

## Jury Member Report – Doctor of Philosophy thesis.

**Name of Candidate:** Yaroslav Menshenin

**PhD Program:**

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

**Supervisor:** Prof. Edward Crawley

**Co-advisor:**

**Chair of PhD defense Jury:**

**Email:**

**Date of Thesis Defense:** 31 August 2020

**Name of the Reviewer:** Claus Thorp Hansen

I confirm the absence of any conflict of interest

**Signature:**



**Date: 13-07-2020**

*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

The Doctoral Thesis “Model-based Framework for System Concept” contains Abstract, List of publications, List of conference presentations, Acknowledgements, Table of Contents, List of Symbols and Abbreviations, List of Figures, List of Tables (pages numbered 4 – 32) and 7 chapters, References and two appendices (pages numbered 33 – 364).

The thesis is well-written: Clear in its structure and in line of thinking. The overall structure of the thesis is logical and straightforward to follow.

*My key concern regarding the thesis:*

The primary purpose of a research project is to generate new knowledge. Within the areas of engineering design and systems engineering, we often see research projects having not only the purpose to generate new knowledge but also a purpose to generate approaches, methods or tools for industrial practice/application.

The thesis “Model-based Framework for System Concept” articulates a clear application focus: in the Abstract it is stated, “This dissertation is motivated by the desire to elaborate in details the notional content of a system concept and to provide the means of encoding and analyzing space systems concepts in a digital environment. In this thesis a model-based *system concept representation framework* is developed and presented.” [My underlining] I observe the motivation for the work originates from practice/application and the result pursued is to develop a framework, whereas a purpose to generate new knowledge is not stated. Throughout most of the thesis, I find bias towards application at the expense of new knowledge.

In order to obtain a proper balance between the primary purpose of research (to generate new knowledge) and the secondary purpose (practice/application), **I ask the candidate to formulate relevant research questions and hypotheses.** The research questions could be outlined in a section 1.5 Research questions and hypotheses, and then they can be applied throughout the remaining chapters, e.g. in chapter 2 to focus the literature review, and in chapter 3 to make a sound and solid argumentation of why there are 5 propositions.

With respect to the formulation of research questions, it is important to note that a formulation like “Is it possible to ...?” is not productive, because the answers becomes ‘yes’ or ‘no’. It is difficult to write a conclusion based on yes/no answers.

*Other comments regarding the thesis:*

Section 2.4.2 Concurrent Engineering Centers in the World is problematic for two reasons. Firstly, the content is not really a part of a literature review. Secondly, I find the argument “This makes us confident that concurrent engineering is ...” rather weak. It is not clear to me why “dozens of engineering concurrent engineering centers appeared” in a world of almost 200 countries and 7 billions people is an indication of effectivity.

Section 2.6 Summary. Here the candidate states, “In summary, in the chapter we briefly reviewed ...” I agree with the candidate, that the literature review is brief. This is not a quality indicator for a thesis. **I propose the candidate use explicitly formulated research questions to frame the literature review.**

Chapter 3. Creating a System Concept Representation framework describes the developed framework in details. It is a clear and well-structured chapter. I have some comments regarding this important chapter of the thesis.

1. The framework is based upon five propositions, but there is no argumentation why these five propositions are sufficient. When I study the framework it seems to me at least two propositions are missing, viz. system life cycle and tractability of the system embodiment process.

The fifth proposition is ConOps, which relates to the use or operation of the system. I agree that use/operation is important to take into account, when designing systems, but maintenance and repair processes and their attributes (time, quality, efficiency, cost, and flexibility) are also very important for many types of systems, e.g. aircraft- and space systems. In Andreasen et al. (2015) we find a chapter on "Product Life Synthesis", so why is 'system life cycle' not included as a proposition?

When a concept is selected for further development, much design work remains to be carried through, viz. the system embodiment process. Thus, during concept selection it is important to consider not only the attributes of the concepts alternatives in relation to the five propositions and the 'system life cycle', but also the tractability of the system embodiment process. For introduction of the term 'tractability', see Asimow "Introduction to design" (1962). Why is 'tractability' not included as a proposition?

**I ask the candidate to set up a thorough argumentation for the content of the system concept representation framework.** I argue that the five propositions of the framework is not sufficient to describe a system concept.

2. For the solution-neutral process, the framework defines one attribute. It is not clear to me why only one attribute is sufficient. According to Andreasen et al. (2015) any activity/process can be measured by the 'universal virtues': cost, quality, time, efficiency, flexibility, risk and environmental effects. Thus, I would expect more than one SNP attribute is required?

Furthermore, on page 76 it is stated, "The solution-neutral process "transporting" has an attribute "safely", since regardless the chosen concept, transporting should be performed in a safe manner." With respect to solution-neutral this is non-sense to me. Firstly, why "safe"? Any universal virtue, e.g. time and environmental effects, are equally important. Secondly, it is only because the candidate thinks about air- or space transportation he sees "safe" transportation as an important issue. If he was thinking about bicycles as means of transportation "safe" would not be an important issue, but "energy consumption" might be. Thus, I argue Solution-neutral process attributes do not exist. It is not until the systems architect begins to think about possible solutions the attributes pops up: Air- or space transportation has to be "safe", whereas bike transportation has to be "energy effective".

**I do not expect the candidate to make any changes in the thesis regarding the comment on solution-neutral process attributes, but I would like to discuss it at the defence.**

3. Section 3.5.3 Applying the Methodology to the Running Example of Aircraft Concept demonstrates an application of the framework to the "tube and wing aircraft" and the "blended wing body aircraft". In order to understand figures 3.13 and 3.14 illustrations of the two concepts are necessary. **I ask the candidate to insert illustrations** (sketches, drawings or photos) of the two aircraft concepts.
4. In table 3.7 both the generic form attribute and the specific form attribute is set to "Cost" without an argument or explanation. It seems to me to be an arbitrary choice of attribute. What kind of cost: production cost or operation cost? Setting the generic form attribute to "Fuel consumption" could be equally relevant and sensible. **I ask the candidate to include an argument or explanation** regarding the generic and specific form attribute.
5. On page 86 it is stated, "... highlights four key conceptual decisions. First, the operand .... Next the process..." [My underlining] Four conceptual decisions requires 'First', 'Second', 'Third', and

'Fourth'; and not only 'First' and 'Next'. **I ask the candidate to describe** all four key conceptual decisions.

6. On page 117 we find figure 3.32 (a) with strange attribute values.
  - SNO value attribute is "Taste", but "Temperature" is missing. Explanation: A good cup of coffee requires the coffee drink having right taste and right temperature!
  - SNP attribute is "Safely". This is strange: Which user is concerned about "safety" when brewing their daily cup of coffee? A more relevant SNP attribute could be "Time", as the author write on page 128, "... an Espresso Machine is the option which will provide you a coffee faster." [My underlining] 'Faster' relates to time, not to safety.

**I ask the candidate to reconsider** the attribute values in the example **and explain** his choice.
7. On page 119, we see illustrations of the two concepts Espresso Machine and French Press. This is good for the reader's understanding, thank you. Likewise as mentioned in comment 3, this reader needs illustrations of the "tube and wing aircraft" and the "blended wing body aircraft" concepts.

Chapter 4. Validating System Concept Representation Framework Through Analytical Surveys. The purpose of the chapter is to validate the proposed framework through analytic surveys of patents, urban architectural patterns and software patterns. The chapter is clear in structure and well written. The chosen validation method is sensible, the analyses are comprehensive (both Small-N and Large-N analysis) and the results are convincing.

Chapter 5. Case study I: Suborbital Humans Spaceflight Mission and chapter 6. Case study II: Space communication Mission contain two case studies to demonstrate the utility of the proposed framework thorough application to suborbital human spaceflight systems and through space communication systems respectively. Both chapters have the same overall structure, and they are very detailed in filling in application data into the framework. The chapters conclude that the required utility of the system concept representation framework is demonstrated and an approach to support formal analysis, such as conceptual similarity assessment, is possible. The method chosen to demonstrate the utility of the propose framework through two case studies is convincing and with all the details provided in the chapters nothing is hidden to the reader.

I have only two critical comments regarding chapters 5 and 6:

1. Figure 5.5, page 195. It is not clear to me why Specific Form Attribute is "Cost". It seems to me to be an arbitrary choice of attribute. What kind of cost: production cost or operation cost? Setting the generic form attribute to "Fuel consumption" could be equally relevant and sensible.
2. On page 205 the author states, "Thus, the model-based concept framework can be effectively used to capture the conceptual difference between alternative concepts." [My underlining] I cannot find any measurement (numbers) of effectivity. **I ask the candidate to explain how effectivity has been measured and include results**, or if it has not been measured please delete the word "effectively".

Chapter 7 contains the conclusions of the research work. In content chapter is good. **I ask the candidate to revise the conclusions taking required research questions and hypotheses into account.**

The quality of publications: According to the List of publications, the candidate is first author of nine publications: two journal articles and seven conference papers. Furthermore, the candidate has six conference presentations. In my opinion, this is impressive with respect to both research quality and productivity.

**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*