

Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Eldar Shakirov

PhD Program: Engineering Systems

Title of Thesis: Integrated analysis of engineering and manufacturing change management in the additive manufacturing context: a simulation-based modeling framework

Supervisor: Professor Ighor Uzhinsky

Co-supervisor: Professor Clement Fortin

Co-supervisor: Professor A. John Hart (MIT)

Name of the Reviewer:

I confirm the absence of any conflict of interest

(Alternatively, Reviewer can formulate a possible conflict)

Signature:



1 -06-2021

Date: DD-MM-YYYY

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 impact of additive manufacturing (AM) is a subject of great debate, much of it based on hope and faith rather than on specific case studies and analysis. More importantly, in today's highly integrated and fast paced production systems the impact of the significant process change that AM represents, a rigorous evaluation of the new technology must be truly comprehensive. This work represents such an evaluation by placing it in the context of Integrated Change Management (ICM). It does so both by developing ICM beyond the current limits, and then testing that methodology on the AM case. This is highly appropriate given the ability of AM to adapt quickly to design changes. However, the treatment of the a truly integrated production system with AM is novel and also vital to understanding the ultimate role of AM in manufacturing.

The Author has done an extremely thorough review of the literature and gleaned from it a number of techniques that support this work. In the very important context of manufacturing change management, the work uses discrete event simulation using simplified probability triangular distributions. This is highly appropriate for this level of system analysis, and allows for robustness analysis of the results.

This reviewer believes there are several significant results. There are few if any in depth examples of Integrated change management, and most importantly in the area of additive manufacturing. Although the author qualifies the results as in the context of AM, he also makes the case that with additional work the ICM framework can be generalized to any new process technology introduction if sufficient data about the change is available. This is highly significant in that process innovation is typically very slow in even the most progressive industries, owing to the lack of understanding of the full integrated impact of the change. This work could set the stage for much faster and successful new process introduction.

The results are immediately applicable to any design changes that could benefit from using the LBPM process. It also provides a general framework that can be extended to other processes, but the direct applicability in those cases may still need further investigation.

The summary of issues to be addressed before/during the thesis defense
This reviewer is making an annotated copy of the thesis available to Mr. Shakirov. The majority of comments are minor, but the critical ones are the following:

- Make very clear that the ICM framework that is developed is general, but is driven by the needs of using an AM process, and that the case study is for that process. At times it is not clear how general the work is. Is it always driven by the characteristics of AM? This is important to the generalization discussion in Chapter 6.
- A number of the figures of the integrated system are not useful as presented. For example, Figure 5.12 shows a manufacturing system diagram with more than 100 symbols and none are either readable or defined. Whether this is a standard format or not, it should be legible and fully explained.
- Other comments sent with the manuscript include clarifications, grammar suggestions and error corrections.

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

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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