L6: 3D Geovisualisation, Virtual and Augmented Reality

Terminology

3D geovisualisation – visualising geospatial data in 3 dimensions

Virtual reality – 3D visualisation supported by special display devices and responsive equipment:
- the meaning is ”artificial reality”? Not a good term - this could fit every ”model” of the reality - even a map.
- 3D visualisation is **NOT** automatically virtual reality!

↓

Virtual reality = 3D visualisation + immersion + interaction

↓

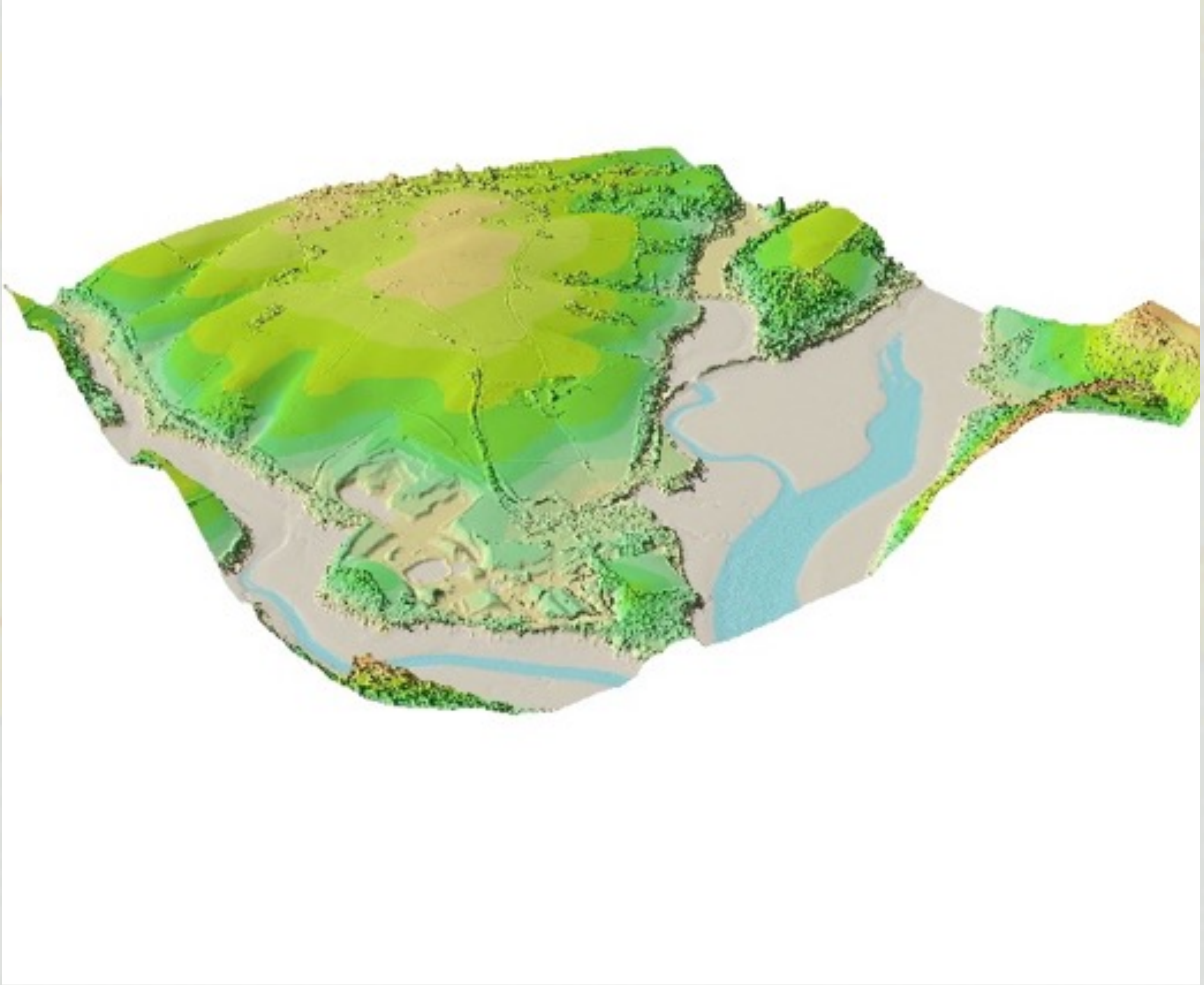
Immersion – plunging/being present and entirely surrounded by the virtual environment.

A true virtual reality has 100% immersion:
– the observer has the feeling of being entirely inside and surrounded by the virtual environment

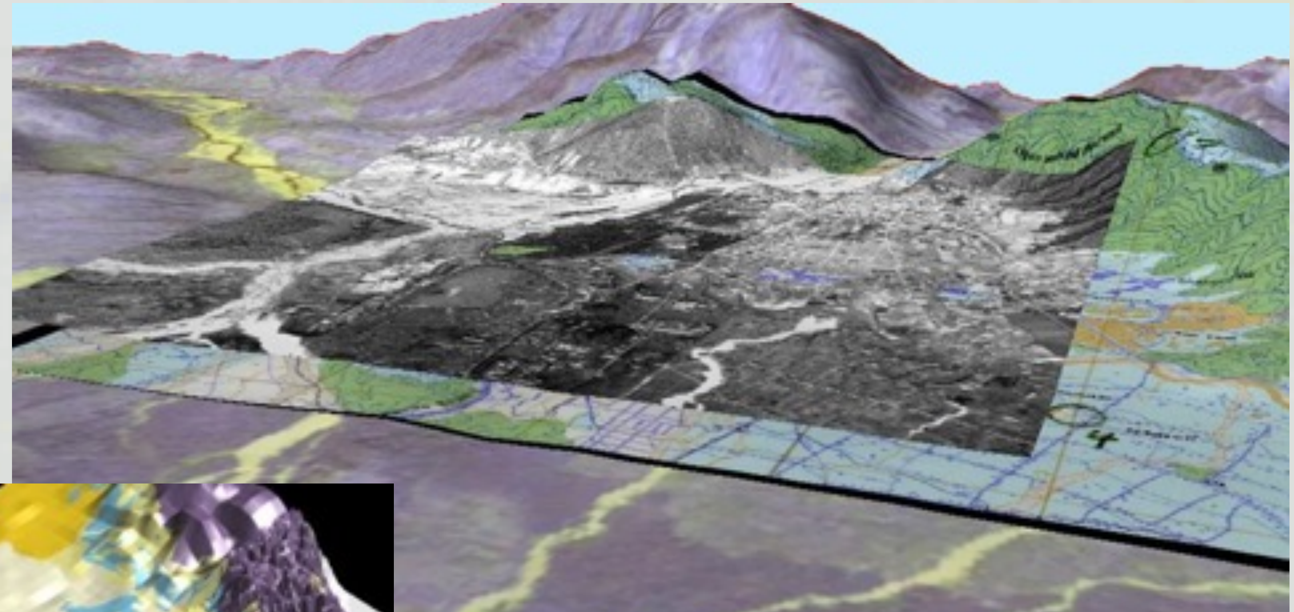
Augmented reality – the 3D model is projected/superimposed on the picture/model of the real world:
- you see a real picture + the virtual model at the same time
- used for mobile and ubiquitous computing - outdoor systems with vision based tracking

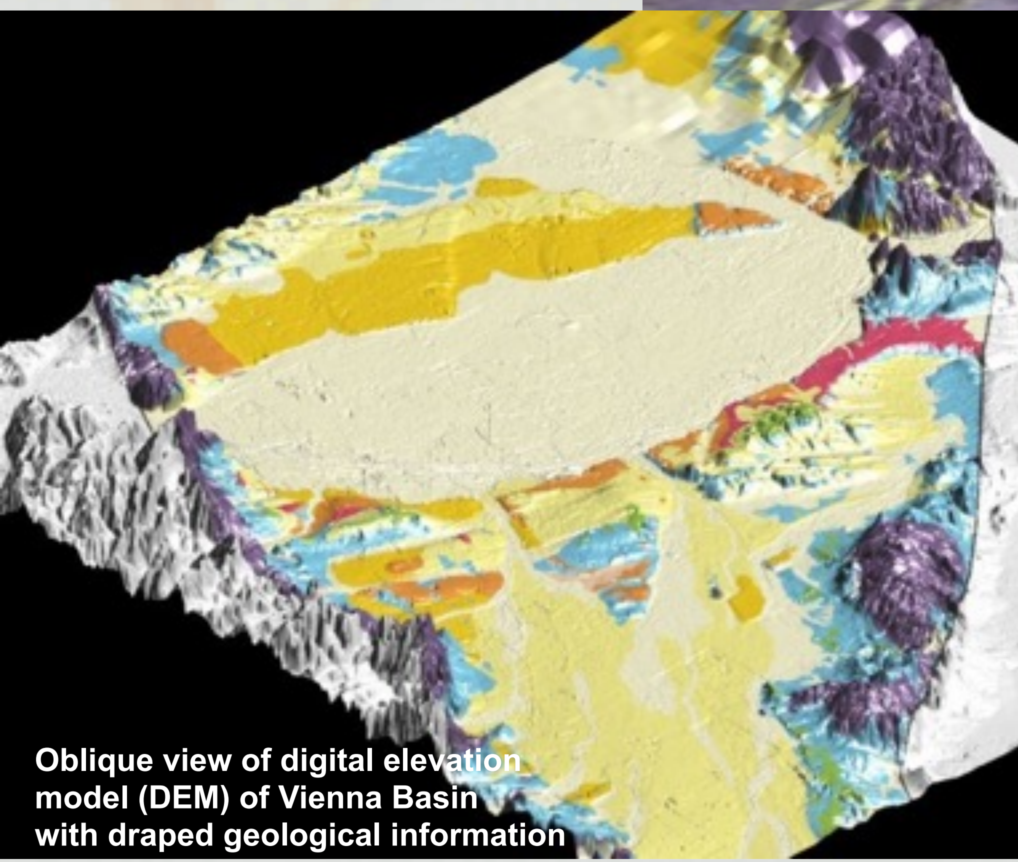
Examples

3D geovisualisation

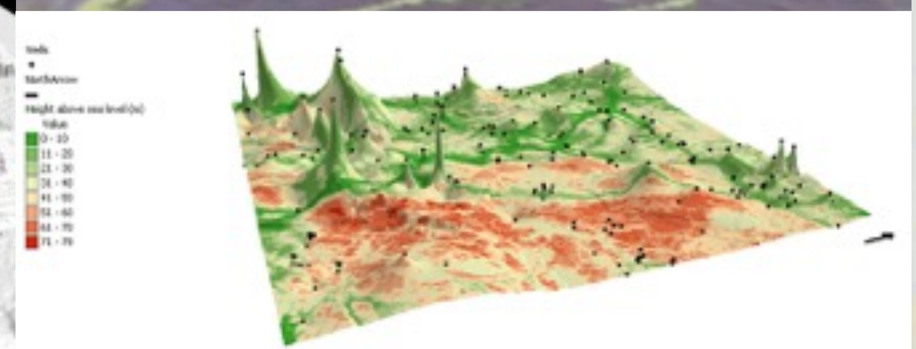


3D geovisualisations – drapping a satellite image or a thematic map over a 3D visualisation of the terrain

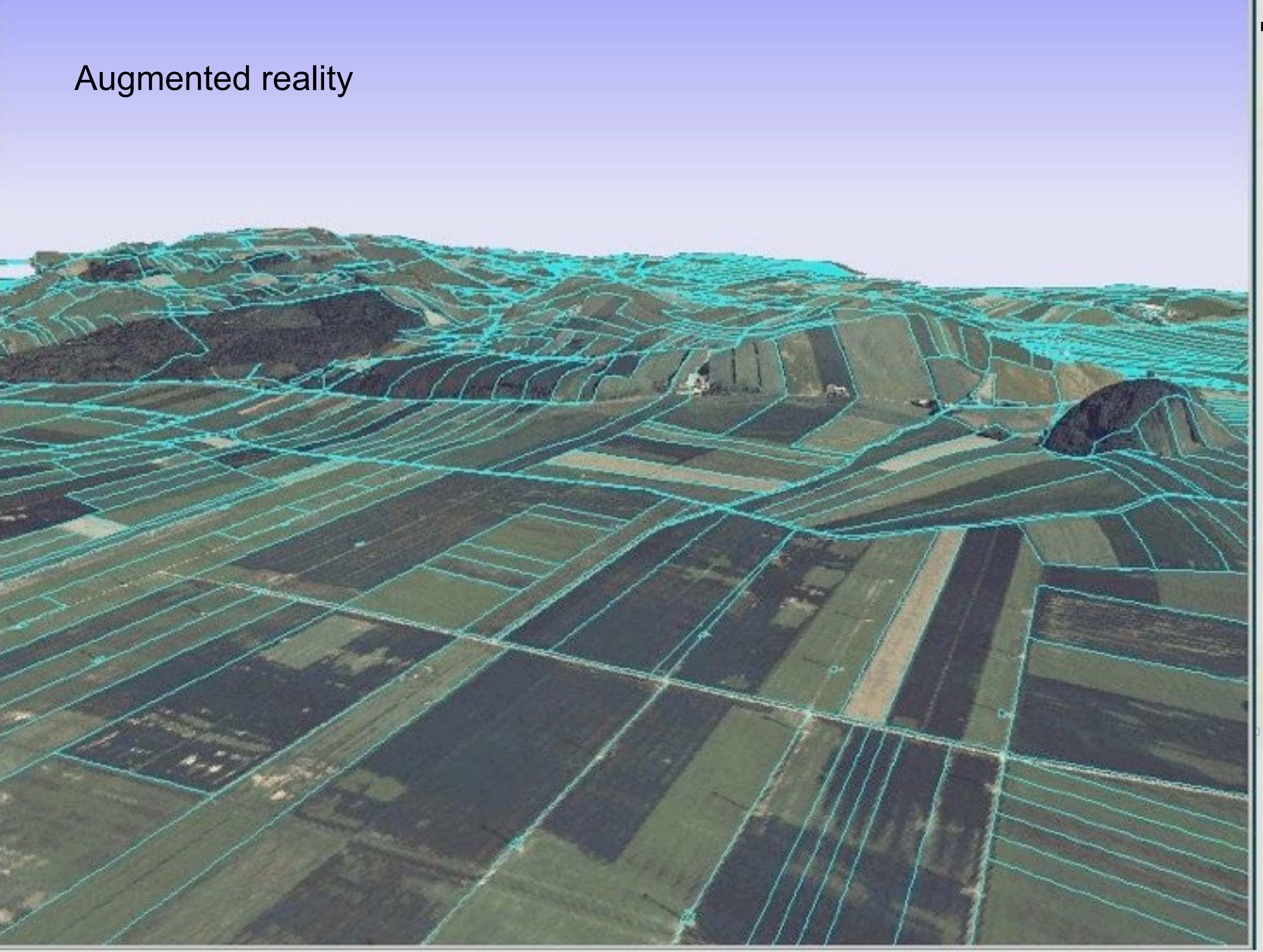




Oblique view of digital elevation model (DEM) of Vienna Basin with draped geological information




Virtual reality


Augmented reality

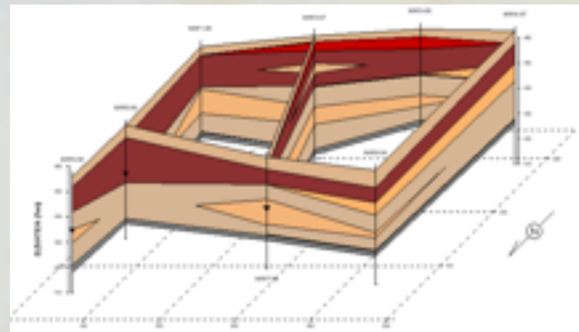

R.K.MAROON

Basic principles of 3D geovisualisation

Perception of **three independent geographic dimensions**

Depth cues

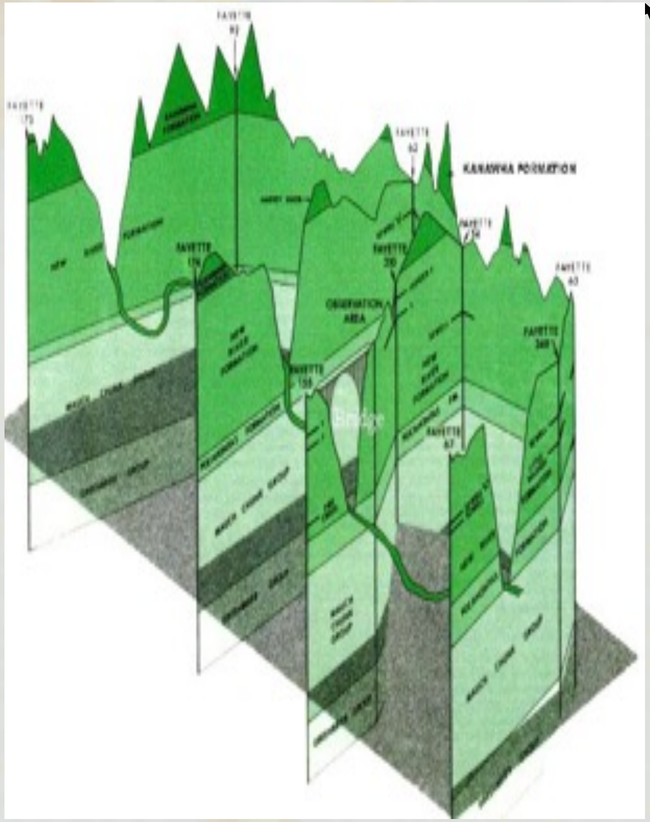
- perspective
- occlusion
- view angle
- distance
- shading
- binocular parallax



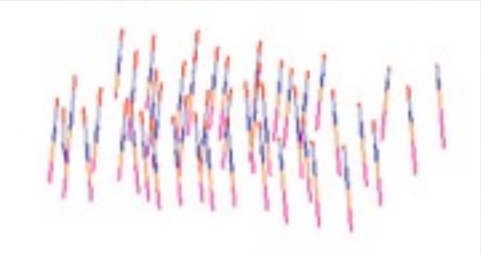
Perception of **three independent geographic dimensions**

3D visualisation in geology

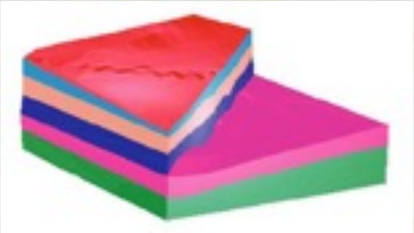
Fence diagrams



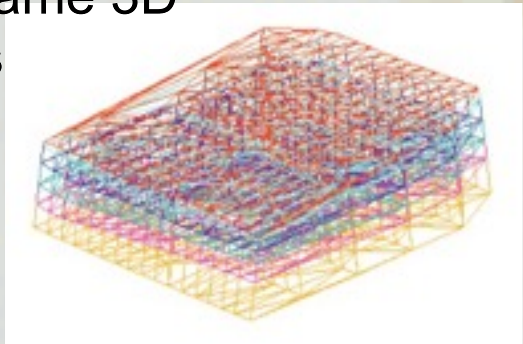
Borehole distribution



Solid 3D models

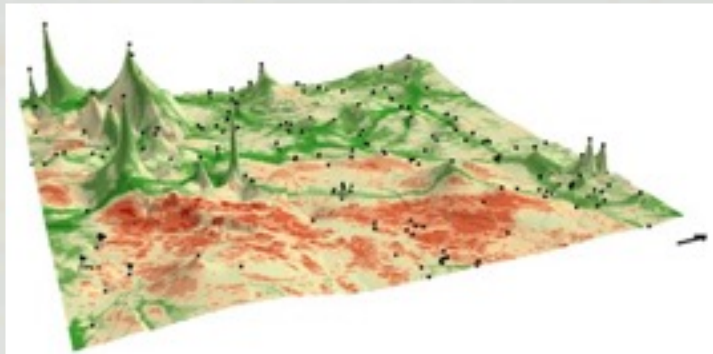


Wire-frame 3D models



Perception of **two independent geographic dimensions and a space-related attribute**

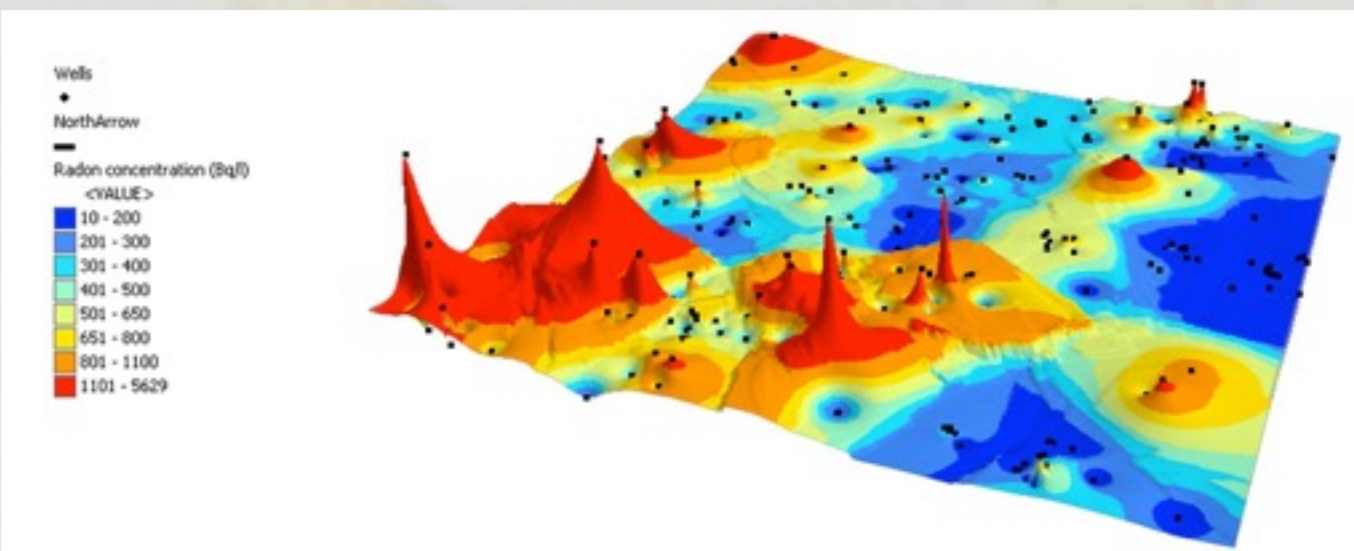
perspective

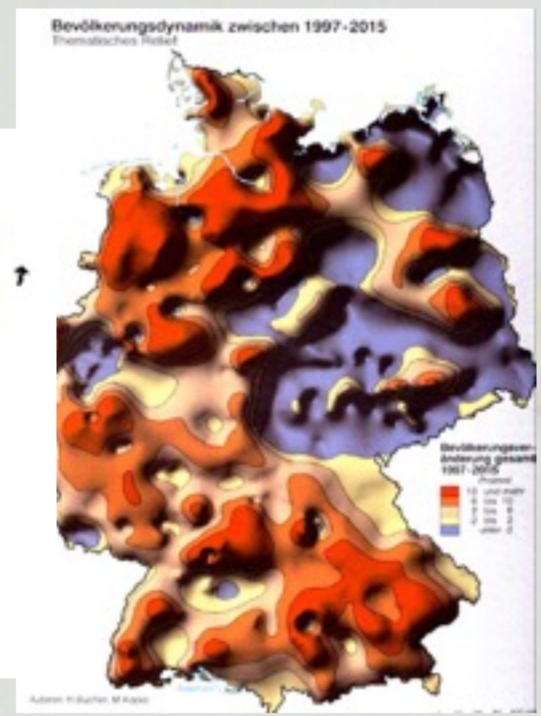


Depth cues

occlusion

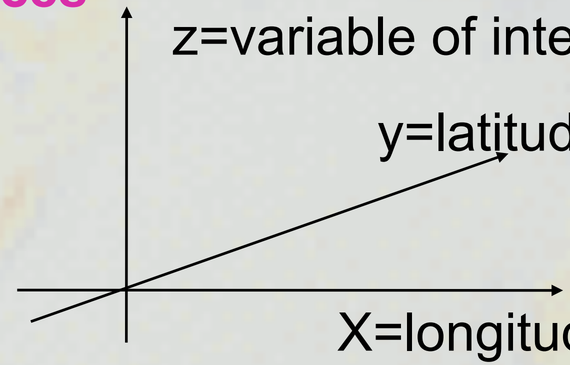
Shading + layered tints



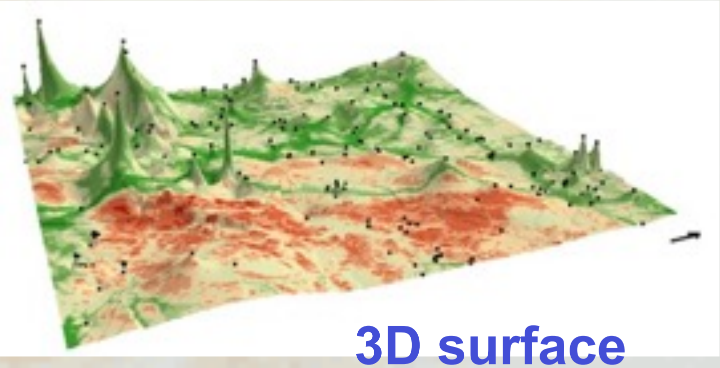


Perception of **two independent geographic dimensions and a space-related attribute**

3D Surfaces



Basic 3D structure

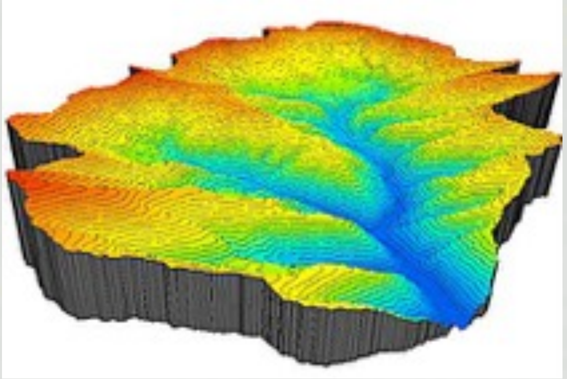


3D surface

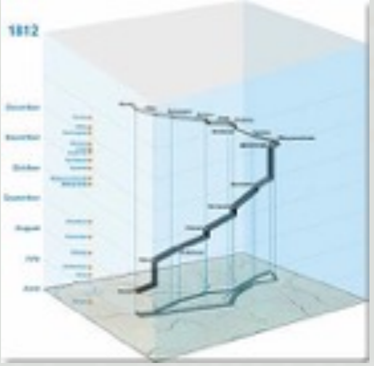
Draping over
a thematic map or a
raster surface

3D surface types

z=elevation/depth



z=time



z=another variable

Population density
Temperature
Density of human activity
River/stream flow
Magnetic variation
Etc.

Google Earth

http://earth.google.com

DEM + draped satellite picture

Himalayas, The Alps

Satellite picture + 3D city model

New York

2D map vs. 3D geovisualisation

2D map:

- displays one or many slices of a 3D solid

- presents an unnatural ground plan with no or little depth cue

- offers a relatively unbiased overview and orientation

- allows a high degree of design freedom

- needs a legend

- demands high mental effort for symbol interpretation

3D geovisualisation:

- displays a 3D surface and/or its internal structure

- presents a natural view with one or many depth cues

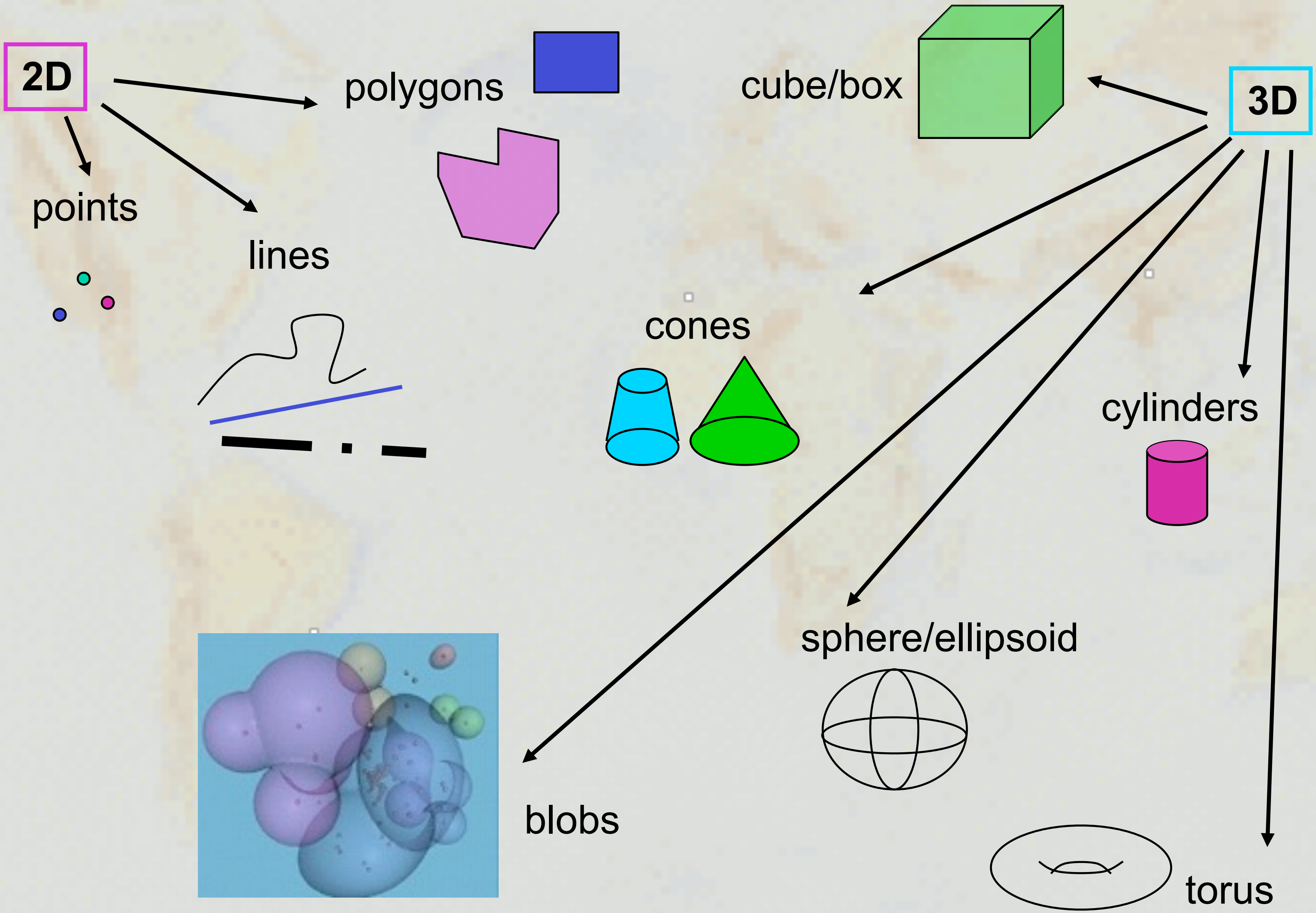
- makes the estimation of distance and orientation difficult

- allows high degree of immersion

- does not always need a legend

- demands little mental effort for the understanding

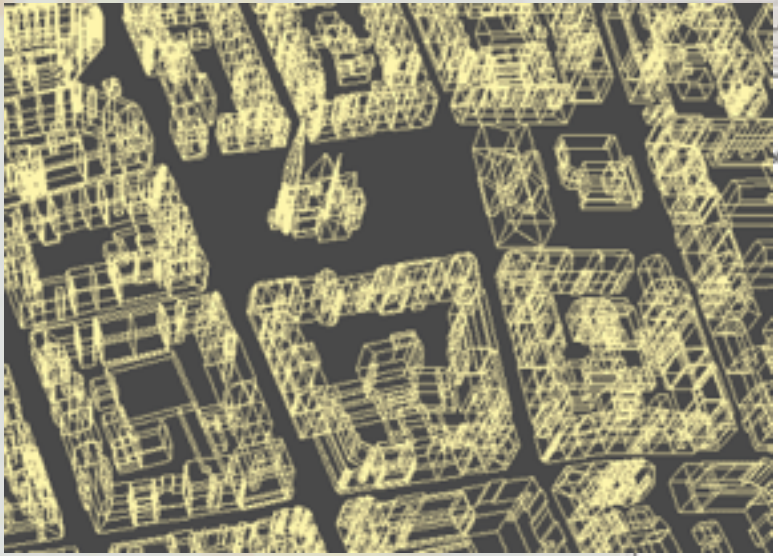
Geometric primitives

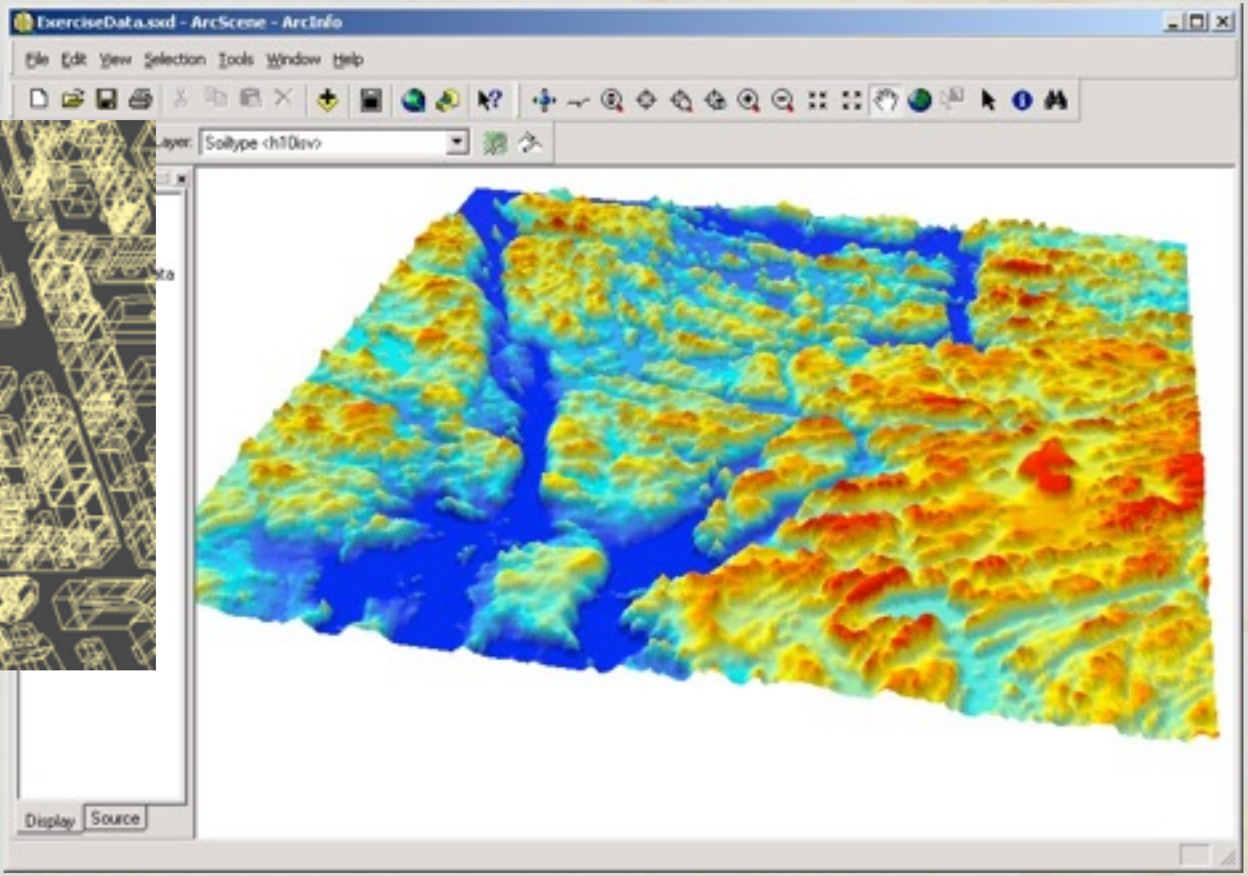


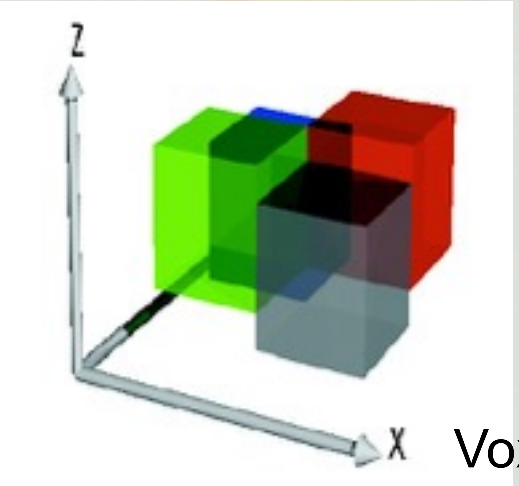
Geometric 3D models

Surfaces

Wireframe models





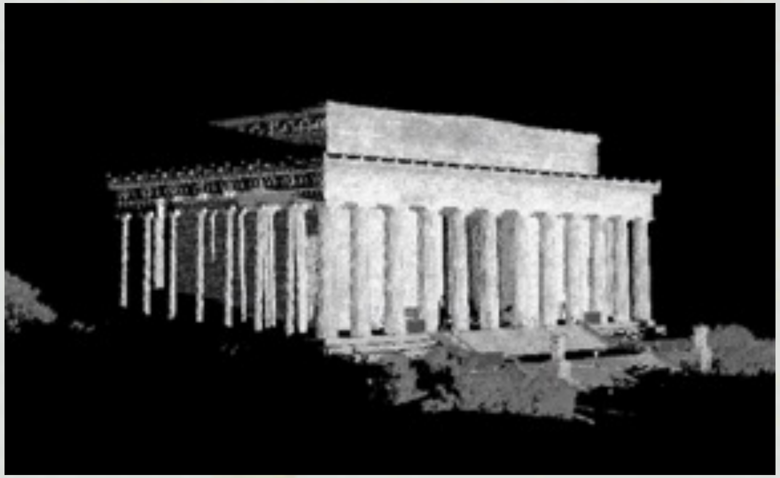


Voxels = 3D pixels

Methods for producing 3D models

Laser scanning - LIDAR

Result: a 3D point cloud



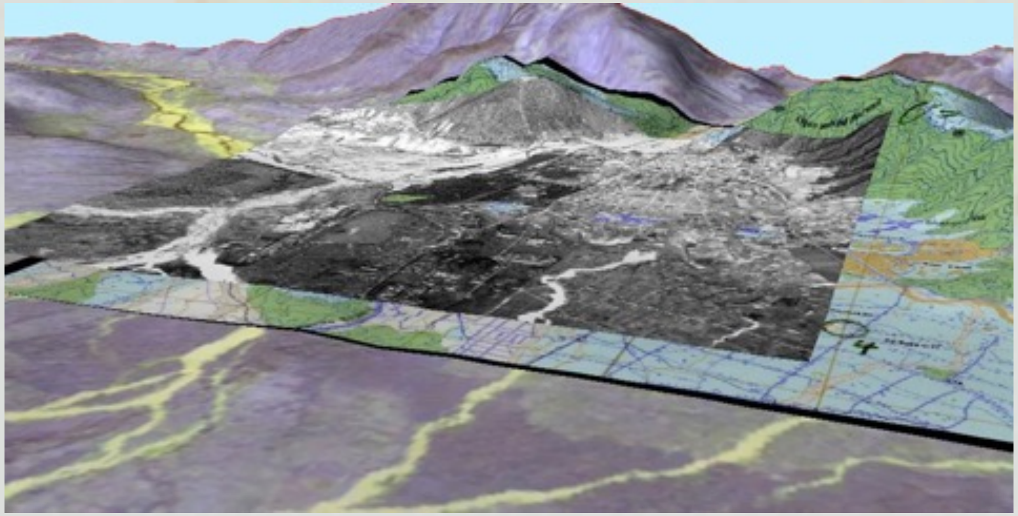
3D models by ArcGIS 3D analyst (lab 8)

3D models from elevation data

draping over

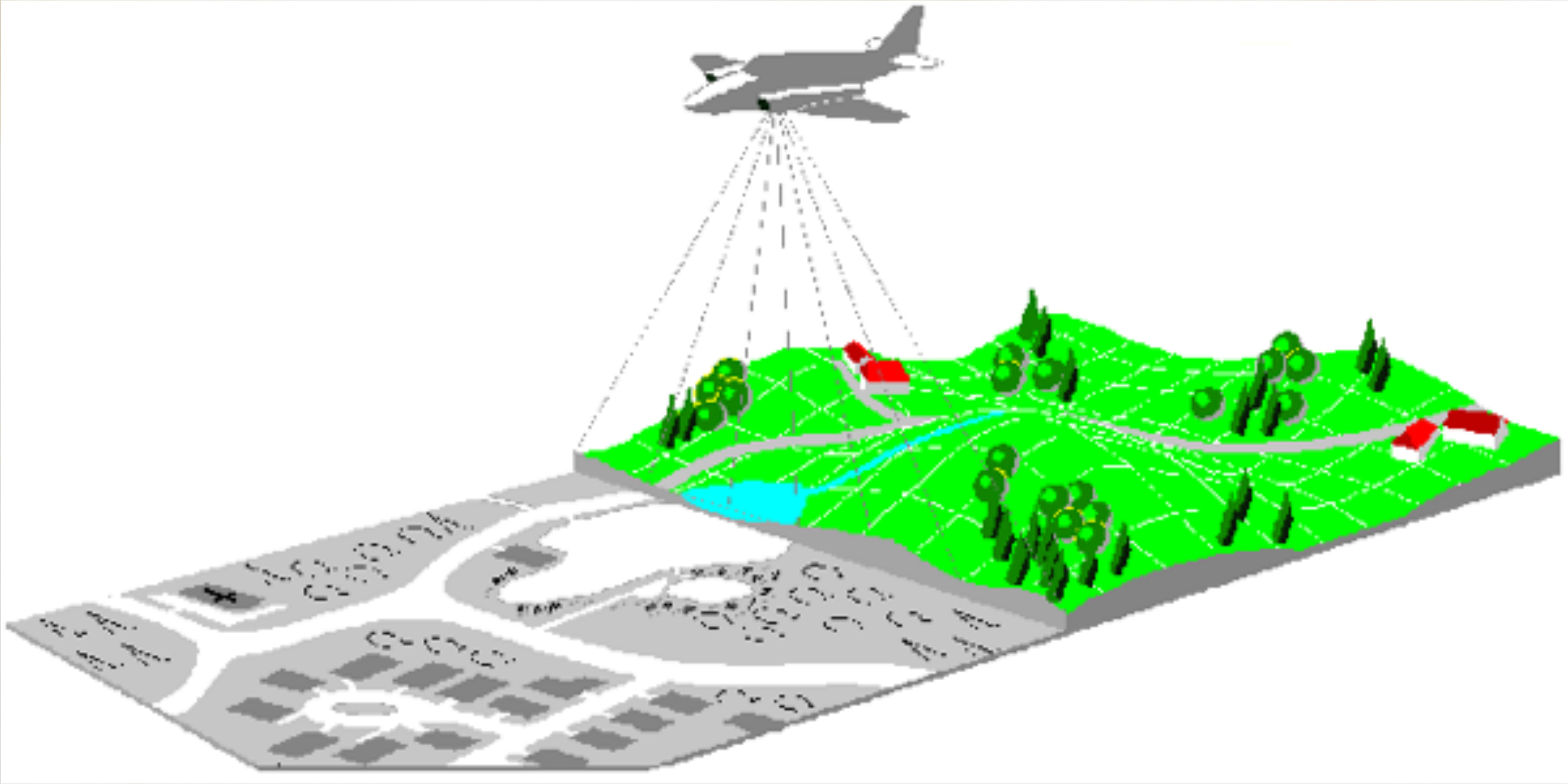
Satellite images

thematic maps (shape or raster)



Laser scanning – LIDAR = ”light detection and ranging”:

- measures distance from the laser to every point in the field of view
- does not produce a conventional camera image, but a 3D cloud of distance points



Characteristics of LIDAR

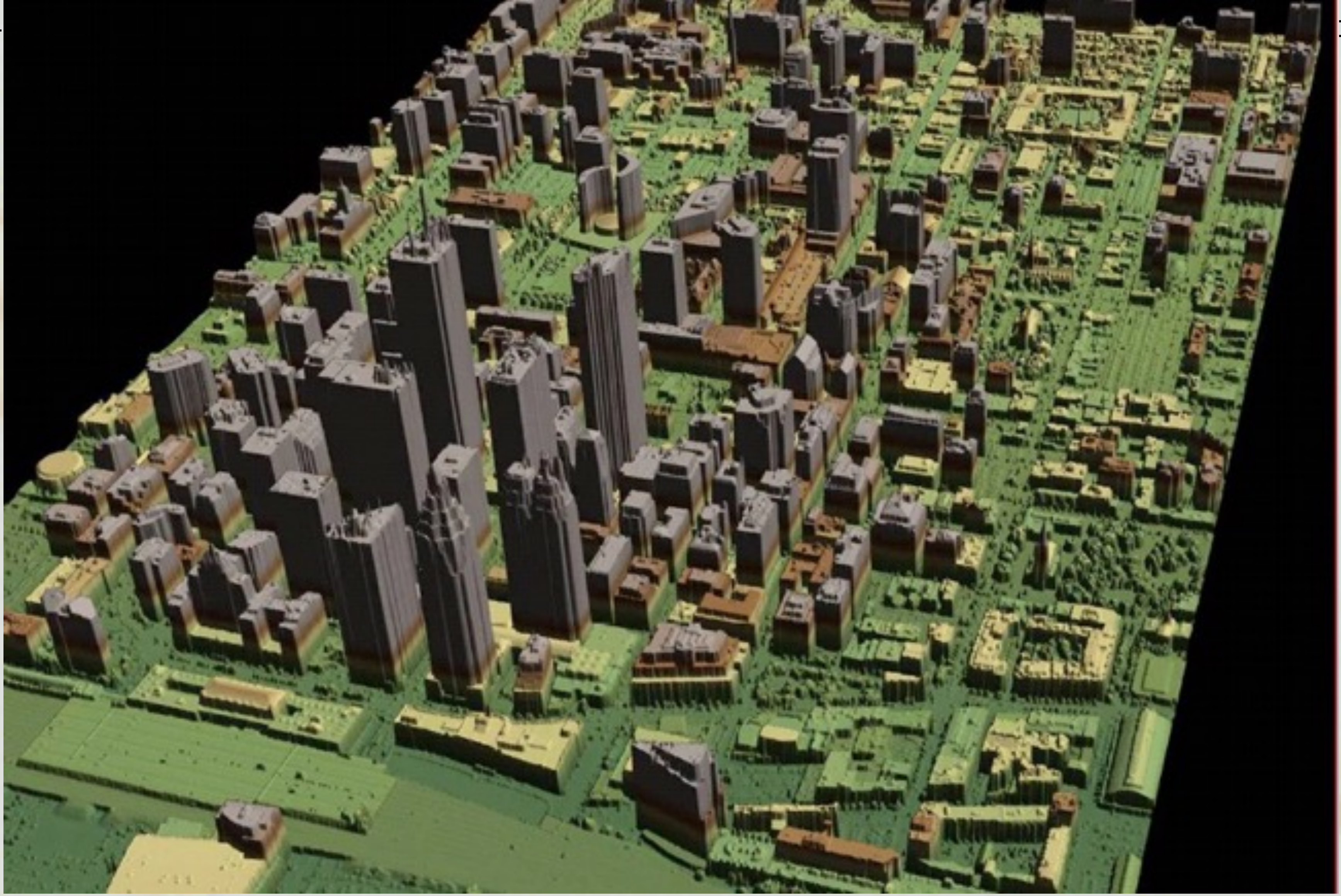
It has an infinite depth of focus

Accuracy in centimeter range

It is an active scanning system

It does not require external illumination (measuring at night ok).

It is not affected by the sun.



Airborne Laser Terrain Mapping- ALTM DEM display of downtown Toronto by Optech & MDRobotics. Vertical resolution: 10 cm, horizontal: 30 cm. ~ 10^8 data points collected in a flight time of 30 minutes.

Differences between an image and a point cloud

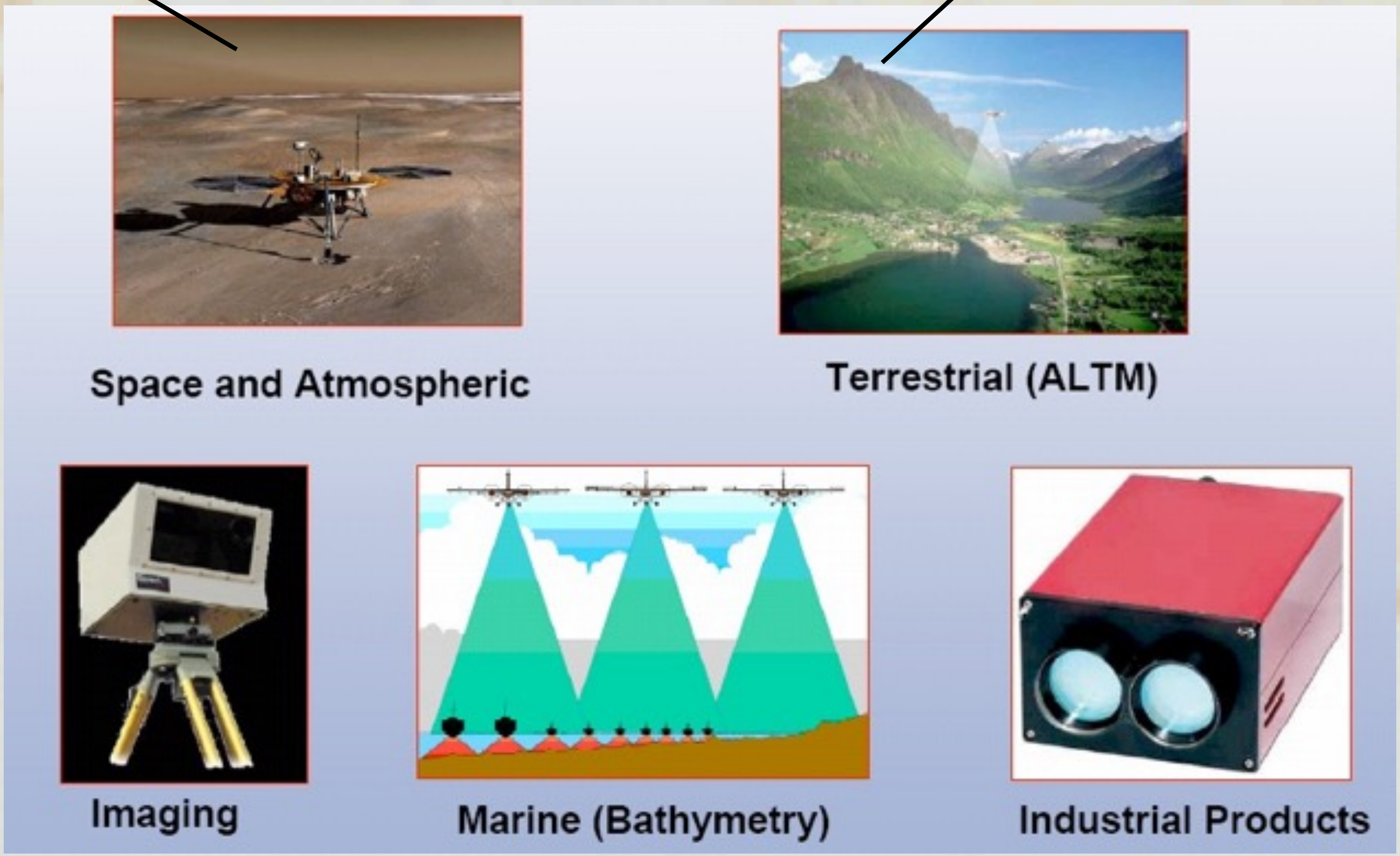
Image: dependent on the external illumination, you can't see inside the window

Cloud: shows the "surface" of the scene, shadows are empty areas (no points), you can "see" inside the window.

LIDAR applications

MARS exploration

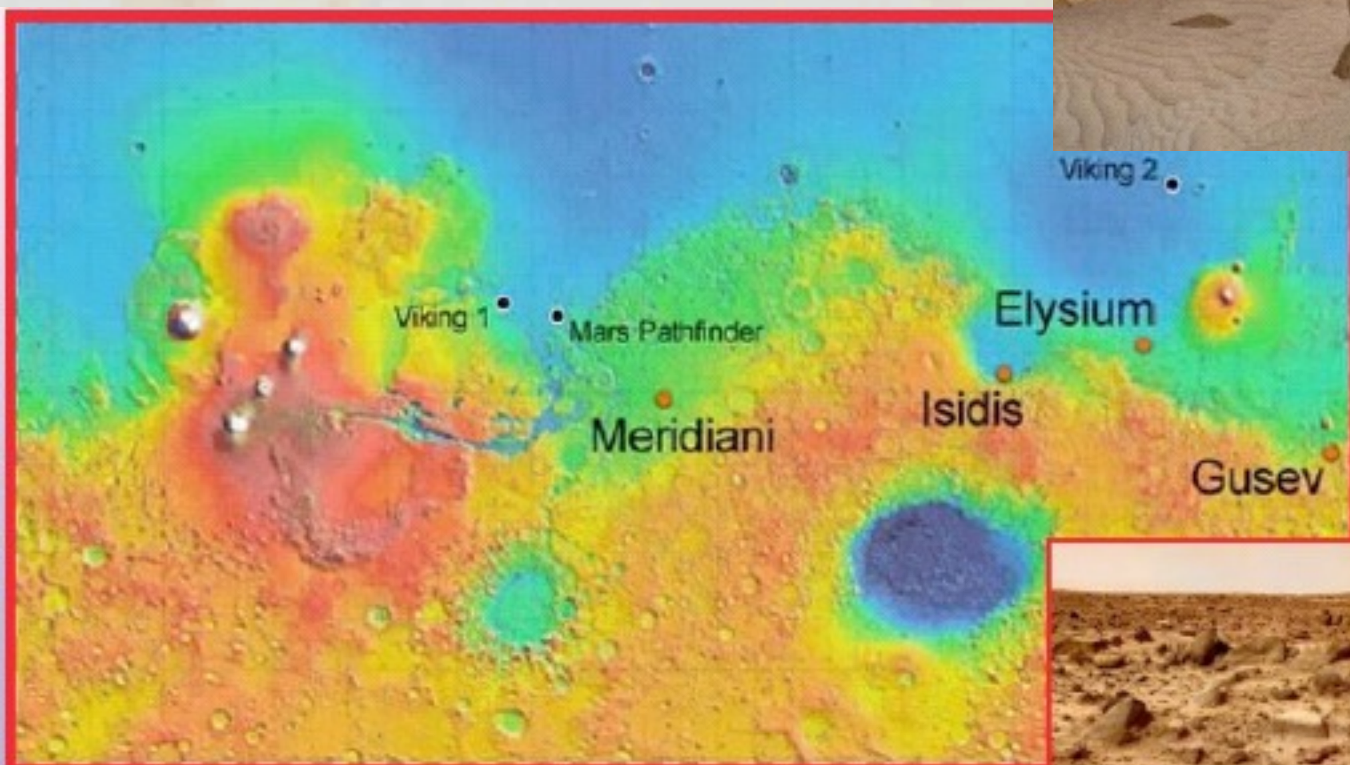
Digital terrain mapping



Lidar-based Autonomous Planetary Landing System – LAPS: 2001-2004

Finding a good place to land: avoiding obstacles.

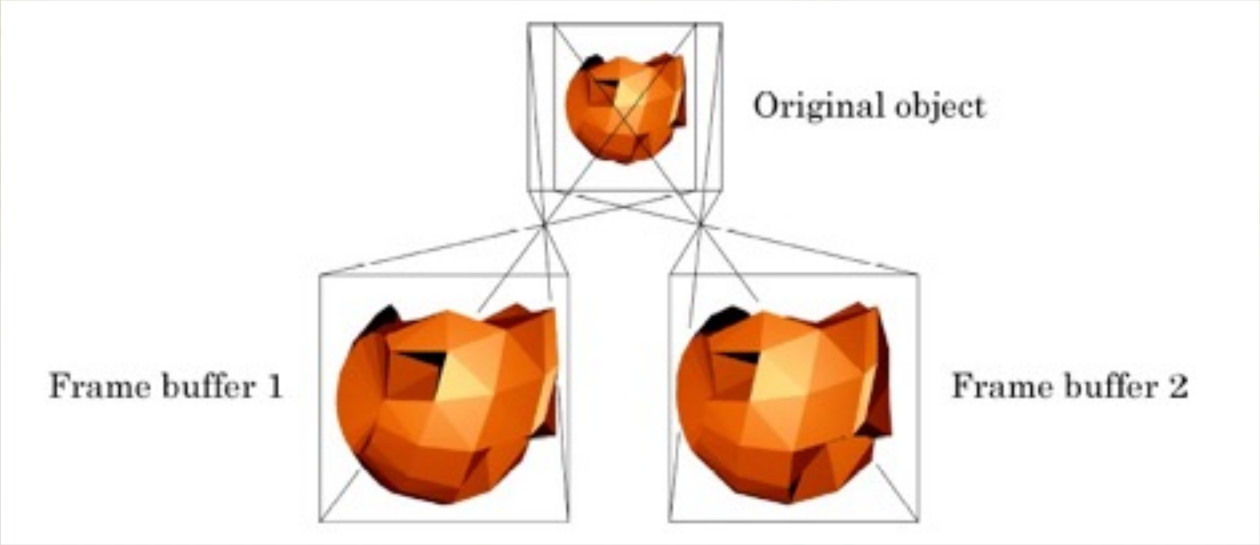
Data can be processed on the spacecraft: no need to send images to Earth & back (takes too long for guiding a real-time landing procedure).



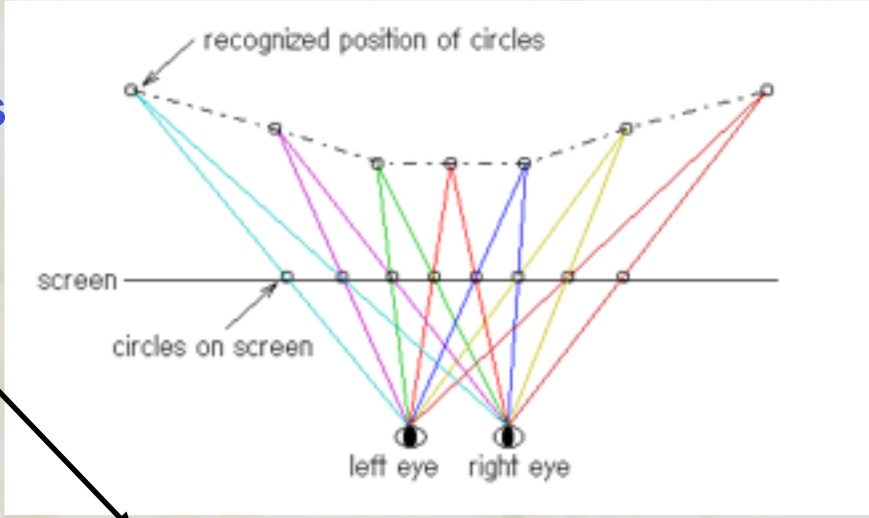
Stereoscopic visualisation – another way to show 3 dimensions

Monoscopic visualisation: one image only, 3D effect created either by the rotation/transformation effects on the display or by drawing the model in perspective.

Stereoscopic visualisation: 3D effect obtained by simultaneously projecting two displaced images, which are constructed by observing the scene from two separate viewing points.

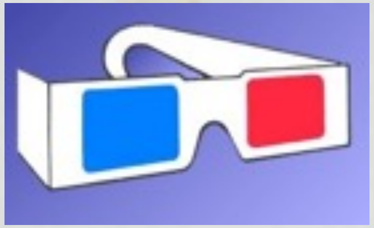


2 types of stereoscopic visualisations



Anaglyphs

A moving or still picture consisting of two slightly different perspectives of the same subject in contrasting colors that are superimposed on each other, producing a three-dimensional effect when viewed through two correspondingly colored filters.



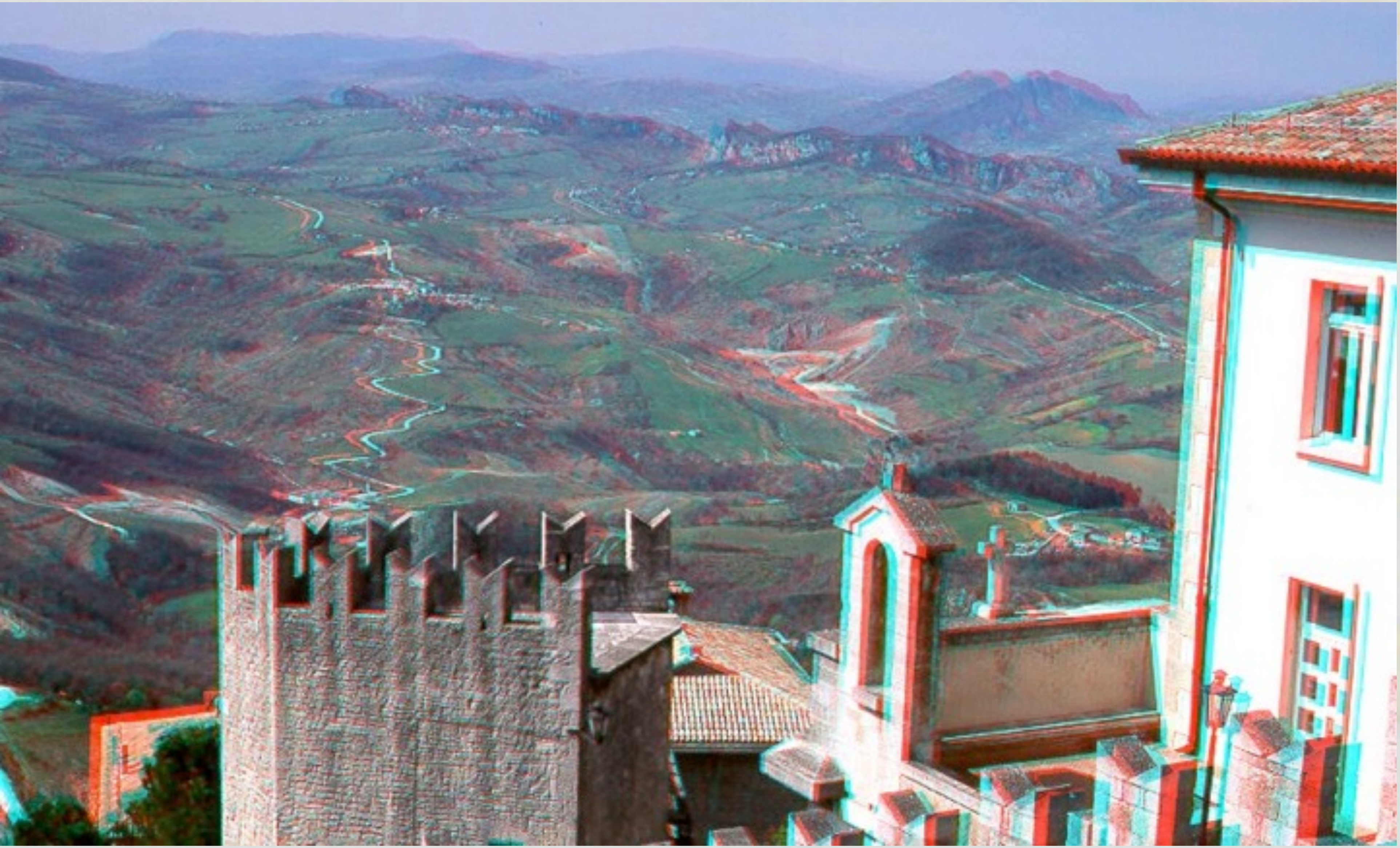
The observer has to wear special anaglyph glasses that shift the images together into 3D (Cosmonova style).

Stereograms

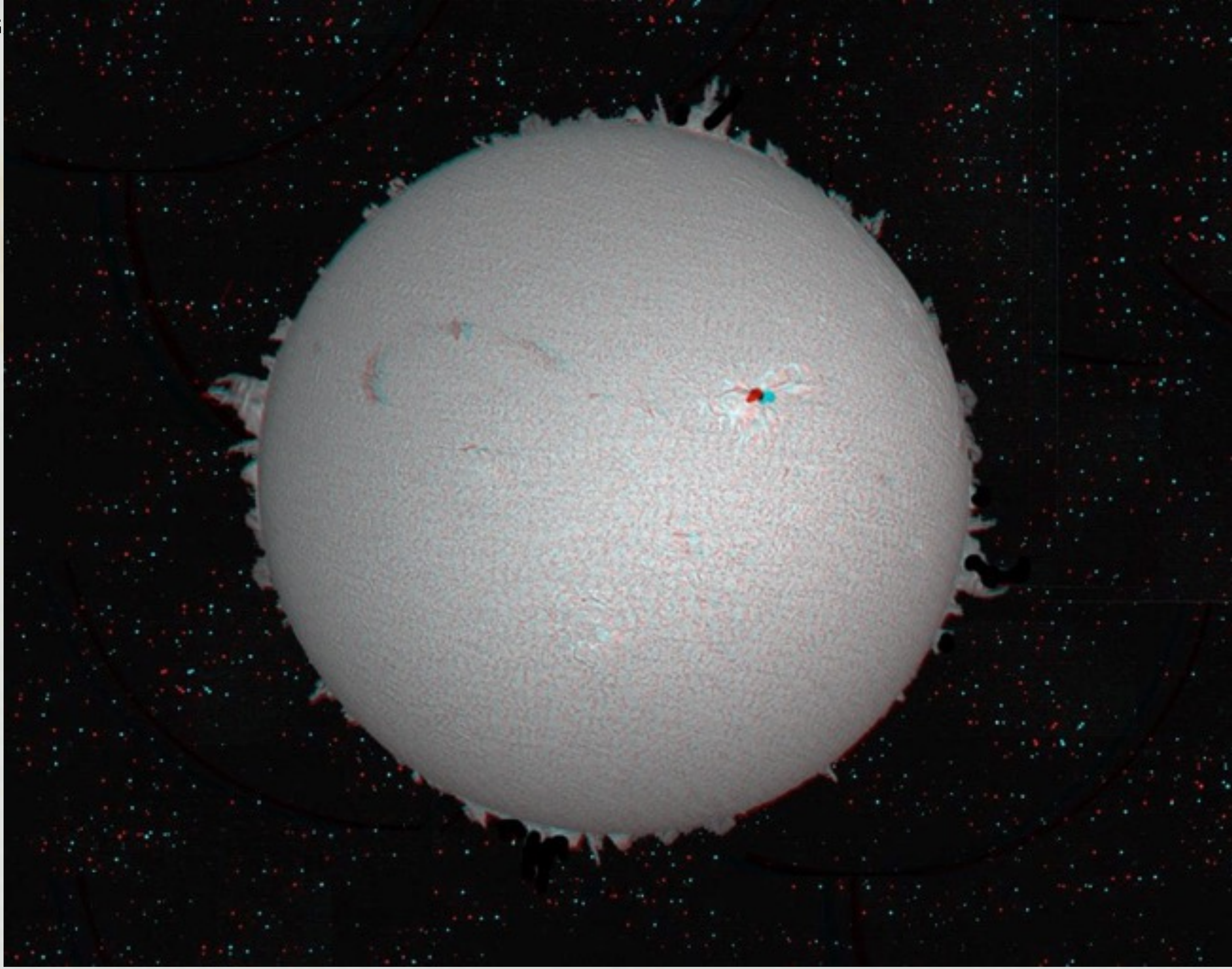
No glasses necessary.

A 3D image from two stereoscopic images hidden inside another image.

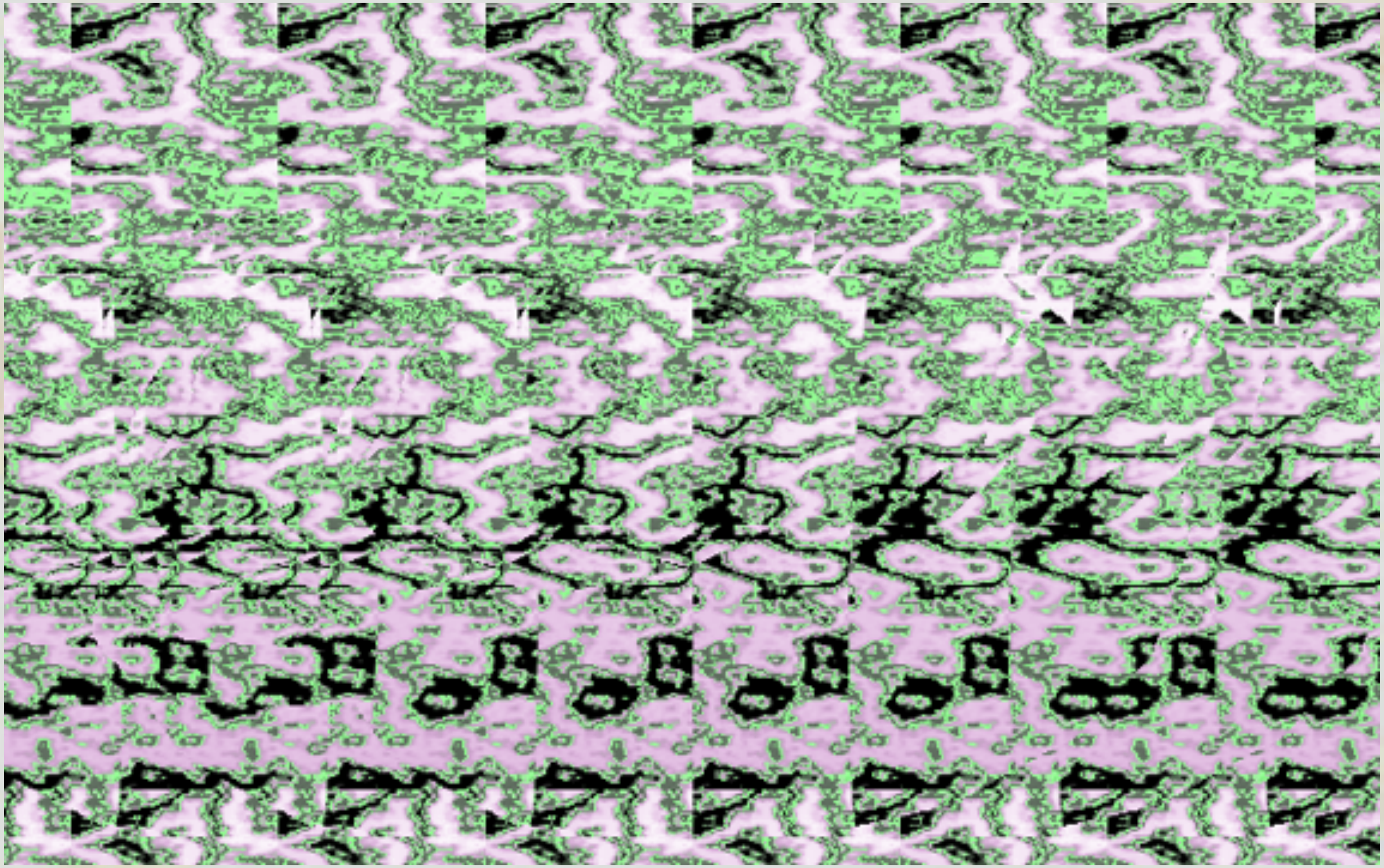
An anaglyphic image of Stockholm



An anaglyphic image of San Marino



An anaglyphic image of the Sun



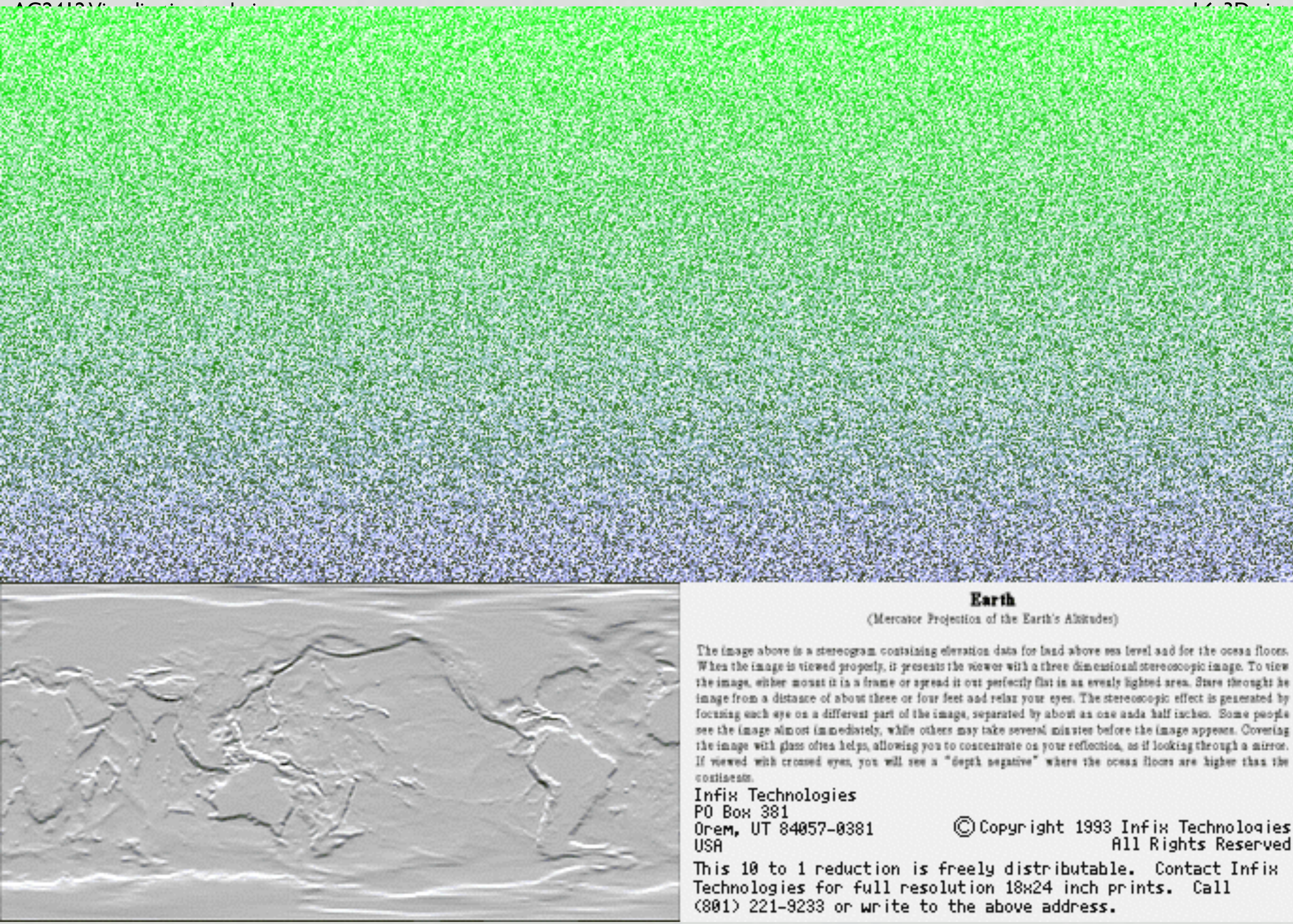
A stereogram of a teacup

Tips on how to view 3D stereograms:

1. Pick a spot on the picture (the middle seems to work best) and just stare at it.

2. Allow your eyes to relax, don't just stare AT the image, try to stare THROUGH it, as if you were looking at some object far away behind the image. You'll notice your eyes will go slightly out of focus. This is normal.

3. Keep staring, don't give up, once you begin to see the first image, it gets much easier. ☺


Earth
(Mercator Projection of the Earth's Altitudes)
The image above is a stereogram containing elevation data for land above sea level and for the ocean floors. When the image is viewed properly, it presents the viewer with a three dimensional stereoscopic image. To view the image, either mount it in a frame or spread it out perfectly flat in an evenly lighted area. Stare throught he image from a distance of about three or four feet and relax your eyes. The stereoscopic effect is generated by focusing each eye on a different part of the image, separated by about an one anda half inches. Some people see the image almost immediately, while others may take several minutes before the image appears. Covering the image with glass often helps, allowing you to concentrate on your reflection, as if looking through a mirror. If viewed with crossed eyes, you will see a "depth negative" where the ocean floors are higher than the continents.
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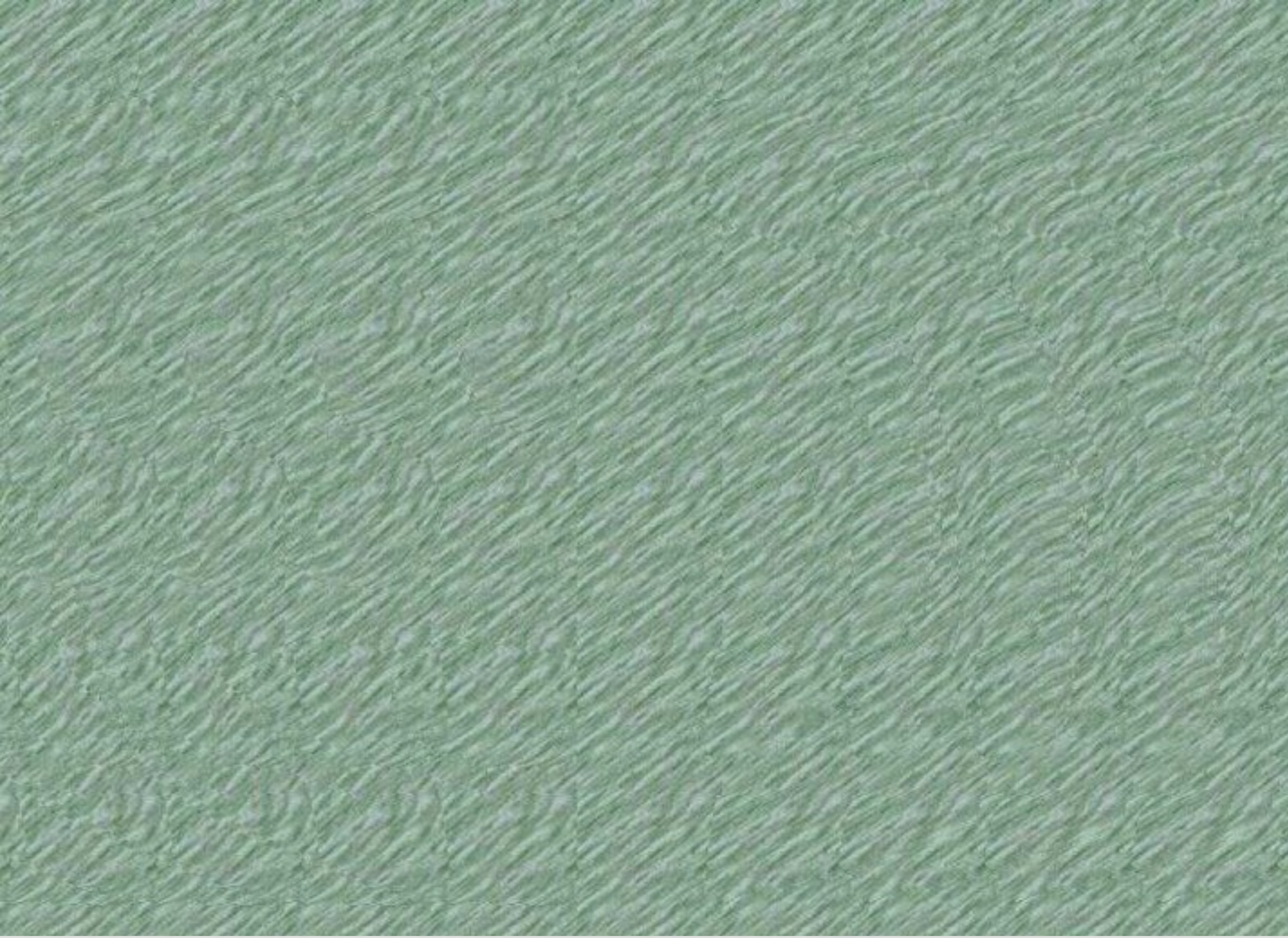
l reality



What do you see here?

Virtual Reality - environments

Virtual reality = 3D visualisation + immersion + interaction

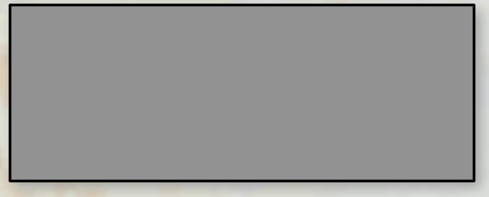
How to achieve immersion and interaction – **display environments**:

- back and front projection
  Projecting images on screens of different shapes (dome, torus, cylinder)
  Examples: the immersive workbench, the CAVE
- head-mounted displays
  Projecting images on a screen that one wears in front of the eyes
  Helmet displays, goggle stereoscopes (anaglyph glasses)
  Problems: heavy, difficult communication with others (concealed eyes)
- holographic screens
  Images projected as interference patterns on special screens
  Problems: small screens, bad optics
- volumetric imaging
  Display unit is a 3D matrix
- lenticular screens
  Display unit: a large number of small lenses projecting different light rays on the screen. Use: reproducing stereoscopic images for multiple observers

Environment for a single user:

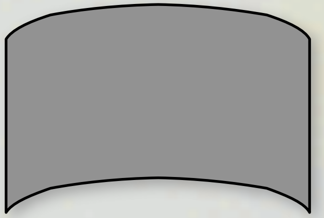
A head-mounted display + a navigation device (a computer mouse, a glove)

Environments for multiple users:

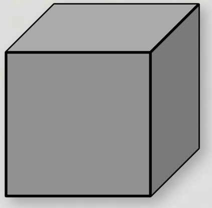


3D auditorium – a powerwall

A panorama

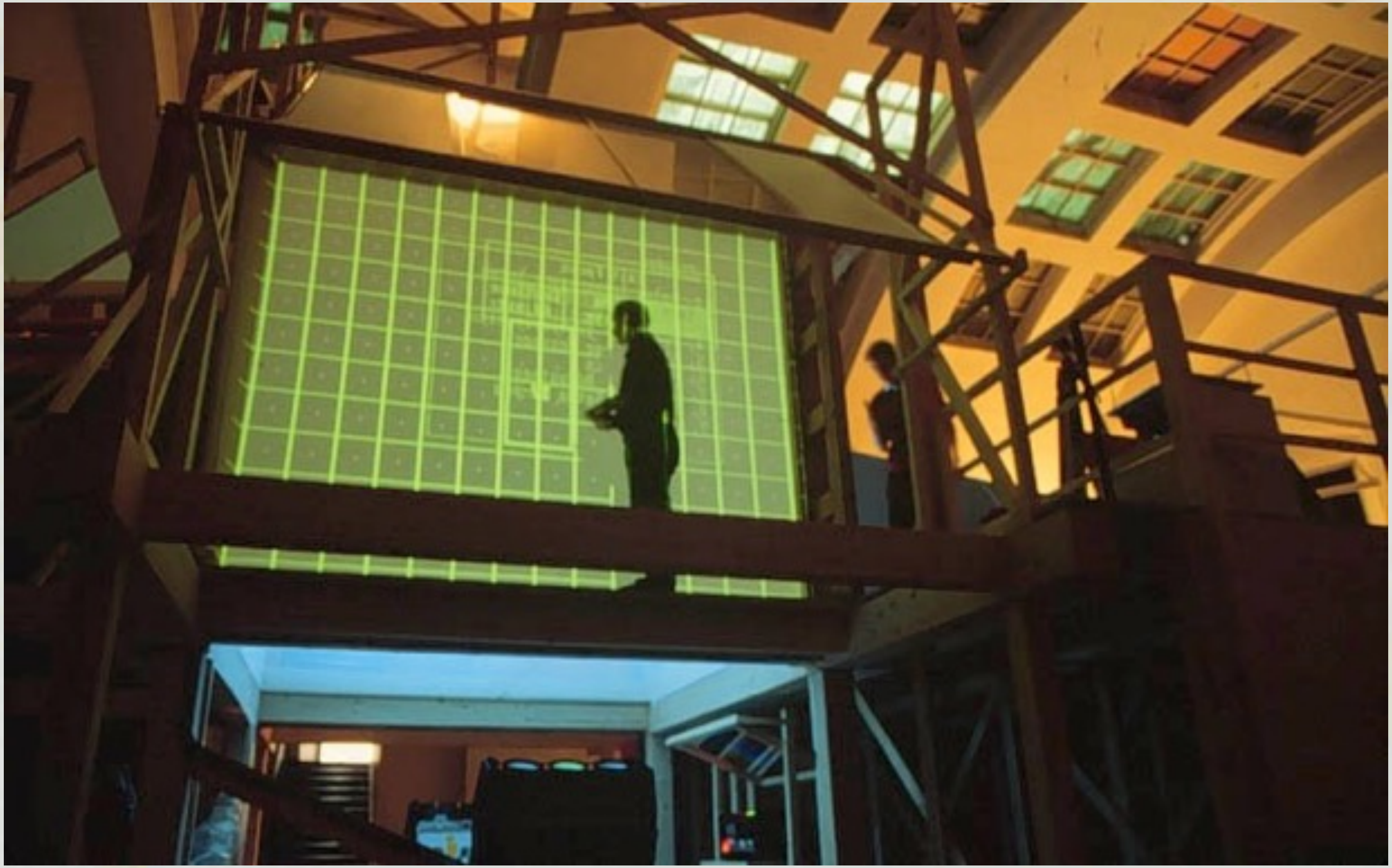


A CAVE – Cave Automatic Virtual Environment (5 or 6-sided)



VR cube at KTH:
http://www.pdc.kth.se/projects/vr-cube/

A dome



VR cube at KTH

A panorama display

VRML – Virtual Reality Modelling Language

How are the 3D models described in computers? -> VRML models
VRML model = a world file = *.wrl

```
#VRML V1.0 ascii

Separator {
   Separator {
                Info {
                   string       "Created by DSA, Inc.
contact: Dean Gonzalez  phone: (719) 593-5974
No redistribution restrictions."
                }
                Separator {
                   ShapeHints {
                                vertexOrdering              COUNTERCLOCKWISE
                                shapeType     SOLID
                                faceType      CONVEX
                   }
                   Separator {
                                Material {
                                   ambientColor             0.004 0.06 0.24
                                   diffuseColor             0.008 0.12 0.48
                                   specularColor            0.5 0.5 0.8
                                   shininess    1
                                }
                                Sphere {
                                   radius       0.9989
                                }
....
```

Earth.wrl -> an ascii file with descriptions for the 3D objects

Free VRML viewers:
Contact, Cortona, CosmoPlayer
http://www.int3d.com/help/vrmlviewer.html

An example: A 3D model of an island in Seychelles

http://www.birdisland3d.com/

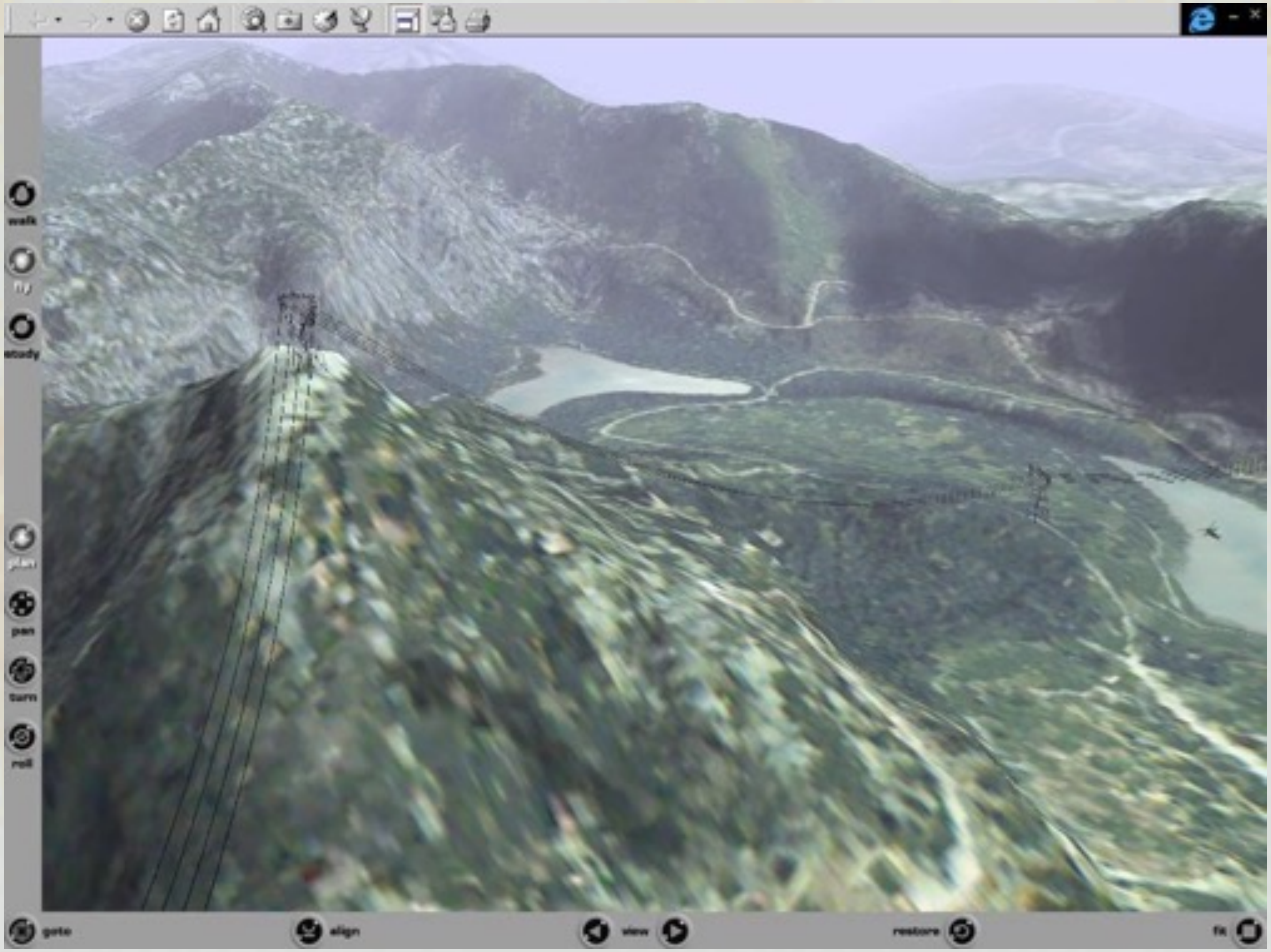
Another example:
a virtual city - Ljubljana

http://www.ljubljana.si/en/ljubljana/virtual_ljubljana/default.html

Some applications of 3D visualisations, VR and AR:

Public participation in the planning process:

showing the public a 3D model of a planned site/city area instead of just paper plans



Education:

showing geological/geographical processes to school children

- Digital Earth

- an AR book for geology/volcanology
http://www.hitlabnz.org