NOAA CO-OPS Continuous Global Navigation Satellite Systems at NWLON Stations

Field Installation Guide

Engineering Division
Center for Operational Oceanographic Products and Services
NOAA National Ocean Service

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1. Introduction

NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) has been establishing continuous Global Navigation Satellite Systems (cGNSS) at National Water Level Observing Network (NWLON) stations from 2018 to date [1]. The purpose of this document is to provide details of the field installation procedure, based on the six cGNSS that CO-OPS has installed at the time this document was written. It should be noted that antenna siting and installation methods are still a work in progress, details of which are specific to each individual location.

All of the six cGNSS field stations that have been installed by CO-OPS to date consist of Trimble brand components. Based on an updated review of commercial-off-the shelf available GNSS equipment, CO-OPS has recently procured several Septentrio brand GNSS systems, for future installations at NWLON sites. Familiarization, integration and testing with Septentrio components remains a work in progress. This first version of CO-OPS cGNSS field installation guide will focus solely on Trimble based systems. This will be an evolving document that gets revised and reissued following CO-OPS implementation of new cGNSS station components.

2. High Level System Overview

The schematic in figure 1 provides a high level overview of cGNSS system design for all CO-OPS installations to date. The system's primary components can be classified into 3 categories:

1) GNSS Measurement System: receiver, antenna
2) Communications: wireless gateway modem, antenna
3) Power: solar panel, batteries, charge regulator

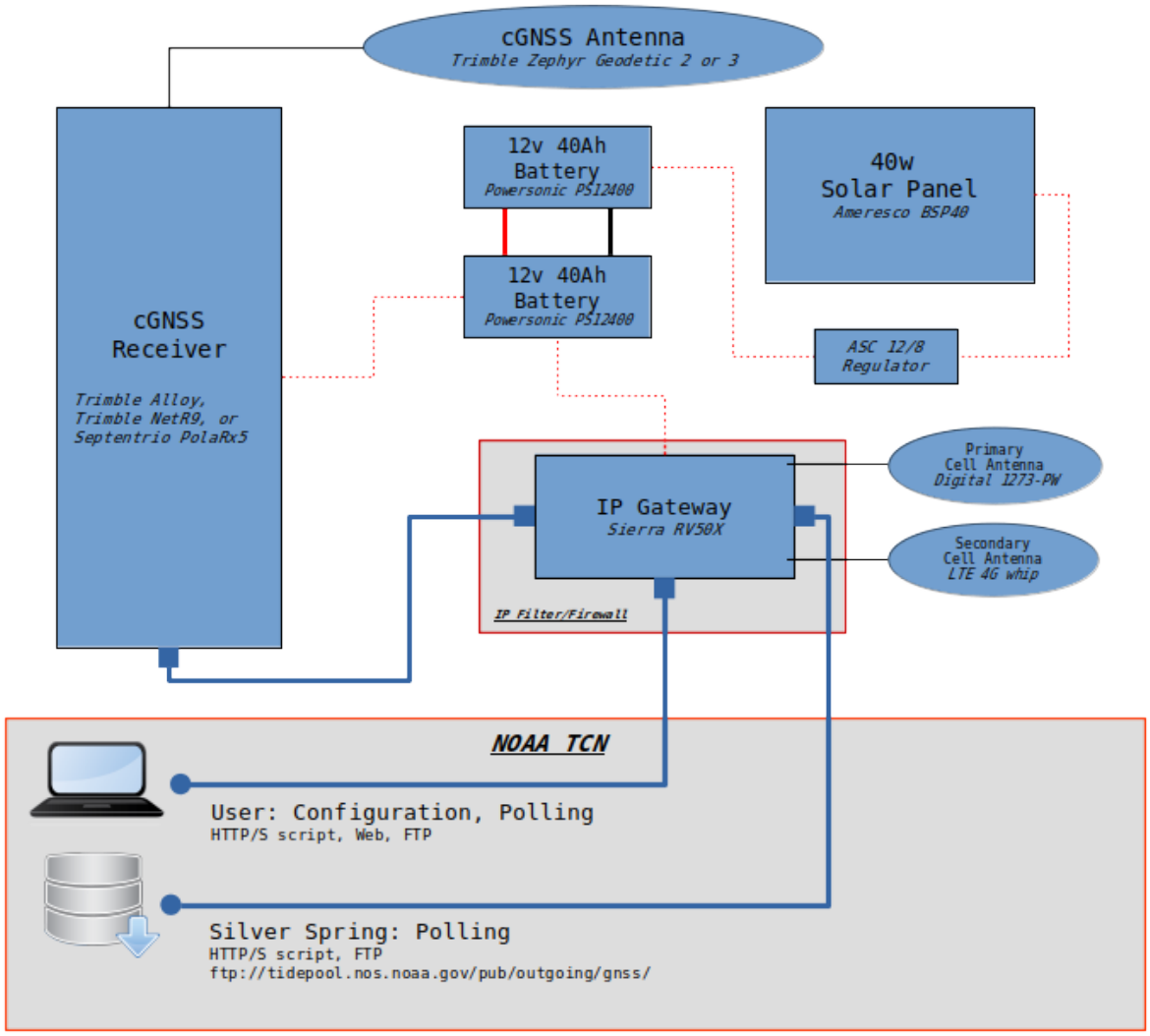


***Figure 1**. cGNSS system design schematic.*

All six cGNSS installations that CO-OPS has completed to date have involved installing the following primary system components **inside of the existing enclosure** (or tide house) at the NWLON stations:

- GNSS receiver
- Wireless gateway modem
- Solar regulator
- Batteries

And the following primary system components (along with all associated mounting hardware) **outside of the enclosure:**

- GNSS antenna
- Wireless gateway antenna

- Solar panel

3. Installation Procedure

3.1. GNSS, Communications and Power System Components - Inside Enclosure

Specific orientation and location of components inside of the existing NWLON enclosure will be determined during site reconnaissance. Two general recommendations for all sites:

1.) The cGNSS system should be completely standalone, with no connections to the NWLON station components

2.) The cGNSS system components should be clearly labelled, so not to be confused with existing, identical components of the NWLON system during any future field maintenance visits to the NWLON station.

Figure 2 shows one example of cGNSS system components installed inside of the NWLON enclosure at the Dahlgren, VA station. At this site, GNSS components are installed just below the NWLON station's primary data collection platform (DCP) box.

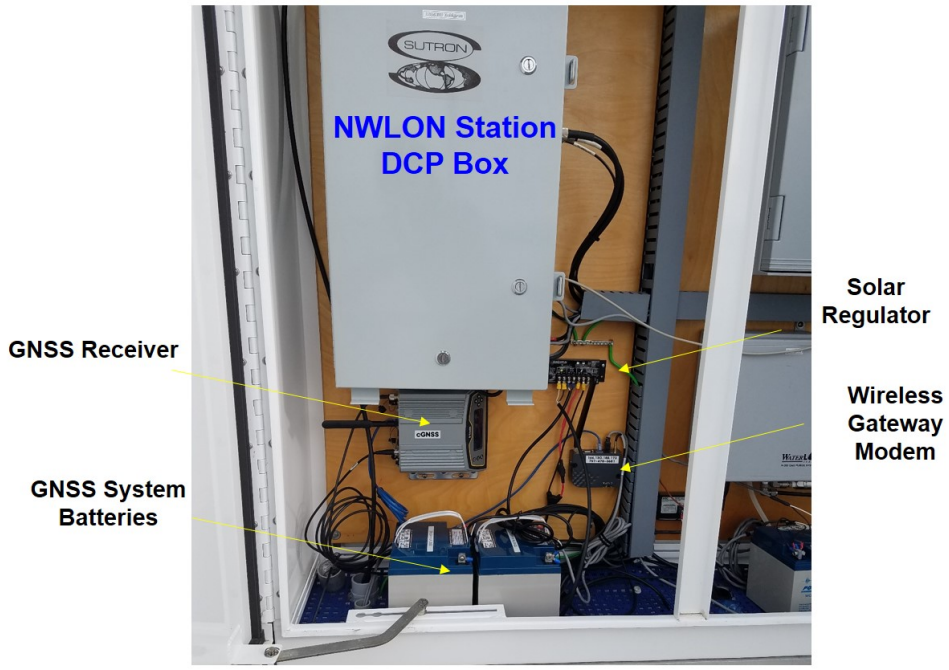


Figure 2*. E*xample of cGNSS system components installed inside of the NWLON enclosure at the Dahlgren, VA station

3.2. Mast and GNSS Antenna, Solar Panel, and Wireless Antenna - Outside Installation

Specific orientation of components to be installed outside of the NWLON station enclosure will be determined following site reconnaissance. Details will vary for every site and will be included in an installation design package. The Engineering Division will always pursue an effort to include members of the planned Field Operations Division installation team throughout the full installation design review process.

Figure 3 shows one specific example of cGNSS system components installed outside of the NWLON enclosure at the Dahlgren, VA station. Figure 4 shows a design drawings for a variety of different cGNSS mast and antenna design types that have been developed to date.

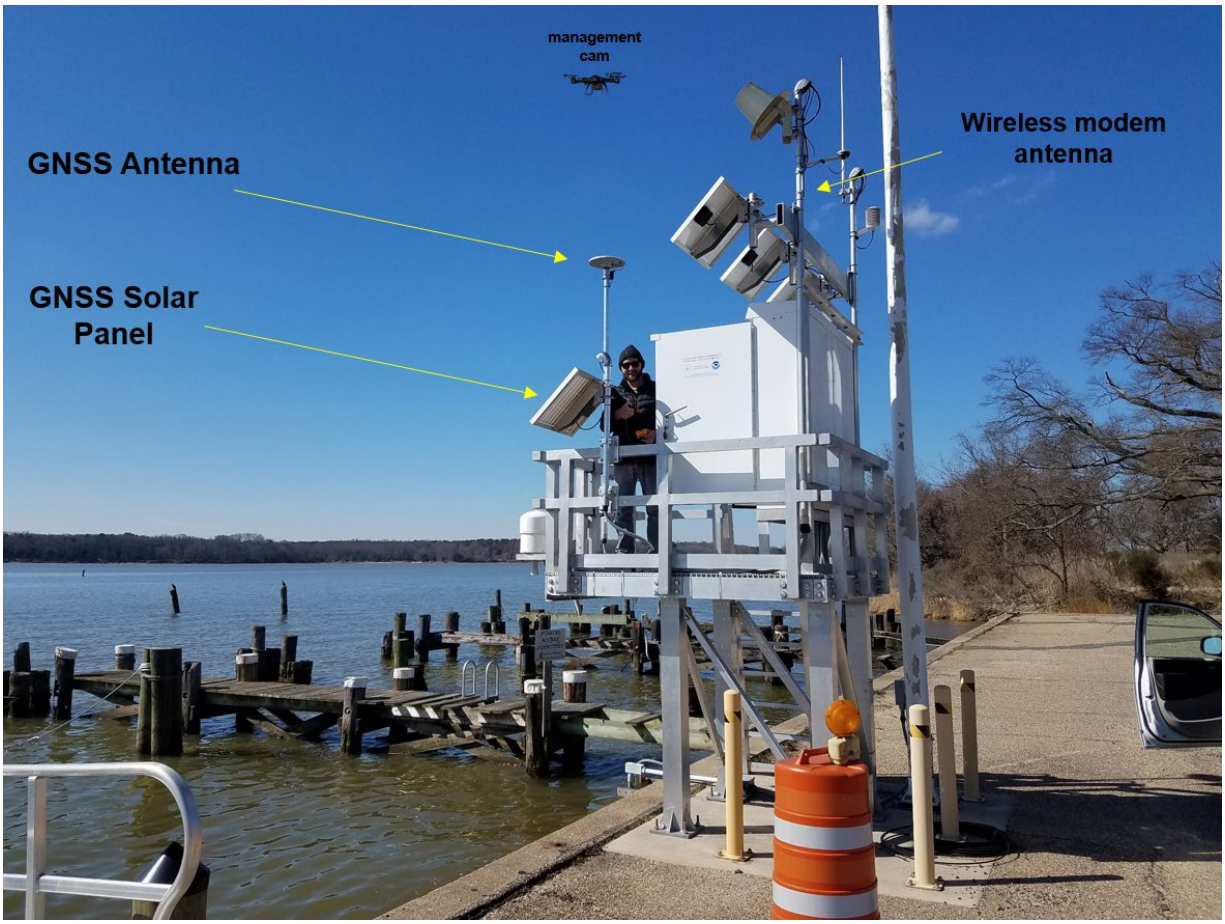


***Figure 3**. E*xample of cGNSS system components installed outside the Dahlgren, VA station

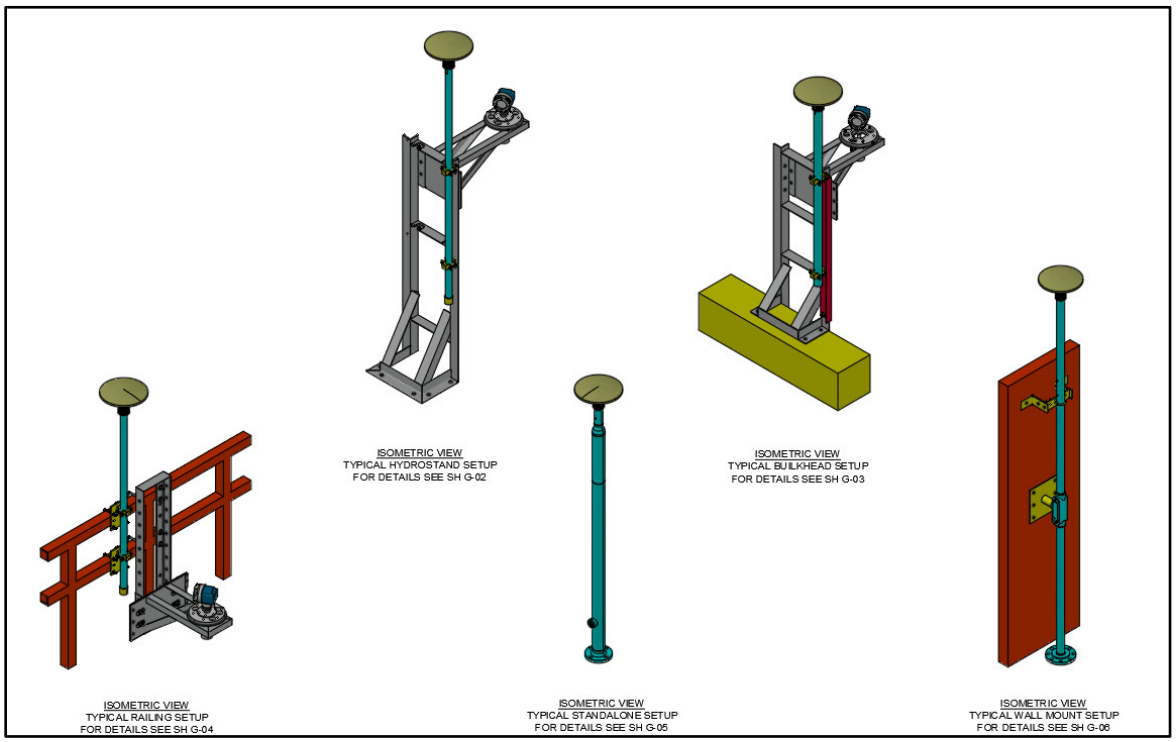


***Figure 4**: Typical Mast and GNSS Antenna Setups*

3.2.1 GNSS Antenna and Mast

Sequence for GNSS mast and antenna installation generally is as follows:

1) Prepare the infrastructure the antenna mast is to be secured to. If the installation drawing calls for a locking pin hole to be drilled, typically for hydrostand or railing installs, carefully measure and mark the center with a center punch. When drilling the hole take care to avoid drilling at an angle or “egging” the hole as this will allow the antenna mast to move, losing its vertical stability. Remove all burrs and raised edges so the mounting components will sit flush. If the installation drawing calls for concrete anchors, prior to drilling the concrete anchors use a rebar detector to ensure that full embedment can be achieved.
2) Assemble the antenna mast and supporting infrastructure per the installation drawing. Prior to attaching the antenna mast, run the antenna cable through to avoid chafing the cable against the locking pin. Leave enough cable length for a drip loop and terminate the antenna cable if necessary.
3) Place the leveling monument on top of the antenna pole and tighten with a 3/8" rod. Remove the brass insert and level the monument using the GNSS leveling kit. Take a photograph of the bubble level once complete.
4) Screw the brass insert onto the antenna then place the antenna and insert into the leveling monument.
5) Use a compass to ensure the #1 marking underneath the antenna, on the outer edge, is facing North.

6) Install conduit as necessary, the conduit run should be kept as short as possible. Connect the GNSS receiver with an approximately 8-12 inch loop kept in the receiver enclosure, reterminate if necessary.
7) Create a drip loop below the GNSS antenna and secure to the monument with a split neoprene tube and UV resistant zip ties to avoid chaffing due to wind.
8) Steps shall be taken to waterproof the antenna, use duct sealing putty around the cable opening in the antenna mast and wrap the cable termination at the GNSS antenna tightly in black electrical tape.

Additional details on procedures for level surveying the GNSS antenna during installation can be found in reference 2.

3.2.2 Solar Panel

Installation of the required solar panel can often be a significant challenge due to space considerations. The cGNSS power system is independent from the station power system.

a. Prior to the installation trip (during design phase), identify a location for the solar panel mounting.
b. ED & FOD to collaborate on design / hardening requirements for solar panel mounts.
c. During installation, determine / adjust the actual on-site mounting location / angle as needed, and confirm there is no shading of existing solar panels or interference with other stations equipment.

3.3 System Integration - Wiring, Cables and Connectors

Figures 5-6 include annotated figures describing all key components and connections or primary system components. Details for two different model cGNSS receivers used by CO-OPS to date are shown, the Trimble NEtR9 and Trimble Alloy, along with the make/model wireless modem in common use at the time this manual was written. Figure 6 provides a cable/connector/wiring diagram and list. Info in figures 3-6 can be followed to complete system integration following installation and mounting of all system items inside and outside of the enclosure. Specifics of GNSS antenna cable and connectors will vary for each site, depending on run length. Engineering Division's Chesapeake Instrument Laboratory (CIL) will make a cable selection after reconnaissance activity is complete, during the installation design process.

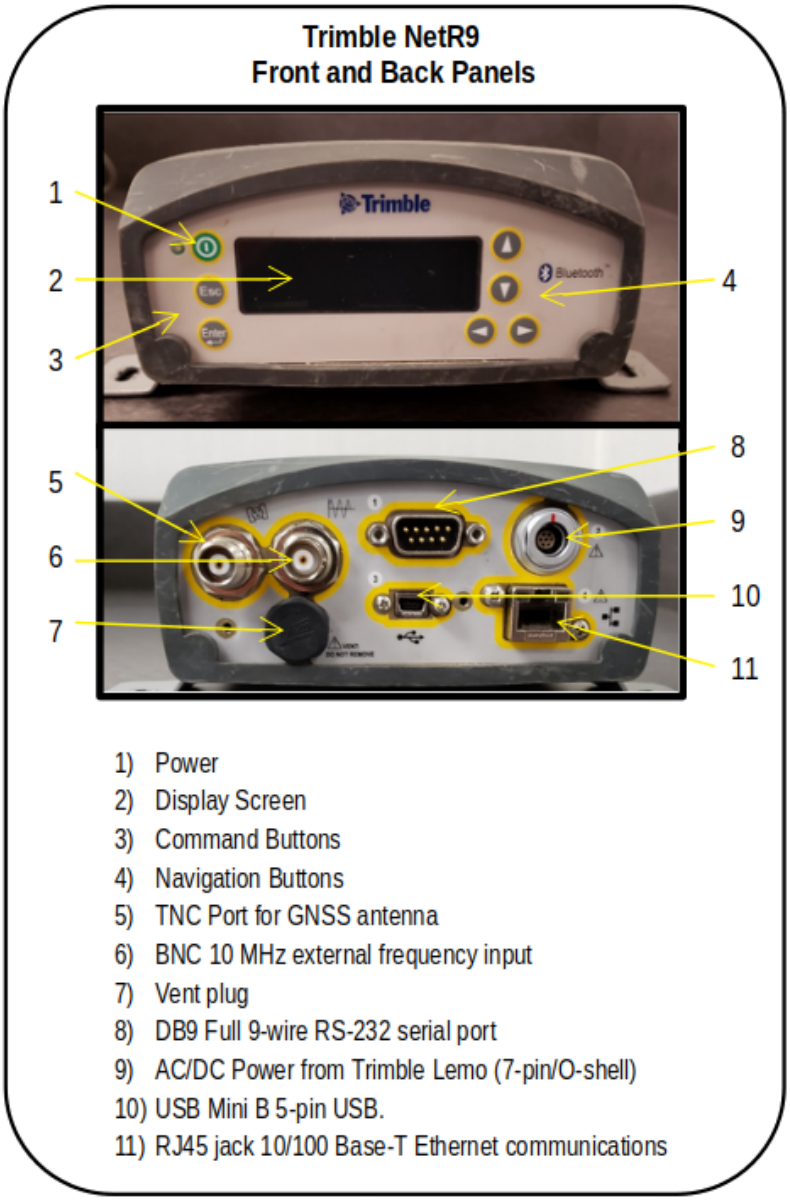


***Figure 5**: Front and back panel of the Trimble NetR9 receiver.*

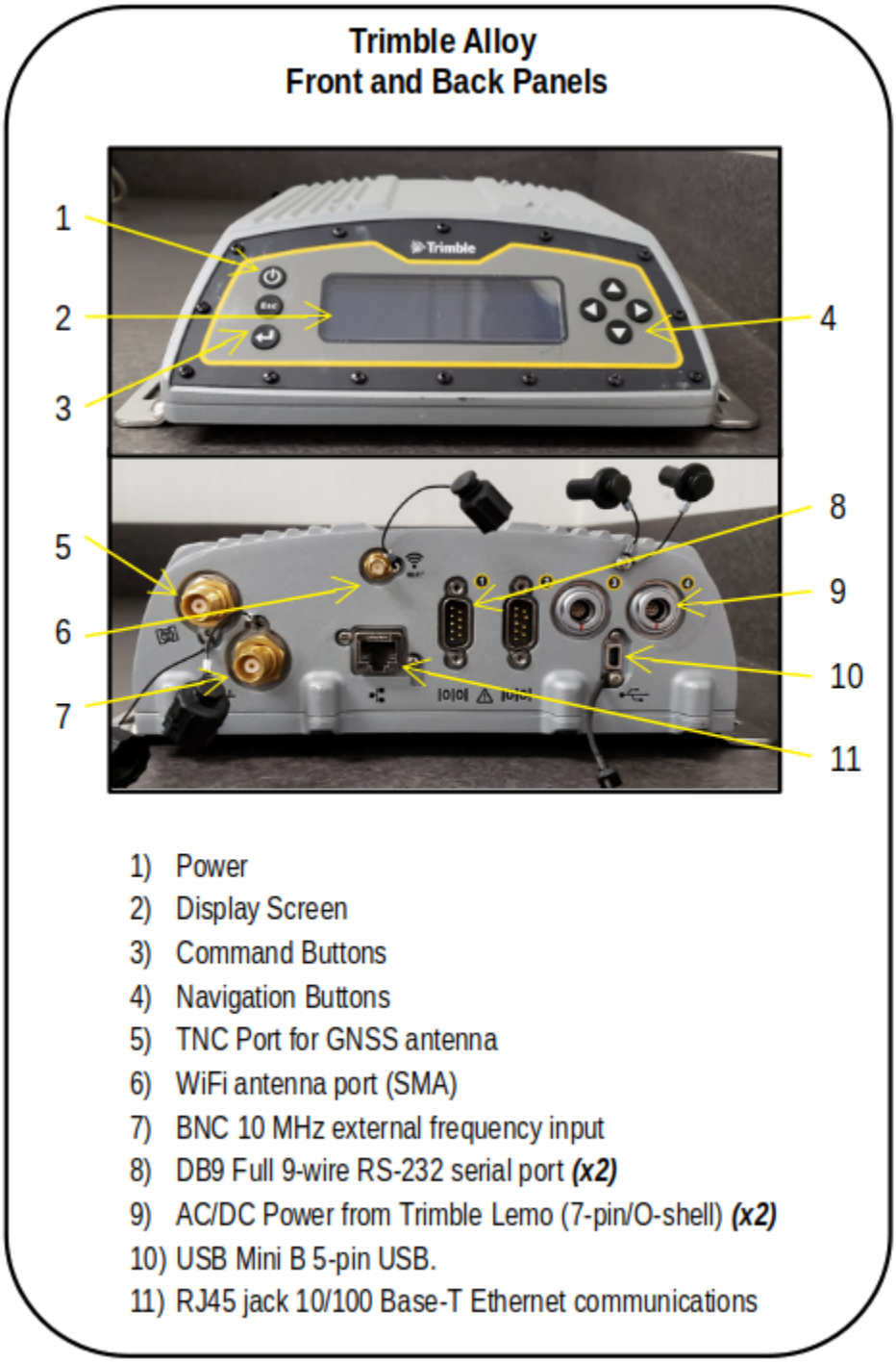
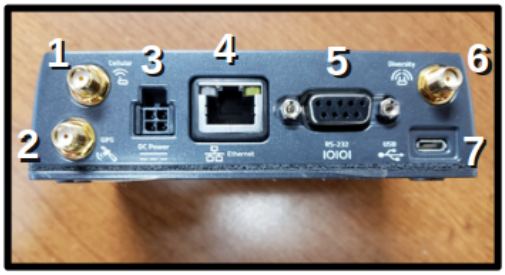


***Figure 6**: Front and back panel of the Trimble Alloy receiver.*

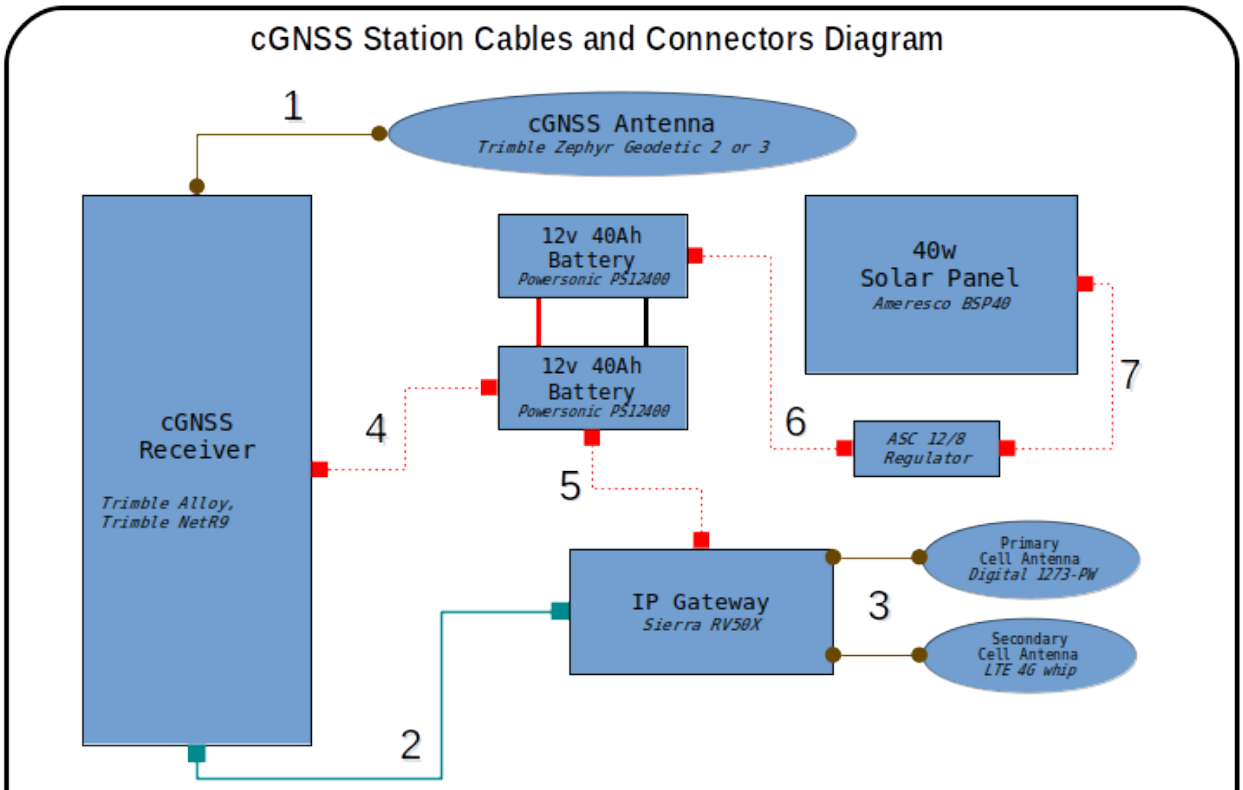
Sierra Wireless RV50

1) Cellular antenna port (SMA)
2) GPS port (optional) (SMA)
3) Power, I/O
4) 10/100 RJ45 Ethernet port
5) DB9 RS232 serial interface
6) Diversity antenna port (SMA)
7) USB input



8) Network LED
9) Signal strength LED
10) Network activity LED
11) Power LED
12) IP Address/MTN

***Figure 7**: Sierra wireless IP modem.*



#	Connection 1 *(low loss where applicable)*	Cabling *(low loss where applicable)*	Connection 2 *(low loss where applicable)*
1	NetR9/Alloy TNC-F connector	RG58,RG213 or better coaxial cable (LMR240, 400 recommended)	Zephyr Geodetic II/III TNC-F connector
2	NetR9/Alloy RJ45 Ethernet port	RJ45 CAT5 patch cable	Sierra Wireless RV50 RJ45 Ethernet port
3	RV50 IP Modem SMA-F antenna connector	RG58, 50Ω RG213/U coaxial cable	4G SMA-F (or N-type) Antenna port
4	NetR9/Alloy 7-pin Power	Trimble 59044: 0S/7P/M / Power Cable	Powersonic Battery Terminals
5	Sierra Wireless Power	Sierra Wireless 4 port power/IO cable	Powersonic Battery Terminals
6	Powersonic Battery Terminals	Carol 16AWG 2 conductor power cable	ASC 12/8 Charge Regulator Output Terminals
7	Ameresco Solar Panel Terminals	Carol 16AWG 2 conductor power cable	ASC 12/8 Charge Regulator Input Terminals

Figure 8. *System cable and connector diagram*

3.6. Post Installation Check

After the completion of the installation, the field crew must follow the final system check list provided in Appendix B and ensure that the Engineering Division's Configuration and Operational Engineering Team (COET) has all of the system metadata and photos listed in the following section. The system check will require an IP connection confirmation and several system configuration checks from a remote supporter back at ED in Chesapeake, VA.

4. System Metadata

The GNSS field installation crew must ensure that metadata listed below is collected and provided to the Engineering Division's Configuration and Operational Engineering Team (COET) for each GNSS system installation. More details regarding GNSS system metadata can be found in reference 4.
cGNSS SITE ID:

- Receiver Make
- Receiver Model
- Receiver SN
- Receiver firmware
- IP Modem SN
- IP modem address
- Antenna Make
- Antenna Model
- Antenna SN
- ARP to Phase Center Offset
- Radome
- Satellite Tracking
- Sampling Scheme
- Date of installation
- Date/time of initial cGNSS system startup

Photos:
Make sure to take all photos of system components and installation as listed in section 3 of reference 4.

5. References

1. Engineering Division cGNSS project Google site and documentation archive: https://sites.google.com/a/noaa.gov/co-ops-ostep/home/currentprojects/gnss

2. Breuer, E., Stepnowski, J, Heitsenrether, R., cGNSS at NWLON - Level Survey Procedure, ED\OSTEP Document, Apr 2020: https://drive.google.com/file/d/1nA9jMQzisBjsAKwCliNSpsfeCON3cm6v/view

3. Heitsenrether, R., Harrison, K., Breuer, E., cGNSS at NWLON - System Design Description, ED\OSTEP Document, March 2020: https://drive.google.com/file/d/1qvZziqzZBYCWzZWKmg2m_70hOHyhTYjF/view

4. Grodsky, A., cGNSS Metadata S.O., April 2020: https://sites.google.com/a/noaa.gov/co-ops-ed-2020/home/ed-file-cabinet/cGNSS%20Metadata%20SOP%20Final%20050520.docx?revision=1

APPENDIX A - GNSS System Equipment List

Item	Who Will Bring	Packed? (Initial)	Box #
GNSS SYSTEM			
Net R9 receiver			
Cabling - NetR9 receiver to power			
Cabling - antenna to NetR9 receiver (RG58)			
2 GNSS antenna cable terminal TNC connectors			
Cabling - NetR9 to IP modem			
Zephyr Geo III GNSS antenna			
Antenna radome & attaching hardware			
NetR9 receiver mounting hardware (inside enclosure)			
Pole/mast for GNSS antenna			
36" Precision level for antenna "tie"			
SECO GNSS antenna mount, antenna extension, SECO antenna level & misc.			
Nist Cert. Tape Measaure for antenna "tie"			
Hardware for attaching mast to MW radar stand, vertical "stop" for mast			
Liquid tight 3/8" (1/2" ID x 0.7" OD) hose & fittings; bottom of antenna mast into MWWL leveling collar penetration			

COMMUNICATIONS			
Sierra IP modem			
Cabling - IP modem to power			
IP antenna			
cabling - IP antenna to modem			
IP antenna mounting hardware			
sma-ntype pigtail x2			
polyphaser			
4g antenna w/mount			
Hardware for mounting IP modem (inside enclosure)			
POWER			
40W solar panel			
Solar mounting assembly & DCP enclosure support assembly w/harware			
solar regulator			
cabling - solar panel to regulator			
cabling - solar regulator to batteries			
2 x 40 Ah batteries			
Extra battery terminals			
hardware for battery terminals			
MISC/EXTRA/SPARE			
Extra conduit (in case run through existing MW conduit fails)			
Conduit fittings			

Monkey poop (duct sealant)			
extension cable			
Battery charger			
extra Andrew clamps (2 pair)			
1.5" pipe section			
ubolts (JEGS sets, qty 2)			
Tool and Misc Equipment			
Basic tool bag (wrenches, screw drivers, snips, etc)			
Dewalt kit (Drill and Sawzaw)			
Drill bits and step bit			
Dewalt batteries & charger			
Hole saw set			
Hole saw bit			
Fish tape			
conduit lube			
Bandit tool + straps			
Tie wraps			
Electrical tape			
Crimping tool			
Extra TNC connectors			
Shrink tube			
Magnifying glasses			
safety harness			
hot spot with 'trusted' IP address			
Misc. Tools			

APPENDIX B - Post Installation Checklist (steps of things to check after install complete, before leaving site

1. Check all cables and connectors, ensure everything is securely attached
2. Check all wireless IP modem and GNSS receiver wiring connection to the power source
3. Ensure all cGNSS system components inside of the station enclosure are clearly labelled, so anyone can see they separate from the NWLON system.
4. Ensure the #1 antenna marking is pointing North.
5. Ensure all adjustable components of the GNSS antenna mount are tightly secured and the antenna is securely in place.
6. Confirm the GNSS receiver is on and logging, using the display screen
7. Confirm the wireless IP modem is on and signal reception is suitable, using LED display lights
8. Call Chesapeake Instrument Lab (CIL) contact. Using receiver web interface, CIL must check the following remotely:
    a. IP connection OK, wireless signal strength is adequate
    b. Battery status OK
    c. GPS and GLONASS satellites are being tracked
    d. Sampling configuration is correct
    e. Satellite data are being logged to 24 hr daily file on receiver internal memory
    f. All other logging sessions are disabled
    g. Receiver wifi is disabled
    h. Correct antenna type is selected
    i. Vertical reference is the bottom of the antenna (ARP, no vertical offset is applied)