



Feasibility Study of Integrating IDELIX's Pliable Display Technology into the COPlanS Technology Demonstration Software

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1. Abstract

This document examines the potential for enhancement of Defence Research and Development Canada's Collaborative Operations Planning System (COPlanS) technology demonstration software in the areas of collaboration and data visualization using IDELIX's Pliable Display Technology. In particular, it begins by outlining several possible forms of general collaboration that apply to the application and then defines a number of areas within the application with collaboration and data visualization improvement potential. Each of these areas is subsequently analyzed in depth with specific details of how enhanced collaboration and data visualization can be attained with PDT. Finally, rough orders of magnitude are provided for all defined features and potential implementation approaches.

2. Introduction

The purpose of this document is to outline how the Collaborative Operations Planning System (COPlanS), developed by Defence Research and Development Canada Valcartier (DRDC Valcartier), can be enhanced through the use of improved collaboration techniques and visualization methods using IDELIX's Pliable Display Technology (PDT).

It is assumed that the reader is familiar with the COPlanS application and has a basic understanding of how IDELIX's PDT works.

3. Potential Enhancements to COPlanS

3.1. Collaboration

Traditionally, software was developed with a single user in mind. However, with the increase in network capabilities, software support for multiple users has become more widespread. A major difficulty in the design of such software is that the requirements for a collaborative system are often quite different than those for a single user system. Designing software for a collaborative environment is difficult.

When considering collaboration in the design of a software system, it is useful to realize that there are different kinds of collaboration that may be supported. These kinds of collaboration lie along two axes, namely time and space, with two values along each axis resulting in 4 different collaboration scenarios (see Figure 1 below). Supporting collaboration in these different situations often requires differences in design.

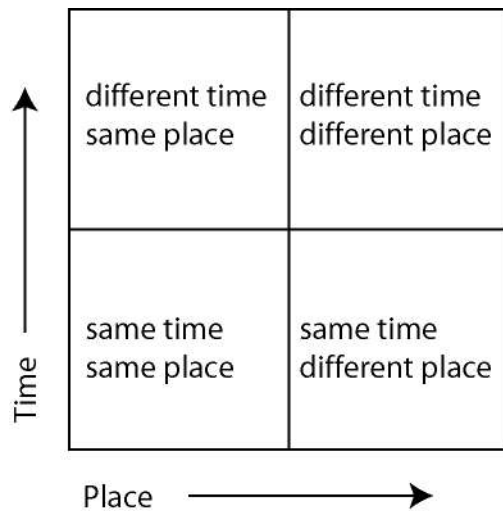


Figure 1 – Different Kinds of Collaboration

Some examples of collaboration that fit into the 4 categories are:

1. Same time, same place:
 - a. Users working together on a tabletop display.
 - b. Users working together on an electronic whiteboard.
 - c. Users gathered around a single computer.
2. Same time, different place:
 - a. Users working on their individual computers, collaborating over the internet.
 - b. Users working on their individual computers, talking on the phone.
3. Different time, different place:
 - a. Users sending email to one another asking questions about a project.
 - b. Users copying files over to a central repository, to be accessed later by somebody else at a different location.
4. Different time, same place:
 - a. Users leaving notes on a tack-board for one another.
 - b. Users drawing comments on a large printed diagram, to be seen later by somebody else.

3.2. Collaboration in COPlanS

The COPlanS system is a very complex piece of software, supporting a very complex planning process involving many people. Currently, activities such as on-line planning, video teleconferencing, on-line chatting and on-line white boarding are all supported by the application while future versions will potentially add interactive war gaming, mission rehearsal and synthetic environments to the list of its collaborative features. However, the

model for COPlanS interaction seems to be based upon the interaction model that existed prior to the development of the COPlanS system. An attempt has been made for established real-world interactions, be they voice communication, paper-based notes, or computer-based communications, to have equivalents designed into the COPlanS system. For example, maps, which may have previously existed as large paper maps or electronic maps shown on a dedicated computer viewing system, are shown in their own sub-window in COPlanS.

Modeling COPlanS interactions on previously established interactions is extremely valuable in order to allow users to adjust to the system. However, a designer must be careful to not abandon previously available, and potentially critical, forms of collaboration. For example, it is possible for several people to gather around a large paper map pinned onto a wall and discuss a problem but it is much more difficult for multiple people to gather around a small computer monitor. The affordances of these two systems are remarkably different, meaning they naturally encourage and support different types of behaviour. When affordances differ between a predecessor system and a successor system, a designer must design the new system in such a way as to make up for lost capabilities.

It is thus desirable for special collaboration capabilities to be built into COPlanS. These capabilities could be used to mimic or compensate for lost collaboration capabilities not naturally supported by the COPlanS interaction model. These capabilities could also make possible new forms of collaboration that were not possible prior to the existence of COPlanS.

3.3. Natural COPlanS Collaborative Capabilities

The basic COPlanS architecture is based on a centralized database of knowledge that is accessible to all interested users. This architecture naturally supports two of the kinds of interaction shown in Figure 1, namely the two cases where collaboration is distributed across time. Since data is stored centrally, changes made by one user are automatically made available to other users who access the data later. The centralized data store is constantly up to date, and regardless of what point in time a user logs on, they are up to date, and ready to work.

Since collaboration across time is naturally supported by the existing COPlanS architecture, it is useful to focus on the current weak-point of COPlanS, namely simultaneous collaboration, either in one place, or spatially distributed. Simultaneous collaboration is a capability that is not naturally supported by the COPlanS architecture.

3.4. COPlanS Enhancement Options

Below are a number of areas where COPlanS can potentially be enhanced as well as a subset where PDT can assist with collaboration by providing improved visualization of the information being presented:

- General Visual Collaboration
- PDT in the COPlanS GIS
- PDT in the COPlanS GIS Operating on a Collaboration Tabletop
- Enhancing the Visual Diagramming Components of COPlanS
 - Workflow Management (Workflow Diagrams)
 - Mission Analysis (Effect Based Diagrams)
 - Order of Battle Asset Visualization (ORBAT Charts)

4.

5. General Visual Collaboration

5.1. Visual Highlighting Approaches for Multiple Users

A number of approaches to providing visual highlighting for collaboration purposes among multiple users are discussed below. The approaches range from the simple use of remote cursors to the more complex use of a universal annotation tool.

5.1.1. Remote Cursors

When multiple users are working simultaneously, but remotely, they may need to develop an awareness of what the remote users are doing. This can be done by showing cursors of remote users moving over the screen of a local user. A local user would have his own cursor with which to interact with data, but he would also see “ghost” cursors representing the current actions of remote users. However, a question arises as to what to show when the screen content of a local user is different from that being shown on a remote user’s desktop. For example, a remote user may be working on a map, while the local user may not have the map visible. Thus, it is proposed that a remote user’s cursor only be shown if the cursor is over content that is currently visible to the local user.

5.1.2. Multi-User Radar View

Cursors, as previously described, can give some level of awareness as to the actions and intentions of remote users. There are also other ways to promote awareness. One way is to offer a sort of “awareness map” that displays the locations of multiple users in a large display space, such as a map. When remote users are collaborating simultaneously in a large display space, they will frequently navigate to different parts of the display space. This can result in confusion if they assume that they are looking at the same area. A map of the entire display space with individual rectangles indicating individual user locations can be used to communicate to different users the views of their collaborators. This reduces confusion, improves efficiency, and reduces the occurrence of errors.

5.1.3. Awareness Lenses

Lenses could be used for promoting awareness of the actions of remote users. In much the same way as cursors were suggested for use above, lenses would provide a local user with hints as to what remote users were doing. Two advantages of using lenses are the fact that lenses can provide a detailed view of the actions of remote users and a local user would be unlikely to confuse his cursor with a remote controlled lens.

5.1.4. Universal Annotation

When multiple users are working together remotely, whether simultaneously or at different points in time, it is often useful to be able to make ad-hoc comments regarding any part of the data being operated on. This commentary can take any form. Therefore, it is desirable to provide absolute flexibility in what form these comments can take. It is suggested that COPlanS offer the capability of marking up data with “virtual crayons” that function as crayons would on a piece of paper. A user could scribble text or diagrams anywhere within the context of the data. These notes could then be accessed by any other user and possibly deleted or modified by other users as well.

5.1.5. Central Note Board

A central shared note board could be used for making comments that need to be read by other users but do not fit into any of the standard workspaces for whatever reason.

5.2. Synchronization Approaches for Two Users

5.2.1. Multi-User Master/Slave Synchronization

Sometimes it can be desirable for two remote users to have their remote applications tied together. In this situation the two applications would be in identical states at all times. The two users would be able to either simultaneously control the workspace, or pass control to one another using some protocol.

Synchronization of this sort serves to minimize confusion and can be useful if one user wants to provide a second remote user with a “walk-through” of a situation.

The mechanism for synchronizing two systems can take one of two forms. In the first form, the slave machine would be a dumb display host, essentially receiving screenshots over the network from the master. The main advantage to this approach is that it is relatively easy to implement while the main disadvantage is that it is highly bandwidth dependent. The alternative is for the two systems to be synchronized via messaging of the application state. System state synchronization could be achieved by sending mouse events over the network or by explicitly setting the state of application components. The advantage of this approach is conservation of bandwidth while the disadvantage is the complexity of the synchronization process.

5.2.2. On-Demand Synchronization

While the previous example dealt with prolonged system synchronization, it could be useful to have the option of performing a one-time system synchronization. In this scenario, a user would request the software to synchronize to the state of a remote collaborator. The system would immediately put the software in a state identical to that of the collaborator. Immediately after this action, however, control would be returned to the user and the user would be free to navigate away from this original state without any impact on the state of the remote collaborator’s system. This function would be useful if two collaborators wanted to start with the same initial state but then wanted to work in parallel.

5.3. Architectural Considerations

The example collaboration scenarios described above require that COPlanS be able to provide efficient communication between users, made possible by efficient communication between users’ machines. In order for awareness to be improved, tools such as remote cursors, awareness lenses, and others necessitate up to date display of relevant data. If components meant to promote awareness and collaboration are out of date, due to bandwidth or latency issues, awareness and collaboration may in fact be hampered.

There are two main possibilities when considering communication, either a TCP/IP based client/server architecture or a TCP/IP based peer-to-peer architecture. Considering the existing COPlanS architecture, which is client/server, it would seem natural for collaboration functions to also be client/server in nature. In fact, this would be ideal for such suggested functionality as the central note board, universal annotation, remote cursors, and multi-user radar views. All of these examples can potentially involve many users, rather than just two. A peer-to-peer architecture would also be possible but would require a web of many constantly open network connections. Also, a centralized client/server architecture would minimize the need for complicated synchronizations. It is useful to note that a centralized client/server architecture puts great reliance on reliable connections. It should be safe to assume reliable networking for the purpose of the proposed collaboration functionality, since reliable networking would be a requirement for basic functioning of COPlanS anyway.

For the case of functionality involving only two users, such as on-demand synchronization and master/slave synchronization, a client/server architecture is not such a clear choice. For this functionality, a central server would only serve to insert an extra step in communication, which could be an unnecessary performance bottleneck. For two-user collaboration, a direct peer-to-peer connection may be more appropriate. Response time would be faster, and bandwidth could possibly improve.

6. PDT in the COPlanS GIS

The amount of information available to the war fighter has increased dramatically in recent years. This increase in the quantity of information has not necessarily led to improved situational awareness and better decision-making. The complexity of the modern battlefield is such that problems of interoperability, collaboration, correlation, fusion, and overload are replacing the old problem of insufficient information.

One of the key functionalities offered by COPlanS is a GIS. In using the GIS the resolution of an image often exceeds that of the display. Information is seemingly lost as data is taken out of context by traditional viewing methods such as zooming, panning, or using separate or inset views. Each of these approaches disconnects the area of interest from the underlying information, thus inviting errors in interpretation. As data density continues to increase and display screens get smaller, innovations in visualization software and data interaction are necessary to ensure timely, accurate military decisions are being made.

Using a magnifying lens metaphor, detail appears within the center of the PDT focal region and blends smoothly into the background context using the lens periphery or shoulder. Once PDT is integrated within a host application, tools commonly used to perform editing, annotation, or other data interaction functions can be applied with complete accuracy to the information appearing within the lens. PDT replaces recurring zooming and panning steps and the use of inset windows that result in workflow inefficiencies and important information being pushed off the screen or hidden from view. Additionally PDT facilitates new visualizations such as area specific blending and collaboration.

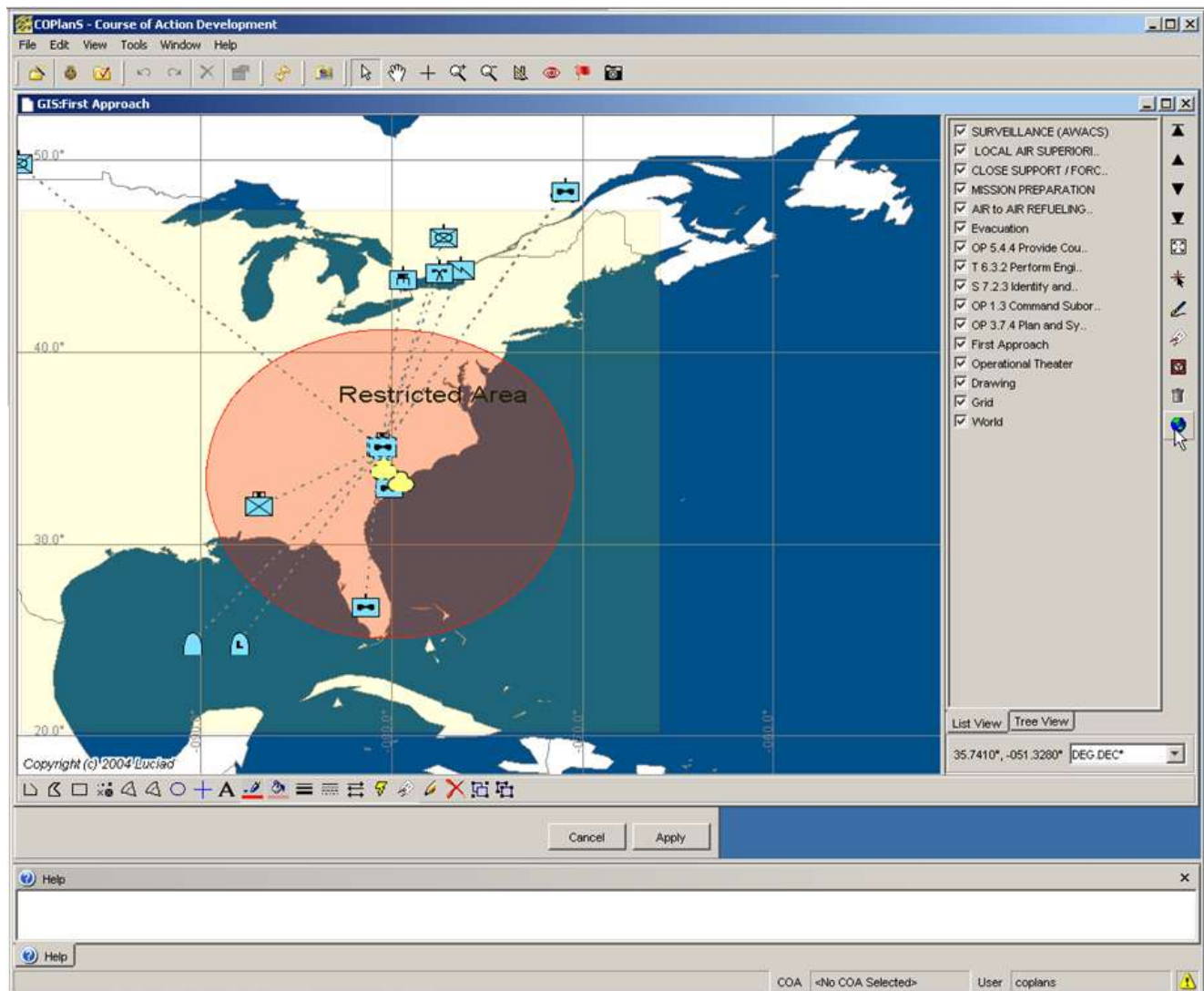


Figure 2 – Cluttering of the GIS Mission Planning Map

6.1. On-Map Mission Planning

The GIS mapping tool is one of the most essential components of the COPlanS application since much of the Coarse of Action (COA) sketching and planning is map-based. Viewing stacks of GIS layers and military symbols can make the screen appear cluttered and confusing (see Figure 2 above). Existing zooming and panning tools don't properly address the need to analyze a detailed region of interest on a map and understand how this detail relates to the context of the surrounding image. Standard inset views are also highly problematic in that they hide information and break visual continuity with the surrounding context outside the area of interest.

6.2. PDT Enhancement of On-Map Mission Planning

The benefits of integrating PDT into the GIS component of the COPlanS application are numerous and compelling. First, PDT extends traditional zoom and pan capabilities by allowing users to view detail within a region of the map without losing a view of the surrounding context. The magnified area and the background map remain seamlessly connected. Second, PDT can help users view multi-layer GIS data while conserving communication bandwidth between the application viewer and the base GIS data. To reduce data download time the PDT-enhanced application would only request data for the relevant area of interest (i.e. the area currently covered by the lens). The integration of PDT also makes it possible to view different layers and combinations of layers within the lens from the layer being displayed in the base image. Finally, PDT's unique "undisplace" feature permits accurate distance measurement and symbol placement within a PDT lens thereby eliminating time consuming and inefficient zooming and panning.

The following sections describe, in detail, PDT related functionality that can potentially be integrated into the GIS component of the COPlanS application.

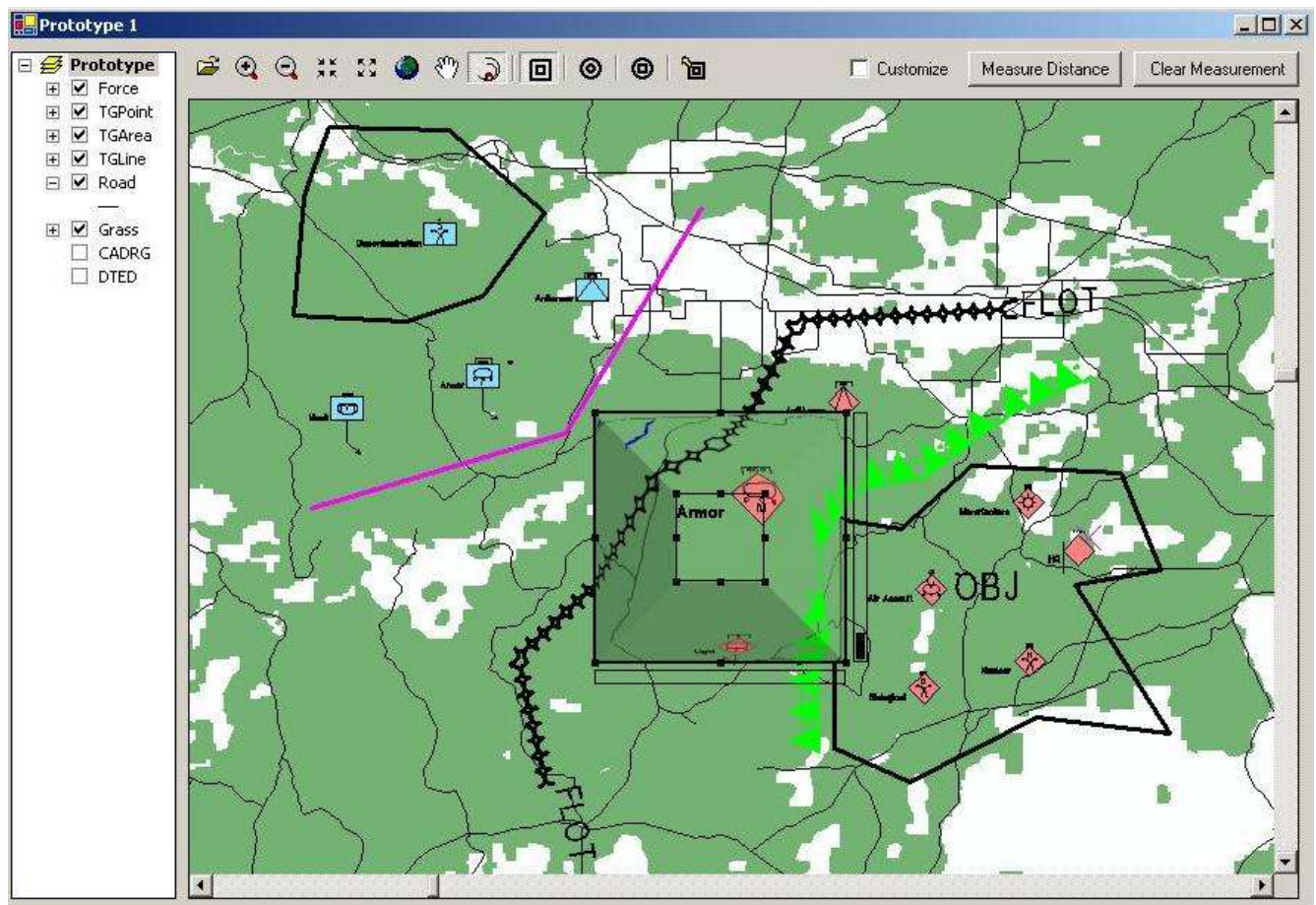


Figure 3 – PDT Lens on a Map

6.2.1. PDT Lens Providing Focus plus Context

PDT is a powerful alternative to existing zooming and panning tools. PDT lenses represent an enhancement to the GIS client application user interface for rapid exploration of large geo-spatial areas and for providing local detail with full situational awareness without hiding information. PDT's user interface provides the user with direct and intuitive control over the presentation of data within the lens (see Figure 3 above).

6.2.1.1. Lens Control

The following PDT lens controls can be implemented:

- Modular Design Lens Control (MDLC) including magnification slider, scoop slider and user resizing via point, click and drag.

The end user would be able to change the parameters of each lens by using the associated MDLC, independent of other lenses on the same image. The end user would be able to configure each occurrence of the lens as follows:

- MDLC controls are always visible
- MDLC controls are only visible when lens is selected

6.2.1.2. Lens Shapes and Lens Creation

First, the following PDT lens shapes can be implemented and made selectable by the end user when the lens is being added to an image.

- Pyramid

Cone

Square

The shape of an existing lens can be configured to be changeable. Third, when a lens is selected it can be made to appear optically centred on the screen viewing area of the image. In addition, it is possible to enable the end user to pre-configure the size, magnification level, MDLC colours, scoop setting) since these settings are saved on the target machine and applied to all users and images. Also, when a lens is subsequently placed on an image, the lens can be sized as per the "pre-sized" as described above. Finally, the end user can be allowed to selectively remove each lens uniquely from an image.

Rendering Options

As to image rendering the user can be given control over image warping, image shading and image anti-aliasing. The three options for image warping are the triangle, fast and pixel warpers. The triangle image warper produces a more accurate and detailed image than the fast image warper. However, on computers with slow CPU's the motion of the lens can be jerky when using the triangle image warper. Thus, in order to improve lens response while it is being moved, the fast image warper should usually be used in these situations. Both image shading and image anti-aliasing can be either turned on or turned off.

In order to provide a set of user-friendly controls over image rendering, the following image warping, shading and anti-aliasing options can be implemented:

Quality (using pixel image warping, shading and anti-aliasing,

Quality/Performance (using pixel image warping only), and

Performance (using fast image warping only).

Options

The following lens options that can be included:

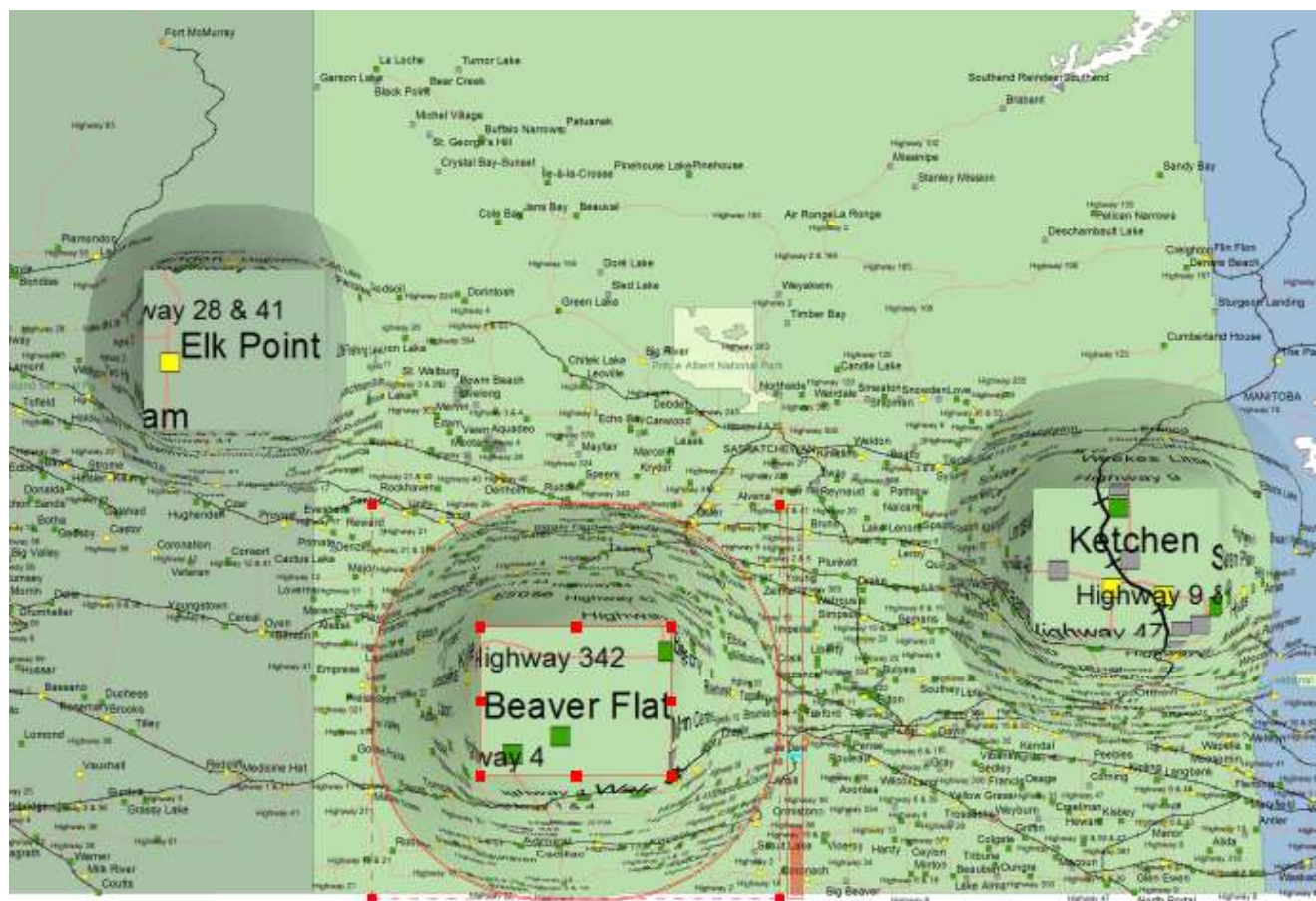
On or off when moving lens

Controls for selected lens

Controls for non-selected lenses

supported

enses. These lenses can highlight multiple areas of interest, perform precise point-to-point measurements without panning, and on (See Figure 4 below).



s on a Map

be supported on a single image. The only limit would be one based upon the amount of memory on the user's computer.

to support folding. The user can also be given the ability to "unfold the lens" through the single click of a GUI button.

ile a Lens is on an Image

tool can be maintained. In addition, when an image is panned, the PDT lens can be configured to remain locked to the image, locked to the screen where placed, or disappear.

ile a Lens is on an Image

n tool can be maintained. Also, when one or more PDT lenses are on an image and the user globally zooms the image, the maintain their sizing relative to the screen. In addition, when the image is zoomed, the magnification of the lens can be the image within the lens will change as a function of the global zoom times the zoom setting of the lens. And finally, when an PDT lens can be configured to remain locked to the image where placed, locked to the screen where placed, or disappear.

made available in the GIS portion of the application.

ility, through an easy to use UI, to zoom the entire image to the scale of the focal region of a PDT lens.

MDLC controls can be rendered invisible with an indication that the image has been zoomed in.

Allowed to increase or decrease the zoom level of the image.

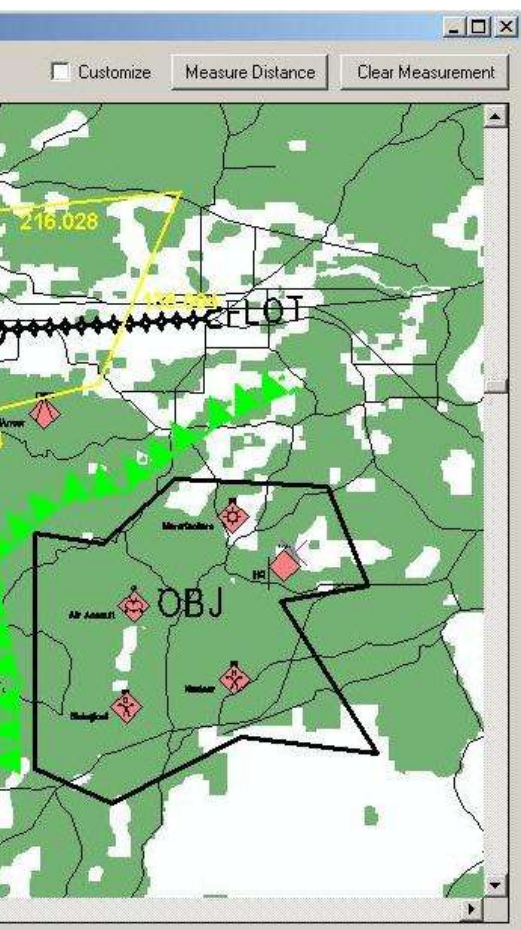
Can be allowed to reverse the zoom to scale operation previously executed.

Can be made to remain operational.

Positioned to be consistent with the zoomed in image and the MDLC controls can be made visible.

The level of magnification prior to zooming out even if the user had changed the zoom level while zoomed to scale.

Typically faced with many unnecessary navigation steps when using these tools at an adequate scale for precise data authoring. PDT, where symbols can be “dropped” into place precisely, while eliminating the need for zooming and panning. PDT speeds spatial production workflow.



the user to perform fully precise distance measurements spanning a large extent of the data without the need for awkward length, perimeter, and radius measurements within the GIS application can similarly benefit when the measuring tool is

y to turn on and off a shaded snail trail (that will show where the PDT lens has been on the image) as well as clear the snail

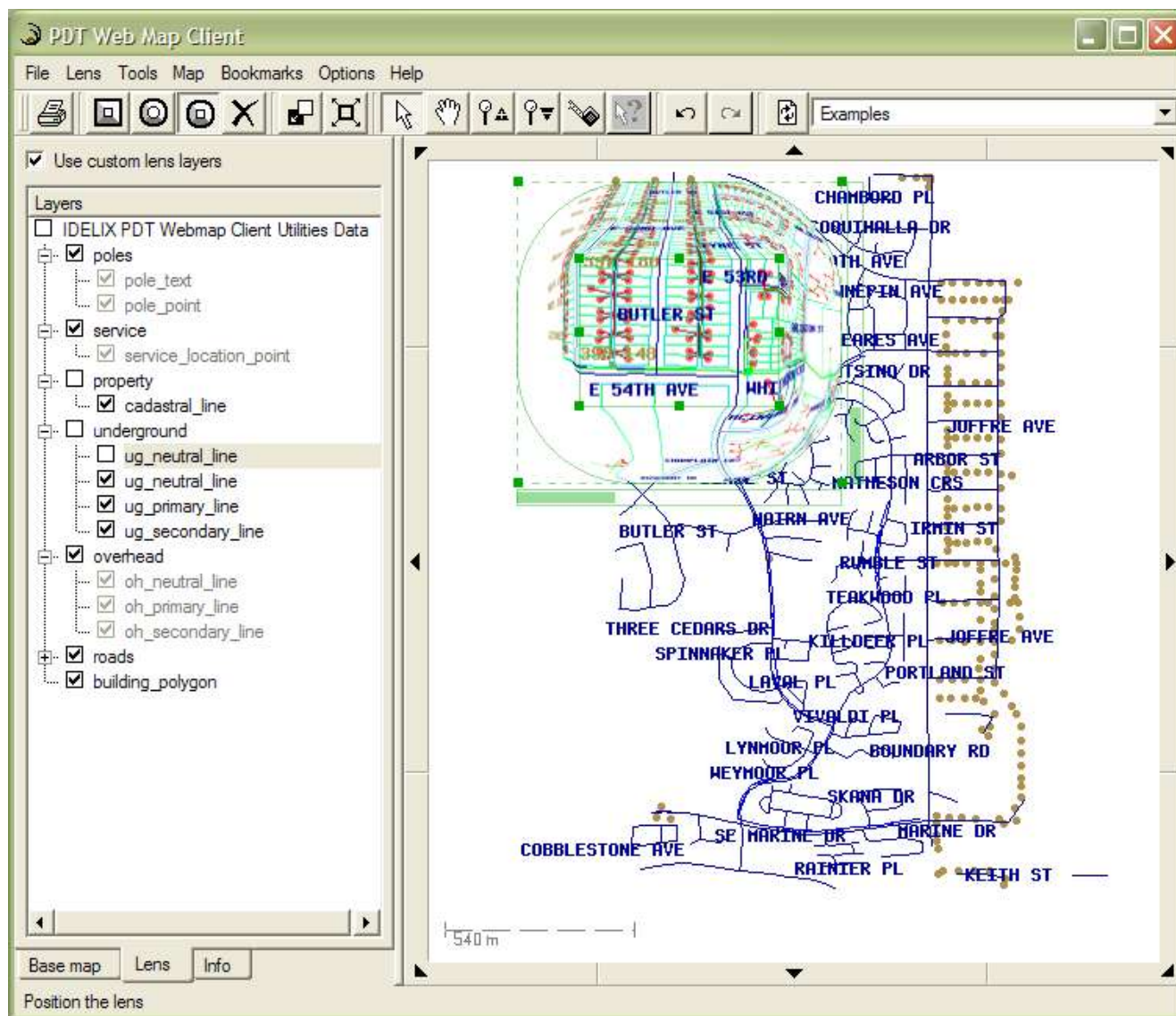
Trails

y to drive a PDT lens to automatically and sequentially traverse an image over a prescribed path. If desired, a shaded snail trail has been and the image (including the snail trail) can be saved so that the user may return to the image at a later date to

ology. In order for the user to obtain the situational awareness of the battle theatre the map is typically zoomed out to a large scale. Symbols are clustered very closely together and often overlap each other as well as occlude parts of the map image. By zooming in to a map of smaller scale (for example, 1:50,000). The symbols are now placed on the smaller scale map thus reducing the visual

and Transparency

map viewer by linking data layer selection to data layer visibility within the PDT lens. This can be accomplished by creating user-defined data layers displayed on a GIS map (see Figure 6 below).



blending of data visible outside the lens with data visible inside the lens. As such, the PDT lens can be used to de-clutter the map. The second is the ability to blend layers, with varying degrees of layer transparency, to allow for better interpretation of the map while a second layer was a geo-rectified image of the location, a user would be able to more quickly and precisely locate features. Transparency adjustments were provided.

Web GIS, to collaborate in real time. A lens placed on one occurrence of the GIS can be automatically placed on a second occurrence on a TCP/IP based network. For details of enablement, see the section 4 discussions on synchronization approaches and

a Collaboration Tabletop

supporting remote collaboration. However, local collaboration can be equally important. As previously mentioned, standard people gathering around discussing some topic. In such a situation, it is better to have a large display of some type, either a large screen or a set of devices driven by some direct interaction such as a pen, a stylus, or some tactile input, and it is desirable for the system to support all these devices. Such devices currently exist, one being the Microsoft Surface. It is proposed that we identify the functionality within COPlanS that would benefit most from supporting naturally collaborative interaction on an appropriate device.

A projected, gesture-based, light table called the DiamondTouch Table (see Figure 7 below). The DiamondTouch (DT) Table is a multi-touch device that supports touch events on an individual user basis. This ability makes the DT Table a very useful device in the area of human-computer interaction.

The DT Table has antennas embedded in the touch surface. Each antenna transmits a unique signal. When a user touches the surface, the antennas detect the signal and route it through the user's body to a conductive pad on the user's chair.

use on a single surface.

one way to interact with geo-spatial data.

can be deployed into a forward command and control situation.

le has no effect on a users input actions).

ired with projector, stand, carrying cases etc).

re aspect involving multiple users and where one (or more) large, shared display surfaces can be beneficially used. Typically, multiple disciplines must come together in order to produce a high quality output. The team can be gathered around a single DT Table or multiple. Given the capability of the DT Table, it is well suited to be used in the following environments and applications:

ware applications available. The only software applications that exist are several basic programs that demonstrate some of the insight to the possibilities of using the DT Table in a military environment they do not provide sufficient functionality to be fielded. Designed from inception to support multiple simultaneous users and accept multi handed gestures as input.

e. This application ingests JPEG imagery and displays it on the table. Using two fingers, one from each hand, a user can zoom. As the user separates their fingers, the PDT lens can be sized. The users' finger is then used to move the lens around the table. The user can also select a pen and annotate a region of interest by drawing on the table with a finger.

Given the fact there are no commercially deployable table aware (gesture-based, multi-user) applications available, we can see the benefits that a DT Table with appropriate software can offer. Given the target users and use scenarios identified earlier in

input device (such as the DT Table). As a result there is an inherent risk associated with the implementation of such an application technologies, as well as geo-spatial expertise, this risk can be mitigated.

Table aware application be used. The first phase should be aimed at developing an initial prototype table aware application that the desired functionality can be obtained and documented. Only then will it make sense to develop a more complete prototype or test with users and thoroughly evaluated in order to fully understand the potential benefits prior to finalizing any subsequent

As possible to run existing PC applications on the table and use a mouse paradigm as an input device, the true benefits of the table for dual hand based gesture inputs from a user and almost all software programs do not allow multiple simultaneous users to use the table. What is required is a multi-user application that allows the use of hand gestures in order to fully exploit the

.).

aster data in common file formats.

- Straight Line – distance is measured in a straight line by defining a start and stop point.
- Polygon – distance is measure by following a polygonal path defined by the user.

7.2.6.7. Tool Bars

- Tool bars should be modular with logical functions grouped together.
- Each user should be able to detach a tool bar of choice and position it as desired on the table.
- The tool bars should be colour coded so that they can be associated with each user.
- A later version of the application could have toolbars that can orient as appropriate to the position of the user, but this is challenging to implement in common development frameworks and will require additional effort.

7.2.6.8. Layers and Transparency

- Be able to ingest multiple files and display two of the files as layers.
- Be able to define what file is displayed inside the lens and what file is displayed outside the lens.
- Be able to change the transparency of the layers within the PDT lens.

7.2.6.9. Remote Collaboration

- The application should support collaboration between 2 (or more) geographically dispersed tables that are connected via an IP based data link.
- It should be possible to pass control from one table to another table at the option of a moderator.
- Actions on the control table should be copied on the remote table. This should include annotation and mensuration as well as PDT lens configuration and movement.

7.2.6.10. Calibration

The application should have a calibration routine bundled or built in so that the table can be calibrated.

8. Enhancing the Visual Diagramming Components of COPlanS

This section examines the potential for enhancing the visual diagramming components of the COPlanS application.

8.1. Workflow Management

The Workflow Diagram component of COPlanS (created using the JViews visual diagramming tool from ILOG) is currently used to create, display and manage relatively simple process workflows (see Figure 8 below). However, the potential for the creation of significantly more complex workflows does exist. Workflow diagrams for complex decision paths can quickly grow to a level where it is impractical or impossible to display the entire structure in a single window. In such cases users typically choose zooming and panning tools to view a portion of the diagram at a “readable” scale. This often results in inefficiencies and a loss of situational awareness as important information is pushed off the screen.

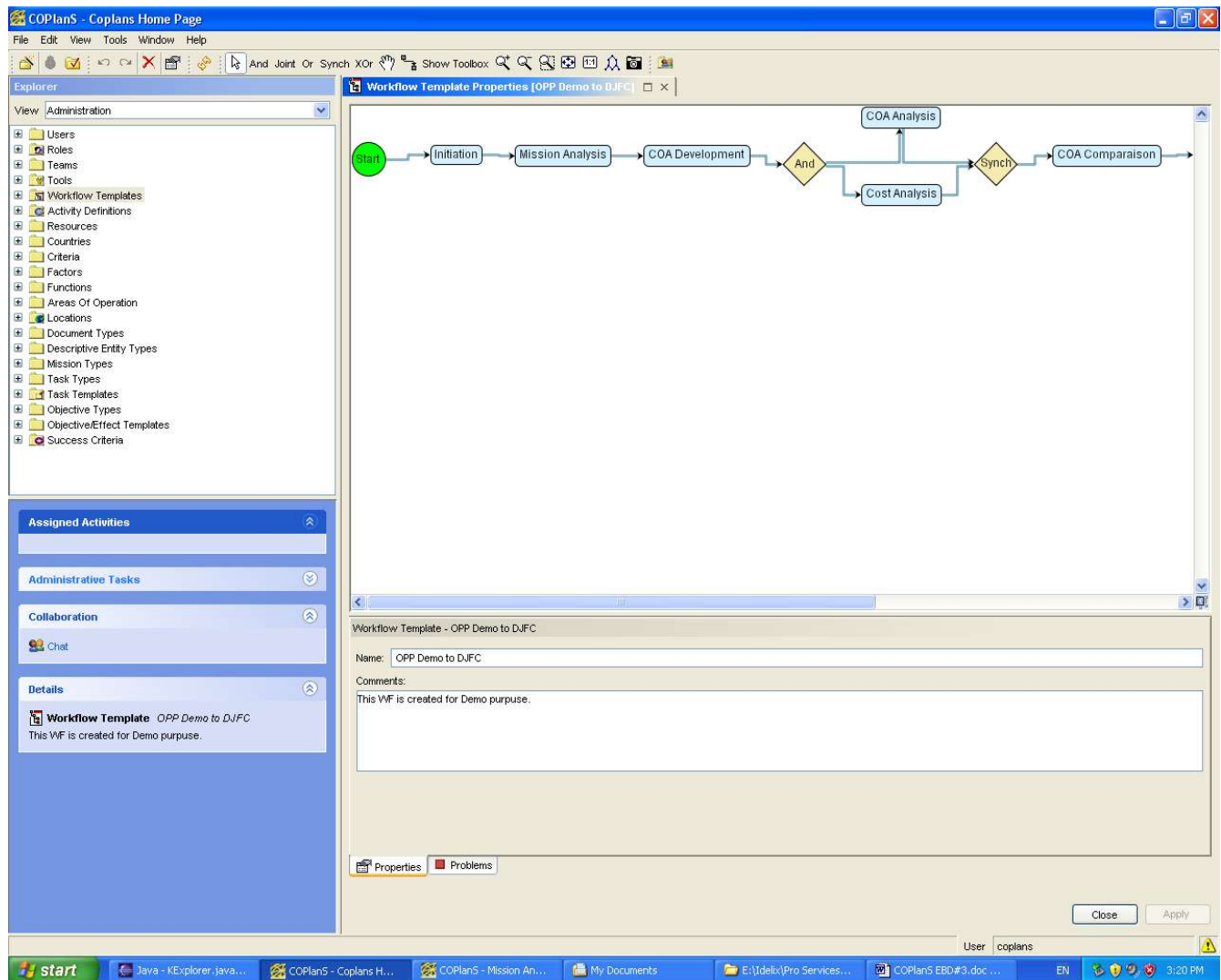


Figure 8 – Typical Workflow Diagram in COPlanS

Also, as stated in the DRDC fact sheet (IS-228-A), the new version of COPlanS will support multi-level workflows where planners will be able to define activities which in themselves are workflows involving a subset of activities. The ability to capture conditional workflow processes is also being considered.

8.2. Mission Analysis

The Effect Based Diagram component of COPlanS (created using the JViews visual diagramming tool from ILOG) is currently used to display and modify relatively complex process workflows (see Figure 9 below) used for detailed mission analysis. In such cases users typically choose zooming and panning tools to view a portion of the diagram at a “readable” scale. This often results in inefficiencies and a loss of situational awareness as important information is pushed off the screen.

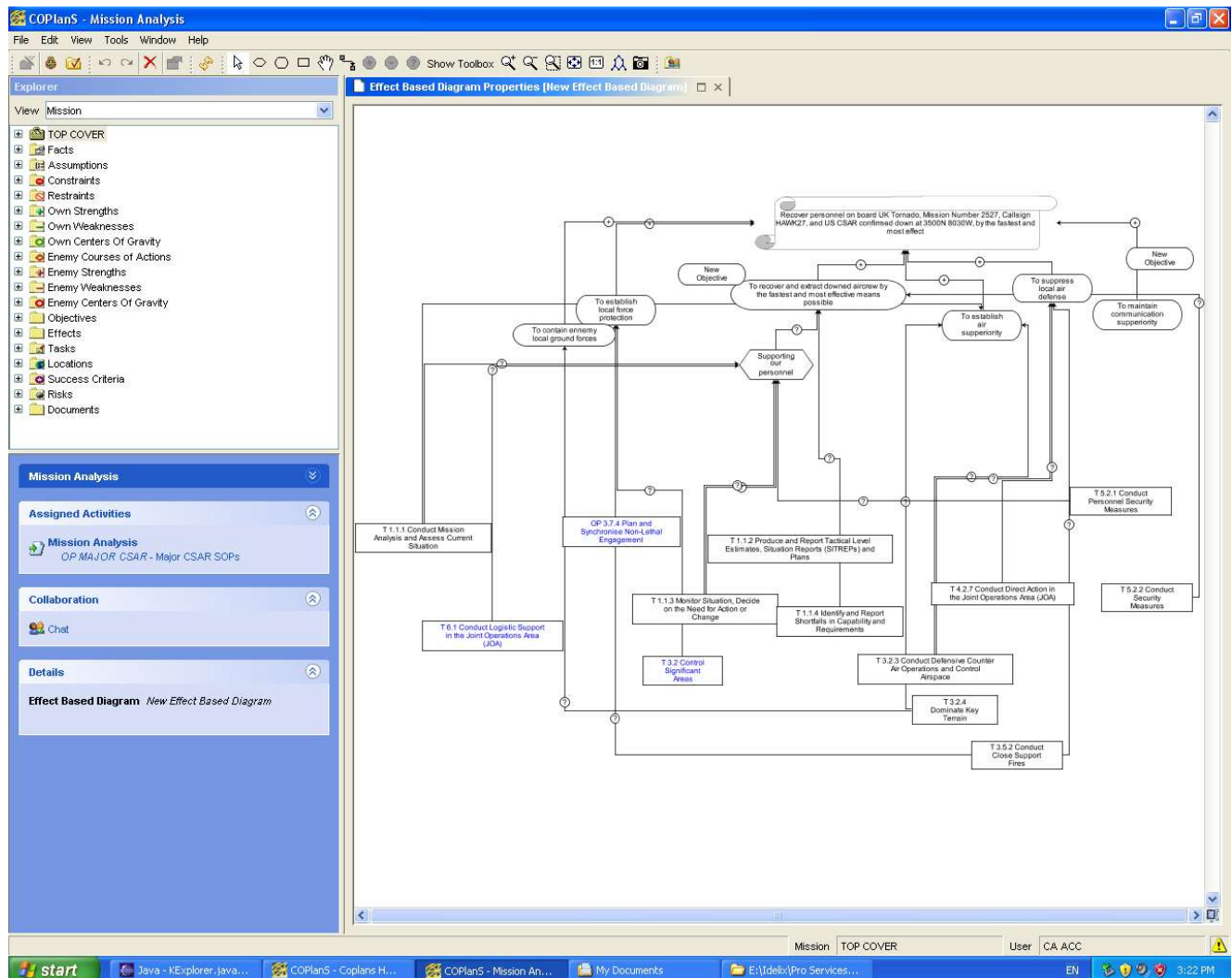


Figure 9 – Typical Effect Based Diagram in COPlanS for Mission Analysis

8.3. Order of Battle (ORBAT) Asset Visualization

The ORBAT (Order of Battle) browser in COPlanS (created using the JViews visual diagramming tool from ILOG) allows commanders to visualize and formulate analysis about the assets and resources available to them for a given task (see Figure 10 below). Similar to Workflow Diagrams, ORBAT charts can become complex and difficult to view in their entirety on computer screens.

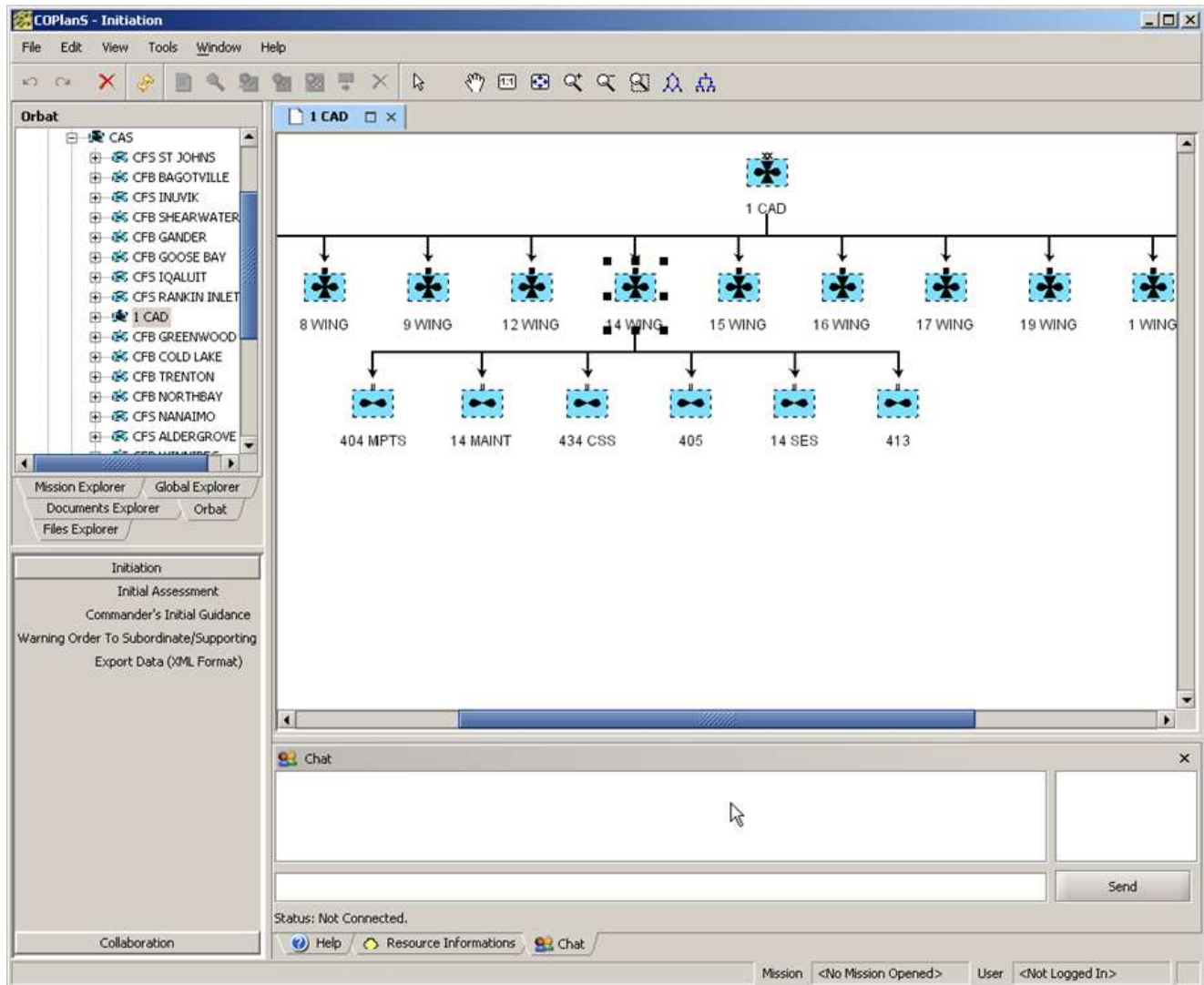


Figure 10 – Typical ORBAT Chart in COPlanS

8.4. Detail-in-Context for Visual Diagramming in COPlanS

Several components of COPlanS, specifically the Workflow Diagrams, the Effect Based Diagrams, and the ORBAT Charts display a network of discrete data elements connected by logical relationships. Logical relationships are communicated to the user visually, using position and connecting symbols such as arrows. This data is inherently different from the type of data usually associated with PDT enabled applications. Typical PDT applications deal with continuous data where positional relationships are inherent in the data. For example, map data is continuous, and objects on the map have real-world positions. In an ORBAT chart, however, the relationship of different components is purely logical, and how those relationships are shown is up to the display process.

While detail-in-context rendering can have a significant positive impact in viewing discrete networks of abstract data, PDT is not the ideal detail-in-context approach. Rather, it is suggested that a detail-in-context approach designed from the ground up for viewing of networks of discrete logically related data be employed. Rather than magnifying data in a continuously varying manner, the technique would magnify individual objects independently without distorting any one discrete object. Logical connections, represented by lines or arrow, would not be distorted but would instead simply have their start and end-points moved to accommodate reshaped objects. There have been several techniques similar to the one described developed in the academic community. The differences between the techniques mostly have to do with how objects are moved about the screen, if at all, and how much objects are magnified, depending on their relationship to the object of interest.

Perhaps the most challenging part of the proposed work would be to determine which technique would be most appropriate for COPlanS. This may be further complicated by the fact that the ORBAT charts, being hierarchical data sets, may benefit from a different detail-in-context approach than the other components. Hierarchies are a specialized subset of general network graphs and detail-in-context algorithms can be fine tuned to suit this special case.

9. Rough Order of Magnitude (ROM) Estimates by Feature

This section provides rough order of magnitude (ROM) estimates of the effort required to implement various collaboration and data visualization features mentioned in the preceding discussions. These estimates are provided for comparison purposes only.

9.1. General Visual Collaboration

9.1.1. Visual Highlighting Approaches for Multiple Users

9.1.1.1. Remote Cursors

- Level of Effort: Low
- Risk: Medium
- Payoff: Medium
- **Priority: Medium**

9.1.1.2. Multi-User Radar View

- Level of Effort: Medium
- Risk: Medium
- Payoff: Medium
- **Priority: Medium**

9.1.1.3. Awareness Lenses

- Level of Effort: High
- Risk: High
- Payoff: High
- **Priority: Medium**

9.1.1.4. Universal Annotation

- Level of Effort: High
- Risk: Medium
- Payoff: High
- **Priority: High**

9.1.1.5. Central Note Board

- Level of Effort: Medium
- Risk: Low
- Payoff: Medium
- **Priority: Medium**

9.1.2. Synchronization Approaches for Two Users

9.1.2.1. Multi-User Master/Slave Synchronization – Dumb Display Host

- Level of Effort: Medium
- Risk: Low
- Payoff: Medium
- **Priority: High**

9.1.2.2. Multi-User Master/Slave Synchronization – Application Synchronization

- Level of Effort: High
- Risk: Medium-High
- Payoff: Medium
- **Priority: Low**

9.1.2.3. On-Demand Synchronization

- Level of Effort: Medium
- Risk: Medium
- Payoff: Low
- **Priority: Low**

9.2.

9.3. PDT in the COPlanS GIS (Note: Assumes access to GIS source code)

- Level of Effort: Medium

- Risk: Low

- Payoff: High

- Priority: High

1. PDT Lens Providing Focus plus Context

Level of Effort: Low

Low

High

High

Assisted Functionality

Low

/

High

g Map

oration Tabletop (Note: Assumes access to table aware GIS application source code)

9.5.

9.6. Enhancing the Visual Diagramming Components of COPlanS

9.6.1. Enhancement of Workflow Diagrams

- Level of Effort: TBD

- Risk: TBD

- Payoff: TBD

- Priority: TBD

9.6.2. Enhancement of Effect Based Diagrams (Mission Analysis)

Level of Effort: TBD

TBD

TBD

TBD

9.6.3. Enhancement of ORBAT Charts

TBD

D

TBD

Models

proposed and properly integrate PDT into an existing application, the integrator must have access to the image rendering application. While this type of integration is not necessarily difficult it must be done with full access to the image processing pipeline application. This is an area that third party developers have not traditionally had access to. Given this background, the following identified and will be referred to later in this report.

Required Functionality

original author of the application, integrates PDT using the SDK. Since the OEM owns the source code they have access to the application in order to properly integrate PDT. The obvious benefit of this model is that the architecture and implementation are completely understood. The downside is that the OEM must first develop a detailed understanding of PDT and then define the interfaces. As PDT is a relatively new technology and most OEMs have not yet been exposed to it, IDELIX feels, with some recent results in a less than optimal implementation.

Access to the Image Processing Pipeline; IDELIX Integrates

Access to the image-processing pipeline. Once the APIs are made available, IDELIX can proceed with the integration of PDT. The benefit is that the OEM retains control of its product and does not need to expose its' source code to an external integrator. If implemented, it is expected that the resulting integration would be of high quality. However, given the extensive effort involved to both define the interfaces and subsequently implement PDT through those interfaces, it is expected that this model would be relatively expensive.

Jointly Integrate Required Functionality

Both parties work together to integrate PDT into the target application. Access to the source code is provided to IDELIX with the resulting integration meeting the initial requirements and expectations. The primary issue here is usually cost since two companies must assign resources, often located geographically to be most effective. The resultant travel and living expenses can be a significant additional cost to the project. There is often an overlap of duties between the two organizations that can increase integration costs further.

Required Functionality

Access to the OEMs source code and performs all integration of PDT into the target application. This is a model that IDELIX has used in the past. For example, this method was used for the integration of PDT into ITT's Rapid Access Image Viewer (RAIV) and Mobile (MRAIV) clients. Included in this model is the provision of time for IDELIX to transfer to the OEM the knowledge of how PDT was implemented. This is typically done by providing both SDK related training and a detailed code review explaining where and how PDT is implemented in the OEM software. Once the OEM has received this training they are fully capable of maintaining the code base while IDELIX provides support to the OEM on an ongoing basis. However, there is a significant risk with this option in that an OEM vendor may be reluctant to share code with IDELIX as this code may contain part or all of their core intellectual property.

Integrator Integrates Required Functionality

The integrator is given access to the OEM's source code and performs all integration of PDT into the target application using the OEM's SDK. The main issue with this implementation option is that an appropriate third party vendor, one that is familiar with both the base application and the SDK, may be difficult to find. Also, as stated previously, the OEM vendor may be unwilling to share their source code with the integrator.

Application to Specification

The integrator develops a new application that is both compliant with the required functionality, as defined by the customer, and has integrated PDT into the application. One of the benefits of this model is that one organization has control over the development of both the core functionality and the integrated PDT application. The organization that will be the most familiar with the PDT SDK and its implementation challenges.

Integrator Produces an Application to Specification

The integrator produces a new application that is both compliant with the required functionality, as defined by the customer, and has integrated PDT into the application. The advantage of this model is that one organization has control over the development of both the core functionality and the integrated PDT application.

¹ OEM is the Original Equipment Manufacturer. In the case of software the OEM is defined as being the writer of the software.

ality. Again, the main issue with this implementation option is that an appropriate third party integrator, one that is familiar with technology and the PDT SDK, may be difficult to find.

11. Rough Order of Magnitude (ROM) Estimates by Implementation Model

This section provides rough order of magnitude (ROM) estimates of the effort required to implement PDT based on the models presented in the previous section. These estimates are provided for comparison purposes only since the actual effort required to implement PDT is highly dependent on the conditions of integration and the feature set selected.

11.1. General Visual Collaboration

11.1.1. Multi-User Master/Slave Synchronization for 2 Users – Dumb Display Host

11.1.1.1. OEM (Call-Fusion, Webex, etc.) Integrates Synchronization Functionality

- Pros:
 - Vendors are very experienced with this type of synchronization
- Cons:
 - Secure deployments can be relatively expensive
- Level of Effort: Medium
- Risk: Low-Medium
- Payoff: Medium
- Priority: Medium

11.1.1.2. OEM Provides APIs; IDELIX Integrates

- This option should be considered since synchronization is not an IDELIX core competency

11.1.1.3. OEM and IDELIX Jointly Integrate Functionality

- This option should not be considered since synchronization is not an IDELIX core competency

11.1.1.4. IDELIX Integrates

- This option should not be considered since synchronization is not an IDELIX core competency

11.1.1.5. Third Party System Integrator Integrates Functionality

- This option should not be considered since this type of synchronization is likely not a core competency

11.1.1.6. IDELIX Produces an Application to Specification

- This option should not be considered since synchronization is not an IDELIX core competency

11.1.1.7. Third Party System Integrator Produces an Application to Specification

- This option should not be considered since this type of synchronization is likely not a core competency

11.1.2. Multi-User Master/Slave Synchronization for 2 Users – Application Synchronization

11.1.2.1. OEM (Thales) Integrates Synchronization Functionality

- Pros:
 - Thales familiar with code since developed application
- Cons:
 - Application synchronization is very difficult
- Level of Effort: High
- Risk: High
- Payoff: Low
- **Priority: Low**

11.1.2.2. OEM Provides APIs; IDELIX Integrates

- This option should not be considered since synchronization is not an IDELIX core competency

11.1.2.3. OEM and IDELIX Jointly Integrate Functionality

- This option should not be considered since synchronization is not an IDELIX core competency

11.1.2.4. IDELIX Integrates

- This option should not be considered since synchronization is not an IDELIX core competency

11.1.2.5. Third Party System Integrator Integrates Functionality

- Cons:
 - Application synchronization is very difficult
- Level of Effort: High
- Risk: High
- Payoff: Low
- **Priority: Low**

11.1.2.6. IDELIX Produces an Application to Specification

- This option doesn't make sense

11.1.2.7. Third Party System Integrator Produces an Application to Specification

- This option doesn't make sense

11.2.

11.3. PDT in the COPlanS GIS

11.3.1. PDT Enhancement of On-Map Mission Planning

- Level of Effort: Varies
- Risk: Varies
- Payoff: High
- **Priority: High**

11.3.1.1. OEM (Luciad) Integrates PDT Functionality

Pros:

- GIS application architecture and code known well by OEM vendor
- Cons:
 - OEM vendor may choose not to participate
 - Conflicting priorities in application development cycle for OEM vendor; could be hidden delays
 - OEM vendor has no knowledge of PDT
- Level of Effort: Med-High
- Risk: High
- Payoff: High
- **Priority: Low**

11.3.1.2. OEM (Luciad) Provides APIs to the Image Processing Pipeline; IDELIX Integrates PDT

- Pros:
 - IDELIX can provide PDT knowledge and expertise to the development effort
 - More time flexibility for the customer since defined project stages
- Cons:
 - OEM vendor may choose not to participate
 - Highly conflicting priorities in application development cycle for OEM vendor; hidden delays likely
 - Multiple vendors to deal with
- Level of Effort: High
- Risk: Med-High
- Payoff: High
- **Priority: Low**

11.3.1.3. OEM (Luciad) and IDELIX Jointly Integrate PDT Functionality

- Pros:
 - IDELIX can provide PDT knowledge and expertise to the development effort
 - Maximum understanding and knowledge applied to development effort

- Cons:
 - OEM vendor may choose not to participate
 - Conflicting priorities in application development cycle for OEM vendor; could be hidden delays
 - Multiple vendors to deal with
- Level of Effort: Med-High
- Risk: Med
- Payoff: High
- **Priority: Med**

11.3.1.4. IDELIX Integrates PDT Functionality

- Pros:
 - IDELIX can provide maximum PDT knowledge and expertise to the development effort
- Cons:
 - High risk since OEM vendor may choose not to share their source code
- Level of Effort: Low-Med
- Risk: Med-High
- Payoff: High
- **Priority: High**

11.3.1.5. Third Party System Integrator Integrates PDT Functionality

- Cons:
 - Depends on experience with Luciad GIS
 - Depends on experience with PDT
 - High risk since OEM vendor may choose not to share their source code
- Level of Effort: High
- Risk: High
- Payoff: High
- **Priority: Very Low**

11.3.1.6. IDELIX Produces an Application to Specification

- Pros:
 - Single source Canadian vendor
 - Purpose built application will provide maximum usability
 - Highest degree of control over development process
 - No legacy code to contend with
- Cons:
 - Removal of current OEM vendor GIS application
- Level of Effort: Med-High
- Risk: Med
- Payoff: High

- **Priority:** **Med**

11.3.1.7. Third Party System Integrator Produces an Application to Specification

- Pros:
 - Single source vendor
 - Purpose built application will provide maximum usability
 - Highest degree of control over development process
 - No legacy code to contend with
- Cons:
 - Removal of current OEM vendor GIS application
- Level of Effort: Med-High
- Risk: Med-High
- Payoff: High
- **Priority:** **Med-High**

11.4.

11.5. PDT in the COPlanS GIS Operating on a Collaboration Tabletop

11.5.1. Software Functionality Implementation for a Table Aware Application

- Level of Effort: Varies
- Risk: Varies
- Payoff: High
- **Priority: High**

5.1.1. OEM Integrates Functionality

This option cannot be considered since there are no current GIS OEM applications for the MERL table

2.OEM Provides APIs to the Image Processing Pipeline; IDELIX Integrates

option cannot be considered since there are no current GIS OEM applications for the MERL table

OEM and IDELIX Jointly Integrate Functionality

option cannot be considered since there are no current GIS OEM applications for the MERL table

IX Integrates Functionality

cannot be considered since there are no current GIS OEM applications for the MERL table

Party System Integrator Integrates Functionality

not be considered since there are no current GIS OEM applications for the MERL table

duces an Application to Specification

- Single source Canadian vendor
- Purpose built application will provide superior usability
- High degree of control over development process
- No legacy code to contend with
- Cons:
 - Removal of current OEM GIS application
- Level of Effort: Medium
- Risk: Medium (3 phased approach only)
- Payoff: High
- **Priority: Medium**

11.5.1.7. Third Party System Integrator Produces an Application to Specification

- Pros:

- Single source vendor
- Purpose built application will provide superior usability
- High degree of control over development process
- No legacy code to contend with
- Cons:
 - Removal of current OEM GIS application
- Level of Effort: Medium
- Risk: Medium (3 phased approach only)
- Payoff: High
- **Priority: Medium**

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12.0.2.

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This document examines the potential for enhancement of Defence Research and Development Canada's Collaborative Operations Planning System (COPlanS) technology demonstration software in the areas of collaboration and data visualization using IDELIX's Pliable Display Technology. In particular, it begins by outlining several possible forms of general collaboration that apply to the application and then defines a number of areas within the application with collaboration and data visualization improvement potential. Each of these areas is subsequently analyzed in depth with specific details of how enhanced collaboration and data visualization can be attained with PDT. Finally, rough orders of magnitude are provided for all defined features and potential implementation approaches.

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