



NAFEMS

A Strategic Approach to Implementing Engineering Simulation

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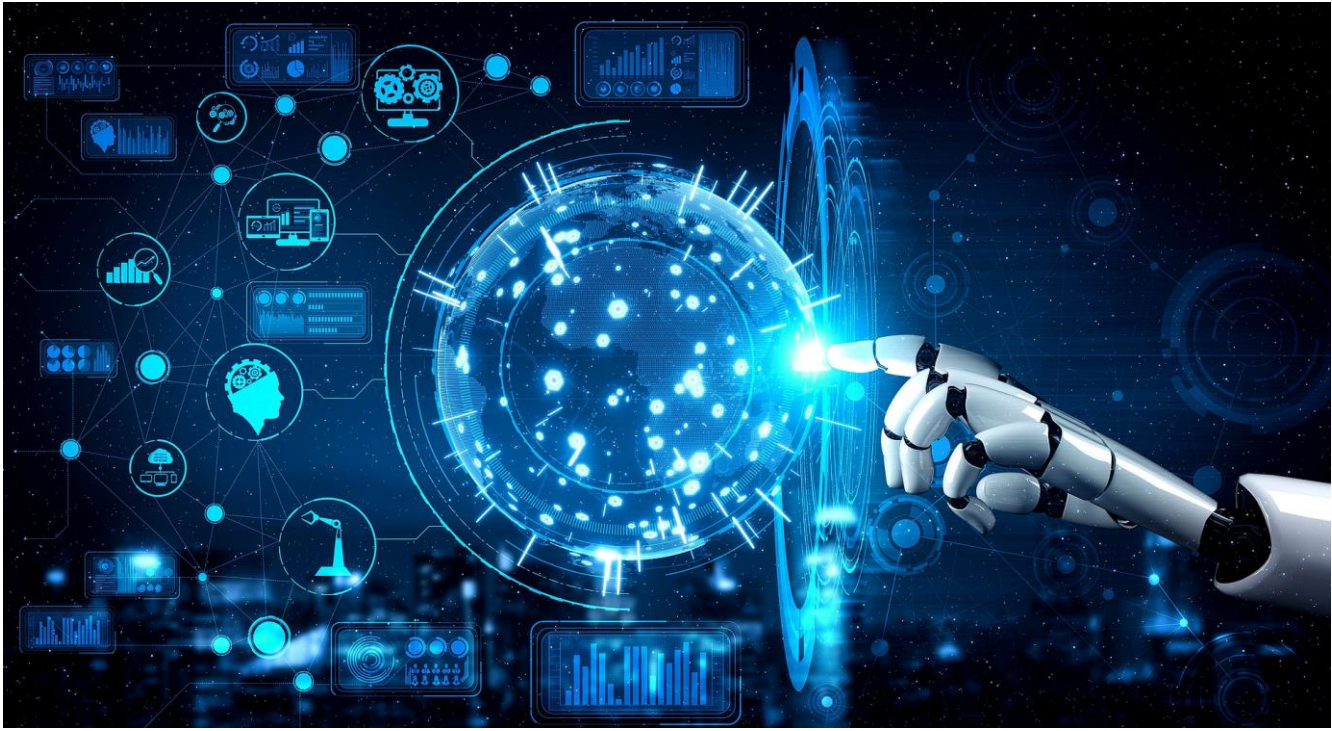
THE INTERNATIONAL ASSOCIATION FOR THE ENGINEERING MODELLING, SIMULATION, AND ANALYSIS COMMUNITY



A Strategic Approach to Implementing Engineering Simulation

- Simulation Today
- Simulation Strategy
- The Strategy Pyramid
- Building a Strategy
- Getting Organised
- What's your Position?
- Closing the Gap
- Building the Business Case
- Planning Implementation
- Some Practicalities
- Finding out More



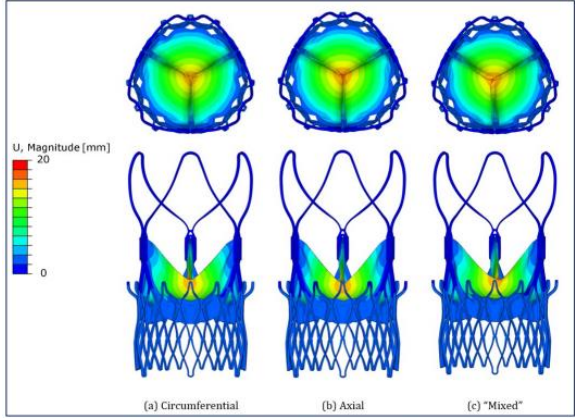
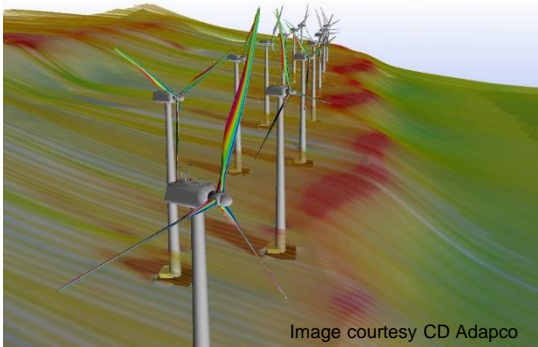


Simulation Today

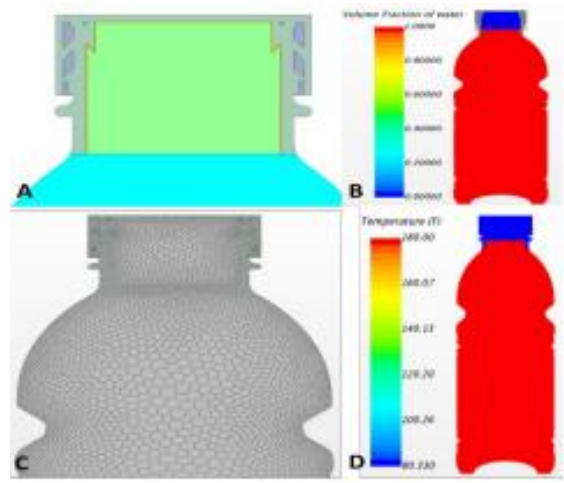
Engineering Simulation Today

Simulation is Making a Massive Contribution

Modelling and Simulation is a critical capability enabling fast, effective and efficient product development and delivery across a multitude of sectors.



Caballero et al. Deflections with varied fibre alignment



Developing concepts, refining and optimising designs, ensuring robustness, & signing off final designs

Today's products could not be delivered without Modelling and Simulation!

Questions from Business Leadership

Simulation IS
a Strategic
Capability

- What are the Blockers stopping us from getting where we want to be?
- Can Engineering Simulation help develop our ground breaking new product technology?
- Why does it take so long to get results from our Engineering Simulation?
- Why can't we answer more requirements / use cases with Simulation? How do we close the gap?
- Can I rely on the results I get from simulation?
- Can I eliminate testing of physical prototypes?
- Why didn't Simulation predict this Quality problem?
- Why does Engineering Simulation cost so much?
- What Value and Benefit does our Engineering Simulation capability actually deliver?



Challenges Facing Organisations

Its not easy!



Product Technology

- New product technologies requiring new physics and multi-physics
- Increasing complexity
- New requirements and regulation



Methods

- Organisation lacks confidence in results
- Method capability gaps
- Significant customization required



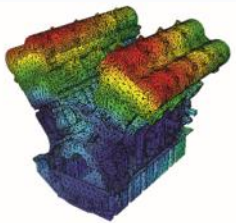
Process

- Take too long
- Process inefficiencies. Significant overhead.
- Complex process interdependencies



Tools

- Needs have changed. Wrong tools for the job
- Complex tool landscape. Duplication across org
- Locked-in to legacy tools. Tool obsolescence



Models

- Poor input quality (e.g. CAD). Model Quality
- Keeping up with design changes
- Limited sharing and re-use across organisation



People and Organisation

- Lack of collaboration and sharing across organisation
- Lack of ownership in the M&S team
- Lack of key skills and capacity. Changing requirements



Data

- Sourcing appropriate and reliable data
- Categorising and labelling data
- Poor data management across organisation



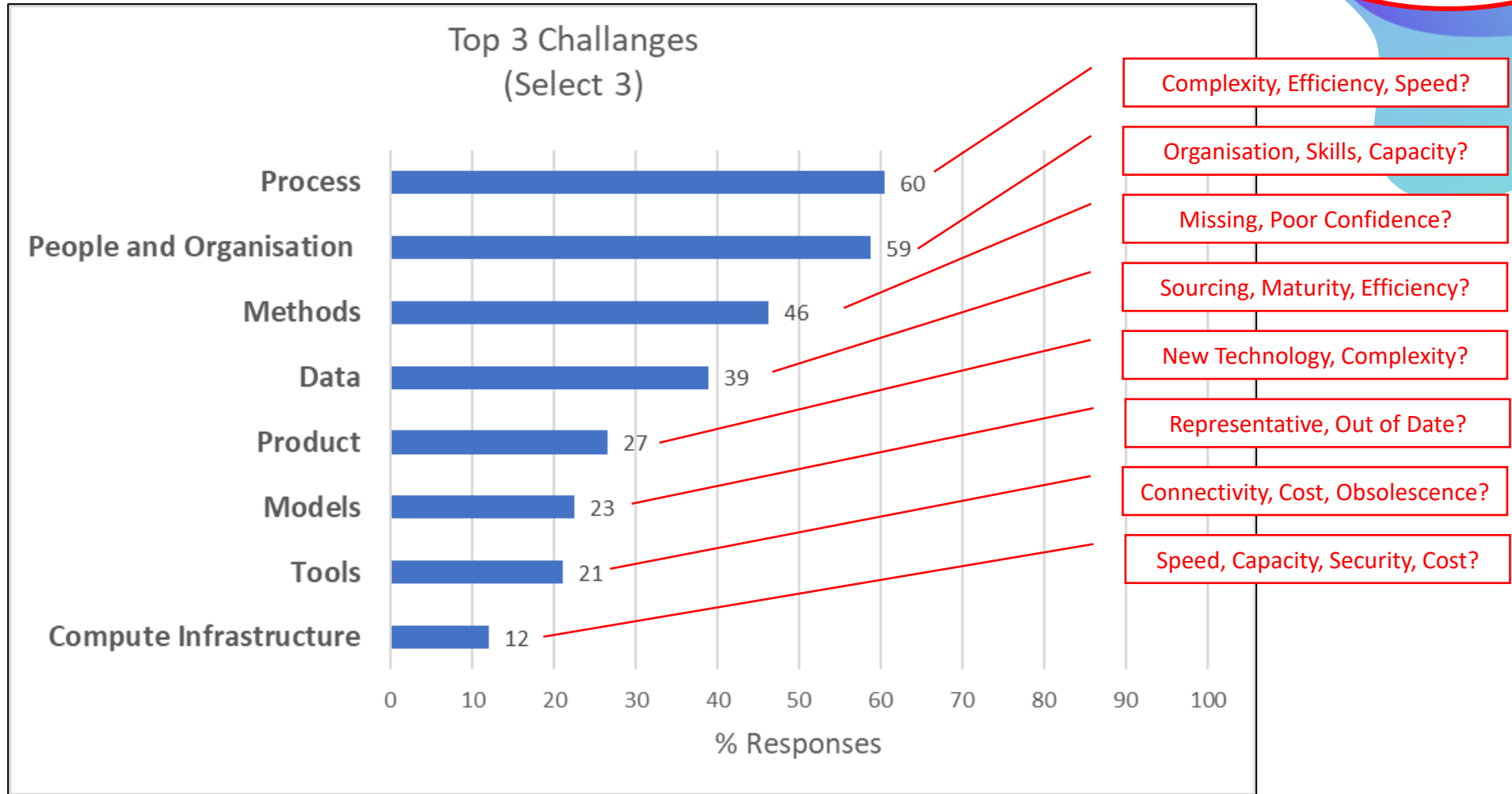
Compute Infrastructure

- Need for increasingly large scale models
- Insufficient compute capacity
- Utilizing the latest technology (e.g. Cloud)



Mini Survey Results from Strategy eLearning

What do others think?



Consolidated result from 155 participants representing multiple industries

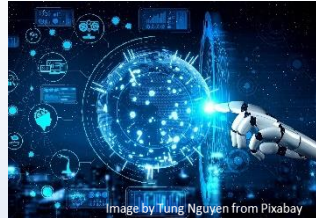
Trends and Opportunities

Is my business making the most or preparing for the latest trends and opportunities?
How might any of these technologies benefit or impact my business?

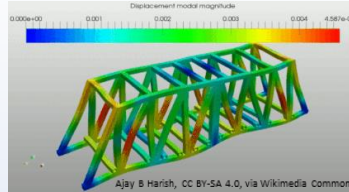
Should you follow the trend?



Data Analytics / Artificial Intelligence



Democratization



RAPID (Non-FE) Analysis Tools



Graph Technology



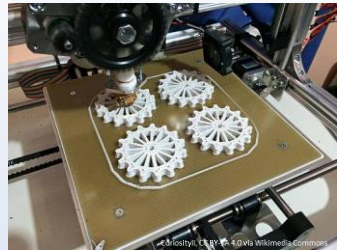
Open Source Software



Remote Working



Digital Twins



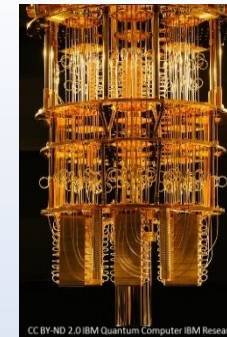
3D Printing



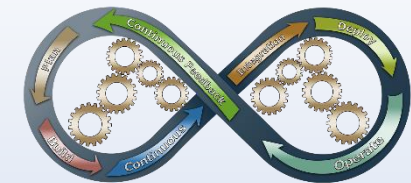
Industry 4.0



Cloud Computing



Quantum Computing



Agile Development


Whats your Strategy to take advantage or respond to new trends?



Simulation Strategy


Some Advice from Experts on Strategy

Prefer action
over
Strategy?



"Though no one can go back and make a brand new start, anyone can start from now and make a brand new ending."

Marcus Aurelius
Roman Emperor
161-180 AD




"Rowing harder doesn't help if the boat is heading in the wrong direction."

Kenichi Ohmae
"Mr Strategy"
Author, Professor,
Consultant



"Strategy without tactics is the slowest route to victory, tactics without strategy is the noise before defeat."

Sun Tsu
Ancient Chinese
Military Strategist



"Sound strategy starts with having the right goal."

Michael Porter
Author, Academic,
Consultant

Cmproject, CC BY-SA 4.0 via Wikimedia Commons

Why do Organisations use Simulation?

What are your Goals?

*Deliver **better** products*

- Develop New Product Technology
- Improve Product Capability and Functionality
- Optimise Product Performance across Attributes

*Deliver **more** products **faster***

- Develop and Deliver Product to Market Faster
- Deliver More Product Variants in the Same Time
- Reduce Failure Modes and Error States (Find issues earlier)
- Faster to Final Release and Sign-Off

*Reduce **development** **costs***

- Improve Efficiency of the Product Development Process
- Reduce overall time and resources (Faster & fewer design cycles)
- Reduce or eliminate prototype build and testing

*Reduce **product** & **operating** **cost***

- Minimise Complexity
- Optimise for Material and overall Product Cost
- Increase re-use and commonality
- Minimise Production and Operating Cost

*Reduce error states: **Improve** **product** **quality***

- Improve Robustness to Real Use Noise Factors
- Reduce Quality Escapes and in-service failures
- Reduce Warranty Costs and Improve Customer Satisfaction

More Better Product, Faster, at Reduced Cost and Higher Quality



How can Simulation Help? What Does it Take?

Simulation can help achieve Goals

ESSENTIAL ELEMENT	DESCRIPTION
PROCESS	<i>Efficient</i> processes that define the simulation workflows and <i>aligned</i> to the overall development processes.
METHODS	<i>Capable</i> and <i>effective</i> methods to define how to model the specific physics required to deliver the product requirements.
TOOLS	<i>Capable</i> and <i>connected</i> tools to model the correct physics accurately.
MODELS	<i>Representative</i> and <i>accurate</i> models that reflect the latest design intent
DATA	<i>Reliable</i> and <i>accessible</i> technical data to define material properties, technical specifications, modelling parameters, and use cases.
PEOPLE & ORGANISATION	<i>Skilled</i> and <i>experienced</i> people with product knowledge and experience of the tools and methods, organised effectively to maximise collaboration and efficiency.
COMPUTE INFRASTRUCTURE	<i>Sufficient, reliable</i> and <i>flexible</i> computing infrastructure and resources to execute the complex and large scale simulations.

The 7 Essential Elements Required for Capable, Effective and Efficient Simulation





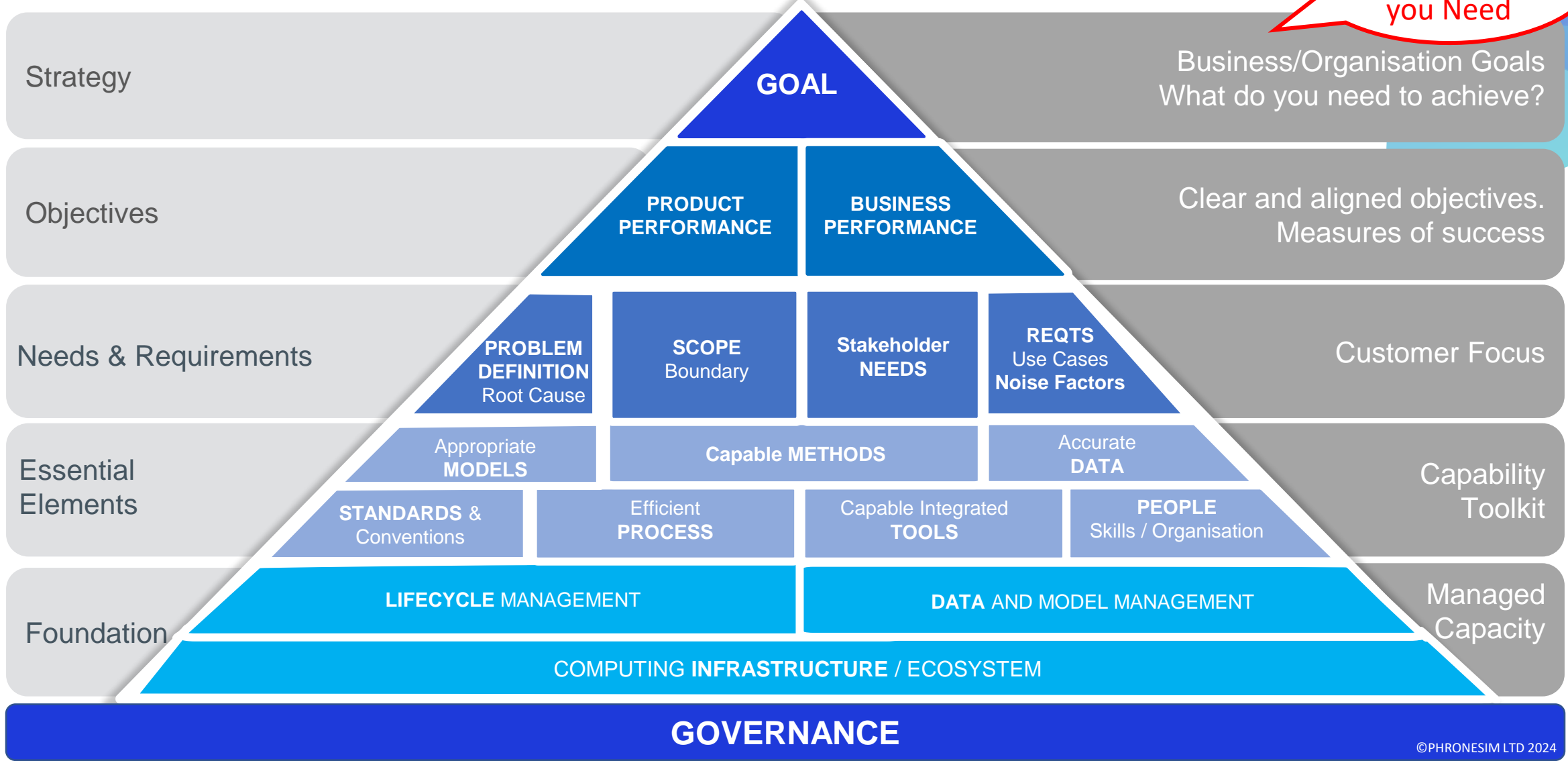
The Strategy Pyramid

Image by Edi Nugraha from Pixabay

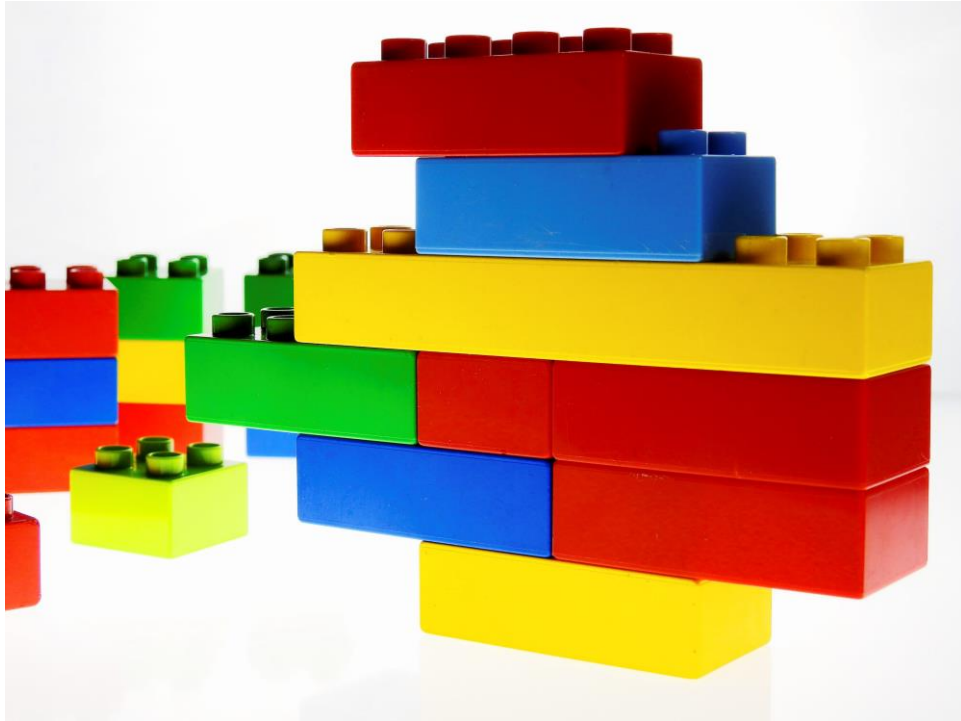


Strategy Framework – Capability Pyramid

Contains Everything you Need



All elements are important. Overall capability is as strong as the weakest link



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Building a Strategy



High Level Phases in Building a Strategy

Steps to Build
a Strategy

Get Organised - Goals / Requirements / Needs

Current State Maturity / Gap Analysis

Gap Closing Actions / Improvement Options / Priorities

Roadmap / Business Case / Funding / Approval

Planning / Resourcing / Implementation/ Governance

Fundamental Steps to Build and Implement a Strategy





Getting Organised



Image by Steve Buisinne from Pixabay



Who are the Stakeholders?

Who needs to be involved?



**Business
Leader**



**Engineering
Leader**



**Project
Manager**



**Component
/ System
Engineer**



**Simulation
Manager
/
Test
Manager**



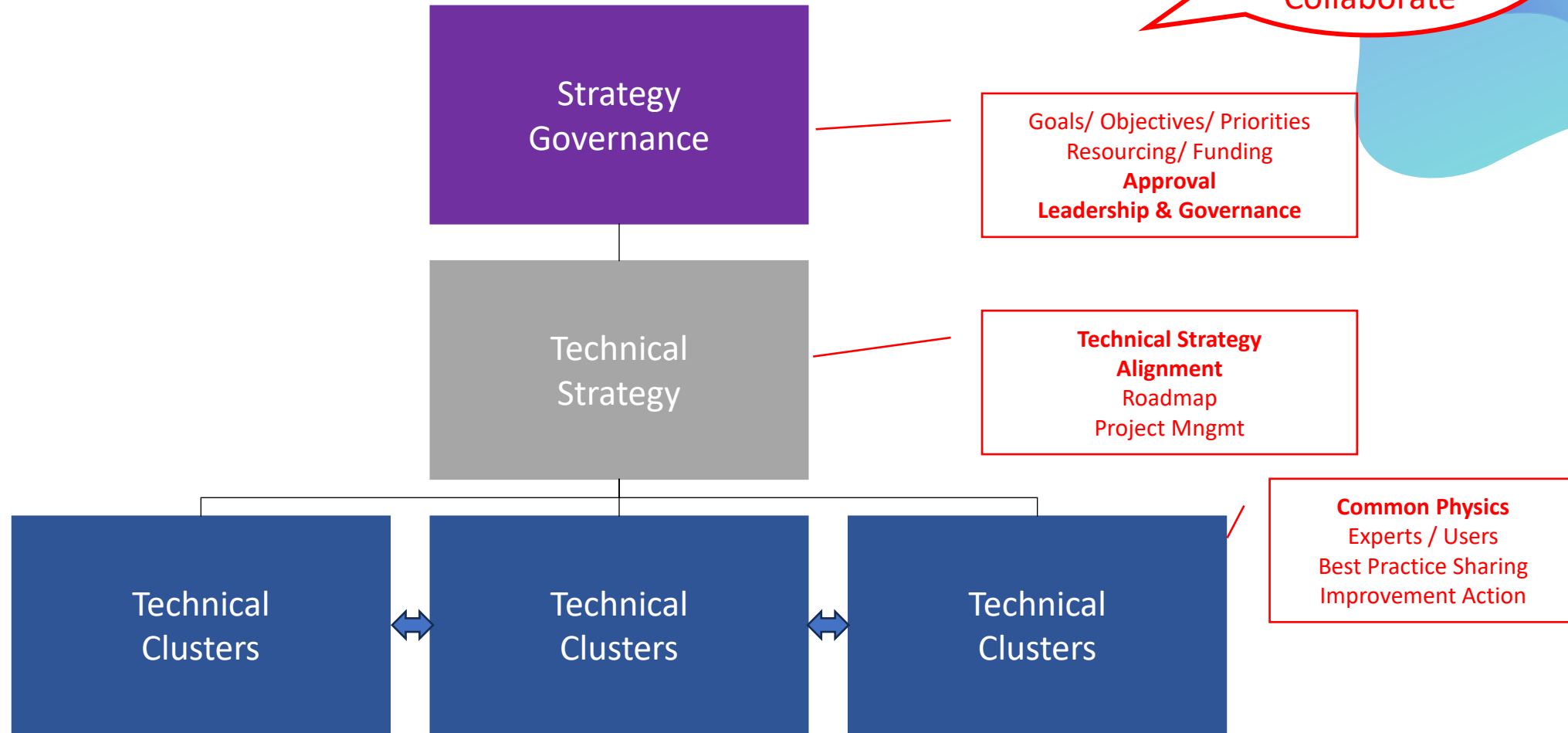
**Engineer
/
Simulation
Analyst**

What do stakeholders need? What do they contribute?



Creating a Collaborative Strategy Organisation

Organising Stakeholders to Collaborate



A Model for a Collaborative Organisation for Modelling and Simulation Strategy

Establishing Product and Business Goals



Agree Goals & Priorities?

PRODUCT GOALS			BUSINESS GOALS		
Category	Priority? 1/2/3	Detail	Category	Priority? 1/2/3	Detail
Develop Concept	2	Refinement of established concept	Speed to Market	1	Need income from sales to fund large investment for small company.
Prove New Technology	1	Modelling complex integrated multiphysics safety critical systems	Efficiency	2	Small versatile team, but inefficiency from multiple design iteration?
Refine Performance	1	Achieving performance targets. Speed = 200mph, Payload = 200lb ...	Reduce Cost	3	Inherently high value high cost product.
Deliver Capability, Functionality	2	Ensure performance for full range of use cases and noise factors	Development Costs	1	Need to minimise time, resource, prototype, mnfg and test costs.
Optimise for Cost, Weight, & Attributes	1	Minimising weight whilst maintaining safety and reliability critical.	Operating Costs	2	Relatively small scale manufacturing. High cost in motors and electronics.
Certify / Sign-Off	2	Strict regulation and certification. Simulation to support physical test.	Skills and Knowledge	2	Goal to minimise inefficiency from multiple design iteration.
Deliver Variants	3	Modelling to support efficient development of variants to follow	Flexibility / Responsiveness	2	Likely small skilled and versatile team. Focus on agile processes.
Quality/ Robustness	1	Must be reliable and robust to noise factors with extremely high confidence	Maximise Value	3	Primary value from getting more product to market faster

Review, Agree and Prioritise Product and Business Goals



What's your Current Position?

Organisation Simulation Capability Maturity (OSCM)

Whats your Status?

Aspect	Key Criteria	Maturity Level				
		0	1	2	3	4
		Insufficient Poor Confidence Limited Coverage (<25%) Ad-hoc No Plan No KPI	Needs Reviewed Low Confidence Partial Coverage (25-50%) Partially Applied Actions Identified Improvement Started	Comprehensive Medium Confidence Established/Aligned (50-75%) Fully Applied Improvement Plan In progress - On track	Embedded High Confidence Fully Implemented (75-90%) KPI Monitored Actions Complete Goals Achieved	Systemic/Innovator Certification Level Governed (90-100%) Maintained Continuously Improved Futured
Strategy	Comprehensive Aligned		ASSESSMENT →			
Process	Efficient Aligned			ASSESSMENT →		
Methods	Modular Capable Validated			ASSESSMENT →		
Models	Appropriate Representative Aligned Planned Managed		ASSESSMENT →			
Tools	Capable Connected			ASSESSMENT →		
Data	Validated Traceable		ASSESSMENT →			
People and Organisation	Ownership Skilled Certified			ASSESSMENT →		
Computing Infrastructure	Capacity Flexibility			ASSESSMENT →		

OSCM

- Addresses the whole Simulation organisation and all M&S capability elements
- Aimed at identifying gaps to focus improvement actions on improving effectiveness and efficiency to achieve business goals.

- 0-4 Maturity Scale
- Target level based on business and product goals
- 10 key industry criteria per element
- Assessment based on stakeholder discussion and evidence

OSCM used to Assess the Organisations Overall Status

OSCM Assessment Process

Gather Input
Review
Improve



Criteria
Questionnaire



Documents,
Data and Metrics



Discussion

Aspect	Key Objectives	Maturity Level				
		1	2	3	4	5
Strategy	High-level	Not defined	Needs Reviewed	Established	Established	Established
	Operational	Not defined	Needs Reviewed	Established	Established	Established
Process	High-level	Not defined	Needs Reviewed	Established	Established	Established
	Operational	Not defined	Needs Reviewed	Established	Established	Established
Methods	High-level	Not defined	Needs Reviewed	Established	Established	Established
	Operational	Not defined	Needs Reviewed	Established	Established	Established
Tools	High-level	Not defined	Needs Reviewed	Established	Established	Established
	Operational	Not defined	Needs Reviewed	Established	Established	Established
Data	High-level	Not defined	Needs Reviewed	Established	Established	Established
	Operational	Not defined	Needs Reviewed	Established	Established	Established
People and Organisation	High-level	Not defined	Needs Reviewed	Established	Established	Established
	Operational	Not defined	Needs Reviewed	Established	Established	Established

Review and
Assessment

Core Simulation Capability	Potential Opportunities
Process	Identify and address bottlenecks Reduce resources Improve speed Improve process robustness
Methods	Expand coverage and confidence Improve product performance Reduce testing Reduce error states Modularise and improve automation
Tools	Align tools to needs Reduce complexity number and costs of tools Improve tool chain connectivity to improve quality and efficiency
Models	Improve quality Improve planning Improve sharing and re-use. Reduce duplication
Data	Improve data quality Improve data findability and useability Improve data traceability
Organisation	Improve collaboration and sharing Better align skills to current and future needs
Compute Infrastructure	Ensure appropriate capacity Ensure efficient flexibility

Improvement
Opportunities





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Gap Closing

Building an Improvement Plan

Improvement Opportunities

Identify Appropriate Actions

Essential Element	Suggested Priority Action
Strategy	Clear Goals for M&S. Comprehensive strategy. Funded improvement roadmap. Leadership ownership and support. KPI Metrics Dashboard
Process	Documented and Aligned to overall product process. Efficiency reviewed . Process Automation .
Methods	Method Confidence Metric applied. Integrated Quality Controls.
Tools	Tool Strategy in place. Requirements and status audit.
Models	Model Strategy . Modelling standards and best practices. Modelling plan aligned to requirements
Data	Data Management Strategy (standards, verification) Data Maturity Metric adopted. Simulation Data Management [SDM] adopted.
People and Organisation	Skill Requirements analysis. Skills audit and development plan (Certification) Strategy Governance organisation in place.
Compute Infrastructure	Sufficient compute Capacity . Performance monitored. Demand forecasting and capacity planning. Latest technologies reviewed.

Actions based on Goals, Gaps and Priorities. Important to Maintain Balance.





Building The Business Case

*Achieving
Return on Investment*

Modelling and Simulation Benefits

Real Benefits
But Beware
Overoptimism

Deliver **better** products

Deliver **more** products
faster

Reduce **development**
costs

Reduce **product &**
operating cost

Reduce error states:
Improve product
quality

Category	Detail	Metric
Introduce New Product Technology	Deliver product with new technology	↑ Revenue
Improved Product Functionality	Increased Customer Satisfaction	↑ Revenue
Optimized Performance	Assess alternatives and variants	↑ Revenue
	Increased Customer Satisfaction	↑ Revenue
Deliver more product variants in same time	Deliver more product	↑ Revenue
	Reduce time to market	↓ Devpt time
Faster to Market	Increased sales sooner.	↑ Revenue
Reduced Failure Modes and Error States (find earlier)	Unexpected Design Failures	↓ Devpt Cost
	Faster to release final design	↓ Devpt time
	Cost of Prototype	↓ Devpt Cost
Reduced or Eliminated Testing	Cost of Test Facility	↓ Devpt Cost
	Cost of preparation and instrumentation	↓ Devpt Cost
	Cost of a Test	↓ Devpt Cost
Improved Efficiency of Product Development Process	Faster Design Cycles.	↓ Devpt Cost
	Fewer Design Cycles	↓ Devpt Time
Minimized Product Costs	Reduced product costs by finding optimum solution	↓ Product Cost
Optimise Production Costs	Optimise Production processes (Resource, Speed, energy, material)	↓ Delivery Cost
Improved Quality.	Reduced warranty cost	↓ Warranty
Improved Robustness to Noise Factors	Anticipate and reduce sensitivity to noise factors	↓ Warranty
Reduced Quality Escapes States	Increased Customer Satisfaction	↑ Revenue
Reduced in Service Failures	Increased Sales	↑ Revenue
Predictive Maintenance	Predict timing and nature of maintenance reqts	↓ Maintenance

Identify Measurables. Assign Contribution. Impacted budget? Timescale?

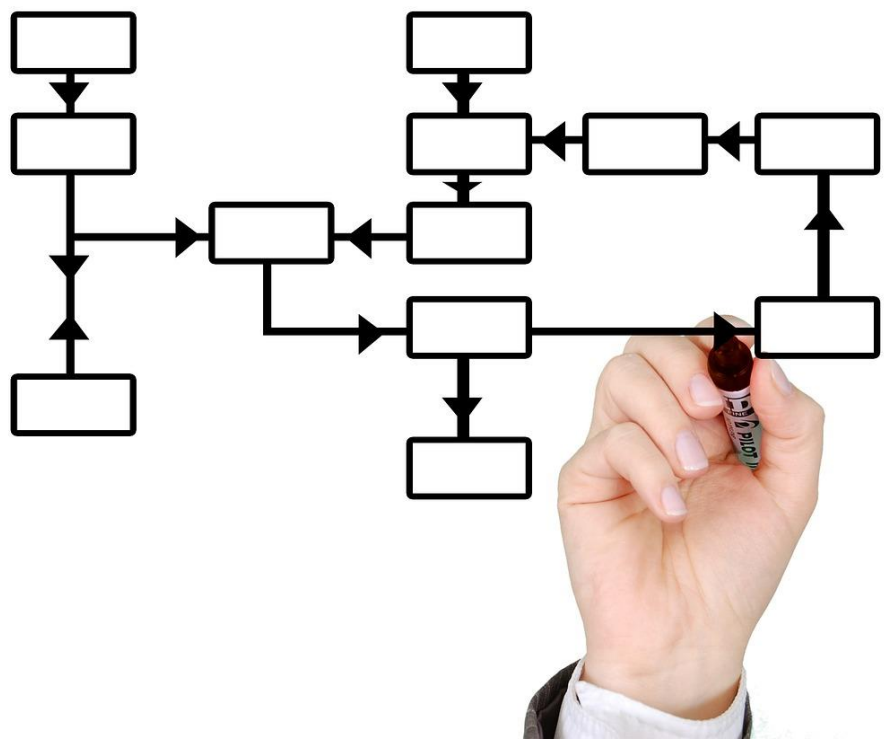
Modelling and Simulation Costs

Be realistic about costs and timing

Element	COSTS		Typical Cost		Notes
	Type	Detail	Measure	£k	
TOOLS	Resource	Benchmark and Evaluation Cost	Per tool	££	External, internal cost depending on scale of evaluation.
	Software	Tool Purchase / Lease	Per Seat*	££	*Depends on vendor licence agreement, procurement strategy and scale. Subject to negotiation
	Resource	Integration and Connector Devpt	Per connector	££	Higher cost if non standard and bespoke
	Contract	Development (Additional capability)	Per feature	££	Developing additional functionality. Lower cost if mutual benefit. Higher cost if bespoke.
	Software	Ongoing Lease costs	Per seat / annum	££	Significant variation based on strategy and role (e.g. Structures, Crash, CFD, MBSE)
	Resource	Training	Per person	£	Varies on tool and existing skill of candidate
	Software	Maintenance (tool and internal)	Per Seat	£	Depends on strategy (e.g. purchase / lease), and vendor contract
PEOPLE / RESOURCES	Resource	Skill Development and Training	Per Person		Depends on skills required and recruitment
	Resource	Method Development Internal	Per person	££	Internal resources used for development have better experience & knowledge of the organisations needs & the engineering but would be somewhat diverted from operational projects. Knowledge retention of new method is better
	Resource	Method Development External	Contract	£££	External resources more expensive. Maybe able to better focus on the project. Knowledge transfer is more difficult. Maintenance of the resulting capability is more difficult.
	Test	Verification and Validation	Per Test	?	Cost of Prototype Design and Manufacture. Cost of test facility. Cost of Test
	Resource	Product Delivery (Using simulation to deliver product)	Per Method	?	Depends on scale and complexity
COMPUTE INFRASTRUCTURE	Resource	Product Delivery (Using simulation to deliver product)	Per Person	££	Number of people required to deliver simulation depending for duration of simulation contribution.
	Hardware	Workstation	Per Seat	£	Depending on strategy and purchasing power of organisation
	Hardware	HPC	FLOPS	££££	Depends on IT strategy and scale
	Service	Cloud	vCPUhour GB	tbc	Depends on scale of demand and provider.
	Software	Operating Systems and Software	Per user	?	Scaled to operation
	Operations	Network		?	Depends on IT strategy: speed, capacity, distances
	Hardware Service	Storage	Tb / annum	?	Depends on strategy (inhouse / cloud). Storage costs coming down massively, but demand for storage also increasing massively. Important to exercise active management of Simulation Output Data
	Energy	Power and Cooling	kWh	?	Can be significant for a large datacentre
Resource	Maintenance	Per Person	££	Depend on scale and complexity	

How much for how long? Don't forget indirect costs!



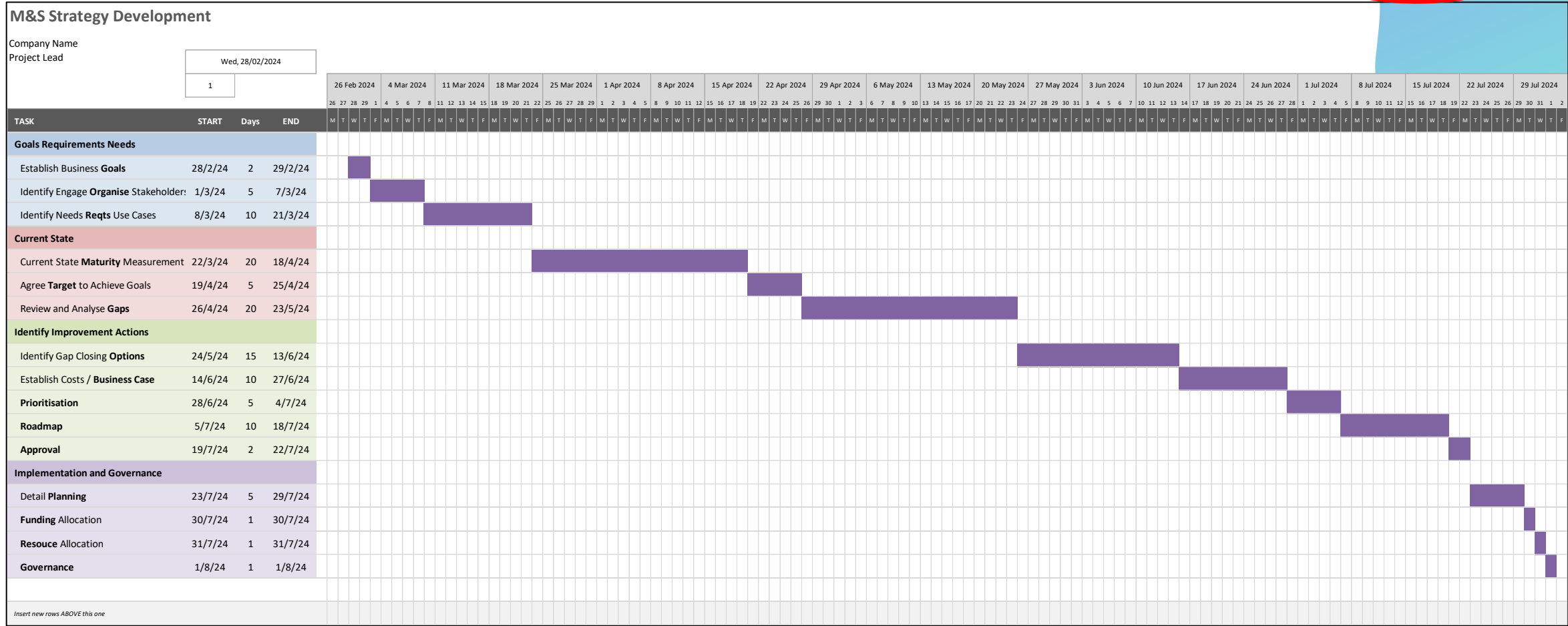


Planning Implementation

Image by Gerd Altmann from Pixabay

Practical Steps to Building a Strategy

Creating a plan
How committed?



Timing Depends on Organisation Scale Product Complexity, Status Resource & Commitment

Measuring Progress – KPI Dashboard



% Requirements with Method at target Confidence

Confidence

M&S Process Cycle Time (Efficiency)

(Efficiency)

Models Number (%Reuse)

(%Reuse)

Compute Resource %Utilisation

%Utilisation

Tools Number (% Utilisation)

(% Utilization)

Data Maturity

Key Skill Gaps (Development Plans on track)

Plans on track



Potential Key Strategy Leadership Dashboard Metrics



It's the Real
World?



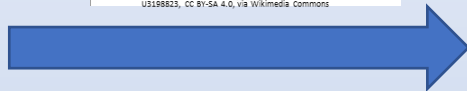
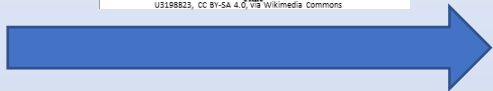
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Some Practicalities

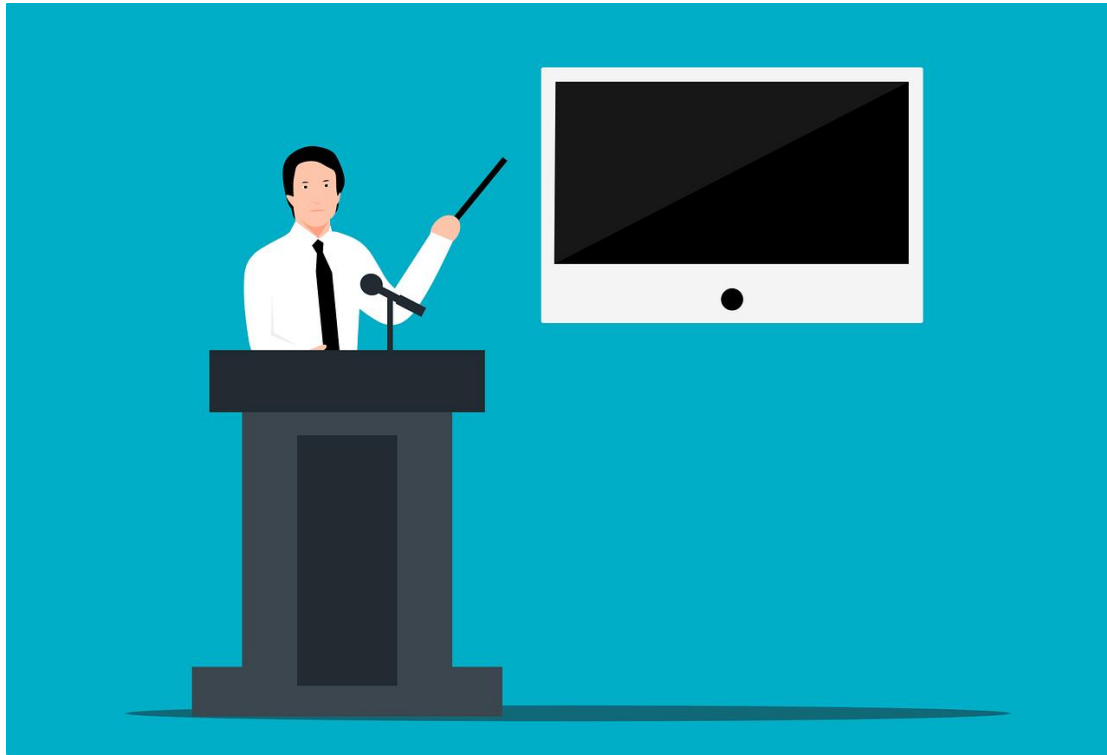
Strategy Implementation Practicalities

Anticipate!
Be Prepared!

Leadership Support / Sponsor	Communicate Constantly	Capacity for Capability Improvement	Realistic COSTS / BENEFITS	Plan Delivery and Implementation
Clear Goals Managing Conflict	Availability of Skills & Resources	Make or Buy?	Availability of Funding	Managing Change
Getting Everyone Onboard & Aligned	Working with Suppliers	Delivery Speed	Controlling Costs	Governance
Keep it Manageable Avoid Scope Creep	Managing Legacy	Efficient Project Mngmt	Securing Benefits Focus on Quick Wins	Operation & Maintenance



Change is Hard. Be prepared for the challenges.



Finding Out More & Getting Help

How to Learn More



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How to Implement a Modelling & Simulation Strategy

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Unlock the Full Potential of Modelling and Simulation in your Organisation

How to Implement a Modelling & Simulation Strategy

The technological advances of recent years have led to a massive increase in product complexity. Businesses need to make sure they can engineer and deliver efficient and optimised products to not only lead but also remain competitive.

Maximising the opportunities and benefits gained from the latest digital engineering capabilities is critical. Adopting local optimum solutions is ineffective, so businesses must invest in a comprehensive and coordinated approach to achieve the global optimum and maximise the effectiveness of their digital engineering capability.

To achieve this, you need a Digital Engineering (Modelling and Simulation) Strategy that takes account of the tools and the processes, methods, models, data, organisation, and computing infrastructure.

This high-level training course focuses on modelling and simulation tools from a C-level perspective, identifying **business goals, product requirements** and **organisation needs** before introducing a framework that will **become the foundation** of your comprehensive Modelling and Simulation strategy.

It also addresses the challenges you'll face when deploying the strategy, and shows you how to **tackle them head-on** to ensure successful implementation.



Five-Session e-learning masterclass

3/3.5 hours per session
PDH Credits - 15

Attend the live sessions, or view the recordings at your convenience.

Please click here to view the FAQ section, or if you need to contact NAFEMS about this course.

Engineering Board PDH Credits
**IT IS YOUR INDIVIDUAL RESPONSIBILITY TO CHECK WHETHER THESE E-LEARNING COURSES SATISFY THE CRITERIA SET-OUT BY YOUR STATE ENGINEERING BOARD. NAFEMS DOES NOT GUARANTEE THAT YOUR INDIVIDUAL BOARD WILL ACCEPT THESE COURSES FOR PDH CREDIT, BUT WE BELIEVE THAT THE COURSES COMPLY WITH REGULATIONS IN MOST US STATES (EXCEPT FLORIDA, NORTH CAROLINA, LOUISIANA, AND NEW YORK, WHERE PROVIDORS ARE REQUIRED TO BE PRE-APPROVED)*



What is the Maturity Assessment Service ?

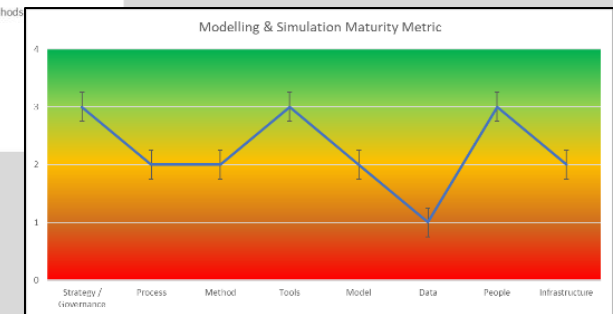
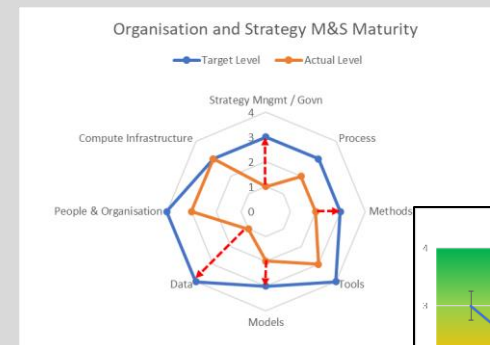


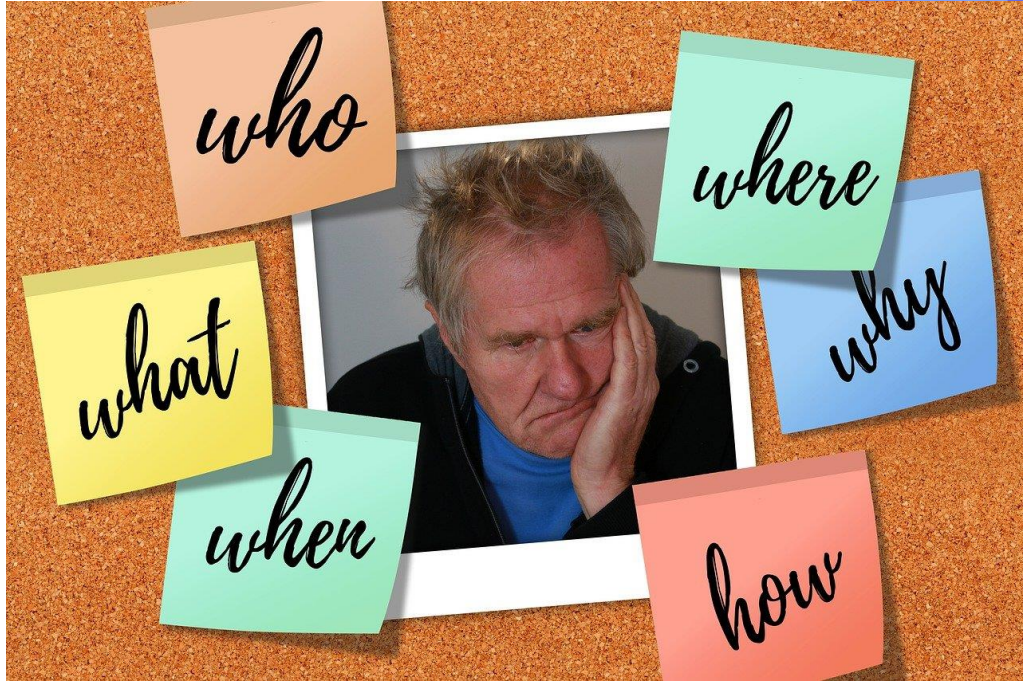
Independent
Help

- An **independent assessment** of ALL aspects of your Modelling and Simulation capability
- Aligned to your product and business **goals**
- Uses an established **framework (OSCM™)** to assess the strength and weaknesses of each of the core elements of an effective and efficient M&S capability
- Provides a **standardised** score reflecting the level of maturity of each of the core elements of your M&S capability compared with best practice criteria
- Identifies areas the organisation should **target and prioritise** improvement action to achieve goals
- Provides a summary of potential **improvement** approaches and **options**

Aspect	Key Criteria	Maturity Level				
		0	1	2	3	4
Strategy	Comprehensive Aligned	Insufficient Poor Confidence Limited Coverage (<25%) Ad-hoc No Plan No KPI	Needs Reviewed Low Confidence Partial Coverage (25-50%) Partially Applied Actions Identified Improvement Started	Comprehensive Medium Confidence Established/Aligned (50-75%) Fully Applied Improvement Plan In progress - On track	Embedded High Confidence Fully Implemented (75-90%) KPI Monitored Actions Complete Goals Achieved	Innovator Certification Level Governed (90-100%) Maintained Continuously Improved Future
Process	Efficient Aligned			ASSESSMENT	ASSESSMENT	
Methods	Modular Governed Validated			ASSESSMENT	ASSESSMENT	
Models	Appropriate Representative Aligned/Shared Managed		ASSESSMENT	ASSESSMENT	ASSESSMENT	
Tools	Capable Connected				ASSESSMENT	ASSESSMENT
Data	Validated Traceable		ASSESSMENT	ASSESSMENT	ASSESSMENT	
People and Organisation	Ownership Clear Certified			ASSESSMENT	ASSESSMENT	
Computing Infrastructure	Capable Flexible				ASSESSMENT	ASSESSMENT

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Thank You
Q & A
?????