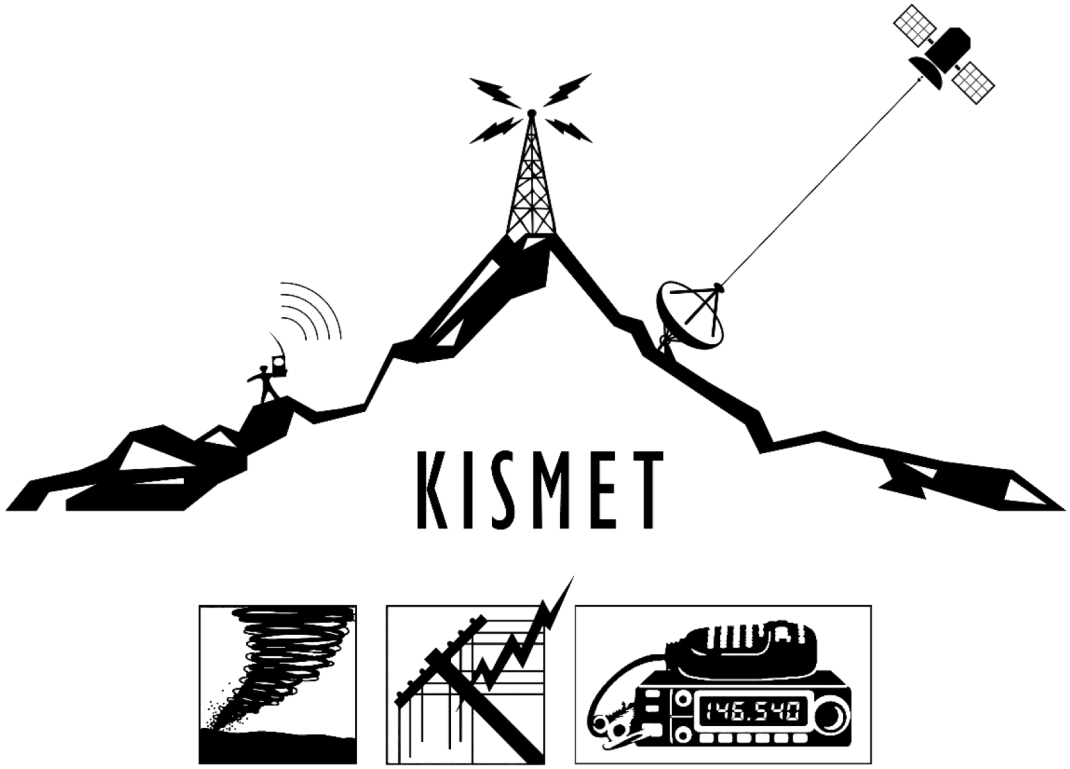


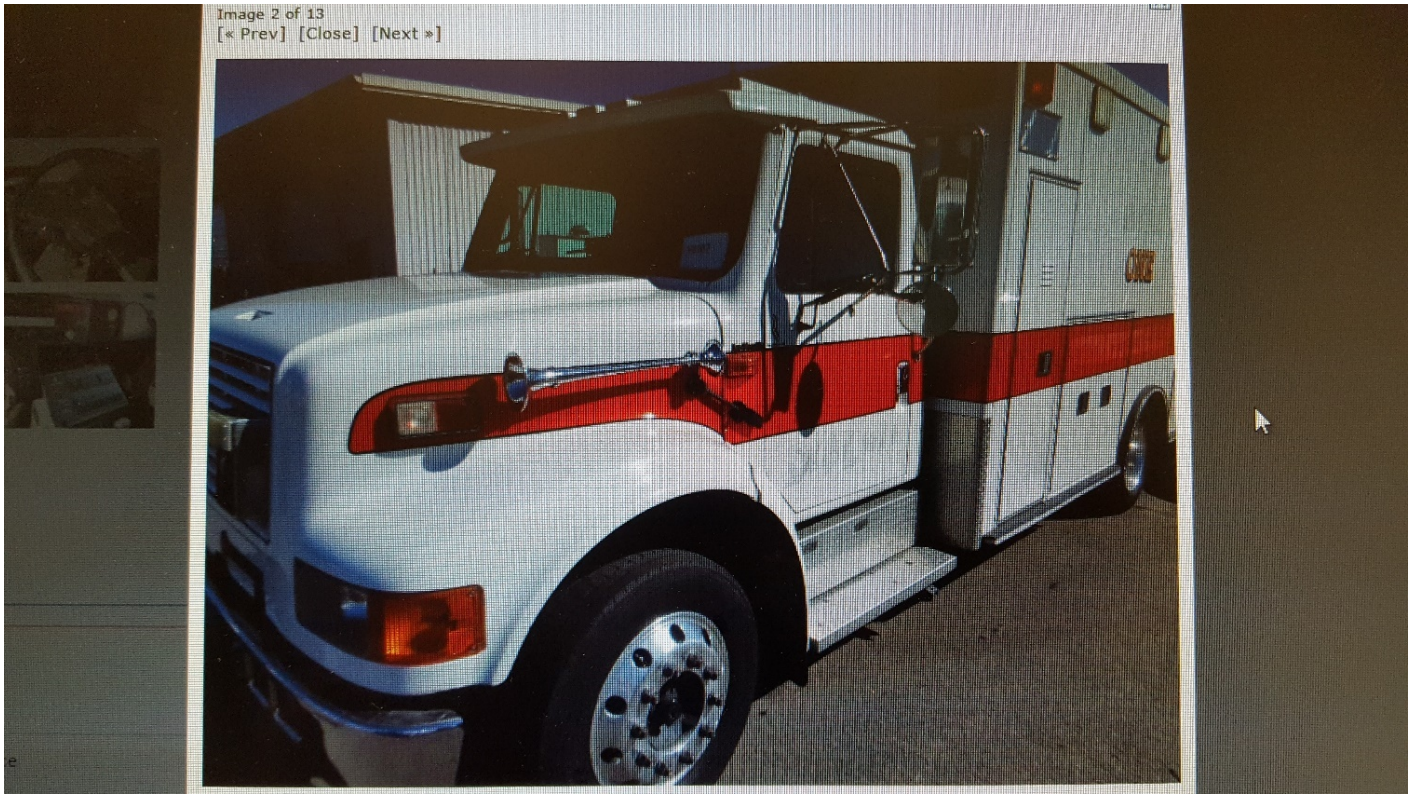
Mobile Communications for the 21st Century

Exploring the process of designing and building a communications vehicle with the need for digital voice, data and analog communications

MicroHAMS - March 2019

Point of Discovery

- **Randomly spotted a used ambulance on the Public Surplus auction website**
  - It was conveniently located in Everett, WA
  - Had a reasonable starting price of around $1,500
  - 2001 International 4700LP Road Rescue



Acquisition Process

- **Fought competitively for the truck in a Dutch Auction**
  - Eventually reached the final bid price of $6,200
- **Changed the vehicle classification from commercial to private/recreational**
  - Drastically reduced the license fees beings it is no longer being used commercially “for-profit” as originally intended

Cleanup Process

- **Stripped off the decals and bathed it in solvents**
- **Removed the unit number placards**
- **Cleaned and sterilized everything from head to toe**
- **Removed unnecessary items**
  - Medical supply cabinets, glove holders, oxygen and suction equipment, cabinetry doors, gurney and its floor mounts
- **Repaired any aluminum and fiberglass body damage**

Build Process

- Installed 4 AGM batteries in the old oxygen compartment for “house power”
  - Totaling 400 Ah
- Installed a 2000-watt pure-sine inverter and tethered it to the AGM batteries

Build Process

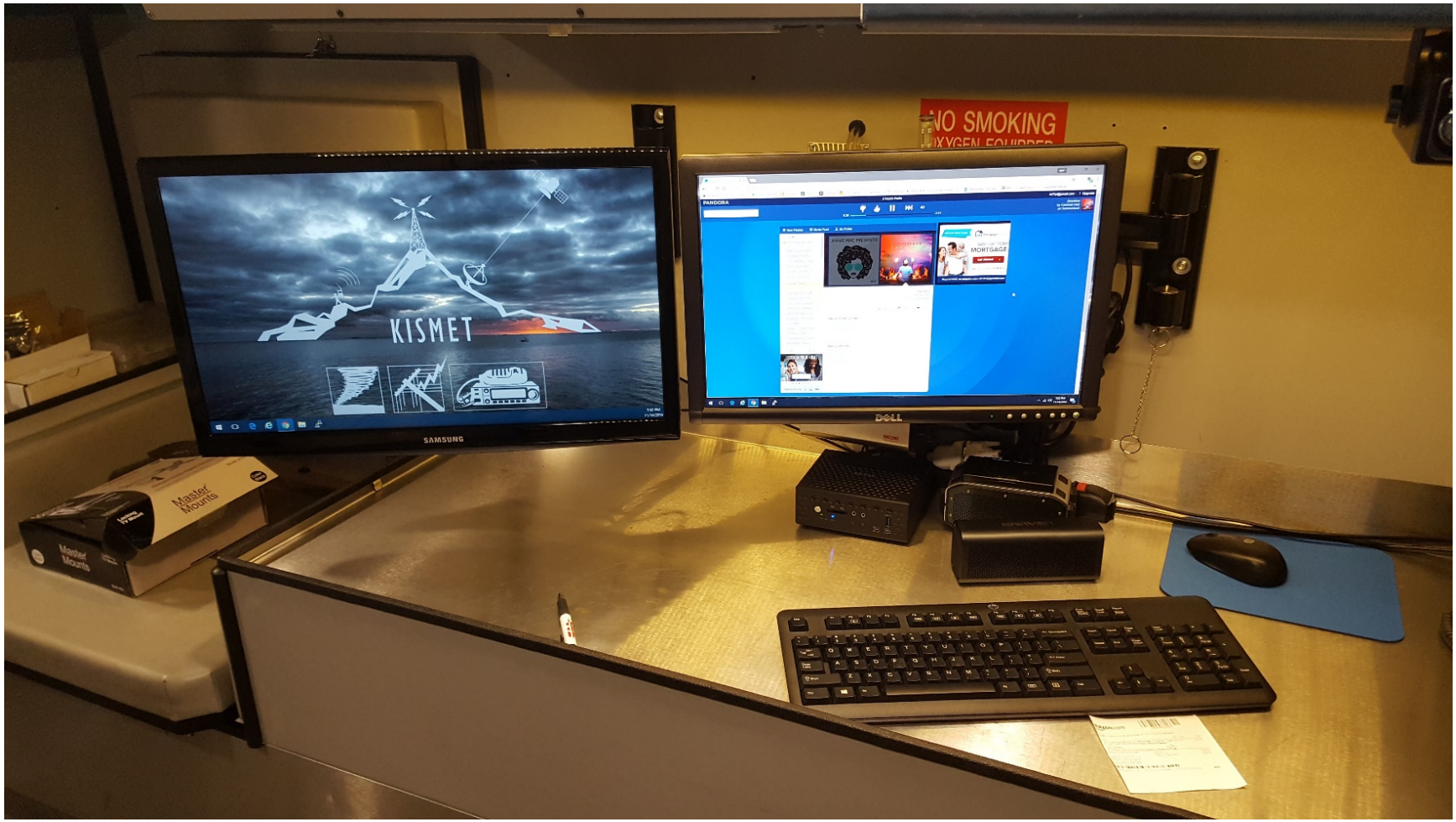
- **Installed a Battery Isolator solenoid to automatically balance the charge between the house batteries and chassis batteries**
  - When plugged into shore power, it bonds the two sets of batteries together when it senses a lower voltage on the chassis batteries to keep them charged
  - When the engine is running, it works in the opposite manner by engaging the solenoid when it senses a lower voltage on the house batteries
  - Also provides backup engine starting power by pressing a button to engage the solenoid, should the chassis batteries become depleted while out in the field

Build Process

- **Installed the first two radios that were on hand**
  - VHF Motorola Spectra with dual remote-mount heads
  - Tri-band B-Tech VHF/UHF/220 with remote head
  - Tethered the two radios to the pre-existing NMO mounts on the roof

Build Process

- **Installed a computer console**
  - Zotac Mini PC w/ SSD
  - Two monitors with lockable articulating wall mounts



Build Process

- **Fabricated and installed the first rack in the forward cabinet**
  - Populated it with network equipment
    - Business grade Sophos router
    - Sophos Wireless AC access point
    - PoE network switch
    - Ran CAT6 between the rack and computer console
    - Added a battery backup

Build Process

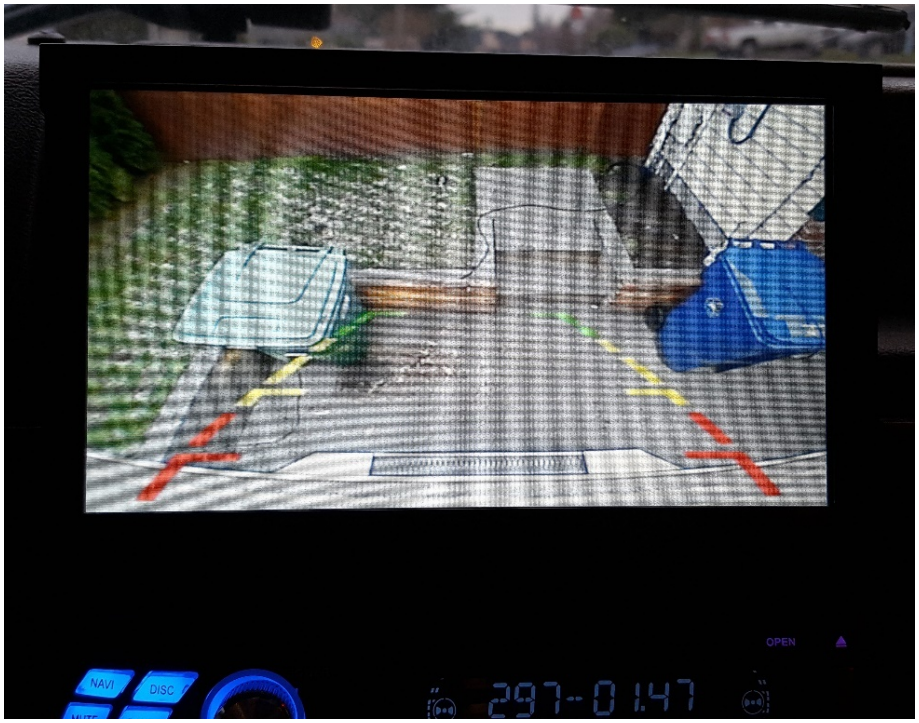
- **Upgraded the majority of interior and exterior lighting to LED's**

Build Process

- **Placed a dehumidifier and heater in the vehicle**
  - Moisture had become a problem during the winter months after working inside the truck a lot as it would tend to collect and freeze
  - Hasn't been a problem since

Build Process

- **Replaced the factory stereo with an Android-based touchscreen system**
  - The system was chosen for its ability to load any Android apps and be tethered to a WiFi hotspot for web-enabled applications (APRS, Navigation, etc.)
  - Also installed a backup camera and tethered it to it

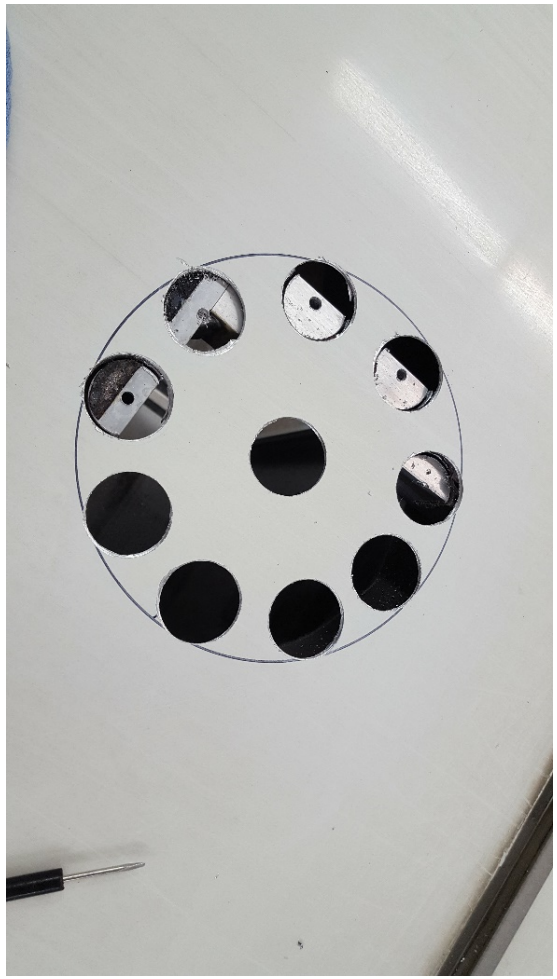


Build Process

- **Prepare to install a 42-foot pneumatic mast**
  - Having snowfall on the roof with a heater inside proved to be a great way to identify cross members in the roof that would have otherwise been invisible

Build Process

- **Prepare to install the 42-foot pneumatic mast**
  - Measured out the appropriate location and cut the hole in the roof



Build Process

- **Installed the 42-foot pneumatic mast**
  - Used a Genie boom lift to lower the mast through the roof and bolted it onto a custom steel platform

Build Process

- **Finalized the install**
  - Extended the mast to verify it was fully operational
  - Added plumbing to the inside section of the mast so any water can cleanly drain out when fully extended

Build Process

- **Designed a logo and fitted it for proper alignment**
  - Ordered a paint mask of the logo in preparation for painting the vehicle

Build Process

- **Paint the vehicle**
  - Weekend 1: Sanded down the entire body of the vehicle
  - Primed the rear of the vehicle with a catalyzed primer
    - Keeps any missed contamination below the surface from transferring through to the final coat
  - Applied black paint to the rear of the vehicle

Primer

Paint

Build Process

- **Paint the vehicle (cont'd)**
  - Applied the paint mask of the logo and proceeded to paint it gray with added pearl to make it glisten
  - Applied clear coat to give it a shiny appearance

Build Process

- **Paint the vehicle (cont'd)**
  - Weekend 2: Primed, painted, and clear coated the front
  - Also painted the awning to match (yet to be installed)

Build Process

- **The finished product after two very long weekends**

Build Process

- **Dedicated a portable 3000-watt pure-sine generator to the truck and housed it in a rear compartment**
  - Honda inverter generator - Model: EU3000iS

Build Process

- **Installed an automatic satellite dish for DirecTV reception**
  - Winegard Trav'ler – Model: SK-SWM3
    - Chosen for its best reception due to the size of the reflector
  - Paired it with a DirecTV HD receiver

Stowed

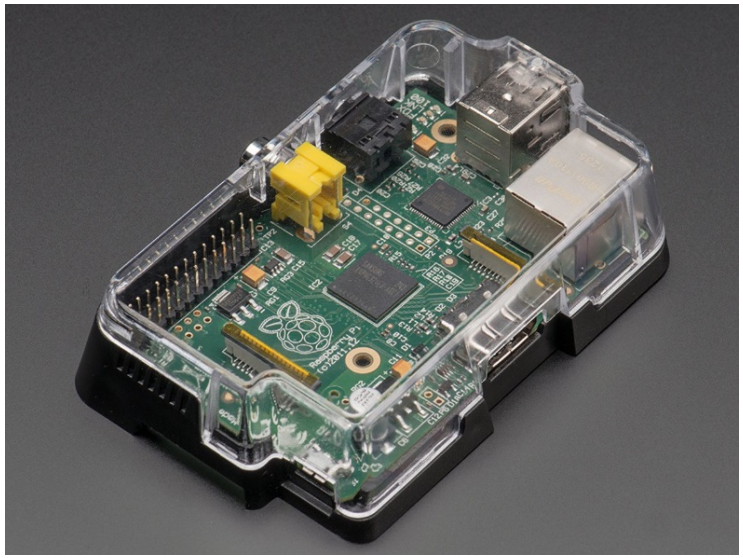
Deployed

Build Process

- **Added a secondary 12-volt air compressor and a hose reel to the mast compartment so the pneumatic mast can maintain elevation in a long-term deployment**
  - Non-lockable pneumatic masts have a tendency to sag after long-term use without adding more air

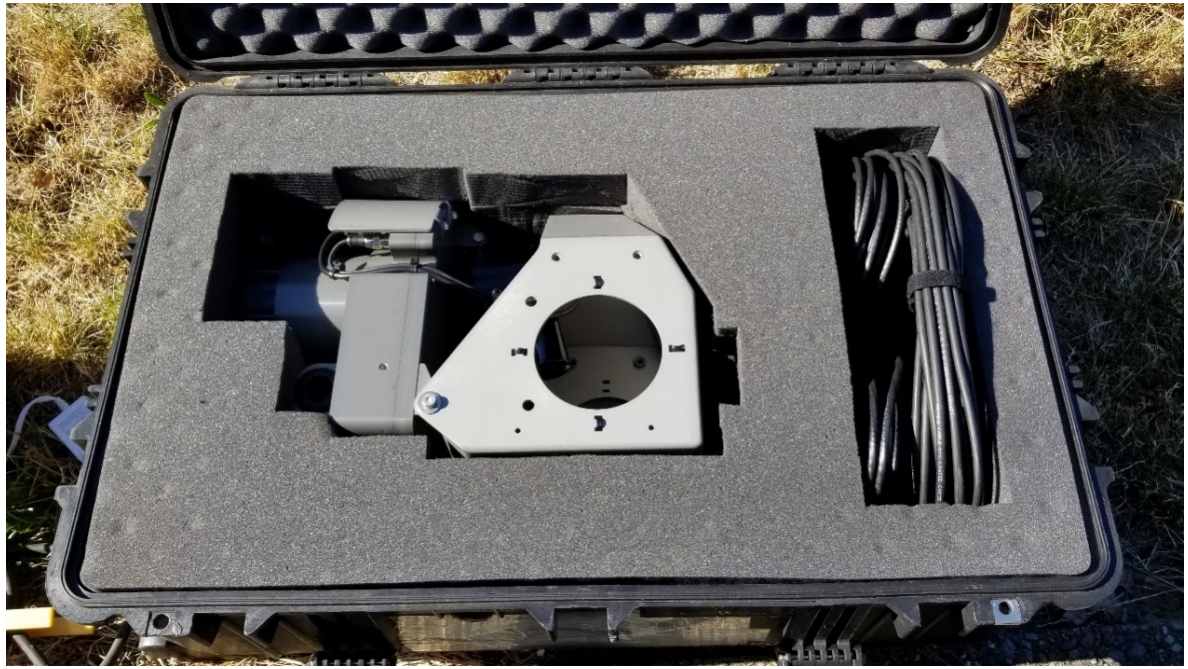
Build Process

- **Installed a VoIP phone and an onboard phone system**
  - The VoIP phone is a Sangoma S500 with 4 lines
    - Line 1: Local extension to the onboard phone system
    - Line 2: Extension to the phone system at Kyle's house via VPN
    - Line 3: Extension to the phone system at Kyle's house via HamWAN
    - Line 4: Extension on the HamWAN phone system
  - The phone system is a Raspberry Pi running Asterisk
    - It has its own dedicated DID so the truck can be accessed from the public switch network



Build Process

- **Purchased a GPS and compass enabled antenna pointer, primarily for use with HamWAN**
  - Made by Nextmove Technologies – Model: LinkAlign 360EER
  - It allows you to save specific coordinates (cell sites) into memory for quick and easy deployment
    - Automatically locks onto the heading of the chosen cell site
    - Also added the ability for the pointer to communicate with the Mikrotik Metal radio to automatically peak the signal via SNMP



Build Process

- **Installed the first radio rack in the right-hand cabinet**
  - Custom cut a two-post rack to fit into the original cabinetry

Build Process

- **Had the first radio rackmount custom made by Novexcomm**
  - For a Motorola XPR 5550 UHF (DMR) and a Motorola XTL 5000 800MHz
  - When doing custom work with Novexcomm, it is best to drop-ship any new radios to them so everything can be fitted to perfection

Build Process

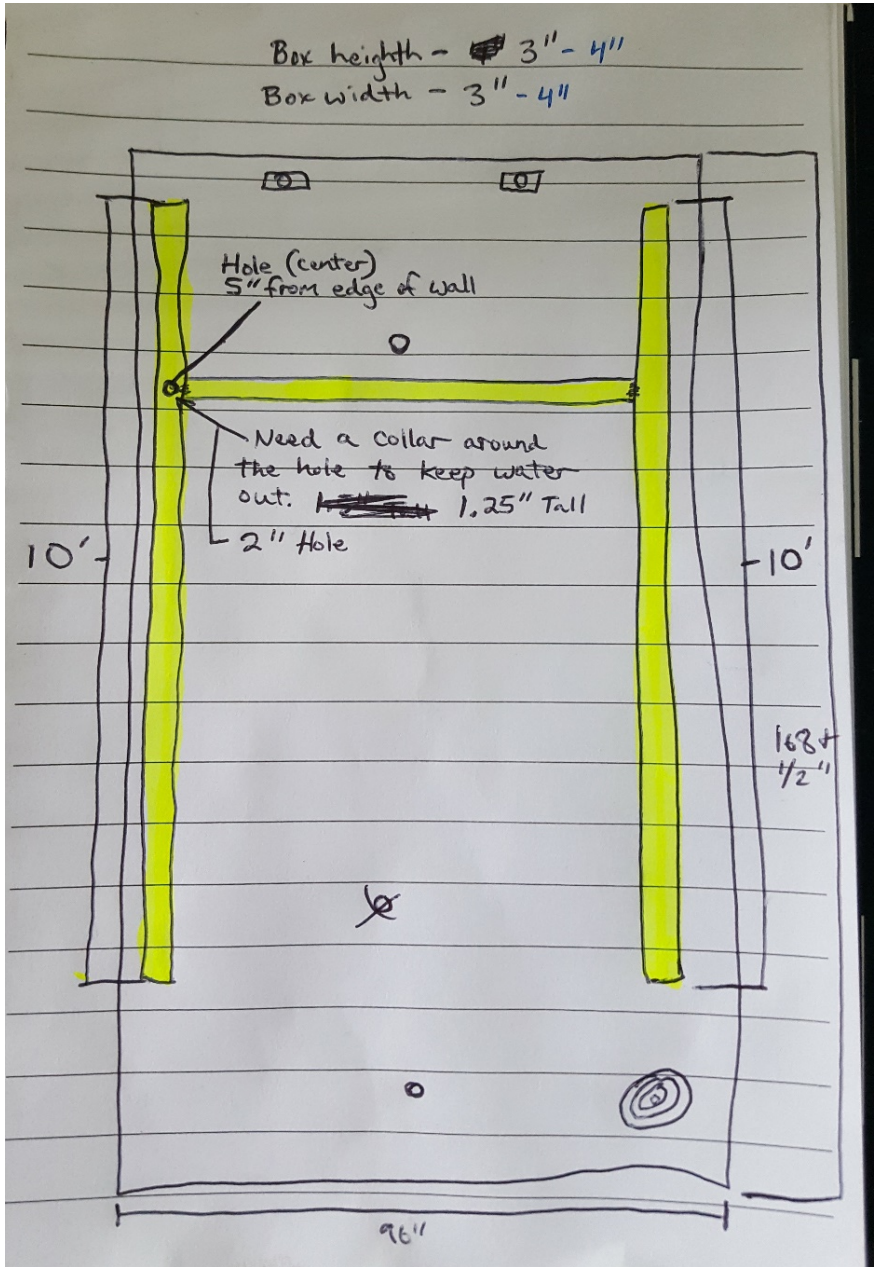
- **Installed a Motorola MCS 2000 VHF 110-watt with two remote heads for use between the cab and rear workspace**
  - The MCS 2000 was chosen due to the vehicle already being wired for the same model radio in its past life
  - The vehicle was also previously wired for tactical headsets in the cab, with the ability to communicate via the MCS 2000 with a PTT button in the dash

Build Process

- **Installed a secondary head for the 800MHz radio in the cab for access while underway**

Build Process

- **With a need to easily add more antennas, Kyle started designing an antenna rail idea to be mounted on the roof of the truck**
  - The design was to take two C shaped pieces of aluminum and place one over top of the other (with the top one being slightly larger)
  - Ended up going to Smiley's Inc. in Mount Vernon to have them fabricate two 10-foot aluminum rails with end caps and thumb screws



Build Process

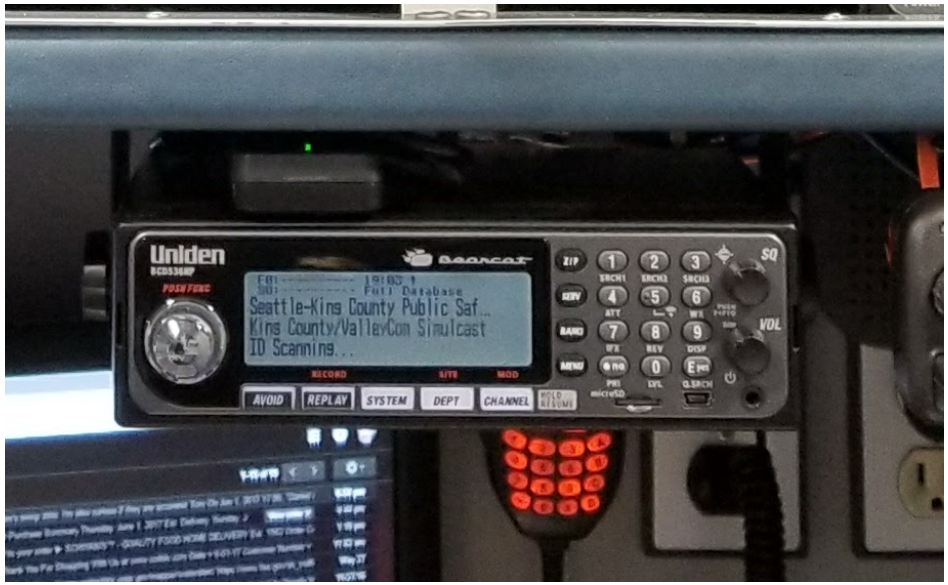
- **The forward section of each antenna rail is the only point where a hole was drilled for the coax to pass through the roof**
  - To keep moisture from entering the vehicle, a collar around the coax entry hole was applied to divert water around it, should moisture ever make its way inside the rail
- **NMO mounts were installed on the top rail caps in 2-foot intervals**
  - The coax safely lays inside the rail until it reaches the hole for vehicle entry

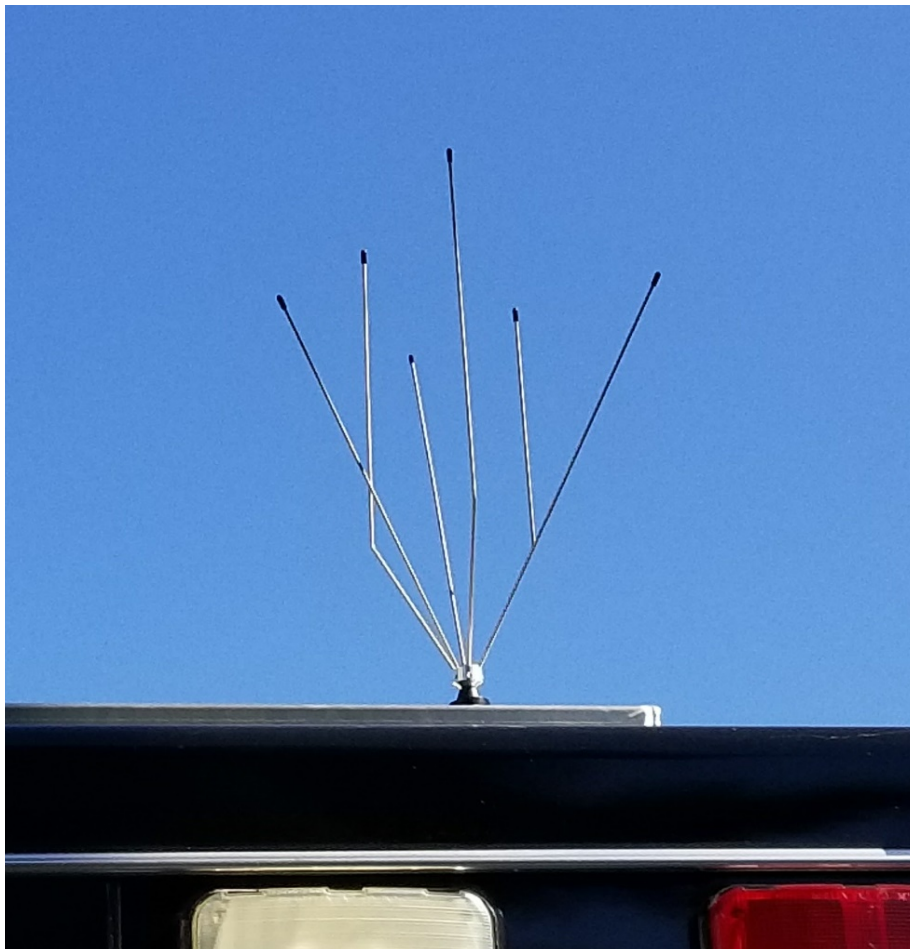
Build Process

- **Installed an Icom ID-5100 for D-Star capability**
  - Had a custom rackmount made for it by Novexcomm

Build Process

- **Installed a Uniden BCD536HP scanner for situational awareness of analog, P25, DMR, and NXDN communications**
  - Paired it with a wideband 25MHz to 6GHz MP antenna





Build Process

- **Cut another large hole in the roof and installed an air conditioning unit with heating capability (heat pump)**
  - It was installed so the interior climate could be controlled without the need to run the engine
  - Due to the high amperage draw, a separate circuit was added to keep it independent from the pre-existing circuitry
  - When out in the field, it can be powered by the portable generator

Build Process

- **Added two more custom made Novexcomm rackmounts**
  - One to house a CB and the B-Tech tri-band radio
  - The other to house a TNC-X, Kantronics PacketCommunicator, clock, voltage readout for the house batteries, and a KISMET backlight to fill the remaining space
  - The B-Tech tri-band radio was interfaced to the PacketCommunicator primarily for Winlink communications

Build Process

- **Installed 7 new wideband antennas (VHF/UHF/700-900MHz)**
  - Two of which are PCTEL – Model: PCTWSLMR
  - The remaining five are Browning – Model: BR-136

Build Process

- **Installed a laptop stand in the middle of the cab**
  - Used for additional navigation, APRS (via APRSIS32), and other forms of digital communications

Build Process

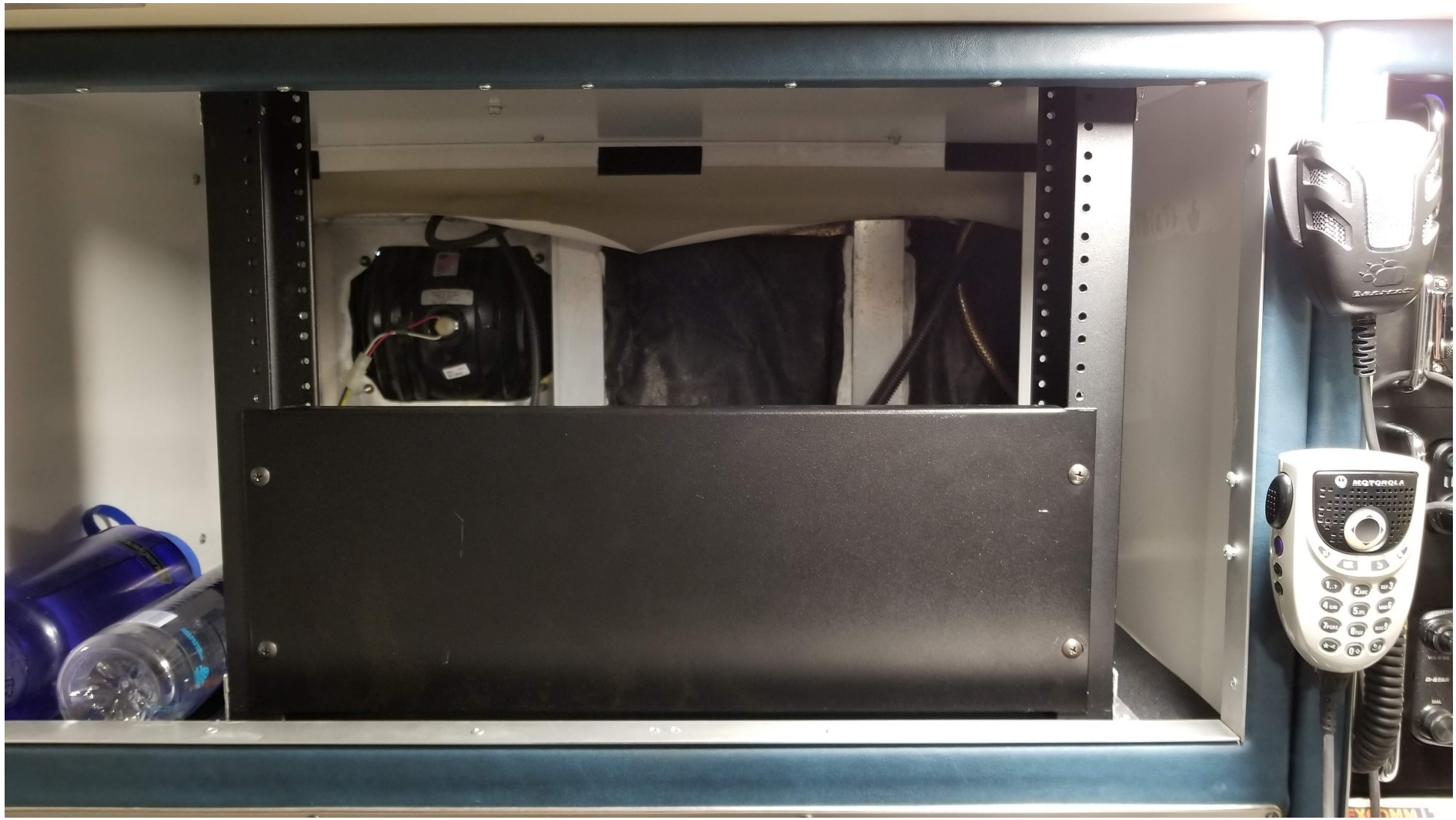
- **Installed a Kenwood TM-D710G radio in the ceiling compartment of the cab**
  - Its primary purpose is for tracking the vehicle with APRS and to give the driver/passenger access to UHF while underway
  - It was paired with another Browning wideband antenna that is mounted on the roof of the cab
  - It has a built-in TNC that is also capable of interfacing with the laptop while underway, should the need arise

Build Process

- **Mounted a water-tight box on the roof with quick-connects for quick and easy interfacing with equipment on the mast**
  - Installed two water-tight N-Type connectors
  - Installed two water-tight RJ45 connectors

Build Process

- **Installed the second radio rack in the left-hand cabinet**
  - Custom cut a two-post rack to fit into the original cabinetry



Build Process

- **Had two more custom rackmounts made, one for two high-powered radios and the other for speakers and magnetic mic holders**
  - Paired it with a VHF Motorola XTL 5000 110-watt
  - And a UHF Motorola XTL 5000 110-watt

Build Process

- **Installed a VHF Analog/DMR repeater in the forward network rack**
  - A Hytera RD982S

Build Process

- **Installed a cellular booster for repeating the signal inside the vehicle with support for multiple users and all US carriers**
  - A Weboost Drive 4G-X with interior panel antenna
  - Paired with a low-profile 4G Laird antenna on the roof

Build Process

- **Fabricated an alternative mount for the mast to support an NMO mount antenna and a PTZ camera**

Build Process

- **Added a WiFiRanger to the truck for connecting to nearby WiFi via an externally mounted 2.4 and 5 GHz antenna**
  - The WiFiRanger makes it easy to manage connections with the ability to set priorities and control a portal for segregated guest access
  - All of its previous connections are retained in memory so it can automatically connect the next time you're in range
  - It also has the ability to automatically test multiple connections and pick the one with the best throughput

Build Process

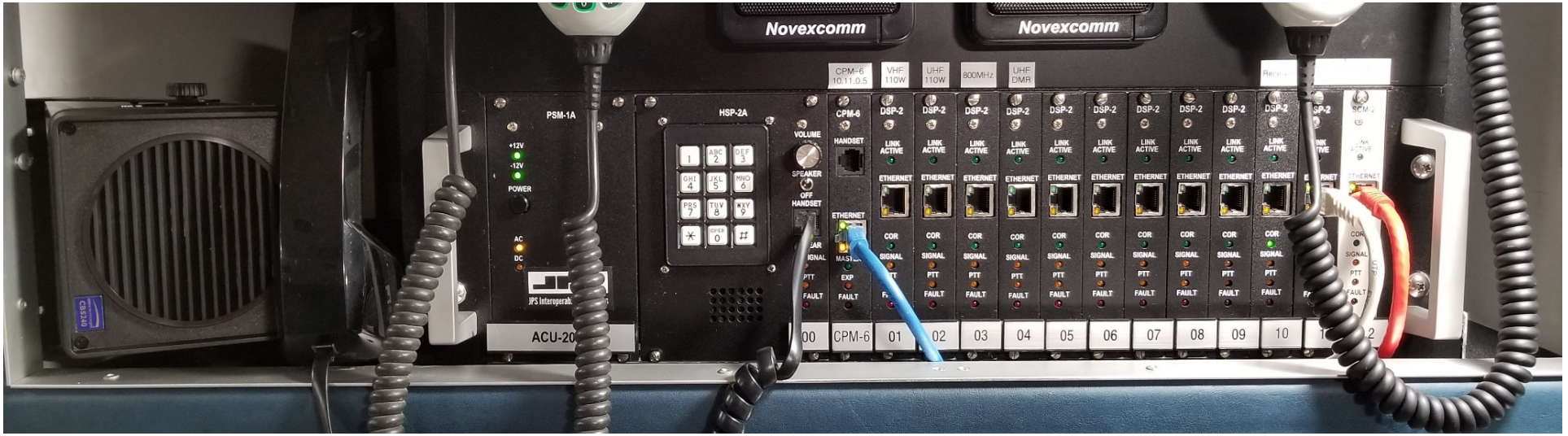
- **Installed a rack-mounted VHF duplexer and paired it with the Hytera repeater**
  - It has the ability to interface with a roof mounted antenna or an antenna that can be mounted onto the mast

Build Process

- **Installed a JPS ACU-2000 Interoperability Gateway**
  - It provides the ability to easily patch two or more radios together in a single net or up to 7 separate nets
  - It was configured with 11 DSP-2 modules
    - 10 of them are dedicated to interfacing with radios
    - 1 of them is dedicated to RoIP communications
      - RoIP gives you the ability to control and communicate over any connected radio via a remote PC console
      - Also has the ability to interconnect with other JPS ACU Interoperability Gateways or Network Extension Units

Build Process

- **Installed a JPS ACU-2000 Interoperability Gateway (cont'd)**
  - It was additionally equipped with one SCM-2 module
    - It allows the ACU to interface with the onboard phone system via the VoIP SIP protocol
    - When a radio is patched to the SCM-2 module, it allows the ACU operator to initiate a phone call, giving the phone user the ability to communicate via radio
    - It also has the ability to do the same in reverse, allowing the phone user to initiate the call if patching has already been activated



Additional Photos

“Out in the field” at Haunted Fort Casey

Additional Photos

Additional Photos

In operation during a SAR mission

Additional Photos

5th Saturday exercise – Communicated with SnoCo DEM via VoIP and Winlink over HamWAN

Additional Photos

Night ops at a Ragnar Relay

Future Plans

- **Interface the cab mounted Kenwood radio and the Hytera repeater to the ACU-2000**
- **Install an airband radio and also interface it with the ACU-2000**
- **Mount the already painted awning to the passenger side of the truck**
- **Upgrade the halogen scene lights to LED's**
  - Will allow for a much longer runtime on batteries, prolonging the need to run a generator during night operations
- **Design and fabricate a more permanent mast mount that can hold the HamWAN dish pointer, the PTZ camera, and a couple of vertical antennas all at the same time**
- **Install a generator that is permanently fixed to the truck**

That concludes this presentation

Any questions?

If anyone would like to tour the vehicle or get a demonstration of some of the items we covered today, we will be out in the parking lot during the lunch break and will gladly show you around.