Towards comprehensive data demands:

A long-term strategy for public clients' asset life cycle data needs

***An exploration** of a*
continuous improvement approach
for the formulation of
comprehensive data demands
in the Bau- und Liegenschaftsbetrief NRW (BLB NRW) of Germany

TU Delft Department of Management in the Built Environment
BK Bouwkunde

Graduation Laboratory | AR4R010 | Theme 8: User Perspective

Prof. mr.dr. E.M. (Evelien) Bruggeman | Main Mentor
Dr.ir. A. (Ad) Straub | Second Mentor
Prof. M. (Moritz) Fleischmann-Bergstein | Third Mentor
Leonardo Micolta Diaz | Student (5684773)

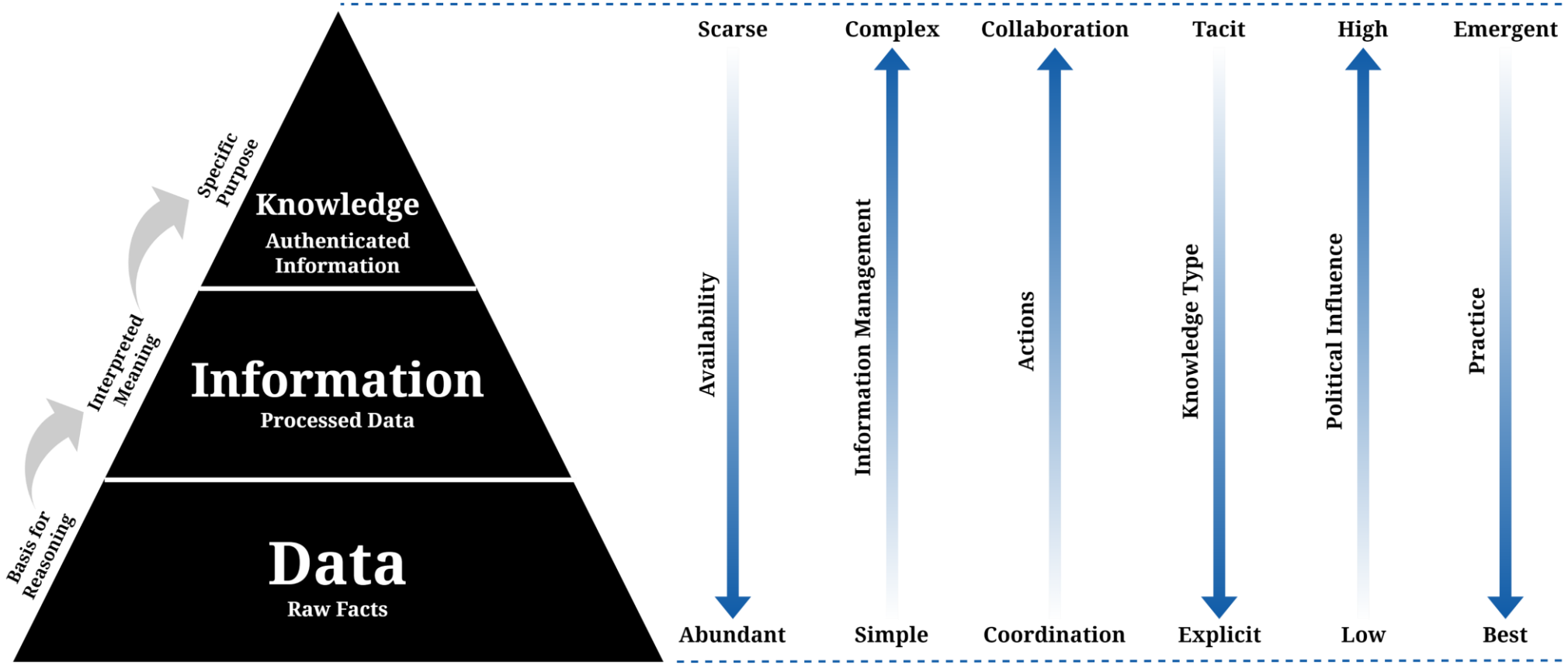
Digitization in AECOO sector

“The conversion of analogue (physical) information into digital (binary) data formats”

(Koutamanis, 2022; Vrana & Singh, 2021)

digital data

1



1. Knowledge semantic levels and relationships to domains Adapted from (Ford, 2024; Parsanezhad, 2015)

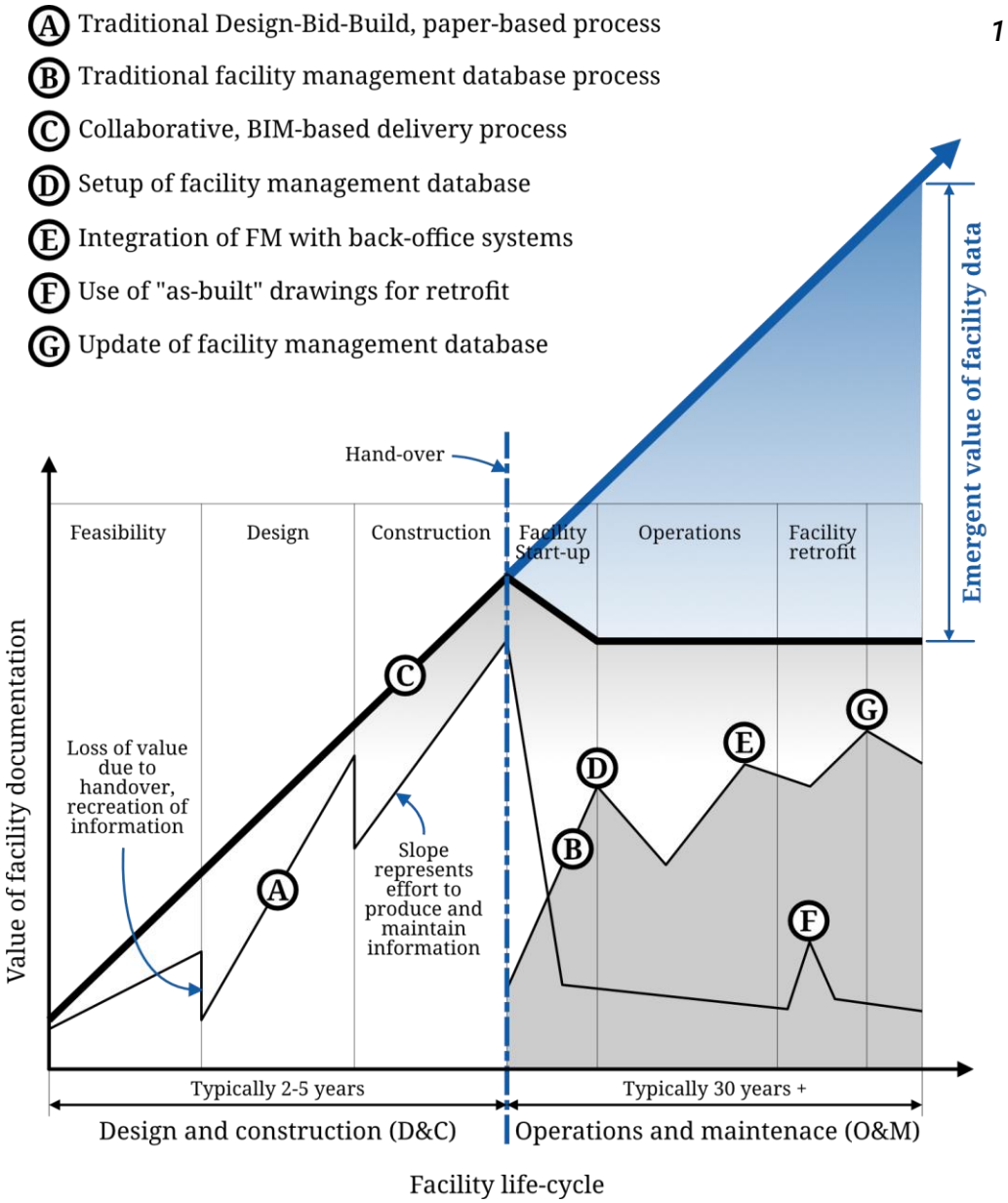
Digitalization in AECOO sector

“The process by which digital data is used by information technology (IT) to simplify specific operations”

(M. May et al., 2023; Vrana & Singh, 2021)

efficiency & performance

The Promise…



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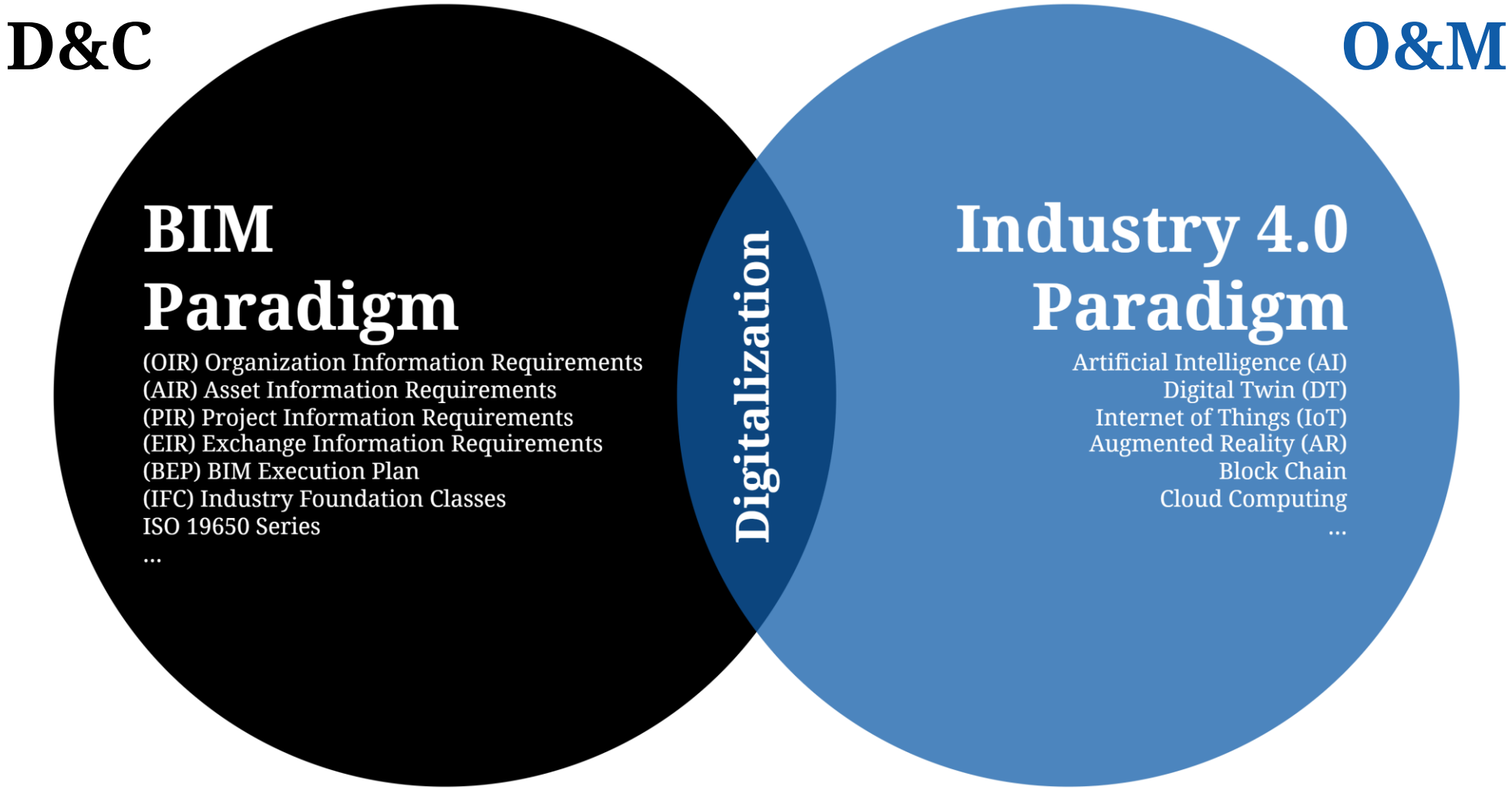
BIM

Building Information Modelling

1. Conceptual diagram of information flow, according to Figure 4-1 (Eastman, 2011)

Merging Paradigm



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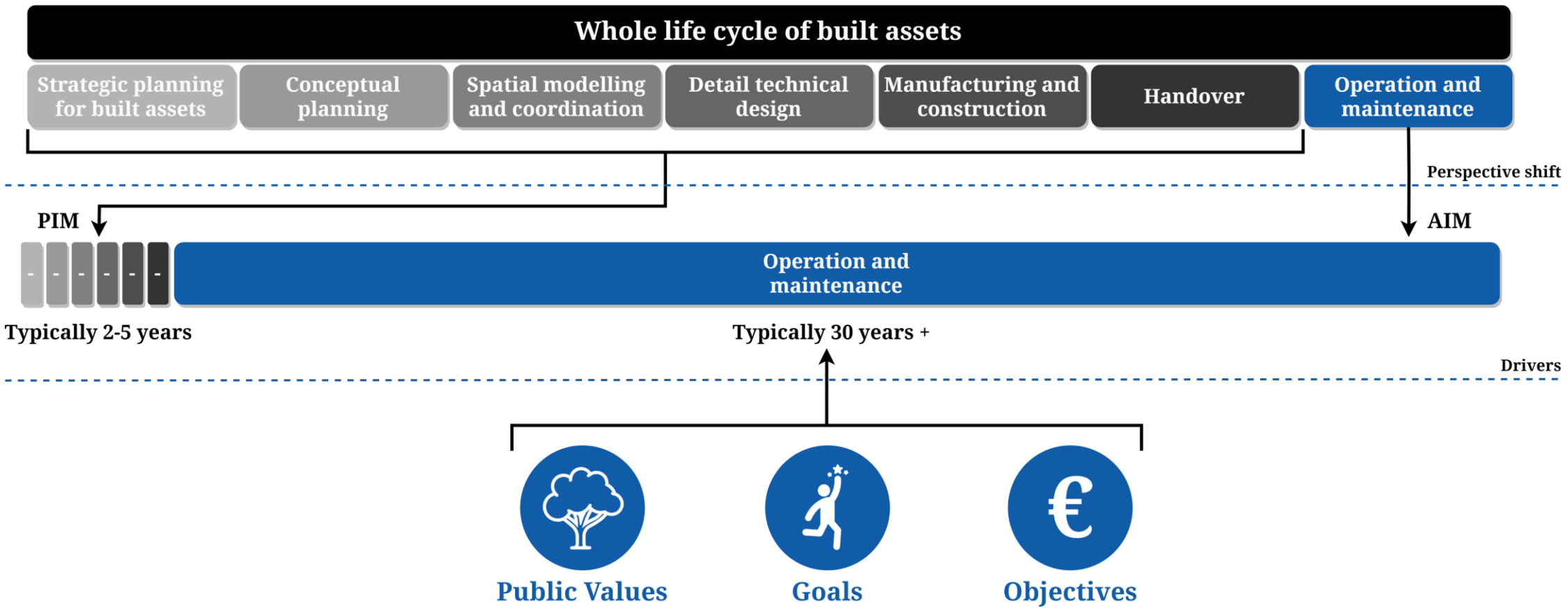


1. The importance of the operating phase within the life cycle of a built asset, adapted from (Ashworth & May, 2023)

Digital transformation in AECOO sector

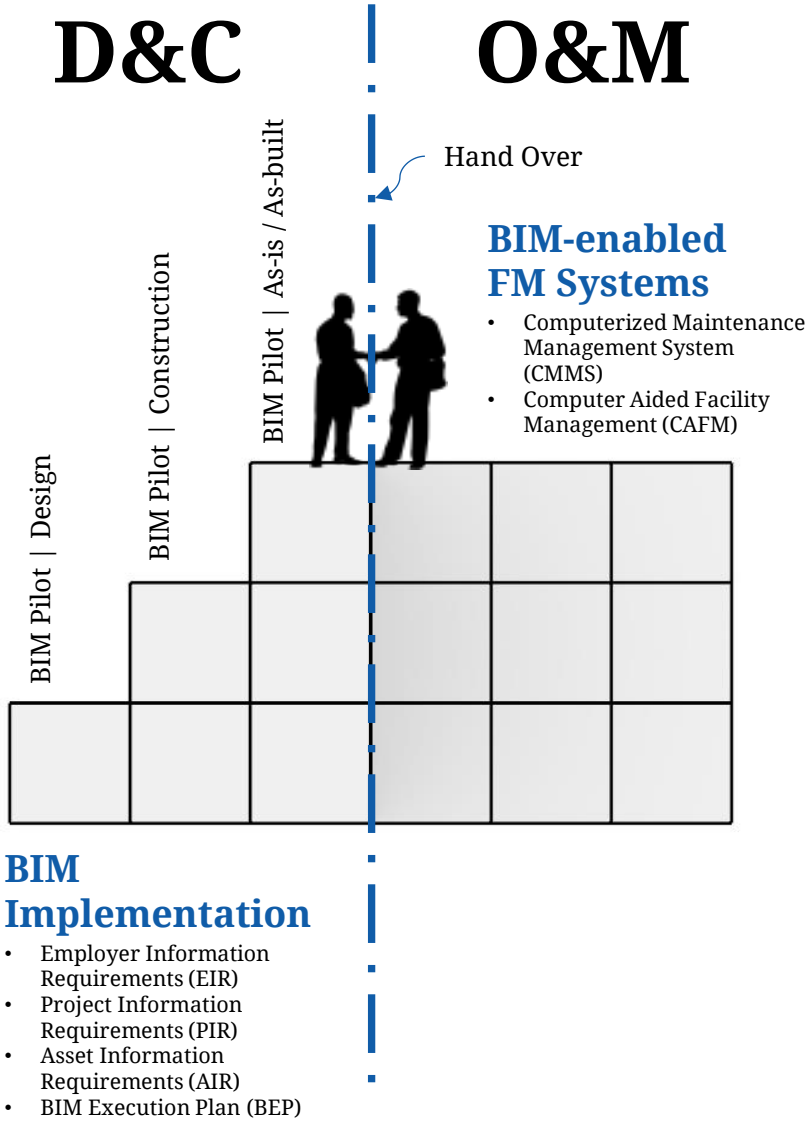
“The concepts and methods used to deploy and implement information technology to create added value for an organization”

(M. May et al., 2023; Vrana & Singh, 2021)

added value

However...

Theory



Praxis

Public procurement

“public clients influence in procurement and ability to set requirements are key drivers of industry-wide adoption of information technology”

(Lindblad & Guerrero, 2020)

data demands

Public clients in the driver’s seat

Lindblad & Guerrero (2019):

“public clients play a role in stimulating innovation in the AEC sector: Client-led or Supplier-led role”

Lindblad & Karrbom Gustavsson (2021):

“*public clients must first consider intra-organizational process changes before exerting influence on external actors*”

The lack of a well-defined, long-term strategy for capturing and managing facility data across the asset life cycle in the AECOO sector impedes public clients from formulating comprehensive and holistic data demands, limiting the impact of digital transformation efforts.

People

“Actors are not self-contained entities, but rather defined by their relationships and interactions with other elements in the network”
(Lindblad, 2019)

Socio-Technical

Resistance to Change	**Competing Policies**	**Knowledge Management**
Data Interoperability	**System Efficiency**	**System Capacity**

Practical-knowledge Gap

When professionals' actual behavior differs from their advocated behavior (Miles, 2017)

Kuitert et al. (2019):

“*Public Clients often revert to old patterns and behaviors.*”

Lindblad (2019):

“*Hybrid approaches combine new practices with old habits and logics are commonplace.*”

Managerial actions

“actions integrated into a continuous improvement approach to break down information "silos" while addressing prevailing social factors”

(Kuitert et al., 2019)

information silos

Game Rules ➡ Game Plans

procedural obligations are formally well-arranged in today's public construction client organizations and procedural values are explicitly contextualized in commissioning tasks (Kuitert et al., 2019)

Need for explicit implementation guidelines (Wildenauer, 2023)

How can public clients develop a comprehensive and holistic framework for data demand formulation that aligns with their asset life cycle needs, organizational goals, and desired public values?

Data demand formulation

Theoretical Research

Social Aspects
vs.
Technological Aspects

complex system modeling

+

Managerial actions

Empirical Research

Current State
vs.
Desired State

(mis)alignment

Case Study

Bau- und Liegenschaftsbetrieb NRW

(The Construction and Real Estate Company of The State of North Rhine-Westphalia)

Bau- und Liegenschaftsbetrieb NRW

8
Main Locations

2894
Employees

1

8233
Construction Projects

286 Mill.€
Federal Projects

573 Mill.€
State Projects

86 Mill.€
Other Projects

4038
Owned Buildings

579 Mill.€
Maintenance

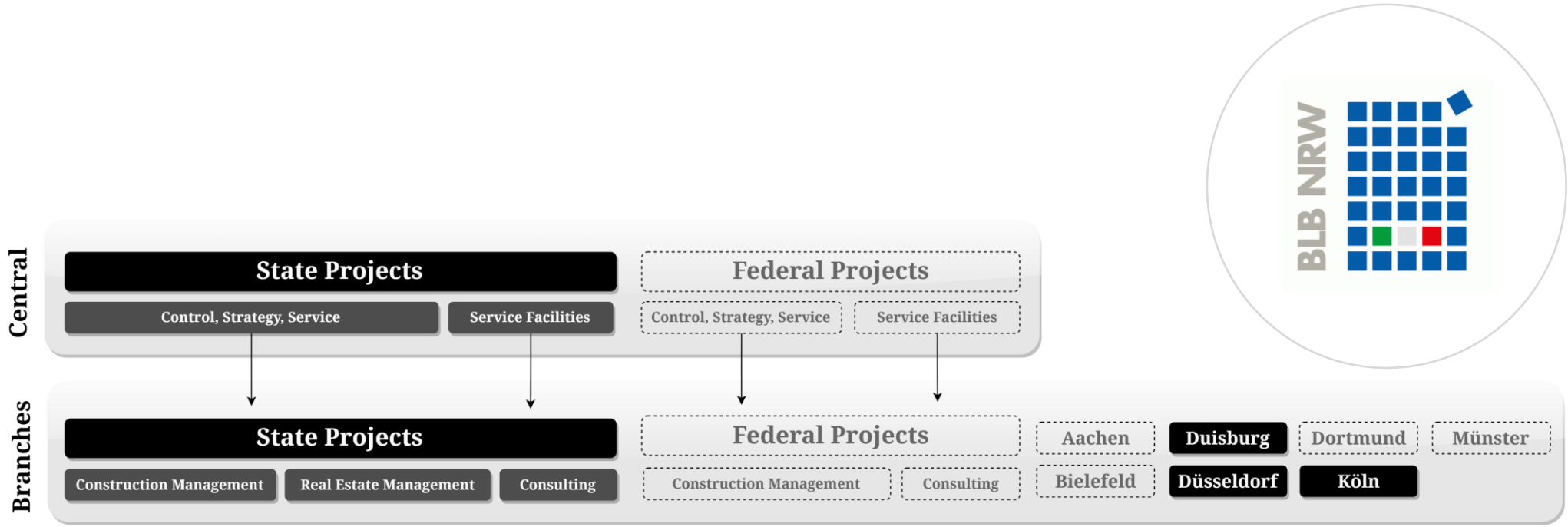
10,3 Mill.m²
Rental Space

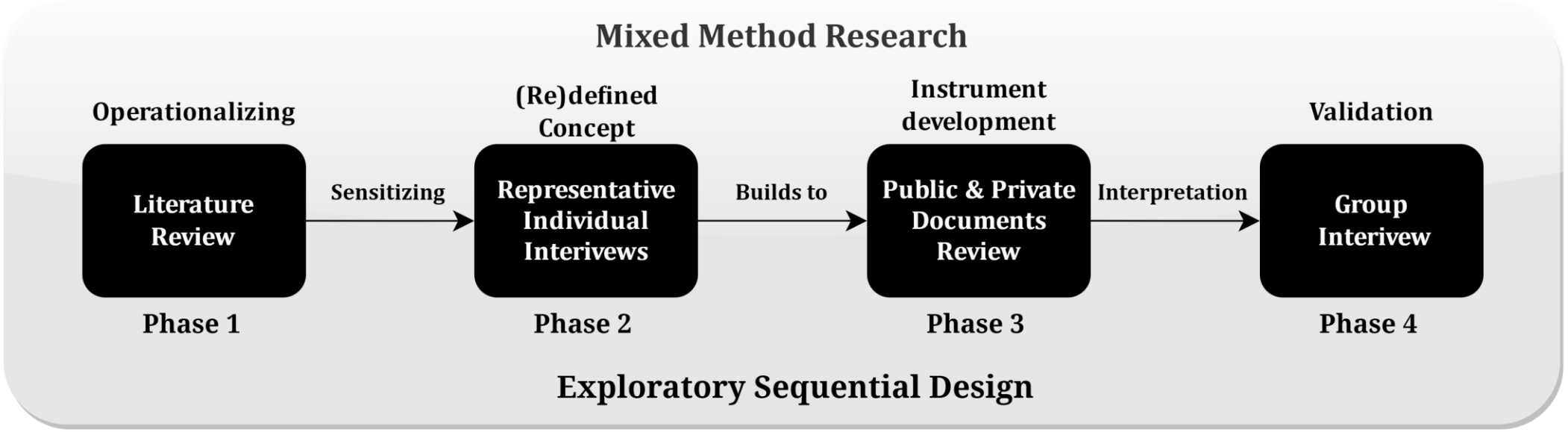
1,5 Bill.€
Rental Income

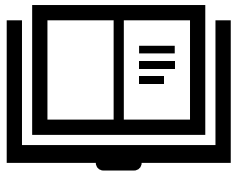
Early BIM Adopter

9,3 Bill.€
Total Balance Sheet

1. Numbers, Data and Facts (Dec. 2022). https://www.blb.nrw.de/blb-nrw/profile-und-aufgaben

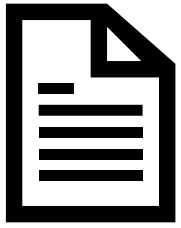

Central
State Projects
Control, Strategy, Service
Service Facilities
Federal Projects
Control, Strategy, Service
Service Facilities
Branches
State Projects
Construction Management
Real Estate Management
Consulting
Federal Projects
Construction Management
Consulting
Aachen
Bielefeld
Duisburg
Düsseldorf
Dortmund
Köln
Münster



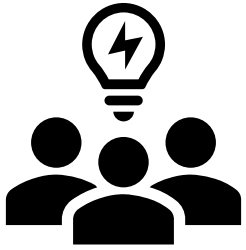


1 X
Theoretical Framework

20 X
Semi-structured Interviews

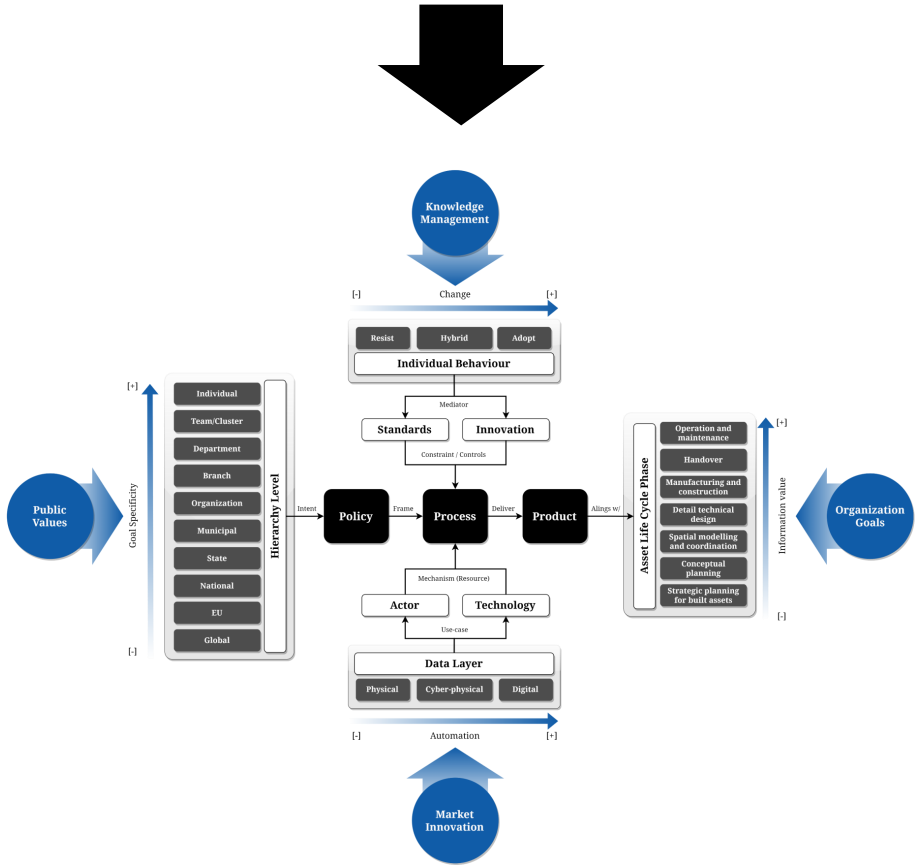


13 X
Document Analysis



2 X
Focus-group Sessions

Literature Review



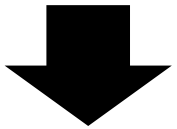
Public Clients BIM Implementation Status Quo

Social Aspects Themes

Technological Aspects Themes

Exploration

Interviews



Phase 2

Emergent Topics

Evidence Search

Document Analysis

Phase 1

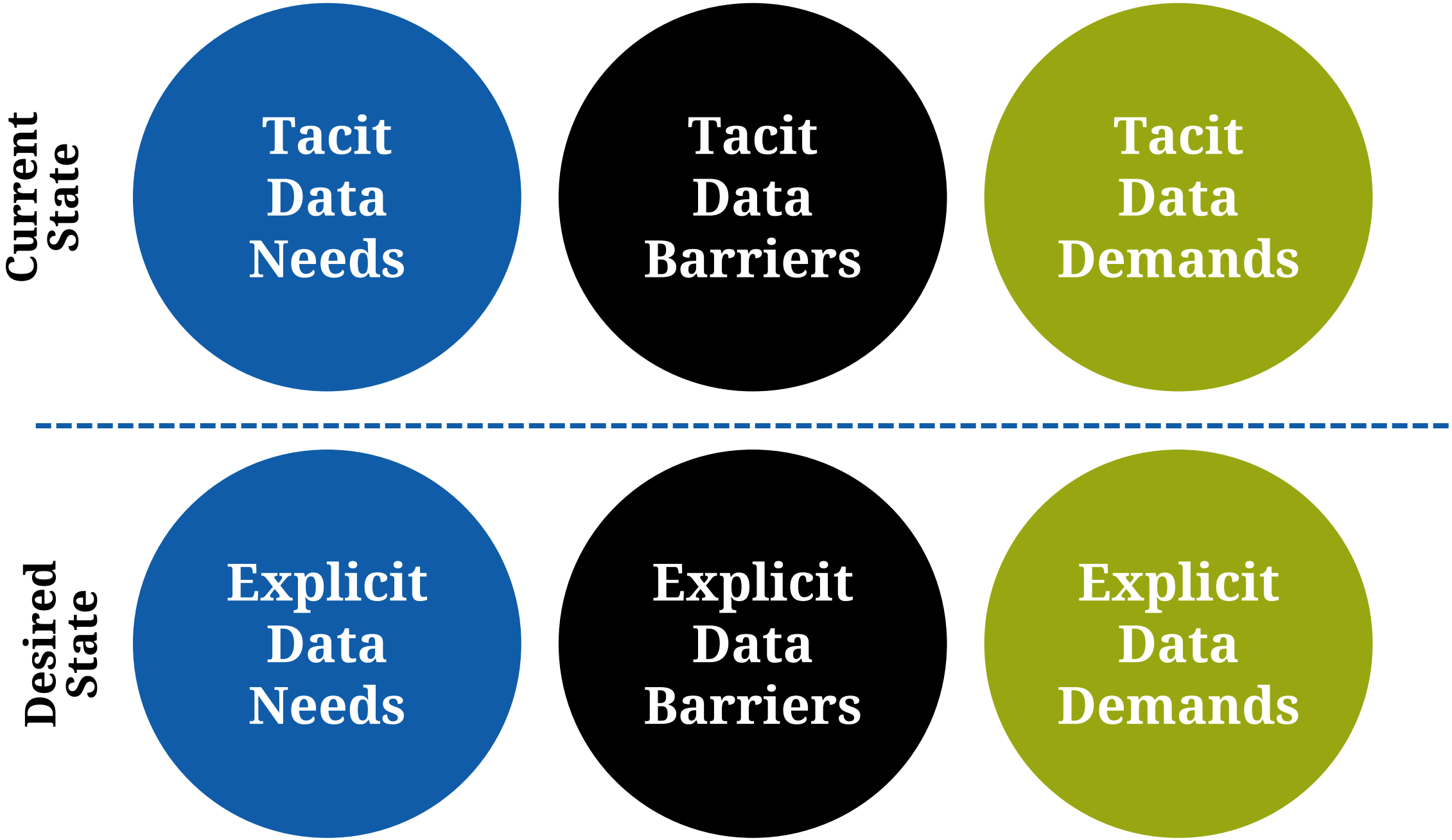
Literature Themes

Phase 2

Emergent Topics


Interview Analysis
Document Analysis
Current State
(Mis)alignment
Desired State
Tacit Knowledge
Explicit Knowledge

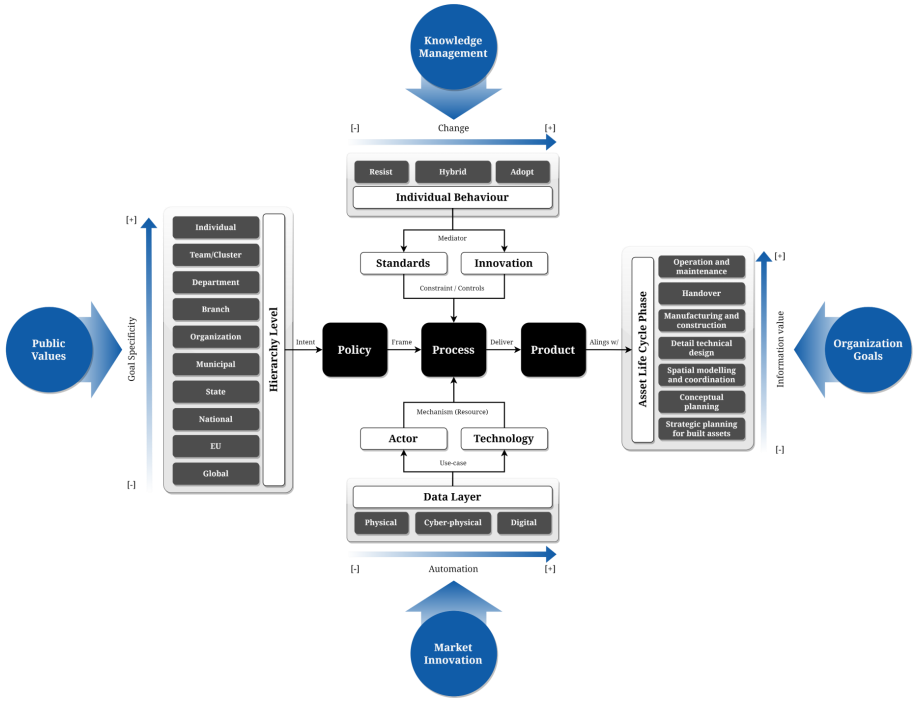
Analysis Dimensions



Managerial Actions

Essential Elements

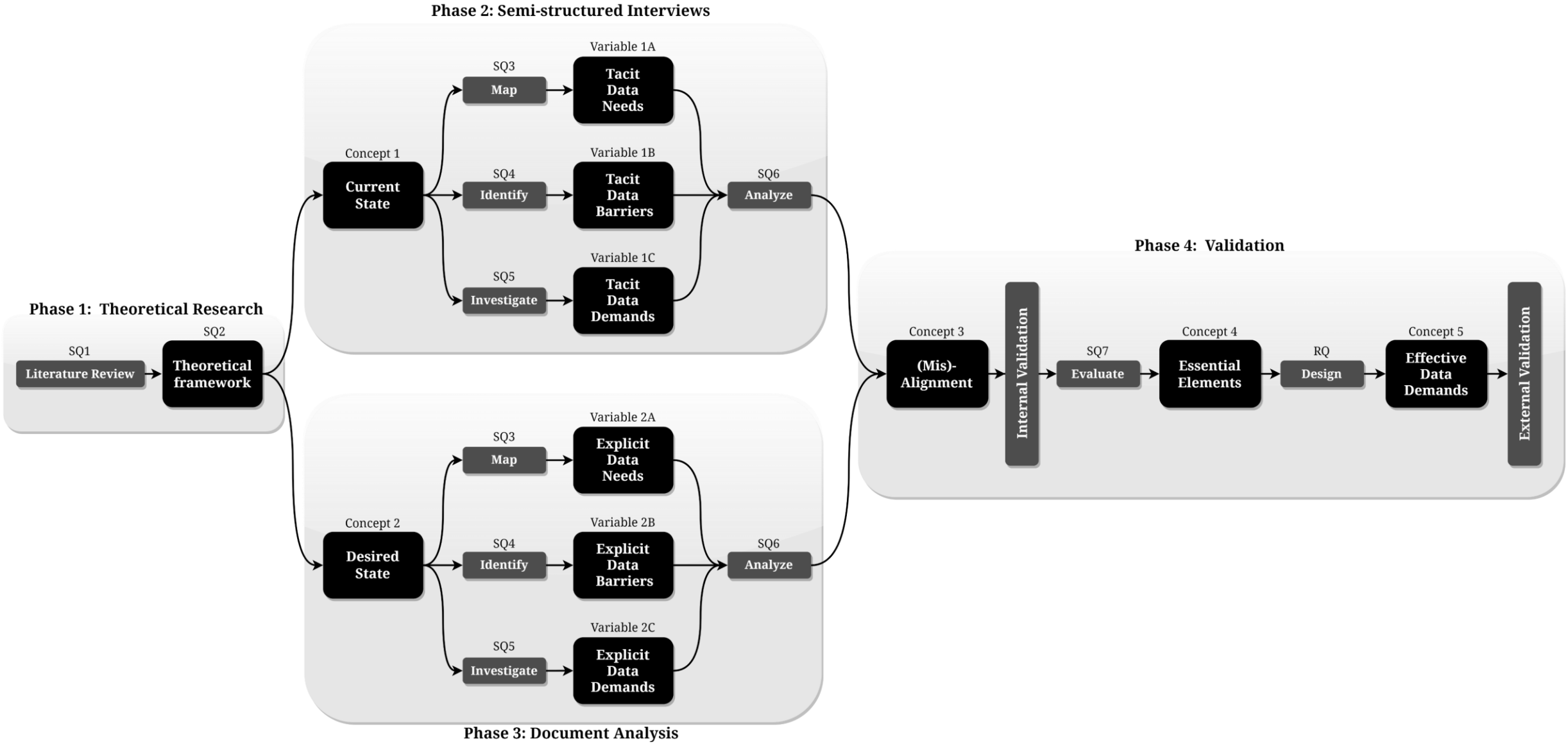
Data demand formulation



Managerial actions

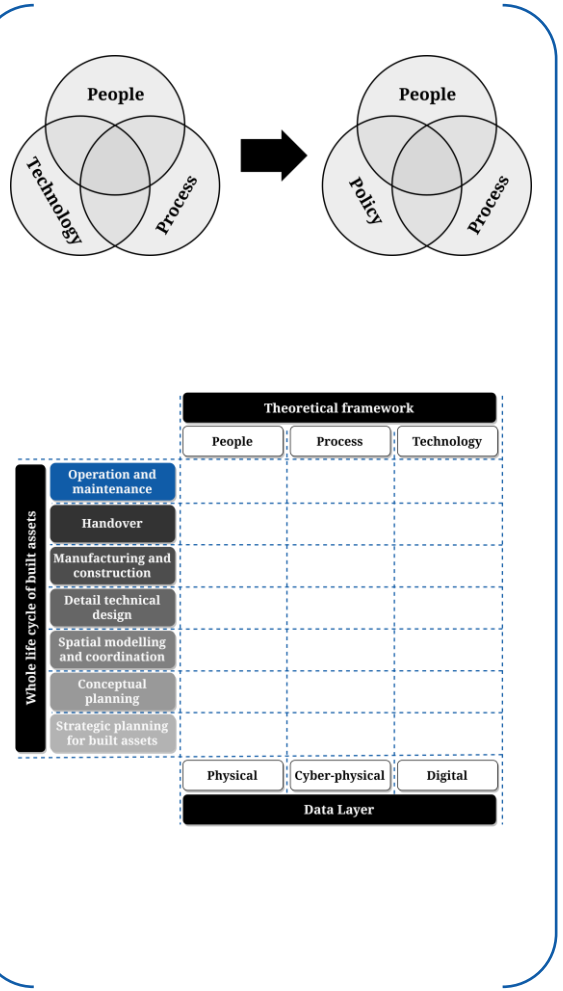
+

Essential Elements

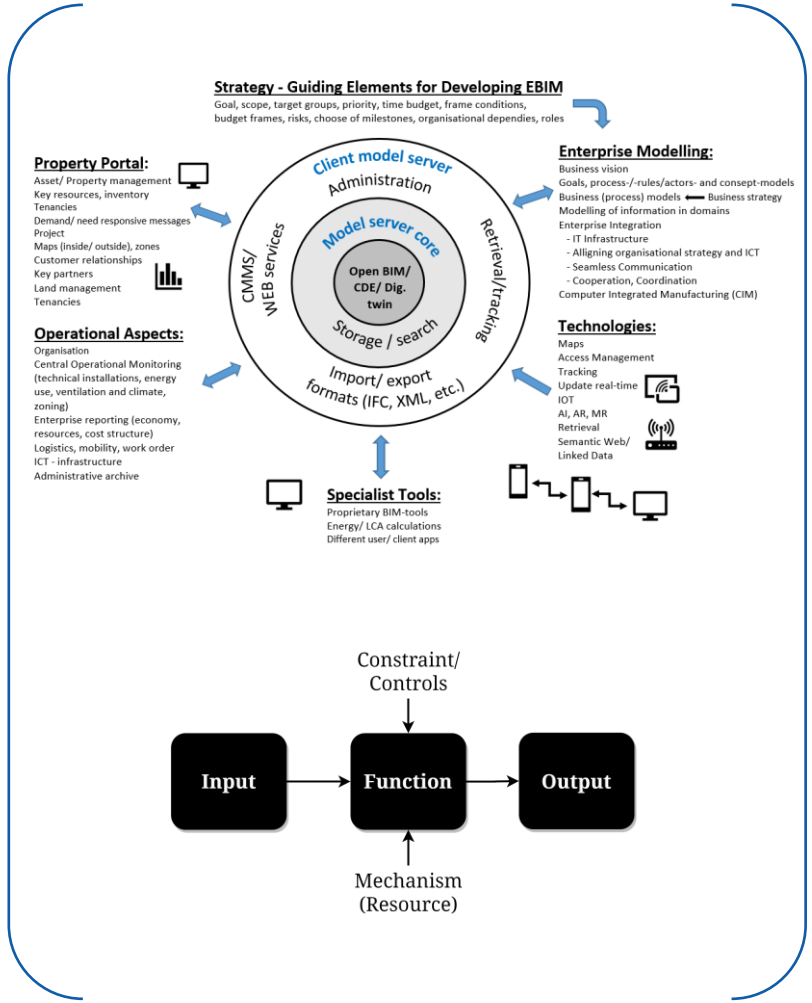

Phase 2: Semi-structured Interviews
Variable 1A
SQ3
Map
Tacit Data Needs
Concept 1
Current State
Variable 1B
SQ4
Identify
Tacit Data Barriers
SQ6
Analyze
Variable 1C
SQ5
Investigate
Tacit Data Demands
Phase 4: Validation
Phase 1: Theoretical Research
SQ1
Literature Review
SQ2
Theoretical framework
Concept 3
(Mis)-Alignment
Internal Validation
SQ7
Evaluate
Concept 4
Essential Elements
RQ
Design
Concept 5
Effective Data Demands
External Validation
Variable 2A
SQ3
Map
Explicit Data Needs
Concept 2
Desired State
Variable 2B
SQ4
Identify
Explicit Data Barriers
SQ6
Analyze
Variable 2C
SQ5
Investigate
Explicit Data Demands
Phase 3: Document Analysis

Framework

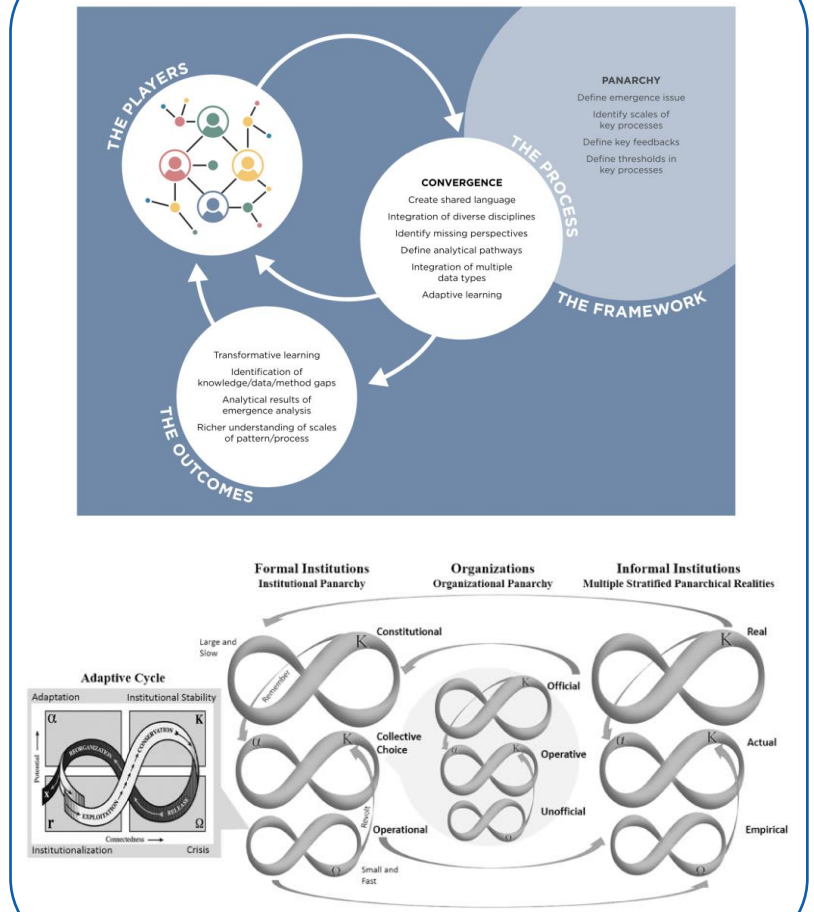
SQ2: What theoretical framework can be used to evaluate an organization's current state in relation to its desired state in digital transformation adoption efforts?



PPT Variants

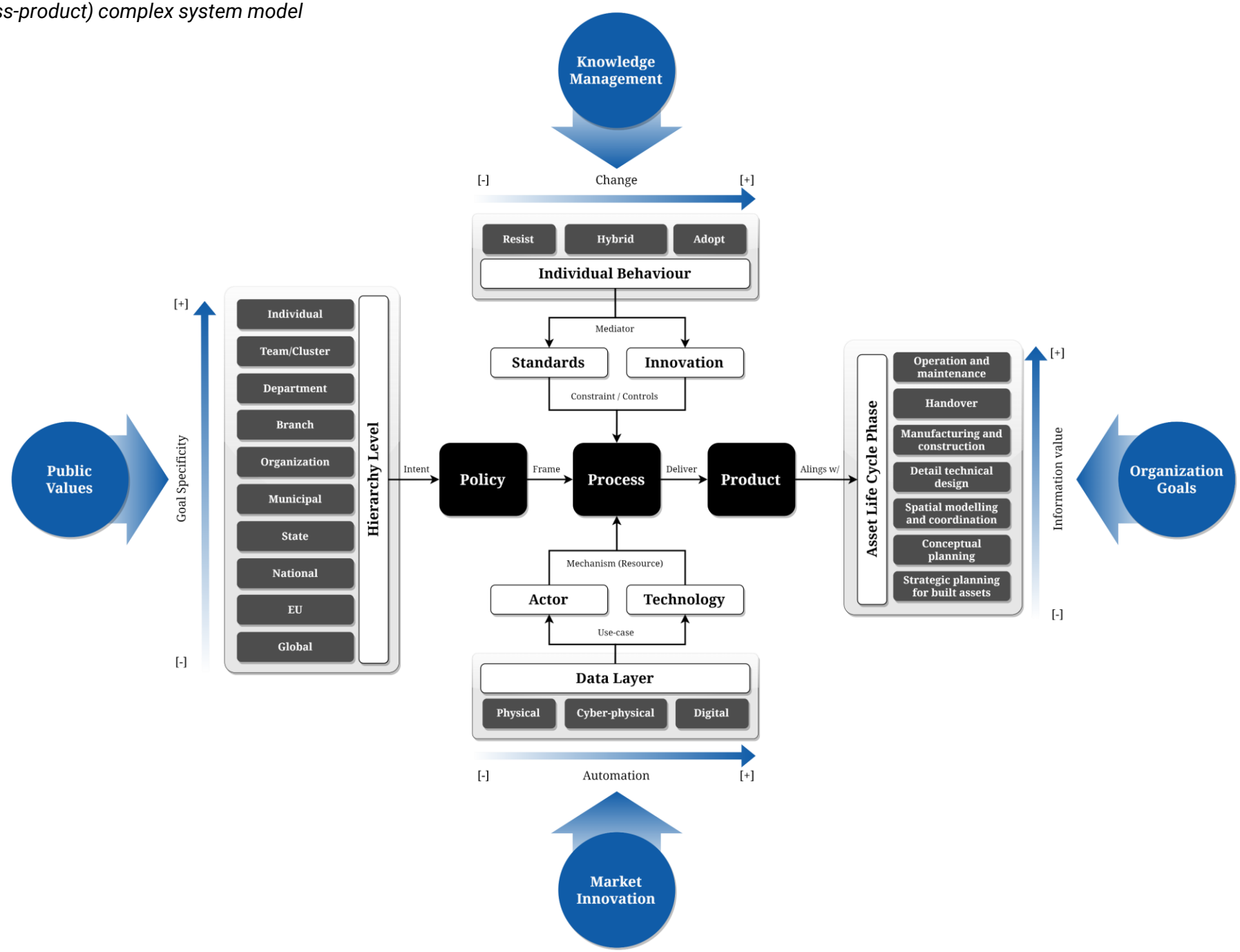


Modelling

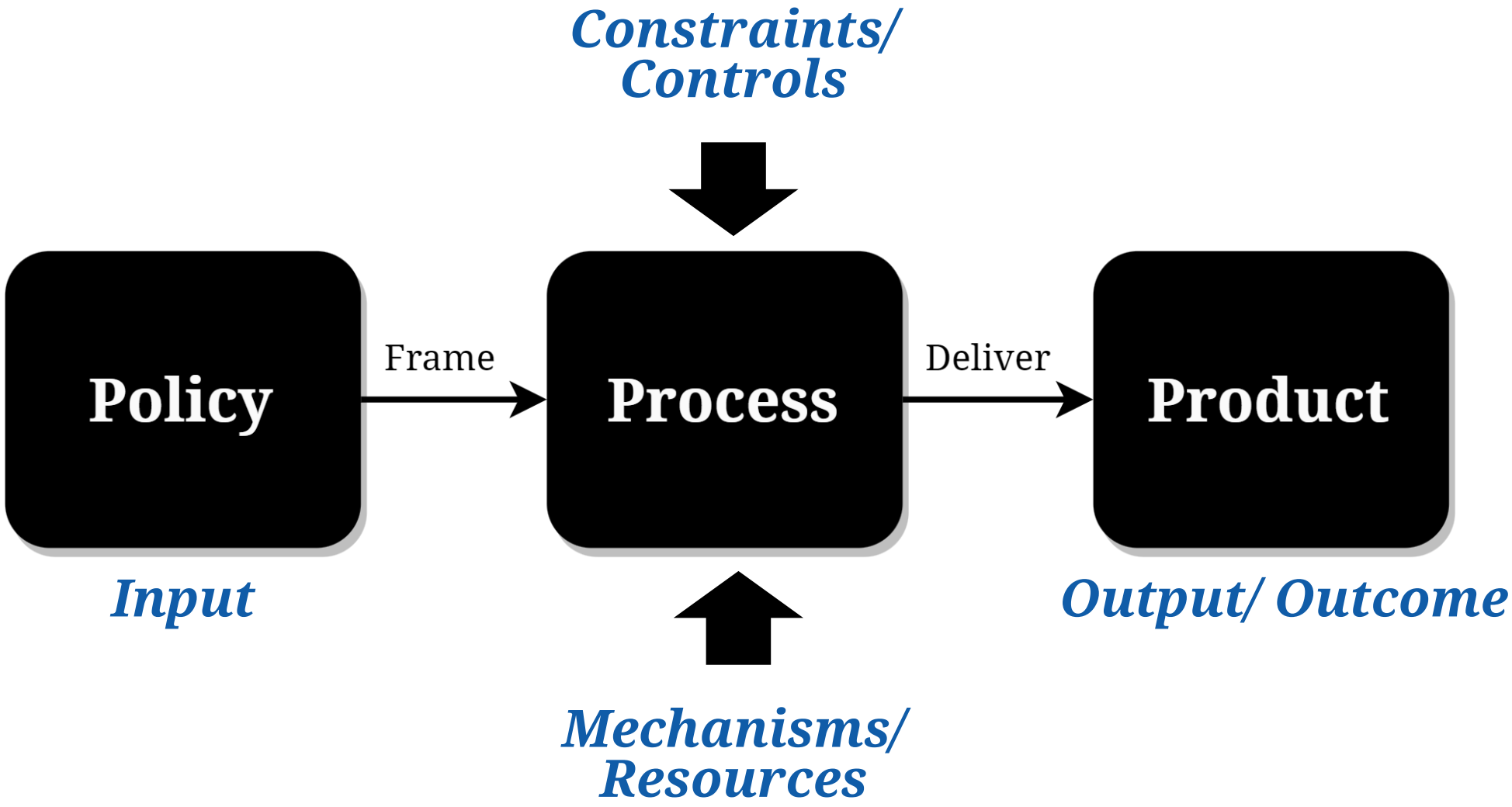


Complex SES

PPP (people-process-product) complex system model



PPP (people-process-product) complex system model



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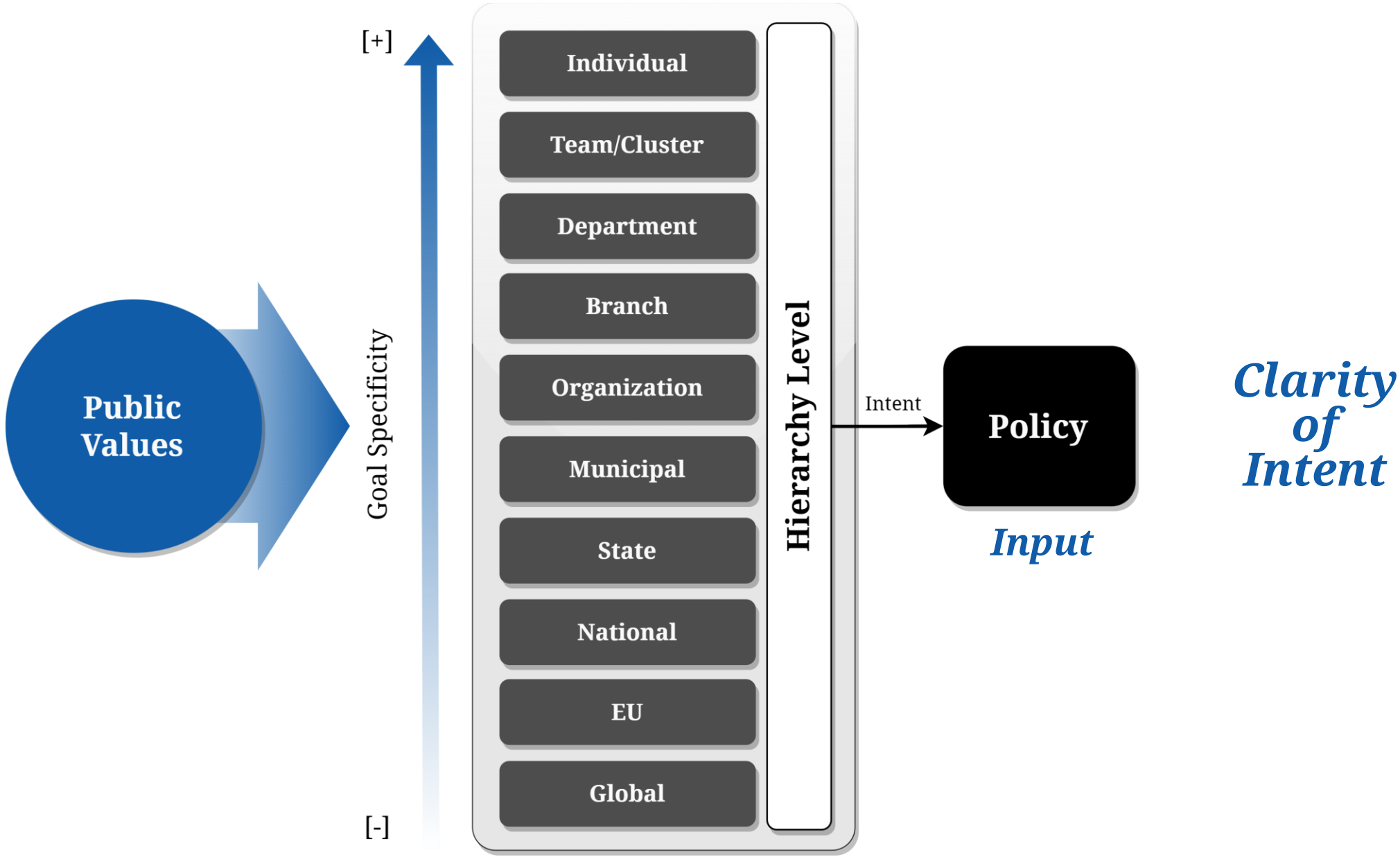
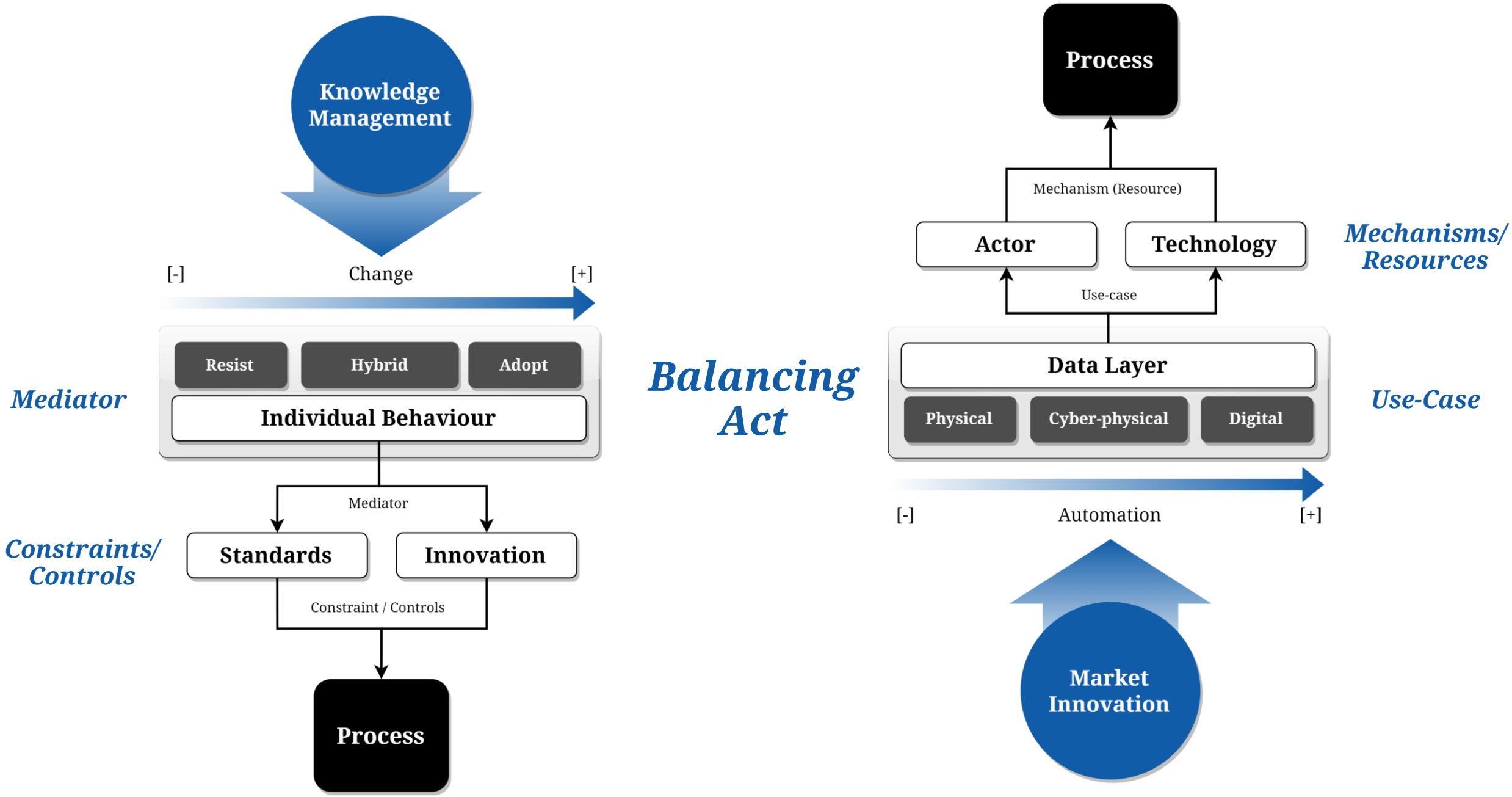


PPP (people-process-product) complex system model



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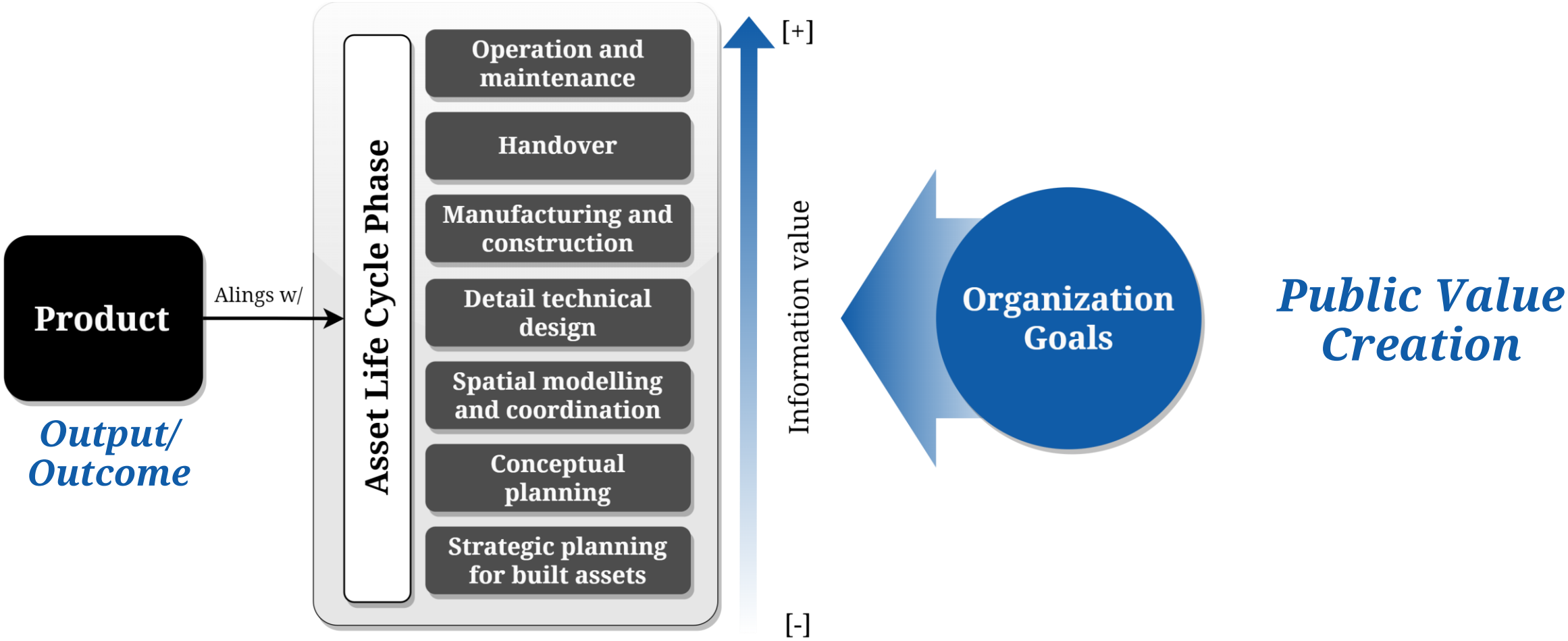

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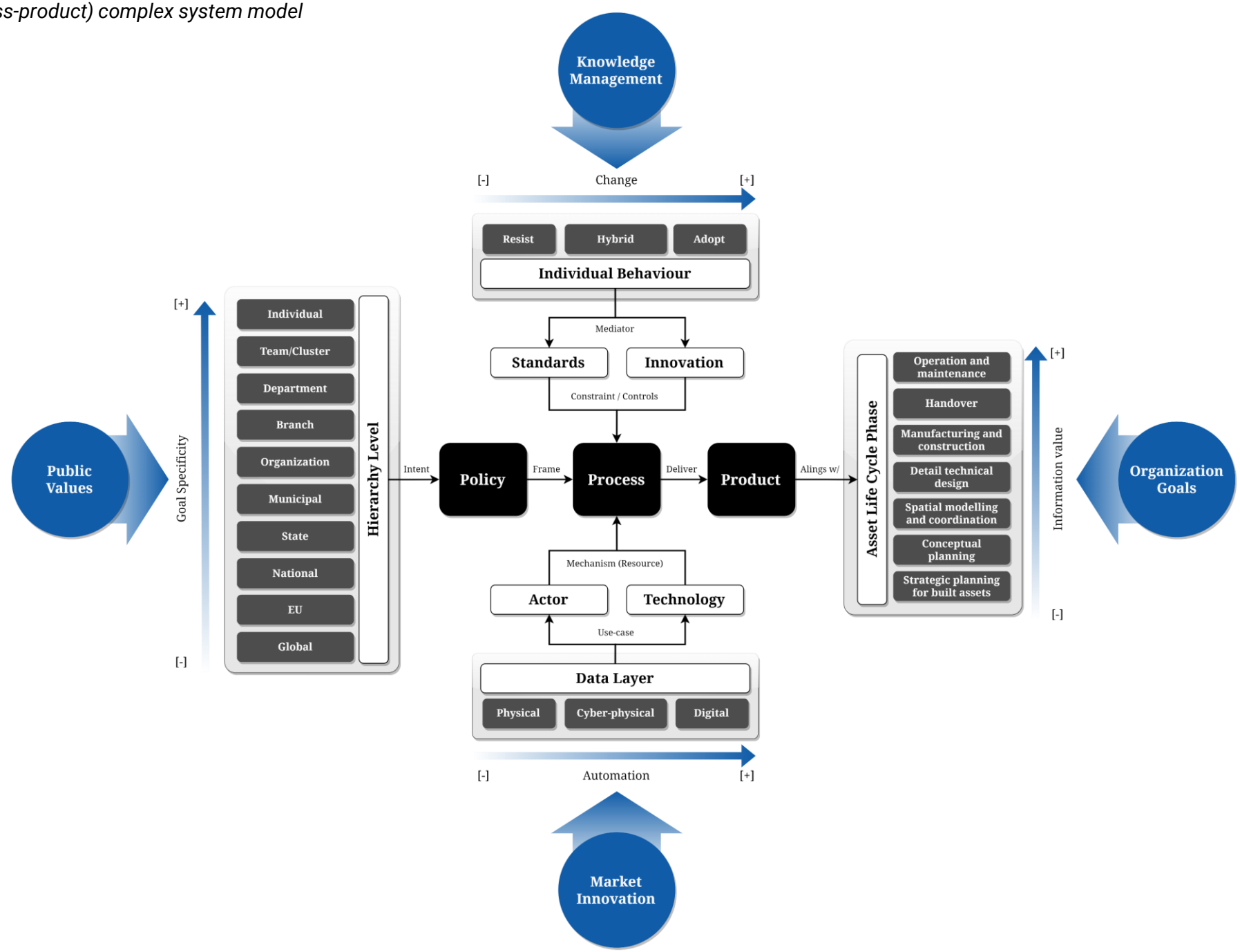
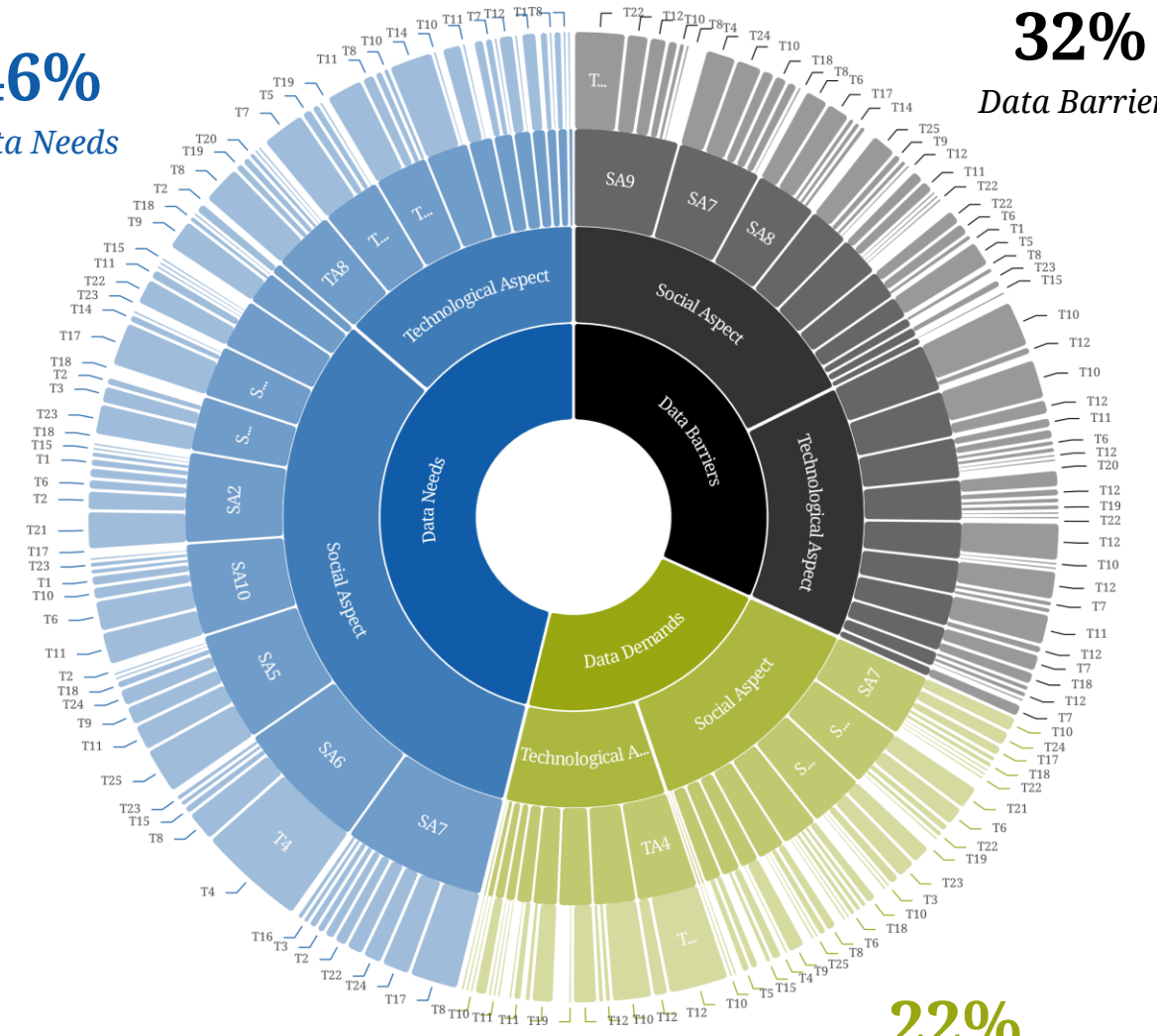


Design

RQ: How can public clients develop a comprehensive and holistic framework for data demand formulation that aligns with their asset life cycle needs, organizational goals, and desired public values?

46%
Data Needs

32%
Data Barriers



22%
Data Demands

63%
Social Aspects

37%
Technological Aspects

70%
Social Aspects

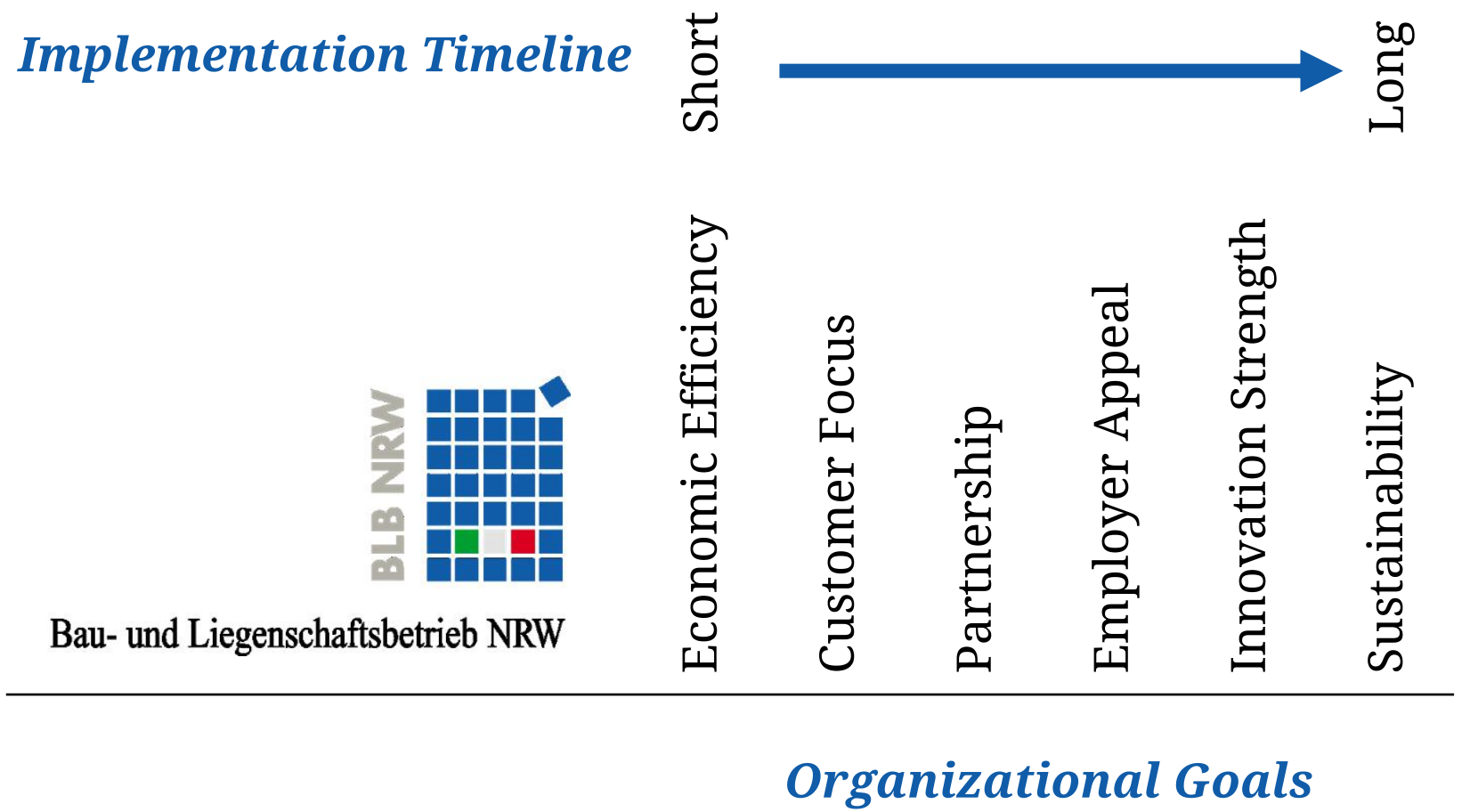
30%
Technological Aspects

56%
Social Aspects

44%
Technological Aspects

59%
Social Aspects

41%
Technological Aspects


Implementation Timeline
Short
Long
Economic Efficiency
Customer Focus
Partnership
Employer Appeal
Innovation Strength
Sustainability
BLB NRW
Bau- und Liegenschaftsbetrieb NRW
Organizational Goals

Organizational Goals

Implementation Timeline: Short → Long

Themes

		Economic Efficiency	Customer Focus	Partnership	Employer Appeal	Innovation Strength	Sustainability
SA1	*Collaboration*	x	x	x	x		
TA1	*Data Access*	x			x	x	
TA4	*Data Relevance*	x	x				x
TA6	*Data Storage*					x	
SA2	*Goal Interpretation*				x	x	
SA4	*Knowledge Archiving*	x			x	x	
SA5	*Knowledge Gaining*				x	x	
SA6	*Knowledge Sharing*				x	x	
SA7	*Maturity*	x	x				
SA8	*Power Dynamics*	x	x	x			
SA9	*Preference*				x	x	x
SA10	*Stakeholder Relations*		x	x	x		
TA7	*System Capability*	x				x	x
TA8	*System Efficiency*	x				x	x
TA9	*System Legacy*			x	x		
TA10	*System Usability*	x		x	x	x	

Organizational Goals

Implementation Timeline: Short → Long

Topics

		Economic Efficiency	Customer Focus	Partnership	Employer Appeal	Innovation Strength	Sustainability
T1	*Client / Tennant*	x	x	x			
T2	*Continuous Improvement*	x			x	x	x
T4	*Coordination*	x	x	x			
T5	*Documentation*	x					x
T6	*External Governance*		x	x			
T7	*information Access Rights*	x		x			
T8	*Information Distribution*		x	x			
T10	*Information Quality*				x	x	x
T11	*Information Search*	x			x	x	
T12	*Information Structuring*	x	x			x	x
T13	*Integration & Mentoring*			x	x		
T14	*Internal Governance*	x	x	x	x		
T15	*Leadership & Proactivity*				x	x	x
T17	*Roles & Responsibilities*	x	x	x	x		
T19	*Software & Hardware Resources*	x			x	x	
T20	*Software Support & Updates*	x			x	x	
T21	*Sustainability*	x			x	x	x
T22	*Task Completion*	x					
T23	*Teamwork*		x	x	x		
T24	*Templates & Guidelines*	x				x	
T25	*Training & Development*	x			x		

Alignment

- *Strategic prioritization of robust systems and effective stakeholder engagement to drive progress*
- *Organization's commitment to sustainable practices and the production of high-quality, actionable data to support innovation*
- *Fostering a structured yet flexible approach to achieving strategic objectives*
- *Well-integrated approach to enhancing operational capabilities while promoting a culture of collaboration and continuous learning*

Misalignment

- *Outdated systems and integration challenges, which constrain the organization's ability to modernize and leverage interconnected data platforms effectively*
- *Unclear authority structures and ambiguous task definitions hinder efficiency and stakeholder engagement*
- *Potential conflicts between individual or departmental priorities and the broader organizational goals, particularly in achieving economic efficiency and customer focus*
- *Inefficiencies in accessing and maintaining critical data systems*

Essential Elements Influencing Data Needs

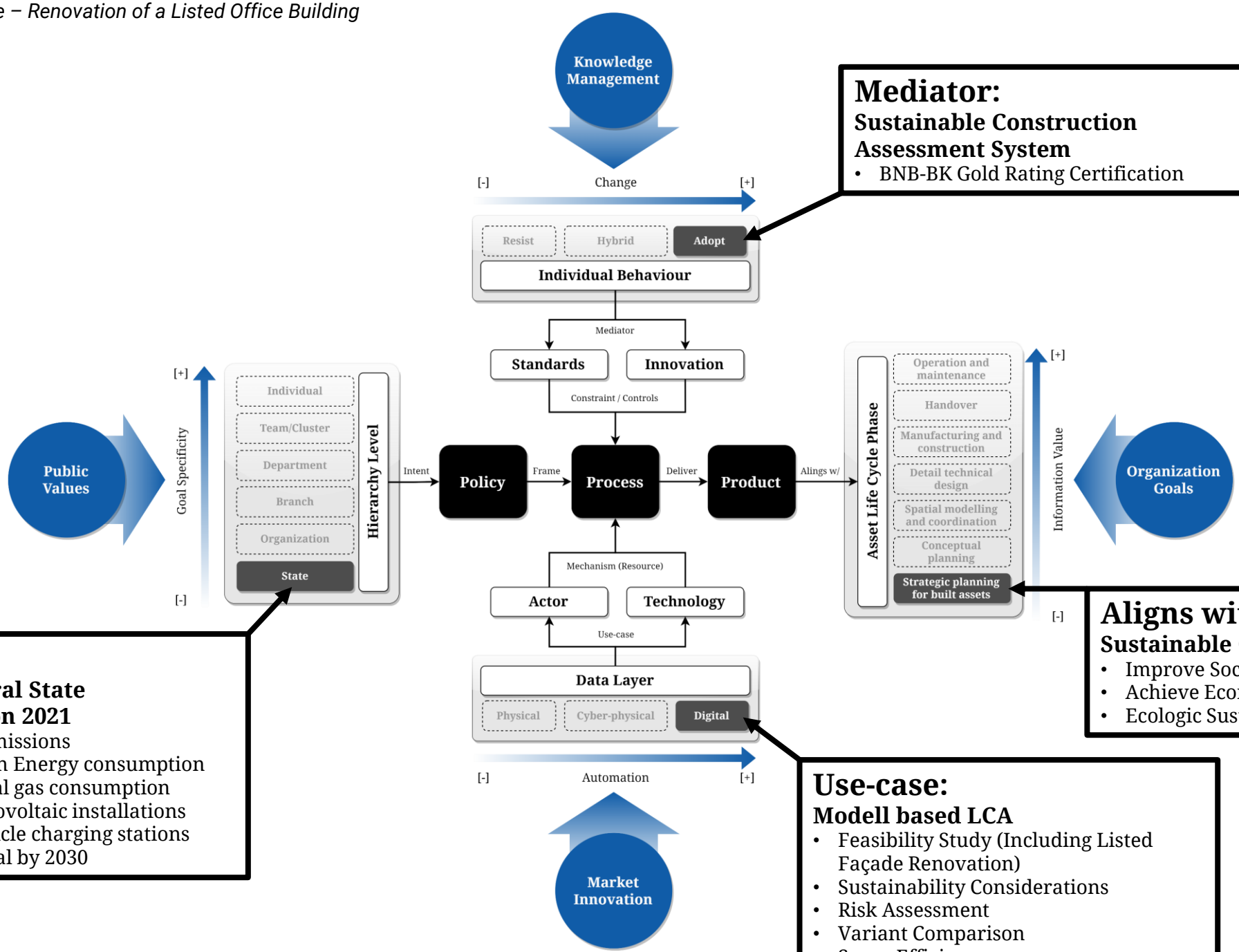
Relevance	Social Aspects		Technological Aspects	
	Topics	**Themes**	**Topics**	**Themes**
1	**T17** *Roles & Responsibilities*	**SA7** *Maturity*	**T21** *Sustainability*	**TA7** *System Capability*
2	**T4** *Coordination*	**SA10** *Stakeholder Relations*	**T10** *Information Quality*	**TA8** *System Efficiency*
3	**T11** *Information Search*	**SA5** *Knowledge Sharing*	**T12** *Information Structuring*	**TA9** *System Legacy*

Essential Elements Influencing Data Barriers

Relevance	Social Aspects		Technological Aspects	
	Topics	**Themes**	**Topics**	**Themes**
1	**T10** *Information Quality*	**SA7** *Maturity*	**T10** *Information Quality*	**TA8** *System Efficiency*
2	**T22** *Task Completion*	**SA2** *Goal Interpretation*	**T12** *Information Structuring*	**TA9** *System Legacy*
3	**T24** *Templates & Guidelines*	**SA9** *Preference*	**T11** *Information Search*	**TA2** *Data Interoperability*

Essential Elements Influencing Data Demands

Relevance	Social Aspects		Technological Aspects	
	Topics	**Themes**	**Topics**	**Themes**
1	**T4** *Coordination*	**SA2** *Goal Interpretation*	**T10** *Information Quality*	**TA3** *Data Processing*
2	**T10** *Information Quality*	**SA1** *Collaboration*	**T21** *Sustainability*	**TA4** *Data Relevance*
3	**T23** *Teamwork*	**SA7** *Maturity*	**T12** *Information Structuring*	**TA7** *System Capability*



Mediator:
Sustainable Construction Assessment System
- BNB-BK Gold Rating Certification

Intent:
Climate Neutral State Administration 2021
- Reduce C02 emissions
- Increase Green Energy consumption
- Reduce natural gas consumption
- Increase photovoltaic installations
- Expand e-vehicle charging stations
- Climate neutral by 2030

Aligns with:
Sustainable Organization
- Improve Social Sustainability
- Achieve Economic Sustainability
- Ecologic Sustainability

Use-case:
Modell based LCA
- Feasibility Study (Including Listed Façade Renovation)
- Sustainability Considerations
- Risk Assessment
- Variant Comparison
- Space Efficiency

Standards:

BNB-BK 2017

- Ecologic Quality
- Economic Quality
- Sociocultural Quality
- Process Quality
- Location Characteristics

BLB BIM Guidelines

- Templates 14a,b,c,d & 15,16

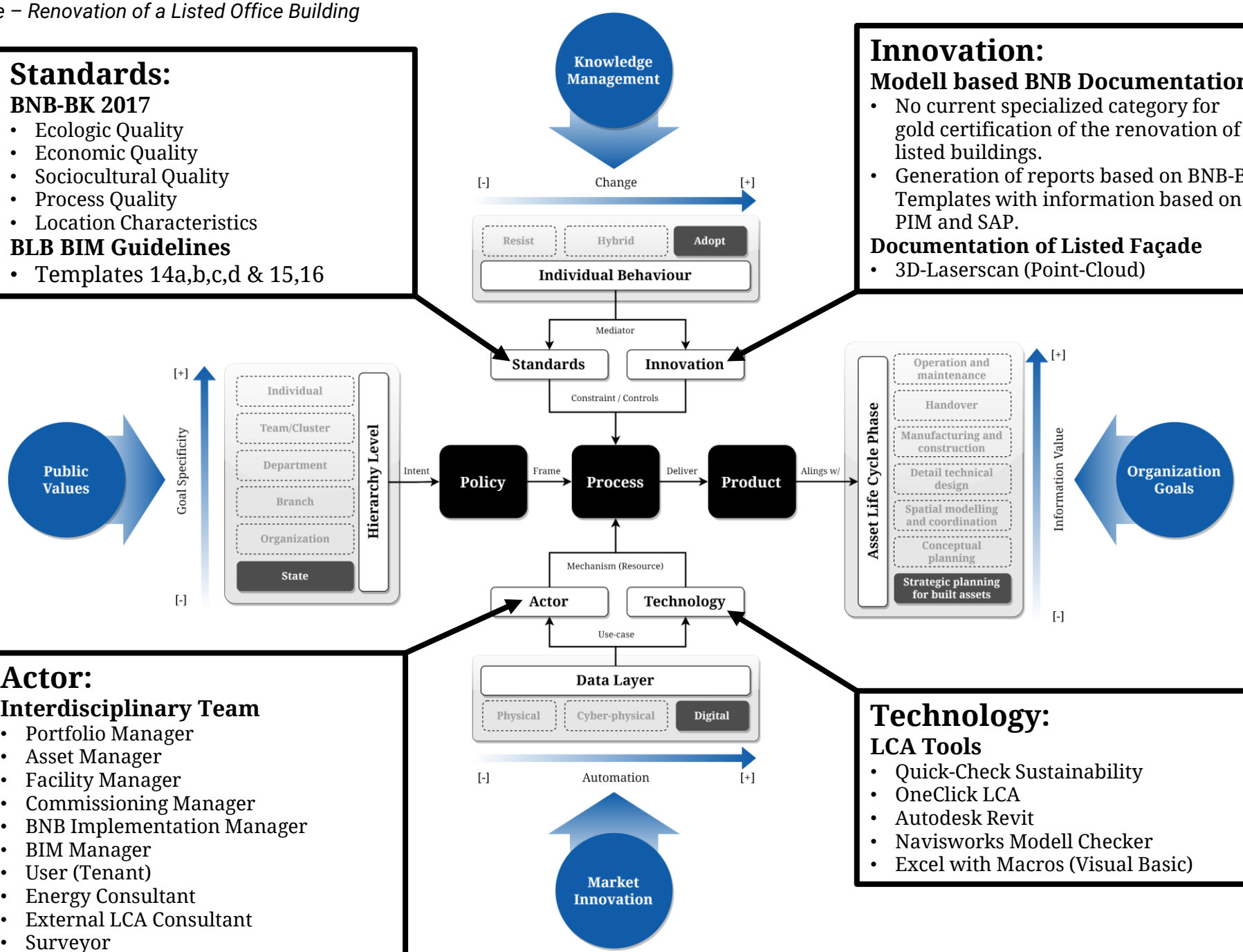
Innovation:

Modell based BNB Documentation

- No current specialized category for gold certification of the renovation of listed buildings.
- Generation of reports based on BNB-BK Templates with information based on PIM and SAP.

Documentation of Listed Façade

- 3D-Laserscan (Point-Cloud)



Actor:

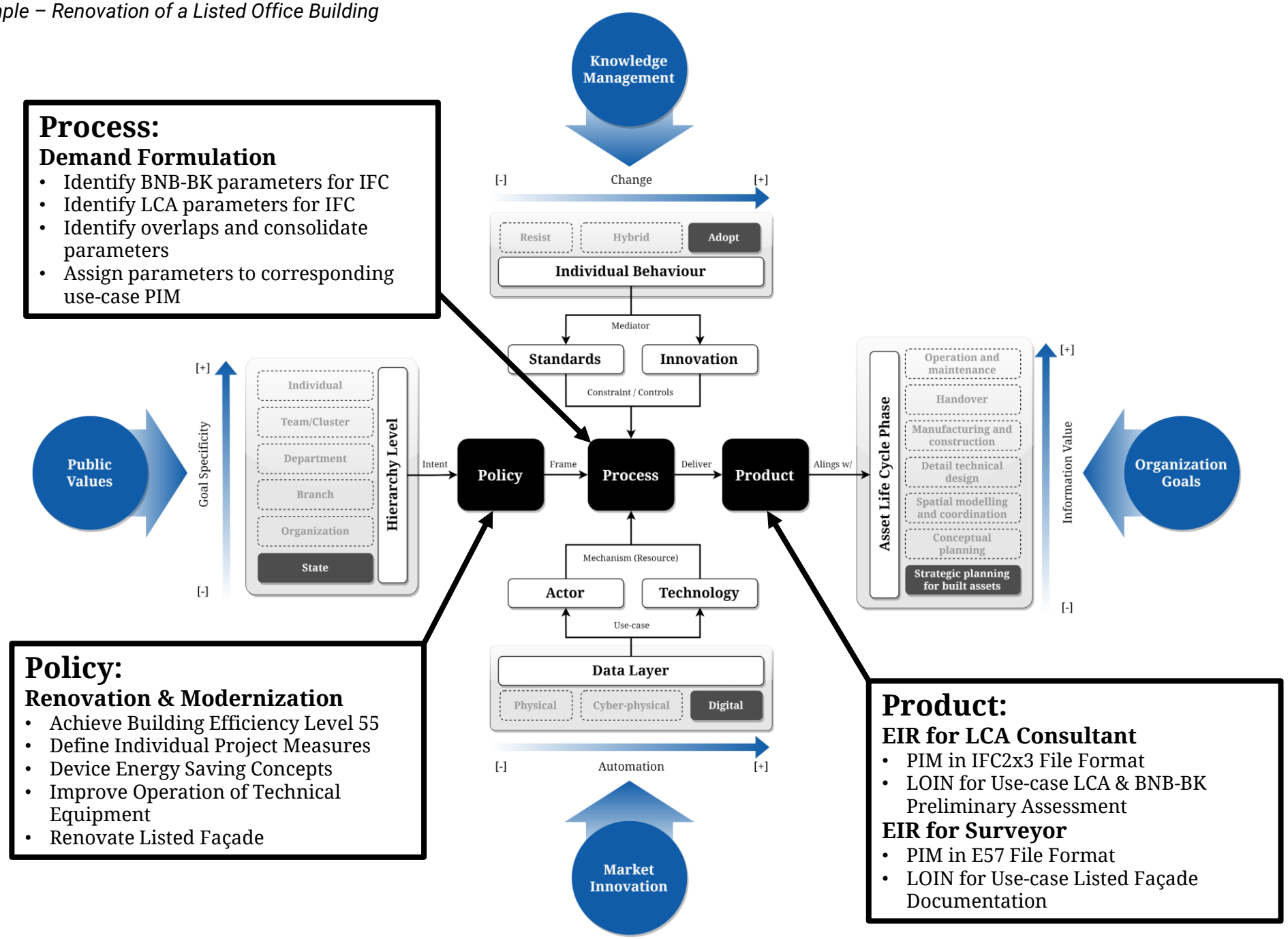
Interdisciplinary Team

- Portfolio Manager
- Asset Manager
- Facility Manager
- Commissioning Manager
- BNB Implementation Manager
- BIM Manager
- User (Tenant)
- Energy Consultant
- External LCA Consultant
- Surveyor

Technology:

LCA Tools

- Quick-Check Sustainability
- OneClick LCA
- Autodesk Revit
- Navisworks Modell Checker
- Excel with Macros (Visual Basic)



Process:

Demand Formulation

- Identify BNB-BK parameters for IFC
- Identify LCA parameters for IFC
- Identify overlaps and consolidate parameters
- Assign parameters to corresponding use-case PIM

Policy:

Renovation & Modernization

- Achieve Building Efficiency Level 55
- Define Individual Project Measures
- Device Energy Saving Concepts
- Improve Operation of Technical Equipment
- Renovate Listed Façade

Product:

EIR for LCA Consultant

- PIM in IFC2x3 File Format
- LOIN for Use-case LCA & BNB-BK Preliminary Assessment

EIR for Surveyor

- PIM in E57 File Format
- LOIN for Use-case Listed Façade Documentation

LCA Data Needs	Format	Property Set	Parameter	Data Type	Unit	Description
Target Embodied Carbon Emmisions	IFC2x3	Pset_LCA	EmbodiedCarbonTarget	Real	tC02e/t	Target value of tons of C02 emissions per tons of material
Estimated Embodied Carbon Emmisions	IFC2x3	Pset_LCA	EmbodiedCarbonEstimate	Real	tC02e/t	Estimated value of tons of C02 emissions per tons of material
Target Green Energy Consumption	IFC2x3	Pset_LCA	GEConsumptionTarget	Real	kWh	Target green energy consumption in kilowatt-hour
Estimated Green Energy Consumption	IFC2x3	Pset_LCA	GEConsumptionEstimate	Real	kWh	Estimated green energy consumption in kilowatt-hour
Etc...	...	...	...	...	...	...

+

	Essential Elements Influencing Data Needs			
	Social Aspects		Technological Aspects	
Relevance	Topics	Themes	Topics	Themes
1	**T17** *Roles & Responsibilities*	**SA7** *Maturity*	**T21** *Sustainability*	**TA7** *System Capability*
2	**T4** *Coordination*	**SA10** *Stakeholder Relations*	**T10** *Information Quality*	**TA8** *System Efficiency*
3	**T11** *Information Search*	**SA5** *Knowledge Sharing*	**T12** *Information Structuring*	**TA9** *System Legacy*

Considerations

T17: Who is responsible for ensuring all data needs have been compiled?
T4: How many rounds of coordination do we need to establish the data needs?
T11: Where is the information regarding model based LCA?
SA7: Do we have the in-house expertise to evaluate a model based LCA?
SA10: Which stakeholders need to be consulted/invited to the LCA data needs definition?
SA5: How do we communicate the lessons learned/ outcomes of the LCA data needs definition?

T21: Which values of the existing asset related to energy & gas consumption need to be linked to the PIM?
T10: How important is the completeness, consistency and accuracy of the information to be delivered?
T12: How and where does the PIM fit into the organization information structure?
TA7: Does the current Soft-Hardware landscape support the use of the PIM format?
TA8: Which tools are best suited to document the data needs?
TA9: Which BLB Platforms are incompatible with the PIM and what is the impact?

Actions

T17: Assign or elect individual during kick-off meeting, document this decision
T4: Establish a roadmap for the group meetings
T11: Gather all relevant information and centrally link to all information sources
SA7: Identify in-house experts available & willing to of assistance to the project
SA10: Establish a few open meetings between external & internal stakeholders
SA5: Device a concept for what, how and when knowledge is to be shared

T21: Consult AM & FM about current information quality and structure
T10: Prioritize the data needs into “must have", "nice to have", and “given”
T12: Draw a diagram of where PIM could be used and in which platforms
TA7: Identify which platforms support the PIM
TA8: Identify new tools for managing data needs with machine readable formats
TA9: Describe and document workarounds for incompatible platforms

LCA Data Needs	Format	Property Set	Parameter	Data Type	Unit	Description
Target Embodied Carbon Emmisions	IFC2x3	Pset_LCA	EmbodiedCarbonTarget	Real	tC02e/t	Target value of tons of C02 emissions per tons of material
Estimated Embodied Carbon Emmisions	IFC2x3	Pset_LCA	EmbodiedCarbonEstimate	Real	tC02e/t	Estimated value of tons of C02 emissions per tons of material
Target Green Energy Consumption	IFC2x3	Pset_LCA	GEConsumptionTarget	Real	kWh	Target green energy consumption in kilowatt-hour
Estimated Green Energy Consumption	IFC2x3	Pset_LCA	GEConsumptionEstimate	Real	kWh	Estimated green energy consumption in kilowatt-hour
Etc…	…	…	…	…	…	…

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	Essential Elements Influencing Data Barriers			
	Social Aspects		Technological Aspects	
Relevance	Topics	Themes	Topics	Themes
1	**T10** *Information Quality*	**SA7** *Maturity*	**T10** *Information Quality*	**TA8** *System Efficiency*
2	**T22** *Task Completion*	**SA2** *Goal Interpretation*	**T12** *Information Structuring*	**TA9** *System Legacy*
3	**T24** *Templates & Guidelines*	**SA9** *Preference*	**T11** *Information Search*	**TA2** *Data Interoperability*

Considerations

T10: Who is responsible for ensuring the information quality?
T22: Can the market supply the information requirements?
T24: Are there existing templates or guidelines for the parameter nomenclatures?
SA7: Do we have in-house expertise in defining data needs?
SA2: What related data needs derived from organizational goals can be included?
SA9: What project specific parameters could be introduced to test innovative developments?

T10: What tools can be used to check the information quality?
T12: How to verify that the information structure is suited for the use-case?
T11: How to search if a data needs have been already defined?
TA8: What issues exist in the information exchange between platforms?
TA9: How to exchange information with legacy platforms?
TA2: How to integrate analog legacy data into the project?

Actions

T10: Assign or elect an information quality manager for the project
T22: Consult with external parties to gauge the market maturity level
T24: Research current developments in LCA open standards
SA7: Identify in-house experts available & willing to of assistance to the project
SA2: Discuss weather organizational goals are align project data needs
SA9: Clearly demark which parameters are deviating from standards and why

T10: Establish workflows for information quality control routines
T12: Research publications illustrating workflows for the use-case
T11: Investigate if similar approach has been attempted for other projects
TA8: Benchmark the workflows of import/linking PIM to the various platforms
TA9: Identify data formats compatible with legacy platforms
TA2: Establish workflow for digitizing and processing the relevant analog data

LCA Data Needs	Format	Property Set	Parameter	Data Type	Unit	Description
Target Embodied Carbon Emmisions	IFC2x3	Pset_LCA	EmbodiedCarbonTarget	Real	tC02e/t	Target value of tons of C02 emissions per tons of material
Estimated Embodied Carbon Emmisions	IFC2x3	Pset_LCA	EmbodiedCarbonEstimate	Real	tC02e/t	Estimated value of tons of C02 emissions per tons of material
Target Green Energy Consumption	IFC2x3	Pset_LCA	GEConsumptionTarget	Real	kWh	Target green energy consumption in kilowatt-hour
Estimated Green Energy Consumption	IFC2x3	Pset_LCA	GEConsumptionEstimate	Real	kWh	Estimated green energy consumption in kilowatt-hour
Etc...	...	...	...	...	...	...

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	Essential Elements Influencing Data Demands			
	Social Aspects		Technological Aspects	
Relevance	Topics	Themes	Topics	Themes
1	**T4** *Coordination*	**SA2** *Goal Interpretation*	**T10** *Information Quality*	**TA3** *Data Processing*
2	**T10** *Information Quality*	**SA1** *Collaboration*	**T21** *Sustainability*	**TA4** *Data Relevance*
3	**T23** *Teamwork*	**SA7** *Maturity*	**T12** *Information Structuring*	**TA7** *System Capability*

Considerations

T4: How do we ensure the data demands do not overlap within the requests?
T10: Which data needs can be incorporated into the demands earlier than usual at this phase?
T23: How to ensure the interdisciplinary data needs are capture in the demands?
SA2: How to ensure that the project goals align with organizational goals?
SA1: Are the data demands providing a basis for better operations & maintenance?
SA7: Is the organization ready to work integrate the PIM into existing workflows?

T10: Are we requesting too much information for the use-case?
T21: Can all the sustainability data needs be delivered with the PIM?
T12: What other data formats can be demanded to supplement the PIM?
TA3: How to update information on the platforms that link to the PIM?
TA4: How to check if the PIM adheres to the information quality?
TA7: Are the available tools and platforms the best solutions for the use-case?

Actions

T4: Consolidate the data demands in a data base or central storage location
T10: Assess if the use-case can be expanded from classical frameworks
T23: All interdisciplinary team members should review the data demands
SA2: Host rounds with external stakeholders to discuss the data demands
SA1: Discuss with AM and FM the data demands
SA7: Arrange workshops and training sessions with O&M team

T10: Perform a final assessment of data demand inclusion in a group-session
T21: Demark which data demands are best delivered in other digital formats
T12: Describe other data formats needed along side the PIM
TA3: Determine automatic or manual workflows for updating PIM
TA4: Describe in the EIR the need for the BEP to incorporate IQ routines
TA7: Evaluate alternative tools and platforms for the use-case

Contributions

Framework

- *Framework to support strategic alignment in program formulation while fostering organizational memory through documentation of interconnected data, processes, actors, and outcomes.*
- *Holistic tool to align organizational goals with public values and technical capabilities, ensuring informed decision-making and efficient resource management within complex socio-technical systems*

Case-study

- *Existence of a Practical-knowledge gap within the context of study*
- *In alignment with literature observations, social aspects are more prevalent than technological aspects*
- *Mapping of influencing factors of the current state of data needs, data barriers, and data demands in the organization*
- *Distilling of influential aspects into essential elements and example of how to translate these into actionable managerial tasks*

Discussion

Framework

- *The model provides a nuanced and actionable framework for tailoring digital transformation initiatives to specific organizational contexts*
- *Complex problems necessitate complex solutions*
- *Serves as a bridge between theoretical frameworks and practical implementation*
- *In isolation, does not offer sufficient guidance to overcome information silos*
- *Client-led and supplier-led roles may be concurrently applied in a project, provided initiative if initiatives are not "black-boxed"*

Case-study

- *Alignment necessitates a nuanced understanding of organizational data demands*
- *Knowledge management emphasizes that systematic knowledge sharing and archiving are essential for fostering organizational resilience and leveraging past experiences to inform future decision-making*
- *Empirical research guides best practices for aligning organizational needs, addressing barriers, and meeting data requirements (best practice, best fit, best model)*
- *Data stewards can play a critical role in unification and integration layer functions of Information Models*

Practical Implications

Framework

- *Improved Alignment of Policy, Processes, and Data Needs*
- *Development of Organizational Maturity*
- *Public Sector Innovation through Digitalization*
- *Continuous Feedback Loops for Policy and Process Adaptation*

Case-study

- *Customized Approaches to BIM Implementation*
- *Enhanced Focus on Socio-Technical Barriers*
- *Role of Leadership and Change Management*
- *Prioritization of Data Interoperability and Quality*

Limitations

Framework

- *Theoretical Scope – external variables not fully explored (regulatory changes, market dynamics, technological innovations)*

Case-study

- *Selection bias methodological limitations*
- *Contextual Limitations – Front runner, single case study*
- *Data Limitations – internal documents idealized and normative representations and relevance*
- *Sector-Specific Limitations – public sector operates distinctly from private sector*
- *Temporal Limitations - snapshot rather than a longitudinal understanding*

Further Research

Framework

- *Positioning emergent technologies (AI, IoT, DT)*
- *Relationship between policy development and technological adoption*
- *Strategies specific for overcoming resistance to change*
- *Stakeholder dynamics in digital transformation*

Case-study

- *Comparative studies across sectors*
- *Longitudinal case study to validate framework and application*

Recommendations

Framework

- *Adoption of a holistic socio-technical framework*
- *Integration of feedback loops for continuous improvement & capturing mechanisms for organizational remembrance*
- *Promote innovation through public procurement*
- *Policy integration across hierarchical levels*
- *Integration of long-term sustainability goals into digital transformation strategies*

Case-study

- *Enhancing coordination and knowledge sharing*
- *Regularly assess current state of digital transformation against the desired state*
- *Implementation of customized BIM strategies*
- *Investments in organizational maturity and training*
- *Importance of data governance and quality*


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