

I. IDENTIFICATION DATA

Thesis name:	Usage of technology LTE-V in V2X applications
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Type of thesis :	Master
Faculty:	Faculty of Transportation Sciences
Department:	Department of Transport Telematics
Thesis reviewer:	Ing. Martin Volný
Reviewer's department:	INTENS Corporation s.r.o.

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment	challenging
<i>Evaluation of thesis difficulty of assignment.</i>	
<p>The topic of the thesis is focusing on new technology, which could be possibly used in C-ITS systems. I see this topic challenging due to the fact, that this technology (LTE-V) is not mature at the moment and there are not many hardware / software products available, the standardization is not completed, interference between different technologies operating on 5,9GHz band is expected etc. On the other hand, the LTE-V technology has been tested, for the purpose of this theses, on the same principles as ITS G5 technology, which is being widely deployed in several EU countries including the Czech Republic. Therefore, I see the main challenge in getting access to the LTE-V technology and perform initial testing and comparison with ITS G5.</p>	

Satisfaction of assignment	fulfilled with minor objections
<i>Assess that handed thesis meets assignment. Present points of assignment that fell short or were extended. Try to assess importance, impact or cause of each shortcoming.</i>	
<p>The master's thesis author has defined objectives, which should be met in his final document. The points were:</p> <ul style="list-style-type: none"> - Analyses of cooperative systems implemented in CR and Europe; author has addressed this topic even more. He looked on experiences in other countries (continents) as well, where projects from USA, Australia and Asia has been stated. Unfortunately, the description of the projects is very basic and not consistent in the terms of depth of information provided. There are described challenges, technological approaches nor experiences / lessons learned. I would recommend to spent little more time in examine the projects and try to keep their description in the same format and level of depth. - Analyses of telecommunication technologies suitable for usage in cooperative systems (ITS G5, LTE-A, LTE-V), in this chapter the author performed correctly initial high-level overview of technologies followed by more detail description of LTE-V technology as this is the main technology to be used for the thesis development. - Evaluation of the use cases defined for ITS G5 also in LTE-V technologies (incl. transmitter message and safety mechanism), this requirement has not been addressed in the master's theses at all. The use cases eg. Road Work Warning, Weather condition warning etc. are being executed by C-ITS messages (defined by ETSI / ISO standards) as DENM, IVI, SPAT-MAP, SRM/SSM atd. These messages need to be in accordance to EU legislation secured by signature received from national PKI system. This would have been very valuable contribution to this thesis and to the comparison on Use case usage with different technologies. - Proposal of testing methodology and scenarios for verifying LTE-V technology, this requirement has been addressed by the theses author in acceptable depth and the proposed methodology followed basic testing and evaluation principles. - Lab verification of technology LTE-V and evaluation results, this requirement has been addressed partly where the theses author did not described / performed the Lab testing in order to set etalon for followed field testing. The filed testing was performed in limited conditions (time, number of runs, number of messages sent etc.), which set's the ground for evaluation. The evaluation methodology was described correctly in accordance with collected data and results available. <p>Generally I can confirm, that the master's theses have systematic structure and in principle meets the theses objectives.</p>	

Method of conception

correct

Assess that student has chosen correct approach or solution methods.

Testing of suitability of LTE-V technology for usage in C-ITS systems is a challenging task from the point of accessibility of the appropriate hardware components and software solutions tailored for the testing purposes. Therefore, the reliance on hardware and software availability created time pressure for the theses author to perform more, in depth testing, which could generate more data base for proper scientific evaluation. Based on the lack of the appropriate components, the author has tried his best to fulfill the master's theses assignment. I personally will appreciate testing of more LTE-V operational modes especially the mode 3, which is dependent on the mobile network operator. This mode should bring major benefits compare to mode 4, which was used for testing. The mode 4 is in principle the same as ITS G5 where both are operating on 5.9GHz. In this case I would appreciate comparison of these two technologies in the theses, but this was not performed. In the lights of the time pressure and reliance on third party assistance it seems, the method of conception was selected and deployed correctly.

Technical level

C - good.

Assess level of thesis specialty, use of knowledge gained by study and by expert literature, use of sources and data gained by experience.

By reviewing the master's theses, I did not have the opportunity to meet with the author personally, I got the feeling that the author has gained the good knowledge of C-ITS systems, its operational modes and technologies suitable for its operation. The problematic of C-ITS require more, in depth, knowledge of ETSI/ISO standards, Use case catalogue knowledge, technical radio operation experience inc. spectrum allocation etc. Despite of lacking these detail knowledge / experiences in this filed, the author has shown structured approach and get good knowledge on LTE-V operation.

Formal and language level, scope of thesis

B - very good.

Assess correctness of usage of formal notation. Assess typographical and language arrangement of thesis.

The master's theses author has followed the typical document structure, which is easy for orientation and clear for readers. The language for this thesis is English, which is in very good level with some minor typo errors and wrong sentence creation. The information character of the master's theses is generally good as it is describing the C-ITS system, technology suitable for the C-ITS system and testing / evaluating one the technology selected. Personally, I miss little more author's overview and his personal conclusions to this topic.

Selection of sources, citation correctness

B - very good.

Present your opinion to student's activity when obtaining and using study materials for thesis creation. Characterize selection of sources. Assess that student used all relevant sources. Verify that all used elements are correctly distinguished from own results and thoughts. Assess that citation ethics has not been breached and that all bibliographic citations are complete and in accordance with citation convention and standards.

The reference to external data sources / documents / web pages etc. is used correctly. In some cases, the source provides more information, which has not been used by author and to my opinion could increase information provision for better understanding of the described topic.

Additional commentary and evaluation

Present your opinion to achieved primary goals of thesis, e.g. level of theoretical results, level and functionality of technical or software conception, publication performance, experimental dexterity etc.

The topic of the master's theses was selected sensitively as LTE-V technology is being viewed as possible supplementary / complementary technology to ITS G5 both operating on 5.9GHz dedicated frequency for traffic safety applications. I would appreciate if the theses include more information about ITS G5 in comparison to LTE-V supported by extensive testing and evaluation. This should include radio performance, use case deployment, security integration etc. I do appreciate the fact that the hardware and software for LTE-V was for the testing borrowed by third party (company T-Mobile Czech Republic) and there was time limitation for better software setting, use case scenario development, and limited testing period. Despite of this the field testing (I am missing laboratory testing to avoid any radio disturbances) could had more scenario runs for collecting bigger data sources for evaluation. This evaluation is based on limited data sources and therefore could not be

taken as reference, which is correctly stated by the author in the conclusions. I would personally expect usage of Use cases for transmission of particular messages over the SW stack (according to ETSI EN 302 665 and other relevant standards) and comparison with transmitting the same use case over ITS G5 technology. The conclusions of the master's theses are summarizing the work executed and referring to limited time, missing personal and material cast, not good location selected for testing etc. All these facts have negative impact on the quality of the master's theses, where I could imagine that the author could possibly spent more time on theoretical comparison and use more of available testing.

III. OVERALL EVALUATION, QUESTIONS FOR DEFENSE, CLASSIFICATION SUGGESTION

Summarize thesis aspects that swayed your final evaluation. Please present apt questions which student should answer during defense.

Generally, I would like to confirm, that this master's theses are well balanced between theoretical work and field testing, despite of the conclusions cannot be used for prove of advantages / disadvantages of LTE-V technology use for C-ITS systems. The master's theses have been well structured, clear to understand, bring new technology for evaluation for use in C-ITS systems, allows for testing and evaluation. Unfortunately, there have not been enough data to perform high quality evaluation.

As a benefit to the author could be use of mathematical tool MATLAB and development of script used for evaluation of gathered data, without which the data analyses would not be possible. The map matching process was executed correctly as well and the results could lay base stone for further evaluation of the LTE-V technology.

The master's theses were prepared in English language, which is huge benefit to the author for future continuation of the work in the field of C-ITS as most of the available documents, hardware and software products are in English.

What do you think about usage of LTE-V technology for C-ITS and which mode (3 or 4) has advantage over the ITS G5?

Is there possibility for coexistence between LTE-V and ITS G5 technologies in the same frequency band eg. 5.9GHz?

I evaluate handed thesis with classification grade **C - good**.

Date: **11.6.2019**

Signature:

