

Constructing a Safety Net in the Circus of New Technology.

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Almost 4 years ago I was asked to be the design specialist for the new British Columbia Forest Inventory. The area was 100,000,000 hectares (1/4 of a billion acres). This is nearly 3 times the size of Finland where this conference is being held. Some of the difficulties of scale will be obvious, especially since many of the areas are parks or wilderness with no simple access. From the first day, we were invited to imagine the uses for "new technology", and we certainly were inclined toward anything which would make life easier. I have a simple philosophy about inventory projects - I do not like failure. This is not to say that I do not like new ideas or new techniques, but they have an appalling failure rate. When enough time and money has been spent on new ideas, of course, they cannot be *called* "a failure" - but "interesting and instructive processes" do not please me much either. I am particularly drawn to a comment by Gene Woolsey in his editorial policy for the journal *Interfaces*. It discusses his *requirement* that authors demonstrate the financial savings of the project before it would be published. He states: "Assertions that the customer 'felt better' after the work was completed will be treated with the humor they deserve, and submitted to the *American Journal of Psychology*" (Woolsey, 1976).

We had a large number of problems to solve, a limited number of opportunities for testing, and great expectations by all kinds of people that knew nothing about inventory. Large projects like this are similar to learning a new trapeze trick.

RULE 1: DO NOT WORK WITHOUT A NET !!

This is particularly important when your equipment has a strong tendency to fail. My particular job in the new inventory process was the overall statistical design, and many people reviewed the details and specialized techniques. Even though I have a significant amount of practical field experience in forest inventory, there is nothing like doing this work on a daily basis. This is important if you hope to balance the effort involving highly detailed field work. We worked hard to obtain the time and commitment of a number of very practical and experienced people to sort out the fine details of the vegetation measurements. *There is no substitute for experience of this sort.* No matter who *plans* a new circus stunt we should remember that somebody has to go out and *do* it. We had better listen to those people.

RULE 2: IF *YOU* ARE THE ONE FLYING THROUGH THE AIR, YOU ARE PARTICULARLY AWARE OF THE NET - PEOPLE WHO *WATCH* ARE NOT NEARLY AS CONCERNED.

One of the problems with new technologies is that they are usually individual items (sometimes very clever ones), and inventories are *systems*. As with all systems, it is the balance and design that count, not individual parts that may delight or amaze you. It is not wrong to put jeweled bearings on wheelbarrows, but it is probably unwise and inappropriate - no matter how satisfying. A desirable goal of systems is to develop balance and depth in their design. The introduction of new technology usually works against this goal.

Consider, for instance, the introduction of personal computers to offices - a clearly appropriate move, no doubt about it. What did they forget? The first thing they forgot was that the mainframe organization backed up their data regularly. Individuals *do not* back up their work. The memos which were no longer held up by secretarial backlogs were also no longer filed for future reference. The bottlenecks that acted to hold up the paperwork were also one of the few sources for integrating what was going on in the building. In the end, even the floppy drives everyone used went out of style and often the data could no longer be read. *Scientific American* recently printed an article about how unlikely we are to be able to read computer storage media even in the relatively near future.

Did any of these things cause computers to fail? No. The machines failed enough on their own in the early years. These problems caused *offices* to fail. Did we get these problems under control? Almost, but not quite yet. Should we have gone to personal computers in the office place? Most certainly, but many of the problems could have been foreseen, and let this be clear - they *were* problems. The goal was not to get computers to work - it was to get offices to work better with computers as part of that system.

With untried (and often failing) new technology the trick is to plan for its introduction when it eventually *does* work, using training to emphasize the principles it will introduce. You want people to automatically think along those lines when the time comes. We need enough pilot testing to work out the problems of how it fits into the organization, the information flow, and the documentation procedures. In my opinion, we can expect to go through at least one full set machines for a new technology before we learn how to *think* about the techniques and how to control them. Therefore, the major emphasis in adopting a new technology is not "how to make it work", because it will almost never work well enough initially. The major emphasis should be "how do we *think* about this, how will we fit it into our business, and how will we transfer the data to the next machine?".

In addition, I believe that we need to *plan* for failure in new technology. There are two reasons for this. The first reason is that it does the project no good to fail (even partially) because of a new technology. The solution for this seems clear to me. Have a backup for

most of the systems in an inventory scheme, and particularly for those involving new technology. When it is likely (not obvious) that these systems are undermining the success of the project, switch to the other method as the main thrust (but keep working on the newer method). In this way you take the pressure of time off the new technology that you need to develop. Too much pressure seldom helps the development of a new technology. There is a tendency to ignore the overall process while you are just trying to get the mechanical aspects of a single part working.

The second reason to anticipate problems is that a record of failure is not good for a new technology. It sours the bystanders on the concept when the real failure was often just the execution or the timing. People remember a bad taste long after the problem has been fixed. New technology requires testing and a certain amount of patience and tolerance - not only to make it function, but to take the time to fit it into the business.

Certainly, the premier current example must be the use of Geographic Information Systems (GIS). They are so clearly a correct idea, and so clearly a disaster over the last few decades. Now that the machines really have the power they need, the software could really be written, and the need is becoming urgent, have we really learned how they fit into the process? I would suggest that we have learned very little.

I believe that we have managed to succeed with another technology, the Global Positioning System, for one simple reason. We knew *exactly* what the question was ("Where am I?"). With GIS we have simply not sorted out the questions. The sellers believe that the answer "is GIS", but are not sure what the questions are. Too much emphasis is on making it work, too little on asking the fundamental questions. It would be a shame if this goes on much longer, because this kind of failure is not good for anyone.¹

RULE 3) UNTIL THE NEW STUNTS WORK, USE THE OLD ONES.

Some low tech safety nets.

For the purpose of this discussion, I include the use of new sampling systems and other ideas, because new technology is just one instance of the same problem - introducing needed but untried change into a processes. "New" to one organization, or course, may be old hat to another one. As background, the new inventory design for British Columbia is a simple adjustment scheme where estimates initially made on all vegetation polygons are sorted into a list, sampled systematically, then adjusted based on the ground measurements.

Estimated polygon values & photointerpretation:

Like everyone, we have heard promising comments about automated, space-based estimates for polygon features. We have done less to explore these than I would wish, but in the end we are prepared to bring out the simple stereo viewers, sit down legions of photointerpreters and do the job the long hard way. We believe that automated systems

¹ By the year 2000, GIS had begun to work reliably – as expected.

have a long way to go, and trying to do them with satellites just makes the job that much tougher. We are dealing with a situation where we have a good many photointerpreters available in British Columbia, but the expense for this will be large. If this system fails, because of elapsed time or from expense, then we are willing to use our old maps (with their estimates of volume, for instance) as the first stage for the new inventory.

Coordination:

Interlocking systems are a guarantee of trouble. As far as possible, we have uncoupled the processes carried out on sample locations. This is done for two reasons. First, it allows groups working on individual problems to proceed with that work at their own pace. What little we lose in efficiency here is well worth the cost. The reduced pressure on each of these groups is a great advantage. Second, if some of this information simply is not worth the cost at each sample location then the procedure can take place on some proportion of the locations. Having too many processes coupled together increases tension, increases the chance of delay or failure, and I believe that it will eventually increase cost - no matter what the claims of efficiency might be. If some of the groups fail, they are simply left behind while other groups move ahead.

Compilation:

There is no way that every compilation can be agreed upon before the inventory and fully tested. Even if that were possible, someone would soon change a site index curve and want to apply it. The raw data is stored close to its original format. Standard calculations (such as tree volume) are added back into the raw data, so they become available without repeated computer processing.

Data storage

Hard copy - period. The original cards can easily be stored, of course, but we plan on printing out a copy from the computer records in the same format for comparison. Again, all the computer records are to be produced on paper. "Paper lasts" - there is a long history for this statement. I simply do not believe that the data is safe "out there in electromagnetic space", no matter what the computer jocks may believe. We will, of course, plan to use on-line databases, but we assume that there will be a disaster or at least a need to show that a disaster did *not* happen. I remember a computer programmer once telling me that he might have changed a set of data "to metric" twice, many years ago, *but he was not sure*. There were no records to check. Hard copy - period !!

Sampling Design & credibility

If all else failed, we could simply compute a simple average from our sample. We believe that much more sophisticated use of the data will be made, but this simple approach remains open to us. If a simple calculation is all that a reviewer will believe, then we will be prepared to furnish the answer in this way. For the most part, the proposed statistical methods have a long history, backed up by publications and experience. Only the combination of parts is in any way unique, like much of new technology.

Quality Control

Someone can always make mistakes or at least commit outright fraud. For this reason, there is not only the usual quality control check within the system, but the system is being designed for a formal outside audit. This will allow the people of British Columbia the option of an outside agency to assure them that the overall answers are roughly correct. We will not depend upon honesty and correct data - although we expect it. It has been suggested that we should be able to generate a valid sample plan for any outside agency who wishes to check the answers on any attribute of the inventory.

Direct overall measurements

There are many assumptions, tables and studies used by the inventory. We expect that all of them will be reasonable and as correct as we can make them. We may use high tech measurement systems to measure upper stem diameter or taper. In the end, however, we will fall trees and measure them on the ground. The attempt here is to wrap as many possible problems as we can into one bundle and check them all at once.

Remeasurement

We do not particularly plan to remeasure the plots. Nonetheless, we are able to this if it is necessary or desirable. The locations are noted on the photos, the maps, and by UTM coordinates. There will undoubtedly be someone who wants to revisit them, if only to subsample the data for quality control. The sample locations are a valid sample of the land base in the entire province, not just for vegetation samples.

Evaluating new technology

When I am told about the merits of new technology I take a pretty simple approach. I begin by assuming that I am the potential victim, and therefore I am the one who takes the fall. A surprising number of people do not do this. I ask roughly the following questions, tailored to suit the particular technology.

1) How will I know when it fails ?

If the answer is "it just will not" or "we have to be optimistic" or (the very worst) "there is no way" then the discussion is terminated. Anyone who cannot figure out how to recognize failure is not likely to do me much good.

2) What happens when this is (broken, stolen, not responding) ?

If the whole system must stop, then I am immediately concerned. Count on it - it will break. At the very least I prefer technology which is developed for lots of work in parallel, rather than a lineal system where stopping one part of the system stops everything. In every case, the person in the field needs a backup plan.

3) *Who do I call on Sunday at 3:00 in the afternoon when I have a problem ?*

This usually causes a nervous giggle as the first response. My own view of most software, for instance, is that the programmers home phone number should be displayed with every system error message. Better yet, a beeper. The acid test : "Get them on the phone, *right now ... I'll wait*".

4) *Tell me the name of a client who will swear that this works well.*

In this instance I want the name of the guy his company will call at 2:00 in the morning when the panic is on, not some vice-president who knows next to nothing about the details (and does not know the answer to question #1). This is also the first person I would talk to about who to hire, so that I do not have to repeat the nasty and expensive lessons of adopting this technology.

5) *What is it that the business really needs, beyond this particular solution ?*

I want to talk with someone who knows where we are going, and roughly how we might get there. If the answer is "Oh, well this is just simply IT", then the discussion is terminated. This person knows no more about the directions of the business than the people pushing the old solutions. At this point, it usually becomes clear that they do not know what is currently done either.

Conclusion:

All things considered, I am a great fan of new technology. I believe, however, that the big gains are to be made by systems which show balance, backup and flexibility. These kinds of systems should give us enough slack to develop new technology and enough time to introduce the principles they represent into the thinking of our profession. That time and tolerance would do a lot to insure that new technology does not get an unfairly bad reputation, and that any failures are just part of the business - not the end of it.

References:

Woolsey, Gene; A Triennial Editorial Policy; Interfaces; Vol 6, #4, August, 1976.

This paper was give at an international meeting on forest inventory in Tempere, Finland.