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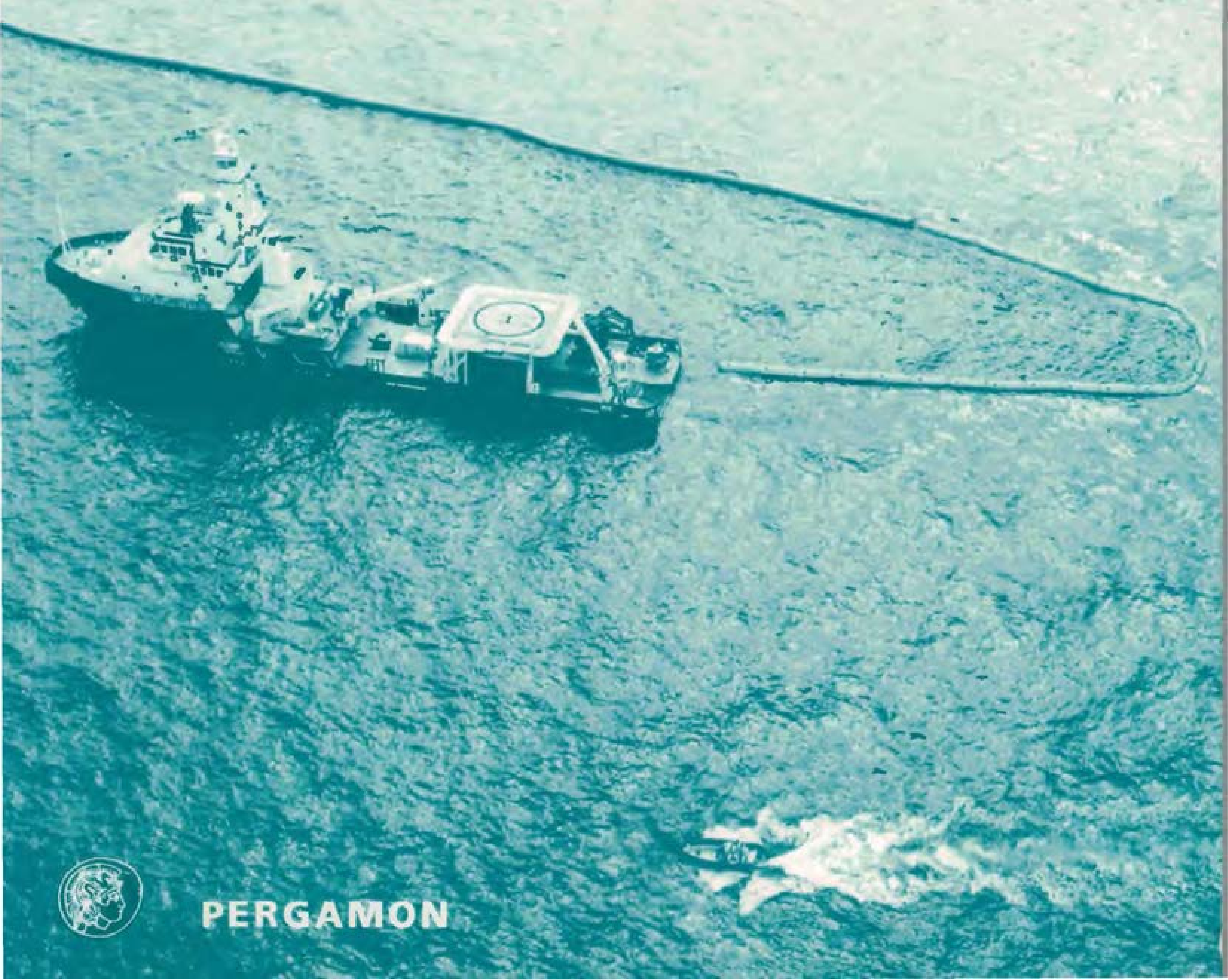

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TECHNICAL NOTE

Air Cushioned Vehicles: Efficient Alternative Transportation For Spill Response

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During the first 72 h of a spill, the focus is on stabilization of the casualty and on open water recovery. As the oil moves into shallow water, technology often gives way to labor and the ensuing battle is won or lost on an efficient means of transporting a vast network of responders and their equipment. From an operations perspective, transportation alternatives can be evaluated, most simplistically, by two standards: speed and cargo capacity. How fast can resources be delivered to the site? What is the payload of the vehicle delivering the resources? As the life of the incident grows and more resources are committed to the project, the issues of delivery speed and delivery volume become more critical. The traditional means of transporting a response organization by land, air, or water always seem to leave a gap in efficiency, particularly when mounting a shoreline clean-up campaign. This paper seeks to build enthusiasm within the response community for viewing the air cushioned vehicle (ACV) as the amphibious alternative in marine spill response transportation. Theory, case histories, and personal experience are used to develop support for planning ACVs into future response roles.

Keywords: **Air cushioned vehicle, hovercraft, logistics, marine oil spill.**

Transport Options

In developed urban areas, transportation to the shoreline may be achieved through the public highways. Under these conditions, air and water routes become less important. In remote and coastal areas, close highway access to the spill may not be possible. The overland option can become restricted by the use of a staging area only in the vague proximity of the clean-up zone requiring transfer of personnel and materials to smaller payload vehicles. Given these restrictions, air and water routes may be preferable.

Historically, the helicopter has been the air delivery system employed in marine spill response. Universally available, the helo is speedy and adaptable to a variety of landing zone situations. Its utility is limited by a small payload and visual flight rules. Personnel safety can also be a consideration, especially when boarding novice contract labor at a busy landing zone.

Water routes to the intertidal zone have typically been serviced by a variety of shallow draft vessels with, perhaps, the landing craft being the most common. Landing crafts are strong performers in the categories of payload capacity and reduced visibility operations. However, they are frustratingly slow as well as not always being available in sufficient numbers to support a sizeable response.

Is there an alternative to the 'big three' delivery systems when the mission statement calls for more speed, carrying capacity, and flexibility than the traditional can provide? Consider the air cushioned vehicle (ACV) or hovercraft as an alternative in marine spill response transportation.

Principles of ACV Operation

Hovercraft are rigid hulled vehicles utilizing a cushion of air to raise their hard structures above the surface they travel. Flexible rubber-like skirts are employed to enhance the capture of the volume of air generated by the vehicle's lift system. This seal system increases the hover height enabling the craft to traverse a broad spectrum of terrain (such as mud, water, marshland, ice).

Diesel and turbine engines provide the main power source for the lift/propulsion system of the hovercraft. The prime movers can either be dedicated to a single system, such as powering the centrifugal lift fan only, or the engine output can be split through a transmission. Steering is by rudders mounted aft of the propulsion fans. Bow thrusters and varying power to the propellers contribute to the craft's unique manoeuverability. Trim (bow up, bow down) is achieved by rapid transfer of the fuel ballast.

Supported by a low pressure cushion of air, hovercraft are very terrain tolerant. The size of the obstructions the ACV may safely traverse is limited by the height of its skirt. This true amphibious nature allows the hovercraft to make full use of its radar with minimal concern directed toward water depth. The low pressure air cushion is also very friendly to the sensitive intertidal zone. ACVs can deliver tremendous payloads at a footprint of between 127 and 195 kg m^{-2}, less than the impression made by a person.

Canadian Coast Guard Evaluation of ACVs in Spill Response

Hovercrafts have been a part of the Canadian Coast Guard fleet since the early part of 1970. They have been assigned multi-mission roles ranging from search and rescue to icebreaking and buoy tending. In 1977, the Canadians began studying the hovercraft as an asset in spill response. Initial experiments employed a Bell Aerospace Canada Textron vehicle, the Voyageur. The Voyageur was a well deck forward hovercraft that had seen service in the Arctic and St. Lawrence River system. Like most hovercrafts, it offered both speed (21 m s^{-1} cruising, 41 m s^{-1} maximum) and high payload capacity (20.3 t). Experiments were conducted using the Voyageur as a vehicle for dispersant application. Emphasis was placed on investigating the effects of air turbulence generated by the hovercraft on the dispersant behavior (Gill, 1978).

Later, in the summer of 1986, more extensive field trials were conducted with a British Hovercraft Corporation SR.N6 hovercraft in the Strait of Georgia. The SR.N6 vehicle is a substantially different craft from the Voyageur. While the Voyageur was configured as a flat deck work platform, the SR.N6 was modified chiefly for search and rescue. Though the speed of the SR.N6 was comparable to the Voyageur, its payload capacity was only 8618 kg. The objective of the study was to test further the interference the hovercraft created with dispersant behavior (Dickens *et al.*, 1988).

As a dispersant platform, the hovercraft proved quite successful in accessing areas otherwise attainable by aircraft only. Their high-speed and high-payload capabilities make them cost competitive in this role. Large volume displacement of oil by the ACV's lift/propulsion system never became problematic during the experiments. Although field tests with ACVs were encouraging, it was not until 1990 that a hovercraft was to support a significant spill response in Canadian waters.

The AP 1-88.250 Responds to the *Rio Orinoco* Incident

In October 1990, the *Rio Orinoco*, a liquid asphalt tanker, was driven aground in the Gulf of St. Lawrence after mechanical problems shut down her main engine. Though the cargo tanks remained intact, the grounding punctured the ship's fuel tanks. Spilled fuel contaminated 60 km of beaches on Anticosti Island, a remote, sparsely populated wilderness area owned by the provincial government. Only minimal overland access was available to the island's beaches. Strong winds, high energy seas, and shoal waters made this a difficult area to support beach clean-up operations by conventional water craft.

Initial transportation needs were met through the use of helicopters; however, inefficiencies were apparent in delivering almost 100 beach workers in helos capable of only a four-person payload. Time became of the essence as snow and progressively shorter seasonal days threatened to terminate the clean-up operation.

To assist the oil spill and salvage response, the Canadian Coast Guard deployed their British Hovercraft Corporation AP 1-88 Series 250 hovercraft. Diverted from its assigned buoy tending station, the AP 1-88 traveled the 463 km to Anticosti Island in 9 h. At first light following its arrival, the AP 1-88 was transporting crews and equipment to the spill site.

Ideally suited for a spill response mission, the AP 1-88 is a modified British Hovercraft Corporation vehicle. It is 24.5 m in overall length with a 11.0 m beam overall. The bow ramp and well deck design enable it to carry a 10 000 kg payload at an average cruising speed of 18 m s^{-1}. A detachable hydraulic deck crane is available to assist cargo operations (Fig. 1).

Prior to the mobilization of the AP 1-88, clean-up crew deployment with boats, helicopters, and all-terrain

Fig. 1 The AP 1-88.250 uses its deck crane to handle cargo during the *Rio Orinoco* incident.

vehicles had taken up to 4 h. Replacing these conventional methods of logistical support with the hovercraft enabled the Canadian Coast Guard to transport, in a single trip, 87 beach responders. Transit time, including stops at four different work sites, was under 1 h. On days when sea conditions were extremely rough, the hovercraft utilized its full amphibious capabilities by setting course across the tidal flats to avoid breaking surf (Fig. 2).

In addition to transporting beach personnel, the AP 1-88 deployed containment boom, removed 333 028 kg of contaminated beach soils, and ferried personnel and salvage equipment to the stranded ship. These tasks were accomplished regardless of the visibility conditions.

The SR.N-6 and the *Tenyo Maru* Incident

Off the Pacific Coast of Washington State (U.S.A.), on 22 July 1991, a 111 m Japanese fish factory ship, the *Tenyo Maru*, was struck amidships by a deep draft grain carrier. Within 10 min the *Tenyo Maru* sank in international waters. Fuel from the sunken vessel began escaping immediately. Estimates of the spill ranged from 227 t to upward of 374 t of No. 6 intermediate fuel oil and No. 2 diesel.

After assessing the environmental risk to the area, the Canadian Coast Guard invoked the 'Canadian–U.S. Joint Marine Pollution Contingency Plan' to organize a joint response. Offshore skimming operations were launched within 2 days of the sinking. Seven days after the collision, oil washed ashore on Washington beaches.

Like Anticosti Island, much of the Washington coast and the west coast of Vancouver Island is remote, unspoiled wilderness. Only a small portion of the shoreline is visible from public access roads. Indeed, those wishing to experience the coast must hike National Park, Provincial Park, or tribal beaches.

As part of the Canadian Coast Guard response team, an SR.N-6 hovercraft was assigned to a broad multi-task mission. Built by British Hovercraft Corporation, the SR.N-6 has an overall length of 14.7 m and a beam overall of 7.7 m. Configured primarily for search and rescue, the SR.N-6 is considerably smaller than the AP 1-88 mobilized during the *Rio Orinoco* incident. The full cabin design of the SR.N-6 still enables it to carry a 8618 kg payload at a cruising speed of 15–21 m s^{-1}.

During its mission, the SR.N-6 traveled 3975 km conducting pollution surveillance and transporting personnel and equipment to impacted areas both onshore and at the wreck site offshore. Heavy fog, common on the Pacific Coast at that time of the year, did not impair hovercraft operations though cruising speeds were reduced to 15 m s^{-1} in areas of less than 450 m visibility.

Fig. 2 Well out of the surfline, the AP 1-88.250 prepares to get underway from the beach with the *Rio Orinoco* appearing in the background.

During the period that the SR.N-6 was assigned to the *Tenyo Maru* incident, two working trips were made to the U.S. clean-up sites. The purpose of these trips was to evaluate further the potential air cushioned vehicles offer in supporting an oil spill response.

On one trip, surveillance was conducted on beaches, kelp beds, and tidally submerged rocks. The craft was dynamically held on-station while observers departed to inspect marine mammal rookeries isolated from small boats due to breaking surf (Fig. 3). Pocket beaches were also visually inspected by hovercraft. These tiny beaches, surrounded on three sides by sheer rock bluffs, are also rarely accessible by boat and represent a high-risk mission for helicopters.

On another trip, two response crews were transported using the SR.N-6. One crew was harvesting oil-contaminated kelp from small skiffs. The other crew was conducting traditional beach clean-up operations (Fig. 4). The SR.N-6 successfully menoeuvered bow-on to the beam of the skiffs and dynamically held position while personnel and supplies were transferred. At this point, the craft actively demonstrated that it could safely support vessels ranging in size from an 83 m buoy tender to a 4 m inflatable skiff.

To the American clean-up crews operating on the ocean beaches during the *Tenyo Maru* incident, use of the SR.N-6 was only an experiment. Yet one cannot help but superimpose the positive results of that experiment on the traditional air logistic means of supporting oil spill clean-up tasks on sensitive beaches, shores, and tidal flats. In a 30 day period, 485 air hours were logged in multiple helicopters transporting personnel in increments of 3–4 individuals per trip. During that same period, 101 helicopter air hours were logged in external load waste disposal operations in increments of 580 kg or less per trip. Like the lessons learned by the responders to the *Rio Orinoco*, access to a high-speed, high-payload, all-weather ACV can significantly improve efficiency over the current standard.

The Next Generation Coast Guard ACVs

Committed to enhancing the capabilities within their fleet, the Canadian Coast Guard has issued a contract for the construction of a new British Hovercraft Corporation AP 1-88 series 400 hovercraft. This 28 m overall, welded aluminum vehicle will be of well deck design and be able to transport a 25 000 kg payload at speeds of up to 28 m s^{-1}. Four 597 kW diesel engines will drive the lift fan/propulsion system. Launching of the new craft is currently scheduled for 1996.

Fig. 3 Dynamically holding position to the swell, the SR.N-6 embarks a biological assessment team at a marine mammal rookery during the *Tenyo Maru* incident.

Fig. 4 The SR.N-6 shown supporting traditional beach clean-up methods during the *Tenyo Maru* incident.

Economic to operate at $480 (1994 Canadian) per full power hour, the AP 1-88.400 nonetheless carries a hefty construction cost of $7.3 million (1994 Canadian). To make this type of capital investment pay, the new hovercraft will fulfill a multi-mission role. It will serve a variety of government agencies by performing buoy tending, icebreaking, fisheries patrols, search and rescue, and oil spill response. With over 50 m^2 of available cargo area, the AP 1-88.400 will act as a fast self-propelled barge.

ACVs in Response Planning

The Canadian Coast Guard has experienced encouraging results with air cushioned vehicles in marine pollution control roles. It is interesting to note that the Canadian fleet is relatively small, with three hovercraft operating throughout the country. From this small fleet, two vehicles were assigned to spill response during the *Rio Orinoco* and the *Tenyo Maru* incidents.

The largest operator of air cushioned vehicles in the world is the United States Navy. Given the Navy's historical role of dispatching resources to support the clean-up of spills of national significance, it would be encouraging if future Federal On-Scene Co-ordinators (FOSC) would request the support of U.S. Navy hovercraft. Deployment from the navy hovercraft fleet would enhance the traditional delivery systems employed during oil spills and set a striking example of the ACV utility in environmental response.

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