SP.717 (D-Lab) Spring 2005
Session #35 notes

Kinkajou Case Study

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The Kinkajou projector is currently being field trialed in Mali, in a night-school women's literacy project. In this class, we'll look at what's worked well, what hasn't worked so well, and what this can teach us about markets and design specs.

Why "Kinkajou?" It's an animal with great night vision.

Kinkajou's genesis was the MIT Design that Matters (DtM) class, 2.009, in 2002. This class set out to develop a prototype microfilm projector: small, extremely portable, and not reliant on distributed electric power.

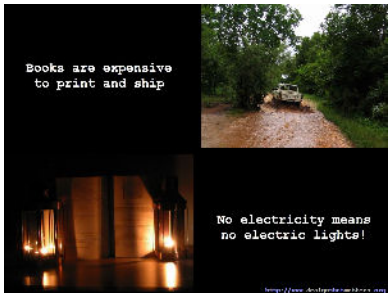
See these websites for more background and photographs.

- Design that Matters (http://www.designthatmatters.org)
- Kinkajou Design Journal blog (http://kinkajou.designthatmatters.org/)
- DtM portfolio description of the Projection System (http://www.designthatmatters.org/proto_portfolio/portable_library/index.html)

In Mali, women are not free to study during the day. They have to work and take care of children; furthermore, school rooms are otherwise occupied during the day. They try to have literacy classes by kerosene laterns but this is difficult and awkward.

The DtM team connected with World Education, an NGO that runs literacy programs in Mali and 12 other countries.

In regions that are remote, with poor roads, and no electric lighting, books are not very useful.

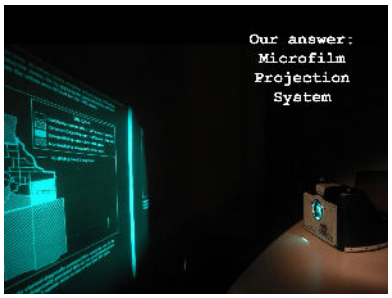


Kinkajou basic specs:

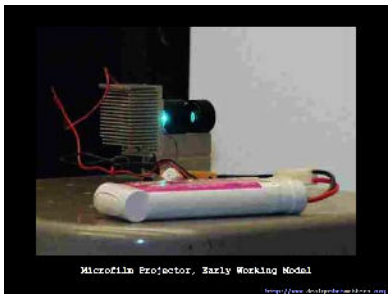
- projector to "replace" books (for use with "canned" content)
- projector for text and outline drawings
- projector for use in dark, hot, dry, dusty environment
- projector for use where there's no electric power available (even a car battery)
- Lifetime to exceed 500 hours
- Cost less than $50

The dusty environment means the optical path must be sealed. Car batteries not even readily available (with charging), so a built in battery with solar charging was necessary.

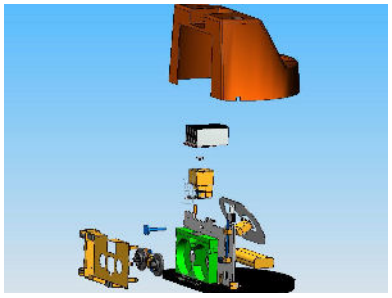
USAID contributed $500,000 grant to support testing and dissemination.



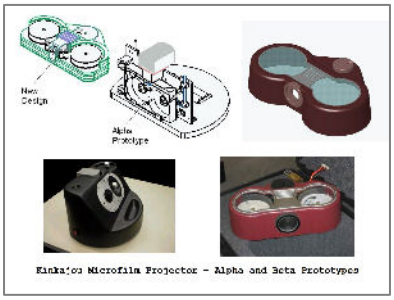
The DtM team started with a basic test rig to validate the LED and optics. The photo shows a large heat sink. The heat sink can be mounted outside the overall package – no airflow across the LED or optical path itself – allowing the sealed package that's dust resistant.

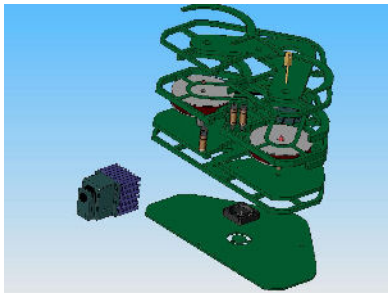


Slide shows an exploded schematic. Original designs had a "quick changeable" film cassette based on a VCR package with powered film advance. 5 W Luxion LED, condenser lens, mirror, and projector lens. Alan notes the way this VCR cassette package turned into an aside that was hard to break out of, let go of.



The beta prototype was actually taken to Mali. "The crew discovered the water jet cutter. Entire device is composed of plastic sheets machined in the cutter." Since the film plane is horizontal, the optical path is more direct leading to fewer parts, lower cost. Note the small fan at the bottom, forcing air across the pin based heat sink.; it turns out the power consumed by the fan more than paid off in terms of improved LED performance and reliability.

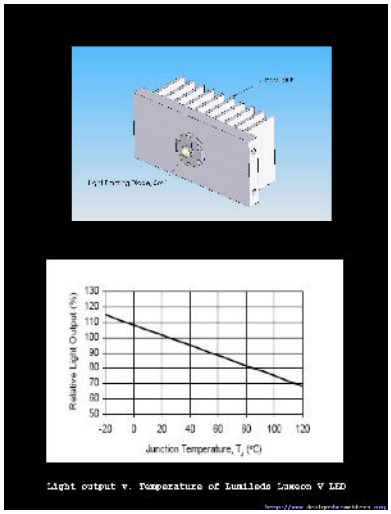




The prior art for comparison with Kinkajou is the large "Boite des Images" – a 6' tall wooden box with full-size scroll of images. The concept of Kinkajou could be expressed in relation to this previously used device, this was helpful to be able to do.

DtM benchmarked some competition from the Fisher-Price ViewMaster projector. It sells for $16 USD, with beautifully formed low-cost plastic lenses, <$1 each, compared to the Kinkajou prototype's $50 lenses. Fisher-Price was willing to make a special run of 2,000 lenses for the DtM project! DtM wound up working with a Cambridge-based optics consultant that had worked on this projector, combined aspects of the ViewMaster system and a toy telescope.

Graph shows Light Output vs. LED junction temperature. The cooler you can keep the LED package, the better the light output. Thus the heat sink and overall thermal design of the system received lots of attention.



Schematic of the 3rd generation (gamma) prototype design. The device gets smaller and simpler. The heat sink is integrated into the package itself – an extruded aluminum piece. It turned out that funding decisions were delayed; the extrusion die was too expensive for a small run (10 units), so Alan made a single version on the lab's CNC lathe by hand.

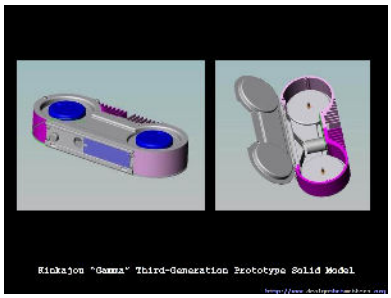
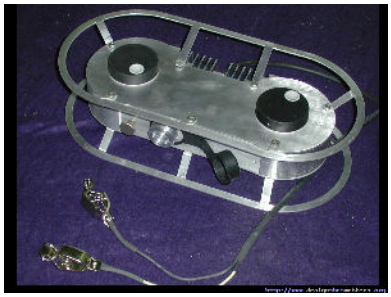
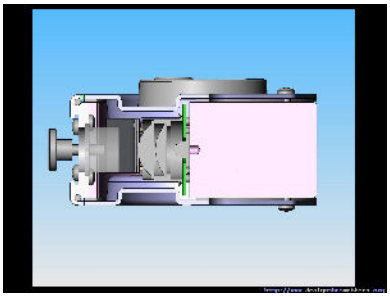


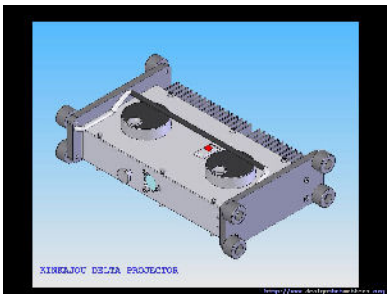
Photo of a 3rd generation gamma prototype, with some modifications on the above design. The oval bars on top and bottom are "crash bars", protecting the device. The bars also served as a handle and simplified cord storage. However, design reviews generally found these "ugly" so they were removed. Note also the leads to the external battery.



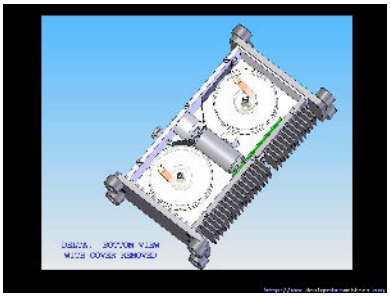
Side view schematic, highlighting the optical path. Turned out the optics couldn't manage such a short optical path. Lesson: complete the science before you lock into the packaging.



4th generation (delta) schematic. Very similar "guts" but the box is simpler, lower costs, using off the shelf heat sink rather than a custom die.

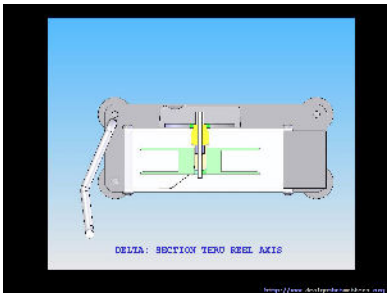


Delta bottom view with cover removed. Focus happens by sliding the knob by the lens in or out of the box. Frictional drag and a 1-way clutch on each reel keeps the film in place, allows it to forward appropriately.

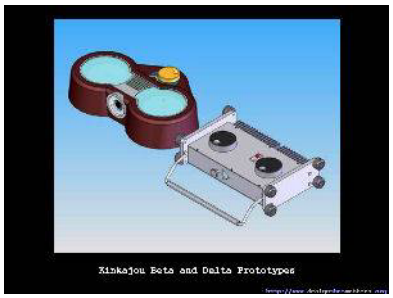


Exploded view. Notice all the screws; you couldn't achieve $50 system cost target with so many individual pieces, instead do it with snap fit. There's a small microprocessor on board to manage the 12V to 6.5V switching power supply and current regulator, also monitors temperature (auto shut-down) and logs lifecycle data via software.

Delta section through the reel axis, highlighting many gaskets and seals to keep dust out.



Comparing size of alpha and delta versions.



Kinkajou delta unit has gone into field trials.

Groups in Bangladesh are also interested. It turns out they want a few different features, but the current design has been refined to the point that there's very little flexibility remaining.

Back to the design specs slide. What where successes? Inconsistencies? The combo of no-electric-power, at night, only "canned content," means relatively low power; but it only serves a relatively small niche, and low-volume production makes it hard to achieve the $50 USD unit cost target. They're having trouble finding 20,000 users that fit this set of constraints. Bangladesh has 20,000 schools that could use them, but adds additional requirements to support more spur of the moment content, maybe even a computer hook up. That requires a much more powerful light…hotter system…in the end, it turns into a much different device.

Q: With all the screws, do people have a tendency to open it up?
A: Over the two trips to Mali, that hasn't been a problem. The biggest problem so far is that some of the teachers seem not sure how to use it, e.g. how far from the wall to be, when and how to use the content during class.

Q: How much does a roll of microfilm cost?
A: About $10

What have we learned about the design process? Did we need to actually make four prototypes? How else might the team have approached the problem? In retrospect, two versions probably shouldn't have been made, alpha and gamma.

- Alpha prototype was driven by the VHS cassette, and people having preconception that it was important. The whole layout was built around this concept which had never been validated.
- Gamma prototype presumed that they'd have money to produce 75 units. Alan admits he "fell in love with the extrusion" in this design. When the funding didn't come through, and the design was so tightly connected to higher volume assumptions, it needed to be redesigned for production of 10-45 units. Should have looked at other alternatives early on.

The beta version needed to be made; reasons include:

- support field trials and collect user feedback.
- validate the scientific analysis
- explore assembly issues
- gain understanding of human factors
- gives you something to demonstrate when seeking additional funding (demonstration)

And of course, the final delta version needed to be made.

The design process is analogous to seeking the source of the Nile River, moving upstream from the ocean. You can get diverted on what are ultimately "side branches" (especially when you fall in love with a particular idea too early), or you can run out of resources before you actually get to your goal.

Amy Smith notes that Alan, having had years of product design experience, was able to guide this design relatively smoothly. Without that sort of mentoring from experience, projects can become mired down trying to do things that "aren't feasible." Of course, occasionally it's a good thing to not know a problem can't be solved, that's where breakthroughs come from.