Case study: CHADA v2 population with composite materials characterization data from the D-STANDART project

Julian DeMarchi, PhD

Senior Scientist, Royal Netherlands Aerospace Centre NLR

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the European Union

d-standart.eu

intro

advisory board

aerospace and wind energy representatives

Rolls Royce	Fokker Aerostructures	Siemens Gamesa	Embraer	Coexpair (SME)

intro

partners

consortium

GA: 101091409
Timeline: 1 Jan 2023 – 31 Dec 2025
Duration: 36 months

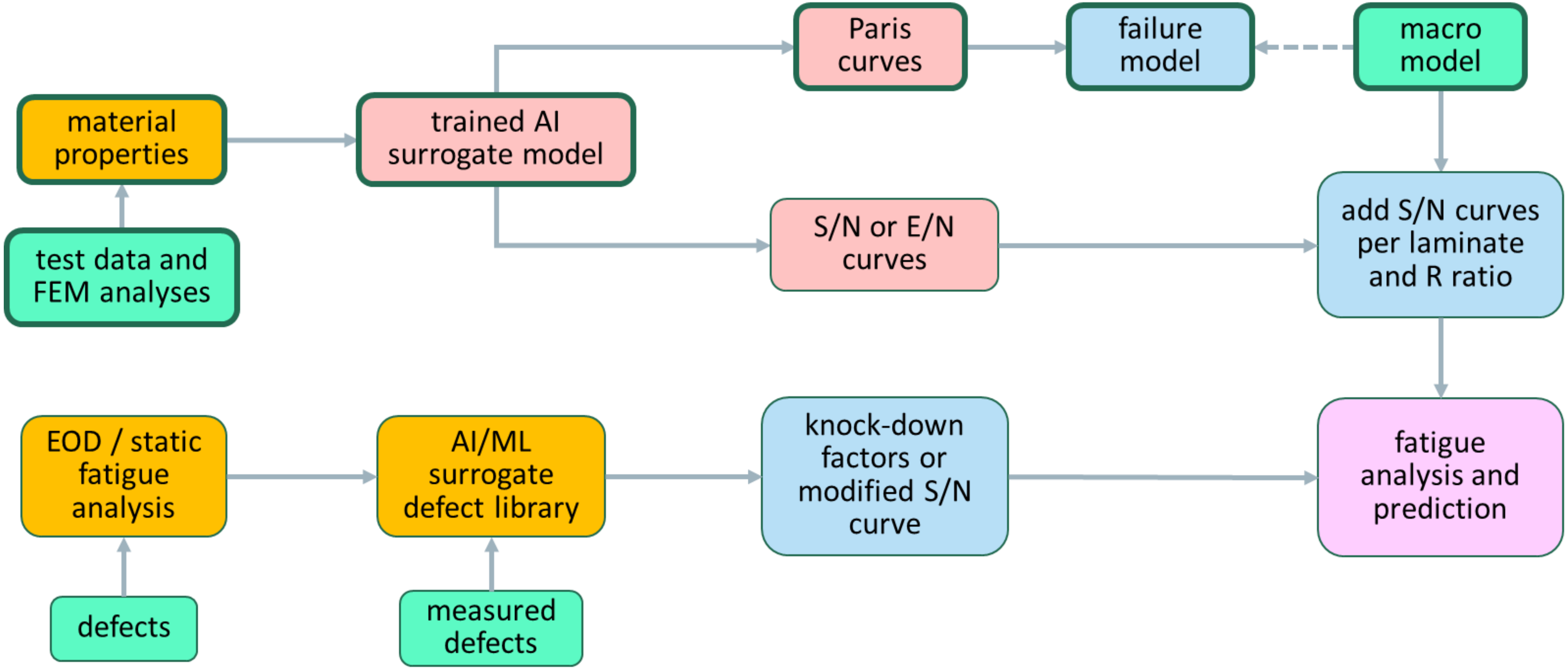
6 Beneficiaries, **4** Affiliates
3 Associated Partners
7 European countries

5 RTOs
1 IND
2 SMEs

intro

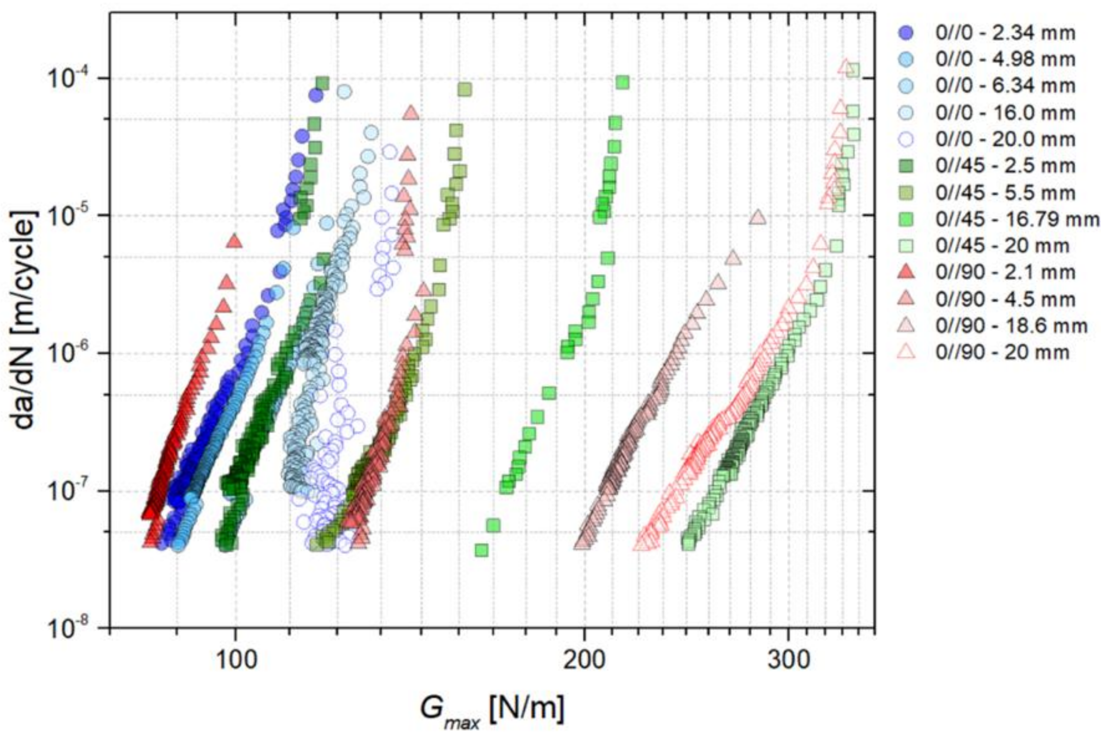
Technical context

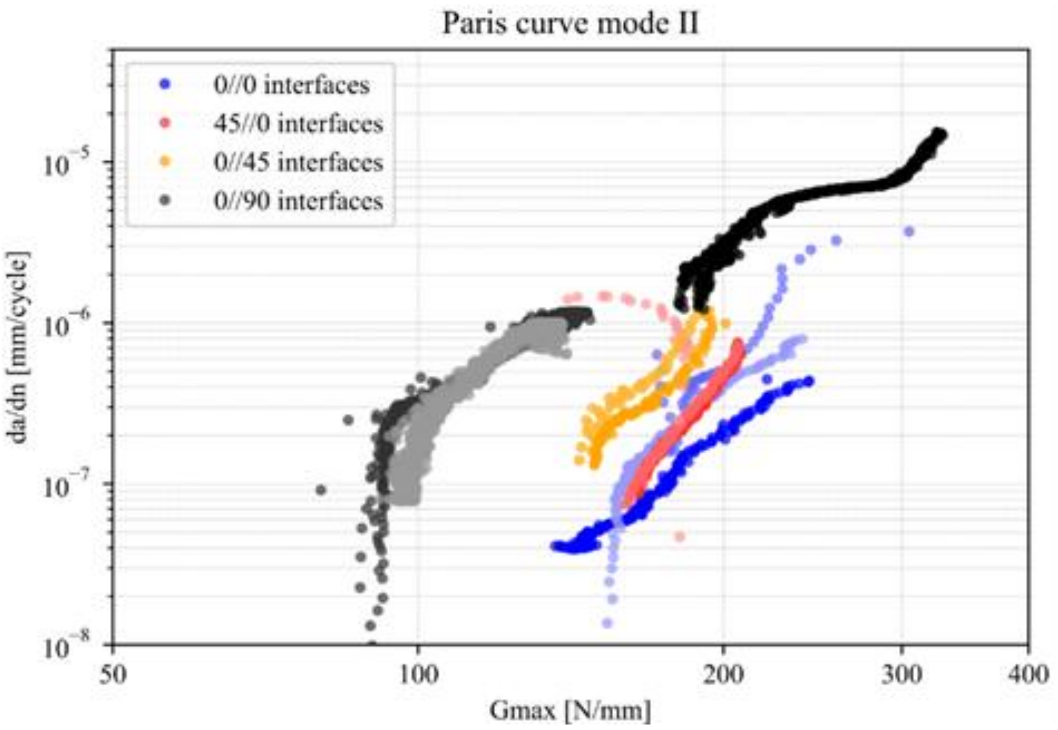
based on existing ASTM / ISO standards



Example result/outcome

based on existing ASTM / ISO standards





Mode I: Main effect at longer pre-cracks -> more fibre bridging

Mode II: Strong effect, also for short pre-cracks

01 Framework

Contextual overview

EMMO

CHAMEO

CHADA

EMMC – European Materials Modelling Council

nanoMECommons – mechanical materials testing

D-STANDART

Characterization of composite materials at meso scale

Framework

EMMC Ontology

datapoints to capture within digital thread

- **CHADA**
  - Raw material characteristics data
  - Raw material storage data
  - Material characteristics data
  - Fabrication data (layup, process fluctuations and settings/ranges, debulk)
  - Test setup

- **MODA**
  - Model setup (geometry, material assignments, boundary conditions e.g. kinematic constraints, mesh size, element type, temperature & moisture distribution, loading, in short which settings)
  - Solver, artificial damping/viscosity, implicit/explicit analysis, solution scheme, multi-physics/multi-(sub)model simulations, built-in “stock” versus end-user “custom” blocks (e.g. solver subroutines/AI or surrogate models/User elements)
  - Model outputs (stress & strain fields, damage propagation predictions, others TBD)

Framework

EMMC Ontology

datapoints to capture within digital thread

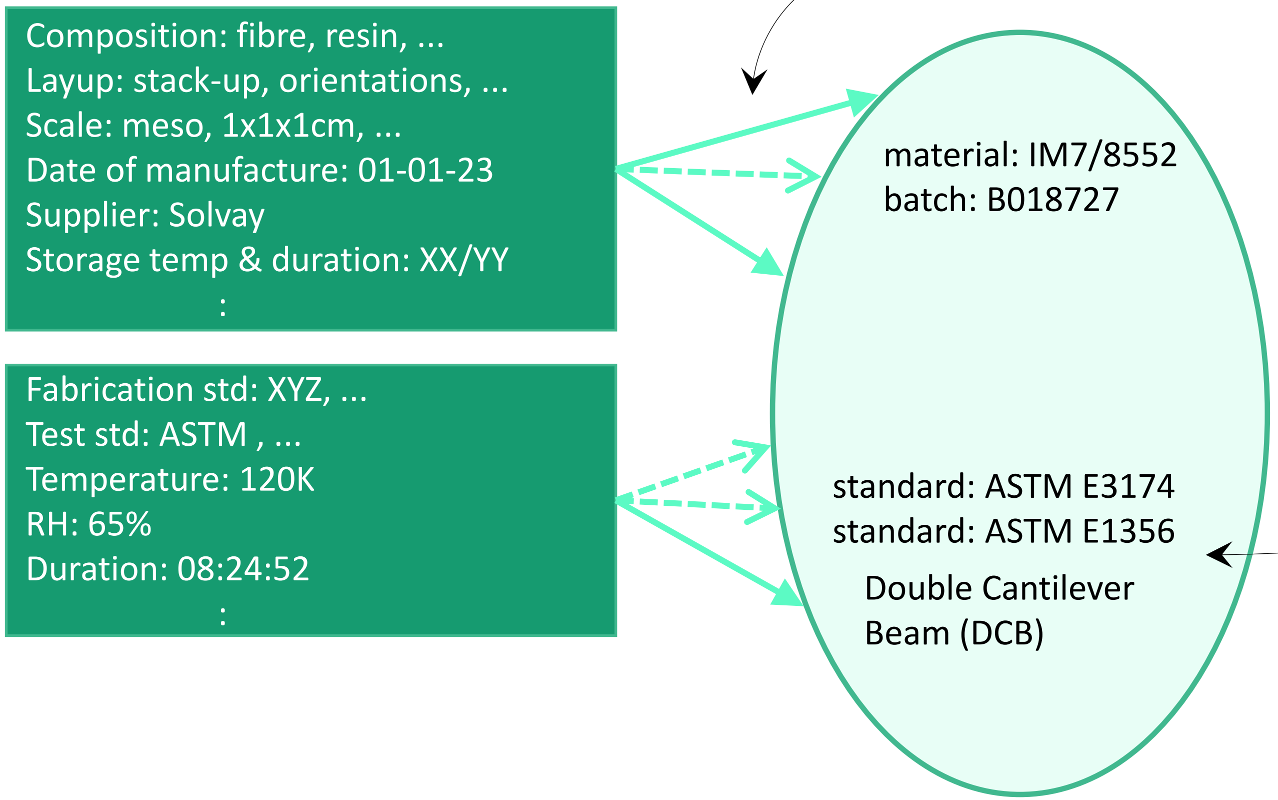
- **LCA**
  - Energy usage
  - Processes/workflows, equipment, transportation/storage
  - Material inputs (IM78552 Zoltek) inc. consumables, PPE, prepregs, vacuum bags etc. etc.
  - Waste (e.g. trimming, excess/unused materials)

Framework

Materials characterization

ontological mapping

Extracted, detailed metadata map onto EMMO nodes, adapted/extended as necessary for D-STANDART.

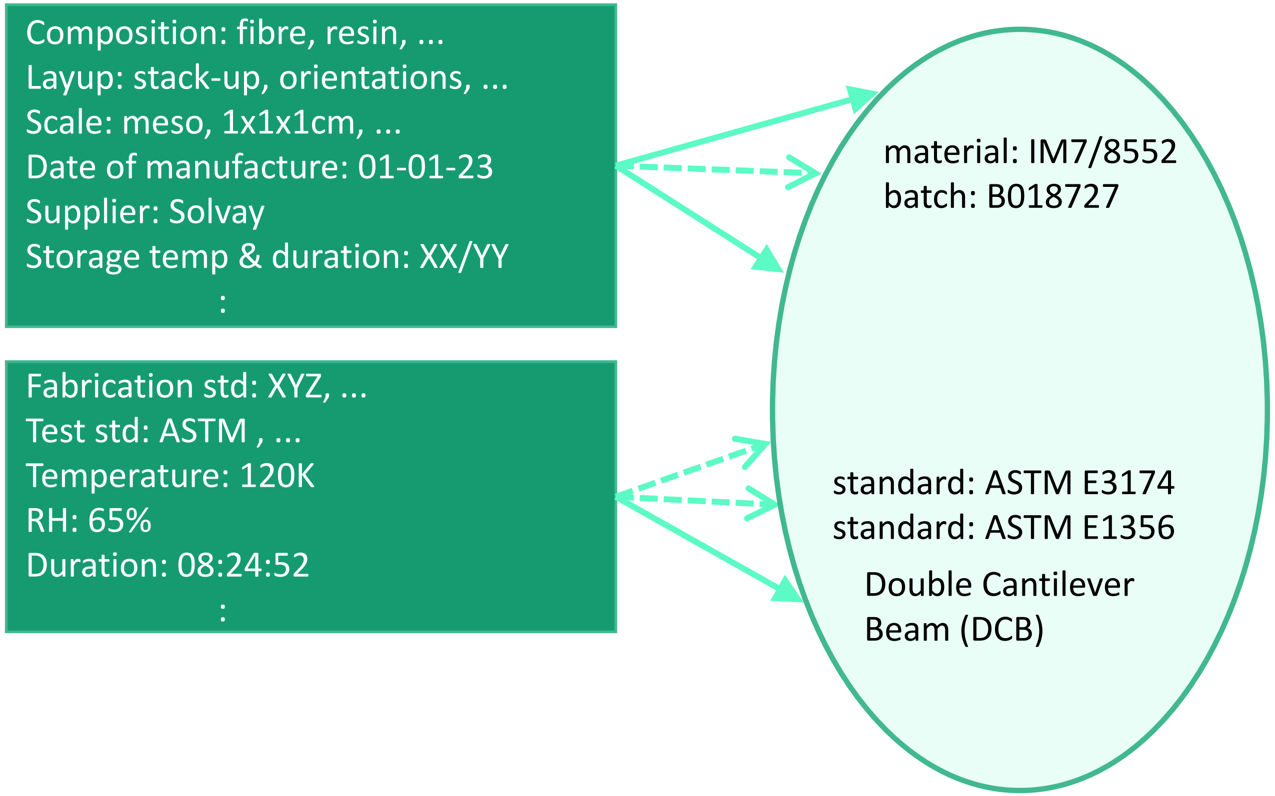


Gross elements of the metadata can be captured and/or represented using CHADA fields.

Materials characterization

ontological mapping

The required EMMO nodes are matched to input fields and marked as “mandatory”, “optional”, etc.
This way we can ensure that delivered (meta)data are complete.



mandatory
optional

The data are then stored into the digital thread, labelled with the metadata, and linked together like in a Petri diagram.

Digital Thread data population

CHADA example

Workflow

1. Initiate Experiment/Test

- Material
- Test specification

2. Conduct Test

- Test procedure
- Results

3. Analyse results

- Models applied
- Derived parameters
- Conclusions

Applicable Standards

- Metadata
  - who
  - what
  - when
  - where
  - why
  - how
  - circumstances
  - equipment
  - etc.
- CHADA template

Digital Thread

1. Placeholder for test
2. Test results
3. Post-processing & Analysis results

Concrete examples

- **STS**: Demo of the materials characterization digital thread interface.
- **CHADA**: Example CHADA templates based on the CHADA v2 update (CENELEC CWA 17815-2025).
- **API**: The application domain-specific electronic format developed for our own composite materials testing.

02 Approach

Approach

Aims: improving lifetime estimation of composite structures

- **Objective 1**: Develop a framework for managing digital threads.
  - We started with a front-end UI, with the idea that people would enter and upload all the data manually.
  - Now we are more focused on a back-end API for automated import of huge amounts of data, tasking the UI for searching.
- **Objective 2**: Develop placeholders (templates) for digital threads to support coupling AI technologies to fatigue model.
  - Initially the digital thread only contains test results.
  - We would like it to also contain simulation results, incorporating these as the AI continues learning.
- **Objective 3**: Support design (CAE) software making use of digital threads.
  - We started with a CHADA-style input interface, but realized this was not tailored to also include MODA
  - In the future we would like to include MODA as a way of automatically regenerating results based on processed test results

Approach

Constraints: standardization and uptake by industry

- **Constraint 1**: Ensure the data are FAIR.
  - From the very beginning we have ensured we capture sufficient data for our own researchers to replicate their own results.
  - Searchability is expected to improve by transitioning from a traditional RDBMS to an RDF-capable DB.
- **Constraint 2**: Ensure provenance and traceability of the data within the project digital thread.
  - This has been done from the very beginning, by maintaining strict traceability from the results back to the source data.
  - We did this using our own metadata tags (demo in a moment).
- **Constraint 3**: Apply existing and developing EU standards to the extent feasible.
  - Here we are applying the EMMO via CHAMEO and the (updated) CHADA v2.
- **Constraint 4**: Provide feedback from lessons learned to facilitate uptake of the CHADA within the project application domain.
  - This has been done via participation in the CHADA v2 update by CENELEC.

Approach

Challenges: searchable links via materials ontology

- **Challenge 1**: Adapt the updated CHADA v2 (CENELEC CWA 17815-2025) to suit needs specific to meso-scale composites characterization.
  - Now the CHADA is far more generally applicable, also for composite materials and at the mesoscale.
- **Challenge 2**: Ensure uniformity and consistency of data capture across multiple organizations.
  - This was a major challenge, we had to develop our own domain-specific translators for this (demo in a moment).
  - The main aim here was to convert partner-specific metadata to a consistent form of JSON-LD for (future) import to RDF DB.
- **Challenge 3**: Retain linkages to the EMMO, via the CHAMEO.
  - We are updating this for the v2 CHADA and the recent CHAMEO metatag updates.
- **Challenge 4**: Make it as easy as possible, leveraging existing materials test standards, and using domain-specific terminology.
  - We provided translations from the composites material characterization domain, via the CHAMEO, to the EMMO.

Approach

Results: a consistent and viable digital thread

- **Result 1**: Adapt and extend the CHADA with data fields needed for our specific application domain.
  - This was made possible by generalizing the CHADA (v2). We ensure provision of all possible CHADA v2 database endpoints. These are however not all populated. In addition, we provide domain-specific endpoints, reachable via CHADA queries.
- **Result 2**: Automatically translate test-centre-specific formats into our application-domain CHADA format.
  - We developed scripting to automatically identify and import metadata via CHAMEO tags.
- **Result 3**: Render the adapted CHADA in machine-readable form.
  - Since the imported metadata are already CHAMEO tagged, they can be exported as CHADA.
- **Result 4**: Produce a web-hosted digital thread service to capture the test results and make them searchable.
  - This service already exists, however the search functionality is expected to improve when transitioning to SPARQL.
- **Result 5**: Make the results indexable to export them for machine learning purposes.
  - This is already intrinsically supported via the CHAMEO and CHADA tagging.

Main challenges

Main challenges

- Ensuring that metadata from different lab tests are recorded and preserved with uniform structure and quality
- Making those metadata searchable in an effective, efficient, and useful way
- Ensuring that source data can be consistently and reliably stored, discovered, accessed, and retrieved
- Coupling materials characterization metadata into the EMMO
- Automation

03

D-STANDART

and sister projects

MatCHMaker

cross-fertilisation

EC sister projects

Project No.	Project Name	Project Focus
101091409	D-STANDART	Durability Modelling of Composite Structures with Arbitrary Lay-up using Standardized Testing and Artificial Intelligence
101091621	AddMorePower	Advanced modelling and characterization for power semiconductor materials and technologies
101091534	KNOWSKITE-X	Knowledge-driven fine-tuning of perovskite-based electrode materials for reversible Chemicals-to-Power devices
101091687	MatCHMaker	Open data and industry driven environment for multiphase and multiscale Materials Characterization and Modelling combining physics and data-based approaches
101092211	CoBRAIN	Integrated Computational-Experimental material Engineering of Thermal Spray coatings
101091912	AID4GREENEST	AI powereD characterization and modelling for GREEN STeel technology

...thank you!

FOLLOW US ON:

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- Digital thread (NLR)
  - Julian DEMARCHI
  - Email: Julian.DeMarchi@nlr.nl
  - Phone: +31 88 511 3729
- Project Coordinator (NLR)
  - Marco NAWIJN

[redacted]

- Project Management Officer / Communication (L-UP)
  - Mathieu LIONS / Peggy FAVIER

[redacted]

standart
for Durability Modelling of Composites

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