Hovercraft: a second coming?

Demand for hovercraft has picked up, especially within the last decade, spearheaded by (but not confined to) the military and utility sectors. Alan Bliault, FRINA assesses the technical evolution of these specialist craft, with a particular focus on the vessels produced by Griffon Hoverwork

Hovercraft have been through a roller coaster of development since their initial R&D in the late 1950s and rapid commercialisation in the 1960s/1970s based initially on aerospace technology. Hovercraft ferries grew to the quintessential cross-channel BHC SR.N-4 type within the decade. Their speed (higher than 70knots in calm conditions) and convenience made them a popular service. While somewhat noisy, the journey was brief. The craft continued in service for over 30 years, until the Channel Tunnel and large, high-speed catamarans supplanted them at the turn of the 21st century.

Passenger services across the Solent, UK – from Southsea to Ryde on the Isle of Wight (IOW) and Southampton to Cowes, IOW – have also been successful. However, while the former is still a popular service, the Southampton route has become one serviced by fast catamaran craft with considerable success. Many other possible ferry routes were trialled with hovercraft through the 1970s, but most did not get past studies or initial trial operations.

A service to Oita Airport, Japan run with Mitsui hovercraft was long in operation, but was not continued after the service life of the original craft. It is understood that the route is now being reconsidered for hovercraft. Globally, a great many existing and new short passenger ferry routes have successfully adopted fast catamarans since the millennium, and this trend continues.

Military, paramilitary and utility missions have been much more successful markets for hovercraft since the 1970s. Currently, the US Navy is in the process of replacing its fleet of 90 landing craft air cushion (LCAC) vessels, or 'ship-to-shore transporters', that provide rapid access to much of the world's undeveloped coastline, whether for military interventions or for disaster relief, with payloads up to 67tonnes carried in a well deck. Similar craft are also in operation in South Korea and Japan, while Russia has its own equivalent design in operation.

Evolution of a brand

The cross-Solent service by Hovertravel from Southsea to Ryde has seen a whole succession of hovercraft as the technology has matured, and now operates with the latest in the form of the Griffon Hoverwork 12000TD.

Griffon Hoverwork Limited is a fusion of two organisations that have had close links to Hovercraft Development Ltd (HDL), the company formed for technology development from the original patents by Sir Christopher Cockerell. Hoverwork grew out of the maintenance arm of Hovertravel, while Griffon started with 12-seat passenger craft in the 1980s and grew to build larger craft for utility, paramilitary and coast guard duties, and for airport crash rescue.

Between Griffon and Hoverwork, 188 craft have been built for customers in 43 different countries since 1983, with payloads ranging from 500kg to 22,500kg. The spread of deliveries by payload up to the 12000TD is summarised in Figure 1. The largest market in terms of numbers has been that for utility and coast guard missions, particularly where coast guards have had extensive estuarine areas to patrol for rescue or contraband. India is one such example. In Canada, seasonal ice has long been a natural control task for the coast guard in the St Lawrence that is efficiently dealt with by hovercraft, and more recently logistics in the shallow North Caspian has become a regular operation with a BHT 150.

The larger craft fleet derived from the AP1-88 and latterly BHT designs built by Hoverwork comprise: 12 AP1-88 and one BHT 130 passenger craft; and six AP1-88 craft and two BHT 150 well deck utility craft. All except one are in operation/available for service, which, to an extent, shows the durability of a welded marine grade aluminium structure and diesel powerplant.

Demand, post-2008

In the 1980s and 1990s, progressive increases in the cost of fuel led to adoption of high-speed diesel powering

Figure 1: The spread of Griffon Hoverwork deliveries by payload

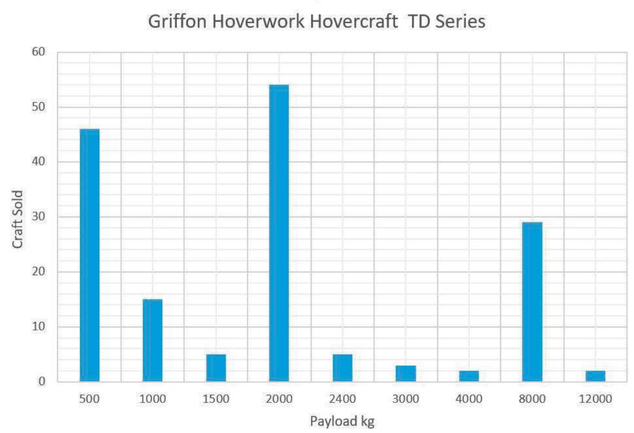

Figure 2: The 'traditional' layout of Griffon's 2400TD craft

of large hovercraft, and then also for the small 1,000kg and lower payload craft. Alongside this, hull construction moved from riveted high-tensile aerospace aluminium (the BHC SR.N series craft) to welded marine-grade aluminium. Propulsion efficiency was improved on the medium and smaller craft by introduction of ducted propellers and fans. This also helped reduce the noise footprint from the earlier SR.N craft.

Both Hoverwork and, separately, Griffon evolved these basic configurations until once again, after the 2008 financial crisis, operational economy for commercial craft really needed a boost. This led to the development and construction at Hoverwork of one BHT 130 craft for the IOW service, having a higher passenger capacity anticipating increasing passenger volume.

While the craft was a technical success, being essentially a modernised version of the smaller craft it replaced, it did not provide the economic results desired by the operator. So Griffon prepared a more radically updated design, the Griffon 12000TD, tailored to the IOW route (see Technical Particulars).

Above this size (12tonnes payload), Griffon has over the last decade also studied much larger payload craft with a drive-through well deck. At present, a payload of 40tonnes or so is practical for powering at high speeds with modern high-speed diesels, while above this, if the demand is for a 70tonne battle tank or equivalent, then gas turbine powering is the only practical option if full speed remains critical, as used by the US Navy. Most countries have much lower requirements, and so there may yet be a practical market for such larger craft powered by diesel engines.

At the other end of the scale, Griffon had a challenge to improve the design features of its craft in the 1,000kg payload range. This has taken some radical thinking to solve, in addition to a programme of work with the authorities in the UK to implement simplified regulations [1] compared to the IMO High Speed Craft Code and the earlier British Hovercraft Safety Requirements (BHSRs). This has resulted in the Griffon 995ED design, of which two craft have been delivered so far.

The 995ED

The 'traditional' configuration for a hovercraft has been a passenger and/or cargo area forward with the machinery, lift fans and propulsion at the stern (see Figure 2). Diesel engines and propulsion ducts result in dry LCG being aft, and so ballast tankage and a trim system is necessary. On large craft this can be accommodated but, for craft in the range up to 3,000kg payload, the penalty is significant.

Around 70% of Griffon's fleet by numbers are in this category, with 32% in the 1,000kg size range (Figure 1). With increasing demand for improved efficiency and advancing environmental regulations, a development programme was started in 2013. The challenges are particularly strong for the 1,000kg class as these craft are often trailered to an operating area.

Griffon conducted a customer review of specification priorities before following a stage-gate project delivery process [2] for a new 995kg payload design. Key issues addressed were: reduced acquisition and operating costs; higher payload fraction; and reduced delivery lead time. The ballasting issue was addressed by a change in powering configuration.

Meeting current regulations and customer requirements meant use of two engines for redundancy. These could then be placed forward and aft with suitable transmission for the propulsion, to better balance the craft. The transmission system selected for propulsion was electric drive, for high efficiency. Each of the two diesel motors was designed as a modular package including a closed circuit cooling system, belt-driven lift fan and electric power generator. One unit is mounted forward of the passenger compartment and the second aft of it. Lift system design studies concluded that mixed-flow fans would provide improved performance compared to earlier centrifugal units, as well as a smaller package dimension.

With propulsion using electric motors' direct drive to the fans it was then possible to consider rotating the ducts for directional control, rather than installing rudders. Reverse thrust simply requires the motor controller to demand reverse rotation, a simpler installation than variable pitch fans.

Turning to the structural design, lightweight welded aluminium structures have a tendency to built-in stresses that make joint design difficult, increasing

TECHNICAL PARTICULARS

Griffon 995ED

Length	8.6m (hovering); 8.2m (transit)
Breadth	5.2m (hovering); 2.2m (transit)
Height	3m (hovering)
Obstacle clearance	0.5m
Payload, max	995kg
Dry weight	1,205kg
Power	2 × Ford Tiger, 170kW
Service speed	30knots
Max wave height	0.75m
Endurance	4 hours
Cabin area	3.6m × 2m
Passengers, max	8

Figure 3: The Griffon 995ED was demonstrated across a wide range of terrains

Figure 4: Hovertravel's Griffon 12000TD *Island Flyer*, pictured approaching the terminal at Ryde, IOW

construction costs. An alternative that is used increasingly in automobiles is adhesive bonding. This allows higher strength to be employed once suitable joints have been designed and matching adhesive selected.

This is not a simple challenge for hovercraft. Car bodies can be heated in an autoclave to cure the joints. Griffon also needed bonds that would retain their strength at high operating temperatures in service. The end result of research and trials supported by Lotus Lightweight Structures of Wellingborough was an epoxy system that fully cures at room temperature within seven days.

The electric power control system was also a challenge. This is not a hybrid system with batteries as a 'capacitor' to smooth power delivery, as implemented for car manufacturers deploying proprietary motors. The project eventually settled on motors supplied by specialist Yasa Ltd, Oxford, and a motor control system from Sevcon Engineering, Gateshead (part of Borg Warner), with overall vehicle control system developed internally by Griffon.

A prototype was built and trials began in 2016, followed by demos in a wide range of terrains, including the Arctic (Figure 3). A second craft is currently located in the Far East, with a third being delivered to Russia. For existing customers, the 995ED has somewhat different handling characteristics, though has proven to be responsive and stable.

With the current trend for 'explorer' mega yachts and cruise ships, Griffon has had enquiries for hovercraft to use as tenders for sorties to locations unreachable by other craft. Review of garage constraints and other requirements for such missions led once again to the specification for the 995ED [3]. For smaller vessels, the folding side bodies of the craft minimise the space occupation in a garage, though deployment does require an open deck area for preparation before launching. Large exploration cruise vessels might in future offer a stern ramp for simpler deployment; this would also be consistent with deployment of larger RIB boats in open water locations.

The 12000TD

Development of the 12000TD (Figure 4) targeted simplification of the configuration adopted in the late 1970s for the AP1-88, which had: four engines; two driving fans for lift and forward rotating thrusters in the sidebodies; and two main propulsion engines driving twin stern-mounted ducted propellers.

A configuration with two engines installed behind the main passenger cabin, each driving a variable-pitch ducted propeller and a mixed flow lift fan package via toothed belts, was selected for the 12000TD, simplifying the machinery and control system outfit and reducing noise. The engines are MAN D2862 12-cylinder v90 24.2litre models, rated 793kW, selected for their track record for low maintenance and best-in-class fuel consumption. They are also compliant with the latest MARPOL emissions regulations. Cooling is a closed circuit water system with radiators assisted by the lift fan flow.

Electric power from engine-driven generators is used for forward-mounted side thruster fans, to assist craft turning while static, or maintaining heading while starting from a ramp in a headwind (the equivalent of close-manoeuvring a ferry to a jetty). These installations are vestigial compared to the AP1-88's bow thruster system, while providing the control needed. Operating experience on the Solent with the 12000TD has shown that they are rarely used.

Welded aluminium is still used for the main hull, while the superstructure incorporates a significant number of GRP panels, including the lift fan volutes

TECHNICAL PARTICULARS

Griffon 12000TD

Length	23.7m (hovering); 22.8m (transit)
Height	7m (hovering)
Obstacle clearance	1.5m
Payload, max	12,000kg
Power	2 × MAN D2682, 1,586kW
Service speed	45knots
Endurance	5 hours
Passengers, max	80

Figure 5: Caspian Offshore Construction Company is using a refurbished hovercraft, renamed *Caspian Falcon*, for offshore logistics

and covers. The passenger cabin has seating for 80 passengers in eight rows of 3/4/3 configuration.

Taking a trip on the Hovertravel-operated 12000TD from Southsea to Ryde in August 2019, I found the craft comfortable. Crossing some short chop, the skirt system responded rather more softly than I remember from the earlier AP1-88 craft and even earlier SR-N6. Later, talking with the Griffon Hoverwork engineers, I realised why. The present craft doesn't have the compartmented cushion that was a hallmark of BHC. This part of the design evolution is essential for minimising and easing maintenance of course.

The 12000TD skirt is lightly tapered to give a responsive but plough-in resistant bow geometry, and the stern skirt is a continuous geometry with rounded corners. Griffon has spent some time developing the detail for the segments in the stern and stern quarter area to give the best possible performance over very shallow water, and also in yawed or turning operation, as sideslip is a special characteristic of amphibious hovercraft (and can be very enjoyable!).

Skirt systems are manufactured in upper and lower sections; the lower sections (fingers or segments) in reinforced natural rubber material that gives longest mean time between replacement (MTBR). The upper loop sections of the skirt are in lighter weight, neoprene-coated fabric, with rip stops moulded in. Current experience is an average of 800-1,000 operating hours MTBR for segments. While the Hovertravel craft will clock this up rapidly due to their work schedule, most of the Griffon utility fleet take far longer and so skirt maintenance is less of a maintenance cost issue.

Hovercraft redeployment

The longevity of the AP1-88 and other Griffon craft has created a secondary challenge, in that refurbishment and redeployment has become a secondary business – in a smaller way, a little like the secondary market in catamaran ferries. A recent example has been for oilfield logistics in the Caspian.

During the 1990s and the early development of one of the world's largest oilfields – Kashagan in the North Caspian off Kazakhstan – the operator consortium tested a number of different means to transport personnel and freight to the drilling platforms some 40km from shore, but in 4m water depth, with temperatures as low as -40°C in winter and over 40°C in summer. An AP1-88 was trialled on a lease contract for a while, with some success, at the end of the 1990s during appraisal drilling. The project has had a bit of a chequered history since then, due to the sulphurous crude, but main production successfully began in 2016.

Caspian Offshore Construction Company has had a logistics contract for personnel and freight between the land base at Atyrau and the offshore production island for a number of years, and has a fleet of variously sized boats and barges. In 2016, the company investigated using a hovercraft for all-year fast logistics and looked for a suitable craft. A BHT 150 – the former *Suma-X*, operated in Alaska, Aleutians East Borough, as a village transport at Akutan to an island airstrip from 2006-2012 – became available. It was procured and refurbished at Griffon before being delivered to Atyrau in autumn 2018, starting operation on 17th October as *Caspian Falcon* (see Figure 5).

The craft can carry up to 22.5tonnes of freight in its well deck and a significant number of personnel in its enclosed cabin. Having a top speed of around 45knots, it is able to act as an intermediate in reaction time between the boats in summer and helicopters. In winter, over the ice, it comes into its own. The main challenge in the winter period is that the shallow ice is broken into rubble mounds moved around by the weather. *SBI*

1. The Hovercraft Code (Code of Practice 24), Maritime and Coastguard Agency, MS/08/19/01, 08 December 2015, available at www.dft.gov.uk/mca (search on 'Hovercraft Code')
2. M J Downer, "Development of High Technology Hovercraft", RINA Conference, *Innovation in Small Craft Technology*, 13-14 April 2016, London, UK
3. M J Downer, "Development of Hovercraft as Explorer Yacht Tenders", RINA Conference, *Design and Construction of Super and Mega Yachts*, 14th – 15th May 2019, Genoa, Italy

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