Riding the Wave of the Next Revolution: ‘Intelligence’ and ‘Meaning’ in Measurement Processes as a Paradigm of Change

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Background

- We are currently in the middle of a geospatial revolution
  - Technology, techniques and mindsets are changing
- There are profound parallel changes in society and the economy happening around us
- The threat of change is causing uncertainty, confusion, anxiety, ill feeling and conflict
- Perhaps a place to start trying to understand this revolution is the previous revolution

Background: Aside

"Today the world changes so quickly that in growing up we take leave not just of youth but of the world we were young in. I suppose we all realize the degree to which fear and resentment of what is new is really a lament for the memories of our childhood."

— Peter Medawar, Presidential Address to the British Association for the Advancement of Science, 3 Sept., 1969.

Surveying Revolution 1550-1650

- In Europe prior to around 1550, surveying existed, but not as we know it
- Measurement was primarily linear, orthogonal and local
- Mapping was as much pictorial as representational and was very local
  - Henry V had no maps of France for his military campaign of 1415, and neither did the French
- A Roman-era surveyor would have been right at home!

Surveying Revolution 1550-1650

- Nothing much had changed since the Ancient Greeks and Romans had developed surveying expertise to c. 300 AD
- After 1550, things begin to change rapidly
- Inventions and other new developments came with a rush
  - These innovations totally change surveying from what it was in 1550, to a very different creation by 1650

Surveying Revolution 1550-1650

- Some of these inventions and developments:
  - Theodolite, a means of turning any angle
  - Trig. tables based on an angle as the argument
  - Logarithms
  - Slide rule
  - Co-ordinates
  - Triangulation
  - Traversing
  - Tripods
  - Verniers
  - Telescope
  - Plane table

Surveying Revolution 1550-1650

- Changing technology led to changing techniques:
  - With co-ordinates, angle measurement, trig. tables and logarithms, it was possible to work with random points across the terrain
  - With triangulation, it was possible to measure and map entire nations, then continents
  - With co-ordinates, it became possible to draw maps to scale, rather than as pictorial representations

Surveying Revolution 1550-1650

- With the support of the right tools, surveying became highly mathematical, rather than arithmetic based
- With the spread of triangulation, the question of the exact shape of the Earth became critical
  - Surveying moved from thinking about local surveys to concern with the size and shape of the entire planet
  - This discussion ‘raged’ from about 1650 to 1740

Surveying Revolution 1550-1650

- In this 100-year period, we see a total change in the nature of surveying:
  - Equipment changes
  - Techniques change
  - Methods of working (mathematical) change
  - Focus of interest (mindset) changes
- These are the characteristics of revolutions

Surveying Revolution 1550-1650

- In the surrounding society, we find related changes:
  - Renaissance is in full flower — Middle Ages are in decline
  - Science and Art are flourishing as influences
  - Exploration is expanding, discovering New Worlds
  - Commerce is changing from local trading to a more global mercantile approach
  - Exploration of alternative political, land tenure and religious arrangements
  - Creation and rise of professions

Surveying Revolution 1550-1650

- Not all the major changes happened in 1550-1650
- But this period of 100 years saw the changes with the most profound impacts
- Later developments, such as calculus and least squares adjustment, added refinements, rather than major changes
- The change by around 1650 appears to be almost total: none of the pre-revolutionary equipment made it to

Surveying Revolution 1950- ?

- After the dust had settled around 1650, surveying settled down to a more even rate of development
- Most developments were evolutionary, rather than revolutionary, in nature
- Triangulation and traversing were the primary means of positioning, and the equipment was fundamentally the same in 1950 as in 1750
- Techniques were also much the same in 1950 as in 1650

Surveying Revolution 1950- ?

- Around 1950, everything started to change:
  - Radar technology and scientific developments around WWII led to the development of EDM
  - Instruments became more electronic, with electronic data recording
  - Computers started to be used for surveying work
  - Triangulation was replaced by trilateration (briefly), then by high-precision traversing

Surveying Revolution 1950- ?

- Although photogrammetry was developed in the mid-late 19th century, it became much more widespread after WWII with the greater spread of aviation
  - Photogrammetry was the harbinger of the primary change in measurement, but we didn't see it at the time
- Satellite geodesy enabled the linking of the continents and the determination of continental drift, as well as planetary reference frames (WGS and ITRF)

Surveying Revolution 1950- ?

- GPS was, in reality, an incremental shift in positioning, as we still need to take the instrument to each point to record its location (the same as tacheometry)
- The real change GPS has brought is being embedded in many other devices
- Laser scanners, LiDAR, scanners in general, imagery and radar systems represent the really profound impact technologies of this revolution

Surveying Revolution 1950- ?

- The initial outcomes of the surveying revolution:
  - Traditional methods became better, faster, cheaper
  - Global reference frames became standard
  - Everything became electronic, including the data
  - Electronic imagery became more important
- But there were apparently no fundamental changes in how we did things: we still had to ‘visit’ every point we measured

Surveying Revolution 1950- ?

- The really big change was in photogrammetry, but wasn't obvious until laser scanners and digital (softcopy) photogrammetry brought it down to Earth:
  - We don't visit every point
- This means that we collect point locations without the additional 'intelligence' and 'meaning' that was traditionally collected while visiting each point
- This makes data collection far more efficient, in terms of point locations: the image and the point-cloud are now the basic data units

Efficiency vs Effectiveness

- When you collect data by visiting each point, you usually provide an indication of what the point is (its meaning) and how it connects to other points to represent real-world objects (intelligence)
- We can't do that at rates of thousands of points per second
- Compared to collecting a point per minute, collecting 1.5 million points per second is almost a billion times faster
- The trade-off is that of speed (efficiency) vs getting the

The Biggest Change

- The biggest change is moving the determination of ‘meaning’ and ‘intelligence’ to later in the process
- We have a point cloud with very limited additional information, and we have to figure it out after the event
- As a consequence, the source of the data becomes less important: any point cloud will do
  - You can get it from terrestrial scanners, airborne LiDAR, digital photogrammetry, IfSAR, even

The Biggest Change

- So the biggest change is how we collect and process measurement data, together with its form (point clouds)
- The current problem is how to add the meaning and intelligence in a reliable way, as well as determine the quality of the overall dataset that results
- At present we have some software tools (e.g., for forming surfaces), we have a ‘human in the loop’ approach, and there are efforts to expand machine pattern recognition

Meanwhile, Back at the Ranch ...

- So while we are dealing with all this technological change, what's the rest of the world doing?
- After about 1750, the world started industrializing, first slowly, then with increasing speed
  - **Bonus Question**: What technology really started the Industrial Revolution in England?
- Industrialization changed economies, societies, families, politics, human interactions, almost everything

The Rest of the World

- Industrialization peaked in the period 1950-1965
- After this, employment declined as automation removed the bottom tiers of workers
  - This paralleled the reduction of the bottom tiers of agricultural workers in the Industrial Revolution
- Industrial products started to become commodities, so margins were reduced, just as it happened in agriculture

The Rest of the World

- Meanwhile, information started to rise as a sector of the economy, globally, starting around 1910
  - The information sector covers people who deal in tokens (information) rather than goods or services
  - Services are very transitory, but tokens last and have lasting value
- The people leaving and/or not going to industrial jobs went into information or service jobs

The Rest of the World

- Computers became the automation tool of the information sector, introducing efficiencies in operation starting in the 1960s, and becoming widespread with the growth of PCs
  - Employment in the information sector peaked around the 1980s, as the lowest tiers of employees were removed, just as in agriculture and manufacturing before
- The widespread use of computers also started the

The Nature of Knowledge

- For most of history, knowledge was equated with scarcity
- Pre-Gutenberg, books were hand-copied
- Post-Gutenberg, books were hand-edited and hand-typeset
- The lecture was devised as a means of supplying the lecturer's knowledge to the largest audience, in a world where books were rare
- Even after books became more common, the lecture was

The Nature of Knowledge

- Knowledge was placed in books to outlast individuals
- Books were edited and ‘judged’ before publication, which slowed dissemination
- ‘Peer review’ is the gold standard for knowledge testing
- Books are ‘authoritative’ knowledge sources

- So what happens when the Internet comes along?

Knowledge and the Internet

- The Internet has been a disruptive technology for knowledge, for several reasons:
  - It destroyed the privileged positions of publishers and ‘experts’ as the authority on knowledge
  - It undermined traditional ideas of ‘authority’ in knowledge
  - By breaking monopolies on media creation and dissemination, it changed entire information sectors,

Knowledge and the Internet

- The Internet shifts us from a consuming society, largely created by the industrial era, back towards the older mixed production/consumption model, as far as information is concerned: we can now be ‘prosumers’
- ‘Knowledge’ can now be generated and disseminated by anyone, to anyone, in any volume
  - But what is the quality of this stuff?
  - Is it really ‘knowledge’?
  - How can we tell?

Knowledge and the Internet

- There are several models for ‘knowledge verification’ (in effect, turning textual information into knowledge) or ‘quality control’ on the Internet:
  - Wikipedia (experts and some general feedback) and wikis in general
  - amazon.com (lots of user ratings and comments) *
  - Blogs (lots of feedback and expansion of ideas)
  - Twitter and similar sites (followers, re-tweets, etc.)

* amazon.com, for example ...

The product ...

* amazon.com, for example ...

The comments ...

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By **b.bingham** - See all my reviews

This review is from: **Child's White Zebra Pimp Suit Costume (Size: Samll 6-8) (Toy)**

We bought this outfit for little Johnny, as he wanted something sharp to wear to Spring Fling carnival. His little friend Amber wore the "Child's Red Happy Hooker Costume (Size XS)" and together they just looked cute as a button!! At the end of the day he came home so excited, and he loved the costume so much he started wearing it regularly! I had no idea he would get so much use out of it. He's even added accessories, like gold chains and bling rings (though I really don't understand where he got the money... oh well, probably just cheap things from the dollar store).

This turned out to be a great investment for Johnny. My only complaint is that it doesn't come with the hat, as pictured, which was disappointing for him... but he soon managed to get his hands on the cutest little purple velvet fedora which makes him look sooooo elegant!

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★★★★★ **Thoroughly satisfied**, June 11, 2009

By **C. Wareham "the bass thing"** (London, UK) - See all my reviews

REAL NAME

This review is from: **Child's White Zebra Pimp Suit Costume (Size: Samll 6-8) (Toy)**

Thanks to the credit crunch and my subsequent unemployment, I was at a bit of a loss when my young son asked me for an outfit to attend a school friends fancy dress party. On the one hand I couldn't really justify the money for an expensive outfit, but on the other I felt I couldn't let the little fella down. So it was with some relief that I happened across this costume. Junior was able to wow the other kids at the party, and now earns the household a little bit of extra income by pimping his sister in the nearby red light district.

Knowledge and the Internet

- The flood of ‘information’ on the Internet means we need to change our knowledge skills:
  - Pre-Internet, it was all about searching and accepting authoritative documents (books and peer-reviewed papers)
  - With the Internet, it is all about filtering and finding other ways to provide ‘authority’
  - With the Internet, everyone can create and disseminate knowledge, not just ‘experts’ and

Knowledge and the Internet

- Spatial information is starting to flood onto the Internet:
  - Google Earth, Google Maps and similar services
  - ArcGIS.com and similar GIS portals
  - Flickr, photo sharing sites, personal blogs, Facebook, etc.
- It is becoming increasingly easy to mash these various data sources together, and so combine spatial data in increasingly complex and productive ways

Attaching Meaning

- There are two common ways to attach meaning to digital data, which we can term the ‘file system’ and ‘tags’
- On a PC, we build a directory structure to help us organize digital data, the simplest being “My Documents,” “My …”
  - Parallel example is library cataloging
- On an iPhone, there is no apparent file structure, and everything is tagged

Attaching Meaning

- The tagging approach works well when we want a large group to help us assess information
  - Several websites are set up to facilitate this, e.g., delicious.com
- The hierarchical structure works well when we know everything about the subject ahead of time
- This limitation is why relational databases superseded hierarchical databases

Meanwhile, Back at the Revolution …

- Our model of modern measurement has shifted the addition of intelligence and meaning to after data collection
- The source of the data has become less important, as the quality control part also comes after data collection
- If we want to create spatial knowledge, we need to bring to the dataset ‘intelligence,’ ‘meaning’ and quality control
- The Internet is creating the model for how this works for knowledge generally, which we can apply to spatial

Meanwhile, Back at the Revolution …

- We now have a general model for how we can include anyone's spatial data in a larger piece of spatial knowledge, as it is similar to how we include our own measurements
- With our understanding of measurement errors, error propagation and least squares adjustment, we can assess the quality of any spatial data and determine its overall contribution to the quality of the resulting knowledge
- We have a model for assessing the validity and quality of

Meanwhile, Back at the Revolution ...

- Note that there is a critical role for experts at every step of the processes here:
  - Measurement of high-quality spatial data (esp. control)
  - Incorporation of different data sources with suitable weightings for quality
  - Contribution to the assessment of the resulting spatial knowledge, primarily based around quality
- Who are the experts?

Meanwhile, Back at the Revolution ...

- We are still in the middle of the current surveying revolution, probably with some decades left to run
- The two really big changes are hitting us now:
  - Deferring the determination of ‘meaning’ and ‘intelligence’ as well as being able to ‘crowdsource’ parts of this
  - Changing the nature of knowledge and its creation
- Still to come is the impact of widespread contributions to

What is to be Done

- There is still a critical role for experts, but it is no longer exclusive for most spatial knowledge applications
  - Exceptions would include boundary determinations
- The role of surveyors in guaranteeing the connection between the tokens (spatial data, information and knowledge) and reality is increasingly important
- Note that this ‘reality guarantee’ is not the only measure of the importance or usefulness of spatial knowledge

What is to be Done

- The FIG prediction for a global shortage of surveyors in 10 years is predicated on the role of surveyors remaining about the same, and the demands being about the same
- At this point in the revolution, guesses based on everything staying the same are a little suspect
- The role of surveyors will change, dramatically, as information and knowledge systems change, e.g.,
  - GIS/LIS/GNSS will change demand for boundary work

Summary

- The real Surveying Revolution is just beginning:
  - Thus far, it's only been rapid evolution
- We will change everything about the profession in the next 40 years:
  - What we do, the skills we use, how we are experts, what we mean by 'authority,' how we share what we do
  - In 2050, the profession will probably be unrecognizable to us from today's perspective, and totally different to

Summary

- To deal with the changes, we need broader skills, as well as more focused skills in certain areas
- We need to be more open and connected (like the Internet)
- We need to rethink who we are as a profession, what our role in a post-modern, information society and economy should be, and how we fulfill that role
- We need to be internationally connected and accredited,

Apocalypse Now?

- Imagine the situation of a late 15th century ‘surveyor’ looking to the future in 1513:
  - With sufficient insight, it would seem that everything he had known about surveying was coming crashing down
  - The skills needed to keep up—trigonometry, logarithms, angle turning, co-ordinate geometry—would seem almost impossible to someone who only did arithmetic
  - The mindset of new surveyors would be

Apocalypse Now?

- But while surveying changed so as to be unrecognizable, its importance only increased after the revolution:
  - Geodetic and surveying problems were key drivers in mathematics until about 1820
  - The debate about the size and shape of the Earth drove expeditions across the planet, and changed politics
  - Privately owned land became the foundation of modern free economies and political systems
  - Mapping and charting became critical for modern

Apocalypse Now?

- These positives were unimaginable to our late 15th century surveyor, who only saw potential losses
- How does that compare with today's surveying profession?
- We can look into the apparent apocalypse, or we can look into a positive future: the choice is ours
- What are we thinking and feeling, individually and collectively?

Apocalypse Now?

"We wring our hands over the miscarriages of technology and take its benefactions for granted. We are dismayed by air pollution but not proportionally cheered up by, say, the virtual abolition of poliomyelitis."

— Peter Medawar (1969)

"With our thoughts we make the world."

— Gautama Buddha

Thank you!

Questions?