

## Jury Member Report – Doctor of Philosophy thesis.

**Name of Candidate:** Mikhail Nikolaev

**PhD Program:** Engineering Systems

**Title of Thesis:** Concept selection of innovative complex engineering systems considering systems emergent properties

**Supervisor:** Professor Clement Fortin, Skoltech

**Name of the Reviewer:** Professor Alexey Nikolaev, Skoltech

I confirm the absence of any conflict of interest  (Alternatively, Reviewer can formulate a possible conflict)	<b>Date: 15-11-2022</b>
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*The purpose of this report is to obtain an independent review from the members of PhD defense Jury before the thesis defense. The members of PhD defense Jury are asked to submit signed copy of the report at least 30 days prior the thesis defense. The Reviewers are asked to bring a copy of the completed report to the thesis defense and to discuss the contents of each report with each other before the thesis defense.*

*If the reviewers have any queries about the thesis which they wish to raise in advance, please contact the Chair of the Jury.*

### **Reviewer's Report**

Reviewers report should contain the following items:

- Brief evaluation of the thesis quality and overall structure of the dissertation.
- The relevance of the topic of dissertation work to its actual content
- The relevance of the methods used in the dissertation
- The scientific significance of the results obtained and their compliance with the international level and current state of the art
- The relevance of the obtained results to applications (if applicable)
- The quality of publications

The summary of issues to be addressed before/during the thesis defense

The thesis of Mikhail Nikolaev is devoted to the important topic of the development of new decision-making methodologies and tools that can be applied at the stages of the concept and architecture selection in complex engineering systems. With increasing complexity of modern engineering system as well as the level of their heterogeneity (e.g. introducing parts related to software, sensors, computer vision, etc. subsystems and elements to “traditional” mechanical and electromechanical systems), the topic of the thesis is very timely and of clear academic and practical application value.

The thesis combines literature review, description of the methodologies and tools for the complex systems design decision-making process proposed by the author as well as the results of the application of these tools and methodologies in several practical cases. The topic of the dissertation is well-correlated with its actual content.

As the themes to be additionally addressed by the author (may be as the directions for the further research) I see the following:

- The notion of “system emergent properties” is among the central ones in the thesis research. As well presenting the novelty of the research the author claims “For the first time, emergent properties were used for design decision making in complex systems...”. At the same time point of view stating that ability of a system to exhibit emergent properties is an intrinsic property of the system and the indication that we deal with the system but not separated components, is broadly accepted. In this logic, emergent properties are naturally and automatically accounted for during design decision-making. This is just the target of an engineer to make design decisions assuring that planned emergent properties will be exhibited by the system. In this respect additional clarification of what is meant by the author with the notion of “system emergent properties” would be beneficial for better understanding of novelty proposed by the author.
- The author analyses various methodologies related to the analysis of complex engineering systems. Despite broad and extensive literature review, the author is not mentioning TRIZ (theory of inventive problem solving). TRIZ and its further developments deal with “meta-principles” of technical systems evolution. It would be interesting to see additional elaboration and ideas of the author if accounting these meta-principles can/should take place during system design decision-making.
- The author claims the development of new methodologies and tools for the design decision-making for the concept selection of complex systems. In this respect it is important to consider what are the conditions when previous methods (e.g. value-based decision-making approach and “traditional” House of Quality) do not work and to be substituted by STOEP and MHoQ. In turn, limitations for the applicability of the newly proposed approaches and models should be considered as well.
- In the Appendix presenting endorsement letters from the organizations piloted the emergence approach, there is a mentioning of the resulting time savings of 1 month and 1.5 month. This leads to the question – what would these organizations do within these 1 and 1.5 months if they do not use newly suggested decision-making methods but use “traditional” ones? Would this time be spent on additional data collection? Or experts’ input gathering? Or experiments? As a result of this additional time, would these organizations come to the same decision as generated using novel approaches?
- The Acts mentioned in the previous question are dated by March 2021 and September 2021. Would be interesting to know if these organizations are continuing to use newly suggested

approaches for their design decision-making? Or they are back to “traditional” ones? Or their workflow implies design decision-making once in several years?

In conclusion, considering the importance of the thesis topic, large amount of work performed by the author, perspective new tools and methodologies, as well as real cases of their pilot application, the research presented in the thesis can be recommended for the formal thesis defense procedure.

#### Provisional Recommendation

*I recommend that the candidate should defend the thesis by means of a formal thesis defense*

*I recommend that the candidate should defend the thesis by means of a formal thesis defense only after appropriate changes would be introduced in candidate's thesis according to the recommendations of the present report*

*The thesis is not acceptable and I recommend that the candidate be exempt from the formal thesis defense*