New vehicles for public health work over difficult terrain*

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THE EXPRESSION 'DIFFICULT TERRAIN' is usually meant to imply surfaces over which mobility is difficult for conventional means of transport and often includes various water conditions as well as land. In the field of public health engineering it is becoming increasingly common for activities to be undertaken in areas involving such surfaces.

The reasons for this happening are attributable to two major factors: firstly, the ever-rising cost of land values (while population and associated activity steadily increases, land area remains constant); and, secondly, the protection and maintenance of the environmental health of the country and the conservation of its natural features. Land shortage not only means that more difficult areas of land have to be used and crossed but also that land reclamation becomes an economical proposition.

An aspect of deep concern for the country's environmental health is the fouling of rivers, lakes and coastal areas by waste products, fuels and chemicals. This pollution very often occurs in areas which are unspoilt by human development, or are remote or perhaps almost inaccessible and it is areas of this nature which may often present the problems of mobility.

Above, SEIGA Tortoise buoyant-wheel vehicle working in sludge lagoon

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What is difficult terrain in practice?

As mentioned previously, the term includes not just land surfaces but also water in various conditions and situations. The following examples, by no means exhaustive, illustrate the extremes which may be encountered and which a vehicle designer has to take into account when providing machines for all-terrain use:

Natural conditions

Beaches – shingle, sand, mud, rock; marshes – grasses, gulleys, reed; mud flats – muds of various types (varying cohesion, plasticity); peat bog – dry, water-saturated; water – shallow, weed infested, partly frozen; ice – over water (varying thickness), over ground (varying thickness).

Man-made conditions

Sludge lagoons, oil spills.

Combinations of these conditions with and without sloping surfaces are, of course, common and tend to produce the most serious challenges to mobility.

Vehicle characteristics required

The support of a vehicle can be achieved in a number of fundamental ways. At the present time the major support principles of vehicles in general are those shown in the left-hand column of Fig. 1:

These principles of support, used either separately or in combination, lead to a wide variety of vehicle types, but to be able to operate over difficult-terrain surface conditions only a relatively few are really practical. The particular device or system used for supporting the vehicle determines the scope of the vehicle's application. The three types of vehicle with the widest application for difficult terrain work are the helicopter, the air-cushion vehicle and the buoyant-wheel vehicle. The power requirements of the helicopter are relatively high and this is reflected in costs, tending to rule it out for many jobs.

In the last 20 years the amphibious hovercraft and the buoyant-wheel (floating capability) vehicle have emerged as very effective tools in specialised circumstances. Both offer very low-ground-pressure (typically 0.1 lb/in^2 (0.007 kg/cm^2) to 1.6 lb/in^2 (0.122 kg/cm^2) fully loaded) and in the context of this article this single feature is the secret of their usefulness. Another feature common to both is that they cause the absolute minimum of disturbance to the surface over which they are operating, either from their means of support or propulsion.

A justifiable criticism of many hovercraft is that they are extremely noisy, this noise coming from the use of high-tip-speed propellers, not from the hovercraft principle itself. Relatively quiet craft in the smaller sizes are now available and could have been available 15 years ago; the technology was there but the will to do anything about it was not.

Silent operation

With buoyant-wheel vehicles, propulsion of the vehicle is by the wheels themselves and is therefore silent. When operating in soft conditions such as peat bog or marsh, the buoyancy and shape of the wheels has the effect of reducing the footprint pressure when softer ground is encountered. This result is in contrast to a tracked vehicle which, when it sinks into soft ground, is devoid of any significant increase in upward supporting force. Fig. 2 shows a tracked vehicle sinking in soft marsh conditions.

The buoyant wheeled vehicle has an advantage over the air-cushion vehicle in that it possesses considerable gradient-climbing capability. Air-cushion vehicles in their present form are limited to steady-climbing slopes of about one-in-ten. To achieve much better would demand uneconomical levels of power or the use of a ground-contact propulsion device, a possible future development.

Another characteristic often required of vehicles working in mixed terrain is the ability to pass from one surface type to another – for example, to move from firm ground to soft ground and on to liquid mud, into marsh and out to open water. As a general rule, both the buoyant-wheel and air-cushion vehicle types can do this, provided in the case of the air-cushion vehicle that gradients are not too steep and that marsh areas are not excessively covered in deep vegetation.

Practical applications

The development of buoyant-wheel vehicles for practical use was initiated 15 to 20 years ago by the Seiga Harvester Company of Denmark. Originally designers and manufacturers of tractors and reed-harvesting equipment, they encountered a need to provide effective flotation in reed marsh conditions for their harvesting equipment. They therefore undertook the design and development of their own special types of vehicle for this purpose and this has resulted today in a whole range of unique vehicles having from three to six wheels.

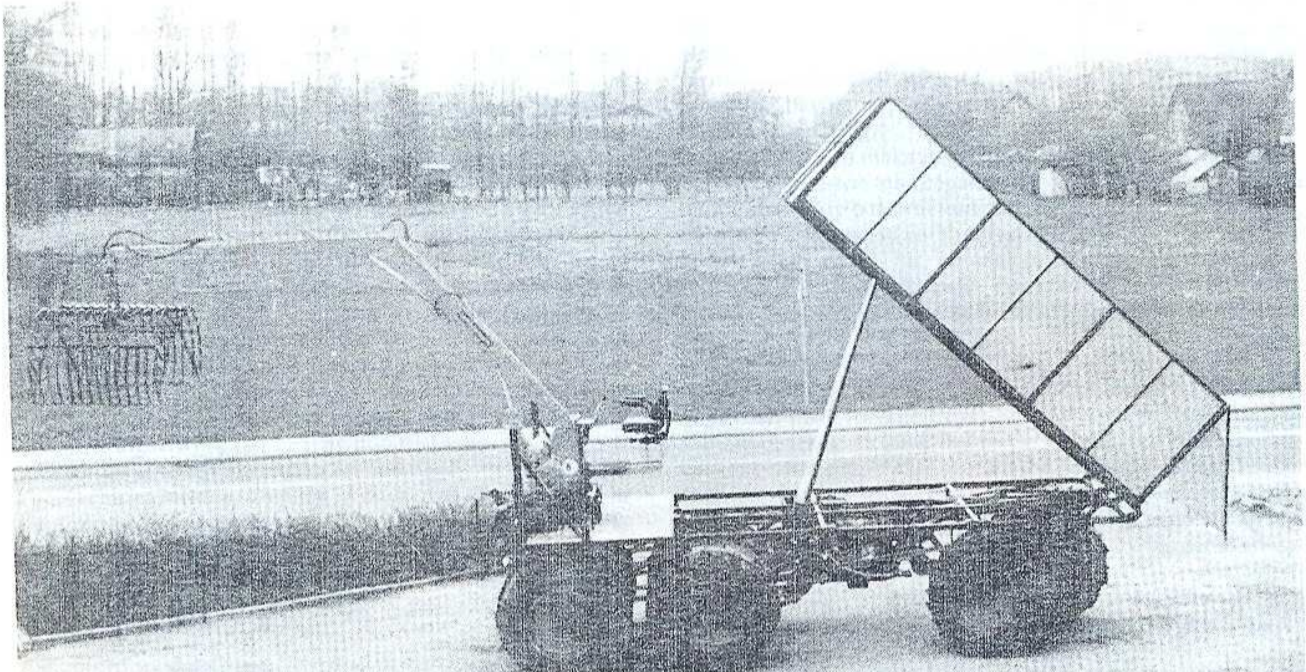
Over 400 of these vehicles are now operating in 22 countries

Vehicle support principle	*Conditions under which principle can support Vehicle*		*Examples of vehicles in their principle operating domain*			*Difficult terrain when in combination*	
	When Stationary	*When in Forward motion at design operating speed*	*Vehicle in air*	*Vehicle below water surface*	*Vehicle over water*	*Vehicle over soft land*	*Vehicle over hard land*
Discharge of stored masses	Yes	Yes	Rocket	–	Rocket	Rocket	Rocket
Buoyancy	Yes	Yes	Balloon Airship	Submarine	Ship Buoyant-wheel vehicle	Buoyant-wheel vehicle	Buoyant-wheel vehicle
Fluid flow lifting surface (aerofoil & hydrofoil)	No	Yes	Aeroplane Helicopter	–	Hydrofoil vessel Seaplane Helicopter	Helicopter	Helicopter Aeroplane
Planing surface	No, over water Yes, over land	Yes	–	–	Speed boat Air boat Hydro-copter	Sled Air boat Hydro-copter	Sled (limited)
– variant with air-cushion	Yes	Yes	–	–	Air-cushion vehicle (hover-craft)	Air-cushion vehicle (hover-craft)	Air-cushion vehicle (hover-craft)
Caterpillar track – negligible buoyancy	Yes	Yes	–	Sea bed vehicle	–	Tracked vehicle (limited)	Tracked vehicle
Wheel – negligible buoyancy	Yes	Yes	–	Sea bed vehicle	–	–	Truck

Different terrain vehicles (bracket spanning Buoyant-wheel vehicle to Air-cushion vehicle rows)

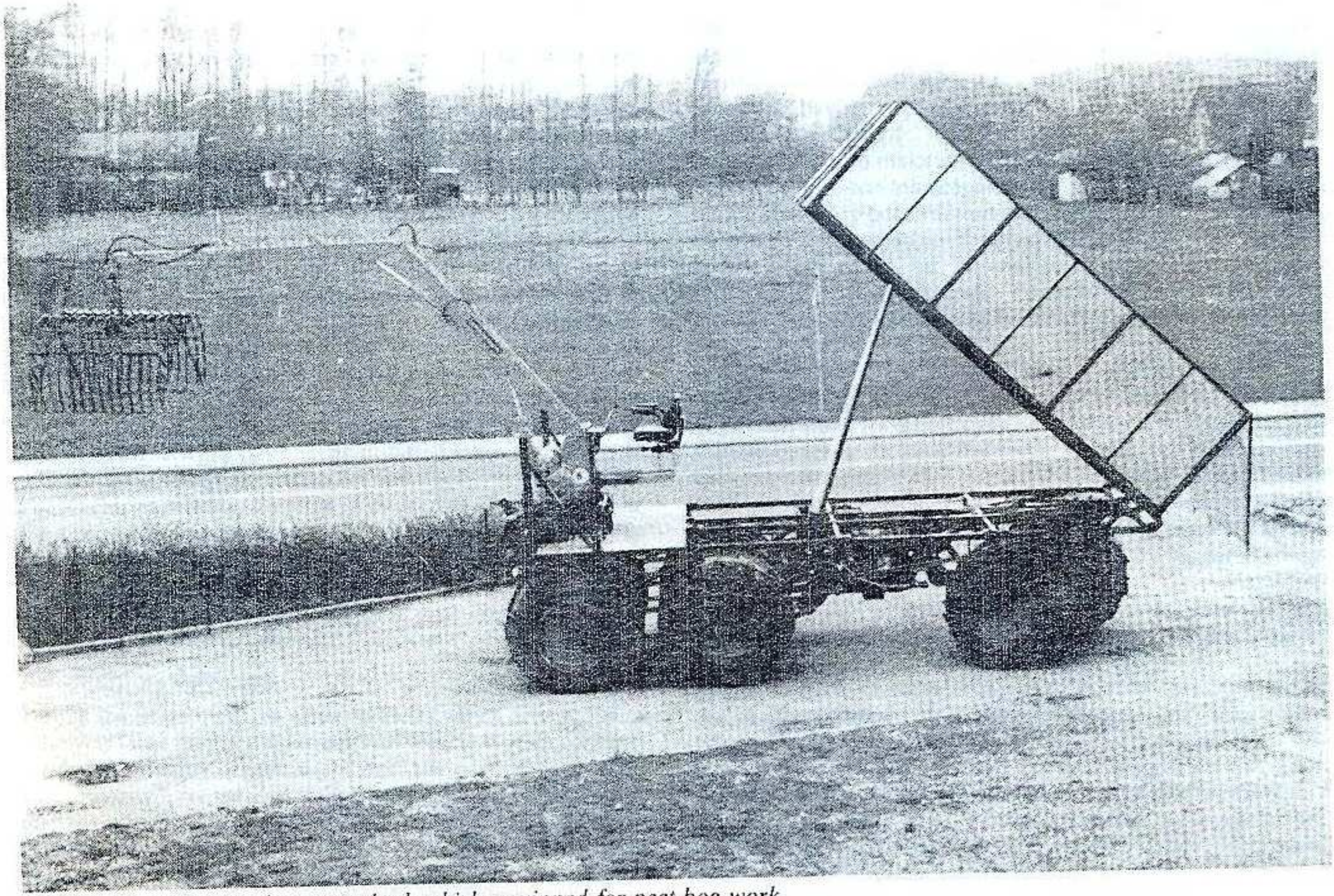
Fig. 1. A classification of vehicles depending upon their principle of support

Tracked vehicle sinking in marsh



SEIGA Giant Tortoise buoyant-wheel vehicle equipped for peat bog work

Tracked vehicle sinking in marsh



SEIGA Giant Tortoise buoyant-wheel vehicle equipped for peat bog work

Trans-Hover T6 ½-ton-load hovercraft

and are being used in an ever-widening range of applications. Four- and six-wheel versions are currently in production with load-carrying capabilities of 2 to 3 tons and up to 4 tons with corresponding trailers, all operating at ground pressures not exceeding 1.6 lb/in² (0.122 kg/cm²) fully loaded.

These vehicles, known as the Tortoise and the Giant Tortoise, are 3.15m (10ft 4in) wide and 3.10m (10ft 2in) and 6.40m (21ft) long for the 4-wheel and 6-wheel versions, respectively. They are powered by Lombardini 49-hp diesel engines and are designed for maximum ease of maintenance in the field. In their basic form they are high-mobility working platforms, very easily adaptable for the fitting of a wide range of equipment.

While now engaged in large numbers in reed harvesting, they have also been used in extensive lake restoration work in Sweden involving channel digging in marsh (amphibious excavators), mud pumping and rotavating of underwater root felts prior to removal. Lake restoration work has also been undertaken by these vehicles in Lake Tunis, where a Tortoise was fitted with algae-skimming equipment to remove floating masses of algae from the heavily-polluted lake.

Other tasks which have been carried out by these buoyant-wheel vehicles include sampling in sludge lagoons, sampling in Thames mud in connection with the Thames barrier work, mopping up oil spills in ice, water and mud at Sullom Voe, the transport of fresh water pipes over peat bog areas in the Shetlands, the transport of peat over peat bog in Northern Ireland and site survey work.

Air-cushion vehicles

Unlike the Seiga buoyant-wheel vehicles which are unique, a relatively large number of air-cushion vehicle types have been produced by many organisations over the past 20 years. The vast majority have created their own assault on public health through noise! More recently though, a number of air-cushion vehicles have been built which can be said to be relatively quiet (typically 58 dBA at 150m (approx. 500 ft)) and capable of carrying payloads of ¼- to 1-ton at about 30 knots.

A number of these craft employ ducted propellers designed by the writer and it is noticeable that this principle of propulsion is being taken up by the builders of larger air-cushion vehicles. It is an easy engineering task to make almost anything hover, but to do it efficiently, quietly and under control and with good economics is much harder. These essential characteristics are, however, beginning to appear in small hovercraft of a type having application to the broad subject of public health engineering.

A craft soon to make its appearance in Britain is the Trans-Hover T6, a ½-ton load capacity air-cushion vehicle of welded aluminium alloy construction and, at only 2.44m (8ft) width, able to be transported without restriction on normal roads and hence being ready for immediate action if, for instance, required as a rescue vehicle. Powered by a Renault petrol engine, this craft will possess features specifically designed to enable its thrust and lift systems to be operated at optimum settings for the terrain over which it is operating.

This exchange of power between thrust and lift is especially important when travelling over 'semi-porous' surfaces, such as shingle beaches. In such instances, the air loss from the air-cushion is not simply that around the periphery of the flexible skirt but also air escapes down into the porous surface. Consequently, a greater quantity of air has to be supplied to the cushion if the craft is to remain supported by the air-cushion. Amongst the many potential uses of such a craft it is anticipated that it will be employed for anti-oil pollution work, site survey, pest control and various civil engineering site support functions.

The buoyant-wheel vehicle uses tyres at low pressure, which are in effect trapped air cushions; the hovercraft uses a continuously supplied air-cushion at very low pressure. Both systems reduce ground pressure by increasing footprint area. Both systems can support vehicles over water. It seems highly probable that these basic principles will be developed further in the future, both separately and in combination, to provide vehicles with even greater mobility for future and as yet unknown tasks.