



# conveyance

helping scientists convey their planning goals

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Carnegie Mellon



# Our Team

Steve Hillenius

Jon Bidwell

Jessa Hafer-Zdral

Joanna Bresee

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technical lead

user research lead

web/document lead

design lead

project manager



# Our Client



## HCI Group

NASA Ames Research Center

# Agenda

Project Overview

Research

Visioning

Iterative Design

Conclusions

# PROJECT OVERVIEW

## Lunar Exploration



*Image Credit: NASA*

# PROJECT OVERVIEW

## Lunar Exploration

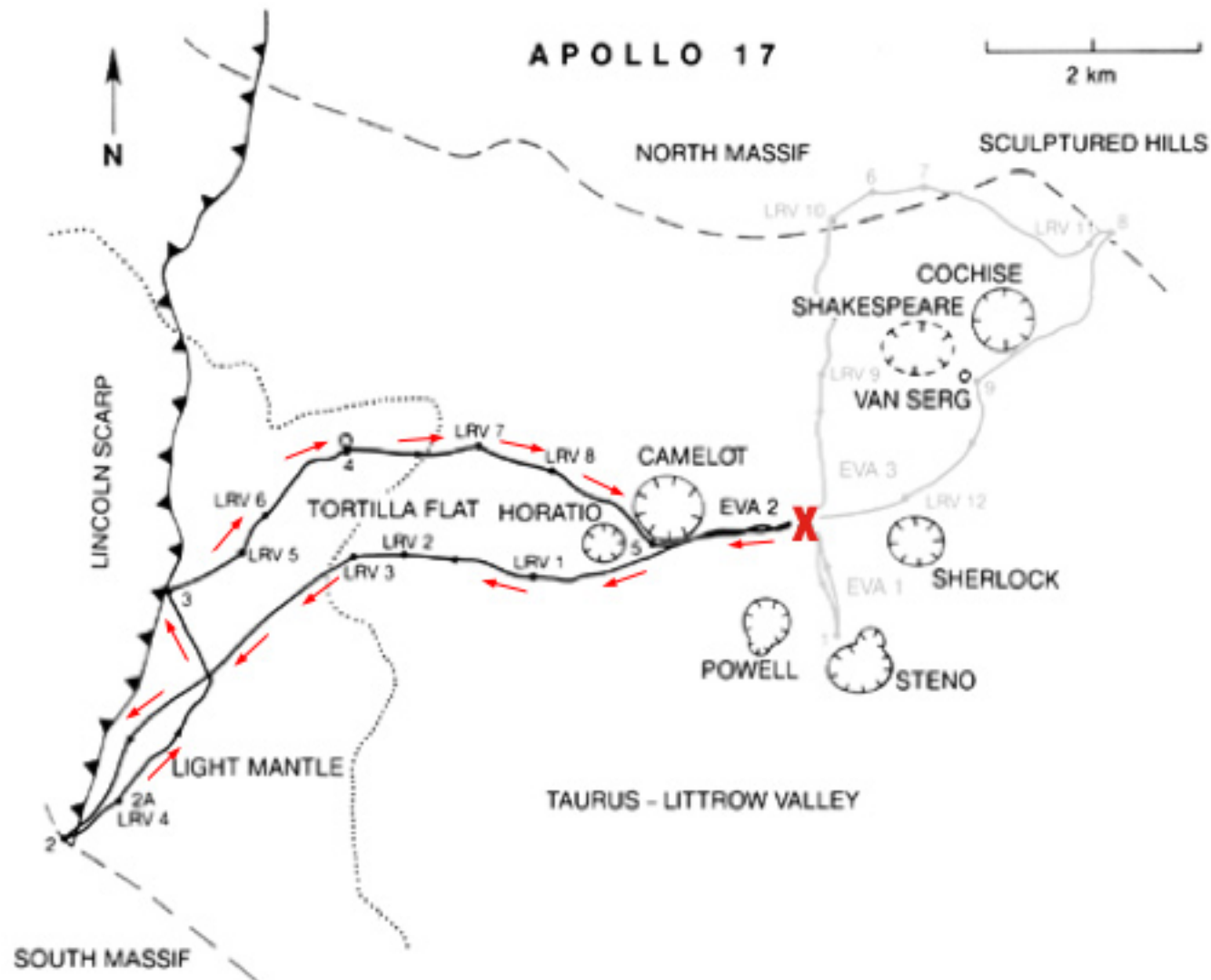


Image Credit: NASA

# PROJECT OVERVIEW

## Lunar Exploration

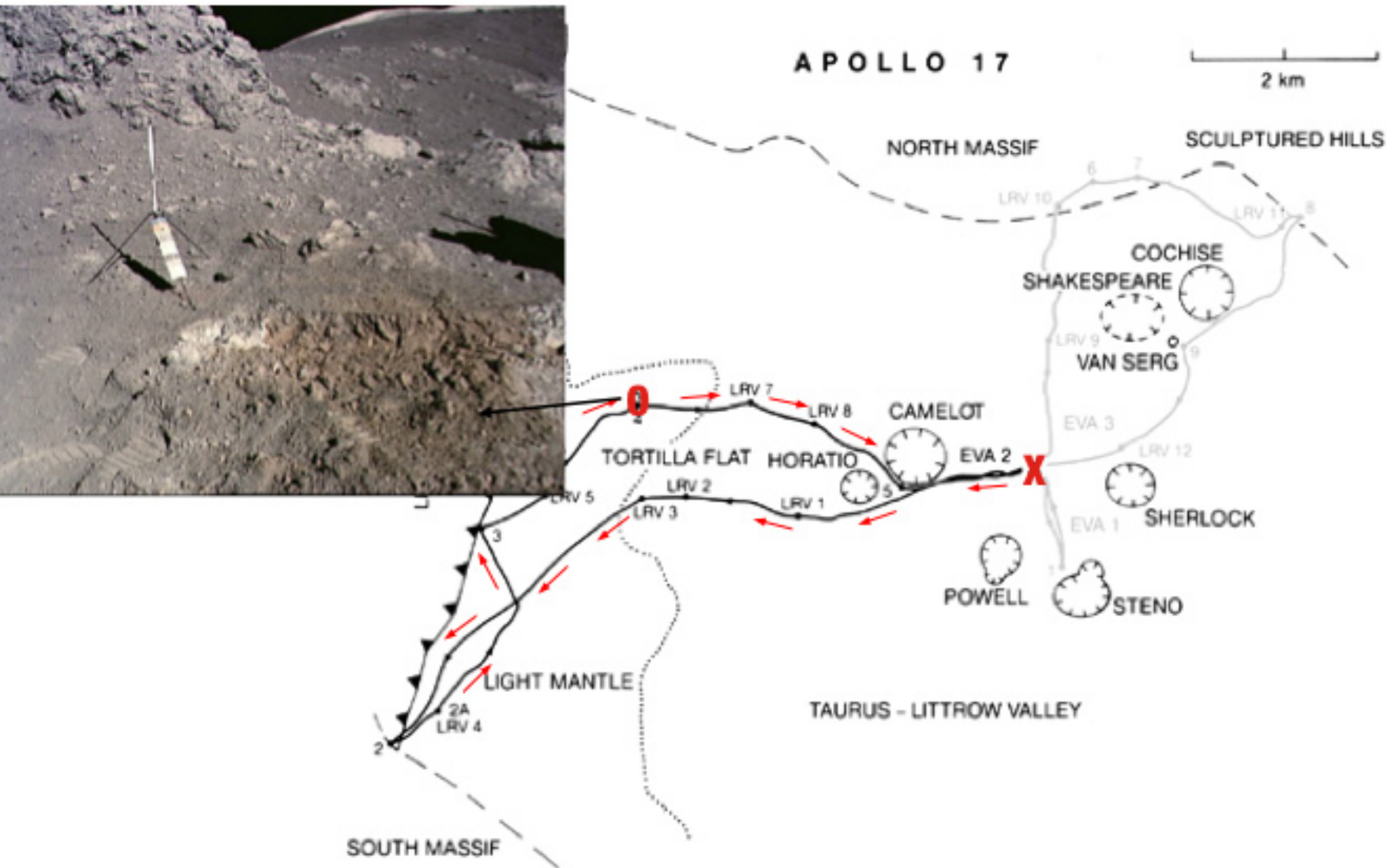


Image Credit: NASA

# PROJECT OVERVIEW

## Robotic Reconnaissance

Advance field exploration

- Improve science return
- Reduce operational risk
- Improve crew productivity



*Image Credit: NASA*



# PROJECT OVERVIEW

## Planning Process



Jim  
Science Team

# PROJECT OVERVIEW

## Planning Process



Jim  
Science Team



Andy  
Engineer

# PROJECT OVERVIEW

## Planning Process



Jim  
Science Team



Andy  
Engineer



Donna  
Flight Team

# PROJECT OVERVIEW

## Planning Process



Jim  
Science Team



Andy  
Engineer



Donna  
Flight Team

# PROJECT OVERVIEW

## Planning Process



**“Take an image of this ridge.”**

**“Is that what you wanted?”**

**“No, a little bit to the right.”**

**“Is that better?”**

**“See where my hand is? Take it there.”**

Jim  
Science Team

Andy  
Engineer

Donna  
Flight Team

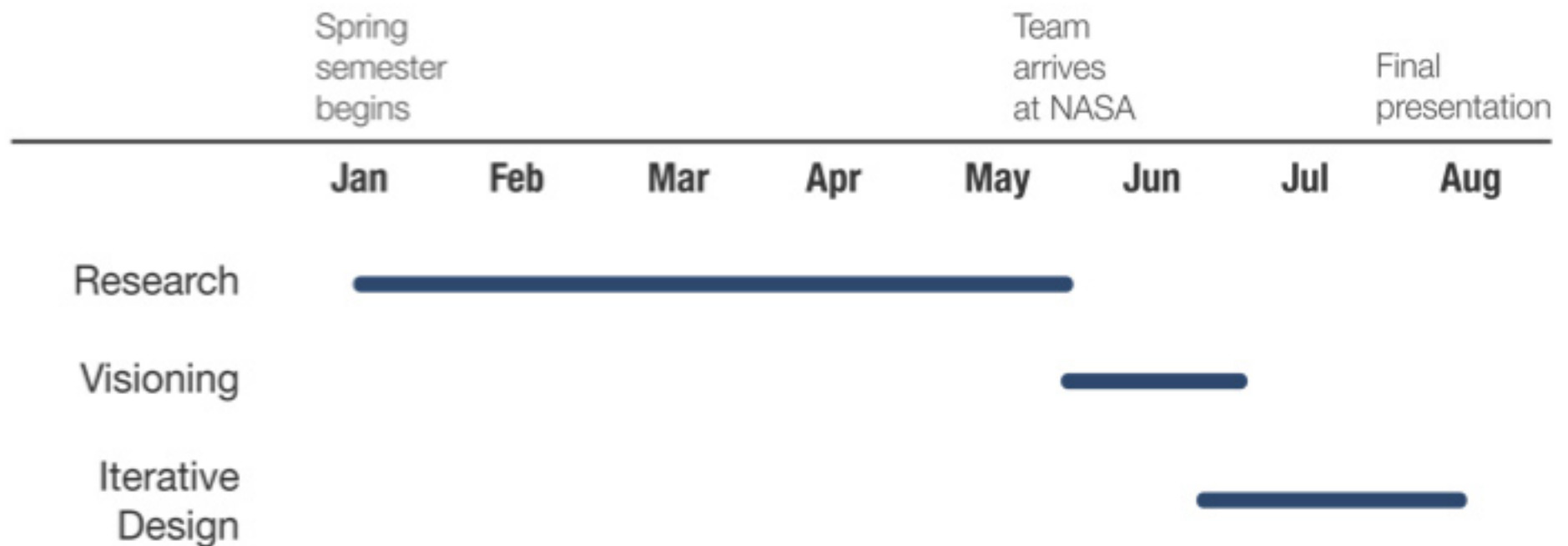
# PROJECT OVERVIEW

## Focus

Help scientists clearly communicate their planning goals to flight operations.

# PROJECT OVERVIEW

## Timeline

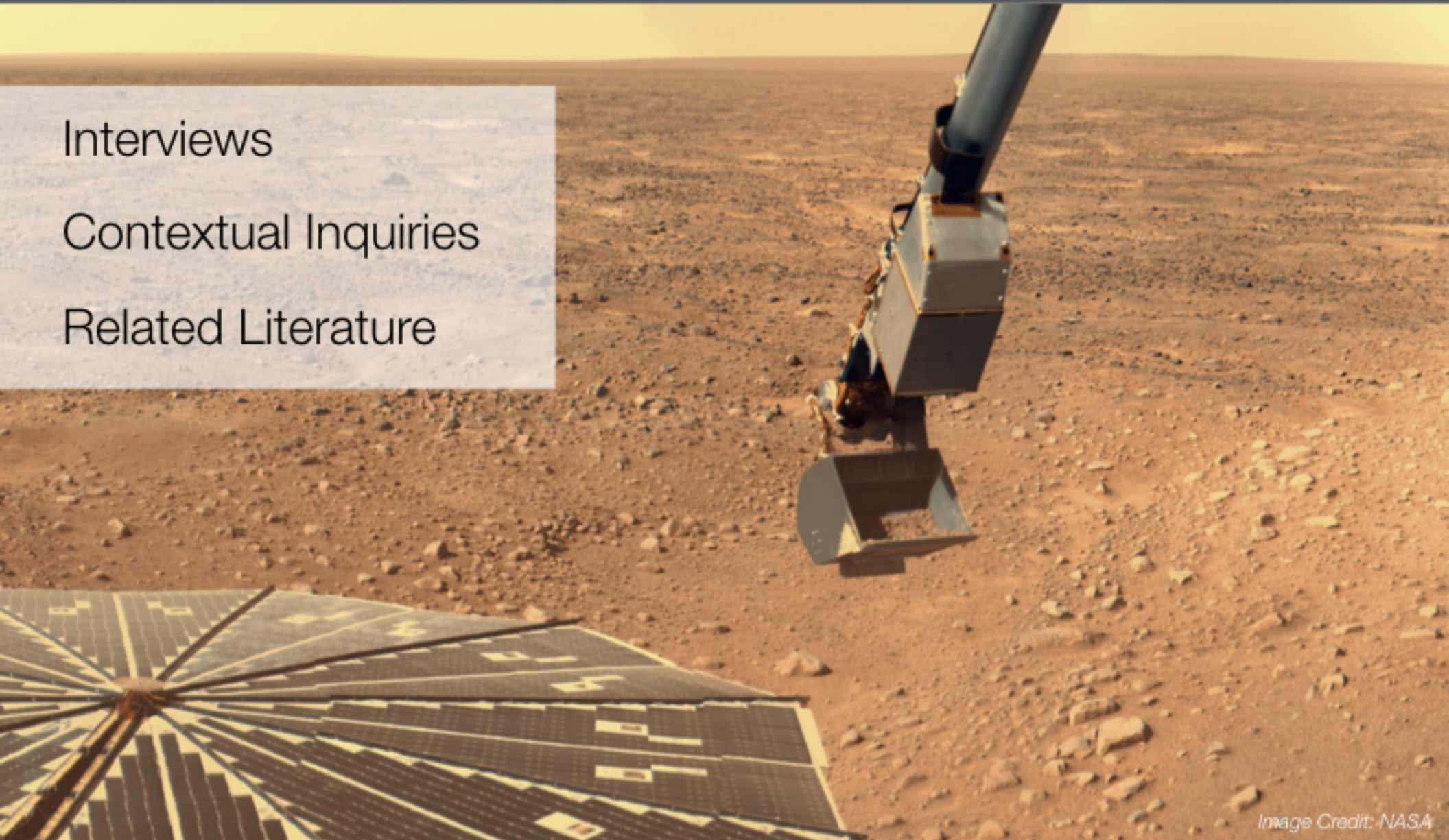


# RESEARCH Methods

Interviews

Contextual Inquiries

Related Literature



*Image Credit: NASA*



# RESEARCH Domains



Phoenix Lander



Mars Exploration Rovers (MER)



Mars Desert Research Station



CMU Machine Shop

# RESEARCH

## Key Findings

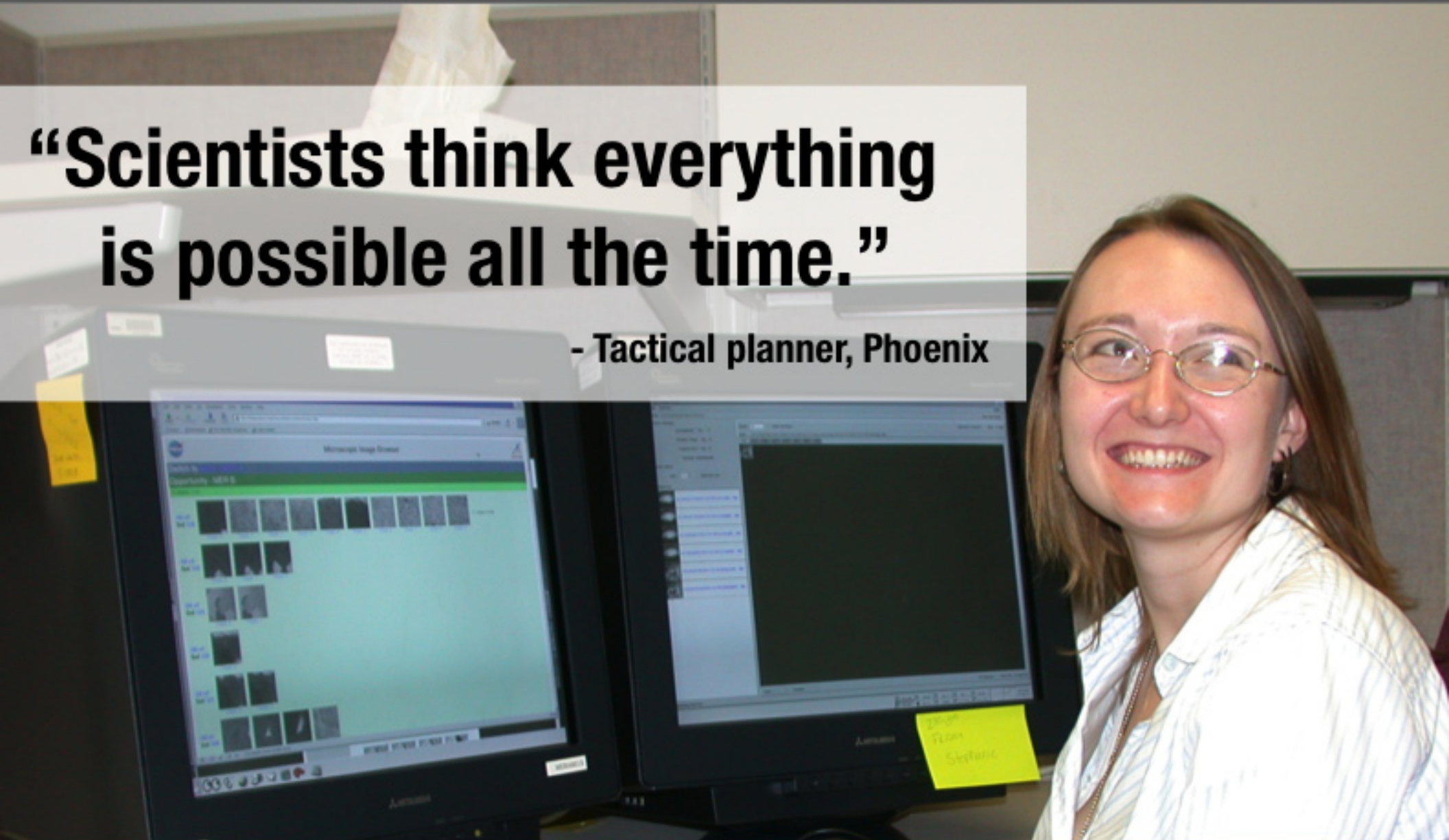
1. Scientists were not able to communicate in a language engineers could use
2. Ongoing local problem solving required immediate communication

# RESEARCH

## Key Findings

**“Scientists think everything is possible all the time.”**

**- Tactical planner, Phoenix**



# RESEARCH

## Key Findings

1. Scientists were not able to communicate in a language engineers could use
2. Ongoing local problem solving required immediate communication

# RESEARCH Key Findings

The screenshot displays the Microsoft Outlook 2003 interface. The main window shows the 'Inbox' folder with a list of emails. A specific email titled 'reminder' from Dheeraj Sanghi is selected and its content is visible in the main pane. The email text reads:

**reminder**  
 Dheeraj Sanghi [dheeraj@iitk.ac.in]  
 To: Gopesh Tiwari  
 Two things:  
 1. Test at 2:00 PM  
 2. Send a mail to ug00@lists.iitk.ac.in asking the to move to exchange server.  
 -dheeraj  
 ==  
 Dheeraj Sanghi  
<http://www.cse.iitk.ac.in/users/dheeraj>  
 Professor, CSE Dept., and Off: 259-7077, 7638 2  
 259-0725, 7586  
 Head, Computer Center Off: 259-7252, 7651 2  
 IIT Kanpur, UP 208016

Below the email content, a chat window titled 'Fastpath Conversation with Luis' is open, showing a conversation between 'pcabellor' and 'luis' regarding a Firefox knowledge base article and a restore procedure.

On the right side of the screen, a 'Spark - mark' window shows a contact list for 'Mark Sendon Petrie', including names like Aaron Johnson, Anthony Dalton, and Barry Talls. A weather widget on the far right indicates '18 Thursday' with 'A few clouds' and a 'FRONT WARNING'.

# RESEARCH

## Key Findings

**“You don’t have the time to look in twenty different places to find out if you’ve been communicated with.”**

**- Lead tactical SPI, Phoenix**

# RESEARCH

## Key Findings

**“Visuals helped a lot when they were there.”**

**- Sequence engineer, MER**

# RESEARCH

## Key Findings

1. Scientists were not able to communicate in a language engineers could use
2. Ongoing local problem solving required immediate communication



# VISIONING Process

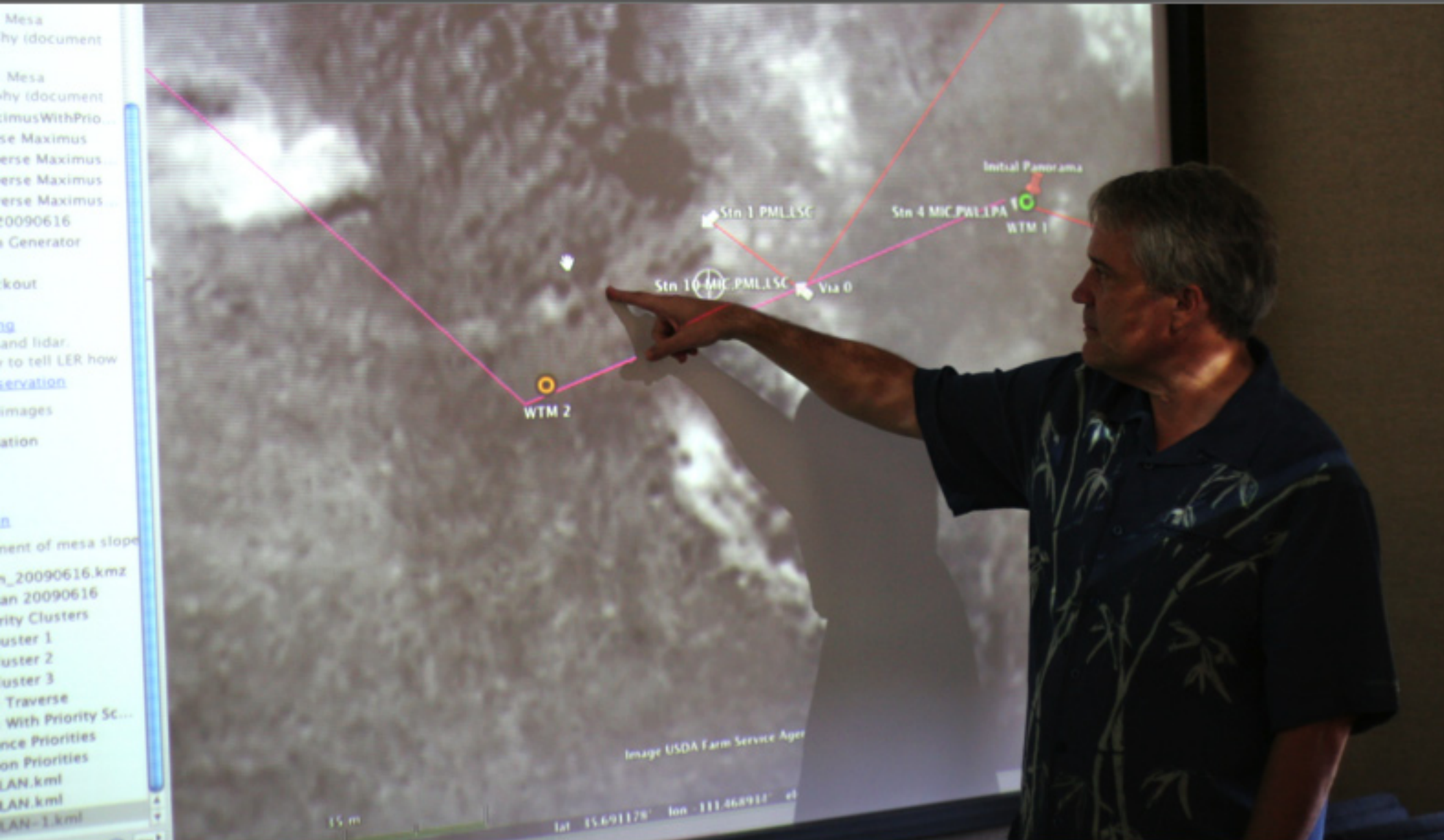
## Brainstorming Needs validation



# VISIONING Field Test



# VISIONING Field Test



# VISIONING Findings from the Field Test

Science and Flight Teams plan in different languages

Context of the map is important

Science Room discussion is not transferred into the plan



# VISIONING

## Design Goals

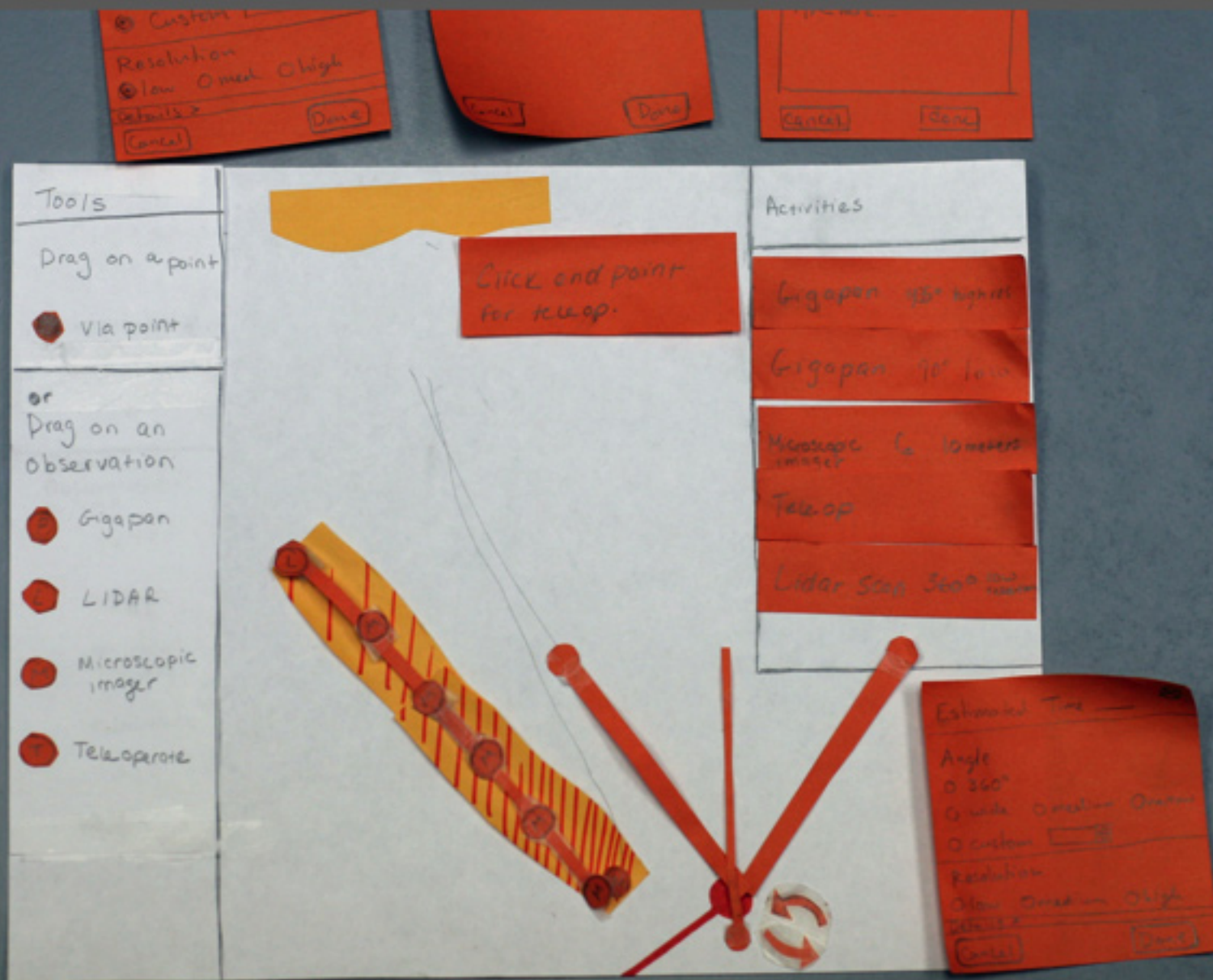
Create a tool that will allow the scientists to generate plans

Contextual information of the map is important

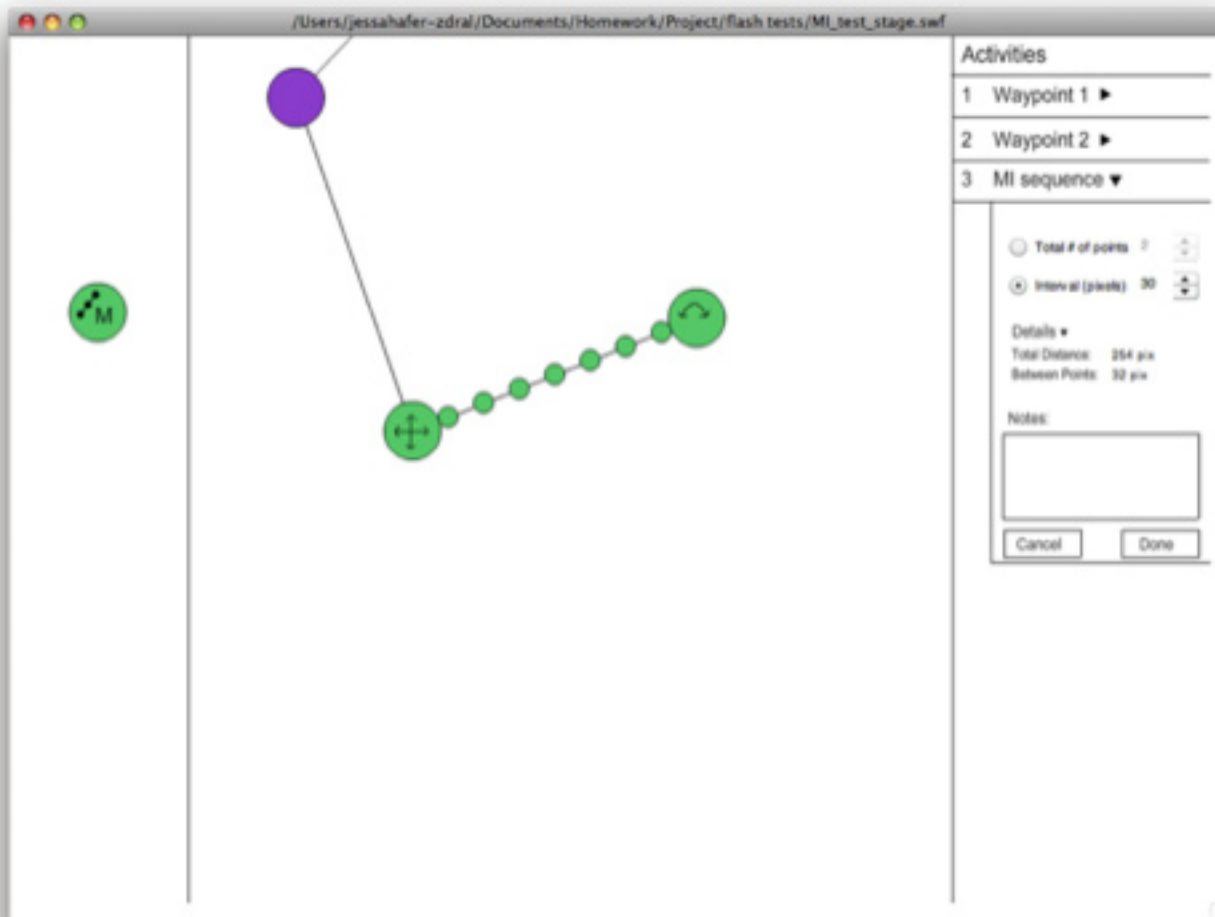
Focus on data, not instrument settings

Capture science goals within the plan

# ITERATIVE DESIGN Paper Prototyping



# ITERATIVE DESIGN Digital Prototyping



# ITERATIVE DESIGN Digital Prototyping

Exec Plan Print Plan

Drag a point onto the map

Via Point

Remove Point

Panoramic Point

ME Point

Lidar Point



Current Tasks

Waypoint 0 Type VIA  
+ add an intent

Waypoint 1 Type VIA  
+ add an intent

Waypoint 2 Type PANO  
+ add an intent

Please enter your intent:

checking out area 1 that i m]

Lat 37.41044423572905  
Long -122.06538261596456

Cancel Add Intent

Waypoint 3 Type PANO  
+ add an intent





# conveyance

helping scientists convey their planning goals

# ITERATIVE DESIGN

## Interface Features

Field of view visualization

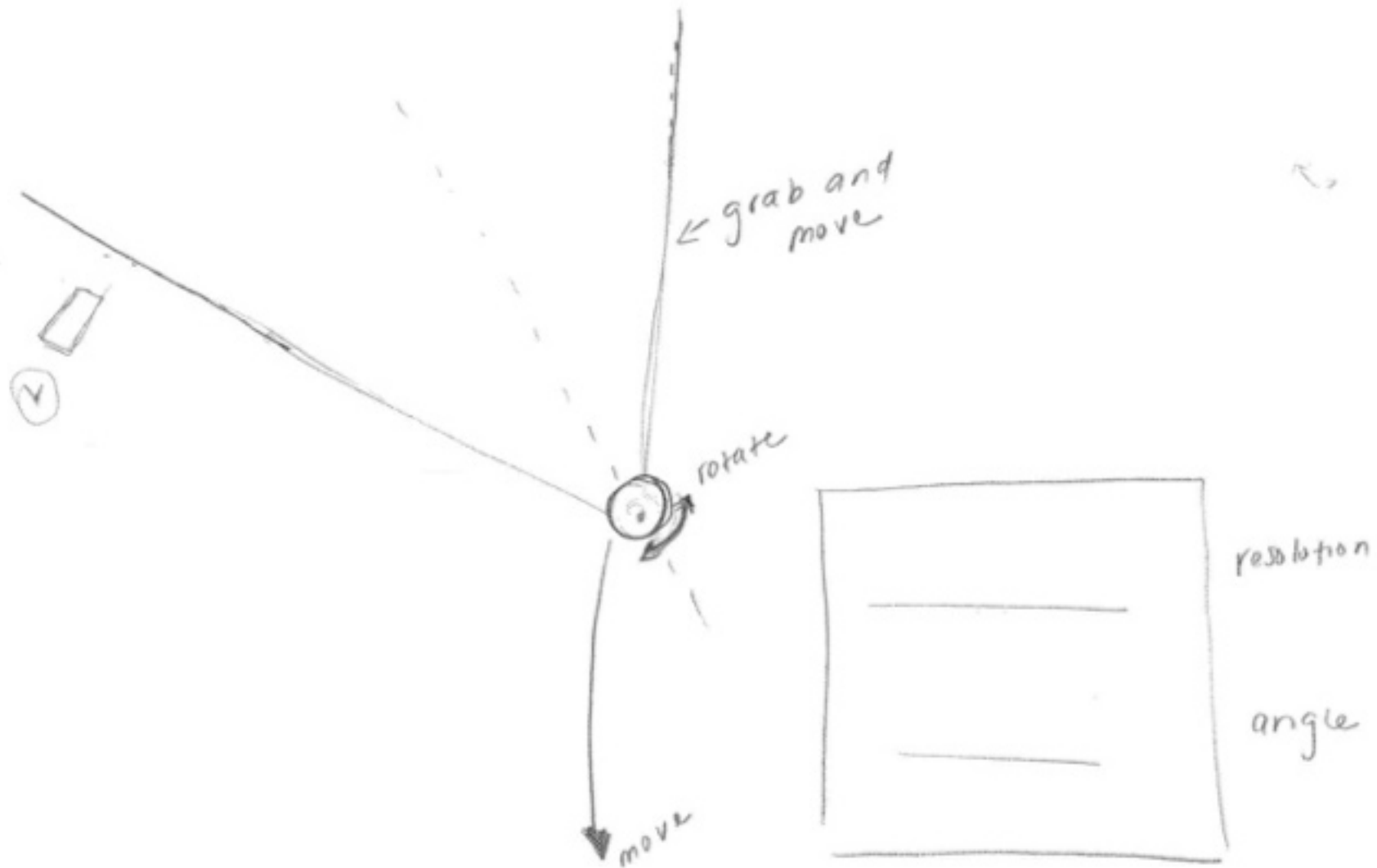
Activities list

Tool bar

Notes field

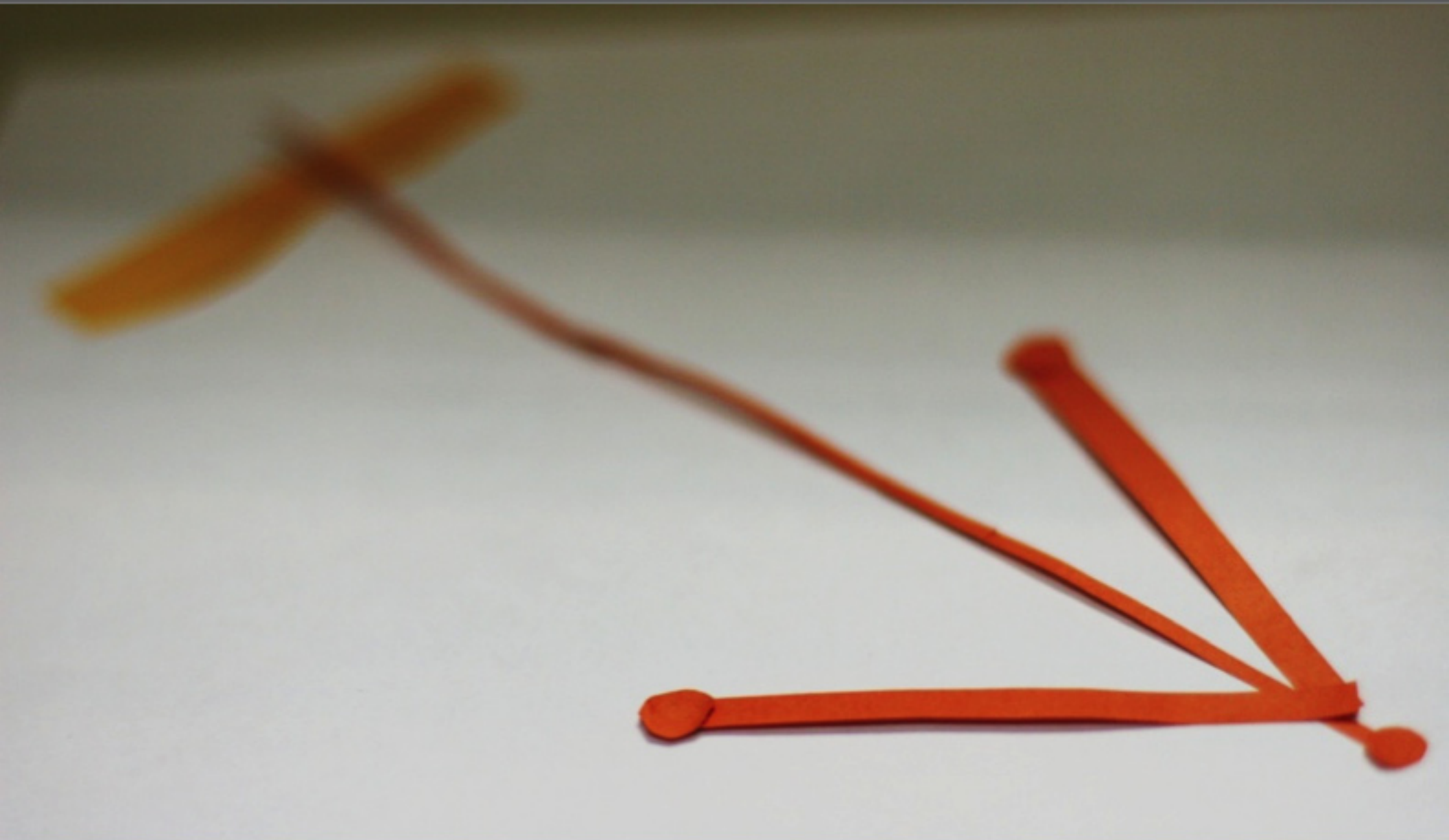
# ITERATIVE DESIGN

## Field of View Visualization



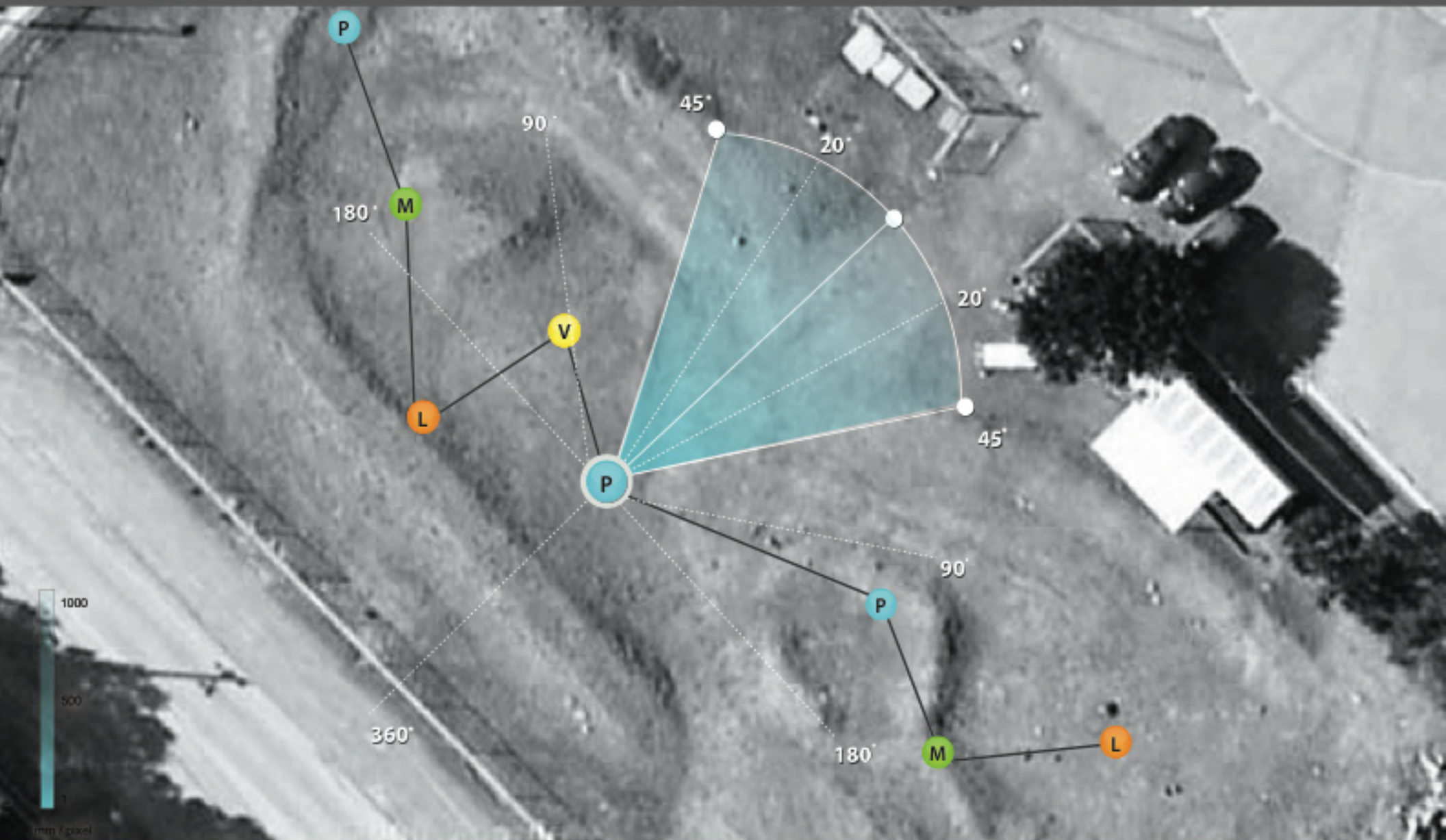
# ITERATIVE DESIGN

## Field of View Visualization



# ITERATIVE DESIGN

## Field of View Visualization



# ITERATIVE DESIGN

## Activities List



# ITERATIVE DESIGN

## Activities List

The image shows a collection of hand-drawn sketches and activity lists on a grey background. At the top, there are three orange sticky notes. The first note on the left is titled 'Estimated line' and contains the following text: 'Angle', '0 360°', '⊙ Custom [input box]', 'Resolution', '⊙ low ⊙ med ⊙ high', 'Details >', 'Cancel', and 'Done'. The middle note contains 'Total number [input box]', 'Total Distance [input box]', 'Cancel', and 'Done'. The third note on the right is titled 'Intent of teleop' and contains 'Type here...', 'Cancel', and 'Done'.

Below these are three white sheets of paper. The left sheet is titled 'Tools' and contains two sections. The first section is 'Drag on a point' with a red dot icon and the text 'Via point'. The second section is 'or Drag on an observation' with two red dot icons and the text 'Gigapan' and 'LIDAR'. The middle sheet is a large white sheet with a yellow sticky note at the top that says 'Click end point for teleop.' and a yellow and red striped object at the bottom. The right sheet is titled 'Activities' and contains four orange sticky notes with the following text: 'Gigapan 45° higher', 'Gigapan 90° low', 'Microscopic imager ⊙ 10 meters', 'Teleop', and 'Lidar Scan 360° low resolution'.

# ITERATIVE DESIGN

## Activities List



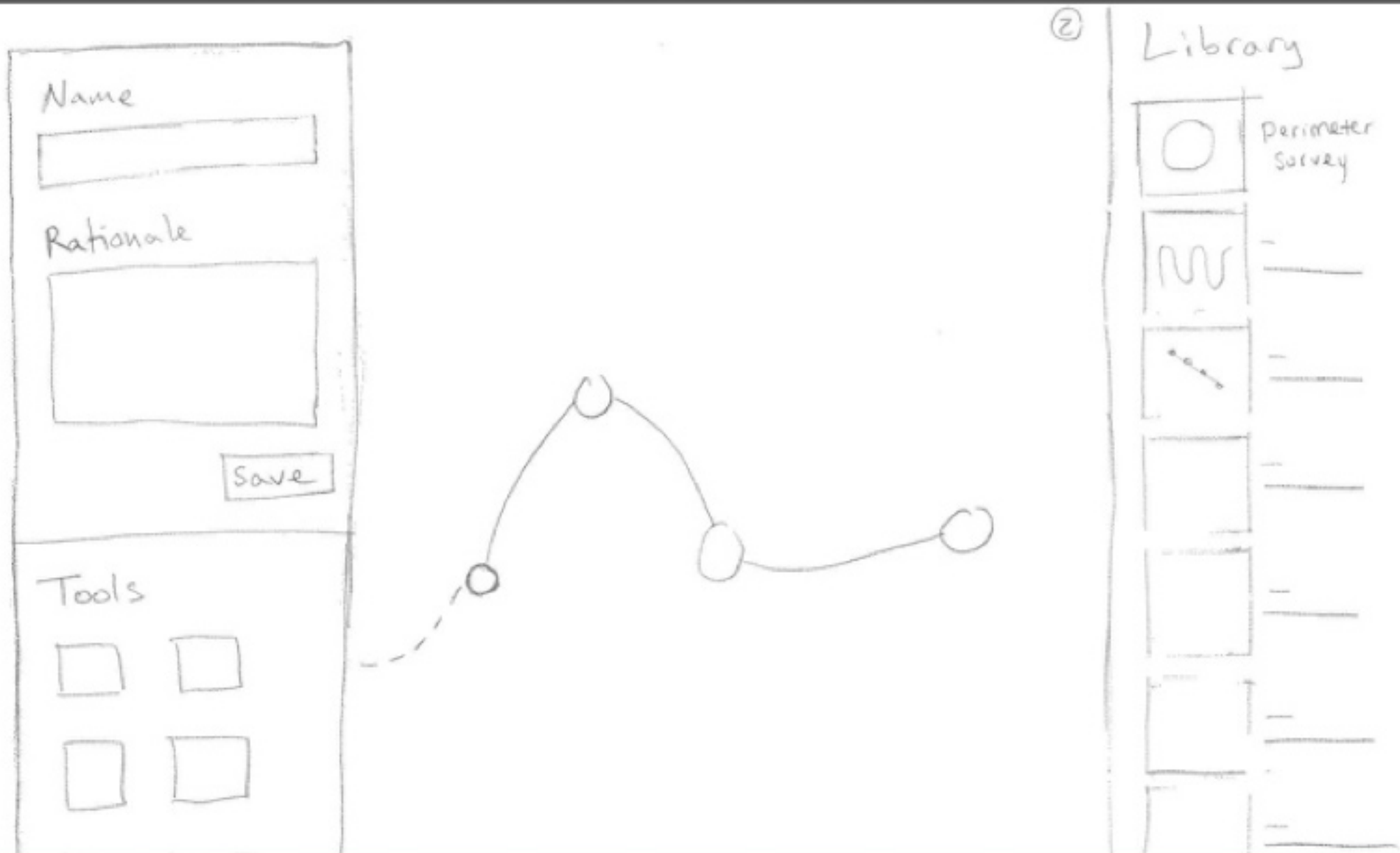
### activities

- 1 **P** 30 min [add note](#) ✕
  - 2 **M** 10 min [add note](#) 🗨️ ✕
  - 3 **L** 20 min [add note](#) ✕
  - 4 **V** 10 min [add note](#) 🗨️ ✕
  - 5 **P** 20 min [add note](#) ✕
- select resolution**
- high 100 mm/pixel 20 min
  - medium 50 mm/pixel 10 min
  - low 10 mm/pixel 5 min
- 6 **P** 20 min [add note](#) ✕
  - 7 **M** 20 min [add note](#) ✕
  - 8 **L** 20 min [add note](#) ✕



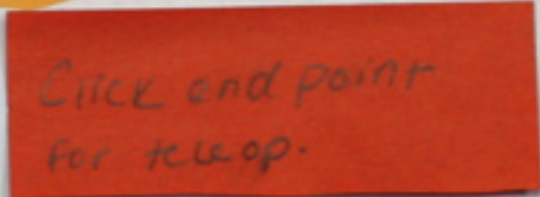
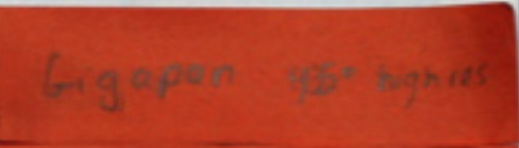
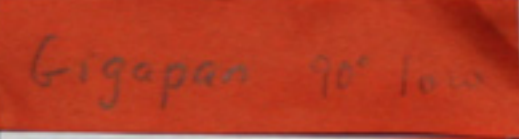





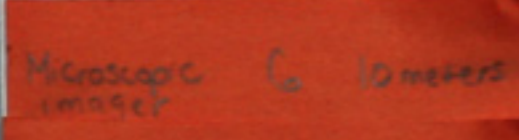
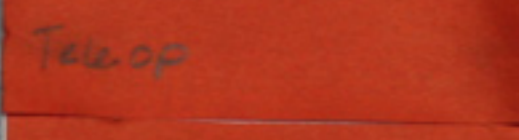
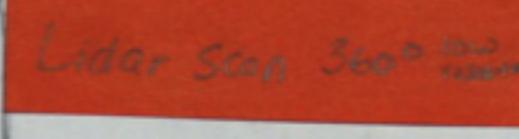
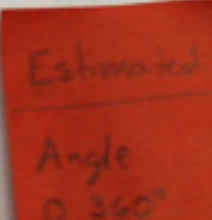
total time 84 minutes



# ITERATIVE DESIGN Tool Bar



# ITERATIVE DESIGN Tool Bar

| Tools  |  | Activities  |
|--|--|---|
| Drag on a point<br> Via point   | <br> | <br>  |
| or<br>Drag on an observation<br> Gigapan<br> LIDAR<br> Microscopic imager<br> Teleoperate |   | <br><br><br> |

# ITERATIVE DESIGN

## Tool Bar

drag a point  
to the map



via point



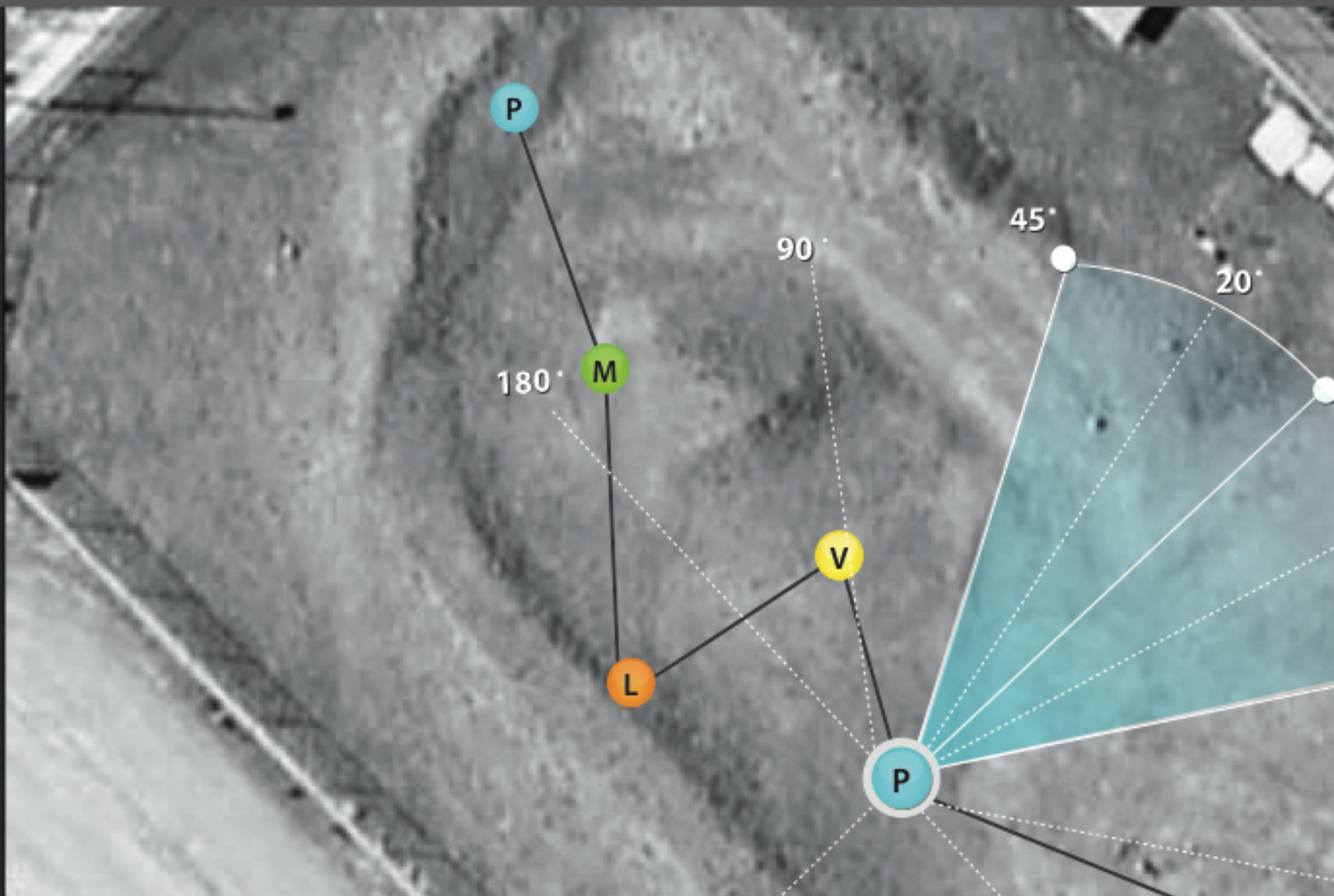
panorama



microscopic  
imager

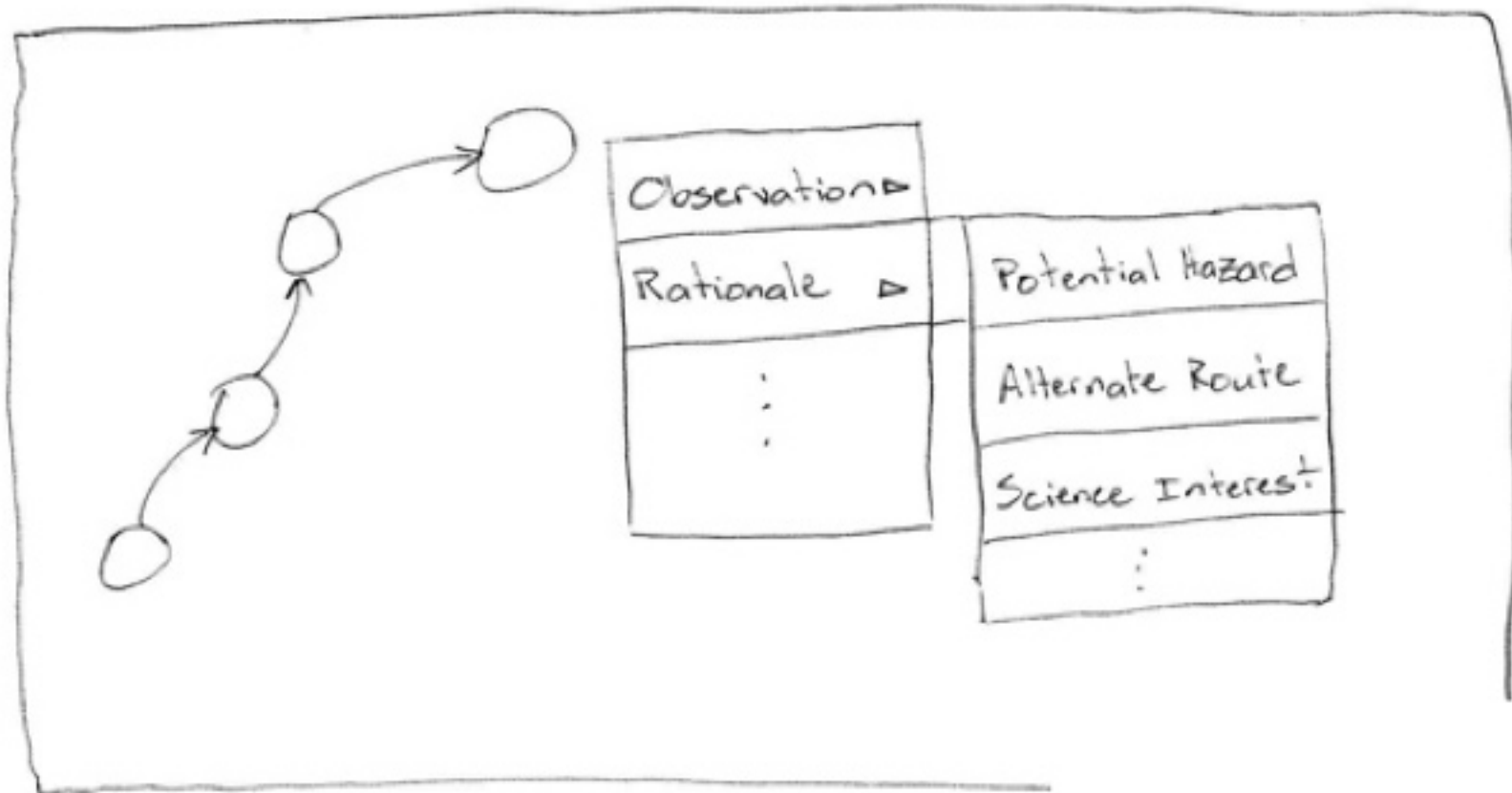


lidar



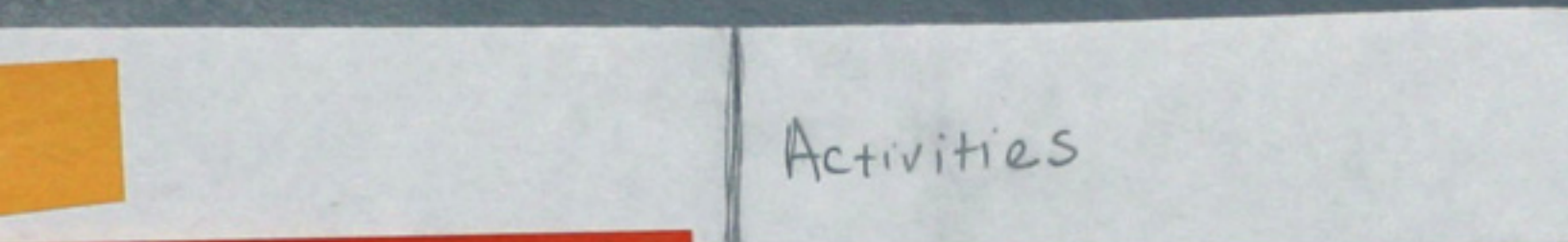
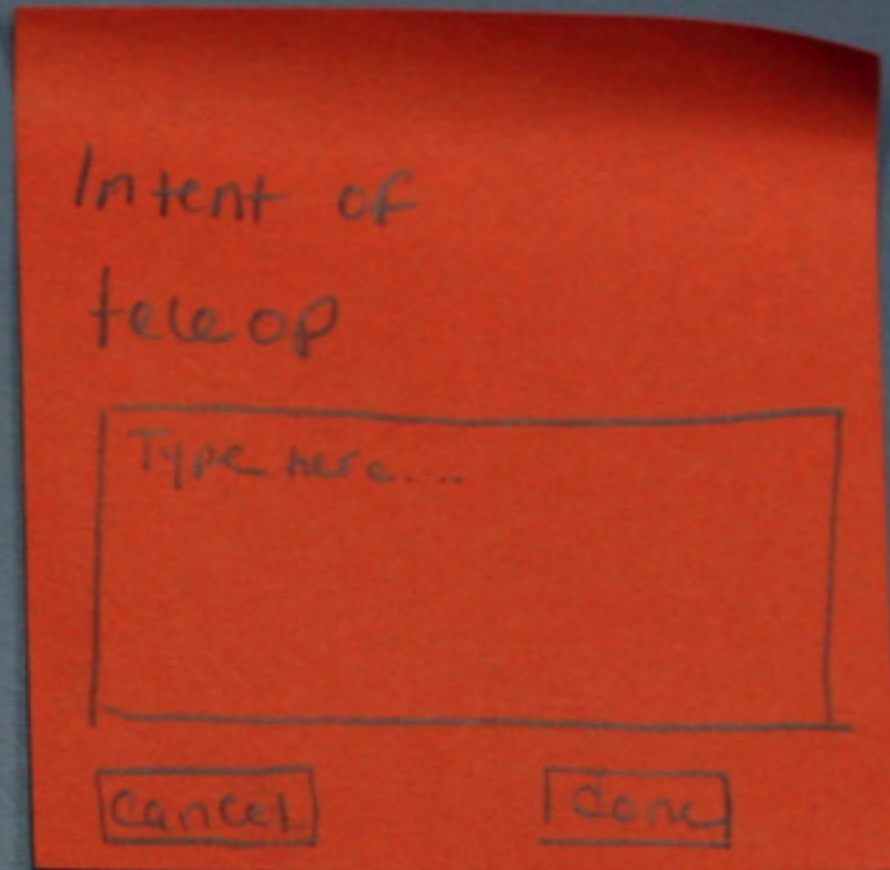
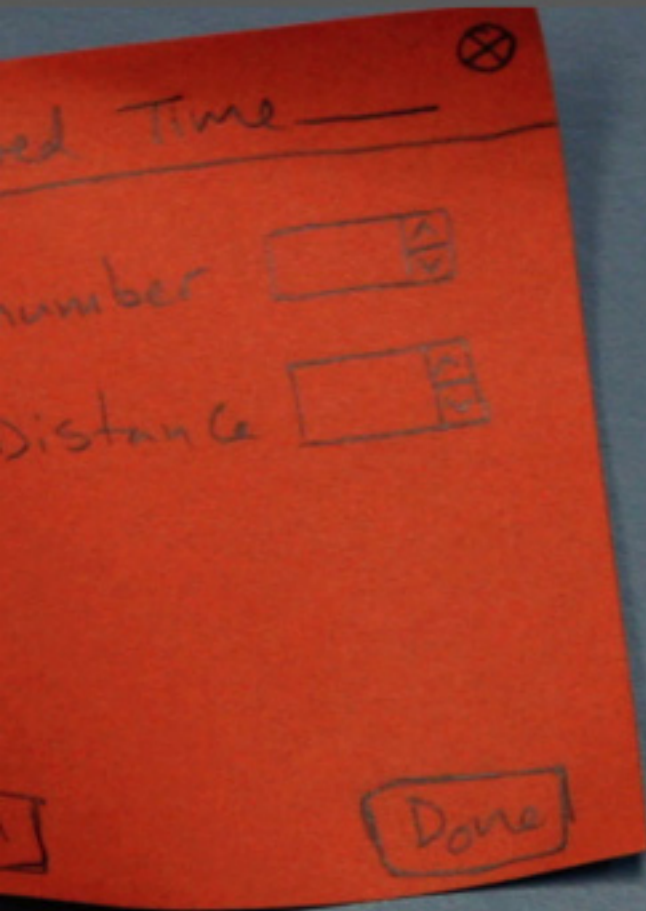
# ITERATIVE DESIGN

## Notes Field



# ITERATIVE DESIGN

## Notes Field



# ITERATIVE DESIGN

## Notes Field



### activities

- |   |   |        |          |   |
|---|---|--------|----------|---|
| 1 | V | 30 min | add note | ✕ |
| 2 | L | 10 min | add note | ✕ |
| 3 | P | 20 min | add note | ✕ |
| 4 | M | 10 min | add note | ✕ |
| 5 | P | 20 min | add note | ✕ |

science: Professor, Metamorphic petrology, geochemistry, and metamorphic rocks and thermobarometry.

Right: Investigated how river channels process large pulses of sediment via field and experimental work.

cancel

add note

- |   |   |        |          |   |
|---|---|--------|----------|---|
| 6 | L | 20 min | add note | ✕ |
| 7 | P | 20 min | add note | ✕ |

total time 84 minutes

# ITERATIVE DESIGN

## Operational Readiness Tests

### Goals

- Test in context
- Determine if science goals are being conveyed to the flight team

# ITERATIVE DESIGN

## Operational Readiness Tests



Simulated robotic reconnaissance



# ITERATIVE DESIGN

## Operational Readiness Tests



Science team



Flight team

# ITERATIVE DESIGN

## Operational Readiness Tests

### Results

- Intuitive and easy to use
- Field of view visualization successfully conveyed instrument constraints and observation goals
- Notes field successfully communicated planning goals

# CONCLUSIONS



Jim  
Science Team



Andy  
Engineer



Donna  
Flight Team

# CONCLUSIONS



**“Take an image of this ridge.”**

**“Is that what you wanted?”**

**“No, a little bit to the right.”**

**“Is that better?”**

**“See where my hand is? Take it there.”**

Jim  
Science Team

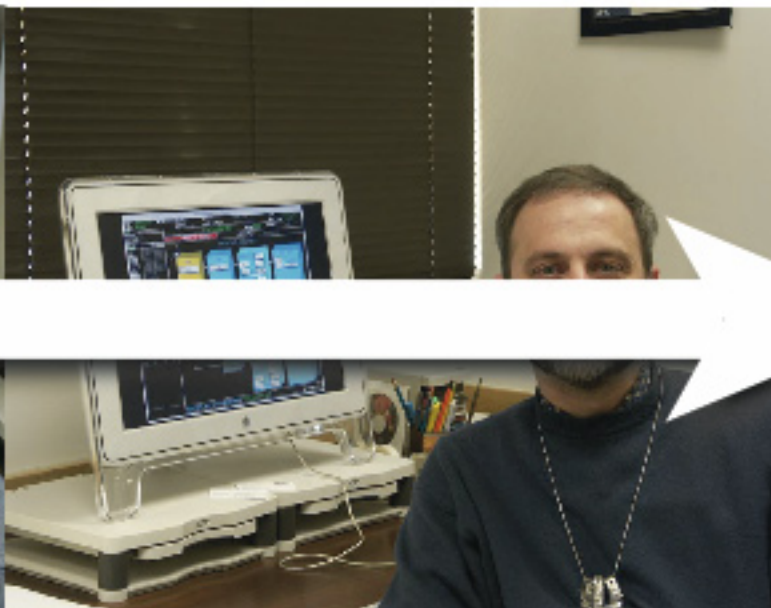
Andy  
Engineer

Donna  
Flight Team

# CONCLUSIONS



Jim  
Science Team



Andy  
Engineer



Donna  
Flight Team

# CONCLUSIONS

## Future Directions

Hypothetical planning

Data context and analysis

Collaborative decision making

# Special Thank You to:

## **NASA Ames**

HCI Group

Intelligent Robotics Group

## **Faculty Advisors**

Anind Dey

Sara Kiesler

## **Fellow MHCI classmates**



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