Map Making for BHUTAN

When you open a book, the end papers are the thick paper pasted down inside the front and back covers. They hide the binding, and make a mechanical interface for the package. Often they are simply thick paper, sometimes textured. Occasionally, there is some artwork. Usually it’s the bookish equivalent of wallpaper, and most people flip past them without a second thought. The end pages in BHUTAN are a little different, and the process of creating them was full of interesting twists and turns…

In early June of 2003 I gave a sneak preview of the BHUTAN book at the TEDMED meeting in Philadelphia. We had only conceived the idea of a really big book a few weeks before, and MIT students Leonardo Bonanni and Ming Zhang stayed very late with me the night before their graduation to produce the first prototype.

After I sat down, the fellow next to me said, “I bet you need a really big dustjacket for that! Maybe I could draw one for you…” It was David Macaulay. It was a bit like having Leonardo Da Vinci offer to help touch up my homework. A few weeks later we got in touch. Rather than a dustjacket (which wouldn’t have worked in that size) we settled on the idea of an end page and we homed in on the idea of a map. Nothing sets the tone for a journey like maps and charts. We kicked around a few ideas. Here was David’s first:
The only color was orange-gold — the national color of tiny Bhutan, almost like a peephole to see into the book. The border was meant to pick up colors from their traditional architecture.

As we began working by email in August, David and Chris Newell and I all got carried further into a more involved design, something richer and more engaging than the plain map above. Our (or really, my) worry was that the surface area was so large that this would be seen like wallpaper: something to skip past. I wrote: “I loved the idea of a spread which has the context map... and a few other small items on top of a big Bhutan map almost as if they were scraps of paper pinned there with little map pins. Maybe these could be done as separate pieces and then photoshopped together into a big image for printing...” Here is the second rough sketch:

I thought it was fantastic. The world atlas shows Bhutan’s place in the world, with a bigger map of Bhutan over it, and sketches tacked around the edges. It had the feel of seeing an artist’s journey laid out on a big drafting table. I liked the unusual angle of the maps (with north turned about 40 degrees clockwise). The smaller sketches were very evocative, and would expand beautifully as photographs in the following pages. Here were some ideas:
We thought the front and back endpages could be variations on this, using different sketches but the same organizing motif. One idea was to use photos of pre-trip items (tickets, passport, camera, guidebook) drop-shadowed onto the map — and then in the back endpage, replace these with post-trip souvenirs (scarves, carved items, masks, etc).

By now it was September. David needed to move on to his next big project, and we had to shift into printing and publishing high-gear. He came up with the following idea:
This was more formal, and it was impossible not to like the ideas in it — the globe map for context in the upper left, balanced by the dharma wheel in the upper right, with a border made out of Bhutanese woodwork (starting with the window frieze at the top). And there was still room for the little sketchbook pieces around the periphery. We talked about colors, and felt the map and surrounding elements should be muted so as to complement (not compete with) the vivid photographs.

**Tinting and Compositing the Final Map**

By now it was September 16th and we had to push ahead on production of the rest. After a period of soul-searching, a FedEx arrived at MIT. When we saw David’s final drawings, it was clear he had gone far beyond our last resting point. The package contained a foamcore board that was about 30x40” roughly half the size of the final print, with elements taped in place. It was dazzling:
Wow.

The sketches around the edges had become finished drawings, and were puzzled together around the outline of the map in a very clever way. The modest frieze and border were now a full-blown rendering of the woodwork from the interior of the dzongs. A manilla folder held all the individual paper or vellum drawings. They were pencil, or ink in some cases. It was very handsome. The foam core board showed the positioning of all the elements. Now all we had to do was scan, composite and print.

Everything was scanned at 1200dpi. But printing those scans at full scale produced noticeably lumpy aliasing artifacts (and many drawings needed to be enlarged by about 2x). So the artwork was processed with Adobe Streamline to convert it to PostScript renderings. This wasn't totally straightforward: the fine details and variety in the drawings required a lot of tweaking to the parameters in Streamline. But on the whole it worked well. Here's a closeup of David's drawing of the Taktsang monastery, which he'd put into a circular frame overlaying the other pieces:
I worried that the composite piece would have been too big to edit in Photoshop, since even when an image is manageably sized, the working set used by Photoshop to manage multiple layers and histories is much larger. We'd surely blow past 2Gb limits and cause infinite thrashing. Illustrator couldn't really handle the big page size. Instead, we opted for Adobe InDesign, since that really is intended for page compositing. InDesign had plenty of merits — it could do drop shadows, complex text effects, and multilayered compositing using the other Adobe formats. I figured that to color the drawings, I'd read the EPS pen-and-ink sketch into Photoshop, create a painted underlay, and then sandwich the two together with InDesign.

I wasn't actually planning to do much coloring, but for starters, the map border, and especially the roads and rivers, were confusing. They had to be different colors. As soon as I tinted them (blue for the rivers, tan for the roads, and Bhutanese orange for the national boundary) the rest of the map looked problematic. So I began creating an underlay for the circular map of the world. I discovered that Streamline had left plenty of opaque white patches (for understandable reasons, not worth going into here), and so had to use a multiply transparency mode to get them to blend. I also noticed that a plain colored surface — like tan for the land area — looked "flat" at full size. So in Photoshop I began using texture effects (chalk, burlapped pastels, watercolors) for the colors.

The coloring had a domino effect, because now every element needed tinting. A tableau of this complexity required a lot of compositing and delicate adjusting. I also added map
labels for the regions, rivers, districts, towns, as well as captions for the features. After some fishing around, we settled on a typeface designed by Jonathan Lee (JSL Ancient) which was redolent of old 17th century British Caslon, with a slightly distressed, antique look. The whole thing took about a week of hard work. I liked the look:

The blank white spaces were still big, but filling them in with some of the little iconic drawings David had provided, and some caption text, made the image rich enough. It also offset the wonderfully intricate border drawings. Here are some more detailed sections:
The color helped a lot with details like the prayer flags fluttering on the old cast iron chain-link bridge. Without it, it takes a long time to discern what's what in those complex scenes. Many viewers would have a hard time understanding them.

The decision to use a consistent typeface for the captions and labels worked pretty well,
although you can’t really see them here. Captions were added throughout — boxed text
captions with a drop shadow were floated onto the detailed drawings. The little iconic
drawings sprinkled throughout the map (like these monks playing long horns) also added
splashes of color without being too disruptive. They all had captions as well. As a snapshot
of the whole kingdom, the map actually covers many of the most salient details that a
visitor would recall.

I reasoned that this document architecture, using InDesign, would allow me to easily
change the color underlays as needed — to tone down the colors, change the textures,
and generally tune up the final print. When it was nearly done, I pressed print to send a
draft to our Epson printers, and held my breath. I held my breath for a long time …

Five hours later, a print came out. It had a few transparency bugs, which I figured I could
fix. But to my chagrin, I found it did not print to our big HP5500 DesignJet. I tried
numerous paths: I tried exporting PDF from InDesign, but Acrobat could neither print it, nor
render a big (printable) JPG image. I tried shipping the PDF directly to the printer, but the
result was a mess. It took awhile to diagnose why. The printer has a PDF 1.3 rendering
engine; the exported PDF was 1.5 (which includes more advanced transparency effects).
I tried a few more things, and began investigating other software for anything that could take PDF1.5 and "RIP" out a printable page. I tried getting InDesign to render PDF 1.3. It crunched away for 22 hours (on our 3.2GHz Dell with 2Gb of memory). Then it died.

At this point, I got in touch with friends at Adobe (Tasha Mulvihill, who put me in touch with Steve Amerige) to get top gun help. Adobe swung into action. Several of their divisions took a look at our horsepill. After a few days, a suggestion came from one of the divisions to try simplifying the pen-and-ink drawings using a feature in Illustrator to remove the white boxes. This would in turn simplify InDesign's rendering, since we'd now have black ink strokes laid on top of the color backings in normal transparency mode. And that, we thought, would simplify InDesign's rendering. Well, it didn't. Illustrator couldn't handle any of the complex drawings (it ran for the better part of a day and produced a mess). These headbutts went on for a very long week. Eventually, a suggestion came from an InDesign engineer with a method for exporting a PDF that was fully rasterized (i.e., all pixels and no vectors). And that worked. It ran for about 2 hours, but at 300dpi, it did indeed produce a PDF image that Acrobat displayed. Unfortunately, that did not print either. And Acrobat again failed to "save as..." a JPG or TIF. On closer inspection, the PDF image was made up of a zillion little JPG puzzle pieces. After playing around with Acrobat, I found I was able to crop it into four chunks and save the individual chunks as images. This wasn't a snap (it took a long time to open the cropping window). I figured I would put these four (huge!) pieces together in Photoshop by hand, and save the whole thing as a giant TIF.

The full image would be 80x60"x(300dpi)²x3(RGB) = 1.3Gb. Pictures that size are just barely editable in Photoshop (2Gb is a high limit since most all current machines have a 32-bit architecture). What's more, a CMYK image (which I figured the printer would need to make internally) would be 1.7Gb. Even a slightly higher dpi (say, 325) would break this limit.

This method worked, but not without a last wrinkle. Photoshop (version 7, since version 8 was not quite out yet) failed to save the big JPG file. But it did save the TIF image, which weighed in at about 500Mb after LZW compression. The printed results were very good.

So in summary, the production pipeline that worked was:

- scan artwork at 1200dpi
- convert to EPS using Streamline
- draw color underlays using Photoshop (output JPG images)
- with InDesign, assemble ink-on-color pieces and fit them together, adding captions
- export to PDF 1.3 / Acrobat 4.0 at 300dpi with all rasters (not vectors)
- using Acrobat, crop the PDF into four big chunks with slight overlaps
- using Photoshop, assemble the four big chunks into one whole 1.3Gb TIF (JPG)

In retrospect this was really the only feasible production path, and we're lucky that up to date Adobe tools (InDesign, Photoshop and Acrobat) were available. I don't think this would have worked with the previous versions that were out a year ago.

**Technical Insights for Production and Big Panoramic Images**

As a side effect of all of this technical thrashing, we sorted out some other production nuances. In general, our page spreads are 80x60" and contain photographs and a small bit of caption text. When these are built at full image resolution, the result might be an 8x6k pixel image (say). That seems both big and small — big because it represents two 35mm slides scanned at grain resolution (6x4k pixels) and about 150Mb; and small because printing it at 80x60" means the dpi resolution is 100dpi. Working within Photoshop, the multilayered image and a few text layers can easily be a 400Mb (or more) PSD file, but it compresses way down to a 15 or 20Mb JPG or 50Mb PDF image.

The HP DesignJet lets you spool JPG or PDF files directly to the printer, and those images work fine; in fact, the printer, and its ink/media combinations, help a lot in scaling up. It is important to note that fine-grain film, like Fuji Velvia, has a 9micron rms grain size, which means about 36mm/.009mm = 4000 grains across the 36mm direction on a piece of film. That's all there is, and it is necessary to scrub the grain noise out and sharpen delicate edges before scaling up to this size. (We do this with NeatImage and filters tuned for our
combination of Kodak HR500 scanner and film; some hand editing in Photoshop may be required as well. As a practical matter, we scan slightly above this size and slightly below Nyquist, to yield a 6x4k image for a 36x24mm piece of film. A medium-format film, like 6x7cm, yields an image that is 6666x7777 at grain resolution, and would scan at about 7500x8750, producing a 200Mb image.

However, although the image prints well, the text rendering in those JPG images, done by Photoshop, is performed at whatever the resolution is (say, 100dpi) so the text looks lumpy although the image scales up pretty well. Unfortunately, the PDF rendering (which of course is done in the printer) isn’t much better, and there are interpretive differences in the PDF text rendering that are not consistent with what one lays out in Photoshop. For example, to get text to stand out over a dark background, it helps to silhouette it with an outer glow. But PDF renderers don’t always render that text effect in the same way as Photoshop. Moreover, the PDF files print slowly because the printer needs to reprocess them every time. This is problematic.

The solution is to use Photoshop to render each output spread at 300dpi which produces correctly rendered text at sufficiently (printably) good quality. Of course, Photoshop 7 can’t save those enormous JPG images (bug), but Photoshop 8 (now called Photoshop CS) can. In this way, our entire BHLITAN book is implemented as a set of 80x60° spreads, each of which is rendered as a big JPG image. Since the book is about 50 spreads, the full collection of images can be stored in the printer, and simply zapped out in production.

One other observation is that for printing really large, ultra high resolution images (like panoramas that are stitched together), a large panoramic image of, say, 10x60k pixels (1:6 aspect) is about 1.8Gb. On 5‘-wide paper this would be 5x30‘ at 166dpi. Realistically, producing such an image with current digital cameras is difficult but could be done with, say, a Canon 1Ds (the current top-end digital camera, with an 11Mp frame size of about 4x2.7k) in portrait mode, wherein you sweep three horizontal strips of images, each of which yields a 4x60k image, and then combine. A 35mm film camera is about the same. One could capture a higher resolution image by using bigger film. Again, one would have the difficulty of blowing past 2Gb file size limits. These limits have been fixed in a few printers, but not with the HP 5500PS. It will probably be several years before these limits are extended; 64 bit processing and systems architectures are only beginning to emerge. By the time they do, I would expect cameras will capture frames in the 20Mp range (12Mp is the current top end), and the production of this sort of panoramic image should be possible.
The practical resolution of the printer is currently 600dpi, meaning that in a 300dpi image each pixel is formed by a 2x2 ink jet "splat." That seems close to the practical limit of this printing technology; details finer than that will likely be blurred in the ink. It implies that a 5x30' image would need to be 18000x108000 = 1.95Gp = 5.8Gb, and that the vertical (portrait) resolution would need to be something like 8k pixels (implying a 96Mp frame). The limits are in the scanning, not the printing.

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mike@media.mit.edu

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