



# **How to Implement a Modelling & Simulation Strategy**





## You may be wondering.....

*‘Why should I be bothered about a  
Modelling and Simulation Strategy?  
I’m too busy actually doing the job!  
Our organisation just wants the results!’*

The answer is that simulation is highly likely to be critical to your organisation’s success. It’s also highly complex and impacts the whole organisation. It consumes significant budget, resources and time throughout your product creation and delivery processes. Most importantly it impacts the performance of the products you deliver to your customers.

There is no doubt that operating an effective and efficient simulation capability in your organisation can provide a significant competitive advantage and help achieve your business goals. This requires many elements to be working in harmony and cannot be taken for granted. Indeed, get it wrong and your organisation could be wasting a substantial amount of money, resources, and time– and potentially delivering sub-optimised products.

For many years considered a supporting act to the product creation process, engineering simulation has been used in many organisations for several decades, time in which it has evolved from a specialist niche activity to become a core capability in the design process. It is engineering simulation that makes it possible to perform many iterations of product designs ahead of release to ensure they meet their targets, are optimised, and are robust against noise factors across a massive range of use cases and scenarios.

Hence, it is important for organisations to understand their goals, assess their current position, and implement a strategy that addresses all the elements of their Modelling and Simulation capability to unlock its full potential.



Figure 1:  
New products, such as the next generation of electric vehicles, have become increasingly more connected and complex.

## Modelling & Simulation IS Critical to Your Organisation

Whether you are creating the latest planes, trains, automobiles, wind turbines, nuclear reactors, or medical devices, Modelling & Simulation (M&S) is likely to be at the heart of the process, providing critical capability in research, development, design, manufacturing, delivery, and servicing of products. Indeed, the teams of engineers and analysts diligently and expertly using simulation to refine and optimise designs are the unsung heroes of their organisations. Hence M&S is a critical function in today's businesses, enabling the development and delivery of products, capabilities, and services.



## Everything has Changed, Including the Role of Modelling & Simulation

Modelling and Simulation has been around a very long time, although exactly how long is the subject of much debate. Theories of discretisation were being developed in the 1940s, and what became known as the Finite Element Analysis method was developed in the 1950s by Boeing and Bell Aerospace. In 1965 NASA funded a project led by Dick MacNeal, to develop a more capable FEA software program, which became NASTRAN. Since then, many new tools and physics have been developed and many new vendors have emerged. Today the 'Global Simulation Software' sector is worth over \$10bn annually and is assessed to be growing at over 10% per year. So, over 70 years in development and still going strong!

Over that period everything has changed and products have changed massively. Enabled by new technology, new materials, and new manufacturing methods, products have become more complex, connected, and integrated, and are powered by new, clean technologies (Figure 1).

Organisations have also evolved, driven by relentless global competition, the need to reduce development and product costs, improve product and process innovation, speed to market, flexibility & agility, and deliver more with less.

As capability and experience have increased, the role of engineering simulation has evolved from being the "supporting act", typically providing data for experts, supporting test, and investigating post-test failures, but seen as supplemental to the mainstream design process. Increasingly this role has shifted towards the "leadership" level of design creation, integrating complex systems, optimising product performance, reducing cycle times, reducing sensitivity to noise factors and improving robustness. Consequently, engineering simulation is taking on more responsibility and accountability for product performance and delivery as well as achieving business goals.

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## What Questions Should Leadership Ask About Their M&S Capability?

Given the critical role simulation plays in today's organisations, business leaders need to know how well it is performing. They should be asking;

- **What are our goals for M&S? What do we need our capability to do? Is our capability aligned to our goals? Are we aligned across the organisation?**
- **What is the maturity of our capability? How effective and efficient is it? How are we measuring this?**
- **What is constraining us in achieving our goals? Has our progress stalled?**
- **Have we still got the right process, methods, tools, organisation, and infrastructure for today and tomorrow?**
- **Are we missing an opportunity presented by new technologies?**
- **Do we have a strategy for M&S? What is it?**
- **Do we have an improvement plan?**
- **How do we govern our M&S capability?**



## A Framework for a Modelling and Simulation Capability Strategy

Many elements make up a Modelling and Simulation capability. Each of these needs attention and can be usefully represented in a Strategy Framework (Figure 2).

The Framework contains all the elements necessary for an effective capability. It starts with the organisation's goals, and then refines these into product and business objectives. The next layer considers the detailed needs defined by customer and stakeholder's requirements. At the heart lie the core capabilities of Process, Methods, Tools, Standards, Models, Data, and People. These capabilities are supported by the foundations (such as Data Management and Computing Infrastructure) necessary to enable any capability to operate. This is all underpinned by Governance of the whole strategy, capability, and organisation.

The Framework provides a deliberately comprehensive and holistic strategy and can be used at a whole organisation level, or considered for a specific use case. Consideration of every element is critical to ensure an effective and efficient M&S capability overall.

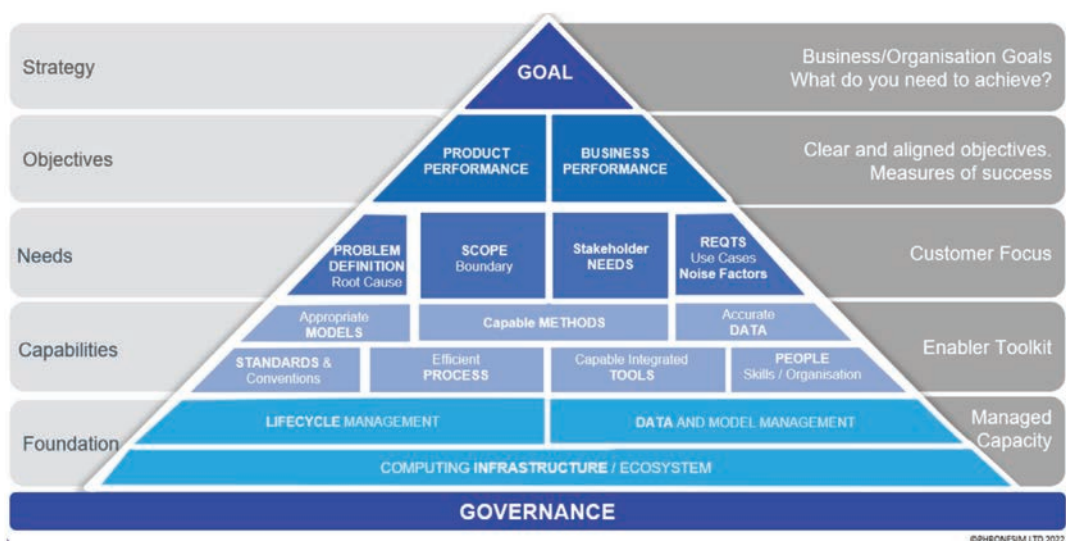


Figure 2: Framework for a Modelling and Simulation strategy.



Figure 3: Product and business goals for M&S.

## What's Your Goal?

The first question your organisation needs to address is, 'What is your Goal?'. Indeed, 'What does your organisation need from Modelling and Simulation?' Almost certainly you will be using it to generate data to inform decisions regarding the performance of a component, system, product or environment, but what are your organisation's specific goals and priorities? Is your goal focussed on improving the product, or improving the business performance (Figure 3)?

Of course, in reality it is going to be a combination of many factors across both aspects, i.e., improving both product and business. The good news is that, with the right strategy and improvement plan, it is likely both aspects can be addressed simultaneously.

Often, businesses set ambitious objectives for Modelling and Simulation organisations to meet, such as:

- **Improve product performance by x%**
- **Reduce product failures by y%**
- **Reduce product variable cost z%**
- **Reduce design cycle time by 50%**
- **Reduce dependency on physical testing by 100%**

Hence, to consider how to achieve these objectives organisations must ask:

- **What level of capability would be required to achieve our goals and objectives?**
- **What is the maturity of our capability today?**
- **What do we need to do to close the gap?**
- **How do we do it?**

## What Can Go Wrong? What Might Be Constraining Your M&S Capability?

We know that achieving a fully effective and efficient Modelling and Simulation capability is hard, and that each element of the Framework (Figure 2) needs attention. Over time, issues can develop, affecting effectiveness and efficiency. Let's consider potential issues for just three elements from the Framework.

Element		Maturity						
		Process	Methods	Tools	Models	Data	People and Organisation	Computing Infrastructure
4	Comprehensive Strategy Accurate / Robust Design Lead Evidenced / Validated Maintained / Governed			Target ↑	Target ↑	Target ↑	Target ↑	Target Assessment
3	Holistic Strategy Repeatable / Verified Design Critical Implemented Measured / Managed	Target ↑	Target ↑	Assessment	↑	↑	Assessment	
2	Established Strategy Established Credibility Design Support Planned / In progress Some gaps	Assessment	Assessment		Assessment	Assessment		
1	Strategy in Development Building Credibility Research/Scoping Studies Plan in Development Significant gaps							
0	Just starting No strategy No evidence No Plan Uncoordinated							

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Figure 4: M&S Organisation Strategy and Management Maturity Metric (OSM<sup>3</sup>)



## Tools

Issue	Why	Leads to / Symptoms
Tools no longer do the job	Poor selection. Needs have changed.	Additional development Additional tools
Tools are inaccurate or cannot model the physics	Wrong tool Product complexity Real world Multiphysics	Artificially separating the physics Sub-optimal solutions Unexpected error states Lack of confidence
Too many tools	Over time many tools added Few tools removed.	Complex tool landscape High maintenance High purchase and operating costs
Tool landscape complexity	Procurement based on localised needs. Lack of alignment.	Lack of sharing. Duplicated modelling & development
Poor connectivity and interoperability	Tool landscape complexity Lack of standardisation	Inefficient processes Increased data transfer errors
Engineers waiting for licences	Inadequate capacity Inflexible licensing	Delayed results Poor user behaviour
Tool lock-in	Methods customised for specific tools High cost of change	Stuck with sub-optimal tools High maintenance costs Increasing tool obsolescence

Figure 5: Some potential issues for tools.

## Methods

Issue	Why	Leads to / Symptoms
Incomplete coverage of requirements	Lack of investment in methods Complex physics / Use cases	Sub-optimal designs Dependence on physical test
Inaccurate results or surprise failures. Quality Escapes	Sensitive designs. Methods not accounting for noise factors, variation and uncertainty	Late discovery Redesign
Lack of confidence in methods and results.	Relying on un-verified methods	Additional verification method Increased cycle time
Results presented without confidence metric	Lack of objective maturity metric	Uncertainty over results
Highly customized methods.	Localised optimums Unique to experts Lack of modularisation	Limited sharing Significant maintenance Lack of flexibility and re-useability
Duplicated Methods. Variable Method implementation	Lack of documentation or Exemplar. Lack of collaboration and sharing	Duplication of effort In-efficient Lack of Learning
Routine methods take too long to execute	Limited automation	Design cycle time In-efficient use of resources

Figure 6: Some potential issues for methods.

## People and Organisation

Issue	Why	Leads to / Symptoms
No agreed strategy	Lack of leadership support No overall lead for M&S	Sub-optimal M&S capability
Poor workflow handover in end-to-end process	Unclear or conflicting roles and responsibilities for M&S	Delayed completion of M&S Gaps or duplicated effort
Un aligned process methods and tools.	Lack of strategy, ownership of M&S. Poor coordination & collaboration	Uncoordinated development Inefficient process
Method, Model Duplication	Lack of collaboration, sharing and reuse	Inefficiency
Conflicting M&S decisions	Lack of strategy & governance Organisation politics	Sub-optimal solutions In-efficiency
Skill and capacity misalignment	Lack of planning and status assessment. Lack of futuring.	Delayed development and or operation

Figure 7: Some potential issues for people and organisations.

## You Need to Know Your Organisation's Modelling and Simulation Maturity!

To understand what your organisation needs to do to meet its goals it is first necessary to understand your current status.

A number of Maturity Metrics have been developed over the years to do this [1]. Each has been developed for different purposes but they are mostly aimed at measuring credibility of methods when applied in a specific use case.

With the addition of criteria and a scoring system (Figure 8), the Framework can not only be used to assess the overall maturity of an organisation's Modelling and Simulation capability, but also for a specific use case.

The maturity assessment can be completed by considering each element in turn and gathering evidence (such as documents or information from stakeholders). Based on scaled criteria, an assessment can then be made for the maturity status of each element.

Strategy Element	Actions
<b>Process</b>	<ul style="list-style-type: none"> <li>Review current Simulation and Modelling processes across the whole organization. Assess alignment to PD process.</li> <li>Assess Efficiency? Value stream analysis for key process to identify and reduce waste. Identify improvement actions.</li> <li>Review common and bespoke process. Strategy for process management and Automation. (SPDM)</li> </ul>
<b>Methods</b>	<ul style="list-style-type: none"> <li>Review requirements. Audit current capability. Introduce confidence metrics</li> <li>Modularise to maximise sharing and re-use. Automate common and routine methods.</li> <li>Identify gaps, prioritize, improvement projects.</li> </ul>
<b>Modelling</b>	<ul style="list-style-type: none"> <li>Audit Model requirements and usage.</li> <li>Model Standards and Conventions</li> <li>Opportunities for commonality and sharing. Model Management.</li> </ul>
<b>Tools</b>	<ul style="list-style-type: none"> <li>Review requirements. Tool selection criteria.</li> <li>Audit landscape. Remove duplication</li> <li>Capability and efficiency metrics.</li> <li>Assess tool chain connectivity status.</li> </ul>
<b>Organization</b>	<ul style="list-style-type: none"> <li>Appoint overall lead for M&amp;S. Review M&amp;S organization. Ensure cross functional alignment and collaboration.</li> <li>Assess current and future skill requirements. Qualification and experience status. Training and development needs.</li> <li>Apply Governance Framework</li> </ul>
<b>Data</b>	<ul style="list-style-type: none"> <li>Document data requirements per method and process.</li> <li>Introduce standards for data types, formats, structure, use and management.</li> <li>Consider data management options (SPDM)</li> </ul>
<b>Infrastructure and Computing</b>	<ul style="list-style-type: none"> <li>Current and Future requirements. Current structure and capacity. Utilization and operating costs.</li> <li>Review future technology options and opportunities (e.g. Cloud).</li> </ul>

Figure 8: Example best practice improvement approaches and actions.

# Using Best Practice Improvement Approaches

Having completed the maturity and the gap assessment the organisation should then agree priorities before identifying appropriate improvement projects.

Depending on the nature of the gaps some improvements may be straightforward and quick to implement, but others may be complex requiring significant funding, resources, and time. It's important to consider that improvements may be required across the strategy elements to achieve an effective overall outcome.

It's likely that a short, medium, and long-term plan and roadmap will be required.

Best practices are available (Figure 8) and most organisations will have established processes for improvement projects. There are also many papers, publications, and training courses available through NAFEMS covering specific subject areas in much more detail.

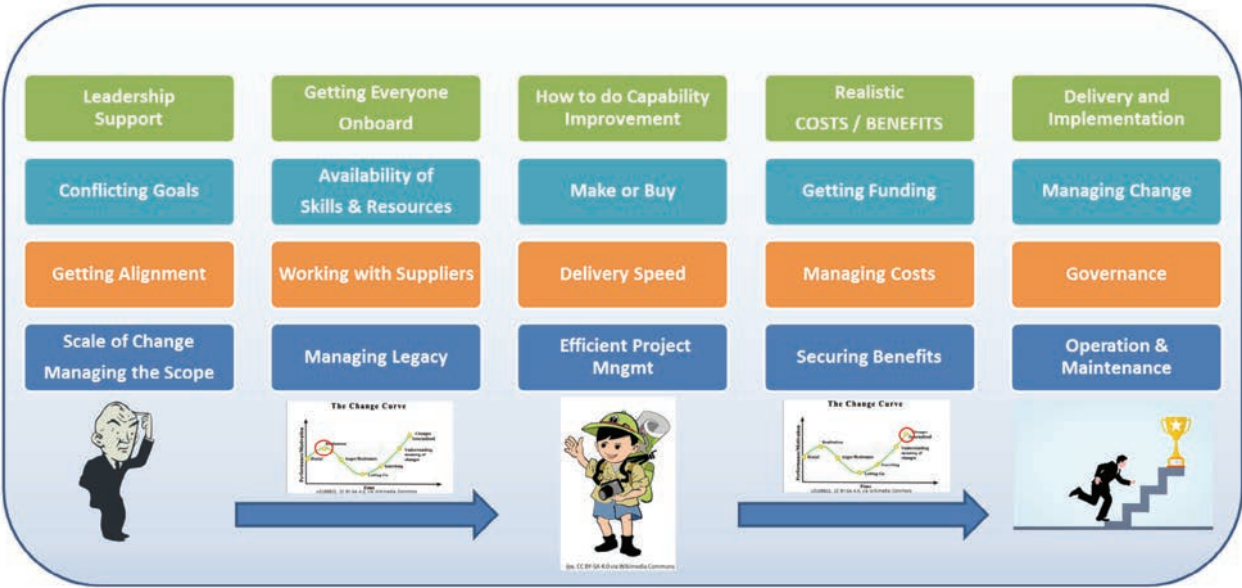


Figure 9: Typical challenges faced when implementing a Modelling and Simulation strategy.

## The Practical Bit. Change is Hard!

Whether starting from scratch or maturing an existing capability, achieving an effective and efficient outcome in any organisation is hard.

There are many obstacles and challenges to be faced (Figure 9), starting with identifying someone to take an overall lead in organising, developing, and implementing the strategy. Getting engagement and time from stakeholders and aligning on a common direction are also typical challenges. Anticipating and tackling these in advance is critical to ensure the strategy can be progressed successfully.





## Summary and Key Messages

Modelling and Simulation is critical to our organisations today taking a lead in creating, maturing, and optimising product designs, but organisations cannot take for granted that their capability is fully effective and efficient.

- **It's been a 70-year journey but there is still much to do**
- **Everything has changed**
- **Organisations need to ensure their capability is achieving its full potential?**
- **Many elements (the Framework) make up a capability and all need attention**
- **Organisations need a strategy and leadership for their M&S**
- **Assessing the current maturity is crucial to identify the gaps and opportunities**
- **Improvement initiatives need to align to business goals and across the organisation**
- **Be prepared for the practical challenges**



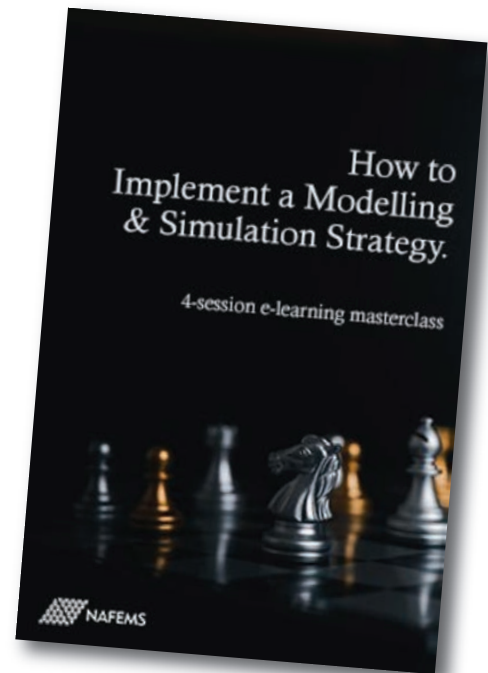
## In Short:

- | **Get Organised**
- | **Take a Lead**
- | **Have a Strategy.**



# How to Learn More

If you would like to learn how to help your organisation maximise the effectiveness and efficiency of its Modelling and Simulation capability there is a new 4-session NAFEMS eLearning Masterclass.



## How to Implement a Modelling & Simulation Strategy

### Course Content:

- The need for a strategy
- Establishing business goals and stakeholder needs
- Assessing your current state - Maturity assessment and gap analysis
- Introducing the strategy framework
- The critical elements of a Modelling and Simulation capability
- Best Practices for building capability
- Strategy implementation and practicalities
- Costs benefits and the business case
- Organisation and governance

For more  
information

contact Jake Brimelow  
[jake.brimelow@nafems.org](mailto:jake.brimelow@nafems.org)



## References

- [1] J.-F. Imbert and W. L. Oberkampf, "Survey of Maturity Assessment Procedures for Computational Simulation," presented at NAFEMS World Congress, Stockholm, 2017.



### Andy Richardson

is Founder and Director at PHRONESIM Ltd. He is a Chartered Engineer and Fellow of the Institution of Mechanical Engineers with 30 years' experience at Jaguar Land Rover with 20 years at senior management level including 10 years as Head of Simulation. He held several other engineering senior management positions including Advanced Engineering, and Vehicle Attribute Engineering roles including Aerodynamics, Packaging, Weight & Vehicle Analysis and Durability and Robustness. Recently Andy spent 2 years as Senior Manager for Airframe Methods and Tools at Airbus.

Andy is a member of the NAFEMS Business Impact and Simulation Data Management Working Groups as well as the NAFEMS UK Steering Committee.

Andy holds a BSc in Engineering from Coventry Uni, an MSc in Numerical Modelling (Aston Uni) and an MBA (Warwick Uni Business School).