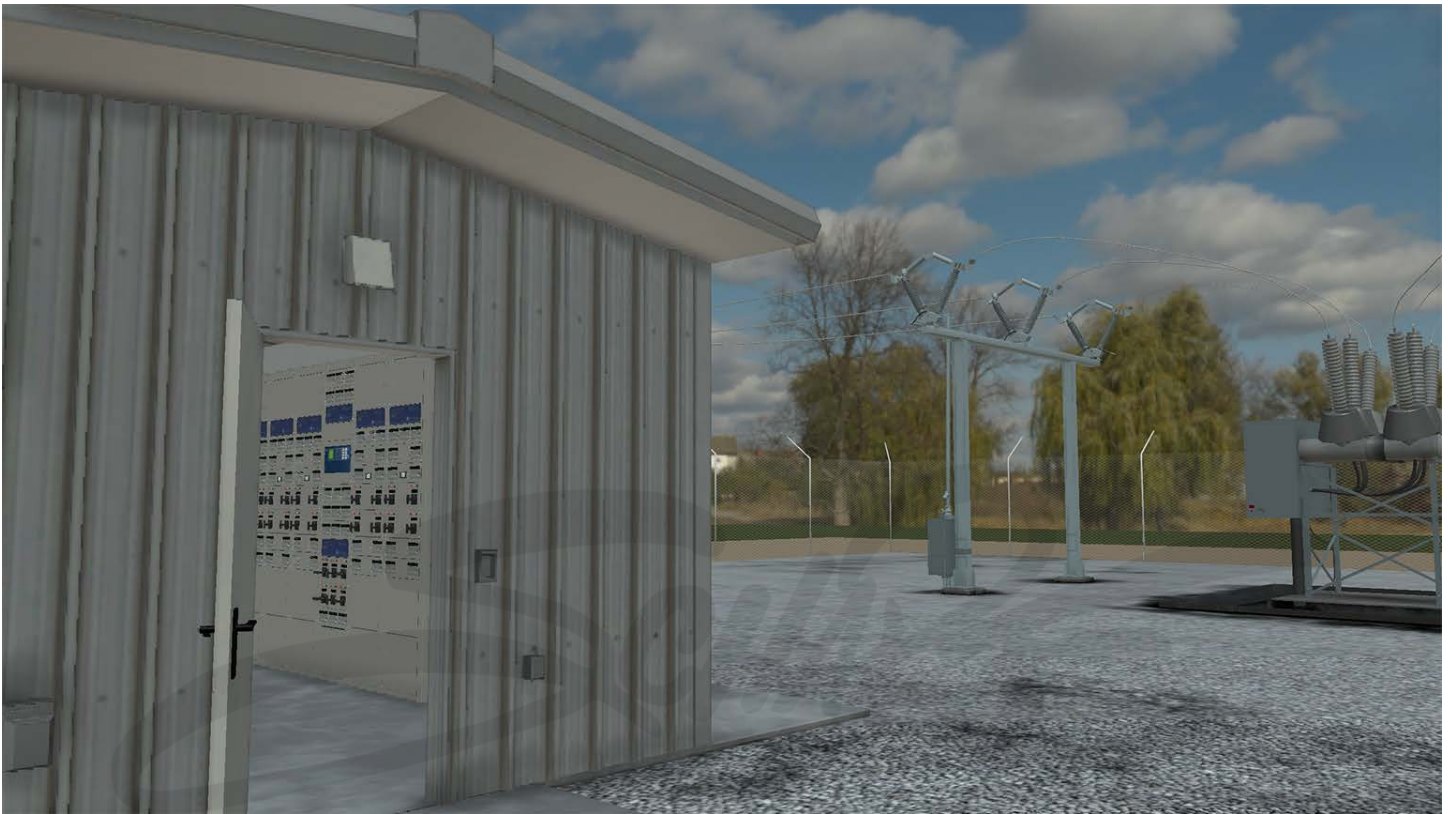# MDUG ETSC (Electric Transmission Switching Communications) VR Experience Design Document

Please NOTE: **This document has been created for both the client and offshore outsource development resources. This document contains no proprietary information.**

Document Version History

Version #	Date	Written/Revised By	Description
Draft V0.1	2023-08-10	Eric M. Scharf Solution Design Architect	• Initial design document for MDUG ETSC VR experience application
Draft V0.2	2023-08-24	Eric M. Scharf Solution Design Architect	• Various text and imagery content updates from client group feedback
Draft V0.3	2023-08-25	Eric M. Scharf Solution Design Architect	• Added Login Screen and Help Screen references
Draft V0.4	2023-08-29	Eric M. Scharf Solution Design Architect	• Various text and imagery content updates including further details for the Script Instructions, Clearance Tag, and Scenario Selection screen
Final V1.0	2023-08-31	Eric M. Scharf Solution Design Architect	• Added section for Physical Task Failure

MDUG ETSC (Electric Transmission Switching Communications) VR Experience Design Document

DOCUMENT PURPOSE

This document exists to reasonably confirm all required functional, user experience, and visual requirements for production of the ETSC VR storyboard which will inform development of the ETSC VR simulation application *(ETSC)* for use within Pico Neo3 Pro VR headsets. Upon completion of development, a user *(switchman)* will be able to repeatedly and safely engage in *virtual approximations* of real-world three-way communications with an ESO. The ESO – in the case of ETSC – will be *the application itself* (using pre-recorded soundbite statements, procured from "Switching Instructions," for correspondence with the switchman).

SUBSTATION VR ENVIRONMENT

1) **ETSC involves one *optimized* substation VR environment (the environment).**
   a. An optimized environment ensures the platform on which ETSC is being played (Pico Neo 3 Pro VR headset) is always demonstrating reasonable performance (in visual quality, smooth motion, and overall speed).
2) **The environment layout will be based upon a substation "oneline diagram."**
3) **The environment will be comprised of visual assets (3D models).**
4) **Each 3D model – with which the switchman is expected to interact – will include functional logic (one or more "collision volumes") which can be activated through switchman behaviors/choices.**
5) **All 3D models – identified within the substation "oneline diagram" *below* – will be capable of receiving *some level* of switchman interaction.**
   a. A switchman attempts to walk through a closed-and-locked gate to the environment, and that action activates a collision volume to prevent that switchman from penetrating that gate.
   b. A switchman reaches for a physical handle that would open a closed switch, and that reaching action activates a collision volume that activates an animation of that handle from a closed to open position.
   c. Collision volumes will also be in place – throughout the environment – to ensure a switchman *can never wander* beyond the environment.
6) **The environment – for navigational purposes only – will be *functionally* divided into three regions (which will be accessible through similar teleportation mechanisms to what was previously developed for "Inside Leak Investigation" and "Outside Leak Investigation").**
   a. Region 1: The fenced-in substation.
   b. Region 2: The northeast collection of switches (1804, 1805, 1806) *beyond* the fenced-in substation.
   c. Region 3: A single southwest switch (508) *beyond* the fenced-in substation.
   d. Regions 2 and 3, respectively, are expected to be located "a few miles" *beyond* the fenced-in substation.
   e. A switchman – upon entering the environment for each ETSC scenario being played – will always be spawned (or appear) next to an MDUG-branded bucket truck 3D model (as if the vehicle had just been exited).
      i. The bucket truck will be static and parked on or next to the driveway that leads to the entrance (gate) of the environment.

7) **When the switchman must travel to-and-from any of the three environmental regions, the switchman will use the "oneline diagram" option from the smartwatch toolset (through the following user experience).**
   a. The oneline diagram will appear on a clipboard within the switchman's left controller.
   b. The switchman will then be able to aim their right controller laser at any of the three subtly highlighted circles or *hotspots* (shown below) and press their right forefinger trigger button.
   c. The switchman's view of the environment will quickly, smoothly fade to black.
   d. The switchman's view of the environment will quickly, smoothly reappear.
   e. The switchman will be standing within the region they selected, and the bucket truck will be parked near them (to loosely convey the real-world travel a switchman must undertake to reach that selected region).

Dakota Transmission Substation
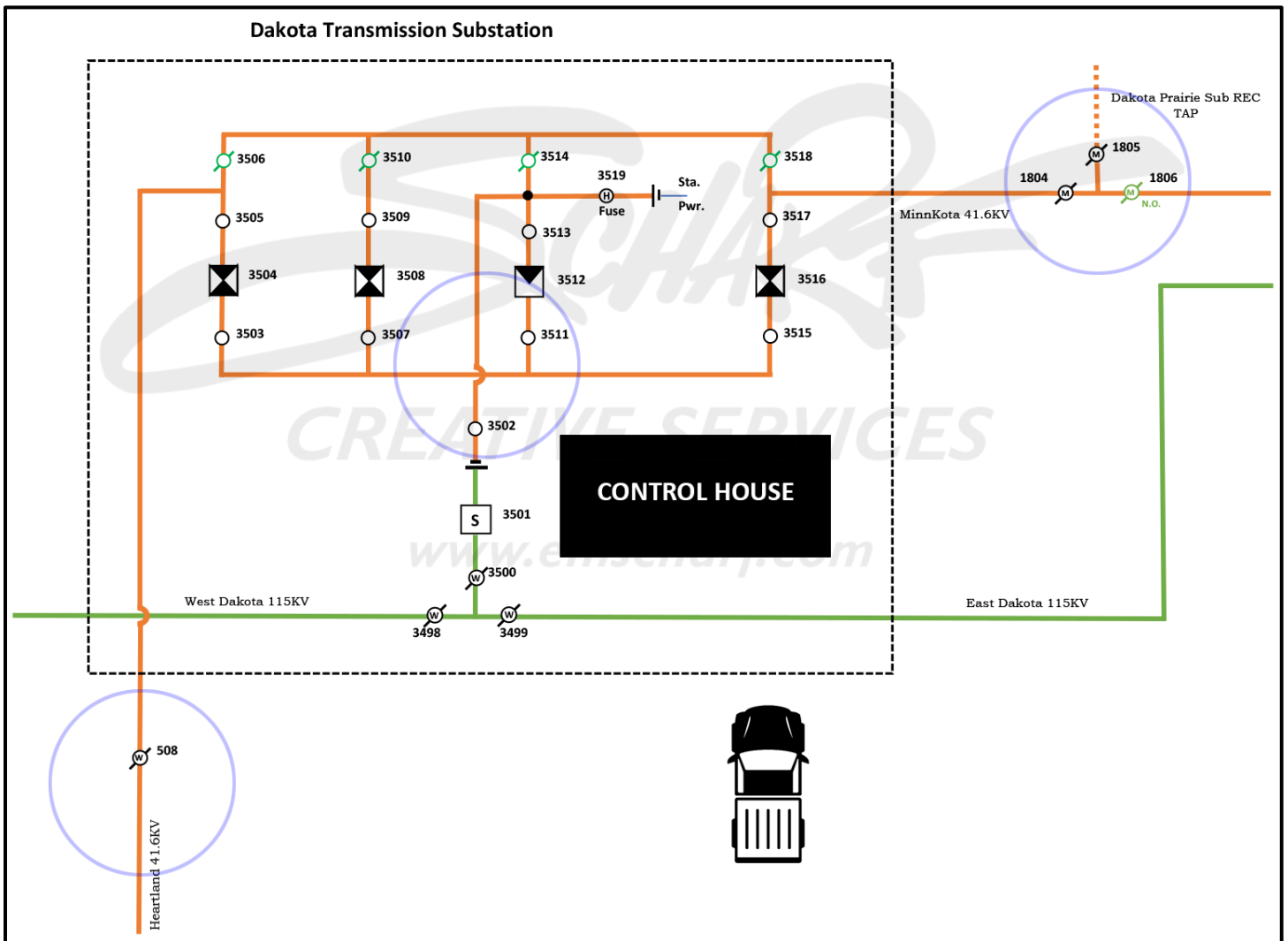
SMARTWATCH TOOLSET

Below are visual representations of the smartwatch toolset options available to the switchman within ETSC.

1) **The smartwatch toolset (as with "Inside Leak Investigation" and "Outside Leak Investigation") will be accessible through the following user experience from the switchman's left controller.**
   a. The switchman raises their left controller as if they were looking at a real-world watch.
   b. The switchman presses the "Y" button on their left controller.
      i. This activates the toolset (where the "no selection" option – at the beginning of any scenario – will always be preselected by default).
      ii. The switchman can then press the "Y" button again to toggle through each of the available toolset options.
      iii. Upon identifying their desired toolset option, the switchman can then press the "X" button.
      iv. The selected option will appear in their appropriate controller and the toolset will disappear (until the switchman needs to activate it again).

Toolset options in their _unselected_ states.   **Toolset options in their _selected_ states.**

Below are descriptions of each toolset option. Some descriptions include in-depth user experience steps.
Please NOTE : **ALL options will be appropriately scaled for *maximum* readability/viewability.**

1) **No Selection**
    a. The switchman can use this option to clear their hands/controllers of any toolset options (just like within Inside Leak Investigation and Outside Leak Investigation).

2) **Switching Instructions**
    a. The switchman can user this option to toggle through the clipboard-mounted switching instructions.
    b. **As each *step* is completed, that step will appear "grayed out" (*viewable* by the switchman yet no longer accessible, as a reminder – in case of distraction – of their progress).**
    c. When selected from the smartwatch toolset, the switching instructions will appear in the switchman's left controller.
        i. Switchman interactions with the switching instructions will occur with the switchman's right controller.

3) **Padlock with Key**
    a. The switchman can use this option to unlock or lock *all lockable components* within the environment.
    b. **While the icon for this option conveys a padlock with a key, when this option is selected, the representative 3D model (appearing within the switchman's right controller) will be *contextual*.**
        i. If the switchman is approaching a closed entrance with a traditional lock cylinder, a *key* 3D model will appear in their right controller to unlock that entrance or remove that padlock.
            1. In the case of a padlock being unlocked, that key would become partially transparent in the switchman's controller while a duplicate key would animate into that padlock and the shackle would animate open. The padlock would then disappear.
        ii. If the switchman is approaching a device that requires a padlock to be refastened, a padlock 3D model will appear in the switchman's right controller to then be fastened onto the device.
            1. That padlock would become partially transparent in the switchman's controller while a duplicate padlock would be animated closed onto the correct area of a given device.
        iii. *Please NOTE:* Once a lock cylinder/padlock has been locked or unlocked, the contextual 3D key or lock will appear/remain in the switchman's hand until another smartwatch option is selected.
        iv. The representative 3D model will *never* involve real world *card key* or *key fob* variations.
   c. All locked components will include the fence gate, the control house entrance, and device padlocks.

4) **Clearance Tag**
    a. The switchman can use this option for two purposes:
        i. Entering information (that *must* be displayed on the clearance tag) before the clearance tag is hung on a given device.
   ii. Hanging a clearance tag on a given device and refastening that clearance tag within that device's padlock.

A) This is the front of the clearance tag.

B) The front of the clearance tag offers *no interactivity* for the switchman.
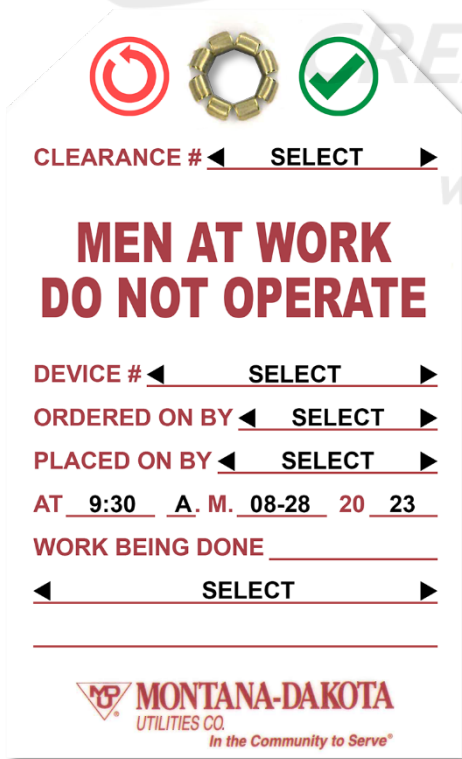
C) The is the back of the clearance tag (in a *default/incomplete* state).

D) **Each of the fillable fields (e.g., CLEARANCE #, DEVICE #, ORDERED ON BY, PLACED ON BY, AT, and WORK BEING DONE) which display SELECT by default (as a visual cue) can be completed within the environment through the following user experience:**

    a. The switchman activates their smartwatch toolset, selects the clearance tag option, and it appears in the switchman's left controller.

    b. The switchman aims their right controller laser at either the back (left) or next (right) arrows (which bracket a given entry field – DEVICE # *for example*) and presses their right forefinger trigger to activate field into displaying a series of values from which to choose (e.g., 508, 1804, 3501) until finding a satisfactory entry.

    c. ***Please NOTE:*** The AT field will be *auto-populated* to the current time and date of the switchman's play session.

    d. The switchman then selects the green CONFIRM button or red RESET button.
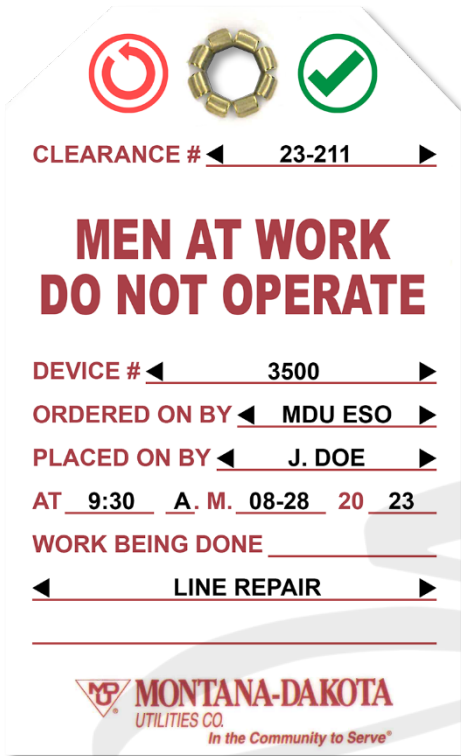
E) This is the back of the clearance tag when *completed.*

F) As previously described, the switchman can aim their right controller laser at the green CONFIRM button or red RESET button and press their right forefinger button.

G) ***Please NOTE:*** The switchman can *also* choose to go back to *any* of the available fields (except for the auto-populated AT field) and continue to manipulate them (through the back and next buttons) to display different data entries.
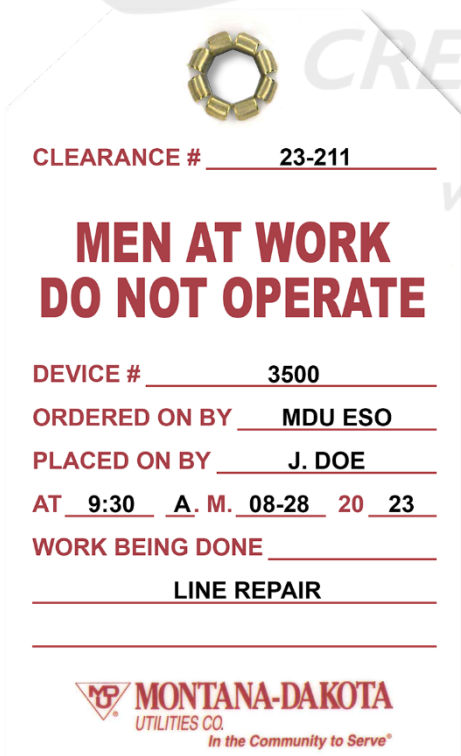
J) Once the back of the clearance tag has been completed and the green CONFIRM button has been selected, the back and next arrows will disappear, and the clearance tag will appear as shown (on the left).

K) The switchman – when next to the appropriate device – will then be able to reach out with the clearance tag in their right controller and gesture towards the area of the device where the clearance tag would normally be hung.

L) The clearance tag would then pop onto or appear on the device.

M) The switchman would then select the padlock with key option from their smartwatch toolset.

N) A padlock 3D model would contextually appear in the switchman's right controller.

O) The switchman – *still* next to the appropriate device – will then be able to reach out with that padlock in their right controller and gesture towards the area of the device where the padlock would normally be locked into position.

P) The *locked* padlock would then pop onto or appear on the device.

5) <u>**Rubber Gloves**</u>

    a. The switchman can use this option for two purposes:

        i. Obligatory inspection of the rubber gloves (or electrical protective gloves).

            1. A switchman does not typically have more than one pair of rubber gloves, and – if defective – the switchman, by protocol, would have to return to their office to procure a replacement pair.

                i. The switchman will only be required to review the rubber gloves, and there will be a collision volume associated with the rubber gloves to ensure the switchman's decision to review the rubber gloves is acknowledged within ENDEAVR user reporting.

        ii. Wearing rubber gloves when engaging any devices within the substation environment.

            1. The switchman can choose (correctly or incorrectly) to put the rubber gloves on or take them off at any time.

6) <u>**Binoculars**</u>

    a. The switchman can use this option for a zoomed-in view on any of the switches for which they changed positions (from closed to open and from open to closed).

    b. The binoculars user experience will be:

        i. The switchman activates their smartwatch toolset and selects the binoculars option.

        ii. The binoculars appear in the switchman's right controller.

        iii. Then, the switchman aims their left controller laser at the area of the substation environment they wish to view close-up.

        iv. Then, the switchman pulls their left controller's forefinger trigger.

        v. Then, the switchman's view changes to a zoomed-in binocular-style view on the specified area (with a black shroud boarder surrounding the specified area).

        vi. Once the switchman is satisfied with their zoomed-in viewing of the specified area, the switchman pulls their left controller's forefinger trigger.

        vii. Then, the switchman's view returns to normal.

        viii. When the switchman is done using the binoculars option, they can activate their smartwatch toolset and select another option or no selection.

7) <u>**Oneline Diagram**</u>

    a. The switchman can use this option to view the clipboard-mounted online diagram.

    b. This option will be scaled appropriately for *maximum* readability.

    c. The oneline diagram user experience will be:

        i. The switchman activates their smartwatch toolset and selects the online diagram option.

        ii. The oneline diagram will appear on a clipboard within the switchman's left controller.

        iii. The switchman will then be able to aim their right controller laser at any of the three subtly highlighted circles (shown below) and press their right forefinger trigger button.

        iv. The switchman's view of the environment will quickly, smoothly fade to black.

     v.   The switchman's view of the environment will quickly, smoothly reappear.

    vi.   The switchman will be standing within the region they selected, and the bucket truck will be parked near them (to loosely convey the real-world travel a switchman must undertake to reach that selected region).

   vii.   The online diagram will still be active in the switchman's left controller (in the event the switchman meant to travel to one of the other environment regions).

  viii.   When the switchman is done using the online diagram option, they can activate their smartwatch toolset and select another option or no selection.

8) **Phone**

    a.   The switchman can use this option to correspond with the ESO.

    b.   The phone icon will resemble the current "Call 911" symbol from Inside Leak Investigation and Outside Leak Investigation, but it will instead read as "Call ESO."

        i.   The phone user experience will be:

            1.   The switchman activates their smartwatch toolset and selects the phone.

            2.   The phone (generic smartphone) will appear in the switchman's right hand/controller.

                a.   This allows for the switchman – when necessary – to hold their clipboard-mounted switching instructions (or other toolset options) in their left hand/controller.

                b.   The switchman will be able to both hold their phone in their right hand/controller while using their right hand/controller laser to interact with their clipboard-mounted switching instructions (when prompted by the ESO to do so).

            3.   When the switchman is done using the phone option, they can activate their smartwatch toolset and select another option or no selection.

9) **6 Steps of Switching**

    a.   The switchman can use this option to view the "6 Steps of Switching" card.

        i.   The switchman will be able to toggle between the front ("6 Steps") and back ("6 Steps Nomenclature") of the card.

SCENARIOS

Switchman activities within ETSC (outside of understandable, off-schedule, exploratory curiosity) will be controlled by scenarios, which are accessible by MDUG trainers within The ENDEAVR XR Management Platform (ENDEAVR).

1) Each scenario will be based upon one set of detailed-yet-conversational "Switching Instructions."
   a. Switching Instructions will be created and provided by MDUG ETSC SMEs.
2) Scenario variables – within a given Scenario Settings screen through ENDEAVR – *will* include the ability to:
   a. Change the condition/status of any device (within the substation yard or within the control house).
      i. *Examples* of device conditions/statuses would be OPEN and CLOSED.
   b. Change the gate entrance from closed-and-locked to open-and-unlocked.
   c. Change the control house entrance from closed-and-locked to open-and-unlocked.
   d. Change the condition of environment elements for which inspection is required (e.g., rubber gloves, fence straps, devices).

LOGIN SCREEN

The ETSC Login screen will be *identical* in look and functionality to the login screen used within "Inside Leak Investigation" and "Outside Leak Investigation."

SCENARIO SELECTION SCREEN

While there has been some discussion about an ETSC Scenario Selection screen (that would appear directly after the Login screen), there is one issue that makes it an *untenable* feature to pursue. There can only be ONE active scenario at a time. An MDUG trainer – from within ENDEAVR – would select which scenario would be active.

An *existing* ENDEAVR-based solution – called **Scenario Randomization** – can be activated, however, to allow ENDEAVR to push all available scenarios, one scenario at a time and in random order, to a given switchman's VR headset. This existing feature can ensure all switchmen have access to multiple scenarios within a fresh, unpredictable order.

A Scenario Selection screen _will not be pursued_ due to the above understanding.

HELP MENU

There will be a robust help menu available within the ETSC environment. As with "Inside Leak Investigation" and "Outside Leak Investigation," the help menu will be tastefully positioned within all regions of the environment so that – when the switchman presses the "A" button on their right controller, the help menu will appear in an unobstructed manner.

1) **Trigger = *Primary Interaction* with Tools** is for single-stage tools (which only require *one* controller).
2) **Trigger = *Secondary Interaction* with Tools** is for multi-stage tools (which require *two* controllers).
   a. **Examples of multi-stage tools:** Binoculars, Clearance Tag, and Oneline Diagram.

MDUG Electric Transmission Switching Communications Controls

Use your *virtual hands* to interact with objects.

LEFT

Thumbstick = Move Forward, Back, Left, Right
Trigger = *Secondary Interaction* with Tools
Trigger = Teleportation
Home = Exit Simulation
Grip = Turn Left 90°
Y = Activate Tools Menu
Ȳ = *Toggle* Tools Menu Options
X̄ = *Select* Tools Menu Option

RIGHT

Primary Interaction with Tools = **Trigger**
Exit Simulation = **Home**
Turn Right 90° = **Grip**
Open Help Menu = **A**

NOTE: Press **Grip** *once* to quickly turn 90°. *Press-and-hold* **Grip** to smoothly turn, then *release* **Grip** at any interval to stop turning.
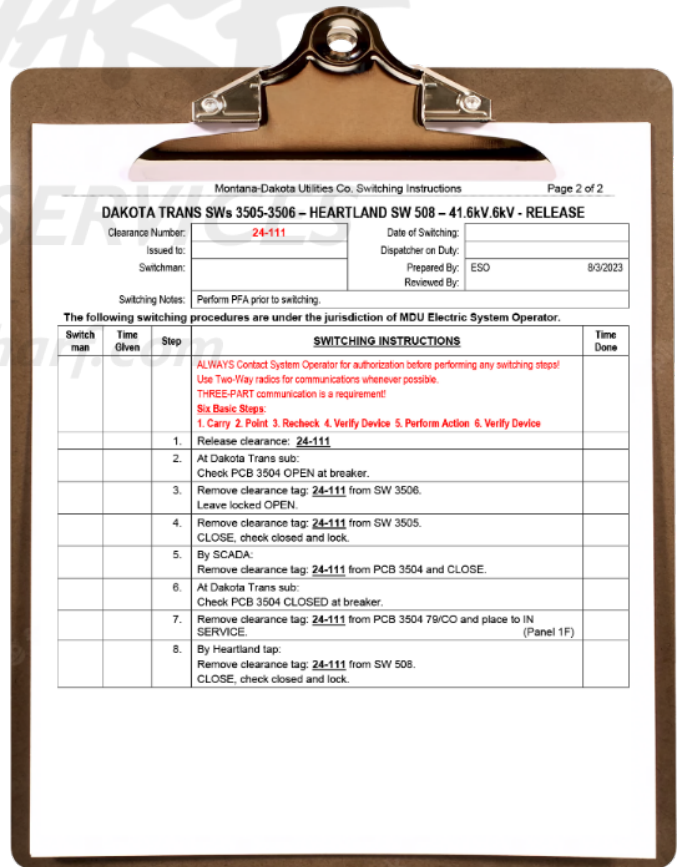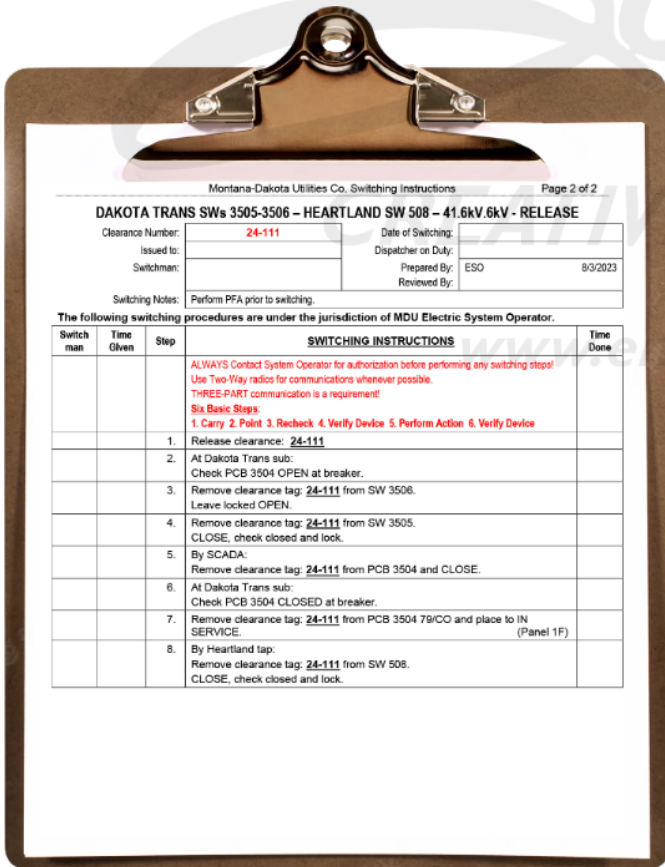
SWITCHING INSTRUCTIONS SOLUTION

The key ETSC learning goal requires mimicry of the three-way communication that occurs between a remote ESO and an onsite switchman (because of the persist challenges in listening, understanding, memorization, and restatement that comes with that real-time, real-world correspondence). As the project SOW does not include multiplayer capability, voice recognition functionality, or A.I., a creative *approximation* is required.

THE FIRST HURDLE TO APPROXIMATING THREE-WAY COMMUNICATION is to acknowledge that forms, scripts, or ANY kind of *detailed*, type-written materials introduced within a VR environment can create the following concerns:

1) Favoring the vision quality of one switchman over another (where a given switchman's real-world contact lenses or corrective lenses alone still may prove insufficient to bridge the visibility gap).
2) Provoking a switchman into spending too much time within the VR headset (which, in turn, *may* cause some motion sickness side effects).

The images below convey how a set of clipboard-mounted switching instructions (2-pages in length) would *approximately* appear within the environment.

As the ESO remotely completes the switching instructions form – *after* the required correspondence and physical activities have been finished during correspondence with the switchman – certain elements of that form *will be removed* from the switchman's view (with the previous concerns in mind).

The altered switching instructions (*without* Switch man, Time Given, Time Completed columns) are displayed below.

Page 1 of 2 — DAKOTA TRANS SWs 3505-3506 – HEARTLAND SW 508 – 41.6kV - PLACE

Montana-Dakota Utilities Co. Switching Instructions — Page 1 of 2

Step	SWITCHING INSTRUCTIONS
	ALWAYS Contact System Operator for authorization before performing any switching steps! Use Two-Way radios for communications whenever possible. THREE-PART communication is a requirement! **Six Basic Steps:** 1. Carry 2. Point 3. Recheck 4. Verify Device 5. Perform Action 6. Verify Device
1.	By SCADA: Check Dakota - Heartland 41.6kV line looped through.
2.	OPEN Dakota PCB 3504. Tag with clearance: **24-111**
3.	At Dakota Trans sub: Place PCB 3504 79/CO Recloser Cutout to OUT OF SERVICE. (Panel 1F) Tag with clearance: **24-111**
4.	Check PCB 3504 OPEN at breaker.
5.	Check SW 3506 locked OPEN. Tag with clearance: **24-111**
6.	OPEN SW 3505. Check open and lock. Tag with clearance: **24-111**
7.	By Heartland tap: OPEN SW 508. Check open and lock. Tag with clearance: **24-111**

8.	Issue clearance: **24-111**
	Boundaries:
	  • At Dakota Trans sub:
	    ☐ SW 3505
	    ☐ SW 3506
	  • By Heartland tap:
	    ☐ SW 508

Page 2 of 2 — DAKOTA TRANS SWs 3505-3506 – HEARTLAND SW 508 – 41.6kV.6kV - RELEASE

Montana-Dakota Utilities Co. Switching Instructions — Page 2 of 2

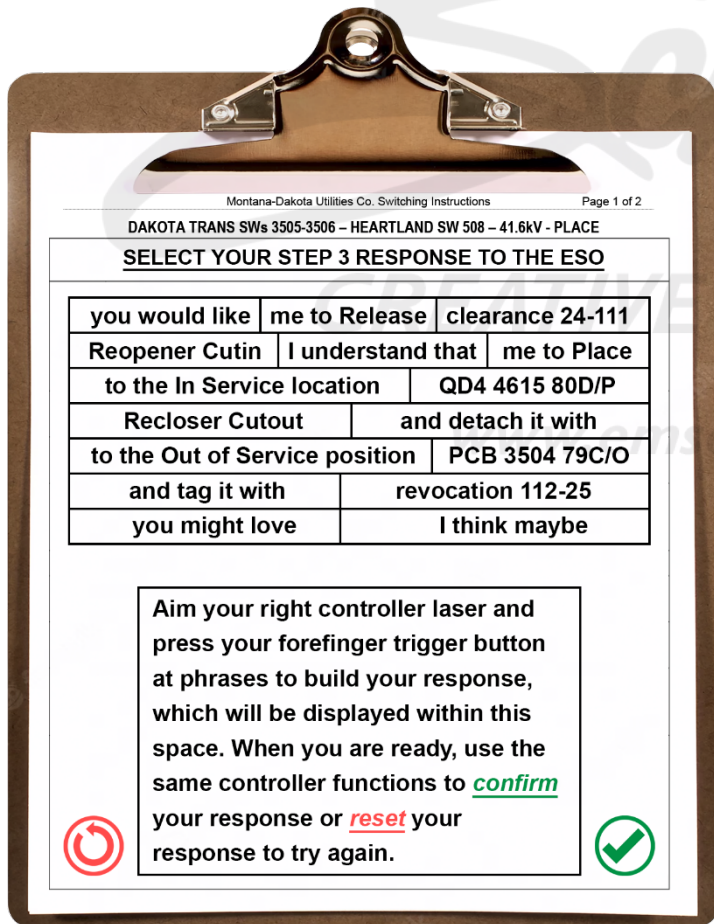| Step	SWITCHING INSTRUCTIONS
	ALWAYS Contact System Operator for authorization before performing any switching steps! Use Two-Way radios for communications whenever possible. THREE-PART communication is a requirement! **Six Basic Steps:** 1. Carry 2. Point 3. Recheck 4. Verify Device 5. Perform Action 6. Verify Device
1.	Release clearance: **24-111**
2.	At Dakota Trans sub: Check PCB 3504 OPEN at breaker.
3.	Remove clearance tag: **24-111** from SW 3506. Leave locked OPEN.
4.	Remove clearance tag: **24-111** from SW 3505. CLOSE, check closed and lock.
5.	By SCADA: Remove clearance tag: **24-111** from PCB 3504 and CLOSE.
6.	At Dakota Trans sub: Check PCB 3504 CLOSED at breaker.
7.	Remove clearance tag: **24-111** from PCB 3504 79/CO and place to IN SERVICE. (Panel 1F)
8.	By Heartland tap: Remove clearance tag: **24-111** from SW 508. CLOSE, check closed and lock.

THE SECOND HURDLE TO APPROXIMATING THREE-WAY COMMUNICATION involves the switchman being able to successfully respond to ESO commands/prompts *without* the need for real-time, spoken dialogue.

THE THREE-WAY COMMUNICATION SOLUTION WILL BE ACHIEVED THROUGH THE BELOW "WORD CLOUD" CONCEPT.

STEP 3 from page 1 of the example switching instructions has the ESO sharing the following with the switchman.

> **ESO: "My indication is showing PCB 3504 is Open. At this time, I would like you to Place PCB 3504 79C/O Recloser Cutout to the Out of Service position and tag it with clearance 24-111."**

1) Once the ESO *(the application itself)* audibly projects that statement as a *pre-recorded* soundbite, the application would activate a change to the how the switching instructions are displayed.
2) The switchman would suddenly be shown a word cloud from which to formulate their response to the ESO.
   a. The below *example* displays a variety of sentence fragments from which to build a response.
3) The switchman can take their time reviewing the sentence fragments, aim their right controller/laser at the appropriate fragments, and press their forefinger trigger to make their selections.

Montana-Dakota Utilities Co. Switching Instructions   Page 1 of 2

DAKOTA TRANS SWs 3505-3506 – HEARTLAND SW 508 – 41.6kV - PLACE

SELECT YOUR STEP 3 RESPONSE TO THE ESO

you would like	me to Release	clearance 24-111
Reopener Cutin	I understand that	me to Place
to the In Service location		QD4 4615 80D/P
Recloser Cutout		and detach it with
to the Out of Service position		PCB 3504 79C/O
and tag it with		revocation 112-25
you might love		I think maybe

Aim your right controller laser and press your forefinger trigger button at phrases to build your response, which will be displayed within this space. When you are ready, use the same controller functions to *confirm* your response or *reset* your response to try again.

1) Once the switchman makes their selection (by selecting the green CONFIRM button on the bottom right or the red RESET button on the bottom left), the application will revert the word cloud screen back to the original switching instructions page.
2) The ESO can then respond with "That is correct, call me back when you complete this step."
   a. *OR* the ESO can respond with "That is incorrect. Let's repeat this step."
3) Then, the ESO can repeat the original instruction to allow the switchman to try again (for as many attempts as it may take).
   a. The number of attempts and the times at which those attempts are made can be recorded within ENDEAVR and reviewed within user reports.

Again – once a response has been completed to their satisfaction – the switchman can aim their laser (of their right controller) at the CONFIRM button and press their right forefinger trigger to submit their response to the ESO.

The below image represents an _in-progress_ word cloud.   **The below image represents a _completed_ word cloud.**

Please NOTE: The text and button sizes within this word cloud concept are _purposely_ pronounced, as the width of the controller laser _can_ overwhelm undersized buttons (which is why the CONTINUE and COMPLETE buttons are substantial in size for the _work order_ option within the previously delivered "Inside Leak Investigation" and "Outside Leak Investigation" VR experiences). As a result, the switchman should be able to _comfortably_ select sentence fragments. The switchman will also _not have to strain their vision_ to view their choices as they assemble their response to the ESO.

PHYSICAL TASK FAILURE

While the word cloud concept deals specifically with the quality and accuracy of the switchman's *response* to the ESO's script instruction, the switchman – following that response – may still fail the physical part of the required task.

1) The switchman may read an ESO instruction, may hear the ESO repeat that instruction over the phone, and the switchman may respond in the affirmative to that instruction, yet the switchman may (after providing that response) still:
   a. Perform physical tasks *correctly* on an incorrect device.
   b. Perform physical tasks *incorrectly* on a correct device.
2) While the switchman – in the real world – can *reengage* the ESO over a misinterpreted instruction through additional, corrective phone correspondence followed by performance of further, corrective physical tasks, the following streamlined approach will help the switchman avoid getting caught in a "device engagement loop" that takes away from the communication focus.
   a. **Upon completing the ESO-instructed device engagement, the switchman calls the ESO back to report their updated status (e.g., tasks performed and on which device), and the ESO (approximately) states:**
      i. "You misinterpreted my instructions. The simulation will now conclude."
         1. **The application would then close and deposit the switchman back at the ENDEAVR user interface screen (from where the switchman could then select the ETSC icon and reengage the application for another play session).**