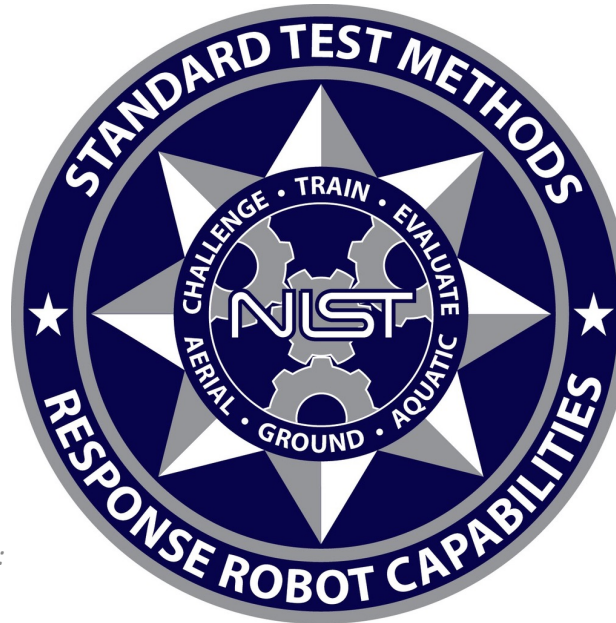


# Dexterity, Strength, and C-IED/EOD Tests

## Ground Robots

Version 2021A



*Sub Committee Chair:*

**Adam Jacoff**

Intelligent Systems Division  
National Institute of Standards and Technology  
U.S. Department of Commerce

*Committee Chair:*

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# Dexterity: Simple Tasks in Various Orientations and Elevations

## Classification Metrics

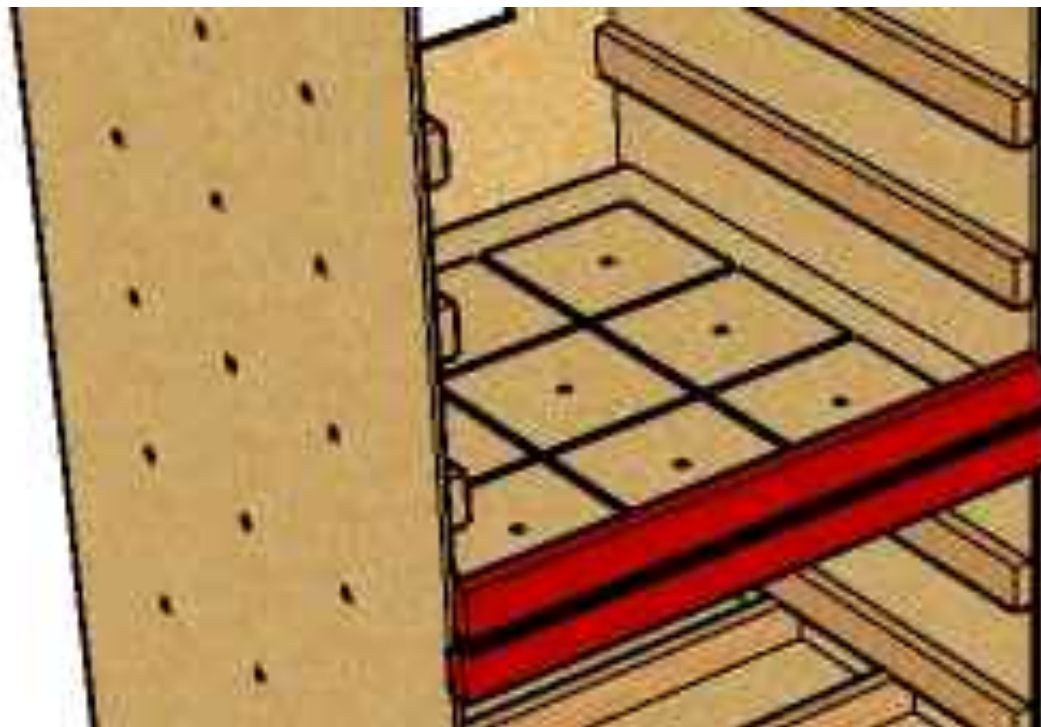
### TOUCH/INSERT TOOL

#### PEG TOOL



### INDESTRUCTIBLE INITIAL APPARATUSES

#### OVER/UNDER TASK SHELVES (3 x 3 GRID)



### MORE DEXTERITY REQUIRED

#### OMNI OBJECT



# Dexterity: Ground Tasks with Some Terrain Complexity

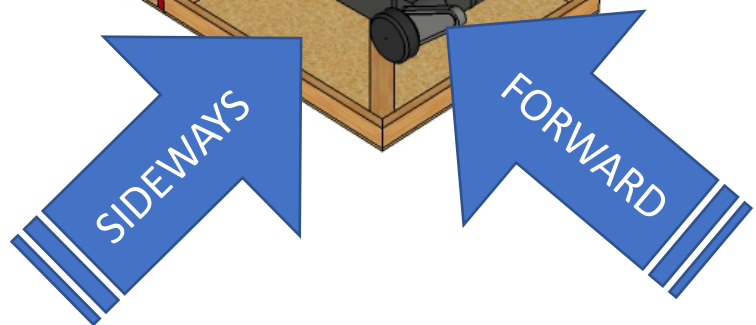
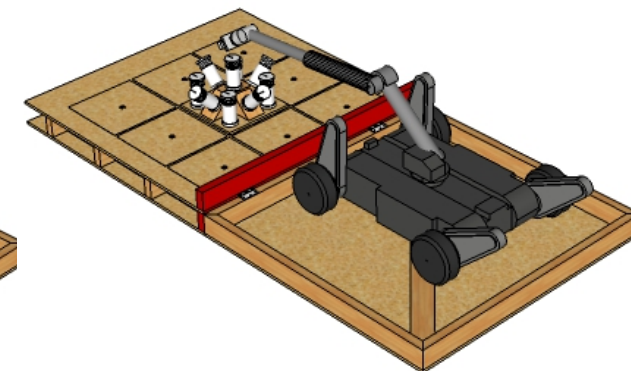
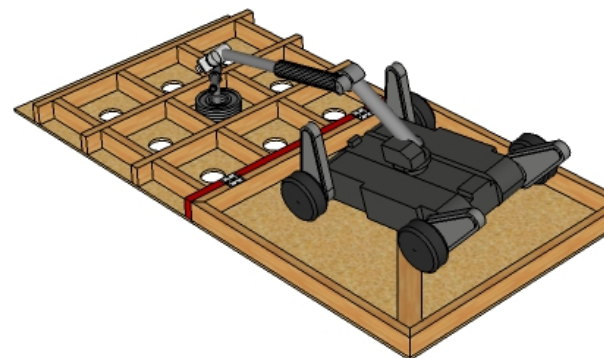
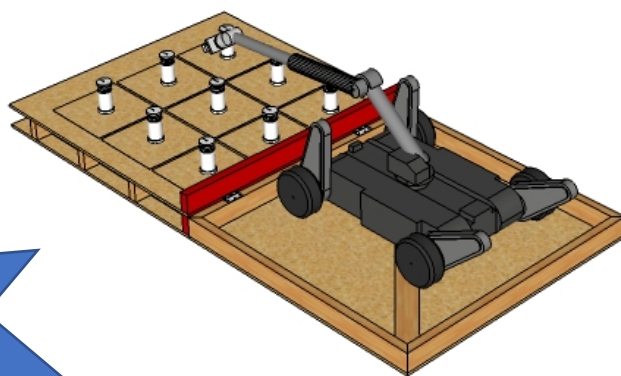
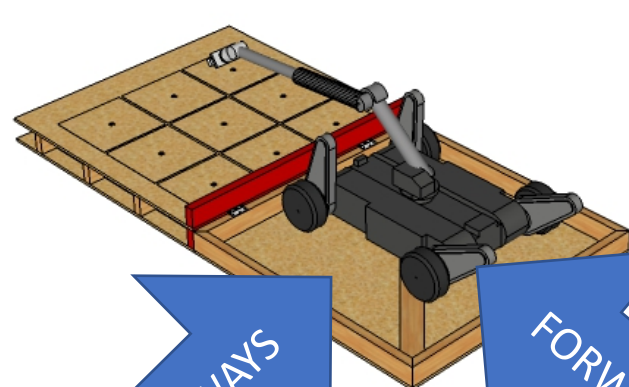
## Classification Metrics

TOUCH/INSERT TOOLS  
(9 Repetitions)

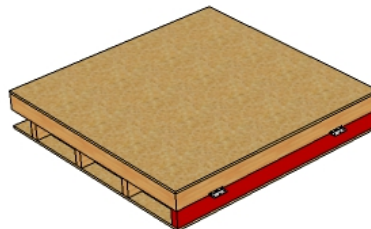
INSPECT, INSERT, ROTATE, EXTRACT  
(9 Repetitions)

PLANAR REMOVE & PLACE  
(9 Repetitions)

OMNI PIPE TASKS  
(9 Repetitions)



DIAGONAL CURB TERRAIN  
MAKES GROUND CONTACTS MATTER.

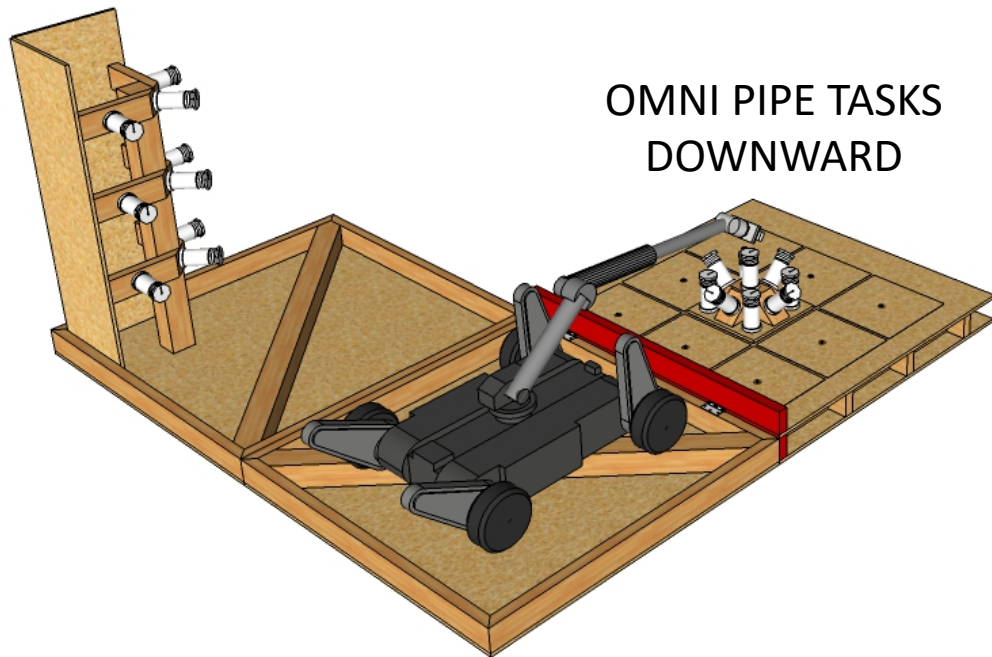


FOLD OVER TO STOW TERRAIN ON TASK PANEL  
(HINGED)

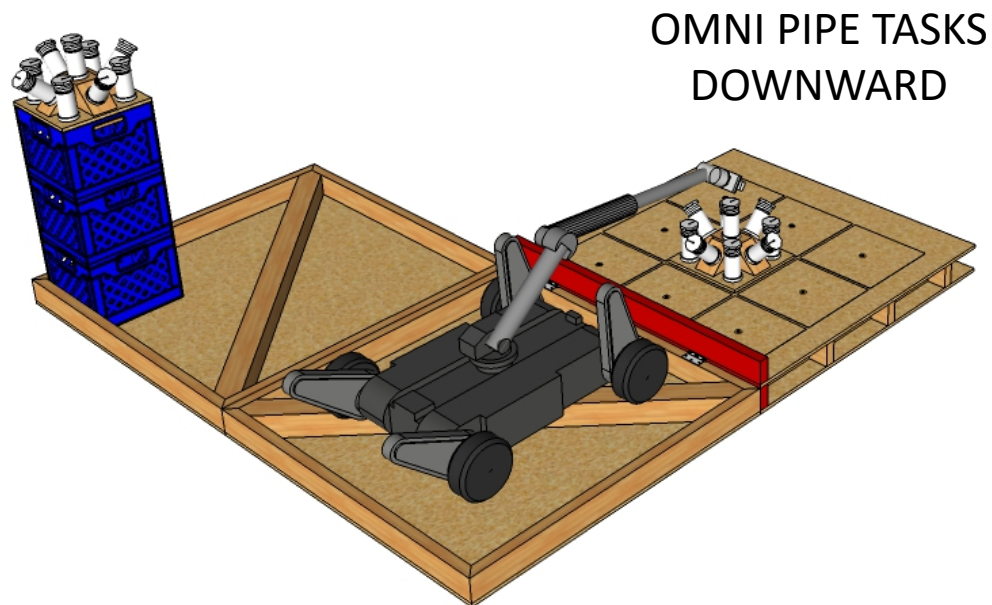
# Dexterity: Ground Tasks and Elevated Tasks

## Classification Metrics

CYLINDRICAL PIPE TASKS  
FORWARD/ELEVATED  
30cm (12in) Increments



OMNI PIPE TASKS  
DOWNWARD/ELEVATED  
30cm (12in) Increments





# Dexterity: Ground Tasks and Elevated Tasks

## Classification Metrics





# Dexterity: Ground Tasks and Elevated Tasks

## Classification Metrics





# Dexterity: Elevated Shelf Tasks (Over/Under)

## Classification Metrics



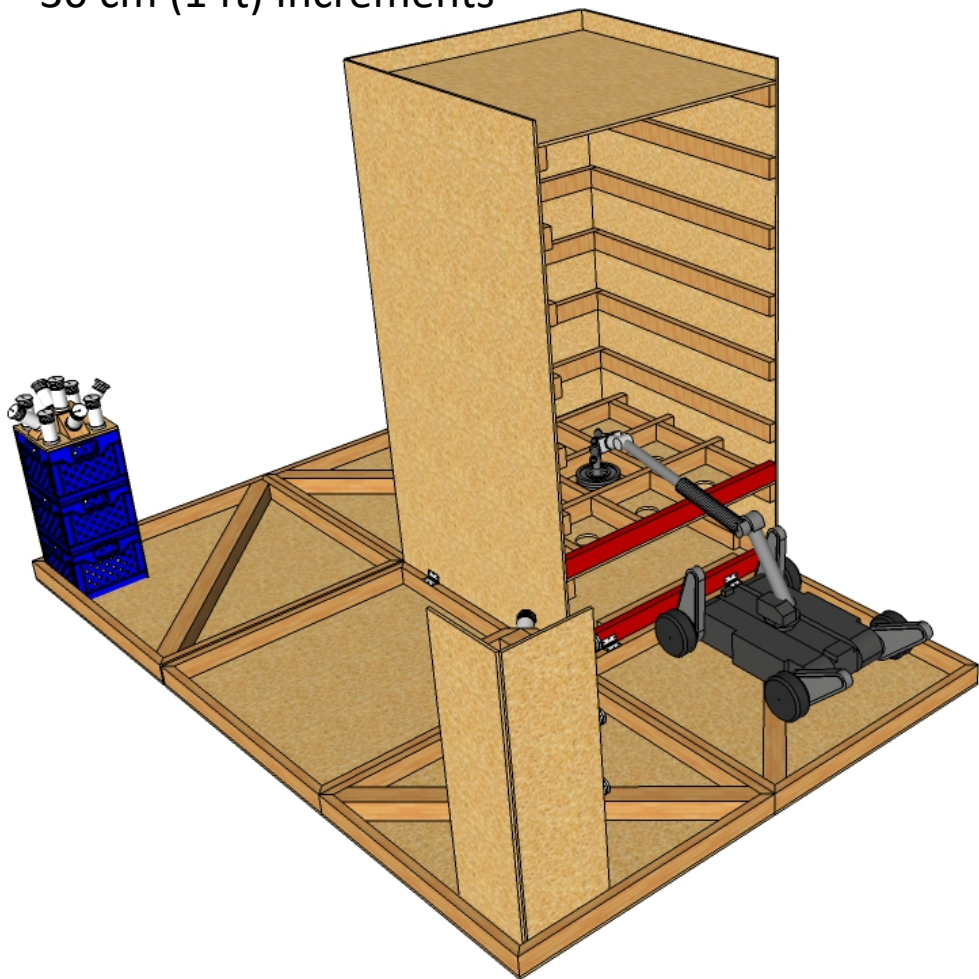


# Dexterity: Elevated Wall Tasks (Forward)

## Classification Metrics

### ELEVATED SHELF TASKS

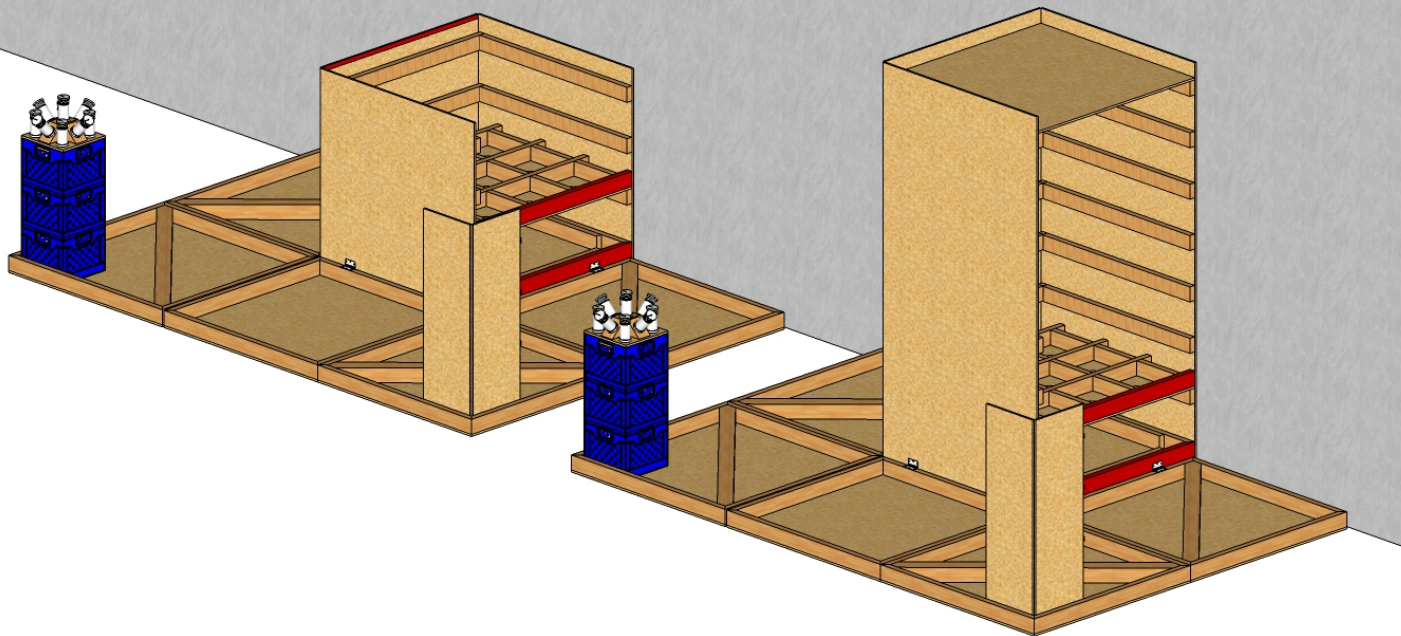
30 cm (1 ft) Increments



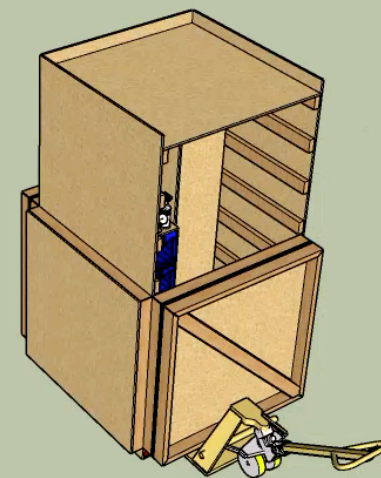
## Dexterity: Fold, Stow, and Move Classification Metrics

120 cm (4 ft) Shelf

240 cm (8 ft) Shelf



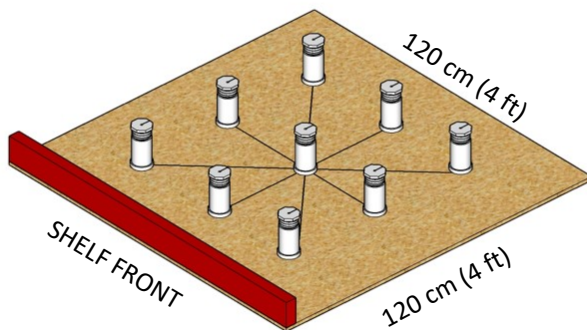
Fold to Stow and Pallet Jack





# Dexterity: Planar Tasks (Basic)

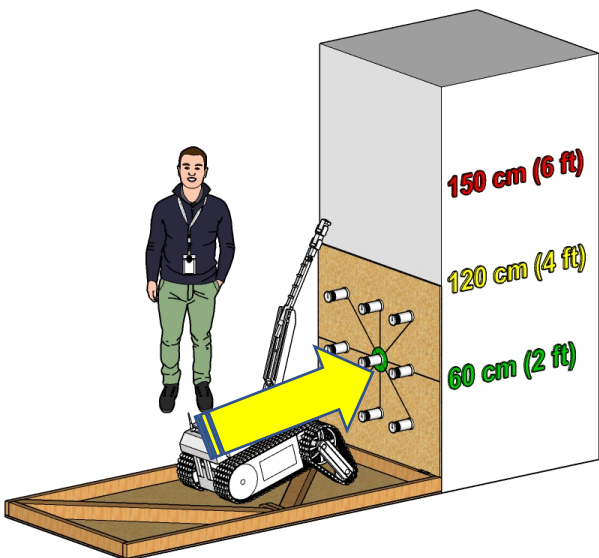
## Classification Metrics



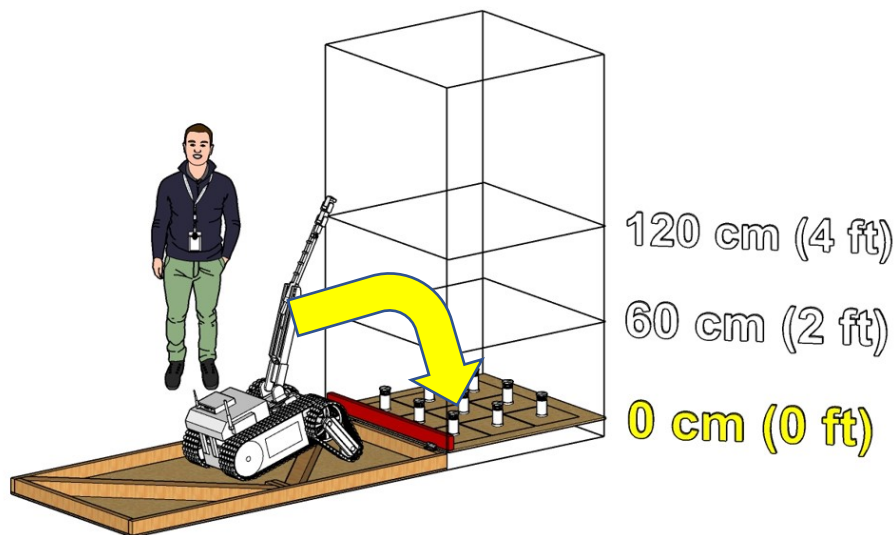
### ALL PIPES TASKS CONTAIN FOUR TESTS

- Inspect (WK54271)
- Touch/Insert (WK54272)
- Rotate (WK54273)
- Extract & Place (WK54274)

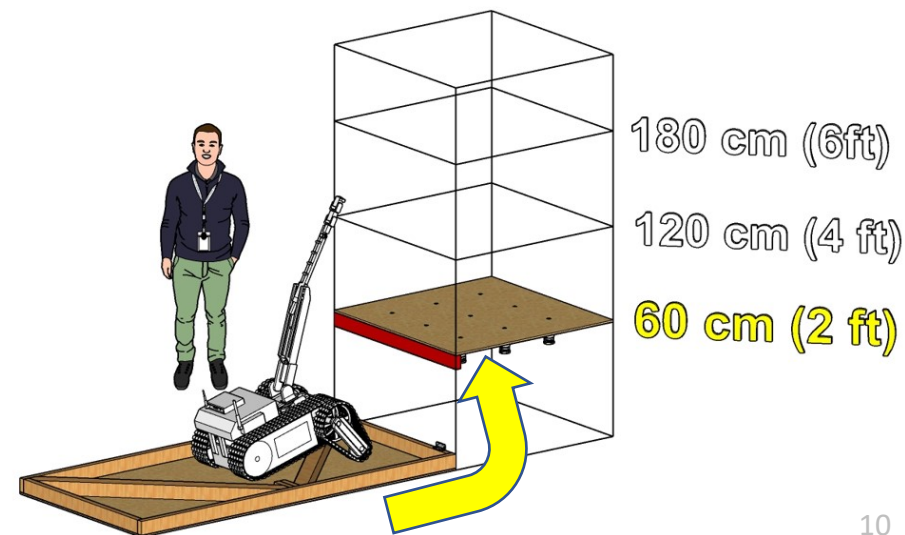
### FORWARD



### DOWNWARD



### UPWARD



# Dexterity: Planar Tasks (Basic)

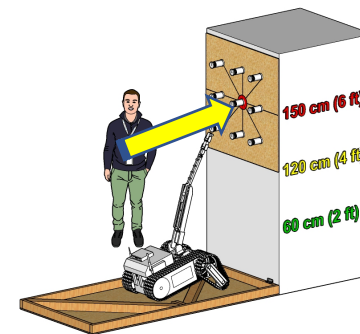
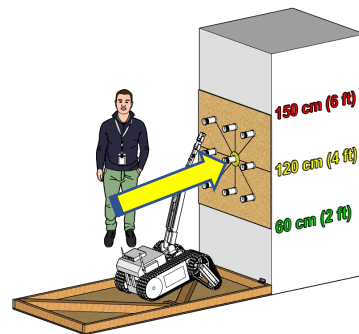
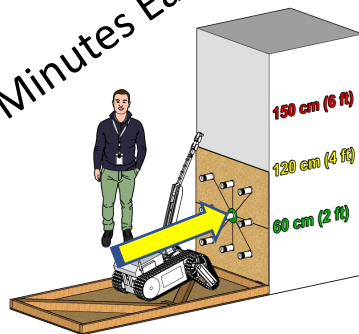
## Classification Metrics

### PLANAR TASKS

#### Forward (Wall)

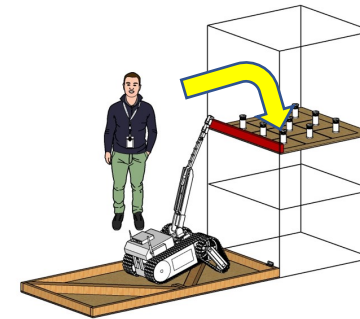
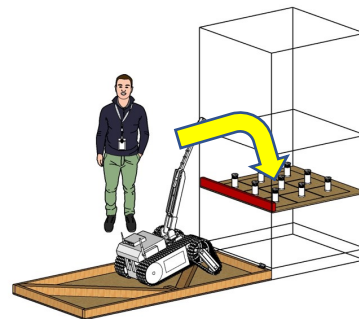
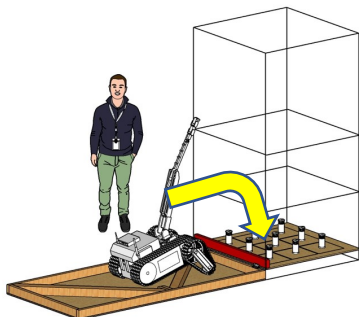
- 180 cm (6 ft)
- 120 cm (4 ft)
- 60 cm (2 ft)

10 Minutes Each



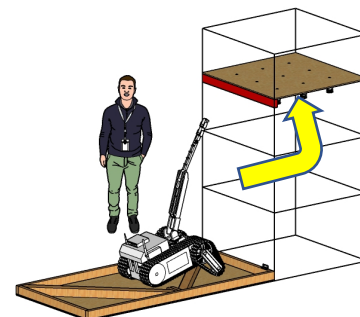
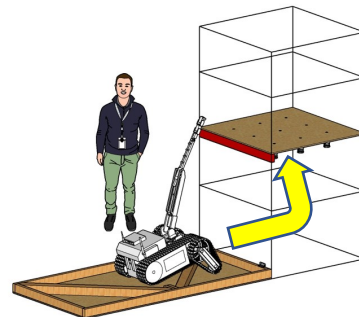
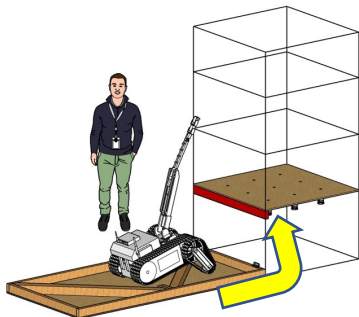
#### Over (Shelf)

- 120 cm (4 ft)
- 60 cm (2 ft)
- 0 cm (0 ft)



#### Under (Shelf)

- 180 cm (6 ft)
- 120 cm (4 ft)
- 60 cm (2 ft)



# Dexterity: Cylindrical Tasks (Intermediate)

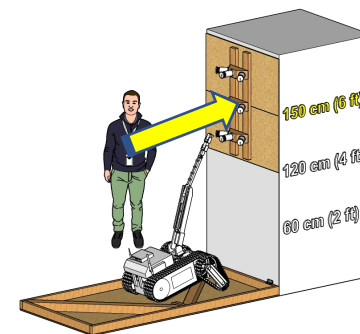
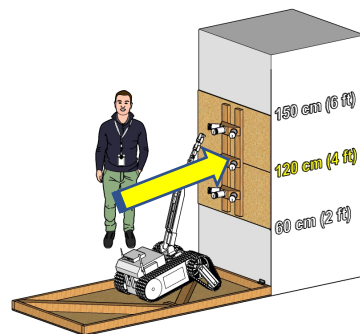
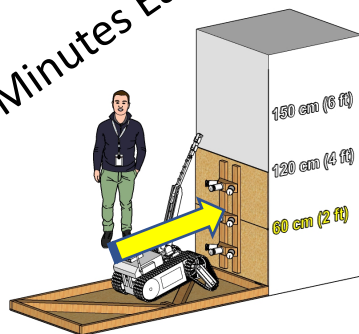
## Classification Metrics

### CYLINDRICAL TASKS

#### Forward (Wall)

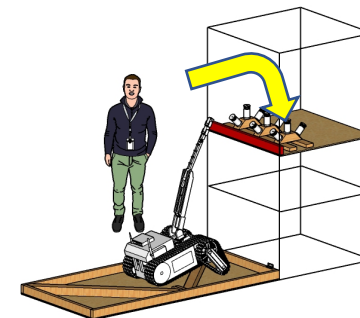
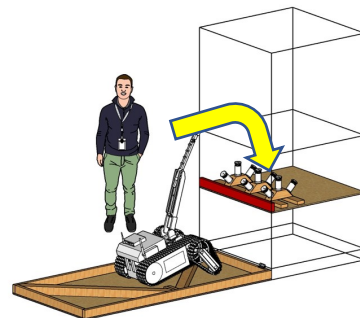
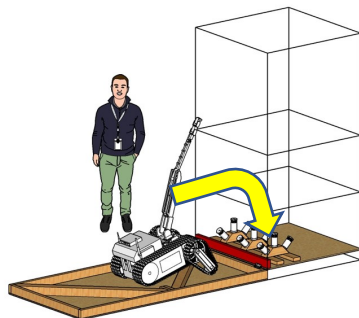
- 180 cm (6 ft)
- 120 cm (4 ft)
- 60 cm (2 ft)

10 Minutes Each



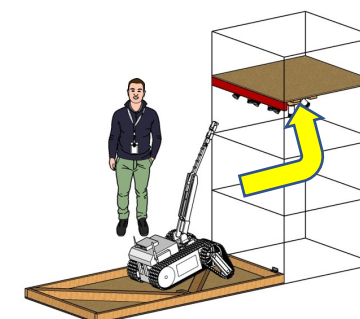
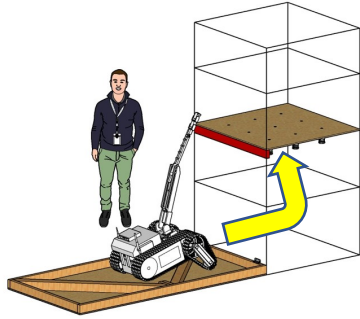
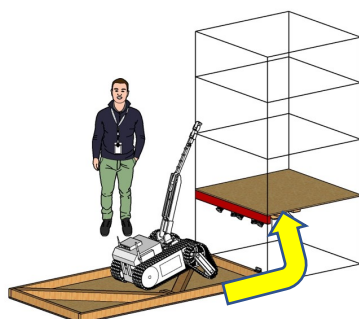
#### Over (Shelf)

- 120 cm (4 ft)
- 60 cm (2 ft)
- 0 cm (0 ft)



#### Under (Shelf)

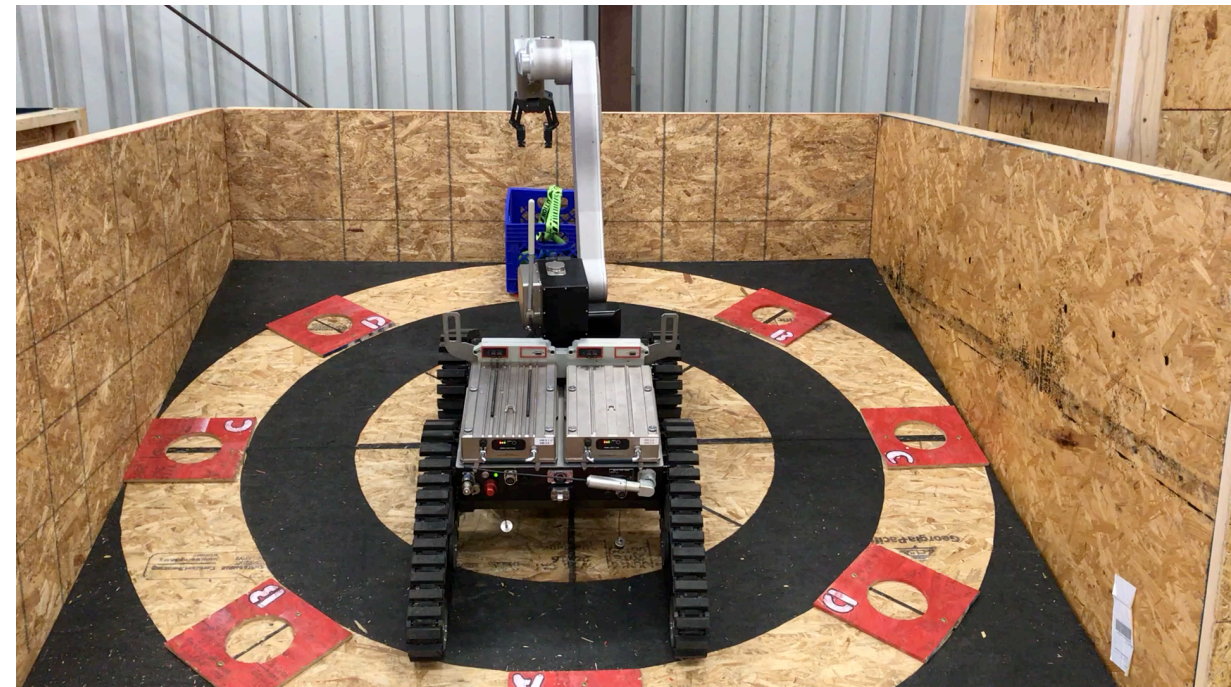
- 180 cm (6 ft)
- 120 cm (4 ft)
- 60 cm (2 ft)





# Strength: Grasp-Carry-Place On A Slope (15° or 30°)

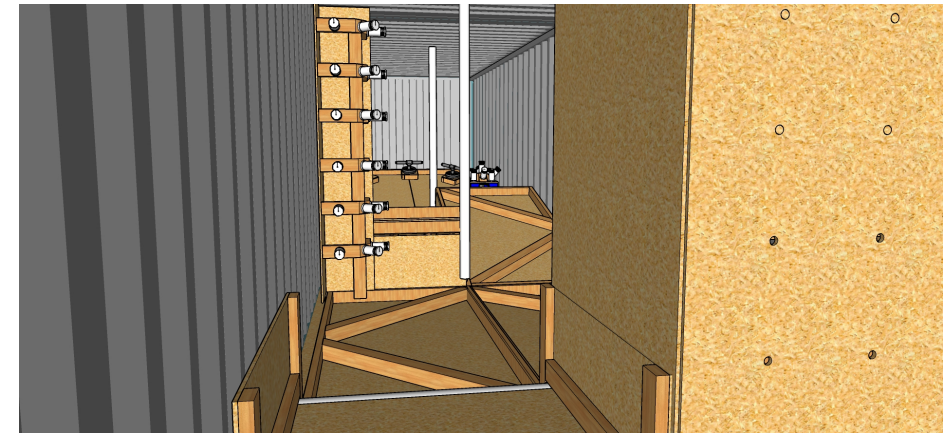
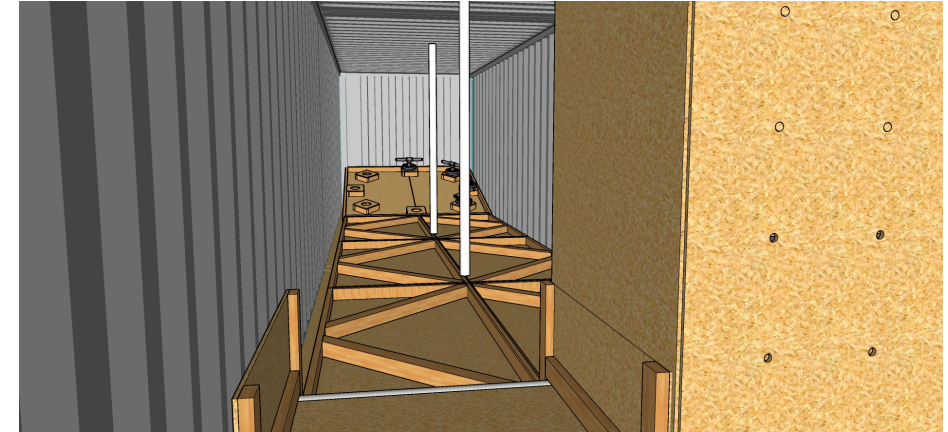
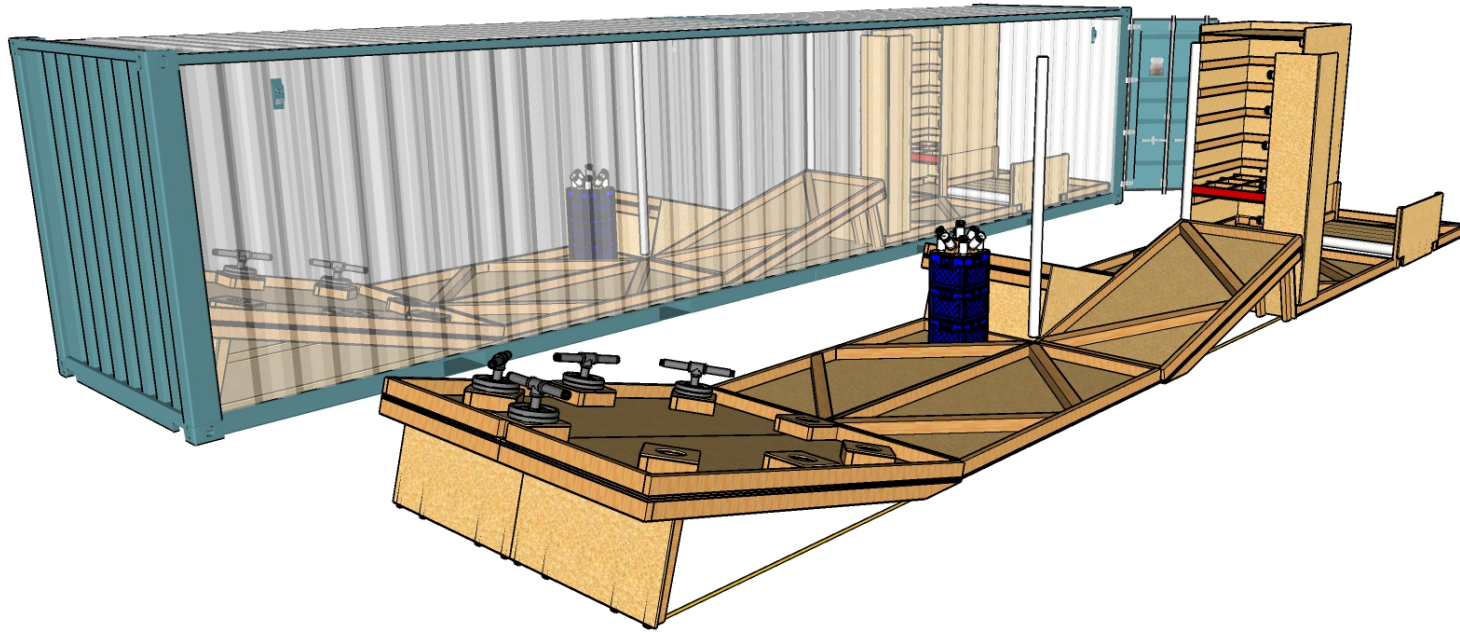
## Classification Metrics





# Shipping Container Test Facility in Your Parking Lot

## Dexterity and Strength Tests



# C-IED/EOD Tests

## Ground Robots



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Intelligent Systems Division  
National Institute of Standards and Technology  
U.S. Department of Commerce

*Sponsor:*

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# Building Access

## C-IED/EOD Essential Mission Tasks

### Open Doors

Open and pass through push and pull doors with lever handles and springs.



### Search Hallways

Negotiate confined spaces (for the scale of apparatus) to find specific hazmat labels.



### Avoid Entanglements

Pass through the Center in Alley adjustable width opening with tarps on the floor.



### Cross Hurdles

Use coordinated articulators to cross rolling pipe hurdles in any orientation.



### Ascend/Descend Stairs

Ascend/descend stairs in any orientation. (Always belayed with a safety rope!)



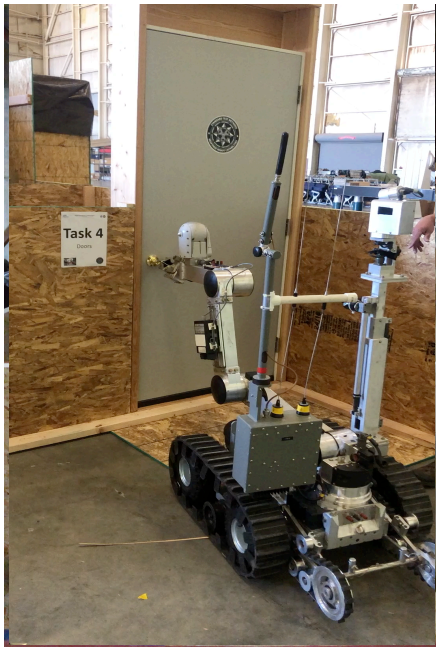


# Building Access

## C-IED/EOD Essential Mission Tasks

### Open Doors

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### Avoid Entanglements

Pass through the Center in Alley adjustable width opening with tarps on the floor.



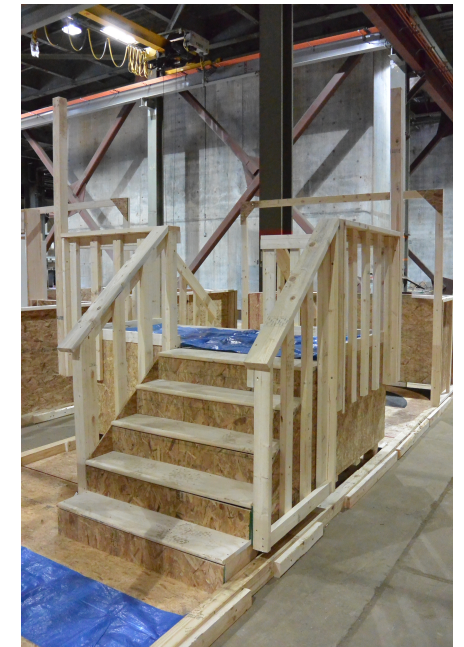
### Cross Hurdles

Use coordinated articulators to cross rolling pipe hurdles in any orientation.



### Ascend/Descend Stairs

Ascend/descend stairs in any orientation. (Always belayed with a safety rope!)





# Embedded Scoring Tasks in Scenarios

## C-IED/EOD Essential Mission Tasks



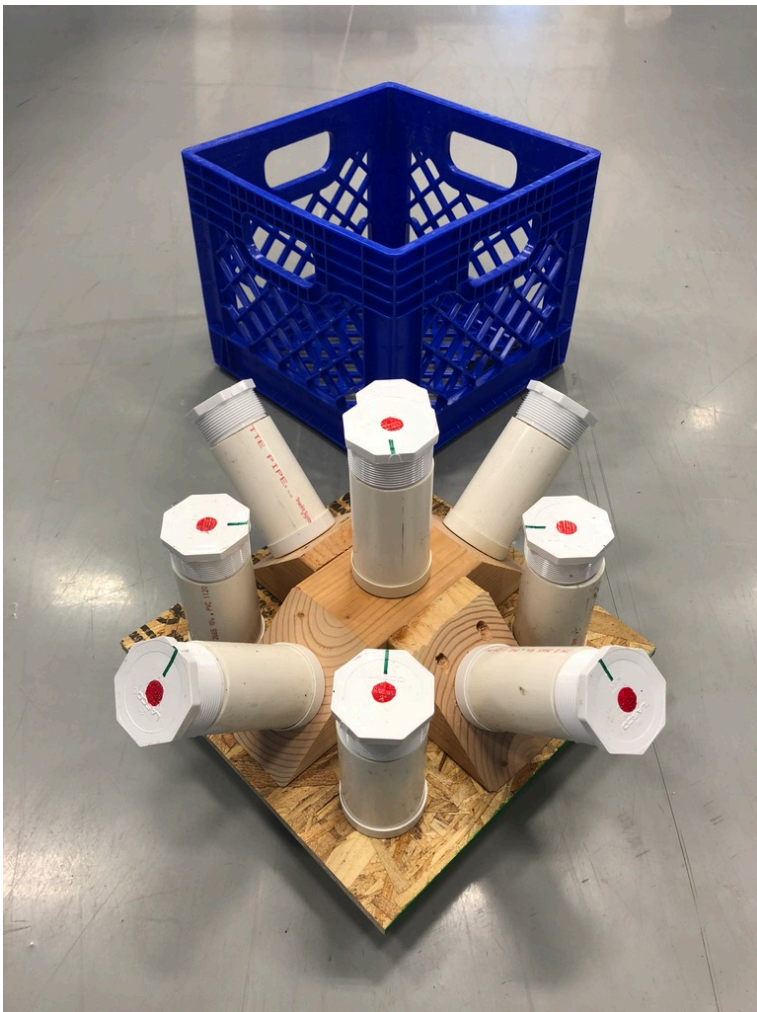


## Dexterity: Omni Tasks

### C-IED/EOD Essential Mission Tasks

#### PIPE TASKS

- TOUCH
- ROTATE
- EXTRACT
- PLACE
- INSPECT



PRESS OVERSIZED SWITCH



HOOK SECONDARY LINE



E-STOPS



DRY GRANULAR  
(SAND)

SMALL PARTS  
(NUTS)

SOFT GRASP  
(PAPER OR COTTON)

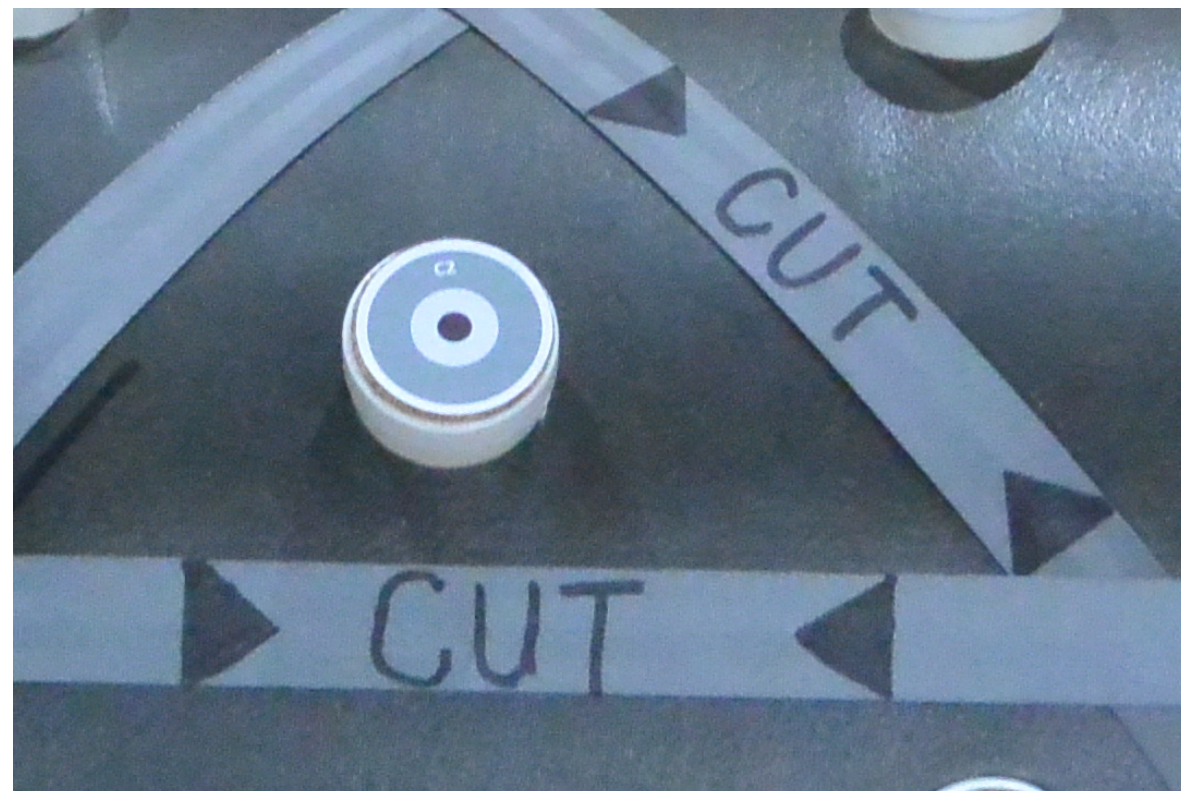
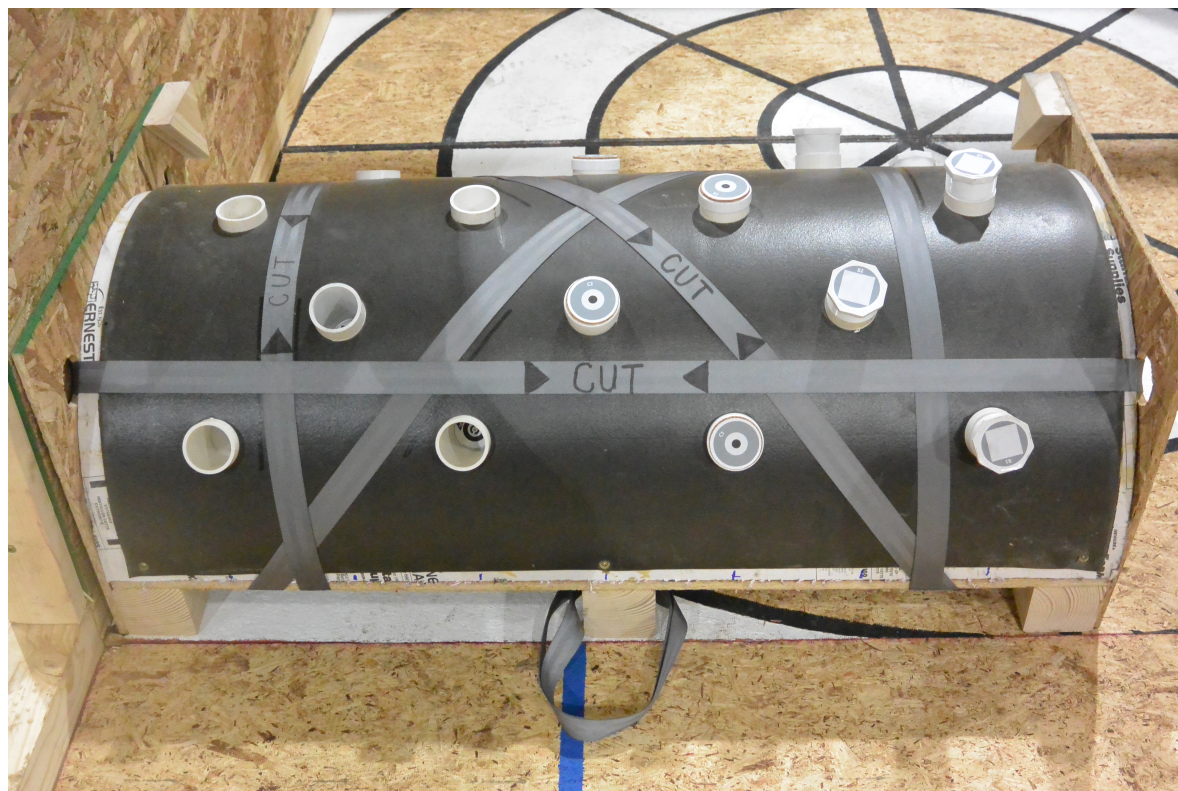
WET  
(BLUE CHALK & Water)

LARGE PARTS  
(BLOCKS)



## Dexterity: Cylindrical Tasks: Cut Ropes/Straps

### C-IED/EOD Essential Mission Tasks





## Strength: PBIED Drag or Lift/Roll C-IED/EOD Essential Mission Tasks





# Dexterity: Packages, PBIED, and Other Tasks

## C-IED/EOD Essential Mission Tasks

### Weighted PBIED Sled with Tow and Roll Over Tasks



OMNI IED WITH COMPONENTS  
IN PIPES TO X-RAY AND IDENTIFY



OMNI  
IED

OMNI  
E-STOPS

OMNI  
VALVES



# Vehicle Underbody Inspection

## C-IED/EOD Essential Mission Tasks





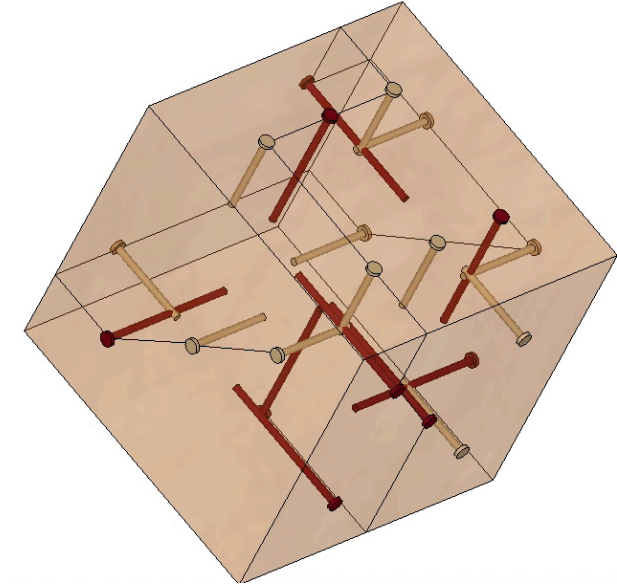
## Place MWB Disruptor C-IED/EOD Essential Mission Tasks





# X-Ray Dice

## C-IED/EOD Essential Mission Tas

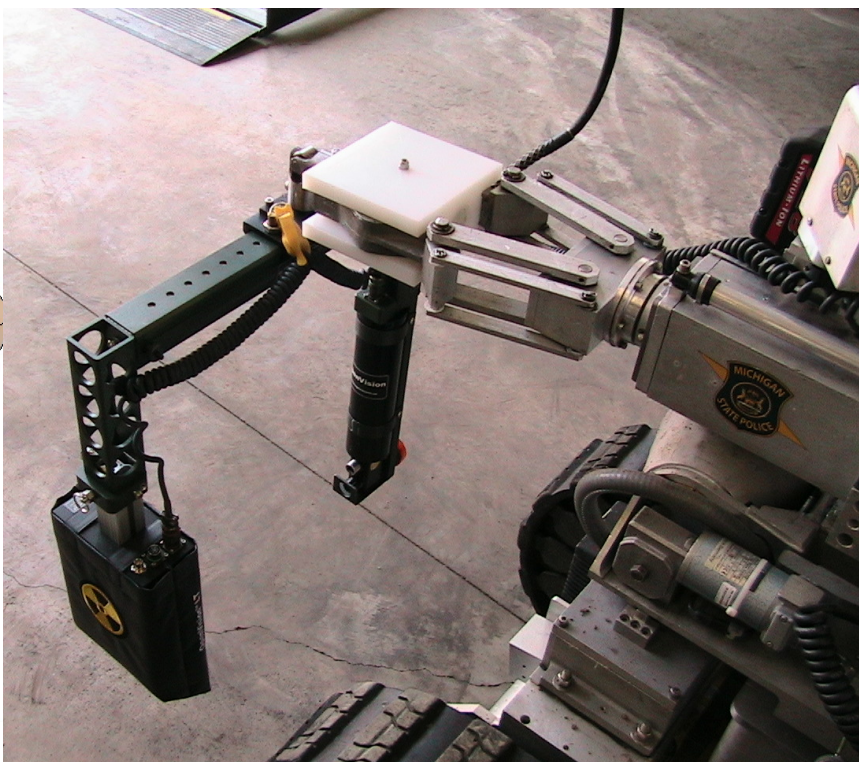
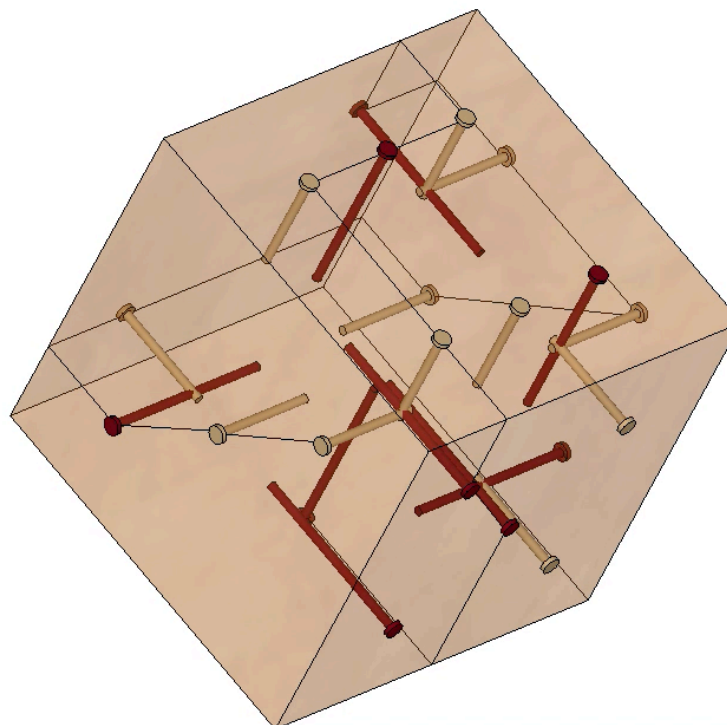




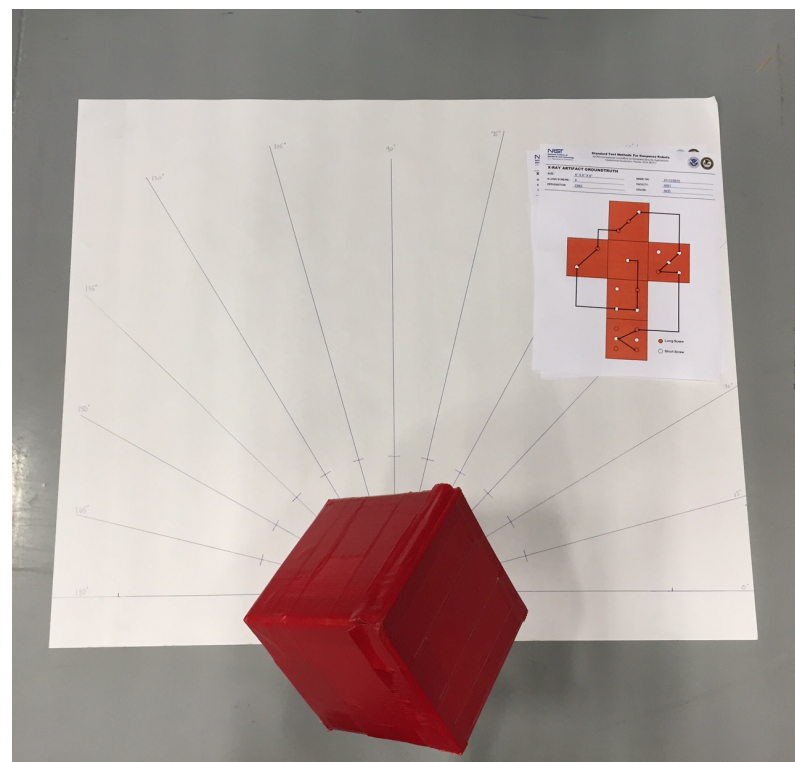
# X-Ray Dice

## C-IED/EOD Essential Mission Tasks

### Continuous Imaging

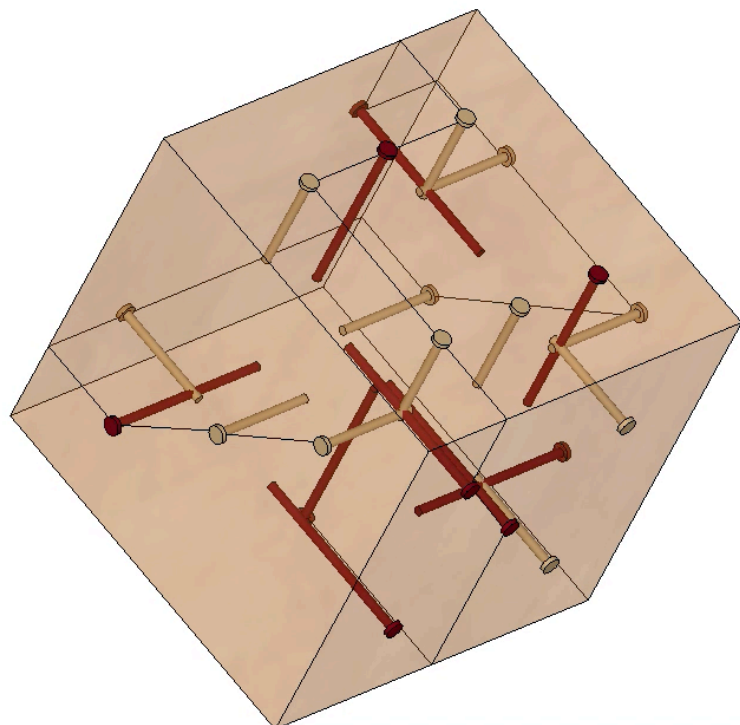


### Series of Single Images



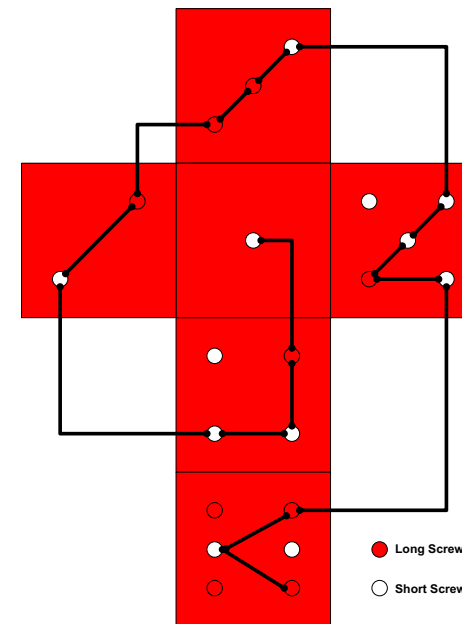
# X-Ray Dice

## C-IED/EOD Essential Mission Tasks



### X-RAY ARTIFACT GROUNDTRUTH

SIZE:	<u>4" X 4" X 4"</u>	MADE ON:	<u>01/13/2015</u>
# LONG SCREWS:	<u>9</u>	FACILITY:	<u>NIST</u>
DESIGNATION:	<u>C663</u>	COLOR:	<u>RED</u>





## VBIED Access

### C-IED/EOD Essential Mission Tasks

BREAK GLASS  
VERTICAL ARRAY



BORE HOLES  
VERTICAL ARRAY



BREAK GLASS  
3x3 ARRAY





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