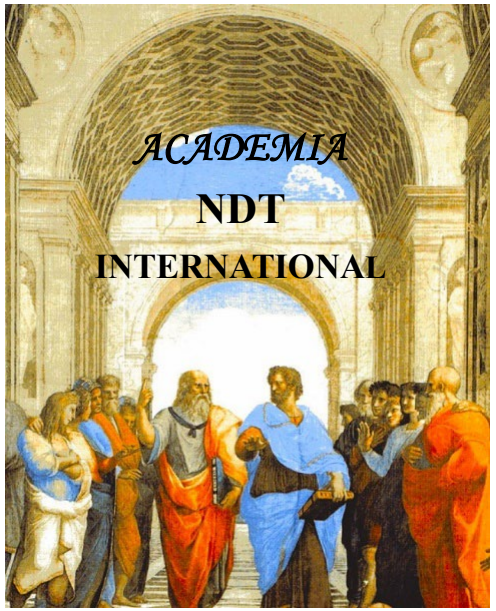

Syllabus
for future *NDT Integrity Engineer*

Peter Trampus
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Educating the future NDT engineer seminar

Johnstone, UK, January 26, 2024

Subsistence

World at a glance:

- 8 billion people
  - 200 countries
    - 200 languages
      - 40 religions
        - various social systems
          - …

Basis of functioning society (*country specific*):

- redistribution of existing goods (*different forms of taxes*)
- production of new values, innovations – ***scientific / engineering products***

Engineers' activities (*design / construction / operation*) are always

- determined by **market** requests,
- connected to **safety**,
- related – directly or indirectly – to **money** (cost / profit)

Safety – Reliability – Risk

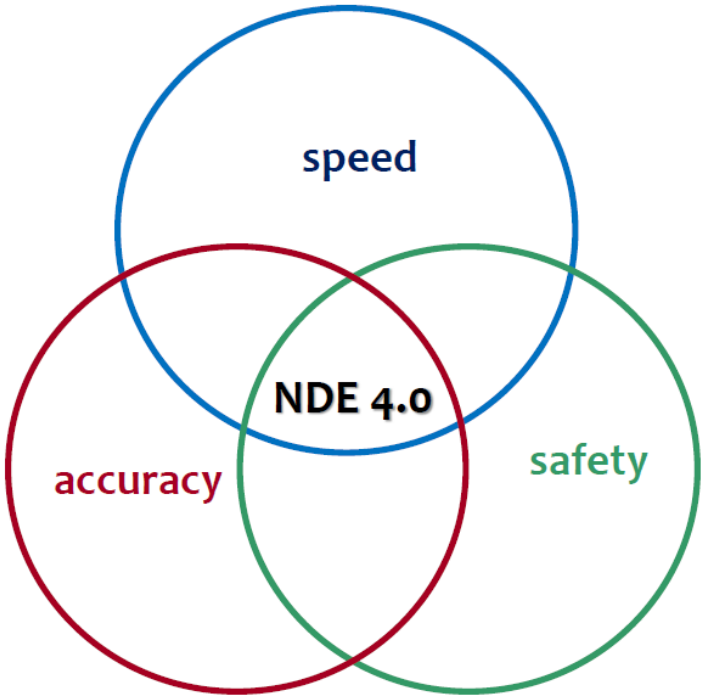
To ensure **safety** we must invest **money** to perform

- investigations to determine *material behaviour*,
- NDT to detect *deviations, i.e. flaws*,
- calculations to determine *stress / strain, temperature, magnetic, etc. fields*

Risk (risked money) must always be considered!

***Safety – Reliability – Risk* concept**

Concept is to realize at **existing technical level**



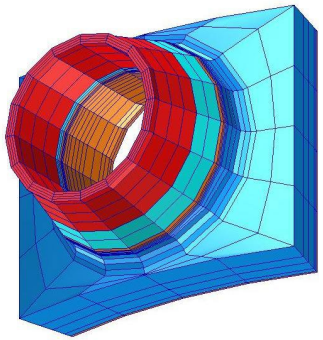
Today: in harmony with Industry 4.0 (NDE 4.0)

Overall need: ensuring structural integrity

Analytical, FEM calculations

Loading, environment

Power uprate



Changes in material properties (e.g. embrittlement, loss of toughness)

Crack propagation (e.g. fatigue, corrosion)

Fracture mechanics assessment (deterministic or probabilistic)

Material properties

Mechanical, microstructure testing

Decrease in safety margin

Flaws

NDT | NDE

Structural integrity

Relatively new discipline integrating engineering areas:

- refers to **safe operation** of engineering structures, their **residual life** and the way to achieve it (**life management**)
- *ESIS definition: …addresses the science and technology that is used to assess the margin between safe operation and failure*

Structural integrity assessment:

- evaluation of resistance against strength and fracture

Tools of assessment / measurement:

- fracture mechanics, numerical calculations
- materials science, degradation effects
- **non-destructive testing / evaluation (*NDT / NDE*)**
- risk analysis

Bottom line: *NDT is not an end but a means*

End: *needs* of the environment using NDT

- ***SAFETY – social need***
  Saving human, natural and built environment in case a structure fails due to non-detection of a flaw

- ***PRODUCTIVITY – commercial need***
  Optimizing service life and performance of assets being inspected

Means: *response of NDT community to fulfil the needs*

- Means = NDT system
  Equipment
  Procedure
  Human

Right response to the needs:

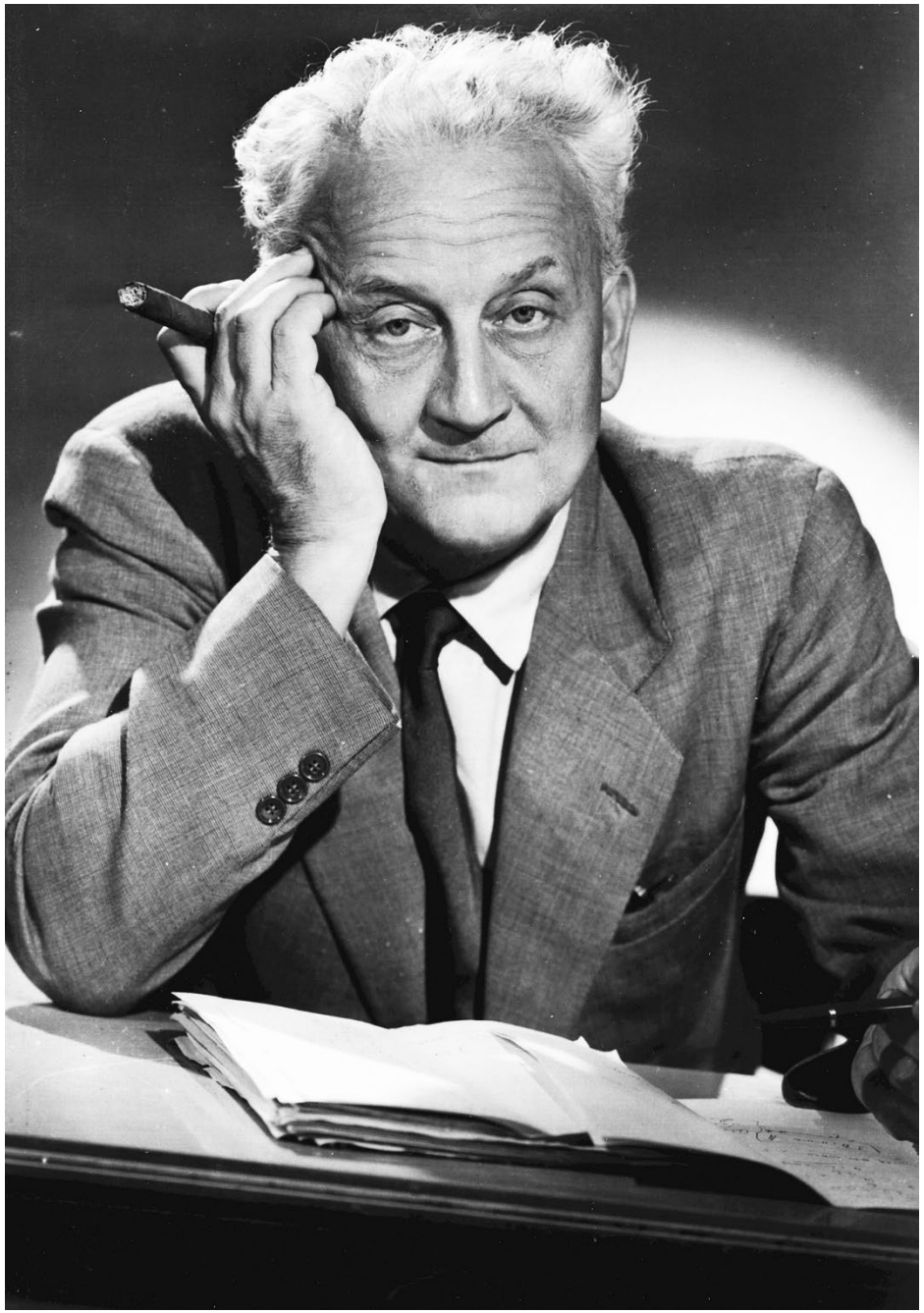
NDT integrity engineering

NDT integrity engineering is a discipline / profession

- to develop **NDT / NDE**
- involving **materials science, fracture mechanics**, and other sciences
- that would guarantee and enhance the **reliability and safety**
- by ensuring **integrity** of structures and components

Broader context

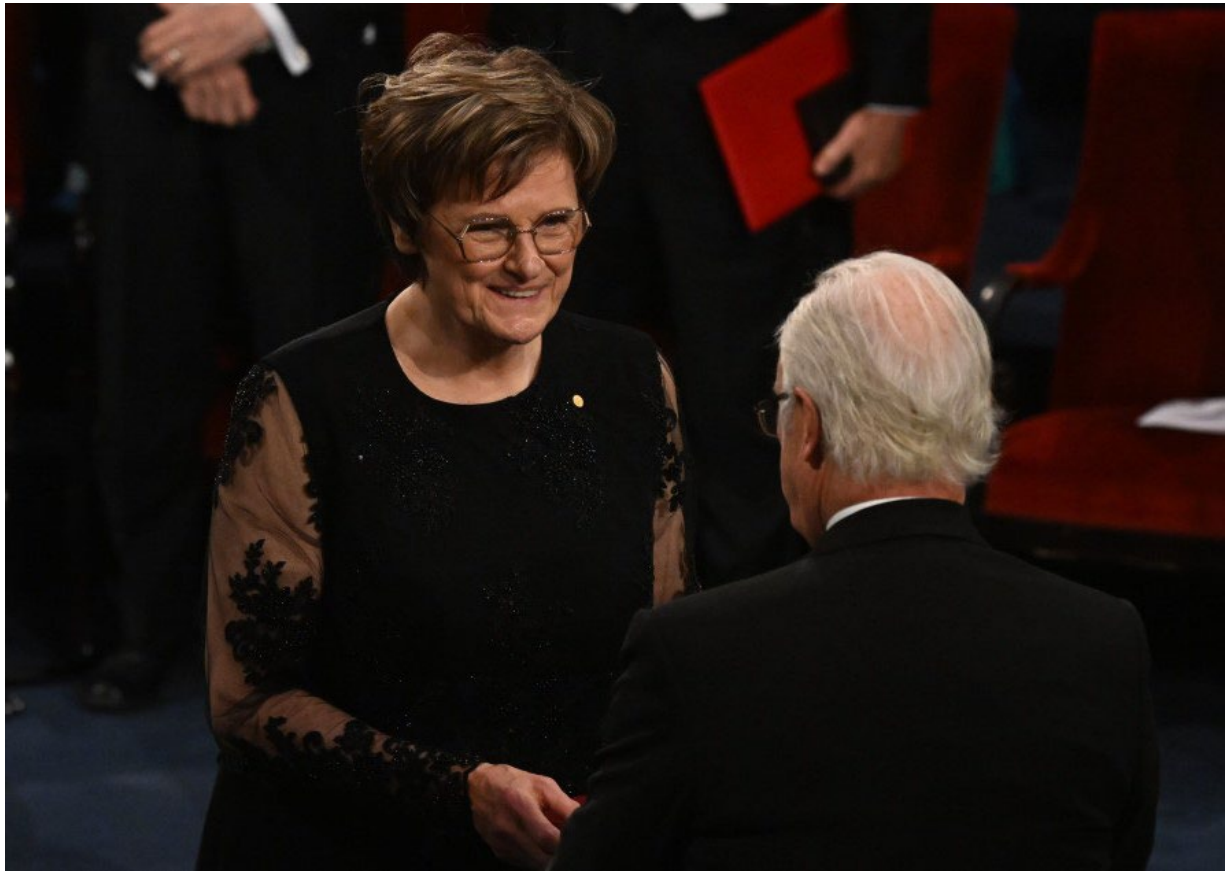
- **EC vision: European Education Area by 2025**
  - Social Summit, Gothenburg, 2017 (*informal discussion on **education and training***)
  - 1st European Education Summit, Brussels, January 2018
  - …
  - 6th European Education Summit, Brussels, November 2023
- Actions clearly demonstrate both **the need for** and **the intention to increase the level of competency in *engineering areas***
- **Current NDT / NDE**
  - belongs to **STEM** (***S****cience*, ***T****echnology*, ***E****ngineering*, ***M****athematics*), a family collecting most important areas of emerging technologies
  - **requires to join other professions also aiming to adjust / improve their educational programs**



„The future will be like the school of today”

Albert Szent-Györgyi,
Hungarian Nobel Prize Winner
in Physiology or Medicine
(vitamin C)
1937

Bright day – December 10, 2023, Stockholm



Katalin KARIKO – *Physiology or Medicine*

Ferenc KRAUSZ – *Physics*

Historical retrospect of NDT engineering

- 1967, Fall Conference of ASNT – **NDT engineering profession – a „new profile”** *(R.B. Socky)*
- 2016, ASNT Research Conference – **NDE engineer – the „missing subject matter expert”** *(J.C. Duke)*
- 2016, ISO/TS 21759 (working document) – **Non-destructive testing – Guidelines for Training, qualification and certification of NDT Engineers**
- 2018, 12th European Conference on NDT – **NDT integrity engineering** *(P. Trampus, V. Krstelj, Academia NDT International)*
- 2019, EFNDT-EWF Working Group – **European NDE Engineer**
- 2019, ASNT Engineering Council (NDT Engineering Committee) – **NDT engineer**
- 2022, ISO 9712 Annex E (informative) – **Engineering of NDT**

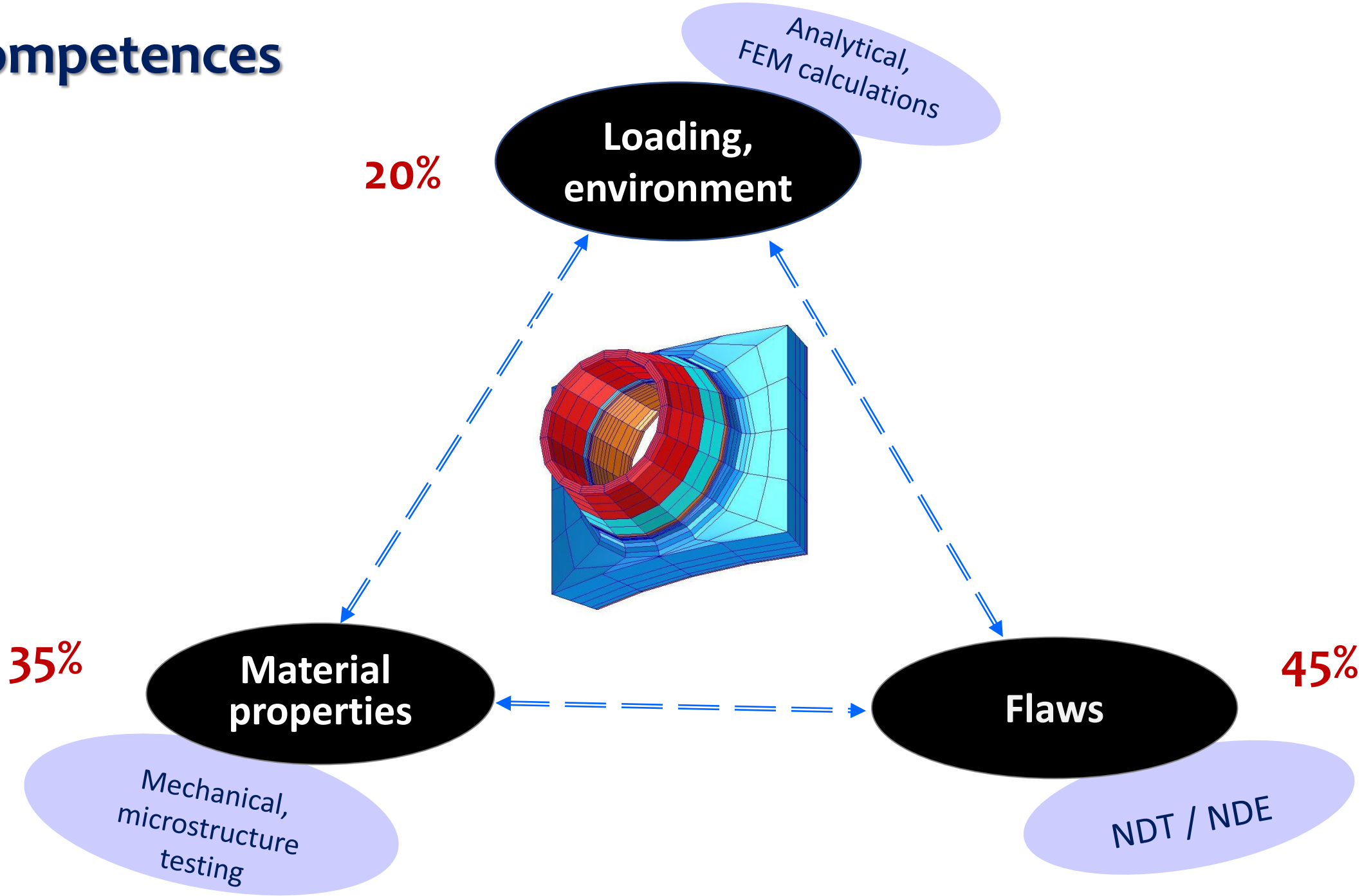
„NDT integrity engineering” courses, Hungary

- Postgraduate, two-semester courses (2020, 2022)
- Courses are pioneer and *First of a Kind*
- Pilot project of ***Academia NDT International***

Courses jointly developed and implemented by:

- *Technical Faculty, University of Debrecen, Hungary*
- *Hungarian Association for Non-Destructive Testing (MAROVISZ)*
- *Hungarian Chapter of European Structural Integrity Society (ESIS)*

Competences



Course curriculum

Subject groups	Weight	Subject
Numerical methods, applied mathematics	20 %	Statistical methods
		Problem solving with machine learning
		Basics of Finite Element Method (FEM)
		FEM applications in structural integrity analysis
Degradation effects, structural integrity assessment	35 %	Engineering methods of operability
		Fracture mechanics – Principles and material properties
		Operating conditions – Material degradations I
		Operating conditions – Material degradations II
		Safety, reliability, risk
NDT/ NDE methods, techniques and application areas	45 %	Modern condition monitoring
		Industry 4.0 and NDE
		Reliability of NDE
		Modelling and simulation of NDE
		NDE methods and applications I
		NDE methods and applications II
		Thesis

General competences

NDT integrity engineers *must understand and speak* the entire „NDT language”

It means:

- clear **understanding** on NDT and non-destructive characterization of materials
- awareness of **possibilities** and **limitations** of various NDT methods
- practical **experience** in some of the major NDT methods

Competences on NDT / NDE

- **Physical basis** of major NDT methods (*traditional and up-to-date*)
- **Application areas** of various methods and their limitations
- **Reliability** of NDT
- **Early detection** of materials degradation
- **Structural Health Monitoring** strategies and techniques
- Impact of development of **information technology** and **micro- and nanoelectronics**
- **NDE 4.0**
- NDT **modelling and simulation** and their use
- NDT system **qualification** (*performance demonstration*)
- **Globalization** of NDT

Competences on materials science

- **Manufacturing** processes of usual engineering materials
- Potential **failures** associated with manufacturing with special regard to welding
- **Mechanical properties** (tensile, fracture mechanics, low- and high-cycle fatigue, creep etc.)
- **Microstructural characterization** of materials' actual condition
- „Materials' response" to loading and environment, i.e. service induced **degradation** processes and effects
  - fatigue crack initiation and growth
  - local corrosion
  - creep
  - erosion
  - wear
  - embrittlement and loss of toughness
  - …

Competences on loading and environment

- Awareness of **physical fields** arising in the component during operation
  - mechanical
  - thermal
  - magnetic
  - electric
  - electromagnetic
- Basics of **analytical and numerical methods** of physical field calculations
- **Consequences of degradation** processes, e.g. wall-thickness reduction, unstable crack growth, loss of loadbearing cross-section
- Basics of **fracture mechanics** with special regard to linear elastic fracture mechanics, and engineering approaches

General engineering competences

- Awareness of wider **multidisciplinary context** of engineering
- General **ability to solve** engineering problems by applying relevant analytical, computational and/or experimental methods
- **Ability to consult** and apply codes of practice and safety regulations
- Awareness of **economic, organizational and managerial** issues such as project, risk and change management
- Ability to **communicate** information and solutions with engineering community and society at large, if necessary
- Ability to **function effectively** in national and international context as an individual and as a member of a team, and to cooperate with engineers and non-engineers

Facts – experiences

Basic concept:

- Focus on unity of engineering mentality (*safety – reliability – risk*) and its economic consequences
- Overall view on safe operation of components / systems
- Recognition of importance of service induced degradations

Course participants (so far):

- Oil, gas, nuclear sector, R&D institutes
- Practitioners, welding engineers (25 persons altogether)

Teachers:

- University professors
- Leading industry representatives

COVID: negatively influenced the first course (practical training suffered)

After-course interviews: generally positive acceptance

Students after graduation ceremony

Thank you four your attention!