ETN Meeting & Workshop March 2019 in Pau (France)
27./28 March 2019

Assessing Remaining Life of Critical Gas Turbine Parts

Institute of Test and Simulation for Gas Turbines
German Areospace Center
Prof. Dr. S. Reh
Institute Director

Overview

- Introduction of German Aerospace Center
- Introduction of Institute of Test and Simulation for Gas Turbines
- Life Assessment for Gas Turbine Parts

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- **Introduction of German Aerospace Center**
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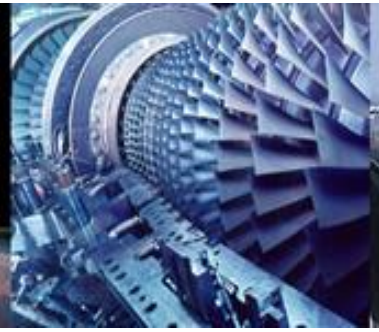
Introduction of German Aerospace Center

- 20 Research Site in Germany
- 40 research institutes dedicated to: propulsion, combustion, gas turbines, …
- Offices in Paris, Brussels, Washington and Tokyo
- 8000 Employees
- Large test facilites (wind tunnels, compressor, combustor, turbine)
- Operating 2nd largest research aircraft fleet in world
- Research in Aeronautics, Space, Energy & Mobility

2nd largest research fleet worldwide

Aeronautics

Space



Energy

Mobility

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Introduction – DLR-Institute SG in Augsburg

Key Figures of the Institute

- Founded in June 2017
- Investment: ca. 48 Mio. €
- Base funding: 8,3 Mio. €/a
- Targeted head count: 50 - 60
- Current head count: 18
- Located in Augsburg Innovation Park
- Property 13000m² purchased
- Planning of new institute building started
  → Moving in 2022
- Close cooperation with major universities established (Munich, Manchester, UCB, Lyon)
- Office and lab space rented in Technology Center Augsburg
  → Simulation and Testing started


Technology Center Augsburg

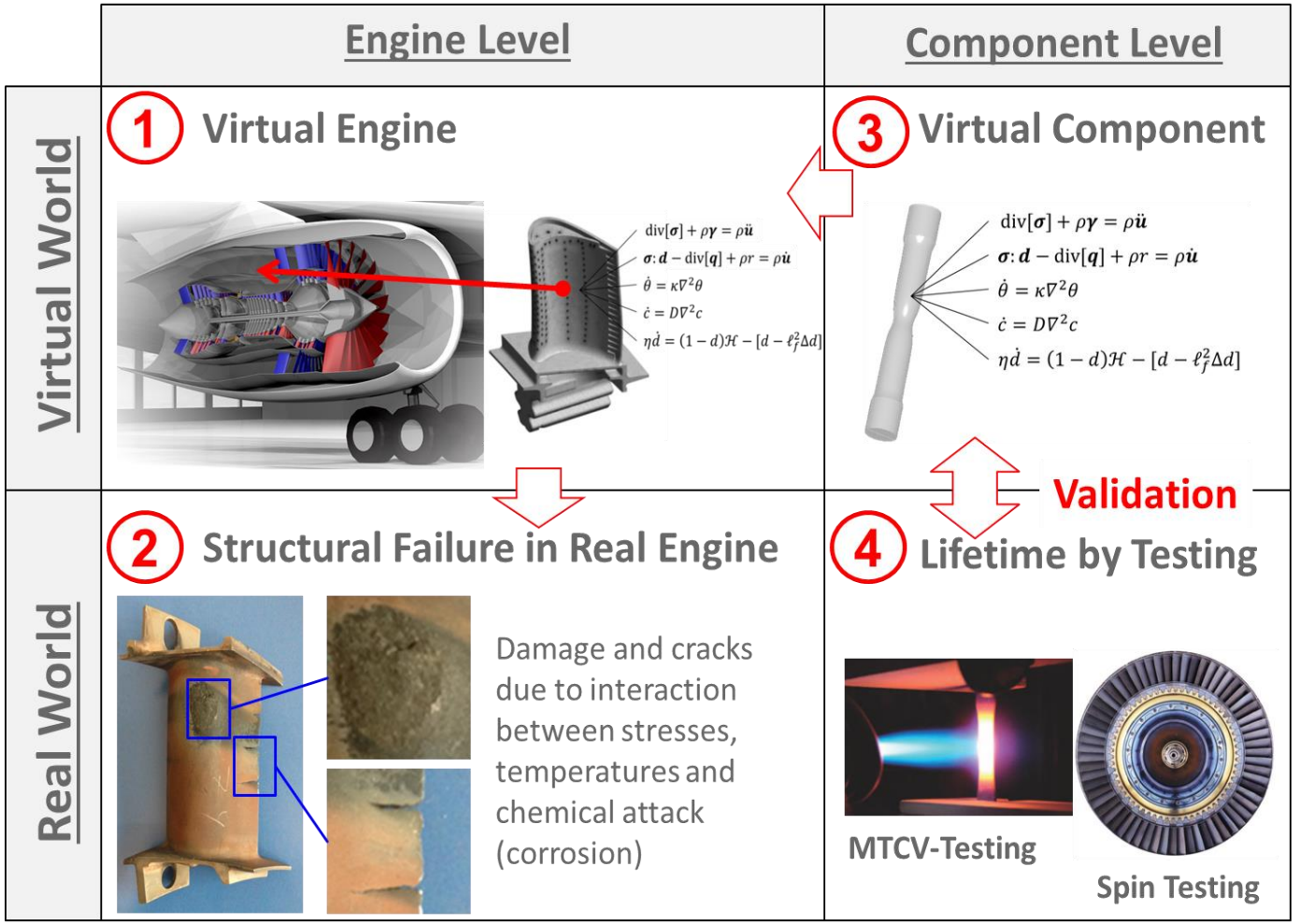
Introduction – DLR-Institute SG in Augsburg
Research Topics

Research Fokus:

- Test and Simulation of the Structural Lifetime of GTs

Research Groups on:

- Lifetime assessment of components under real engine conditions (MTC)
  → mechanical
  → thermal
  → corrosion
- High-temperature testing of components & specimen under pressure w. real combustion gas
- Spin testing for lifing of bladed rotors with 1:1 size



Overview

- Introduction of German Aerospace Center
- Introduction of Institute of Test and Simulation for Gas Turbines
- **Life Assessment for Gas Turbine Parts**

Life Assement for Gas Turbine Parts
General Approach

- Numerical assessment method
  - Digitize Geometry
  - Generate boundary conditions
  - Build FEM model with 1:1 size crack as inspected
  - Assess remaining lifetime with crack propagation by adapting FEM model accordingly

- Guidelines based on experience
  - Fast … if it works
  - Tend to be arbitrary – lack of real life physics

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Time consuming

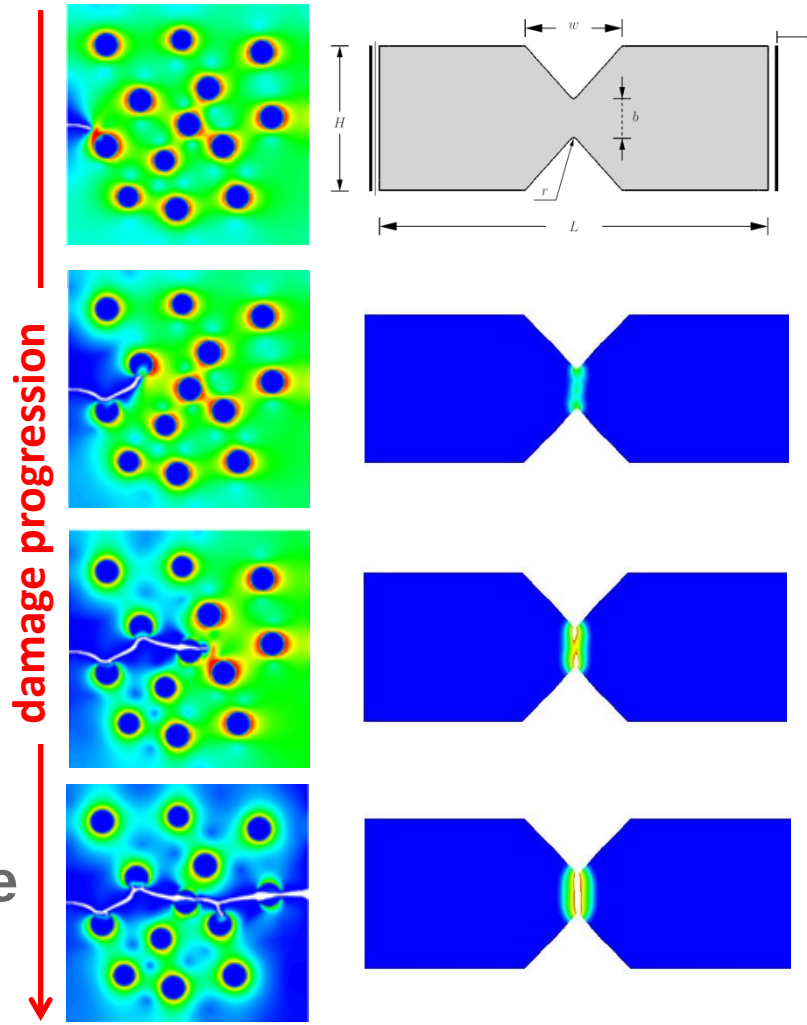
- Guidelines based on experience
  - Fast … if it works
  - Tend to be arbitrary – lack of real life physics

If it would be this easy …

Life Assement for Gas Turbine Parts
Fast assessment method of turbine part life

- New method to assess part life (since a few years):
  - *Phase Field Method for Damage*
  - Applicable for simple models
  - No remeshing effort – model of undamaged part is OK
  - Real life damage can be captured (e.g. bifurcation)
  - Life until initial failure and remaining lifetime after failure and after repair can be assessed
  - Assessment of remaining life is possible within hours or a few days depending on complexity (introduce cracks & damage as inspected)

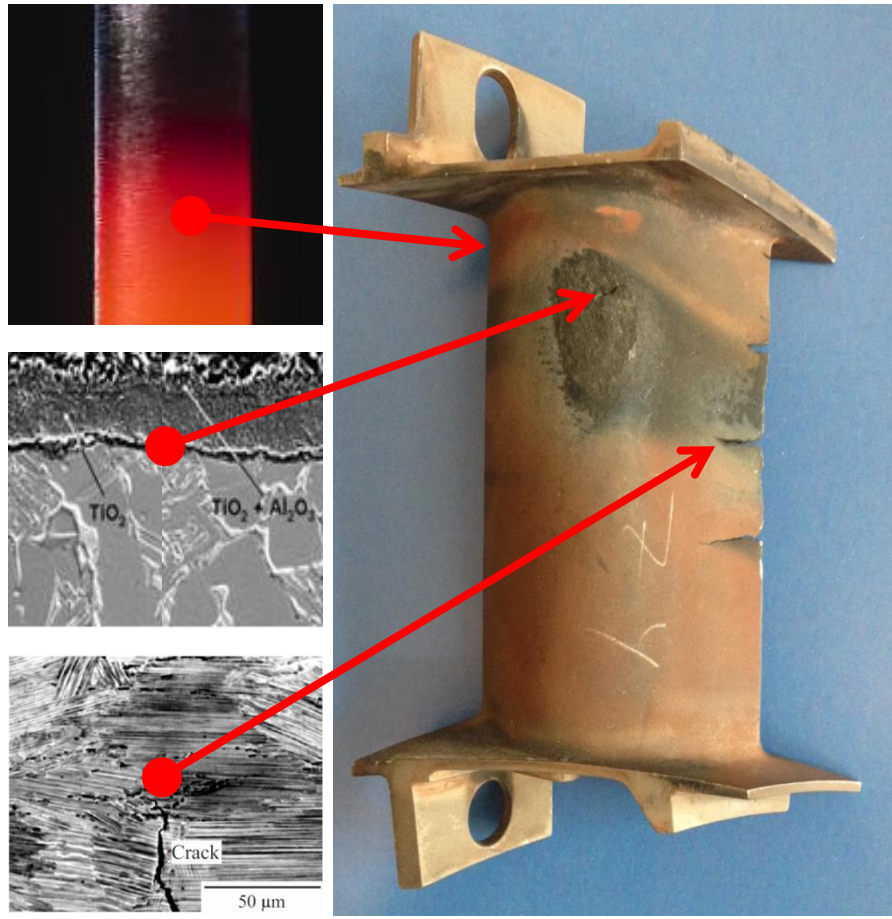
Requirements:
- Digital models of critical parts prepared ahead of time



Life Assement for Gas Turbine Parts

Assement Procedure

- **Mechanical Problem**
  - Balance moments
  - Energy Balance
- **Thermal Problem**
  - Heat Conduction
- **Chemical Problem (Corrosion/Oxidation)**
  - Diffusion and Degradation
- **Lifing and Fracture**
  - Crack Initiation & Damage Progression

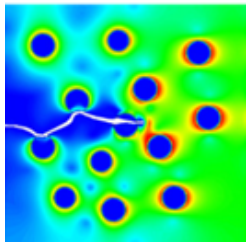


Vane

Life Assement for Gas Turbine Parts
Remaining Lifetime Assessment Suggestion for Examples

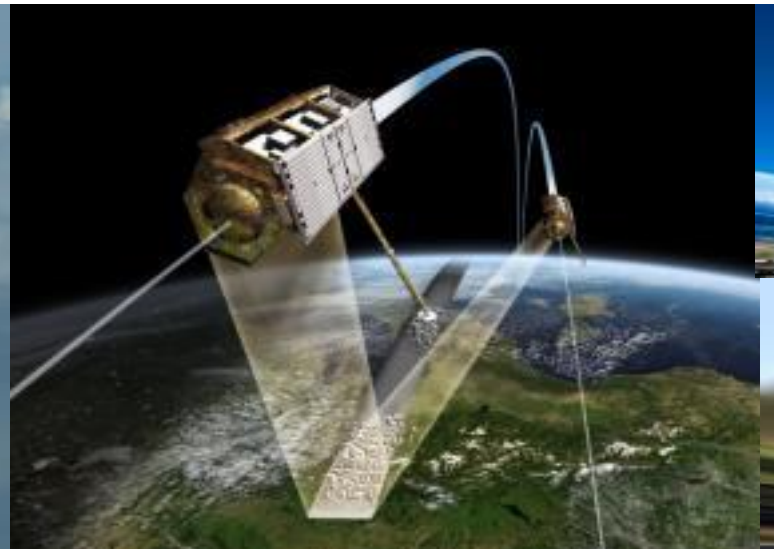
- Digitize Crack from Inspection (incl. bifurcations)
- Project crack into digital model of part
  - Damage as inspected is initial starting point of lifetime assessment
  - Calculation of remaining life can be automated → no specific skills needed
- Numerical effort for lifetime assessment is in the order of hours or a few days
- Assessment is still based on physical methods

Cracks on 2nd stage nozzle of F-class gas turbine (Source: EDF, Jean Luis Meyer , EXPECTATIONS OF AN OPERATOR ON GT COMPONENTS LIFE ASSESSMENT)



Life Assement for Gas Turbine Parts
Contribution to Guideline Generation

- Select as a set of critical parts as indicated by field reports
- Assume typical damages seen in the field
  → analyze the remaining lifetime using fast phase field method to obtain additional data points
- Combine guidelines without physical basis with the additional data points to develop more physical based guidelines
- Numerical effort for lifetime assessment is in the order of days or weeks – can be done up front (if tool set-up is prepared)



Thank you for your attention!

DLR Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center