# Human-Augmented Technology Interaction (HATI) for Improving Construction Quality Control and Task Monitoring:

# An Application of Augmented Reality (AR) for Visualization and Remote Project Management Support


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# Introduction

- Research project 1/31/2020 to 12/31/2022
- Project consists of five phases
  - Phase 1 - User Interface Defined (Complete)
  - Phase 2 - Iterative AR Development (Complete)
  - Phase 3 - Field Testing of Developed AR (In-Progress)
  - Phase 4 - Data Analysis (In-Progress)
  - Phase 5 - Finalizing and Report Findings

# Introduction

Current issues (NDOT/Nationwide?)

- Lack of manpower (vacancies)
- Imperfect contract plans
- Inexperienced personnel due to retirements
- Travel budget constraints
- Miscommunication
- Time

# Introduction

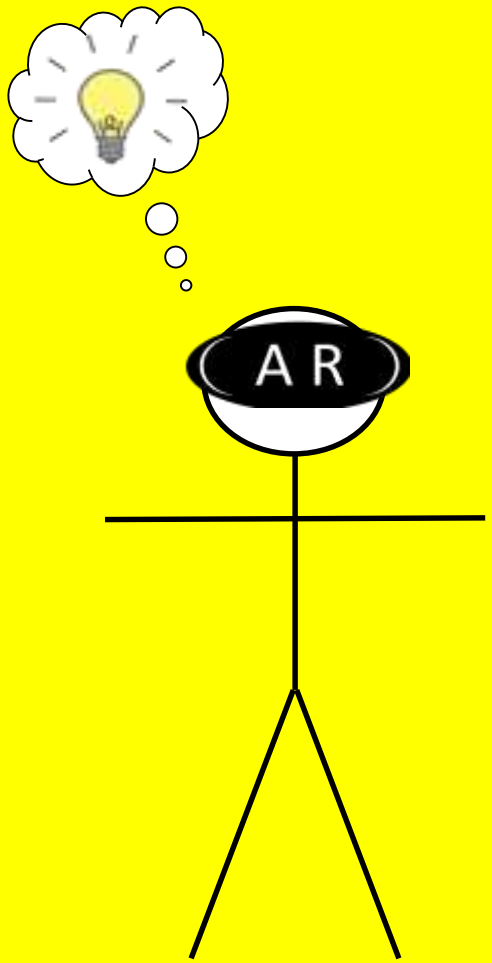
Assistance with Data Collection

- Crew 903 (Luke Rollins, Kody Livreri, Jaime Hovietz)
- Crew 904 (Sam Thompson & Shaun Wang)
- Crew 913 (Alma Piceno-Ramirez & Ian Neeley)
- HDR (Reid Kaiser & Dean Weitzel)

Problem: Stakeholders cannot always be physically present on project sites to monitor tasks and provide guidance to field engineers.

# Project Concept (Planned)

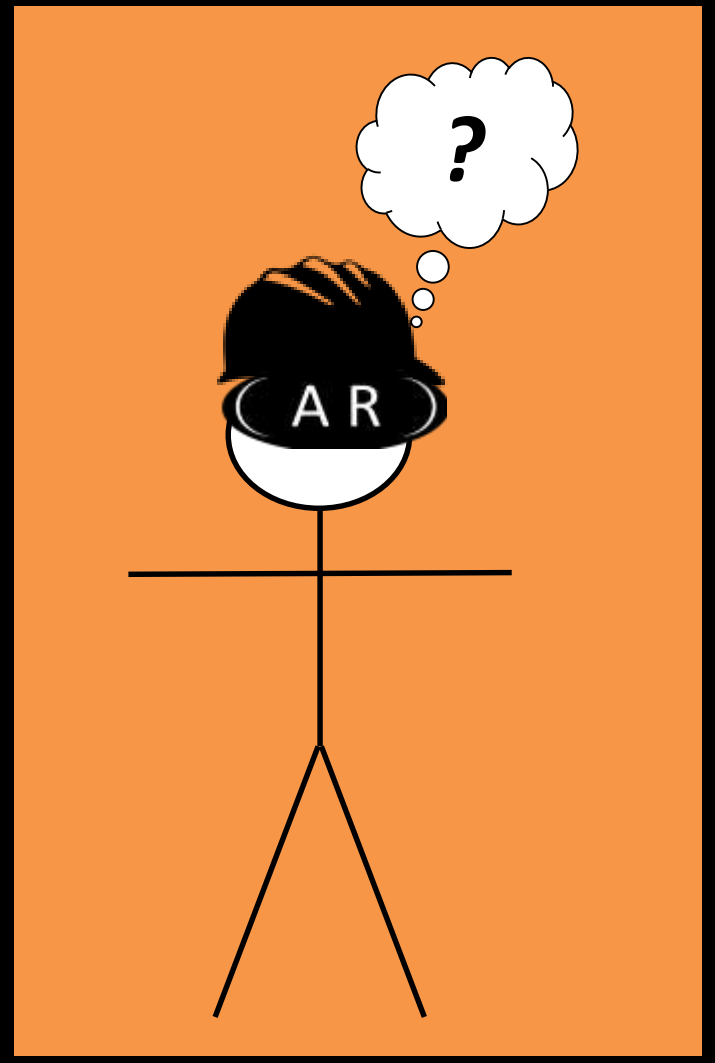
User in Office



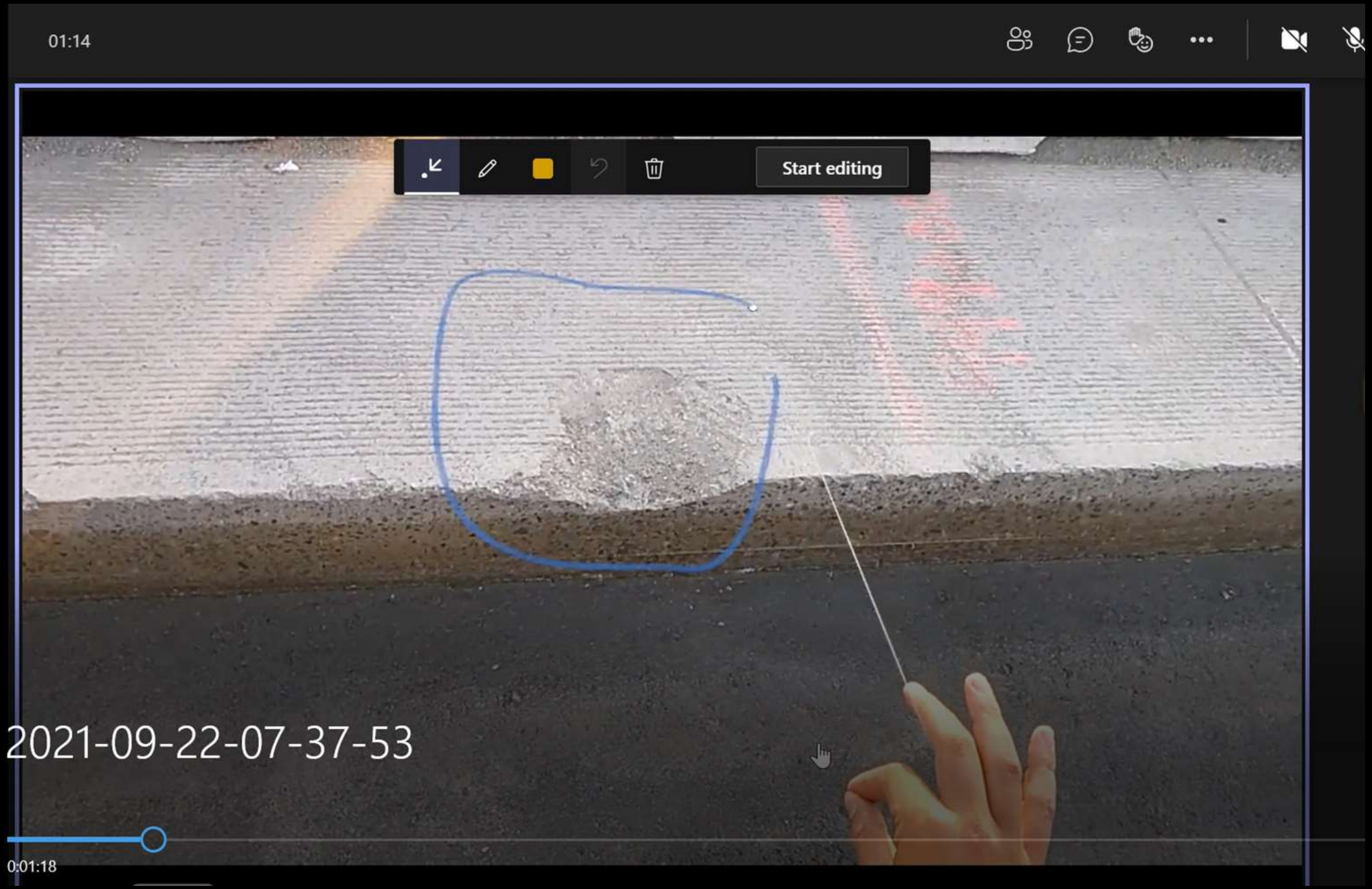

Phone: Quick, but prone to errors

In-person: Effective, but time consuming

Aim: Consistent and efficient understanding of problem context through AR.




User Onsite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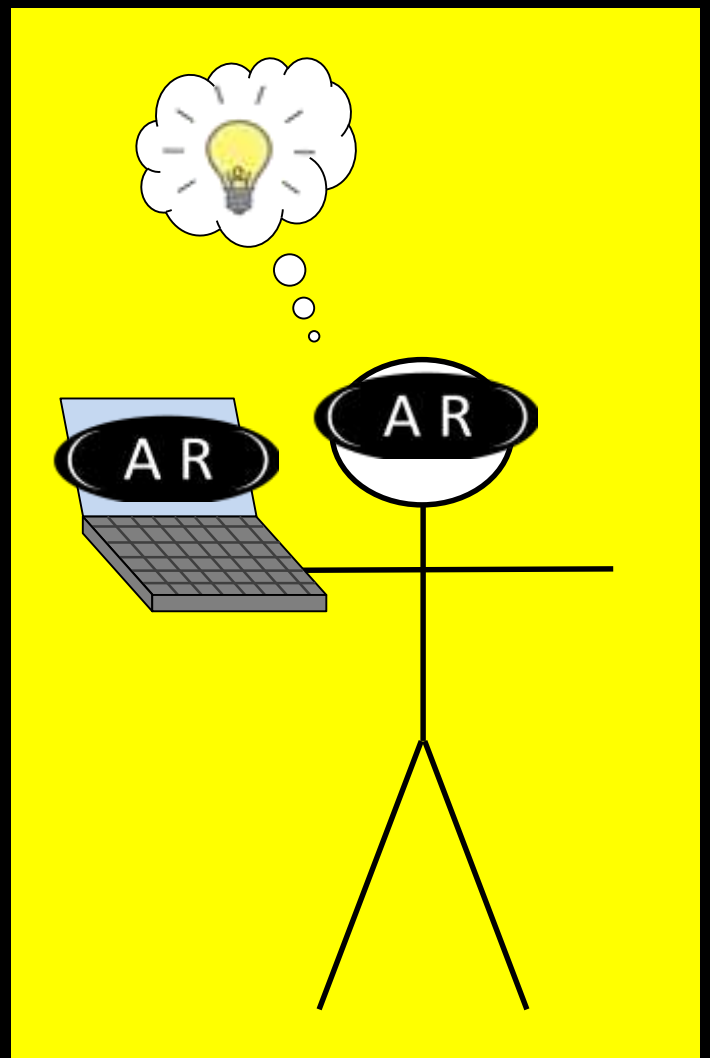
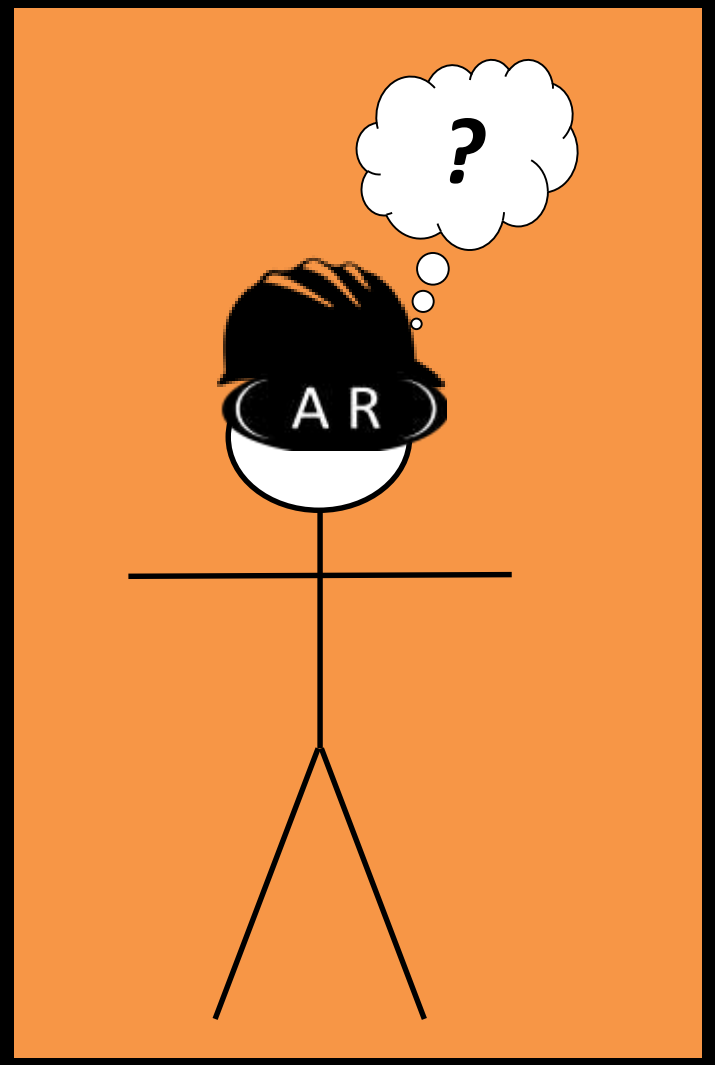
Trimble

08:30
Monday, January 8

# Project Concept (Actual)

Offsite User

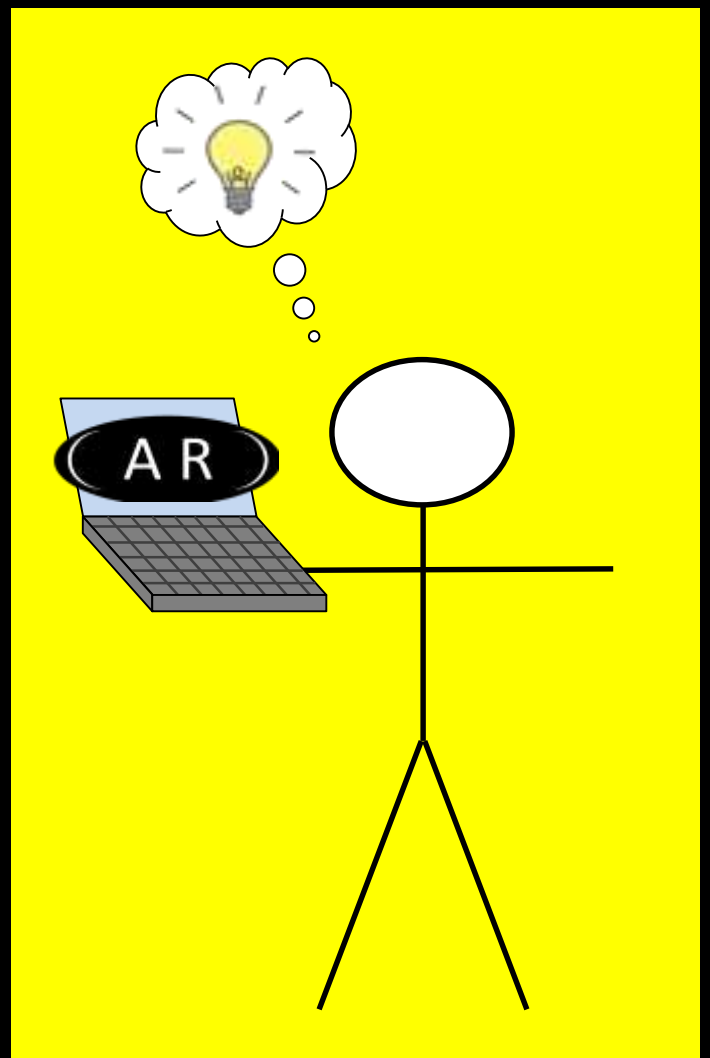


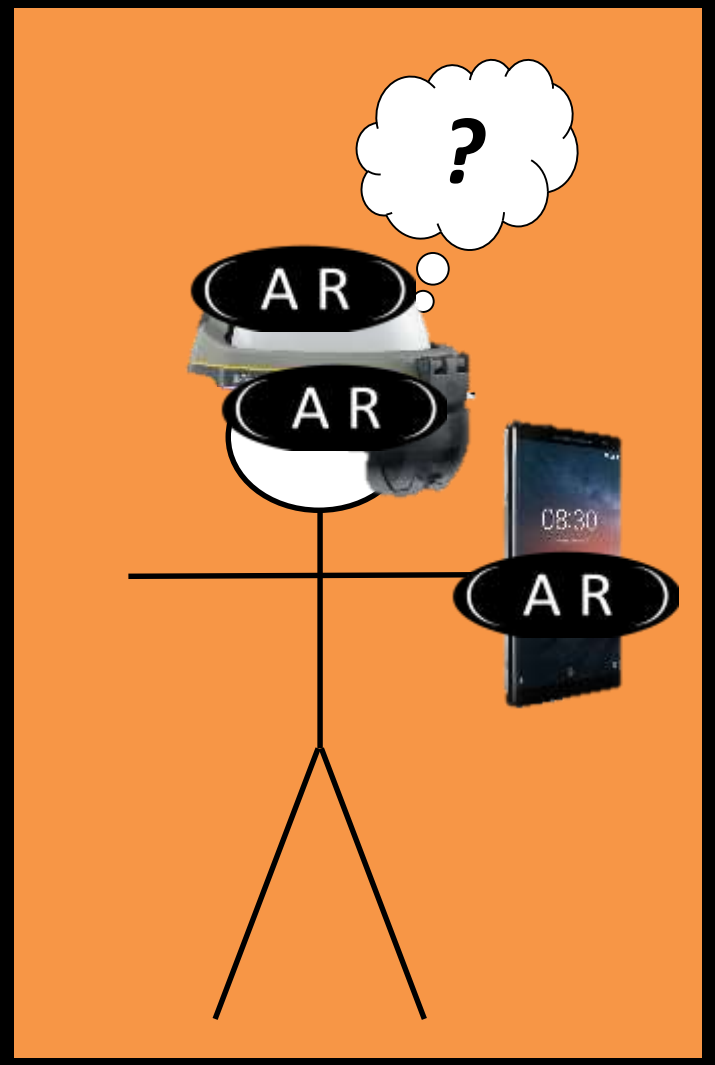




Onsite User

# Project Concept (Actual)

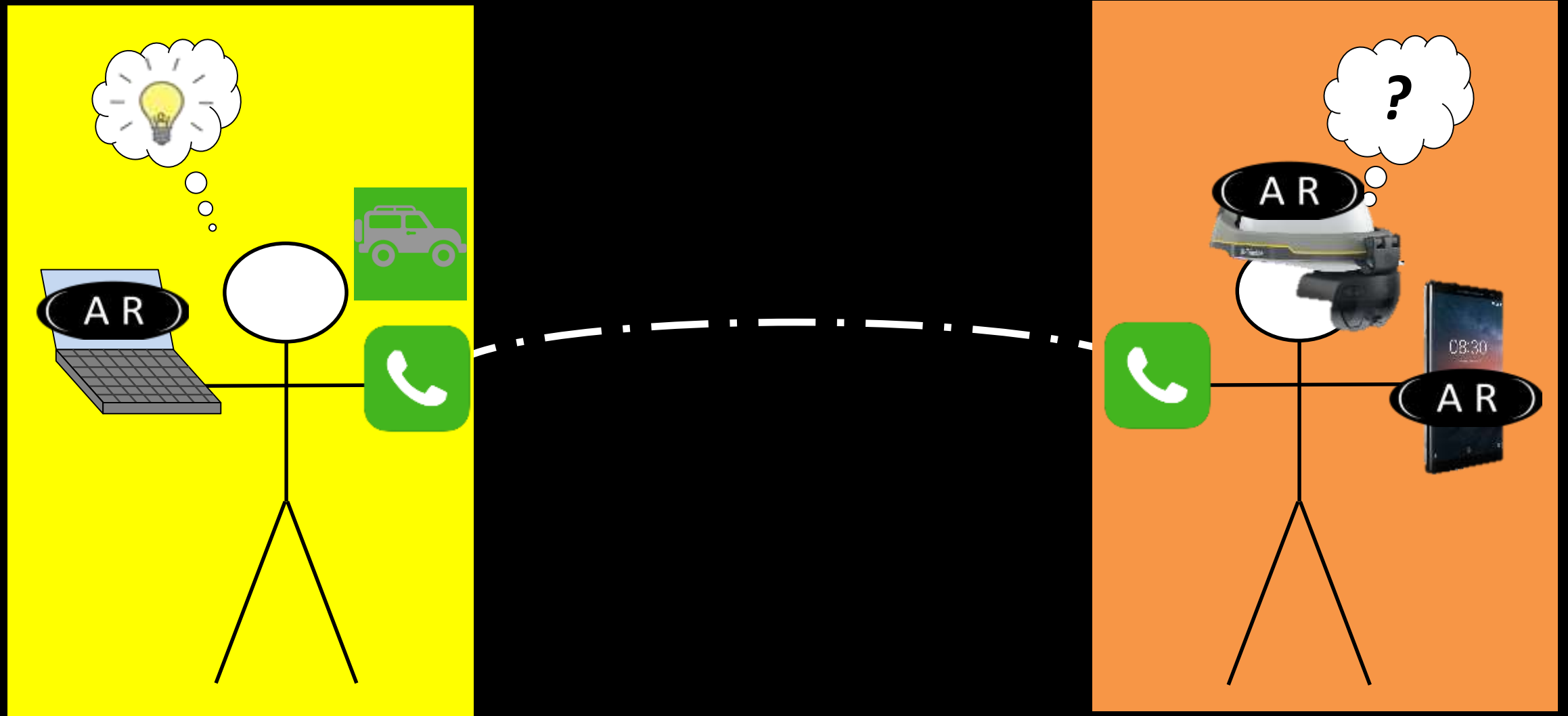
Offsite User




Onsite User

# Project Concept (Actual)



08:30
Monday, January 8
AR

AR
Trimble

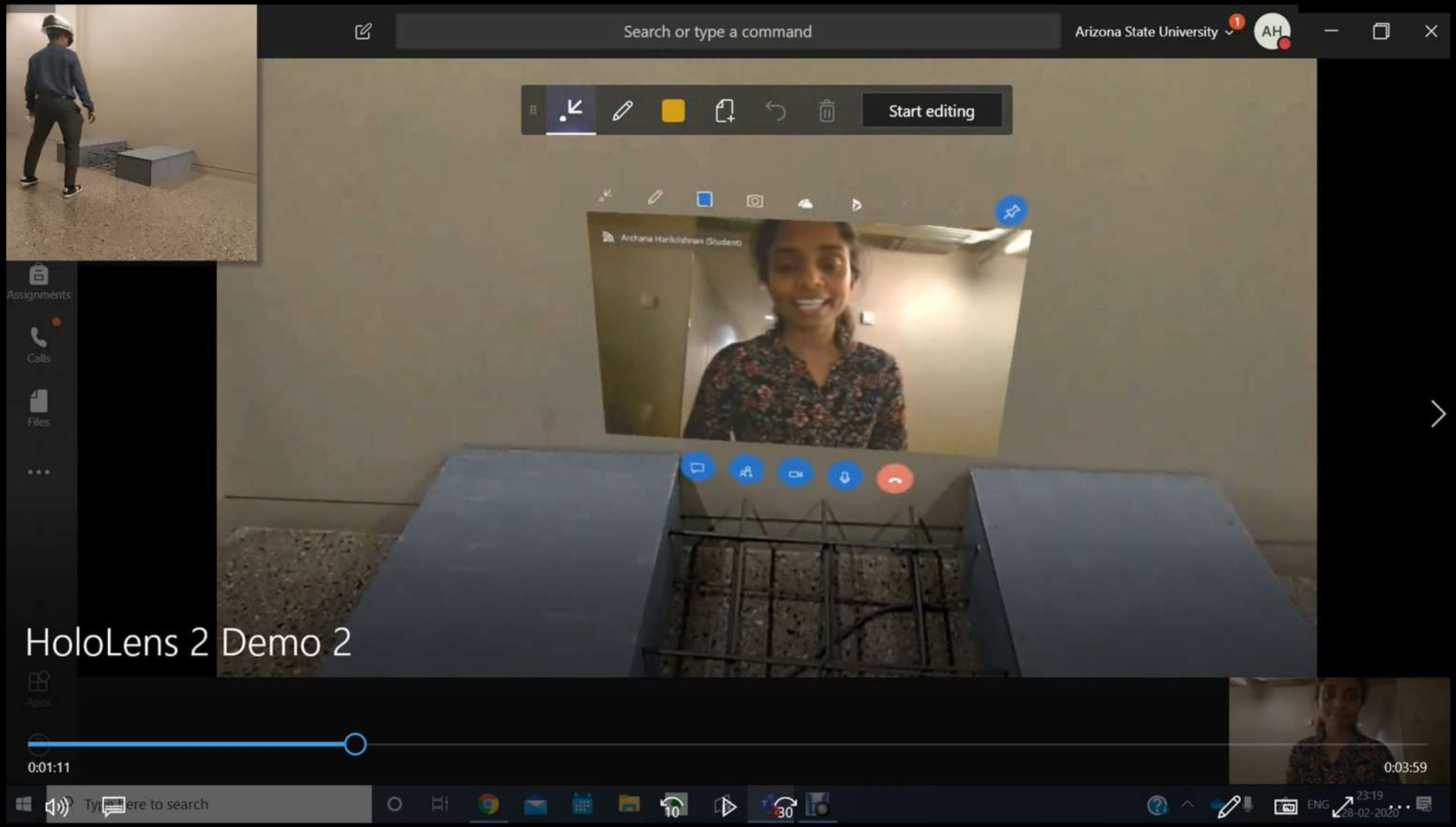
# Demo

Physical mock-up

Closure pour

# Demo

# Demo


Search or type a command
Arizona State University
AH
Start editing
Archana Harikrishnan (Student)
Assignments
Calls
Files
HoloLens 2 Demo 2
0:01:11
0:03:59
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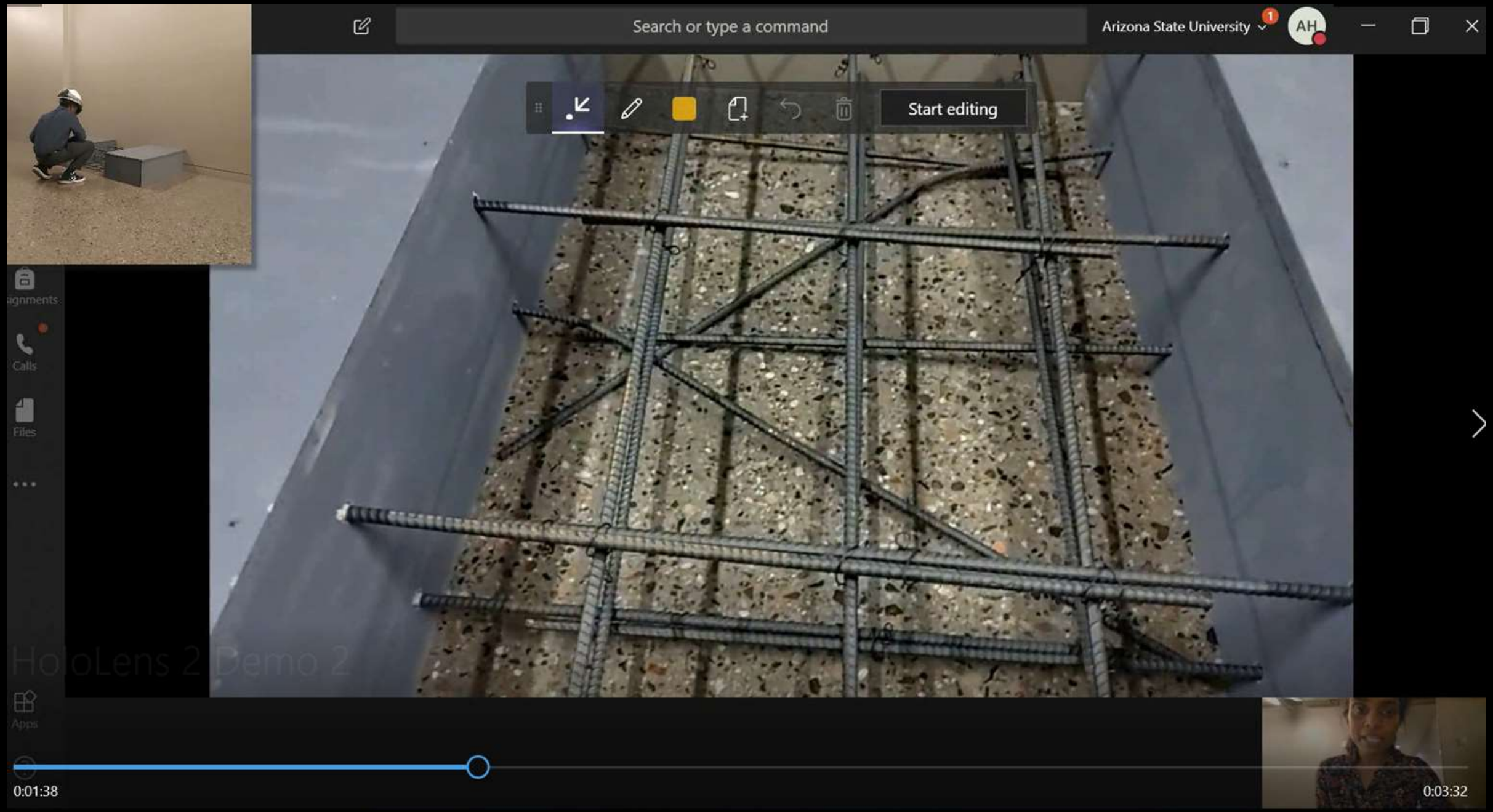
ENG
23:19
28-02-2020

# Demo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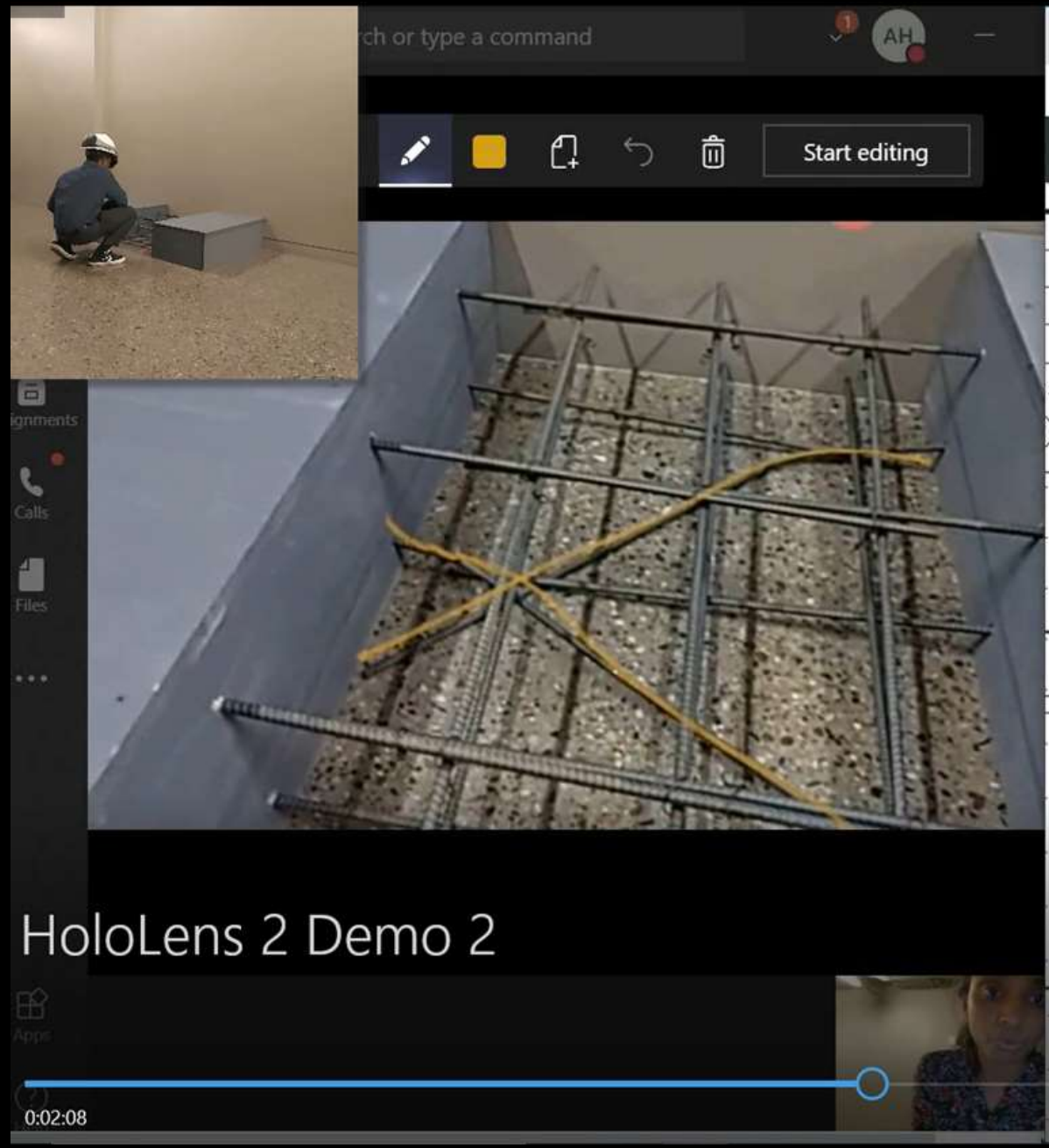
Arizona State University
AH
Start editing
Calls
Files
Apps
0:01:38
0:03:32

# Demo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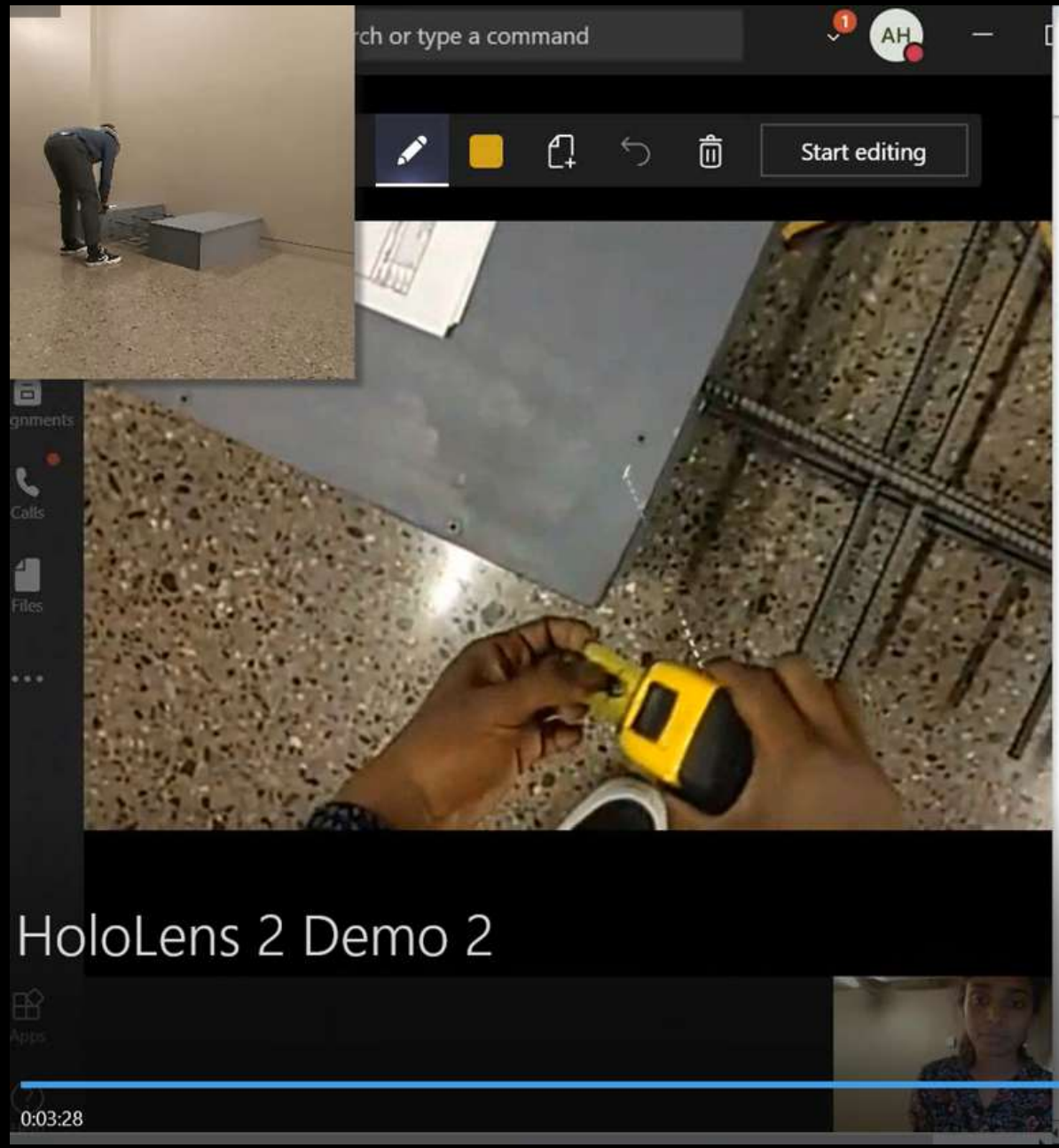
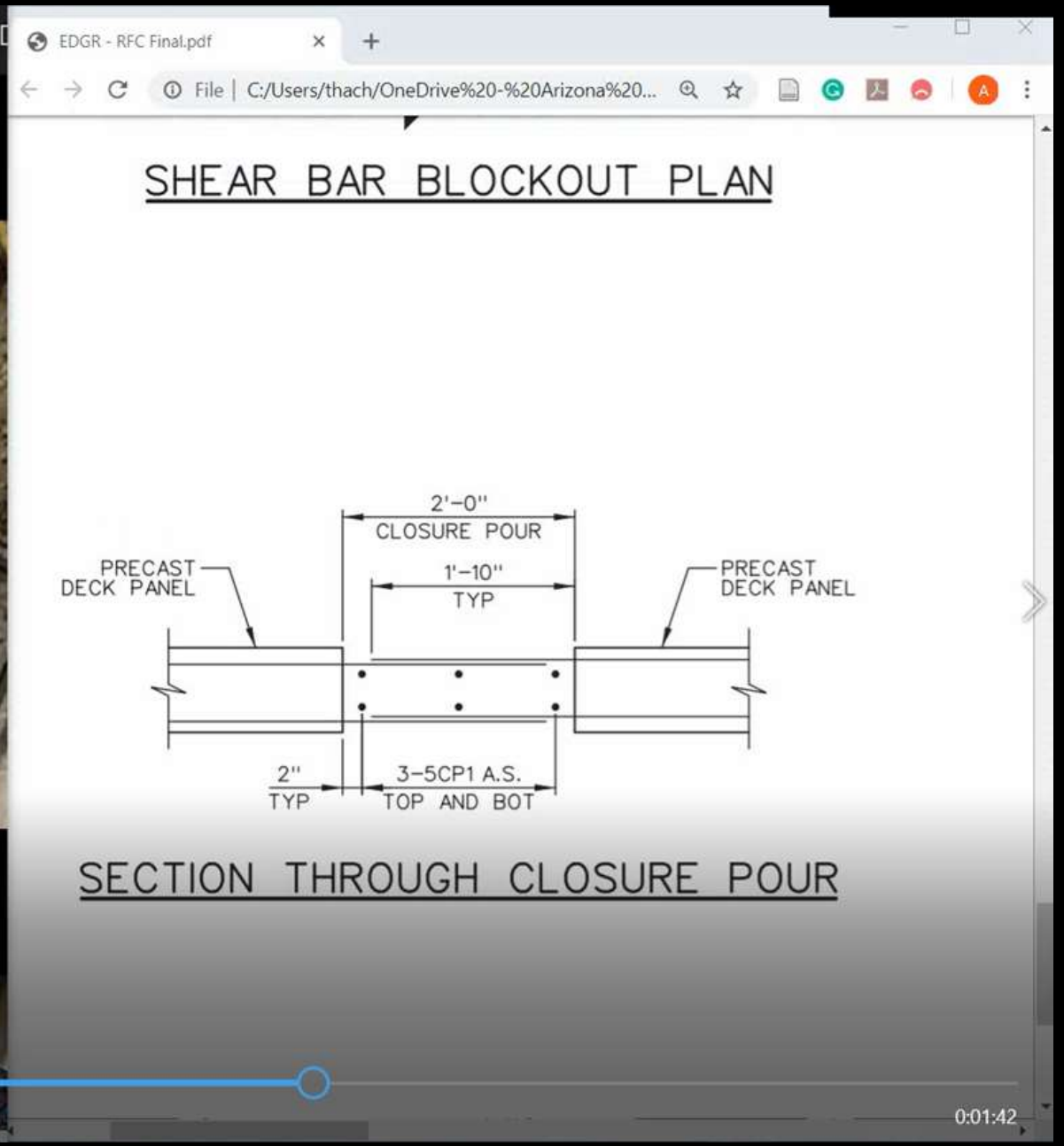
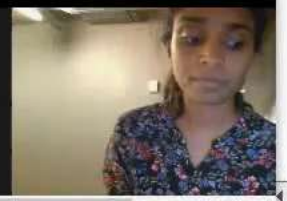
HoloLens 2 Demo 2
0:02:08
EDGR - RFC Final.pdf
File | C:/Users/thach/OneDrive%20-%20Arizona%20...
EDGR - RFC Final.pdf
2 / 3
STATE
PROJECT NO.
COUNTY
SHEET NO.
NEVADA
NHP-STBG-015-1(158)
CLARK
B124
7'-11 13/16"
25'-0"
END PANELS
ABUT #2
S18
S19
PANEL EDGE FOR POST-TENSIONING END BLOCKOUTS SEE NOTE 2, TYP
G1
G2
G3
G4
G5
G6
G7
G8
G9
G10
G11
G12
℄ I-15 SB PRECAST DECK PANEL, TYP
"I15-SB" 2093+77.28
"I15-SB"
PRECAST DECK PANEL ASSEMBLY PROCEDURE
1. PLACE PRECAST DECK PANELS BETWEEN ABUTMENTS FROM ABUTMENT #1 TO ABUTMENT #2.
2. PLACE ABUTMENT DIAPHRAGMS.
3. PLACE REMAINING DECK PANELS FROM END OF APPROACH SLAB #1 TO END OF APPROACH SLAB #2.
4. COUPLE POST-TENSIONING DUCTS AND INSTALL TENDONS.
5. GROUT TRANSVERSE JOINTS.
6. STRESS POST-TENSIONING TENDONS AND GROUT POST-TENSIONING DUCTS.
7. GROUT VOID BETWEEN THE GIRDERS AND PANELS AND IN SHEAR BAR BLOCKOUTS.
8. PLACE REINFORCING AND FORM BRIDGE BARRIER RAIL.
9. PLACE BARRIER RAIL CONCRETE.
10. GRIND AND RE-GROOVE DECK AS REQUIRED.
11. REPEAT STEPS 1 TO 10 FOR PHASE 2.
12. FORM LONGITUDINAL CLOSURE POUR JOINT AND PLACE REINFORCING.
13. PLACE CLOSURE POUR CONCRETE.
0:03:02

# Demo


rch or type a command
AH
Start editing
HoloLens 2 Demo 2
0:03:28


EDGR - RFC Final.pdf
File | C:/Users/thach/OneDrive%20-%20Arizona%20...
SHEAR BAR BLOCKOUT PLAN
2'-0"
CLOSURE POUR
1'-10"
TYP
PRECAST
DECK PANEL
PRECAST
DECK PANEL
2"
TYP
3-5CP1 A.S.
TOP AND BOT
SECTION THROUGH CLOSURE POUR
0:01:42

Start editing



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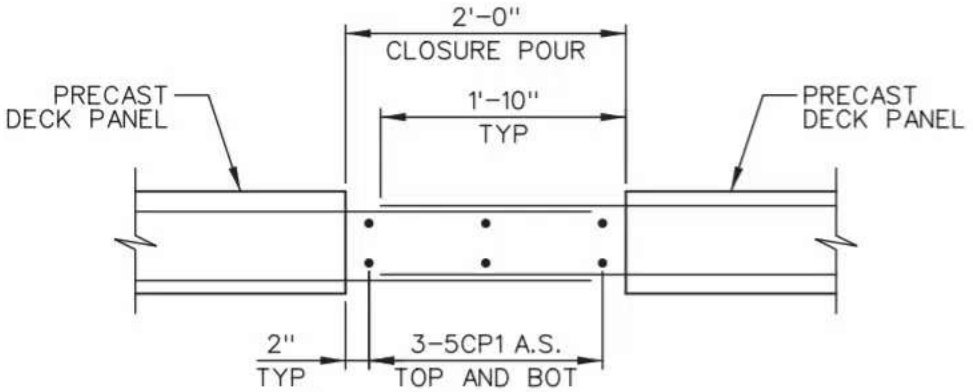
# SHEAR BAR BLOCKOUT PLAN




## SECTION THROUGH CLOSURE POUR

Assignments
Calls
Files
Apps
Help

Type here to search

ENG 23:21 28-02-2020

# Practical Applications

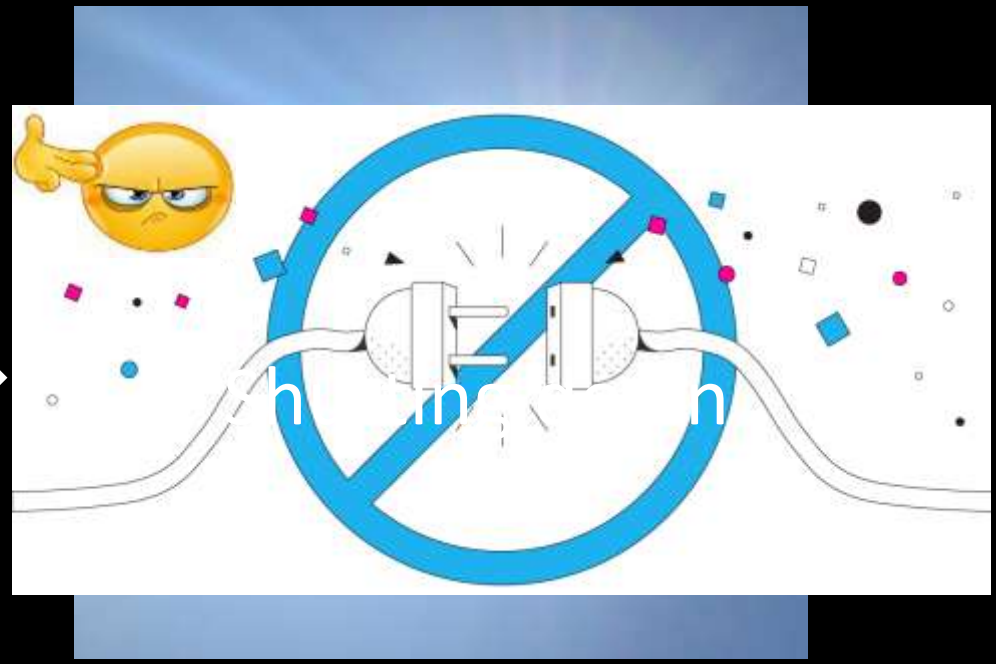
- Field inspector/tester communicating with RE
- RE communicating with applicable technical expert
- Independent Assurance (IA) inspector performing visual audit of Quality Assurance (QA) inspector
- Visual project documentation

# Demo

Successful

# Demo

What can go wrong?



# Demo

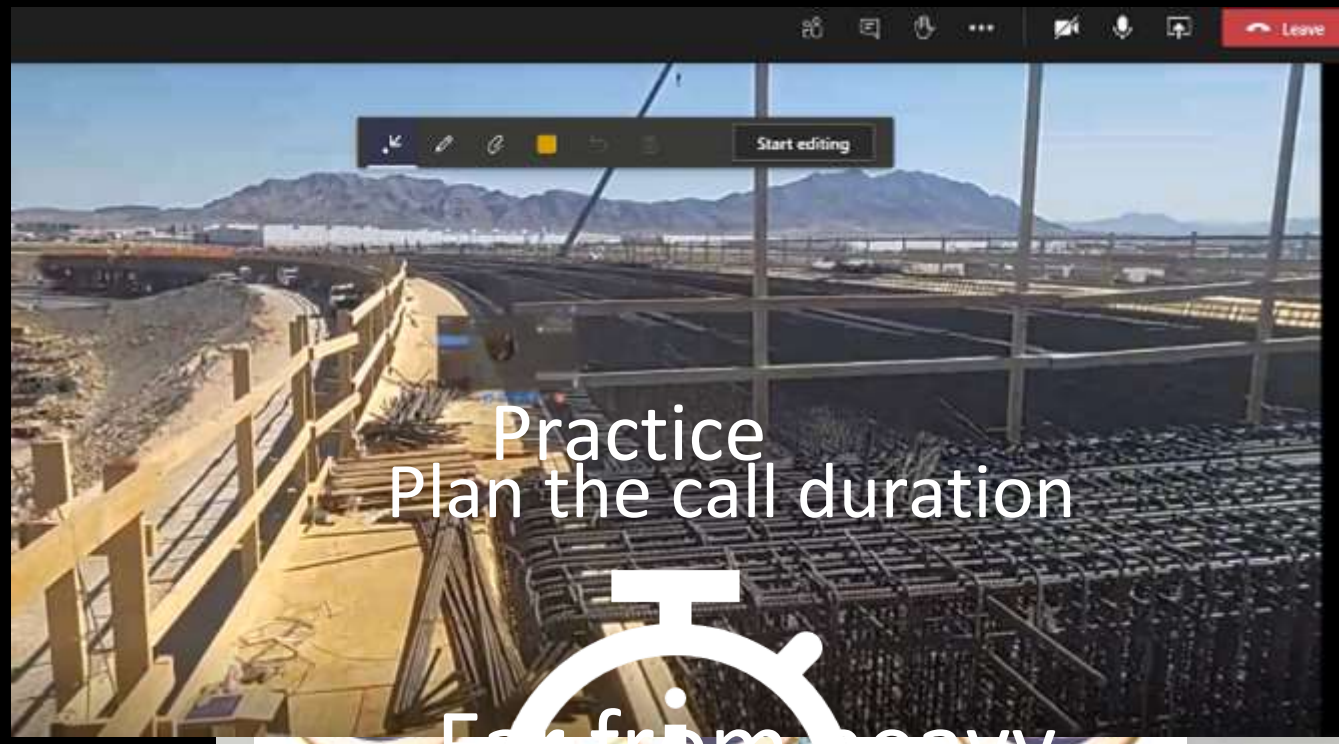
## What can we do?

Noise

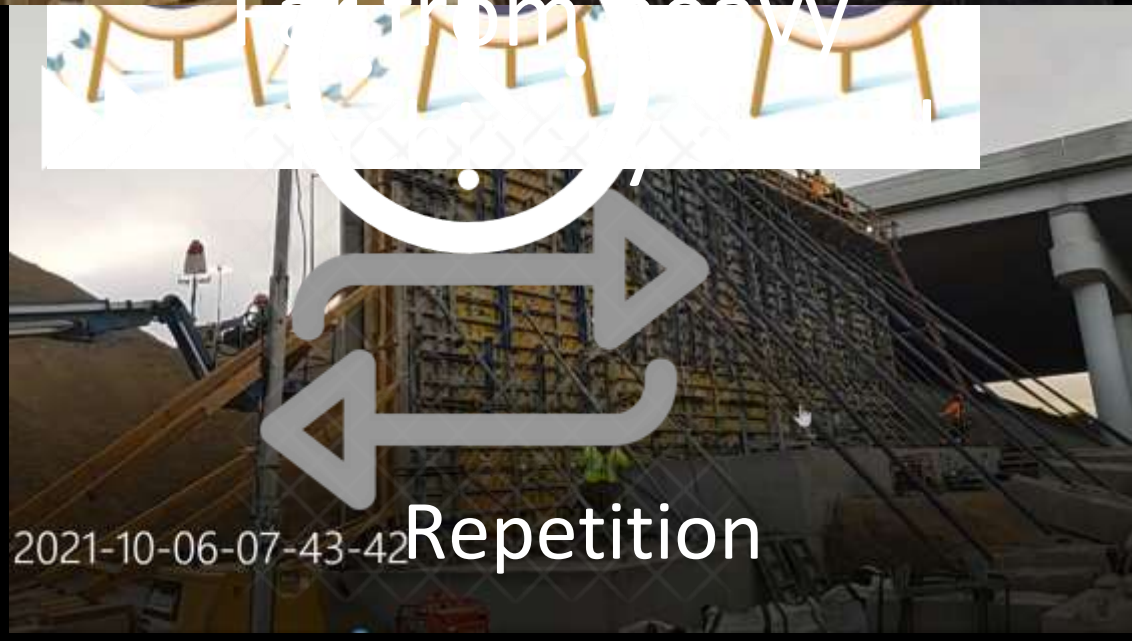
Weight

Crafted tinted film mask

Manipulation




Practice
Plan the call duration




Repetition

# Data Collection

Work Completed

- Literature review
- Surveys – traditional modes of communication
- Field testing
  - Video Recordings
  - 17 recorded calls
- Interviews – Perceptions on AR call experience

Upcoming Work

- Focus groups – How do we modify our deliverables to make them useable?

# Mixed Reality (MR) Selection Framework

| | Factors | Cell-phone/ tablet based AR | Trimble XR-10- (HoloLens 2-) based AR |
|---|---|---|---|
| | **related to site conditions** | | |
| 1 | Requires internet connection (i.e., WiFi or hotspot) | | |
| 2 | Functions at high temperatures above 86°F | | |
| 3 | Functions at high temperatures above 95°F | | |
| 4 | Usable in bright sunlight without modifications | | |
| 5 | Usable in bright sunlight with shading device * | NA | |
| 6 | Usable in low light condition (night) | | |
| 7 | Usable in high wind condition | | |
| 8 | Usable during rain and snow | | |
| 9 | Usable during dust condition | | |
| 10 | Usable around high human traffic | | |
| 11 | Usable in moist condition | | |

| Legend | |
|---|---|
| | Possible and tested |
| | Tested and not possible |

NA: Not Applicable.

*Shading device: Crafted tinted film mask, installed at the front area of the holoLens.

# Mixed Reality (MR) Selection Framework

| | Factors | Cell-phone/ tablet based AR | Trimble XR-10- (HoloLens 2-) based AR |
|---|---|---|---|
| | **related to AR specifications** | | |
| 1 | Enables remote synchronous communication | | |
| 2 | Enables sharing virtual drawings in case paper drawings are missing | | |
| 3 | Enables the ability to intuitively annotate through AR to identify points of interest † | | |
| 4 | Enables the use of both hands during discussion | | |
| 5 | Supports discussions involving multiple points of interest †, requiring physical movement and a clear view of the site | | |
| 6 | Supports discussions involving far and unreachable point of interest † | | |
| 7 | Enables recording calls for documentation | | |
| 8 | Supports discussion calls involving more than 2 users | | |
| 9 | Needs training sessions before use | | |
| 10 | Needs safety awarness during the use | | |
| 11 | Supports power bank charging during the use | | |
| 12 | Supports privacy and promote data security | | |
| 13 | Supports upgrades | | |
| 14 | Supports data storage and high memory | | |

| Legend | |
|---|---|
| | Possible and Tested |
| | Tested and Not Possible |

NA: Not Applicable.

† Point of interest: This refers to the location of the built element(s) or object(s) that are relevant to the discussion. For example, for a concrete column inspection call, the concrete column itself would be the point of interest.

# Next Steps for NDOT

- Present findings to SLT/ELT
  - Benefit/Costs
    - Software licenses
    - Hololens or other similar device
    - Cell phones/IPads
    - Training
    - Possible maintenance/updates on hardware and software

# Thank You!

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