Trench Depth	Up to 1.1 metre
Pull Force	50 tonnes max
Size (L x B x H)	9.4m x 4.4m x 4.2m
Weight	14.4 tonnes
Cable type	All telecom cables, 1.5 metres bend radius throughout
Repeaters	All telecom repeaters, up to 400mm diameter
Water Depth	1,500m (2,000m optional)
Soil Types	Very soft clay to firm clay, all sands
Surveillance	5 cameras, 2 Pan and tilts, O.A sonar, echo sounder, compass
Control System	From surface using sophisticated control system

PLOUGH SPECIFICATION

1.1 System Component Weights and Dimensions

Subsea Plough (all assemblies fitted)	:	14,200 kg		
Submerged Weight	:	11,300 kg (approx)		
Lengths	:	Auxiliary share deployed & skids down	8.9m	
		Auxiliary share deployed & skids up		9.9m
		Auxiliary share raised & skids down		8.3m
		Centre of emergency lift points to forward point of skids when down	3.7m	
Widths	:	Across skids	4.0m	
		Across front of chassis	4.1m	
		Across stabilising wheels	4.4m	
		Across rear of chassis	2.8m	
Heights	:	Top of front camera cage	3.8m	
(with 1.5m share extension fitted)		Top of umbilical termination post		3.6m
Ref: PF6438	:	Top of auxiliary share when raised	4.2m	
		Top of tow swivels when drawbar at 90° and steering at 0°	4.5m	

1.2 General Specification

The general arrangement of the Plough is illustrated in Figures 1.1, 1.2 and 1.3.

Burial system	:	Minimum pull, passive blade temporarily lifting a soil wedge for trenchless burial with minimum soil disturbance and thus best cable protection.
Cutting disc	:	Plough is fitted with a freely rotating cutting disc. When deployed, the disc defines the inclined face of a trapezium of soil that is lifted to bury the cable.
Operation	:	Pulled by tow rope from surface vessel.
Control	:	Full remote control from shipboard control console whilst being towed.
Operating depth	:	1500 metres maximum
Towing forces	:	Normal Ploughing (1000mm deep) 10-50 tonnes Maximum permissible pull at Plough 50 tonnes Onset of yield 80 tonnes At water depths beyond 1000m tow forces should be less than 20t. In 1500m water depth, the maximum tow force is limited to 30t with 15° vertical tow angle.
Burial depth	:	Maximum possible cutting depth to underside of cable 1100mm in favourable conditions. In strong soils, it

		may not be possible to reach this depth, because the Plough will not penetrate, or the 50 tonnes maximum tow force will be exceeded. With the burial share extension fitted, the maximum tow force is limited to 50t. The maximum trench depth is increased to 1500mm, soil conditions permitting.
Depth control	:	The cutting depth of the Plough is continually variable between 100mm and 1100mm. Depth accuracy is better than 50mm in normal conditions. Cutting depth may be reduced to 0mm by use of the Plough stabilisers. In addition they can be used to assist with depth control in soft conditions
Rear Stabilisers	:	Hydraulically adjustable rear stabilisers in wheel form are used to assist with deployment and recovery, and to prevent undue sinkage in soft ground conditions. Each wheel incorporates a travel encoder and either wheel can be used to provide the Plough travel and speed signal. Each stabiliser cylinder is fitted with a transducer and either can be used to provide the signal for trench depth.
Cable and Repeater size	:	Cables from 17mm to 150mm diameter. Repeaters up to 380mm diameter, 3m long with semi rigid ends (NB Repeater route is 400mm in diameter).

		Cable splice boxes up to 150mm diameter will pass through the share.
Repeater burial	:	An auxiliary share creates an open trench for repeater burial. With the Plough operating at maximum cable burial depth, coverage over the repeater is 500mm minimum.
Cable bend radius	:	1.5m minimum along the cable path during normal Ploughing.
Soil type	:	Any, with good rock ripping capability. Soft mud capacity 5 kPa minimum.
Ploughing conditions	:	30° side slope, 30° fore and aft in ideal conditions.

Note: This is dependant on the seabed composition and direction of installation. However typically we would expect to be able to plough down slopes of up to 12 degrees in fine sands, less in soft clays and more in dense sands or firm clays. For side slopes, this would be around 8 to 10 degrees depending on soil type and depth of share penetration. For ploughing up slopes we can go to in excess of 30 degrees, assuming there are no significant side slopes. The key is selecting a good route; the survey is instrumental in this!

Steering	:	Hydraulic power steering providing approximately +/- 12° of steering angle between the tow rope and the direction of travel. Actual maximum angle depends on soil conditions.
Tow rope vertical angle	:	Nominally 10° to 15° above the horizontal.
Ploughing speed	:	Up to 1 m/s.

Cable tracking	:	Visual, by means of the forward television camera and sensing by lateral cable angle detector.
Cable counter	:	Active cable length measurement as the cable passes through the Plough.
Emergency Recovery	:	Attachment points for an emergency recovery ropes are provided.
Wear parts	:	Parts subjected to high wear are made from very hard, wear-resistant steel, coated on critical areas with chrome and tungsten carbide deposited by electric arc welding methods. Easily replaceable wear plates are provided for areas of highest wear. Ultimately, the complete Plough share (or body) can be replaced as required.
Structure	:	Fabricated from high strength steel.
Corrosion Protection	:	Corrosion protection is achieved in a number of ways depending on the nature of the material being protected.
Paint	:	Post fabrication shot blasting to SA 2
Phosphate micron		1 coat EPIGRIP L425 (Zinc Epoxy primer Grey) DFT 100
		1 coat EPIGRIP L653 (Epoxy HB Intermediate Cream)DFT 150 micron

	M137(Isocyanate	1 coat RESISTEX free Gloss White) DFT 40 micron
Cathodic Protection	:	Suitable sacrificial anodes are distributed across the structure to minimise corrosion of the Plough chassis and internal sections are sprayed with textyl 506.
Plough heading	:	Curvetech HT300 thruster unit positioned at the top of the rear port stabiliser is used to assist in maintaining plough heading in strong side currents.

1.3 Hydraulic System

Motor	:	15 kW 3 Phase, 2000V 50/60 Hz Oil filled and pressure compensated.
Pump	:	Constant displacement gear pump giving 36 litres/min up to 250 bar at 60 Hz.
Motor Cooling	:	Electric motor is supplied with cooled filtered oil by means of an oil circulation pump driven directly off the motor shaft. Circulation pump delivery 6.3 litres/min.
Hydraulic functions	:	**Front Valve Tank:** Pump unload Port skid up/down Starboard skid up/down Disc up/down Steering port/starboard **Rear Valve Tank:** Port stabiliser up/down Starboard stabiliser up/down Stabiliser float/fixed Drawbar up/down Repeater burial share up/down Accumulator charge/discharge Depressor up/down Depressor float/fixed Thruster Port/Stbd
Directional control	:	Solenoid operated spool valves
Float function control	:	Solenoid operated poppet valves
Overcentre valves	:	Dual overcentre valves provide leakproof load holding

		and working port relief protection.
Cylinders	:	Heavy duty marine type with stainless steel rods, chrome plated welded swivel eyes. With incylinder transducers and counter balance valves where appropriate.
Valve tanks	:	Stainless steel, oil filled and pressure compensated.
Reservoir	:	Flexible pressure compensated, 100 litres working capacity.
Manifolds	:	Stainless steel
Pipework	:	Mostly flexible hoses multispiral. Rigid pipes stainless steel
Fittings	:	Stainless steel SAE 'O' ring flange type where possible.
Hydraulic oil	:	Houghton Vaughan Hydrodrive HPE 118

1.4 Transducers

1.4.1 Pressure

Sensors (3)	:	Water depth Depressor pressure Hydraulic system pressure

1.4.2 Displacement

Sensors (10)	:	Port skid position Starboard skid position Steer angle Port stabiliser position Starboard stabiliser position Drawbar position Depressor position

		Hydraulic oil volume in reservoir	
		Disc position	
		Auxiliary share position	

1.4.3 Force

Sensors (4)	:	Cable tension in Plough	(15t SV
		Port pull force (80t SWL)	
		Starboard pull force (80t SWL)	
		Umbilical cable tension at Plough (15t SWL)	

1.4.4 Temperature

Sensors (2)	:	Motor temperature (Platinum resistor)
		Electronics pod temperature (Integrated semi conductor device).

1.4.5 Moisture Ingress

Sensors (4)	:	Hydraulic oil reservoir moisture ingress
		Electronics pod moisture ingress
		Motor moisture ingress is continuously monitored via the Line Insulation Monitoring System.

1.4.6 Inclination

Sensors (2)	:	Pitch
		Roll

1.4.7 Altitude

Sensors (1)	:	Altitude (Echo Sounder)

1.4.8 Heading

Sensors (1)	:	Plough heading

1.4.9 Rotary Encoder

Sensors (3)	:	Plough travel (Starboard wheel) Plough travel (Port wheel) Cable travel (Lay cable)

1.4.10 Angular Displacement

Sensors (2)	:	Vertical tow angle Horizontal cable entry angle

1.4.11 Proximity

Sensors (5)	:	Drawbar down Depressor down Repeater in bellmouth Cable in share Share point worn

1.5 Surveillance Equipment

The surveillance equipment comprises television cameras, associated lamps, pan and tilt units and obstacle avoidance sonar.

1.5.1 Cameras

Three monochrome, CCD, fixed focus subsea television cameras are provided. Two of which are mounted on pan and tilt brackets and one which is fixed.

1.5.2 Lamps

Five lamps are provided, suitably positioned to provide optimum illumination for the CCD cameras. Each lamp is individually switched from the control console.

1.5.3 Pan and Tilt Units

Two electrically-powered subsea pan and tilt units are provided, located one at the front and one at the rear of the Plough, each of which carries one of the subsea cameras.

1.5.4 Sonar

Two sonar heads are mounted at the front of the Plough where they are used for obstacle avoidance. One unit is used as an operational standby.

1.5.5 Acoustic Positioning

Provision is made for a standard transponder/responder to be fitted on the plough. The supply of the transponder/responder units is not included in this contract.

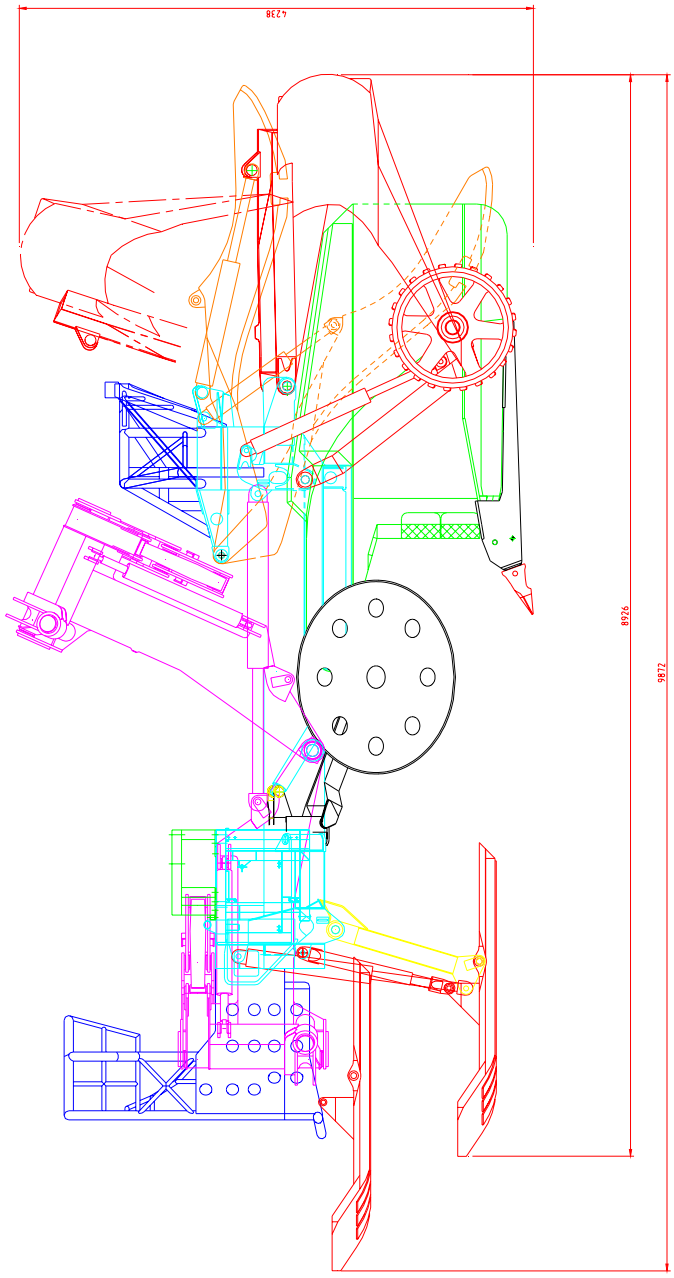
2 PLOUGH DESCRIPTION

2.1 General

The cable Plough can bury telecommunication cables, power cables and oilfield umbilicals either as they are laid, or in a post lay burial mode. The Plough is shown in Figs 1.1, 1.2 and 1.3.

The Plough is primarily intended for use in simultaneous lay and bury operations. For simultaneous lay and burial the lay cable touches down on the seabed ahead of the Plough. As the Plough moves forward it picks the cable up off the seabed and buries it. This technique is made possible by the steering mechanism which allows the Plough to track along the cable without moving it sideways across the seabed. Cables with a low submerged weight may be laid directly into the bellmouth at the front of the Plough. In this mode of operation the Plough is deployed and recovered with the lay cable passing through the Plough and with the tow cable and umbilical connected. The system is diverless in normal operation. Post-lay burial operations will require the use of divers to load and unload the cable on the seabed.

The Plough has a patented method of cutting through the soil. The Plough can bury cables to a maximum depth of 1100mm achieving 1000mm of cover. With the share extension fitted the Plough can bury cables to a maximum depth of 1500mm.



Figures 1.1 Side View of Cable Plough (PF6438A Issue 1)

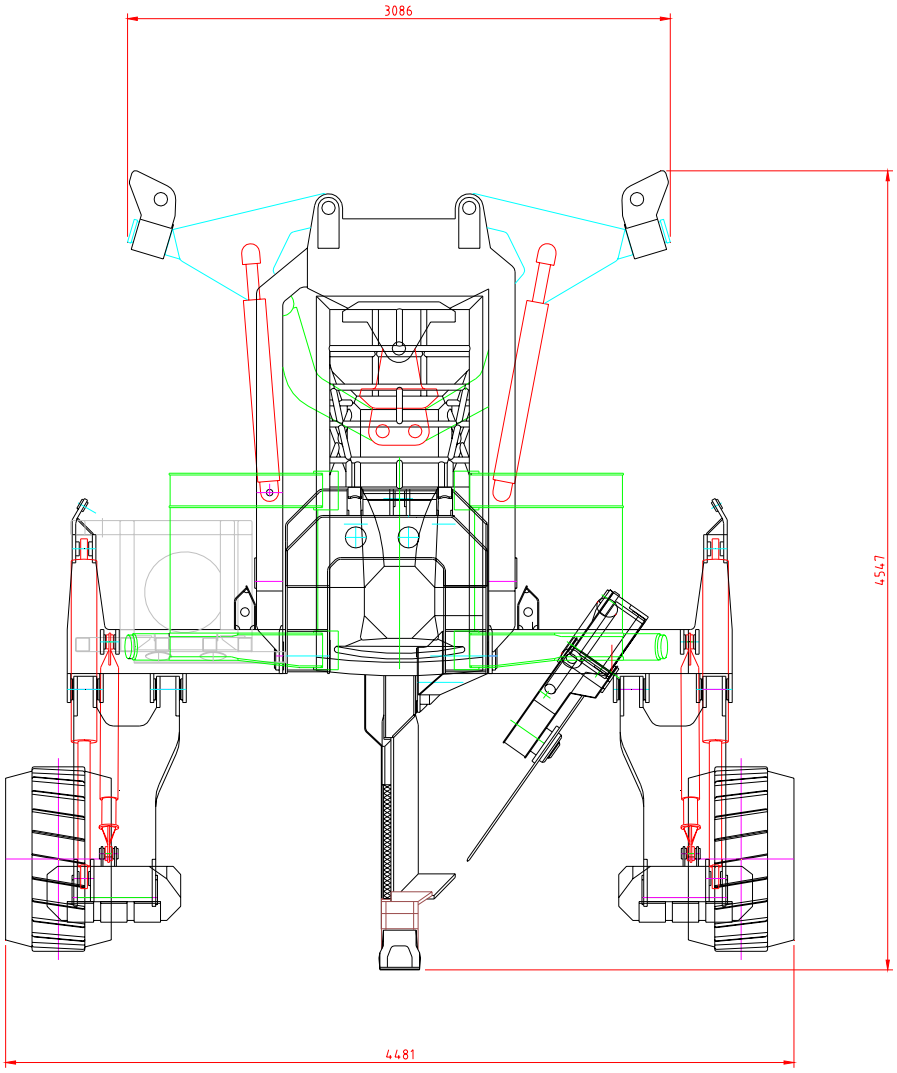


Figure 1.2 Front View of Cable Plough (PF6438B Issue 1)

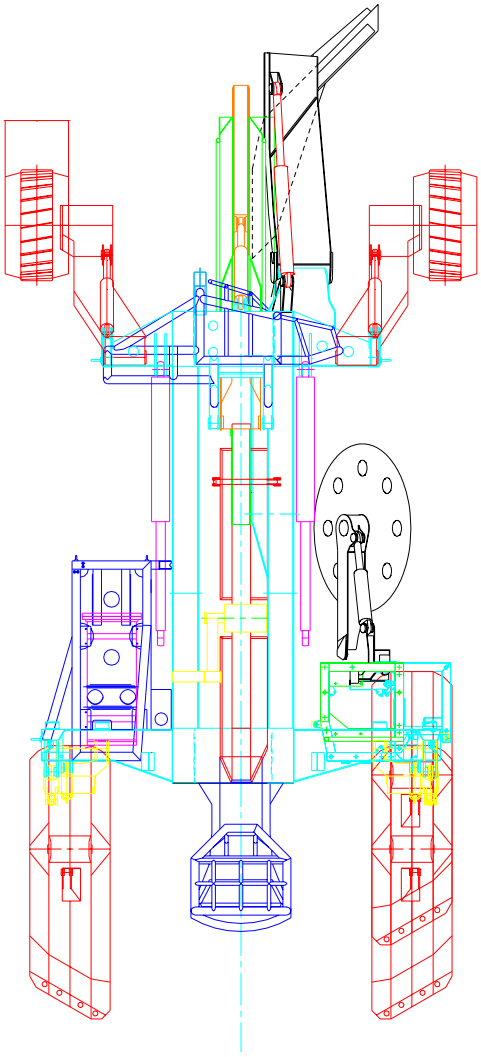


Figure 1.3 Plan View of Plough (PF6438C Issue 1)