FH | JOANNEUM
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Bachelor's Thesis

Safety as Service

Service oriented Architectures for safety-critical Systems

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Declaration of Academic Honesty

I hereby affirm in lieu of an oath that the present bachelor's thesis entitled

"Safety as Service - Service oriented Architectures for safety-critical Systems"

has been written by myself without the use of any other resources than those indicated, quoted and referenced.

Graz, 16 March 2015

Stefan LENGAUER,

Preface

This thesis was written as part of the internship at Virtual Vehicle at Inffeldgasse xx from April to July 2015. VV is specialzed in ... and .. . However the functional safety area in which i worked has very similar “brothers” in other engineering fields like trains or aviation.

- da ich daneben and er tu studiere - praktisch - am ideal match concerning the location as well as the themengebiet.

One of the challenges in the conduction of this project was the location of the necessary hardware, which was at the department's facility. This required a physical attendance at the university for the majority of the work. Also the literature research proved difficult, since there is not yet that much material covering this specific topic.

With regard to this obstacles I am satisfied with the outcome of this project and I hope to provide the reader with a broad overview on the basics of Large Eddy Simulation as well as its advantages and disadvantages.

Thus I want to thank everyone who supported me writing this thesis.

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Abstract

One of the major challenges the automotive industry has to face today is the constantly growing complexity of E/E (Electrics/ Electronics) systems. This is even hardened by the regulations of the ISO26262 norm in order to

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Kurzfassung

Large Eddy Simulation, ein Teilbereich der numerischen Strömungsmechanik, erfährt in letzter Zeit erhöhte Beachtung dank der steigendenden Leistungsfähigkeit der erforderlichen Hardware, insbesondere CPU und Speicher. In den meisten Bereichen ist sie aufgrund ihres hohen Ressourcenaufwandes noch nicht Industriestandart, aber in naher Zukunft wird sie ein wichtiges Instrument zur Untersuchung von komplexen Strömungsproblemen werden.

Aus diesem Grund beinhalted dieses Bachelorprojekt die Durchführung einer hoch- auflösenden Simulation eines Wärmeübergangs an einem dreidimensionalen Flügel- profil. Die, für diese Aufgabe gegebene Geometrie, ist ein NACA 0012 Flügelprofil und die verwendeten Softwarepakete beinhalten Ansys ICEM und Ansys CFX.

Anschließend werden die erzielten Resultate mit den Resultaten einer vergleichbaren RANS Simulation verglichen, welche momentan Standart für industrielle Anwendungen sind. Diese Auswertung dient als Grundlage für die darauffolgende Untersuchung und Diskussion der Anwendbarkeit der Large Eddy Simulation.

List of Figures

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List of Abbreviations

CAD	Computer Aided Design
CDS	Central Difference Scheme
CFD	Computational Fluid Dynamics
DES	Detached Eddy Simulation
DNS	Direct Numerical Simulation
GS	Grid Scale
GUI	Graphical User Interface
HPC	High Performance Computing
HPCC	High Performance Computing Cluster
LES	Large Eddy Simulation
RANS	Reynolds-averaged Navier Stokes
SGS	Sub Grid Scale
SST	Shear-Stress Transport
VLES	Very Large Eddy Simulation

Chapter 1

Introduction

Due to the very different comprehension of certain terms by different people from different fields of research The first part of my work during the internship was the creation of a glossary describing certain given terms ... in order to unify the understanding of these terms and create a basis for discussions ans researches.

- The glossary was later taken as standard for this tasks ... - and deals with the terms: *service*, *system*, *system of systems*, *architecture*, *service-oriented architecture*, *configuration*, *static reconfiguration*, *dynamic reconfiguration*, *inter-core communication*, *intra-core communication* and *binding*. The most important parts of this glossary will be covered within this chapter. - furthermore a database with the used literature was created in order to provide the necessary references for the glossary and provide a ... where to find further information for the employees.

- disambiguity safety and security - what is safety and fault tolerance

STANDARD 26262 - ASIL levels

1.1 service

1.2 bindings

1.3 literature database

- The literature database was written with SqL - contains most of the used references - which are of relevance - helps to gain further knowledge on the various topics

- sqldump in the appendix - description of the literature and estimation of their relevance
- rating of the ressources (1-5)

Chapter 2

Methods

Chapter 3

Results

Chapter 4

Discussion

As mentioned in the abstract the aim of this project is the conduction of a heat transfer by means of a Large Eddy Simulation, afterwards comparing the obtained results with the results of a RANS simulation of the same flow problem and analyzing deviations and similarities, as well as evaluating the applicability of the LES for technical flow investigation.

4.1 Investigation of the wall heat flux

As basis for the inspection and evaluation served the wall heat flux on the wing surface. The examination relied on the results obtained from the simulations, which are plotted in Figure **??** and the calculation results, belonging to them, in table **??**. Although in this plot it seems like there is just one graph per simulation type, there are actually two for each - one for the upper side and one for the bottom side of the wing. However, due to the symmetry of the geometry and the flow conditions their heat transfer along the profile is almost the same, appart from minor numerical inaccuracies.

The heat transfer resulting from the RANS equations features a heavy flunctuation at the front end of the airfoil. This is physically illogically and results most likely from the application of the SST (Shear-Stress Transport) turbulence model for this simulation. The LES results seem more convincing in this respect and it can be observed that they feature a much higher wall heat flux at the front section of the wing and a lower one at the rear section, while it is equal to the stationary simulation at about forty percent wing depth. This agrees with the exectations, because in a turbulent flow the heat transfer is much better than in a laminar flow for the turbulent vortices movement favors the energy exchange [**?**].

4.1.1 Interpretation of the dimensionless numbers

This subchapter is dedicated to analysing of the dimensionless number refered to in table **??**. The Reynolds number is of course the same for all solutions since it is independent from heat transfer. The parameter of interest is the Foude number, which is almost equal to one for a cylinder. For the transient solution the Froude number shows a deviation of about fourteen percent from this value. What causes this inaccuracy may be the subject of further investigations, but an interesting fact here is, that it is still closer to the desired result than the stationary simulation.

4.1.2 Comparison Large Eddy Simulation and RANS equation

As already mentioned the Large Eddy Simulation requires massive resources and a very sophisticated mesh compared to the RANS equations. However there are significant reasons, why LES becomes more and more attractive than RANS. One major drawback of the RANS equations is, that they are not sufficiently reliable in terms of prediction of heat transfers, as it is the case with this simulation, where the RANS equations come up with a physically rather questionable behavior of the heat transfer distribution.

On the other hand one should be aware of that a slightly inappropriate modelling of the LES can easily lead to completely wrong results. Accordingly LES requires a deeper knowlege of the subject, but in return it is capable of dealing with plenty of different flow conditions, without relying on a priori assumptions [**?**, **?**].

Chapter 5

Conclusion

Unfortunately there were nowhere experimental results of a heat transfer on a NACA airfoil to be found and therefore the LES method could only be evaluated by comparing with other CFD results. Accordingly one interesting task for future investigations would be the comparison of the results from this project to experimentally achieved results.

Furthermore it has to be stated that the documentation and reference material for the Large Eddy Simulation is rather meager and it seems that the Ansys Software tool are more dedicated to stationary simulations. Due to the long calculation durations it appears rather cumbersome and errors in the simulation setup can cost a vast amounts of time. Therefore it became obvious that LES requires more experience and knowledge in CFD in order to produce reliable results

Nevertheless there are various reasons to prefer the LES, as stated in chapter 4.1.2, and thus it is most likely to become more frequently applied for technical flow investigation in the future.

Appendix A

Appendix

- sqldump database - html grafik