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A study was performed to determine Special Operation Forces (SOF) requirements for highly detailed feature and attribute data sets for urban operations. These needs were compared to the capability offered by the DMA VPF-based product, Urban Vector Smart Map (UVMap). From interviews with SOF officers, the specific features and attributes required were determined and prioritized. A value-adding process was considered for enhancing the baseline UVMap product for SOF use. Source material requirements and software available for value-adding were also considered. A Phase II approach was outlined to demonstrate value-adding to UVMap as a prototype process leading to an enhanced capability for Force XXI.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

PREFACE

This report is being prepared under DA Contract DACA76-96-C-0001, "Topographic Technology Enhancement." The study was conducted between February 1996 and July 1996 under the supervision of the Contracting Officer's Representative, Ms. Karen Fulkerson, Special Studies Division, Digital Concepts and Analysis Center (DCAC), U.S. Army Topographic Engineering Center (TEC), Alexandria, Virginia 22315-3864.

Mr. Walter E. Boge was Director and Colonel Richard Johnson was Commander, Deputy Director, and subsequently acting Director of the U.S. Army Topographic Engineering Center during the time of the preparation and publication of this report.

LIST OF SYMBOLS, ABBREVIATIONS, AND ACRONYMS
USED IN THE REPORT

CA	Civil Affairs
CD-ROM	Compact Disk - Read Only Memory
CIA	Central Intelligence Agency
CONUS	Continental United States
COR	Contracting Officer's Representative
COTR	Contracting Officer's Technical Representative
DCAC	Digital Concepts and Analysis Center
DIA	Defense Intelligence Agency
DIGEST	Digital Exchange Standard
DMA	Defense Mapping Agency
DPW	Director of Public Works
DSPW	Digital Stereo Photogrammetric Workstation
DZ	Drop Zone
FACC	Feature Attribute Coding Catalog
GEOREF	Geographic Reference
GIS	Geographic Information System
HLZ	Helicopter Landing Zone
ITD	Interim Terrain Data
LOC	Lines of Communication
MC&G	Mapping, Charting & Geodesy
MGRS	Military Grid Reference System
MOBA	Military Operations in Built-up Areas
MOUT	Military Operations on Urbanized Terrain
NATO	North Atlantic Treaty Organization
NCA	National Command Authority
OCONUS	Outside Continental United States
OOTW	Operations Other Than War
POC	Point of Contact
PSYOP	Psychological Operations
SF	Special Forces
SLF	Standard Linear Format
SOAR	Special Operations Aviation Regiment
SOF	Special Operations Forces
SPOT	Systeme Pour l'Observation de la Terre
TAC	Terrain Analysis Center
TEC	Topographic Engineering Center
TLM	Topographic Line Map
TUM	Terrain Update Module
USASOC	United States Army Special Operations Command
UTM	Universal Transverse Mercator
UVMap	Urban Vector Smart Map
VPF	Vector Product Format

EXECUTIVE SUMMARY

This report details an evaluation of how well the DMA UVMap meets requirements for highly detailed urban terrain data expressed by representatives of the U.S. Army Special Operations Forces (SOF). When the product does not meet those requirements, the differences are noted and examined for priorities in value-adding to the UVMap database. Potential sources for finding the information to add to the data is also suggested. A process for value-adding this information to enhance the UVMap database is then discussed in terms of source data, tools to perform the process, personnel to perform the function, and procedures to follow. Concluding the report is discussion of a case study which could be executed in a subsequent project which would implement results of this project and demonstrate the feasibility of value-adding information using DMA's UVMap as a base.

1.0 INTRODUCTION

This report documents the research and conclusions involved in determining the features and attributes to value-add to an existing Defense Mapping Agency (DMA) Urban Vector Smart Map (UVMap) dataset (also known as VMap 3). These features and attributes were derived from interviews with U.S. Army Special Operations Forces (SOF) personnel in March 1996. The requirements gained from this process were compared to the available data within the DMA data set to determine additional data to be value-added to meet end-user (SOF) requirements for high resolution urban vector map data.

The U.S. Army deals with Military Operations in Built-up Areas (MOBA), also known as Military Operations on Urbanized Terrain (MOUT), in its doctrine as presented in Army Field Manuals 100-5, Operations, dated 14 June 1993, and 90-10, Military Operations on Urbanized Terrain, dated August 1979.

> Urban operations present unique and complex challenges to Army forces. . . They can constrain technological advantages; they impact on battle tempo; they force units to fight in small, decentralized elements; they also create difficult moral dilemmas due to the proximity of large numbers of civilians. . .
>
> FM 100-5, Operations, Chapter 14, The Environment of Combat

To prevent problems and maintain the desired tempo of operations in modern warfare, U.S. Army doctrine specifies the avoidance of large scale mounted battle in urban terrain. A preferable alternative is to contain an urban area, bypass it and seize the more militarily significant objective. However, in today's world political climate, the United States is increasingly conducting military operations on urban terrain such as Mogadishu, Port-Au-Prince, Monrovia, and Srebenica. These operations are conducted at the small unit level where command and control down to the individual soldier is critical. The troops best suited for these missions are the Special Operations Forces, who are designed to operate most efficiently on urban terrain. They have the greatest need to know the urban terrain and both the advantages and challenges it offers.

This report is an examination of the SOF requirements for high resolution urban terrain data and the ability to meet those requirements through application of both standard and value-added data. The methodology used here applies to this examination only. The results of this study are not meant to represent the broader requirements of the Army.

2.0 BACKGROUND

2.1 ARMY DEFINITION OF URBAN DIGITAL TOPOGRAPHIC DATA (DTD)

The United States Army has examined requirements for highly detailed, large scale urban-oriented digital terrain data (DTD) since the mid-1980's. Modern growth of urban areas throughout the world had assured that future Army operations would occur there. Digital data to support this type of combat was non-existent. In 1990 the United States Army Topographic Engineering Center (TEC) developed a concept and prepared a draft prototype specification for High Resolution Urban Specific Data Sets (HIRUS). TEC subsequently conducted a survey to determine the need for this high resolution data to support Army forces. This need was definitively established for a wide range of users, but the largest response for this data was received from the Army Special Operations Forces (Lee, 1992). The HIRUS survey results further revealed that the respondents wanted detailed features and attributes which could be queried for further information. Additionally, requirements were stated for topographic data beyond traditional Mapping, Charting, and Geodetic (MC&G) products, including geospatial information that could be linked with other data, such as imagery and text, to form an enhanced geographic product.

Subsequently, in 1993 DMA produced the first prototype Urban Vector Smart Map (UVMap). UVMap is a vector-based digital data set based on the DMA hardcopy City Graphic product. The data set is standardized to meet the coding and format requirements of the Digital Exchange Standard (DIGEST) Feature Attribute Coding Catalog (FACC) and Vector Product Format (VPF) standards, respectively. All features and attributes found in UVMap are listed in the product's draft Military Specification, MIL-U-89035; as this report was published, the most recent edition of the UVMap specification was dated 23 May 1995.

TEC evaluated this first UVMap prototype (Lee, 1993) based on the needs stated in the previous HIRUS study (Lee, 1992). Results of the 1993 study stated that UVMap was a good start, but additional work was needed to meet the needs of the Army. Specifically, there were needs for improved data definition and indexing, coordinate precision, increased data content, better data display, and denser population of the attribute data.

DMA produced two additional UVMap prototypes. The most current UVMap prototype data set, covering Havana, Cuba, was released in mid-1995. This is the prototype that serves as the foundation for the project discussed in this report.

Through this project, TEC seeks to both revalidate and update the results of the 1992 HIRUS study and the 1993 HIRUS/UVMap comparison effort.

The objectives of this study are to research completeness of the UVMap data set, research Army SOF requirements for very highly detailed urban data, find data and production resources available for use in value-adding, establish a plan for a value-adding concept, and propose a feasible case study in which to perform value-adding to the UVMap product.

2.2 U.S. ARMY SPECIAL OPERATIONS FORCES

TEC focused on examining Army SOF requirements because of that branch's high previous interest in this urban data. The five principal SOF missions (per FM 100-5) are unconventional warfare, direct actions, special reconnaissance, foreign internal defense, and counterterrorism. Additionally, SOF troops may participate in activities such as security assistance, humanitarian assistance, antiterrorism, counterdrug operations, personnel recovery, and operations with other U.S. military components. To perform these missions the Army SOF is organized into five types of units.

Special Forces (SF) units conduct all of the principal SOF missions and activities stated above. These troops are what many consider to be the "Green Berets."

Ranger units are designed to deploy rapidly and conduct joint strike operations with special operations units of all services. They can also conduct conventional warfare operations and perform as light infantry when integrated with other combat arms.

Special Operations Aviation units are uniquely organized and equipped to support special operations missions. They both support the SF in all missions and can conduct autonomous reconnaissance and direct action.

Civil Affairs (CA) units perform a dual role. They provide liaison support between civilian authorities and the U.S. Army in a given operational area and, when required, operate civil government services in the absence of the lawful government.

Psychological Operations (PSYOP) forces use a variety of communications media (radio, TV, print, etc.) to influence foreign audiences' attitudes and behaviors to benefit U.S. interests. Such activities are politically sensitive and approval authority for such operations may reside with the President of the United States and his National Command Authority.

SOF generally operate in small team units to optimize economy of force and minimize operational security issues. SOF excel in small unit operations due to their training; each soldier is trained to perform a variety of tasks in support of the given operation. Typical SOF missions, including counterterrorism, counterdrug operations, and personnel recovery (i.e. hostage recovery), require detailed plans with multiple contingency plans. Preparation for these missions requires equally detailed mission rehearsals. Hence, the SOF generally require highly detailed terrain data sets that include both feature and elevation information, are robust in feature and attribute content, and can be utilized in a myriad of mission rehearsal scenarios. Indeed, the SOF, by virtue of needs for detail in urban terrain and the existence of no other high resolution digital urban product, have arguably the most stringent requirements for value-adding features and attributes to a UVMap database. They were the most logical Army force to interview for a UVMap value-adding study.

3.0 GOALS AND APPROACH

The following outline specifies the objectives that were to be accomplished in this study, and the methodologies used to achieve them.

Goal 1. Research completeness of UVMap Prototype

- Acquire UVMap prototype and research its history/production method
- Run statistical summary for data completeness
- Compile feature/attribute content list

Goal 2. Collect representative Army SOF requirements

- Research SOF missions and deduce potential features and attributes of importance
- Contact appropriate personnel for assistance in requirements collection
- Organize, prepare for, rehearse, and execute interviews with members of SOF

Goal 3. Compare UVMap to collected requirements, and categorize/prioritize results

- Document and prioritize each of the following categories:
  - A. Features and attributes required; both are in specification (include within this list those situations where DMA has not populated the attribute information)
  - B. Features and attributes required; neither is in specification
  - C. Features and attributes required; feature in specification but attribute is not
  - D. Features not required but in specification

Goal 4. Analyze Army's capabilities for value-adding

- Collect and assess resources which could be used in the value-adding process
- Collect and assess information on DMA and Army mapping-capable facilities

Goal 5. Establish Implementation Plan and Suggest Case Study for a Value-Adding Exercise

- Based on results of previous work, create flowchart that outlines a viable value-adding sequence
- Formulate an exercise that would be cost-effective, technically feasible, achievable within constraints of Phase II timeframe and funds, and exhibit quantifiable results.

4.0 METHODOLOGY

4.1 RESEARCH COMPLETENESS OF UVMAP PROTOTYPE

Upon acquiring the UVMap CD-ROM, DCAC members and the contractor began research into the history and prospective user community for the product. The history, standards, and production methods for the product are outlined earlier in this report. Discussions with DMA personnel revealed that UVMap had evolved from a requirement from the intelligence community, and that no formal requirement for the product had been issued to DMA from the Army.

DCAC personnel used TEC's statistical software package called VPF STAT software to perform quantitative checks on data completeness in the UVMap prototype. The check produced a list of features and their associated attributes that are found in that dataset. More specifically it revealed the percentage of attribution completion within each theme of the UVMap prototype, as seen in Table 1.

TABLE 1. DEGREE OF COMPLETENESS OF FEATURES AND ATTRIBUTES WITHIN UVMAP PROTOTYPE DATASET (HAVANA, CUBA)

Coverage	# of Features	# of Attributes	Populated Features	Total Attribute Fields	% of Completion
Library Ref	1	1	1	1	**100%**
Tile Ref	1	2	8	8	**100%**
Boundary	4	6	228	516	**44%**
Data Quality	1	8	8	32	**25%**
Elevation	2	5	2668	2889	**92%**
Hydrography	13	15	1226	3602	**34%**
*Industry	19	15	254	23250	**1%**
Physiography	3	10	6	129	**5%**
Population	21	25	10831	79027	**14%**
Transportation	23	36	96131	381708	**25%**
Utilities	8	17	4239	76	**2%**
Vegetation	3	11	0	6255	**0%**
TOTAL	**99**	**151**	**115600**	**497493**	**23%**

*For example, within this table the selected coverage (or theme) is Industry. In this theme there are 19 features from this theme in the dataset (e.g. building, mine, chimney, tower, crane, cooling tower, tank, silo, conveyor, depot). For each feature there can be up to 15 attributes to describe that feature. Not every feature has the same attributes, though. A (storage) tank can have attributes of height, width and product, while a mine can have a name, area, width, and product. Not all features in the database have their attributes populated. In the case of Havana there are no building (point) features that are attributed, though there are 229 building (point) features as discovered by the VPF STAT software check of the database. There are 10 possible attributes for each feature. Thus, there are 2,290 total possible attributes (229 features X 10 attributes per feature) and none are populated (filled) for a 0% completion. For the Industry theme there are 23,250 total possible attributes, of which a total of 254 are populated for a completion percentage of 1%.

4.2 COLLECT REPRESENTATIVE ARMY SOF REQUIREMENTS

The SOF requirements research constituted the foundation for the study. As previously mentioned, DMA and the Army Deputy Chief of Staff for Intelligence (Topography) office (ODCSINT) informed the research team that no formal Army requirements existed for UVMap. SOF data requirements were typically expressed as geographic areas needed for war or contingency operations. They are generally classified and stated as requirements for specific city graphics or military city maps. Thus, in order to collect requirements for UVMap from the SOF community, the research team prepared to travel to the SOF and gather specific information through an interview process.

Fort Bragg, NC was selected as the site for the interview process in order to access members of the U.S. Army Special Operations Command (USASOC) and the 7th Special Forces Group. All five SOF elements (Special Forces, Ranger, Aviation, Psychological Operations, and Civil Affairs) have units or representatives at that location. Also, full time staffing of the mapping, charting, and geodesy (MC&G) office is available through USASOC, which would contribute to a smooth and successful interview process.

Preliminary discussions with Washington area SOF officers indicated that successful interviews with SOF troops would require preliminary research into the SOF missions. The contractor examined the Army field manuals dealing with SOF and urban warfare (FM 100-5, FM 31-20, and FM 90-10). Then, TEC and the contractor assembled a team of four persons to gather the requirements at the U.S. Army Special Operations Command (USASOC), Fort Bragg, NC. The members were:

Ms. Karen Fulkerson	TEC DCAC
Mr. Clifford Jordan	TEC DCAC
Mr. Glenn Frano	TEC Terrain Analysis Center (TAC)
Mr. William Watts	OptiMetrics, Inc.

*Assisting the team at USASOC was Mr. William Farr, Command MC&G Officer.

Prior to the interviews, this all-civilian interview researched Army manuals to learn of the organizations, roles, and missions of the SOF units. The background information helped the team gain credibility with the SOF personnel and imparted structure to the interview process. The Army manuals cited describe SOF missions in detail and include sample operations orders and scenarios. The manuals made it possible to envision the type of urban terrain data needed for SOF operations, allowing the team to project the sample feature/attribute lists used in UVMap demonstrations for each of the five SOF mission areas.

To help prepare the SOF troops for the interviews, these lists of projected features and attribute requirements were sent to USASOC about two weeks before the formal visit. Concurrently, the interview/UVMap briefing process was rehearsed at TEC with LTC Art Perritt, a former SOF officer and current member of the DMA Special Operations Command Customer Support Team. From this rehearsal, the research team learned that their presentation would be most effective if requirements were collected before the UVMap was demonstrated. By using this sequence, the characteristics of the prototype would not influence the interview response. This methodology was consistent with the general approach of the research: determine SOF requirements for urban vector data and then address the ability of UVMap to satisfy those requirements. Thus, the interview was structured to optimize the data collected from the SOF personnel while still providing a demonstration of UVMap capability.

LTC Perritt informed the team that the SOF personnel were familiar with very basic MC&G products, such as the City Graphic and TLM. However, the troops rarely received products beyond these due to mission urgency and the corresponding lack of robust resources. This information was helpful in gaining the troops' interview perspective.

Five interviews were conducted with SOF personnel during 26-28 March 1996. Each interview focused on one of the five SOF units. In total, 19 soldiers contributed their urban mission experiences and impressions about feature and attribute requirements that would have been most beneficial to them.

The method employed to collect feature/attribute information required the soldiers to recall an urban mission scenario. The SOF troops were asked to envision an urban mission, either real or training, that they had performed and think through it from receipt of the mission, through planning and rehearsal, to execution and evaluation. In that process they were asked to recall all of the elements of the urban terrain they required to successfully accomplish the mission. The interviewees were also told not to constrain their responses based on current technology, but to simply state their needs. The team's rationale for this approach was based on the knowledge that the rapid technology advancements of today's society would likely provide solutions to any current hardware, software, and data limitations.

While requirements collection occurred, one member of the team was noting the features requested and building a UVMap display for demonstration during the second half of the interview process. The UVMap prototype had been pre-loaded on the hard drive for ease of use and presentation.

The interviewees were impressed with the compactness of the computer and the relative ease of displaying the information. However, the interviewees were dissatisfied by the limited attribution of the data set and the overall lack of data content beyond that typically available in a hardcopy City Graphic.

The interviews with the SOF personnel were rewarding. The information gained in the interviews (presented in the next section of this report) gave the research team the SOF mission perspective as well as a new respect for the job these forces perform on behalf of their country.

4.3 COMPARE UVMAP TO COLLECTED REQUIREMENTS, CATEGORIZE RESULTS, PRIORITIZE RESULTS

When all interviews were complete, the data collected from each of the five SOF units were tabulated into one table (Appendix A). Duplicate entries were noted as part of the tabulation process in order to assist in data prioritization. Feature and attribute information was alphabetized for ease in locating specific items. Each feature and attribute was then checked against both the prototype dataset and the UVMap military specification to determine if the appropriate feature or attribute was available.

Upon examination of the data, four different categories emerged:

- Data where features and attributes are required and both are in the specification
- Features and attributes required; neither is in the specification
- Features and attributes required; feature is in specification, attribute is not
- Features are not required but are in the specification

Each of these categories is discussed below.

4.3.1 Features and Attributes Required; Both are in the Specification

For the purposes of this study, if the features and attributes needed by the SOF troops already exist in the specification, there is no need to value-add to this information (unless there are unpopulated attributes, as discussed below). This data was retained in the interview notes and the consolidated list (Appendix B). Shown in

Table 2 are the features and attributes captured during the interview that are required by the interviewed forces and already exist in the UVMap specification.

TABLE 2. FEATURES AND ATTRIBUTES REQUIRED BY SOF WHERE BOTH ARE IN SPECIFICATION

FEATURES	ATTRIBUTES
1. airfield	runway construction type
2. antenna	height
3. bridge	construction material
	height above water
4. building	function
5. cemetery	type
6. dams	material composition
7. electric power line	capacity
8. landfill	type
	existence
9. mining shafts	type
10. pipelines	product carried
11. radio tower	height
12. railroads	gauge
13. roads	surface material composition
	lane width
14. religious facility	denomination
15. vegetation, trees	height
16. water towers	size by volume

Although certain features and attributes are in the UVMap specification, a requirement still exists to add attribute values to the data set. This is due to the lack of attribute population within the data set, as illustrated earlier in Table 1. In the UVMap prototype, only 23% of the attributes are populated. Across the thematic layers of the prototype, attribution population varies widely, from a 92% completion rate in the elevation theme to 0% completion rate in the vegetation theme. Since UVMap is and will be for the near future created from the digitization of hardcopy City Graphics, empty attribute fields will remain an issue for UVMap users. Thus, any value-adding exercise based on UVMap should address not only information that does not currently exist in the specification, but also information on existing features and attributes which are in the specification but have not been portrayed due to DMA's production limitations.

4.3.2 Features and Attributes Required; Neither is in the Specification

This category is one of the key aspects of the study, since it shows those features and associated attributes not in the UVMap specification, yet needed by the Army Special Operations Forces to execute their missions. It is, then, a list of elements that not only are candidates for value-adding activities , but also are suitable for being added to the UVMap specification itself. Table 3 is a prioritized list of these features and their respective attributes. Priority has been established based on the number of times the elements were mentioned as requirements by the SOF troops. The highest priority requirements and their justifications are discussed below.

This list reveals much about the way SOF perform their missions. The first feature, power grid and facilities, is important to all troops. Control of electrical power is as essential to fighting at night for the SF as it is essential to the CA, who seek to keep the daily lives of the civilian populace at or near normal in an otherwise crisis situation.

Like the electrical grid, the requirement for demographic information was stated by all five SOF elements. Though this information has not historically been considered "geographic" in nature, it is important to the execution of SOF missions, which by doctrine are centered in the highly populated urban environment. Cities can be subdivided by political, economic, religious and ethnic boundaries, all of which can cause volatile relations between urban neighborhoods. Since working with population groups is essential in any urban operation, SOF needs to know where these subdivisions are located in order to evaluate the locations of friendly and hostile forces.

A third feature required by SOF personnel is utility tunnels. Like the electrical grid, this need stems from the control requirement, but it also assists in the assessment of possible access and egress routes for target facilities.

The existence of cellular phone towers on this list shows that the SOF realizes that in many third world countries the local telephone services have skipped generations of communications technology and moved from 1950's to 1990's equipment with no intervening installation of previous systems. Control of these towers will likely mean control of local communications, which is essential for successful SOF operations.

The fifth item, obstacles, is a feature that exists in other DMA data sets, such as Interim Terrain Data (ITD), but does not appear in UVMap. It is very important in conducting the defense of a city and in providing transportation planning for the populace.

TABLE 3. FEATURES AND ATTRIBUTES REQUIRED BY SOF WHERE NEITHER ARE IN SPECIFICATION

FEATURES	ATTRIBUTES
1. power grid & facilities	type
	service areas
	geographic area served (for interdiction)
2. utility tunnels	fully attributed with utility, depth, construction, dimensions, age
3. cellular phone towers	
4. demographics & population	socioeconomic class areas
	how many people in an area
	ethnic concentrations by geographic area
	ethnic areas
	political subdivisions
	language areas
	density
	number of habitants
	ability to further attribute
	create empty attribute for custom label
5. beach information	depth and slope
	bottom condition
	tidal information
6. border crossing sites	
7. NGO (non-governmental orgs) locations	name
8. obstacles	type
9. pedestrian facilities	type
10. rubbled areas	
11. soils	type and bearing capacity
12. terrain slope	

4.3.3 Features and Attributes Required; Feature is in Specification, Attribute is not

This category provides another important element of this study. In this situation SOF troops are looking for greater descriptions of the urban area of operations. This focuses more on the structures that exist in a given urban area, such as buildings, airfields, and industrial and communications facilities. The challenge of value-adding these attribute elements to the base UVMap and potentially also including them in the UVMap specification is similar to the challenges projected in the previous section.

Table 4 outlines those features specified by SOF that require additional attribution. Again, priority of placement on the list is based on the frequency of discussion during the SOF interviews.

TABLE 4. FEATURES AND ATTRIBUTES REQUIRED FOR SOF WHERE FEATURES ARE IN SPECIFICATION BUT ATTRIBUTES ARE NOT IN SPECIFICATION

FEATURES	ATTRIBUTES
1. buildings	height
	all dimensions, x,y,z
	# stories
	entrances (denoted by azimuth)
	basement information
	distance between buildings
	attic information
	mission or function
	roof construction
	roof type
	roof strength
	construction type
	stairs, external and internal
	blueprint information for searching buildings
	architecture (picture if possible)
	walls
	wall thicknesses
	utility information
	building construction details (to not blow apart)
	elevation (not height)(height needed also)
2. airfields	capability
	runways capabilities
	communications capabilities
	fuel points
3. military installations	function (engineer, signal, chemical, etc.)
4. industry	capability
	relative national importance
	LOCs around them
	raw material locations
5. radio stations, antennas, & broadcast facilities	call sign
	frequency and station id
	frequency (or range of frequencies)
	age
	material composition
	equipment type
	relay stations
6. bridges	height
	number of piers
	location of piers
7. dams	water capacity
8. athletic fields	type
	lighted or not
9. landfills (disposal areas)	type of contaminated material
and other contaminated sites	
10. monuments of national significance	historical annotation

TABLE 4 (CONT'D). FEATURES AND ATTRIBUTES REQUIRED FOR SOF WHERE FEATURES ARE IN SPECIFICATION BUT ATTRIBUTES ARE NOT IN SPECIFICATION

11. market areas	type
12. parks	type
13. pipelines	servicing what area
14. quarry (see Mine)	type
15. roads	segment length
	ability to color code for classification
16. religious churches, mosques, temples, synagogues	
17. sports facilities	
18. sewage treatment	capacity
	age
19. streams	depth
	width
	water source (springs, lake, runoff, glacier, etc)
20. tunnels (road only, no others shown)	length
	width
	height
	ceiling composition
	depth of cover
	cover material
21. utilities	age
22. vegetation	height
	temporal variations
	type (trees, shrubs, grass,
	agric vs. non-agric
23. warehouses (attribute for industry bldgs.)	type
24. water bodies	drainage area
25. water supply system	capacity
	geographic area served (for interdiction)
26. zoos	type (national, petting, theme)

4.3.4 Features Not Required, but in Specification

As noted earlier, the interview process consisted of requirements discussions with SOF personnel, followed by a demonstration of the UVMap prototype. This interview design was used to gain complete requirements data without introducing bias for or against the prototype product. The process focused on what was needed, but not currently found in the database. Conversely, several items were found in the database that the troops did not need.

Universal displeasure was expressed for the built-up area tinting used in the UVMap prototype. This tinting, a relic of the prototype's foundation in the hardcopy City Graphic, is used in lieu of showing each building in a densely populated urban area. Built-up area tinting yields scant information to SOF.

Although technically not a feature, the geographic reference grid received little support during the interviews. The SOF aviators were the only group endorsing its inclusion on the prototype; they use it for enroute navigation. It is also used by other services aviation used in a joint operation. The preferred reference system for ground forces is the Military Grid Reference System (MGRS). This is the system on which the soldiers are trained and is the one they typically use for the majority of their careers.

4.3.5 Additional Information from the Interview Process

While conducting the interviews with SOF, other requirements were discovered. These notes do not fit neatly into a list, but are important in optimizing the potential use of UVMap (and other DTD) by the SOF. The complete list of information is in Appendix C. However, some points are noted here for emphasis.

- All SOF personnel interviewed indicated displeasure with the interface between the UVMap data and the application software used to display it. For these interviews, the display software used was provided by DMA and is called VPFVIEW. This interface requires a certain amount of mapping knowledge in order to be executed correctly. One example of the problems with this interface is in feature display. To display features, the operator must first successfully enter and select from a menu of feature classes. Feature classes attempt to "subgroup" features based on their orientation (is it a point, line or polygon?) and the VPF theme in which they exist. However, unless a soldier is quite familiar with subgrouping logic, the feature class subdivisions are confusing, and much time is wasted trying to discern which feature class to access for feature display. Soldiers should not be expected to know this organization scheme in order to display features rapidly.

- The SOF troops also want to be able to click on a point on the display and find out what is there, with the results in simple layman's terms. In VPFVIEW, executing a query on a feature results in a display where the FACC code is portrayed along with the feature name. Also, all attribute codes are displayed along with their values. As an example, embassies are important to SOF troops. But with UVMap, embassies are not depicted with a special symbology; they appear just like all of the other buildings being displayed. This forces troops to "shoot in the dark", trying to find which building feature has a Building Function Code (BFC) attribute with a value of 66 (Embassy) in order to get the information they need. The data set/software interface could be improved to make this simple query user-friendly and fast.

- Similarly, the ability to "point and click" on a feature, such as a road intersection, and get a coordinate system readout is critical to mission operations. Another way of getting this information would be to facilitate a constant coordinate of the cursor's position.

- Symbology of features was mentioned repeatedly. The location of certain features such as schools and hospitals needs to be constantly available to the troops. Road classifications need to be displayed constantly for access and egress of reinforcements. Using special symbology tools that work with the FACC and VPF standards in a database would greatly improve the usability of that database.

- Improvements in the data/software interface and symbology will also assist the need for successful portrayal of complex features, i.e., features that are alike in their purpose. The VPF standard already makes use of the complex feature scheme. An example of a complex feature is a military installation. A complex is made up of a series of subcomponents, each of which has an identity within FACC (the installation, for example, consists of roads, buildings, fields, air facilities, etc.); yet these subcomponents are all part of the larger feature. The ability to intuitively understand what features are part of a complex without excessive querying would enhance the usage of the data set, no matter who is using it.

- Electronic hyper-linking between features in UVMap and other-source materials, such as imagery and/or blueprint information, would greatly expand the data set's utility. Being able to see an image of a building's exterior along with detailed information on its infrastructure widens the soldier's knowledge of the building, allowing them to better plan for and execute the mission.
- SOF exhibited a continued bias towards printed information over the computer. This is because computerized information currently provides little more than the hardcopy map itself. Technology needs to address this by building ruggedized machinery that are electronically linked to each other as well as to extraneous information sources.
- The SOF Aviation personnel expressly indicated interest in creating a customized information theme on which they could portray data derived from other sources, such as aviation charts and its unique symbology. They also desire the ability to topologically link this theme to the others found in UVMap, which causes an impact on the VPF standard upon which the prototype is based. In fact, the issue of topologically linking newly added information, whether feature or attribute or attribute value, to previously existent data will be the largest issue addressed as this effort progresses.

4.4 ANALYZE CAPABILITIES FOR ARMY VALUE-ADDING

4.4.1 Collect and Assess Value-Adding Resources

Acquiring source data for value-adding to UVMap may be difficult. The degree of difficulty is dependent on the ability to access the data and harmonize it with the existing database. Potential value-adding resources are listed in Table 5.

TABLE 5. POTENTIAL SOURCE DATA FOR VALUE-ADDING

Imagery	
	SPOT
	Landsat
	Controlled Image Base
	Interferometric Synthetic Aperture Radar
	National Assets
Aerial Photos	
Ground Photos	
Other MC&G products	
	Digital
	Hard Copy
Intelligence Agency Reports	
International News Reports	
Blueprint Information/Engineering Drawings and/or data	

These sources can be effectively used to provide feature and attribute information to the UVMap database. An example of how these resources can add value to UVMap is given in Table 6. The left column lists the features stated as requirements by SOF but unavailable (or not adequately attributed). The right column shows which data resources might best provide the needed feature information.

TABLE 6. REQUIRED INFORMATION VERSUS POTENTIAL SOURCE DATA

REQUIRED INFORMATION	POTENTIAL DATA SOURCE
1. Power grid and facilities	Blueprint Information/Engineering Drawings
	Field Reports
	Imagery and Photos
2. Demographics & Population	Multiple Reports
	Hard Copy Maps
3. Utility Tunnels	Blueprint Information/Engineering Drawings
	Multiple Reports
4. Cellular phone towers	Imagery and Photos
	Multiple Reports
5. Obstacles	Imagery and Photos
	Multiple Reports
6. Rubbled Areas	Imagery and Photos
	Multiple Reports
7. Beach Information	Imagery and Photos
	Multiple Reports
	Hard Copy Maps
	Digital MC&G Products
8. Border Crossing Sites	Imagery and Photos
	Multiple Reports
	Hard Copy Maps
	Digital MC&G Products
9. NGO (non-governmental orgs) locations	Multiple Reports
10. Pedestrian Facilities	Multiple Reports
	Hard Copy Maps
	Blueprint Information/Engineering Drawings
	Imagery and Photos
11. Soils	Hard Copy Maps
12. Terrain Slope	Imagery
	Hard Copy Maps

SOF troops are aware of and use all of these sources; however, as mentioned previously, integrating this data/information will require software improvements. Another issue that will be further discussed later in the report is the use of classified resources to embellish the UVMap data set.

No matter what type of resources are used to enhance UVMap, an issue that will be encountered involves data coding standards. For many of the features and attributes stated as requirements by SOF personnel, FACC (UVMap's coding standard) has no available coding structure. As part of this study, at the suggestion of DCAC's Standards Division, the Tri-Service A/E/C CADD Standard was analyzed and found to be a potential source for expanding the data content of UVMap while maintaining adherence to current coding standards. The issue of making the FACC and Tri-Service standards work together in one database is being explored by USACE and will have to be resolved before some of the listed data resources can be used to add value to UVMap.

4.4.2 Research Army Mapping Production Capabilities

The task of value-adding can in theory be performed by assets from a variety of organizations. Currently, however, this task is being accomplished only by TEC. The capability to update data exists at TEC in terms of personnel, hardware, and software, but VPF data updates are not being performed anywhere within the Army. TEC expects to be able to perform value-adding operations on at least some VPF data sets during FY97.

DMA, though not an Army asset, is capable of value-adding data. However, DMA is not currently equipped to receive field-supplied, value-added information. COL Richard Johnson, current Director and Commander of TEC, proposed a system that supports the value-adding process from user to DMA (Johnson, 1995).

Though beyond the scope of this study, a DMA value-adding process and system are needed. As information is added to a database at any level, consideration must be given to the way in which the data is verified and traced back to its source. Beyond COL Johnson's paper (which was written while he was stationed at DMAHQ), DMA has not yet made recommendations as to how this should be done.

Army topographic troop units can perform value-adding. To some extent they already do, using hard copy and soft copy products. Topographic troop support is accomplished on a tasked basis through the General Support Company of the topographic battalions, or by assignment of troops not actively engaged in other projects. This level of support has decreased as the Army has downsized, since the number of positions for topographic troops has diminished. The result is fewer personnel assets available, greater personnel turbulence, a decrease in training time available, and a commensurate decrease in production capability. Nevertheless, Army topographic troops are capable of assembling special products from multiple sources to assist combat commanders in making decisions about the terrain, using state-of-the-art hardware and software.

SOF troops do not receive direct support from topographic troops. The SOF has access to much classified material, but when it comes to mission execution, their transportable data resources are limited and no backup support is available. The standard product used is the 1:50,000 topographic line map; other hard-copy product if available provides supporting information. The Battalion/Brigade level Intelligence

Officer (or S-2) gives the SOF troops whatever products are available, at which point the troops begin mission planning. Battalion level product enhancement, if any, is done quickly for the mission

SOF units can have responsibility over designated geographic areas. If so, they become familiar with the languages, customs, terrain, military organizations, and the people of the area. This further assists in the collection of relevant information. In essence, then, SOF personnel already perform value-adding to their own database of information for potential mission areas. If the vector information value-adding process were made friendly enough for the end-user to perform, SOF troops could do that as part of their information collection efforts.

5.0 RESULTS

5.1 ESTABLISH IMPLEMENTATION PLAN AND SUGGEST CASE STUDY FOR PERFORMING VALUE-ADDING

Shown below is a flowchart depicting the recommended value-adding process. The comparison between UVMap and the SOF requirements revalidates the data to be added. Resources are found and integrated using the designated tools, personnel, and procedures. The result is an "enhanced" UVMap product. This final product is then available to the SOF users. Its contents could also be shared with DMA and/or other Army components.

This diagram also allows the reader to review all of the research performed in this effort up to this point.

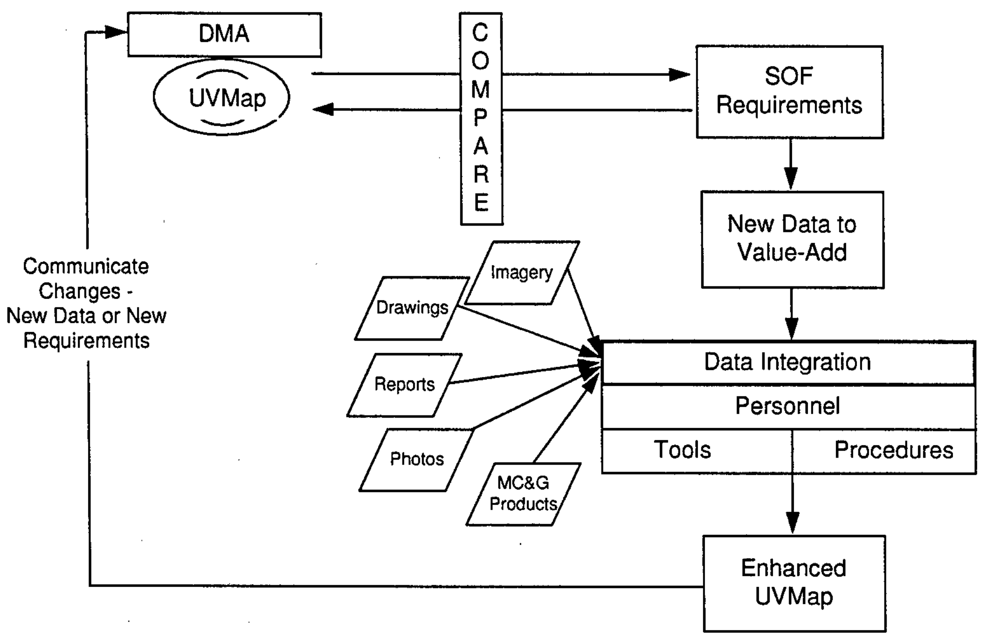

Figure 1. Flow chart for value-adding

The Case Study is the implementation of the findings of this project. It is designed to provide the structure needed to accomplish value-adding in an orderly, realistic, timely, and cost-effective manner. It should demonstrate both the utility and the process of value-adding. This section is a discussion of the parameters that will make this value-adding process happen.

The topics to be examined in this discussion of the Case Study are:

Site Selection
Standard DTD Acquisition
Value-added Features and Attributes Determination
Value-adding Resource Acquisition
Software Tools Acquisition
Value-Adding Personnel Resource Determination
Value-Adding Standards Identification

5.1.1 Site Selection

The selection of the physical location of the Case Study is dependent on the factors listed below:

- Availability of UVMap
- Availability of resource data for value-adding
- Potential benefit of area to SOF (for either operations or training)
- Accessibility of the area to the team for research and verification
- Existence of requisite features that SOF has requested

The availability of UVMap to use as a base for value-adding is a priority item in order to achieve credible results. The specifications, catalog, and structure of UVMap data make it attractive as a foundational database. However, unclassified UVMap data sets are not currently available. Classified UVMap data produced by DMA contractors should be available in FY97 for approximately 10 urban areas.

The availability of resources for use in value-adding to the base data set must be considered in selecting the site. A lack of data will hinder the ability to add information to the data set. Using notional data is possible, but is not desirable from a research or credibility point of view. The list of required-but-not-available data is extensive enough that there should be a complete mix of features and attributes to be added to the base. Concurrently, adequate resources for these features and attributes that are slated to be value-added must be readily available during the Case Study.

Selection of a location corresponding to a potential SOF operation or training site will increase interest in the product, especially if there is a revalidation with SOF prior to and during Case Study execution. SOF troops can be valuable participants in this process, if given the time, resources, and opportunity to participate. Value-adding efforts of interest to SOF may allow TEC to acquire additional resources, such as reports and imagery, that SOF typically receive. This prospect and its potential administrative impact must be further explored.

Site accessibility is key towards performing preliminary research over the area prior to executing the Case Study. It also facilitates field check verification visits after the Study is complete. However, if the Case Study site is determined to be in an OCONUS urban area, achieving the goal of site accessibility may be problematic and/or prohibitively expensive.

One known site of interest to the SOF is the McKenna MOUT training site, located at Fort Benning, GA. Many data sets exist for this site and it has priority in the geospatial research and development community. However, no known UVMap coverage exists at this site and many of the features required by SOF are not present.

The ideal case study site should contain within it a mix of features and attributes not currently found in the UVMap data set. Multiple value-adding goals can be achieved if the site provides: 1) the opportunity to populate attribute fields currently left blank due to DMA's production methodology, 2) the opportunity to add attribute fields to existent features from the UVMap specification, and 3) the opportunity to add new feature/attribute data that is not currently in the UVMap specification. Such an exercise would constitute a rigorous exercise of the ability of VPF products to maintain topology during the value-adding process.

Making the Case Study site selection would be the first objective in a potential Phase II effort. At that time, TEC, Army SOF, and contractor personnel would be able to assess timely information on UVMap availability and weigh it against the other parameters listed above to arrive at the most effective overall site choice.

5.1.2 Standard DTD Acquisition

At the time this report was finalized, no standard, unclassified production versions of UVMap were in existence. DMA expects to have in-house production capability for UVMap during FY97 and has ten UVMap products under contract production. A final specification is being prepared at this time; its release is expected to occur early in FY97. This specification will be a refinement of the 23 May 95 draft version, as agreed upon by the military services.

5.1.3 Value-added Features and Attributes Determination

The features and attributes required by SOF for inclusion in the urban database have been discussed in this report and are found in Tables 2, 3, and 4. A subset of these features and attributes, along with existent attribute population, will be the core set of information to add to the database. This will demonstrate the capability of the value-adding process to the SOF. There may be some additional information that the

SOF requires upon closer examination of the process; accommodating these additional items may be necessary in the Case Study.

5.1.4 Value-adding Resource Acquisition

Potential data sources are listed in Table 5. Actual data sources to be used depend on the Case Study location and the features and attributes to be added. Acquisition of these sources will be complex. If, for example, the urban area in question is OCONUS, the required information will probably reside in the following locations:

- National intelligence agencies (CIA, DIA)
- DMA (digital and hard-copy products)
- Military services (Army, Navy, Air Force, Marines, Coast Guard)
- Corps of Engineers (OCONUS construction, foreign contacts)
- State Department (especially for embassies)
- U.S. Agency for International Development
- News services

Some source material may also have to be procured from commercial and/or foreign sources. This could provide TEC with the opportunity to introduce the SOF to new sources for their work as well.

5.1.5 Software Tools Acquisition

Tools that perform value-adding to VPF are limited. ARC/INFO, the widely used Geographic Information System (GIS) software marketed by Environmental Systems Research Institute (ESRI), can perform value-adding to VPF data. It is used by DMA contractors in their current production of UVMap. Once the hard-copy city graphics are digitized into ARC INFO format, the dataset is then converted into VPF. In some cases the ARC INFO data has been passed to users in the field without further conversion to VPF.

Another software tool under development at TEC is the Terrain Update Module (TUM). TUM performs feature and attribute data updates and densification functions for Interim Terrain Data (ITD) in Standard Linear Format (SLF). A TEC contractor is currently upgrading this software to correct user-defined problems and provide user-requested enhancements to make the software more robust. One of these enhancements is to provide a VPF version of the software. This contract is funded and in place.

A third software tool in use now at both TEC and in the field is the Digital Stereo Photogrammetric Workstation (DSPW), developed by General Dynamics Corporation. DSPW extracts terrain information from remotely sensed digital data and hard copy imagery. The extraction process is operator driven and features are attributed and digitized. It is not currently capable of utilizing VPF data, but could be further developed. It is a commercially available product where further development would be driven by market potential.

Near-term developments in value-adding functionality for VPF data could prove to be significant for this project. The precise tool to use in value-adding should be determined based on operational capability, cost effectiveness, and availability to researchers (and future users).

5.1.6 Value-Adding Personnel Resource Determination

As described in Section 4.4.2, value-adding can be accomplished by personnel from the following four elements:

- DMA
- TEC
- Topographic troop units
- End-user troop units

DMA will be considered as a possible value-adding resource, due to their familiarity with day-to-day data production. However, their participation as a component of the process is unlikely due to their focus on transition and continued critical production of MC&G products. With their advent of the Global Geospatial Information and Services (GGI&S) concept and their transition to being part of the National Imagery and Mapping Agency (NIMA), DMA has many issues with which to deal currently.

TEC's Operations Directorate is the most likely candidate to be used for this effort due to their experience in creating Army-driven geospatial data and their cost effective location relative to DCAC. TEC personnel are experienced in operating systems on which value-adding can be accomplished (ARC-INFO, TUM, DSPW), and they are familiar with Army DTD requirements.

Topographic troop units have equipment needed for performing value-adding and are familiar with Army DTD requirements as well. Their principal drawback is their location and their potential need to withdraw from this effort to support other missions.

End-user troop units are certifiably the most familiar with what type of information needs to be added to the UVMap data set. It is for this reason that the initial requirements were derived from them. The concern with using these troops to perform value-adding, though, is identical to those outlined for the topographic troop units; further, they lack the specific hardware and software needed for performing value-adding.

Consideration will be given to each unit or agency depending on the nature of the Case Study site and resources available from each agency.

5.1.7 Value-Adding Standards Identification

One of the challenges in performing value-adding to UVMap is that it must be done in accordance with the UVMap specification and its associated military standards (VPF and FACC). These standards force the value-adding process to be accomplished in an organized manner; they provide rules governing feature/attribute format, naming, placement, coding, symbolization, accuracy, error content, coordinate system, description, file structure, directories, distribution medium, and organization. Fortunately, the standards have been built with opportunities for expansion.

FACC was created by 11 NATO member nations as a standard for exchanging data for geographic information systems. To meet the needs of the members individually and collectively the FACC was organized to be as specific as possible with respect to features and attributes, yet allow for expansion of the codes for those features required by a specific nation. Thus, there is room for additional codes needed as a result of value-added features and attributes. The rules for documenting features and attributes are contained in DIGEST, Part 4, section 5.3.

UVMap's VPF component was also created with possibilities for expansion. The VPF Standard allows for the ability to create and attribute features, yet maintain the data's topological structure. It also allows for the construction of customized themes, where users could denote particular features and attributes of importance.

The tools for performing the value-adding must use their own internal procedures to read and import standard UVMap data (or any data adhering to the VPF and FACC standards). This is typically being addressed as these software tools are developed, as stated in Section 5.1.5. Finally, the actual alteration or enhancement of the UVMap data must in done in conformance with the current specifications so that the resulting data set is further readable and usable by those who use standard UVMap data.

5.2 ISSUES

This section deals with topics which are directly related to the value-adding concept and study but beyond the scope of this contract. These issues arose during the execution of the project.

1. What can be done about those features that are required, but already exist in the database as attributes of another feature?

This issue was addressed briefly in Section 4.3.5. Some specific building types which the SOF wanted to see displayed are in the UVMap data set, but only as attributes of the generic feature "Building" (FACC AL015). Table 7 shows the required features and their attributes. In each case, in order to learn what type of building is present, the user must access the attribute "Building Function Code" (BFC) and determine which value (if any) has been given. For the SOF, this type of nested information is unacceptable; important features need to be either visibly obvious by looking at the UVMap display, or readily accessed by a "point and click" capability.

This table raises a further question. What other information is nested within FACC, and can it be displayed to suit the needs of the soldier? Repeatedly during the interviews, SOF personnel described their familiarity with the 1:50,000 hardcopy Topographic Line Map (TLM). A software package that can interpret UVMap information and display it as it would look on the TLM (in which building types, road classifications, and other important information is visible at a glance to the user) may be a useful development concept.

TABLE 7. FEATURES AND ATTRIBUTES REQUIRED BY SOF REQUIRED FEATURE IS ATTRIBUTE OF ANOTHER FEATURE

REQUIRED FEATURES	ATTRIBUTION
1. Embassy	nation
2. Government Center	type
	type records
3. Hospital	type
	services
	specialties
	capacity
4. Museum	significance
5. Market area	type
6. Police Facilities	function
7. Schools	type

2. If more than one group is involved in value-adding, who performs which function?

Four groups were noted as possible candidates for performing value-adding. A possibility exists that each could perform part of the work, based on expertise or availability; another possibility would be for value-adding to be divided out based on geographic area. This concept of "cross- organizational" interaction should be considered as the value-adding concept is expanded.

3. **Can an Army-DMA value-adding infrastructure be created?**

The feedback loop needed to deliver new information back to DMA has never worked well. Now that possibilities exist to pass digital information back to DMA, there are still no standard procedures and no infrastructure to accomplish this. This issue should be addressed in the near future as DMA reorganizes its operational concept (to GGI&S) and its mission (as part of the new NIMA).

4. **How can value-added data be verified and/or validated in order to allow its integration into DMA's holdings?**

This problem relates back directly to the previous question. The procedures and infrastructure developed to get value-added data accepted by DMA into their holdings must contain a section where the data is quality checked. Horizontal and vertical feature and elevation accuracies of value-added data must fall within predefined ranges, just as DMA-produced data does. Only after this is achieved should value-added data be integrated into DMA's geospatial database.

Although they do not currently perform field checks on the data they produce, DMA may require field checks to be performed on value-added data. The organizations responsible for completing this and the manner in which it is done are topics that should also be addressed as the value-added data verification infrastructure is developed.

5. **How does one determine what portion of value-added data is forwarded for inclusion in another database?**

Some value-added data are inherently volatile, such as the existence or condition of a road or bridge, or the type and height of vegetation. Such data may not be suitable for forwarding to a data warehouse. Determining which features should be forwarded for warehousing is an issue that should be resolved jointly by value-adding data producers and DMA.

6. **How do classified and unclassified products and data become fused without violating security procedures?**

The current project has been accomplished using only unclassified information. However, future work may involve classified sources; further work with the SOF likely will require clearances and accesses not previously needed.

Using classified source data for value-adding will almost certainly cause additional administrative work and cross-organizational security procedures. Classified work will also place restrictions on the hardware used and the sites where the work is completed. Fortunately, secure hardware and work sites are available at both TEC and the contractor's facility; however, for the reasons outlined above, efforts will be made to maintain this research project in the unclassified mode.

In a "real life" value-adding scenario, dealing with the security issue has broad implications not only for data fusion, but also for intra-organizational relations and security matters. This issue must be fully examined before a value-adding infrastructure is solidified.

7. **What will be the effects of value-adding on Army doctrinal principles and organization, as expressed in the Training and Doctrine Command's (TRADOC's) tenets of DTLOMS (doctrine, training, leader development, organizations, materiel, and soldiers)?**

The value-adding process has the potential to significantly change the way the Army gathers and processes geographic information. Roles currently assigned to the combat, intelligence, and engineer troops could in theory change enough to alter current organizations, staffing, and funding. This is an issue that should be examined by TRADOC.

8. **What would be the impact of "harmonizing" data historically received by intelligence sources with data historically received from the MC&G community?**

SOF has asked for a great deal of information to be integrated into one database. The intelligence and geospatial data communities should work together to address and resolve issues concerning data media, formats, symbology, coding, and other technical issues, so that the data they provide can be used compatibly.

6.0 CONCLUSIONS

The Special Operations Forces personnel at Fort Bragg have stated their requirements for very highly detailed feature data sets in the urban environment. These requirements were compared to the capability offered by the DMA VPF-based, very large scale urban vector map product, UVMap. From this comparison, a list of features and attributes required by the SOF, but not existing in UVMap, was developed. This list contains possible features and attributes to be added to an appropriate UVMap database. The list was categorized based on how the requirements were addressed in the current UVMap specification. Priorities were assigned to the desired elements based on level of interest exhibited by the SOF personnel.

The requirements analysis process not only identified the required data for the project, but also revealed information about the SOF. These forces are highly professional and intelligent, operating in a climate where they have little time from receipt of a mission order to completion of the plan of execution. They execute with whatever material they have at their disposal. The aggressive participation of these soldiers in the requirements analysis of this project indicated that they have the potential to be an integral part of the solution.

Other resources for value-adding were evaluated. Use of UVMap as the base data set is logical, since it has the most support in current and future production as a standard DMA vector product. Source data and information for value-adding will come from a variety of resources. The successful integration of this value-added data into the UVMap data set requires manipulation within specification constraints while maintaining a focus on the SOF requirements.

Just as there is a wide variety of data to add, there is also a variety of tools potentially applicable to perform the value-adding operation. This provides an opportunity for choosing the optimum approach. Technological advancements in software development have yielded rapid change, and there is reason to believe that continued technological evolution will assist this value-adding process in the near- and long-term.

Finally, a generic implementation plan and case study exercise were outlined to test the value-adding process and assess it for operational use, possibly in a multi-organization effort. Outlying issues were discussed and recommendations for action on these issues were made.

As the future brings advancement in technology, it also brings new possibilities for DTD users. Value-adding is occurring now in the laboratory and can occur soon in the geospatial data production centers. It is beginning to reach into the field Army through the topographic troops. As the Army becomes the digital force of the 21st Century, with greater hardware, software, and data capabilities, the prospects for initiating and maintaining an effective infrastructure for performing, manipulating, validating, and storing value-adding information to DTD are better than ever before. The issue of developing this infrastructure from the end-user to DMA must be supported by all affected organizations.

7.0 PHASE II GOALS AND APPROACH

The contractor, OptiMetrics, Inc. proposes the following goals and approaches to execute Phase II of this Study. Details of this case study approach will be refined through further discussions with TEC and will be defined in the Phase II proposal. The following summarizes OptiMetrics' approach to Phase II, the UVMap Value-Adding Case Study.

Goal 1. Select a Case Study Location

Approach: Upon receipt of the Phase II award, review the available UVMap products. Based on this review and the factors discussed in Section 5.1, consult with the TEC COTR and SOF POC, and select a specific city for the case study.

Goal 2. Define the Features and Attributes to be Added to the Case Study Product

Approach: In discussions with TEC and the SOF, OptiMetrics will review the results of Phase I and recommend a list of features and attributes from Tables 3 and 4 to be added to the Case Study product.

Recommendations will be reviewed with TEC and SOF personnel and a final list will be developed.

Goal 3. Determine Value-Adding Process for the Case Study

Approach: A value-adding plan/process for the case study will be developed, addressing all factors described in Section 5.1.

Goal 4. Execute Value-Adding Program

Approach: OptiMetrics will be responsible for leading the value adding process, as developed in Goal 3. OptiMetrics may also utilize subcontractors to provide software support and/or provide data for inclusion in the value-adding process.

Goal 5. Product Quality Control and SOF Satisfaction

Approach: OptiMetrics will ensure that the UVMap value-added product meets SOF needs by briefing them on the plans prior to program execution; they will also provide an interim product for hands-on evaluation by SOF personnel at least twice during the contract duration. This will be in the form of a demonstration that will highlight the tools used in value-adding and the resulting display of data, both original and value-added.

Goal 6. Final Deliverables

- The completed value-added case study database in VPF format.
- Any software developed or modified for use in the value-adding process.
- A Final Report documenting activities for the entire effort, including the process used for value-adding and the final results of the effort.

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APPENDIX A

Interview Results
By SOF Type Unit

Special Forces

FEATURES	ATTRIBUTES
buildings	length, width, height
	entrances
	walls
	composition
	basements
	distance between buildings
	attics
demographics	socioeconomic class areas
	population density
	ethnic concentrations geographic area
air fields (and strips)	fully attributed
Open areas, fields, etc	for helo LZ and extraction see below
Power grids	capacity
	substation
Power lines	height
	capacity
police facilities	
hospitals	
hydroelectric facilities	
pipelines	
vegetation	height
	temporal variations
	type
swamps, grasslands, etc	type
roads	fully attributed
	ability to color code for classification
tunnels	fully attributed
water works	capacity
dams	height
	composition
	water capacity
railroads	gauge
bridges	location of supports
	construction material
	height above water
	stream information at that point
radar sites	
underground lines, pipelines, stations	
athletic fields	type
	lighted or not

FEATURES	ATTRIBUTES
production (factories)	type
pedestrian facilities	type
repair facilities	
mass transit above and below ground	
religious facility	denomination
telecommunications facilities	fully attributed

Interview Results
Psychological Operations

FEATURES	ATTRIBUTES
radio station	call sign
	frequency
antenna	range of freqs
	height
	geographic extent
population	density
	ethnic grouping
	ability to further attribute
city regions	market places
	gathering locations
sports facilities	
schools, etc	
drop zones	
print shops	
telecommunication towers	other capabilities on tower
	height
HLZs	
airfields	capability
police facilities	level (substation)
Industry	type
	capability
	relative national importance
Monuments of national significance	historical annotation
radio broadcast antenna	frequency (range of frequencies)
	age (and period built in)
	material composition
	call signs

Interview Results
Civil Affairs

FEATURES	ATTRIBUTES
Industry (most critical item)	type
	national importance
	LOCs around them
	raw material locations
	agricultural
warehouses	type
stockyards	type
Landfills	type
and other contaminated sites	contaminated?
	in-use or closed
rubbled areas	
roads	fully attributed
bridges	fully attributed
airports	fully attributed
	runways capability and extents
	commo capabilities
	transportation systems in and out
secondary air transit systems	
ports and harbors	locs
	shipping capacities
	docks, wharves, cranes
vegetation	agric vs. non-agric
broadcast facilities	type equipment
	relay stations
	towers
	repeaters
government centers	type
	type records
population areas	density
	number of habitants
	create empty attribute for custom label
hospitals	type, services, specialties, capacity
Buildings	function
	architecture (picture if possible)
transportation net	fully attributed for operation, maintenance, etc
utilities	fully attributed with age
military installations	function (engineer, signal, etc)
Police facilities and installations	function
water bodies	function
	drainage area
water towers	size
parks	type
sewage treatment	capacity

FEATURES	ATTRIBUTES
	age
utility tunnels	fully attributed with age also
historical sites	significance
monuments	significance
memorials	significance
museums	significance
religious churches, mosques, temples, synagogues	type
cemeteries	type
DPW sites	fully attributed with utilities
obstacles	location, if known, good for value adding in field
zoos	type
pipelines	type
	product(s) carried
	servicing what area
electrical grid	type
	capacity
	substations
	servicing areas

Interview Results
Ranger

FEATURES	ATTRIBUTES
buildings	roof type and strength
	construction type
	external vs internal stairs
	include photos, especially current ones
	blueprint information for searching buildings
	wall thicknesses
	wall compositions (with utility, i.e. gas, electric, water, information)
airfields	fully attributed like any city for seizure mission
beach information	depth and slope
	bottom condition
	tidal information, mean high and low water
streams	depth
	width
	water source
military installations	same as CA
transportation net	capacities for monitoring aves of app
pipelines and pump stations	type
electrical grid	capacity
	geographic area serviced (for interdiction)
water supply system	capacity
	geographic area serviced (for interdiction)

Interview Results
Special Operations Aviation

FEATURES	ATTRIBUTES
radio & TV towers	elevation
	station id with frequency
border crossing sites	
NGO (non-governmental orgs) locations	
terrain slope	for landing or discharging personnel or cargo
LZs and DZs	may be GIS related
soils	type and bearing capacity by location
vegetation	type, height, seasonal variation, location
demographics	ethnic areas
	political subdivisions
	language areas
government facilities	type
police stations	type
embassies	nation
buildings general	roof construction (for landing on)
	building construction details (to not blow apart)
	elevation
power lines	elevation particularly those over 50 ft.
any antenna or guy wire	elevation particularly those over 50 ft.
satellite dishes	
airports and airfields	with improvements
	runway construction
	fuel points
religious and historical sites	type
market areas	type
power generation facilities	grid lines
prisons	guard towers
local host government residences	
bridges	dimensions
railroad tracks	type
mining shafts	type
water bodies	
cellular phone towers	
pipelines	
quarries	
location (navigation) in priority of use	terrain features
	hydro features
	manmade features towns, roads, rivers, stream beds, power lines, towers, railroads, satellite dishes, stadiums, clover leafs, industries, orchards, swimming pools, golf courses, warehouses, trucking company

FEATURES	ATTRIBUTES
	use mil grid in obj area and georef enroute
hospitals	location (avoid collateral damage)
	type for a resource
rivers with docks and locks	
dams	
hydroelectric facilities	
bus depots	
taxi locations	
caves	size
	wet or dry
ports and harbors	

APPENDIX B

Unprioritized Composite Table of Interview Results

USASOC Interviews, Mar 96

FEATURES	ATTRIBUTES
airfields (and strips)	fully attributed
airfields	capability
airfields	fully attributed like any city (for seizure mission)
airports	fully attributed
	runways capability and extents
	communications capabilities
	transportation systems in and out
airports and airfields	with improvements
	runway construction
	fuel points
antenna	range of freqs
	height
	geographic extent of signal
any antenna or guy wire	elevation particularly those over 50 ft.
athletic fields	type
	lighted or not
beach information	depth and slope
	bottom condition
	tidal information, mean high water and low water
buildings	height - all dimensions,
	entrances
	walls
	composition
	basements
	distance between buildings
	attics
buildings	function
	mission
	architecture (picture if possible)
	roof type and strength
	construction type
	external vs internal stairs
	blueprint information for searching buildings
	wall thicknesses
	wall compositions (with utility information)
	elevation
bus depots	type
border crossing sites	
bridges	fully attributed
	location of supports

FEATURES	ATTRIBUTES
	construction material
	height above water
	stream information at that point
	dimensions
broadcast facilities	type equipment
	relay stations
	towers
	repeaters
caves	size
	wet or dry
cemeteries	type
cellular phone towers	
dams	height
	composition
	water capacity
demographics	socioeconomic class areas
	population density
	ethnic concentrations by geographic area
	political subdivisions
	language areas
drop zones	
Public Works sites	fully attributed with utilities
Electric power grids	capacity
	substation
Electric power lines	height
	capacity
hydroelectric facilities	
electric power lines	elevation particularly those over 50 ft.
electrical grid	type
	capacity
	substations
	servicing areas
power generation facilities	grid lines
embassies	nation
government centers	type
	type records
hospitals	type, services, specialties, capacity
	type for a resource
historical sites	significance
HLZs	
Open areas, fields, etc	for helo LZ and extraction see below
Industry	type
	capability
	relative national importance
	national importance

FEATURES	ATTRIBUTES
	LOCs around them
	raw material locations
	agricultural
Landfills	type
and other contaminated sites	contaminated?
	in-use or closed
LZs and DZs	may be GIS related
mining shafts	type
Monuments of national significance	historical annotation
military installations	function (engineer, signal, etc)
memorials	significance
museums	significance
market areas	type
NGO (non-governmental orgs) locations	
obstacles	
parks	type
pipelines	
production (factories)	type
pedestrian facilities	type
population	density
	ethnic grouping
	ability to further attribute
print shops	
police facilities	level (substation)
police facilities	function
police stations	type
pipelines	type
	product(s) carried
	servicing what area
pump stations	type
prisons	guard towers
ports and harbors	land lines of communications access
	shipping capacities
	docks, wharves, cranes
population areas	density
	number of habitants
	create empty attribute for custom label
quarry	type
radar sites	
railroads	gauge
railroad tracks	type
roads	fully attributed
	ability to color code for classification
repair facilities	
radio station	call sign

FEATURES	ATTRIBUTES
	frequency
	gathering locations
radio broadcast antenna	frequency (range of frequencies)
	age (and period built in)
	material composition
	call signs
radio & TV towers	elevation
	station id with frequency
regions (city)	market places
rubbled areas	
religious churches, mosques, temples, synagogues	type
religious facility	denomination
religious and historical sites	type
residences, local host government	
rivers with docks and locks	
swamps, grasslands, etc	type
sports facilities	type
schools, etc	
stockyards	type
sewage treatment	capacity
	age
streams	depth
	width
	water source
soils	type and bearing capacity
satellite dishes	
terrain slope	for landing or discharging personnel or cargo (HLZ)
tunnels	fully attributed
transit, mass above and below ground	
telecommunications facilities	fully attributed
telecommunication towers	other capabilities on tower
	height
transportation net	fully attributed for operation, maintenance, etc
	capacities for monitoring avenues of approach
terrain slope	for landing or discharging personnel or cargo
underground lines, pipelines, stations	
utilities	fully attributed with age
utility tunnels	fully attributed with age also
vegetation	height
	type
	agric vs. non-agric
	seasonal variation
water works	capacity
warehouses	type
water bodies	function

FEATURES	ATTRIBUTES
	drainage area
water towers	capacity
water supply system	capacity
	geographic area serviced
zoos	type

APPENDIX C

Additional Information

Interview Results

Special Forces

1. Want profile shots complementing satellite imagery; this is to find the blind spots around buildings.
2. Want gridded area, 1 km by 1 km, to look at everything in that area
3. Computed distances.
4. "We want to spend most of our time training for the mission, not looking for maps and intel.
5. Open areas for HLZs require soils, slope, vegetation, vertical obstructions, obstacles, drainage, water bodies.
6. Want 3D capability.
7. Want sun angle for shadows.
8. Need to be able to plot location of friendlies.
9. Eliminate tinted built-up areas vice individual buildings. Built-up area tint is of no use.
10. Need variable scale at zoom.
11. Need capability for hard copy output.
12. Line of sight capability.
13. Label contour lines.
14. Like selectable scale.
15. Any info you get helps, you can always take some away.
16. Split-basing of interest. If on mission for a few weeks (Bosnia) they set up a mission support site and pass info. They like multi-function computers (geographic, log, translator).
17. GPS and commo of high interest. Used with JSTARS to prevent friendly fire casualties, particularly with allied armies (SOF troops as LNOs).
18. Do like clickable features for more information.

Psychological Operations

1. A legend is needed as a reference tool bar.
2. Hard copy needed for both data and screen.
3. An on-line update of UVMap data is a good idea.
4. Use of lat long and UTM grids is ridiculous.
5. PSYOP likes having a translator of names for english, english version of the name, and the name in the local language.
6. PSYOP operations always lead another operation. Planning must be timely; approval authority is the NCA (sometimes stovepiped).
7. PSYOP products must be fast. Digital transmission is a good idea.

Civil Affairs

1. The CA mission is to get people's lives back to normal as soon as possible.
2. CA must know the whole infrastructure.
3. Zoos can be culturally significant areas.

Ranger

1. Ranger mission is to be anywhere in the world in 18 hours.
2. They love photographs especially for target folders and mission planning and rehearsal. Includes both ground shots and aerial photos.
3. Rangers take 1:50K map on missions along with written intel and aerial photos.
4. Rangers also like to have info readable by night vision goggles (NVG).
5. Rangers pass intel to CA, esp about bldgs, conditions, etc.

Special Operations Aviation

1. Like hard copy.
2. Aviators like to fly at a particular elevation which gives them the vantage point of seeing the terrain at a certain scale of map they are using.
3. Interested in creating their *own* thematic layer.
4. Very interested in air avenues of approach. (derived information)
5. SOAR supports the missions. They are the direct/indirect fire for ground forces. In theater they are to go from mission receipt to execution in 96 hours.
6. Rehearsals? They link up with ground forces and rehearse particularly infiltration, actions on the objective, then exfiltration.
7. Aviators use the *same product* as the ground forces.
8. Aviators like the largest scale possible. Hard copy material used in flight and is not vulnerable to loss of power.

GLOSSARY

ARMY SPECIAL OPERATIONS FORCES (ARSOF OR SOF): Special Army forces organized, trained, and equipped to perform the principal missions of unconventional warfare, direct actions, special reconnaissance, foreign internal defense, and counterterrorism. They also participate in the collateral activities of security assistance, humanitarian assistance, antiterrorism, counterdrug operations, personnel recovery, and special activities with other military service components. (FM100-5).

ATTRIBUTE: A descriptor or characteristic of a feature. Examples include building height, road composition, railroad gauge, or pipeline capacity.

CIVIL AFFAIRS (CA): Type SOF unit that provides liaison to civil authorities in an operational area and, when required, operates civil government services in the absence or non-existence of the lawful government (FM100-5).

FEATURE: An object or entity that exists on or near the surface of the earth, such as a bridge, tree, building, road, etc.

FEATURE ATTRIBUTE CODING CATALOG (FACC): A NATO Digital Exchange Standard coding scheme that represents real world features in three levels of detail - feature, attribute, and attribute value. (UVMap MilSpec).

MILITARY GRID REFERENCE SYSTEM (MGRS): A system of intersecting parallel lines superimposed on maps and charts in an accurate and consistent manner to permit identification of ground locations with respect to other locations and the computation of direction and distance to other points. (DoD Glossary of MC&G Terms).

MILITARY OPERATIONS IN BUILT-UP AREAS (MOBA): Military operations planned and conducted in regions where man-made construction affects the tactical options available to the commander. This is synonymous with MOUT. (Defense Science Board Report).

MILITARY OPERATIONS ON URBANIZED TERRAIN (MOUT): This is synonymous with MOBA. (Defense Science Board Report).

PSYCHOLOGICAL OPERATIONS (PSYOP): A SOF mission and type unit employed to influence favorably the attitudes and behaviors of specific foreign audiences and reduce the will, capacity, or influence of hostile forces to wage war or otherwise threaten US interests. (FM100-5).

RANGER: A type SOF unit that is rapidly deployable, airborne capable, and trained to conduct joint strike operations with (or supporting) special operations units of other US military services. Ranger units also conduct light infantry operations in conventional warfare when integrated with other combined arms elements. (FM100-5).

SPECIAL FORCES (SF): A type SOF unit organized, trained, and equipped to conduct special operations, including all principal special operations missions and collateral activities. (See SOF). (FM100-5).

SPECIAL OPERATIONS AVIATION REGIMENT (SOAR): The SOF unit with specialized aviation assets dedicated to conducting special operations missions. Capabilities include short-, medium-, and long-range lift and limited light-attack. (FM100-5).

TERRAIN UPDATE MODULE (TUM): A software module developed by the U.S. Army Topographic Engineering Center to update and intensify Defense Mapping Agency

Interim Terrain Data (ITD), and to generate digital terrain data in ITD format when ITD is not available. TUM uses imagery, and digitized photos and maps for source data.

UNIVERSAL TRANSVERSE MERCATOR (UTM): UTM is a military grid system based on the transverse Mercator projection applied to maps of the earth's surface extending to 84^{N} N and 80^{N} S latitudes. (DoD Glossary of MC&G Terms).

URBAN VECTOR SMART MAP (UVMAP): A DMA vector-based geospatial data product with City Graphic content. It is implemented in the Vector Product Format (VPF) and uses the (NATO) Digital Exchange Standard (DIGEST) Feature Attribute Coding Catalog (FACC) scheme for display of data. Data are separated into 10 thematic layers, where each layer contains thematically consistent data. The layers are organized into coverages contained in VPF libraries. (UVMap MilSpec).

VALUE-ADDING: An operation performed on existing geospatial data that enhances the value of the data for future use. Enhancements include data verification, correction, update, densification, supplementation, reformatting, fusing, or resampling. (Johnson, 1995).

VECTOR PRODUCT FORMAT (VPF): VPF is the standard data format for all DMA vector products. It uses relational modeling techniques, is media independent, uses a geographic coordinate system and includes extensive metadata. VPF supports all levels of topology. Supported data sets come with limited display and query capability called VPFVIEW. (Baxter, briefing).