ABSTRACT
To support planning of massive transportations under time-critical
conditions, in particular, evacuation of people from a disaster-
affected area, we have developed a software module for
automated generation of transportation schedules and a suite of
visual analytics tools that enable the verification of a schedule by
a human expert. We combine computational, visual, and
interactive techniques to help the user to deal with large and
complex data involving geographical space, time, and
heterogeneous objects.

Categories and Subject Descriptors
H.1.2 [User/Machine Systems]: Human information processing –
Visual Analytics; I.6.9 [Visualization]: information visualization.

Keywords
Visual Analytics, geovisualization, transportation planning, task-
centered visualization design, coordinated multiple views.

1. INTRODUCTION
In time critical situations, software tools automating some of
people’s activities or suggesting solutions to problems are of great
benefit. However, machine-generated solutions can generally be
used only after a verification and validation by a human expert,
who takes the responsibility for the decisions made. Hence, the
expert needs tools that enable effective reviewing of these
solutions in the shortest possible time. Although visualization
plays a great role here, large amounts of information cannot be
efficiently examined without the involvement of computational
techniques for analysis and summarization.

We have developed a software system to support civil protection
services in planning evacuation of people from disaster-affected
areas. The system includes a module that automatically builds
transportation schedules and a suite of techniques enabling the
inspection of the schedules by a human planner. To handle large
amounts of data, we integrate interactive visual displays with
technical techniques for data transformation, according to the
paradigm of visual analytics (Thomas and Cook 2005, Keim
2005). This distinguishes our approach from the usual tools (e.g.

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In (Andrienko et al. 2007), we described the main features of the
automated schedule builder and presented our task-centered
design of the tools for schedule examination. We also
demonstrated the appropriateness of the tools for the task by an
example of schedule analysis. In this presentation, we focus on
the display manipulation techniques, coordination between
different views, and dynamic transformations of the data.

2. VISUAL ANALYTICS TOOLS
2.1 The data to be examined
In an emergency evacuation, it is necessary to schedule the
transportation of many people from multiple sources (original
locations) to multiple destinations (shelters). There may be
diverse categories of people such as general public, disabled
people, and critically sick or injured persons. These categories
need to be handled differently, which includes the selection of
proper destinations and proper types of vehicles as well as proper
timing of the transportation.

The input data for the evacuation planning include (1) the sources
of the endangered people, (2) the numbers and categories of these
people, (3) the latest allowed departure times per place and
category; (4) possible destinations and their capacities, by people
categories; (5) types of vehicles and their capacities for the people
categories they are suitable for; (6) available vehicles and their
initial locations. The automated schedule generator produces a
collection of transportation orders assigned to the vehicles, where
each order specifies one trip of a vehicle: source and destination
locations, start and end times, and the category and number of the
people to be delivered. One schedule may consist of hundreds of
orders. A human planner cannot examine each order individually,
especially under time-critical conditions. Hence, the information
needs to be presented to the planner in a summarized form
adequate to the purpose of detecting possible problems (e.g.
people remaining in the sources, time limits exceeded, etc.) and
understanding their reasons.

2.2 Dynamic aggregation
To provide a summarized representation of the data while
enabling the planner to focus on various subsets, we combine
interactive filtering of the data with dynamic aggregation. The
user may set one or more data filters of different types: by people
category, by time interval, by source, and/or by destination. The
aggregation is applied to the portion of the data that have passed
through the filters and immediately re-applied when the filters
change. For this purpose, several types of dynamic aggregators
are created. A dynamic aggregator is a special object linked to a
number of data records and able to derive certain statistical
summaries from those records which satisfy current filters. These
summaries are presented on visual displays, and the aggregators
are responsible for updating the displays when the filters change. Different types of aggregators are attached to individual locations (e.g. counters of remaining people in the source locations and counters of used and free capacities in the destinations), to pairs of locations (trip aggregators), or to the entire territory (e.g. aggregator of people by states and calculator of the vehicle use).

2.3 Visualization and user interaction
A transportation schedule is a complex construct involving geographical space, time, and heterogeneous objects (people and vehicles) with states and positions varying in time. All this information cannot be appropriately presented in a single display. Our toolkit includes several coordinated views presenting different aspects: (1) a summary view of the transportation progress over time (Figure 1), which also serves as a direct manipulation interface to the time filter; (2) a map display showing the situation on a user-selected time interval (Figures 2, 3); (3) a source-destination matrix presenting summarized data for pairs of locations, which serves as a direct manipulation interface of the filter by source and/or destination; (4) a Gantt chart providing a detailed view of the distribution of the trips over time. All the views are dynamically updated when the user changes current filters: selects an item category, a time interval, a source, and/or a destination. In our presentation, we are going to demonstrate how the tools enable detection of possible problems and investigation into their reasons.

3. CONCLUSION
To support efficient examination of large transportation schedules involving multiple geographical locations and diverse categories of transported items and types of vehicles, we combine interactive visual displays with dynamic aggregation and summarization of the data. This research is conducted within the integrated EU-funded project OASIS – Open Advanced System for Improved Crisis Management (IST-2003-004677, 2004-2008; http://www.oasis-fp6.org/). We have presented out tools to potential users, professionals in civil protection and crisis management, who expressed their high interest and wish to have such tools at their service. Next year, the users will test and evaluate the tools in the course of the trials of the entire OASIS system, which will take place in two European countries.

4. REFERENCES