NEON SENSOR COMMAND, CONTROL, AND CONFIGURATION: TRIPLE REDUNDANT ASPIRATED AIR TEMPERATURE

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Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	01/07/2014	ECO-00427	Initial release
B	06/09/0215	ECO-03004	Updated heater control logic and Updated information regarding “extreme” assembly and added Future Updates Section

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1 DESCRIPTION

1.1 Purpose

This document specifies the command, control, and configuration details for operating the Triple Redundant Aspirated Air Temperature (TRAAT) assembly and sensor. It includes a detailed discussion of all necessary requirements for operational control parameters, conditions/constraints, set points, and any necessary error handling. All Level 0 Data Products generated by the sensor are identified.

1.2 Scope

This document specifies the command, control, and configuration that are needed for operating the TRAAT assembly. It does not provide implementation details, except for cases where these stem directly from the sensor conditions as described here. This document assumes that air temperature will be measured using a Thermometrics Climate PRT Probe (NEON P/N: 0303550001, 0303550002, 0317690001, or 0303550003 depending on required cable length) (AD[02]) and a Met One Instruments 62789 Aspirated Radiation Shield (NEON P/N 0329810000). There is no firmware associated with this assembly.

2 RELATED DOCUMENTS AND ACRONYMS

2.1 Applicable Documents

Applicable documents contain information that shall be applied in the current document. Examples are higher level requirements documents, standards, rules and regulations.

AD [01]	NEON.DOC.000001	NEON Observatory Design
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.000654	ATBD Triple Redundant Aspirated Air Temperature
AD [06]	NEON.DOC.002002	Engineering Master Location Sensor Matrix
AD [07]	NEON.DOC.000807	ATBD 3D Wind-Turbulent Exchange
AD [08]	NEON.DOC.000780	ATBD 2D Wind Speed and Direction

2.2 Reference Documents

Reference documents contain information complementing, explaining, detailing, or otherwise supporting the information included in the current document.

RD [01]	NEON.DOC.000008	NEON Acronym List
RD [02]	NEON.DOC.000243	NEON Glossary of Terms

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

3 INTRODUCTION

The sensor configuration and sensor command and control described here are related to the TRAAT data product. A description of how sensor readings shall be converted to air temperature data product is presented in the associated ATBD (AD[05]). The TIS used to generate this data product consists of 6 components: three Platinum Resistance Thermometers (PRTs), one aspirated shield fan, a turbine, and a snout heater. An "extreme" TIS is used at sites where continual icing is eminent. The only difference between this "extreme" assembly and the normal TIS is the addition of a heater in the top of the assembly. Configuration settings and the command and control structure are described separately for each component.

Table 1. TRAAT sensor-related L0 DPs and other ancillary DPs associated with this document. Note '00n' represents the tower top level where the TRAAT is located. See AD[06] for site-specific details

Data product	Sample Frequency	Units	Data stream ID
PRT resistance at temperature T (R_{t1})	1 Hz	Ω	NEON.DXX.XXX.DP0.00003.001.001.001.00n.001
PRT resistance at temperature T (R_{t2})	1 Hz	Ω	NEON.DXX.XXX.DP0.00003.001.001.001.00n.002
PRT resistance at temperature T (R_{t3})	1 Hz	Ω	NEON.DXX.XXX.DP0.00003.001.001.001.00n.003
Fan Speed	1 Hz	RPM	NEON.DXX.XXX.DP0.00003.001.002.001.00n.001
Turbine Speed (S_T)	1 Hz	RPM	NEON.DXX.XXX.DP0.00003.001.003.001.00n.001
Snout heater Status (H_s)	State Change	Binary	NEON.DXX.XXX.DP0.00003.001.004.001.00n.001
[E] Top heater Status (H_t)	State Change	Binary	NEON.DXX.XXX.DP0.00003.001.005.001.00n.001
3D Sonic Anemometer U component (U)	TBD	m s^{-1}	NEON.DXX.XXX.DP1.00012.001.001.00n.001
3D Sonic Anemometer V component (V)	TBD	m s^{-1}	NEON.DXX.XXX.DP1.00012.001.002.00n.001
*2D Sonic Anemometer U component (U)	1 Hz	m s^{-1}	NEON.DXX.XXX.DP0.00001.001.001.001.n-1.001
*2D Sonic Anemometer V component (V)	1 Hz	m s^{-1}	NEON.DXX.XXX.DP0.00001.001.002.001.n-1.001

* The 2D wind speed from the level below tower top, represented as 'n-1', will be initially used until such time that wind speed observations from the 3D sonic anemometer become available. [E] Component only used in the "extreme" TIS

4 OVERVIEW OF SENSOR CONFIGURATION

4.1 Temperature sensors

The temperature sensors do not require any configuration.

4.2 Aspirated shield

The current assembly design includes one fan and one turbine that are housed within the aspirated shield. The fan ensures that the temperature sensor is adequately aspirated. The turbine is used to monitor the flow rate within the aspirated shield and ensure that sufficient aspiration is present. Sensor configuration settings are shown in the tables below.

Table 2. Aspirated shield fan configuration settings

Parameter	Default Setting
Aspirator fan	On
Acquisition rate: Fan speed	1 Hz
Raw data	Fan speed (NEON.DXX.XXX.DP0.00003.001.002.001.00n.001)

Table 3. Aspirated shield turbine configuration settings

Parameter	Default Setting
Aspirator turbine	Off
Acquisition rate: Turbine speed (RPM)	1 Hz
Raw data	Turbine speed (NEON.DXX.XXX.DP0.00003.001.003.001.00n.001)

4.3 Heater

The heater(s) do not require any configuration.

5 COMMAND AND CONTROL

5.1 Heater control

The heater(s) shall be used to melt ice that is restricting the flow of air through the aspirated shield. Figure 1 represents the logic for cycling the heater on and off as well as assessing whether or not the assembly is functioning properly. Z represents the time period that the heater shall be switched on during a single heating event. Based on the assumptions in Appendix A, z = 448 seconds. If the design differs from these assumptions, a new value for z shall be calculated.

At the time of the last update to this document, the framework of Problem Tracking and trouble ticketing remains TBD. Although no trouble ticket will be generated, heating will cease after three ON/OFF cycles of the heater(s).

Additional inputs include: 1) the heater status, 2) turbine speed, 3) temperature sensor output for the current timestamp, which is used to determine whether freezing conditions are present, and 4) the 2D wind speed measurement from the corresponding tower level, which is needed to account for wind induced bias in the turbine measurement when wind speeds are > 12 m/s. The real-time horizontal wind speed is required for heater control, as shown in Figure 1. Initially, horizontal wind speed will be determined from data products NEON.DXX.XXX.DP0.00001.001.001.001.n-1.001 and NEON.DXX.XXX.DP0.00001.001.001.001.n-1.001 according to Eq. (3) in AD[08]. Likewise, real-time temperature is determined by first individually averaging each PRT ohm reading over a period of thirty seconds using the 1 Hz observations from the three PRTs, i.e. data products NEON.DXX.XXX.DP0.00003.001.001.001.00n.001, NEON.DXX.XXX.DP0.00003.001.001.001.00n.002, and NEON.DXX.XXX.DP0.00003.001.001.001.00n.003. The median value of the three PRTs averages, in ohms, will then be used to determine the current temperature condition. In the event that one PRT has malfunctioned then the thirty second averages from the two remaining PRTs will be averaged to determine the current temperature condition. Additionally, if only one PRT is functional its thirty second average will be used to determine the current temperature condition.

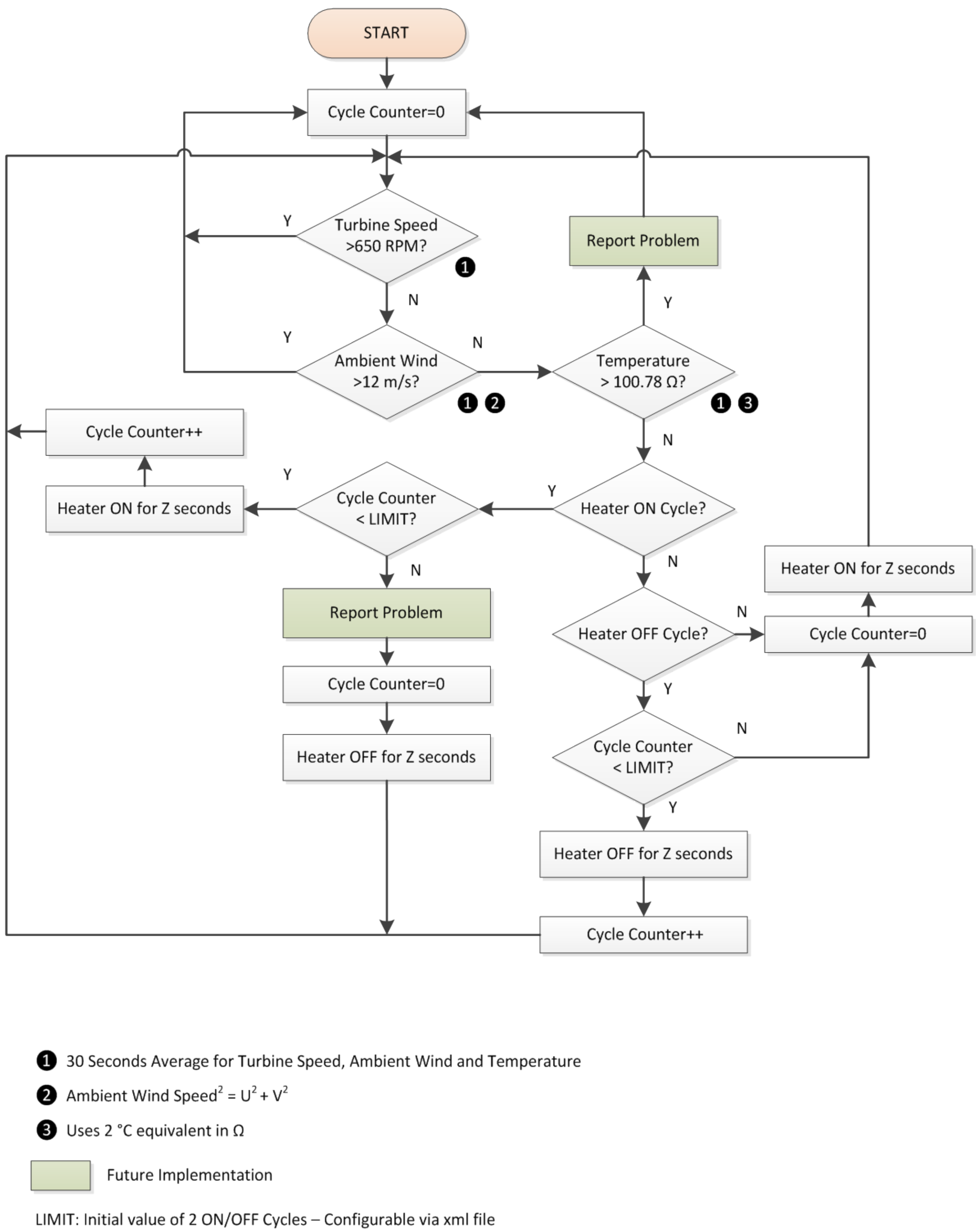

Figure 1: Command and control for turning the heater on as well as generating flow rate flags in the event of a sensor malfunction

6 FUTURE UPDATES

In the event of an aspirated shield malfunction, the problem tracking and reporting system will issue a trouble ticket, as specified in Figure 1 as "report problem."

Once the 3D sonic anemometers have been deployed on the tower top, horizontal wind speed will be determined via data products NEON.DXX.XXX.DP1.00012.001.001.00n.001 and NEON.DXX.XXX.DP1.00012.001.002.00n.001 according to AD[07].

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 inlet tube of the aspirated shield over a length of 20.32 cm (8 inches). The diameter of the aspirated shield inlet is 8.90 cm (3.5 inches).

The volume of the 20.32 cm length of the aspirated shield inlet is 1264.14 cm^3:

$$1264.14 = 20.32 \times \pi \left(\frac{8.90}{2}\right)^2$$

The volume of the 20.32 cm length of the aspirated shield inlet covered in 0.31 thick ice is 1446.40 cm^3:

$$1446.40 = 20.32 \times \pi \left(\frac{8.90 + 0.31 + 0.31}{2}\right)^2$$

Therefore, the volume of ice covering the aspirated shield is 182.26 cm^3:

$$182.26 = 1446.40 - 1264.14$$

If we assume a density of 0.92 g cm^{-3} for ice, the weight of the ice is 167.68 g:

$$167.68 = 182.26 \times 0.92$$

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 56,005 W s:

$$56005 = 167.68 \times 334$$

If we assume a 250 W heater is used, the heater would need to be on for 224 seconds to melt the ice:

$$224 = \frac{56005}{250}$$

To provide additional heat to ensure melting, the time is doubled to give a heating time (z) of 448 seconds.