

VISUALISATION AND PRESENTATION OF THREE DIMENSIONAL GEOSCIENCE INFORMATION

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INTRODUCTION

Geoscience Australia is the national geoscientific agency in Australia. Its role is to provide spatial data, information and impartial advice to help government and other stakeholders manage Australia's natural resources and diverse environments, and make informed decisions about land use, regional development, the built environment and urban safety from natural hazards (1).

The organisation is responsible for collecting, maintaining, and facilitating access to vast amounts of geoscientific and fundamental spatial data and information. This includes topographic, thematic and geothematic (geological, geophysical, mineral, petroleum, marine, and geohazards) information, satellite imagery, geodetic data, publications, atlases, and educational material. Access to this information includes on and off-line geographic information systems and databases, publications and maps, digital and hard copy reports, and direct data downloading.

Geoscience Australia is increasingly using 3D applications and tools to model, visualise and add value to its fundamental data holdings. While this has opened up new and innovative ways of interpreting and viewing data it has also presented a challenge to find ways of providing access to this information for our clients.

THE THREE DIMENSIONAL CHALLENGE

Geoscience Australia is continually researching, developing and adding value to the data that government and industry requires. A significant proportion of this ongoing development has involved the collection of increasingly detailed digital elevation and bathymetric data and the construction of regional scale three dimensional models representing the subsurface (ie not exposed) geological structures. Specialist software applications are used for the construction, visualisation, and manipulation of these datasets. These same software applications, while containing a rich array of tools to generate visualisations, are often limited to snapshots or image captures to represent the information outside the application. Unfortunately this normally involves reducing an interactive three dimensional model to a static two and a half dimensional image or series of images. This was acceptable a decade ago when the majority of geoscience data was presented in two dimensions such as maps or geological cross sections because computer hardware and software imposed limits on scientists and technicians. However advances in technology, combined with the widespread availability of fast computers and the explosion of information accessibility through the web, means there is now no reason to limit the display of this information to only two dimensions.

The challenge for Geoscience Australia cartographers and scientists has been - how do we dynamically present the resulting visualisation of our datasets to the geoscientific and wider community in a form that they will be able to easily utilise, understand, and ultimately benefit from.

Our research and development has lead in two directions:

- the production of movies or fly-throughs;
- the generation of Virtual Reality Modelling Language (VRML) products.

MOVIES

The creation of movies or fly-throughs is not a new area of development in the geoscientific field. The requirements for producing a movie - knowledge, tools, and data - have existed to some extent for a number of years. However, a number

of factors such as cost of hardware/software and expertise, combined with the perception that a movie was a special one-off style of product initially lead to its sporadic use for visualisation purposes in Geoscience Australia. The last two years have seen these inhibiting factors resolved to a point where it has become possible to employ movies as regular and cost effective methods for visualisation. In fact the application of movies within Geoscience Australia has progressed to a point where they are now a standard product for many of our projects.

The benefits of using a movie include:

- **Control** - the viewing of a movie is essentially a passive experience where the creator controls what the viewer will see and hear and in what sequence they will experience events. Interaction with a movie is generally limited to play, stop, and pause with the possible use of a slider bar to move quickly through the various scenes. This lack of interactivity and ability to control content ensures that the viewing experience, and therefore transfer of information, is consistent for everyone.
- **Portability** – there are myriad movie file formats available for use today. These different formats all have specific advantages in relation to compression, quality, size, media, and platform. Of these file formats the ubiquitous nature of the Mpeg-1 format, combined with its ISO standard compliance, ensures that any movies created in this format will be viewable on all systems. This is regardless of where the content and the movie were originally generated.
- **Content** – a distinct advantage of using movies is the ability to combine seemingly disparate media such as images, text, audio, video, and animation into a coherent product. The animation or fly-through process facilitates the inclusion of spatially referenced datasets such as digital elevation, GIS, and remote sensing data as content as well as providing a meaningful context for other media. The role of audio is particularly important because its purpose is to engage our auditory senses and to enhance and clarify the simultaneous visual experience.
- **Impact** – another major advantage of movies is the impact they can have upon the viewer. A movie can serve several purposes ranging from an introduction or overview of a subject to the display of a very specific sequence of events. No matter what the subject, a movie has the potential to create an emotional response from the viewer. A positive emotional response will lead to greater retention and recall of the subject and will also hopefully spark curiosity and an increased interest to view other associated material.

Movies can be viewed as an independent product or they can be combined with other applications such as slideshows, html, GIS projects, and pdf reports. Movies can be delivered or viewed via the web, cdrom, dvd, from the hard drive, and on VHS tape.

When utilised correctly a movie provides a very powerful and versatile method for transferring specific information and knowledge in a consistent way to the viewer.

MOVIE PRODUCTION

Production of movies within the geoscientific environment is no different to the tried and true methods employed by professional production companies. Figure 1 describes the workflow used within Geoscience Australia to produce movies which may vary considerably in length and complexity.

1. Concept/Storyboard

This first step is one of the most important stages in the production of a movie. When the term 'Storyboard' is mentioned people immediately imagine teams of talented artists producing detailed sketches depicting frame by frame action. In reality, for our purpose, a storyboard may consist of a few very rough sketches with some simple directions or even just the written directions. In Geoscience Australia this is prepared by the cartographer in consultation with project scientists. Without a storyboard the production process becomes very much a hit or miss gamble as to whether the final product will meet the needs of the project and ultimately, the user. The storyboarding process is much the same as normal project planning. It involves planning the direction, flow, timing, and overall look and feel of the movie as well as ensuring that the concept will be appropriate for the target audience. The storyboard also serves as a reference for anyone involved in production of the movie.

2. Gather Media

Movie content is essentially a mix of still images, text, audio, and video footage (referred to in the industry as 'media'). Audio may also consist of production music, narration, and sound effects. The 'video' footage Geoscience Australia

normally uses consists mainly of animation or fly-throughs that have been generated within ERDAS Imagine Virtual GIS. The advantage of using a software package such as Virtual GIS lies in the package's ability to display digital elevation data, satellite imagery, GIS data, and three dimensional models together in a common **spatially referenced** environment. The resulting animation created from this spatially referenced environment provides an important framework to incorporate other pieces of content into the movie. Another important advantage is the ability to create a flight path where the speed, altitude, azimuth, and pitch of a camera can be fully adjusted to create a fly-through of the data. This animation and any other video footage is usually rendered or captured to uncompressed avi format.

It is important that all copyright and intellectual property issues relating to the media being used for the movie be addressed before proceeding to the next stage.

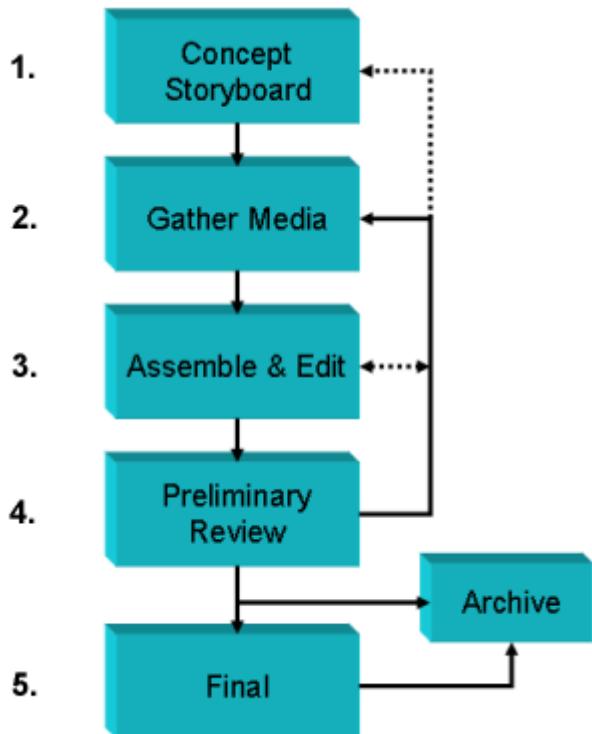


Figure 1. The fundamental steps in creating a movie.

3. Assemble and Edit

A member of the Geo-Visualisation team, using the storyboard as a guide, assembles the various media into a timeline using non-linear video editing software. While this process appears easy it can become quite complex when the various pieces of media are combined with transitions, moving paths, text, titles, and credits to form the completed movie. This stage also tests the suitability of the various media. It is not uncommon, for example, to find that an image may lack resolution or that the pace of a fly-through is too slow when compared with the rest of the movie. In these situations tools within the video editing package may be able to adequately resolve the problem, otherwise the media may have to be recaptured.

4. Preliminary Review

Once the video editing technician has completed the task of compiling the movie a preliminary copy is created for reviewing. The review process involves the project scientists and managers as well as members of the Geo-Visualisation team and ensures that the movie reflects the original concept as outlined in the storyboard and will serve its intended purpose. This process is an iterative one where, depending upon the complexity of the project, it may be necessary to revisit and modify any one of the previous steps before the editing process is judged to be finished.

5. Final Copy and Archiving

The last stage in the process is to create the final copy of the movie prior to archiving. The final copy of the movie is created in uncompressed avi format before being converted to Mpeg-1 for distribution. The size of these movies varies depending upon their intended application. For example, a movie which is to be used for promotional purposes in a booth at a conference with a duration of 3 minutes will normally have a resolution of 640x480 at 25 frames per second

and have a physical size of approximately 120 megabytes. The large size of the file reflects the higher quality compression settings and the ability to enlarge the movie to fill the entire computer video screen without noticeable loss of image or playback quality. These settings are altered to provide a much smaller file size for use on cdroms, web, and slideshows. The total project including all media, the timeline, the final uncompressed movie, the distribution copy and all metadata are archived for possible future use or referral.

EXAMPLES OF MOVIES

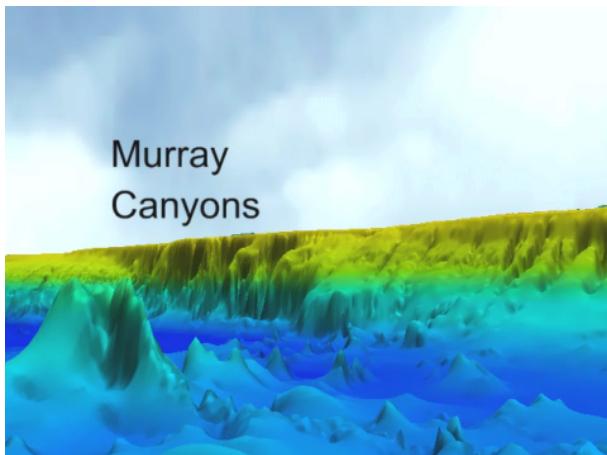


Figure 2. Murray Canyons (South Australia) bathymetric fly-through movie.

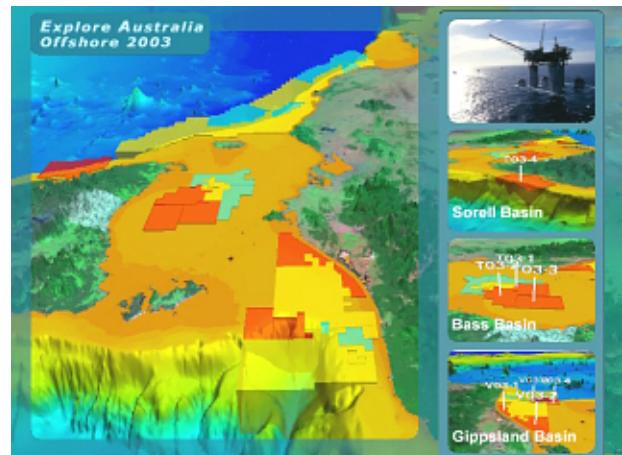


Figure 3. Promotional movie for Acreage Release at APPEA 2003.

VRML MODELS

Virtual Reality Modelling Language (VRML) is a 3D content development language for the internet. VRML, a simple language used to describe 3D objects and scenes, was conceived in 1994 at the first World Wide Web Conference. Since that time VRML has undergone a number of revisions and became an ISO/IEC standard in 1997. Current efforts in VRML development have been concentrating on developing an XML version called X3D which will maintain backward compatibility with VRML while taking advantage of the developing XML environment (2). Throughout its life VRML has been constantly criticized, however despite this it continues to survive as a viable method to publish 3D models on the web and also as a common file format for transfer between 3D modelling packages. In fact most 3D modelling, CAD, and GIS applications have the ability to export to VRML.

Geoscience Australia utilises a number of expensive and complex software applications such as ArcGIS, Gocad, EVS, and ERDAS Imagine Virtual GIS for visualisation (and other) purposes. These are normally operated on high-end computers – typically dual processor, with 2 Gb (gigabytes) or more of memory, and special OpenGL compliant 3D graphics cards. Our clients do not always have the same high-spec hardware or software applications and therefore require an alternative way for viewing visualisations created in these packages. Exporting our visualisations to VRML enables them to be viewed by anyone with a basic computer running a browser and free VRML plug-in. It is also possible to combine visualisations from the different packages as well as integrate other information to create a VRML project which is both highly interactive and informative.

The benefits of using VRML include:

- **Interactivity** - unlike a movie which is a passive experience, a VRML model is interactive and is therefore classed as an 'active' experience. This means that a user is actively involved in exploring the model by using the navigation tools provided by the VRML plug-in, such as explore, pan, slide, goto, etc. The level of understanding of information a user may obtain from a model will also vary due to the interactive nature of these projects. This can be controlled to some extent by providing preset viewpoints and 'virtual guided tours' displaying aspects of the model. However a major benefit of using VRML is in not limiting users but instead allowing them to discover information by examining relationships between various parts of the model and viewing those same relationships from any aspect they may choose.

- **Accessibility** - VRML models require a web browser and a plug-in, both of which can be freely obtained for the major platforms. While not absolutely necessary, a good 3D graphics card will also improve the response of the model when manipulated, which in turn enhances the exploring capabilities.
- **Customisation** - the VRML language not only contains node descriptions for geometry, it also contains descriptions for animation, interaction, proto, and script nodes. The script nodes in particular allow javascript or java to be used for extending the standard capabilities of a VRML model. The proto nodes allow an element of object reuse to make file sizes more compact for downloading as well as providing a method for extending the basic geometry to more complex types. Depending upon the type of VRML plug-in used to view the model you may also be able to programmatically interact with the model via the web page or another application.
- **Integration** - VRML is principally designed for the display of 3D geometry. However it can also display text, 2D images, sound, and movie files in the 3D environment. Objects within the model can also be utilised as hyperlinks enabling a user to move from model to model or access other types of data such as html documents or database information. VRML models can be embedded in a web page with or without associated information or they can be used in other applications such as Powerpoint.

It is essential to understand that in the majority of cases VRML models which are exported from other modelling packages will need to be processed further before they are ready for general use. Unfortunately due to the different methods used by applications to export these models it is not always a straightforward process to clean and optimise the model. Once this task has been performed the model can be customised and embedded in a web page.

VRML models, when implemented correctly, are powerful and versatile method of delivering information in an interactive environment which encourages information discovery.

MODEL PROCESS

The VRML modelling process developed within Geoscience Australia involves the stages shown in Figure 4. This process has evolved through trial and error and will continue to evolve as VRML makes the transition to X3D.

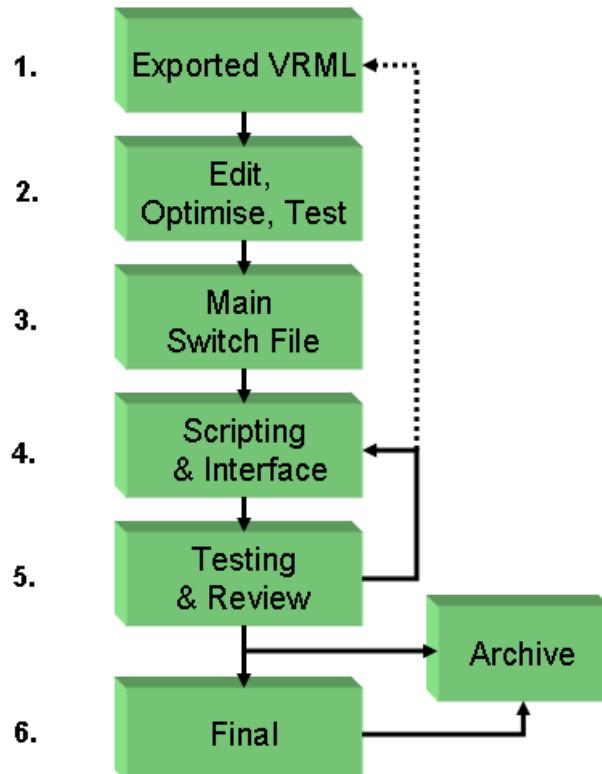


Figure 4. The fundamental stages in creating a VRML project.

1. Exported VRML

The exported VRML consists of VRML files which have been produced by (exported from) a package such as Gocad. The aim at this stage is to break up a large project, which may have many different types of surfaces and volumes, into component VRML models. These component models will form layers which can be switched on or off through an html interface when the project is completed. This process also creates a modular project where an update to a layer will only affect that particular component file and not the whole model.

2. Edit, Optimise, Test

All VRML models exported from applications must be edited using a text editor to remove extraneous and duplicate information such as viewpoint, background, and lighting settings. The optimisation stage involves running each VRML file through a series of automatic routines to remove duplicate coordinates, reduce colour definitions, and reduce coordinate decimal places to a level that the VRML plug-in will manage. The objective of the optimisation stage is to make the VRML file as efficient as possible without altering the appearance to any discernable level. The final step at this stage is to test the individual VRML files to ensure that they still display and behave as expected after the editing and optimisation stages.

3. Main Switch File

Once all of the component files have been created and edited the main switch file can be assembled in a text editor. The purpose of this file is to facilitate the display of the various component files in a common viewing space. This is achieved by creating a switch node containing an inline node for every component file which can be accessed by the external javascript interface. This file will also be the central container for all of the lighting, viewpoints, scripts, and animation nodes as well.

4. Scripting and Interface

The main switch file requires a javascript interface to access and switch on or off the component VRML files. The web page container is divided into a series of frames to allow for the embedded model, project title and logos, and two javascript interfaces - one for the switching of layers and the other to access predefined viewpoints and scripting for animating or rotating the model.

5. Testing and Review

Once the project has been assembled it is tested to ensure that all layers and custom scripting behave as expected in the targeted browser/plug-in environment. The review process involves project scientists and managers examining the VRML project in comparison to the original model to ensure that it matches it as closely as possible. Before posting to the web the VRML project must also pass a Quality Assurance (QA) test. This QA process is performed by an independent member of staff with no previous involvement in the project. This independence ensures the process is rigorous from a technical, scientific, and client point of view.

6. Post to Web and Archive

This final stage involves compressing the VRML component files using gzip to create the smallest possible downloadable files before posting to the project web site. The gzip style of compression must be used as it is the only compression format the VRML plug-ins will recognise. Another benefit to creating a VRML model as a series of component files is that the end user will only download the files as they switch each layer on. This method avoids the need for one large download and instead allows for progressive downloading of the model. The completed project and all source files and documentation are archived.

PRESENTING THE PRODUCT

The completion of a movie or VRML model project is not necessarily an end to the process of presenting geoscience information. A movie or VRML model can be distributed and used on its own with reasonable success. However, it has been our experience that creating an interface which integrates the movie or model with other associated information, provides the user with a more informative environment.

An example of this is the 'kiosk' style project (Figures 5) completed by the Geo-Visualisation team in March 2002 for a major petroleum exploration conference. The task was to create a fly-through movie for display at the Geoscience Australia conference booth depicting the new offshore acreage release areas for petroleum exploration. A decision was taken to create one major movie depicting all release areas around Australia as well creating smaller movies with higher

detail for each individual area. A web interface was then created to link these movies, associated images and text to an image map. This image map (top right image, figure 5) provided a geographical frame of reference for selecting all available information about a particular exploration region. The web interface provided the user with a meaningful context to view the various information contained in the kiosk. The kiosk project was a simple low-cost solution which significantly enhanced the purpose of the original movies as well as creating a more user friendly interface for conference delegates.



Figure 5. Acreage Release 2002 interactive kiosk.

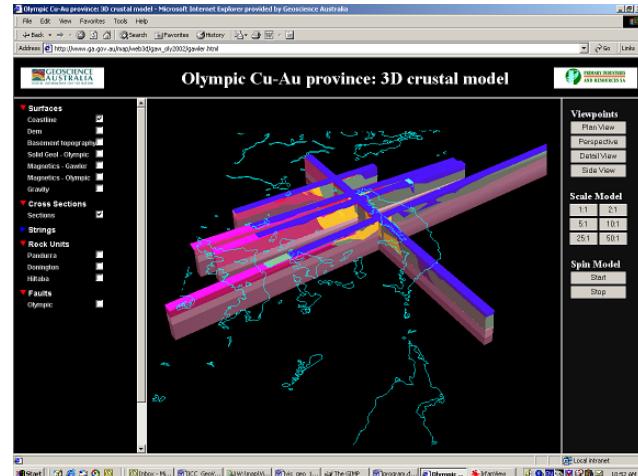


Figure 6. Gawler Craton 3D Crustal VRML model.

VRML models also benefit from significant interface enhancements which can vastly improve the user experience. An example of this can be seen in the Gawler project VRML product (Figure 6) http://www.ga.gov.au/map/web3D/gaw_oly2002/gaw_intro.html. Once again we have used a web interface to simplify the task of viewing the model and associated information. This is achieved through the use of javascript driven collapsable menus (left panel, figure 6) and buttons (right panel, figure 6) combined with hyper-links to html pages and the model itself. Without these enhancements the model would be unwieldy to manipulate and difficult for the user to understand.

Until now I have described the use of movies and VRML models as separate products. However, they can be used quite effectively together in conjunction with a web interface to form an integrated product. We have found that a fly-through movie can provide an excellent overview or introduction to a geographic region, especially for a user unfamiliar with the territory. Once the user has been introduced to the geographic region they can examine in more detail various parts via the VRML models. This style of product provides the user with both interactive and non-interactive methods to explore the information.

FUTURE DIRECTIONS

The immediate future direction for 3D visualisation research and development within Geoscience Australia will concentrate on implementing refinements to established workflows, techniques, documentation, and end products. This is vital to provide a solid platform from which to further develop visualisation and presentation capabilities well into the future.

Based on current and emerging technologies our longer term approach will include the following areas for evaluation and development:

- VCD and DVD content delivery;
- Application of web streaming for content delivery;
- Adoption of Synchronised Multimedia Integration Language (SMIL);
- Monitoring of MPEG 4 & 7 developments;
- Implementation of X3D as a progression of VRML .

Combined with these will be the constant monitoring of industry developments with regard to technology, formats, and the application of appropriate international standards.

To date, in the short period of time that we have been engaged in 3D product development, the Geo-Visualisation team has had some spectacular successes and received wide acclaim from colleagues and clients. The challenge now is to build upon these successes by taking advantage of the rapid advances in computer technologies and harnessing the power and pervasiveness of the world wide web.

Built and presented in the correct way, 3D visualisation products are powerful tools for the interpretation, presentation, and exploration of geoscience concepts and information. One picture may well be worth a thousand words, but one interactive 3D visualisation speaks volumes.

TERMINOLOGY

APPEA	Australian Petroleum Production Exploration Association, body representative of the oil and gas exploration and production industry in Australia.
AVI	Audio Video Interleave, a common Microsoft video format for PCs.
DVD	Digital Video Disk or Digital Versatile Disk, the next generation of optical disc storage technology.
GZIP	popular data compression program.
HTML	HyperText Markup Language, non-proprietary publishing language for the World Wide Web.
JAVA	programming language developed by Sun Microsystems which allows World Wide Web pages to contain code that is executed on the browser.
JAVASCRIPT	programming language that is used to add interactivity to web pages.
MPEG	Motion Pictures Expert Group – name given to a group of international standards developed for compressing audio and video, eg, MPEG-1, MPEG-2, MPEG-4.
PDF	Portable Document Format, is a universal file format that preserves the fonts, images, graphics, and layout of any source document, regardless of the application and platform used to create it, developed by ADOBE.
VCD	Video Compact Disk, CD that contains moving pictures and sound which uses the MPEG compression standard.
VRML Plug-in	piece of software that is used to expand the functionality of the browser to enable the loading and viewing of VRML models.
XML	Extensible Markup Language, designed to improve the functionality of the Web by providing more flexible and adaptable information identification.

REFERENCES

1. http://www.ga.gov.au/about/corporate/service_charter.jsp
2. AE Walsh, M Bourges-Sevenier, Core Web3D, p.38, 40, 46, 48 (1999).