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Modifications and Reinforcement of Aanderaa Bottom Mooring Dome for Tide Gauge Deployment

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Abstract: - **Tide is an important oceanographic phenomenon and has significant influence in global scale. Tides influence the mixing and stratification in sea and estuaries, which is responsible for biological activities. Tidal data is useful in establishment of chart datums for demarcation of coastline for fixing offshore territorial limits, both on the sea surface and on the submerged lands of the Continental Shelf. Tides enhance the fish productivity which is of economical importance. Also, the tide generated current is commercially significant for navigation. One of the important oceanographic instruments is tide-gauge, that measure and records tide parameters. The existing pre-deployment technique involves usage of heavy chains and synthetic ropes, which is tedious and time consuming process. In this paper, we present low-cost, portable and robust modifications in existing Aanderaa bottom mooring dome for tide gauge deployment. The redesigned dome can be readily assembled or dissembled during and after its use. It offers easy maintenance and servicing, and can be use over a longer period.**

Keywords:- **SeaGuard tide gauge, semi-spherical plastic dome, deployment technique, synthetic ropes, stainless steel components, counter weights**

I. INTRODUCTION

Tide gauge (WLR- Model no.794) (Figure. 1a), manufactured by M/s Aanderaa Data Instruments, Norway is a self-recording Water Level Recorder [1-3] deployed to the seabed to measure wave and tide parameters. For obtaining a good, reliable and quantative data, it is utmost important to deploy the tide gauge to the bottom of the seabed [4]. For this purpose, the tide gauge is placed inside a hollow, semi-spherical plastic dome [5], manufactured by M/s Aanderaa Data Instruments (Figure. 1b). In offshore region, where very strong under water currents are encountered, the dome as well as the instrument may drift and can cause possible damage to the instrument. To carry out measurements in such a hostile condition, counter weights need to be attached to the dome in order to couple the dome to the seabed as well as make it stable at its mooring position. The existing pre-deployment technique involves the use of heavy iron chains as counter weights. The iron chain is tied at the base of the dome (Figure. 1c) using thin synthetic (Polypropylene, Sisal etc) ropes. The iron chains used are extremely heavy (weighs from 50 kg to 200 kg). During the field program, number of persons is required for loading, tying, deploying, retrieval and unloading the chains. Since the chains are made of iron metal, regular use and contact with sea water, it corrodes and rusts faster. Also, there may be a possibility of trapping of the fingers between the chain links while tying the chains to the dome base. Most importantly, if the seabed is rocky, chain may entangle with the rock, which in turn may incline the dome and the instrument. As a result, the dome will not sit properly on the sea bed and may affect the tidal data recording. For obtaining reliable tidal data, it is very important to place the tide gauge vertically straight in the dome before mooring. Therefore, the tide gauge is placed vertically inside the dome by tying it to the circular ring on the dome surface using thin (approx. dia: 4 mm) synthetic rope. The tide gauge is tied by keeping the tide sensor above the circular ring as shown in Figure. 1d. Here the important drawback is the instrument no longer remains in vertically straight position in the dome. Also the position of the tide sensor which should be ideally just above the circular ring on the dome surface is displaced because of unevenness in tying, which may alter the data measurement. Further, a thick synthetic rope (approx. dia: 24 mm) is worn and tied through four circular openings (Figure. 1e and 1f) located near the circular ring on the surface of the dome in such a way that the dome can be lifted up and deployed uniformly along with the instrument in the sea using an automated winch on-board the vessel. However, here also the unevenness in the lifting was observed. When lifted up through winch the dome appears to be inclined due to load concentrated at one point (shift of Center of Mass). Also, there is some possibility of the rope and the sensor of the instrument to stumble with each other while lifting and deploying. Synthetic ropes has few important drawbacks such as weakening of ropes due to prolonged exposure to Sunlight, ageing and worn out of threads from the rope which results into loss in its tensile strength [6] and when used underwater, there is possibility of the rope getting damage due to fish bites [7]. Thus the usage of heavy iron chains and synthetic ropes in the existing pre-deployment technique makes it tedious and time consuming process. In this paper, we present innovative, low-cost and robust modifications in the existing design of the mooring dome so that it can be efficiently deployed.

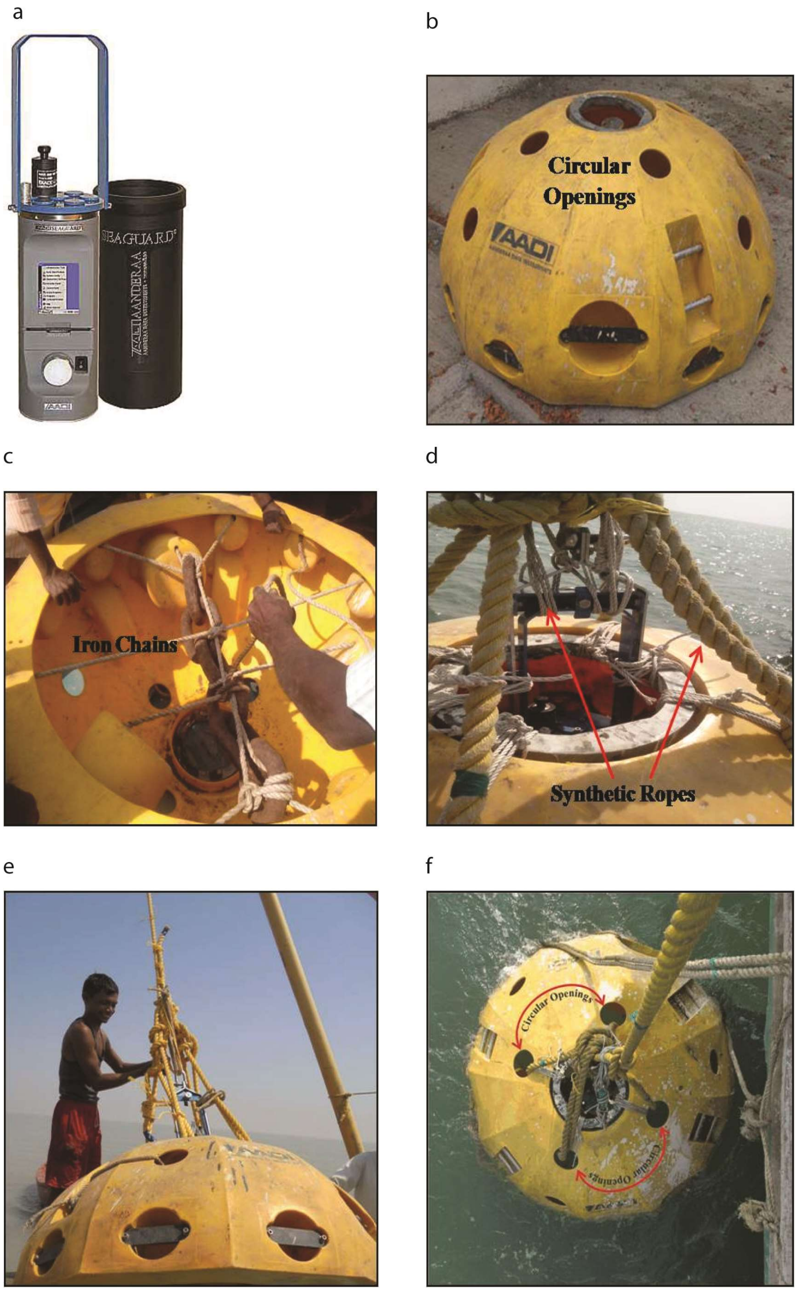

Figure 1: Existing pre-deployment technique for tide gauge deployment:
a) Aanderaa tide gauge. b) Submersible plastic dome. c) Heavy iron chains tied at the base of the dome. d) Tide gauge tied to the ring of the dome using synthetic ropes. e) Lifting of tide gauge and dome using winch. f) Deploying of tide gauge & dome.

II. MATERIALS AND METHODS

2.1 Innovative Modifications and Reinforcement to the mooring dome

To fix and tie the tide gauge into the dome and the entire dome (with instrument) using synthetic ropes and finally deploying it, takes about 2 to 3 hours as per the field experience. To avoid the use of synthetic ropes and heavy iron chains in pre-deployment process, an inexpensive, portable and robust modification were carried out to the dome. Earlier, an attempted to build a mooring frame for DCM12 current meter was done by Kumar et al. (2004) [8] during 2003, and collected satisfactory data.

2.1.1 MS cylindrical blocks as counter weights

The plastic dome consists of hollow slots/cabinets of different sizes pre-existing all over its surface (Figure. 2a). Near the base of the dome three big size hollow slots are situated. The inner diameter and the depth of these slots were measured and then the slots were drilled with two holes at equidistant from the center of its base. The diameter and the depth measurements of the slots were used as dimensions for developing Mild Steel (MS) cylindrical block weights. These blocks were drilled in similar fashion in order to coincide with holes in the slots. There are total 3 cylindrical blocks developed which are identical in all aspects. Each block is duly powder-coated by anti-corrosive paint. Each block is then reinforced using Stainless Steel (SS) components and finally a complete weight assembly is formed (Figure. 2b). These 3 weight assemblies are used as counter/dead weights. Each weight assembly is placed into the dome slots and fixed with a duly coated MS plate, screwed to the dome at the slot edges (Figure. 2c). The weight assembly is fixed from the inner side of the dome using thicker SS extra-large washers, in order to constraint the rolling of the block within the slot under extreme water currents. The important aspect of these counter weight assemblies installed in the dome surface, is the equivalent mass distribution over the dome (Figure. 2c). Each weight assembly weighs about 60 kg; hence a total mass of 180 kg is equally distributed. It may mention here that some areas on the west coast of India such as Dahej, Hazira and some estuaries have extreme under water currents. Therefore, there are chances of drifting of the dome which may lead to error in the data and perhaps the loss of instrument. In case of rocky seabed as discussed earlier, since the counter weights are now located on the surface of the dome, the percentage of hitting the instrument from bottom of the dome is negligible as compared to iron chains tied at the base of the dome.

Figure 2: Modifications and reinforcement in dome & Counter weights design:
a) Pre-existing slots on dome surface. One of the slot (closer view) and holes drilled at equidistant in the slot. b) MS cylindrical block design and SS components for reinforcement into the block to form a complete block assembly. c) Installation of block assembly in the dome slot and fixing it using SS components on both front and back side. A complete dome with counter weight assemblies installed over the surface.

2.1.2 SS clamps for holding the Tide gauge into the Dome

In existing pre-deployment method, the tide gauge is placed inside the dome using thin synthetic ropes as shown in Fig.1d. In this, the major drawback was the diversion of the instrument from its vertical position, due to uneven tying of the ropes. Because of this, the sensor position which should be ideally just above the circular ring on the surface of the dome is shifted way off from its ideal position as seen in Figure. 1d. To eliminate the diversion in the instrument position, SS detachable clamps for holding tide gauge dome were designed & developed. A pair of SS 'C' shape clamps (Figure. 3a) is fixed to the tide gauge mooring frame below the sensor near the cylindrical metal case. Another pair of SS 'E' shaped clamps (Figure. 3b) is fixed to the top of the mooring frame such that the tide gauge is well secured with its mooring frame. After clamping the tide gauge with both types of clamps, a complete frame assembly (Figure. 3c) is ready to be placed in the dome. Tide gauge frame assembly is placed in the dome by fixing the 'C' shaped clamps into the circular ring on the dome surface (Figure. 4a & 4b). Important aspect behind developing these clamps is the tightness, sturdiness and robustness which are essential to hold the tide gauge firm in the dome under extreme under water currents. Another important objective is, even if the dome inclines while sitting at the sea-floor, the circular ring where the instrument is fixed, is movable which provide ability to the instrument to remain vertically straight with respect to dome surface (Figure. 4c & 4d).

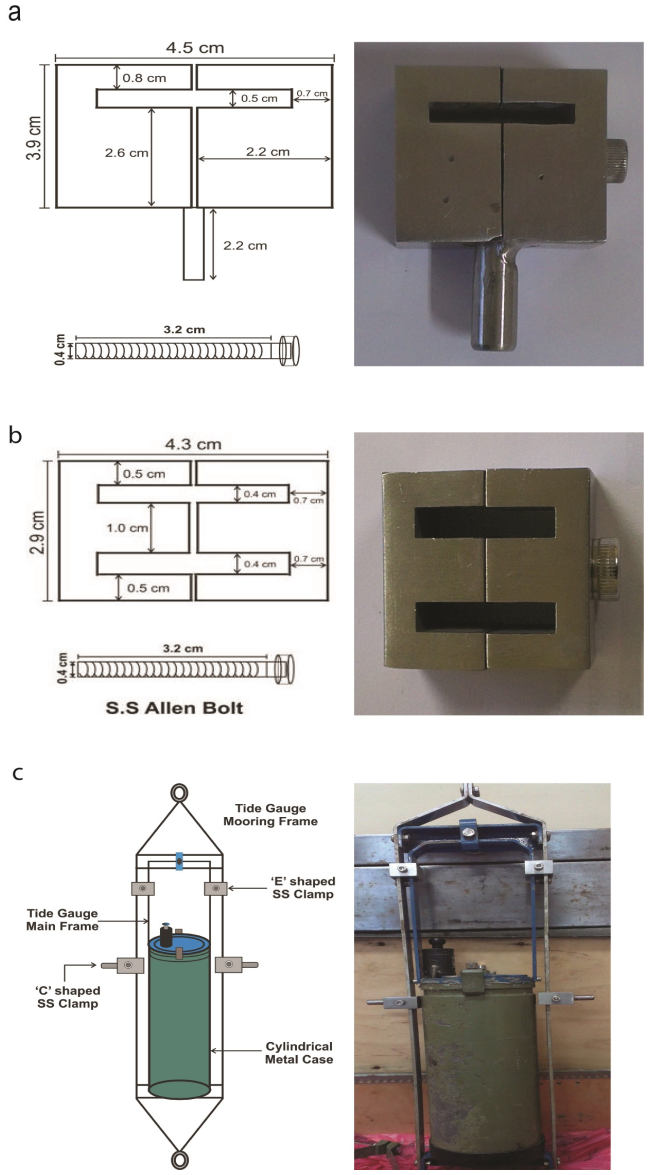

Figure 3: Design and reinforcement of components for tide gauge:
a) SS 'C' shape frame holder clamp. b) SS 'E' shape frame holder clamp. c) Tide gauge frame assembly.
Finally, the entire dome with the Tide gauge is ready for the deployment.

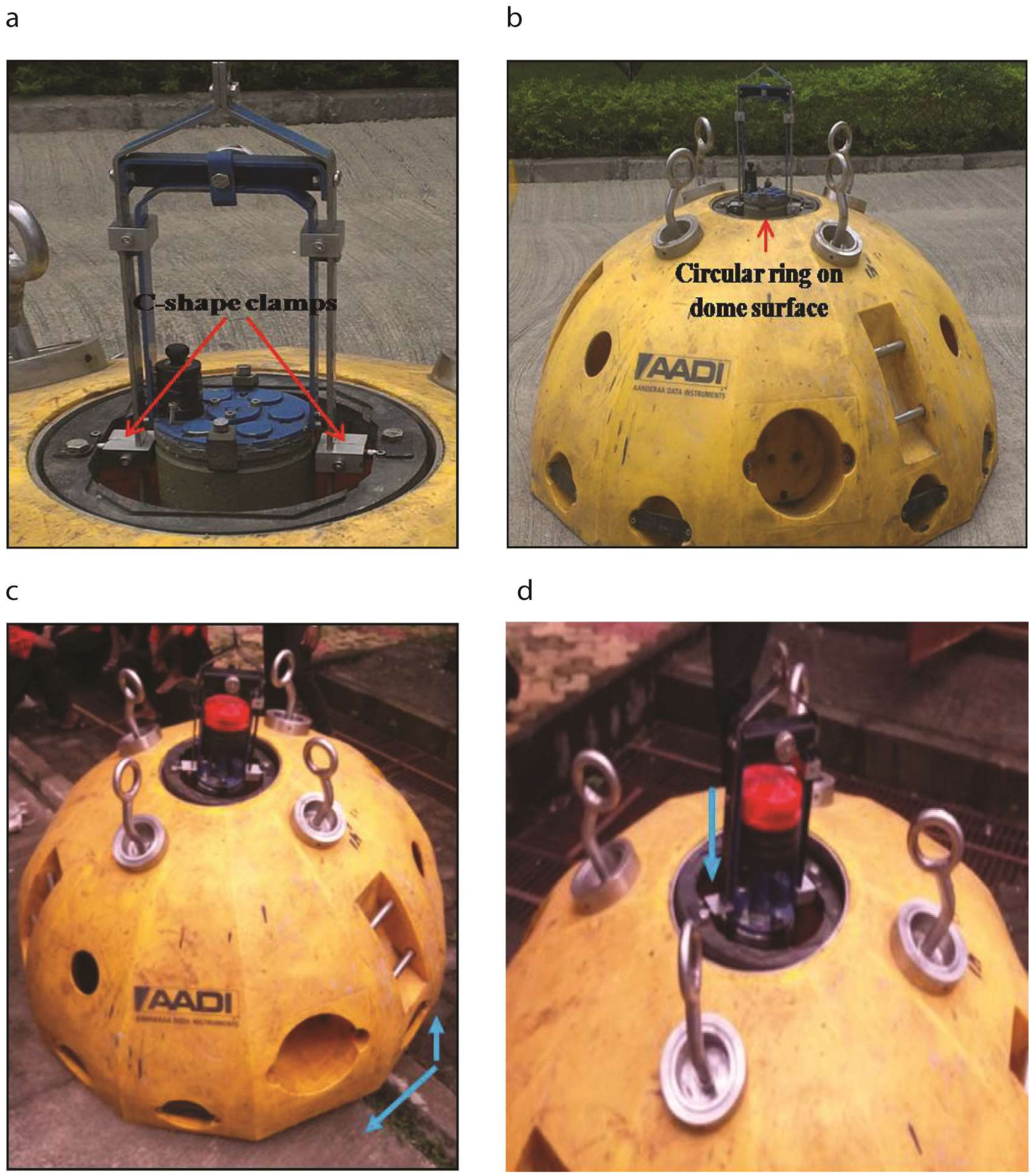

Figure 4: Tide gauge assembly installed in self-aligning circular ring:
a) Tide gauge placed into the circular ring using 'C'shape clamps. b) Tide gauge in dome. c) Dome in inclined position with respect to ground level. d) Tide gauge in vertically straight position with respect to inclined dome.

2.1.3 Stainless Steel Hook Loops

The plastic dome has few circular openings (Figure. 1b) all over its surface as inlets and outlets for the water while submerging. Four such openings are situated near the circular ring, through which thicker ropes are worn for lifting the dome (Figure. 1f). To overcome the drawbacks caused by the ropes, a stainless steel assembly is designed and implemented over the circular openings. It includes a thick SS ring welded to rod (which is inclined at an angle of 45° from horizontal) on inner circular ring made of SS, which is inserted through the circular opening from inner side of the dome. This entire base is locked by an outer SS ring. The whole assembly is called "Hook-Loop" (Figure. 5a). Such four hook-loops are fitted on the dome facing each other (Figure. 5b). The objective behind designing hook-loop assembly was to lift maximum load. Each of these is high capacity hook-loops which can lift maximum load up to one ton.

2.1.4 Stainless Steel Wire Rope with Snap Hooks

In existing pre-deployment method, the dome is lifted and deployed using thicker synthetic ropes (Figure. 1e & 1d). Due to this, the dome is unbalanced while lifting. Also, synthetic ropes itself have few drawbacks as discussed earlier [6-7]. Therefore, the synthetic ropes has now been replaced by SS (7×7, 304 type) wire-ropes [9] with a ring on one end and a snap hook on the other end (Figure. 5c). Each rope is of high capacity strength, which can easily lift load up to one ton. In this observation, four such wire ropes with snap hooks are clubbed together in one set (Figure. 5d). The most important advantage of using SS wire rope with snap hooks is, it can be clamped to the dome easily and faster as compare to tying the ropes and can lift the dome straight uniformly without unbalancing it. After installing the counter weights into the dome and connecting SS components like wire-rope and snap hooks to the dome, the entire dome is ready for mounting the instrument.

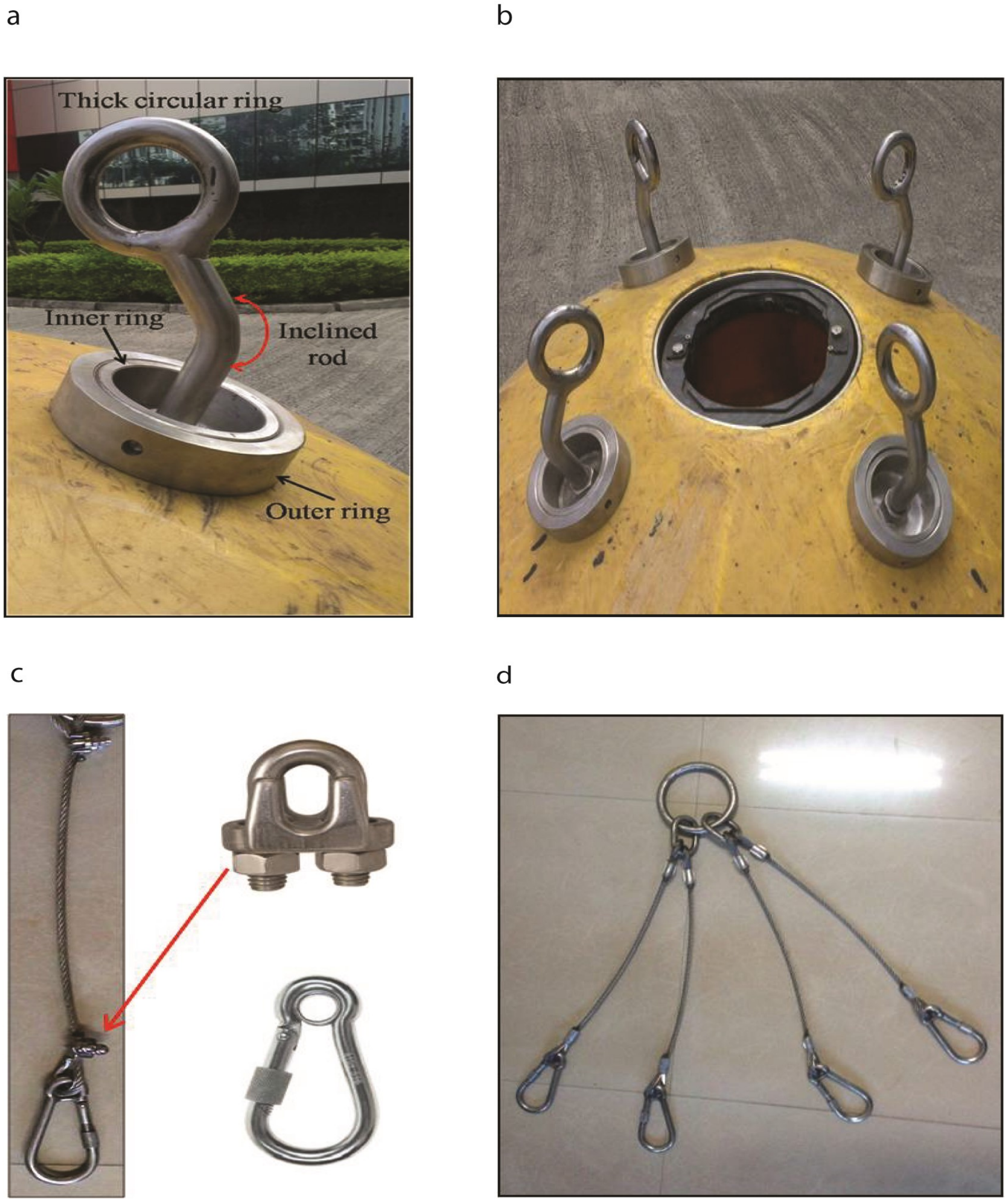

Figure 5: Design and reinforcement of components for lifting and deployment of the dome: a) SS Hook-loop assembly. b) Hook-loop assemblies. c) SS Wire rope & Snap-hook. d) SS Wire rope & Snap-hook set.

2.2 Redesigned Pre-deployment Technique – An easy approach

Besides unevenness caused by the tying of synthetic ropes which unbalances the dome while lifting, another major drawback is the time duration required for deploying the instrument. The new redefined pre-deployment technique makes use of inexpensive, portable and robust components designed that can be easily assembled and implemented to the dome. After connecting all the components viz. counter weights, snap hooks, SS wire ropes to the dome and the instrument fixed inside, the entire dome is all set for mooring (Figure. 6a). The total time required for installing the counter weights into the dome, placing and fixing the instrument to the circular ring on the dome using SS clamps, connecting the SS wire rope set to the dome and finally lifting and deploying the entire dome with instrument in the sea (Figure. 6b), is about 25 to 30 minutes. Due to this, the time span of the entire process is reduced to more than half as compared to the older pre-deployment method. This proves to be time efficient technique.

III. RESULT AND DISCUSSION

Field Testing and Tide data comparison

During the pre-monsoon phase, SeaGuard tide gauge in dome was deployed in 10 m depth at Kodinar (Gujarat, India) using existing pre-deployment technique for time duration of 15 days (9th to 25th November 2013). Tide level data was continuously recorded every 10 min while the pressure accuracy in this instrument is 0.02% FSO (Full Scale Output) [10]. In the time series plot (Figure. 6c), few kinks were observed in water level data (blue curve lines) during the neap tide. Since in the old pre-deployed technique, chains are tied below the dome using synthetic ropes. Due to unevenness in tying of chains the total mass of the dome is not equally distributed, which lead to mass unbalance in the dome, as a result the dome was inclined towards one side, while mooring and sitting on the seabed. Also during the neap tide, when the water level is low, currents are strong enough to drift the unbalanced dome over the sea bed. Because of these factors, the error was incorporated in the data while recording. This error in the data is observed as kinks/distortion in the graph. The new redesigned pre-deployment technique was tested at the same place with the same instrument during the post-monsoon phase for 15 days (5th to 21st April 2014). The time series plot (Figure. 6c) showed there was no kink in the water level data (red curve lines). In new redesigned pre-deployment technique, cylindrical weights are placed in the slots over the surface of the dome; hence the total mass is equally distributed over the dome. As a result, the dome is stable during mooring and while sitting at the sea bed. Because of the balanced weights, the dome is steady at the position where it was moored and is unaffected by the strong underwater currents. The data in the graph was recorded during the neap tide. This provides satisfactory justification for using the low cost, portable and robust modifications reinforced in Aanderaa bottom mooring dome for tide gauge deployment.

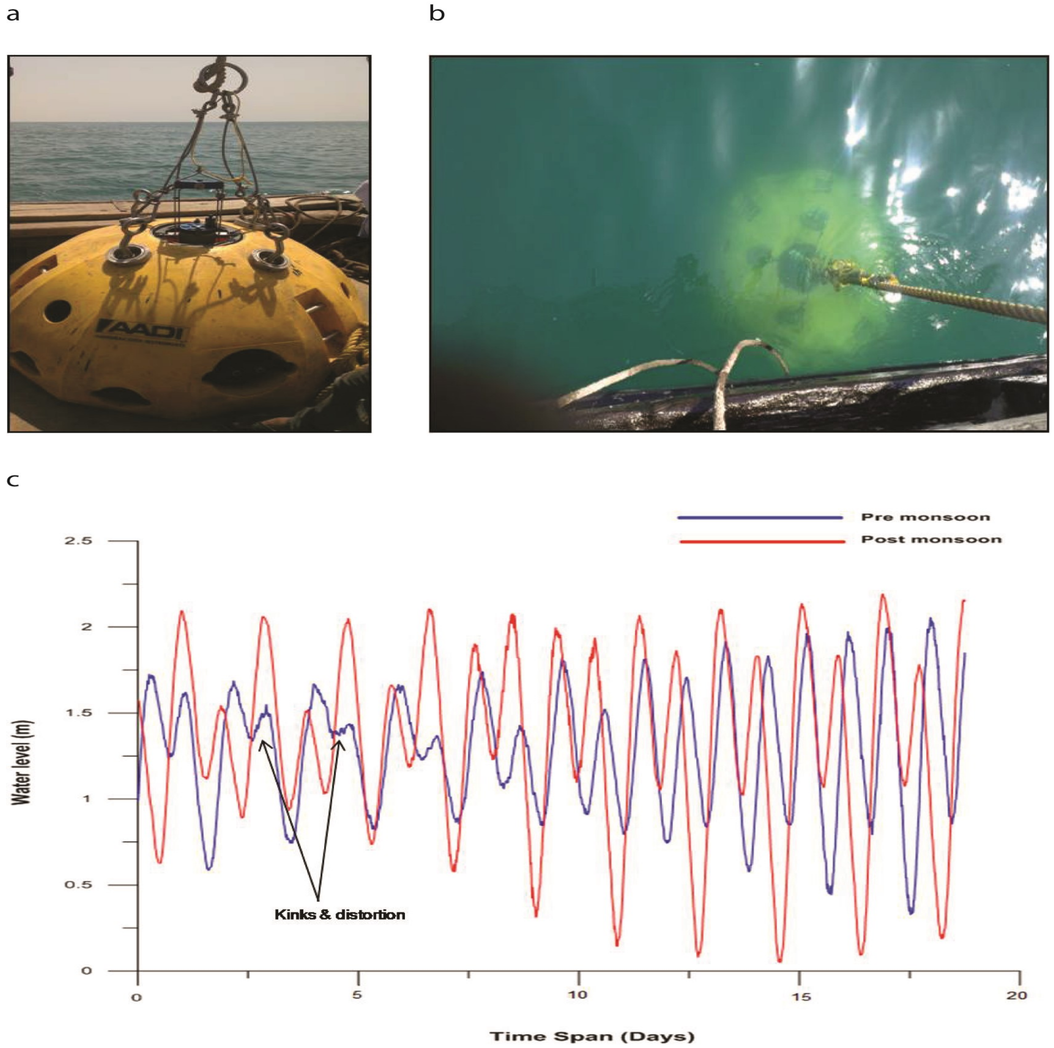

Figure 6: Redesigned pre-deployment technique for tide gauge deployment:
a) Dome with the instrument ready for the deployment. b) Dome deployed in the sea. c) Time series plot of water level data.

IV. CONCLUSION

The new redefined pre-deployment technique has several advantages over the older technique;

- It uses low-cost, portable and robust components which can readily assemble and implemented and can be easily dissemble, during and after the use.
- All the components are made from marine grade (306L) Stainless Steel material; there are no issues of ageing, rotting or worn as compared to synthetic ropes.
- It offers easy maintenance and servicing, and can be used over a longer period.

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REFERENCES

[1]. Ningaloo Reef-Technical report (March 1998), Australian Institute of Marine Science.
[2]. D’Onofrio E, Dragani W, Speroni J, Fiore M (2003) Propagation and amplification of tide at the northeastern coast of the Antartic Peninsula: an observational study. Polar Geosci., 16: 53-60.
[3]. Richter A, Rysgaard S, Dietrich R, Mortenson J, Peterson D (2011) Coastal tides in West Greenland derived from tide gauge records. Ocean Dynamics, 61: 39-49.
[4]. Richter A, Marcos M, Monserrat S, Gomis D, Ruiz S, Liebsch B, Dietrich R (2005) Comparison and combination of coastal and off-shore tide gauge measurement from Eivissa Island, Western Mediterranean. Mar Geod., 28(4):271–289.
[5]. Bottom mooring dome (2011) https://www.aanderaa.com/productsdetail.php?Real-Time-Monitoring-System-in-Abu-Dhabi-Port-UAE-40.html.
[6]. Peter Davies, Nick O’Hear (2008) How twist can affect braided marine ropes. Sea Technology, 49(7): 25-32
[7]. Trask R.P, Weller R.A. (2001) Moorings. Academic Press (doi:10.1006/rwos.2001.0304) 1850-1860.
[8]. Ashok Kumar K, Chandramohan P, Pednekar P.S, Diwan S.G (2004) Bottom mounting seabed mooring frame for high current field. 3rd Indian National Conference on Habour & Ocean Engineering, Goa.
[9]. Steel wire ropes, http://www.steelwirerope.com/WireRopes/Constructions/MarineGrade/7x7-stainless-steel- wire-rope.html, April 21, 2016.
[10]. Operating manual SeaGuard WLR, Aanderaa Instruments