

When the Spray behaves in an unexpected manner, exception code is triggered; dependent upon software flags, different courses of action will result.

**v0610 Exception Flags:** These dictate the action taken when an exception occurs.

- 1) **Op\_Mode.** Defines the operation mode of the glider (controlled by the Spray code), which affects the course of action after a reset:
  - 0 = Waiting to start the mission: get user input from the main menu.
  - 1 = We've started the mission, but have not finished the first dive.
  - 2 = We are past the first dive.
  - 1 = A shore command has been sent to perform a remote Reset.  
Re-start the mission.
- 2) **Amp\_Action** If the pump current exceeds AmpMax, the action taken for the next dive will be dictated by Amp\_Action (to change, use shore command 'C'):
  - 0 = Take no action (no changes are made to the mission).
  - 1 = Change to 100m depth dives (but maintain the route).
  - 2 = Abort the mission.
- 3) **PMP\_Action** = Action to take when there is a deep pump failure (fails to rise after pumping; change using shore command 'P'). The PUMP\_RECOVERY is attempted (see definition below), and then the following action is taken for the next dive.
  - 0 = No changes are made to the Spray mission (ignore).
  - 1 = Go to shallow (100 m) dives.
  - 2 = Do shallow dives AND head for the HOME waypt.
  - 3 = Abort the mission.
- 4) **SBD\_Action** = Action to take when there has been no SBD comms in 48 hrs (change using shore command 'P'):
  - 0 = No changes are made to the Spray mission (ignore).
  - 1 = Head for the HOME waypoint.
  - 2 = Do shallow (100m) dives AND head for HOME.
  - 3 = Abort the mission.
- 5) **Max\_Rst** = Maximum spurious resets allowed before going to the abort code (change using shore command 'P'):
  - If Max\_Rst=0 or 1, then a spurious reset will go directly to the abort code. If the number of spurious resets is <Max\_Rst, then the Spray pumps to get to the surface, does satellite/GPS comms, and then continues with the next dive with the same mission settings.
- 6) **Bad\_GPS\_H** = Course to steer when both GPS fixes during a surface cycle are bad (change using shore command 'M'):
  - If  $0 \leq H \leq 360$ , then will steer this heading (degrees True).
  - If  $H = -1$ , then the Spray will just do circles.
  - If  $H = -2$ , then it will steer the last valid direction.
  - If  $H = -3$ , then it will head for the last valid direction to the HOME waypoint.

**Actions:** These are the possible actions to take at the time of an exception.

- 1) **SHALLOW DIVE** we go to 100 m dives but continue the mission.
- 2) **GO HOME.** We stay in the mission mode, but head for the HOME waypoint.
- 3) **PUMP RECOVERY.** If the hydraulic pump malfunctions turning around from descent-to-ascent, then the Spray will try up to ten times to (pump one minute, wait one-to-four minutes, dependent upon vertical velocity) to try to recover

(deemed recovered if the vertical ascent speed is  $> 5$  cm/s). Action taken for the next dive is controlled by **PMP\_Action**.

- 4) **ABORT**. The mission is aborted, and the glider enters the 'abort mode' (described in detail below) where it alternates with getting a GPS fix, sending it back through Iridium, and operating the Argos beacon for a fixed duration (nominally 15 minutes).
- 5) **DROP WEIGHT**. This drops the emergency weight. This either happens in the ABORT code if the satellite communication fails repeatedly, or if we exceed the maximum operation depth.

**Exceptions:** These Spray exceptions will trigger one of the actions above.

- 1) **RESET**. This may occur due to a power glitch, an illegal software operation (i.e. a divide-by-zero, or a stack overflow), or a shore-command reset request.
  - Op\_Mode=0 : Reset occurred before starting a mission, enter main menu.
  - Op\_Mode>0 : Spurious reset, go to ABORT if #of resets  $\geq$  Max\_Rst.  
else it will try to continue the mission.
  - Op\_Mode<0 : Remote reset request: re-start the mission.
- 2) **TOO DEEP**. The Spray has exceeded the maximum safe operation pressure of the housing (1500 m)...DROP WEIGHT and go to ABORT.
- 3) **BAD DEEP PUMP**. If the Spray fails to ascend (pressure does not decrease, thus bad pump) during the transition from descent to ascent, then PUMP RECOVERY is attempted, and PMP\_Action dictates the action for the next dive.
- 4) **HIGH PUMP CURRENT**. If the current exceeds AmpMax, the pump is immediately turned off (always). The action at the end of the dive is set by Amp\_Action (see above). If it is during the deep pump, we also enter PUMP RECOVERY.
- 5) **BAD SURFACE PRESSURE**. After attempting a GPS fix and Iridium transmission, the surface pressure is checked. If the value is  $>20$  m, then we are not at the surface when we think we should be (i.e. a bad pump)...go to ABORT.
- 6) **FAILED COMMUNICATIONS**. After MaxSat hours (EEPROM parameter) have passed without any successful Iridium message transfers, then it is deemed that satellite communications have failed. The **SBD\_Action** value is used to decide the course of action.
- 7) **FAILED COMMUNICATIONS, FIRST DIVE**. If Spray fails to get a GPS fix and send messages back through Iridium, either at the start or the end of the first dive, it goes to ABORT.
- 8) **FAILED GPS**. If no GPS fix has been acquired in MaxGPS hours (EEPROM parameter), the flag GPS\_Abort is set true, and we head for the HOME waypoint. Before MaxGPS hours have expired with no good fix, the glider uses the BAD\_GPS\_H to decide what course to steer (see above).
- 9) **SHALLOW WATER**. If the GPS has failed (GPS\_Abort=true), and we have done three profiles where the water depth $<50$  m, then go to ABORT.

**ABORT code:**

- 1) Turn on the Argos beacon.
- 2) Run the hydraulic pump for up to ten minutes.
- 3) Initialize Argos\_Time to the EEPROM parameter value (nominally 15 minutes), and initialize the PUMP\_AGAIN flag to false.
- 4) Enter the following loop, until a 'w' is entered from the serial port.
  - a. turn on the Argos beacon for Argos\_time. If PUMP\_AGAIN=true, or depth is >10 m, then run the pump again to try to gain more buoyancy.
  - b. get a GPS fix (allow up to GPS\_Time (EEPROM), nominally 15 min).
  - c. transmit the fix via Iridium (up to 20 minutes, can be changed by a shore command).
  - d. If we have failed to get a GPS fix AND send it back via Iridium, set PUMP\_AGAIN to true. If we fail this test three times in a row (i.e. probably a bad antenna), double the Argos\_time (rely on Argos more heavily).
  - e. If we fail three times in a row to send anything back through Iridium, and to see less than 3 GPS satellites, then DROP WEIGHT (drop the emergency weight; turns on the burn wire circuitry for three minutes).

If the Spray is on the bottom, then it will take ~3 hours before the weight is dropped:

Time	t=0 minutes,	enter abort code.
	t=10	finished with extra pump attempts.
	t=10	Enter Argos/GPS/SBD loop:
	t=10	Start Loop #1: Argos on, try running pump if z>10.
	t=25	Argos off, GPS on.
	t=40	GPS off, SBD on.
	t=60	Start Loop #2: SBD off, Argos on. Run pump if z>10
	t=75	Argos off, GPS on.
	t=90	GPS off, SBD on.
	t=110	Start Loop #3: SBD off, Argos on. Run pump if z>10
	t=125	Argos off, GPS on.
	t=140	GPS off, SBD on.
	t=160	SBD off.
		BURN WIRE ON for three minutes.
		DOUBLE ARGOS time to 30 minutes.
	t=160	Start Loop #4, etc.