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DEVELOPMENT OF TERRAIN ANALYSIS DATABASE USING MILITARY GEOGRAPHIC INFORMATION SYSTEM

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DEVELOPMENT OF TERRAIN ANALYSIS DATABASE USING MILITARY GEOGRAPHIC INFORMATION SYSTEM

By

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DEVELOPMENT OF TERRAIN ANALYSIS DATABASE USING MILITARY GEOGRAPHIC INFORMATION SYSTEM

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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
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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 mengandungi 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 Juruter 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 v
pangkalan data terbuka untuk maklumat geospatial pertahanan supaya dapat dikongsi oleh semua pengguna aplikasi SMG haruslah dikaji kesesuaianannya 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.
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I certify that an Examination Committee met on 24\textsuperscript{th} August 2002 to conduct the final examination of Mohd Zambri bin Mohamad Rabab on his Doctor of Philosophy thesis entitled “Development of Terrain Analysis Database using Military Geographic Information System” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

(MAJOR MOHD ZAMBRI MOHAMAD RABAB)

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TABLE OF CONTENTS

ABSTRACT .............................................................................................................................................ii
ABSTRAK .............................................................................................................................................iv
ACKNOWLEDGEMENTS ...................................................................................................................vii
APPROVAL SHEETS ...........................................................................................................................ix
DECLARATION FORM ..........................................................................................................................xi
LIST OF FIGURES .............................................................................................................................xv
LIST OF TABLES ......................................................................................................................................xix
LIST OF ABBREVIATIONS ..................................................................................................................xx

CHAPTER

1 INTRODUCTION ..................................................................................................................................1.1
  1.1 General .............................................................................................................................................1.1
  1.2 Statement of Problem .....................................................................................................................1.2
  1.3 Objective of Research ....................................................................................................................1.5

2 LITERATURE REVIEW .....................................................................................................................2.1
  2.1 Geographic Information System (GIS) for Defence Application ..................................................2.1
  2.2 Elements for MGIS ........................................................................................................................2.3
    2.2.1 Hardware ..................................................................................................................................2.3
    2.2.2 Software ..................................................................................................................................2.4
    2.2.3 Data .........................................................................................................................................2.5
    2.2.4 People ......................................................................................................................................2.6
  2.3 Military Geospatial Information (MGI) .........................................................................................2.7
    2.3.1 The Foundation of MGI Infrastructure ....................................................................................2.7
      2.3.1.1 Elevation and Bathymetric Data .........................................................................................2.8
      2.3.1.2 Feature Data ......................................................................................................................2.8
      2.3.1.3 Spatial Imagery ..................................................................................................................2.9
    2.3.2 The Significance of Remote Sensing Imagery in Providing MGI Information ......................2.9
    2.3.3 The Development of MGI for MGIS Application ....................................................................2.14
    2.3.4 The Development of MGI for MAF Projects .......................................................................2.17
      2.3.4.1 Background ......................................................................................................................2.17
      2.3.4.2 Computer Assisted Mapping System (CAMS) Products ...............................................2.19
    2.3.5 Military Geospatial Information (MGI) Standards .................................................................2.20
      2.3.5.1 Digital Geographic Information Working Group (DGIWG) ...........................................2.21
      2.3.5.2 North Atlantic Treaty Organization (NATO) Military Agency for Standardization (MAS) .........................................................................................................................2.22
  2.4 Development of TA Database .......................................................................................................2.22
    2.4.1 Definition of TA ......................................................................................................................2.24
    2.4.2 Military Requirement for TA ..................................................................................................2.25
    2.4.3 Terrain Analysis System .........................................................................................................2.27
  2.5 Mobile Geospatial Engineering System (MGES) ........................................................................2.30
  2.6 Cross Country Movement (CCM) Model for Defence Planning ................................................2.35

3 MATERIALS AND METHODS ..........................................................................................................3.1
  3.1 Study Area .....................................................................................................................................3.1
  3.2 Materials .......................................................................................................................................3.2
    3.2.1 Hardware ...............................................................................................................................3.2
# RESULTS AND DISCUSSION

## 4.1 Phase 1 - The Establishment of TTM Database

### 4.1.1 The TTM feature and Attribute Codes

### 4.1.2 Issues of TTM Database

### 4.1.3 Prototype TTM Database

### 4.1.4 The Importance of TTM Database to the Development of TA Database and MGIS Projects of MAF

## 4.2 Phase II - The Establishment of Terrain Analysis (TA) Database

### 4.2.1 Terrain Analysis (TA) Feature and Attribute Codes

### 4.2.2 Surface Configuration – Slope Layer

### 4.2.3 Vegetation Layer

#### 4.2.3.1 Bare Ground Feature

#### 4.2.3.2 Agriculture Feature

#### 4.2.3.3 Plantation Feature

#### 4.2.3.4 Grass Feature

#### 4.2.3.5 Brush Feature

#### 4.2.3.6 Forest Feature

#### 4.2.3.7 Swamp Feature
4.2.3.8 Built Up Area Feature ......................................................... 4.52
4.2.4 Surface Material- Soil Layer .................................................. 4.54
4.2.4.1 Soil Type Feature .............................................................. 4.54
4.2.4.2 Soil Data from the Department of Agriculture, Malaysia ........ 4.55
4.2.5 Surface Drainage Layer ......................................................... 4.60
4.2.5.1 Stream Feature ............................................................... 4.61
4.2.5.2 Dam Feature ................................................................. 4.66
4.2.5.3 Other Surface Drainage Features .................................... 4.68
4.2.6 Transportation Layer ........................................................... 4.69
4.2.6.1 Road Feature ................................................................. 4.70
4.2.6.2 Road and Railroad Bridge Feature .................................. 4.76
4.2.6.3 Other Transportation Features ...................................... 4.79
4.2.7 Obstacle Layer .................................................................... 4.81
4.3 Phase III – Analysis for TA Products and the Construction of User Interface Menu ................................................................. 4.84
4.3.1 The Development of User Interface Menu for TA Layers ........ 4.84
4.3.2 Future Development of User Interface Menu ....................... 4.93
4.3.3 The Production of Cross Country Movement (CCM) Product .... 4.94
  4.3.3.1 Result of Preparing the Data for Raster Conversion ........... 4.96
  4.3.3.2 Output of the Terrain Effects ......................................... 4.101
  4.3.3.3 Result of CCM Products .................................................. 4.104
4.3.4 Analysis of CCM Products .................................................. 4.108
4.3.5 Mobility Model for Future Research ...................................... 4.110
4.4 The Effectiveness of Using Remote Sensing Imagery for Updating TA Database ......................................................... 4.110
4.5 The Significance of Using GPS in Collecting TA features .......... 4.111
4.6 The Significance of TA Database to MAF ................................ 4.113
4.7 Future Development of Military Geospatial Database ............ 4.116

5 CONCLUSION AND RECOMMENDATION ........................................ 5.1
5.1 Conclusion ............................................................................ 5.1
5.2 Recommendations for Future Study ....................................... 5.2

REFERENCES ............................................................................. R.1
APPENDICES ............................................................................... A.1
VITA .......................................................................................... V.1
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURES</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>MGIS for Defence Application ........................................... 2.2</td>
</tr>
<tr>
<td>2.2</td>
<td>The Element of Terrain Analysis Information ........................... 2.24</td>
</tr>
<tr>
<td>2.3</td>
<td>Process of Military Decision Making ...................................... 2.26</td>
</tr>
<tr>
<td>2.4</td>
<td>Phase I of Terrain Analysis System ...................................... 2.28</td>
</tr>
<tr>
<td>2.5</td>
<td>Phase II of Terrain Analysis ............................................. 2.29</td>
</tr>
<tr>
<td>2.6</td>
<td>Phase III of Terrain Analysis System .................................... 2.30</td>
</tr>
<tr>
<td>2.7</td>
<td>Type of Vehicles and Equipments for MGES ............................... 2.31</td>
</tr>
<tr>
<td>2.8</td>
<td>Sample Product of RMS .................................................. 2.34</td>
</tr>
<tr>
<td>2.9</td>
<td>Sample Product of TDA .................................................. 2.34</td>
</tr>
<tr>
<td>2.10</td>
<td>Example of Cross Country Movement (CCM) Product ...................... 2.36</td>
</tr>
<tr>
<td>3.1</td>
<td>Location of Study Area for Phase I ...................................... 3.3</td>
</tr>
<tr>
<td>3.2</td>
<td>Location of Study Area for Phase II and III ............................ 3.4</td>
</tr>
<tr>
<td>3.3</td>
<td>Flowchart of the Development of TTM Database .......................... 3.7</td>
</tr>
<tr>
<td>3.4</td>
<td>Flowchart for Phase II .................................................. 3.12</td>
</tr>
<tr>
<td>3.5</td>
<td>The Flowchart of Producing Mosaic from IKONOS Imagery .............. 3.16</td>
</tr>
<tr>
<td>3.6</td>
<td>The Process of Enhancing the Imagery ................................... 3.17</td>
</tr>
<tr>
<td>3.7</td>
<td>Mosaicked IKONOS Imagery File ........................................... 3.18</td>
</tr>
<tr>
<td>3.8</td>
<td>Accuracy Assessment of IKONOS Imagery .................................. 3.19</td>
</tr>
<tr>
<td>3.9</td>
<td>Flowchart for Ground Verification Using Geo Explorer 3 (Data Preparation in Office) .................................................. 3.21</td>
</tr>
<tr>
<td>3.10</td>
<td>Flowchart for Ground Verification Using Geo Explorer 3 (Collecting Ground Verification Data in the Study Area) ..................... 3.22</td>
</tr>
<tr>
<td>3.11</td>
<td>Flowchart of Ground Verification Using Geo Explorer 3 (Back to Office) .......................................................... 3.23</td>
</tr>
<tr>
<td>3.12</td>
<td>Recharging of GPS Batteries and GPS Data Transfer into Notebook .......................................................... 3.24</td>
</tr>
<tr>
<td>3.13</td>
<td>The Use of Data Dictionary Editor to create the Ground Verification GIS Database Structure ..................................... 3.26</td>
</tr>
<tr>
<td>3.14</td>
<td>Implementation of Setting Processes in Data Dictionary Editor ....... 3.26</td>
</tr>
<tr>
<td>3.15</td>
<td>Data Transfer Menu ..................................................... 3.28</td>
</tr>
<tr>
<td>3.16</td>
<td>Collecting Base Reading .................................................. 3.29</td>
</tr>
<tr>
<td>3.17</td>
<td>The Use of Rover to the Proposed Destination ............................ 3.30</td>
</tr>
<tr>
<td>3.18</td>
<td>Collecting Ground Verification Information ................................ 3.32</td>
</tr>
<tr>
<td>3.19</td>
<td>Haga Altimeter ........................................................... 3.33</td>
</tr>
</tbody>
</table>

xv
3.20 Licor 189 ............................................................................................................. 3.34
3.21 GPS Data Transfer into Notebook in the Field ............................................. 3.35
3.22 Main Modules Integrated with Main Project .................................................... 3.40
3.23 Flowchart of the Development of User Interface Menu for TA Layers ............. 3.41
3.24 Flowchart showing the Production of CCM Product ...................................... 3.44
3.25 Sample Picture of M1 Tank ............................................................................. 3.46
3.26 Sample of Grid Calculator User Interface Menu ........................................... 3.47
3.27 Sample of Grid Queries Operation ................................................................. 3.48
3.28 Grid Operation for Spatial Analysis ............................................................... 3.50
3.29 The Conversion from Vector to Raster Dialog Box ....................................... 3.51
4.1 The TTM Database was Stored in Separated Folder Based on Layers ............... 4.3
4.2 Boundary Layer of CAMS Database in DXF Format ....................................... 4.7
4.3 Boundary Layer of TTM Database ................................................................. 4.7
4.4 Building Layer of CAMS Database in DXF Format ......................................... 4.8
4.5 Building Layer of TTM Database ................................................................. 4.8
4.6 Relief Layer of CAMS Database in DXF Format .............................................. 4.9
4.7 Relief Layer of TTM Database ...................................................................... 4.9
4.8 Transportation Layer of CAMS Database in DXF Format ............................... 4.10
4.9 Transportation Layer of TTM Database .......................................................... 4.10
4.10 Hydrography Layer of CAMS Database in DXF Format ............................... 4.11
4.11 Hydrography Layer of TTM Database .......................................................... 4.11
4.12 Utility Layer of CAMS Database in DXF Format ........................................... 4.12
4.13 Utility Layer of TTM Database ..................................................................... 4.12
4.14 Miscellaneous Layer of CAMS Database in DXF Format ............................. 4.13
4.15 Miscellaneous Layer of TTM Database ......................................................... 4.13
4.16 Vegetation Layer of CAMS Database in DXF Format .................................... 4.14
4.17 Vegetation Layer of TTM Database ............................................................... 4.14
4.18 All layers of TTM Database were Overlaid to Display as Topographic Map ....... 4.16
4.19 Feature and Attribute Codes Structure of TA Database ................................. 4.20
4.20 Sample of DTM and Slope Data of Study Area ............................................. 4.22
4.21 Bare Ground Feature on IKONOS Imagery .................................................. 4.25
4.22 Agriculture Feature on IKONOS Imagery ..................................................... 4.28
4.23 Coconut Tree on IKONOS Imagery ............................................................... 4.33
| 4.54 | F1 Factor for M1 Tank ................................................................. 4.102 |
| 4.55 | F2 Factor for M1 Tank ................................................................. 4.102 |
| 4.56 | F3 (Dry) Factor for M1 Tank ....................................................... 4.103 |
| 4.57 | F3 (Wet) Factor for M1 Tank ....................................................... 4.103 |
| 4.58 | CCM (Dry) Product for M1 Tank in Raster ....................................... 4.105 |
| 4.59 | CCM (Wet) Product for M1 Tank in Raster ....................................... 4.105 |
| 4.60 | CCM (Dry) Product for M1 Tank in Vector ....................................... 4.106 |
| 4.61 | CCM (Wet) Product for M1 Tank in Vector ....................................... 4.107 |
| 4.62 | Geography Network Website Enabling Users to Access the Geospatial Database ................................................. 4.118 |
# LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLES</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>The comparison between Type of Standard Spatial Data and NIMA’s standard format</td>
</tr>
<tr>
<td>2.2</td>
<td>Mapping Scale and Level of Details in Military Standard</td>
</tr>
<tr>
<td>3.1</td>
<td>M1 Tank Characteristics</td>
</tr>
<tr>
<td>3.2</td>
<td>Estimation of Vegetation Roughness (VR) Related to Types of Vegetation</td>
</tr>
<tr>
<td>3.3</td>
<td>Estimation of RCI Value from Soil Characteristic</td>
</tr>
<tr>
<td>3.4</td>
<td>Estimation of Surface Roughness for Soil</td>
</tr>
<tr>
<td>3.5</td>
<td>Categories for Speeds and CCM Map Units</td>
</tr>
<tr>
<td>4.1</td>
<td>Sample Feature and Attribute Codes Structure of TTM Database for Transportation Layer</td>
</tr>
<tr>
<td>4.2</td>
<td>Slope category for TA database</td>
</tr>
<tr>
<td>4.3</td>
<td>Statistics of Plantation Feature</td>
</tr>
<tr>
<td>4.4</td>
<td>Statistics of Forest Feature</td>
</tr>
<tr>
<td>4.5</td>
<td>Soil Unified Soil Classification System</td>
</tr>
<tr>
<td>4.6</td>
<td>Soil Classification using DOA Format and USCS</td>
</tr>
<tr>
<td>4.7</td>
<td>Statistics of Road Feature</td>
</tr>
<tr>
<td>4.8</td>
<td>Products of Terrain Analysis</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
</tr>
<tr>
<td>ADF</td>
<td>Australia Defence Forces</td>
</tr>
<tr>
<td>ADRG</td>
<td>Equal Arc Second Raster Chart/map Digitized Raster Graphics</td>
</tr>
<tr>
<td>ALBE</td>
<td>Airland Battlefield Environment</td>
</tr>
<tr>
<td>ALZ</td>
<td>Air Landing Zones</td>
</tr>
<tr>
<td>AMM</td>
<td>Army Mobility Model</td>
</tr>
<tr>
<td>AMSAA</td>
<td>Army Materiel System Analysis Activity</td>
</tr>
<tr>
<td>BCTP</td>
<td>Battle Command Training Program</td>
</tr>
<tr>
<td>C3I</td>
<td>Command, Control, Communication and Intelligence</td>
</tr>
<tr>
<td>CAD</td>
<td>Computer Aided Design</td>
</tr>
<tr>
<td>CADRG</td>
<td>Compressed Equal Arc Second Raster Chart/map Digitized Raster Graphics</td>
</tr>
<tr>
<td>CAMMS</td>
<td>Condensed Army Mobility Model System</td>
</tr>
<tr>
<td>CAMS</td>
<td>Computer Assisted Mapping System</td>
</tr>
<tr>
<td>CCM</td>
<td>Cross Country Movement</td>
</tr>
<tr>
<td>COA</td>
<td>Course of Action</td>
</tr>
<tr>
<td>CD ROM</td>
<td>Compact Disc Read-Only-Memory</td>
</tr>
<tr>
<td>DFAD</td>
<td>Digital Feature Analysis Data</td>
</tr>
<tr>
<td>DGIA</td>
<td>Defence Geographic and Imagery Intelligence Agency</td>
</tr>
<tr>
<td>DGIWG</td>
<td>Digital Geographic Information Working Group</td>
</tr>
<tr>
<td>DGN</td>
<td>Intergraph Design Format</td>
</tr>
<tr>
<td>DIGEST</td>
<td>Digital Geographic Information Exchange Standard</td>
</tr>
<tr>
<td>DIGO</td>
<td>Defence Imagery and Geospatial Organization</td>
</tr>
<tr>
<td>DMA</td>
<td>Defence Mapping Agency</td>
</tr>
<tr>
<td>DMS</td>
<td>Defense Mapping Section</td>
</tr>
<tr>
<td>DNMM</td>
<td>Directorate of National Mapping Malaysia</td>
</tr>
<tr>
<td>DSMM</td>
<td>Department of Survey and Mapping Malaysia</td>
</tr>
<tr>
<td>DST</td>
<td>Data Storage and Transfer</td>
</tr>
<tr>
<td>DTED</td>
<td>Digital Terrain Elevation Data</td>
</tr>
<tr>
<td>DTM</td>
<td>Digital Terrain Model</td>
</tr>
<tr>
<td>DTSS</td>
<td>Digital Topographic Support System</td>
</tr>
<tr>
<td>DXF</td>
<td>Digital Exchange Format</td>
</tr>
<tr>
<td>ECW</td>
<td>Enhanced Compressed Wavelet</td>
</tr>
<tr>
<td>ER</td>
<td>Earth Resource</td>
</tr>
<tr>
<td>ERS</td>
<td>Earth Resource Mapper Raster Image</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information System</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>HLTZ</td>
<td>Helicopter Landing Zones</td>
</tr>
<tr>
<td>HQ</td>
<td>Headquarters</td>
</tr>
<tr>
<td>ICT</td>
<td>Information and Communication Technology</td>
</tr>
<tr>
<td>IFSAR</td>
<td>Interferometric Synthetic Aperture Radar</td>
</tr>
<tr>
<td>INS</td>
<td>Inertia Navigation System</td>
</tr>
<tr>
<td>IPB</td>
<td>Intelligent Preparation of Battlefield</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
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<tr>
<td>ITD</td>
<td>Interim Terrain Data</td>
</tr>
<tr>
<td>JMTK</td>
<td>Joint Mapping Toolkit</td>
</tr>
<tr>
<td>JPEG</td>
<td>Joint Photographic Experts Group</td>
</tr>
<tr>
<td>KPH</td>
<td>Kilometre per Hour</td>
</tr>
<tr>
<td>LCD</td>
<td>Liquid Crystal Display</td>
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</tbody>
</table>
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

xxi
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>UTM</td>
<td>Universal Transverse Mercator</td>
</tr>
<tr>
<td>VAT</td>
<td>Vital Asset Protection</td>
</tr>
<tr>
<td>VCI</td>
<td>Vehicle Cone Index</td>
</tr>
<tr>
<td>VITD</td>
<td>Vector Product Interim Terrain Data</td>
</tr>
<tr>
<td>VPF</td>
<td>Vector Product Format</td>
</tr>
<tr>
<td>VR</td>
<td>Vegetation Roughness</td>
</tr>
<tr>
<td>VRF</td>
<td>Vegetation Roughness Factor</td>
</tr>
<tr>
<td>WES</td>
<td>US Army Engineer Waterways Experiment Station</td>
</tr>
<tr>
<td>ZOE</td>
<td>Zone of Entry</td>
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</table>
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.
1.2

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