

The *TimeMap* Kiosk: Delivering Historical Images in a Spatio-Temporal Context

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Abstract: The TimeMap project of the Archaeological Computing Laboratory at the University of Sydney is investigating the use of geographic information systems (GIS) for mapping spatio-temporal data using a snapshot-transition model. The project has developed a viewer application (TMView) which will display both local and Internet-accessible datasets together in a time-enabled map window. Along with normal GIS functionality, the viewer uses time-based filtering to display time slices on demand and can generate simple map animations as AVI files. A Java map viewer for Internet-accessible datasets is under development.

TMView has been used to implement a museum kiosk at the Museum of Sydney. The kiosk gives museum visitors access to a variety of digital resources drawn dynamically from a database. These are displayed in against series of historic maps that have been geo-registered to fit the modern map base.

Key words: Geographic Information Systems, Spatio-Temporal GIS, TimeMap, Internet, Sydney, Historic maps.

Introduction

Our first presentation of *TimeMap*¹ at CAA97 (Johnson 1999) introduced the snapshot-transition model for storing vector-based spatio-temporal data, and touched on many aspects of modelling and presenting spatio-temporal data such as fuzzy boundaries, temporal uncertainty, time-slice mapping and map animation.

While we are still grappling with the issues of spatio-temporal data modeling and temporal interpolation, we have developed a robust *TimeMap* viewer application (TMView) which will display both local and Internet-accessible datasets together in a time-enabled map window. The viewer uses time-based filtering to display time slices on demand and will generate simple map animations as AVI files.

TMView was used to implement a museum kiosk – Sydney *TimeMap* – at the Museum of Sydney in November 2000. We have also developed a simpler Java viewer for Internet-accessible datasets. The Java map viewer does not yet support time queries.

The TMView application – currently at version 3.0 – can be downloaded from the *TimeMap* web site (www.timemap.net). The Java map viewer can be viewed on the Electronic Cultural Atlas Initiative search pages, accessible from the *TimeMap* web site.

TimeMap Windows Viewer

TMView is a Windows application written using Borland Delphi and the ESRI MapObjects GIS component². TMView creates map layers on the fly by applying an SQL filter to vector datasets (stored locally as ESRI shapefiles), allowing the map to be updated as the time limits are changed. A time bar beneath the map – which can be zoomed in to individual days, months or years, or out to the full time range of the datasets displayed – allows the user to set the time limits by dragging the ends of the current time range shown by the grey bar (Figure 1).

Metadata attached to each dataset give the program information such as the way in which time fields are stored, which fields to use in labeling and how to construct URLs from attribute data to link objects on the map to database-driven web sites. Tools on the toolbar allow access to the attribute information attached to each map object, as well as linking to constructed URLs or to URLs stored directly in a data field. The key map in the top left corner can use one or more vector or raster datasets, which may or may not appear on the main map.

Internet datasets

TMView can search an Internet-accessible metadata clearinghouse developed for the Electronic Cultural Atlas Initiative (www.ecai.org). It is hoped that the clearinghouse will

eventually index numerous publicly-accessible archaeological and historical datasets with a spatial and temporal component. A typical search screen is shown in Figure 2.

The clearinghouse indexes datasets accessible via the Internet and provides two sorts of metadata: *descriptive metadata* (based on Dublin Core) and *connection metadata* (information on the type of server, naming of tables and fields, passwords, georeferencing etc.). TMView uses the descriptive metadata to search for datasets by geographic area, time period or keyword, and uses the connection metadata to directly access and download all or part of a dataset for display in the map window. Datasets downloaded from the Internet are cached locally as shapefiles (for vectors) or JPG files (for rasters) and may be used offline, so that TMView MapSpaces can be packaged with TMView as CD-ROM products or transferred to a standalone computer for kiosk use.

The TMView application does not directly access datasets on Internet servers. Instead it communicates using the CORBA standard with a middle-tier application server (Figure 3) which has the necessary drivers to talk to the ECAI clearinghouse and supported data servers. The middle tier currently supports data served as JPG, GIF or shapefiles on a web server, several common SQL data servers and the MrSID image server. Other drivers are under development, including support for the Open GIS Consortium standards.

MapSpace manager

TMView has a MapSpace Manager window (Figure 4) which supports the design and saving of multi-layer maps as MapSpace files (analogous to ArcView projects or MapInfo Workspaces). MapSpaces define the datasets to be used (including non-local datasets accessible via the ECAI metadata clearinghouse), the SQL filters to be applied to create map layers, the symbology to be applied for each layer, and spatial and temporal limits. MapSpaces can be saved as local files, as files on a web server or – along with appropriate metadata – in the ECAI clearinghouse, from which they can be downloaded by other users (along with the data from datasets indexed in the clearinghouse).

Layer control

One of the key features of TMView is its handling of both time and layer display scaling. While many desktop mapping programs allow one to set the range of scales over which map layers display, most programs simply turn layers off if they fall outside the chosen scale range. It is hard to find out what layers exist and where more detailed information is available by zooming in (e.g. to specific site plans for individual archaeological sites within a city or regional map).

In TMView, layers can be set to display both within particular scale ranges and within particular date ranges using a visual metaphor (Figure 5, right). Rather than disappearing altogether, layers which lie outside their display range are collapsed to a single greyed-out line in the legend and a symbol is displayed

next to them (see Figure 5 left). A clock symbol indicates that the layer lies outside the current time range for the map, a plus magnifying glass indicates one must zoom in to see the layer, and a minus magnifying glass that one must zoom out. When a greyed-out layer is highlighted in the legend, its spatial extent is flashed on the map and its temporal extent is flashed on the time bar.

The layer control dialogue also allows setting of other layer behaviours, including whether the layer should be switched on when the map is first displayed, whether it should appear in the legend, whether its symbology should be displayed in the legend and whether a temporal filter should be applied.

Java map viewer

While much of our work has gone into development of the Windows map viewer and data preparation toolkit, it became clear that the download and installation of a complex Windows application was a significant hurdle for the average user simply wishing to retrieve data in a web browser. This led us to develop a Java mapping applet, illustrated in Figure 6. The applet is an intelligent client which downloads vector and raster data and allows local zooming, panning and querying of the downloaded data. This contrasts with the approach of downloading an image generated on a server and returning to the server for each pan, zoom or enquiry. The intelligent client approach makes for a much more responsive application once the initial download has been completed.

The Java map viewer may either be pasted into a web page – in which case it will display a set of datasets specified by their ID numbers in the ECAI metadata clearinghouse – or it can be called to display the results of a clearinghouse search such as that shown in Figure 7.

In setting up the Sydney *TimeMap* museum kiosk, and test datasets for the ECAI metadata clearinghouse, we have developed a number of worldwide datasets of general utility. These include a georeferenced world image (Figure 1) based on the GTOPO30 1km Digital Elevation Model (a 250Mbyte bitmap image compressed in MrSID format and served through the multi-resolution MrSID image server) and a worldwide database of cultural heritage sites (served through a MySQL database).

The worldwide database of cultural heritage sites was seeded with the UNESCO World Heritage listing and is being updated by student volunteers using a password-protected web front-end, with the aim of building a moderately comprehensive worldwide coverage of major archaeological sites.

Metadata creation tools

For TMView and the Java mapping applet to access datasets through the ECAI metadata clearinghouse, descriptive and connection metadata must be created and registered with the clearinghouse. We have developed two methods of creating metadata and registering datasets: a web-browser interface using

JavaScript and a Windows metadata editing toolkit (TME). The Windows editing program provides additional functionality such as a 'wizard' to prepare the metadata, a utility to create shapefiles from database tables and a 'data pump' to upload local datasets to an Internet-accessible server.

TME uses the middle tier application server to support registration of metadata with the clearinghouse and the 'data pump' which uploads vector GIS datasets to standard SQL data servers. TME allows point, line and polygon map data to be stored in any standard SQL data server, obviating the need for an expensive spatially-enabled SQL server or GIS data server. Effective vector GIS datasets can thus be served with freeware such as MySQL on a PC-based Linux server (MySQL is also widely available on commercial ISPs, making it a readily available method for serving spatial data without the help of a specialized GIS lab).

TME tightly controls the entry of metadata using definitions stored in the ECAI clearinghouse (cached locally so the program can be used offline). All elements are qualified by a scheme chosen from those permitted for the element, and where the scheme is a controlled list, values are chosen from a pull down menu. Mandatory and non-repeating elements are enforced. Default sets of metadata are defined to speed data entry, and metadata can be exported and imported in various formats.

Sydney *TimeMap*

The Museum of Sydney describes itself as 'a multi-media, multi-disciplinary installation about the nature and narration of this place now called Sydney'. We installed the first public-access *TimeMap* kiosk – termed 'Sydney *TimeMap*' – at the museum in November 2000, funded by an Australian Research Council grant, in partnership with the Historic Houses Trust of NSW (parent body of the museum) and ESRI Australia. The project provides an opportunity for testing the *TimeMap* methodologies within a data-rich and historically well documented environment, and for assessing user reaction.

Sydney *TimeMap* uses the *TimeMap* viewer, TMView, to provide a time-enabled interactive map interface to a rich and expanding collection of historical images of Sydney, presented in the context of contemporary and modern maps. The kiosk (Figure 8) consists of a Pentium III-500 with Matrox G400 dual head card, twin LCD monitors and a mouse – there is no keyboard. TMView is displayed within a wrapper written in Macromedia Director, which allows the user to choose from a menu of *TimeMap* MapSpaces (left-hand screen in Figure).

MapSpaces have been created for each 20 year period since the European settlement of Sydney along with a number of specific themes such as Cadigal (the Aboriginal inhabitants of Sydney prior to the European invasion) or Archaeology (excavated sites and the NSW Heritage register). As the user rolls over the menu on the left-hand screen, appropriate images and interpretative text for the corresponding MapSpace are displayed on the right-hand screen (Figure 9).

Once launched by the Director wrapper (when the user clicks

on one of the menu entries), TMView uses SQL queries against a master database of digital resources and their spatial and temporal locations to create different map layers showing image viewpoints with the direction of view (Figure 10). Users can overlay modern features (coastline, street grid) onto historical maps warped to fit modern coordinates and examine historical images from the relevant periods in context. Unlike many multi-media applications, the kiosk presents information from a continuously expanding database rather than data programmed into the system.

The kiosk application also displays points representing sites in the NSW Heritage Office site register, positioned by geocoding against an address database. As the pointer is passed over points representing sites or image viewpoints, the name of the site or title of the view is displayed. Clicking on the Heritage Office sites brings up the appropriate web-generated page from the Heritage Office site register.

The kiosk application is a valuable window into user reactions to computerized presentation of historical information, both through logging user interaction and through feedback from users. User reaction has been very positive towards the flexibility and opportunities for personal exploration that *TimeMap* affords. We are using user feedback to improve the kiosk interface and develop ideas which will contribute to a full-scale exhibition at the Museum of Sydney planned for installation in 2003.

Digital image database

A common problem with smaller projects is the use of file-based data, such as Microsoft Access databases or ESRI shapefiles, which can only be shared on a local network and updated by a single user at a time. The problem is compounded if multimedia resources are stored directly in a database, resulting in unwieldy files.

While background map data for Sydney *TimeMap* was stored as file-based resources (and later placed on our server and registered with the ECAI clearinghouse), the collection of many scanned historical images (along with sound and multimedia resources) by people working in two separate institutions demanded the use of a server-based approach. This collection of spatially and temporally located digital resources was, from the outset, stored as a web-accessible server database developed using freeware tools under Linux. We used MySQL as the server database and Zope and Python to provide a web-based interface.

Resources are defined as a particular source document, such as a map, photograph or painting. The resource may exist in several digital versions, such as alternative scans at different resolutions, an original scan and a cleaned up or colourized version, or a reduced resolution version of the original. The database stores the attributes of each resource, and all files which relate to that resource are identified by the database ID of the record storing the attributes, which is allocated sequentially.

Different digital versions of the same original document are distinguished by a set of standard suffixes such as *_original*, *_cleaned* etc. and may be placed in a number of directories

which are identified in a configuration file. This allows us to keep the original high resolution scans, some of them up to 60 Mbytes, in a separate directory from cleaned up and resampled images of adequate quality for all normal purposes.

The web-based database access software searches all the listed directories and displays all versions of a particular resource. The resources are shown initially as thumbnails, but web resolution and original resolution images can be displayed by clicking on the appropriate links (11). All resolutions are generated on-the-fly by Python scripts which resample the images to the desired size, so that multiple resolution versions of a resource need not be stored.

The web-based software can also create web pages on the fly, using a template which defines the format of the page, the database information to be included, and the location and size of the image to be displayed. For kiosk use, a Python script generates – in three separate directories – a thumbnail, a web resolution image and an appropriate web page, again using an HTML template to determine the layout of the page and the database fields to be displayed in it. This script is used to create fixed pages which can be placed on a CD-ROM or accessed locally from a hard drive, rather than depending on an Internet connection to access the server database directly.

Figure 12 illustrates the web pages generated by TMView using the two templates in the Sydney *TimeMap* kiosk application. When a user marquee-selects a number of image viewpoints on the kiosk interface, a scrollable list with basic information is generated from the thumbnails directory. When the user clicks on a single image viewpoint, or selects from the thumbnail list, the kiosk displays the web page for a single image.

Of the 1000 images included in the database, ranging from some of the first topographic sketches of the settlement to contemporary photographs, almost 400 were included in the kiosk installation. The selection was made for a variety of criteria, including aesthetic, technical and copyright issues, but most of those not used in the kiosk remain as geo-referenced images available for further research.

Issues with historical maps

The Sydney *TimeMap* kiosk uses historical maps as a backdrop to contemporary images, site register data, excavated archaeological sites and other historical information. Twenty-three maps were registered, and the final display includes fourteen. These range from a 1788 plan of the encampment and fleet by John Hunter to aerial photograph mosaics from 1956, 1970 and 1994. In developing the map backgrounds we have had to solve a number of problems, both anticipated and unanticipated.

In the first place, it is essential to scan source maps at the highest reasonable resolution (e.g. 600 dpi), and this is not always possible on-site. The owners of rare maps rarely allow them off the premises, and may not be happy to allow them to be scanned or to provide space to set up a scanning facility on-site. The alternative we used in some cases was large format photography

followed by scanning of the positive transparencies on a production quality scanner. In cases where we were able to scan the maps directly, we used a Abakos DeSKan Express scanning system which scans the map in controlled 180 mm strips with an overlaid graticule and stitches them together into an image of up to A0 size. We adopted a minimum scanning resolution of 300dpi and 24 bit colour.

The images generated are, of course, very large – up to 250 Mbytes – and are best archived as TIF files at original resolution, then compressed with a pyramid wavelet compression scheme such as MrSID for delivery. The MrSID compression not only reduces the image size substantially, but also speeds up image display and reduces download volumes when images are accessed over the web. Both TMView and the Java applet viewer allow download and display of lower resolution overviews and progressive update of resolution as the map is zoomed in.

Having obtained a high resolution scan of the map, the next step is geographic registration, which is normally carried out by identifying common points between the historic map and a modern map base. As maps become further removed from the present, the number of persistent points identifiable in the historic map tends to decline – street corners move, buildings are demolished, rivers wander and coastlines are built out. Furthermore, details of secondary importance to the mapmaker, such as the coastline or riverbanks, are often sketched in rather than accurately mapped.

In practice we have found that the best modern reference maps for city environments (we have worked on both central Sydney and on Parramatta) are the detailed cadastral maps. Cadastral information – property ownership – has been one of the driving forces of European large scale map making, and while coastlines, development plans and even mapped buildings are often fanciful, the basic property ownership grid of the city is faithfully represented. With suitable historical interpretation to take account of street realignment, subdivision and redevelopment it is possible to accurately locate cadastral boundary points on historical maps into a modern coordinate space.

A second method of increasing the hit rate for early maps has been to start by registering accurate topographic surveys from the mid nineteenth century, and then using those maps as a map base for registration of earlier maps. Since the structure of Sydney, and many other cities, changed more drastically between the nineteenth and twentieth centuries than throughout the late eighteenth and the nineteenth centuries, the commonality between nineteenth century and earlier maps is far greater than with modern maps.

Maps as historical documents

On some early maps of Sydney, we were unable to identify enough persistent points for registration of the whole map area. Even when adequate registration points can be identified, there is often an embarrassing lack of fit highlighted by the coastline, because the maps are simply not scale accurate. All one can do is either to fudge the registration by inventing points to squeeze

recognizable features into a semblance of modern reality or, as we have chosen to do, to leave the glaring inaccuracies as witness to the historical reality of early mapmaking (Figure). A high priority of the next stage of research is develop a registration system that will systematically capture information about discrepancies in the historical maps.

The other problem which faced us with the Sydney *TimeMap* kiosk was the fact that different historical maps covered different areas, were generally oriented to magnetic north rather than grid north (approximately 14 degrees rotation) and came out irregularly shaped after warping to modern coordinates. Trimmed of excess borders, we ended up with a set of ugly, inconsistent rhomboids inappropriate to the museum's sharp design principles.

To solve this problem we devised the idea of a 'map table' – a uniformly shaped rectangular area on which the scanned and warped historic map is superimposed (Figure 14) as a representation of the historic document with all its supporting material (map key, marginal labeling) and flaws (holes, torn edges). To highlight the nature of the map as a historic document, these latter features are emphasized with a slight drop-shadow.

Notes

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End notes

¹ *TimeMap* is a registered trademark of the University of Sydney

² Earlier versions of TMView used MapInfo Professional and MapX, but technical reasons led us to switch to MapObjects and the open-standard shapefile format.

References

Johnson, I. 1999. Mapping the fourth dimension: the TimeMap project. In *CAA97: Computer Applications in Archaeology 1997*. BAR International Series 750. 21pp [on CD-ROM].

Figures

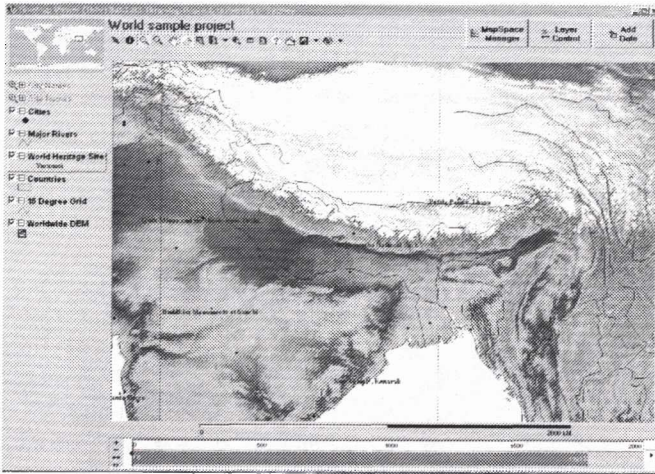


Figure 1. TimeMap viewer (TMView) map window with UNESCO World Heritage Sites superimposed on a 1km digital elevation image

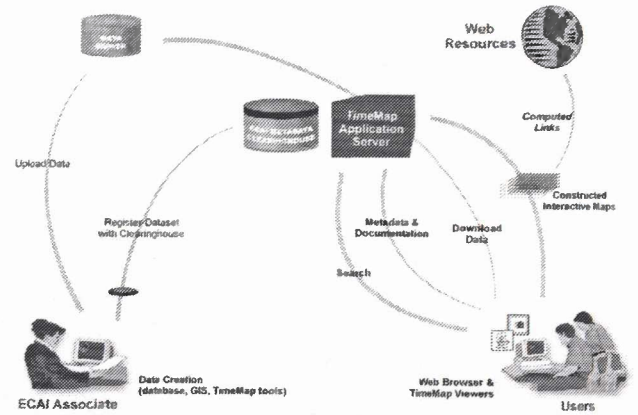


Figure 3. The relationship between TMView, the ECAI clearinghouse and the middle-tier TimeMap application server

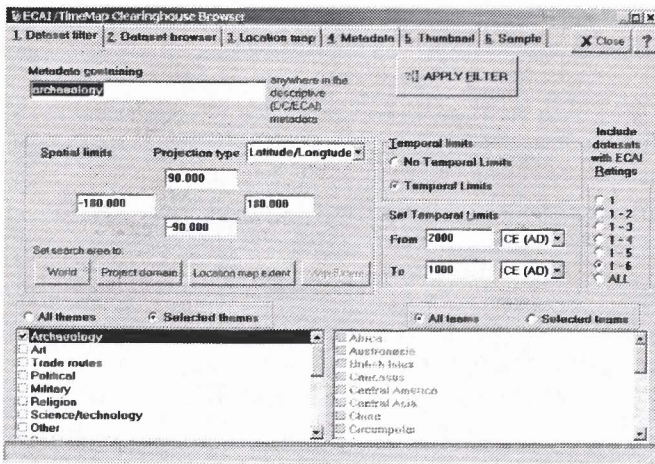


Figure 2. TMView Clearinghouse search filter and results

ID	ECAI Dataset title	Doc	Imp	Thn	Updated	Press
8	Historic photos (20th C) of Sydney including many oblique a				6/23/01 2:21:06 PM	
48	Stein's photographs of archaeological sites, early 1900s				3/30/01 12:31:00 PM	
157	World Cultural Heritage sites (ACL)				6/11/01 2:41:45 PM	
206	Photography of Sir Marc Aurel Stein's travels, early 1900's				6/5/01 11:47:35 PM	
211	Sasanian Empire Extent in 270 ce				6/7/01 5:40:35 PM	
213	Sasanian Empire Extent in 570 ce				6/7/01 5:39:44 PM	
214	Sasanian Empire Archaeological Site Images				6/7/01 5:26:48 PM	
215	Gazetteer of Sasanian Empire Sites from Tubinger Map				6/7/01 5:26:31 PM	
216	Sasanian Seal Collection of Edward Gans at UC Berkeley				6/7/01 5:26:00 PM	
235	Archaeological Sites in the Sydney CBD (Sydney TimeMap)				6/7/01 5:16:31 PM	
241	Aboriginal Place Names of Sydney CBD (Sydney TimeMap)				6/11/01 6:11:49 PM	
242	Links to Historical Images of Sydney (Sydney TimeMap)				7/12/01 3:59:28 PM	
244	European Place Names of Sydney CBD (Sydney TimeMap)				7/14/01 12:23:52 PM	
251	Map Of Sydney 1780 (Sydney TimeMap)				7/11/01 9:36:50 PM	
262	Historical images of Sydney (Sydney TimeMap)				7/14/01 12:25:50 PM	
269	World Heritage Sites				7/14/01 12:29:57 PM	
278	Grave Sites in Cambodia (CGP)				7/2/01 4:05:14 PM	

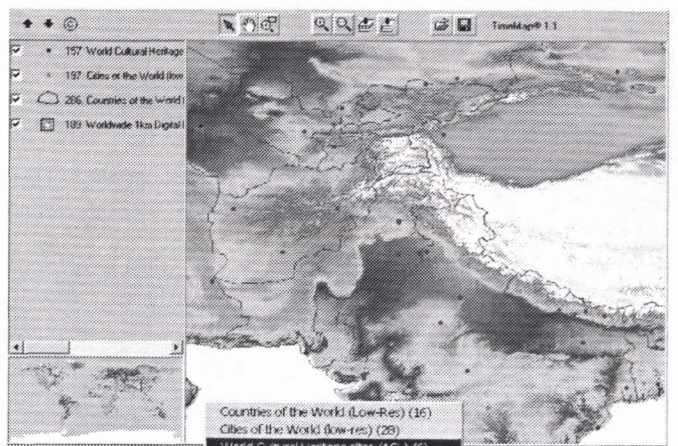


Figure 6. Java map viewer showing world cultural heritage sites (UNESCO listing) superimposed on 1km digital elevation image and world country outlines

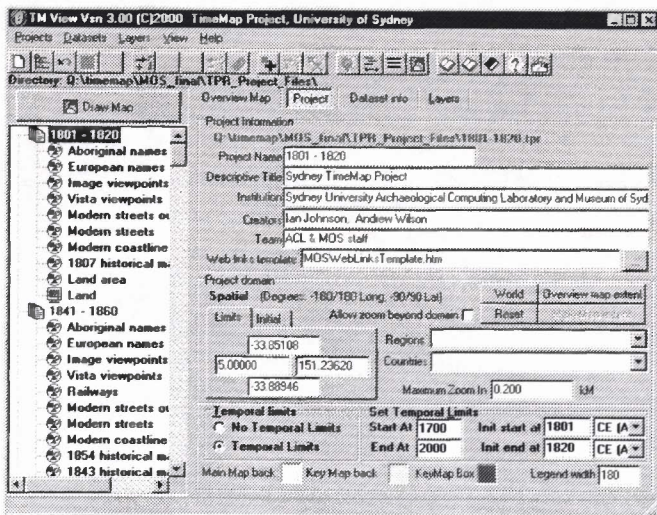


Figure 4. TMView MapSpace manager

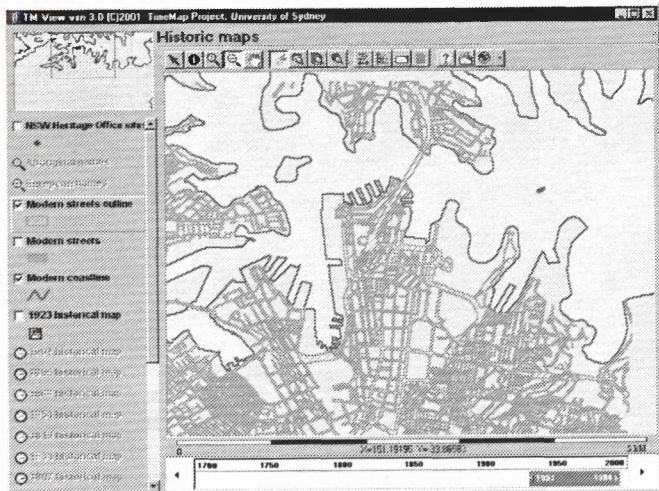
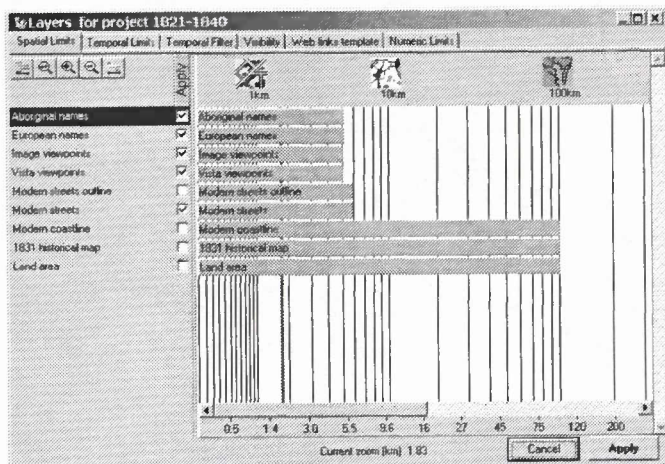


Figure 5. TMView scale visibility – map window with disabled layers and configuration dialogue



ECAI Clearinghouse Search Results

To draw a map, check boxes to indicate the datasets to include, then click Make Map button. Click on the name of a dataset for information about the dataset, or "www" to go to the web site, or "tms" to download the associated TimeMap Mapspace file..

Key (w) indicates password required.

- 3: **University of Sydney School of Archaeology, Home Page**
Published by School of Archaeology, University of Sydney
Created by Ian Johnson
Not yet rated
- 8: **Historic photos (20th C) of Sydney including many oblique air photos from 1930s**
Published by AIRPHO Project, Macleay Museum, University of Sydney
Created by Llewellyn, Richard
Sydney, Historic, Not yet rated
- 9: **Chinese Biographical Database maintained by Marilyn Levine**
Published by Lewis-Clark State College
Created by Levine, Marilyn A.
China, Not yet rated
- 26: **National Archaeological Database (NADB) Reports (USA)**
Published by US National Park Service
Created by Childs, Terry
USA, Prehistoric, Not yet rated
- 45: **Household data for The Rocks 1865**
Published by NA (unpublished thesis) by Wayne Mullen 1993, held by the Department of Prehistoric and Historical Archaeology, University of Sydney
Created by Mullen, Wayne
Not yet rated
- 48: **Stein's photographs of archeological sites, early 1900s**
Published by ECAI
Created by Pascal Simon
China, Not yet rated

Figure 7. ECAI clearinghouse search results showing web sites, datasets and passworded datasets. Datasets are included in the map by checking the boxes



Figure 9: Sydney TimeMap dual screen interface – Macromedia Director wrapper



Figure 8. The Sydney TimeMap kiosk application at the Museum of Sydney

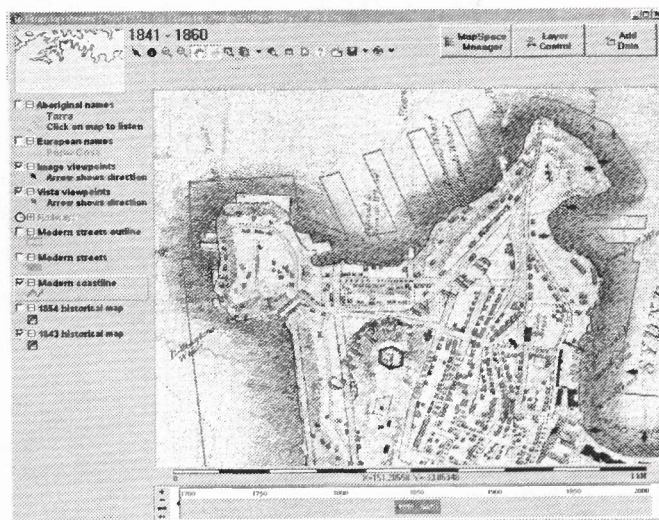


Figure 10. A historical map overlaid with modern coastline, image viewpoints and directions

Sydney TimeMap Assets Listing

Sydney TimeMap Asset 36

Aerial shot of Contemporary CBD - [A]
 1952 [1]
 View

6000 [2]
 Fish eye of CBD or fish eye of CBD]
 1992 [1]
 View

Sydney Harbour Trust map of Walsh Bay [Sydney Harbour Trust map of Walsh Bay]
 ©1926 [1]
 Maps - View

Figure 11. Web-based access to the digital image database showing thumbnail views and a higher resolution image generated on the fly

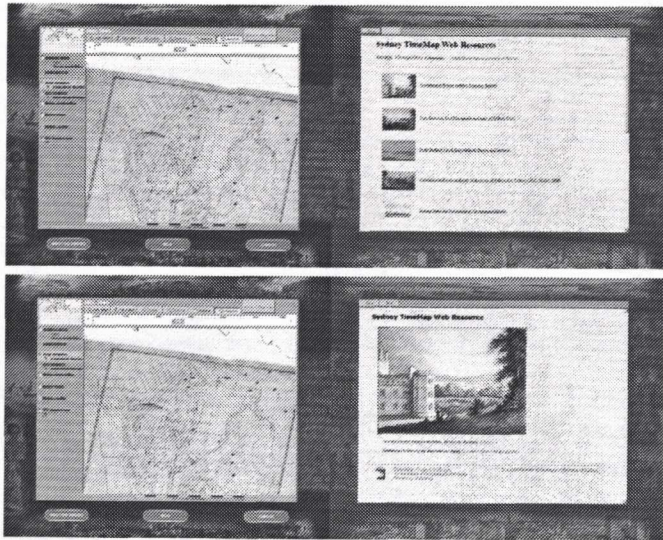


Figure 12. Web pages generated from the Sydney TimeMap kiosk application by the thumbnail template (above) and by the single item template (below).

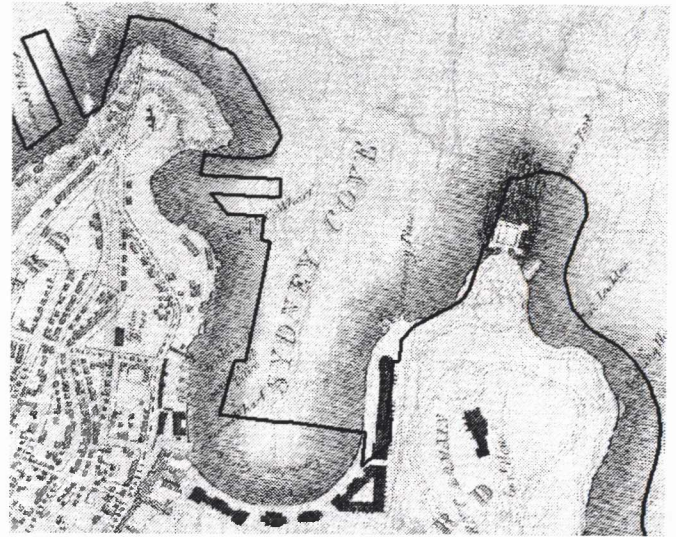


Figure 13. An 1844 map showing the effect of scale error across Sydney Cove (centre)

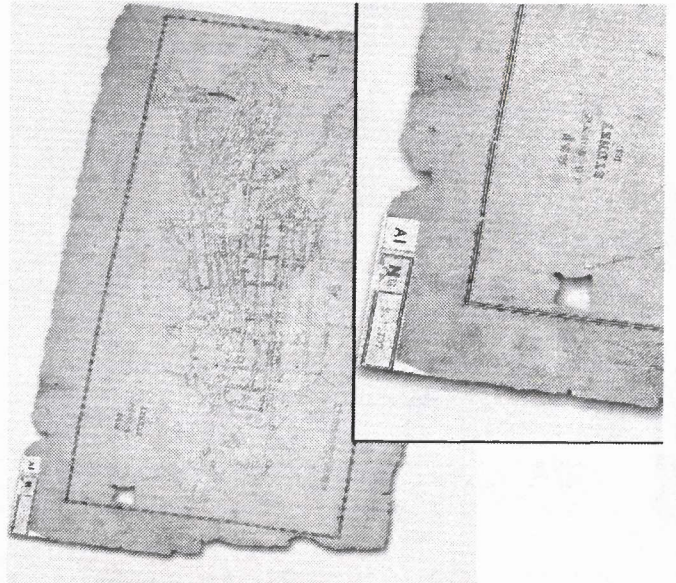


Figure 14. Map of Sydney presented as a historical document on a 'map table' display (detail of map shows use of drop-shadow to emphasise the map as a historical document)