Mapping and Coordinates

By David M. Horwood, O.L.S.

With the great interest generated from the Accurate Ontario Digital Cadastre project, the concepts of mapping and coordinates have come to centre stage. However, I believe there is a general misconception of what these terms really mean when put into practice. As a registered Geographic Information Manager (GIM) with 25 years of experience implementing parcel data management systems, I can provide some insight into the meanings of these terms from the land information professional's perspective and the issues created by the misapplication of these concepts.

When I think about mapping, I'm reminded of a story that a colleague told me many years ago that has remained vivid in my mind. It concerns a king and a wizard …

"You can be replaced by Harry Potter, you know!"

Credit: www.CartoonStock.com

There was a king and a wizard in an ancient kingdom. The king was obsessed with maps and the wizard was charged as the king's map maker. As time went on, the wizard would present to the king more and more detailed maps of the kingdom. However the king was never satisfied and would send the wizard back to produce an even more detailed map. This strife between the king and wizard escalated over the years until one day the king exclaimed to the wizard; "I've had enough of these approximations. I order to you to produce a one to one map." The wizard paused for a moment, looking at the king with an air of reflection. He then took the king by the hand, led him to the outside balcony overlooking the kingdom, pointed at the countryside and said: "Your majesty, it is already done."

There are many definitions of the word map. A map is normally defined as a diagrammatic representation of the Earth's surface (or part of it). However the moral of the story is that the usefulness of the map is based on how well it abstracts reality. The real world is already out there, so making the map too detailed not only increases the cost to create the map, but it can also decrease its utility. Therefore a working definition of a map is a useful abstraction of reality.

So from a practical standpoint, it is important to decide what the map will represent. As it becomes more detailed, there is a point of diminishing returns. Moreover, the cost to keep the map maintained increases exponentially the more frequently it is updated and the more detailed and accurate the representation. Generally there is a "sweet spot" where the beneficiaries gain the most from the detail, accuracy and timeliness of the map. Beyond this, little more benefit is realized and customers will generally not pay for the increased cost.

With regard to coordinates, I perceive a similar misconception. A vast majority see coordinates as absolute, representing an unchanging position for an object. Coordinates are now required by regulation to appear on registered and deposited plans, however, even before this many municipalities required coordinates on plans. There was a study commissioned by the Canadian Council on Geomatics (CCOG) in 2002 ("Coordinates in Context") which looked at the viability of elevating coordinates in the hierarchy of evidence for boundary determination. The study found that there was no legal impediment to this. In fact existing legislation, e.g., for deferred monumentation in Alberta, could be used as a model by essentially extending the monument deferral period to the end of time, in which case the coordinates themselves become the evidence.

However, I believe that elevating the status of coordinates is unwise. A coordinate is simply a measurement along arbitrary X and Y (and Z) axes from an origin, no different in concept than a bearing and a distance (i.e., a polar coordinate). In planar coordinate systems, like Universal Transverse Mercator (UTM) or Modified Transverse Mercator (MTM), a coordinate usually is defined by both a projection and a datum (origin), e.g., UTM Zone 17 North American Datum 1983 (NAD83). Coordinates are rarely directly measured but computed from other observations, even in the case of Global Navigation Satellite Systems (GNSS) where the coordinate is calculated from a multiple distance intersection from satellites and generally also using another known point.

As GNSS improved, it was found that coordinates even in the same datum and projection were not fixed. The Earth is dynamic with both gradual (tectonic plate movement) and dramatic (earthquake) changes over time. The earthquake in

March 2011 moved some areas of the coast of Japan by 4 metres (http://www.bbc.co.uk/news/science-environment-12732335). Moreover, the basis for our GNSS positioning relies on a three dimensional Earth-Centred, Earth-Fixed (ECEF) coordinate system, since the GNSS satellites are orbiting around the Earth's centre of gravity. This centre of gravity also changes over time and is one of the reasons that current realizations of the World Geodetic System 1984 (WGS84) do not match current realizations of NAD83, since the Earth's centre was updated based on the more accurate Earth Gravitational Model 1996 (EGM96) for WGS84 but not for NAD83. This also means that there is a datum transformation between NAD83/Canadian Spatial Reference System (CSRS) and the equivalent WGS84/International Terrestrial Reference Frame (ITRF) coordinate system of the same epoch, resulting in between a one to two metre shift (http://www.geod.nrcan.gc.ca/faq_e.php#27). This shift is apparent when comparing mapping in Ontario (which uses NAD83) with online mapping systems such as Bing, Google or ArcGIS (which all use WGS84). As Albert Einstein discovered one hundred years ago, there is no absolute frame of reference.

This highlights the importance of permanent physical reference points on the ground which can be used to re-establish positions over time. Granted these reference points need not be on every corner, but they need to be local to a set of corners so that the movement of the reference point is likely to be related to the movement of related corners. A few strategically placed permanent reference points (ideally inter-visible and accessible using both terrestrial and GNSS methods) could serve one or more subdivision plans and/or a number of reference plans. Moreover, errors in application of a scale factor in local measurements will be less severe than those applied to a coordinate, which is essentially a measurement from the equator. Which would you trust more: a tie from an original building or a measurement from Ecuador?

From a practical standpoint it is important to remember that a coordinate is not absolute but a computed relative measurement and when comparing coordinates it is critical to take projection, datum and epoch into consideration. Common coordinate systems are useful, and required in order to construct land information systems. However these coordinate systems are necessarily a snapshot in time and need to be periodically updated to keep pace with the continual changes of the real world.

Proper consideration of the concepts of mapping and coordinates can help build land information systems that are useful, timely and accurate. The real world changes continually as time passes and map and coordinate based information systems need to be designed from the beginning to capture the essential information (and no more) and to embrace and reflect changes over time.

David M. Horwood, O.L.S. is a Geographic Information Manager. He is President of S.E.A. Graphics Inc. He can be reached by email at **dhorwood@interlog.com.**

Calendar of Events

January 23 to 25, 2012
International LiDAR Mapping Forum
Denver, Colorado
www.lidarmap.org/ILMF.aspx

February 7 to 9, 2012
9th Annual ORCGA Damage Prevention Symposium
Collingwood, Ontario
www.orcga.com

February 22 to 24, 2012
120th AOLS Annual Meeting
The Spatial Profession – A Life Without Limits
Ottawa, Ontario
www.aols.org

May 6 to 10, 2012
FIG Working Week 2012
Rome, Italy
www.fig.net/fig2012

May 14 to 17, 2012
Global Geospatial Conference 2012
Spatially Enabling Government, Industry and Citizens
Quebec City, Quebec
www.gsdi.org/gsdiconf/gsdi13

May 15 to 17, 2012
2012 Canadian Hydrographic Conference
The Arctic – Old Challenges, New Approaches
Niagara Falls, Ontario
http://chc2012.ca