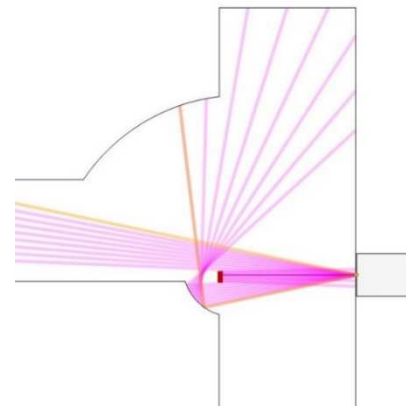
Imperfection 510 – Burn through



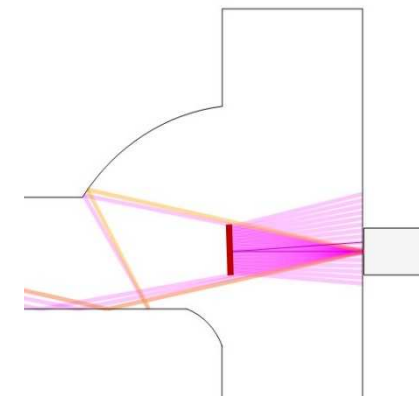
Imperfection 402 – Lack of penetration



Imperfection 4011 – Lack of side fusion



Imperfection 4013 – Lack of root fusion



Imperfection 401 – Lack of fusion



Thank you for your attention!