3d Geovisualization and Geographic Exploration Systems

Agenda for workshop

- Background
- Geovisualization - a paradigm for the future
- 3d is a special case

Break

- Geographic Exploration Systems (GES)
  - Digital Earth
  - Virtual Globes
  - GRIFINOR

Break

- Hands on - a chance to interact with GRIFINOR

3D GeoInformation

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Background

3D GeoInformation

- Centre for 3D GeoInformation was opened in 2001 as an European Regional Development project - target2
- From beginning there was a strong cooperation with both government and private companies
- There has been a strong belief in Virtual Environments for communicating georelated information
- One of the goals was to create a Virtual Geographic Infrastructure

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Ideas behind Centre for 3DGI

3D GeoInformation

- Inspired by
  - Several large-scale terrain models
  - The building of VR Media Lab
  - The need for 3d solutions in GI Science
- Development Project - from ideas to (virtual) reality
- Running 2001-2006
- Staff - 7 academics:
  - Surveyors, computer scientist, planners and PhD-students

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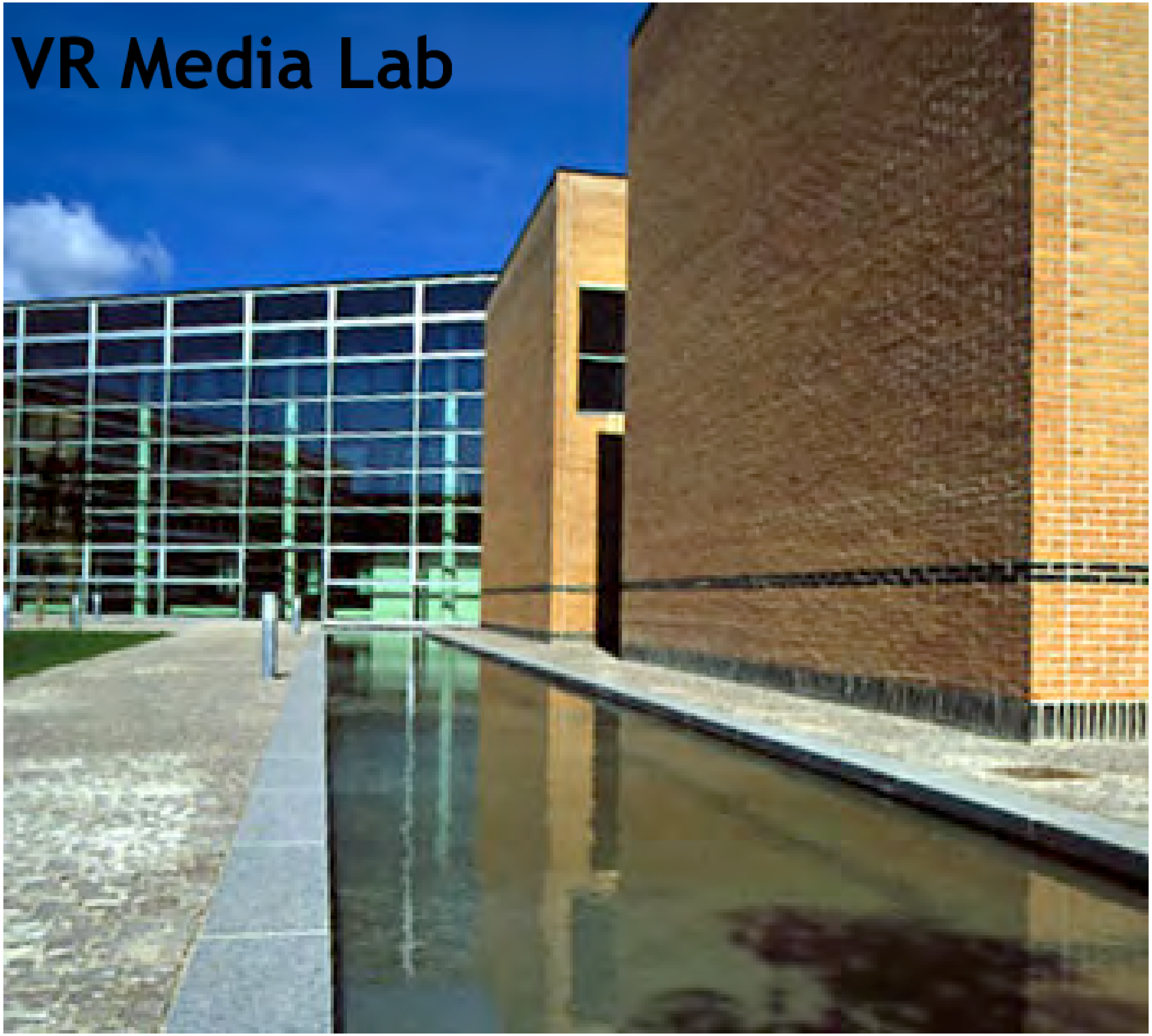
VR Media Lab



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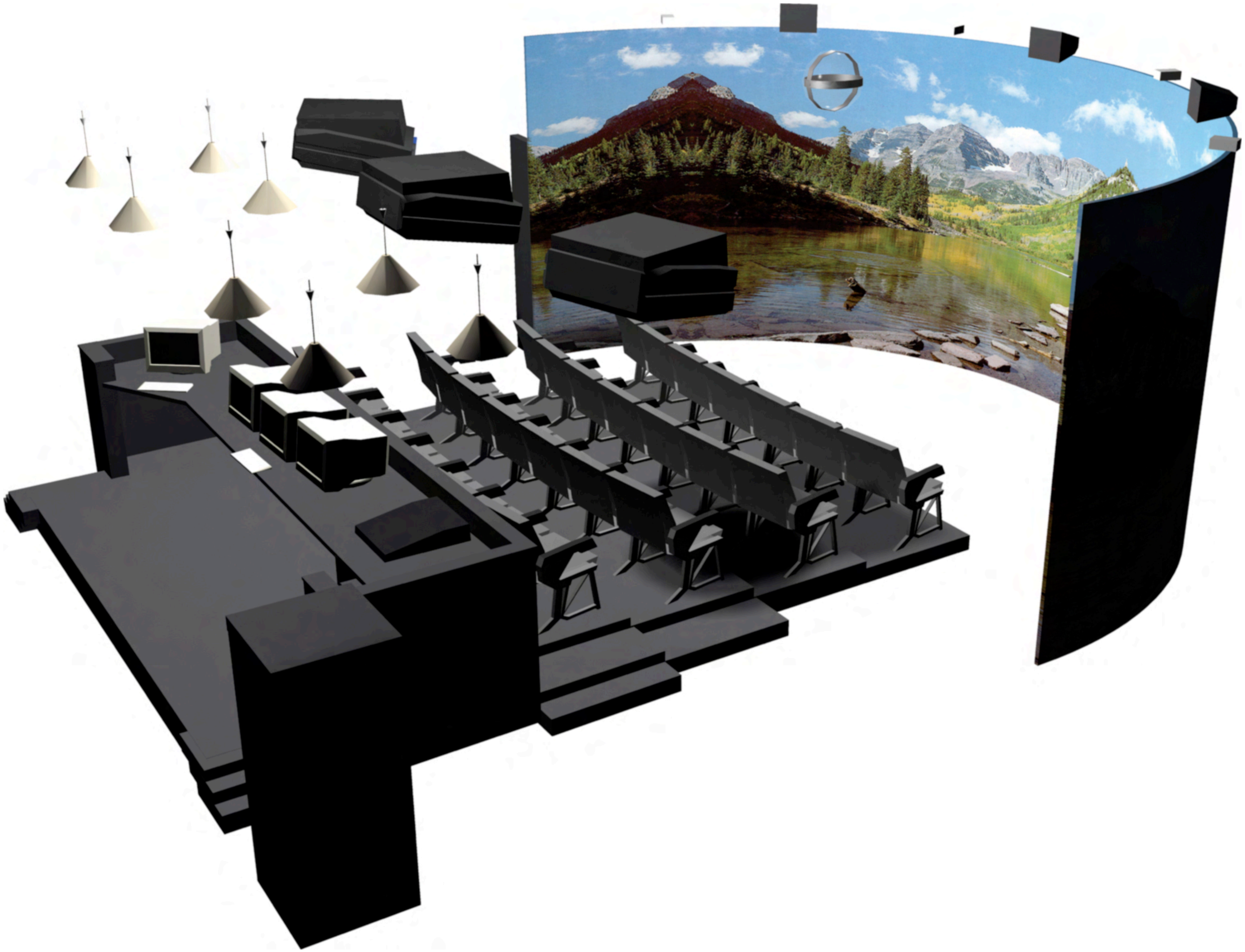

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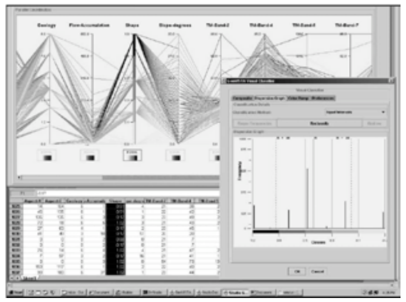
Geovisualization

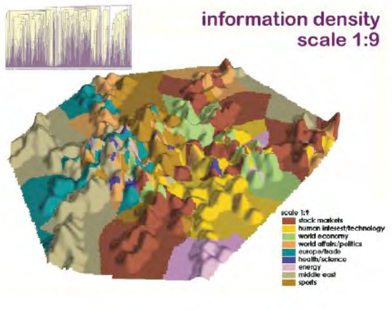
- From ICA Visualization group
- Kraak & MacEachren
  (Cartography and Geographic Information Science,Vol.28,No.1,2001)
- "Beyond the map"
- Towards:
  - Exploration
  - Interaction and dynamics
  - Interoperability
- 3d becomes a way to deliver your message

Focus areas

- Exploratory Data Analysis

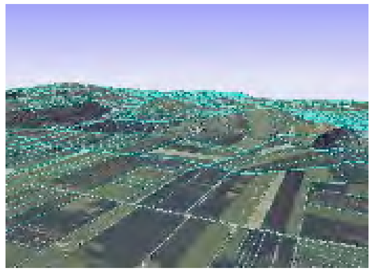


- Information landscapes



- Collaborative systems

- Geo-virtual environments



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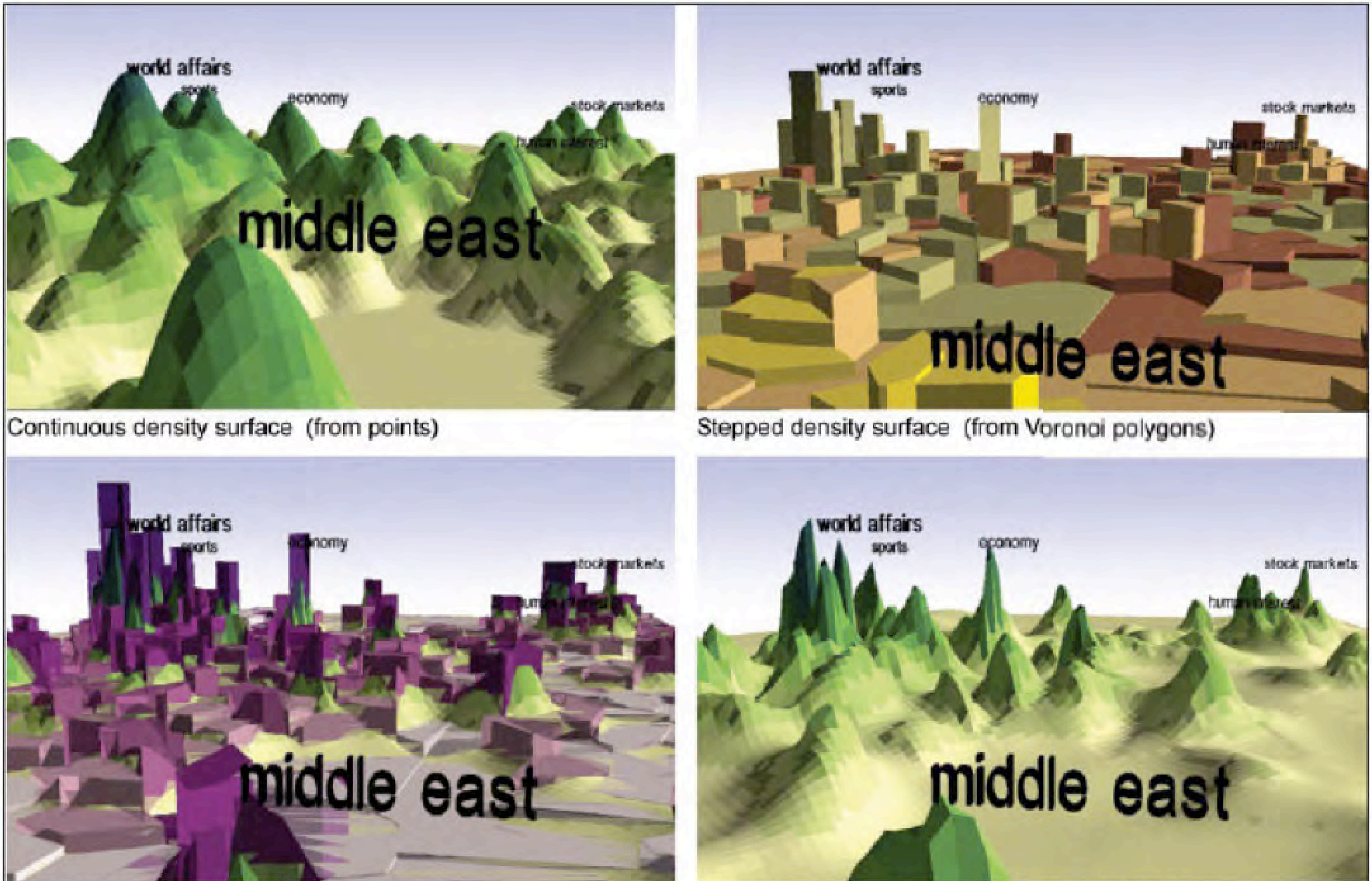

Continuous density surface (from points)

Stepped density surface (from Voronoi polygons)

Pycnophylactic reallocation (Tobler, 1979)

Pycnophylactic surface (from Voronoi polygons)

Textures and 3D shapes communicating geographically related information (Skupin and Fabrikant 2003).

Why 3d?

3D GeoInformation

- Simple transformation between model, data and reality
- Presentation: 3d models are natural og cognitively easier to interpret and is thereby suitable to communicate ideas and visions
- Exploration: the human vision is made to quickly interpret a large amount of content or data in a scene. There are relations in a scene which the human brain percieve, often without being conscious about it. A large amount of data can therefore be communicated
- Immersion: The user can be manipulated through hardware interfaces to get the feeling of immersion into the scene and thereby to have a strong sense of being in a physical world. This has been used in adventure oriented models, as well as in product development of for instance engines
- Documentation: Much geoinformation contain height information that are only handled as attribute information in 2d. In 3d, a more exact documentation can be performed
- Simulations and dynamics: temporal simulations of 3D data can cause a more realistic and more exact simulation than in 2d

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From 2d to 3d

- There is a long way from our usual 2d map to a full semantic 3d model
- We will need a better ontology for understanding the different objects in 3d
- Topology issues are much more complex in 3d
- Better to focus on interoperability than on verisimilarity and photo-realism
- It is not enough to have the objects - we also need better indexing mechanisms to be able to query the systems faster (realtime)

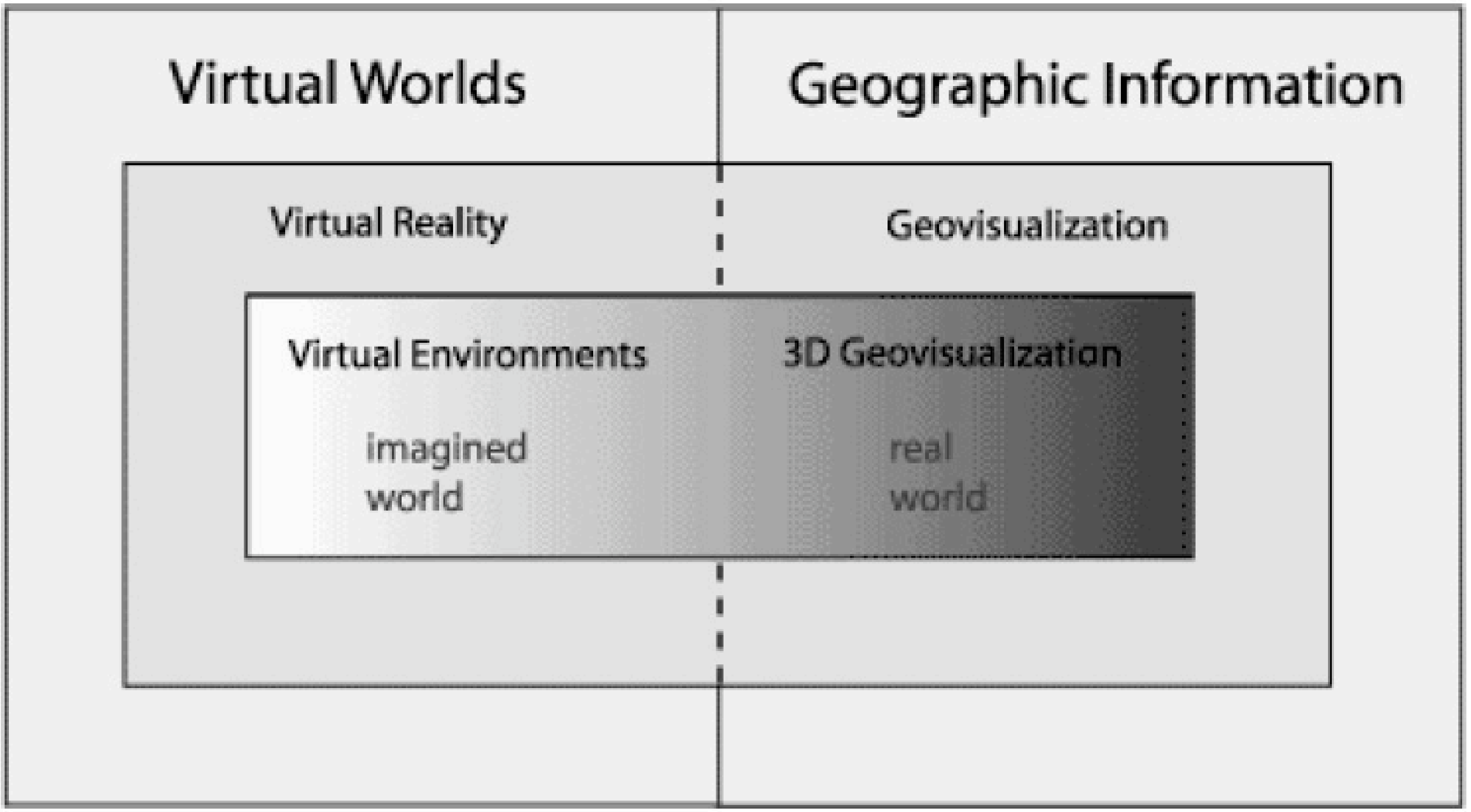
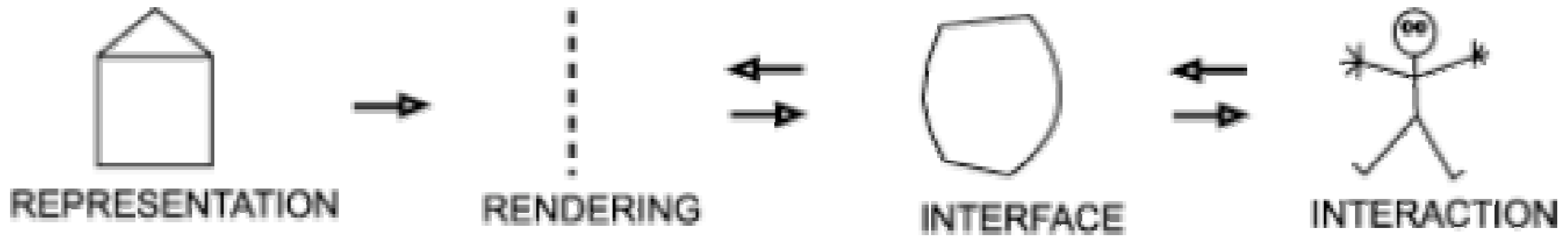


Figure 1.6: Relationship between Virtual Worlds and Geographic Information. Virtual Worlds and Geographic information is two separated scientific realms while Virtual Reality and Geovisualization profit from some of the same concepts. The line between these are therefore dashed in the figure. Virtual Environments reflects usually an imagined world though it also contains real worlds. Likewise 3D Geovisualization usually contains real worlds, though imagined worlds occur.

(Figure is taken from an yet unpublished ph.d. thesis by Anette Nielsen, 3DGI)

3d in Geovisualization

- Representation
  - Datastructure, conceptual models
- Rendering
  - Graphics, virtual environments
- Interface
  - Display type, pseudo, stereo or real 3d
- Interaction
  - Navigation and wayfinding



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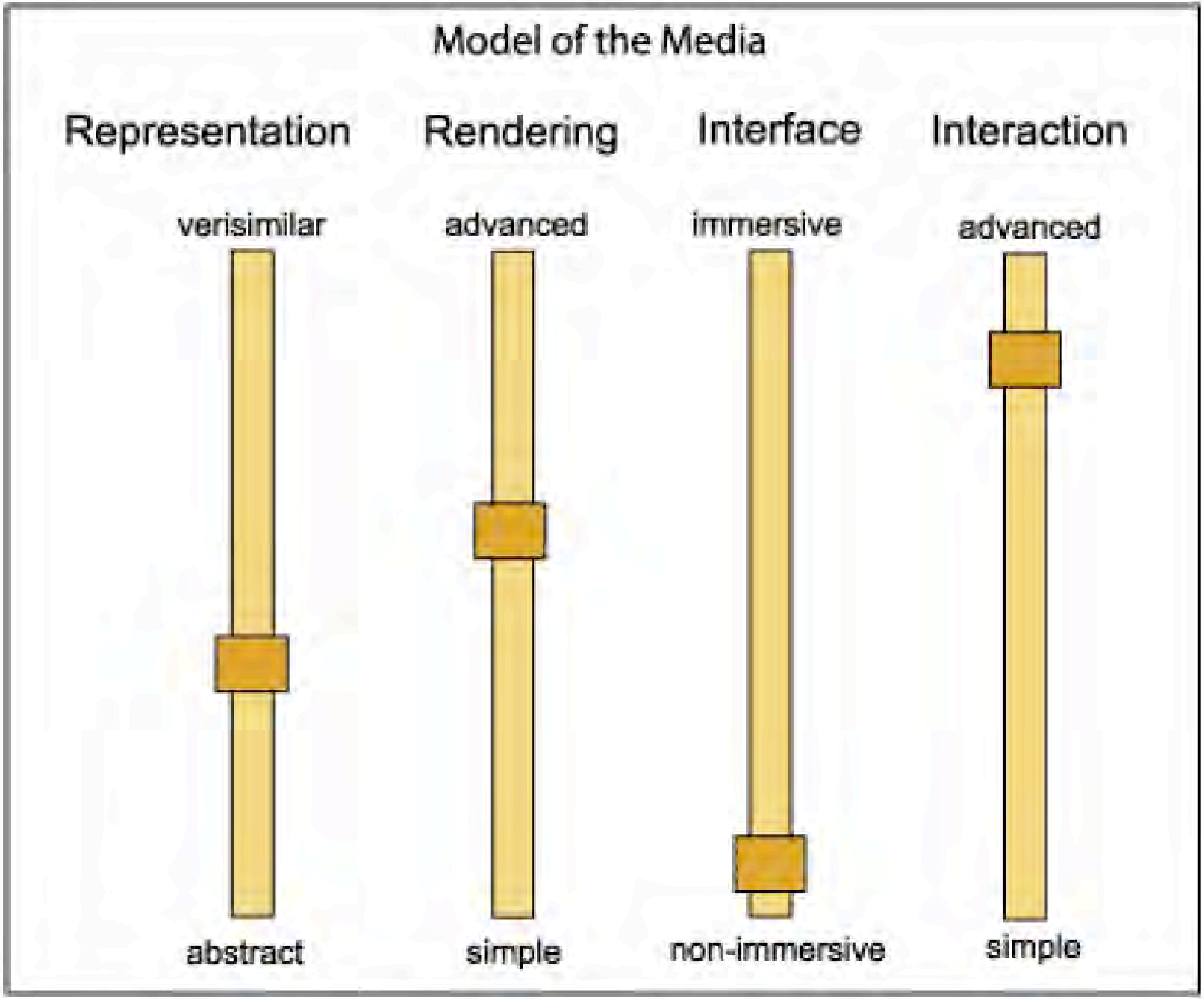

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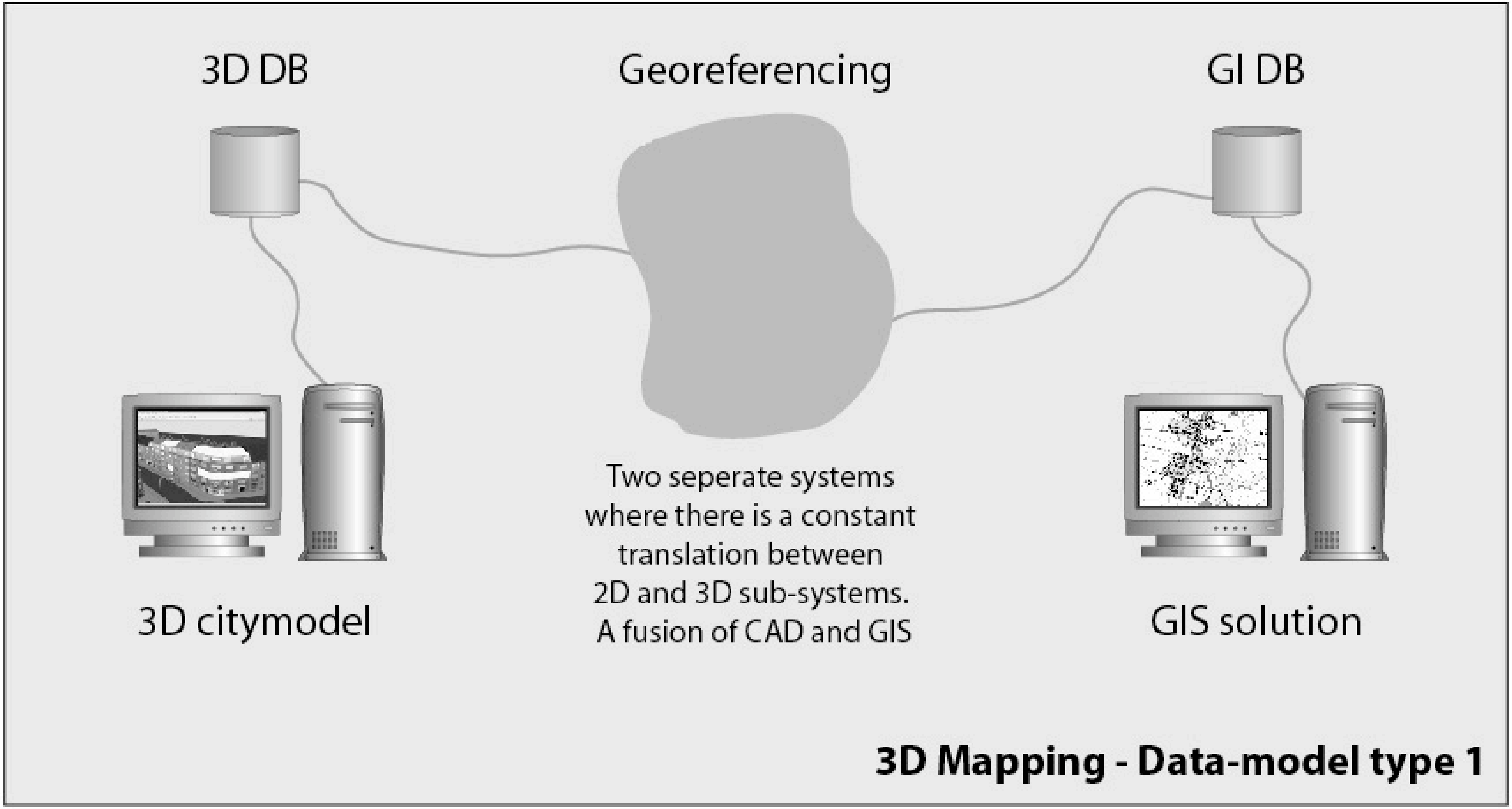
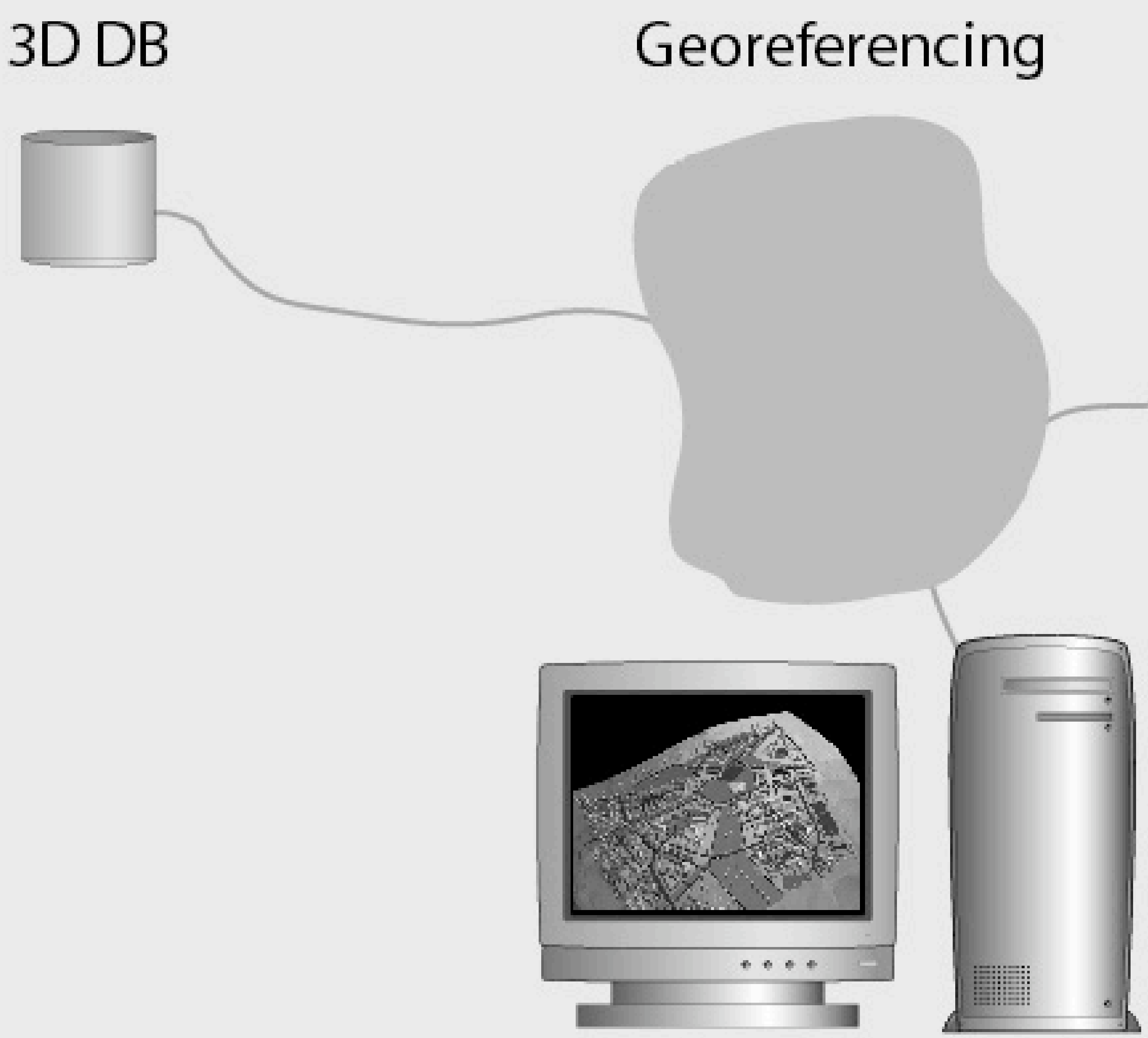

3D DB
Georeferencing
GI DB
Two seperate systems
where there is a constant
translation between
2D and 3D sub-systems.
A fusion of CAD and GIS
3D citymodel
GIS solution
3D Mapping - Data-model type 1



A combination where the 3D visualisation is enriched with thematic geodata. The data is kept in seperate databases due to the difficuties to implement 3D structures into the geoinformation database and visa versa.

3D Mapping - Data-model type 2

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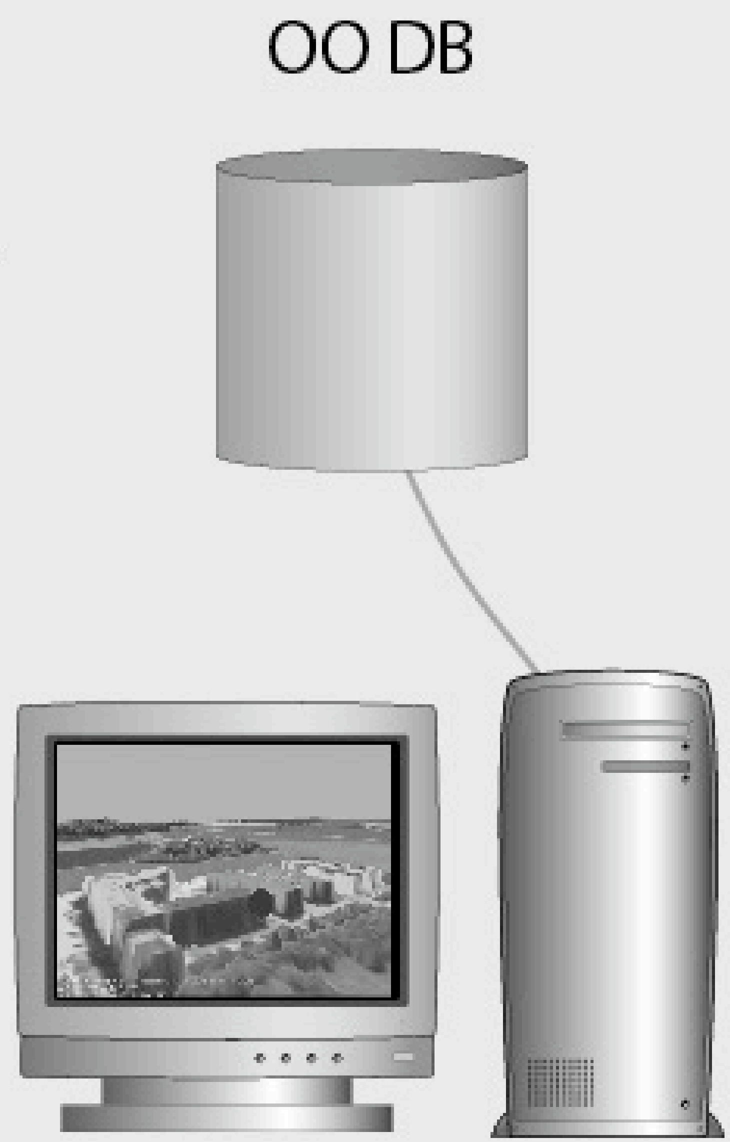
The ultimate solution for 3D.
An object-oriented database
with real 3D structures in the map
generated from different geodata-
sources.This type of datamodel
is very depending on a clear
objectclassification.



3D Mapping - Data-model type 3

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Fragmentation in Geometry

- When urban 3d models are produced they are pure CAD models due to the way geometry are stored
- To be more precise it is a facetted B-rep
- It is in indeed a patchwork of faces and polylines
- Problems relate to semantics and further work on the model such as holes and surfaces on surfaces (eg. windows)

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Fragmentation in Topology

- At the moment there are no easy way to create topology in a 3d city model
- Topology in 3d is still a research subject - due to the complexity of the problem
- That means Geovirtual Environments in 3d lacks the topology

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Fragmentation in Semantics

- The lack of semantics in 3d citymodels is serious!
- There is a great need for more “intelligence” in the models
- Most of the 3d models are “multi-purpose” models which means it is difficult to agree on the object-model

Fragmentation in Geography

- Until now it has been normal to have each city model in it's own database
- The ideal system would make all models accessible through a common geographic interface
- This interface would be The Earth - or to more direct: The Digital Earth!

Fragmentation in Time

- There are no clear definition of time in relation to spatial models
- Time can be represented in several different ways
  - as static
  - as dynamic
  - as real-time
- Still not a clear definition of real-time!

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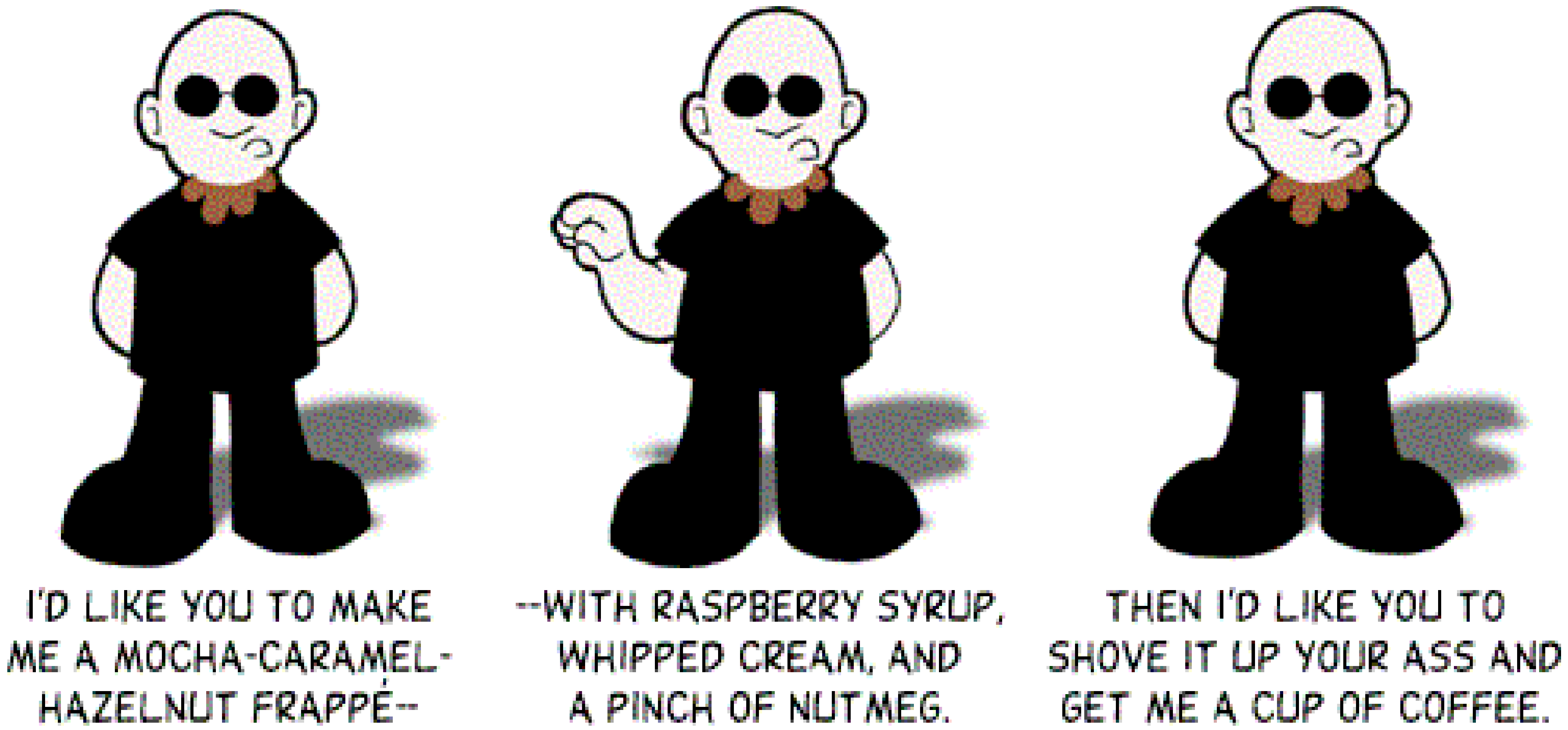
Break!



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Geographic Exploration Systems

3D GeoInformation

- Democratization of geoinformation
- Digital Earth
  - Al Gore speech
  - Future of DE
- Earth exploration
- Virtual Globes
  - Google Earth
  - NASA World Wind
  - Virtual Earth (MS)
  - ArcExplorer
  - ...and many others
- GRIFINOR

See a list at http://www.nanocarta.com/wiki/index.php?title=Virtual_globes

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How does GES differ from GIS?

3D GeoInformation

- GIS was "invented" during the map era
- GIS is datamodel, datastorage, analysis, query, visualisation in one package
- GIS never became THE answer to the problem
- GIS stayed commercial even though Internet rolled over it like a steamroller
- GES has a focus on data representation, information merger and visualization

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Geoinformation, Internet and Democracy

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> "How can geographic information become a facilitating part of a democratization project?"

- The traditional answer to this question would be a Planning Support System in combination with GIS
- But GIS has never been an obvious partner in connection with either participation or democracy!

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Geoinformation, Internet and Democracy

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- Level 1: Public participation
  - Passive use of geo-information
  - Major progress since Internet (1995 until now)
- Level 2: Public access to geoinformation
  - Not really possible due to lack of interoperability!
  - Initiatives are under way here - e.g. OGC and INSPIRE (Europe)
- Level 3: Public access to methods of analysis
  - Distributed systems, Sevice Oriented Architecture and Object orientation

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Digital Earth and GES

3D GeoInformation

- New paradigms within geovisualization
- Spatial Data Infrastructure where geography would become the interface
  - Digital Earth by Al Gore
  - Alexandria Digital Library
- A three-dimensional model is more politically neutral than a two-dimensional map
- Geographic Exploration Systems defined by David Maguire (among others!)
  - Exemplified through NASA WorldWind, Google Earth, ArcGIS Explorer (GeoFusion technology)

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Geo communities

- Mashups!
  - Google Maps gives you a free API
  - Open standards
- Frappr!
  - Mapping different web communities
  - Geocoding Flickr
- Podcasts!
  - VerySpatial
- Open source programming!
  - OS Geo Foundation

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TIROS I

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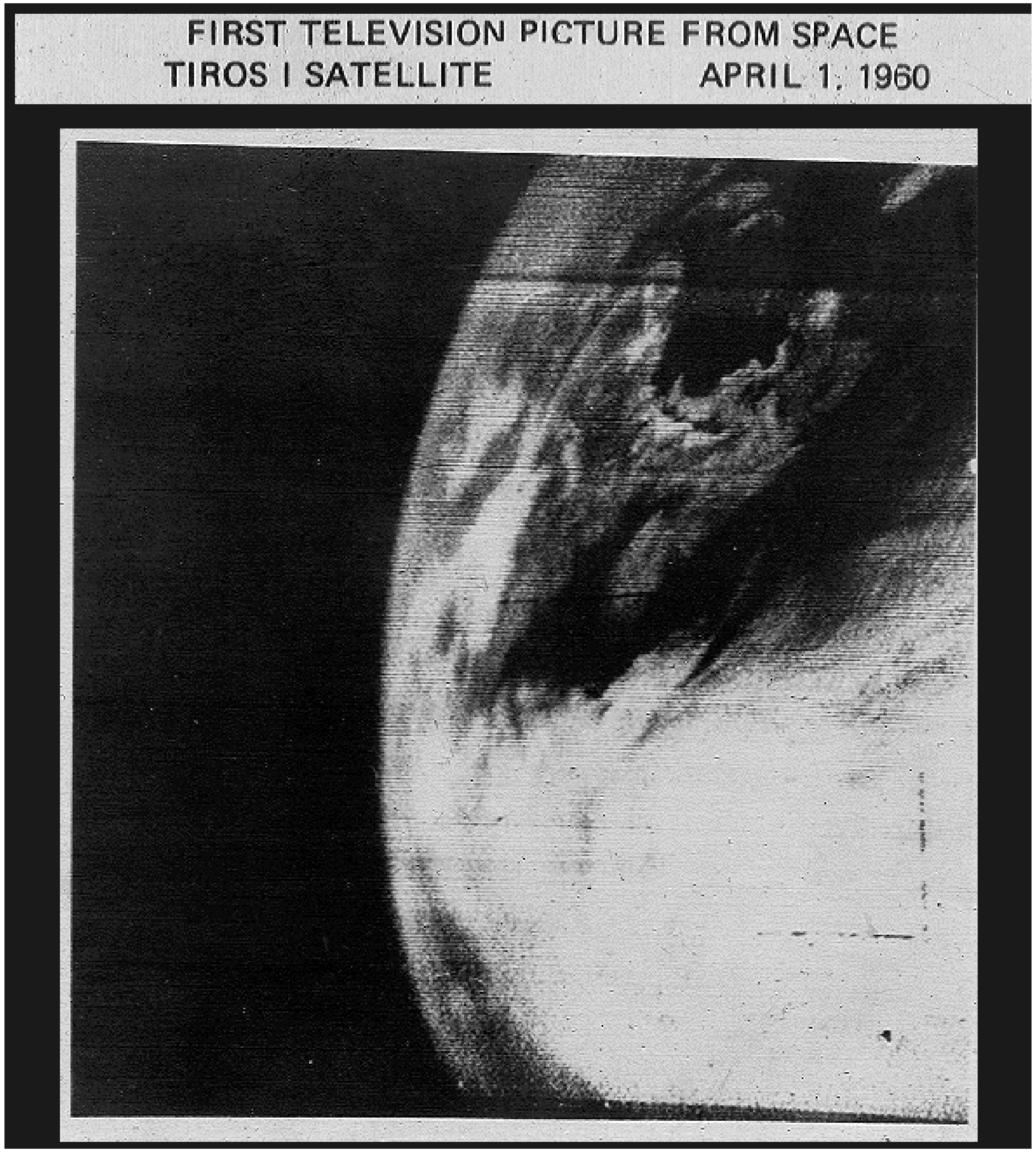
First TV picture of Earth 01.04.1960



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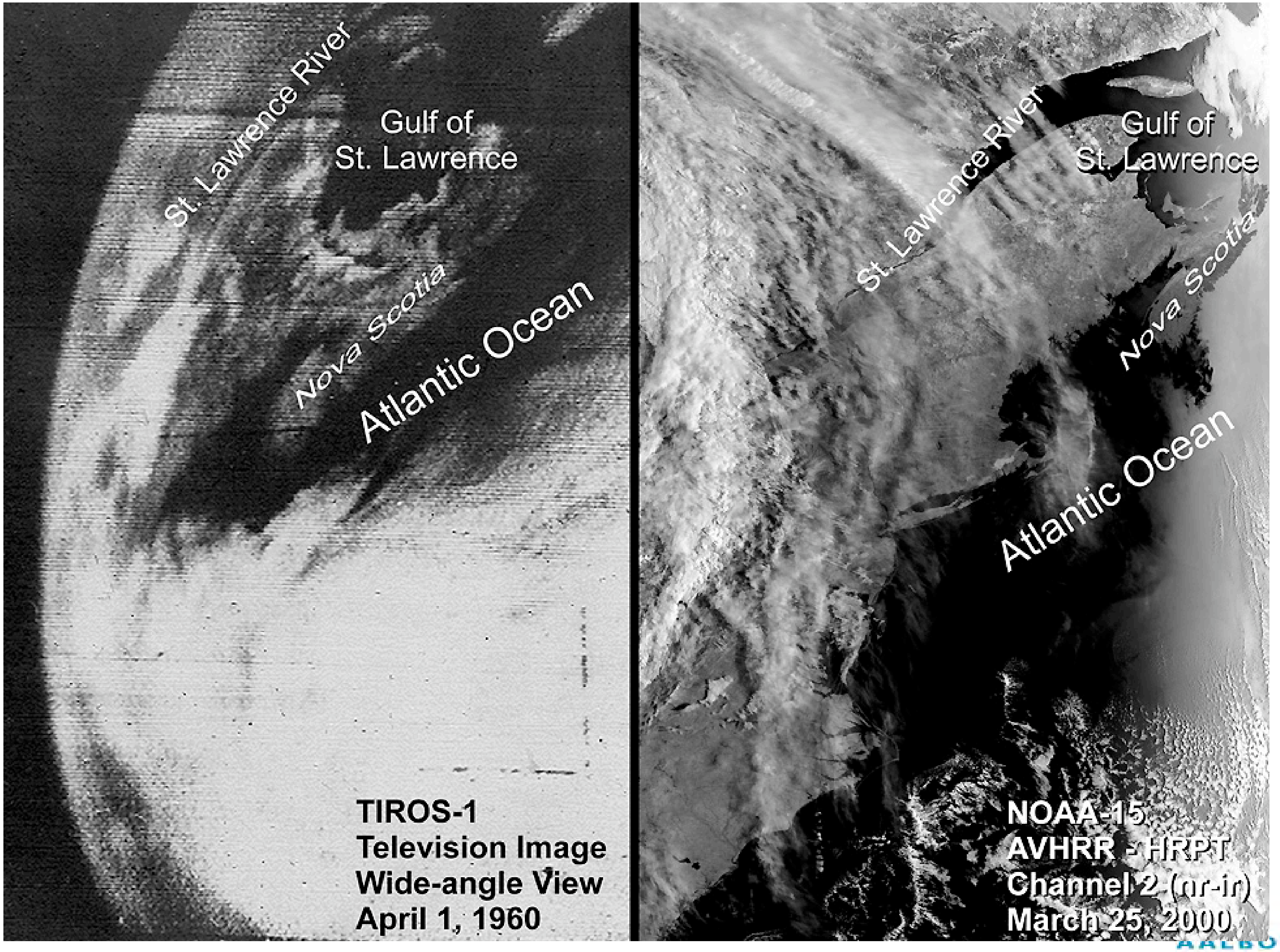
What did TIROS I see?



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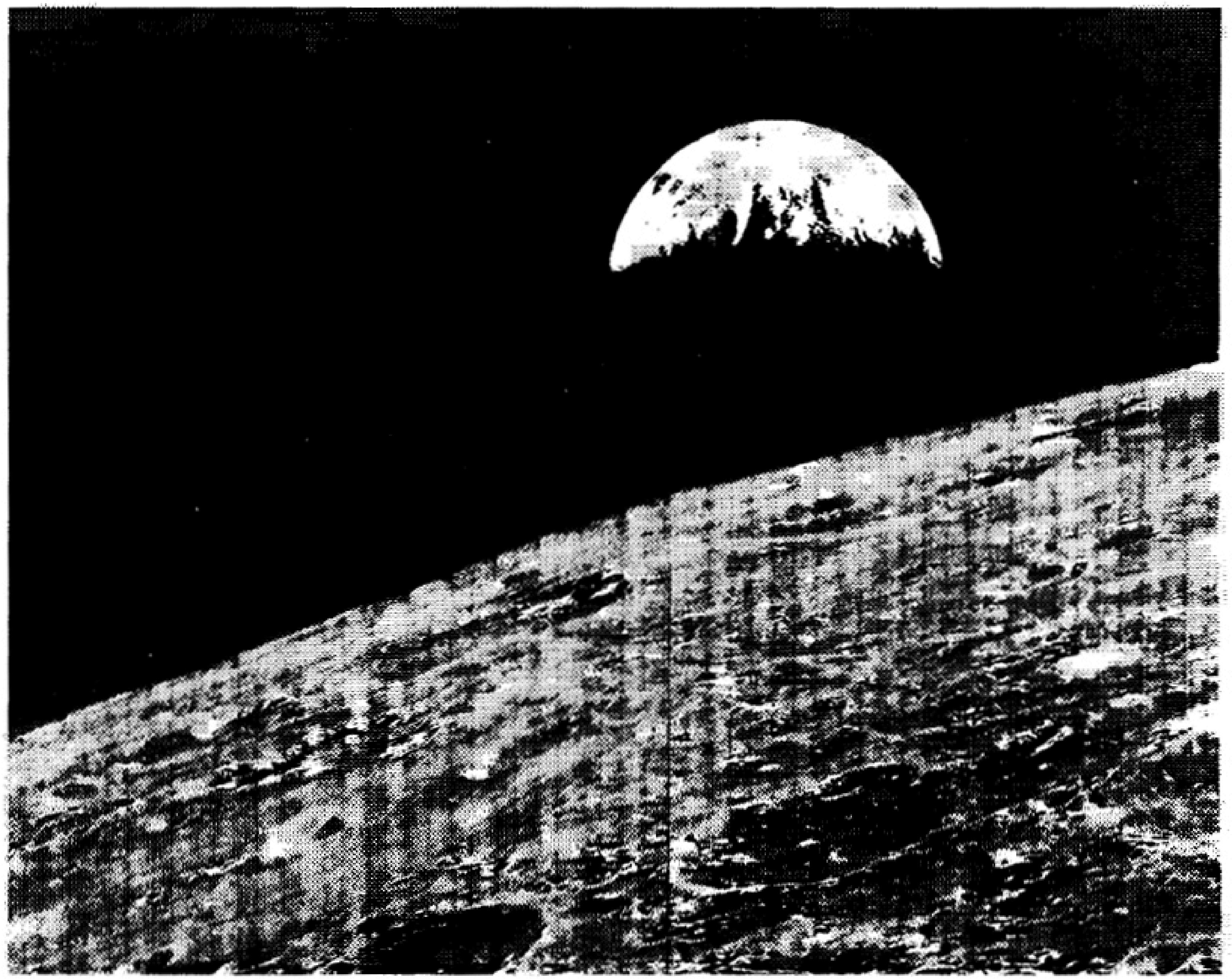
Lunar Orbiter I - 23.08.1966



The first Earth photograph by Lunar Orbiter I shows the cratered lunar horizon and the swirling cloud masses on Earth some 345,700 kilometers away. Taken August 23, 1966, as the spacecraft was about to pass behind the Moon on its 16th orbit, the picture proved valuable to program scientists for what it showed of the lunar surface at an oblique rather than a vertical angle. The illuminated crescent of the Earth shows the U. S. East Coast in the upper left, southern Europe toward the night side of Earth and Antarctica at the bottom of the crescent.

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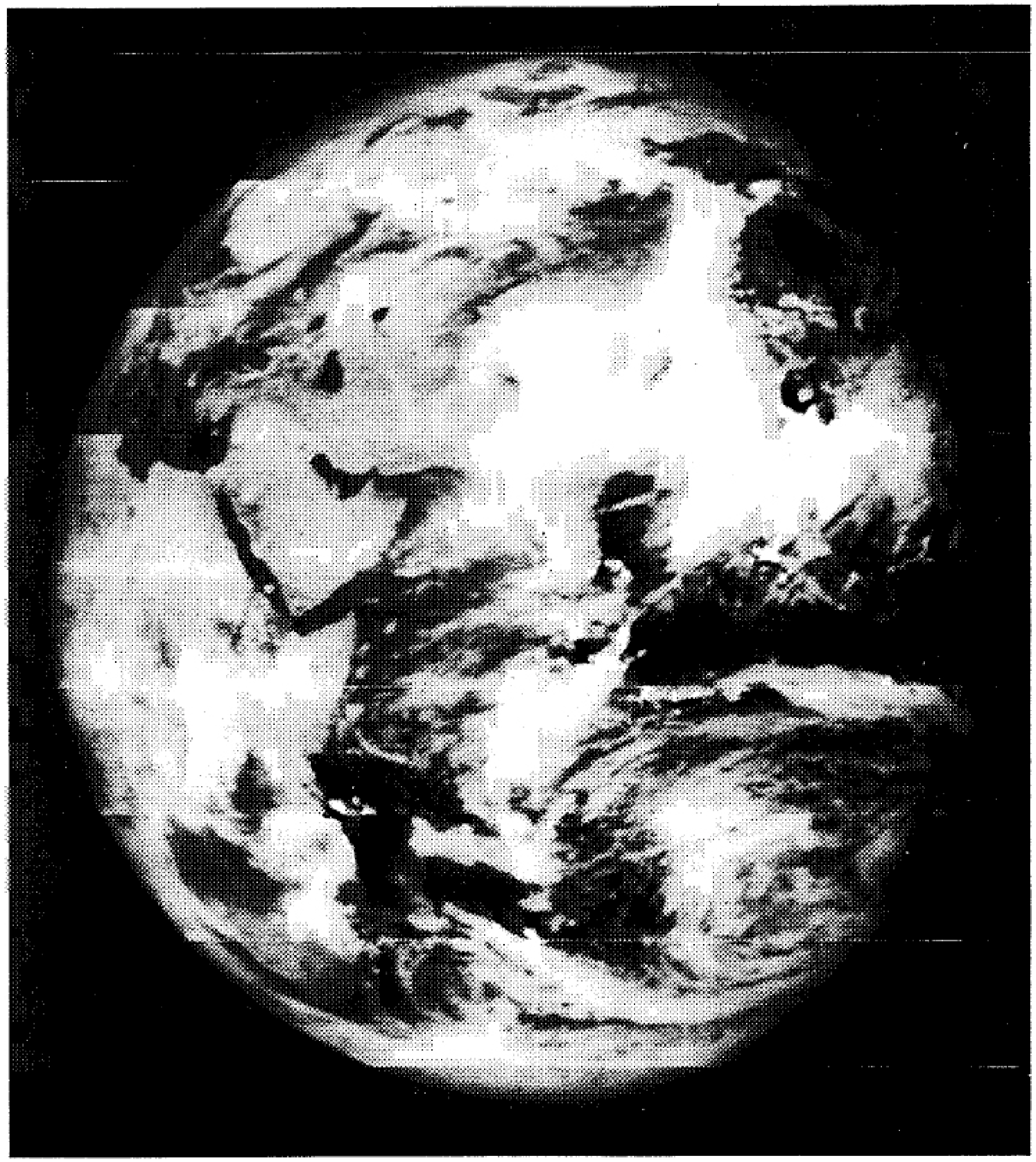
Lunar Orbiter V
08.08.1967



On August 8, 1967, Lunar Orbiter V took this photo of the nearly full Earth with the 610 mm lens. The exposure time was 1/100 second, which was insufficient to compensate for the Earth's high albedo (about 0.36 of 1.0). However, ground processing successfully compensated for overexposure. The sub-solar point was just above and left of the Aral Sea, and the spacecraft's camera line of sight with Earth focused on a point slightly above and right of the Aral Sea. The angle between the subsolar point and the camera's line-of-sight axis intercept was 31.5°. The spacecraft was about 5,860 kilometers above the Moon in near polar orbit, so that the surface is not seen. The picture shows Italy, Greece, Turkey, the Mediterranean, the Red Sea, most of the African continent, Madagascar, India, and Central Asia.

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Apollo 8 - Christmas eve 1968

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- During the 1960's NASA had been very active in the Apollo programme which was to culminate in the summer of '69
- One of the most important missions was scheduled to Christmas of 1968 where Apollo 8 should launch with the purpose to find landing spots on the face of the moon
- For the first time a manned mission was to orbit the moon
- Launch date 21.12 and on the day of Christmas eve 24.12 Apollo 8 went into orbit around the moon
- After the first orbit something very exciting happened. A wonderfull view hit the astronauts...

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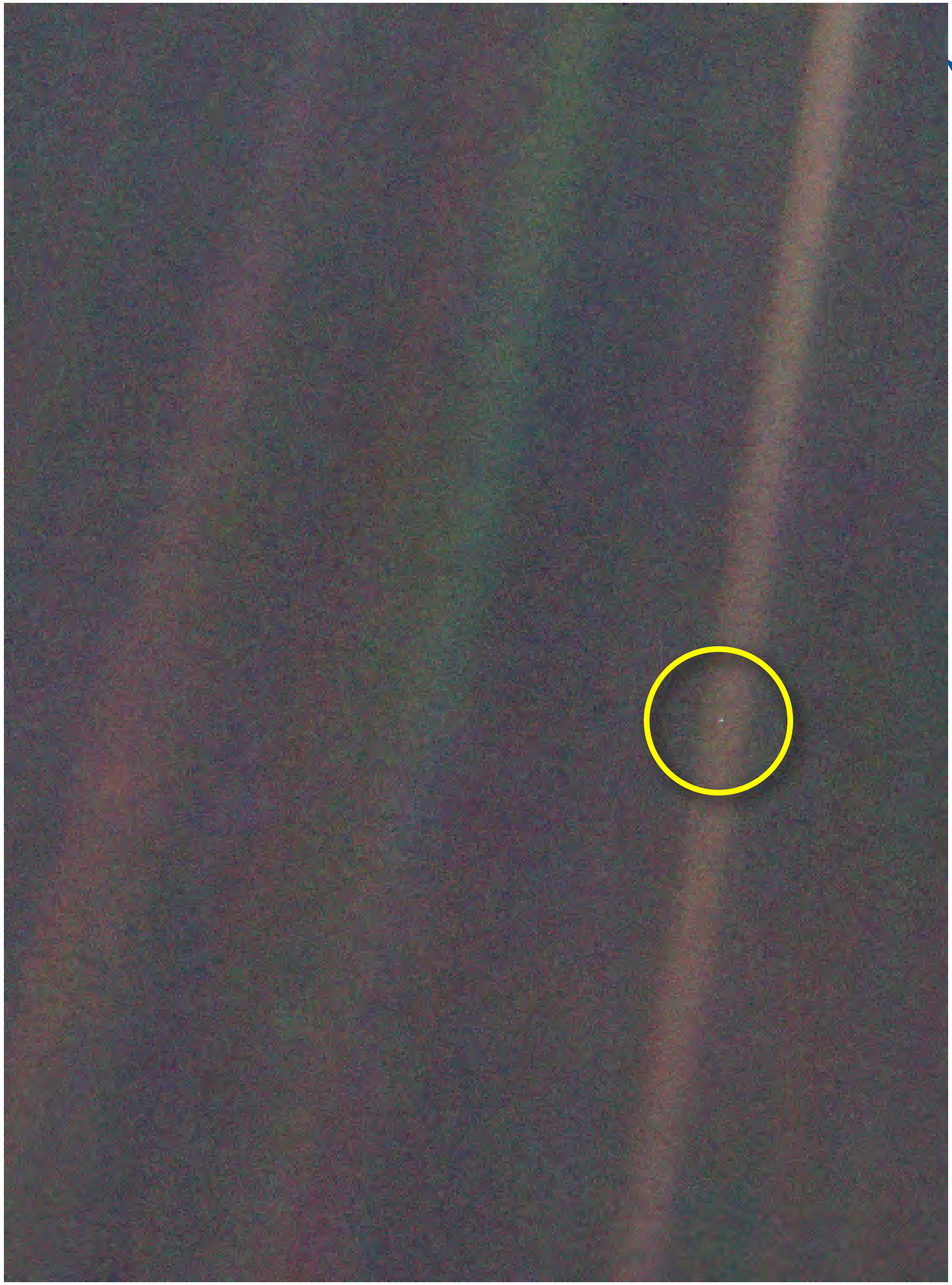
Apollo 17   09.12.1972

"Pale Blue Dot"

- Voyager 1 og 2 was send off towards the edge of the solar system in autumn 1977
- On the way out of the system in 1990 it was decided to turn the cameras on Voyager 1 towards Earth
- Distance to Earth was 6.000.000.000 km.
- This is described in the novel by Carl Sagan with the name "Pale Blue Dot"



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How Google Earth became!

- After the political and research oriented initiatives in the late 1990's, a group of researchers at UC San Diego developed GeoFusion which is a developer platform for geodigital solutions.
- This is in fact an Open Source platform, and it is used in a long series of applications launched after 2000
- Among other in a commercial project called Keyhole in 2001
- Keyhole was to be used as 3d visualisation to a long list of more administratively applications
- Google bought Keyhole in 2004 - and they launched Google Earth in spring 2005

The Geoscope

3D GeoInformation

… The new educational technology will probably provide also an invention of mine called the Geoscope - a large two-hundred-foot diameter (or more) lightweight geodesic sphere hung hoveringly at one hundred feet above mid-campus by approximately invisible cables from three remote masts… …The two-hundred-foot geoscope will cost about fifteen million dollars. It will make possible communication of phenomena that are not at present communicable to man’s conceptual understanding…

The Geoscope may be illuminated … …The consequences of various world plans could be computed and projected. All world data would be dynamically viewable and picture able and relay able by radio to all the world, so that common consideration in a most educated manner of all world problems by all world people would become a practical event.

from Education Automation, R. Buckminster Fuller, 1962

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Dymaxion

GRIFINOR

New 3D open source platform

What is GRIFINOR?

3D GeoInformation

- Decentralized platform for 3D geo-vizualisation
- Organizes data according to geocentric coordinates
- The data is visualized in a 3D model of the Earth, which can be accessed from the Internet

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What is original?

- Common points with other similar systems (Google Earth, Nasa Worldwind):
  - It provides a virtual representation of the Earth in 3D
  - It is “zoomable”: different levels of detail
- Original features:
  - Accessible directly from the Web
  - Decentralized network
  - Object-oriented design
  - Terrain data structure
  - Navigation

Decentralized network

- No central server
- Each user can visualize his own data on his computer, and share it if he wishes.
- Decentralized network structure, similar to that of the World Wide Web.

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Index for Distributed Spatial Object (DSO-index)

- Distributable data structure suitable for indexing 3d objects on world scale
- DSO-index is based on an octree-like data structure
- All nodes and objects are directly or indirectly referenced from the same top node. This top node can be used for arbitrary number of servers
- When used for visualization, the index allows for querying the visually most important objects at a given viewpoint
- The index is used for dynamically changing the fidelity of the visualization according to the capabilities of the hardware and the network as well as user preferences
- Objects can be cached locally and clients can form a peer-to-peer network to relieve object servers

Topographic surface representation indexed using global grid

- For terrain we use a seperate index solution
- The indexing transformation uses a method that divides three-dimensional space through a tessellation of a sphere
- This tesselation of a sphere is known as a global grid
- The global grid is a special case of Voronoi tesselation
- Tesselation is made in multiple resolution which is used for indexing LOD

Geo-embedded visual navigation

- Estimate the gravitational up vector at any given position of the user in relation to the globe and aligning the view accordingly
- On a global scale it is more apparent that the navigation works differently, simply because it is more obvious that the world is spherically represented
- Similar to navigation of planar maps, the user can, for example, look over a 3D area, which is actually part of a spherical model; looking down one could zoom-in and zoom-out and pan to any side
- This provides a natural experience for humans and offers a visual navigation and perception at many scales

An entirely object-oriented design

- GRIFINOR is programmed in Java, which is an object-oriented language
  - Each geographic feature is an object from a programming point of view
  - These objects can interact with each other, and with potential applications.
- The object oriented design
  - allows interaction with applications
  - is a source of interoperability

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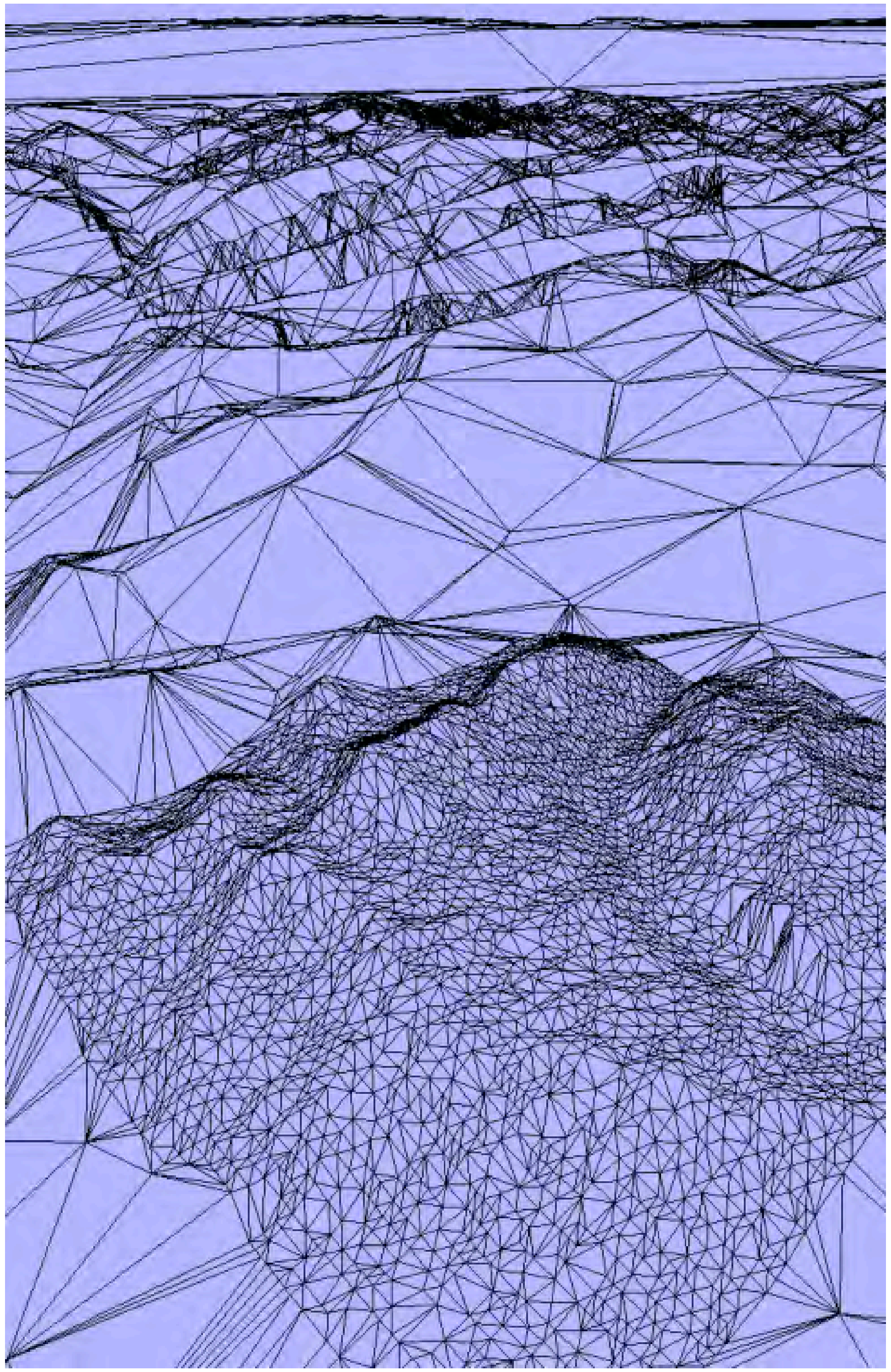
Terrain data structure



- In Google Earth the terrain representation is based on raster data structure.
- In GRIFINOR, on the other hand, it is based on TIN: triangulated irregular network.
  - good for analytical purposes, TIN is used in industry

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Ontology is needed!

- GML - Geographic Markup Language
  - It will not happen for a long time!
- IFC - International Foundation Class
  - Did you know that IFC has 2160 different objects?
- X3D/VRML - Virtual Reality Modeling Language
  - Not really an ontology - More the start of an intensive library of different profiles
- SEDRIS - Synthetic Environment Data Representation and Interchange Specification
  - Has been standard for military simulation for a long time
- CityGML
  - Is now adopted by OGC, EuroSDR and will become widespread
- KML - Keyhole Markup Language
  - Actually a proprietary standard, but could develop into a De facto!

Summary

3D GeoInformation

- GRIFINOR adresses the need for a global object-oriented solution for browsing geoinformation of many kinds
- Consider this as the engine for future applications within many areas concerning urban issues
- Further research should be done regarding implementation of a better raster engine for the system
- We have opened for online access to a prototype of GRIFINOR - please contact us if you are interested in this!

Acknowledgements for GRIFINOR

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- European Regional Development Fund (ERDF)
- Aalborg University, Denmark
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- COWI A/S, Denmark (formerly known as Kampsax)
- Informi GIS, Denmark

- GRIFINOR is developed in a cooperation between Aalborg University and Jan Kolar

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Break!

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