Physical Terrain Modeling in a Digital Age

Mr. Lawrence Faulkner
President
Solid Terrain Modeling, Inc.
340 Fillmore Street, Fillmore CA 93015
lfaulkner@stm-usa.com

Keywords, Solid, Terrain, Physical, Decision Making

Abstract

The momentum of digital geospatial data collection combined with fast network delivery, cheap computer memory, storage and powerful processors point to a future of virtual landscapes, fly-throughs and synthetic environments. Data presentation through a computer screen will certainly play an increasingly important role; however, in spite of these factors and indeed, because of them, some interesting results have emerged from the rapid prototyping technologies when applied to geospatial data.

Physical terrain models are not new. In the 17th century, the French launched a program to model all the fortified cities on their borders. The program lasted from 1668 to 1870 and was discontinued, not because the models failed to communicate effectively, but because the strategy of closed towns as national defense was abandoned in the face of 'modern' warfare.

Sophisticated construction methods now allow geospatial data to be rendered in physical form in a very short time. The question remains "Are there advantages to physical data presentation?" and if so, what are they? What situations justify the time, expense and space required?

More interesting still is the prospect of combining physical models with "live" temporal data or simulations creating a hybrid of old and new technologies. A specific example of this technique will be discussed in detail where vehicles were tracked in real-time and their positions displayed in the context of a physical terrain model of the area. This particular example is interesting since multiple visualization technologies were available to the spectators and it provides, at least anecdotal, evidence of how people preferred to consume the data.

TIME TO EAT

The geospatial data industry has found its feet with respect to the collection and distribution of data. The business models have started to mature as well and we find many private firms getting into the fields that used to be dominated by State and Federal programs.

Growth is not just on the collection side. Geo-data is being bought and consumed by an ever-increasing array of customers and there is money to be made in organizing and presenting the information for these entities who want and need to do business. This type of growth is being driven by our ability to collect and present geo-spatial data that departs somewhat from the traditional cartographic elements found on the map in the gas station. The new crop of data consumers may have little familiarity with the conventions we've created and used to convey elevation information and assume we can present three-dimensional (3D) information as easily as does a video game.

Our industry has focused a lot of attention on the diverse methods of collection, storage solutions and, to some degree, on presentation methods, but it seems to me that tacit assumptions are being made about the long term goals and methods of data presentation; therefore, I would like to present a few challenges to those vague visions of the future.

[Alright – the visions of the future are not really that vague, if any audience has an idea of where this industry is headed, it's this audience.]

We, as a group, seem to assume that hard copy maps will disappear, but I don't believe it for a minute. Compare this with the predictions for the Paperless Office of the 1980's; the paper didn't disappear. Paper maps are here to stay.

If I were to credit the electronic display of content with the increased volume of hard-copy output, I would be missing the point. It was the electronic distribution of source material combined with the ability to easily print the important stuff that drove the increase of paper

in the paperless office. I think if we examine the situation at a finer resolution, we would find that the decision to print hard copy shifted what we used paper for. Paper was no longer *required* for all written communications, but it was *preferred* for some types of information.

We like to read on paper rather than on the screen when we really need to concentrate on the subject matter or when we want to write notes in the margins and pass along our edits. I don't know why this is true; the tools for consuming and editing content electronically exist and are really pretty good and there is just something about the tactile, physical nature of printed material that we prefer, in some circumstances.

We should learn from observing the way people prefer to consume their data and try to understand why.

PEOPLE ARE COMPLICATED

As we present geospatial data to evermore diverse audiences, I believe we will find their average level of technical sophistication, with respect to map reading, declining. It's not good or bad, it's just a fact, and we should take the attitude that the users are important, necessary and should be respected for the value they bring to the process of interpreting and making decisions based on the data we present. Educational differences, language barriers and varying levels of trust between the individual users need to be considered and accommodated in any important decision making event, and that's what I'm really focusing on, the *decision-making process in a group*.

There is a big difference between preparing data to be consumed by an individual and preparing data for a group to consider. A skilled person can use the existing digital display methods to a great advantage, leveraging the flexibility of on-screen presentation to see their areas of concern. The trick is for that person to effectively present their analysis to a group and convey enough information to allow the group to make its decision. This is where the processes that work for trained analysts may diverge from the process that will work well for a group.

Getting a group immersed in a synthetic environment is technically difficult, but possible. I think the biggest challenge is to preserve the natural techniques that people use to communicate with each other while giving everyone access to the data-space under consideration. Eye contact, body language, side-bar conversations are lost in the typical classroom style of a 3D fly-through presentation. I have found that introducing a physical, 3D model into the middle of the group is an effective way around this human barrier.

PEOPLE LIKE MODELS.

Present a paper to a group. Pass out copies to everyone. Project the main points on a big screen and start going over the text – what happens? Half your audience will start reading the handouts and the other half will stare at the screen and read the bullet points over and over while you speak. They aren't being rude, they are looking to see what you've said about the issue they are most concerned about and until you've demonstrated that you will address those concerns, it's hard to get them to hear anything else. You can try to make them wait until the end before they ask questions, but those questions are usually the real meat of the discussion and most of your audience will sit there starving, so to speak.

Contrast that approach with putting everyone around a table, dropping a big fat model down in the middle and everyone engages right from the start.

The sheer volume of data contained in a large model gives everyone the chance to begin putting their thoughts in order, even while you explain to them what they are looking at. While a typical screen can present about a million pixels at a time, the model can show many hundreds of millions of pixels and everyone gets to focus on the parts they are most interested in. That's what you want. You want your audience to focus; you want them to start thinking and learning right from the start. You can move that focus around the scene easily by pointing and explaining, but you won't have to exclude the rest of the dataset while you go through your analysis.

Now, those interpersonal dynamics start to work in your favor. The participants are facing each other, reading each other's faces and noticing where their colleagues are focusing their attention. You are going to get interrupted to explain features and issues out of sequence, and that's OK, you can do it quickly without destroying the context of the main presentation. The presentation naturally becomes a discussion and, so what if the hungriest members get fed first? The sequential nature of the presentation becomes a more 'random access' style buffet and, in the end, it saves time and energy.

The real bonus is that the level of participation and comprehension goes way up. The model is a very democratic tool. People will find it easy to understand

others and make themselves understood – that's the goal. You get better decisions, faster.

ABOUT THE MODELS

It's not hard to agree that physical models add a lot of value to a group discussion, but getting a good model hasn't been easy. So let's talk about how new technology has made it easier.

There are methods loosely grouped as 'rapid prototyping' that can render complex digital data in a physical form straight from the computer. My company has focused on creating new technology to render terrain data in a physical form without the hand-work of traditional methods.

We start with a solid block of high-density foam and cut the digital elevation model into it using a numerically controlled machine. We then print the aerial photograph directly onto the terrain using an inkjet printer. The process takes just a few days, not weeks, and the results are accurate to a high degree of precision.

The level of detail available in the model is almost entirely dependent on the resolution of the input data; it's mostly a matter of choosing a scale that is appropriate for the subject and available data density. It's basically the same data you would use to create a regular image drape over terrain, but you get the whole scene all at once, not parceled out through the limited viewport of a computer screen.

We render, for our commercial customers, many models for visitor's centers of parks and museums, but the real value comes out when the models are used for complex and contentious decision making.

Attorneys presenting to jury or land planners, trying to get approval to develop a hillside, face the same situation as a military planner might encounter when presenting a particular course of action. There are many stakeholders who need to be convinced that the planned course of action is the best one, and, if not, what is a better plan? The plans and the data come together into an understandable presentation that opens the door for participation and constructive criticism. When the stakes are high, the model becomes an invaluable tool.

I believe the value comes from the fact that the model is solid and unchanging as contrasted with digital presentation which derive their value from the ability to change what is seen rapidly. Since the model does not change, the viewers feel they can 'trust' the data and they can navigate the scene on their own without the possibility of getting lost. There are no skill level barriers to interaction with a model. No one has to be taught how to use it and, because it is such an intuitive tool, you will likely receive input and participation from more of the group.

EXTENDING THE CONCEPT

I have been trying to find a place at the table for physical models, justifying the time and expense it takes to produce them with the benefits during critical discussions. I am not trying to minimize the importance of on-screen presentation methods and, indeed, would like to introduce the concept of the integration of physical and digital presentation models.

"Once a map is printed it is dead", it has been said of paper renderings, attempting to drive home the value of "live" maps and the dynamic nature of on-screen map presentation. My company has combined the physical models with projection technologies to allow temporal information to be animated upon the physical model in real time.

A recent demonstration of this technique was presented during DARPA's autonomous vehicle race called The Grand Challenge. Competing in the race were driverless mechanical vehicles which were run through the desert, just South of Las Vegas. The course was kept secret until two hours before the start, at which time the vehicles were programmed with the course and expected to navigate without further human help. It was a high visibility event for DARPA and very well attended.

Solid Terrain Modeling, Inc. was retained to create models of the race course area and provide real-time location information of the vehicles during the 10-hour event. Using an array of data projectors and tapping into DARPA's network, we were able to display the course area, as a printed on the 3D model, and we projected the race course as well as the positions of each of the contestants.

More by default than by design, our display tent became the gathering place for anxious team members wanting the latest information on their 'bots. We ended up hosting a documentary film crew who used the information feed we provided to coordinate camera crews in the air and on the ground. Our 30' x 30' tent became so crowded we had to keep the viewers moving so everyone would get a chance to see. We hosted thousands of people that day.

There is no doubt that the spectators were engaged and fascinated by the models, but it was more than that.

The viewers told me that the combination of models and live position information, projected onto them, felt like a totally new way to view geospatial data, despite the fact that terrain models are not new and data projection isn't new, this combination struck them as completely novel. Part of the effect comes from the literal nature of the physical model. It is not an artist's rendering which tend to be handsome, but somewhat impressionistic and relatively content free. With a hand painted surface, you will necessarily only be able to see what has already been interpreted and translated by the artist. I think the literal aerial photo is more exciting because it is still waiting for interpretation and discovery by the viewer.

It is possible to keep extending the integration of models and projectors to include feedback sensors that will allow users to interact with the database by interacting with the model directly. It is easy to imagine coordinating the information displayed on a model with one or more computer screens to supplement the capability. All these scenarios will be carried out in the years ahead and they all leverage the accessibility, easy interpretability and persistence of a foundation dataset rendered on a physical model.

CONCLUSION

Physical terrain models should be included in the vision of geospatial data presentation because they bring tangible value to group discussions and decision making.

Synthetic environments face serious technical challenges and even more serious interpersonal challenges many of which are naturally overcome by using physical, rather than digital, models.

The potential exists to get the best of both worlds, if we consider using physical models as the foundation upon which we deliver our data.