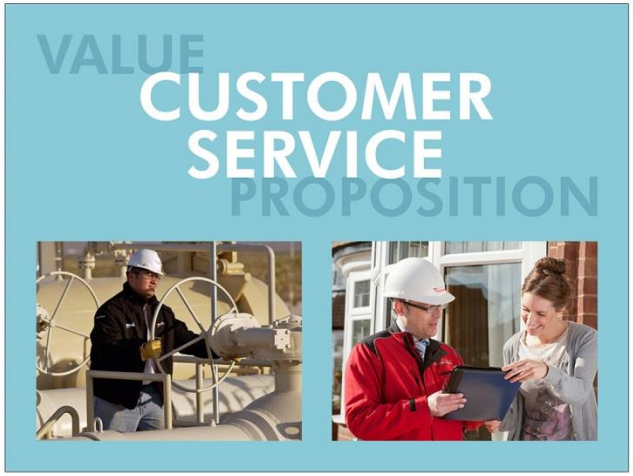


MidAmerican Energy
Remote Fault Indicator Experience

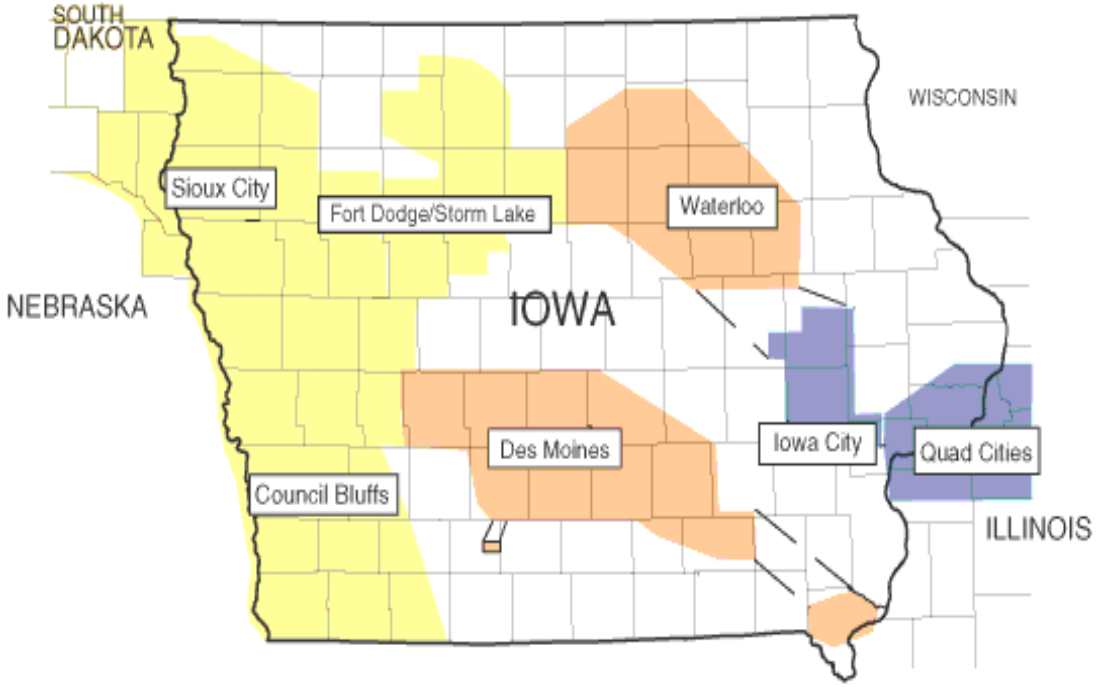
Terry Smith – Manager, Distribution Control

MidAmerican ENERGY
OBSESSIVELY, RELENTLESSLY *AT YOUR SERVICE*®

MidAmerican T&D Electric System

- Electric provider to ~ 815,000 customers in Iowa, Illinois, and South Dakota
- 12,500 MW of generation capacity, including ~7,400 MW of wind generating capacity installed

- 4,700 miles of transmission (345 kV, 161 kV, 69 kV)
- 25,000 miles of distribution primary
  - 75% Overhead, 25% Underground based on miles
- 1,100 Distribution feeders (13 kV, 4 kV)

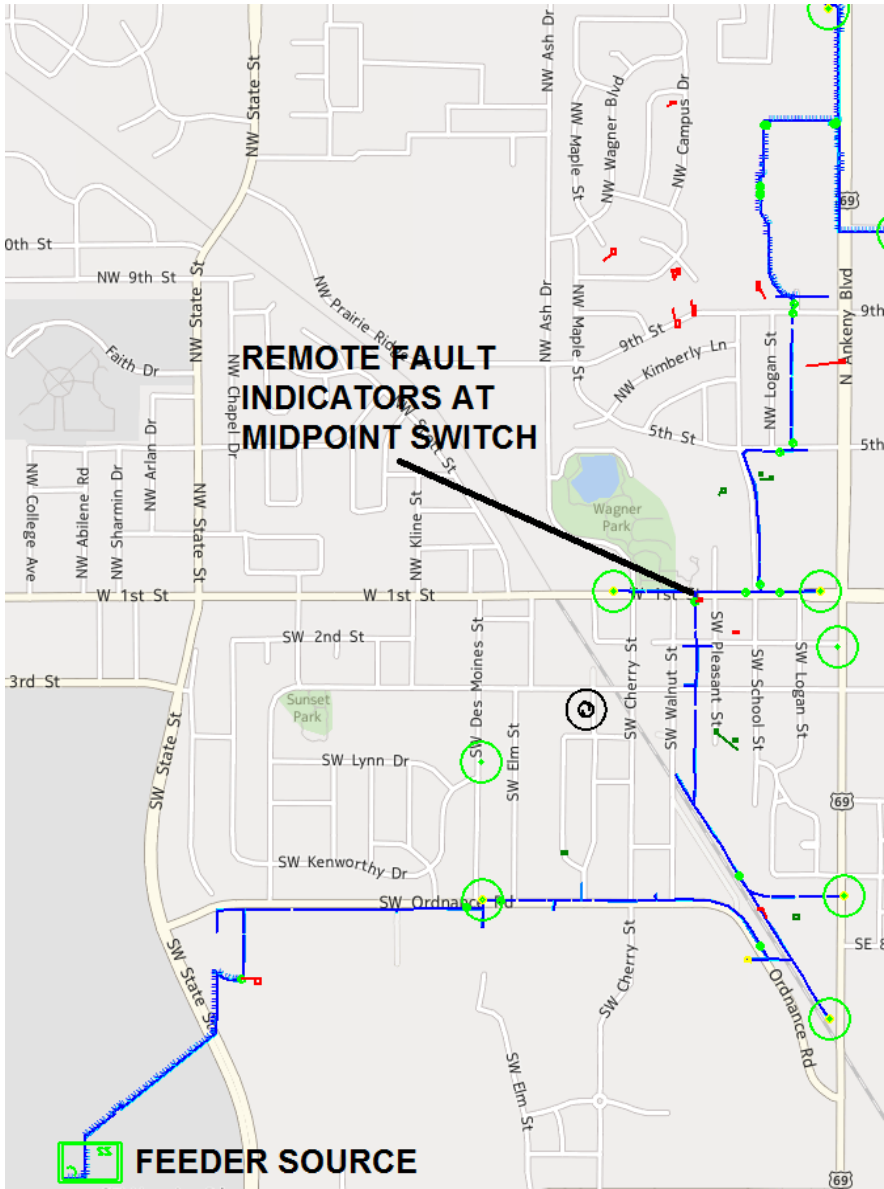


Remote Fault Indicators at MEC

- Low-cost opportunities to improve reliability
- Pilot of Remote Fault Indicators in 2014
  - 60 devices (20 locations) overhead distribution feeders only
  - Cellular communications to locally hosted software
- Pilot needed to validate
  - accuracy of devices
  - availability of communications
  - establish field and control room acceptance
- History of inaccurate info, low confidence in flashing fault indicators

Remote Fault Indicators at MEC

- Typical Pilot Applications
  - Midpoint switch of larger feeders (>1,000 customers), and active history
- Following an event, route first responder to midpoint switch
  - Open Midpoint Switch
  - If fault was detected downstream, remotely close breaker
  - If no fault detect downstream, first responder instructed to close normal open tie
  - In either case, half of customers are restored as soon as responder arrives
  - Reduces patrol area to faulted half



Remote Fault Indicators at MEC

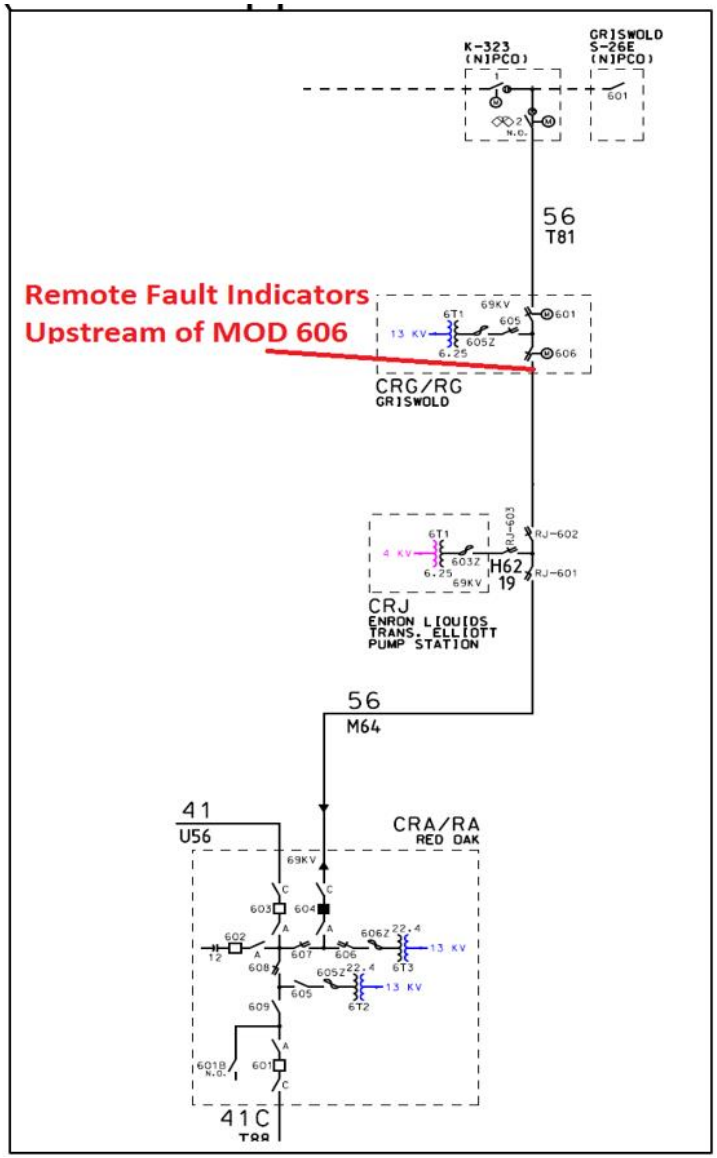
- Great success of pilot over ~2-year period
- Additional 150 devices installed in Q1 2017
  - Pilot of five UG distribution feeder mainline locations, three 69 kV locations (radial)
- Additional 500 devices installed in Q1 2018
  - Additional UG locations, and eight additional 69 kV locations
- System-wide deployment 2019-2021
  - 500 devices installed in 2019
  - 1,000 devices installed in 2020 (4G)
  - 500 installed in 2021 (4G)
- Total of ~2,600 devices (800 locations)

Remote Fault Indicators at MEC

- Practical other uses deployed
  - UG feeder exits
  - Non-telemetered substations
  - Critical loads (hospitals, key accounts, etc)
  - Easy to move (overhead applications), have used for temporary applications, i.e. state fair, mobile substations, etc.
  - Circuits with mystery operations (multiple locations)
  - 69 kV, radial and networked
- No False Indications, hundreds of operations experienced

Remote Fault Indicators at MEC

69 kV Application
(Radial Tapped Sub – with N.O. Tie)

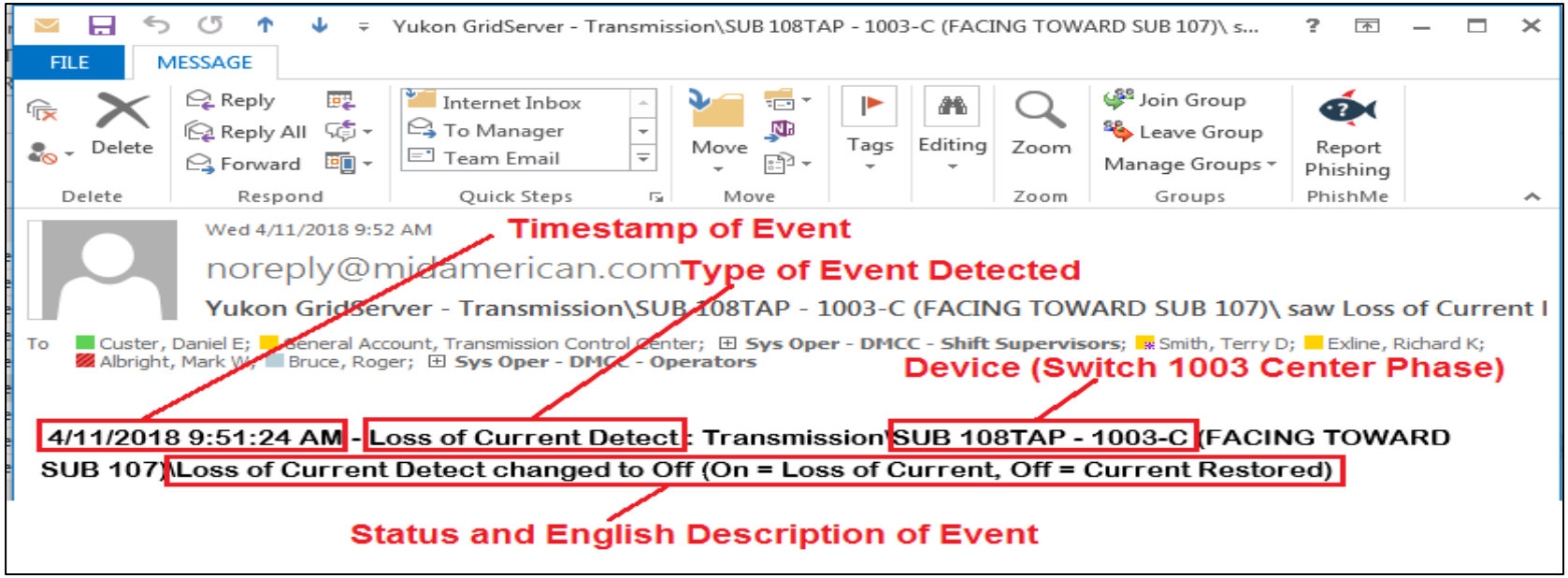


Remote Fault Indicators at MEC

Underground Distribution Application (Padmounted Switchgear)

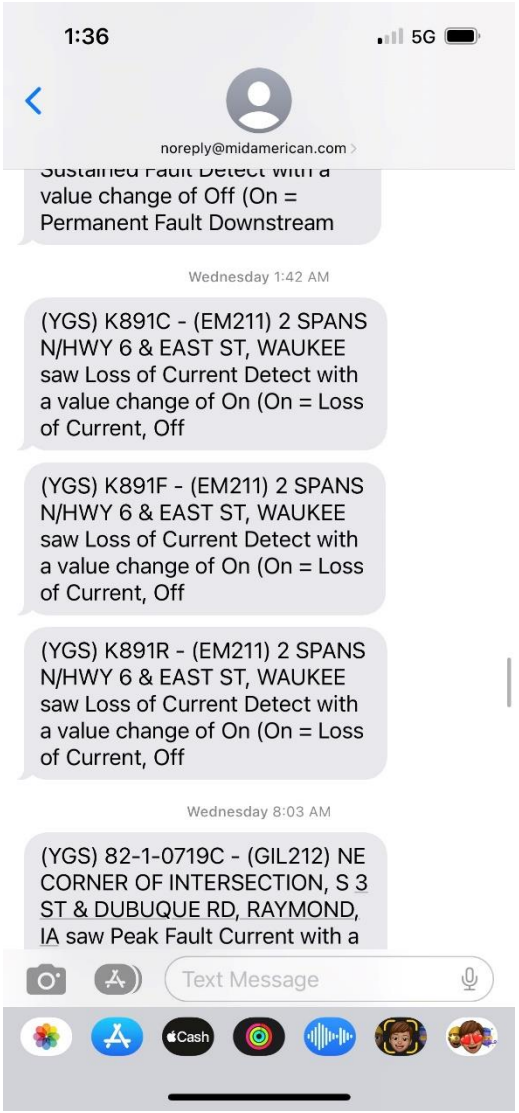
Remote Fault Indicators at MEC

- No DMS to route fault indicator data directly
- Initial use of email/text as “interim” solution



- Currently using event driven text and email notifications to real-time desk
  - Permanent Fault
  - Loss of Current
  - Momentary Fault
  - Additional notifications emailed to management for Loss of Communication or Battery Issues

Remote Fault Indicators at MEC



Visual T&D for Network 69 kV Application

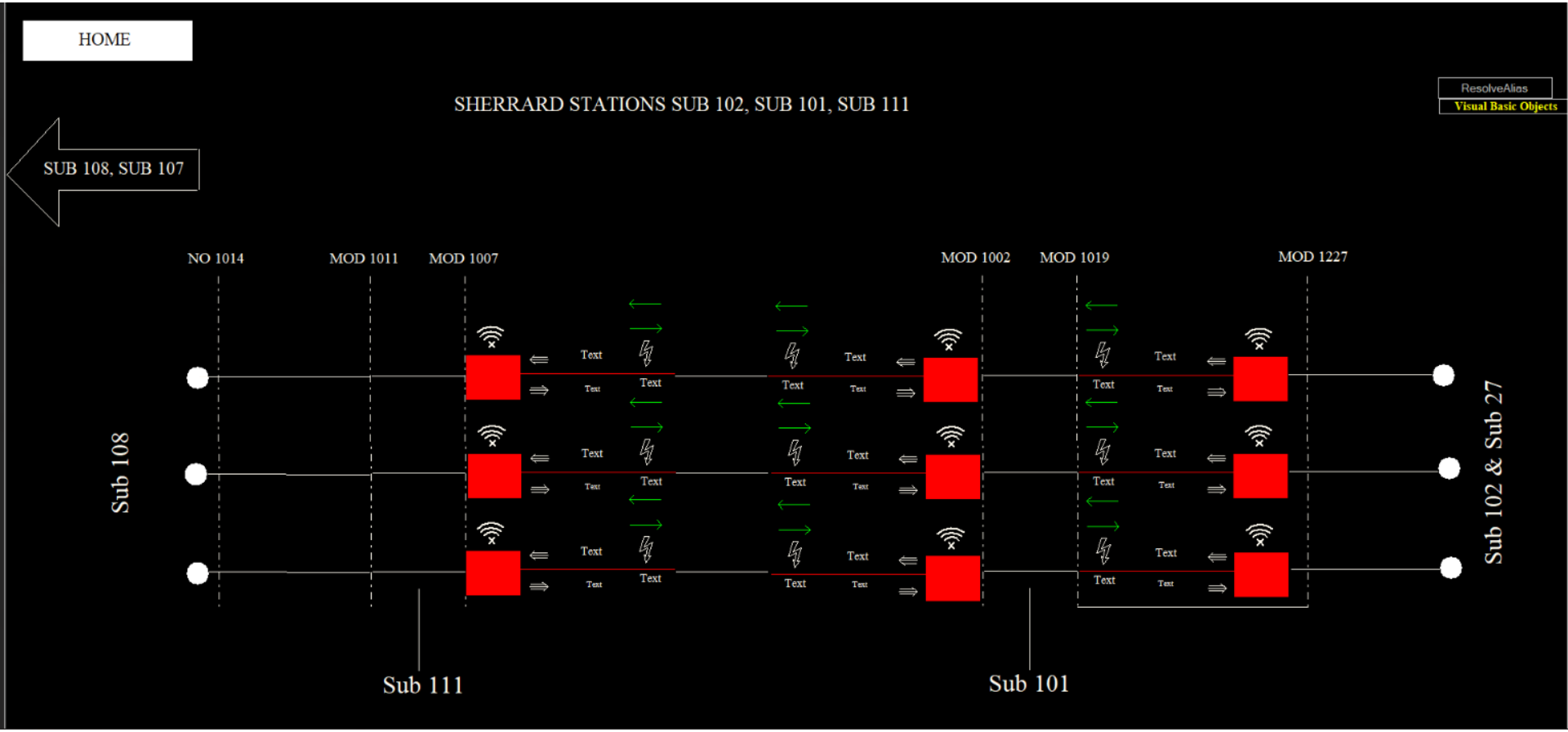
- Need to include fault direction for network situations (not possible via text/email approach)
- Visual T&D Application
  - SCADA-like interface
  - Schematic development, and point association
  - Will use for next 2-4 years while transitioning to DMS

Visual T&D for Network 69 kV Application

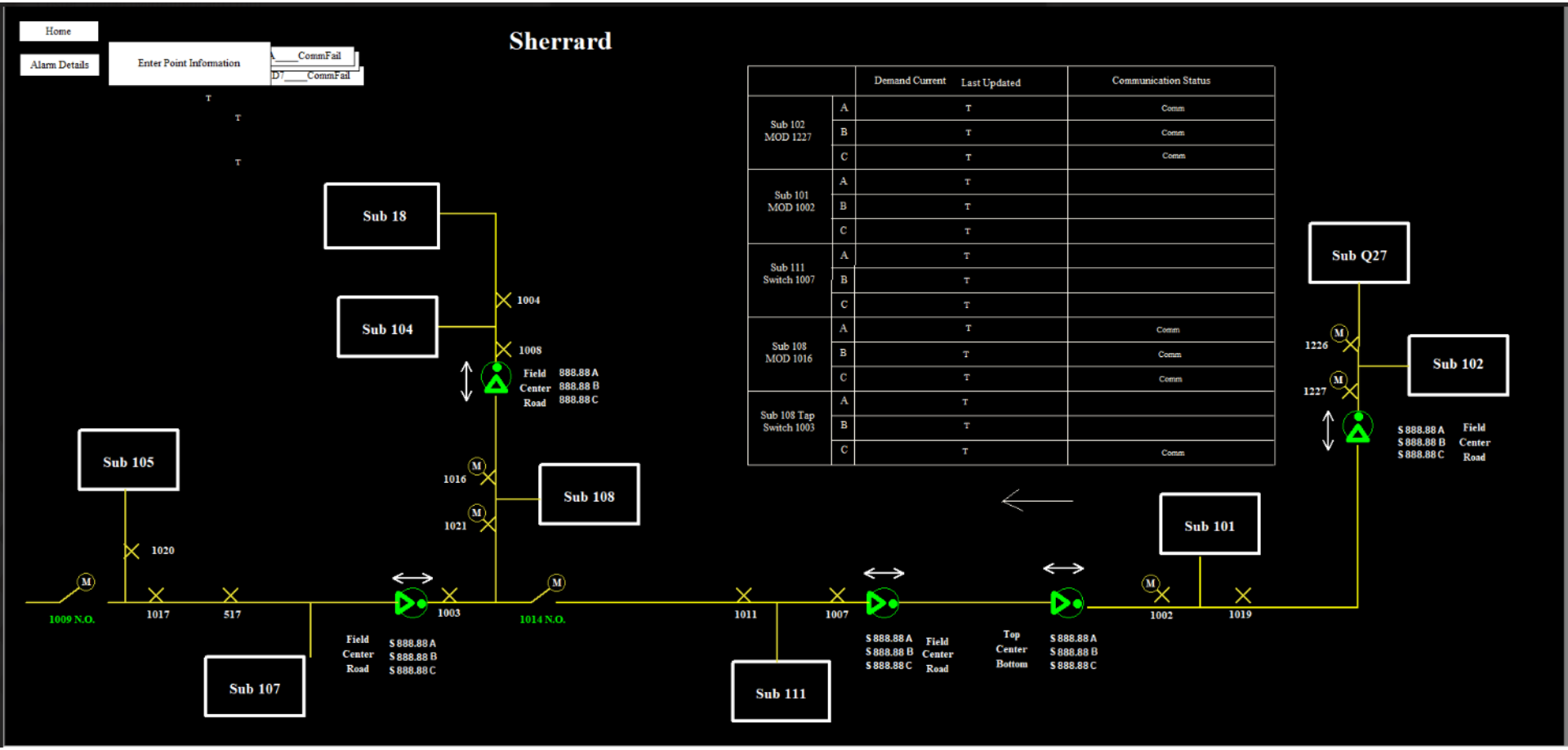
Transmission

- Sherrard
- Inwood Tap - Inwood & Hudson Jct - Sioux River
- Sac County - Schaller - Odebolt - Lake View
- Red Oak - Enron - Griswold
- Clarinda - New Market - Bedford
- Blackhawk - Dewar - Jesup
- Clarksville - Allison
- Humboldt East - Rutland Tap - Gilmore City
- Sherrard (Quad City) Sub 102. Sub 101. Sub 111
- Sherrard (Quad City) Sub 104. Sub 108. Sub 107
- Sac County - Schaller - Odebolt - Lake View
- Eastside - Lawton - Moville - Kingsley
- Pomeroy
- Little Sioux - Grand Meadow - Correctionville

Visual T&D for Network 69 kV Application



Visual T&D for Network 69 kV Application



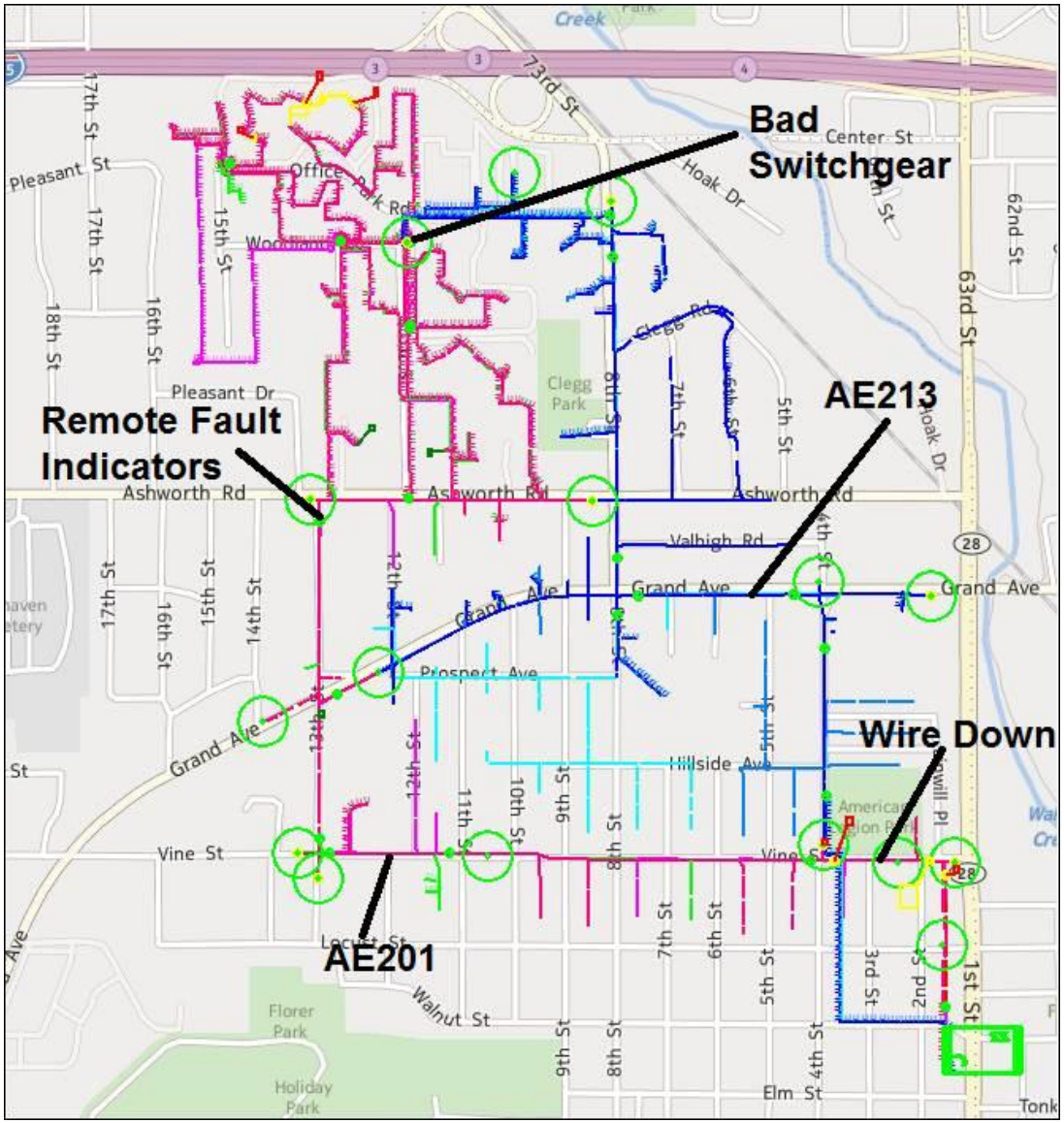
Remote Fault Indicators at MEC

- Challenges with fleet of 2,600 devices
  - Initialization to cell network and downloading settings, multiple steps and time to setup individually
  - Firmware upgrades
  - Incompatible external sim cards (4G) vs. onboard
  - Device status/health-check
- Opportunities
  - Firmware updates, device management
  - 4G lifecycle
  - Line disturbance, fault waveforms
  - Pre-programmed from factory IP, Cell provider… Plug in battery and install
  - Speed up interface

Remote Fault Indicators at MEC

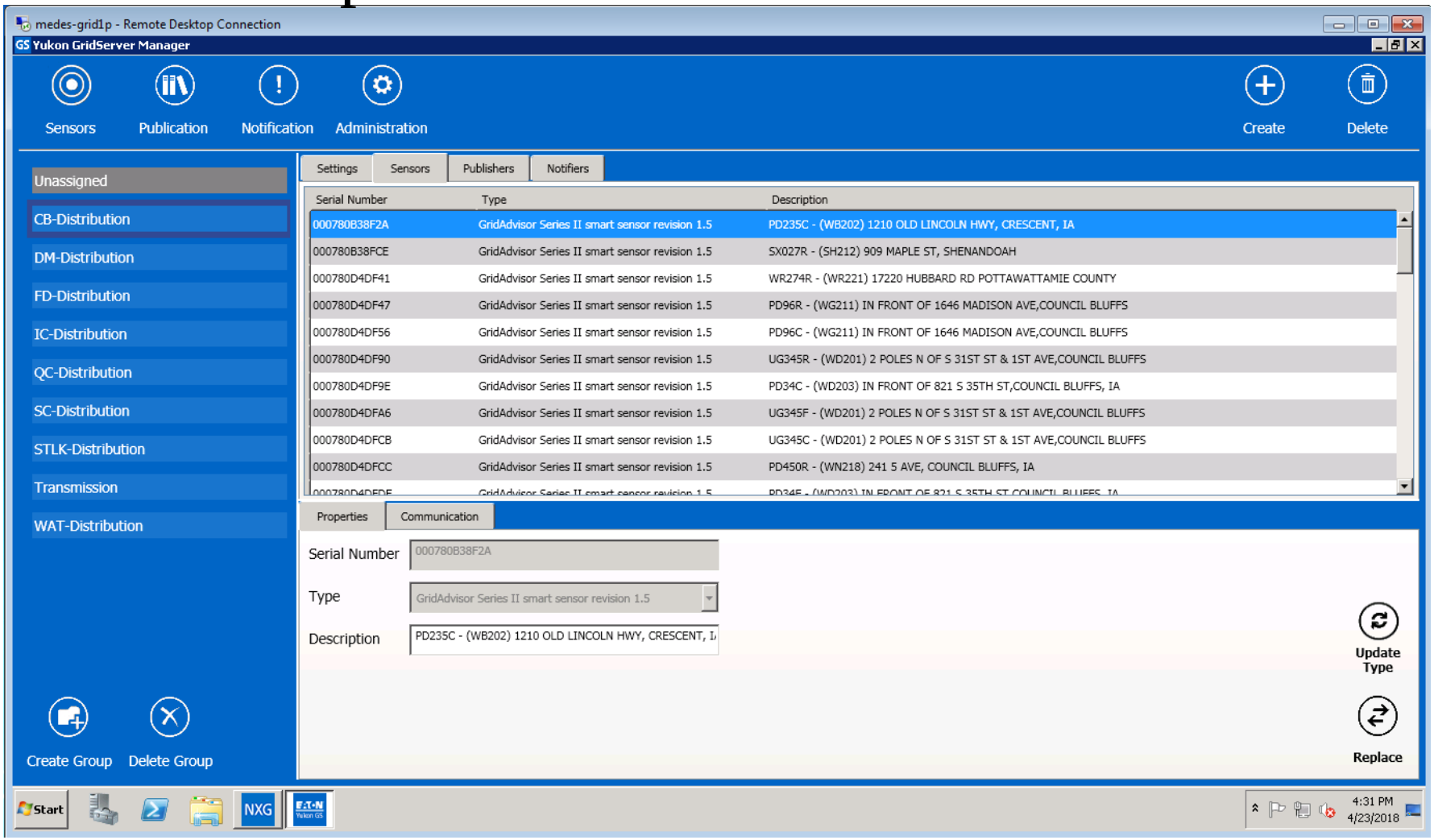
- Future state
  - Increasing DA capabilities at midpoints (includes built-in fault indication)
    - Padmount retrofit
    - Overhead
  - Generally in locations where fault indicators were previously installed.
    - Repurpose the fault indicators from these locations to other circuits or, midpoint of the midpoint
  - Build-out of ADMS system to integrate all field devices, and further expand (visibility, customer service, etc)
    - Will incorporate fault indicators as part of this to support future automation (FLISR)

Interesting Events



Remote Fault Indicators at MEC

- Device Setup



QUESTIONS??