The TSL Aerospace Air Cushion Vehicle AT2500 Mk 1 , ***Sandwave***

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Introduction

TSL Aerospace was contracted by Mistral Hovercraft to build and refine a conceptual design for an ACV. The desire for the new craft was to achieve a quieter operating vehicle, that was diesel powered and constructed of a rugged yet light, hull and cabin section. The design payload is 2000lb in a combination of up to 10 passengers or cargo.

Prior to this, we had not been involved in the air cushion vehicle world. The programme was brought to TSL primarily because of our ability to structurally weld thin aluminum sections, and provide the necessary engineering and manufacturing support to complete the project. The systems, procedures and controls we use in our regular aerospace business far exceeded the initial demands of quality control. From the beginning, the 2500 would be reviewed and inspected by Transport Canada, throughout all of the stages of construction as it was our intention to have the craft certified by Transport Canada as a commercially licensed ACV. Our ISO 9000 processes allowed us to manufacture the craft in a reliable, and repeatable fashion, while accommodating component and design changes on the fly.

TSL Aerospace became very interested in this project when it was promoted to us by Mistral Hovercraft. It was seen as an opportunity for our small company to further develop its manufacturing techniques and complete project management. Of great interest to us was the opportunity to develop and integrate the systems and equipment to operate the craft. This included the hydraulically driven lift fans, Fly-By-Wire thrust control system, the mechanical thrust fan drive system, and the complete electrical/electronic instrumentation system. At the same time we increased our supplier base, and knowledge of commercially procured products as we developed the mechanics of the AVC operating systems.

The true defining characteristic of this craft is that it offers tremendous reduction in noise that will allow for operations in just about any area. Currently most hovercraft are limited because of the high noise levels consistent with the propeller driven thrust systems.

Manufacturing

The hull, cabin, forward deck and fan shrouds are manufactured from 5000 series aluminum alloy. The component parts are fabricated and welded together into primary substructures. These in turn are bolted and sealed to complete the assembly.

Welding a structure of this size in the material gauges used demanded that the welders and fitters used precise skills to eliminate the risks of overheating and tempering the components. Although the original concept for the welded aluminum hull was brought to us, the effects of the heat adsorption had not been considered for this mass. Therefore it was necessary to assemble the cut aluminum sheets onto a fixture and weld the structure in such a fashion to allow for radiant air cooling. Sections were welded following predetermined paths, allowing for the thin material to expand without causing or at least minimizing sheet rippling. The rippling and stress generation is consistent with these thin materials.

During the build phase several tools were built to assist in the manufacturing process. The largest was the welding galley. This aid, allowed the welders to manipulate the position of the hull. The entire assembly could be raised, lowered, tilted or rotated. This tool was specifically designed to allow the welders the most comfortable positions from which to weld the craft, thus reducing the fatigue levels.

The welding method used on the entire craft was TIG. This method allowed for much greater control of the joints and although typically slower in a manufacturing environment such as this. In order to achieve the high standard of material control and traceability, all parts, components, materials etc. were received and logged into a lot control book. This is a complete record that traces every part to the original manufacturer. The welding rod was also treated in this fashion. Documenting the amount and day received, along with its identifying lot numbers. Once quality control was satisfied, the accompanying control documents were filed for future reference. All of this preparation was used to ease the anticipated concerns from Transport Canada with respect to craft certification.

As a prototype, progress was slow. It took close to three months to complete the hull and primary subassemblies. The fitting of the cabin, control and instrumentation systems took another two months, and the final assembly and testing, another two months. During this time the workforce ranged from two welders to seven assemblers. As with a project of this nature, several redesigns took place in the mid and latter periods that created a virtual standstill of the programme.

While quick fixes or Band-Aid solutions could have been employed, we were looking at the long term manufacturing of the vehicles. There was a great likelihood that if we did not accurately document and correct or develop drawings to consolidate the modifications, it would be impossible to effectively consider producing additional craft.

The Vehicle

The AT2500 is 25'8" in length, 13'6" in width and stands 5'9" high. On cushion the craft is 7'3". Its design weight is 6300lbs wet, and with the 2000lb payload was designed to meet or exceed the buoyancy requirements of Transport Canada. The skirt consists of over 70 individual finger segments. These fingers are designed to be field replaceable in the most inhospitable climates. The attachment is eased by the use of separate hardware and backing plates for each, eliminating the need to remove adjacent components to replace a single section.

The pilots position is on the port side. Craft control is accomplished by the use of three toggle switches for the lift controls, a side mounted "Joystick" and a vernier type throttle control. Instrumentation consisted of individual lift fan tachometers for the port and starboard lift fans, a temperature gauge, ammeter, engine tachometer, oil temperature and boost gauge. Three separate fuel gauges show the individual tank levels. A fuel pump is used to transfer fuel into the aft cell for pick up by the engine, or if considered necessary, for ballast.

The craft is fitted with a enclosed passenger cabin section, that is completely removable. Full length windows provide for a relatively unobstructed view for the passengers. The primary entrance is through a forward door, ahead of the pilots station. The windows on both sides of the of the forward compartment and the three front windows are manufactured from a military specification ballistic plastic. This is the same material as currently used in subsonic fighters. The passenger windows double as emergency exits.

Engine coolant is plumbed to the forward compartment, starboard station where it flows through a heat exchanger. This provides heat for the craft and through a series of ducts, facility to de-ice all front windows. The heat is ducted past the heat exchanger and into the cabin area.

The aft cabin wall is covered in a sound adsorbing material. This is to increase the passenger comfort, but with a weight penalty. The passenger seating areas are constructed from the same aluminum materials. The pilots seat is a Recaro design that is fully adjustable. Inspection holes, across the seats allow for daily inspection of the interior side hull of the vessel. The battery compartment is forward in the entrance step. A power cut-off switch is immediately in front of the pilot. The battery is designed for low temperature use and as such offers the highest cranking amps available in its voltage range.

The engine selected for the AT2500 is the Caterpillar Model 3126 and is transversely mounted, immediately behind the cabin firewall. The drivetrain rotate two large squirrel cage fans inside of ducted scrolls.

Operations

Operating the hovercraft has been made as simple as possible. During the pre-start checklist, thrust control is set to a neutral position. The craft lift is established after engine start. The lifting is done with the three, individually controlled fans. Once stabilized at the operating RPM, control can be given to the thrust doors on the scrolls. The joystick requires little pressure to operate the doors and can be maintained in a cruise profile without "hands on". Power is set through the vernier throttle control and if necessary, port and starboard lift can be individually trimmed to optimize fuel consumption.

The craft was outfitted to meet the present requirement of TP5579. All lights and accessories conform to the regulation of the much larger craft.

The Future

The future of a craft in this size and weight category does show a lot of promise in varied applications. However, a problem with the certification of the craft and the operator licensing seems to weigh heavily in this industry. This is a situation that will require the efforts of the members present and Transport Canada, to define and outline areas of authority and responsibility.

Specifications Model AT2500

Overall Length and Beam	Length 28 feet, width 14.5 feet. Road width 8.5 feet.
Payload & Capacity	Certified to carry 10 passengers. Capable of 2000 pounds payload. Can be configured for carrying stretchers.
All up Weight	8700 pounds, including payload.
Engine	Powered by a 250 H.P Caterpillar marine diesel.
Fuel Capacity & Range	40 US gallons, for an operating range in excess of 4 hours.
Thrust	Quiet propulsion. Two squirrel cage fans provide quiet operations while producing 600 lbs thrust. Provides a cruise speed of 30 mph or 50 kph.
Lift	2 main and 1 rear centrifugal fans offer maximum efficiency for operations on water. Variable lift offers fuel economy in cruise conditions.
Control System	Electronic control of thrust and lift. The fly-by-wire system for thrust provides stable and responsive forward, reverse, turn and hover functions.
Maneuverability	The maneuverability and stability of the craft allows it to operate over water with a wave height of 2 feet and can negotiate solid terrain with obstacle height of 1.5 feet.
Skirt	Air cushion is contained within 82 separate skirt segments or "fingers" that are easily replaced.

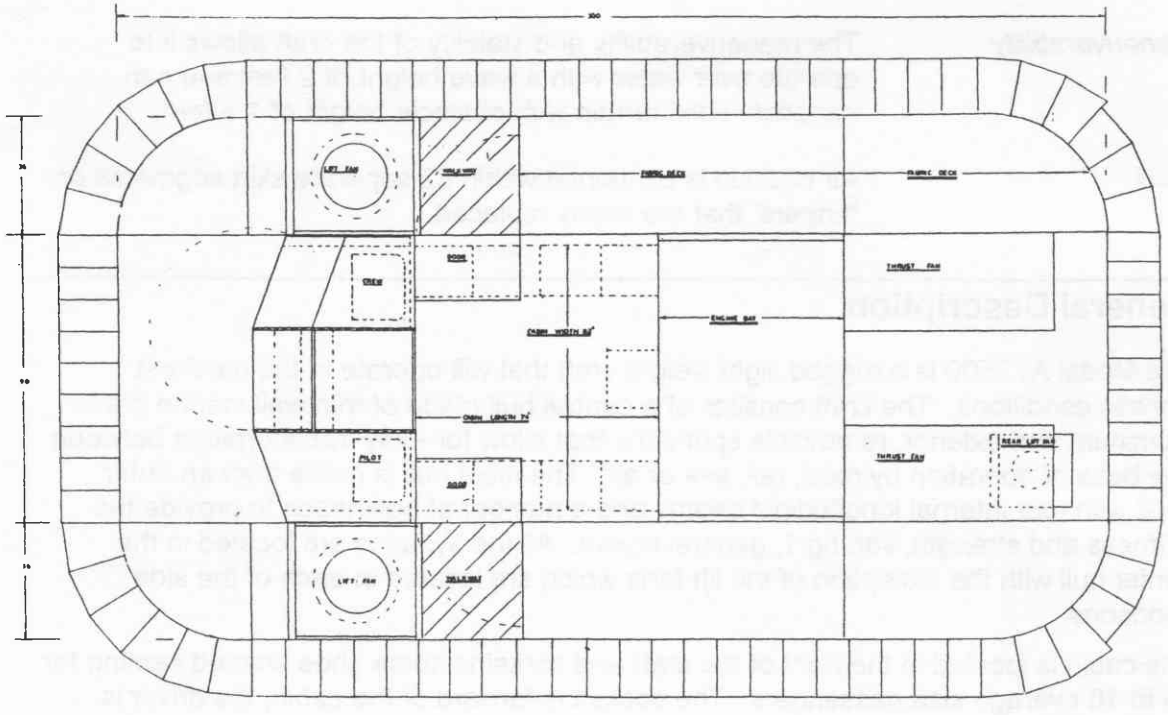
General Description

The Model AT2500 is a rugged, light weight craft that will operate in the harshest climatic conditions. The craft consists of a central hull made of thin wall marine grade aluminum and exterior, removable sponsons that allow for easy transportation between any base of operation by road, rail, sea or air. The main hull is made from an outer shell with four internal longitudinal beams and a number of bulkheads to provide the stiffness and strength, see fig 1, general layout. All the systems are located in the center hull with the exception of the lift fans which are located in each of the side sponsons.

The cabin is located in the front of the craft and contains horse shoe shaped seating for up to 10 average size passengers. The cockpit is forward of the cabin, the driver is located on the left hand side in an area that also contains the instruments and controls.

Entrance is through a front door and down three steps between the two front seats. Two emergency doors are positioned just behind the drivers seat on both port and starboard sides.





Model AT2500 "Mistral" Prototype
TSL Aerospace Technologies

Construction of the New AP.1-88/400 Canadian Coast Guard Hovercraft

A.G. Stanton
Hike Metal Products Ltd.
Wheatley, Ontario

This is a brief presentation from a building perspective of the new AP.1-88/400 hovercraft for which we were contracted to build two off for our Canadian Coast Guard.

Construction of the two craft began almost 26 months ago after the contract were consummated between ourselves and GKN Westland Aerospace of Great Britain. GKN in turn had their contract with the Canadian government as prime contractor and we acted as sub-contractor to them for the actual construction. The project got underway as a design/build concurrent arrangement due to time constraints. However, much of the fundamental design existed or was adapted from their predecessor, the "Waban Aki", a smaller version of the /400 craft which the Canadian Coast Guard had built and received some ten years earlier from Westland.

This gave us the ability to start and proceed while Westland proceeded with preparation of the rest of the nearly 1,500 drawing details. We were also required to implement a comprehensive Q.A. system at the start which met both with GKN Westland and government requirements.

Fabrication and welding of the light weight aluminum structure presented the first challenge. Although our company has certification in both steel and aluminum to the Canadian Welding Bureau 47.1 and 47.2, division 2.1, the hovercraft came under a new set of rules in order to meet GKN Westland Aerospace quality requirements. In the first instance the Canadian Welding Bureau did not have standards for MIG welding of aluminum sheet under 3 mm. This meant all testing had to be sent back to Westland labs in East Cowes, U.K., for testing and welder qualification. We had to develop for ourselves new procedures for MIG welding 1.5 and 2.0 mm sheet from one side. For most of the panel sections we built and alignment jig which trapped the sheets each side for the square groove butt joints, while automatic track welding was set up utilizing Gulco Kat machines and pulse MIG welding machines with water cooled guns. Pure Argon was used throughout for shielding the weld arc.

The majority of the transverse beams were also welded using a jig and automatic track welding while others in way of the main landing pads were bolted to retain the full strength of the tempered alloy sections.

Hull bottom and deck planks were welded sequentially together also using the automatic track welding system, as well as much of the fabricated structural fillet welding.

Once the main structure was complete we moved on to the lift fans and propulsion assemblies outfit. All main shaft lines were set up and installed utilizing laser alignment equipment which provided a very high degree of accuracy.

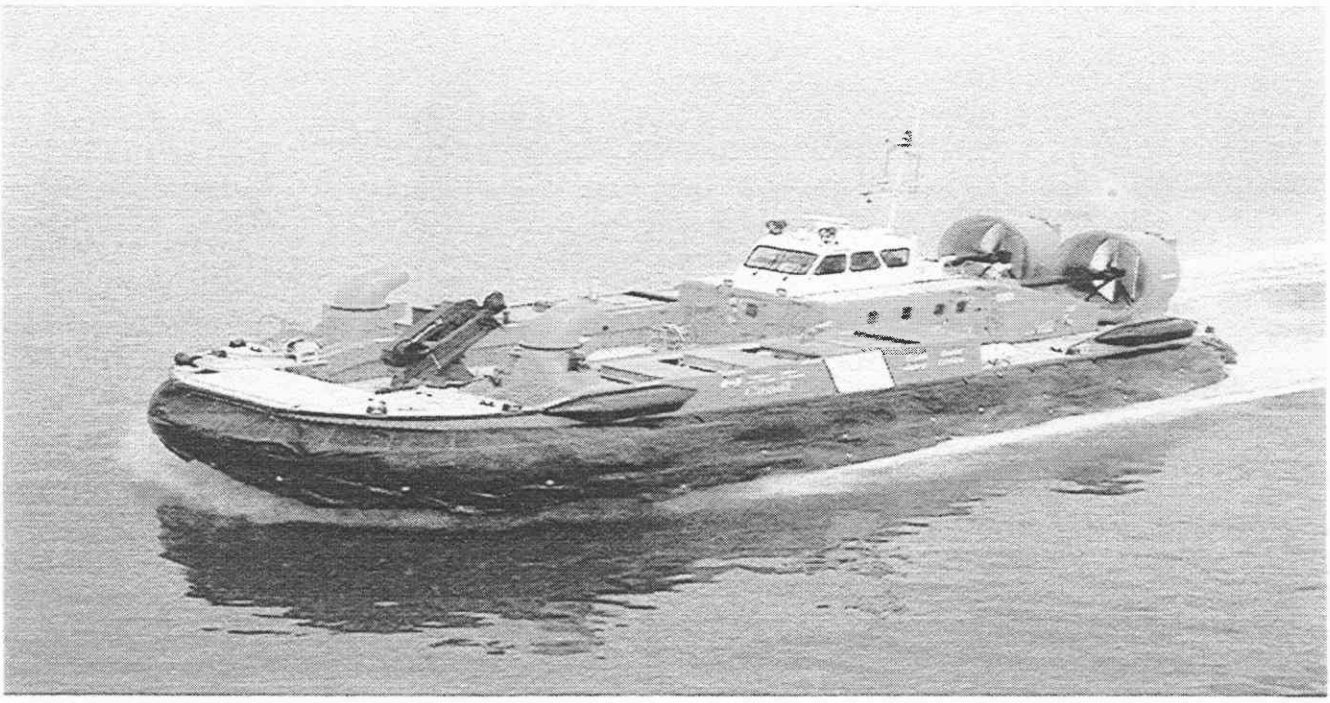
During this phase other systems such as electrical, fuel piping, controls, hydraulics and cooling systems were also begun. Many of the parts of these systems were prepared or prefabricated within the plant for final fitting on the craft. First testing was also initiated at the time. All 26 individual buoyancy hull compartments were subjected to a 24 hr air pressure leak test, utilizing a hygrometer to indicate 2 psi.

Once most of the craft appendages were pre-fitted the craft was prepared and painted utilizing a two part polyurethane system from Cautaulds Aerospace paint division in the U.K., which was applied with electro-static paint spray equipment. After the painting process appendages were then permanently fitted back, along with the close loop skirt system which was essentially fitted last. Upon completion of the outfit the lift fan engines were run-up and the craft was brought up on hover and towed out of the assembly building onto the paved and concreted test pad where its full series of ATR's were concluded prior to the final sea trials.

Aéroglisseur «SIPU-MUN» Hovercraft

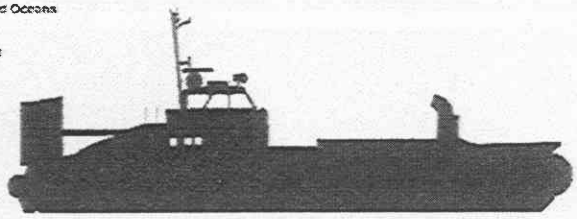
Garde Côtière Canadienne - Canadian Coast Guard

Constructeurs/ Builders	GKN Westland Aerospace Hike Metal Products Ltd
Modèle/Model	AP.1-88/400
Longueur/Length	28.5 m
Largeur/Beam	12.0 m
Puissance/Power	2818 kW (total)
Type	Caterpillar
Vitesse max./Max. speed	50 nœud/knot
Croisière/Cruise	45 nœud/knot
Masse max./Max. weight	70 t
Livraison/Delivery	Mars/March 1998



Pêches et Océans Canada / Fisheries and Oceans Canada

Garde côtière / Coast Guard



SIPU MUIN

Caractéristiques

Type	Aéroglisseur
Modèle	P1-38/400
Longueur	28,5 m
Largeur	12,0 m
Puissance	2 818 kW
Vitesse maximale	50 nœuds
Vitesse de croisière	45 nœuds
Poids maximal de l'appareil	70 000 kg
Equipage	8
Constructeur	GNK Westland Aerospace-Hike Metal Products Ltd, Wheatley, Ont.
Fin de construction	Mars 1998

Le VCA *Sipu Muin* est un aéroglisseur lourd et puissant capable à aussi un rôle essentiel pour prévenir les inondations dans l'est du Canada. Il est utilisé pour le déglaçage des rivières et des berges le long du Saint-Laurent difficiles d'accès pour les brise-glaces conventionnels.

Il sert également de baliseur dans la région Laurentienne et est doté d'un treuil lui permettant de soulever des poids de l'ordre de 5 000 kg. Sa capacité de chargement de 23 000 kg et sa polyvalence lui permettent de transporter une multitude de cargaisons et de passagers dans des endroits difficilement accessibles. Il peut également transporter du matériel roulant par l'entremise d'une rampe d'accès direct au pont de chargement. Cette caractéristique le rend particulièrement utile lors des opérations de dépollution, car il est aussi totalement amphibie. On le sollicite régulièrement pour des missions de recherche et de sauvetage ainsi que pour des travaux de construction et d'entretien des aides à la navigation.

Le VCA *Sipu Muin* travaille surtout entre Montréal et Trois-Rivières, mais, comme les autres unités de la flotte de la région Laurentienne, il peut être rapidement déployé sur tout le territoire couvert par la Garde côtière. La base de l'aéroglisseur est située à Trois-Rivières.

Particulars

Type	Hovercraft
Model	AP1-38/400
Length	28.5 m
Breadth	12.0 m
Power	2,818 kW
Maximum speed	50 knots
Cruising speed	45 knots
Maximum weight	70,000 kg
Crew	8
Builder	GNK Westland Aerospace-Hike Metal Products Ltd, Wheatley, Ont.
Construction completed	March 1998

The ACV *Sipu Muin* is a powerful and heavy hovercraft. Its essential role is to prevent flooding in Eastern Canada by breaking up the ice covered rivers and shores along St. Lawrence River where conventional icebreakers are unable to operate.

The craft is used as a buoy tender in the Laurentian Region and is equipped with a crane capable of lifting weights up to 5,000 kg. Its versatility and payload of up to 23,000 kg give it great flexibility for transporting any combination of freight and passengers in difficult areas. Vehicles can be loaded directly on deck through a bow ramp. This feature makes it particularly useful in pollution clean-up operations since the craft is fully amphibious. Other applications include search and rescue, construction work and aids to navigation maintenance.

The ACV *Sipu Muin* is used primarily between Montréal and Trois-Rivières but, like any other Coast Guard unit, it can be deployed rapidly anywhere in the territory within Coast Guard jurisdiction. The hoverport is located in Trois-Rivières.