An Internet Appliance for Individual Well Being

Mechanical Engineering 310 Fall Design Document

Team Our Team Name
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1 Executive Summary

(To hide these blue remarks, set `commentson` *in me310report.tex)*

Suggested length of this section: 2-2.5 pages including a couple figures. This the most important section to edit carefully. It should stand alone. Assume it is the *only* section that your corporate liaison's boss will read.

- Introduce the reader to what your project is about.
- You can use your Fall Brochure as a starting point.
- Say something brief to introduce the design team (local + global).
- Motivate the current project direction (based on findings from users and experts, benchmarking, CEP or CFP, etc.).
- What you did is less important than **what you learned**. What findings or insights do you have?
- Make sure your current "Point of View" comes across. The person who reads only the Executive Summary should still have an idea who your User is.
- Include images that capture the gist of your design problem and vision. If an image from your CFP, CEP is helpful, use it! Because this is a stand-alone section, it's fine to duplicate any images from this section elsewhere in the main document.

The remainder of this section is adapted from [7], a pretty good Fall document, done in Latex. See comments added to the source .tex file that highlight the outline and logical flow.

Example text

Engineers must work with distributed teammates around the world. More than ever, designers are tackling all stages of design with remote coworkers who they may never actually meet face to face. Functioning in this distributed environment can be challenging both technically and socially. While there are many tools for managing data and capturing concepts, sharing the output of these tools between distant teammates requires thoughtful planning and continued effort to include distant coworkers during meetings. Also, distributed team members often feel a sense of isolation – studies have shown that people will collaborate more with people in the same room than with their distributed coworkers who are calling in [9]. Developing a way to "level the playing field" for distributed designers is essential for achieving effective distributed design.

Autodesk has approached our team of three engineering students at Stanford University and three engineering students at Pontificia Universidad Javeriana to tackle the problem of how to get engineers to collaborate better. To gain an understanding of what makes great collaboration, we surveyed existing collaboration technology, talked with designers, and ran scenarios for different collaboration environments and strategies. We focused on solutions for the early stages of the design process between small, geographically distributed teams.

After researching a plethora of communication devices for sharing audio, displaying video and sharing drawings, we realized that the critical issue was not how to input drawings or video. Instead, the more pressing issues are how designers share the output of the tools and how to capture

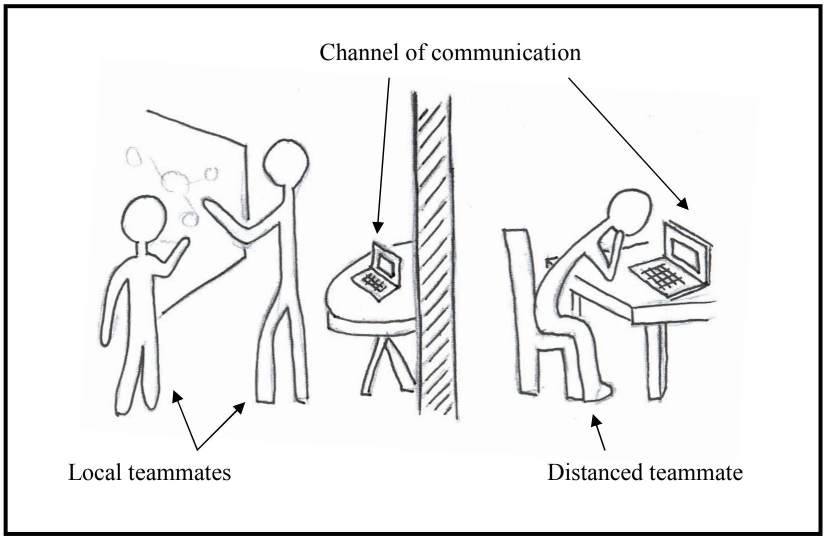

Figure 1.1: *An incomplete sense of participation occurs during distributed design meetings*

records of the information that is created. During the brainstorming phase, where ideas are generated quickly and randomly, finding a way to record a meaningful and accessible archive of concepts is especially difficult with existing collaboration tools.

Another important component of improving collaboration is getting people to work together as a *cohesive group*, whether distributed or not. How do you deal with the coworker who keeps dominating the conversation? How do you get a quiet person to be more involved? What if no one is responding to your idea – do they not like it or do they simply not understand? The ME310 Autodesk team hypothesizes that applying one of the key tenants of improvisational acting could assist with these social frustrations: have a moderator. Improvisational dialogue is critical to successful brainstorming, and can potentially be facilitated by objective feedback and guidance from a third person observer.

In early prototypes, we tested the ability of uncrowded auxialiary communications channels to pass information without disturbing the flow of conversation. By prototyping a tactile feedback system, we found that it provided a non-intrusive way to get someone's attention, and more importantly created a sensation of proximity with distributed teammates.

Our vision for the final product is to better enable dialogue by displaying explicit teammate feedback and participation level, made visible to the entire team. Imagine knowing when someone wasn't paying attention, or that your teammates thought you were talking too much, or that everyone really thinks you're idea is pretty cool. All of this information could be displayed without saying anything. In addition to simply providing a platform to share information, the designed system will monitor the quantity of inputs and determine individual participation level, and also offer the opportunity for direct feedback. The objective is to provide a real-time answer to a common wonder - what are my teammates really thinking?

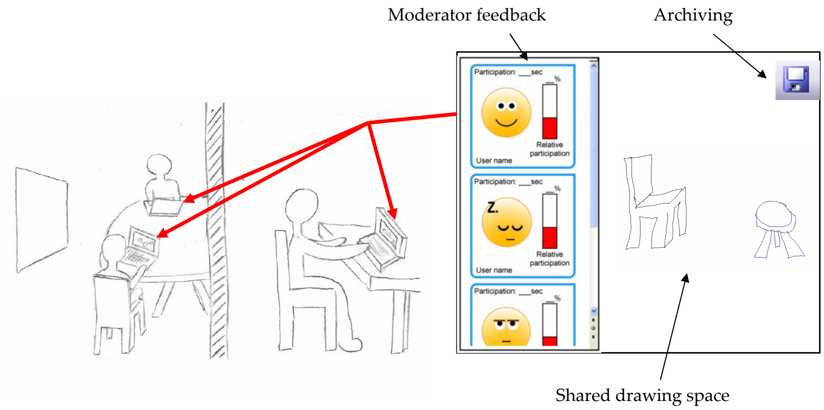

Figure 1.2: *Vision for a more effective distributed design meeting (images from fall quarter experience prototype).*

Latex tips:

- These remarks in blue disappear if you select \commentson{remark} in me310report.tex
- Most teams will find the default report cover sheet too plain and will want to substitute a hand-made cover sheet that they pre-pend to the PDF file from Latex.
- References are linked using the `cite` command. The template is set up to use a bibliography style that is close to the style used by IEEE and other journals with citation numbers in square brackets (e.g., [1]) and printed alphabetically in the Bibliography section. The `plainurl310.bst` style is better than most others for printing URLs. Note that Google Scholar can give you citations in Bibtex format for Latex (click “cite” beneath listing).

Contents

List of Figures

List of Tables

When creating figures and tables, use "caption[short caption for ToC]{Long and descriptive caption, as one finds in Nature or Science, etc.}" to get a nice formatting effect.

Glossary

3d audio technology Simulation that creates the illusion of sound sources placed anywhere in 3 dimensional space, including behind, above or below the listener.

action-event control Process where a user action creates an physical event.

API Application Programming Interface.

array of microphones Microphones linked together to expand the effective coverage area.

Ausim 3D audio hardware company.

Automatic beam steering Signal processing technique to narrow the microphone coverage area. Used to pick out a speaker and suppress background noise coming from directions other than that of the speaker.

Benchmarking A process of researching and observing to understand the state of the art for a given field or topic.

Brainstorming A process by which groups of people generate ideas

Brainwaves A common term that refers to post-synaptic potentials measured from many neurons in the brain

CDR Center for Design Research at Stanford University

CFP Otherwise known as a Critical Function Prototype, this is a prototype built to test a concept that is critical to addressing the problem statement.

Client Computer program that accesses a server.

Client-server paradigm A computing architecture which separates the client from a server over a computer network.

Crowded channel A communication channel that is clogged with information.

CVE Acronym for Collaborative Virtual Environment. This is a virtual environment that support more than one user at the same time.

Dark Horse An idea that is unlike the others preceding it, an outlier.

It's a sign of a successful team that the glossary becomes extensive. Define any non-obvious or invented terms. For example, if you reference something by an acronym, that might be a glossary term. Teams also coin terms to describe design features. Don't define obvious stuff (axle, keyboard).

2 Project Context

What is the context for this project? The answer to this question includes:

- information about the division of the partner company that is collaborating on this project – their situation, their motivation;
- relevant current and predicted future trends that provide context;
- the Problem Statement, which has its roots in the corporate project brief but is now revised on the basis of new information.

As you adapt material from Mission #3, be sure to account for new information that has come in, including:

- feedback from the teaching team on the original version – electronic feedback and some hardcopy is available; ask if you can't find it;
- additional input from the partner school and from the company itself;
- insights and findings from subsequent benchmarking, need-finding, activities.

Suggested length: Up to half a page to a page each for the Need Statement and Problem Statement (plus figures, if any). Another page or two for the design team.

2.1 Corporate Partner

- Who is the corporate unit?
- What is their context?
- What issues, opportunities and challenges do they face?
- What motivates this project from the companys perspective?

Feel free to include any figures, including the SWOT analysis from the original version, but don't feel obliged to insert them verbatim. In any case:

- Properly cite any externally obtained images, plots etc. Short web-page citations (not to an article) can be done using a footnote and url (see example for SWOT definition below).
- Make sure the fonts are large enough and clear enough when printed. Where possible, get PDF exports (instead of jpeg, etc.).

In addition to SWOT analysis,[1] another useful way to organize business-related information is the "Business Canvas Model" [11], for which the template is shown in figure 2.1.

Also, while the details of the Corporate Context mission are new for 2016, some similar information can be found in a few ME310 Spring documents such as 2012 Electric Mobility Norway [3] and Symbioseé [4].

[1] https://en.wikipedia.org/wiki/SWOT_analysis

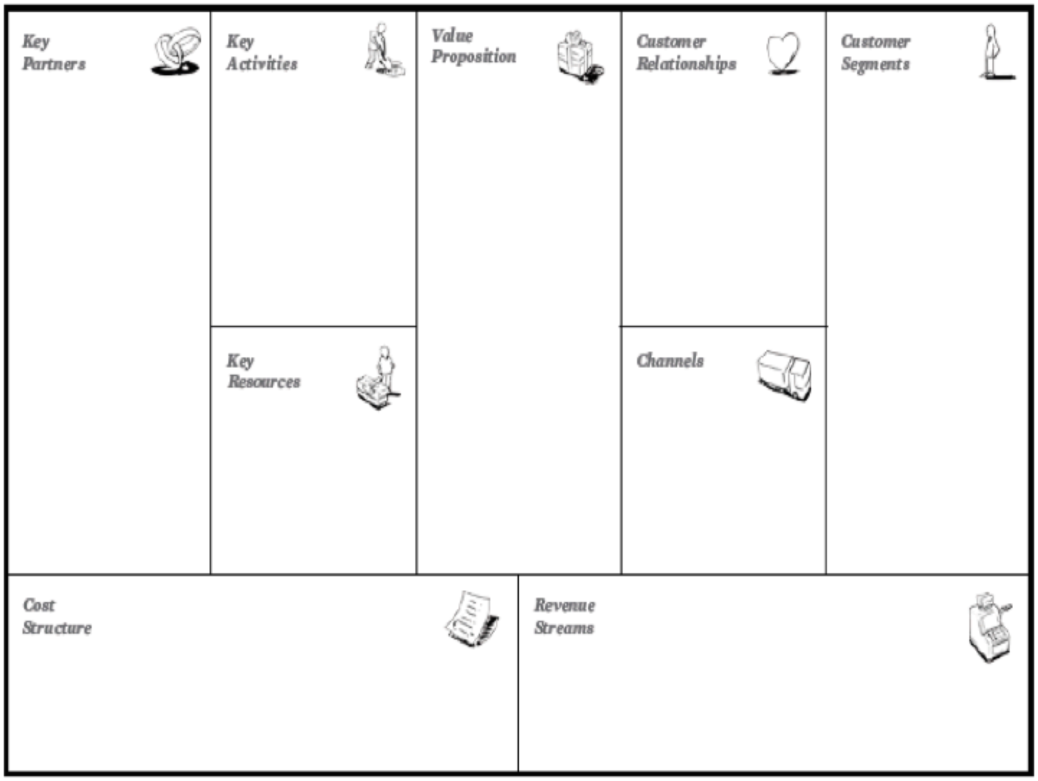

Figure 2.1: *Business Canvas (from [11]).*

2.1.1 Corporate Liaisons

Say who the liaisions are and give their contact information.

2.2 Trends

What societal and technical trends provide context for this project? Per Dr. Bill Cockayne, [2], it's worthwhile to project into the future as well.

Figures 2.3 and 2.2 provide a couple of examples of trend data that might provide context for a project. Regrettably, the figures were not available in PDF, so they have limited resolution.

2.3 Problem Statement

Redefine the problem statement for this project in your own words. You can start with the Corporate Project brief, but you now know more, in part as a result of having talked with the Corporate Liaisons. This statement should motivate the need-finding and benchmarking chapters that come next.

The fragment of text below is again taken from [7], and has a nice tone when explaining some of the problems they addressed with their project.

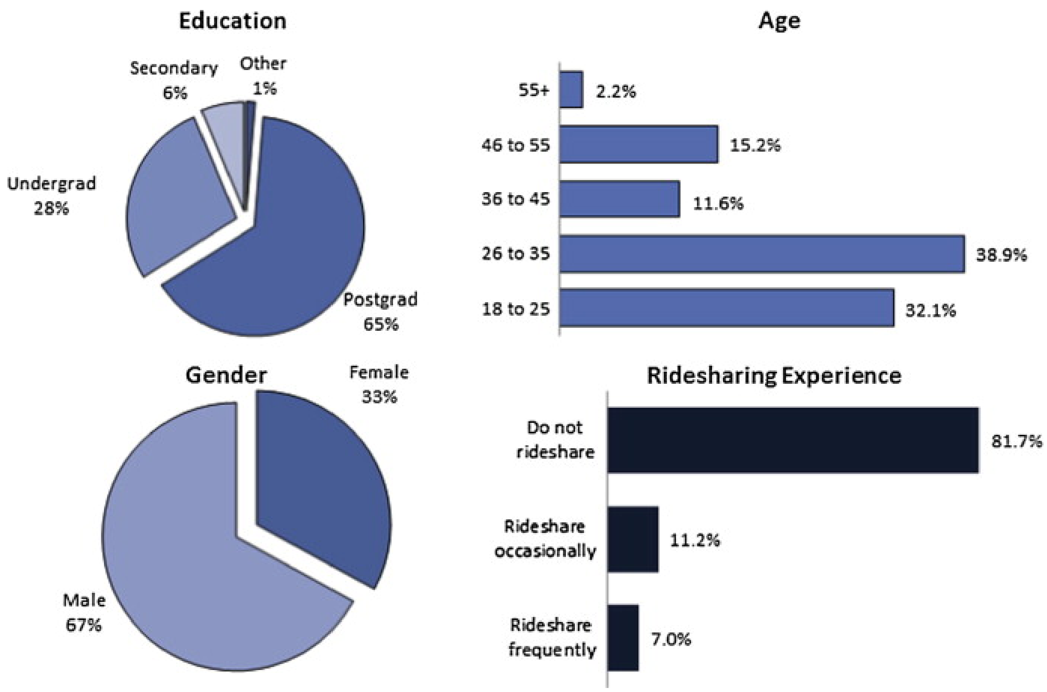

Figure 2.2: *Demographics of ride-sharing in northern Europe [10].*

In order to facilitate remote collaboration in the early design stage, we first break down the problem into the following three areas.

- Social Dynamics
- Communication tools
- Idea storage and decision making

Early ideation is a very social process and requires effective interperson communication. Current teleconferencing tools lack efficacy in recreating the level of social dynamics present in face-to-face communication.

Communication tools are a means with which we transmit ideas to each other. This could be either through speaking, body language, or drawing. The early ideation stage requires a rapid exchange of ideas between all participants in a meeting. How can we utilize communication tools effectively to make such a dialog easier?

Finally, the brainstorming stage presents a plethora of ideas that need to be archived and categorized for effective decision making. How can we make it easier for meeting participants to save their ideas and retrieve them later? How can information be viewed to facilitate decision making?

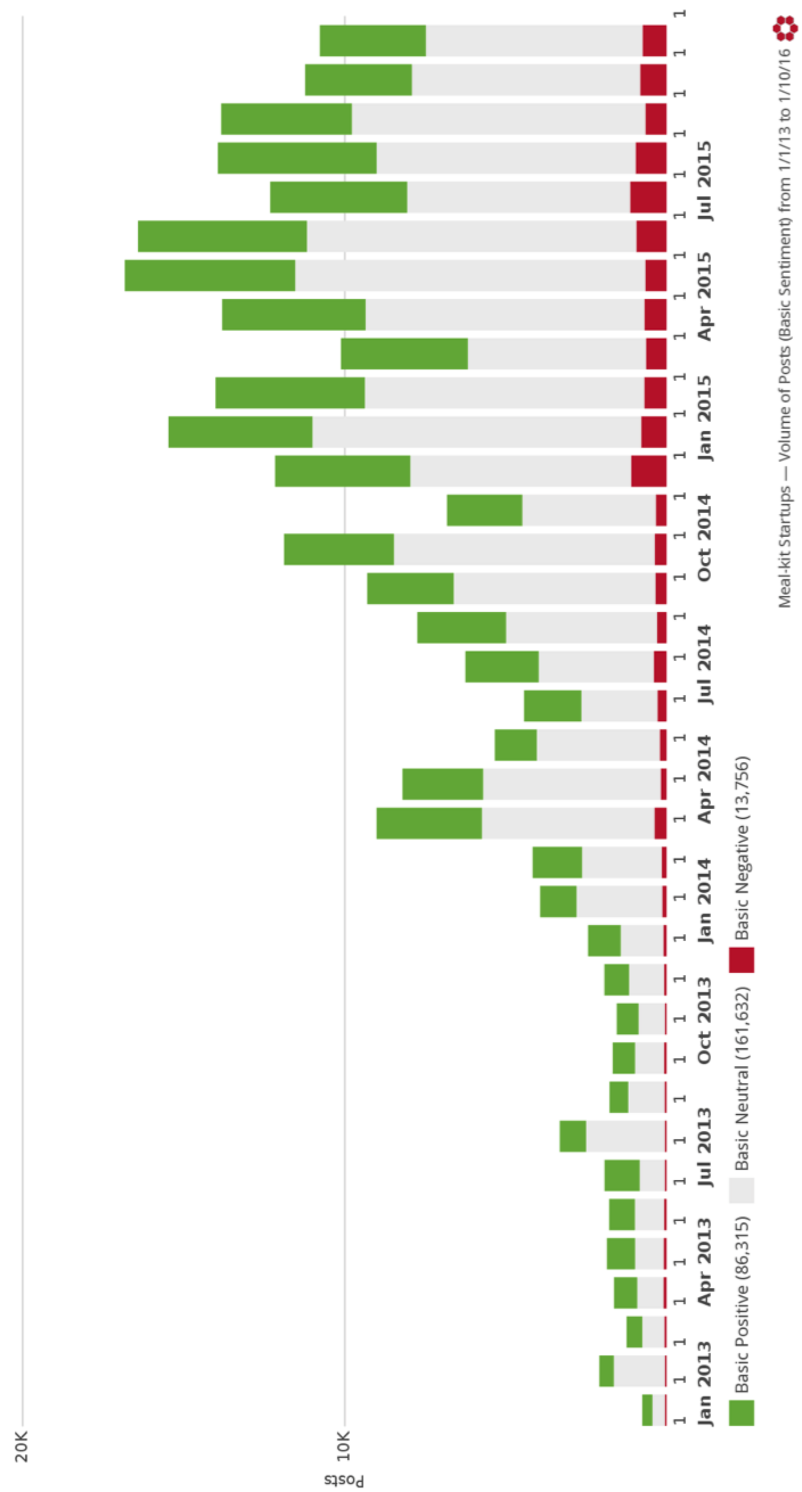

Figure 2.3: *Growth and user sentiment regarding Blue Apron and similar services [8]. – Rotate figure and fill page so that fonts are readable.*

Table Examples in Latex

Here is a centered tabular form that is 3/5 of the current text width and has a horizontal line but no vertical lines:

a label spanning 3 merged cells			label 4
item 1a	item 2a	item 3a	item 4a
item 1b	item 2c	item 3c	item 4c

For anything more complicated than the examples in this section, it may be easiest to do the table in MS Word other program, create a pdf and include the pdf in a table environment. Because pdf files have scalable fonts, the print resolution will be good! For example, Table 2.1 is taken from an Audi fall document [5] done in MS Word and pasted as PDF into Latex. Notice that the fonts are smooth (not bitmaps) if you zoom in.

Requirement	Metrics	Rationale
Relevant controls should be within reach of the driver and front passenger	Users must be able to reach controls without having to lean.	In order to allow for minimal distraction while driving, user should not need to shift positions.
Controls should be comfortable to use.	Users will report no feelings of awkwardness or fatigue from trying use the controls. Buttons will push down with a reasonable amount of force.	Users will not want to use a system that is uncomfortable.
System interface should be distributed throughout the vehicle.	Controls will be spread out over the cockpit.	When all the functions are combined into one control, the system becomes too complicated to use, resulting in a steep learning curve.
System will retain the Audi "genes"	Integration of the interface will allow previous Audi drivers feel like they are just in another Audi	Users like consistency. A vehicle brand should be dependable, in-line with its current look, feel, and overall theme.

Table 2.1: *Physical Requirements from [5], used here just to illustrate how PDF can be pasted in as a table*

Floating Figures in Latex

In scholarly and technical writing, unlike in blogs and Googledocs, the figure does not have to appear immediately after the text that cites it. However, an issue with ME310 reports is that they have more figures than most scholarly writing, and Latex runs out of room to “float” them. If this happens, put in a `clearpage` command and Latex will unload its queue of figures, putting some on pages by themselves if necessary (which is fine). See `Resources/AboutTheME310LatexTemplate` linked to the Fall Documentation assignment for this and related tips.

Figures 2.3 and 2.2 show a couple of ways of dealing with figures. In the former case, the figure is rotated to landscape and made to fill a page so that the text becomes readable.

3 Users and Needs

Who are the potential users? What are their needs? What did we do to discover this? What insights have we gained? – This chapter also includes User Personas. It is an updated version of Mission #4 and, if at all possible, should include material from the global team.

This section is the summary result of your user need-finding both for Mission #4 and subsequently. It provides the background for the "Point of View" or hypothesis that guides your work.

- Who wants or needs your product? Why do they want it? Or, what need does the product area address?
- What evidence do you have to substantiate the need? Use citations or other evidence you've gathered empirically through observations and interviews.

3.1 User and Needs Identification

Explain any particular interviews and observations undertaken. Focus on insights; details (e.g., transcripts of dialogs) should go in an appendix section.

3.2 Personas

Describe the personas, what findings are incorporated in them, and what insights they provide for the design. Ideally include some images of your personas, like "Kevin" in figure 3.1 from the 2011 Lockheed project [6].

3.3 Need Statement

The remaining text is taken from [7].

The design world has changed dramatically in the last decade. The widespread advancement and usage of digital prototyping tools has made it simpler and faster to realize new ideas. At the same time, globalization is requiring designers from remote locations to combine their ideas and make design decisions.

With the advancement of computational power and communication speed, digital prototyping tools have made it possible to transmit complex drawings around the world. Most digital tools that promote remote collaboration target the idea-to-conception stage of development. The early ideation stages of engineering design, however, are still more effective when discussed locally. The problems of effective communication and effective decision-making in this setting are still largely unsolved. Internet tools setup the virtual meeting space, yet communication is still not as effective as meeting in the same room. Often meeting participants cannot truly work together as they do face-to-face.

Wouldn't it be perfect to have a new tool that focused on the interaction aspects of remote collaboration? Imagine a tool that makes communication effortless, as if the participants were in

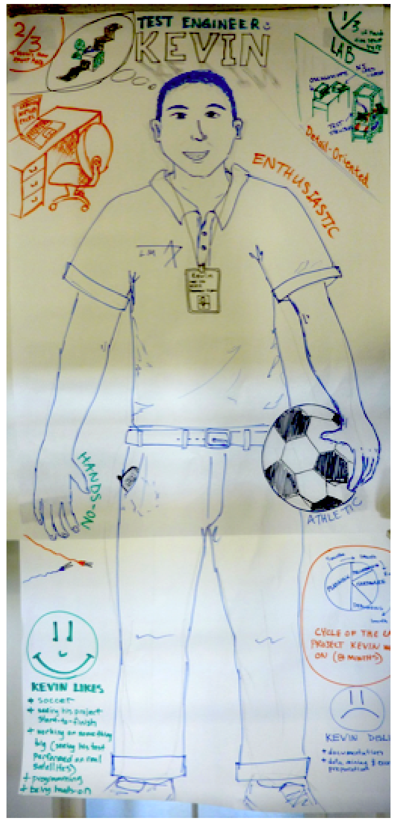

Figure 3.1: *A persona for a satellite testing project (from [6]) (– ideally could say a bit more in the caption)*

the same room. Such a tool could increase the ideation potential of remote meetings and make remote brainstorming a reality.

4 Benchmarking

The text in this section is excerpted from the Benchmarking section in [7].

4.1 Technology benchmarking

The team's research and benchmarking efforts were focused on three major categories: human-machine interfaces and input devices, social dynamics, and communication. The methods the team utilized to research items in these three main categories included trying out hardware, drawing on previous experience, participating in improv exercises, researching existing solutions, and speaking to experts from design, neuroscience, and computer science.

4.1.1 The Nintendo Wii - Accelerometer-based input)

Figure 4.1: *People playing Wii Sports on the the Nintendo Wii. There should be a citation to the URL this photo came from.*

The team investigated some unconventional means for data input. Gesture-based input devices like the Nintendo Wii controller offer the possibility of an intuitive, and compelling way to interact with someone at distance via digital means. For navigating through Windows or other applications, the team found the Wii to be more challenging than a conventional mouse. Accelerometers are adept at capturing large motions rather than precision pointing and would need to be utilized as such. Potential applications could be for interfacing with avatars or tactile feedback systems. The

Wii controller could be used as a gesture-based communication device to control a personal avatar or send and receive tactile messages.

Key lessons learned

- Accelerometer based input devices could be used in gesture-based or tactile communication, but do not fare well in precision pointing.
- Gesture-based interfaces generate excitement. People want to use input devices that respond to gesture.

4.1.2 CyberGlove ®

Figure 4.2: *CyberGlove gesture-based input device. There should be a citation to the URL this photo came from.*

The rest of this subsection is omitted for brevity

4.1.3 EEG and Participation Monitor

The team met with Alicia Warlick, a researcher in the Stanford Neuroscience Department, and her research in monitoring brainwaves. We discussed the possibility of monitoring whether meeting participants were actively paying attention by using an EEG. This is a method for measuring the activity level of the brain. There is opportunity to use this as a metric for testing our final product, or potentially in the product itself as a means to collect data on user participation level.

Key lesson learned

- Electrodes could be placed on the users forehead and scalp (as in Fig. 4.3) to measure EEG readings, which conveys information about whether someone is engaged in what they are doing, or if they are withdrawn.

The rest of this subsection is omitted for brevity

Figure 4.3: *Example of the first available wireless EEG tool, made by IMEC. There should be a citation to the URL this photo came from.*

5 Prototyping

The text in this section is excerpted from the relevant Design Development sections in [7].

5.1 Critical Function and Critical Experience Prototypes (CFP/CEP)

The initial benchmarking phase lead the team to realize that there were three major challenges to solve: bridging the proximity gap, moderating brainstorming, and conveying and recording ideas. The team decided to tackle all three of these major challenges and designed four CFPs in an attempt to solve, or at least start answering, some of the questions these challenges brought up.

5.1.1 Tactile CFP

The team wanted to come up with a creative solution that would enhance distance communication. Although we identified software having an important role in our solution, we wanted to try to design something physical. We had to answer these questions that were raised after the benchmarking process:

- How can we simulate proximity for remote meetings?
- How can we implement action-event control?
- What senses can we stimulate that aren't normally used?
- What is a low bandwidth solution?

The team decided that building a tactile messaging system would address all four of the aforementioned questions. Tactile messages could replace common interpersonal interaction found in same room meetings. It is normal to welcome each other with a handshake, make eye contact throughout a meeting, smile at each other, and give high-fives to congratulate others. These occurrences are all absent from distance meetings. A tactile message corresponding to each of these gestures would allow users similar opportunity to communicate as if they were sharing the same physical meeting room.

The team learned that immersive activities like videogames take advantage of action-event control to offer users a seamless means to interact with their environment. A tactile message could quickly be sent over an open channel and pressing the ?on? button would instantly message the recipient.

Out of the five senses (sight, hearing, taste, touch, and smell), sight and hearing are the most relied upon during meetings. The team considered possibilities in taste and smell messaging but continued with touch, since delivery of tactile messaging was much more straightforward. Since conventional distance meetings only send and receive auditory and visual information, tactile messages would be distinct and easy to identify. The team believed that tactile messages (high, low, or off) would be low bandwidth.

The team wanted to test the effectiveness of tactile messaging and decided against a TCP/IP protocol that sent messages between Stanford and PUJ. The code to write such a protocol was extant and it was unnecessary to include it in our prototype. The team simplified the setup and created two stations separated by physical barriers (a wall and 50' of distance), to simulate a distance meeting.

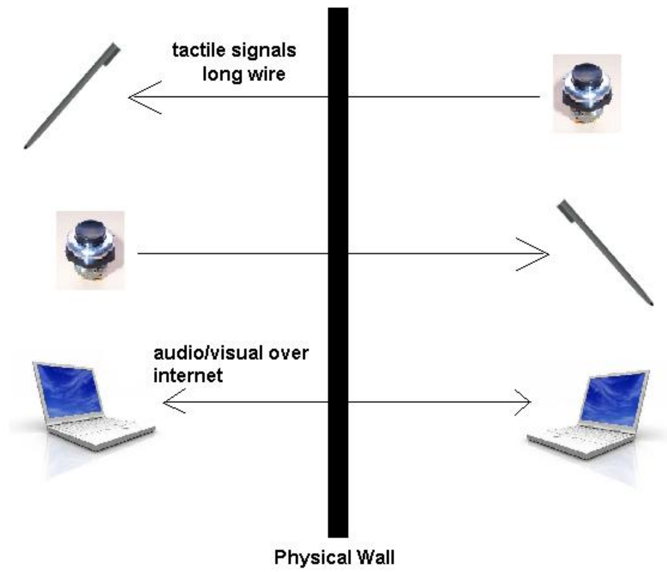

Figure 5.1: *The team's whiteboard during a brainstorm session*

Each station would have a vibrating tactile device for each seated participant at that station and a high/low button assembly to activate the vibrating tactile device for each participant at the other station. Initially the devices were supposed to operate as ”on” or ”off.” The team decided that having more variability in the operating speeds of the motors would increase the number of different messages that could be sent, and added a high and low voltage button (1.2V and 0.6V).

We were curious to see if effective communication could take place if a distant colleague could see what sketches his distant colleague was drawing. To test this, we used webcams to send live video of what the participants drew on their drawing pads to the other stations.

5.1.1.1 What is critical about this CFP?

The team identified these questions as critical before testing:

1. Can it create immersion?
2. Does it improve upon existing communication tools?
3. Is it easy to understand?
4. Is it intuitive?
5. When should it be used?

5.1.2 Tactile Messaging CFP Description

The tactile messaging system was comprised of small Jameco vibrating motors (1.3VDC 8,500 RPM) mounted to ball point pens and wrist patches. A simple switchable voltage supply circuit was created to give each vibrating motor a high (1.2V) and low (0.6V) vibrating speed (5.3). Each

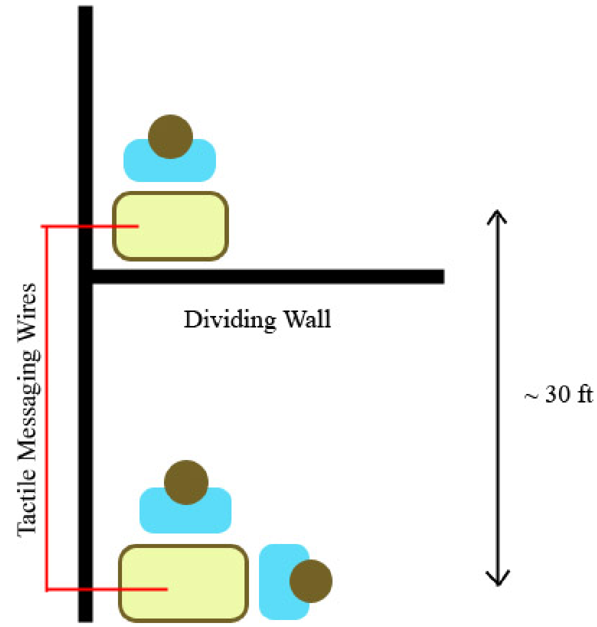

Figure 5.2: *The orientation of the two tactile messaging stations.*

voltage level was buffered with LM324 opamps, and the circuits were implemented on protoboards. The high and low speeds were selected by switches.

(Text omitted for brevity)

Four independent circuits were created to provide messaging to two motors on each side. 90' 16-gauge wire was passed between two stations in the meeting setup shown in 5.4. Power supplies provided the 9V signal on each side.

In addition to the tactile hardware, Skype was used for video and audio communication. Video was supplied by standard webcams. We mounted the webcams on risers to show video of a sheet of white paper used as the shared drawing space. We chose to focus the video on ideas rather than facial expressions.

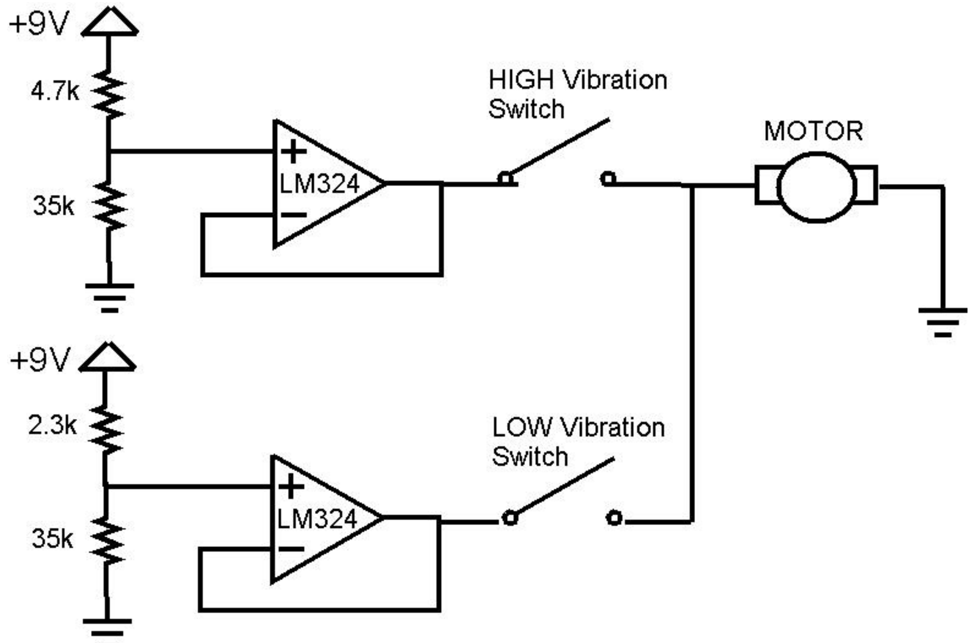

Figure 5.3: *A simple voltage dividing circuit provided 1.2V (HIGH) and 0.6V (LOW) buffered output voltages for the vibrating motor. Switches triggered the high and low voltages.*

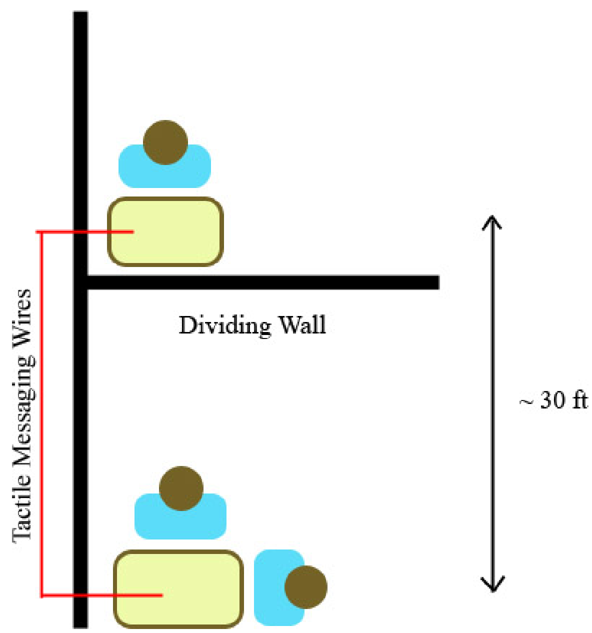

Figure 5.4: *Layout of seating during test meeting. Two participants met on one side, with the remote user separated by a wall 50 ft away.*

5.1.3 Moderator CFP Description

5.1.3.1 Layout

The participation moderator was created by using pre-made desktop software applications called widgets. The desktop was set to a white image, with personal spaces for each participant mapped off by a black boundary and labelled with the participant name. In each personal space, a unique Yahoo! Widgets timer was placed. Unique timer's were used to foster a sense of identity- when glancing at the moderator, the team members could instantly recognize their widget rather than look for their name.

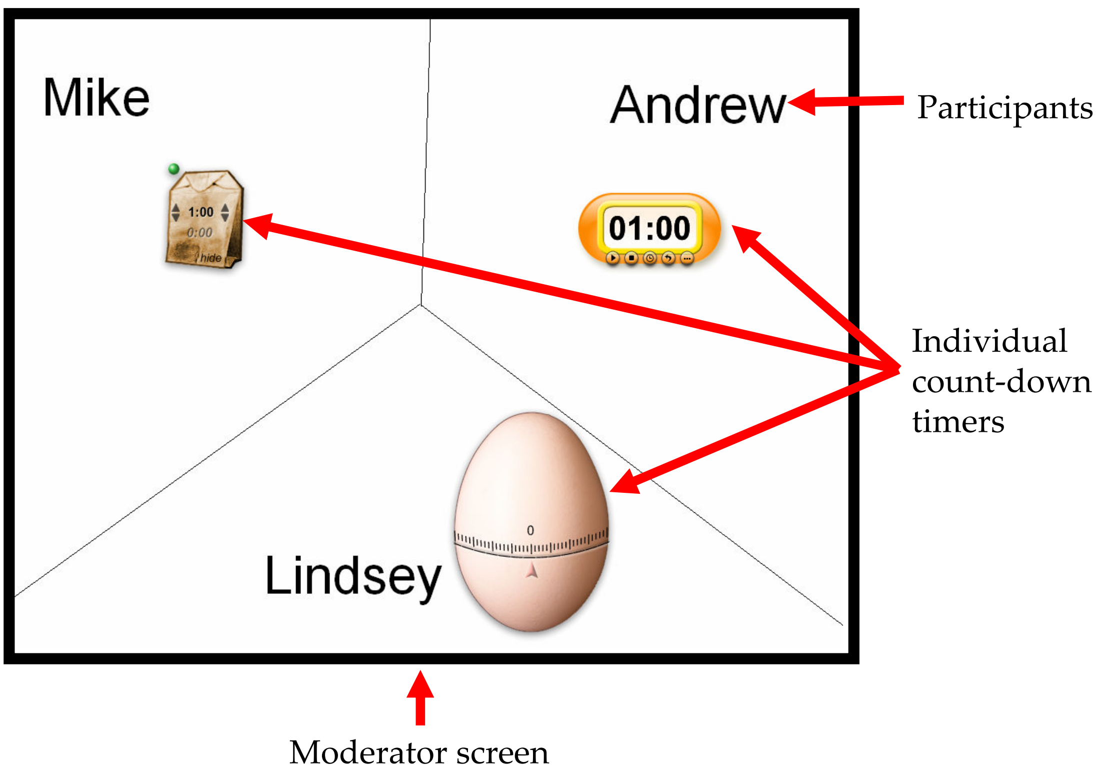

Figure 5.5: *View of moderator display*

(Text omitted for brevity)

Each was simply a countdown timer with a default starting time, t_s. As they begin counting down, the amount of time remaining is visible. By clicking twice on any widget, it would reset and begin counting down again from t_s. The timers were manually reset by one of the teammates during the meeting whenever someone had an interaction. When any timer runs out, it would sound an alarm, designating that the meeting come to a halt until the non-active team member contributes to the conversation. The hypothesis was that, because the timers were visible to the entire team, each member would consciously make an effort to speak before their timer ran out and that no timer would actually buzz, although the rotation of speakers would greatly increase.

The moderator screen was displayed on a 32" LCD display that was positioned 6' from the center of a table where the group met. The layout is detailed in Figure 5.6. No video or audio conferencing was used – all team members were local. The objective of the moderator is to support dialogue in meetings, regardless of whether the members are distributed or not. Audio was recorded of each meeting using Cubase software and an IBM laptop's internal microphone, which was placed in the center of the table so each participant could be heard.

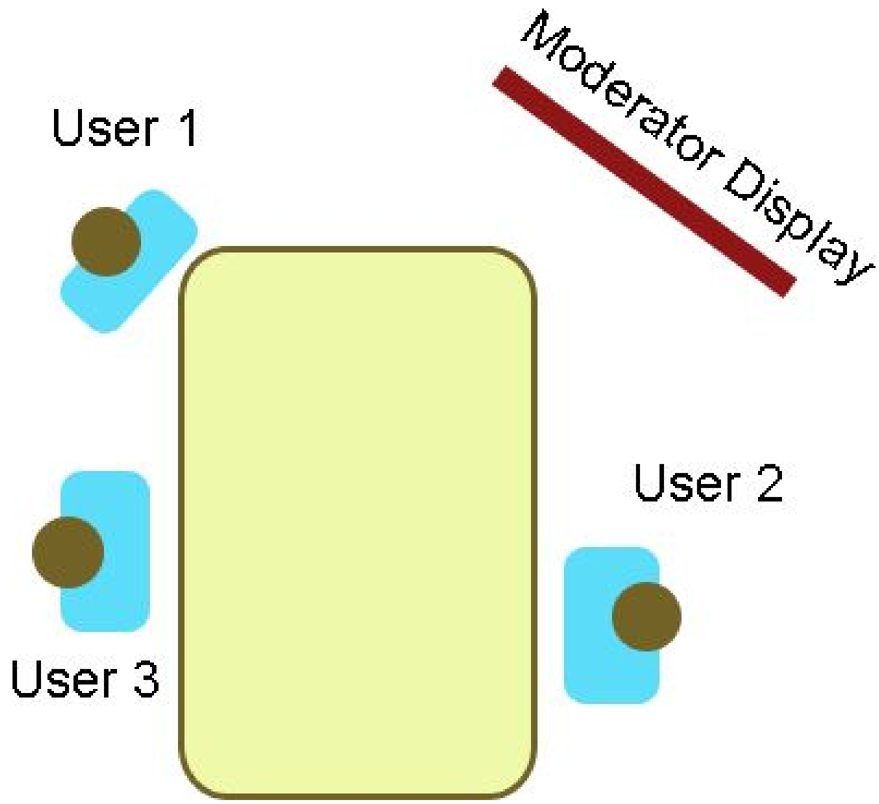

Figure 5.6: *Layout of design meeting with moderator prototype*

5.1.3.2 Procedure

Three meetings were run to test the moderator. The subject of each was the same - our team brainstormed potential final products knowing the key lessons learned after our benchmarking. Three meetings were run in succession, each lasting 30 minutes. The intention of this was to eliminate any personal changes between meetings. For example, if Mike has a really bad day before coming in for a second meeting, he may be much less talkative than in the previous meeting, but not as a result of the moderator. The first meeting served as the control, and no moderator was used. The two subsequent meetings used the moderator with t_s at 2 minutes and 1 minute.

The audio files were analyzed manually by playing back the audio recordings for each meeting and recording the length of each comment that every person made. Fifteen minutes of audio during the middle of each meeting was processed. The data are available in Appendix A.1.

5.1.4 CFP Lessons Learned

Ideally there should be something among these findings that reflects back to the personas. Are there particular findings in light of the personas? Do the findings cause you to modify your personas?

Tactile sensation is an effective means of communicating contextual information. The messaging system delivered instant vibration between the two stations, helping preserve the flow of conversation without impeding it. Using the vibrations to alert the other users that you wanted to say something was a good way to make comments at the precise time you intended. The tactile devices were **easy to use** and the participants were encouraged to use them as they saw fit. We noticed that **vibrations were used most frequently to add emphasis** ? to accompany laughter, to confirm agreement, offer praise for a good idea ? and to interrupt the speaker. Interruptions consisted of calls for clarification on a point raised or disagreement with an opinion. Interrupting someone who is speaking can cause the speaker to lose his train of thought or become otherwise agitated. We noticed that **users preferred to send low speed vibrations** as a gentle interruption as a first attempt to get the speaker's attention. If the first few low speed vibrations did not stop the speaker, the high speed vibrations could be sent, and these usually registered right away. We observed that users reserved high speed vibrations for urgent or important messages.

The signals were mostly easy to detect, but it was **not always clear what those signals were trying to communicate**. Ambiguous or superfluous signals distracted the receiving user from the meeting and the confused user would ask, "Did you just buzz me?" or "?Why did you buzz me?" These confused questions would stall the meeting for everyone until the sender was revealed and was able to explain what they were trying to communicate.

Vibrations, however, were easily detectable despite loud side conversations, a party in a neighboring room, and constant distractions from people walking by. We attribute this to the fact that the tactile channel is uncrowded compared to the audio channel. In a loud environment it is difficult to pick out audio communication from Skype. Visual distractions make it difficult to focus on the laptop monitor. The tactile sensation rarely stimulated in a teleconference, thus making the slightest vibration very noticeable.

We tried two different vibrating interfaces, a vibrating pen and a vibrating wrist patch. The wrist patch was unanimously rejected by the participants because 1) the double stick tape that connected the patch to the user's skin was either too sticky and removed arm hair or not sticky enough after a few uses and would fall off, 2) was tethered to the power supply and restricted movement to the point where the hand with the patch was essentially stationary, 3) vibrations on your wrist are not comfortable, and 4) worry that the patch might give the user an electrical shock. The pen had a practical use, writing, and although the pen was connected to the power supply, the user was not, and the range of motion was adequate enough to write anywhere on the drawing space.

We finally compared the tactile messaging conference to previous experiences with video conferencing and audio conferencing. These results are summarized in Appendix A.1.

The tactile messaging critical function prototype was a success in that it definitively answered all the critical questions we asked ourselves before testing.

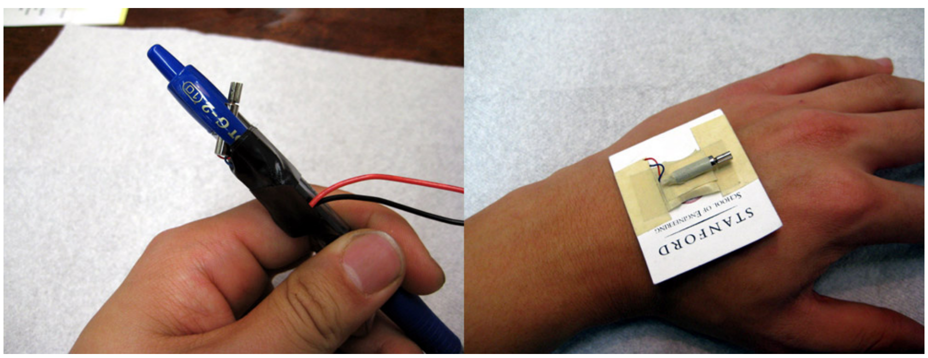

Figure 5.7: *The orientation of the two tactile messaging stations. (Note: the wires connecting the patch to power supply are not in this photo)*

6 Vision

Based on your explorations and prototyping, give your best description of what the proposed design might be. *Take a point of view and assert it!*

- A CAD rendering or systems diagram, or schematic, or a concept drawing will to help explain your vision.
- A bit of rationale leading up to the vision is fine, but if you find yourself adding too much rationale, or discussing design alternatives or how the vision came about, you are writing text that should probably be included in the previous chapters where you describe insights from prototyping, need-finding, etc. This section focuses on what the vision is, not how you arrived at it.

  The text below is taken from the Design Vision section in [1].

6.1 A semi-autonomous vehicle for urban mining

Within the broad topic of "Urban Mining" we have refined the problem statement to focus on *Extraction* and *Separation* within commercial deconstruction projects. Based on our need-finding and benchmarking explorations in Chapters 3 and 4, these are the most time-consuming, expensive and potentially hazardous operations that currently impede the onsite reuse of demolished bulding materials in new construction.

By making this process more efficient, we can encourage the collection of more of these valuable materials, and make doing so more cost effective for contractors. Our proposed solution is a semi-autonomous vehicle to assist construction workers with tasks such as grinding concrete, removing steel reinforcing bars ("rebar") and cutting tubes and pipes (Fig. 6.1).

Although many details remain to be specified, we envision the urban mining behicle as having three general characteristics:

1. It must be designed for the user with the specific task of deconstruction in mind and provide the necessary functionality and ease of use to displace current methods.
2. It must provide value to the customer by increasing the efficiency of building deconstruction.
3. It must align with the demands of the crowded urban environment low noise and low emissions.

We believe that an all-electric version of the current Volvo CE skid-steer loader, with an articulated multi-degree of freedom arm in place of the current buckets and grabbers would accomplish these three goals.

The articulated, multi-DOF arm would allow the operator to easily reach, cut, and remove specific materials, thus speeding the process of extraction and sorting.

A quick tool change capability for the arm would mean that operators could always use the most efficient tool for the task without time consuming and frustrating tool change operations.

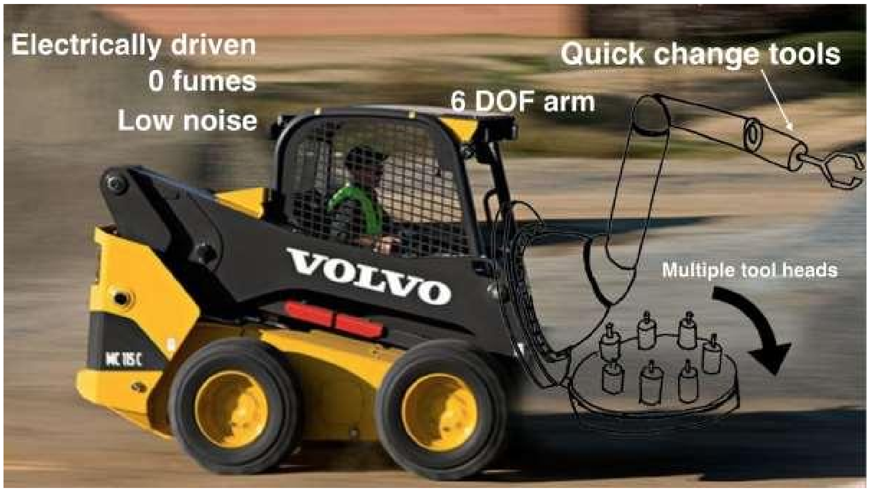

Figure 6.1: *An envisioned semi-autonomous deconstruction vehicle, with a pallet of tools and quick-change mechanism.*

And finally, the all-electric drive and actuation system would be much quieter than todays diesel machines, eliminate the fumes generated by burning diesel in enclosed spaces, and reduce the operating cost of these machines for the company.

7 Design Requirements

What will be required for any solution that (i) is consistent with your current vision and (ii) meets your user's needs?

In 2013-14 we experimented with omitting Requirements for the Fall Documents. It was a mistake – even preliminary requirements are useful for coming to grips with the problem space.

Articulating design requirements is critical for a team that starts with a broad problem and needs to determine *what to design*. The team proposes a *class of design solutions* that would fulfill the *requirements*. These are among the first items of value that teams can deliver!

As the design continues, requirements become more concrete and detailed. The direction of the project may change, leading to different kinds of requirements. Typically, new *de facto* requirements are discovered and documented. Ultimately, competing designs are evaluated with respect to the requirements. If you can't tell whether a design satisfies the requirements, the requirements are too vague!

In the fall, requirements will be preliminary. Still, it is worthwhile to articulate what you think will be needed, given what you've learned thus far. You might find that the 3-column format (e.g., Table 7.1) demands more precision than you have at this stage.

The remainder of this section contains sample requirements (not an exhaustive set but enough to give an idea) from Autodesk Fall 2007-08 [7] and Audi Fall 2008-09 [5].

Introduction

The Autodesk collaboration tool must enhance communication between groups of distributed engineers as they engage in brainstorming. We have focused on enabling this collaboration via tools that:

- enable users to communicate naturally and through multiple channels;
- enable the team to better utilize their teammates, be they local or distant;
- capture the information that was presented.

Our benchmarking and prototyping efforts have led to a preliminary definition of what the product will require. The requirements address what the product functionally needs to do and what it physically needs to be. Because of the wide range of functional opportunities that exist for the product, few physical restrictions are imposed at this stage in the design.

7.1 Functional Requirements

Table 7.1 lists requirements for improving interactions among distributed team members. Table 7.2 presents more specific requirements for the equipment associated with the vision. Table 7.3 describes the requirement associated with rapid setup for impromptu meetings.

7.1.1 Functional constraints

See table 7.4 for functional constraints.

Requirement	Metrics	Rationale
The product will balance the number of interactions in distributed design meetings among the team members.	Interactions are questions or statements that develop a concept. The total number of interactions per person during a design meeting will be called n_i. The solution must reduce the standard deviation of n_i between team members as compared to the closest publicly-available competing product.	The number of times someone interacts in a meeting is one measure of engagement. Brainstorming is a highly social process which thrives on the input from a variety of perspectives. By effectively improving the communication between distributed teams, team members will be more engaged and participate more.

Table 7.1: *Requirement for improved communication*

7.1.2 Opportunities

- Utilize existing tools. – There are many collaboration and input tools that exist; our product does not need to be a replacement for them. It could potentially supplement them.
- Offer new lines of communication:
  - Facilitate side conversations between distributed users.
  - Utilize the uncrowded channels offered by other senses than audio/visual, such as tactile.
- Be the moderator:
  - Collect feedback from users directly, via voting, or indirectly. Enable the replacement of video, which conveys very little useful feedback during design meetings.
  - Encourage the participants to be engaged by monitoring participation.
  - Display feedback and participation to attendees non-verbally,potentially through the use of avatars.
- Allow for easier information capture and storage
  - One button information capture
  - User-driven archiving
- Assist user communication in non-native languages.
  - Audio buffering
- The product can promote interaction with those who are not experts in remote interaction and are not equipped with expensive facilities:
  - usable for low bandwidth connections;
  - able to be set up within a typical conference room;
  - able to be set up and started without expert knowledge.

7.1.3 Assumptions

- Each user has, and is able to use:

Requirement	**Metrics**	**Rationale**
The solution must transmit sound at close to the rate of normal conversation.	The listener must hear the speaker with less than 0.3 seconds lag.	Audio latency creates a sense of distance. Mobile phone to mobile phone conversations have an average latency of 0.3 seconds, which is noticeable but not disruptive.
Users can capture drawings to share with distributed teammates that are legible.	Input device must be able to resolve a drawing at 50 points per inch (specifically, they must capture 50 percent contrast modulation at this frequency).	Drawings by mechanical pencil and ball point pens typically have lines of 0.5mm thickness, which translates to a resolution of 50 points per pinch (ppi).
Users will be able to capture drawings to share with distributed teammates without disrupting the flow of the discussion.	Drawings must be captured and sent within 17 seconds. This is assuming the input device is properly set and there are no external complications.	We found through benchmarking that sketches are used primarily when describing a concept, and are of little use afterwards. The sketches must be captured and sent before the context of the discussion has changed. Seventeen seconds was found to be about the average comment length during brainstorming in our prototyping.
Users will be able to see the drawings clearly.	Drawings must be displayed with a resolution of at least 72 ppi.	The display must be able to resolve at least as a standard computer monitor.

Table 7.2: *Required mediums of communication for effective concept development*

  - a personal laptop,
  - a mouse,
  - a microphone.

- Users will speak with a volume of at least 30 dB, as measured when 1 meter from the microphone.

Requirement	Metrics	Rationale
The tool must start up quickly for impromptu meetings.	It must be able to be started in less than 40 seconds. This time is calculated from the moment someone decides to start the system, to the point when the tool is ready to use, with full functionality. If the solution requires use of personal laptops, assume these are already booted up.	Our benchmarking has shown that collaboration tools can fall into disuse if it requires a lengthy setup time. This amount of time is within the range of initiation times for multiple popular conferencing solutions.

Table 7.3: *Social requirements for effective design meetings*

Requirement	Metrics	Rationale
The bandwidth required must not be prohibitive to standard offices.	The product will require less than 100 Mbps.	The population of potential users would dramatically decrease if the product required more connectivity than a T1 line, which is typically $\approx$ 100 Mbps.

Table 7.4: *Functional constraints*

7.2 Physical requirements

For variety, Fig. 7.5 shows a requirements table from an Audi fall document [5] done in MS Word and pasted as PDF into Latex. Notice that the fonts are scalable if you zoom in.

Requirement	Metrics	Rationale
Relevant controls should be within reach of the driver and front passenger	Users must be able to reach controls without having to lean.	In order to allow for minimal distraction while driving, user should not need to shift positions.
Controls should be comfortable to use.	Users will report no feelings of awkwardness or fatigue from trying use the controls. Buttons will push down with a reasonable amount of force.	Users will not want to use a system that is uncomfortable.
System interface should be distributed throughout the vehicle.	Controls will be spread out over the cockpit.	When all the functions are combined into one control, the system becomes too complicated to use, resulting in a steep learning curve.
System will retain the Audi "genes"	Integration of the interface will allow previous Audi drivers feel like they are just in another Audi	Users like consistency. A vehicle brand should be dependable, in-line with its current look, feel, and overall theme.

Table 7.5: *Physical Requirements from Audi 2008-09*

7.2.1 More physical requirements

Here is an example of a Physical Requirements table from a spring document. The 4th column is probably not appropriate for Fall. This example is include to show how one can make a long table that spans multiple pages.

Requirements	**Metric**	**Rationale**	**Requirements met?**
Use limited force to activate mechanical mechanism(s)	Force required for activation is < 20 N	User should be able to operate system without excessive force	The design should fulfill this requirement, however final gas spring and seat securer installation and thereafter testing will confirm this
System is ergonomic	User should be able to operate all mechanisms 4 times in the span of 1/2 an hour without any serious exertion (no sweating, strained breathing, or muscle soreness) and should be able to use the system for 2 hours without muscle cramping or other physical afflictions	System should be physically comfortable to use for a long commute time	User testing needs to be performed; initial prototyping seems to show this is satisfied
System is durable and robust	Lasts at least 2 years of daily use and its structure cannot be significantly altered by an average man or woman applying a full impact force on structural elements of the module	As part of a PT system, all modules should be resistant to daily use by an average human and vandalism	Robust materials such as steel and actual public transport-quality seats and flooring has been used; needs to be tested

continued on next page

continued from previous page

Requirements	**Metric**	**Rationale**	**Requirements met?**
Parts can be easily replaced and easy to maintain, including easily cleaned and water resistant	Takes no more than 5 min for one person to replace parts of a single module; module can be fully cleaned in 15 minutes; module shows no signs of corrosion over its 2 year life span	PT parts see significant wear and it should be convenient to replace modules as necessary	Needs to be verified
Seat is comfortable	Seat is breathable (from fully soaked takes <15 to air dry) and has a high thermal conductivity (seat adjust to room temperature from a 20-degree difference in less than 5 minutes)	Commuter should have a pleasant commuting experience while seated	Good quality seats of actual public transportation quality have been procured and used
Module should be safe	There should be no pinch points, sharp points, or possibilities for latches or other physical mechanisms to fail	System should not cause any users bodily injury	Mechanisms have been designed to avoid pinch points; final verifications needed
System should be aesthetically pleasing	At least 80% of surveyed users should react positively to the device forms	A pleasing system will encourage adoption and use	Visual language was established earlier on in the design phase; final aesthetic styling still needed upon final integration

Table 7.6: *This physical requirements table is from a spring document to show splitting across pages and addition of a 4th column regarding whether design meets the requirements*

7.3 Business requirements (or Venture requirements)

An element of me310-global thinking introduced in 2012-13 is to be more aware of the client's business model and context. This is not so much about designing a new business model as it is about awareness. The main discussion of this business model belongs in chapter 2. Here is where you list any particular requirements or ramifications for your design vision that arise from the context of the corporate partner and its business situation.

8 Team Profiles and Reflections

8.1 Stanford Team

See other recent reports for other ways of introducing the team. To the extent that the characteristics of the team influence the project direction, this is of interest to the reader.

Team *Papier Mâchè*, was assembled from individuals with a diversity of thinking preferences, interests and backgrounds. There is some evidence that such diversity enhances team creativity [12] [13], even if it creates additional challenges for team management.

Larry Leifer
Status: Professor, Mechanical Engineering
Contact: leifer@cdr.stanford.edu
Skills: deisgn, mechatronics, welding, prototyping
Computing: Solid Works, Matlab, basic C programming, Forth

Born in Santa Barbara I remain a surfer at heart. My research is focused on instrumenting, understanding, supporting, and improving design practice through the development of design theory. BS in in Engineering Science, MS in Product Design, PhD in Biomedical Engineering, all from Stanford. Founder of the Center for Design Research and one of the founding faculty members of the Hasso Plattner Design Institute at Stanford (aka the d.school).

Favorite activities include surfing, hunting and wayfaring, and frequent trips to Lucerne, Switzerland.

Mark Cutkosky
Status: M.E. Graduate Student
Contact: cutkosky@stanford.edu
Skills: woodworking, masonry, soldering, Lasercamm
Computing: Matlab, C, Python, Perl, Inkscape, basic Unix

Born and raised in Pittsburgh PA, I worked at ALCOA as a machine designer before getting my Ph.D. from Carnegie Mellon University in Robotics. My research applies analyses, simulations, and experiments to the design and control of bio-inspired robots, robotic hands, tactile sensors, and devices for human/computer interaction. In manufacturing, my work focuses on multi-material rapid prototyping methods.

My lab: http://bdml.stanford.edu

George Toye
Status: Consulting Professor, Mechanical Engineering
Contact: deputy@me310.stanford.edu
Skills: machining, welding, foreign languages
Computing: Solid Works, Assembler, Eagle, various computer languages

Originally from Taiwan, I grew up in Montreal and San Francisco. BSME from U.C. Berkeley and Ph.D. from Stanford in M.E. I have also worked in various Bay Area consulting and high technology startup firms. My expertise includes mechatronics (I have sometimes taught ME218) and Unix/Linux server management. My own company is http://www.withinc.com/.

8.1.1 Coach

Say who your team's coaches are and give some basic information and contact information.

8.2 Global Partner Team

8.3 Reflections

Reflections could either go here or with each team mini-profile above. The main point of these reflections is to reflect on what you've learned (about the project, about design, about yourself...) and provide wisdom for future teams.

9 Resources

Include lists of human, institutional and vendor resources here with contact information. This is not for direct citations, which go on the Bibliography.

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A Appendices

A.1 Moderator Prototype Data

Adapted from Autodesk Fall 2007-08 [7].

	Length of Contribution (s)		
# Contributions	Andrew	Mike	Lindsey
Unmoderated			
1	40	2	15
2	50	22	25
3	30	1	3
4	8	13	19
5	68	5	21
6	5	2	9
7	6	21	17
8	17		5
9	14		12
10			6
2 min. moderated			
1	53	10	1
2	10	2	7
3	28	2	2
4	3	5	4
5	9	40	2
6	7	2	15
7	3	3	
8	39	25	
9	19	2	
10	10		
11	17		

	Length of Contribution (s)		
# Contribu	Andrew	Mike	Lindsey
1 min. moderated			
1	14	12	8
2	10	2	4
3	13	21	11
4	5	4	3
5	8	3	12
6	1	3	3
7	4	2	7
8	9	6	6
9	5	2	10
10	4	3	2
11	6	3	2
12	23	5	2
13	2	7	4
14	8	6	2
15	3		12
16	4		
17	5		

Figure A.1: *Length and number of contributions collected from recorded moderator test meetings*