Disruptive Innovation and the Future of Surveying

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December 2015

It goes without saying that the digital revolution has had an enormous impact on surveying. Adapting to those changes is a challenge that we surveyors all meet (or not) in our own way.

Several weeks ago I read the book "Innovation" by Walter Isaacson. Of the many points made, the following resonated with me. Isaacson claims that:

- Attempting to predict the future is less productive than working to create the future. When the future of surveying is discussed, I'd like to think that efforts to create the future will be pursued and that the leadership will be found to realize the future that is envisioned.

- There remains a constructive tension between those who feel that advancements should be shared freely (open source software) versus those who insist (as did Bill Gates) that creative ingenuity deserves compensation. I believe Isaacson presents a balanced view and in some ways I'd like to think we can have it both ways. What does it take to capture benefits from each perspective? At least, the possibilities should be discussed honestly and respectfully.

The 2016 ABET Symposium is labeled "Technical Education Building a Better World" and will be held in April 2016 in Florida. Track 3 of the Symposium is titled, "Disruption and Innovation in Technical Education." A partial description of Track 3 is "Policymakers and other key stakeholders believe that technical programs are distinctively positioned to help institutions respond to growing demands to contribute to local and regional economic development. This track showcases practical initiatives at schools with a wide range of missions, resource bases and locations that respond to this imperative." I ask, "What does that have to do with surveying?"

Wikipedia: Disruptive innovation is an innovation that creates a new market and value network and eventually disrupts an existing market and value network, displacing established market leaders and alliances. Several questions I have are:

- In what way does disruptive innovation apply to accreditation procedures? From the ABET perspective, disruptive innovation may be considered in terms of ABET processes and the conduct of accreditation activities. That is legitimate. For example, computerized testing has made significant inroads and is evidence of ABET adaptions. But, shouldn't accreditation involve both process and content? From the professional perspective (engineering, surveying, and other spatial data applications) disruptive innovation is more directly related to the curricular content of what students are learning and being taught. Given that education does not happen without first learning how to learn, discussions of what is taught/learned should be a legitimate follow-up that accommodates innovation.

- It is well known that the digital revolution significantly impacts professional practices and procedures – especially as related to 3-D digital spatial data. At what point should ABET address disruptive innovation as it relates to the content of accredited programs?

- In what way does disruptive innovation apply to surveying practice and surveying education and what is the best way to address those challenges? Is that the prerogative of professional societies, the boards of licensure, the NCEES, standards organizations, educational institutions, governmental agencies, or surveying educators?

A case can be made that surveying educators and surveying education can and should contribute to a future of Surveying in which the entire spatial data community recognizes and embraces the importance of surveying in at least three areas:

- Boundaries: In general, the surveying profession has statutory responsibility for determining and retracing boundaries. Yes, there are differences between the talent and competence needed for various boundary determinations such as lot surveys, subdivision design, retracements of "old" property lines, geopolitical boundaries, and international boundaries. For example, on November 21, 2015, International Boundary Marker No. 1 west of El Paso, Texas was peacefully rededicated by the Southern New Mexico and the El Paso Texas Branches of ASCE. Representatives from Mexico also attended. By contrast, the critical integrity of international boundaries was illustrated in November 2015 when the Turkish government shot down a Russian fighter plane for violating its sovereign territory. The Russians claimed that their plane never left Syrian airspace. Is it possible that both claims are correct – depending upon the definition/interpretation of the boundary? https://en.wikipedia.org/wiki/2015_Russian_Sukhoi_Su-24_shootdown.

- Practice: It should be safe to assume that licensed surveyors have the ability to collect, analyze, manipulate, and organize 3-D digital spatial data as needed to solve a wide range of problems and to participate on par with other disciplines in the evaluation and management of risk on behalf of a wide range of clients. There are many cases in which that assumption is legitimate. But, here too, there is a range of talent and expertise needed to address a broad range of challenges brought by various clients. Yes, licensure is important and correlation does exist between licensure and competence, but licensure is not prima facie evidence of qualifications to perform a given task. Disruptive innovation presents a challenge to established methods, policies, and procedures for both professional practice and the licensing process.

  Surveyors have long argued (and even recently) that engineers have no business performing surveys for a number of reasons. One reason is that many civil engineering graduates do not take enough courses or receive sufficient instruction in surveying to establish competency. That certainly is a good argument, but for the person who learns how to learn and who diligently applies themselves, learning principles of boundary location, learning how to use GPS, and learning how to handle 3-D digital spatial data does not necessarily require taking a college course in same. I would suggest that a better reason for castigating engineers is that anyone not qualified to perform a survey (even if licensed as a surveyor) should not perform the task/service. That becomes much more subjective because learning itself is a subjective process and experience in one area of practice does not necessarily qualify one to perform in another. This line of reasoning belies the fact that we all learn at different rates, at different times, and often, for different reasons - which brings the discussion full circle back to disruptive innovation. The challenge exists at all levels for individuals to learn more and to progress in the level of experiences such that society is the benefactor of competent service in all endeavors.

- Spatial Data Accuracy: How good is good enough? The best answer may be, "It depends." Issues of spatial data accuracy weigh heavily in both the question and the answer. In the past, the answers were related to standards/specifications, equipment, procedures, personnel, measuring conditions, and other less quantifiable factors. The digital revolution has made it possible and feasible to quantify spatial data accuracy with much better mathematical certainty. That capability supports better decisions when answering the question – how good is good enough?

The specific disruptive innovation for spatial data (and surveying) referred to here is a consequence of using the 3-D Global Spatial Data Model (GSDM) which is based on the assumption of a single origin for 3-D spatial data, use of the Earth-centered Earth-fixed rectangular coordinate system implemented by the U.S. DoD for the constellation of GPS satellites, rules of solid geometry for computation of location in 3-D space, and standardized rules of error propagation given by:

$$\Sigma_{YY} = J_{YX}\, \Sigma_{XX}\, J_{XY}^{t}$$

where: Σ_{YY} = the covariance matrix of computed result.
Σ_{XX} = the covariance matrix used in the computations.
J_{YX} = Jacobian matrix of partial derivatives of the result with respect to the variables.

Adoption and use of the GSDM can be justified on the ground that it:

1. Has been proven mathematically sound and is rigorous for all location computations in 3-D space on, near, or in the Earth.
2. Is applicable for all spatial data disciplines all over the world.
3. Avoids problems of distance distortions implicit in the use of conformal map projections.
4. Allows engineers to design with local 3-D flat-earth geometry while preserving geometrical integrity at all levels. Even long corridor projects can be seamlessly accommodated.
5. Handles issues of spatial data accuracy for both network and local accuracies.
6. Will accommodate continued use of many existing coordinate systems in a subordinate manner.
7. Can also be used for rigorous scientific applications involving 3-D digital spatial data.
8. Includes solid geometry equations that are less complicated than geodesy & map projection equations.
9. Provides an umbrella global model "clearing house" for numerous applications.
10. Gives more insight into what is happening "in the black box."

The GSDM can be viewed as "disruptive" in that:

1. It is conceptually different than that to which we are accustomed. . . .
   See http://www.globalcogo.com/setepaper.pdf
2. Most potential users are not aware of the benefits to be realized in using the GSDM.

3. Equipment and software vendors have a huge investment in existing data handling processes.
4. Research is still conducted according to assumptions of traditional horizontal and vertical concepts.
5. Many educational programs will need to modify existing curricula to accommodate the 3-D GSDM.
6. Existing standards need to be updated in light of improved methods for handling spatial data.
7. Boards of licensure will need to update existing testing materials and grading processes.
8. Many users feel threatened by "loss of control" in adapting to a broader model.
9. Additional monies will need to be allocated and spent in order to implement use of the GSDM.

Examples of existing/potential uses of the ECEF system and the GSDM:

1. The ECEF system is the basis of operations for global navigation satellite systems (GNSS).
2. Tracking moving objects (both position & detect-and-avoid) in, on, above, or near the Earth:
   - Aircraft, ships, missiles, drones, trucks, trains,
   - Driverless cars, machine control for construction, and others
3. Transportation studies and coordination of disparate data sets in the permitting process.
4. Underground mapping of thousands of mine shafts throughout the world.
5. Off-shore positioning for energy exploration and production.
6. The National Cadastre and the basis for the National Geospatial Data Infrastructure.
7. Mapping of all kinds and as the basis of "virtual reality." For example, see http://sensorsandsystems.com/will-virtual-reality-take-over-as-the-ultimate-form-of-a-map/