EMMC-CSA

European Materials Modelling Council

Report

Expert meeting on

Business Decision Support Systems (BDSS)

March 27, 2018, 9.30 – 16.00 CET

Fraunhofer, Brussels BE, Rue Royale 94, 1000 Bruxelles, Belgium

TABLE OF CONTENTS

The EMMC-CSA project has received funding from the
European Union's Horizon 2020 research and innovation programme
under Grant Agreement No 723867

1. Executive summary

1.1 Description of the meeting and objectives

The European manufacturing industry has identified a challenge in its ability to adopt physics-based materials modelling (structure, property, performance predictions) in part due to the disconnect of the benefits of materials modelling outcomes with business objectives, and also the lack of communication of tangible and intangible benefits to relevant internal stakeholders to the business[1,2]. Other barriers to adoption of materials modelling are explored in various EMMC-CSA[3] related expert meetings and workshops[4], and this expert meeting focused on the specific communication barrier and how it may be addressed by software tools which enable the connection between modelling and business data/information. This software solution has been promoted by the EMMC as a Business Decision Support Systems (BDSS)[2].

The expert meeting was held on March 27th in Brussels with invited attendees representing manufacturing industry experts and developers of BDSS solutions. The **objectives** of the expert meeting were to:

1. Consolidate stakeholder needs/requirements to include materials modelling in the BDSS of manufacturing organizations;
2. Gain insight on best practices for materials modelling integration in business decision-making for materials/process/product design;
3. Gain feedback for NMBP-23-2016 BDSS implementation strategies (FORCE[5] and COMPOSELECTOR[6] projects), research and commercial offerings.

The **organisation of the meeting** (please see the agenda in Table 1) consisted of an introduction by the European Commission (Anne De Baas, EC) to objectives for materials modelling in the EC LEIT NMBP programme, and to the BDSS concept (Tom Verbrugge, DOW), followed by eight Flash talks facilitated by invited experts and BDSS developers, and two discussion sessions facilitated by EMMC-CSA members. Flash talk presentations were shared by Hein Koelman (DOW), Ali Karimi (Continental), Jean-Luc Leon-Dufour (Airbus), Sami Majaniemi (VTT), Stijn Donders (Siemens), Katya Vladislaveleva (Data Stories), Peter Klein (ITWM Fraunhofer, FORCE project), Salim Belouettar (LIST, COMPOSELECTOR project). Further experts in attendance and included in email communications for preparation and outcomes were Adham Hashibon (IWM Fraunhofer, FORCE project), Lempesis Nikolaos (ETH Zurich), Benedikt Ziebarth (BOSCH), Adam Kowalski (Unilever), Georgios Tritsaris (Deregallera), Patrycja Polinska (Goodyear), Michel Fouinneteau (Airbus), Thomas Merz (Airbus). Meeting organizers and discussion session facilitators from the EMMC-CSA included David Cebon (Granta Design), Davide Di Stefano (Granta Design), Gerhard Goldbeck (Goldbeck Consulting), Tom Verbrugge (DOW), and Donna Dykeman (Granta Design), all FORCE and COMPOSELECTOR partners.

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[1] EMMC Roadmap, 2015: https://emmc.info/wp-content/uploads/2015/04/EMMC_Roadmap_V3.0.2.pdf

[2] European Commission, NMBP-23-16 Funding Call on the topic of BDSS, 2015: https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/nmbp-23-2016

[3] European Materials Modelling Council, EMMC, Coordination and Support Action, https://cordis.europa.eu/project/rcn/205444/results/en

[4] EMMC Workshops and Events Listing: https://emmc.info/events/

[5] FORCE, Formulations and Computational Engineering. https://www.the-force-project.eu/

[6] COMPOSELECTOR, Polymer Composites Business Decision Support System. https://www.composelector.net/

Table 1: BDSS expert meeting agenda

Topic	Time (CET)	Duration (min)	Presenter	Expected Outcome
Welcome & Introductions	09:30	00:10	Tom Verbrugge (DOW)	Round table introductions, Meeting overview
Introduction to EMMC-CSA, BDSS	09:40	00:20	1. Anne De Baas (EC) 2. Tom Verbrugge (DOW)	1. Overview of EC vision for materials modelling; 2. Overview of BDSS methodology
Flash Talks – Session 1 (15 min/talk)	10:00	00:45	1. Hein Koelman (DOW) 2. Ali Karimi (Continental) 3. Jean-Luc Leon-Dufour (Airbus)	Review of implemented BDSS by end-users
Break	10:45	00:15		
Discussion Session 1	11:00	01:00	Sessions led by GRANTA, GCL, DOW with participation of Delegates	Objective: Consolidated BDSS Definition and Requirements 1. Key Attributes 2. KPIs of a BDSS 3. Type of projects
Group photo & Lunch	12.00	00:50		
Flash Talks – Session 2 (15 min/talk)	12:50	00:45	1. Sami Majaniemi (VTT) 2. Stijn Donders (Siemens) 3. Katya Vladislavleva (Data Stories)	Review of BDSS strategies by tool developers
Break	13.35	00:15		
Flash Talks – Session 3 (20min/talk)	13.50	00:40	1. Peter Klein (ITWM Fraunhofer, FORCE project) 2. Salim Belouettar (LIST, COMPOSELECTOR project)	Review of BDSS strategies by H2020 projects
Discussion Session 2	14:30	01:00	Sessions led by GRANTA, GCL, DOW with participation of Delegates	Objective: Analysis of BDSS strategies presented in Flash Talks
Break	15.30	00:10		
Summary Session	15:40	00:20	Gerhard Goldbeck (GCL)	1. Review of the day 2. Next EMMC-CSA activities on BDSS
End	16:00			

1.2 Major outcomes and recommendations

The major outcomes of the meeting, as summarized in this document, are:

1. Input to the definition of a BDSS from the end-user and tool developer perspective, supported by the Flash Talks on existing BDSS (research and commercial offerings) and Discussion Sessions. Sweet spots for combined materials and business modelling were identified as: i) open research questions; ii) characterising a material system; iii) understanding effects of processing on properties; iv) Screening hypothetical new materials; v) Computer-aided design; vi) substitution; vii) understanding failure mechanisms. More detail on these topics will be given in the Report. The definition and theory to define a BDSS is an ongoing effort of the EMMC, FORCE and COMPOSELECTOR projects.

2. A list of attributes (characteristics or functional requirements) that either are supported by the BDSS solutions presented or were recommended by the manufacturing industry experts. The attributes will be presented in this Report under a high-level classification structure to help characterize the BDSS and its use for the manufacturing industry. For example, here are the classes of attributes for the BDSS software tool:
   a. Economic (costs of infrastructure, personnel);
   b. User Experience (functionality needed to have a positive experience using the BDSS);
   c. Value Proposition (sector and/or type of project and/or end-user targeted by the BDSS; specific messaging needed to convince senior management to invest in a BDSS);
   d. Underlying Technology (IT requirements, tool or software technical requirements).

163 attributes were captured for the BDSS. The attributes captured (and their classes) are not meant to be exhausted or prescriptive, but a guide to what end-users and tool owners see as important for articulation of BDSS capabilities for the manufacturing industry.

3. Recommendations for conditions to enable further adoption of materials modelling by the manufacturing industry:
   a. For easier model selection, the creation of model categories defined by types of materials, processes, boundary conditions;
   b. Common benchmarks to assess models, such as NAFEMS' assessment of finite element code;
   c. Standards for virtual testing performance for part certification (e.g. NAFEMS Guidelines), expressed by OEM's in support of virtual coupon testing using micro-to-continuum scale modelling.

Meeting organization and outcomes are detailed in the remainder of this Report, and meeting outcomes are integrated in further EMMC-CSA Deliverables.

2. Meeting Report

2.1 BDSS Context

Each Flash Talk presenter was invited to address a specific set of questions to give the audience a comparable overview of each BDSS solution:

1. *Tell us about your decision-making tool or methodology (BDSS) and how it integrates material model outcomes: is it a spread sheet? a discussion between key internal/external stakeholders? a single button, fully automated tool? a project management tool (e.g. JIRA)? a combination of the above?*
2. *What models are integrated in your BDSS: nature of the models – theory-driven (electronic, atomistic, mesoscopic, continuum) and/or data-driven?*
3. *Who are the main actors using the BDSS, and what types of projects do they use it for: managers, materials engineering, modelers, etc. (exact job titles preferred)? Who is initiating discussions, who feeds the information into a business decision, etc.? What phase in the product life cycle is it used for (e.g. front/back end research, design decisions, etc.)? Is it being used with or offered to value/supply chain partners and customers?*
4. *What are the main benefits, or performance indicators, linked with integrating material model output with business decisions: reduced cost, product improvements, reduced time-to-market, and/or other business benefit?*
5. *Is your BDSS working successfully to include materials modelling outcomes? What is your vision of success?*

The **Flash Talks by manufacturing experts** shared high-level overviews of their business processes (e.g. stage-gates to evaluate market, risks, costs, value proposition, resources, etc.) and how stakeholders communicate their needs and receive data/information for decision-making. Materials modeling plays a role in: predicting material properties, determining the value proposition of the material in the targeted applications, determining most promising routes for material development (e.g. formulations) [DOW]. Modeling outcomes are used to: develop and communicate the overall value proposition, determine material value, define areas for improvement in material development, score different development tracks, support NPV/Investment/Risks assessments [DOW]. Experts agreed that their entire decision-making process is not digitalized and relies heavily on interpersonal communication between many stakeholders, or Business Entities (Materials and Process, Structural Analysis, Designers, Business Strategy and Finance/Procurement, Marketing, Manufacturing, Quality, Programs, Suppliers, Specific lead customers feedback, EH&S, Intellectual Property, etc.). Attributes that influence investment decisions in technology such as BDSS are reduction of innovation and lead time, time-to-market by accelerated decisions/development, reduction of manufacturing costs, improved confidence in decision-making processes (manufacturer and customer) thus improving the sales relationship. End-users recommended BDSS developers target the early phases in projects or programs where design principles and material are chosen, but also expressed benefits at late life cycle phases (e.g. improve models with feedback on in-service product performance and end-of-life value).

The Flash Talks by BDSS developers demonstrated state-of-the-art commercial and research solutions aimed at: 1) making materials and process modelling easier for businesses to use and gain benefits from by providing a simple, automated interface which receives input and produces output/results for validated models (Siemens, VTT, DataStories) where cost/time effectiveness and ease-of-use are designed into the software solution; 2) in addition, the ability to demonstrate the value of materials modelling and how it can influence the bottom line, Return on Investment, or Net Present Value (VTT, Siemens, COMPOSELECTOR), 3) in addition, offering the cost of modelling (time, expense) to an end-user as part of the decision-making process to pursue materials and process modelling options (FORCE, COMPOSLECTOR). The numbering 1 to 3 does not reflect maturity of the system (Siemens and DataStories presented mature commercial systems, VTT a mature research system, and FORCE and COMPOSELECTOR solutions are in the proof-of-concept phase), nor is it necessarily a goal for all solutions to report on modelling cost/time effectiveness as this may be well understood as part of the value proposition of the system (e.g. validated models and code, enhanced computing power). Rather, FORCE and COMPOSELECTOR are exploratory systems to demonstrate the BDSS concept as part of an EMMC mandated project. It should also be noted that less explicit paths to resource management (e.g. ERP software) can be made by the Siemens PLM solution, but this is beyond the scope of the current research phase of the BDSS.

2.2 BDSS Functional Requirements

The definition and theory to define a BDSS is an ongoing effort of the EMMC, FORCE and COMPOSELECTOR projects, and hence a formal definition will not be reported here. As previously noted, the BDSS end-users can be very diverse, as are their requirements on functionality of the BDSS. Collecting functional requirements from software end-users is a typical exercise in software development. Quality Attributes: in the field of computing are the overall factors that affect run-time behavior, system design, and user experience. They represent areas of concern that have the potential for application wide impact across layers and tiers. Some of these attributes are related to the overall system design, while others are specific to run time, design time, or user centric issues. The extent to which the application possesses a desired combination of quality attributes such as usability, performance, reliability, and security indicates the success of the design and the overall quality of the software application. Common Quality Attributes can be classed as Availability, Conceptual Integrity, Interoperability, Maintainability, Manageability, Performance, Reliability, Reusability, Scalability, Security, Supportability, Testability, User Experience/Usability[7], among others. Attributes drawn from the discussion at the BDSS expert

[7] Microsoft Application Architecture Guide, Chapter 16: Quality Attributes. Microsoft Corporation, 2009. https://msdn.microsoft.com/en-gb/library/ee658094.aspx

meeting were consolidated into the following classes: Economic, User Experience, Value Proposition, Technology (explanations for each class is given in Table 2).

In Discussion Session 1, Consolidated BDSS Definition and Requirements, meeting participants were divided into three groups to discuss the following:

1. BDSS Attributes – create a list of attributes (or characteristics) to describe the requirements of a BDSS, or how an end-user would expect it to function for their needs (example attributes for a BDSS, business and material/product/process, and model/simulation were given to participants to help stimulate discussion)
2. Identify the KPIs (or types of KPIs) you expect the BDSS to report on for decision-making (e.g. economic, technical, life cycle, etc.)
3. Identify combinations of KPIs and application 'sweet spots' for the BDSS. Sweet spots may be described by:
    - Industry type – formulation, manufacturing, etc.
    - Application area – product type
    - Development Stage – research, concept design, detailed design, production, maintenance
    - Stakeholder
        i. Internal – department (R&D, TSD, Commercial, Marketing)
        ii. External – value/supply chain (customers, suppliers)

Discussion Session 2, Analysis of BDSS Strategies, facilitated an evaluation of BDSS strategies shared in flash talks. Participants were divided in 4 groups, each evaluating a different BDSS strategy (Flash Talk) against 5 pre-defined questions, considering how the responses to each question may be considered a strength or a weakness by the end-users present. Categorization of whether an attribute of a BDSS strategy is a strength or weakness can be considered subjective for a specific application, field of interest or R&D phase, and hence a strength to one end-user may be a weakness to another. The point of the session was not to be overly critical of the solutions, but rather to stretch the understanding of how to apply the presented solutions to different manufacturing business scenarios as represented by the end-users at the meeting. The five critical questions were:

1. Application: Are there use cases where materials/data modelling cannot be supported by this BDSS strategy?
2. Project Type: Can the BDSS be applied across all R&D phases?
3. Attributes: What attributes are present (or not) in this strategy?
4. KPI: What KPIs of the BDSS are addressed, or not?
5. Communication: Does the BDSS strategy engage your stakeholders? Who?

The combined, generalized outcomes from these two discussions sessions, along with the Flash Talks are summarized in six tables of recommendations to BDSS developers:

1) Table 2: Example BDSS Attribute Classes
2) Table 3: Recommended BDSS Acceptance Criteria
3) Table 4: Example Business Entities (i.e. stakeholders) and Attribute Classes
4) Table 5: BDSS Requirements for Business Entities within a Manufacturing Organization
5) Table 6: Sweet Spots for BDSS Application within a Manufacturing Organization

Table 2: Example BDSS Attribute Classes

Attribute Class (explanation)
Economic (cost and time of infrastructure, personnel for implementation)
User Experience (functional requirements of stakeholders for ease of use of models/simulation tools/data/information/outcomes)
Value Proposition (typically position statements regarding the types of problems and quality and benefits of outcomes which requires support from other attributes, notably Economic)
Technology (1. non-functional expectations of technology to ensure aspects such as security, interoperability, traceability, etc.; see Quality Attributes definition for software; 2. technical solutions)

Table 3: Recommended BDSS Acceptance Criteria

Attribute Class	Acceptance Criteria
Economic	Reduced lead time and cost
Technology	Meeting security aspects
Technology	Interoperable (wrt models, solvers, databases, data formats)
Technology	Plugin topology optimizer
Technology	Exploration and hypothesis generation tool
Technology	Integrated dataset creation
Technology	Traceability
Technology	Manual/API import
Technology	Flexible platform
Technology	Ranking of solutions
Technology	Display of the things that matter to the business decision (i.e. Business KPIs)
Technology	Automated
Technology	Interoperability - ability to plug in tools
Technology	Database management and access systems of material properties and commercial information of a structured and unstructured nature
Technology	Cognitive computing technology to capitalize on legacy data
Technology	Simulation learned data
Technology	Dynamic business information (pricing, market, risks, IP)
Technology	Materials modelling workflows
Technology	Pre- and post-processing tools
Technology	Database of test results to support prediction based on big data
Technology	Use of project management tools
Technology	Scalability
Technology	Multi-attribute virtual material optimization
Technology	Enterprise-wide access to data
Technology	High level of automation
Technology	Leverage HPC infrastructure
Technology	Ecosystem of integrated solvers
Technology	Connect to any in-house application
Technology	Data mining
Technology	Trends analysis
Technology	Configurations are stored, managed and can be reused
Technology	Plugin architecture for modelling and simulation
Technology	semantic integration

Technology	various modelling paradigms and languages can be used together
Technology	open source solver libraries
Technology	Leverage HPC infrastructure
Technology	supports surrogate model constructions (fast to simulate, automatable)
Technology	Fully automated machine learning algorithms and predictive analytics workflows
Technology	Reports with immediately actionable recommendations
Technology	Cloud hosted
Technology	Standalone
Technology	Enterprise hosted
Technology	Browser-based self-service analytics for non-data scientists
Technology	Interactive narrative of what matters in your data
Technology	Fully automated analysis workflows
Technology	Export predictive models to Excel or C/C++
Technology	Automatic export to Powerpoint
Technology	Automated analytics toolbox for Matlab users
Technology	Automatic scaling
Technology	Automatic handling of categorical variables
Technology	Robust predictive models with local error bounds
Technology	Best algorithms for variable selection and ML for regression
Technology	Model-guided experimental design
Technology	Discovers the minimal list of necessary and sufficient performance drivers
Technology	Interactive real-time what-if scenarios (performance profilers)
Technology	Search space reduction
Technology	Hypothesis generation
User Experience	Story generator (human factor is important)
User Experience	Ability to relay model insight (quantifies the output)
User Experience	Integration of 'know-how'
User Experience	Reduced design space based on prior knowledge
User Experience	Pareto front browser
User Experience	Interactive display
User Experience	Trade-off analysis
User Experience	Identifies the most important (necessary, sufficient) parameters that affect outcomes
User Experience	Tool targets decision support for domain expert
User Experience	Can analyse many different hypothesis/scenarios
User Experience	Domain (subject matter) expertise imbedded to interpret results
User Experience	Clear / Intuitive presentation of information
User Experience	Only see one's own data
User Experience	Reference data available as a starting point
User Experience	Easy to use optimizer
User Experience	Indicates where to sample next in the design space
User Experience	Supports knowledge of how to exchange models, and retains knowledge of existing model
User Experience	Integration of validation process using experimental data
User Experience	Usability – for all different user types
User Experience	Useful reporting formats and analytics
User Experience	Advises which moda to choose
User Experience	Guides industry through the KPI selection
User Experience	Displays of business KPIs that matter

User Experience	Multi-criteria selection
User Experience	Decision tools for each stakeholder skill
User Experience	User-Friendly platform for very different stakeholders (engineering, procurement, ...)
User Experience	Scores different development tracks
User Experience	Modelling optimization strategies and methods
Value proposition	Value chain integration
Value proposition	Enterprise-wide solution
Value proposition	Clear application scope (product world vs materials engineering)
Value proposition	Easy to sell internally
Value proposition	Easy to test
Value proposition	Easy to access
Value proposition	Quality of the data identified
Value proposition	Improves understanding of material/process/product
Value proposition	Reduces amount of testing
Value proposition	Cost: Accessible total cost of ownership
Value proposition	Facilitates modelling decisions
Value proposition	Necessary configurations for the domain
Value proposition	Scale: Concentrated on a modelling scale
Value proposition	Engages key internal stake-holders, multi-functional teams, during critical design reviews
Value proposition	Time: Shorten screening phase
Value proposition	Cost: decreases qualification/certification cost
Value proposition	Better understanding of material for design optimization - product improvement
Value proposition	Simulation for large number of materials
Value proposition	Simulation for a small subset of materials
Value proposition	Manufacturing process optimization
Value proposition	Knowledge transfer from past experience (big data exercise)
Value proposition	Integration of reliable models
Value proposition	Collaborative platform to allow real optimum solution
Value proposition	Cost: Reduces development time and cost
Value proposition	Guide to experiments
Value proposition	Integration of physical experiments
Value proposition	Scale: Bridge length scales to tackle more challenging questions
Value proposition	Cost: Transfers savings to the customer (e.g. Cycle time benefits)
Value proposition	Quality benefits - lower part rejection rate, increase productivity
Value proposition	Tailored to specific performance benefits (e.g. lower weight of a part)
Value proposition	Ability to model integration of complex parts
Value proposition	Defines areas for improvement in the material development process
Value proposition	Theory- and data-driven modelling for structure-property prediction
Value proposition	Data-driven for identifying candidates for formulations with improved performance
Value proposition	Accessible data/information to customers (feasibility/benefits of solutions in customer application)
Value proposition	Time: Faster and more efficient innovation process
Value proposition	Offers a market advantage to customers
Value proposition	Materials data management
Value proposition	Decision making and product optimization
Value proposition	Accurate 3D CAE product performance prediction with minimal testing
Value proposition	Reduced model preparation time

Value proposition	Higher quality models
Value proposition	Time: Shorter time-to-market for end user products
Value proposition	Multi-discipline integration
Value proposition	Open Access
Value proposition	Time: Reduced number of tests (time, cost)
Value proposition	Easy to deploy across organizations
Value proposition	Multi-discipline collaboration
Value proposition	All models have confidence intervals to guide extrapolation

Table 4: Example Business Entities (i.e. Stakeholders) and Attribute Classes

Business Entity	Attribute Class
Finance/Procurement	Return on Investment
IP Management/Legal	Freedom to Operate
Regulations	Risk Assessment
Marketing	Business Strategy
	Market Opportunity
	Market Readiness
Supply Chain Management	Customer
	Supplier
Human Resources	Skills Investment
	Resource Management
HSE	Sustainability
	Safety
IT	Security
Product Development	Materials
	Modelling
	Structural
	Product Design
	Manufacturing Process
	Life cycle assessment
	Resources

Table 5: BDSS Requirements for Business Entities within a Manufacturing Organization

Business Entity	Acceptance Criteria (able to report on ...)
HSE	Handling S-KPI (safety-KPI)
Finance	Return on investment
Finance	Global cost across product life cycle
HSE	Risk (definition needed - could add a KPI for Environmental Regulation)
Finance	Cost of resources (people, investment, time)
Marketing	Market opportunity
Product Development	Technology readiness level (TRL)
Product Development	Manufacturing readiness level (MRL)
IP/Legal	Competitor position / freedom to operate / IP constraints
Product Development	Lead-time reduction
Product Development	Microstructure
Product Development	Behaviour (e.g. rheology, flowability, mechanical stability)
Product Development	Property development (e.g. thermal, electrical, mechanical, chemical)
Product Development	Degradation properties (e.g. char temperature, oxidation)
Product Development	Operational times (e.g. demoulding, heating/cooling)
Product Development	Health, Environment, Safety (e.g. VOC)
Product Development	Applied density
Product Development	Solidification properties (e.g. gel-time, tack-free time, rise time, gelation temperature, vitrification temperature, degree of cure)
Product Development	Final technical properties (mechanical, thermal, electrical, chemical)
Product Development	Final technical behaviour (e.g. Creep, stress relaxation, fatigue)
Product Development	Final non-technical properties (e.g. Sensorial)
Product Development	Health, Environment, Safety
Product Development	Robustness
Product Development	Effects of defects on performance and manufacturing-related aspects

Table 6: Sweet Spots for BDSS Application within a Manufacturing Organization

Application Sweet Spot	Processes that should be supported by the BDSS
Open (Research) Questions	Search-Space reduction, hypothesis generation
	Prioritized choices/candidates
	Could also be a product performance task force
	Limitation: atomistic modelling requires information about formulation not shared by supplier, IP issue; but, parameterized data-based models can be useful for supply chain interaction
	'Just feasible' material models (from Research) to integrate into product design install base
	Hazard, functional KPIs related to social responsibility
	Broaden design space via physics-based models
	Early stage guidance
	Estimation of extreme/edge cases
	Early stage guidance
	Experimental guidance/reduction
	Model-guided DOE for multi-physics solutions (chemistry/physics/mechanical engineering)
Characterising a Material System	Virtual allowables development (need standards for virtual testing performance for part certification, e.g. NAFEMS Guidelines)
Understanding effect of processing on properties	Residual stress development
Screening hypothetical new materials	De-risking certification; material producer is main actor, linked to OEM needs
	Well-established applications such as polymers, alloys, resins
Computer-aided material design	Tuning properties
	New and complex applications such as semi-conductors, formulations
Substitution	Regulated chemicals, scarce materials such as Rare Earth Elements
Understand failure mechanisms	Corrosion, inclusion growth, embrittlement, etc.

3. CONCLUSIONS

Main messages:

1. End-users identified a wide range of application sweet spots for BDSS systems, ranging from open research questions to virtual testing for material qualification. All sweet spots can be identified with materials and process selection and/or innovation.
2. End-users recommended BDSS developers target the early phases in projects or programs where design principles and material are chosen, but also expressed benefits at late life cycle phases.
3. Materials modelling needs to be complemented by other sources of information for a BDSS system to function as envisioned, e.g. regulations, economic factors, IP issues, etc., to meet the requirements for multiple decision-making stakeholders. This implies that a BDSS needs to gather information from other sources and present the users with a picture, narrative or report which represents the system-level complexity, as completely and accurately as possible.
4. End-users of BDSS gave many recommendations for Quality Attributes to support definitions of User Experience, Technology, and Value Proposition, which indicates their enthusiasm to have a system which solves their challenges in communication and connecting materials and business models. Economic attributes were expressed but was not a limiting factor.
5. User Experience should be designed so that the BDSS is intuitive for users with different backgrounds and skills. This includes tools for visualization of the results tailored on the user expertise level and for the selection of simulation workflows, KPIs, etc.
6. The BDSS should be easy to adopt and sold internally. This calls for a clear and focused Value Proposition, and for easy integration with existing company business processes and tools. For large manufacturing organizations, integration or interoperability with ERP, PLM and data/information management systems may be appropriate.
7. Actual time-to-solution of the models is a critical aspect to consider in the design of any BDSS system. The manufacturing experts present recommended functionality such as 'interactive, real-time analysis of what-if scenarios', but such an experience is beyond the current state of the art of materials modelling for many use cases, particularly when it comes to discrete modelling. An approach to overcome this issue has been identified in the use of surrogate models based on simulation and/or characterization data (VTT).
8. BDSS non-functional requirements such as security, interoperability, and traceability must be fulfilled in the offering to manufacturing clients, irrespective of business size.
9. Cloud hosted systems are not excluded a priory and seem to be gaining preference. This could lower implementation costs which is particularly relevant for SMEs.
10. The manufacturing experts see opportunities for materials modelling to improve their business performance, and have made some clear recommendations not only for BDSS development, but also to leverage established verification and validation procedures (NAFEMS) and to lobby for wider acceptance of virtual material property generation as part of formal material qualification programs.

The EMMC-CSA would like to extend our gratitude to all participants of the BDSS expert meeting, and the wider community who are supporting this discovery phase in building and demonstrating systems to meet the needs of the European manufacturing industry.

Authors	Donna Dykeman, Davide di Stefano (both Granta Design Ltd.)
Contributing EMMC-CSA partners	DOW, Goldbeck Consulting Ltd.

EC-Grant Agreement	723867
Project acronym	EMMC-CSA
Project title	European Materials Modelling Council - Network to capitalize on strong European position in materials modelling and to allow industry to reap the benefits
Instrument	CSA
Programme	HORIZON 2020
Client	European Commission
Start date of project	01 September 2016
Duration	36 months

Consortium		
TU WIEN	Technische Universität Wien	Austria
FRAUNHOFER	Fraunhofer Gesellschaft	Germany
GCL	Goldbeck Consulting Limited	United Kingdom
POLITO	Politecnico di Torino	Italy
UU	Uppsala Universitet	Sweden
DOW	Dow Benelux B.V.	Netherlands
EPFL	Ecole Polytechnique Federale de Lausanne	Switzerland
DPI	Dutch Polymer Institute	Netherlands
SINTEF	SINTEF AS	Norway
ACCESS e.V.	ACCESS e.V.	Germany
HZG	Helmholtz-Zentrum Geesthacht Zentrum für Material- und Küstenforschung GMBH	Germany
MDS	Materials Design S.A.R.L	France
Synopsys / QW	Synopsys (former QuantumWise A/S)	Denmark
GRANTA	Granta Design LTD	United Kingdom
UOY	University of York	United Kingdom
SINTEF	SINTEF AS	Norway
UNIBO	ALMA MATER STUDIORUM – UNIVERSITA DI BOLOGNA	Italy
SYNOPSYS	Synopsys Denmark ApS	Denmark

Coordinator – Administrative information	
Project coordinator name	Nadja ADAMOVIC
Project coordinator organization name	TU WIEN
Address	TU WIEN | E366 ISAS | Gusshausstr. 27-29 | 1040 Vienna | Austria
Email	nadja.adamovic@tuwien.ac.at emmc-info@tuwien.ac.at
Project web-sites & other access points	https://emmc.info/