Using Preconfigured Tablets Underwater to Increase Data Rate Recording and Improve Dive Efficiency

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***Abstract*— All underwater work carried out by divers is inherently inefficient because of the time limitations of the diving and the logistical cost of delivering the dive team to the point at which they can work. Work can be made more efficient through improvement of operational technique and often simple and inexpensive technology. Optimizing data and sample collection and team training are is a primary facet of determining operational procedures. Where observations are required, systematization of data observation and recording, which allow the observer a limited number of choices, can dramatically reduce data recording time required and also insure consistency of data. In addition, where accurate compilation of data by a number of observers having different skill levels or even different languages is required, systematization insures a broad consistency. Tablets configured for particular observations or to serve other purposes allow rapid data acquisition and transfer to computers for storage and analysis.**

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I. Scientific Diving, Observation and Data

Scientific diving in shallow-water areas traditionally has provided a great deal of seabed and biological information. Although modern advances in robotics, ROV and AUV are extremely useful in water deeper than divers can commonly reach, a scientific or technical diver can record and interpret a wide variety of data very inexpensively, as well as operate equipment. In some instances where particularly specialized or complex observations are to be made or work is to be done, in our opinion nothing beats having divers on the spot. Recognized safe work practices exist for an extremely wide variety of situations [1].

Scientific and technical diving is a proven, relatively inexpensive methodology, which to many simply has the character of a type of transport (through a water medium). Diving at its simplest is simply a means to allow someone to access underwater sites. In addition to sea-bottom and ocean properties can best be sampled as well as observed directly.

Characterization of high-resolution features of the sea floor has often proven difficult, even for -specialists, because there is a wide variation in the way even trained observers can describe the same or similar seafloors. Specialists can observe and construct an intensely detailed dataset that may suit their particular interests or applications, but over-complicated datasets almost are difficult to integrate with other specialized observations. Without a system that constrains information input and recording, much dive time can be wasted. With a good information recording system, however, both professional and amateur divers can make consistent observations according to a well laid-out system in which the main attributes to be recorded have been clearly defined [2].

Although filtering the observational input by constraining it may obscure some interesting if not valuable observations, the filtering will result in a coherent output that can be convolved with data acquired using the same systematics. A primary rule in scientific diving is not to send a diver down unprepared with the instructions to simply record what he finds or thinks important. Although systematization at the level of data input may restricts many observers to less than they are capable of recording, systematization has the potential to cut dive bottom time considerably while producing an easily interpretable dataset. This is the essence of diving efficiency.

II. Elements of Data Fusion

The ultimate purpose of any project in which seafloor or oceanographic information is collected (including sampling), is to be able to bring the data together or to compile it rapidly along with other data. It is then available to be used by a wide range of individuals and institutions for purposes that may not have been envisaged by the data acquisition project. A good dataset can stand on its own merits.

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All information will be contained within a data handling system. Although limited capability software may be used for single jobs, the information contained within it may be dead-ended. Where cost determines software, the principle that data should only be entered once should be maintained. Ideally, a sophisticated geographical information system (GIS) with a linked relational database will be used. Because of cost and proprietary issues, an open GIS may be used. A data fusion system must be capable of accessing numerical, image, text, and special products such as video and operational information such as navigation and incidents through the GIS interface. There are a number of commercial products available, with different levels of flexibility and operator skill. We recommend that no matter which system is used, it must be able to export data to other similar systems and to other software programs.

In addition to defining the nature of the data to be acquired, the data handling system should take into account the need to maintain and transfer: 1) Spreadsheet or database-friendly data. 2) Easy data handling from recording to database and product output production. In other words, data input should take into account not only processing but the intended output. 3) Flexibility of the database and its ease of use (i.e., use command buttons and menus rather than command lines. 4) Insuring the diving information recording system is easily accessible through electronic communication, preferably wireless. 5) All data must be geographically referenced and include numerical relationships, such as orientation of features within sites, between sites, and with external data must be maintained.

II. Systematizing Data Entry on Preconfigured Tablets

Each project will have its own objectives and operational limitations. With training and familiarity, observers should make more decisions faster and more reliably. The types of data to be recorded fall into three categories:

1. Choice selection. For many of the descriptors, only a limited number of choices are offered in each category. The observer must select the best choice in each category, even though he/she might regard the situation to be marginal between two choices. It's all about making choices. With enough choices, randomness will be minimized and with enough data recorders, data will tend to become normalized to form a valid statistical dataset.

2. Orientation and numerical entries. Although the presence and type of features can be denoted through choice selection, enumeration allows for a more detailed statistical treatment. In the case of orientation, for instance, actual measurements or a segmented compass rose can be used. Actual measurements can be entered in different ways. For instance, orientation can be entered as a line, a number and water velocity and orientation (strike and dip) of surfaces can be a line, a number or an arrowhead. Any measurements should be made to whole units for simplicity.

3. Specific descriptions. In only a few cases will specific descriptions of any features be necessary or advisable. A means for inputting notes that can be made from time to time to supplement the selected data enhances opportunities. In practice, however, little of this noted information could be easily convolved with other notes.

Because of the extra bottom time that is required to enter written descriptions or to record a video, these activities are likely to have an impact upon the number of dives, that is, the dive schedule. Operational efficiency will be affected, perhaps strongly, if observers persist in making lengthy descriptions apart from the systematized schedule. However, it is recognized that occasionally an observer will wish to record an observation for which there would be no provision in a selection-only system. It is important not to upset divers unnecessarily.

II. Tablet Histories and Development

A systematized data recording system for a number of high-resolution, shallow-water bottom features has been devised. We show two examples of preconfigured tablets in the next section only as a solution that worked once for us. Others will configure their tablets, as they desire.

We do not intend to claim a continuous development of tablet data recording or any priority to doing anything first as similar data recording efforts have been undertaken broadly by divers. The best answer to producing uniform site observations has been through the use of data recording sheets on which observers must pick from only a limited number of choices for the most relevant bottom character. It is widely recognized that this forces observers to use a uniform descriptive terminology and produces numerical data that can be tabulated.

In the beginning (analog data recording for those of us old enough to remember), he best answer to systematic survey was through the use of data recording sheets, which functioned as diver notepads. These could be completely unsystematized, note-based or fully preconfigured, depending on the nature of the job and the focus of the project manager. Over time, experience drove observation toward a uniform descriptive terminology.

Our first tablet was configured for use by a number of divers to characterize seafloor areas for mine-countermeasures and engineering applications [3]. In this special circumstance, it was important to record the data in a 'language-free' manner. This may not normally concern individual diving teams. Our tablet had to be used by divers of different nationalities who did not speak a common language. Because of this, duplicate layout and content table faces were prepared with instructions and notation in the different languages that divers would be using.

The system provides a hard copy record for each site that can be shared by simple copying, and archived at more than one site. Once enumerated, the data can be treated statistically as well as graphically. Observations are made on a transparent overlay that can itself be a hard-copy archive.

To facilitate data quality and rapid compilation, tablets were prepared with quick-fitted Mylar overlays. As a tablet was brought to the surface, or when the divers would move to a different area, the used Mylar would be removed and a fresh sheet inserted. In this way a grid of systematized observations could be made without divers surfacing. When divers surfaced, the information (the selected choice boxes and measurements) on each Mylar recording sheet would be entered into a file that could be sent as an e-mail attachment or by some more secure, encoded wireless transmission to a data center [4]. When the information files arrived at the remote data center, the data was entered on a graphical reproduction of the tablets that the divers had used underwater. This resulted in data being compiled in a digital dataset literally before the dive team had returned to its mother ship or base, and in some cases, before they had even gotten out of the water.

The first tablet had two faces, each of which dealt with related seafloor observations. On this table pencils were used to make observations. Figure 1 shows general sediment types with some orientations while Figure 2 shows geomorphological elements. Activated buttons on the graphical interface used by the data compiling facility at a dry remote location allow for easy movement between tablets, adding record, opening other table, etc.

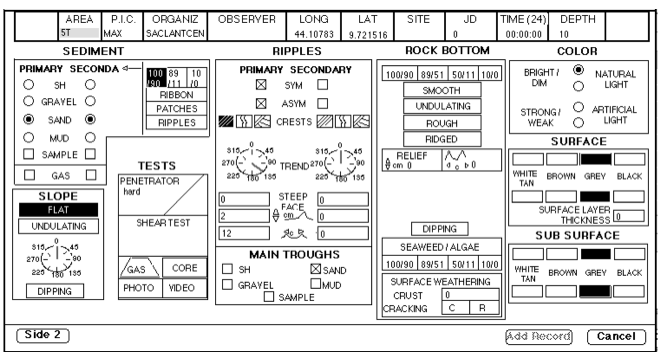

Figure 1. Side 1 of the seafloor tablet.

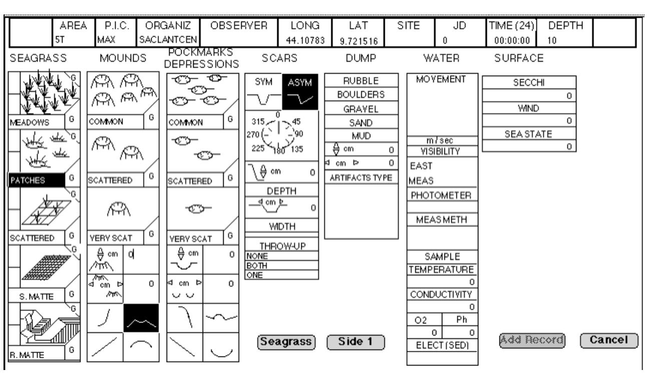

Figure 2. Side 2 of the seafloor tablet.

A second tablet, which was also two sided, (Figs. 3, 4) and was used to assist mapping seafloor with variable amounts of sea grass. This data was then used to paramatize side scan imagery of the seafloor where there were variable amounts of sea grass.

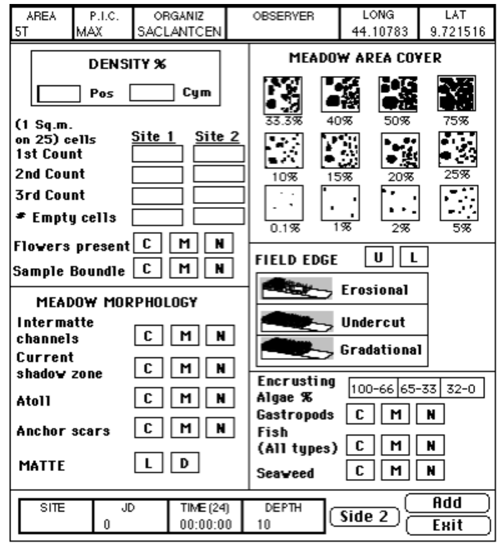

Figure 3. Side 1 of the sea grass tablet.

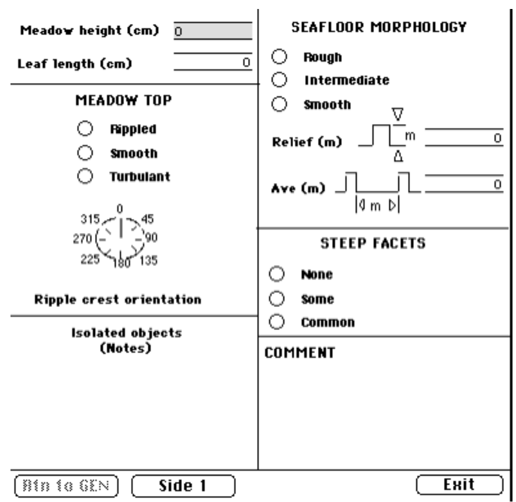

Figure 4. Side 2 of the sea grass tablet.

IV. Advanced Concepts

Further development of the tablet concept was carried out at the Naval Research Laboratory in Washington DC during 1998. At this time the design and production of a submersible digital tablet with wireless connectivity (for surface communications) was undertaken. Some of these have been superseded by commercial tablet developments, but our concept of dedicated sensors and measurement apparatus may still be applicable. Compact, low-power sensors are now increasingly available. Some of them are monolithic, with no moving parts. Others have flexible components, and others are MEMS, (microelectromechanical systems). All of them can be easily interfaced with any of several commercial microcontrollers and configured to work with existing operating systems.

Application of micro-electronic mechanical systems (MEMS), onboard cameras capable of operating at different wavelengths, underwater communication systems, and selectable or interchangeable digital tablet faces for direct encoding of data were tested. The list goes on, following the interest of the project manager or sponsor. The objective was to make the tablet itself a direct input device to the control GIS system. This would allow direct input from multiple project sites and participants operating in multiple locations, with literally no respect for distance.

A sensor option for parameter of interest, such as a CTD is suitable for incorporation. The external sensors also could include a water clarity (turbidity) sensor, with an internal tilt sensor and electronic compass. On-off, self-test and new-dive buttons, plus a small display for the state of the system also could be included. Other sensors for water chemistry, including the partial pressures of gases (oxygen, carbon dioxide, methane, etc.) and trace metals or chemicals (mercury, lead, PCBs, etc.) could be included. Sensor size and flexibility is much less of an issue than it was even a few years ago and improvements in microelectronics and miniaturizing of computers is amazing.

V Future of Diver Tablets

In a manner of speaking, the future is now for underwater diver tablets. Although not designed to work underwater, specially waterproofed tablets or enclosures for ordinary commercial tablets can be configured with software applications that will provide a direct analog input by the diver. In the same way that digital cameras can be taken under water, tablets and their onboard cameras and sensors can be taken underwater. It may be necessary to provide an enclosure in which air pressure can be maintained at ambient depth pressures throughout the course of a dive or the touch screen face of the tablet could even be exposed to the water.

Where measurements are required that are additional to those that can be made with a table, a lightweight housing that containing the sensors can be implemented in which the tablet fits into a slot or enclosure on it. The sensor frame may contain a battery that will support substantial work time submersed, as well as a range of sensors, special cameras, etc. that are required for the particular project. A sensor frame also can provide substantial protection.

We are not directly concerned with developing information system tablets for diver use at this time. However, we hope that this short paper assists others in applying the tablet concept, upgraded to its full electronic form.

VI Conclusions

Analog tablets from which data can be extracted remain the least expensive data recording system that will allow a group of people having different levels of science training and experience to significantly increase the efficiency of a diving project.

Tablet development, that is, the hardware itself, is no longer necessary. A number of tablets exist whose operating range coincides with the environmental conditions encountered by wet scientific divers, although these will have to be placed in waterproof sleeves in which pressure depth compensation can be made to allow normal touchscreens to be operated.

Software applications that will run on one or more tablet operating systems can be written using a number of developer systems. The functions in existing applications for gaming and menu / operation instruction can be utilized.

The full range of capabilities of tablets can be used. Onboard cameras for still and video, compass and inclinometer, one-touch data entry, and text can all be used.

Care must be taken to minimize the information to be recorded or dive efficiency will be affected. The fundamental aspect of efficiency, which is to allow shorter bottom time and more dives per diving day / project, and allow more sites and information to be gathered in a period of time, should be maintained.

Deep ocean and planetary versions of tablets can be designed and fabricated. These are envisaged as being mainly for use in unconventional situations involving very high or low pressures and temperatures found outside the normal range of shallow water diving in which most wet scientific diving takes place.

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