Container & Cargo Location (*CCL) Buoy*

A MARINE BUOY TO ASSIST IN LOCATING LOST VESSEL CONTAINERS AND CARGOS AS WELL AS TO SERVE COASTAL COMMUNITIES IN SEARCH & RESCUE, AND SCIENCE

A purpose-designed and constructed marine buoy to manually attach by a line to floating lost containers or other cargos to track and locate them by visual identification, an Automatic Identification System (AIS) transponder and, if sunk, by a sonar pinger.

The buoy can be used as a marker to aid the search and rescue of a person overboard or for the scientific study of surface or sub-surface offshore/coastal currents. Multiple applications ensure the buoy is not a “stranded asset” and increase marketing opportunities, including Coastal Guardian Stewards, Marine Search & Rescue Organizations, Marine Research Agencies, and Commercial/Recreational vessel operators.

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MARINE BUOY TO TRACK AND LOCATE ACCIDENTALLY DISCHARGED CONTAINERS AND CARGO, AS WELL AS TO SERVE COMMUNITY INTERESTS IN SEARCH AND RESCUE, AND MARITIME SCIENTIFIC RESEARCH

"Container & Cargo Location (CCL) Buoy"

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About EnviroEmerg Consulting

EnviroEmerg Consulting focuses on emerging regional, national, and international environmental issues related to oil and hazardous material spill risk, prevention, preparedness, and response. Sectors include transportation (vessel, rail, road, pipeline) and industrial (manufacturing, storage). Clients include agencies, companies, First Nations, and non-government organizations. Stafford Reid (Principal) has 48 years of experience in environmental management.

The Intention

The intention is to design and construct a marine buoy that a tether-line can manually attach to a floating, container (general-purpose and tank) or other cargo (drums, boxes) to track and locate it by visual identification, Automatic Identification Systems (AIS) transponders and - if sunk- by a sonar pinger. Hereon referred to as a: *Container & Cargo Location (CCL) Buoy*.

The *CCL buoy* facilitates container and/or cargo location, whether stranded on shore or sunk to the seabed, to initiate rapid salvage and recovery operations. Practical locating and tracking reduce collision hazards by other boaters and mitigate environmental damages as containers eventually break apart and release their contents. The contents can entangle marine life and contaminate seabeds and shores. Mitigation measures then become exponentially more expensive.

The French organization CEDRE identifies the tactic of attaching a line buoy to floating containers in their operational guideline titled: *Containers and packages lost at sea*. *CEDRE* are international experts in accidental water pollution related to response support, contingency planning, training, analysis, testing, and research. Their guide recommends marking a floating container or cargo - such as drums - with a buoy or beacon. The beacon can be radio or satellite. The guide then outlines a buoy's generalized choice and parameters, such as having a 50-meter or more line with a means of attachment, such as a magnet or shackle. The *CCL Buoy's* design aspects consider *CEDRE's* guideline recommendations. The guideline also noted that "general-purpose containers –commonly seen on a container vessel are not impermeable to water. An empty one can sink in about ½ hour. In contrast, tank containers are impermeable as tank containers can hold between 13 to 19 tonnes of liquids (*e.g.,* dangerous goods/chemicals/hazardous substances). They tend to float at or near the sea surface. Steel, Plastic or Kraft (cardboard) drums have various floating capacities and resistance to degradation that range from days to decades.

General Purpose Container

Tank Container

Steel Drum

Kraft Drum

The *CLL Buoy* can be used as a lifebuoy marker to aid in the search and rescue of a person overboard. It can be used to study surface or sub-surface offshore/coastal currents scientifically. Multiple applications ensure the *CLL Buoy* is not a "stranded asset" and increases marketing opportunities, including clients such as Coastal Guardian Stewards, Marine Search & Rescue Organizations, Marine Research Agencies, and Non-government Organizations and Commercial/Recreational vessel operators.

The Context

International Perspective:

The *Maritime Safety Committee* of the *International Maritime Organization* (IMO) is getting closer to instituting mandatory reporting requirements for containers lost overboard. This worldwide initiative recognizes the severe hazard to navigation and safety at sea, mainly recreational sailing vessels, fishing vessels, and other small craft. There are also well-documented environmental impacts when a container breaks apart and discharges its contents. This initiative is essential given the growth in container shipping traffic and the number of containers on board each vessel. There are approximately 6,500 containerships currently active with a combined capacity of nearly 26 million *Total Equivalent Units* (TEU).[1] In 2019, the *World Shipping Council* reported that the international shipping industry transported approximately 226 million containers annually.

[1] TEU _ Total Equivalent Unit. Containers are built-in 20-foot and 40-foot lengths. One 40-foot container is equal to 2 TEUs.

The *World Shipping Council* estimated that an average total of 1,382 containers were lost at sea each year of 12 years (2008-2019). Many weather-related incidents exist, especially in the winter of 2020-2021. Over the past two years, the average was over 3,100 containers lost each year. As the size of containerships continues to increase, so does the risk of container/cargo loss.

See Appendix 1 image gallery to support the concept and context.

National Perspective:

Clear Seas – the *centre for responsible marine shipping* - has undertaken numerous West coast studies that pertain to container ship traffic and casualty interventions. What stands out is that container ships on the West coast are getting more frequent. They are the most problematic for emergency towing rescue owing to their high windage and corresponding drift rate that increases the likelihood of a swift grounding on a coastal shore if there is a loss of propulsion. The greater the number and higher the stacked containers, the more possibility of loss overboard during high-seas, collisions, and/or onboard fire.

More than 4,000 large ships travel the trade routes through the waters in Canada's Pacific region. Container ship traffic is dominant. The largest containership to call on a Canadian port was Prince Rupert in 2017, with 14,500 TEUs on board. As a reminder that marine accidents can happen in Canada, the *Zim Kingston* container incident near the Juan de Fuca Strait (Vancouver Island) entrance on October 22nd, 2021, resulted in the loss of 109 containers, of which only four were recovered because they were stranded on shore. In 2016 *Hanjin Seattle* container incident in the same locale lost 35 containers. The US and Canadian Coast Guards deployed floating tracking buoys, which are designed for an oil spill that moves with winds, not currents. There needs to be a solution for real-time container and cargo surface and sub-surface tracking, marking their final location where they sink or strand.

In March 2022, the House of Commons Standing Committee on Fisheries and Oceans studied Marine Cargo Container Spills. The study motion is:

> *That, pursuant to Standing Order 108(2), the committee undertake a study of marine cargo container spills on Canada's marine environment about (i) the environmental impacts of cargo container spills; (ii) improving response times and efficacy to cargo spills; (iii) addressing jurisdictional gaps to improve collaboration with volunteer, charitable organizations, provincial and territorial agencies, municipalities, and indigenous communities during spill responses; (iv) improving polluter responsibility and financial accountability*

After a series of witness presentations and meetings, the committee provided in October 2022 a report of their findings to parliament titled: *Marine Cargo Container Spills*. A key recommendation (4) was:

> *That, in collaboration with major shipping nations, the Government of Canada work with the International Maritime Organization to develop standards and requirements for locating devices to be incorporated in shipping containers. The* ***Canadian Coast Guard, in consultation with Transport Canada, considers the feasibility of installing location and tracking devices, e.g., transponders, on shipping containers to assist in locating lost and sunken containers****. (bold emphasis added).*

Given the millions of containers worldwide, equipping each of them with locating and tracking transponders is not feasible. Maintenance of them alone would be insurmountable. There is a more practical and manageable solution for container surface and sub-surface tracking and final location marking.

Recommendation 24 was more relevant to developing a *CCL Buoy*:

> *That the Government of Canada reviews the Canadian Coast Guard's drift modelling capabilities, which are essential to effective responses to marine spills*

The merit of fixing a buoy with a beacon to lost containers - even just a few of them - helps:

1. To establish an approximate determination of remaining unmarked containers spread and disposition to focus underwater detection by vessel-based searches with sonar, magnetometer and/or remotely operated camera.
2. To find marked containers sunken on the seabed or stranded on shore to recover before breaking them apart and releasing contents.

Both measures reduce significant effort and expenditure of undertaking underwater detection and will initiate more timely salvage operations. There has yet to be an attempt to locate the sunken containers of the *Zim Kingston* and the *Hanjin Seattle* as they are too complex and expensive.

A Paradigm shift in Preparedness

The *CCL Buoy* has other potential applications, such as supporting marine science by tracking sub-surface offshore or coastal currents by lowering the line with drogue at different depths or using it as a surface tracker moved by winds and currents for oil spill tracking or simulation. It can be a person-overboard (lifesaver) marker on a vessel for immediate rescue, much like the *International Maritime Organization's* SOLAS Man Overboard marker, but without the signal orange-smoke generation aspects. It can simulate a submerged body to ascertain recovery locations. Several *CCL Buoys* can be kept on container vessels attached to containers about to fall over-board – when safe to do so – or just thrown over-board for drift analysis. As well they can be discharged from aircraft during an event.

Other applications ensure the device doesn't become a "stranded" asset with a single purpose. It justifies expenditures and opens market opportunities. This requires a paradigm shift in Canada's environmental emergency planning, preparedness, and response to:

1. Recognize the importance of an initial response by communities, particularly First Nations - which is referred to as Tier 1 local response.
2. Acquire response equipment with multiple uses <u>during</u> the entire course of a marine casualty incident as well as <u>between</u> incidents to serve a community - which ensures an optimal return on investment.
3. Utilize boating skills and navigational knowledge of local coastal and inland residents to operate small vessels, such as their Coast Guardian vessels, herring boats, landing crafts, *etc.,* that can deploy small-scale response equipment - which empowers a community.

Challenges

Some of the design and construction challenges for a *CCL Buoy* include, but are not limited to:

- Small and low-cost construction by using off-the-shelf materials wherever possible
- Rugged and weather resistant if stored outside on a vessel, such as an overboard buoy
- High visibility when floating, such as in colour, reflectors, LED lights *etc*.
- Long battery life when stored in a warehouse or on-board a vessel
- Easy activation that cannot be done inadvertently
- Light line deployment that is reliable and will not tangle during deployment
- Geographic Positioning activation that does not require a subscription OR is very fast to establish
- Sonar pinger that is simple but effective for underwater locating
- Reconfigurable to replace the battery and reset it for the next deployment
- Configured and laboratory/field tested to simulate oil trajectory on water (no line deployment) or sub-sea currents with line deployed with a small drogue attached.

Design & Construction Considerations

General Components:

The reel system with deployment tether-line housing and core body with tracking electronics (GPS, pinger, battery) of the *CCL Buoy* should be integrated and about the size of a football. The two components could be 3-D printed.

A separate light wand can be attached, including a small wind anemometer and direction device integrated with the tracking electronics data communication.

The reel and body are detachable to access the line and replace batteries/electronics. The core body with electronics must be waterproof to at least 100 meters (approx. 300 feet) in depth or greater. Outside contacts for the light wand must be corrosion-resistant and protected.

If required, the CCL Buoy should be constructed of high-impact, fade-resistant plastic and marine-grade stainless steel. It should have high visibility reflectors for nighttime visual locating. There should be no edges/apparatus to catch the tether line. The entire buoy and any accessories should be in a secure, water-tight box attached to a wall/railing.

The tether-line length is a function of its strength, diameter, and amount on a reel. The longer, the better so that a sunken container resting on the seabed still results in the tethered buoy being on the surface.

Without any tether line extended, the *CCL Buoy* should closely simulate the trajectory of spilled oil based on wind strength, direction, and water current. With the tether line extended and an attached small drogue should simulate the current at the drogue's depth.

The primary attachment method is a magnet, with the option of using a carabiner-like shackle or manual tying.

Design and Function Considerations:

The following table outlines some design and function considerations of each component of the *CCL Buoy*, beginning with the bottom container/cargo attachments to the buoy's light wand with the option to add a radar reflector and wind anemometer.

Component	Function	Design	Considerations
ATTACHMENTS TO CONTAINER OR CARGO (Magnet, Carabiner, or Tie-on)			
Magnet	Primary means of attachment. Attached manually to a metal container or steel drum. The magnet can be attached directly by hand or casting, with an extended pole (with a metal tip), or fishing by dropping down into water.	Small and strong such as neodymium fishing magnets.	Need to self-correct on surface being attached to that includes a rounded surface (e.g., metal drum). Magnet strength is calibrated to tether-line strength, and sea forces (currents), but still be able to pull off manually without breaking the tether-line. Needs to be rust resistant. The magnet is attached to lead-line by a small carabiner-like shackle.
Carabiner Shackle	Manually attached to the container's side-end haul points, to any other cargos such as non-metallic ones.	Sized to fit the dimensions of standard container's haul points, easy handling as needs to be clipped on manually.	The carabiner's strength needs to match the tether-line's strength and potential current/wind pull. Rust resistant. Need to be attached to/removed from lead-line by small carabiner-like shackle.
Tie-on	A 1 meter long, floating line that can be tied to a container or cargo and connected to the buoy's lead-line.	Tie-on as a high visibility, floating line with at least ¼ inch dimension.	Needs to be able to tie on object by a person wearing gloves, in the dark, and wavy conditions. The tie-on is attached to lead-line by small carabiner-like shackle.
FLOATING LEAD-LINE BETWEEN ATTACHMENT TO TETHER-LINE			
Lead-line	A lead-line is attached to the end of the reel's tether-line. The container /cargo attachments (magnet, carabiner, tie-on) are connected to the lead-line	A 5 meter, high-visual, floating line of ¼ inch thickness can be easily seen, handled, and thrown. It has loop for magnet, carbineer, or tie-on on attachment and another loop to attach to reel's tether-line – using a small shackle.	The lead-line is separate from the buoy and not part of the thinner, longer tether-line of the buoy's reel. It is attached to the reel's tether-line prior to deployment. The lead-line is intended to make line/attachment handling easier. It is kept in the buoy's storage box as an accessory.

Component	Function	Design	Considerations
Lead-line Float	Float on the lead line is used to assist in attaching a magnet whereby the magnet is kept at an optimal depth when cast or hand deployed.	A small float that attaches to the lead-line and can be adjusted for distance from the magnet	Float allow the magnet to float and let the container/cargo intercept. Float also facilitate casting and retrieval. It can just slide and held by friction on the lead line.
DEPLOYMENT TETHER-LINE (Stored within Buoy in Reel Housing)			
Tether-line	Tether-line is a thin, strong line that can be unreeled from within the buoy's reel housing.	Minimum of 50 meters (164 ft): maximum length determined by line's thickness and sizing of reel. Need to manage maximum stress of buoy pulled by currents.	Need to be rot-proof when stored in reel-housing as reel-housing is not waterproof. Example could be high-visible braided fishing line that is in the 29 kg (44 lb) strength capacity or greater.
REEL (Inside, bottom of Buoy)			
Reel	Internal, integrated reel with buoy to hold, deploy and re-wind tether-line.	Deployment feature includes having some friction to prevent free-wheeling tangle. Line's deployment results only when buoy is pulled to submergent. There can have over-ride to pull line out by hand. Re-winding by separate attachable handle.	The force to pull-out tether-line is based on internally-set friction as primary release of line is based on the pull strength as buoy begins to submerge as container/cargo sinks past the maximum length of the tether-line. Inadvertent releasing of tether-line needs to be minimized when buoy is still on surface to avoid unwinding of line away from marked container/cargo by currents and wind. Over-riding of reel-friction can be done to manually pull-line out when used for subsea current studies with a drogue. Reel-housing of buoy has small external clip that line can be looped-tied to at desired length and at the end-of-its-run so that pulling pressure is

Component	Function	Design	Considerations
			not on the reel mechanism itself. Rewinding is by an attachable, separate crank handle. The internal attachment lug should be standardized to a hardware ratchet wrench that can be used as a back-up device. The handle is kept in the buoy's storage box as an accessory Rewinding of the tether-line needs to be evenly dispersed across reel's spool. As such, tether line opening would be a slot, not a hole.
	REEL LINE LENGTH DETERMINATION/COUNTER (Separate Device)		
REEL LINE COUNTER	Reel line counter to determine how much line has been deployed when using for current studies with a drogue.	A line-length counter is a separate attachment to bottom of reel-body of buoy that the line passes through.	String counters are available such as used in road marking and hip-chains. Device needs to be easy installable at bottom of buoy and not fall off. Measurement read-out in meters. The counter is kept in the buoy's storage box as an accessory
	BUOY (Floatation and Electronics)		
Buoy (Floatation)	The core-body of the buoy serves as both floatation and to hold electronic tracking device (GPS, pinger) and battery.	Floatation is calibrated to consider weight of battery /electronics / and attached reel-housing with it tether-line so as to simulate oil trajectory. As a water-sealed component, it must withstand water pressures when the buoy is submerged to a high-depth – the deeper, the better.	Core-body of buoy needs to be sized and designed to minimize current/wind forces when tether-line is fully deployed and attached to a sunken container. Buoy requires a retrieval handle that will not tangle with the tether-lines. Top of buoy is fitted with a light-want attachment that with terminals protected from seawater (when stored) and corrosion-proof. The reel-housing is attached to the bottom of the core-buoy

Component	Function	Design	Considerations
			such as using a bayonet – locking system with securing latch.
Buoy (Tracking Electronics)	Tracking electronics (GPS, pinger) and battery and LED light terminal are integrated into the core-buoy body.	Access to electronics/battery is by removal of reel-housing.	Consideration is required to whether to build each tracking electronics into the buoy or incorporate third-party systems that slip-inside. There require indicators of activations of each element, and battery life. Activation should be simple, such as a pull tab. After use, electronics/battery/activator needs to be re-configured for use again.
LED LIGHT-WAND (attached to top of buoy)			
LED Light-wand	An attachable strobe light for visual locating	A 45 cm (approx..18 in) to 60 cm (approx..24 inch) long, light-wand with strobe-capable LED is an attached to top of the buoy and activated along with tracking electronics.	A light wand is where the entire apparatus illuminates with some fresnel (directional) features. Mounting should be simple and secure, with direct contact to terminals. The mounting system should provide some flexing of the light wand to reduce breakage. It is kept in the buoy's storage box as an accessory.
RADAR REFLECTOR (Attached to top of light-wand)			
Radar Reflector	Radar reflector attached to top of light wand for locating, as well as enhanced visual sighting.	A fold-out, very light radar reflect that can be attached to the top of – or inserted over - the light-wand to enhance the emittance of light by reflection.	The radar reflect can also be used to capture wind-force a trajectory of the buoy as wind plays a dominate role in the movement of surface oil.
WIND ANEMOMETER AND DIRECTION (an accessory mounted on top of light-wand)			
Wind Measurement	To provide real-time wind strength and direction.	Real-time wind strength and direction is important data to determine the tracking and speed of floating debris as well as oil.	An accessory is a wind anemometer and direction device that can be installed on top of the light-wand and integrated with the tracking device data transmissions.

Testing and Evaluating

There is laboratory and field testing of a *CCL Buoy* to ensure it meets design/construction specifications and user expectations. A partial testing list includes:

- Ensuring the attachment (magnet, shackle or tie-on) to container/cargo, its short lead-line, long tether-line, and the connection to the buoy are all calibrated so as not to break under current/wind forces, as well as jerking in waves/swells when attached, and during deployment/retrieval.
- Reel friction is calibrated to ensure the tether line is only deployed when fully extended, the container/cargo is on the seabed, and the buoy begins to submerge. Tether-line should not deploy on the surface to avoid entanglement and moving away from the attached object. The short, floating lead line serves the purpose of keeping in proximity to the object.
- Pressure testing the buoy to a maximum submergence depth with a fully extended tether line.
- Tracking and trajectory analysis of the buoy to simulate:
    - Surface oil movement without tether-line deployed
    - Submerged (over-washed) oil under waves with tether-line deployed and appropriately sized/configured drogue.
    - Deep-water currents in offshore and coastal passages with tether-line deployed, appropriately sized/configured drogue, and pre-determined depth.
- Evaluating the merits of wind direction and strength anemometer
- Assessing wind interaction on a radar reflector
- AIS device transmission and receiver performance
- Sonar pinger performance and detection.

Evaluating the CCL Buoy from a user's perspective regarding different deployments is essential. This requires hands-on field testing of the buoy, which can be without its electronics. Evaluators include the Canadian Coast Guard, Coastal Guardian Stewards (First Nations), Royal Canadian Search and Rescue, Fisheries and Oceans Canada/Environment Canada and Climate Change.

Cost and Operation

The cost of a *CCL Buoy* would largely be influenced by what off-the-shelf components can be used, with most manufacturing left to the plastic parts. The target price-point would be what a recreational boater might pay to have as an over-board marker rather than an expensive scientific instrument. A purpose-design, weather-sealed storage box with the listed accessories is part of the system.

The main operational cost could be a subscription to a satellite-based Automatic Identification System (AIS) transponder. There is the option to activate AIS only when required. This can be done by radio/phone call back to an emergency dispatch/operations centre to arrange services. In a marine emergency, the time factor must be considered.

Battery selection should focus on storage and activation duration as the priority.

Appendix 1 - Image Gallery for Operational Context

The following images define the problem and working environments for a *Container & Cargo Location (CCL) Buoy* to mitigate and address.