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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: Doctor of Technical Sciences Fedor Krasnov

I confirm the absence of any conflict of interest	**Date: 14-11-2022**

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

The PhD thesis prepared by Mikhail Nikolaev and entitled "Concept selection of innovative complex engineering systems" consists of five sections: Introduction, three chapters, and conclusion. The text is written and organized according to the Russian state standard GOST P 7.0.11-2011 for writing theses for candidate of science and doctor of science academic degrees. However, the first five pages differ from this standard as they were prepared according to the requirements of the Skoltech template for doctoral theses. In general, the text is well written, structured, and consistent. Captions to all figures and tables and references to all mentioned and used literature sources are properly given.

The dissertation starts with the Introduction, where the author gives comprehensive information on research relevance, applied methodology, research question, personal contribution, etc. The dissertation research as given in this section stays at the intersection of several disciplines: systems engineering, Russian Federation systems

analysis, design of complex systems, and innovation theory. Oil and gas industry, or petroleum engineering, which is used for case studies, is not shown on the related picture as it plays only a supporting role. Chapter 1 is devoted to two separate topics: firstly, it gives a clarification of basic systems engineering terms used in the thesis. Secondly, it provides a review of design decision-making techniques and tools applied to innovative complex systems. The review is not comprehensive, but it is profound enough for literature analysis and further use. The author well explains why he added the clarification of terms in his thesis.

Chapter 2 is the core of the whole dissertation. It describes scientific contributions brought by the author in a consequent and reasonable manner. The candidate starts by analyzing emergent properties and organizing them into an ontology, continues by using this ontology for modifying the Value-based decision-making approach, and finishes by developing decision-making models. Although the author calls them models, he actually provides a new decision-making framework based on systems emergent properties instead of traditionally used systems values. Chapter 3 is devoted to case studies and demonstrates the proof of the workability of the proposed decision-making framework.

The following notes are to be made: Firstly, the dissertation by Mikhail Nikolaev possesses several places that use research results obtained by other people from his research group (complementarity in systems), or obtained in collaboration with companies and scientists (case studies). However, the candidate properly cited these places and sufficiently provided his own scientific contributions. Secondly, one more moment is that from the point of view of Systems Analysis, as understood by the Russian Federation scientific school, the PhD thesis lacks mathematics. However, from the point of view of Systems Engineering, as understood in western countries, the style of the prepared work is appropriate enough. Thirdly, it was a wise decision of the candidate to use case studies from the oil and gas industry, as nowadays this industry experiences the rise of interest in systems engineering practices (examples: Tyumen State University, Scientific Center of Gazpromneft, etc.). Finally, although the candidate met all the requirements in publications as set by Skoltech, I would recommend him to think of publishing a good Q1 paper on case study 3 (architecture selection of the LNG transportation system) that can be done after the defense.

Overall, the dissertation by Mikhail Nikolaev possesses the certain scientific value equal to the level of the thesis for the Skoltech PhD degree or the candidate of technical sciences degree. This thesis deserves to be defended for the Skoltech PhD degree. However, the following corrections are to be made in the text:

1) Basic explanation of the term “systems emergent properties” has a very simple example in the Introduction section (p. 12). Although the dissertation is devoted to complex systems, a relatively simple system (train) is used for its clarification. The candidate needs to consider an option of changing this example on a more complex system, which is recommended to be from the oil and gas industry to align with the whole thesis.
2) It is not obvious why DOI numbers are not used for references in the reference list. Although Russian state standards GOST P 7.0.11-2011 and GOST 7.1-2003 establish no need to put DOI for the reference list, for the PhD degree similar to dissertations defended in many other leading Russian Federation

institutions, adding DOI numbers needs to be considered.

3) The author mentioned the current-day 4th Industrial Revolution, called “digital transformation,” in the early beginning of the Introduction section. In Chapter 2, he noted uncertainties brought by innovations while describing design decision-making specifics of technological innovations. However, it is not obvious from his thesis, how did the author consider such uncertainties in his decision-making models? Innovation process can lead either to success, or to failure, and this uncertainty is definitely to be considered in decision-making models, applied to technological innovations. Therefore, there is a need to provide additional explanation on this in the text.

Provisional Recommendation

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

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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*