Archiving MBSE Data: the why, what and how

Adrian Murton – Airbus UK

GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT 2019

Archiving & Retrieving MBSE Data: the why, what and how

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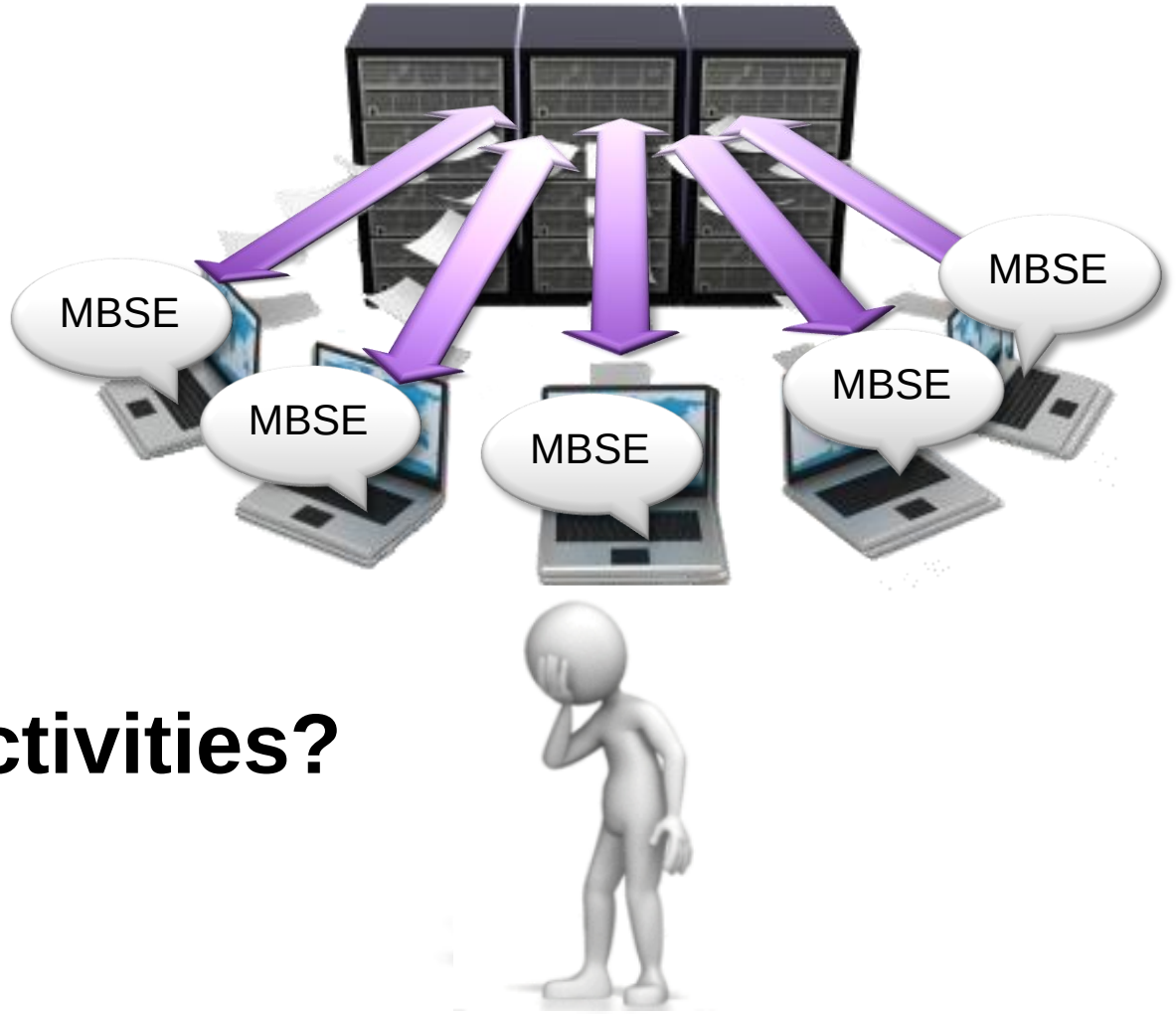
Agenda

- **Why do I need to archive MBSE data?**
- **What MBSE data do I need to archive?**
- **How do I archive MBSE data?**
- **Summary**

Audience Participation

Hands up if you have:

- **An MBSE project?**
- **Multiple MBSE projects?**
- **MBSE Archive and Retrieval activities?**



Agenda

Why do I need to archive MBSE data?

- **What MBSE data do I need to archive?**
- **How do I archive MBSE data?**
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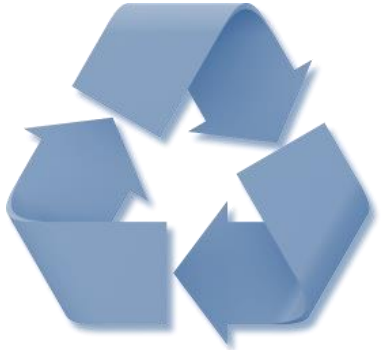
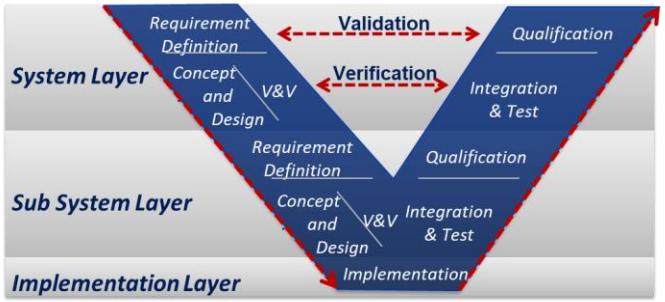
Why do I need to archive MBSE data

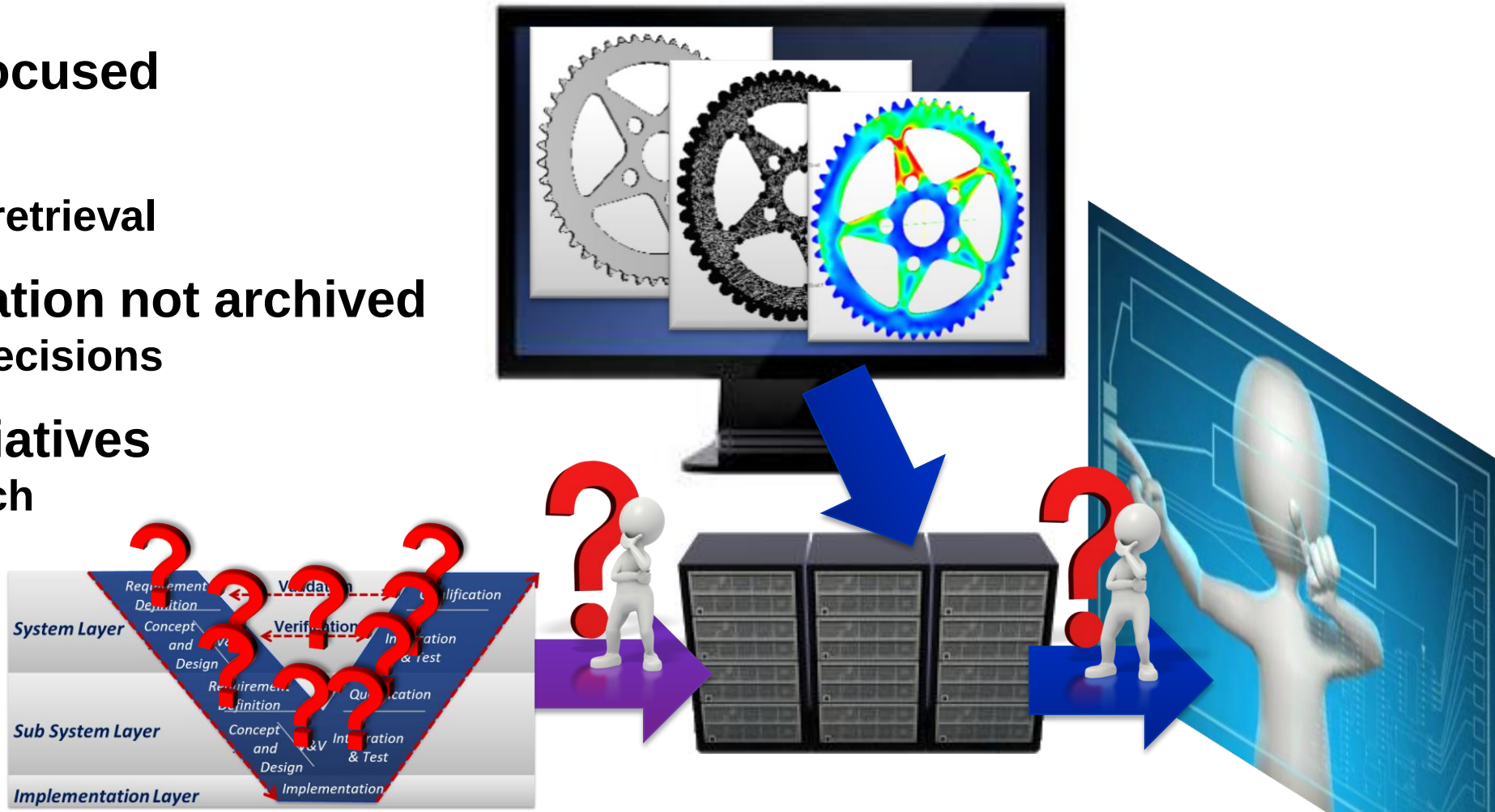
- **Regulations and Authorities**
- **Internal procedures**
- **Reuse**
- **Supporting V&V**
  - **Models to requirements**
  - **Requirements to models**





Issues around archiving MBSE data

- **Geometry model focused**
- **Vault everything**
  - **No thought about retrieval**
- **Contextual information not archived**
  - **e.g. rationale for decisions**
- **Multiple MBSE initiatives**
  - **No unified approach**



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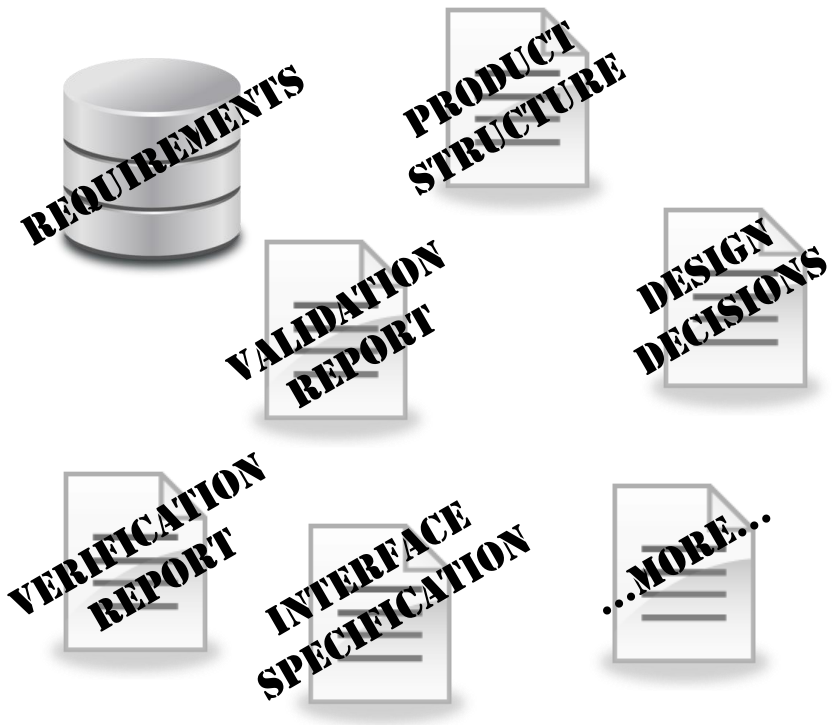
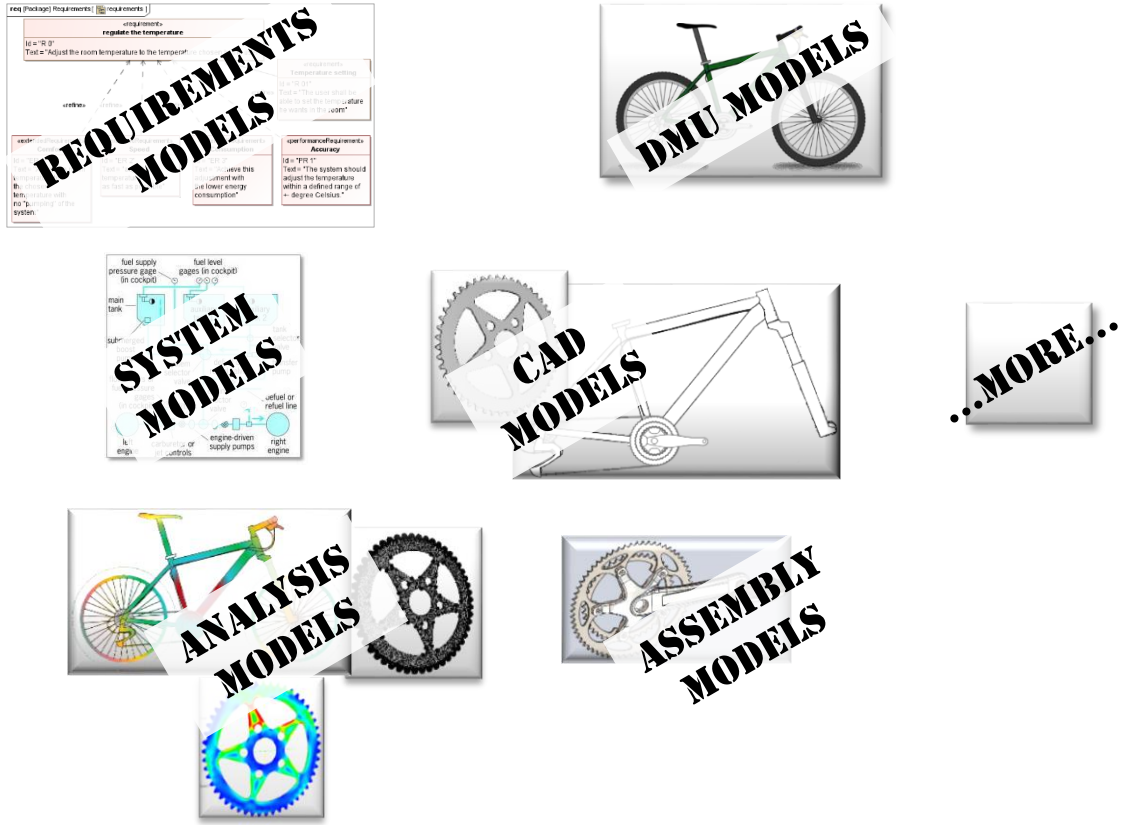
Moving towards an MBSE approach

Document based Systems Engineering

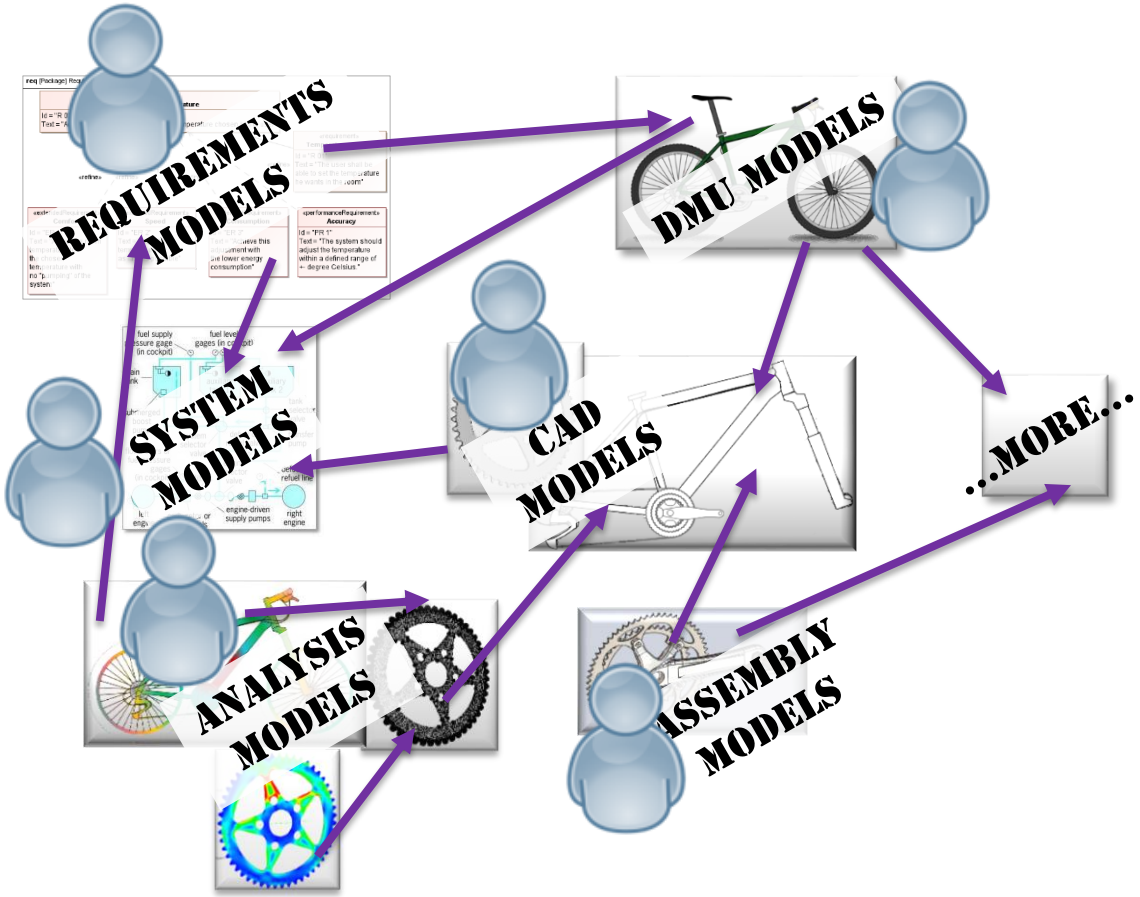


Model based Engineering

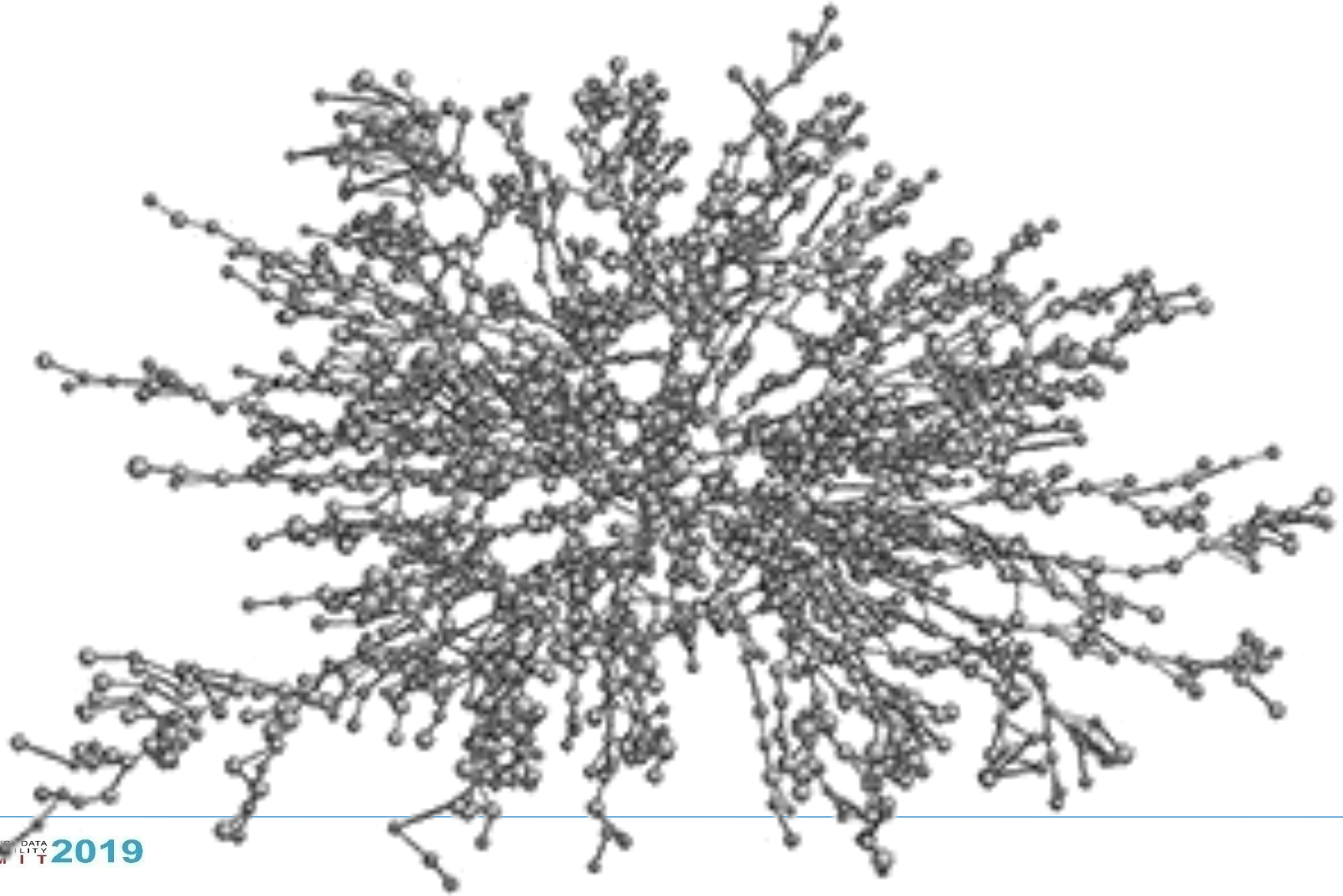


Arriving at an MBSE approach

Model Based Systems Engineering



MBSE – Network of links



MBSE – Vast range of types of data

System of interest
Environment System
Justification
Model as Realization
Assumption
Breakdown: Physical Logical, Functional
Sub-system
Decision
Model dependency
Component
Approval
Integration MODEL
Interface MODEL
Person
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Results Model
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Allocation
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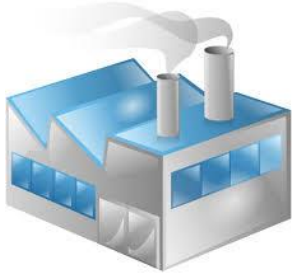
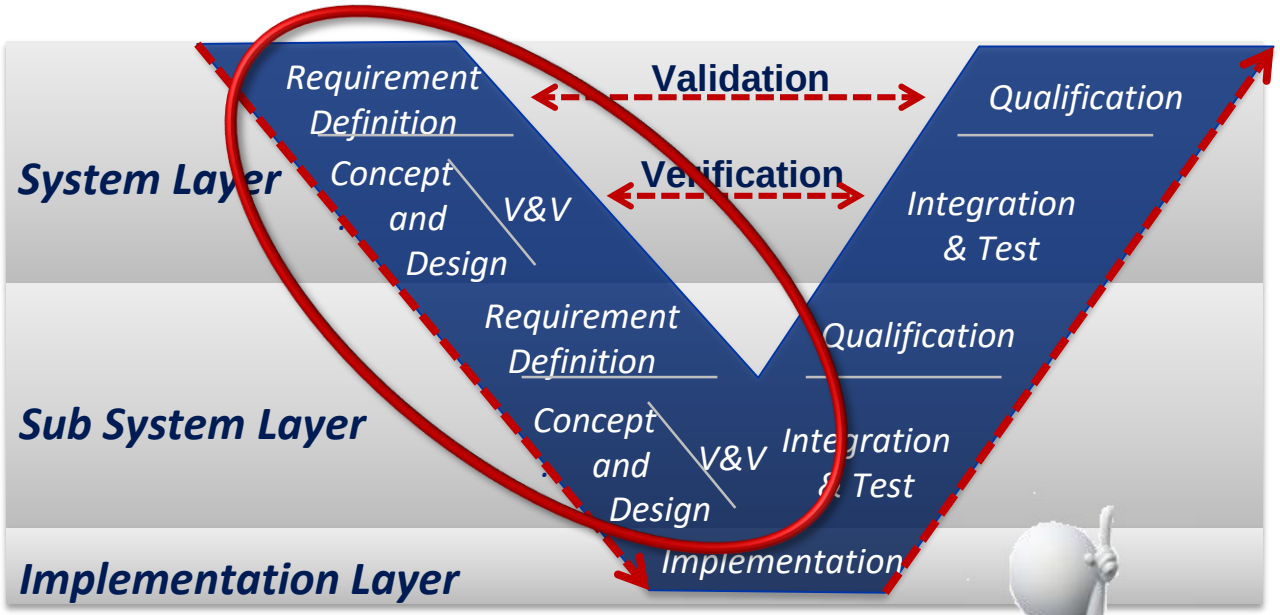
…more…
Certification

MBSE Example

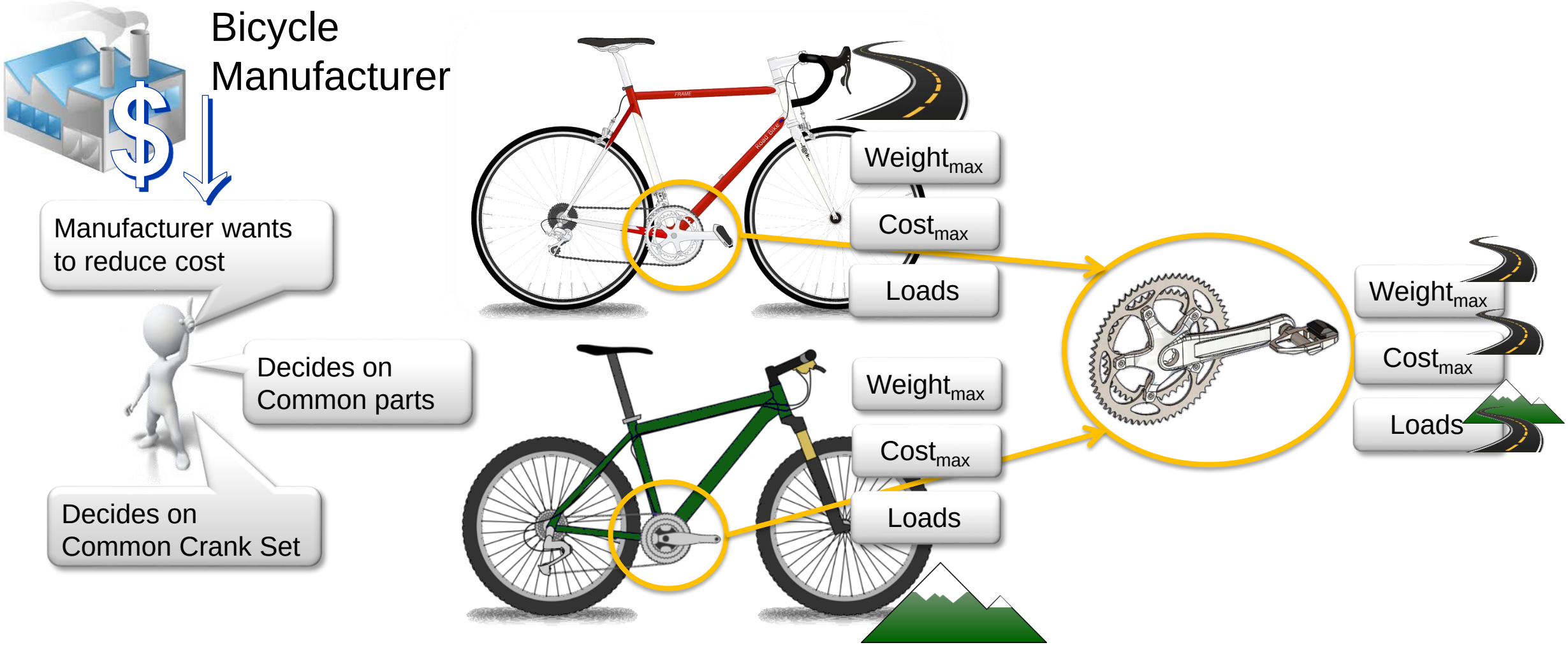


Bicycle Manufacturer



Example from
GPDIS 2018 MBSE workshop

MBSE Example: Problem Overview



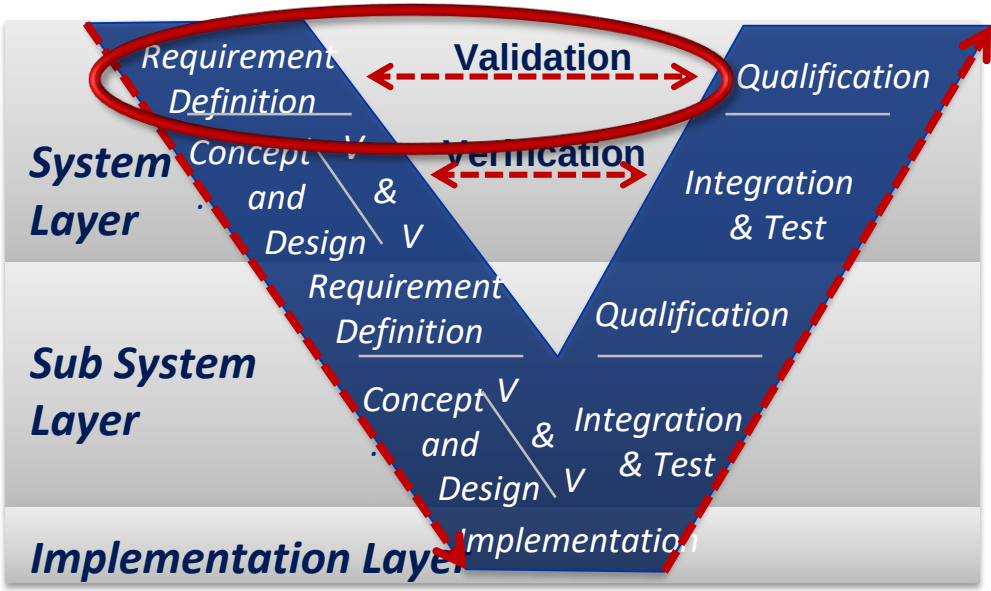
MBSE Example: Process steps

- **Understanding Existing Requirements**
  - MBSE data - overview
  - MBSE data - more details
- **Requirement Definition and Validation**
  - MBSE data – overview
- **Design and Requirement Verification**
  - MBSE data - overview

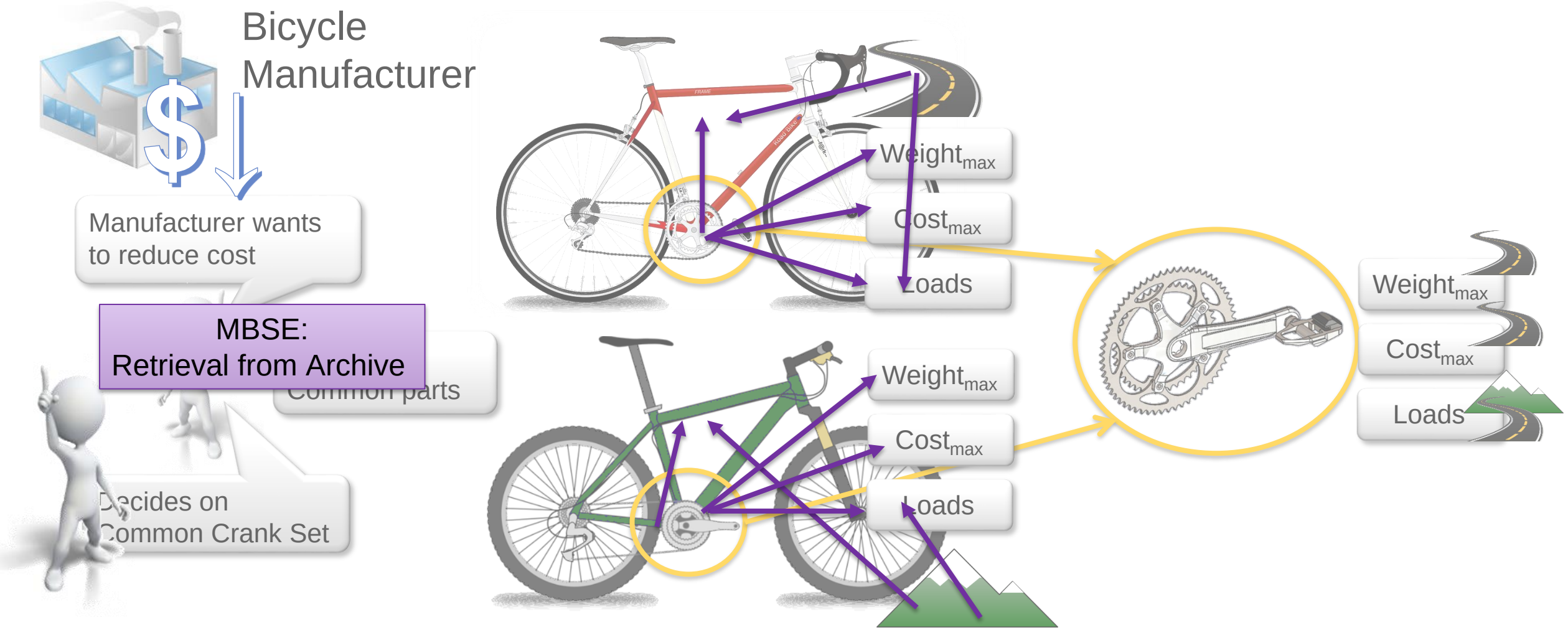
RETRIEVE

ARCHIVE

ARCHIVE



MBSE Example: Understanding Existing Requirements (overview)



MBSE Example: Understanding Existing Requirements (overview)

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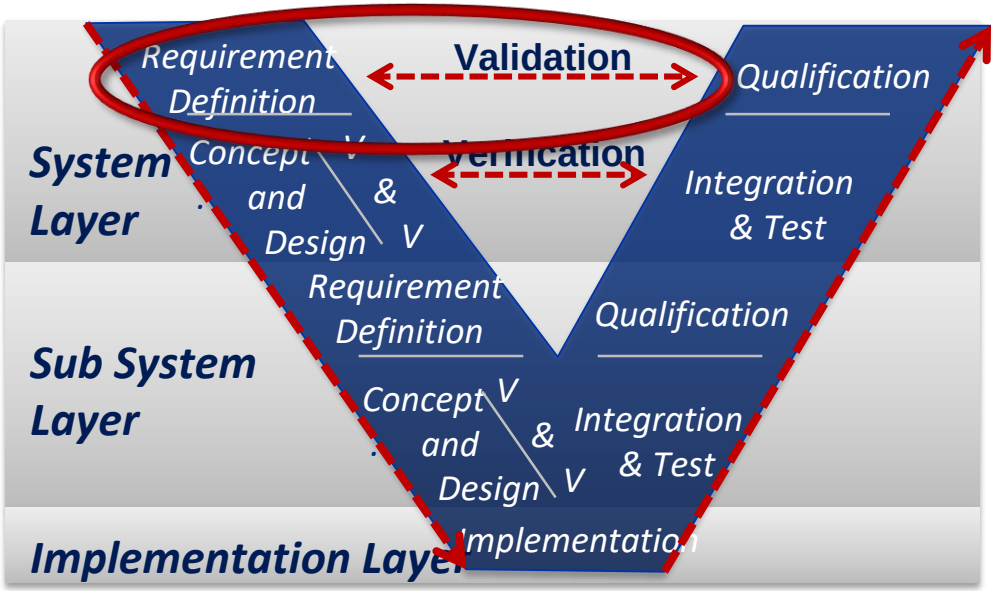

MBSE Example: Understanding Existing Requirements (detail)
Bicycle Physical, Logical, Functional breakdown

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System of interest

Bicycle (Physical)

- Frame (diamond)
  - Frame
  - Front fork
  - Seat post
  - Head s
- Pedal Crank structure
  - Pedal
  - Crank
  - Crank set
- Steering
  - Handlebars
  - Handlebar stem
  - Brake lever
- Whe
  - Fro
  - Re
- …Brakes, Seat, Chain,

Bicycle (Logical)

- Propulsion System
  - Force input system
  - Load transfer system
  - Speed ratio system
  - Idling system
- Braking System
  - Front Braking system
  - Rear Braking system
  - Actuator system
- Lighting System
  - Electricity Generation system
  - Electricity Distribution system
  - Front lighting system
  - Rear lighting system

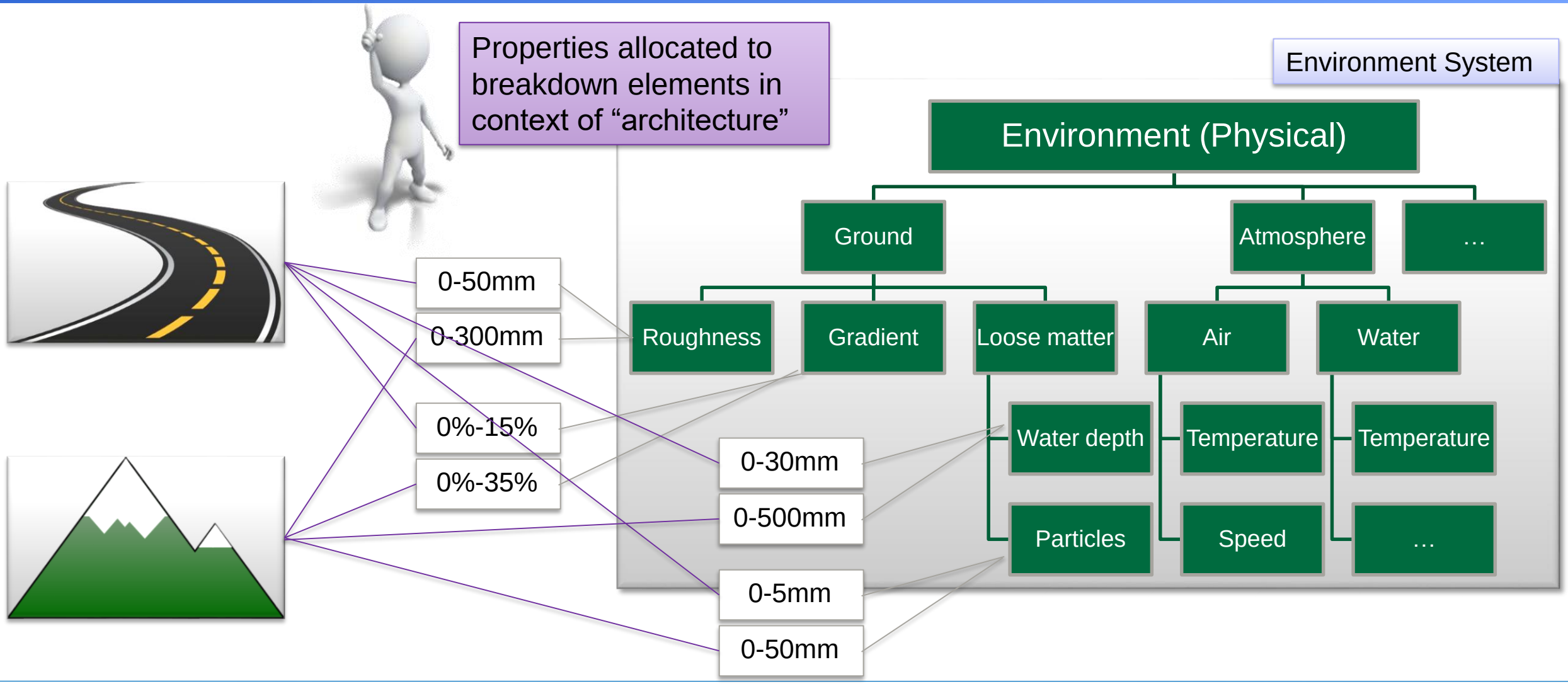
Bicycle (Functional) provide transportation

- In Service
  - Provide propulsion
  - Provide Adjustment
  - Enable maintenance & servicing
- In Production
- …

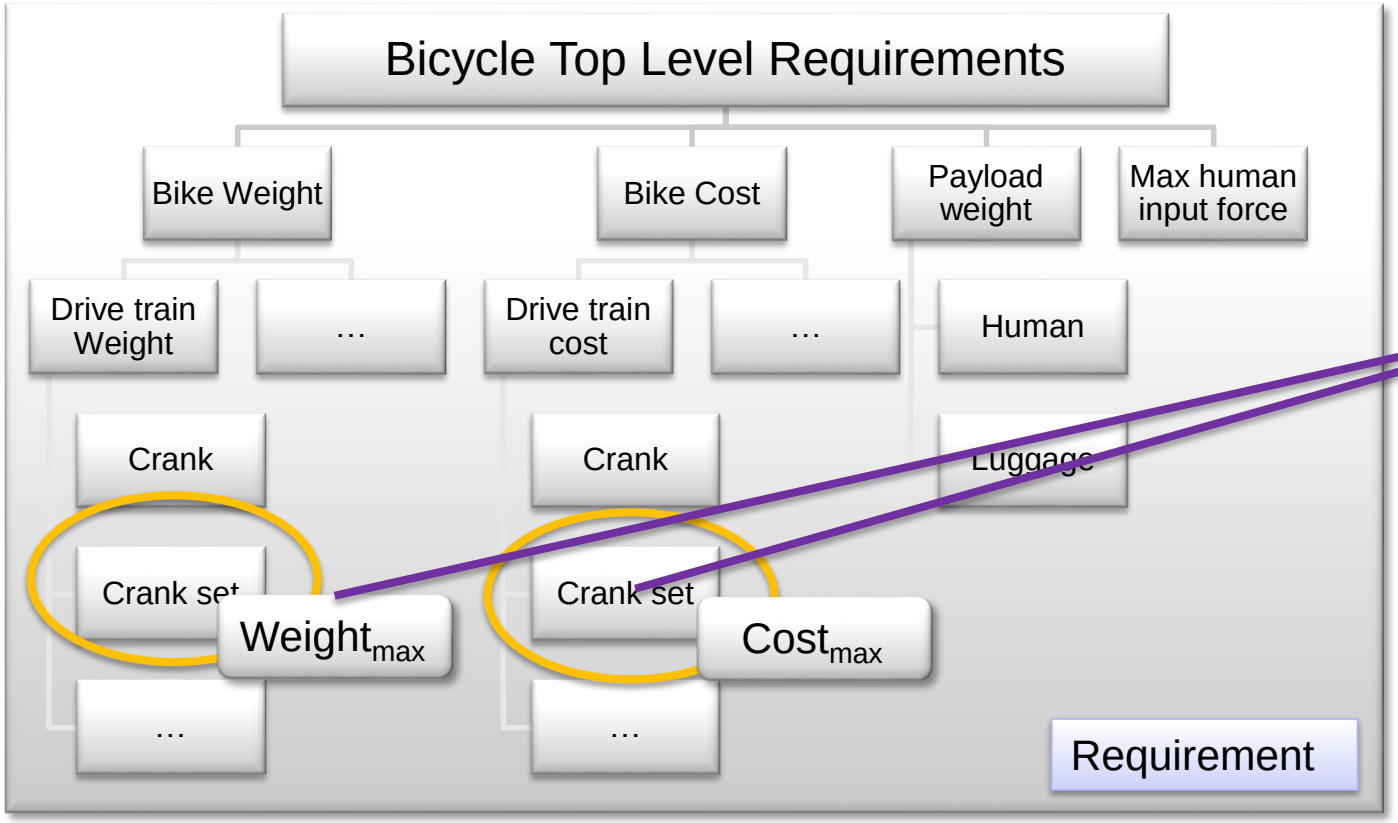
Component
Sub-system

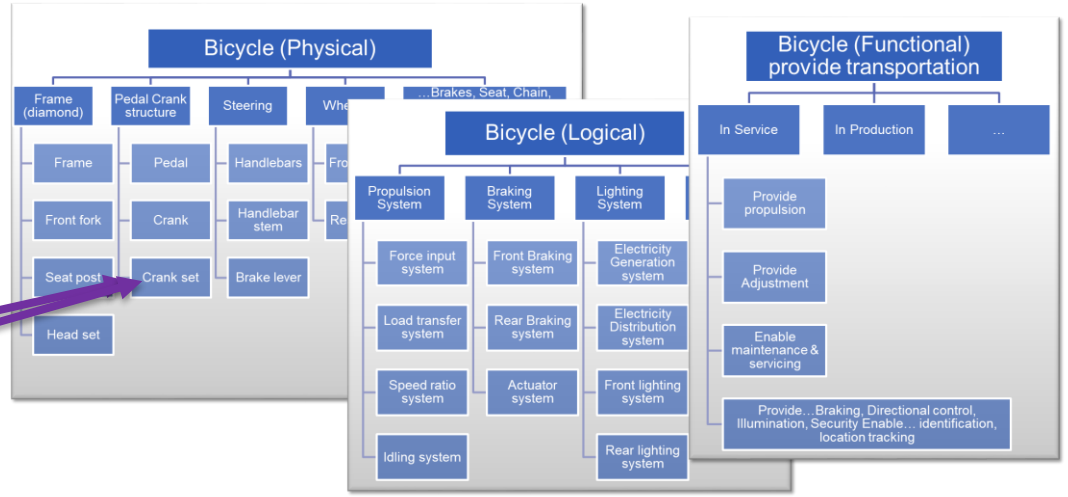
Allocations between breakdowns, can be generic (as shown) or in context of a specific bicycle “architecture”

MBSE Example: Understanding Existing Requirements (detail)
Generic Environment Physical breakdown



MBSE Example: Understanding Existing Requirements (detail)
Top Level Requirement allocation (Crank set weight and cost)





Requirement allocated to elements in the breakdown in the context of a bicycle architecture, indicate that the **elements should satisfy** the requirements

MBSE Example: Understanding Existing Requirements (detail)
Traceability of emergent requirements (Crank set loads)

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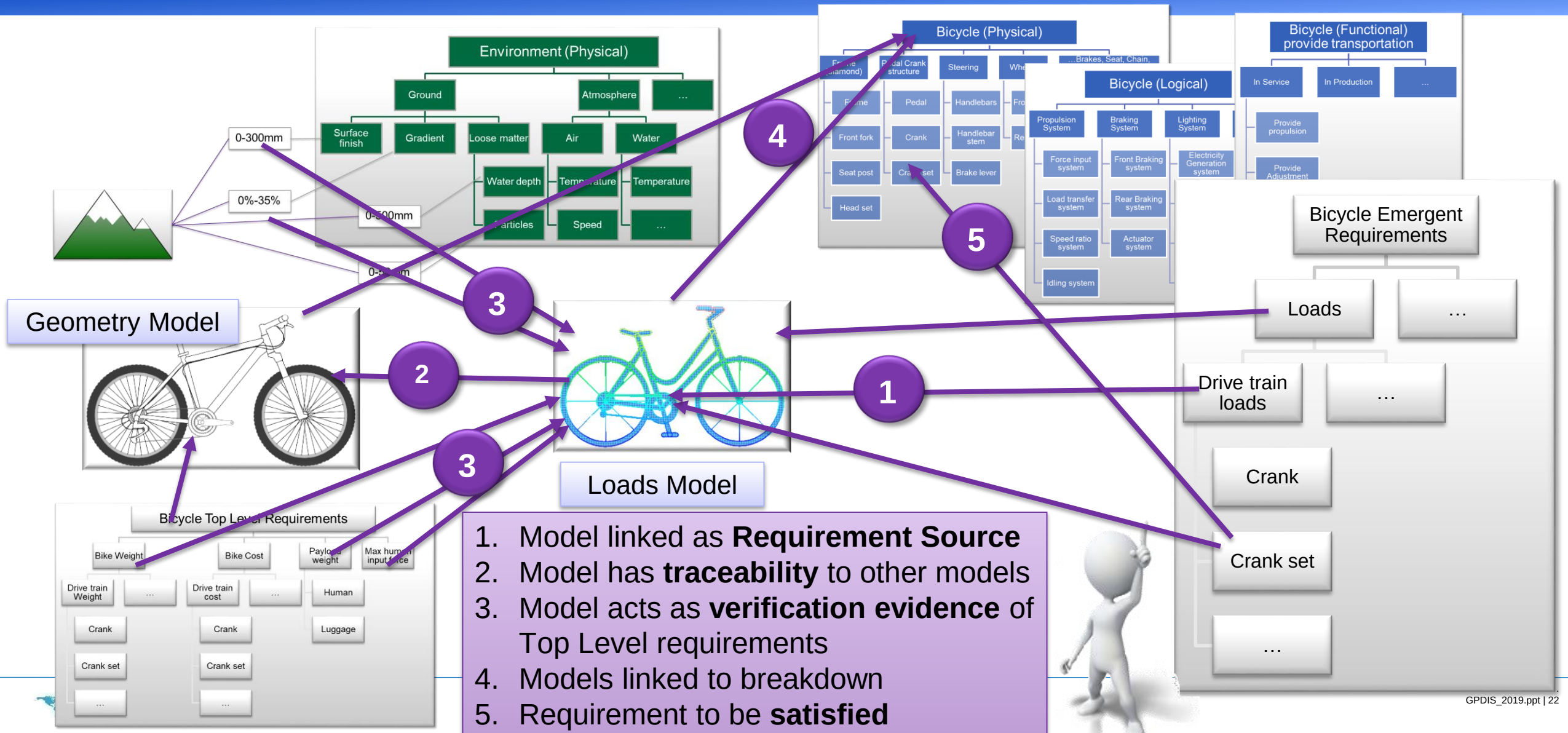
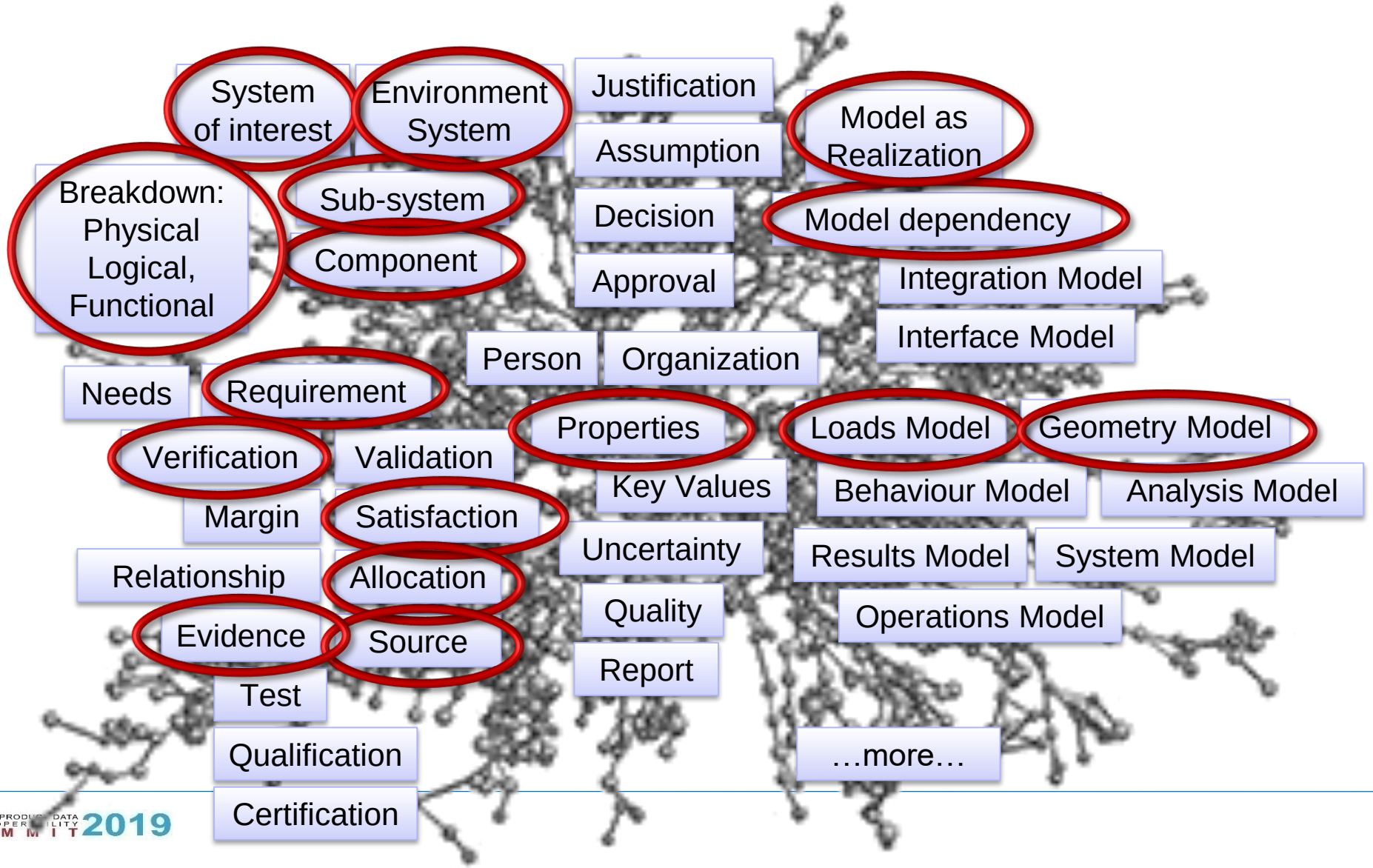


1. Model linked as **Requirement Source**
2. Model has **traceability** to other models
3. Model acts as **verification evidence** of Top Level requirements
4. Models linked to breakdown
5. Requirement to be **satisfied**

MBSE Example: Understanding Existing Requirements (detail)



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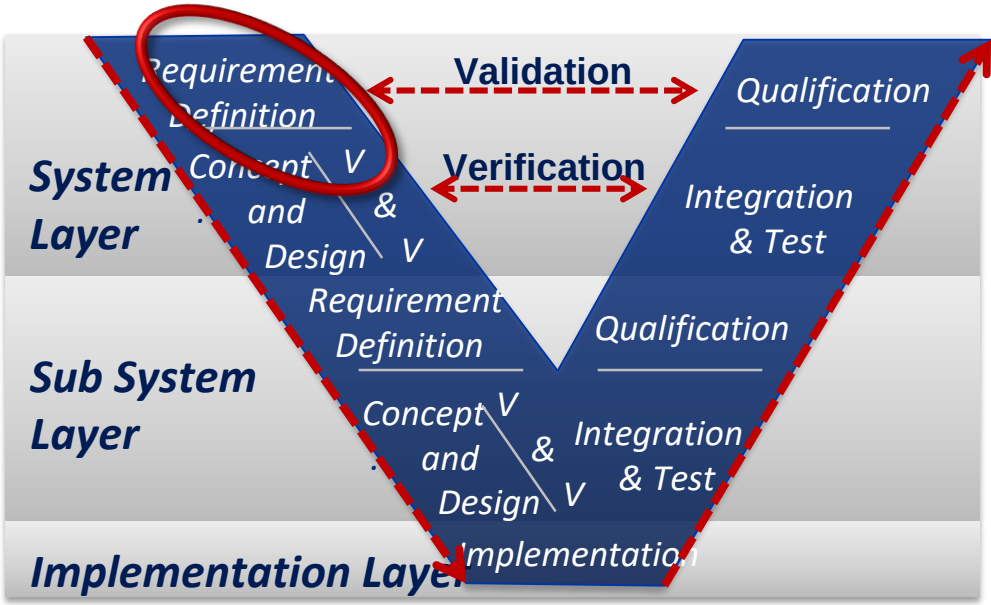
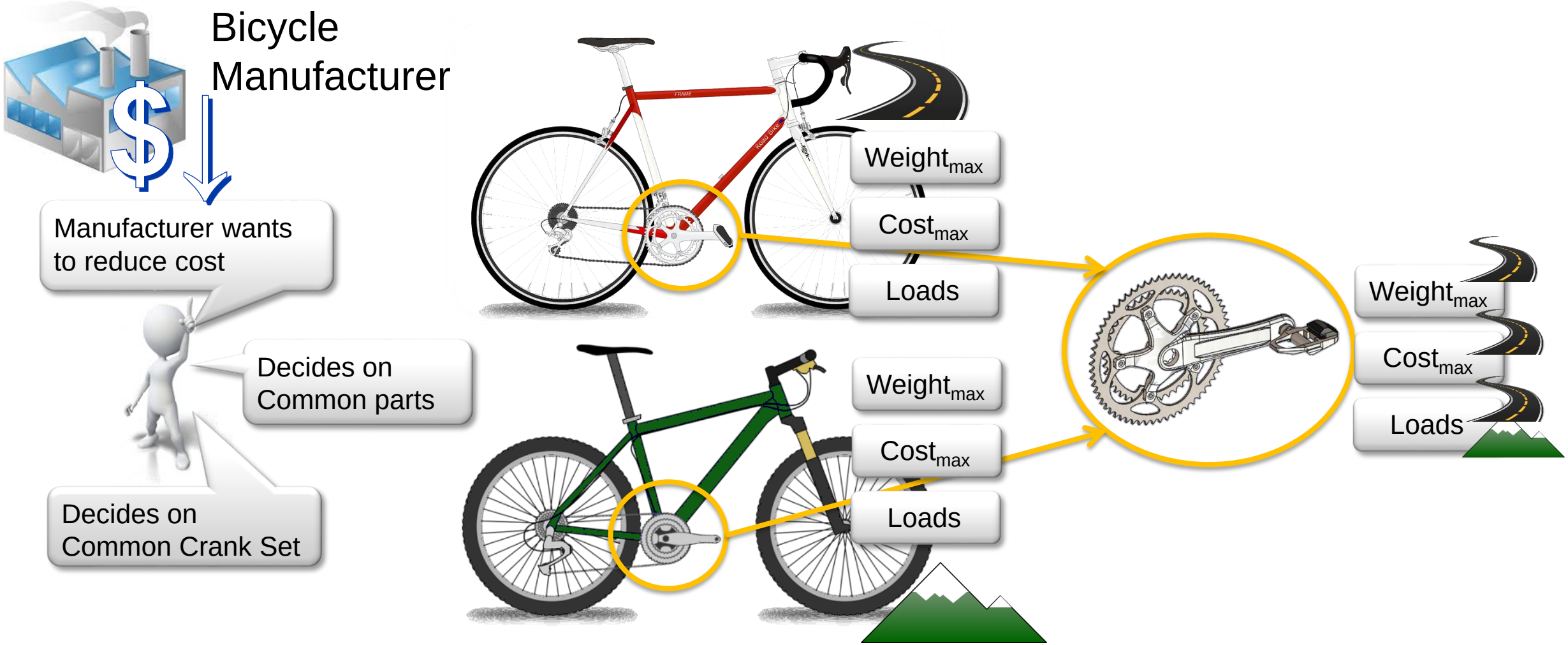


MBSE Example: Requirement Definition & Validation (overview)



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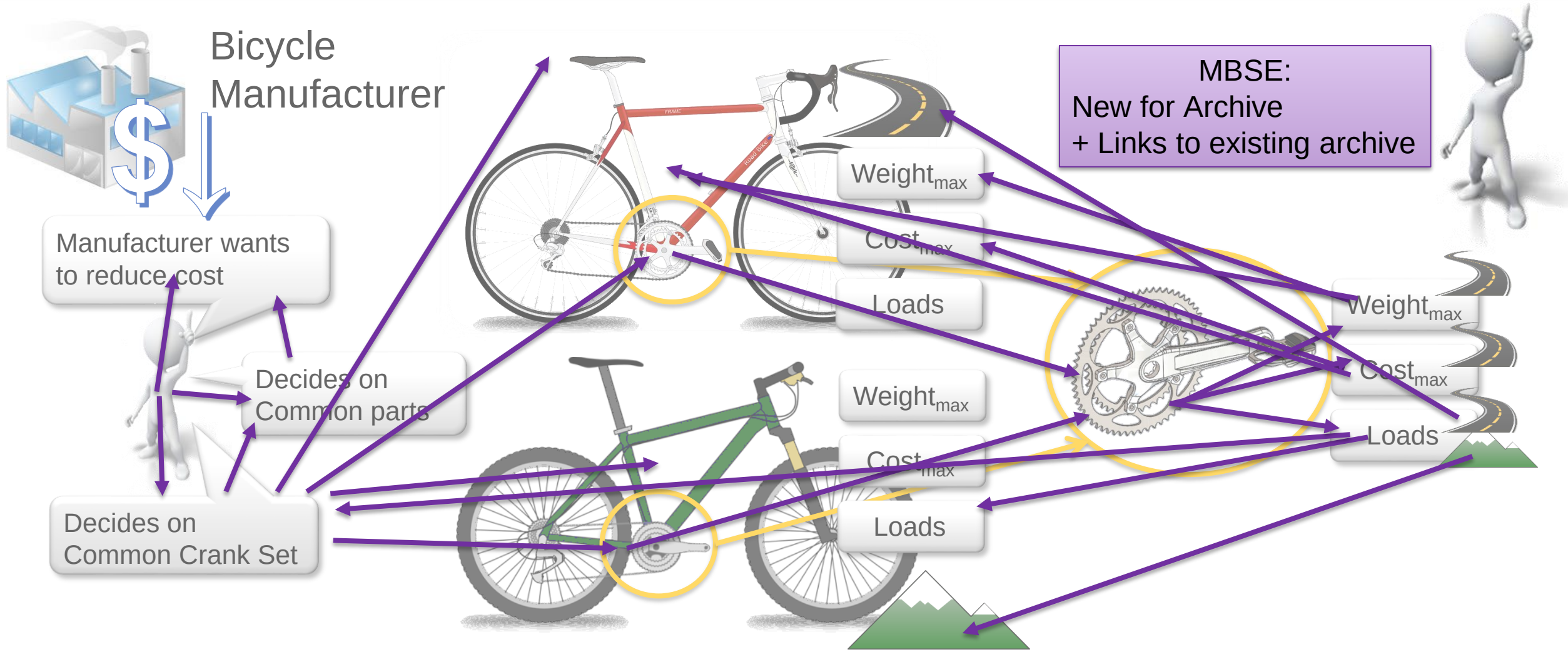

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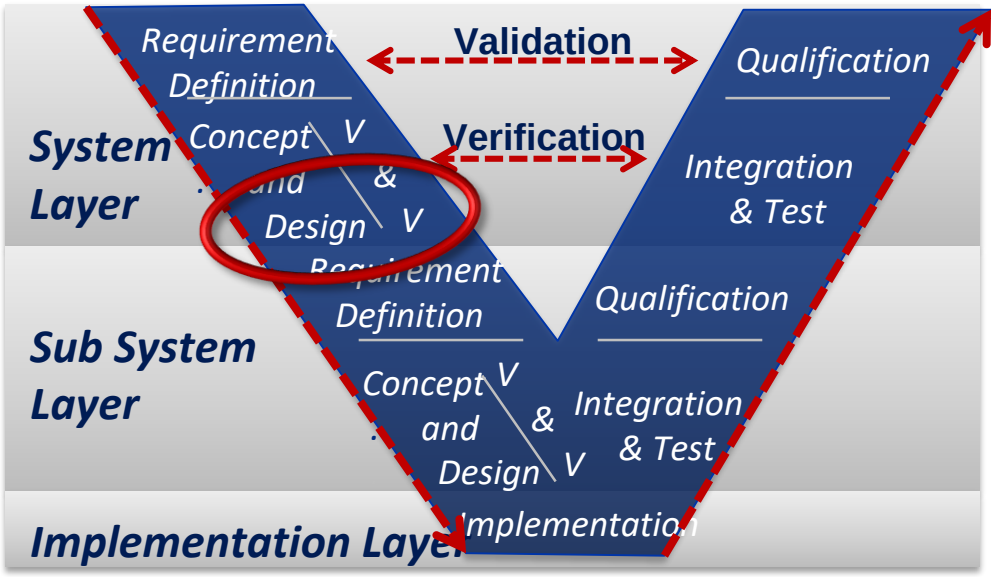
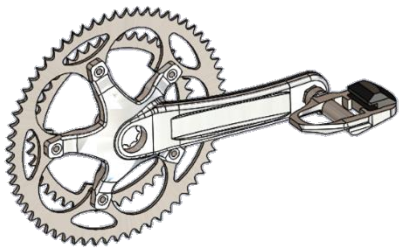


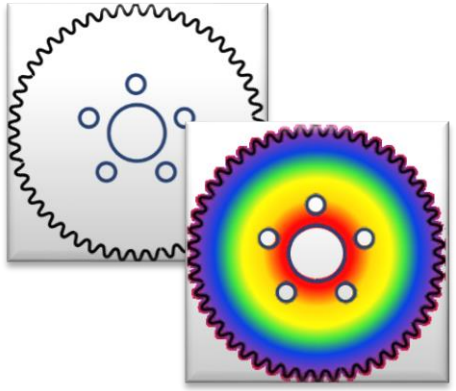
MBSE Example: Design and Requirement Verification (overview)



Weight$_{max}$

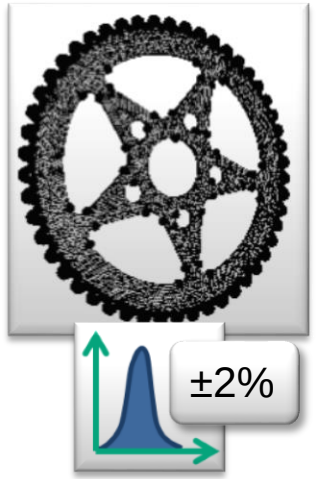
Cost$_{max}$

Loads



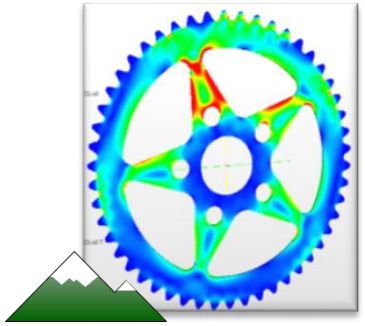
Cost | -10%

Weight | +5%



±2%

Loads | +30%



Loads | +10%

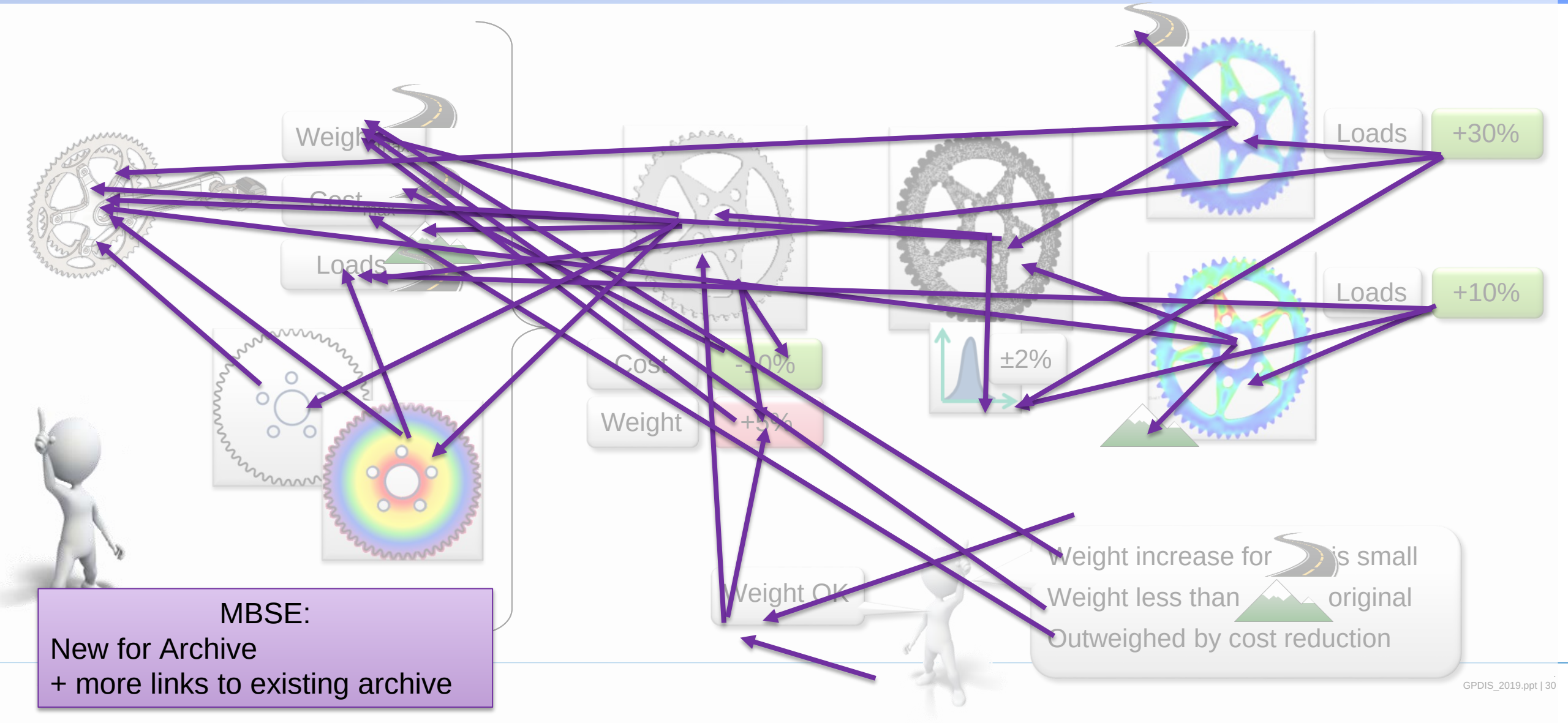
Weight OK

Weight increase for is small

Weight less than original

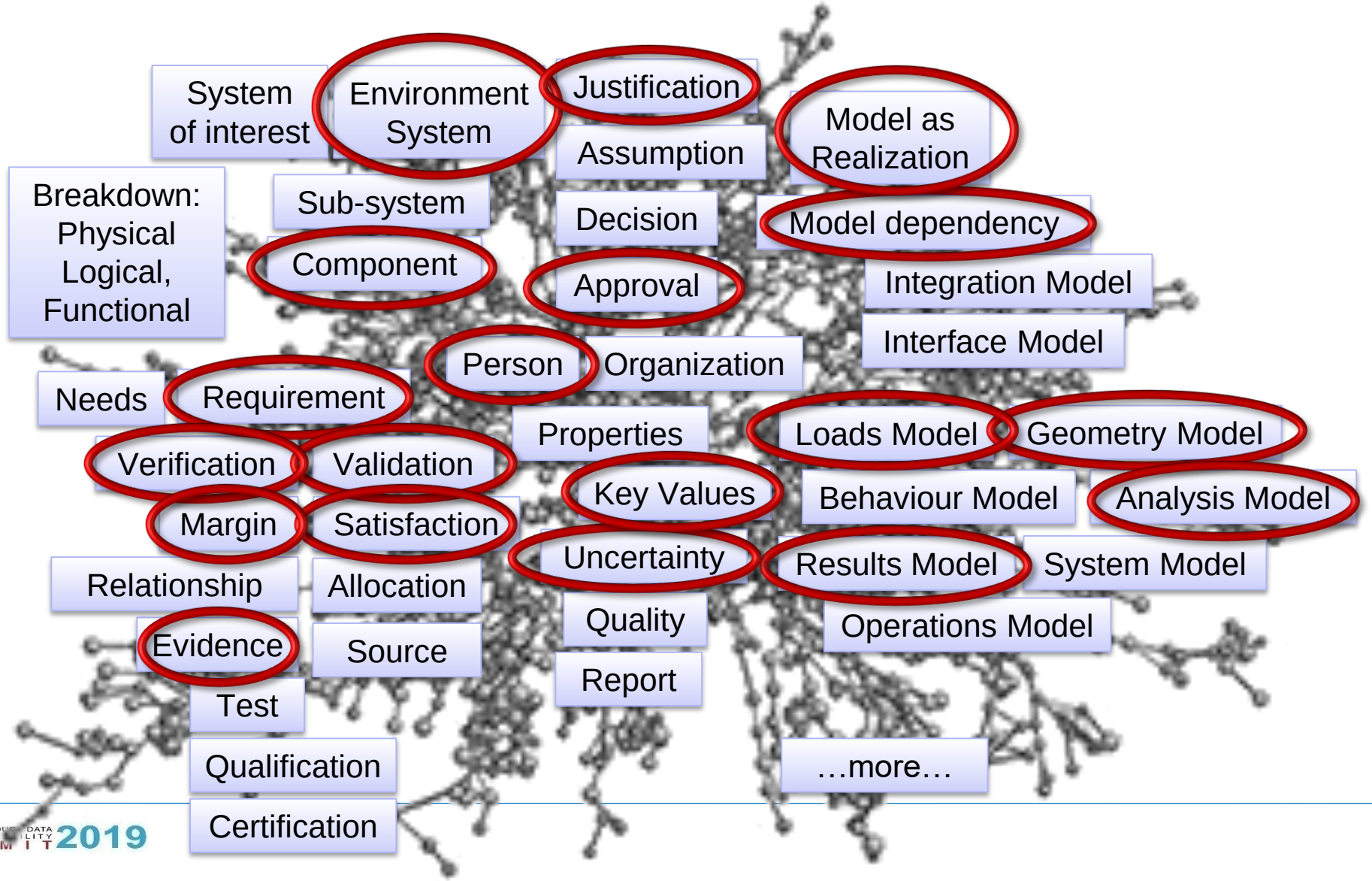
Outweighed by cost reduction

MBSE Example: Design and Requirement Verification (overview)



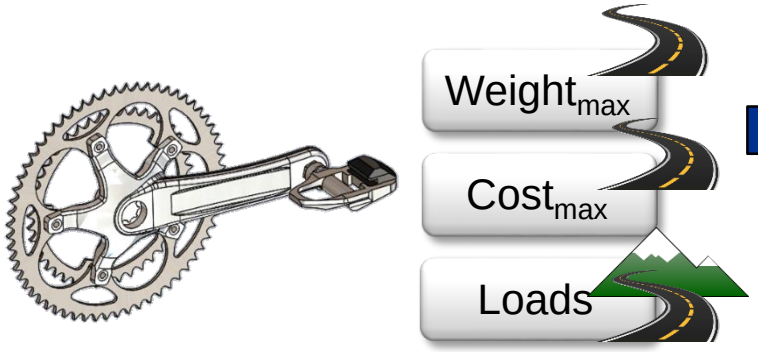
MBSE:
New for Archive
+ more links to existing archive

MBSE Example: Design and Requirement Verification (overview)

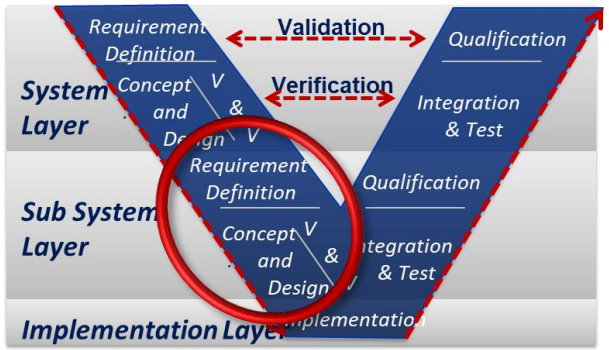


MBSE Example – Summary

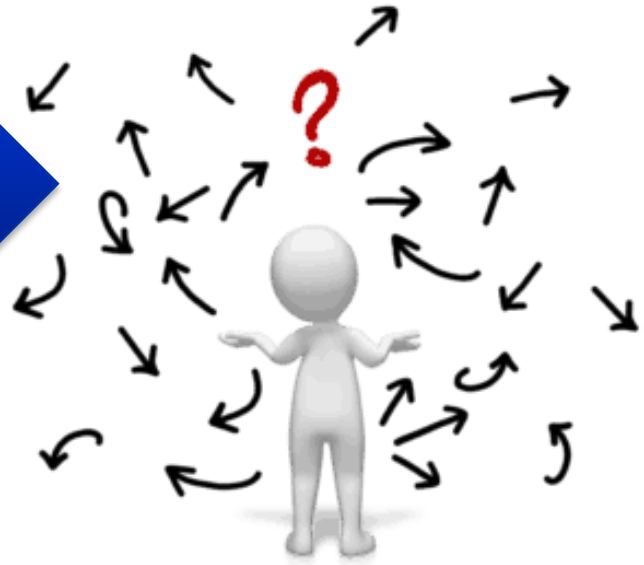
Simple Example:
MBSE Data overview



Partial V-Cycle



Already a
complex problem



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High level requirements for archiving and retrieving MBSE data

- **Archive all the "required" data**
  - **Not just the models but also the links between the models**
- **Ability to retrieve usable data in N years time**
  - **Where N can be greater than 50**
- **Use standard processes**
  - **E.g. ISO 14721**
- **Use standard data formats**
  - **E.g. ISO, W3C, OMG etc**
- **Exploit existing work in the area**
  - **E.g. LOTAR project**

LOTAR – Long Term Archiving and Retrieval

Americas Sector Chair

Boeing Rick Zuray

Hosting organization
PDES, Inc.

Hosting organization
AIA
AIA-EMC

European Sector Chair

Airbus Jean-Yves Delaunay

Hosting organization
ASD-STAN
ASD-SSG

Hosting organization
ProSTEP iViP

TAC
Technical Advisory Committee

Certification Authority
FAA

Regulatory Authority
DoD

TSC
Technical Steering Committee

Certification Authority
EASA

Regulatory Authority
National MoDs

LOTAR International Project Group

Voting Members
Associated Members
Contributing Members

Vendors & Implement.
CAx-IF

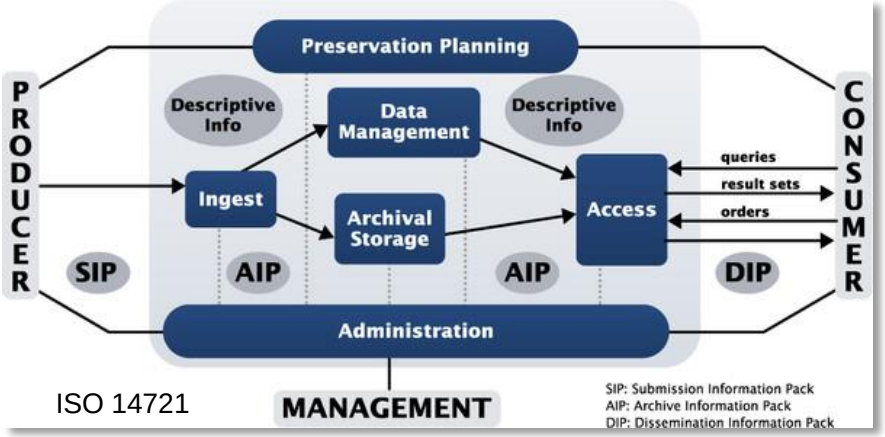
Vendors & Implement.
xDM-IF

Standardization
ISO, OASIS

Standardization
EN, NAS

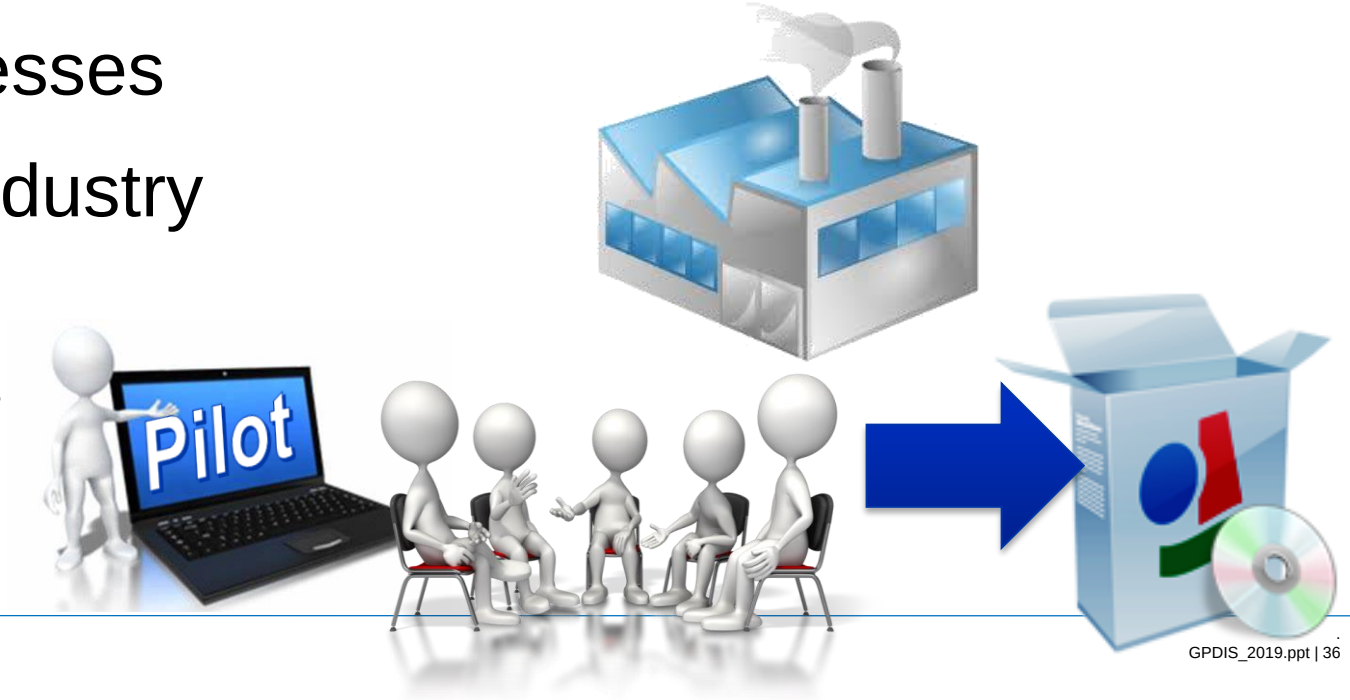
LOTAR Goals for Archive and Retrieval

International Organization for Standardization



ISO 14721

- Develop a standard series
  - ASD-STAN: European Norm (EN) 9300-xxx series
  - AIA: National Aerospace Standard (NAS) 9300-xxx series
- Standardize Methods and Processes
- Provide recommendations for industry
- Enable COTS
  - via Funded Pilots + Implementer Forums



LOTAR – member companies

Member Organizations:

- AFNeT
- Airbus Commercial Aircraft
- Airbus Defence & Space
- Airbus Helicopter
- BAE Systems
- Boeing
- Embraer
- GE
- Gulfstream
- Lockheed Martin
- SAFRAN
- Sandia National Laboratories

Solution & Service Providers:

- ACCR, LLC.
- ADV/DM
- Autodesk
- Cimpa
- CT CoreTechnologie
- Dassault Systemes
- DataKit
- Elysium
- Eurostep
- International TechneGroup
- Jotne EPM Technology
- PROSTEP AG
- PTC
- Siemens PLM
- Techsoft 3D
- Theorem Solutions

Contributing Members:

- NIST
- Purdue University
- Wichita State University

www.lotar-international.org/lotar-organization/member-companies.html

LOTAR International project Technical Working Groups

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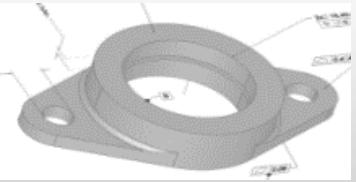
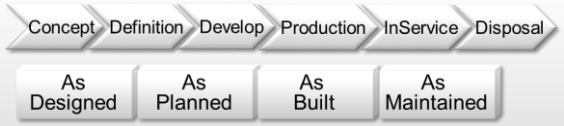
Mechanical 3D CAD with Product and Manufacturing Information (PMI)



STEP:
AP203
AP214
AP242

EN/NAS 9300-1xx series 2004 →

Product Data Management (PDM)



STEP AP239, AP242

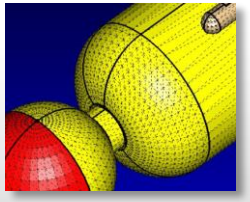
EN/NAS 9300-2xx series 2004 →

Composites and Advanced Manufacturing

STEP AP203 AP242

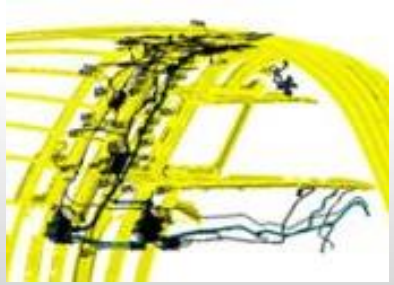
EN/NAS 9300-3xx series 2009 →

3D Visualization



Requirements and Compliance Documents 2012 → 2017

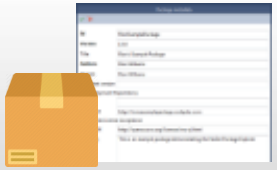
Wiring Harness



STEP
AP242

EN/NAS 9300-4xx series 2012 →

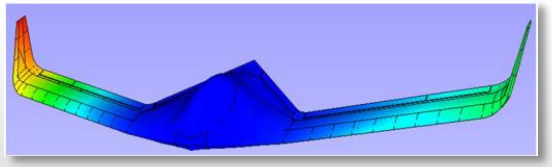
Meta Data for Archive Packages



STEP
AP239
AP242

EN/NAS 9300-21 2012 →

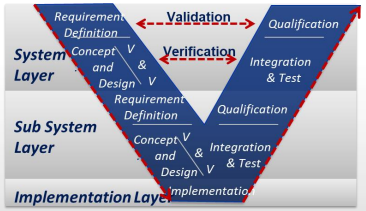
Engineering Analysis and Simulation



STEP AP209

EN/NAS 9300-6xx series 2014 →

MBSE



STEP AP233 , AP239, AP242, AP243
FMI, SysML, AADL. …more…

EN/NAS 9300-5xx series 2018 →

Common Process and Basic parts

EN/NAS 9300-001-099 series

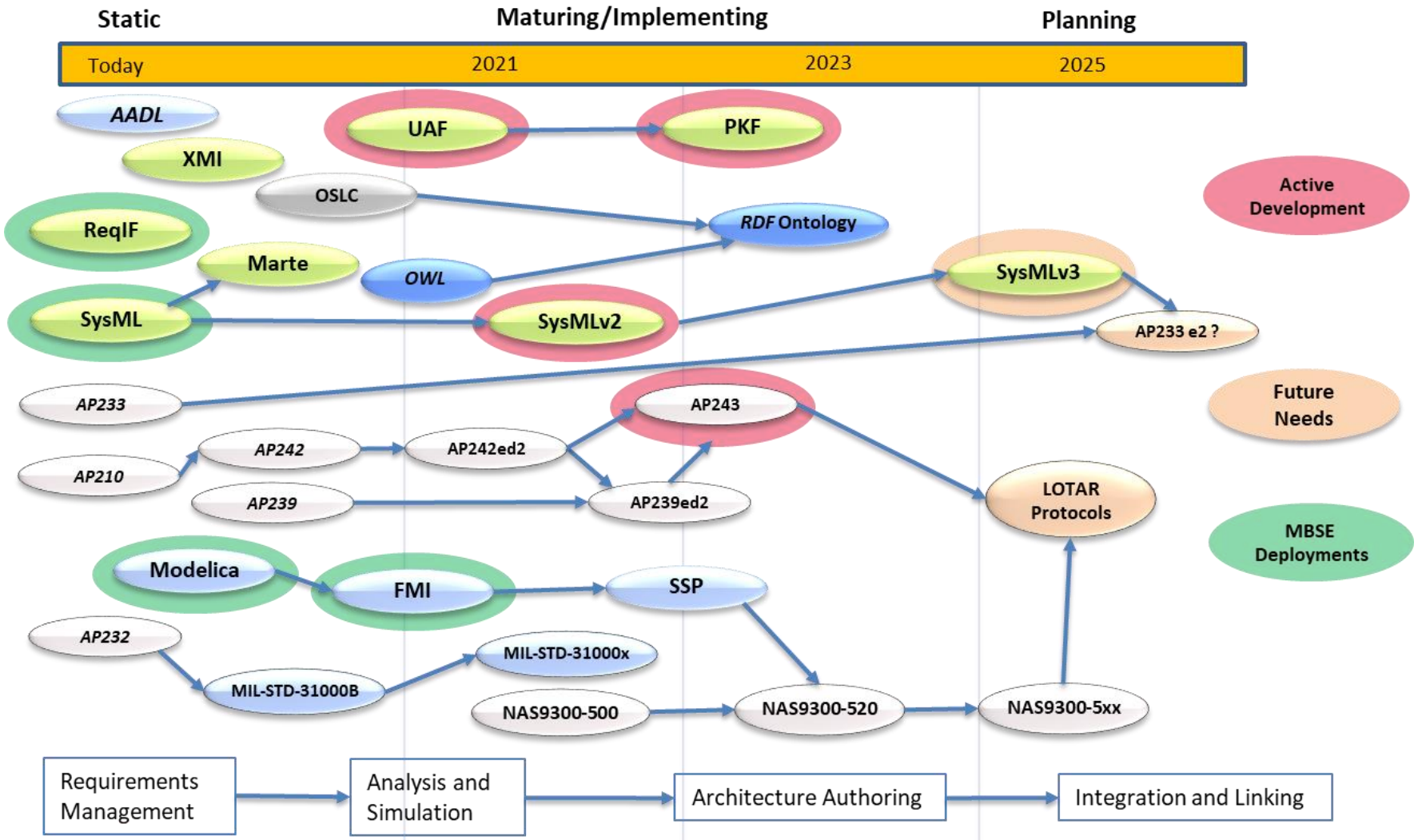
2004 →

LOTAR MBSE WG - standards under consideration

- **ISO 10303:**
  - **AP232 – Technical data packaging**
  - **AP233 – Systems Engineering**
  - **AP239 – Product Lifecycle Support**
  - **AP243 – Collaborative aspects of MBSE**
- **OMG:**
  - **SysML**
- **SAE:**
  - **AADL**
- **Modelica:**
  - **FMI – functional mock-up interface**
- ***… more …***

MBSE for PDES – Proposed Standards Roadmap

Global Product Data Interoperability Summit | **2019**



Partners ISO MODELICA OMG OASIS W3C PDES, LOTAR, AFNeT, prostep ivip, INCOSE, NASA MBSE community

LOTAR MBSE Working Group – Planned parts breakdown

- **500: Fundamentals and Concepts**
- **510: Requirement** management “text, graphics, table based” and “parameter based” information
- **515: Validation and Verification** requirements information (expanding Part 510)
- **520: Analytical models** described by specification or executable code, containing differential, algebraic and discrete equations
- **530: Models** defined using **architecture description languages** (ADLs), ISO 42010, e.g. industry standards: AADL, SysML, UML

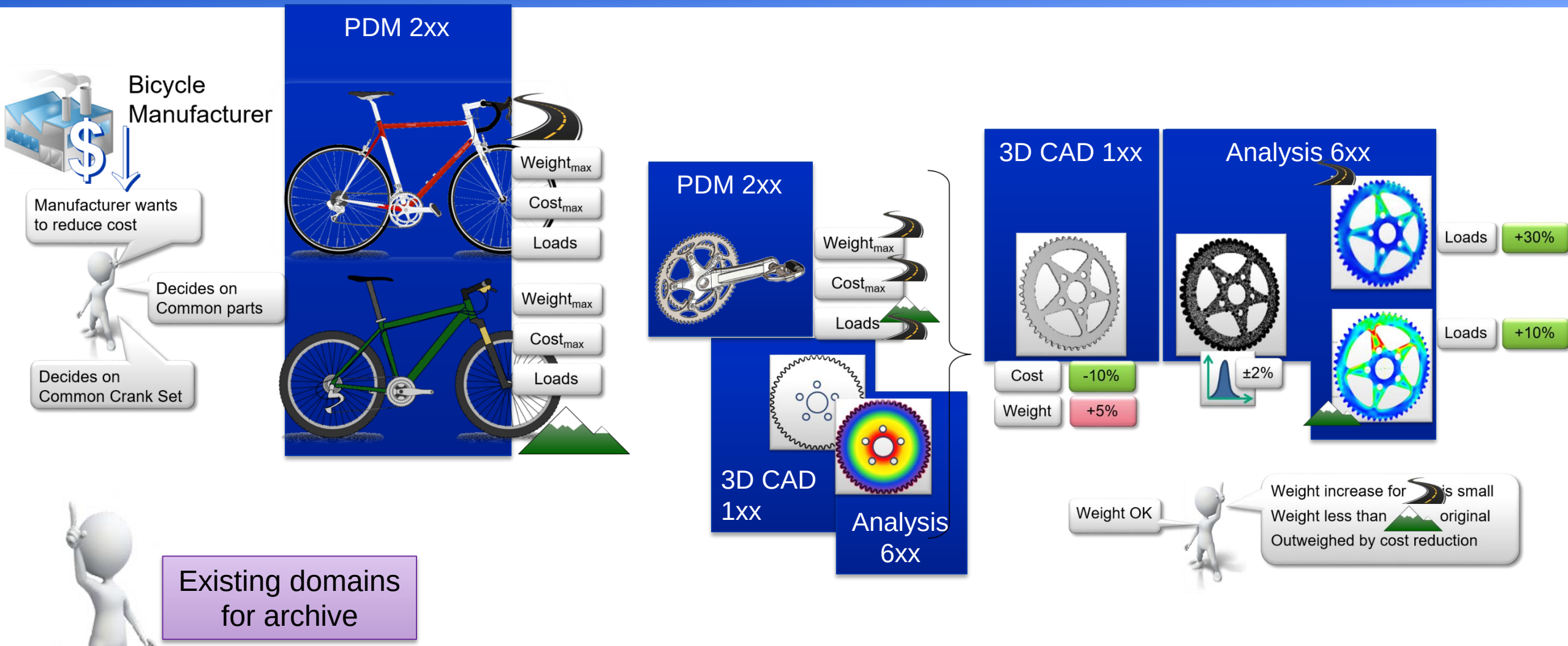
LOTAR MBSE Working Group Status

- **Meetings / Workshops**
  - Kick off meeting Q4 2018
  - Three F2F workshops
  - Bi-weekly teleconferences
- **Deliverables**
  - Draft P500 (MBSE concepts) created
  - P520 (Analytical models) will be developed next
  - Use Case demonstrators being specified for development in 2020
- **Contact the following to be involved:**

Mark Williams
The Boeing Company
Mark.williams@boeing.com

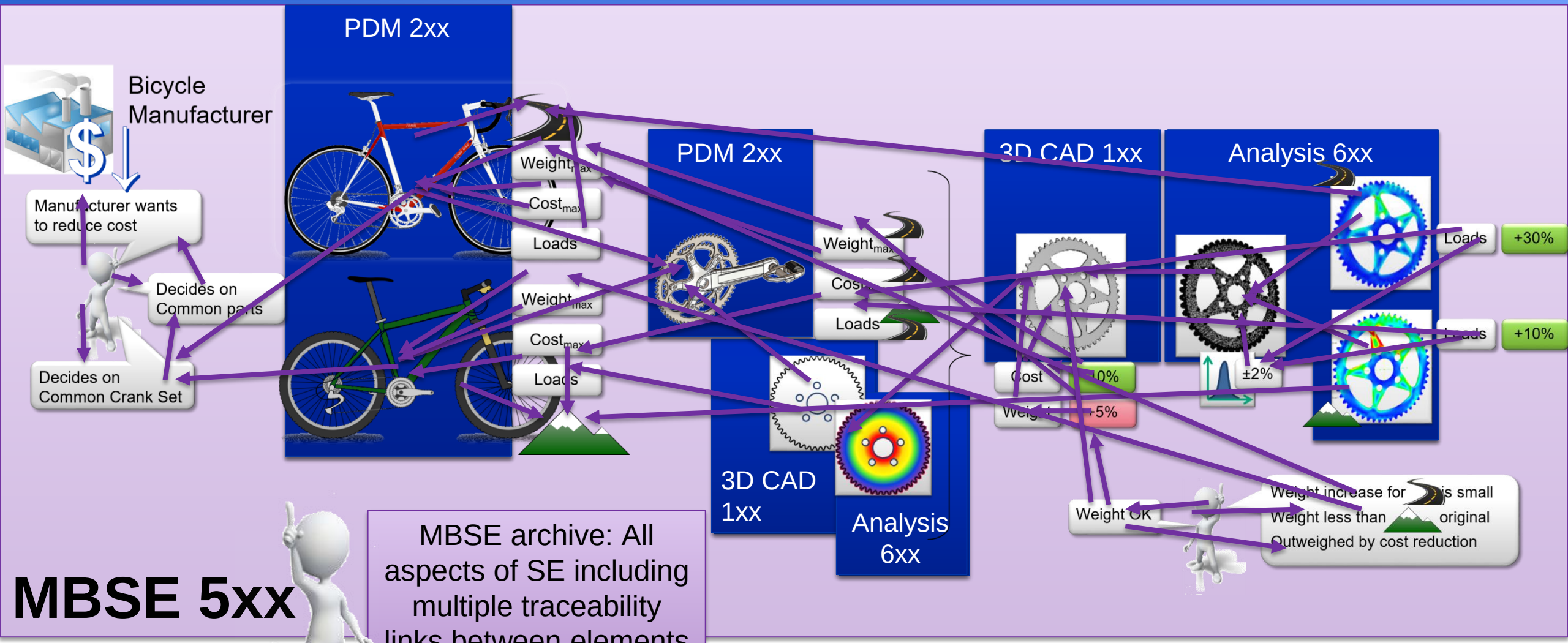
Ad Murton
Airbus Operations Ltd
Adrian.murton@airbus.com

LOTAR Parts coverage on Bicycle example



Existing domains for archive

LOTAR MBSE parts coverage on Bicycle example



MBSE archive: All aspects of SE including multiple traceability links between elements

MBSE 5xx

Agenda

- **Why do I need to archive MBSE data?**
- **What MBSE data do I need to archive?**
- **How do I archive MBSE data?**
- **Summary**

Summary

- **Why:**
  - **To satisfy regulatory and business needs**
  - **As MBSE becomes the default way of working, there is a need to archive and retrieve the data**
- **What:**
  - **The contextual data to support the model based lifecycle**
- **How:**
  - **LOTAR MBSE WG – de facto lead for Aerospace companies**
  - **Early days – opportunity to be involved and influence**

Any Questions?