



# EXPLORING MODEL-BASED SYSTEMS ENGINEERING WITH DASSAULT SYSTÈMES

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# AN INTRODUCTION TO MODEL-BASED SYSTEMS ENGINEERING

**As products become more complicated, consumer demand inevitably increases.**

**We all now look for smart TVs and connected appliances that can communicate with their environment within both the home and the car. We want to buy products, which have some form of autonomous functionality or in-built machine learning. While in industry and manufacturing, we constantly push for R&D innovation so that capabilities can grow in relevancy and competitiveness.**

Designing and manufacturing a modern vehicle for example, is now a monumental undertaking. Yet, the development process is traditionally siloed, inefficient and often results in wasteful and expensive rework as not all stakeholders have access to a single source of truth.

As a result, conventional ways of working can only take us so far in ensuring that these complex, more technologically advanced products are produced on time, on budget and with a reduced risk of recalls.

But what if it didn't have to be like this?

What if engineers and developers from various disciplines could all work together on a multi-disciplinary virtual prototype to simulate exactly how the product will be used, before ever building a physical prototype?

What if you could streamline the process of innovations, harness the creativity of everyone involved in the project and speed up the time to market?

What if your primary means of information exchange between engineers wasn't document-based but instead, one development platform - providing 360 degree visibility, total collaboration, digital continuity and the integration of all R&D disciplines?

New levels of product complexity have resulted in this demand for a new working methodology.

Here at Dassault Systèmes, we believe that Model-Based Systems Engineering (MBSE) is the answer we've all been looking for.

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# WHAT IS MBSE?

## The formalised application of modelling to support:

- System requirements
- Analysis
- Design
- Verification & Validation activities

MBSE starts in the conceptual design phase and continues throughout development and later lifecycle phases.

It is a term that predicates the use of modelling to analyse and document key aspects of the Systems Engineering Lifecycle. It is broad in scope but provides a single point of truth, which is reflected in a set of living artefacts.

“

*MBSE is a common language and a nomenclature that describes a system and its requirements, functions, logical architecture, and its physical representation in the virtual world.*

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**Peter Krantz,**  
CATIA Sales Director,  
Dassault Systèmes

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**“ MBSE is a model-based management strategy that allows you to have all the information in a single data-base so that everyone collaborates on a single model and can generate documents from that one single truth source. It was developed to replace Document-Based Systems Engineering - the process whereby lots of artefacts and documents are produced across different formats without one holistic overview of how it all correlates and what everything means. ”**



**James Towers, Associate Consultant at Scarecrow and a visiting lecturer in MBSE at the University of Warwick**



# WHY EMBRACE MBSE?

**Models are created to deal with complexity. In doing so, they allow us to understand an area of interest or concern and provide unambiguous communication amongst different divisions and invested parties.**

The principle goals of MBSE are as follows:

## ➔ **Enhanced communications**

- With stakeholders
- Within the engineering project teams
- Across spoken language barriers

## ➔ **Quality improvements**

- Early identification of requirements issues
- Enhanced system design integrity
- Improved specification of allocated requirements to hardware and software
- Fewer errors during integration and testing
- More rigorous requirements traceability
- Consistent documentation

## ➔ **Growth in productivity**

- Improved impact analysis of requirements changes
- Improved interaction across a multi-discipline team
- Reuse of existing models to support design and technology evolution
- Auto-generation of documentation

## ➔ **Reduction in risk**

- Improved cost estimates
- Early, and on-going, requirements validation and design verification

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## TWO THINGS TO KNOW ABOUT MBSE

### ① MBSE connects different disciplines coherently

It is essentially the glue that holds together the different engineering domains and other relevant stakeholders and makes the dissemination of information such as, concepts, plans, first implementation of the hardware, software, and mechanics, plus the testing and development views, that much easier.

### ② MBSE is not just for the experts.

Although MBSE will help create a common language and methodology, it isn't just for the systems engineers or technical experts. All stakeholders need to understand and buy-into the system so that investment is consistent and models can be transformed, read, reviewed, released, annotated, changed and re-used.

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# THE DASSAULT SYSTÈMES DIGITAL DIALOGUE VIRTUAL EVENT

In order to develop the conversation around MBSE further, Dassault Systèmes hosted a virtual Digital Dialogue event in September 2020.

We invited speakers from across industry sectors to share their experiences of implementing MBSE in order to increase collaboration and improve engineering efficiency.

Over the following pages, we will look at the outputs and insights delivered by the event.

Peter Krantz opened our virtual conference by asking

“ *Would it help to have traceability from early requirements to enhanced detail on mechanical systems, electrical and software?  
Would it help to have an early concept architectural-level definition before you start with product definition to make trade-off studies and decide if a particular function should be mechanical, electrical or software-driven?* ”



Peter Krantz,  
CATIA Sales Director,  
Dassault Systèmes

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**“*MBSE is the answer but the challenges often exist around the digital transformation required from within an organisation or across a complete supply chain. There is never one MBSE journey that fits all customers so I’m delighted to be able to hear from different voices today on their MBSE experiences and where they are on this journey.*”**



Peter Krantz, CATIA Sales Director, Dassault Systèmes

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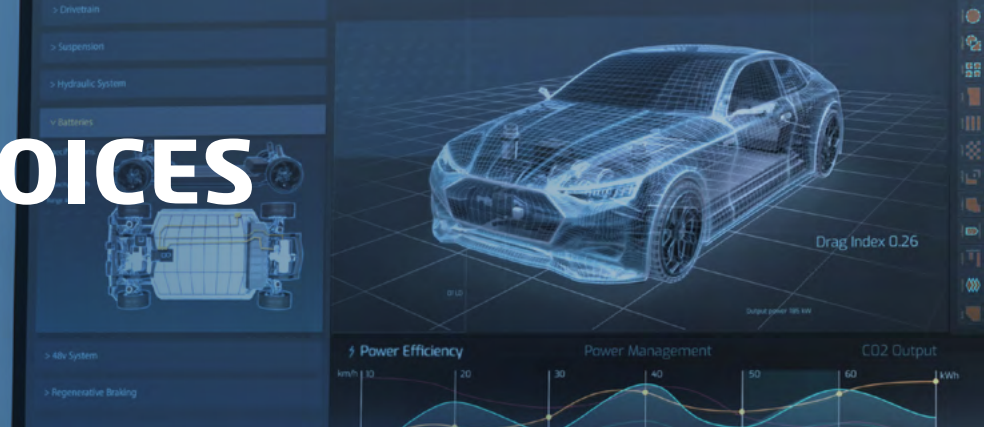
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# DIGITAL DIALOGUE VOICES ON MBSE



## Scott Reid, UK MBSE Technical Lead at Capgemini

Scott is an experienced Systems Engineer with a background in the Defence sector, focused on military vehicle development. At our Digital Dialogue event, he spoke about the need for products to become more autonomous, more responsive and more aware of the environment within which they are working. He also discussed how, by moving to an MBSE approach, it is allowing manufacturing and operational issues to be anticipated, while assessing system impacts on the environment.

“

*These shared systems models complement the adoption of other high-valued technologies, such as AI, IoT, Big Data and Digital Time,*

Scott told delegates.

*It's a hub to bring everything together and build a real collaborative environment. We can link all data and enable a digital twin to provide full site or systems analysis. MBSE provides a truly holistic view of our systems and allows us to effectively integrate different aspects of the product life-cycle to bring together both the digital and physical product.*

*It provides a single source of truth to the product lifecycle and drives collaborations across many different functions and teams.*

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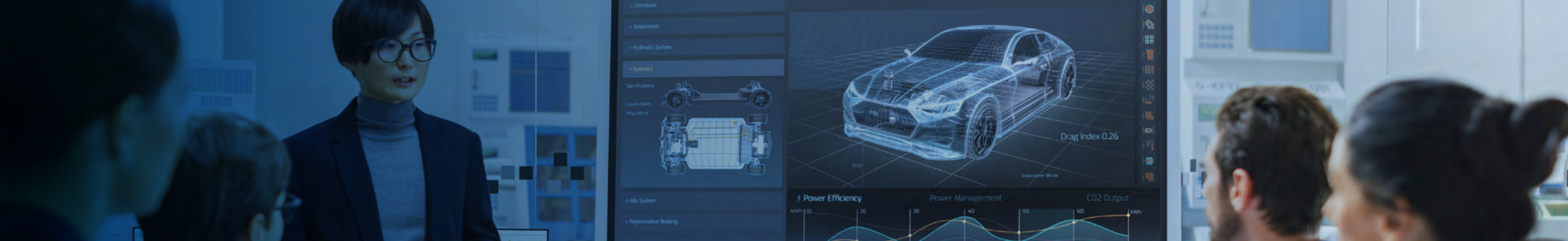
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## Scott cites the holistic benefits of implementing MBSE across product development, the industrial system and operations / maintenance as follows:

### ➔ Product Development

- Reduction in overruns cost
- Reduced time to market
- Reduced innovation risks
- Improved reliability
- Improved performance
- Improved customer experience

### ➔ Industrial System

- Reduced creation time
- Increased production capacity
- Support for product personalisation
- Provision of industrial traceability
- Improvements to predictive maintenance

### ➔ Operations & Maintenance

- Reduced overruns cost
- Reduced innovation risks
- Improved reliability
- Improved customer experience

Scott concludes:

“

*The most common implementation of MBSE is at product level but there is a growing expansion towards industrial and operational modelling as well.*

*Implementing MBSE across all three provides the additional advantage of being able to analyse change impacts and trade offs across the entire life-cycle.*

*For example, a change in a component design may give a small optimisation in a product model, which will then have a large implication of time and cost in an industrial model.*

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Scott Reid,  
UK MBSE Technical Lead at Capgemini

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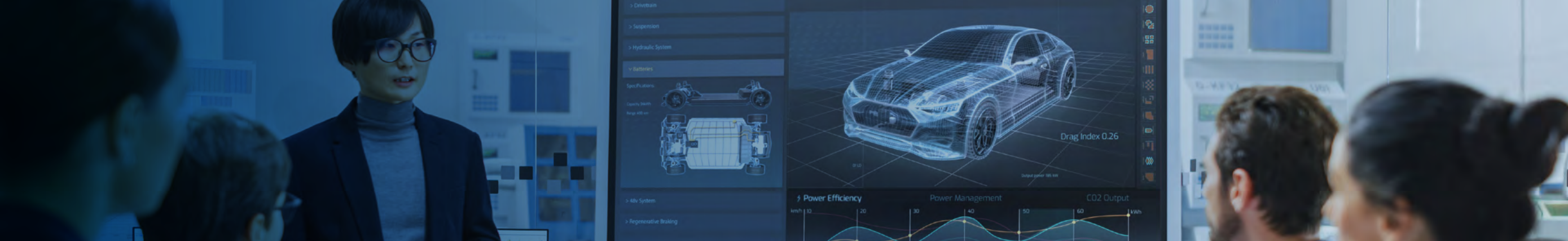
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**James Towers,**  
**Associate Consultant, Scarecrow and visiting lecturer in MBSE at the University of Warwick**

James Towers is an MBSE consultant working across a diverse range of sectors. He spoke to delegates about what a successful MBSE strategy should look like as a pre-cursor to the interactive workshop element of our Digital Dialogue event.

“

*The key elements of an effective MBSE strategy are high-level buy-in so that all your initiatives can align with the broader strategy of your organisation; an MBSE champion - someone who can fight your corner when people show resistance to change; allocated budget and resources so that it's managed as a change project; plus the option to bring in consultant expertise along with the investment to train and mentor people from within.*

*MBSE is possibly closer to software development than document-based systems engineering. There is a lot more use of tools, abstract concepts, model administration etc. So a different working culture is required. You open your modelling tool every day. It's not one of your activities, it's the only activity.*

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## PERSONAS REQUIRED FOR MBSE

### ➔ Modellers

- Proficient tool knowledge
- Proficient language knowledge
- An understanding of how to work with integrated toolsets
- Understanding of AF
- Ability to follow process
- Able to guide consumers around the model

### ➔ Wider community

- Able to grasp a basic understanding of MBSE principles and benefits in order to support and fund the initiative

### ➔ Specialists

- Detailed tool knowledge
- In-depth language understanding
- Able to create and edit AF and tool profiles
- An understanding of tool integration setups
- Ability to create and edit document templates
- Ability to tailor MBSE process for each project
- Able to train modellers

### ➔ Model consumers

- Proficient language knowledge
- The skills and knowledge to use the platform

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# THE VIRTUAL INTERACTIVE WORKSHOP

The interactive audience element of our Digital Dialogue event, saw Pierre Maurel, Industry Business Consultant Expert at Dassault Systèmes, join James Towers and Scott Reid to review audience responses to two key questions:

1. What do you consider to be the essential elements of a MBSE business case?
2. What do you consider to be the essential elements of a successful MBSE strategy?

**Those answers to the first question that resonated the most among our audience were:**

- To establish an organisation's digital thread and have complete access to all available information.
- To improve communication and traceability.
- To better understand the context of the business, identify what is of the greatest value and to establish future benefits.

**“ Identifying and presenting the business value of MBSE is crucial. Is it to get products to market quicker? To become more competitive? By evaluating those activities that will ultimately deliver value, you can engineer the company transformation as a complete system. ”**



Pierre Maurel,  
Industry Business Consultant Expert at  
Dassault Systèmes

**Those answers to the second question that resonated the most among our audience were:**

- Start small and have a clear goal. Recruit a core team of people who understand the basics before attempting to reply on a project.
- Get all departments involved so that buy-in and participation is across the board.
- Have in place a clear roadmap for progression, which is clearly communicated and planned.

**“ It's important to understand where the business is today and where you want to get. By identifying your goal and starting small, you can bring stakeholders, engineers and everyone onboard so that they all understand the role they have to play. ”**



Scott Reid,  
UK MBSE Technical Lead at Capgemini

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# THREE LESSONS ON MBSE

## Lesson One: MBSE IS A LONG-TERM STRATEGY



**Kongsberg Defence & Aerospace:**

**Torfinn Tobiassen,**  
Manager of Hardware Development at Kongsberg Defence & Aerospace has over 25 years experience

Over the past ten years, he has been responsible for implementation of MBSE for Kongsberg's missile division.

“ For us, MBSE really started in 1996 due to a need for a functional description of the missile product from the safety team. At the same time, the software department started doing object orientated design, using the modelling tool UML and an MBSE tool called Slate.”

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“*In the early days however, it was hard to get an agreement on what the model should look like as each division used a different language and would therefore constantly misunderstand each other.*

*Ten years later, we started two projects in parallel - the MBSE Testbed and the MBSE JSM.*

*Testbed's objective was to understand MBSE in more detail and align the processes, language and definitions. JSM started the use of the SysML software system. It wasn't until 2015 however that we finally agreed what the MBSE model should look like and it was only then that the two projects could combine. Today, we have a division-wide decision to use MBSE but we've still got a fair way to go before full implementation across all different disciplines.*

*I believe it will take another ten years before we understand MBSE's efficiencies. We have carried out some early-stage comparisons with Document-based Systems Engineering and the early signs are a 50% increase in efficiency. Tests are ongoing though. You just have to believe in it but be patient as it takes time. Implement small-scale initiatives to prove it works and to keep both champions and sponsors onside.”*



Torfinn Tobiassen,  
Manager of Hardware Development at Kongsberg Defence & Aerospace

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## THREE THINGS NEEDED FOR LONG-TERM MBSE IMPLEMENTATION

- ➡ **A strong commitment from management and key technical persone**
- ➡ **A motivated and highly-skilled core team - if people need convincing, hire new people instead**
- ➡ **Comprehensive understanding of the details and definitions of model-based thinking**

### Torfinn's five rules of change management

1. Think big, start small. Evolve as you go
2. Respond to needs
3. Only roll-out solutions that work (if it doesn't work, your distractors will use it against you)
4. Headhunt motivated people (we use students, eager to learn, open-minded)
5. Be patient, never give up (focus on initial goal and never lose sight)

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## Lesson Two: ACHIEVE C-SUITE BUY-IN AND TAKE EVERYONE ON THE JOURNEY TOGETHER



### **Scania:**

Scania, a world-leading provider of transport solutions is, together with its partners and customers, driving the shift towards sustainable transportation systems. As part of this journey, the company is experiencing a shift towards simulation-based product development using MBSE.

**Peter Blom,**  
**Scania's Senior Business IT Analyst**

“

*We are at the start of our MBSE journey but we already have the support from the very top of the organisation. Our ambition is for 3D models to be the information carriers throughout the whole product development system. In parallel with our current platform, we are upgrading to implement the Dassault Systèmes 3DEXPERIENCE platform to form a common platform to support MBSE.*

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**“We believe in what we’re doing but the challenge is definitely around agreeing who has responsibility overall since the tools are controlled by different parts of the business, which have their own language and individual priorities. This journey will see us bring everyone together to drive forward in the same direction. We need everyone to see the same picture. You can only achieve this if you have the commitment from the very top of the organisation.”**



**Peter Blom,**  
Scania’s Senior Business IT Analyst

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## Lesson Three: WIN HEARTS AND MINDS WITH STRUCTURES AND EXPERTISE



**CLAAS KGaA mbH:**

**Jörg Heihoff-Schwede,  
Requirements Engineering Domain Lead at CLAAS KGaA mbH**

He is on a journey from requirements engineering to MBSE in order to achieve a truly connected farm management system for the leader in agriculture machinery.

“

*In 2017, we submitted our first pilot application for a RE-S Framework. It took two years to come to fruition. We then set up the Systems Engineering Solution Lab (SESL). Over time, mindsets within the organisation have changed as the long-term commitment has played out, which is an advantage.*

*We started a Domain Systems Evaluation, the first step in Architecture Modelling Enhancement of SE Education. We started with requirements but we were always setting the mindset for Systems Engineering. Preparing methodologies, structures and mindsets is important along with having motivated people and experts onboard.*

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# FINAL THOUGHTS



**Justin Garnett,**  
Business Consultant for Dassault  
Systèmes

**1 What are the key enablers for business change?**  
Start with the Why.

**2 Decide on the WHAT?**  
What do you plan to deliver and over what time-frame? Develop a plan that the deliverers can believe in.

**3 How will you succeed?**  
Do you have the resource, skills and knowledge?

**4 Change management is driven by people.**  
Don't under-invest in the right people.

**5 Invest in your change network.**  
Spend time explaining the why and selling your plan. Find your advocates and harness their enthusiasm to drive change from the middle outwards.

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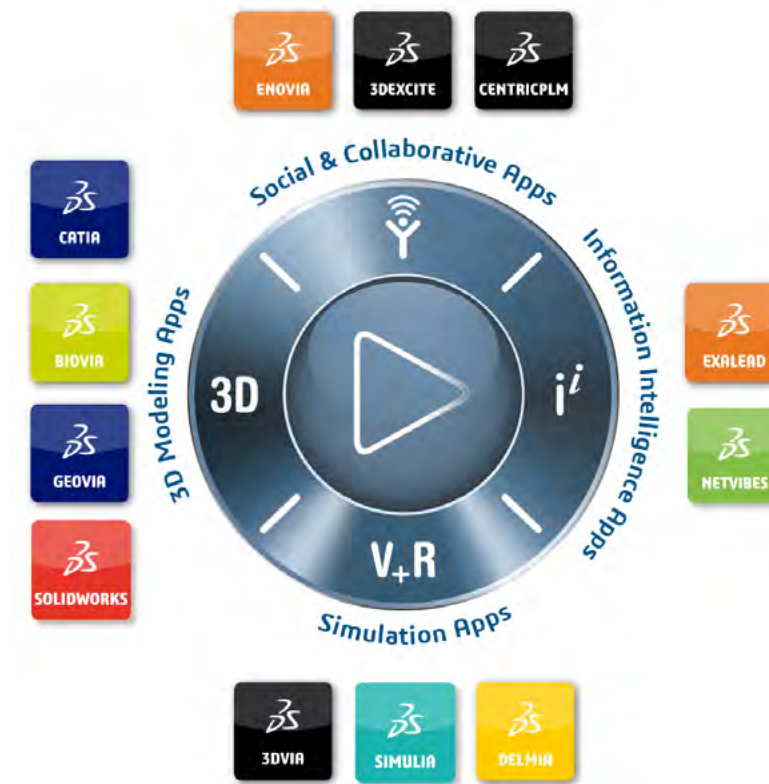
## FIVE DOS AND DON'TS FOR MBSE

### ➔ Dos

1. Do define an approach to MBSE which applies to your particular project
2. Do plan and manage the modelling process
3. Do add additional content as required to solve a particular need
4. Do verify your models as you develop them
5. Do question simulated results

### ➔ Don'ts

1. Don't model in isolation from other teams
2. Don't assume a standard MBSE methodology will simply give you answers - it still requires engineering know-how
3. Don't take what a tool vendor tells you at face value - verify that the tool gives you what you need in your overall approach
4. Don't model without understanding the inputs and outputs of the modelling exercise
5. Don't use the same data when developing and then testing the model



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