GISTC 空间智能 因融至慧 | 2023地理信息软件技术大会
2023 Geospatial Information Software Technology Conference

# The Future of GIS

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&
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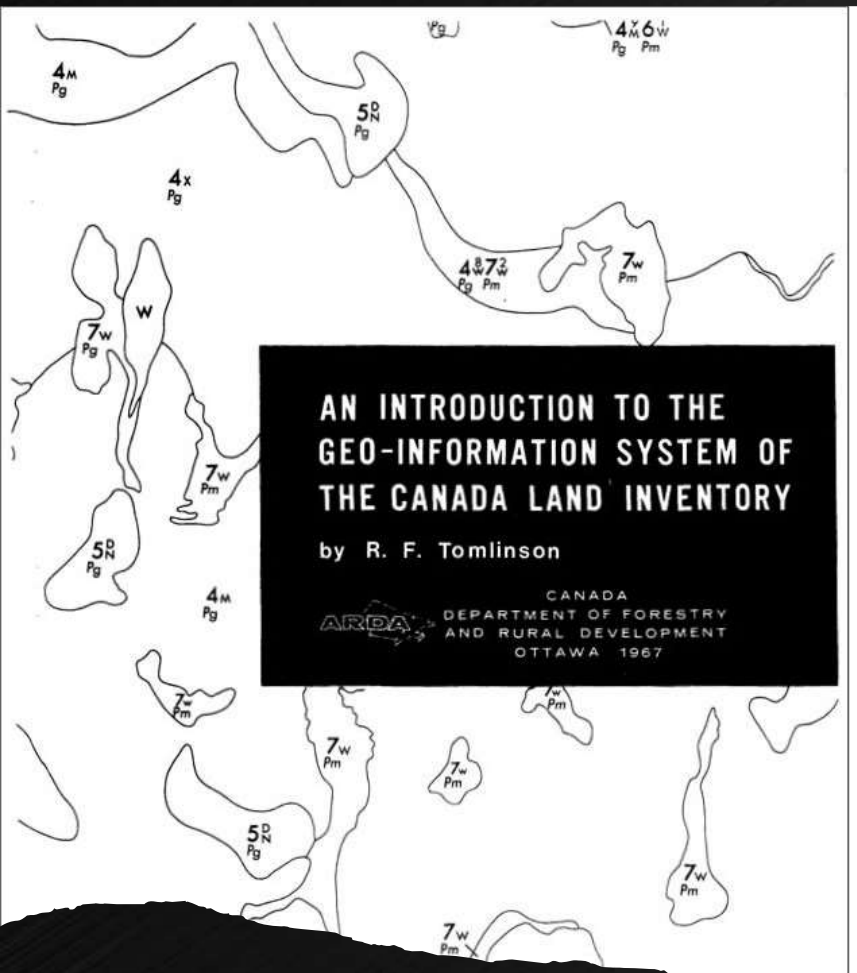
# 不出戶，知天下…(老子)

Without leaving home,
you can know the whole world…
(Lao Zi)

1

# Look into the Past of GIS and GI-Science

# Some Publications

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## Geographical information science*

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**Abstract.** Research papers at conferences such as EGIS and the International Symposia on Spatial Data Handling address a set of intellectual and scientific questions which go well beyond the limited technical capabilities of current technology in geographical information systems. This paper reviews the topics which might be included in a science of geographical information. Research on these fundamental issues is a better prospect for long-term survival and acceptance in the academy than the development of technical capabilities. This paper reviews the current state of research in a series of key areas and speculates on why progress has been so uneven. The final section of the paper looks to the future and to new areas of significant potential in this area of research.

### 1. Introduction

The geographical information system (GIS) community has come a long way in the past decade. Major research and training programmes have been established in a number of countries, new applications have been found, new products have appeared from an industry which continues to expand at a spectacular rate, dramatic improvement continues in the capabilities of platforms, and new significant data sets have become available. It is tempting to say that GIS research, and the meetings at which this research is featured, are simply a part of this much larger enthusiasm and excitement, but there ought to be more to it than that.

What, after all, is the purpose of all of this activity? Expressions such as 'spatial data handling' may describe what we do, but give no sense of why we do it. This was one of the themes behind Tomlinson's keynote address at the First International Symposium on Spatial Data Handling in Zurich in 1984 (Tomlinson 1984). The title of the conference suggests that spatial data are somehow difficult to handle, but will that always be so? It suggests a level of detachment from the data themselves, as if the U.S. Geological Survey were to send out tapes labelled with the generic warning 'handle with difficulty'. It is reminiscent of the name of the former Commission on Geographical Data Sensing and Processing of the International Geographical Union. A quick review of the titles of the papers at that or subsequent meetings should be enough to assure anyone that their authors are concerned with much more than the mere handling and processing of data—from a U.S. perspective, that the community is more than the United Parcel Service of GIS.

Geographical information systems are sometimes accused of being technology driven, a technology in search of applications. That seems to be more true of some periods of the 25-year history of GIS than of others. For example, it is difficult to

*Based on keynote addresses by the author at the Fourth International Symposium on Spatial Data Handling, Zurich, July 1990 (Goodchild 1990), and EGIS 91, Brussels, April 1991 (Goodchild 1991).



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## Cartography and the others – aspects of a complicated relationship

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**ABSTRACT**

Cartographic visualizations have been known for thousands of years and have brought forth a wealth of different map projections and cartographic products. Yet, cartography as an independent science has been established only about 100 years ago and sometimes its position among the spatial disciplines is challenged by the scientific community. In this respect it is a young science based on a very long tradition of map making, globe production, and the development of map projections. Maps and map related visualizations play an important and indispensable role in many other spatial disciplines such as geography and geodesy. Cartography has many overlaps with these traditional disciplines as well as with the more recent ones of photogrammetry and remote sensing. This paper reviews fundamental aspects of the conception of space and time throughout human history, the historic development of cartography from a technique of map making to a spatial science, highlighting major milestones in the history of the discipline. As a young science and confronted with major technological developments in the late 20th century cartography underwent several crises as to what exactly is cartography and how it relates to other spatial sciences, in particular to geographic information systems. Major pitfalls and misconceptions are discussed and the three major scientific pillars of cartography are identified. The relationships of cartography with neighboring disciplines are discussed and the position of cartography vis a vis the others is delineated. Finally, desirable future developments of scientific cartography are discussed.

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**KEYWORDS**
Cartography; GIS; geodesy; photogrammetry; remote sensing

### 1. Introduction

Everything that happens, happens at a certain location and at a certain point in time. Humans as spatio-temporal beings living in 3D space have been contemplating the character of space and time since the early development of higher civilizations. Their philosophical thoughts about space and time can be traced back thousands of years and are found in philosophical and religious writings – mostly creation stories – in every highly developed civilization around the globe. The general tone of these tales is that out of chaos or nothing a higher being created the gods, the earth and the sky (i.e. the natural world), followed by placing humans into this world.

Ancient examples of these creation myths are the Babylonian Creation Myth also known as Enuma Elish after the first words of the text in Akkadian language (Mark 2018), the Chinese creation story of Nuwa who crated human beings from the mud of the Yellow River (Mark 2016), the Book Genesis of the Christian Bible, or the Metamorphoses of the Roman poet Ovid where he describes how a god ended chaos by splitting off the earth from the sky and the sea from the land

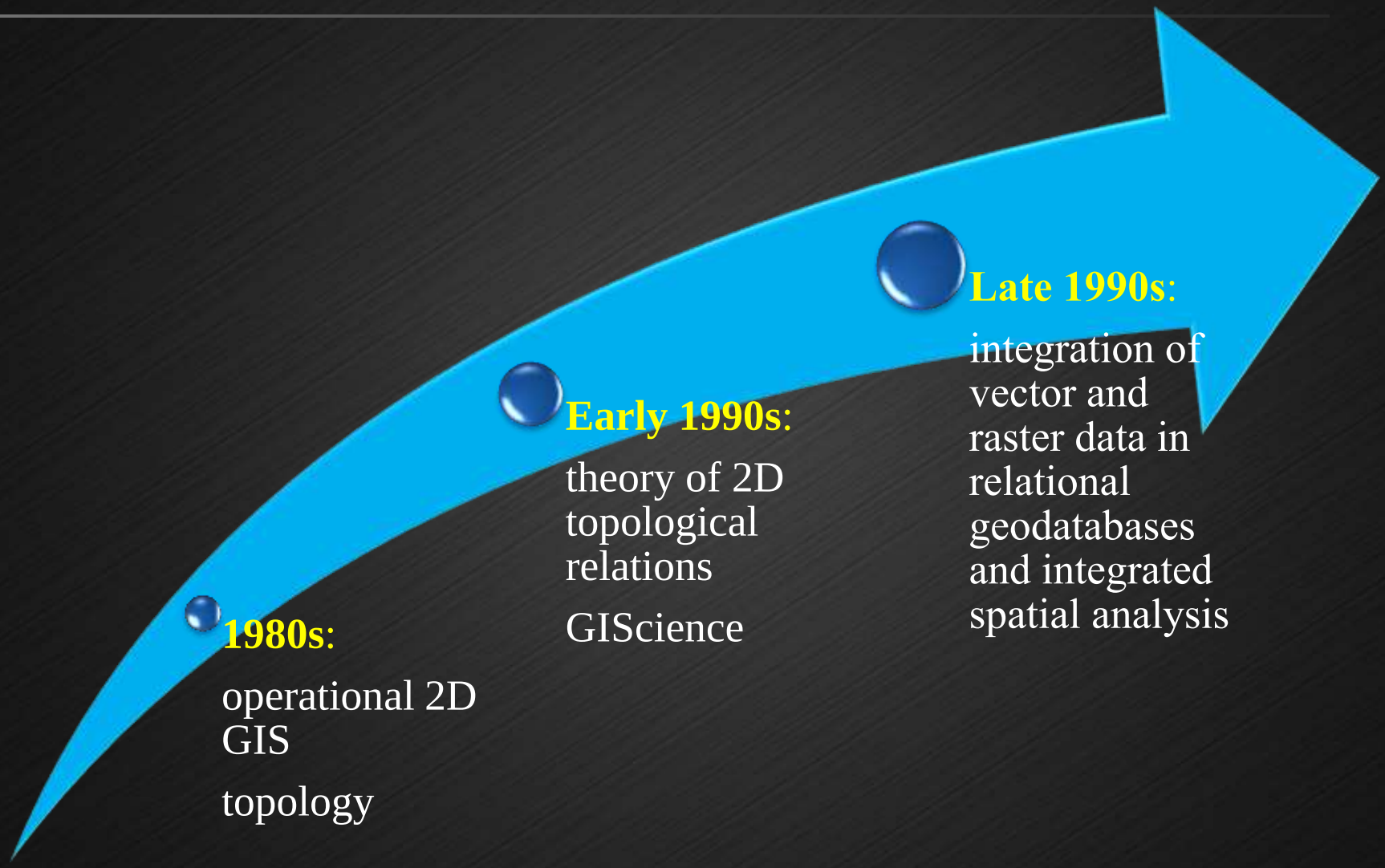
particular the nature of space and time. The classical approaches by the ancient Greek philosophers Heraclitus and Parmenides who – despite contrary opinions about the nature of being – are considered to be the fathers of ontology, the atomistic world view of Democritus, and the theory of forms developed by Plato are well known.

The nature of time is nicely examined in the Confessions of Augustine of Hippo where in book 11, chapter 14 he admits his dilemma: "What, then, is time? If nobody asks me, I know it. If I wish to explain it to the one who asks, I do not know."[1] One of the most complete and sophisticated approaches to the philosophy of space and time is given by the German philosopher Immanuel Kant in his book Critique of Pure Reason published in 1781.

### 2. Highlights of cartography and its identity crises

Cartographic representations have been produced for thousands of years from early rock paintings and carvings to the development of sophisticated map projections and the underlying mathematical principles. It

# GIS Evolution 1



fzg
Institut für Digitale Bildverarbeitung und Graphik

DIBAG - BERICHT NO. 2

# DESBOD - SYSTEMSPEZIFIKATION

M.RANZINGER, W.KAINZ, F.LEBERL

**1981**

DIGITALE ERFASSUNG, SPEICHERUNG UND BEARBEITUNG ORTSBEZOGENER DATEN

POJEKTBEGINN:
1. MAI 1981

PROJEKTBEAUFTRAGTER :
FORSCHUNGSGESELLSCHAFT-
JOANNEUM

PROJEKTVERANTWORTLICHER:
F.LEBERL

GRAZ, 1.NOVEMBER 1981



4. Jede 1-Zelle liegt an der Grenze einer 2-Zelle.

Fig. B.3 veranschaulicht die topologische Beschreibung einer Karte. Es gibt drei 2-Zellen, sechs 1-Zellen und vier 0-Zellen.


0-Zellen: 1,2,3,4
1-Zellen: a,b,c,d,e,f
2-Zellen: S,K,St

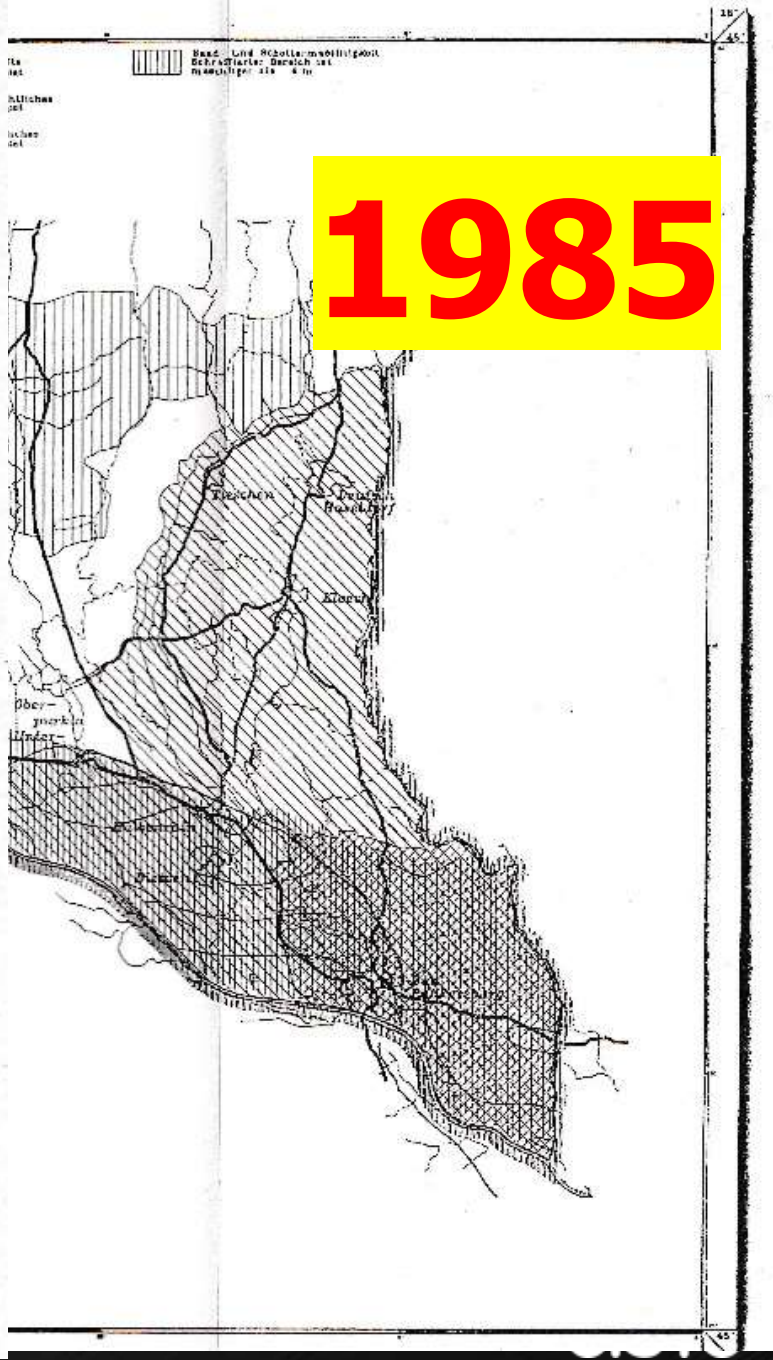
Fig. B.3

Durch diese Darstellung wird es möglich, die Struktur der Karte, z.B. die Beziehungen von Gebieten zueinander, in einem Computer darzustellen, wenn bestimmte Anforderungen erfüllt sind. Diese seien hier nur vage angedeutet:

F1. Jede 1-Zelle inzidiert mit genau zwei 2-Zellen.

F2. Bei jeder 0-Zelle gibt es einen eindeutigen "Schirm", d.h. eine zyklisch abwechselnde Kette von 1-Zellen und 2-Zellen.

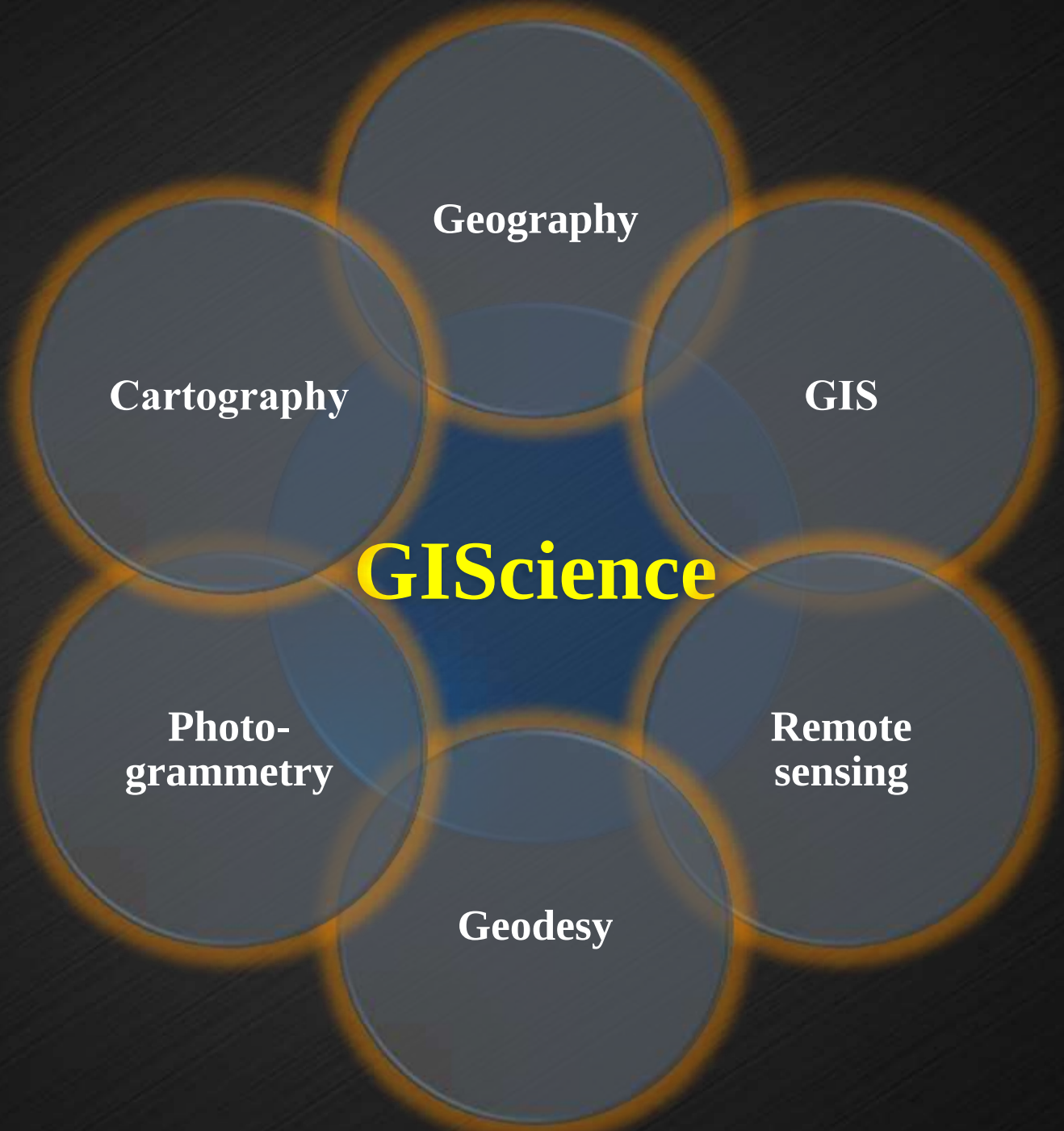
**1985**



# Geo-Information Science

Geo-Information Science is the integration of different disciplines dealing with spatial information.

- *"…Research on the generic issues that surround the use of GIS technology…*
- *…Both research about GIS and research with GIS…"* (Goodchild 1992)


Geography
Cartography
GIS
GIScience
Photo-
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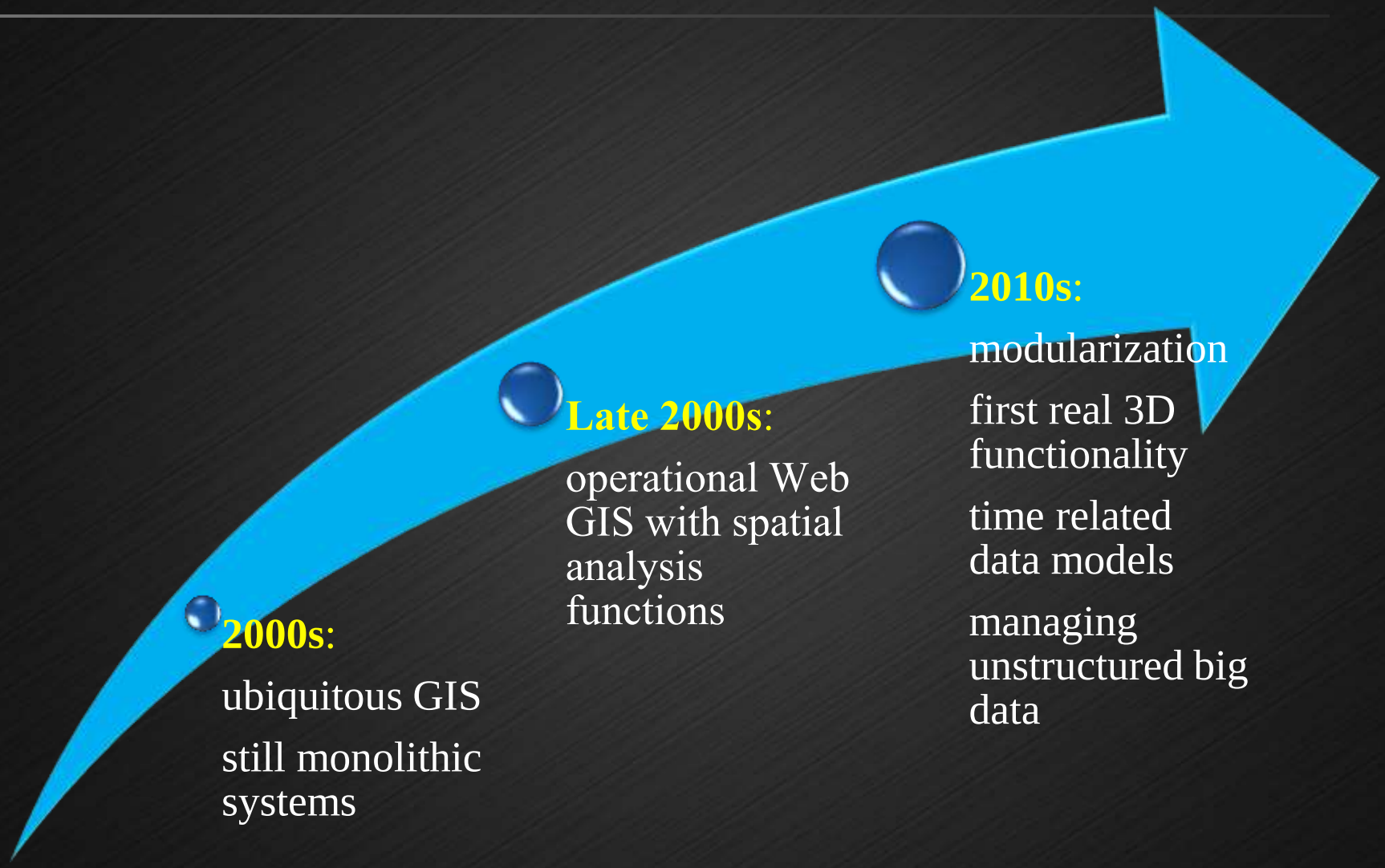
Remote
sensing
Geodesy

# GIS Evolution 2



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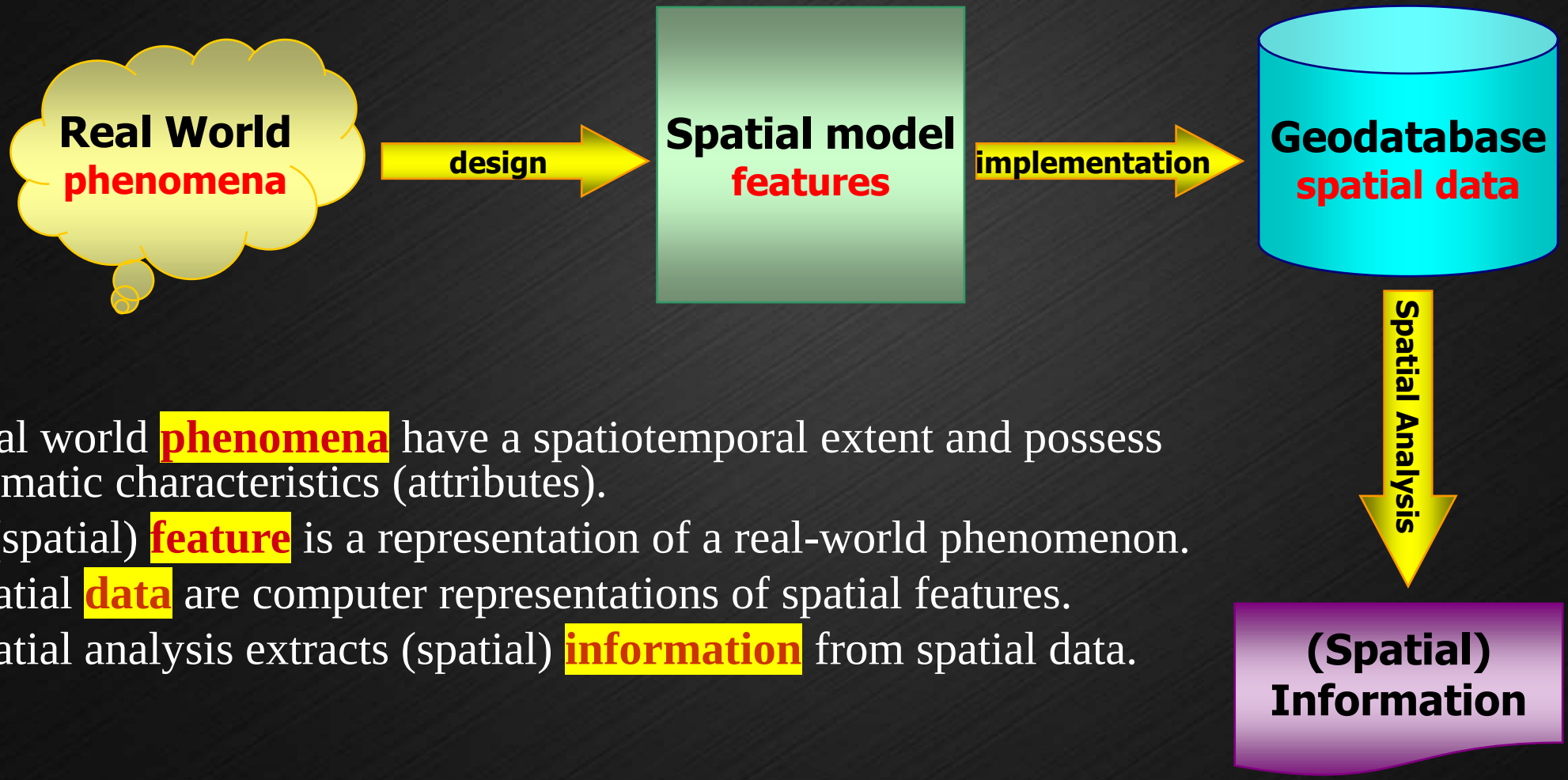
# Spatial Modeling – The Core of GIS

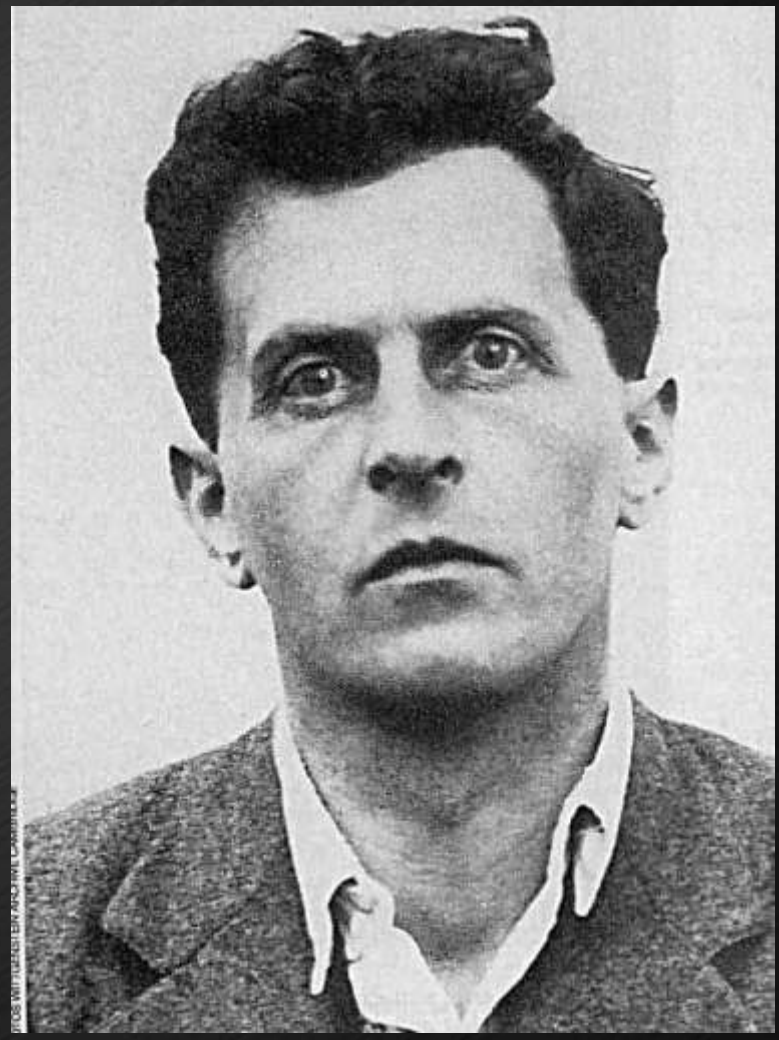
# Spatio-Temporal Modeling & Analysis




- Real world **phenomena** have a spatiotemporal extent and possess thematic characteristics (attributes).
- A (spatial) **feature** is a representation of a real-world phenomenon.
- Spatial **data** are computer representations of spatial features.
- Spatial analysis extracts (spatial) **information** from spatial data.

# Ludwig Wittgenstein

- 1889 – 1951
- Austrian philosopher
- Mainly working on logic
- 1921: Tractatus logico-philosophicus (Logical-Philosophical Treatise)



# Modeling

## Quote from Wittgenstein

- 2.12 “A **picture** is a **model of reality**.”
- 2.14 “What constitutes a picture is that its **elements** are **related** to one another in a determinate way.”
- 2.15 “The fact that the elements of a picture are related to one another in a determinate way represents that **things** are **related** to one another in the same way.”

## Concept of a map or database

- 2.12 “A **map/database** is a **model of reality**.”
- 2.14 “What constitutes a map/database is that its **features/objects** are **related** to one another in a determinate way.”
- 2.15 “The fact that the features/objects of a map/database are related to one another in a determinate way represents that **phenomena** are **related** to one another in the same way.”

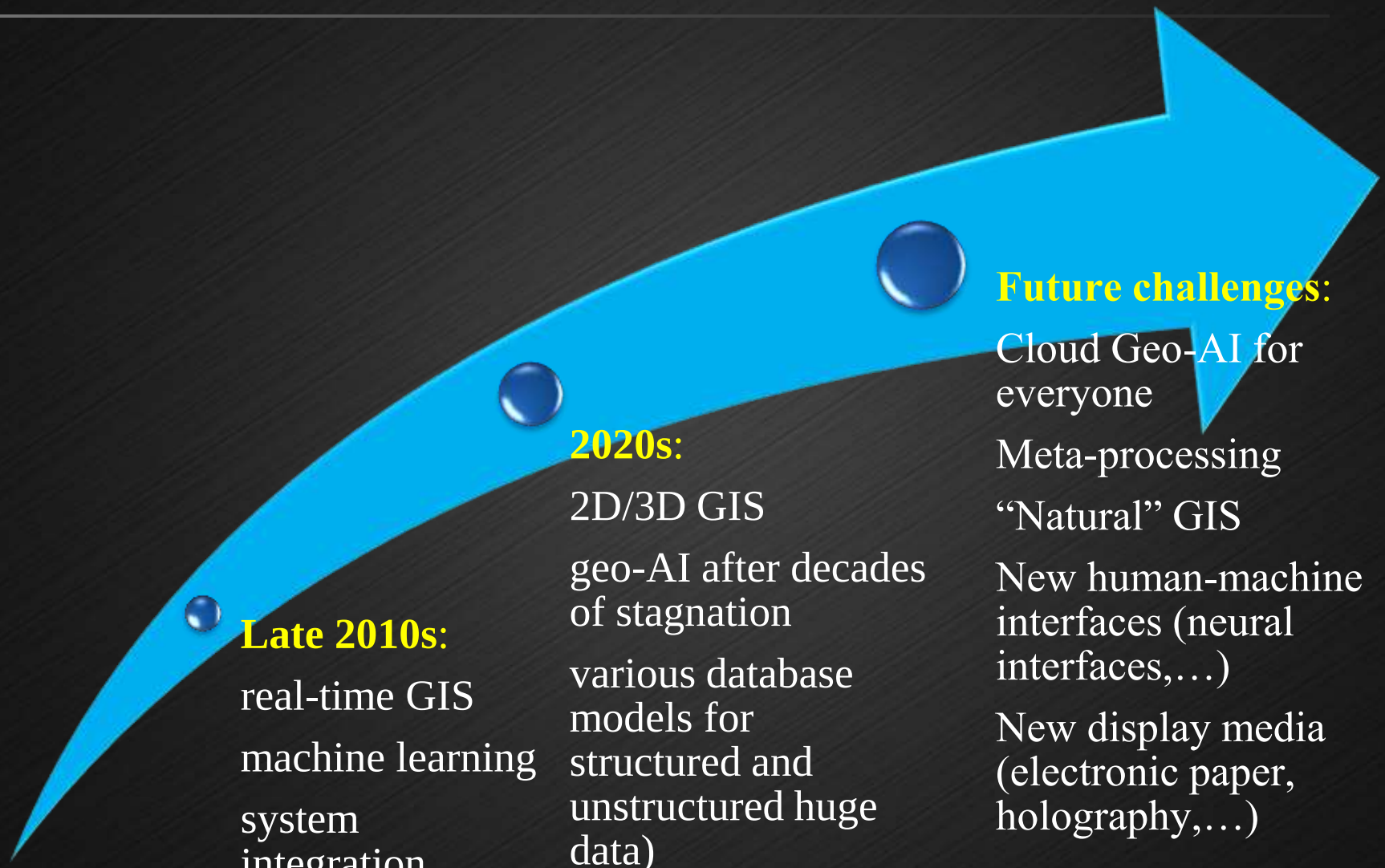
3

# Current GIS and Beyond

# What is GIS?

- GIS is not
  - Pushing buttons
  - Making maps
- GIS is about Spatio-temporal analysis
  - Integrated analysis of vector and raster/image data
  - Using 2D and 3D data
  - Considering time

# GIS Evolution 3 and Beyond



**Late 2010s:**

real-time GIS

machine learning

system integration (CAD, BIM, LBS,…)

**2020s:**

2D/3D GIS

geo-AI after decades of stagnation

various database models for structured and unstructured huge data)

dominance of RS

**Future challenges:**

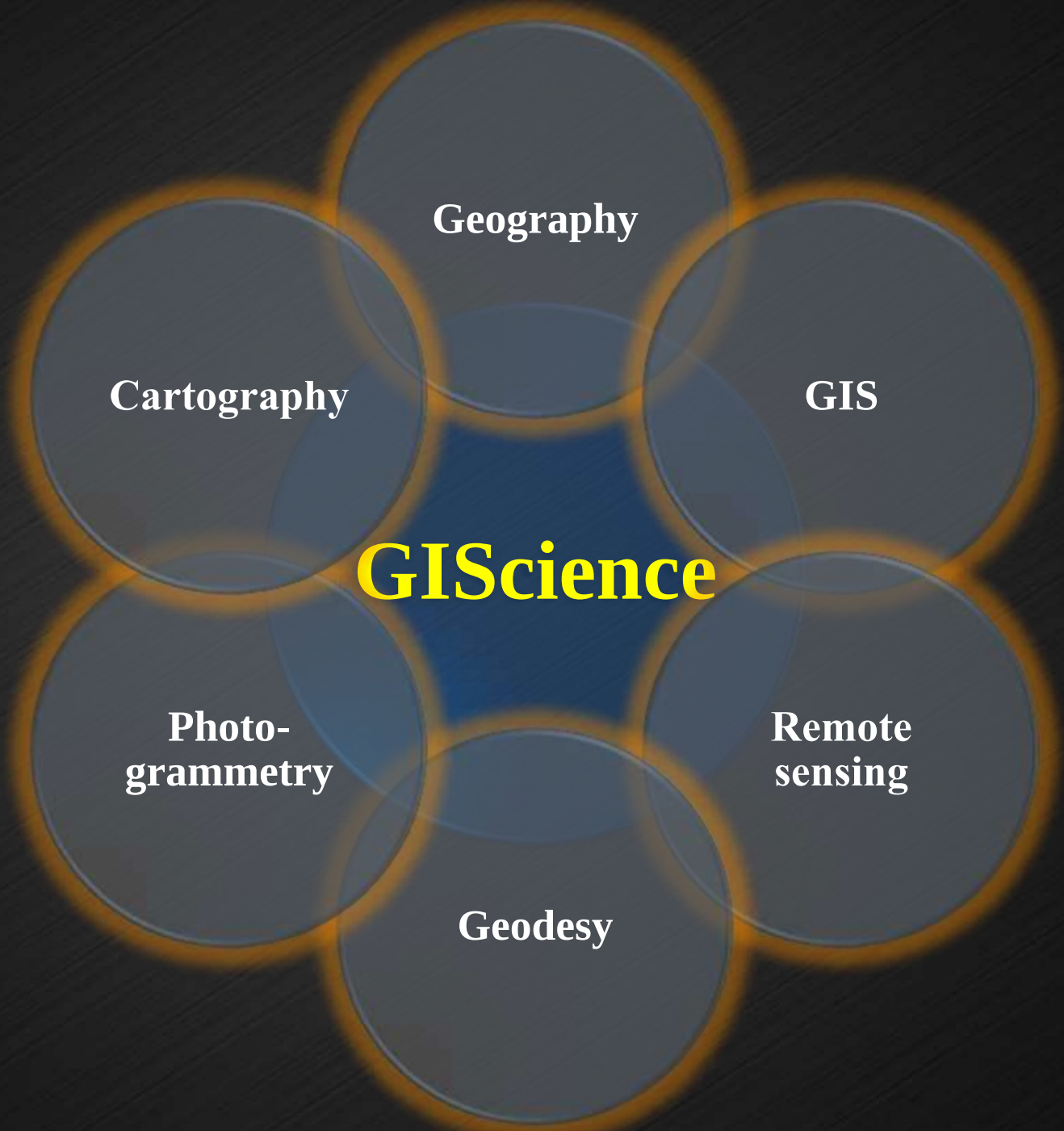
Cloud Geo-AI for everyone

Meta-processing

“Natural” GIS

New human-machine interfaces (neural interfaces,…)

New display media (electronic paper, holography,…)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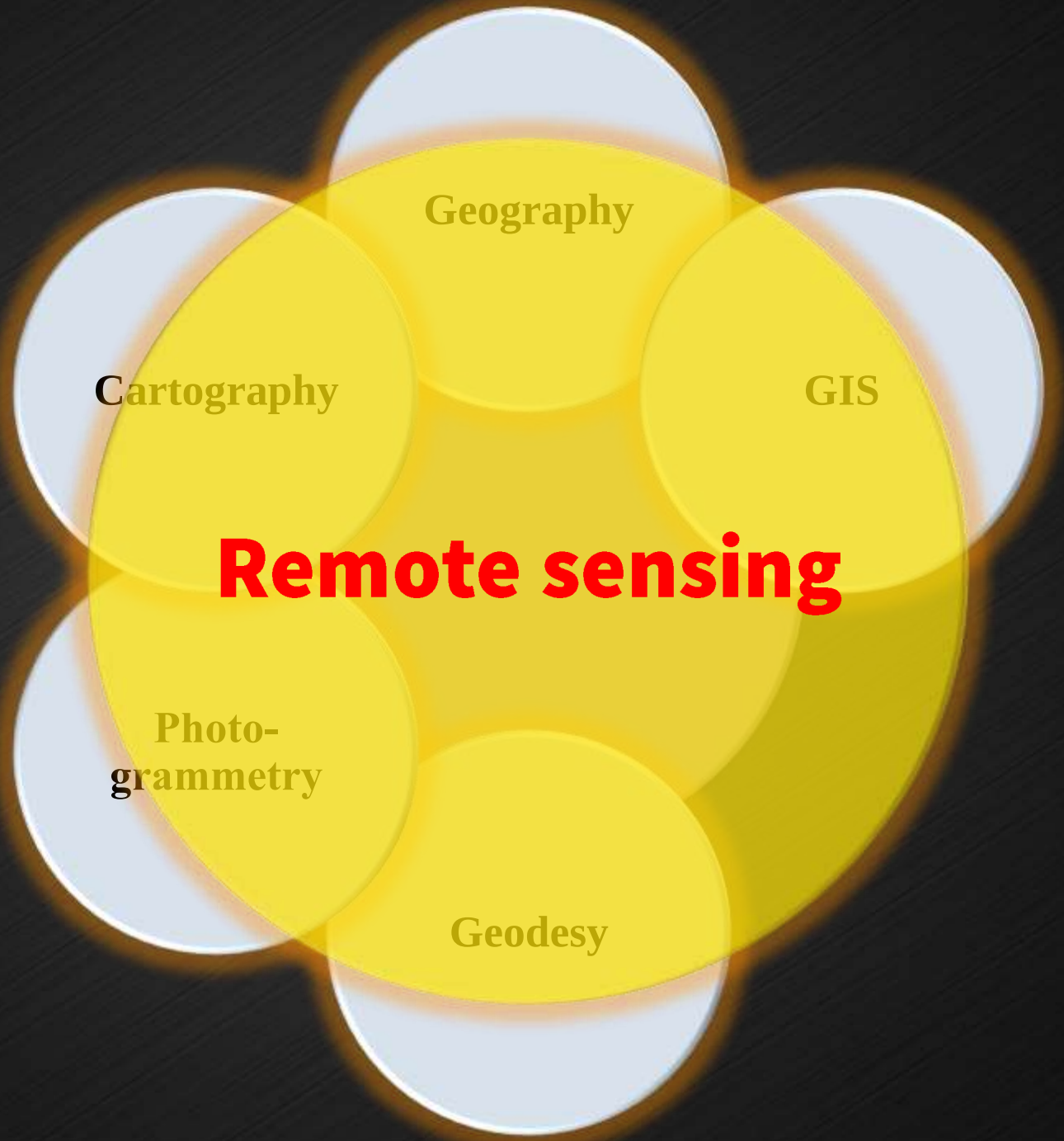
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# Component-Based Systems

- Functional components on the web and in the cloud
- Tool repositories
- Thin clients with “thick” functionality

# Artificial Intelligence

- Work started in 1956
- Some progress (game strategies, theorem solving, etc.) in the following 20 years
- Slowdown in the 1970’s
- Expert system hype in the early 1980’s followed by a decline until the late 1990’s and early 2000’s.
- Strong increase in activities and funding from the early 21st century on due to increase in computing power and availability of huge amounts of data (data mining, machine learning, deep learning)

# Cloud Geo-AI

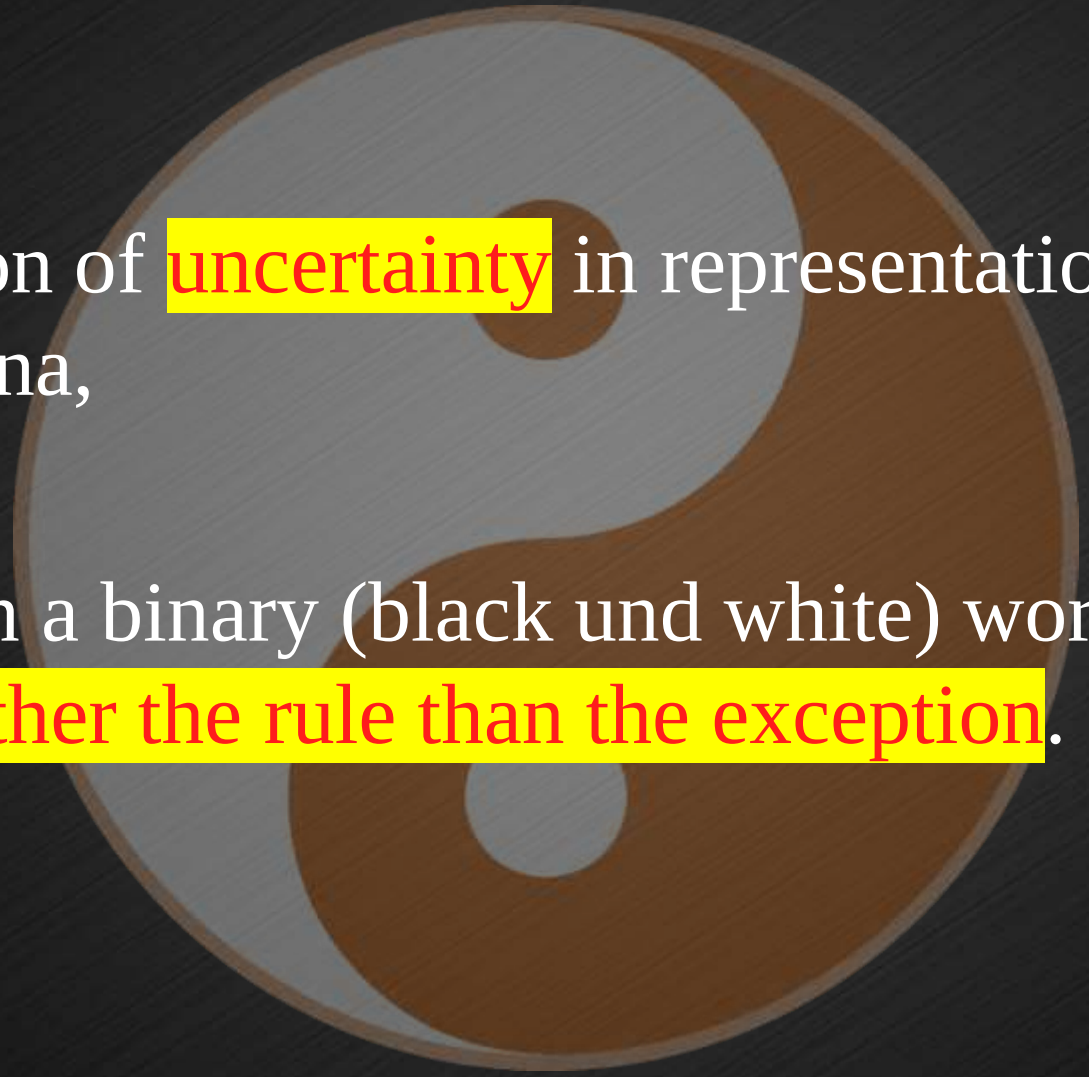
- A kind of Geo-Siri, Geo-Alexa, or Geo-WolframAlpha
- ChatGPT: many options but also great risk

# Better Use of Metadata

Meta-processing

- Look at the metadata and decide whether a certain operation makes sense
- "Quality propagation"

# “Natural” GIS



Full consideration of uncertainty in representation and analysis of spatial phenomena,

because…

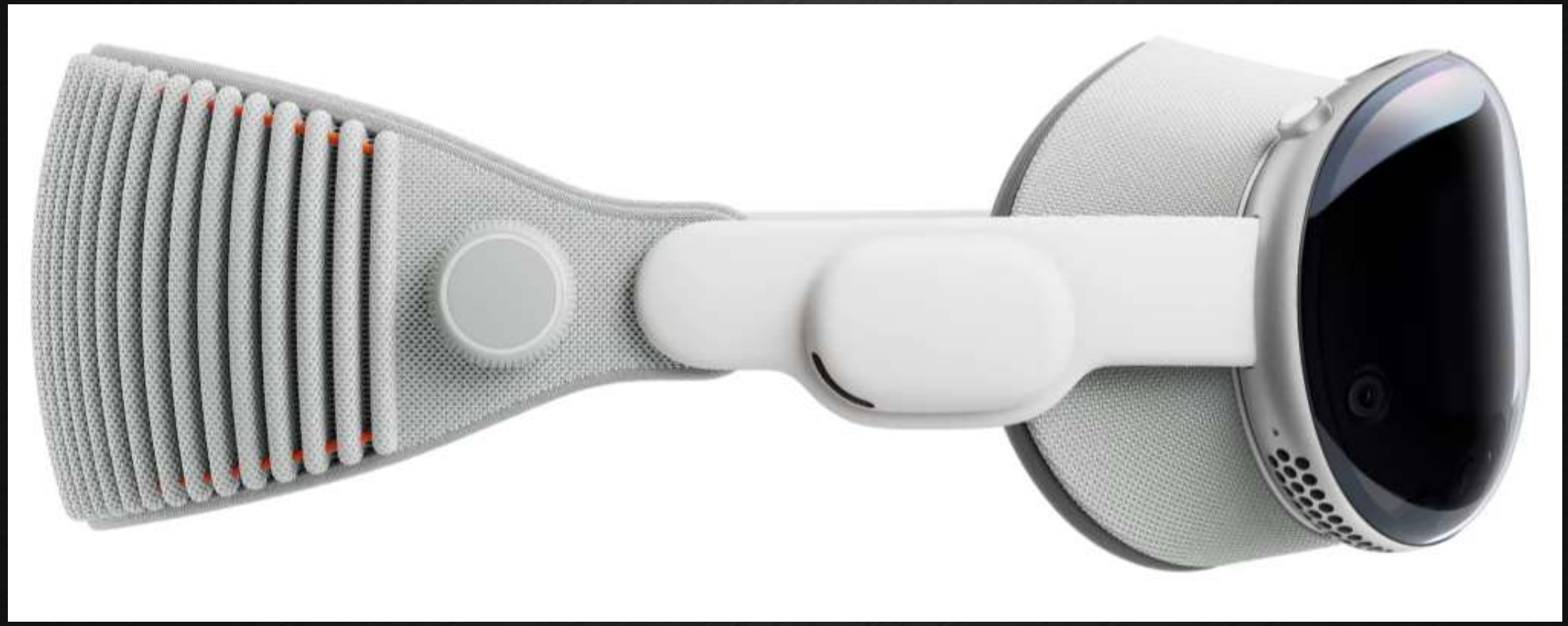
We do not live in a binary (black und white) world, and uncertainty is rather the rule than the exception.

# Novel Display Technologies for GIS

- Hyper globes
- Immersive displays
- Foldable screens
- Human-machine interfaces
- Holography

# Hyper globes

# Immersive displays



# Human machine interfaces

Stargate Atlantis

# Holograms

Stargate Atlantis

# The future of GIS

- Has just begun and is
  - 3D
  - Dynamic
  - Real-time
- For real and virtual worlds
- Becoming an intelligent model of reality

不出户, 知天下…

如果我们有地理信息科学。

“Without leaving home, you can know the whole world”…

if we have geographic information science.

# Thank You All!

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