UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF TERRAIN ANALYSIS DATABASE USING MILITARY GEOGRAPHIC INFORMATION SYSTEM

MOHD ZAMBRI BIN MOHAMAD RABAB

DEVELOPMENT OF TERRAIN ANALYSIS DATABASE USING MILITARY GEOGRAPHIC INFORMATION SYSTEM

By

MOHD ZAMBRI BIN MOHAMAD RABAB

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, In Fulfillment of the Requirements for the Degree of Doctor of Philosophy

August 2002

Abstract of thesis presented to the Senate of the Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

DEVELOPMENT OF TERRAIN ANALYSIS DATABASE USING MILITARY GEOGRAPHIC INFORMATION SYSTEM

By

MAJOR MOHD ZAMBRI BIN MOHAMAD RABAB

August 2002

Chairman: Major Prof Dr Kamaruzaman Jusoff

Faculty: Forestry

The Information and Communication Technology (ICT) that includes military geospatial information will play a key role in the Revolution of Military Affair (RMA) for future warfare. The Terrain Analysis (TA) database is one of the military geospatial information that needs to be established in the Malaysian Armed Forces (MAF) in order to enable various Military Geographic Information System (MGIS) to perform analyses and produce Tactical Decision Aids (TDA) products.

This study focused on the establishment of TA database structure that consisted of several layers namely Surface Configuration – Slope, Vegetation, Surface Material – Soils, Surface Drainage, Transportation and Obstacle Layers. A prototype TA database was established in order to evaluate the effectiveness of the database in generating Cross Country Movement (CCM) map. Results revealed that the topographic data from Department of Survey and Mapping Malaysia in Topologized Topographic Mapping (TTM) database, soil data from Department of

Agriculture and the analyses of IKONOS imagery and ground data collection using GPS Geo Explorer 3 have contributed significantly to the development of prototype TA database. GIS technology was thoroughly utilized in implementing a user interface menu and CCM map from prototype TA database. Results showed that GIS technology has provided a powerful tool in successfully generating both products.

The results of this study have contributed significantly to the science and art of military aspect of terrain. Most of the MAF projects especially the Command, Control, Communication and Intelligence (C3I) system that use MGIS will benefit from the TA database structure for producing and analyzing various TDAs products. This study has produced the first TA database for the country and hopefully to be used by the Royal Engineer (RE) Corps. The structure of TA database will be proposed to higher level military council in order to officially implement in MAF.

Future study shall focus on the automatic rapid extraction of TA feature and attribute from hyperspectral, airborne Interferometric Synthetic Aperture Radar (IFSAR) and Light Detection and Ranging (LIDAR) imageries. Such study should also focus on validating soil data from the Department of Agriculture in accordance with military engineering specification. Implementing open and shared database concept for military geospatial information is also an important research that is required. The development of CCM products using NRMM II model and the enhancement of user interface menu for TA database should be further investigated and implemented.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Doktor Falsafah

PEMBANGUNAN PANGKALAN DATA ANALISA MUKA BUMI MENGGUNAKAN SISTEM MAKLUMAT GEOGRAFI KETENTERAAN

Oleh

MEJAR MOHD ZAMBRI BIN MOHAMAD RABAB

Ogos 2002

Pengerusi: Mejar Prof Dr Kamaruzaman Jusoff

Fakulti: Perhutanan

Maklumat geospatial pertahanan yang merupakan sebahagian daripada Teknologi Maklumat dan Komunikasi akan memainkan peranan utama di dalam Revolusi Hal Ehwal Tentera bagi peperangan masa hadapan. Maklumat data Analisa Muka Bumi (AMB) adalah salah satu daripada maklumat geospatial pertahanan yang perlu diwujudkan dalam Angkatan Tentera Malaysia (ATM) untuk membolehkan pelbagai Sistem Maklumat Geografi (SMG) ketenteraan melaksanakan analisis dan menghasilkan produk-produk Bantuan Keputusan Taktikal (BKT) bagi merancang operasi ketenteraan.

Fokus kaji selidik ini adalah kepada pembangunan struktur pangkalan data AMB yang mengandugi lapisan-lapisan seperti Kecerunan, Tumbuh-Tumbuhan, Tanah, Saliran, Pengangkutan dan Halangan. Pangkalan data prototaip AMB telah dibangunkan bagi menilai keberkesanannya dalam menghasilkan peta *Cross Country*

Movement (CCM). Keputusan kajian telah menunjukkan bahawa data pemetaan topografi berdigit daripada Jabatan Ukur dan Pemetaan Malaysia (JUPEM) dalam format Pemetaan Topografi Bertopologi (PTB), data tanah daripada Jabatan Pertanian Malaysia dan hasil analisis imej satelit IKONOS serta pengumpulan data di lapangan menggunakan peralatan GPS Geo Explorer 3 telah dapat menyumbang kepada pembangunan pangkalan data prototaip AMB. Teknologi SMG telah digunakan sepenuhnya dalam membangunkan menu paramuka untuk pengguna dan peta CCM daripada pangkalan data prototaip AMB tersebut. Teknologi SMG telah digunakan dengan jayanya untuk menyediakan dan menjanakan kedua-dua produk tersebut.

Hasil kajian selidik ini telah dapat menyumbangkan kepada seni dan sains terhadap aspek muka bumi tujuan ketenteraan. Sistem-sistem canggih ATM seperti projek Pemerintahan, Pengawalan, Perhubungan dan Perisikan (P4) yang berasaskan SMG akan mendapat manfaat daripada struktur pangkalan data AMB tersebut untuk mengeluarkan pelbagai produk BKT. Kajian ini telah menghasilkan struktur pangkalan data AMB yang pertama untuk negara Malaysia dan berharap ianya akan digunakan oleh Kor Askar Jurutera DiRaja. Struktur pangkalan data AMB yang dibangunkan akan diketengahkan untuk kelulusan majlis tertinggi ATM supaya ianya dapat dilaksanakan di ATM.

Kajian akan datang perlu difokuskan kepada penawanan pantas secara automatik terhadap butiran dan atribut AMB daripada imageri yang diperolehi melalui konsep *hyperspectral, airborne Interferometric Synthetic Aperture Radar* (IFSAR) *and Light Detection and Ranging* (LIDAR). Kajian juga harus ditumpukan kepada pengesahan data tanah yang diperolehi daripada Jabatan Pertanian Malaysia menurut spesifikasi dan piawaian kejuruteraan tentera. Perlaksanaan konsep

pangkalan data terbuka untuk maklumat geospatial pertahanan supaya dapat dikongsi oleh semua pengguna aplikasi SMG haruslah dikaji kesesuaiannya di dalam ATM. Penjanaan produk CCM menggunakan model NRMM II serta peningkatan untuk mencanggihkan menu paramuka pengguna bagi memanipulasi pangkalan data AMB perlu dibuat kajian yang lebih mendalam.

ACKNOWLEDGEMENTS

First and foremost, I would like to express my heart-felt gratitude to my major supervisor, Maj Prof Dr Kamaruzaman Jusoff for his guidance, encouragement, support and friendship. I thank him for his input in this study, for his patience and for the knowledge I gained from his comments and suggestions. I would like to thank my supervisory committee members, Assoc Prof Dr Azizi Hj Muda and Dr Anuar Abdul Rahim for their constructive criticism that substantially improve this study. I would also like to extend my appreciation to Field Research Assistants, Pak Lah, Hasif, Ashwan and Pak Mat, who have provided full commitment in assisting the collection of ground data and ground verification analysis over the study area.

I would like to acknowledge Brig Gen Dato' Pahlawan Mohamad Tairobi Abdul Razak, the Chief Engineer of Royal Engineer Corps for his blessing and continuous encouragement in completing this study. Special appreciation also goes to Col Jamil Tahir, the Director of Defence Mapping for his continuous support, patience, diligence and invaluable help. I thank him for allowing me to continue with the study while at the same time working as a full time military officer. I would also like to extend my appreciation to Brig Gen (Retired) Dato' Abdul Rahman Ismail the former Director of Defence Mapping for his first blessing in pursuing with this study.

Special appreciation also goes to the Department of Survey and Mapping Malaysia, Department of Agriculture Malaysia and Department of Forestry Peninsular Malaysia for providing useful data that contributed to the success of the study. I am sincerely thankful for their assistance to overcome inherent weakness in understanding their data structure.

Finally, all I have accomplished would not have been possible without the consistent support of my family. To my parent Mohamad Rabab Yaakob and Siti Mariam Ahmad, wife Maj Dr Liana Ma Abdullah and son Muhammad Danish Aiman who not only endured without protest the loneliness while I prepared my dissertation, but also provided their loving encouragement throughout this long study.

This thesis submitted to the Senate of Universiti Putra Malaysia and was accepted as fulfillment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee are as follows:

Kamaruzaman Jusoff, Ph.D.
Professor
Faculty of Forestry
Universiti Putra Malaysia
(Chairman)

Azizi Hj Muda, Ph.D.
Associate Professor
Faculty of Science and Environment Studies
Universiti Putra Malaysia
(Member)

Anuar Abdul Rahim, Ph.D.
Lecturer
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

AINI IDERIS, Ph.D.
Professor/Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

TABLE OF CONTENTS

LIST OF FIGURES

FIGURES **PAGE**

LIST OF TABLES

TABLES **PAGE**

LIST OF ABBREVIATIONS

ADF	-	Australia Defence Forces
ADRG	-	Equal Arc Second Raster Chart/map Digitized Raster Graphics
ALBE	-	Airland Battlefield Environment
ALZ	-	Air Landing Zones
AMM	-	Army Mobility Model
AMSAA	-	Army Materiel System Analysis Activity
BCTP	-	Battle Command Training Program
C3I	-	Command, Control, Communication and Intelligence
CAD	-	Computer Aided Design
CADRG	-	Compressed Equal Arc Second Raster Chart/map Digitized Raster Graphics
CAMMS	-	Condensed Army Mobility Model System
CAMS	-	Computer Assisted Mapping System
CCM	-	Cross Country Movement
COA	-	Course of Action
CD ROM	-	Compact Disc Read-Only-Memory
DFAD	-	Digital Feature Analysis Data
DGIA	-	Defence Geographic and Imagery Intelligence Agency
DGIWG	-	Digital Geographic Information Working Group
DGN	-	Intergraph Design Format
DIGEST	-	Digital Geographic Information Exchange Standard
DIGO	-	Defence Imagery and Geospatial Organization
DMA	-	Defence Mapping Agency
DMS	-	Defense Mapping Section
DNMM	-	Directorate of National Mapping Malaysia
DSMM	-	Department of Survey and Mapping Malaysia
DST	-	Data Storage and Transfer
DTED	-	Digital Terrain Elevation Data
DTM	-	Digital Terrain Model
DTSS	-	Digital Topographic Support System
DXF	-	Digital Exchange Format
ECW	-	Enhanced Compressed Wavelet
ER	-	Earth Resource
ERS	-	Earth Resource Mapper Raster Image
GIS	-	Geographic Information System
GPS	-	Global Positioning System
HLZ	-	Helicopter Landing Zones
HQ	-	Headquarters
ICT	-	Information and Communication Technology
IFSAR	-	Interferometric Synthetic Aperture Radar
INS	-	Inertia Navigation System
IPB	-	Intelligent Preparation of Battlefield
ISO	-	International Organization for Standardization
ITD	-	Interim Terrain Data
JMTK	-	Joint Mapping Toolkit
JPEG	-	Joint Photographic Experts Group
KPH	-	Kilometre per Hour
LCD	-	Liquid Crystal Display

LIDAR	-	Light Detection and Ranging
LOC	-	Lines of Communication
MACRES	-	Malaysian Center for Remote Sensing
MAF	-	Malaysian Armed Forces
MAPI	-	Mobility Application Programmer's Interface
MAS	-	Military Agency for Standardization
MGI	-	Military Geospatial Information
MGIS	-	Military Geographic Information System
MLC	-	Military Load Class
MMC	-	Military Mapping Committee
MOBA	-	Military Operations in Built-up Areas
MOOTW	-	Military Operations Other Than War
MORSES	-	Mobile Remote Sensing Engineering System
MOU	-	Memorandum of Understanding
MOUT	-	Military Operations in Urban Terrain
MSI	-	Multi Spectral Imagery
NALIS	-	National Infrastructure of Land Information System
NATO	-	North Atlantic Treaty Organization
NBC	-	Nuclear, Biological, and Chemical
NIMA	-	National Imagery and Mapping Agency
NRMM	-	North Atlantic Treaty Organization Reference Mobility Model
R&D	-	Research and Development
RCI	-	Rating Cone Index
RDZ	-	Resupply Drop Zones
RE	-	Royal Engineer
RMA	-	Revolution of Military Affair
RMR	-	Royal Malay Regiment
RMS	-	Rapid Mapping Support
RTV	-	Rapid Terrain Visualization
SMSP	-	Soil Moisture Strength Prediction
STANAG	-	North Atlantic Treaty Organization Standardization Agreement
TA	-	Terrain Analysis
TACISYS	-	Tactical Information System
TACOM	-	US Army Tank Automotive Command
TAP	-	Terrain Analysis Products
TAS	-	Terrain Analysis System
TDA	-	Tactical Decision Aid
TIFF	-	Tag Image File Format
TLM	-	Topographic Line Map
TMC	-	Technical Management Committee
TOPOSS	-	Topographic Support System
TTADB	-	Tactical Terrain Analysis Database
TTM	-	Topologized Topographic Mapping
UAV	-	Unmanned Aerial Vehicle
UK	-	United Kingdom
USA	-	United State of America
USACE	-	US Army Corps of Engineers
USCS	-	Unified Soil Classification System
USDA	-	United States Department of Agriculture

UTM	-	Universal Transverse Mercator
VAT	-	Vital Asset Protection
VCI	-	Vehicle Cone Index
VITD	-	Vector Product Interim Terrain Data
VPF	-	Vector Product Format
VR	-	Vegetation Roughness
VRF	-	Vegetation Roughness Factor
WES	-	US Army Engineer Waterways Experiment Station
ZOE	-	Zone of Entry

CHAPTER 1

INTRODUCTION

1.1 General

Murshardin (2001) in his paper titled "Impact of Information Technology and Information Warfare on Malaysian Armed Forces (MAF)" has emphasized the importance of Information and Communication Technology (ICT) in Revolution of Military Affair (RMA) for future warfare. Computer and electronic devices may become dangerous weapon in the future warfare. Therefore, information that includes geospatial and attribute will play a key role in any future operation.

Military Geospatial Information (MGI) provides information of our world to enable Military Geographic Information System (MGIS) extracting knowledge for specific strategies and planning purposes (Australian Defence Organisation, 2000). The MGI plays a very important role in military operation. Its importance is almost as critical as the importance of logistic supports such as ammunition, ration, petrol and water, which can affect the success of military operation. Sun Tzu (500 B.C.) has explained the importance of terrain or MGI for total victory of military operation other than knowing own and enemy forces capabilities (Giles, 2001). The need of MGI is even more so for the present and future condition of warfare due to the expansion of operation areas, increased mobility and also rapid changes have occurred in the technology that supports the modern warfare. In contrast to these increases, the time available to respond to problems has decreased.

At present, topographic maps at the scale of 1:50,000 are widely used by military community and they have been familiar with the graphics and map symbologies represented on the topographic map. However, these elements cannot provide tactical information about certain features. For example, the road element portrayed on the topographic map does not have tactical information such as the width and type of construction material. This limits the use of topographic map for tactical planning purposes. Tactical information of features that are significant to military operation is usually stored in Terrain Analysis (TA) database. The TA database comprises several layers namely slope, vegetation, soil, transportation, surface drainage and obstacle. The TA database at the scale of 1:50,000 is part of the MGI databases that is useful for planning tactical operation.

Technology of MGIS has enabled the management of tactical information in TA database be implemented digitally and effectively. For instance, 1 Topo Survey Squadron of Australia Defence Forces (ADF) and 42 Survey Regiment of United Kingdom Defence Forces have utilized MGIS for collecting, managing and utilizing their TA database to produce various products of Tactical Decision Aid (TDA) and Rapid Mapping Support (RMS) (Abdul Rahman,1997 ; Flegg,2002).

1.2 Statement of Problem

Understanding the terrain of operation area is vital to mission success. Army commanders need to understand the terrain of operation area thoroughly in order to win the battle. Therefore, Engineer Corps has been asked to analyze the terrain for the use of military commanders. In most countries in the world such as the United States of America (USA), United Kingdom and Australia, this discipline has been greatly emphasized. The establishment of the National Imagery and Mapping