Operational Analysis and Mission Engineering: A strategy and framework to analyze any industrial ecosystem

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Research Completed:

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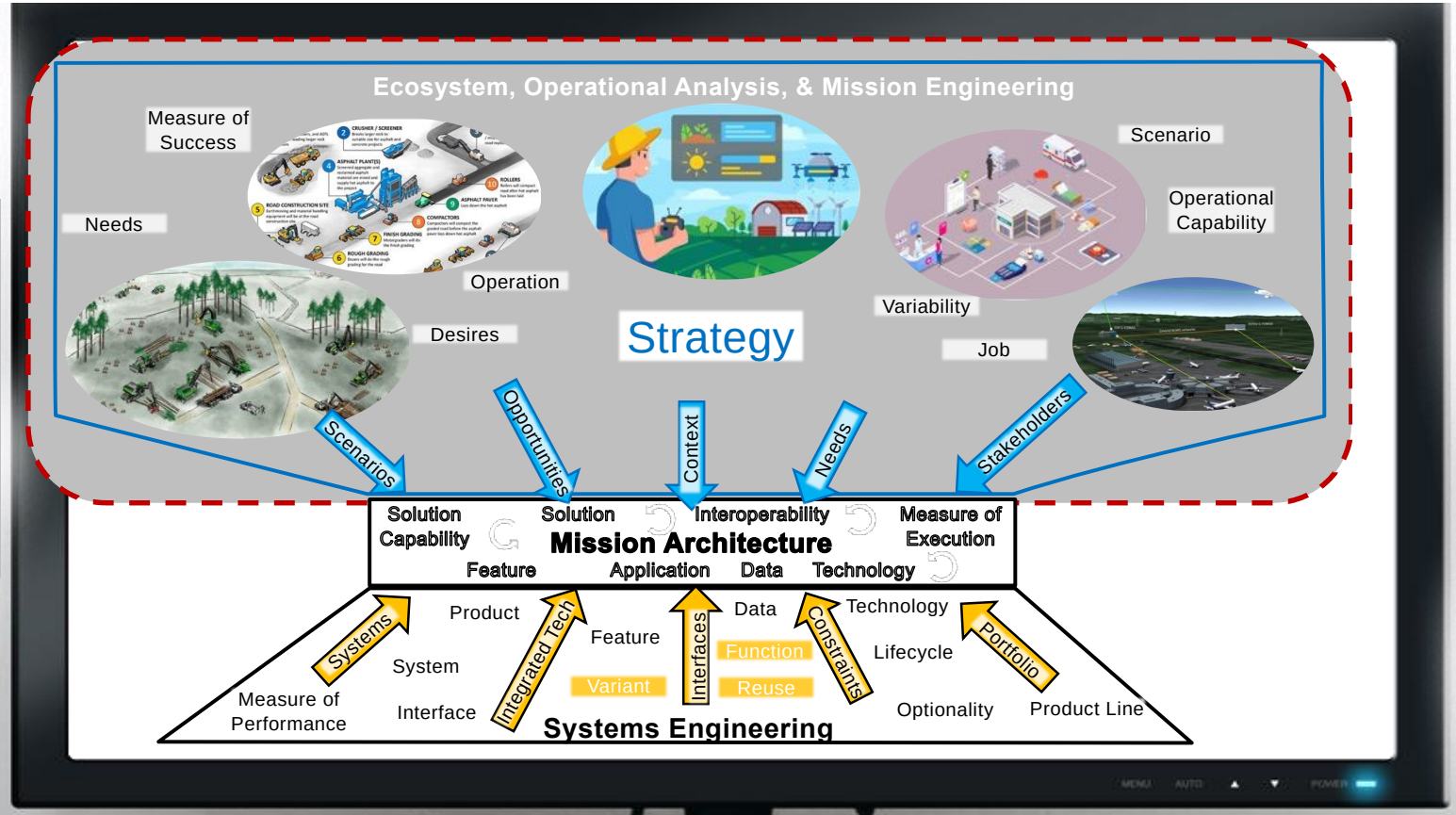


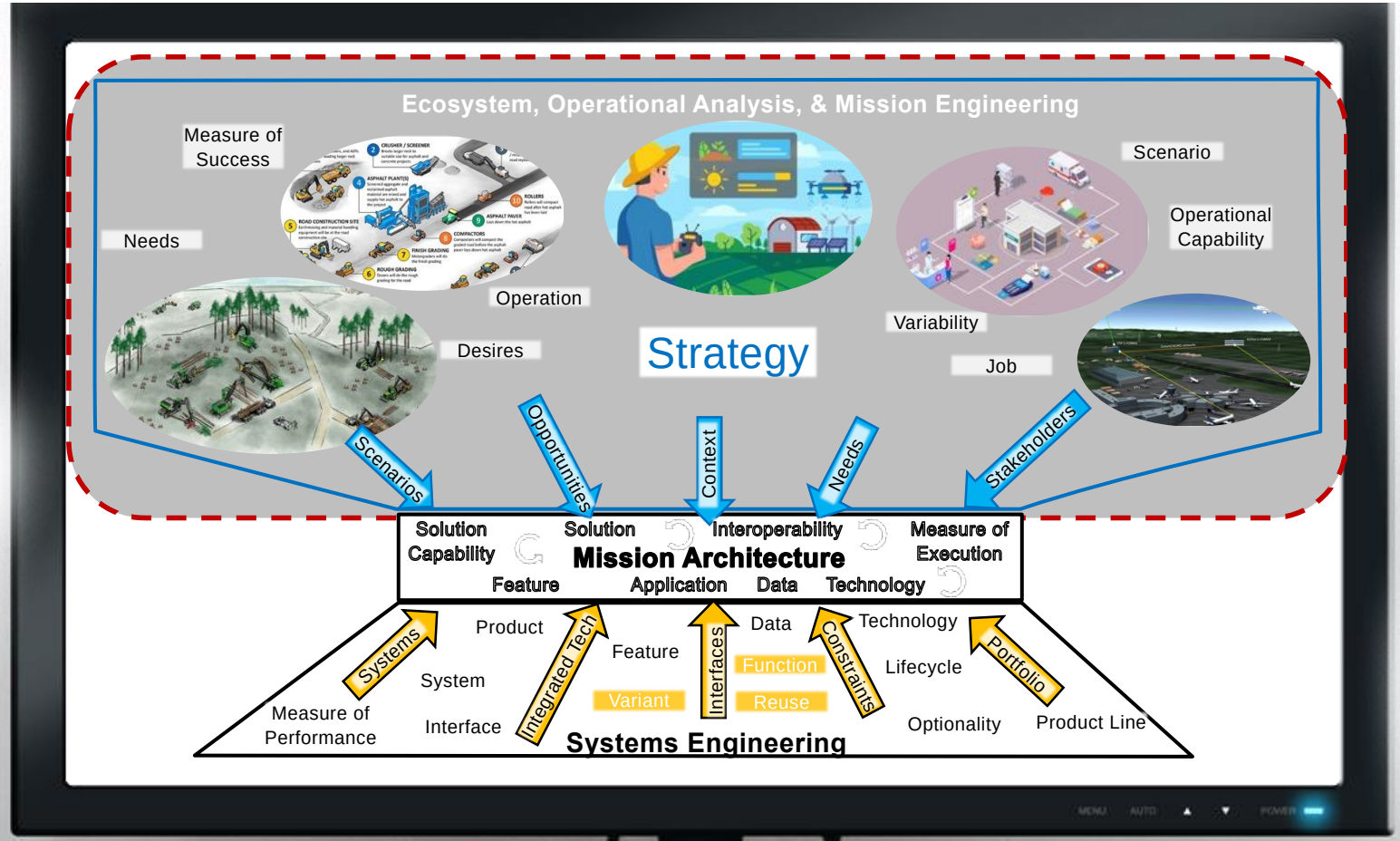
Agenda

- Background
- Industrial Ecosystems
- Operational Ontology
- Operational Analysis
- Mission Engineering & Mission Threads
- Future Work

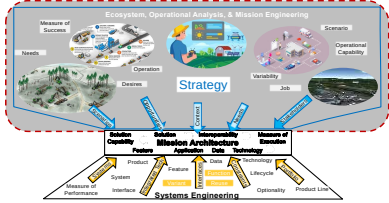
Problem Statement

- **To** deliver a framework and structure that can be adapted and tailored within an industry when operational analysis and mission engineering are required (Value Needed)
- **By** understanding both the inherent relationships within and the dependency between operational analysis and mission engineering (Action Needed)
- **Using** existing principles, architecting methods, tools and practices consistent with academic research and governance (Process or System Delivering Value)
- **While** satisfying thesis requirements for the MIT System Design and Management program completion

Industrial Ecosystems

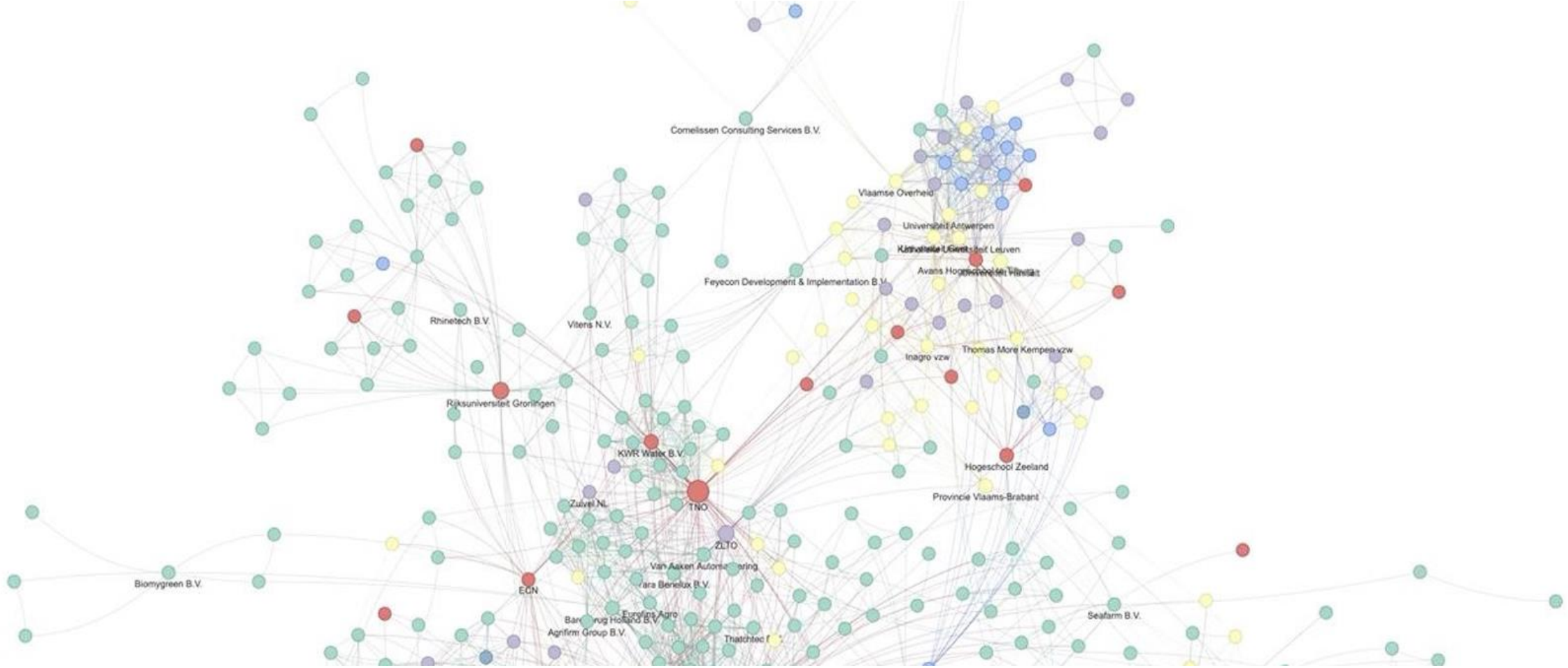


Industrial Ecosystems

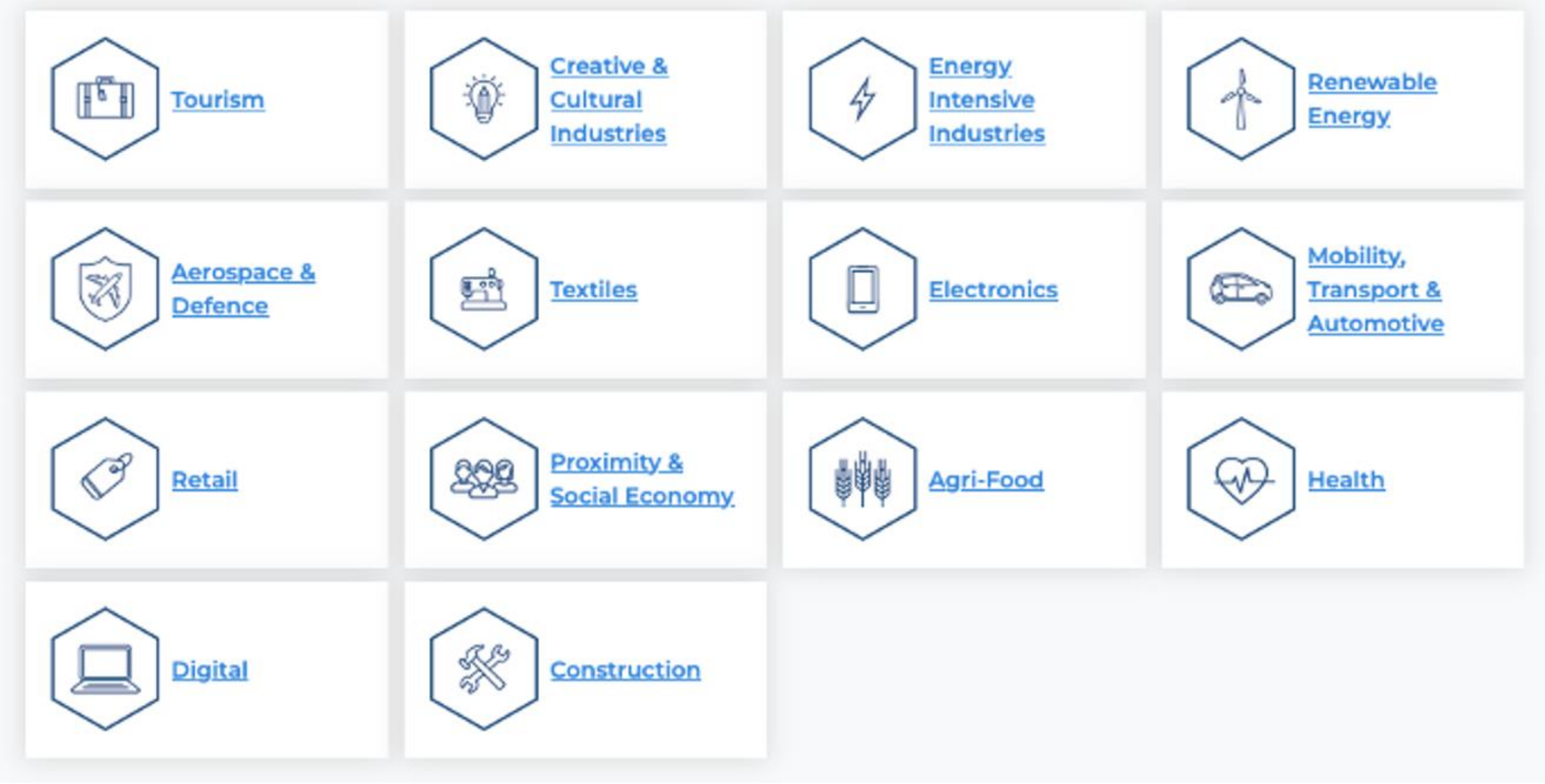


- **Industrial ecosystem** - A systems-based multidisciplinary description that seeks to understand the emergent properties of value-added and non-value-added behaviors of a complex combination of human/natural systems
  - The industrial ecosystem encompasses the entire flow of goods and services from the source to consumption, not just the individual enterprise that resides within the specific industrial ecosystem category
  - Understanding these ecosystems allows us to understand the socioeconomic and sociotechnical implications within a categorized ecosystem
- Enterprises tend only to understand where their products, process, and services are used
  - They can take advantage of significant opportunities to provide additional value to their stakeholders through an aligned strategy
  - They want to understand the sociotechnical and socioeconomic risks over the long term in a socially responsible way, as society demands this in the 21st century
  - They need to consider the why, what, and how of the industrial ecosystem when developing an enterprise strategy

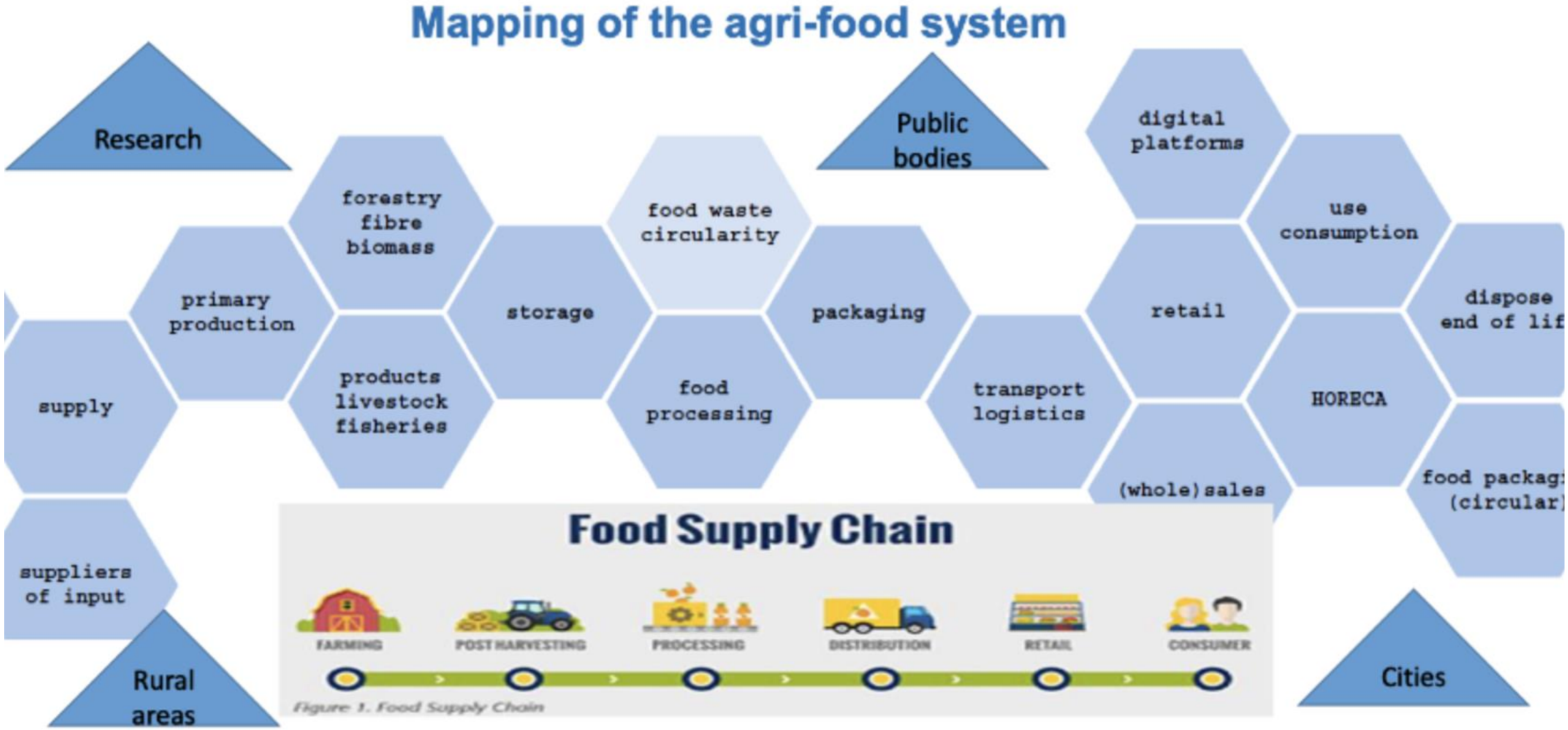
Example Ecosystem –
Tracing of complex links across firms, sectors, and institutions



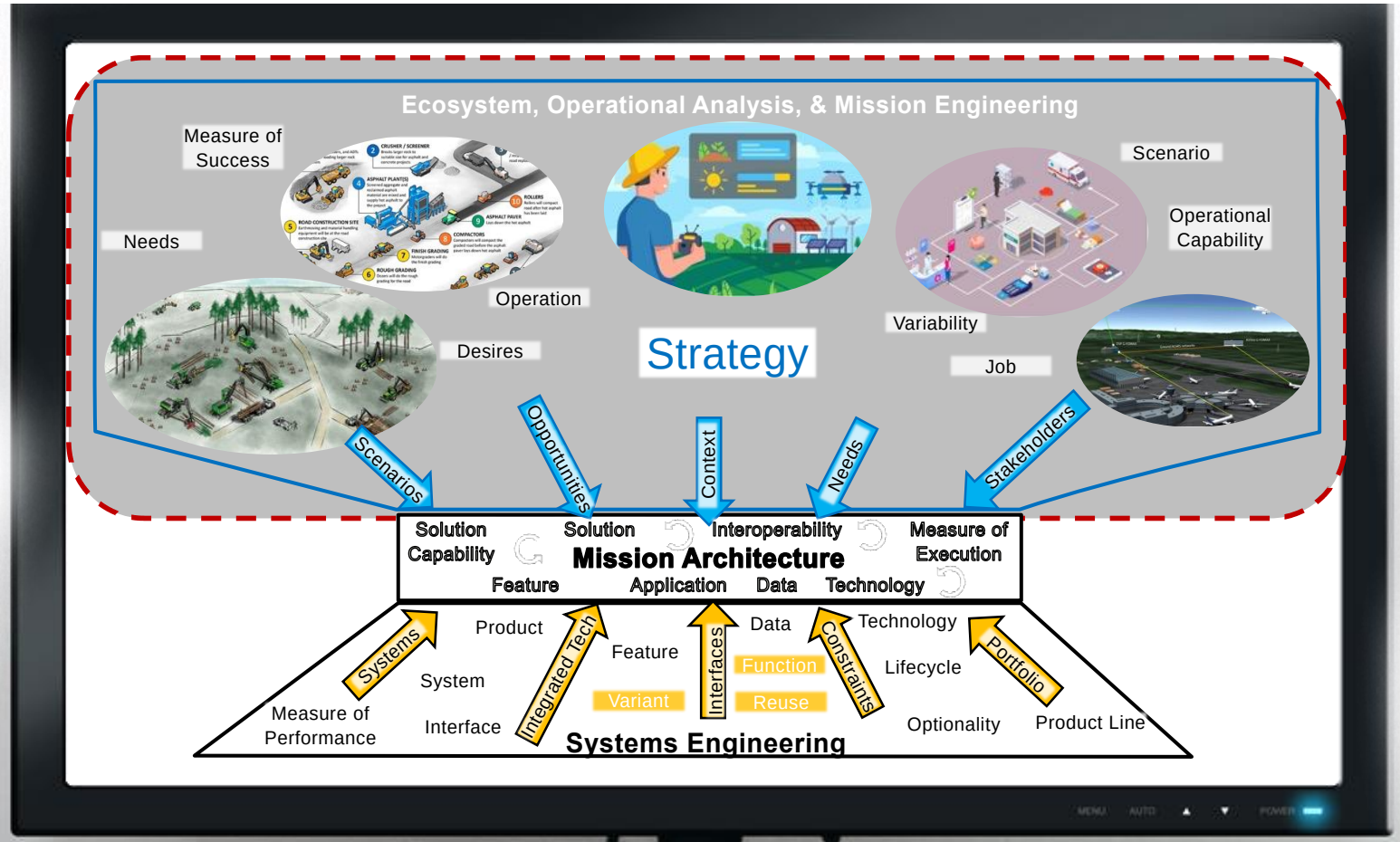
Industrial Ecosystem Classification (Ref: Industrial Ecosystems/European Cluster Collaboration Platform)



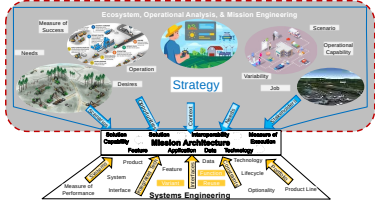
Complex Relationship Network (Interfaces)



Operational Ontology



Operational Ontology



- **Operational Ontology** – Decompose industrial ecosystems into an ontology that would provide hierarchical categories to apply fundamental system design, management principles, and tools to enhance our operational understanding.
  - Enterprises, during strategy development, need structures of elements for the classification and explanation of these entities within the context of the systems
- I am capturing the knowledge within a certain domain as a model
  - The enterprise can answer complex questions through the relationships across the domain through this model
  - This enables the understanding of the information as a basis for structure
- Enterprises need to consider the why, what, and how of the operational ontology when developing an enterprise strategy in a logical/theoretical yet practical way
- Revise based on socioeconomic and socio-technical trends emerge

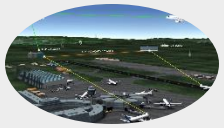
Operational Ontology Development

RM = Relationship Management

Industrial Ecosystem(s) (Healthcare, Commercial Aviation, Agriculture, etc.)







AOL 0

RM

Operational Analysis (Release Analysis to define missions)

AOL 1

RM

Mission Engineering (Release mission(s) for architecture development)

AOL 2

Research Needed

RM

Mission Architecture

AOL 3

Research Needed

RM

Technology Roadmap

AOL 4

Recently some work has been done

RM

Portfolio Management

AOL 5

Research Needed

RM

Product Development

AOL 6

Academic, industry, and INCOSE development

RM

Order Fulfillment

AOL 7

Research Needed

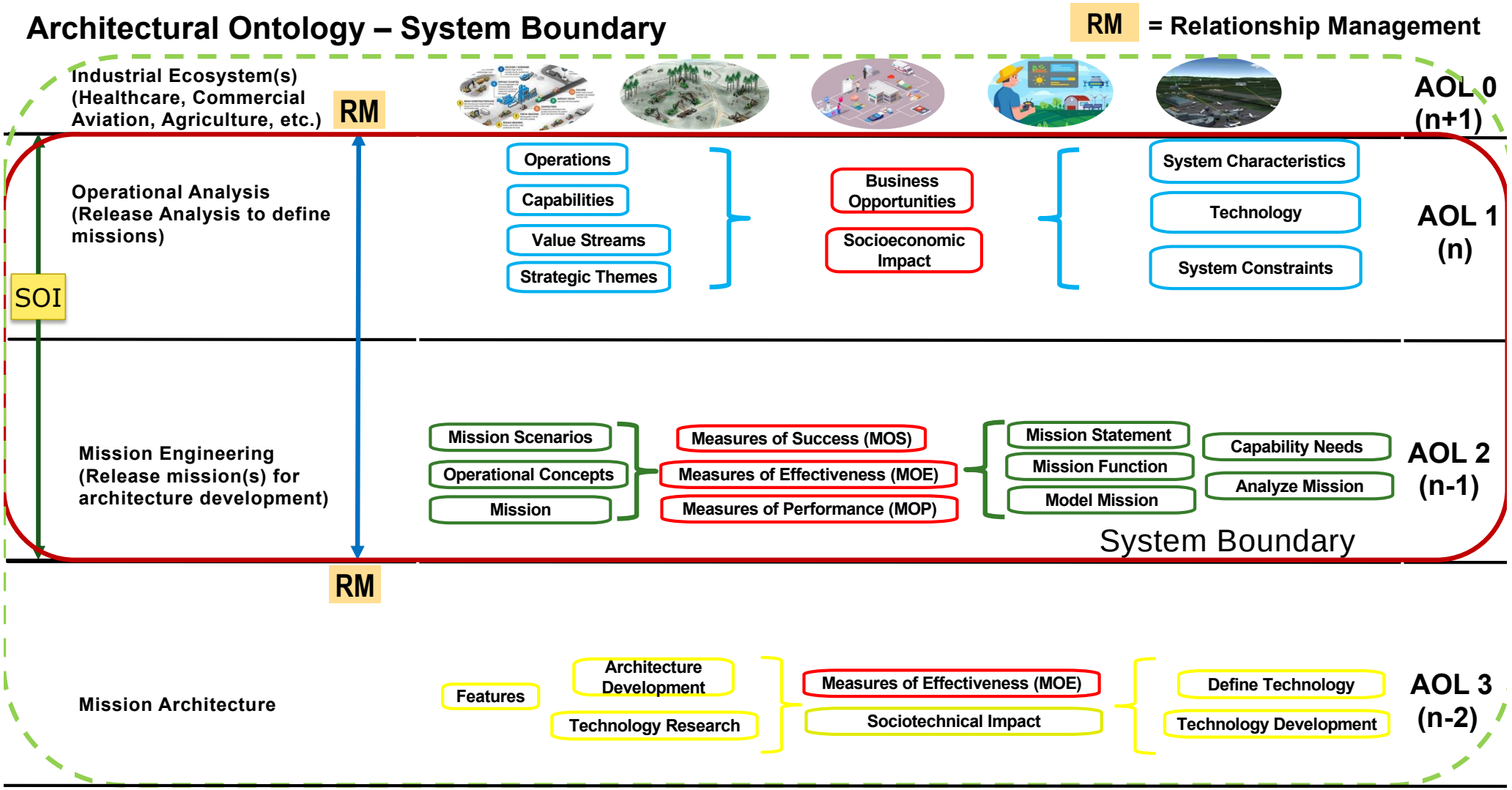
RM

Life Cycle Management

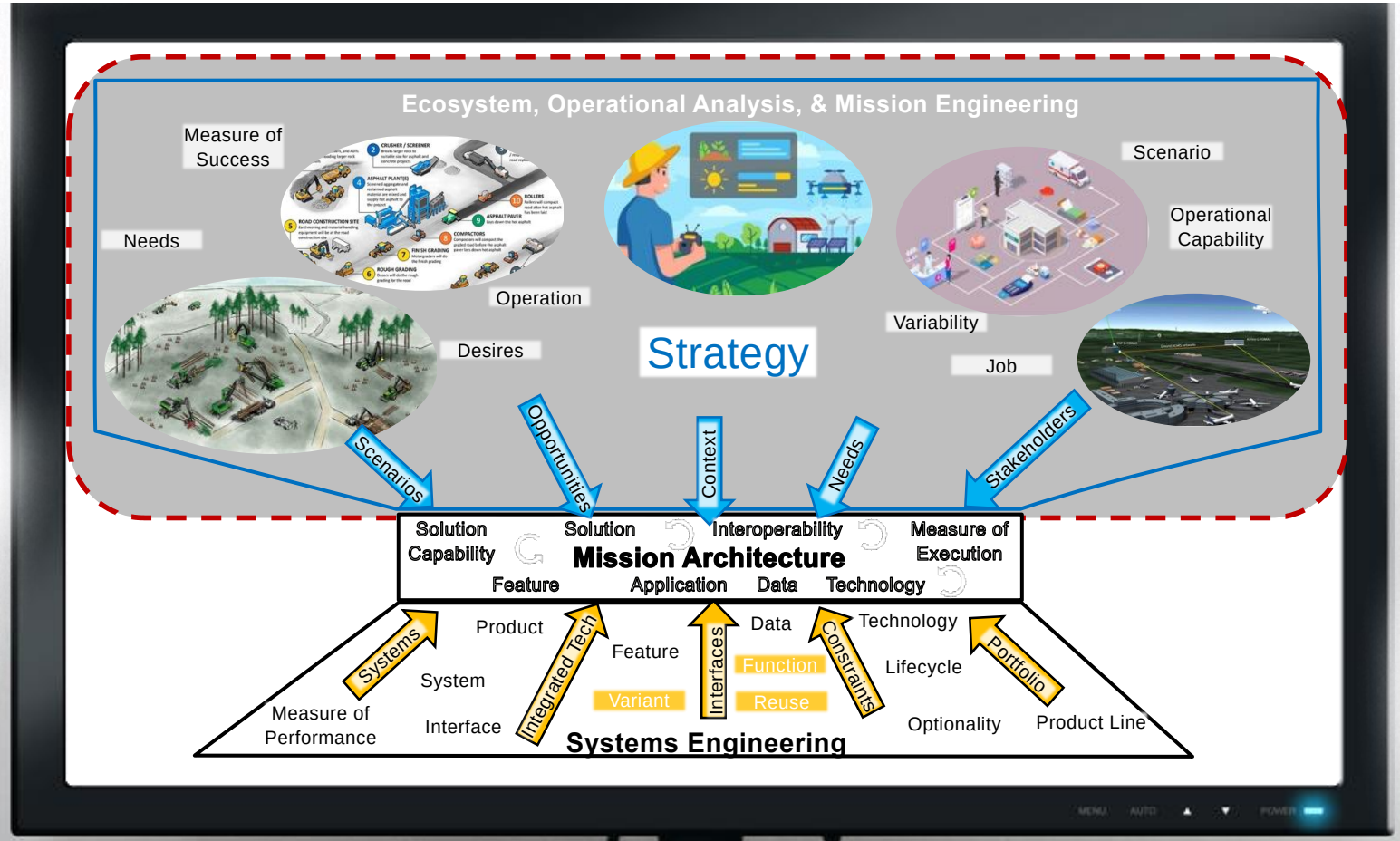
AOL 8

Research Needed

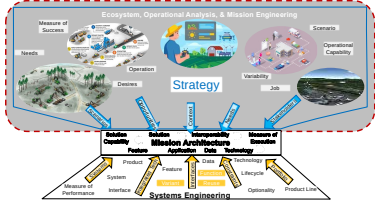
Architectural Ontology, Boundary, and Scope



Operational Analysis

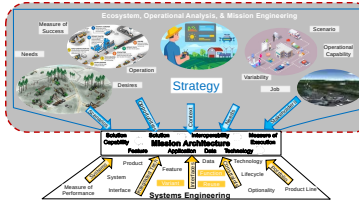


Operational Analysis and Mission Engineering



- Perform operational analysis on the Production System (SoS)
  - Examples: commercial aviation, healthcare systems, agriculture, infrastructure, mining, forestry, etc.
  - Define and develop scenarios
  - Identify potential business opportunities
- Engineer your missions (Mission Engineering)
  - Understanding the impact on operational analysis
  - Understanding Economic Headroom
  - Identify which mission provides the most business and customer value
- Identify technologies needed
- Review and align to business portfolio
- Develop mission architecture
- Define business and product strategy
- Initiate product and services projects to meet customer and business need

Why, What, and How of Operational Analysis



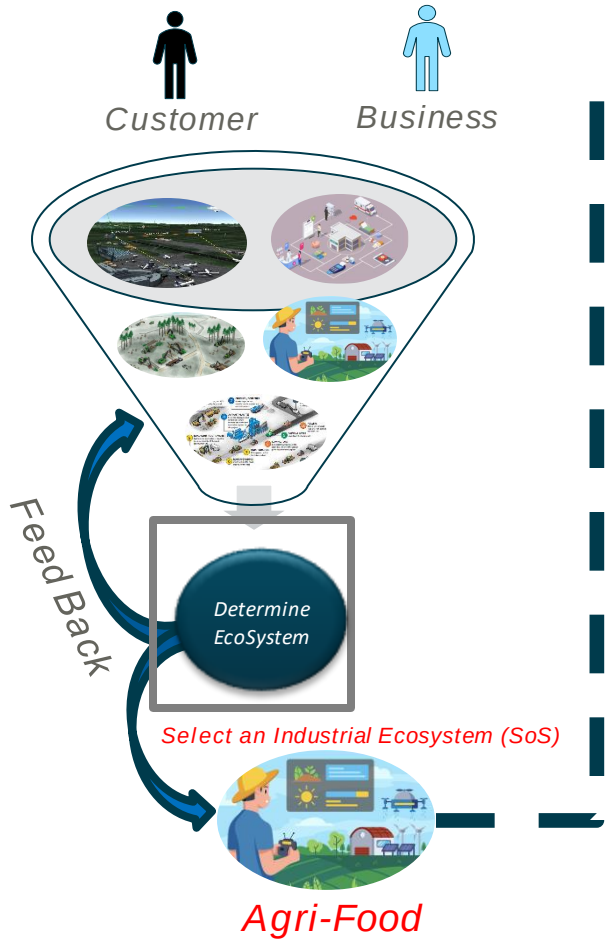
- **Why Operational Analysis?**
  - Today many enterprises only think about the internal environment in the form of products, services, and processes
  - To remain relevant, they must understand how they fit in the larger ever-changing ecosystem
  - Innovation must understand the sociotechnical and socioeconomic impact on the ecosystem to affect the enterprise positively

- **What is/is not the Operational Analysis?**
  - Operational analysis is an external look to recognize gaps and opportunities to assist in identifying emerging needs, technology, etc., for sustainability and innovation within an enterprise

- **How does Operational Analysis work?**
  - It defines the necessary operational characteristics and relationships within the larger context of the ecosystem
  - Then within this more extensive ecosystem, we can discern opportunities and threats to the enterprise
  - Identify all critical relationships within the broader ecosystem and our enterprise

- **What is the deliverable of Operational Analysis?**
  - A prioritized list of opportunities as well as critical relationships for technology and mission development
  - Assures our internal enterprise environment is aligned with the external ecosystem before engineering our missions
  - A ranked list of opportunities, relationships, and technology needed for mission engineering

Operational Analysis Process Map



Identify Operational Stakeholders
Define Operational Needs
Define Operational Depictions (Vignettes)
Define Operational Environment
Define Operational Characteristics
Define Operational Elements
Identify Operational Relationships
Define Operational Boundaries

Ecosystem

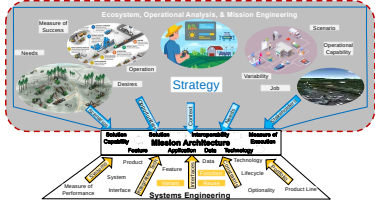
Identify Operational Stakeholders
Define Operational Needs
Define Operational Depictions (Vignettes)
Define Operational Environment
Define Operational Characteristics
Define Operational Elements
Identify Operational Relationships
Define Operational Boundaries

Enterprise

Select Operation (n -2)
Define Operational Measures
Define Operational Conditions
Define Operational Scenarios
No
Define SoS Entity
No
Define SoS Attributes
Identify Opportunities/Hypothesis
All Operations Reviewed

Production System

Release to Mission Engineering (n…)



Technology Swimlane

Ecosystem Swimlane

Opportunity

- Perform Operational Analysis
- Determine Economic Headroom
- Prioritize Opportunities
- Deliver Customer **Needs**
- Define Customer **Mission and KPIs** (MOS, MOE)

Opportunity

- Determine **Customer Price** Based on the capability of architecture to meet KPIs
- **Prioritize Architecture Development** based on ROI
- **Allocate R&D** Based on ROIs

Discovery

Architecture

- Identify Architectural Decisions
- Identify Technology Needed
- Tradeoff Alternatives
- Develop Tech Roadmap
- Define **Architecture**
- Author and Allocate **Requirement**
- Review and Approve Derived requirem

Development

Architecture

- **ROI** (*support PxPS*)
- **Value and Cost Allocation** to Products and Technology
- **Align Timelines** Across Portfolios

Delivery

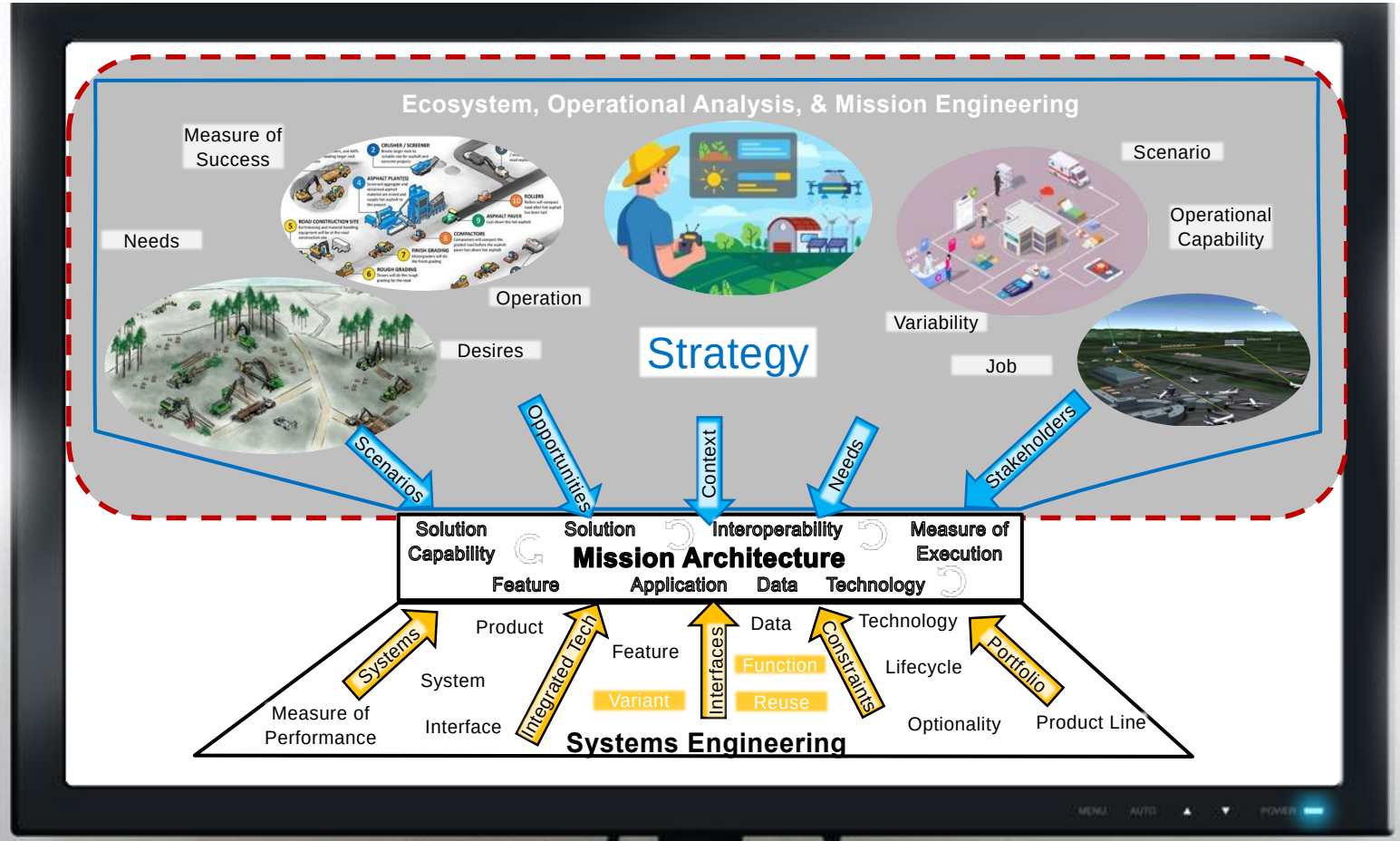
Execute

- Communicate **Current Capab**
- Derive **Requirements**
- Derive SLn+1 Reqs
- **Deliver Product** through PDP
- **Verify and Validate** Solution

Execute

- **Estimate Cost B**ased on Physical Architecture
- Calculate **ROI** from Allocated ROI and Product Cost (*supports PxP*)

Mission Engineering



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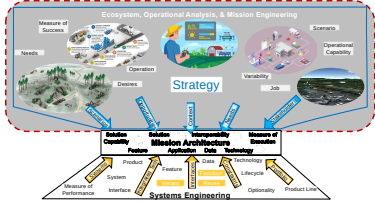

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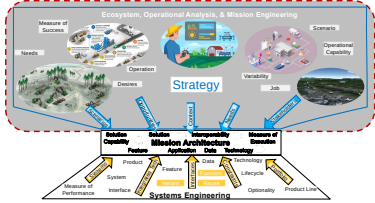
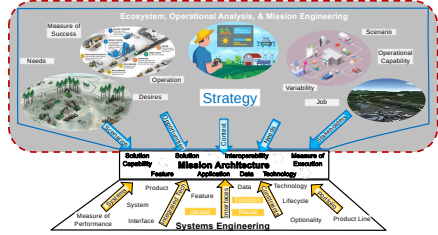
Why Mission Engineering?

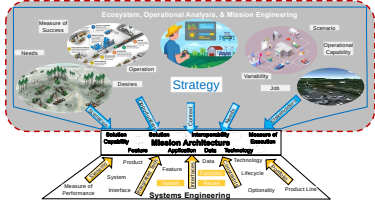


- Aligns operational opportunities and the respective relationships to the engineered missions within the operational ontologies.
- Assess the disruptive technology (competitive threats), with the socioeconomic (i.e. environmental) influences, to avoid business risk to the business from a financial and customer perspective
- The key first step is aligning the operational SoS to the engineered missions and assessing the sociotechnical impact.
  - Few attempts have been made to develop operational analysis and mission engineering from an overall SoS perspective
- Limited experience and knowledge exist within all industries

Why, What, and How of Mission Engineering



- **Why Mission Engineering?**
  - It assures our engineered mission(s) are aligned with the internal enterprise environment and the external ecosystem.
  - The output feeds the development of our internal mission architecture and technology roadmaps while maintaining alignment with the ecosystem
- **What is/is not the Mission Engineering?**
  - Mission Engineering analyzes the operational opportunities, relationships and technology, and acquisition needs through integration to achieve the mission goals in line with the internal and ecosystem goals
- **How does Mission Engineering work?**
  - Develops individual missions while maintaining the relationships between the internal enterprise and the external ecosystem
  - The missions are then stitched together to better understand the internal and external environment tradeoffs.
  - We also develop a detailed understanding of the socioeconomic and sociotechnical impacts and documents.
- **What are the deliverables of Mission Engineering?**
  - Internal enterprise mission(s)
  - Internal enterprise mission(s) relationships
  - Internal enterprise mission(s) relationships to the external ecosystem as defined in operational analysis



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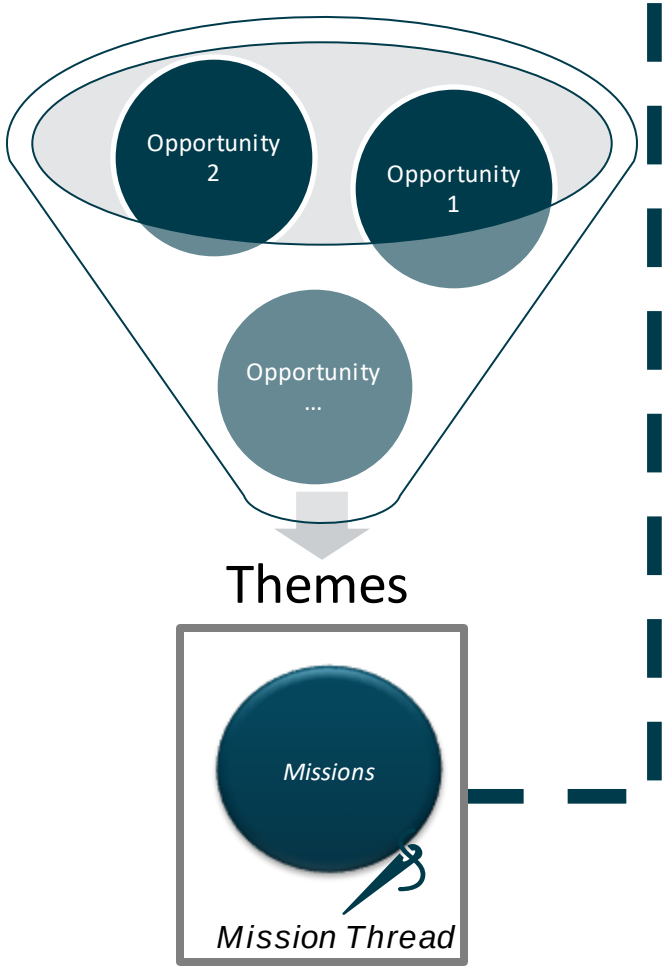
Mission Engineering Process Map



Operational Opportunities/Hypothesis

Review Operational Boundaries

Review Operational Stakeholders

Review Operational Needs

Review Ecosystem Parameters

Review Enterprise Parameters

Affinitive Opportunities

Prioritize Opportunities

Define Mission Themes

Define Theme Dependencies

Define Theme System Problem Statement SPS

Define Business and Customer Perspective

Perform Gap Analysis

Identify Technology

Assign Technology Risk Level (TRL)

Assign Integration Readiness Level (TRL)

Assign Advanced Degree of Difficulty (AD^2)

Define Technology Timelines

Define Technology Progression with dependencies

Develop Concept of Operations (ConOps)

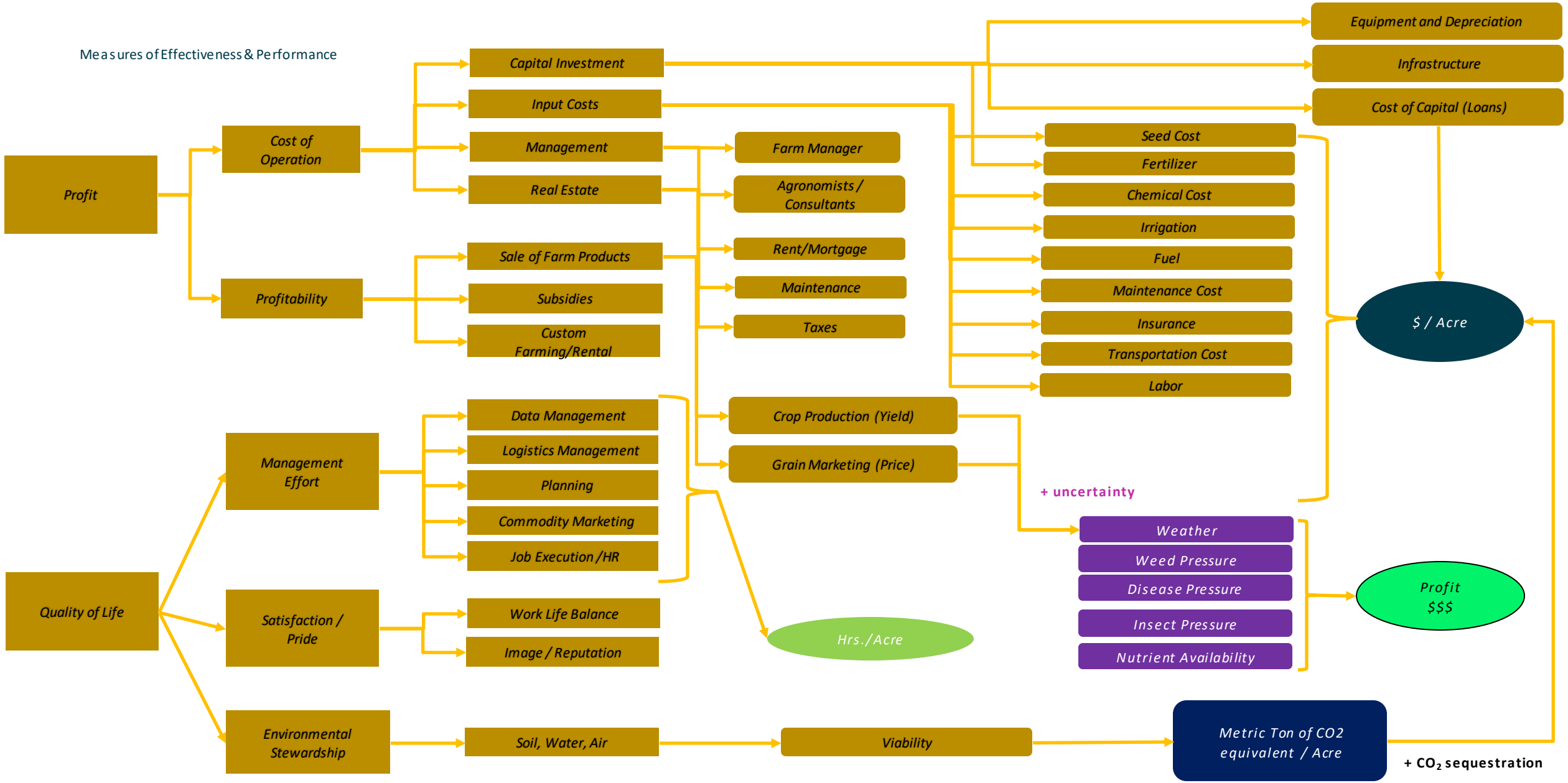
Develop Operational Concepts (OpsCon)

Develop Measures of Effectiveness

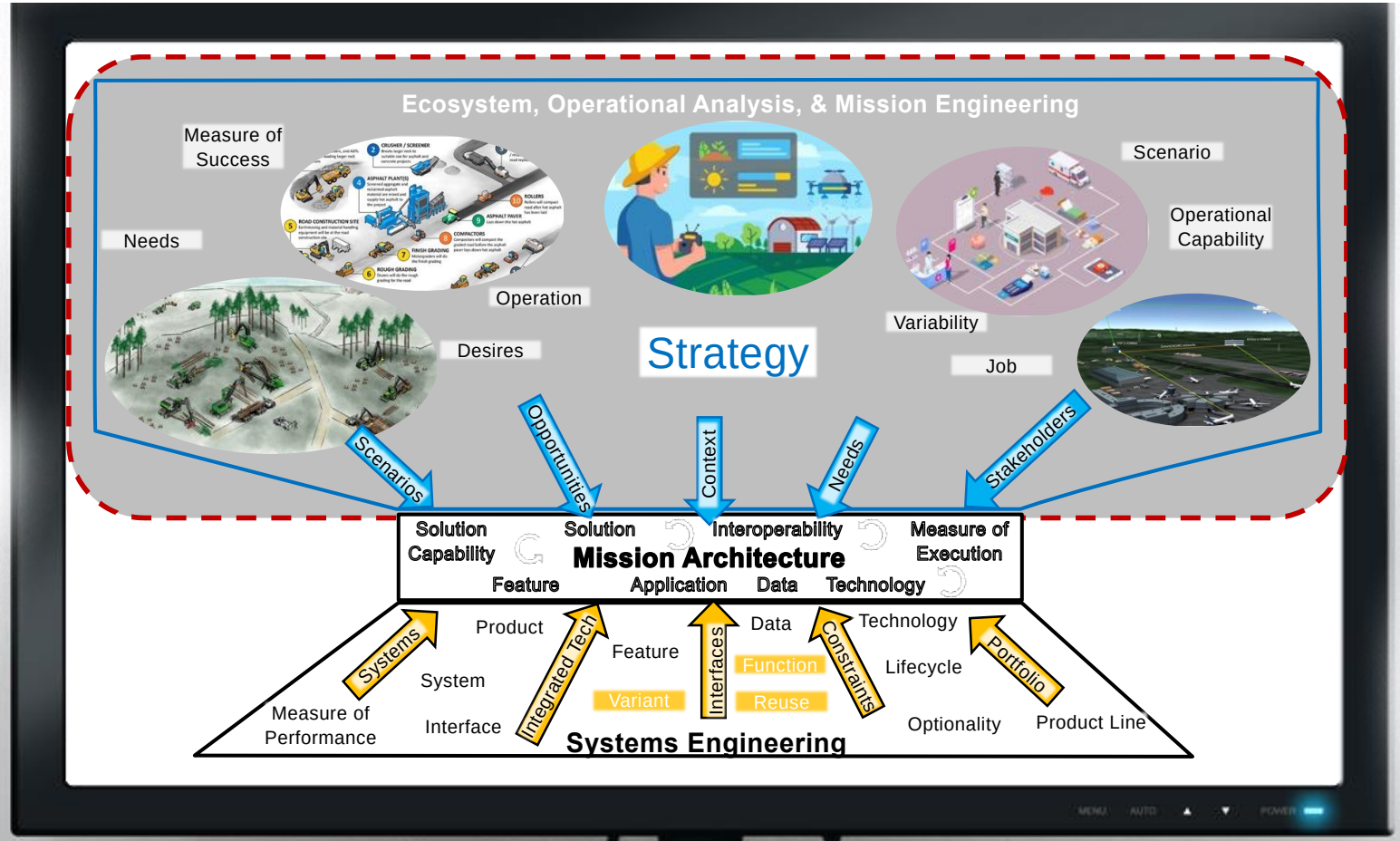
Develop Measures of Performance

Release to Mission Architecture

Release to Strategy Development Team


Measures of Effectiveness & Performance
Profit
Cost of Operation
Profitability
Capital Investment
Input Costs
Management
Real Estate
Sale of Farm Products
Subsidies
Custom Farming/Rental
Farm Manager
Agronomists / Consultants
Rent/Mortgage
Maintenance
Taxes
Equipment and Depreciation
Infrastructure
Cost of Capital (Loans)
Seed Cost
Fertilizer
Chemical Cost
Irrigation
Fuel
Maintenance Cost
Insurance
Transportation Cost
Labor
$ / Acre
Quality of Life
Management Effort
Satisfaction / Pride
Environmental Stewardship
Data Management
Logistics Management
Planning
Commodity Marketing
Job Execution /HR
Work Life Balance
Image / Reputation
Soil, Water, Air
Viability
Crop Production (Yield)
Grain Marketing (Price)
Hrs./Acre
+ uncertainty
Weather
Weed Pressure
Disease Pressure
Insect Pressure
Nutrient Availability
Profit $$$
Metric Ton of CO2 equivalent / Acre
+ CO2 sequestration

Structure & Framework



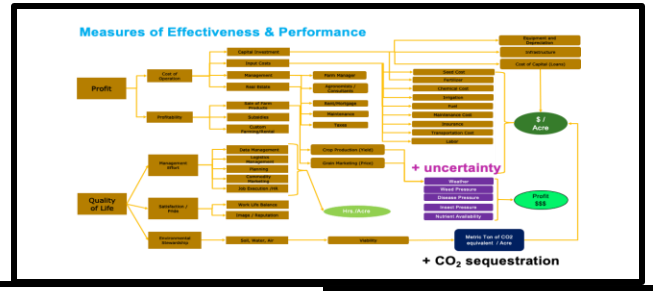
Framework & Structure

Metrics

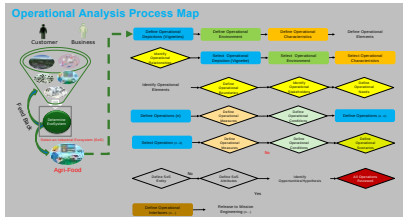
Methods

Frameworks

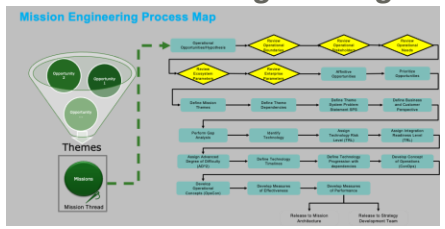
MOE & MOP



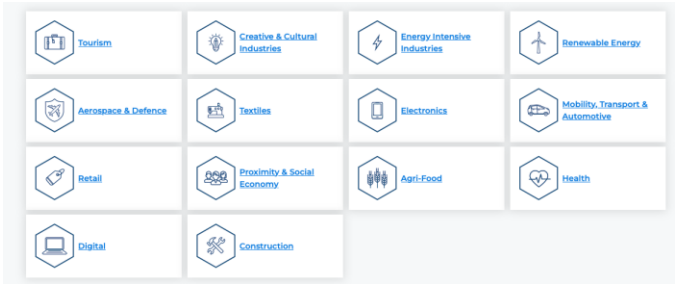
Operational Analysis



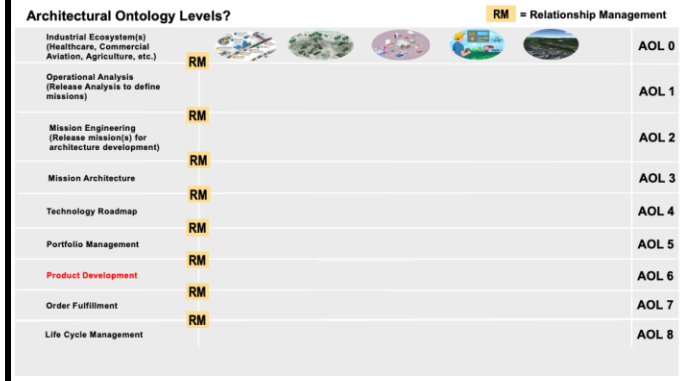
Mission Engineering



Industrial Ecosystem

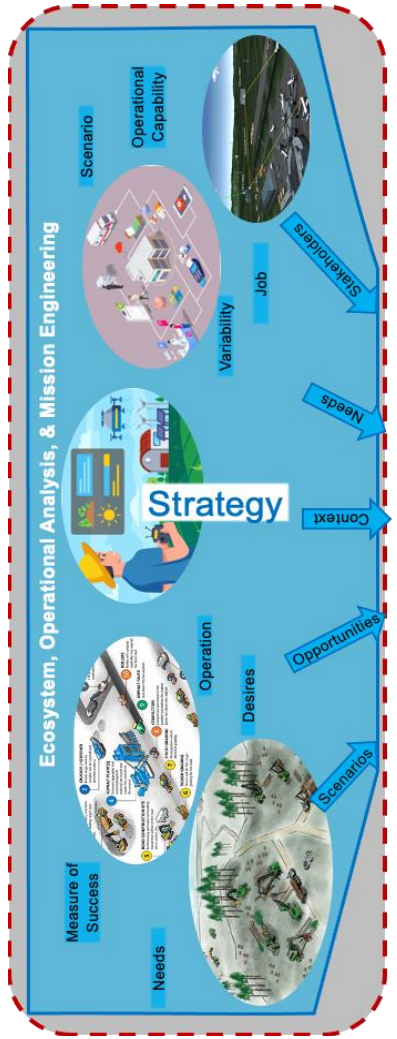


Operational Ontology



Inputs

Enterprise



Questions