Chapter 1 – INTRODUCTION

1.1 BACKGROUND

Modelling the geometric and physical properties of 3D urban terrain represents a significant opportunity to enhance the generation of the Common Relevant Operational Picture (CROP). Such modelling can support visualization, which in turn enhances the user's situational awareness in complex urban scenarios. Of equal and increasing significance are inputs to non-visualization tasks as line of sight, mission planning, change detection, sensor network capability assessment, threat analysis and the calculation of acoustic, chemical and EM propagation. In the frame of this effort, 3D models include geospatial, physical and contextual information in addition to geometric models.

An increasing need for 3D urban models for use in situational awareness, mission planning is suggested by military operations, peace-keeping, humanitarian operations and homeland security embedded in urban areas. The increasing prevalence and performance of ground-based, aerial and space-based sensor systems and networks used for tactical reconnaissance and surveillance of urban areas are now capable of providing data for generation of the 3D models.

1.2 OBJECTIVES

The group focused on the exploitation of data representing urban areas and the generation of the corresponding 3D model instances. In general the objectives of the SET-118 Task Group were the modelling of urban 3D structures, the automatic reconstruction of scenes, and the assessment of results. Research areas were:

- Data exploitation techniques;
- Data preparation and fusion;
- Extraction of 2D and 3D geospatial data (information) for urban terrain; and
- Automatic 3D model reconstruction.

The technologies under investigation covered both active and passive sensors, including LIDAR, video, and Interferometric Synthetic Aperture RADAR (InSAR).

1.3 SUMMARY OF ACTIVITIES

One of the main interests of the Task Group was the regular exchange of information on national research and development activities. In the following a brief overview about the most important activities of group during the period of 2007 through its end in 2010 is provided:

- In September 2007 German and U.S. members of the group participated in a field experiment in the training site "Bonnland" in Germany. The main purpose of the test was the acquisition and provision of point clouds captured by a modern flash laser system mounted on a moving vehicle. Great efforts were made to understand this new technology, to study the recorded waveforms, and to co-registered the individual points clouds by appropriate algorithms.
- Concerning the system technologies under consideration several workflows were established with data from passive and active sensors and the corresponding up-to-date evaluation algorithms. Data captured by modern flash laser (Section 3.2.1) was successfully co-registered by the ICP algorithm explained in Section 3.3. Results are shown in Section 3.3. Airborne captured infrared images were used to determine the sensor's path and to reconstruct the scene simultaneously

(Section 3.1). Based on the resulting point cloud a surface reconstruction was performed by computing the isosurface of a signed distance field (Section 4.2.4). The processing was done offline, buts most of the applied algorithms possess real-time capabilities.

- For the specification of the accuracy of scene reconstructions at hand the group collected, developed and studied various metrics and evaluation criteria (Chapter 5).
- For benchmarking and the investigation on different data sources a common data pool was built up. But because of the diversity of the sensors data and the need to implement corresponding specialized algorithms, this data pool has not been embraced.

1.4 COMMON MISUNDERSTANDINGS

The group identified several conceptual misunderstandings. Two of them are discussed and highlighted here:

1) *Model vs. Model Instance*

   A model is a description of our environment or of observed phenomena as simple as possible containing representations appropriate for specific applications, parameters and rules how to interpret theses representations. Specifying the parameter values for given models leads to the task of model instantiation, which, in the context of urban terrain, is the reconstruction of the scene. Colloquially, these terms are used interchangeably and one has to infer from the context what is meant. In Chapter 5, model instances are evaluated but not the models that were used.

2) *Dimensionality of Representation*

   Many approaches and products bear the label “3D” but are actually not three-dimensional from the scientific point of view. Terrain models which represent the surface by a single-valued height as a function of latitude and longitude have the dimension 2.5D and appear like rubber blankets (cf. Figure 4-14 in Section 4.3.1) – for each point in the XY-plane exactly one height value Z can be specified. Geo-information systems often store the third dimension, e.g., building heights, as attributes which lead to 2.75D representations permitting the representation of vertical walls. Real 3D representations permit representation of tunnels, passages and roof overhangs also. Figure 1-1 illustrates the situation in cross-sections and Table 1-1 compiles pros and cons for different representations. In this table, “+” and “++” denote positive and very positive, respectively, and “–” and “– –” denote negative and very negative.

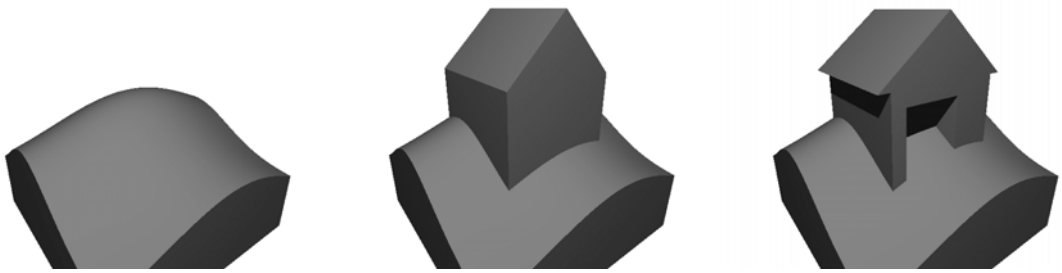

Figure 1-1: Continuous 2.5D, 2.75D and 3D Surfaces.

Table 1-1: Discussion and Assessment of Various Scene Representations.

	Point Cloud	**2.5D Surface Representation (e.g., a depth image)**	**3D Model**
Amount of Data	very large (– –)	large (o)	moderate (+)
Level of Abstraction	low (– –)	moderate (o)	high (+)
Procedure (Level of Readiness)	–	automatic (+)	automated (o)
Time Required for Instantiation	little (+)	moderate (o)	large (–)
Model Knowledge	no (–)	generic, often implicit	explicit
Semantics, Object Description	no (–)	no (–)	yes (++)