NATIONAL MARITIME MUSEUM

Royal Institute of Navigation
Science Technology Practice

Symposium

After Longitude – Modern navigation in context

National Maritime Museum, Greenwich, London
Thursday–Friday, 22–23 March 2012

Frank Reed

Lunars and 19th-century American commerce in the Pacific

An analysis of the significance of lunars (lunar distance observations for longitude) based on the extensive logbook collections of American whaling vessels and other commercial vessels in New England museum archives, especially those of Mystic Seaport Museum in Connecticut.

While lunars appear to have faded rapidly from common use on British vessels, they remained an active, important navigational tool through about 1850 aboard American vessels which, especially through the whaling industry, had converted vast stretches of the Pacific Ocean, including the Hawaiian Islands, into an American lake. Primary-source evidence for lunars includes direct statements of longitudes in formal logbooks as well as actual calculations preserved on scrap paper and otherwise unused pages in the backs of old logbooks. The evidence shows a relatively consistent pattern of lunar distance use related to the phase of the Moon that is not recorded in navigational manuals or secondary-source histories.

Dr Wolfgang Koberer

Position without calculation: Analogue instruments for position finding in astronomical navigation

One of the main complaints about astronomical navigation – especially of finding longitude by lunar distances – was the tediousness and length of the computations required. According to some sources it took for instance several hours to reduce a lunar distance to find local time and longitude. Short methods and tables were devised to cut down on the labour of calculation but still the methods required quite some time and effort and perhaps a mathematically bent navigator. This even applied after the advent of the Position Line Navigation.

Therefore during the past centuries – after Harrison and Maskelyne – a lot of ingenuity was invested in inventing analogue instruments which would

remove the need for lengthy calculations. Actually the earliest drawing of such a device can be found in the 16th century with similar instruments in later publications.

Since the 19th century such devices were actually built. They never really found a place in the practice of navigation and with the advent of satellite navigation they have become completely obsolete. The talk will present the most important examples and try to show how they supposedly worked.

Terry Hayward

The early development of air navigation

The paper will outline the problems that faced aviators during the early years of flying. It will discuss how the navigation techniques developed by mariners were adapted to meet the new challenges and describe the new techniques and equipment devised to overcome the problems of navigating in three dimensions with no reference to landmarks.

Guy Boistel

Unity and diversity of the naval observatories throughout the world, 1800–1914

This study proposes to draw up a first panorama of the naval observatories during the 19th century, in Europe and in the world, studying their establishment and their evolution.

On the basis of the assertion of the astronomer Lewis Boss who made in 1891, a clear distinction between astronomical observatories and naval observatories, and with the help of a comparison between the observatories of the Bureau des longitudes and the French navy in Paris (Parc Montsouris), the U.S. Naval Observatory or the naval observatory at Nikolaiev (Russia), of the Black Sea Fleet, we show that this distinction is quite not so simple.

As a matter of fact, at the end of the 19th century, some naval observatories, regularly in charge of the time service for seafarers, have also a considerable astronomical activity (comets, small planets), as well as a scientific activity concerned with geophysics or oceanography. We thus try to find clear comparison criterions between civilian and military naval observatories and their scientific concerns, throughout the world and mainly in Europe, between 1800 and 1914. Some particularly interesting cases are presented, like the scientific evolution of the Seewarte of Hamburg or the case of the observatory of Bidston near Liverpool for example.

Yuto Ishibashi

Accurate time for mariners: Time-keeping and signalling in mid-Victorian Liverpool

The aim of this paper is to investigate how scientists and engineers engaged in a process that led to effectively distributing accurate time to mariners in Victorian Liverpool.

In the middle of the 19th century, Liverpool was a place where the method of communicating accurate time for the purpose of navigation was significantly improved. Initially, a time ball was attached to the Liverpool Observatory where its principle intended role was to display accurate time in the large seaport.

Once the Royal Observatory at Greenwich launched the public time-service, the Electric Telegraph Company created another time ball at their Liverpool office in 1853. This was a new development as it was operated by an electric current from London. Then John Hartnup, the director of the Liverpool Observatory, who questioned the accuracy of the company's time ball, succeeded in setting up a public clock in the city that was electrically controlled from the observatory. This was also made possible through the cooperation of the other telegraph company, which allowed him to relentlessly engage in the pursuit of disseminating time to the chronometer makers and the local populace. This paper will argue that a series of newly established technologies in Liverpool was of great importance to the history of time-keeping, signalling, and navigation.

Norman Bonnor

Navigating at 50,000 and 500 feet during the Cold War of the 1950s and 60s

This talk covers the navigation systems and techniques used in the Valiants, Victors and Vulcans of the Royal Air Force during the 1950s and early 1960s for operations at high altitude. The early problems of poor reliability, and the methods used by the crew members to achieve better accuracy, are discussed.

The story continues with how these techniques and training methods were changed to cope with low level operations required by the introduction of improved surface-to-air missiles in the Soviet Union.

Frank Reed

Lunars in the Space Age

While lunars (lunar distance observations) for the determination of Greenwich Mean Time generally ceased to be significant by the middle of the

19th century except in rare circumstances, lunars have enjoyed a modest renaissance among modern navigators for a variety of reasons, most especially as a simple means of testing sextants. But they were also observed by astronauts in orbit in navigational experiments in the early days of manned space flight. NASA archival material demonstrates that lunars were successfully observed with hand-held sextants by astronauts in orbit almost 40 years ago. The observations can be analysed using the standard methodology of circles of position extended to three-dimensional space. These lunars yield position fixes, rather than time determinations, and that principle can also be applied to navigation on the surface of the Earth.

Pat Norris

The longitude challenge in deep space

The proliferation of global navigation systems such as GPS rigorously tied to a Greenwich longitude reference does not assist with the challenge of navigating in deep space, i.e.: beyond low Earth orbit. The equivalent coordinate in deep space is the Right Ascension of the Ascending Node which is referenced to the First Point of Ares. In practice, spacecraft trajectory information referenced to a planetary ephemeris will to some extent be inconsistent with radar measurements taken at a ground facility whose coordinates are referenced to Greenwich longitude. This paper will illustrate the issue by describing the significant impact this space age longitude problem had on the *Apollo* moon landings. The continuing relevance of the issue to deep space navigation will be discussed.

Nick Ward

From lighthouses to e-Navigation

Lighthouses were once a vital means of navigation round our coasts. They are still important as a hazard warning and to confirm positions arrived at by electronic means. However, Global Navigation Satellite Systems (GNSS) are now the primary method of maritime navigation and will be central to its future, in the form of e-Navigation.

This paper looks at the history and changing roles of visual aids to navigation, the development of radio-navigation, from beacons through hyperbolic systems to satellite navigation. The advantages and limitations of the different systems are considered and the measures that will be needed to meet the performance requirements of e-Navigation are assessed.

Richard Easton

From Harrison to GPS

The development and deployment of accurate clocks aboard GPS satellites is a modern analogue to John Harrison's work on the marine chronometer during the Longitude competition of the 18th century. John Harrison solved the longitude problem by building an accurate clock that essentially synchronized time between the departure port and the ship's current position. *Circa* 1 June 1964, Roger Easton from the Naval Research Laboratory discussed the accuracy of the Hydrogen Maser with Dr Arnold Shostak from the Office of Naval Research. They agreed that it made range measurement using accurate clocks in satellites feasible, and soon after Easton started work on TIMATION, the main predecessor system to GPS. The atomic clocks used in GPS are about 10^6 more accurate than Harrison's clock. GPS provides world-wide clock synchronization to everyone who can detect its radio waves.

Winning acceptance of a novel concept often requires a bridge between current techniques and the new approach. US Navy navigators in 1965 used celestial navigation which measures a star's angle above the horizon. An important analog that sold TIMATION was the celestial transformation. Instead of determining the star's angle, the navigator measured the time a signal from a TIMATION satellite took to arrive at a receiver.

This paper will discuss these and other developments between 1770 and 1973 which led to the initial selection of GPS's characteristics.

Heloise Finch-Boyer

What does digital do? Representing and acting on 'safety' and 'accuracy' as paper sea charts became digital charts 1977–2010

This paper explores the nature of geographical representation by showing how marine navigation charts have shaped ideas about the reliable depiction of the world. Well into the late 1990s, ship captains and governments considered the paper sea chart, a centuries-old tool for marine navigation, as the safest way for ships to navigate. Their (over)reliance on paper representations of the world influenced the international development and acceptance of digital navigation charts.

I look at why paper sea charts were considered safer and more accurate, helping us think theoretically about the properties of digital versus paper cartographic representations. Unlike in the aviation industry which adopted digital charts from the 1970s, shipping companies, national chart-makers and the International Maritime Organisation (the UN body concerned with the sea) considered that digital sea charts were not as safe or as truly representative of the world as paper sea charts.

I demonstrate why entrepreneurs thought digital charts were safe, and why international policy-makers rejected digital chart innovations as 'unsafe' until

2002, by showing how discourses about the safety or 'truth' of marine charts were conceptually and semiotically coupled to the material form of charts as paper or digital.

Paul Saunders

Automated position reporting – aspirations and their realisation, across domains

Investigation of archive material shows that, long before navigation system accuracy and communications technology could support the concept, it was recognised that automated reporting of a vehicle's position had the potential to increase flexibility, safety and effectiveness in civil and military, air, land and maritime navigation operations.

Research further shows that inertial systems provided the first realistic means of generating position reports for automated reporting. When combined with radio ranging techniques in the Joint Tactical Information Distribution System (JTIDS), a robust cooperative navigation system emerged, before and independent of GNSS. A revolutionary change in air-to-air combat operations was the result. Moreover, the associated change in tactical level operational philosophy provided the impetus for development of many of the more general concepts of Network Centric Warfare (NCW); especially Shared Situational Awareness and Self Synchronisation, which have, however, depended on the widespread introduction of integrated GPS equipment to progress towards realisation.

Although terminology differs, NCW concepts can be used yet more generally, to describe recent developments related to Automated Position Reporting (APR) in the civil air and maritime domains; based on use of Automatic Dependent Surveillance – Broadcast and the Automatic Identification System respectively.

This paper examines the aspirations, current operational impact and future challenges and benefits associated with APR, in its various guises – across domains.

Dr S E Taylor

Electronic navigation systems on fishing vessels: applications in sub-sea hazard avoidance

This paper describes the development of electronic charts of sub-sea hazards and their associated systems for the Fishing Industry. The use of these systems are vital for the safety of UK fishermen since a number of vessels have in the past sunk as a result of their trawl gear becoming jammed on sub-sea infrastructure. The systems are in regular use by the UK fishing industry, especially in the North Sea where there is great potential for conflict between the Fishing Industry and the offshore oil and gas industry.

The project arose out of close co-operation between Oil and Gas UK, The UK Cable Protection Committee (UKCPC), The UK Sea Fish Industry Authority (SFIA) and the Fisheries Legacy Trust Company (FLTC) with technical support from ourselves Geomatix. The use of the electronic charts benefits all parties concerned – fishing vessels can avoid these hazards when trawling and can operate more safely whilst the oil and gas companies suffer less damage to seabed infrastructure. A recent spin-off from this project is a unique stand-alone warning device for the fishing industry known as FishSAFE. Using the same dataset as the other systems FishSAFE uses a look-ahead algorithm to audibly alert the fisherman of the presence of seabed infrastructure well in advance of a possible collision. The paper will describe the development of these systems – from planning to data gathering and product delivery.

Heather Maguire

Airwaves and waterways: digital aids to navigation and the changing nature of seafarers' work

Looking around the wheelhouse of *Victorious/John J. Carrick*, as she traveled slowly through the St. Lawrence Seaway, I tried to make sense of the vast array of aids to navigation made available to the crew: ECDIS, AIS, Radar, DGPS, and SatC – the list could go on.

'Which of these is the most important?' I asked the Captain.

'All of them. A carpenter doesn't just use a hammer,' Captain Mark replied.

Based upon my month-long ethnographic journey that covered over 4000 nautical miles through the Great Lakes – St. Lawrence Seaway system and out into the North Atlantic – this paper aims to consider the changing nature of seafaring work with the advent of new (digital) technologies. I argue that while these technologies increase the efficiency and safety of the vessel and provide navigation crew with different information than was previously available, they simultaneously call into question the tacit knowledge that navigators develop. Navigators' use of their senses and intuition, which is based upon many years of lived experiences, is being challenged by the privileging of electronic data such as that made available by ECDIS, AIS and VDR.