Cosmic Cats - Project Phase 10

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Introduction

It is likely that efforts for space colonization will fail, unless there are advanced systems in place to sustain human life. Every resource and piece of infrastructure will require constant and precise monitoring by its inhabitants, and in a fragile environment such as space, there is little room for error. An average Mars colonist will be exposed to an extremely large and complex workload, and may need to respond quickly to emergency situations. This leads into our problem space, which addresses the need to reduce the complexity of a martian's workload and to reduce the possibility of human error via technological assistance. The variability of this problem is what makes it interesting. There is a need for colonists to have technological assistance; however, what degree/type of assistance would be optimal? Development of such systems is constrained by expenses (time and money), and there are benefits to leaving some tasks up to humans. This is an open-ended optimization problem, and it also raises the question of what should be prioritized.

Related Work

The technological and financial feasibility of exploration on Mars has been investigated constantly by researchers as pioneering Mars is at the forefront of human exploration. The independent assessment of the technical feasibility for the Mars One program by Do, S., Owens, A., Ho, K., Schreiner, S., & de Weck, O. [1] identified life support and utilization systems as expensive and difficult to maintain. The exponentially growing costs of the system results in the program becoming unsustainable.

Brain - Computer interfaces (BCI) which are devices that can monitor brain activity and understand the brain's neural patterns as action and intention is innovative and emergent. Living and doing work in outer-space is mentally and physically demanding, utilizing BCI may be able to assist the users on Mars in their ability to complete tasks, thus increasing the chances of a Mars mission to be more successful [2].

Alling, A., Nelson, M., Silverstone, S., & Van Thillo, M. investigated the human factor considerations of long-term space habitation in their article Human factor observations of the Biosphere 2 [3]. They identified that the colonists must meet stringent physiological and psychological requirements, that they should have substantial knowledge of the construction of life support systems, and noted a need for a more comprehensive real-time modeling and information system, in order to help colonists make better and faster decisions.

User Needs Research and Results

We used a questionnaire and interview to conduct user research, aiming to answer two questions: what aspects of technology are users most comfortable with, and which kinds of tasks would it be useful to automate or simplify using technology?

From the questionnaire we found that an overwhelming majority of participants were familiar and proficient with their computer and/or phones for completing various tasks. Furthermore, we gathered data on automated systems and preferences for automated tasks. A majority of subjects indicated that they would like chores to be automated, for the primary purpose of saving time. However, responses were split for more complex tasks like driving. Subjects trusted automated systems to perform tedious and simple tasks, but not complex and variable tasks.

The interviews gave us more insight on how users might respond to specific interfaces. Subjects were more concerned with performance than learning curves, and were very receptive to automated home tech for completing menial tasks. On the information presentation side, subjects wanted information to be sorted by priority, and to be visible all in one place. Useful day-to-day information mentioned by subjects fell primarily under real-time environment updates.

Ideation

We began by sketching potential solutions to tasks found in our problem space, one of which can be seen in Figure 1. We also agreed that the best device for a user in our problem space would be a bracer that can connect to a spacesuit, since it is the most portable system. Eventually we decided to go with the bracer idea, and began our interface design with the solvability of our brainstormed tasks in mind. Our design emulated technology that users would be familiar with, such as a tablet or phone.

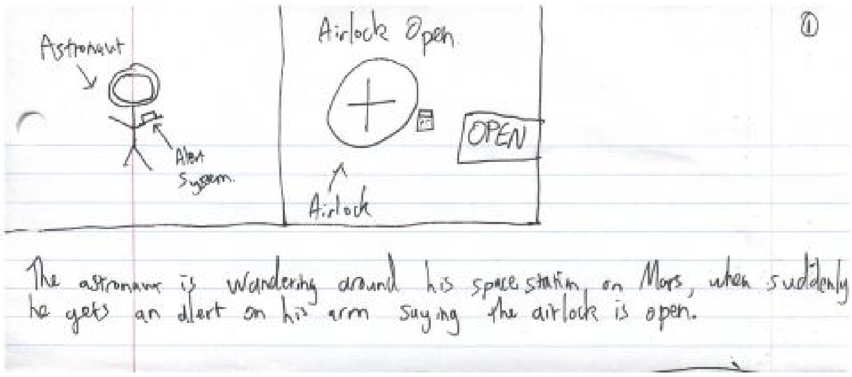
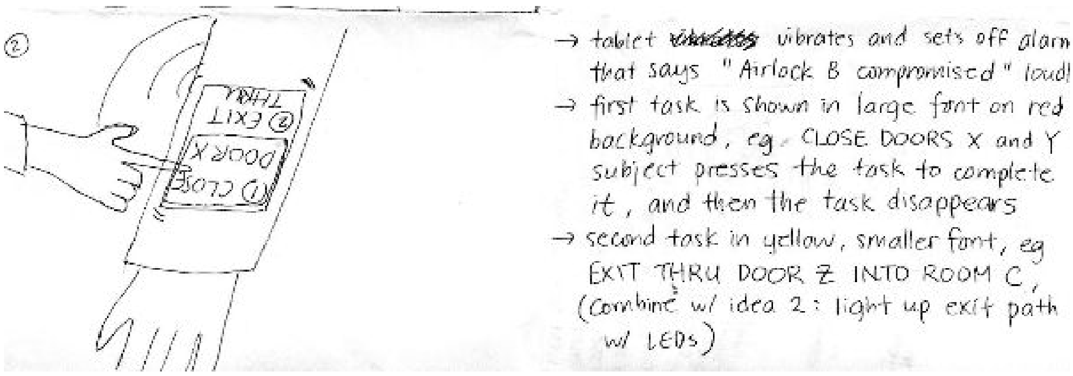


Figure 1 (above), Figure 2 (below). Sketch of user's response to emergency alert.



Prototype Description

Our initial paper prototype resembled a tablet in landscape mode with various functions displayed as buttons on a screen. Some major changes seen in the high-fidelity prototype were: addition of a status icon bar at the top, more system status information, more confirmation messages. We iteratively improved our design using the feedback we obtained from usability research. A major design choice which did not change was the screen division concept - on the left hand side, we provide system information, and the right hand side is where all our "actions" are.

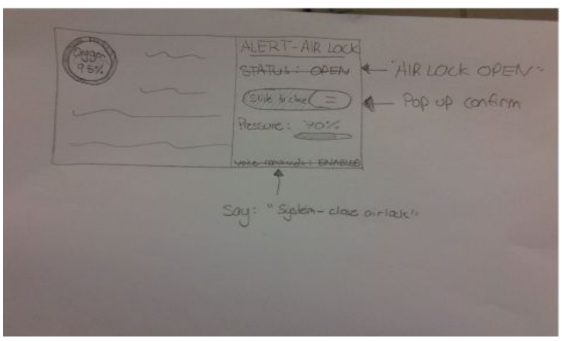


Figure 3 (left). Initial design for emergency alert function.

Figure 4 (right). Final prototype, showing the main screen of the bracer.

Usability Research and Results

We asked participants to carry out the following tasks with the prototype:

1. "You have put on your astronaut suit. The suit has a special slot for the bracer. Dock your bracer in the suit and sync to it; view the oxygen level of the suit." Participants needed to sync to the suit in order to view suit info.
2. "Send a message to your colleague, Bob, indicating that he should meet you in room A2 at 2pm."
3. "You accidentally spill dangerous chemicals during an experiment. The room is contaminated, put the lab you are in under lockdown." Participants needed to lock down the room by closing all airlocks connected to other rooms.

Issues discovered during usability research:

1. Syncing task:
    a. Not sure what device we're syncing to.
    b. Need confirmation that sync was successful.
    c. Need some indication of whether the device is synced or not.
    d. Can't unsync from device, or choose which device to sync to.
2. Messaging task:
    a. Doesn't make sense to record message and then choose recipient manually, just include recipient in speech ('Send <message>...to Bob').
    b. Unclear whether device has detected/received/processed any speech input, give better feedback on current status of the system.
3. Lockdown task:
    a. Participants initially unclear about what 'emergency lockdown' is.
    b. Participants also unclear about the function of airlocks in this context.
    c. No location info given for either airlocks or user.
    d. No option to lock down any other airlock, other than the default.
4. General:
    a. Make more system status information visible, esp on left screen.

Changes made as a result:

1. Represent sync status with a symbol in the status bar: red bluetooth symbol if unsynced, solid blue bluetooth symbol if synced.
2. Added option to manually search for available devices and sync to them.

3. Added option to unsync from currently paired device in the status bar.
4. Added pop-up confirmation screens prior to most state changes.
5. Replace ‘file delivery’ with ‘settings’, which is more relevant/frequently used.
6. Perpetual battery info in status bar, location & room air pressure on left screen.
7. Instead of ‘voice commands: ENABLED’ on bottom of screen, replace with speech suggestion: ‘Say <action> or <action>’ for more clarity.
8. Make left screen display relevant, action-specific info:
    a. Suit info: in addition to oxygen level, also include temperature.
    b. Messaging info: tabs for recently sent messages, inbox.
9. Messaging:
    a. Auto-detect recipient from speech input.
    b. Give clearer instructions for speech format, ‘Send <msg> to <name>’.
    c. Add intermediate status screens for recording speech, processing, and sending message.
    d. Add option to send another message after completion.
10. Emergency lockdown:
    a. Use entire screen for task - system status not relevant to task.
    b. Remove all references to airlocks, use ‘select rooms to lock down’.
    c. Display map of building and marker for user’s location on the left side of the screen, and require user to select which rooms in the building to lock down by tapping the rooms and confirming the lockdown.
    d. Represent closed airlocks using red Xs on the map.

Visual Design

Our major design choices were as follows:

- We chose a horizontal layout for the screen of the bracer, following our intention for the bracer to be docked on the arm of the suit.
- We chose a left-right split screen format, so that we could display info from multiple scopes without requiring users to navigate through menus.
    - The right side was reserved primarily for actions, while the left side was intended for status info (such as location, temperature, etc)

- We frequently paired text with corresponding icons in order to give users quick visual cues (microphone, bluetooth, loading bars, etc).
- For the messaging function, we chose to implement it purely with speech-to-text mode, since users may not have their hands free and the screen may be too small for effective typing.
- We mostly reserved a bright red colour for emergency lockdown functions for obvious reasons (clear distinction from other elements, red = alert)
- We dedicated the entire screen for the emergency lockdown action, since we didn't want to distract the user with unnecessary info while they were attempting to complete a critical task.

Typefaces & Colours

Colours (as HEX or RGB codes)	
Background colour(s)	#1B788A, #68C0C1
Text colour(s)	#FFFFFF, #000000, #F25245, #5D40AD, #3A93A3
Action colour(s)	#FCA249, #A18482, #ED2D1E, #F25245, #00C611
Icon colour(s)	#00C611, #D5483D, #5D40AD, #FFE76C, #FCA249
Fonts (typeface name, weight and point size)	
Calibri	10, 12
Franklin Gothic Book	12, 16, 20, 28, 36

Conclusion

We learned how to make a user friendly interface and a product that would benefit users in our given problem space. Through data we collected and multiple prototype stages, we refined our design, and we are happy with the outcome. As a next step, we would most likely add more functionality to the prototype and refine the information displayed to the user. Since this is a smart wearable device, there is a lot it could potentially do, and the platform allows for a lot of flexibility.

References

1. Do, S., Owens, A., Ho, K., Schreiner, S., & de Weck, O. (2016). An independent assessment of the technical feasibility of the mars one mission plan – updated analysis. Acta Astronautica, 120(Complete), 192-228.doi:10.1016/j.actaastro.2015.11.025
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3. Alling, A., Nelson, M., Silverstone, S., & Van Thillo, M. (2001). Human factor observations of the Biosphere 2, 1991-1993, closed life support human experiment and its application to a long-term manned mission to Mars. Life support & biosphere science: international journal of earth space, 8(2), 71-82.