GeoTec 2010 — Panel on

GeoWorld Industry Outlook

Panelists

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The GeoTec Event is proud to announce that the extremely successful GeoWorld Industry Outlook panel returns to the Toronto conference completely intact. This panel is an annual discussion that looks at the most-important industry topics in 2010 and beyond, and it's routinely named one of the most valuable elements of the GeoTec Event conference.

Questions Considered: The discussion focuses on issues, opportunities, concerns, considerations and future directions in the GIS industry. Included below are comments made by Joe Berry, **jberry@innovativegis.com**.

This document is posted at **www.innovativegis.com/basis/present/GeoTec10/OpeningPanel_JKBresponses.pdf**.

1) *Geoslavery broadly refers to the use of spatial technology to encroach on privacy and civil rights either indirectly (monitoring and surveillance) or directly (real-time tracking and control). Although this issue received considerable attention a decade ago, it appears to have dissipated in the post-911 era.* **Do you believe the social/political concern will be revived as our industry advances? If so, how will it manifest itself, and what are the implications at the local, provincial, national and global levels?**

With any technological advancement there comes a potential downside. The threat of "geoslavery" is real, but for the most part it is greatly exaggerated and offset by the "cyber-liberation" brought on by shedding the paper map and tossing the out-dated magnetic compass. While the thought that "great-honking computers" will know everything about where we go, what we do, what we buy affronts our private space psyche and smacks of Orwellian control …the reality is much different.

In modern society, spying and control occurs without geo-referencing all the time. Your shopping basket is scanned to automatically total the bill, keep track of inventory, and help to determine in-store specials and out-of-store marketing. If you use a preferred customer card "they" know who you are and, yes, where you live and work. But that's a far step from a knock on your door and confrontation over the sleazy brown-bag novel you purchased …it hasn't happened yet, and Orwell's book spoke of 1984.

But that doesn't mean that the issue is dead. As reported in the Economist a few years ago, a particularly paranoid person suggested that "*…they are always watching you. Use cash. Do not give your phone number, social security number or address. Do not fill in questionnaires. Demand that credit firms remove you from marketing lists. Check your medical records often. Keep your telephone number unlisted. Never leave your mobile phone on. Do not use credit or discount cards. If you must use the Internet, use someone else's computer. Assume that all calls, voice mail, email and computer use are monitored."*

Could this extremist view pull satellites from the sky and yank the GPS chip from your cell phone? …probably not. But it does suggest that we need an open and global debate about what is and isn't geo-slavery. Madonna's unsuccessful court case attempting to block the public posting of high resolution aerial photography that included her Malibu beach house established, at least in the US, that neither airspace nor general purpose imagery are private. Hence, satellite, bird's-eye and street views of your house will remain in the cyber sphere, along with its attached attributes describing its current market valuation and number of bathrooms (e.g., www.zillow.com).

What seems to be driving the issue is not so much the technological expression (the "*geo-*" component) but the interpretation of what is and isn't private (the *"-slavery*" component). That leaves geotechnology pretty much out of the

debate. It will be courts, public policy, legislation and international treaties that officially dictate what is and isn't geo-slavery—more of a social concern than a technical capability.

But the "unofficial verdict" from the streets could play a major role as well. In the US, there is a ground swell of conservatism, disapproval of anything smacking of government or corporate meddling, and ardent defense of perceive personal rights, liberties and freedoms. If the current brush fires are fanned they could engulf much of the growing exuberance for posting spatial data. Couple this with the quandary as to "who owns" the data, maintains it, verifies its authenticity, accuracy and precision— in short, "who is responsible" for the data? That implies costs and legal liabilities which could be an additional wet blanket tossed on the stampede to web-ify all spatial information. In short, the *post*-post-911 era could change everything.

So in summary, I believe "geo-slavery" and the concern for privacy are valid and real concepts that could greatly affect the current rush to "web-ify" all things geographic ….particularly if the "unofficial voices" of concern grab the airways and political debate.

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Note: *for more discussion see notes from* ***Geoslavery or Cyber-Liberation: Freedom and Privacy in the Information Age****, Bridges to the Future 2005-2006 Event, Wednesday, September 14, 2005, 7:00-9:00 pm, University Of Denver, are posted online at—* **http://www.innovativegis.com/basis/Misc/Geoslavery/** (*download .pdf*)

2) Please tell us about a new technology or idea that you think will change the industry that currently no one (or almost no one) is talking about?

Note: This would eliminate cloud computing or open-source or most of the things you hear talked about in media or conferences. Obviously there will be some people aware of it, but not the "mainstream" geotech crowd.

I will forego my usual diatribe about the implication of dodecahedrals, voxels and 3-dimensional GIS data structures on the future of geotechnology …important, but not necessarily new. However I can't contain myself to just one new thing.

My first thought is far from a new thing but in its digitally resurrected form it is opening new doors—"**stereo photogrammetry**." It has been around for a long time …it got me started in GIS in the 1960's through the inspiration of a professor who got hooked in the 1930's. So what could possibly be new about a technology that is several decades old? …it's 3D— which is even redefining Hollywood and the future of cinema.

Actually it's not 3D as much as it is its technical expression— *Parallax* which cab be defined as… "*an apparent displacement or difference in the perceived position of an object viewed along two different lines of sight*." It is an angular measure that can be used to derive depth in an imaged scene. So like the movies, future map displays will be routinely 3-dimensional …like wow! ...they will jump out at you.

But it goes beyond the wow-factor— it's a whole new set of spatial data because maps are numbers first, pictures later. By analyzing the parallax value at any location in an image one can calculate its depth relative to all other locations. As ground-based video imagery is becoming more and more prevalent in spatial databases, this feature provides a handle for enhanced classification. To date, color (or simply intensity in black and white imagery) has been the primary condition for classifying features in a scene. Now when a detectible glob is in the scene, its position (right , left, forward and back) can be used as an additional bit of information to classify streaming video. *(Note: I encourage interested folks to visit the Photosynth website (http://photosynth.net/) to become familiar with Microsoft's revolutionary software that "mashes" photos together to create a 3D scene that anyone can view and move around in)*

The other new thing is "**crowdsourcing**" …a topic for a whole session yesterday in the emerging technologies track. But in case some of you missed the session, a short review with sidebar discussion might be in order. Crowdsourcing is the hot new term that mashes the words "crowd" and "outsourcing" to describe *the act of taking tasks traditionally performed by a team of in-house specialists, and outsourcing the tasks to the community through an "open call" to a large group of people (the crowd) asking for their input*.

In the context that most interests me, it extends the "social science tools" for consensus building and conflict resolution we have used for years to calibrate and weight spatial models. For example, a model for routing an electric transmission line that considers engineering, environmental and development factors can be executed under a variety of scenarios that reflect different influences of the criteria map layers derived from different stakeholder groups. The result is infusion of the collective interpretation and judgment required for effective cognitive mapping—participatory input.

In the past, the calibrating and weighting the model usually involved a small set of representatives sitting down in a room and hashing out a presumed collective opinion of a larger group's understanding, interpretations and relative weightings. Crowdsourcing suggests you could hang a routing model out on a website, invite folks to participate, have some GUI's that let them interactively set the model's calibrations and weights, and then execute their scenario. They could repeat as

often as they like, and once satisfied with a solution they would submit the model parameters. Sort of a virtual public hearing but with more refined interaction and less stale doughnuts and lukewarm coffee.

In short, I believe two "old but new" technologies are important to watch— 1) "stereo photogrammetry" as a basis for map analysis, as well as "wow" visualization, and 2) "crowdsourcing" with scientific control for setting the parameters of spatial models.

3) **As a follow up, what are some applications where geotechnology should be used, but currently isn't (or is at least highly underutilized)?**

Let me rephrase the question slightly— to "*what are some applications where geotechnology isn't achieving its full potential?*" The counterintuitive answer is …"in many of fields that have strong mapping legacies." This is in part because GIS was initially sold as a cost savings tool in organizations that had mapping departments. Hence the application focus was on automating current business models.

For early adopters, such as natural resource organizations the first step was often a "SAUNA"—Situation Analysis and User Needs Assessment. The dominant voices during these discussions often came from the existing map makers and users within an organization and the discussion tended to focus on "what do we currently do (mapping and inventory procedures) and how could we do it better (meaning more efficient)." Rarely were voices heard that said "I don't really use maps much, but was wondering if this new technology could do something that would help me make better decisions (entirely new business models)"— at least in part because such voices weren't at the table, and even if they were they had no idea about modern map analysis tools to frame their thoughts.

This situation highlights the differences between the "*-ists*" and the "*-ologists*" who are present in many organizations. In the GIS debate, the "*-ists*" pragmatically focus on programs emphasizing tools needed to display, query and process spatial data (a Data and Information focus). The "*-ologists*" in the group, tend to have a broader vision of engaging users (e.g., ecologists, sociologists, hydrologists, epidemiologists, etc.) who tend to focus on the spatial relationships that support decision-making (an Information and Knowledge focus).

What I find interesting is that the most innovative applications have come from fields that weren't dominated by mensuration and mapping "*-ists*." For example, *precision agriculture* fully embraces the Spatial Triad of RS, GPS and GIS but goes a step further for good measure— **IDI** (intelligent devices and implements). This process first assesses the relationships among factors driving crop production, such as nutrient levels, pH, and seeding rates, then derives prescription maps for site-specific management action, that, in turn, are played out on-the-fly as a GPS-enabled fertilizer rig rolls across a field. All this newfangled technology costs about fifty cents an acre over a single "whole field" petcock setting.

Another example of innovative application from a traditionally map-challenged group is in *geo-business*, particularly the retail sales and marketing sectors. Now they hover over each item purchased, whether cash, check or click, and whenever possible tie it to the ground so they can create sales density surfaces throughout a community and mine this information along with demographics and lifestyle data for spatial relationships they can utilize. Like the farmer, marketers have discovered that understanding spatial patterns can help grow sales, just like it helps grows corn.

Now let me retreat somewhat from voicing such an irreverent and politically incorrect viewpoint …that traditional mapping fields have been laggards in geotechnology. Like the tortoise and hair, the map-savvy organizations are springing forward with a host of new and innovative applications, now that their extensive data bases are in place and management has a broader view of geotechnology's potential beyond simply spatial record-keeping.

So what is the distillation? …that a strong mapping legacy has not been strongly correlated with GIS innovation. The most important driver is an understanding of a spatial problem or opportunity— domain expertise over mapping expertise.

4) *According to the U.S. Administration on Aging, the number of Americans over the age of 65 in 2030 is likely to rise to 72.1 million, or 19% of the population (the figures in the 2000 U.S. Census were 35 million and 12.4%, respectively).* **How can GIS be used to make our communities more Age Friendly?**

Geotechnology has an important but **supporting role** in making our communities more Age Friendly. Outside of Google Earth tours and hooking actual town data to Grand Theft Auto so Granddad can virtually steal the neighbor's car and outrun the local cops, I don't see much direct interaction.

However, traditional applications in **land use and infrastructure planning** will benefit greatly from geotechnology, such as determining the best locations for new parks, outdoor spaces, public transportation routes, community health clinics, and opportunities for social participation, to mention just a few.

Better **access to and delivery of services** for the aging will be a dominant role. For example, meals on wheels might adopt UPS routing and tracking technology; social networking could be enhanced by geo-query; spatially-enabled cell phones can "speak" to what is around, as well as how to get home; and GPS bracelets can serve as alarms in case of emergency or unsafe wandering.

But the real payoff is even further behind the scene, as GIS is utilized to make sense of the **spatial patterns and relationships** of where people are today and temporal/spatial models for projecting where they likely will be as they age. This information will be a key ingredient in anticipating needs and scaling services so budgets, health care workers, social opportunities and the like are in place when they are needed.

In short, GIS will help facilitate solutions (support role), primarily by applying technology to better understand and anticipate spatial factors that can make our communities more "age friendly"— 1) land use and infrastructure planning, 2) access to and delivery of services, and 3) temporal/spatial models for projecting the "where and when" of future needs.

5) *Recently there has been considerable movement toward "Open Source GIS," particularly with developing nations. In addition, much of the earlier "GIS commercial space" has been eroding (e.g., database development, data visualization, etc.) or usurped by non-traditional GIS companies (e.g., Google, Oracle, etc.).* **What do you think the GIS industry membership will look like in 10 or 20 years? What companies will be the major actors?**

In a single word …"different." The 1970s saw Computer Mapping automate the drafting process through the introduction of the digital map; the 80s saw Spatial Database Mining link digital maps to descriptive records; the 90s saw the maturation of Map Analysis and Modeling capabilities that moved mapped data to effective information by investigating spatial relationships; and finally, the past decade focused on Multimedia Mapping that emphasizes *data delivery* through an Internet proliferation of data portals and *advanced display mechanisms*.

In the early years there was a scattering of small companies primarily finding niches in particular disciplines and applications. This gave way to a more general purpose "toolbox" view in the 90s and the industry coalesced into a few large GIS companies servicing a wide array of applications with "flagship" software packages. This set of major actors and technological expressions are still pretty much in the driver's seat of geotechnology …at least for a little while longer.

But a baton transfer of "all things geographic" from flagship GIS companies to more generic information and access companies began a decade ago. The exponential growth of the technology and breadth of its applications has sealed the transfer—like the boutique store (viz. GIS company) losing customers to the big box stores (viz, GE and Bing Maps).

However I believe that the geotechnology baton is posed for at least two more forward passes. It seems that Tweeter, Facebook and MySpace are awakening to the idea that geography is a really cool way to show friends exactly what are doing AND WHERE you are doing it. Location stamps on photos and video are becoming as common as time stamps …throw-in a link to GE and the transfer is complete.

Less on the radar is big database companies' interest in geotechnology (viz. Oracle and Sybase). They have been developing "spatial data-blades" for several years and have incorporated considerable GIS capability into their software. What has been holding them back is an easy way to automatically stamp individual data records with a universal geographic identifier. The complexity and multiplicity of current referencing systems and transformations keep them "pulling at the bit" at a slow trot. Soon they will be galloping with geotechnology when a standard "universal key" is in play.

That key is already here, but most folks, even those in the GIS community, aren't aware. USGS in conjunction with numerous other groups have established a raster/grid-based referencing schema for the globe using Lat/Lon WGS84—1m, 10m, 30m, 90m and 1km patterns. This means that there is a consistent "square partition" for every location on the face of the earth. That suggests that any spatially dependent record can be easily plunked into one of these "bins" as a single compound number for column/row, and all other data and database systems will immediately know where it is. No more geodedic hoops to hop through for the geographically-challenged among us (viz. "unwashed" IT types) …the gates have sprung open and the race is on by pre-conditioning the globe for a geo-reference universal key.

So what do I **think the GIS industry membership will look like in 10 or 20 years? …and what companies will be the major actors?** Most of the visualization tasks will be in the hands of multimedia giants with a lot of the routine applications expressed as mash-ups. Most of the current flagship actors will be absorbed into the big hitters with

one part of their intellectual property going the multimedia folks (geo-referencing, basic storage and visualization expertise) and the other part going to database folks (primarily data conversion and analytics). What traditional GIS companies remain likely will retrench into application-specific arenas …sort of a return to their roots and committed clientele. The bulk of the action, however, will be primarily in the hands of the big hitters of the computer industry.

In summary, our next evolutionary leap will see GIS even more closely knitted into the fabric of society with our current industry mix giving way to large multimedia and database companies— fledgling geotech has certainly got their attention.

6) How complete is the GIS toolbox? Are most of the spatial information processing and analysis capabilities in hand, or are there significant new capabilities on the horizon?

My read is that most of the **GIS Toolbox is fairly complete** within the confines of our current application needs (primarily geo-query, display and basic models) and data forms (2D vector and raster/grid).

A key element for developing new applications lies in domain expertise as much as mapping know-how. The geometrical increase in awareness and use of geotechnology by the masses will lead to entirely new and innovative applications that we haven't even dreamed of as geotechnology specialists. The only way we could drop the ball is to retreat further into our disciplinary cave. As more users begin "thinking with maps" instead of querying them, spatial reasoning and problem solving will be employed to develop solutions using the current map analysis toolbox and stimulate thoughts about new capabilities.

The trigger for resurgence in development of **significant new analytical capabilities** will come from the technical front. I see a radical change in geo-referencing from our 400 year reliance on Cartesian "squares" in 2-D and "cubes" in 3-D to hexagons for 2-D and dodecahedrals for 3-D that will foster entirely new analytic capabilities and modeling applications.

To conceptualize the difference, imagine a regular square grid morphing into a grid of hexagons like a tray in a bee hive. The sharp corners of the squares are knocked-off resulting the same distance from the centroid to each of the sides defining the cell …a single consistent step instead of two different types of steps (diagonal and orthogonal) when moving to an adjacent location. Now consider a three-dimensional world with 12-sided volume (dodecahedral) replacing a cube …a single consistent step instead of a series of differing steps to all of the surrounding locations.

This shift in spatial theory will revolutionize our concept of geographic space. At a minimum, it finally will dispel the false assumption that the earth is flat …at least in the map world that stacks two-dimensional map layers like pancakes. At a maximum, it will enable us to conceptualize, analyze and actualize spatial conditions within the full dimensionality of the real world.

Now all we need to do is to figure out a way to fully account for time, as well as space, in our mapping for a temporally dynamic representation of geography—but that's another story to be written by another generation of geotechnologists.

7) *The Spatial Triad recognizes the interdependence and importance of the links among remote sensing, GPS and GIS.* What additional fields might be added to the mix (e.g., computer science, multimedia/webpage design, robotics, etc.) to meet future application requirements? And if the "disciplinary tent" is expanding, how will the private, public and academic sectors respond and adapt?

The Spatial Triad—RS, GPS and GIS—is a relatively new paradigm. *Remote Sensing (the oldest)* is used to measure and classify the earth's cover, *the Global Positioning System (the newest)* is used for location and navigation, and *Geographic Information Systems (the framework)* is used for storage/retrieval, mapping and analysis of spatial information.

For example, in Precision Agriculture RS, GPS, and GIS are combined with "**intelligent devices and implements (IDI)**"—an application that integrates robotics (as also noted in Question 3). The Spatial Triad is used to assess the relationships among factors driving crop production, such as nutrient levels, pH, and seeding rates, and then derive prescription maps for site-specific management action. For example, a prescription map can be generated that identifies the right amount phosphorous, potassium and nitrogen for each ten-foot grid location in a field. The map is transferred to a flash card that is inserted into a controller that adjusts a bank of servos to deliver the precise mixture of P, K and N to each grid location as the fertilizer rig moves across the field—an intelligent implement.

In a similar fashion, an "intelligent" variable-rate seeder can adjust seeding rates to changes in the micro-terrain— more seeds in the depressions and less on the side and top slopes for drought prone areas; the opposite seeding program for high moisture areas. The RS/GIS/GPS plus IDI approach can be extended to most applications requiring spatially depend variations in machinery for on-the-fly control.

A totally different kind of extension involves linking "**social science tools**," such as consensus building and conflict resolution software to calibrate and weight spatial models. For example, a model for routing an electric transmission line that considers engineering, environmental and development factors can be executed under a variety of scenarios that reflect different influences of the criteria map layers derived from different stakeholder groups. The result is infusion of collective interpretation and judgment required for effective cognitive mapping.

This linkage is in part the basis for the hot new term "*crowdsourcing*" that mashes the words "crowd" and "outsourcing" to describe *"the act of taking tasks traditionally performed by a team of in-house specialists, and outsourcing the tasks to the community through an "open call" to a large group of people (the crowd) asking for their input*," such as calibrating and weighting a spatial model.

However I believe the Spatial Triad extension that will have biggest impact in the next couple of decades will be the full integration of advanced "**data mining technology**", such as CART (Clustering and Regression Trees), induction models and neural network analysis for statistically analyzing spatial patterns and relationships. This will require a rethinking of both the GIS and statistical communities—from paradigms of discrete spatial objects and random sampling to recognition of continuous spatial surfaces that account for and utilize spatial correlation and autocorrelation. But that's another story and beyond the scope of this forum ...involving the "dismal and unsettling" science of statistics.

So **how will the private, public and academic sectors respond and adapt?** It primarily depends on the degree of innovative and entrepreneurial spirit in an organization. To date the bulk of geotechnology application has been for gains in efficiency and cost savings that support current business practices. While tremendously useful and resourceful, the applications tend to work "within the box" and usually don't create entirely new products, services, markets or completely new ways of addressing and expressing an organization's mission.

The single most import factor enabling innovation is the thickness of the wall of the organizational box, or disciplinary silo. Adding additional fields to the Spatial Triad assumes leadership that is constantly seeking new ways of doing business and is actively involved with other fields. If this is present, the organization will respond and adapt easily to extensions beyond mapping; if not present, then there will be an unhealthy resistance to change.

8) What technical innovations in spatial data structure, display, processing and/or analysis do you see on the horizon?

By far the most radical **technical innovation** in mapping since the discovery that the world wasn't flat will be a wholesale revamping of geo-referencing and data structure. The changes will be huge and shake the very core of GIS—the Cartesian coordinate system itself …a spatial referencing concept introduced by mathematician Rene Descartes 400 years ago.

The current 2D square for geographic referencing is fine for "static coincidence" analysis over relatively small land areas, but woefully lacking for "dynamic 3D movements, connectivity and flows." It is likely that Descartes' 2D squares will be replaced by hexagons (like the patches forming a soccer ball) that better represent our curved earth's surface …and the 3-dimensional cubes replaced by nesting polyhedrals for a consistent and seamless representation of three-dimensional geographic space. This change in referencing extends the current six-sides of a cube for flow modeling to the twelve-sides (facets) of a polyhedral—radically changing our algorithms, as well as our historical perspective of the mapping sciences.

The new geo-referencing framework will provide the needed foothold for solving complex spatial problems, such as intercepting a nuclear missile using supersonic evasive maneuvers or tracking the air, surface and groundwater flows and concentrations of a toxic release. While the advanced map analysis applications coming our way aren't the bread and butter of mass applications based on historical map usage (visualization and geo-query of data layers) they represent natural extensions of geospatial conceptualization and analysis …built upon an entirely new set analytic tools, geo-referencing framework and a more realistic paradigm of geographic space.

Another canonic change will be in how we perceive geographic space itself—from an assemblage of discrete spatial objects (points, lines and polygons) to a continuous surfaces and volumes that track the gradient nature of most geographically distributed phenomena. Our grandchildren will reflect in shocked wonder on the artificial boundaries we imposed, much like we are shocked by the ancients' ardent belief that the world is flat and you could sail off the edge.

Note: For more on “pending prospects” in geotechnology, see www.innovativegis.com/basis/MapAnalysis/, select Topic 27, *GIS Evolution and Future Trends*