OCEAN BOTTOM SEISMIC RECORDING
TOWARDS A DESIGN SOLUTION

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The fundamental requirement for an OBS is to have a sensor that accurately registers the ground motions and pressure variations over the amplitude and frequency range of interest, and recording system that stores that data without degrading it, and with an adequate time resolution. To be useful the signal handling part of the system must be included in an overall package that allows deployment, location and release and recovery over the range of depths of interest. In practice many compromises must be made, dictated by limitations of cost, complexity and size and availability of suitable components. The objective should be to achieve a practical working solution with the best possible sensor implementation.

The previous paper discussed the nature of the seabed and of simple models based on spring-mass resonances within the seabed-sensor system. Seismic waves arrive near vertically from 'p' waves and are assumed to arrive near horizontally for 's' waves, and the way that the sensor responds to these different excitations is very different. Using this model, vertically arriving signals excite the mass-spring system made up of the seabed elasticity over the whole base area, and the body mass, whereas horizontally travelling waves will produce both a translation dependent on the body mass and shear strength and elasticity of the seabed, and rotations about horizontal axes dependent upon the moment of inertia of the body about some point on or in the seabed and the elastic properties of a smaller effective base area. Since these resonances represent low pass filters cutting off the high frequency response of the sensor, it is vital to optimise the design to push the resonances as high as possible.

The key factor in controlling the coupling is the importance of the rotational modes, which are frequently of lower frequency that the vertical resonance, and thus often sit within the main energy band of the signals. The only way this can effectively be done is to ensure that the moment of inertia of the body is kept as small as possible, and that the centre of mass is as near the 'effective' seabed interface so that the applied force and resonant period are both handled. This needs to be coupled with a force/base area, i.e. an effective bearing pressure, that is appropriate for a range of sediment densities.

These sensor design constraints make it extremely difficult to achieve good coupling in any self landing and ascending (SLA) OBS that has the motion sensors within or rigidly attached to its main structure, although several good ROV deployed and recovered nodes with integral sensors exist. Given that any SLA OBS will almost inevitably have a poor seismic response, the sensor package must be separate from the main part of the recording and delivery package with its inevitably bulky buoyancy – a deployed geophone. Soil mechanics engineers use models for the motion of bodies standing on the seabed that assume that a section of the seabed moves with the body – i.e. that the body's motion is coupled back into the seabed and effectively contaminates the incoming signal. This means that not only does the sensor package need to be disconnected from the motion of the main package, but it also needs to be outside the zone of seabed contaminated by the (predominantly rotational) motions of the main package. Choosing a suitable separation is somewhat arbitrary, but clearly any design that places the sensor housing within the confines of the supports of the main structure is likely to fail the separation criterion. Most common SLA systems with deployed geophones use gravity to drop the sensors when the unit is settled on the seabed or as it settles, and to avoid the possibility or the sensors being projected into the bottom at an angle a vertical drop is desirable. A number of systems use a trigger on contact with the seabed, some use a time-delayed link.

The design of the delivery and recovery systems with anchor, release and buoyancy is a matter of practicality. Environmental concerns are making the use of concrete anchors difficult in some areas, even when 'dissolving' concrete made of gypsum is specified, and for shallow and mid depths it is likely that we shall have to move to pop-up buoys bringing Kevlar ropes to the surface, at least as a notional anchor recovery method to placate the authorities.

Buoyancy normally takes the form of either glass spheres, possibly contining the electronics in compact systems, or syntactic foam. Depending upon the depth rating required, the spheres offer a around 70% of volume as buoyancy, whereas the foam is generally limited to 50 or 60%. Where the payload in not within the glass sphere, high strength corrosion resistant aluminium alloy is a common choice for pressure vessels, yielding a reasonable compromise between cost, strength and corrosion resistance. For complete freedom from corrosion problems titanium can be used, and due to its greater strength it makes an advantageous material for deep water (6000m) use, although for mid ocean depths there are design compromises between the stability and strength of the tubes. As a simple rule of thumb, the tubes themselves are about neutrally buoyant, the negative buoyancy derives mainly from the bulk of the endcaps, so long tubes are more efficient.

The acoustic release housing and actuator can be either a self contained commercial unit, or integrated within a sphere or tube along with the recording system, with a separate release actuator. Commercial release systems are usually housed in very heavy stainless steel tubes and often require at least one 17 inch glass sphere for buoyancy. These delivery system considerations will generate a weight and buoyancy budget that will allow a draft design. In order to allow for expeditious deployments and recovery the rise and sink rates must be estimated, based on the frontal area and drag factor. Speeds are proportional to the square root of the area - drag product , and it is difficult to engineer rise rates greater than about 1.5 m/sec. A major part of the design involves reliability estimates for the various components, and calculations of the effects, usually fatal, of various failure modes. One such factor that is now well understood is low pressure leakage as the OBS sinks through the first few metres or rises near the surface where pressure is not enough to compress faulty joints. A further reliability issue that is often overlooked is the enormous suction that mud exerts upon any part of the OBS that needs to be recovered. Given the uniformity of reliability of the usual system components there is now rarely a case for duplicating components.

These design arguments offer a range of potential designs. Their implementation will normally require a combination of custom designed and made components and standard commercial items. Realising a compact system that can be replicated at low cost will usually mean using more custom components and fewer ready made systems, as an analysis of current designs will show.