Back to the Drawing Board: Cartography vs. the Digital Workflow

Dave Imus
Imus Geographics
P.O. Box 161
Eugene, OR 97440
Tel: 541-344-1431
Email: Dave Imus <cwgji@attbi.com>

Pat Dunlavey
Pat Dunlavey Cartographics
40 Oblong Road
Williamstown, MA 01267
Tel: 413-458-9273
Email: pat@pdcarto.com

Presented at:
International Cartographic Association (ICA)
2002 Mountain Cartography Workshop
Timberline Lodge, Mt. Hood, Oregon

INTRODUCTION

When we embarked on making a reference map for the state of Alaska, we were pleased with the wealth of available GIS data. After several months of filtering and editing the data, and ultimately producing a prototype map, we decided to start over almost from scratch. We literally went back to the drawing board to compile a manuscript on mylar for subsequent digitizing. In so doing, we were able to achieve useful generalization of linework, and employ local distortions to weave the information together for the most legible presentation. We were also able to draw from a variety of sources without biases introduced by the effort of filtering and integrating data from multiple digital and non-digital sources.

IN THE BEGINNING…

One of us (Imus) published a map of the State of Oregon in 1998, using exclusively non-digital techniques. Though the map has been extremely successful, the roughly 5,000 man-hours invested in its production is much too costly as a model for future maps of this type. We decided to prepare a map of Alaska designed similarly to the Oregon map, but taking maximum advantage of available digital data and digital production techniques.

Prior to embarking on this project we had experience with two successful collaborations: a wilderness map in Oregon, and a map of Chugach State Park, Alaska. Our collaboration was split along digital/analog lines. Dunlavey took responsibility for digital production, including gathering and editing digital data, as well as digitizing from paper sources and manuscripts usually compiled and supplied by Imus. Imus developed the overall projects, performed field work and informant interviews, compiled some information onto Mylar manuscripts and onto US Geological Survey maps, and led the cartographic design process. Chugach State Park was notable for the absence of suitable digital data for most of the map area, with the result that most of the map content was manually digitized, and the digital elevation model used in shaded relief was generated from the digitized contours. (The greater than 500 hours required merely to digitize the contours from 17 USGS quadrangles for Chugach was made somewhat more efficient and much more ergonomic by using a stereoplotter with photographs of the source maps loaded where the aerial photos would normally go! See Figure 1)

Figure 1 - Tracing maps: an unconventional use for a stereoplotter

Both of these maps employed relatively large scales (1:63,360 and 1:100,000), and demanded precision not always supplied by readily available public domain geographic data. We hoped that our map of Alaska, which would be at a scale of 1:3 million, could be different – that we could produce a high quality map almost entirely from publicly available data.

We set out to do just that, and acquired over three gigabytes of geographic data for hydrology, transportation, boundaries, place names, land cover and elevation. Several months were spent methodically examining each dataset, developing translation and conversion procedures (using The Feature Manipulation Engine from Safe Software for vector data and GRASS GIS for raster data), and assembling into a FreeHand/MAPublisher document, with the raster background assembled in Photoshop.

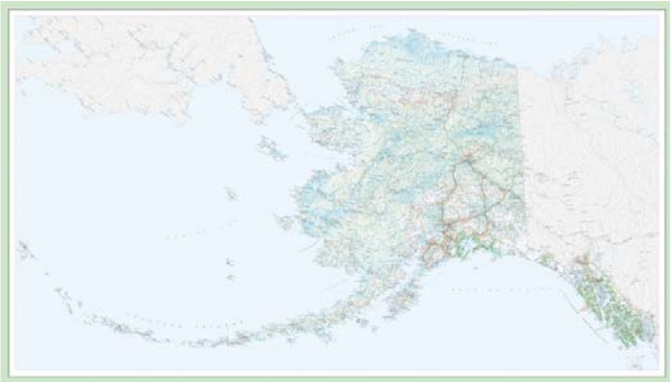

Figure 2 - After several months work, we had a map of Alaska...

LINEWORK HEADACHES – TROUBLE WITH OFF-SHELF GIS DATA

Much effort was spent on the linework, which in Alaska consists overwhelmingly of coast lines, glaciers, and drainage. It is typical in geographic data which has received standard processing for inclusion in a GIS that linework is topologically noded. Lines are broken at any topologically significant point. Unfortunately, the Alaska drainage dataset failed to include any attribute information that could be used to reassemble the original linework (such as an original element ID). In fact, the Alaska drainage data did not have any useful attribute information *at all* other than the designation of whether an element was part of a single line stream, a bank line, or an island. One attribute that we initially had hoped for to help us join up stream segments turned out to simply be a classification based on the length of the stream segment. (We are mystified as to the value of this attribute, aside from the fact that it can be generated without human intervention!) In the end, we could find no attribute that could be used to join up stream line segments effectively. The noded stream linework frequently included segments of almost zero length where multiple stream branches intersect.

Cartographically, it is very useful to be able to distinguish tributaries and distributaries from the main stem, and to have continuous line strings as much as possible. Doing so allows more efficient symbolization, and makes possible automated point filtering and smoothing. Once redundant points have been filtered, manual point editing is much more efficient. While, in our opinion, automated cartographic generalization of digital linework is not ultimately worthwhile, at least the question can be debated. On the other hand, generalization of topologically noded linework seems to be quite impossible.

We tried joining stream segments by geometry – that is, any line segments sharing an end point were candidates for joining (using the ArcFactory in FME). However when following the main stem of a drainage, tributary streams or side-branches in a braided stream were as likely to be joined as further segments from the main stem (sometimes it seemed to be *more* likely). This did not reduce the hand-editing work required, relative to interactively joining segments one by one.

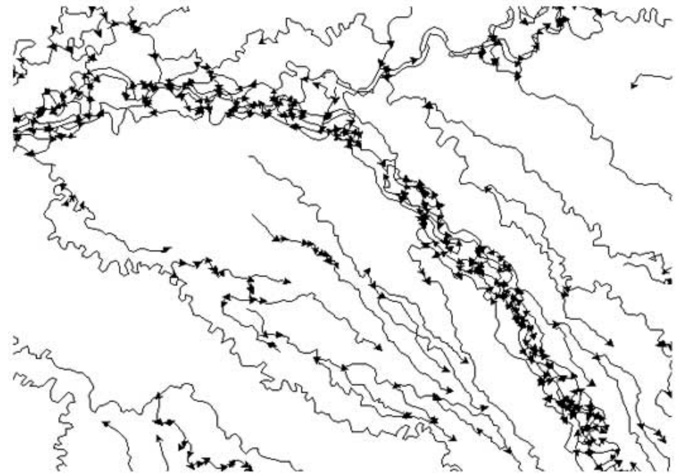

Figure 3 Arrowheads indicate individual stream segments. Extreme segmentation of linework everywhere, but especially in braided streams, makes cartographic manipulations such as generalization and application of fills or line styles extremely time consuming.

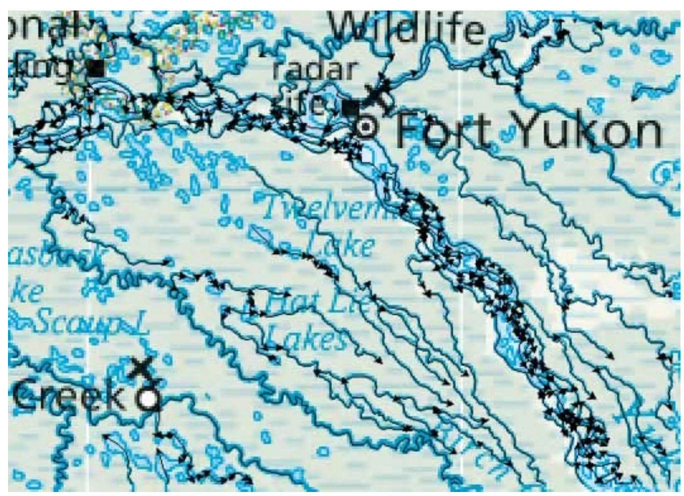

Figure 4 - Same as Figure 3, overlaid on image of the map. (Blue type, which is 4.5 pt, provides an indication of scale.)

Another aspect of cartographic manipulation involves the selection of those geographic features to include, and those to exclude, as appropriate for the scale and purpose of the map being developed. In the case of the drainage data layer, there was an overabundance of stream courses shown, with no attributes available to help in choosing which ones to exclude.

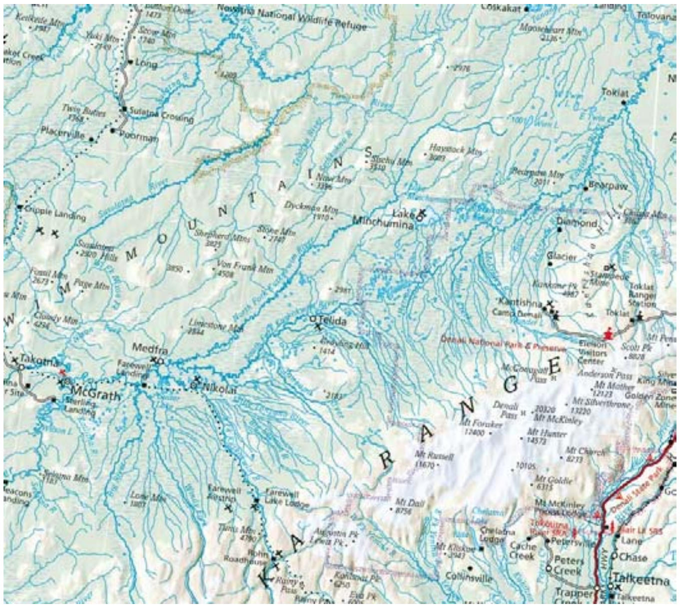

Figure 5 - Inappropriately dense drainage on the north slope of the Alaska Range. Because the drainage geodata included no information on the physical attributes of the streams, it was not possible to determine which streams should be kept, and which may be deleted. The heavier weight rivers shown here were inferred by us, based on their length and number of tributaries.

Another problem with the drainage can be seen in the following illustration. The upper Yukon River is a heavily braided stream, with wide channels being quite rare. Yet it is shown here as a two-bank river with widths approaching 2 miles/3.2 km in spots (see Figure 6 near Stevens Village). In one of our attempts to cope with the obviously bad Yukon River data, we began inventing river islands, as can be seen between Purgatory and Venetie Landing.

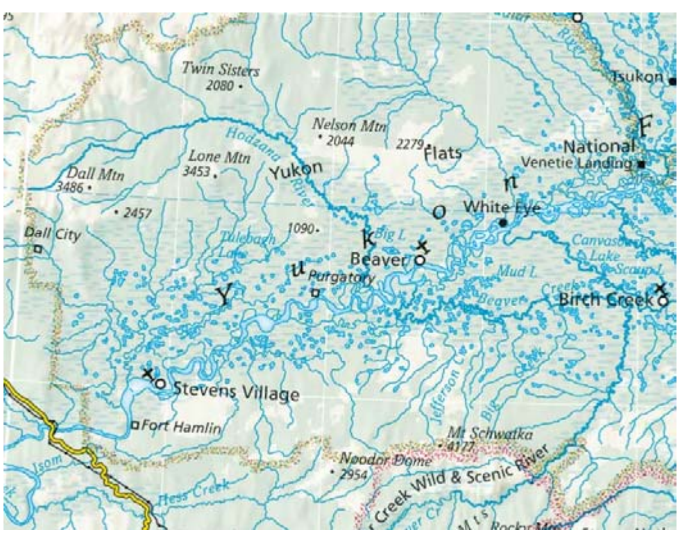

Figure 6 - Missing islands in the Yukon River. Despite rigorous documentation of sources and methods found in standard GIS metadata, accountability for data quality is often completely absent. Here, the Yukon River is indicated as an occasionally miles wide open watercourse, when in fact, it is a very extensively braided stream with numerous narrow channels.

CARTOGRAPHIC MANIPULATION IN A DIGITAL ENVIRONMENT

In addition to orchestrating overall content and symbology, the cartographer must employ generalization and selective distortion of features in order to present the clearest possible view of the geography. We refer to this process as cartographic manipulation. The combination of manipulations will be unique to any map.

GIS data, as a rule, is not designed with cartography in mind. This is especially true for primary source data – data that has been generated by field and/or remotely sensed surveys. Secondary source data – data that has been digitized from a preexisting cartographic product – will tend to carry forward the manipulations that were employed for that source. In either case, however, the data tends to imply a scale which dictates traits like linear point density, and criteria for inclusion and exclusion of features based on size.

When a cartographer researches off-shelf GIS data for a map project, he will reject most material whose implied scale is smaller than the map he is developing, since it will have insufficient information density. Therefore, the tendency will be to use data that is at a larger implied scale than he needs, and will require a substantial amount of cartographic manipulation.

It is obvious that when working in the digital environment, one must use digital editing tools. Unfortunately, whereas computer-aided drawing tools are generally excellent at creating new geometry, they tend to be rather poor at modifying existing geometry, particularly when that geometry consists of a large number of vertices. This is even true to a significant degree for linework which has been simplified by using Bezier curves. Modifying the shape of a line described by Bezier curves often involves many manipulations of the vertex points and their handles until the desired result is obtained. We are not sure why the developers of FreeHand and Illustrator, or for that matter, MicroStation, ArcView, etc., seem to overlook this need. A "redraw" mode for the standard freeform path tool that patches a newly drawn section into the underlying selected path would probably go a long way towards solving the problem.

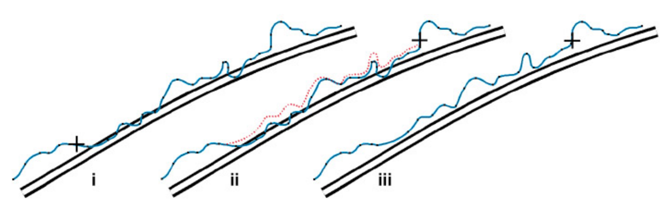

Figure 7 - Redraw path tool we'd like to see. After selecting the path to modify (i), draw new path shape (ii), and when done, the original path incorporates the redrawn section (iii).

In the case of our Alaska drainage however, such a tool would not have helped much because, as described earlier, we did not have continuous paths to begin with. Any manipulations of the drainage network required first joining tens of thousands of stream segments.

THE HAND DRAWN MANUSCRIPT

Modern computer-aided cartography utilizing GIS data has largely led to the demise of the hand-drawn manuscript. Many would not lament its passing. For our Alaska project, we began with a work flow that was primarily digital, with the majority of source material coming to us as digital data (Figure 8).

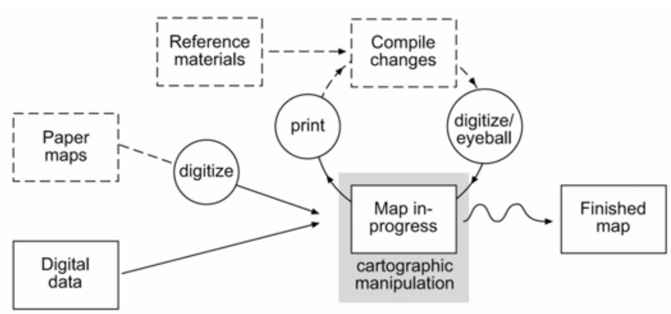

Figure 8 – This illustration shows how we initially produced our Alaska map. Solid lines indicate work in a digital environment; dashed lines indicate a non-digital environment. Perhaps most important was that geographic information, once in a digital form, would remain in a digital form. This required that cartographic manipulations occur in a digital environment.

In our case, after several months of working with digital data in a digital environment using the work flow above, we found that we were unable to perform the necessary cartographic manipulations to our satisfaction.

The problem was exacerbated by the fact that we are a long-distance collaboration, and also a collaboration between one who is digitally savvy, and one who is more comfortable with the traditional tools of the cartographic craft: paper maps and reference materials; light table and Mylar; pen and pencils.

After much discussion, we decided to abandon this process in favor of a modified workflow, where the cartographic manipulation occurs in a non-digital environment (Figure 9).

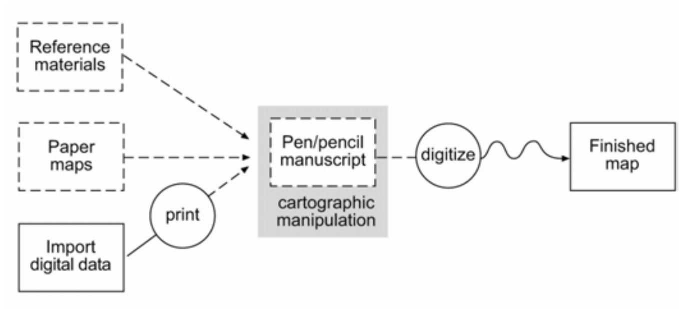

Figure 9 – A somewhat idealized hybrid work flow. This illustration may look familiar to cartographers who have been around a while. However, instead of going from manuscript to scribe films, peel-coats, paste-up, etc., we take it back into the digital environment for finish cartography. Cartographic manipulation occurs in the non-digital environment.

The work that we had done up to this point was not wasted. From the digital data, we had produced a very fine primary reference map with good geographic control. This digital map provided a big first step in the manual manuscript preparation that followed. However we did not take the digital data and pipe it directly into the final product. Instead, we printed out the digital data and used it like any other non-digital source in the compilation of the pen/pencil manuscript. This enabled the compilation of all the information without a digital vs. non-digital bias, and enabled the necessary cartographic manipulations to occur in the most efficient way.

To compile the hand-drawn manuscript, we registered paper reference materials to a print-out of the digital map and traced onto Mylar at three times the final map scale. As information was compiled onto the manuscript the cartographic manipulations that were so difficult when working digitally became, ironically, virtually automatic. Line weights and symbol sizes on the manuscript were selected to reflect the finished map symbology, so that offsetting map elements for legibility was completely intuitive.

Imus compiled manuscript tiles, which Dunlavey then digitized in MicroStation on a large format digitizing tablet. Because it is much more efficient to draw in a digital environment than it is to edit, the total efficiency may have been greater than manipulating the digital data that we had, to a cartographic standard that we could accept.

At the time of this writing, the project is ongoing. Both manuscript preparation and digitizing are proceeding in sections. In the first phase, we are compiling linework and some point symbology. Later, the manuscript tiles will be upgraded with additional point symbology and type.

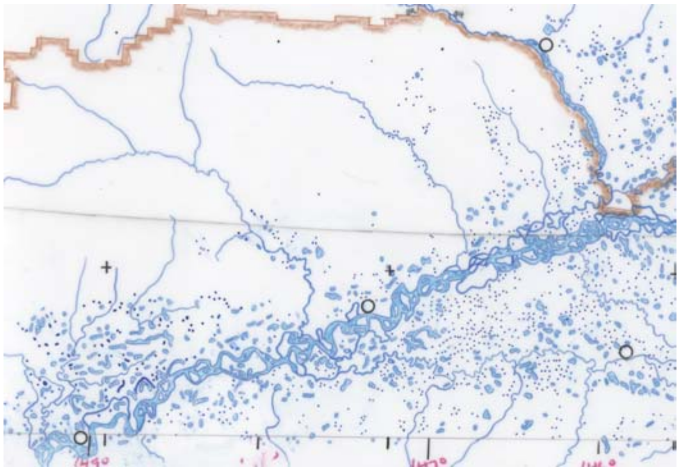

Figure 10 - Hand drawn linework of upper Yukon River (same area as in Figure 6)

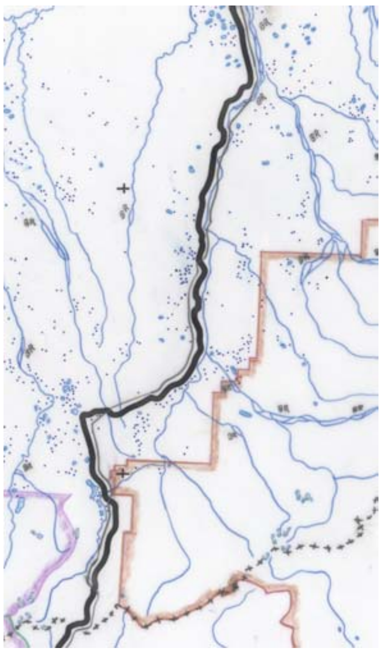

Figure 11 – On this manuscript, the Trans-Alaska Pipeline, highway and rivers are offset to improve legibility

CONCLUSION

Many have remarked how computers and the almost instantaneous availability of geographic data over the internet have revolutionized cartography, and that is certainly true. As is typical in most revolutions however, the lessons of the past often need to be relearned. The cartographer's job is much more than plugging geographic data into a map sheet. GIS data is not gathered in a way that is designed to be useful to cartographers, nor realistically could it be. It is meant to be useful to analysts and managers. While it certainly can cut down the laborious hand-work that is often found in cartography, it does not necessarily eliminate or even shortcut the mind and eye and hand work that is at the core of advanced cartographic design. We have found in this project that the cartographic manipulation process works most effectively in the non-digital domain. In the future, when digital tools become more powerful and intuitive, we anticipate being forced to modify this conclusion. However, our objective here is to assert that, at least for the most demanding map projects, that day has not yet arrived.