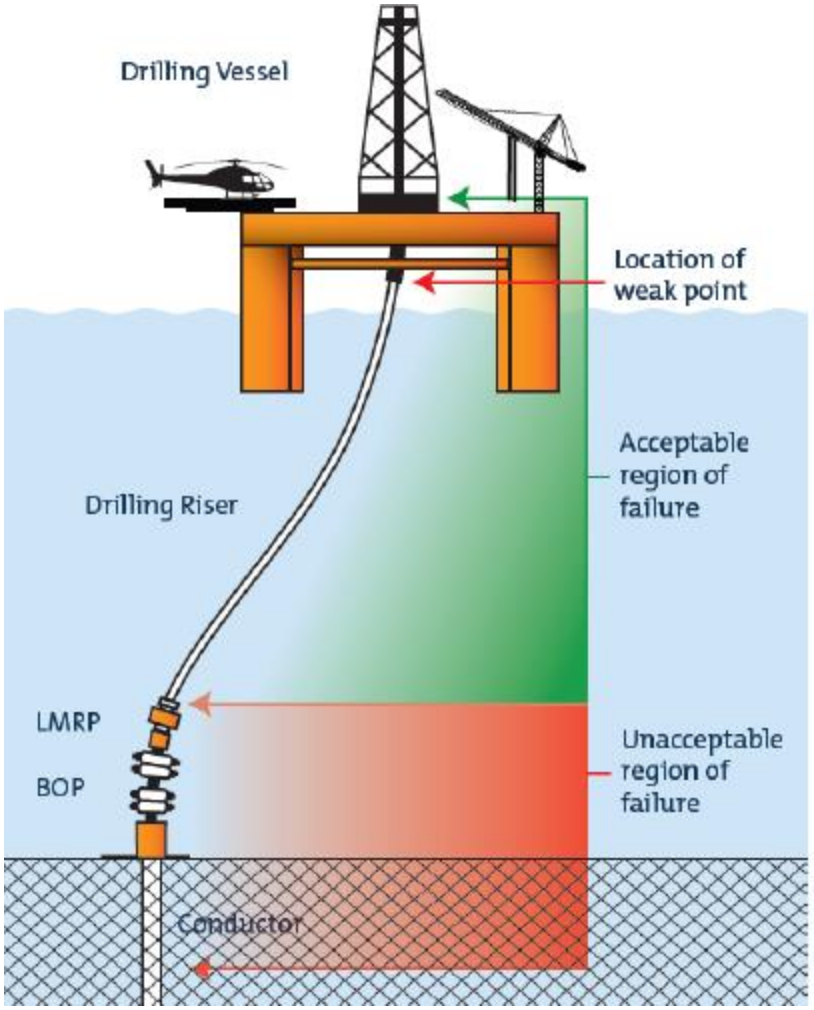
Plasticity and Fracture Technology
for Offshore Applications

Impact and Crashworthiness Lab

Well Integrity Threat Scenario

Focus of MIT research on :

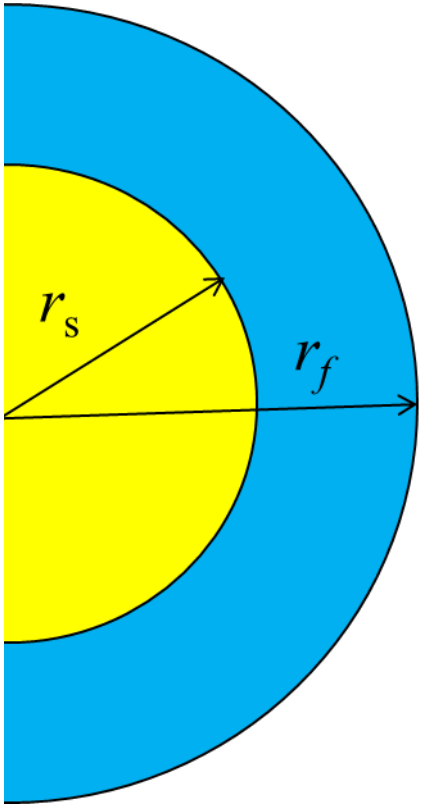
- Prediction of riser fracture at the weakest point
- Response at riser/LMRP/BOP interface after parting
- Response of wellhead conductor and soil

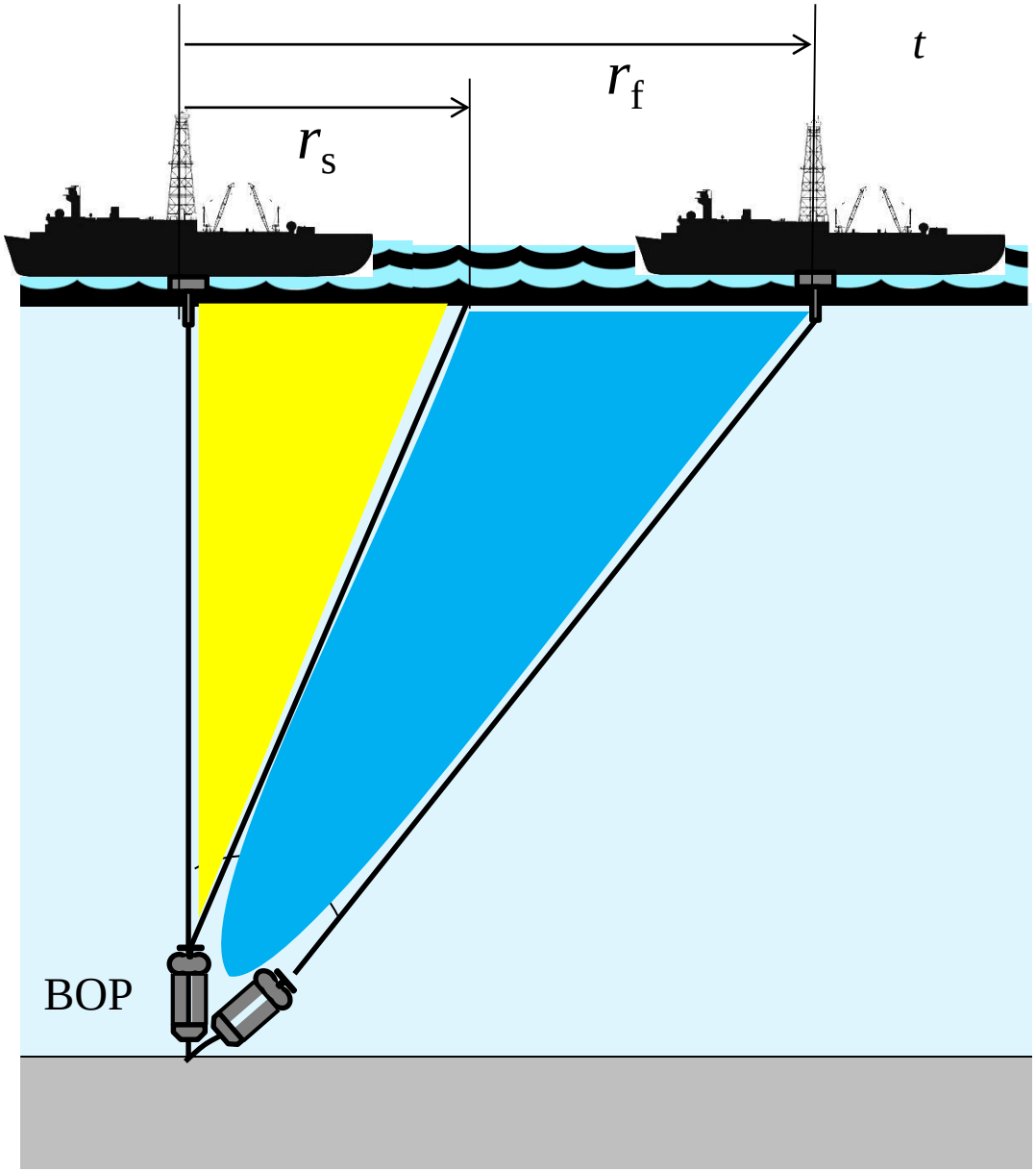


Development of Watch Circle Criteria

r_s = radius of drift off at maximum stroke of tensioner device

r_f = critical drift off to fracture



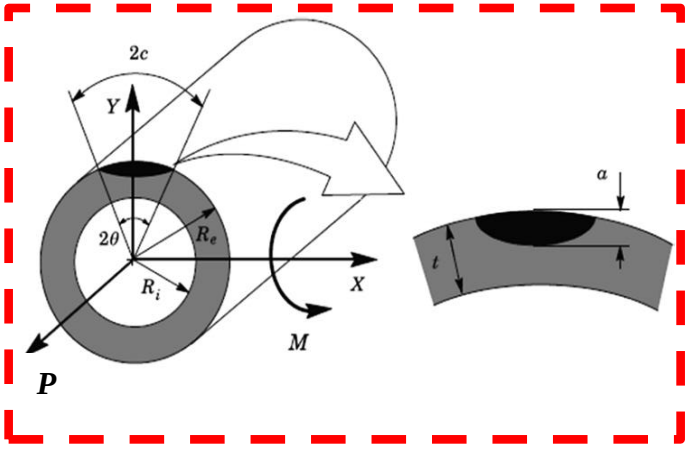


Fracture Prediction of Riser after Critical Drift Off

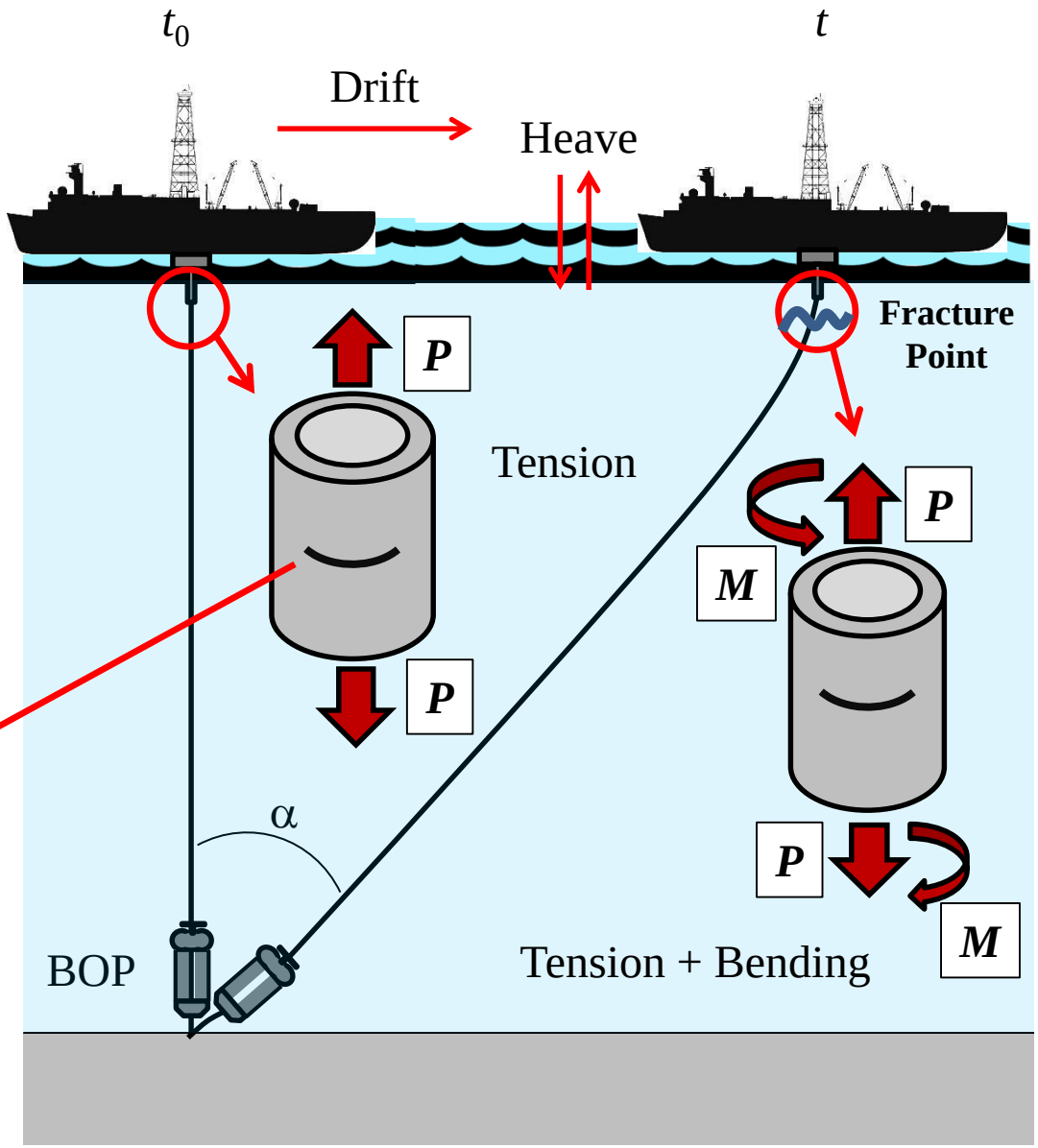
MIT Fracture Technology can predict:

- Crack free riser
- Riser with surface flaws
- Fracture of girth weld

Surface crack-like defect



Elliptical shape represents well real part -through wall cracks



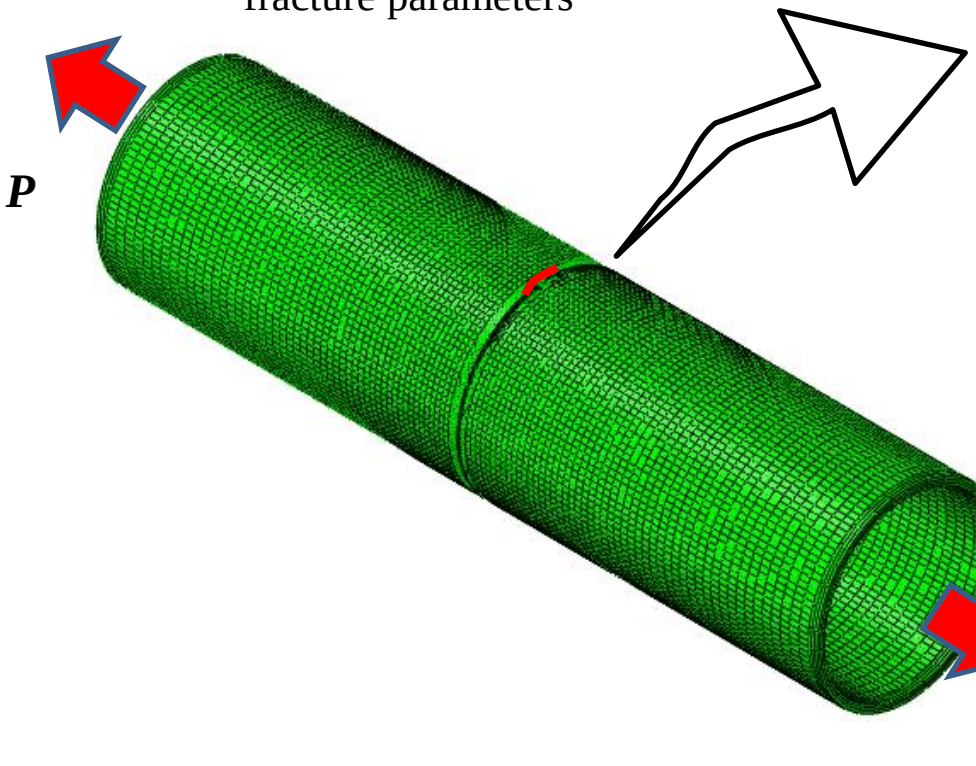
Numerical Study of Initiation and Propagation of Crack

Dimensions:

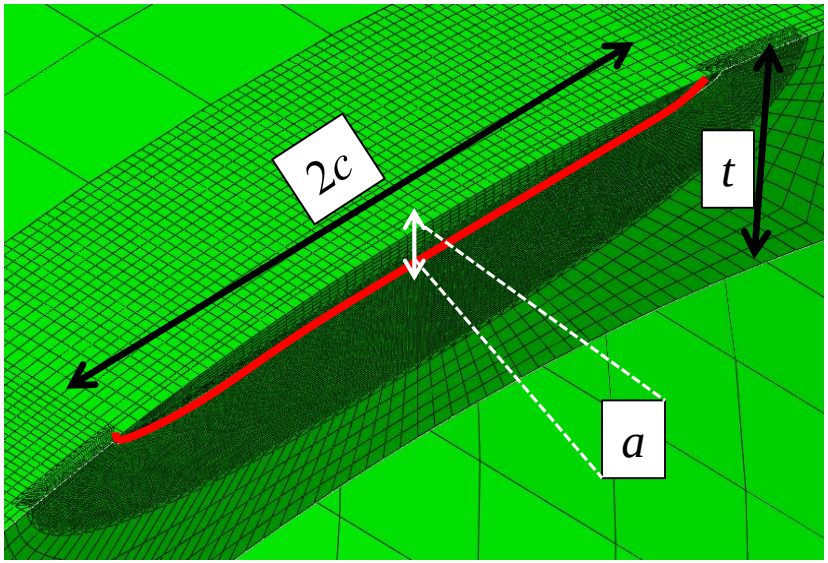
- OD = 0.540 m
- ID = 0.496 m
- t = 0.022 m

Material:

X70 pipeline steel, characterized by a number of plasticity and fracture parameters



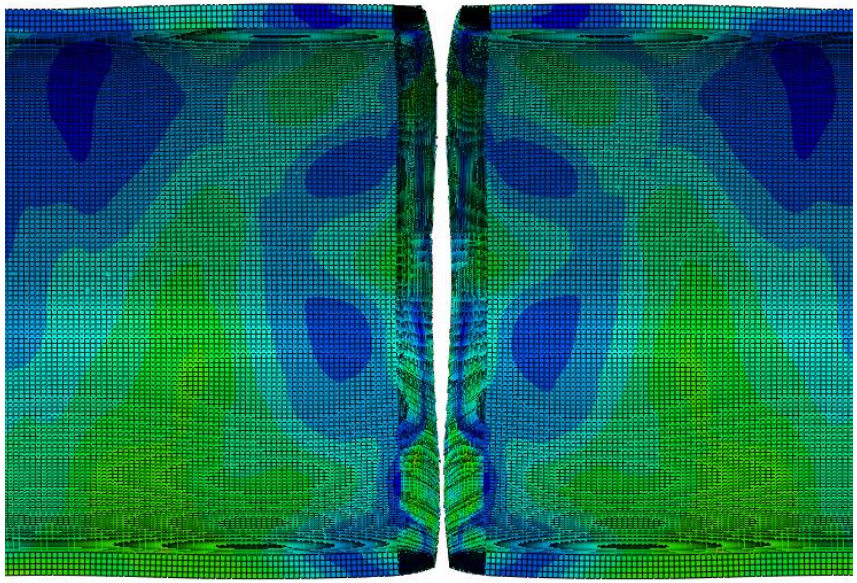
Crack initiates from a local surface flaw

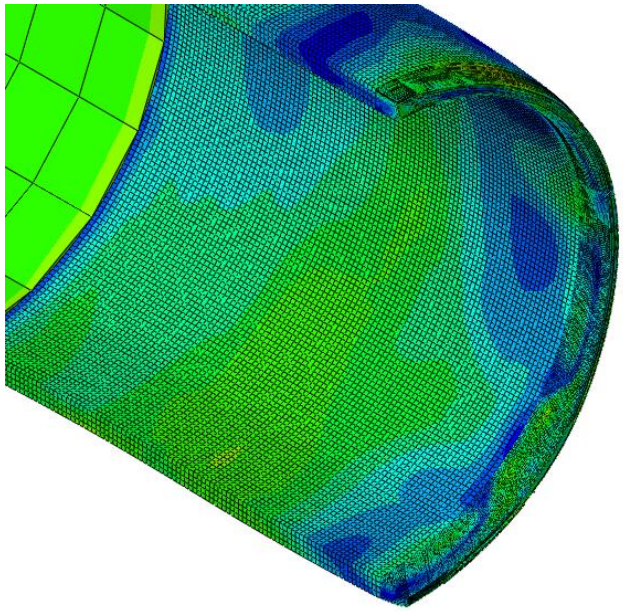


Surface crack characterized by

a = 3 mm
$2c$ = 150 mm

Appearance of Circumferential Crack





Experimental Program on Small Scale Tests

- Actual riser length: 1800 m
- Scale model length: 0.3 m
- Scale: 1:6000

- Actual riser diameter: 500 mm
- Scale model diameter: 0.127 mm
- Scale: 1:4000

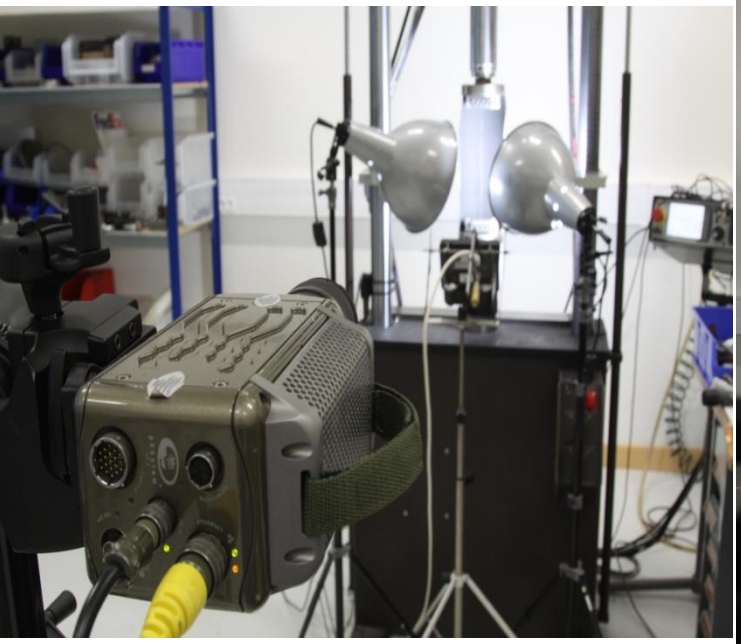
- Riser material: X70 Steel
- Wire material: Stainless Steel

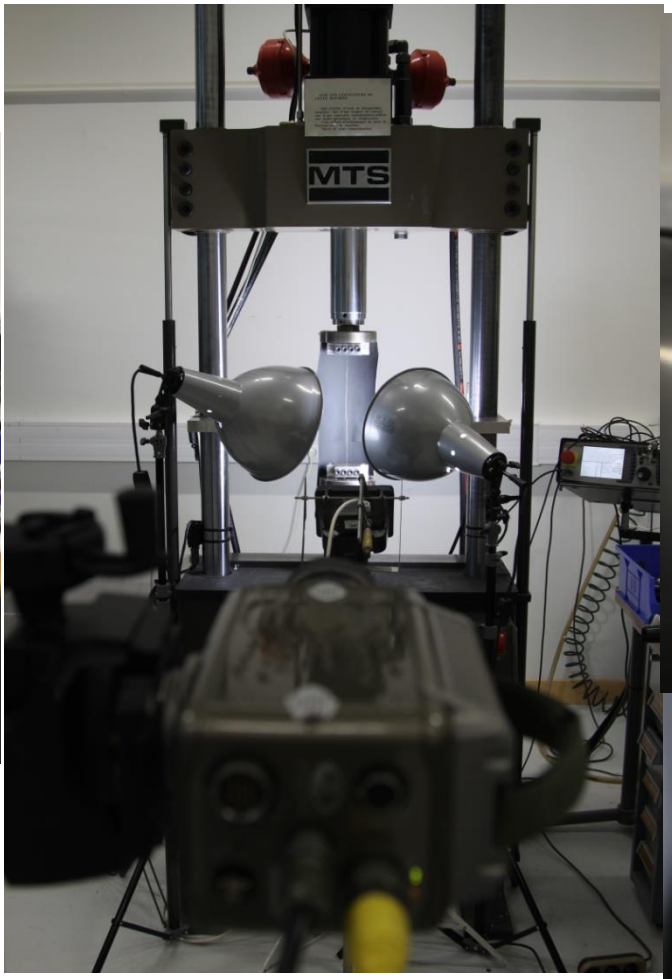
In air

In water

High Speed Camera Experimental Set Up

Hydraulic MTS Uniaxial Testing Machine



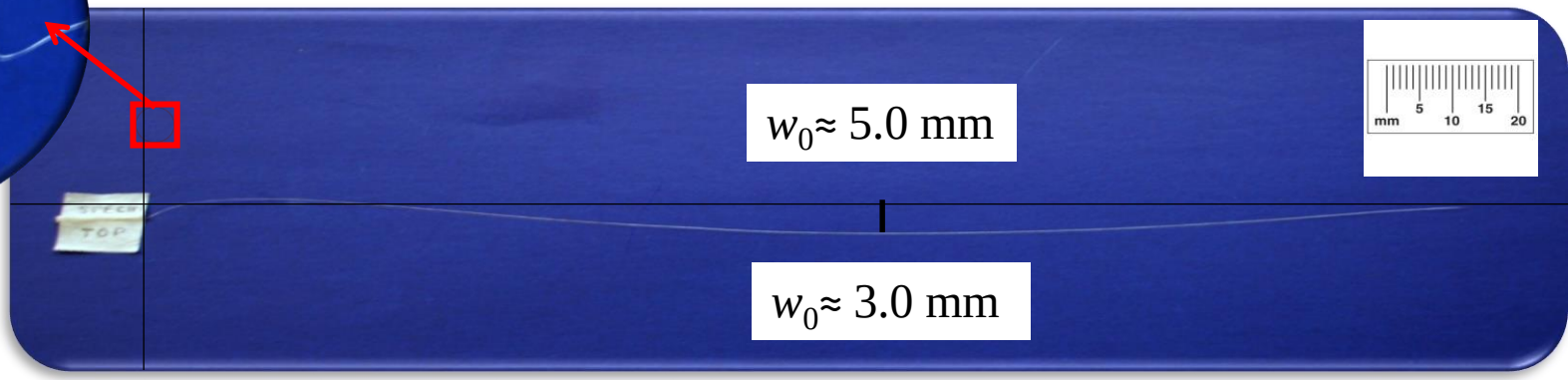


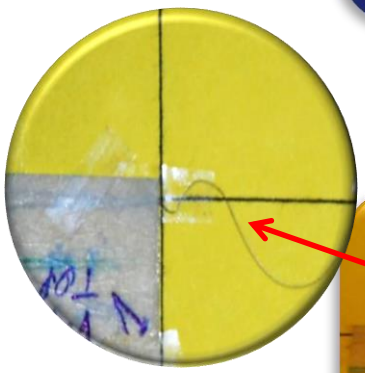
Camera Set up:

- High speed Camera (Phantom 7.3)
- Frequency 20kHz
- Resolution: 800x136 pixeles
- Number of Images: 77481 images
- t = 3.9s

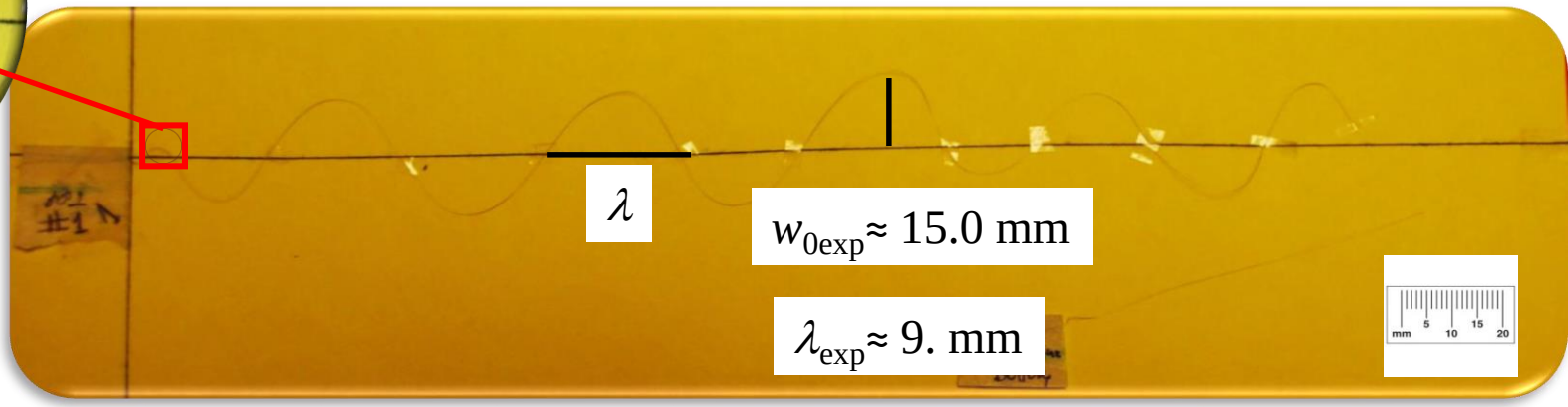
Final Shape of wire after fracture

"in water"





"in air"



Sequence of transient shape of the wire after reflection of unloading wave

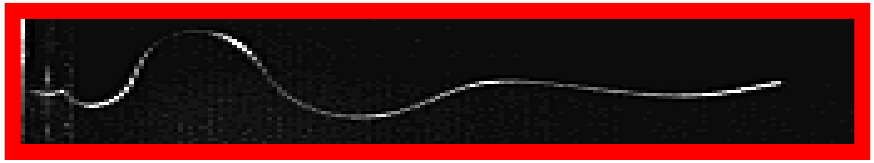
High Speed Photography

t = 0.26msec

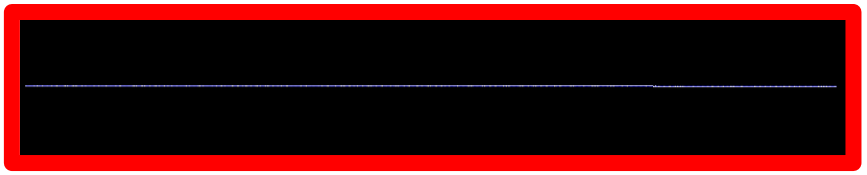
t = 0.56msec

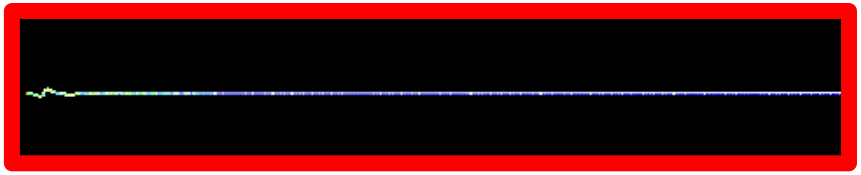
t = 2.48msec

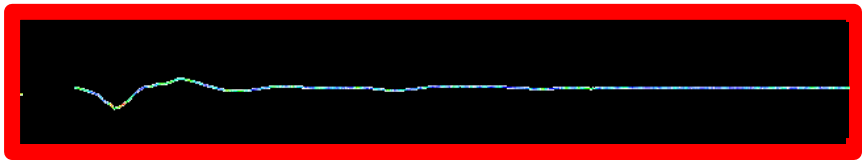
t = 4.40msec

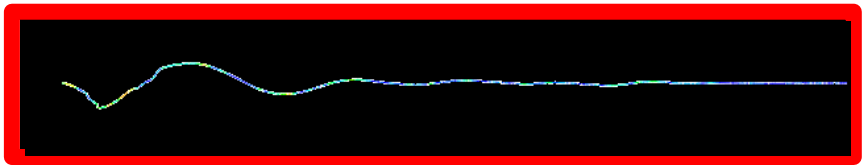


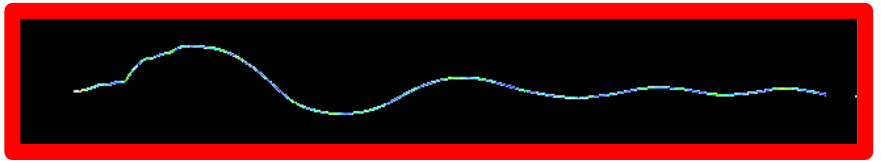
Numerical Simulation



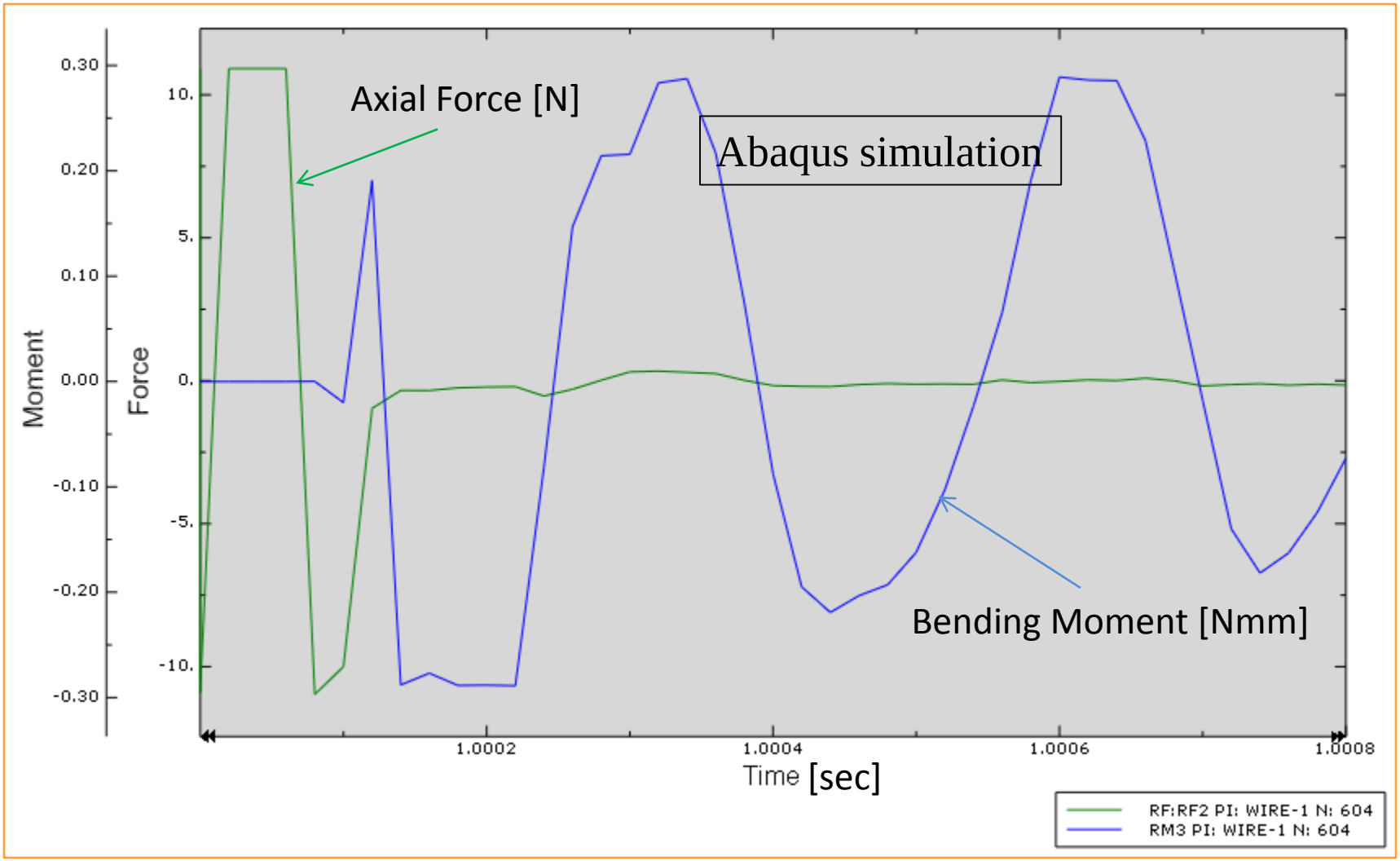








Time history of Bending Moment and Axial Force at Clamp End (Interface with BOP)

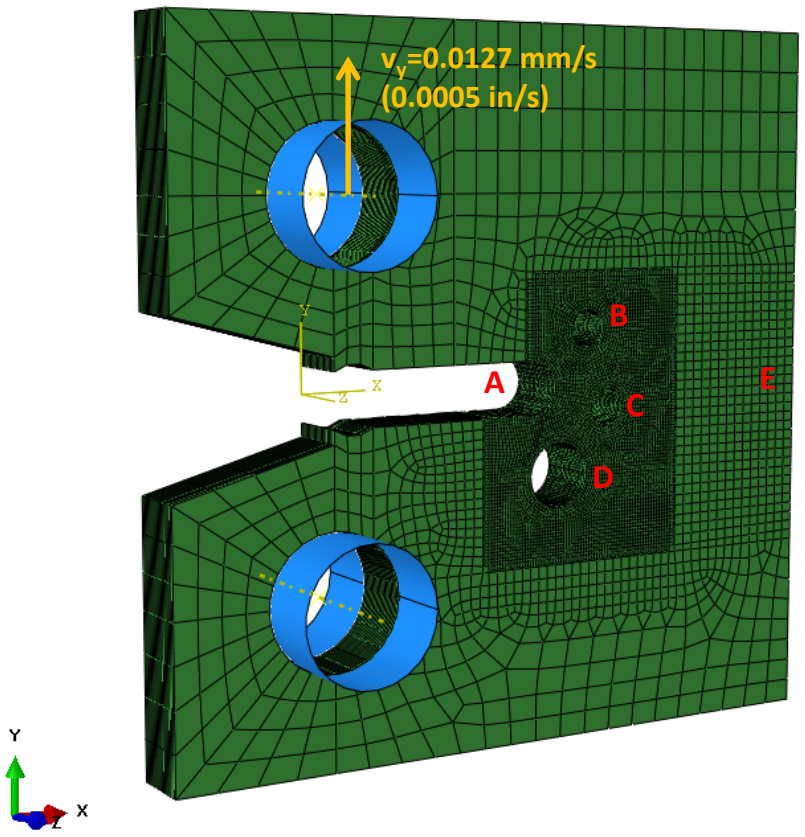


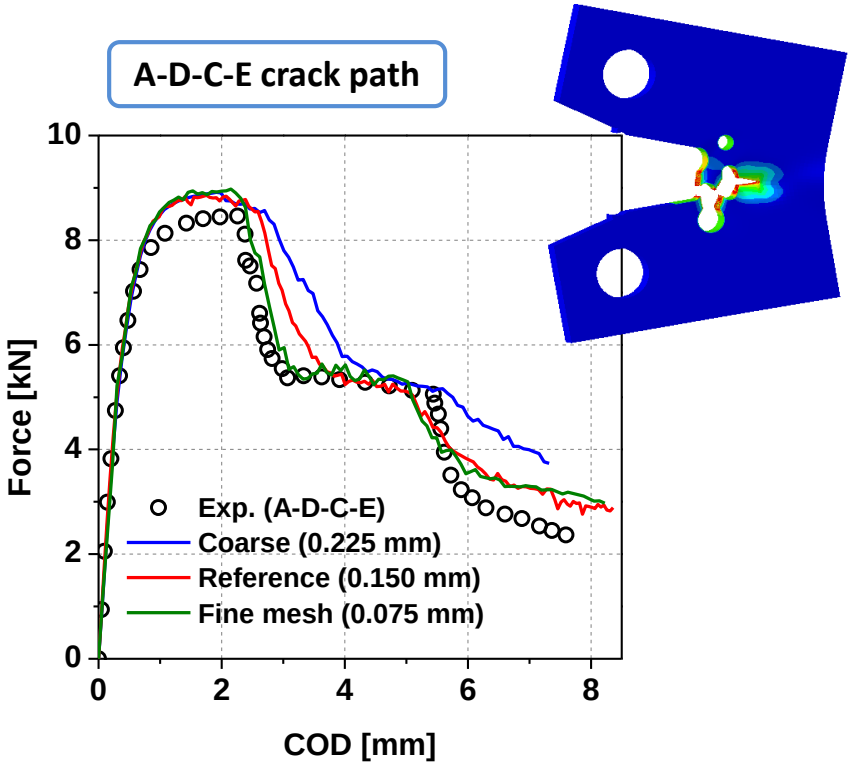
Industrial Support of ICL in 2010-2016

- AcelorMital (Fracture Consortium)
- American Iron and Steel Institute (AISI) (Fracture Consortium)
- Aperam (Fracture Consortium)
- Bettis Nuclear Lab (Fracture Consortium)
- Boston Power (Battery Consortium)
- BP (Joint project with Mike T)
- Chrysler (Fracture Consortium)
- Constellium (Fracture Consortium)
- Daimler (Battery Consortium)
- Ferrari (Fracture)
- Fiat (Fracture Consortium)
- Ford (Fracture Consortium)
- Ford (Battery Consortium)
- GM (Fracture Consortium)
- Honda (Fracture Consortium)
- Hyundai Motors (Fracture Consortium)
- Jaguar Land-Rover (Battery Consortium)
- JFE Steel (Fracture Consortium)
- LG Chem (Battery Consortium)
- Nissan (Fracture Consortium)
- NREL/DOE (Battery Consortium)
- Posco (Fracture Consortium)
- PSA (Fracture Consortium)
- Pratt&Whitney (Fracture Consortium)
- Shell Oil (Fracture Consortium)
- Tenaris (Fracture Consortium)
- Toyota (Battery Consortium)
- ThyssenKrupp Steel (Fracture Consortium)
- US Steel (Fracture Consortium)
- Volskwagen (Fracture Consortium)
- Voestalpine Steel (Fracture Consortium)
- Altair (Associate Members)
- Simulia (Associate Members)
- LSTC (Associate Members)
- ESI Group (Associate Members)
- AutoForm (Associate Members)

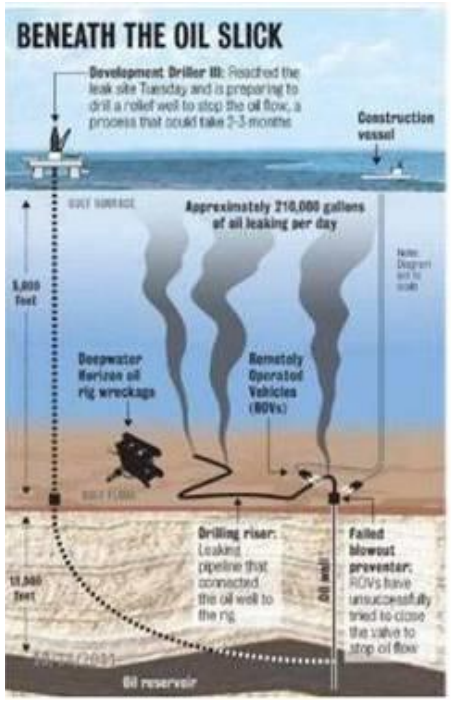
ICL Experience in Ductile Fracture Prediction

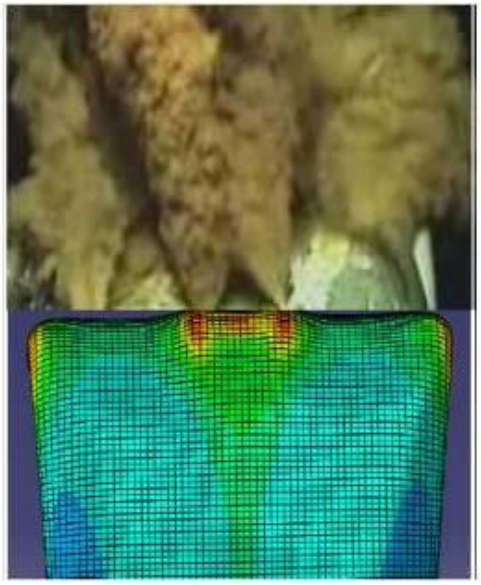
Winning MIT Team in Sandia Challenge (2012)



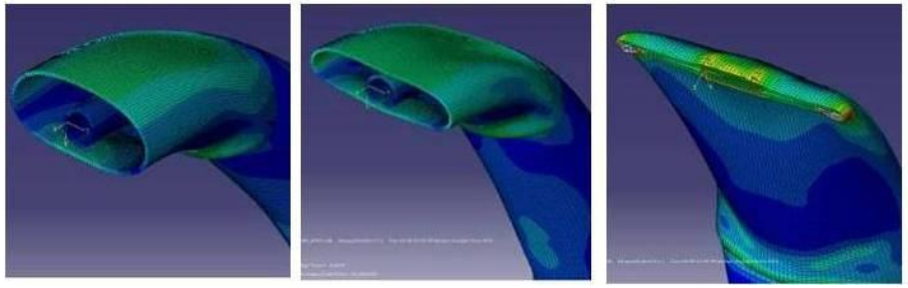


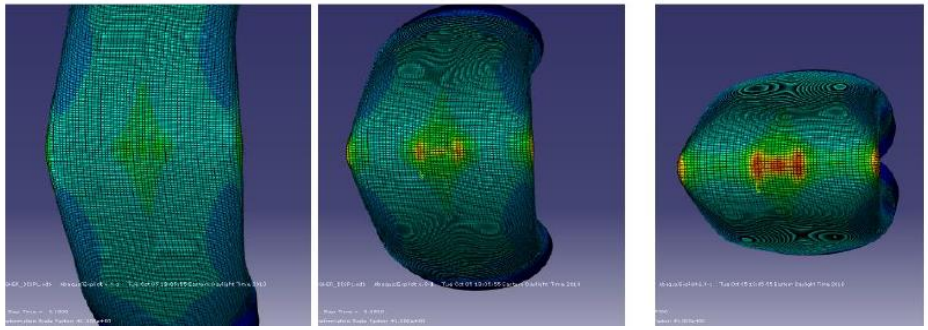
Extreme Bending of Riser with Fracture





Shear dominated fracture





MIT Simulation of Shear Ram

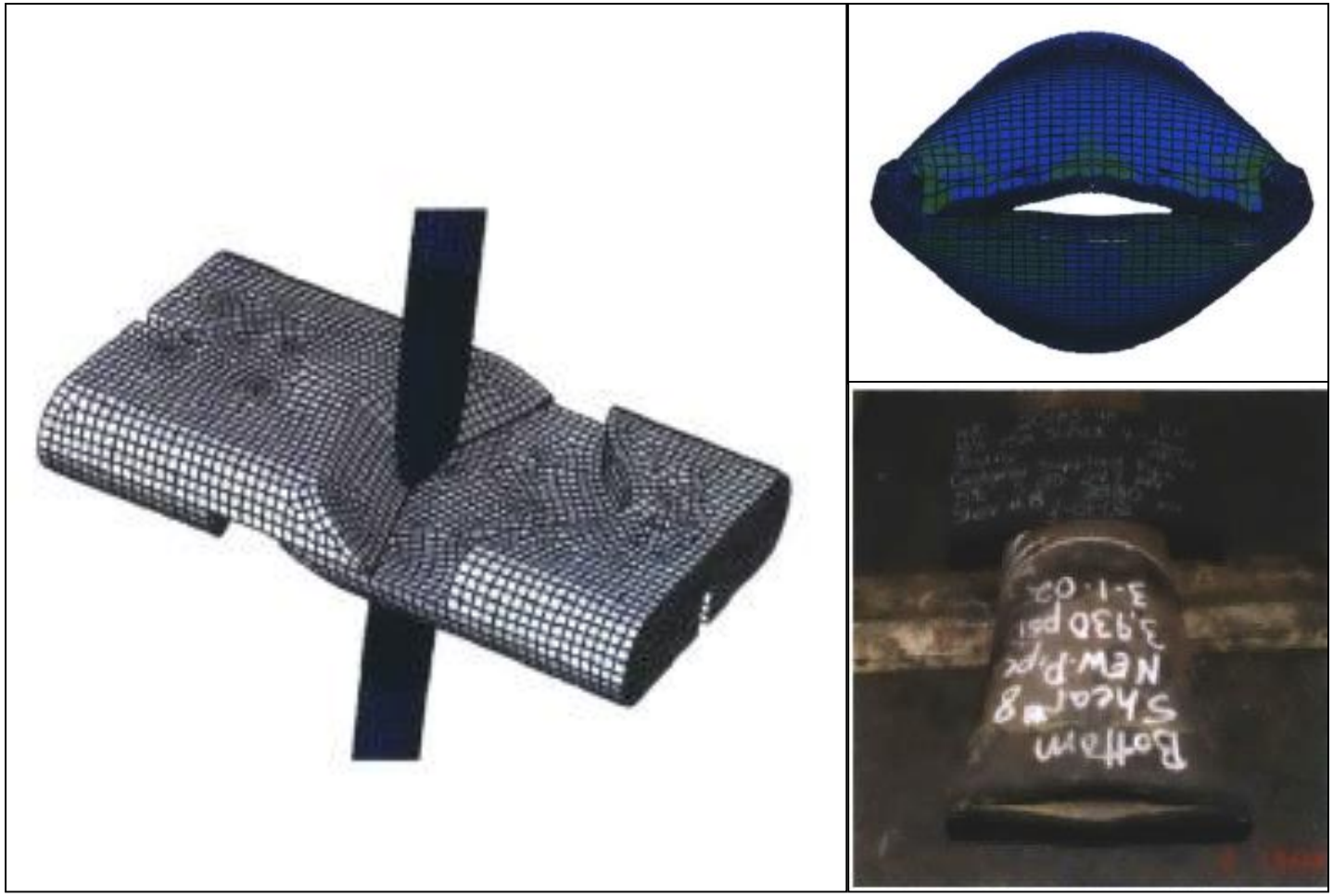
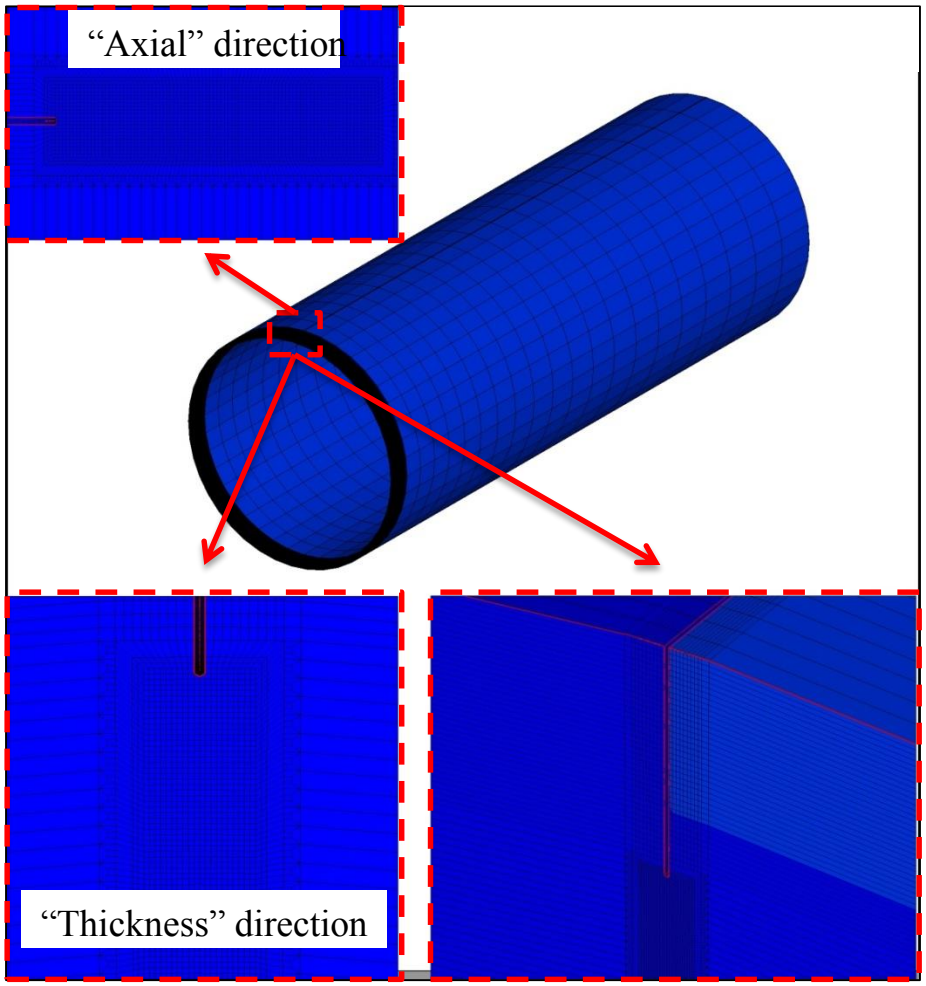
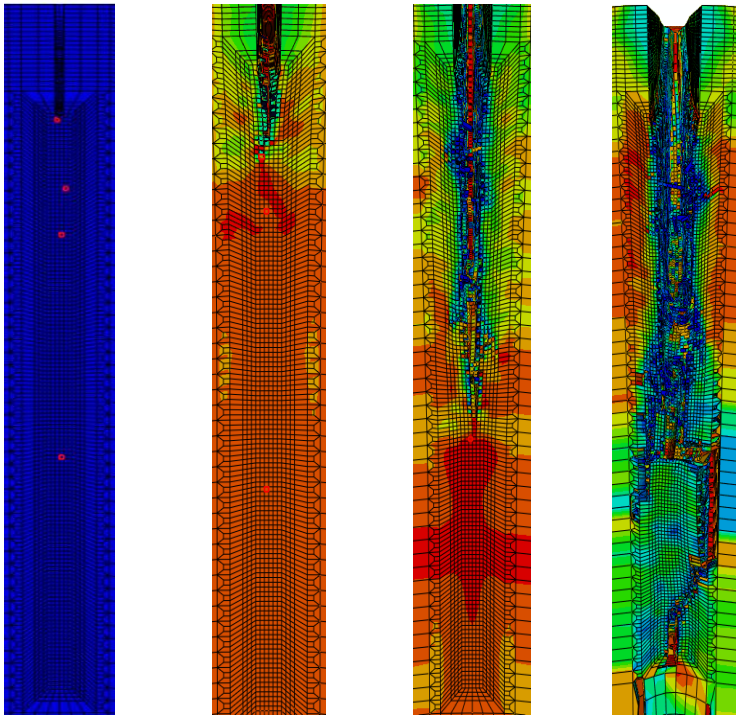


Photo Courtesy of West Engineering Services, 2004

Prediction of Pipe Bursting Using MMC model





"Thickness" direction

Proposed future work

1. Determination of plasticity and fracture properties of offshore steels under loading/unloading cycles.
2. Study of the effect of magnitude of surface imperfection on riser failure in tension (both initiation of fracture, crack propagation until full separation)
3. Prediction of a fracture of girth welds.
4. Failure of a riser due to low cycle fatigue (wave action combined with drift).