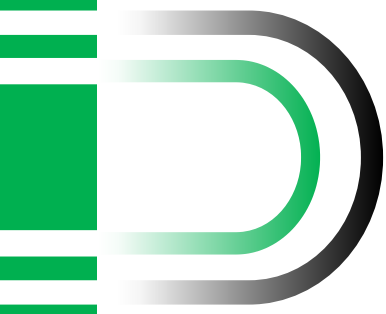

VMAP
Standards Community e.V.

VMAP USER MEETING 2025

CONFERENCE PROCEEDINGS

18 & 19 FEBRUARY 2025

SCHLOSS BIRLINGHOVEN, SANKT AUGUSTIN, GERMANY

TABLE OF CONTENTS

CONTENTS

THE VMAP STANDARDS COMMUNITY

The lack of software standards in virtual engineering workflows and incompatible interfaces for the transfer of virtual data not only cause additional costs and complex manual adaptation but also lead to inflexible IT solutions, loss of information and significant delays in the overall design process. The standardization of data interfaces in CAE is therefore vital for all industry segments where simulation processes are central to the product and process design.

In December 2022 sixteen founding members – partially coming from the initial ITEA project – established the VMAP Standards Community (VMAP SC), registered as a not-for-profit association. The VMAP SC association promotes science and research. It is concerned with the scientific investigation of the application possibilities as well as further development and maintenance of an open software standard that can be used for industrial and academic applications in a generally and free accessible manner. VMAP SC is open to all interested parties who wish to use or contribute to the standardization efforts of the association. The association wishes to carry the VMAP standardization efforts into the future.

In particular, at the time of the foundation of this association there are still open scientific questions concerning at least the following technical disciplines:

- Storage of complete simulation models and consideration of further simulation disciplines and discretization methods
- Connection to product management and design data,
- Linking of virtual simulation data with real measurement and sensor data,
- Semantic and cross-disciplinary organization of data via ontologies,
- Support for AI-based analysis and prediction methods.

A solution to these and future questions is to be made possible by the association within the framework of current R&D projects or projects still to be developed. In this context, projects/project applications/funding programs of various research institutes are to be linked.

The association's activity is aimed at making the results of scientific activity accessible to the general public, which is usually done by publishing them.

VMAP WORKING GROUPS

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

The VMAP SC e.V. is actively advancing the VMAP Standard across three key domains: measurement data storage, complete model data storage, and external wrapper development. These initiatives are driven by dedicated working groups, each focusing on specific aspects of the standard's evolution.

The VMAP Sensor & Experimental Data Working Group focuses on standardizing the storage of measured and experimental data within the manufacturing industry. Their work has primarily addressed use cases in blow moulding and additive manufacturing processes. A notable application emerges from the blow moulding domain, where stereography and thermography data must be seamlessly integrated into the validation process alongside simulation data. This integration demands a standardized format capable of storing both test and simulation data without information loss. The group is expanding its focus to additive manufacturing processes, particularly Laser Direct Energy Deposition (DED), exploring how the VMAP Standard can accommodate measurement and monitoring data across various manufacturing stages.

The VMAP Full Model Storage Working Group is developing capabilities to store boundary conditions within VMAP files, enabling direct simulation initiation from these files. A significant application from this group involves storing numerical data, including boundary conditions, in the VMAP Standard. Jet engine design, which requires tool coupling, standardized data exchange, and support for multi-fidelity data, exemplifies the need for these capabilities. By integrating these data components into the VMAP Standard, complex use cases benefit from a comprehensive data exchange format. Current development efforts concentrate on implementing unified boundary conditions storage.

The VMAP Wrapper Development Working Group, though in its early stages, is addressing the critical need for external wrappers across various tools used within associated projects and by working group members. This initiative responds to the growing demand for harmonized CAx data across engineering domains and industry sectors, aligned with broader digitalization and standardization requirements. The VMAP 1.2 specification and IO-Lib's support for measurement and experimental data streamlines the correlation between simulation and test data. As more software wrappers are developed, validation processes will become increasingly efficient.

VMAP WORKING GROUP – FULL MODEL STORAGE

Oliver Kunc,
DLR e.V., Institute of Structures and Design

Working Group Members: BAM, BETA CAE, BMW, DLR BT, DLR SY, FhG SCAI, HTW Berlin, Key to Metals

The VMAP Complete Model Storage working group aims to store boundary and initial conditions in the VMAP file so that, in the future, a simulation can be directly initiated using the VMAP file. While the original use cases of VMAP addressed the storage of simulation results, a common interest is to also ensure their reproducibility. Integration of all necessary boundary and initial data in numerical form into the VMAP Standard will provide a comprehensive data exchange format. This presentation will give an overview of the current state of the work.

VMAP WORKING GROUP – WRAPPER DEVELOPMENT - VMAP AS A KEY ENABLER FOR THE SUSTAINABILITY & COMPONENT QUALITY ASSESSMENT OF COMPOSITE MANUFACTURING PROCESSES BASED ON SIMULATIVE APPROACHES

Andreas Schuster, Martin Rädel and Jean Lefèvre
DLR, Institute of Lightweight Systems, Germany

Digital continuity is a critical aspect of virtual product development because it ensures a seamless flow of data and information across the various stages of product design, development, and lifecycle management. Thus, it plays a significant role in virtual end-to-end product assessment & development processes like the German aerospace center (DLR) Virtual Product House (VPH) approach.

The latter covers the digital design [1], virtual manufacturing [2] & virtual testing [3] of composite lightweight aerospace structures in a continuous process and is currently extended to take the eco-efficiency assessment during manufacturing into account as an key performance indicator (KPI). The developments are based on a common computational structural mechanics (CSM) language and its eco-system that uses VMAP for its heavy data storage & exchange [4, 5].

In an exemplary scenario, the effects of modifications of manufacturing processes on the structural performance for resource-intensive manufacturing steps are investigated. In a thought experiment one can deviate from the standard autoclave cure cycle in a resin transfer molding (RTM) manufacturing process to increase its eco-efficiency. On the other hand, the structural performance of the thermoset composite component must not fall below the required specifications as a result of these changes. In the VPH approach, the effects of the changes on the structural performance are investigated by means of loosely coupled CSM & computational fluid dynamics (CFD) simulations along the manufacturing process chain.

Different representations of the same problem for different solution techniques are used in the assessment process, see Figure 1. Due to the heterogeneity of the abstractions, solvers and their result data, interface implementations and wrappers around this information are required. For the investigated prototypical case, this includes discretization-dependent results as well as three-dimensional point cloud data. The present publication describes the interface & continuity approach based on the COmmon Structural Mechanics fOrmat

(COSMO) language and the VMAP implementation as well as the requirement for mapping functions based on state-of-the-art interpolation methods.

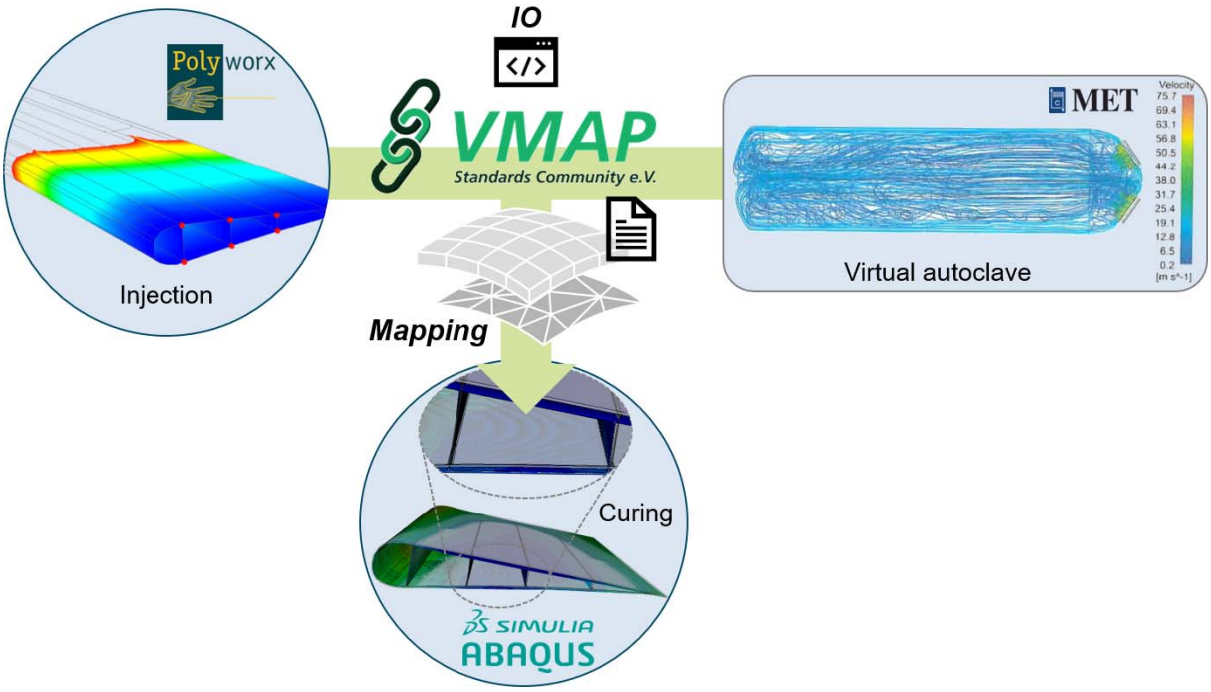

Figure 1: Interacting simulative assessment steps in the investigation of effects in manufacturing process changes on the manufacturing eco-efficiency and component structural performance

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Solutions for Workflow & Data Management

ENHANCING SIMULATION WORKFLOWS - LEVERAGING VMAP, META, AND ANSA FOR OPTIMIZED RESULTS HANDLING

Thanasis Fassas
BETA CAE Systems SA, Epanomi, Greece

Over the past few years, VMAP has supported the storage and exchange of various results, enabling seamless multi-disciplinary workflows. In such workflows, where multiple software solutions are utilized, VMAP ensures that results can be shared and processed without regression.

Having been part of this project from the very beginning, we have integrated support for the VMAP format in our products, making it readily available to our users. In this presentation, we will explore a new approach for handling these results, allowing users to combine the power of the META post-processor to evaluate extracted results and save them in a format compatible with ANSA pre-processor for further simulations.

The final step toward this goal is to implement full support for the VMAP format in our META post-processor. With META, users can unlock a broad range of capabilities and introduce new functionalities for working with VMAP files. Equipped with various 2D plots, isofunctions, and an extensive array of toolbars, users can efficiently visualize and analyze the results.

Going a step further, users can create new results by combining existing ones. The built-in reporting functionality in META facilitates the exchange of critical information among users, while the automation capabilities streamline the entire post-processing workflow.
Once the post-processing is complete, users can save the necessary results and import them into the ANSA pre-processor, ready to set up the next analysis.

MPCCI TOOLS FOR VMAP – DETAILS ABOUT MPCCI TOOLS AND EXTENSIONS

Andre Oeckerath
Fraunhofer Institute for Algorithms and Scientific Computing – SCAI, Sankt Augustin, Germany

The MpCCI tools are a collection of software designed to facilitate the coupling of various simulation programs. They enable the consideration of multiple physical effects in simulations by ensuring seamless data transfer between different software packages.
The use of the VMAP standard within the MpCCI tools allows for efficient handling and exchange of data between coupled simulations. This enhances interoperability and improves the accuracy of results in complex simulation scenarios that involve multiple physical processes. The MpCCI tools are particularly valuable in research and development, where multidisciplinary approaches are required. By providing a robust framework for code coupling, these tools enable researchers and engineers to explore intricate systems more effectively, leading to better insights and innovations in fields such as fluid dynamics, structural analysis, and thermodynamics.

The presentation will give an overview on present and planned support of the VMAP standard in MpCCI tools.

METADATA & ONTOLOGIES – ONTOLOGY-BASED SEMANTIC AND META DATA MANAGEMENT

Arpitha Nagaraja , Xuebilian Gong
Fraunhofer Institute for Algorithms and Scientific Computing – SCAI, Sankt Augustin, Germany

Effective data management remains a critical challenge, particularly when dealing with heterogeneous data across industries. Ontologies have emerged as a standardized approach to data representation, enabling seamless interoperability while embedding semantic meaning to enhance automation, communication, and decision-making. By providing a structured framework for knowledge representation, ontologies facilitate efficient data integration, sharing, and reuse across diverse systems.

In the manufacturing sector, the rapid push for digitalization has intensified the need for semantically enriched, interoperable data, driving the emergence of technology-driven solutions that leverage ontologies and semantic web technologies. However, the lack of integration among different but related ontologies across manufacturing domains continues to fragment data semantics, leading to interoperability barriers and limiting the potential for digital transformation.

VMAP, an open standard for data storage and transfer in virtual manufacturing chains, plays an important role in addressing this challenge. Standardization of data via VMAP facilitates structured data exchange, ensuring that relevant meta data is captured effectively. Thus, in turn, supports the development of ontologies by providing a common framework for organizing and harmonizing data across different engineering and manufacturing processes. Aligning different ontologies and establishing common semantic standards allows seamless interoperability between simulation tools, CAD/CAM systems, and manufacturing workflows, improving data consistency and usability.

A preliminary framework has been conceptualized, outlining the foundational architecture for ontology-based data management. We are now refining this framework, incorporating advanced technologies to enhance scalability, automation, and interoperability, ultimately driving smarter and more connected digital manufacturing ecosystems. This research contributes to the development of a smarter, more connected digital manufacturing ecosystem, fostering collaboration, efficiency and data-driven innovation.

Demands from Projects for Semantic Data Organization

PROJECT INSHAPE - CHALLENGES IN DATA ACQUISITION AND MANAGEMENT IN ADDITIVE MANUFACTURING RESEARCH

Prof. Mike Holenderski[1], Richard Off[2]
[1] Eindhoven University of Technology, Eindhoven, Netherlands
[2] Technical University of Munich, Munich, Germany

Project InShaPe Consortium: Technical University of Munich, Eindhoven University of Technology, EOS GmbH Electro Optical Systems, Oerlikon AM, SILIOS Technologies, BEAMIT Group, Aenium Engineering, AMEXCI, Bavarian Research Alliance, Technion – Israel Institute of Technology, Institute of Metals and Technology

The additive manufacturing process laser-based powder bed fusion of metals (PBF-LB/M) is revolutionizing manufacturing industry by enabling the creation of highly complex three-dimensional metal structures through the precise melting of powder using a laser beam. The EU project InShaPe aims to push the boundaries of this technology by leveraging innovative techniques such as beam shaping and advanced process temperature monitoring with multispectral imaging. This will enhance the productivity, sustainability and economy of the process by increasing the process speed, reducing the energy consumption and avoiding waste (e.g. spatter and support structures). An overview of the two developed innovations installed on an EOS M290 is given in Figure 2.

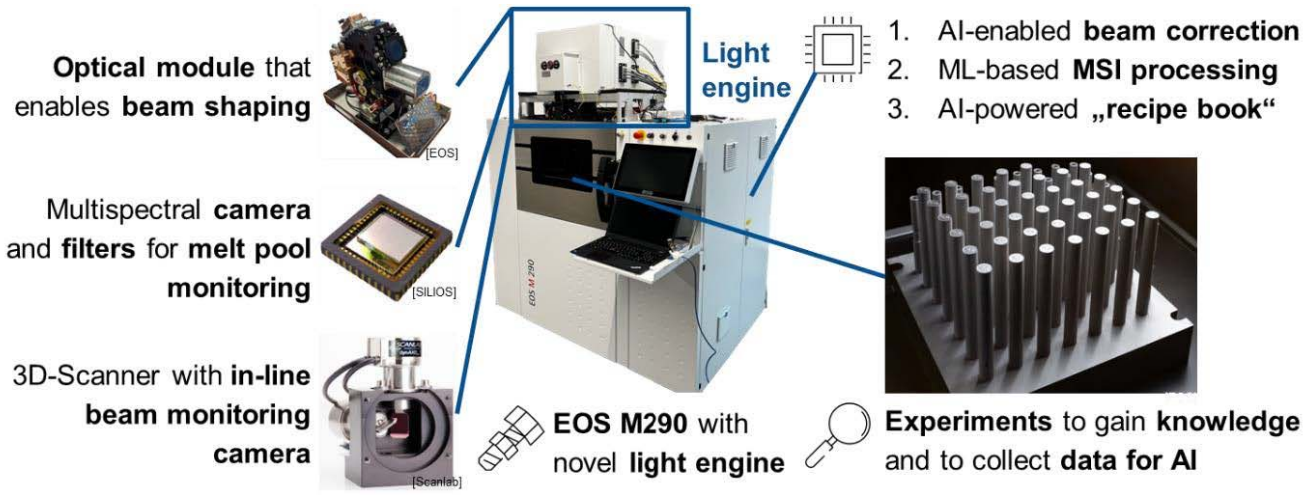

Figure 2: InShaPe technology overview (EOS M290 Beam Shaping)

Artificial Intelligence (AI) and Machine Learning (ML) technologies are essential to reach the goals of the project, as ML-based multi-spectral Image (MSI) processing and an AI-powered

"beam shaping recipe book" are at the core of the project's software stack. Therefore, data from various sources must be acquired, stored and processed systematically to implement AI and ML techniques and to document the conducted experiments as a basis for conclusions. Figure 3 gives an overview of the InShaPe data sources, which can be divided in three major categories:

1. Pre-Process: simulation data, job preparation data and design of experiments. Data from these sources is already available before the manufacturing process starts as it is essential for the build job planning.
2. In-Process: monitoring and machine data. This data is captured during the process. A significant challenge here is the time synchronization of the different data sources.
3. Post-Process: post-process data, including analysis and evaluation results, like density, mechanical or microstructural measurements, as well as conclusions drawn from these results.

A significant challenge of the project is the data acquisition and the structured storage and processing of the data. The data acquisition is held back by non-standardized or vendor-closed export options (Paraview, EOS-Job), complicating e.g. the data processing of MSI images and the complex time-synchronization between in-process machine and MSI data.

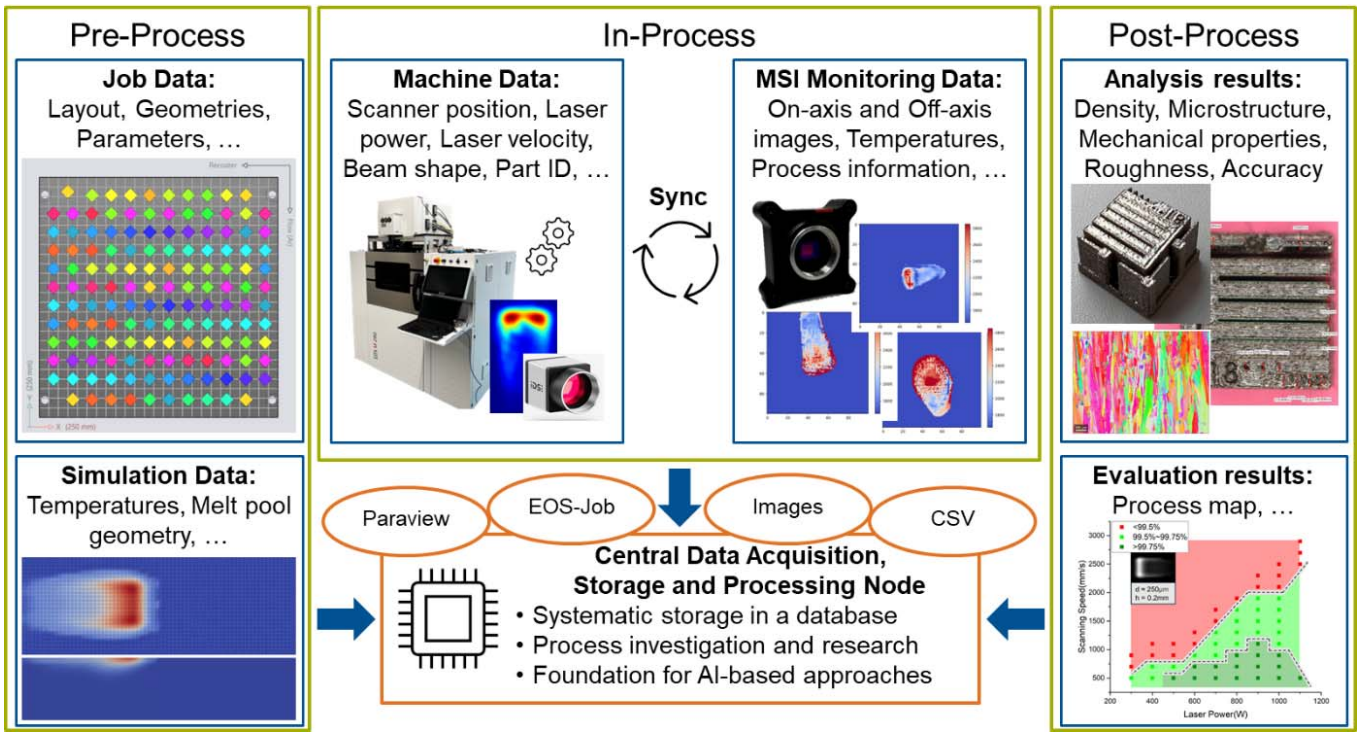

Figure 3: Overview of InShaPe Data Points

A single build job can create several million data points, so the overall amount of data is massive. Right now, a suitable storage solution for such highly heterogeneous,

unstructured, and extensive data is under investigation. As our previous attempts of implementing AI-methods have shown, it is of high importance that the data is well organized, annotated and maintained in a central data store providing standardized access to software tools, as the manual selection and formatting of data points for particular investigations is not feasible. Moreover, the implemented storage solution should be open for including additional data sources and formats for different machine types. At the moment, there is no open-source tool or standard for systematically storing and organizing AM data in research, which is a significant bottleneck and results in a need for action.

The talk will summarize the EU project InShaPe with a focus on the current data acquisition and storage situation. Some preliminary attempts to implement ML and AI methods using the current data will be presented. The talk will be concluded with an outlook on a more suitable data platform and possible cooperation and collaboration points with the VMAP UGM consortium.

PROJECT ALABAMA & GEAR-UP - PROCESS MONITORING AND MATERIAL TESTING OF ADVANCED LASER-BASED ADDITIVE MANUFACTURING APPLYING THE VMAP INTERFACE

Vegard Brøtan
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

Through the Horizon projects ALABAMA and GEAR-UP we aim to further develop the laser-based additive manufacturing methods to significantly improvements within speed, material microstructure and performance, environmental impact and cost.

ALABAMA: (Adaptive Laser Beam for additive manufacturing) investigates directed energy deposition of metals with laser beam (DED-LB/M), where a laser melts feedstock (either powder or wire) in a stepwise fashion. Metals deposited by this method tend to struggle with anisotropy and can contain internal stresses and imperfections.

The project aims to ensure good properties through the development of highly customized laser-based production, and new adaptive multi-laser-beam technology. This is accomplished by adjusting lasers both temporally and spatially. Adaptive laser technology will be tested on products made from different alloys in three use-cases, namely aerospace, maritime and automotive. These industries account for a large production volume across Europe and the projected impacts are profound:

- 10-33% in cost savings
- Reduction of defects by ~50% in deposited materials
- Reduction in material waste of 10-50%
- Reduction in CO2 emissions of 5 million tons/year

GEAR-UP: (Green Engineering, Analysis, & Reskilling for Unbounded Production) project tackles sustainable manufacturing in three additive manufacturing processes. Metal Laser Beam Powder Bed Fusion (PBF-LB/M), Metal Laser Beam Directed Energy Deposition (DED-LB/M) and Fiber-reinforced polymer Material Extrusion (MEX-FPR). The project has material

producers to recycled materials for off-chemistry testing. Effects of high trace elements in secondary alloys on material behaviour during DED-LB/M and PBF-LB/M is then tested. In the MEX-FRP case the aim is to increase the use of recycled carbon and textile fibres in ME-FRP of composites.

Thereby the project aims to foster human involvement in advancing circularity and sustainable technology adoption through training and global collaborative networks.

Non-standard Processes: As the projects employ unique methods and custom add-ons, ontologies must be developed to represent these within the VMAP structure.

Process Monitoring: Integrating various process monitoring results with process parameters, specifics, and further testing is crucial for development.

Material Testing: Extensive optical and mechanical investigations are conducted on test specimens in both projects. Standardizing the connection between each sample's performance, process monitoring and specifics, and special parameters will ensure seamless data flow and exchange.

VMAP Wrapper: The VMAP wrapper can serve as an integrator, facilitating the exchange of monitoring data, material testing results, and performance metrics with processing data.

PROJECT PIONEER - OPEN INNOVATION PLATFORM FOR OPTIMISING PRODUCTION SYSTEMS

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

PIONEER aims the development of an open innovation platform and interoperable digital pipeline for addressing a design-by-simulation optimisation framework. It integrates inline feedforward control strategies for enhancing the efficiency of the industrial systems in high-mix/low-volume production schemes. This approach connects materials modelling and materials characterisation, simulation-based digital twins and data-driven models, updated through distributed production data from embedded IoT edge devices and product quality.

PIONEER establishes a unified methodology demonstrated through two case studies. The first involves multidisciplinary optimisation for ensuring certified path planning strategies for the manufacturing of topology optimised structural elements through Wire-Arc Additive Manufacturing (WAAM) in the construction sector –i.e., low-volume production schemes–. The second focuses on optimising design and manufacturing strategies for the manufacturing of Carbon Fibre Sheet Moulding Compound (CF-SMC) components in automotive –i.e., high-mix production schemes.

Domain Specific Ontological Solutions

PMD – ADVANCING DIGITAL WORKFLOWS IN MATERIALS SCIENCE: THE ROLE OF PMDCO IN DATA INTEGRATION AND SEMANTIC REPRESENTATION

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The field of Materials Science and Engineering (MSE) is undergoing a transformative shift towards digitalization, emphasizing the need for structured and interoperable data management. The Platform MaterialDigital Core Ontology (PMDco), now in version 3.0, addresses these challenges by providing a robust mid-level semantic framework. PMDco bridges the gap between abstract high-level ontologies, such as the Basic Formal Ontology (BFO) standardized in ISO/IEC 21838-2, and highly specific domain terminologies to ensure consistency and interoperability across diverse MSE applications. Developed through MSE community-based curation, PMDco facilitates the integration of real-world data from experiments, simulations, and industrial processes.

This presentation will explore PMDco's role in enabling advanced digital workflows and its integration into demonstrators within the Platform MaterialDigital (PMD) initiative. Highlighted use cases include the semantic representation of tensile test data in compliance with ISO 6892-1:2019-11, utilizing the corresponding tensile test ontology (TTO) built on PMDco. Through an electronic laboratory notebook (ELN), data from experiments performed by undergraduate students were transformed into machine-actionable knowledge graphs, demonstrating the potential for education and fully digitalized experimental procedures.

Additionally, a possible extension of PMDco as a linking point for semantically representing simulation data will be presented, aligning with the focus of VMAP. This includes linking experimental, simulation, and computational datasets to create comprehensive, FAIR-compliant knowledge ecosystems. By showcasing best practices in data acquisition, semantic integration, and knowledge graph generation, this presentation underscores PMDco’s versatility and its critical role in advancing digital MSE workflows.

BIO-INFORMATICS – SEMANTICS & ONTOLOGIES

Prof. Dr. Martin Hofmann-Apitius
Fraunhofer Institute for Algorithms and Scientific Computing – SCAI, Sankt Augustin, GERMANY

The work in the Bioinformatics business area represents the entire data-based value chain of translational biomedical research in science and industry. Using automated processes, biomedical knowledge is extracted from scientific literature and made available in searchable, structured form. Semantic technologies help to represent complex biological and medical knowledge in comprehensive knowledge graphs. These computer-readable models map entire medical indication areas. One example is the complete complex of neurodegenerative diseases, such as Alzheimer's or Parkinson's. The knowledge-based models are then used to interpret and model patient-related data and make individualized predictions. Another research topic is data-driven models in drug development. Current big-data architectures and modern methods of machine learning and artificial intelligence are used in this work.

Our focus is on the following domains:

1. Unstructured information mining: 35% of all data in the world are health-related data. About 80% of this data is unstructured data. The Software and Scientific Computing group develops algorithms and software tools that enable the quick discovery and exploration of knowledge in structured and unstructured freely available sources.

2. Knowledge-graph technologies: Our graph models represent data and knowledge in computable form. Shared semantics lay the foundation of data and knowledge interoperability. Biomedical knowledge graphs play a central role in big data integration. Bringing unstructured text into a structured, comparable format is one of the key assets. As cause-and-effect models, knowledge graphs can potentially facilitate clinical decision making or help to drive research towards precision medicine. Data and Knowledge Management, sometimes also called Information Management, is a core topic of Data Science. It is also an interdisciplinary field touching economics (how efficient and expensive is the solution?), psychology (do people use this solution in a way that was intended?) and of course computer science. Our aim is to build sustainable data infrastructure for biomedical data, personalized medicine, drug repurposing, reproducible AI and knowledge discovery.

3. Models combining data and knowledge: Models integrating data and knowledge form the basis for our approaches towards precision medicine. Now you can analyse patient-level data given the state of knowledge about disease mechanisms.

4. Actionable insights & decision support: AI and Data Science help us to not only identify new signals in data, but also to perform data interpretation in a way that we can use the insights from our analysis to support decision making in R&D and clinical therapy.

VMAP Semantics

PROJECT BASE - BATTERY PASSPORT FOR RESILIENT SUPPLY CHAIN AND IMPLEMENTATION OF CIRCULAR ECONOMY

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

In response to the EU Regulation (EU) 2023/1542, the BASE project aims to develop a Digital Battery Passport (DBP) service that enhances transparency and sustainability throughout the battery lifecycle. To maximize its utility, the initiative brings together several partners from diverse sectors, including automotive, marine, and stationary energy storage. Ultimately, the Regulation seeks to facilitate a transition from a linear to a circular economy in the battery industry. To achieve that, a complex, global network of material flows has to be mirrored by a complementary flow of information enabling customers to make informed decisions and providing recyclers with the essentials for efficiently closing the loop. As a legally compliant service, the DBP relies rather on semantic modelling than on AI to capture the physical and logical framework of the battery and battery value chain data. We will discuss the chosen approaches to represent the physical device, the up- and downstream data flows, as well as some practical challenges.

ADVANCED LASER-BASED MANUFACTURING: MULTIPHYSICS MODELLING AND INTEROPERABILITY WITH VMAP STANDARDS

Bijish Babu, Daniel Berglund
Aerobase Innovations AB, Sweden

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

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Project RESTORE Consortium: Dalforsån, Aerobase Innovations, FIAT, Cranfield University, EIT Manufacturing, Endurance, EWF, Flowphys, Fhg SCAI, GSMC, Industrialisation Des Recherches Sur Les Procede, Intellegens Limited, IRIS, Lucchini, MSC Scanning, Navtek, Parida, Phd Controlled Solutions, TVS, Welding Alloys

The ALABAMA, RESTORE, and GEAR-UP projects are revolutionizing manufacturing technologies through multi-physics modelling. These initiatives tackle urgent challenges, including process optimization, sustainability, and material efficiency in the aerospace, automotive, marine, and manufacturing industries. However, a lack of standards poses a significant challenge to integrating, structuring, and exchanging simulation data across disciplines. This ensures efficiency, interoperability, and AI readiness in multi-physics modelling workflows.

ALABAMA: The ALABAMA project innovates laser-based manufacturing processes by moving beyond conventional Gaussian laser profiles. These standard profiles can induce steep thermal gradients, leading to vaporization, instability, and defects. ALABAMA focuses on adaptive laser beam shaping (e.g., flat-top, ring, and saddle beams) to optimize melt pool geometry and minimize defects like porosity or spatter. Multi-physics simulations are instrumental in understanding these laser-material interactions' thermal, fluid, and mechanical dynamics. This enables real-time control of laser systems, ensuring defect-free and high-productivity processes.

RESTORE: RESTORE promotes remanufacturing to extend product life, reduce waste, and foster a circular economy. This project revitalizes high-value components by integrating subtractive machining with additive techniques (e.g., laser cladding) and post-processing heat treatment using Laser. Multi-physics modelling supports this hybrid approach by simulating thermal and mechanical stresses during material deposition. These insights are

essential for optimizing microstructural evolution and mechanical integrity in repaired components, ensuring cost-effective and environmentally sustainable solutions for industries.

GEAR-UP: The GEAR-UP project tackles sustainable manufacturing by developing advanced material models and multi-physics frameworks. A central focus is understanding the effects of trace elements in recycled materials, such as steel, on their performance during deformation or joining. The project enables predictive modelling of manufacturing processes by integrating phase evolution kinetics, deformation-induced failure mechanisms, and thermal simulations. This allows industries to adopt recycled materials without compromising performance or safety, paving the way for sustainable usage.

Across all three projects, multi-physics modelling is a backbone, bridging complex physical phenomena—thermal, mechanical, metallurgical, and fluid mechanics. These simulations are tools for understanding and guiding optimization, ensuring that manufacturing processes meet stringent quality and environmental standards. The VMAP wrapper is envisioned as a critical enabler for seamless data exchange across various simulation software environments. Adopting the VMAP standard ensures interoperability, efficiency, and usability in multi-physics modelling workflows. Let's look at the crucial requirements for the VMAP wrapper.

Standardized Data Exchange: The VMAP wrapper is expected to enable seamless data transfer between simulation tools. It should facilitate the export/import of material properties, boundary conditions, load cases, and results in a consistent format. This ensures that thermo-mechanical-metallurgical and fluid mechanics software can communicate without data loss or compatibility issues.

Interoperability with Multi-Physics Software: Modern engineering workflows require multi-physics simulations, integrating structural, thermal, and fluid mechanics analyses. The VMAP wrapper must ensure interoperability between these environments, allowing efficient coupling of CFD, structural, thermal, and other simulation methods. By doing so, engineers can streamline workflows, reducing manual reconfiguration and improving simulation accuracy.

Material Property Transfer: Material modelling often involves complex, non-linear behaviours requiring accurate data transfer. The VMAP wrapper must standardize material property exchange, ensuring that advanced material models (such as anisotropic composites or phase-changing alloys) can seamlessly integrate into various solvers.

Efficient Data Management: Large-scale simulations generate extensive datasets, requiring efficient storage and retrieval mechanisms. The VMAP wrapper should offer optimized data structuring, enabling users to manage high-fidelity simulation data locally and in cloud environments. This is crucial for iterative design processes where multiple simulations are conducted to refine models.

User-Friendly Interface for Engineers: Engineers, particularly those using commercial solvers like MSC Marc, might not be familiar with complex data formats. A user-friendly

VMAP interface should provide an intuitive workflow, minimizing the learning curve and reducing data transfer errors. Ideally, the wrapper should include automated data validation to detect inconsistencies before import/export.

Data Structuring and Labelling: Structured simulation data is essential for machine learning (ML) applications. The VMAP wrapper must support variable tagging (e.g., material properties, boundary conditions) and metadata labelling, allowing AI/ML models to process simulation results without requiring manual reformatting.

Bidirectional Data Flow: The wrapper should enable two-way communication between simulations and ML models. Simulation outputs can inform ML models, while ML-driven predictions can be reintegrated into simulations, allowing iterative design improvements and AI-assisted process optimization.

The VMAP wrapper can be an integrator that facilitates the exchange of simulation data, ensuring efficiency and interoperability in multi-physics workflows.

DIMAT - BRIDGING INTEROPERABILITY GAPS IN MANUFACTURING WITH A BOTTOM-UP APPROACH TO MANAGING SEMANTICS

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Manufacturing processes inherently involve diverse actors with varying expertise, leading to challenges in effective communication and collaboration. Insufficient standardization further complicates knowledge exchange and hinders data interoperability. While ontologies have been extensively developed and supported by numerous publicly funded projects as a solution to these challenges, their application often entails significant overhead in adaptation, integration, and maintenance.

In this talk, we present a bottom-up approach to overcome this barrier, starting with flexible vocabularies tailored to specific use cases and linking them to upper-level ontologies at a later stage. This pragmatic approach enables a swift path to interoperability by removing the need for a fully developed ontology as a prerequisite.

Central to our approach is a versatile and user-friendly vocabulary management system designed to accommodate different types of users. Domain specialists register new terms, while ontology experts perform quality control and later link these terms to upper-level ontologies. Once curated, the terms are used to create harmonized data representation for datasets, processes, and other resources within the ecosystem.

Our approach is demonstrated through application cases in materials development from the European project DiMAT, showcasing its ability to enable collaboration, enhance interoperability, and streamline data annotation without compromising on flexibility or scalability. This contribution highlights a practical and efficient pathway toward mitigating communication barriers in complex manufacturing environments.

VMAP in Industry

GGS – THE POSSIBILITY OF EMPLOYING THE VMAP STANDARD IN THE GGS PROGRAM TO ENHANCE DATA TRANSFER, SIMULATIONS, AND COLLABORATIONS

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Project GGS Consortium: TU Delft, Eindhoven University of Technology, University of Twente, University of Groningen, TNO, NHL Stenden University of Applied Sciences, Leiden University, Utrecht University, Nova College, avans University of Applied Sciences, In Summa, Max-Planck Institute, Philips, Bosch, TATA Steel, SKF, Bouwen met Staal, Nedschroef, VDL Groep, Nederlandse Onttinningsfabriek, FNsteel, SGS Société Générale de Surveillance SA, Auto Recycling Nederland, KE-Works, Dillinger, EX MENTE, Volvo, Alleima, Researchable, Space XYZ, DevControl, M2i

The Groeien met Groen Staal (GGS) program seeks to transform the Dutch steel sector into fully green steel by 2050. Over 31 industrial and research partners will develop and demonstrate innovative technologies to meet Dutch and European sustainability goals by 2030 and 2050. This initiative involves prominent private companies such as Bosch, Philips, SKF, Tata Steel, and Volvo, as well as international collaborators and educational institutes led by the Dutch M2i (Materials to Innovation) institute. The program's impact areas include climate goals, economic benefits, resource autonomy, and human capital. The initiative is structured into five themes: system change, production, processing, use, and recovery, encompassing 43 projects.

One key focus is the Processing theme, which will give steel the properties to make it ready to use after production. The focus is on adapting processing steps to green steel and making it more sustainable.

Another focus is on the Use theme, which aims to adapt manufacturing processes to green steel and assess the impact on products. This involves developing a digital twin of the material and process, exploring reuse possibilities, and implementing robustness control methods. Simulating and predicting the production of metal parts made from various types of steel, through multi-stage, multi-step, and multi-process simulations, with micro accuracy is a complex and challenging task. To accurately predict structural response, heat transfer, etc. it is essential to correctly define material behaviour.

So, using a standard approach to interface between different software, methods, and data that are used by teams of the program and a means for collaboration and the data transfer without the need for processing it to fit the needed format, will increase the efficiency and performance and make collaborations easier. By using the VMAP standard (which has been already implemented in several packages), different parties from the whole GGS program

who employ various software, experiments, or methods for material modelling, simulations, analysis, and development can interact with each other based on a, already available, validated standard and improve when necessary.

DEMANDS FROM STANDARDIZATION OF FILE FORMATS IN CAE SIMULATIONS

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In the pursuit of efficiency, Volkswagen is intensifying its virtual development processes across the entire automotive development cycle. Central to this transformation is the streamlining of CAE simulation and complex data management aspects. The adoption of vendor-independent standardized data formats, such as VMAP, is an important building block in this endeavour.

The various beneficial aspects of standardized data formats -- such as support of simulation workflows, enrichment with machine readable meta data, and cooperation with simulation data management systems -- are discussed with respect to the digitalization of the automotive development process.

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.

VMAP

Standards Community e.V.

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