The Form Design of the Datacatcher: A Research Prototype

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Abstract
This pictorial exposes aspects of the decision-making process during the form design of a research prototype called the Datacatcher: a mobile electronic device that receives a continuous stream of location-based sociopolitical messages. Manifesting a physical device generated a myriad of demands on top of our research agenda that included issues with both technology and manufacturing. This pictorial will demonstrate how research through design has to tackle issues beyond core research questions in creating research devices, and suggest that because such seemingly irrelevant concerns are crucial for how research questions are embodied, those concerns themselves become integral to the research.

Authors Keywords
Design; research through design; form; prototype; batch production; mobile device.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction
The Datacatcher is an always-on mobile device designed to display data about its location from a number of online sources, intended to highlight sociopolitical differences across the UK. Topics include average house prices, typical income, the number of pubs or GP surgeries. Turning the device’s dial one way scrolls through all the messages that have appeared on the device; turning it the other way accesses a set of poll questions that

Figure 1. A batch produced version of the Datacatcher, a research device that displays a continuous stream of location aware sociopolitical messages.

can be answered using the dial to select among alternatives. Questions cover a range of topics from pollution to politics, including some that are more playful (e.g. 'What are the dogs like here? handbag / working / attack'). 130 of these devices were batch produced during a research project run by the Interaction Research Studio to investigate Third Wave HCI [5].

This pictorial reflects burgeoning interest in visual documentation, using images to provide insight into the design process that brought the Datacatcher into being. This responds in part to observations that the complex processes involved in designing devices should be better represented in the HCI literature [2,6,8,10]. The photographs used in this pictorial are themselves an output of a reflexive process to document the design thinking and making involved in the multiplicity of practices that constitute research through design [7]. They are curated in order to illustrate key stages in the design process, however they should not be viewed as indicative of a linear model of design [4] but rather as particular moments, or way points, in the complex biography of the Datacatcher that are indexical to its making. Moreover, I end my account prior to the completed devices being given to participants, as their experiences with the devices are described elsewhere [3].

The research agenda of the Datacatcher project was to design a device that would support multiple orientations to data that gave a sense of the sociopolitical texture of the neighbourhoods where it is used. The messages are derived from public and private datasets, such as the census and credit agency data. The message feed on the device was aimed at making data more transparent and empowering — indeed, during a test of an early version of the Datacatcher, one participant said that it presented 'Big Data for little people'. To understand the various engagements the Datacatcher would afford, we planned to distribute all of the prototypes to people in the Greater London area to use for several months. We planned to hire two documentary filmmaking teams to capture these experiences and it would be through the participants voices that we would create a kind of polyphonic, fragmentary story of living with the devices (see figure 11).

Background

In terms of how artefacts are typically manifested, used and evaluated the Datacatcher is an unusual example as it is a

Figure 2. Left, a proof of concept prototype built from NET Gadgeteer [9] modules. Right, the batch production version of the Datacatcher featuring a single, bespoke, printed circuit board.

device that is a product of research through design. Its design brief has a lineage that reaches back into a funding proposal and into the previous work of the design team that created it [1]. It is a technological device, but is not a tool for performing tasks, nor does it facilitate gaming or entertainment, nor does it connect to anything that might generate a revenue stream and despite its name, it doesn't harvest data for anyone other than the participant using it. It is a product designed and built for exploration and does not sit within the consumer landscape often used to locate electronic artefacts. However, it does share qualities with devices that belong to categories that the Datacatcher does not. It has a screen, a control and a battery that needs to be charged. It connects to the Internet through the cell phone network. It is robust and safe to use, and if a problem arises then there is a telephone support line.

Form Design

This pictorial will use visual material to help describe some of the more detailed considerations driving the design of the Datacatcher's form. Although this may seem of little relevance to the project's key research questions, the form design itself is key to the identity of the Datacatcher, how it will be used, and crucially how people's expectations of the device are shaped by how it looks and feels. As with other research through design projects, the research questions are supported by and to a certain degree presented through the form design [1].

The Datacatcher is designed as a handheld object that has a screen on one end and a large control dial set in a recess underneath. On the end opposite of the screen is a small on/off switch and a charging socket. At the time of writing the devices are about a year old and have been used by hundreds of people both in a long-term field trial and subsequent public engagement events. A common initial question from people who have used it (other than why it isn't an app [3]) is why is it shaped like a torch/flashlight? Although the Datacatcher shares affordances with this familiar form, it was not our intention to imitate such an object (even though some users have described the device as illuminating). Instead, our design decisions were shaped by a constellation of criteria and demands that resulted in the device being handheld, powered by a large battery and with an output that appears from the end plane of the form.

Proof of Concept

The Datacatcher's design team is experienced in making technical research prototypes [1], yet producing 130

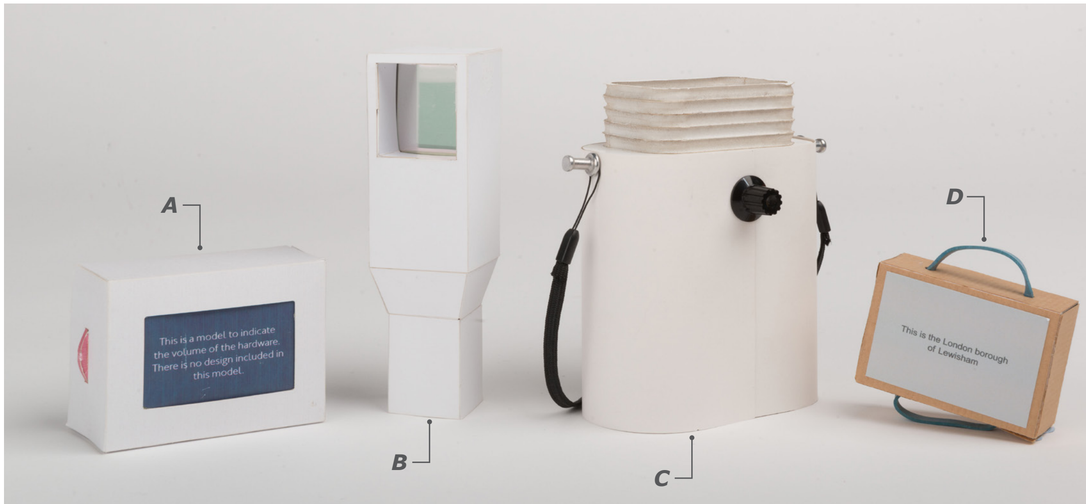

Figure 3. Sketch models. (A) This simple form echoes a 'pager' and encloses the expected volume of electronics and battery at an early stage in the design process (B) A handheld case similar to an 'otoscope' featuring a translucent screen that would overlay text on the view through the display. (C) A model of a device that would hang around the neck like a pair of binoculars featuring a screen that can be viewed by glancing through the top aperture. (D) A device that loops or hangs onto other objects to become a small personal or public display.

highly finished and robust devices raised new and unexpected challenges. The sheer scale of the production introduced issues with materials, processes and manufacturing, and the technical complexity of building what was essentially a GPRS cell phone from scratch was a few steps beyond our comfort zone. Early in the design process we created a working prototype using modules based on the .NET Gadgeteer platform [9] that could receive a continuous feed of location-specific messages compiled on a remote server (see Figure 2). This version was built around a cell phone module (GPS was too power-hungry for a device intended for continuous use), which would report cell tower identifications back to our server that could be used as a rough proxy for the device's location. Although this method was coarse, it was more than adequate for the granularity of most datasets. The prototype also featured a small e-ink type of monochrome display that would be used in the final version of the prototype, even though we would evaluate many others during the design process.

The Design Brief

We added lessons from the working prototype to refine our brief prior to the beginning the form design:

- A mobile device which streams sociopolitical information in response to the device's location
- that would connect to a remote server compiling data scraped from data sources such as government sites, credit agencies, the UK census, Twitter™ and Wikipedia™ and
- allow participants to contribute their own, location relevant opinions
- using GPRS cell phone technology to approximate location and
- be capable of being switched on continuously for days between battery charges

Mission Creep

The brief focuses on our core research agenda for this project, but it also introduces demands that are outside this. Resolving issues with manufacturing, radio interference and power management became a sizeable part of our research activity and these are embodied in the final form of the Datacatcher as much as the core research interests were. Dealing with concerns beyond our key research questions is common to many of our research through design projects, though often unreported. The rest of the pictorial aims to demonstrate

Figure 4. Sketch models. (A) An iteration of the previous pager style model with detailing to tilt the screen on flat surfaces and a cut-through hole allowing a cycle lock to pass through. (B) Exploring flexible materials such as rubber and foam around a hard screen. (C) A periscope model, where the screen is viewed via a mirror and a handle that acts as a dial. (D) This concept includes user-poll buttons which allow positive, neutral or negative responses to questions and has a large volume in the base to house batteries as we began to realise the need for a substantial power source. (E) This maquette incorporates the screen within a convex handheld mirror, in response to a proposal suggesting that the Datacatcher should focus users on their surroundings rather transporting them away, as is the case with most mobile technology.

some of the decision making and development made during the form design process of the Datacatcher that shows how fundamental issues seemingly outside our key research agenda became influential during our research activity.

Initial Ideas
Figures 3 & 4 show a small selection of the numerous sketch models that were made to explore early questions of how the Datacatcher might be used (At home? Carried by hand? Mounted on a car dashboard? Perhaps left in a public space as a form of electronic graffiti?). During this period of study we investigated some very specific usage scenarios, and one idea that was quite obsessively explored was the notion of providing various methods to attach the device to other objects. Two maquettes shown in figure 3 (D) & 4 (B) both feature built-in elasticated bands for strapping to articles such as bags, buggies, handlebars or clothing, while the prototype on the far left of figure 4 (A) features a hole cut through the body designed to allow be used with a bicycle D-lock for securing the device in public locations. The idea of a cut–through became a feature of the final form, provide a space for the dial and thumb, while retaining the ability to be used as an attachment point.

The idea introduced with the simple pager-style sketch (A, figure 3) was the notion that the screen should be the main point of visual contact when holding the device, and that all of the physical bulk of the batteries and electronics should disappear behind the screen. We returned to this concept repeatedly in sketches. Over time it combined with the upright form of the otoscope style model (B, figure 3, and popular among our team), and modified further to take into account the apparent need for a large battery (see below). The result was a convergence on the form factors shown in Figure 5, all of which place the display on the end plane of a cylindrical form.

The Battery
As we progressed with the electronic hardware development, it became clear that we would need a high-capacity power source. So we abandoned ideas of using user-replaceable AA batteries and began exploring options with rechargeable lithium-ion battery packs (as seen in the device on the far right of figure 5). We eventually had to use a relatively large 4600mAh battery pack that added considerable volume to the handle in the Datacatcher’s final form. This was softened by significantly filleting

Figure 5. We began incorporating batteries in proposals for the Datacatcher form. All the models on this image incorporate different specifications of high-performance batteries housed within the device's handle. Most use combinations of rechargeable AA and AAA batteries that that we hoped would meet the power requirements of the device as well as having the advantage of being user replaceable. However, we were developing hardware in parallel to the form design and it became clear at this stage that the device would demand a larger power source if we were going to achieve several days usage with a single charge.

(rounding) the edges of the device to wrap around the battery, but it did add an appreciable weight to the device, which some participants commented on as being a slight drawback [3]. However we imagined that the usability of the Datacatcher would be impaired if users were expected to have to charge the device more often than a smart phone and so we decided that compromising the form with the added bulk would be worthwhile. None of our participants subsequently complained about battery life during the field trial.

Getting Real

We had been 3D printing 'sketches' in house on a machine which uses an additive process called fused deposition modelling (FDM). This builds objects by laying down molten plastic in layers. While this process is very useful for development, it doesn't produce parts particularly quickly and the end results can be fragile, so this process would be unsuitable for production in large numbers.
We initially investigated low-volume injection moulding solutions for the final production, however we were keen on the appeal of the seamless cases that we could make on our FDM machine because they felt so comfortable in the hand. Injection moulding the parts would have added a split-line or seam lengthways through the case, which would both lose the appeal of the 3D printed cases and add a kind of ordinariness which we believed would be detrimental to the field study. The only way to produce the form we had been converging on would be through using additive manufacture.

After some investigation, we elected to develop the final form for a technique called selective laser sintering (SLS) which is a process that can produce incredibly strong parts by fusing nylon powder, we could also subcontract the production of all the cases to a bureau specialising in additive manufacturing. An additional advantage with this

Figure 6. Maquettes produced with a 3D printer, that begin to address batch production opportunities and issues.

process was that we could develop the form using our in-house 3D printer before handing the final design over to be manufactured, as the build technique is so similar. So we set about developing the Datacatcher with as few parts as possible, while taking full advantage of the fact that using the additive process we could make parts that are impossible to produce using traditional moulding techniques. The manufacturing process would enable us to maintain the cut-through hole that we were developing. The blue model, center of figure 6, was our first attempt at building the hole into an inner core or chassis of the Datacatcher.

Figure 7. The development of the cut-through from hook to hole. The blue model on the far right is the first to have the tunnel of the hole printed within the inner core section, which matches up with the two holes in the outer sleeve.

The Hole

The final cut-through hole evolved from both the earlier concept of adding accessories such as a cycle locks and a later idea having a built-in hook that could be used to hang the device. Eventually, the hole became the place to locate the thumb operated dial-interface of the Datacatcher, but can also be used to hold the device from the thumb when being carried around. This design feature also creates a space for the internal antenna away from the planes of the PCB and the display, significantly improving radio reception. As an object, this detail also helps place the device in a category outside the landscape of commercial electronics. The casing would be irrational to mass-produce, and so the Datacatcher would become unusual object to encounter: it looks different and feels different to other computational devices.

The Inner Core

As we developed the form for production on a 3D printer, we narrowed the number of parts down to three. The cut-through hole proved challenging when rationalising these components, but was the perfect feature for showcasing the possibilities of additive manufacturing over conventional plastic moulding. Figure 8 is the near-final form of the outer sleeve, and various iterations of LCD screen holder and inner core. The inner core was the part that required the greatest development as this had to incorporate the structure of the cut-through hole, the battery, electronics, encoder (dial), antenna and power switch. As we developed the inner core, we were able to reduce the number of parts from three to two (figure 9), as we worked out a way to incorporate the LCD screen holder by developing a slot for it to slide into. The inherent strength of SLS and the possibilities of additive manufacturing allowed us to develop components that would be impossible to produce by any other method. The simplicity of the outer core belies the complexity of the inner core, which features several printed fasteners allowing the two parts of the case to be held together with just one screw.

3D Printer Variance

We had designed, developed and optimised the design of the housing on our own FDM printer before outsourcing the production of 130 units using SLS. In theory, the resulting parts should have been identical, however were very different. Using the same 3D data, a part printed on an FDM machine is not identical to a part printed on a SLS machine. There are different tolerances with each method and most importantly, there are different characteristics to way each very slightly shrink and warp after building.

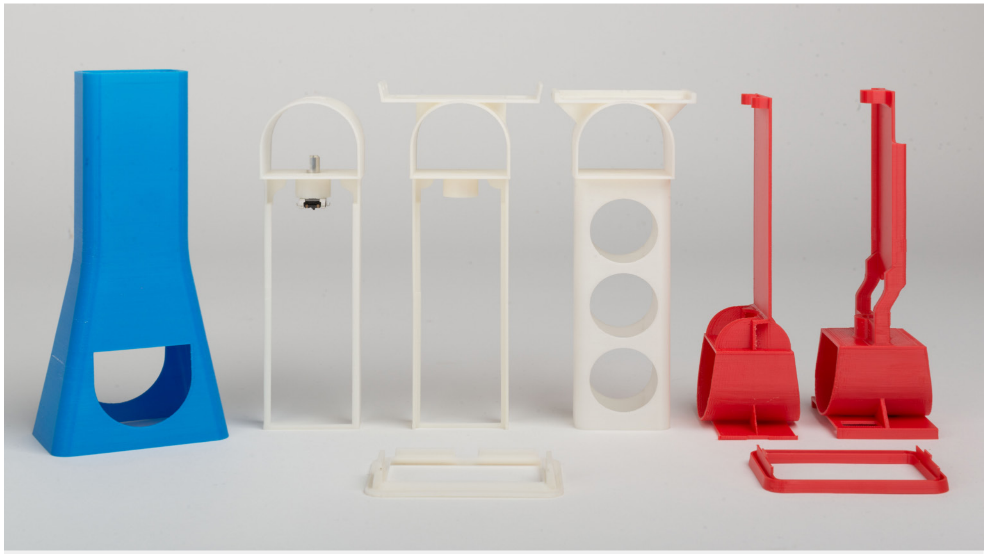

Figure 8. Developing an inner core separate from the outer sleeve. The inner core is designed to hold all the internal electronics and parts and for quick assembly. Despite sub-contracting as much of the manufacture as possible, all assembly was carried out in-house.

Figure 9. As we developed the inner core, we were able to reduce the number of parts from three to two as we worked out a way to incorporate the LCD screen holder by developing a slot for it to slide into. The simplicity of the outer sleeve belies the complexity of the inner core.

The Datacatcher housing consisted of two parts, designed to clip together with a fine seam where they join around the screen edge. We had optimised the design using our FDM machine and the versions we had made were perfect, but the first samples returned to us that were built on an SLS machine were terrible: the clips did not work and the display and PCB would not slide into the channels built to hold them. Worst of all, the joint between the display bezel and sleeve was inconstant and crooked.

After much back and forth with three different bureaus, we modified the design to achieve the same quality of fit as the ABS printed versions, adding and removing microns from clips and shut lines of 3D drawings. However key to the quality assurance was specifying exact orientation and position of each multiple in the SLS machine's build chamber: A major difference between the SLS and FDM process is that each SLS build takes roughly the same time as the material chamber has to be progressively filled with nylon powder whether it is being fused by the laser or not. This means that bureaus tessellate as many parts as possible into each build and we found that different angles that our components were being built in greatly affected the consistency of the final part, creating rounded edges and steps on flat surfaces. Our final specification to the bureau was not just a refined 3D drawing but also the exact position of each multiple in the build chamber. This level

Figure 10. An assembled inner core of a Datacatcher next to a disassembled one. Parts that attach to the inner core are right to left: rotary encoder, mainboard PCB, cell phone antenna, battery, LCD screen and breakout board, dial, SIM card, switch cover, ribbon leads.

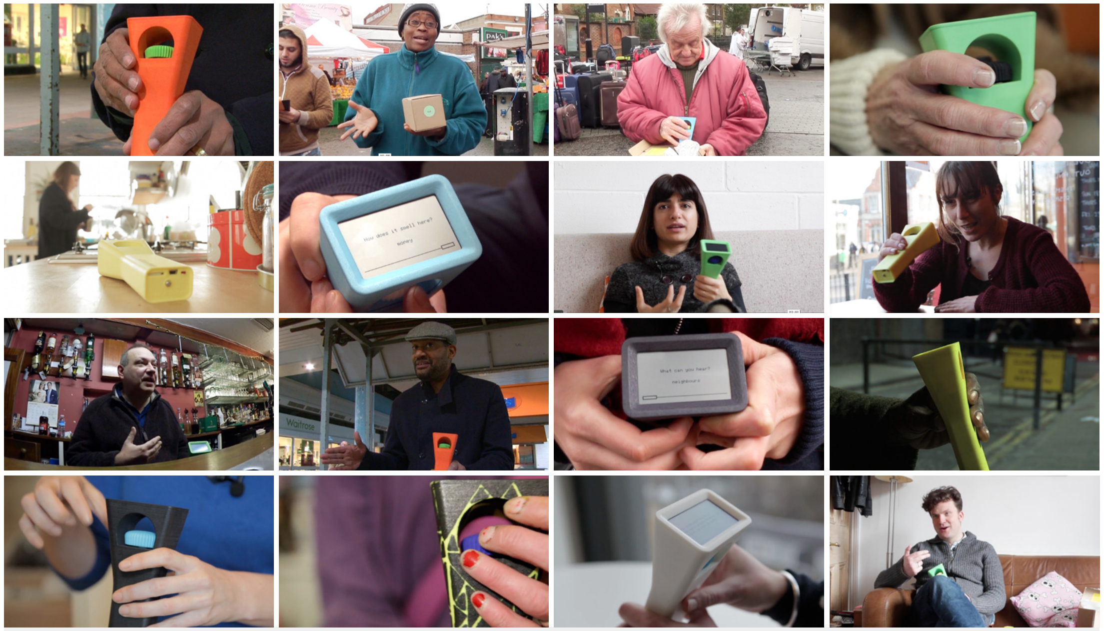

Figure 11. A selection of stills from documentaries of participants describing their experiences of living with their Datactcher. All 54 films can be accessed at vimeo.com/channels/datacatcher

of engagement with a production process may at first seem irrelevant to our research interests, but controlling the quality of the physical form is crucial if the form is embodying the research agenda.

Discussion

In the Interaction Research Studio, we practice research through design and much of our day-to-day activity involves dealing with issues that are not directly related to core research questions. Tackling these issues though is fundamental in being able to manifest research prototypes that can adequately serve our research agenda, to the extent that these non-core issues become part of the research itself. The Datacatcher project was a large and ambitious endeavour. The key research questions were addressed via the manipulation and the redistribution of big data by a remote server, exploiting cell phone infrastructure to deliver sociopolitical location-aware short messages to a device.

The device though has to embody the whole experience and capture the essence of the research agenda. The form design is crucial for this and the Datacatchers had to be detailed so as to resolve issues we had manipulating so much technology to deliver the messages. Had the device been uncomfortable to hold, difficult to read, tricky to charge, demanding to operate, or just fragile, none of our participates would have engaged with our research questions as they would have been too preoccupied with its problems. Design is crucial for research through design, and it needs to be acknowledged as being part of the research itself.

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