STATEMENT

By prof.PhD.Eng. George Dimitrov

Member of the Scientific Jury, appointed by order of the Rector of St. Ivan Rilski UGM No. P-109 of 03/02/2020 on the dissertation for obtaining the educational and scientific degree "Doctor".

Author of the dissertation: Eng. Othman Abdulmohsen Al-Kherayef, PhD student, independent preparation for the Department of Surveying and Surveying.

Thesis topic: "Defining altitude reference systems by combining geodetic observations on Earth - research on baseline determining and implementation of the Altitude Reference System of the Kingdom of Saudi Arabia", professional field 5.7. Architecture, Construction and Surveying.

I. Biographical data about the PhD student:

Osman Abdulmohsen was born on 05.10.1967 in Riyadh, Kingdom of Saudi Arabia.

Professional qualification. In 1991 he graduated from the Faculty of Engineering at King Saud University as a Bachelor of Geodesy. In 1995 he completed a course in geodesy at the School of Military Surveying at the British Royal Army Corps of Engineers (UK). In 2003 he completed his training in GNSS Data Analysis Software course at the University of Bern, Switzerland. In 2006 he participated in a training course with officers from the Internet Technology Department at Saudi Arabia Armed Forces (MOA) based on PC basics.
In 2007 he obtained an International Certificate of Computer Knowledge (ICDL).

Professional experience. In 1993 he was appointed as a lecturer at the Institute of Military Geodesy and Geographic Studies and as such worked during the periods 1997-1998 and 2001-2002. From 1993 to 1995, he was the Director of the Digital Landscape Information Section. In 1995 he was member of the Yemen Border Renewal Team. From 1997 to 2001, he was the Director of Digital Information Production Division and Director of the Digital Division for production of mobile cards. In 2001-2002 he was at the same time the head of the oversight team on the border project with Yemen. In 2001, he was a member of a working team reviewing all surveys on the existing geodetic network. In 2004, he was the Chief Technical Specialist in the teams for the overview of the Surveying Network of Saudi Arabia and a member of the drafting committee for the Directorate General for Saudi Arabia military surveying. In 2007-2009 he chaired the Category Adjustment Committee in the field of geodetic work and a member of the Committee for Structuring the Military Formation of the General Committee on Geodesy. In 2008-2009 he was a lecturer at the Institute of Military Geodesy and Geography and leader of the field team on the project for building a network of points from the vertical deformation monitoring network. In 2009-2012 he was a manager in the Department for the Geodetic Vertical Reference System of the Directorate General. In 2010 – 2013 he participated in the stabilization and measurement of leveling benchmarks. In 2013-2014 he was project manager of the Permanent Reference Stations of Saudi Arabia and in 2013 - 2015 he was Assistant Director-General of the Directorate-General for Higher Geodesy and Earth Studies at the General Surveying Commission.

He has had a total of 9 publications co-authored with distinguished surveyors. He has participated in various conferences and trainings. He has received are accolades and awards. He has made relevant contributions and involvement in initiatives supporting the Kingdom of Saudi Arabia's 2030 Program. He has achievements and contributions to The development of engineering work (as a manager and in the preparation of national conferences in Higher Geodesy: 2013, 2015 and 2016.

II. Summary of the dissertation

Structure of the thesis. The dissertation contains an introductory Chapter 1, four main chapters: 2,3,4,5 and concluding notes collected in the last Chapter 6, as well as the literature, tables and figures used.

Chapter 1 covers Introduction, research problems, current status, main research tasks, suggestions for solving them, and Acknolwledgement.

The introduction justifies the relevance of the study, defines the purpose, indicates the object, subject and area of the study, as well as the tasks that must be solved to achieve the goal, introduced and defined. To achieve this goal some basic tasks are outlined.

Due to the long historical period of the data having different nature, different accuracy, solution, etc. currently derived orthometric elevations for TG used for local and regional VRF definition mismatch or have large disparities along coastlines even in smaller territories or islands. Apart from such problems those orthometric heights show large inconsistencies w.r.t. those derived by Least Squares Method (LSA) of precision leveling networks. These problems would cause distortions in the precision leveling networks if some TG orthometric heights (derived from geoid models) had to be fixed during the LSA procedure. Such examples still exist for historically old leveling networks for the USA, Canada, Australia, the European Vertical Reference Framework (EVRF), KSA Jeddah'69 in Saudi Arabia and more.

At present, the impact of the Spatial Reference Systems in day-to-day activities is increasing for global, regional and local applications. All new remote and terrestrial measurements require geodetic attachment to the Spatial Reference Systems for different applications and with different coverage. I consider the topic is up-to-date.

Chapter 2 gives the essential theoretical fragments that provide the necessary basis for the study. **The geodetic basis** is discussed here and the important aspects are emphasized such as: Geodetic coordinate systems; fundamentals of physical theory of the figure of the Earth; height and height output theory; research is important for most communities using traditional measurement methods as well as current and progressive data collection methods.

Chapter 3 discusses the applied methodologies and deals with the various geodetic methodologies used to identify appropriate approaches to solve the problem of altitude source data in a new multilateral way, using the specific advantages of data sources currently available:

- Global geopotential models;
- Ground (precision leveling, gravimetric measurements, GNSS) and air (gravity) measurements;
- Coastal oceanographic data;
- Surveillance (satellite altimetry).

Chapter 4 focuses on some practical aspects related to the geodetic infrastructure needed to provide the empirical data to address the Altitude Datum Problem, in particular in the Kingdom of Saudi Arabia. **Chapter 4** deals with data and the availability of information about numerical experiment.

The results of each numerical experiment included in this study are analyzed in depth in **Chapter 5**, highlighting various important details of the additional observational methods that are included to achieve better quality results and optimize the level of use of available measured data. . This chapter analyzes the numerical results from the various experiments

Chapter 6. The last Chapter 6 contains Conclusions, Recommendations, Contribution Claims, Bibliography and Annexes. In this final chapter the results of the study are summarized and interpreted in terms of possible implementation to establish new formulations for the KSA Vertical Date. Some practical recommendations have been made regarding the implementation of the VDP solution strategy. A critical appendix on the extent of the research is included as well as the author's suggestions and requirements. This chapter also summarizes the concluding remarks. According to the author, the findings and contributions discussed in this dissertation can be viewed together with the efforts of the entire global geodetic community

- From static to dynamics / time change of enhanced VRF and VD;
- Precise to ultra-high precision VRF and VD;

- From local / national to regional / global coverage of VRF and VD. This could be the basis of an ARABREF satellite reference framework planned to be implemented as UN-GGIM (Arab State Research Group).
- From national / regional VRF and VD to a unified World Reference Altitude System and an enhanced KSA-VRF based on the new KSA-GEOID20 can be seen as an important implementation of IRHS in KSA territory.

Literature. The author cited 78 literature sources examined or used in the study. I regard the references cited as up-to-date.

III. Claims for Scientific and Applied Contributions to the Thesis.

The main scientific results are summarized in the relevant claims for scientific contributions. The material on which the contributions of the dissertation are formulated is presented as a complete independent scientific research in an interdisciplinary scientific and applied field. In his work the PhD student has formulated 12 contribution claims, grouped into 3 main categories:

2.1. Contributions to the development of methodologies for improving the Vertical Reference Framework and the Vertical Datum, as well as the Vertical Datum for Saudi Arabia.

2.2. Contributions to the definition of the problem of a new Vertical Datum and finding a numerical solution.

2.3. Contributions to the use of important findings of particular relevance to numerical solutions to problems. OF m-VDP.

The conclusions and contributions are presented in the 4 publications:

The significance of the contributions is present. They develop and enrich the existing theory and "toolkit". They can serve as a basis for further refining and increasing the reliability of this activity. And so they have my support and recognition.

IV.On the chosen research methodology.

The methodological basis of the study are basic theories and common methods of scientific knowledge are used. Some specific scientific research methods have been properly selected and successfully implemented. Existing theories have been successfully used and appropriate algorithms and software applied. Contemporary world trends are used. With the research done the PhD student achieves the chosen goal and proves his working hypotheses indisputably.

V. The reliability of the data and results obtained is confirmed by the processing, analysis and models created. The PhD student's authorship and personal contribution to the research, the development of the dissertation, the publications submitted and the scientific contributions are beyond doubt. Therefore, I believe that these contributions are his own work.

VI. Using the results obtained in the dissertation and recommendations for their future implementation.

The applicability of the results obtained in the dissertation is indisputable.

Research in dissertation work can serve practitioners, PhD students, lecturers and students researching and studying elevation systems problems. The dissertation can serve as a supplementary textbook and as a part of various instructions for activity in the field.

VII. Critical notes

I have not noticed serious gaps and inaccuracies in the dissertation.

However, the following critical remarks can be made:

1. Common definitions are given in some places, which can be found in many textbooks and handbooks.
2. Extra details are provided on some issues.
3. Some of the contributions could be even better justified.
4. Some stylistic inaccuracies are noted in some places.

These remarks do not diminish the value of the dissertation, which is well-crafted and accurate and, in my opinion, a completed scientific work.

VIII. Overall assessment. The PhD student has correctly navigated in this difficult matter and has achieved good results. The problems in the thesis are in one important area. Serious generalizations have been made and applied aspects have been sought.
I reckon that the PhD student has gone into detail about the problem, which allowed him to scientifically justify the necessary research and to obtain the necessary useful scientific and above all practical results. Research is related to information that has been properly processed, analyzed and summarized. It is shown that the PhD student monitors the developments and innovations in this field and rationally uses the information, he has made a proper assessment of the current state of the problem and is consistent with the tendencies in the development of the scientific field. I have no objections, both in content and in the way of presenting the informatio, as a scientific approach and style. The style is academic, with a strong emphasis on analysis and synthesis of results.

IX. Abstract for the dissertation.

The abstract (The author referred to it as **EXTENDED SUMMARY**) has been developed in accordance with the established requirements. It presents the purpose, the scientific tasks, the subject, the object and the main thesis of the research. The volume covers 53 standard pages. The presentation in the abstract follows the structure in the dissertation. The main content of the individual chapters is then presented in brief form, the main conclusions are synthesized and a well-grounded conclusion is made. Particularly impressive are the color illustrations: drawings, diagrams, diagrams and images. The scientific contributions made and the author's claims are correctly reflected. The trend for future research is outlined. The layout is of high quality.

X. Conclusion

The dissertation work is designed in a competent and accurate manner and represents a completed scientific research. The problems addressed in the dissertation are current and in an important area. The PhD student has properly navigated in this difficult matter and has achieved good results. Serious generalizations have been made and applied aspects have been sought. The thesis of Eng. Otman Abdulmohsen is a scientific study, which is a modern and original contribution to science and practice. The solutions presented are a solid basis for further development and refinement of this activity.
Based on the aforementioned qualities of the dissertation presented and the results achieved, as well as the scientific and applied contributions, I give **a positive assessment** of the dissertation work and propose **that the PhD student Othman Abdulmohsen Al-Kherayef be awarded the scientific and educational degree DOCTOR OF SCIENCES**".

March 2nd 2020

(Prof. D.Sc. Eng.G.Dimitrov)