Benefits of a Surveying Manual of Practice

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Earlier this year I was asked to comment on a document designed to provide guidance for survey technicians gathering data in support of a variety of professional services. In my opinion, the proposed document is an excellent idea because that is a "field I helped plow" over 40 years ago. Admittedly, the technology is a bit different now but the challenges of using 3-D digital spatial data highlight the benefits that can be realized by careful evaluation of procedures and implementation of modern survey practice.

Hypothesis:

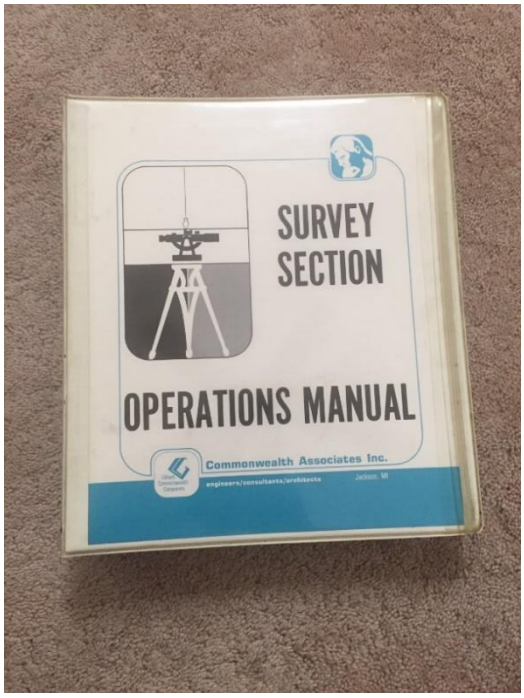
The return on investment in a **Manual of Practice** can be very attractive**.** Opportunities for the geospatial data community (especially surveyors) to contribute to an expanding global economy can be improved by adopting better procedures for handling spatial and geospatial data. Development of a Manual of Practice supports that goal by. . .

- Investigating the role and defining a model for handling 3-D geospatial data that exploits modern measurement systems and the characteristics of 3-D digital spatial data.
- Developing standards and procedures designed to enhance the competence and effectiveness of "those who get the job done" – that is, involving and getting "buy-in" from technicians.

I can relate specifically to the need for established procedures to be used by survey technicians for survey data collection and related manipulation. If my comments give the impression of shooting from the hip, I'll accept that criticism. Aspiring technicians and seasoned professionals are both invited to use what is appropriate and to share success stories with colleagues. In my experience, our "Operations Manual" enhanced both the quality and efficiency of our services to customers, clients, and society.

1. During the 1970s I worked in the Survey Section of Commonwealth Associates, Inc., a mid-sized international engineering firm serving, among others, the electric utility industry. Although the company was involved in many aspects of engineering and design, I worked in the transmission line division – and assisted on projects in various parts of the U.S., in Iran, and in Brazil. It was a valuable experience and I learned from many talented professionals. A clear mission and teamwork were essential for success, but the team also relied on the motivation and competence of each participant. The unofficial company motto was, "time and money being no object, Commonwealth personnel can do anything." The company hired talented persons, paid us well, and did not tolerate disloyalty. A lot could be said about those larger issues. The focus of this article is detail/execution.

2. At any one time, we had multiple crews on multiple projects in multiple states. One of the best things the Survey Section did was to develop what we called an "Operations Manual." It contained standard information about the company's organizational structure, polices pertaining to field operations – time sheets, per diem, responsibility for company vehicles/equipment, and the like. But, more important, we included information about surveying operations; organization of field notes, number of repetitions for angles and distances, tolerances of leveling sight distances, criteria for traverse closure checks, equipment calibrations, data reduction procedures for state plane traverses, and a summary of Federal Geodetic Control Committee (FGCC) Standards and Specifications as applied to the work we did. Our crews rarely performed astronomical observations but when we did, yours truly prepared specifications tailored to the job – including first-order Polaris observations with a Wild T-3 theodolite on a nuclear power plant site in Wisconsin.



3. Ground control for photogrammetric mapping constituted a large part of what we did. Preparing easement documents and staking tower location for construction were also significant activities. Mohammad Reza Pahlavi, the Shah, was in power in Iran in the 1970s and Commonwealth Associates had design and construction management responsibilities for 1,000 km of high-voltage transmission line in Iran. No problem - remember, Commonwealth can do anything. Well, consider that, due to politics, it was impossible to get an aerial mapping camera into the country much less to put it up in an airplane to take pictures. Yes, the plan and profile documents needed to be developed from on-the-ground surveys and the timeline for completion was tight. A mapping subcontractor from England was hired for the job. With Commonwealth's international reputation on the line, quality control on all aspects of the project was very important.

   I had no involvement in selecting the subcontractor, but I was dispatched to London for a week in January 1978 to review and evaluate the capability/performance of the subcontractor. I was "pumped" and pretty cocky by the assignment and probably did a poor job of hiding it. But I was overwhelmed by the hospitality of my hosts, by their technical capacity, by their work ethic, and by the impressive workflow utilized on the project. All observations were booked onto paper tape, flown to London (or via teletype?), and computer processed to produce the plan/profile documents (remember, this was the mid-late 1970s before internet and GPS). I was quite humbled by the whole experience. Oh yes, that is where I experienced my first taste of escargot, enjoyed a tour of the London Boat Show, and embarrassed my host by ordering a glass of milk to go with my spaghetti lunch one day. I guess you just don't do that in an English pub. The "moral" of all this . . . there is no substitute for doing a good job right.

4. Yes, much of the foregoing philosophy can be covered in a basic document. Nominal benefits can accrue even with a modest level of "standardization." But, greater benefits are to be realized from participation and buy-in from top management, from middle management responsible for developing/implementing the policies, and from the technicians who enjoy the luxury of knowing what is expected of them and knowing where to get answers when unexpected circumstances arise. Many companies have at least "informal" procedures in place and that is commendable. May I share additional comments that may or may not be conducive to "smoother operations"? In my opinion, technicians are, by and large, quite competent and take pride in doing a good job well - especially when they understand the big picture and recognize the contribution of each team member in achieving the stated objective. Resorting to rote operations can be counterproductive and demoralizing. That can be the difference between performance specifications and detailed specifications. A roofing contractor may function well using detailed specifications, but performance specifications are more closely aligned with professional services.

My comments are directed to the complexity of the task and the level of competence needed to do a good job right. Acknowledging the talent and effort needed to develop the models for handling spatial (survey) data, there is no task that (given unlimited time and money) cannot be accomplished. Many professionals take great pride in those achievements – even going back hundreds of years. The rub is that, with the advent of the digital revolution, the assumptions and models need to be revisited. That statement might be heresy but let's stick with it a bit.

What is the role of a model and why does that matter in spatial/geospatial practice?

In the past 200 years mathematicians, geodesists, and scientists have solved problems related to geometrical geodesy and the accuracy thereof. The models work and many important engineering projects give evidence of their successful application. The question now is, 'how can we justify continued emphasis on 2-D mapping models to handle 3-D data?" **We can and must do better!**

5. I have been a fan of conformal mapping for nearly 50 years. As an undergraduate at the University of Michigan, I worked for Professor Ralph Berry on the Skew Orthomorphic Projection that he designed for the Michigan Geo-Ref System. He asked me to develop an algorithm (it was primarily interpolation) to compare digitized positions of geodetic control monuments as plotted on USGS 7 ½ minute topographic maps with the published geodetic positions. The digitized monument positions were "calibrated" by digitizing the known latitude and longitude on each of the four corners of the map sheet. With that information, the digitized latitude/longitude of the plotted control monument were converted to GEO-REF plane coordinates (Berry provided the algorithm for the orthomorphic projection). That gave a unified plane coordinate system for the entire state with a scale factor on the central axis of 0.9996. The Michigan Department of Natural Resources implemented the GEO-REF system as shown in the following link. See specifically pages 4 and 5.

   https://www.michigan.gov/documents/DNR_Map_Proj_and_MI_Georef_Info_20889_7.pdf

   Yes, the results are very beneficial for that particular application. My point is that the complexity of the underlying conformal mapping mathematics, especially for the oblique Mercator projection, can be quite daunting. I used the algorithm provided by Professor Berry, but the serious student of the oblique skew orthomorphic projection should, among others, reference a PhD dissertation from The Ohio State University.

   https://etd.ohiolink.edu/!etd.send_file?accession=osu1486647101628433&disposition=inline

   Other sources such as Snyder's Projection Manual 1395 also deserve consideration. The point is that very talented persons have developed rigorous mapping procedures that **work**. Although the complexity of conformal mapping equations can be an obstacle for many spatial data users, the "fallback" position for many (including me) is to rely on the work of previous professionals by programming the equations they derive. For example, T. Vincenty, former Geodesist at NGS, summarized the mapping equations for inclusion in NOAA Manual NOS NGS 5. I have spent considerable time studying the skew orthomorphic equations and I am happy to rely on the Vincenty version of those mapping equations. He provided to me a personal copy of his summary (dated 31 August 1984) of equations used in NGS Manual 5.

   Specific points include. . .

- Technicians and "data collectors" can do a better job if they know (or have the opportunity to understand) the underlying "rules of the game." A survey guide can be a valuable tool for routine operations. Admittedly, modern practice includes many "black box" operations.

- Map projection models are strictly 2-D, but modern measurement systems routinely collect 3-D digital spatial data. The 3-D global spatial data model (GSDM) is all-encompassing and accommodates modern measurement. The best model is the one that is both simple and adequate – see http://www.globalcogo.com/simple.html.

- The GSDM equations are all "simple" by comparison to the derivation of conformal mapping equations – e.g., see the OSU PhD dissertation linked above. By comparison, the most difficult equation in the GSDM is the iteration for converting X/Y/Z to phi/lambda/height.

- Low-distortion projections (LDPs) can be used very beneficially – I've done it. However, the conversion algorithms and data reduction procedures have a history of serious misuse by those who fail to understand even some of the fundamentals involved – see Appendix C of the Purdue Master's Thesis in 1980 - http://www.globalcogo.com/EFB-Thesis-1980.pdf

- The LDPs being proposed for use with the 2022 reference frames have understandable benefits. However, the underlying algorithms need careful evaluation, justification, and discussion prior to being declared "official." For example, there is no need for the proposed LDPs to be conformal – see . . .
  https://ascelibrary.org/doi/10.1061/%28ASCE%29SU.1943-5428.0000295

- People who are responsible for collecting, processing, analyzing, and displaying spatial data can enjoy a greater level of competence and achievement without relying on "black box" algorithms. But, I too rely on "black box" equations - http://www.globalcogo.com/A96.pdf

- The GSDM provides a convenient way to establish, track, and use standard deviation information. Spatial data accuracy is an important concept for all spatial data users – see for example http://www.globalcogo.com/EFB-SaGES-ALTA-NSPS.pdf

- Undoubtedly a transition will take time but, with the goal of making efforts of technicians more efficient, implementing the GSDM can offer immediate benefits. Twelve projects showing benefits of using the GSDM include www.globalcogo.com/3D-projects.html.

- NGS has revised the timeline for publication of the modernized NSRS. "Doing it right" is essential and budget restrictions are a given – hence the schedule suffers!
  https://www.ngs.noaa.gov/web/science_edu/webinar_series/delayed-release-nsrs.shtml

- Given the elegance and simplicity of solid geometry equations, ECEF coordinates will eventually supplant latitude/longitude/height as the primary computational basis for geometrical geodesy and local Δe/Δn differences will replace state plane coordinates.

- NGS is to be commended for developing and promoting excellent science and geodesy. But isn't it also true that some of the underlying models need revisiting? See – www.globalcogo.com/digital-future.pdf.