DR.SC.-01 REQUEST FOR APPROVAL OF THE DISSERTATION TOPIC[1]

GENERAL INFORMATION AND PERSONAL CONTACT INFORMATION OF THE DOCTORAL CANDIDATE

First and last name, and title of the doctoral candidate:	Nikola Horvat, mag. ing. mech.		
Provider of the study programme:	University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture		
Name of the study programme:	Mechanical Engineering, Naval Architecture, Aeronautical Engineering, Metallurgical Engineering		
Scientist ID of the doctoral candidate:	365145		
Approval of topic for acquiring a PhD *(please fill in appropriate box)*:	☒ within programme-based doctoral study	☐ on the basis of scientific achievement	☐ Dual doctorate (Cotutelle de these)
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CURRICULUM VITAE OF THE DOCTORAL CANDIDATE

Education *(in chronological order, with most recent first)*:	1. **University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture**, Mechanical Engineering - Design, Master's degree 2. **University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture**, Mechanical Engineering - Design, Bachelor's degree
Work experience *(in chronological order, with most recent first)*:	01.12.2017. - today: Research and Teaching Assistant, Chair of Design and Product Development, Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb (teaching, research, cooperation with industry)
Bibliography and active participation in conferences:	1. Martinec Tomislav, Horvat Nikola, Škec Stanko, Štorga Mario. Verbal Engagement in Teams Solving a Conceptual Design Task // Proceedings of the 15th International Design Conference (DESIGN 2018) / Marjanović, Dorian; Štorga, Mario; Škec, Stanko; Bojčetić, Nenad; Pavković, Neven (ur.). Zagreb, 2018. str. 2075-2086 (presentation, international review, published paper, scientific). 2. Horvat Nikola. Analysing Team Activities in Engineering Design, Fourth Annual PhD Workshop, PhD Study of Mechanical Engineering, Naval Architecture, Aeronautical Engineering and Metallurgical Engineering, Book of Abstracts / Parunov, Joško ; Kožuh, Stjepan ; Bauer, Branko ; Duić, Neven ; Jokić, Andrej ; Landek, Darko ; Lisjak, Dragutin ; Lulić, Zoran ; Majetić, Dubravko ; Matijević, Božidar ; Runje, Biserka ; Sorić, Jurica ; Terze, Zdravko

[1] Please name file as: DR.SC.-01 – Last name and first name of Doctoral Candidate.doc
Please send the filled -out form DR.SC.-01, in electronic and written format, and signed, to the appropriate Registrar's Office.

	(ur.). Zagreb: Faculty of Mechanical Engineering and Naval Architecture Faculty of Metallurgy, 2018. str. 15-15. (presentation, domestic review, published paper, scientific). 3. Horvat, Nikola. Analysing Team Activities in Engineering Design // *Fourth Annual PhD Workshop, PhD study of Mechanical Engineering, Naval Architecture, Aeronautical Engineering and Metallurgical Engineering* Zagreb, Hrvatska, 2018 (Conferences and workshops, Verbal) 4. Martinec, Tomislav; Horvat, Nikola; Škec, Stanko; Štorga, Mario. Verbal Engagement in Teams Solving a Conceptual Design Task // *DESIGN 2018* Dubrovnik, Hrvatska, 2018 (Conferences and workshops, Verbal)
TITLE OF THE PROPOSED TOPIC	
Croatian:	Timski tranzicijski procesi podržani tehnologijom virtualne stvarnosti u razvoju proizvoda
English:	Virtual Reality Supported Transition Processes in Teams Developing Products
Title in the language of the dissertation (if it is not Croatian or English)	
Area/field/branch (if the doctoral study is performed in a branch)**:**	Engineering / Mechanical Engineering / General Mechanical Engineering (Design)

PROPOSED OR POTENTIAL MENTOR(S)

(name the second mentor in case of interdisciplinary research or if there is another reason for more than one mentor)

	First name and last name, and title:	**Institution, country:**	**E-mail:**
First mentor:	Stanko Škec, Assistant Professor	University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture	stanko.skec@fsb.hr
Second mentor:			

MENTOR'S COMPETENCES – list of up to five relevant works published in the last five years

First mentor:	1. Martinec Tomislav, Škec Stanko, Savšek Tomaž, Perišić Marija Majda: "Work sampling for the production development: A case study of a supplier in European automotive industry", Advances in Production Engineering & Management, Vol. 12 (2017), 4, pp. 375-387, doi:10.14743/apem2017.4.265 2. Snider Chris, Škec Stanko, Gopsill James, Hicks Ben: "The characterisation of engineering activity through email communication and content dynamics, for support of engineering project management", Design Science, Vol. 3 (2017), e22, pp. 1-31, doi:10.1017/dsj.2017.16 3. Škec Stanko, Cash Philip, Štorga Mario: "A Dynamic Approach to Real Time Performance Measurement in Design Projects", Taylor & Francis UK: Journal of Engineering Design, Vol. 28 (2017), pp. 1-32 4. Škec Stanko, Štorga Mario, Tečec Ribarić Zlatka: "Work sampling of product development activities", Tehnički vjesnik-Technical Gazette, Vol. 23 (2016), 6, pp. 1547-1554, doi:10.17559/TV-20150606151030 5. Škec Stanko, Štorga Mario, Marjanović Dorian: "Mapping Risks on Various Product Development Process Types", Transactions of FAMENA, Vol. 37 (2013), Issue: 3, pp. 1-16
Second mentor:	

TOPIC OUTLINE	
Summary in Croatian *(no more than 1000 characters with spaces):*	Tranzicijski procesi se u razvoju proizvoda često manifestiraju kao timski pregled konstrukcije s ciljem dijagnosticiranja problema, verifikacije kvalitete obavljenog konstrukcijskog zadatka, te validacije specifikacija za nadolazeće aktivnosti. Brojna istraživanja ističu uvođenje i utjecaj novih tehnologija, kao što je virtualna stvarnost (VS), za podršku timu u dijeljenju informacija te prikazu i pohranjivanju znanja pri tranzicijskim procesima. VS tehnologija može potencijalno skratiti vrijeme upravljanja i manipulacije digitalnim konstrukcijskim objektima, pomoći u identifikaciji konstrukcijskih problema i poboljšati komunikaciju između članova tima. S obzirom na važnost tranzicijskih procesa u razvoju proizvoda te nužnost uvođenja novih tehnologija, cilj ovog istraživanja je razvoj teoretskog modela timskih tranzicijskih procesa i istraživačkog eksperimentalnog okvira za proučavanje timskog rada podržanog virtualnom stvarnošću u kontekstu pregleda konstrukcija.
Summary in English *(no more than 1000 characters with spaces):*	The transition processes in product development are often manifested as team design reviews with the main purpose of diagnosing problems, verification of the quality of the work achieved, and validation of the specifications for the upcoming activities. Recent research points out the introduction and influence of new technologies, such as virtual reality (VR), as support for information sharing, and representation and capture of knowledge throughout transition processes. VR technologies can potentially decrease the time for navigating and manipulating objects, improve spatial awareness, help in identifying design issues and improve communication among team members. By taking into consideration the importance of transition processes and the necessity for introducing new technologies, this research aims to develop a theoretical model of team transition processes, and experimental research framework for studying virtual reality supported teamwork within the context of design reviews.

Introduction and overview of research conducted hitherto *(suggested length: 7000 characters with spaces)*

In product development organisations, where products are to be conceived, designed and implemented, innovation is the primary mechanism to sustain competitive advantage [1]. In those organisations, teams are considered as the core building blocks [2] due to their ability to draw on different perspectives and expertise, which is especially salient in the context of new product development [3]. By general definition that can be adopted in the product development domain, a team is a set of at least two individuals that interact adaptively and dynamically through specified roles while working towards shared and valued goals [4,5].

Traditionally, design team members have been co-located, and their communication has been face-to-face. However, due to technological (e.g. information and communication technology) and organisational (e.g. globalisation) advances, team members are nowadays often distributed across the globe, have limited face-to-face contact and work interdependently with the support of electronic communication means [6]. Such teams are often referred to in the literature as virtual teams [6,7]. A recent survey from 2016 [8] found that the number of virtual teams is growing with 85% of respondents (n=1372) working in virtual teams. However, there are still ambiguities related to their performance and effectiveness [7]. Researchers point out the lack of studies related to transition processes [7,9,10] during which teams' primary focus is on evaluation and/or planning activities as a guide to accomplish the team goal [11]. As such, team transition processes serve as critical mediators through which team inputs influence team outcomes [10,12]. However, transition processes are still not well understood, and their implications on the team outputs still require further examination [10]. Therefore, research of the transition processes might provide a better understanding of teamwork and team outputs in general, but also give insights on their effect on other processes of the virtual design team [7].

The common manifestation of transition processes in product development are design reviews of which the main purpose is to diagnose problems [13], verify the quality of the work achieved [14], and validate the specifications for the upcoming activities [15]. Although design reviews are of key importance in context of product development [16], they have rarely been empirically studied. There are only a few reported studies in the field of design reviews. D'Astous et al. yielded three main findings in their study of design reviews: 1. software development review meetings include the design of alternative solutions, 2. shared understanding is a pre-requisite for evaluation and 3. importance of argumentation as a part of design review [15]. Huet et al. proposed a model of aerospace design review process consisting of three activities: sharing information about, evaluating and managing the design. They also suggested that sharing information, decision making, exploring, and evaluating are key exchange elements of design review [14]. Linhares et al. proposed a collaboration-conflict process model of design review consisting of three functions: review, negotiation and argumentation [17]. Liu et al. observed construction review meetings in the later phases of the design process and proposed a design review model consisting of three activities: understand design intent, validate requirements and concerns, and resolve design issues [18].

Recent design review research points out the influence of new technologies such as virtual reality (VR) [19,20] which has been used as a technology to support teams in representing and capturing knowledge in product development. As the support to knowledge representation, VR technology helps in the information sharing – a challenging activity, since during transition processes different decisions are addressed simultaneously by team members from various backgrounds [21]. There is a common

understanding that VR technologies used in transition processes of product development may potentially decrease the time for navigating and manipulating objects [22], improve spatial awareness [19,22], help in identifying design issues [23], improve communication and collaboration among team members [19,24] and it thus might have a significant impact on transition processes and team outputs.

VR technology proved to be useful for teamwork activities where members of the team share the same digital space even though they are in different physical locations thus providing more immersive interaction between them [7]. Currently available VR tools allow transferring hand gestures (e.g. [25]) and/or body postures (e.g. [26]) in virtual worlds, immersive sketching (e.g. [27]), and allow navigation and manipulation of digital objects with the use of gestures, voice and/or additional devices (e.g. [28,29]). It is thus not surprising that VR technology is already actively used in design practice as support to decision making and innovation [23] and that already has a large impact on design theory [7] and practice [20]. VR technologies as teamwork support might augment the current knowledge about virtual teams [7], and it is thus important to consider its use when studying teams.

Although conducted research on the transition processes in product development identified their main characteristics, these processes are still not well understood. Also, the implications of these processes on design team outcomes still remain insufficiently explored. Existing models of the transition process in product development are based on the studies of co-located teams [14,15,18] which mostly use traditional communication means. Moreover, studies which investigated transition processes in product development rarely included VR technologies as communication means for the team processes. On the other hand, research on VR technologies in transition processes focused mainly on potential implementation issues and advantages of VR support. Given the importance of transition processes in product development and the introduction of new technologies, bridging these two perspectives seems to be a necessary research step for a better understanding of recent advancements in design practice. To be more specific, by taking into account possibilities of VR technologies, exploration of VR supported teamwork for transition processes in product development might result in better understanding of teamwork within this context and lead to contributions for both theory and practice.

Objective and hypotheses of research[2] *(suggested length: 700 characters with spaces)*

The research aims at developing an experimental research framework for studying VR supported teamwork within transition processes in product development and a theoretical model of team transition processes in the same context. Metrics for measuring the effect of VR technologies will be identified through the experiments of team transition processes, while design review case study will be conducted to validate the proposed theoretical model.

The main research hypothesis:

Virtual reality technologies within teamwork augment understanding of the transition processes during product development and improve execution of evaluation/planning activities throughout development projects according to defined metrics.

Material, participants, methodology and plan of research *(suggested length: 6500 characters with spaces)*

Research methodology is based on the Design Science Research framework [30] which consists of three cycles of research activities: Relevance cycle, Design cycle, and Rigour cycle.

Within the *Relevance cycle*, the research will be positioned within the circumstantial environment to ensure relevance of the conducted study. Within the circumstantial environment, requirements from the perspective of organisational systems, people within the organisation, teams and teamwork, and technical systems to be developed will define the problem space. These requirements will be associated with, but not limited to, the transition processes across product development, design teams' behaviour, and VR technologies. The requirements will be identified based on previous research findings and insights from the real (industrial) environment. Identification of requirements from previous research studies includes a systematic review of both scientific and expert literature within the research area by defining literature sources, keywords and search criteria. This step will be followed by the extraction of data, categorisation of publications and synthesis of literature findings. Identification of requirements from the industrial environment will be based on mixed method research approach that embraces which both qualitative (e.g. interviews, observational methods) and quantitative (e.g. questionnaires and tests) data gathering techniques. Furthermore, in the case of qualitative data, content analysis methods can be used. In the later research phases, this cycle ensures that the research findings are disseminated and represented to the appropriate environment.

During *Design cycle*, an experimental framework that enables the study of the VR supported teamwork for transition processes in product development and a theoretical model of team transition processes will be designed to satisfy requirements and specifications identified in the circumstantial environment. More precisely, this cycle will begin with defining a reference model of team transition processes supported by VR technologies. The proposed model will consist of previously defined or assumed factors related to VS technologies on particular aspects of team transition processes. Based on the initial study conducted in the real environment and an overview of the current frameworks for studying transition processes, a new experimental framework will be designed and implemented. The experimental research framework for studying teamwork supported by VR technologies will embrace necessary infrastructure, the design of experiment and methodology for data gathering and analysis. Within the first step of defining framework,

[2] The sequence of listing the objective and hypotheses depends on the area of research.

variables will be identified and specified, including a detailed description on how to measure them in a reliable and valid way. The following step includes a definition of relationships between identified variables and their effects aiming to understand their mutual relations. To explore these relations, experiments will be designed taking into consideration the available research equipment. Finally, methods for qualitative and quantitative analysis of gathered data will be defined. In addition to these steps, the proposed framework will comprise guidelines for participant sampling and consideration of ethical issues necessary for this type of research. Implementation of the research framework will be done through the series of experiments with teams performing transition processes. Obtained experimental results, coupled with an overview of the current models of transition processes, will be used to propose a theoretical model of team transition processes within a product development context.

The *Rigour cycle* links the research and knowledge base to compare the results of the conducted theoretical and experimental study with the existing knowledge and methodologies, and to ensure that validation findings are added to the knowledge base. A review of the scientific literature will be conducted to compare new findings with existing knowledge base related to team transition processes, models of teamwork and team behaviour and variables used in teamwork studies (especially those related to transition processes and VR technologies). This cycle also includes usage of both qualitative and quantitative data analysis techniques and identification of validation criteria for the proposed theoretical model. Systematic validation of expected contributions will be conducted based on the identified criteria and hypothesis will be confirmed or rejected. Finally, the validation of the theoretical model of team transition processes and discussion on experimental framework for studying VR supported teamwork within transition processes will result in extensions and advancements of the existing knowledge base related to transition processes and team behaviour models. In addition, it will allow a systematic research approach for exploring VR technologies within the context of transition processes.

The research will be mainly conducted using the equipment from CADLab (www.cadlab.fsb.hr). One part of the equipment is already part of the CADLab inventory such as equipment used for data gathering from experiments (e.g. camera) The rest of the equipment required to conduct experiments (e.g. virtual reality system and workstations for rendering virtual environments) will be acquired as a part of CSF research project TAIDE (www.taide.org). Furthermore, collaboration with the DEPICT lab (www.ltu.se/depict) which is located at the Luleå University of Technology – LTU (Sweden) will provide additional advanced technology equipment for studying virtual teams. Beside the traditional equipment for monitoring usage of VR technologies, the DEPICT lab has the equipment to measure brain activity, eye and muscle movements, pulse, respiration, skin redness, brain waves and accompanying software needed to interpret and analyse gathered content. Part of the equipment from both labs is mobile, and it can be brought outside the university, enabling thus execution of study in an industrial environment.

The study in an industrial environment will involve employees from product development organisations that will participate during the initial phases to identify research requirements, but also in the later phases of the research to validate the proposed model through a set of controlled experiments. In addition to studying employees from the product development organisations, part of the study will be executed using FMENA students as participants, mainly when developing an experimental procedure and for conducting initial experiments.

Expected scientific contribution of proposed research *(suggested length: 500 characters with spaces)*

The expected contribution of the proposed research is manifested through:

1) A theoretical model of team transition processes within product development which includes models of evaluation/planning activities, team behaviour models and models of information content being transformed throughout the process.
2) An experimental framework that enables the study of the VR supported teamwork for transition processes in product development.
3) A design review case study with the aim to validate the proposed team transition process model.

List of literature cited *(no more than 30 references)*

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Total cost estimate of proposed research *(in kuna)*

100.000

Proposed sources of funding for research

Type of funding	Title of project	Project leader	Signature
National funding	TAIDE – Team Adaptability for Innovation-Oriented Product Development	Mario Štorga, Professor	
International funding	ELPID – E-learning Platform for Innovative Product Development	Stanko Škec, Assistant Professor	
Other types of projects	Resources of the Chair of Design and Product Development (cooperation with industry, international DESIGN conference organization)	Mario Štorga, Professor	
Self funding			
Session of the Ethics Committee at which consent was given to the research proposal[3]			

Agreement of the mentor and the doctoral candidate to request for topic approval

I declare under responsibility that I agree with the topic whose approval is requested.

Signature

Stanko Škec, Assistant Professor

Signature

Nikola Horvat, mag. ing. mech.

STATEMENT

[3] Fill out only if needed

I declare under responsibility that I have not submitted a request for approval of an identical dissertation topic at any other university[4].

Zagreb, 20.11.2018.

Signature

Nikola Horvat, mag. ing. mech.

Official stamp here

[4] Not required in case of dual doctorate (*Cotutelle de these*)