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The Ocean Map that can be trusted - About the making of sea charts as it was and as it will be

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Abstract:

For centuries the drawing of a map of coastal waters or ´sea chart´, was in the hands of the navy of a coastal nation. This was considered logical as the need for charts primarily was in warfare. Since as of today the commercial shipping has differing requirements, the demand for bespoke charts for use by e.g. large container ships or cruise ships is growing. The International Maritime Organization (IMO), a specialized agency of the United Nations, stipulates in its Safety Of Life At Sea regulations (SOLAS) that only charts published by national authorities such as the Hydrographic Office (HO) of a Navy shall be used in navigation at sea. This, however, puts an HO in a predicament: whom shall it serve in the first place, the Navy or the Chamber of Commerce? In his paper the author outlines why charts by HOs in some cases are no longer suitable, and how to make ´non-governmental charts´ equivalent to 'official charts' so that they can be accepted by the IMO for use in navigation.

JEL Classification: L91, L92, O18

Keywords: sea charts, shipping, marine traffic

1 Introduction

To interest the reader who may not be an insider to the seafarer's domain, I chose the term 'ocean map' for the title. The correct term in use among navigators is 'sea chart', 'nautical chart' or simply 'chart' (Wikipedia 2018i). In the title I add somewhat provocative that charts should be trustworthy, which is unfortunately not always the case as I will demonstrate in this paper. Please note that such opinion does not find the support of the chart producers that are mostly state-run.

In the context of this paper, a 'map' means a 'land map', i.e. it shows features on dry land, whereas a 'chart' renders the topography underwater plus objects ashore that can be used to identify a ship's position when navigating along the coast. It mainly serves the need to know where the shallow waters are, so that deep going vessels can avoid them. In business, a 'chart' can also be used to steer around 'financial hazards' – which is NOT the subject of this paper.

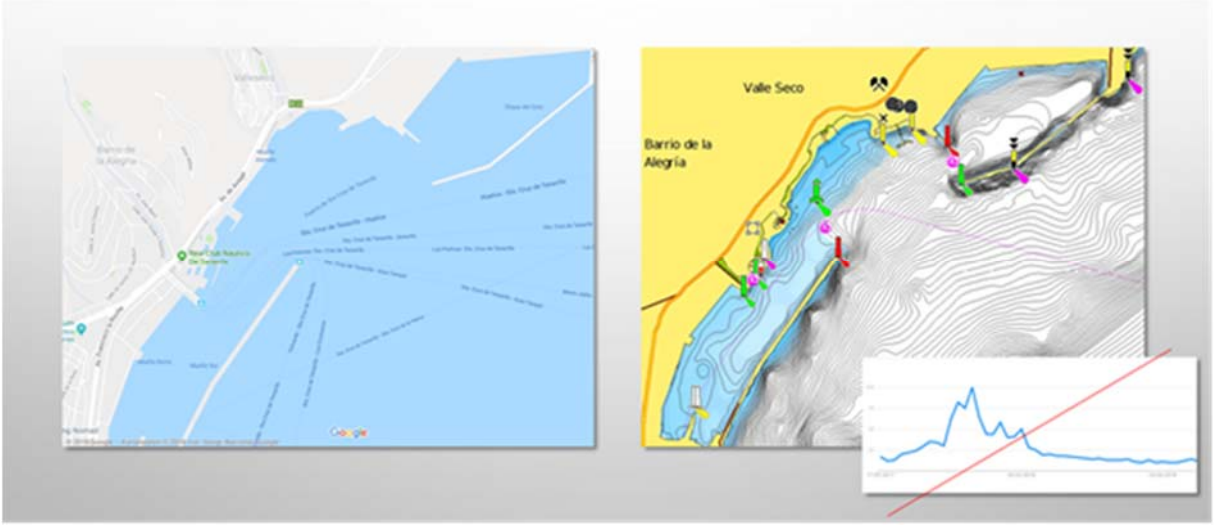

Figure 1: Map vs. Sea Chart, NOT a business chart! (Google Maps 2018)

Nautical charts have been made for thousands of years - the earliest examples are from 500 B.C. (Wikipedia 2018f). They contained grossly drawn coast lines and outlined the sea areas. Later so called ´portolan charts' featured 'compass directions and estimated distances observed by the pilots at sea' (Wikipedia 2018j). But it was not until the 19th century when underwater topography was first grossly surveyed and depicted on charts using 'lead lines', or later single beam echo sounders starting from the 1930s (Wikipedia 2018g).

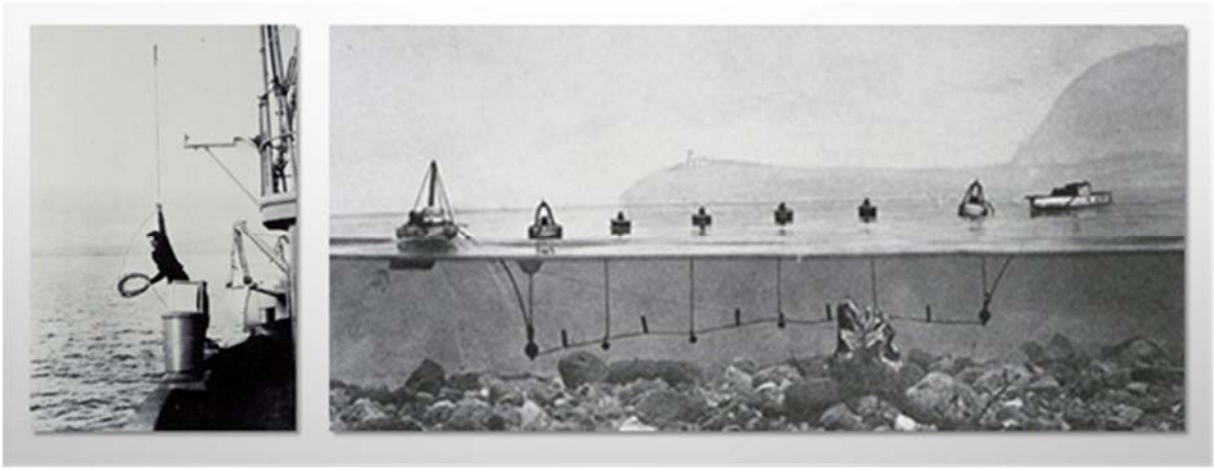

Figure 2: Lead lines and wire dragging to measure water depth and underwater hazards (NOAA 2018b; Wikipedia 2018a)

In the 1970s multi-beam echo sounders finally made it possible to collect big amounts of depth information, so that the seabed could be made visible to detail and without gaps. The latest development is in autonomous underwater vessels that can roam the coastal waters and collect data independently from a survey ship (Wikipedia 2018b).

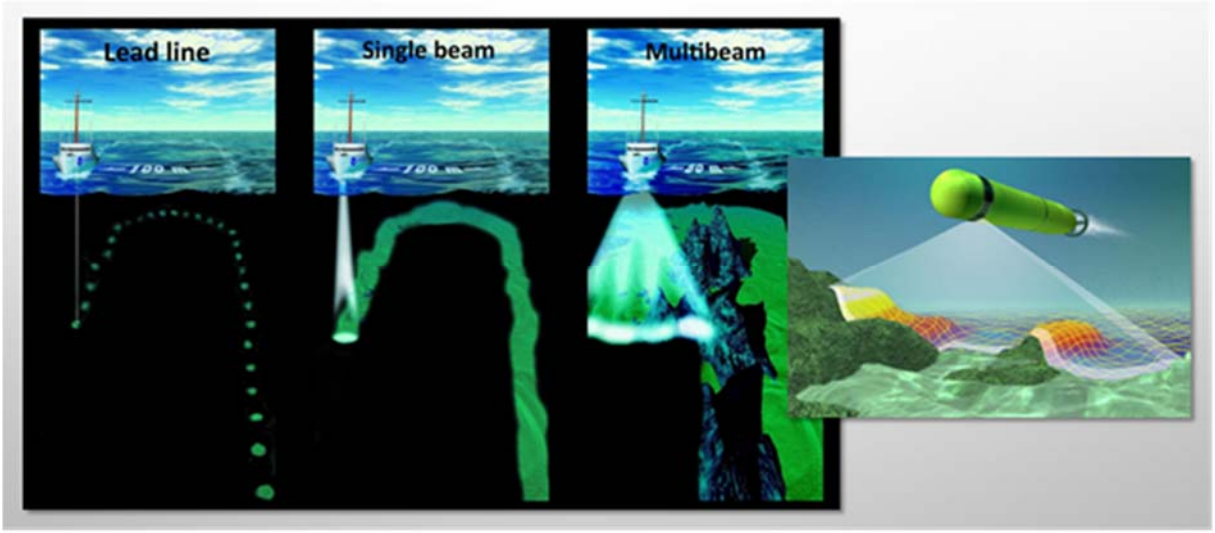

Figure 3: How bathymetric data is collected (SEG 2018; Czech Technical University In Prague 2018)

Temporary charts are compiled from dense ‘bathymetry’ depicting a terrain model of the seafloor as contour lines (called depth contours or isobaths) with selected depths (soundings), and typically also provide surface navigational information such as buoys and beacons (Wikipedia 2018c). Other than in marine warfare, a nautical chart mainly serves the needs of commercial shipping which is to mark a safe passage or fairway. Channels free of underwater obstacles are shown in white whereas areas shallower than the ship’s draft are in blue shades. Hazards such as wrecks, rocks or peaks are shown as isolated objects.

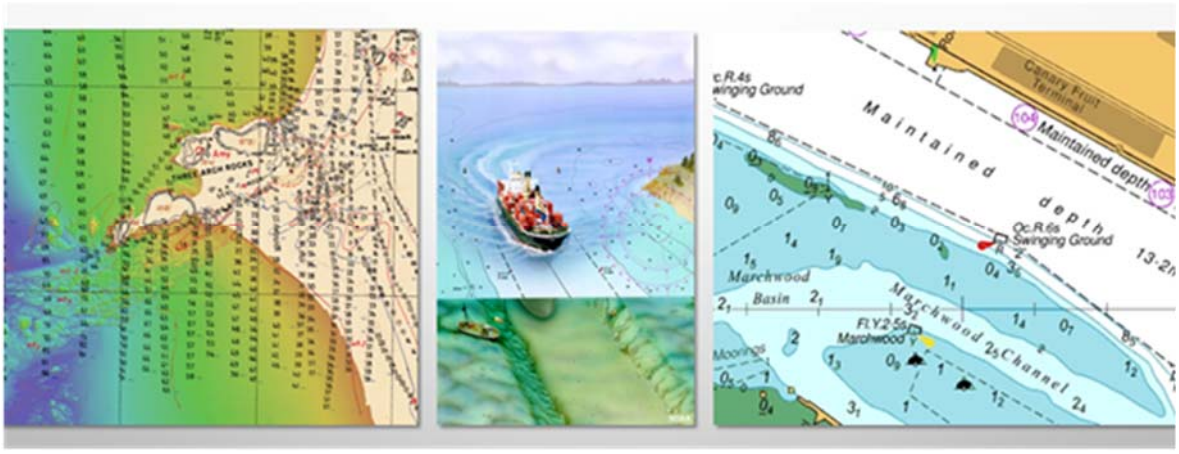

Figure 4: From raw survey data to nautical chart to support safe passage (David Evans and Associates Inc. 2018; o.A. 2018c; Admiralty 2018a)

2 The Status Quo

The role of nautical charts in safe navigation is at least inconclusive which becomes obvious if one studies the organisational structure of their producers. All but three coastal nations – Sweden, the USA and Germany – run a Hydrographic Office (HO) that is part of the navy. Also note that large parts of Africa do not even have an HO so that other nations have to survey their coastal waters to reach the ports (Wikipedia 2018h).

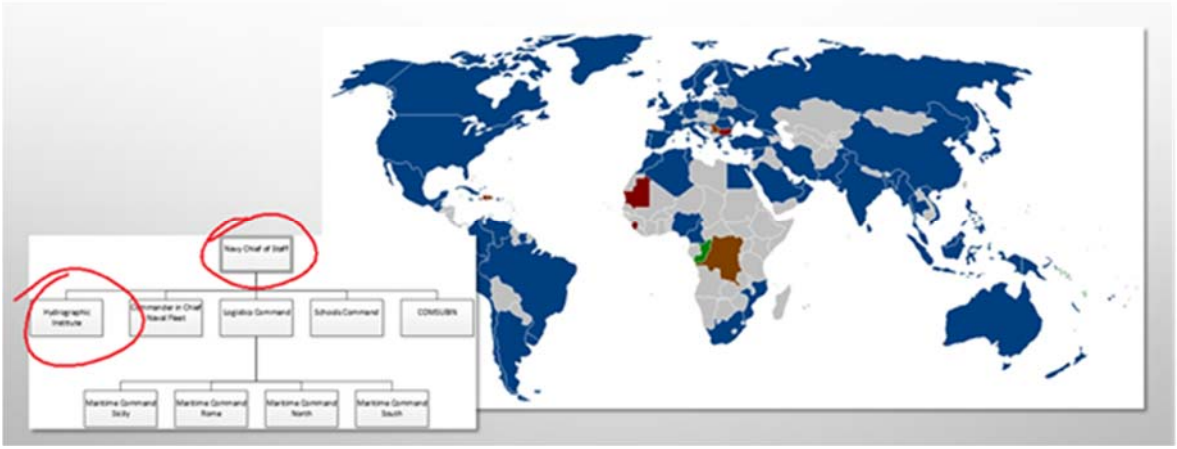

Figure 5: By whom charts are made (Wikimedia 2018b, 2018a)

The history of maps is closely related to the strategic interests of nations. The United Kingdom Hydrographic Office (UKHO) is a prominent example (UK Hydrographic Office 2018). Being the biggest in the world its chart supply for seafarers called the ‘Admiralty Service’ is orchestrated by the Ministry of Defence. Consequently Admiralty Charts also cover the remote areas of this planet though they are of little if no interest to commercial vessels.

Figure 6: For whom charts are made - in the first place (Admiralty 2018b; Wikimedia 2018d; o.A. 2018d)

As of today twenty coastal nations have established their own HO. Notwithstanding, only 20% of the world's underwater topology have so far been explored (NOAA 2018c), in contrast to the surface of most planets and moons of our solar system. The dry face of Mars, for example, is 100% known to us.

The waters on Earth can only be penetrated from the orbit of satellites by deriving the depth from the ocean currents or the characteristic of waves such as breakers at the coast. These methods are however not very reliable.

Only navies with a large budget can afford to roam the oceans to survey the vast waters. At best corridors can be mapped with deep reaching SONARs. Again, this mainly serves the scientific or strategic interests.

Figure 7: The vast unknown at home (o.A. 2018a, 2018b; NOAA 2018a)

While the exact extent of the Mariana Trench, the South China Sea or the coast of Antarctica may be of general interest, the thousands of civilian vessels are in need for up-to-date and precise charts of the coastal waters. With their budget stretched thin, the HOs of most nations try to meet the differing demands.

Since the start of container shipping in 1968, the size of the vessels has grown from a capacity of 1,500 to 22,000 containers (AGCS Allianz 2018). Some ships have reached a length overall of 400 meters. Still, charts are drawn in scales that may have been suitable for the ships of the 1950s, for the container ships of the actual generation they merely can serve as overview charts.

Figure 8: How the pressure builds up (Wikimedia 2018c; AGCS Allianz 2019)

An example from Australia demonstrates the dimension of this challenge. The normal i.e. official and openly available approach chart to the port of Cairns is of a scale and a detail that does not allow for the passage of large vessels. The port pilots, however, have access to a more detailed chart of much better resolution (Di Lieto et al. 2018). The issue is that the captain of a ship entering the harbour is blocked by regulations from loading the improved chart to his navigation system which potentially results in a disagreement between the captain and the pilot. Sharing mental models is in fact the essence of Bridge Resource Management (BRM) whose ultimate aim is the prevention of accidents (Mukherjee 2018).

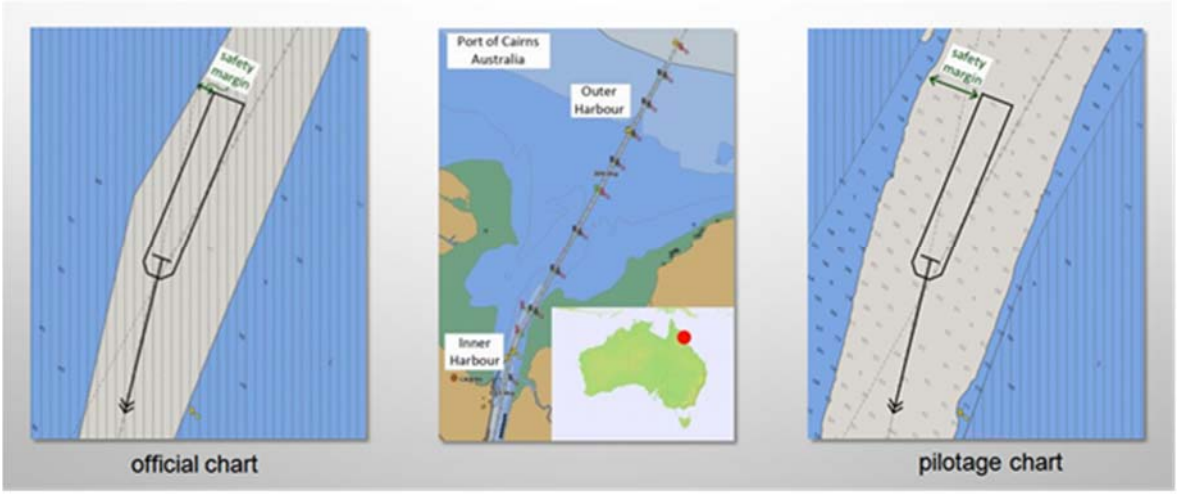

Figure 9: Bespoke charts for secure passage (Hydro international 2018c, 2018b, 2018a)

Out in the big void of the Oceans, off the beaten tracks, the situation can be worse. Many remote islands have not seen a fresh survey of their coastal waters for decades if not centuries. All officially published charts shall contain a 'source diagram' that discloses the date of the surveys on which the compilation of the chart is based. To the mariner the diagram shall suggest that the chart may no longer reflect reality. This way responsibility is shifted from the producer of the chart, i.e. the issuing HO, to the mariner.

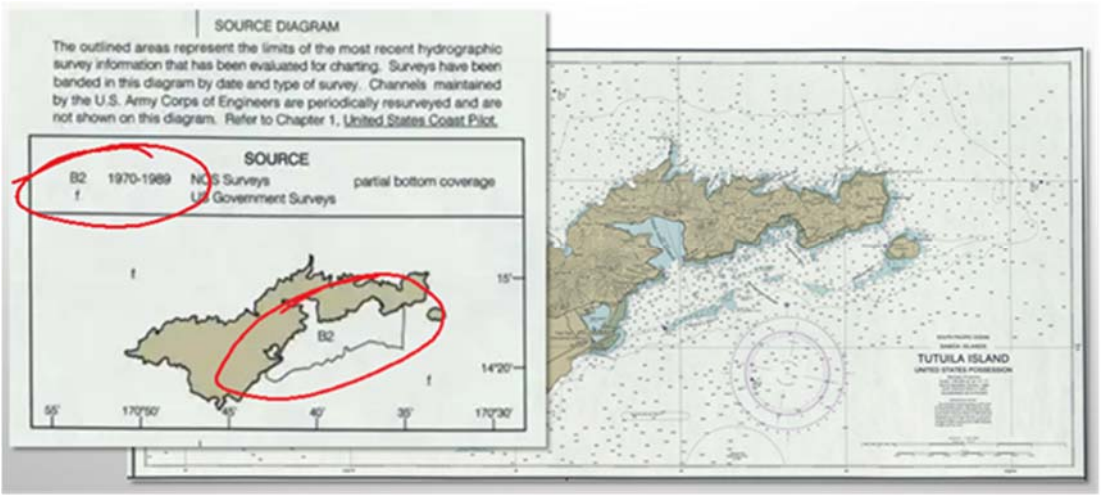

Figure 10: Off the beaten tracks (The University of Texas at Austin 2018)

What this means to the captain of a cargo ship that has to navigate away from the main shipping routes in order to reach a remote port of call, can be demonstrated by the fate of the 'MS Pacific Challenger' (Mukherjee 2018). It did run aground a reef in poorly surveyed waters of the South Pacific. In the aftermath, the experts in the field agreed that it was the fault of the ship management to go direct through poorly surveyed waters instead of following the beaten tracks further to the north and down the coast of Papua New Guinea. But life isn't as simple as that – there is economical pressure. Fuel costs, cargo sensitive to tropical temperatures, perhaps the shipping company back in Europe demanding a fast transit in order to meet the next charter in time. Especially the cruising industry with its large passenger ships is in jeopardy when navigating to increasingly remote places.

Figure 11: Uncharted reefs (Maritime Accident 2018a, 2018b, 2018c)

Moreover, experts agree that in the not too distant future ships might no longer need a crew on board to be steered through narrow passages. The nautical officer of the future can very well sit in a control centre ashore from which she remotely controls the ship's course (Maritime Accident 2018d). It goes without saying that this job will be impossible without a portfolio of well maintained and precise charts.

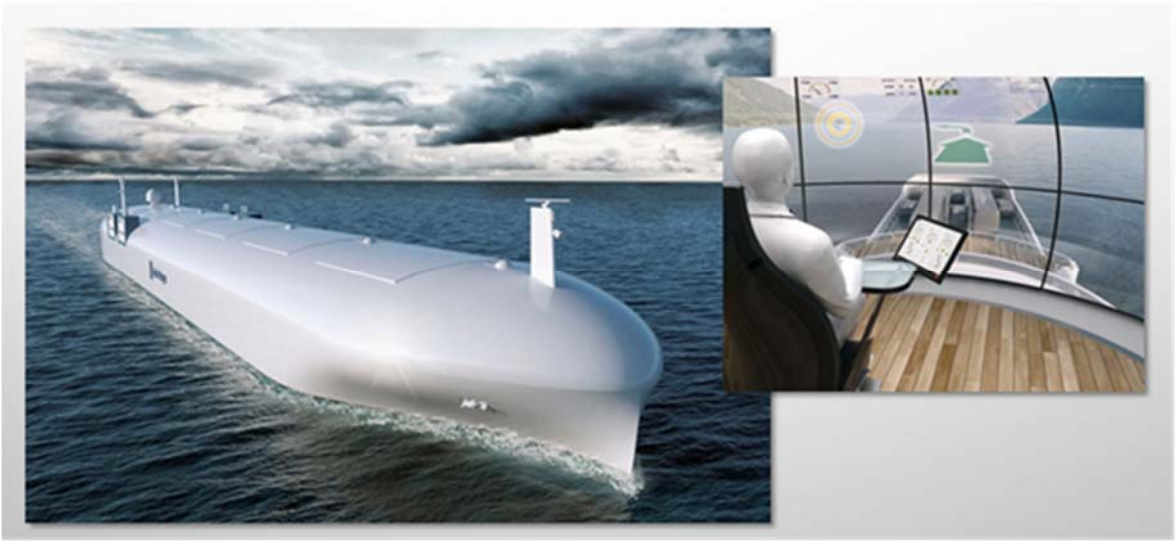

Figure 12: Autonomous ships need precise charts (Ventker Henderson 2018; Safety at Sea 2018)

No matter how navigation technology evolves, the Hydrographic Offices remain on track when it comes to product liability. With the advent of the charts designed to be displayed on computers known as Electronic Navigational Charts (ENC) , the HOs established the concept of the 'zone of confidence', or ZOCs. With ZOCs charts are categorized in ratings based on accuracy both in depth and position (Jon Walker 2018). There has been a heated debate at the International Hydrographic Organization (IHO) about the use of CATZOCs of which the author was a witness. Obviously HOs don't like to be explicit about the accuracy of their charts because they might be held liable for an accident if the chart was incorrect (Admiralty 2017). Hence, the current practise is to downgrade the charts by assigning a category to the zone of confidence that is lower than the actual source information would allow for. This can be driven to the extreme by assigning the value 'not assessed' or 'U' to the position and depth accuracy rendering the chart virtually unusable. Not a problem for the HO being a state owned instance, but definitely a problem to the captain who may have to rely on the chart to reach the port of call.

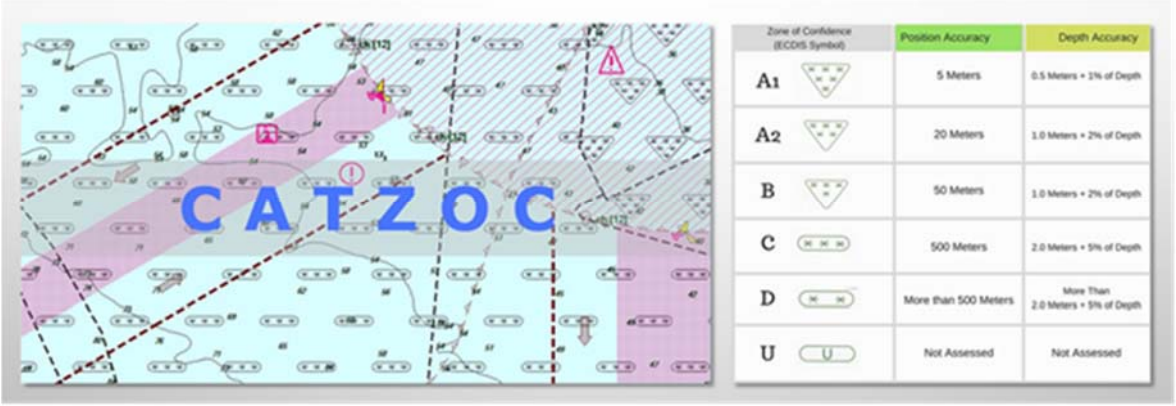

Figure 13: A way to escape liability (MySeaTime 2018; Learnmarine 2018)

To complicate matters, the International Maritime Organization (IMO) (Hydro international 2018d) requires from its Safety of Life at Sea (SOLAS) regulation that only charts published by national authorities such as the Hydrographic Office (HO) of a Navy shall be used.' (IMO 2018a) This effectively means that there is currently no legal alternative to charts made by HOs – a true predicament given the need for better charts from whatever source. Nevertheless, the IMO recently addressed autonomous ships which may pave the way for better charts (IHO 2018).

So, let us summarize the situation:

- state-run hydrographic offices are not solely committed to commercial shipping
- big ships, confined waters – there is a demand for unbiased chart services
- ships in uncharted territory need up-to-date charts
- independent hydrographers have no market because of the SOLAS mandate.

3 How to Change the Status Quo

The HOs of the coastal nations have a monopoly on charts. The United Kingdom Hydrographic Office is combining the charts into portfolios for a worldwide distribution service to the shipping industry. In parallel, many ports run their own bathymetric survey and create charts to for use by the local pilots only. These more accurate and up-to-date charts are usually not included to the openly available portfolio of charts by the national HO. Instead they are worked into the official charts as an additional source, a process that can take a year or two because HOs are used to the paper chart printing cycles. Meanwhile ships are getting bigger and autonomous thus - in the absence of adequate charts - creating disaster-prone situations.

One way if not the best way out of this situation is in acknowledging the status of 'unofficial' i.e. non-SOLAS compliant charts, as equivalent to the 'official' charts by the HOs. How can this possibly be done?

Converting ‚unofficial' to ‚equivalent'

In the SOLAS convention the requirement for the exclusive use of charts by HOs is based on the assumption that only nations have the resources to survey the oceans and their coastal waters. The latest development in technology that brought down the size and cost of operating SONAR equipment has not yet been taken into account. International shipping and the related insurance industry got used to the HOs' monopoly founded in SOLAS. Officers of Port State Control are required to check the ships for compliant charts. The ship is considered not seaworthy if the charts are not up-to-date or from a non-governmental source (IHO 2018) which results in penalties, blacklisting, costs due to the ship's delay, and potentially in higher insurance costs.

Charts other than by HOs are thus not acceptable to shipping companies. This will only change if non-governmental i.e. 'unofficial' charts are established as equivalent to 'official' charts. For this to achieve trust in unofficial charts has to be built up.

In the financial world trust is established through Credit Rating Agencies (CRA) (IHO 2018). Although their very existence is often questioned, they are a corner stone of the banking industry because they rate the likelihood of a debtor's default. The classification societies of the shipping world such as DNV/GL or Bureau Veritas (IMO 2018b) are probably a more suitable model for assessing the reliability of a chart. The subject of the rating/ classification would not be whole organisations, such as HOs, port authorities or commercial entities, but the nautical charts issued by them. For the drafting of this rating/ classification agency I choose the name 'ChartVeritas'.

To kick-start the quest for better charts, ChartVeritas also shall encourage whoever collects bathymetry to provide their data such as ships using their echo sounders going in an out ports, cable laying companies, or companies doing offshore exploration. The collected depth information then can be processed into charts that are more actual and richer in content.

ChartVeritas shall offer legal advice to surveyors and chart compilers. There are regulations in place that can render even the innocent recording of echo sounder data an illegal act (Wikipedia 2018e).

Perhaps ChartVeritas' most challenging task will be to lobby at the IMO level in order to make SOLAS chapter V accepting non-governmental charts. It can achieve this by joining non-governmental organisations which 'have been granted consultative status with IMO' (Wikipedia 2018d). It also can advise shipping companies that see the need for advanced nautical charts; their ships are registered with 'flag states' (Wikipedia 2018d) and they pay for the right to carry the flag which is to many states a major contribution to the national budget. Every flag state has a single vote at IMO level when it comes to amendments to the SOLAS regulations. To be ac-

cepted, an amendment to SOLAS needs a two-thirds majority vote of the flag-states that are attending an assembly.

4 The Making of ChartVeritas

ChartVeritas will be no doubt a major undertaking. Here are the major steps in the short term:

Set up a team – ChartVeritas will be started by a team of experienced marine cartographers, former entrepreneurs, and software engineers; later a sales and marketing manager will join the team

Launch a website – the first web presence of ChartVeritas will feature a mission statement in the form of a white paper, and it will come forward with milestones of its implementation

Start a blockchain – the blockchain will save the ratings; every rating to be made will be recorded, so tempering with results will be impossible; in addition the blockchain is to hold ChartVeritas' own crypto currency that will be used to reward contributors to the project.

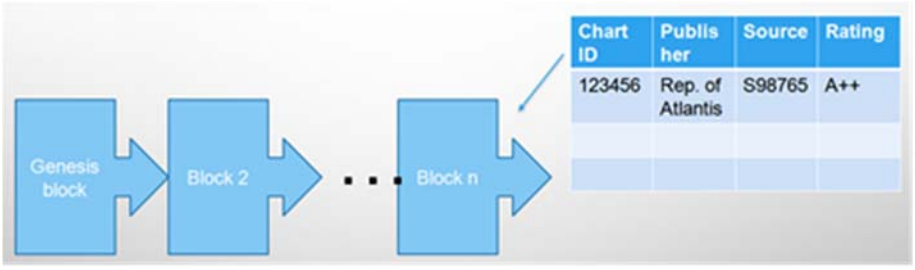

Figure 14: ChartVeritas blockchain

Develop a rating scheme for charts – currently, no rating of charts exists, no one has done it before; ChartVeritas' cartographers will develop the scheme in cooperation with a hydrographic academy that is prepared to do so.

Associate with insurance companies – collaboration with the insurance industry is essential to ChartVeritas' success; we need to first educate the insurers on the prospect of this venture, and then develop insurance policies that can be offered to the shipping industry as well as the producers and publishers of unofficial charts.

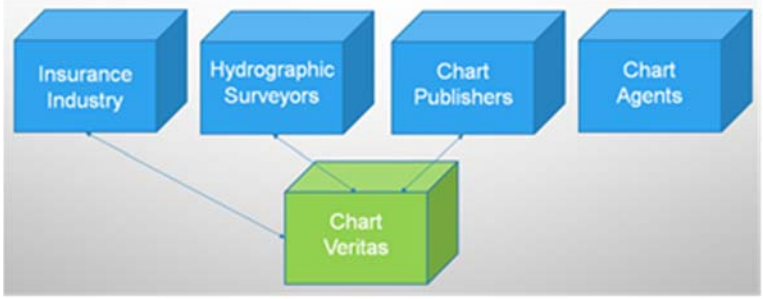

Figure 15: Cooperation with associates

Implement a bathymetric database – actual data of shallow waters is needed to design charts from scratch; contributors to the database will be rewarded with the ChartVeritas' crypto currency.

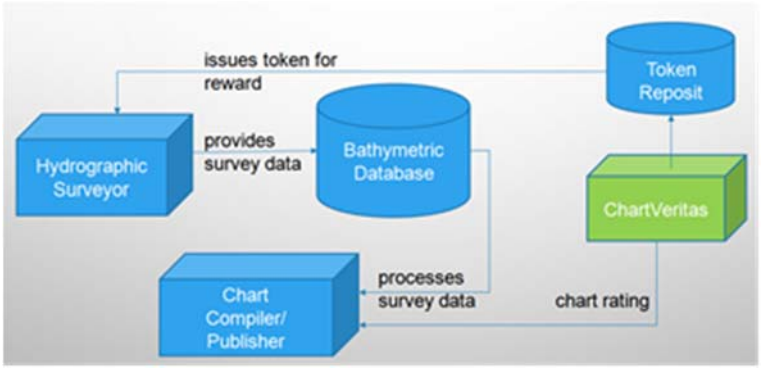

Figure 16: Source database and rewards

5 Summary

It will likely take several decades to establish ChartVeritas as an influential player. I have no doubt that we need the rating of sea charts. Ships are growing in size, marine traffic is ever increasing, and robotic ships need a verified navigational database. A single uncharted rock can result in a loss of lives at sea, and an environmental disaster. It is time to verify the status of charts as we already do with every nut and bolt that is installed on board of a ship. Charts can be no exception.

"A journey of 1000 miles begins with one step." Confucius

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