

Thesis Changes Log

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PhD Program: Engineering Systems

Title of Thesis: Model-based Processes and Tools for Concurrent Conceptual Design of Space Systems

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Date of Thesis Defense: 31 January 2020

The thesis document includes the following changes in answer to the external review process.

General
<p>I want to thank all the reviewers for the time they took reading my manuscript and for all of their helpful comments and remarks.</p> <p>As a result of their kind feedback, I have made several changes reported in detail below. In general, many spelling and grammar errors were corrected. A significant change, suggested by Prof. Horvath, is the splitting of the previous chapter 5 into two chapters 5 and 6. Furthermore, several figures were increased in size to improve the readability of the contained text.</p> <p>Finally, a dedication and acknowledgments were added. All changes together increased the number of pages to 288.</p>
P.Grogan
<p>1. Artifact assessment/validation based on expert elicitation could be supported by a clear set of key requirements or functions resulting from the expert questionnaire in Chapter 4 and expert interview in Chapter 6. Its current form reports feedback results but does not distill or synthesize key qualities related to the proposed artifacts beyond broad categories of "expert availability" and "integrated tool chain." Taking this perspective helps distinguish more significant contributions to broader research goals from the particular implementation selected in this work.</p>
<p>Response: Indeed, there was a gap in the line of argument from the analysis of the survey results to the support implementation.</p> <p>Modifications to the thesis: The challenges described in section 4.2 are now referenced and used as a basis for the specification of the concurrent conceptual design tool in the new chapter 6, section 6.1.</p>
P.Grogan
<p>2. Similar to the above comment, the case studies in Chapter 7 largely report results of the conceptual design activities without relating to assessment or evaluation of specific functions or capabilities of the proposed artifacts. A lot of data is presented related to the number and type of changes and resulting dependencies; however, it is not clear to the reader how this relates to the proposed artifacts. Does it characterize the design problem or how the design team used the artifact? There is only limited value in</p>

demonstrating the participants completed a design activity (existence proof). A richer discussion or synthesized narrative would help understand what key insights or lessons learned could be acquired from each case. The "Observations" subsection in the first set of pilot studies is a good start but should be synthesized into a cogent evaluation.

Response:

The analysis of the data regarding the types of changes aims at showing the actual design process by associating it to different design steps.

Modifications to the thesis:

In the explanations of activity, analyses were reformulated in their conclusions.

The Summaries of design studies 8.4.5, section 8.5.7 were enriched with learnings gained regarding the process and the tool.

P.Grogan

3. Some of the automatically generated N-squared diagrams in Chapter 7 are very difficult to read due to overlapping text (especially in Figure 7-19). Building on the above point, what should the reader obtain from these visualizations? Does it characterize the design problem or provide insight about how the design team used the proposed artifacts? Are there certain dependency structures beneficial for applications of concurrent design?

Modifications to the thesis:

Several figures throughout the text have been scaled up to increase text size improve readability. Where N²-diagrams (now Figure 8-10, 8-15 and 8-16) remained hard to read, the referring text now better explains the take-aways.

P.Grogan

4. Chapter 8 tackles a large research objective to transfer the work developed for applications of conceptual design (specifically but not exclusively space systems) to other areas of strategic management and technology roadmapping. The introductions in 8.1-8.3 are sufficient to explain how concepts can be generalized; however, section 8.4 is insufficient to characterize an application and should be expanded. It is understood that some details cannot be disseminated due to confidentiality issues; however, the thesis must provide comprehensive assessment to better justify the utility or value of the approach to technology roadmapping.

Response:

We presented the adaptation of our methodology to corporate technology roadmapping. Due to the limited timeframe of our industrial project and organizational limitations, we could not compare the roadmapping before and after changing the methodology.

Modifications to the thesis:

The sections 8.3 and 8.5 have be revised for clarity, and section 8.4 now better explains how the process has been implemented and which obstacles were encountered.

P.Grogan

5. There are numerous typological errors throughout, especially in Chapter 8. Note that "it's" is a contraction of it is (not common to use contractions in technical writing) and "its" is possessive.

Grammatical mistakes such as those related to the word "it's" have been corrected throughout the text.

I.Horvath

1) The presentation of the work suggests a multiyear and intensive teamwork. Explanation on the own contribution (independent research work and genuine scientific achievements) of the PhD candidate to the laboratory development, theory forming, and implementation of

the software tools.

Response:

All genuine research work has been conducted exclusively by myself, including literature review, survey, methodology development, interviews.

This is confirmed by the fact that the related publications first-authored by me (page 4) carry only advisors as co-authors.

The ideation, design, and development of the software tool was also mostly done by me, only receiving some support for the coding from a programmer for one year. Evidence for that can be found in the history of contributions to the public source code repository

(<https://github.com/cedesk/data-exchange/graphs/contributors>).

The conducted case studies (chapter 7) involved teams of students and credits are given to them for the reproduced design artifacts.

The technology roadmapping use case (chapter 8) reports the industrial project work of a team, and credits are given to the contributions of two colleagues.

Modifications to the thesis:

The description of the tool for managing roadmaps now also reports the author's role as analyst and mentions that the implementation work was done by two software developers.

I.Horvath

2) More concrete information about the literature review of the current state of the art of model-based concurrent conceptual design should be included in Chapter 3.

Response:

The research objectives in chapter 3 were based on the gaps contained in the literature review about concurrent conceptual design of space systems (section 2.8).

Modifications to the thesis:

The review of the literature about concurrent conceptual design of space systems in chapter 2 identified research gaps (sections 2.8.3 Tools and section 2.8.4 Processes).

The research goals in chapter 3 now make explicit reference to these identified gaps.

I.Horvath

3) Higher clarity should be achieved with regard to the second descriptive study of the chosen research methodology. Its objectives and contents should be specified.

Modifications to the thesis:

The application of the design research methodology (previously in section 3.3) is now described more clearly in section 1.4. In particular, the expert interviews and the case studies are now correctly associated with the second descriptive study.

I.Horvath

4) It is recommended to divide the current Chapter 5 into two chapters that are dedicated to the specification of the overall methodology and the development of the tools, respectively.

Modifications to the thesis:

The description of the design support tool was moved to a separate, new chapter 6.

I.Horvath

5) Higher clarity should be achieved in terms of the relationship of Chapters 6, 7 and 8 to the second descriptive study of the chosen research methodology, and the performance validity of the proposed methodology and the set of tools.

Modifications to the thesis:

The application of the design research methodology is now described more clearly in section 1.4. In particular, the expert interviews (now chapter 7) and the case studies (now chapters 8 and 9) are now correctly associated with the second descriptive study.

I.Horvath

6) Additional definitions and systematic use of the terms can facilitate clarity and understandings. The text can benefit from a proof-reading and local brush-ups.

Response:

The thesis' scope is the conceptual design phase. Sometimes, when we use to broad term "design", we actually mean "conceptual design".

Modifications to the thesis:

A definition of the term "conceptual design" has been added to section 2.4.

In other parts of the text, such as the abstract, the term "design" has been expanded to "conceptual design" to reduce ambiguity.

I.Horvath

7) Certain figures (e.g. 1.1) are too small for a convenient reading in printing. Readability of figures should be improved by using proper font sizes.

Modifications to the thesis:

Many figures have been improved in readability by increasing the size to match the labels' font size with the main text.

I.Horvath

Regarding the survey ... no details provided about the strategy and measures of sampling (criteria and requested size). ... No statistical significance analysis was applied on the outcome of the survey.

Response:

The analysis of the statistical significance were left out by mistake, but they were already published in (Knoll et al., 2018a).

Modifications to the thesis:

More explanation on the survey population and sample was added to the section 4.1.1.

The subsequent sections were enriched with data on the statistical significance of the survey results.

I.Uzhinsky

1. One of the pillars of the author's design approach (page 22) is introduces as "co-location in a shared workspace". But among multiple times listed later issues for implementation of the proposed methodology there are statements like (Page 83) "Despite the association that Concurrent Design is generally means co-location, it is very common to have remote participants. This is related do the limited availability of experts with specific knowledge." The point is that without experts with deep knowledge in the subject – the whole process cannot result in any valuable outcome. My personal experience is that the most part of these activities are done with remote online participations of the subject experts.

Response:

According to literature (section 2.8), concurrent conceptual design of space missions generally implies a co-located team.

But our survey (section 4.1.3) revealed that only 15% of the experts have purely co-located conceptual design studies.

Modifications to the thesis:

The phrase regarding the challenge of expert availability (section 4.2) has been reformulated in order to express its relation to remote participation better.

“The remote participation is a compromise to involve experts with knowledge on a specific aspect of the space mission who can not be brought on-site for the entire CCD study.”

I.Uzhinsky

2. One of the cornerstones of the introduced methodology is application of parametric modeling in the conceptual design process. The point is that there is a long way from developed descriptive models of the system (like, SysML-type) to the appropriate quantitative models. The only viable approach for the development of quantitative high-level models is to derive these models as meta models-from the more detailed first-principle based system models. So, integration of processes for selection or creation of the necessary first-principle system model with their subsequent parametrization is of high importance for the proposed methodology. These issues have not been addressed in the presented paper.

Response:

As an outcome of our survey, we defined the challenges that our work is addressing (section 4.2). The issue of creating parametric models is mentioned in section 4.3 as an open question and shall be addressed in future work.

Modifications to the thesis:

The paragraph on the open question “models from scratch” in section 4.3 has been reformulated.

I.Uzhinsky

3. One of important results of the author’s efforts is the development of the CEDESK software tool. It would be great to discuss B&C-s of using of this tool in comparison with, for example NoMagic products, particularly after their integration within the Dassault Systems 3D environment, or with Phoenix Integration tools.

Modifications to the thesis:

In combination with the distinction of the section on the CEDESK tool into the new chapter 6, the text also now contains an explanation of the different types of tools and their applicability to concurrent conceptual design, such as PLM systems, MDO and MBSE tools.

In the introduction of chapter 6 we also motivate the development of our tool and how it distinguishes from other tools available on the market.

I.Uzhinsky

4. I’d recommend a thorough grammar check of the whole paper. For example, “it’s” is used in multiple (dozens of) times instead of “its”. Obviously, these two items have very different meanings. Another point is the use of masculine forms (“his”, “he”) instead of gender neutral ones (like “one’s”, “participant”, and so on). There are some strange sentences in the paper, like “Different from existing tools, ...” (page 26) that should be re-written.

Modifications to the thesis:

The orthographic mistakes related to possessive word forms and gender-neutral formulations were corrected. The sentence reported above and other similar constructions were improved.