

**TDW-Live**

Congresbury, Bristol - 15 Nov 2018

# **Simulation Based Acquisition - Past or Future?**

Andy Fawkes



# Overview

- **What is Simulation?**
- **What is/was Simulation Based Acquisition?**
- **Historical Context**
- **Past or Present?**

Who am I?

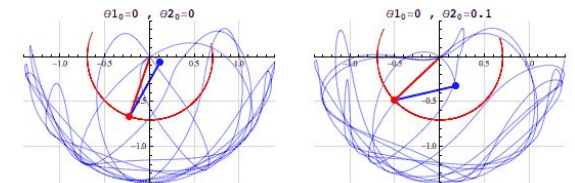
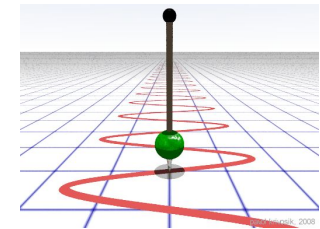
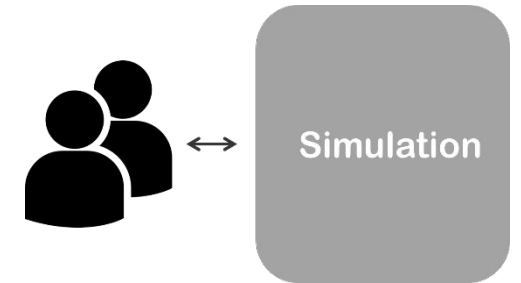
- Engineer FIMechE MRAeS
- 10 years submarine research, education & procurement
- 20 years modelling and simulation, MoD and industry
- Consultant for Bohemia Interactive Simulations and Ocean Software

# What is Simulation?

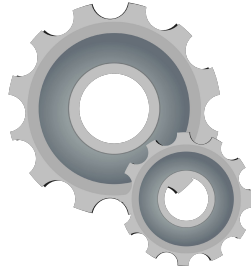
- A Simulation is an imitation of the operation of a real-world process or system
- A Simulation requires a Model
  - The model represents the key characteristics, behaviours and functions of the system/process
  - The simulation represents the operation of the model over time
- *Modelling & Simulation (M&S) an embracing term*

# What is Simulation?

- Humans Inside or Outside
- Runs in Real or Non-Real Time
- Some Systems have Order
- Some Systems are Chaotic
- Some are Random



# Simulation Categories (LVC)



Equipment

Real

Live

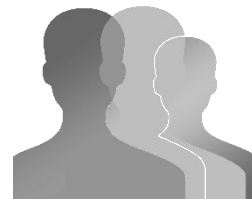
Simulated

Virtual

Constructive

Real

Simulated



People

# Additional Realities

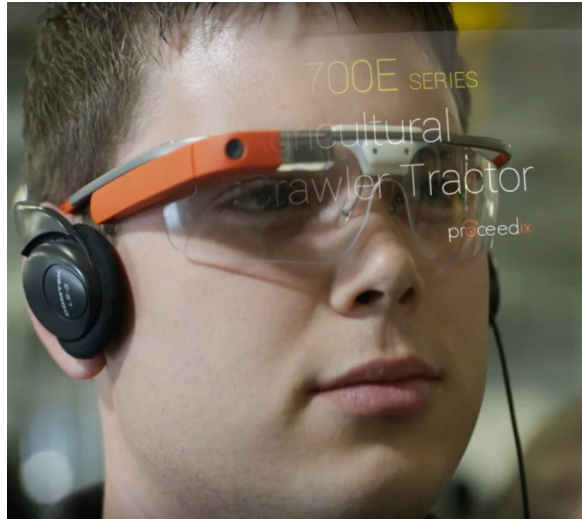
**Reality**

**The real world**



**Augmented Reality**

**Information layered over vision**



**Mixed Reality**

**Blend of real & digital information to enhance reality**



**Virtual Reality**

**Fully virtual world**





**"Thanks to major investments in research and observations, today's five-day forecast is as reliable as the two-day forecast of 20 years ago"**

**Michel Jarraud, World Meteorological Organization 2014**



# What is Real?

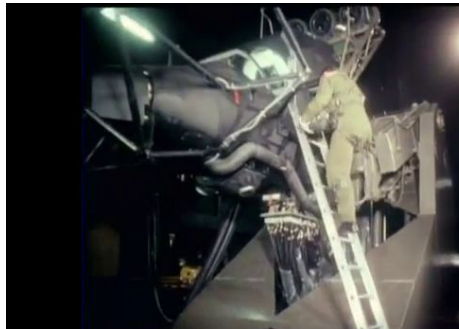
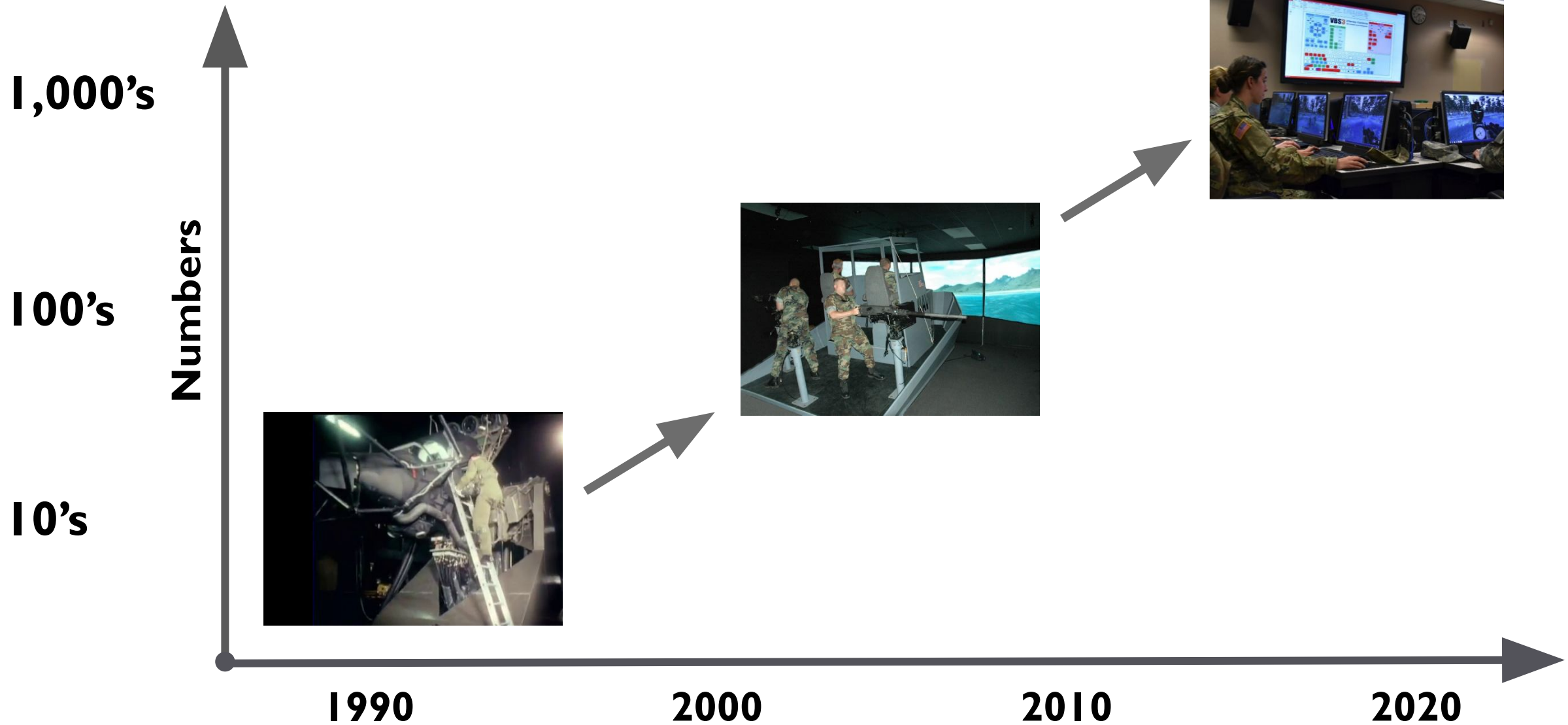




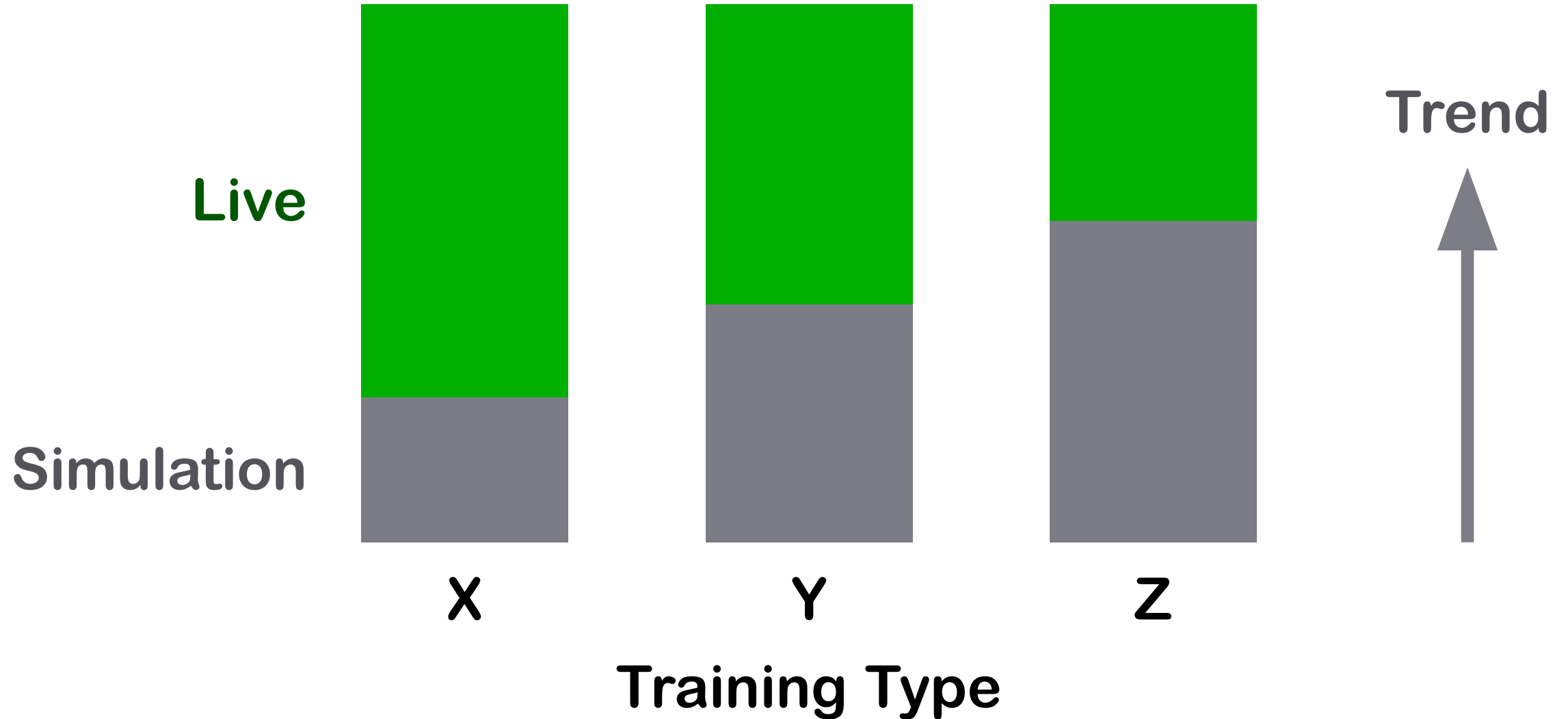
# Simulation Now - Land, Sea, Air, Anywhere



# Military Access to Simulation



# Live & Simulation Based Training





# Why Simulation?







## Machine Learning Agents



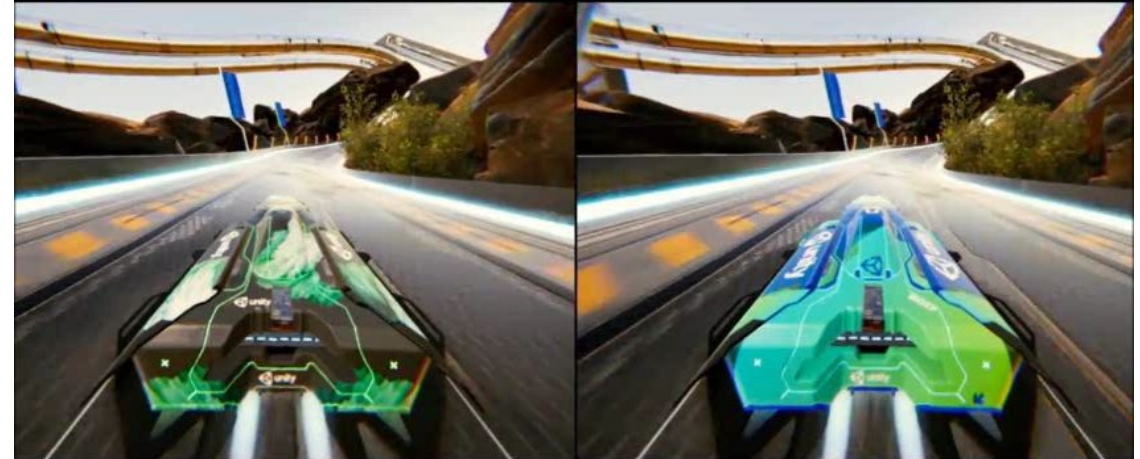
# Unity Games Engine Machine Learning Agents *AI Training*



## Machine Learning Agents

Simultaneous Training Demo

Imitation learning



# What is/was Simulation Based Acquisition?

# The SBA Vision

**“an acquisition process in which DoD and industry are enabled by robust, collaborative use of simulation technology that is integrated across acquisition phases and programs.”**

**US DoD Acquisition Council (1997)**

# SeBA?

## Synthetic Environment Based Acquisition

**“The consistent and coherent application of modelling, simulation and SE technology within, and across, both acquisition phases and programmes to facilitate the attainment of the Smart Acquisition goals of faster, cheaper, better”**

**UK MoD 1990s**



# Why Then?

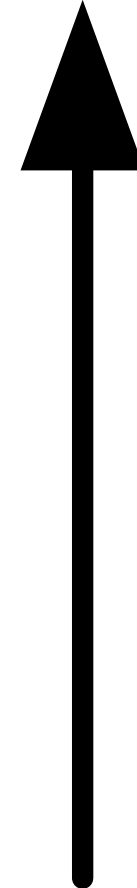
**Faster**



**Cheaper**



**Better**

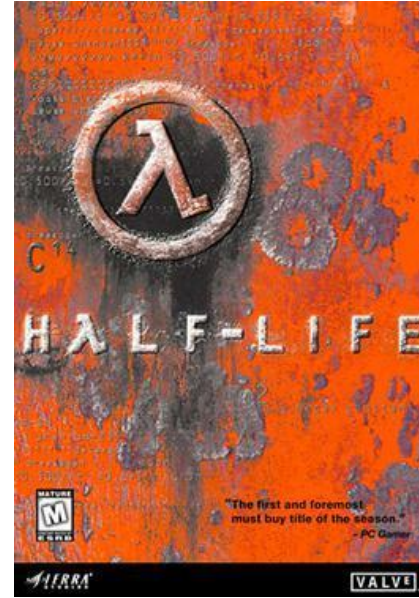


**Modelling &  
Simulation  
Technology**

# 1990s - Popular Consciousness

1995 – *Toy Story* Film

1998 – *Half-Life* Video Game

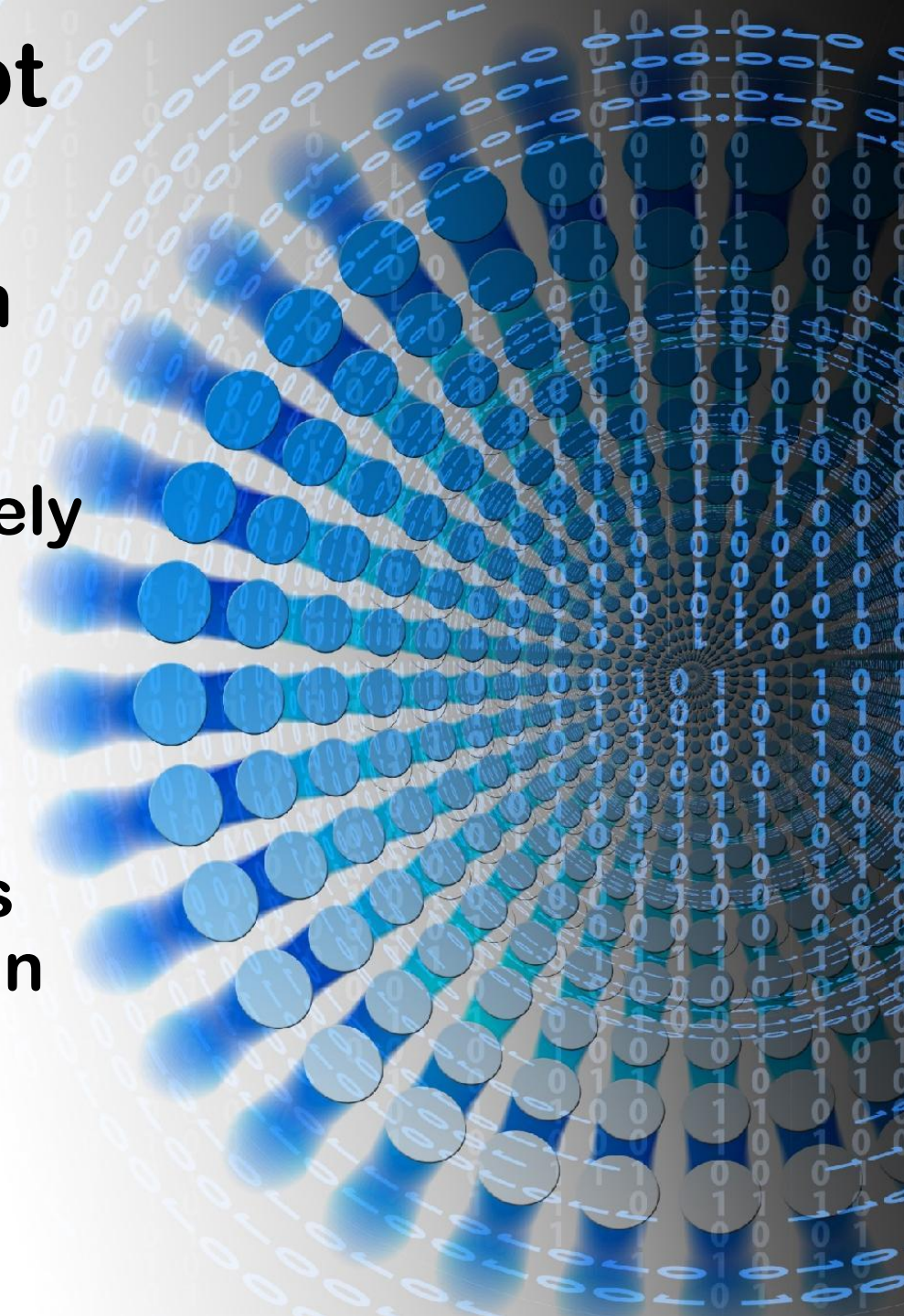


# SBA Concepts



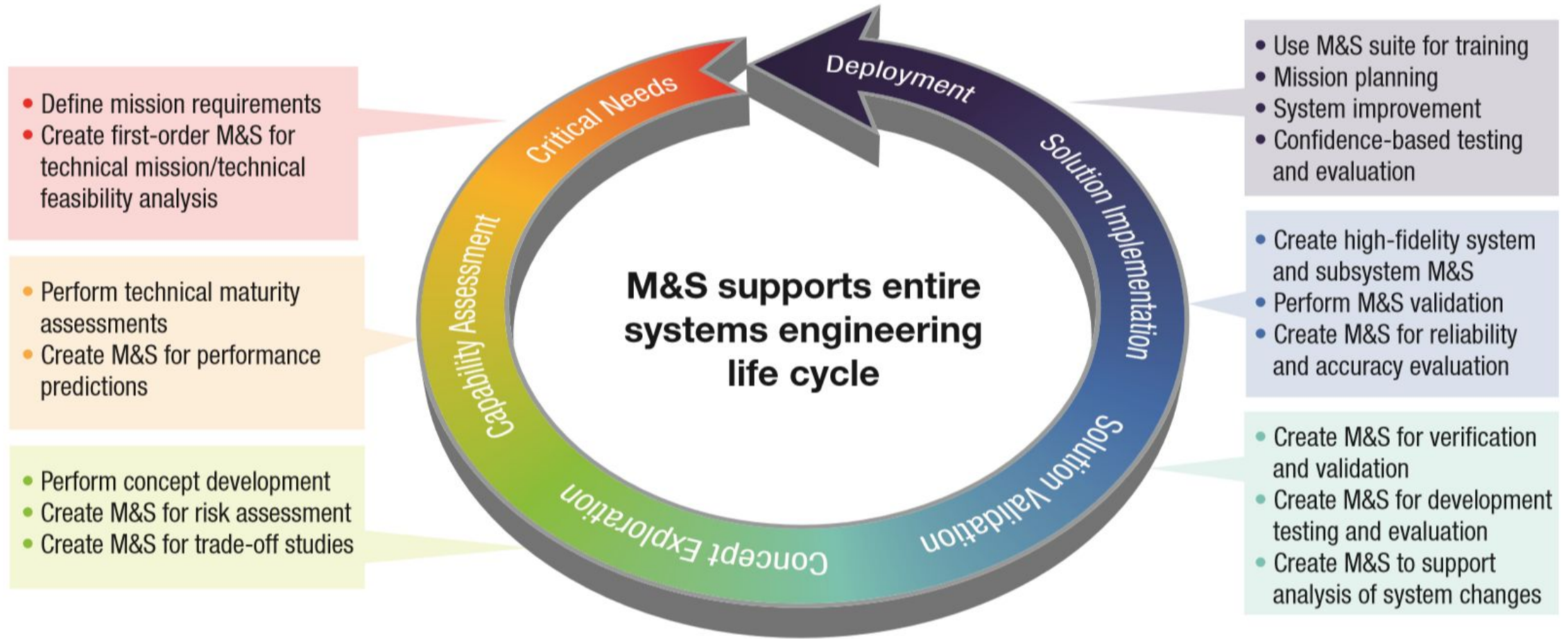
# Central SBA Technical Concept

- A common set of reference data called a Digital Product Definition (DPD)
  - Data which accurately and completely described the proposed system, its operational context, design, and program data (cost, schedule, and logistics)
  - Accessible through life to all parties involved in the acquisition process in Government & Industry





# M&S Supporting the Systems Engineering Life Cycle



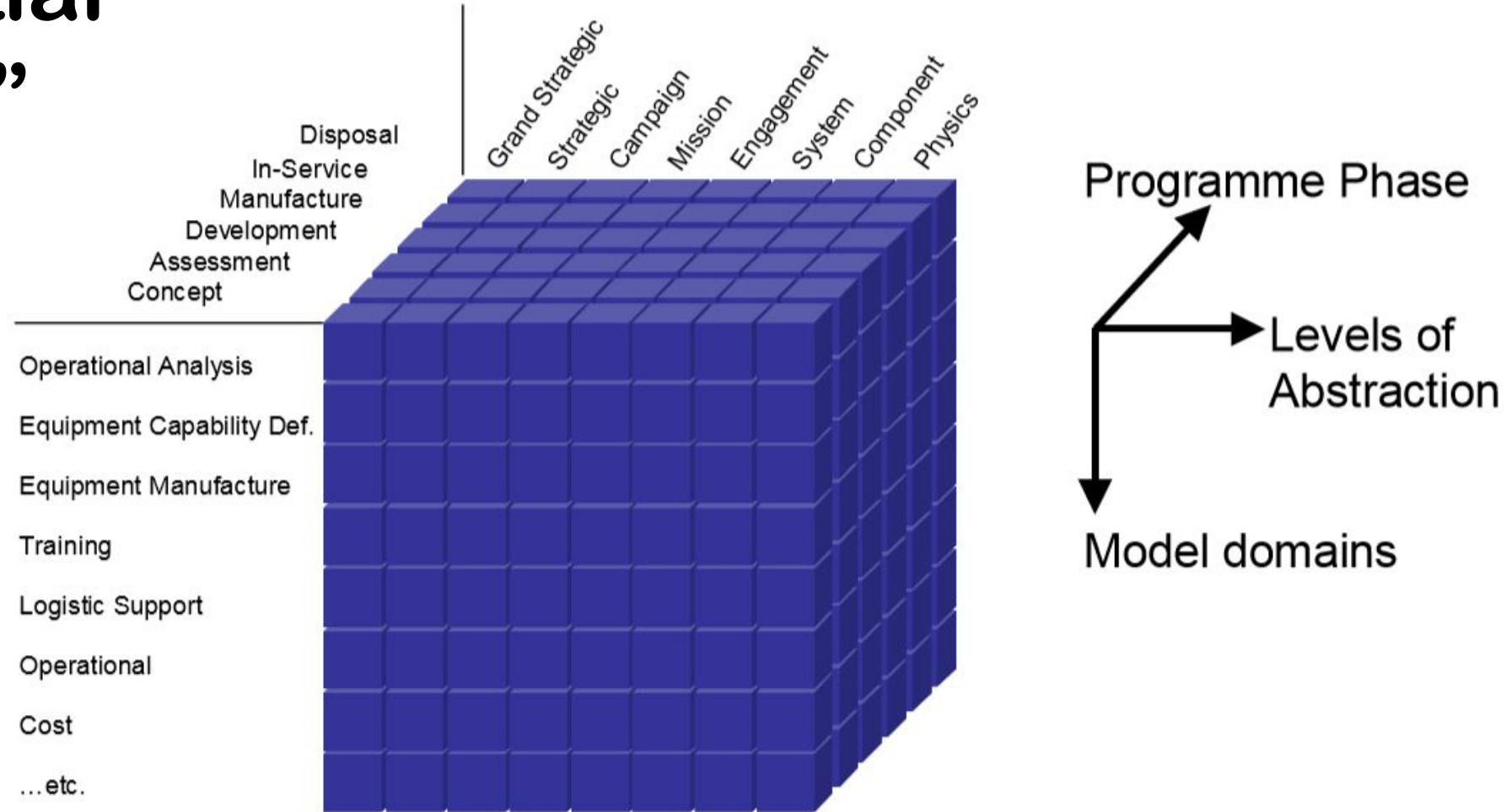
# SBA - Sharing Models and Data

Through the DPD, SBA would enable sharing across:

- **Manufacturing Simulation Software**
- **Manufacturing Facility Simulation Software**
- **Weapon System Software**
- **Training System Software**
- **Cost Analysis Software**
- **Mission Support Software:**
  - Mission Intelligence
  - Mission Planning software
  - Mission Rehearsal
  - Mission Execution
  - Mission Debrief



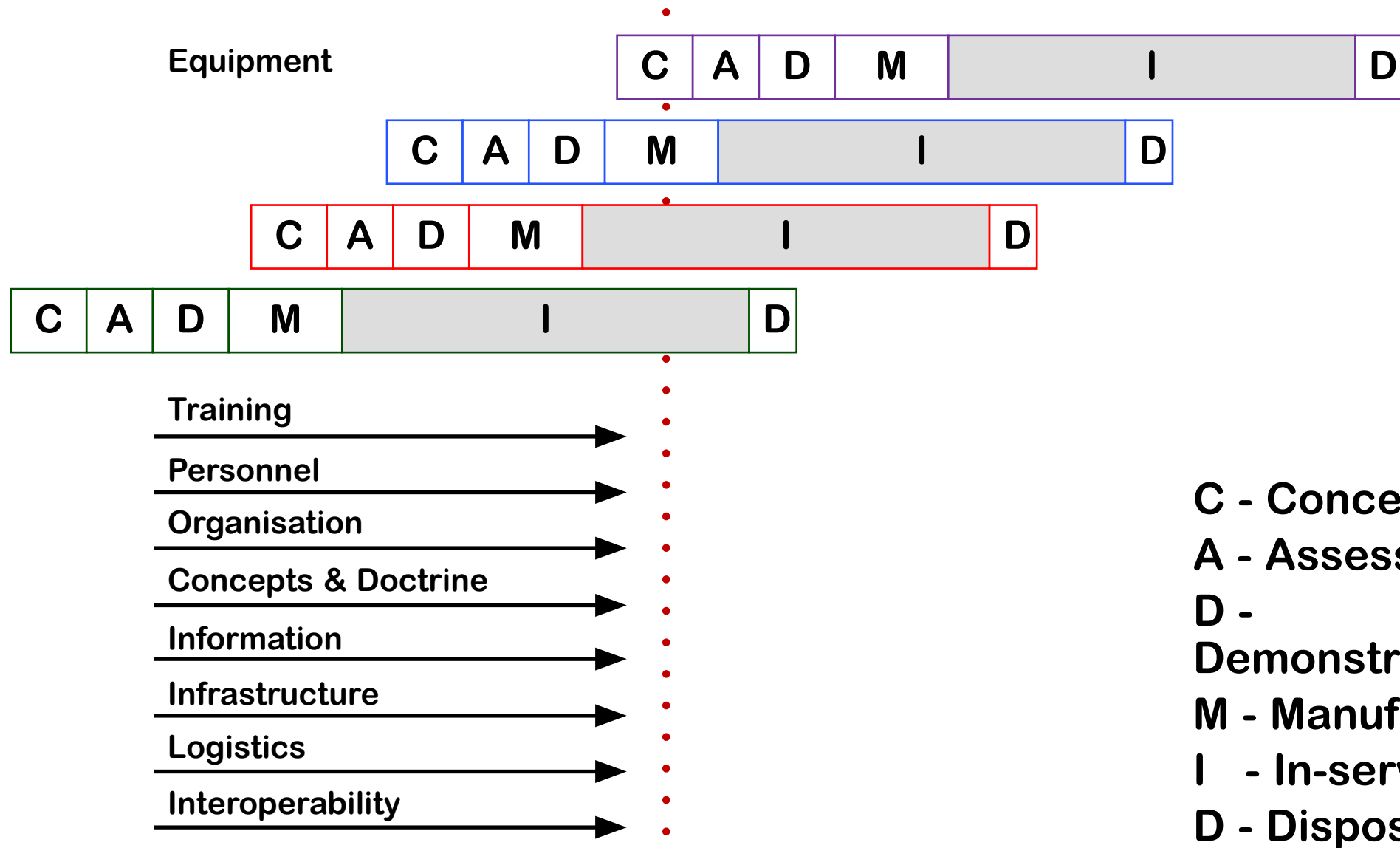
# “The Potential SE Space”



1. A single model will fit in one cube
2. A “Task SE” may well span several cubes
3. The “Enterprise SE” will encompass the whole space

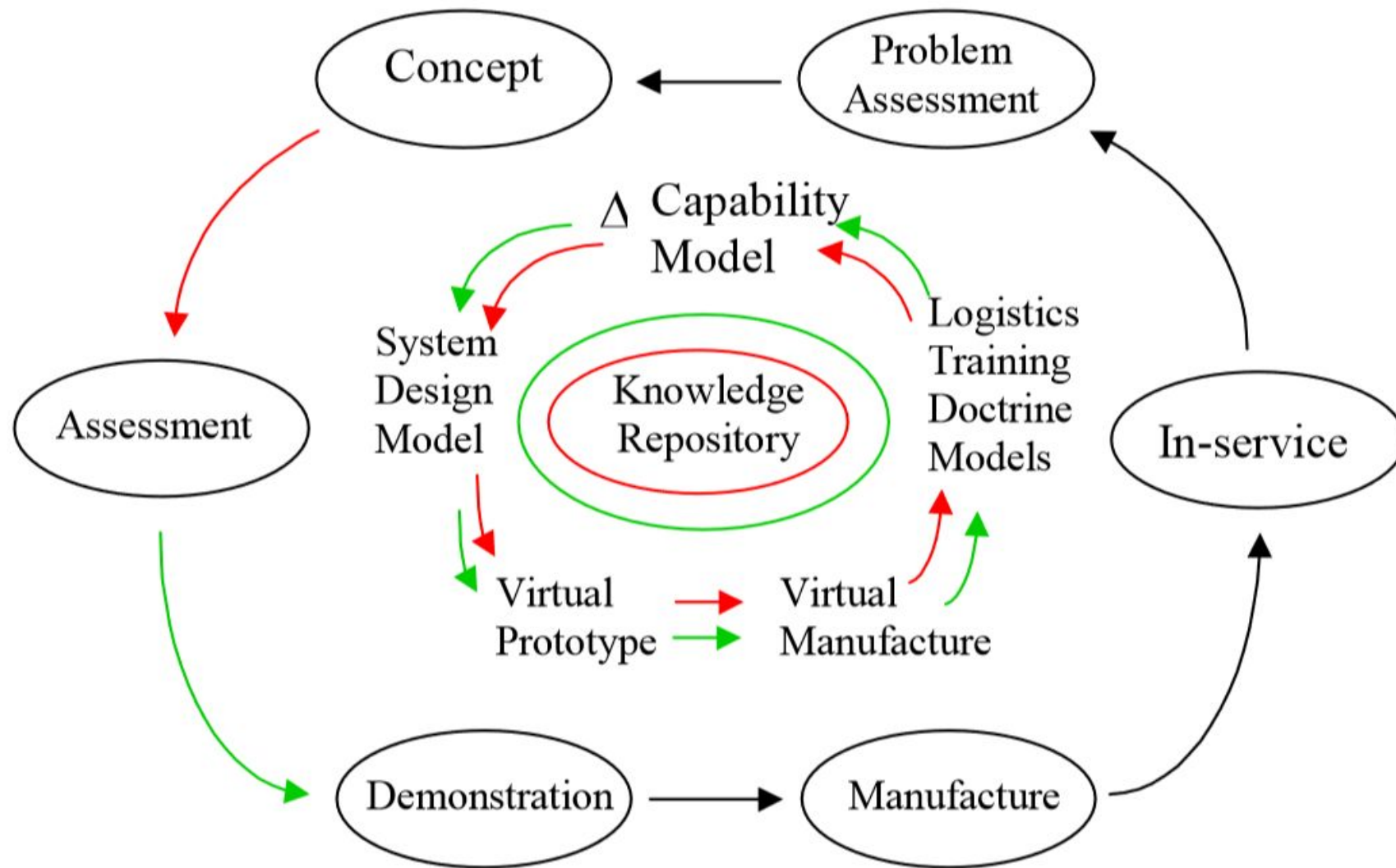
# SBA Integrating Military Capability (UK)

## Lines of Development





# Temporal Context - The UK “SeBA Wheel”

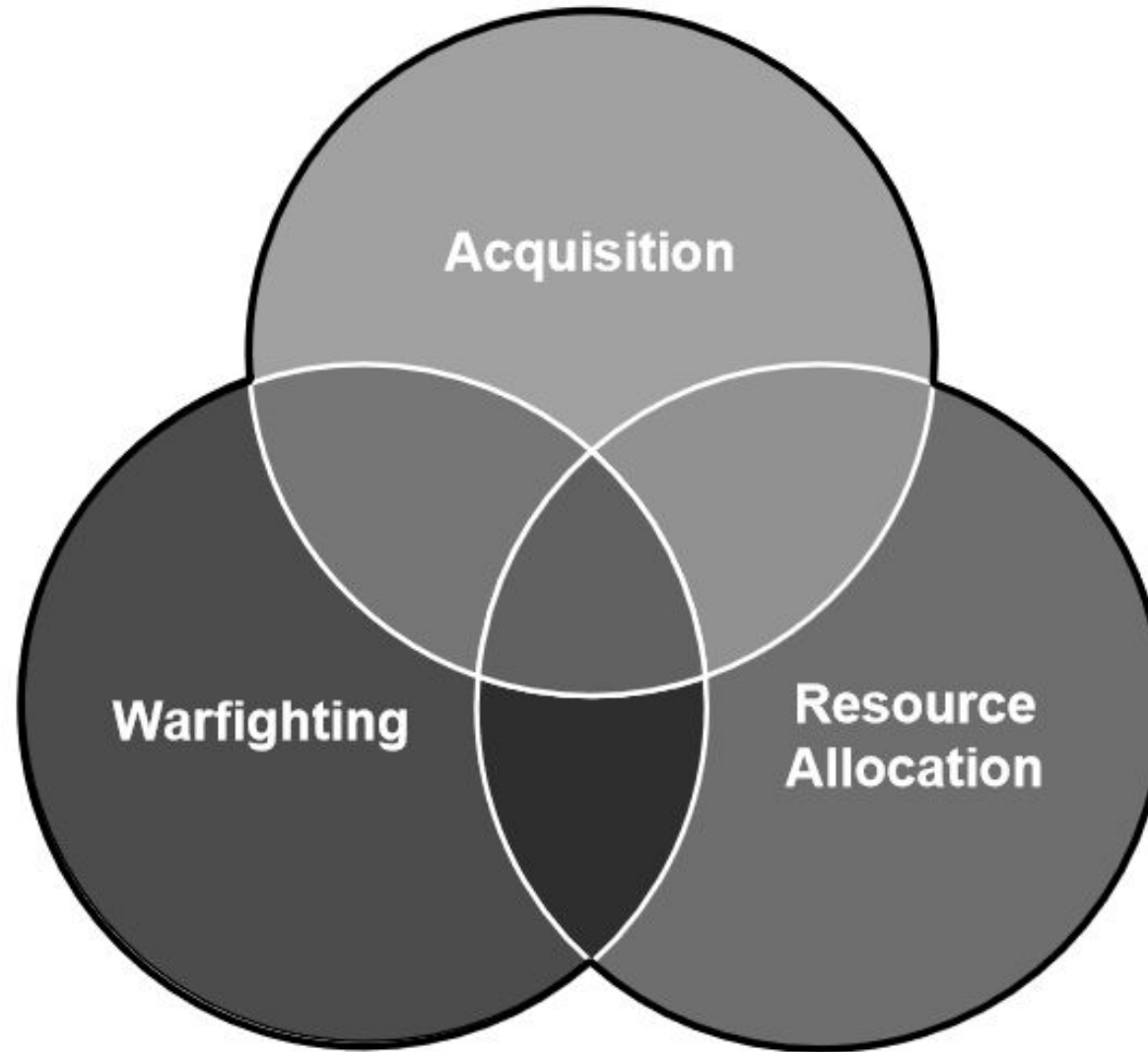


# SBA – It's all about Sharing

- **Within Projects**
- **Across Projects**
- **Over Time**



# SBA Linking Communities





**Confused by SBA?**

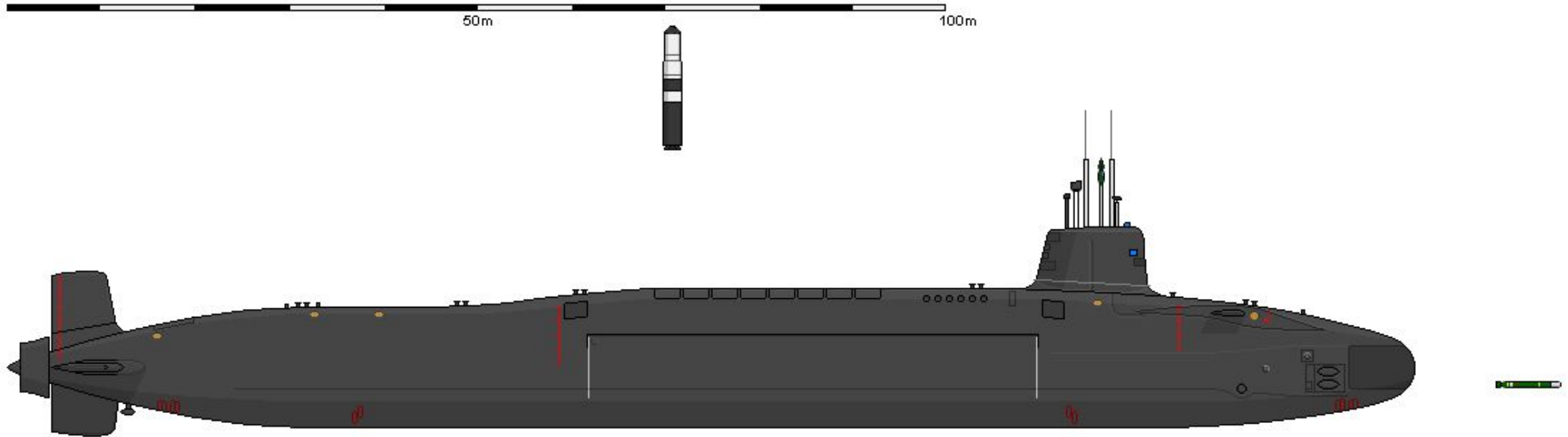


# SBA had a Number of Different Messages



# Historical Context

# UK Vanguard Class SSBN – A “Perspex Twin”



1980s - 1/5<sup>th</sup> Scale Perspex Model Supported the Design & Build and Later, Refits

# 1994 - Joint Strike Fighter (F-35)

**General Muellner, JSF Program Manager, sought to use an unprecedented level of M&S to:**

- Facilitate fully developed & validated operational requirements**
- Conduct trade-off analyses of critical user defined performance parameters**
- Integrate team of users & developers**
- Evolve requirements over time**
- Reduce future strike systems development, procurement, & support costs**



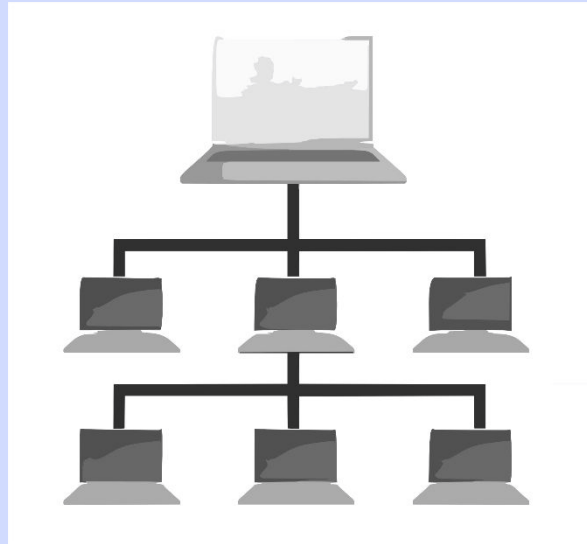
# 1997 - US DoD Acquisition Council

**“an acquisition process in which DoD and industry are enabled by robust, collaborative use of simulation technology that is integrated across acquisition phases and programs.”**

**The SBA Vision**

# 1998 - SBA Challenges Recognised by DoD

## Technical



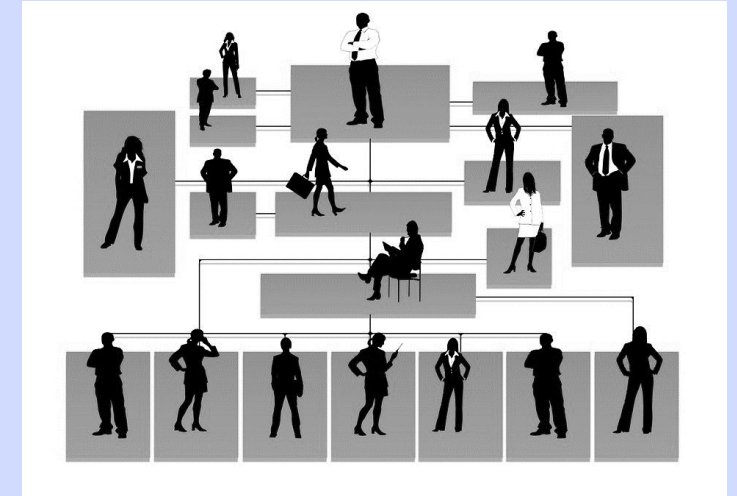
- Interoperability of M&S Tools
- Data Description Availability
- Security/Sensitivity of Data
- Physics-based M&S
- Hardware/Software Limitations
- Variable Resolution

## Cultural



- Acquisition Processes
- Incentives for M&S Use
- M&S Workforce
- Acceptance of M&S

## Managerial



- OSD and Service Guidance
- Ownership of Data
- VV&A Requirements
- Funding Process
- Use of System Models

# UK MoD/Industry SeBA Collaboration

- **National Capability Demonstrators (NCDs)**
  - **FlasHLAmp (1996-98)**
  - **ADSE (1997-98)**
  - **Project Vitesse (1996-99)**
  - **SeBA (99-02)**
- **FOAS (1999-00)**
- **NIREUS (1998-03)**
- **EUCLID 11.13 (2000-03 )**
- **NMSG-003 - Feasibility Study on M&S Technology in Support of SBA (2003)**

# 2001 - Joint Strike Fighter

***Lockheed Martin had “achieved a 50 plus percent reduction in acquisition cycle time and cost via M&S, and the savings have been incorporated into our proposal bid”***

**Mr. Frank CAPPUCCIO**

**Vice President JSF, Lockheed Martin Corporation  
National Defence Industries Association SBA Conference  
June 2001**

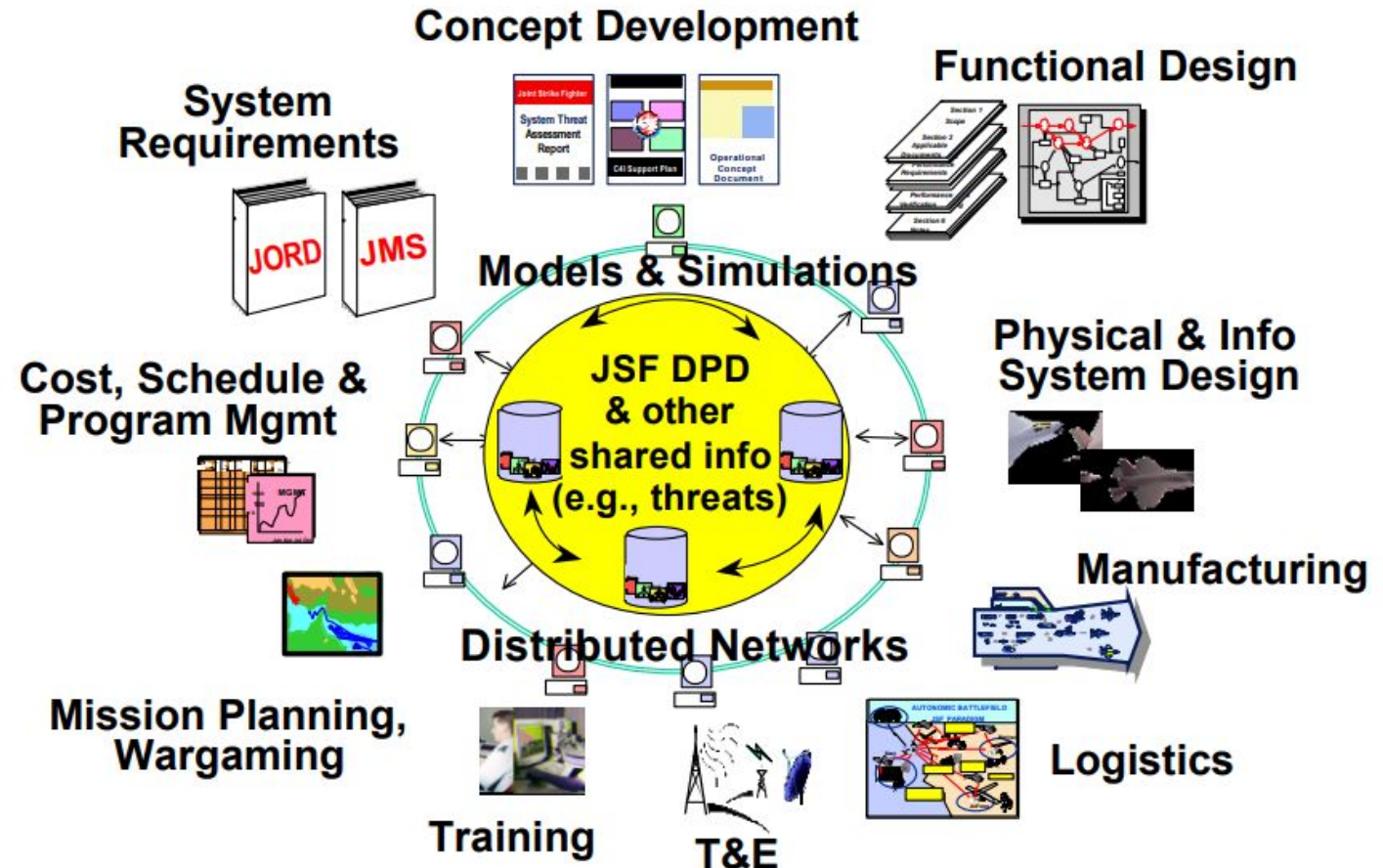
**SBA was listed as one of the significant contributors to the saving of one flying prototype**

# 2002 - JSF Digital Product Data



## Simulation Based Acquisition (SBA): Shared Info is the Hub of IPPD

(JSF M&S Support Plan Fig. 5-3)



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# 2003 - SBA In Trouble?



- In 2003, SBA was eradicated from DoD terminology by removing “SBA” from all DoD 5000-series publications, thus vanishing as a distinct DoD initiative
- “The acquisition community appeared to conclude that SBA was over-sold, over-complicated, and misunderstood”

# What Went Wrong? v DoD SBA Challenges

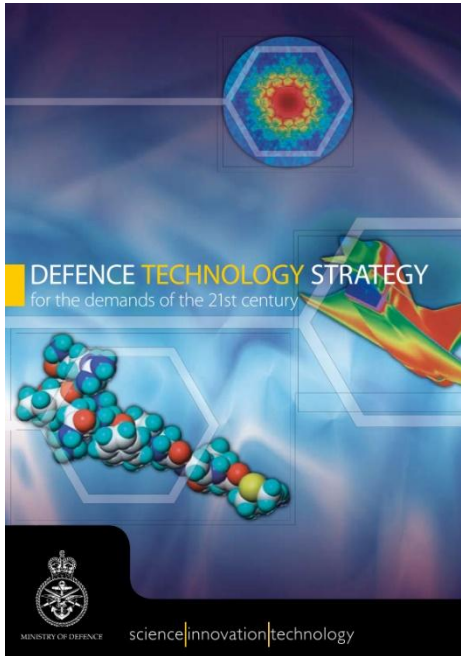
|    | SBA Challenges                |  | comment                          |
|----|-------------------------------|--|----------------------------------|
| 1  | Interoperability of M&S Tools |  | Cross-Domain Weaknesses          |
| 2  | Data Description Availability |  | Stovepipe Projects               |
| 3  | Security/Sensitivity of Data  |  | IPR & Security Challenges        |
| 4  | Physics-based M&S             |  |                                  |
| 5  | Hardware/Software Limitations |  |                                  |
| 6  | Variable Resolution           |  | “Fair Fight” Issues              |
| 7  | Acquisition Processes         |  | Many other Initiatives           |
| 8  | Incentives for M&S Use        |  | Spend to Save Challenge          |
| 9  | M&S Workforce                 |  | M&S not Mainstream Skill         |
| 10 | Acceptance of M&S             |  | Act of Faith?                    |
| 11 | OSD and Service Guidance      |  | Guidance but is it Followed?     |
| 12 | Ownership of Data             |  | IPR & Security Challenges        |
| 13 | VV&A Requirements             |  | Guidance Generated but Followed? |
| 14 | Funding Process               |  | Stovepipe Funding                |
| 15 | Use of System Models          |  | Some Progress                    |

# My Own Experience

- **Confusing Multiple Messages**
- **Confusion with Other Procurement Change Initiatives**
- **General Lack of Knowledge about the Use of M&S**
- **Gulf between “M&S Enthusiasts” & Mainstream Procurement**
- **Weak connections with Training and Simulation Community**
- **Organisational & Funding Stovepipes**
- **Lack of Clear Incentives**

# Though SBA Lived On...

## UK Defence Technology Strategy (2006)



“MoD will work in collaboration with industry, using existing fora such as the Synthetic Environments Tower of Excellence and initiatives including the Integrated Modelling and Simulation Support for Acquisition (IMSSA) project, to develop a joined-up defence wide modelling and simulation capability”

## Naval Air Warfare Center Existing Online SBA Guidance

### Simulation Based Acquisition (SBA)

- [DoD Modeling And Simulation Coordination Office \(M&SCO\)](#)
- [Navy Modeling And Simulation Management Office \(NAVMSMO\)](#)
- [Army Modeling And Simulation Office \(AMSO\)](#)
- [Air Force Agency For Modeling And Simulation \(AFAMS\)](#)

### SBA VISION

An Acquisition Process in Which DoD and Industry are Enabled by Robust, Collaborative Use of Simulation Technology That Is Integrated Across Acquisition Phases and Programs.

### GOALS OF SBA

- Substantially Reduce the Time, Resources, and Risk Associated With the Entire Acquisition Process;
- Increase the Quality, Military Worth and Supportability of Fielded Systems , While Reducing Total Ownership Costs Throughout the Total Life Cycle;
- Enable Integrated Product and Process Development (IPPD) Across the Entire Acquisition Life Cycle.

### SBA EXPLAINED

- Revolutionary Acquisition Initiative
  - Emphasizes Modeling & Simulation as a Primary Tool
  - M&S Applied and Sustained Throughout the Life Cycle
  - Virtual Life Cycle Product Validation Before Production
  - Re-use Across Programs & Phases
  - Enables Iterative Development and IPPDs
- Major Impact On T&E Culture and Purpose
  - Digital Representations are Tested
  - Physical Test Articles Are Primarily For Model Verification and Validation
- Major Paradigm Changes in Three Domains
  - Culture. An evolved culture in which enterprise-wide cooperation is the rule and individual technical contributions and innovations are encouraged and efficiently managed. The culture also recognizes and creates incentives for high level tradeoffs both within a system as well as between systems, and without institutional or service imposed barriers.





# “Digital Thread” & “Digital Twin”



Credit: Boeing

AVIATION WEEK  
NETWORK

AVIATIONWEEK  
& SPACE TECHNOLOGY

Step **INSIDE** the next evolution

## USAF Selects Lead Programs For ‘Digital Twin’ Initiative

*Aviation Week & Space Technology*

**Graham Warwick**

Jan 26, 2015

Digital system models are seen as key to regaining understanding of complex systems

### Threading the Needle

Over the years, the U.S. Air Force has come to rely more and more on industry for its technical understanding of the systems it acquires. To reverse that process and bring costs and risks more under its control, the service is experimenting with creating and carrying digital system models through the entire life cycle of a program.

The acquisition process now being piloted has two key elements: the “digital thread,” a model of the system that begins at conceptualization and evolves through its life to retirement; and the “digital twin,” a model of the system as built, including any manufacturing discrepancies, that is used to support the system in service.



# Doctrine & Equipment Analysis



## Preparation



Prepare the scenarios used for the analysis



## Authoring



Modify the parameters of the analysis

## Simulation

Play the scenario



or



## Shadow gaming

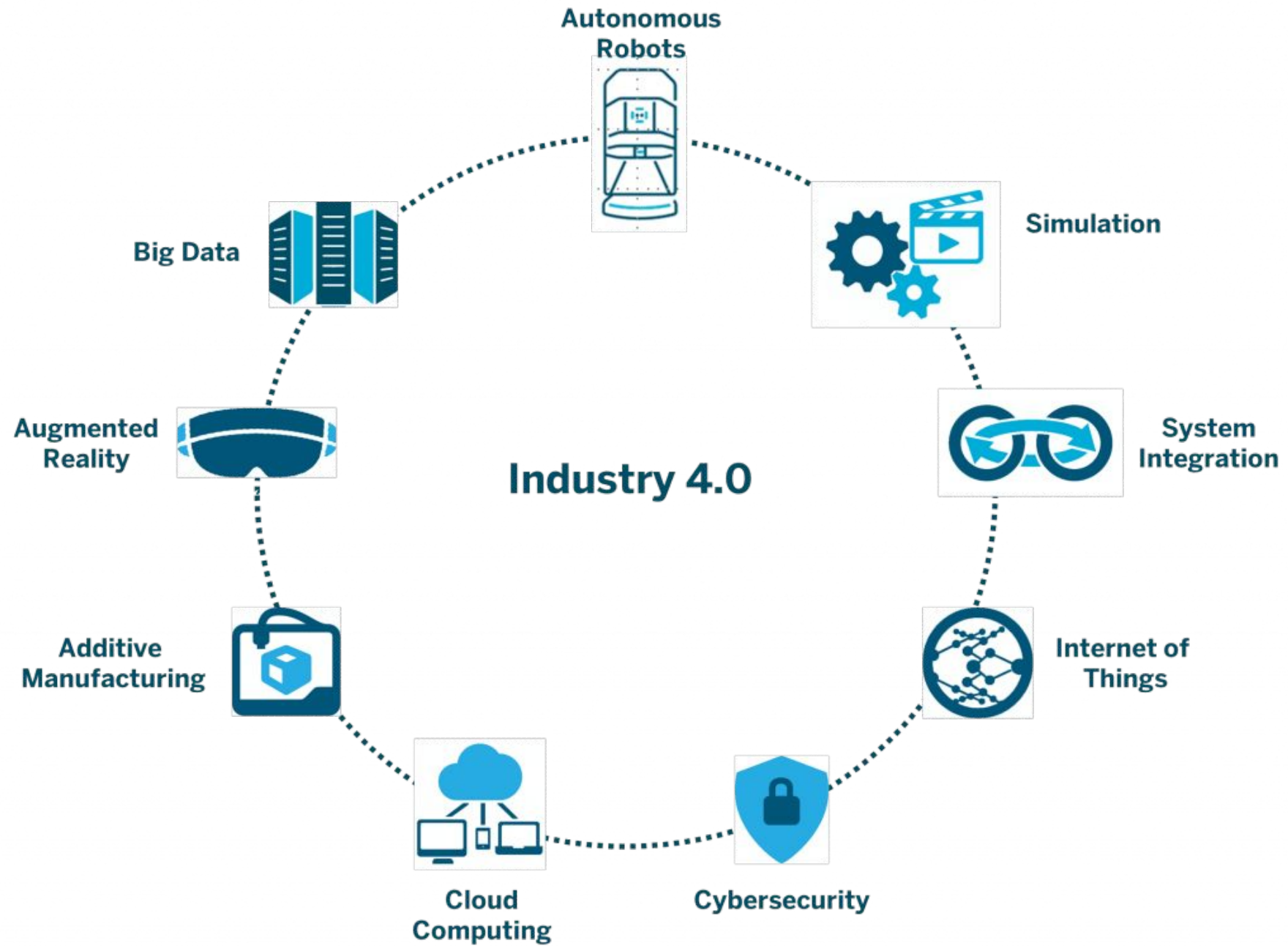
Use a monte-carlo batch



## Analysis

& presentation







# The Price of Data



# F-35 (2018)







- **War is chaotic**
- **No battle plan withstands contact with the enemy**
- **“All but war is simulation”**



# Black Swan

Pre-1697



Post-1697



The challenge of modelling and simulating a world with unknown unknowns



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# **Simulation Based Acquisition - Past or Future?**

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# SBA – A Future?



- Technology
- Incentives



- People & Culture
- Data Sharing/Security
- Other Initiatives



# Messages

- **Simulation Touches all Aspects of Acquisition, Operation and Support**
- **The engineering simulation and training simulation communities need to work together closely**
- **Simulation Technology is Constantly Developing**
- **Simulation Closely Linked to Data**
- **“Digital Sibling” is a more appropriate term than “Digital Twin” – the real world cannot always be 100% predicted**
- **Translate Initiatives for Non-Experts – Keep it Simple!**

**Georg Wilhelm Friedrich  
Hegel (1770-1831)**

**“we learn from  
history that we do  
not learn from  
history”**





THINKE

