

# The End is Nigh; The Fall of Paper Charts

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## Abstract

Recently some HO's have stopped production of their lithographic paper charts. Can the end of the line for all paper charts be far behind? In an all-digital world the paper chart is the ultimate anachronism.

The paper chart has been the central paradigm of our business. As we move away from that paradigm what are we moving towards and what are we leaving behind ?

It is important at this point to realize how we got to where we are today, how our approaches evolved steadily to meet the needs of our users. The paper chart evolved to fit those needs but is limited by being frozen in time and scale. The basic navigation needs are not changing so whatever we do we need to continue to provide products that are useful for mariners to make safe and efficient journeys.

## Introduction: Paper Charts – Is This Really The End?

We live in interesting times. In fact, the last 30 years have been interesting times in the world of hydrography. In 1984 GPS was operating at a test level but even then it was obvious that hydrographic surveying would never again be the same, for the major technical challenge – offshore positioning - would soon diminish to a commodity service.

What many of us did not count on was the huge impact GPS would have on our customers - a change that would prove to be orders of magnitude more important than simplifying horizontal positioning. Users with the same level of position accuracy as the hydrographic surveyor - that was unprecedented. Add to this the slow but steady evolution of GIS to electronic charting systems and soon the HOs of the world had their world turned upside down.

A common element throughout this period though was the steadfastness of the end product - the paper chart, a product with a rich history, the linkage that took us in one continuous sweep all the way back to James Cook.

Fast forward; here we are, staring at the ever-so-obvious writing on the wall that the paper chart days are numbered, surpassed by technology and ignored by a new generation of users ready to move on. This great product, borne of centuries of evolution, now dismissed as an alien artifact by a new generation bred on Google and iPads. To the generation now flooding the navigation schools the world over the paper chart is an anachronism, a historical icon, to be framed and mounted on a wall in your father's den.

*So it goes*, as Kurt Vonnegut would say.

## SOLAS and Mandatory ECDIS Carriage

SOLAS Chapter V Regulation 19.2 ushers in the mandatory carriage of ECDIS on all vessels engaged in international voyages. The regulation includes an implementation

timetable depending upon vessel size but with complete implementation by July 2018. If you are a shipowner you are already deep into planning for ECDIS implementation, assuming you haven't outfitted already.

What does this mean for paper charts?

For professional mariners the paper chart is reduced, at best, to a backup role to ECDIS. The regulations permit the use of up to date paper charts at adequate scale to cover the intended voyage as a backup to a failure of ECDIS. In practice however most ships are being fitted for ECDIS with ECDIS as the backup. This would reduce paper charts to a tertiary backup. The up-to-datedness caveat however is proving to be a poison pill for paper charts, driving the costs to the point at which few ships will choose this option (Ref. #1, 2, 3).

In other words, for the professional mariner there is little or no future for the paper chart. This puts the HOs of the world in an awkward position as a prime mandate since their creation has been the provision of nautical charts for safe and efficient marine commerce. And "charts" has always meant paper charts, punched out of heavy lithographic presses, to be stored then shipped to a dealer network. Handling paper has been a major aspect of day-to-day life in most HOs.

### **The Paper Chart and the Non-SOLAS Market**

Outside of SOLAS there remains the case for the workboat, small craft and inland waterways market.

This is a significant market but one that has already been undergoing change and wide-scale adoption of Electronic Charting System (ECS). Here we have seen, and can expect to continue to see, a continuation of the current erosion of sales of paper charts as users switch to the improved situational awareness of such systems and to the convenience of purchasing digital charts online. As younger users begin to dominate this market the interest in maintaining an up to date folio of paper charts drops further (Ref.# 4).

It is conceivable that there would remain a small user market for paper charts but at a small fraction of the current level. At some point it will prove uneconomical to continue to print paper charts in the traditional manner.

### **How a Disruptive Technology Could Help**

Print On Demand (POD) technology provides an ideal transitional strategy for printing paper charts. It carries several strategic advantages over conventional lithographic printing such as no excess stock, printing up to date charts, no warehousing, remote printing etc.

POD is a classic Disruptive Technology. That is, following the general definition of a Disruptive Technology it initially offered a poorer quality of printing but had major strategic attributes to make up for this. Then after implementation, came gradual improvements on the quality side while maintaining the strategic advantages.

By providing a means to print on demand fully up to date charts a HO is relieved of the burden of printing in bulk and then storing and correcting its stock as the charts are sold long after the printing date. Just-on-time printing means no warehousing. In addition, as other mapping agencies also pull away from lithographic printing, the heavy presses have come under less usage and the cost per print rises to meet the fixed cost. In some cases HOs have been left without in-house printing as the host printing agency removed the last of these giant presses.

POD's strategic advantages are too strong to overlook and so POD is now becoming a common printing technology by HOs. One key advantage is remote printing allowing certified printers the right to print a chart anywhere. NOAA OCS has developed a method for certifying private sector POD printers through a quality control process similar to ISO 9000. This allows the OCS to initially certify and then monitor the quality of the printing done at these businesses (Ref# 5).

In summary, POD allows the HO to step away from the responsibility and cost of the end printing and put this into the hands of trusted agents who in turn are paid by the end user.

### **At the Crossroads: the Two Product Dilemma**

Most HOs have dedicated the past decade or more to the provision of ENC's in addition to their paper charts. This has been and continues to be a heavy burden. Despite great efforts to build supporting systems that allow both the ENC and the paper chart (and its Raster twin) to be updated in parallel, maintaining two independent products is a drain on resources. It also perpetuates the "common release" phenomena whereby both ENC and paper chart are held to a common level for official release. In many cases this delays the release of ENC editions until the paper chart edition is equally ready. The same usually holds for Update Messages that are equally paired with Notice To Mariners; one waits for the other.

The motivation for such a common release policy is that there can be one, and only one, "official" chart of an area and ENC and paper are simply the media on which it is available. This concept is valid when the ENC has identical content to the paper chart and the release dates are simultaneous and timely. But the ENC can be and often is far more than the paper chart. Concurrent release has the unintended consequence of delaying release to the professional mariner.

Until this is resolved that situation will prevail. The solution is having one and only one "official" product and given the weight of SOLAS this clearly should be the ENC.

### **We Really Need to Talk About ... Paper**

So where does that leave the paper chart? If the ENC is the official product then paper charts become optional - and this leaves the door open to many alternatives. POD technology expands upon those options.

Nevertheless one cannot simply walk away from paper charts.

For one thing paper charts are still considered a legitimate backup to ECDIS - as long as they are up to date and adequate for the planned voyage. So there is an assumption that HOs will provide them to such users. In reality most users are outfitting for ECDIS/ECDIS (primary/backup) and not ECDIS/Paper Chart as the "up to date and adequate for the planned voyage" clause imposes a substantial financial burden on shipowners. The cost of maintaining two sets of charts (ENCs and paper charts) makes the ECDIS/ECDIS option cheaper and simpler to implement.

A second consideration is that the paper chart is a "foundation product" for a myriad of other uses in engineering, science, coastal zone management, and yet to be documented uses. Withdrawal of paper charts might place a substantial burden on other agencies that take the provision of nautical charts for granted. These users however, in the main, do not need the same "official" status that nautical charts have. Many would also be as well served by digital data or the ability to print the paper chart themselves via POD.

The history of nautical charts being provided by HOs has been so embedded into most coastal countries that inevitably the charts are often cited in law or specific statutes, Orders In Council etc. as they are often the only official literature about a specific geographic area. Withdrawal of the cited charts leaves a gap that would have to be filled. A survey of where such citations occur would be essential prior to any change in policy.

The concept of the paper chart being useful beyond its nominal use as a navigational device applies to many cases simply because there is no other official document to fill that need. The chart can be used in scientific studies, in engineering, and in many other cases yet to be fully documented. The nautical chart in these cases acts as a base or a foundation product. Withdrawal of the paper chart may suit the navigation community but the impact to the wider world beyond is not fully known.

### **Goodbye to Paper - What We Leave Behind**

According to communications guru Marshall McLuhan (Ref # 6) whenever you change media in communications you gain in one area but you always give something up. So taking the nautical chart as a means of communications and paper as the medium being replaced, then by leaving paper we are leaving something behind.

In fact a few things.

#### **Ease of Voyage Planning**

First the paper chart lends itself very well to voyage planning. Having the chart spread out on the table gives the mariner a bigger picture than can be displayed on an ECDIS. Having several charts together on the table and shuffling from one to another gives the mariner the big picture of the voyage from end to end. It also facilitates communicating the plan to a larger group.

Additionally the planner can zoom into any specific areas of interest. Small scale or large scale, it is there at a glance. That's very difficult to do on ECDIS with the same ease.

### **Visual Appearance of Chart Quality**

A feature of paper charts that is difficult to achieve on ECDIS is the immediate appearance of a chart-age/quality indicator. Older paper charts have a special look about them that telegraphs their age. Whether it be the lack of colour, the focus on land terrain, the size and fashion of the soundings, contour lines etc. Those charts today look exactly like the first day they were published 50 or so years ago. What conclusions mariners can make from this look would vary from case-to-case but without question the impression of age is there to see: the chart is old and has not had a modern survey. So too is the case in frontier areas where the data is old and sparse. This "sparseness" is especially telling; navigators need no note to tell them to be cautious as the sparseness of data leaps out at them. Chart age or survey completeness can be digital attributes coded into the meta data but displaying these attributes with the same immediacy and clarity as done on paper is very difficult to replicate in the ENC world where uniformity is the general case.

### **The Logic of Chart Scale**

One of the most frequently quoted advantages of digital map and chart systems is the ability to zoom in to attain more detail and zoom out to give a broader view. This differs sharply from the paper map or chart, which is by definition at a fixed scale. This variable scaling of the data (call it a Google-Earth effect) can be very useful and to the casual user is so common as to appear perfectly natural. Nevertheless casual zooming in and out relies on some clever software and extensive up-front generalization work. It is also a feature that can have the hidden and sometimes dangerous side effect of over-scaling.

Taking a step back from the over-scaling issue for the moment, consider the benefits of a fixed scale. Born of necessity the fixed scale facilitated the development of a modern and systematic approach to surveying and mapping which has carried all thorough the 18th to the 20th century and accounted for probably 98% of all the mapping done to date. Mapping became a science whereby sample observations were taken, analyzed and results presented in a way that the lay public could understand and use. This idea of systematic sampling underlies almost all mapping done up until the end of the 20th Century when the concept of scale-less mapping first became conceivable.

Sampling is a concept deeply embedded into traditional mapping and charting. Sampling varied by factors founded in logic and determined after a systematic analysis of the terrain, the likely end-uses, the technology, facilities, equipment and manpower available, the risks involved and very much the budget allocated. Consider that, in the end, the map or chart had to be printed upon a piece of paper of a fixed size. For charting purposes most charts were sized to fit on a typical ship's chart table. Large charts were cumbersome and hard to store and more likely to rip or crumple. The chart scale was chosen to coincide with the complexity of the area being surveyed. Navigating through a narrow channel meant that mariners had to be able to position themselves within that channel on the chart and that in turn meant that the channel had to be depicted at a certain physical size. A top-down approach had the physical size of the chart dictating the chart scale which in turn dictated the survey scale which dictated the sampling rate - and vice versa. An occasional bottom-up approach had newly discovered and significant-to-navigation features dictating a larger chart scale, often portrayed as an insert. Scale and mapping are heavily interconnected.

Although digital publishing promises to "free us from the chains of Gutenberg" the constraints of printing provided us with the motivation for key intellectual developments such as cartographic generalization and formed the basis of modern cartography. Chart scale, so obvious on the paper chart, was the logical glue that held all of the information together. ENC's do not dispose of scale but they make it much less obvious and permit actions like over-scaling which pushes the limits of the information the chart is showing.

### **Nevertheless Paper Charts Are Doomed**

Despite all of those attributes stated above, paper charts really are doomed. Doomed because they no longer are the best means to pass navigational information to the mariner as ECDIS has formally become the definitive way forward. Doomed because an incoming generation has no use for any information that is not digital. Doomed because no one wants an information source frozen in time and stuck in one and only one way to display itself. Doomed because modern ship design has no room on the bridge for chart tables and cabinets. Doomed because no one wants to spend their time or money painstakingly correcting or adding new information and crossing out the old. Doomed because they are expensive and time consuming to make, to warehouse and to ship. Doomed because they complicate the efficient production of ENC's and Update Messages. Doomed because both print and ENC editions cannot be produced at the same rate for simultaneous release. And doomed because no mapping agency wants to carry the cost of heavy lithographic presses any longer.

As to all of those advantages stated earlier – they can be accommodated with improved voyage planning software such as the Admiralty e-Navigator and future developments in display technology.

### **Paper Products in a Digital World**

With perhaps only a few exceptions, the sales of paper charts are down considerably and trending ever downwards. This parallels the publishing industry everywhere as paper-based information products are down across the board. Digital books sales have been cannibalizing their paper equivalents for years and set to eclipse them in 2017. Newspaper sales and down as are magazine, trade journals and the like. Books, maps, magazines, they are becoming niche products. There will always be a place for some specialized printed books but it is clear that the future for paper products is niche - or nothing (Ref #7).

### **Why The ENC Should Dominate All Hydrographic Products**

Given that the ENC is the SOLAS mandatory product, the paper chart becomes optional and optionality opens the door to a variety of possibilities. The paper chart can remain as it is today or it can be re-published in a variety of ways that meet a specific demand. Nevertheless this will always be a niche area as it is clear that the ENC is the primary product for safe and efficient marine navigation. Therefore the ENC should be the foundation or point of departure for all other products.

### **The "ENC-Out" Approach**

Designers often work from a central purpose or theme; e.g. interface-centric designs focus on how the user interacts with the product, whereas algorithmic-centered designs

focus on solving a central technical issue. Cars can be designed from the beginning to look powerful and fast while others focus on a utilitarian look. The trade-offs always favor the central theme, the base idea or philosophy that guides the design.

Organic design on the other hand incorporates new features incrementally at a slow pace. Some, like the nautical chart have not really changed much over many years and charts created 50 or 75 years ago are still functional and still in use. They do not look that different from one produced 5 or 10 years ago. Trying to take this kind of organic, slowly accreting design into the digital era is fraught with trouble as the early pioneers of ECDIS knew and so they set about a completely different design philosophy.

That is how we end up with two products so divergent in design that it is hard to imagine the underlying digital infrastructure being similar. In fact the two products are so dissimilar that you have to go far upstream to find their common root.

Coming back down that stream to make the paper chart is costly and time consuming. We propose a completely different approach - the ENC-out design. In this case the paper chart uses the ENC as the point of departure, i.e. the ENC is the root source for the paper chart.

This is only possible if one sets aside the paper chart standards of the past and instead focuses on making a paper-based product from the ENC, a P/ENC.

**The P/ENC Paper Chart**

The P/ENC is founded on three principles: one, the ENC provides the primary source data; two, the format of the P/ENC is open and tailorable to different end-products and three, the conversion to a paper product is largely automated with human intervention focused only on clarifying the presentation.

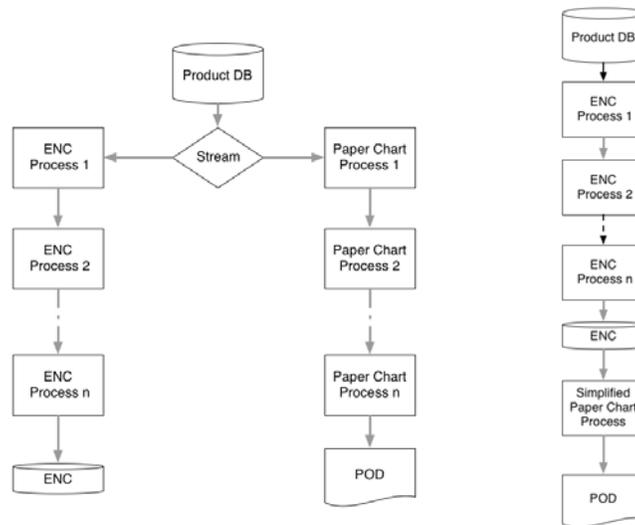


Figure 1: Paper chart as parallel or as serial output from ENC

ECDIS mandation has opened the door to develop a new type of paper product, one completely untied to the conventions of the past. ECDIS also provides the window into eNavigation tools and the portal to directly access navigationally important information from its source. The P/ENC will carry all of the foundation information for a nautical chart but will have a look more compatible with the ENC.

The big issue will revolve around the text information (title block, place names, light characteristics etc.) and the ancillary or marginalia. Much of this information can be printed in the border area or even on the back of the chart. The text fields that fall within the chart boundary need to appear in a clear and decipherable way but this can be accomplished via indexing. Light characteristics for example can be printed on the margin and referenced via a light or buoy index. The Scale can be printed outside the border area and a grid superimposed.

### **Same Source, Different End**

A paper chart unchained by existing standards can take many different forms. One can be similar to that of a conventional paper chart. Another approach is to make a series of paper charts into a long continuous roll to form a customizable emergency "Get Me Home" chart sequence. Alternatively other charts could be bundled into Get Me Home booklets based on geographic region. These could be used as emergency charts or for pleasure craft. Allowing the market to run free will encourage innovative chart designs to flourish and for niche products to emerge.

It may be the beginning of the end for paper charts but there will always be a need for nautical charts of one form or another. From that perspective the future looks quite promising.

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*Note: The opinions expressed in this paper are those of the two authors and do not necessarily reflect those of the Canadian Hydrographic Service nor those of IIC Technologies.*