

## Jury Member Report - Doctor of Philosophy thesis.

**Name of Candidate:** Yuri Sarkisov

**PhD Program:** Engineering Systems

**Title of Thesis:** Design, modeling, and control of cable-suspended aerial manipulator

**Supervisor:** Associate Professor Dzmitry Tsetserukou, Skoltech

**Co-advisors:** Dr. Konstantin Kondak, DLR; Dr. Christian Ott, DLR

**Name of the Reviewer:** Gonzalo Ferrer, Assistant Professor, CAIT, Skoltech

I confirm the absence of any conflict of interest

(Alternatively, Reviewer can formulate a possible conflict)

**Date: 26-01-2022**

*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

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

The main topic of the present PhD thesis, by Y. Sarkisov, is related to aerial manipulation (more accurately cable suspended manipulation) tasks and the techniques to achieve a successful long reachability of the manipulators while ensuring stability and safety. The topic of research is a hot and active area of research, highly relevant in the robotics and controls disciplines, gaining track every year. I consider the thesis novel and innovative, probably it will create a positive impact for future works.

The thesis document is well structured and well written, the figures provided are detailed and clear. The quality of the manuscript is evident. Chapter 1 provides an introduction material with the motivation and goals, very clearly presented, with

multiple examples to current research projects and publications. Chapter 2 introduces the background and common notation to be later used in the manuscript.

Chapter 3 reports the platform developed as well as many of the common convention for the systems, all explained in detail: the concept of suspended aerial manipulator (SAM), hardware realization and its control strategy. Part of the content of this chapter corresponds to the ICRA 2019 publication.

Chapter 4 is dedicated the the optimal dampening of oscillations in a suspended cable, an essential feature for manipulation. Classical control techniques are used to fulfill the research objectives and verified on simulation. The system is equivalent to a double pendulum and a single IMU estimates the partially observable state variables. This chapter corresponds to the ICRA 2020.

Chapter 5 models and proposes a control strategy for the winch cable actuators paired with the robotic arm, ensuring good alignment with the gravity vector regardless of the manipulator configuration.

Chapter 6 and 7 are a field work report of the real systems implementing SAM, providing a complete evaluation, data from the system and the study of some potential applications. It is very valuable material since typically, other works provide simplistic simulation conditions while the student went one step further. Of course, this is a team effort which involves multiple researchers and two laboratories, but it is worth mentioning it.

**The relevance of the topic of dissertation work to its actual content.**

The topic of the dissertation coincides with the content.

My only comment, and this is not a concern, is that the term aerial is not accurate to the SAM idea and I got the wrong impression of a flying platform supporting the SAM. It is a great motivation, but in practice the system in the real world has been validated in crane-based platforms, and given the dimension of the system, it looks a more convenient platform to use.

**The relevance of the methods used in the dissertation.**

The methods used in the dissertation are adequate, mostly based on control theory, kinematic chains and dynamic systems.

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

The scientific significance is high. The student has published his results in top conferences in the robotics field, 2 ICRA conferences as main author, 1 ICRA as author and IROS as an author. Other important publications are in Journal of Intelligent Robotic Systems and a side topic in RAL (Q1 in robotics).

This is an outstanding outcome for a PhD graduate.

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

The results obtained are relevant, there is a chapter entirely dedicated to potential uses.

**The quality of publications.**

The list of publications fullfills the program requirements, including 1 IROS (Core A), 3

ICRA Core B conferences (I consider ICRA a Core A, since it is next to iros the most important conference in robotics), one Q1 and Q2/Q1 journal.

### **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*