

Enterprise Modelling for Lifecycle Engineering on the Example of Sustainability

Capella Days 2023

Agenda

Introduction | Industrial Eco-System

Context | Digital Farming Solutions

Example | Modelling of Enterprise Eco-System with ARCADIA

Summary & Lessons learned

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Summary & Lessons learned

SIEMENS

Industrial Business

Digital Industries



Smart Infrastructure



Mobility



Siemens Healthineers¹



Portfolio Companies



Siemens Advanta



Siemens Financial Services



Services

Siemens Real Estate



Global Business Services



¹ Publicly listed subsidiary of Siemens; Siemens' share in Siemens Healthineers: 75%

Digital Industries



72,700 employees¹



€ 19,5 billion in revenue²



Software (industrial)
#1 market position



Factory Automation
#1 market position



Motion Control
#1 market position



Process Automation
#2 market position



Customer Services

¹ As of September 30, 2021 | ² For fiscal 2022

Industry Megatrends

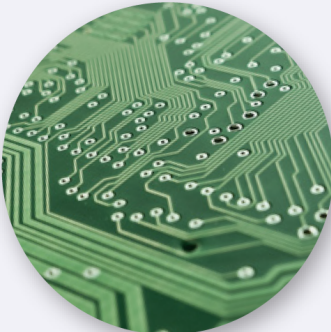
MEGATRENDS expected to influence systems engineering through 2035.



1. Sustainability



2. Interdependent World



3. Digital Transformation



4. Industry 4.0/
Society 5.0



5. Smart Systems



6. Complexity Growth

Source: INCOSE Vision 2035

Sustainable Development Goals

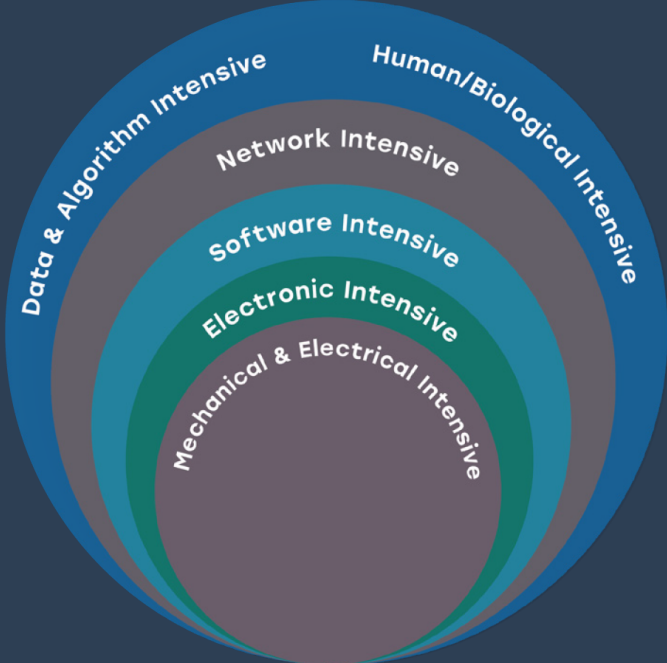


United Nations Sustainable Development Goals: <https://sdgs.un.org/goals>

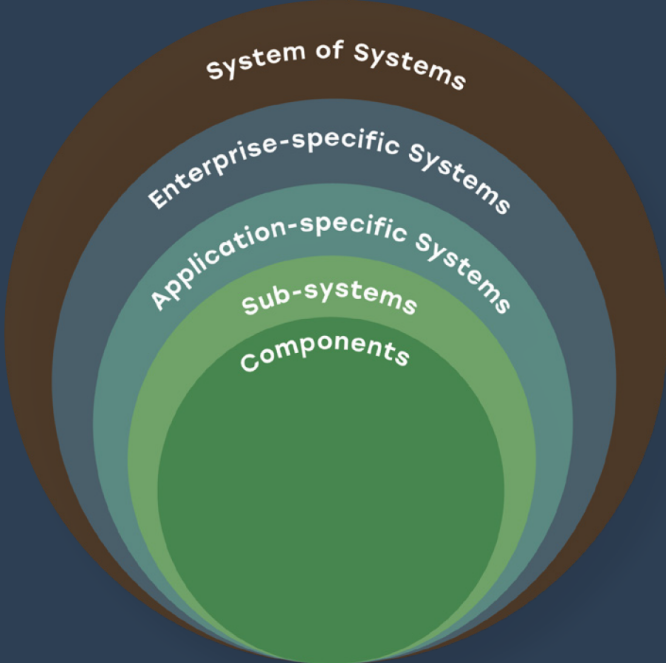
Source: INCOSE Vision 2035

Increasing complexity requires holistic view on Eco-System

► Complexity increases over time due to the integration of ever more complex layers of technology.



Technology-driven complexity
↑
Scope-driven complexity



► Complexity increases with systems scope expansion due to proliferation of interfaces and governance mechanisms.

Source: INCOSE Vision 2035

Global Context of Systems Engineering



Source: INCOSE Vision 2033

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Digital Farming Solutions

Industry Examples

Vertical Farming Technology



Heavy Equipment



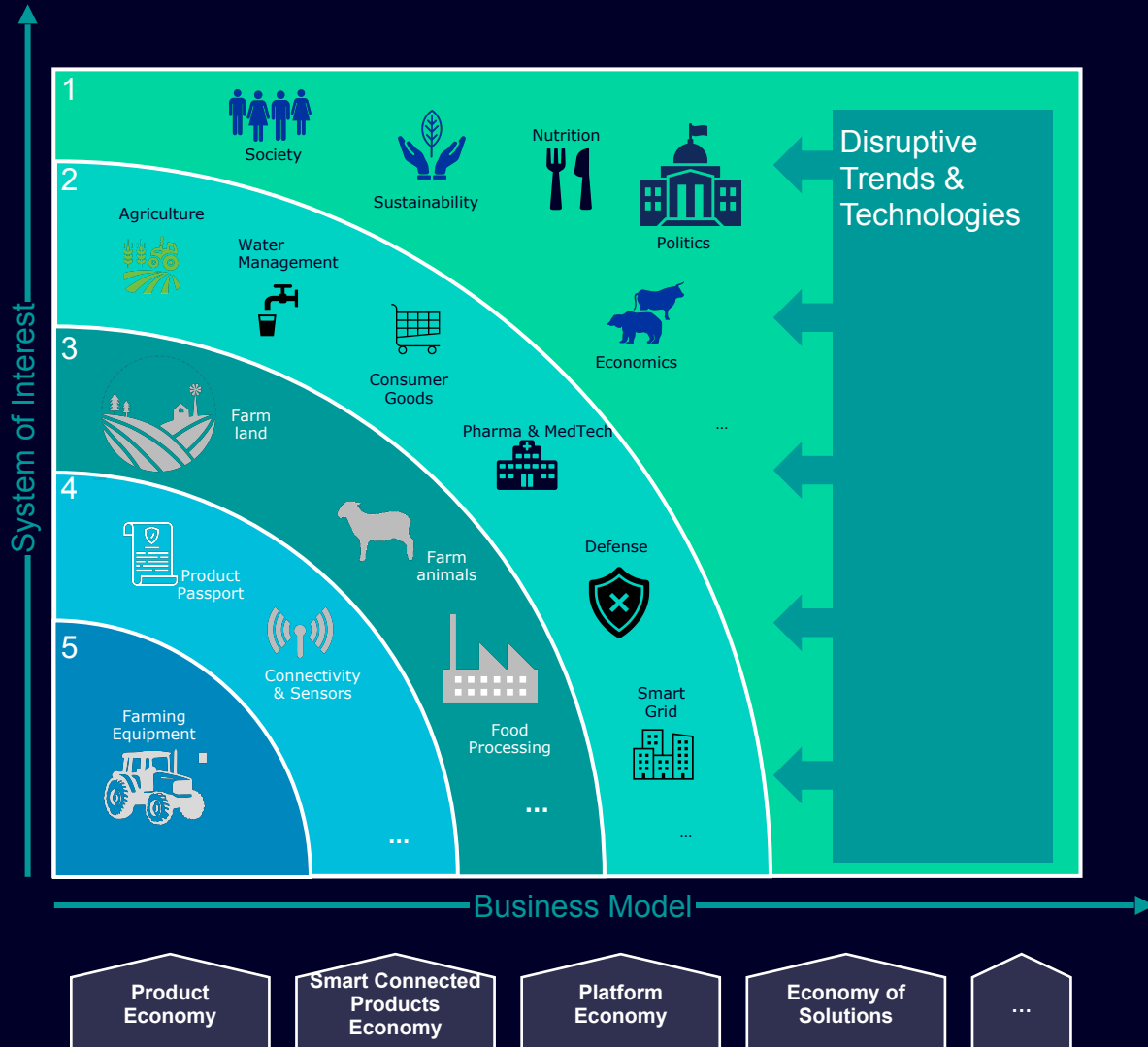
Smart Farming



<https://www.plm.automation.siemens.com/global/de/industries/heavy-equipment/agriculture/>

Systems Thinking and Engineering of Eco-System

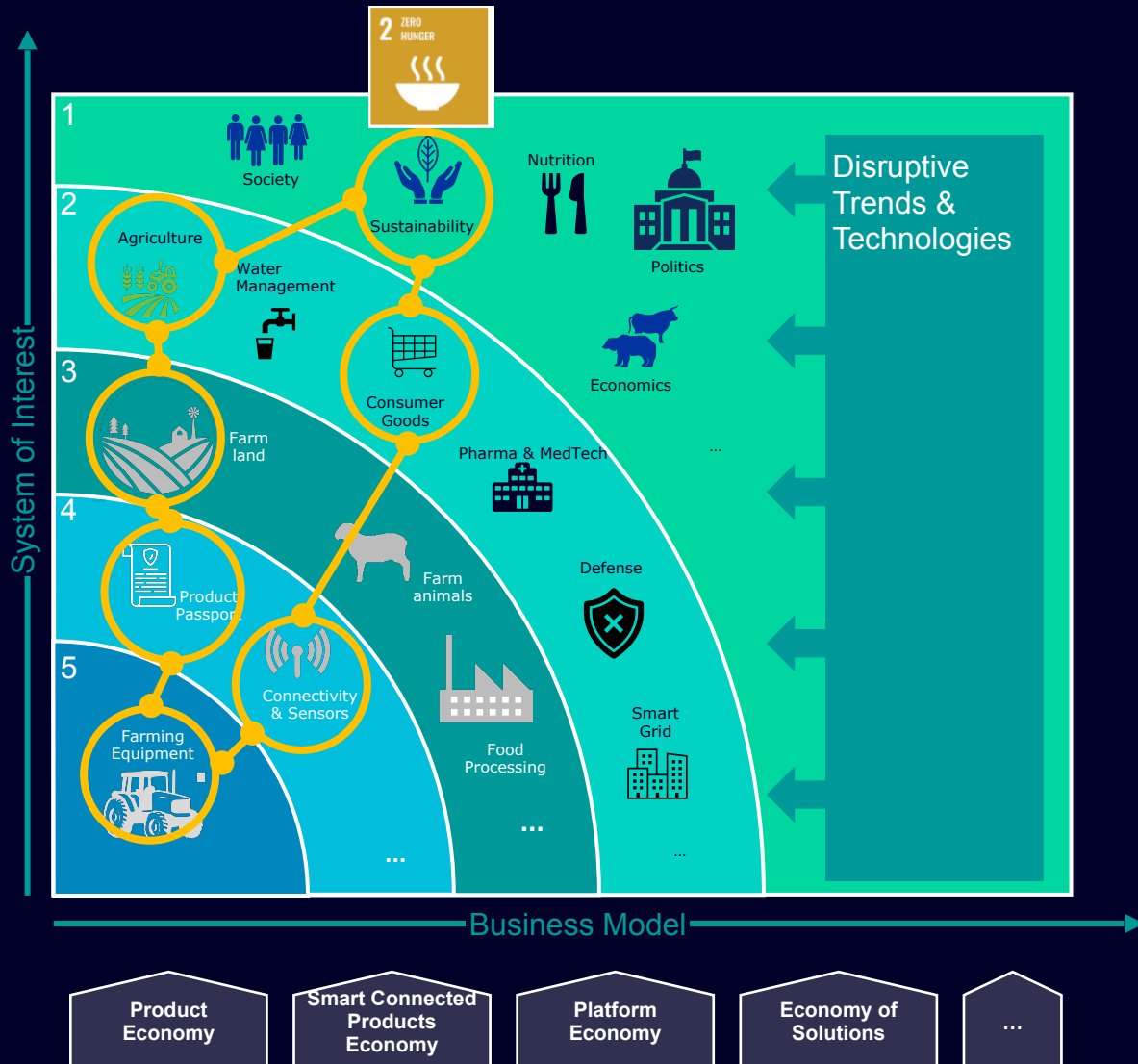
Example: Digital Farming Solution



Level 1	Society Eco-System Society, Sustainability, Nutrition, Economics, Politics, Legal, ...
Level 2	Industrial Operating System Agriculture, Water, Consumer Goods, Pharma & MedTech, Defense, Energy, ...
Level 3	Customer Usage System Farm land, Farm animals, Factory...
Level 4	Product Operating System Digital Product Passport (Conformity & Regulatory Compliance), Connectivity, Predictive Maintenance,...
Level 5	Product System Farming Equipment

Systems Thinking and Engineering of Eco-System

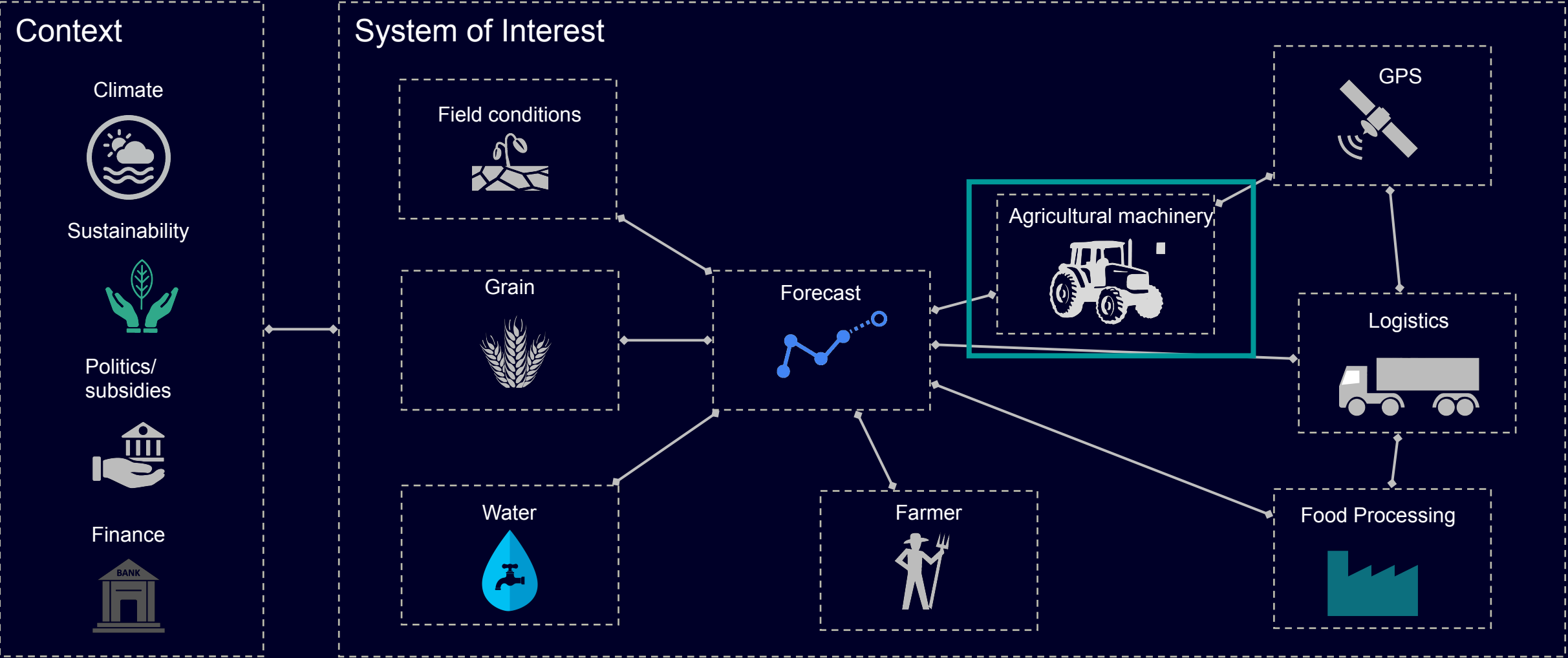
Example: Digital Farming Solution



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Operational Analysis | Operational Actors/Entities

Example: Digital Farming Solutions



Agenda

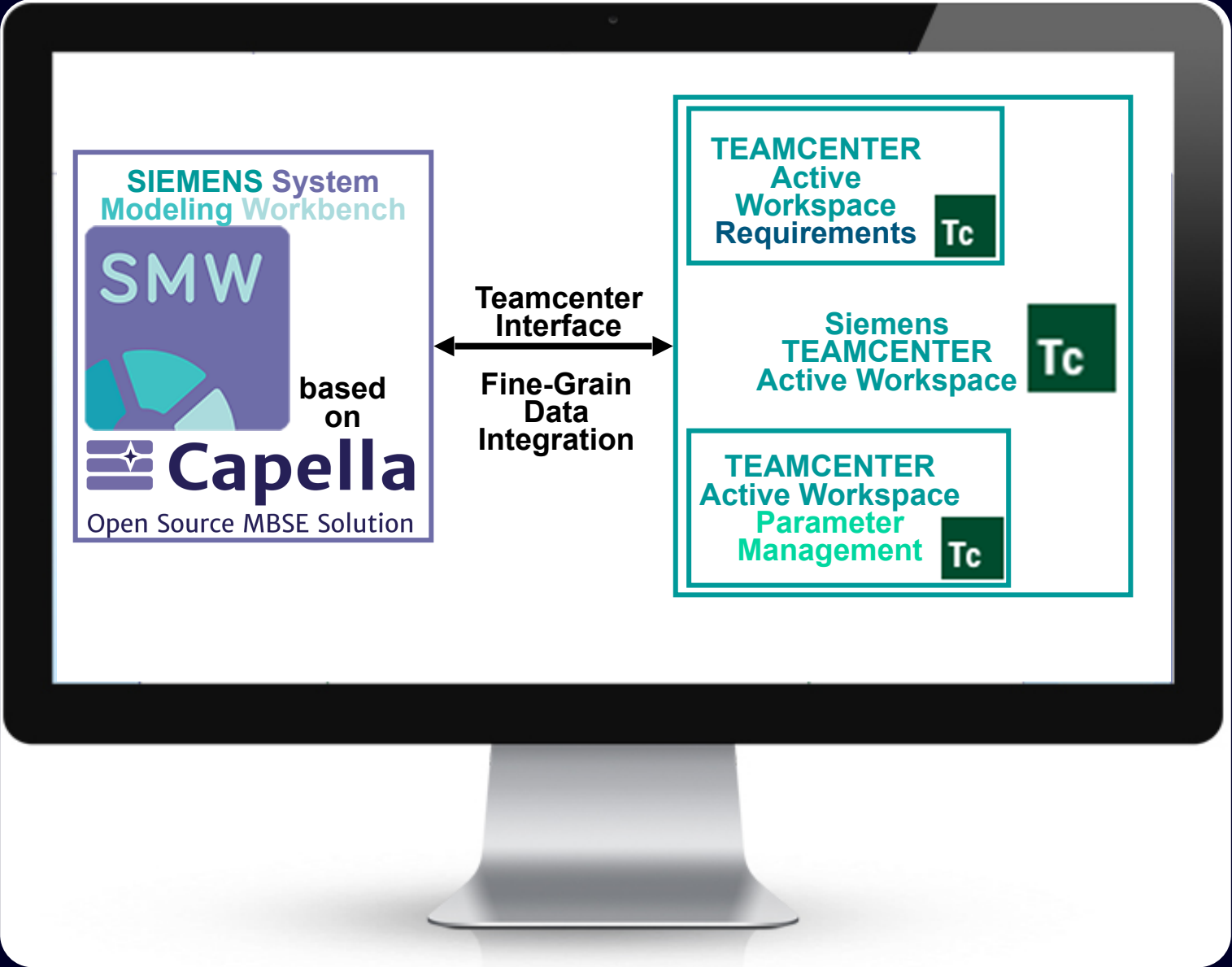
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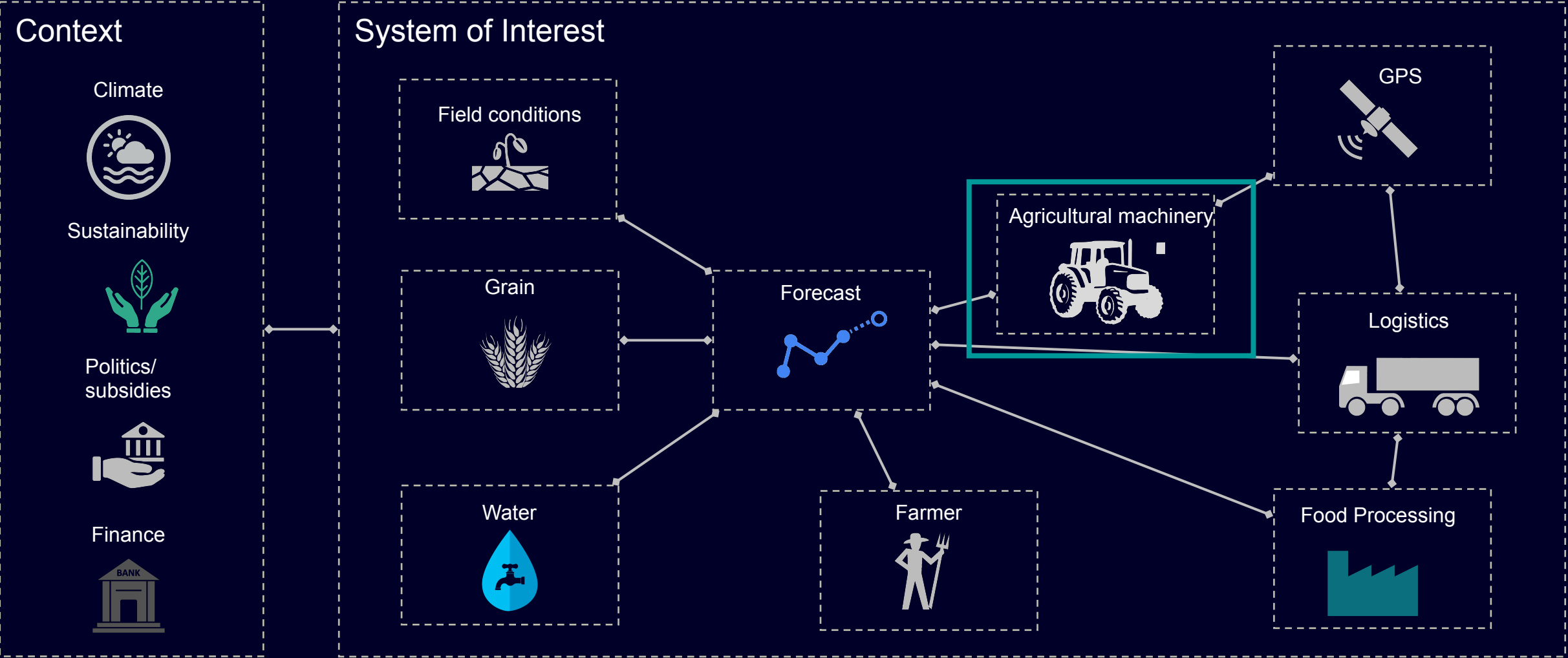
Summary & Lessons learned

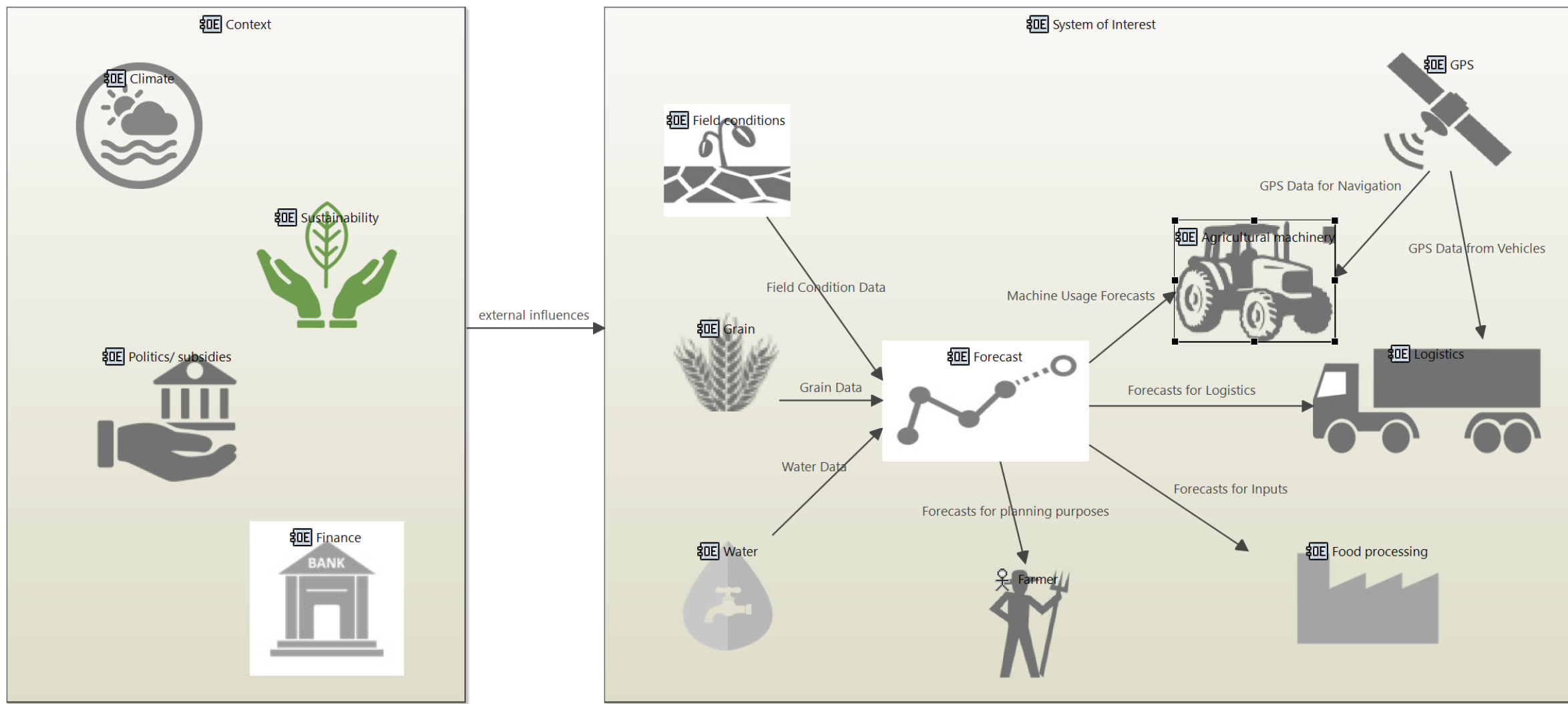
Environment used to create the Example Model



Operational Analysis | Operational Actors/Entities

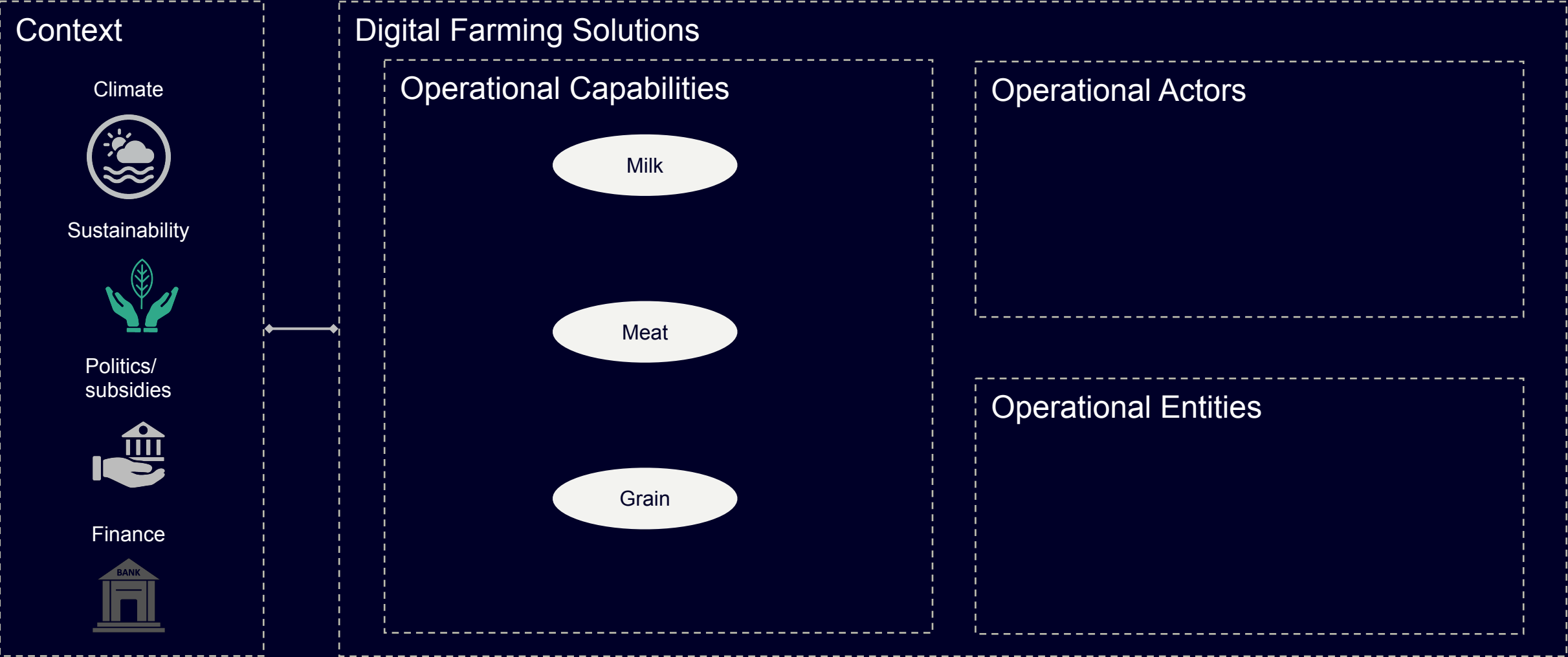
Example: Digital Farming Solutions





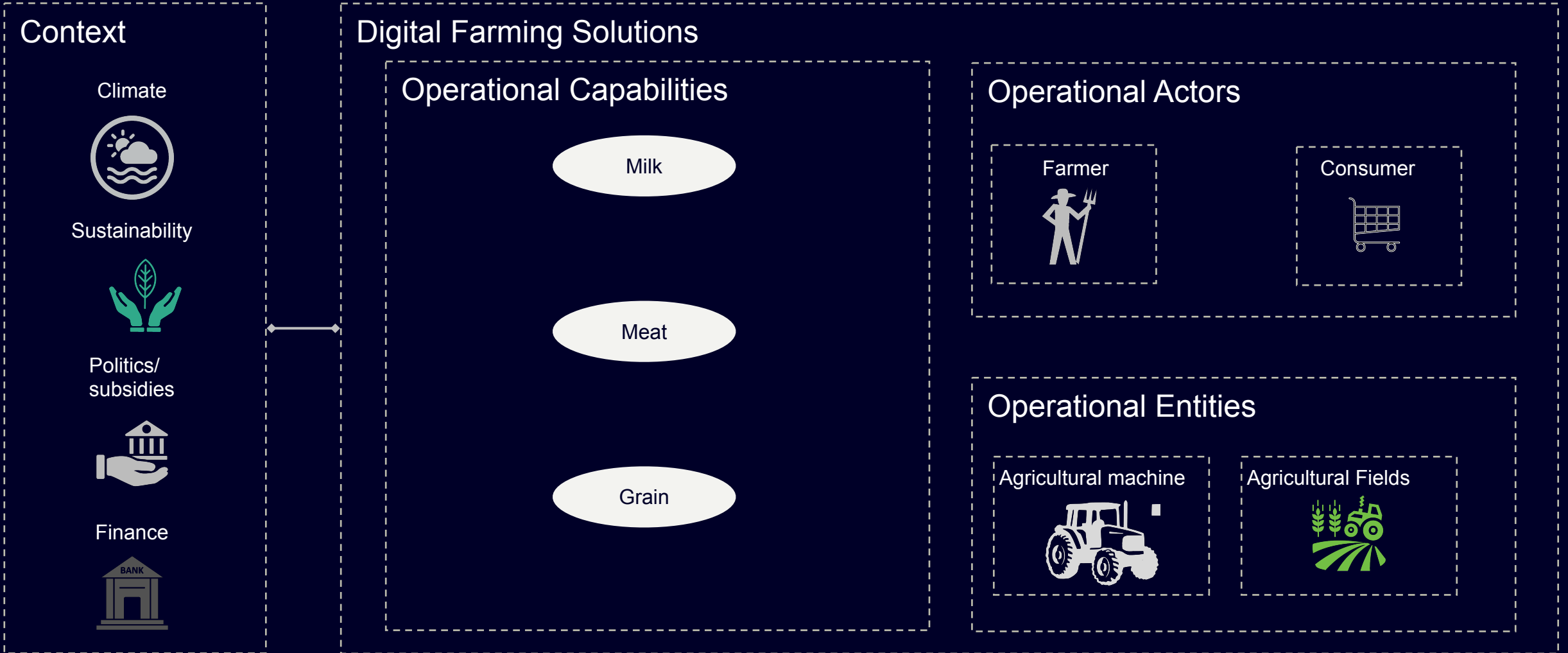
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Example: Digital Farming Solutions



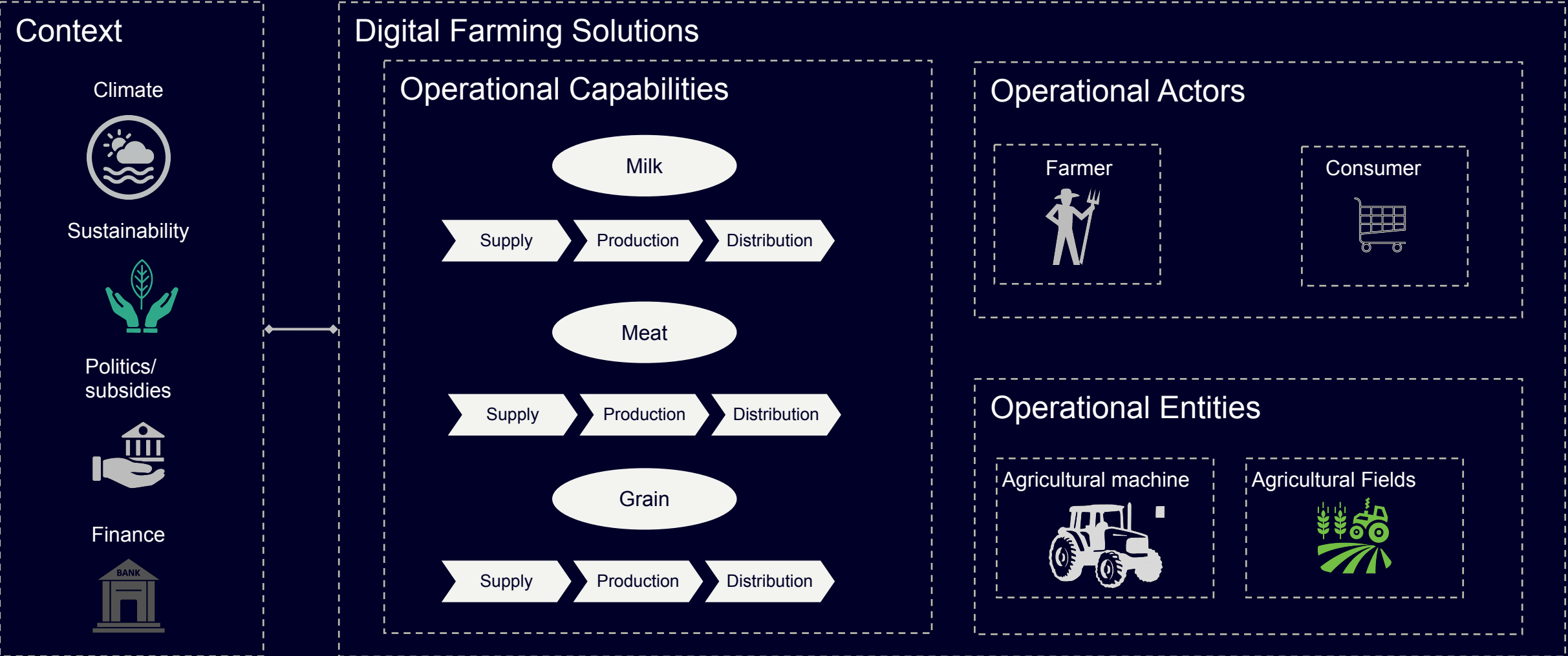
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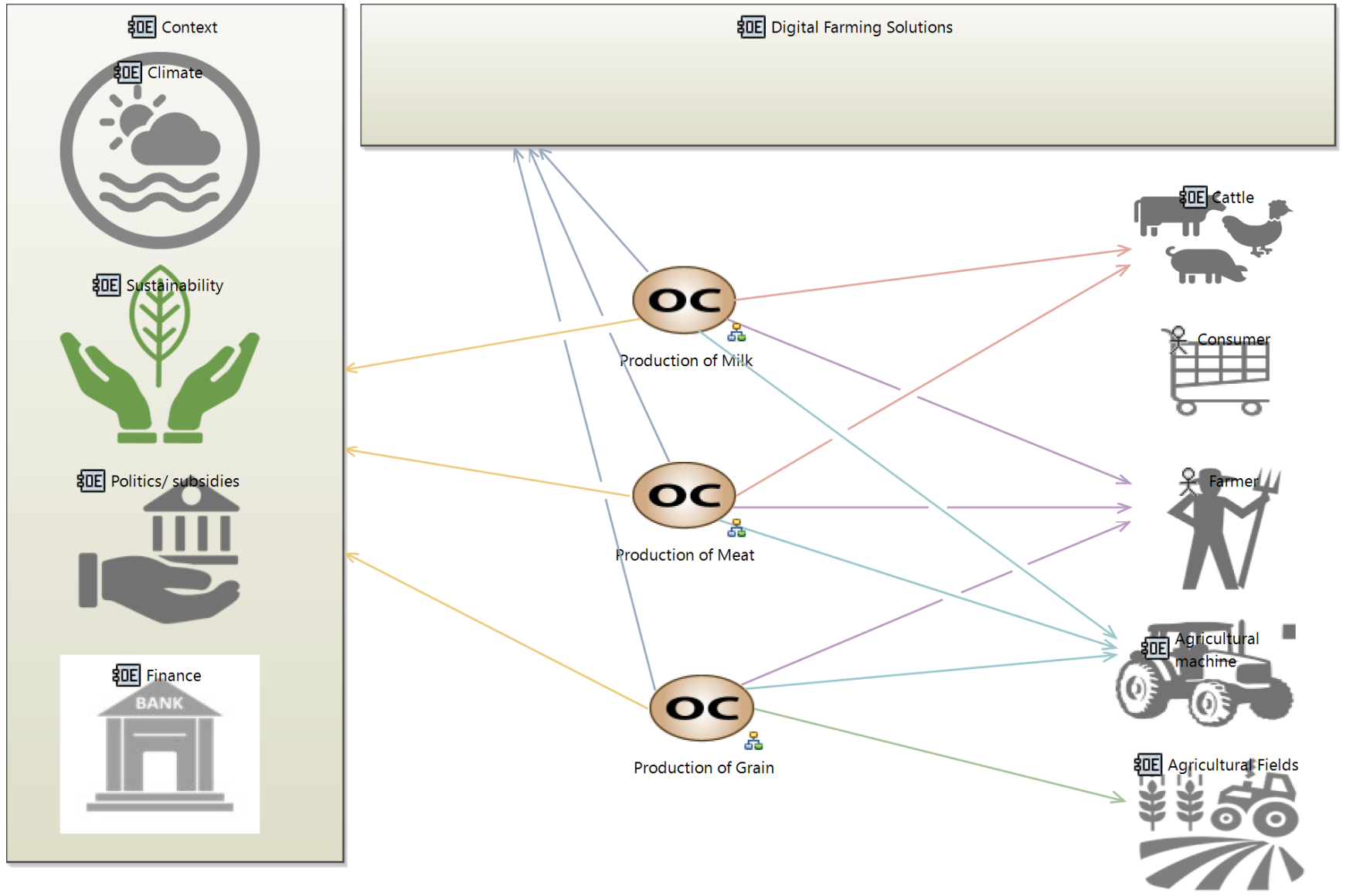
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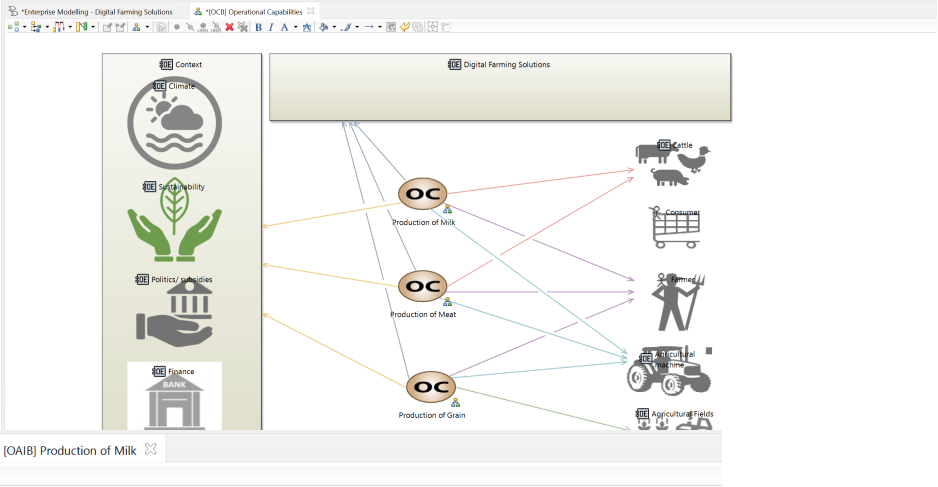
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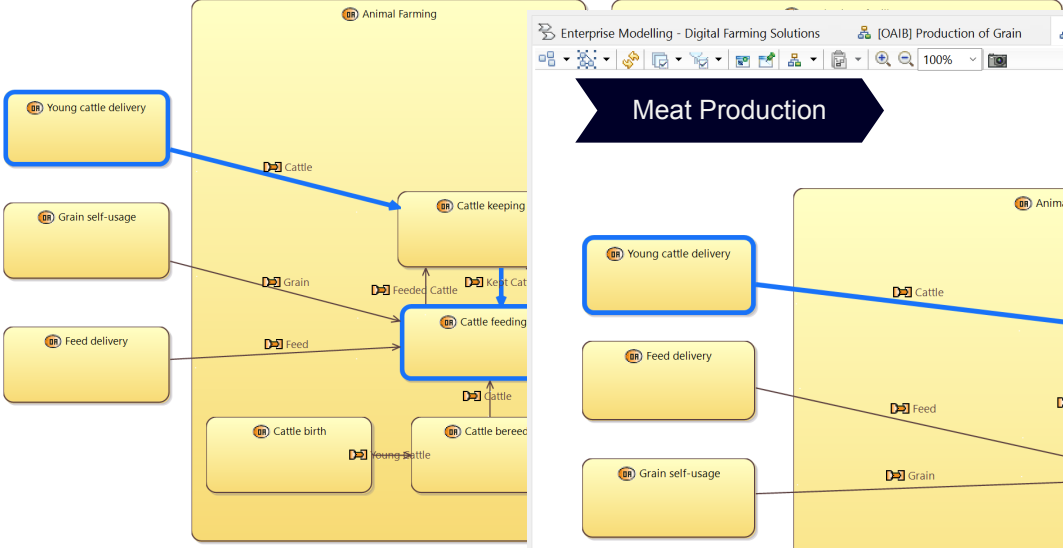




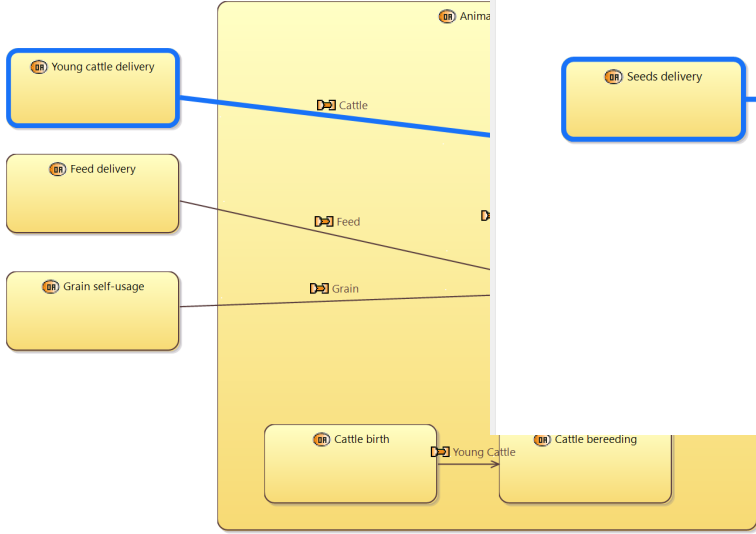
Capella Screen Shot



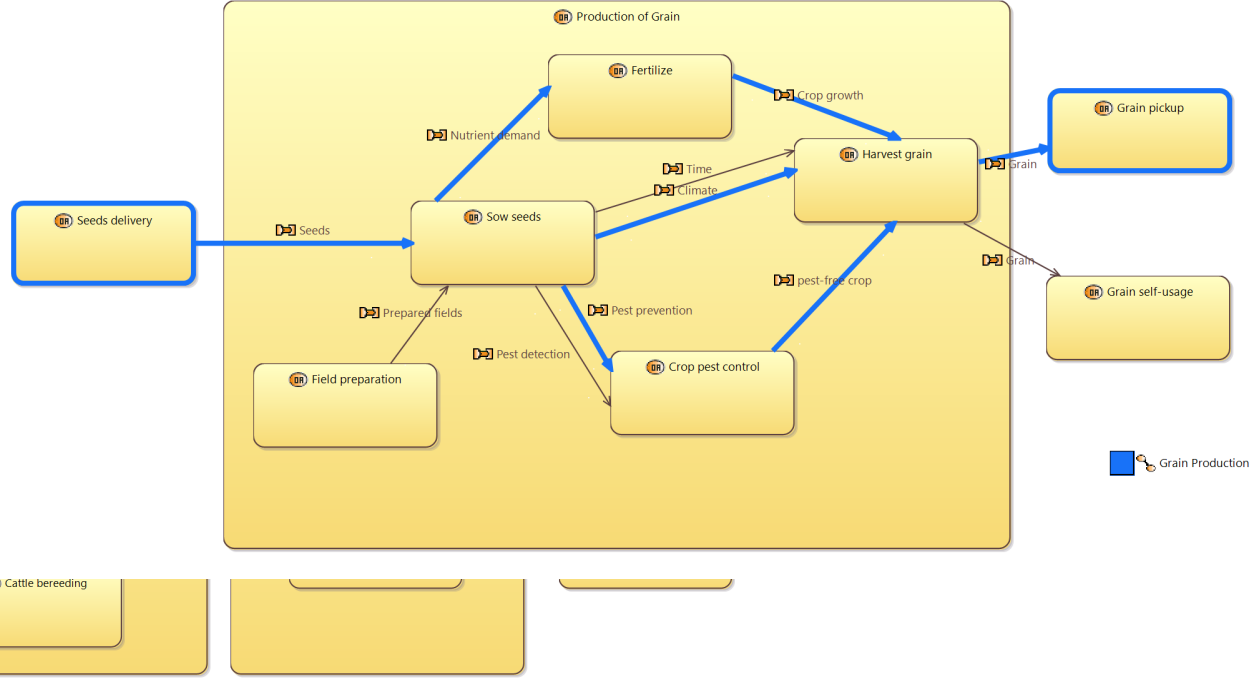
Milk Production



Meat Production

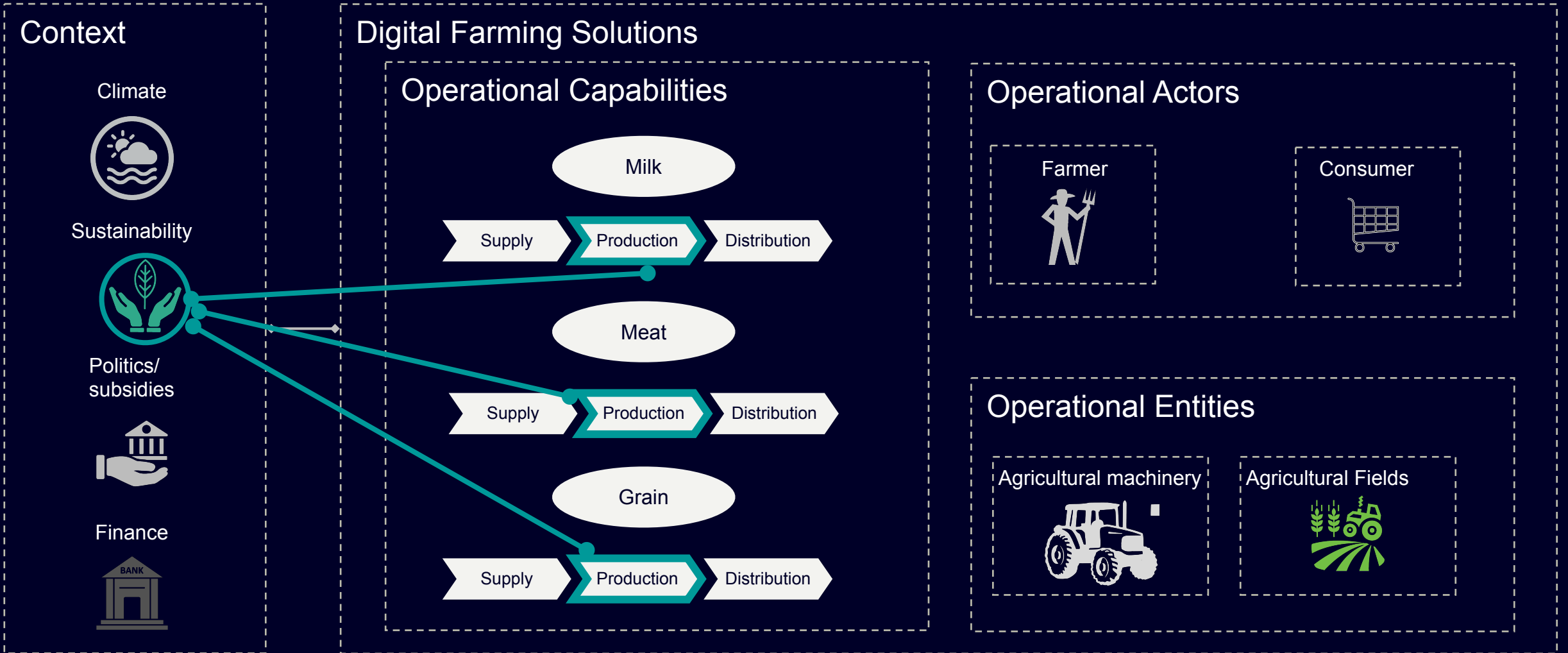


Grain Production



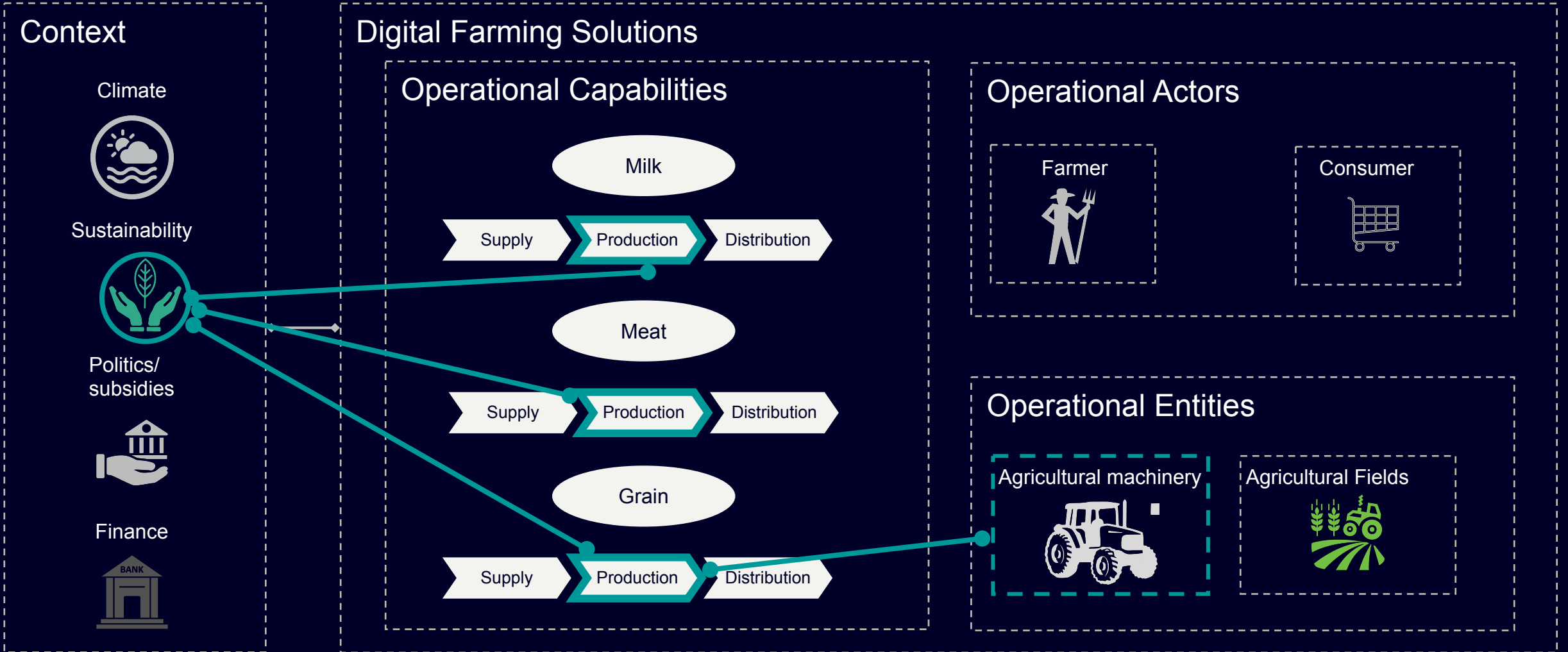
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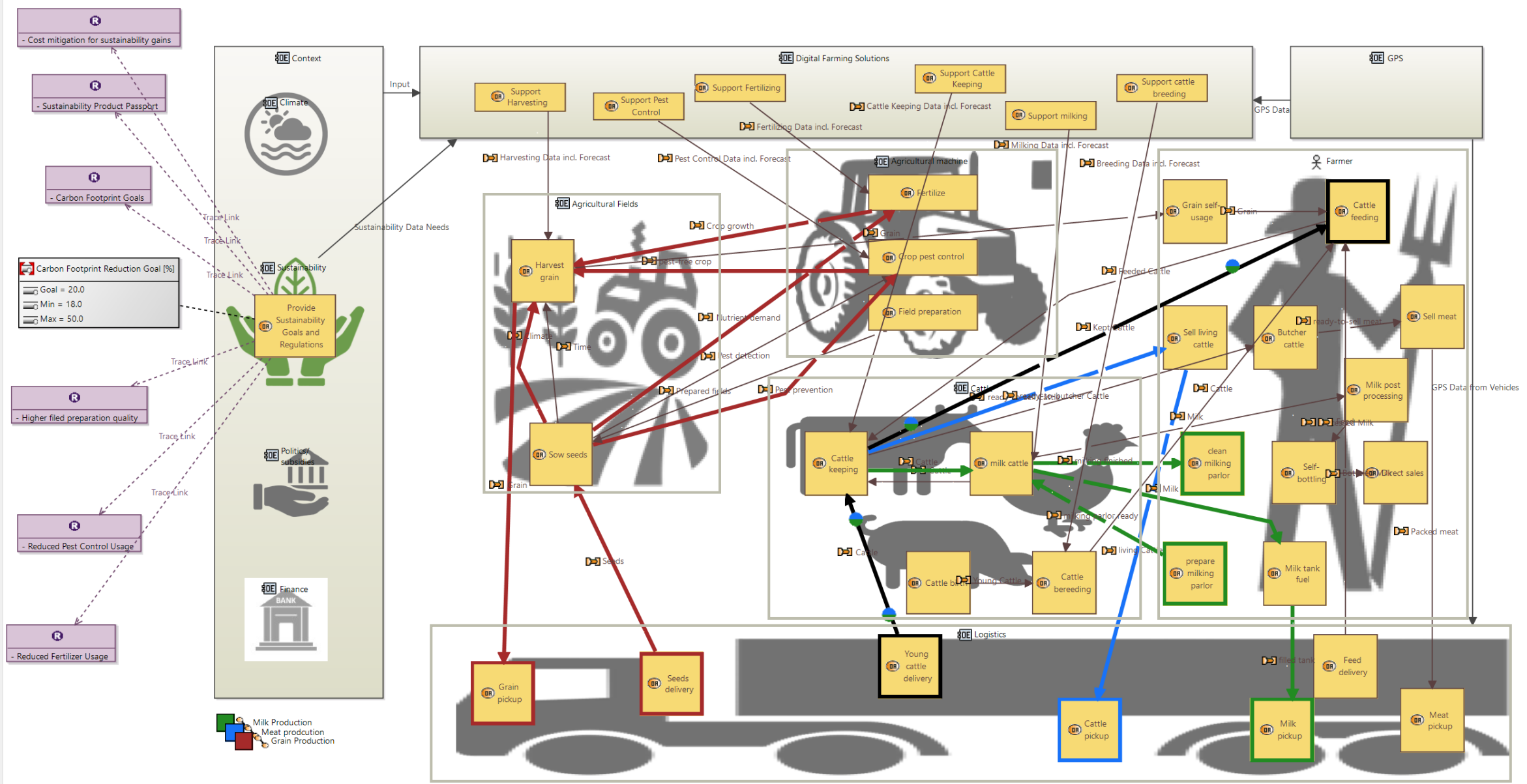
Example: Digital Farming Solutions



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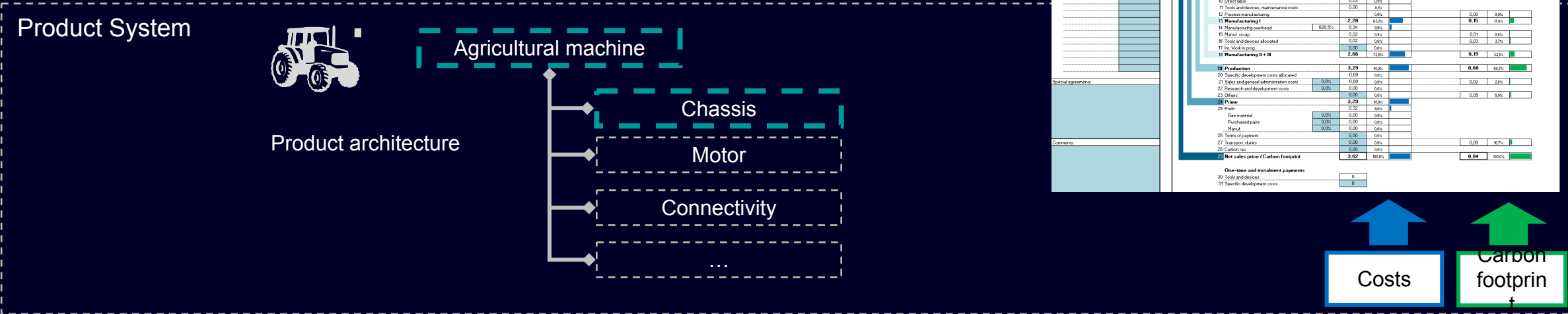




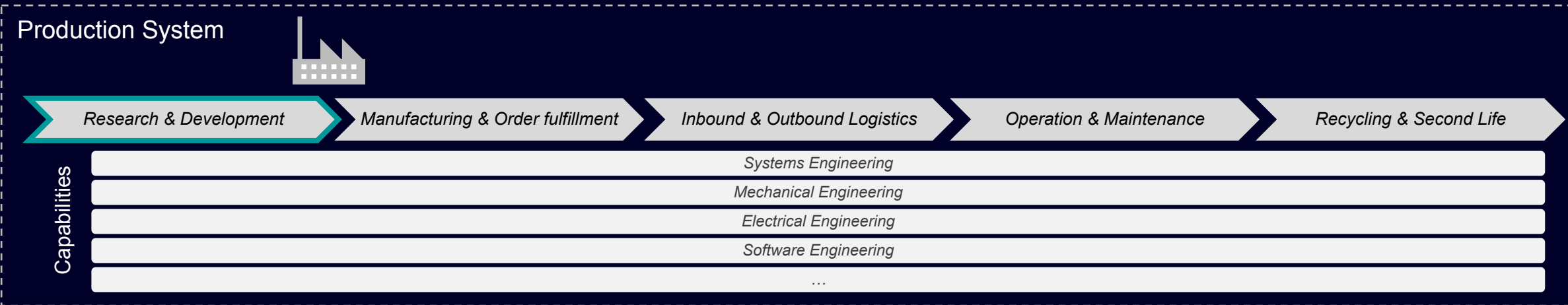
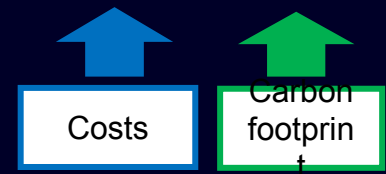
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Example: Digital Farming Solutions

Business Engineering



SIEMENS																																																																																																																																																																																																																																																																																																																																																																																																					
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<table border="1"> <thead> <tr> <th colspan="2">Dimese</th> <th colspan="4">Costs</th> <th colspan="4">Carbon footprint</th> </tr> <tr> <th></th> <th></th> <th>%</th> <th>EUR/Unit</th> <th>Unit</th> <th>Fraktion</th> <th>%</th> <th>kg CO2e/Unit</th> <th>Unit</th> <th>Fraktion</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Raw material</td> <td>0.00</td> <td>0.00</td> <td>0.0%</td> <td></td> <td>0.00</td> <td>0.0%</td> <td></td> <td></td> </tr> <tr> <td>2</td> <td>Purchased parts</td> <td>0.55</td> <td>0.55</td> <td>100%</td> <td></td> <td>0.30</td> <td>28.0%</td> <td></td> <td></td> </tr> <tr> <td>3</td> <td>Direct material</td> <td>0.02</td> <td>0.02</td> <td>4%</td> <td></td> <td>0.47</td> <td>45.7%</td> <td></td> <td></td> </tr> <tr> <td>4</td> <td>Manufact. scrap</td> <td>0.00</td> <td>0.00</td> <td>0%</td> <td></td> <td>0.00</td> <td>0%</td> <td></td> <td></td> </tr> <tr> <td>5</td> <td>Material overhead</td> <td>0.00</td> <td>0.00</td> <td>0%</td> <td></td> <td>0.00</td> <td>0%</td> <td></td> <td></td> </tr> <tr> <td>6</td> <td>Process material</td> <td>0.00</td> <td>0.00</td> <td>0%</td> <td></td> <td>0.00</td> <td>0%</td> <td></td> <td></td> </tr> <tr> <td>7</td> <td>Material</td> <td>0.57</td> <td>0.57</td> <td>100%</td> <td></td> <td>0.43</td> <td>38.8%</td> <td></td> <td></td> </tr> <tr> <td>8</td> <td>Manufacturing overhead costs</td> <td>0.00</td> <td>0.00</td> <td>0%</td> <td></td> <td>0.00</td> <td>0%</td> <td></td> <td></td> </tr> <tr> <td>9</td> <td>Setup costs / Costs</td> <td>0.00</td> <td>0.00</td> <td>0%</td> <td></td> <td>0.00</td> <td>0%</td> <td></td> <td></td> </tr> <tr> <td>10</td> <td>Direct labor</td> <td>0.00</td> <td>0.00</td> <td>0%</td> <td></td> <td>0.00</td> <td>0%</td> <td></td> <td></td> </tr> <tr> <td>11</td> <td>Tools and devices, maintenance costs</td> <td>0.00</td> <td>0.00</td> <td>0%</td> <td></td> <td>0.00</td> <td>0%</td> <td></td> <td></td> </tr> <tr> <td>12</td> <td>Process manufacturing</td> <td>0.00</td> 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<td>19</td> <td>Production</td> <td>3.29</td> <td>3.29</td> <td>59%</td> <td></td> <td>0.69</td> <td>65.7%</td> <td></td> <td></td> </tr> <tr> <td>20</td> <td>Specific development costs allocated</td> <td>0.00</td> <td>0.00</td> <td>0%</td> <td></td> <td>0.00</td> <td>0%</td> <td></td> <td></td> </tr> <tr> <td>21</td> <td>State and general administration costs</td> <td>0.00</td> <td>0.00</td> <td>0%</td> <td></td> <td>0.00</td> <td>0%</td> <td></td> <td></td> </tr> <tr> <td>22</td> <td>Research and development costs</td> <td>0.00</td> <td>0.00</td> <td>0%</td> <td></td> <td>0.00</td> <td>0%</td> <td></td> <td></td> </tr> <tr> <td>23</td> <td>Others</td> <td>0.00</td> <td>0.00</td> <td>0%</td> <td></td> <td>0.00</td> <td>0%</td> <td></td> <td></td> </tr> <tr> <td>24</td> <td>Price</td> <td>3.29</td> <td>3.29</td> <td>100%</td> <td></td> <td>0.69</td> <td>65.7%</td> <td></td> <td></td> </tr> <tr> <td>25</td> <td>Price</td> <td>0.32</td> <td>0.32</td> <td>100%</td> <td></td> <td>0.00</td> 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<td></td> <td></td> </tr> <tr> <td>30</td> <td>Net sales price / Carbon footprint</td> <td>3.62</td> <td>3.62</td> <td>100%</td> <td></td> <td>0.84</td> <td>80.0%</td> <td></td> <td></td> </tr> <tr> <td colspan="10">One-time and installation payments</td> </tr> <tr> <td>30</td> <td>Tools and devices</td> <td>0</td> <td>0</td> <td>0%</td> <td></td> <td>0</td> <td>0%</td> <td></td> <td></td> </tr> <tr> <td>31</td> <td>Specific development costs</td> <td>0</td> <td>0</td> <td>0%</td> <td></td> <td>0</td> <td>0%</td> <td></td> <td></td> </tr> </tbody> </table>										Dimese		Costs				Carbon footprint						%	EUR/Unit	Unit	Fraktion	%	kg CO2e/Unit	Unit	Fraktion	1	Raw material	0.00	0.00	0.0%		0.00	0.0%			2	Purchased parts	0.55	0.55	100%		0.30	28.0%			3	Direct material	0.02	0.02	4%		0.47	45.7%			4	Manufact. scrap	0.00	0.00	0%		0.00	0%			5	Material overhead	0.00	0.00	0%		0.00	0%			6	Process material	0.00	0.00	0%		0.00	0%			7	Material	0.57	0.57	100%		0.43	38.8%			8	Manufacturing overhead costs	0.00	0.00	0%		0.00	0%			9	Setup costs / Costs	0.00	0.00	0%		0.00	0%			10	Direct labor	0.00	0.00	0%		0.00	0%			11	Tools and devices, maintenance costs	0.00	0.00	0%		0.00	0%			12	Process manufacturing	0.00	0.00	0%		0.00	0%			13	Manufacturing I	2.28	2.28	41%		0.15	14.6%			14	Manufacturing overhead	620.00	620.00	100%		0.00	0%			15	Manuf. scrap	0.00	0.00	0%		0.00	0%			16	Tools and devices allocated	0.00	0.00	0%		0.00	0%			17	Inv. stock change	0.00	0.00	0%		0.00	0%			18	Manufacturing II + III	2.66	2.66	47%		0.19	18.2%			19	Production	3.29	3.29	59%		0.69	65.7%			20	Specific development costs allocated	0.00	0.00	0%		0.00	0%			21	State and general administration costs	0.00	0.00	0%		0.00	0%			22	Research and development costs	0.00	0.00	0%		0.00	0%			23	Others	0.00	0.00	0%		0.00	0%			24	Price	3.29	3.29	100%		0.69	65.7%			25	Price	0.32	0.32	100%		0.00	0%				Raw material	0.00	0.00	0%		0.00	0%				Purchased parts	0.55	0.55	100%		0.30	28.0%				Manuf.	0.00	0.00	0%		0.00	0%			26	Terms of payment	0.00	0.00	0%		0.00	0%			27	Transport, duties	0.00	0.00	0%		0.00	0%			28	Carbon tax	0.00	0.00	0%		0.00	0%			29	Carbon tax	0.00	0.00	0%		0.00	0%			30	Net sales price / Carbon footprint	3.62	3.62	100%		0.84	80.0%			One-time and installation payments										30	Tools and devices	0	0	0%		0	0%			31	Specific development costs	0	0	0%		0	0%		
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7	Material	0.57	0.57	100%		0.43	38.8%																																																																																																																																																																																																																																																																																																																																																																																														
8	Manufacturing overhead costs	0.00	0.00	0%		0.00	0%																																																																																																																																																																																																																																																																																																																																																																																														
9	Setup costs / Costs	0.00	0.00	0%		0.00	0%																																																																																																																																																																																																																																																																																																																																																																																														
10	Direct labor	0.00	0.00	0%		0.00	0%																																																																																																																																																																																																																																																																																																																																																																																														
11	Tools and devices, maintenance costs	0.00	0.00	0%		0.00	0%																																																																																																																																																																																																																																																																																																																																																																																														
12	Process manufacturing	0.00	0.00	0%		0.00	0%																																																																																																																																																																																																																																																																																																																																																																																														
13	Manufacturing I	2.28	2.28	41%		0.15	14.6%																																																																																																																																																																																																																																																																																																																																																																																														
14	Manufacturing overhead	620.00	620.00	100%		0.00	0%																																																																																																																																																																																																																																																																																																																																																																																														
15	Manuf. scrap	0.00	0.00	0%		0.00	0%																																																																																																																																																																																																																																																																																																																																																																																														
16	Tools and devices allocated	0.00	0.00	0%		0.00	0%																																																																																																																																																																																																																																																																																																																																																																																														
17	Inv. stock change	0.00	0.00	0%		0.00	0%																																																																																																																																																																																																																																																																																																																																																																																														
18	Manufacturing II + III	2.66	2.66	47%		0.19	18.2%																																																																																																																																																																																																																																																																																																																																																																																														
19	Production	3.29	3.29	59%		0.69	65.7%																																																																																																																																																																																																																																																																																																																																																																																														
20	Specific development costs allocated	0.00	0.00	0%		0.00	0%																																																																																																																																																																																																																																																																																																																																																																																														
21	State and general administration costs	0.00	0.00	0%		0.00	0%																																																																																																																																																																																																																																																																																																																																																																																														
22	Research and development costs	0.00	0.00	0%		0.00	0%																																																																																																																																																																																																																																																																																																																																																																																														
23	Others	0.00	0.00	0%		0.00	0%																																																																																																																																																																																																																																																																																																																																																																																														
24	Price	3.29	3.29	100%		0.69	65.7%																																																																																																																																																																																																																																																																																																																																																																																														
25	Price	0.32	0.32	100%		0.00	0%																																																																																																																																																																																																																																																																																																																																																																																														
	Raw material	0.00	0.00	0%		0.00	0%																																																																																																																																																																																																																																																																																																																																																																																														
	Purchased parts	0.55	0.55	100%		0.30	28.0%																																																																																																																																																																																																																																																																																																																																																																																														
	Manuf.	0.00	0.00	0%		0.00	0%																																																																																																																																																																																																																																																																																																																																																																																														
26	Terms of payment	0.00	0.00	0%		0.00	0%																																																																																																																																																																																																																																																																																																																																																																																														
27	Transport, duties	0.00	0.00	0%		0.00	0%																																																																																																																																																																																																																																																																																																																																																																																														
28	Carbon tax	0.00	0.00	0%		0.00	0%																																																																																																																																																																																																																																																																																																																																																																																														
29	Carbon tax	0.00	0.00	0%		0.00	0%																																																																																																																																																																																																																																																																																																																																																																																														
30	Net sales price / Carbon footprint	3.62	3.62	100%		0.84	80.0%																																																																																																																																																																																																																																																																																																																																																																																														
One-time and installation payments																																																																																																																																																																																																																																																																																																																																																																																																					
30	Tools and devices	0	0	0%		0	0%																																																																																																																																																																																																																																																																																																																																																																																														
31	Specific development costs	0	0	0%		0	0%																																																																																																																																																																																																																																																																																																																																																																																														



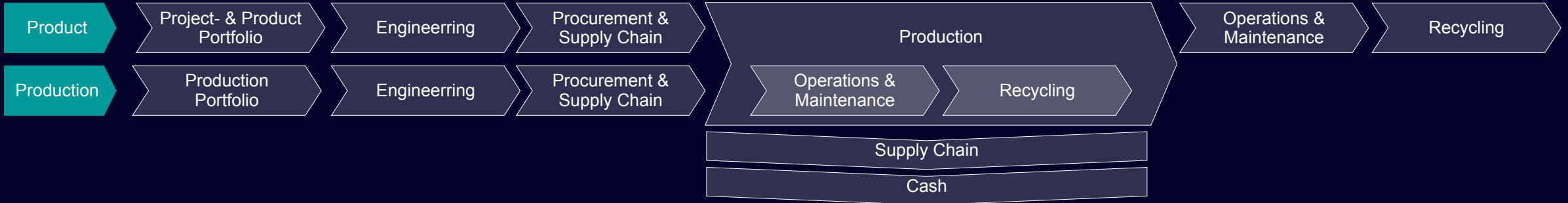
Digital Enterprise - A Product centered Approach, with synchronized Architecture Information Technology (IT) and Operational Technology (OT)



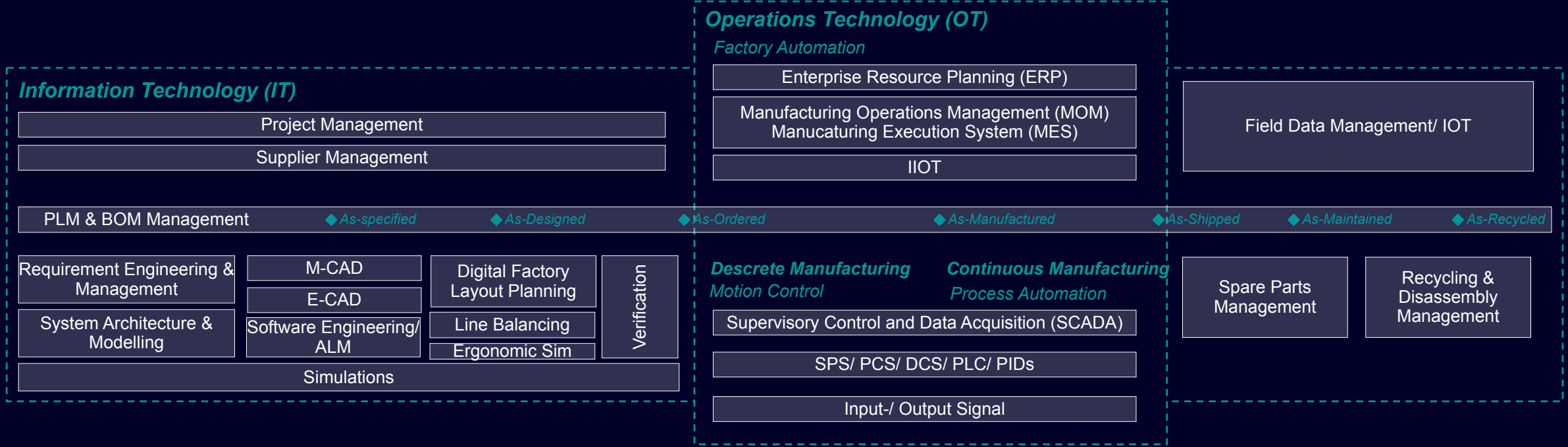
Typical IT/OT Capability Architecture

ILLUSTRATIVE

Product & Production Lifecycle



IT & OT Capability Architecture



Examples of Product Engineering Capabilities

Digital Enterprise

Digital Engineering

Product Engineering

Capabilities

- Systems Engineering
- Requirement Engineering
- Mechanical Engineering
- Electrical Engineering
- Software Engineering
- Useability Engineering
- ...

Sub-Capabilities

- Systems Thinking
- Systems Lifecycle Management
- Systems Innovation & Concept
- Systems Architecture & Modeling
- Model-based Engineering & Simulation
- Systems Integration & Model-based V&V
- ...

Production Engineering

Agenda

Introduction | Industrial Eco-System

Context | Digital Farming Solutions

Example | Modelling of Enterprise Eco-System with ARCADIA

Summary & Lessons learned

Summary & Lessons Learned

A

Megatrends

Industry Context is changing with higher frequency, where enterprises need to adapt faster

B

Eco-System Modelling

Products and enterprise work in eco-systems, where enterprises need to understand the dependencies

C

Lifecycle Engineering

For sustainable products all phases of the lifecycle are “managed”, enterprises need to consider this already in engineering

Agenda

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Summary & Lessons learned

Thank you for your attention.

