Time and Tide...

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Like many others I suspect, I use the summer to catch up on my reading. And this year I finally caught up with a book I meant to read some time ago and that is now out in paperback (and hence good for the beach): *Longitude* by Dava Sobel (4th Estate, London, ISBN 1 85702 571 7). It is a story of inspiring vision and small-minded bigotry, fashioned around a heady brew of technology, politics, money and religion.

The story centres on one of the biggest technological problems of the 18th century – how to know where you are at sea. It was easy enough to know one's N/S position (latitude) – by reading the angle of the sun at noon; but there was no way to ascertain with accuracy the E/W position (longitude). The problem was highlighted when Admiral Sir Clowdisley Shovell (what a fabulous name) was leading his small fleet of prize ships, full of captured treasure, back to England after a series of skirmishes in the Mediterranean. Anxious to avoid coastal rocks, Sir Clowdisley summoned all his navigators – who agreed that they were safely west of the Brittany peninsula. So they continued north into a foggy night and on October 2nd 1707 Sir Clowdisley's flagship – the *Association* – struck the Scilly Isles. Shortly afterwards three of the four other ships also struck the rocks and sank. Over 2,000 men and an astronomical quantity of treasure were lost. They thought they were out in the Atlantic well to the west of any danger, and they paid a heavy price for their miscalculation.

Spurred on by a catalogue of death and destruction, and in particular the disaster of Sir Clowdisley's fleet, Parliament finally established the Longitude Act of 1714, which offered a prize of £20,000 to any person able to provide a 'Practical and Useful' means of measuring longitude. Enter one unknown and largely self-educated clockmaker from Yorkshire – John Harrison.

Harrison was confident that he could provide a solution based on accurate time-keeping. He argued that all the navigator needed to know was the *current* time on board ship (from observation of the sun), and – simultaneously – the time at one's home port. The difference between these two times provides the E/W measurement since every hour of time represents 15 degrees of longitude. The ship therefore must carry a clock set to time in the home port and kept at that time as a benchmark to compare with the 'on-board' local time. In order to win the prize, Harrison had to measure longitude to within half a degree, and this meant building a ship's clock capable of maintaining time to a precision that was quite unheard of in the early 18th century. It was normal for clocks of the time to be accurate to within 15 minutes in 24 hours. Harrison's challenge was to build one that did not gain or lose more than 3 seconds in 24 hours.

It is a fascinating story and Harrison's technical wizardry shines through it as he moved from the original prototype H1 (1737), through a series of refinements in H2 (1741), H3 (1759), H4 (1760) and finally H5 (1770). In the process, and in pursuit of his personal Holy Grail, Harrison tackled and cracked innumerable technical difficulties, for example temperature regulation, lubrication and balance.

- Changes of temperature as ships sailed from the Arctic to the Tropics created havoc with the precision of movement of the clock mechanisms. It was Harrison who developed a bi-metal strip (brass and iron riveted together) and used it to enable the clock to adjust itself for temperature change.

- Having started life as a carpenter, Harrison's first solution to the problem of bearing surfaces was to use lignum vitae, which exudes its own grease and therefore has a self lubricating quality. Later he develop the caged ball-bearing whose smooth operation is central in so much machinery to this day.

- The clocks of Harrison's day all used pendulums to regulate their movement, but the pitching and rolling of a ship destroys the regular swing of the pendulum. Harrison developed a series of ever more subtle springs and escapements to replace the pendulum, which eventually allowed the development of the chronometer.

But the story is not by any means all technical. It is also – in parts – hilarious and sad, particularly in the context of the competing theories that existed for determining longitude (of which there were many given the value of the prize). The Wounded Dog theory for example – proposed by Sir Kenelm Digby – relied on the crazy idea that the yelping of wounded dogs could be made to signify noon in London!

Somewhat less ludicrously, the Lunar Distance Method was not an 18th century contraceptive plan but was rather the source of Harrison's major competition. It was the theory favoured by the official astronomers of the day – perhaps because it provided them with endless lucrative employment. The idea was that the movement of the moon could be mapped against the whole field of stars and result in star tables that would allow the navigator to compare the observed position of the moon from the ship to the position that the moon would be in (say) London. Some highly complex mathematics was then needed to translate the difference between the two into a longitude position. Nevil Maskelyne, the Astronomer Royal (in residence at the newly established Greenwich observatory) was determined to undermine Harrison's clocks and sell his Nautical Almanac full of tightly packed astronomical data. Between 1765 and 1811 he published 49 issues, and sailors around the world became used to the tedious task of calculating their position using it. Those sailors that did not have a Harrison chronometer had no real alternative and interestingly, it was through this custom and practice that Greenwich became the Prime Meridian – zero degrees of longitude. But Maskelyne's solution to the longitude problem was an astronomer's solution. Harrison's was a practical man's solution – and sea captains were practical men (Cook loved it). So as Harrison's famous chronometer became more and more available, Maskelyne's almanac became increasingly redundant – for sea captains at least.

Several things about this fascinating story resonate with me in terms of design and technology in schools. There is for example a plentiful measure of triumph over adversity, for not only did Harrison overcome his lack of formal education but he also battled for years to overcome the technical difficulties that littered his path. And then he battled for more years to gain acceptance for his design against sceptical authority. No-one succeeds at design and technology without staying power. Ask Dyson.

And then there is the gratifying triumph of the innovative practical man over the 'experts', the revered and incredibly well resourced occupants of the Greenwich observatory – the high priests of the new science of astronomy – who failed to provide a 'Practical and Useful' solution to the problem because they were so wrapped up in their abstruse science that they failed to think about the user – and make it useable. How often have we seen that in our classrooms? The youngsters whose imagination and innovation enables them to design beyond the limits of their supposedly 'brighter' peers or even of their teachers. Design and technology is a risk environment with a delightfully iconoclastic tradition.

But the final resonating quirk in this story concerns what we might call Mandelson's monument to the millennium. I have watched with interest (from a wonderfully located pub overlooking the Thames at Greenwich) as the 'Dome' has taken shape. It is (I think) an innovative and beautiful structure. I make no comment about its proposed contents – about which I know as little as most people.

At one level the Dome might be seen as a monument to Maskelyne, in the sense that his essentially inadequate solution to the longitude problem none the less resulted in the Greenwich meridian fixing London as the datum from which the world is measured. But at a more profound level, I prefer to see the dome as a monument to – and a celebration of – the qualities that enabled Harrison to lay a ruler around the earth.