

GeoTime Visualization for Peace Support Operations

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1. INTRODUCTION

Visualization display techniques allow people to see, use and interact with large amounts of multi-dimensional data in a natural and easy manner, particularly in complex, time sensitive situations. Information visualization techniques amplify cognition by increasing human mental resources, reducing search times, improving recognition of patterns, increasing inference making, and increasing monitoring scope [1, 6]. These benefits translate into significant system and task related performance objectives [7].

As more information is available, from more sources, commanders with advanced visualization capabilities will be able to make the most of this data without being overwhelmed. Operational and planning tasks are both amenable to visualization support. Previous work with DARPA's Command Post of the Future program has shown the importance of multiple, shared, tailored views rather than one common operational picture, and has demonstrated significant progress for Force-on-Force scenarios [3, 7]. There is an opportunity to explore potential high payoff, leap ahead tailored visualization techniques suitable for the unique demands of Peace Support Operations (PSO) and that build on the success to date. This paper reports on one new concept for geo-temporal visualization conceived during a research project sponsored by DRDC in 2002.

The term Operations Other than War (OOTW) covers a wide range of activities, for example domestic operations in Canada (Ice Storm 98), humanitarian assistance abroad (Honduran earthquake), or peace support operations (Bosnia). In order to focus the initial work, the investigation and analysis was confined to peace support operations. However, it is believed that the conclusions and concepts developed here for PSO would also apply to other types of OOTW. The work also focuses on visualization as a tool for commanders. These capabilities would be used by subordinates and staff too.

2. METHODOLOGY

The research was conducted in a collaborative manner with subject matter experts (SMEs). A cognitive task analysis "lite" methodology was followed consisting of a review of references from Army Lessons Learned Centre [2, 4], structured interviews and issues analysis. "Visioning" exercises included iterative brainstorming, design ideas and concept development. Sketches of potential visual solutions, "information landscapes", were developed and reviewed. The subject matter experts who participated in the study were:

- LCol. Peter Bartlett (Ret.)
- Col. George Oehring (Ret.)
- LCol. Jack Springer (Ret.)
- LCol. Chris Sproule (Ret.)
- LCol. Greg Taylor (Ret.)

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All SMEs had served in Bosnia-Croatia and those experiences largely informed this study. However, other postings also included: El Salvador, Lebanon, Cyprus, Golan, Sinai and Rwanda.

Cognitive task analysis (CTA) is a layered system-based framework that is used to optimize the match between a task's cognitive demands and the design solution [5]. It is an extension of traditional task analysis techniques and provides information on the knowledge, thought processes and goal structures implicit in task performance. CTA can also be an information visualization design task. Effective interactive information visualizations require appropriate representations for particular domains and tasks. They are a cognitive tool for the practitioner user, not the technologist. An iterative, creative collaborative research approach with users is necessary for success. We believe it is not possible to create effective techniques without a deep collaboration with knowledgeable practitioners.

3. SME INTERVIEW HIGHLIGHTS

Extensive notes were taken during the SME interviews. Afterwards, the notes were reviewed and reduced to individual observations. These were then grouped into common themes. These observations of work practices serve to inform expert human information interaction and visualization researchers and designers of the nature of command work in PSO situations.

The study investigated a number of information, communication and decision-support issues, and several visualization concepts were developed. This paper focuses on one concept that came to be called GeoTime. The following interview highlights are SME statements pertaining to PSO that helped inspire the GeoTime concept.

- There is no difference between OOTW and War. There is a continuum of operations ... war, peace making, peace keeping. At any time, you need to be prepared to fight. OOTW analysis and decision processes are just like war.
- Never again will there be two sides and one line like Cyprus. The non-contiguous battlefield, with multiple belligerents, will be typical. There will be more and uglier PSOs. They will be increasingly complex, variable and unpredictable.
- Preparation for patrolling involved researching issues including who, where and what. The history of local commanders and incidents was reviewed.
- For success in negotiations, homework is key. You need to know what someone did before you. Not knowing gets you in trouble, or wastes your time by going over the same ground again and again.
- Tracking and being aware of history is important. For example, a ceasefire was organized around a religious calendar event. The event presented an opportunity and knowing about the event made it possible.
- The head of civil affairs had been there twenty months and had the history.
- You need to keep track of trends. What happened here? What keeps happening here? There are patterns. Belligerents keep trying the same thing with new rotations. When the attack came, it did come from the area where many previous earlier attacks had also originated.
- The discovery of emergent trends ... persistent patterns ... sooner rather than later would be useful. For example, the XXX Colonel that tends to show up in an area the day before something happens.
- We were not overwhelmed with information. We were overwhelmed with events, and never having enough information. So you often ended up reacting more than initiating.
- In my mind, I see critical incidents in time and space. Linearly.
- Any display must be customizable ... smallpox, starvation, artillery, sandbags ... things that piss people off.
- Much more detail is collected and reviewed for OOTW than for War. In War, you fight through the terrain and move on. In OOTW, it's the same piece of ground, over and over again.

- It's a difficult task to present to subordinates the assembled picture to which they helped contribute. You need to bring them along with you as you explain intent.
- Every six months a valuable knowledge base is created, and every six months, it's lost. We need to make better use of the knowledge base. It's a valuable historical record. The lack of a historical record contributes to loss of life.
- A lack of a historical record about events, factions, populations, culture, etc. is information that is lost. The same mistakes are made over and over. Agreements among factions take longer to make.
- We were supposed to protect the YYY. We didn't even know how many there were. It would've been useful to have a profile of all the villages in the area. A clear depiction of the demographic situation. A recent record of all military activity in an area would be useful.
- The 1 PPCLI (an Army Battalion) Microsoft Access database used in Afghanistan in 2002 recorded, in three weeks, 500 incidents of who-what-when-where on shootings, bombings, fires, mines, meetings, kidnaps, thefts, assaults, etc.
- Even if just 50 to 75% of the event record (war diaries) could be harnessed, made accessible and readily available, it would be a 200 times improvement. It would be a remarkable aid for you and for the people that follow you.
- Exerting effective C2 is hardest in OOTW since it's based on information you don't have. The situation is complex and detailed, and you don't have the information to deal with it. You could step into a TOC for a classical military situation and get right up to speed. Not sure you could do that in OOTW.

At the conclusion of the interview process, a summary problem statement was produced and reviewed with the SMEs. The statement was directed to innovative visualization concepts for situation awareness and C2 in OOTW.

Maintaining situation awareness is a complex and time consuming activity in many OOTW situations. Several belligerents may exist, each with their own forces, agendas, objectives and relationships. The peacemaker/keeper that is standing between them must monitor their activities and communicate with them in order to create and maintain stability. Each side is trying to deceive the other including the peacemaker/keeper. This situation may continue for months or years, and vary in intensity from supporting elections to full-scale war and genocide. The atmosphere is reactionary.

In order to operate effectively towards a resolution, the peacemaker/keeper must have a clear understanding of the issues, context, motivation, personalities, geography and cultures involved, and they must know how these have changed over time. The ultimate goal is to fix problems, resolve issues and forge productive relationships.

4. GEOTIME - EVENTS IN SPACE AND TIME

In PSO, there is a need to understand the history of events in a single picture. This interactive display could be used to locate areas of activity, to find out information about a place or a time, or to discover emerging patterns. An evolving, reusable, transferable history of events would help avoid repetition of mistakes, would reduce the risks during force rotations, and would help to overwhelm opponents with knowledge. The picture would be built up over time from many sources. Individual reports would be geo-located.

Figure 1 shows an early concept sketch for GeoTime. The current situation state is shown on a geographic plane. Parallel timelines, connected to specific locations, contain events over time. Related events can be connected in time by a path. People would be able to zoom in to specific geographic or time regions, as well as drill down to details, photos, reports and additional information.

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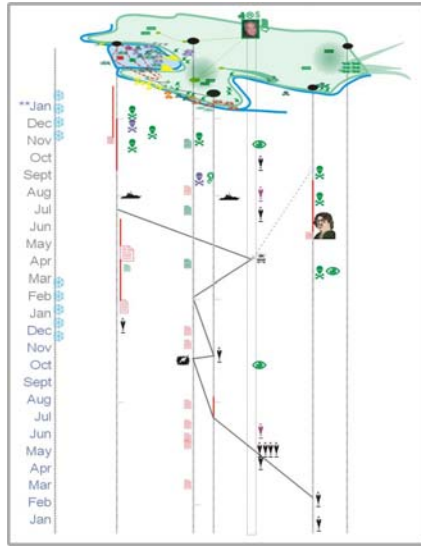


Figure 1: GeoTime Concept Sketch Showing Entity Track in Time and Space



Figure 2: Icons and Symbols

The GeoTime concept is an integrated map, schedule, history and journal utilizing a combined spatiotemporal display. Many events could be tracked in time and space concurrently. People could quickly see patterns. GeoTime is imagined as a tool for use in the field or an operations center. It would work with many types of information, e.g. vehicles, people, events, SITREPS, notes, photos, organizations, patrols, boundaries, agreements, sensor coverage, cultural events, weather, political events, etc.

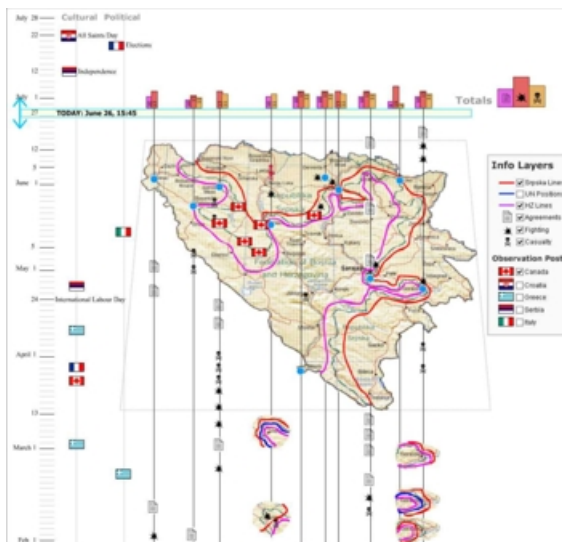


Figure 3: GeoTime – Theater Wide

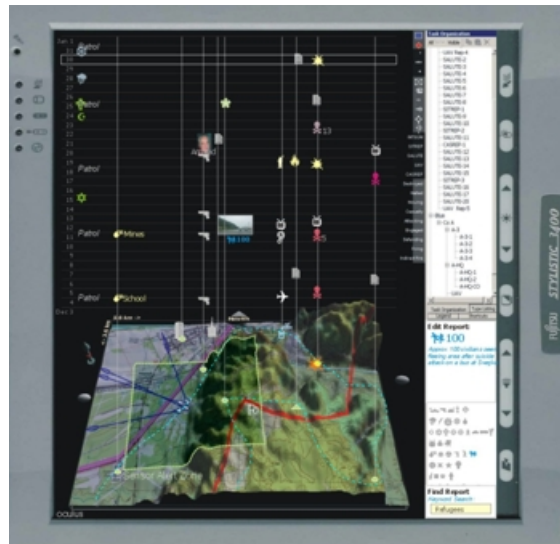


Figure 4: GeoTime for a Patrol

As shown in Figures 3 and 4, both large and small scale area of operations could be supported by GeoTime.

Figure 3 shows event totals over time along the top of the display. Cultural, political and other non-geographic events are shown along the left of Figure 3. Boundary movements are also shown. It is expected a layer based system would be used to control the display. In Figure 4, for more tactical situations, 3-D terrain and features become more relevant.

5. SUPPORTING FUNCTIONALITY

A number of analytical challenges would need to be resolved to support the GeoTime concept. For example, flexible multi-dimensional filters would be needed to allow the commander to focus on events by location, by feature, by mission, by source, etc. Commanders should be able to select and combine filters to “find” the issues and “construct” an awareness. To make this easier for the user, data about the data would be used to structure the filters. Ontological filtering (i.e. by essential linguistic properties and relations) would allow meaningful combinations of event type, report source, object type, issue type. Commanders could guide/steer according to relevancy.

A new level of tailorable, “constructive” representations would be needed. What is shown and how it is shown needs to be fluid and tailorable by the user for any situation. Different situations, and different users would mean, for example, varying the information content combinations, level of detail, and the scope of time. The challenge is to make the representations vary to suit, without changing the nature of the viewer's interpretation.

Future events would need to be supported too. Seeing events over time over geography is not just about the past. GeoTime should also include significant known future events (e.g. marching season in Ireland), and also be used for planning operations.

Data cleaning would be critical in an imagined future information environment with field reports coming in from many sources, in varying levels of detail and on overlapping topics. Commanders and staff will need to efficiently and quickly see priorities, redundancies, errors, conflicts and uniqueness. Analytical algorithmic methods, may assist in this. However, new visualization display and interaction methods would be needed to harness human judgement for the interpretation of ambiguity, and to maximize the productivity of a combined human-analytical system.

Annotations would allow commanders, for some situations, to mark their emphasis on an event or set of events. Key people, places, things and nuances could be highlighted. Focus could be provided. Annotations are an “interpretation” layer that can help bring events into focus.

An extraordinary amount of detail would need to be supported. In OOTW, the same piece of ground is forever being disputed. This is a unique OOTW requirement. In geographic terms, it may mean seeing house-to-house detail. The same applies to people, events, organizations and issues. In a village of 100 houses, 400 people, and anything from perhaps one to ten events per day, depending on the conflict level, this aggregates to hundreds to thousands of events in a year. It is a visualization challenge to see, use and manage this extraordinary level of detail effectively.

6. USE CASE SCENARIOS

Two use case scenarios were described during the research study for GeoTime. The first is a six month handover by a Battalion Commander to an incoming replacement. The second is a formation redeployment

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decision when a sector of four battalions is reduced in strength by one battalion. These and other use cases assisted in testing concepts and illustrating their impact on organizational performance factors.

6.1 Six Month Handover

In this first case, a Battalion Commander presents a handover briefing to an incoming replacement commander. An imagined workflow by the Commander would consist of the following:

- Our deployment zone, terrain features and critical events are on this first display:
 - *These are the boundary areas and how they shift.*
 - *Here are the main routes, and deployments in flanking sectors.*
 - *Previous and current Canadian OPs (Observation Posts) and patrol routes are displayed here.*
 - *This historical timeline of critical events and records shows the scheduling problems around water and bridge usage, which have been a major reason for confrontation in this sector.*
- Belligerent organization, deployment, and emplacements are highlighted on this next series of displays:
 - *The first display shows organization of belligerent forces, with their key leadership and chain of command. Mr X of YYY causes the most problems.*
 - *Belligerents have been pushing back and forth in the areas shown on this display, and the associated timeline shows the major incidents that have occurred.*
 - *Review my notes from negotiations between belligerent forces. You can see my travel schedule on this display, and links to the meetings, personalities, and agreements I have worked on. You will be expected to continue in a similar fashion.*
- Boundary conflicts have regularly occurred in two hotspots:
 - *Belligerent forward lines have shifted back and forth as shown on this display.*
 - *Incidents have been synchronized with the movement of General XXX, who has a history of lying and breaking agreements.*
 - *OP “Catwalk” can expect continued activity of the sort shown on the timeline.*
- Upcoming cultural dates displayed on this timeline may lead to increased tensions:
 - *This religious holiday may result in many requests for civilians crossing boundaries. There is a history of resulting disturbances.*
- Finally, the Red Cross runs refugee centers here:
 - *Extra support is required on these access routes for protection.*

6.2 Formation Redeployment

In this next case, a sector with four battalions is to be reduced in strength by one unit owing to a coalition nation’s unexpected withdrawal just prior to the second year of a peacekeeping mission. An imagined workflow by the Commander would consist of the following:

- The UN sector Brigade commander must devise an immediate plan to realign the remaining three battalions and redistribute the formation’s undiminished tasks.
- The commander concludes that the main factors affecting the redeployment are:
 - *Location, nature and frequency of belligerent military activity.*
 - *Location, type and likely intent of opposing and potentially opposing forces.*
 - *Centers of continuing humanitarian and security efforts.*
- Using the GeoTime Visualization tool described here the commander is able to quickly -
 - *Identify historical military “hot spots” that must be addressed by either, some, or all of the sector’s defensive deployment, mere presence, observation, and/or patrols, etc.*
 - *Assess which of the sector’s differing unit(s) is/are best suited for the above tasks.*
 - *Determine the distribution of tasks based on specific unit strengths, geographic and cultural dimensions and relative equity.*
 - *Issue new written and graphical orders.*

- The initial deployment approach, which was typically based on a unit strength/size per area equation (i.e. cookie-cutter) becomes a strength/intent based deployment; as shown in Figure 5 and 6.

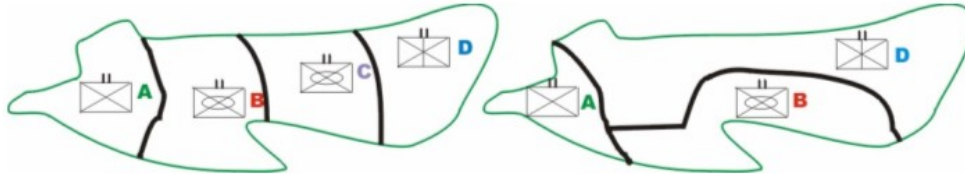


Figure 5. Typical strength / area (cookie-cutter) deployment.

Figure 6. New strength/intent deployment enabled by OOTW Visualization Tools.

7. CONCLUSIONS

The GeoTime concept is a new interactive information visualization technique that fuses the two previously separate paradigms of mapping and scheduling. It would show multiple types of information in a map-oriented display, providing context and trends over time. It would allow commanders to gain better understanding of complex current events. Many levels of detail would be accessible and viewable.

The results of an initial study have been presented together with the new GeoTime visualization concept. Additional development of the concept would require a technical implementation, representative data sets and a series of iterative experiments and collaborative concept exploration with SMEs.

The intent of GeoTime is to allow the commander to quickly react to events with insight. One significant benefit imagined would be derived just from the belligerents knowing that PSO forces can maintain knowledge, can track recurring events, and be quickly aware of complex situations soon after arriving in an area of operation. More confidence would be created. Fewer “testing” events by belligerents would need to be dealt with during the mission.

8. ACKNOWLEDGEMENT

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