Reenvisioning Ghost-Trapping

From sketches to sheet metal and military-grade weapon parts, a look at the redesign process of the Ghostbusters' proton pack and neutrino wand

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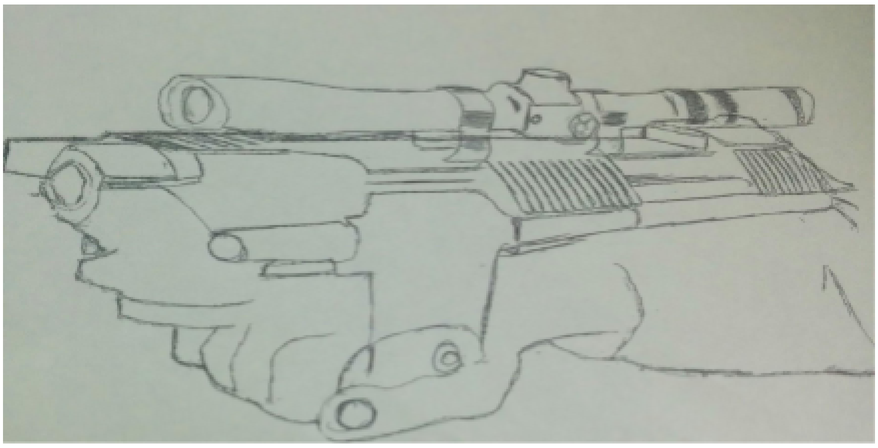
The proton pack and neutrino wand tool is essential to the Ghostbusters' success. Without it, the team members wouldn't be able to trap the ghosts that terrorize people in their homes and offices. The proton pack is effective, as the Ghostbusters always manage to complete their tasks, but the existing design leaves plenty of room for improvement. For instance, pieces of the proton pack are exposed to potentially harmful matter such as ghost slime and dust from old buildings. The pack and neutrino wand are also heavy and bulky. Our team's redesign of the proton pack and neutrino wand aims to minimize these issues and improve the pack's usability and efficiency.

DESCRIPTION

The Ghostbusters must be prepared to head out on ghost-trapping missions at any given moment. Their success heavily relies on the quality of their equipment. As we drew our initial sketches, we determined several critical points. First, all parts of the tool needed to be lightweight so it wouldn't hold the Ghostbusters back. Second, it had to allow for flexibility and mobility, as the team members often must navigate tight spaces and dark areas. Third, it needed to be user-friendly for novice and veteran users alike. Finally, the exterior needed to be sturdy and protect the fine, inner-technology of the device from hazards.

Those points helped to determine what essential features we needed to include in the final prototype.



Neutrino wand initial sketch

The neutrino wand's features include:

- Riflescope to spot the ghost from far
    - Calibrated parallax-free at 50 yards for shorter rimfire ranges. Featuring coated optics and a 30/30 reticle
    - Magnification: 3-7x
    - Field of View (ft@100yds/m@100m): 21/7@3x-10/3.3@7x
    - Exit Pupil: 6.7-2.9mm
    - Eye Relief: 2.55"
    - Click value: 1/4
- Live view monitor to track ghost from closer distances
    - We used an LG Exceed 2 phone for this monitor
    - 4.5 inch WVGA Display with Gorilla Glass touch screen. Android 4.4.2 KitKat
    - 5 Megapixel autofocus camera
    - Video player with touch lock, Play on Screen Function
- Wand used to aim at and stun ghost
- Lasersight used to improve accuracy
    - Power Requirement: 1 x 3V CR123A battery
    - Laser Class:3R
    - Output Power:5-20mW
    - Wave Length:532nm
    - Weight:410g
    - Height:130mm
    - Length:165mm
    - Width:32mm
    - Tube Diameter:6mm
    - Green Laser sight
    - Metal 22mm Picatinny Rail Mount
    - Switch button
    - Pressure Pad Switch and "8"type mount
- Handheld grip with finger slots and trigger
- Adjustable cloth arm brace that anchors the wand to the user's arm

Proton pack initial sketch

The proton pack features are as follows:

- Switch to turn on pack and light bulb to indicate power status
- Padded backpack straps for comfort
- Aluminum vents that push out heat generated by the pack
- Hose that connects the pack to the neutrino wand
- Wood frame enclosed by sturdy sheet metal exterior

The prototype aimed to maintain the basic features of the proton pack depicted in the original *Ghostbusters* movie while restructuring the interface to better accommodate the users. The prototype needed to feel familiar to people who have used the original proton pack but improve their interactions with the equipment.

Low-fidelity prototyping

USER ANALYSIS

The proton pack was primarily designed for the Ghostbusters, a group of parapsychologists who investigate ghost sightings for people living and working in New York City. Peter Venkman, Raymond Stantz and Egon Spengler — the original trio — are expert-level proton pack users. A fourth teammate, Winston Zeddemore, is more of a beginner. Spengler and Stantz designed and developed the original equipment, so they likely would be most prone to user bias when testing a prototype for a new model.

While their expertise levels vary, the Ghostbusters all have experience with responding to emergency situations and fighting the ghosts that wreak havoc on the city. The environments in which they work also vary, but they often seem to be dusty, dark and old. Past emergencies occurred at a public library, a hotel and a 1920s apartment complex.

The team members have grown used to dealing with the less glamorous parts of the job, such as handling gooey ghost slime that often drenches them. They wear protective suits, gloves, goggles and boots, but the exterior of their existing proton packs does not adequately protect the equipment from such material. The packs are also bulky, which takes a toll on the already physically demanding jobs.

The proton pack needed to be as compact and lightweight as possible so it doesn't slow them down. We determined we needed to have a protective layer to combat the slimy situation and to prevent the slime from destroying the equipment. Through some interviews with our early user testers, we learned that safety was a major concern. We looked into creating a lock and voice-activated software so the tool would recognize the correct users. We ultimately did not implement these features, but they assisted in the creativity process and could be added at a later time if the market were to actually go to market. The features we ultimately honed in on were related on the simple tasks of finding a ghost and shooting it without causing extra fatigue upon the users.

FEATURE ANALYSIS

Nielsen's design principles guided our development of features for the redesign:

- Use simple language and interfaces for novices
- Support users' locus of control
- Manual methods in the case of failure [the riflescope can be used if the live screen display fails]
- Limit the amount of information recall needed for users [the new equipment builds upon muscle memory]
- Add shortcuts for expert users [automatic ghost targeting can be turned off in favor of manual tracking]
- Error messages, if any, will be clear and the system will allow for quick recovery
- Sequence of events will be well-organized

We first examined the original neutrino wand design. The aesthetics influenced our decision to use military grade materials for our prototype. The materials are sleek and achieve the aesthetic appeal we strived for. A key difference between the original wand and the new wand is the grip. The original wand uses a handheld grip, much like a traditional gun. After several design iterations, we settled on creating a forearm attachment and detachable foam finger grip connected to a trigger that users operate with their thumb. Other parts of the wand — riflescope, live view display, base and laser — are also easily removable, allowing for customization, cleaning and easy upgrades as needed.

The neutrino wand's base is made from cloth and fits like a wrist brace. It's sturdy but highly adjustable, allowing for users with different arm sizes to comfortably wear the tool without fear of it slipping. The flexibility of the material allows for a wide range of motion, giving users the feeling of complete control over their actions. A mid-project redesign of the base and grip is further described in the design process section.

The proton pack features a lightweight wood and polished sheet metal exterior with two flexible and adjustable straps. Heat vents on the lower back of the pack disperse energy. A switch turns on the pack, as indicated by a light that turns on when the pack is powered up. The redesigned pack removes all clunkiness of the original design. We aimed to eliminate the gimmicky look of the original pack and simplify the interface so users would not be distracted by exposed wires and ribbons. We modeled our aesthetic after Apple, known for its elegant minimalism, and retained only the most essential parts of the pack.

While developing the prototype, we kept in mind possible user limitations because the features work to support the users' tasks. Their chief goal is to stun and trap ghosts, and the proton pack must be able to counter the negative energy that ghosts are made of with a proton stream. Because the Ghostbusters wear big gloves while working, the features needed to allow for larger, clumsier hands. They work in sometimes harsh environments, and their equipment must be able to withstand such situations.

DESIGN PROCESS

Several rounds of user testing helped refine our prototype. After developing a low-fidelity prototype, we recruited three University of Maryland undergraduate students for usability testing. Two of the users had previously shot several types of guns. The third student had never before picked up a gun. The prototype — made of a backpack, cardboard, styrofoam and plastic bags held together with packing tape — allowed test subjects to focus on the interface and not the aesthetics.

Throughout the test, we analyzed users' actions to see if they would see the correct controls, understand the functionality of the controls and identify system feedback. We asked users to put on the pack and wand, climb a flight of stairs and aim at a picture of a ghost-like target. We asked each user to use one of three methods: silent observer, talk-aloud and constructive interaction.

The user tests showed that in a rush or without guidance, a user might accidentally put on the neutrino wand incorrectly. The wand lacked any clear directions for placement, as we discovered when our constructive interaction user slipped on the gun backward. Even when users later corrected the error, two users were unsure how to aim at and shoot the target. One user noticed a "target acquired" message on the screen, but he said he did not know if that meant the ghost had been trapped or just spotted. Clearly, language would need to be revised, and the trigger would need to provide users with tactile or audible feedback.

One strength of the prototype was that tasks were minimally affected by memory load. None of the users had difficulty recalling the proper order of completing tasks, and all eventually managed to spot the target and trap the ghost.

In a post-test interview, the users said they felt comfortable with the prototype's size, but all three requested that the next iteration of the prototype more closely emulate a gun. They found that a cardboard forearm base and grip inhibited mobility of both the wrist and elbow joints. The two users who were experienced gun shooters said they longed for the comfort and familiarity of a pistol or rifle. The third user, who had never shot a gun, said he could work with a strapped-on wand if it featured a more developed hand grip.

In the next round of prototyping, we revised the wand's grip and added buttons and switches to the interface. The resulting equipment strongly resembled a gun — at least from a distance — and drew concern from evaluators. While users strongly preferred the gun-like feel, we determined safety was a top priority and we would have to make the final design look less like a gun. In the field, a Ghostbuster would not want to be mistaken for a criminal with a gun-like object in hand. Such a design could frighten passersby (as if they're not already terrified of the ghost in the room) or attract police attention.

In this round, we tested six University of Maryland students and alumni between the ages of 20 and 23. We tested five men and one woman.

A pretest questionnaire gave us a strong sense of the users' experiences with using similar equipment. Five of the six users had experience with using guns, and the same five have played video games that involve shooting. None of the test users had ever served in the military, an important consideration because the wand utilizes military weapon parts. All rated their hand-eye coordination as a 3 or 4 on a scale of 1 to 5, with 5 being perfect hand-eye coordination. Four of the six users had seen Ghostbusters at least once, and all users were at least somewhat familiar with the concept of using a proton pack to target ghosts.

During the usability tests, each of the three observation methods was used twice, giving us an opportunity to see how some users interacted with the equipment without any prompts compared to those who had some guidance. Three users tested the pack indoors, and three tested it outside. No user struggled to pick up the proton pack, but four users carried it with one arm, leading us to determine that the pack's weight was too unrealistic. The hose stayed firmly in the proton pack but slipped out the end of the neutrino wand during two tests. One user got tangled up in the hose but recovered without assistance.

We noticed that each user had a different method for targeting the ghost. Some used the riflescope; others used the live view display. Some tried both tools, and one used neither feature. "The phone [live view display] makes it a little bulky, and I feel like I might accidentally knock it off," one user said. Later in the interview, he returned to the targeting idea and said both features could serve related but different purposes. The riflescope, he said, could be used for corner leading, so a

Ghostbuster could observe a situation while still hiding behind a corner. The screen, then, could be used for closer target accuracy.

The participants all found the target without hesitation, but they all struggled to find the trigger located on the left side of the wand above the hand grip. Users in this group and the earlier round of testing requested that the trigger be placed in a spot that felt more natural. They wanted to shoot with their index finger, not their thumb. They wanted more of a trigger action and sound feedback to know they captured a ghost. We detached the trigger from its spot on the hand grip and gave participants the chance to demonstrate where they would prefer to see a trigger instead.

Post-test interviews and questionnaires with the six users led us to make the following adjustments or add these features in the final prototype:

- Location of trigger: placed more prominently upon the hand grip
- Switch and light bulb shows when proton pack is on
- Working laser light
- Ghostbusters branding on proton pack
- Sheet metal and wooden frame to solidify the proton pack's exterior
- Flexible forearm base and detachable hand grip to replace gun-like hand grip

QUANTITATIVE EVALUATION

We conducted usability tests on the final prototype with six users. The tests focused on speed and efficiency, learnability and memorability. After a tutorial, which took about 2 minutes and 15 seconds each time, users attempted to target and trap a ghost. The test consisted of the same steps described in the second round of usability tests.

While several groups created hardware projects, we were the only team that created the proton pack and neutrino wand. The others designed ghost traps. Still, some observations made during these usability tests helped us to compare the learnability and functionality of our project to the other hardware projects.

Our tutorials took by far the most amount of time out of all the hardware groups. With the exception of one user, who required just a 16-second overview, our tutorial took about 2 minutes, 15 seconds, as mentioned above. Two of the ghost trap groups spent just over a minute on their tutorials, and the third ghost trap group's tutorial lasted 30 seconds. That's not to say our tutorial was too long for our prototype's needs — it's possible, for instance, that our neutrino wand and proton pack had more steps and features than some of the traps. But memorability is one key to the equipment's success; drone on too long, and a beginner user might miss out on critical components.

During the testing phase of the night, we allowed users to ask questions as they walked through the steps of aiming at and shooting a ghost. We offered some guidance if users seemed unsure of how to use a feature, but we made sure to document the questions. We also kept the timer running.

The first user required guidance throughout the entire test and took 1 minute, 56 seconds to complete the tasks. At the start of his test, he needed help with putting on the proton pack because he had already strapped on the neutrino wand. He found the riflescope to be "way too awkward." Then, he switched from the riflescope to the live view display on the phone but found the change to be cumbersome. The phone had turned off earlier in the test, and he wasn't sure how to turn it back on. When he finally tracked the ghost, he wasn't sure how to shoot it. He saw the trigger but didn't know how to push down on it.

The next few users passed on listening to the tutorial because they had already heard it once when the first user was preparing for the test. As with the first user, Tester 2 required assistance with sliding into the pack's straps. One of our team members then handed him the wand to strap on. Strapping on the wand took 26 seconds — far too long for a Ghostbuster working in an emergency situation. In the amount of time he took just to strap on the wand, users testing the ghost trap would have been able to deploy, open and close the trap as many as eight times. That's eight ghosts our Ghostbusting tester would have missed out on because he was stuck sliding his wand on. Once he finally had the wand it place, it took Tester 2 and additional 1 minute, 22 seconds to aim and fire at the ghost. After the test, he told us the device was too heavy and loose. Stronger straps could solve this issue.

The third user also noted the heaviness of the wand. The hose also fell out of the back of the wand when he slipped his wrist into the base. While he needed guidance on using the trigger, he said he liked the feeling of the button and envisioned its connection to the live view display screen. He used the display screen to spot the ghost, and it took him about 16 seconds from start to finish to complete the task. He felt control over the weapon since it was so closely attached to his arm.

Tester 4 placed the pack on without assistance or any out-loud thoughts. But the neutrino wand, he said, was far too tight. As he tried to put it on, the hand grip detached from the wand's base and needed to be readjusted. The live view display also switched off while he was performing the tasks, which took him about 40 seconds to do. In the future, we could simply adjust the phone screen's settings to turn off display settings after a longer period of time.

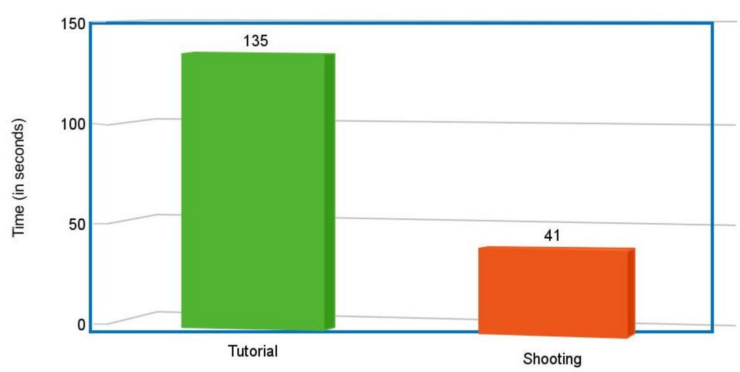
Tester 5 had difficulty finding the proton pack straps behind her. “But that’s kind of just a backpack problem for me,” she said. She had to remove her watch before attempting to put on the neutrino wand. She had difficulty sliding into the base, and when we asked if it was painful, she said she wasn’t hurting but that she didn’t think the tool was “built for my bone structure.” We ended her test after about a minute, but we still gained valuable information. It was clear that the wand wasn’t quite as flexible as we’d intended. We had purchased a small sized medical brace as our brace, and the addition of glue, paint and other supplies caused the brace dimensions to stick and shrink further. Only the smallest hands could fit into it. Still, this prompted our team to make the final wand more accessible to different sized users.

Tester 6 trapped the ghost in 9 second. He had the added benefit of watching other sample users walk through the whole process, so his experience seemed a little rehearsed compared to the others. For future studies, it will help to study users individually to avoid such bias.

The last user, Tester 7, had not already seen our tutorial. He quickly looked over the equipment as we breezed through the features. He slipped into the pack much faster than the other users and trapped the ghost within 16 seconds.

Some of the users offered final recommendations that we incorporated into prototype as we touched up the final interface. Most notably, we discovered that users have varying preferences for how they interact with the trigger. Some prefer that the button rests on top of the hand grip, while others want it to be more on the side. The hand grip also calls into play handedness. We designed the neutrino wand for a right-handed person, but a left-handed test user discovered that the grip and base work equally well on the left arm. At this stage, we realized that like other parts of the wand, the hand grip needed to be detachable so users could place it on the side most convenient for themselves.

Time chart



A feature that likely would have helped users understand the ghost-targeting process is if we had brought in the laser. We have been avoiding bringing the laser to class because it is pretty powerful and did not think we should take the risk until the final presentations. For that reason, we had to tell users to pretend a laser beam came out when they pressed the trigger. Tactile or audible feedback could also enhance the ambience.

DISCUSSION

Ghostbusters might be fictional, but the proton pack and neutrino wand design could serve legitimate real-world purposes. We imagined the design concepts could be applicable in creating weapons for specialized military units and SWAT teams. No matter the group goal, critical needs such as comfort, mobility, modularity, adjustability and sturdiness would hold consistent. Any of these users would need to be able to carry the equipment for an undetermined length of time and hold it with relative ease.

The groups' environments may also vary, so the equipment must also be able to adapt to such changes. Often, changes become necessary right in the field, so the equipment must be lightweight and highly mobile. The existing neutrino wand's design includes a forearm base that allows for flexible movement and offers a storage space for an extra small tool.

The neutrino wand's design involves modularity and can easily be broken down into smaller parts for storage. It utilizes two visual acuity methods: a riflescope and a live view display. Both function similarly and serve as a backup in case the other option fails — perhaps the phone's battery dies or the riflescope goes out of focus. They also help users to stay on target no matter the brightness of the environment.

In a military-like case or police situation, safety is vital, and the design of both the wand and the pack considers this need. The live view display provides a way to view an environment from a safe distance. The pack can serve as energy storage for a taser wand (instead of neutrino wand) used to subdue criminals. The pack would also provide extra energy and power, allowing users to stay in the field for longer durations of time.

The design could serve other types of users as well, especially if the wand concept is seen solely as a tool and not a weapon. Astronauts could use a revamped wand as a portable power tool strapped to their forearm as they're fixing the International Space Station, a telescope or other spacecraft. The tool would be powered by the attached proton pack, which provides power, and controlled by the trigger-like button affixed to the hand grip. The joystick moves in all directions and could help prevent injuries caused by repetitive motions.

Currently, space tools like hand drills have a pistol-like grip and a large screen that displays information. It's designed with an astronaut's gloves in mind. The tool is also modular so engineers can add modifications later on. Engineers aren't too quick to change the design since it's worked pretty well since 1997, but the tools aren't without their faults. Astronauts face severely limited mobility and often suffer from hand fatigue. Even with special grips and handles, using the tools can get exhausting quickly. Freeing astronauts from having to tightly grip a gun-like grip — and instead strap the tool on their forearm — could have enormous impacts on the lengthy spacewalks. As NASA begins its early preparations for sending humans to Mars or Russia starts prepping for a moon base, this could be a prime time to rethink the design of existing space tools.

The parts of the proton pack could also be separated and reworked for biomedical purposes. A February 2015 article by IEEE's Evan Ackerman discusses how the Defense Advanced Research Projects Agency and Open Source Robotics Foundation have developed prosthetic limbs that simulate an actual working limb. It works via a brain-wired interface, similar to an innovative design created at Johns Hopkins University's Applied Physics Lab, which they announced in 2013. Our design could use the concept of energy storage by minimizing the size of the storage pack and using a smaller hose similar to the existing DARPA and OSRF design shown here. In this case, our aim wouldn't be to reinvent the wheel so much as it would be to integrate our pack and wand concept with existing bionic designs. Many firms are working in conjunction with federal government agencies to find ingenious methods to alleviate the trauma of losing limbs in battle. The research and development findings would also assist the general civilian population, in cases where individuals have lost limbs due to illness, injuries or genetic makeup.

In all three cases, slightly reworked versions of the existing proton pack and neutrino wand show that the design is transferable across fields. Certain environmental factors — maybe the frigid temperatures of space or a hot desert climate — would affect specific design aspects, but the general shape of the equipment could still be used.

When we began sketching our initial ideas for the proton pack and wand, we never saw the paranormal as a major challenge in the interface design. The actual logistics of capturing a ghost were secondary; we held the assumption that technology used in the film — neutrinos that zapped ghosts, for example — would suffice. That allowed us to concentrate our efforts on improving the interface itself. We considered the needs of the users and saw how they aligned with the needs of users in other fields, such as military, aeronautics and space, and biomedics. In all cases, some design principles remained consistent. Developing a lightweight, sturdy and stylish device that minimized the possibility for user error was essential. While our final round user tests shows that more work could be done before the product actually would go to market, the proton pack still achieves our main goals.

IMAGE SOURCES

https://www.tucsonaz.gov/files/police/swat1.png
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