The test of new mini AXBT and its possible mission in typhoon surveillance flight at western Pacific

Po-Hsiung Lin[1] Yu-Hung Hsiao[2] Yih Yang[2] Chia-Ying Tu[3] Chi-seng Lee[4]

[1]National Taiwan University
[2]Taiwan Ocean Research Institute, NARL
[3]Taiwan Typhoon & Flood research Institute, NARL
[4]LIFT Tech Co., Ltd

Outline

- DOTSTAR Review (Typhoon surveillance observation with dropsonde deployed by AIDC G100 Jet in western Pacific)
- Request of AXBT data in western Pacific (Motivation)
- Development of Mini AXBT
- Next step

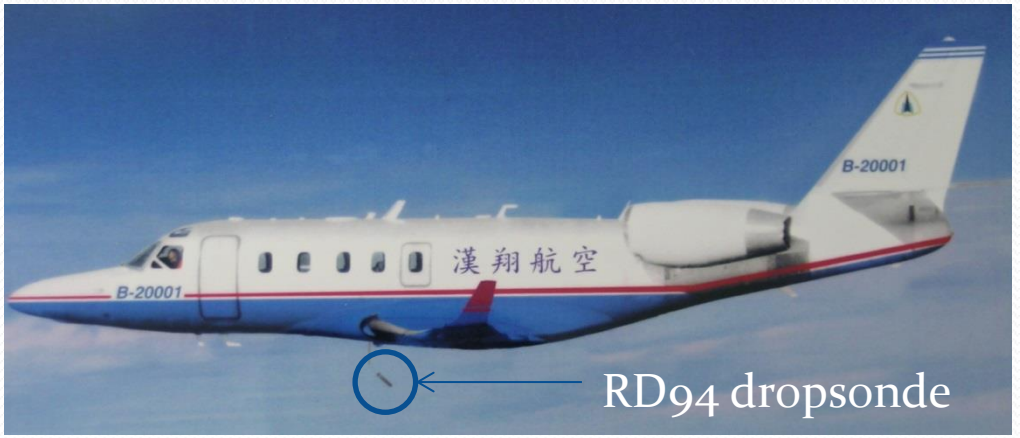
DOTSTAR Review

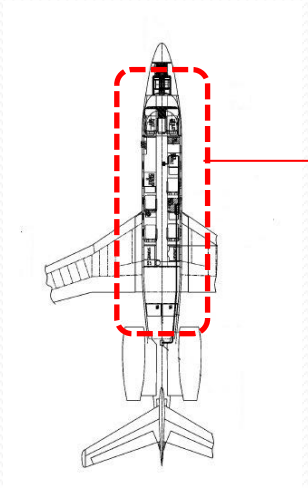
DOTSTAR
(Dropwindsonde Observations for Typhoon Surveillance near the Taiwan Region)

- ✈ Pre-Phase: 2002 summer (visiting NOAA/RHD, AOC)
- ✈ Phase 1 : 2003-2005 (NTU, supported by NSC)
- ✈ Phase 2: 2006-2012 (NTU, supported by CWB + 2008 TPARC + 2010 ITOP)
- ✈ Phase 3: 2013~ (TTFRI, supported by CWB)

NTU: National Taiwan University
NSC: National Science Council, Taiwan

CWB: Central Weather Bureau (Taiwan)
TTFRI: Taiwan Typhoon and Flood Research Institute

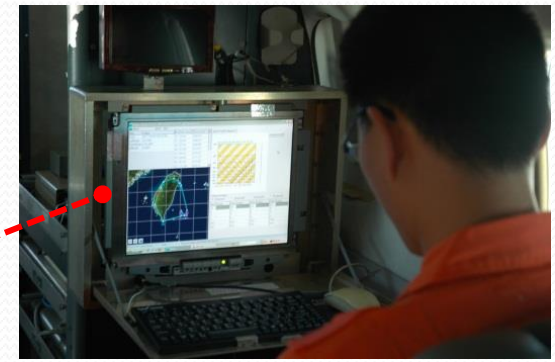




pilots

gate

Satcomm



TEMP Coding

System Engineer

internet

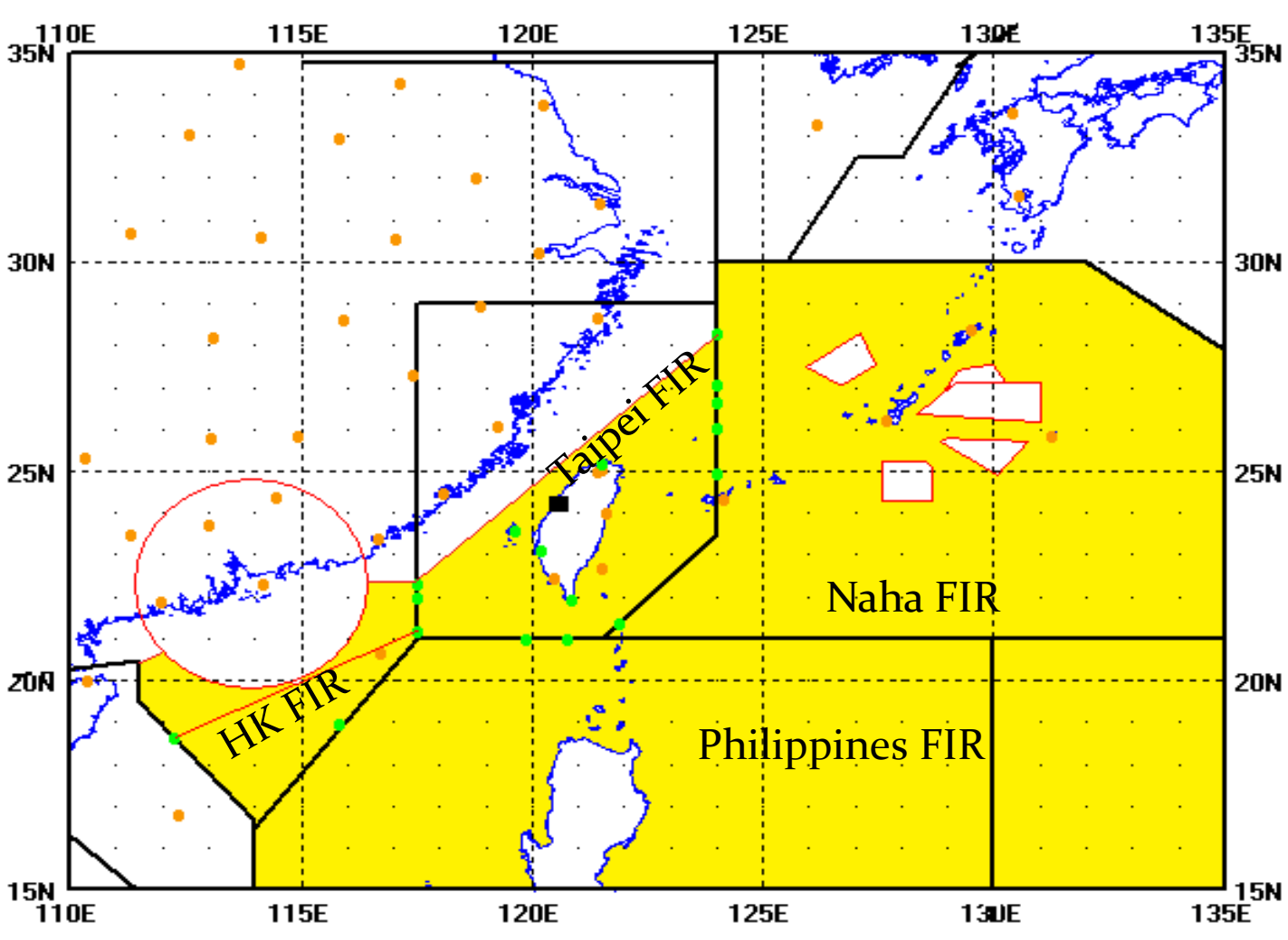
Vaisala EM122 Launcher

PI / Visitor

AVAPS operator

toilet

Flight domain of DOTSTAR with AIDC-G100 Jet

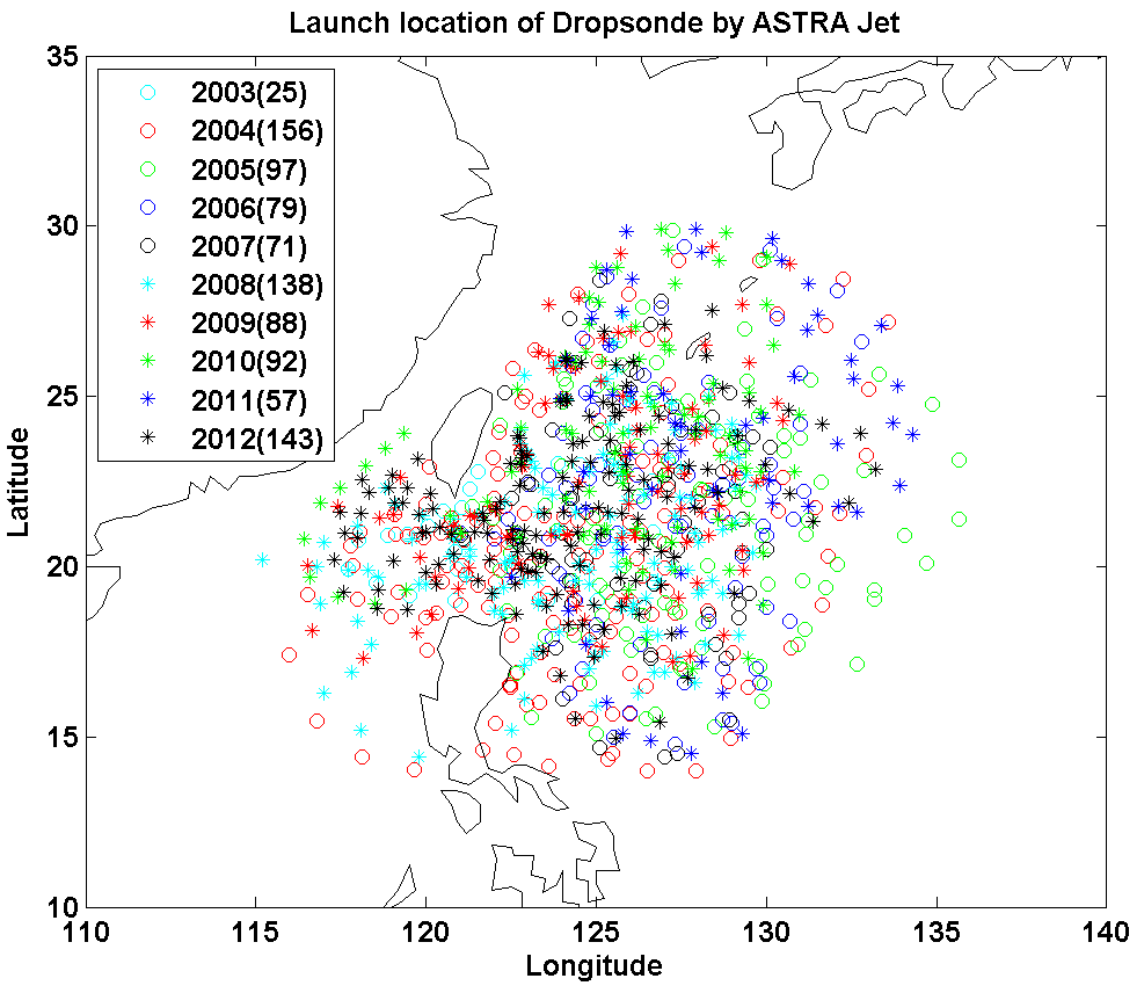


1051 Dropsondes from 2003 to 2012

(10% bad, most of this number contributed by old RD93 dropsonde before 2009)

Flights: 64

Typhoons : 49



Motivation

- AXBT* drop for typhoon intensity study during TPARC (2008) + ITOP (2010)– (Peter Black, NRL)
- OCPI** index for typhoon intensity Lin, I-I et al. (2013)
- ~4 times of tropical storms frequency happened in Western Pacific more than Atlantic Basin

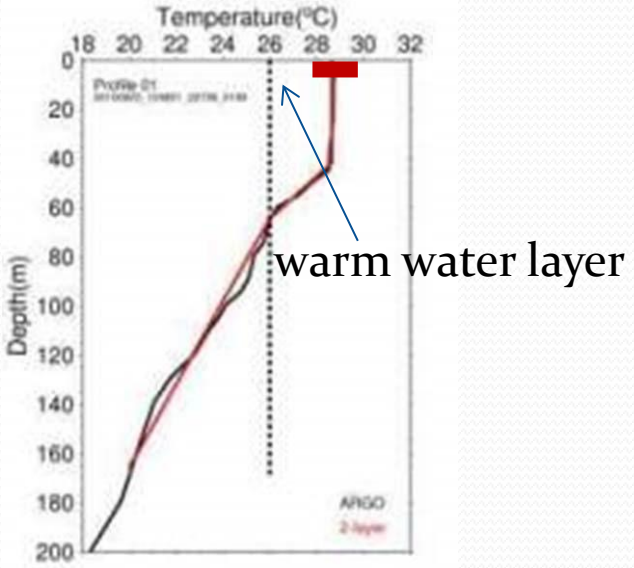
*AXBT: Airborne Expendable Bathythermograph
**OCPI: Ocean Coupling Potential Intensity

$$V_{OC\_PI}{}^2 = \frac{\bar{T} - T_0}{T_0}\frac{C_k}{C_D}(k^* - k)$$

T_{sst}

SST_PI

OCPI



Sea surface temperature (T_{sst})→ mean of warm water layer (down to 26℃)

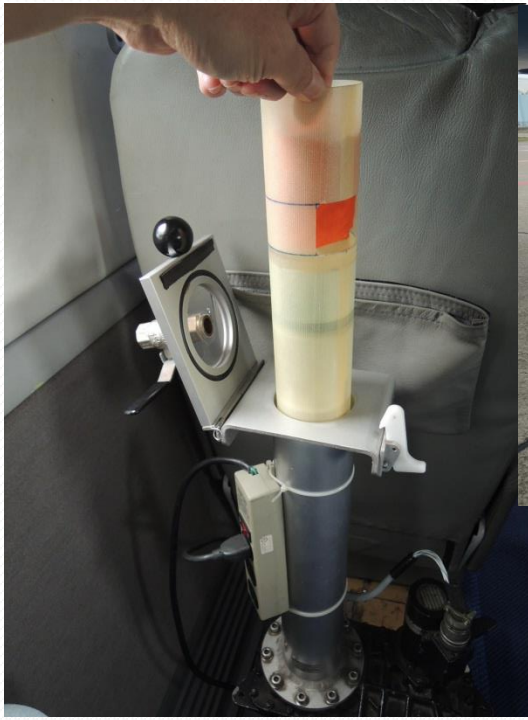
AXBT used in P3 and C130 aircrafts

From Po-Hsiung Lin (NTU)

From Peter Black (NRL)

Development of Mini AXBT

- A mini* AXBT should be made for fitting Vaisala EM122 Launcher in AIDC G100 Jet to get OCPI
- DORIS** is developed by NTU, TORI and TTFRI from 2012



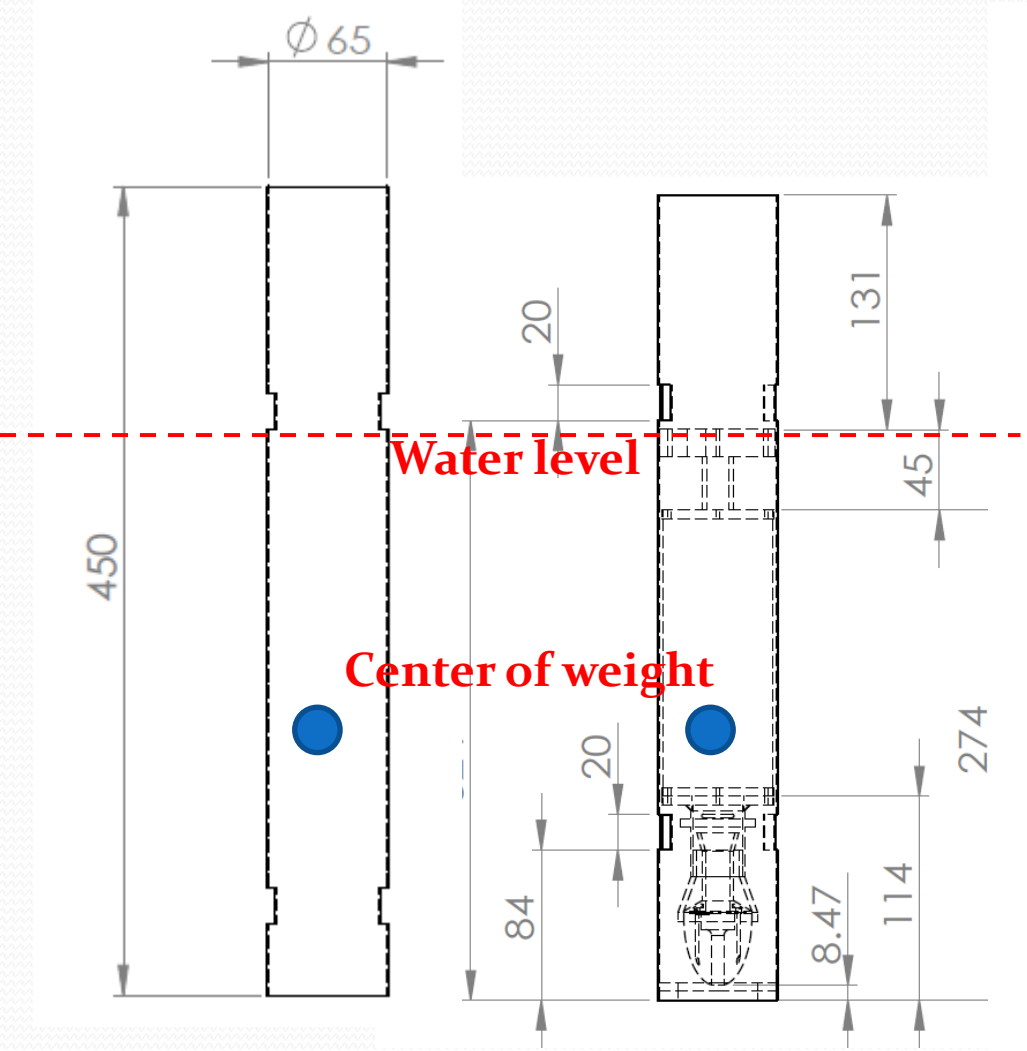
*same size of RD94 dropsonde

** a sea nymph in Greek mythology

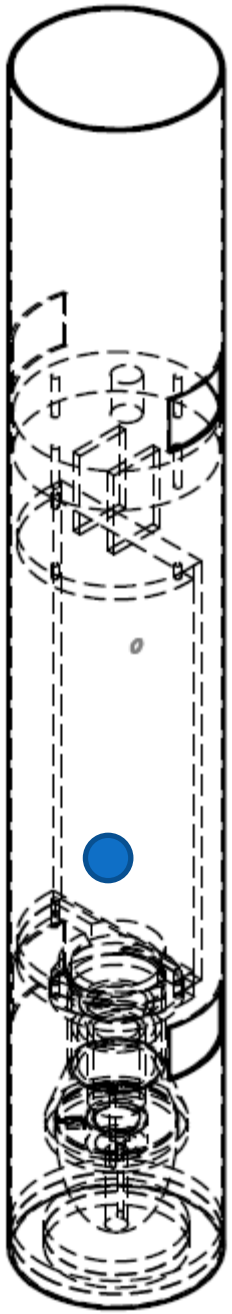
NTU: National Taiwan University

TORI: Taiwan Ocean Research Institute

TTFRI: Taiwan Typhoon & Flood Research Institute



Dimension of Mini AXBT (DORIS)



Upper sector:

Parachute
Sensors over sea surface

Seal sector:

Satellite & GPS antenna

PCB board
iridium transmitter
battery

Bottom sector:

Roller + magnet wire
+iron bullet anchor

parachute 38*38cm^2 (31g)

> 500m length magnet wire + iron bullet (500g)

FRP tube:
45cm length + 6.5 cm diameter
(120g)

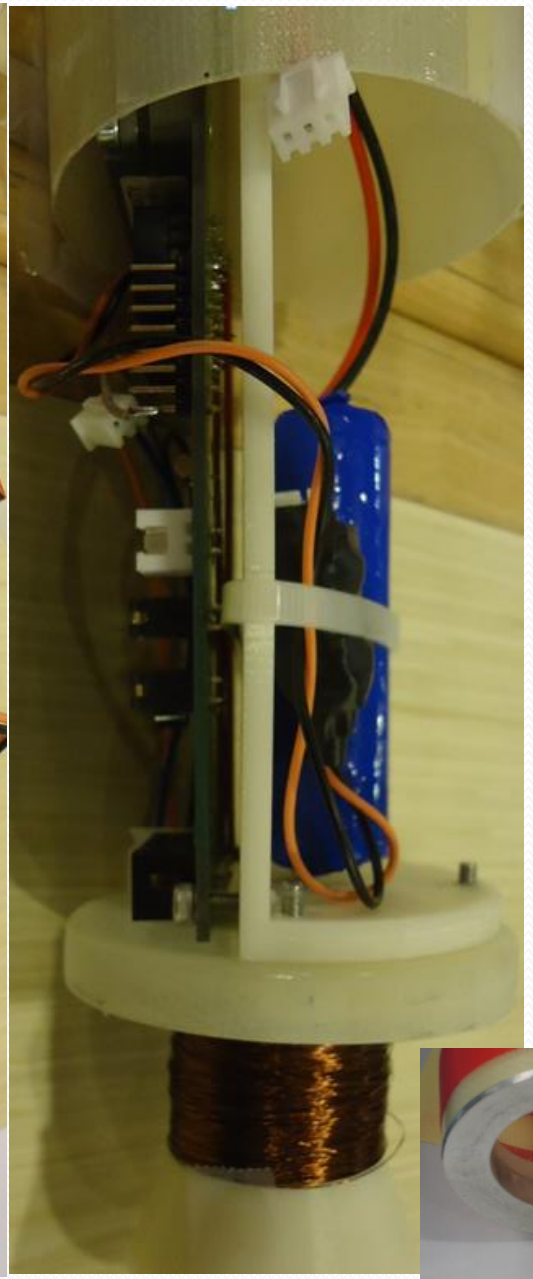
lithium battery: 51 g * 5 (255g)

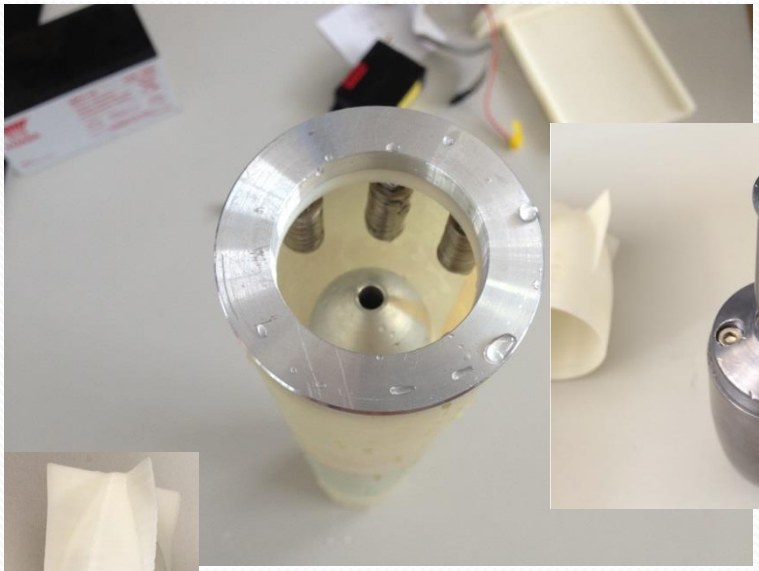
Parachute disconnecting kit

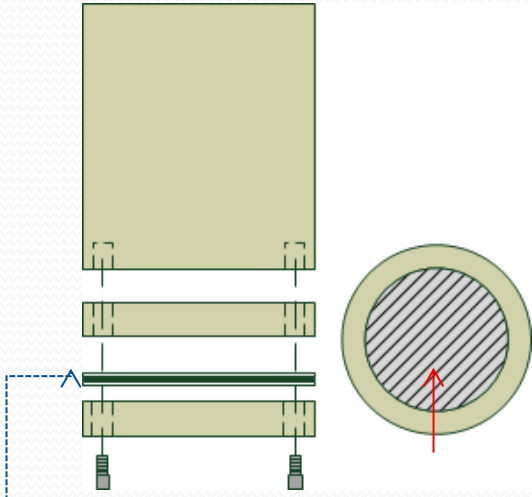
PCB board + Iridium&GPS antenna
(160g)

weighting ring + glue seal (150g)

Total weight: ~1200g





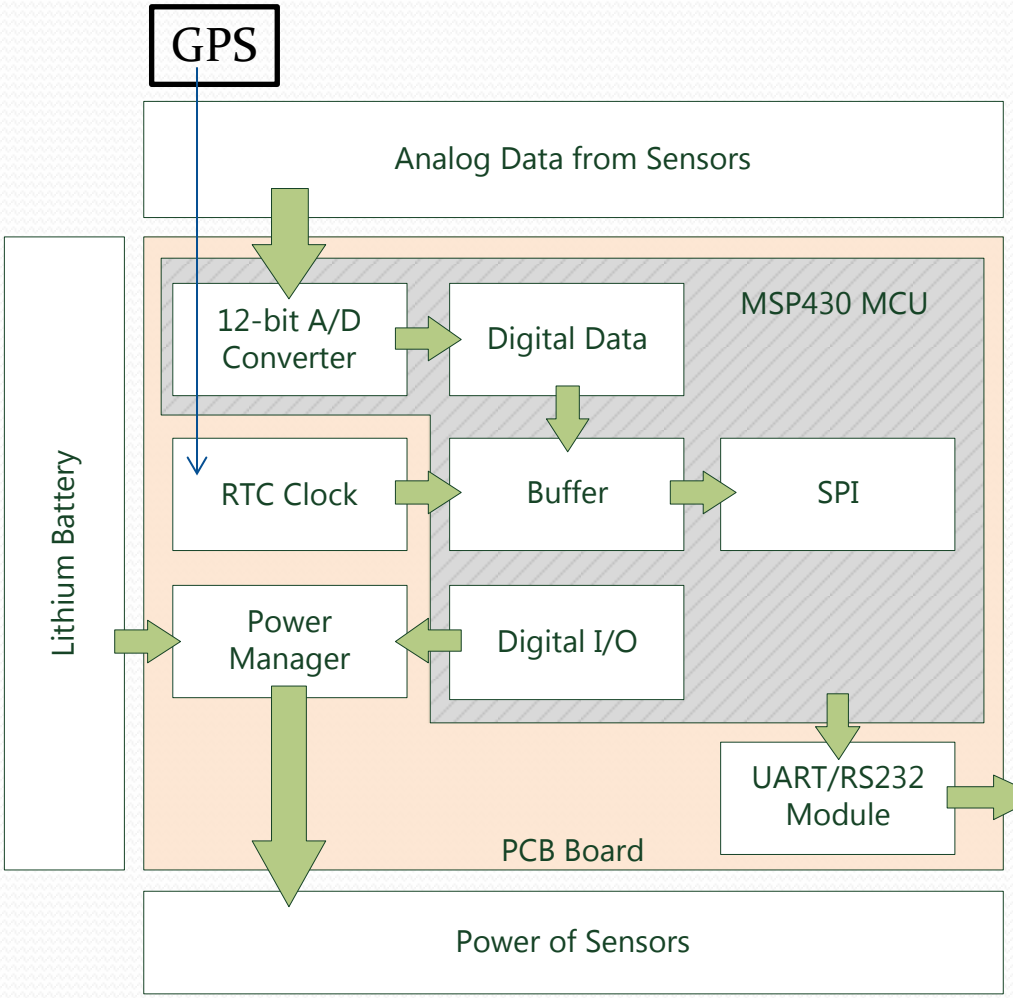


3 layers of wafer paper

Configuration of Mini AXBT

- Tube: Fiberglass, length 45 cm, diameter 6.5 cm
- Drag parachute: (38 cm^2 Square based pyramid)
- measurements: (1) sea surface temperature (2)under water temperature (> 500m)– triggering by sea water (ground) and 1 Hz sampling rate
- Communication: Iridium transmitter
- Time and location: GPS module
- Power: five 3.7V lithium batteries
- Lifetime: ~ 1 week (if data pack was sent every 10 min.)→drifter
- Total weight: ~1.2 kg (~ 3 times more than RD94 dropsonde)
- Material Cost: ~US$ 800

PCB diagram

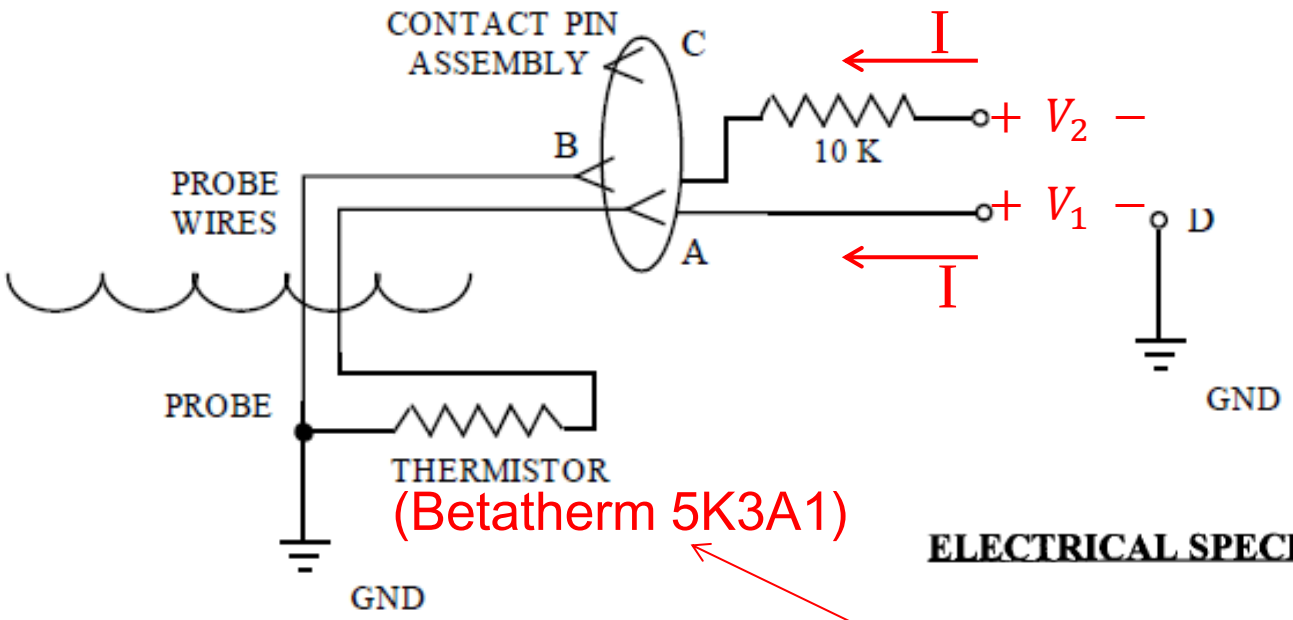


Iridium 9602 SBD transmitter
+ antenna

magnet wire +
Betatherm 5K3A1 Thermistor (accuracy : ± 0.1 ℃)

Circuit diagram of XBT

$I = 30 \times 10^{-6} A$ (constant current)



ELECTRICAL SPECIFICATION

Resistance @ 25°C: **5,000 Ohms**
Tolerance: **±0.2°C from 0°C to 70°C**
Operating Range: **-55°C to +150°C**
Beta Value 0/50: **3892 +/- 1,0%**
Alpha Value @ 25°C: **-4,39%/°C**

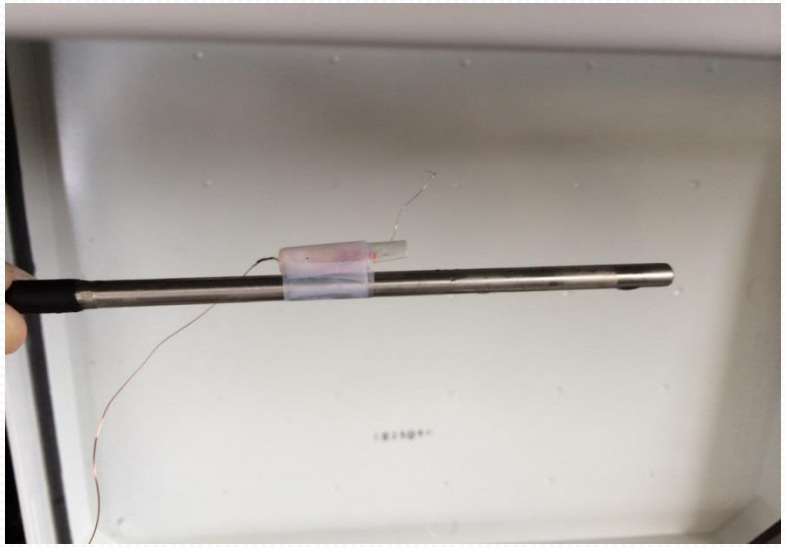
$$V_1 = I \cdot (R_{thermistor} + R_{wire} + R_{water})$$

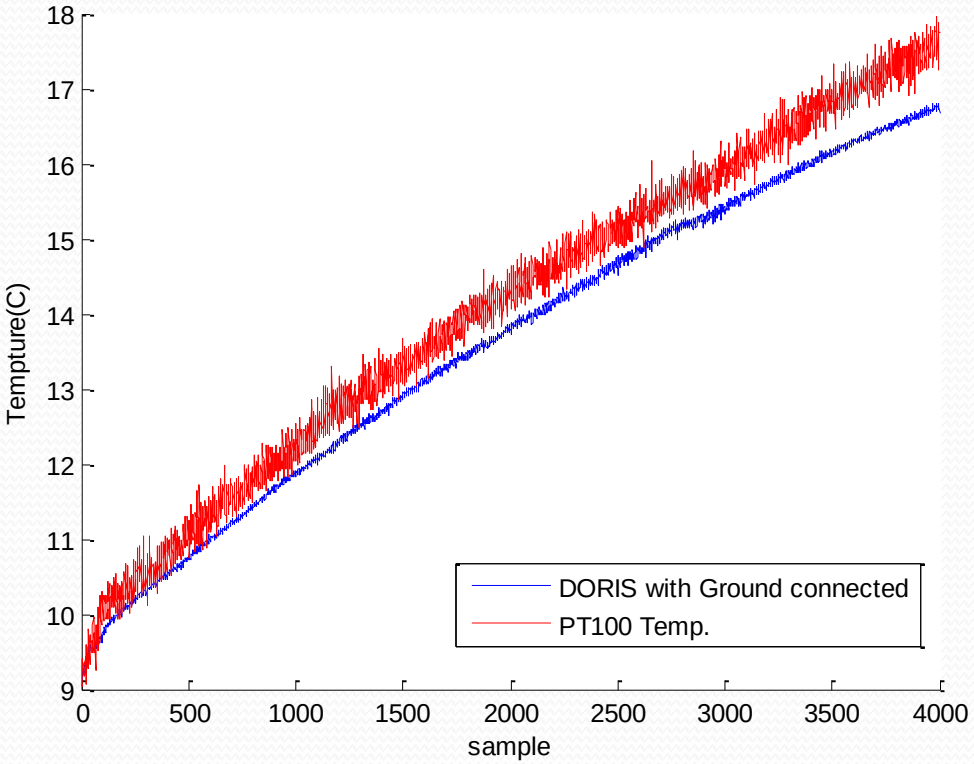
$$V_2 = I \cdot (10^4 \Omega + R_{wire} + R_{water})$$

$$V_2 - V_1 = I \cdot (10^4 \Omega - R_{thermistor})$$

Sensor test in water tank

Comparison between DORIS Thermistor and PT100 probe temperature

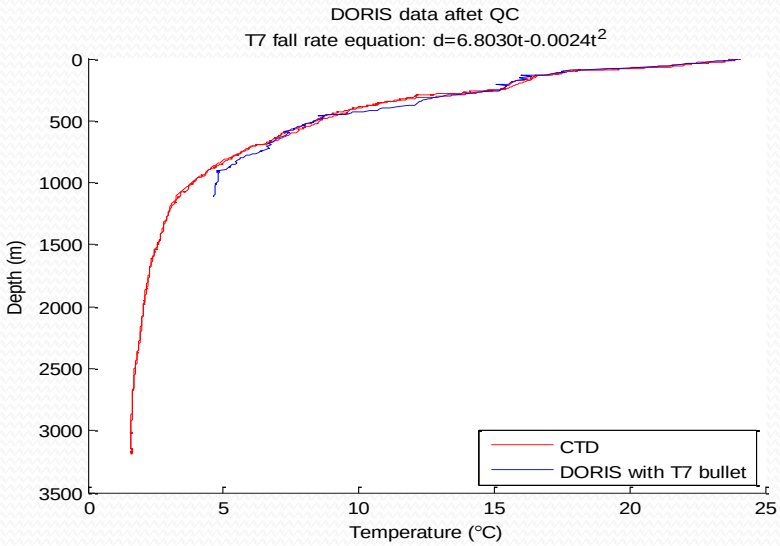


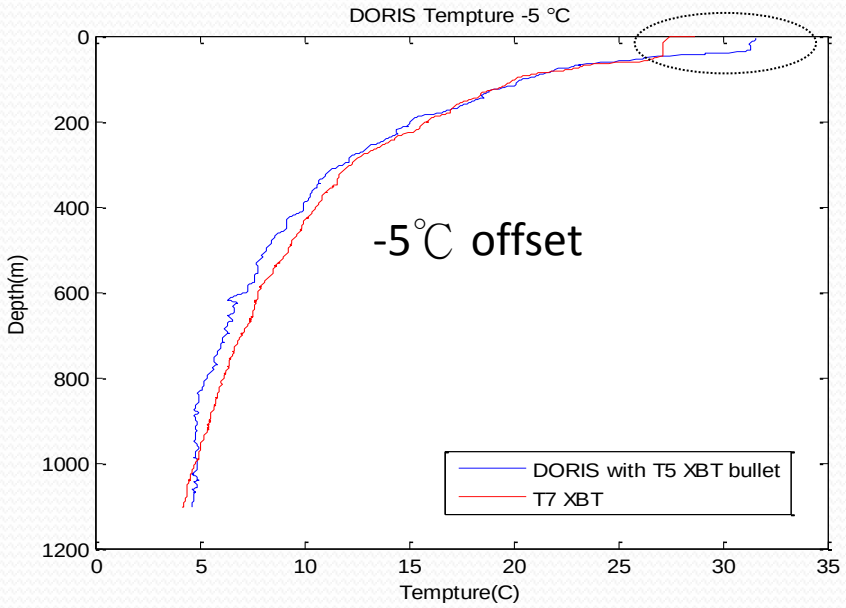


Field test-1

- Inter-comparison of temperature profiles between DORIS (with TKS T5 bullet) and CTD and TSK XBT-T7 bullet during OR5 cruise

2014/03/28



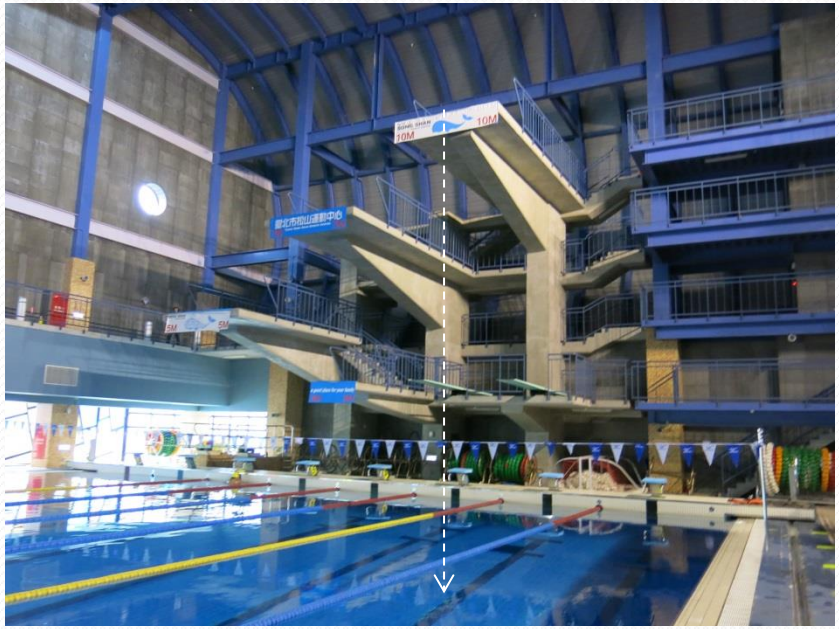


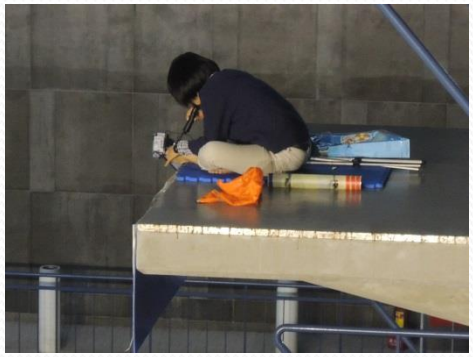
Field test-2

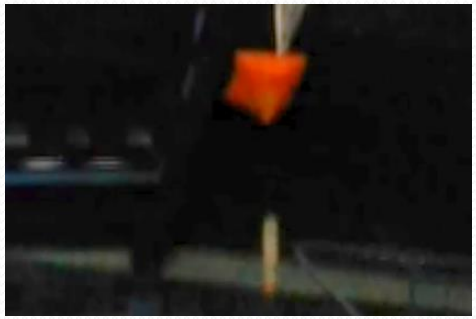
- Water drop

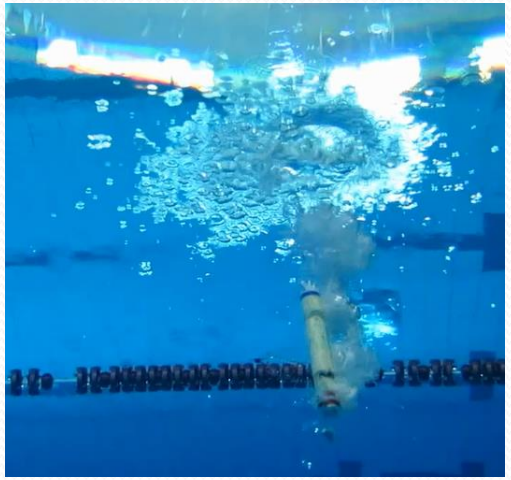
  wafer paper broken, bullet sink,magnet wire rolling

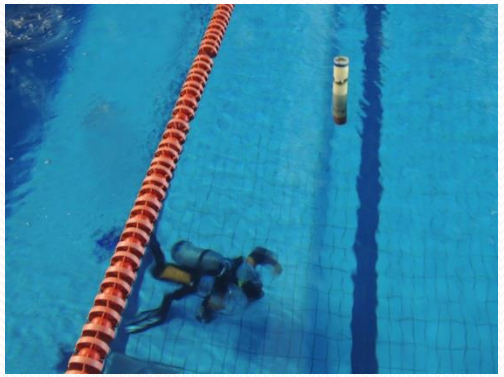
  _Taipei public swimming pool (10m diving tower + 5m depth)











YouTube keyword: Mini-AXBT

https://www.youtube.com/watch?v=u6bGOgr900A&feature=youtu.be

Field test-3

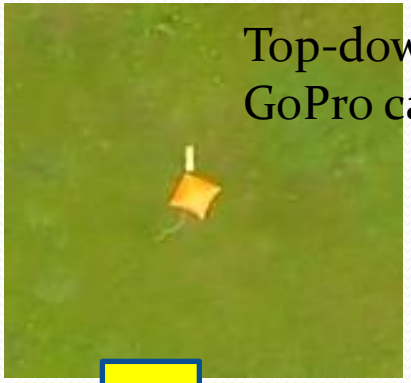
- Air drop

parachute opening, air drag

_model helicopter (up to 300m)

Side view
JVC video

Broken by grassland hit



Top-down view
GoPro camera

YouTube keyword: Mini-AXBT

https://www.youtube.com/watch?v=fMz-lFlMg-0&feature=youtu.be

Next Step

- Finding FREC (Fall Rate Equation and Coefficients)
- function test in DORSTAR-2014 typhoon flights
- joining field campaigns after 2014

XBT FREC (Fall Rate Equation and Coefficients)

$\mathbf{z\ (t) = a * t - b * t^2}$

t : time deployed(second)

z : depth (m)

a ~ b * 4000

b correction for mass loss

TSK and Sippican Corp.

$\mathbf{z\ (t) = 6.828 * t - 0.000182 * t^2}$

Kizu et al. proposed new FRECs:

TSK $\mathbf{z\ (t) = 6.5407 * t - 0.0018691 * t^2}$

Sippican $\mathbf{z\ (t) = 6.705 * t - 0.001619 * t^2}$