NEON SENSOR COMMAND, CONTROL, AND CONFIGURATION (C3) DOCUMENT: SPECTRAL PHOTOMETER

PREPARED BY	ORGANIZATION	DATE
Jeffrey Taylor	FUI	08/12/2012

APPROVALS	ORGANIZATION	APPROVAL DATE
Kate Thibault	SCI	12/06/2022

RELEASED BY	ORGANIZATION	RELEASE DATE
Tanisha Waters	CM	12/06/2022

See configuration management system for approval history.

The National Ecological Observatory Network is a project solely funded by the National Science Foundation and managed under cooperative agreement by Battelle. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
DRAFT	08/12/2012	ECO-00647	Initial release
A	12/06/2022	ECO-06925	Updated NEON logo and branding Minor formatting fixes

TABLE OF CONTENTS

LIST OF TABLES

1 DESCRIPTION

1.1 Purpose

This document specifies the command, control, and configuration details for operating NEON's spectral photometer measurements. It includes a detailed discussion of all necessary requirements for operational control parameters, conditions/constraints, set points, and any necessary error handling.

1.2 Scope

The Cimel Spectral Photometer (sun photometer) CE-318N (NEON P/N: 0303660001) RD [03] will be used throughout the NEON Observatory to monitor atmospheric aerosol properties. Sites prone to freezing temperatures will use an additional heating device. Software version ASTP Win 1.22b and firmware version 5.20G shall be used to operate these sensors across the observatory while always maintaining full compliance with AERONET standards and procedures. This document specifies the command, control, and configuration that are needed for operating these sensors. It does not provide implementation details, except for cases where these stem directly from the sensor conditions as described here.

2 RELATED DOCUMENTS AND ACRONYMS

2.1 Applicable Documents

AD [01]	NEON.DOC.000001	NEON Observatory Design (NOD) Requirements
AD [02]	NEON.DOC.000291	NEON Configured Sensor List
AD [03]	NEON.DOC.005003	NEON Scientific Data Products Catalog
AD [04]	NEON.DOC.005005	NEON Level 0 Data Products Catalog
AD [05]	NEON.DOC.XXXXXX	Spectral Photometer Standard Operating Procedures (TBW)
AD [06]	NEON.DOC.XXXXXX	Spectral Photometer Algorithm Theoretical Basis Document (TBW)

2.2 Reference Documents

RD [01]	NEON.DOC.000008	NEON Acronym List
RD [02]	NEON.DOC.000243	NEON Glossary of Terms
RD [03]	AERONET	AERONET Deployment Handbook v1.2 2010
RD [04]	Cimel.	SunPhotometer User Manual v4.6 2002

2.3 Acronyms

Acronym	Explanation
ATBD	Algorithm Theoretical Basis Document
C^3	Command, Control, and Configuration Document
SOP	Standard Operating Procedures
QA/QC	Quality Assurance/Quality Control
TIS	Terrestrial Instrument System
L0	Level 0
L1	Level 1
ENG	NEON Engineering group
CI	NEON Cyberinfrastructure group
DPS	NEON Data Products group
CVAL	NEON Calibration, Validation, and Audit Laboratory
P/N	Part Number

2.4 Verb Convention

“Shall” is used whenever a statement expresses a convention that is binding. The verbs “should” and “may” express non-mandatory provisions. “Will” is used to express a declaration of purpose on the part of the design activity.

3 INTRODUCTION

This document describes the configuration, command and control for the spectral photometers and their corresponding data products (NEON.DDD.SSS.DP0.00044.001.***.001.00N.001). So as to be compatible with international AERONET measurement protocols, the sensor will be operated through the control box using the aforementioned software. For information regarding maintenance or topics concerning computer algorithms, please refer to the SOP (AD [5]) and ATBD (AD [6]) documents, respectively.

4 SENSOR CONFIGURATION

So as to conform with AERONET data processing protocols, all data streams collected by the sensor shall be communicated directly to a local PC and then sent to the AERONET processing system. The PC will use proprietary AERONET software to manage all of these actions. The raw data generated by the measurements will also be stored locally in their native binary-formatted files for direct transport to CI (NEON.DDD.SSS.DP0.00044.001.001.001.00N.001). The L0 data products will then be extracted from these raw data files by CI for storage in the NEON raw data repository. Currently, the only known method for implementing this process is to convert these raw, binary files into ASCII-compatible files with Cimel's proprietary "ASTP Win" software.

Independent of the sensor data processing, command and control will be managed with the heater and other devices directly through the DAS (see *DESIGN ASSUMPTIONS* below). Sensor configuration settings are shown in the table below.

Table 1. Sensor configuration settings. The heater operates independently of the spectral photometer.

Parameter	**Default Setting**
Acquisition Speed	1200 baud
Location (lat/lon)	Defined by location (see relevant site characterization report)
Local Solar Time	Defined by location
Measurement Mode	Auto (O'Neill)
Raw Data Measurements	All recorded and provided via AERONET, independent of Command, Control, & Configuration

5 COMMAND AND CONTROL

5.1 Measurement

All measurements will be automatically controlled by scenarios which contain a sequence of measurement commands based on atmospheric airmass (which, in turn, are based on location and local time). The AUTO mode controls all of the commands for these measurements and requires no external intervention other than an internet connection. A complete description of these scenarios can be found in RD[03].

5.2 Error Handling

The Sunphoto Spectrometer is automatically designed to move to the "PARK mode" when any errors are encountered to ensure that the sensor does not sustain any damage. As the actual error codes are only available after AERONET processing (up to several hours after data acquisition), Command & Control based on error codes is not possible. It is assumed that the engineering assembly will detect when the instrument is in three different error modes: 1. the instrument has parked for a prolonged period of time due to moisture accumulation, 2. the instrument has parked for a prolonged period of time due to freezing conditions that inhibit movement, and 3. the instrument has parked for a prolonged period of time due to another error.

DESIGN ASSUMPTIONS: The NEON engineering assembly for the Spectral Photometer shall have the capability to directly monitor through the DAS:

1. when the instrument is in "PARK mode";
2. the temperature of the instrument;
3. the status of instrument heater operation; and
4. moisture on the surface of the instrument that may enter into the optical head.

The Level 0 Data Products associated with this assembly are as follows:

Assembly Device	Data Format	Data Product
Park Detection Switch	Binary	NEON.DDD.SSS.DP0.00044.001.002.001.00N.001
Instrument Chassis Temperature Sensor	Volts (?)	NEON.DDD.SSS.DP0.00044.001.003.001.00N.001
Instrument Heater	Binary	NEON.DDD.SSS.DP0.00044.001.004.001.00N.001
Instrument Chassis Moisture Sensor	Binary	NEON.DDD.SSS.DP0.00044.001.005.001.00N.001

Error codes are managed automatically by AERONET when operated in the AUTO mode. In the event of a power failure, the spectral photometer may need to be re-configured with the default settings, either automatically or manually (**Table 1**).

5.3 Heater controls

As measurements are done in the AUTO mode the instrument should not be parked for > 15 minutes unless there is the threat of water entering the optical head or there is an operating error (such as freezing conditions generating ice that prohibit movement of the sensor). If the moisture sensor located on the instrument detects water, then the heater should be operated to attempt to melt water and associated ice. If the moisture sensor does not detect water but the instrument has been parked for > 15 minutes, heater control should also be applied to attempt to melt ice that has potentially built up. If, after 2 attempts, operation of the heater fails to remove the sensor from park, NEON problem resolution and tracking shall be initiated (see Figures 1-2).

Initially the heater shall be configured as always switched off, since the sensor generates some heat even with the heater off. The built-in moisture sensor is automatically configured to force the instrument to park in the event of sufficient moisture build up. With this consideration, it will be necessary to heat the moisture sensor, along with the rest of the instrument, to ensure that there are not conflicting operations.

When the heater is operated, it should be turned on for a single event that lasts for a predefined period of time (z), after which it shall be turned off. Based on the assumptions in Appendix A, z = 25 mins. If the design differs from these assumptions, a new value for z shall be calculated.

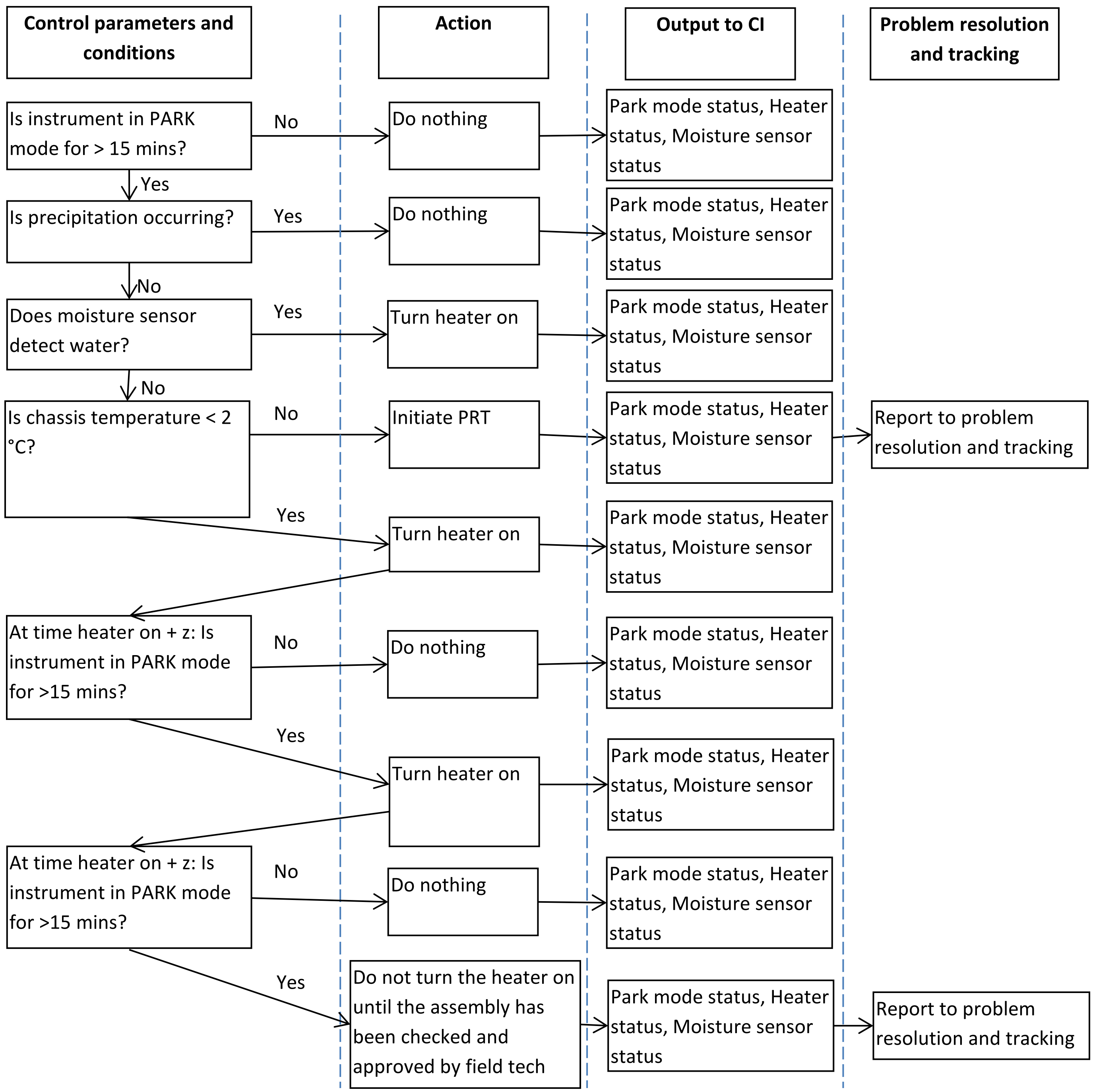

Figure 1. Command and Control for turning the heater on.

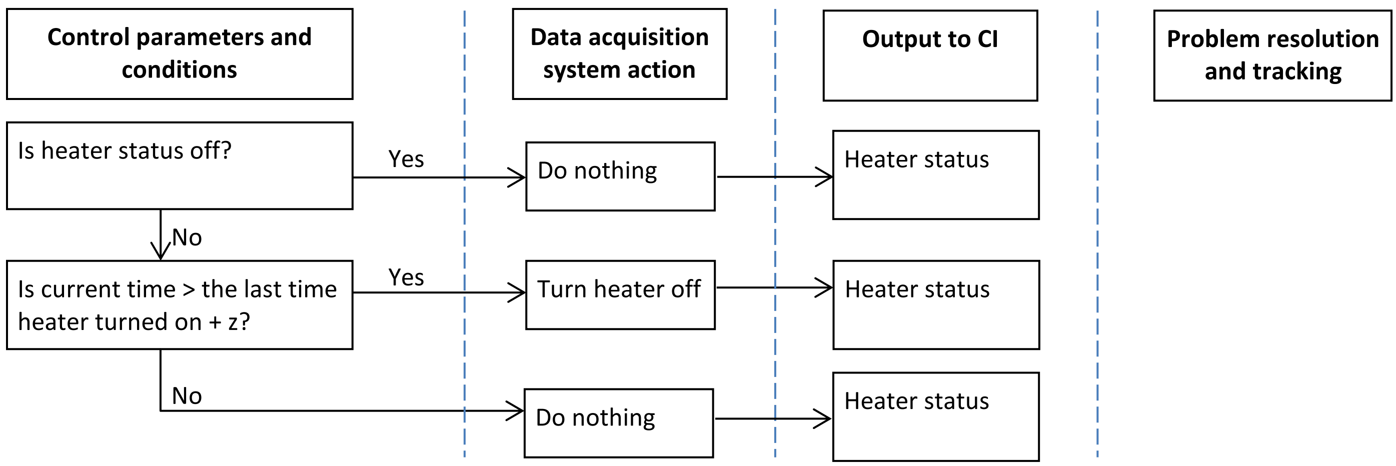

Figure 2. Command and Control for turning the heater off.

6 APPENDIX

6.1 Appendix A – Rationale for Heating Time

The heater shall be sufficient to melt ice that is 0.31 cm (0.125 inches) thick on the outside of the robot body of the sensor. The robot has a length of ~25.0 cm and a diameter of ~10.0 cm.

The total volume of the robot is 1963.5 cm^3:

$$1963.5 = 25.0 \times \pi \left(\frac{10.0}{2}\right)^2$$

The volume of the robot covered in 0.31 cm thick ice is 2087.1 cm^3:

$$2087.1 = 25.0 \times \pi \left(\frac{10.0 + 0.31}{2}\right)^2$$

Therefore, the volume of ice covering the robot is 123.6 cm^3:

$$123.6 = 2087.1 - 1963.5$$

If we assume a density of 0.92 g cm^{-3} for ice, the weight of the ice is 113.7 g:

$$113.7 = 123.6 \times 0.92$$

The enthalpy latent heat of fusion for ice is 334 J g^{-1} (i.e., 334 W s g^{-1}). Therefore, the energy required to melt the ice is 37 990 W s:

$$37\,990 = 113.7 \times 334$$

If we assume a 50 W heater is used, the heater would need to be on for 759.8 seconds (~12.7 mins) to melt the ice:

$$759.8 = \frac{37990}{50}$$

To provide additional heat to ensure melting, the time is doubled to give a heating time (z) of 25 mins.