

## A FIRST GENERATION ENC SERVICES

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### Abstract

The effectiveness of the principles underlying the World Electronic Navigational Chart Database (WEND) has been brought into question by the less than optimal service delivery models existing in 2009. It is contended that the delays in the provision of comprehensive Electronic Navigational Chart (ENC) services, partly as a result of real world challenges in generating the required international production capacity, have been the major factor in the growth of a large market in unofficial data services. However, the future course of electronic charting is now clearly pointing towards a model, recognizable as a WEND, but modified according to regional requirements. This paper reviews the challenges in the delivery of an early official integrated vector chart service aspiring to world coverage, launched by the United Kingdom Hydrographic Office. A number of separate strands are examined, including the significant technical challenges in the translation of historic charted data into the new format and the provision of a robust supply chain from data acquisition to the ultimate delivery of data to the end user.



### Résumé

L'efficacité des principes qui sous-tendent la base de données mondiale pour les cartes électroniques de navigation (WEND) a été remise en question par les modèles de délivrance de services peu satisfaisants existants en 2009. On avance que les retards dans la fourniture de services exhaustifs en matière de cartes électroniques de navigation (ENC) ont été le facteur déterminant eu égard au développement d'un vaste marché de services de données non officielles, en partie du fait des défis pratiques rencontrés pour atteindre la capacité de production internationale requise. Toutefois, le développement futur de la carte électronique s'oriente maintenant clairement vers un modèle identifiable en tant que WEND, mais modifié selon les prescriptions régionales. Cet article examine les défis rencontrés dans la fourniture du premier service officiel de cartes vectorielles intégré visant à une couverture mondiale, lancé par le Service hydrographique du Royaume Uni. Diverses tendances sont examinées, y compris les défis techniques significatifs dans la conversion de données historiques portées sur les cartes au nouveau format et la fourniture d'une chaîne d'approvisionnement robuste depuis l'acquisition des données jusqu'à la fourniture ultérieure de données à l'utilisateur final.



### Resumen

La eficacia de los principios subyacentes de la Base Mundial de Datos de Cartas Electrónicas de Navegación (WEND) ha sido puesta en duda por los modelos de entrega de servicios poco satisfactorios existentes en el 2009. Se sostiene que los retrasos en el suministro de servicios exhaustivos en materia de Cartas Electrónicas de Navegación (ENC), en parte como resultado de los desafíos del mundo real a los que se ha enfrentado para alcanzar la capacidad de producción internacional requerida, han sido el factor determinante en el crecimiento de un amplio mercado en los servicios de datos no oficiales. Sin embargo, el desarrollo futuro de la cartografía electrónica señala ahora claramente hacia un modelo, reconocible como WEND, pero modificado según los requerimientos regionales. Este artículo revisa los desafíos encontrados en la entrega del primer servicio oficial de cartas vectoriales integrado que aspira a una cobertura mundial, lanzado por el Servicio Hidrográfico del RU. Se examinan diversas tendencias, incluyendo los desafíos técnicos significativos en la conversión de datos históricos representados en las cartas en el nuevo formato y el suministro de una cadena de aprovisionamiento robusta desde la adquisición de datos hasta la entrega ulterior de datos al usuario final.

The UKHO has played a significant part in the shaping of standards in nautical charting throughout its long history. In the latter part of the 20<sup>th</sup> Century, it became one of the leading providers of charts and services for vessels engaged in long distance trading. This position was not actively sought, but grew from the high standards of charting demanded by the Royal Navy, sustained by the efforts of its own surveyors at sea and many dedicated cartographers ashore. Throughout the 20<sup>th</sup> Century, hydrographic skills transferred from the old colonial powers, as newly independent countries sought to build their technical capability. The products and services of UKHO are now sustained by the hydrographic data of the Member States of the International Hydrographic Organization (IHO), delivered through bilateral arrangements, for the benefit of mariners worldwide. While many hydrographic offices produce national and regional charts, the provision of worldwide coverage may only be achieved through a comprehensive series of inter-governmental bilateral arrangements recognizing copyright and intellectual property. As perhaps the most complete physical manifestation of the IHO's hydrographic effort, the resultant paper charts and publications remain at the leading edge of the commercial market for carriage compliant products.<sup>1</sup>

The potential for electronic charting to improve navigational safety was recognized by the international community in the 1980s, including some early studies in the North Sea Hydrographic Commission. With the widespread availability and reduced costs of increasingly powerful computer processors, as well as an accurate and ever-present space based navigation system, conditions were favorable for the commercial development of this technology. The accompanying performance standards for Electronic Chart Display and Information Systems (ECDIS) (introduced in 1995)<sup>2</sup> and a common exchange standard for hydrographic data (IHO Special Publication n° 57 (S-57) edition 3.0 introduced in 1996) provided the necessary, but perhaps not sufficient, technical underpinning for the manufacture of both display systems and their navigational data content. Some UK ENC were published at a relatively early stage, although progress was initially constrained by the significant cost<sup>3</sup> and technical challenge. Unsurprisingly, the development and production of ENCs centered on the national hydrographic offices with a mature capability, a situation that did not materially change until well after 2005. As a result, ENC coverage was restricted to isolated areas of excellence, with some strategic straits being covered by cooperative international ventures. This patchy coverage provided a significant influencing factor in explaining the International Maritime Organisation (IMO) Maritime Safety Committee's reluctance to adopt what appeared to provide a positive contribution to navigational safety. In terms of im-

provement of navigational safety at sea, the core *raison d'être* for the IHO and an essential part of IMO's wider remit, the authoritative Det Norske Veritas (DNV) Classification Society published a report in April 2007<sup>4</sup> which asserted that ECDIS was a cost-effective risk control option for many combinations of ship types, size and age. Nevertheless, the lack of continuous high quality coverage along the main shipping routes discouraged shipping companies from the significant financial investment in ENCs. However, with an ECDIS system (or even non-type approved electronic chart system) fitted, many of the significant benefits of ENCs could already be enjoyed by the use of other products such as the Admiralty Raster Chart Service (ARCS) and unofficial vector charts in a variety of proprietary formats. The most significant advantages are, firstly, improved real time spatial awareness, leveraging GPS positioning and linkage to other navigation aids, such as ARPA, and, secondly, an updating system which requires little operator input. Weighing the relatively modest costs of such electronic chart services against their operational benefits, it is un-surprising that display systems for non-ENC data have proliferated. Their utility is such that, even without the *imprimatur* of carriage compliance, they far outweigh the market penetration of ENCs. As a major provider of papers charts with a large naval customer, UKHO may have been expected to develop a competing ENC service at an early stage, but it is contended that a major factor discouraging such an initiative was the existence of the WEND principles.

The stated purpose of the WEND is to ensure a consistent level of high-quality updated ENCs through integrated services that support the SOLAS Chapter V chart carriage requirements. The principles of WEND are thoughtfully constructed and strict adherence could have resulted in the desired comprehensive coverage through the efforts of Member States of the IHO. However, subsequent difficulties in building a comprehensive worldwide database have exposed the failure of the WEND proponents to recognise the limitations in the corporate IHO production capability. Perhaps the most important defining feature of WEND is the responsibility placed on IHO Members States to establish, for waters of national jurisdiction, a mature supply system for ENCs and their subsequent updating. This is facilitated by either nationally produced ENC coverage, or through arrangements with other States to produce the necessary ENC coverage on their behalf. Only one ENC should exist for each area in the relevant navigational usage band; this effectively prevents any single nation providing an ENC "world view" based on a mixture of adopted, derived or compiled charts, which could have provided a digital equivalent of, for example, the Admiralty standard navigational (paper) chart series.

As the WEND concept effectively removes the possibility of a single official producer creating a world series based on ENC data derived from other nations' data, such a series will only be completed when the final producer Member State either makes its ENCs available for distribution or allows another to act on its behalf. Under the WEND principles, the IHO intended to address overall coverage on a regional basis through Regional Hydrographic Commissions. The record of success within the various Commissions is mixed, but in general the level of coordination anticipated has not been forthcoming. The "unofficial" market contains no such hindrance; indeed one producer demonstrated that the provision of consistent world vector charting was a straightforward technical proposition.<sup>5</sup> Another unintended consequence of placing producer responsibilities on individual hydrographic offices was the very inconsistent quality of the ENC output. Developing an ENC production capability is neither simple nor inexpensive and sometimes the loss of a single key compiler may affect the entire national output. This is a particular risk while ENC trained compilers are in short supply and the majority of hydrographic office resources are otherwise engaged in paper chart production. Similarly, it was difficult to foresee the degree to which ENCs would be used as an instrument of national sovereignty, with individual nations extending coverage into disputed waters (and beyond). The built-in assumption of WEND is that nations would cooperate fully to ensure worldwide availability.<sup>6</sup> Unhappily, the reality of the current state of the chart database suggests that the WEND principles have failed to address the growth in capacity needed to deliver the WEND architects' vision, leading to their subordination to national and commercial priorities as the main ENC service providers attempted to address market demand by a variety of direct supply arrangements with producer nations working outside the general understanding of the WEND principles.

Market research during 2004<sup>7</sup> indicated that the barriers to widespread adoption of ENCs could be grouped into three main issues. Firstly, the coverage was not continuous, particularly along the arterial sea highways between the main trading nations. In Europe, regional trade could be supported by near complete ENC coverage; there were others areas of excellent coverage across the globe, but these tended to be isolated and based around the more developed nations. Secondly there were concerns about consistency, perhaps arising from different national interpretation of the exchange standard S-57 and portrayal elements. But other issues also contributed to this disjointed picture. The best ENC coverage is probably that compiled from rich underpinning hydrographic source data. Unfortunately, virtually all producers were forced through economic necessity or operational expediency to convert many of their existing paper charts into vector data. This process

had a number of short term benefits, primarily that of allowing a relatively rapid growth in the ENC portfolio, but it is unlikely to deliver the full potential that digital charts offer. It is important to note that most unofficial charts are also digital facsimiles of existing paper charts. Finally, given the relatively limited coverage and consistency, the ENCs did not represent good value for money in comparison with the existing paper chart coverage. Somewhat exaggerated calculations were made which showed that ENC costs were significantly more expensive than paper charts for long term use. The challenge presented to the IHO and its Member States was clear: address these issues or allow unofficial data to prevail in the digital environment, perhaps ultimately leading to the exclusion of ENCs from the commercial market. For its own survival as a provider of world charting, UKHO had to take a position of leadership in this arena. There was also the related issue for UKHO that the UK Royal Navy had already entered into a comprehensive fleet-wide ECDIS fitting programme and would need a quality-assured and carriage compliant ENC folio, suitable for distant operational deployments.

At the end of 2006, UKHO sought to address this challenge in the most direct way, by the decision to develop the Admiralty Vector Chart Service (AVCS). The aim was to provide comprehensive ENC coverage from a trusted source to recognized standards. The service sought to combine all available ENCs, validated either through a RENC service or independently by UKHO. New ENCs were to be manufactured by UK, using existing paper charts as source material, to bridge the gaps in existing coverage, until the producer nation had developed its own manufacture and maintenance capability. To overcome concerns in relation to consistency, permissions were to be sought to "harmonize" adjoining ENCs, so that the mariner was presented with a continuously smooth flow of data on passage. To focus production efforts, it was decided to concentrate on the main trade routes, identified from a number of sources, and the top 800 ports<sup>8</sup> and their approaches, which accounted for 80% of port calls made by merchant vessels.

The original launch date of May 2007 proved over-ambitious and perhaps, in a similar vein to the WEND principles, reflected a gross underestimation of the real world problems of this complex undertaking. Despite strenuous efforts to persuade IHO Member States of the advantages of allowing UKHO to harmonize ENCs within national boundaries, and with the adjoining coverage of other nations, there was little enthusiasm for this concept. If UKHO were to undertake this work, it would have delivered a modified (or perhaps "derived") ENC, which would have been distributed solely through the medium of AVCS, in order to recover the significant production costs.

This was, for many nations, clearly at odds with WEND objectives. Interestingly, the concept of harmonization had also been recognised and subsequently embraced by a number of Regional Hydrographic Commissions, most notably the Baltic Sea Hydrographic Commission, in their work package which was initiated in 2007. At a more local level, bilateral partners such as France and UK meet regularly to ensure chart coherence at the maritime boundary. All this is possible with the close cooperation of willing partners, which is often sadly absent. Although much of the production of infilling ENC's required data permissions from the relevant responsible nation (often the adjacent littoral state, but in other regions a capable third party such as France), some of the early production by UKHO was commenced with little insight into the aspirations and intentions of the relevant national hydrographic offices. Undoubtedly, some of this early output was wasted in the duplication of work already underway, but many of the remaining gaps were filled with either UK or locally produced ENC's. This coverage was particularly important along trade routes which passed through the littoral waters of developing nations. Undoubtedly, some of this early output was wasted in the duplication of work already underway, but many of the remaining gaps were filled with either UK or locally produced ENC's. This coverage was particularly important along trade routes which passed through the littoral waters of developing nations.

A further key factor in the achievement of the necessary coverage was the necessity of encouraging new supplier nations to join a Regional Electronic Navigation Centre (RENC). To date, several key ENC supplier nations have chosen not to join either of the two European-based RENCs or the International Centre for ENC's partner in Australia (AUS-RENC); in this case it was necessary to secure a direct supply into the UKHO Value-Added Reseller (VAR) operation. At the time of writing, these include Japan, United States, Canada, Korea, India and China. Therefore, some of the trading nations most dependent on globalization and maritime trade are content to distribute their ENC's without consolidation through a RENC, which is one of the central building blocks of WEND. The two RENCs are not by any means similar bodies. Their controlling bodies ("Steering" or "Advisory" groups made up of representatives from the RENC Member States) have quite different views on the control of data distribution, with one (PRIMAR) operating a more sophisticated service for distributors, which extends well beyond basic validation and collation of ENC's. Such differences do not detract from the more important functions common to both. It was therefore necessary to offer an integrated service that combined the output of the two RENCs, which provide effective vehicles for ENC consistency and reliability, with the individual national suppliers. A substantial engagement plan was devel-

oped to bring several of these nations into the supply chain; this was to be another challenge for which the early timetable proved over-optimistic.

At the Extraordinary WEND meeting, held in Monaco in October 2007, UK presented their ideas for realizing the WEND concept through the new service. The proposal centred on the three main tenets of seamless coverage, improved consistency and reduced ENC costs. By this time, some of the key challenges in providing a safe and reliable service were becoming apparent and it is worth examining these in some detail.

All ENC's are expected to refer to the WGS84 datum, so that positions derived from GPS navigation are directly plotted. Yet many of the paper charts that provided the source material for ENC's were referred to a local horizontal datum and, in many remote areas, the bathymetric data is sparse, drawn from diverse sources and relatively old. It is interesting to note that the positioning of modern offshore structures on these often ancient charts may have been plotted using unconverted GPS-derived geographical co-ordinates, as this was considered a more safe practice. There are a number of dangers inherent to the paper to ENC conversion, not least in the presentation of old data in a new electronic format which incorporates no clear method to definitively indicate the provenance of the data<sup>9</sup>. The ENC may therefore appear misleadingly accurate. Additionally, given the often incomplete geodetic network ashore, applying straightforward datum transformation may not be possible and there is consequently a lengthy and expensive process to ensure consistency with satellite imagery. Provided a coastline has recognizable features, it may be accurately referred to WGS84, but the position of hydrographic features on the same chart cannot be adjusted with the same confidence unless their positional relationship to land features is well established. This latter issue is particularly problematic in archipelagic regions, some of which straddle key sea lanes.

As with paper charts, there is an expectation that ENC's will contain the most up-to-date information available to the charting authority. Indeed, the definition of an ENC is that such updating is incorporated into the chart. There are unfortunate examples which indicate that ENC maintenance is not always of a high standard. For example, in 2008 Country A issued a Notice to Mariners warning of the "non equivalence" of a number of ENC's within its country portfolio which, although not stated in the notice, resulted from a failure to update these charts for 4 years. Also in 2008 the entire ENC portfolios of countries B and C were temporarily withdrawn from service until a robust updating regime was in place. This is not a criticism of any individual office. In reality it is very difficult to run the parallel paper and digital output within already constrained budgets.

One solution already available is for larger partners, with agreement of the producer nation, to take on the routine updating task. Another seductive panacea is the implementation of a national hydrographic database. In principle, this should allow trained personnel to manage a definitive set of data from which charts could be produced in any desired media. There is little doubt that contemporary technology is beginning to deliver the hardware and software to underpin this capability, but the associated training requirement presents a significant overhead. A common thread running through the various difficulties described is that of availability of resources, particularly trained “digital” cartographers.

A third issue, previously mentioned, is the problem of creating a single “world view” when so many near neighbours cannot agree on what that view should look like. Many overlapping ENC’s in the same navigational usage band have been inadvertently introduced during the manufacture phase. This is perhaps unsurprising since most ENC’s are based directly on paper chart coverage. Such overlaps exist at both national and trans-boundary level, but they may be readily solved over time. More insidious are the deliberate overlaps produced in association with disputed sovereignty claims. This contravenes the WEND principles, which call for the establishment of bilateral “technical arrangements”, based on sound cartographic practice, rather than political status. For example, country D unilaterally issued its own national coverage (which also covered waters of their near neighbour) to duplicate existing coverage, which had been issued some time previously after joint agreement by several countries (including country D!). At the 11th WEND Committee meeting, held in Tokyo in September 2008, the committee members provided the moral authority for integrated service providers to take action which could address this problem<sup>10</sup>. In reality, this issue is almost certainly best addressed by the infringing nations concerned and it would be difficult for a service provider to take unilateral action. For some nations it appears that the depth of concern about disputed maritime boundaries transcends issues relating to navigational safety and the hydrographic office is used to propagate the views of their respective foreign ministries. Unofficial data providers may in general avoid such structures.

The development of ENC’s from the perspective of the IHO has been very much about the issues above. Less emphasis has been placed on the distribution services that bring the charts to the mariner on the bridge. This is not a practical problem for most hydrographic offices, which rely on capable government and commercial organizations to provide end-user services. Nevertheless, for the mariner the service delivery element is crucial in ensuring the timely arrival of ENC’s, corrected

up to the latest Notice to Mariners. The IC-ENC RENC concept is that this area is best left to capable service providers (known as Value Added Resellers or, more commonly, VARs) who deal directly with the end user, in a competitive environment. This theoretically promotes innovation in both delivery techniques and the service or product provided alongside the ENC’s. Typically this might include routing or port information. In reality, with the lengthy delay in the creation of a true WEND, the fertile environment necessary for such innovation has not been evident, and few of the ENC-based services match the utility and scope of their better established “unofficial” rivals. However, AVCS provides the first WEND-based service with comprehensive global coverage and one might expect that, with the mandated ECDIS carriage requirements ahead, this situation will rapidly improve.

At the time of writing discussions are once again underway to better coordinate the activities of the RENC’s. Although this is a potentially positive move, it may nevertheless be some time before the WEND emerges in the form envisaged by its creators and the full benefits of ECDIS, including the relatively straightforward distribution options, are therefore unlikely to be apparent in the short term<sup>11</sup>. To put matters into perspective, there appears little doubt that the integrated picture offered by ECDIS is already highly popular, safe and effective in the hands of well-trained bridge teams. AVCS is, for the time being, the most significant ENC service with a coverage approximating to WEND. Although it represents a first generation service, there are plans to rapidly expand its scope in order to meet the needs of the navigator, including chart folio management and voyage optimization tools. For the foreseeable future, there will be a significant effort in providing the outstanding coverage, particularly in the busy Far East sea lanes, and in improving the quality and consistency of the existing coverage. The IHO 2010 deadline for the provision of adequate ENC coverage is imminent and with the 2012-18 ECDIS carriage timetable looming there can be little relaxation on this effort. In its notable efforts to engineer an efficient solution to the provision of worldwide ENC coverage, the IHO provided a technical framework and guidance for its Member States which may yet prevail. However, the rate of expansion of coverage has been disappointing and it is arguable that without the catalyst of AVCS, the IHO would have possessed insufficient collateral to convince the IMO’s Maritime Safety Committee that it was time to mandate the use of ECDIS.

**This paper represents the views of the author and not the official view of the UK Hydrographic Office.**

## References

<sup>1</sup> Carriage compliant products are those charts and publications, produced under the authority of official government hydrographic offices, normally required by the Maritime Safety Administrations of the State in which an individual ship is registered. These are required under IMO SOLAS Chapter V. Even in 2008, conventional paper products are outselling the equivalent ENC's and digital publications by a factor of at least 10:1.

<sup>2</sup> IMO Resolution A.817(19), which also defined the ENC as a *database, standardized as to content, structure and format, issues for use with ECDIS on the authority of government-authorized hydrographic offices. It contains all the chart information necessary for safe navigation and may contain supplementary information in addition to that contained in the paper chart....*

<sup>3</sup> The first ENC manufactured in UK is estimated to have cost £30,000

<sup>4</sup> DNV Technical Report no. 2007-0304 (revision 1 published 10 Apr 07) *The Effect of ENC coverage on ECDIS Risk Reduction* (Vanem, Gravir and Eide)

<sup>5</sup> With significant resources at its disposal, the US National Geospatial Intelligence Agency also produced a world vector chart system (Digital Nautical Chart – DNC) at an early stage for the US Navy, but this was not directly compatible with the S-57 data exchange standard.

<sup>6</sup> The efficacies of the WEND principles are dealt with in depth in the paper “The WEND Concept for a Worldwide ENC Database – Past or Future?” (Hecht/Kampfer/Alexander) *International Hydrographic Review* Vol.8 No.2 Nov 2007

<sup>7</sup> “*Barriers to the Adoption of ECDIS*” (Capt Paul Hailwood), commissioned by UKHO and Singapore MPA, published Oct 2004

<sup>8</sup> As defined by deadweight tonnage by Lloyd’s Register Fairplay, with routes extracted from AMVER data and commercial shipping information sources.

<sup>9</sup> The “CATZOC” (Category Zone of Confidence) method is used to present information relating to the positional accuracy of hydrographic data within the chart. Already a rather crude measure, it is not always applied with great care and is presented to the mariner in a less than intuitive manner.

<sup>10</sup> The S-57 standard requires that there is no overlap of ENC data within usage bands. ECDIS systems will

operate unpredictably in areas where overlapping ENC data is present; for this reason overlapping ENC data is not acceptable in end-user services. Where overlapping coverage exists the producing States should recognize their responsibility and take the necessary steps to resolve the situation. In situations where overlapping data cannot be resolved through negotiation, the ENC producer(s) can anticipate that an end user service provider may need to take action itself to eliminate the overlap or discontinue services until the issue is satisfactorily addressed. Any such action to eliminate overlap should be communicated in advance to the affected ENC producer(s) and be based on guidelines that emphasize navigation safety, such as the following:

1. Scale of the data compiled in the ENC,
2. Currency of data in the ENC - i.e. most recent surveys, shoalest soundings, wrecks, rocks, and obstructions,
3. Avoidance of dividing navigationally significant features between producers. For example, Traffic Separation Schemes should be handled by one producer or the other.

GUIDELINES FOR THE IMPLEMENTATION OF THE WEND PRINCIPLES section 1.7 as endorsed by the 11th WEND Committee Meeting, Tokyo, 2-5 September 2008.

<sup>11</sup> One factor the DNV report did not consider is the significant challenge of training the several hundred thousand deck officers who will be required to operate “paperless bridges”. There are already several cases of groundings associated with the incorrect use of ECDIS. This should not, however, detract from the substantial safety improvements inherent in the maintenance of real-time spatial awareness.

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## Biography of the Author

**Vaughan Nail** has recently left the post of UK Deputy National Hydrographer and returned to duties with the Fleet. As Hydrographer of the Navy, he is responsible for the operational effectiveness of hydrographic, oceanographic and meteorological specialist ships, facilities and personnel. He has been a hydrographic specialist since 1981 and taken part in a variety of operations in home waters and overseas, most recently as the first Commanding Officer of HMS Enterprise. A Fellow of the Institute of Marine Engineers, Scientists and Technologists, he is also a Chartered Marine Scientist and chair of the Hydrographic Services and Standards Committee of the International Hydrographic Organisation.