A New View of Delft

Delft geodesists and industrial designers show 3D perspective based on seventeenth century drawings and prints

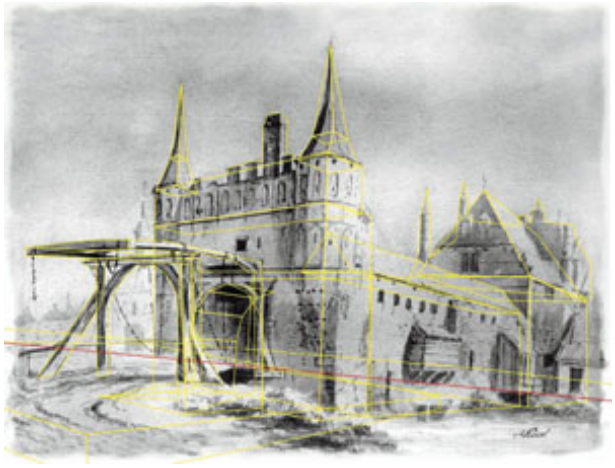
Johannes Vermeer (1632-1675), View of Delft, ca. 1660-61, Mauritshuis, The Hague. The Schiedam Gate is in the centre, with the Rotterdam Gate on the right. The sunlight strikes the houses along the Geer canal as well as the tower of the New Church. The foreground and quays are in the shade cast by the clouds, and the small patches lit by direct sunlight give a strong sense of depth to the composition.

In order to gain a comprehensive view of the consequences of large infrastructure operations, good imaging techniques are essential to present projects in a clear manner. At the Delft Department of Geodetic Engineering, Virtual Reality techniques have been linked for the first time to geographical information systems (GIS). Not only can this result in nice visuals of future landscapes, it has also brought to life the historic Delft of the days of Vermeer. At the department of Industrial Design Engineering a series of computer animations was created in the project Walking with Vermeer, that lets the viewer stroll through the streets of seventeenth century Delft.

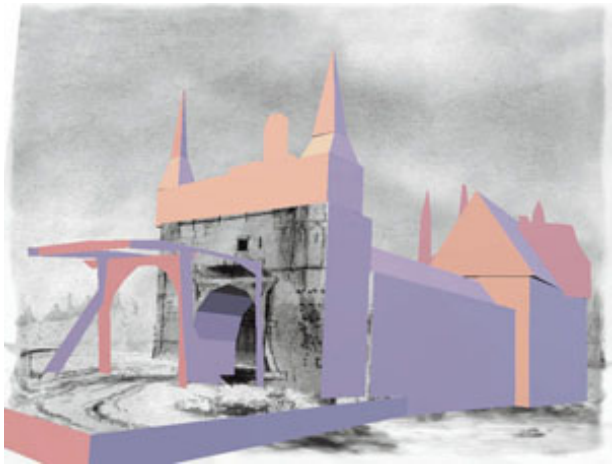
Together with Amsterdam art historian Kees Kaldenbach, geodesists at TU Delft have created a new View of Delft. Using a computer display and Virtual Reality techniques, the computer application lets the user look down upon the town as it appeared in 1660, the year in which Johannes Vermeer painted his world famous View of Delft. You can fly over seventeenth century houses and streets, along the Delft canals, passing the Old Church on your way to the town centre

to see the central market place with the Town Hall and the New Church at opposite ends. Since this bird's eye view does not show the town in detail, a second demo program has been made, taking you on a seventeenth century tour of the town. This demo was also initiated by Kaldenbach. The Walking with Vermeer animations, which were created at the ID-Studiolab of the department of Industrial Design Engineering, takes you on a virtual stroll through the town. You pass a town gate with its heavy oak beams, and walk through the streets where Vermeer went.
'The first time I saw this, I went wow!', says art historian Kaldenbach, 'I have this insatiable appetite for images. This is a brilliant way of bringing the art of the Old Masters to life for the general public.'
Kaldenbach has been fascinated by Vermeer for as long as he can remember.
In his living room in Amsterdam he has had a full-size replica of Vermeer's View of Delft hanging on the wall for over 25 years – the original is in the Mauritshuis in The Hague.
Kaldenbach: 'Vermeer shows us the town early in the morning sometime in the first half of May, with the morning sun catching the red tiled roofs of the houses along the Lange Geer canal and the tower of the New Church.'

Seventeenth Century Tour of the Town At the ID Studio Lab of the department of Industrial Design Engineering, researcher Aldo Hoeben has also caught the Vermeer bug. Hoeben, who graduated in February 2001, works part-time at the department, spending the remaining time at his own media design agency, studiopko in the town of Schiedam near Rotterdam.
Hoeben: 'When I was still a student I looked at the merits of various software packages for sketching designers. We are currently using a Tablet PC, which lets you draw with a pen on a touch screen. The thing is, you need software that really takes advantage of the unique qualities of such a machine.'
During his research, he encountered the Canoma software package. Canoma is one of the first software packages that lets you use sketch-like techniques to design in 3D using a photograph or sketch as a basis instead of an abstract model. The designer adds the correct geometrical data to the sketch turning it into a 3D object. The ID Studio Lab people were looking for the right material to use to practice on when Amsterdam art historian Kees Kaldenbach contacted them. He turned out to be an expert on the seventeenth century Delft of Vermeer (1632-1675) and his contemporaries. Over the years, Kaldenbach had collected an impressive portfolio of reproductions of paintings, prints, and drawings from different sources, including the Delft Municipal Archives.
'There is probably no other spot that has been sketched and painted as often as the southern harbour of Delft, with its comings and goings of canal boats and barges,' Kaldenbach says. His extensive image archive was used to select a number of connecting drawings and prints with good perspective. Graduate student Petrik de Heus helped to create the fabulous Walking with Vermeer



Using the Canoma program, which was expressly designed to produce 3D geometries, Aldo Hoeben worked with Kees Kaldenbach to process drawings showing seventeenth century Delft into a 3D animation. After scanning the drawing of the Rotterdam Gate (Jan van Kessel, 1641-1680), a simple geometry is superimposed on the image. The Rotterdam Gate is subdivided into blocks, trapezoids, cones, and rectangles.



For each of the geometry's surfaces, Canoma extracts a texture from the original image.

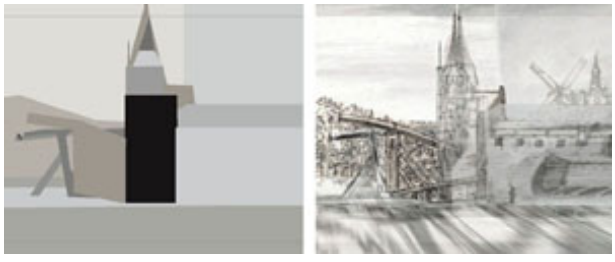
Based on the completed geometrical structure and the added textures, new views can be calculated.

computer animation. You can imagine yourself on a historical film set as you pass through the south town gates that Vermeer painted in his View of Delft, and walk into the seventeenth century town. The Rotterdam Gate and the Schiedam Gate were demolished in 1834-1836, but the armoury is still there. The characteristic details for this tour were taken from various drawings and prints that were joined in an operation that took quite a bit of improvisation. Using Canoma, the images were transformed into 3D representations, which were then spliced together into a series of QuickTime movies. The movies can be viewed on the Industrial Design Engineering web site.

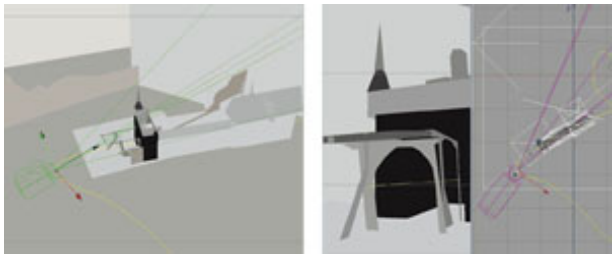
Wireframe of a newly created perspective (on the left): a side view of the Rotterdam Gate. In the image on the right, the corresponding textures have been applied.

Josua de Grave (ca. 1645-ca. 1712) also produced a drawing of the Rotterdam Gate. This picture was made from a different viewpoint and thus provides additional information about the surroundings of the Gate.

Side view of the Rotterdam Gate as a wireframe (left) and filled in with textures (right) created using the drawing by De Grave.



In this image, the two side view compositions of the Rotterdam Gate have been superimposed, revealing that both the wireframe (left) and the rendered version (right) are mismatched. This results in a number of interesting artefacts, including the different positions of the drawbridge beams.



Camera obscura

It took about 100 hours to define sufficient detail and manipulate and process the prints with the computer program. According to Hoeben, it is a time-consuming process, but it yields splendid results. Each time the imaginary tourist changes position, the perspective also changes, and the program has to calculate the image from the new point of view, keeping everything else in the right perspective. One problem was that the designers encountered proportional discrepancies between different drawings or prints.

‘At some overlaps in particular, interesting artefacts occur, which have their own aesthetic,’ Hoeben says. ‘Whatever the case, the idea of using modern technology to walk through seventeenth century drawings is a new one, and hasn’t been shown before.’

Another problem was that the perspective in some sketches did not always match reality. The software on the other hand required the geometry to be exactly correct, or all kinds of mathematical problems would be introduced. Like today’s artists, painters in the seventeenth century knew a trick or two to manipulate perspective. For example, we assume that Vermeer used a camera obscura for his work. Vermeer’s famous View of Delft itself was actually not used for the computer animation, one of the reasons being that the panorama, offers little perspective information.

‘And let’s face it,’ Kaldenbach says, ‘in a way Vermeer’s work is too sacred to be used in such a way.’

Does a seventeenth century tour of the town provide Kaldenbach with additional insight into Vermeer’s work?

‘To be honest, no it doesn’t,’ the art historian admits, ‘rather the reverse. The more you look at Vermeer’s work, the more you marvel at it. He really worked magic, there’s no doubt about it. Everybody agrees that Vermeer managed to find brilliant solutions to a number of imaging problems by using very subtle manipulation, but exactly how he did it remains a mystery. Curiously, the recipe remains a secret.’

Visualising Plans

Geodesist Ir. Edward Verbree first met Kaldenbach in the summer of 1998. A year before, the GIS Technology section of the TU Delft, where Verbree works as a lecturer, had embarked upon a relatively large externally funded project as part of the Land, Water, Environment, and Information Technology programme. This

government investment scheme aims at improving and supporting decision-making processes. One of the products developed during the project is a geographical information system (GIS) using geographical data visualized in 3D in an interactive environment.
Verbree: 'The idea is not new. Look at the ancient cartographers. Medieval maps always show the town and surrounding countryside in a bird's eye view, with recognizable town gates and church spires. However, this ploy cannot be maintained for larger areas – just try drawing a map of Greater London from the air. So, today we process geographical data in two-dimensional maps, the real world squashed flat. Houses have been abstracted down to little squares, and roads become lines. By adopting such uniform rules, you can make a map of the whole country, and compare different maps. Even so, a 3D image still is much easier to understand.'
Large planning projects with new infrastructure such as motorways and railways, involve «selling» the plans to the authorities and the people. Public discussion is increasingly important. To make such discussions really work, the parties involved need to see what the proposed alterations will look like in reality. A new building can be presented by means of a photomontage, or an artist's impression, but large infrastructure projects like new stretches of rail track require different presentation techniques to show the visual effects.
Verbree: 'Public discussion should be more than just feedback of the 'fine, it looks very nice' kind. The public should also be able to assess different modifications to the plan to decide on the final details. For instance, if you're going to have a noise barrier in front of your house, the least you can expect is a say in the material used for its construction; you might want the transparent option.'

Vermeer's Delft

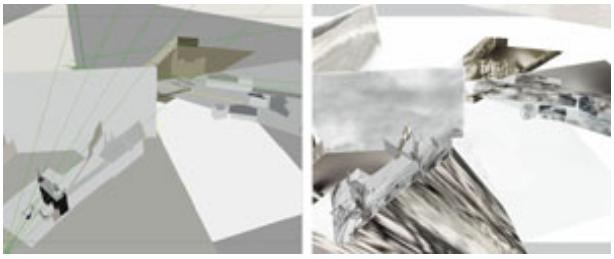
Looking for a scientific exercise to make an easy-to-understand, three-dimensional geographical information system, the thoughts of the Delft geodesists first went to the northeast branch of the Betuwe railway. A number of different engineering consultants were ready to provide the necessary data, but the entire plan was cancelled for political reasons. Design data for another project, the construction of the Westerschelde Shorelink, also proved difficult to obtain because this project had already been finished.
Verbree: 'So we decided to create our own project, and at that precise moment, Kees Kaldenbach knocked on our door with his plan to visualise Vermeer's Delft for the public. All the data we had of the old town came from his collections of views of buildings and some old maps. Kaldenbach wanted a virtual reality computer animation that would give you an animated bird's eye view of Delft as it was in the days of Vermeer. He came at exactly the right time.'
Kaldenbach had spent years analysing the picture down to the smallest detail. He knows the history of every building, dress and boat in the painting View of Delft by Vermeer.
'Information like that can be processed by a

A bird's eye view clearly shows how the geometrical structures derived from the pictures by Van Kessel and De Grave have been slotted together. These two images match only in the side view shown earlier.

Frame of an image from the Walking with Vermeer animation. On the right is a plan view in which the route of the virtual camera can be seen. The plan view was used by the animator to prevent the virtual camera from being moved through a wall.

Engraving of the Delft armoury by Pieter Smith (1667). This building strikes the eye as soon as the virtual tourist passes through the Rotterdam Gate. Unfortunately, the stepped gables of the original have disappeared from the surviving building, which now houses the Delft Army Museum.

Two drawings combined: on the left, the town side of the Rotterdam Gate, with the Capels Bridge to the right. The next building is the Schiedam Gate, which is closed. Continuing to the right we see the Kethel Gate, which provides access to the town harbour quay. The houses on the right are located on the south side of the Oude Delft canal.



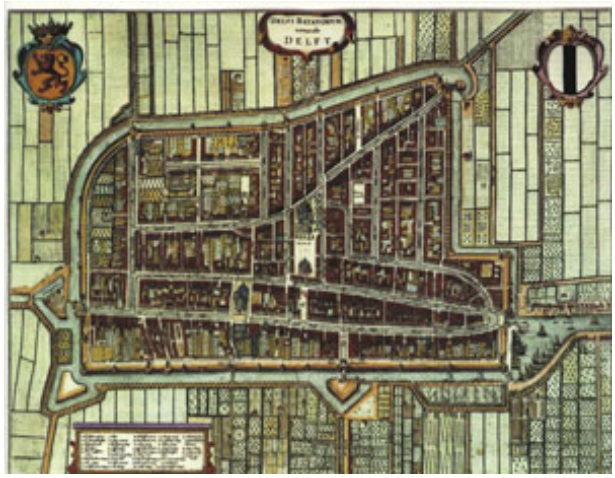
geographical information system,' Verbree says. 'This involves extracting the relevant details from the map, modelling them into the system, and then visualising the result for the user. Visualisation can take the form of a new map, but it can also be done using computer animation.'
There are two basic methods for modelling data in a geographical information system. The first is to start by looking at the real world, then modelling it using polygons, lines and points, and presenting the result visually in the form of a map. The other method is to start with the map and to reconstruct the real world from it. The real-world of the seventeenth century Delft has disappeared, but old maps of the town still exist, as do drawings and pictures of a number of buildings. These enabled the researchers to construct a 3D animation, which may prove to be of interest to historians and other enthusiasts.

Karma
Advanced computer software was used to create the 3D animation in four steps. The first step involved digitising a historic map of Delft using a flat-bed scanner. For this purpose, Kaldenbach and Verbree chose a map drawn at the end of the seventeenth century by Frederik de Witt.
Verbree: 'By scanning the map, we had obtained an electronic image in which every house and street appeared as different picture elements.'
This information was then transformed to a Geographical Information System (GIS) as a system of polygons, lines and points. A point indicates a location, and a polygon is a boundary. In this way, the program defines a simple, rectangular house as a rectangle. Other polygons represent streets, canals, or arable land, with each of the polygons being given its own object identity. The GIS system lets you use different layers, so a bridge over a canal receives both the code «street» and the code «water». The next step is to give each of the rectangles representing houses its own characteristic height, previously recorded for each object. The resulting map is already quite realistic, with blocks of houses on it. The fourth and last step is to use 3D Computer Aided Design (3d CAD) software to create three-dimensional representations of a number of GIS objects so they can be visualised in space. The program used for this purpose is Karma, a powerful piece of software developed by the department of Geodetic Engineering in cooperation with the departments of Technical Mathematics and Technical Informatics at TU Delft. The team was joined by an external company, mcw-studios, for the last bit of this stage. Finally, various 3D objects such as houses and churches were «wallpapered» with photorealistic textures obtained by taking bits from pictures of walls, tiled roofs, etc. In this way, buildings and windmills, the town ramparts, and the Old and New churches were given a realistic appearance, using historical images from old paintings and drawings whenever possible.
Every time the viewer changes position, the changing image must be instantly recalculated from the model in a process called real-time rendering. For this to work,

Bird's eye view of a composition containing the geometrical structures derived from the four preceding prints. On the left image shows the wireframe, the right shows the added textures. Note the way in which the texture of water looks distorted in the image on the right. This is the result of stretching a small section of the original image to cover a much large area. From his normal walking perspective, looking almost parallel to the elongated plane, the viewer will hardly notice the difference.

Detail of the seventeenth century map of Delft showing the town harbour and a modern map of the same area.


View of Delft from the same viewpoint (Hooikade) as seen in the seventeenth century and in the twenty-first century.


Map of Delft after Frederick de Witt (late seventeenth century).

the hardware, the software, and the model itself must be of the highest standard. To add even more realism, the viewer wears 3D goggles that present a stereoscopic view, with real depth information. The system displays different images for the left and right eyes, which alternate at high speed (30 times per second). The 3D goggles separate the images, presenting each one to the correct eye, enabling the brain to reconstruct the stereoscopic image.

Open GIS Standard

Navigation in the 3D world created by computer programs is not a simple task, so users have to be trained to some degree. The demonstration version for the general public has been made «monkey-proof» by removing all the interactive options, leaving the user with just a navigation button. For other applications, e.g. the design of large infrastructure projects, the program includes a number of interaction features, enabling users to introduce changes and assess the results.

Verbree: 'Our main challenge was to build a single system that planners could use to present their ideas at both local and national levels, and that can be updated according to the latest insights. This also means that the maps to be used can be kept up to date. Planners, design consultants, ecologists, and landscape designers are still focused on their own bit of the design process. In many cases, goverment politics will upend this process, and each stage will be marked by new rounds of public discussion. If one could collect all the basic data in a single GIS, which all the parties involved could then use to base their processes on, you would save lots of time and money, and it would become much easier to include any ideas which occur halfway through the process.'

The Karma system's architecture has been conceived according to this principle. In future, land registry, ordnance survey, national planning department, and municipal services will work with open geographical databases based on the Open GIS standard. This will enable data from property tax files, water board administrations, etc. to be linked using standard computer software, with access being provided through the Internet. In consultation with the industry, standardisation is fast becoming reality.

Verbree: 'The ideal situation would be to have geographical base data in one location, for example the information kept in the Geo Database Management System of the Netherlands' Kadaster (Cadastre and Public Registers Agency), and to be able to query that information from different applications. That's the type of system we should be working towards.'

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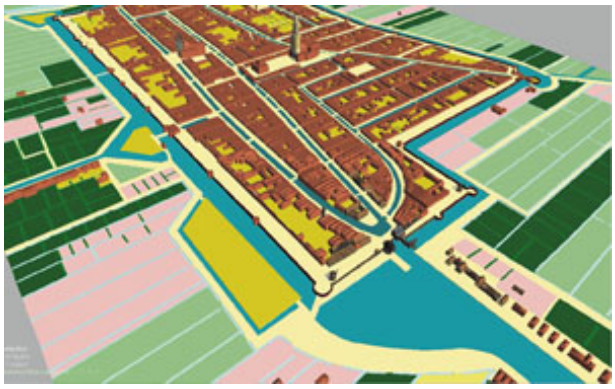
or

First, De Witt's map was scanned. Then the ArcView GIS program was use to establish the coordinates of all the objects on the map (houses, canals, trees, etc.) in the form of polygons. The resulting 2D data is compatible to the Ordnance Survey system, so data can be exchanged with other systems.



The geographical data contained in the previous image can be used to generate a perspective from any viewpoint. The GIS objects are retrieved from the database, then visualised by the WorldToolKit virtual reality software package.

View of the Old Church (lower left) and New Church (at the far end of the market place). Since these two buildings remain visible whatever the viewpoint, they have been enhanced with the original texture and added detail to the spires.

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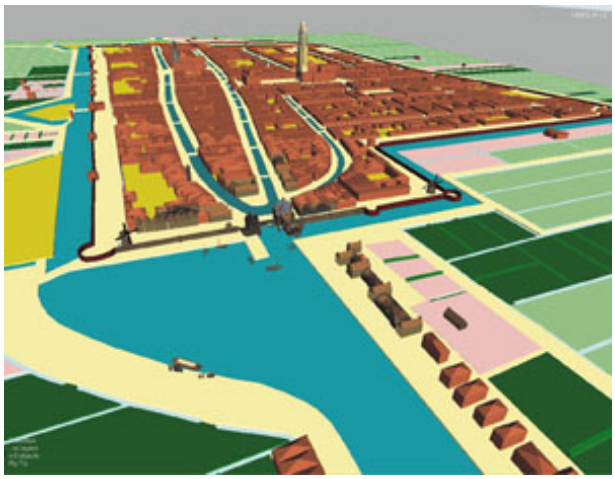
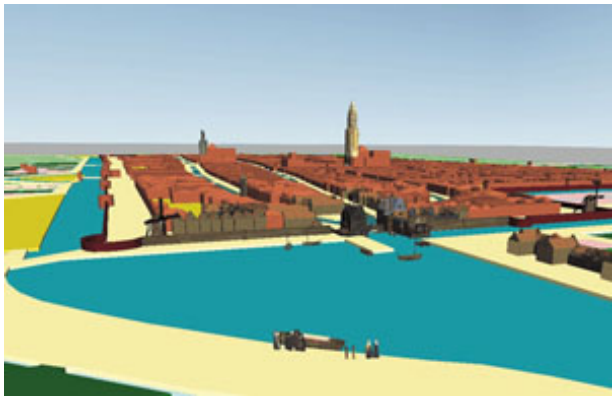
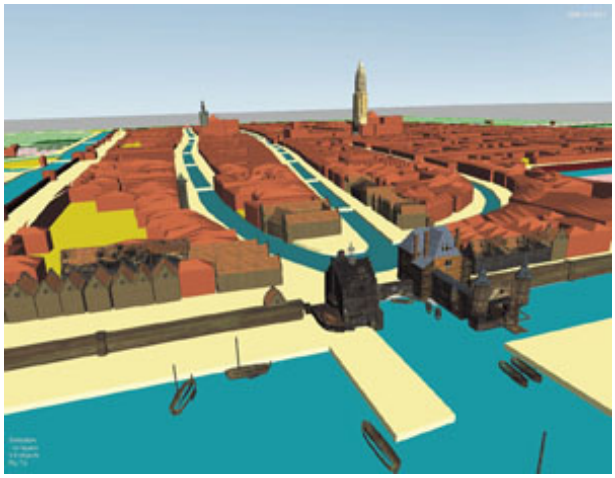


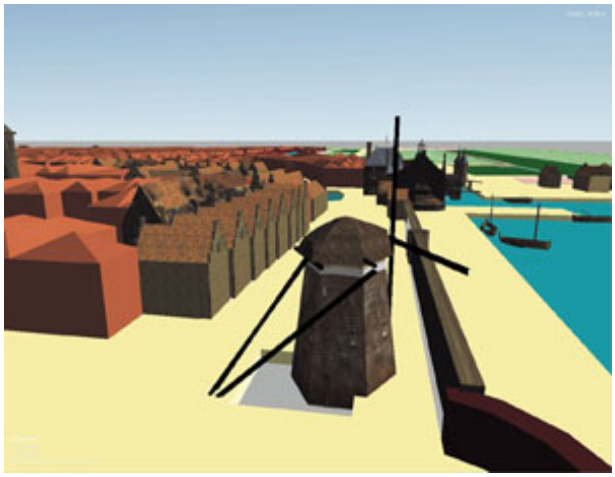
In order to make real-time manipulation possible, only the southwest corner of Delft has been given added detail, including artificially generated roofs. The most characteristic buildings, such as the churches and town gates, were modelled using 3D Studio software. These «real» 3D models replace their 2D GIS counterparts only after the perspective has been generated.



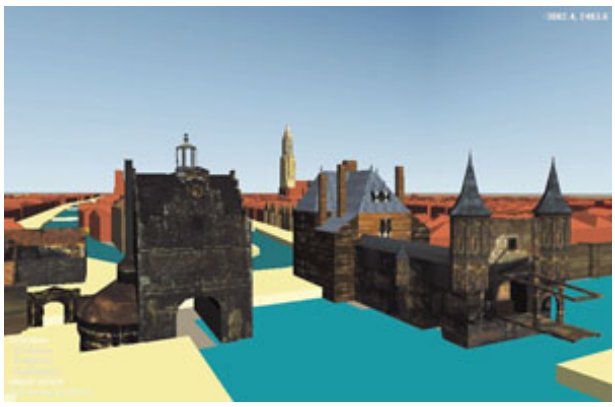
The people visible near the lower edge of the image are «cutouts» taken from Vermeer's View of Delft and inserted in the correct location in the model.



The Schiedam and Rotterdam gates and drawbridge. Combining perspectives based on GIS data with the enhanced 3D models of the churches and town gates produces realistic perspectives in a minimum of time. Clicking on an object yields additional information such as year of construction, residents, etc.



A «free» interpretation of one of the windmills near the south end of the town. To enable it to be stored in the geodatabase, the windmill was reduced to a simple square. Only when the square is retrieved into the virtual reality environment is the 3D model of the windmill displayed. Even so, the underlying square remains active in order to enable the GIS to be queried.



Composition showing the Schiedam Gate, the New Church, and the Rotterdam Gate. Note the «correct» width of the New Church spire, matching the exaggerated one in Vermeer's View of Delft. Wherever possible, the textures of the characteristic buildings were taken from Vermeer's painting, in which the spire still has its original shape. This kind of added information is difficult to generate from a normal GIS, but the combination with VR makes it possible.