TEAM **KAIROS +**
NASA Ames HCI Group

MATE:
Mobile Assistant for Task Execution

SUMMER REPORT 2012

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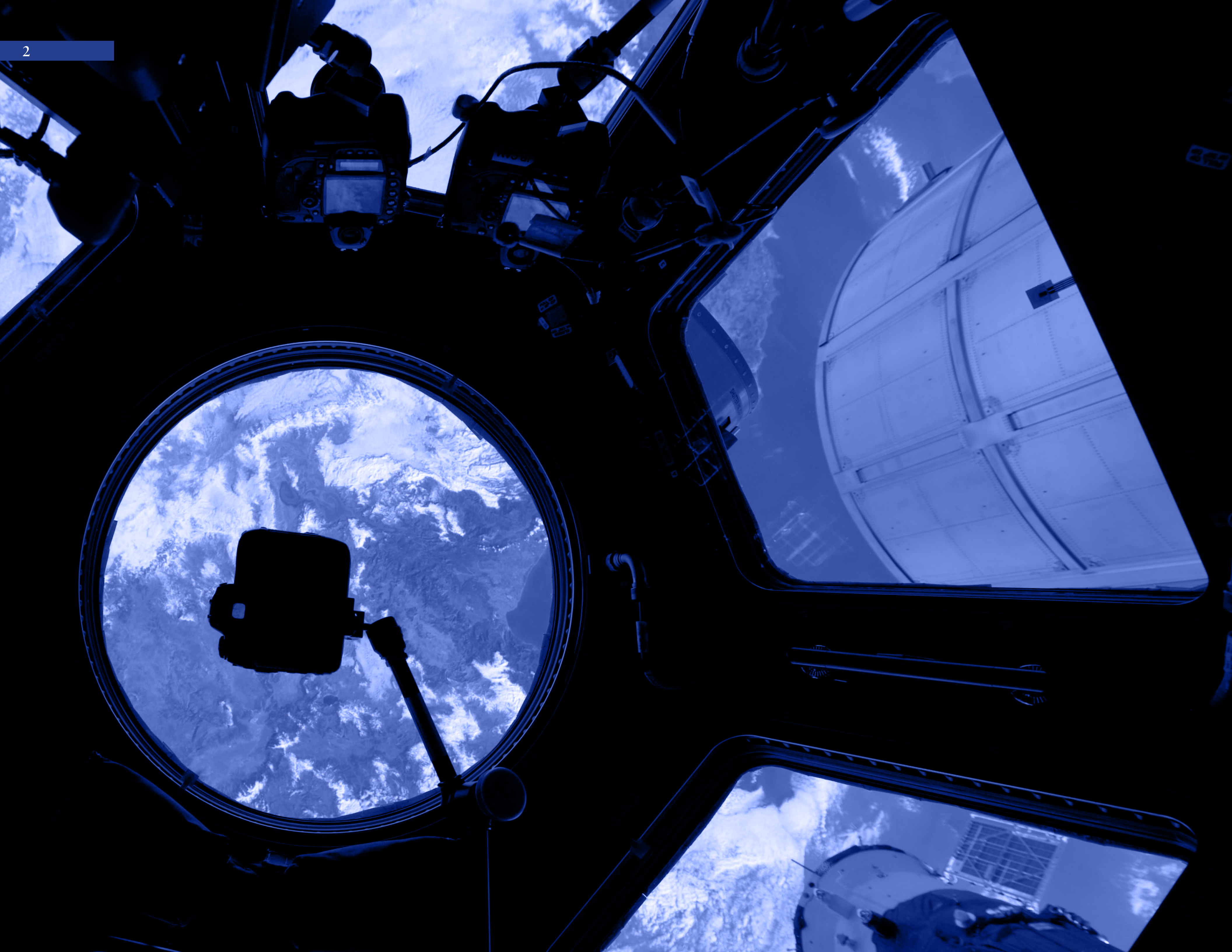

MATE: *Mobile Assistant for Task Execution*

kairos |ˈkaɪrɒs| NOUN

the propitious moment for decision or action.

ETYMOLOGY: *Greek καιρός opportunity; weather.*

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INTRODUCTION

EXECUTIVE SUMMARY

As the Space Shuttle era ends and NASA shifts its focus to the exploration of near-earth objects and beyond, new operational conditions will require crewmembers to perform their duties with increased autonomy. A software system that facilitates executing complex, scheduled tasks with minimal support from ground crew will be critical to the long-term success of such missions.

The goal of Team Kairos is to understand how crewmembers and ground crew communicate in different mission contexts to accomplish scheduled tasks, and to develop a mobile solution that facilitates and coordinates the completion of those tasks. Our work culminated in the generation of a working prototype that supports operations both on the International Space Station and future exploration missions.

PROJECT OVERVIEW

Our team was tasked with creating a mobile application for access to key activity execution support data. This mobile crew assistant is meant to integrate a set of tools necessary for a crewmember to fulfill his or her daily tasks. In the spring, we explored, brainstormed, and gathered ideas to assist with setting and understanding the scope of our project. In our final semester, we stepped through multiple design and development iterations of our mobile application.

USER EXPERIENCE DESIGN GOALS

Working from the spring semester's research and analysis, we combined our findings with relevant usability guidelines in human-centered design in order to develop the following user experience goals. As we progressed through multiple cycles of iteration, these fundamental principles guided the development of each prototype, insuring that the user's best interests were never far from our thoughts.

- Support crewmember autonomy
- Reduce ground crew uncertainty
- Make activities easier to execute
- Prevent user frustration
- Encourage a bond between user and device
- Provide shallow and intuitive navigation

DESIGN PROCESS

We developed a series of prototypes by gradually increasing the fidelity of each successive prototype and making changes elicited from user feedback. Beginning with paper sketches, we moved to an interactive PDF, a functional (but visually unstyled) iOS prototype, and finally a fully-designed iOS prototype. We grounded our feature selection and design decisions on our primary and secondary research from the spring semester. We designed and conducted four rounds of usability testing to evaluate our prototypes on many criteria, including ease of use of and the memorability of the system's features.

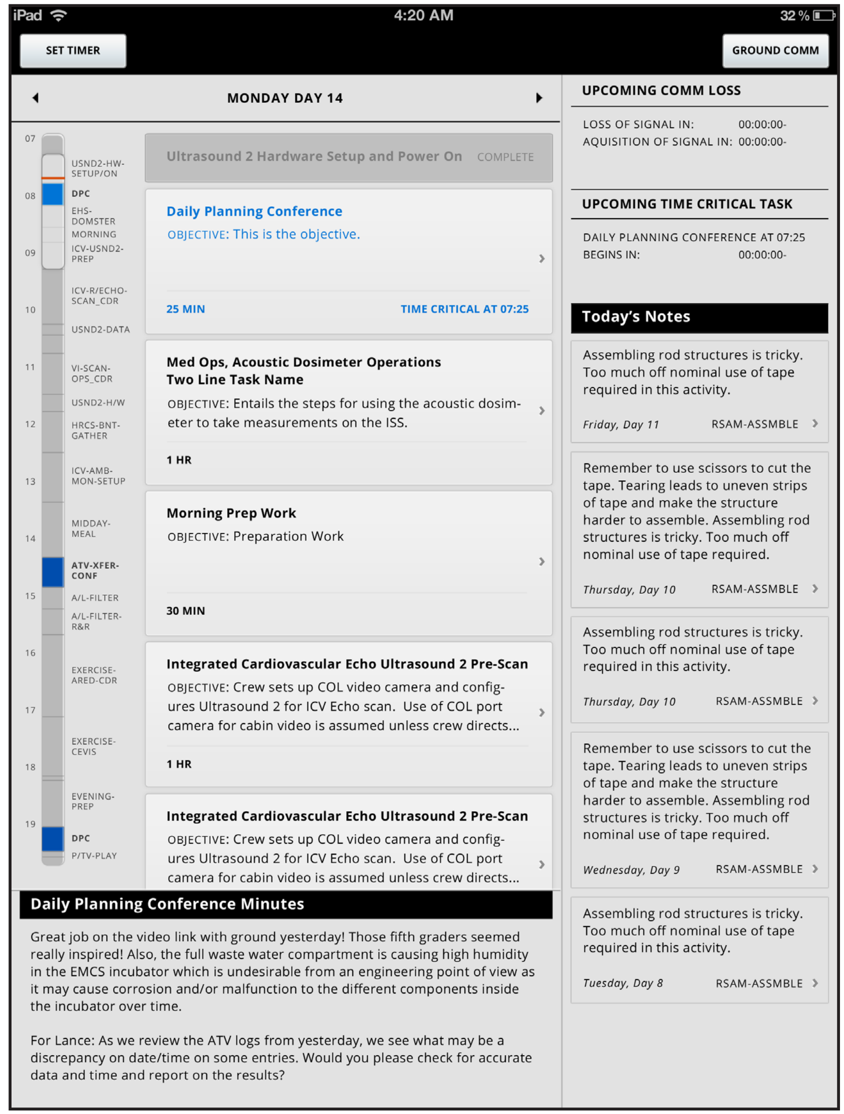
SOLUTION

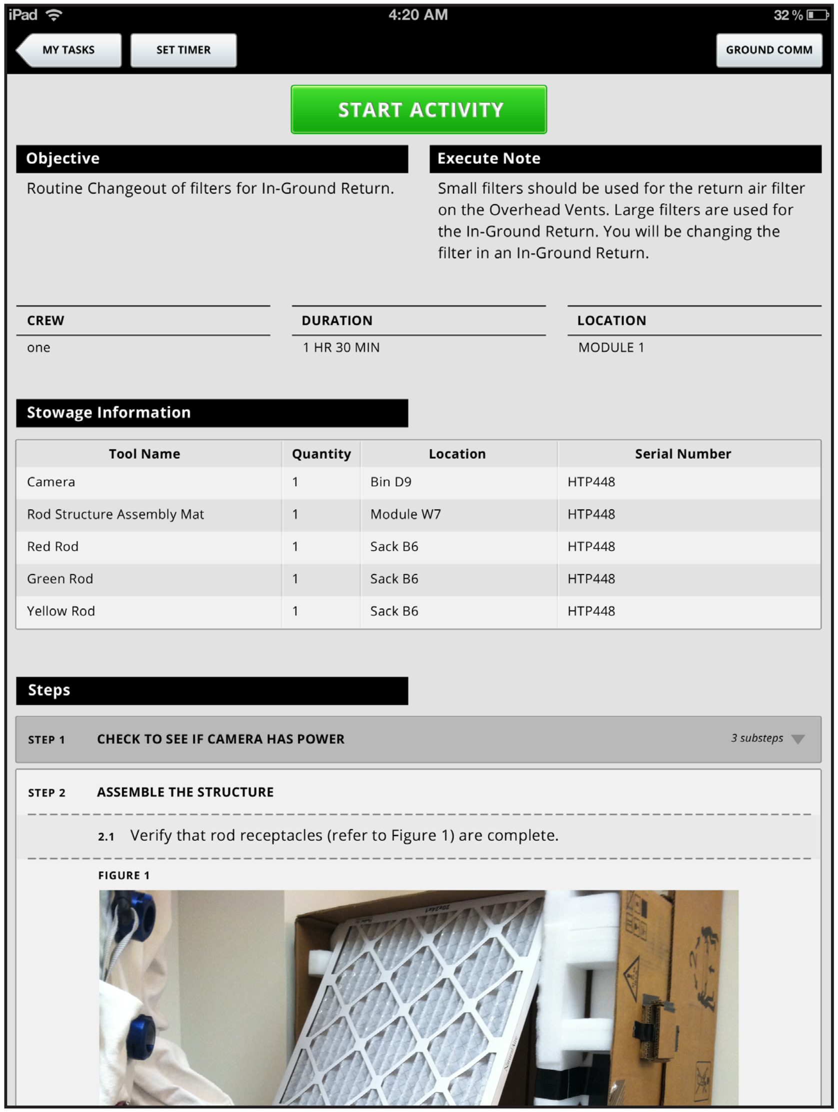
The culmination of our process is the Mobile Assistant for Task Execution, or MATE. MATE presents four key features: the crewmember's list of daily activities (the "home view"), a dedicated activity view for each activity (the "activity view"), persistent notetaking, and a ground communication panel.

MATE

HOME VIEW

The home view gives a crewmember an overview of his or her day as well as relevant contextual information—including recent notes, scheduled lapses in communication, and the most recent daily planning summary.



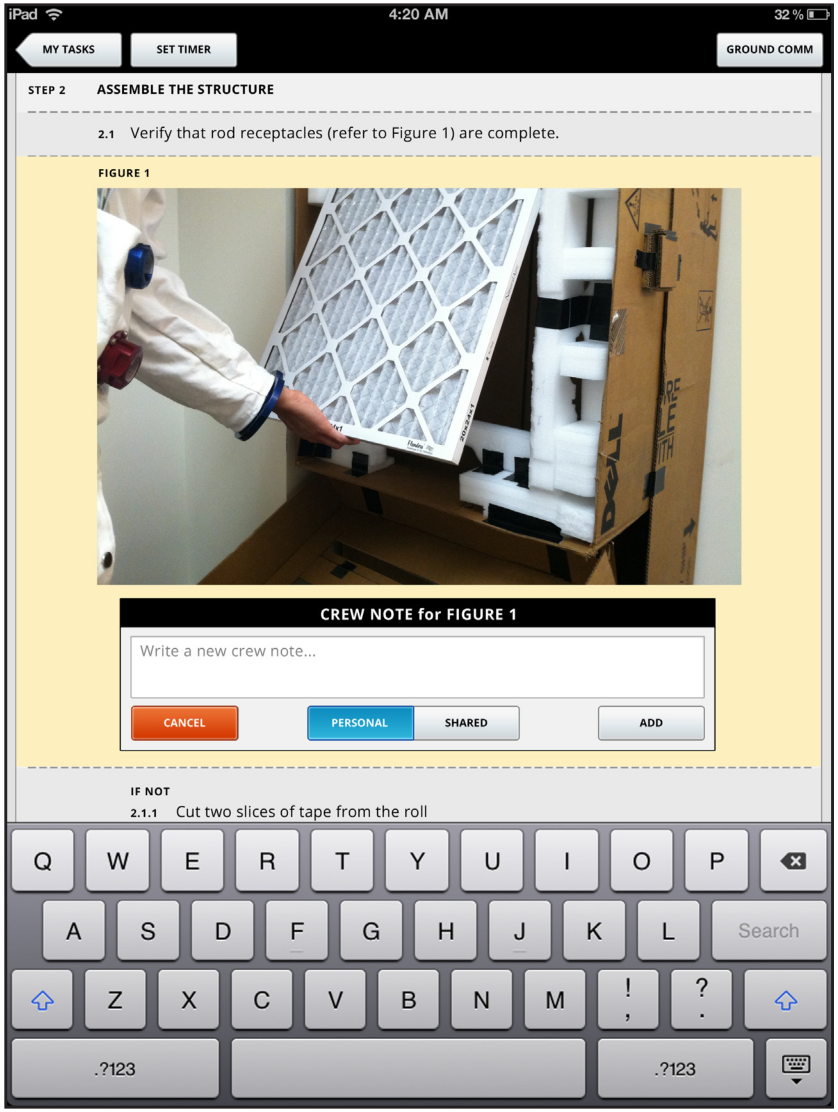


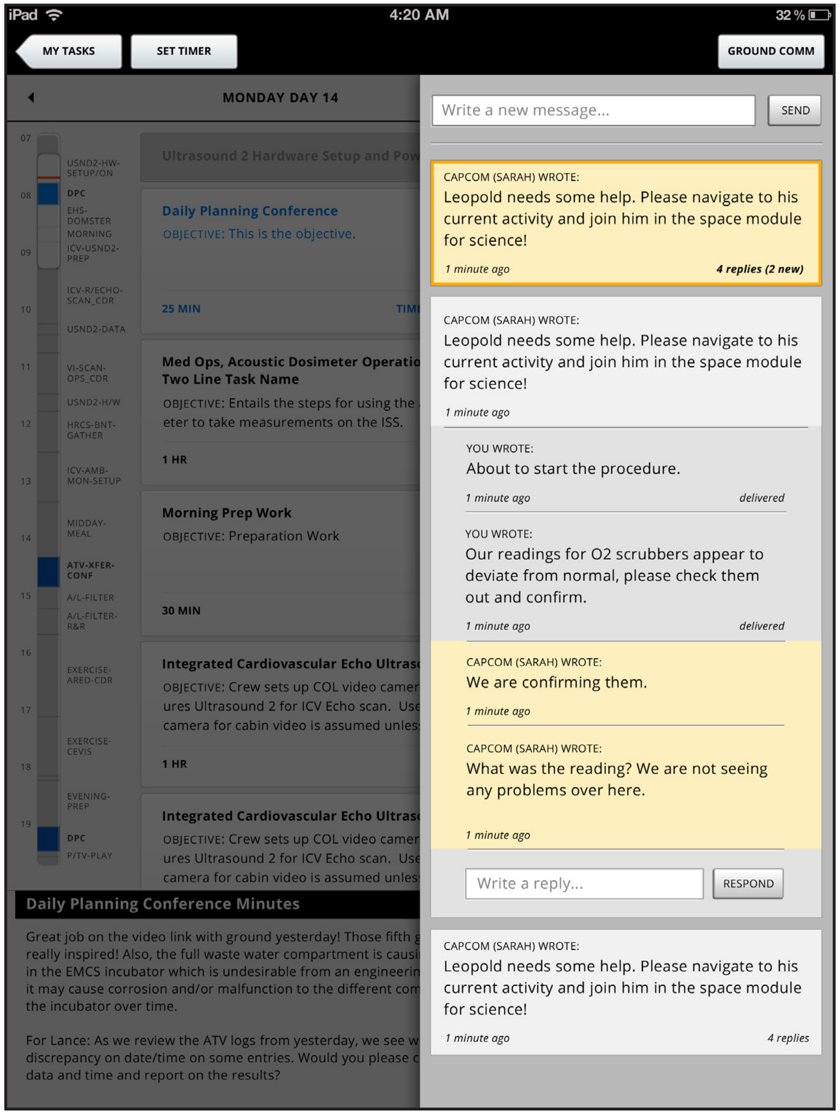
ACTIVITY VIEW

The activity view provides the crewmember with all of the information needed to execute a scheduled activity. Features such as progress-marking and step folding help reduce cognitive load during execution, while a built-in timer helps the crewmember stay on schedule without feeling rushed.

NOTETAKING

The notetaking interface lets crewmembers create persistent notes for long-term communication and later use. On the home view, crewmembers can record notes and reminders on the entire day. On an activity view, crewmembers can author notes about a specific step for their own use or make a shared note for other crewmembers to see.





GROUND COMMUNICATION

Ground communication, a text-based message center, allows crewmembers and ground crew to communicate with one another asynchronously. Non-intrusive visual notifications also inform crewmembers of incoming messages.

BACKGROUND

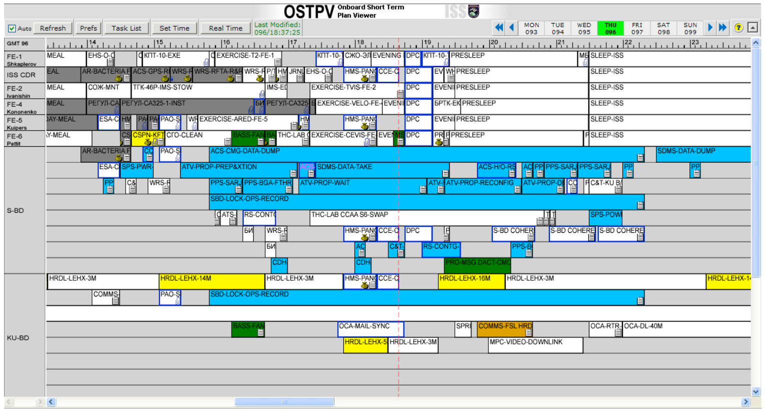
PROBLEM BACKGROUND

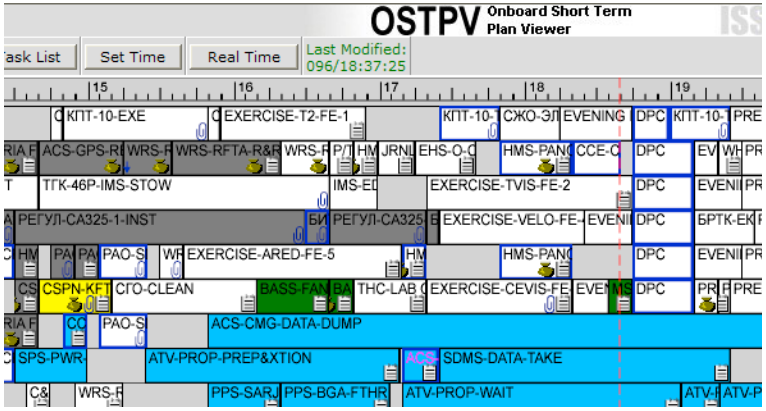
The primary schedule-viewing tool currently aboard the International Space Station (ISS) is the Onboard Short-Term Plan Viewer (OSTPV). It allows crewmembers to view their daily schedules as well as the schedules of other crewmembers and ground crew. This tool operates alongside a procedure and inventory viewer, Integrated Viewer (IView), such that crewmembers can jump directly from a scheduled activity to specific instructions and inventory requirements for that activity. Each activity contains zero or more referenced procedures. Procedures are currently stored as either Microsoft Word or XML files, and inventory stowage locations are stored in the Inventory Management System, with procedure-specific tool locations authored in the Automated Stowage Note tool.

NASA has prototyped mobile crew assistants in the past. A mobile version of Score—a planning tool developed at Ames Research Center—was used in NEEMO, NASA's underwater analog mission, in 2011. Mobile Score, later known as NASA Playbook, is a web application which presents a mobile-centric version of OSTPV's content.

Although NASA Playbook provides a mobile schedule viewer, it does not significantly reimagine the presentation of procedure data, nor does it introduce new functionalities that support task execution. We have therefore focused the majority of our efforts in these areas.

1. Aquanaut 1 interview, p. 94, ln. 28, Research CD Appendix

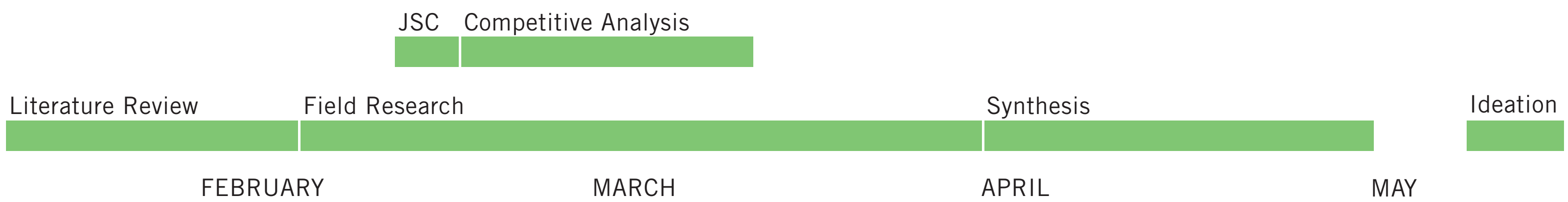




"If I wanted to know what task I was supposed to be doing right now, that actually took a bit of work [...] it's super compressed on the timeline and it just—there were a lot more buttons on this thing than you needed" [1].

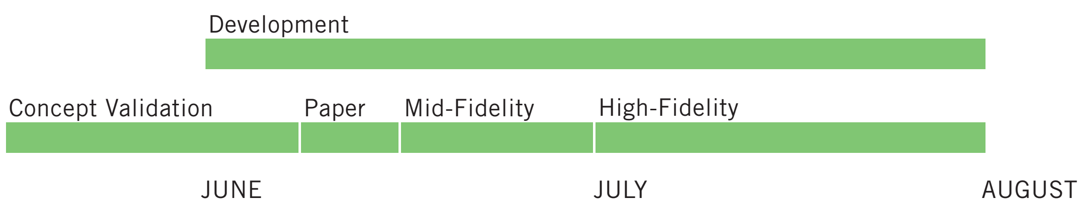
SPRING SCHEDULE

In the spring, we conducted research, including interviews and contextual inquiries in analogous domains.



SUMMER SCHEDULE

In our summer semester, we worked on the design and development of our prototype.



FIELD RESEARCH

SPRING 2012 RESEARCH

To ensure that our ultimate design addresses the complex problems of procedure execution and meets our users' true needs and desires, we gathered data to discover these criteria and guide the design process. Because of the difficulties inherent in speaking with crewmembers, much of our research focused on studying analogous domains in which complex procedures are regularly executed. Our field research in the spring included observation at Johnson Space Center, three contextual inquiries in analogous domains, five semi-structured interviews with key stakeholders, and enlightening conversations with former crewmembers.

FINDINGS

After conducting, analyzing, and synthesizing our research, the data revealed several salient themes across all domains. Considerations acknowledged unique contextual elements or constraints of the domain, while insights provided actionable opportunities.

CONSIDERATIONS

- In high pressure operations, staff must provide assertive direction and moral support
- Future missions must account for intermittent ground–crewmember communication
- Inventory management issues can delay procedure execution
- Individual crewmembers read and understand procedures at varying degrees of granularity

INSIGHTS

- Critical contextual information should not be obscured by items of less immediate concern
- Methods that encourage memory recall can support consistent procedure execution
- Existing procedure support systems do not prioritize users' most pressing needs
- Instructive systems should not make superfluous demands on users' cognitive load

CONCEPT IDEATION

At the end of our research process, we commenced a series of brainstorming activities where we generated over fifty possible solutions. Later on, these were refined based on speed dating and card sorting activities held with our clients and other NASA employees. These concepts were vetted against our findings from research.

CONSIDERATIONS

In high pressure operations, staff must provide both assertive direction and moral support

In any field that differentiates between "on-stage" and "off-stage" operations, tensions can arise between those who do and those who plan. The success of human-to-human communication and support systems rely heavily on a delicate balance of cultural factors and considerations. Although ground is there to provide crewmembers with necessary information, psychological support becomes crucial during stressful operations. Conversely, ground must also know when crewmembers are able to be interrupted or even criticized.

Future missions must account for intermittent ground–crewmember communication

As crewmembers travel further away from Earth, they can no longer expect the near-instant communications they currently enjoy. Instead, delays of up to twenty minutes may become commonplace for missions to a near-earth asteroid or beyond. NASA's current systems are tailored for near-instant communications, though analog missions have experimented with procedure execution under both communication delay (in which a data connection is constant, but significantly delayed by distance) and intermittent communication (in which no connection can be made from the station's current position). Both cases present a problem when dealing with tasks that require constant ground support to be executed properly.

Inventory management issues can delay procedure execution

Crewmembers benefit from an inventory management system that provides support for navigating through the large volume and types of tools available on ISS. However, problems may arise when needed parts are not readily accessible during procedure execution. Problems in finding, replacing, and accounting for the right tools for each specific procedure can increase frustration.

Individual crewmembers read and understand procedures at varying degrees of granularity

Crewmembers have a variety of prior experience—from pilots to chemists to doctors to teachers. NASA chooses crewmembers who understand the considerations and challenges associated with scientific research in space. These crewmembers are trained on skills, not the ability to execute a specific procedure. NASA relies on detailed procedures on missions to provide the reference tools and instructions necessary for any crewmember to complete any task; however, given the wide variety of background knowledge crewmembers can have, these procedures are read and understood at different levels of granularity. Sometimes they will only glance at it briefly; sometimes they will not use it all.

INSIGHTS

Critical contextual information should not be obscured by items of less immediate concern

In both OSTPV and in Mobile Score, crewmembers are presented with a large-scale view of task execution. These views include information about tasks that are not scheduled to occur for several hours, and they often obscure the tiny sliver that may represent their current task. Similarly, in IView, crewmembers are presented with a large level of detail for the entire length of a procedure. These details often obscure important notes involving how procedures should be executed. Because crewmembers are generalists in their training and procedure knowledge, systems should be adapted to make scheduled tasks and procedures as easy to follow as possible, even taking into consideration the varying level of complexity. The current systems prioritize the availability of data over user focus, which can have a detrimental effect on procedure management by users.

Methods that encourage memory recall can support consistent procedure execution

Industries such as aviation, surgery, theater, and nuclear power have been known to use a formalized checklist system in order to prevent errors and bring a routine to checking pre and post task. In our research with surgeons, we discovered that nurses read off the inventory of the supplies before and after each operation as a matter of routine to ensure that no tools or supplies had been lost in the process. Likewise, stage managers also use checklists. Stage managers and backstage crew have checklists that are created, modified, then followed, ensuring that all the crewmembers have their necessary props and tools. Additionally, the stage manager uses a “prompt book” to annotate specific occurrences as they happen on stage, and these notes are solidified by creating a revised prompt book. This new book is essentially a set of procedures used as a guide by the actors and crew to guide the remainder of the performances.

Existing procedure support systems do not prioritize users' most pressing needs

As the experiences of crewmembers increase our knowledge of how humans adapt to space and advances in technology open doors to novel ways of supporting them, NASA must make important decisions on how to incorporate these elements into their operations. The accelerating pace of technology, crucial partnerships with commercial space flight companies and a focus on targets increasingly distant from earth promise to fundamentally alter the way operations and procedures are executed. Existing models may need to be drastically altered, and emerging insights from crewmembers will need to be captured, evaluated, and implemented quickly and efficiently in order to maintain nominal operations in light of these constantly changing criteria. Going forward, the need for crewmembers to communicate effectively and operate independently will only increase.

Instructive systems should not make superfluous demands on users' cognitive load

Crewmembers have a lot on their minds during operations. From their scheduled tasks to unexpected circumstances to the necessities of everyday life, there are a multitude of concerns competing for their attention. Ideally, support systems like OSTPV and IView would produce next to no additional demand on crewmembers' attention, conveying their schedule and procedure information instantly and with complete clarity. There are specific areas in which existing software can be changed or improved to lessen their imposition on cognitive load. At both the smallest and largest scales of the software— the procedure instructions and the overall window and UI structure—fundamental improvements can be made so that crewmembers can dedicate their entire minds to the tasks at hand, rather than to their instructions.

USER EXPERIENCE GOALS

We embodied the following user experience goals throughout our design process:

PREVENT USER FRUSTRATION

One of our earliest inspirations was a video of ISS crewmember Garrett Reisman expressing frustration at the control OSTPV held over his life—bemoaning that “the bars,” in reference to a persistent Marcus Bains line throughout OSTPV, never stopped. A Marcus Bains line refers to the line in an appointment book representing the current time of day, or in this case, the red line that moves throughout the crews’ schedule to show their current time. From experiential complaints like this to simply creating a stable system that would not crash on users, easing frustrations is especially important to do for people in high-stress situations.

Supporting Insights:

- All insights—each of our insights involve user frustration to some extent

SUPPORT CREWMEMBER AUTONOMY

Current tools and practices rarely experiment with giving the user more control over his or her daily schedule, though this will be a crucial element in future missions.

Allowing crewmembers to have more control over their personal schedules is not only an important consideration for future space exploration missions, but a fundamental human consideration. Whether they desire more autonomy in performing their technical tasks or simply want to feel more in control, this is one of the most important psychological factors to consider in an assistive system. Our primary challenge has been striking a balance between allowing the crewmember the freedom to do as they see fit and implementing the necessary restrictions required for ground crew to know what is transpiring during the mission.

Supporting Insight:

- Existing procedure support systems do not prioritize users’ most pressing needs

MAKE ACTIVITIES EASIER TO EXECUTE

Making clearer, more visually distinct execution instructions both makes for a more pleasant experience and requires less of the crewmember’s precious attention. This would be created through introducing a language of visual hierarchy, adding support tools, and generally creating a more pleasant experience. In fact, the aim was for the user to notice more of what they were working on and spend less time and attention on figuring out the application’s interface itself.

Supporting Insights:

- Critical contextual information should not be obscured by items of less immediate concern
- Instructive systems should not make superfluous demands on users’ cognitive load

REDUCE GROUND CREW UNCERTAINTY

Ideally, the system should balance the cost of interrupting the crewmember's day with the importance of keeping the ground crew up to date on what is currently happening.

As mentioned previously, allowing crewmembers more freedom during their missions endangers ground crew awareness of their crewmembers' activities. Ground crew is accustomed to constant communication availability with crewmembers and expect to be updated on their progress throughout the day. We must ensure that giving autonomy to crewmembers does not detract from the ground crew's comfort, nor their ability to do their job. We strove to give ground crew as much information as possible with only minimal direct input from crewmembers.

Supporting Insight:

- Methods that encourage memory recall can support consistent procedure execution

ENCOURAGE A BOND BETWEEN USER AND DEVICE

As users grow accustomed to personal electronic assistants in general, the use of familiar systems in space remains key.

To truly create a viable assistant, the user must feel comfortable with the device, including feeling a certain degree of ownership. Our application should strike a balance between the existing systems and the HAL 9000 of *2001: A Space Odyssey* fame, being neither an impersonal brick nor an authority figure. Crewmembers should feel comfortable using their MATE from training through successful mission execution.

Supporting Insight:

- Existing procedure support systems do not prioritize users' most pressing needs

PROVIDE SHALLOW AND INTUITIVE NAVIGATION

The user's location within the application should always be immediately apparent. Given the cognitive load demanded of crewmembers in executing complex activity procedures, we should aim to keep the application's navigation and use as intuitive as possible.

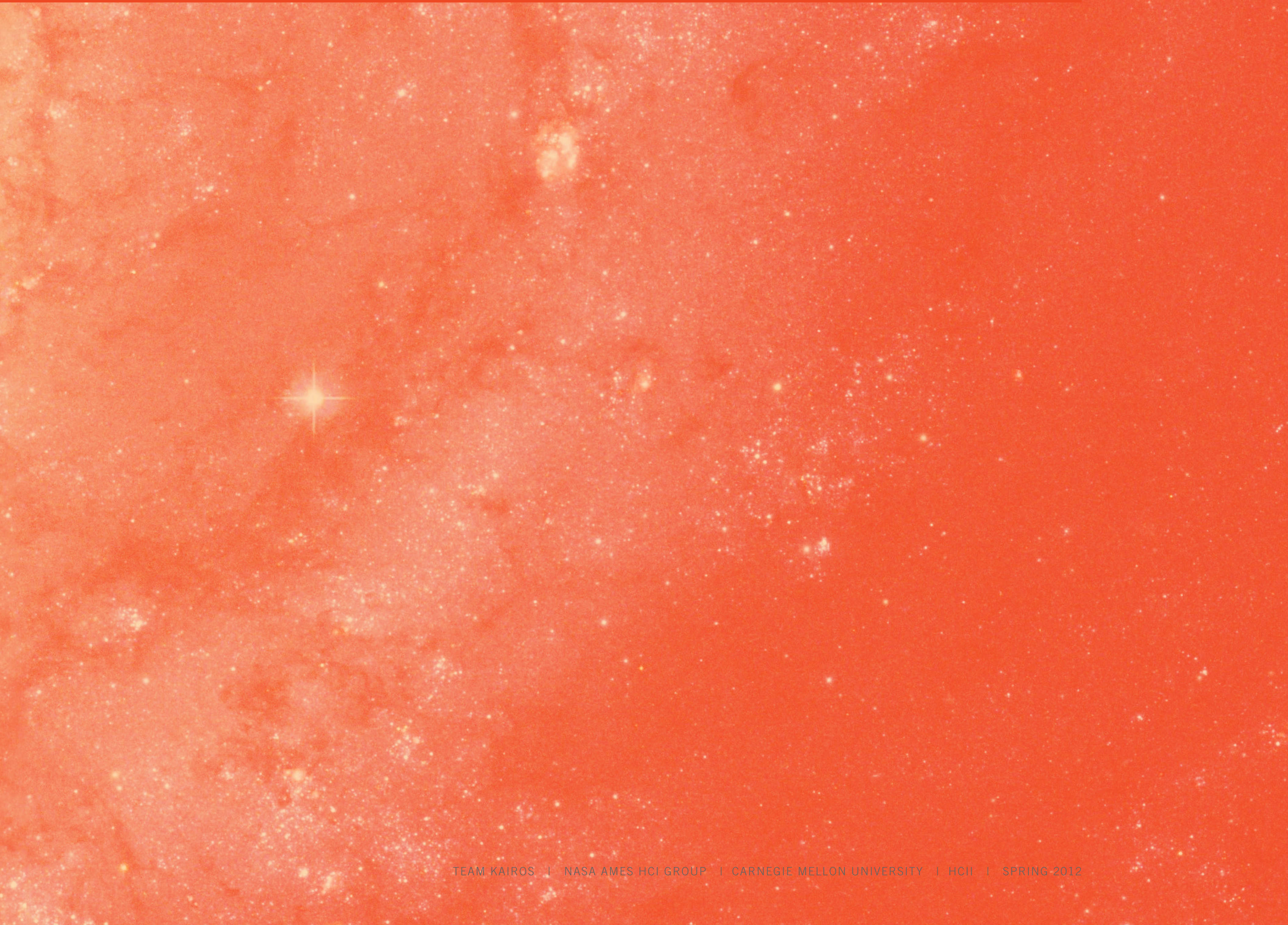
Throughout development, we purposely strove to limit the complexity of our application by keeping its navigation shallow. The user is required to change screens only when switching activities, and all application-wide functionality takes the form of slide-out drawers or popup menus to reinforce the notion that the user has not navigated away from his or her current screen.

Supporting Insight:

- Instructive systems should not make superfluous demands on users' cognitive load

Please refer to the Spring Report 2012 for more detailed information on our findings.

SOLUTION



OVERVIEW

Drawing from our spring research, we designed and produced the Mobile Assistant for Task Execution (MATE). This application combines elements of two existing NASA tools, the Onboard Short-Term Plan Viewer (OSTPV) and the Integrated Viewer (IView).

It builds upon the existing conceptual model of ***a schedule-oriented primary navigation screen from which users access individual activities and their procedures, but also examines concepts absent from existing NASA systems including a view focused on individual schedules, inline notetaking, and an integrated ground communication panel.*** *It allows crewmembers to easily understand the time constraints of their schedule without burdening them with less-relevant details. Overall, it presents a schedule- and activity-viewing experience that is quickly familiar in content and style to NASA, while still exploring new concepts in data presentation and interaction.*

KEY INTERACTIONS

Arising from both our spring research and iterative development over the summer, these features represent the core functionality that offers the most critical support to crewmembers. As our prototypes progressed, they remained the primary focus of our developing and testing cycles.

HOME VIEW

Reimagining the swimlane-based schedule as a task list brings a user's most relevant information forward, not obscuring the most pressing information while also allowing the user to browse through activities at will.

The home view presents the crewmember's daily activities as well as information such as the activity objective, duration, time criticality, and place in a sequence. An adjacent vertical timeline shows an overview of a crewmember's entire day and doubles as a secondary scrollbar. From this view a user can also leave a note for themselves in a sidebar.

Supporting Insight:

- Critical contextual information should not be obscured by items of less immediate concern

ACTIVITY VIEW

Visually distinguishing steps in a procedure and allowing completed steps to be minimized greatly increases the legibility of procedures. Our system allows notes to surface precisely where they are most relevant. Simplifying the informational hierarchy of procedures ensures that users can see what they need quickly and easily.
The activity view is at the heart of our solution. While leaving the text of procedures intact, we have restructured how this data is represented. The activity view has consolidated information that makes use of a grid structure, buttons to indicate starting and finishing an activity, and expandable / retractable steps.

Supporting Insights:

- Critical contextual information should not be obscured by items of less immediate concern
- Methods that encourage memory recall can support consistent procedure execution
- Instructive systems should not make superfluous demands on users' cognitive load

NOTETAKING

As in analogous domains, better notetaking can serve as a valuable method of memory cuing for crewmembers.

In an activity page, crewmembers can tap a button to associate a note with any substep; they then proceed to author the note in its proper place in the substep. These notes will then appear any time that crewmember returns to that activity in the future, should they leave the default setting of "personal." If the note is marked as "shared", this note will be accessible to all other crewmembers as well.

Supporting Insight:

- Methods that encourage memory recall can support consistent procedure execution

GROUND COMMUNICATION

By enabling easier communication with Ground, better information can be gathered and applied towards improving future procedure execution. A formalized system of task feedback will establish healthy communication practices, especially as communication delay comes into play.

The ground communication panel allows crewmembers to stay in touch with ground crew without the overhead or instantaneous nature of a voice loop. While the existing system requires effectively a phone call between crewmembers and ground crew, our system allows crewmembers to send a message to ground crew from anywhere their mobile device may be; ground crew can then respond as necessary. Drawing from our spring research, we opted for text-based communication for pragmatism—it is viable even under communication delay—and simplicity—it is easier for a crewmember to organize his or her thoughts in text than through voice.

Supporting Insights:

- Methods that encourage memory recall can support consistent procedure execution
- Existing procedure support systems do not prioritize users' most pressing needs

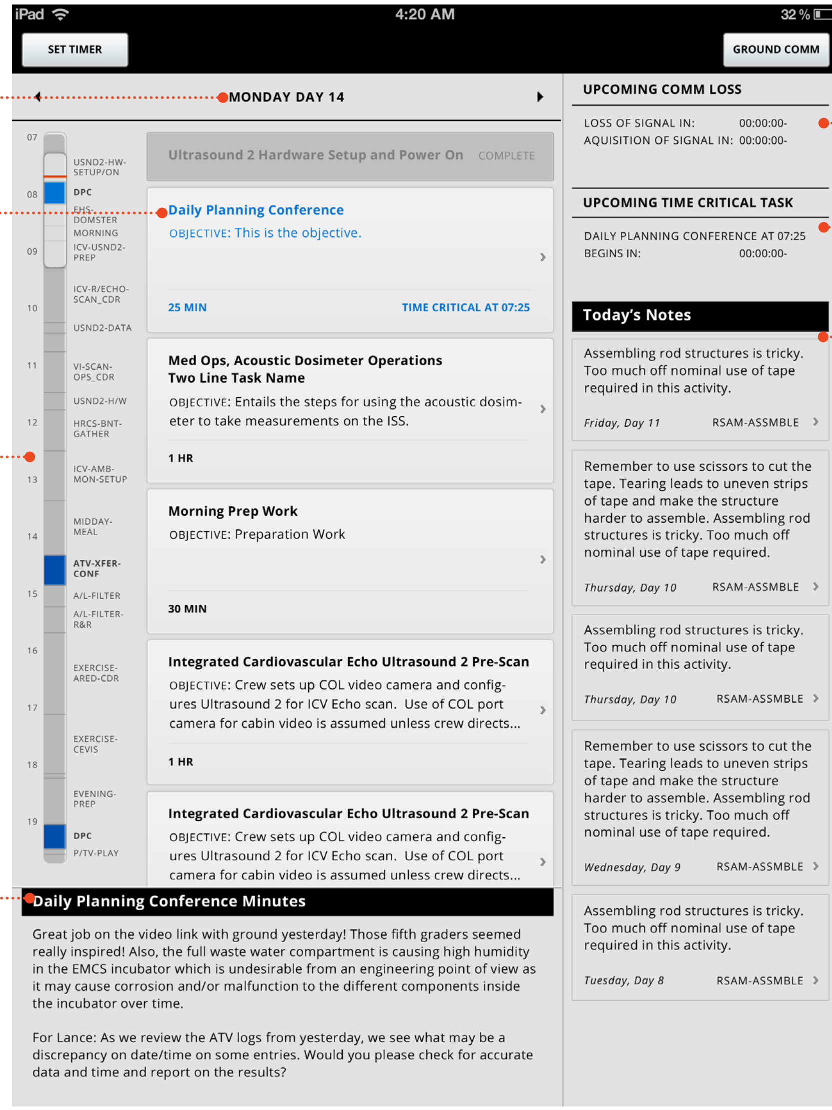
HOME VIEW

A date picker allows the user to select another day to view.

Selecting an activity takes the user to the activity screen.

A timeline indicates the duration of each task during the day. Scrolling on the timeline scrolls the task list to the top of the view.

Daily Planning Committee minutes are at the bottom of the screen.



For quick reference, these indicate the next time critical activity and comm loss.

Displays general notes taken by the crewmember.

ACTIVITY VIEW

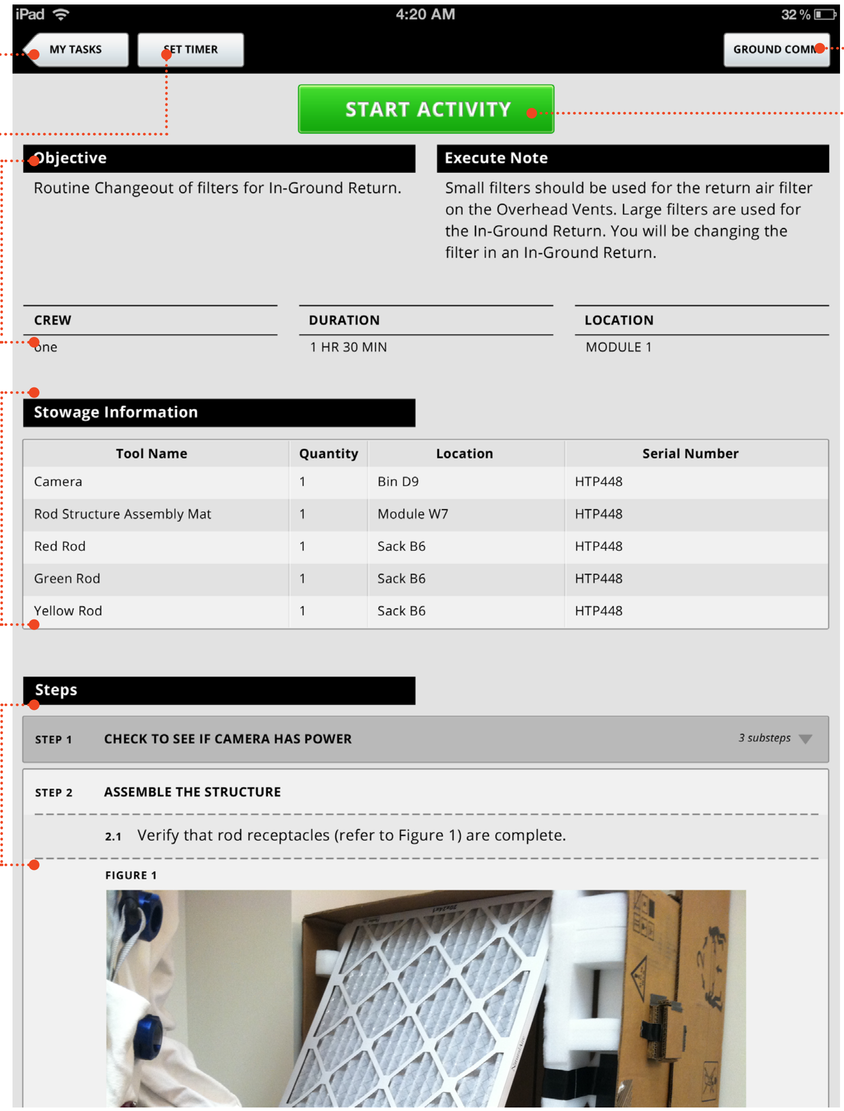
Button takes user back to the home view.

Opens the timer.

Supplementary activity information.

Provides location and serial numbers for tools and parts needed in this activity.

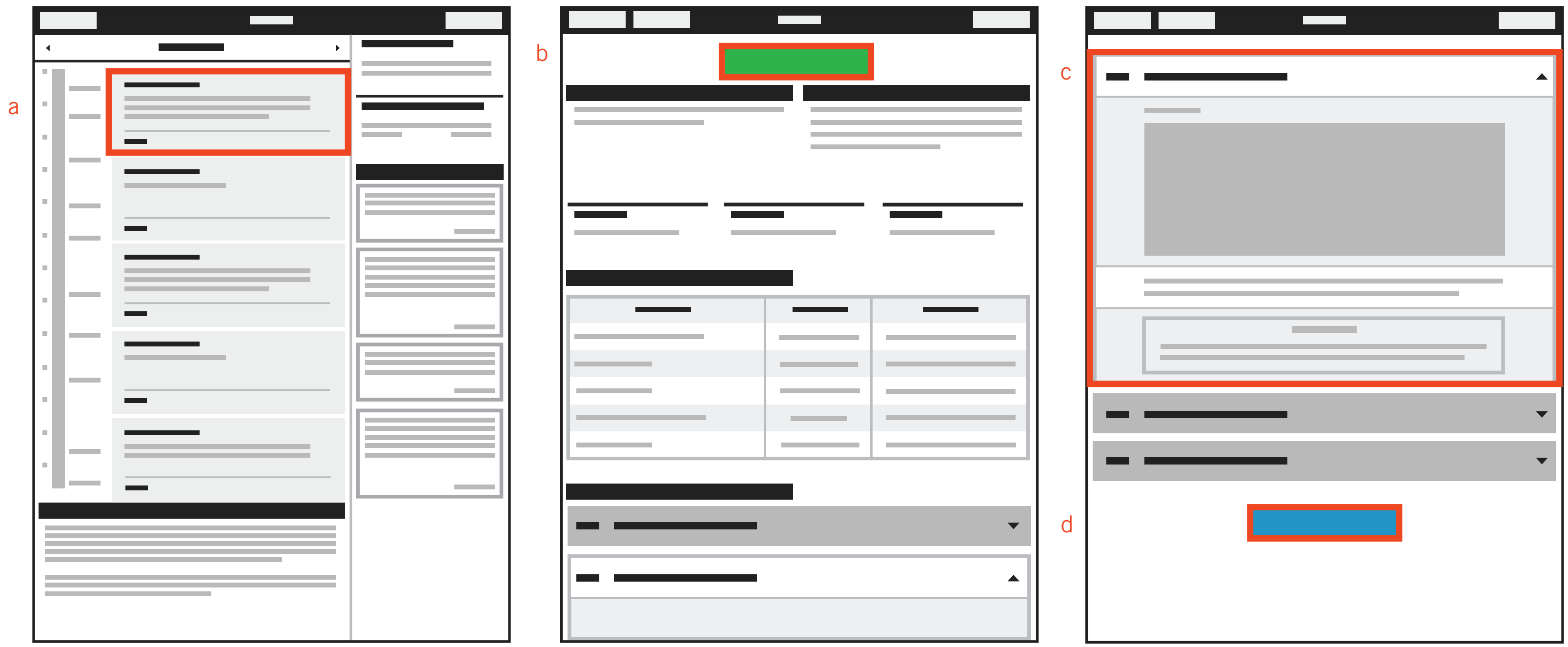
Tapping a step opens substeps.



Opens ground comm.

Tapping the Start Button changes it to Pause. This communicates to ground that the user has started the activity.

ACTIVITY EXECUTION WORKFLOW



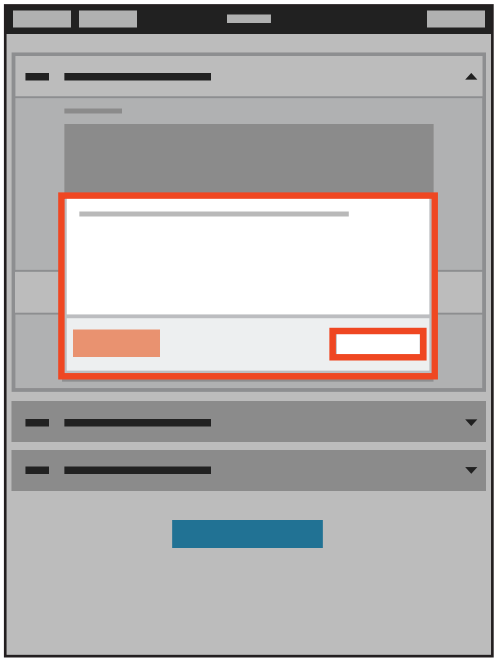
a. The crewmember taps on a task to open the activity.

b. The crewmember taps the Start Activity button to communicate to ground that they have begun the activity.

c. The crewmember taps on a step to expand the substep. He or she proceeds through the activity, opening subsequent steps.

d. When finished with the activity the crewmember taps on the Finish Activity button.

e



f

g

e. In a pop-up, the crewmember can leave feedback about the activity, or can choose not to leave feedback.

f. The crewmember taps continue and finish button to confirm he or she has finished the task.

g. The user is brought back to the home view, where the activity is now greyed out and marked as complete.

NOTETAKING WORKFLOW

a. The crewmember taps on a step to highlight it.

b. The crewmember taps the Add Note button to add a crew note to the step.

c

d e

f

c. The crew note text field appears, and the crewmember writes a note.

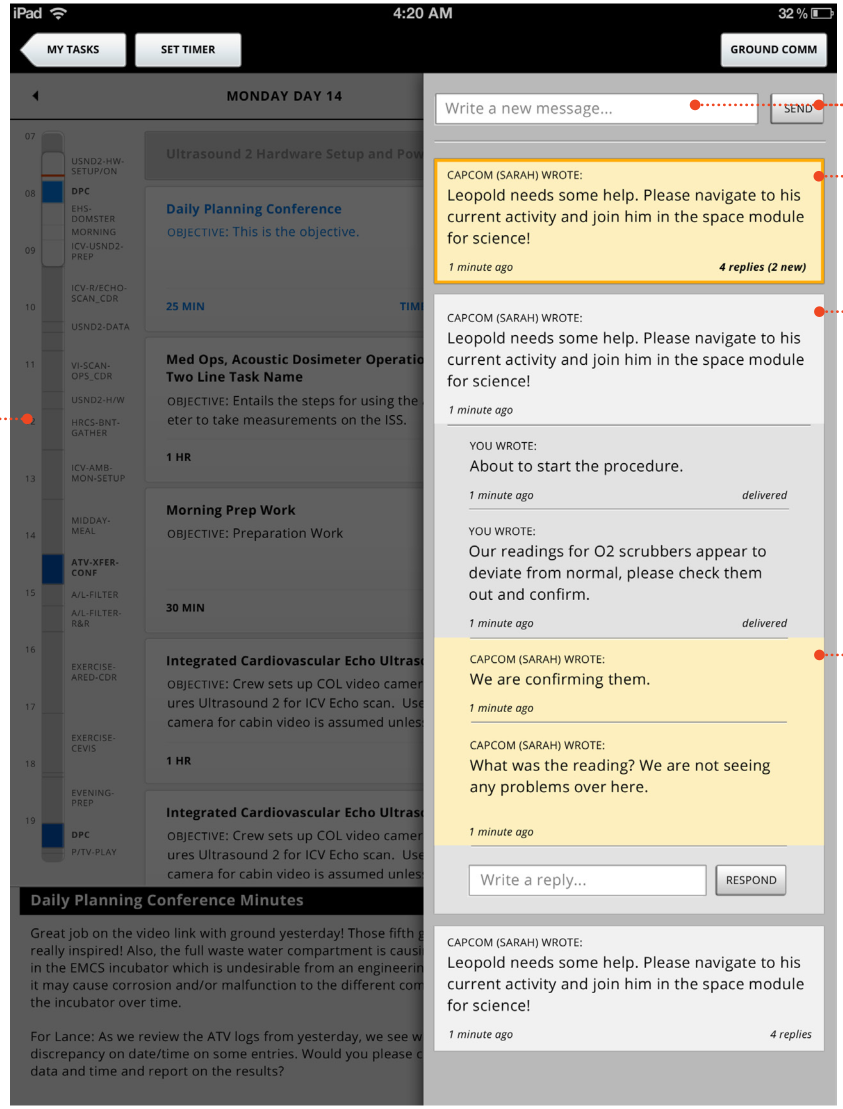
d. The crewmember chooses to marks the note as either personal or shared.

e. The crewmember taps the Add Note button to finish.

f. The note is attached to the activity step for future reference.

GROUND COMMUNICATION

Items underneath the ground comm panel are inactive. Tapping outside of the ground comm panel closed the panel.



To write and send a new conversation.

An unread message or reply to a thread is highlighted.

Tapping the conversation opens it, with responses indented beneath the first message. Lighter messages are from ground and darker messages are from the user.

The unread messages in the thread are highlighted.

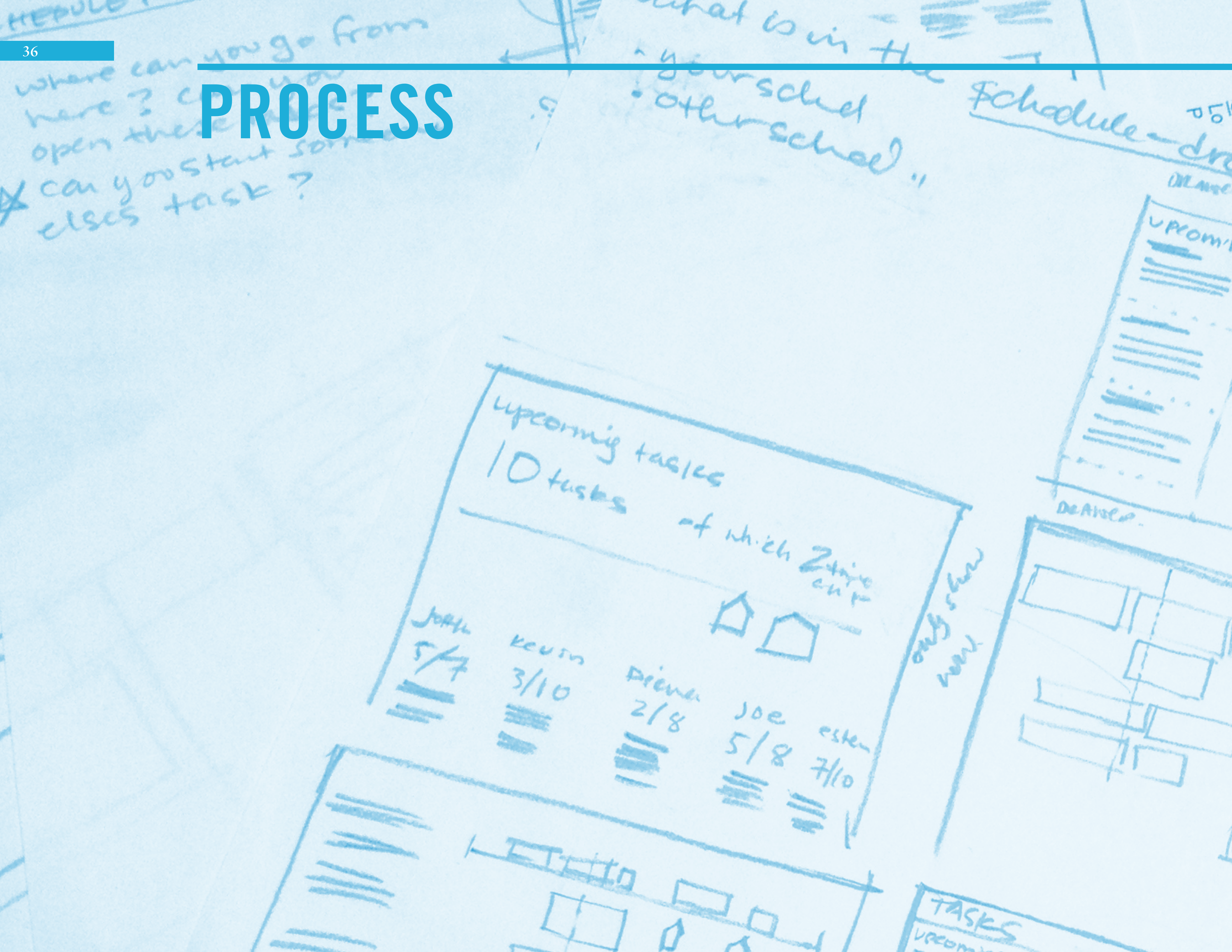
TECHNICAL DOCUMENTATION

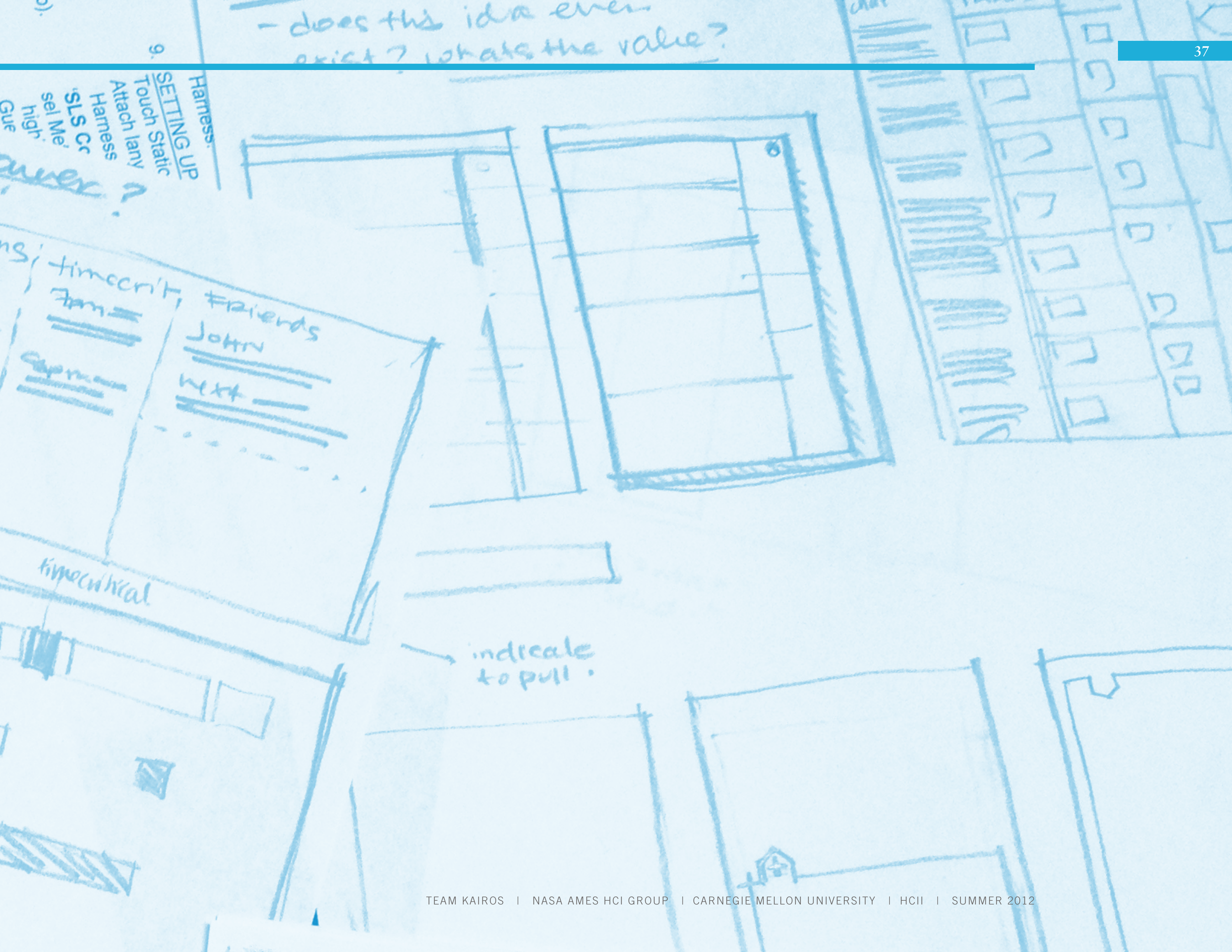
Because the development of this prototype involved technical choices that may be instructive to future project teams, we included a description of those choices here.

We implemented MATE as a native iPad application. We chose iOS early in our design process after rejecting a more reusable, web-based application for a number of reasons. For instance, prototyping would be faster with full use of native iOS interactors and Xcode features since users would experience fewer surprising responses to incompletely-architected UI element behaviors. Also, as we were uncertain of which device hardware features we might use in our final design, we wanted to ensure we had access to the full range of the device's hardware.

There is a web-based ground communications panel that provides those running usability tests the ability to communicate with the user's iPad via the ground communication panel on the application. The ground communication server is a VPS hosted on Linode, running Ubuntu. We used the Django framework to write the software that manages and saves the communication to a PostgreSQL database.

PROCESS


where can you go from here?
can you start someone elses task?
upcoming tasks
10 tasks
of which 2 . . .
only show new.
kevin
3/10
2/8
joe
5/8
7/10
Schedule
TASKS


- does this idea even exist? what's the value?
SETTING UP
Touch Static
Attach lany
Harness
Friends
John
timecritical
indicate to pull.

OVERVIEW

Our research served as a framework for iteratively building and testing design concepts. The design and development of our prototype took place over four iterative rounds, each at increasing levels of fidelity. We practiced user-centered design methodologies, which included a constant focus on crewmember needs via our user experience goals, early and continual testing, and iterative design and development. Usability testing, evaluation, and collaborative design refinement were employed at all stages, although the exact methods employed varied with each prototype. Some of the methods employed included brainstorming, card sorting, visioning sketches, rapid prototyping, and speed dating. Later iterations relied on expert reviews, think alouds, and an Operational Readiness Test (ORT). In order to maximize time and resources, technical implementation of the final prototype began early and continued in parallel to prototype testing, but was not fully implemented until later stages of testing.

From concept validation to the final Operational Readiness Test (ORT), we conducted usability testing sessions for each prototype and recorded the data for later review and analysis. This led to a process in which each iteration built upon the successes and failures of the last, allowing substantive changes to be made between rounds while still retaining the project's essential focus on activity execution.

Prototype 0	*Prototype 1*	*Prototype 2*	*Prototype 3*	*Prototype 4*
CONCEPT VALIDATION	PAPER PROTOTYPE	INTERACTIVE PDF	MID-FIDELITY iOS	HIGH-FIDELITY iOS
Speed Dating	Cognitive Walkthrough	Think Aloud Protocol	Think Aloud Protocol	Think Aloud Protocol
Card Sorting	Expert Review	with guided script	with one-session scenario	with two-session scenario
10+ participants	4 participants	4 participants	6 participants	3 participants

PROTOTYPE 0: CONCEPT VALIDATION

We began our design process by ***brainstorming over a hundred conceptual ideas*** *for our prototype. We narrowed the field down to fifty concepts, which* ***we tested using speed dating and card sorting techniques.*** *We conducted a workshop with members of the NASA Ames HCI Group, using this opportunity to validate our findings and uncover any unexpected opportunities.*

Concepts include:

- Drilling into information/ context at different levels
- Fold away skipped steps
- Other crewmembers' schedules are visually distinct from yours
- Consistent UI area for supplementary information, e.g. stowage, notes, images
- Crewmembers can embed rich media in activities
- Leave advisories for future crewmembers
- Notetaking transfers between training on earth and mission in space
- Task-based, not swimlane-based, procedures
- Less-regimented scheduling
- Time-tracking within procedures
- Gather time elapsed, feedback, inventory use, etc., to improve future procedures
- The device feels like it's yours
- System supports switching between users

TESTING

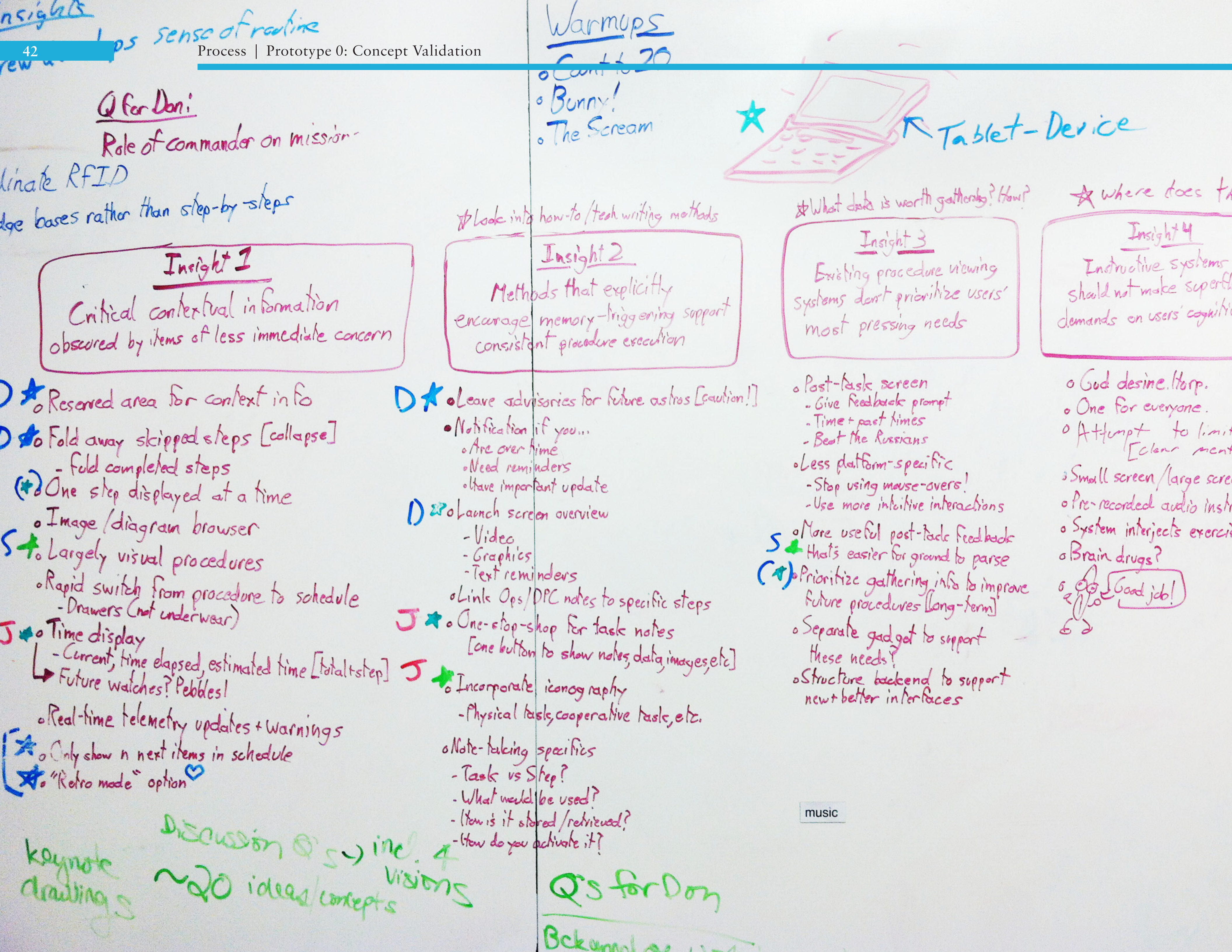
GOALS

After incorporating many concepts and designs from brainstorming, we presented them to our clients and some of our stakeholders in order to validate ideas and guide future iterations.

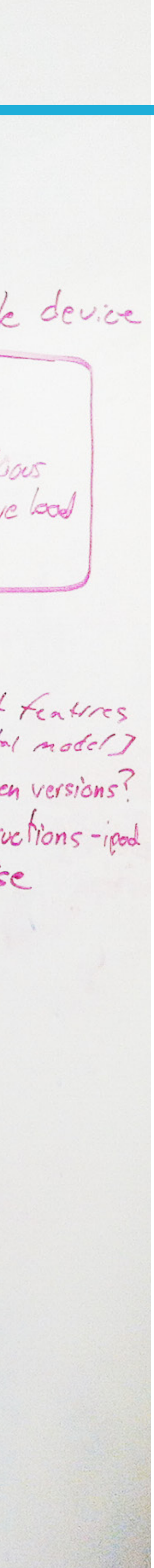
PROTOTYPE	METHODS	PARTICIPANTS
Concept Validation	Speed Dating Card Sorting	10+ members of the NASA Ames HCI Group

KEY FINDINGS

- Limit our focus to a handful of impactful, related features to avoid diluting our concept
- Focus on notetaking, activity viewing and other features that are neglected in current NASA software
- Incorporate concept validation ideas that have proved popular and feasible amongst our users



Warmups
Count to 20
Bunny!
The Scream
Tablet-Device
Q for Don:
Role of commander on mission
RFID
bases rather than step-by-steps
Look into how-to / tech writing methods
What data is worth gathering? How?
where does
Insight 1
Critical contextual information obscured by items of less immediate concern
Insight 2
Methods that explicitly encourage memory-triggering support consistent procedure execution
Insight 3
Existing procedure viewing systems don't prioritize users' most pressing needs
Insight 4
Instructive systems should not make superfl demands on users' cognit
Reserved area for context info
Fold away skipped steps [collapse]
- Fold completed steps
One step displayed at a time
Image / diagram browser
Largely visual procedures
Rapid switch from procedure to schedule
- Drawers (not underwear)
Time display
- Current, time elapsed, estimated time [total + step]
Future watches? Pebbles!
Real-time telemetry updates + warnings
Only show n next items in schedule
"Retro mode" option
Leave advisories for future astros [caution!]
Notification if you...
Are over time
Need reminders
Have important update
Launch screen overview
- Video
- Graphics
- Text reminders
Link Ops/DPC notes to specific steps
One-stop-shop for task notes
[one button to show notes, data, images, etc]
Incorporate iconography
- Physical task, cooperative task, etc.
Note-taking specifics
- Task vs Step?
- What would be used?
- How is it stored / retrieved?
- How do you activate it?
Post-task screen
- Give feedback prompt
- Time + past times
- Beat the Russians
Less platform-specific
- Stop using mouse-overs!
- Use more intuitive interactions
More useful post-task feedback that's easier for ground to parse
Prioritize gathering info to improve future procedures [long-term]
Separate gadget to support these needs?
Structure backend to support new + better interfaces
God desine Harp.
One for everyone.
Attempt to limi
Small screen / large scre
Pre-recorded audio inst
System interjects exerci
Brain drugs?
Good job!
music
keynote drawings
Discussion Q's
~20 ideas / concepts
4 visions
Q's for Don



DESIGN AND DEVELOPMENT

We began by generating as many potential design concepts as possible. To this end, we conducted two brainstorming sessions, the first of which drew inspiration from the primary insights of our spring semester.

We then underwent a round of "subversive brainstorming," in which we questioned our assumptions about the project thus far and purposely attempted to generate ideas which deviated from the norm. From the extensive list of design concepts generated from these techniques, we picked the twenty most promising ideas to turn into sketches.

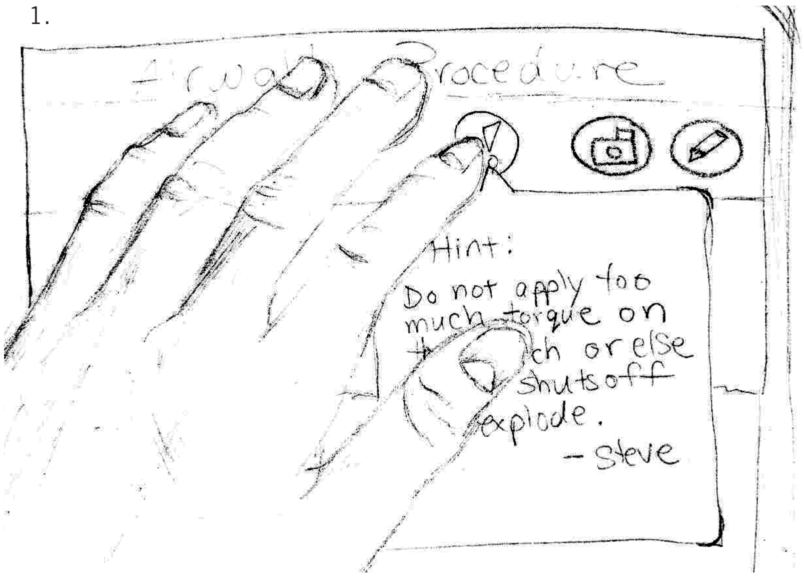
METHODS AND PARTICIPANTS

To evaluate the chosen concepts, we used two methods—speed dating and card sorting. In speed dating, each concept is quickly shown to a group of participants in order to glean their initial impressions. Our card sorting exercise involved taking a printed series of potential features and clumping them into synergistic groups or adding descriptive adjectives or modifier words to each.

Participants choose features and modifiers in a card sorting exercise.

SELECTED CONCEPT SKETCHES

1.



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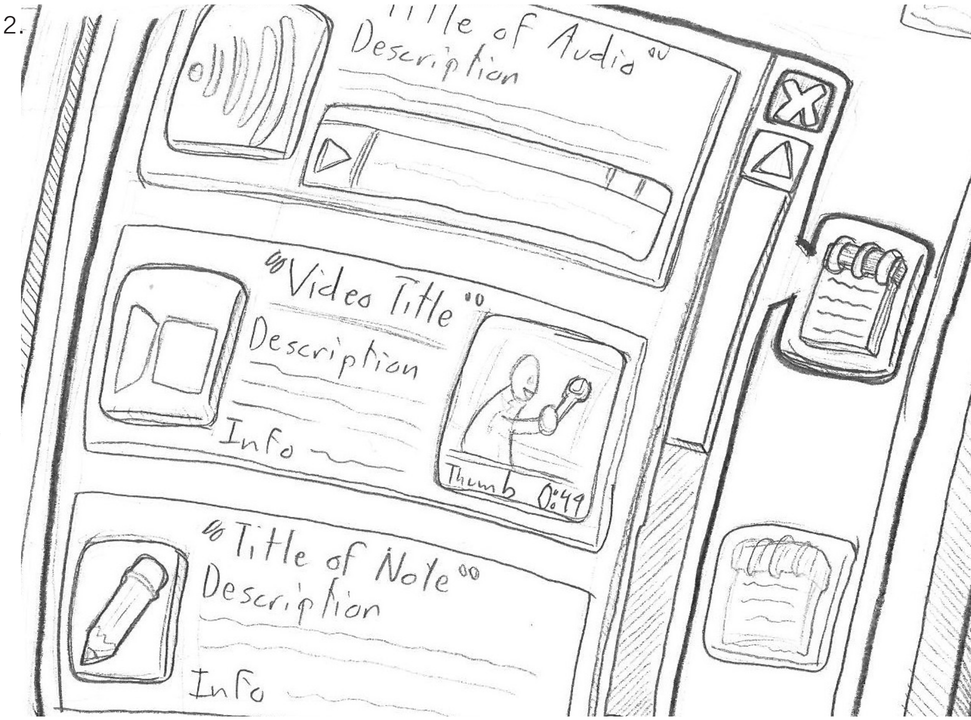

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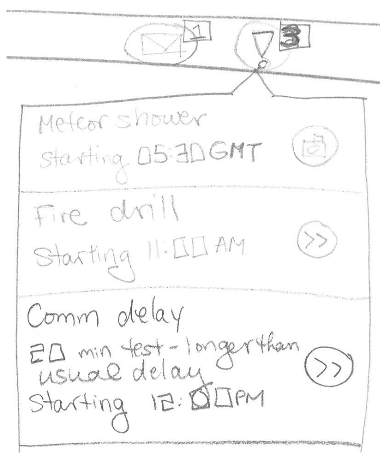
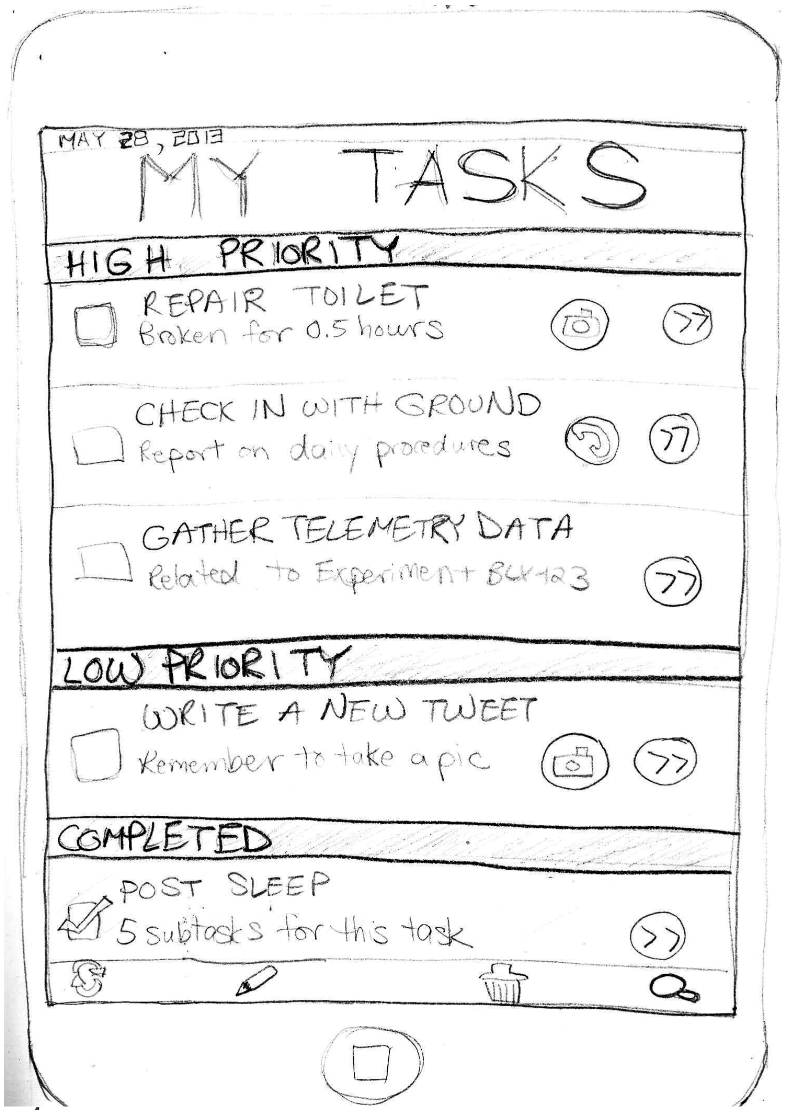


1. The ability to easily leave advisories for your fellow crewmembers was well-received from the start.

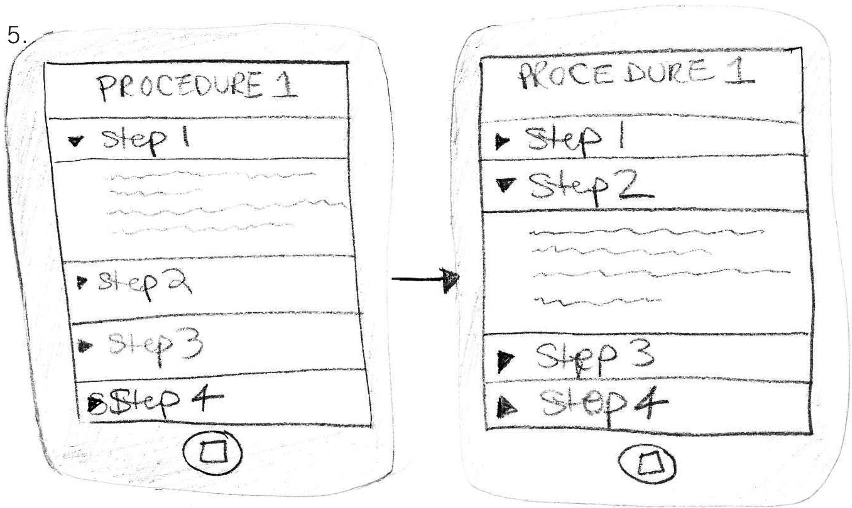
2. Quickly seeing all of the notes associated with a step seemed quite useful, as did the option to utilize many different types of media when taking notes.

3. We thought that notifications would be a simple way of drawing attention to a particular part of the screen while using a minimal amount of screen space. Participants seemed to agree.



4.

5.

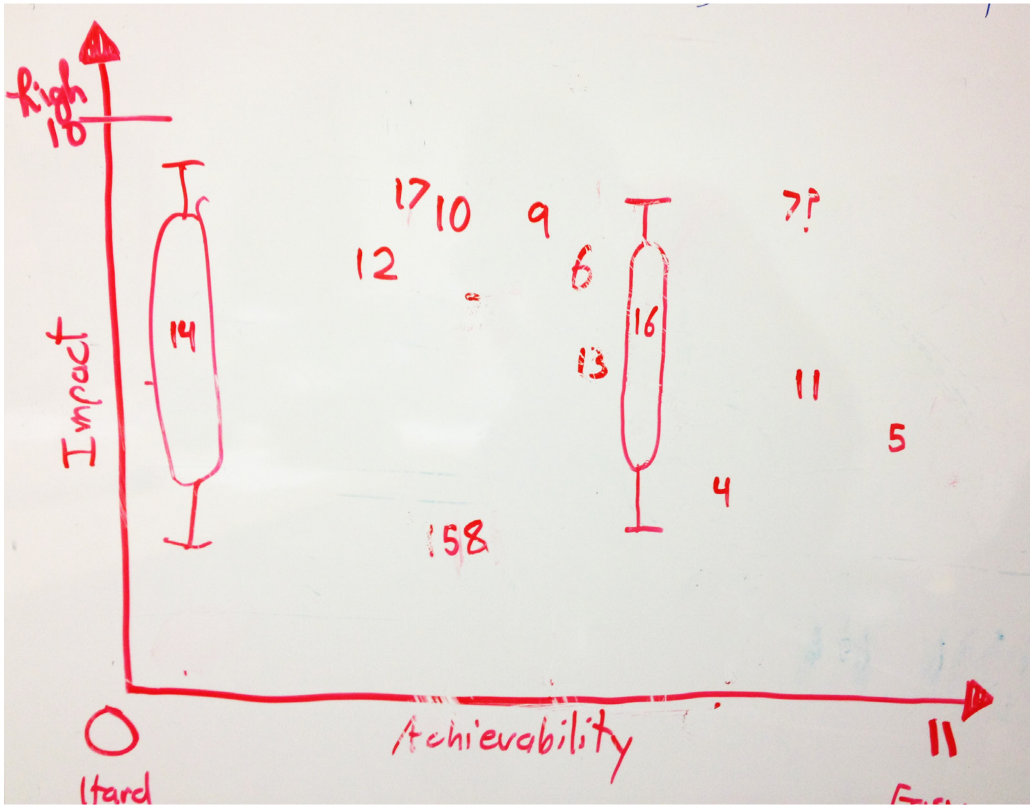


4. Listing activities as a series of equivalent tasks is a large departure from the current paradigm of time-based swimlanes. Nevertheless, task-based activities garnered a great deal of support.

5. Having steps fold down to reveal their associated substeps made a great deal of sense as a space-saving interaction to our participants.

EVALUATION

After documenting our findings from the session, we determined which of the concepts presented had the most positive response from users—as well as support from our research findings. We also created an impact–achievability grid, mapping each successful vision depending on two axes—benefit to the user and real-world cost. We then identified several concepts to focus on developing for our first true prototype.



We gave each concept a number and then subjectively ranked the impact and achievability of each. The scales range from hard and low-impact (at the bottom left) to easy and high-impact (at the top-right).

This chart shows a concept and the degree to which it addresses each of our considerations, insights, and user experience goals. The total score of each feature helped us scope which to design.

KEY ● +1 ◡ +.5 ◡ –.5 ● –1

		CONSIDERATIONS				INSIGHTS				USER EXPERIENCE GOALS						
		STRESS AND SUPPORT	COMMUNICATION DELAY	INVENTORY	MANY PROCEDURES	DON'T OBSCURE CRITICAL INFORMATION	SUPPORT MEMORY RECALL	PROGRESS REPORTING/ TECHNOLOGY CHANGES	LESSEN COGNITIVE LOAD	SUPPORT CREWMEMBER AUTONOMY	REDUCE GROUND CREW UNCERTAINTY	MAKE ACTIVITIES EASIER TO EXECUTE	PREVENT USER FRUSTRATION	ENCOURAGE BOND BETWEEN USER AND DEVICE	PROVIDE SHALLOW, INTUITIVE NAVIGATION	
UI/ HIERARCHY	Drilling into information/ context at different levels					+1			+1		+.5		+1		+1	4.5
	Fold away skipped steps					+1			+1			+1			+1	4
	Other crewmembers' schedules are visually distinct from yours	+1				+1					–1			+.5		1.5
	Consistent UI area for supplementary information					+1			+1					+1	–1	3.5
NOTE TAKING	Crewmembers can embed rich media in procedures			+.5	+1		+1							+1		3.5
	Leave advisories for future crewmembers				+1	+1			+1	+1		+1			+1	6
	Note-taking transfers from training to mission in space				+1		+1					+1	+.5	+1		4.5
OTHER	Task-based, not swimlane-based, procedures					+1			+1	+1	–1		+1			3
	Less-regimented scheduling	+1	+1							+1	–1		+1			3
	Time-tracking within procedures					+1		+1		–.5	+1				+1	3.5
	Gather feedback and data to improve future procedures							+1	+1		+1	+1				4
	The device feels like it's yours							+.5				+1	+1	–1		1.5
	System supports switching between users							+1	+1	+.5				+1		3.5

MAJOR TAKEAWAYS

The following concepts garnered the most support in our evaluations sessions, subsequently serving as starting points for later prototype development.

HIDE INTERFACE ELEMENTS WHEN THEY ARE NOT PRESENTLY NEEDED

Whenever possible, we attempt to present only the most essential information, primarily through the use of expandable data fields. These tuck away superfluous material until it is needed, presenting the user with a manageable, uncluttered interface.

Supporting Insights:

- Critical contextual information should not be obscured by items of less immediate concern
- Instructive systems should not make superfluous demands on users' cognitive load

NOTETAKING TRANSFERS BETWEEN TRAINING ON EARTH AND MISSION IN SPACE

Many of our analogous domains demonstrated the great value inherent in notetaking. We envision this process as one not only afforded by an interface element, but as a potential shift in the way NASA trains its crewmembers. By encouraging notetaking throughout training, crewmembers will be able to easily reestablish mental connections to procedures they practiced months ago when the time comes to conduct actual procedures in space.

Supporting Insight:

- Methods that encourage memory recall can support consistent procedure execution

USE TASK-BASED ACTIVITY LISTS TO SUPPORT AUTONOMY

One of the most interesting insights from our discussions with crewmembers was a perceived lack of autonomy. Despite their prestigious roles and extensive training, they still occasionally felt like puppets or lab rabbits. We attempted to address these psychological and functional issues by displaying an imposing swimlane view of their schedule and procedures into a daily, personalized list of activities.

We strove to design an application that would make crewmembers feel empowered and calm rather than stressed and constrained. Our interface provides easy access to the list of crewmembers' upcoming and finished activities, rather than emphasizing a continuous, exact marker of where crewmembers are in a timeline.

By replacing regimented, swimlane-based schedules with a more fluid, task-based approach, we subtly shift the measure of progress throughout a crewmember's day. Instead of judging their day simply by how much time has passed, crewmembers can now see how much science they have contributed by tracking their completed activities. Additionally, by giving each activity equal visual weight and listing them sequentially, we allow crewmembers the flexibility to execute them out of order, if desired.

Supporting Insight:

- Critical contextual information should not be obscured by items of less immediate concern

ENCOURAGE USER TO FORM A BOND WITH THE DEVICE

As opposed to having numerous stationary laptops installed at various intervals within the ISS, we intend for MATE to be allocated to each crewmember at an individual level. In addition, the application will retain notes taken by the crewmember during training, and later display them for the crewmember during actual activity execution. In this way, a personal device stays with the crewmember, allowing for a sense of consistency and familiarity.

Supporting Insights:

- Methods that encourage memory recall can support consistent procedure execution
- Existing procedure support systems do not prioritize users' most pressing needs

GATHER TIME ELAPSED, CREW FEEDBACK, ETC., TO IMPROVE FUTURE PROCEDURES

Our application is intended to capture the start, pause, and end of each procedure in order to improve the estimations of future activities. Instead of being lost in a verbal conversation, feedback from crewmembers on procedures and stowage can also be captured by the application and taken into account for the future.

Supporting Insight:

- Existing procedure support systems do not prioritize users' most pressing needs

PROTOTYPE 1: PAPER

Taking feedback from Prototype 0's speed dating session, we began generating ***concepts for our first full interface,*** *to be realized in paper. We started by sketching the refined wireframes on paper, creating a low-fidelity mockup of our interface.*

This prototype was designed to ***test and validate several high level concepts*** *within our application, while remaining deliberately generic and flexible.*

TESTING

GOALS

By walking participants through a series of screens outlining a representative interaction within our application, we sought to validate specific features and high level concepts

PROTOTYPE	METHODS	PARTICIPANTS
Paper	Cognitive Walkthrough Expert Review	Three NASA HCI Professionals One NASA Intern

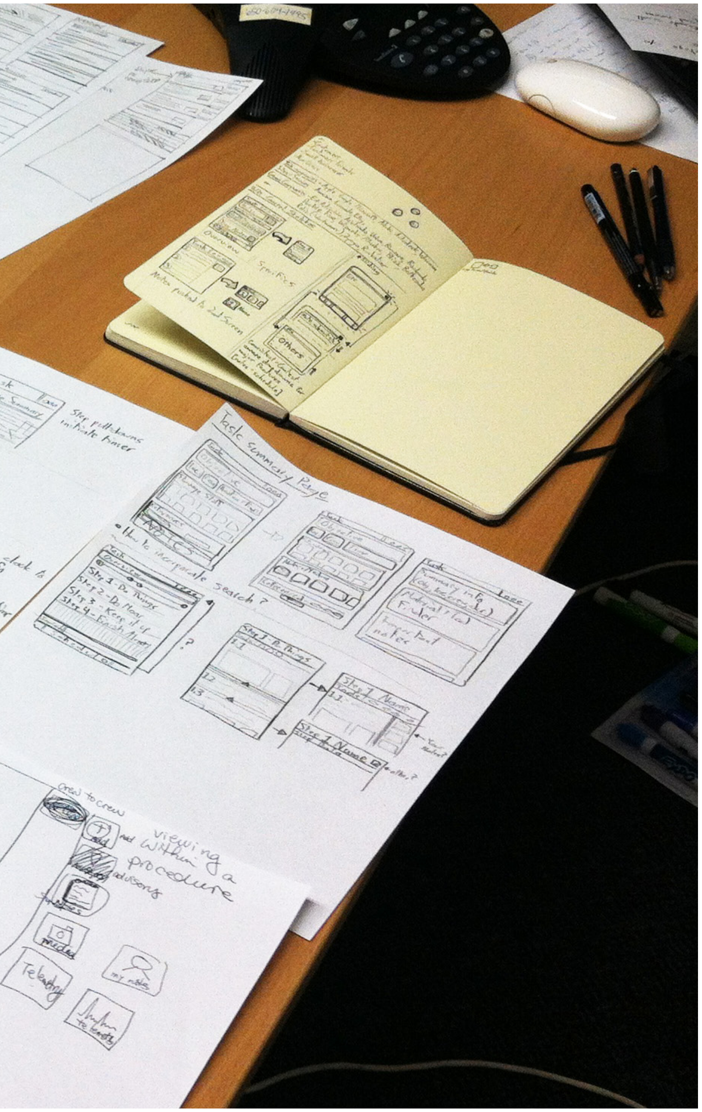
KEY FINDINGS

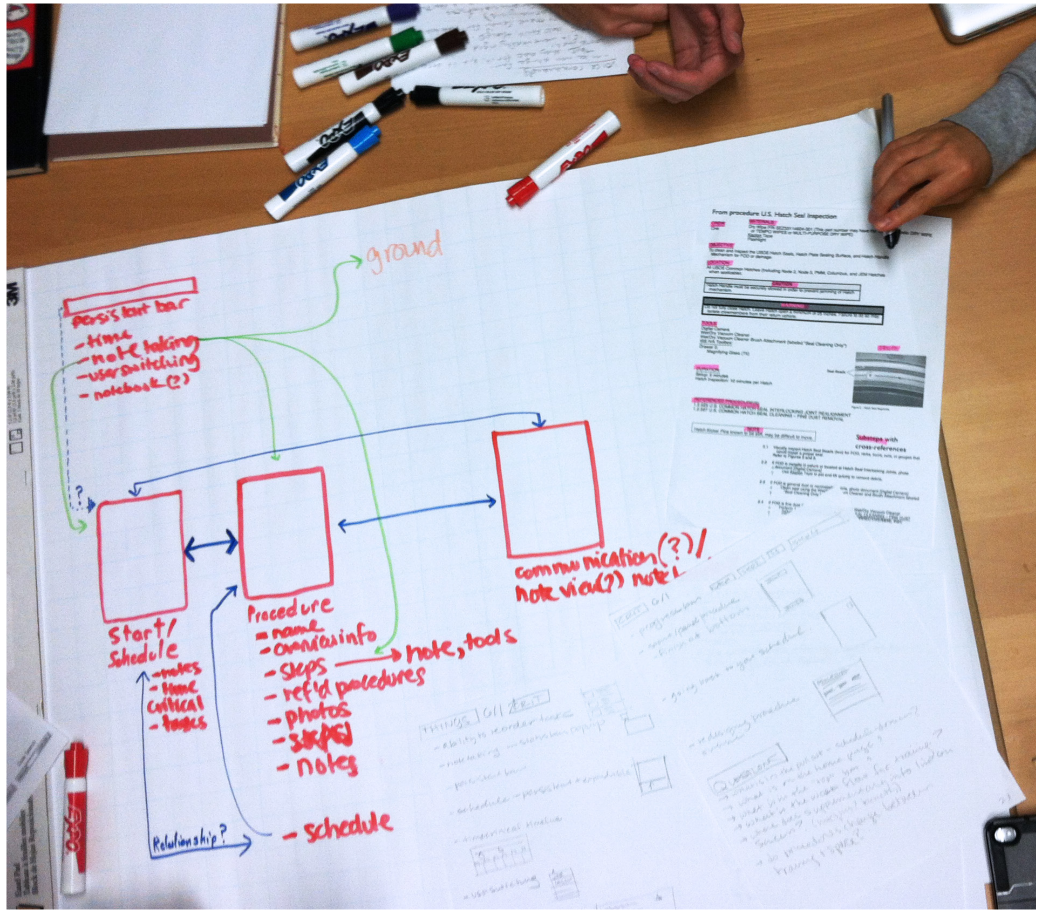
- Fundamental interaction principles are difficult to test in low-fidelity prototypes and led to user confusion
- Breakdowns occurred due to unclear iconography and lack of affordance in buttons
- Users easily understood the application's structure and high level concepts, despite difficulties with detailed elements

DESIGN AND DEVELOPMENT

As this was our first formal interface design, there were many fundamental decisions to be made during this iteration. After deciding on core functionality and which features to develop, we began collectively sketching a plethora of wireframes. Topics ranged from general grid structure to the specific implementation of certain buttons and text fields.

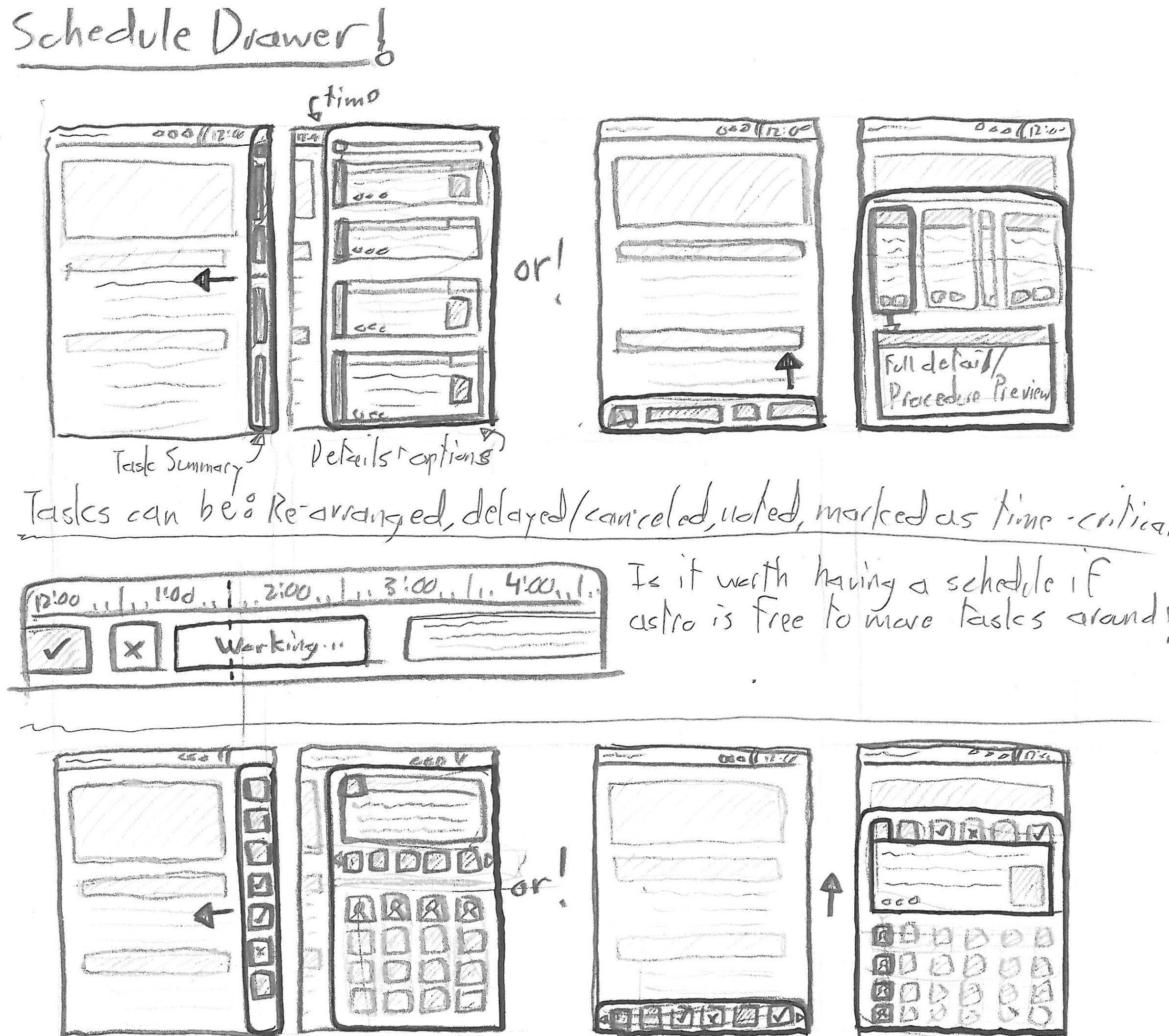
Time-boxing sketching and frequent critiques allowed us to align our visions and make feature decisions.

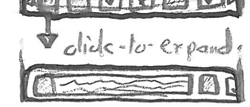




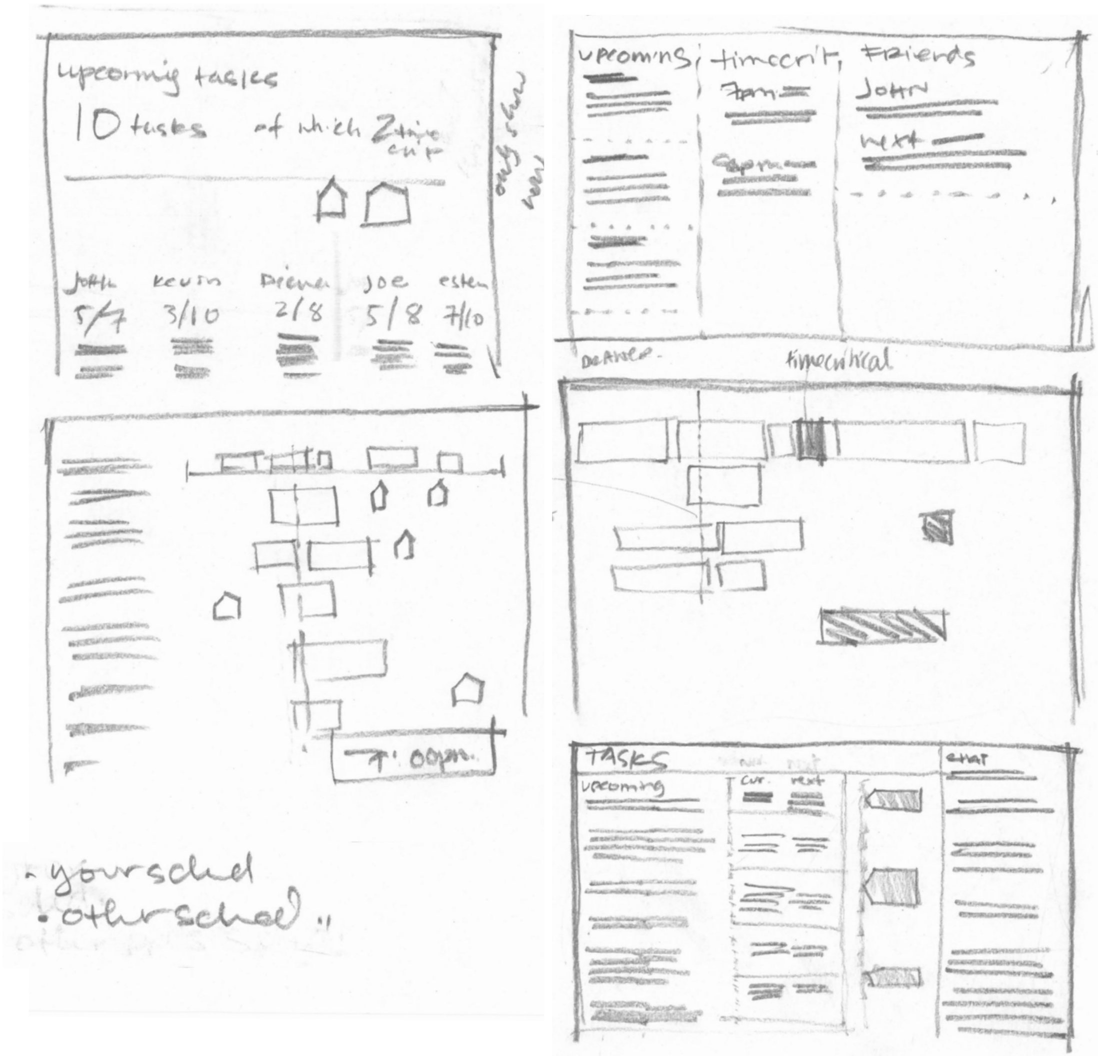
An initial system map helped us understand navigating through the application.

Initial concept sketches tried to resolve questions about the home view layout and interactions. How could we make the task list feel task-oriented, not time-oriented? Perhaps the individual tasks could be rearranged at the user's discretion.



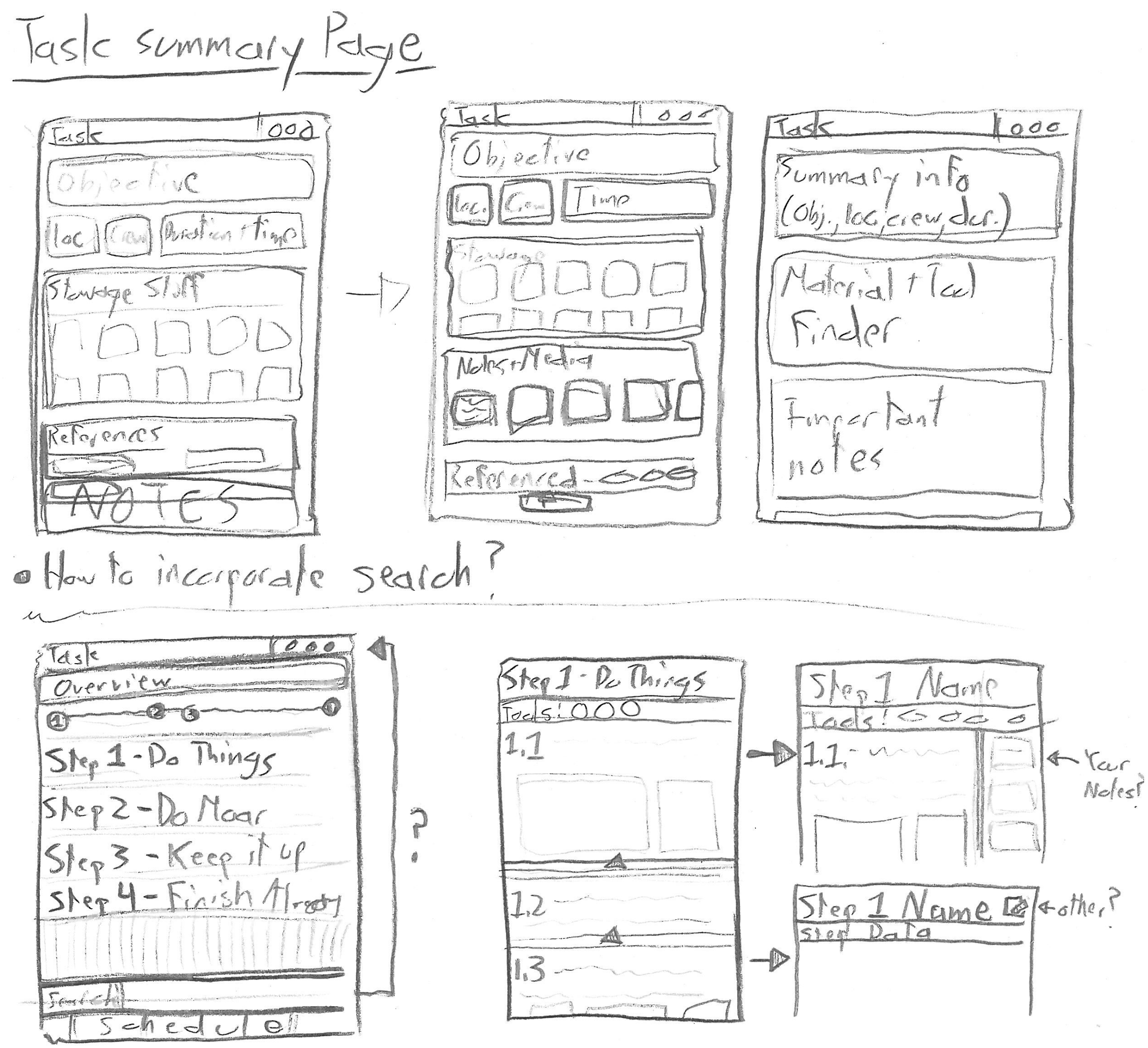


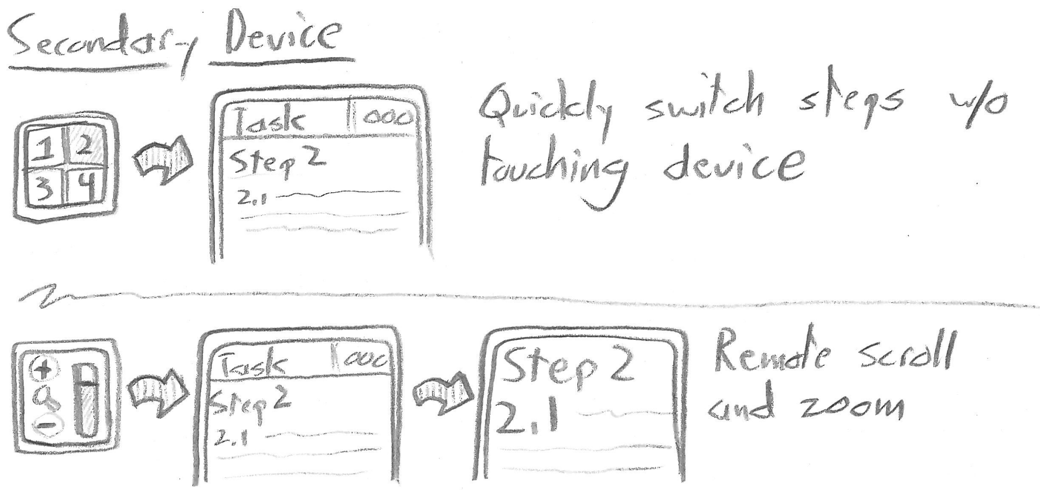
In a pull-out drawer, a quick view of everyone's schedule could be found. These sketches show potential areas of the screen from which the drawer could be accessed.



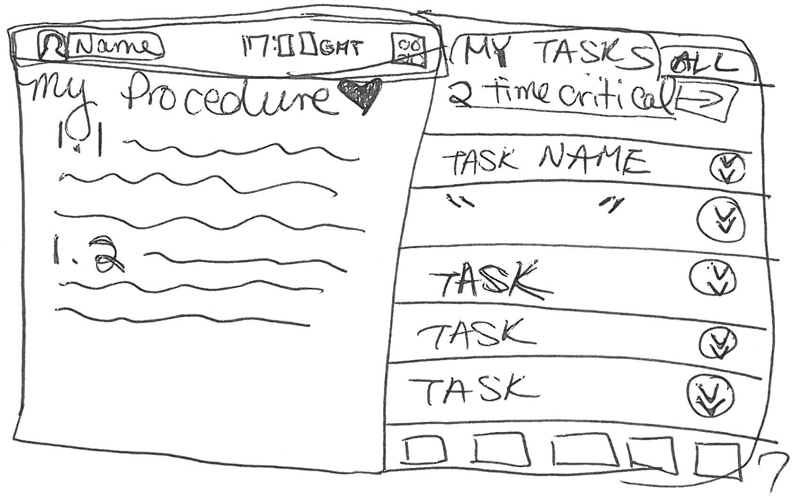
Other explorations of the home view placed focus on time-critical tasks, other crewmembers' schedules, and other contextual information. We tried combining swimlane views of important events in the day along with detail views of each upcoming activity.

We tried many different arrangements for the complex information within an activity, such as the objective, stowage data, and steps. We tried to resolve the workflow from the task list to an activity.





We considered pushing individual steps to a secondary device, such as an iPod Touch.



A slide-out drawer would provide quick access to the user's most pressing information needs.

We looked at the persistent items in the navigation bar. How does user switching work? Assuming that all users do not each have their own device, they would need to have easy and fast authentication to view their schedules. One idea was to have a persistent indicator of the user name at the top that allowed them to switch task lists quickly.

SELECTED PROTOTYPE SCREENS

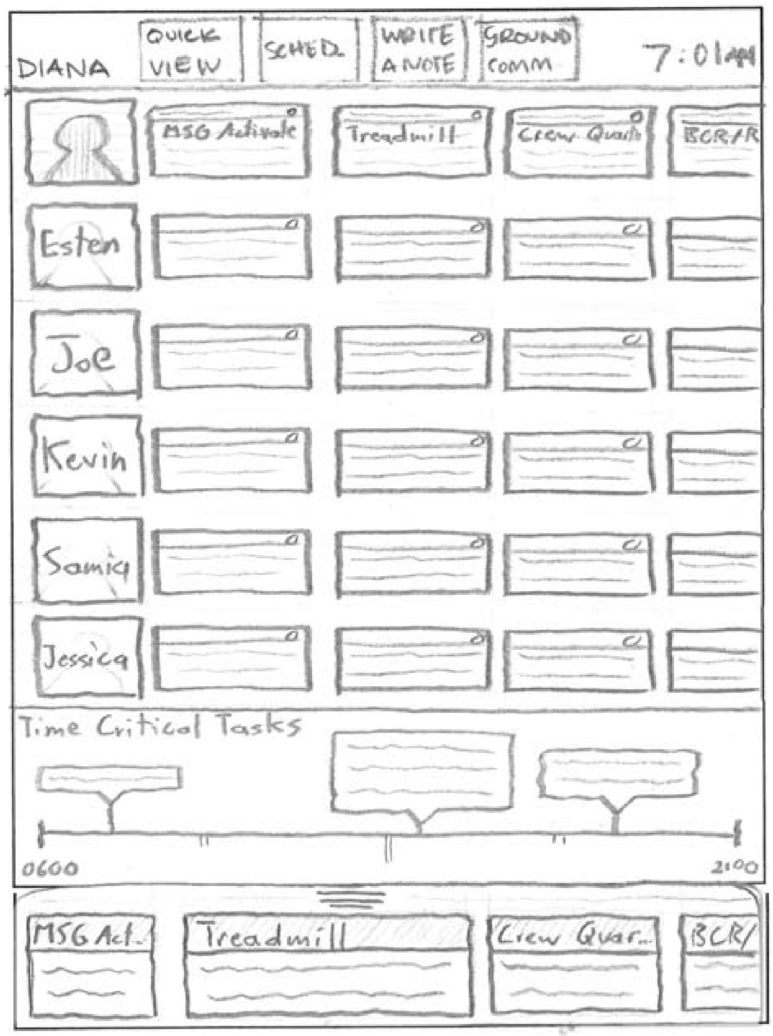
In Version A of the home screen, the screen is divided between the user's upcoming tasks, other crewmembers' tasks, and viewing time-critical tasks.

A persistent navigation bar provides access to other views.

User's individual upcoming tasks with objective and other key data at a glance.

Other crews' current tasks are shown in a running list.

Time critical tasks highlighted in a vertical timeline.



In Version B of the home screen, the emphasis is on other crewmembers' tasks. The user's time-critical tasks are near the bottom, along with upcoming tasks.

PROTOTYPE 1: PAPER

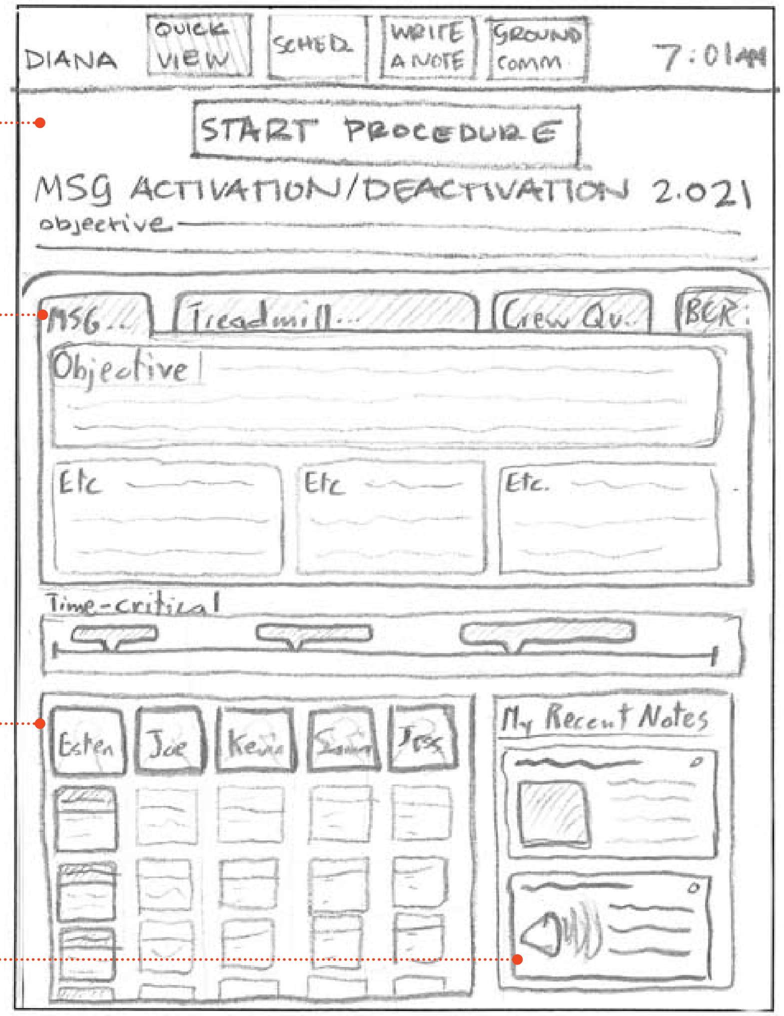
The quick view explores the possibility of quick access to the user's upcoming tasks through tabbed navigation, as opposed to navigating to the entire station's schedule.

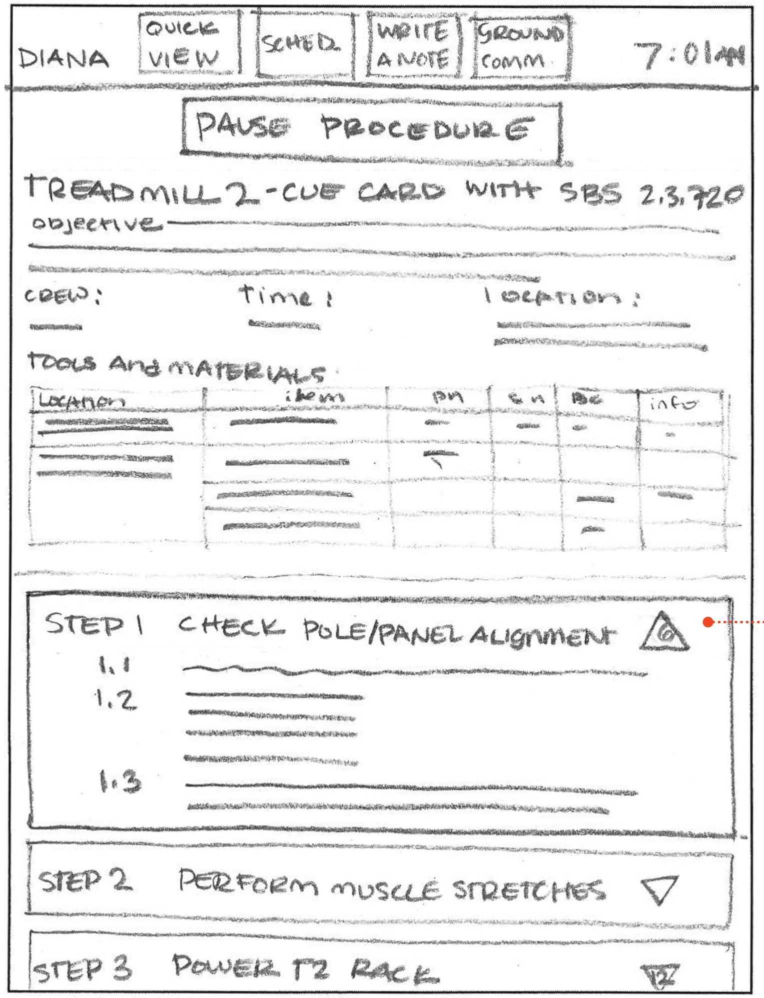
The information in quick view can be accessed anywhere. For instance, here it is brought up from within a procedure.

A few upcoming tasks can be browsed with tabbed navigation. This allows more fluid task viewing and switching.

Other crews' tasks can be viewed and accessed from this area. Selecting another crew's name brings up a view of his or her entire schedule.

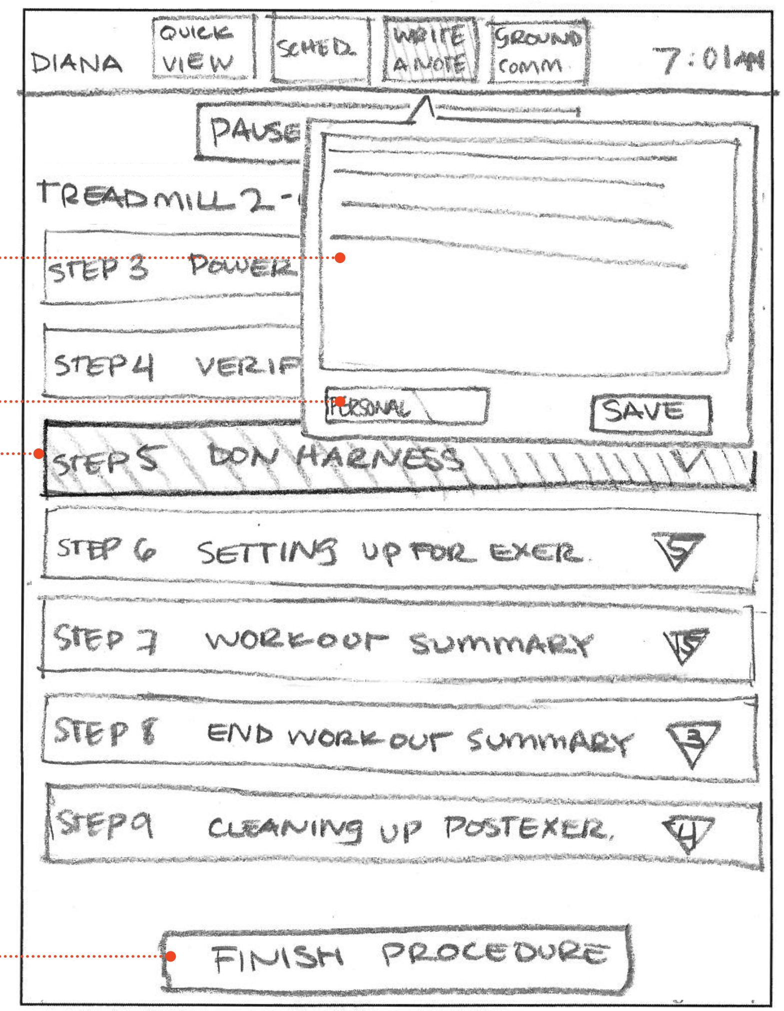
Recent notes, whether text, audio, or video, are displayed at a glance.





Steps can be expanded or retracted to reveal their substeps. An icon indicates how many substeps a step contains.

Notetaking is accessible with a pop-under text input field that allows sharing. The user can associate the note with a particular step.

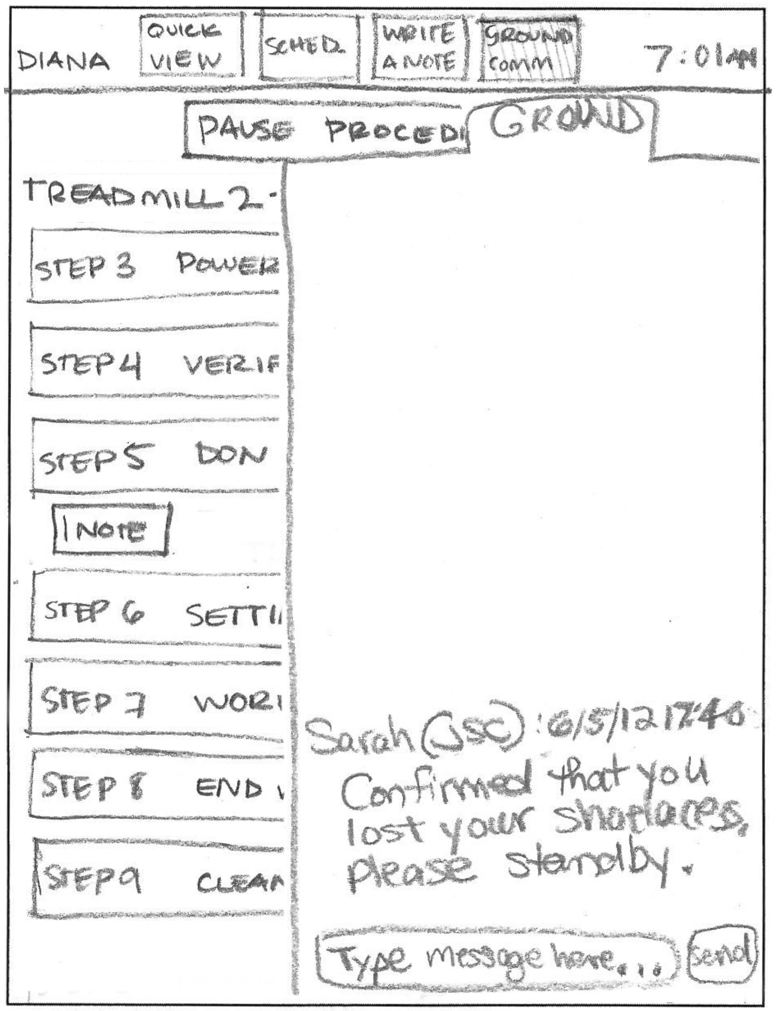


Notes are taken in a pop-down text input field from anywhere in the application.

The personal option shows the note only to the users, while shared notes are also displayed in other user's views.

Notes can be associated with a step, which becomes highlighted upon selection.

The end of each activity has a "finish" button, which take the user to the home view. It also marks the activity as completed.



Ground communication is a panel with a chat dialogue area. Messages are labeled by sender and date and time sent.

Participant conducting an expert review of the paper prototype.

EXPERIMENT DESIGN

For our first prototype, we created a test in which the user took on the role of a crewmember going through his or her daily tasks. The scenario had the user make a change in his or her schedule by switching his or her current task, perform a task out of order, take a digital note, and notify the ground crew of an unexpected complication. This series of interactions was done with a paper prototype, which required us to explain what was happening on each page, then switch to the next one ourselves. To take advantage of the fluency of paper prototyping, we tested two versions of the paper prototype using the same scenario, repeating the scenario with each variation.

METHODS AND PARTICIPANTS

In groups of two, we carried out a modified cognitive walkthrough / expert review with four NASA HCI Group members. For each page of the paper prototype, we explained the intended functionality and paused for feedback from the user before repeating the process for subsequent screens.

EVALUATION

After documenting our notes from the sessions, we created an affinity diagram to identify UI concepts and application features which deserved further attention and iteration. We paid special attention at this early stage to additional design opportunities, areas of confusion, and things our users liked.

MAJOR TAKEAWAYS

CONSTRAINTS OF USING PAPER

We ran into a few stumbling blocks with this test, some of which were due to the limitation of paper prototyping. For instance, it was difficult to recreate interaction techniques, such as scrolling, found in a typical mobile application. Users were not able to replicate the experience of scrolling to bottom of a procedure without switching to a new paper screen.

UNCLEAR INTERFACE ELEMENTS

In this test we observed issues such as a lack of affordance for buttons and unclear symbology. There were also problems in understanding the iconography and visual elements of the paper wireframe, which we took into consideration during evaluation.

HIGH LEVEL CONCEPTS

Even at low-fidelity users were able to follow along with the guided scenario and interact with the system. While the details of functionality were yet to be resolved, users understood the concept and purpose of taking personal notes as well as using the panel to send messages to ground. A source of confusion was revealed as users interacted with a home view and quick view, as users generally did not understand why they were two separate views. This encouraged us to redesign our activity viewer to display information in a way that aligned with user expectations.

PROTOTYPE 2: INTERACTIVE PDF

After initial high level concept validation in our speed dating session and approval of our first rough interface in Prototype 1, we had defined our final functionality to the point where we were ready to create our ***first interactive prototype.*** *Another round of wireframe sketching further* ***defined the functionality of the most important elements*** *within the application. A coherent narrative was developed that would touch upon each of these features,* ***guiding the user through a defined scenario*** *while still allowing them a degree of autonomy.*

TESTING

GOALS

While using a semi-interactive PDF's on a tablet device, we observed the user's workflow as they executed an actual procedure.

PROTOTYPE

Interactive PDF

METHODS

Think Aloud Protocol

PARTICIPANTS

Four NASA Interns

SCENARIO SUMMARY

In a simulated space station environment, we tested users on a complete but artificial procedure of our own devising, from tool gathering to final documentation.

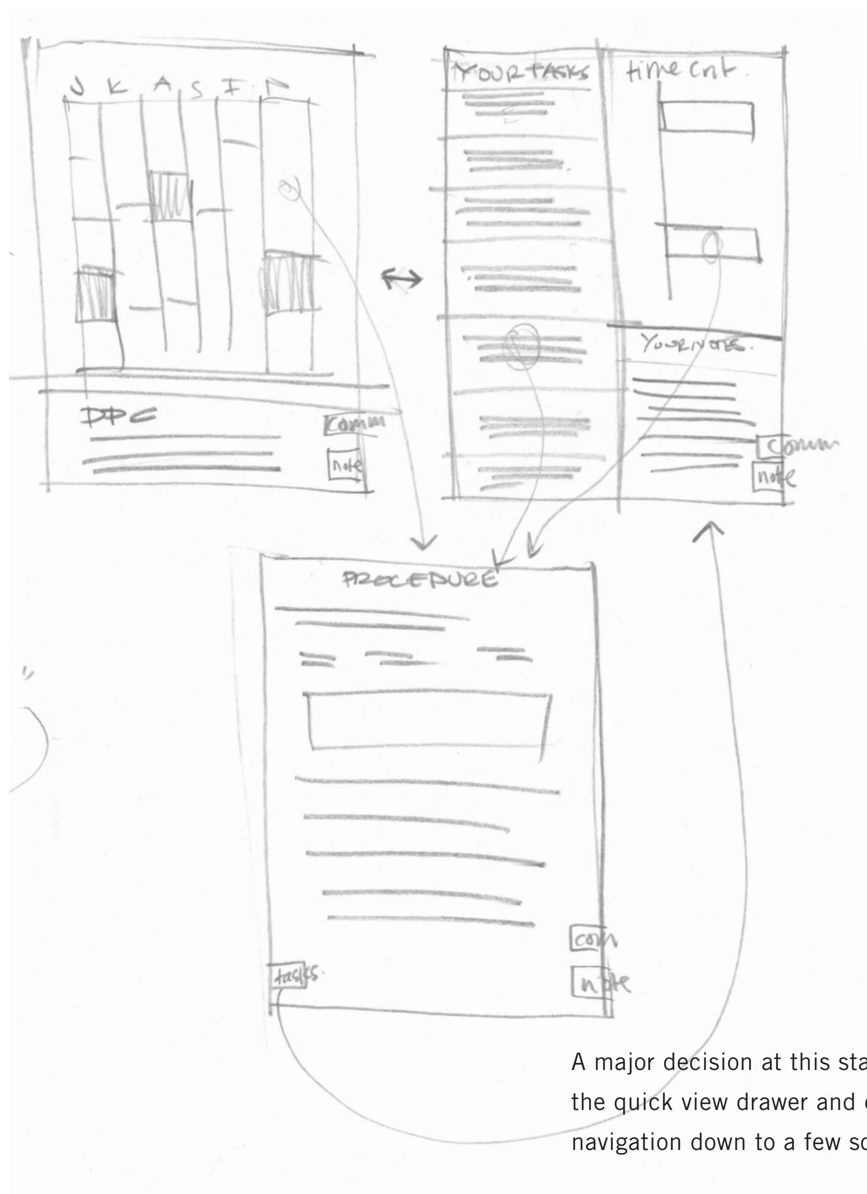
KEY FINDINGS

- Discoverability concerns lead us to re-envision our testing strategy to gauge the memorability of MATE as an expert system
- For note taking to succeed as a feature, it must be as quick, flexible and intuitive as writing on paper, not bogged down by cumbersome interactions
- Features that take advantage of users' existing conceptual models are more appealing

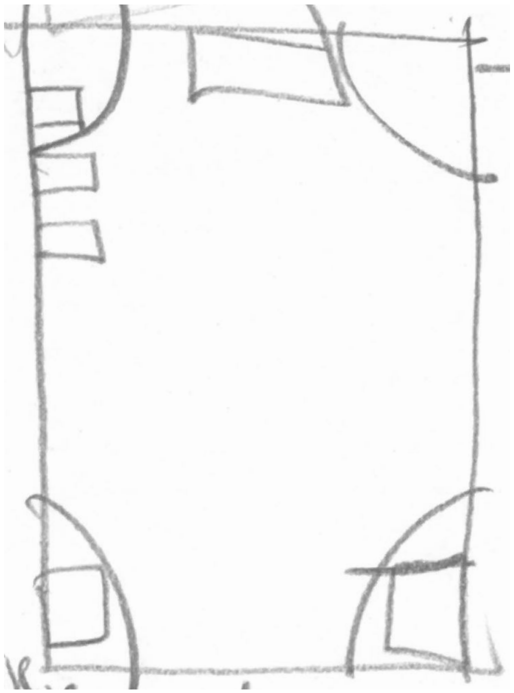
DESIGN AND DEVELOPMENT

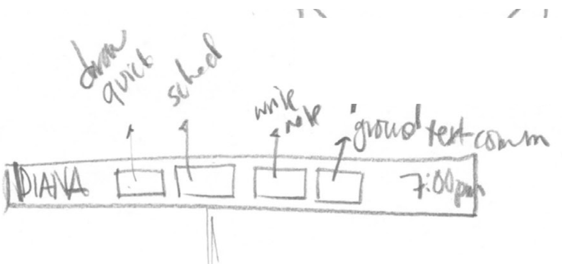
This round of sketching focused on investigating the step-by-step flow of important interactions. Of prime importance were the notetaking and ground communication workflows. These features are available to the user in any screen and require a flexible interaction supported by information that is much more dynamic than static. We also explored proper button position, the placement of indicators and text fields, and intuitive associations.

Development began in earnest at this point. Although our prototypes were not yet ready for a properly coded iteration, our developers preemptively developed techniques for pulling real information into our design, based on NASA's existing XML procedure data.

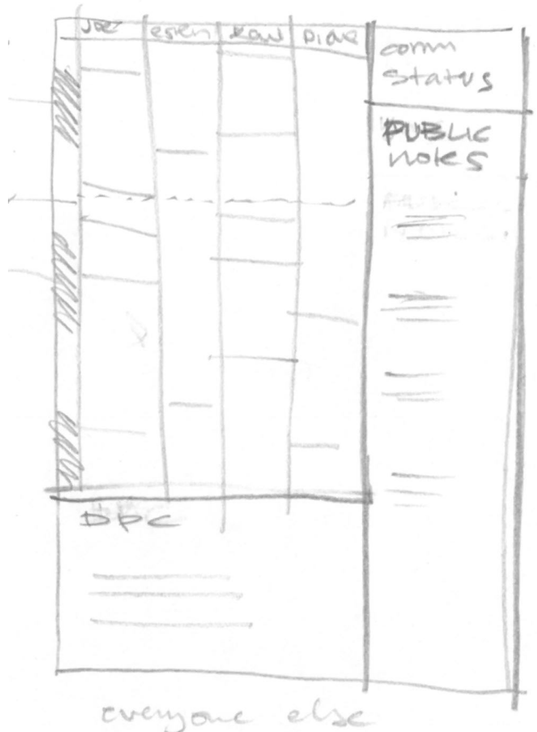


A major decision at this stage was removing the quick view drawer and condensing the navigation down to a few screens.

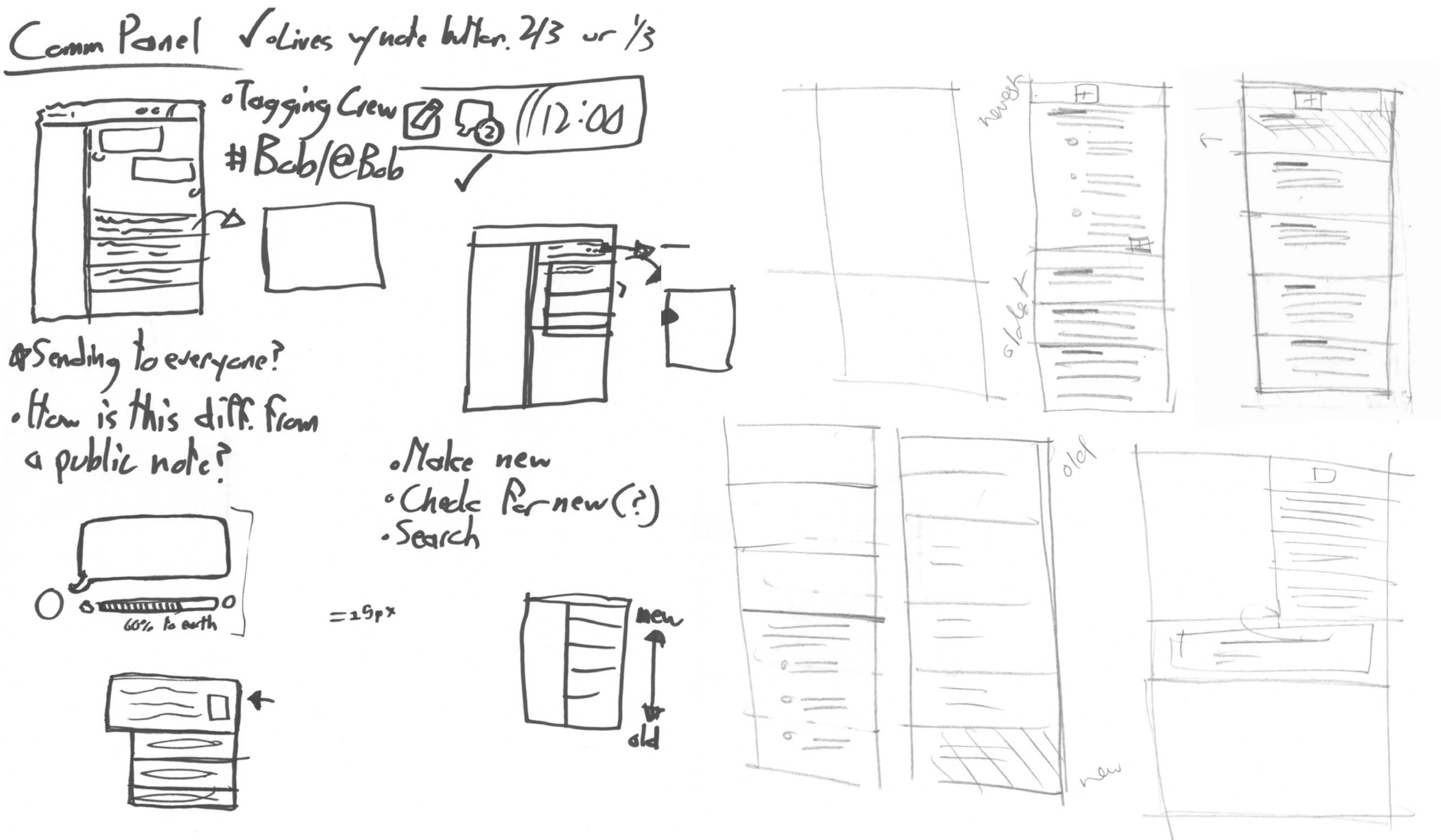




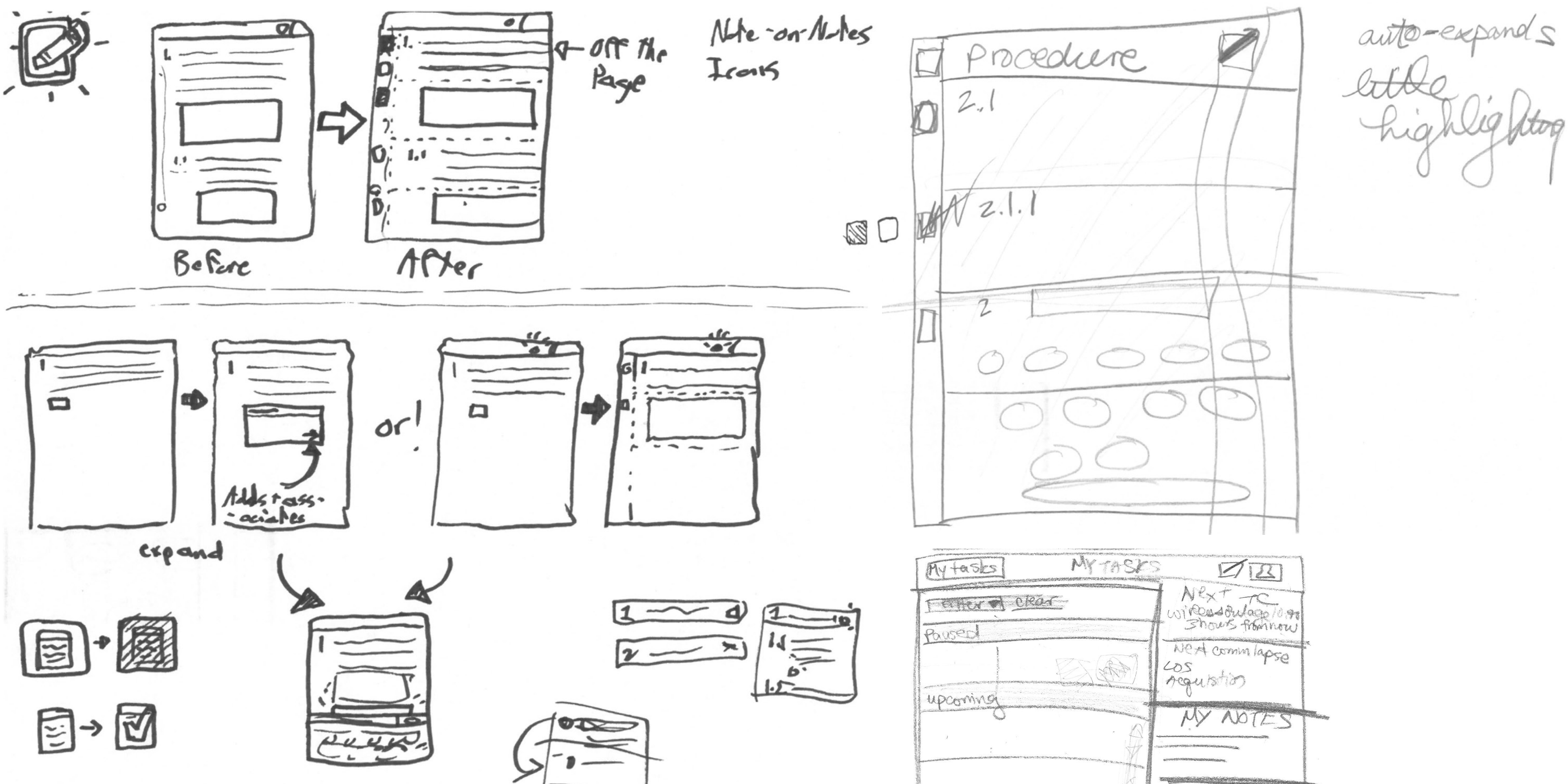
We explored touch areas, gestures, and navigation bars to move between screens of the application.

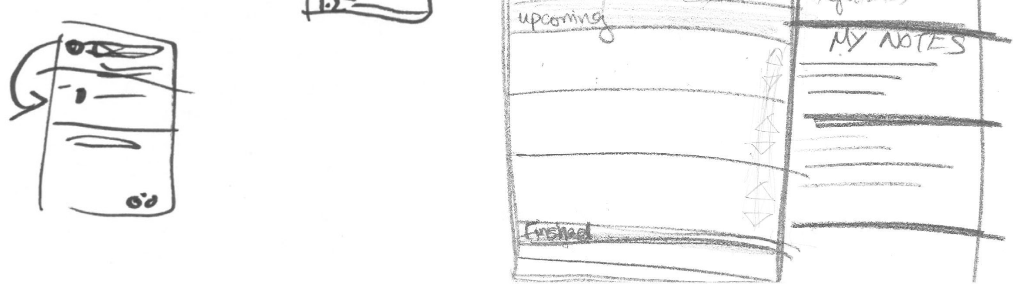


We continued to iterate on the home view showing the user's personal tasks, accessing other crewmembers' schedules, and displaying important contextual information.



These sketches delved into the ground communication panel. We explored how messages could be threaded and how to reply to a thread or start a new thread. A search bar in case of a large number of message could prove useful. We also considered the purpose of the ground communication panel, who could read the messages, and what differentiated ground communication from writing notes.





Explorations on “notes mode” looked at how to initiate notetaking, how to select steps to add notes, and also how to place notes in the activity or task page.

SELECTED PROTOTYPE SCREENS

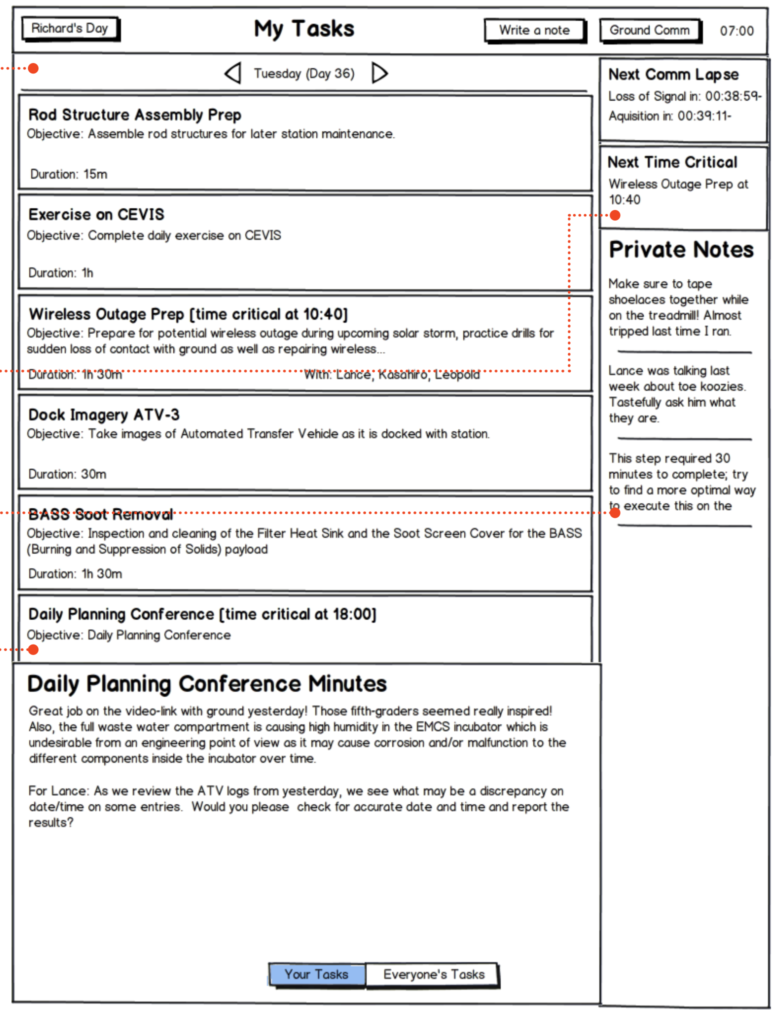
The majority of the home view is dedicated to the user's daily activities, presented in a task list format.

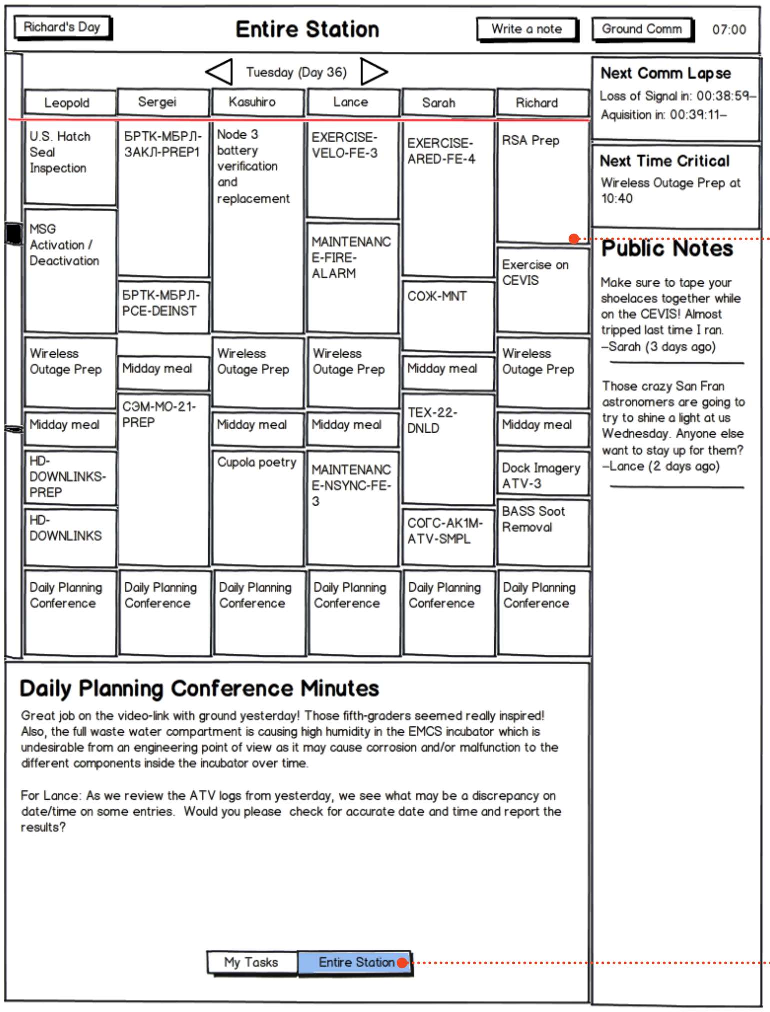
A date picker allows the changing of the view to a new day.

The upcoming communication delay and time-critical times are called out with text.

The most recent notes taken by the user are aggregated here.

A list of activities are presented in order, each item contains a brief outline and key data.





A major decision was to remove the quick view drawer. Other crewmembers' schedules are accessible as a full screen swim-lane view.

The schedules of the entire station.

Nagivation between your schedule and the entire station's schedules.

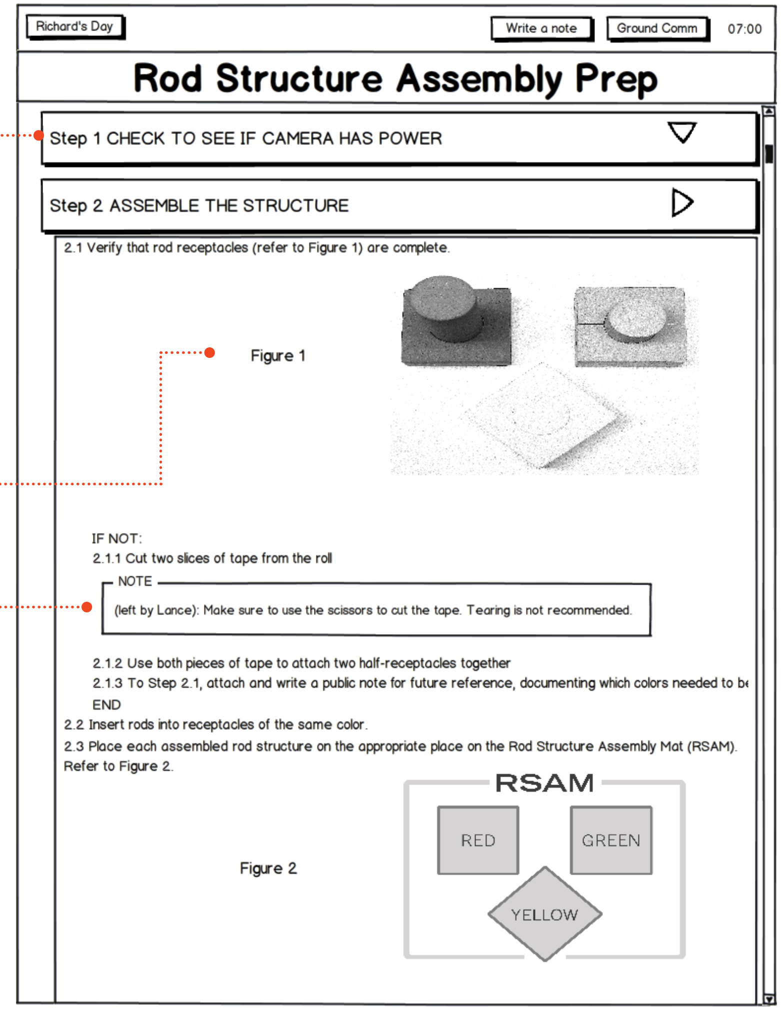
PROTOTYPE 2: INTERACTIVE PDF

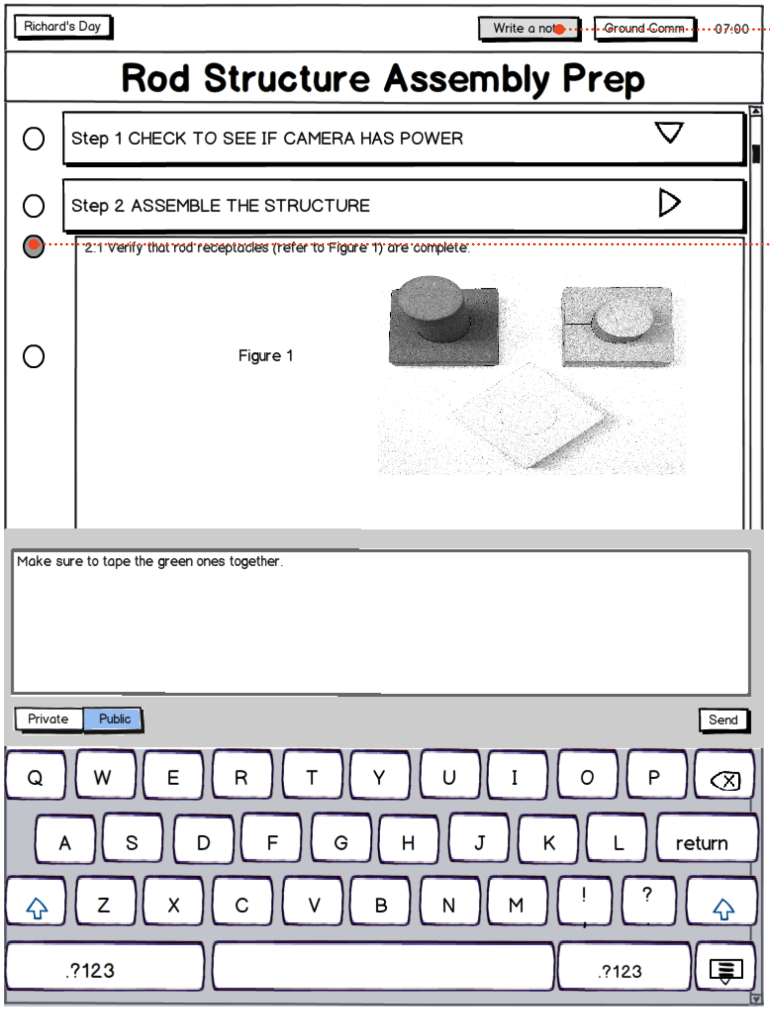
In activity view, steps expand and contract to reveal substeps, notes, and images. New notes can be added at any time, and the procedure will update with the new information.

A closed step only indicates the name of the step. Selecting the step expands the information below.

Figures and notes are shown right beside the substep that it is referencing.

Notes can be left by crewmembers and shared with others. They are marked by author and attached to the procedure.





The notes button at the top bar creates a notetaking mode, with step selection bubbles and a keyboard.

The selection bubble allows users to attach a note to a particular step.

EXPERIMENT DESIGN

Once we determined which functions were worth pursuing, we needed a way to have the user touch on all of them within a single session. To that end, we developed a short prompt for the user that would gently guide the user along the path we desired. Even though they did not have complete control over this process, there was decidedly more freedom to explore in this prototype than in the strict progression of Prototype 1.

For this iteration, we took great pains to create a testing environment that shared similarities to the conditions in which our final application would be used. Not only was the interface now contained within a real tablet device, but the user was instructed to perform a “scientific” activity. The user was tasked with gathering the necessary stowage to create a Rod Structure Assembly out of colored foam blocks while taking a note, communicating with ground crew and viewing both their own tasks and those of the station’s other crewmember.

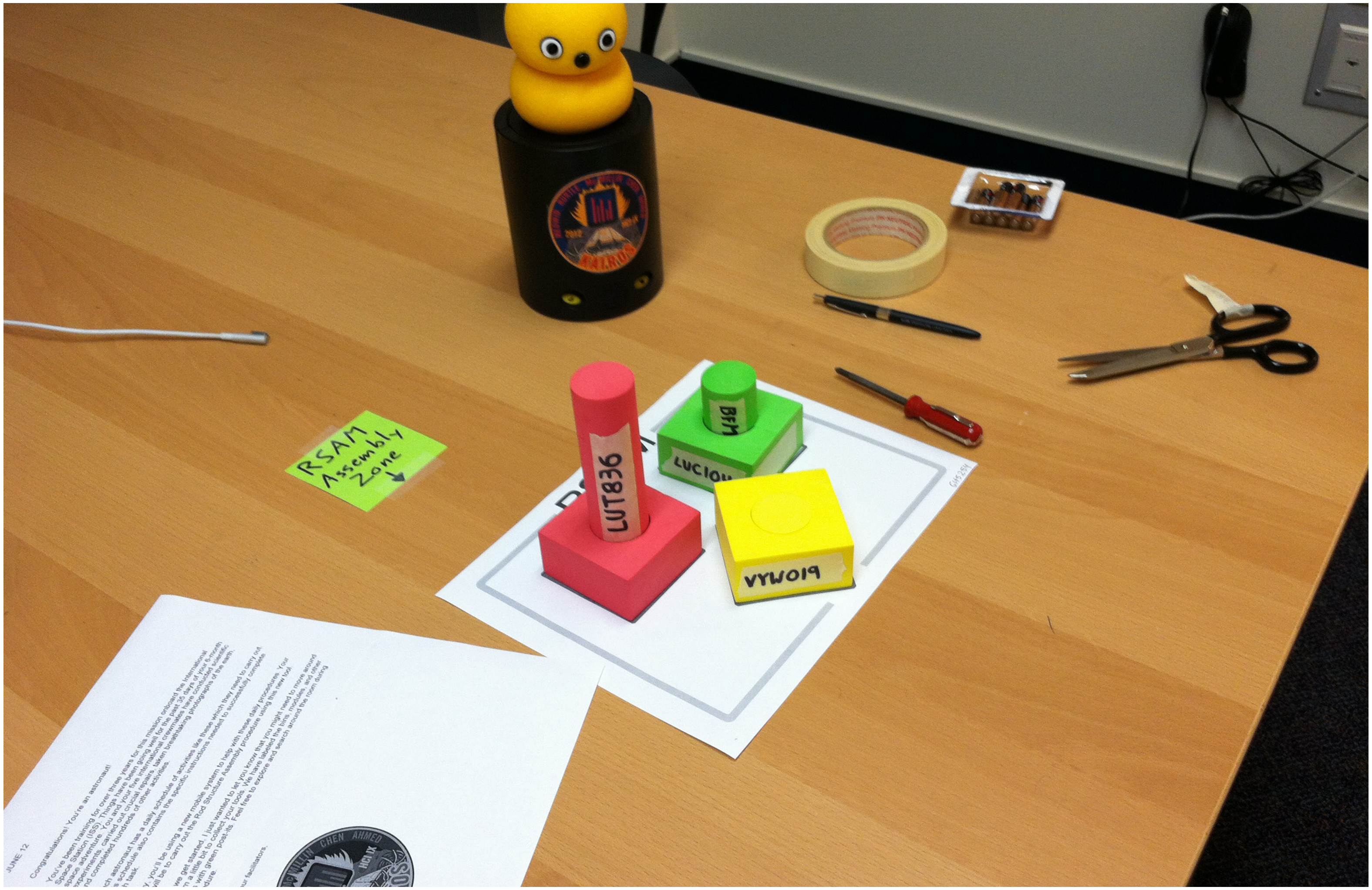
TESTING

Two team members oversaw a series of four think aloud tests conducted with NASA interns. After briefly explaining the life and responsibilities of a crewmember, subjects were instructed to guide themselves through the execution of our invented task. Users were filmed and observed as we watched for frustrations, successes, and errors.

EVALUATION

Following the think aloud, notes and findings were consolidated into spreadsheets of feedback reports. We then re-watched video recordings of each session, noting the most telling user reactions. These findings were then turned into another affinity diagram, with data comprised of comments and quotes from the users and organized by areas of concern.

A major client review of the prototype revealed several new concerns, such as the importance of timekeeping for the crew. They also suggested that we focus our efforts on a smaller, more manageable set of crucial features, rather than designing and developing too broadly. Following this session, we developed a focus on four specific areas of importance for for the next prototype—notes, interruptibility, home view and activity view.



Assistant Project Manager Keepon oversees a user's execution of the Rod Assembly Task as part of Prototype 3.

MAJOR TAKEAWAYS

DISCOVERABILITY BREAKDOWN

Many users had a great deal of trouble finding a few specific features. Although we remedied this error with our later designs, it made us realize that we should focus our efforts on testing an expert system. This insight greatly affected our experiment design for Prototype 3, as we decided to implement a specific training session in addition to a usability test. We hypothesized that this session would minimize discoverability issues while still allowing us to create an intuitive workflow.

NOTETAKING ASSOCIATIONS

Users had a great deal of trouble with notetaking, a crucial component of the application. Half failed to notice the notetaking button and instead searched for a physical notepad to use, while others didn't notice that notes are associated with specific steps or substeps within a procedure.

CONCEPTUAL MODELS

The ground communication feature yielded interesting results in this test. Some users expected messages in the ground communication panel to link to a referenced procedure, although this functionality was not actually supported in our prototype. Additionally, users instantly identified with the use of a number and highlights as an indication of unread messages from ground crew. These observations lead to the insight that users' conceptual models of ground communication were similar to those they were used to experiencing in social media applications.

PROTOTYPE 3: MID-FIDELITY iOS

Building upon the successful feature implementations of Prototype 2, we began with another round of targeted sketching in order to address users' concerns and errors. ***We also developed an extensive experiment scenario*** *which would carry through to all subsequent rounds of testing. It was at this point that we began to develop a formal design language for the finished application, making aesthetic decisions that would remedy previous ambiguities in the interface's structure and hierarchy. As the design progressed, the scope of this prototype narrowed to* ***focus on the performance of the application and its features,*** *prioritizing functionality over visual polish.*

TESTING

GOALS
We determined user performance with a fully-interactive application utilizing native iOS interaction techniques and incorporating MATE's custom features.

PROTOTYPE
Mid-Fidelity iOS

METHODS
Think Aloud Protocol

PARTICIPANTS
Six NASA Interns

SCENARIO SUMMARY
After constructing full-scale mechanical props, our participants executed an actual NASA-sanctioned procedure involving realistic physical constraints and functional application features.

KEY FINDINGS

- Even with an intuitive workflow and a clean layout, visual design is indispensable in an application's usability
- The user should have to option to ask the application for help with performing simple yet cognitively demanding tasks, like timekeeping and wayfinding
- Users want the device to assist them in the tedious aspects of task execution, or to aid them when their memory alone may be insufficient

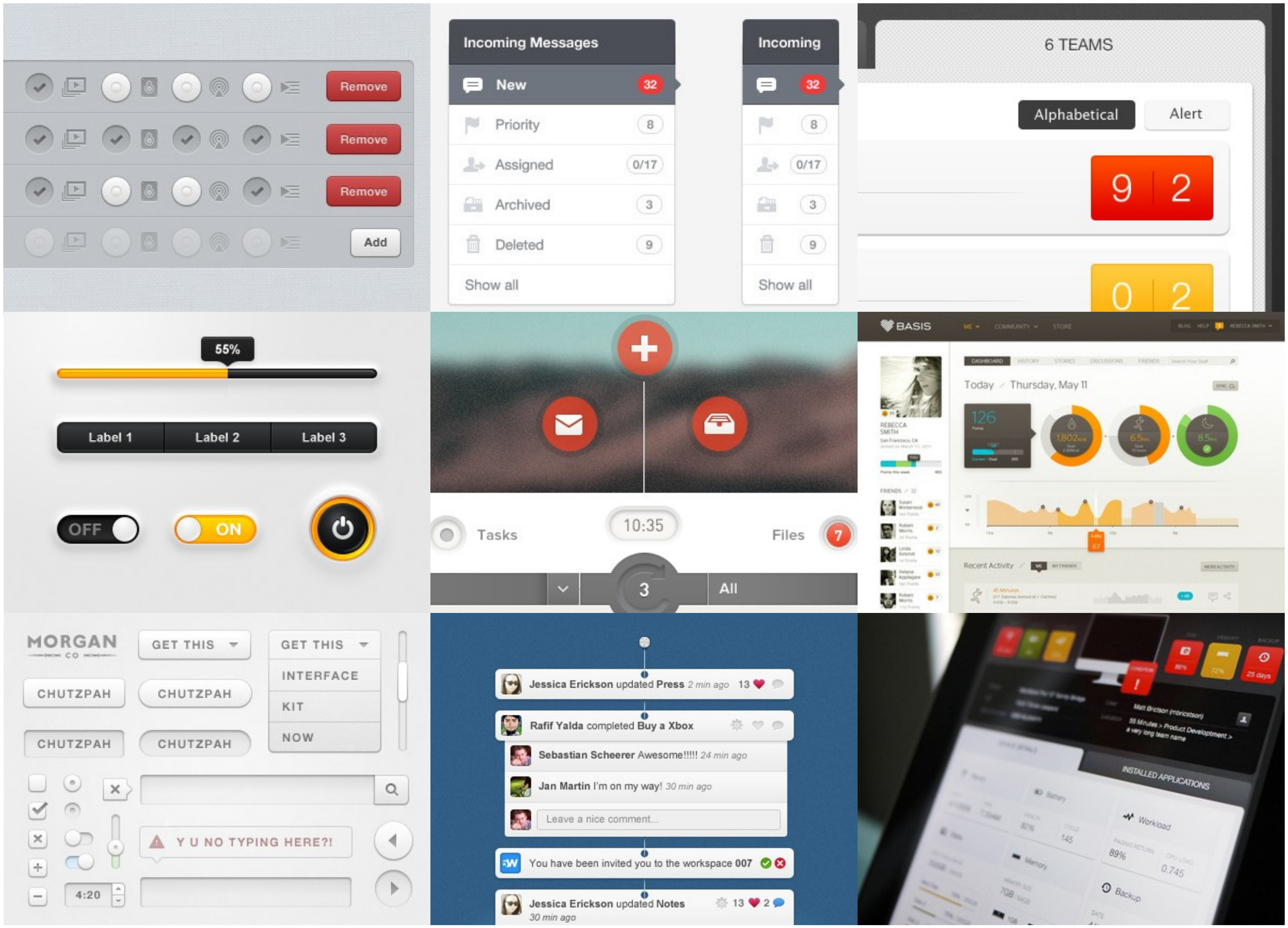
DESIGN AND DEVELOPMENT

For this prototype, it was important for us to observe how users expected UI elements to behave, so we built an almost fully working version of our prototype using the basic Apple-provided interactors on iOS, without layering on any custom visual design beyond the general view layout. The application supported creating and viewing content, but that content did not persist, nor did the application send messages to or receive messages from a ground crew.

While development on the application frontend was taking place, backend development was also continuing in preparation for next prototype. The basic groundwork for a system supporting messaging between “space” (our iPad application) and “ground crew” (the backend server) was completed.

As the first step in establishing a finalized visual design language, we began collaboratively creating a moodboard to align our thoughts on how the application should look. By discussing the images we were drawn to, we honed in on a design direction to explore. In keeping with NASA as well as the density of the information display, we gravitated towards clean, subtle interfaces, using color to pull out important or interactive elements.

DESIGN LANGUAGE MOODBOARD



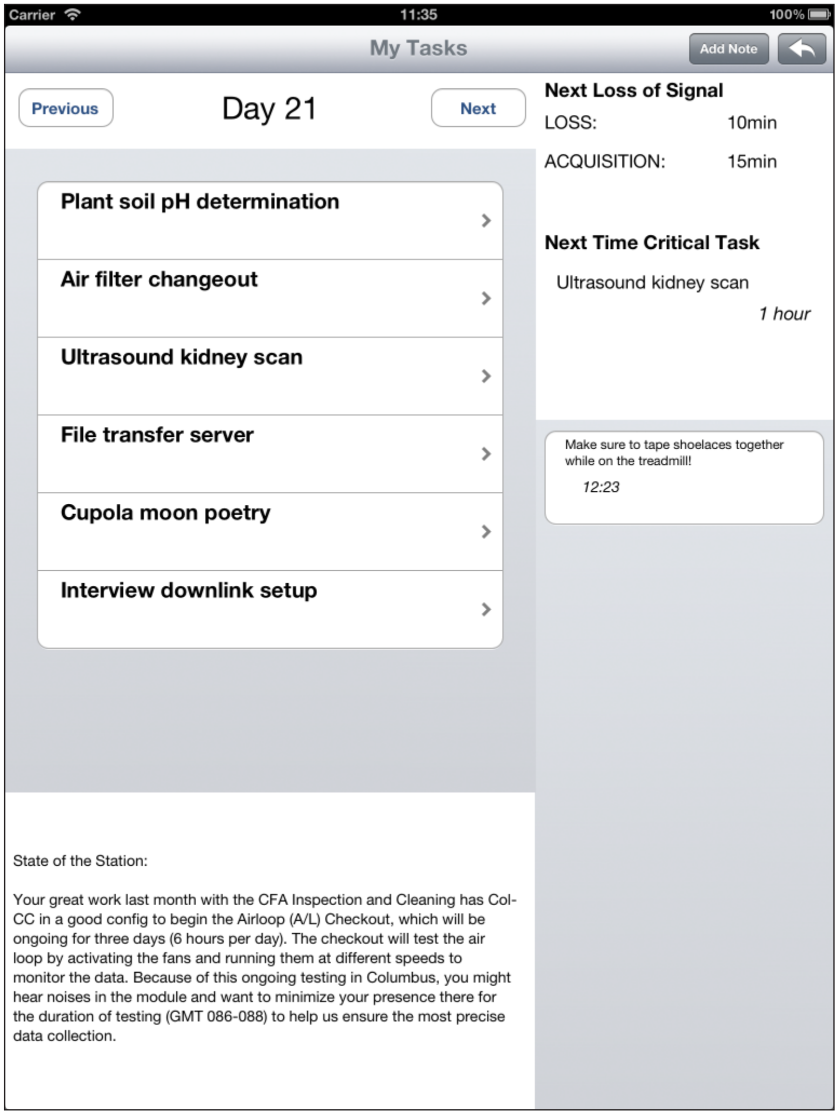
From left to right, top to bottom:

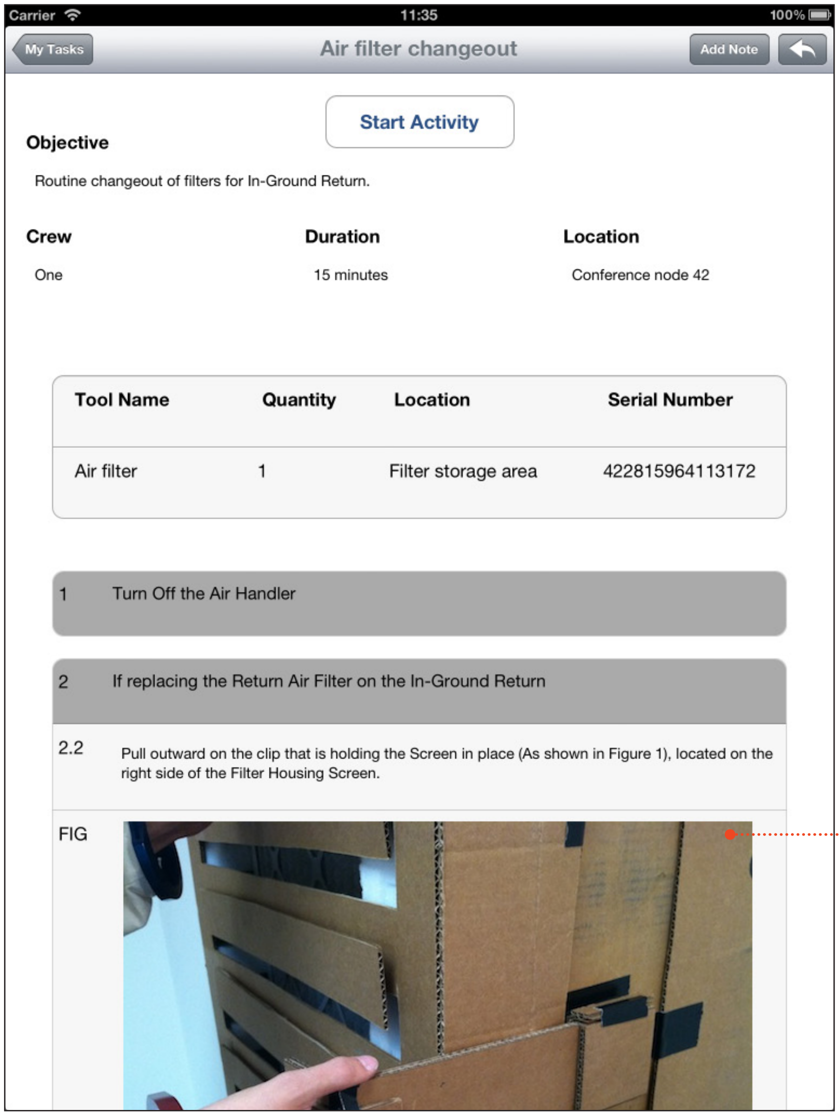
1. *Knuston, Morgan A.*
2. *Kyee*
3. *Wu, Jason*
4. *Dimovski, Vlade*
5. *Noble, James*
6. *Hara*
7. *Knutson, Morgan A.*
8. *Wiljenum*
9. *Wu, Jason*

SELECTED PROTOTYPE SCREENS

Our first fully interactive home screen dedicated the majority of its real estate to its primary feature, the list of daily tasks.

Although fonts and final visual design are not finalized, a hierarchy of importance is established based on the proportional size of each element.



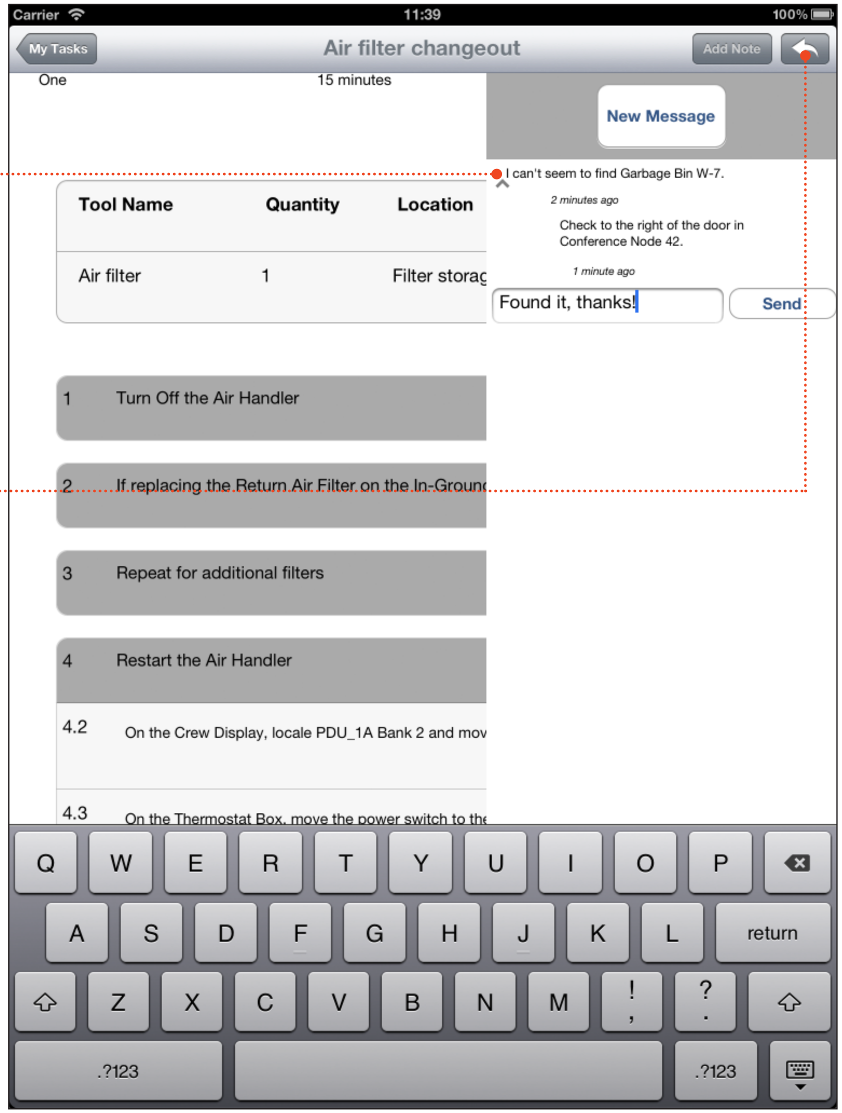


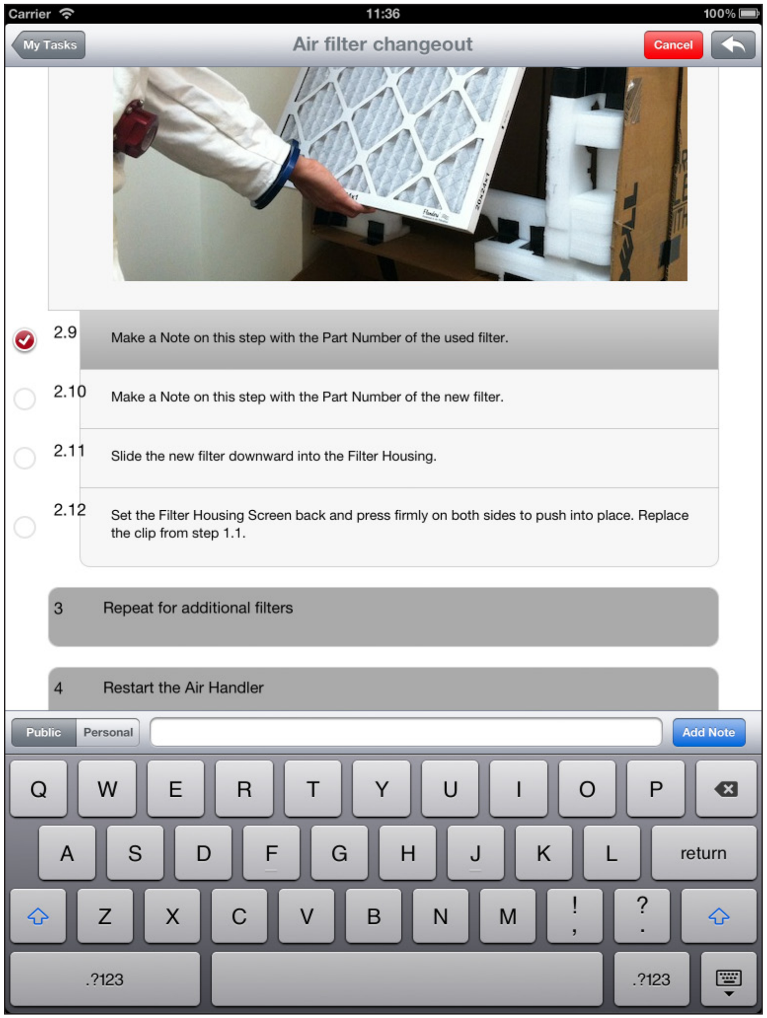
The activity screen, complete with expanding steps, finally allowed us to test important interaction paradigms on an iPad.

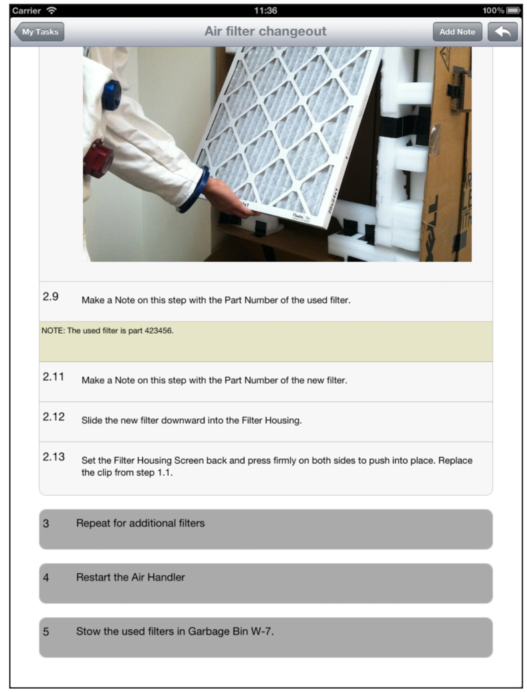
Although we took pains to preserve the integrity of the original procedure, we had to add our own photos to accommodate the makeshift air filter.

Ground communication also suffered from a lack of distinguishing visual elements, causing some users to lose track of where it ended and a procedure began.

The use of the curved arrow icon was also a source of confusion, as were nested replies.







One major feature that we were eager to test in this prototype was notetaking. Due to the primitive nature of this iteration's graphics, users had difficulty determining how to associate a note with a particular step. The keyboard's entry animation also tended to disorient users, causing them to lose track of their place within the procedure. This particular step drew the ire of many participants for its agonizing 15-digit serial number, resulting in many asking for the ability to leave a photographic note on a step.

A participant executes the Filter Screen Changeout procedure. This task was designed to test physical constraints while simulating realistic mechanical maintenance.

EXPERIMENT DESIGN

Discoverability concerns in Prototype 2 led us to reevaluate our testing methodology. Since astronauts would be spending two to three years training with this system, we chose to test MATE as an expert system. As such, we developed a testing protocol that called for a two-day venture which would separate training and execution into distinct phases, which we then shortened to a one-day version for Prototype 3 testing.

The protocol included a brief orientation process with execution of an actual DSH procedure, the true focus of our application. Our conference room was outfitted to approximate the limited physical space of the DSH, complete with superfluous items, crowded space, and less-than-ideal working conditions. We then developed a protocol that began with a training session for the iPad itself, the interface and functionality training, procedure training, then actual procedure execution.

TESTING

Again pairing into teams of two, we met with users in our simulated space station environment. Over the course of two days, we tested six NASA interns through a combination of system training and procedure execution. Our most ambitious test to date, we conducted an air filter-changing procedure in which users experienced a built-in element of urgency as they (with a fair amount of success) strove to complete the task within a given time limit. Following the test, we administered a post-task survey and conducted a brief interview.

EVALUATION

Evaluation consisted of a formal affinity diagramming process in which we organized comments by feature, focusing once again on the themes of notetaking, ground communication, daily task view and activity execution. We also reviewed the video taken during each test, tracking especially insightful quotes and observations about constraints of the system.

As a quantitative measurement for this prototype, we developed a modified version of the System Usability Scale (SUS), a time-tested usability metric. Our version included such queries as “I would be happy using this system frequently” and “I felt that I was in control of my activity while using this system,” as well as other elements that targeted our stated UX goals. Our 6 users rated the system as an 87 / 100, indicating that our system tests far above the average score, which is 68 [1].

1. *See Appendix CD for SUS results*

MAJOR TAKEAWAYS

VISUALLY DISTINGUISHED ELEMENTS

Throughout the tests, users tended to skip things. They sprinted past the task's objectives and stowage notes, diving straight into the first step. They missed specific substeps within the procedure; they failed to expand steps. The primary cause of this confusion, we decided, was a lack of visual hierarchy. This prototype worked excellently for testing interactions, but suffered for its lack of visual clarity.

USER WAYFINDING

Users needed a bit more assistance from their mobile assistants. Many expressed concern when confronted with a ten minute time frame in which to complete their task, while others had difficulty keeping track of where they were within the activity's many substeps. To alleviate these burdens, we decided to develop a flexible timer and a method of bookmarking your current step in the next prototype.

DESIRE FOR RICH MEDIA

During notetaking, many users expressed a desire to record media other than text. Similarly, they enjoyed having instructional illustrations and diagrams within the procedure. Although rich media notes were an initial focus of our project, we had to compromise and decided that such functionality was not technologically feasible for the timeframe of our project.

PROTOTYPE 4: HIGH-FIDELITY iOS

This test showcased a nearly-completed prototype, at last ***unifying visual design and technical development.*** *Visual design details were added to the functional skeleton of Prototype 3, as well as additional features requested during testing. We tested with HCI professionals employed at NASA Ames, individuals uniquely equipped to offer insights on space-related usability issues.* ***A two-day scenario allowed for an even more realistic usability test,*** *as participants underwent training before executing a series of interrelated tasks.*

TESTING

GOALS

We observed the effect of final visual formatting on a procedure execution scenario that includes interruption, task switching and multiple activities. In this way, evaluated performance with specific focus on user experience design goals.

PROTOTYPE	METHODS	PARTICIPANTS
Mid-Fidelity iOS	Think Aloud Protocol Expert Review	Three NASA Ames HCI Professionals

SCENARIO SUMMARY

After training participants on both the use of the application and a specific procedure, a second execution phase required them to conduct both scientific and mechanical activities while maintaining awareness of an upcoming time-critical task.

KEY FINDINGS

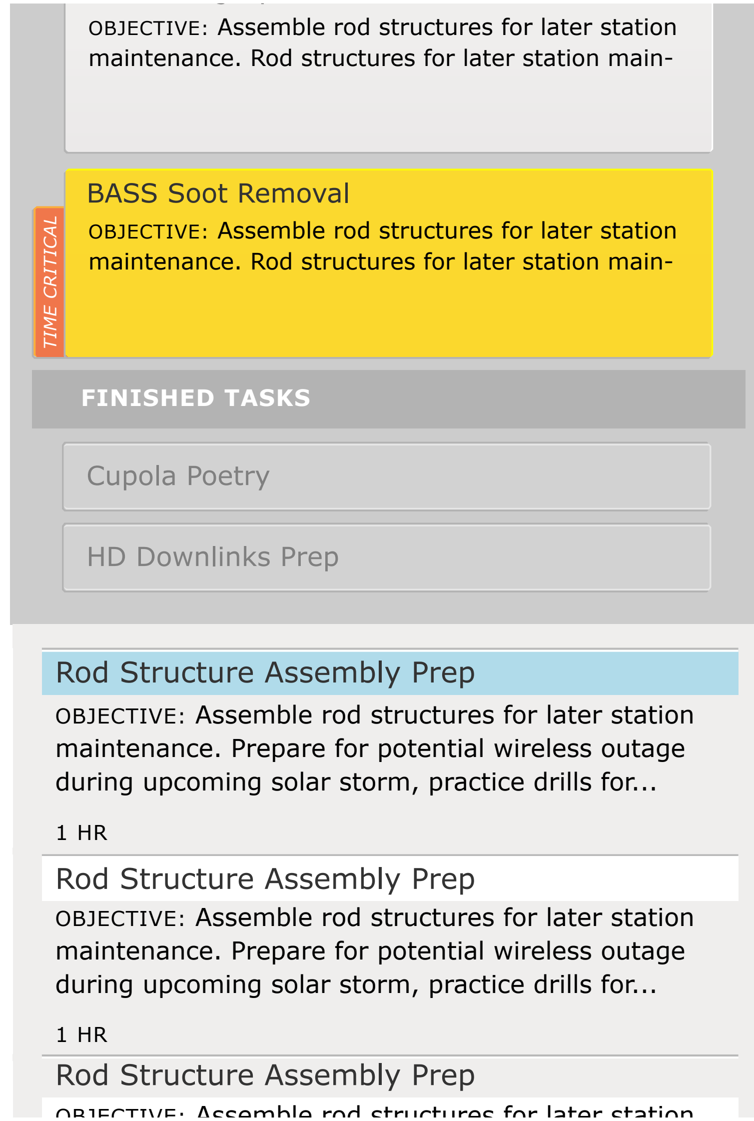
- Users are confused over mixed metaphors in the interaction paradigm of ground communication; they expect it to behave like other communication applications they've interacted with, but not a combination of them
- MATE should accommodate users with dramatically different workflows and in varied physical conditions, particularly during notetaking and activity-viewing
- Based on training sessions, our application has performed well in striking a balance between intuitiveness and learnability
- You can lead a user to the start activity button, but you can't make him or her click it

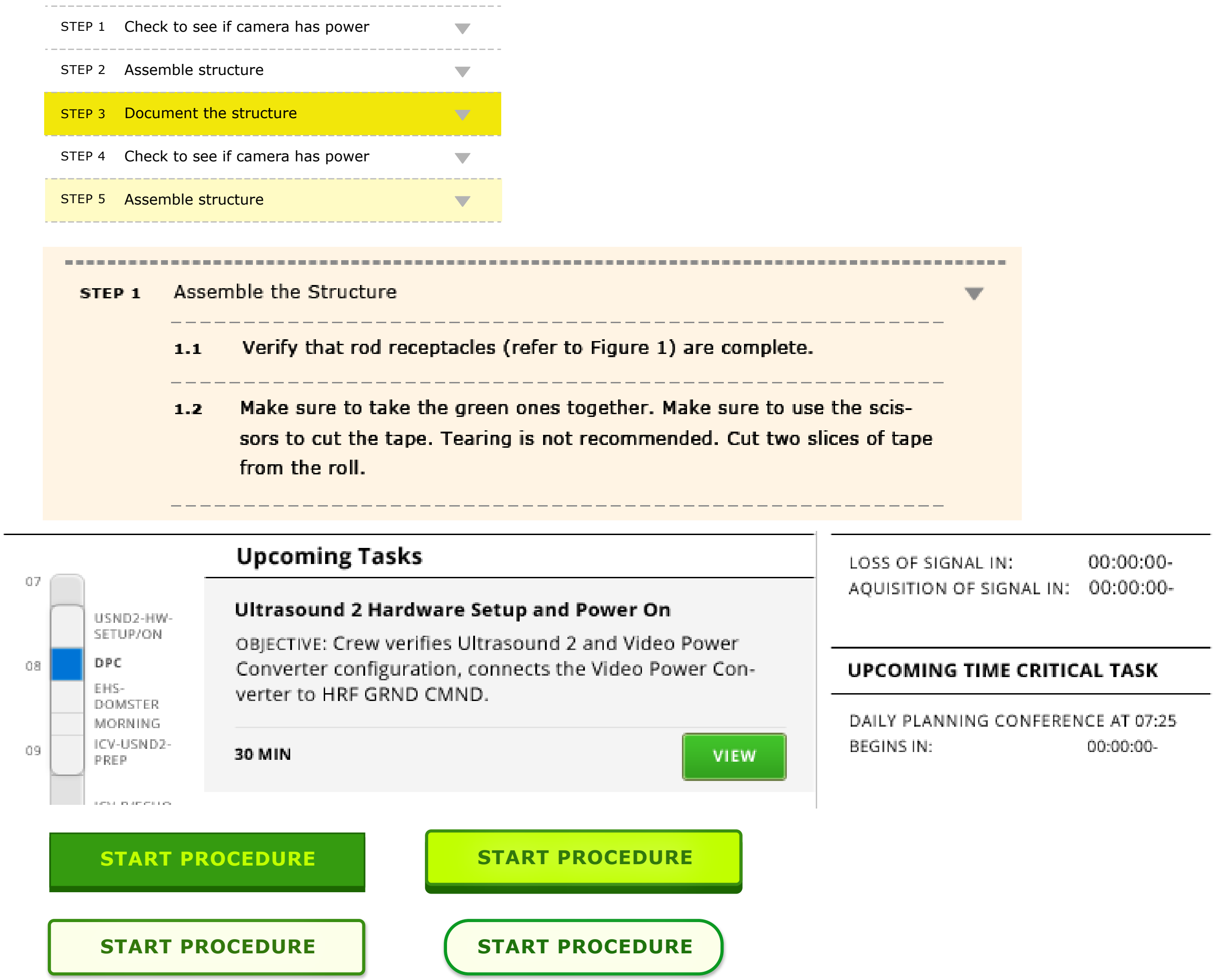
DESIGN AND DEVELOPMENT

Continuing from visual design started during Prototype 3, we developed a visual language for our information display. We looked specifically at how we could use color to indicate state changes, show warnings, or indicate actionable items.

Prototype 4 involved integrating the design into the existing codebase. This involved creating resources for each interactor described in the design, as well as overhauling the basic code to work with new interactions designed since testing Prototype 3. The ground communication panel was simplified, and the process of adding notes was greatly improved. At this point, we connected the backend to the iPad client and made sure any messages from ground, notes, and finished procedures would persist when the application was closed.

We also developed a ground communications panel for the testing team to communicate with users via the ground communications section of the prototype. This “Wizard of Oz” test allowed us to demonstrate interruptibility and natural communications with an outside group. We simulated communication delay by having the client check the server for new messages every thirty seconds.

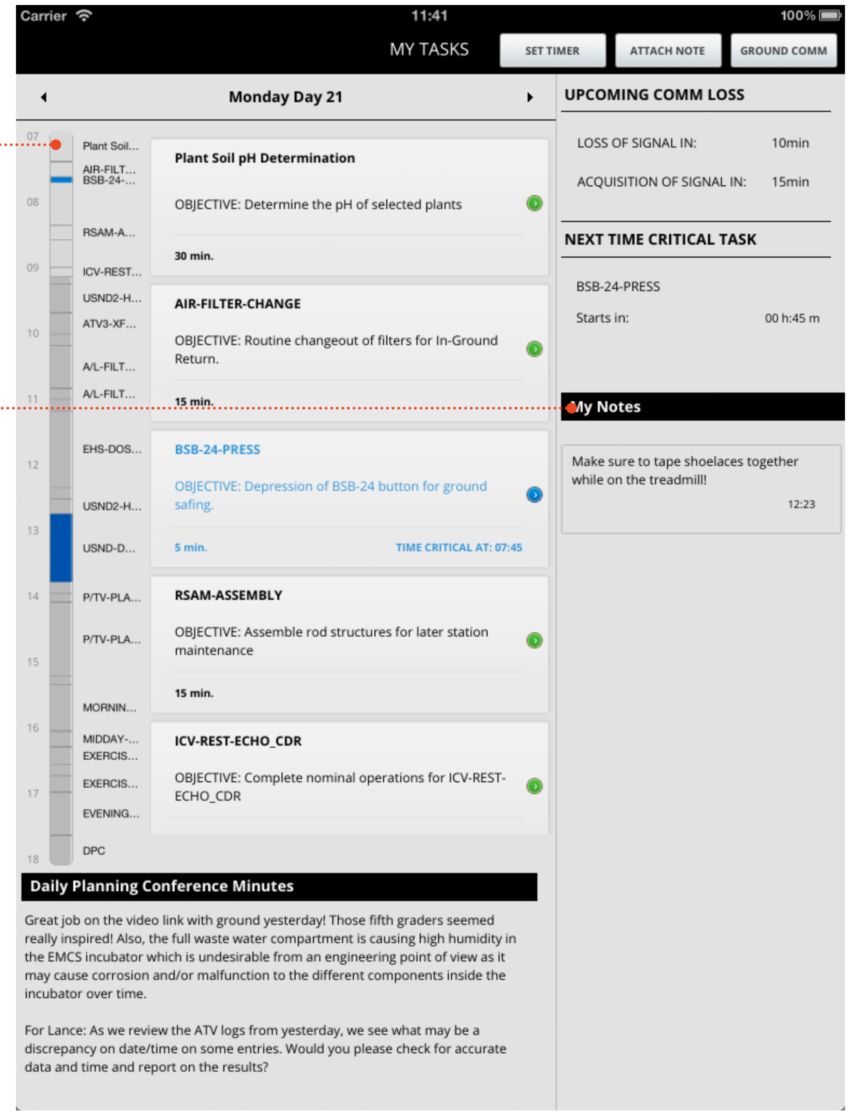


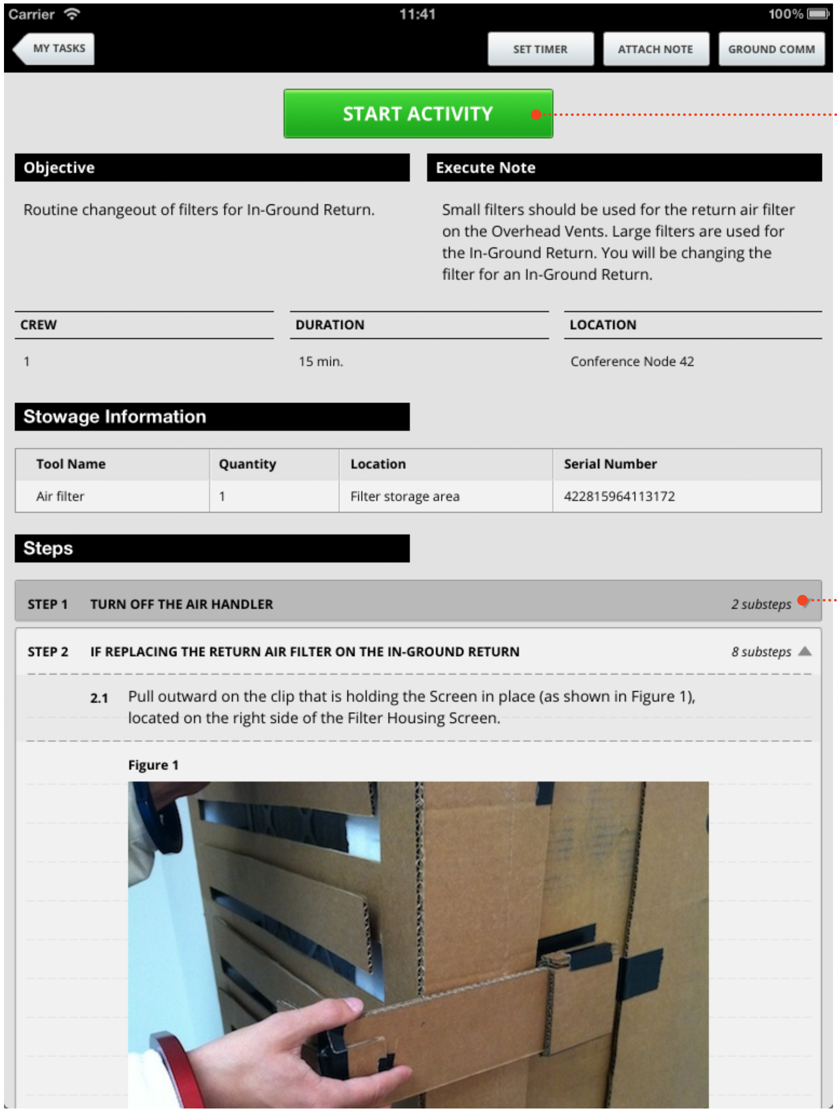

STEP 1 Check to see if camera has power
STEP 2 Assemble structure
STEP 3 Document the structure
STEP 4 Check to see if camera has power
STEP 5 Assemble structure
STEP 1 Assemble the Structure
1.1 Verify that rod receptacles (refer to Figure 1) are complete.
1.2 Make sure to take the green ones together. Make sure to use the scis-sors to cut the tape. Tearing is not recommended. Cut two slices of tape from the roll.
Upcoming Tasks
07
USND2-HW-SETUP/ON
08
DPC
EHS-DOMSTER
MORNING
09
ICV-USND2-PREP
Ultrasound 2 Hardware Setup and Power On
OBJECTIVE: Crew verifies Ultrasound 2 and Video Power Converter configuration, connects the Video Power Con-verter to HRF GRND CMND.
30 MIN
VIEW
LOSS OF SIGNAL IN: 00:00:00-
AQUISITION OF SIGNAL IN: 00:00:00-
UPCOMING TIME CRITICAL TASK
DAILY PLANNING CONFERENCE AT 07:25
BEGINS IN: 00:00:00-
START PROCEDURE
START PROCEDURE
START PROCEDURE
START PROCEDURE

SELECTED PROTOTYPE SCREENS

A vertical timeline was added to give the user a sense of where they are in their day, task listings contain more detailed information, and the entire page was combined with new visual elements.

My Notes on the home view now show only general notes or reminders taken on the day by the crewmember.



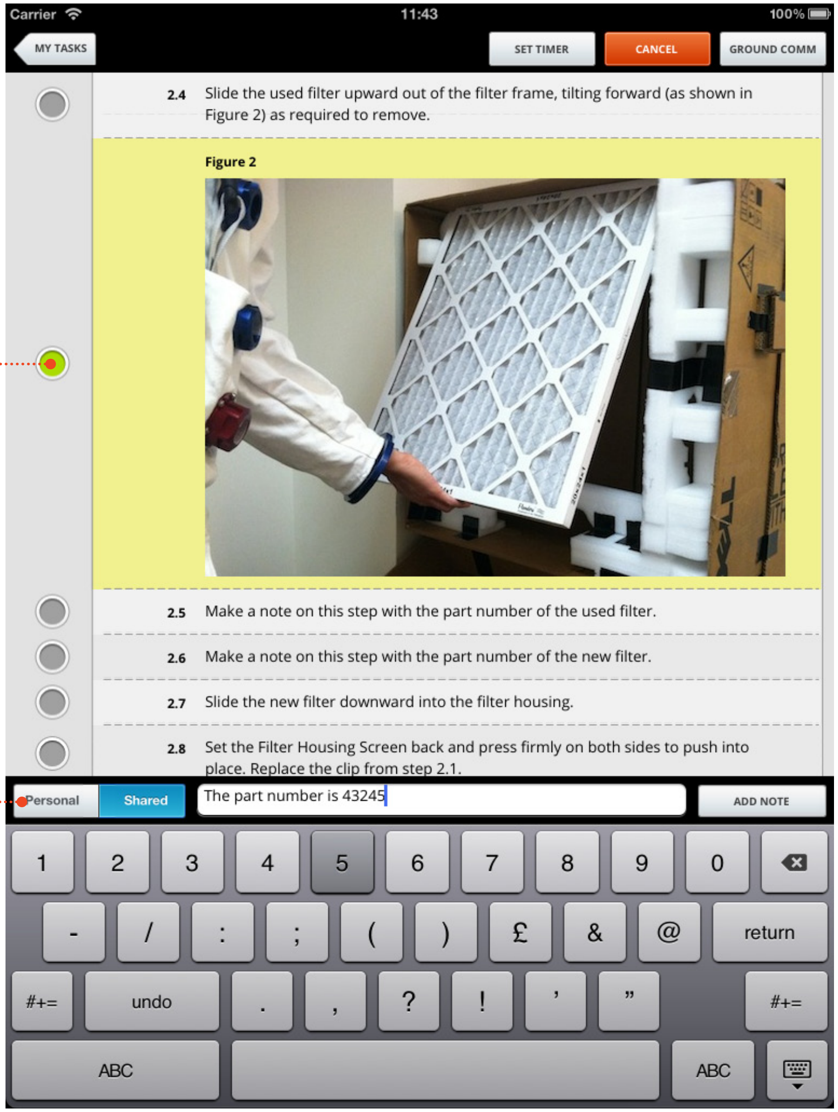


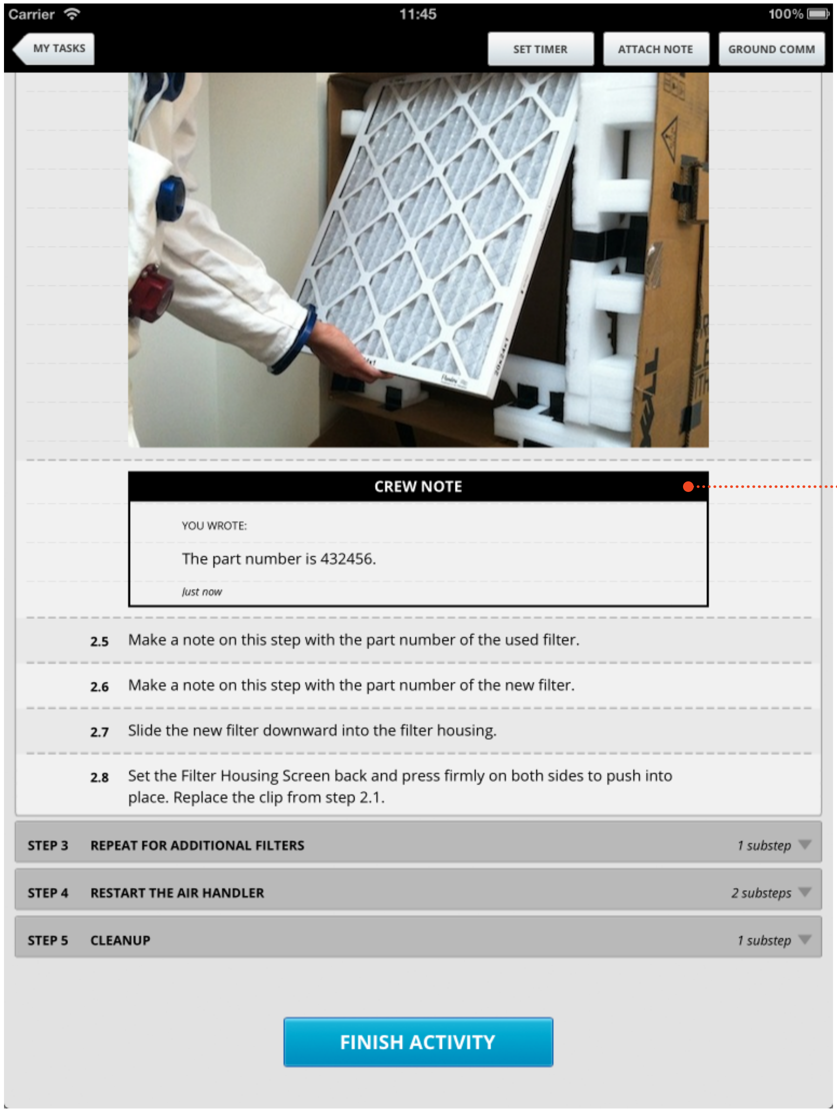
Of note in the activity view is the extremely vibrant “start” button at the top of the screen. Despite its strong visual treatment, compliance was highly variable.

Indicators were added to each step indicating how many substeps they contain, as well as providing an affordance for their expandability.

Notetaking made significant progress between Prototypes 3 and 4, developing a strong visual language that made it clearer where a user should tap to associate a note with a particular step.

"Personal/Shared" designations also became solidified in this iteration, with participants being surprisingly helpful to their unseen compatriots.



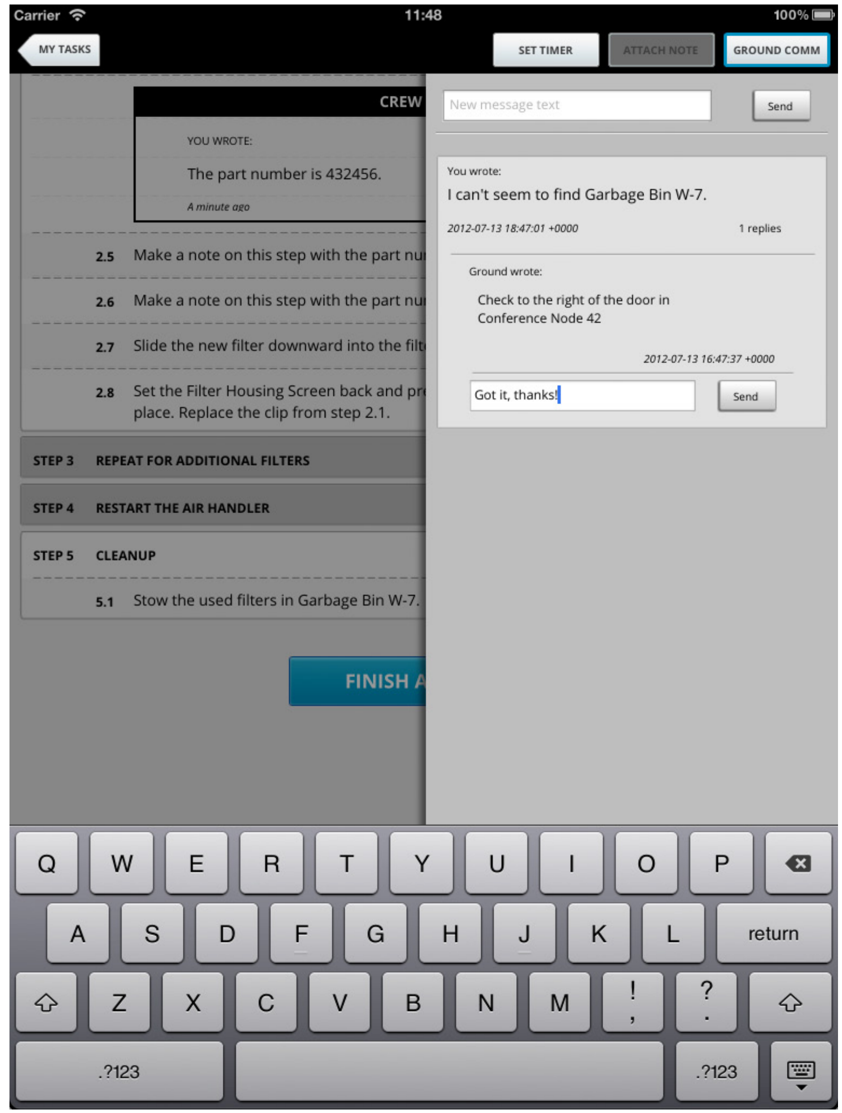


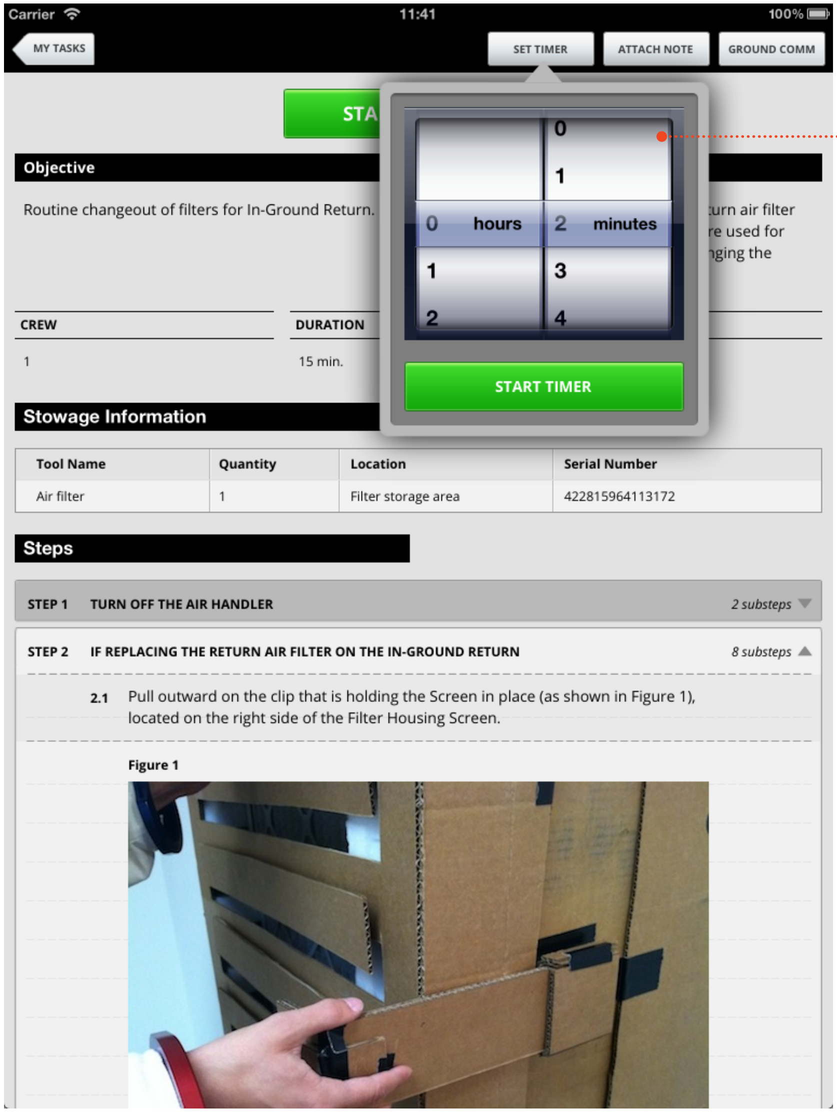
This is an example of a completed note coming into existence. Our participants expressed some confusion during this process, as the note itself seems to pop up very suddenly and intrusively. However, they also enjoyed being able to see the helpful messages left by previous users.

The ground communication drawer proved to be an effective, if occasionally confusing, tool for asynchronously texting ground crew. Much of the confusion came from a lack of a clear cognitive model. Was this an email client? An instant messenger? A threaded comment system?

In Prototype 4 we were able to communicate with users throught the test, simulating the ground crew. The participants found this helpful, turning to ground communication to ask questions or for clarifications.

This “Wizard of Oz” ability revealed many usability breakdowns dealing with new message affordances. There was no visual distinction to tell participants where new replies surfaced in the panel, nor did the panel reorder threads so that newly replied threads moved to the top.





After several users in Prototype 3 expressed concern over time tracking, the timer takes its cues from a simple egg timer. An all-purpose, no-hassle tool, it simply allows users to count down a set amount of time without being loud or intrusive. We took care not to force the user to time steps, instead providing them with an optional item to aid in their activity execution.

Participants were trained both on a scientific procedure and the application itself.

EXPERIMENT DESIGN

After deciding to limit the scope of Prototype's 3 test, we were finally prepared to conduct a full two-day scenario to test the system's memorability. Users were selected from among the NASA Ames HCI staff, as their input on visual elements and interaction paradigms would be especially valuable for the final prototype we would have an opportunity to iterate. Additionally, they possessed a keen understanding of crewmembers' workflow and daily life.

In addition to familiarizing users with interface elements and functionality, this test would allow us to validate our proposed model of transferring notes taken during training to execution. After being trained, the second day of testing would focus on observing how users adapted to a workflow which involved many interrelated tasks. We would observe how they behaved when their current task was interrupted, when they felt the need to communicate with ground crew, and how the pressures of time-critical events affected their execution process.

TESTING

The first day of testing consisted of a training period for the application, a process intended to simulate crewmember training and familiarize users with MATE's interface and functionality. Users were trained on how to use the application and execute the procedure they would be asked to conduct on the second day of testing. As our users are also usability experts, we asked them for feedback on the interface and about cultural considerations at NASA.

For day two, participants returned and executed the procedure from the previous day in a separate room. During this second day of testing, we examined how users dealt with unplanned interruptions by introducing an emergency activity while they were conducting the practiced task, all under a time constraint imposed by an upcoming time-critical activity. We then conducted a post-task interview as well as another SUS survey.

EVALUATION

Evaluation once again consisted primarily of qualitative evaluation, with a specific focus on gathering feedback on our six usability goals [1] and observing complications that arose from conducting more than one task simultaneously. In a break from previous testing protocols, one team member administered every session, while note takers rotated between each. This allowed individuals to take charge of relating important insights to the team, while the persistent administrator provided high-level concepts that arose in each session.

After organizing and accumulating notes, we extracted important user quotes, grouping them by the features to which they pertained. As this was our final opportunity to iterate on a prototype, we specifically focused on ways in which we could directly improve existing features, rather than taking a more exploratory approach. We also noted changes that would be too cumbersome to implement or differed too dramatically from the existing design. The best of these potential changes are documented in *Further Considerations*.

1. *see p.20 for a full description of our user experience goals*

MAJOR TAKEAWAYS

MIXED METAPHORS PRODUCE LACK OF CLARITY IN GROUND COMMUNICATION

Users had difficulty in forming a mental model for how to properly utilize ground communication, unsure if it behaved more like an email client, an text messenging application, or a forum thread. This led to both uncertain interactions within the panel, at least initially, and difficulty in discovering new messages. Furthermore, not all users noticed the visual status notification that indicated a new message was waiting, although over time they were able to better learn this interaction. These observations led us to re-address the role of ground communication and how we could best fit our intended functionality to his or her mental model of noticing, sending, and receiving messages.

USERS HAVE DRAMATICALLY DIFFERENT WORKFLOWS

Even within a relatively narrow system, each user managed to approach his or her activities through very different means. From specific functions like adding a note to finding ways to fill his or her downtime until an upcoming time-critical task, it was clear that our prototype needs to accommodate individual workflows as much as possible. We also validated our research assumption that users will utilize the application to find activity of an appropriate duration to complete while waiting for an upcoming time-sensitive activity.

MATE HAS A LOW LEARNING CURVE

The two day testing scenario was tremendously successful, both in teaching users the application and in simulating the actual training situation of crewmembers. After being trained for approximately 20 minutes, users were able to use MATE and all of its features (nearly) flawlessly. Interestingly, training on the activity seemed to be less effective, as each participant executed the activity with slight variations to the written instructions.

NO ONE TAPS “START”

Perhaps the most frustrating part of this prototype was users’ seeming disinterest in the aptly-labeled “Start Activity” button. Despite the great deal of time invested in positioning and designing the button to maximize visibility, it was often skipped over, along with the rest of the procedure preceding the execution instructions. This problem has proved difficult to resolve, as there are few solutions that do not directly interfere with the user’s autonomy or place additional burdens on the user’s cognitive load.

SUMMARIZED FINDINGS

USER EXPERIENCE GOALS

- Support crewmember autonomy
- Reduce ground crew uncertainty
- Make activities easier to execute
- Prevent user frustration
- Encourage a bond between user and device
- Provide shallow and intuitive navigation

MATE STRIKES A BALANCE BETWEEN INTUITIVENESS AND LEARNABILITY

So much of user-centered design practice focuses on making an application "walk-up-and-use." In a traditional market, users are largely left to their own devices when it comes to learning how an interface functions, leading to frustration if it is not immediately understood. At NASA, however, crewmembers will receive training with a system and use it extensively over a period of up to several years. This changes the onus from discoverability to memorability, as the system is taught rather than purely based on intuition.

With this in mind, applying those same user-centered practices found in walk-up-and-use applications to an expert system such as MATE is a potent combination. By creating a clear, simple interface with a small but powerful cache of tools, we are able to limit cognitive overload caused by displaying too much information on the screen at one time while retaining quick access to features the crewmember will commonly need. Our usability tests have shown that even after an orientation period as short as ten minutes, participants were able to successfully locate and utilize all of MATE's essential features.

Familiar interaction paradigms also contribute to MATE's learnability. Test participants felt immediately comfortable with conceptual models from their daily technology use, such as notifications like those present in many social media websites and instant messenger-style communication with ground. Leveraging prior knowledge makes the system not only easier to learn, but more familiar and enjoyable.

Supporting UX Goals:

- Make activities easier to execute
- Prevent user frustration
- Encourage a bond between user and device
- Provide shallow and intuitive navigation

MATE GIVES USERS THE ABILITY TO DO THINGS THEIR OWN WAY

As our research indicated abundantly, astronauts are atypical individuals. Described as "preposterously motivated," and "the type of person who wants their A+ to be better than everyone else's A+," it should come as no surprise that they would desire to do things their own way. Both our interviews and project prompt indicated that astronauts both desire and require the autonomy to conduct their daily duties as they deem best.

User autonomy was one of our key focuses from the beginning, but it was only later that we realized the importance of a more generalized flexibility in our application. Although the organization of the home view always encouraged crewmembers to tackle their daily activities in an order they see fit, the ability to conduct their workflow in a personalized manner wasn't immediately apparent. This led us to design features with a degree of flexibility and redundancy.

For example, MATE saves the state of marked steps within activities, allowing the user to switch tasks and come back to the original without losing track of their position. Additionally, the recommended inclusion of multimedia notes provides a system for crewmembers to take notes in whatever format they feel is most appropriate and useful. No two crewmembers have the same workflow, so no two MATE sessions will behave in exactly the same way.

Supporting UX Goals:

- Support crewmember autonomy
- Reduce ground crew uncertainty
- Make activities easier to execute
- Prevent user frustration
- Encourage a bond between user and device

MATE PRESENTS THE NECESSARY INFORMATION WITHOUT BEING DENSE

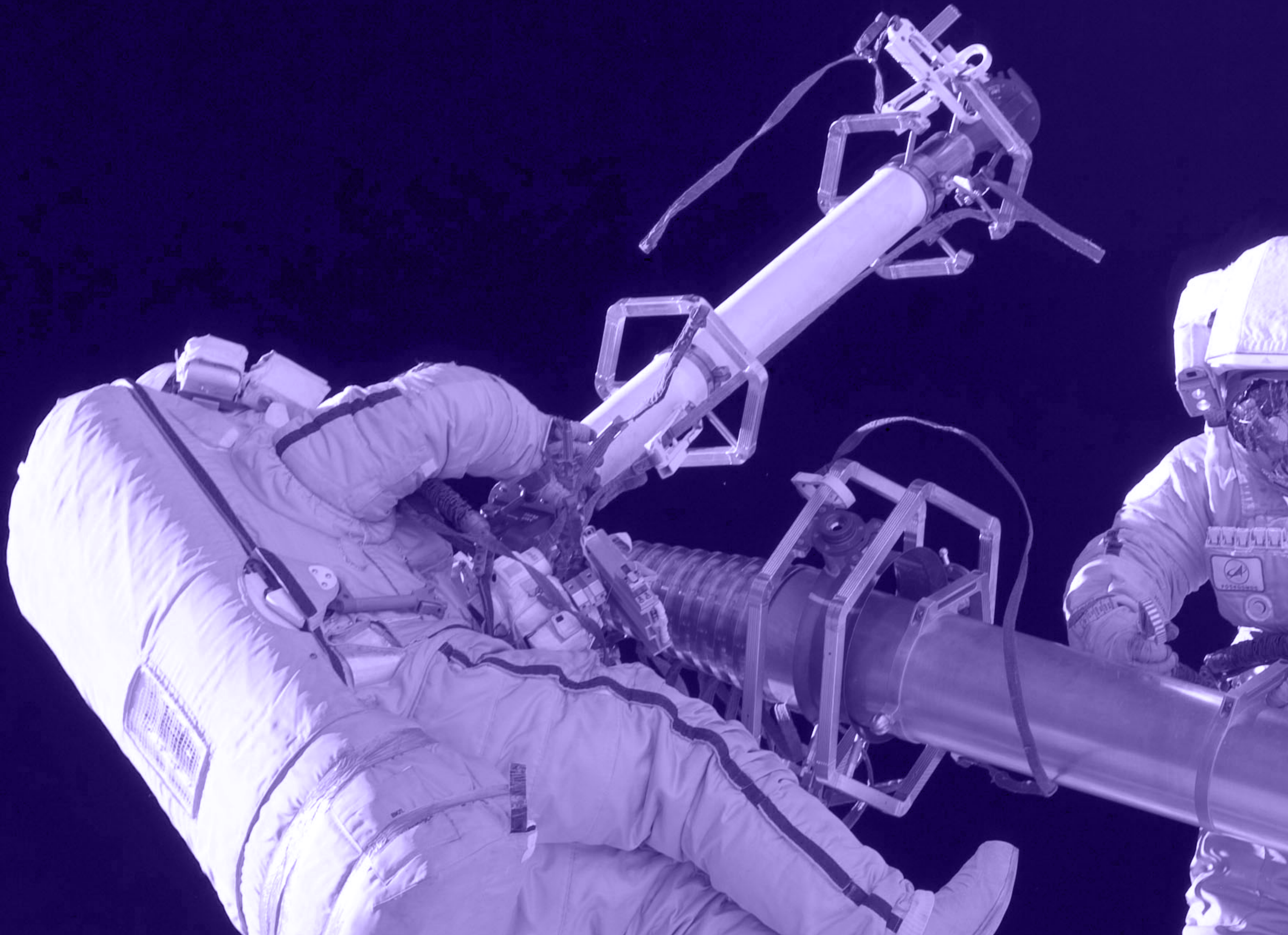
It is generally acknowledged that NASA engineers love data-dense displays. There are many considerations that must be taken into account during daily operations, so giving the crewmember access to as many of them as possible is crucial. However, single screens with that amount of information may lead cognitive overload.

By hiding away information that is not immediately relevant, we are able to retain a clean, uncluttered screen without losing the ability to bring up data as they are needed. Notes, ground communication and other features exist as drawers or alternate modes that the user is free to access at any time, but remain hidden when they are inactive.

Supporting UX Goals:

- Make activities easier to execute
- Prevent user frustration
- Provide shallow and intuitive navigation

FURTHER CONSIDERATIONS




РОССИЯ

FURTHER CONSIDERATIONS

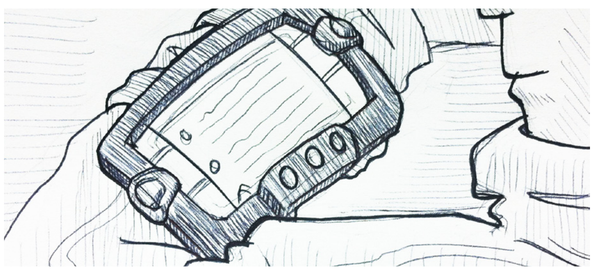
At the beginning of the summer semester, one of our greatest challenges was deciding upon a realistic and meaningful project scope. Even after MATE's core functionality was decided upon, various elements were removed or altered with each new iteration. An unfortunate, albeit inevitable, result of this process was that many fascinating features and ideas had to be left unexplored. Here we present the most interesting of these discarded concepts.

RELATED CONCEPTS

The following ideas, generated through our research and visioning sessions, gained much support during early rounds of concept validation and internal discussions. Though they were eventually declared to be out of scope for our prototype, they still represent interesting directions for future investigation.

SECONDARY DEVICE

A tempting exploration was pushing certain functionality to a smaller, wearable device. In this way, only the most relevant information is shown, requiring less attention to the secondary device or to information that may not be immediately needed. The complications inherent in developing a secondary device—combined with the lack of support from our research findings—resulted in this concept being shelved.

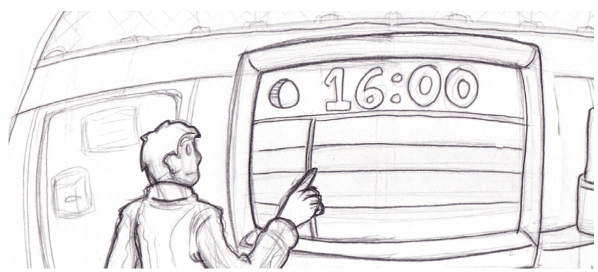


INVENTORY MANAGEMENT

Although this issue arose during research, we decided that inventory management would not be prioritized in our system. Although intimately related, considerations inherent in locating, storing, and tracking physical tools were too numerous and varied to be explored simultaneously with activity execution.

LARGER DISPLAYS

One promising concept from our brainstorming sessions was to utilize a large display that would provide an at-a-glance view of crewmembers' shared schedules. However, the cost and resource demands of such a device outweighed the benefits. Additionally, it likely would have proved cumbersome to prototype.

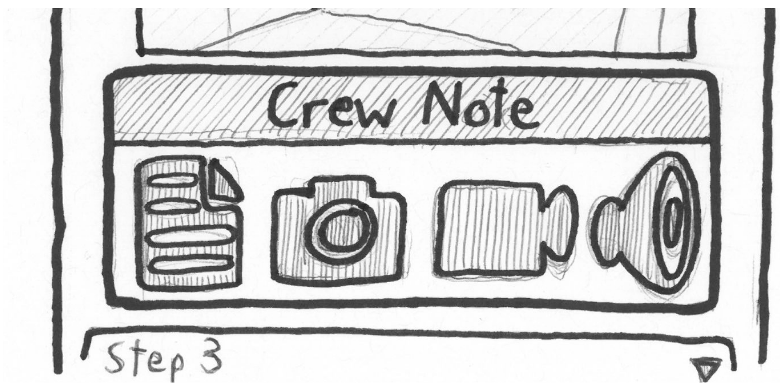


POTENTIAL FEATURES

We believe the following concepts and features would be worthwhile additions to MATE but, due to technical and time restraints, we did not prototype or test them.

EMBEDDING RICH MEDIA

From our research, we found that contextual references helped minimize procedure errors. For instance, the ability to look at illustrated diagrams or photos related to the current activity would be helpful for users as they are performing a task. Existing procedure documents on ISS often lack contextual feedback or physical cues beyond words or photos associated with a step. By providing crewmembers with the capability to add their own photos, videos, and audio recordings, we free them to leave relevant notes in the most useful format.

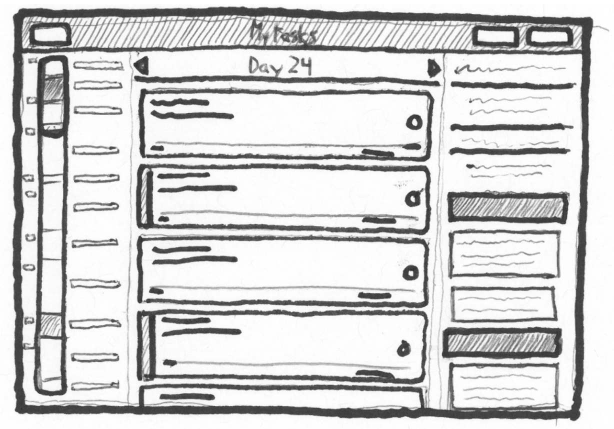


USER SWITCHING

Selecting the user's name in the top bar could allow for easy user switching and, consequently, new user authentication.

LANDSCAPE AND PORTRAIT DEVICE ORIENTATION

It would be useful to allow the device to be used when turned in either orientation. Some users expressed a preference for typing in a landscape mode, while our device is fixed to a portrait orientation. We decided to keep the formatting consistent and to focus establishing core functionality that could later be adjusted for either orientation.



ENTIRE CREWS' SCHEDULES

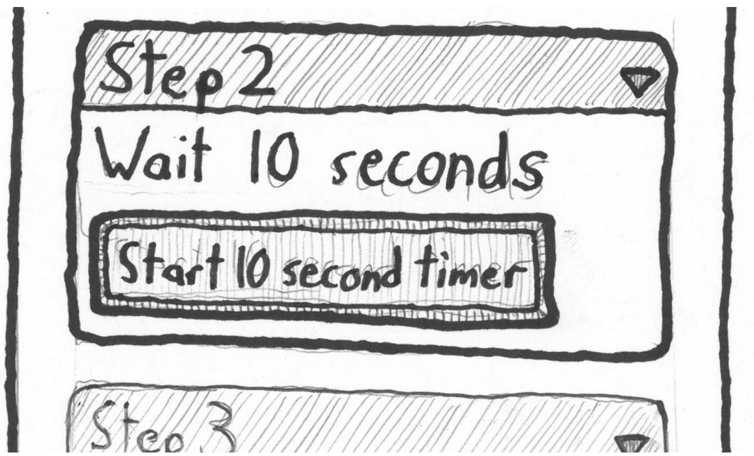
While we wanted to present a large-scale view of all crews' schedules similar to that of OSTPV, this option has not been fully implemented as of yet. This additional view would have to be integrated in such a way that does not detract from the "shallow" navigation of the entire system.

ADJUSTABLE TYPE SIZES

When the mobile assistant is not near the user, the type size would automatically increase so that reading would be convenient at a distance. When crewmembers need to perform a task that doesn't allow them to pick up and move the mobile device, or requires them to stow the mobile device temporarily on some surface, a larger type size could facilitate distant use.

SMART CONTEXTUAL FEATURES WITHIN STEPS

We considered embedding features within the procedure that allow the user to execute physical tasks within the application itself. For instance, instead of reading instructions and then adjusting a thermostat, they could use do so from the device. Additionally, text fields within procedures would allow for direct data input for ground crew use.

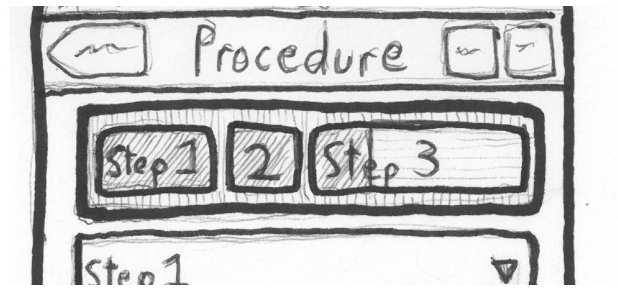


EXPANDED GROUND COMMUNICATION

In later rounds of testing, users required more functionality from the ground communication panel than it currently provides. If this becomes the primary method for reporting back to earth, it deserves to be examined in more depth.

PROGRESS TRACKING BAR

Users expressed a desire to know how far they had progressed in an activity as a function of its total length. This would be a useful feature, but would require extensive data about exactly how long each step and substep takes. If this feature were to be implemented, it should be built upon the experiences of previous crewmembers—ideally gathered passively by MATE.



CHECK OFF EACH STEP

As our spring research showed, crewmembers are extremely motivated individuals with a propensity towards perfectionism. Thus, some may very well desire the ability to manually mark their completion of each step within a procedure as a means of directly tracking their progress. This same functionality could also be applied to stowage lists, allowing users to more easily track which materials have already been gathered.

NEXT STEPS FOR MATE

Although MATE has a necessarily limited development timeline, the following are steps that we would like to take if development were to continue in earnest.

FORMALLY RESEARCH TECHNICAL WRITING / INSTRUCTION MANUALS

Further research into the latest literature on technical instruction manuals could provide insight into best practices for presenting dense sequential information.

INFERENCE AND BACKGROUND INFORMATION GATHERING

More passive data could be gathered from the procedure, such as by automatically measuring time to complete each task in order to make better estimations in the future.

START AND TIME TRACKING COMPLIANCE

Since our research indicates variable compliance in progress monitoring on OSTPV, further research into strategies for nonintrusive methods for monitoring the real-time completion status of each task would be useful.

CONDUCT FIELD TEST WITH DESERT RATS / NEEMO

Usability tests in the future could include analog crewmembers who are closer to our target users in terms of experience and understanding of mission contexts.

INVESTIGATE PHYSICAL PROPERTIES IN A SPECIFIC CONTEXT, E.G. MPCV, DSH

While our tests attempted to simulate crowded conditions, we were not able to test our application in an actual analog mission. For instance, testing on the DSH would be useful to discover whether the core functionality supports execution in context.

ADAPT TO SUPPORT APPROVED NASA TRAINING PROCEDURES

Our current procedure data was adapted from analog procedures. As a next step, the system should be tested with procedures from ISS or other NASA training procedures.

ABOUT

ABOUT US

Our interdisciplinary team of five Carnegie Mellon Master of Human–Computer Interaction students, working with the HCI Group at NASA Ames Research Center, seeks to design, develop, and evaluate an interactive prototype that will assist crewmembers in the process of carrying out their tasks. Over the course of eight months, we covered an end-to-end process from researching and understanding our domain to conceptualizing, developing and iterating on our prototype.

To gain an informed understanding of planning and execution, we began by conducting extensive background and user research in human space missions and analogous domains with similar challenges. Our research investigated the scope of complex procedure execution in the context of increasing user autonomy, response to unpredictable conditions, and communications across multiple groups.

Following the research phase, we focused on the development of a solution that had the potential to be incorporated into current and future systems at NASA. Beginning with the ideation phase, we analyzed the data we found from research and synthesized our findings to design a prototype that would meet the needs and desires of our users. In the design and development phase, our efforts involved iteratively designing, developing, and testing our prototype.

DIANA CHEN, PROJECT LEAD
Diana Chen has a BA from University of California Berkeley. She combines psychology, mobile UI design, and theater in order to create delightful user experiences. Her favorite space movie is *Spaceballs.*

JOE MEDWID, USER EXPERIENCE LEAD
Joe Medwid has an undergraduate degree in architecture from the University of Virginia. As User Experience Lead, he uses his varied skills in interface design, storyboarding, illustration, and improvization in order to create truly engaging design. His favorite space movie is *Wall-E.*

ESTEN HURTLE, TECHNICAL LEAD
Esten Hurtle has a degree in journalism from the University of Missouri and has worked on digital news projects for a variety of clients. He focuses mainly on software development and enjoys new opportunities in mobile and data analysis. His favorite space movie is *Sunshine.*

KEVIN MCMILLIN, RESEARCH LEAD
Kevin McMillin has a BS in computer science from Barrett, the Honors College at Arizona State University, where he explored design toolkits for physical learning games. He dives deeply into new domains with past projects in unified communication, simulated social networks, and Esperanto. His favorite space movie is *The Cat From Outer Space.*

SAMIA AHMED, DESIGN LEAD
Samia Ahmed has an undergraduate degree in communication design and human-computer interaction from the School of Design at Carnegie Mellon University. Samia believes in an iterative design process, clear communication, and strong typography to synthesize user research into meaningful systems. Her favorite space movie is *Galaxy Quest.*

THE HCII

The Carnegie Mellon Human-Computer Interaction Institute is an interdisciplinary community of students and faculty dedicated to research and education in topics related to computer technology in support of human activity and society. The master's program is a rigorous 12-month curriculum in which students complete coursework in programming, design, psychology, HCI methods, and electives that allow them to personalize their educational experience. During their second and third semesters, the students participate in a substantial Capstone Project with an industry sponsor.

The Capstone Project course curriculum is structured to cover the end-to-end process of a research and development product cycle, while working closely with an industry sponsor on new ideas or applications that may work with their existing human-to-machine technology. The goal of this 32-week course is to give each student the opportunity for a "real-life" industry project, similar to an actual experience in a research/design/development setting.

Company sponsors benefit from the innovative ideas produced by the students, to fix existing systems or reach into new markets. Some companies also use this project as a recruiting tool, offering industry positions to the top producers in their project team.

For questions about the content, or to learn how to sponsor a project please contact:

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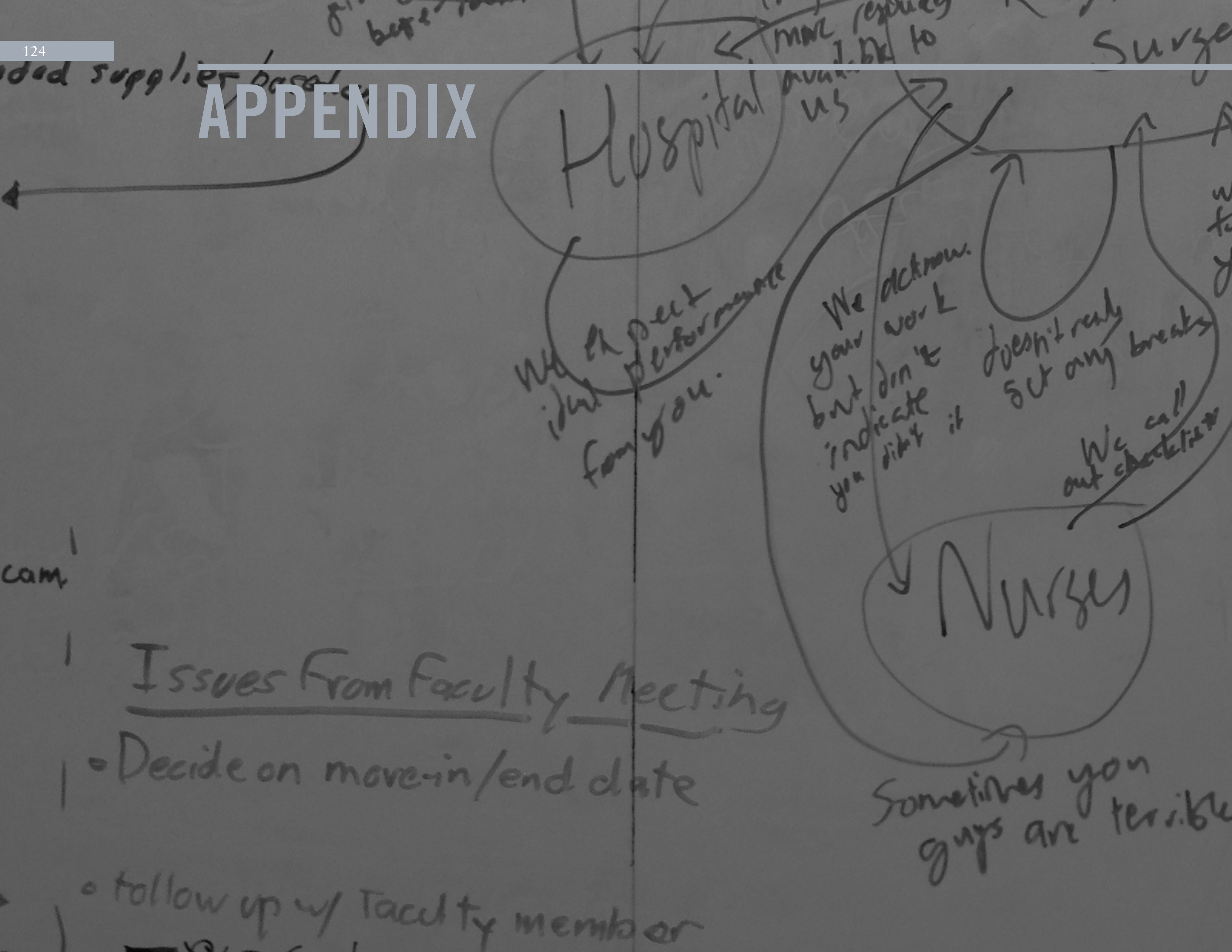
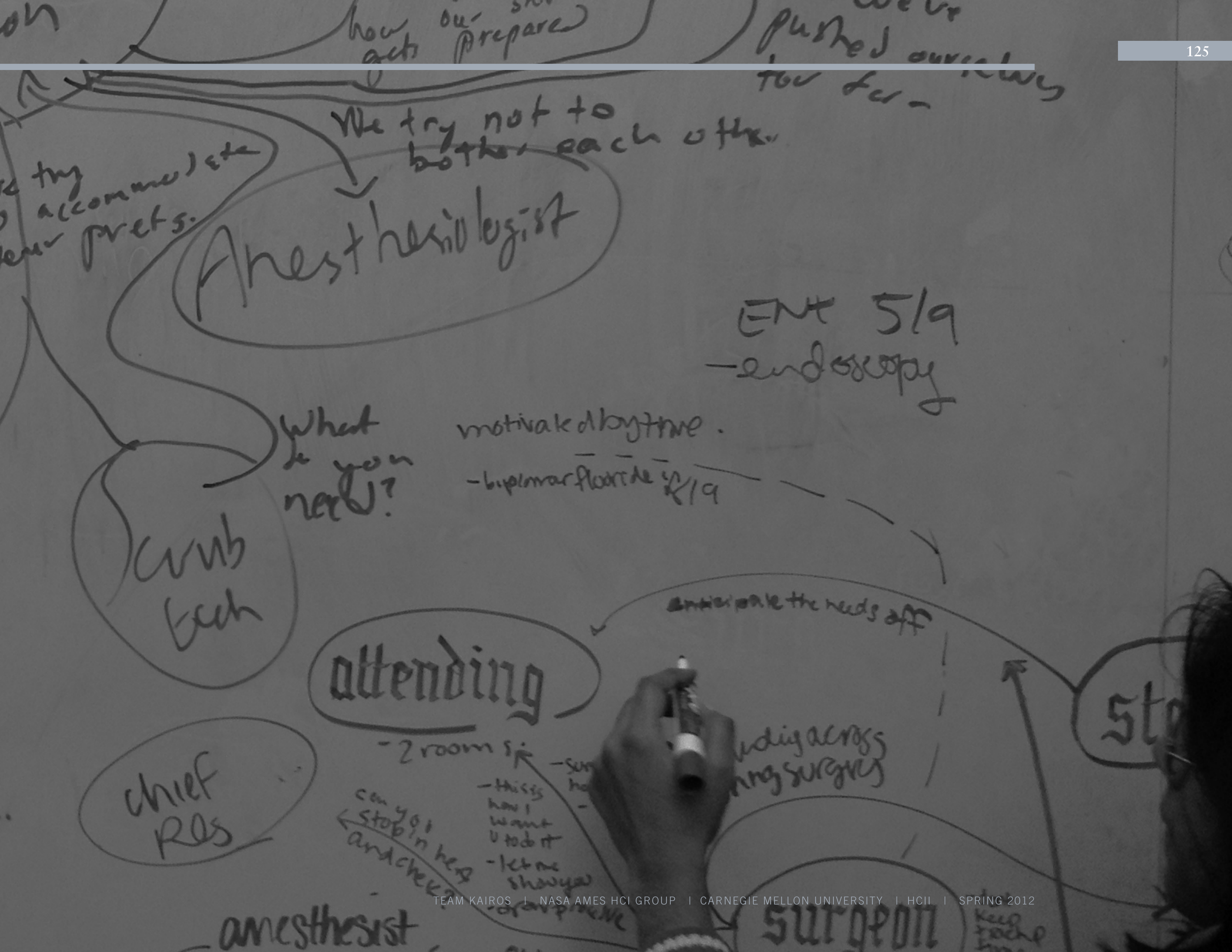
TEAM KAIROS | NASA AMES HCI GROUP | CARNEGIE MELLON UNIVERSITY | HCII | SUMMER 2012

APPENDIX


Hospital
We expect ideal performance from you.
We acknow. your work but don't indicate you did it
doesn't really get any breaks
We call out checklists
Nurses
Sometimes you guys are
Issues From Faculty Meeting
• Decide on move-in/end date
• follow up w/ Faculty member


We try not to bother each other
Anesthesiologist
ENT 5/9
-endoscopy
What do you need?
Scrub tech
attending
chief Res
surgeon

PROTOTYPE 2 SCENARIO

MAIN POINTS TO TEST

- Starting and Stopping procedures
- Pausing procedures - how would they do this? mental model
- Ground communication
- Taking a note
- Getting information about others' schedules
- Finding tasks in personal view
- Finding relevant notes
- Explore the My Tasks screen and Everybody Else's screen

SCENARIO

- *Participant receives the following prompt:*

Congratulations! You're an astronaut!

You've been training for over three years for this mission onboard the International Space Station (ISS). Things have been going well for the past 35 days of your 6-month space adventure. You and your five international crewmates have conducted scientific experiments, carried out crucial repairs, taken breathtaking photographs of the earth, and completed hundreds of other activities.

Each astronaut has a daily schedule of activities like these which they need to carry out. This schedule also contains the specific instructions needed to successfully complete each task.

Today, you'll be using a new mobile system to help with these daily procedures. Your task will be to carry out the Rod Structure Assembly procedure using this new tool.

Before we get started, I just wanted to let you know that you might need to move around this room a little bit to collect your tools. We have labeled the bins, modules, and other locations with green post-its. Feel free to explore and search around the room during the procedure.

- *Start on "home screen", prompt says which task to do [first one].*

- *Gather tools*

- *Start the following procedure:*

Name: RSAM-Prep-Work
Rod Structure Assembly Prep

Objective: Assemble rod structures for later station maintenance.
Duration: 15 minutes
Number of Crew: One
Location: Conference Node 42

Materials:
1 Rod Structure Assembly Mat (RSAM)
3 AAA Batteries
1 Camera
1 (large) Red Rod
1 (medium) Green Rod
1 (small) Yellow Rod
1 Red Rod Receptacle (or 2 Red Half-Receptacles)
1 Green Rod Receptacle (or 2 Green Half-Receptacles)
1 Yellow Rod Receptacle (or 2 Yellow Half-

Receptacles)
1 Roll of Tape
1 Pair of Scissors
1 Phillips head screwdriver

Locations to Use (for stowage note in Procedure):
BinA (filing cabinet):
BinA11 (top shelf)
BinA12 (bottom shelf)
BinA12:A.1 - subshelf of BinA12
BinA12:A.2 - subshelf of BinA12
SackB6 (floating sack in space)
Module W7 (the computer)
BinD9 (bin with astronaut clothes)

Overview: Put together structure, document with camera.

1. Check to see if camera has power.
1.1 Press the orange button to turn on the camera.
IF NOT:
1.2. Replace batteries
1.2.2. Open green battery compartment at the bottom of the camera using screwdriver
1.2.3. Remove old batteries (three)
1.2.4. Dispose of old batteries (Wastebin 3)
// CAUTION: Be sure you dispose of them in correct wastebin
1.2.5. Install new batteries (three)
1.2.6 Reattach green battery compartment cover with screws
END

2. Assemble the structure
2.1 Verify that rod receptacles (refer to Figure 1) are complete.
IF NOT:
2.1.1 Cut two slices of tape from the roll
NOTE (left by Lance): Make sure to use the scissors to cut the tape. Tearing is not recommended.
2.1.2 Use both pieces of tape to attach two half-receptacles together
2.1.3 To Step 2.1, attach and write a public note for future reference, documenting which colors needed to be taped.
END
2.2 Insert rods into receptacles of the same color.
2.3 Place each assembled rod structure on the appropriate place on the Rod Structure Assembly Mat (RSAM).

3. Document the structure
3.1. Take an image of assembled structure in place using camera
3.2. Mark as complete.

- *Ground then interrupts: "Leopold needs some help. Please navigate to his current activity and join him."*

- *Participant navigates to "Everybody Else" screen and locates Leopold's current task.*

- *End!*

PROTOTYPE 3 SCENARIO

Evaluate overall performance of app and its features while executing a real procedure.
Time: 35-50 Minutes

PART 1: INTRODUCTION
Purpose: Make user feel engaged and at ease
~ 5 Minutes
Engage user by bringing them into a real-ish training scenario
Give user a brief outline of ISS, astronaut life, etc.
Have user sign appropriate documents
Turn on camera, film everything

PART 2: INTERFACE AND FUNCTIONALITY TRAINING
Purpose: Train user to lessen discoverability influence, quantitatively evaluate features
~ 10-15 Minutes
Go over basic iPad functionality (Gestures, etc)
Explain Task view and relevant information on this screen

Explain relevant parts of Procedures, including Stowage, Ex/Op Notes + Start/Finish
Use another procedure for this.

Explain Note Taking mode
Brief exercise(s) to test various use cases, measure metrics (e.g. time to complete, time to discover, number of errors)
Explain Ground Comm mode
Brief exercise(s) to test various use cases, measure metrics

PART 3: PROCEDURE
Purpose: Evaluate use of procedure data, in-situ note taking + ground comm.
~ 10-15 Minutes
Instruct user to perform Filter procedure, starting at Task screen
Make special note of how user uses procedure information
Hands-off!
Need to add to the procedure a prompt to write their own note

PART 4: POST-TASK SURVEY + INTERVIEW
Purpose: Formally evaluate interface + overall experience qualitatively and quantitatively
~ 5 Minutes
System Usability Scale (Modified?)
Questions about specific features - Notes, Task View, etc.
Talk to user about experience.
Anything that they want to add?

PROTOTYPE 3 MOODBOARD CITATIONS

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PROTOTYPE 4 SCENARIO

TRAINING PHASE OUTLINE

Purpose: Simulate actual astronaut training with our app while gathering qual. / quant. information
Estimated Time: 30-40 Minutes
Note: Whenever possible, adapt methods from existing NASA training material

PART 1: INTRODUCTION

Purpose: Make user feel engaged and at ease
~ 5 Minutes
Engage user by bringing them into a real-ish training scenario
Give user a brief outline of ISS, astronaut life, etc.
Have user sign appropriate documents

PART 2: INTERFACE AND FUNCTIONALITY TRAINING

Purpose: Train user to later test memorability of expert system, quantitatively evaluate features
~ 5-10 Minutes
Go over basic iPad functionality (Gestures, etc)
Explain Task view and relevant information on this screen
Explain Note Taking mode
Explain Ground Comm mode
Explain how to use the Timer

PART 3: PROCEDURE TRAINING

Purpose: Observe note taking behavior, test note taking system, simulate real training scenario
~ 15-20 Minutes
Drill into specific procedure that will be conducted during Space Phase (Plant PH)
Explain relevant parts of Procedures, including Stowage, Place Marking + Start / Finish
Walk user through task, briefly explaining any manual skills needed
Encourage / require user to take a certain number of notes during Procedure Training
Carried over to Space Phase

PART 4: POST-TRAINING SURVEY

Purpose: Formally evaluate interface + overall experience qualitatively and quantitatively
~ 5 Minutes
System Usability Scale (Modified?)
Determine system memorability / confidence in future performance
Questions about specific features - Notes, Task View, etc.

INTERIM OUTLINE

Estimated Time: 1 day / weekend
Purpose: Simulate training / execution gap, allow us to test memorability of system
Notes carry over between phases

Space Phase in different physical location, if possible
Prototype should not change between phases, other than to add users' notes
Show all Public notes from other users(?)

Space Phase Outline
Purpose: Test “actual” operation conditions within procedures, memorability and note carry-over.
Estimated Time: 40 - 50 Minutes (Until Time-Critical Event comes up)

PART 1: INTRODUCTION
Purpose: Jog users’ memory and clearly outline proceedings
~ 5 Minutes
Welcome astronaut back + get them “in-character”
Remind user of how ISS works and outline their plan for today’s tasks
Explain that all notes have been carried over from practiced procedure
User has one main task to complete before a time-sensitive task comes up, but can optionally do any number of their daily procedures

PART 2: PRACTICED TASK
Purpose: Test procedure view, note carry-over, difference in conditions, interruption
~ 10-15 Minutes
User starts at “my tasks,” navigates to correct procedure
User begins carrying out practiced procedure
Observe use of notes / compare performance to practice session
Certain parts of task are different than they were on ground (PH difference, call ground)
Observe adaptations
User interrupted in task by Ground, told to stop work and carry out another procedure (Air Filter Change-Out)

PART 3: UNPRACTICED TASK
Purpose: Test procedure legibility on unfamiliar task, effects of interruption.
~ 10 Minutes
Have user do Air Filter task / other similar procedure

User reports back to ground upon completion
What do they do afterwards? Do they easily transition back to Plant procedure?

PART 4: RETURN TO TASK / TIME OUT
Purpose: Observe ability to recover from interruption, track time
~ 5-10 Minutes
Does user go back to finish first task, or wait for time sensitive?
See if user knows when time-sensitive task comes up
Give user the option of starting other quick tasks if they finish early
Test ends at time-critical task (Button Press)

PART 5: POST-TRAINING SURVEY
Purpose: Formally evaluate interface + overall experience qualitatively and quantitatively
~ 5 Minutes
System Usability Scale or other similar test - Same from previous day
Determine system memorability / confidence in future performance
Comparison of features from Training Phase
How much did Training experience / MCA help with actual execution?
Were the notes you took helpful?

PROJECT PLAN FOR SUMMER 2012

	Due Date	Deliverable
Week 1	24-May	Overview of Project plan
Week 2	31-May	Concept poster or functionality outline
		Initial paper prototype
		User testing and data collection plan
Week 3	7-Jun	Paper prototype testing results (1)
Week 4	12-Jun	Balsamiq prototype/user results (2)
	14-Jun	Faculty Meeting: prototype 2 results
Week 5	21-Jun	Peer Critique
Week 6	27-Jun	Interactive round user testing results (3)
	28-Jun	Faculty Meeting: Initial draft of UI specs
Week 7	5-Jul	Peer Critique

	Due Date	Deliverable
Week 8	10-Jul	ORTs testing today/tomorrow
		UI spec in progress
		Feedback movie under development
	12-Jul	ORT user testing results (4)
		Faculty Meeting
Week 9	19-Jul	Report walkthrough on 18th or 19th
		(includes UI specs)
Week 10	24-Jul	Landing day (tentative date)
	26-Jul	Presentation/website walkthru 26th 5pm
		(includes feedback movie)
Week 11	2-Aug	Final Presentations to Clients

APPENDIX CD

Appendix CD includes:

- Summer report
- UI spec
- Sketches
- Prototypes
- Usability testing data
- Feedback movie
- Photographs

Thank you to

OUR CAPSTONE FACULTY AND STAFF

David Bishop, Jason Hong, Brad Myers, Jenna Date, Katie Scott, Jessica Stanley, and Nicole Willis

NASA

Don Kalar, Jessica Marquez, Mike McCurdy, the HCI Group, and everyone we spoke to at JSC

OUR RESEARCH PARTICIPANTS

without whom our project would not be possible


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