

**VMAP**

*Standards Community e.V.*

VMAP

USER FORUM

2026

CONFERENCE PROCEEDINGS

24 & 25 FEBRUARY 2026

SCHLOSS BIRLINGHOVEN, SANKT AUGUSTIN, GERMANY



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# THE VMAP STANDARDS COMMUNITY

The VMAP Standards Community e.V. (VMAP SC) is a registered non-profit association founded in December 2022 by 16 founding members, anchored at Fraunhofer SCAI (Schloss Birlinghoven, Sankt Augustin, Germany). It stewards the VMAP Standard, the world's first open, vendor-neutral CAx (Computer-Aided Engineering) data interface standard, enabling seamless interoperability across simulation tools throughout manufacturing workflows. The ITEA project that created VMAP won the ITEA Award of Excellence for Standardisation 2021, with documented efficiency gains of 50% faster innovation speed and 40% reduction in virtual process chain setup time.

VMAP SC operates through a two-tier meeting structure:

- Quarterly Assembly Meetings: Quarterly Assembly Meetings (Full Plenary) — open to all members; current R&D project updates, new specification proposals, and standard extensions are presented, discussed, and voted on. Technical documents are distributed ahead of each session for member review.
- Working Group Sessions: Working Group Meetings — each technical working group holds dedicated sessions on its own schedule to advance specification drafts; output is fed into the next Assembly meeting.

Supported Projects (Completed & Running)

| Project               | Description  |
|-----------------------|--|
| <b>VMAP</b>           | The founding ITEA project (2017–2020) that created the original open standard for integrated virtual material modelling in manufacturing — now the specification baseline. |
| <b>VMAP Analytics</b> | ITEA follow-on project delivering smart analytics for multi-scale material and manufacturing modelling; final review completed April 2024.                                 |
| <b>Pioneer</b>        | Open innovation platform combining product development, virtual engineering workflows, and production data to optimise manufacturing systems.                              |
| <b>Restore</b>        | Sustainable remanufacturing with increased automation and recycled content in laser- and plasma-based processes.   |
| <b>ALABAMA</b>        | Adaptive Laser Beam project for additive manufacturing processes.  |
| <b>SmartEM</b>        | ITEA4 project defining an open reference architecture for engineering model spaces.  |
| <b>GEAR-UP</b>        | Green Engineering, Analysis & Reskilling for Unbounded Production — sustainability-focused manufacturing initiative.   |
| <b>BASE</b>           | Battery Passport for Transparency & Circularity; developing semantic models for digital battery passports.   |

VMAP SC keeps its community informed and involved through a mix of digital channels and in-person events.

- **Website:** [vmap-standard.org](http://vmap-standard.org), where all the content is posted and can provide a quick overview into the use cases. The VMAP IO Library is available for download after accepting the VMAP SC License Terms, which ensure a single, consistent implementation of the standard.
- **Newsletter:** The periodic newsletter covers project milestones, upcoming events, and standard updates.
- **LinkedIn:** An active company page used for event announcements, news, and community updates.
- **Annual User Forum:** A flagship public conference held each February at Fraunhofer SCAI's Schloss Birlinghoven campus; features project presentations, working group updates, and community networking.
- **Conference Presence:** VMAP SC regularly hosts workshops and stands at NAFEMS events (World Congress, DACH Conference, Multiphysics & Multibody Dynamics Conference) and other CAE/simulation conferences globally.

# VMAP WORKING GROUPS

The **Complete Model Storage Working Group** has a clear and ambitious goal: to make it possible to initiate a simulation directly from a VMAP file. Today that's not fully achievable because the standard doesn't yet comprehensively store boundary conditions and the other numerical data that solvers need to run. This working group brings together BETA CAE, Key to Metals, BMW, HTW Berlin, BAM, DLR BT, DLR SY, and FhG SCAI to close that gap systematically.

A jet engine design, for example, requires coupling across multiple tools, standardized data exchange, and support for multi-fidelity data. If VMAP can store the complete model definition — geometry, materials, and now boundary conditions; it becomes the single source of truth for an entire simulation chain rather than just a handoff format between individual steps.

The working group is now working through how to properly classify and structure conditions in the VMAP standard. The core question is how to split what has broadly been called "boundary conditions" into meaningful, technically distinct categories.

In classical simulation terminology the distinction matters: boundary conditions (BCs) constrain the solution at the spatial boundary of the domain and persist or vary throughout the simulation e.g. a prescribed surface temperature, a fixed nodal displacement, a convection coefficient on an exposed face. Initial conditions (ICs) describe the state of the entire system at the start of the simulation, they are temporal anchors, like a uniform starting temperature field, a pre-stressed state inherited from a prior forming step, a residual strain distribution.

In practice, these are regularly conflated. A temperature field mapped from a thermal simulation into a structural solver could legitimately be read as either a BC or an IC depending on the receiving solver's logic. Without explicit classification in the VMAP data structure, that ambiguity becomes a concrete interoperability failure.

The group needs to arrive at a defensible taxonomy and validate it against real use cases spanning different physics and solver combinations. Solver vendor input is not optional at this stage. All partners are well-positioned to stress-test whatever classification scheme is proposed before it becomes normative.

The **Additive Manufacturing Working Group** launched in direct response to a clear signal from the community: demand for standardized Additive Manufacturing data was a prominent theme at the VMAP User Forum 2025. Several VMAP SC member organizations are already active in AM-focused projects like Pioneer, Restore, Gear-Up, ALABAMA, Valid3D; and they identified a shared need for common guidelines and standards covering both simulation and measurement/monitoring data. The group, including partners Aerobase, SINTEF, TUM, TWI, SCAI, Reden, Eindhoven University of Technology, AIMEN, University of Patras, amSight, Cranfield University have been meeting regularly since June 2025.

The challenge AM poses for data standardization is genuinely harder than most manufacturing domains. Processes are highly transient, build sequences are layer-by-layer, thermal-mechanical-microstructural phenomena are tightly coupled, and there is growing pressure to feed simulation data directly into ML and AI workflows. A dedicated working group is the only realistic way to understand the core issues and build a standard that resolves them.

Two goals that set this working group apart from earlier VMAP efforts are the explicit focus on ML/AI readiness, which requires structuring and labelling data so that ML algorithms can consume it without manual reformatting, and enabling bidirectional data flow between simulation and ML models. The requirement to incorporate experimental and measurement data for model validation and calibration are equally essential to the standardization goal.

To establish a concrete factual baseline, a structured data collection template was distributed to all partners covering AM process focus, critical data parameters (melt pool physics, scan strategy, layer-specific variables, energy input distribution), simulation requirements, data exchange challenges, validation and monitoring data, priorities, and concrete use case examples. Analysis of the collected data revealed consistent pain points now being worked through in the meetings. This partner analysis will feed directly into the AM extension specifications document.

# **VMAP based Software Solutions**

# VMAP IOLIB, WRAPPERS AND FORMAT CONVERTER

Andre Oeckerath  
Fraunhofer SCAI, Sankt Augustin, Germany

The VMAP IO library is a reference implementation of the VMAP standard in C++ with interfaces to other programming languages. Its further development is managed and organized by Fraunhofer SCAI. This presentation provides an overview of the ongoing development and shows results of the improved compression of data in the VMAP standard on selected sample data.

The VMAP Wrapper GUI provides an intuitive interface for converting CAX data into the VMAP Standard using the Python interface of the VMAP IO library in collaboration with freely available Python modules like VTK, pyNastran or pandas. Supported result formats include Abaqus (.odb), CalculiX (.frd), Nastran (.op2), LSDyna (d3plot), Fluent (.cas.h5) and OpenFOAM (.foam) for simulation data as well as process monitoring and measurement data.

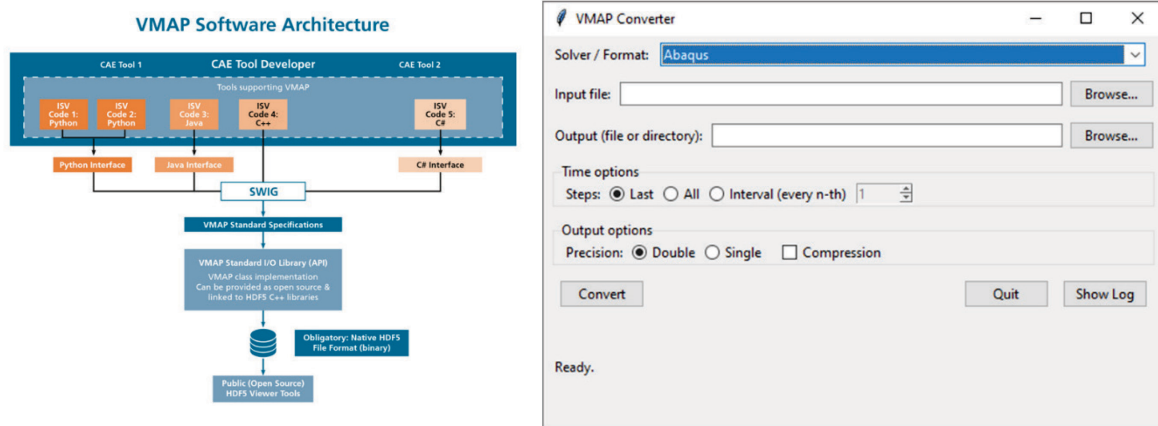


Figure 1: VMAP Software Architecture & GUI

# EXPLORE YOUR VMAP DATA WITH PARAVIEW

*Louis Gombert  
Kitware Europe, France*

ParaView is an open source, multiplatform data analysis and visualization application, used to post-process simulation data at scale. We will learn how to use ParaView efficiently to analyse VMAP data using the VMAP ParaView plugin and explore recent additions to the application that help you gain insight on your data and craft stunning visualizations for your presentations and publications.

# USING VMAP TO VISUALIZE MOLDFLOW RESULTS IN SYNERA

*Hendrik Schütte  
Synera GmbH, Bremen, Germany*

Synera is a low-code software for connected engineering used to automate recurring tasks in the product development process. It standardizes workflows and formats across multiple industries, domains, and teams which usually work in disconnected silos using different software. Although there are some loose standards, most commercial packages, for example from Dassault, Siemens or Autodesk, rely on individual input and output formats.

To streamline data across multi-domain workflows, it requires standardized formats like the VMAP Standard. This presentation showcases how VMAP is used in post-processing rheological simulations of injection molded parts using the software Moldflow from Autodesk which is particularly difficult because these results contain multiple node or element-based result formats across three different mesh types.

# **VMAP and Semantic Concepts**

# DIGITAL TRANSFORMATION IN MATERIALS SCIENCE: PMD CORE ONTOLOGY (PMDCO) – PATTERNS & APPLICATIONS

*Markus Schilling<sup>1</sup>, B. Bayerlein<sup>1</sup>, P. von Hartrott<sup>2</sup>, J. Waitelonis<sup>3</sup>, H. Nasrabadi<sup>3</sup>, K. Zarapova<sup>2</sup>, F. Thonage<sup>4</sup>, B. Skrotzki<sup>1</sup>, T. Hicke<sup>1</sup>*

<sup>1</sup> *Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin, Germany,*

<sup>2</sup> *Fraunhofer-Institut für Werkstoffmechanik (IWM), Freiburg, Germany,*

<sup>3</sup> *FIZ – Leibniz Institute for Information Infrastructure, Karlsruhe, Germany,*

<sup>4</sup> *Leibniz-Institut für Werkstofforientierte Technologien (IWT), Bremen, Germany.*

The digitalization of Materials Science and Engineering (MSE) demands standardized, interoperable approaches for representing complex experimental and simulation data. To address this challenge, the Platform MaterialDigital Core Ontology (PMDco) provides a mid-level semantic framework that bridges high-level ontologies and domain-specific terminologies. PMDco version 3.0, recently released, introduces significant enhancements based on a full alignment with the Basic Formal Ontology (BFO) as standardized in ISO/IEC 21838-2. This alignment ensures conceptual consistency and facilitates integration across heterogeneous data sources while enabling FAIR-compliant workflows.

First addressing the idea behind a mid-level ontology in MSE, this presentation emphasizes its role in harmonizing diverse data models and supporting machine-actionable knowledge representation. New features and design patterns introduced in PMDco 3.0 will be highlighted, which strengthen interoperability and provide reusable modeling structures for common MSE concepts. Practical applications and prototype implementations will be discussed.

PMDco has been developed through active community involvement, and its future evolution relies on continued collaboration and discussion within the MSE community. Participation is strongly encouraged to ensure that PMDco remains relevant, comprehensive, and widely adopted. More information and opportunities to contribute can be found at [materialdigital.de](http://materialdigital.de) and [github.com/materialdigital/core-ontology](https://github.com/materialdigital/core-ontology).

# SEMANTIC MATERIAL DATA FOR SIMULATION: A CAE-NEUTRAL FRAME-WORK BASED ON JSON, KNOWLEDGE GRAPHS, AND VDA231-301

*Uwe Diekmann  
Matplus, Wuppertal, Germany*

As simulation-driven engineering evolves, demand grows for semantically rich, traceable, and interoperable material data. This paper presents a CAE-neutral Material Master System, developed by Matplus and deployed at leading industrial clients. Built on JSON-based material cards, JSON Schema validation (aligned with VDA231-301), and knowledge graphs, the system links raw test data—ingested directly from lab equipment—to processing history and constitutive models, ensuring end-to-end provenance. It supports advanced workflows like curve fitting and fatigue analysis across solvers (LS-DYNA, Abaqus, PAM-CRASH). Having actively contributed to the VDA231-301 standard, Matplus is committed to collaborative development of future material data frameworks for digital engineering. Given VMAP's mission to establish a unified, semantic framework for material data in simulation, we see strong alignment with our approach and welcome opportunities to collaborate—such as contributing test-anchored, model-fitted material representations to enrich the VMAP standard for industrial use cases.

# VMAP AS ENABLER: EXPANDING PMDCO'S COMPUTATIONAL SCOPE AND SHAPING AAS STANDARDS FOR ENGINEERING SIMULATIONS

*Thomas Hanke*

*Fraunhofer-Institut für Werkstoffmechanik IWM, Freiburg, Germany*

The increasing complexity of computational engineering processes—spanning CAE simulations, CAD-based analyses, and multi-scale modelling—demands standardized, interoperable approaches for data exchange and semantic representation. This presentation explores two strategic opportunities for the VMAP Consortium to advance standardization efforts in this domain.

First, we address the opportunity for VMAP to participate in the creation of an Industrial Digital Twin Association (IDTA) Asset Administration Shell (AAS) sub-model definition. The AAS framework, central to Industry 4.0 data ecosystems and Eclipse Dataspace implementations, provides a vendor-neutral vocabulary for describing digital twins and their associated data. By contributing to an AAS sub-model specification for computational processes in engineering, VMAP can help establish a standardized interface that enables seamless integration of simulation data into industrial data spaces and digital twin environments.

Second, we present VMAP's contribution to the Platform MaterialDigital Core Ontology (PMDco) through the development of a domain-specific ontology for computational processes. While current PMDco-aligned semantic workflow descriptions primarily cover python-enabled simulations on HPC clusters, there is a clear need to broaden this scope. The proposed VMAP domain ontology aims to semantically describe CAE simulations, CAD processes, and related computational workflows, enabling their integration into FAIR-compliant, machine-actionable workflow descriptions.

# MPCCI SIMS – SEMANTIC INFORMATION MANAGEMENT BASED ON VMAP ONTOLOGY CONCEPTS

*Arpitha Nagaraja, Priyanka Gulati, Xuebilian Gong  
Fraunhofer-Institut für Algorithmen und Wissenschaftliches Rechnen SCAI, Sankt Augustin,  
Germany*

The VMAP standard has established itself as a vendor-neutral solution for CAE data storage, providing a unified HDF5-based format that encompasses geometry, discretization, variables, systems, and material properties. While VMAP ensures interoperability across diverse simulation tools, unlocking the full analytical potential of this standardized data requires a semantic layer that transforms raw datasets into machine-interpretable knowledge.

This presentation introduces the VMAP Ontology, an OWL-based semantic framework that formalizes the conceptual relationships within VMAP data structures. The ontology extends beyond hierarchical classification to encode explicit relationships between entities—such as linking material properties to specific geometric regions, connecting discretization schemes to result variables, and capturing provenance across simulation workflows. By representing VMAP's core groups (SIMULATION & MEASUREMENT) as interconnected semantic concepts, the ontology enables advanced reasoning and intelligent querying capabilities impossible with traditional file-based access.

Bridging VMAP's structured storage with semantic representation required developing comprehensive mapping tables that establish precise correspondences between the standard's HDF5 schema and the ontology's knowledge model. These mappings handle complexities including unit conversions, discretization abstractions across different numerical methods, and cross-group references while preserving semantic integrity during knowledge graph construction.

The Semantic Information Management System (MpCCI SIMS), operationalizes this infrastructure by ingesting VMAP data, applying ontological mappings, and constructing queryable knowledge graphs. SIMS provides a modular platform where engineers can perform natural language queries translated into SPARQL, enabling complex questions across heterogeneous datasets without requiring knowledge of underlying schemas.

We will demonstrate SIMS capabilities through a live prototype showcasing how standardized storage, formal semantics, systematic transformation, and intelligent access converge to unlock new possibilities for engineering insight and digital transformation in CAE workflows.

# **VMAP based Use Case Integration**

# ENABLING DIGITAL CONTINUITY IN VIRTUAL MANUFACTURING FOR ECO-EFFICIENCY ASSESSMENT OF LIGHTWEIGHT STRUCTURES BY MEANS OF A DOMAIN-SPECIFIC STRUCTURAL MECHANICS LANGUAGE

*Martin Raedel<sup>1,2</sup>, Andreas Schuster<sup>1</sup>, Felix Schoenitz<sup>1</sup>, Jean Lefèvre<sup>1</sup>*

*<sup>1</sup>German Aerospace Center (DLR) Virtual Product House (VPH), Bremen, Germany*

*<sup>2</sup>German Aerospace Center (DLR) Institute of Lightweight Systems (SY), Braunschweig, Germany*

The increasing complexity and demands on modern composite aerospace structures necessitate the integration of multiple assessment steps into a cohesive digital workflow during virtual product development. Traditional approaches often result in fragmented solver-specific data, duplicated efforts for various simulation tools with the resulting inconsistencies or recurring implementations of the same functionalities for different software products.

To address this challenge, we propose a common domain-specific language (DSL) for computational structural mechanics to bridge the gap between various simulation methods. This DSL enables seamless coupling of different assessment steps by means of adapters to commercial simulation software, allowing for the efficient reuse of information and minimization of redundant implementations.

We present approaches and examples how a software eco-system surrounding this standard can facilitate the coupling of digital design [1], virtual manufacturing [2] and testing [3] methods of composite aerospace structures. Therein, we address functional implementations for the preparation and transfer of data from different sources, e.g. other simulations and experiments.

By demonstrating the feasibility and effectiveness of our approach, we aim to contribute to the advancement of virtual product development in the aerospace industry, ultimately enhancing the design, performance, and efficiency of complex composite structures and risk-mitigation in virtual product developments by early insights into the structural behaviour during manufacturing and testing.

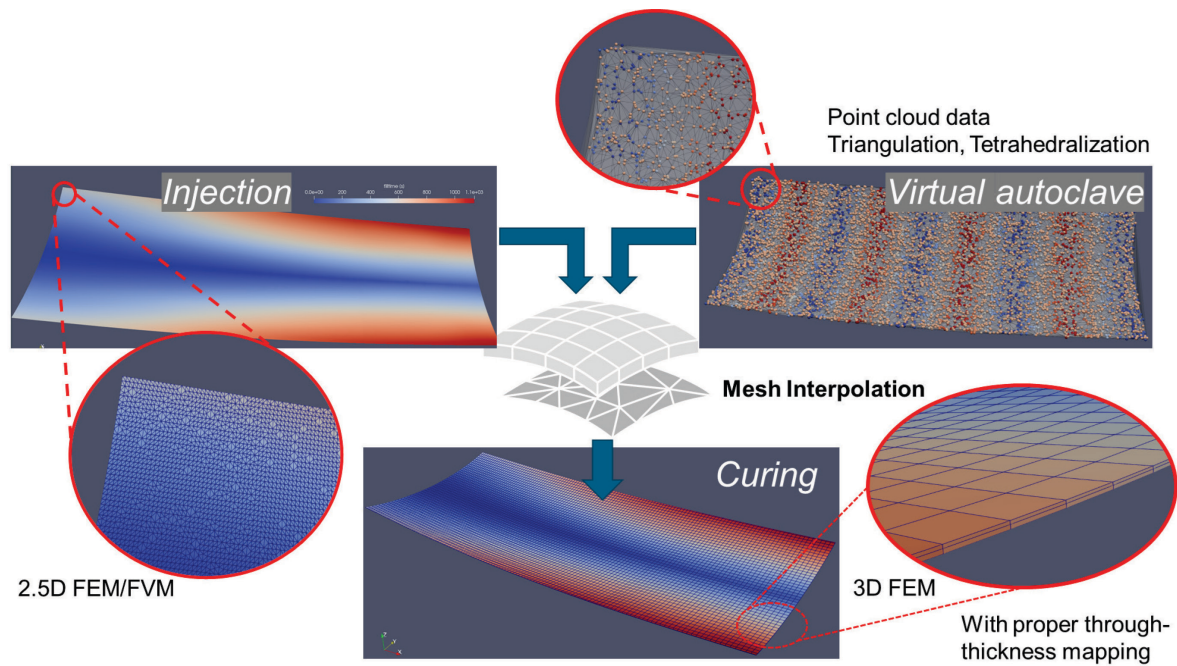


Figure 2: Simulation Model

[1] Fabian Lange et al. "Digital Multi-Disciplinary Design Process for Moveables at Virtual Product House". In: Deutscher Luft- und Raumfahrtkongress (DLRK). Bremen, Sept. 2021. URL: <https://elib.dlr.de/146809/>.

[2] Martin Rädels et al. "Towards Robustness Assessment in Virtual Testing – Manufacturing Influences by Simulation-based Methods in the Virtual Product House". In: Deutscher Luft- und Raumfahrtkongress (DLRK). Bremen, Sept. 2021. URL: <https://elib.dlr.de/189104/>.

[3] René W. Hollmann et al. "Virtual Testing of Multifunctional Moveable Actuation Systems at Virtual Product House". In: Deutscher Luft- und Raumfahrtkongress (DLRK). Bremen, Sept. 2021. URL: <https://elib.dlr.de/146686/>.

# APPLICATION OF THE VMAP STANDARD IN THE INTEGRATIVE DEVELOPMENT AND OPTIMIZATION OF INDUSTRIAL PACKAGING

*Olaf Bruch<sup>1</sup>, Daniel Grotenburg<sup>2</sup>, Alexander Busch<sup>1</sup>*

*<sup>1</sup>Hochschule Bonn Rhein Sieg, Grantham Alee 20, 53757 Sankt Augustin, Germany*

*<sup>2</sup>RIKUTEC Germany GmbH & Co. KG, Altenkirchen, Germany*

Extrusion blow molding represents the standard manufacturing process for hollow plastic components used in industrial packaging and technical applications, such as canisters and intermediate bulk containers (IBCs), as well as large-format rainwater tanks. During the production process, a hollow tube, known as a parison, is extruded and expanded against the surfaces of a cooled mold. Residual stresses induced during the solidification phase partially relax after demolding, causing shrinkage and warpage in the final article.

Deviations from the desired nominal geometry act as imperfections in component tests such as top load tests and therefore have a significant influence on the mechanical performance of the component. At the same time, it is well known that the specific conditions of the manufacturing process led to locally varying, orthotropic, process-dependent material properties.

A comprehensive understanding of the interactions between residual stresses, geometric imperfections, and anisotropic material behaviour is therefore essential and forms the basis for a simulation-supported development chain. The presentation focuses on the employed CAE tools and, in particular, on the interfaces and data exchange between the various simulation and optimization software packages, which are facilitated and accelerated through the use of the VMAP Standard and available external tools, such as MpCCI-Mapper.

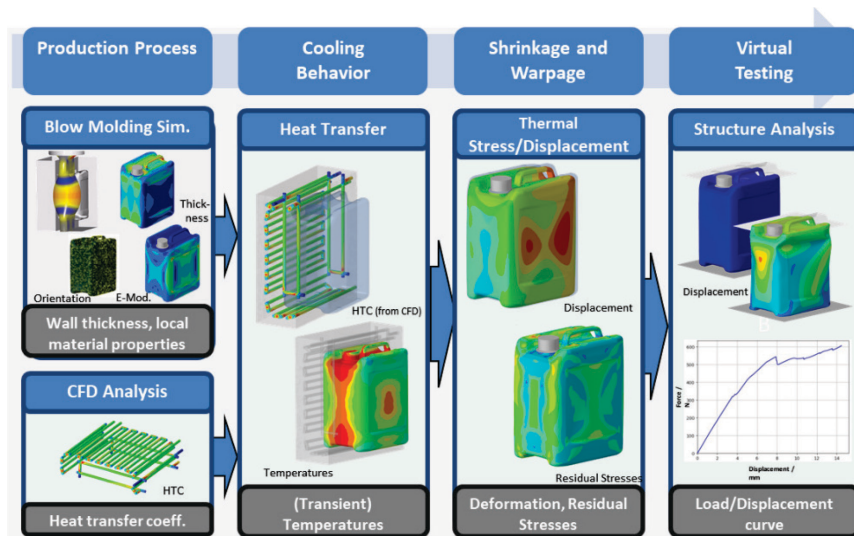


Figure 3: CAE-Workflow für extrusion blow molded parts [1]

[1] Bruch, O., Michels, P., Busch, A., Grotenburg, D., Altenbach, H.: The Impact of Shrinkage and Warpage on the Mechanical Behavior of Blow Molded Plastic Products, ACEX2024

# BASE-DIGITAL BATTERY PASSPORT: COMMON ONTOLOGY CONCEPT FOR VARIOUS SYSTEMS

*Astrid Maaß*

*Fraunhofer Institute for Algorithms and Scientific Computing – SCAI, Sankt Augustin, GERMANY*

*Project BASE Consortium: Fraunhofer IEG, Adscensus, Artech International, Aspilsan Enerji, BEEPLANET Factory, Corvus Norway, European Lithium Institute, Exitcom Recycling, Fondation Pour L Institut De Hautes Etudes Internc, Ford Otomotiv, Innd Batteries, Mercedes-Benz Turk, Navtek, Parakeet, Rok Metals, Seraph Consulting, SQM, Technovative Solutions, University Of Surrey, Fraunhofer SCAI, Fraunhofer ISE*

The EU Regulation requires that every battery with a capacity greater than 2 kWh shall have an electronic record (a “battery passport”) to support sustainability and safety. Given the diversity of applications—from e-bikes and electric vehicles to industrial and maritime batteries—a flexible, generic concept is needed to describe current and future deployments. The passport will feature a QR code attached to the battery that links users to information tailored to their role and access rights.

The EU-project BASE is a three-year initiative with 19 international partners to develop a trusted, interoperable Digital Battery Passport (DBP). Four pilot use cases will demonstrate applicability and performance. The solution will also deliver AI tools for predicting metrics such as State of Health (SoH) and Remaining Useful Life (RUL).

Drawing on training data collected for these AI models, we outline the abstracted concepts and present a roadmap for building an ontology as an integral part of the BASE-DBP solution.

# **VMAP for Additive Manufacturing**

# PIONEER: BUILDING THE BRIDGE BETWEEN MODELLING, MAN-UFACTURING, AND DATA-DRIVEN INNOVATION

*Félix Vidal Vilariño*  
*AIMEN, Spain*

*Project Pioneer Consortium: AIMEN, ESI, Engineering Ingegneria Informatica, Limitstate, EBBAMS, TTP, Fankom, Tekniker, ENSAM, Imperial College London, University of Patras, CORE Innovation Center, Fraunhofer SCAI, IRES, CLESGO, Marelli, MX3D*

Advancing industrial efficiency in high-mix/low-volume production requires innovative digital solutions that seamlessly integrate simulation workflows, process control strategies and data-driven optimisation algorithms. The development of an open innovation platform and an interoperable digital pipeline is designed to enable a design-by-simulation optimization framework. The approach integrates feedback and inline feedforward control strategies to enhance the performance of industrial systems by linking materials modelling, materials characterization, simulation-based digital twins, and data-driven models. The framework dynamically updates through distributed production data collected from embedded IoT edge devices and product quality metrics. This unified methodology is being presented for the topology optimized structural elements via Wire-Arc Additive Manufacturing (WAAM) in the construction sector, exemplifying a low-volume production scheme.

# AEROCRAFT: AI-DRIVEN CLOSED-LOOP TOOLPATH PLANNING AND THERMAL SIMULATION FOR DED

*Midhun Xavier, Daniel Berglund  
Aerobase Innovations AB, Sweden*

Directed Energy Deposition (DED) enables near-net-shape fabrication of complex metallic geometries; however, the process is highly sensitive to thermally induced defects, including porosity, delamination, residual stress, and microstructural inhomogeneity. These defects arise from the interaction between heat-source dynamics and the scan strategy, yet conventional toolpath planners generate trajectories based solely on geometric considerations, without accounting for the cumulative thermal history.

This work presents AeroCRAFT, an end-to-end AI-driven toolpath planning and thermal simulation platform that closes the loop between scan strategy, thermal response, and defect prediction in DED. The framework integrates deterministic geometric toolpath generation with a voxel-based thermal finite element (FEM) module to enable automatic preprocessing and transient temperature-field evaluation.

AeroCRAFT addresses the limitations of traditional scanning methods - including unidirectional, bidirectional, serpentine, and concentric strategies - by introducing a transformer-based attention model that is trained using reinforcement learning to optimize scan sequencing. The AI agent determines toolpaths by considering both geometric factors and user-defined goals such as hotspot reduction, defect minimization, or achieving specific microstructures.

Real-time thermal evaluation is performed using process- and temperature-based quality metrics, including Energy per Unit Length (EUL) and  $HAI_{10}$  thermal exposure indicators, enabling quantitative assessment of build integrity during process planning. Toolpaths, process parameters (laser power, scan speed, dwell time, surface normal), orientation data, and full temporal temperature fields are exported in the VMAP HDF5 standard format, enabling seamless interoperability with downstream FEA solvers and robotic systems such as LS-DYNA (\*BOUNDARY\_THERMAL\_WELD\_TRAJECTORY), Abaqus, CalculiX, and KUKA KRL programs.

The integrated deterministic and AI-driven planning framework, combined with VMAP-compliant digital thread export, demonstrates a scalable pathway toward closed-loop, defect-aware DED process planning, reducing empirical trial-and-error and enabling systematic optimisation of complex geometries prior to physical deposition.

# IN-PROCESS NDT AND ADAPTIVE LASER CONTROL FOR QUALITY ASSURANCE OF ADDITIVELY MANUFACTURED METALLIC COMPONENTS

*Sander Grønnerød  
SINTEF Manufacturing, Norway*

*Project ALABAMA Consortium: SINTEF Manufacturing, Fraunhofer SCAI, Fraunhofer IWS, EURECAT, Luleå Technical University, Aerobase Innovations AB, IRIS S.R.L., Flowphys AS, Centro Ricerche Fiat, Nordic Additive Manufacturing, GKN Aerospace Sweden AB, Manufacturing Technology Norwegian Catapult Center, Technovative Solutions Ltd*

*Project GEAR-UP Consortium: SINTEF Manufacturing AS, Aerobase Innovations AB, FlowPhys AS, Fundació Eurecat, CelluCircle, COLFEED4Print, S.L., Fraunhofer SCAI, Technovative Solutions LTD, Welding Alloys France SAS, EIT Manufacturing South SRL, Aker Solutions Hydropower AS, 3D Production AS*

Powder bed fusion (PBF) and directed energy deposition (DED) are two of the most important methods of additive manufacturing (AM), with a combined market share of around  $\frac{3}{4}$  in the AM domain. At present, parts manufactured by both processes see industrial applications in aerospace, energy and automotive industries. The widespread application, however, is hindered by strict certification requirements, lack of in-process quality assurance and models to predict material variability. It is in SINTEF's interest through cooperation with the VMAP standard community, to ease the industrial adaptation and improve quality of parts manufactured by AM. This is partially achieved by applying innovative new methods of process monitoring, improvements on laser technology, standardized data and semantically structured workflows. For the VMAP 2026 working group we will provide recent developments in-process monitoring for laser-based powder bed fusion (PBF-LB) and adaptive laser positioning for laser-based directed energy deposition (DED-LB).

Nikon SLM Solutions provides a melt pool monitoring (MPM) system that records electromagnetic radiation in two photodiodes, each sensitive to a distinct band of wavelengths, see Figure 1. The system is meant to identify faults and imperfections during builds, by giving its users layer-wise information on photodiode counts. The sensors acquire data at a rate of 10 000 recordings per second.

Currently, research on the MPM system has aimed to correlate maps of layer-wise counts and their histogram distributions to porosity [2], as well as a tool for qualitative relations to temperature. SINTEF has expanded on monitoring by converting emitted signals into absolute temperatures and providing 3D visualization of the melt pools, see Figure 2.

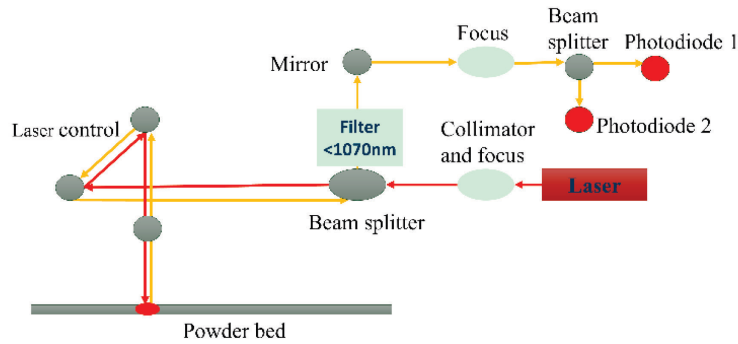


Figure 4: Simplified illustration of the MPM system [1]

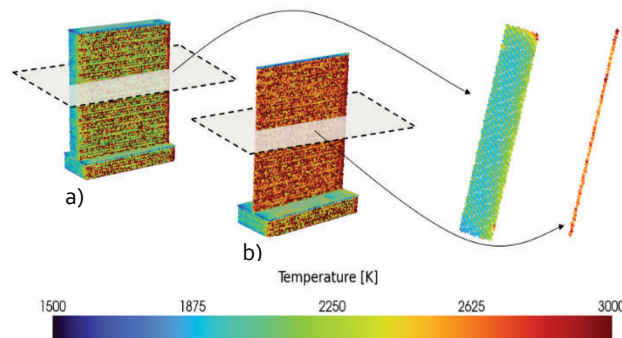


Figure 5: Visualization of MPM data in 3D [1]

In collaboration with Fraunhofer SCAI on the GEAR-UP project and through the VMAP standards community, we will try to synergize data exchange between locations of monitored results to other forms of destructive and non-destructive characterization.

In the ALABAMA project we have created a laser positioning system to influence microstructures during DED-LB of Ti6Al4V. Initial promising results showed that microstructures are highly influenced by process parameters and laser patterns. VMAP provides an interesting prospect in providing a bridge between parameter sets, laser formation and path planning done during prints at SINTEF, with the output of material models developed by Aerobase and characterization at Eurecat. Material models may be further extended to optimize path planning at SINTEF, also requiring standardized datasets and structured workflows.

[1] S. Grønnerød, N. Macallister, K. Zhang, S. Mellemeister, V. Brøtan, «*In-situ characterization of melt pool temperature in commercial PBF-LB system*»

[2] A. Engelhardt, T. Wegener, T. Niendorf, "A Pragmatic Approach for Rapid, Non-Destructive Assessment of Defect Types in Laser Powder Bed Fusion Based on Melt Pool Monitoring Data," *Materials*, vol. 17, no. 13, p. 3287 Jul 2024, doi: [10.3390/ma17133287](https://doi.org/10.3390/ma17133287)

# **VMAP Requirements and Strategy**

# SMART CAE DATA ANALYSIS AND ENHANCEMENT REQUIREMENTS FOR VMAP

*Dr. Rodrigo Iza Teran*

*Fraunhofer Institute for Algorithms and Scientific Computing – SCAI, Sankt Augustin, GERMANY*

Learning from previous designs in product development is a very appealing objective in engineering. Ideally an assistant system can be designed that, considering engineering requirements and functional constraints, identify from previous designs, the most similar ones. This can speed up product design significantly. This type of analysis is called Smart CAE Data Analysis. We present an approach where engineering geometric based design changes or materials ones, and their corresponding outcomes are learned from a bundle of several model variations and simulations. A combination of this input-output information is represented as a knowledge graph, and this is the information used to describe it and compare it with other similar ones.

In the Standard VMAP, developed in a Eureka RD&I Cluster on software innovation(ITEA) project, coordinated by SCAI, data is stored hierarchically, with different layers providing metadata of simulation steps and model parts. A SPDM (Simulation Process and Data Management) Ontology is being developed as part of the VMAP standard to allow flexible access to metadata wherein binary bulk data is kept in a hierarchical, also flexible, data format. This addresses known issues in SPDM systems to handle bulk data, provide domain flexible domain knowledge and deal with the multiplicity of proprietary data formats in CAE context.

An extension of the VMAP Ecosystem to enable Smart CAE Data Analysis over simulation bundles could be realized. The VMAP System provides already two ontologies: a storage ontology and a routine ontology for data extraction and processing. The CAE Data Analysis could use the routine ontology for data exchange from proprietary formats whereas semantic information (from the Smart CAE Data Analysis Knowledge Graph) should be interlaced with the available VMAP ontology system. The main requirement for such an extension is to allow executing queries over multiple design changes and outcomes from many simulations in an analysed bundle. An additional requirement for merging these systems is an efficient parametrization of the geometry input and output, that is provided within the Smart CAE Data Analysis Framework.

# VMAP FOR AI: STANDARDISING HIGH-FIDELITY TRAINING DATA FOR INDUSTRIAL INTEROPERABILITY

*Ian Symington*  
*NAFEMS Ltd, UK*

Training data in the form of high-fidelity physics-based simulation results is an enabler for data-driven engineering, but proprietary binary output file formats can limit the flow. As part of the NAFEMS ASSESS Initiative's focus on Machine Learning, this presentation demonstrates the use of VMAP to create vendor-agnostic training datasets that ensure interoperability and preserve neutrality.

We present two key showcases: a simple data-driven benchmark designed to demonstrate the potential and pitfalls of data driven modelling and a massive (>100GB) industrial dataset based on a CAE workflow developed by Piaggio to design conrods. We detail the conversion of the Piaggio dataset from ANSYS to VMAP, establishing it as a neutral "challenge problem" for the community. This work confirms VMAP's capability to handle large-scale physics data and highlights its vital role in enabling a multi-vendor ecosystem for data-driven design.

# BECOME A MEMBER OF VMAP SC!

Learn how to join our community of engineering and scientific professionals. We are a community largely formed by engineers from mechanical and computational engineering domains.

## **Who is the VMAP standard aimed at?**

You work as an employee or freelancer in the field of mechanical engineering or the integration of CAx tools. If you have a lot to do with the exchange of data between different tools in the field of virtual development and physical measurement, then you can benefit from the VMAP standard. Instead of having to work with many native data formats, the VMAP standard allows them to solve IO problems much more easily using a single open data format.

## **Who can join?**

If you think, you can benefit from the VMAP Standard and contribute to the development & extension of the VMAP Standard, then we would be happy to hear from you. The VMAP SC is open to any institution from industry, software-domain, and academia as well as for natural persons.

## **How can I become a member?**

Applications for Membership should be submitted in writing to the VMAP SC Board. The application of a legal person should state the name of the natural person designated to represent the applicant. The Association should be informed of any subsequent change in the power of representation. The short letter of intent should be written on the company (in this case applicant) letterhead. The VMAP SC will process your request promptly and will then be able to offer you membership.

## **What are my benefits?**

Members of the VMAP SC can actively influence the long-term strategy and technical development of the standard at an early stage. Current developments, ongoing R&D projects and new extension approaches for the standard are presented, discussed, and finally voted on at the quarterly plenary meetings.

## **What's expected of a me?**

Members of the VMAP SC are invited to quarterly plenary meetings. Technical documents (specifications, implementations, applications) are distributed before and after these meetings - members are asked to evaluate these documents and then contribute their constructive opinions at the meetings. Members are of course also invited to actively participate in individual working groups to help shape the standard and its extensions.

## NOTES





**VMAP**  
Standards Community e.V.

Members



Hochschule  
Bonn-Rhein-Sieg  
University of Applied Sciences



**VMAP Standards Community e.V.**

Fraunhofer SCAI  
Schloss Birlinghoven 1  
53757 Sankt Augustin  
Germany

Website: [vmap-standard.org](http://vmap-standard.org)

Email: [info@vmap-standard.org](mailto:info@vmap-standard.org)