

**BIPLANE
RIDES**



FLIGHT INSTRUCTION

GLIDER RIDES



Operating Spray gliders

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IFREMER Brest

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www.ifremer.fr/lpo/gliders

EGO website

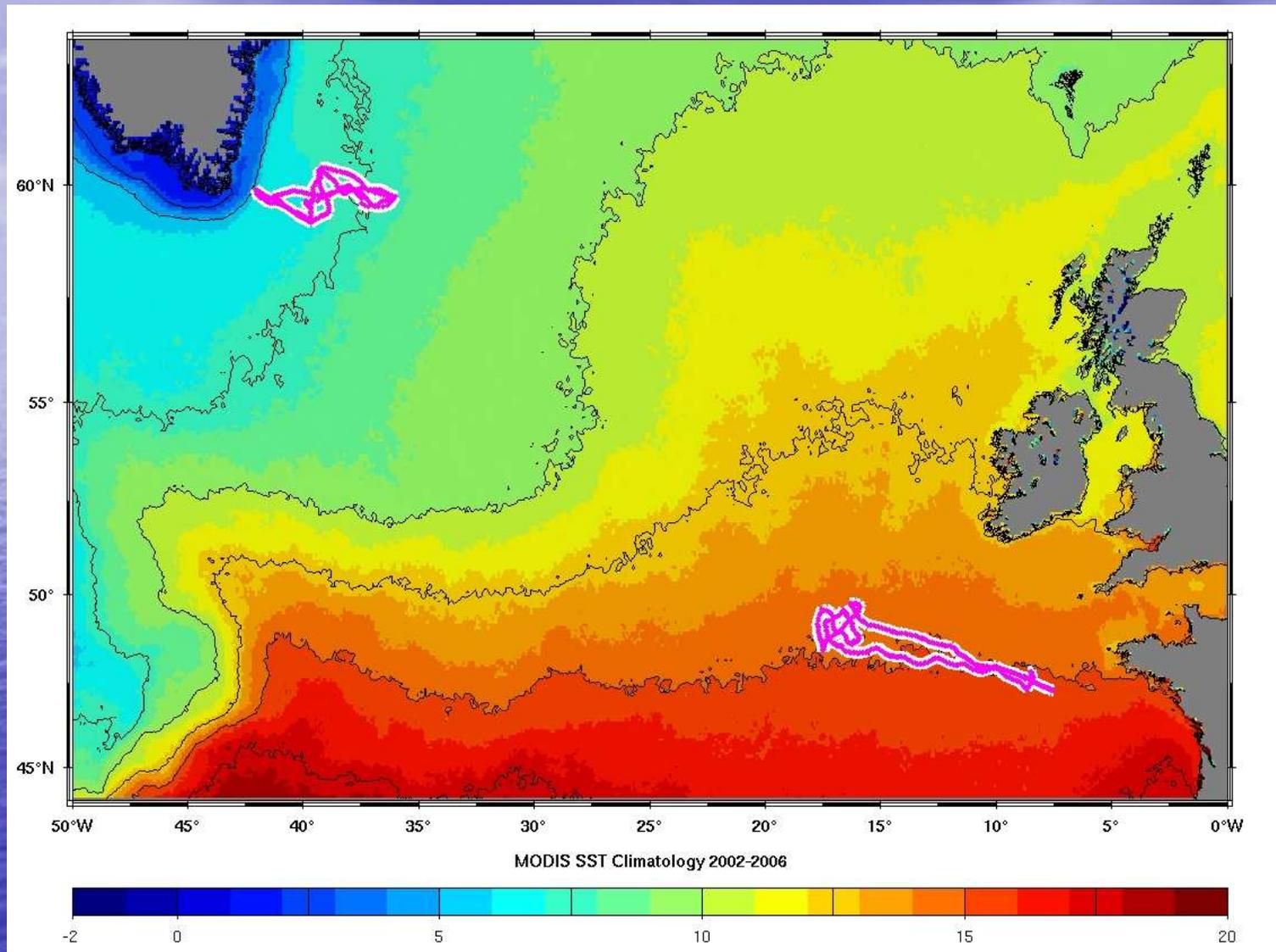
Spray SIO website

The Autonomous Underwater glider « Spray »

J. Sherman, R.E. Davis (SIO)
W. B. Owens, J. Valdes (WHOI)

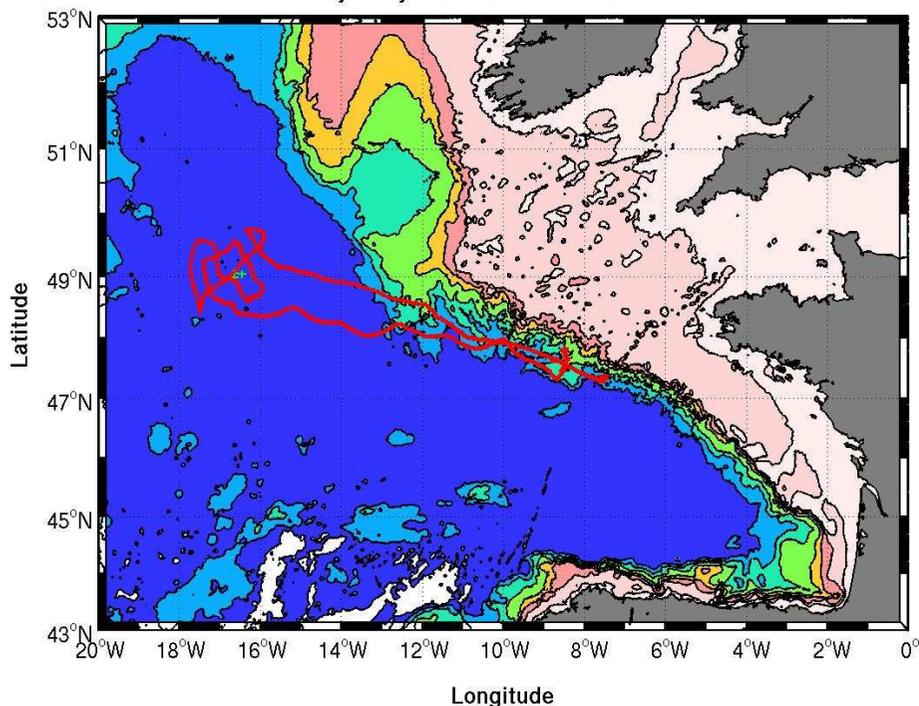
IEEE J.Oceanic Eng., Vol.26, n°4,
Oct 2001

ATLANTIC OCEAN



Demonstration in 2006 with Spray004 around MERSEA

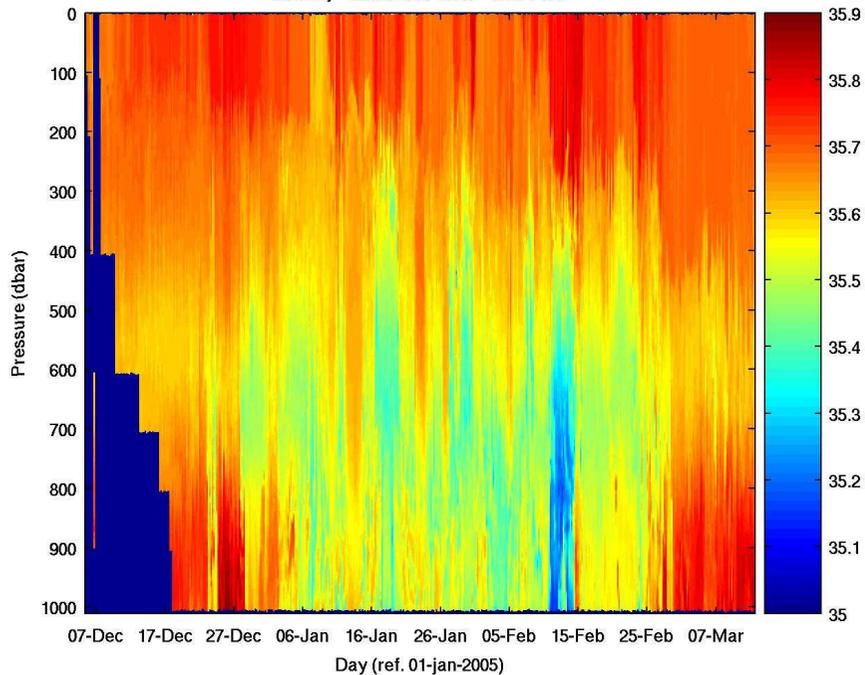
Trajectory - 12/03/2006 13:49 - dive #473



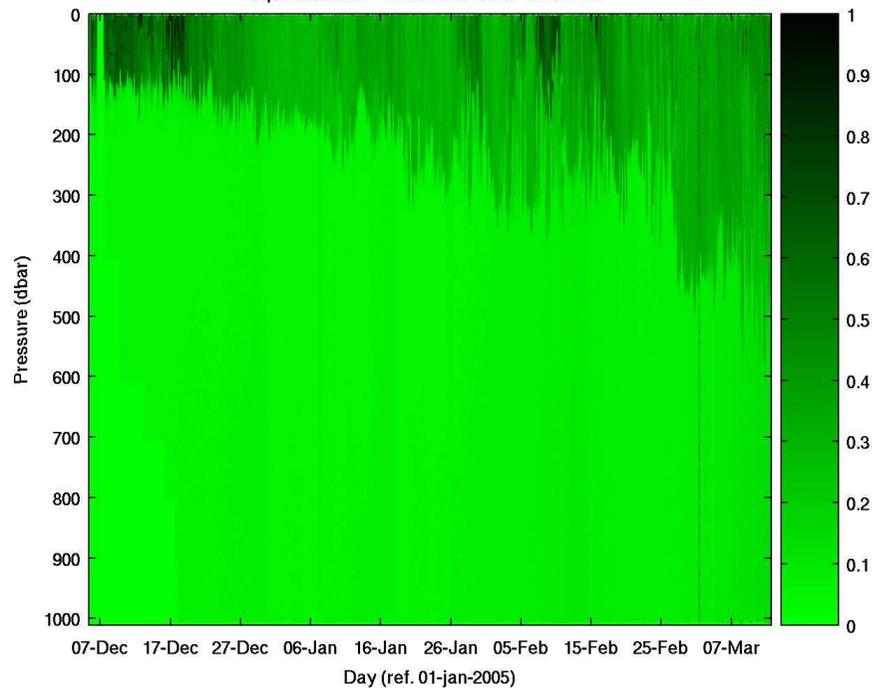
MERSEA-PAP1

- Spray004 (T-S-F)
 - 4 dec. 2006 – 14 march 2007
 - 97d, 473 profiles, 2440km
 - Depl. and recov. from Brest
- Specificities:
- Good behavior (Could go 30 add. Days?)
 - Excellent cooperation with SIO

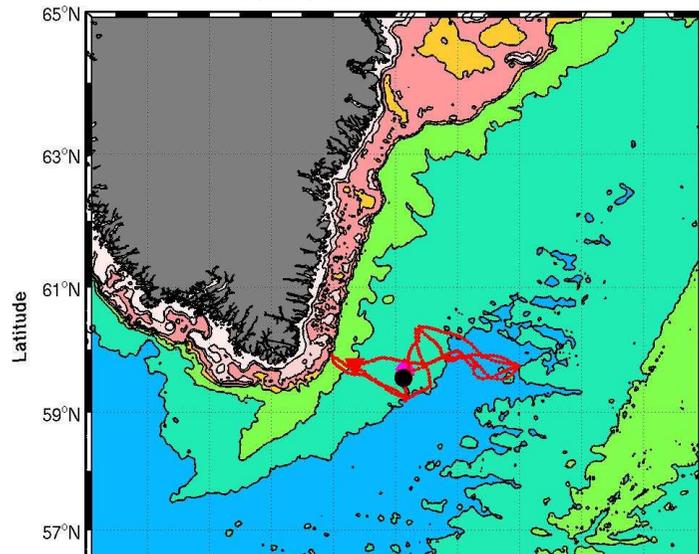
Salinity - 12/03/2006 13:49 - dive #473



Optical sensor - 12/03/2006 13:49 - dive #473

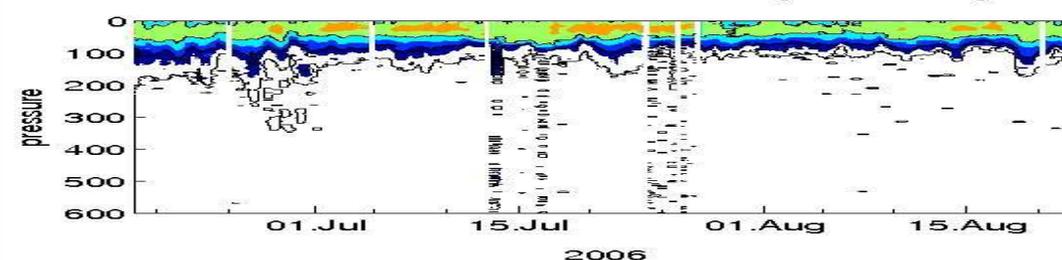
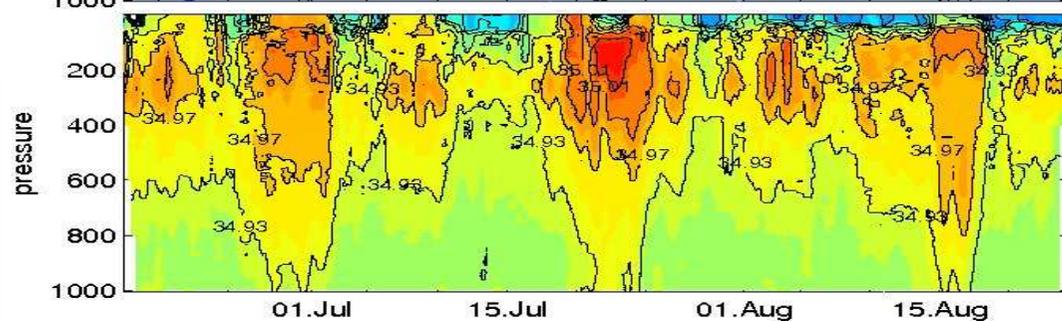
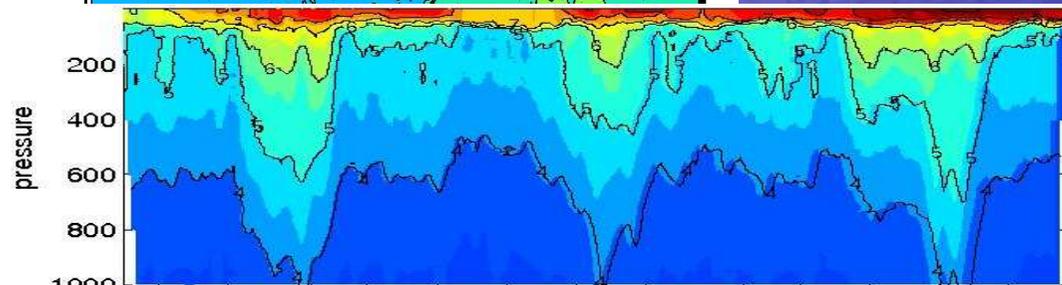


Trajectory - 24/08/2006 09:03 - dive #314



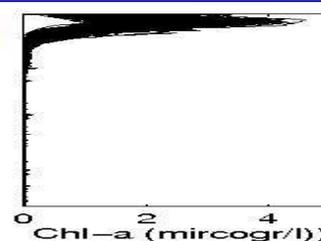
MERSEA-CIS1

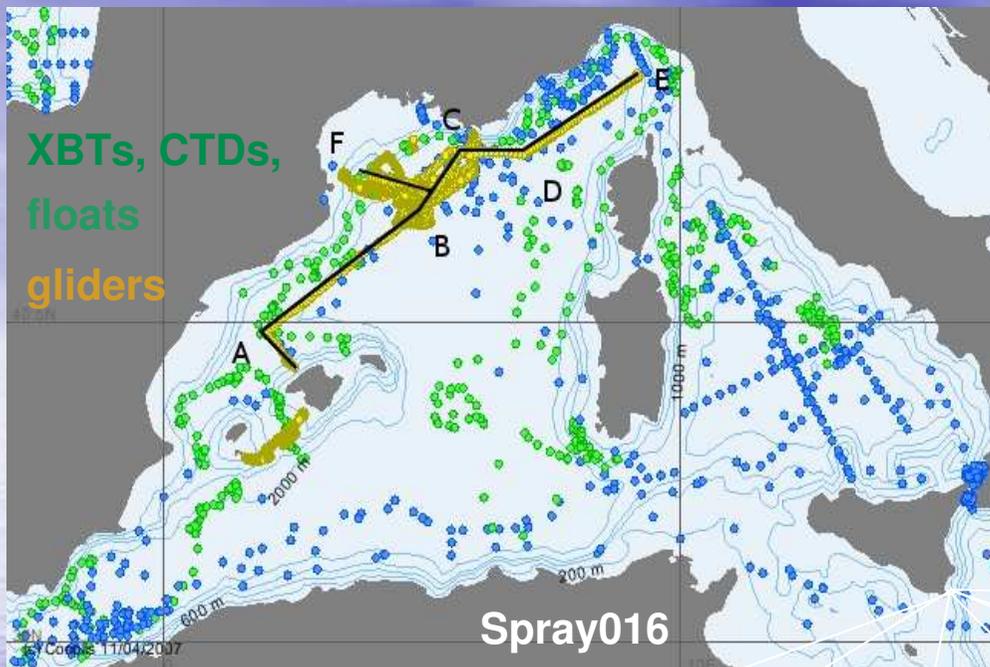
- Spray004 (T-S-F)
- 18 June 2006 – 24 August 2007
- 67d, 310 profiles, 1680km
- Depl. and recov. from research vessels



Specificities:

- Mission limited by ship availability
- First boundary current excursion



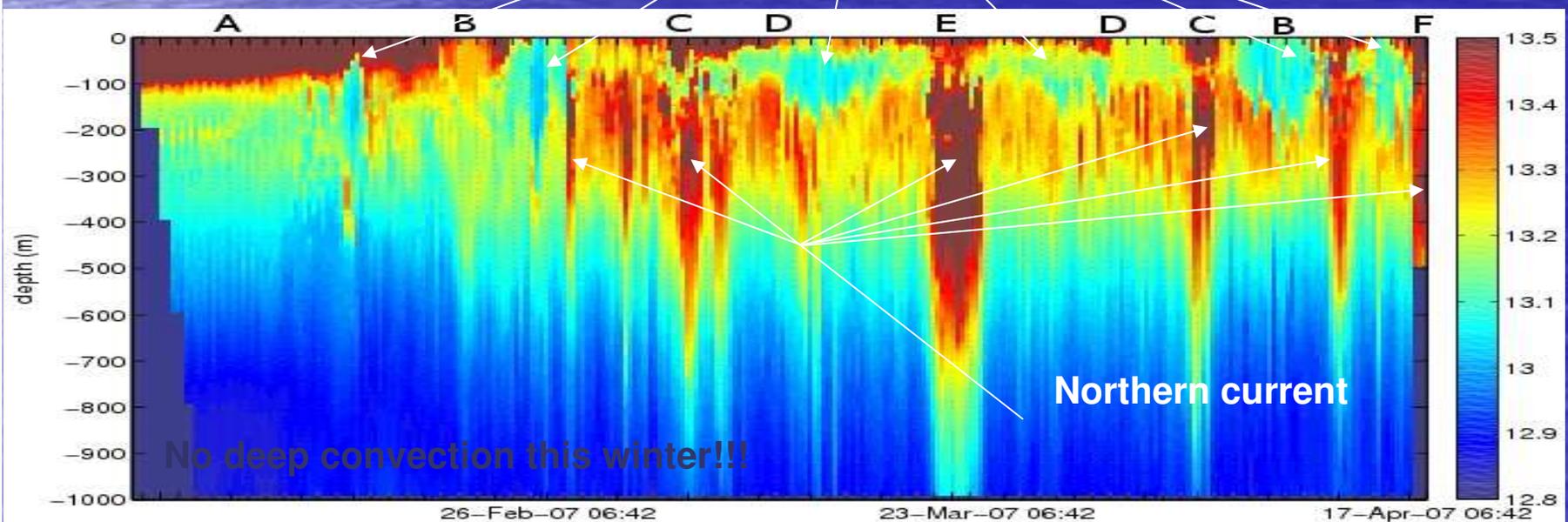


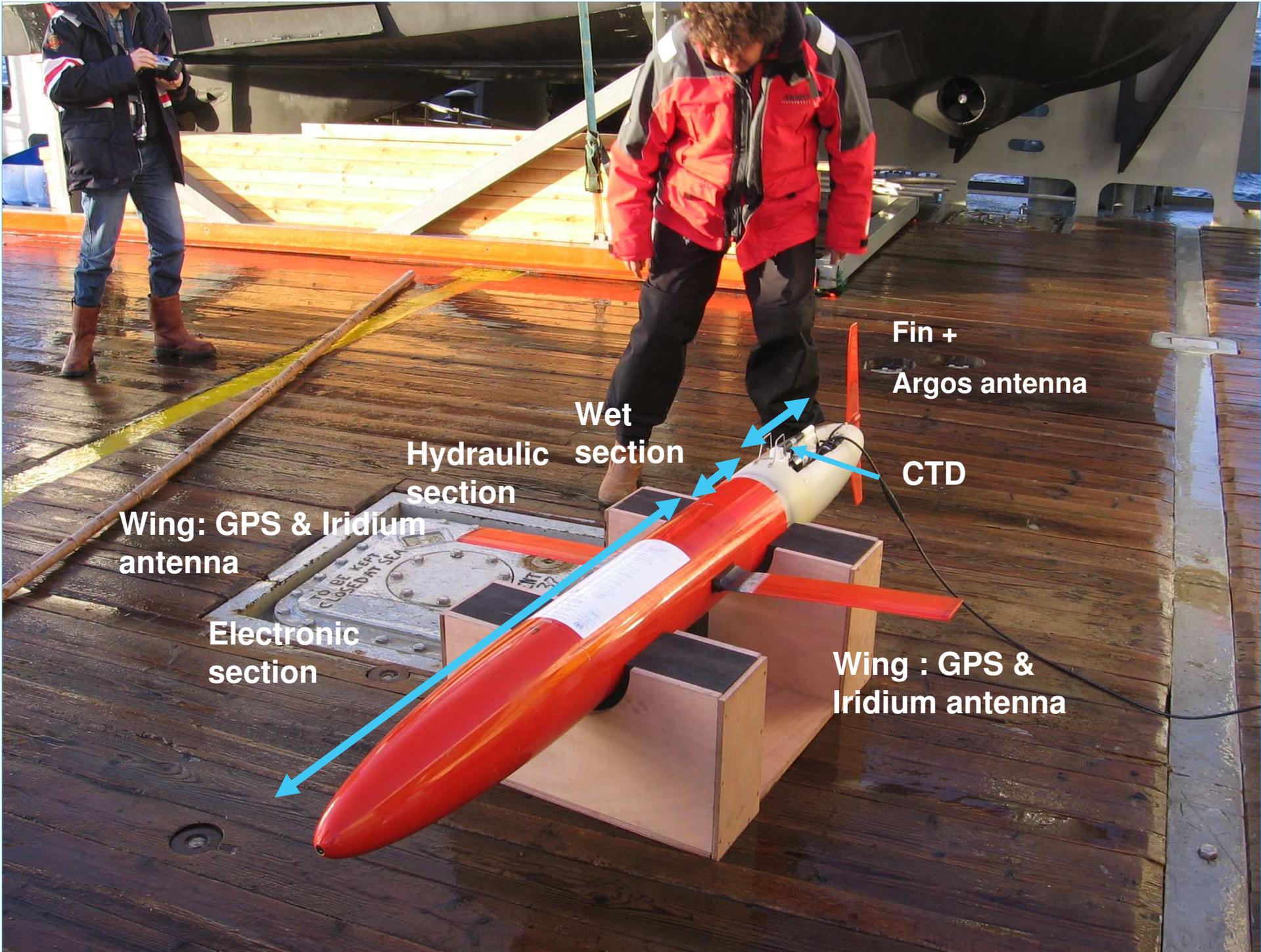
7 gliders
6 gliders simultaneously
From December 2006 to June 2007

~3200 profiles
(200m and 1000m depth)

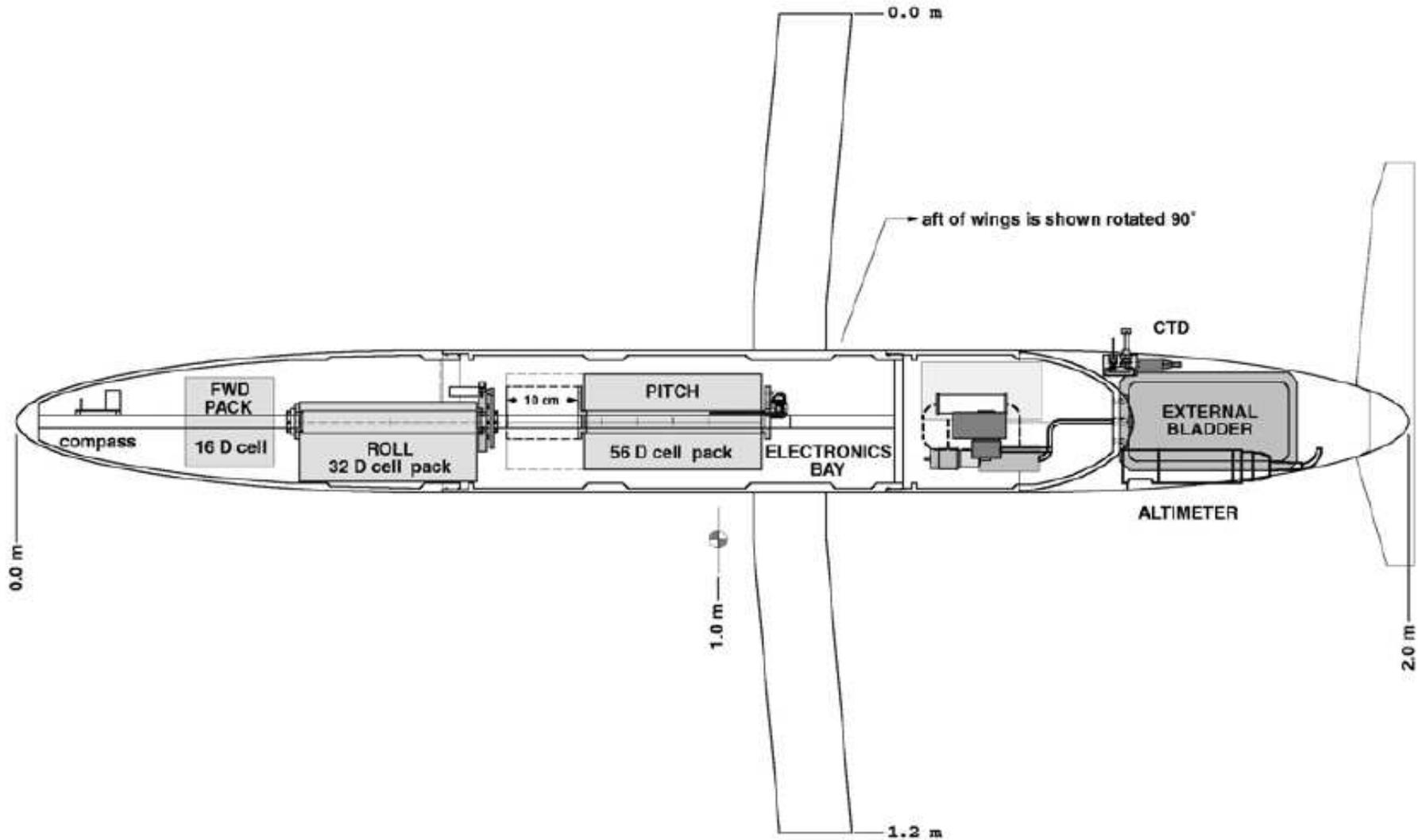
Large, meso, and small scale processes

Winter mixing, subduction





Inside Spray



Some characteristics



From / Mnfg	SIO/BlueFin
Depth range	1000m (1500m)
Endurance (with CTD+Opt)	3000 km 4 x1000m dives/day 500 dives 140 days Longest 143 days, 900 dives 600m
CTD sensor	Pumped Seabird
Comms	Iridium (email) + Argos
Weight, Payload	W=51 kg, P=3.5 kg

Pressure hull

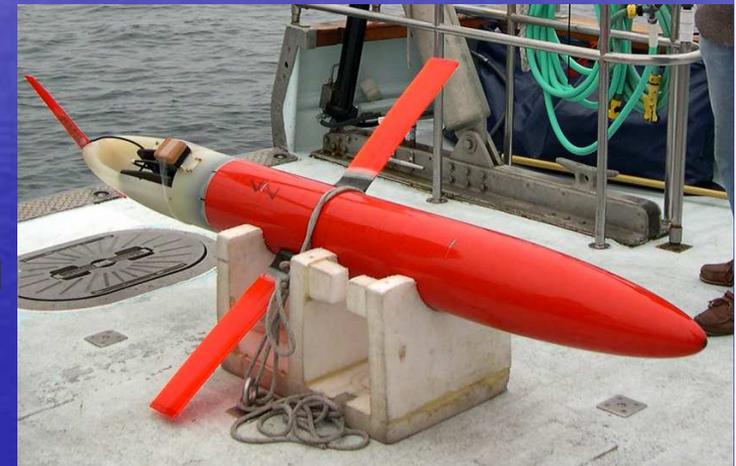
- Aluminium 6061 T6
- 3 parts :
 - Slender ellipsoid shaped nose : $L = 63\text{cm}$
 - middle cylinder $L = 66\text{cm}$
 - rear case $L = 33\text{cm}$
- $L = 200\text{cm}$; $\varnothing = 20\text{cm}$

Wet section

- Solid propylene
- $L = 70\text{ cm}$

wings/rudder

- Molded urethane,
- $L=49\text{cm}$, $l=10\text{cm}$; $WS = 120\text{cm}$
- fixed rudder $L=49\text{cm}$, $l=7\text{cm}$

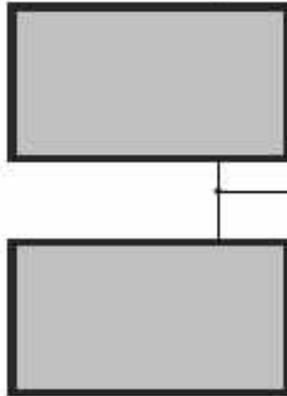




Hydraulic system

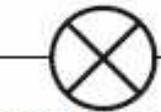
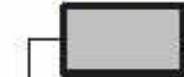
Outside

External Reservoir (two bladders)



Inside ~10 psia

High-P Filter: 105 um



High P Solenoid Valve

Check Valve



High P Pump



Low-P Filter : 2 um



Oil Pressure Sensor

$V_{out} = DP$

Oil Input P

Spray Interior P

Six-Port Manifold



Internal Reservoir (two bags), ~700 cc



Fill Port

Fill Port

Oil $V_{out} = (\text{Spray Interior P}) - (\text{Oil Input P})$.
As the interior reservoir is depleted, the pump starts to draw a vacuum on the oil input line, increasing V_{out} .
The CPU monitors V_{out} , and stops the pump when $DP = 1.0$ psi.

Operational Summary:

At the surface, start of a dive cycle (external bladders are full).

High-P solenoid valve is opened.

The vacuum inside Spray draws in all of the oil (~10 minutes).

The Spray sinks, gliding down.

At 50 m depth:

The pump recirculates for 16 s.

The valve is closed, and the pump runs another 16 s (some oil is now in the external bladders).

At the bottom of the dive:

The pump runs until the correct vertical velocity is reached.

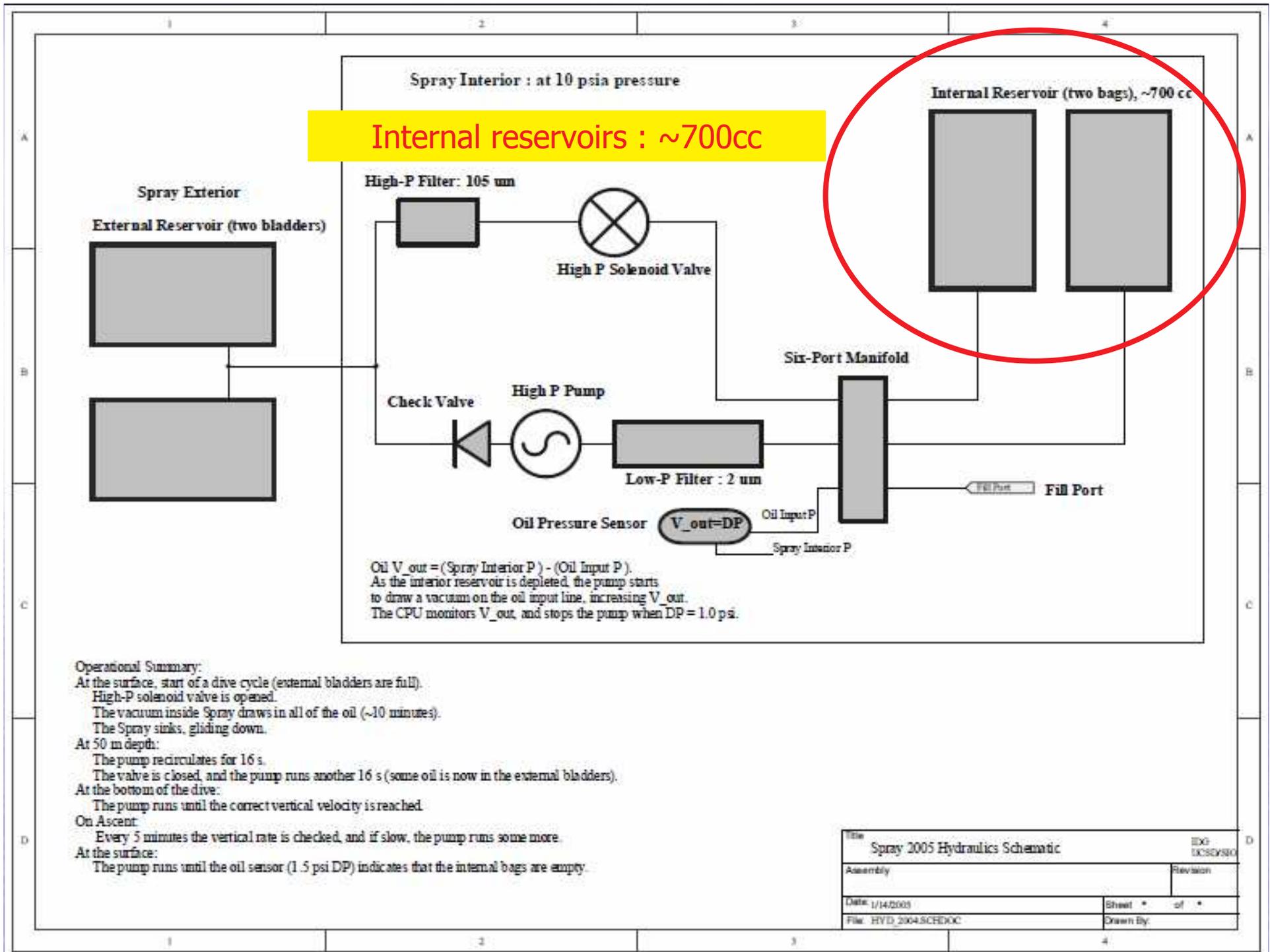
On Ascent:

Every 5 minutes the vertical rate is checked, and if slow, the pump runs some more.

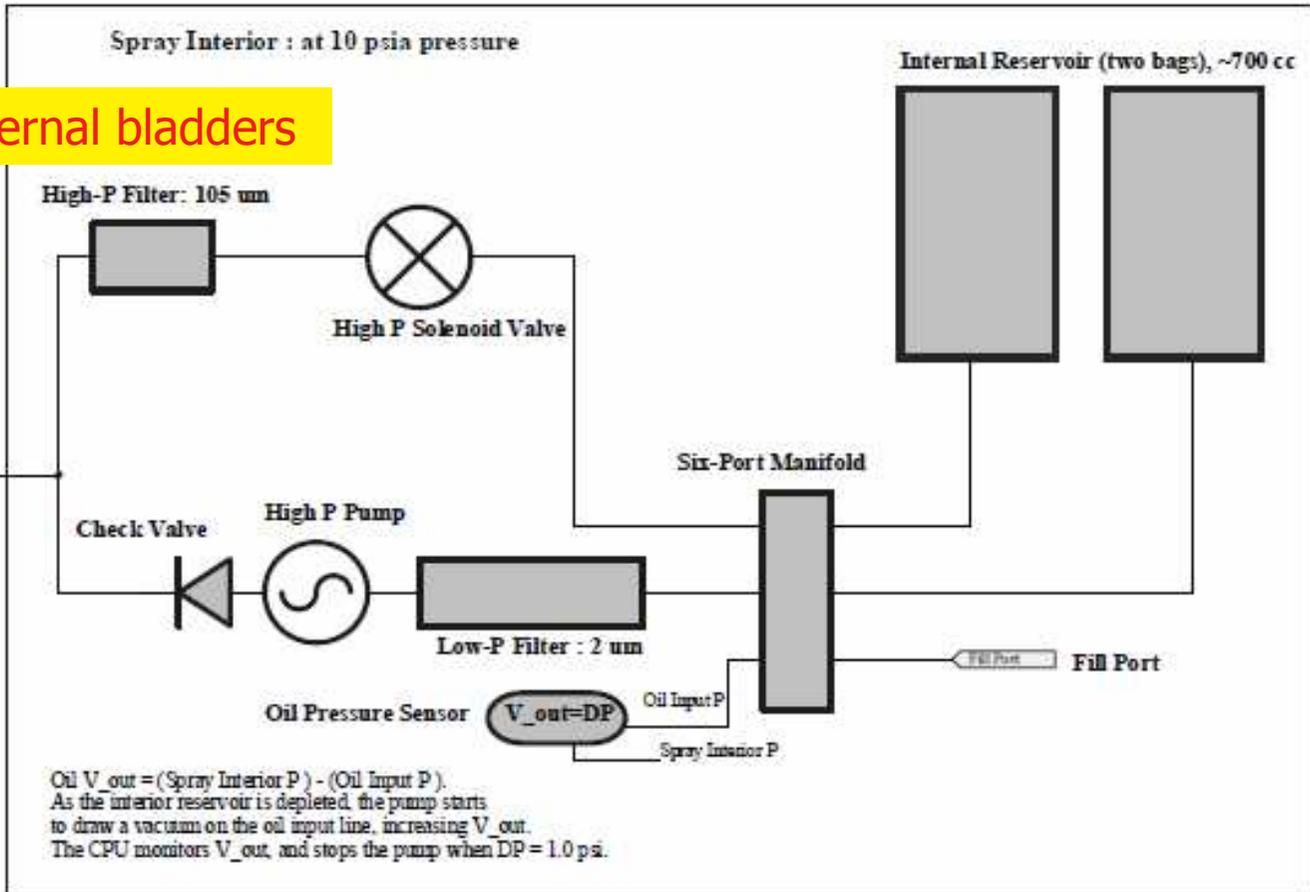
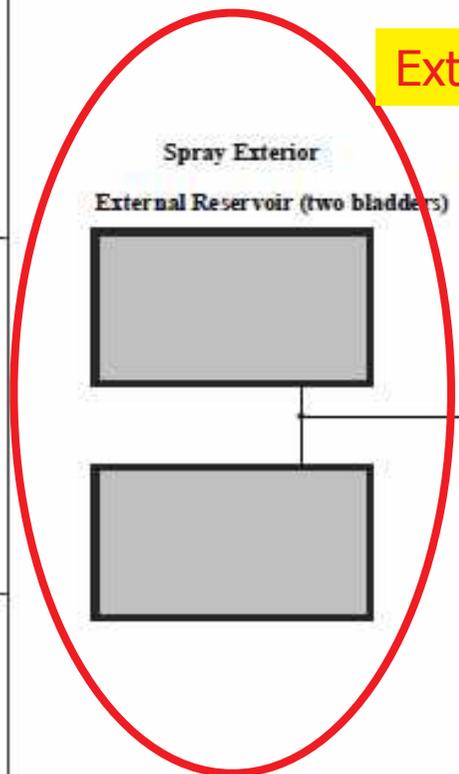
At the surface:

The pump runs until the oil sensor (1.5 psi DP) indicates that the internal bags are empty.

Title		EDG	
Spray 2005 Hydraulics Schematic		UCSC/SSG	
Assembly		Revision	
Date: 1/14/2005	Sheet * of *		
File: HYD_2004.SCHDOC	Drawn By:		



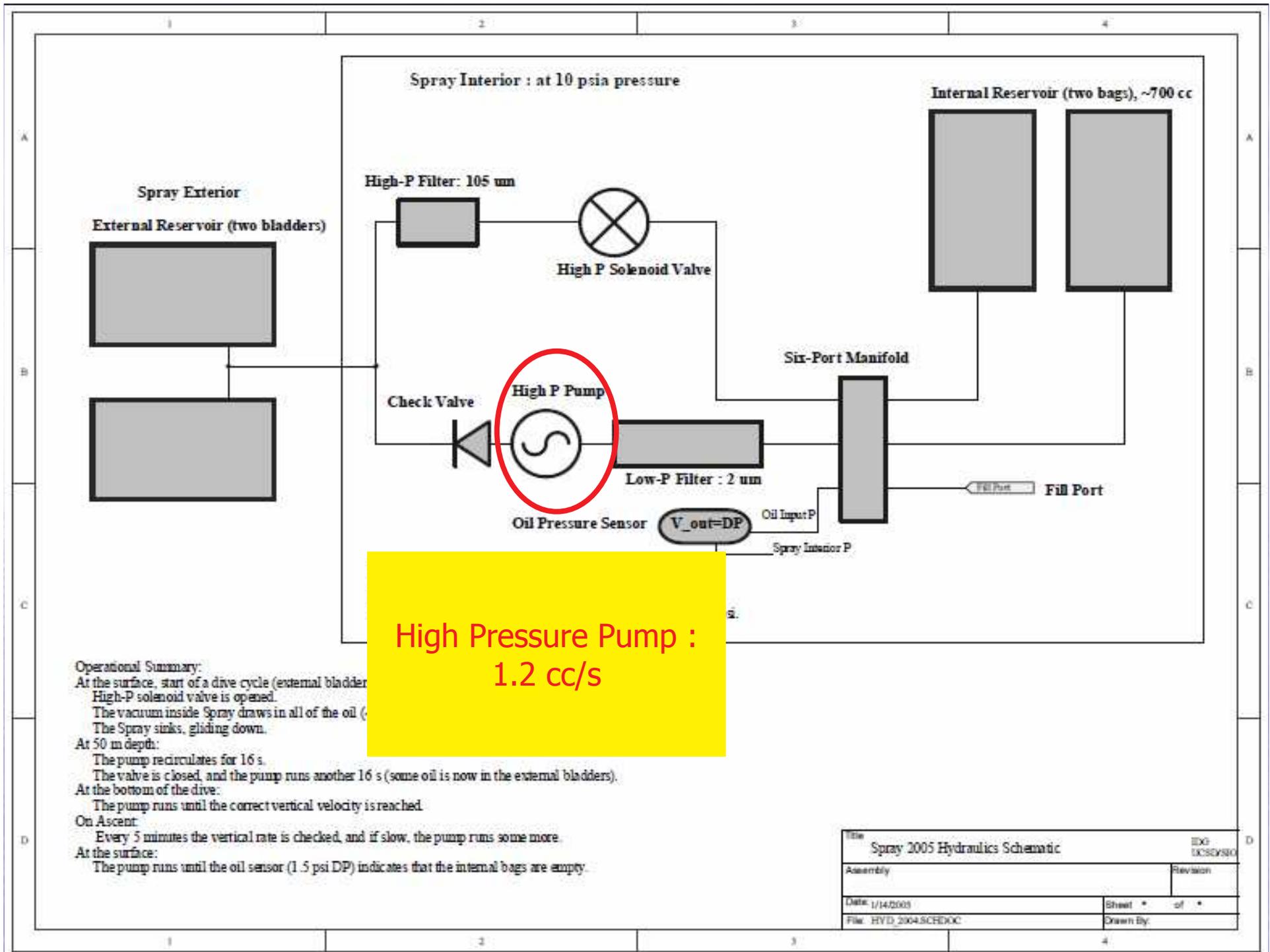
External bladders



Operational Summary:

- At the surface, start of a dive cycle (external bladders are full).
 - High-P solenoid valve is opened.
 - The vacuum inside Spray draws in all of the oil (~10 minutes).
 - The Spray sinks, gliding down.
- At 50 m depth:
 - The pump recirculates for 16 s.
 - The valve is closed, and the pump runs another 16 s (some oil is now in the external bladders).
- At the bottom of the dive:
 - The pump runs until the correct vertical velocity is reached.
- On Ascent:
 - Every 5 minutes the vertical rate is checked, and if slow, the pump runs some more.
- At the surface:
 - The pump runs until the oil sensor (1.5 psi DP) indicates that the internal bags are empty.

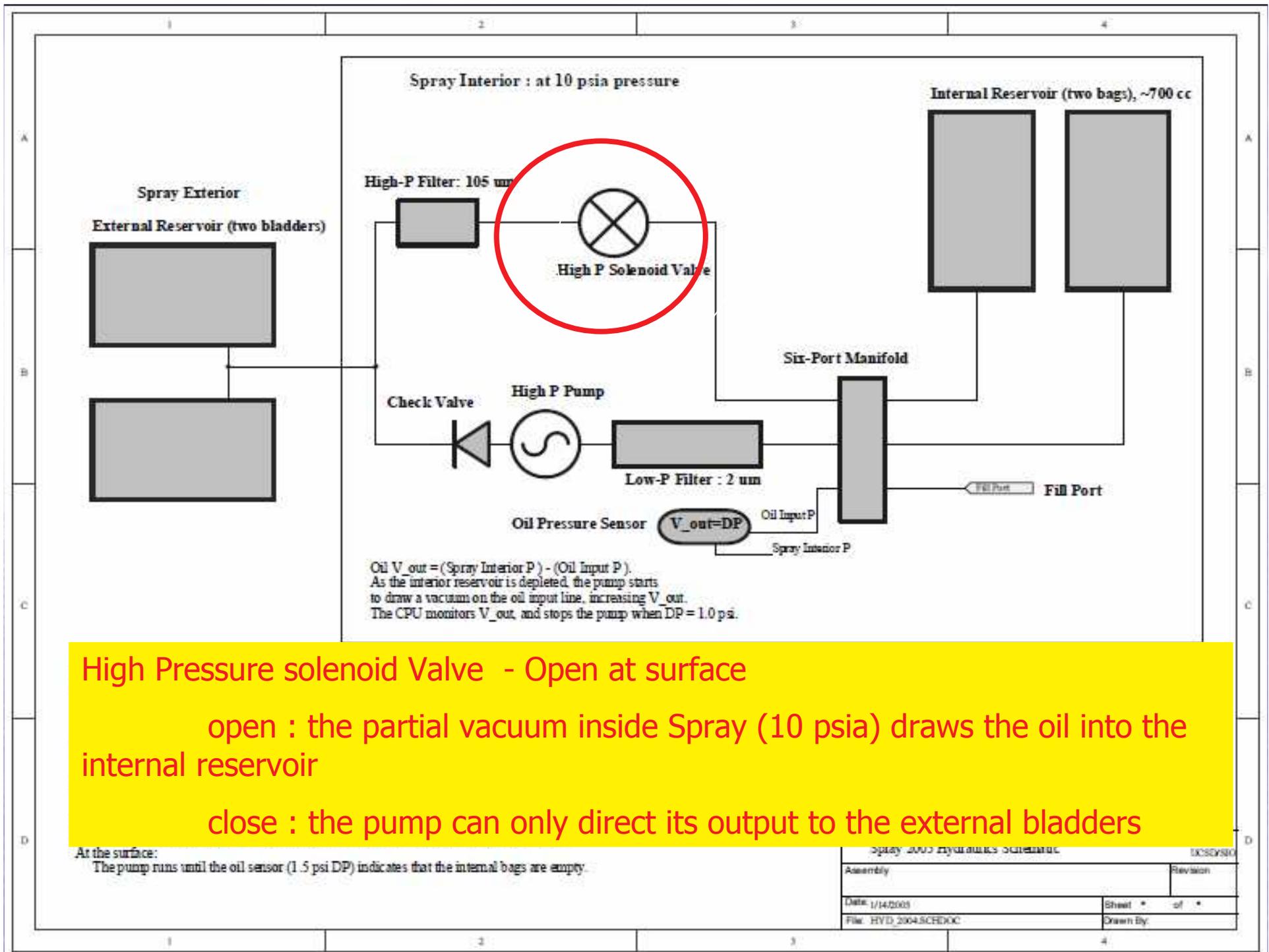
Title		EDG UCSC/SSG	
Spray 2005 Hydraulics Schematic		Revision	
Assembly		Sheet * of *	
Date: 1/14/2003	File: HYD_2004.SCHDOC		Drawn By:



High Pressure Pump :
1.2 cc/s

Operational Summary:
 At the surface, start of a dive cycle (external bladder)
 High-P solenoid valve is opened.
 The vacuum inside Spray draws in all of the oil ()
 The Spray sinks, gliding down.
 At 50 m depth:
 The pump recirculates for 16 s.
 The valve is closed, and the pump runs another 16 s (some oil is now in the external bladders).
 At the bottom of the drive:
 The pump runs until the correct vertical velocity is reached.
 On Ascent:
 Every 5 minutes the vertical rate is checked, and if slow, the pump runs some more.
 At the surface:
 The pump runs until the oil sensor (1.5 psi DP) indicates that the internal bags are empty.

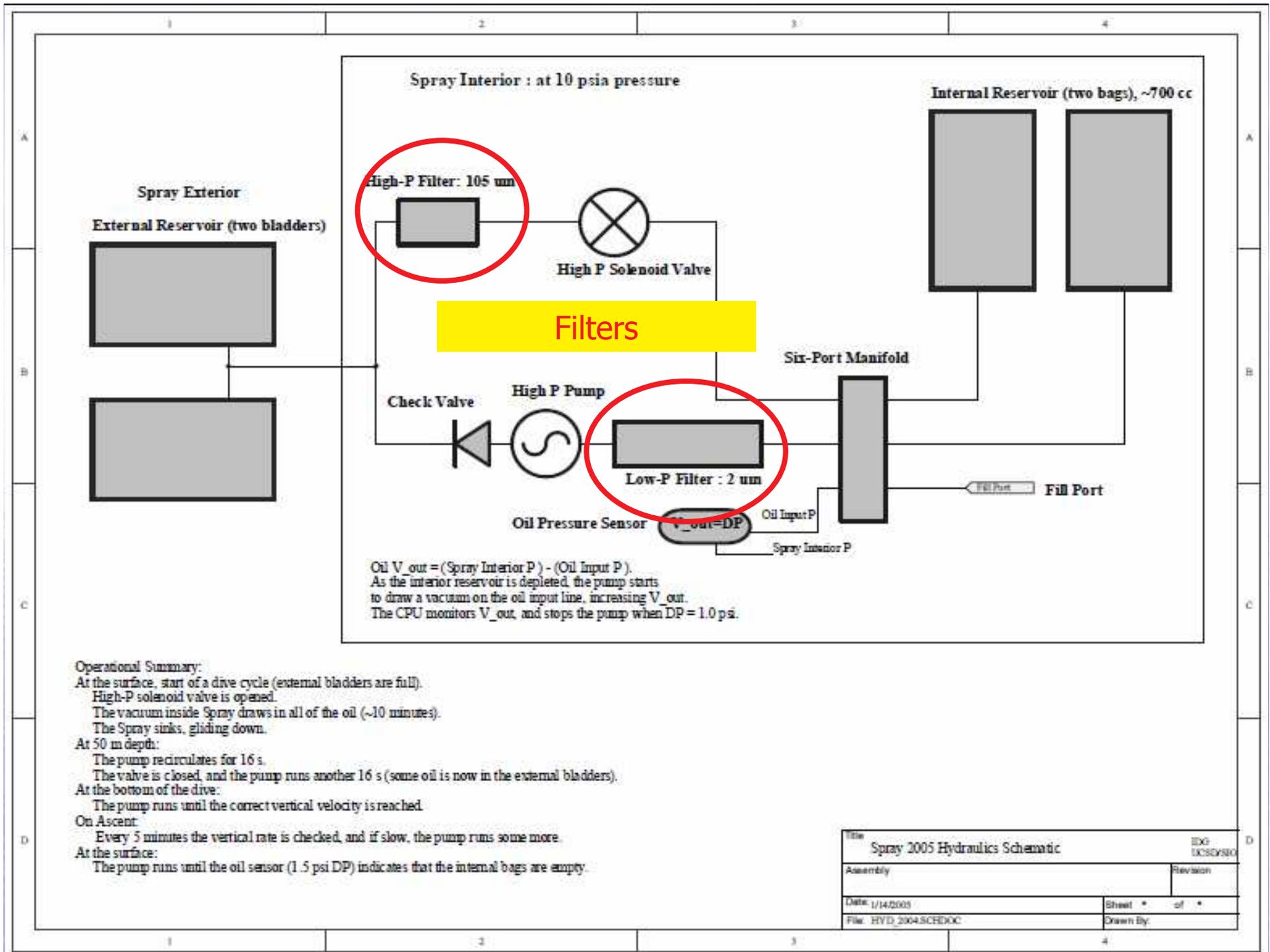
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Assembly		Sheet * of *	
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File: HYD_2004.SCHDOC			

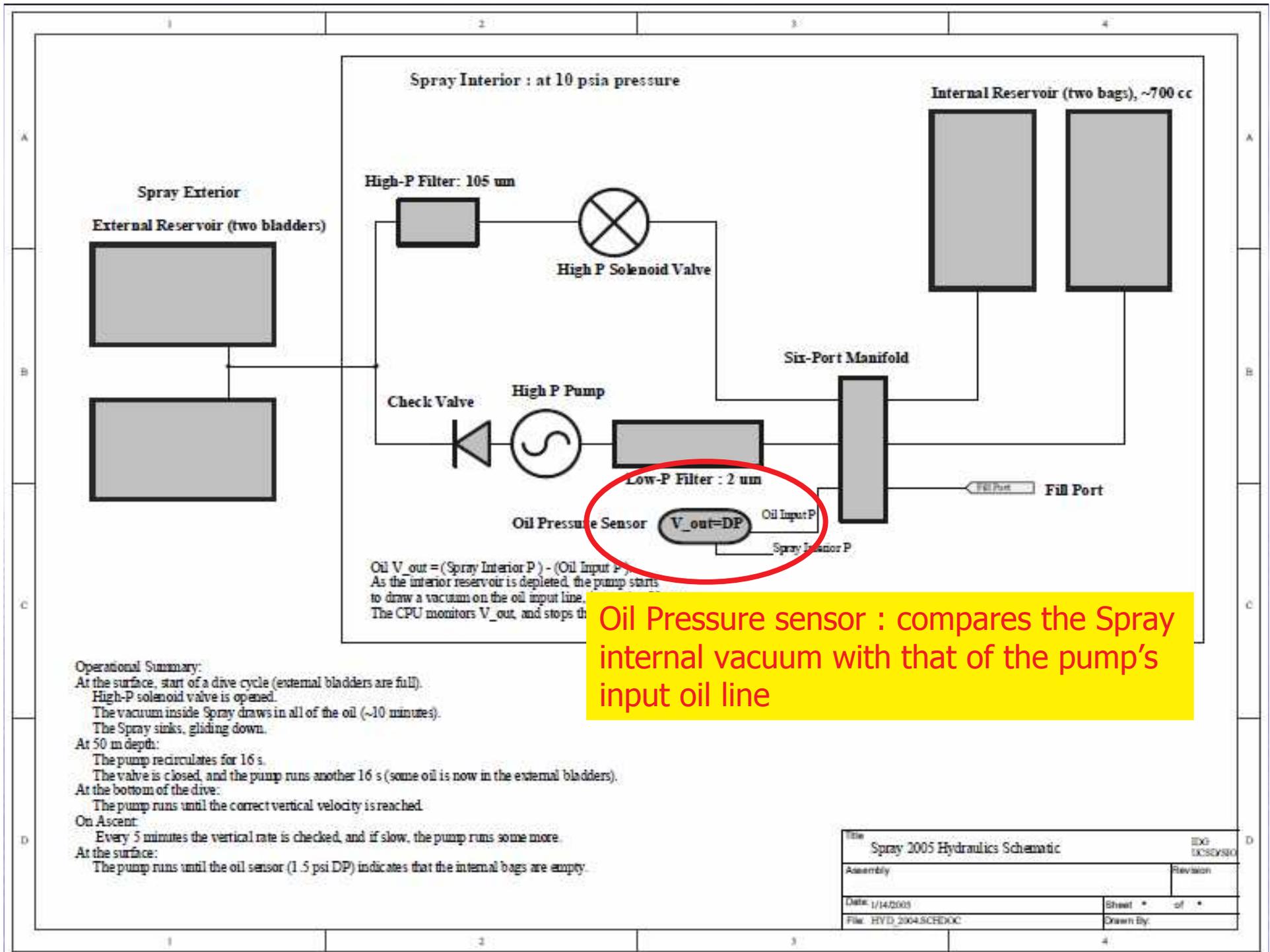


High Pressure solenoid Valve - Open at surface

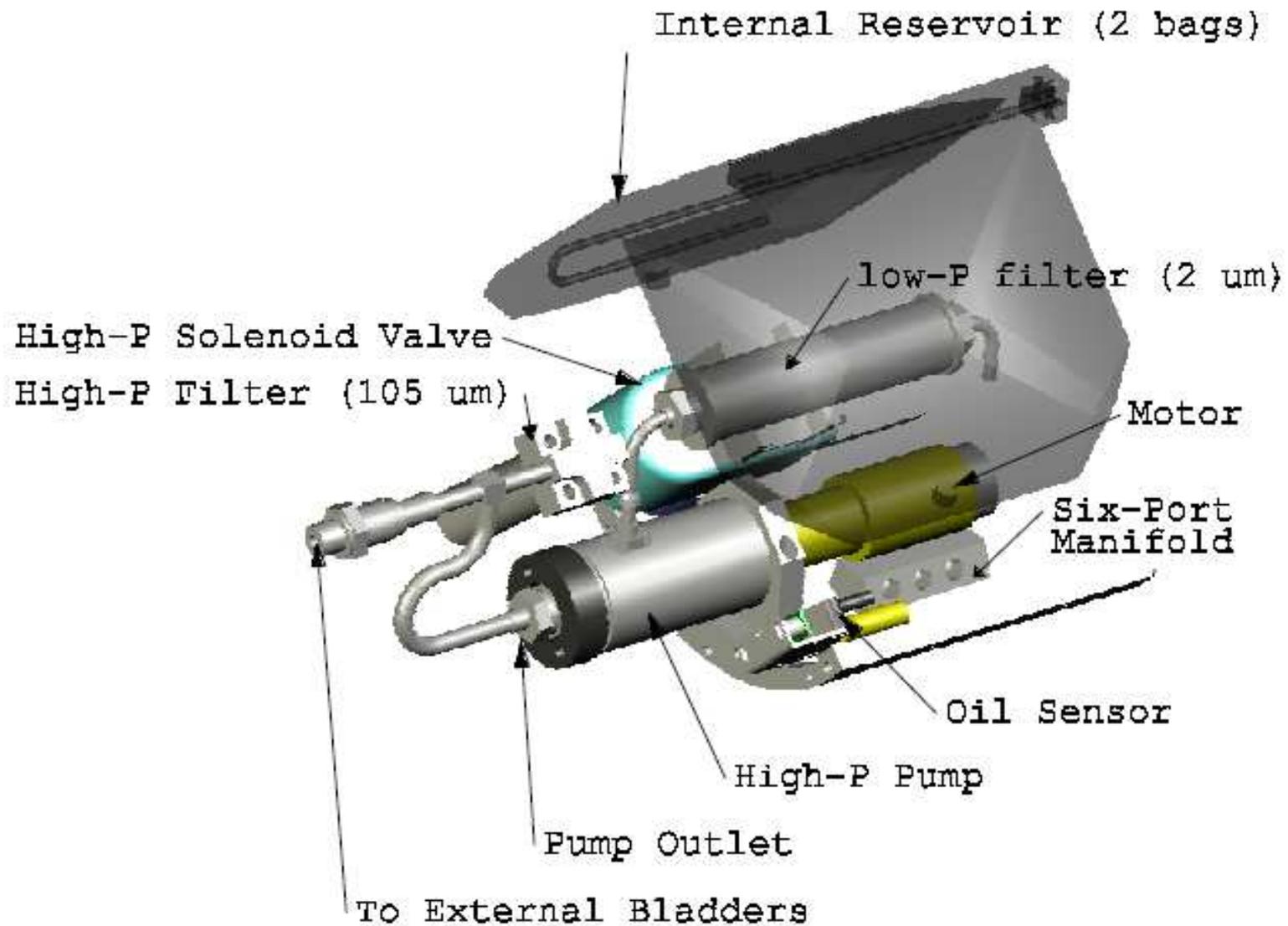
open : the partial vacuum inside Spray (10 psia) draws the oil into the internal reservoir

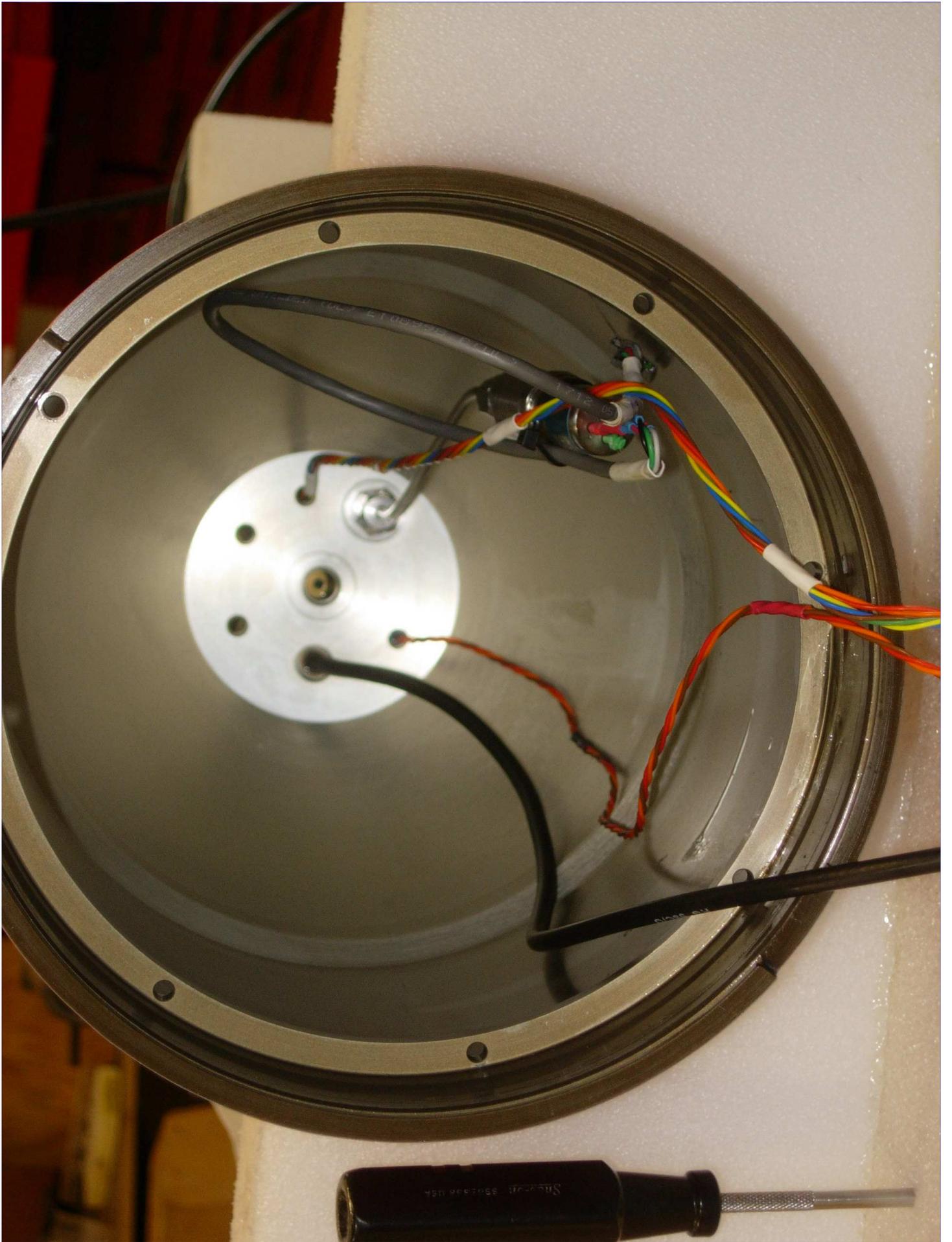
close : the pump can only direct its output to the external bladders

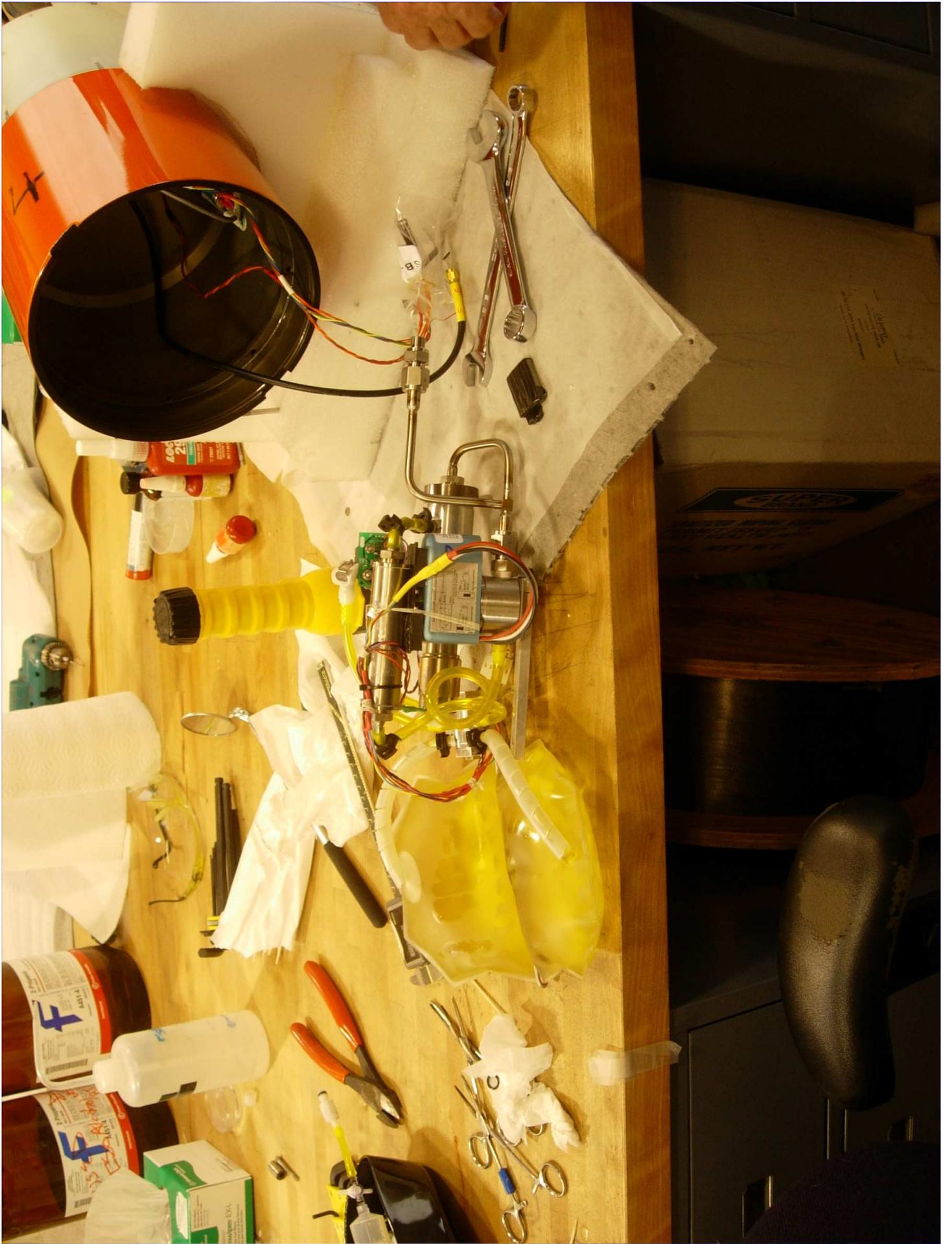




Schematic view









Hydraulic operations for 1 dive cycle

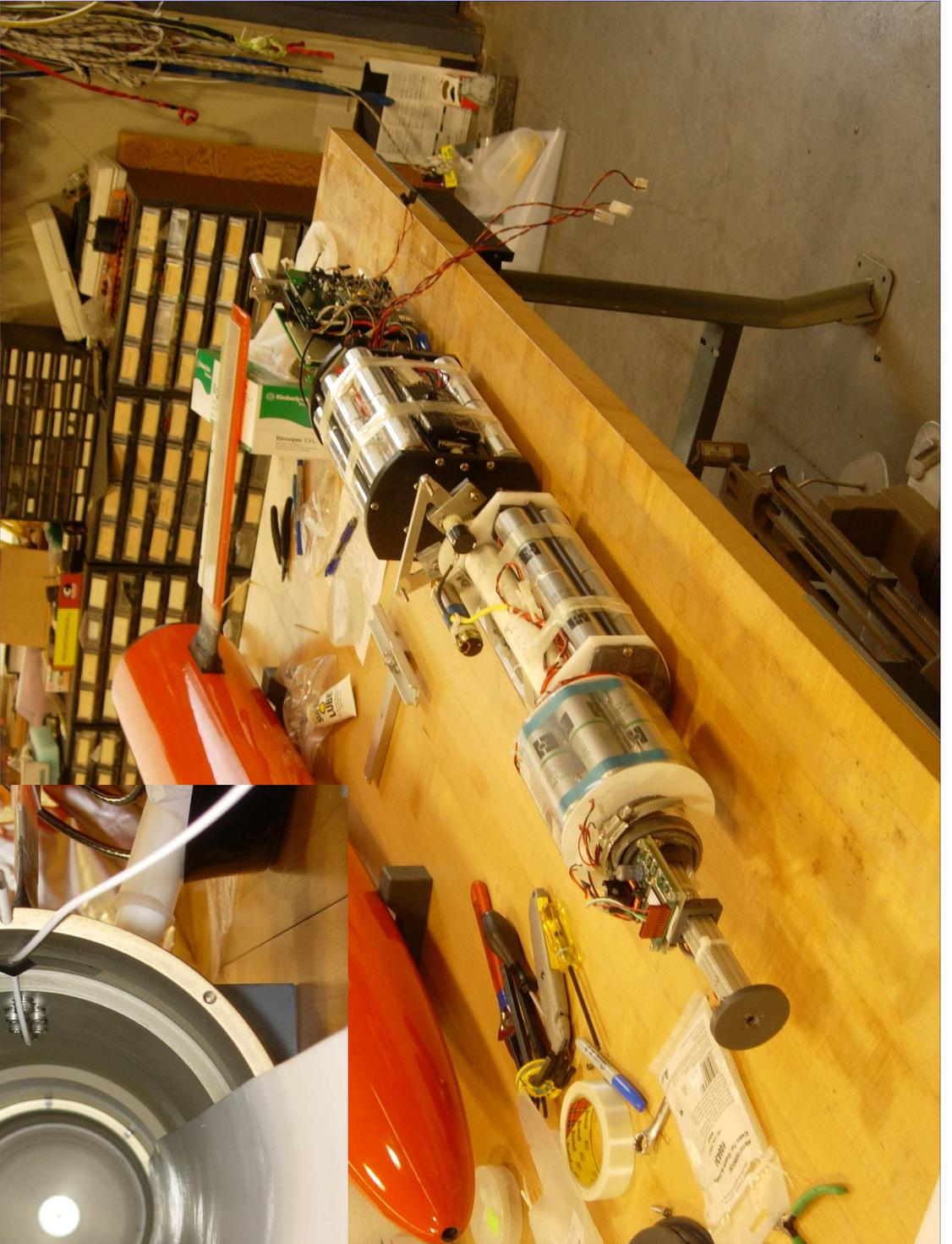
- Spray at surface, external bladders full.
- The solenoid valve is opened, Spray's internal vacuum draws in all of the oil from the external bladder (takes ~10 minutes).
- Spray sinking, gliding on the way down. At 50 m depth, pump runs for 16 s, the solenoid valve is closed, Spray pumps another 16 s, moving ~16 cc into the external bladders. This external oil ensures that there is no pressure difference between the external bladders and the high pressure porting, preventing bladder extrusion through the hydraulic port.
- bottom of the dive, pump runs until Spray reaches the correct vertical velocity for ascent.
- pump runs periodically on ascent to maintain the correct vertical velocity (checked every five minutes).
- At the surface, the pump runs until the oil sensor indicates that the internal bags are empty (dP ~1 psi). This provides maximum buoyancy to ensure optimal antenna performance.

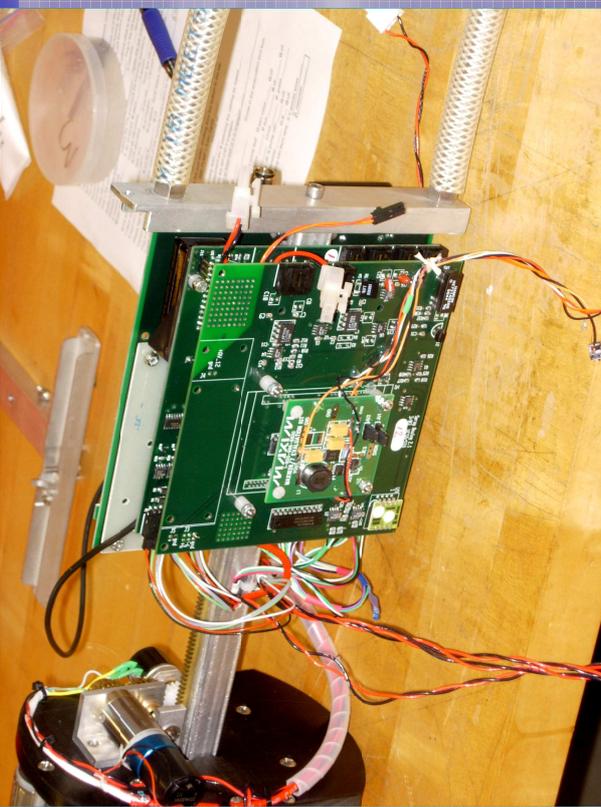
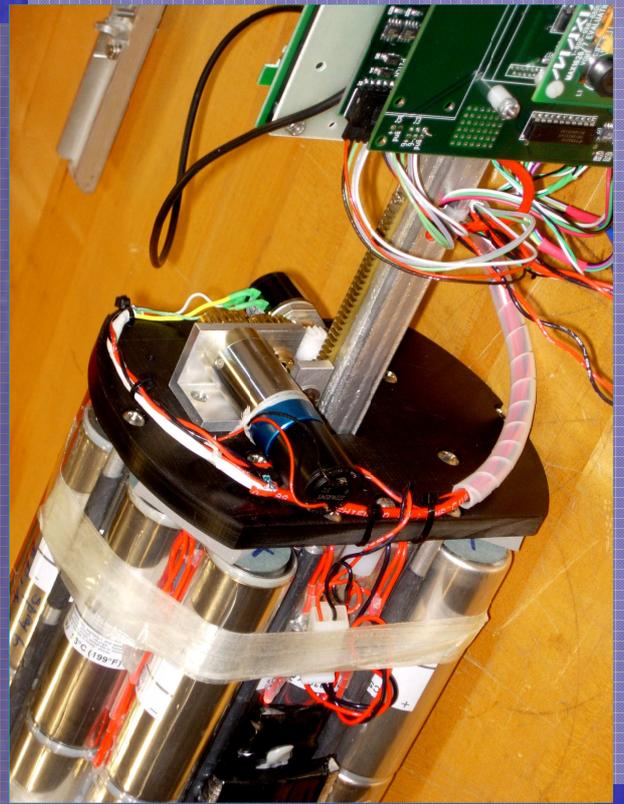
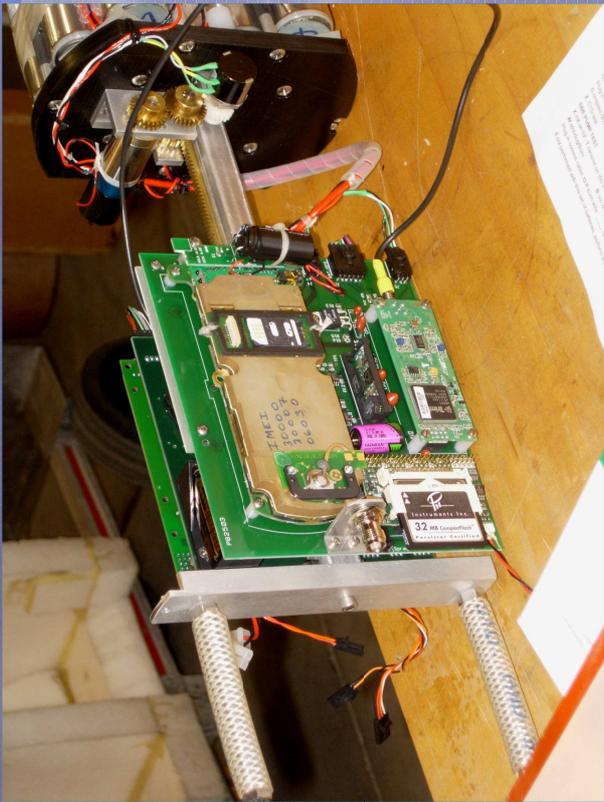
Electronics

- Buoyancy control : pump, valve, differential oil pressure sensor
- Attitude control : pitch, roll, compass, altimeter
- Scientific sensors commands : CTD, (optical, acoustical)
- Processing and storing data
- Navigation : dead reckoning, waypoints
- Communication : sending data, receiving commands
- Emergency scenarii : no comms, no GPS, pump problem, Argos beacon, drop weight
- Watchdog

Electronics (2)

- Onset TT8 : main
- Persistor CF1 : storage on FlashCard
- Software : 3 levels
 - Board OS (code download)
 - Glider OS (menu-oriented)
 - Glider application (mission mode)
- Low consumption





Energy

- Lithium CSC primary batteries
- 52 DD Electrochem cells
- 14V (44 cells) and 7V (8 cells)
- ~12 kg
- 13 MJ

Sensors

- CTD SBE pumped version
- Fluorometer (in pumped circuit)
- Optode
- Sontek ADP
- More...

Data

Sampling

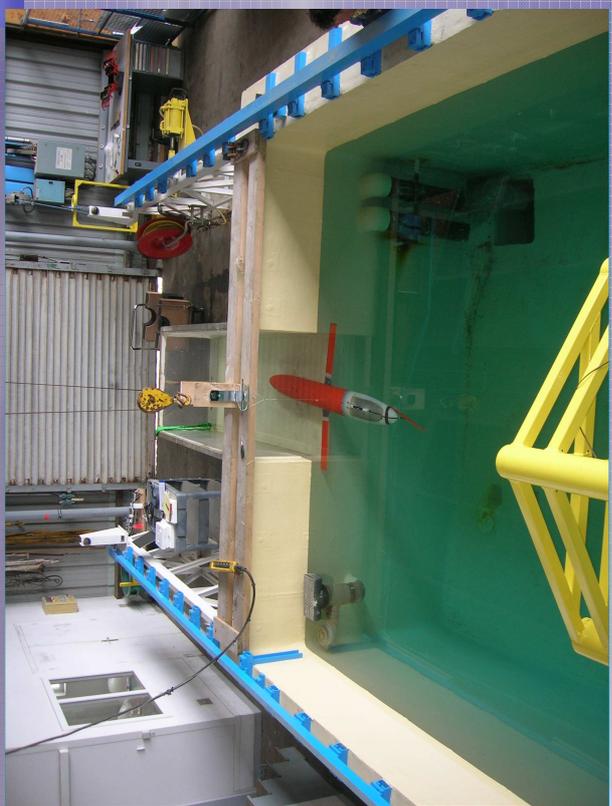
- both casts : 8s / ~ 1 m (flight & engineering)
- Up cast only : CTD & additional sensors
- ADP : special case

- Data :
 - raw : stored on board
 - 4 months, 4 sensors : 128 MB compatible
 - decimated : 24-32s/3-4 m (sensors+GPS+eng.)
 - 1 message / dive

Ballast and Trim

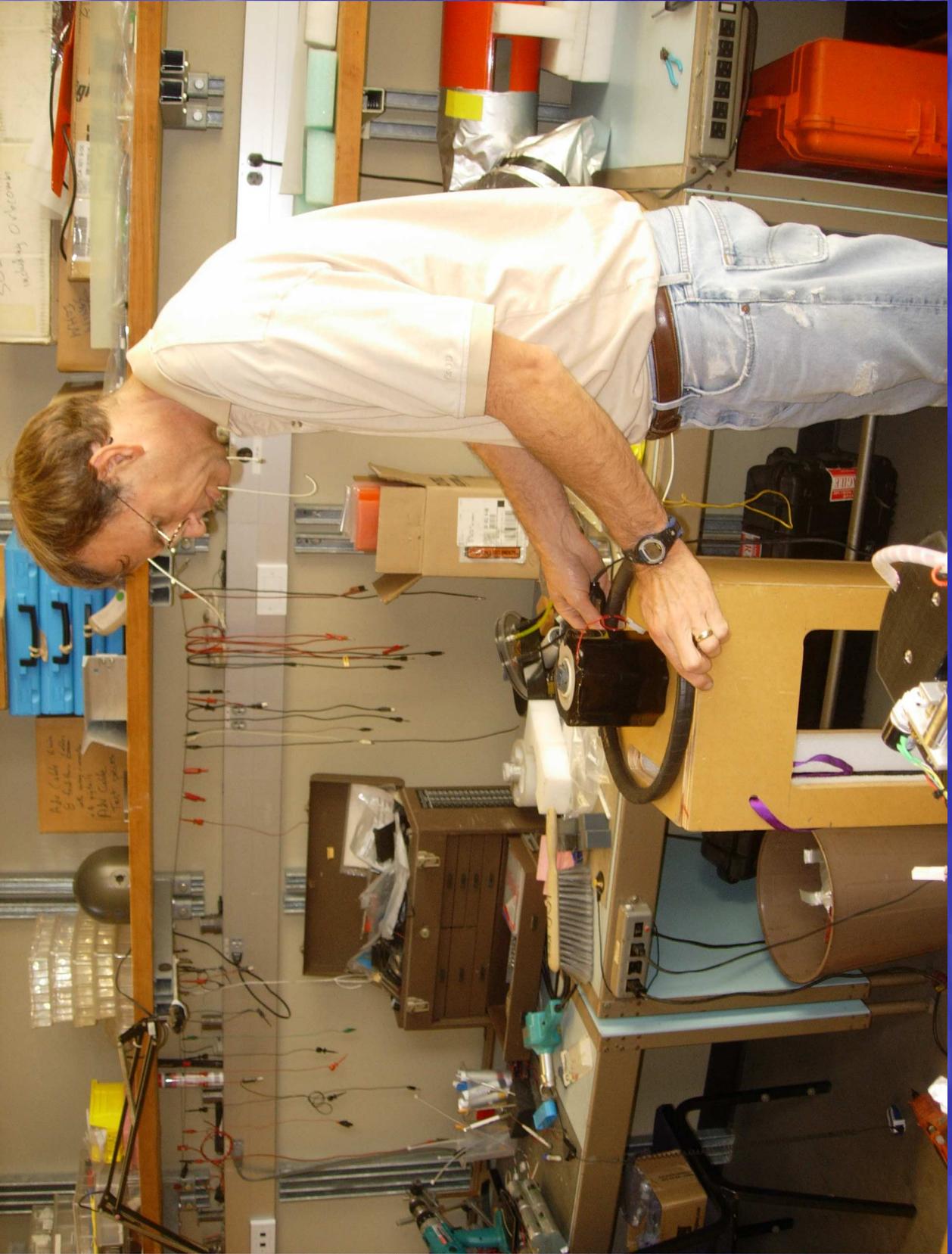
- Target weight of 250 g in the less dense water of deployment area
 - Volume 750 cc available, 150 cc for compressibility → 600 cc useable
- Adjust surface attitude for communication (pitch & roll)

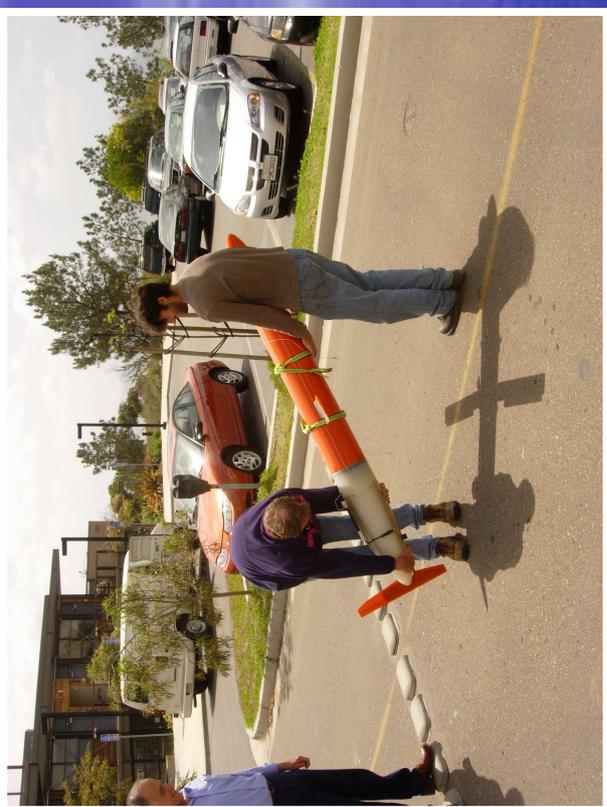




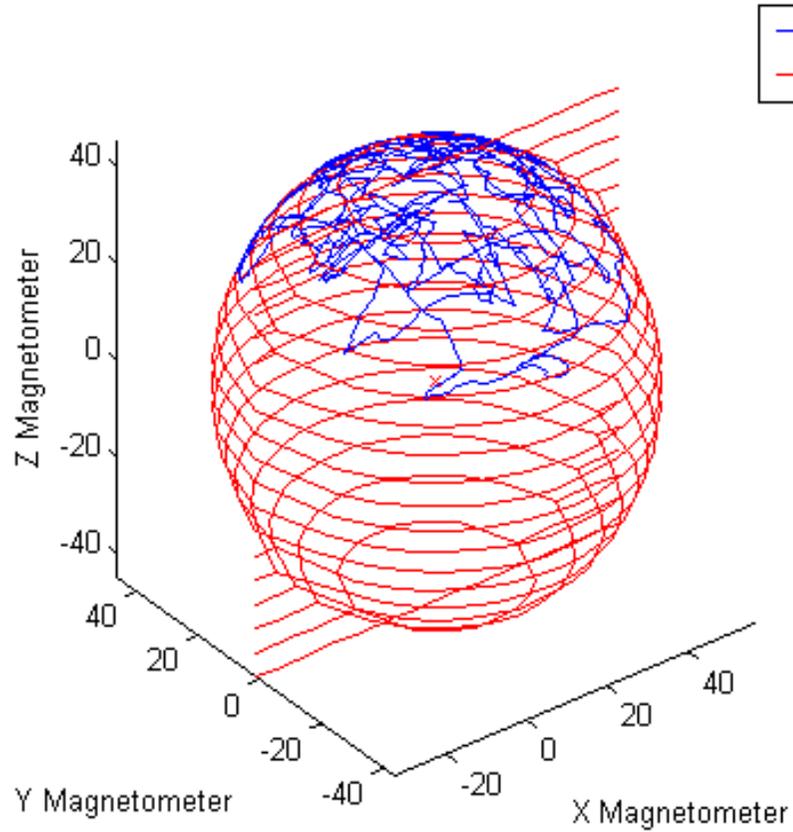
A background image showing a vast blue ocean under a blue sky with wispy white clouds. The horizon line is visible in the distance.

Compass calibration





Calibration for spray16_p_ap3_c_ompass_0ldway.txt



— Magnetometer Readings
— Estimated Sphere

Table (°)	Spray Compass (°)		Spray - Table (°)	Roll (°)	Pitch (°)
	Tr 1	Tr 2			
0	1.3		+1.3	0.4	0.2
45	77.7	77.7	+32.7	0.9	0.6
90	118.0	118.2	+28.0	1.5	0.5
135	148.0		+13.0	1.8	0.0
180	176.1	176.4	-3.6	1.7	-0.4
225	204.8		-20.2	1.4	-0.7
270	236.8	236.6	-33.2	0.9	-0.8
315	278.1		-36.9	0.4	-0.4
0	1.3	1.4	+1.3	0.4	0.2

Table (°)	Spray Compass (°)		Spray - Table (°)	Roll (°)	Pitc h (°)
	Tr 1	Tr 2			
0	353.9		-6.1	-1.5	0.2
45	48.8		+3.8	-1.0	0.4
90	99.9	99.8	+9.9	-0.4	0.4
135	142.2		+7.2	-0.1	0.0
180	179.4	179.3	-0.6	-0.2	-0.5
225	217.3		-7.7	-0.5	-0.9
270	257.2	257.2	-12.8	-1.0	-0.9
315	302.8		-12.2	-1.6	-0.5
0	354.2	354.0	-5.8	-1.4	0.0

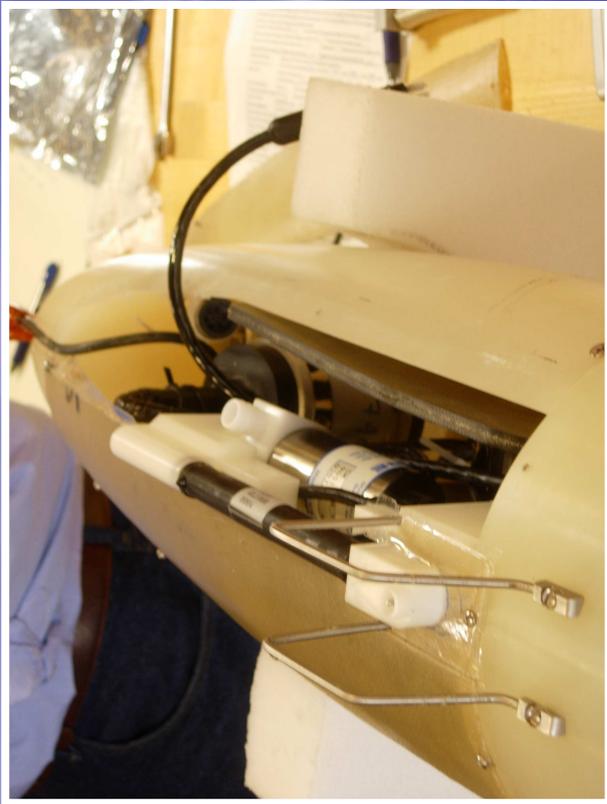
Internal

Table (°)	Spray Compass (°)	Spray - Table (°)	Roll (°)	Pitch (°)
0	358	-2	-1.5	0.2
45	40	-5	-1.0	0.4
90	85	-5	-0.4	0.4
135	130	-5	-0.1	0.0
180	176	-4	-0.2	-0.5
225	223	-2	-0.5	-0.9
270	270	0	-1.0	-0.9
315	315	0	-1.6	-0.5
0	358	-2	-1.4	0.0

« In house »

A blue-tinted photograph of a vast ocean under a cloudy sky. The text "Sensors calibration" is centered in white.

Sensors calibration

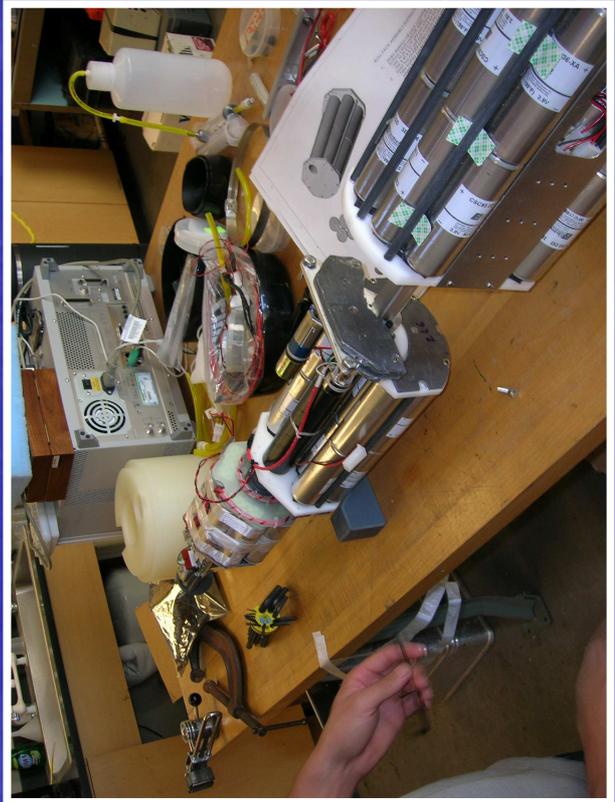




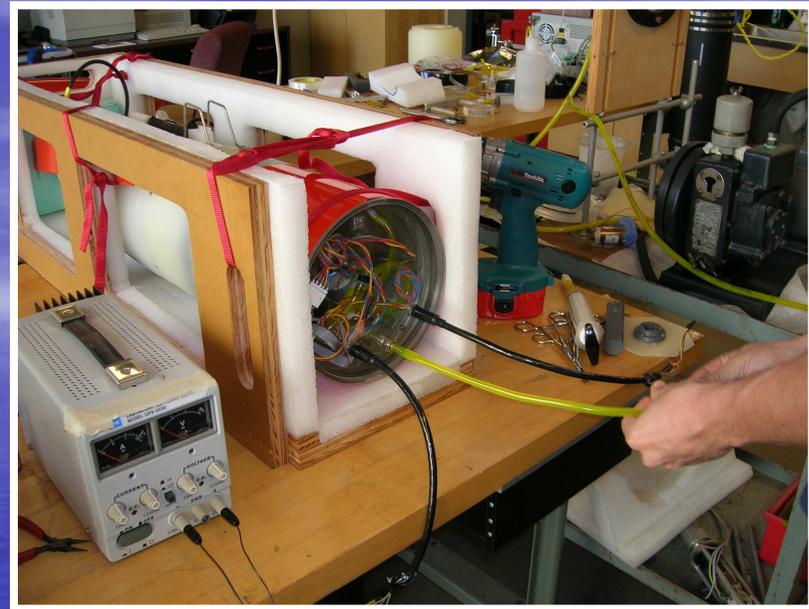


A blue-tinted photograph of a vast ocean under a cloudy sky. The word "Maintenance" is centered in white text.

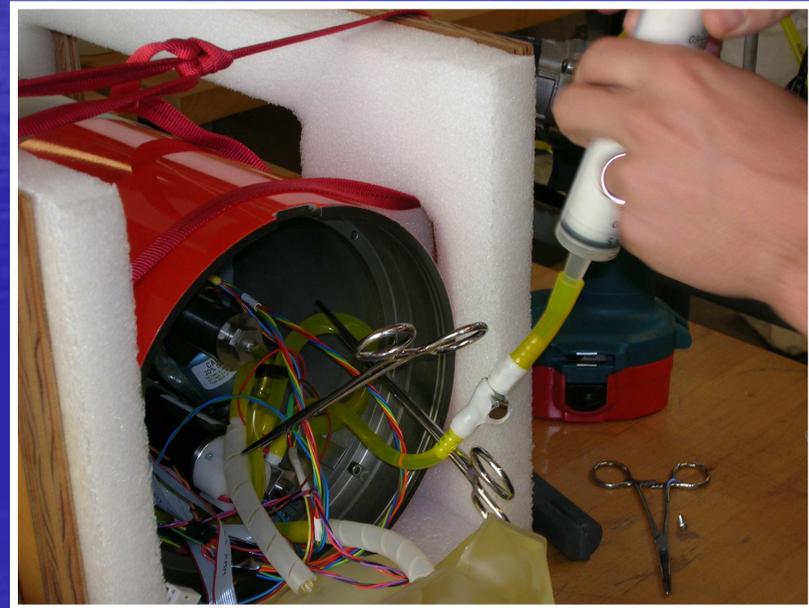
Maintenance



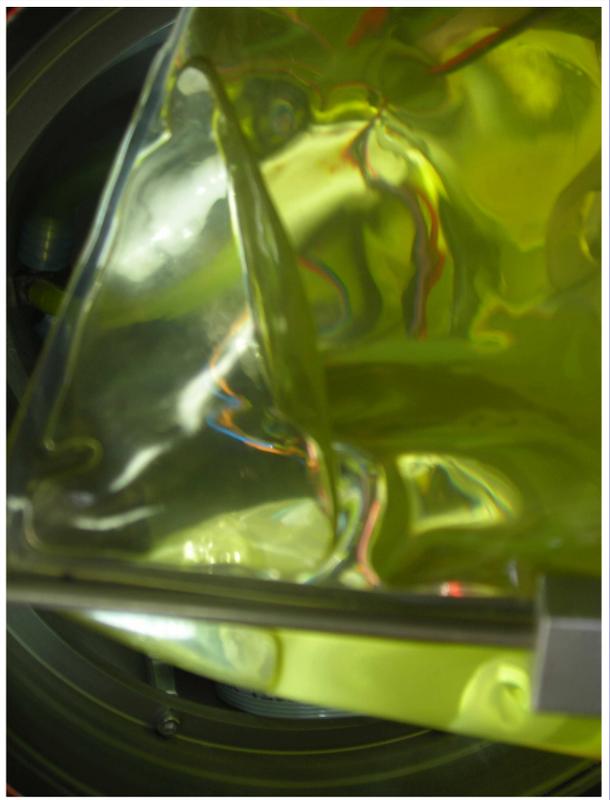
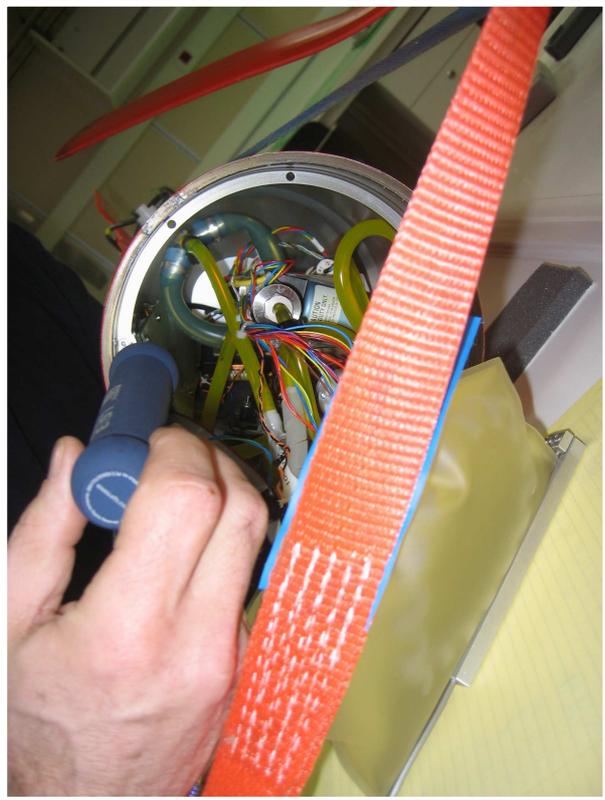
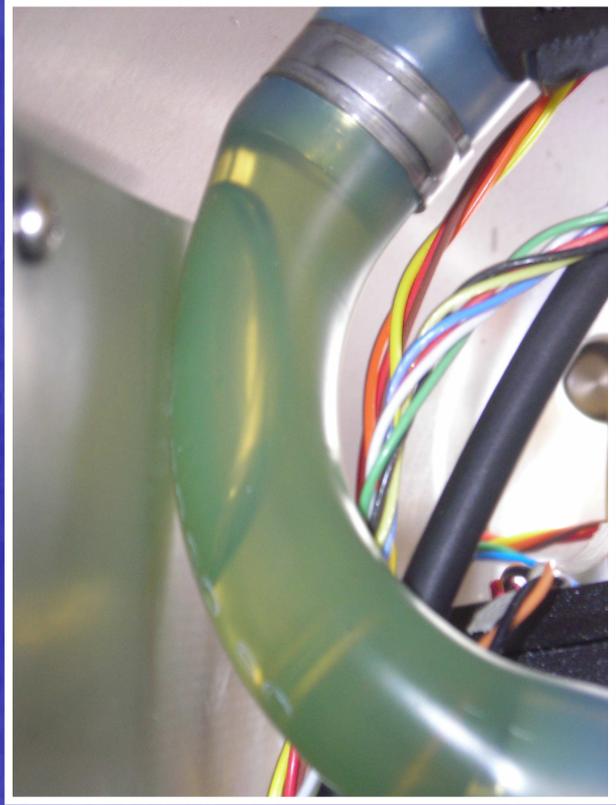
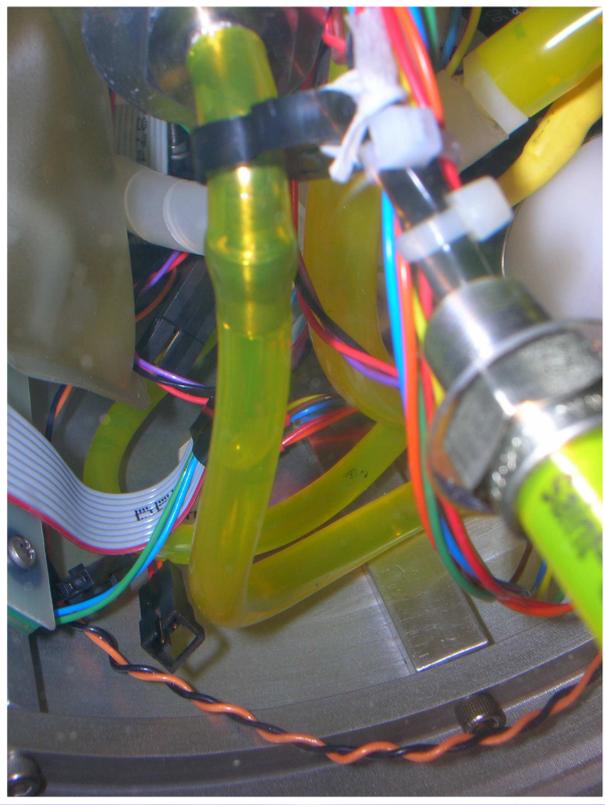
Nomenclature /Revision	Datée	Numéro	Poids (g)	Poids ancien (g)	Ecart (g)
Groupe Pitch					
3PD1209 / 639B	12/06	0073	1769	1772	-3
3PD1209 / 639B	12/06	0074	1767	1769	-2
3PD1210 / 627A	12/06	0037	870	886	-16
3PD1211 / 639A	12/06	0073	889	890	-1
3PD1211 / 639A	12/06	0074	887	890	-3
Total			6182	6207	-25
Groupe Roll					
3PD1208 / 639B	12/06	0073	1773	1775	-2
3PD1208 / 639B	12/06	0074	1772	1777	-5
Total			3545	3552	-7
Groupe Forward					
3PD1212 / 639B	12/06	0073	881	881	0
3PD1212 / 639B	12/06	0074	884	877	+7
Total			1765	1758	+7
Poids et écart total			11492	11517	-25



1 US Allen set – 1 flashlight



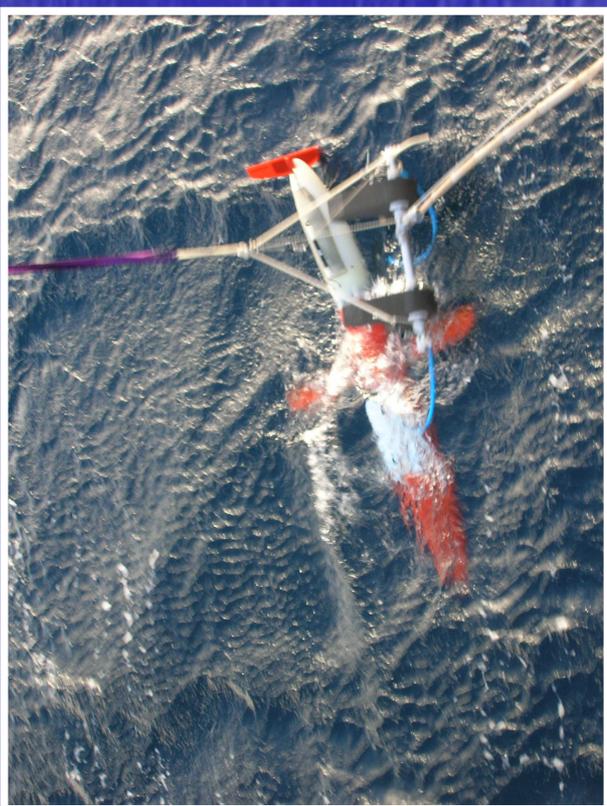
1 screw driver

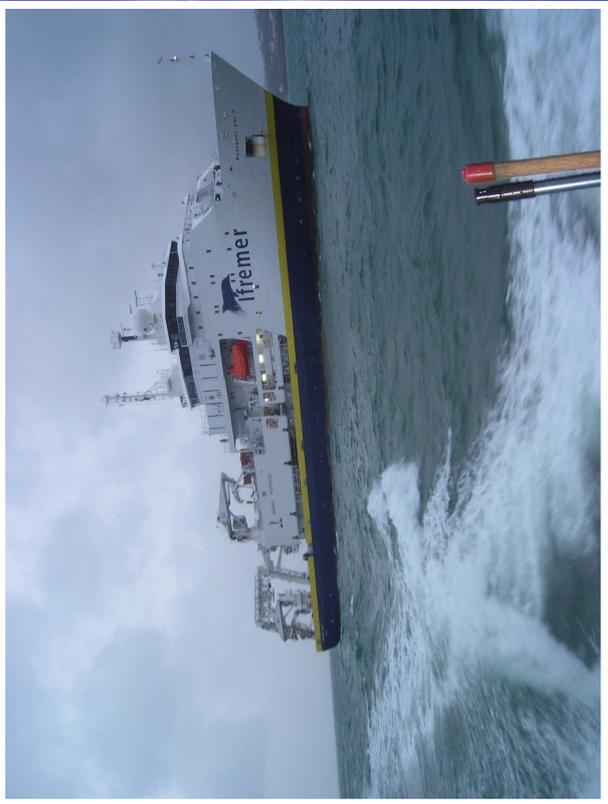
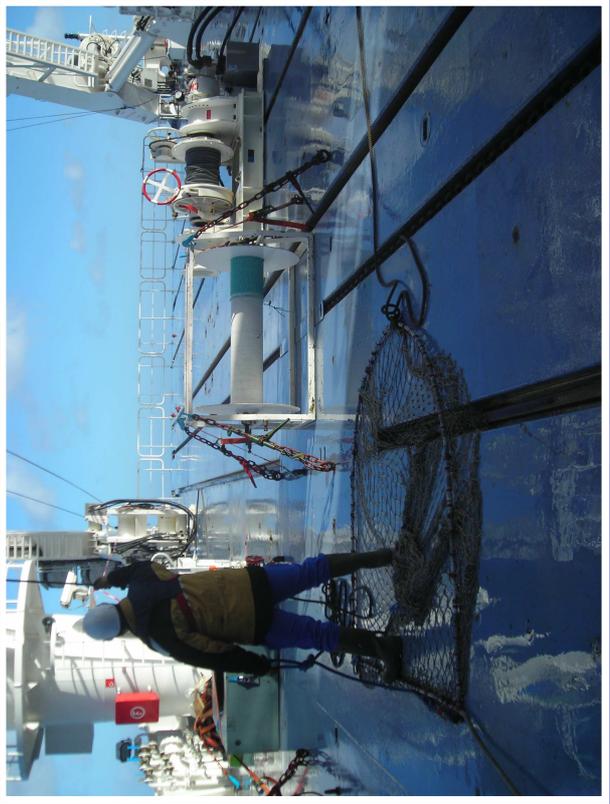


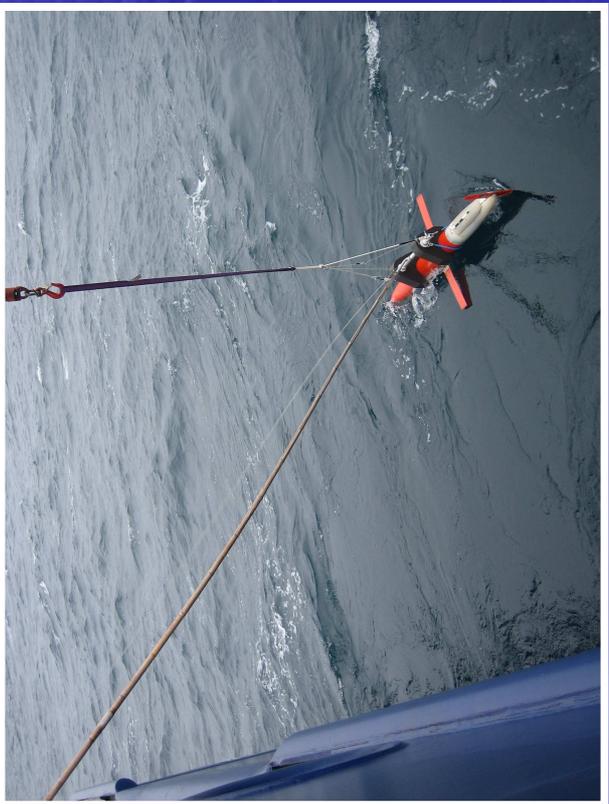
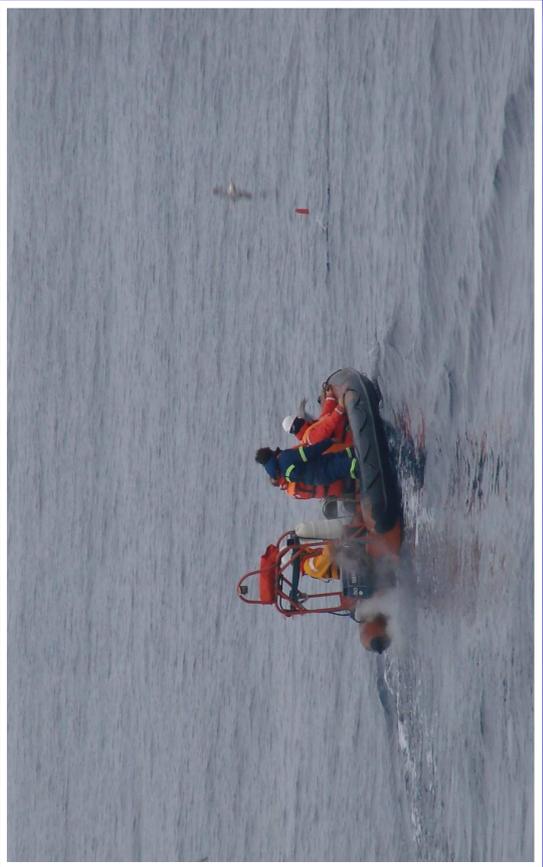


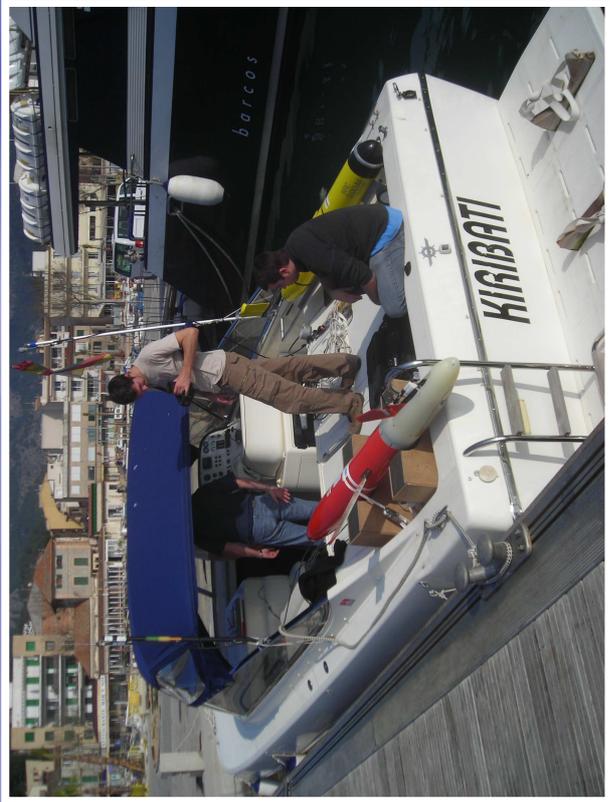
Deployment / Recovery

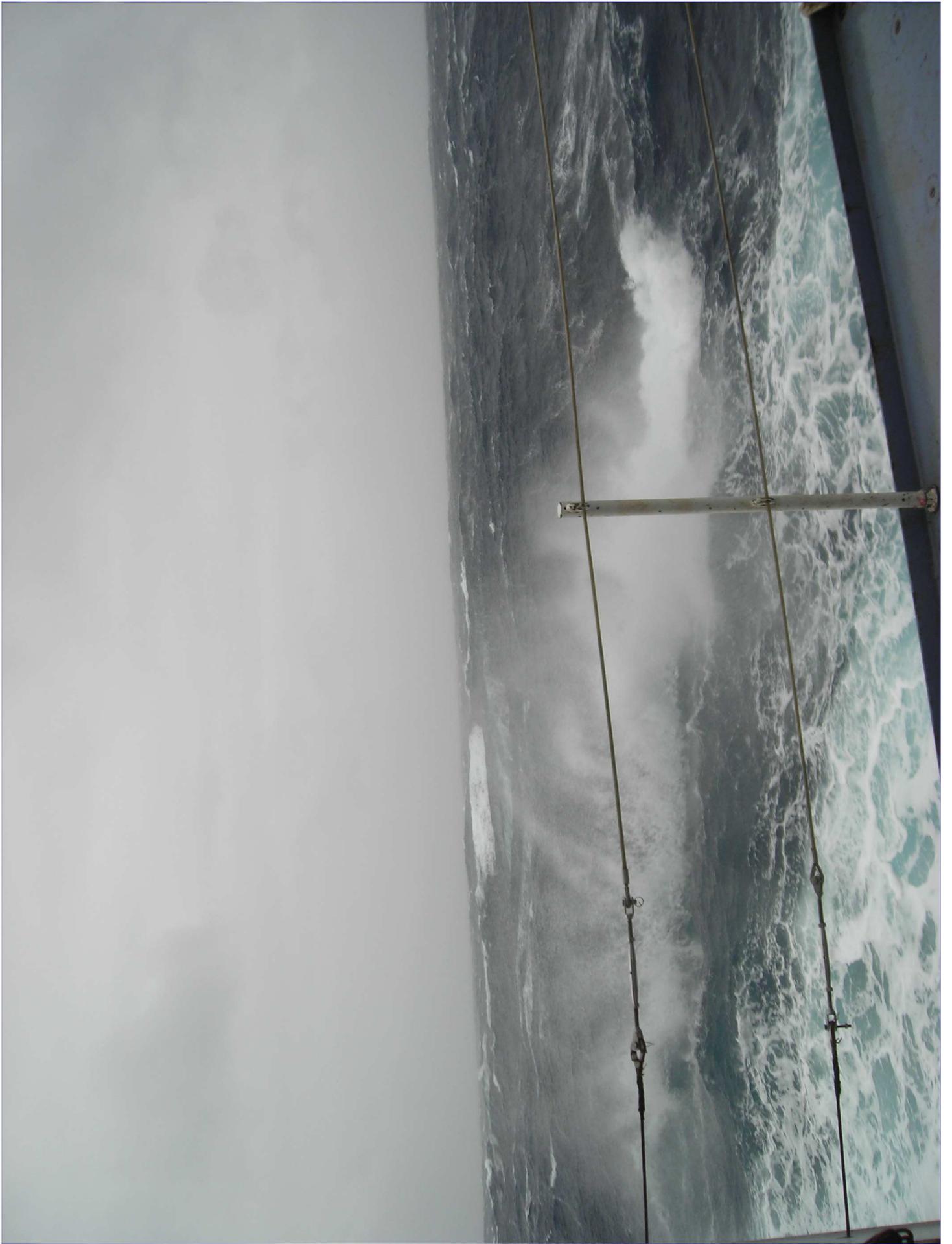


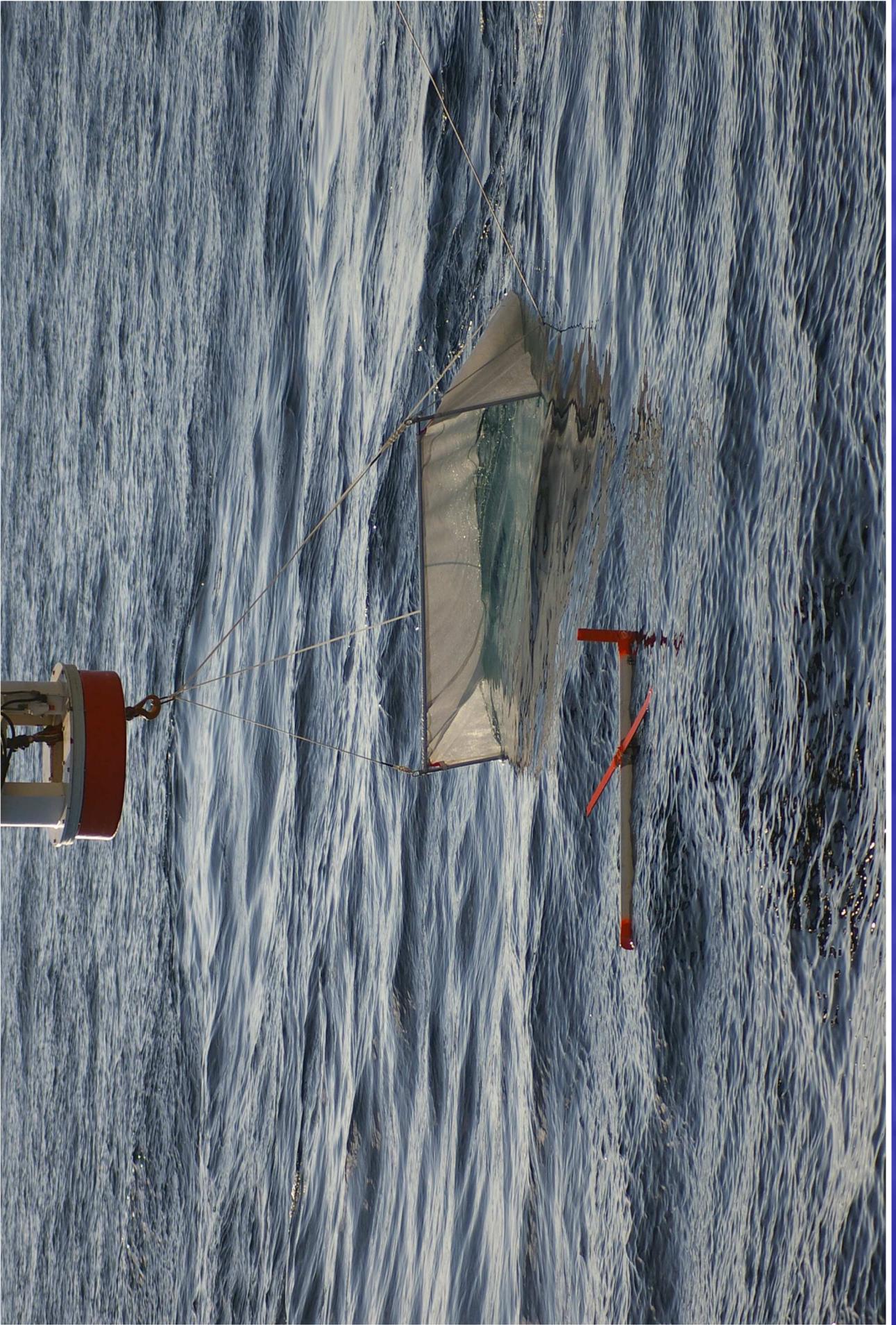


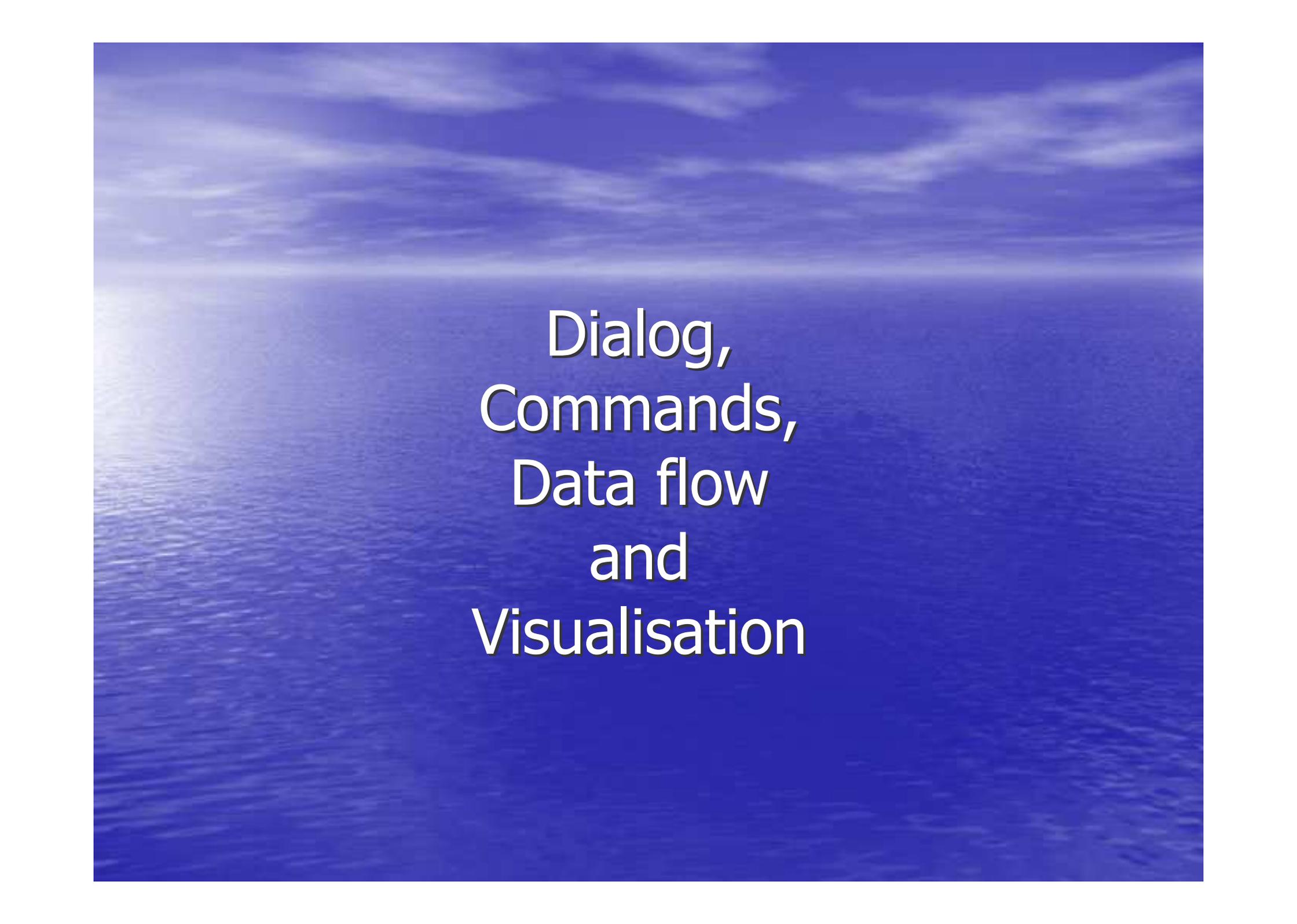






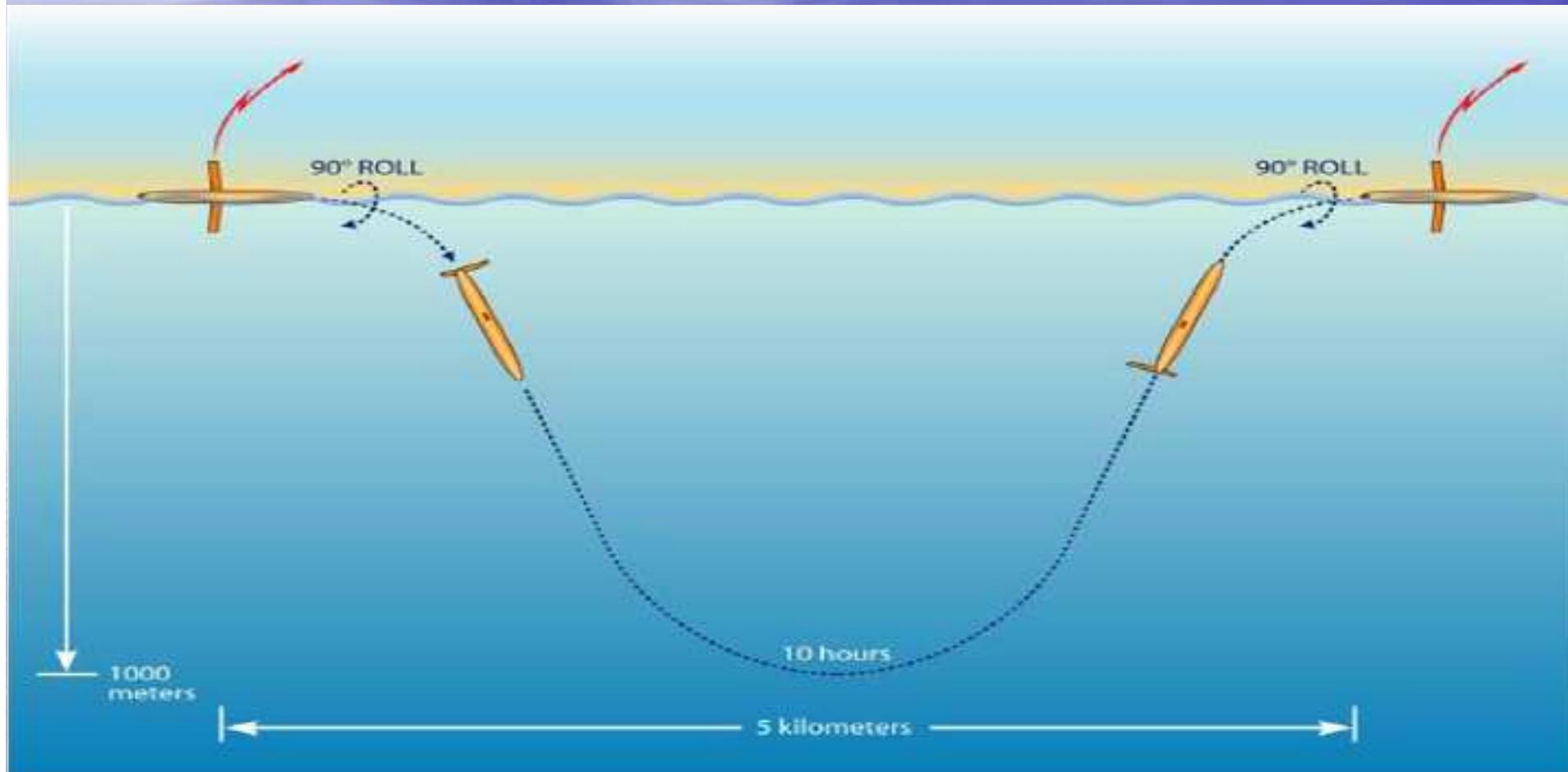






Dialog,
Commands,
Data flow
and
Visualisation

Surface attitude



Iridium Short Burst Data Services

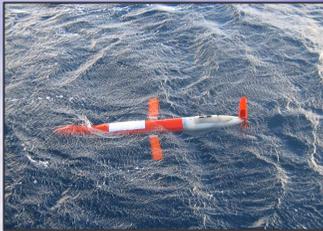
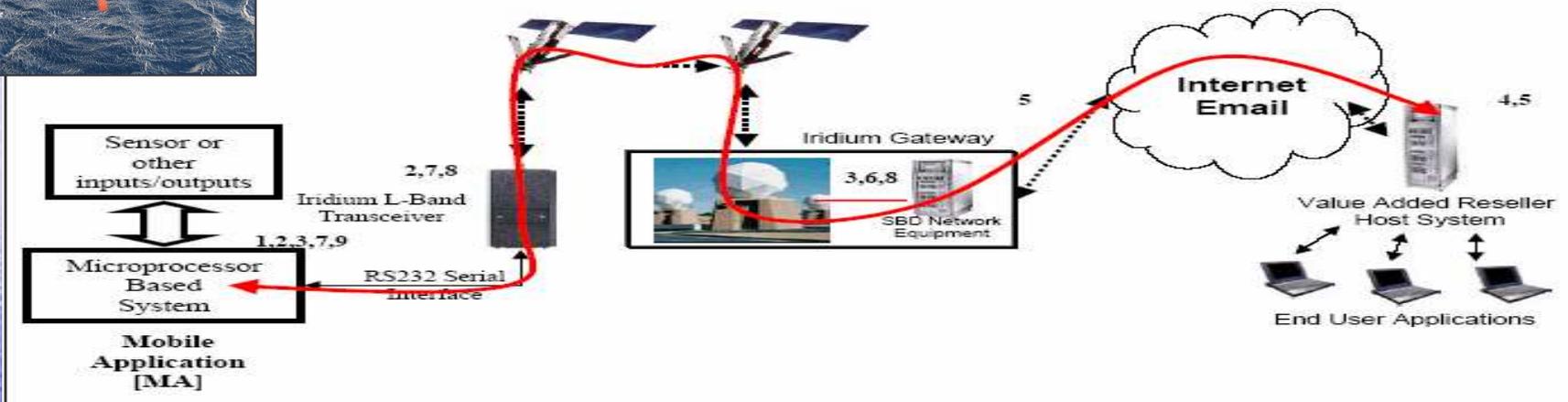


Figure 7
A SBD Data Call from a remote application (ISU) to the Internet.



Sequence of Events: MO-SBD

1. MA loads the MO-SBD data message into the L-Band Transceiver.
2. MA instructs the L-Band Transceiver to send the SBD Message to the Iridium Gateway
3. Iridium Gateway SBD Equipment receives the SBD Message; sends an acknowledgement to the MA and creates an email message with the SBD data message as an attachment to the email.
4. Email message is sent to the destination email server hosted by the Value Added Reseller for processing of the data message.

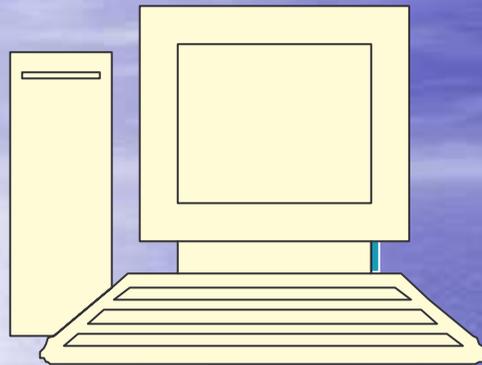
Sequence of Events: MT-SBD

5. Email message is sent to the Iridium Gateway server by the Value Added Reseller's Host Server.
6. Iridium Gateway SBD Equipment receives the MT-SBD Message and stores it in a database.
7. The MA initiates a "Mailbox Check" and the MT-SBD Message is downloaded to the L-Band Transceiver.
8. The L-Band Transceiver sends an acknowledgement to the Iridium Gateway that the MT-SBD Message has been delivered.
9. MA extracts the MT-SBD Message from the L-Band Transceiver and processes the message.

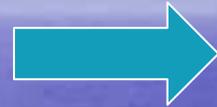
Comms scheme

- Spray : send/receive mails
 - 5 primary addresses at Iridium provider
 - Send sbd files ~2kb/file
 - Receive commands (a few bytes)
 - Automatic processing (perl, C & matlab scripts) run on mail reception (sendmail, procmail, .forward, ...)
 - Forward data to an unlimited number of mail addresses

Session automatique

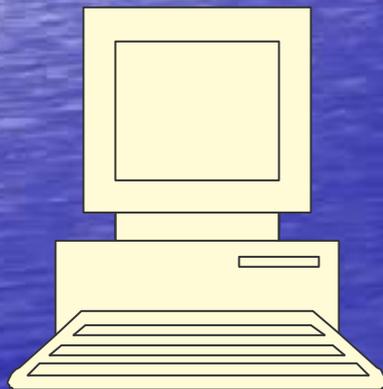


Mail server



Automatic Transfer (Coriolis, users, ...)

Recover/Send mails



Groundstation



- Decode data from the attached file
- Check integrity
- Produce plots for website
- Notify shortlist users status summary
- Notify errors and abort (SMS)
- Parser for commands and route

Lab mode : Menu driven

```
BAS>
    MAIN MENU Spray    4    Dive #    0    Op_mode = 0 in Mission
mode
IRIDIUM SBD is implemented
SBE CTD Version
NO 16-bit A/D
          ESC Abort prog : U.pdate menu
C.ompass      : D.ebug modules : E.eprom menu ←
F.lash CF1    : G.PS test      : H.yd pump test
L.ow-power mode: M.otor test      : N.av test
I.ridium test : R.ead results  : S.how params
T.est start   : W.atchdog/Burn : X.mit on RF
Y. 12-bit a/d : Z. CTD test      : 0. set Dive#=0
    BAS>

          pitch/roll motor test Oct 29 2005
          Pitch/Roll Motor Menu
Q.uit motors tst : U.pdate menu : M.easure pots
P.ort roll       : S.tbd roll  : X.mit pitch
A.ft pitch       : F.wd pitch  : 0. pitch
G.PS (stbd)wing up: I.su (port) up : Z.ero roll
M_1>
    pot pitch =    2100, roll =    1997
```

Parameters

- Eeprom Menu

Q.uit eeprom : U.pdate menu : C.ontrol Values
M.ission primary : 2.Mission secondary : A.DP values
N.avigation : P.itch&Roll Values: S.ensor Values
D.isplay All : F.ind Name : X.change value

- **Mission primary** : the mission parameters most likely to be modified
- **Mission secondary** : the mission parameters that need to be set just once
- **Navigation Parameters** : general behavior during nav (Current corr., mag. Var., no GPS, ...)
- **Pitch and Roll values** : should only be changed after ballast/trim adjustments
- **Sensor values** : should only be set at the initial electronics calibration
- **Control values** : pitch, roll, pump engineering values
 - A small subset only modified from shore

Field mode : Commands + route (parsers)

- E-mailed to Iridium system
- Acknowledged by Iridium
- Acknowledged by Spray at surfacing in instrument status

Route / Waypoints

- Waypoints structure
 - Lat, Lon, Valid
- Route structure
 - # of wpts,
 - current wpt,
 - Wpt reached ? radius, range and/or finish line
 - route direction (direct /reverse)
 - what to do at end of route ?



