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# Jury Member Report – Doctor of Philosophy thesis.

**Name of Candidate:** Yaroslav Menshenin

**PhD Program:** Engineering Systems

**Title of Thesis:** Model-Based Framework for System Concept

**Supervisor:** Prof. Edward Crawley

**Name of the Reviewer: Ola Isaksson (Professor)**

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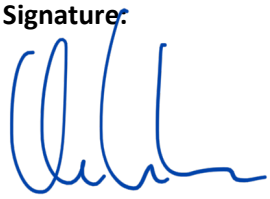
| I confirm the absence of any conflict of interest<br><br>(Alternatively, Reviewer can formulate a possible conflict) | **Signature:**<br>  <br>**Date: 01-08-2020** |

*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

## Brief evaluation of the thesis quality and overall structure of the dissertation

The thesis covers 333 pages (refs excluded) and build on 9 accepted or published manuscripts in peer-reviewed journals (2) and conferences (7). The 2 journal contributions that have been published already in relevant journals for the thesis topic.

The thesis is quite ambitious in scope for a PhD thesis, aiming to provide a rather complete coverage of a model based framework for design of systems. The work is analytical and theoretical, and since the ambition is to support practice it is a limitation that practitioners and industries have not directly been involved or interviewed. The author is aware and have made a good effort to validate the proposed framework.

The literature in section 2 provide a research clarification and a well-balanced review of relevant literature on systems engineering and design science, positioning relevant work to the proposed framework of the thesis with focus on conceptual design. Four opportunities for contribution was identified. The gaps and deficiencies in existing theories could have been analysed further and it is clear that the thesis is development focused in its character.
The main contribution of the thesis, the proposed framework with its five propositions is presented in chapter 3, how the system concept representation framework was inspired by DNA molecular structure, build further on Design theory and systems engineering approaches. Chapter 4 serve as an analytical validation how the framework based on analysing a range of different patents and patent types. Chapters 5 and 6 (150 pages) validated the use for suborbital human spaceflight systems and space communication systems respectively. Chapter 7 summaries the conclusions and contributions of the thesis, including its limitations and suggestions for further work.
The framework proposed is ambitions and claim to cover several different situations, applications and levels of detail. The overall structure is appropriate with justification and clarification of the research area (Chapter 1 and 2), the proposition (chapter 3) and the three different ways of validating the framework are necessary to demonstrate its generalizability. Concluding section (7) bulid on the thesis content and demonstrate awareness and insight into what may be the next step.
In total, the thesis is well written, its length leave room for worked through examples that can be followed and sections of historical development in the areas treated. The style and quality of writing is good and easy to follow.
Critique can (always) be raised, and some remarks to be discussed at the defense is listed below.
The research gap (p 40) seem more to an objective rather than a gap. It would be interesting to learn about what deficiencies in current theories (reviewed) that the proposed framework can do better?
In the thesis, a range of decisions of what method, theory or tool to make use of are made. Sometimes, the rationale for selecting one before another is not clear. As one example, why the OPM was selected in favor of SYS ML? What could – potentially, be better represented if SYS ML would have been selected?
The validation sections are set up to be objective, yet have been carried out by the author(s). How much does personal knowledge and framework tacit knowledge influence interpretation and mapping?

## The relevance of the topic of dissertation work to its actual content

Model Based approaches to systems engineering has been focused for the last decade(s), yet the topic of the thesis emphasise more the design approach of systems. This is more rarely treated in systems engineering literature. Conversly, engineering design literature rarely cover the full width of a systems

engineering problem. As such the thesis topic is quite relevant, and the content well reflect this duality in its content.

## The relevance of the methods used in the dissertation

The thesis is organized following the Design Research Methodology (DRM) by Blessing and Chakrabarti, which is appropriate for the topic studied.

The proposed method/framework is analytically validated. Validation (Chapter 4) is conducted by applying the framework to analyse three categories of patents using 29 criteria derived from the framework. Efforts have been made and described to ensure objective analysis of different patents.

Chapter 4 and 5 that demonstrate the use of the framework for different systems on several levels on real and realistic application examples serve as a first step to validate applicability, generalizability and utility of the "features" of the framework.

Considering the breath of the approach, the choice of methods use is quite appropriate.

## The scientific significance of the results obtained and their compliance with the international level and current state of the art

Conceptual design on a systems level is a timely topic to study, where the thesis combine conceptual development as seen from a design science tradition with the means of managing the complexity of systems in the systems engineering domain.

The framework contribute well to the ongoing research on how to design complex systems and make advantage of a formalized modelling approach for definition, communication and analysis.

The framework proposed build on fundamental principles from design science (solution independence, functional representation etc) that enable representation of alternatives sub solutions of a system, formally model functional interactions between the decomposed modules that follow the decomposition. Formal, and visually represented, classification of decomposition and specialization relationships is interesting as it enables analysis using e.g. DSM based methods. One such analysis proposed, similarity assessment is a good example of metrics of systems in design situations.

In line with present state of art, the framework increase DSM interactions by categorizing them and visualizes multiple interaction types in DSM style representations, which provide more information to the system architect. Expanded use of DSM is also rightfully claimed by the authors.

"Classical" systems engineering, even model-based systems engineering has predominately been used to model and represent one version of a system, whereas the proposed framework enable design of systems considering alternative solutions on multiple levels of granularity. The five propositions of the framework (stakeholders, solution neutral-environment, solution-specific environment, integrated concept, and concept if operation) span a wide array of systems design dimensions into one integrated framework.

As a reviewer, I found the proposed method that further the use context into the definition interesting. The "Concept of Operations – ConOps", allow the in use (Delivery of function) conditions to be included in the system model generated. This is an interesting contribution to state of art.

As such the proposed framework is conceptually richer than most model based frameworks proposed, at least from a design perspective.

A remark and criticism is that the utility and implementation of the system is likely to reveal a number of issues that is not yet discovered. It would have been most valuable with system engineering architects and practitioners feedback on the framework.

## The relevance of the obtained results to applications (if applicable)

The framework is a promising approach for next generation model based design support for systems. It is highly relevant as it is expected that automated and digitalized design approaches on complex systems are likely to expect that a large amount of alternative conceptual configurations need to be defined and evaluated.

The relevance as a design support for primarily systems architects of the modelling approach proposed are several, including the ability to compare alternative system concepts.

It is expected that the framework need further research and development before practical utility can be claimed, something authors also recognize when summarizing the work

## The quality of publications

Two of the appended papers have already been published in relevant, systems engineering oriented journals, and several peer reviewed papers have been presented and published at design science oriented conferences. This is relevant. As a next step, it would be appropriate also with contributions (journal) to the design science community.

**Provisional Recommendation**

***X*** *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*