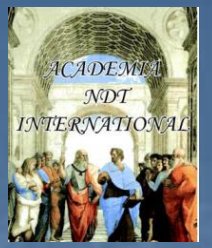

Updated syllabus for future NDT masters in France

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Motivations and Outline

- Introduction
  - Many areas of activity : Non-Destructive Testing and Evaluation (NDTE)
  - Industry 4.0 is a major challenge in which NDTE have an important role
  - Paradoxically, there is little training at the master's or engineer level to train NDTE specialists in France
  - There are several universities/engineering schools that offer topics in NDTE
- Methodology
  - Taking advantage of the specificities and skills of each institution
  - The ambition of French academic teachers and researchers in NDTE to develop a strong and emerging network
  - Examples of Curriculum with NDT parts at the master level
- Conclusions, discussion and perspective

https://www.ndt.net/article/ecndt2023/papers/ECNDT2023_PRESENTATION_303.pdf

Some NDT news from French media

Industry: "la Nouvelle-Aquitaine " mobilizes on non-destructive testing To succeed in factory 4.0, the factory of the future, it is essential to master the non-destructive testing of industrial parts.

La tribune (2019)

"Non-destructive testing: professions of the future and more than *1,000* recruitments at Safran"

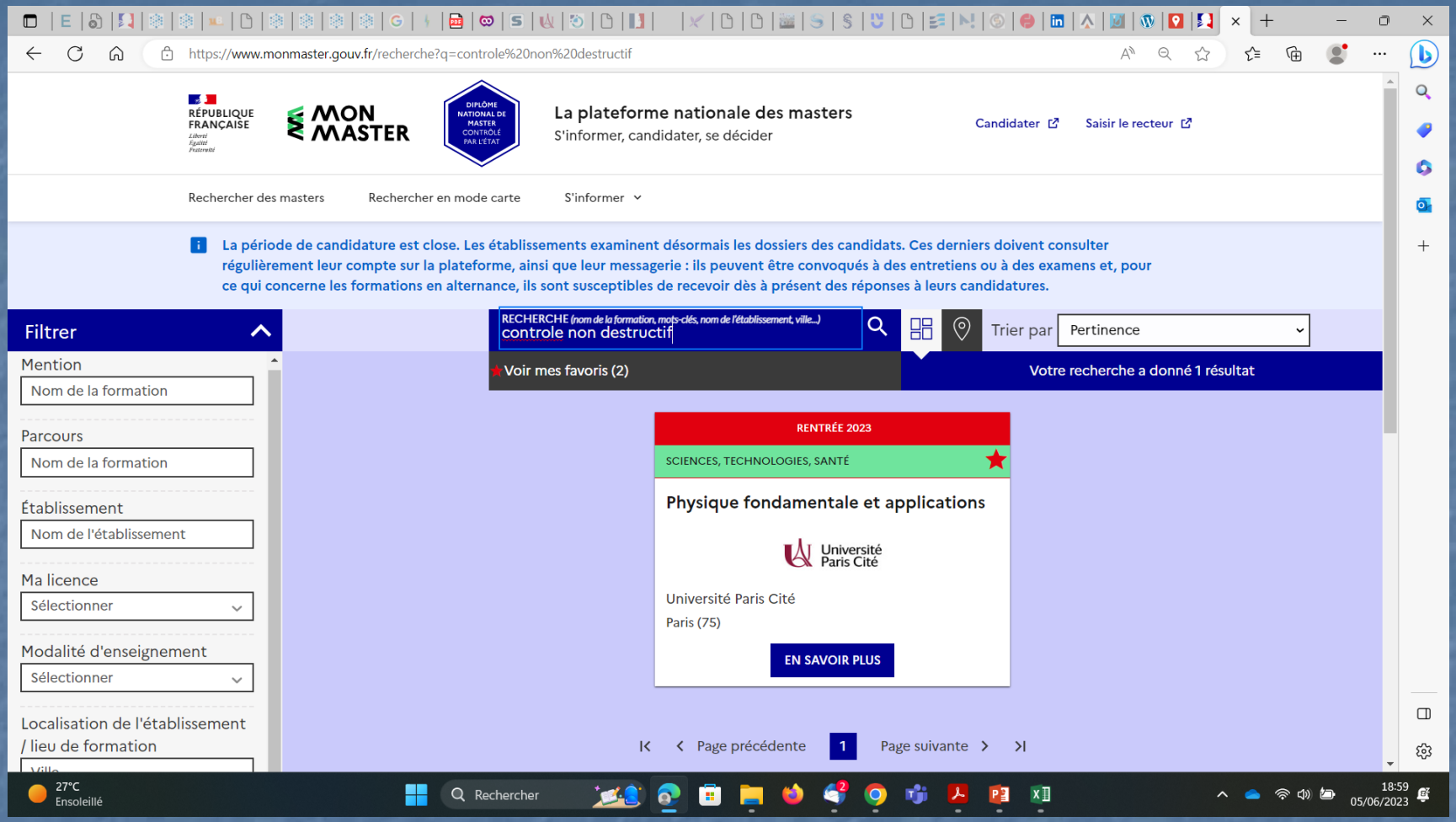
hellowork (2019)

Usine nouvelle (2023)

Nuclear: a non-destructive testing platform inaugurated in Chalon-sur-Saône : A "European nuclear school"

Les echos (2023)

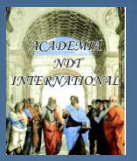
NDT Masters in France



The official French Master portal : no specialized NDT Master Training !

https://www.monmaster.gouv.fr/

Masters with NDT topics



1. École Nationale Supérieure de Techniques Avancées (ENSTA ParisTech) - Mastère Spécialisé (MS) en **Contrôle Non Destructif** et Mesures Industrielles. Site web : https://www.ensta-paris.fr/

2. Université de Technologie de Compiègne (UTC) - Master Recherche en Mécanique, spécialité **Contrôle Non Destructif**. Site web : https://www.utc.fr/

3. Université Paris-Est Créteil (UPEC) - Master Professionnel **Contrôle** Qualité et **Non Destructif** (CQND). Site web : https://www.u-pec.fr/

4. Institut National des Sciences Appliquées (INSA) Lyon - Master Recherche en Mécanique, spécialité **Contrôle Non Destructif**. Site web : https://www.insa-lyon.fr/

5. École Supérieure des Techniques Aéronautiques et de Construction Automobile (ESTACA) - Mastère Spécialisé en **Contrôle Non Destructif**. Site web : https://www.estaca.fr/

6. Université de Bourgogne - Master Professionnel Procédés, Contrôle et Matériaux Métalliques: Industrie du Nucléaire (PC2M). CND en alternance. Site web : https://blog.u-bourgogne.fr/master-pc2m/

7. Université de Nantes - Master Recherche en Sciences et Techniques, spécialité **Contrôle Non Destructif** et Mesures. Site web : https://www.univ-nantes.fr/

8. Université de Lorraine - Master Recherche en Mécanique, spécialité **Contrôle Non Destructif**. Site web : https://www.univ-lorraine.fr/

9.Université de Technologie de Troyes (UTT) - Master Recherche en Sciences et Technologies, spécialité Contrôle Non Destructif et Fiabilité des Matériaux. Site web : https://www.utt.fr/

Masters with NDT topics

9. Institut National Polytechnique de Toulouse (INPT) - Master Recherche en Mécanique, spécialité Contrôle Non Destructif et Mesures. Site web : https://www.inp-toulouse.fr/

10. Université de Technologie de Belfort-Montbéliard (UTBM) - Master Recherche en Mécanique et Energétique, spécialité Contrôle Non Destructif. Site web : https://www.utbm.fr/

11. Université Claude Bernard Lyon 1 - Master Recherche en Sciences et Technologies, spécialité Contrôle Non Destructif des Matériaux et Structures. Site web : https://www.univ-lyon1.fr/

12. Université de Lille - Master Recherche en Sciences de l'Ingénieur, spécialité Contrôle Non Destructif. Site web : https://www.univ-lille.fr/

13. Institut Supérieur de Mécanique de Paris (ISMEP) - Master Recherche en Sciences et Génie des Matériaux, spécialité Contrôle Non Destructif et Intégrité des Structures. Site web : http://www.ismep.fr/

14. Université de Strasbourg - Master Recherche en Physique, spécialité Contrôle Non Destructif. Site web : https://www.unistra.fr/

15. Université de Bordeaux -Le Cursus Master en Ingénierie IMSAT (Ingénierie et Maintenance des Systèmes pour l'Aéronautique et les Transports) ; https://evering.u-bordeaux.fr/Nos-formations/Cursus-Master-en-Ingenierie-IMSAT

16. École d'ingénieur POLYTECH Dijon-Ex ESIREM – Formation ingénieur en alternance sur 3 ans Matériaux et Contrôle Non Destructif (Ouverture septembre 2023) Site web : https://esirem.u-bourgogne.fr/wp-content/uploads/2023/04/cnd.pdf

Examples

1. Lyon (Open NDE)
2. Le Mans (ECND Academy)
3. Blois (NDT Integrity Engineering)
4. Dijon (Material Engineering and NDT)
5. Paris Sorbonne university/Abu Dhabi

(Specialization in Non-Destructive Characterization with Applications for Cultural Heritage)

1. Lyon (Open NDE)

Engineer level NDT training

Goal : train students with a cross-disciplinary vision of NDT without being specialists in all NDT methods

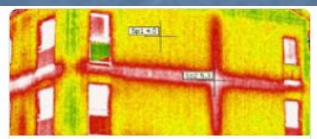
- Program elaboration in concertation with industrials
- Well balanced program between industrial and academic
- Experimental activities ratio : 30 %
- Training specialized on NDT :
  - All methods/technics
  - Materials (metal, ceramic, composites, …) and manufacturing process (welding, casting, additive manufacturing)
  - Data analysis (simulation, IA, …)

1. Lyon (Open NDE)

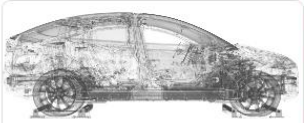
Moodle dedicated platform for NDE courses

- https://moodle.opennde.org/

Some topics



Thermographie infrarouge
Méthodes CND volumiques



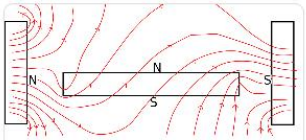
Tomographie par rayons X
Méthodes avancées en CND

Traitement du signal et de l'image, ...
Analyse et exploitation des donné...

POD, fusion de données, contrôlabilité
Analyse et exploitation des donné...

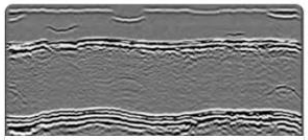
Problème inverse
Analyse et exploitation des donné...

Projet Matériaux
Matériaux et CND



Magnétoscopie
Méthodes CND surfaciques

Méthodes électromagnétiques avancées
Méthodes avancées en CND



Méthodes ultrasoniques avancées
Méthodes avancées en CND

Méthodes visuelles avancées
Méthodes avancées en CND

Normalisation
Introduction aux CND

Passeport numérique
Analyse et exploitation des donné...

1. Lyon (Open NDE)

Companies involved

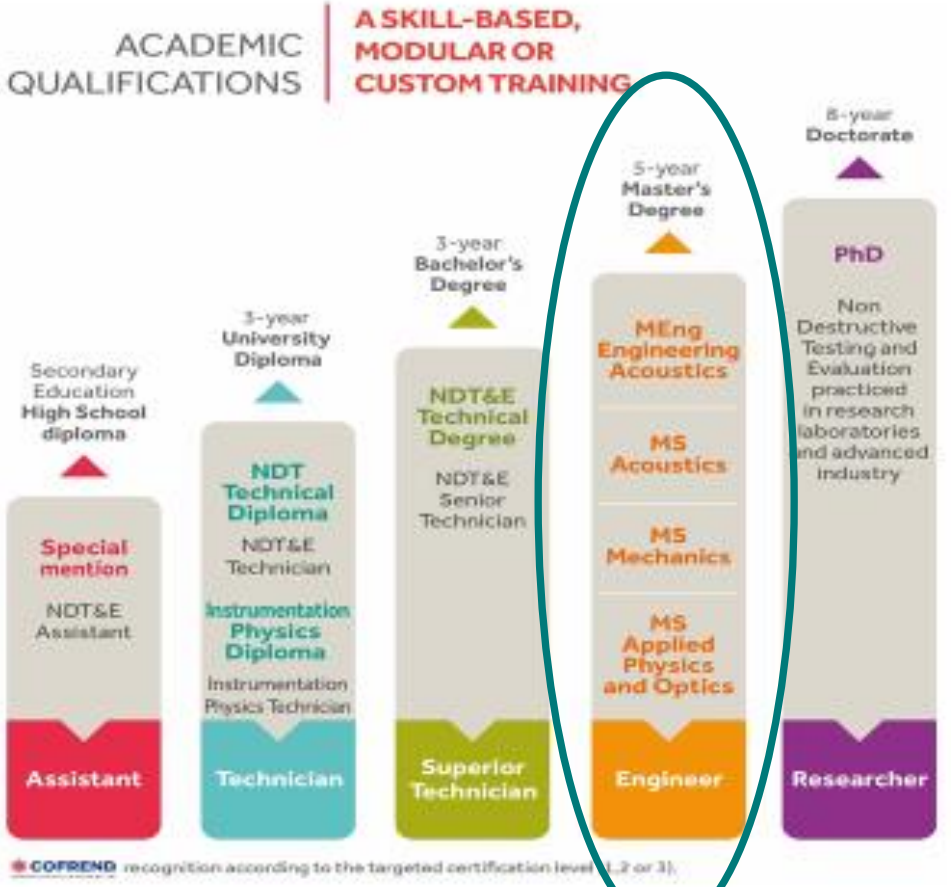
COFREND – Confédération Française pour les Essais Non Destructifs
SAINT-GOBAIN
EDF
cea
framatome
VINCI ENERGIES
BAKER HUGHES a GE company
Cerema
COMSOL
Ctif
NEUTRONS FOR SOCIETY
MISTRAS
precend
THALES
afnor NORMALISATION
SAFRAN
Sites – VEILLE SUR VOS STRUCTURES
sofranel
TERAKALIS
EFER NDT VISION
cnrs – dépasser les frontières
Le Mans Université
INSA VALOR
INSA – INSTITUT NATIONAL DES SCIENCES APPLIQUÉES CENTRE VAL DE LOIRE
Aix*Marseille université – Initiative d'excellence
IN2P3 – Institut National de Physique Nucléaire et de Physique des Particules

2. Le Mans (ECND Academy)

NDT Master@Le Mans université

ECND Academy
Le Mans Université

Le Mans Université



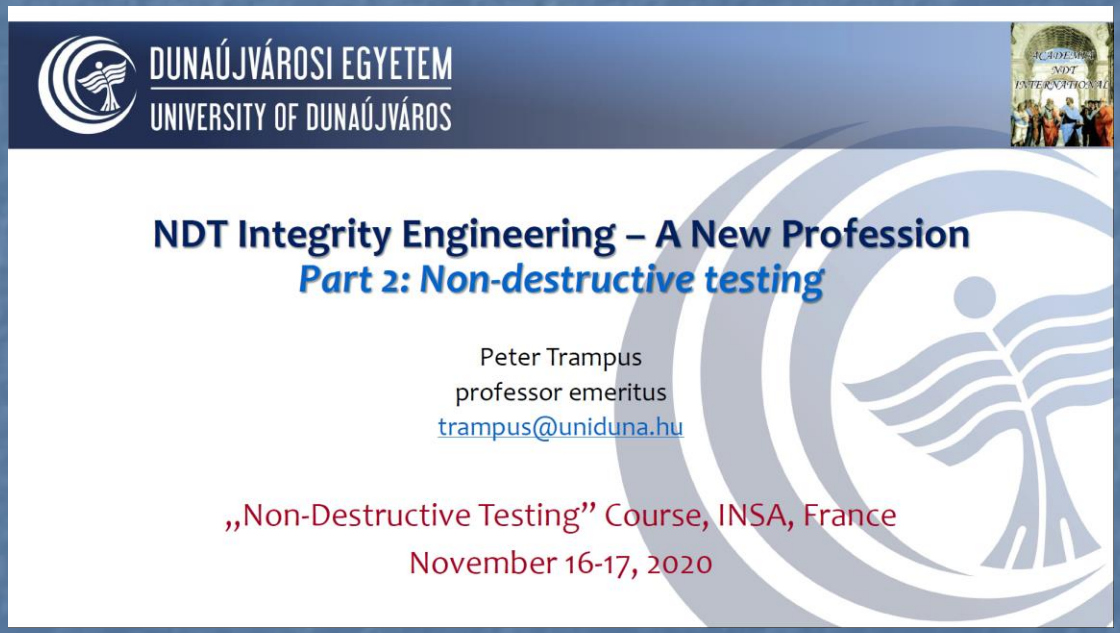
9 DEGREES
+ 26 SHORT COURSES

TAILORED TO BUSINESS NEEDS

* invest in your skills

3. Blois (INSA Centre Val de Loire)

NDT topics : NDT Integrity Engineering



https://www.insa-centrevaldeloire.fr/en/training/master

4. Dijon (Polytech Dijon)

New: opening September 2023

Material Engineering and NDT

https://esirem.u-bourgogne.fr/wp-content/uploads/2023/04/cnd.pdf

- Engineering degree (Master level)
- 3-year apprenticeship with a company

Content :

- Extensive training in material science
- About 225h of training in NDT
- Engineering science & advanced tools

5. Paris Sorbonne University/Abu Dhabi

(Specialization in Non-Destructive Characterization with Applications for Cultural Heritage)

Master in Physics with NDT topics

Contact: valerie.leguyon@sorbonne.ae
Dr Valerie Le Guyon – Head of the Sciences and Engineering Department

Master in Physics

- **2-year program (including a 6-months internship) - taught in English**
- **Designed with the Lab. d'Archeologie Moleculaire et Structurale - Sorbonne Universite**
- **Degree awarded by Sorbonne Universite**

Innovative program to educate highly skilled NDT scientists, exposed and trained to multi-disciplinarity.

5. Paris Sorbonne University/Abu Dhabi

Master topics

Theoretical courses (about 50%)

- ✓ Quantum and Statistical Physics, Material Science, Atomic and Molecular Physics, Vibrations and acoustics
- ✓ Heritage Science, Ethics, Scientific computing, Big Data and Artificial Intelligence
- ✓ Fields of application for NDT: space science, forensics, industry, authentication, quality control, etc

Hands-on & Project-related courses (about 50%)

- ✓ Lab sessions on specific techniques
- ✓ Small projects on the analysis of cultural heritage artefacts
- ✓ Long project run with Archaeology students, on an archaeological site in the UAE
- ✓ 6-month full time internship & Master thesis, in the UAE or abroad, in an academic lab or in a company, in fields applying NDT

https://www.sorbonne.ae/study/postgraduate-study/master-in-physics-specialisation-in-non-destructive-characterisation-with-applications-for-cultural-heritage/

Faculty members

Dr Stavros Christopoulos – Physics / Atomic, molecular and optical physics -**Dr Joumana ElRifai** – Engineering / MicroElectronics Mechanical systems - **Dr Delphine Syvilay** – Physics and Heritage Science - **Dr Omar El Dakkak** – Mathematics / Statistics and Probability - **Dr Samuel Feng** – Applied and Computational Mathematics - **Dr Christophe Moulherat** – Heritage science / Specialist in Textiles - **Pr Maguy Jaber** – Director of the LAMS – Sorbonne Universite - **Dr Philippe Walter** – LAMS – Directeur de recherche CNRS

5. Paris Sorbonne University/Abu Dhabi

Current projects:

Heritage Science

- ✓ Face veils
- ✓ Al Sadu: traditional weaving techniques
- ✓ UAE archaeological artefacts
- ✓ Dutch ceramics from ships wreckage
- ✓ Development of 3D scans and holographic images
- ✓ Application of Virtual reality in heritage science

Notre-Dame de Paris:
Immersion into an extraordinary restoration

Fabrication of samples by diffusion of nanoparticles or nano-printing:

Material Science

- ✓ Smart optical films
- ✓ Nanostructured layers for energy harvesting
- ✓ Electrocaloric effect in liquid crystals
- ✓ Nano-diffusion or nano-printing

5. Paris Sorbonne University/Abu Dhabi

Mobile Heritage Science Lab:

A unique set of portable instruments in the region:
Raman, UV-vis-IR, FTIR, hyperspectral, RX, XRF, Ultrasound, 3D scanner, …

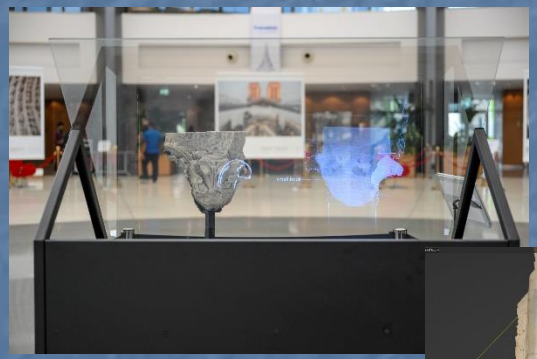
5. Paris Sorbonne University/Abu Dhabi

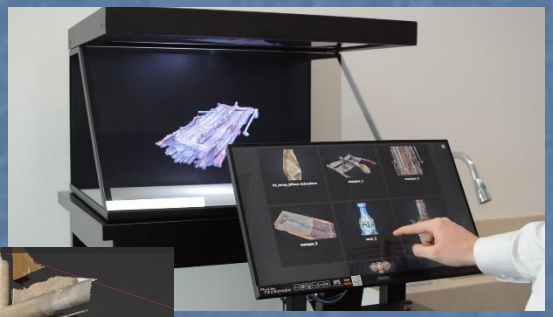
A few images

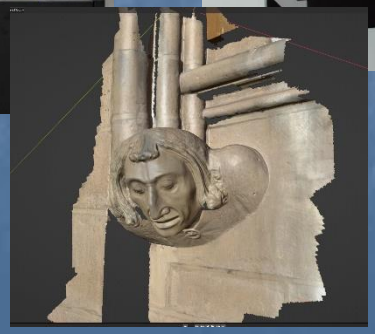
Textiles: Face veils

High definition 3D digital microscope

Holographic tables







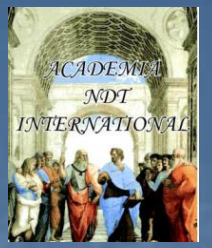
Traditional weaving techniques

Conclusion and perspectives

- Highlight the NDT needs and federate **different actors** (industrials/academics) **within the AI ecosystem**

- Provide strong actions to **national bodies in France** in order to increase the visibility of NDTE within finances

- Define actions closely to **students** using international organizations (European Union, IEEE UFFC, etc.)



Thank you !
Questions ?