**Operation Notes Regarding Spray Diagnostics** **updated 06 Nov 2006**

This note outlines what to watch for in the GPS ('G') and Engineering ('E') lines. Our biggest concerns are losing GPS and/or Iridium, having the hydraulic pump fail, or ultimately, running out of batteries. By looking at the feedback from the G and E lines (plus weather), we have to decide the severity of the problem, and the course of action required. First, a general description of the problems and how they manifest themselves:

**Pump problems:** The pump can become less efficient (clogged filter, clogged check valve, etc.) which will result in a slower pump rate, thus a longer pump time, a slower ascent rate, and an overall longer time to perform a dive. Depending upon where the problem actually is, the pump may perform less work (i.e. a clogged inlet check valve), and the current will drop. The glider will likely have less buoyancy at the surface, and thus the antennas will be lower in the water; so a slow pump may cause marginal communications.

A pump motor problem will be indicated by a higher current (more friction in the gearbox or bearing, or a winding problem), until a catastrophic problem occurs (motor binding up from overheating), which will cause the emergency weight to be released. The average current should stay below 2.1 amps at 1000 m.

**GPS problems:** The severity of the GPS failure can range from total antenna failure (no satellites in view), very poor coverage (no fix, but a few satellites were seen), to marginal (a long time to get a fix, less than 6 satellites in view, lower SNR compared to the average). Poor/marginal coverage is either a partial antenna failure, bad weather conditions (mainly dependent upon sea state), or little reserve buoyancy at the surface.

**Iridium problems:** Poor satellite reception (from either a faulty antenna, bad weather, or little surface buoyancy) will result in multiple tries at sending a message and a longer time spent at the surface. Poor/no communication can also be from the Iridium Service Provider having problems. At this time, if this is suspected, then Chandra Birdwell at Global Information Technologies should be contacted (chandra.birdwell@gitsat.com). It would be best to ask Jim Dufour or Lloyd Regier to talk to her.

**Weather** check FNMOC, quikscat, and local weather buoys for input on the glider weather conditions.

A large wave height with a short period generally affects the GPS. A transition, where wind and dominant swell directions are different, can cause the wing to get blown to a bad angle. If the wind is above 30 knots, it is normal to have occasional occurrences of no fixes.

**The GPS Line (0610 code)**

```
G  170 2 06 Nov 2006 13:31 1 +31 43.89 -121 26.90  100  7  28  47  79  2.5  0 0    31.7315 -121.4483
G  171 1 06 Nov 2006 13:36 1 +31 43.90 -121 26.87   50  8  20  43  74  1.6  0 1    31.7317 -121.4478
G  171 2 06 Nov 2006 16:21 1 +31 43.42 -121 28.21  210  7  11  47  83  1.3  0 0    31.7237 -121.4702
i   1  2  3  4   5   6  7  8  9   10    11   12     13 14  15  16  17  18  19 20      21        22
i= 1 = dive#
2 = mission status at time of fix
        0=start of mission, 1=start of dive, 2=end of dive, 3=in abort mode
 (3,4,5) = date
(6:7) = time (UTC)
8 = valid flag: 0=bad fix, 1 = good
(9 10) Latitude
(11 12) Longitude
13 = Tfix = time (s) to acquire a fix
14 = Nsat = # of satellites in view
15, 16, 17 = minimum, mean, and maximum SNR of the satellites in view
18 = HDOP
19 = GPS Health (4 bits) : b0=incomplete almanac, b1=bad back-up battery, b2=poor satellite coverage, b3=antenna fault.
20 = Wing Index and roll status.
21, 22 = Latitude, Longitude, decimal degrees.
```

The time for one dive can be computed from the start/end dive GPS times. If it lengthens, either we're fouled on something, or the hydraulic pump is having problems. Check the pump time and motor current.

Iridium transmit time is estimated by the GPS times (start-of-dive(N+1) – Tfix(N+1) – end-of-dive(N) ), good to 1 minute accuracy): This has been 3-5 minutes. If it's long, likely the number of tries in the Engineering line is high as well. You can also use this time, plus the GPS fixes, to estimate surface current.

Tfix =Time to acquire a fix; can be anywhere from 40-900 s. It depends on weather, antenna performance, and reserve surface buoyancy. It will also improve when the fixes are closer in time (it has a better idea of satellite orbital information).

Nsat = # of satellites in view: generally 7-8, maybe 5-6 in bad weather, or lower if marginal antenna or marginal buoyancy.

GPS SNR (min, mean, and max), has lots of variability. Overall trends should be watched, with longer Tfix and lower SNR indicating either poor weather or an antenna problem. Check the pump times and motor current.

Wing/Roll status: see Spray_TXT _0610a.doc for a description. Value>3 indicates a potential roll problem.

## The Engineering line (v0610, added parameters 26, 27, 28 ).

```
E  170  505 14.31 1.07 104.016 225  17 -1931 -1940 +31.084 -122.662  1  1  5 0 1 00  240 13  29 -1033   0  58  -4  25 350 100 4020
E  171  507 14.28 1.08 104.016 228  17 -2056 -1844 +31.084 -122.662  1  1  5 1 1 00  240 16  25 -1029   2  57  -4  19 360 100 4020
i   1   2   3    4     5    6   7    8    9     10     11   12 13 14  16 17 18 19  20  21  22  23  24 25 26  27  28
i=1 = dive #
2 = max depth [dBar].
3 = Battery Volts (while pumping down deep).
4 = Pump current [amps] (while pumping down deep).
5 = altimeter reading at max depth [dBar].
6 = computed heading to steer (desired heading, TRUE as of code V0608) [degrees].
7 = pitch angle (degrees).
8, 9 = dead-reckoning East and North component [m].
10, 11 = waypoint latitude and longitude
12 = Ntries = # of tries sending an Iridium SBD message.
13 = Nsent = # of messages sent.
14 = Navg = # of points averaged for each output point in the SBD profile.
15 = SBD status of last message sent.
16 = Wing used (used for Sprays with antenna switches).
17 = Status of Shore-based command.
18 = Surface pressure counts (gives idea of pressure sensor drift).
19 = Tpump1 = time to pump deep(seconds = Tpump1*10) to get to neutral buoyancy.
20 = Tpump2 = remaining time pumped (s = Tpump2*10); includes ascent and surface pump times.
        Tpump = Tpump1 + Tpump2 = total time pumping.
21 = Internal vacuum ( in-Hg *100 ).
22 = Time ( seconds/10) until the max amps was observed during the deep pump.
23 = max amps (ampere = x*0.02) during the deep pump.
24 = JUL06 = Integrated error used in PI loop for heading control.
                counts/1.92 = [degrees] roll required to go straight.
25 = time (s) required to send the last message via SBD.
26 = Time (s) From time at surface (P<2) until the GPS is turned on.
27 = Time (s) to leave the surface (after GPS is off, until P>2 dBar ).
28 = Exception Status Word (printed in hexadecimal)..Let b0 = bit[0] = Lsbit, b15 = bit[15] = Msbit.
     b0 = Pump Recovery was required.              b8 = CF1 Close File error.
     b1 = Drop Weight Activated.                   b9 = High pump amps at the 50 m safety pump.
     b2 = Pressure>20 m 'at the surface.'          b10= Press=0 counts (broken) 'at the surface.'
     b3 = Depth>1500 m detected.                   b11= No SBD message sent in the last 48 hrs.
     b4 = The Altimeter triggered turn-around.     b12= Cannot overcome the current (current-bucking mode).
     b5 = Backed off the surface.                  b13= Spurious Reset Detected (added OCT06).
     b6 = Extra pumps req'd at end of ascent.      b14= Altimeter reading is from an ADP.
     b7 = Took >700 s to leave the surface.        b15= Not Used.
b12=1 means that although current correction is applied, the current is too strong to maintain course.
b14 is used to help interpret the altimeter reading in the 'E' line.
```

**Diagnosing the engineering parameters:**

Volts: It is dependent upon load (higher current will have lower volts), but will be relatively flat until 10% of the battery life is left; it will then decrease quite rapidly to 11-12 V for the remainder.

Amps = Pump current down deep. It is ~linear with depth (~0.4 amps at surface, ~1.0 amps at 500 m).

Ntries=#tries sending an Iridium message from the last dive. Typically Ntries=1-2; if higher, then bad weather, bad antenna/buoyancy, or bad ground station link.

Tpump (total pump time) indicates pump speed. If this increases, and ascent speed/total dive time decreases, then we have a slower pump. To compensate, increase 'bpump' (see SBD shore command '**C**' ).

**Action to Take for the following symptoms:**

**Battery**: Volts <13.5, go to 100m dives and arrange for recovery. If <12.0 V, then there is less than 10% life left, put in abort mode (unless currents are strong, and not likely able to get a boat there soon; you'll have to weigh benefit of low drift versus losing contact completely).

**Pump**:

1) MAXON motor: keep current below 2.1 amps ( should be ~2.0 amps at 1000 m).
2) higher pump times/slower ascent rate. Increase 'bpump' (see SBD shore command 'C'). Going to a shallower depth will also decrease the load on the pump, and may improve the efficiency of a faulty pump.

**GPS**:

1) No satellites: if recovery is not feasible, go to 100 m dives, and use location from the SBD emails (Doppler-estimated positions) to manually steer the glider (the risk is if the wing is severely damaged and there is a leak at high pressure, the glider may be lost entirely). If recovery is OK, put in the abort mode and count on using Argos plus SBD fixes to locate.
2) Marginal satellite coverage: Check ascent, dive times and pump times. Also check the weather. If all of these are OK, go to 100m dives and see if coverage improves. Typically less time between GPS fixes will improve its performance.

**Iridium** (SBD messages):

1) No messages: check with the service provider, and hope their system is momentarily down. Otherwise, check Argos to see if it is on the surface in abort mode. If the pump failed deep, then it may take the equivalent of one dive cycle to end up in the abort mode with the emergency weight dropped. If it is a bad antenna, it may take up to 2 days to abort due to bad communications, at which point it hopefully will show up via Argos messages.
2) Marginal connection (high # of tries, long time on the surface): Check the weather, ascent rate, dive times, pump times for other problems. If those are OK, decide action dependent upon ability to recover. If recovery is OK, put in the abort mode. If not, go to 100 m dives and hope things don't get worse before you can recover.

If in doubt, go to a shallower depth while trying to figure out what's wrong. If something is trending upwards (and it's likely not due to the weather), go to a shallower depth. 100m dives will let you get out of the surface currents, and hopefully at least hold a station.