Towards the combination of risk analysis, constructability and sustainability for the lifecycle management of construction projects

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General remarks and definitions

- The **overall technical project performance** is the level of success in terms of meeting:
  - the stated technical performance specifications
  - the mission to be performed

- Primary project success determinants:
  - **cost** (of realization)
  - **time** (of completion)
  - **quality** (the conformance to all the specified requirements)

- Additional determinants (considered separately or encompassed in *quality*)
  - **Client satisfaction**
  - **…**

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General remarks and definitions

- **Constructability**

  The optimum use of construction knowledge and experience in planning, design, procurement and field operations to achieve overall project objectives

- **Buildability** (encompassed in constructability)

  The extent to which the design of a building facilitates ease of construction, subject to the overall requirements for the completed building

- **Constructability program**

  The application of a disciplined, systematic optimization of construction-related aspects of a project during the planning, design, procurement, construction, test and start up phases by knowledgeable, experienced construction personnel who are part of a project team, in order to enhance the project's overall objectives

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General remarks and definitions

- **Sustainability**

  The concept of promoting the development that meets the needs of the present without compromising the ability of future generations to achieve their own needs

- **Risk analysis**

  The collective mathematical methodology to assess risk, which allows a systematic process of making decisions to accept a known or assumed risk and/or the implementation of actions to reduce the harmful consequences or probability of occurrence of the risk

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Constructability, sustainability & risk analysis throughout the project lifecycle

- **Constructability** transpires mainly the initiation, execution and delivery project lifecycle phases, with possible extension to the use (operation and maintenance – O&M) phase
- **Sustainability** transpires the whole project lifecycle, but most prominently the post-delivery phases use and end of life
- **Risk analysis** transpires the whole project lifecycle

RISK ANALYSIS				
			SUSTAINABILITY	
CONSTRUCTABILITY				
INITIATION	EXECUTION	DELIVERY	USE	END OF LIFE
PROJECT LIFECYCLE				

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Intertwinements between constructability, sustainability and risk analysis

- Conceptually integrated from the outset
- Practically integrated for:
  - construction materials
  - targeted O&M issues
  - Partial waste management

CONSTRUCTABILITY

- Rarely associated in specific
- Constructability as a mere type of risk, rather than a broad concept
- Risk management tools follow the aforementioned assumption

SUSTAINABILITY

RISK ANALYSIS

- Mostly integrated in the post-delivery project lifecycle phases

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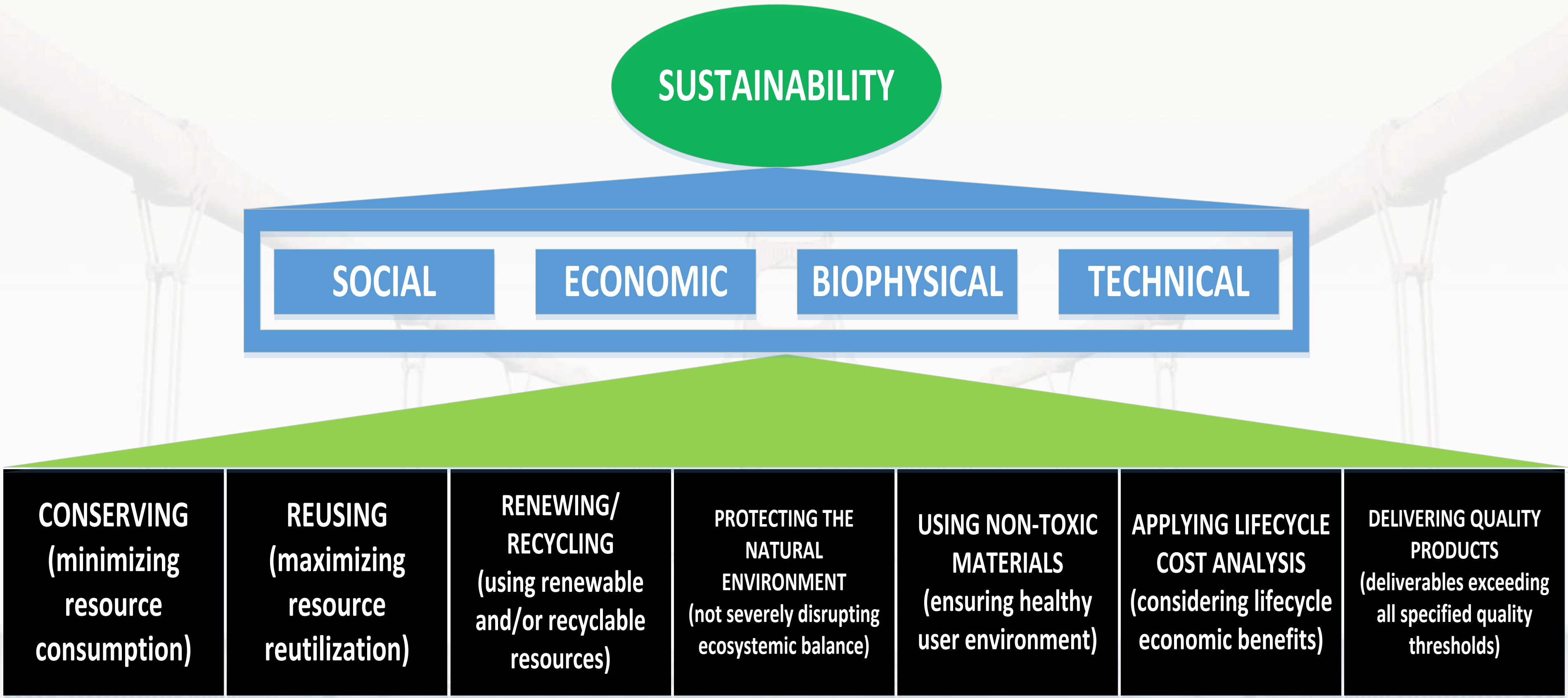
Links and interfaces – Sustainability



The seven sustainability principles (SPs) are practically implemented through unique and overlapping economic, social and environmental sustainability performance indicators (EcSPI, SoSPI, EnSPI)

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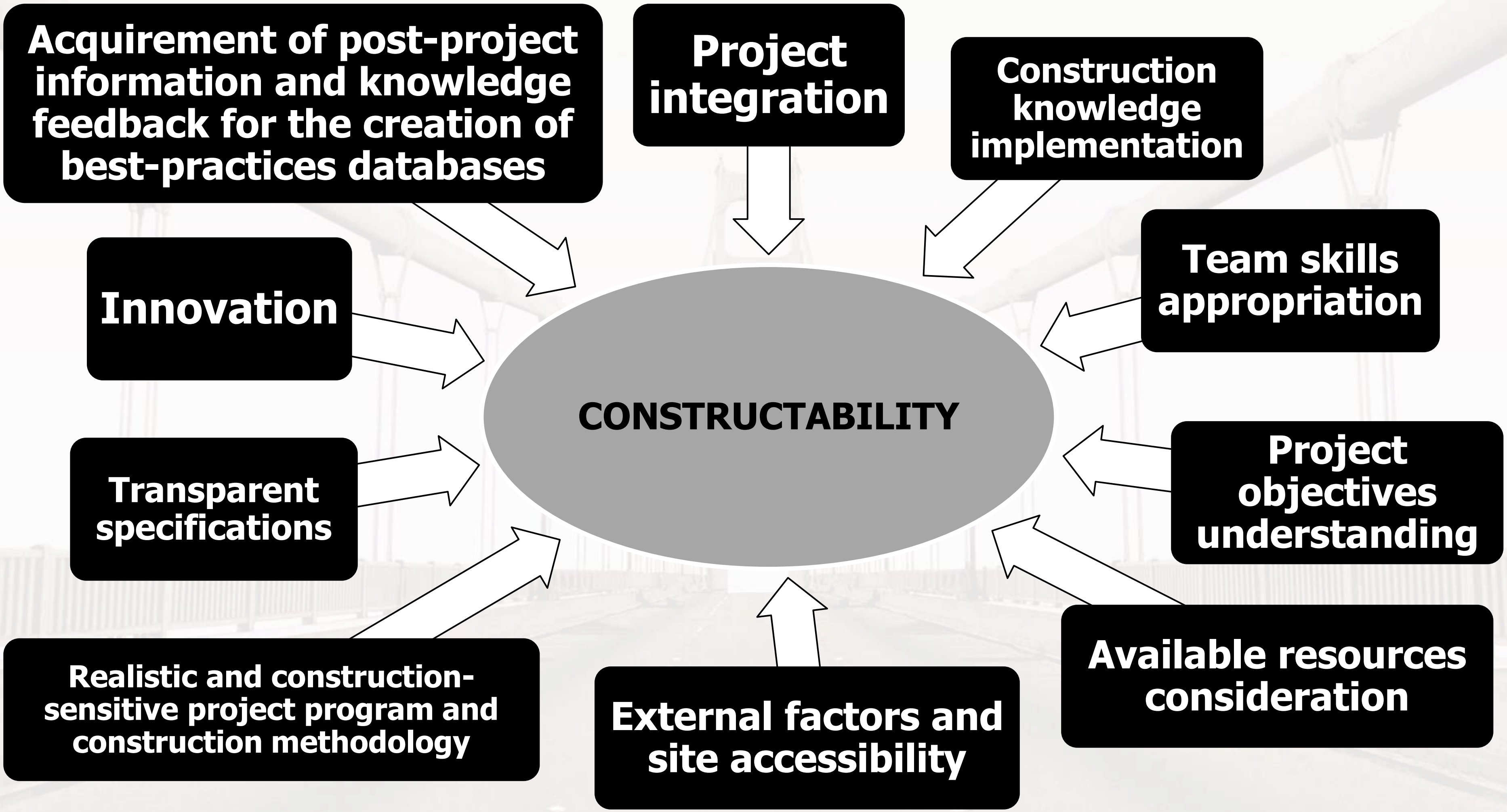
Links and interfaces – Constructability



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Links and interfaces – Constructability

INITIATION encompasses

i) Feasibility study
ii) Design and construction contractual procurement
iii) Conceptual planning

- CC1
- CC2
- CC3
- CC4
- CC5
- CC6
- CC7

→

EXECUTION encompasses

i) Subcontractual procurement (if applicable)
ii) Continuation of designs
iii) Start of field operations

- CC8
- CC9
- CC10
- CC11
- CC12
- CC13
- CC14
- CC15

→

DELIVERY encompasses

i) Finalization of designs
ii) Finalization of field operations
iii) Project delivery

- CC16
- CC17
- CC18
- CC19
- CC20
- CC21
- CC22
- CC23

The CCs are not monolithic doctrines, but define a detailed framework of the applicational methodology of constructability

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Links and interfaces – Risk analysis

Risk identification → **Qualitative and/or quantitative risk assessment** → **Risk response** → **Risk monitoring**

- Risk analysis (and subsequently, risk management) involves various methodological, analytical and mathematical tools
- Its implementation, like the implementation of SPIs and CCs (which are the applicational notions of SPs and CPs, respectively), should take into account case- and region-related aspects, constraints and frameworks

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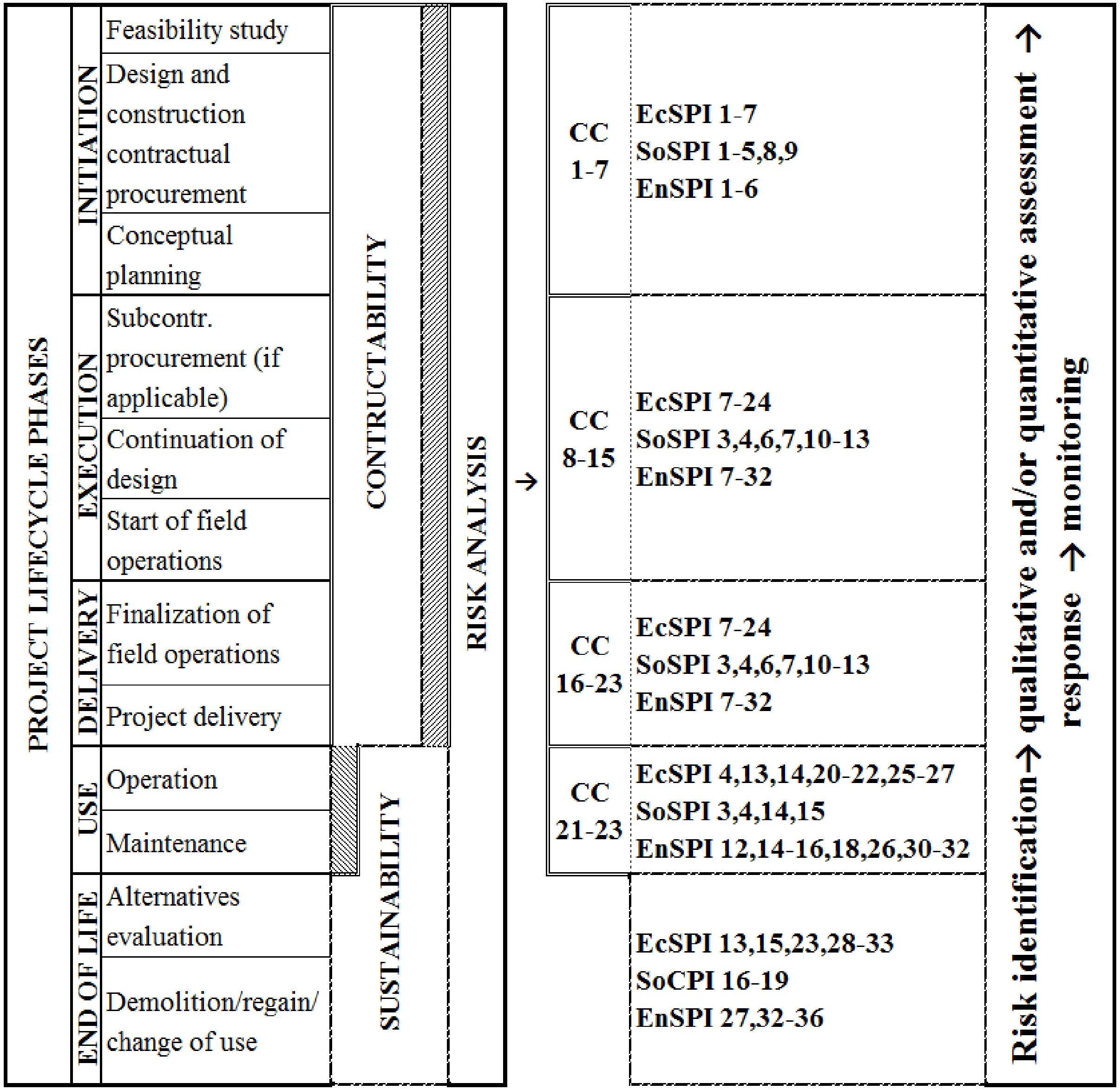
Links and interfaces – Integration



- Furtherly discretizing the project lifecycle phases
- Considering the extension of constructability to post-delivery and sustainability to pre-delivery ones
- Utilizing risk analysis in the risk management plans for the whole project life-cycle

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Conceptual schema of the integrated framework

1 - Risk identification

- Basic risk checklist via literature review
- Checklist discretization according to the SPI-transpired CCs and bare SPI clauses (when applicable)
- Discretized checklist expansion and update via expert knowledge acquisition

- Identifying risks through a variety of methods (e.g. literature review, expert knowledge through structured questionnaires, targeted interviews, the Delphi method etc.)

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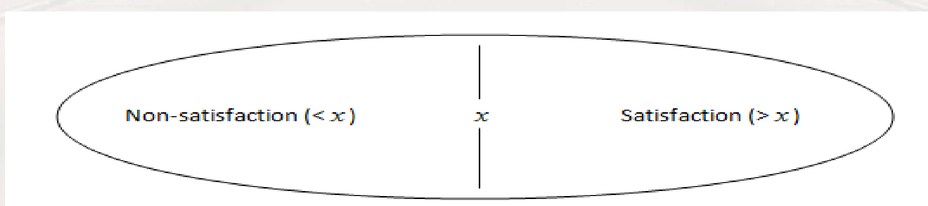
Conceptual schema of the integrated framework

2 - PST_i establishment

- Establishment of the performance satisfaction threshold per element
- Establishment of the base value per threshold

- Establishing distinct satisfaction thresholds per SPIs-transpired CCs for phases 1-4 and per SPI clause for phase 5
- Considering a base value $PST_i = x_i \in \Re, i \in [1,2,...,29], i \in \aleph$ for each threshold and creating the corresponding sample space per threshold



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Conceptual schema of the integrated framework

3 - Risk assessment and response

- Computation of the internal risk probabilities of occurrence per element $P_i(STI_i = x_i)$

- Qualitatively and/or quantitavely assessing the probability of occurrence of the internal risk per element (the event of not achieving the base value of the corresponding threshold) $P_i(STI_i = x_i)$

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Conceptual schema of the integrated framework

4 - Intermediate aggregation and monitoring

- Weighted aggregation of $P_i(STI_i = x_i)$ per project lifecycle phase
- Production of $P_{tot,j}$
- Visualization of intermediate results

- Aggregating the computed probabilities of all elements per phase to assess $P_{tot,j}, j \in \{1, 2, ..., 5\}$

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Conceptual schema of the integrated framework

5 - Final aggregation and monitoring

- Weighted aggregation of $P_{tot,j}$
- Production of SCS (Sustainability & constructability satisfaction score)
- Visualization of final results
- Creation of lessons-learned and best-practices databases

- Aggregating of $P_{tot,j}$, $j \in \{1, 2, ..., 5\}$ to assess SCS (constructability and sustainability satisfaction at the project level)
  - The mode of aggregation (Boolean, fuzzy or probabilistic) and the weighting of each of the individual $P_{tot,j}$ (fuzzy or other), depend on the desired level of user's involvement, the methodological choices of the previous steps, the desired format of the analytical deliverables etc.

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Conceptual schema of the integrated framework

The final results will indicate holistically the project performance through:

- the successful integrated implementation of sustainability and constructability
- the risks and their probability of occurrence that may affect the implementation of constructability and sustainability throughout the whole project lifecycle

The intermediate and final results could be visualized into BIMs and encoded into lessons-learned and best-practices databases

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Considerations for the applicability of the schema in infrastructure

In the initiation phase

- Sustainability and constructability are facilitated on the outset by contractual strategies favoring close early stakeholder cooperation (e.g. design-and-build)
- Provisions and delineated plans for the operation, maintenance and deconstruction phases are also taken into consideration
- Performance thresholds and the corresponding calculated probabilities in this phase are heavily influenced by the stakeholders' behavior against risk

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Considerations for the applicability of the schema in infrastructure

In the execution and delivery phases

- Heavy SPIs-enriched constructability implementation is required, for the management of the project both as a single entity and segmentally
- <u>Performance thresholds and the corresponding calculated probabilities in this phase may be more easily quantifiable due to the risks being of a more technical nature</u>

In the use phase

- Heavy influence of the choices made on the previous phases
- <u>Performance thresholds are connected mainly with the deliverables of quality and all the associated ones (project utility, user satisfaction etc.)</u>

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Considerations for the applicability of the schema in infrastructure

In end of life phase

- Risks are mainly associated with sustainability, infrastructure capacity, environmental and residual values, and the repercussions of the deconstruction process towards the encompassing environment
- Design and construction provisions to facilitate the process of deconstruction should have been taken into consideration in the previous phases
- Lessons-learned and best-practices databases are concluded
- <u>Performance thresholds and the corresponding calculated probabilities in this phase are largely quantifiable in the terms of the corresponding SPIs</u>

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Conclusions

- The currently nonexistent integration of sustainability, constructability and risk analysis, prevents from developing a fundamental cognitive and methodological framework for the management and the performance monitoring of a construction project throughout the whole lifecycle

- The development and practical implementation of the conceptual schema can produce a powerful descriptive and provisional tool to be used preliminary (at the initial, long-term project management plan), intermediately (at the management of the processes currently taking place) and at the end of the project lifecycle (to normalize obtained construction experience and knowledge)

Thank you for your attention!