RV *Investigator* Voyage Plan

Voyage #:	**IN2016_T03**		
Voyage title:	Transit Brisbane to Sydney		
Mobilisation:	15–16 November 2016		
Depart:	Port of Brisbane, 12:00, Friday, 18 November 2016		
Return:	Garden Island, Sydney: 07:00, Monday, 21 November 2016		
Demobilisation:	N/A – Dry dock activities at Garden Island		
Voyage Operations Manager	Mark Scanlon	Contact details:	Mark.scanlon@csiro.au

Contents

1 Voyage Summary

1.1 General

IN2016_T03 will be undertaken on completion of demobilization of voyage IN2016_V06 in Brisbane.

The voyage will depart from Brisbane & end in Sydney where the vessel will be dry docked at the Garden Island graving dock

1.2 Scientific Objectives

One Argo Float will be deployed during transit from Brisbane to Sydney.

Refer to section 5.3 for way points of Argo float deployments and Appendix A for Argo float deployment procedure including pre deployment checklists & record sheets

1.3 Voyage Objectives

The Primary objective of IN2016_T03 is to transit the investigator to Sydney for dry dock activities & deploy 1 x Argo float. During the transit the following activities will be ongoing

- Multibeam maintenance – 1 x Konsberg technician on board;
- CTD Shaft removal preparations – 1 x Rapp technician on board.

1.4 Voyage Activity Summary

The following list details the key activities planned for 2016_T03 (Refer to section 4.2 for a detailed activity schedule):

- Confirm all demobilization work is complete whilst alongside in Brisbane;
- Confirm wires have been spooled off from the 2 x CTD winches, and spooling equipment is loaded onboard;
- Depart Port of Brisbane with pilot on board;
- Clear port limits and disembark pilot;
- Transit to Argo deployment location & deploy 1 x Argo float;
- Transit to Garden Island.

The master will adjust course & speed accordingly to ensure the vessel arrives at Garden Island at first light on 21st November

2 Definitions & Abbreviations

AHC	Active Heave Compensation
ALARP	As Low as Reasonably Practicable
ASP	ASP Ship Management Group
CSIRO	Commonwealth Scientific & Industrial Research Organisation
JSA	Job Safety Analysis
FAT	Factory Acceptance Testing
MNF	Marine National Facility (A CSIRO business unit)
PTW	Permit To Work
RV	Research Vessel
SAT	Sea Acceptance Trials
SIT	(CSIRO) Seagoing Instrumentation Team
TBT	Toolbox Talk
VOM	Voyage Operation Manager
VM	Voyage Manager

3 Health Safety & Environment

3.1 General

CSIRO and ASP Ship Management (Who manager the RV Investigator on the CSIRO's behalf) Are committed to providing a safe working environment to the ship's crew and visiting science teams whilst minimizing the impact to the environment to as low as reasonably practicable (ALARP).

Whilst onboard all visiting science personnel shall conduct all activities in accordance with the vessels standard operating procedures (including the permit to work system).

3.2 Permit to Work

ASP operates a PTW system for high risks activities onboard RV Investigator, including (but not limited to):

- Hot Work;
- Confined Space Work;
- Working at Height;
- Working near or over the edge.

The permit to work system is managed by ASP's Chief Officer, as part of the vessels Safety Management System (SMS) and details the risk mitigation requirements (lock out / tag out, exclusion zones, signage / barricade requirements etc).

3.3 Toolbox Talks

A toolbox talk (TBT) shall be conducted onboard the Investigator before each new phase of operations. The TBT shall outline the work to be carried out and shall include but not limited to the following:

- Sequence, co-ordination and details of work to carried out;
- Hazards/control measures/emergency response contingency plans;
- Roles & responsibilities, including communication protocols, for those involved in the activity;
- Safe areas/escape routes/muster points;
- Barriers, exclusion zones and signs;
- A TBT shall be given to personnel on both shifts where applicable.

For science activities involving equipment deployment / recovery this will typically be in the form of a TBT lead by the chief IR who will be in charge of all equipment / instrumentation handling activities. All personnel involved in the activity is required to sign onto the TBT / JSA to confirm they understand the task, and the risks involved. Personnel who have not signed onto the TBT shall remain clear of operations until complete (The science team not involved are typically asked to standby in sheltered science workshop to observe main deck deployment / recovery operations).

3.4 Personal Protective Equipment

All personnel shall wear personal protective equipment (PPE) suitable for the task at hand. The visiting science teams will be responsible for providing and wearing the following PPE as a minimum:

- Steel capped safety boots;
- Safety Glasses;
- Clothing suitable to the expected weather conditions;
- Safety Gloves.

The MNF will provide the following equipment for use by visiting science teams (as applicable) throughout the voyage:

- Hard Hats;
- Life Jackets;
- Fall Restraint Harnesses;
- Cold Weather Climate for low latitude expeditions;

All equipment provided for use by the visiting science team shall be cleaned and return on completion of the voyage.

3.5 Environmental Controls

ASP & CSIRO have the goal of no significant environmental incidents occurring during operation of the RV Investigator. *Investigator* routinely works in sensitive marine environments including marine parks. As such environmental risks associated with work onboard the investigator need to be manage to as low as reasonably practicable (ALARP) conditions.

In particular visiting science teams are to:

- Follow ASP / CSIRO safe working procedures at all times when onboard;
- Comply with all signage in labs regarding to disposal of chemicals;
- Comply with safe work instructions when working with chemicals onboard the Investigator;
- Notify the Master / VM or Chief Scientist in the event of an environmental incident, no matter how small.
- Select chemicals based on lowest toxicity;
- Minimise quantities of chemicals brought onboard to ALARP;
- Store chemicals / solvents / oils in dedicated HAZMAT store onboard the vessel;
- Store gas cylinders in dedicated lockers, segregated from fire hazards / ignition sources.
- Ensure all user supplied equipment is thoroughly washed prior to mobilization to minimize the risk of transporting organisms / pests onboard the RV Investigator
- Pass on any lessons learnt

3.6 Actions In The Event Of Emergency

In the event of an emergency during operations, all equipment shall be shut down, seafastened and made safe immediately. Work permits (if any) are to be returned to the bridge officer. Personnel shall proceed to their allocated emergency muster point as instructed by the ASP ship crew in accordance with the RV Investigator Emergency Response Plan.

The primary response to an emergency on the vessel will be managed by the vessel's Master and marine crew who are employees of ASP. The Chief Scientist, CSIRO Voyage Manager and other voyage participants will provide assistance as required and as directed by the vessel Master and marine crew. ASP has primary responsibility for the safety of the vessel and those on board, including emergency response, incident and environmental reporting.

3.7 Voyage Specific Risks

- The key challenge around completion of the sea trials program will be managing safe operations in testing new / modified equipment for the first time. A number of high risk activities have been identified and will be mitigated as follows:

- Maintaining safe distance from marine Hazards during bow thruster & rudder SAT's;
- Maintaining exclusion zone around wires under tension during load / function testing;
- Restricting trawling trials to daylight activities only, noting the limited experience of the ship's crew with trawling operations.

ASP Standard Operating Procedures, JSA's and toolbox talks will be followed throughout the voyage to reduce risk to operations to ALARP.

4 Scientific objectives

4.1 General

The sole scientific objective of the voyage is to deploy 1 x ARGO float as per section 4.2

4.2 ARGO Float Deployments

1 x ARGO Float will be deployed during transit from Brisbane to Sydney. Refer to the table below for way points of Argo float deployments and Appendix A for Argo float deployment procedure including pre deployment checklists & instructions for recording actual deployment location & notifying CSIRO's ARGO team.

Argo Float ID	Latitude	Longitude
0640	28° 45'S	154° 00E

Table 4.2: ARGO Float Deployment Location

4.3 Piggy-back projects (if applicable)

N/A

4.4 Special Requests

N/A

4.5 Permit Requirements

N/A

4.6 Investigator equipment (MNF) Requirements

The following equipment is required to meet the scientific objectives of the voyage:

ID	Description	Qty	Dimensions (mm) [L x W x H]	Weight (kg)	Essential	Desirable
1.	Scientific Equipment					
	ARGO Float (ID 640)	1	1.5 x 0.5 x 0.5	45	Yes	

Note that three other Argo floats (ID's 7605, 0633, 0763) will be mobilised on-board in Brisbane for deployment during transit from Sydney to Hobart.

4.7 User Equipment Requirements

N/A – No 3rd Party science team onboard during transit

5 Voyage Details

5.1 General

The Voyage is planned to take 4.5days, with the vessel adjusting speed accordingly to meet the into dock time in Sydney.

5.2 Voyage Execution Plan

Personnel new to the vessel or those who have not sailed in the previous 6 months will undergo an ASP Seagoing Induction at 14:00 on the 17th November.

The vessel will depart Grain Terminal, Port of Brisbane, at midnight of the 16th November 2016.

The following vessel schedule for IN2016_T03 is based on a steaming speed of 10 knots and is indicative in nature. The master will be responsible for detailed passage planning to ensure arrival in Dry dock on the morning of 21/11/2016.

Date	Time		Activity
	From	To	
18/11/2016	12:00	16:00	Depart Grain Terminal, Port of Brisbane & transit to Brisbane PBG
18/11/2016	16:00	10:00	Disembark pilot at Brisbane PBG & transit to ARGO deployment site (162Nm, 16Hrs @10knots)
19/11/2016	10:00	10:30	Deploy ARGO float
19/11/2016	10:30	21:30	Transit to outside of Sydney PBG (350Nm, 35Hrs @10knots)
20/11/2016	21:30	06:00	Standby & board Pilot @ PBG first light
21/11/2016	06:00	07:00	Transit & berth at Garden Island, Sydney
17/11/2016-21/11/2016			In Parallel to transit & ARGO deployment the following activities will take place: • Multibeam maintenance / testing (Konsberg); • Preparation of CTD winches (Rapp); • General preparations for dry dock.

5.3 Waypoints and stations

The steaming times below are based on a speed of 6knots to use the allowable transit time available. The Master is responsible for adjusting vessel speed & course as required.

Name	Decimal Latitude	Decimal Longitude	Distance (nm)	Total Distance (nm)	Steaming time (hrs)	Total Steam (hrs)
Brisbane Grain Terminal	-27.380	153.164	-	-		
Brisbane PBG	-26.955	153.332	27	27	4	4
ARGO Float Deployment	-28.75	154.00	135	162	16	20
Sydney PBG	-33.834	151.301	350	512	35	55
Garden Island Dry Dock	-33.862	151.226	5	517	1	56

5.4 Voyage Track

The planned voyage below detail during IN2016_E02. The voyage track will be adjusted as required by the master / crew taking into consideration weather, other vessels and the other operational considerations as required. Location of bow thruster SAT will be determined by the master depending on local weather conditions, the location below is given as an example only

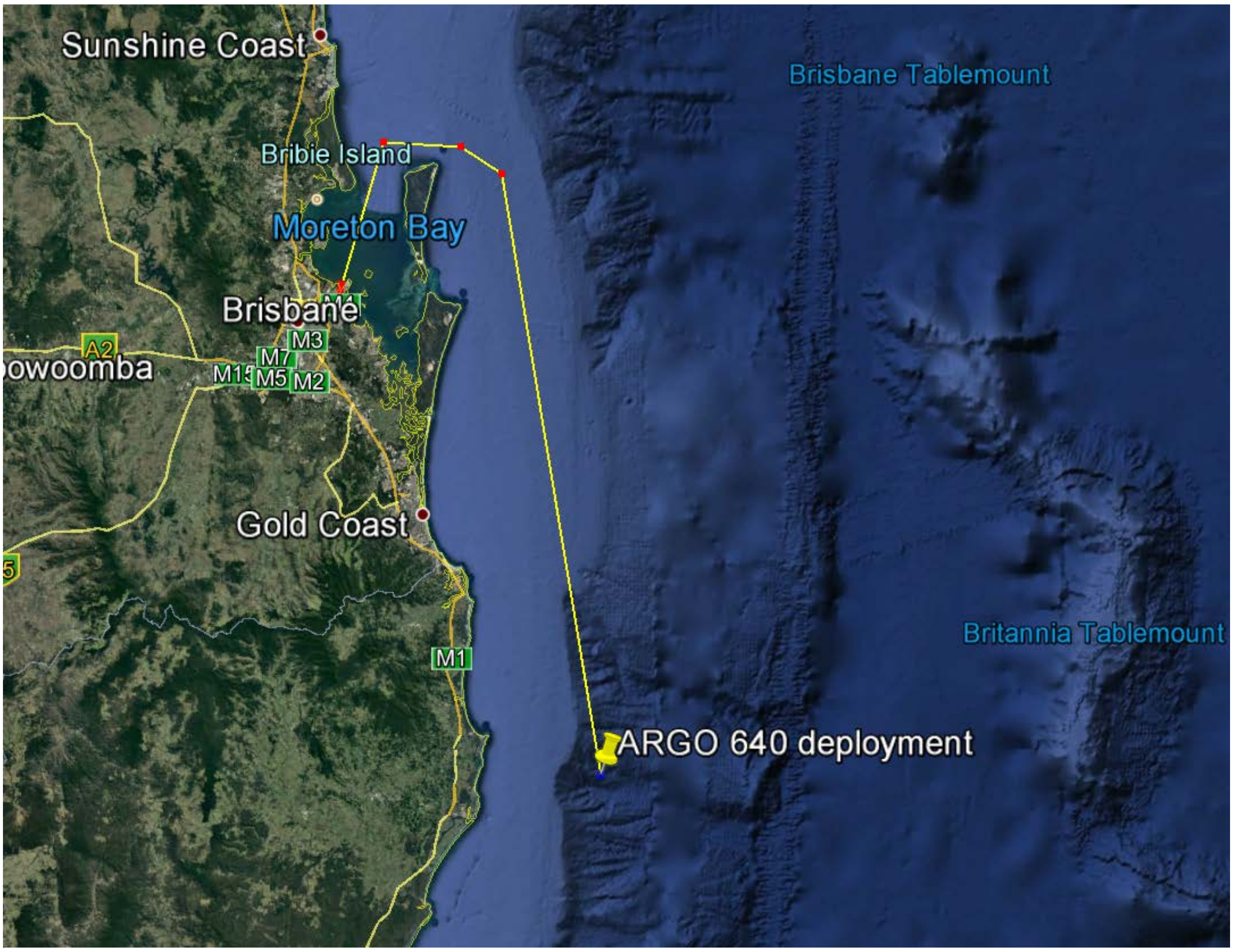

Figure 5.4.1: Voyage Track, Brisbane to ARGO deployment site

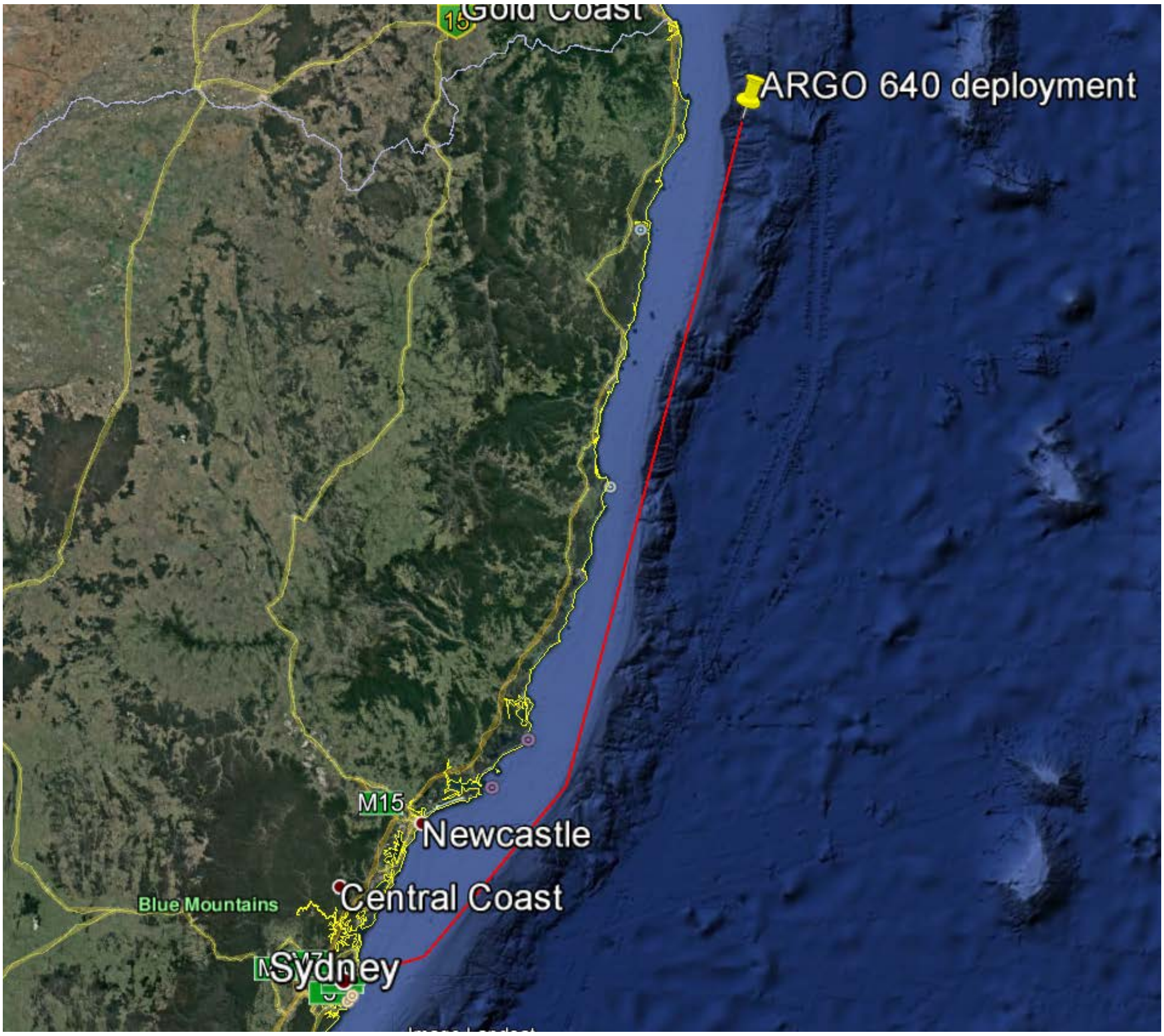

Figure 5.4.2: Voyage Tack, ARGO deployment Site to Sydney

APPENDIX A – ARGO Float Deployment Documents

ID	Drawing Title
1.	0640 Deployment & Instruction check Sheet
2.	Lithium Battery Material Safety Data Sheet
3.	Lithium Battery Safety & Handling guide
4.	What is this Argo Float Information sheet
5.	ARGO Brochure

ARGO DEPLOYMENT CHECK SHEET

Check Profiler Hull Number:

Hull Number	**0633**
Deployment Latitude:	**XX° XX' S**
Deployment Longitude:	**XX° XX' E**

Deployment Position: CTD Test Site #2

Check that water depth is greater than **2000** metres: ☐ **YES**

Check that the crate is in good condition, open the crate and check that the cardboard boxes with the Argo floats inside are undamaged.

Remove the deployment cardboard box with harness from the crate, remove the plastic cover and attach the deployment rope to the harness ring at the top of the box. *Remove any plastic from the water release mechanism at the bottom of the box*.

The float is now ready to deploy. Ensure that the free end of the deployment rope is tied off in case the rope slips out of your hand. Take a loop around a railing or bollard to take the weight when deploying the float.

The ship speed should be less than 15 Knots however if it is practical and convenient to do so, a slower speed is preferred for deployment. Deploy the float from the leeward side stern of the ship, lowering the float until the bottom of the cardboard box just touches the water causing the water release to operate.
Retrieve the harness and deployment rope for re-use.

Note the following information on this sheet:

Deployed Latitude	
Deployed Longitude	
Deployed Date and Time (UTC)	
Water Depth (meters)	

After Successful deployment:
Email ArgoDeployments@csiro.au
Include Hull No. deployment Latitude, Longitude, Date, Time & Water Depth

If you have any problems:
Contact: Email ArgoDeployments@csiro.au
Alan Poole Ph.Mob +61 418 528330
Craig Hanstein Ph.Mob +61 467 718754

Notes:

ELECTROCHEM
CREATING TOMORROW

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Greatbatch

MATERIAL SAFETY DATA SHEET

Issued: 8/30/2011

Section 1 – IDENTIFICATION

Product Name:

LITHIUM SULFURYL CHLORIDE
CELLS AND BATTERIES

Hermetically-Sealed Lithium Sulfuryl Chloride Cells & Batteries
All Electrochem CSC & PMX Cells and Batteries

Section 2 – COMPOSITION/INFORMATION ON INGREDIENTS

Sulfuryl Chloride 7791-25-5	**TLV/PEL: N/A**
Lithium 7439-93-2	**TLV/PEL: N/A**
Chlorine 7782-50-5	**ACGIH: 1.5mg/m3 TLV/TWA**
Carbon 1333-86-4	**ACGIH: 3.5 mg/m3 TLV/TWA**

Section 3 – HAZARDS IDENTIFICATION

****DANGER**** INTERNAL CONTENTS ARE EXTREMELY HAZARDOUS. LEAKING FLUID IS CORROSIVE AND DANGEROUS UPON INHALATION. BATTERY MAY BE EXPLOSIVE AT HIGHER TEMPERATURES.

Do not expose to temperatures above the maximum rated temperature as specified by the manufacturer due to leak hazard.

If cell or battery leaks or vents

Primary Routes of Entry: Inhalation.
Carcinogenicity: Not listed by NTP, IARC, or regulated by OSHA.
Health Hazards: **Acute –** Vapors are very irritating to skin, eyes, and mucous membranes. Inhalation of Thionyl chloride or sulfuryl chloride vapors may result in pulmonary edema.
Chronic – Overexposure can cause symptoms of non-fibrotic lung injury.
Signs and Symptoms of Exposure: Eye and mucous membrane irritation.
Medical Conditions Generally Aggravated by Exposure: Asthma, other respiratory disorders, skin allergies, and eczema.

Section 4 – FIRST AID MEASURES

Eye Contact: Flush with running water for at least 15 minutes. Hold eyelids apart. Seek immediate medical attention. Contact results in acidic burns.
Skin Contact: Rinse with large amounts of running water. Avoid hot water and rubbing skin. If burns develop, seek medical attention. Contact results in acidic burns.
Inhalation: Remove to fresh air. If breathing is difficult, administer oxygen. If not breathing, give artificial respiration. May result in pulmonary edema.
Ingestion: Drink copious amounts of water (or milk if available). Do not induce vomiting. NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON. Immediately seek medical attention.

Section 5 – FIRE FIGHTING MEASURES

Flash Point: N/A **Auto-Ignition Temp:** N/A **Flammable Limits:** N/A
Extinguisher Media: Copious amounts of water. Lith-X powder, Class D fire extinguisher, Dry Lithium Chloride, Graphite Powder, Pyrene G-1 may not be effective on resulting secondary fires.
Special Fire Fighting Procedures: Cover with Lith-X powder, Class D fire extinguisher, dry lithium chloride, or graphite powder. DO NOT USE CO_2, Class ABC, or soda ash extinguisher. Wear protective breathing apparatus; a positive pressure Self Contained Breathing Apparatus (SCBA), or Air Purifying Respirator (APR). Be aware of secondary fires.
Unusual Fire and Explosion Hazards: Do not short circuit, recharge, over discharge (discharge below 0.0 Volts), puncture, crush or expose to temperatures above the maximum rated temperature as specified by the manufacturer**.** Cell may leak, vent, or explode. If a bright white flame is present, lithium content is exposed and on fire.

Section 6 – ACCIDENTAL RELEASE MEASURES

Accidental Releases: Do not breathe vapors or touch liquid with bare hands (see section 4).
Waste Disposal Methods: Evacuate area. If possible, a trained person should attempt to stop or contain the leak by neutralizing spill with soda lime or baking soda. A NIOSH Approved Acid Gas Filter Mask or Self-Contained Breathing Apparatus should be worn. Seal leaking battery and soda lime or baking soda in a plastic bag and dispose of as hazardous waste.
Other: Follow North American Emergency Response Guide (NAERG) #138 for cells involved in an accident, cells that have vented, or have exploded.

Section 7 – HANDLING & STORAGE

Storage: Cells should be stored at room temperature, approx. 21°C (70°F). Do not store batteries in high humidity environments for long periods. High Temperature storage will degrade performance.
Precautions: Do not short circuit or expose to temperatures above the maximum rated temperature as specified by the manufacturer. Do not recharge, over discharge, puncture or crush.
Other Conditions: Do not store cells in close proximity of other combustible / flammable materials.

Section 8 – EXPOSURE CONTROLS / PERSONAL PROTECTION

<u>When handling internal components:</u>

Respiratory Protection: NIOSH Approved Acid Gas Filter Mask, or Self-Contained Breathing Apparatus.
Protective Gloves: Nitrile or PVC, Gloves should be 15 ml (0.015 in), or thicker.
Eye Protection: Chemical Worker Safety Glasses or face shield.
Ventilation To Be Used: Negative pressure chemical fume hood.
Other Protective Clothing & Equipment: Chemical Laboratory Safety Glasses, Protective Apron, Acid Resistant Protective Clothing, and face shield.
Hygienic Work Practices: Use good chemical hygiene practice. Do not eat or drink when handling contents. Avoid unnecessary contact.

Section 9 – PHYSICAL/CHEMICAL CHARACTERISTICS

Boiling Point:	Sulfuryl Chloride: 69oC
Vapor Pressure:	Sulfuryl Chloride: 105mm @ 20 °C
Vapor Density:	Sulfuryl Chloride: 4.7 (air = 1)
Solubility in Water:	Sulfuryl Chloride: Decomposes violently on contact with water.
Specific Gravity:	Sulfuryl Chloride: 13.8 lb/gal
Melting Point:	Sulfuryl Chloride: -54 °C
Evaporation Rate:	No Data
Water Reactive:	Sulfuryl Chloride hydrolyzes to form sulfuric, chlorosulfuric, and hydrochloric acids and strongly acidic wastewater.
Appearance & Odor:	Sulfuryl Chloride – Yellow; sharp, pungent odor.
Other:	N/A

Section 10 – STABILITY & REACTIVITY

Stability: Stable **Incompatibility:** N/A **Hazardous Polymerization:** Will not occur.
Conditions to Avoid: Temperatures above the maximum rated temperature as specified by the manufacturer due to leak hazard. High humidity for extended periods.
Hazardous Decomposition Products: Sulfur Dioxide $_{(g)}$, Hydrogen Chloride $_{(g)}$, Hydrogen $_{(g)}$

Section 11 – TOXICOLOGICAL INFORMATION

Acute Toxicity (as applicable):

Thionyl Chloride		**Sulfuryl Chloride**	
LC_{50} (Inhalation):	500 ppm (rat 1-hr)	**LC_{50}** (Inhalation):	130-250 ppm (rat 1-hr)
LD_{50}:	N/A	**LD_{50}:**	N/A
Eye Effects:	Corrosive	**Eye Effects:**	Corrosive
Skin Effects:	Corrosive	**Skin Effects:**	Corrosive

Section 12 – ECOLOGICAL INFORMATION

Aquatic Toxicity: Do not let internal components enter marine environments. Avoid releases into waterways, wastewater or groundwater.

Section 13 – DISPOSAL CONSIDERATIONS

Proper Shipping Name: Waste Lithium Batteries
UN Number: 3090
Hazard Classification: Class 9 (Misc.)
Packing Group: II
Labels Required: MISCELLANEOUS, HAZARDOUS WASTE
Waste Disposal Code: D003
Other: All lithium thionyl chloride batteries should be disposed of by a certified hazardous waste disposal facility.

Section 14 – TRANSPORT INFORMATION

US DOT (per 49 CFR 172.101) and IATA/ICAO
Proper Shipping Name: Lithium Metal Batteries
UN Number: UN 3090 (UN 3091 for *Lithium Metal Batteries Contained in Equipment or Lithium Metal batteries Packed With Equipment)*)
Hazard Classification: Class 9 (Misc.)
Packing Group: II
Labels Required: MISCELLANEOUS HAZARD CLASS 9, LITHIUM BATTERY LABEL (IATA 7.4.8)
Other: CARGO AIRCRAFT ONLY (Forbidden as cargo aboard passenger aircraft)
Shipping Requirements
DOT: Lithium batteries and cells are subject to shipping requirements exceptions under 49 CFR 173.185.
IATA: Shipping of lithium batteries in aircrafts are regulated by the International Civil Aviation Organization (ICAO) and the International Air Transport Association (IATA) requirements in Special Provision A48, A88, A99, A154, A164 and Packing Instruction 968, 969, or 970.

Section 15 – REGULATORY INFORMATION

OSHA Status: This product is considered an "Article" and the internal component (thionyl chloride / sulfuryl chloride) is hazardous under the criteria of the Federal OSHA Hazard Communication Standard 29 CFR 1920.1200.

Section 16 – OTHER INFORMATION

Lithium Battery Safety
With proper use and handling, lithium batteries have demonstrated an excellent safety record. The success and wide use of lithium batteries is partially due to the fact that they contain more energy per unit weight than conventional batteries. However, the same properties that result in a high energy density also contribute to potential hazards if the energy is released at a fast-uncontrolled rate. In recognition of the high-energy content of lithium systems, safety has been incorporated into the design and manufacture of all Electrochem batteries. However, abuse or mishandling of lithium batteries can still result in hazardous conditions. The information provided here is intended to give users some guidelines to safe handling and use of Electrochem lithium batteries.

Cell Abuse
In general, the conditions that cause damage to cells and jeopardize safety are summarized on the label of each cell. These conditions include:

- Short Circuit
- Charging
- Forced Over discharge
- Excessive heating or incineration
- Crush, puncture or disassembly
- Very rough handling or high shock and vibration could also result in cell damage.

Cell Handling and Inspection Guidelines
The most frequent forms of cell abuse can easily be identified and controlled in the workplace. It is our experience that inadvertent short circuits are the largest single cause of field failures.

Problems associated with shorting as well as other hazardous conditions can be greatly reduced by observing the following guidelines:

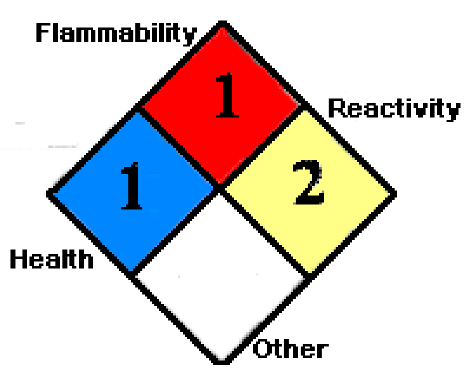
- Cover all metal work surfaces with an insulating material.
- The work area should be clean and free of sharp objects that could puncture the insulating sleeve on each cell.
- Never remove the shrink-wrap from a cell or battery pack.
- All persons handling cells should remove jewelry items such as rings, wristwatches, pendants, etc., that could come in contact with the battery terminals.
- If cells are removed from their original packages for inspection, they should be neatly arranged to preclude shorting.
- Cells should be transported in plastic trays set on pushcarts. This will reduce the chances of cells being dropped on the floor, causing physical damage.
- All inspection tools (calipers, rulers, etc.) should be made from non-conductive materials, or covered with a non-conductive tape.
- Cells should be inspected for physical damage. Cells with dented cases or terminal caps should be inspected for electrolyte leakage. If any is noted, the cell should be disposed of in the proper manner.

Cell Storage
Cells should be stored in their original containers. Store cells in a well ventilated, cool, dry area. Store cells in an isolated area, away from combustible materials. Never stack heavy objects on top of boxes containing lithium batteries to preclude crushing or puncturing the cell case.

Handling During Product Assembly
All personnel handling batteries should wear appropriate protective equipment such as safety glasses.

- Do not solder wires or tabs directly to the battery. Only solder to the leads welded to the cell by the manufacturer.
- Never touch a cell case directly with a hot soldering iron. Heat sinks should be used when soldering to the tabs, and contact with the solder tabs should be limited to a few seconds.
- Cells should not be forced into (or out of) battery holders or housings. This could deform the cell causing an internal short circuit, or fracturing the glass to metal hermetic seal.
- All ovens or environmental chambers used for testing cells or batteries should be equipped with an over-temperature controller to protect against excessive heat.
- Only precision convection ovens should be used for cell testing. Lesser ovens may exhibit uneven heating and hot spots that can exceed the rated temperature of the battery.
- Do not connect cells or batteries of different chemistries together.
- Do not connect cells or batteries of different sizes together.
- Do not connect old and new batteries together.
- Consult Electrochem before encapsulating batteries during discharge. Cells may exceed their maximum rated temperature if insulated.
- Although we have provided a general overview of lithium battery safety and handling, we urge you to call us with any questions. Our technical services staff will be pleased to assist you with your questions.

NFPA RATING



- For cells or battery packs involved in an accident, cells that have vented, or exploded, follow the North American Emergency Response Guide (NAERG) #138.
- **24-HOUR EMERGENCY RESPONSE PHONE NUMBER:**
  (800) 255-3924

Rev. 2010A
Date: 05/05/2010

Primary Lithium Battery Safety and Handling Guidelines

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Introduction

Electrochem Solutions Inc., a subsidiary of Greatbatch Ltd., manufactures a wide variety of lithium batteries in various sizes, temperature ranges, and rate capabilities. As a tested expert in design, manufacturing, assembly, and integration, we are synonymous with reliability and safety. For decades, the world's top research institutions, industry leading companies, and government agencies have chosen Electrochem Solutions Inc. for the best in non-rechargeable and rechargeable power assurance. We are standard in critical applications such as oil and gas services, military communications, medical devices, oceanographic monitoring and more, ensuring power in places where others fall short.

The success of these systems is partially due to the fact that they contain more energy per unit weight than conventional batteries. However, the same properties which result in a high energy density also contribute to potential hazards if the energy is released at a fast, uncontrolled rate. With proper use and handling, Electrochem cells and batteries have demonstrated an excellent safety record. The cells and batteries manufactured by Electrochem are used safely and successfully in many applications where safety and reliability are of the utmost importance.

Due to the recognition of hazards associated with high energy density systems, safety has been incorporated into the design and manufacture of all Electrochem primary lithium cells and batteries. While we have designed our cells and batteries to be tolerant of adverse conditions, these very active chemical systems have limitations. Certain hazards are associated with exposure to heat and its subsequent effects on sealed cells. These hazards include the potential for cell venting, explosion, and/or fires. The initial source of heat can be external (welding, soldering, etc.) or internal such as heating caused by short circuiting, excessive running currents for prolonged periods of time, forced over-discharge, charging, or excessive mechanical abuse.

Specifically, mechanical abuse in the form of excessive shock or vibration can result in case deformation, crushing, and damage to the electrode materials.

Most primary lithium cells have a warning printed on the label that cautions against the following conditions:

- Short-circuit
- Charging
- Forced over-discharge
- Excessive heat or incineration
- Crush, puncture, or disassembly

Not guarding against these conditions may result in a hot cell or a battery pack that could vent or explode. With Electrochem cells, the ensuing hazards associated with a hot cell typically will not occur the instant the cell is abused. Rather, the cell will heat up over a period of time. This can take place in a matter of seconds or hours. Subsequently, the end result has the potential to result in a cell vent or explosion once the critical temperature is reached. All Electrochem primary cells and batteries are labeled with their maximum operating temperature, indicated in degrees Celsius. This temperature should not be exceeded.

Safe Handling Guidelines

The guidelines identified in this document should be incorporated into all areas of the facility as Best Management Practices and/or Safe Work Practices.

The intent of this section is to provide primary lithium cell and battery users with guidelines necessary for safe handling of cells and batteries under normal assembly and use conditions. This document will address three principle areas:

1. Receiving, inspection, and storage of cells and batteries
2. Handling during product assembly
3. Packaging for shipment

Receiving, Inspection, and Storage

In general, the conditions that cause damage to cells and batteries and jeopardize the safety of personnel are summarized on the label of each cell. These conditions include:

- Short circuit
- Charging
- Forced over-discharge
- Excessive heating or incineration
- Crush, puncture, or disassembly
- Rough handling or excessive shock and vibration

The most frequent form of handling abuse during Receiving Inspection and Storage is inadvertent short circuiting. Control measures to protect against this form of abuse should be implemented throughout the workplace. It is Electrochem's experience that inadvertent short circuits during handling are the largest single cause of field failures. More specifically, accidental short circuiting is a common occurrence in a receiving inspection environment due to frequent handling.

All Electrochem high-rate cells are internally protected against the hazards associated with short circuits. This is accomplished by incorporating a fast-acting use under the terminal cap. While the fused cells are less likely to heat, vent, or explode under a direct short circuit condition, they will be rendered non-functional. Steps should be taken throughout the receiving and inspection processes to avoid short circuiting cells and batteries.

Issues associated with short circuiting, as well as other hazardous conditions, can be significantly reduced by observing the following guidelines:

- Cover all conductive work surfaces with an insulating material
- Work areas should be free of sharp objects that could puncture the insulating material

- Never disassemble a cell or battery pack or attempt to replace a blown fuse
- Conductive materials (jewelry, etc.) should not be worn by personnel handling cells and batteries
- Cells should be stored in their original packaging or by similar means
- Cells should be moved in trays using pushcarts to reduce the probability of dropping. Dropped cells or batteries should be treated as a potential Hot Cell
- All inspection tools should be non-conductive, or covered with a non-conductive material
- Cells should be inspected for physical damage
- Open-circuit-voltage (OCV) should be checked. The nominal OCV for each cell is printed on the label
- After a cell has been inspected, it should be returned to its storage container
- If leads or tabs need to be trimmed, cut only one at a time

Cell Storage

Storage of hazardous materials is generally regulated by Federal, State, and local regulations. These regulations will vary by region and it is up to each user to determine the appropriate regulations to comply with. Along with regulatory guidance, the following guidelines should be followed:

- Cells should be stored in their original containers or equivalent
- Cells should be stored in a dry, well ventilated area. Ideally, cells will be stored in a temperature controlled environment at 23°C or below.
- Cells should be segregated from other combustible or flammable materials
- Fresh cells should be isolated from depleted or used cells
- Appropriate fire extinguishing means should be available
- Storage areas should be equipped with sprinklers
- Appropriate personal protective equipment should be available
- Exercise caution when stacking boxes to prevent crushing of cells in lower boxes

Handling During Assembly

The guidelines identified in this document should be incorporated into all areas of the facility as Best Management Practices or Safe Work Practices. Additional precautionary measures should be observed in production areas to avoid more serious problems associated with heat, particularly around soldering and welding equipment or during routine performance testing at elevated temperatures. These guidelines include, but are not limited to:

- Written work and training instructions for each manufacturing procedure
- Transport cells in trays on pushcarts to reduce the probability of dropping
- Heat sensitive sheets can be placed on top of cells. These will change color when heated. Some heat sensitive sheets have life expectancy limitations.

- Never solder or use improper assembly techniques when attaching leads or conducting tabs to the cell case
- Heat sinks should be used when soldering to tabs. Contact should be limited to a few seconds
- Use caution when handling cells around solder pots. When tinning leads, only tin one at a time to prevent short circuiting. A cell dropped into a solder pot can short circuit and become a Hot Cell
- Cells should not be forced into housings as this can lead to deformation
- Excessive force should not be used to free a battery or cell from a housing
- Ovens or environmental chambers should be equipped with over temperature protection
- When loading cells and/or packs during short duration electrical tests, use caution not to exceed the current rating of the fusing
- When loading cells and/or packs during long duration performance tests, use caution not to exceed the maximum continuous current rating of the cells
- Cells subjected to continuous high current discharge may overheat, resulting in an unsafe condition. The risk of overheating is elevated when the cells are in an insulated environment

Packaging for Shipment

The regulations that govern the transportation of primary lithium batteries and cells include the International Civil Aviation Organization (ICAO), the International Air Transport Association (IATA) and the International Maritime Dangerous Goods Code (IMDG). In addition to international requirements, domestic regulations must be adhered to. The United States Department of Transportation (DOT) regulates the shipment of lithium cells and batteries domestically under part 49 of the Code of Federal Regulations (49 CFR).

All shipments of hazardous materials in must comply with current packaging regulations based on the United Nations Manual of Tests and Criteria. The packaging requirements require performance oriented packaging, meaning that a package must pass the following:

- Drop test
- Vibration test
- Leak proof test (where applicable)
- Internal pressure test (where applicable)
- Stacking test

These tests are performed by authorized independent testing organizations or by an authorized packaging supplier. Once a packaging system has been certified, the packaging is stamped with a UN marking. UN marked packaging may only be used to transport hazardous materials that have been used in the packaging tests. Electrochem packaging may only be re-used when packaged in its original configuaration.

Lithium cells and batteries are classified as a hazardous materials in the United States unless the specific cell or battery meets an exemption in the 49 CFR. Consult current regulations to determine whether or not an exemption applies.

When transporting lithium cells and batteries by air, IATA Dangerous Goods Regulations must be adhered to. The provisions of the IATA DGR require cells and batteries to meet the requirements of the UN Manual of Tests and Criteria, Part III Subsection 38.3. Electrochem Solutions can provide a Transport Certificate acknowledging that a specific lithium cell or battery meets the testing requirements. This certificate is maintained as long as no changes are made to the cell or pack as manufactured and transported from Electrochem.

The United States DOT prohibits the transportation of primary lithium metal cells and batteries aboard passenger-carrying aircraft into, out of, or within the United States. Consult current regulations for details on exemptions and package weight restrictions associated with this prohibition.

Battery Pack Assembly

While Electrochem cells possess a high power and energy density, many applications require even greater voltage, current, or capacity than a single cell can provide. The solution can be a battery pack of series and/or parallel configured cells. Electrochem Solutions can provide this system or it may be designed and built by the users of Electrochem cells. The following guidelines should be followed:

- Series fuses should be fitted external to the battery to allow for replacement
- Blocking diodes should be implemented wherever multiple cells are tied in parallel
- Thermal cutoff (TCO) or resettable polymeric positive temperature coefficient (PTC) devices can be used to prevent a battery pack from exceeding a safe operating temperature
- Both the surrounding environment and the heat output of a pack during operation should be evaluated to ensure a safe operating temperature is maintained
- Additional thermal management should be considered for large batteries or batteries intended to run at high rates
- Cells connected in series should not have a center voltage tap
- Batteries should not be encapsulated without first consulting with Electrochem Solutions
- Battery compartments should be designed to allow for expansion of the battery pack
- All cells and batteries should be protected against excessive shock and vibration

Battery Fabrication

It is essential that engineering drawings and work instructions are reviewed and completed prior to the initial pack construction. The general handling procedures outlined in this document should also be observed. Safety procedures should be in place to prevent any hazards that may arise while assembling and handling battery packs.

Personnel assembling battery packs should adhere to the following recommendations:

- All jewelry should be removed to prevent short circuiting the battery
- Appropriate personal protective equipment should be worn
- Cells received from Electrochem should remain in their original packaging until they are placed into the battery pack
- Work surfaces should be non-conductive
- Do not solder directly to the cell case
- Solder tabs extending from the cell should be insulated
- Avoid cutting or piercing the insulating shrink wrap on the cells
- Loose wires should not be stripped until they are ready for termination
- Wires should be trimmed one at a time

- All packs should be labeled with the appropriate warnings as they appear in the cell label
- Certain potting materials may be exothermic. Utilize thermal management techniques to remain within the safe temperature range of the cells
- Never disassemble the cell

Handling Under Adverse Conditions

Abusive conditions discussed in this document must be avoided to ensure the safe operation of Electrochem cells and batteries. Errors in pack design and assembly can result in emergency conditions that the user must be equipped to mitigate. The intent of this section is to provide a general knowledge of how to handle cells and batteries that have been subject to these adverse conditions. This document will focus on the following:

- Hot cells
- Leaking or venting cells
- Cells that have exploded
- Fires involving lithium batteries

The guidelines in this document are minimum recommendations. Each user shall determine the personal protective equipment needs, training, and emergency response procedures for cells and batteries that are involved in emergency conditions.

Only trained and equipped emergency responders shall be allowed to respond to a vented cell incident. Consult federal, state, and local regulations for emergency response regulations and training requirements.

Hot Cells

A hot cell is a condition that arises due to a short circuit of the cell or battery, either internal or external. The cell/battery temperature rises as the event continues which can lead to the cell reaching critical temperature and the potential to vent or explode.

The following are guidelines for a hot cell emergency response. A hot cell is a potentially dangerous situation and extreme caution needs to be exercised. Only properly trained and equipped emergency responders shall be allowed to respond to a hot cell incident. Consult federal, state, and local regulations for emergency response regulations and emergency responder training requirements.

As soon as a hot cell is detected, all personnel should be evacuated from the affected area. The area should then be secured to ensure no unauthorized personnel enter.

If the situation allows, prior to evacuating, the person that identified the hot cell should quickly determine if an external short circuit is present. After the short is removed, the cell temperature should start to fall. The area should remain evacuated until the cell has cooled to room temperature and has been removed from the area. If the hot cell situation persists, an emergency response may need to be implemented.

Equipment for responding to a hot cell emergency should include a non-contact means of temperature monitoring (thermal imager, thermometer, etc.); safety glasses and an impact resistant face shield; body, arm, and hand protection; and a means by which to move or pick up the battery or cell.

Response Procedure

- Evacuate and secure area as soon as hot cell is detected
- Monitor the temperature from a safe distance using a non-contact thermometer or thermal imager
- If temperature monitoring equipment is not available, keep the area evacuated and secure and do not handle the cell/battery for at least 24-hours
- If the cell cools, continue to monitor until it reaches ambient temperature
- Remove the cell from the area once it is cool
- Dispose of the cell in accordance with waste or recycling protocols

Vented Cells

Electrochem cells have a very high energy density. It is the combination of high voltage and capacity coupled with high reliability and lightweight construction that make Electrochem cells attractive for many specialty applications. When a large amount of energy is contained in a small package, the results can be disastrous if the system is abused.
All Electrochem lithium cells are hermetically sealed in a stainless steel case. A glass-to-metal seal is used as an insulator for the positive terminal. Under normal conditions, a cell will not leak or vent, however; cell leakage or venting can occur if the cell is overheated or the glass seal is compromised by excessive physical abuse.

The severity of a vent can range from a slight leak of electrolyte around the glass-to-metal seal to a violent expulsion of material through the seal or an explosion. In instances where the cell is unrestrained, this can lead to the cell becoming a projectile.

It is unlikely that any lithium battery would explode. These events are rare and are usually the result of an abusive condition or misuse that raises the cell temperature above its critical point. In the event of a lithium battery explosion, a room can quickly fill with a dense white smoke that can cause severe irritation to the respiratory tract, eyes, and skin. Precaution must be taken to limit exposure to these fumes.

The electrolyte contained in Electrochem cells can cause severe irritation to the respiratory tract, mucous membranes, eyes, and skin. Electrolyte reacts with moisture to form Hydrogen Chloride (HCl) and Sulfur Dioxide (SO_2) gases. Some electrolytes can release Bromine (Br_2) and Chlorine (Cl_2) gases as well as HCl and SO_2.

Equipment for responding to a vented cell should include a non-contact means of temperature monitoring (thermal imager, thermometer, etc.); safety glasses and an impact resistant face shield; respiratory, head, body, arm, and hand protection; neutralizing agent (baking soda); individual, sealable plastic bags; and a means by which to move or pick up the battery or cell.

A leaking cell can be handled quickly by trained and equipped assemblers or an emergency response team. After ensuring that the cell is not hot, capture the cell, place it into a sealable plastic bag, fill the bag with baking soda and seal it. Place that bag into a second bag and seal it as well. This will neutralize any leaking electrolyte and stop the formation of fumes. Once the cell is captured, and in a safe place, ventilate the affected area. Ventilation should last as long as it takes for the odor to dissipate. The cell can then be disposed of in accordance with your hazardous waste disposal procedures.

Should a cell explode, ensure that all personnel are evacuated and accounted for from the affected area. Ventilation should be initiated and remain in place until the smoke is cleared and the odor is gone. Clean up of the affected area involves sweeping up any debris and containing it in a sealable plastic bag. The debris may consist of metallic pieces of the cell. Ensure that this debris is not in contact with any other cells, as this may lead to a hot cell. The affected area should be cleaned with a baking soda/water solution or a commercially available liquid acid neutralizer. After cleaning is complete, a second wipe down with a typical cleaning solution may be necessary.

The bag of debris can be disposed of in accordance with applicable hazardous waste disposal regulations. Contact your waste disposal coordinator for proper markings and packaging requirements.

Fires Involving Lithium Batteries

WARNING

The following statements are intended for guidance purposes only. Attempting to fight a lithium battery fire should only be attempted by trained and equipped responders. Consult federal, state, and local regulations for emergency response regulations, emergency responder training requirements, and fire brigade training and protective equipment requirements. Cells or batteries exposed to excessive heat beyond their recommended temperature range can explode. During thermal decomposition chlorine (Cl_2), hydrogen chloride (HCl), and sulfur dioxide (SO_2) can be formed.

In the unlikely event that primary lithium batteries are involved in or near a fire, the principle concern is personal safety. The area should immediately be evacuated and all personnel accounted for. Emergency response organizations, either internal or external, should be immediately notified. The secondary concern in the unlikely event of a fire involving lithium batteries is to prevent the spread of the fire and minimize cell venting. The most effective way of achieving these goals is through the use of large amounts of water. Lithium metal is a water reactive material; however in the unlikely event of a lithium fire, the lithium would be rapidly consumed thus minimizing the risk of a lithium-water reaction.

Flooding the area with water accomplishes two tasks. The water will cool surrounding cells and batteries and reduce the likelihood of additional cells venting. Flooding waters will also help to extinguish any secondary fires present in the area. In the event of a cell venting, a water fog pattern will help to reduce airborne concentrations of sulfur dioxide gas. The water will become a very weak sulfuric acid and is typically diluted by the large amounts of water used.

When attempting to fight a lithium battery fire, appropriate personal protective equipment should be worn. Respiratory protection should include self contained breathing apparatus and protective clothing should include firefighter turnout or bunker gear per local regulations.

Portable fire extinguishers should be considered a last resort for fighting a lithium battery fire as they require emergency responders to be in very close proximity to the fire. There are several types of portable extinguishers available commercially.

Class D fire extinguishers (copper based) have been developed for and proven successful for extinguishing lithium and lithium alloy fires. The compound acts as a smothering agent and also acts as a heat sink. Copper-based extinguishing media is able to cling to vertical surfaces. Care should be taken to ensure that Class D fire extinguishers are of the copper-type, and not sodium chloride. The sodium chloride extinguishing agent is not intended for the high heat of a lithium fire, nor will it cling to vertical surfaces.

Graphite-based extinguishing media are effective on smaller lithium metal fires. These work by smothering the fire. This material will not cling to vertical surfaces, but has been developed for high-heat metal fires such as magnesium and lithium.

First Aid Procedures for Electrolyte Exposure

Electrolyte composition will vary depending on the type of cell used, but the first aid procedures remain constant. Electrolyte will react with moisture to yield sulfur dioxide, hydrogen chloride, and chlorine depending on the electrolyte. Immediately refer to the Material Safety Data Sheets for additional information.

> Eyes – flush with cool water for at least 15-minutes. Hold eyelids open and rinse thoroughly. Seek immediate medical attention
>
> Skin – flush with cool water for at least 15-minutes. Remove contaminated clothing. Seek medical attention if necessary.
>
> Inhalation – move to fresh air. If difficulty breathing, administer oxygen according to local protocols. If not breathing, begin artificial respirations and seek immediate medical attention.
>
> Ingestion – DO NOT INDUCE VOMITTING. Drink copious amounts of water. Notify Poison Control or seek immediate medical attention. Never give anything to drink to a person that cannot swallow.

Cell/Battery Disposal

Electrochem primary cells and batteries require special handling for disposal. Disposal requirements are region specific and many waste handlers have further requirements that need to be followed when disposing of cells or batteries. Primary cells and batteries can be recycled or disposed of as a hazardous waste.

General practices that should be followed when packaging a cell or battery for disposal or recycling include:

- Secure terminals to prevent short circuiting
- Package each cell or battery in a manner that prevents shorting with the container or another cell/battery
- Package leaking cells/batteries in a manner that contains the leak (refer to Vented Cells)
- Use packaging material that is in compliance with local regulations

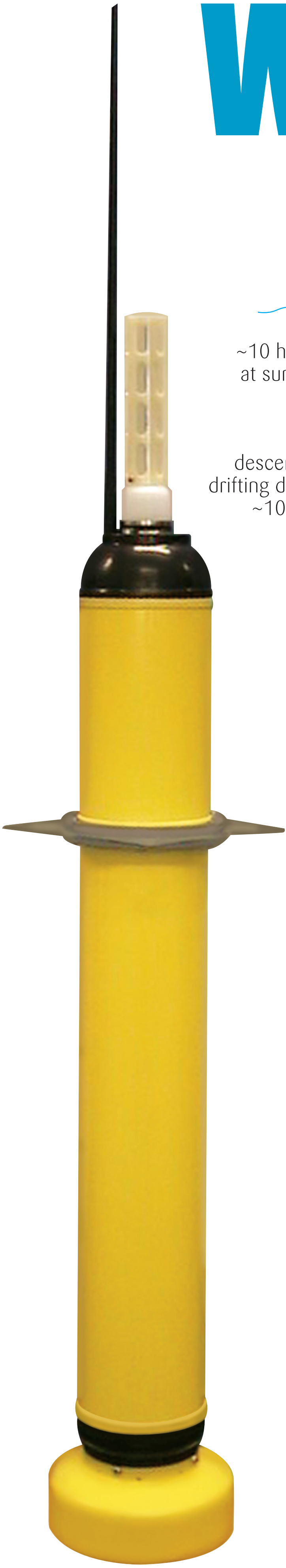
Regulatory Considerations

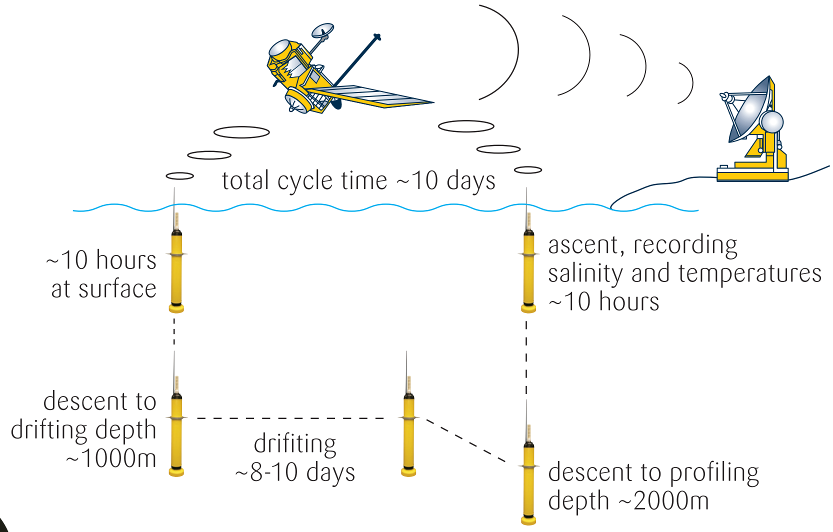
Each region of the world has differing regulations that the end user of Electrochem cells and batteries is responsible for complying with. Throughout this document, recommendations have been made on the safe and proper handling of lithium cells and batteries. These recommendations do not take into consideration local requirements or regulations. It is the responsibility of each end user to establish their own internal policies and procedures while adhering to all applicable local regulations.

This document is not intended to provide all the information that you will need to be able to work safely. The guidelines are established to help facilitate site specific guidance in accordance with local regulations.

Electrochem Solutions is a resource to our customers. If there are concerns around the safe handling of Electrochem cells or batteries, we will help to address those concerns. Our goal is to provide all of our customers with safe and reliable portable power. Safety starts with those handling the cells or batteries.

What is this?





Have you found something like this floating at sea or washed up on the shore?

Argo floats are instruments that are used by ocean science research programs to collect profiles of water temperature and salinity, from sea surface to depths down to 2000m. When the Argo is at the sea surface its data is transmitted to satellites which in turn relay the data to research centres in Australia and other countries. These data are very important for understanding the characteristics of the ocean environment.

What should you do if you find an Argo float?

> If you find an Argo drifting in deep water, it is best if you leave it alone. It will return to deep water when it has finished transmitting its data to satellite.

> If you think the float is damaged (perhaps it looks broken or has been hit by a boat), then it can be retrieved (if safe to do so) and returned to land.

> If you take a damaged Argo back to land, or if you find an Argo washed-up on shore, please notify the local contact person listed below and he/she will notify the relevant research centre.

The scientists in the ocean research centres will greatly appreciate your assistance in recovery of damaged or beached Argo floats.

WARNING: do not attempt to open the Argo. It contains lithium batteries which are dangerous when exposed to water. The sensitive instruments will also be damaged if the float is opened.

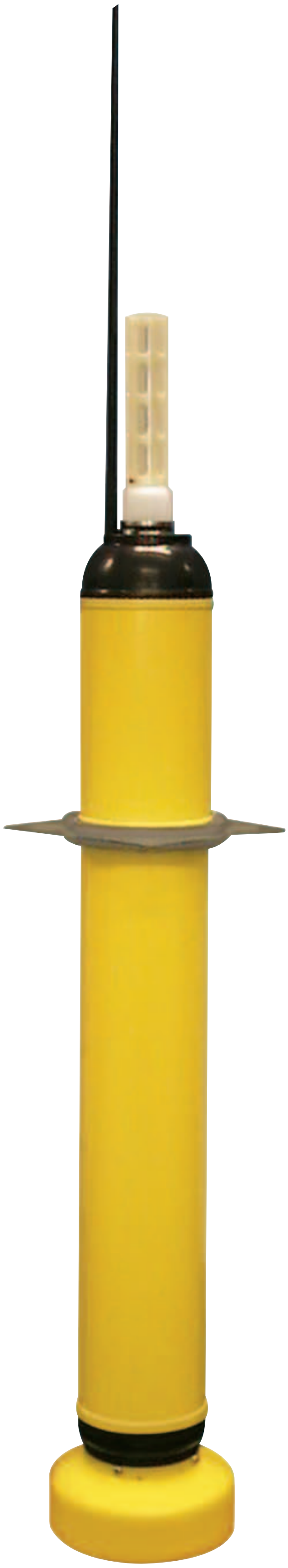
Please notify

Organisation: ....

Local Contact Person: ....

Phone: ....

Address: ....



An ocean observing system for the 21st century

Australia is a founding contributor to Argo, an innovative project to gather upper ocean data using robotic floats. Working in a fleet of more than 3,000 autonomous drifting sensors, the 1.5-metre tall profilers routinely collect sub-surface observations from throughout the global ocean. Critically, they have revolutionised the acquisition of year-round, near real time information on ocean and climate conditions.

Argo floats drift at depths between 1 and 2km. Every 10 days each instrument automatically descends to 2000m and then returns to the surface measuring temperature and salinity as it ascends. These data and the float's position are transmitted to satellites and relayed to data centres. The float then dives to begin a new cycle, a process that continues until battery life is depleted (150-200 cycles or about four years or more).

Argo data complement other observations obtained from ships, moored instruments and earth-observing satellites. Their profiles are used in operational ocean and climate analysis and forecasting, and oceanographic and climate research.

Australia deployed the first 10 floats in the global Argo program in the Indian Ocean in 1999. Since then, we have deployed more than 500 Argo floats. Globally, more than 8000 floats have been deployed. Around 800 floats need to be deployed per year to maintain coverage and replace floats that exhaust their batteries and cease to operate. Optimum global density is one float every 3° of longitude and latitude which requires around 3000 active floats to cover the open ice-free oceans.

Australia currently has funds to deploy around 50 instruments a year for the next two-five years. Argo Australia is a joint project between CSIRO's Wealth from Oceans National Research Flagship, the Bureau of Meteorology, the Antarctic Climate & Ecosystems Cooperative Research Centre, Australia's Integrated Marine Observing System and the Royal Australian Navy. About 120 float deployments a year are needed to maintain coverage in the oceans around Australia; our international partners provide half of these floats.

Why are Argo data needed?

Scientists are increasingly concerned about global change and its regional impacts. Sea level is rising at an accelerating rate of 3 mm/year, Arctic sea ice cover is shrinking and the upper oceans are warming globally. Extreme weather events cause loss of life and significant burdens on societies and the insurance industry.

Launching floats. The temperature/salinity sensors and satellite communication antenna are at the top. The bladder that controls rise and fall of the instrument is at the bottom.

Oceans store and transport vast amounts of heat across our planet. The water in the oceans' top three metres has the same heat capacity as the entire atmosphere and so oceans play a large role in climate over seasonal and longer time periods. Lack of global measurements of ocean heat and fresh water patterns has limited scientific understanding of its role and the ability to forecast climate and ocean conditions.

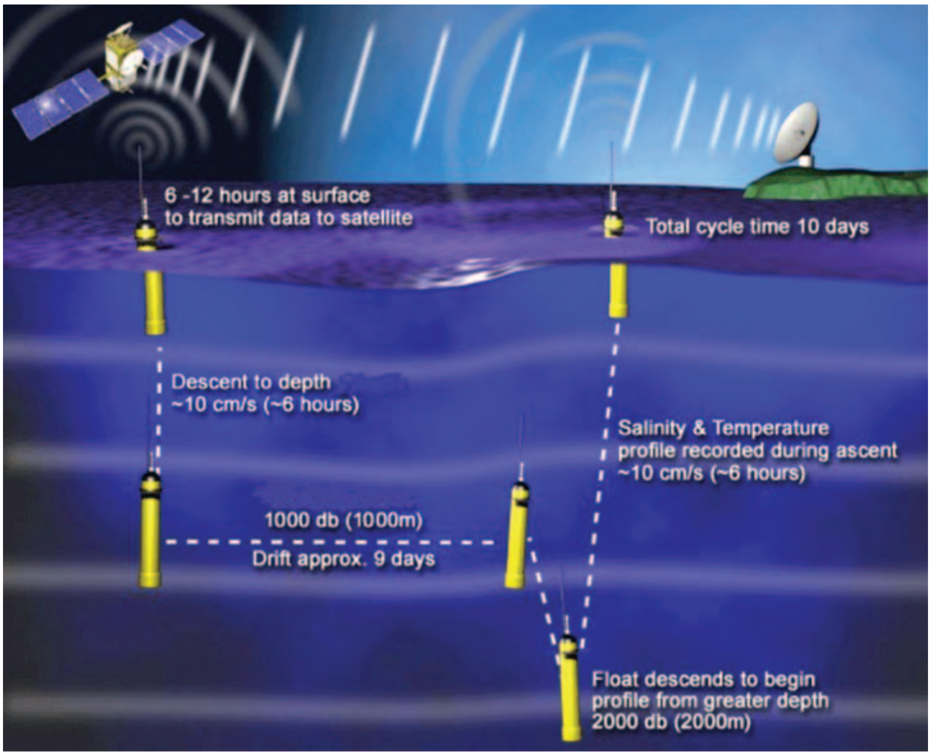
In particular, Argo has revolutionised our ability to monitor remote Southern Hemisphere oceans; the floats return data from these previously inaccessible areas, most notably in winter when air-sea interactions are very intense and ships leave the area. The subsurface float drift allows scientists to monitor currents that transport heat and water across entire ocean basins, an aspect of the ocean rarely directly measured.

Argo is sponsored by the World Climate Research Programme's Climate Variability and Predictability project (CLIVAR) and by the Global Ocean Data Assimilation Experiment (GODAE). It is a pilot project of the Global Ocean Observing System (GOOS).

How do the floats work?

The floats drift at one to two km depth and rise to the surface like hot-air balloons by pumping fluid from inside the float to an external bladder, which increases in volume, making the instrument less dense (more buoyant) than the surrounding seawater. After transmitting its profile measurements at the surface, the fluid is drawn back inside the floats so they fall back to their drift depth. A key advantage is that floats can be deployed from either aircraft or ships although almost all Australian floats have been deployed from shipping.

Ensuring reliable operation and high data quality during the floats' planned lifetime is a major challenge, and work continues to increase float reliability. Australia now has floats that have performed reliably for more than 8 years and the technology is continually improving.



The operating sequence of an Argo float.

Argo, Jason and other ocean observations

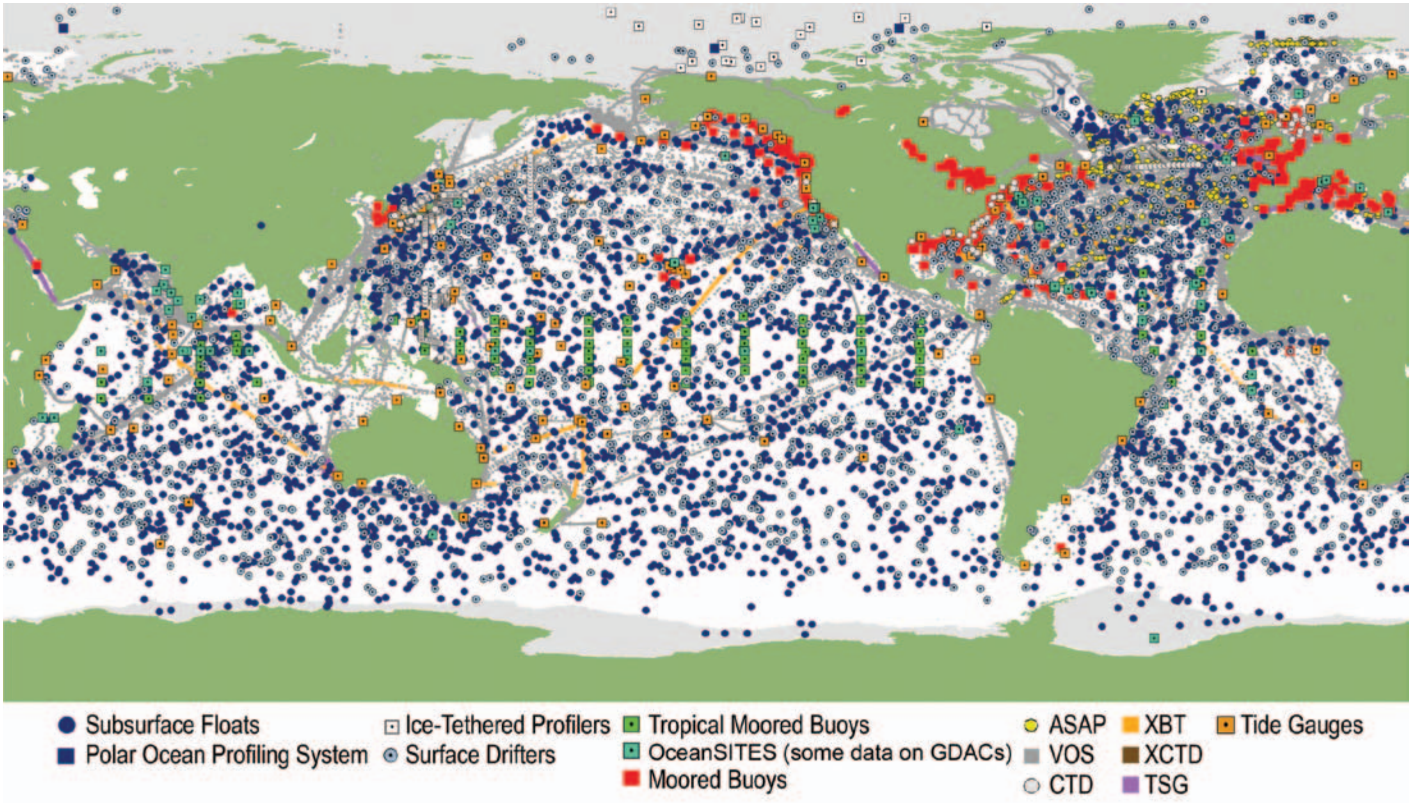
Argo is closely linked to the *Jason* altimetry satellite missions. Satellite radar altimeters reveal the shape of the ocean surface as it is influenced by currents and heat storage. A series of such satellites (ERS-1/2, TOPEX/Poseidon, EnvisatJason-1) have partnered with the profiling float program. *Jason-2, Cryosat* and coverage from other new generation altimeters provide even more information.

Argo is the central element of the ocean observing system, supplying *in situ* subsurface measurements which complement the detailed rapid coverage of satellite systems. Argo data are unique because they are not confined to shipping routes, they have truly global reach and they measure temperature, salinity and subsurface currents all year round, providing data in real time (ie accessible to scientists within 24 hours).

Delivering and using Argo data

Free and timely access to data is a fundamental principle of Argo. Users in operational analysis and forecast centres need information within hours. They receive Argo data via the meteorological Global Telecommunication System (GTS) – over 90% of the data is available within 24 hours. Other users get data from global data centres in Monterey, California, USA and Brest, France. These provide the same rapid data as the GTS as well as a "delayed-mode" version with improved salinity calibrations made by regional science experts. The "delayed-mode" data are of high accuracy and are used in climate and oceanographic applications where a delay of several months is acceptable.

A major user of Argo data is BLUElink – a collaboration between CSIRO (through the Wealth from Oceans Flagship), the Bureau of Meteorology and the Royal Australian Navy aimed at developing an operational ocean forecasting capability for Australia. Australia's seasonal climate forecasting system run by the Bureau of Meteorology is also beginning to exploit Argo data.



Who makes the floats and how much do they cost?

Most Argo floats are made by commercial companies in North America and Europe but some are manufactured by research institutions in the USA. Each float costs around US$18-23,000; communication, deployment and calibrations costs approximately double the through-life cost of each float. Thus each depth-to-surface profile from an Argo float costs about US$200 which is comparable to the cost of the less accurate, shallower temperature profile collected by eXpendable BathyThermographs used before Argo.

How is the Argo project operated and funded?

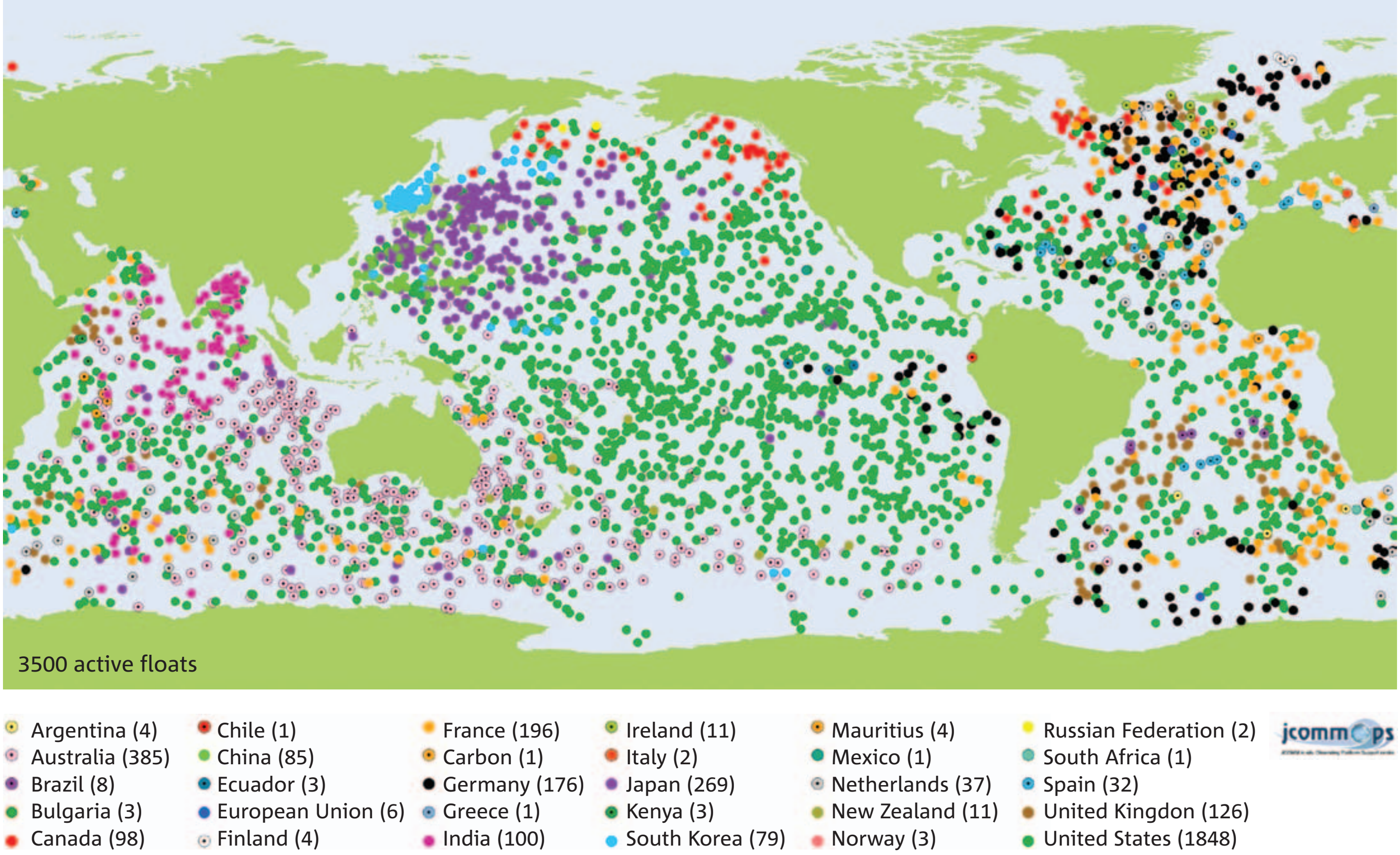
Project planning is the responsibility of the Argo Steering and Data Management Teams. Members represent the contributing science agencies plus other experts. Although Argo is planned internationally, it is funded through national ocean and climate research programs. Thirty countries and the European Union, contribute to the present float array. Many other countries assist with float deployments and allow access to their exclusive economic zones (EEZs).

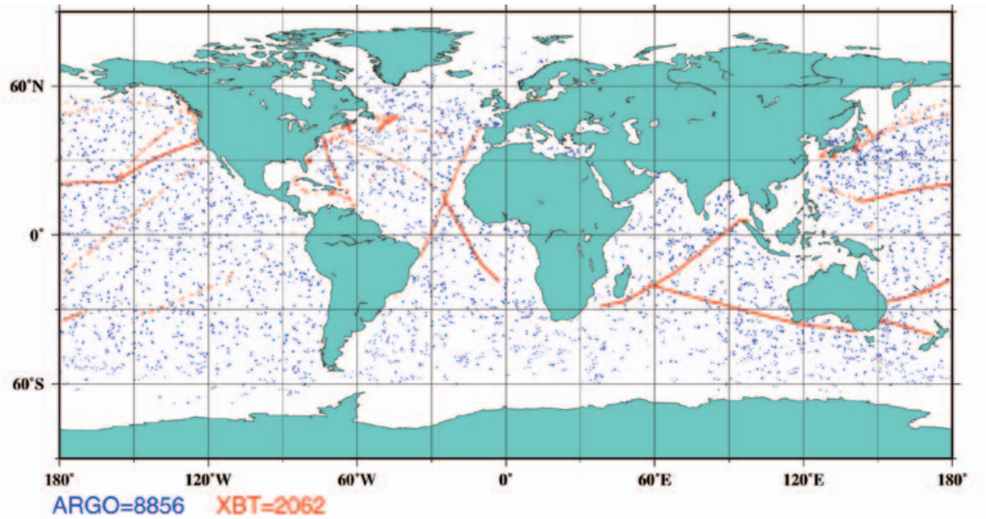
Each contributing country has its own regional priorities and organisational structure, but all are committed to the principles of Argo. An Argo Information Centre monitors the array development, focusing on issues relating to floats operating in EEZs.

Next steps and needs

Scientific, technical and operational evaluation of the program has improved float performance and the accessibility and quality of data. Final quality control is producing data approaching the high standards needed for some climate applications. Outside Argo, profiling floats are making other physical, chemical and biological measurements and profiling under ice. New communication methods now provide faster data transfer, more detailed profiles and two-way communication in which float cycles can be altered. Although Argo is the central element of GOOS, the global oceanographic community still depends on research ship observations for salinity calibrations, measuring seawater chemistry changes, and to reach the bottom two km of the ocean currently out of Argo's reach, though 'Deep' floats are now under development.

International Argo is now the dominant source of ocean profile data. Argo requires countries to provide committed funding, so the array can be maintained beyond 2012. Present estimates of float life imply that approx 800 float deployments a year will be needed to maintain the global array – at a total cost of about $US20 to 25 million annually.





Argo gives year-round coverage in areas far from shipping routes, and particularly in the Southern Ocean where Australia is a significant researcher. Argo (blue) and expendable bathythermographs (XBT) temperature profiles (red) deployed from ships. XBTs measure the upper 700m of ocean.

For further information

- Antarctic Climate & Ecosystems Cooperative Research Centre: www.acecrc.org.au
- Argo Australia: www.imos.org.au/facilities/argo-australia.html
- Argo information and data: www.argo.net
- Australia's Integrated Marine Observing System – www.imos.org.au
- Satellite altimetry sealevel.jpl.nasa.gov • www.aviso.oceanobs.com
- Climate Variability (CLIVAR): www.clivar.org
- GODAE: www.usgodae.org/argo/argo.html
- Global Ocean Observing System (GOOS): www.ioc-goos.org/
- Wealth from Oceans Flagship: www.csiro.au/WealthFromOceans
- BLUElink: www.bom.gov.au/bluelink
- Bureau of Meteorology: www.bom.gov.au
- Royal Australian Navy: www.navy.gov.au

Contact Argo: Argo International Project Office, Scripps, Institution of Oceanography, UCSD 9500 Gilman Drive, La Jolla, CA 92093 - 0230, USA. www.argo.ucsd.edu

CSIRO Marine and Atmospheric Research, GPO Box 1538 Hobart, Tasmania 7001 Australia
Phone: +61 3 6232 5172 **Fax:** +61 3 6232 5123 **Email:** ann.thresher@csiro.au

IMOS Integrated Marine Observing System

CSIRO

Australian Government
Bureau of Meteorology

NAVY

ace CRC ANTARCTIC CLIMATE & ECOSYSTEMS COOPERATIVE RESEARCH CENTRE

June 2012

APPENDIX B – Scientific & Trials Personnel List

ID	Surname	First name	Organisation	Role
1	Palmer	Rod	CSIRO	Voyage Manager
2	Steven	Van Graas	CSIRO	GSM Support
3	Tara	Martin	CSIRO	Observer
4	Muhtar	Latif	Konsberg	Multibeam Technician