

# APEX Profiling Float

User Manual

P/N 301308, Rev. 9



**TELEDYNE**  
**WEBB RESEARCH**  
Everywhereyoulook™

Teledyne Webb Research,  
a Business Unit of Teledyne Instruments, Inc.  
49 Edgerton Drive  
North Falmouth, MA 02556  
U.S.A.  
Tel: (508) 563-1000

<http://www.teledynemarine.com/webb-research/>



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# QUICK-START GUIDE

This quick-start guide encompasses the steps required to deploy the Teledyne Webb Research APEX profiling float right out of its crate without having to read this entire manual. Perform the steps below, and if desired, refer to the referenced page numbers of the manual for more detail. When viewing this manual as a PDF using Adobe Reader, you can click the step numbers or the referenced page numbers to go to the detailed descriptions.



**NOTE** *The APEX profiling float is shipped ready for deployment without any operator intervention. However, at your discretion, before deploying the float in STEP 3 below, the Reset tool can be used to start the mission and verify that the self test has passed. Similarly, connecting a PC to the float to start the mission allows you to verify that the self test has passed before deploying the float plus view the test results. It is not necessary to use the Reset tool or a connected PC to start the mission. The self test will be performed and the mission will start if the float is deployed directly from its crate. To start the mission using the Reset tool, refer to [“Starting the Mission using the Reset Tool”](#) on page 2-5. To start the mission using a connected PC, refer to [“Connecting a PC to the Float”](#) on page 2-10 and connect a PC to the float. Then refer to [“Starting the Mission with a Command from a Connected PC”](#) on page 2-6 and start the mission. After starting the mission using the reset tool or a connected PC, the float should be deployed after the self test is complete but before the end of the Mission Prelude phase which by default is 120 minutes, otherwise unexpected results may occur. For information on the Mission Prelude phase, refer to [SECTION 3: “Operating Modes.”](#)*

**STEP 1:** Unpack the float from its crate and allow it to warm up indoors if it has been stored at a temperature of -2°C or less. Refer to page 2-1.

**STEP 2:** Remove the plastic bag from the CTD, and then remove any protective caps and plugs from the optional sensors. Save these items to use again if the float is to be stored at a later time. Refer to page 2-3.

**STEP 3:** Verify that the air compartment of the bladder is *deflated*, and then deploy the float. Refer to page 2-8.

# Table of Contents

Table of Contents.....	iv
List of Figures.....	xi
List of Tables .....	xii
Battery Hazard Warnings.....	xiii
Alkaline Battery Hazard.....	xiii
Lithium Battery Hazard .....	xiii
Maximum Depth Warning.....	xiii
Communications Loss Warning .....	xiii
Preface.....	xiv
Purpose of this Manual .....	xiv
Warnings, Cautions and Notes.....	xv
Documentation Changes.....	xv
Returns.....	xvi
Customer Service .....	xvi

## SECTION 1: Overview..... 1-1

1.1	Operation.....	1-1
1.2	General Description .....	1-2
1.2.1	Housing.....	1-2
1.2.2	Bladder .....	1-2
1.2.3	CTD .....	1-4
1.2.4	Antenna.....	1-4
1.3	General Operating Theory .....	1-4
1.3.1	Controller Board.....	1-5
1.3.2	RF Board .....	1-5
1.3.3	GPS Receiver .....	1-5
1.3.4	Iridium Modem .....	1-5
1.3.5	Battery Packs.....	1-5
1.3.6	Air Pump.....	1-5
1.3.7	Buoyancy Pump.....	1-5
1.4	Other Float Configurations and Options .....	1-6

1.5	Additional Float Types .....	1-6
1.5.1	APEX Deep Profiling Float .....	1-6
1.5.2	APEX-BGC Biogeochemical Profiling Float .....	1-7
1.5.3	APEX-AMS Advanced Multisensor Profiling Float.....	1-7
1.5.4	APEX-EM Electromagnetic Profiling Float.....	1-8
1.5.5	Customer Specials .....	1-8
1.6	Deployment Methods.....	1-8

## **SECTION 2: Setup, Test and Deployment.....2-1**

2.1	Unpacking and Inspection .....	2-1
2.2	Preparing the Float for Deployment.....	2-3
2.3	Starting the Mission.....	2-4
2.3.1	Starting the Mission by Deploying the Float Directly from its Crate .....	2-5
2.3.2	Starting the Mission using the Reset Tool .....	2-5
2.3.3	Starting the Mission with a Command from a Connected PC .....	2-6
2.3.4	Running the Self Test from a Connected PC .....	2-7
2.3.5	Self Test Progress and Diagnostic Messages.....	2-8
2.4	Deploying the Float.....	2-8
2.5	Recovering the Float.....	2-10
2.6	Connecting a PC to the Float .....	2-10
2.7	Enabling and Disabling Lowpower Standby Operation .....	2-12
2.8	Optional Pre-deployment Testing .....	2-12
2.8.1	Testing the Float.....	2-12
2.8.2	Viewing and Editing the Configuration Parameters .....	2-13
2.8.3	Transferring Files.....	2-14

## **SECTION 3: Operating Modes.....3-1**

3.1	Idle Mode.....	3-1
3.2	Mission Mode .....	3-3
3.2.1	Mission Prelude Phase .....	3-4
3.2.2	Park Descent Phase .....	3-5
3.2.3	Park Phase .....	3-6
3.2.4	Deep Descent Phase.....	3-8
3.2.5	Ascent Phase .....	3-10
3.2.6	Surface Phase .....	3-12

3.3	Recovery Mode.....	3-14
3.4	Emergency Mode.....	3-14

## **SECTION 4: System Files..... 4-1**

4.1	Configuration Files.....	4-1
4.1.1	mission.cfg File.....	4-1
4.1.2	system.cfg File.....	4-2
4.1.3	sensors.cfg File.....	4-4
4.1.4	sample.cfg File.....	4-5
4.2	Log Files.....	4-13
4.2.1	science_log.bin File.....	4-14
4.2.2	vitals_log.bin File.....	4-14
4.2.3	system_log.txt File.....	4-14
4.3	Converting the science_log.bin and vitals_log.bin Files to CSV Files.....	4-15
4.4	Reading the science_log.csv File.....	4-15
4.5	Reading the vitals_log.csv File.....	4-19
4.6	Converting system_log.txt Files to Readable Text.....	4-21

## **SECTION 5: Modifying the Mission Plan ..... 5-1**

5.1	Setting up RUDICS/PSTN Communications with the Float.....	5-1
5.2	Setting up SBD Communications with the Float.....	5-2
5.3	Modifying the mission.cfg File Configuration Parameter Settings Locally from a Connected PC.....	5-3
5.4	Modifying the mission.cfg File Configuration Parameter Settings Remotely.....	5-4
5.5	Modifying the sample.cfg File Configuration Parameter Settings Remotely.....	5-5
5.6	User Commands.....	5-6
5.6.1	File System Commands.....	5-6
5.6.2	Console Commands.....	5-7
5.6.3	Mission Parameters Commands.....	5-8
5.6.4	Modem Commands.....	5-8
5.6.5	Mission Commands.....	5-9
5.6.6	System Commands.....	5-10

## SECTION 6: CTDs .....6-1

6.1	SBE 41CP CTD.....	6-2
6.1.1	Specifying the SBE 41CP CTD Hardware Configuration .....	6-2
6.1.2	Specifying the SBE 41CP CTD Sampling Behavior .....	6-2
6.1.3	Uncompressing and Reading the SBE 41CP CTD Log Files.....	6-3
6.1.4	Show Command .....	6-5
6.1.5	SBE 41CP CTD Factory Configuration .....	6-6
6.2	SBE 41 CTD.....	6-7
6.2.1	Specifying the SBE 41 CTD Hardware Configuration .....	6-7
6.2.2	Specifying the SBE 41 CTD Sampling Behavior.....	6-7
6.2.3	Uncompressing and Reading the SBE 41 CTD Log Files .....	6-8
6.2.4	Show Command .....	6-8
6.2.5	SBE 41 CTD Factory Configuration .....	6-9
6.3	SBE 41N+pH CTD.....	6-10
6.3.1	Specifying the SBE 41N+pH CTD Hardware Configuration .....	6-10
6.3.2	Specifying the SBE 41N+pH CTD Sampling Behavior .....	6-10
6.3.3	Uncompressing and Reading the SBE 41N+pH CTD Log Files .....	6-13
6.3.4	Show Command .....	6-14
6.3.5	SBE 41N+pH CTD Factory Configuration .....	6-16
6.4	RBRargo CTD.....	6-17
6.4.1	Specifying the RBRargo CTD Hardware Configuration .....	6-17
6.4.2	Specifying the RBRargo CTD Sampling Behavior .....	6-17
6.4.3	Uncompressing and Reading the RBRargo CTD Log Files .....	6-18
6.4.4	Show Command .....	6-19
6.4.5	SBE RBRargo CTD Factory Configuration .....	6-19

## SECTION 7: General Maintenance .....7-1

7.1	Cleaning and Inspecting the Float after Recovery.....	7-1
7.2	Replacing the Float Batteries.....	7-1
7.3	Battery Usage.....	7-1
7.4	Storing the Float .....	7-2

## APPENDIX A: Optional Sensors .....A-1

A.1	Oxygen Sensor (Aanderaa) .....	A-3
A.1.1	Specifying the Oxygen Sensor Hardware Configuration.....	A-3
A.1.2	Specifying the Oxygen Sensor Sampling Behavior .....	A-3
A.1.3	Specifying the Oxygen Sensor In-Air Measurement Behavior in Accordance with the SCOR Recommendation.....	A-3
A.1.4	Uncompressing and Reading the Oxygen Sensor Log Files .....	A-4
A.1.5	Show Command .....	A-5
A.1.6	Factory Configuration .....	A-7
A.2	Oxygen Sensor (JFE Advantech).....	A-8
A.2.1	Specifying the Oxygen Sensor Hardware Configuration.....	A-8
A.2.2	Specifying the Oxygen Sensor Sampling Behavior .....	A-8
A.2.3	Specifying the Oxygen Sensor In-Air Measurement Behavior in Accordance with the SCOR Recommendation.....	A-8
A.2.4	Uncompressing and Reading the Oxygen Sensor Log Files .....	A-9
A.2.5	Show Command .....	A-10
A.2.6	Factory Configuration .....	A-11
A.3	Fluorometer .....	A-12
A.3.1	Specifying the Fluorometer Hardware Configuration.....	A-12
A.3.2	Specifying the Fluorometer Sampling Behavior.....	A-12
A.3.3	Uncompressing and Reading the Fluorometer Log Files .....	A-13
A.3.4	Show Command .....	A-15
A.3.5	Fluorometer Factory Configuration .....	A-15
A.4	C-Rover Transmissometer .....	A-16
A.4.1	Specifying the C-Rover Configuration .....	A-16
A.4.2	Specifying the C-Rover Sampling Behavior .....	A-16
A.4.3	Uncompressing and Reading the C-Rover Transmissometer Log Files.....	A-16
A.4.4	Show Command .....	A-17
A.4.5	C-Rover Transmissometer Factory Configuration.....	A-18
A.5	Radiance Radiometer .....	A-19
A.5.1	Specifying the Radiance Radiometer Hardware Configuration .....	A-19
A.5.2	Specifying the Radiance Radiometer Sampling Behavior .....	A-19
A.5.3	Uncompressing and Reading the Radiance Radiometer Log Files.....	A-19
A.5.4	Show Command .....	A-20
A.5.5	Radiance Radiometer Factory Configuration.....	A-21



- A.6 Irradiance Radiometer ..... A-22
  - A.6.1 Specifying the Irradiance Radiometer Hardware Configuration ..... A-22
  - A.6.2 Specifying the Irradiance Radiometer Sampling Behavior ..... A-22
  - A.6.3 Uncompressing and Reading the Irradiance Radiometer Log Files ..... A-22
  - A.6.4 Show Command ..... A-23
  - A.6.5 Irradiance Radiometer Factory Configuration ..... A-24
- A.7 Nitrate Sensor ..... A-25
  - A.7.1 Specifying the Nitrate Sensor Hardware Configuration ..... A-25
  - A.7.2 Specifying the Nitrate Sensor Sampling Behavior..... A-25
  - A.7.3 Uncompressing and Reading the Nitrate Sensor Log Files ..... A-26
  - A.7.4 Nitrate Sensor Frames..... A-27
  - A.7.5 Show Command ..... A-27
  - A.7.6 Nitrate Sensor Factory Configuration ..... A-28
  - A.7.7 Nitrate Sensor Post Deployment Cleaning..... A-28
- A.8 Compass..... A-30
  - A.8.1 Specifying the Compass Hardware Configuration ..... A-30
  - A.8.2 Specifying the Compass Sampling Behavior ..... A-30
  - A.8.3 Uncompressing and Reading the Compass Log Files..... A-30
  - A.8.4 Show Command ..... A-31
  - A.8.5 Compass Factory Configuration ..... A-31

**APPENDIX B: Ice Avoidance .....B-1**

- B.1 Surface Ice Detection..... B-1
- B.2 Ice Breakup Detection ..... B-4
- B.3 Ice Cap Detection..... B-4

**APPENDIX C: Time of Day Operation.....C-1**

- C.1 *Standard* Time of Day Operation..... C-1
- C.2 *Extended* Time of Day Operation..... C-1
- C.3 Unreachable Time of Day Operation ..... C-1
- C.4 Configuration Parameters that Affect Time of Day Operation ..... C-2
- C.5 Example Time of Day Operation..... C-3

**APPENDIX D: Argos Telemetry .....D-1**

- D.1 Argos Configuration Files..... D-1
  - D.1.1 Argos system.cfg File..... D-2
  - D.1.2 Argos sensors.cfg File..... D-2
  - D.1.3 Argos mission.cfg File..... D-2
  - D.1.4 Argos sample.cfg File ..... D-3
- D.2 Argos Mission Prelude Phase..... D-3
- D.3 Argos Surface Phase ..... D-7
- D.4 Float Status Information..... D-12
- D.5 Emergency Mode..... D-13
- D.6 Converting the Argos Messages to Text Files..... D-14

**APPENDIX E: Diagnostic Messages Example ..... E-1**

**APPENDIX F: Unsupported/Modified Features ..... F-1**

## List of Figures

<b>Figure 1-1:</b> APEX Profiling Float Profiling Cycle .....	1-1
<b>Figure 1-2:</b> The APEX Profiling Float with Pumped Type CTD and Non-pumped Type CTD.....	1-3
<b>Figure 2-1:</b> APEX Profiling Float Accessories.....	2-2
<b>Figure 2-2:</b> Plastic Bag to be Removed from CTD .....	2-3
<b>Figure 2-3:</b> Cap and Plugs to be Removed from Pumped Type CTD .....	2-3
<b>Figure 2-4:</b> RESET Label on Float Housing.....	2-6
<b>Figure 2-5:</b> Hole in Damper Ring.....	2-9
<b>Figure 2-6:</b> APEX Profiling Float being Deployed.....	2-9
<b>Figure 2-7:</b> Communications Cable Connected to Zinc Anode and Terminal Post (Pressure Sensor) .....	2-11
<b>Figure 3-1:</b> Operating Modes and Factory Default mission.cfg File Configuration Parameter Settings.....	3-2
<b>Figure 4-1:</b> Example Sampling Behavior from a sample.cfg File.....	4-8
<b>Figure 4-2:</b> Example science_log.csv Printout .....	4-16
<b>Figure 4-3:</b> Example vitals_log Printout.....	4-20
<b>Figure 6-1:</b> Example Rows of SBE 41CP CTD Data in a science_log.csv File .....	6-4
<b>Figure 6-2:</b> Example Rows of SBE 41 CTD Data in a science_log.csv File.....	6-8
<b>Figure 6-3:</b> Example Rows of SBE 41N+pH CTD Data in a science_log.csv File .....	6-14
<b>Figure 6-4:</b> Example Rows of RBRargo CTD Data in a science_log.csv File .....	6-19
<b>Figure A-1:</b> The APEX Advanced Multisensor (AMS) Profiling Float with Pumped Type CTD and Non-pumped Type CTD.....	A-2
<b>Figure A-2:</b> Example Row of Oxygen Sensor Data in a science_log.csv File .....	A-5
<b>Figure A-3:</b> Example Row of Oxygen Sensor Data in a science_log.csv File .....	A-10
<b>Figure A-4:</b> Example Row of FLbbAP2 Fluorometer Data in a science_log.csv File.....	A-13
<b>Figure A-5:</b> Example Row of FLbbbbb Fluorometer Data in a science_log.csv File.....	A-14
<b>Figure A-6:</b> Example Row of FLbbcd Fluorometer Data in a science_log.csv File .....	A-15
<b>Figure A-7:</b> Example Row of Transmissometer Data in a science_log.csv File .....	A-17
<b>Figure A-8:</b> Example Row of Radiance Radiometer Data in a science_log.csv File .....	A-20
<b>Figure A-9:</b> Example Row of Irradiance Radiometer Data in a science_log.csv File.....	A-23

**Figure A-10:** Example Row of Nitrate Sensor Data in a science\_log.csv File..... A-26

**Figure A-11:** Example Row of Compass Data in a science\_log.csv File ..... A-31

**Figure B-1:** Example Ice Avoidance Behavior of Float when Surface Ice is Detected followed by when Ice Breakup is Detected ..... B-2

**Figure C-1:** Example Time of Day Operation with Four Profiling Cycles..... C-4

**Figure D-1:** APEX Float with Argos Telemetry ..... D-1

## List of Tables

**Table 4-1:** RBRargo CTD Rate Entries Versus Sample Interval ..... 4-10

**Table C-1:** Estimated Float Travel and Park Time Calculations for the First Ascent at 245 Minutes after GMT 00:00 ..... C-5

**Table C-2:** Estimated Float Mission GMT Times Based on Float Leaving the Surface at 00:40 GMT..... C-6

**Table D-1:** Test Message 1 ..... D-4

**Table D-2:** Test Message 2 ..... D-5

**Table D-3:** Data Message 1 ..... D-7

**Table D-4:** Data Message 2 ..... D-9

**Table D-5:** Data Message 3 ..... D-10

**Table D-6:** Data Message 4 ..... D-11

**Table D-7:** Argos Emergency Message ..... D-13

## Battery Hazard Warnings

Teledyne Webb Research APEX profiling floats use either lithium or alkaline batteries as a power source. Since the use of either of these battery types can result in a fire, explosion or other hazards, only properly trained personnel should select and install the batteries in an APEX profiling float. Because there is no way to completely eliminate these hazards, Teledyne Webb Research shall not be liable for any consequential, special, incidental, indirect, multiple, administrative, or punitive damages, or any damage of an indirect or consequential nature arising out of, or related to, the use of lithium or alkaline batteries in performance of the Teledyne Webb Research APEX profiling floats.

### Alkaline Battery Hazard

When alkaline batteries are confined in a sealed housing, there is a small chance that a combustible gas can accumulate and cause a fire or explosion. To minimize the chances of this occurrence, Teledyne Webb Research has added a catalyst inside the APEX profiling float housings which recombines hydrogen and oxygen into water. The housings are also designed to relieve excessive internal pressure buildup by having the upper end cap vent.

### Lithium Battery Hazard

Lithium batteries pose an even greater risk than alkaline batteries, as contact with water can result in a fire or explosion. Although APEX profiling floats are completely sealed, there is always a small chance that a leak has occurred.

## Maximum Depth Warning

Deploying an APEX profiling float to a depth that exceeds its 2000-meter depth rating will result in a catastrophic failure. Do not exceed the depth rating of an APEX profiling float.

## Communications Loss Warning

Communications with an APEX profiling float is over an Iridium satellite network. RUDICS and dialup modems require a primary and an alternate phone number as well as a username and password combination. This information is stored on the APEX profiling float and should be verified through communications testing before deploying it, as unknown or incorrectly stored values can prevent communication, resulting in its loss.

# Preface

The APEX (Autonomous Profiling Explorer) profiling float is an autonomous drifting profiler that acquires water column profile data, such as water conductivity, temperature and pressure, while ascending from a depth of up to 2000 meters. The APEX profiling float also includes the hardware and firmware to support a high level of operator flexibility and multiple functions.

## Purpose of this Manual

This manual provides information on the setup, testing and deployment of an APEX profiling float. It encompasses its latest operational features as of the current revision. Updates to this manual can be obtained by request at [apex@teledyne.com](mailto:apex@teledyne.com) as features are continually added or updated.

This manual is divided into the following seven sections and six appendices:

**Section 1: Overview.** Provides an overall description of the APEX profiling float, including the APEX-BGC Biogeochemical and APEX-AMS Advanced Multisensor profiling floats.

**Section 2: Setup, Test and Deployment.** Provides instructions on how to unpack, prepare for deployment, activate, test, and deploy the APEX profiling float.

**Section 3: Operating Modes.** Illustrates and describes the operating modes performed by the APEX profiling float.

**Section 4: System Files.** Describes the configuration and log files included on the APEX profiling float.

**Section 5: Modifying the Mission Plan.** Describes how to modify the mission plan locally before deploying the float and remotely after deploying the float. In addition, it lists and describes the available commands that can be used to control some of the float functions and access its files.

**Section 6: CTDs.** Provides information on the available CTDs, including their hardware configuration and how to read their data log files and specify their sampling behavior.

**Section 7: General Maintenance.** Provides some cleaning and battery replacement recommendations for the APEX profiling float.

**Appendix A: Optional Sensors.** Provides information on the available optional sensors that can be installed on the float, including manufacturer references and sensor configuration parameters.

**Appendix B: Ice Avoidance.** Illustrates and describes the ice avoidance function that can be enabled before or after deployment of an APEX profiling float.

**Appendix C: Time of Day Operation.** Illustrates and describes the time of day operation.

**Appendix D: Argos Telemetry.** Provides information on the optionally available Argos telemetry link, including descriptions of the transmitted test and data messages. In addition, instructions are provided on how to convert Argos message files to text files.

**Appendix E: Diagnostic Messages Example.** Provides an example of the progress and diagnostic messages displayed when starting the mission from a connected PC.

**Appendix F: Unsupported/Modified Features.** Lists and describes those features on the older APF-9 APEX profiling float that are not currently supported or are replaced.

## Warnings, Cautions and Notes

Where applicable, warnings, cautions and notes are provided in this manual as follows:



**WARNING** Identifies a potential hazard that could cause personal injury or death to yourself or to others.



**CAUTION** Identifies a potential hazard that could be damaging to equipment or could result in the loss of data.



**NOTE** Recommendations or general information that is particular to the material being presented or a referral to another part of this manual or to another manual.

## Documentation Changes

Teledyne Webb Research reserves the right to make changes to the design or specifications of the APEX profiling float at any time without incurring any obligation to modify previously delivered units. In addition, while considerable effort has been made to ensure that the information in this manual is accurate and complete, Teledyne Webb Research assumes no liability for any errors or omissions.

## Returns

Before returning an APEX profiling float for any reason, contact Teledyne Webb Research customer service for a Return Material Authorization (RMA) and return instructions. Additional information can be found at <http://www.teledynemarine.com/webb-research/support>.



**WARNING** *Do not attempt to open the APEX profiling float housing before returning the float to Teledyne Webb Research. If the float was recovered from the ocean, it may contain water. This situation presents a safety hazard due to the possible chemical reaction of the batteries with the water. Before returning a float to Teledyne Webb Research, contact Teledyne Webb Research customer service for instructions on how to properly prepare the float for shipment.*

## Customer Service

We welcome your comments and suggestions for improving our products and documentation as well as developing better ways of serving you. Should you require service or support for an APEX profiling float, contact Teledyne Webb Research customer service using any of the following means:

**Site URL:** <http://www.teledynemarine.com/webb-research/support>

**Mail:** 49 Edgerton Drive  
North Falmouth, MA 02556

**Telephone:** (508) 563-1000

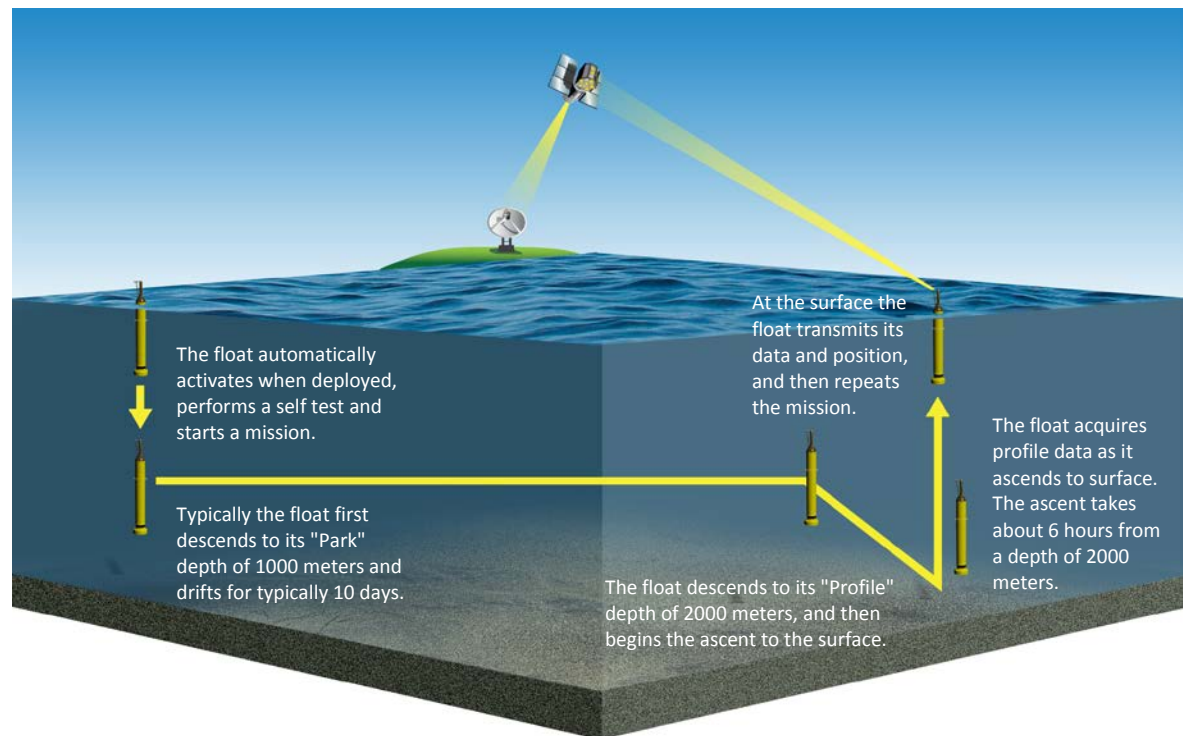


## SECTION 1: Overview

The Teledyne Webb Research APEX (Autonomous Profiling Explorer) profiling float, or "float" for short, is an autonomous drifting profiler that acquires water column profile data, such as water conductivity, temperature and pressure, while ascending from a depth of up to 2000 meters. When at the surface, the collected data are transmitted over the Iridium satellite network to a shore based server. Depending on the type of batteries used, the sensors installed and the sensor sample rates, a float typically has a life of up to four years during which it can descend to its maximum depth and ascend to the surface approximately 150 times.

### 1.1 Operation

The APEX profiling float automatically descends and activates when it is deployed, performs a self test, which includes an ascent to the surface, and starts a mission by descending to its "Park" depth, which is usually 1000 meters as shown in Figure 1-1. It will drift for typically 10 days at the Park depth and then descend to a deeper depth, the "Profile" depth, which is usually its maximum rated depth of 2000 meters. After reaching the Profile depth, the float will ascend to the surface while acquiring profile data. The trip



**Figure 1-1: APEX Profiling Float Profiling Cycle**

to the surface from 2000 meters takes approximately 6 hours. When at the surface, a GPS position fix is obtained, and the data and position of the float are transmitted over the Iridium satellite network to a shore based server. While at the surface, the float can download configuration files over the Iridium satellite network to modify its mission configuration parameters which include the Park and Profile depths, the ascent rate and other parameters. In the same manner the float can modify its sample configuration parameters which specify its sampling behavior. After transmitting the information, the float repeats the mission beginning with its descent to the Park depth.

## 1.2 General Description

An APEX profiling float is shown in two configurations in Figure 1-2, one with a "pumped" type CTD, and the other with a "non-pumped" type CTD. Otherwise the floats are similar. The float is composed primarily of a housing, oil and air bladders, the CTD, and an antenna. It is also capable of interfacing with additional, optional sensors.



**NOTE** For information on APEX profiling floats with Argos telemetry, refer to APPENDIX D: "Argos Telemetry."

### 1.2.1 Housing

The housing is constructed of anodized aluminum and coated with yellow epoxy paint. Carbon fiber housings are also available. It includes a damper disk which minimizes bobbing motion at the surface and has a hole to pass a line through during deployment. Contained inside the housing are all the electronics, hydraulics, battery packs, and mechanical systems required for operation. The float housing is rated to 2000 meters of water depth; however, lighter, thinner walled housings are available for shallower applications, and because they are lighter, they can include a larger battery payload. Upper and lower end caps seal the housing. In the unlikely event that the internal pressure increases excessively, as from battery gassing, either end cap will vent the excess pressure by temporarily breaching. A zinc anode is attached to the upper end cap for corrosion protection. The upper end cap also includes a seal plug which allows manual venting of the housing. Venting should *always* be performed before opening the housing.

### 1.2.2 Bladder

A rubber bladder that is composed of two compartments, one for oil and one for air, is contained inside a cowling which is mounted to the lower end cap of the float. The oil compartment fills with oil from a reservoir inside the housing; the air compartment fills with air from inside the housing. Filling the oil compartment causes the float to ascend

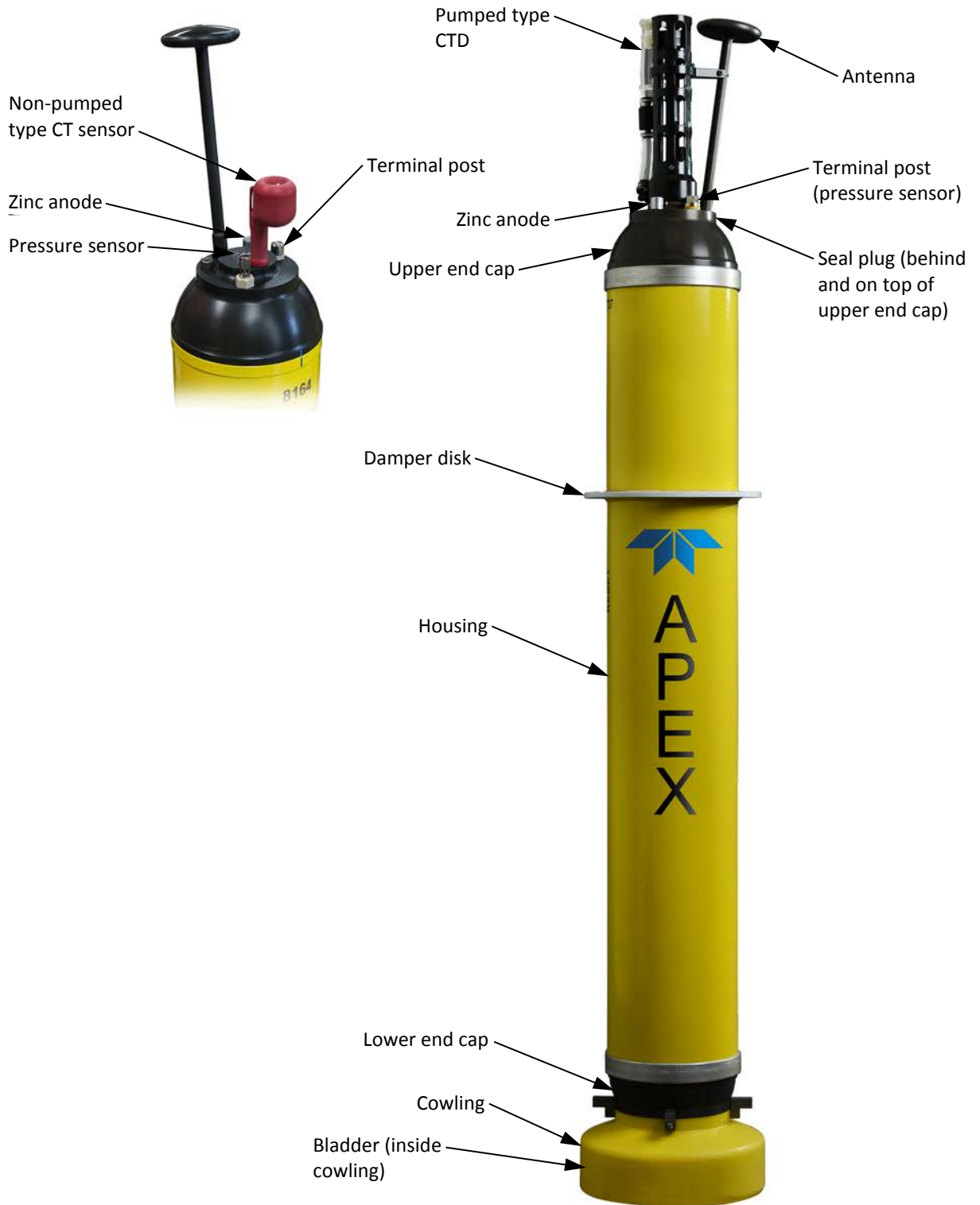


Figure 1-2: The APEX Profiling Float with Pumped Type CTD and Non-pumped Type CTD

from depth, as its volume increases without changing its weight; removing the oil causes it to descend, as the volume decreases. This method works because increasing the volume of the float without changing its weight decreases its density, and decreasing the volume increases its density. The ascent rate is controlled by adjusting the amount of oil in the oil compartment. The air compartment is filled only when the float is near the surface to ensure that the antenna remains above water.

### **1.2.3 CTD**

The CTD, including its pressure sensor, is mounted to the upper end cap. Either the pumped type CTD or the non-pumped type CTD can be installed.

For the pumped type CTD, a pump provides water flow to the temperature and conductivity sensors through a U-shaped flow path during every measurement cycle. The U-shaped path prevents flow due to water currents when the pump is not running, and ensures consistently compensated measurements of temperature and conductivity to yield accurate salinity calculations. It also includes anti-fouling devices. The pump is off between measurement cycles to conserve power. It is also off when the float is near the surface to prevent surface contaminants from being ingested. It remains off while the float is at the surface. The pressure sensor is a premium strain gauge type, and temperature is measured using a thermistor.

The non-pumped type CTD uses an inductive type conductivity sensor that is resistant to contaminants and therefore can measure conductivity all the way to the surface. The pressure sensor is a piezo-resistive transducer with a nickel based super alloy diaphragm that resists corrosion, and temperature is measured using a thermistor that is co-located with the conductivity sensor.

### **1.2.4 Antenna**

The antenna is mounted to the upper end cap. This antenna connects both to a GPS receiver for float position and to an Iridium modem for data communications.

## **1.3 General Operating Theory**

The major functional components of the float are a Controller board which controls its operation, an RF board for communications, a GPS receiver which acquires float position, an Iridium modem which enables communications with the float over the Iridium satellite network, and alkaline or lithium battery packs which power the float. An air pump is used to inflate the air compartment of the bladder, opening a valve deflates the air compartment, and a buoyancy pump is used to inflate and deflate the oil compartment.

### 1.3.1 Controller Board

The operation of the float is controlled by the Controller board. This board controls the air and buoyancy pumps and interfaces with the GPS receiver, the Iridium modem, the CTD, and any additionally installed science sensors. It also includes the float's microcomputer, an internal clock, operational firmware and program and data memory, and it inputs and processes signals from a leak detector and internal temperature, pressure and humidity sensors.

### 1.3.2 RF Board

The RF board serves as a platform for the GPS receiver, the Iridium modem and other communications devices if required.

### 1.3.3 GPS Receiver

The GPS receiver acquires float position and performs time synchronization of the internal clock on the Controller board with the GPS satellite time if needed when the float is on the surface. The receiver is a Garmin GPS 15xL GPS Receiver which shares the antenna with the Iridium modem and connects to the RF board.

### 1.3.4 Iridium Modem

The Iridium modem provides two-way data communications with a shore based server over the Iridium satellite network. The RUDICS/PSTN modem is an Iridium 9523 Satellite Transceiver which shares the antenna with the GPS receiver and connects to the RF board. The SBD modem is a 9602 Satellite Transceiver.

### 1.3.5 Battery Packs

Alkaline or lithium battery packs, or both, are used to power the float, depending on the operator requirements. Refer to "Battery Hazard Warnings" on page xiii for information pertaining to the existing hazards for these battery types.

### 1.3.6 Air Pump

The air compartment of the bladder is inflated by using the air pump to pump air into it from the housing, and it is deflated by opening a valve to allow the air back into the housing.

### 1.3.7 Buoyancy Pump

The oil compartment of the bladder is inflated by using a piston to push oil into the compartment from an oil reservoir and deflated by using the piston to pull oil out of the

compartment back into the reservoir. The piston is a component of a buoyancy pump that is powered from a gear motor. The piston position is tracked using counts from 147 to 3720. At 147 the piston is pulled all the way in which deflates the bladder, increases the density of the float and causes it to descend. At 3720 the piston is pushed all the way out which inflates the bladder, decreases the density of the float and causes it to ascend.

## 1.4 Other Float Configurations and Options

The standard configuration for the APEX profiling float includes a 2000-meter depth rated housing, a CTD, an Iridium modem, and a GPS receiver. However, other configurations can be built that include one or more of the following:

- Light weight, noncorrosive carbon fiber housing.
- Iridium Short Burst Data (SBD) low latency, short messaging two-way satellite communications link.
- Optional sensors, including an oxygen sensor, turbidity, fluorometer, and others.
- Argos telemetry



**NOTE** For information on APEX profiling floats with Argos telemetry, refer to APPENDIX D: “Argos Telemetry.”

## 1.5 Additional Float Types

Four additional float types are available to suit a variety of specific research requirements:

- APEX Deep
- APEX-BGC Biogeochemical
- APEX-AMS Advanced Multisensor
- APEX EM Electromagnetic
- Customer specials

### 1.5.1 APEX Deep Profiling Float

The APEX Deep profiling float is rated to 6000 meters and is contained in a 17-inch diameter glass sphere housing encapsulated in a yellow ribbed hard hat.

### 1.5.2 APEX-BGC Biogeochemical Profiling Float

The APEX-BGC Biogeochemical profiling float is an APEX profiling float that includes the following sensors:

- Oxygen sensor
- Fluorometer
- pH (optional)

The oxygen sensor measures dissolved oxygen, and the fluorometer measures chlorophyll fluorescence and particulate backscattering. A connector on the outside of the housing is included with the float for connecting the cable from the fluorometer. The oxygen sensor is internally connected. In addition, the pumped type CTD can optionally include a pH sensor which measures pH in salt water. For more information on these sensors, including where they are mounted on the float, refer to APPENDIX A: “Optional Sensors.”

### 1.5.3 APEX-AMS Advanced Multisensor Profiling Float

The APEX-AMS Advanced Multisensor profiling float is an APEX profiling float that can include any one or more of the following sensors:

- Oxygen sensor
- Fluorometer
- C-Rover Transmissometer
- Radiance radiometer
- Irradiance radiometer
- Nitrate sensor
- Compass
- pH

The oxygen sensor and the fluorometer are the same as that used for the APEX-BGC Biogeochemical profiling float. The radiance and irradiance radiometers both measure spectral light, the C-Rover transmissometer measures optical transmittance of sea water, and the compass provides heading and tilt measurements. In addition, the pumped type CTD can optionally include a pH sensor which measures pH in salt water. For more information on these sensors, including where they are mounted on the float, refer to APPENDIX A: “Optional Sensors.” The APEX-AMS Advanced Multisensor profiling float also includes an Expansion board which is used to interface with the additional sensors. Upper and lower connector rings on the outside of the housing are also included for connecting the cables from the externally mounted sensors.

### **1.5.4 APEX-EM Electromagnetic Profiling Float**

The APEX-EM Electromagnetic profiling float acquires water column current velocity data along with other profile data, such as water conductivity, temperature and pressure.

### **1.5.5 Customer Specials**

For specific research requirements that require one or more sensors that are not currently available with an APEX-BGC Biogeochemical or APEX-AMS Advanced Multisensor profiling float, a customer special of an APEX profiling float can be provided that integrates these sensors. The float can be customized with the required hardware, firmware and internal and external connections.

## **1.6 Deployment Methods**

APEX profiling floats are deployed from research vessels as well as merchant ships, such as Volunteer Observing Ships (VOS) or Ships of Opportunity (SOOP). As merchant ships are continuously under way at speeds of up to 25 knots or more and have decks as high as 25 meters above the waterline, floats can be packaged in biodegradable cardboard containers which can be hand deployed under these conditions using lines to lower them over the side. A float can also be deployed from a stationary research vessel by passing a line through the hole in the damper disk and carefully lowering the float over the side while holding both ends of the line. Once in the water, one end of the line is released and pulled through and out of the hole. A line should never remain attached to a float. A third deployment method is by air. For instructions on how to air deploy a float, contact Teledyne Webb Research customer service.



## SECTION 2: Setup, Test and Deployment

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This section provides instructions on how to unpack, prepare for deployment, activate, test, and deploy the Teledyne Webb APEX profiling float.

### 2.1 Unpacking and Inspection

Included with each shipment of one or more floats is an accessories and documentation set as shown in Figure 2-1. The set includes the following items:

**Reset tool.** The Reset tool is used to manually start the mission beginning with a self test.

**Cowling plug.** The cowling plug is used to seal the large hole at the bottom of the cowling. It is a spare component.

**Small cowling plugs.** The small cowling plugs are used to seal the small holes at the bottom of the cowling. They are spare components.

**RS-232 Current Loop Converter.** The RS-232 Current Loop Converter enables bidirectional communications between the float and a PC. It includes a 25-pin to 9-pin serial port adapter for a PC that uses a 9-pin RS-232 serial port.

**15 VDC Power Supply.** The 15 VDC Power Supply is used to power the RS-232 Current Loop Converter.

**Communications cable.** The communications cable is used to connect the RS-232 Current Loop Converter to the float.

**Universal AC adapter plugs.** Four universal AC adapter plugs enable connection of the 15 VDC Power supply to most any type of power outlet.

The floats are carefully packed in wooden crates. The accessory items are packed in a plastic bag and included with one of the floats. Every effort is made to pack the floats to protect them during shipment. However, carefully inspect the crates for any signs of external damage. After inspecting the crates, locate and remove the packing list and verify that all of the items are included. Open the crates and inspect each float for damage that might have occurred during shipment. If any damage is found, either to a crate or to a float, immediately report the damage to Teledyne Webb Research and to the freight carrier.



**Figure 2-1: APEX Profiling Float Accessories**

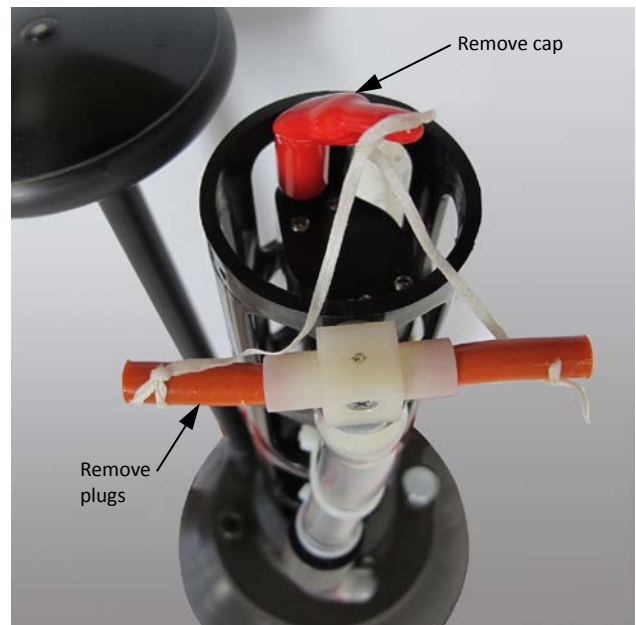
## 2.2 Preparing the Float for Deployment

To prepare the float for deployment:

1. Remove the float from its crate, and using the foam cradles packed with the float, lay it on a flat, horizontal surface.
2. Allow the float to warm up indoors if it has been stored at a temperature of  $-2^{\circ}\text{C}$  or less.
3. Remove any plastic bags covering the CTD as shown in Figure 2-2.
4. For a float with a pumped type CTD only, remove the cap and two plugs from the CTD along with any protective caps from the optional sensors as shown in Figure 2-3. Save the caps and plugs to use if the float is to be stored at a later time.



**Figure 2-2:** Plastic Bag to be Removed from CTD



**Figure 2-3:** Cap and Plugs to be Removed from Pumped Type CTD

## 2.3 Starting the Mission

The float will start a mission whenever any one of the following operations is performed:

- The float is deployed directly from its shipping container and pressure activates at depth.
- The Reset tool is swiped against the float housing.
- A command to start the mission is sent from a connected PC.

Once the mission starts, the float will enter the Prelude phase. During the Mission Prelude phase, the float runs an internal self test, obtains its GPS position, performs time synchronization of the internal clock with the GPS satellite time if needed, uploads log files to the server, receives configuration files from the server, and waits for the time specified by the **PreludeTime** configuration parameter to expire, after which the float will begin its descent to the Park depth for the first profiling cycle. For information on the Mission Prelude phase and all of the configuration parameters, refer to SECTION 3: “Operating Modes.”

If the Reset tool or a command is used to start the mission to verify float operation before deployment, several events can be monitored. The float will vibrate as the buoyancy pump runs, the compartments of the bladders in the cowling will fill with oil and air, and log files will appear on the server. Once any of these events is observed, the float is ready for deployment.

When starting the mission using the Reset tool or a command, the float *must* be outside with a clear view of the sky. It should also be deployed within 120 minutes after starting the mission as described in “Deploying the Float” on page 2-8.



**NOTE** *The float will perform a self test and some mission preparation tasks for each of these operations prior to the actual mission start. The self test can also be run from a connected PC as described in “Running the Self Test from a Connected PC” on page 2-7. This option does not start the mission and is recommended to verify adequate battery capacity when a float has been in storage for an extended period of a year or more.*



**CAUTION** *When the self test is running, both the oil and air compartments of the bladder will inflate causing the bottom of cowling to expand slightly. If the float is resting on deck in its upright position, it could topple over causing damage to the CTD or to the antenna. Before starting the mission with the Reset tool or the PC, or before running the self test from a connected PC, secure the float such that it will remain stable during the self test.*

The self test performs numerous checks, several of which are the following:

- CTD current draw
- RF board current draw
- Humidity
- Leak detection
- Internal vacuum pressure leak detection
- Battery voltage
- Buoyancy pump
- Air bladder inflation
- Iridium modem
- Telemetry
- GPS receiver



**NOTE** When starting a mission by using a command from a connected PC, or running only the self test from a PC, a single beep will sound before the test, and either a single beep for pass or ten beeps in succession for fail will sound after completion of the test. It may be difficult or not possible to hear these beeps in a noisy environment, such as on the deck of a ship. If possible, it is best to listen for the beeps in a relatively quiet environment while pressing your ear against the housing below the damper disk.

### 2.3.1 Starting the Mission by Deploying the Float Directly from its Crate

The mission will start, beginning with a self test, after the float is deployed directly from its crate and it descends to or below its pressure activation depth. For instructions on how to deploy the float, refer to “Deploying the Float” on page 2-8.

### 2.3.2 Starting the Mission using the Reset Tool

To start the mission using the Reset tool:

1. Slowly swipe the Reset tool against and across the housing beginning about five centimeters *above* the RESET label and ending in a semicircle about five centimeters below the RESET label. This label is shown Figure 2-4.

After about 30 seconds, a beep will sound for about three seconds, and then the float will perform the self test which includes inflating both the oil and air compartments of the bladder. The self test typically takes about 25 minutes to complete. If all of the checks performed by the self test pass, the beep will sound again for about three seconds, files will be uploaded and downloaded over the Iridium satellite network, and at the end of the Mission Prelude phase, the mission will start. For information on the Mission Prelude phase, refer to SECTION 3:



**Figure 2-4: RESET Label on Float Housing**

“Operating Modes.” Should any

one or more of the checks fail, ten short beeps will sound to indicate that the self test failed. The float should not be deployed if the self test fails.

2. Check that the air compartment of the bladder is deflated by temporarily removing the large cowling plug and verifying that you can insert your finger inside the hole.

### 2.3.3 Starting the Mission with a Command from a Connected PC

To start the mission with a command from a connected PC:

1. Connect a PC to the float and start a terminal program as described in “Connecting a PC to the Float” on page 2-10.
2. Enter `m_state`. The float should respond as in the following example:

```
03/01/16 15:26:24 APEX-v2.3.17
Onboard Datetime:      03/15/2016 14:55:33
Mission State:         IDLE
Time in IDLE state:    0000:00:02
Activation Pressure:   25.0 dbar
Standby Mode:          OFF
Debug Verbosity:      0
```

Mission State must be "IDLE." If Mission State is not "IDLE," enter `m_idle`, and then enter `m_state` again and verify that Mission State is "IDLE."

3. While listening to the float, enter `m_deploy`.

A beep will sound for about three seconds, and then the float will perform the self test which includes inflating both the oil and air compartments of the bladder. The self test typically takes about 25 minutes to complete. Progress and diagnostic messages will be displayed on the PC as described in “Self Test Progress and Diagnostic Messages” on page 2-8. If all of the checks performed by the self test pass, the beep will sound again for about three seconds, files will be uploaded and downloaded over the Iridium satellite network, and at the end of the Mission Prelude phase, the mission will start. For information on the Mission Prelude phase, refer to SECTION 3: “Operating Modes.” Should any one or more of the checks fail, ten short beeps will sound to indicate that the self test failed. The float *should not* be deployed if the self test fails.

4. Verify that the cowling bottom is slightly expanded during the test, indicating bladder inflation.
5. Disconnect the PC from the float. To abort the mission, reconnect and enter `m_idle`.

### 2.3.4 Running the Self Test from a Connected PC

When running the self test from a connected PC, the mission will not start. To run the self test from a connected PC:

1. Connect a PC to the float and start a terminal program as described in “Connecting a PC to the Float” on page 2-10.
2. Enter `m_console`.
3. Enter `m_state`. The float should respond as in the following example:

```
03/01/16 15:26:24 APEX-v2.3.17
Onboard Datetime:           03/15/2016 14:55:33
Mission State:              CONSOLE
Time in CONSOLE state:      0000:00:02
Activation Pressure:        25.0 dbar
Standby Mode:               OFF
Debug Verbosity:           0
```

4. While listening to the float, enter `sys_self_test`.

A beep will sound for about three seconds, and then the float will perform the self test which includes inflating both the oil and air compartments of the bladder. The self test typically takes about 25 minutes to complete. Progress and diagnostic messages will also be displayed on the PC as described in “Self Test Progress and Diagnostic Messages” below. If all of the checks performed by the self test pass, the

beep will sound again for about three seconds. Should any one or more of the checks fail, ten short beeps will sound to indicate that the self test failed. The float should not be deployed if the self test fails.

Note also that the cowling bottom slightly expands, and then after the test, deflates. This process happens relatively quickly.

5. Enter `m_bye` and then disconnect the PC from the float.

### 2.3.5 Self Test Progress and Diagnostic Messages

When starting the mission from a PC or running the self test from a PC, progress and diagnostic messages will be displayed on the PC as in the following partial example:

```
eng> sys_self_test
*****
Start Float Test
  Float: f7718
  Time:  2016-03-18 20:04:55
*****
03/17/16 18:19:04 APF11-v2.4.8
Battery Voltage:    14.70 V
Float Current:     32.6583 mA
Coulomb Count:    227.4443 mAh
Bladder Pressure:  8.3 dbar
Internal Vacuum:  8.2 dbar
Piston Position:  260 counts
```

For the full example text, refer to 7.4 APPENDIX E: “Diagnostic Messages Example.”

## 2.4 Deploying the Float

A float is ready for deployment directly from its crate after preparing it for deployment as described in “Preparing the Float for Deployment” on page 2-3.



**NOTE** *If a float has been in storage for an extended period of a year or more, a self test from a connected PC should be run to obtain the battery voltage and coulomb counter values. This information should be provided to Teledyne Webb Research customer service before deploying the float to verify that the battery capacity is adequate for the intended mission.*





**NOTE** *If the mission is started by using the Reset tool or a command from a connected PC, the float should be deployed after the self test is complete but before the end of the Mission Prelude phase which by default is 120 minutes, otherwise unexpected results may occur.*

Typically, floats are deployed from a stationary or moving vessel. They can also be air deployed. For instructions on how to air deploy a float, contact Teledyne Webb Research customer service.

To deploy the float:

1. Pass a line through the hole in the damper ring. This hole is shown in Figure 2-5. The line should be able to easily slip through the hole and support the weight of the float which is approximately 25 kg (55 lb).
2. While holding both ends of the line, carefully lower the float into the water as shown in Figure 2-6. Do not let the line continuously slide through the hole while lowering the float, as it may cut through it.



**CAUTION** *When deploying the float, be careful not to let the CTD or other sensors or the antenna strike the side of the ship, as doing so could damage these components.*



**Figure 2-5: Hole in Damper Ring**



**Figure 2-6: APEX Profiling Float being Deployed**

3. When the float is in the water, let go of one end of the line and carefully pull the other end until the entire line passes through the hole and the float is free. Do not leave the line attached to the float.

If the float was deployed directly from its crate or after performing a self test from a connected PC, it will float on its side until the cowling fills with water. Then it will submerge and begin descending. During its descent it will periodically check to see if it is at or below its pressure activation depth. When it reaches or passes this depth, it will begin the self test. The actual depth at which the test begins could be well below the pressure activation depth depending on how often the float checks its depth. During the self test, the float will surface, obtain its GPS position, perform time synchronization of the internal clock with the GPS satellite time if needed, and upload log files and download configuration files to and from the server, respectively, over the Iridium satellite network. The mission will then start with the descent to Park depth.

If the float was deployed after using the Reset tool or a command from a connected PC to start the mission, the mission will start with the descent to Park depth *only* if the float has obtained its GPS position, performed time synchronization of the internal clock with the GPS satellite time if needed, and uploaded and downloaded files over the Iridium satellite network. If not, it will perform or continue to perform these tasks first, and then descend to Park depth.

## 2.5 Recovering the Float

Before recovering the float, it must be placed into recovery mode as described in Recovery Mode on page 3-14. When recovering the float be careful not to damage the CTD or the antenna.

## 2.6 Connecting a PC to the Float

To communicate with the float from a PC, you must connect a PC to the float using the RS-232 Current Loop Converter, and the PC must be running a terminal program, such as Procomm Plus, Tera Term or HyperTerminal. The PC must also have an RS-232 serial port that uses either a 25-pin or a 9-pin connector. A serial port adapter is included with the RS-232 Current Loop Converter for a PC that has only a 9-pin serial port connector. In addition, the settings for the serial port must be as follows:

<b>Baud Rate:</b>	19200
<b>Parity:</b>	None
<b>Data Bits:</b>	8

<b>Stop Bits:</b>	1
<b>Flow Control:</b>	None
<b>Handshaking:</b>	None
<b>Duplex:</b>	Full

To connect a PC to the float:

1. Connect the clamps of the communications cable from the RS-232 Current Loop Converter to the zinc anode and to the terminal post (pressure sensor on some floats) on the upper end cap of the float as shown in Figure 2-7. It does not matter which clamp connects to which part.
2. Connect the 25-pin connector of the RS-232 Current Loop Converter to the RS-232 serial port of the PC. Use the serial port adapter if the serial port of the PC uses a 9-pin connector.
3. Attach the appropriate AC adapter plug for the AC outlet to be used to the 15 VDC Power Supply. To attach the plug, push the button labeled "PUSH" on the power supply, slide out the transparent cover, and then slide in the adapter plug.
4. Plug the 15 VDC Power Supply into the AC outlet.
5. Turn on the PC and start the terminal program.
6. Press the Enter key.

The command prompt ">" will be displayed.



**Figure 2-7: Communications Cable Connected to Zinc Anode and Terminal Post (Pressure Sensor)**



**NOTE** With the PC connected to the float, all entries made by the float to the `system_log.txt` file will be displayed along with the operator entries and float responses in accordance with the verbosity level. The verbosity level is set with the System user command **`dbg_verbosity`**. For information on all the available user commands, refer to "User Commands" on page 5-6. For information on the `system_log.txt` file, refer to "Log Files" on page 4-13.

If the float does not respond, try one or more of the following:

- Check the serial port settings as listed in the previous page.
- Check the connections to the float.
- Be sure the float is not wet.
- Reboot the PC and restart the terminal program.
- Contact Teledyne Webb Research customer service.

## 2.7 Enabling and Disabling Lowpower Standby Operation

Lowpower standby operation is enabled ("on") when a float is shipped. When enabled, the float will remain in a lowpower state during periods when it is not active, drawing very little power from the batteries. When communicating with the float from a PC as described in "Connecting a PC to the Float" on page 2-10, lowpower standby operation can be disabled ("off") by entering `m_console`. Before *disconnecting* the PC, lowpower standby operation should be re-enabled by entering `m_bye`. However, the float will automatically re-enable lowpower standby operation two hours after last entering `m_console`, whether connected to a PC or not.

## 2.8 Optional Pre-deployment Testing

All floats are shipped from the factory fully tested and ready to deploy. Prior to deployment, however, operators can optionally connect a PC to the float to perform some pre-deployment tests which include viewing, editing and transferring files. For instructions on how to connect a PC to the float and start a terminal program, refer to "Connecting a PC to the Float" on page 2-10.

At the command prompt, enter `m_console` to place the float into Console mode, and then enter `dbg_verbosity 5` to enable monitoring of progress messages. The float will automatically exit Console mode in two hours, or before disconnecting the PC from the float, enter `m_bye` to exit Console mode if you are finished with the pre-deployment tests before that time.

### 2.8.1 Testing the Float

Two tests can be run on the float, the self test and the communications test. In addition, a simulated mission can be run out of the water. The communications test is part of the self test but can be run independently.

**Running the self test.** To run the self test bring the float outside and place it where it has a clear view of the sky for Iridium satellite communications and enter `sys_self_test`, or leave the float indoors and enter `sys_self_test -nosky`. Progress and diagnostic messages should be displayed on the PC as described in “Self Test Progress and Diagnostic Messages” on page 2-8.

**Running the communications test.** To run the communications test, enter `modem_test`. The Iridium modem’s primary and secondary numbers are tested and the results are displayed.

**Running a simulated mission.** To run a simulated mission out of the water for a float with a pumped type CTD that *does not* have a pH sensor, first install a plastic water loop filled with deionized water and then enter `m_deploy`. For a float with a non-pumped type CTD, just enter `m_deploy`. The float will cycle through the mission phases based on the various timeout settings of the configuration parameters instead of the water depths while displaying progress messages.



**CAUTION** *Do not use deionized water when running a simulated mission for a float with a CTD-plus-pH sensor. Instead, use UV filtered natural seawater. Use of deionized water with a CTD-plus-pH sensor will affect the calibration of the pH sensor resulting in inaccurate data.*



**NOTE** *Continuous sampling will not run for floats with a pumped type CTD at the surface, as the "pcutoff" pressure of the CTD is typically set to 2 decibars.*

## 2.8.2 Viewing and Editing the Configuration Parameters

The mission, sample, system, and sensor configuration parameters can be viewed and edited directly from the PC and edited remotely over the Iridium satellite network.

**Viewing the configuration parameters.** To view the configuration parameters, enter `fs_cat` followed by a space and the configuration parameter file name: `mission.cfg`, `sample.cfg`, `system.cfg`, or `sensor.cfg`.

**Editing the mission configuration parameters.** To edit the mission configuration parameters directly from the PC, refer to “Modifying the mission.cfg File Configuration Parameter Settings Locally from a Connected PC” on page 5-3 and begin with Step 2. To edit the mission configuration parameters remotely over the Iridium satellite network, refer to “Modifying the mission.cfg File Configuration Parameter Settings Remotely” on page 5-4 and then refer to “Transferring Files” on page 2-14 to download the file from the server to the float over the Iridium satellite network.

**Editing the sample configuration parameters.** To edit the sample configuration parameters remotely over the Iridium satellite network, refer to “Modifying the sample.cfg File Configuration Parameter Settings Remotely” on page 5-5 and then refer to “Transferring Files” below to download the file from the server to the float over the Iridium satellite network.

To edit the sample configuration parameters directly from the PC:

1. Enter `fs_mv sample.cfg sample.old` to rename the current sample.cfg file to sample.old.
2. Enter `sys_capture sample.new` to create a new file called sample.new.
3. Enter the sampling behavior in accordance with “sample.cfg File” on page 4-5.
4. Type "." and then press Enter to exit capture.
5. Enter `fs_cat sample.new` to display the contents of the sample.new file.
6. Enter `fs_mv sample.new sample.cfg` to rename the new file to sample.cfg for use by the float.
7. Enter `m_bye` to reset the float with the new sample.cfg file. This command will also exit Console mode.



**NOTE** To continue with other pre-deployment tests, you must re-enter `m_console` to place the float back into Console mode.

**Editing the system configuration parameters.** The system configuration parameters should not be modified. However, for the RUDICS/PSTN configuration, to edit the username, password or dial strings, enter `modem_dial_config <username> <password> <primary_dial_string> dialup | rudics <alternate_dial_string> dialup | rudics`, where "|" indicates a choice of one of the two parameters.

**Editing the sensor configuration parameters.** The sensor configuration parameters should not be modified.

### 2.8.3 Transferring Files

The mission.cfg and sample.cfg files can be downloaded over the Iridium satellite network from the server to the float. Similarly, the log files can be uploaded from the float to the server. When transferring the files, place the float where it has a clear view of the sky.

**Downloading mission.cfg and sample.cfg files.** To download the mission.cfg and sample.cfg files from the server to the float, enter `modem_transfer`.

**Uploading the log files.** To upload the log files from the float to the server, enter `log_up`, and then enter `modem_transfer`.

## SECTION 3: Operating Modes

The mission of a Teledyne Webb Research APEX profiling float can start in one of three ways: the float is deployed directly from its crate and descends to or below its pressure activation depth at which time it activates, the Reset tool is swiped across the RESET label on the housing, or a command is issued from a connected PC. In all cases the float has four main operating modes:

- Idle mode
- Mission mode
- Recovery mode
- Emergency mode

The float is shipped in Idle mode, and Recovery mode is activated only by the operator, and typically only if the float is to be recovered. The behavior of the float during each mode is determined by the configuration parameters which are in a file called `mission.cfg`. This file is preloaded onto a secure digital (SD) card in the float but can be modified by the operator as described in SECTION 5: “Modifying the Mission Plan.” Figure 3-1 shows a graphical representation of the operating modes, their associated `mission.cfg` configuration parameters and their factory default settings.

### 3.1 Idle Mode

In Idle mode the float will periodically awaken from the lowpower state, deflate the air compartment of the bladder if it is inflated and verify and correct if necessary the piston position in accordance with **MActivationCount**. It will also check for the pressure activation depth indicating that it is underwater. When at or below this depth, the float will activate and go into Mission mode.

The `mission.cfg` file configuration parameters that apply to the Idle mode are **IdleTimerInterval**, **MActivationCount** and **MActivationPressure**:

**IdleTimerInterval.** The time in seconds between which the float momentarily awakens from the lowpower state to verify the piston position and check the pressure. If the pressure is more than **MActivationPressure**, the float goes into Mission mode.

Syntax:	IdleTimerInterval <seconds>
Range:	1–7862400 sec (91 days)
Default:	7200 sec (2 hours)



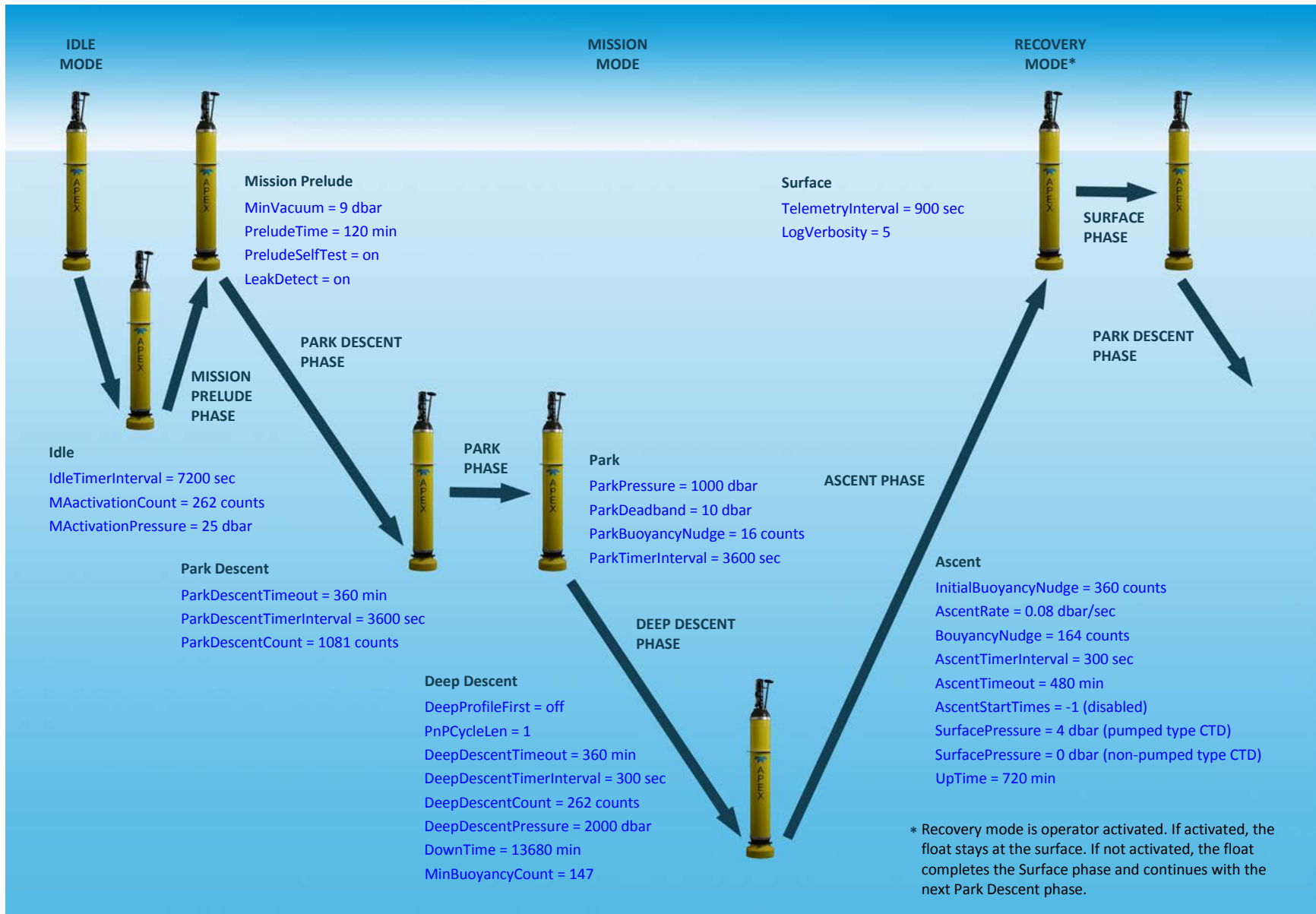


Figure 3-1: Operating Modes and Factory Default mission.cfg File Configuration Parameter Settings



**MActivationCount.** The piston position in counts that will cause the float to descend below its specified pressure activation depth as determined by **MActivationPressure** when it is deployed.

Syntax: MActivationCount <counts>  
 Range: 262–3700 counts  
 Default: 262 counts



**CAUTION** The float will not pressure activate if **MinBuoyancyCount** is greater than **MActivationCount**, as **MinBuoyancyCount** would prevent the piston position from reaching **MActivationCount** which is associated with **MActivationPressure**. It will also not pressure activate if **MActivationCount** does not allow the float to reach **MActivationPressure**. For information on **MinBuoyancyCount**, refer to “Deep Descent Phase” on page 3-8.



**NOTE** Although an **MActivationCount** that is less than **DeepDescentCount** is valid, when descending for pressure activation, the float may go deeper than the Profile depth as determined by **DeepDescentPressure**. For information on **DeepDescentCount** and **DeepDescentPressure**, refer to “Deep Descent Phase” on page 3-8.

**MActivationPressure.** The minimum pressure in decibars at which the float goes into Mission mode. It determines the float’s pressure activation depth. The float checks for this pressure periodically at the rate specified by **IdleTimerInterval**.

Syntax: MActivationPressure <decibars>  
 Range: 5–25 dbar  
 Default: 25 dbar

## 3.2 Mission Mode

In Mission mode the float is directed through six distinct phases, five of which are repeated in a continuous cycle:

- MISSION PRELUDE:** The float ascends to the surface if it is not already there, performs the self test, uploads files, receives mission and sample configuration parameters, and performs time synchronization if needed. If the self test passes, the float proceeds to the Park Descent phase after a specific period. The Mission Prelude phase occurs first, and only once.
- PARK DESCENT:** The float descends to its Park depth of typically 1000 meters.
- PARK:** The float drifts for a specified period while dynamically maintaining its Park depth.

<b>DEEP DESCENT:</b>	The float descends to its Profile depth. Upon reaching this depth, which is typically 2000 meters, the float immediately begins its Ascent phase.
<b>ASCENT:</b>	The float ascends to the surface while measuring and recording profile data. At a specified depth just below the surface, the float begins its Surface phase.
<b>SURFACE:</b>	The float transmits its data and position, performs time synchronization of the internal clock on the Controller board with the GPS satellite time if needed, and receives new mission.cfg and sample.cfg files if available. This phase ends with an atmospheric pressure measurement to check the pressure sensor calibration followed by a new profiling cycle beginning with the Park Descent phase.

### 3.2.1 Mission Prelude Phase

During the Mission Prelude phase, the float begins the self test and surfaces if it is not already at the surface. During the test the float transmits all of its log files and receives new mission and sample configuration parameters, if available, over the Iridium satellite network, acquires and transmits its position, and performs time synchronization and GPS Almanac updates if needed. At the end of the Mission Prelude phase the float resets the mission count to zero and transitions to the Park Descent phase.

The mission.cfg file configuration parameters that apply to the Mission Prelude phase are **MinVacuum**, **PreludeTime**, **PreludeSelfTest**, and **LeakDetect**:

**MinVacuum.** The minimum internal vacuum pressure required inside the housing. It applies only to the self test component of the Mission Prelude phase. Should the actual housing pressure exceed this value, the self test will fail.

Syntax:	MinVacuum <decibars>
Range:	8–10 dbar
Default:	9 dbar

**PreludeTime.** The amount of time in minutes the float will remain in the Mission Prelude phase before transitioning to the Park Descent phase. The float will transition to the Park Descent phase *only* at the end of this period and *only* if the self test passes or **PreludeSelfTest** is set to "off."

Syntax:	PreludeTime <minutes>
Range:	1–600 min (10 hours)
Default:	120 min (2 hours)

**PreludeSelfTest.** If set to "on," the float will transition to the Park Descent phase at the end of the period determined by **PreludeTime** *only* if the self test passes. If the self test fails, the float will go into Emergency mode. If set to "off," the float will transition to the Park Descent phase whether or not the self test passes. In addition, the test results, pass or fail, will be logged to the system\_log.txt file. For information on the system\_log.txt file, refer to "Log Files" on page 4-13.

Syntax: PreludeSelfTest <on|off>  
 Range: on or off  
 Default: on

**LeakDetect.** If set to "on," the float will transition to the Emergency mode upon detection of an internal water leak. If set to "off," the float will only log the condition to the system\_log.txt file. The vitals\_log.bin file also provides the leak detect voltage. For information on the system\_log.txt and the vitals\_log.bin files, refer to "Log Files" on page 4-13.

Syntax: LeakDetect <on|off>  
 Range: on or off  
 Default: on



**NOTE** The **LeakDetect** configuration parameter applies to all operating modes.

### 3.2.2 Park Descent Phase

The Park Descent phase begins with the deflation of the air compartment of the bladder and the partial deflation of the oil compartment. With the compartments deflated, the float begins its descent to its Park depth and will transition to the Park phase upon reaching the Park depth or if it times out attempting to reach it.

The mission.cfg file configuration parameters that apply to the Park Descent phase are **ParkDescentTimeout**, **ParkDescentTimerInterval**, and **ParkDescentCount**:

**ParkDescentTimeout.** The amount of time in minutes allowed for the float to leave the surface and to reach its Park depth. Should the float not reach its Park depth in this period, it will transition to the Park phase.

Syntax: ParkDescentTimeout <minutes>  
 Range: 1–480 min (8 hours)  
 Default: 360 min (6 hours)

**ParkDescentTimerInterval.** The interval in seconds between float samples of the pressure to determine if the Park depth has been reached. The pressure is recorded to the science\_log.bin file. For information on the science\_log.bin file, refer to “Log Files” on page 4-13.

Syntax: ParkDescentTimerInterval <seconds>  
 Range: 1–3600 sec (60 minutes)  
 Default: 3600 sec (60 minutes)

**ParkDescentCount.** The piston position in counts that will cause the float to descend to its Park depth. This configuration parameter is dynamically updated during the Park phase of each profiling cycle in accordance with **ParkBuoyancyNudge** of the Park phase and is applied during the next profiling cycle.

Syntax: ParkDescentCount <counts>  
 Range: **DeepDescentCount– buoyancy\_pump\_max** counts  
 Default: 1081 counts



**NOTE** A float will not reach the Park depth if **MinBuoyancyCount** is greater than **ParkDescentCount**. In addition, **ParkDescentCount** must not be set less than **DeepDescentCount**.



**NOTE** The default **ParkDescentCount** is based on the default **ParkPressure** of 1000 dbar. For information on **ParkPressure**, refer to “Park Phase” below.

### 3.2.3 Park Phase

The Park phase begins immediately after the completion of the Park Descent phase and continues for a period determined by the actual descent time to the Park depth and **DownTime** and **DeepDescentTimeout** of the Deep Descent phase as follows:

**DownTime** – (actual descent time to Park depth + **DeepDescentTimeout**)

Should the float not reach the Park depth before the period specified by **ParkDescentTimeout**, it will transition to the Park phase, and the Park phase period will be:

**DownTime** – (**ParkDescentTimeout** + **DeepDescentTimeout**)

There are two other configuration parameters, **DeepProfileFirst** and **PnPCycleLen**, that will impact the time in the Park phase. These configuration parameters are described in “Deep Descent Phase” on page 3-8. The float can be configured to quickly transition through the Park phase and start a descent to the Profile depth if a descent to the Profile

depth is required for the first profiling cycle, or the float can be configured to omit consecutive descents to Profile depth thus staying in Park longer before doing an ascent.

The mission.cfg file configuration parameters that apply to the Park phase are **ParkPressure**, **ParkDeadband**, **ParkBuoyancyNudge** and **ParkTimerInterval**:

**ParkPressure.** The pressure in decibars associated with the Park depth.

Syntax: ParkPressure <decibars>  
Range: 1–2000 dbar  
Default: 1000 dbar

**ParkDeadband.** The maximum pressure difference in decibars between the actual pressure and **ParkPressure**. When exceeded, the piston position is adjusted by **ParkBuoyancyNudge** to move the float towards the Park depth.

Syntax: ParkDeadband <decibars>  
Range: 1–**ParkPressure**  
Default: 10 dbar

**ParkBuoyancyNudge.** The number of counts to change the piston position from its current position in the direction that will bring the float closer to the Park depth. It is applied after three successive pressure samples that are outside the dead band specified by **ParkDeadband**.

Syntax: ParkBuoyancyNudge <counts>  
Range: 0–3460 counts  
Default: 16 counts

**ParkTimerInterval.** The interval in seconds between float samples of the pressure to determine if the pressure is within the dead band specified by **ParkDeadband**. It is also the interval at which the sensor specified in a sample.cfg entry for the Park phase is sampled. Refer to “sample.cfg File” on page 4-5 for more information on the sample.cfg file. The pressure is recorded to the science\_log.bin file. For information on the science\_log.bin file, refer to “Log Files” on page 4-13.

Syntax: ParkTimerInterval <seconds>  
Range: 60–7200 sec (2 hours)  
Default: 3600 sec (1 hour)



**NOTE** *ParkDescentCount*, as described in “Park Descent Phase” on page 3-5 is dynamically updated during the Park phase in accordance with **ParkBuoyancyNudge** and is applied during the next profiling cycle.

### 3.2.4 Deep Descent Phase

The Deep Descent phase begins with the nearly total deflation of the oil compartment of the bladder and the descent to the Profile depth.



**NOTE** *The float will end the Deep Descent phase and start the Ascent phase if after three successive pressure samples, it detects that it has not descended further and therefore has reached the bottom.*

The mission.cfg file configuration parameters that apply to the Deep Descent phase are **DeepProfileFirst**, **PnPCycleLen**, **DeepDescentTimeout**, **DeepDescentTimerInterval**, **DeepDescentCount**, **DeepDescentPressure**, **DownTime**, and **MinBuoyancyCount**:

**DeepProfileFirst.** If set to "on," the float will, on its first descent only, after the Mission Prelude, remain in the Park phase for five minutes before descending to the Profile depth. If set to "off," the first Park phase period is as described in "Park Phase" on page 3-6.

Syntax:           DeepProfileFirst <on|off>  
Range:             on or off  
Default:           off

**PnPCycleLen.** The number of descents the float will make to the Park depth before a descent to the Profile depth. If **DeepProfileFirst** is "on," then **DeepProfileFirst** will run before **PnPCycleLen** applies.

Syntax:           PnPCycleLen <n>  
Range:             1–255  
Default:           1

**DeepDescentTimeout.** The maximum amount of time in minutes allowed for the float to leave its Park depth and to reach its Profile depth. Should the float not reach its Profile depth in this period, it will stop descending and transition to the Ascent phase.

Syntax:           DeepDescentTimeout <minutes>  
Range:             1–600 min (10 hours)  
Default:           360 min (6 hours)

**DeepDescentTimerInterval.** The interval in seconds between float samples of the pressure to determine if the Profile depth has been reached. The pressure is recorded to the science\_log.bin file. For information on the science\_log.bin file, refer to "Log Files" on page 4-13.

Syntax: DeepDescentTimerInterval <seconds>  
 Range: 5–900 sec (15 minutes)  
 Default: 300 sec

**DeepDescentCount.** The piston position in counts that will cause the float to descend to its Profile depth. This configuration parameter is dynamically updated during each profiling cycle based on the adjustments needed to reach the desired Profile depth.

Syntax: DeepDescentCount <counts>  
 Range: **Buoyancy\_pump\_min– Buoyancy\_pump\_max** counts  
 Default: 262 counts



**NOTE** A float will not reach the Profile depth if **MinBuoyancyCount** is greater than **DeepDescentCount**.



**NOTE** The default **DeepDescentCount** is based on the default **DeepDescentPressure** of 6000 dbar.

**DeepDescentPressure.** The pressure in decibars associated with the Profile depth.

Syntax: DeepDescentPressure <decibars>  
 Range: 1–2000 dbar  
 Default: 2000 dbar

**DownTime.** The allocated time in minutes for the float to leave the surface and to reach the Profile depth, or in cases where **PnPCycleLen** is greater than 1, the time to complete the Park phase.

Syntax: DownTime <minutes>  
 Range: 1–43200 min (30 days)  
 Default: 13680 min (9.5 days)

**MinBuoyancyCount.** The minimum allowable buoyancy position in counts, overriding any other count setting. This configuration parameter prevents the movement of oil from the oil compartment of the bladder into the oil reservoir at the specified count to manage the maximum depth of a descent. In general **MinBuoyancyCount** should be set less than the **DeepDescentCount**.

Syntax: MinBuoyancyCount <counts>  
 Range: **buoyancy\_pump\_min–2000** counts  
 Default: **buoyancy\_pump\_min** counts



**CAUTION** The float will not pressure activate if **MinBuoyancyCount** is greater than **MActivationCount**, as **MinBuoyancyCount** would prevent the buoyancy position from reaching **MActivationCount** which is associated with **MActivationPressure**.

### 3.2.5 Ascent Phase

The Ascent phase begins immediately after the completion of the Deep Descent phase with the partial inflation of the oil compartment of the bladder. With the bladder partially inflated, the float begins its ascent to the surface and starts acquiring profile data. Periodic sampling may be performed at the deeper depths, transitioning to continuous sampling at a specified depth during the ascent until the float is near the surface where the sampling stops. For a float with a non-pumped type CTD, the sampling can continue all the way to the surface.



**NOTE** During the Ascent phase the normal behavior of the float will be modified if ice avoidance is enabled and ice is detected. For information on ice avoidance and how to enable it, refer to APPENDIX B: “Ice Avoidance.”

The mission.cfg file configuration parameters that apply to the Ascent phase are **InitialBuoyancyNudge**, **AscentRate**, **BuoyancyNudge**, **AscentTimerInterval**, **AscentTimeout**, **AscentStartTimes**, **SurfacePressure**, and **UpTime**:

**InitialBuoyancyNudge.** The number of counts to add to the current piston position to start the Ascent phase.

Syntax: InitialBuoyancyNudge <counts>  
 Range: 0–3460 counts  
 Default: 360 counts

**AscentRate.** The rate of ascent in decibars per second that the float attempts to maintain. During the ascent the float measures its actual ascent rate, and if it is less than **AscentRate**, the buoyancy position is moved in accordance with **BuoyancyNudge**.

Syntax: AscentRate <decibars/second>  
 Range: 0.02–0.20 dbar/sec  
 Default: 0.08 dbar/sec

**BuoyancyNudge.** The number of counts to add to the current piston position so as to incrementally increase the buoyancy of the float when its ascent rate is below that specified by **AscentRate**.



Syntax: BuoyancyNudge <counts>  
Range: 0–3460 counts  
Default: 164 counts

**AscentTimerInterval.** The interval in seconds between float samples of the pressure to check the ascent rate and to determine if the surface has been reached. It is also the interval at which the sensor specified in a sample.cfg entry for the Ascent phase that includes an interval parameter setting of 0 is sampled. Refer to “sample.cfg File” on page 4-5 for more information on the sample.cfg file. The pressure is recorded to the science\_log.bin file. For information on the science\_log.bin file, refer to “Log Files” on page 4-13.

Syntax: AscentTimerInterval <seconds>  
Range: 5–3600 sec (60 minutes)  
Default: 300 sec

**AscentTimeout.** The amount of time in minutes allowed for the float to reach the surface. Should it not reach the surface in this period, it will stop sampling and transition to the Surface phase and fully inflate *both* the oil and air compartments of the bladder.

Syntax: AscentTimeout <minutes>  
Range: 1–600 min (10 hours)  
Default: 480 min (8 hours)



**NOTE** When ice avoidance is enabled, **AscentTimeout** is used in ice cap detection. For information on ice avoidance and how to enable it, refer to APPENDIX B: “Ice Avoidance.”

**AscentStartTimes.** Enables time of day operation with the entry of one to as many as four settings. One setting is required; up to three additional settings are optional. The required setting is the minutes after GMT midnight at which an ascent will start after the initial Park phase period. The three optional settings are minutes after GMT midnight at which up to three additional ascents will start on the same day. For these optional settings, the operator must ensure that there is enough time in the day for the float to descend and then ascend at each of the specified times, otherwise the time of an ascent will be extended to the following day. The operator must also take into account **PnPCycleLen** when estimating ascent times. A setting of -1 disables the time of day operation.

Syntax: AscentStartTimes <minutes1> [<minutes2>] [<minutes3>] [<minutes4>]  
 Range: <minutes1> -1, 0–1439  
           <minutes2–4> 0–1439  
 Default: -1 (disabled)

For information on the time of day operation, refer to APPENDIX C: “Time of Day Operation.”

**SurfacePressure.** The pressure in decibars added to the most recently measured pressure at the surface, the sum of which is the pressure at which the conductivity, temperature and pressure sampling stops for a pumped type CTD. It is also the pressure at which the Surface phase begins.

Syntax: SurfacePressure <decibars>  
 Range: 1–30 dbar  
 Default: 4 dbar (for float with pumped type CTD)  
           0 dbar (for a float with a non-pumped type CTD)

**UpTime.** The allocated time in minutes for the float to leave the Profile depth, reach the surface and complete the Surface phase. The difference in the setting of this configuration parameter and the actual ascent time determines the maximum amount of time at the surface.

Syntax: UpTime <minutes>  
 Range: 1–1440 min (24 hours)  
 Default: 720 min (12 hours)

### 3.2.6 Surface Phase

The Surface phase begins when the float ascends to the depth determined by **SurfacePressure** of the Ascent phase. At this depth the piston is pushed all the way out if it is not already there, and the air compartment of the bladder inflates to ensure that the float reaches the surface and that the antenna remains well above the surface. When at the surface the float begins transmitting data. The float remains at the surface until either all of the data have been transmitted or for a period determined by **Uptime** of the Ascent phase, less the actual ascent time, whichever occurs first. However, should the float not reach the surface before the period determined by **AscentTimeout** of the Ascent phase, it will transition to the Surface phase, and the maximum Surface phase period will be:

#### UpTime – AscentTimeout

When at the surface, the float transmits all of its log files, which includes all the sensor and position data, and receives new mission and sample configuration parameters if available over the Iridium satellite network. It also performs time synchronization of the

internal clock on the Controller board with the GPS satellite time if needed and measures the atmospheric pressure to verify the pressure sensor calibration.

Should communications be unsuccessful before the Surface Phase ends, the float will start a new mission without transmitting the recorded data. Should this situation occur, the data will be transmitted during the next Surface phase after the most recently acquired data are transmitted until all of the data are transmitted or the Surface phase ends. While at the surface, the float can be placed into Recovery mode as described in “Recovery Mode” on page 3-14”. In Recovery mode the float remains on the surface until it is recovered or remotely taken out of Recovery mode.



**NOTE** Raw pressure sensor data are recorded to all the log files. When the float is at the surface, a pressure sample is obtained for reference. The pressure difference from zero is recorded to the `system_log.txt` file as an offset and may be used for post processing of science data. The difference is applied to **SurfacePressure** to ensure that the CTD is properly turned off at the correct depth. The log entry is of the form “`update_offset|Surface Offset Pressure: -0.3300.`”



**NOTE** During the Surface phase the normal behavior of the float will be modified if ice avoidance is enabled and ice is detected. For information on ice avoidance and how to enable it, refer to APPENDIX B: “Ice Avoidance.”

The mission.cfg file configuration parameters that apply to the Surface phase are **TelemetryInterval** and **LogVerbosity**:

**TelemetryInterval.** The interval in seconds between which the float attempts to communicate over the Iridium satellite network, or if in Recovery mode, the interval in seconds between which the float transmits its position and log files and downloads new mission and sample configuration parameters. The float continues the attempts until it succeeds or until the end of the period specified by **UpTime** of the Ascent phase, after which a new Descent phase begins.

Syntax:            TelemetryInterval <seconds>  
 Range:            300–7200 sec (2 hours)  
 Default:          900 sec (15 minutes)



**NOTE** Should communications fail, the reason might be that the float has not actually surfaced. To account for this possibility, the float will push more oil into the oil compartment of the bladder after each unsuccessful communications attempt to ensure that the float eventually reaches the surface.

**LogVerbosity.** The verbosity level of the system\_log.txt file entries transmitted over the Iridium satellite network. It corresponds to the second field of the file entries which is the priority.

Syntax:           LogVerbosity <n>  
 Range:            0 (no entries transmitted) to 6 (all entries transmitted)  
 Default:           5

### 3.3 Recovery Mode

Recovery mode is operator activated. If activated, the float remains on the surface indefinitely while transmitting its position and log files and downloading new mission and sample configuration parameters if available at intervals specified by **TelemetryInterval**. If Recovery mode is then deactivated, the float will begin the Park Descent phase of a new mission.

The only mission.cfg file configuration parameter that applies to the Recovery mode is **ActivateRecoveryMode**:

**ActivateRecoveryMode.** Activates or deactivates Recovery mode.

Syntax:           ActivateRecoveryMode or ActivateRecoveryMode <on|off>  
 Range:            on or off  
 Default:           off



**NOTE** By default **ActivateRecoveryMode** is not included in the mission.cfg file. To place the float into recovery mode, the operator can modify the mission.cfg file to include **ActivateRecoveryMode** with no setting or with the setting set to “on.” Similarly, if the float is currently in Recovery mode, sending a mission.cfg file with **ActivateRecoveryMode** set to “off” will deactivate Recovery mode.

### 3.4 Emergency Mode

Emergency mode is activated only if a catastrophic error occurs during any phase or if the float fails the self test during the Mission Prelude phase. If activated, the float will immediately surface. While at the surface, the float will periodically transmit its position and log files and download new mission and sample configuration parameters if available as it does in Recovery mode. Should this situation occur, contact Teledyne Webb Research customer service.

The only mission.cfg file configuration parameter that applies to the Emergency mode is **EmergencyTimerInterval**:

**EmergencyTimerInterval.** The interval in seconds between which the float attempts to communicate over the Iridium satellite network.

Syntax:           EmergencyTimerInterval <*seconds*>  
Range:            300–7200 sec (2 hours)  
Default:          7200 sec (2 hours)



## SECTION 4: System Files

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The Teledyne Webb APEX profiling float includes two types of files: configuration files and log files. The configuration files determine the behavior of the float, its configuration and the configuration of its sensors. The log files contain the acquired data and other information gathered during the profiling cycles.

### 4.1 Configuration Files

The APEX profiling float includes four configuration files:

- mission.cfg
- system.cfg
- sensors.cfg
- sample.cfg

All four files are stored on a secure digital (SD) card on the float, and each contain configuration parameters with factory default settings. For the mission.cfg and sample.cfg files only, the configuration parameter settings can be changed by the operator. The system.cfg and sensors.cfg configuration file parameters are factory set.

#### 4.1.1 mission.cfg File

The mission.cfg file configuration parameters determine the behavior of the float during each of its operating modes as described in SECTION 3: “Operating Modes.”

The following is an example of the entire contents of a mission.cfg file:

```
ActivateRecoveryMode off
AscentRate 0.08
AscentStartTimes -1
AscentTimeout 480
AscentTimerInterval 300
BuoyancyNudge 164
DeepDescentCount 262
DeepDescentPressure 2000.00
DeepDescentTimeout 360
DeepDescentTimerInterval 300
DeepProfileFirst off
Downtime 13680
EmergencyTimerInterval 7200
IceBreakupDays 14
IceCriticalT -1.78
```

```

IceDetectionP 100.00
IceEvasionP 100.00
IceMonths 0000
IdleTimerInterval 7200
InitialBuoyancyNudge 360
LeakDetect on
LogVerbosity 5
MActivationCount 262
MActivationPressure 25.00
MinBuoyancyCount 147
MinVacuum 9.00
ParkBuoyancyNudge 16
ParkDeadBand 10.00
ParkDescentCount 1081
ParkDescentTimeout 360
ParkDescentTimerInterval 3600
ParkPressure 1000.00
ParkTimerInterval 3600
PnPCycleLen 1
PreludeSelfTest on
PreludeTime 120
SurfacePressure 4.00
TelemetryInterval 900
UpTime 720

```

These configuration parameters can be changed by the operator, either locally by using a PC connection to the float, or remotely between missions by using the Iridium satellite network. For instructions on how to change the mission.cfg file configuration parameters, refer to SECTION 5: “Modifying the Mission Plan.”

### 4.1.2 system.cfg File

The system.cfg file includes configuration parameters whose settings set the maximum air bladder inflation, set the minimum and maximum positions for the buoyancy pump, and define some Iridium satellite network values. These configuration parameter settings are factory set and should not be changed by the operator. The factory settings, as listed below, may also be different from float to float.

The system.cfg file configuration parameters are the following:

**air\_bladder\_max.** The maximum pressure in decibars to which the air bladder will inflate. The air pump will shut off if the air bladder pressure reaches this value.

Syntax:            air\_bladder\_max <dbar>

Factory setting:  12 dbar



**buoyancy\_pump\_min.** The minimum piston position in counts. The buoyancy pump will shut off if the piston position reaches this minimum value.

Syntax: buoyancy\_pump\_min <counts>  
 Default: 147 counts (typical, may vary depending on the amount of oil)

**buoyancy\_pump\_max.** The maximum piston position in counts. The buoyancy pump will shut off if the piston position reaches this maximum value.

Syntax: buoyancy\_pump\_max <counts>  
 Default: 3720 counts (typical, may vary depending on the amount of oil)

**float\_Id.** The Controller board serial number specified in NNN-WWYY format, where NNN is a number from 001 to 999, WW is a week from 01 to 52, and YY is a year from 00 to 99.

Syntax: float\_Id <float Id>

For Iridium RUDICS/PSTN the system.cfg file also includes account information, which is the user name, the login password and the primary and alternate dial string parameters required for connecting to a server over the Iridium satellite communications network. For SBD the system.cfg file *does not* include account information.

Syntax: iridium <username> <password> <primary\_dial\_string> dialup  
 | rudics <alternate\_dial\_string> dialup | rudics

Example: iridium apf11 apex 00881600005135 rudics 0015085480980  
 dialup

The primary dial string is used by the float first. The alternate dial string is used only if the primary dial string fails to connect after a fixed number of tries. The dialup option enables the float to connect to a server using the Iridium satellite network, the Public Switched Telephone Network (PSTN) and a modem. The RUDICS option enables the float to connect to a server over the internet using the Iridium satellite network and Router-Based Unrestricted Digital Internetworking Connectivity Solution (RUDICS). Refer to “Setting up RUDICS/PSTN Communications with the Float” on page 5-1 for information on how to set up to connect to the float using these systems.

The following is an example of the entire contents of a system.cfg file:

```
iridium apf11 apex 00881600005135 rudics 0015085480980 dialup
air_bladder_max 12
buoyancy_pump_min 147
buoyancy_pump_max 3720
```

In this example RUDICS is used for the primary dial string, and dialup for the alternate.

### 4.1.3 sensors.cfg File

The sensors.cfg file defines the CTD hardware configuration along with the GPS receiver, the Iridium modem and the optional sensors. The sensors.cfg file configuration parameters should not be changed by the operator.

The sensors.cfg file configuration parameters are **sensor**, **gps** and **modem**:

**sensor.** Specifies the name of the CTD and its hardware configuration.

Syntax:        <sensor\_type> <power\_pin> <power\_port> <com\_port> <baud\_rate>

Default:        sensor type: seabird\_ctd\_41cp (pumped type CTD)

                 power pin:    PIN\_4

                 power port: PORT\_A

                 com\_port:    COM\_2

                 baud\_rate:    B9600

Optional:       sensor type: seabird\_ctd\_41 (pumped type CTD)  
    seabird\_ctd\_41n (pumped type CTD)  
    rbr\_ctd (non-pumped type CTD)

Example:       seabird\_ctd\_41cp PIN\_4 PORT\_A COM\_2 B9600

**gps.** Specifies the name of the GPS receiver. The name is used to define its internal hardware configuration.

Syntax:        gps <gps\_name>

Default:        gps15xh

Example:       gps gps15xh

**modem.** Specifies the name of the Iridium modem. The name is used to define its internal hardware configuration.

Syntax:        modem <modem\_name>

Default:        iridium9523

Optional:       sbd9602

Example:       modem iridium9523

The following is an example of the entire contents of a sensors.cfg file:

```
seabird_ctd_41cp PIN_4 PORT_A COM_2 B9600
gps gps15x1
modem iridium9523
```

For the sensor hardware configuration for the optional sensors, refer to APPENDIX A: "Optional Sensors."

#### 4.1.4 sample.cfg File

The sample.cfg file allows the operator to program the sampling behavior of the float by enabling interval sampling of the CTD and the optional sensors as well as continuous profiling with the CTD over one or more ranges of pressure during one or more phases in Mission mode. Interval sampling and continuous profiling can be performed separately or simultaneously. The sample.cfg file parameters can be changed by the operator remotely between missions by using the Iridium satellite network. For instructions on how to change the sample.cfg file parameters, refer to “Modifying the sample.cfg File Configuration Parameter Settings Remotely” on page 5-5, and for more information on the sample.cfg file along with examples for the specific CTD installed on the float, refer to SECTION 6: “CTDs.”

**Interval Sampling.** Interval sampling specifies, for the CTD and any one or more of the optional sensors, the pressure at which sampling will begin, the pressure at which sampling will end, and the pressure intervals at which a sample will occur. This sampling behavior is specified by entering the phase followed by a single line entry in the sample.cfg file for *each* of any number of sensor and pressure range combinations. When interval sampling two or more sensors at the same depth, they are sampled in the order of the line entries. Interval sampling can also be performed during the Park and Surface phases, where during the Park phase, **ParkTimerInterval** determines the sampling interval.

Syntax: *<phase>*  
 Sample *<sensor type>* [*<start>* [*<stop>* [*<interval>* [*<units>* [*<count>*]]]]]

*phase:* PARK  
 ASCENT  
 SURFACE

*sensor type:* CTD - conductivity, temperature and pressure sensor  
 TD - CTD temperature and pressure sensors  
 OPT - oxygen sensor  
 FLBB - fluorometer  
 XMIS - transmissometer  
 RAD - radiance radiometer  
 IRAD - irradiance radiometer  
 CMP - compass  
 SUNA - nitrate sensor  
 ALL - all the installed sensors

*start:* Start pressure (0–2100) dbar  
*stop:* Stop pressure (0–2100) dbar  
*interval:* Pressure interval (0-100) dbar  
*units:* dbar  
*count:* Number of samples

Brackets ([ ]) around a parameter or group of parameters indicate that it is optional, and entries are *not* case sensitive. The brackets, however, should *not* be included in the entry. In addition, sampling during the Surface phase can *only* be performed for a float with a non-pumped type CTD, and sampling is fixed at 1 sample per second for 10 seconds.

For a sample.cfg file interval sampling entry that *does not* include one or more of the optional parameters, the float uses the following default entries for the specified sensor:

```
start:      2000
stop:       0
interval:   0
units:      dbar
count:      1
```

An interval parameter of 0 is a special case where **AscentTimerInterval** is used to determine the sampling interval for time-based rather than pressure-based interval sampling. Refer to “AscentTimerInterval” on page 3-11 for information on this configuration parameter. Therefore, to sample based on time intervals instead of pressure, set interval to 0 and make the required interval time setting for **AscentTimerInterval**. When *no* sample.cfg file is entered *at all* by the operator, the float uses a single default entry which includes the special case interval parameter of 0:

```
Sample ALL 2000 0 0 dbar
```

The start and stop pressures can be in any order. Equal start and stop pressure entries with *no* entry for the interval parameter causes the sensor to be sampled once at the specified pressure. Interval sampling of a pumped type CTD cannot be performed at the surface. For the Park phase, **ParkTimerInterval** is used to determine the sampling interval. Refer to “ParkTimerInterval” on page 3-7 for information on **ParkTimerInterval**. For this phase the start, stop and interval parameters do not apply.



**NOTE** For the best accuracy, it is recommended that interval sampling between 750 meters and the surface be performed simultaneously with continuous profiling.

Example 1. To sample the CTD and all the optional sensors every 100 dbar beginning at 2000 dbar and ending at 200 dbar, enter:

```
<ASCENT>
Sample ALL 2000 200 100 dbar
```

Example 2. To sample the CTD once at 2000 dbar, once at 1000 dbar, and then every 10 dbar beginning at 400 dbar and ending at 50 dbar, enter:

```
<ASCENT>
Sample CTD 2000 2000 dbar
Sample CTD 1000 1000 dbar
Sample CTD 400 50 10 dbar
```

Example 3. To sample the CTD every 100 dbar beginning at 2000 dbar and ending at 1000 dbar, then again every 50 dbar ending at 50 dbar; the oxygen sensor at 2000 dbar and every 100 dbar beginning at 1000 dbar and ending at 100 dbar; and the fluorometer at 2000 dbar and every 100 dbar beginning at 1500 dbar and ending at 100 dbar, enter:

```
<ASCENT>
Sample CTD 2000 1000 100 dbar
Sample CTD 950 50 50 dbar
Sample OPT 2000 2000 dbar
Sample OPT 1000 100 100 dbar
Sample FLBB 2000 2000 dbar
Sample FLBB 1500 100 100 dbar
```

For a graphical representation of this sampling behavior, refer to Figure 4-1.

Example 4. To sample the CTD, the compass and the radiance and irradiance radiometers, in that order, during the entire ascent and at the intervals specified by **AscentTimerInterval**, enter:

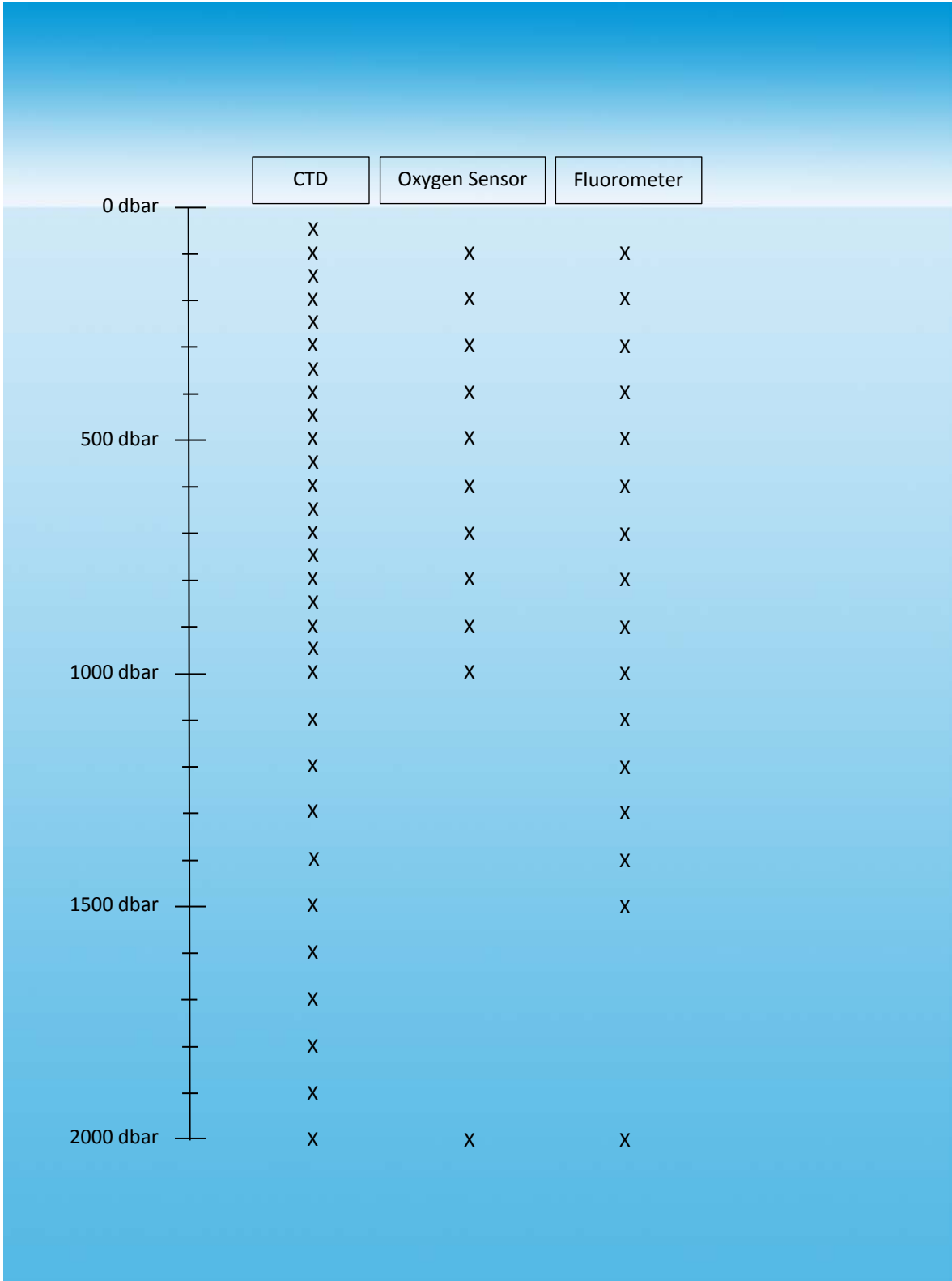
```
<ASCENT>
Sample CTD 2000 0 0 dbar
Sample CMP 2000 0 0 dbar
Sample RAD 2000 0 0 dbar
Sample IRAD 2000 0 0 dbar
```

or

```
<ASCENT>
Sample CTD
Sample CMP
Sample RAD
Sample IRAD
```

Example 5. To sample the CTD of a float with a pumped CTD during the Park phase, and at the intervals specified by **AscentTimerInterval**, enter:

```
<PARK>
Sample CTD
```



**Figure 4-1: Example Sampling Behavior from a sample.cfg File**

**Example 6.** To sample the CTD of a float with a non-pumped CTD at 1 sample/second for 10 seconds at the surface, enter:

```
<SURFACE>
Sample CTD
```

**Example 7.** To sample the CTD 10 times at 500 dbar, enter:

```
<ASCENT>
Sample CTD 500 500 dbar 10
```

**Example 8.** To sample the CTD 5 times each at 1500 dbar, 1000 dbar and 500 dbar, enter:

```
<ASCENT>
Sample CTD 1500 1500 dbar 5
Sample CTD 1000 1000 dbar 5
Sample CTD 500 500 dbar 5
```

**Example 9.** To sample the CTD 5 times every 100 dbar beginning at 1000 dbar and ending at 500 dbar, enter:

```
<ASCENT>
Sample CTD 1000 500 100 dbar 5
```

**Continuous profiling.** Continuous profiling, which applies to the CTD only, specifies for the Ascent phase the pressure at which continuous profiling will begin and the pressure at which continuous profiling will end. For a non-pumped type CTD, both the sample rate in samples per second and a bin size can also be specified, where the bin size is the pressure in decibars over which averaging is performed. For a pumped type CTD, the bin size is fixed at 2 decibars, and the sample rate is fixed at 1 sample per second. This sampling behavior is specified for the Ascent phase by entering the phase followed by a single entry in the sample.cfg file for each of any number of pressure ranges.

Syntax: *<phase>*  
 Profile *<sensor type>* [*<start>* [*<stop>* [*<bin\_size>* [*<rate>*]]]]

*sensor type:* CTD - conductivity, temperature and pressure sensor  
*start:* Start pressure (0–2100) dbar  
*stop:* Stop pressure (0–2100) dbar  
*bin size:* Bin size (2.0 for SBE CTD) dbar  
 Bin size (1.0–10.0) in increments of 0.1 for RBRargo CTD) dbar  
*rate:* Sample rate (1.00 for SBE CTD) sample/second  
 Sample rate (0.01–6.00 for RBRargo CTD) samples/second

Brackets ([ ]) around a parameter or group of parameters indicate that it is optional, and entries are *not* case sensitive. The brackets, however, should *not* be included in the entry.



**CAUTION** A bin size of less than 1 or a rate of more than 1, or both, can result in excessively large data files and battery usage. For dense sampling over one or more specific, relatively short pressure ranges, contact Teledyne Webb Research customer service for instructions.

For RBRargo CTD rate entries in samples/second and their corresponding sample intervals in seconds, refer to Table 4-1.

**Table 4-1: RBRargo CTD Rate Entries Versus Sample Interval**

Rate Entry (samples/second)	Sample Interval (seconds)
4	.25
2	.50
1	1
.50	2
.33	3
.25	4
.20	5
.15	6

For a sample.cfg file continuous profiling entry that does not include one or more of the optional parameters, a float with a *pumped* type CTD uses the following default entries:

```

start:          2000
stop:           SurfacePressure (Refer to "SurfacePressure" on page 3-12.)
bin_size:      2.0 dbars
rate:          1.0 sample/second

```

For a stop of less than **SurfacePressure**, continuous profiling will stop at the "pcutoff" pressure of the CTD. For a *non-pumped* type CTD, the default settings are the following:

```

start:          2000
stop:           0 (Stops when air is detected.)
bin_size:      2.0 dbars
rate:          1.0 sample/second

```



The entry or series of entries in the sample.cfg file must be preceded with a single line to indicate sampling during the Ascent phase as follows:

```
<ASCENT>
```

The start and stop pressures can be in any order, and continuous profiling with the CTD all the way to the surface can *only* be performed for a float with a non-pumped type CTD.

Example 1. To sample a pumped type CTD continuously beginning at 2000 dbar and ending at 1500 dbar, enter:

```
<ASCENT>
Profile CTD 2000 1500
```

Example 2. To sample a pumped type CTD continuously beginning at 2000 dbar and ending at the pressure specified by **SurfacePressure**:

```
<ASCENT>
Profile CTD 2000 0
```

or

```
<ASCENT>
Profile CTD
```

Example 3. To sample a non-pumped type CTD continuously beginning at 2000 dbar and ending at 1500 dbar with a bin size of 5 and a sample rate of 1, enter:

```
<ASCENT>
Profile CTD 2000 1500 5.0 1.00
```

Example 4. To sample a non-pumped type CTD continuously beginning at 1000 dbar for the entire remaining ascent with a bin size of 2 and a sample rate of 1, enter:

```
<ASCENT>
Profile CTD 1000 0 2.0 1.00
```

Example 5. To sample a non-pumped type CTD continuously beginning at 2000 dbar and ending at 1500 dbar with a bin size of 8 and a sample rate of 0.25, and then again beginning at 1500 dbar and ending at 1000 dbar with a bin size of 4 and a sample rate of 0.5, and then for the entire remaining ascent with a bin size of 2 and a sample rate of 1, enter:

```
<ASCENT>
Profile CTD 2000 1500 8.0 0.25
Profile CTD 1500 1000 4.0 0.50
Profile CTD 1000 0 2.0 1.00
```

Example 6. To sample a non-pumped type CTD every 50 dbar beginning at 2000 dbar and ending at 1500 dbar, and then every 20 dbar beginning at 1500 dbar and ending at 1000 dbar, and then continuously beginning at 1000 dbar for the entire remaining ascent with a bin size of 5 and a sample rate of 1, enter:

```
<ASCENT>
Sample CTD 2000 1500 50 dbar
Sample CTD 1500 1000 20 dbar
Profile CTD 1000 0 5.0 1.00
```

Example 7. To sample a pumped type CTD every 50 dbar beginning at 2000 bar and ending at 1500 dbar, and then every 20 dbar beginning at 1500 dbar and ending at 1000 dbar, while performing continuous profiling beginning at 2000 dbar for the entire ascent, enter:

```
<ASCENT>
Sample CTD 2000 1500 50 dbar
Sample CTD 1500 1000 20 dbar
Profile CTD 2000 0
```

or

```
<ASCENT>
Sample CTD 2000 1500 50 dbar
Sample CTD 1500 1000 20 dbar
Profile CTD
```

In addition to the stop parameter, other conditions will stop continuous profiling:

- Continuous profiling will stop at the end of the period specified by **AscentTimeOut**.
- For a float with a pumped type CTD, continuous profiling will stop when it reaches the pressure specified by **SurfacePressure** or when the "pcutoff" pressure of the CTD is reached, whichever occurs first.
- For a float with a non-pumped type CTD, continuous profiling will stop when it breaks the surface, which is when zero conductivity is measured.
- Continuous profiling will stop should Emergency mode be activated.
- Continuous profiling will stop upon detection of ice if ice avoidance is enabled.

## 4.2 Log Files

The APEX profiling float includes up to four log files. These files are transferred *from* the float *to* the server and are referred to throughout this manual as the following:

- science\_log.bin
- vitals\_log.bin
- system\_log.txt
- critical\_log.txt (Provided only for unusual, exceptional error conditions.)

The *actual* file names are prepended with the username, the profile number, the timestamp, and the filetype, and they are appended with an extension as follows:

Syntax:	<username>.<profile number>.<timestamp>.<filename>.<filetype>.<ext>
username:	The account username included in system.cfg
profile number:	A zero-padded 3-decimal number indicating the profile number. For example, the first descent would have a value of 001.
timestamp:	Date and time of the file creation in YYYYMMDDTHHMMSS format
filename:	Name of file
filetype:	Type of log file (.bin or .txt)
ext:	gz

For example, in the following files the username is f0036 and the profile number is 003:

- **f0036.003.20160122T193806.science\_log.bin.gz**
- **f0036.003.20160122T193806.vitals\_log.bin.gz**
- **f0036.003.20160122T193806.system\_log.txt.gz**
- **f0036.003.20160122T193806.critical\_log.txt.gz**

The data in the science\_log.bin and vitals\_log.bin files are in compressed binary format. These two files must be unzipped into uncompressed binary files and then converted to comma separated value (CSV) files that can be imported into a spreadsheet program. The system\_log.txt and critical\_log.txt files are text files containing ASCII characters and can be opened in any text editor, such as Microsoft Notepad. All the files are transmitted over the Iridium satellite network prior to the start of each mission.

### 4.2.1 science\_log.bin File

The science\_log.bin file stores profile data, float position and other information:

- Sensor type
- Time stamp
- Pressure
- Temperature
- Salinity
- Surface position
- pH

### 4.2.2 vitals\_log.bin File

The vitals\_log.bin file stores time stamped system status data:

- Time stamp
- Firmware version and float ID
- Air bladder pressure
- Air bladder pressure in counts
- Battery voltage
- Battery voltage in counts
- Humidity
- Leak detect voltage
- Internal vacuum pressure
- Internal vacuum pressure in counts
- Coulomb counter
- Battery current draw
- Battery current raw
- RSSI value, where RSSI is the Iridium signal strength

### 4.2.3 system\_log.txt File

The system\_log.txt files stores system events, verboisities, errors, messages, and other information in the following format:

*<time stamp>|<priority>|<function\_name>|<message>*

## 4.3 Converting the science\_log.bin and vitals\_log.bin Files to CSV Files

The science\_log.bin and vitals\_log.bin files must be uncompressed and then converted to CSV files before they can be opened in a spreadsheet program. This operation requires that you first download and install Python. To install Python, go to <http://www.python.org/getit/releases/2.7.11> and download and install Version 2.7.11 in the C:\ directory of your server. In addition, the apf11dec.py script, provided by Teledyne Webb Research, must also be saved in the C:\ directory of the server. This script is on the documentation CD.

To convert the science\_log.bin and vitals\_log.bin files to CSV files:

1. Locate the science\_log.bin.gz or vitals\_log.bin.gz file in the home directory of the server. The actual file names will additionally include the float name, the profile number and a timestamp as described in “Log Files” on page 4-13.

2. Enter `gunzip <filename>`.

The specified file will be unzipped to the corresponding science\_log.bin or vitals\_log.bin file with no .gz extension.

3. Enter `python apf11dec.py <filename>`.

The specified binary science\_log.bin or vitals\_log.bin file will be used to generate a corresponding science\_log.csv or vitals\_log.csv file.

4. Open the CSV file in a spreadsheet program, such as Microsoft Excel.

## 4.4 Reading the science\_log.csv File

An example printout of a science\_log.csv file with CTD data is shown in Figure 4-2. In this example only several rows of data are shown to illustrate the structure of the log file. Typically there would be many rows of data.

The columns for the Message rows are from left to right:

- Time stamp in UTC (YYYYMMDDTHHMMSS)
- Firmware version or float ID

The GPS location is always provided both at the start and at the end of the file as shown in the first and last rows of the printout, where the columns for the GPS rows are from left to right:

Message	20161121T223335	Firmware: 07/18/16 20:08:07 DEEP_APEX-v2.3.18			
Message	20161121T223335	FloatId/Username: f0001			
GPS	20161121T223335	-58.6827	-56.0524	5	
CTD_P	20161121T223357	-0.29			
Message	20161121T223357	Park Descent Phase*****			
CTD_P	20161121T223412	-0.3			
CTD_P	20161121T223416	-0.4			
CTD_P	20161121T223515	-0.38			
CTD_P	20161122T135830	1484.48			
Message	20161122T135835	Park Phase*****			
CTD_P	20161122T140340	1483.73			
Message	20161122T140340	Deep Descent Phase*****			
CTD_P	20161122T140447	1483.62			
Message	20161122T140452	Profiling Phase*****			
CTD_P	20161122T140455	1483.72			
Message	20161122T140502	Continuous Profile Started*****			
CTD_PTS	20161122T140526	1483.47	1.3397	34.707	
CTD_PTS	20161122T140741	1476.69	1.3475	34.7078	
CTD_PTS	20161122T141248	1448.63	1.3648	34.708	
CTD_PTS	20161122T174039	1.94	0.2297	33.6195	
Message	20161122T174047	Surface Phase*****			
CTD_bins	20161122T174441	12917	743	1483.59	
CTD_CP	20161122T174832	2.27	0.2294	33.6214	11
CTD_CP	20161122T174832	3.98	0.2295	33.6217	15
CTD_CP	20161122T174832	6	0.2377	33.6214	15
CTD_CP	20161122T174911	1483.36	1.3385	34.7081	41
CTD_P	20161122T180349	0.04			
GPS	20150214T033525	-58.7147	-55.9328	9	

Figure 4-2: Example science\_log.csv Printout

- Time stamp in UTC (YYYYMMDDTHHMMSS)
- Latitude in decimal degrees ( $\pm$ DD.DDDDD) of the surface position.
- Longitude in decimal degrees ( $\pm$ DDD.DDDDD) of the surface position
- Number of GPS satellites used

The columns for the CTD\_P rows under Park Descent Phase, Deep Descent Phase, Profiling Phase, and Surface Phase contain CTD pressure data that were recorded when interval sampling and are from left to right:

- Time stamp in UTC (YYYYMMDDTHHMMSS)
- Pressure in decibars



**NOTE** *If optional sensors are installed, a single CTD\_P row will be automatically added before and after a series of CTD and optional sensor samples.*

The columns for the CTD\_PTS rows under Profiling Phase contain sensor data that were recorded when interval sampling and are from left to right:

- Time stamp in UTC (YYYYMMDDTHHMMSS)
- Pressure in decibars
- Temperature in degrees Celsius
- Salinity in PSU

Although not shown in the example printout, columns under Profiling Phase that contain *only* pressure and temperature data that were recorded when interval sampling would be associated with CTD\_PT rows and would be from left to right:

- Time stamp in UTC (YYYYMMDDTHHMMSS)
- Pressure in decibars
- Temperature in degrees Celsius

The columns for the CTD\_bins row under Profiling Phase contain bin averaging statistics which apply *only* to a float with a pumped type CTD and are from left to right:

- Time stamp in UTC (YYYYMMDDTHHMMSS)
- Number of samples recorded during the mission
- Number of bins recorded during the mission
- Highest pressure in decibars recorded during the mission

The columns for the CTD\_CP rows under Profiling Phase contain sensor data for a float with a pumped type CTD and were recorded when continuous profiling. Similarly, for a float with a non-pumped type CTD, the columns are associated instead with CTD\_CP+ rows under Profiling Phase. For this float there is one additional data column which contains conductivity data.



**NOTE** *When continuous profiling with a float that uses a pumped type CTD, the time stamps in the science\_log.bin file are not the times at which the samples were actually taken. Rather the time stamps are the times at which the data were recorded to the science\_log.bin file which occurs when continuous profiling stops. When continuous profiling with a float that uses a non-pumped CTD, the time stamps are provided by the CTD, and they are the times at which the samples were taken at depth.*

For a float with a pumped type CTD, the columns are from left to right:

- Time stamp in UTC (YYYYMMDDTHHMMSS)
- Bin averaged pressure in decibars
- Bin averaged temperature in degrees Celsius
- Bin averaged salinity in PSU
- Number of samples averaged per bin

For a float with a non-pumped type CTD, the columns are from left to right:

- Time stamp in UTC (YYYYMMDDTHHMMSS)
- Bin averaged pressure in decibars
- Bin averaged temperature in degrees Celsius
- Bin averaged salinity in PSU
- Conductivity in mS/cm
- Number of samples averaged per bin



**NOTE** *If optional sensors are installed, additional rows will be included in the science\_log.csv printout. For information on the fields in these rows, refer to APPENDIX A: "Optional Sensors."*



## 4.5 Reading the vitals\_log.csv File

An example printout of a vitals\_log.csv file is shown in Figure 4-3 . Typically this file would contain many more rows of data, but for illustration purposes, only several are shown. The vitals\_log.csv file is updated at the start of each mission phase.

The columns for the Message rows are from left to right:

- Time stamp in UTC (YYYYMMDDTHHMMSS)
- Firmware version or float ID

The columns for the VITALS\_CORE rows are from left to right:

- Time stamp in UTC (YYYYMMDDTHHMMSS)
- Air bladder pressure in decibars
- Air bladder pressure in counts
- Battery voltage in volts
- Battery voltage in counts
- Humidity in percent relative
- Leak detect voltage in volts
- Internal vacuum pressure in decibars
- Internal vacuum pressure in counts
- Coulomb counter in ampere hours
- Battery current draw in milliamperes
- Battery current raw in milliamperes

The columns for the RSSI rows are from left to right:

- Time stamp in UTC (YYYYMMDDTHHMMSS)
- RSSI value, where RSSI is the Iridium signal strength from 1 to 5 where 5 is the best

	Time Stamp (UTC)	Air Bladder Pressure (dbar)	Air Bladder (counts)	Battery Voltage (volts)	Battery Voltage (counts)	Humidity (%)	Leak Detect Voltage (volts)	Internal Vacuum Pressure (dbar)	Internal Vacuum Pressure (counts)	Coulomb Counter (Ah)	Battery Current Draw (mA)	Battery Current Raw (counts)
Message	20170524T054717	Firmware: 07/18/16 20:08:07 DEEP_APEX-v2.3.18										
Message	20170524T054717	FloatId/Username: apf11										
VITALS_CORE	20170524T074714	10.01	2026	13.69	3115	50	2.3	10.40	4086	1.56	32.5	-421
RSSI	20170524T075218	4										
RSSI	20170524T083622	5										
RSSI	20170524T085519	5										
VITALS_CORE	20170524T095101	11.97	2412	13.69	3117	49	2.3	10.41	4087	7.81	0.0	0
VITALS_CORE	20170524T100035	10.00	2026	13.69	3115	48	2.3	10.40	4086	27.19	0.0	0
VITALS_CORE	20170524T100805	10.00	2024	13.68	3115	50	2.3	10.4	4082	29.70	69.2	-887
RSSI	20170524T100809	5										
VITALS_CORE	20170524T100814	9.99										
VITALS_CORE	20170524T100956	10.00	2025	13.69	3117	50	2.3	10.39	4085	30.95	0.0	0
VITALS_CORE	20170524T101452	10.00	2025	13.69	3116	49	2.3	10.40	4085	34.75	0.0	0

Figure 4-3: Example vitals\_log Printout

## 4.6 Converting system\_log.txt Files to Readable Text

To convert the system\_log.txt file to readable text, enter `gunzip system_log.txt.gz`. The file will be unzipped to the system\_log.txt file which can be opened in a text editor.

The following is an example of the contents of a system\_log file:

```
20121231T205021|6|enable|Enabling the iridium modem
20121231T205024|6|network_quality|Modem quality = 5 on iridium
network.
20121231T205034|6|network_reg|Modem successfully registered
with iridium network. 13 tries remaining
20121231T205034|7|send_rcv_cmd|Sending: AT &C1 &D2 &K0 &R1 &S1
E1 Q0 S0=0 S7=45 S10=100 V1 X4
20121231T205034|7|send_rcv_cmd|Expecting: OK
```



## SECTION 5: Modifying the Mission Plan

---

The APEX profiling float behaves in accordance with a factory programmed mission that can be modified by the operator either locally by connecting the float to a PC or remotely over the Iridium satellite network after the float is deployed. A mission is modified by changing the settings of the configuration parameters in the mission.cfg file. These configuration parameters are downloaded by the float during the Mission Prelude phase and during each Surface phase. In addition, a number of user commands are available that can be used to control some of the float functions and access its files when it is connected to a PC.



**NOTE** *In addition to the mission plan, the sampling behavior of the float can be modified remotely by changing the settings of the configuration parameters in the sample.cfg file. Similar to that for a mission.cfg file, these settings are downloaded by the float during the Mission Prelude phase and during each Surface phase. The settings can also be edited locally by connecting a float to a PC. For instructions on how to edit these configuration parameter settings locally, refer to "Viewing and Editing the Configuration Parameters" on page 2-13.*

### 5.1 Setting up RUDICS/PSTN Communications with the Float

To receive data from a deployed float and to be able modify the float's mission.cfg file remotely, you can set up a server and either connect it to an Iridium gateway using an Iridium modem with a dial-up connection to the Public Switched Telephone Network (PSTN), or use Router-Based Unrestricted Digital Internetworking Connectivity Solution (RUDICS) which enables communications with the float over the internet. For redundancy you can set up both systems, each with its own server, or use one server for both with RUDICS being the primary communications path and PSTN being the secondary. In addition, a PC with an internet connection is required. Use of the PSTN incurs a low setup cost but higher data transfer costs compared to RUDICS which has a high setup cost but lower data transfer costs. In both cases a login account must be created on the server or servers by the system administrator for the float, and a home directory must be assigned for receiving data. This directory must also include the mission.cfg file. For detailed information on how to set up either system, contact Teledyne Webb Research customer service.



**NOTE** Teledyne Webb Research also provides as an optional service a Unix based host server for receiving float data and remotely modifying the mission plan for the APEX profiling floats. Other host server providers are also available. Contact Teledyne Webb Research customer service for more information.

## 5.2 Setting up SBD Communications with the Float

To receive data from a deployed float and to be able modify the float's mission.cfg file while it is deployed, you can set up an e-mail account that uses a Short Burst Data (SBD) service. Compared to RUDICS/PSTN, SBD messages are shorter and can be sent more efficiently. SBD does not use a dedicated traffic channel but rather takes advantage of signals within the existing Iridium interface. Data are transmitted *from* the float as Mobile Originated SBD (MO-SBD) messages that are 1 to 1960 bytes long. Mission plans are transmitted *to* the float as Mobile Terminated (MT-SBD) messages that are from 1 to 1890 bytes long.

MO-SBD messages from the float are transmitted over the Iridium network to an Iridium Gateway. The Iridium Gateway transfers each message as an e-mail attachment to a Value Added Reseller (VAR) which makes the message available to the operator. Similarly, MT-SBD mission plans are made available to the VAR by the operator. The VAR transfers each mission plan as an e-mail attachment to the Iridium Gateway which transmits the plan to the float over the Iridium network.

To set up SBD communications with the float, a login account with e-mail access must be created on a server by the system administrator for the float. A home directory must also be created for receiving data and sending mission.cfg files. The operator must also register with the Iridium service provider and provide the e-mail address. For detailed information on how to set up an SBD communications system, contact Teledyne Webb Research customer service.

## 5.3 Modifying the mission.cfg File Configuration Parameter Settings Locally from a Connected PC

The configuration parameter settings in the mission.cfg file of the float can be modified directly by connecting a PC to the float and using a terminal program to enter commands.



**CAUTION** *ParkDescentCount* and *DeepDescentCount* are dynamically updated during a mission. Therefore they should not be included in the modified mission.cfg file.

To modify the mission.cfg file configuration parameter settings locally from a connected PC:

1. Connect a PC to the float and start a terminal program as described in “Connecting a PC to the Float” on page 2-10.
2. Enter the configuration parameter to be changed and its value in accordance with the following format:

```
mission_set <Configuration Parameter Name> <Value>
```

3. Repeat Step 2 for all the configuration parameter settings that you want to change.
4. If desired, to display a specific configuration parameter setting, enter:

```
mission_get <Configuration Parameter Name>
```

5. If desired, to display all of the configuration parameter settings, enter:

```
mission_get
```



**CAUTION** To save the changed configuration parameter settings, the **mission\_save** command must be entered.

6. To save the new setting or settings, enter:

```
mission_save
```

The float processes the mission.cfg file, checks for and displays errors if any and rejects the save operation if errors are found. An error will be found, for example, if **ParkPressure** is 1500 and **DeepDescentPressure** 1000. If no errors are found, the new settings are saved.

For example, to change **ParkPressure** to 900 and then display and save the new setting, enter:

```
mission_set ParkPressure 900
mission_get ParkPressure
mission_save
```

For more information on these commands, refer to “User Commands” on page 5-6.

## 5.4 Modifying the mission.cfg File Configuration Parameter Settings Remotely

The configuration parameter settings in the mission.cfg file on the float can be modified remotely by modifying the mission.cfg file in the float’s home directory on the server. After the float downloads the modified mission.cfg file, the file is recorded to the system\_log.txt file, enabling verification by the operator when the log file is transmitted.



**CAUTION** *ParkDescentCount* and *DeepDescentCount* are dynamically updated during a mission. Therefore they should not be included in the modified mission.cfg file.



**CAUTION** Some configuration parameters can conflict resulting in an error and the total rejection of the mission.cfg file. Be sure to verify as correct all changed configuration parameters when creating a new mission.cfg file. For example, setting **ParkPressure** to 1500 and **DeepDescentPressure** to 1000 will result in an error and the total rejection of any other changed configuration parameters. Should this situation occur, the existing mission.cfg file will be used and the error will be logged to the system\_log.txt file.

To modify the mission.cfg file configuration parameters remotely:

1. Using a text editor, such as Microsoft Notepad, open the mission.cfg file for editing in the float’s home directory on the server.
2. Enter the configuration parameter to be changed and its value in accordance with the following format:

```
<Configuration Parameter Name> <Value>
```

3. Repeat Step 2 for all the configuration parameter settings that you want to change.

There must only be one configuration parameter and its setting for each line. In addition, it is only necessary for the mission.cfg file to include the changed configuration parameter settings. Unchanged settings need not be included in the



file and can be deleted if present. Comments can also be included in the file by starting the line with a “#” character.

4. Save the modified mission.cfg file and place it into the float’s home directory on the server.

When the float surfaces, it will download the contents of the modified mission.cfg file. Once this occurs the file can be removed from the server so the float does not continue to download the same file each time it surfaces.

For example, to change **ParkPressure** to 900, enter:

```
ParkPressure 900
```

## 5.5 Modifying the sample.cfg File Configuration Parameter Settings Remotely

The configuration parameter settings in the sample.cfg file of the float can be modified remotely by modifying the sample.cfg file in the float’s home directory on the server.



**NOTE** *The sample.cfg file must include all the required parameters, not just the changed ones. Leaving out an entry will result in it being deleted from the file.*

To modify the sample.cfg file remotely:

1. Using a text editor, such as Microsoft Notepad, open the sample.cfg file for editing in the float’s home directory on the server.
2. Delete, change or add entries as described in “sample.cfg File” on page 4-5.
3. Save the modified sample.cfg file.

When the float surfaces, it will download the contents of the modified sample.cfg file. Once this occurs the file can be removed from the server so the float does not continue to download the same file each time it surfaces.

For example, to sample the CTD every 100 dbar beginning at 2000 dbar and ending at 100 dbar, *add* the entry:

```
<ASCENT>  
Sample CTD 2000 100 100 dbar
```

## 5.6 User Commands

The float includes a number of user commands that can be executed when a PC is connected to the float and is running a terminal program. These commands are divided into six main categories:

- File system
- Console
- Mission parameters
- Modem
- Mission
- System

### 5.6.1 File System Commands

The following File System commands are available:

**fs\_cat.** Concatenates and displays the contents of a specific file.

Syntax: `fs_cat <filename>`

Example: `fs_cat system.cfg`

**fs\_cd.** Changes the directory.

Syntax: `fs_cd <directory name>`

Example: `fs_cd download`

**fs\_cp.** Copies the contents of a specified source file to a destination file.

Syntax: `fs_cp <source file> <destination file>`

Example: `fs_cp mission.cfg mission_temp.cfg`

**fs\_df.** Displays file system memory usage.

Syntax: `fs_df`

Example: `fs_df`

```
512-blocks
Filesystem Used Available Capacity Mounted on
sdcard:0: 6976 15736064 15743040 sdcard:0:
```

**fs\_ls.** Lists the files in a specified directory.

Syntax: `fs_ls`

Example: `fs_ls`

```
-rw-rw-rw-      885 mar 22 3917 15:06 mission.cfg
```

**fs\_mv.** Renames a file.

Syntax: `fs_mv <source file> <destination file>`

Example: `fs_mv mission.cfg mission.save`

**fs\_od.** Dumps a specified file in hex format.

Syntax: `fs_od <filename>`

Example: `fs_od mission.cfg`  
00000000 69746341 65746176 6F636552 79726576  
65646F4D ...

**fs\_pwd.** Displays the working directory.

Syntax: `fs_pwd`

Example: `fs_pwd`  
sdcard:0:\download

**fs\_rm.** Removes a specified file.

Syntax: `fs_rm <filename>`

Example: `fs_rm mission.cfg`

**fs\_touch.** Changes the timestamps of a specified file.

Syntax: `fs_touch <filename>`

Example: `fs_touch mission.cfg`

**fs\_wc.** Displays the byte, word and line counts of a specified file.

Syntax: `fs_wc <filename>`

Example: `fs_wc mission.cfg`  
41                    85                    885 mission.cfg

## 5.6.2 Console Commands

The following Console command is available:

**term\_fc.** Displays the console history.

Syntax: `term_fc`

Example: `term_fc`  
0        m\_console  
1        sys\_date  
2        m\_state  
3        mission\_save  
4        mission\_get

### 5.6.3 Mission Parameters Commands

The following Mission Parameters commands are available:

**mission\_set.** Sets a specified mission.cfg file configuration parameter to a specified setting. The setting is not saved until the **mission\_save** command is entered.

Syntax: `mission_set <Configuration Parameter Name> <Value>`

Example: `mission_set ParkPressure 800`  
`ParkPressure 800`



**NOTE** *There are two copies of the mission.cfg file. One is the active copy, and the other is an editable, temporary copy. The **mission\_get** command displays the configuration parameter settings of the temporary copy. The temporary copy becomes the active copy when the **mission\_save** command is entered.*

**mission\_get.** Displays the setting of a specified mission.cfg file configuration parameter of the temporary mission.cfg file. If no configuration parameter is specified, all of the settings in the temporary mission.cfg file are displayed.

Syntax: `mission_get <Configuration Parameter Name>`

Example: `mission_get ParkPressure`  
`ParkPressure 800`

**mission\_save.** Processes the mission.cfg file, checks for and displays errors if any, and if no errors are found, saves all of the changed mission.cfg file configuration parameter settings.

Syntax: `mission_save`

**mission\_print.** Displays all of the active mission.cfg file configuration parameter settings.

Syntax: `mission_print`

### 5.6.4 Modem Commands

The following Modem commands are available:

**modem\_transfer.** Downloads mission.cfg and sample.cfg files if available from the server to the float, and uploads all files from the upload directory of the float to the server.

Syntax: `modem_transfer`

**log\_up.** Compresses and moves all log files to the float's upload directory for uploading to the server.

Syntax: `log_up`

**modem\_csq.** Returns the signal strength of the Iridium network.

Syntax: `modem_csq`

**modem\_serial.** Displays the modem configuration information and serial number.

Syntax: `modem_serial`

**modem\_test.** Tests the Iridium modem's primary and secondary dial up phone or RUDICS ID numbers.

Syntax: `modem_test`

### 5.6.5 Mission Commands

The following Mission commands are available:

**m\_idle.** Puts the float into Idle mode where it waits for pressure activation.

Syntax: `m_idle`

**m\_deploy.** Runs the Mission Prelude followed by the start of the mission.

Syntax: `m_deploy`

**m\_bye.** Exits Console mode, and after the PC is disconnected from the float, enables lowpower standby operation.

Syntax: `m_bye`

**m\_state.** Displays the current state of the float.

Syntax: `m_state`

**m\_console.** Disables lowpower standby for two hours and places the float into Console mode where it does not check for the pressure activation depth or run mission operations unless commanded to do so. Use the **m\_bye** command to exit Console mode.

Syntax: `m_console`

## 5.6.6 System Commands

The following System commands are available:

**sys\_grep.** Searches for and displays lines containing a specified pattern of characters in a specified file.

Syntax: `sys_grep <pattern> <file>`

Example: `sys_grep Rate mission.cfg`  
`AscentRate 0.08`

**sys\_date.** Displays the system date and time.

Syntax: `sys_date`

Example: `sys_date`  
`Wed Mar 22 15:43:44 2017`

**sys\_emerg\_clr.** Executes a system reset that stops the running mission and returns the float to Idle mode.

Syntax: `sys_emerg_clr`



**NOTE** Before using the **sys\_emerg\_clr** command, contact Teledyne Webb Research customer service for recommendations, as sending this command will cause the float to reset and go into Idle mode where it will periodically check for its pressure activation depth.

**sys\_ver.** Displays the system firmware version.

Syntax: `sys_ver`

Example: `sys_ver`  
`03/21/17 22:37:56 APF11-v2.6.1`

**sys\_self\_test.** Runs the self test without starting a mission.

Syntax: `sys_self_test`

**sys\_read.** Samples the specified sensor and displays the data.

Syntax: `sys_read <sensor>`

Example: `sys_read OPT`

**sys\_show.** Displays all of the information available from the sensor.

Syntax: `sys_show <sensor>`

Example: `sys_show OPT`

**sys\_test.** Runs a test of the specified sensor and displays the results.

Syntax: `sys_test <sensor>`

Example: `sys_test OPT`

**sys\_capture.** Captures subsequent command line output into a specified file. Typing "." followed by pressing the Enter key at the end of the command line output ends the capture.

Syntax: `sys_capture`

**dbg\_verbosity.** Sets the verbosity of the system\_log.txt file entries output over the serial interface to a specified level. The range is 0 (no output) to 6 (1 through 6 levels output) as follows:

- 0 – no outputs (default)
- 1 – critical errors
- 2 – major errors
- 3 – minor errors
- 4 – warnings
- 5 – notices
- 6 – informational

Syntax: `dbg_verbosity`

Example: `dbg_verbosity 5`

**log\_verbosity.** Sets the verbosity of the system\_log.txt file entries transmitted over the Iridium satellite network to a specified level. The range is 0 (no output) to 6 (1 through 6 levels output) as follows:

- 0 – no outputs (default)
- 1 – critical errors
- 2 – major errors
- 3 – minor errors
- 4 – warnings
- 5 – notices
- 6 – informational

Syntax: `log_verbosity`

Example: `log_verbosity 5`





## SECTION 6: CTDs

---

The Teledyne Webb Research APEX profiling float includes one of the following CTDs:

- SBE 41CP (Sea-Bird Scientific)
- SBE 41 (Sea-Bird Scientific)
- SBE 41N+pH (Sea-Bird Scientific)
- RBRargo (RBR Ltd.)

For the CTD specifications, refer to the CTD manufacturer's Web site.



**NOTE** Information, including technical descriptions, provided in this section is obtained from the CTD manufacturer documentation and is subject to change without notice.

The following pages contain information about each of these CTDs, including how to specify their hardware configuration, how to specify their sampling behavior along with examples, how to uncompress and read their data log files, how to use the Show command to display all of the information available from the specific CTD, and how to display the as-shipped factory configuration parameters for the CTD.

## 6.1 SBE 41CP CTD

The SBE 41CP CTD from Sea-Bird Scientific is a pumped type CTD that provides both interval sampling and continuous profiling of water pressure, temperature and salinity.

### 6.1.1 Specifying the SBE 41CP CTD Hardware Configuration

A line in the sensors.cfg file specifies the hardware configuration for the SBE 41CP CTD:

```
seabird_ctd_41cp PIN_4 PORT_A COM_2 B9600
```

For more information on the sensors.cfg file along with additional examples, refer to “sensors.cfg File” on page 4-4.

### 6.1.2 Specifying the SBE 41CP CTD Sampling Behavior

Interval sampling and continuous profiling, which can be performed separately or simultaneously, are controlled with entries in the sample.cfg file. In both cases the specified start and stop pressures can be in any order. For more information on using the sample.cfg file along with additional examples, refer to “sample.cfg File” on page 4-5.



**NOTE** For the best accuracy it is recommended that interval sampling between 750 meters and the surface be performed simultaneously with continuous profiling.

**Interval sampling.** The interval sampling behavior for the SBE 41CP CTD is specified using a single entry in the sample.cfg file for each of any number of pressure ranges in accordance with the following syntax:

```
<phase>  
Sample <sensor type> [<start> [<stop> [<interval> [<units> [<count>]]]]]
```

For example, to sample the SBE 41CP CTD every 10 dbar beginning at 1000 dbar and ending at 200 dbar, enter:

```
<ASCENT>  
Sample CTD 1000 200 10 dbar
```

For the Park phase, interval sampling can be performed at the sampling interval specified by **ParkTimerInterval**.

For example, to sample the SBE 41CP CTD during the Park phase, enter:

```
<PARK>  
Sample CTD
```

The SBE 41CP CTD will be sampled at the rate specified by **ParkTimerInterval**.

**Continuous profiling.** The continuous profiling behavior for the SBE 41CP CTD is specified using one or more entries in the sample.cfg file for each of any number of pressure ranges in accordance with the following syntax:

```
<phase>
Profile <sensor type> [<start> [<stop>]]
```

Continuous profiling will automatically stop at the depth determined by **SurfacePressure** or pcutoff. The bin size and sample rate are fixed at 2 decibars and 1 sample per second, respectively.

For example, to sample the SBE 41CP CTD continuously beginning at 1000 dbar and ending at 4 dbar:

```
<ASCENT>
Profile CTD 1000 4
```

### 6.1.3 Uncompressing and Reading the SBE 41CP CTD Log Files

SBE 41CP CTD data are provided in the science\_log.bin file. For instructions on how to uncompress this file, refer to “Converting the science\_log.bin and vitals\_log.bin Files to CSV Files” on page 4-15.

The rows in the science\_log.csv file that contain data that were recorded when interval sampling with an SBE 41CP CTD are the following:

**CTD\_P.** All rows in the science\_log.csv file with the first column label "CTD\_P" contain SBE 41CP CTD pressure data. The columns are from left to right:

<b>Time stamp:</b>	UTC (YYYYMMDDTHHMMSS)
<b>Pressure:</b>	Pressure in decibars

**CTD\_PT.** All rows in the science\_log.csv file with the first column label "CTD\_PT" contain SBE 41CP CTD pressure and temperature data. The columns are from left to right:

<b>Time stamp:</b>	UTC (YYYYMMDDTHHMMSS)
<b>Pressure:</b>	Pressure in decibars
<b>Temperature:</b>	Temperature in degrees Celsius

**CTD\_PTS.** All rows in the science\_log.csv file with the first column label "CTD\_PTS" contain SBE 41CP CTD data that were recorded when interval sampling. The columns are from left to right:

<b>Time stamp:</b>	UTC (YYYYMMDDTHHMMSS)
<b>Pressure:</b>	Pressure in decibars
<b>Temperature:</b>	Temperature in degrees Celsius
<b>Salinity:</b>	Salinity in PSU

The rows in the science\_log.csv file that contain data that were recorded when continuous profiling with an SBE 41CP CTD are the following:

**CTD\_bins.** All rows in the science\_log.csv file with the first column label "CTD\_bins" contain SBE 41CP CTD bin averaging statistics. The columns are from left to right:

<b>Time stamp:</b>	UTC (YYYYMMDDTHHMMSS)
<b>Samples:</b>	Number of samples recorded during the mission
<b>Bins:</b>	Number of bins recorded during the mission
<b>Maxpress:</b>	Highest pressure in decibars recorded during the mission

**CTD\_CP.** All rows in the science\_log.csv file with the first column label "CTD\_CP" contain bin averaged SBE 41CP CTD data.



**NOTE** When continuous profiling with a float that uses an SBE 41CP CTD, the time stamps in the science\_log.bin file are not the times at which the samples were actually taken. Rather the time stamps are the times at which the data were recorded to the science\_log.bin file which occurs when continuous profiling stops.

The columns are from left to right:

<b>Time stamp:</b>	UTC (YYYYMMDDTHHMMSS)
<b>Pressure:</b>	Bin averaged pressure in decibars
<b>Temperature:</b>	Bin averaged temperature in degrees Celsius
<b>Salinity:</b>	Bin averaged salinity in PSU
<b>Samples:</b>	Number of samples averaged per bin

Four example rows of SBE 41CP CTD data extracted from a science\_log.csv file are shown in Figure 6-1.

CTD_P	20170303T050158	3.85			
CTD_PTS	20170303T050208	4.6	11.919	34.7004	
CTD_bins	20170303T050218	12917	743	1483.59	
CTD_CP	20170303T050218	1475.99	1.3475	34.7083	22

**Figure 6-1: Example Rows of SBE 41CP CTD Data in a science\_log.csv File**

For more information on reading the science\_log.bin file along with additional examples, refer to “Reading the science\_log.csv File” on page 4-15.

### 6.1.4 Show Command

The Show command displays all of the information available from the SBE 41CP CTD. To use the Show command, a PC must be connected to the float and running a terminal program.

To display the SBE 41CP CTD configuration information, enter:

```
sys_show CTD
```

The SBE 41CP CTD configuration will be displayed on the PC as in the following example:

```
Model:                SBE 41CP
Version:              7.2.5
Serial Number:       8377
Variant:             CP UW
tswait:              20
pcutoff:             2.00
automatic bin averaging: no
nsamples:           158
nbins:              49
top bin interval:    2
top bin size:        2
top bin max:         10
middle bin interval: 2
middle bin size:     2
middle bin max:      20
bottom bin interval: 2
bottom bin size:     2
include transition bin: no
include samples per bin: yes
real-time output:    PTS

temperature:  12-Apr-16

TA0:          -8.482609e-04
TA1:          2.894297e-04
TA2:          -3.591653e-06
TA3:          1.443891e-07

conductivity: 12-Apr-16

G:            -9.955153e-01
H:            1.501197e-01
```

```

I: -4.438523e-04
J: 5.533339e-05
CPCOR: -9.570000e-08
CTCOR: 3.250000e-06
WBOTC: -1.032698e-06
pressure S/N = 4924326, range = 2900 psia: 13-Apr-16

```

```

PA0: 2.820664e+00
PA1: 3.928967e-04
PA2: 7.270721e-14
PTCA0: 1.077206e+05
PTCA1: 9.338340e+01
PTCA2: 1.166206e+01
PTCB0: 1.052019e+02
PTCB1: -2.697820e-03
PTCB2: 0.000000e+00
PTHA0: 3.179357e+02
PTHA1: -9.059575e-05
PTHA2: 2.859202e-12
POFFSET: 0.000000e+00

```

### 6.1.5 SBE 41CP CTD Factory Configuration

The factory configuration of the installed SBE 41CP CTD is the following:

```

autobinavg = 0
top_bin_interval = 2
top_bin_size = 2
top_bin_max = 10
middle_bin_interval = 2
middle_bin_size = 2
middle_bin_max = 20
bottom_bin_interval = 2
bottom_bin_size = 2
includetransitionbin = 0
includenbin = 1
outputpts = 1
Tswait = 20
Pcutoff = 2

```

## 6.2 SBE 41 CTD

The SBE 41 CTD from Sea-Bird Scientific is a pumped type CTD that provides interval sampling of water pressure, temperature and salinity.

### 6.2.1 Specifying the SBE 41 CTD Hardware Configuration

A line in the sensors.cfg file specifies the hardware configuration for the SBE 41 CTD:

```
seabird_ctd_41 PIN_4 PORT_A COM_2 B9600
```

For more information on the sensors.cfg file along with additional examples, refer to “sensors.cfg File” on page 4-4.

### 6.2.2 Specifying the SBE 41 CTD Sampling Behavior

Sampling is controlled with entries in the sample.cfg file. The specified start and stop pressures can be in any order. For more information on using the sample.cfg file along with additional examples, refer to “sample.cfg File” on page 4-5.

The sampling behavior for the SBE 41 CTD is specified using a single entry in the sample.cfg file for each of any number of pressure ranges in accordance with the following syntax:

```
<phase>  
Sample <sensor type> [<start> [<stop> [<interval> [<units> [<count>]]]]]
```

For example, to sample the SBE 41 CTD every 10 dbar beginning at 1000 dbar and ending at 200 dbar, enter:

```
<ASCENT>  
Sample CTD 1000 200 10 dbar
```

For the Park phase, interval sampling can be performed at the sampling interval specified by **ParkTimerInterval**.

For example, to sample the SBE 41 CTD during the Park phase, enter:

```
<PARK>  
Sample CTD
```

The SBE 41 CTD will be sampled at the rate specified by **ParkTimerInterval**.

### 6.2.3 Uncompressing and Reading the SBE 41 CTD Log Files

SBE 41 CTD data are provided in the science\_log.bin file. For instructions on how to uncompress this file, refer to “Converting the science\_log.bin and vitals\_log.bin Files to CSV Files” on page 4-15.

With the exception of CTD\_bins and CTD\_CP, which are not included, the rows in the science\_log.csv file for an SBE 41 CTD are the same as that provided for an SBE 41CP CTD as described in “Uncompressing and Reading the SBE 41CP CTD Log Files” on page 6-3.

Two example rows of SBE 41 CTD data extracted from a science\_log.csv file are shown in Figure 6-2.

CTD_P	20170303T050158	3.85			
CTD_PTS	20170303T050208	4.6	11.919	34.7004	

**Figure 6-2: Example Rows of SBE 41 CTD Data in a science\_log.csv File**

For more information on reading the science\_log.bin file along with additional examples, refer to “Reading the science\_log.csv File” on page 4-15.

### 6.2.4 Show Command

The Show command displays all of the information available from the SBE 41 CTD. To use the Show command, a PC must be connected to the float and running a terminal program.

To display the SBE 41 CTD configuration information, enter:

```
sys_show CTD
```

The SBE 41 CTD configuration will be displayed on the PC as in the following example:

```
Model:                SBE 41
Version:              7.2.5
Serial Number:       9565
Variant:              Standard
tswait:               3
temperature: 21-Mar-17
  TA0:                -8.177796e-04
  TA1:                2.853510e-04
  TA2:                -3.361656e-06
  TA3:                1.382331e-07
conductivity: 21-Mar-17
  G:                  -1.004127e+00
```



```
H: 1.414276e-01
I: -3.575581e-04
J: 4.619621e-05
CPCOR: -9.570000e-08
CTCOR: 3.250000e-06
WBOTC: 9.360629e-08
pressure S/N = 10449802, range = 2900 psia: 14-Mar-17
PA0: 7.541767e-01
PA1: 3.932653e-04
PA2: -3.032656e-13
PTCA0: 1.680632e+03
PTCA1: 2.568692e+01
PTCA2: 2.626050e+00
PTCB0: 2.448937e+01
PTCB1: -2.125000e-03
PTCB2: 0.000000e+00
PTHA0: 3.275166e+02
PTHA1: -6.205709e-05
PTHA2: -1.461976e-12
POFFSET: 0.000000e+00
```

### 6.2.5 SBE 41 CTD Factory Configuration

The factory configuration of the installed SBE 41 CTD is the following:

```
Tswait = 3
```

## 6.3 SBE 41N+pH CTD

The SBE 41N+pH CTD from Sea-Bird Scientific is a pumped type CTD that provides both interval sampling and continuous profiling of water pressure, temperature, salinity, and pH. A Sea-Bird Scientific SeaFET Ocean pH sensor provides the pH measurements. This sensor is an ion selective field effect transistor (ISFET) type device for accurate long term pH measurements in salt water.

### 6.3.1 Specifying the SBE 41N+pH CTD Hardware Configuration

A line in the sensors.cfg file specifies the SBE 41N+pH CTD hardware configuration:

```
seabird_ctd_41n PIN_4 PORT_A COM_2 B9600
```

For more information on the sensors.cfg file along with additional examples, refer to “sensors.cfg File” on page 4-4.

### 6.3.2 Specifying the SBE 41N+pH CTD Sampling Behavior

Interval sampling and continuous profiling are controlled with entries in the sample.cfg file. In both cases the specified start and stop pressures can be in any order. For more information on using the sample.cfg file along with additional examples, refer to “sample.cfg File” on page 4-5.



**NOTE** For the best accuracy it is recommended that interval sampling between 750 meters and the surface be performed simultaneously with continuous profiling.

**Interval sampling.** The interval sampling behavior for the SBE 41N+pH is specified using one or more entries in the sample.cfg file for each of any number of pressure ranges in accordance with the following syntax:

```
<phase>  
Sample <sensor type> [<start> [<stop> [<interval> [<units> [<count>]]]]]
```

For example, to sample *both* the CTD and the pH sensor every 10 dbar beginning at 1000 dbar and ending at 200 dbar, enter:

```
<ASCENT>  
Sample PH 1000 200 10 dbar
```

To sample *only* the CTD every 10 dbar beginning at 1000 dbar and ending at 200 dbar, enter:

```
<ASCENT>  
Sample CTD 1000 200 10 dbar
```

To sample *both* the CTD and the pH sensor every 10 dbar beginning at 600 dbar and ending at 4 dbar and *only* the CTD every 20 dbar beginning at 2000 dbar and ending at 1000 dbar, enter:

```
<ASCENT>
Sample CTD 2000 1000 20 dbar
Sample PH 600 4 10 dbar
```

For the Park phase, interval sampling can be performed at the sampling interval specified by **ParkTimerInterval** for either the CTD or both the CTD and the pH sensor. Sampling cannot be performed during the Surface phase.

For example, to sample *only* the CTD during the Park phase, enter:

```
<PARK>
Sample CTD
```

The CTD will be sampled at the rate specified by the **ParkTimerInterval** configuration parameter.

To sample *both* the CTD and the pH sensor during the Park phase, enter:

```
<PARK>
Sample PH
```

The CTD and the pH sensor will be sampled at the rate specified by the **ParkTimerInterval** configuration parameter.



**NOTE** Interval sampling of pH cannot be performed during continuous CTD or pH profiling. Entries of this type will be ignored. Furthermore, continuous pH profiling can only be performed when performing continuous CTD profiling.

**Continuous CTD profiling.** The continuous CTD profiling behavior for the SBE 41N+pH CTD is specified using one or more entries in the sample.cfg file for each of any number of pressure ranges in accordance with the following syntax:

```
<phase>
Profile CTD [<start> [<stop>]]
```

Continuous profiling will automatically stop at the depth determined by **SurfacePressure** or pcutoff. The bin size and sample rate are fixed at 2 decibars and 1 sample per second, respectively.

For example, to sample the SBE 41N+pH continuously beginning at 1000 dbar and ending at 4 dbar:

```
<ASCENT>
Profile CTD 1000 4
```

**Continuous pH profiling.** The continuous pH profiling behavior for the SBE 41N+pH CTD is specified using one or more entries in the sample.cfg file for each of any number of pressure ranges in accordance with the following syntax:

```
<phase>
Profile PH [<start> [<stop> [<interval>]]]
```

If no entry is provided for <interval>, a default of 1 second is used.

For example, to sample the CTD continuously beginning at 1000 dbar and ending at 4 dbar and the pH sensor beginning at 1000 dbar and ending at 4 dbar with a sampling interval of 2 seconds, enter:

```
<ASCENT>
Profile CTD 1000 4
Profile PH 1000 4 2
```

Both entries following the phase entry are required. In this example continuous profiling for the CTD and the pH sensor is performed between the same start and stop pressures, and the fixed bin size and sample rate of 2 decibars and 1 sample per second, respectively, are used for the CTD.

To sample the CTD continuously beginning at 2000 dbar and ending at 4 dbar and the pH sensor beginning at 500 dbar and ending at 4 dbar with a sampling interval of 2 seconds, enter:

```
<ASCENT>
Profile CTD 2000 4
Profile PH 500 4 2
```

Again, both entries following the phase entry are required. In this example continuous profiling for the CTD and the pH sensor are performed beginning at different start pressures and ending at the same stop pressure.



**NOTE** By default, the SBE 41N+pH CTD is internally configured to start profiling at 1000 decibars, to stop profiling at 0 decibars and to sample once per second. However, continuous pH profiling can only occur during continuous CTD profiling. When continuous CTD profiling is specified without specifying pH profiling, pH samples will be included when the default pH profiling range coincides with the specified continuous CTD profiling range.

In the following example the CTD is sampled continuously beginning at 1500 dbar and ending at 4 dbar along with the pH sensor beginning by default at 1000 dbar and also ending at 4 dbar, and with a sampling interval of 1 second.

```
<ASCENT>
Profile CTD 1500 4
```

In the following example the CTD is sampled continuously beginning at 2000 dbar and ending at 1000 dbar along with the pH sensor beginning at 1500 dbar and also ending at 1000 dbar with a sampling interval of 1 second. Continuous sampling of the pH sensor is ignored after 1000 dbar even though 500 dbar is specified, as continuous CTD profiling is not being performed in this pressure ranged.

```
<ASCENT>
Profile CTD 2000 1000
Profile PH 1500 500 1
```



**NOTE** Only one entry of sensor type PH is allowed. If more than one entry of this sensor type is included, the *sample.cfg* file will be rejected, and an error message will be logged to the *system\_log.txt* file.

To override the default configuration of the pH sensor and therefore perform no pH sampling, yet sample the CTD as in the above example, enter:

```
<ASCENT>
Profile CTD 2000 1000
Profile PH 0 0 1
```

### 6.3.3 Uncompressing and Reading the SBE 41N+pH CTD Log Files

SBE 41N+pH CTD data are provided in the *science\_log.bin* file. For instructions on how to uncompress this file, refer to “Converting the *science\_log.bin* and *vitals\_log.bin* Files to CSV Files” on page 4-15.

The rows in the *science\_log.csv* file for an SBE 41N+pH CTD are the same as that provided for an SBE 41CP CTD as described in “Uncompressing and Reading the SBE 41CP CTD Log Files” on page 6-3 plus the additional rows listed below.

**CTD\_PTSH.** All rows in the *science\_log.csv* file with the first column label “CTD\_PTSH” contain SBE 41N+pH CTD pressure, temperature, salinity, and pH data that were recorded when interval sampling. The columns are from left to right:

<b>Time stamp:</b>	UTC (YYYYMMDDTHHMMSS)
<b>Pressure:</b>	Pressure in decibars
<b>Temperature:</b>	Temperature in degrees Celsius
<b>Salinity:</b>	Salinity in PSU
<b>pH:</b>	Reference voltage

**CTD\_CP\_H.** All rows in the science\_log.csv file with the first column label "CTD\_CP\_H" contain bin averaged SBE 41N+pH CTD data that were recorded when continuous profiling.



**NOTE** When continuous profiling with a float that uses an SBE 41N+pH CTD, the time stamps in the science\_log.bin file are not the times at which the samples were actually taken. Rather the time stamps are the times at which the data were recorded to the science\_log.bin file which occurs when continuous profiling stops.

The columns are from left to right:

<b>Time stamp:</b>	UTC (YYYYMMDDTHHMMSS)
<b>Pressure:</b>	Bin averaged pressure in decibars
<b>Temperature:</b>	Bin averaged temperature in degrees Celsius
<b>Salinity:</b>	Bin averaged salinity in PSU
<b>PTS samples:</b>	Number of PTS samples averaged in a bin
<b>pH:</b>	Reference voltage
<b>pH samples:</b>	Number of pH samples averaged in a bin

Two example rows of SBE 41N+pH CTD data extracted from a science\_log.csv file are shown in Figure 6-3.

CTD_PTSH	20170310T130912	91.6	21.9224	33.504	-0.960061		
CTD_CP_H	20170310T131412	4.17	21.9914	35.2916	23	-0.960538	23

**Figure 6-3: Example Rows of SBE 41N+pH CTD Data in a science\_log.csv File**

For more information on reading the science\_log.bin file along with additional examples, refer to “Reading the science\_log.csv File” on page 4-15.

### 6.3.4 Show Command

The Show command displays all of the information available from the SBE 41N+pH CTD. To use the Show command, a PC must be connected to the float and running a terminal program.

To display the SBE 41N+pH CTD configuration information, enter:

```
sys_show CTD
```

The SBE 41N+pH CTD configuration will be displayed on the PC as in the following example:

```
Model:                SBE 41N
Version:              5.3.0
Serial Number:       9425
Variant:              41cp
pcutoff:              2.00
automatic bin averaging: no
nsamples:            283
nbins:                0
top bin interval:    2
top bin size:        2
top bin max:         10
middle bin interval: 2
middle bin size:     2
middle bin max:     20
bottom bin interval: 2
bottom bin size:     2
include transition bin: no
include samples per bin: yes
pump sample wait time: 20 sec
real-time output:    PTS
longpt:              1
enableph:            1
measintervalph:     1
pressureonph:        1000
pressureoffph:       0
temperature_1:       07-Feb-17
  TA0:                -8.423786e-04
  TA1:                2.943042e-04
  TA2:                -3.928960e-06
  TA3:                1.509667e-07
temperature_2:       07-Feb-17
  TA0:                -8.163393e-04
  TA1:                2.916159e-04
  TA2:                -3.680900e-06
  TA3:                1.489342e-07
conductivity:        07-Feb-17
  G:                  -9.978469e-01
  H:                  1.514799e-01
  I:                  -3.834221e-04
```

```

J: 5.074354e-05
CPCOR: -9.570000e-08
CTCOR: 3.250000e-06
WBOTC: -7.126914e-07
pressure S/N = 10474358, range = 2900 psia: 02-Feb-17
PA0: 7.433826e-02
PA1: 3.887642e-04
PA2: -2.891686e-13
PTCA0: -4.937697e+03
PTCA1: 1.043480e+01
PTCA2: -7.120038e-02
PTCB0: 2.535888e+01
PTCB1: -2.500000e-05
PTCB2: 0.000000e+00
PTHA0: -5.976322e+01
PTHA1: 5.322828e-02
PTHA2: -3.091781e-07
POFFSET: 0.000000e+00

```

### 6.3.5 SBE 41N+pH CTD Factory Configuration

The factory configuration of the installed SBE 41N+pH CTD is the following:

```

outputpts=1
includetransitionbin=0
includenbin=1
autobinavg=0
tswait=20
top_bin_interval=2
top_bin_size=2
top_bin_max=10
middle_bin_interval=2
middle_bin_size=2
middle_bin_max=20
bottom_bin_interval=2
bottom_bin_size=2
pcutoff=2.000000
setlongpt=1
setenableph=1
setmeasintervalph=1
setpressureonph=1000
setpressureoffph=0

```



## 6.4 RBRargo CTD

The RBRargo CTD from RBR Ltd. is a non-pumped CTD that provides both interval sampling and continuous profiling of water pressure, temperature, salinity, and conductivity.

### 6.4.1 Specifying the RBRargo CTD Hardware Configuration

A line in the sensors.cfg file specifies the hardware configuration for the RBRargo CTD:

```
rbr_ctd PIN_4 PORT_A COM_2 B9600
```

For more information on the sensors.cfg file along with additional examples, refer to “sensors.cfg File” on page 4-4.

### 6.4.2 Specifying the RBRargo CTD Sampling Behavior

Interval sampling and continuous profiling are controlled with entries in the sample.cfg file. In both cases the specified start and stop pressures can be in any order. For more information on using the sample.cfg file along with additional examples, refer to “sample.cfg File” on page 4-5.

**Interval sampling.** The interval sampling behavior for the RBRargo CTD is specified using a single entry in the sample.cfg file for each of any number of pressure ranges in accordance with the following syntax:

```
<phase>
Sample <sensor type> [<start> [<stop> [<interval> [<units> [<count>]]]]]
```

For example, to sample the RBRargo CTD every 10 dbar beginning at 1000 dbar and ending at 200 dbar, enter:

```
<ASCENT>
Sample CTD 1000 200 10 dbar
```

**Continuous profiling.** The continuous profiling behavior for the RBRargo CTD is specified using one or more entries in the sample.cfg file for each of any number of pressure ranges in accordance with the following syntax:

```
<phase>
Profile <sensor type> [<start> [<stop> [<bin_size> [<rate>]]]]]
```

For example, to sample the RBRargo CTD continuously beginning at 1000 dbar and ending at 200 dbar with a bin size of 2 dbars and a sample rate of 1 sample/second, enter:

```
<ASCENT>
Profile CTD 1000 200 2.0 1.00
```

### 6.4.3 Uncompressing and Reading the RBRargo CTD Log Files

RBRargo CTD data are provided in the science\_log.bin file. For instructions on how to uncompress this file, refer to “Converting the science\_log.bin and vitals\_log.bin Files to CSV Files” on page 4-15.

The rows in the science\_log.csv file for an RBRargo CTD are listed below.

**CTD\_PTSC.** All rows in the science\_log.csv file with the first column label "CTD\_PTSC" contain CTD data that were recorded when interval sampling. The columns are from left to right:

<b>Time stamp:</b>	UTC (YYYYMMDDTHHMMSS)
<b>Pressure:</b>	Pressure in decibars
<b>Temperature:</b>	Temperature in degrees Celsius
<b>Salinity:</b>	Salinity in PSU
<b>Conductivity:</b>	Conductivity in mS/cm
<b>Internal conductivity temperature:</b>	Inside temperature in degrees Celsius

**CTD\_CP+.** All rows in the science\_log.csv file with the first column label "CTD\_CP+" contain bin averaged RBRargo CTD data that were recorded when continuous profiling. The columns are from left to right:

<b>Time stamp:</b>	UTC (YYYYMMDDTHHMMSS)
<b>Pressure:</b>	Bin averaged pressure in decibars
<b>Temperature:</b>	Bin averaged temperature in degrees Celsius
<b>Salinity:</b>	Bin averaged salinity in PSU
<b>Conductivity:</b>	Conductivity in mS/cm
<b>Internal conductivity temperature:</b>	Inside temperature in degrees Celsius
<b>Samples:</b>	Number of samples averaged per bin



**NOTE** When continuous profiling with a float that uses an RBRargo CTD, the time stamps are provided by the CTD, and they are the times at which the samples were taken at depth.

Two example rows of RBRargo CTD data extracted from a science\_log.csv file are shown in Figure 6-4.

CTD_PTSC	20150731T041815	240.6587	17.6837	35.425	46.1812	17.6837	
CTD_CP+	20150730T224058	1993.042	2.385803	34.63721	31.68344	2.385803	19

**Figure 6-4: Example Rows of RBRargo CTD Data in a science\_log.csv File**

For more information on reading the science\_log.bin file along with additional examples, refer to “Reading the science\_log.csv File” on page 4-15.

#### 6.4.4 Show Command

The Show command displays all of the information available from the RBRargo CTD. To use the Show command, a PC must be connected to the float and running a terminal program.

To display the RBRargo CTD configuration information, enter:

```
sys_show CTD
```

The RBRargo CTD configuration will be displayed on the PC as in the following example:

```
Model:                RBRargo
Version:              1.300
Serial No.:           060261
Baud Rate:            19200
Available Channels:   8
Enabled Channels:     6
Enabled Channels List:
    conductivity (mS/cm)
    temperature (C)
    pressure (dbar)
    salinity (PSU)
    measurement_count (counts)
    temperature (C)
Regimes: direction = ascending, count = 1, reference =
seapressure
    #1: boundary = 2500, binsize = 2.0, samplingperiod = 1000
```

#### 6.4.5 SBE RBRargo CTD Factory Configuration

The factory configuration of the installed RBRargo CTD is the following:

```
confirmation state = on
streamserial state = off
serial baudrate = 19200
clock = 20170426153828
```

```
channel 1 type = cond07
channel 1 status = on

channel 2 type = temp14
channel 2 status = on

channel 3 type = pres19
channel 3 status = off

channel 4 type = pres08
channel 4 status = on

channel 5 type = dpth01
channel 5 status = off

channel 6 type = sal_00
channel 6 status = on

channel 7 type = cnt_00
channel 7 status = on

channel 8 type = temp11
channel 8 status = on

channels on = 6
outputformat type = caltext01
memformat newtype = calbin00
sampling mode = regimes
sampling period = 1000
regimes direction = ascending
regimes reference = seapressure
settings atmosphere = 10.1325000
```

## SECTION 7: General Maintenance

---

After recovering the Teledyne Webb Research APEX profiling float, it should be cleaned and inspected. The battery usage should also be checked and the batteries replaced if the remaining capacity is not adequate for the next deployment. In addition, the CTD and any other science sensors should be checked and recalibrated if necessary.

### 7.1 Cleaning and Inspecting the Float after Recovery

After recovering a float, wash it with clean, fresh water and inspect the housing and the CTD for damage or corrosion. Also check that the zinc anode on the top end cap is secure and is not excessively corroded. The zinc anode is shown in Figure 1-2 on page 1-3. It should be replaced before redeploying the float. For instructions on how to replace the zinc anode, contact Teledyne Webb Research customer service.

### 7.2 Replacing the Float Batteries

For battery replacement return the float to Teledyne Webb Research.



**WARNING** Do not attempt to open the APEX profiling float housing before returning the float to Teledyne Webb Research. If the float was recovered from the ocean, it may contain water. This situation presents a safety hazard due to the possible chemical reaction of the batteries with the water. Before returning a float to Teledyne Webb Research, contact Teledyne Webb Research customer service for instructions on how to properly prepare the float for shipment.

### 7.3 Battery Usage

Battery usage is determined by the coulomb counter which indicates the current battery usage in mA-hours. This information is provided in the vitals\_log.bin file as described in “vitals\_log.bin File” on page 4-14. This file must be uncompressed and then converted to a CSV file before it can be opened in a spreadsheet program and read as described in “Converting the science\_log.bin and vitals\_log.bin Files to CSV File” on page 4-15.



**NOTE** For an APEX profiling float with a CTD only and lithium batteries, the battery capacity is 108,000 mA-hours. For the same float with alkaline batteries, the battery capacity is 53,000 mA-hours. Floats with additional sensors may have different battery configurations and capacities.

## 7.4 Storing the Float

Floats should be stored in a controlled environment of between 10°C to 25°C. For a float with a pumped type CTD, it should be stored in its original crate with the CTD inside the plastic bag and the red cap and the two orange plugs installed.



**NOTE** *If a float has been stored at a temperature of -2°C or less, allow it to warm up indoors before deployment.*

## APPENDIX A: Optional Sensors

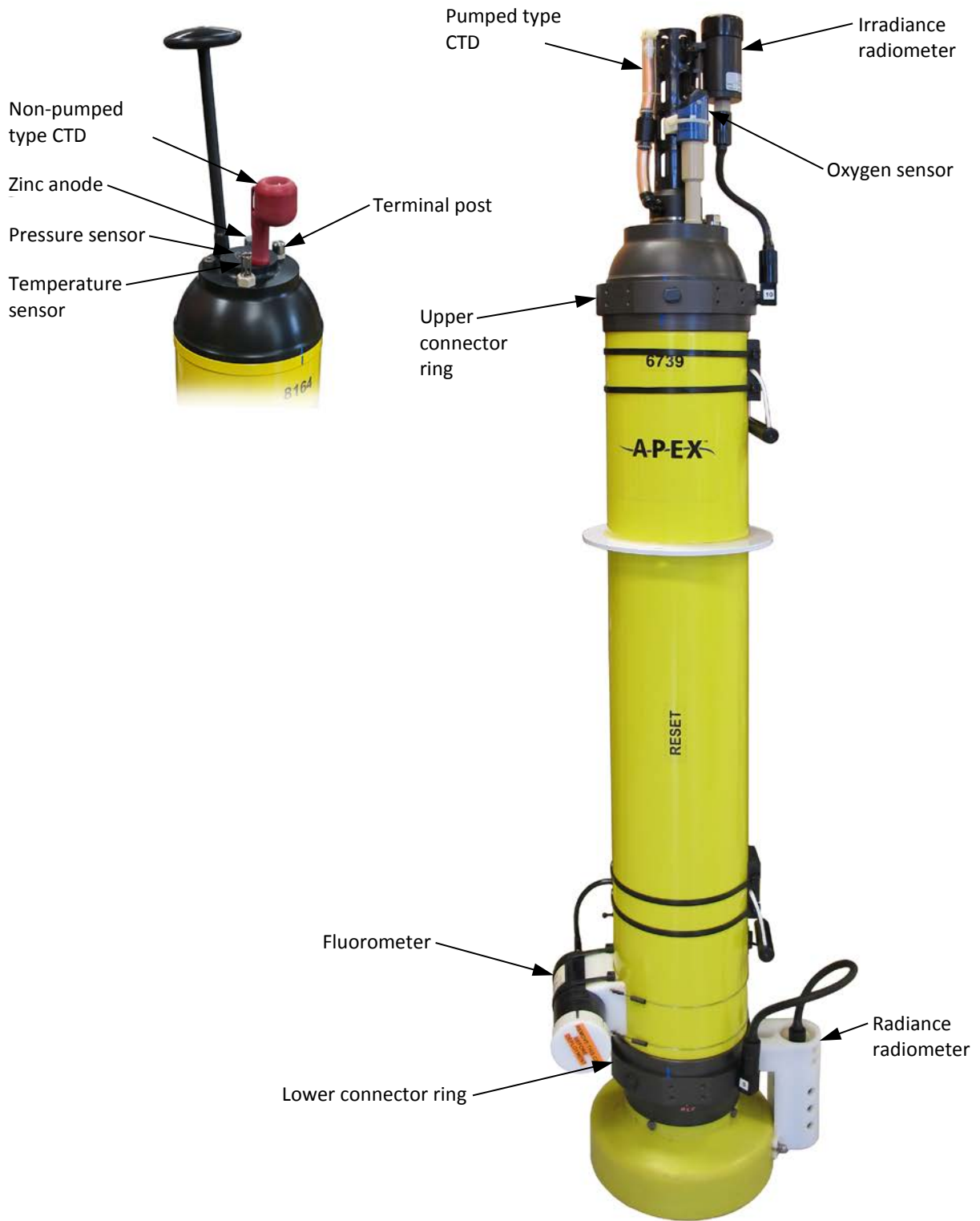
---

The Teledyne Webb Research APEX profiling float optionally includes one or more science sensors in addition to the CTD. Shown in Figure A-1 is an APEX-AMS Advanced Multisensor profiling float with several optional sensors installed. For the specifications for these sensors, refer to the sensor manufacturer's Web site.



**NOTE** Information, including technical descriptions, provided in this section is obtained from the sensor manufacturer documentation and is subject to change without notice.

The following pages contain information about each of the available optional sensors, including how to specify their hardware configuration, how to specify their sampling behavior along with examples, how to uncompress and read their data log files, how to use the Show command to display all of the information available from the specific sensor, and how to display the as-shipped factory configuration parameters for the sensor.



**Figure A-1: The APEX Advanced Multisensor (AMS) Profiling Float with Pumped Type CTD and Non-pumped Type CTD**



## A.1 Oxygen Sensor (Aanderaa)

The Teledyne Webb Research APEX Deep profiling float optionally includes the Aanderaa Oxygen Optode 4330 Oxygen Sensor for periodic sampling of dissolved oxygen using an optical optode that does not consume oxygen. The measurement principle of the sensor is based on fluorescence quenching. The optode's foil is excited by modulated blue light, and the sensor measures the phase of a returned red light. By linearizing and temperature compensating with an incorporated temperature sensor located next to the sensing foil, the absolute O<sub>2</sub> concentration can be determined.

### A.1.1 Specifying the Oxygen Sensor Hardware Configuration

A line in the sensors.cfg file defines the oxygen sensor hardware configuration as in the following example:

```
optode PIN_5 PORT_SPR COM_4 B9600
```

For more information on the sensors.cfg file along with additional examples,, refer to “sensors.cfg File” on page 4-4.

### A.1.2 Specifying the Oxygen Sensor Sampling Behavior

The interval sampling behavior for the oxygen sensor is specified using a single entry in the sample.cfg file for each of any number of pressure ranges in accordance with the following syntax:

```
Sample OPT [<start> [<stop> [<interval> [<<units> [<count>]]]]]
```

For example, to sample the oxygen sensor every 10 dbar beginning at 5000 dbar and ending at 200 dbar, enter:

```
<ASCENT>  
Sample OPT 5000 200 10 dbar
```

The start and stop pressures can be in any order. For more information on using the sample.cfg file to program the behavior of the float along with additional examples, refer to “sample.cfg File” on page 4-5.

### A.1.3 Specifying the Oxygen Sensor In-Air Measurement Behavior in Accordance with the SCOR Recommendation

The APEX Deep profiling float implements dissolved oxygen in-air measurements using Scientific Committee on Oceanic Research (SCOR) Working Group 142 recommendations as referenced in the note in the following page. When the float transitions to Surface phase, 10 measurements are taken at 15-second intervals before and after inflating the air bladders. The results are written to the science\_log.txt file.

The SCOR sampling behavior is specified using a single entry in the sample.cfg file in accordance with the following syntax:

```
<SURFACE>
Measure OPT
```



**NOTE** Bittig Henry, Kortzinger Arne, Johnson Ken, Claustre Hervé, Emerson Steve, Fennel Katja, Garcia Hernan, Gilbert Denis, Gruber Nicolas, Kang Dong-Jin, Naqvi Wajih, Prakash Satya, Riser Steven, Thierry Virginie, Tilbrook Bronte, Uchida Hiroshi, Ulloa Osvaldo, Xing Xiagang (2015). SCOR WG 142: Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders. Recommendation for oxygen measurements from Argo floats, implementation of in-air-measurement routine to assure highest long-term accuracy. <http://doi.org/10.13155/45917>

For example, to sample the oxygen sensor in accordance with the SCOR recommendation, enter:

```
<SURFACE>
Measure OPT
```

#### A.1.4 Uncompressing and Reading the Oxygen Sensor Log Files

Oxygen sensor data are provided in the science\_log.bin file. For instructions on how to uncompress this file and convert it to a CSV file, refer to “Converting the science\_log.bin and vitals\_log.bin Files to CSV Files” on page 4-15.

All rows in the science\_log.csv file with the first column label "O2" contain oxygen sensor data. The columns are from left to right:

<b>Sensor type:</b>	O2
<b>Time stamp:</b>	UTC (YYYYMMDDTHHMMSS)
<b>O2 concentration:</b>	The absolute oxygen content in $\mu\text{M}$ , where 1 Molar = 1 mole/liter
<b>Air saturation:</b>	The relative air saturation in % relative to the nominal air pressure (1013.25 hPa)
<b>Temperature:</b>	The ambient temperature in $^{\circ}\text{C}$
<b>Cal phase:</b>	The calibrated phase in degrees
<b>TC phase:</b>	The temperature compensated phase in degrees
<b>C1 RPh:</b>	The phase measurement with blue excitation light in degrees

<b>C2 RPh:</b>	The phase measurement with red excitation light in degrees
<b>C1 amp:</b>	The amplitude measurement with blue excitation light in mV
<b>C2 amp:</b>	The amplitude measurement with red excitation light in mV
<b>Raw temp:</b>	The voltage from the thermistor bridge in mV

An example row of oxygen sensor data extracted from a science\_log.csv file is shown in Figure A-2:

O2	20170303T045146	127.4541	35.67524	9.444273	42.32684	42.32684	49.97864	7.651794	1090.297	744.6091	397.0721
----	-----------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------

**Figure A-2: Example Row of Oxygen Sensor Data in a science\_log.csv File**

For more information on interpreting the science\_log.bin file along with additional examples, refer to “Converting the science\_log.bin and vitals\_log.bin Files to CSV Files” on page 4-15.

### A.1.5 Show Command

The Show command displays all of the information available from the Aanderaa Oxygen Optode 4330 Oxygen Sensor. To use the Show command, a PC must be connected to the float and running a terminal program.

To display the optode configuration information, enter:

```
sys_show optode
```

The optode configuration will be displayed on the PC as in the following example:

```
Optode Product Name:           Optode Sensor
Optode Product Number:        4330
Optode Serial Number:         1521
Optode SW Version:            4.4.8
Optode SW ID:                  1940006
Optode Node Description:      Optode Sensor #1521
Optode FoilID:                 1206EM
Optode Enable Text:            Yes
Optode Enable Decimalformat:   No
Optode Enable Sleep:          Yes
Optode Enable Polled Mode:     No
Optode Enable SVUformula:      Yes
Optode Interval[s]:           3
```

```

Optode Analog TempLimit[Deg.C]:  -5.000000e+00 3.500000e+01
Optode Analog ConcLimit[uM]:      0.000000e+00 0.000000e+00
Optode Analog SatLimit:           0.000000e+00 0.000000e+00
Optode Analog PhaseLimit[Deg.C]:  0.000000e+00 0.000000e+00
Optode Analog Output:             1521
Optode Analog1 Coef:              0.000000e+00 0.000000e+00
Optode Analog2 Coef:              0.000000e+00 0.000000e+00
Optode Enable AirSaturation:      Yes
Optode Enable Rawdata:            Yes
Optode Enable Temperature:        Yes
Optode Enable HumidityComp:       Yes
Optode Salinity[PSU]:             0.000000e+00
Optode PhaseCoef:                 0.000000e+00 1.000000e+00
0.000000e+00 0.000000e+00
Optode FoilCoefA[1-7]:            -2.988314e-06 -6.137785e-06
1.684659e-03 -1.857173e-01 6.784399e-04 -5.597908e-07
1.040158e+01
Optode FoilCoefA[8-14]:           -5.986907e-02 1.360425e-04 -
4.776977e-07 -3.032937e+02 2.530496e+00 -1.267045e-02
1.040454e-04
Optode FoilCoefB[1-7]:            -3.560390e-07 3.816713e+03 -
4.475507e+01 4.386162e-01 -7.146342e-03 8.906234e-05 -
6.343012e-07
Optode FoilCoefB[8-14]:           0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00
Optode FoilPolyDegT[1-14]:        1 0 0 0 1 2 0 1 2 3 0 1 2 3
Optode FoilPolyDegT[15-28]:      4 0 1 2 3 4 5 0 0 0 0 0 0 0
Optode FoilPolyDegO[1-14]:        4 5 4 3 3 3 2 2 2 2 1 1 1 1
Optode FoilPolyDegO[15-28]:      1 0 0 0 0 0 0 0 0 0 0 0 0 0
Optode SVUFoilCoef:               2.933651e-03 1.245261e-04
2.482191e-06 2.317514e+02 -3.094964e-01 -5.569272e+01
4.559175e+00
Optode ConcCoef:                  0.000000e+00 1.000000e+00
Optode NomAirPress[hPa]:          1.013250e+03
Optode NomAirMix[hPa]:            0.000000e+00
Optode CalDataSat[Deg]:           3.174000e+01 9.910000e+00
Optode CalDataAPress[hPa]:        9.727329e+02
Optode CalDataZero[Deg]:          6.233000e+01 2.445500e+01

```

### A.1.6 Factory Configuration

The factory configuration of the installed Aanderaa Oxygen Optode 4330 Oxygen Sensor is the following:

```
Set Passkey(1000)
Set Salinity(0)
Set Comm TimeOut(1 min)
Set Mode(Smart Sensor Terminal)
Set Enable Text(Yes)
Set Flow Control(None)
Set Enable Comm Indicator(Yes)
Set Enable DecimalFormat(No)
Set Enable Temperature(Yes)
Set Enable AirSaturation(Yes)
Set Enable HumidityComp(Yes)
Set Enable RawData(Yes)
Set Enable Polled Mode(No)
Set Enable Sleep(Yes)
Set Enable RedReference(Yes)
Set Interval(3)
```

## A.2 Oxygen Sensor (JFE Advantech)

The Teledyne Webb Research APEX Deep profiling float optionally includes the JFE Advantech RINKO FT Model ARO-FT Oxygen Sensor for periodic sampling of dissolved oxygen. The sensor is multipoint calibrated and based on the phosphorescence principle for fast response, high accuracy and long term stability in a compact, lightweight package.

### A.2.1 Specifying the Oxygen Sensor Hardware Configuration

A line in the sensors.cfg file defines the oxygen sensor hardware configuration as in the following example:

```
jfe_rinko_ft PIN_5 PORT_SPR COM_5 B38400
```

For more information on the sensors.cfg file along with additional examples, refer to “sensors.cfg File” on page 4-4.

### A.2.2 Specifying the Oxygen Sensor Sampling Behavior

The interval sampling behavior for the oxygen sensor is specified using a single entry in the sample.cfg file for each of any number of pressure ranges in accordance with the following syntax:

```
Sample OPT [<start> [<stop> [<interval> [<units> [<count>]]]]]
```

For example, to sample the oxygen sensor every 10 dbar beginning at 1000 dbar and ending at 200 dbar, enter:

```
<ASCENT>
Sample OPT 1000 200 10 dbar
```

The start and stop pressures can be in any order. For more information on using the sample.cfg file to program the behavior of the float along with additional examples, refer to “sample.cfg File” on page 4-5.

### A.2.3 Specifying the Oxygen Sensor In-Air Measurement Behavior in Accordance with the SCOR Recommendation

The APEX Deep profiling float implements dissolved oxygen in-air measurements using Scientific Committee on Oceanic Research (SCOR) Working Group 142 recommendations as referenced in the note in the following page. When the float transitions to Surface phase, 10 measurements are taken at 15-second intervals before and after inflating the air bladders. The results are written to the science\_log.txt file.

The SCOR sampling behavior is specified using a single entry in the sample.cfg file in accordance with the following syntax:

```
<SURFACE>
Measure OPT
```



**NOTE** Bittig Henry, Kortzinger Arne, Johnson Ken, Claustre Hervé, Emerson Steve, Fennel Katja, Garcia Hernan, Gilbert Denis, Gruber Nicolas, Kang Dong-Jin, Naqvi Wajih, Prakash Satya, Riser Steven, Thierry Virginie, Tilbrook Bronte, Uchida Hiroshi, Ulloa Osvaldo, Xing Xiagang (2015). SCOR WG 142: Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders. Recommendation for oxygen measurements from Argo floats, implementation of in-air-measurement routine to assure highest long-term accuracy. <http://doi.org/10.13155/45917>

For example, to sample the oxygen sensor in accordance with the SCOR recommendation, enter:

```
<SURFACE>
Measure OPT
```

#### A.2.4 Uncompressing and Reading the Oxygen Sensor Log Files

Oxygen sensor data are provided in the science\_log.bin file. For instructions on how to uncompress this file and convert it to a CSV file, refer to “Converting the science\_log.bin and vitals\_log.bin Files to CSV Files” on page 4-15.

All rows in the science\_log.csv file with the first column label "O2" contain oxygen sensor data. The columns are from left to right:

<b>Sensor type:</b>	O2
<b>Time stamp:</b>	UTC (YYYYMMDDTHHMMSS)
<b>Temperature:</b>	The ambient temperature in A/D
<b>Dissolved O2:</b>	The dissolved oxygen in A/D
<b>BL phase:</b>	The blue Light phase in A/D
<b>RL phase:</b>	The red Light phase in A/D
<b>BL amp:</b>	The blue Light amplitude in A/D
<b>RL amp:</b>	The red Light amplitude in A/D
<b>LED time:</b>	The LED accumulated time in tens of milliseconds

An example row of oxygen sensor data extracted from a science\_log.csv file is shown in Figure A-3:

O2	20170303T045146	34345	28422	38619	26898	9433	19622	53125
----	-----------------	-------	-------	-------	-------	------	-------	-------

**Figure A-3: Example Row of Oxygen Sensor Data in a science\_log.csv File**

For more information on interpreting the science\_log.bin file along with additional examples, refer to “Converting the science\_log.bin and vitals\_log.bin Files to CSV Files” on page 4-15. In addition, refer to Chapter 8 of the JFE Advantech “RINKO FT User’s Manual” (p/n A-0133-04) for information on how to convert AD count values to scientific/engineering values.

### A.2.5 Show Command

The Show command displays all of the information available from the JFE Advantech RINKO FT Model ARO-FT Oxygen Sensor. To use the Show command, a PC must be connected to the float and running a terminal program.

To display the optode configuration information, enter:

```
sys_show optode
```

The optode configuration will be displayed on the PC as in the following example:

```
Firmware Version : Ver.1.01
Serial Number    : 0000000006
C0               : 2.989382e-03
C1               : 1.249814e-04
C2               : 2.963225e-06
d0               : 2.910802e-04
d1               : -1.706489e-01
d2               : 1.798828e-01
d3               : 0.000000e+00
d4               : 0.000000e+00
Cp               : 0.000000e+00
e0               : 1.000000e+00
FilmNo           : 000000BA
docaldate        : 2014/01/01
A                : -1.310814e+01
B                : 1.487751e-03
C                : -2.710944e-08
D                : 6.412424e-13
E                : -8.228551e-18
```



```
F           : 5.316122e-23
G           : 0.000000e+00
H           : 0.000000e+00
CO          : 0.000000e+00
tcaldate   : 2017/03/18
```

### A.2.6 Factory Configuration

The factory configuration of the installed JFE Advantech RINKO FT Model ARO-FT Oxygen Sensor is available from the manufacture.

## A.3 Fluorometer

The Teledyne Webb Research APEX profiling float optionally includes one of three versions of the WET Labs Environmental Characterization Optics (ECO) Puck for periodic sampling of chlorophyll fluorescence and particulate backscattering: the FLbbAP2, the FLbbbb which includes a second backscattering wavelength, and the FLbbcd which includes a chromophoric dissolved organic matter (CDOM) channel.

Floats that include the fluorometer along with the CTD provide data essential for understanding oceanic biogeochemistry, the global carbon cycle and climate change. For example, the FLbb measures both chlorophyll fluorescence at 470 nm and backscattering at 700 nm within the same volume. Chlorophyll concentration is determined by directly measuring the amount of chlorophyll-a fluorescence emission from a given sample volume of water. Chlorophyll, when excited by the presence of an external light source, absorbs light in certain regions of the visible spectrum and re-emits a small portion of this light as fluorescence at longer wavelengths. The fluorometer is mounted to the float housing near the bottom. A cable from the sensor connects to a connector ring located at the bottom of the float housing.

### A.3.1 Specifying the Fluorometer Hardware Configuration

A line in the sensors.cfg file defines the fluorometer hardware configuration.

For the FLbbAP2:

```
flbb PIN_7 PORT_EXP COM_8 B19200
```

For the FLbbbb:

```
flbb_bb PIN_9 PORT_EXP COM_10 B19200
```

For the FLbbcd:

```
flbb_cd PIN_9 PORT_EXP COM_10 B19200
```

For more information on the sensors.cfg file along with additional examples, refer to “sensors.cfg File” on page 4-4.

### A.3.2 Specifying the Fluorometer Sampling Behavior

The interval sampling behavior for *all three* versions of the fluorometer is specified using a single entry in the sample.cfg file for each of any number of pressure ranges in accordance with the following syntax:

```
Sample FLBB [<start> [<stop> [<interval> [<units> [<count>]]]]]
```

For example, to sample the fluorometer every 10 dbar beginning at 1000 dbar and ending at 200 dbar, enter:

```
<ASCENT>
Sample FLBB 1000 200 10 dbar
```

The start and stop pressures can be in any order. For more information on using the sample.cfg file to program the behavior of the float along with additional examples, refer to “sample.cfg File” on page 4-5.

### A.3.3 Uncompressing and Reading the Fluorometer Log Files

Fluorometer data are provided in the science\_log.bin file. For instructions on how to uncompress this file and convert it to a CSV file, refer to “Converting the science\_log.bin and vitals\_log.bin Files to CSV Files” on page 4-15.

All rows in the science\_log.csv file with first column field starting with "FLBB" contain fluorometer data. For a fluorometer that includes a third channel, this channel, "BB" or "CD," is appended to the first field as in "FLBB/BB" and "FLBB/CD."

For the FLbbAP2 the columns are from left to right:

<b>Sensor type:</b>	FLBB
<b>Time stamp:</b>	UTC (YYYYMMDDTHHMMSS)
<b>bwave:</b>	The wavelength of the LED used for the fluorometer in nanometers
<b>chl_sig:</b>	The chlorophyll signature in micrograms per liter
<b>nu:</b>	The wavelength of the LED used for backscatter in nanometers
<b>bb_sig:</b>	The backscatter in inverse meters per steradian
<b>therm:</b>	The temperature signal

An example row of FLbbAP2 fluorometer data extracted from a science\_log.csv file is shown in Figure A-4:

FLBB	20161103T031514	470	122	700	487	554
------	-----------------	-----	-----	-----	-----	-----

**Figure A-4: Example Row of FLbbAP2 Fluorometer Data in a science\_log.csv File**

For the FLbbbb the columns are from left to right:

<b>Sensor type:</b>	FLBB/BB
<b>Time stamp:</b>	UTC (YYYYMMDDTHHMMSS)
<b>bwave:</b>	The wavelength of the LED used for the fluorometer in nanometers
<b>chl_sig:</b>	The chlorophyll signature in micrograms per liter
<b>bb_wave0:</b>	First wavelength of the LED used for backscatter in nanometers
<b>bb_sig0:</b>	First backscatter in inverse meters per steradain
<b>bb_wave1:</b>	Second wavelength of the LED used for backscatter in nanometers
<b>bb_sig1:</b>	Second backscatter in inverse meters per steradian
<b>therm:</b>	The temperature signal

An example row of FLbbbb fluorometer data extracted from a science\_log.csv file is shown in Figure A-5:

FLBB/BB	20161103T031514	695	582	700	4130	470	4130	541
---------	-----------------	-----	-----	-----	------	-----	------	-----

**Figure A-5: Example Row of FLbbbb Fluorometer Data in a science\_log.csv File**

For the FLbbcd the columns are from left to right:

<b>Sensor type:</b>	FLBB/CD
<b>Time stamp:</b>	UTC (YYYYMMDDTHHMMSS)
<b>bwave:</b>	The wavelength of the LED used for the fluorometer in nanometers
<b>chl_sig:</b>	The chlorophyll signature in micrograms per liter
<b>bb_wave:</b>	The wavelength of the LED used for backscatter in nanometers
<b>bb_sig:</b>	The backscatter in inverse meters per steradain.
<b>cd_wave:</b>	The wavelength of the LED used for CDOM in nanometers
<b>cd_sig:</b>	The CDOM in ppb
<b>therm:</b>	The temperature signal

An example row of FLbbcd fluorometer data extracted from a science\_log.csv file is shown in Figure A-6:

FLBB/CD	20160319T033732	695	582	700	4130	470	4130	541
---------	-----------------	-----	-----	-----	------	-----	------	-----

**Figure A-6: Example Row of FLbbcd Fluorometer Data in a science\_log.csv File**

For more information on interpreting the science\_log.bin file along with additional examples, refer to “Converting the science\_log.bin and vitals\_log.bin Files to CSV Files” on page 4-15.

### A.3.4 Show Command

The Show command displays all of the information available from the WET Labs ECO Puck Fluorometer. To use the Show command, a PC must be connected to the float and running a terminal program.

To display the fluorometer configuration information, enter:

```
sys_show flbb
```

For an FLbb the configuration will be displayed on the PC as in the following example:

```
FLBB Serial Number:  FLBBAP2-1578
FLBB Version:       FLNTUAPX 4.04
FLBB Average:      30
FLBB Packets:      0
```

For an FLbbbb the configuration will be displayed on the PC as in the following example:

```
FLBB Serial Number:  FLBBBB6K-4240
FLBB Version:       TripletD 4.07
FLBB Average:      30
FLBB Packets:      0
```

### A.3.5 Fluorometer Factory Configuration

The factory configuration of the installed WET Labs (ECO) Puck is the following:

```
$ave=30
$pkt=0
$sto
```

## A.4 C-Rover Transmissometer

The Teledyne Webb Research APEX profiling float optionally includes the WET Labs C-Rover Transmissometer for periodic sampling of optical transmittance of sea water. The transmissometer is mounted to the float housing near the bottom. A cable from the sensor connects to a connector ring located at the bottom of the float housing.

### A.4.1 Specifying the C-Rover Configuration

A line in the sensors.cfg file defines the C-Rover hardware configuration:

```
crover PIN_7 PORT_EXP COM_11 B19200
```

For more information on the sensors.cfg file along with additional examples, refer to “sensors.cfg File” on page 4-4.

### A.4.2 Specifying the C-Rover Sampling Behavior

The interval sampling behavior for the C-Rover Transmissometer is specified using a single entry in the sample.cfg file for each of any number of pressure ranges in accordance with the following syntax:

```
Sample XMIS [<start> [<stop> [<interval> [<units> [<count>]]]]]]
```

For example, to sample the transmissometer every 10 dbar beginning at 1000 dbar and ending at 200 dbar, enter:

```
<ASCENT>
Sample XMIS 1000 200 10 dbar
```

To sample the transmissometer during the Park phase, enter:

```
<PARK>
Sample XMIS
```

**ParkTimerInterval** determines the sample rate at the Park depth. For more information on using the sample.cfg file to program the behavior of the float along with additional examples, refer to “sample.cfg File” on page 4-5.

### A.4.3 Uncompressing and Reading the C-Rover Transmissometer Log Files

Transmissometer data are provided in the science\_log.bin file. For instructions on how to uncompress this file and convert it to a CSV file, refer to “Converting the science\_log.bin and vitals\_log.bin Files to CSV Files” on page 4-15.

All rows in the science\_log.csv file with the first column label "CROVER" contain transmissometer data. The columns are from left to right:

<b>Sensor type:</b>	CROVER
<b>Time stamp:</b>	UTC (YYYYMMDDTHHMMSS)
<b>reference:</b>	Reference raw count
<b>raw_sig:</b>	Signal raw count
<b>corr_sig:</b>	Signal corrected count
<b>therm:</b>	The thermistor temperature raw count
<b>attenuation:</b>	Calculated beam attenuation in inverse meters

An example row of transmissometer data extracted from a science\_log.csv file is shown in Figure A-7:

CROVER	20160319T033739	12181	7	7	544	30.8
--------	-----------------	-------	---	---	-----	------

**Figure A-7: Example Row of Transmissometer Data in a science\_log.csv File**

For more information on interpreting the science\_log.bin file along with additional examples, refer to "Converting the science\_log.bin and vitals\_log.bin Files to CSV Files" on page 4-15.

#### A.4.4 Show Command

The Show command displays all of the information available from the WET Labs C-Rover Transmissometer. To use the Show command, a PC must be connected to the float and running a terminal program.

To display the transmissometer configuration information, enter:

```
sys_show xmis
```

The transmissometer configuration will be displayed on the PC as in the following example:

```
CROVER Model/Type:      BAM
CROVER Serial Number:  CRV2K-079
CROVER Version:         CSTAR 4.14
CROVER Average:         30
CROVER Packets:         0
```

#### **A.4.5 C-Rover Transmissometer Factory Configuration**

The factory configuration of the installed WET Labs C-Rover Transmissometer is the following:

\$ave=30

\$pkt=0

\$sto



## A.5 Radiance Radiometer

The Teledyne Webb Research APEX profiling float optionally includes the Satlantic OCR-504 R10W Radiance Radiometer which combines precision optics and high performance microelectronics for periodic sampling of spectral light in an ocean environment. The radiance radiometer is externally mounted to the float near the bottom. A cable from the sensor connects to a connector ring located at the bottom of the float housing.

### A.5.1 Specifying the Radiance Radiometer Hardware Configuration

A line in the sensors.cfg file defines the radiance radiometer hardware configuration:

```
satlantic_504r PIN_8 PORT_EXP COM_9 B9600
```

For more information on the sensors.cfg file along with additional examples, refer to “sensors.cfg File” on page 4-4.

### A.5.2 Specifying the Radiance Radiometer Sampling Behavior

The interval sampling behavior for the radiance radiometer is specified using a single entry in the sample.cfg file for each of any number of pressure ranges in accordance with the following syntax:

```
Sample RAD [<start> [<stop> [<interval> [<units> [<count>]]]]]
```

For example, to sample the radiance radiometer every 10 dbar beginning at 1000 dbar and ending at 200 dbar, enter:

```
<ASCENT>  
Sample RAD 1000 200 10 dbar
```

The start and stop pressures can be in any order. For more information on using the sample.cfg file to program the behavior of the float along with additional examples, refer to “sample.cfg File” on page 4-5.

### A.5.3 Uncompressing and Reading the Radiance Radiometer Log Files

Radiance radiometer data are provided in the science\_log.bin file. For instruction on how to uncompress this file and convert it to a CSV file, refer to “Converting the science\_log.bin and vitals\_log.bin Files to CSV Files” on page 4-15.

All rows in the science\_log.csv file with the first column label "504R" contain irradiance radiometer data. The columns are from left to right:

<b>Sensor type:</b>	504R
<b>Time stamp:</b>	UTC (YYYYMMDDTHHMMSS)

- Channel1:** An AF formatted value representing the calibrated output in  $\mu\text{W}/\text{cm}^2/\text{nm}$  from channel 1
- Channel2:** An AF formatted value representing the calibrated output in  $\mu\text{W}/\text{cm}^2/\text{nm}$  from channel 2
- Channel3:** An AF formatted value representing the calibrated output in  $\mu\text{W}/\text{cm}^2/\text{nm}$  from channel 3
- Channel4:** An AF formatted value representing the calibrated output in  $\mu\text{W}/\text{cm}^2/\text{nm}$  from channel 4

An example row of radiance radiometer data extracted from a `science_log.csv` file is shown in Figure A-8:

504R	20160323T204807	0.003	0.007	0.0158	0.0151
------	-----------------	-------	-------	--------	--------

**Figure A-8: Example Row of Radiance Radiometer Data in a `science_log.csv` File**

For more information on interpreting the `science_log.bin` file along with additional examples, refer to “Converting the `science_log.bin` and `vitals_log.bin` Files to CSV Files” on page 4-15.

#### A.5.4 Show Command

The Show command displays all of the information available from the Satlantic OCR-504 R10W Radiance Radiometer. To use the Show command, a PC must be connected to the float and running a terminal program.

To display the radiance radiometer configuration information, enter:

```
sys_show rad
```

The radiance radiometer configuration will be displayed on the PC as in the following example:

```
Satlantic OCR-504 Multispectral Radiometer
Firmware version: 5.1.0 - SatNet Type B
Sensor Type:                radiance
Serial Number:              0022
Frame Type:                 short
Header:                     SATFR4
Telemetry Baud Rate:       9600 bps
Maximum Frame Rate:        1 Hz
Initialize Silent Mode:    on
Initialize Power Down:     off
Initialize Automatic Telemetry: on
Network Mode:              off
```

```
networkAddress:                100
Network Baud Rate:             38400 bps
Averaging:                     on
Immersed:                     on
Calibrated Output:            on
Sensor Latency:               0
Calibration Coefficients:
  Optical Channel 1:
    a0: 2148023214.5
    a1: 2.653745e-09
    im: 1.758
  Optical Channel 2:
    a0: 2147769455.6
    a1: 2.538758e-09
    im: 1.752
  Optical Channel 3:
    a0: 2147559434.8
    a1: 2.723878e-09
    im: 1.746
  Optical Channel 4:
    a0: 2148019892.9
    a1: 1.587890e-09
    im: 1.739
```

### A.5.5 Radiance Radiometer Factory Configuration

The factory configuration of the installed Satlantic OCR-504 R10W Radiance Radiometer is the following:

```
set frametype short
set initsm on
set maxrate 1
set initpd off
set initat on
set avg on
set immersed on
set usecal on
set latency 0
set netmode off
```

## A.6 Irradiance Radiometer

The Teledyne Webb Research APEX profiling float optionally includes the Satlantic OCR-504 ICSW Irradiance Radiometer which combines precision optics and high performance microelectronics for periodic sampling of spectral light in an ocean environment. The irradiance radiometer is externally mounted to the float near the top. A cable from the sensor connects to a connector ring located at the top of the float housing.

### A.6.1 Specifying the Irradiance Radiometer Hardware Configuration

A line in the sensors.cfg file defines the irradiance radiometer hardware configuration:

```
satlantic_504i PIN_9 PORT_EXP COM_10 B9600
```

For more information on the sensors.cfg file along with additional examples, refer to “sensors.cfg File” on page 4-4.

### A.6.2 Specifying the Irradiance Radiometer Sampling Behavior

The interval sampling behavior for the irradiance radiometer is specified using a single entry in the sample.cfg file for each of any number of pressure ranges in accordance with the following syntax:

```
Sample IRAD [<start> [<stop> [<interval> [<units> [<count>]]]]]
```

For example, to sample the irradiance radiometer every 10 dbar beginning at 1000 dbar and ending at 200 dbar, enter:

```
<ASCENT>  
Sample IRAD 1000 200 10 dbar
```

The start and stop pressures can be in any order. For more information on using the sample.cfg file to program the behavior of the float along with additional examples, refer to “sample.cfg File” on page 4-5.

### A.6.3 Uncompressing and Reading the Irradiance Radiometer Log Files

Irradiance radiometer data are provided in the science\_log.bin file. For instructions on how to uncompress this file and convert it to a CSV file, refer to “Converting the science\_log.bin and vitals\_log.bin Files to CSV Files” on page 4-15.

All rows in the science\_log.csv file with the first column label "504I" contain irradiance radiometer data. The columns are from left to right:

<b>Sensor type:</b>	504I
<b>Time stamp:</b>	UTC (YYYYMMDDTHHMMSS)

<b>Channel1:</b>	An AF formatted value representing the calibrated output in uW/cm2/nm from channel 1
<b>Channel2:</b>	An AF formatted value representing the calibrated output in uW/cm2/nm from channel 2
<b>Channel3:</b>	An AF formatted value representing the calibrated output in uW/cm2/nm from channel 3
<b>Channel4:</b>	An AF formatted value representing the calibrated output in uW/cm2/nm from channel 4

An example row of irradiance radiometer data extracted from a science\_log.csv file is shown in Figure A-9:

504I	20160323T204743	0.1369	0.3072	0.0223	0.0479
------	-----------------	--------	--------	--------	--------

**Figure A-9: Example Row of Irradiance Radiometer Data in a science\_log.csv File**

For more information on interpreting the science\_log.bin file along with additional examples, refer to “Converting the science\_log.bin and vitals\_log.bin Files to CSV Files” on page 4-15.

#### A.6.4 Show Command

The Show command displays all of the information available from the Satlantic OCR-504 ICSW Irradiance Radiometer. To use the Show command, a PC must be connected to the float and running a terminal program.

To display the irradiance radiometer configuration information, enter:

```
sys_show irradi
```

The irradiance radiometer configuration will be displayed on the PC as in the following example:

```
Satlantic OCR-504 Multispectral Radiometer
Firmware version: 5.1.0 - SatNet Type B
Sensor Type:                irradiance
Serial Number:              0400
Frame Type:                 short
Header:                     SATFI4
Telemetry Baud Rate:       9600 bps
Maximum Frame Rate:        1 Hz
Initialize Silent Mode:    on
Initialize Power Down:     off
Initialize Automatic Telemetry: on
```

```

Network Mode:                off
networkAddress:              200
Network Baud Rate:           38400 bps
Averaging:                   on
Immersed:                    on
Calibrated Output:           on
Sensor Latency:              0
Calibration Coefficients:
  Optical Channel 1:
    a0: 2147551528.8
    a1: 2.141215e-07
    im: 1.368

  Optical Channel 2:
    a0: 2147318656.7
    a1: 2.071143e-07
    im: 1.410

  Optical Channel 3:
    a0: 2147887045.0
    a1: 2.060970e-07
    im: 1.365

  Optical Channel 4:
    a0: 2147172741.4
    a1: 2.039716e-07
    im: 1.372

```

### A.6.5 Irradiance Radiometer Factory Configuration

The factory configuration of the installed Satlantic OCR-504 ICSW Irradiance Radiometer is the following:

```

set frametype short
set initsm on
set maxrate 1
set initpd off
set initat on
set avg on
set immersed on
set usecal on
set latency 0
set netmode of

```

## A.7 Nitrate Sensor

The Teledyne Webb Research APEX profiling float optionally includes the Sea-Bird Scientific Satlantic Deep SUNA (Submersible Ultraviolet Nitrate Analyzer) V2 Nitrate sensor for measuring nitrate concentrations in the ocean based on the absorption characteristics of nitrate in the UV light spectrum.

### A.7.1 Specifying the Nitrate Sensor Hardware Configuration

A line in the sensors.cfg file defines the nitrate sensor hardware configuration:

```
satlantic_suna PIN_10 PORT_EXP COM_11 B9600
```

For more information on the sensors.cfg file along with additional examples, refer to “sensors.cfg File” on page 4-4.

### A.7.2 Specifying the Nitrate Sensor Sampling Behavior

The interval sampling behavior for the nitrate sensor is specified using a single entry in the sample.cfg file for each of any number of pressure ranges in accordance with the following syntax:

```
Sample SUNA [<start> [<stop> [<interval> [<units> [<count>]]]]]
```

For example, to sample the nitrate sensor every 5 dbar beginning at 500 dbar and ending at 5 dbar, enter:

```
<ASCENT>
Sample SUNA 500 5 5 dbar
```

The start and stop pressures can be in any order. For more information on using the sample.cfg file to program the behavior of the float along with additional examples, refer to “sample.cfg File” on page 4-5.



**NOTE** In 2009 Sakamoto developed an algorithm to calculate the most accurate nitrate concentrations by recalculating sea salt extinction using the sample temperature, subtracting the expected absorbance due to the CTD measured salinity at that temperature, referred to as temperature corrected, salinity subtracted (TCSS). Implementing the following sample configuration ensures that the float samples the CTD immediately prior to nitrate sampling and provides the pressure, temperature and salinity to the nitrate sensor to enable TCSS nitrate calculation in real time.

For example, to sample the CTD every 5 dbar beginning at 1000 dbar and ending at 5 dbar and the nitrate sensor every 5 dbar beginning at 500 dbar and ending at 5 dbar, enter:

```
<ASCENT>
Sample CTD 1000 5 5 dbar
Sample SUNA 500 5 5 dbar
```



**NOTE** When sampling with a pumped type CTD and a specified **SurfacePressure** (typically 4 dbar), the nitrate sensor will complete the sampling at the specified **SurfacePressure**. For a non-pumped CTD, the **SurfacePressure** can be set to 0 for interval sampling with the nitrate sensor up to the surface.

For example, to sample a pumped type CTD continuously beginning at 1500 dbar and ending at the pressure specified by **SurfacePressure**, enter:

```
<ASCENT>
Profile CTD 1500 0
```

### A.7.3 Uncompressing and Reading the Nitrate Sensor Log Files

Nitrate sensor data are provided in the science\_log.bin file. For instructions on how to uncompress this file and convert it to a CSV file, refer to “Converting the science\_log.bin and vitals\_log.bin Files to CSV Files” on page 4-15.

All rows in the science\_log.csv file with the first column label "NO3" contain nitrate sensor data. The columns are from left to right:

<b>Sensor type:</b>	NO3
<b>Time stamp:</b>	UTC (YYYYMMDDTHHMMSS)
<b>Nitrate:</b>	Micromolar units ( $\mu\text{M}$ )

An example row of nitrate sensor data extracted from a science\_log.csv file is shown in Figure A-10:

NO3	20170712T174004	0.04
-----	-----------------	------

**Figure A-10: Example Row of Nitrate Sensor Data in a science\_log.csv File**

For more information on interpreting the science\_log.bin file along with additional examples, refer to “Converting the science\_log.bin and vitals\_log.bin Files to CSV Files” on page 4-15.



### A.7.4 Nitrate Sensor Frames

Nitrate APF frames associated with each nitrate sample in the `science_log.bin` file are saved in the `suna_log.txt` file. The *actual* file name is prepended with the username, the profile number, the timestamp, and the file type as follows:

Syntax:	<code>&lt;username&gt;.&lt;profile number&gt;.&lt;timestamp&gt;.&lt;filename&gt;.&lt;filetype&gt;.&lt;ext&gt;</code>
<i>username</i> :	The account username included in <code>system.cfg</code>
<i>profile number</i> :	A zero-padded 3-decimal number indicating the profile number. For example, the first descent would have a value of 001.
<i>timestamp</i> :	Date and time of the file creation in YYYYMMDDTHHMMSS format
<i>filename</i> :	Name of file
<i>filetype</i> :	Type of log file (.txt)
<i>ext</i> :	gz

For example, in the following file the username is `f0036` and the profile number is `003`:

- **f0036.003.20160122T193806.suna\_log.txt.gz**

For the APF frame field formats, refer to the current version of the Sea-Bird Scientific Satlantic “SUNA V2 Manual.”

### A.7.5 Show Command

The Show command displays all of the information available from the Sea-Bird Scientific Satlantic Deep SUNA V2 Nitrate sensor. To use the Show command, a PC must be connected to the float and running a terminal program.

To display the nitrate sensor configuration information, enter:

```
sys_show suna
```

The nitrate sensor configuration will be displayed on the PC as in the following example:

```
SUNA|Serial Number           : SN:1024
SUNA|Application Name       : SUNA-V2
SUNA|Firmware Version       : 2.2.14
SUNA|App Build Date         : Aug 30 2013, 10:43:21
SUNA|Operating Mode         : APF
SUNA|Power Up Time (UTC)    : 08/29/2017 14:16:06
SUNA|Current Time (UTC)    : 08/29/2017 14:16:07
SUNA|Power Active Timeout   : 10
SUNA|Power Cycle Counter    : 515
SUNA|System Reset Counter   : 522
SUNA|Sample Record Counter  : 700
SUNA|Last Sample Rec. Time  : 08/28/2017 21:08:49
```

```

SUNA|Error Record Counter      : 6
SUNA|Last Error Event Type     : -6
SUNA|Last Error Event Time     : 08/11/2017 13:22:26
SUNA|Fiberlite Odometer        : 0050:03:36
SUNA|Calibration File          : SNA1024A.CAL
SUNA|Spec Integration Time     : 225
SUNA|Wavelength Fit Range     : 217.00 <-> 240.00
SUNA|Fitted Concentrations     : 3
SUNA|Baseline Model           : 1
SUNA|Br Temp Compensation     : On
SUNA|Bromide Term in Model     : will be FIXED (to external CTD
value)
SUNA|Absorbance Cutoff        : 10.000000

```

### A.7.6 Nitrate Sensor Factory Configuration

The factory configuration of the installed Sea-Bird Scientific Satlantic Deep SUNA V2 Nitrate sensor is available from the manufacturer. In addition, Teledyne Webb Research provides the following updates to the factory configuration.

- RELAYBRD Missing (Disable Relay Board option if configured)
- SKPSLEEP On (Float manages the nitrate sensor power)
- LGTAVERS 5 (Average 5 fast sequence samples for noise reduction)

### A.7.7 Nitrate Sensor Post Deployment Cleaning

After deployment, the nitrate sensor can be cleaned periodically during the Park Descent, Park, or Deep Descent phase. The cleaning is specified by entering the phase followed by a single line entry in the sample.cfg file.

```

Syntax:  <phase> Bake SUNA [<duration> [<cycle> [<count>]]]
phase:   PARKDESCENT
         PARK
         DEEPDESCENT
duration: Duration for sensor bake (1–15) seconds
cycle:   Mission cycle repetition (1–50)
count:   Repetition counter (1–10)

```

For a sample.cfg file entry that *does not* include one or more of the optional parameters, the float uses the following default entries:

```

duration: 15
cycle:    20

```

*count:*            1

Example. To clean the nitrate sensor during the Park Descent phase 6 times for 15 seconds each every 30 profiles, enter:

```
<PARKDESCENT>  
Bake SUNA 15 30 6
```

## A.8 Compass

The Teledyne Webb Research APEX profiling float optionally includes the True North Technologies (TNT) Electronic Compass for periodic sampling of heading and tilt using a 3-axis magnetometer and a 2-axis tilt sensor. The compass is internally mounted and connected.

### A.8.1 Specifying the Compass Hardware Configuration

A line in the sensors.cfg file defines the compass hardware configuration:

```
tnt_compass PIN_6 PORT_SPR COM_5 B9600
```

For more information on the sensors.cfg file along with additional examples, refer to “sensors.cfg File” on page 4-4.

### A.8.2 Specifying the Compass Sampling Behavior

The interval sampling behavior for the compass is specified using a single entry in the sample.cfg file for each of any number of pressure ranges in accordance with the following syntax:

```
Sample CMP [<start> [<stop> [<interval> [<units> [<count>]]]]]
```

For example, to sample the compass every 10 dbar beginning at 1000 dbar and ending at 200 dbar, enter:

```
<ASCENT>
Sample CMP 1000 200 10 dbar
```



**NOTE** Interval sampling for the compass should coincide with that of the transmissometer, the radiometer and the irradiator if one or more of these sensors are installed.

The start and stop pressure can be in any order. For more information on using the sample.cfg file to program the behavior of the float along with additional examples, refer to “sample.cfg File” on page 4-5.

### A.8.3 Uncompressing and Reading the Compass Log Files

Compass are provided in the science\_log.bin file. For instructions on how to uncompress this file and convert it to a CSV file, refer to “Converting the science\_log.bin and vitals\_log.bin Files to CSV Files” on page 4-15.

All rows in the science\_log.csv file with the first column label "Compass" contain compass data. The columns are from left to right:

<b>Sensor type:</b>	Compass
<b>Time stamp:</b>	UTC (YYYYMMDDTHHMMSS)
<b>Heading:</b>	The float heading in degrees from magnetic north
<b>Pitch:</b>	The float pitch in degrees from horizontal in the direction of motion/heading
<b>Roll:</b>	The float roll in degrees from horizontal, perpendicular to the direction of motion/heading
<b>Dip:</b>	The float dip in degrees with respect to horizontal

An example row of compass data extracted from a science\_log.csv file is shown in Figure A-11:

Compass	20131103T044940	231.8000031	-0.100000001	-2.700000048	2903
---------	-----------------	-------------	--------------	--------------	------

**Figure A-11: Example Row of Compass Data in a science\_log.csv File**

For more information on interpreting the science\_log.bin file along with additional examples, refer to "Converting the science\_log.bin and vitals\_log.bin Files to CSV Files" on page 4-15.

#### A.8.4 Show Command

The Show command displays all of the information available from the True North Technologies (TNT) Electronic Compass. To use the Show command, a PC must be connected to the float and running a terminal program.

To display the compass configuration information, enter:

```
sys_show compass
```

The compass configuration will be displayed on the PC as in the following example:

```
TNT Device Id:          357048
TNT Firmware Revision: TNT1501 Rev 2.64 - PCB 1511 Rev E - 08/06/07
```

#### A.8.5 Compass Factory Configuration

The factory configuration of the installed True North Technologies (TNT) Electronic Compass is as provided by the manufacturer.



## APPENDIX B: Ice Avoidance

---

For Teledyne Webb Research APEX profiling floats that are expected to be deployed in or to drift into regions near the Arctic or Antarctic where surface ice can be present, an ice avoidance function can be enabled before or after deployment. Activation of ice avoidance enables the float to detect the presence of ice and to respond appropriately, preventing catastrophic damage by either being trapped in the ice or by being crushed by floating ice during ice breakup. If ice is determined to be present, ice avoidance will modify the behavior of the float during both the Ascent and Surface phases of each Mission mode in accordance with the settings of specific configuration parameters in the mission.cfg file.

When, and only when, ice avoidance is enabled, the float will perform the following three operations during each profiling cycle:

- Surface ice detection
- Ice breakup detection
- Icecap detection

Shown in Figure B-1 is an example of float behavior when ice avoidance is enabled and surface ice is detected followed by when ice breakup is detected.

### B.1 Surface Ice Detection

With ice avoidance enabled, the float will collect temperature data at intervals of about 2 decibars while ascending through the mixed layer under surface ice, typically starting from 50 decibars. This data collection process occurs during the Ascent phase, and a median temperature is determined which is compared to a threshold temperature below which ice is determined to be present. If the presence of ice is determined, the float will stop its ascent and transition directly to the Park Descent phase of a new mission, bypassing the Surface phase entirely. The float will record to the system\_log.txt file the ice detection event and the total number of ice detection events that have occurred so far. All data collected during the current mission will be recorded to the science\_log.bin and vitals\_log.bin files for transmission during the next Surface phase for which communications are successful.

The mission.cfg file configuration parameters that apply to surface ice detection are **IceMonths**, **IceDetectionP**, **IceEvasionP**, and **IceCriticalT**:

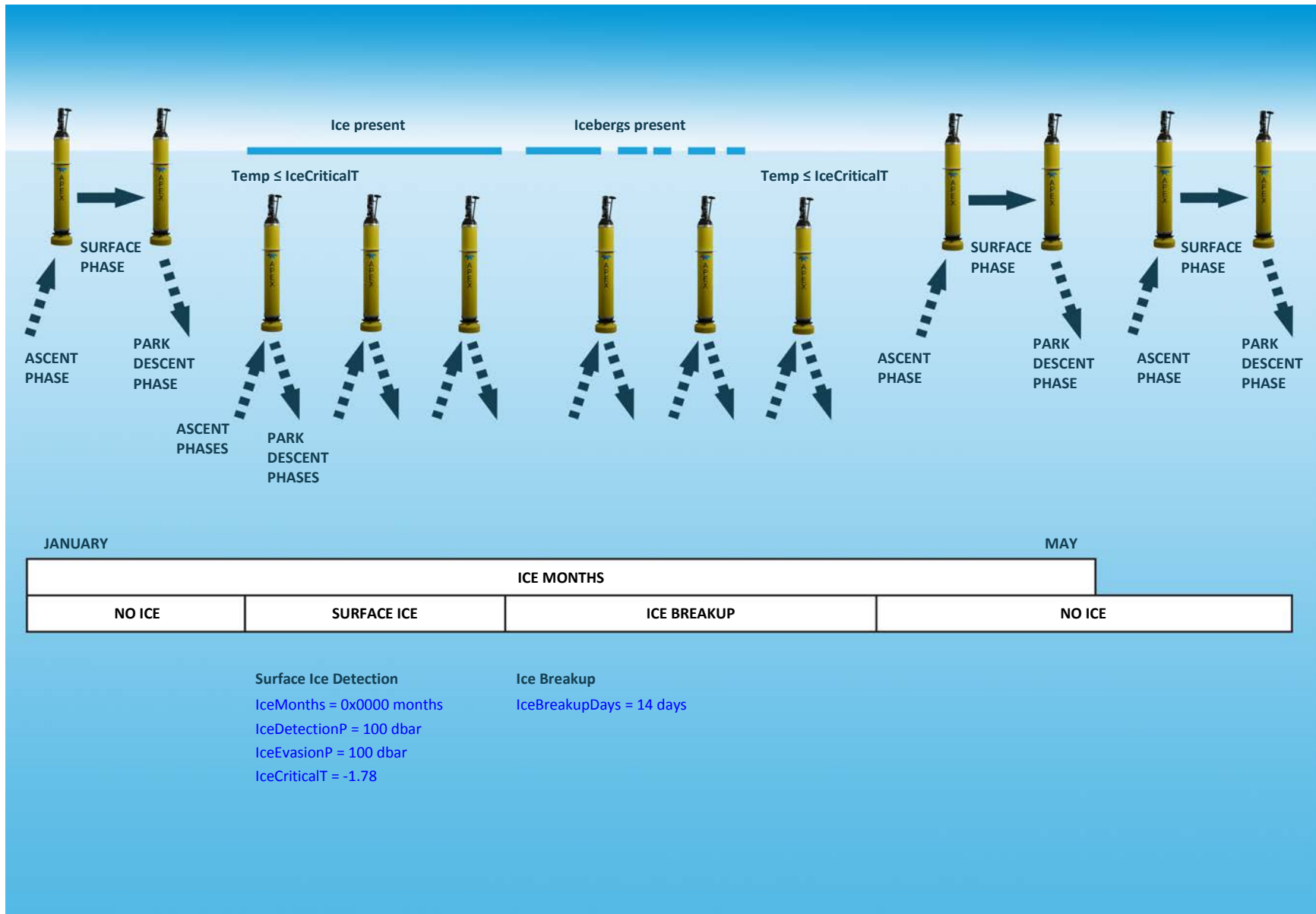


Figure B-1: Example Ice Avoidance Behavior of Float when Surface Ice is Detected followed by when Ice Breakup is Detected



**IceMonths.** Determines the months of the year during which ice avoidance is enabled. To determine the numerical entry, which is in hexadecimal, select one or more months during which to enable ice avoidance, where each month is a “one” bit in a 12-bit binary string representing January (000000000001) to December (100000000000). For more than one month, whether contiguous or not, “or” the values of all the months to determine the binary value. For example, to detect ice during the contiguous months of May to September, the binary value is 000111110000. Converting to hexadecimal, the entry is 0x01f0. For the months January to May and September to December, the binary value is 111100011111. Converting to hexadecimal, the entry is 0x0f1f.

Syntax: IceMonths <months>  
 Range: 0x0000 (never enabled)– 0x0fff (always enabled)  
 Default: 0x0000 months



**NOTE** Ice avoidance should be disabled for at least one month a year to allow the float to attempt to transmit its data and position and to receive new mission.cfg and sample.cfg files if available. This period should be when there is the least likelihood of the presence of ice.

**IceDetectionP.** The pressure in decibars at which temperature data collection begins during the Ascent phase for the purpose of determining the mixed layer median temperature. **IceDetectionP** should be at least 15 dbar greater than that of **IceEvasionP**.

Syntax: IceDetectionP <dbar>  
 Range: 0–100 dbar  
 Default: 50 dbar

**IceEvasionP.** The pressure in decibars at which the float begins processing the collected temperature data to determine the mixed layer median temperature. While processing the temperature data, the float continues to collect more data as it ascends. If the median temperature is below **IceCriticalT**, the ascent is halted and the float transitions to the Park Descent phase of a new mission. **IceEvasionP** should be at least 15 decibars less than **IceDetectionP**.

Syntax: IceEvasionP <dbar>  
 Range: 0–100 dbar  
 Default: 20 dbar

**IceCriticalT.** The water temperature in Celsius below which ice is determined to be present.

Syntax:           IceCriticalT <Celsius>  
 Range:            -3–10 Celsius  
 Default:          -1.78 Celsius

## B.2 Ice Breakup Detection

With ice avoidance enabled, and if ice has been determined to be present the last several missions, then at the start of the Surface phase after determining the *non*-presence of ice, the float will commence the ice breakup period. This period begins with the immediate transition to the Park Descent phase of a new mission, aborting the rest of the Surface phase, and is a specified period during which the float will avoid the surface by transitioning directly from the Ascent phase to the Park Descent phase of a new profiling cycle. The float will also record to the `system_log.txt` file the ice breakup event and the total number of ice breakup events that have occurred so far. All data collected during the current mission will be recorded to the `science_log.bin` and `vitals_log.bin` files for transmission during the next Surface phase for which communications are successful. The breakup period will be canceled, and the float will continue to avoid the surface if the float again determines the presence of ice, otherwise the float will resume normal operations after the breakup period.

The only `mission.cfg` file configuration parameter that applies to Ice Breakup detection is **IceBreakupDays**:

**IceBreakupDays.** The period in days over which the float avoids the surface due to the possible presence of large, crushing icebergs but performs all the other phases during each profiling cycle. The period starts with the first determination of the *non*-presence of ice after having determined the presence of ice over the previous missions.

Syntax:           IceBreakupDays <days>  
 Range:            1–30 days  
 Default:          14 days

## B.3 Ice Cap Detection

If ice is not detected during the Ascent phase following the end of an ice breakup period, the float will attempt to communicate over the Iridium satellite network when it transitions to the Surface phase. The Surface phase begins when the float ascends to the depth determined by **SurfacePressure**. The time allowed for the float to reach this depth from its Profile depth is in accordance with **AscentTimeout**. With ice avoidance enabled,

should the float reach the depth before this time has expired, it will commence telemetry and continue until complete or until the end of the period specified by **UpTime**. Should communications fail, however, *and* the mixed layer median temperature is at or below that of **IceCriticalT**, it is possible that ice is preventing the float from surfacing. In this situation an ice cap is determined to be present, and the float will immediately transition to the Park Descent phase of a new mission, aborting the rest of the Surface phase. The float will also record to the `system_log.txt` file the ice cap detection event and the total number of ice cap detection events that have occurred so far. All data collected during the current mission will be recorded to the `science_log.bin` and `vitals_log.bin` files for transmission during the next Surface phase for which communications are successful. For information on **SurfacePressure** and **AscentTimeout**, refer to “Ascent Phase” on page 3-10.



## APPENDIX C: Time of Day Operation

---

Time of day operation enables the sampling for each profiling cycle to coincide with specific depths and times of the day. Time of day operation is enabled with a setting for the **AscentStartTimes** configuration parameter. For information on the **AscentStartTimes** configuration parameter, refer to “Ascent Phase” on page 3-10.

### C.1 *Standard Time of Day Operation*

Standard time of day operation specifies the time of day at which the float will start its ascent after completing the Park and Deep Descent phases. The time of day is specified by the operator with **AscentStartTimes** which is in minutes after Greenwich Mean Time (GMT) midnight. The float remains at the Park depth for a period based on **DownTime**, the actual Park decent time and the amount of time specified by **DeepDescentTimeout** and **AscentStartTimes**. The settings of these configuration parameters account for the time the float needs to travel to the Profile depth to be ready to start the ascent at the specified time of day. For example, the float could be scheduled to start sampling at 6:00 a.m. at 200 dbars. However, since the time of day specifies the start of the ascent, the float’s ascent rate must be taken into account when determining **AscentStartTimes**.

### C.2 *Extended Time of Day Operation*

Time of day operation allows for *additional* **AscentStartTimes** configuration parameter settings to be specified for the same day. The float will automatically adjust the period of each of the corresponding Park phases based on the actual time of day that it reached the Park depth, the time of day at which it must be at the Profile depth to start the next Ascent phase, and **DeepDescentTimeout**. For these additional Ascent phases, **DownTime** does not apply. For example, the float could be configured to ascend twice in the same day, such as sunrise and sunset, after parking for several days.

### C.3 *Unreachable Time of Day Operation*

If there is not enough time for the float to descend, to park and to do a deep descent such as to meet the time of day for the ascent, the float will park for an extended amount of time to meet the time of day requirement for the following day.

## C.4 Configuration Parameters that Affect Time of Day Operation

The following configuration parameters affect the time of day operation, and their settings should be modified as might be required when enabling time of day operation:

**DeepProfileFirst.** When set to “on,” the float will not use time of day operation during the first profiling cycle. Sampling will be in accordance with the sample.cfg file at the specified depths without regard to the time of day. Time of day operation will be used on subsequent profiling cycles.

**DownTime.** Only used for profiling cycles that use the <minutes1> setting of the **AscentStartTimes** configuration parameter.

**AscentRate.** Needs to be taken into account by the operator when determining the settings for **AscentStartTimes**. **AscentRate** determines how long it will take the float to ascend from the Park or the Profile depth to the surface or to the sampling depths in the sample.cfg file. It is set by the operator, and the default setting is 0.08 dbar/sec.

**DeepDescentTimeout.** Should be set to the expected time for the float to descend from the Park depth to the Profile depth based on **ParkPressure** and **DeepDescentPressure**. Setting **DeepDescentTimeout** in this manner minimizes or removes any time variability in the Deep Descent phase. Variability of the time in the Park Descent and Surfaces phases is automatically compensated for in the Park phase, but some time variability will remain in the Ascent phase, especially if the float encounters a mixed layer near the surface, as a mixed layer may affect the ascent rate of the float.



**CAUTION** If **DeepDescentTimeout** is much less or much greater than the actual descent time, unexpected time of day operation behavior could occur. If set to be much less, the float will start ascending from a shallower depth, the ascent time will be less, and the float may arrive earlier than expected. If set to be much greater, the float will start its descent from the Park depth earlier than expected, reaching the Profile depth earlier than expected and starting its ascent earlier than expected.

**PnPCycleLen.** Enables the float to ascend from the Park depth one or more times before ascending from the Profile depth. With **PnPCycleLen** greater than 1, and when time of day is enabled, sampling for all the ascents can be made to coincide with specific depths and times of the day on the same day for each profiling cycle. However, the time for the float to ascend from the Profile Depth is always longer than the time to ascend from the Park depth. This longer time must be taken into account

when determining **PnPCycleLen** and **AscentStartTimes**. With **PnPCycleLen** set to 1, which is both the default and typical setting, the float descends to the Profile depth from the Park depth for every profiling cycle. For more information on **PnPCycleLen**, refer to “Deep Descent Phase” on page 3-8.

## C.5 Example Time of Day Operation

As an example, to illustrate standard and extended time of day operations, an operator might want to profile from 50 dbar during the Ascent phase at four specific times a day. Sampling could begin, for example, at 6:00 a.m. (GMT 06:00), 12:00 noon (GMT 12:00), 6:00 p.m. (GMT 18:00), and 12:00 midnight (GMT 24:00) of the same day. For this example, the float will park at 500 dbar and descend to 600 dbar before starting the Ascent phase. In between the multiple profiling sessions, the float will remain in the Park phase for 5 days and sample on the 6<sup>th</sup> day. This scenario is illustrated in Figure C-1.

From a 600-dbar Profile depth, ascending at a rate of 0.08 dbars per second to 50 dbar would take the float  $(600 - 50)/0.08 = 115$  minutes.

- If the float needs to be at 50 dbar at GMT 6:00 to sample, **AscentStartTime** would be set to 06:00 – 115 minutes or GMT 4:05 or 245 minutes after GMT 00:00.
- If the float needs to be at 50 dbar at GMT 12:00 to sample, **AscentStartTime** would be set 12:00 – 115 minutes or GMT 10:05 or 605 minutes after GMT 00:00.
- If the float needs to be at 50 dbar at GMT 18:00 to sample, **AscentStartTime** would be set to 18:00 – 115 minutes or GMT 16:05 or 965 minutes after GMT 00:00.
- If the float needs to be at 50 dbar at GMT 24:00 a.m. to sample, **AscentStartTime** would be set to 24:00 – 115 minutes or GMT 22:05 or 1325 minutes after GMT 00:00.

The applicable configuration parameter settings would be as follows:

**AscentStartTimes:** 245 605 965 1325  
**Downtime:** 7200 minutes (5 days)  
**ParkPressure:** 500 dbar  
**DeepDescentPressure:** 600 dbar  
**PnPCycleLen:** 1  
**DeepProfileFirst:** off  
**AscentRate:** 0.08 dbar/sec

The estimated float travel and park time calculations for the first ascent at 245 minutes after GMT 00:00 are shown in Table C-1.

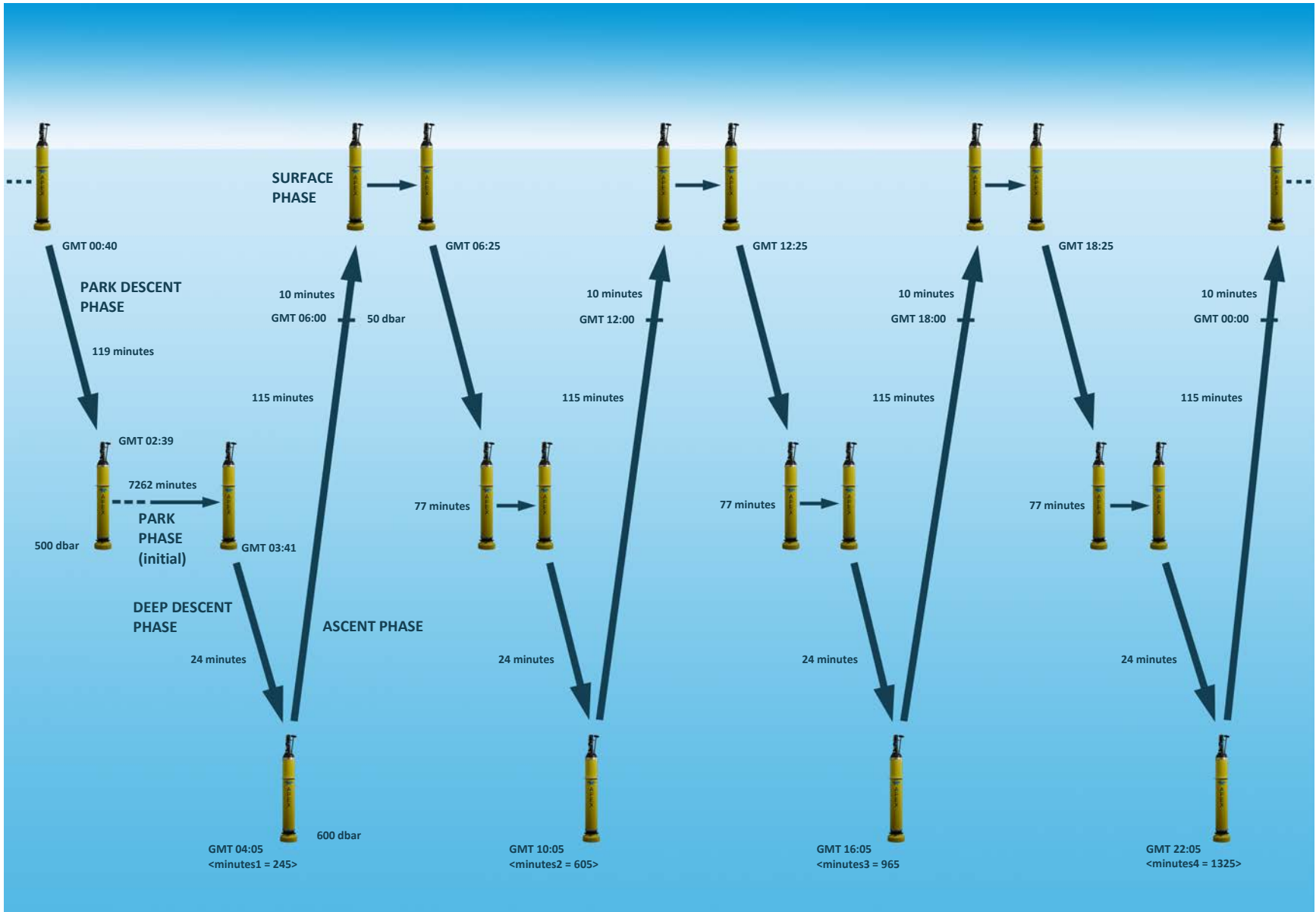


Figure C-1: Example Time of Day Operation with Four Profiling Cycles



**Table C-1: Estimated Float Travel and Park Time Calculations for the First Ascent at 245 Minutes after GMT 00:00**

Mission Leg	Formula	Result
Park descent travel time	500 dbar/0.07 dbar per second	119 minutes
Park time length	7200 – 119 – 24 + 205 minutes	7262 minute (See Note below)
Deep descent travel time	100 dbar/0.07 dbar per second	24 minutes
Ascent leg travel time to 50 dbar	550 dbar/0.08 dbar per second	115 minutes
Ascent leg travel time from 50 dbar to surface	50 dbar/0.08 dbar per second	10 minutes



**NOTE** Without time of day operation, the float would have ended the Park phase and started descending to the Profile depth at GMT 00:16, traveling for 24 minutes to reach it at GMT 00:40. However, in order to reach 50 dbar at GMT 06:00, the float needs to wait in park for an additional 205 minutes to begin the descent to the Profile depth at GMT 03:41. Therefore the float will add 205 minutes to the Park time based on **AscentStartTimes** such that the ascent will begin at GMT 4:05. This additional Park time is automatically calculated and applied by the float for each profiling cycle, as the time the float leaves the surface can vary for each profiling cycle.

In Table C-1 the Mission Leg parameters are as follows:

**Park descent travel**

**time:**

The elapsed time for the float to travel to the 500 dbar park depth at an approximate rate of 0.07 dbar per second.

**Park time length:**

The length of time the float remains in the Park phase as determined by **DownTime**, the actual park decent time, **DeepDescentTimeout**, and the time of day adjustment based on **AscentStartTimes**.

**Deep descent travel**

**time:**

The elapsed time for the float to travel from the 500-dbar Park depth to the 600-dbar Profile depth at a rate of 0.07 dbar per second.

**Ascent leg time travel****time to 50 dbar:**

The elapsed time for the float to travel from the 600-dbar Profile depth to the desired 50-dbar time of day depth at an ascent rate of 0.08 dbar per second.

**Ascent leg time travel****from 50 dbar to surface:**

The elapsed time for the float to travel from the 50-dbar depth to the surface at an ascent rate of 0.08 dbar per second.

The estimated float mission GMT times based on the float leaving the surface at 00:40 GMT are shown in Table C-2. The actual time that the float leaves the surface is variable.

**Table C-2: Estimated Float Mission GMT Times Based on Float Leaving the Surface at 00:40 GMT**

Mission Leg	Formula	Mission GMT Times
<b>Park descent start time</b>	The time the float starts the Park Descent phase	GMT 00:40
<b>Desired sample start time</b>	The desired time to start sampling at 50 dbar at GMT 6:00	GMT 06:00
<b>Ascent start time</b>	$06:00 - 115 \text{ minutes} = 04:05$	GMT 04:05
<b>Deep descent start time</b>	$04:05 - 24 \text{ minutes} = 03:41$	GMT 03:41
<b>Park phase start time</b>	$00:40 + 119 \text{ minutes} = 02:39$	GMT 02:39
<b>Normal Park phase end time</b>	$2:39 + 4 \text{ days } 21 \text{ hours } 37 \text{ minutes} = 00:16$	GMT 00:16
<b>Park phase adjusted for time or day</b>	$03:41 - 0:16 = 3 \text{ hours and } 25 \text{ minutes}$	—

For each of the remaining three ascents in this example, the Park phase period is set by the float based on the time of day it is to reach the Profile depth at the <minutes2>, <minutes3> and <minutes4> settings of **AscentStartTimes**, the actual time of day it begins each Park Descent phase, the 119 minutes required to reach the Park depth, and the 24 minutes required to reach the Profile depth. For example, it will take the float 10 minutes to reach the surface from 50 dbar, placing the float at the surface at GMT 06:10 after the first ascent. Should it take 15 minutes for telemetry, the float will begin the next Park Descent phase at GMT 06:25. It must be at the Profile depth 220 minutes later at GMT 10:05 to begin sampling on the ascent at GMT 12:00, as the <minutes2> setting of **AscentStartTimes** is 605. With 119 minutes required to reach the Park depth from the

surface and 24 minutes to reach the Profile depth from the Park depth, the Park phase period must be 77 minutes:

$$220 - 119 - 24 = 77$$

For the remaining two ascents, the Park phase period will be adjusted in a similar manner and can vary depending on the time of day at which the float actually leaves the surface. At the completion of the Surface phase after the last ascent, the profiling cycles repeat with the initial Park phase of approximately 5 days. Again, the actual Park phase period will depend on the time of day at which the float actually begins the next profiling cycle.



## APPENDIX D: Argos Telemetry

An APEX profiling float can optionally include an Argos telemetry link as shown in Figure D-1. Argos is a satellite based system which collects, processes and disseminates environmental data from fixed and mobile platforms worldwide. During a profiling cycle, the float collects science data along with event and status information, all of which are placed into multiple 31-byte messages. Because the float does not have a receiver, it cannot determine when an Argos satellite is within range for receiving transmissions. Therefore, when at the surface, the float repeatedly transmits these messages for an amount of time at intervals of typically 40–90 seconds to ensure all the messages are received over multiple satellite passes.



**Figure D-1: APEX Float with Argos Telemetry**



**NOTE** For instructions on how to run a script to convert the Argos messages to readable text, refer to “Converting the Argos Messages to Text” on page D-14.

### D.1 Argos Configuration Files

An APEX profiling float with Argos telemetry includes four configuration files:

- mission.cfg
- system.cfg
- sensors.cfg
- sample.cfg

Each file contains configuration parameters with factory default settings. The mission.cfg and sample.cfg files can be changed by the operator; the system.cfg and sensors.cfg files are factory set and should not be changed. Furthermore, files can only be changed using a PC connected directly to the float. The files cannot be changed remotely.

### D.1.1 Argos system.cfg File

With the exception of the Iridium RUDICS/PSTN account information, which does not apply to an APEX profiling float with Argos telemetry, the Argos system.cfg file includes the same configuration parameters described in “system.cfg File” on page 4-2 plus the following additional ones:

**argos\_hex\_id.** The Argos Id in hexadecimal as provided by the Argos service provider.

Syntax:           argos\_hex\_id <Argos Id in hexadecimal>

**argos\_decimal\_id.** The Argos Id in decimal as provided by the Argos service provider.

Syntax:           argos\_decimal\_id <Argos Id in decimal>

**argos\_frequency.** The transmission frequency of the Argos transmitter.

Syntax:           argos\_frequency <MHz>

The Argos system.cfg file configuration parameter settings are factory set and should not be changed by the operator.

### D.1.2 Argos sensors.cfg File

The Argos sensors.cfg file is composed of the following configuration parameters:

**sensor.** Refer to “sensors.cfg File” on page 4-4 for information on this configuration parameter.

**transmitter.** Specifies the name of the Argos transmitter. The name is used to define its internal hardware configuration.

Syntax:           transmitter <transmitter\_name>

Default:           telonics\_st21\_200a

Example:       transmitter telonics\_st21\_200a

### D.1.3 Argos mission.cfg File

The Argos mission.cfg file includes the same configuration parameters described in SECTION 3: “Operating Modes.” However, **TelemetryInterval**, as it applies to an APEX float with Argos telemetry, functions differently from that of an APEX profiling float with RUDIS/PSTN or SBD communications.

**TelemetryInterval.** The time in seconds between each wakeup for the message transmission of the collected science data and event and status information. Data message transmissions will continue until the end of the period specified by **UpTime**. Should the float go into Emergency mode as described in “Emergency Mode” on page

D-13, *only* the Argos Emergency Message will be transmitted each time, and for a period of four hours.

Syntax:            TelemetryInterval <*seconds*>  
 Range:             20–120 sec  
 Default:           45 sec

#### D.1.4 Argos sample.cfg File

Sampling for an APEX profiling float with Argos telemetry is controlled with entries in the sample.cfg file. The maximum number of samples is limited to 128 for each ascent, and *only* interval sampling can be performed. The float cannot perform continuous profiling. The specified start and stop pressures can be in any order. In addition, sampling should only be specified for the Ascent phase. The sampling behavior for the float is specified using a single entry in the sample.cfg file for each of any number of pressure ranges in accordance with the following syntax:

Syntax:            ASCENT  
                      Sample CTD [*<start>* [*<stop>*] [*<interval>*] [*<units>*] [*<count>*]]]]

For example, to sample the CTD every 10 dbar beginning at 1000 dbar and ending at 200 dbar, enter:

```
ASCENT
Sample CTD 1000 200 10 dbar
```

Sampling should not be specified for the Park phase, as the float will perform statistical sampling of pressure and temperature during the Park phase at the sampling interval specified by **ParkTimerInterval**.

## D.2 Argos Mission Prelude Phase

During the Mission Prelude phase for an APEX profiling float with Argos telemetry, the float repeatedly transmits two 31-byte test messages, Test Message 1 and Test Message 2, where the time between each message transmission is specified by **TelemetryInterval**. The test messages are transmitted continuously for the period specified by **PreludeTime** of the Mission Prelude phase. A description of the contents of Test Message 1 is shown in Table D-1 followed by an example output, and for Test Message 2, in Table D-2 on page D-5, also followed by an example output. In the example outputs, approximate values due to conversions are indicated with a “~.”

**Table D-1: Test Message 1**

Bytes	Mnemonic	Description
0	CRC	The CRC for this message
1	MSG	The identifier number for this message
2	BLK	The block identifier for a group of transmitted messages
3	MAJOR	The major firmware revision number
4	MINOR	The minor firmware revision number
5	PATCH	The patch firmware revision number
6–8	FLTID	The <b>Float_Id</b> configuration parameter setting
9–10	SEC	The time in seconds since the start of the Mission Prelude phase
11–12	STATUS	The APF-11 Status
13	TELONICS	The Telonics PTT Status
14–15	P	The pressure in centibars measured once each test-message block
16	ABP	The air bladder pressure in counts measured once each test-message block
17	BAT	The quiescent battery voltage in counts measured once for each test message block
18	UP	The <b>Uptime</b> configuration parameter setting in hours
19–20	DOWN	The <b>DownTime</b> configuration parameter setting in hours
21–22	PRKP	The <b>ParkPressure</b> configuration parameter setting in decibars
23	PPP	The <b>ParkDescentCount</b> configuration parameter setting (park piston position) in counts
24	NUDGE	The <b>BuoyancyNudge</b> configuration parameter setting (during the Ascent phase) in counts
25	OK	The <b>MinVacuum</b> configuration parameter setting (internal vacuum threshold) in counts
26	ASCEND	The <b>AscentTimeout</b> configuration parameter setting in hours
27	TBP	The <b>air_bladder_max</b> configuration parameter setting in counts
28–29	TP	The <b>DeepDescentPressure</b> configuration parameter setting (profile pressure) in decibars
30	TPP	The <b>DeepDescentCount</b> configuration parameter setting (profile piston position) in counts
31		Not used



The following is an example of a decoded Test Message 1:

```

*** TEST MESSAGE 1 ***
Block ID: 9
Firmware Revision: 2.7.0
Float ID: 777-0315
Seconds Since Start of Prelude: 1655
Float Status Bits: 0b00000001000000
Prelude message
Telonics Status Bits: 0b000000
Surface Pressure @ Telemetry (dbar): 0.000
Air Bladder Pressure (dbar): ~12.30
Quiescent Battery Voltage (V): ~15.12
Configured Up Time (hrs): ~21
Configured Down Time (hrs): ~219
Configured Park Pressure (dbar): 200
Configured Park Piston Position (counts): ~2176
Configured Ascent Buoyancy Nudge (counts): ~160
Configured Min Vacuum (dbar): ~9.00
Configured Ascent Timeout (hrs): ~10.00
Configured Max Air Bladder Pressure (dbar): ~11.974
Configured Profile Pressure (dbar): 2000
Configured Profile Piston Position (counts): ~256

```

**Table D-2: Test Message 2**

Bytes	Mnemonic	Description
0	CRC	The CRC for this message
1	MSG	The identifier number for this message
2	BLK	The block identifier for a group of transmitted messages
3	MAJOR	The major firmware revision number
4	MINOR	The minor firmware revision number
5	PATCH	The patch firmware revision number
6	FEXT	The <b>buoyancy_pump_max</b> configuration parameter setting (piston full extension) in counts
7	FRET	The <b>buoyancy_pump_min</b> configuration parameter setting (piston full retraction) in counts
8	IBN	The <b>InitialBuoyancyNudge</b> configuration parameter setting (initial buoyancy nudge to start the Ascent phase) in counts

9	N	The <b>PnPCycleLen</b> configuration parameter setting (park and profile cycle length)
10	PACT	The <b>MactivationCount</b> configuration parameter setting (pressure activation piston position) in counts
11	DPDP	The <b>DeepDescentTimeout</b> configuration parameter setting (Deep Descent phase period) in hours
12	PDP	The <b>ParkDescentTimeout</b> configuration parameter setting (Park Descent phase period) in hours
13	PRE	The <b>PreludeTime</b> configuration parameter setting (mission prelude period) in hours
14	REP	The <b>TelemetryInterval</b> configuration parameter setting (ARGOS transmission repetition period) in seconds
15–18	ARGOSID	The Argos hex Id.
19	ARGOSFREQ	The Argos transmit frequency expressed as the number of Kilohertz away from the center frequency of 401.650 MHz.
20–21	SBESN	The serial number of the CTD
22–23	SBEFW	The CTD firmware revision number
24–27	EPOCH	The current system (GMT) time.
28–29	DEBUG	The debug verbosity
30	VAC	The internal vacuum reading in counts.
31		Not used

The following is an example of a decoded Test Message 2:

```

*** TEST MESSAGE 2 ***
Block ID: 9
Firmware Revision: 2.7.0
Piston Full Extension (counts): ~3728
Piston Full Retraction (counts): ~144
Initial Ascent Buoyancy Nudge (counts): ~304
PnP Cycle Length: 1
Pressure Activation Piston Position (counts): ~256
Deep Profile Descent Period (hrs): 8
Park Descent Period (hrs): 1
Prelude Period (hrs): 6
Telemetry Repetition Period (secs): 45
Argos Hex ID: 0x09d82d35
Argos Frequency: 401.679

```

```

CTD Serial #: 0
CTD F/W Revision #: 0
GMT time: 2017-04-14T14:40:00Z
Log Verbosity: 7
Internal Vacuum: ~9.13

```

### D.3 Argos Surface Phase

During the Surface phase for an APEX profiling float with Argos telemetry, the float repeatedly transmits up to twenty-nine 31-byte data messages, Data Message 1 to Data Message 29, where the time between each message is specified by **TelemetryInterval**. The messages are transmitted continuously for the period specified by **UpTime** of the Ascent phase. Descriptions of the contents of Data Message 1 through Data Message 4 are shown in Table D-3 through Table D-6, respectively, each followed by an example output. In the example outputs, approximate values due to conversions are indicated with a “~.” Data Message 5 through Data Message 29 are structured similar to that of Data Message 4.

**Table D-3: Data Message 1**

Bytes	Mnemonic	Description
0	CRC	CRC for this message
1	MSG	Identifier number for this message
2	BLK	Block identifier for a group of transmitted messages
3-5	FLT	The <b>Float_Id</b> configuration parameter setting
6	PRF	The current mission profile number (wraps to 0 from 255)
7	LEN	The number of PTS samples in this message block
8-9	STATUS	The APF-11 Status
10	TELONICS	The Telonics PTT Status
11	CP	The current pressure in centibars as recorded during the creation of each Argos message block. Each distinct copy of Argos message #1 contains a new pressure measurement.
12-13	SP	The surface pressure in centibars as recorded just prior to the descent to the park depth.
14	SPP	The piston position in counts recorded when the surface-detection algorithm terminated.
15	PPP2	The piston position in counts recorded at time that the park phase of the profiling cycle terminated.

<b>16</b>	PPP	The piston position in counts recorded at the time that the last deep-descent phase terminated.
<b>17–20</b>	CTD	The CTD Status
<b>21</b>	VQ	The quiescent battery voltage in counts measured when the park phase of the profile cycle terminated.
<b>22</b>	IQ	The quiescent battery current in counts measured when the park phase of the profile cycle terminated.
<b>23</b>	VCTD	The battery voltage in counts measured when the CTD sampled after the park phase of the profile cycle terminated.
<b>24</b>	ICTD	The CTD current in counts measured when the CTD sampled after the park phase of the profile cycle terminated.
<b>25</b>	VHPP	The average battery voltage in counts measured during the initial extension of the buoyancy pump at the start of the profile phase of the profile cycle.
<b>26</b>	IHPP	The average battery current in counts measured during the initial extension of the buoyancy pump at the start of the profile phase of the profile cycle.
<b>27</b>	VAP	The average battery voltage in counts measured during the most recent period when the air pump was activated.
<b>28</b>	IAP	The average battery current in counts measured during the most recent period when the air pump was activated
<b>29–30</b>	VSAP	The integrated measure (Volt-Sec) of the volume of air pumped during the telemetry cycle.
<b>31</b>	NA	Not used.

The following is an example of a decoded Data Message 1:

```

*** DATA MESSAGES DATA START ***
Float ID: 777-0315
Profile #: 1
Block ID: 7
# of Profile Samples: 100
Float Status Bits: 0b00000000000001
Deep Profile occurred
Telonics Status Bits: 0b000000
Pressure (dbar): 0.000
Surface Pressure @ Park Descent Start (dbar): 0.000
Piston Position @ Surface Detection (counts): ~3680
Piston Position @ Park End (counts): ~2624

```

Piston Position @ Deep Descent End (counts): ~256  
 CTD Status Bits: 0b000000000000000000000000000000  
 Quiescent Battery Voltage @ Park End (V): ~15.12  
 Quiescent Battery Current @ Park End (cnts): ~255  
 Quiescent Battery Current @ Park End (mA): ~19.92  
 Battery Voltage @ Park End With CTD Powered (V): ~0.00  
 CTD Current @ Park End With CTD Powered (mA): ~0.000  
 Average Battery Voltage During Initial Ascent Nudge (V): ~15.05  
 Average Buoy Pump Current During Initial Ascent Nudge (cnts): ~416  
 Average Buoy Pump Current During Initial Ascent Nudge (mA): ~195.786  
 Average Battery Voltage During Air Pump Activation (V): ~15.05  
 Average Air Pump Current During Air Pump Activation (cnts): ~800  
 Average Air Pump Current During Air Pump Activation (mA): ~97.656  
 Volt-Sec for Air Pumped During Telemetry: 603

**Table D-4: Data Message 2**

Bytes	Mnemonic	Description
0	CRC	CRC for this message
1	MSG	Identifier number for this message
2 - 5	EPOCH	Unix epoch when down time expired.
6-7	TINIT	Time (minutes) when telemetry phase was initiated relative to EPOCH. (2's compliment signed integer)
8	NADJ	The number of active-ballast adjustments made during the park phase
9-10	PRKN	The number of hourly park-level PT samples.
11-12	TMEAN	The mean temperature of park-level PT samples.
13-14	PMEAN	The mean pressure of park-level PT samples.
15-16	SDT	The standard deviation of temperature of park-level PT samples.
17-18	SDP	The standard deviation of pressure of park-level PT samples.
19-20	TMIN	The minimum temperature of park-level PT samples.
21-22	TMINP	The pressure associated with TMIN of park-level PT samples.
23-24	TMAX	The maximum temperature of park-level PT samples.
25-26	TMAXP	The pressure associated with TMAX of park-level PT samples.

<b>27–28</b>	PMIN	The minimum pressure of park-level PT samples.
<b>29–30</b>	PMAX	The maximum pressure of park-level PT samples.
<b>31</b>	NA	Not used.

The following is an example of a decoded Data Message 2:

```

Downtime Expiration Time: 2017-04-23T16:35:46Z
Telemetry Start Downtime End Delta (mins): 376
# of Ballast Adjustments: 46
# of Park Level PT Samples: 211
Mean Temperature for Park Level PT Samples: 4.406
Mean Park Pressure Diff for Park Level PT Samples: 138.900
Std Dev of Temperature for Park Level PT Samples: 0.002
Std Dev of Park Pressure Diff for Park Level PT Samples:
128.700
Min Temperature for Park Level PT Samples: 4.405
Pressure @ Min Temperature for Park Level PT Samples: 358.000
Max Temperature for Park Level PT Samples: 4.406
Pressure @ Max Temperature for Park Level PT Samples: 222.100
Min Pressure for Park Level PT Samples: 221.700
Max Pressure for Park Level PT Samples: 602.200

```

**Table D-5: Data Message 3**

Bytes	Mnemonic	Description
<b>0</b>	CRC	CRC for this message
<b>1</b>	MSG	Identifier number for this message
<b>2</b>	VAC	The internal vacuum in counts recorded when the park phase of the profiling cycle terminated.
<b>3</b>	ABP	The air bladder pressure in counts recorded just after each Argos transmission.
<b>4</b>	PAP	The number of 5-second pulses of the air pump required to inflate the air bladder
<b>5 - 6</b>	PMT	The total length of time in seconds that the pump motor ran during the current profile cycle.
<b>7–8</b>		Temperature
<b>9–10</b>		Pressure
<b>11–12</b>		Salinity

13-14		Temperature
15-16		Pressure
17-18		Salinity
19-20		Temperature
21-22		Pressure
23-24		Salinity
25-26		Temperature
27-28		Pressure
29-30		Salinity
31	NA	Not used.

The following is an example of a decoded Data Message 3:

```

Internal Vacuum @ Park End (dbar): ~10.39
Air Bladder Pressure @ End of Air Activation (dbar): ~0.00
# of 5 Second Air Pump Pulses: 8
Run-time for Buoy Pump (secs): 88
*** Sample Data Start ***
Temperature, Pressure, Salinity
4.406, 1999.000, 16.613
4.406, 1949.300, 16.625
4.406, 1898.500, 16.637
4.406, 1849.100, 16.649
4.406, 1799.300, 16.662
4.406, 1749.300, 16.674
4.406, 1699.400, 16.687
4.406, 1648.600, 16.699

```

**Table D-6: Data Message 4**

Bytes	Mnemonic	Description
0	CRC	Message CRC
1	MSG	Message ID
2-3		Temperature
4-5		Pressure
6-7		Salinity
8-9		Temperature

10–11		Pressure
12–13		Salinity
14–15		Temperature
16–17		Pressure
18–19		Salinity
20–21		Temperature
22–23		Pressure
24–25		Salinity
26–27		Temperature
28–29		Pressure
30		Salinity (byte 1, where byte 2 is contained in Data Message 5)
31		Not used.

The remaining messages, which are Data Message 5 to Data Message 29, each contain a Message CRC, a Message ID, and temperature, pressure, and salinity data. Bytes 21–30 for Data Message 29 are not used.

## D.4 Float Status Information

Float status bits are sent in Test Message 1 as STATUS bytes 11–12 and in Data Message 1 as STATUS bytes 8–9 as follows with Bit 1 as the rightmost bit:

- Bit 1:** Deep profile first
- Bit 2:** Float bottom detection
- Bit 3:** Sample timeout
- Bit 4:** Piston fully extended
- Bit 5:** Ascent timeout occurred
- Bit 6:** Test message
- Bit 7:** Prelude message
- Bit 8:** Ice breakup detection
- Bit 9:** Emergency flag set
- Bit 10:** CTD exception
- Bit 11:** CTD unreliable
- Bit 12:** Ice detection
- Bit 13:** Telecommunications exception
- Bit 14:** Air system bypass
- Bit 15:** Watchdog detection
- Bit 16:** Profile ID overflow



## D.5 Emergency Mode

An APEX profiling float with Argos telemetry will go into Emergency mode if a catastrophic error occurs during any mission phase or if the float fails the self test during the Mission Prelude phase. When in Emergency mode, the float will continuously transmit *only* the Argos Emergency Message for four hours, where the time between each message is specified by **TelemetryInterval**, after which the Emergency mode will be automatically cleared. A description of the contents of the Argos Emergency Message is shown in Table D-7. Once cleared the float will again attempt to run the mission. If the float again goes into Emergency mode, this cycle is repeated until the batteries are depleted.

**Table D-7: Argos Emergency Message**

Bytes	Mnemonic	Description
0	CRC	CRC for this message
1	MSG	Identifier number for this message
2	BLK	Block identifier for a group of transmitted messages
3	MAJOR	Major firmware revision number
4	MINOR	Minor firmware revision number
5	PATCH	Patch firmware revision number
6 - 8	FLT	The <b>Float_Id</b> configuration parameter setting
9	TELONICS	The Telonics PTT Status
10	ABP	The air bladder pressure in counts.
11	BAT	The Quiescent battery voltage in counts
12	VAC	The internal vacuum reading in counts.
13-16	PC	The exception program counter.
17	VAP	The average battery voltage in counts measured during the most recent period when the air pump was activated.
18	IAP	The average battery current in counts measured during the most recent period when the air pump was activated
19 – 20	VSAP	The integrated measure (Volt-Sec) of the volume of air pumped during the telemetry cycle.
21-31	NA	Not used

## D.6 Converting the Argos Messages to Text Files

The Argos 31-byte message files for each surfacing must first be obtained from the Argos service provider and then converted to text files before they can be read. This operation requires that you first download and install Python on a PC. To install Python, go to <http://www.python.org/getit/releases/2.7.11> and download and install Version 2.7.11 in the C:\ directory of your PC. In addition, the `apf11_argos_msgs_decoder.py` Message Decoder script, provided by Teledyne Webb Research, must also be saved in the C:\ directory of the PC. This script, which is on the documentation CD, processes files in two different formats. One format is for factory use only, and the other format is expected to be used by operators.

The Python script `apf11_argos_msgs_decoder.py` Message Decoder script processes message files that can include test and data messages. The script can process message files in a few different formats using program options to indicate the input file format. In most cases the file downloaded from the Argos service provider may have a header line. The python script command includes an “-h” option to process the file header. In addition, the data fields in the input data files are typically separated by a comma. In this case the “-s” option followed by a comma in quotes should be used to indicate that it is the field separation character. If the input data file uses a different field separation character, the “-s” option must be followed by the desired separation character in quotes.

The Message Decoder command is the following:

```
Syntax:      python apf11_argos_msgs_decoder.py [-h] [-s <field_delimiter> ]
              <input-file-name> [ > <output-file-name> ]
```

-h: Indicates that the input data file has a header line to process before the message data, for example “SENSOR 01,” “SENSOR 02,” etc.

-s <field\_delimiter>: Indicates the delimiter used to separate message record fields in the input data file, such as a comma.

<input-file-name>: The name of the file for the messages to be processed. The name may include the directory path.

<output-file-name>: The name of the file to redirect output from the python script. The name may include the directory path.

To convert the Argos messages to text files:

1. Log onto the service provider site and enter the information on the form, including the following:
  - Select “By Platform ID Numbers.”
  - Enter the decimal Id for float.

- Select the time frame for message capture associated with the float's surfacing.
  - Select filed identifiers for SENSOR 01 through SENSOR 31.
  - Select CSV output format.
2. Download the Argos message files from the Argos service provider into a directory of the PC.
  3. Enter the Message Decoder command in accordance with the syntax.
  4. Open the output file in a text display program, such as Microsoft Notepad.



## APPENDIX E: Diagnostic Messages Example

When starting the mission from a PC or running the self test from a PC, progress and diagnostic messages will be displayed on the PC as in the following example:

```
eng> sys_self_test
*****
Start Float Test
  Float: f7718
  Time: 2016-03-18 20:04:55
*****
03/17/16 18:19:04 APF11-v2.4.8
Battery Voltage: 14.70 V
Float Current: 32.6583 mA
Coulomb Count: 227.4443 mAh
Bladder Pressure: 8.3 dbar
Internal Vacuum: 8.2 dbar
Piston Position: 260 counts

-----Mission Parameters-----
ActivateRecoveryMode off
AscentRate 0.08
AscentTimeout 120
AscentTimerInterval 100
BuoyancyNudge 100
DeepDescentCount 1200
DeepDescentPressure 300.00
DeepDescentTimeout 30
DeepDescentTimerInterval 300
DeepProfileFirst off
DownTime 600
EmergencyTimerInterval 7200
IceBreakupDays14
IceCriticalT -1.70
IceDetectionP 50.00
IceEvasionP 20.00
IceMonths 0000
IdleTimerInterval 36000
InitialBuoyancyNudge 200
LeakDetect on
LogVerbosity 5
MActivationCount 262
MActivationPressure 25.00
MinBuoyancyCount 147
MinVacuum 9.00
ParkBuoyancyNudge 20
ParkDeadBand 25.00
ParkDescentCount 2200
ParkDescentTimeout 120
ParkDescentTimerInterval 3600
```

```

ParkPressure 300.00
ParkTimerInterval 3600
PnPCycleLen 100
PreludeSelfTest off
PreludeTime 120
SurfacePressure 4.00
TelemetryInterval 900
UpTime 180
Checksum 6EBA
#-----Sample Config-----
<PARK>
SAMPLE CTD 2500 4 0.0 DBAR
SAMPLE FLBB 2500 0 0.0 DBAR
SAMPLE RAD 2500 0 0.0 DBAR
SAMPLE CMP 2500 0 0.0 DBAR
SAMPLE OPT 2500 0 0.0 DBAR
SAMPLE XMIS 2500 0 0.0 DBAR
<ASCENT>
SAMPLE CTD 2000 4 5.0 DBAR
SAMPLE FLBB 2000 0 5.0 DBAR
SAMPLE RAD 2000 0 5.0 DBAR
SAMPLE CMP 2000 0 5.0 DBAR
SAMPLE OPT 2000 0 5.0 DBAR
SAMPLE XMIS 2000 0 5.0 DBAR
#-----
-----System Config-----
air_bladder_max 12
buoyancy_pump_min 147
buoyancy_pump_max 3720
iridium f7718 iridium 00881600005135 rudics 0017818711053 dialup

-----Sensor Config-----
seabird_ctd PIN_4 PORT_A COM_2 B9600
optode PIN_5 PORT_SPR COM_4 B9600
satlantic_504i PIN_6 PORT_SPR COM_5 B9600
tnt_compass PIN_7 PORT_EXP COM_8 B9600
satlantic_504r PIN_8 PORT_EXP COM_9 B9600
flbb_bb PIN_9 PORT_EXP COM_10 B19200
crover PIN_10 PORT_EXP COM_11 B19200
gps gps15xh
modem iridium9522b

-----
Air Engine Test:
Starting values:
    Internal Vacuum:      8.1 dbar / 11.8 PSI
    Air Bladder:         8.3 dbar / 12.0 PSI
    Battery Voltage:     14.7 V

Inflating Air Bladder:
    Air Engine Pulses:    23
    Air Engine Coulombs:  5.312 mAh
    Air Engine Avg Current: 0.135 Amp

```

```

Air Engine Max Current: 0.167 Amp
Battery Avg Voltage:    14.52 V
Battery Min Voltage:    14.39 V
Internal Vacuum:       7.3 dbar / 10.7 PSI
Air Bladder:           12.0 dbar / 17.4 PSI
Air Engine Test : <<PASS>>

```

```

-----
Buoyancy Engine Test:
Moving Buoyancy from 260 to 617
Moving Buoyancy back to 260
Buoyancy Coulombs:     10.312 mAh
Buoyancy Avg Current:  0.160 A
Buoyancy Max Current:  0.172 A
Battery Avg Voltage:    14.56 V
Battery Min Voltage:    14.51 V
Buoyancy Test : <<PASS>>

```

```

-----
GPS Test:
GPS time/location set
RF Board Max Current:  56.5 mA
Battery Min Voltage:   14.6 V
GPS Test : <<PASS>>

```

```

-----
Modem Test:
Modem: Iridium
Model: 9523
Call Processor Version: DB15002
Modem DSP Version: 1.7 svn: 2358
Audio DSP Version: 1.7 svn: 2459
DBB Version: 0x0001 (ASIC)
Main RFA Version: 0x0004
Aux RFA Version: 0x0004
NVM Version: KVS
BOOT Version: BOOT1004/HW0a(H2GRevD)/02/RAW0a
Serial No.: 300125060544970
SIM ICCID: 8988169234001175827
Testing Primary Number: 00881600005135 (RUDICS)
Uploaded 67 bytes in 9 secs at 7 bytes/sec
Connect : PASS
Login : PASS
Iridium transfer successful
Send File : PASS
Downloaded test.20160318T201241.txt (67 bytes) in 4 seconds, at a rate of 16.8
bytes/sec
Connect : PASS
Login : PASS
Iridium transfer successful
Receive File : PASS
Primary Number Test : PASS
Testing Secondary Number: 0017818711053 (DIALUP)
Uploaded 66 bytes in 12 secs at 6 bytes/sec
Connect : PASS
Login : PASS
Iridium transfer successful

```

Send File : PASS  
 Downloaded test.20160318T201657.txt (66 bytes) in 11 seconds, at a rate of 6.0 bytes/sec

Connect : PASS

Login : PASS

Iridium transfer successful

Receive File : PASS

Secondary Number Test : PASS

Modem Test : <<PASS>>

```
-----
Battery Voltage:          14.66 V          <OK>
Leak Detect :            2.35 V          <OK>
Humidity :               34.4 rH         <OK>
Interval Vacuum :       8.2 dbar        <OK>
-----
```

CTD Test:

CTD Configure : PASS

```
Model:                   SBE 41CP
Version:                 2.0.0
serialNumber:           6390
p cutoff:                2.00
automatic bin averaging: no
nsamples:               2
nbins:                  0
top bin interval:       2
top bin size:           2
top bin max:            10
middle bin interval:    2
middle bin size:        2
middle bin max:         20
bottom bin interval:    2
bottom bin size:        2
include transition bin: no
include samples per bin: yes
pump sample wait time: 20 sec
real-time output:       PTS
```

temperature: 15-sep-15

```
TA0:                    9.575481e-05
TA1:                    2.603125e-04
TA2:                    -1.379168e-06
TA3:                    1.241674e-07
```

conductivity: 15-sep-15

```
G:                      -9.741452e-01
H:                      1.328684e-01
I:                      -2.785533e-04
J:                      3.749422e-05
CPCOR:                  -9.570001e-08
CTCOR:                  3.250000e-06
WBOTC:                  3.071741e-08
```

pressure S/N = 4113762, range = 2900 psia: 08-sep-15



```

PA0:          3.683824e-01
PA1:          1.399666e-01
PA2:          -4.046386e-08
PTCA0:        2.408421e+01
PTCA1:        9.834735e-02
PTCA2:        9.733014e-04
PTCB0:        2.529475e+01
PTCB1:        -2.500000e-04
PTCB2:        0.000000e+00
PTHA0:        -7.539768e+01
PTHA1:        4.974858e-02
PTHA2:        -3.839602e-07
POFFSET:      0.000000e+00
    
```

```

CTD Pressure: -0.1 dbar
CTD Pressure: -0.1 dbar, Temperature: 22.21 C
    
```

CTD Test : <<PASS>>

-----

TNT COMPASS Test :

TNT COMPASS GetInfo : <<PASS>>

```

TNT Device Id:          40035
TNT Firmware Revision: TNT1502 Rev 2.64 - PCB 1511 Rev E - 08/06/07 !0040
TNT COMPASS Get Heading : <<PASS>>
COMPASS Heading:35.900 Pitch:-1.400 Roll:-4.600 Dip:1348.000
    
```

TNT COMPASS Test : <<PASS>>

-----

FLBB Test:

FLBB Configure : PASS  
 FLBB Get Info : PASS

```

FLBB Serial Number:  FLBBBB6K-4229
FLBB Version:        TripletD 4.07
FLBB Average:        30
FLBB Packets:        0
    
```

FLBB Sample : PASS

```

FLBB_BB Ch1:3180 BB0:4130 BB1:4130 Temp:539
    
```

FLBB Test : <<PASS>>

-----

CROVER Test:

CROVER Get Info : PASS

```

CROVER Model/Type:    BAM
CROVER Serial Number: CRV2K-078
CROVER Version:       CSTAR 4.14
CROVER Average:       30
CROVER Packets:       0
    
```

CROVER Sample : PASS

```

CROVER Reference:    10761
CROVER Raw:          10
CROVER Corrected:    9
CROVER Attenuation:  29.7880
CROVER Thermistor:   541
    
```

CROVER Test : <<PASS>>

```

-----
Optode Test:

                                Optode Configure : PASS
                                Optode Get Info  : PASS

Optode Product Name:           Optode Sensor
Optode Product Number:         4330
Optode Serial Number:          1521
Optode SW Version:             4.4.8
Optode SW ID:                  1940006
Optode Node Description:       Optode Sensor #1521
Optode FoilID:                 1206EM
Optode Enable Text:            Yes
Optode Enable Decimalformat:   No
Optode Enable Sleep:           Yes
Optode Enable Polled Mode:     No
Optode Enable SVUformula:      Yes
Optode Interval[s]:           3
Optode Analog TempLimit[Deg.C]: -5.000000e+00 3.500000e+01
Optode Analog ConcLimit[uM]:   0.000000e+00 0.000000e+00
Optode Analog SatLimit:        0.000000e+00 0.000000e+00
Optode Analog PhaseLimit[Deg.C]: 0.000000e+00 0.000000e+00
Optode Analog Output:          1521
Optode Analog1 Coef:           0.000000e+00 0.000000e+00
Optode Analog2 Coef:           0.000000e+00 0.000000e+00
Optode Enable AirSaturation:   Yes
Optode Enable Rawdata:         Yes
Optode Enable Temperature:     Yes
Optode Enable HumidityComp:    Yes
Optode Salinity[PSU]:          0.000000e+00
Optode PhaseCoef:              0.000000e+00 1.000000e+00 0.000000e+00 0.000000e+00
Optode FoilCoefA[1-7]:         -2.988314e-06 -6.137785e-06 1.684659e-03 -1.857173e-01
6.784399e-04 -5.597908e-07 1.040158e+01
Optode FoilCoefA[8-14]:        -5.986907e-02 1.360425e-04 -4.776977e-07 -3.032937e+02
2.530496e+00 -1.267045e-02 1.040454e-04
Optode FoilCoefB[1-7]:         -3.560390e-07 3.816713e+03 -4.475507e+01 4.386162e-01
-7.146342e-03 8.906234e-05 -6.343012e-07
Optode FoilCoefB[8-14]:        0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00
Optode FoilPolyDegT[1-14]:     1 0 0 0 1 2 0 1 2 3 0 1 2 3
Optode FoilPolyDegT[15-28]:    4 0 1 2 3 4 5 0 0 0 0 0 0 0
Optode FoilPolyDegO[1-14]:     4 5 4 3 3 3 2 2 2 1 1 1 1 1
Optode FoilPolyDegO[15-28]:    1 0 0 0 0 0 0 0 0 0 0 0 0 0
Optode SVUFoilCoef:            2.933651e-03 1.245261e-04 2.482191e-06 2.317514e+02 -
3.094964e-01 -5.569272e+01 4.559175e+00
Optode ConcCoef:               0.000000e+00 1.000000e+00
Optode NomAirPress[hPa]:       1.013250e+03
Optode NomAirMix[hPa]:         0.000000e+00
Optode CalDataSat[Deg]:        3.174000e+01 9.910000e+00
Optode CalDataAPress[hPa]:     9.727329e+02
Optode CalDataZero[Deg]:       6.233000e+01 2.445500e+01

                                Optode Sample : PASS

OPTODE 02:251.24 AirSat:92.35 Temp:22.17

                                Optode Test : <<PASS>>
-----
Satlantic OCR Test:

```

```

Satlantic OCR Configure : PASS
Satlantic OCR GetInfo : PASS

Satlantic OCR-504 Multispectral Radiometer
Firmware version: 5.1.0 - SatNet Type B
Sensor Type: irradiance
Serial Number: 0400
Frame Type: short
Header: SATFI4
Telemetry Baud Rate: 9600 bps
Maximum Frame Rate: 1 Hz
Initialize Silent Mode: on
Initialize Power Down: off
Initialize Automatic Telemetry: on
Network Mode: off
networkAddress: 200
Network Baud Rate: 38400 bps
Averaging: on
Immersed: on
Calibrated Output: on
Sensor Latency: 0
Calibration Coefficients:
  Optical Channel 1:
    a0: 2147551528.8
    a1: 2.141215e-07
    im: 1.368

  Optical Channel 2:
    a0: 2147318656.7
    a1: 2.071143e-07
    im: 1.410

  Optical Channel 3:
    a0: 2147887045.0
    a1: 2.060970e-07
    im: 1.365

  Optical Channel 4:
    a0: 2147172741.4
    a1: 2.039716e-07
    im: 1.372

Satlantic OCR Sample : PASS
OCD-504I Ch1:0.0011 Ch2:-0.0009 Ch3:0.0021 Ch4:0.0030
Satlantic OCR Test : <<PASS>>

```

-----

Satlantic OCR Test:

```

Satlantic OCR Configure : PASS
Satlantic OCR GetInfo : PASS

Satlantic OCR-504 Multispectral Radiometer
Firmware version: 5.1.0 - SatNet Type B
Sensor Type: radiance
Serial Number: 0022
Frame Type: short
Header: SATFR4

```

Telemetry Baud Rate: 9600 bps  
Maximum Frame Rate: 1 Hz  
Initialize Silent Mode: on  
Initialize Power Down: off  
Initialize Automatic Telemetry: on  
Network Mode: off  
networkAddress: 100  
Network Baud Rate: 38400 bps  
Averaging: on  
Immersed: on  
Calibrated Output: on  
Sensor Latency: 0

Calibration Coefficients:

Optical Channel 1:  
a0: 2148023214.5  
a1: 2.653745e-09  
im: 1.758

Optical Channel 2:  
a0: 2147769455.6  
a1: 2.538758e-09  
im: 1.752

Optical Channel 3:  
a0: 2147559434.8  
a1: 2.723878e-09  
im: 1.746

Optical Channel 4:  
a0: 2148019892.9  
a1: 1.587890e-09  
im: 1.739

Satlantic OCR Sample : PASS

OCD-504R Ch1:0.0001 Ch2:0.0000 Ch3:0.0000 Ch4:0.0000

Satlantic OCR Test : <<PASS>>

-----  
Battery Voltage: 14.68 V  
Float Current: 57.0349 mA  
Coulomb Count: 266.5068 mAh  
Bladder Pressure: 8.3 dbar  
Internal Vacuum: 8.2 dbar  
Piston Position: 260 counts

\*\*\*\*\*  
Float Test Completed @ 2016-03-18 20:25:14 : <<PASS>>  
\*\*\*\*\*

## APPENDIX F: Unsupported/Modified Features

---

Some features of the APF-9 APEX Controller board are not currently supported in the newer APEX profiling float or are replaced with other similar features. These features and their descriptions are listed below.

**Mission Programming Agent.** The Mission Programming Agent is replaced with several new user commands.

**LBT Menu (Iridium Modem).** The LBT Menu (Iridium Modem) of user commands enables operator configuration and querying of the Iridium modem. Currently the **modem** configuration parameter in the sensors.cfg file is used to identify the Iridium modem type which determines its hardware configuration. The Iridium modem is currently not operator configurable and cannot be queried.

**GPS Menu.** The GPS Menu of user commands enables operator configuration and querying of the GPS receiver. Currently the **gps** configuration parameter in the sensors.cfg file is used to identify the receiver type which determines its hardware configuration. The receiver is currently not operator configurable and cannot be queried.

**FLbb Menu.** The FLbb Menu of user commands enables operator configuration and querying of an FLbb. This menu is not included.

**Sensor Menu.** The Sensor Menu of user commands enables operator configuration and querying of the CTD. Currently the **sensor** configuration parameter in the sensors.cfg file is used to identify and configure the CTD. The CTD is currently not operator configurable and cannot be queried.

**System Diagnostics Menu.** The System Diagnostics Menu of user commands is replaced with sys\_self\_test.

**AtDial.** The **ATDial** configuration parameter is replaced with the user name, login password and primary and alternate dial string parameters in the system.cfg file.

**CompensatorHyperRetraction.** The **CompensatorHyperRetraction** configuration parameter is for floats with N2-compensators. This configuration parameter is currently not supported.

**ConnectTimeOut.** The **ConnectTimeOut** configuration parameter setting is the number of seconds allowed after dialing to connect to a server on the **Iridium satellite** network. This configuration parameter is currently not supported.

**Flash Erase.** The **Flash Erase** configuration parameter is currently not supported.

**Flash Create.** The **Flash Create** configuration parameter is currently not supported.

**FlbbMode.** The **FlbbMode** configuration parameter is currently not supported.

**MaxLogKb.** The **MaxLogKb** configuration parameter is currently not supported.

**Depth Table.** The factory installed **Depth Table** is replaced by the sample configuration file, sample.cfg.

**Piston Count.** The **Piston Count** configuration parameter setting has changed for all configuration parameters with piston count values as follows:

$$\text{APEX piston count} = \text{APF-9 piston count} \times 10000/610.35$$

For example, the APF-9 **ParkPistonPosition** configuration parameter is now **ParkDescentCount**. The **ParkPistonPosition** default setting for the APF-9 was 66. Therefore the **ParkDescentCount** default setting is now as follows:

$$\text{APEX piston count} = 66 \times 10000/610.35 = 1081$$