# Sensor Integration and Knowledge Neworks

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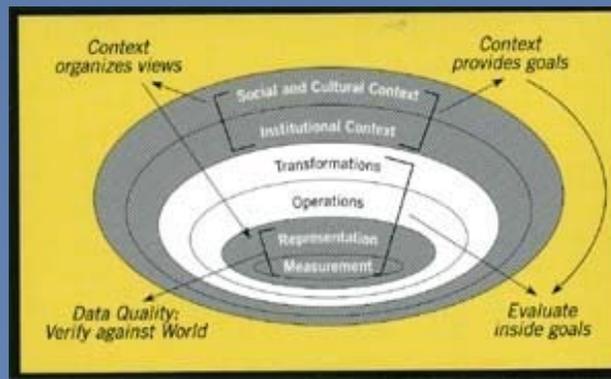
Outline of presentation

- Bigger, faster, better? A story of advances

- Sensors and Networks of Sensors…

  - Some results from GEOIDE past projects

  - What this may subvert / disrupt

- Revisiting the I word: Information

- Knowledge Networks

An open secret:

The power of GIS: Integration of heterogeneous information

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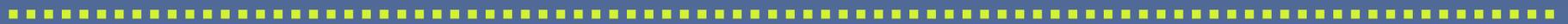
The threat of GIS: Integration of heterogeneous information

Everything is going to get:

Smaller
Faster
Greater capacity
More integrated

…

But, will this marvelous new world be any **smarter**?

Will we be stuck with the same old designs developed for a different set of conditions?

At the entry to New Cuyama, California

Integration at its most basic?
*At least they know it is a joke.*

Faster, faster, better?

- Long-term trends in world economy
  (over 150 years or more)

  - Faster communication
    reduce friction of distance,
    greater control from centers
  - Greater use of information
    to drive out waste
    and for greater control and coordination

  - *Some counter directions as well, particularly recently.*

Avoiding technological determinism

- *It is too easy to present new technology as a wave of the future that should not be resisted.*

- **Technology involves many choices, and the path is not pre-ordained.**

  - **Example: missile guidance (MacKenzie 1990)**

Dante's Inferno
(A guide to many explorations)
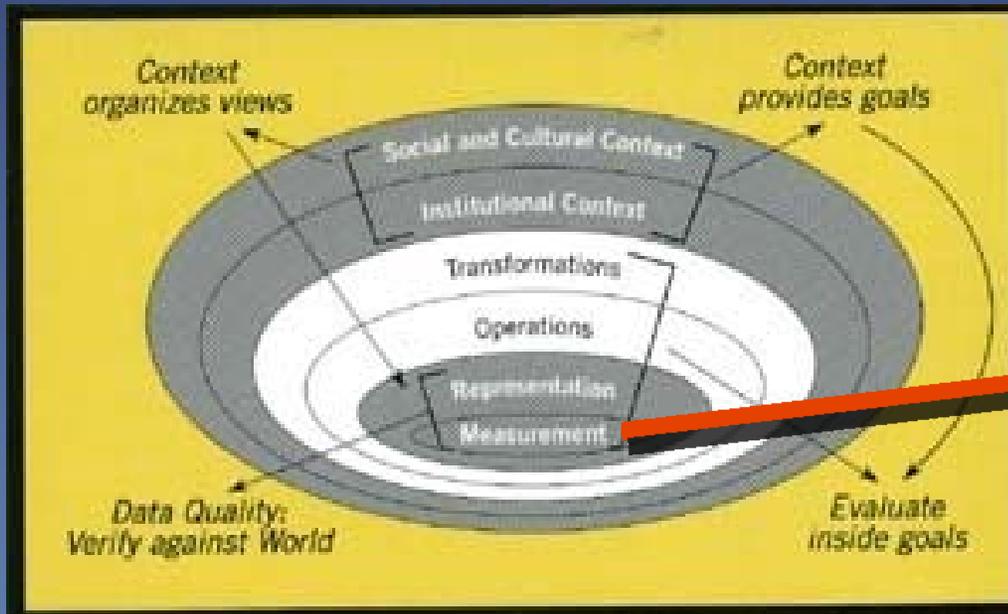
Starting from the center: Measurement – Sensors

Peter Burrough observed that
Chrisman takes the path contrary to Dante

A river gage:
12048000 Dungeness River near Sequim WA

- Location: Fixed

- Time: Controlled

- Height (of water): Measured

- *But how does the roll of paper get from the gage into use as a measurement?*

- *Missing components: the guy with a pickup truck, and the digitizer- many steps…*
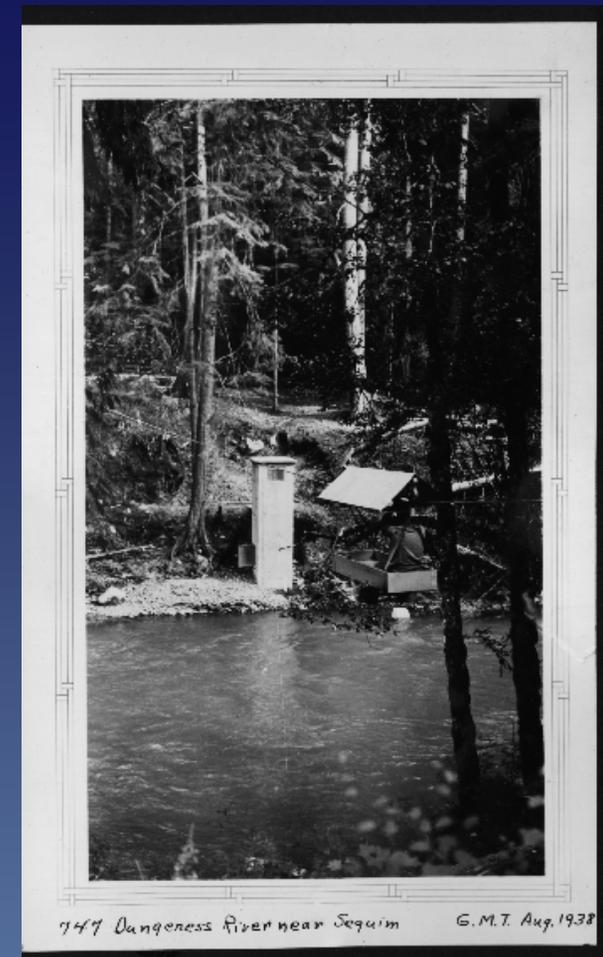
Advances in measurement

Astounding increase
- **In spatial accuracy**
- **In speed of measurement**
- **In smaller sensors – everywhere**
- **In networks to connect sensors**

But some promises have been hard to keep;

- **The « flood » of data from the sky has not overwhelmed our processing capacity.**
- **Too much effort expended in replicating the old ways of seeing the world.**
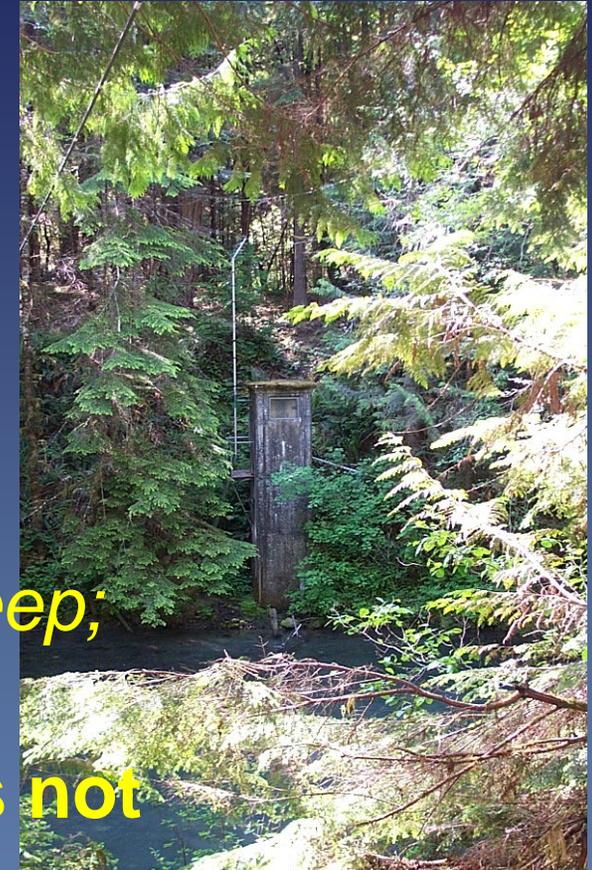
SII-73: SWAN
An Integrated Sensor Web for Watershed Monitoring

- Sensors – with processing and networking power

- Knowledge network across Canada

Sensors to suit

- Motes
- Batteries
- Wireless
- Solar panels?

One design environment, mixed hardware

And more recently, Traffic Pulse (SII 89)

- Part of the move to enroll citizen sensors (Volunteered GI)

- Mobile telephones and mobile computing can provide improved understanding of urban traffic

Sensors everywhere

*Some examples
from GEOIDE past projects*

PIT-tag inserted inside
salmon juvenile
(passive)
Antenna array (active)
placed under the
stream bed
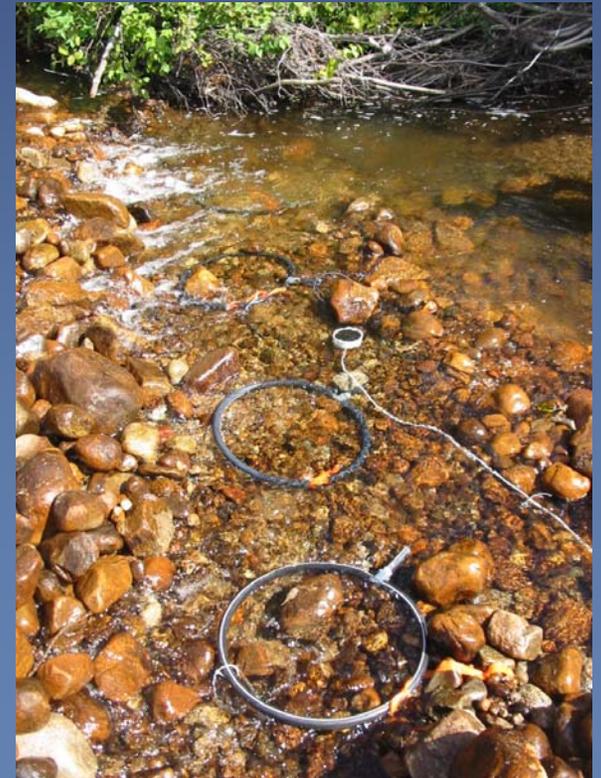
Results: a sensor network opens new science

- *256 antennas*
- *one computer*
- *energy from solar panels*
- *network connection*
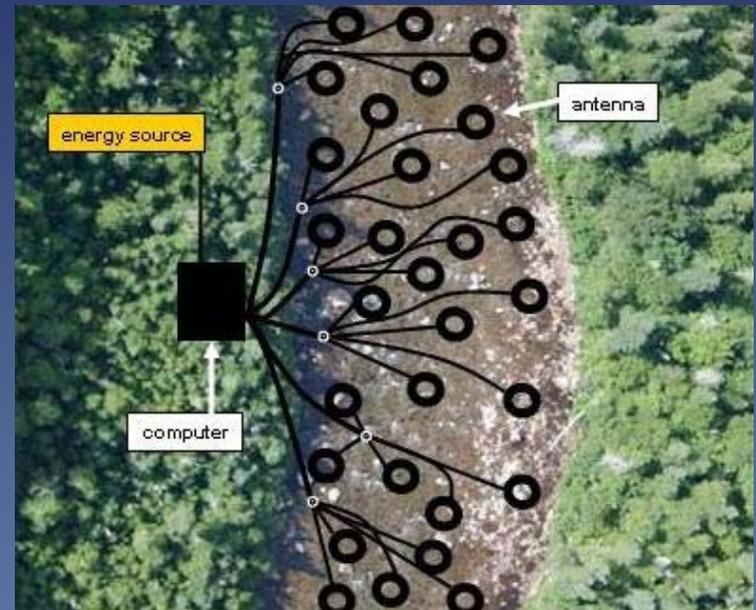
As each fish swims over an antenna, its identity is recorded (in time and space).

Researchers have been able to observe new behavior – beyond 'stay' and 'leave' : « commuters » violates expected « minimum effort » models

GEOSALAR: *Understanding Atlantic Juvenile Salmon Movement and Migration in Rivers and Estuaries*

This project aims at developing tools to:

➤ *Track and predict young Atlantic salmon movements among habitat;*

➤ *Understand how time and stream morphology impact behaviour and reproduction.*

Project No 14 Integrated Modelling of Juvenile Atlantic Salmon Movement and Physical Habitat in Fluvial and Estuarine Environments. Dr. Julian Dodson, Université Laval

GeoSalar – a knowledge network

Multiple disciplines:
- Salmon ecology
  - Laval, UBC, UQ Rimouski
- Resource managers:
  - MRNFQ, Dept Fish & Oceans Canada, BC ILMB. Hydro Québec
- Fishing interests (recreation and commercial)
  - Atlantic Salmon Foundation, tribal bands, fishermen…
- Geomorphology (UQ INRS, McGill, Durham UK)
- Tracking technology (industry)
- Photogrammetry: videography (Genivar)

Results: for each participant- science, management, technology…

Distributed Sensor Networks-
a potentially disruptive technology

- Original GIS process:
  - First, collect the data (centrally)...
  - Then, work to extract the value
- With sensor web:
  - Send query to autonomous sensors
  - Answers calculated by network…

Revisiting an old story

- *Assumptions about the trade-off:*

    Compute / store

    [Eventually it is cheaper to reconstruct relationships than to store them and manage the interactions.]
- Example: topological data structure / shape file

> ***New dimensions of trade-off:***

- Duplicate copies / transmit from center
- **Band-width:** Network makes it more complicated.
- Battery life, distributed energy cost (see band-width)
- Limited memory on handheld/ motes

What is so disruptive?

- Sensor webs decentralize

- It becomes impossible to start by collecting « all » the data…

- Collaboration between collectors becomes central.

- Raises issue of what information will be useful (to whom and when…)

The I in GIS

- The middle word:
- Not the one argued over…
- Yet crucial.

Extract from a paper:

Order from Noise:

Towards a social theory of information

Barbara Poore, US Geological Survey

Nick Chrisman, GEOIDE

Two conflicting models of information

- Both arise from Cybernetics movement in late 1940s

- Shannon [Bell Labs] (publicized by Weaver)
  - Transmission model: encoding as bits

- Norbert Weiner [MIT, Lincoln Labs]
  - Control of aircraft gunnery, cybernetics
  - Feedback as main issue

Shannon's boxes and arrows

Figure 1. After Shannon and Weaver. 1949. The Mathematical Theory of Communication. Chicago, University of Illinois Press p. 34
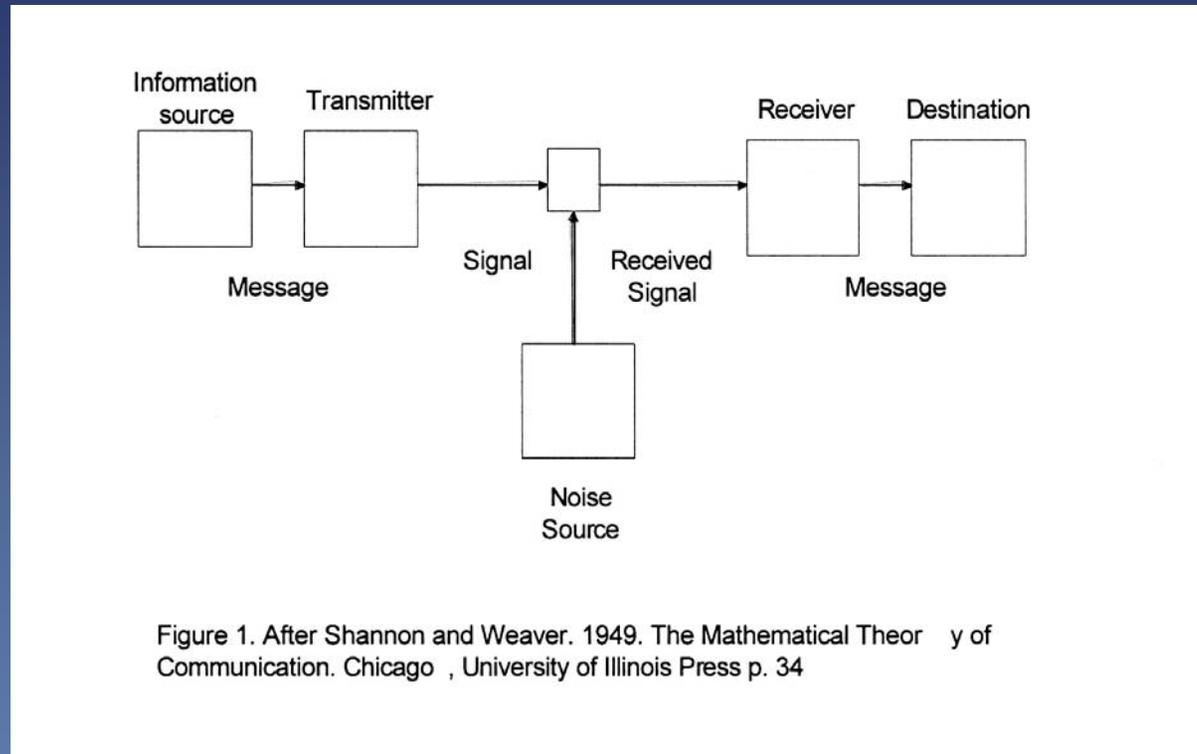
Invariance through transmission;

Meaning not a part of model

Model of refinement
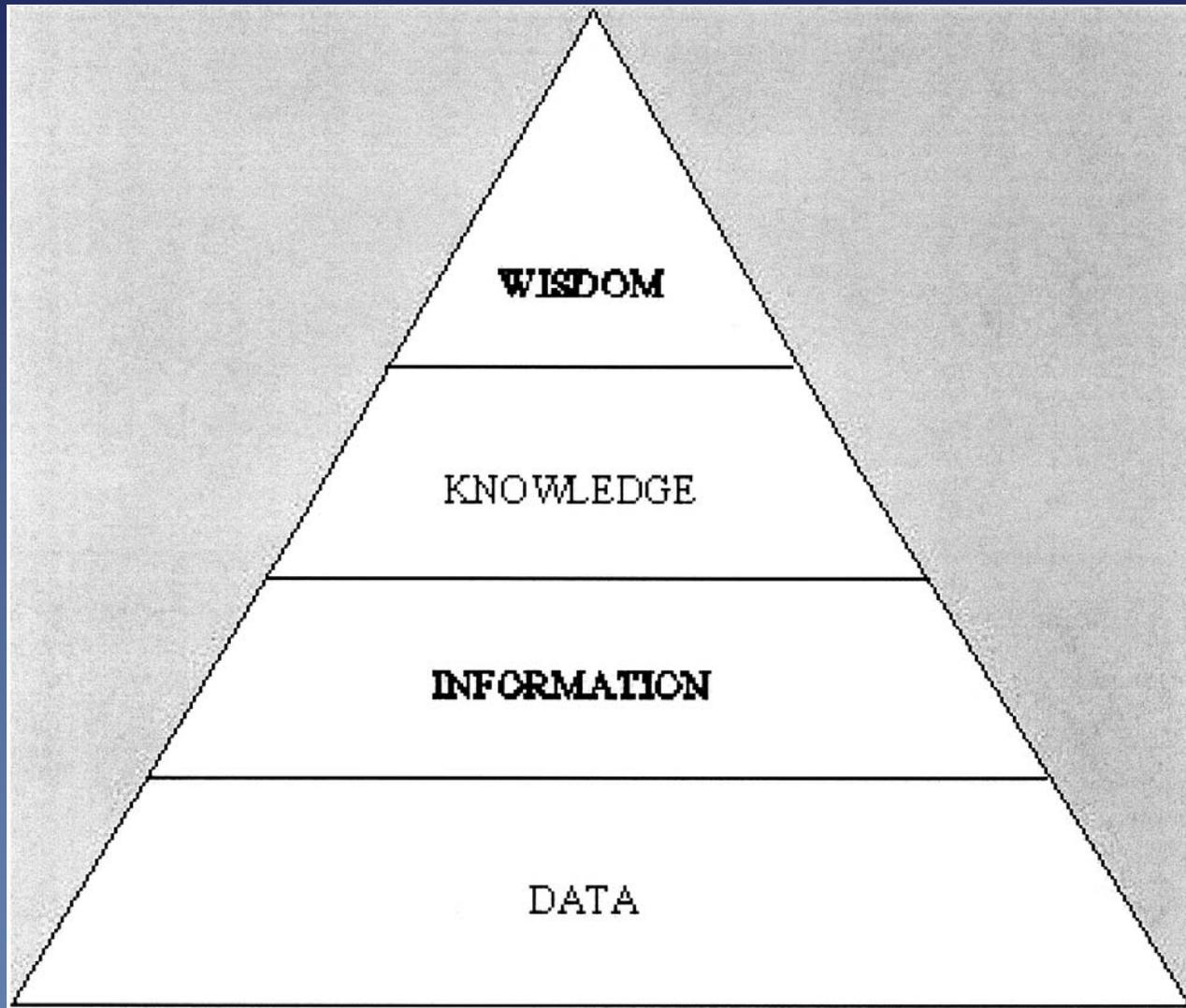
Weiner promotes the mythology

How the information model matters:

Treated as a "thing", information is capital, a precious resource

BUT, information is the result of work, interactions of sensors and humans

- Sensor webs depend on a more social view of information…

A social model of information

Goguen: *an interpretation of a configuration of signs for which some social group is accountable.*

Bateson: *"a difference that makes a difference"*

So, here is the citation:

- **Bateson, Gregory (1972).** *Steps to an Ecology of Mind: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology*. **University Of Chicago Press. ISBN 0-226-03905-6**

- And some context:

- Gregory Bateson, a psychologist, married Margaret Mead.
  - Participated with Shannon, Weaver, von Neumann, Weiner, and other in the Macy Conferences (1940s-50s) – which defined « cybernetics » and modern information theory.
- Count Korzybski (« The map is not the territory ») was not far away…

Bateson's experiment
no consent form needed!

- Hold your hand perfectly still, palm upwards and resting comfortably on a table. With your other hand, drop a small coin into the palm.

- *You will feel the impact, and if the coin is cold, you will feel the coldness of the metal. Soon however, you will feel nothing. The nerve cells don't bother repeating themselves. They will only report to the brain when something changes.*

- ***Information is difference.***

But a difference that makes a difference

- But there are differences and differences…

  - *As you dropped the coin into your palm,*
  - *your eyes told you automatically,*
  - *without your brain even asking,*
  - what the value of the coin was;

- but you were probably not aware what date it was minted.

- *This is because (unless you are a numismatist) the* **value of the coin makes a difference to you** *whereas its* **date doesn't.**

A matter of perspective

- Bateson continued with a story of lizard detecting an incoming insect on a leaf.
- *What is information for the lizard is not information for you, and what is information for you is not information for the lizard.*
- Perspective defines **what counts** as information at all, perspective defines **to whom** the information makes a difference.
- And hence to Goguen's social interpretation of signs- and the importance of responsibility…

Back to Sensors

- How the information model matters:
  - Treated as a "thing", information is capital, a precious resource
  - BUT, information is the result of work, interactions of sensors and humans
  - The value of information is NOT inherent, but the result of perspective (people, purpose, place…)

Limitations of transformational viewpoint

- Tobler's view on transformations:
  - focus on invariance; what is preserved
- BUT, it is exactly the opposite:
  - focus on what is deliberately lost;
  - what does not matter and what does;
  - *the difference that makes a difference*

And a consequence (or two)

- van Foerster: *« you can turn a library upside down, but not a drop of information will flow out »*

- All writing requires an audience; meaning is interpreted by the reader
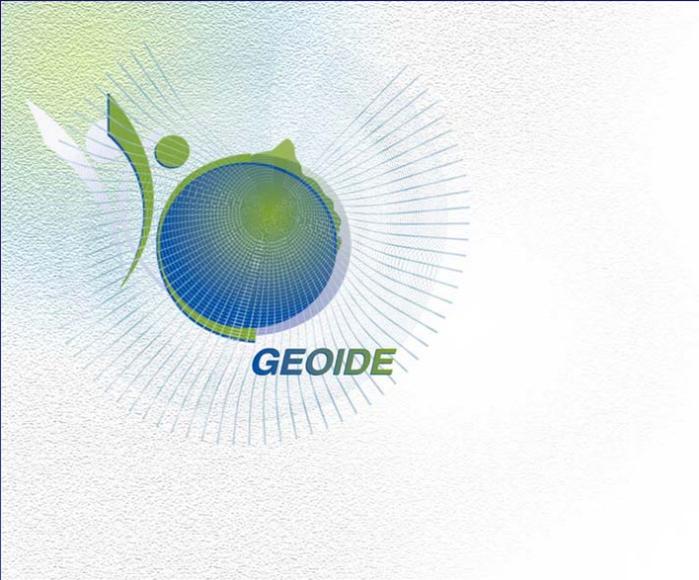
Role of Networks

- **Intellectual progress requires mixing up perspectives.**

- **Interaction between disciplines is necessary.**

- **Fresh perspective comes from student participants.**

Conclusion

- Distributed sensor technology offers new challenges;

- Knowledge networks complete the interaction.

- *Best wishes for a productive Summer School!*

Disclaimer

- The preceeding slide show was neither accurate, nor complete, and its quality is entirely in the hands of the audience.

- Any resemblence of the fictional characters referenced to well-known academics is not coincidental.

- No animals were hurt in the making of this entertainment.