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APEX PROFILER USER MANUAL

Applies to Serial Numbers: Revision Date: 01/20/09

4394   Customer name   University Tasmania
4395   TWR Job Number: 1479
                                                Firmware Revision   APF9I F/W **05/17/07**
                                                Features:

                                                                        APF9I Controller
                                                                        Park and Profile
                                                                        Deep Profile First (DPF)
                                                                        Pressure Activation (optional)
Optional Sensors: Air pump energy consumption limit
Seabird SBE-43 IDO Oxygen Sensor   Time of Day profile control

I.   Alkaline Battery Warning

The profiler contains batteries comprised of alkaline manganese dioxide "D" cells.

There is a small but finite possibility that batteries of alkaline cells will release a combustible gas mixture. This gas release generally is not evident when batteries are exposed to the atmosphere, as the gases are dispersed and diluted to a safe level. When the batteries are confined in a sealed instrument mechanism, the gases can accumulate and an explosion is possible.

Teledyne Webb Research has added a catalyst inside of these instruments to recombine hydrogen and oxygen into H_2O, and the instrument has been designed to relieve excessive internal pressure buildup by having the upper end cap release.

Teledyne Webb Research knows of no way to completely eliminate this hazard. The user is warned, and must accept and deal with this risk in order to use this instrument safely as so provided. Personnel with knowledge and training to deal with this risk should seal or operate the instrument.

Teledyne Webb Research disclaims liability for any consequences of combustion or explosion.

II.   APF9 Operations Warning for APF8 Operators

This APEX manual describes floats using a new controller design. The new design is designated APF9. The prior design, which is still in production and widely used, is designated APF8.

The operator interface and behavior of the APF9 are similar to, **but not identical to**, the operator interface and behavior of the APF8. If you are an experienced APF8 user, please observe appropriate cautions and **do not assume an expected behavior**. Several important differences are listed below. These points should also be helpful to those without an APF8 background.

- To reset an APF9 for a deployment you should hold the Reset Tool stationary against the RESET label until you hear the air pump run. Typically, the air pump will run 2 to 3 seconds after you position the Reset Tool over the RESET label. (For the APF8 it was necessary to hold the Reset Tool in place and then remove it to trigger the float.)
- The serial baud rate for communications is 9600, with 8 data bits, no parity, and 1 stop bit. (The APF8 baud rate is 1200.)
- If not already in Command Mode, an APF9 can only enter Command Mode from Sleep. Either the Reset Tool or a keystroke at the terminal will trigger the transition from Sleep to Command Mode.
- If the APF9 is performing some task (e.g., self tests), it is not listening and cannot be placed in Command Mode with either the Reset Tool or a keystroke at the terminal.
    - o   There is one exception. If the piston is moving, the Reset Tool (but not a keystroke) can be used to terminate the move. The APF9 will transition to its next state or task. Typically this will be either Command Mode or Sleep, so try a keystroke or a second application of the Reset Tool after the piston stops to confirm or trigger the transition to Command Mode.
- If the APF9 is not responding, it is probably busy with some task. Be patient and occasionally try to get the attention of the float with either the Reset Tool or a keystroke.
- The logging verbosity of the APF9 can be adjusted by the operator. The level, Parameter D, Logging verbosity [0-5], adjusts the amount of information provided in diagnostic messages from the float, with 5 being the highest level. A logging verbosity of 2 is the default. **Only level 2 has been thoroughly tested in simulation, so this parameter should be set to 2 for all deployments.** Higher levels are suitable during testing as an aid to float assessment.

III.   APF9I Operations Warning for APF9A Operators

The "look and feel" of the APF9I operator interface is quite similar to the APF9A operator interface. However, there are some differences of which you should be aware:

- The APF9I uses <u>minutes</u>, not <u>hours</u>, for mission parameter timing intervals
- Air bladder inflation is the only visible evidence that the float passed the self-test and is ready for deployment. The APF9I does not make six test transmissions that can be detected with an external RF receiver.
- The maximum air bladder pressure is (and should be) higher in the APF9I (6.2 inHg) than in the APF9A (5.3 inHg). This is to assure robust connectivity for the Iridium antenna.

IV.   Maximum Operating Pressure

APEX profilers have a maximum operating pressure of 2000 dbar (2900 psi).   However, for shallower applications, thinner walled pressure cylinders can be used.   These cylinders have a reduced pressure rating, but less mass, which allows them to carry a larger battery payload. Three cylinder pressure ratings are available:

- 2000 dbar   maximum pressure rating
- 1500 dbar   battery payload typically 14% greater than with 2000 dbar cylinder
- 1200 dbar   battery payload typically 28% greater than with 2000 dbar cylinder

For example, if an APEX profiler is specified by the customer for 1400 dbar maximum (profile) depth, then the 1500 dbar cylinder would normally be used.

<u>**CAUTION:**</u>

If you will be:

- Exposing floats to significant hydrostatic pressure during ballasting or testing
- Re-ballasting and re-programming floats for a depth greater than the original specification

Please contact TeledyneWebb Research to confirm the pressure rating of specific floats. Do not exceed the rated pressure, or the hull may collapse.

V.   Evaluating the Float and Starting the Mission

Profilers are shipped to the customer in Hibernate mode. **The Pressure Activation feature is NOT ACTIVE.** With the Pressure Activation feature included in this version of the APF9I firmware, there are two possible deployment procedures. The procedures are described below.

IMPORTANT: Pressure Activation is NOT automatic for this firmware version of the APF9I. The Pressure Activation feature MUST be MANUALLY ACTIVATED by the OPERATOR using a PC to communicate with the float.

The following sections, "Manual Deployment with the Reset Tool" and "Pressure Activation Deployment", provide operational summaries for these two possible deployment scenarios. Both sections refer to self tests conducted by the float and float function checks performed by the operator.

A detailed description of proper float behavior, self tests, and the associated operator actions and observations needed to evaluate the float for deployment is provided in "Mission Activation and Operator Float Function Check".

IMPORTANT: The float should not be deployed if it does not behave as described in "Mission Activation and Operator Float Function Check".

Teledyne Webb Research strongly recommends testing all APEX Profilers on receipt by the customer and before deployment to ensure no damage has occurred during shipping.

A.   Manual Deployment with the Reset Tool

Shortly before deployment, reset the profiler by holding the Reset Tool over the marked location on the pressure case. Hold the Reset Tool in position for approximately 3 seconds. Remove the Reset Tool only after you hear the air pump activate.

The float will run a brief self test and place itself in a state of maximum buoyancy. This is the Mission Activation phase. During this time the operator should verify proper function of the float (see "<u>Mission Activation and Operator Float Function Check</u>"). The float will telemeter its GPS location and the mission parameters during the Mission Prelude phase. Six hours is typical; the duration of the Mission Prelude can be set by the operator. The piston will be fully extended and the air bladder will be fully inflated during the Mission Activation phase. At the conclusion of the Mission Prelude the float will retract the piston, deflate the air bladder, and begin its pre-programmed mission.

<u>Manual Deployment Summary:</u>

- Hold the Reset Tool over the RESET label
- Mission Activation
  - Air pump runs for 1 second
  - Self tests conducted
    - The self tests can be monitored if a communication cable is connected, see "<u>Connecting a Terminal</u>"
  - If the float passes the self tests:
    - Piston is fully extended
    - Air pump is cycled on and off until the air bladder is fully inflated
    - Air bladder inflation is the only easily verified indication that the float has pass the self tests and is ready to deploy
- Mission Prelude
  - Float telemeters GPS location and mission parameters
    - The telemetry interval is set by the operator, Parameter Mhr
  - Mission Prelude duration is typically 6 hours

The float can be deployed after the Mission Activation phase and confirmation of proper float function have been successfully completed. We advise waiting until the air bladder is fully inflated before deploying the float.

If the float fails the self tests the piston will not extend and the air bladder will not inflate. The float should not be deployed.

B.   Pressure Activation Deployment

To use the Pressure Activation feature you must first connect the provided communication cable between your PC and the float (see "Connecting a Terminal" at the end of this manual for additional information). The normal port settings for an APF9I are 9600, 8, N 1. Press [ENTER] to wake the float from Hibernate mode. The float will respond that it has detected an "asynchronous wake-up" and will enter Command mode. Press [ENTER] in Command mode to display the main menu. Menu selections are not case sensitive. See "APF9I Command Summary" for a complete list of commands.

Press 'a' or 'A' to activate the Pressure Activation feature and start the deployment. The float will run a brief self test (Mission Activation). During this time the operator should verify proper function of the float (see "Mission Activation and Operator Float Function Check"). The float will then fully retract the piston and deflate the air bladder so that it can sink when deployed. Once the piston is fully retracted, the float enters the Pressure Activation phase. During this phase the float makes a pressure measurement every two hours, hibernating between measurements. If the pressure is less than 1500 dbar the float returns to hibernation. If the pressure exceeds 1500 dbar the float fully extends the piston and begins the Mission Prelude.

THE FLOAT MUST BE BALLASTED SO THAT IT WILL SINK BELOW 1500 DBAR WHEN THE PISTON IS FULLY RETRACTED OR THE FLOAT WILL NOT BE ABLE TO PRESSURE ACTIVATE. IT WILL NOT SURFACE AGAIN.

During the Pressure Activation phase the operator can communicate with the float. This does NOT NORMALLY deactivate Pressure Activation. However, a 'k' or 'K' (kill) command during this phase will deactivate Pressure Activation and stop the mission.

DO NOT DEPLOY THE FLOAT AFTER A KILL (K) COMMAND UNLESS YOU HAVE STARTED A MANUAL DEPLOYMENT OR RESTARTED A PRESSURE ACTIVATION DEPLOYMENT. IF YOU FAIL TO OBSERVE THIS CAUTION AND LAUNCH THE FLOAT IT WILL SINK TO A NEUTRAL DEPTH AND STAY THERE. IT WILL NOT SURFACE AGAIN.

In the absence of a kill command the float will automatically resume the Pressure Activation phase after several minutes without operator input. Placing the Reset Tool over the RESET mark during the Pressure Activation phase will start a deployment.

Pressure Activation Deployment Scenario

Using the Pressure Activation feature minimizes operator/float interaction while at sea. A skilled operator can fully test the float while still in the laboratory environment or while the vessel is still at the dock. At the conclusion of testing the Pressure Activation feature can be activated and the float can be left to await deployment. When the vessel is on-station it only remains to launch the float (see "Deploying the Float"). No further communication with the float is required and the float can be reliably deployed by relatively inexperienced personnel.

One caution is in order. The air bladder is not automatically inflated until the beginning of the Mission Prelude phase of a deployment. This means it cannot be checked by the operator during the normal course of a Pressure Activation deployment. Therefore, we strongly recommend that you either:

- Manually inflate and check the air bladder before starting a Pressure Activation deployment. Be sure to manually close the air valve before trying to inflate the air bladder. Starting a Pressure Activation deployment will automatically deflate the bladder.

or

- Start a Manual Deployment with the Reset Tool or an operator command and reassert operator control after the Mission Activation and initial portion of the Mission Prelude phases, with attendant operator float function check, has successfully completed.

Pressure Activation Deployment Summary:

- Establish communication with the float (see "Connecting a Terminal")
- Press 'a' or 'A' to initiate Pressure Activation
- Mission Activation
    - Air pump runs for 1 second
    - Self test conducted
        - The self tests can be monitored if a communication cable is connected, see "Connecting a Terminal"
    - If the float passes the self tests
        - Air bladder is deflated
        - Piston is fully retracted
- Deploy the float
- Pressure Activation
    - Pressure is measured every 2 hours
    - Pressure in excess of 1500 dbar triggers
        - Full piston extension
        - Transition to Mission Prelude
- Mission Prelude
    - During ascent the float looks for a satellite at each telemetry retry interval (Parameter Mhr)
    - Detection of a satellite (surface) triggers
        - Full air bladder inflation
    - Float telemeters GPS location and mission parameters
        - The telemetry interval is set by the operator, Parameter Mhr
    - Mission Prelude duration is typically 6 hours
    - **In this particular version of the APF9I firmware, the Mission Prelude will terminate after the first successful telemetry cycle (or it will time out after 9 hours)**

The float can be deployed after the Mission Activation phase and confirmation of proper functioning of the float have been successfully completed.

If the float fails the self tests the piston will not retract and the air bladder will not deflate. This may be difficult to detect unless a terminal is connected to the float. The float should not be deployed if it fails the self tests.

C. Mission Activation and Operator Float Function Check

1) Secure the float in a horizontal position using the foam cradles from the shipping crate.

2) The minimum internal temperature of the float is -2.0°C. If necessary, allow the float to warm up indoors before proceeding.

3) Remove the plastic bag and three (3) plugs from the CTD sensor as shown in the two images below.

4) Carefully remove the black rubber plug from the bottom center of the yellow cowling as shown in the image below. This will allow you to verify air bladder inflation in the steps below. **Use only your fingers to remove the plug. Tools may puncture or otherwise harm the bladder. <u>Be sure to replace the plug before deployment!</u>**

Note: It can be difficult to replace the plug when the air bladder is fully inflated. We suggest that you reinsert the plug before the bladder is fully inflated. The plug prevents the entry of silt into the cowling in the event the float contacts the sea floor.

5) Start a Manual or Pressure Activated Deployment as described above in the "Manual Deployment with the Reset Tool" and "Pressure Activation Deployment" sections. This will trigger the Mission Activation self tests. Where applicable, the description below indicates where the two versions of the self tests differ.

Verify by ear that the air pump is activated for approximately 1 second.

DO NOT DEPLOY THE FLOAT IF IT DOES NOT BEHAVE AS DESCRIBED BELOW. FLOATS THAT DO NOT PASS THE SELF TESTS SHOULD NOT BE DEPLOYED. CONTACT TELEDYNE WEBB RESEARCH FOR ASSISTANCE.

6) The float will conduct self tests for approximately 15 seconds. Progress and diagnostic messages will be displayed if a terminal is connected to the float (see "Connecting a Terminal" for additional information).

7) If the float passes the self tests:

Manual Deployment: If not already fully extended, the float will fully extend the piston. This process may require up to 25 minutes. The oil bladder will expand during this time. The float will also fully inflate the air bladder.

Pressure Activated Deployment: If not already fully retracted, the float will fully retract the piston. This process may require up to 25 minutes. The oil bladder will deflate during this time. The float will also deflate the air bladder.

The volume of oil in the bladder is difficult to detect by hand. You may be able to hear the pump by placing your ear against the hull. Air bladder inflation can be easily verified as described in Step 4.

8) <u>Manual Deployment</u>: Once the piston is fully extended the float enters the Mission Prelude phase. During this phase it will telemeter its GPS location and the mission parameters. Check for air bladder inflation by sticking your finger (**not a tool!**) through the hole in the bottom of the yellow cowling as described in Step 4 above. **Don't forget to replace the plug before deploying the float.**

The duration of the Mission Prelude is set by the operator. 6 hours is typical. At the end of the Mission Prelude the float will deflate the air bladder, retract the piston, and begin the first descent of the programmed mission.

<u>Pressure Activated Deployment</u>: Once the piston is fully retracted the float will enter the Pressure Activation phase. During this phase it will check the pressure every two hours, hibernating in between. The float will not enter the Mission Prelude phase until it detects a pressure in excess of 1500 dbar. There will be no telemetry nor inflation of the air bladder until the Mission Prelude phase begins and the surface is detected.

When the trigger pressure is detected the float will extend the piston and begin the Mission Prelude. During this phase it will attempt to locate a satellite while ascending. Once a satellite is detected (surface detection), the float will telemeter its GPS location and the mission parameters for the balance of the Mission Prelude.   The duration of the Mission Prelude is set by the operator. 6 hours is typical. At the end of the Mission Prelude the float will deflate the air bladder, retract the piston, and begin the first descent of the programmed mission.

In this particular version of the APF9I firmware, the Mission Prelude will terminate after the first successful telemetry cycle (or it will time out after 9 hours)

9) The float is ready to deploy.

D.   Notes and Caveats

Self Tests: During the self tests the float checks:

- The internal vacuum
- Communication with the CTD
- The internal alarm timer settings

If any of the self tests fail the float will abort the mission. The clearest indication to the operator that this has occurred is the failure of the float to make the initial 6 ARGOS transmissions at 6 second intervals.

If you do not detect these Mission Activation transmissions with the Cat's Meow, DO NOT DEPLOY THE FLOAT!

Manual Deployment: In the case of a Manual deployment, if the float is not deployed before the completion of the Mission Prelude phase,

RESET the float again and wait for it to complete the Mission Activation phase and begin the Mission Prelude before you deploy it.

Pressure Activated Deployment: In the case of a Pressure Activated Deployment, the operator is necessarily absent when the float begins the Mission Prelude. This means the operator does not have the opportunity to check the air bladder for leaks that a Manual Deployment offers.

For this reason we strongly recommend that you manually inflate and check the bladder before starting a Pressure Activated Deployment.

Telemetry Testing: During the Mission Prelude the float will telemeter data to the host server. **The float must have a view of the sky to telemeter successfully**. Starting a manual deployment, allowing the float to complete several telemetry cycles, and confirming the reception of the telemetered files at the host server and back at the float (leave the communications link connected) constitutes a valid and easily conducted test of the full communications system.

VI. Optional sensors:

A. SeaBird IDO Integrated Dissolved Oxygen

In addition to SeaBird model 41 CTD sensor, these APEX carry the (optional) Seabird Model 43 IDO oxygen sensor.   The IDO sensor is integrated to the CTD on the upper end cap of the float.

The SBE-43 oxygen sensor does not report actual oxygen concentration.   Instead it reports the "oxygen frequency" (Hertz) that requires additional processing to obtain oxygen concentration via calibration equations. The calibration equations are expressed in terms of calibration coefficients that are specific to individual IDO sensors.

Testing the optional sensor
Sensors can be tested by connecting a terminal, with the provided interface cable, as described in the APEX Final Test Procedure.

Below is an example of output from the Seabird sensor menu:

> s ?
Menu of SBE41cp functions.
? Print this menu.
Sa Activate CP mode.
Sb Bin-average CP data..
Sc Display the SBE41cp calibration coefficients.
Sd Deactivate CP mode.
Sf Display SBE41cp firmware revision
Sg Enter the SBE41cp gateway mode.
Sk Configure SBE41cp.
Sm Measure the power consumption by SBE41cp.
Sn Display SBE41cp serial number
Sp Get SBE41cp pressure.
Ss Get SBE41cp P T S & O.
Ss Get SBE41cp P & T (low power).
Su Upload CP data.

> s s SBE41cp P,T,S,O: :   1.69 decibars, 24.0569C, 34.9227PSU,8026

VII. Deploying the Float

1) Pass a rope through the hole in the plastic damper plate, which is shown in the image at right. The rope should fit easily through the hole and be capable of supporting 50 kg (100 lb).

2) Holding **both** ends of the rope bight, carefully lower the float into water. The damper plate is amply strong enough to support the weight of the float. However, do not let rope slide rapidly through the hole as this may cut the plastic disk and release the float prematurely.

3) Take care not to damage the CTD or the Iridium antenna against the side of the ship while lowering the float.

4) **Do not leave the rope with the instrument.** Once the float is in the water, let go of the lower end of the rope and pull on the top end slowly and carefully until the rope clears the hole and the float is released.

    It may take several minutes for the cowling protecting the bladder to fully flood with water and the float may drift at an angle or even rest on its side during this period. This is normal behavior and not a cause for concern.

5) Manual Deployment: The float will remain on surface for the duration of the Mission Prelude.

    Pressure Activated Deployment: The float will sink immediately. It will return to the surface within 3 hours and begin the Mission Prelude after detecting a pressure in excess of 1500 dbar.

VIII. Park and Profile

The APF9I float can be set to profile from a maximum depth (Profile Depth) after a programmable number (N) of profiles from a shallower depth (Park Depth). Special cases are conducting all profiles from either the Profile Depth or the Park Depth. The latter is an important special case that can be selected by setting N = 254. This will cause all profiles to start at the Park Depth; the programmed Profile Depth is ignored. Between profiles the float drifts at the Park Depth.
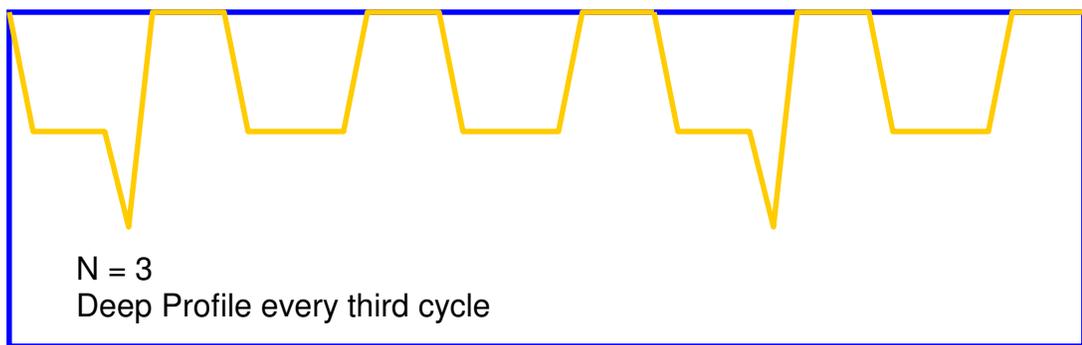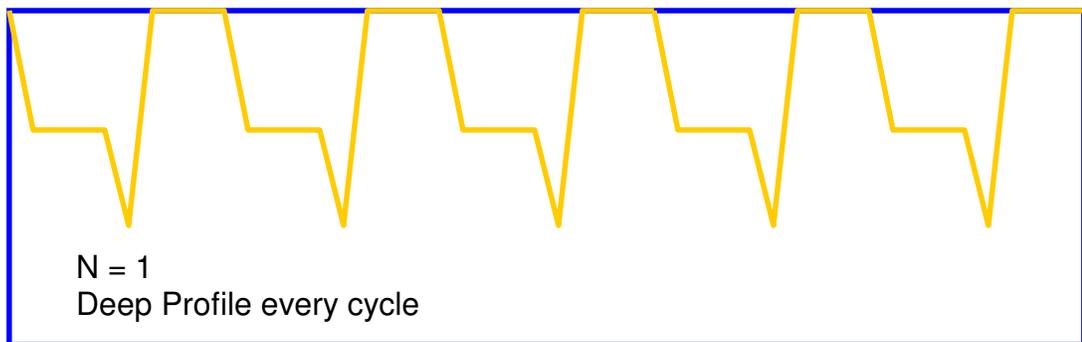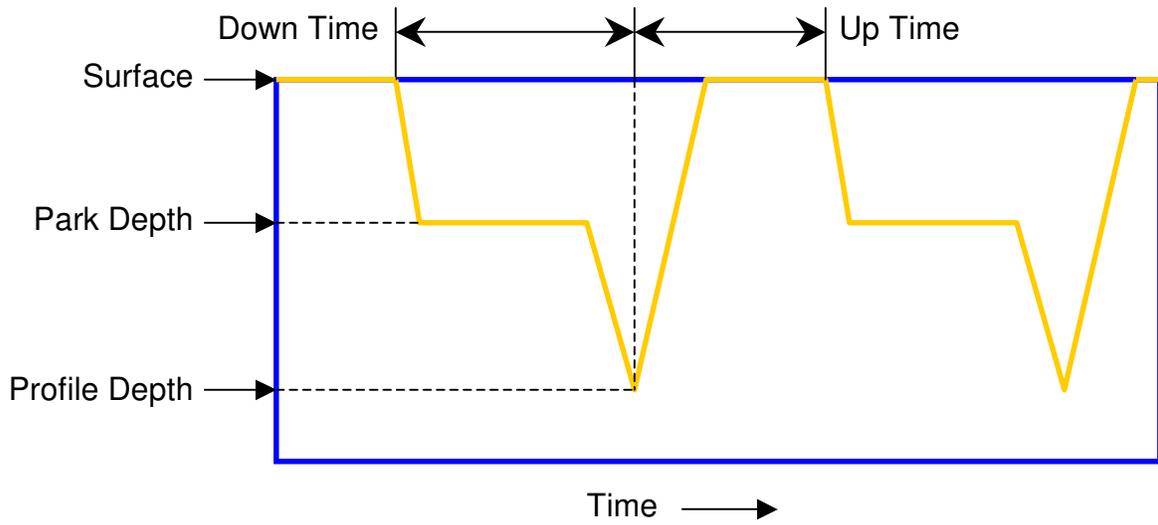
Terminology:
- Park Depth   Intermediate depth at which the float drifts between profiles and from which the float profiles in cycles not evenly divisible by N.
- Profile Depth   Maximum depth to which the float descends from the Park Depth every Nth cycle and from which each Nth profile is conducted.
- Down Time   Programmed time-limit for descending from the surface and drifting at the Park Depth. Down Time is commonly set to 10 days or to 10 days less the Up Time.
- Up Time   Programmed time-limit for ascending from the Park or the Profile Depth and drifting at the surface while transmitting the data acquired during the profile. Up Time is typically set between 12 hours and 20 hours, increasing with the amount of data to be transmitted per profile. The latitude of the deployment also matters; ARGOS satellites are in polar orbits, so the number of satellite passes per day increases with latitude.
- Ascent Rate   The ascent rate of the float is maintained at or above 8 cm/s. The float extends the piston by a user specified amount to add buoyancy when the ascent rate falls below this threshold.

A.   Profile Ascent Timing

Profiles from the Park Depth begin when the operator programmed Down Time expires. The float extends the piston by an operator programmed initial amount and begins the ascent.

When a profile is to begin from the Profile Depth, the float will retract the piston and descend from the Park Depth an operator programmed interval before the expiration of the Down Time. This interval, Parameter Mtj, Deep-profile descent time in hours, provides the additional time needed to descend to and profile from the Profile Depth without losing significant surface time, the period when data from the profile are transmitted.

B. Profile and Profile Cycle Schematics

Down Time / Up Time

Surface, Park Depth, Profile Depth

Time →

N = 1
Deep Profile every cycle

N = 3
Deep Profile every third cycle

Time →

IX.   Deep Profile First (DPF)

Independent of the Park and Profile cycle length, the first profile is always a Deep Profile that begins at the Profile Depth. This means the float returns a CTD profile relatively soon, typically less than a day, after the float is deployed. This feature supports comparison of the initial float profile with a conventional CTD cast from the ship.

The first descent begins at the end of the Mission Prelude. A schematic representation of DPF with a Park and Profile parameter N = 2 is shown below.

N = 2 and Deep Profile First (DPF)
Deep Profile on first cycle and every second cycle

Time ⟶
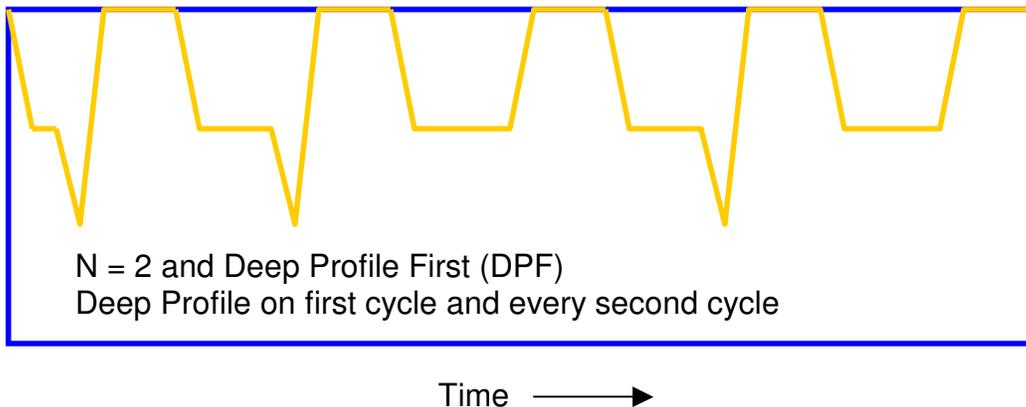
Note: For maximum battery life in ARGO applications, Teledyne Webb Research recommends use of PD > one, with park depth ≤ 1500 db.

X.   Air Pump Limits

At the beginning of each telemetry cycle the float verifies that the air bladder is fully inflated. If the pressure does not exceed the threshold, Parameter Mfb, the float will further inflate the bladder, cycling the air pump on for 1 second and off for 1 second until the pressure exceeds the threshold. The use of the air pump is limited to 2000 Volt·seconds during each profile cycle to prevent excessive battery drain in the event of a problem in the air system that prevents full inflation.

The maximum air bladder pressure is higher (6.2 inHg) in the APF9I than in ARGOS equipped floats (5.3 inHg). The higher pressure allows Iridium floats to ride higher at the surface to assure robust connectivity for the Iridium antenna.

XI.   Setting the Real-Time Clock

The APF9I is equipped with a real-time clock (RTC). The RTC can be set by the operator to any desired reference time. However, the float will automatically update the RTC each time a GPS fix is obtained if the RTC and the GPS satellite disagree by more than 30 seconds.

As a consequence, APF9I floats will end up running on GMT eventually, so the operator should only set the RTC to GMT to avoid confusion and scheduling problems. This is particularly important if the TOD feature is to be used.

To view or set the RTC, enter the Main Menu (see "Connecting a Terminal" and "APF9I Command Summary") and use the 't' command as shown in the examples below:

Viewing the RTC:

```
> t                              ← entered by operator followed by [ENTER]
Real time clock: Fri Sep 25 04:47:05 1970
```

Setting the RTC:

```
> t  07/24/2007:17:11:00         ← entered by operator as mm/dd/yyyy:hh:mm:ss
(Sep 25 1970 04:47:45,  393506 sec) ParseTime()          The time
          string represents the date Tue Jul 24 17:11:00 2007
Real time clock: Tue Jul 24 17:11:01 2007
```

The date and time must be entered in the format shown in the example above. The RTC will revert to 1970 if the batteries providing power to the APF9I are disconnected. In this case the operator should reset the RTC after restoring power to the float.

XII. Time of Day (TOD)

APF9I floats have the option of scheduling profiles so that the float surfaces at a particular time of day (TOD). The APF9I real-time clock is used to dynamically set the end of the Down Time to some user specified number of minutes after midnight. The operator must take into account any difference between the time zone of the deployment and GMT when setting this parameter. **Remember that the RTC of the float will be set to GMT whenever the float obtains a GPS fix, so you cannot control the time zone of the RTC.** This is described in more detail below.

The TOD feature is applied by the float as follows:

- At the start of a descent (end of Up Time), the APF9I computes a Down Time expiration based on the Down Time programmed by the operator.
- If the TOD feature is <u>disabled</u>, the Down Time will expire at that calculated time of the RTC.
  - For example, if the Down Time is set to 120 hours (10 days) and the Up Time ends at 14:00 on July 10, 2007, the next Down Time will expire at 14:00 on July 20, 2007.
- If the TOD feature is <u>enabled</u>, the float extends the Down Time expiration to the next occurrence of "TOD minutes after midnight" on the RTC.
  - For example, if the initial calculation placed the Down Time expiration at 14:00 on July 20, 2007 (as above), but the TOD was enabled and set to 1200 minutes (20 hours after midnight), the Down Time would be extended from 14:00 and set to expire at the next occurrence of 20:00, which is 20:00 on July 20, 2007.

Active ballasting and all other Down Time behaviors continue until the Down Time expires. This will be until 14:00 in the first example and until 20:00 in the second example.

Controlling TOD

The TOD feature must be manually enabled by the operator. This is done by entering the Mission Programming Agent ('m' from Main Menu, see "Connecting a Terminal" and "APF9I Command Summary") and setting Parameter Mtc to an allowed value in minutes. Setting Parameter Mtc to no value will disable the TOD feature.

Enabling TOD

```
> t c 360                          ← entered by operator followed by [ENTER]
The down-time will expire at 360 Minutes after midnight.
```

Disabling TOD

```
> t c                              ← entered by operator followed by [ENTER]
The time-of-day feature has been disabled.
```

Shifting the Time Zone

Because the RTC is necessarily set to GMT, the operator must account for the time zone difference between the float and GMT in setting TOD. For example, assume:

- The float will be deployed in the eastern Pacific (10 hours behind GMT, 12:00 GMT is 02:00 in the eastern Pacific)
- The operator wishes to use the TOD feature to set Down Time expiration to 20:00 in the local time zone

20:00 in the local time zone is 06:00 GMT (10 hours later). Therefore, set TOD to 360 minutes (6 hours). Down Time will expire at 06:00 GMT, which is 20:00 in the local time zone.

Selecting a TOD Value

To select a TOD value, you must first decide what time you wish the float to surface. Then calculate the approximate duration of the profile, which begins with the expiration of the Down Time. The calculation is based on the programmed depth from which the float will ascend and assumes an ascent speed of 0.08 dbar per second.

For example, a 1200 dbar profile requires approximately 4 hours.[1] If you wish to have the float reach the surface at approximately 02:00, set TOD so that the Down Time will expire 4 hours earlier. Four hours earlier is 22:00, which is 1320 minutes after midnight. Therefore set TOD to 1320 minutes.

If profiles are to be conducted from both the Park Depth and the Profile Depth and the operator wishes the float to reach the surface at a consistent time, the Deep-profile descent time, Parameter Mtj, must be set to a reasonable value for the descent from the Park Depth to the Profile Depth. See "Profile Ascent Timing" for additional information.

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[1] (1200 dbar / 0.08 dbar/sec) / 3600 sec/hr = 4.16 hours

XIII. Iridium Data

A.   Iridium Service and Costs

Each float operator must obtain an Iridium SIM card (Subscriber Identity Module) for each APF9I float. SIM cards are obtained from an Iridium provider who you will need to locate and choose. Iridium charges can be a significant expense and it is worth shopping for a good rate. There are a number of providers and the list is not restricted because the connection is coming from a float in the ocean.

Teledyne Webb Research uses STRATOS:

- http://www.stratosglobal.com/StratosGlobal.cfm
- +1-709-748-4233 (Sales Support Worldwide)
- +1-709-748-4280 (Billing Worldwide)

The University of Washington, a customer with a large and growing fleet of APEX floats, uses NAL Research:

- http://www.nalresearch.com/Airtime.html
- +1-703-393-1136 x200

Some Iridium providers are "data only". This is appropriate for a float and is the type of service for which you should ask. Like the service, the SIM card should also be "data only".

You will need to send the SIM card and the unlocking PIN to Teledyne Webb Research for us to be able to build and test the float. If you do not change the PIN from the factory default value you will not need to provide the PIN.

Please keep a record of the SIM card's serial number (ICCID) and phone number (MSISDN). Both numbers are essential and must stay together as a pair. The firmware includes a command, Parameter Hs, to query and display the ICCID and MSISDN of the SIM card. Similarly, please keep a record of the float's Iridium modem (LBT) serial number (IMEI). Parameter Hi will query and display the IMEI of the LBT.

Billing for Iridium service is monthly. Teledyne Webb Research will give you notice 30 days prior to shipment so that you can activate your SIM card. The card must be activated for Teledyne Webb Research to test the float. The monthly cost for a SIM card is typically $30.00 (USD). Calls from the float to the host server are charged by the minute (or fraction there of) at $1.50/minute. Average data transfer rates are in the range 6 Kbytes to 10 Kbytes per minute. Anticipate 20 Kbytes to 50 Kbytes of data for each profile. Typical connection times at the surface are 5 to 10 minutes. Please note that these are approximate costs. Your actual costs will vary with provider and use.

B.   The Float's Iridium Modem and Two-Way Communications

The float's Iridium modem (LBT) is a Model 9522A L-Band Transceiver made by Iridium Satellite, LLC. Peak RF power during transmission is 7 Watts. The LBT is mounted inside the float and is configured for use by Teledyne Webb Research during production. No user configuration or adjustment is required. Production testing includes full verification of float to host server communications. This is the reason for requiring activation of the SIM card 30 days in advance of shipment. Your reception capabilities must also be in place at that time (see "Modem-to-Modem vs. RUDICS").

When the float surfaces at the end of a profile the LBT is used to "register" with the Iridium system. This verifies that the float is able to see the sky. The float then disconnects from the Iridium system and uses the antenna to acquire a GPS fix. The fix is included in the data file returned to the host server (see "Iridium Data"). The LBT is then used to re-register with the Iridium system, upload hydrographic (10 - 20 Kbytes) and engineering (12 - 25 Kbytes) data files, and download any changes to the mission parameters (< 1 Kbyte).

The download file, mission.cfg, is stored on the host server and can be edited there when it is desirable to change the mission parameters. Each active line in the configuration file has the form:

```
ParameterName(argument) [CRC]
```

Inactive lines (comments) start with a '#' character. The CRC can be calculated using a Linux based utility, *chkconfig*, which is part of a software package developed at the University of Washington (see "Modem-to-Modem vs. RUDICS"). A mission.cfg template, which includes all of the mission parameters that interact with each other, is shown below:

```
AscentTimeOut(Minutes)
DeepProfileDescentTime(Minutes)
DeepProfilePistonPos(Counts)
DeepProfilePressure(Decibars)
DownTime(Minutes)
ParkDescentTime(Minutes)
ParkPistonPos(Counts)
ParkPressure(Decibars)
PnPCycleLen()
UpTime(Minutes)
```

The *chkconfig* utility performs parameter sanity checks, so it is a good idea to include all of the commands above so that their safe interaction can be verified before the new configuration is downloaded by the float.

The mission.cfg file should not be empty, but it is sufficient to include only a comment or just a benign command such as `Verbosity(2)` if you do not wish to make any changes.

Other available configuration commands, which do not have interactive dependencies, are:

```
ActivateRecoveryMode()
AirBladderMaxP(Counts)
AtDialCmd()
AltDialCmd()
ConnectTimeOut(Seconds)
CpActivationP(Decibars)
FlashErase()
FlashCreate()
FloatId()
MaxLogKb(Kilobytes)
Pwd()
TelemetryRetry(Minutes)
TimeOfDay(Minutes)
UpTime(Minutes)
User()
Verbosity()
```

Several of these commands should only be used if absolutely required and then only with caution. For example, DO NOT change both the primary and the alternate dial commands at the same time.

Conversely, commands such as CpActivationP(Decibars) might be used frequently to adjust the range of high resolution sampling in response to observations of the water column returned by previous profiles.

C.   Modem-to-Modem vs. RUDICS

For modem-to-modem communications you will need independent primary and alternate host servers, each with a modem connected to the phone system to receive the calls and data from the float. A full description of this equipment and software is beyond the scope of this manual. However, Teledyne Webb Research makes regular use of U.S. Robotics external modems, Model USR3453C, Courier™ 56K Business Modem.

A Linux-based modem-to-modem solution has been developed by Dana Swift at the University of Washington. The software and documentation are available in a "tarball" at no charge; however, it requires some level of Linux expertise on your part to implement. If you are experienced with Linux the process is quite straightforward. You will need to acquire the servers, install and configure Linux, and reconcile any differences between the version of Linux on your host servers and the version of Linux under which the distribution was developed (RedHat Linux 9). The package automates the reception of data messages from multiple floats and fully supports two-way communication. Some user developed documentation of the implementation process is included in the appendices of this manual (see "Host Server and Modem Setup"). Additional Linux based packages for data processing are also available with limited support. Contact Teledyne Webb Research for further information.

An alternative modem-to-modem solution, particularly if you are not comfortable with Linux or do not wish to set up and maintain host servers, is to contract out the reception of the calls and have the data provided to you by email, FTP, or web server. The contractor is then responsible for maintaining the servers and modems. This is similar to the long-standing ARGOS system. There are providers available, see below, and you may wish to investigate this possibility. Contact Teledyne Webb Research for additional information.

Another option is RUDICS, which is available from several providers. These include Iridium Satellite, LLC and NAL Research, Inc. RUDICS is Internet rather than phone system based, which provides additional connection redundancy. The float makes calls as before and these are received at the Iridium ground station. The data are then made available to you using a browser and through a website set up by your RUDICS provider. You do not need to maintain a host server and will only need a computer with broadband Internet access. RUDICS has a large setup cost, but subsequent data costs and connection times are lower compared to modem-to-modem systems.

The most cost effective solution will depend on your level of expertise, the number of floats you are using, and their pattern of use. For a large fleet a combination of RUDICS and modem-to-modem may be needed to provide adequate redundancy.

CLS America, Inc., formerly Service Argos, Inc., is currently building an Iridium data processing capability that will provide SBD and RUDICS data services. CLS America expects this service to be available at or near the beginning of calendar year 2008. Contact Bill Woodward at CLS America for further information.

CLS America, Inc.
Bill Woodward, President
+1-301-925-4411
bwoodward@clsamerica.com
http://www.clsamerica.com

D. Bearer Service Type

The bearer service type (BST) specifies two characteristics of the phone call made from a modem at the Iridium ground station (where the signal from the satellite is received) to the modem on the host server where you are receiving the call and data from the float. These two characteristics of the call from the gateway modem to the server modem are:

- analog (tone) vs. digital (ISDN)
- serial baud rate

The default in many cases is digital. A problem can arise if your local phone company has only a limited number of ISDN lines available. The likely symptom during pre-deployment testing is a report from the float of "No carrier detected". This may occur either before or after a connection is established.

The solution is to force the conversation to be analog. This can be done by embedding a "CBST" command in the Primary and/or Alternate Dial Commands, Parameters Mhp and Mha. A standard dial command has the form:

ATDT0012223334444

ATDT is a command to the modem, 00 is the required calling prefix, and 12223334444 is the phone number of your modem, beginning with the country code. To embed the CBST command, alter the dial command as follows:

AT+CBST=7,0,1;DT0012223334444

The first argument of the CBST command, a '7' in the example above, specifies the baud rate according to the table below. First argument values from the table (0, 1, 2, 4, 6, and 7) also force the conversation to be analog. Your server modem should be set to match the commanded baud rate (or auto select). The second and third CBST arguments are always '0' and '1'.

CBST	Baud Rate
0,0,1	auto
1,0,1	300
2,0,1	1200
4,0,1	2400
6,0,1	4800
7,0,1	9600

E.   Iridium Data

Iridium message files are easily read and displayed ASCII text files and are named with a ".msg" extension. Each message file contains five blocks of data, only one of which requires unpacking. The other blocks are sent in "human readable" form. The five blocks are:

- Park Phase PT samples - hourly, low-power Pressure-Temperature measurements acquired while the float drifts at Park Depth.
- Low resolution PTSO samples - Pressure-Temperature-Salinity-Oxygen measurements collected according to the Depth Table (see "Pressure Table for PTOS Samples"). These samples are acquired while the float is deeper than the Continuous profile activation pressure, Parameter Mc.
- High resolution PTSO samples - 2-dbar bin averages of continuous (1 Hz) Pressure-Temperature-Salinity-Oxygen measurements. These samples are acquired while the float is shallower than the Continuous profile activation pressure, Parameter Mc.
- GPS fixes - location fix acquired when the float surfaces.
- Biographical and engineering data - float information acquired at various times during the profile cycle.

Generally only one telemetry cycle is required to successfully upload the message file to the server. If additional telemetry cycles are required, the float will first acquire an additional GPS fix and then append updated versions of blocks 4 and 5 to the original message for each additional cycle.

More detailed descriptions of each data block, with examples, are provided below.

Park-Phase PT Samples

An example of Park Phase PT samples collected at hourly intervals is shown below. The pressure and temperature data are presented in physical units (decibars, °C). No unpacking step is required. Active ballasting is conducted during the Park Phase and these measurements show the float "hunting up" to a programmed Park Depth. The Unix Epoch is seconds since 00:00:00 on January 1, 1970. MTime is seconds since the start of the current profile.

```
        |------- date -----|   UnixEpoch    MTime       P        T
ParkPt:  Sep 26 2006 20:50:07  1159303807   21614 1030.97   5.0535
ParkPt:  Sep 26 2006 21:50:04  1159307404   25211 1030.45   5.0817
ParkPt:  Sep 26 2006 22:50:04  1159311004   28811 1031.25   5.0639
ParkPt:  Sep 26 2006 23:50:04  1159314604   32411 1025.51   5.0477
ParkPt:  Sep 27 2006 00:50:04  1159318204   36011 1026.95   5.0784
ParkPt:  Sep 27 2006 01:50:04  1159321804   39611 1026.81   5.0511
ParkPt:  Sep 27 2006 02:50:04  1159325404   43211 1014.43   5.1526
ParkPt:  Sep 27 2006 03:50:04  1159329004   46811 1013.95   5.1673
ParkPt:  Sep 27 2006 04:50:04  1159332604   50411 1011.40   5.1861
ParkPt:  Sep 27 2006 05:50:04  1159336204   54011  993.80   5.2302
```

Low Resolution PTSO Samples

The SBE-41cp can operate in either of two modes - low resolution spot sampling or high resolution continuous sampling. Spot samples are single PTSO measurements taken according to the programmed Depth Table (see "Pressure Table for PTSO Samples"). During continuous sampling the CTD makes measurements and then calculates and provides 2-dbar bin averaged measurements to the float. Both modes are typically used during a float profile. Spot sampling is performed when the float is deeper than the Continuous profile activation pressure (Parameter Mc, decibars) and continuous sampling used when the float is shallower than this operator programmed threshold. An example of the low resolution Depth Table based measurements is shown below. The data are delivered in human readable form in physical units of decibars, °C, and PSU. No unpacking step is required.

This firmware was designed for iridium floats with an SBE43 (a.k.a. IDO) oxygen sensor. The IDO sensor does not report the actual oxygen concentration. Instead, it reports the "oxygen frequency" (Hertz) that requires additional processing to obtain oxygen concentration via calibration equations. The calibration equations are expressed in terms of calibration coefficients that are specific to individual IDO sensors

```
$ Discrete samples: 22
$       p       t       s  ofreq
  1000.99   3.8633  34.4704   4073 (Park Sample)
  1998.44   2.1449  34.6194   4699
  1949.02   2.2140  34.6145   4685
  1899.05   2.2602  34.6102   4661
  1849.34   2.3056  34.6082   4638
  1799.28   2.3576  34.6041   4616
  1748.29   2.4284  34.5999   4604
  1698.73   2.4919  34.5946   4573
```

High Resolution PTSO Samples

The 2-dbar bin averaged data are delivered in mildly compressed form to reduce bandwidth requirements. These are the only data in an Iridium message file that are not delivered in human readable form and physical units.

These measurements are encoded as hexadecimal characters with one full ASCII byte for each character ("ASCII encoded hex"). Four characters thus represent a single 16-bit integer. Each measurement is comprised of a PTS triplet (three 16-bit integers), a 16-bit oxygen frequency and an 8-bit integer that records the number of 1 Hz measurements that were averaged in that 2-dbar bin. The resolution of the encoded data is summarized in the table below:

Sensor	Measurement	Resolution
SBE-41cp	Temperature	0.001 °C (1 millidegree C)
	Salinity	0.001 psu
	Pressure	0.1 dbar

An example from an Iridium message file is shown below:

```
# Nov 11 2006 08:17:34 Sbe41cpSerNo[1140] NSample[4192] NBin[488]
      000000000000000000[2]
      002964D8899629A70C
      003C64DA899629A30C
      005064DA899629A20C
      006464DD899629A10A
      007864DE8996299C0B
      008C64E18996299A0B
      00A064E28996299A0A
      00B464E5899629980B
      00C964E3899629940A
      00DD64E2899629930A
      00F064E48996299009
      010564E48996298C0A
      011864E68996298A09
      012C64E6899629880B
      [snippage...]
      25F80FA486A30FD80E
      260C0FA286A30FDA0F
```

- The first set of four hex characters represents the pressure in centibars.
- The second of four hex characters represents the temperature in millidegrees.
- The third set of four hex characters represents the salinity in parts per million (ppm).
- The next 4-bytes represent the oxygen frequency in Hertz.
- The final set of two hex characters represents the number of samples in the average.
- Integers in square brackets after the data, e.g., [2], indicate repeated instances of the same encoded line. In the example above there were two all zero messages in sequence.

 For example, the encoding: 260C0FA286A30FDA0F represents a bin with (0x0F=) 15 samples where the mean pressure was (0x260C=) 974.0dbars, the mean temperature was (0x0FA2=) 4.002C, the mean salinity was (0x86A3=) 34.467PSU, and the mean oxygen frequency was (0x0FDA=) 4058Hz. The PTSO values were encoded as 16-bit hex integers according to the functions   below.

Integers in square brackets '[]' indicate replicates of the same encoded line. For example, a line that looks like: 00000000000000000[2] indicates that there were 2 adjacent lines with the same encoding....all zeros in this case.

A complete specification for unpacking the high resolution hydrographic data, including negative values, can be found in the "Conversion Notes" below.

Conversion Notes:

The pressure range is -3276.7 dbar to 3276.7 dbar. Hex values 0x7FFF, 0x8000, 0x8001, and 0xFFFF are used to flag out-of-range (and edge-of-range) measurements or are otherwise reserved. Pressures in the range -0.15 dbar to -0.05 dbar are mapped to 0xFFFE → -0.2 dbar.

The temperature range is -4.095 °C to 61.439 °C. Hex values 0xF000, 0xF001, 0xEFFF, and 0xFFFF are used to flag out-of-range (and edge-of-range) measurements or are otherwise reserved. Temperatures in the range -0.0015 °C to -0.0005 °C are mapped to 0xFFFE → -0.002 °C.

The salinity range is -4.095 psu to 61.439 psu. Hex values 0xF000, 0xF001, 0xEFFF, and 0xFFFF are used to flag out-of-range (and edge-of-range) measurements or are otherwise reserved. Salinities in the range -0.0015 psu to -0.0005 psu are mapped to 0xFFFE → 65.534 psu.

The O2 frequency range is -4095 to 61439. Hex values 0xF000 (nonfinite), 0xF001 (≤ -4095), 0xEFFF (≥ 61439), and 0xFFFF (missing data) are used to flag out-of-range measurements or are otherwise reserved. Temperatures in the range -0.0015 °C to -0.0005 °C are mapped to 0xFFFE.

To convert the hex values in an Iridium message file to physical units, proceed as described in the table below. The initial conversion from Hexadecimal to Decimal should assume the hex value is an unsigned integer with a range of 0 to 65535.

Measurement	Hexadecimal [Decimal comparison]	Decimal and Conversion Steps	Physical Result
Pressure ≥ 0	0x1D4C (≤ 0x7FFF) → [7500 (≤ 32767)]	P = 7500 P / 10 →	750.0 dbar
Pressure < 0	0xFFFA (≥ 0x8001) → [65530 (≥ 32769)]	P = 65530 (P - 65536) / 10 →	-0.6 dbar
Temperature ≥ 0	0x3EA6 (≤ 0xEFFF) → [16038 (≤ 61439)]	T = 16038 T / 1000 →	16.038 °C
Temperature < 0	0xF58B (≥ 0xF001) → [62859 (61441)]	T = 62859 (T - 65536) / 1000 →	-2.677 °C
Salinity ≥ 0	0x8FDD (≤ 0xEFFF) → [36829 (≤ 61439)]	S = 36829 S / 1000 →	36.829 psu
Salinity < 0	0xFF9C (≥ 0xF001) → [65436 (≥ 61441)]	S = 65436 (S - 65536) / 1000 →	-0.100 psu

O2 ≥ 0	0x3EA6 (<0xEFFF) →	$O2_{raw} = 16038$
		$O2 = O2_{raw} \rightarrow$ 16038
O2 < 0	0xF58B (≥ 0xF001) →	$O2_{raw} = 62859$
		$O2_{2sComplement} = O2_{raw} - 65536$ -2677

GPS Fixes

Before each telemetry cycle the float attempts to acquire a GPS fix. An example of a successful fix, as reported in an Iridium message file, is shown below. The information includes the latitude and longitude of the float, time required to obtain the location, the date and time the information was acquired, and the number of satellites used. Longitude is positive in the eastern hemisphere and negative in the western hemisphere. Latitude is positive in the northern hemisphere and negative in the southern hemisphere. Date and time are presented in the format shown in the example.

```
# GPS fix obtained in 98 seconds.
#        lon     lat mm/dd/yyyy hhmmss nsat
Fix: -152.945  22.544 09/01/2005 104710     8
```

If the float is not able to obtain a GPS fix this block of the message file will instead contain the message below:

```
# Attempt to get GPS fix failed after 600 seconds.
```

Biographical and Engineering Data

The biographical and engineering data occupy the last block in the Iridium message file. These data have the form "key"="value". An example is shown below.

```
ActiveBallastAdjustments=5
AirBladderPressure=119
AirPumpAmps=91
AirPumpVolts=192
BuoyancyPumpOnTime=1539
```

Interpretation of this information requires detailed knowledge of the firmware. A full description is beyond the scope of this manual. Contact Teledyne Webb Research for assistance. General conversions for voltage, current and vacuum are provide below.

Volts	V	8 bits unsigned	$V = (V_{raw} * 0.077 + 0.486)$
Current	MA	8 bits unsigned	$I = (I_{raw} * 4.052) - 3.606$
Vacuum	InHg	8 bits unsigned	$V = (V_{raw} * 0.293) - 29.767$

F.   Pressure Table for PTSO Samples

The Pressure Table, below with values expressed in decibars (dbar), defines where discrete PTSO measurements are acquired during a profile. The change to continuous profiling is controlled by Parameter Mc, Continuous profile activation pressure (decibars). Discrete PTSO samples are taken according to the Pressure Table when the measured pressure is greater than the activation pressure. PTSO sampling is continuous (1 Hz) with 2 dbar bin averages reported when the measured pressure is less than the activation pressure.

Depth Table 26, below, with values expressed in decibars (dbar), defines where PTSO measurements are acquired during a profile.

2000.0	1950.0	1900.0	1850.0	1800.0	1750.0	1700.0	1650.0
1600.0	1550.0	1500.0	1450.0	1400.0	1350.0	1300.0	1250.0
1200.0	1150.0	1100.0	1050.0	1000.0	950.0	900.0	850.0
800.0	750.0	700.0	650.0	600.0	550.0	500.0	450.0
400.0	380.0	360.0	350.0	340.0	330.0	320.0	310.0
300.0	290.0	280.0	270.0	260.0	250.0	240.0	230.0
220.0	210.0	200.0	190.0	180.0	170.0	160.0	150.0
140.0	130.0	120.0	110.0	100.0	90.0	80.0	70.0
60.0	50.0	40.0	30.0	20.0	10.0	6.0	0.0

To prevent fouling of the CTD by surface and near-surface contaminants, the APF9I halts continuous profiling 4 dbar deeper than the most recent surface pressure measurement. As an additional safety feature, the SBE41cp will stop sampling when the measured pressure reaches 2 dbar if it has not already been halted by the float.

XIV. Missions

This section lists the parameters for each float covered by this manual.
To display the parameter list, connect a communications cable to the float, press <ENTER> to wake the float from hibernate and start command mode, and press 'l' or 'L' to list the parameters.
See "Connecting a Terminal" and "APF9I Command Summary" for more information.

INSTRUMENT # 4394
 APEX version 051707 sn 6412

INACTV ToD for down-time expiration. (Minutes)   Mtc
 07200 Down time. (Minutes)   Mtd
 00420 Up time. (Minutes)   Mtu
 00300 Ascent time-out. (Minutes)   Mta
 00060 Deep-profile descent time. (Minutes)   Mtj
 00300 Park descent time. (Minutes)   Mtk
 00360 Mission prelude. (Minutes)   Mtp
 00015 Telemetry retry interval. (Minutes)   Mhr
 00060 Host-connect time-out. (Seconds)   Mht
  985 Continuous profile activation. (Decibars) Mc
 1000 Park pressure. (Decibars)   Mk
 1000 Deep-profile pressure. (Decibars)   Mj
 016 Park piston position. (Counts)   Mbp
 016 Deep-profile piston position. (Counts)   Mbj
 010 Ascent buoyancy nudge. (Counts)   Mbn
 022 Initial buoyancy nudge. (Counts)   Mbi
 254 Park-n-profile cycle length.   Mn
 124 Maximum air bladder pressure. (Counts)   Mfb
 096 OK vacuum threshold. (Counts)   Mfv
 226 Piston full extension. (Counts)   Mff
 016 Piston storage position. (Counts)   Mfs
   2 Logging verbosity. [0-5]   D
 0002 DebugBits.   D
 f540 Mission signature (hex).

INSTRUMENT # 4395

APEX version 051707 sn 6413

INACTV ToD for down-time expiration. (Minutes)   Mtc
00360 Down time. (Minutes)   Mtd
00240 Up time. (Minutes)   Mtu
00120 Ascent time-out. (Minutes)   Mta
00120 Deep-profile descent time. (Minutes)   Mtj
00120 Park descent time. (Minutes)   Mtk
00360 Mission prelude. (Minutes)   Mtp
00015 Telemetry retry interval. (Minutes)   Mhr
00060 Host-connect time-out. (Seconds)   Mht
  985 Continuous profile activation. (Decibars) Mc
  300 Park pressure. (Decibars)   Mk
  300 Deep-profile pressure. (Decibars)   Mj
  070 Park piston position. (Counts)   Mbp
  070 Deep-profile piston position. (Counts)   Mbj
  010 Ascent buoyancy nudge. (Counts)   Mbn
  022 Initial buoyancy nudge. (Counts)   Mbi
  254 Park-n-profile cycle length.   Mn
  124 Maximum air bladder pressure. (Counts)   Mfb
  096 OK vacuum threshold. (Counts)   Mfv
  225 Piston full extension. (Counts)   Mff
  016 Piston storage position. (Counts)   Mfs
    2 Logging verbosity. [0-5]   D
 0002 DebugBits.   D
 d9f4 Mission signature (hex).

Appendix A: Storage conditions

For optimum battery life, floats should be stored in a controlled environment in which the temperature is restricted to the range +10 °C to +25 °C. When activated, the floats should be equilibrated at a temperature between -2 °C and +54 °C before proceeding with a deployment.

If the optional VOS or aircraft deployment containers are used, they must be kept dry, and should only be stored indoors.

Appendix B: Connecting a Terminal

The float can be programmed and tested by an operator using a 20 mA current loop and a terminal program. The current loop has no polarity. Connections should be made through the hull ground and a connector or fitting that is electrically isolated from the hull. This is shown in the image below. In this case one side of the current loop is clipped to the zinc anode and the other is clipped to the pressure port.

The communications cables and clamps are included in the float shipment. An RS-232 to current-loop converter is provided with the communications cables. This converter requires a 12 VDC supply.

The RS-232 communications cable should be connected to the COM port of a PC. Run a communications program such as ProComm or HyperTerminal on the PC. Both programs can be downloaded from various Internet sites. HyperTerminal is generally included with distributions of the Windows Operating System.

COM Port Settings: 9600, 8, N, 1
- 9600 baud
- 8 data bits
- No parity
- 1 stop bit
- no flow control / no handshaking
- full duplex

Teledyne Webb Research recommends the practice of capturing and archiving a log file of all communications with each float. If in doubt about a test, email the log file to your chief scientist and/or to Teledyne Webb Research.

Once you have started the communications program and completed the connections described above, press [ENTER] to wake the float from Hibernate mode. The float will respond that it has detected an "asynchronous wake-up" and will enter Command mode. Press [ENTER] in Command mode to display the main menu. Menu selections are not case sensitive. See "APF9I Command Summary" for a complete list of available commands.

Appendix C: APF9I Command Summary

Uppercase commands are used here for clarity; however, APF9I commands are not case sensitive. The menus presented below were copied verbatim from a terminal session with an APF9I controller. ">" is the APF9I prompt for operator input. The first menu is displayed in response to either a question mark ("?") or the [ENTER] when no preceding command is entered.

Main Menu (Command Mode)

```
> ?
Menu selections are not case sensitive.
?  Print this help menu.
A  Initiate pressure-activation of mission.
C  Calibrate: battery volts, current, & vacuum.
D  Set logging verbosity. [0-5]
E  Execute (activate) mission.
G  GPS module agent.
G? GPS module menu.
H  LBT module agent.
H? LBT module menu.
I  Diagnostics agent.
I? Diagnostics menu.
J  FLASH file system agent.
J? FLASH file system menu.
K  Kill (deactivate) mission.
L  List mission parameters.
M  Mission programming agent.
M? Mission programming menu.
N  Display float serial number.
P  Display the pressure table.
Q  Exit command mode.
R  Activate recovery mode.
S  Sensor module agent.
S? Sensor module menu.
T  Get/Set RTC time. (format 'mm/dd/yyyy:hh:mm:ss')
U  Attach the logstream to a specified file.
V  Close the log file.
```

The sub-menus shown below, GPS (G?), LBT (H?), File System (J?), CTD (S?), and System Diagnostics (I?), are all accessible from the Main Menu (Command Mode) using the appropriate letter and question mark combination. The float remains in command mode when displaying these sub-menus, so the Main Menu commands remain active. Entering the Mission programming agent (M), however, exits from command mode until you quit (Q) the Mission Programming Agent. List Mission Parameters (L) is an active command in both Command Mode and the Mission Programming Agent.

Command Mode Sub-Menus

GPS Menu

```
> G ?
Menu of Garmin GPS15L-W functions.
?  Print this menu.
Ga Upload almanac to GPS15L-W.
Gc Configure the GPS15L-W.
Gf Get GPS15L-W fix.
Gl Log NMEA sentences from GPS15L-W.
Gt Synchronize the Apf9 clock with GPS.
```

LBT Menu (Iridium Modem)

```
> H ?
Menu of modem functions.
?  Print this menu.
Hc Configure the modem.
Hf Query modem's firmware revision.
Hi Query modem's IMEI number.
Hm Query modem's model.
Hr Register the LBT with the Iridium system.
Hs Query SIM card's ICCID & MSISDN numbers.
```

FLASH File System Menu

```
> J ?
Menu of FLASH file system functions.
?  Print this menu.
Jb Print bad-block list.
Jc Create FLASH file system (destructive).
Jd Print the FLASH chip identifier.
Je Erase the FLASH file system (destructive).
Jl Print directory listing of FLASH file system.
Jr Report FLASH errors since file system creation.
Jz Reset FLASH error counters to zero.
```

Command Mode Sub-Menus (continued)

Sensor Menu (Seabird SBE-41cp)

```
> S ?
Menu of SBE41cp functions.
?  Print this menu.
Sa Activate CP mode.
Sb Bin-average CP data.
Sc Display the SBE41cp calibration coefficients.
Sd Deactivate CP mode.
Sf Display SBE41cp firmware revision.
Sk Configure the SBE41cp.
Sm Measure power consumption by SBE41cp.
Sn Display SBE41cp serial number.
Sp Get SBE41cp pressure.
Ss Get SBE41cp P T S & O.
St Get SBE41cp P & T (low-power).
Su Upload CP data.
```

System Diagnostics Menu

```
> I ?
Menu of diagnostics.
?  Print this menu.
a  Run air pump for 6 seconds.
b  Move piston to the piston storage position.
c  Close air valve.
d  Display piston position
e  Extend the piston 4 counts.
g  Goto a specified position. [1-254] (counts)
l  Set maximum engineering log size. [5-63] (KB)
o  Open air valve.
r  Retract the piston 4 counts.
s  Execute the SelfTest().
t  Calculate ToD down-time expiration.
1  Run air pump for 6 seconds (deprecated).
5  Retract the piston 4 counts (deprecated).
6  Extend the piston 4 counts (deprecated).
7  Display piston position (deprecated).
8  Open air valve (deprecated).
9  Close air valve (deprecated).
```

Mission Programming Agent

The interaction recorded below shows the operator entering the Mission Programming Agent from Command Mode (M), displaying the available commands (?), and quitting the agent (Q) to return to Command Mode. Note that the system performs sanity checks on the mission parameters when leaving the Mission Programming Agent. Warnings will be displayed if problems are detected.

```
> M Entering Mission Programming Agent
> ?
Menu selections are not case sensitive.
?  Print this menu.
A  Self-activation pressure. [25-1500] (dbars)
B  Buoyancy control agent.
Bi    Ascent initiation buoyancy nudge. [25-254] (counts)
Bj    Deep-profile piston position. [1-254] (counts)
Bn    Ascent maintenance buoyancy nudge. [5-254] (counts)
Bp    Park piston position [1-254] (counts)
C  Continuous profile activation pressure (decibars).
F  Float vitals agent.
Fb    Maximum air-bladder pressure. [1-254] (counts)
Ff    Piston full extension. [1-254] (counts)
Fs    Storage piston position. [1-254] (counts)
Fv    OK vacuum threshold. [1-254] (counts)
H  Host configuration agent.
Ha    Dial command for alternate host.
Hp    Dial command for primary host.
Hr    Telemetry retry interval. [1-60 minutes].
Ht    Host-connect time-out. [30-300 seconds].
J  Deep-profile pressure. (0-2000] (decibars)
K  Park pressure. (0-2000] (decibars)
L  List mission parameters.
N  Park and profile cycle length. [1-254]
Q  Quit the mission programming agent.
T  Mission timing agent.
Ta    Ascent time-out period. [120-600] (Minutes)
Tc    Time-of-day for expiration of down-time [0-1439] (Minutes).
Td    Down time (0-336 hours] (Minutes).
Tj    Deep-profile descent time. [0-480] (Minutes).
Tk    Park descent time. (0-480] (Minutes).
Tp    Mission prelude. (0-360] (Minutes).
Tr    Telemetry retry interval. [1-360] (Minutes).
Tu    Up time (0-1440] (Minutes).
Z  Analyze the current mission programming.
> Q
All constraints and sanity checks passed.
Quiting Mission Programming Agent.
>
```

(← typographical error in the firmware, range is [1-360])

Listing Mission Parameters

```
> L
 APEX version 062907  sn 1215
INACTV ToD for down-time expiration. (Minutes)    Mtc
 14400 Down time. (Minutes)                        Mtd
 00660 Up time. (Minutes)                          Mtu
 00540 Ascent time-out. (Minutes)                  Mta
 00360 Deep-profile descent time. (Minutes)        Mtj
 00360 Park descent time. (Minutes)                Mtk
 00480 Mission prelude. (Minutes)                  Mtp
 00015 Telemetry retry interval. (Minutes)         Mhr
 00060 Host-connect time-out. (Seconds)            Mht
  1200 Mission activation pressure. (Decibars)     Ma
   985 Continuous profile activation. (Decibars)   Mc
  1000 Park pressure. (Decibars)                   Mk
  2000 Deep-profile pressure. (Decibars)           Mj
   066 Park piston position. (Counts)              Mbp
   016 Deep-profile piston position. (Counts)      Mbj
   010 Ascent buoyancy nudge. (Counts)             Mbn
   022 Initial buoyancy nudge. (Counts)            Mbi
   001 Park-n-profile cycle length.                Mn
   124 Maximum air bladder pressure. (Counts)      Mfb
   096 OK vacuum threshold. (Counts)               Mfv
   227 Piston full extension. (Counts)             Mff
   016 Piston storage position. (Counts)           Mfs
     2 Logging verbosity. [0-5]                     D
  0002 DebugBits.                                   D
  413e Mission signature (hex).
```

Note that Mission Parameters are changed by entering the Mission Programming Agent (M) from the Main Menu (Command Mode).

Appendix D: Returning APEX floats for factory repair or refurbishment

Contact Teledyne Webb Research before returning APEX floats for repair or refurbishment. All returns from outside USA, please specify our import broker:

Consignee: Teledyne Webb Research
82 Technology Park Drive
East Falmouth, MA 02536

Notify: DHL-Danzas Freight Forwarding Agents
Attn: Ellis Hall, Import Broker
Phone (617) 886-6665, FAX (617) 242-1470
500 Rutherford Avenue
Charlestown, MA 02129

Note on shipping documents: US MADE GOODS

CAUTION: If the float was recovered from the ocean, it may contain water, which presents a safety hazard due to possible chemical reaction of batteries in water. The reaction may generate explosive gases (see "Alkaline Battery Warning" at the beginning of this manual).   In this case, be sure to remove the seal plug to ventilate the instrument before shipping. Do this is a well ventilated location and do not lean over the seal plug while loosening it. Use a 3/16 inch hex wrench, or pliers, to rotate the plug counter-clockwise.

Seal Plug

Appendix E: Host Server and Modem Setup

This material was very kindly provided by Terry McKee of the Woods Hole Oceanographic Institution. The material documents her work setting up primary and secondary host servers with modems using the software developed at the University of Washington by Dan Swift. Shell scripts for setting up user accounts, among other things, for each of 12 floats are included. This material is provided as an example. Not all installations will be the same.

```
July 2007


Received 2 Dell Optiplex 745 desktop computers and 2 Hayes Accura
modems (H08-03328-CF) to set up as servers
-----------------------------------------------------------------
--------------

Attempted to install RedHat Enterprise Linux 4, but it would not
install since it lacks SATA drivers which control the CDrom and
the hard drive on the Optiplex.
(external CDrom would not aid installation since disk drives
could not be recognized either.)

Changed course and installed UBUNTU 6.10, using an .iso CD.
Retained Windows XP, shrank it to about 30 gb, added a 20gb vfat,
and left the remaining space (~180 gb) for linux with 2gb swap
space.

Executed all package upgrades.


Basic installation did not include:

mgetty -- found on http://packages.ubuntu.com/edgy/packages

minicom -- installed using System: Administration:  Synaptic
Package Manager: Communications:

tcsh/csh -- installed using System: Administration: Synaptic
Package Manager: Shells

Downloaded Apex Software from runt.ocean.washington.edu/swift:
RemoteHost.zip

unzip -- sx rx chkconfig .sxrc .rxrc

Fooled around with minicom to make sure I could talk to the
modem.
```

Found some directions on the net for how to start up mgetty
properly:
(Ubuntu6.1 deprecated /etc/inittab where mgetty used to be
started)

<http://ubuntuforums.org/archive/index.php/t-2260.h...%3C/t-
150339.html>

****
1. Add a file named ttyS0 (instead of mgetty) to /etc/event.d
with:

start on runlevel 2
start on runlevel 3
start on runlevel 4
start on runlevel 5

stop on shutdown

respawn
exec /sbin/mgetty ttyS0

note the slight syntax changes vs. nerdcentric's ubuntu 6.10.

****

and got these lines from Dana Swift:
port ttyS0
   speed 19200
   data-only y
   port-owner root
   port-group uucp
   port-mode 0660
   debug 4

This did the trick.

Installed sshd using the Synaptic package manager (found under
Networking), so I could communicate remotely. A search of Ubuntu
help gave me the information that I needed to edit
/etc/ssh/sshd_config and uncomment

Banner /etc/issue.net

and restart the ssh daemon.

Apex Iridium-specific Setup

Requirements are:

user iridium and one for each individual float

I created /home/iridium manually according to Dana's directions

Discovered that ubuntu adduser commands are slightly different.

created the .cshrc ~/bin ~/logs directories; copied sx, rx, chkconfig, .sxrc, .rxrc to bin

and used scripts to create the directories for the 12 floats

Scripts are in ~/Apex_setup_files and must be executed as root (sudo -s)

FIRST SCRIPT: (NOTE: ubuntu specific syntax)

```
add_Apex.sh
#!/bin/csh
echo " sample: adduser xxxx
 adduser -shell /bin/tcsh -ingroup iridium -uid 1${1} -home
/home/f${1} f{$1}
```

sample run:

```
./add_Apex.sh xxxx
Adding user `fxxxx'...
Adding new user `fxxxx' (1xxxx) with group `iridium'.
Creating home directory `/home/fxxxx'.
Copying files from `/etc/skel'
Enter new UNIX password:
Retype new UNIX password:
passwd: password updated successfully
Changing the user information for fxxxx
Enter the new value, or press ENTER for the default
        Full Name []: Iridium Apex Drifter
        Room Number []:
        Work Phone []:
        Home Phone []:
        Other []:
Is the information correct? [y/N] y
```

After all are created, check /etc/passwd.

SECOND SCRIPT:

make_cshrc.x   (copies and sets ownership of the .cshrc file
suggested by Dana)

```csh
#!/bin/csh

set float = ${1}

cp ~/Apex_setup_files/.cshrc /home/f$float
chown f$float.iridium /home/f$float/.cshrc
ls -Al /home/f$float/.cshrc
```

to run: ./make_cshrc.x xxxx   etc.

THIRD SCRIPT: creates float specific .sxrc and .rxrc files from
base files -- i.e., substitutes the float id into the path;
creates the bin and logs directories under each /home/float; then
copies and sets ownerships of the files
To run: ./make_rcfiles.x xxxx etc. (where xxxx=float id)

```
make_rcfiles.x
#!/bin/csh

set float = ${1}
sed "s/xxxx/$float/" <.sxrc >.sxrc$float
sed "s/xxxx/$float/" <.rxrc >.rxrc$float

cd /home/f$float
pwd
mkdir bin
mkdir logs

chown f$float.iridium /home/f$float/bin
chown f$float.iridium /home/f$float/logs
ls -l

cp ~/Apex_setup_files/.sxrc$float /home/f$float/bin/.sxrc
cp ~/Apex_setup_files/.rxrc$float /home/f$float/bin/.rxrc

cp ~/Apex_setup_files/sx /home/f$float/bin/sx
cp ~/Apex_setup_files/rx /home/f$float/bin/rx
cp ~/Apex_setup_files/chkconfig /home/f$float/bin/chkconfig

chown f$float.iridium /home/f$float/bin/.sxrc
chown f$float.iridium /home/f$float/bin/.rxrc
chown f$float.iridium /home/f$float/bin/chkconfig
chown f$float.iridium /home/f$float/bin/sx
chown f$float.iridium /home/f$float/bin/rx

ls -Al bin logs

cd ~/Apex_setup_files
pwd
```

After all this, I executed a command to set the permissions for
these directories to 750 as Dana suggested:

chmod 750 /home/f* /home/f*/bin /home/f*/logs   and
chmod 750 /home/iridium /home/iridium/bin /home/iridium/logs

FOURTH SCRIPT:

Before Teledyne Webb Research could make meaningful tests, it was
necessary to create a minimal mission.cfg in each floats home
directory.

make_mission.x
#!/bin/csh

set float = ${1}

cp ~/Apex_setup_files/mission.cfg /home/f$float
chown f$float.iridium /home/f$float/mission.cfg
ls -Al /home/f$float/mission.cfg
/home/f$float/bin/chkconfig cfg=/home/f$float/mission.cfg

to run: make_mission.x xxxx

##

Aug 7, 2007

added security -- installed tcp wrapper...

apt-get install netkit-inetd
gedit hosts.allow and hosts.deny

sudo /etc/init.d/inetd restart

Appendix F: CTD Calibration and Ballasting records

(included in hard copy only)