



**USC** Institute for  
Creative Technologies

# Towards Natural Dialogue with Robots: ARL Bot Language

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## Addressing research problems relevant to transitioning robots from *Tools* to *Teammates*

Vision: Natural and intuitive bi-directional communication

- Spoken **dialogue** with mixed initiative

### Tool



### Teammate

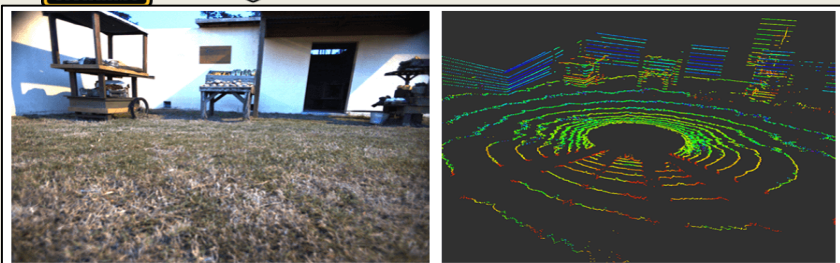




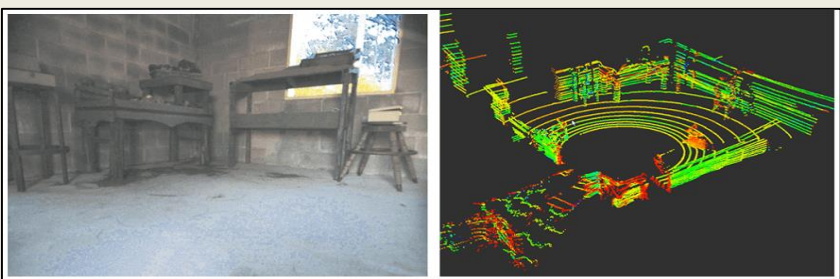
U.S. ARMY

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**RDECOM**

## Project Objectives



H: Enter and scan first room



R: I see a door to the right and a door to the left

H: Scan next open room on left



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Virtual Human  
(DeVault et al., 2014)

- Understand human language use to design robot capabilities needed for effective communication
- Collect data containing natural language commands and associated multimodal data from robot
  - Task: Human “teammate” is engaging in dialogue with robot “teammate”
- Can we successfully leverage dialogue management approaches from Human-Virtual Human (VH) dialogue and apply to robots?
  - Phased “Wizard of Oz” methodology

### Team Members

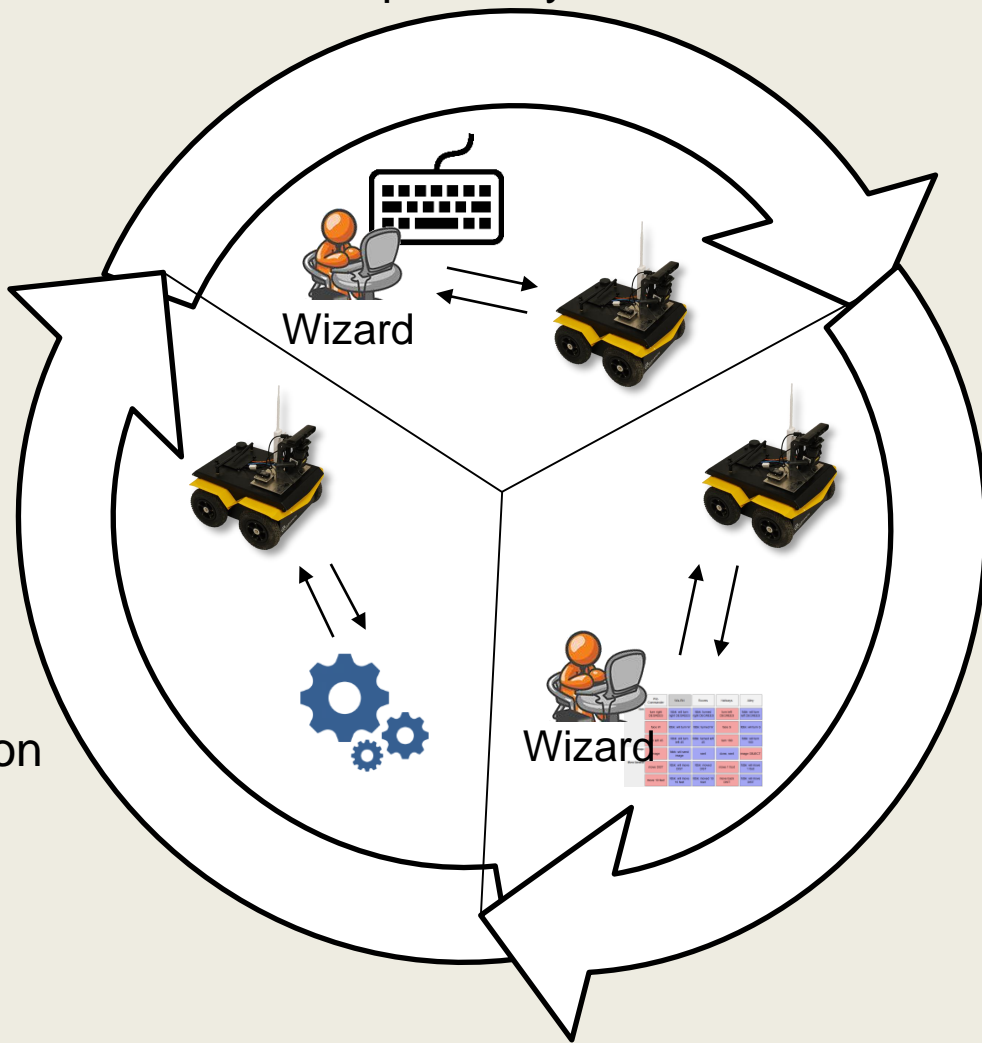
ARL CISD: M. Marge, C. Bonial, C. Hayes, S. Lukin, C. Voss

ARL HRED: S. Hill, A. Evans, A. Fouts, K. Pollard

ICT (Army UARC)@USC: D Traum, R Artstein, A Leuski



## Phase 1 Exploratory Data Collection

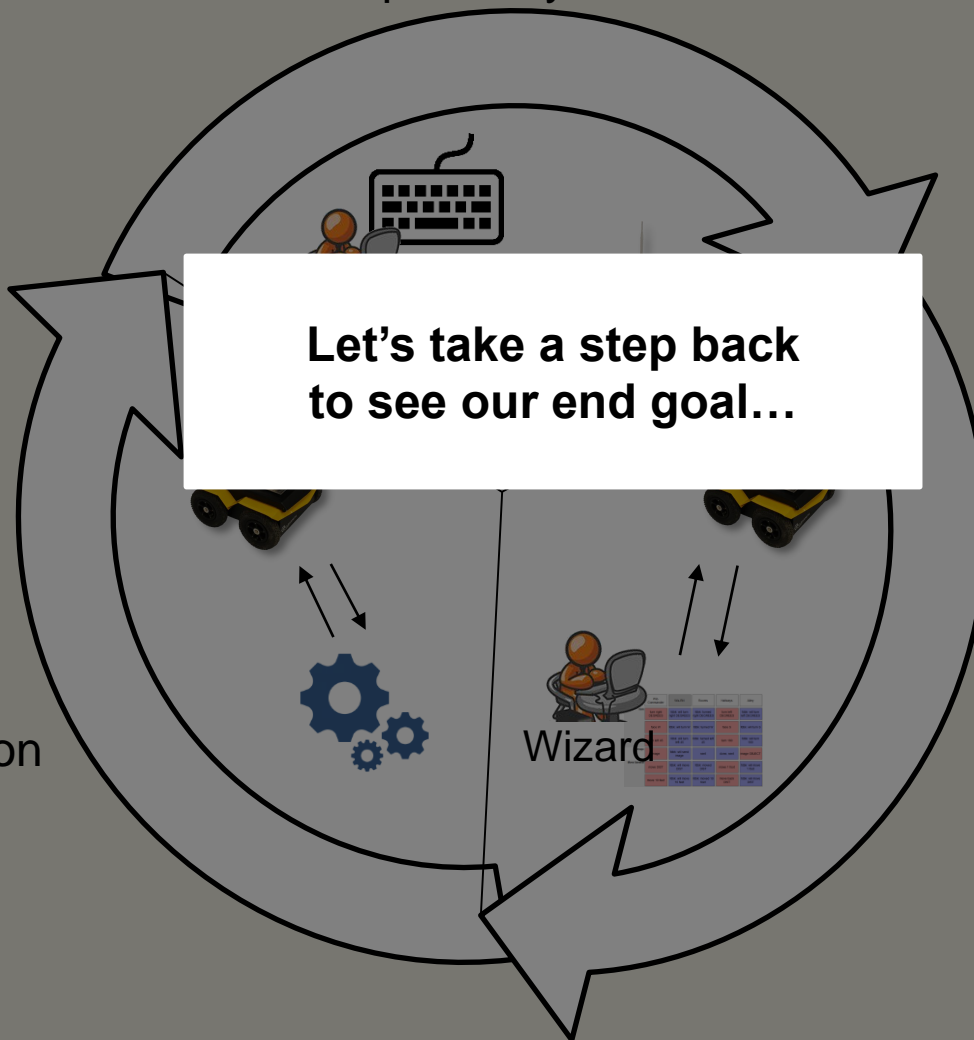


**Phase 3**  
Full Automation  
Of "Wizard"

**Phase 2**  
Automate Some  
"Wizard" Labor



### Phase 1 Exploratory Data Collection



**Let's take a step back  
to see our end goal...**

**Phase 3**  
Full Automation  
Of "Wizard"

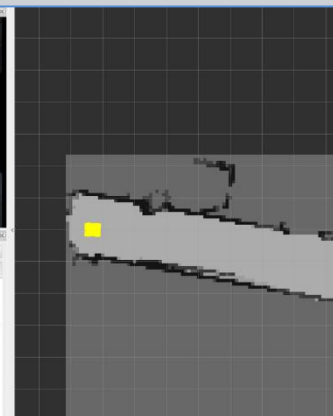
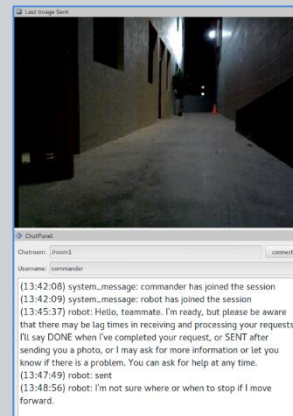
**Phase 2**  
Automate Some  
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## Human Commander



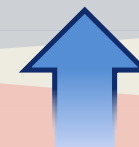
### VIEWS



### VERBAL COMMANDS



### ROBOT (remote from Commander)



(Marge et al., 2016, IEEE RO-MAN)

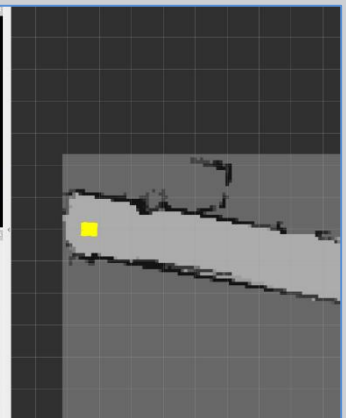
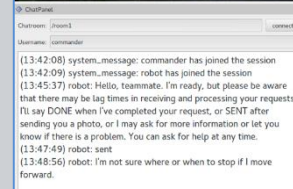
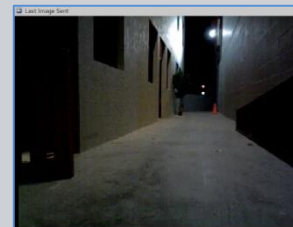
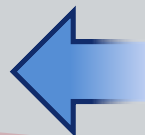


- Dialogue Manager (DM-Wizard) is the “brains” of the robot in natural language interactions

### Human Commander



### VIEWS



### VERBAL COMMANDS



“Behind the scenes”

### DM-WIZARD



Speech -> Constrained Language

Executes commands

### Robot Navigator



### RN MOVES ROBOT



- Robot Navigator (experimenter) navigates robot based on instructions from DM-Wizard

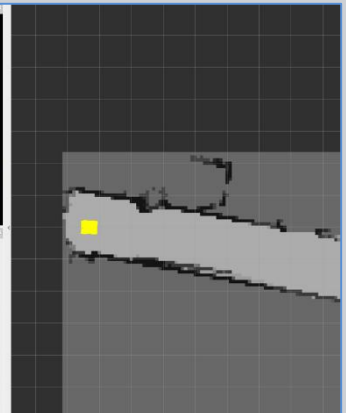
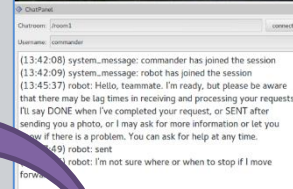
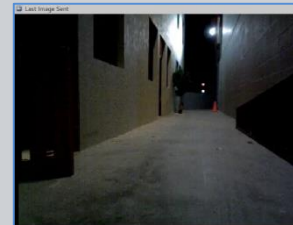


- Dialogue Manager (DM-Wizard) is the “brains” of the robot in natural language interactions

## Human Commander



## VIEWS



VERBAL COMMANDS

## DM-WIZARD



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Executes commands

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RN MOVES ROBOT



“Behind the scenes”

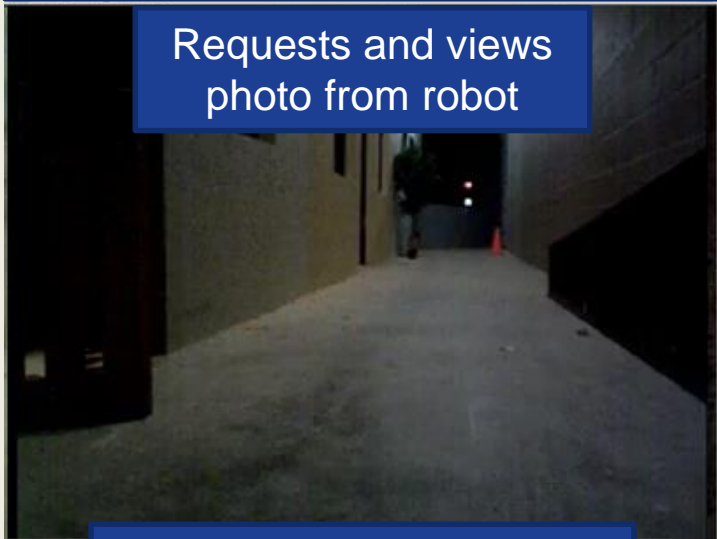
- Robot Navigator (experimenter) navigates robot based on instructions from DM-Wizard





**Commander:** Speaks into microphone

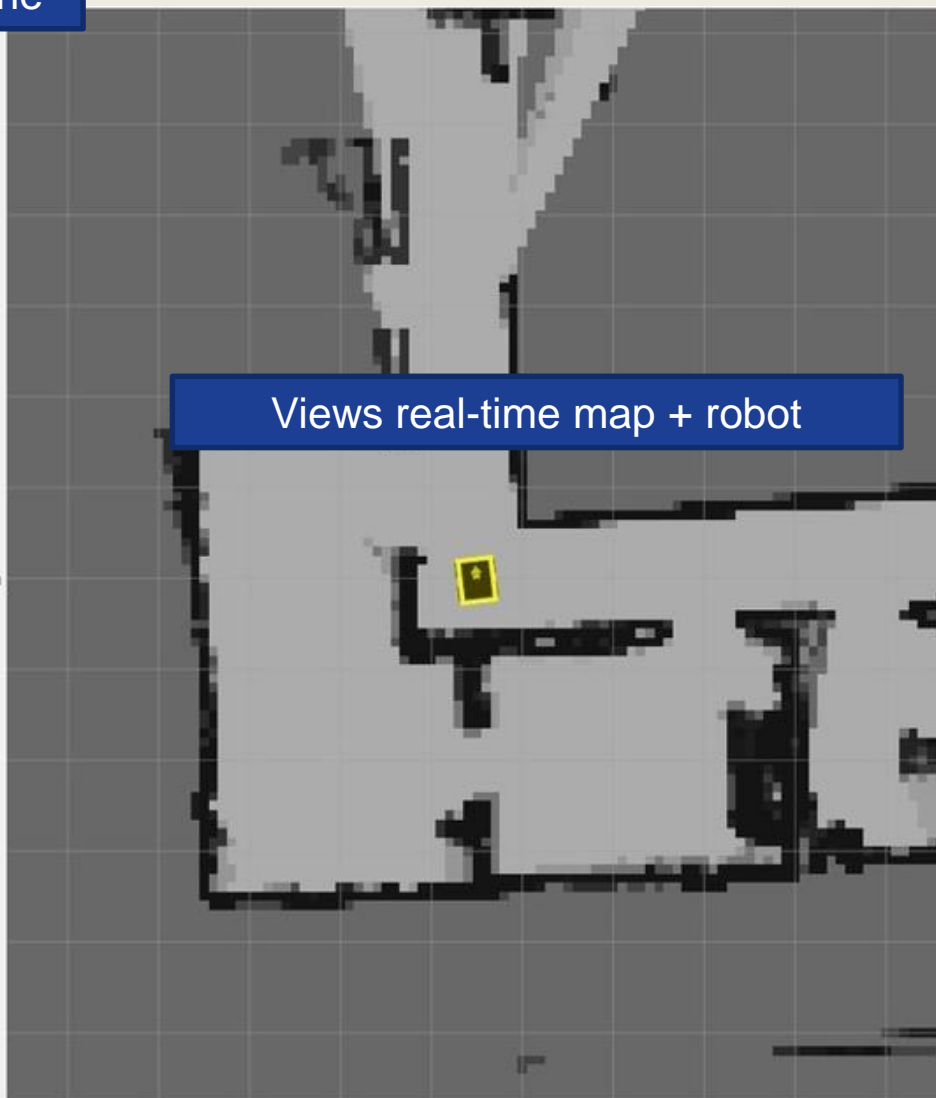
Requests and views photo from robot



Reads DM-Wizard dialogue responses



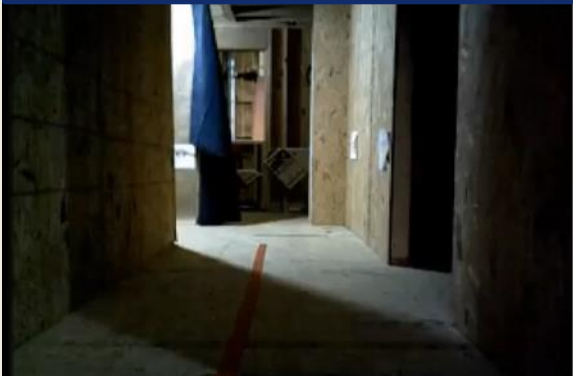
Views real-time map + robot





**Dialogue Manager: Listens to Commander via headphones**

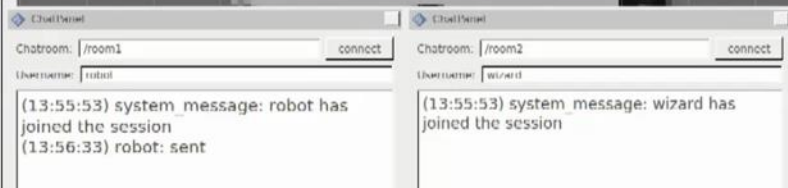
**Views video from robot**



**Views photo sent to Commander**



**Views real-time map + robot**



**Experiment 1: Types responses into chat windows to Commander and Robot Navigator**



The screenshot displays a software interface for a virtual environment. On the left, there are two camera views: 'Front Facing Camera' and 'Last Image Sent', both showing a 3D rendered scene of a hallway with stone walls and a red line on the floor. The main area on the right is a 2D floor plan of the same environment, overlaid on a grid. A yellow square on the floor plan is labeled 'To Commander' and 'To Navigator'. Below the floor plan are two chat windows. The first chat window, titled 'ChatPanel', shows a chatroom named '/room1' with a 'connect' button and a user named 'robot'. The chat history includes: '(13:55:53) system\_message: robot has joined the session' and '(13:56:33) robot: sent'. The second chat window, also titled 'ChatPanel', shows a chatroom named '/room2' with a 'connect' button and a user named 'wizard'. The chat history includes: '(13:55:53) system\_message: wizard has joined the session'. The interface also features a top menu bar with options like 'Interact', 'Move Camera', 'Select', 'Focus Camera', 'Measure', 'Rose Estimate', '3D Nav Goal', and 'Publish Point'.

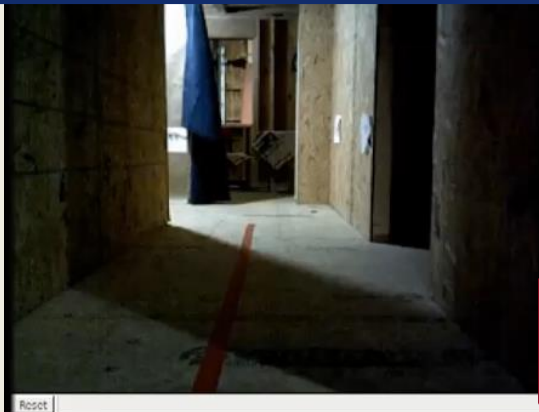


Dialogue Manager: Listens to Commander via headphones

Views video from robot



Views photo sent to Commander



Commander	Wizard	Robot	Dialogue	Reply
turn right 90 degrees	Robot will turn right 90 degrees	Robot turned right 90 degrees	turn left 90 degrees	Robot will turn left 90 degrees
turn left	Robot will turn left	Robot turned left	turn right	Robot will turn right
turn left 45	Robot will turn left 45	Robot turned left 45	turn right	Robot will turn right
image	Robot will send image	Robot sent image	image OBJECT	Robot will send image
image OBJECT	Robot will receive image	Robot received image	image OBJECT	Robot will receive image

Presses buttons on graphical interface to produce replies

Chatroom: //room1  
 User: robot  
 (13:55:53) system\_message: robot has joined the session  
 (13:56:33) robot: sent

User: wizard  
 (13:55:53) system\_message: wizard has joined the session

Experiment 2: DM-Wizard interface instead of typing



# "Move do move south"



Wiz-Co - Mozilla Firefox

Wiz-Co

file:///home/bbyrne/ros/cpr\_jade\_ws/src/command\_pup

Search buttons

Disconnect

**Wiz-Commander**

Screens	Wiz-Commander	Wiz-RN	Rooms	Hallways	Alley		
Task	Intro1- hello	Intro2- thanks	Intro3- lag time	Intro4- feedback	Intro5- help	also_ready	ready
	map appearance	tech issues	standby	hold push-to-talk reminder	task complete		
Feedback	processing	executing	moving	turning	sent	done	done_sent
	action done, photo sent	...	just a moment	hmm	hang on	and...	but...
	however...	hear you	calibrating	calibration complete	yes	no	ok
	ok, got it	reponse: unsure	correct	don't think so	think so	good job	thank you
	hi	sorry	woops	course correction			
Clarify Target	unsure of object referred to	unsure object meant	describe w color, size, position?	describe another way?	unsure where to go	unsure of doorway	unsure doorway meant
	unsure of room	unsure of wall	one to my right?	on the right?	one to left?	on the left?	one closest?
	one ahead?	direct left or ahead left?	direct right or ahead right?	which doorway?	which room?	which wall?	which OBJECT?
	I see multiple doorways	I see multiple walls	I see multiple OBJECT	don't see door on left	don't see door on right	don't see OBJECT, DESCRIPTION	
Clarify Action	unsure where to stop moving forward	unsure where to stop going forward	move capability: distance or object	how far forward go?	how far move forward?	how far back go?	how far back?
	how far DIRECTION?	how far go down hallway?	how far move down hallway?	unsure when to stop turning	unsure when should stop	turn capability: degrees or face	how far turn right?

ChatPanel

Chatroom: /room2 connect

Username: wizard

(17:59:04) system\_message: wizard has joined the session  
 (17:59:24) wizard: send image  
 (17:59:40) wizard: move to alley Door 2  
 (18:00:27) wizard: send image

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ChatPanel

Chatroom: /room1 connect

Username: robot

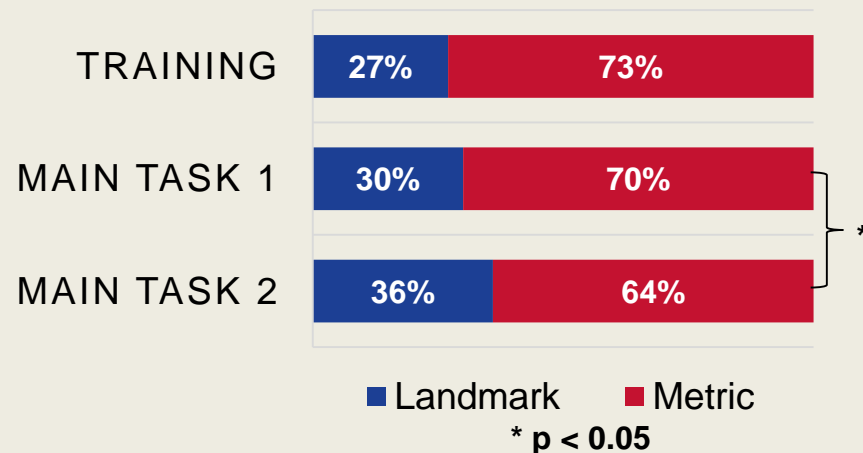
session  
 (17:59:20) robot: done  
 (17:59:26) robot: sent  
 (17:59:37) robot: processing...  
 (18:00:04) robot: moving...  
 (18:00:23) robot: done  
 (18:00:29) robot: sent



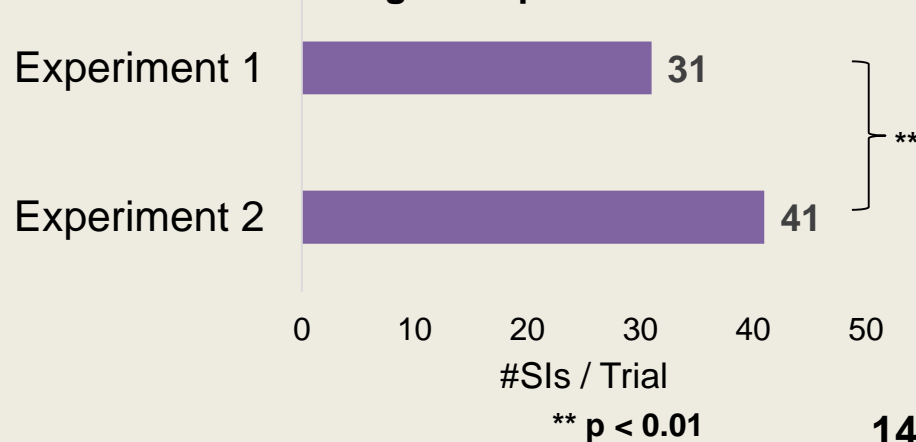
- **Experiment 1:** People use a variety of language when interacting with robots

- **Experiment 2:** DM-Wizard GUI improves data collection by enabling faster data collection (more successful interactions)

Landmark vs. Metric Usage in Instructions to Robot

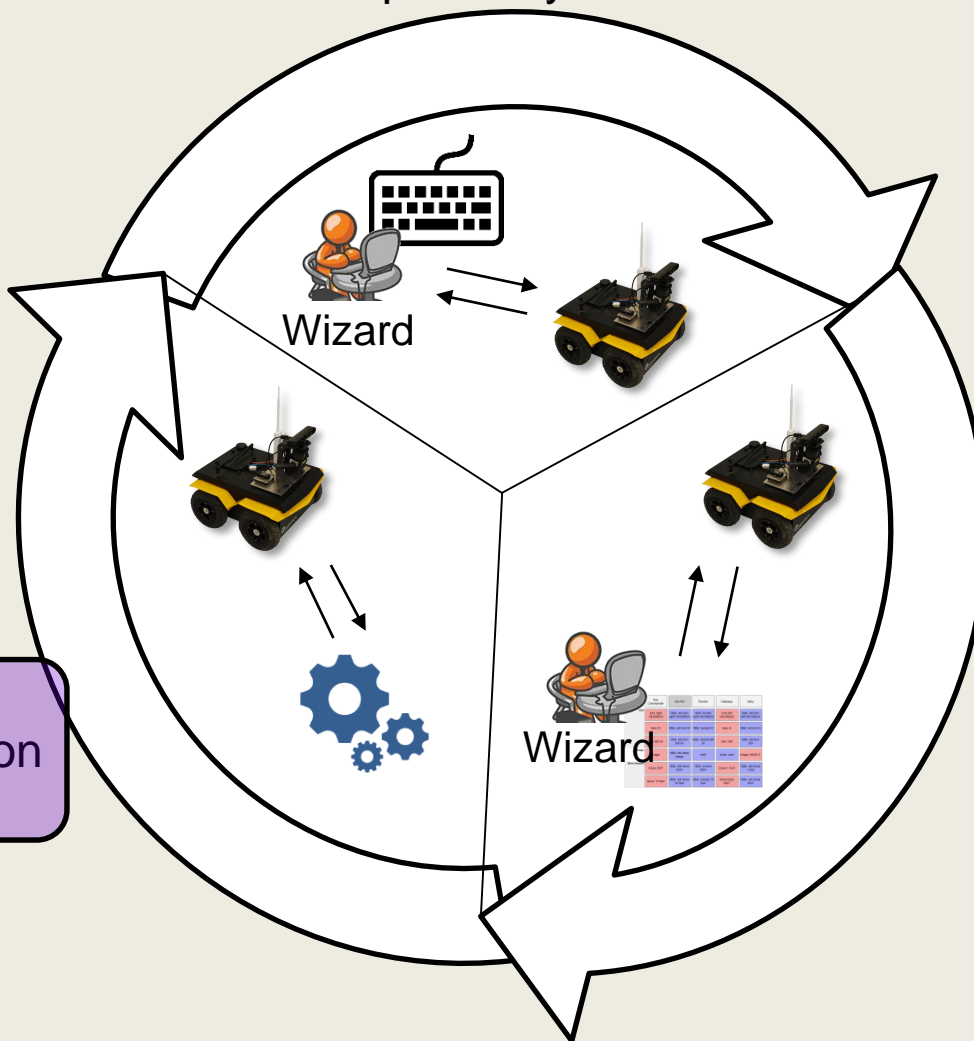


# Successful Interactions per Dialogue: Experiment 1 vs. 2





## Phase 1 Exploratory Data Collection



**Phase 3**  
Full Automation  
Of "Wizard"

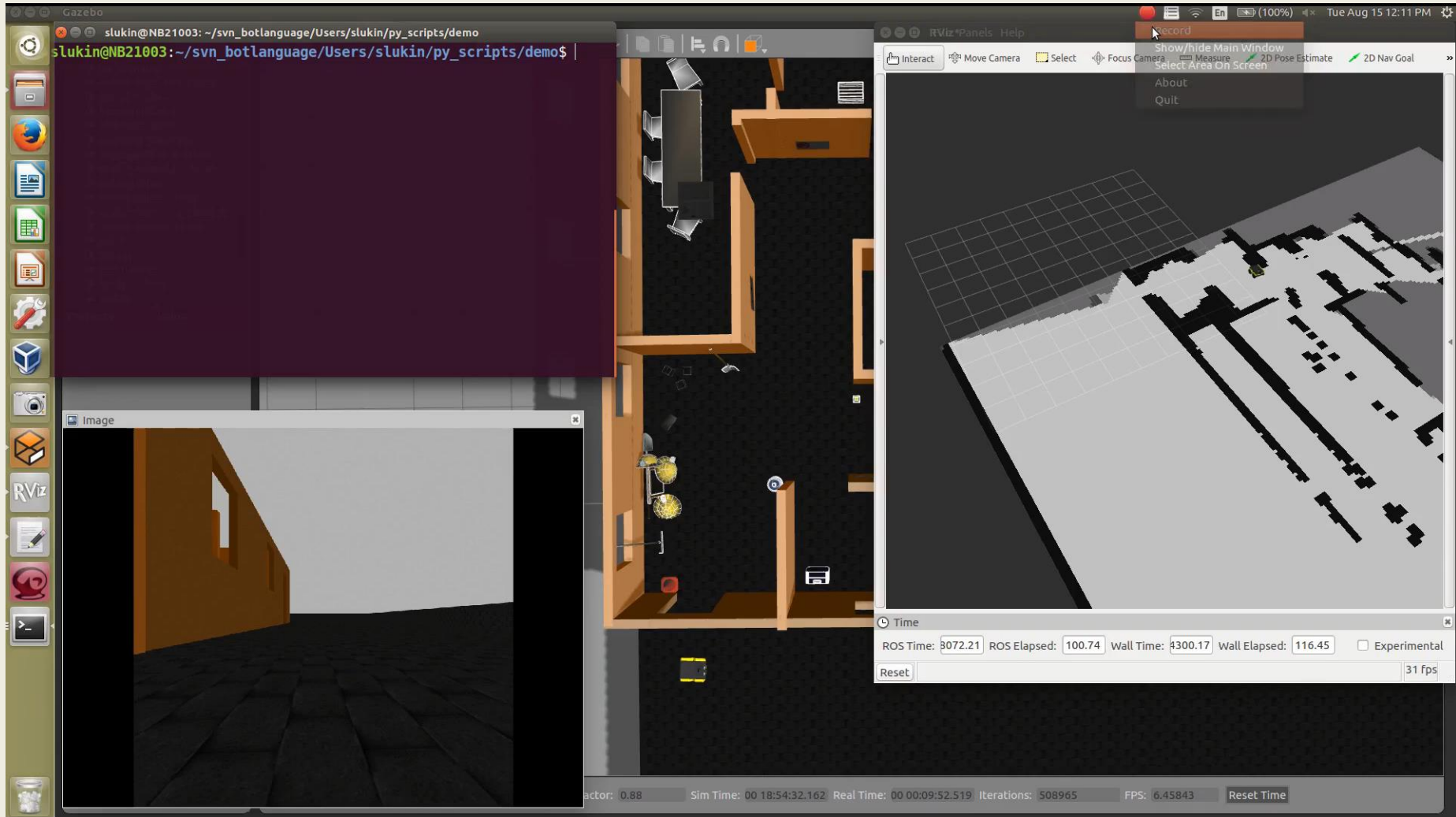
**Phase 2**  
Automate Some  
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# End Goal: Autonomous Dialogue Manager







Research Goal: Studying humans having natural dialogues with robots

- Contributes to natural language & multimodal training data between humans and robots
- Dialogue offers humans a way to supplement a robot's knowledge / understanding of the world
- Evaluating ability to leverage work conducted for virtual humans and apply to robots
- Identifying concepts critical to human-robot dialogue

## Natural language control

*Proceed forward until you reach the target.*



*Which way?*



**Sgt. Blackwell**  
Virtual Human  
Developed at ICT





# Thank You!





## Challenges

How is language used in dialogue with technology (vs. human-human dialogue)?

What will robot need to “know” and “see” in order to have common ground with humans?

Army-unique issues include operational environment and tempo, vocabulary, non-structured environment



## Current State of the Art

Robot has limited understanding of navigation and manipulation commands; no dialogue, only simple one-way replies





## Series of studies planned that will examine:

- » Increased automation support for dialogue management
- » Multimodal inputs (e.g., head nods, eye gaze)
- » Human-robot dialogue in more complex environments

-Natural interaction to enhance situation awareness  
-Simplified control of robotic partners  
-Reduced cognitive load





## Past: Current Defense Laboratory Model

Gates and high walls provide 20th century security, but are barriers to 21st century innovation



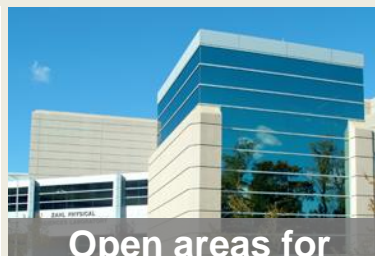
Defense laboratories relatively unchanged since inception (NRL 1923)

## Present & Future: Open Campus Initiative

Reduction in barriers to facilitate collaboration with academia, industry, and small business



Less bureaucracy and paperwork



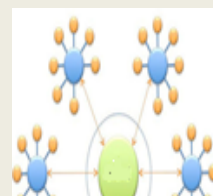
Open areas for researchers and access to existing facilities



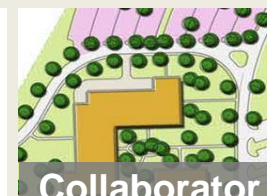
Collaboration between ARL and external scientists



Career path for students and scientists



Hub and Spoke Model



Collaborator presence through EUL



Novel staff opportunities

An enhanced defense research environment that fosters discovery and innovation through collaboration on fundamental research