**Gerard Mercator (1512-1594)**

***Measuring Heaven and Earth***

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Maritime Review, (Seoul, Korea), 2012, p. 5 - 28.

*2012 marks the 500th anniversary of the birth of Gerard Mercator (1512 – 1594), generally considered the father of scientific cartography and thus a key figure in the history of navigation.*

**Life and Work**

Born on March 5th, 1512 as Gerard Kremer in the Flemish town of Rupelmonde, Mercator lost his parents at an early age. Fortunately his uncle, the energetic priest of Rupelmonde, took care of him and paid for his education, first in ‘s-Hertogenbosch in what is now the Netherlands and later at the University of Leuven (Louvain). Prior to his admission there in 1530 he Latinized his name. Gerard Kremer became Gerardus Mercator, and under that name he was about to enter the history books.

Leuven was one of Europe’s most distinguished universities, staffed by some of the brightest minds of the time. It gave Mercator the opportunity to meet Andreas Vesalius, the outstanding anatomist, as well as philosopher and later archbishop Antoine Perronet de Granvelle. But by far his most influential teacher was Gemma Frisius, a Dutch mathematician who also taught and studied geography and astronomy, and specialized in the development of scientific instruments. That wide-ranging background provided Frisius the tools to investigate navigational problems. In 1530, for instance, he published a booklet describing how mariners could determine their position east or west of their home port provided they had an accurate portable clock with them. That clock (or chronometer) would take nearly 250 more years before making its appearance on board but his explanation made Frisius the first to propose a practical solution to the longitude puzzle.

Gemma Frisius also showed an interest in surveying and cartography, publishing the first printed description of triangulation. In it, he described how an area could be surveyed and subsequently mapped by taking sightings of prominent points like church spires or windmills from different locations and then determining their coordinates and the distances between them using trigonometry. This method was naturally a lot easier to apply in flat regions like the Low Countries, where Frisius and Mercator lived and worked. In fact, Mercator would use it for a superbly drawn and highly accurate map of Flanders, which was published in 1540. Having taught himself the art of engraving, he etched it himself in nine copper plates. Assembled, the map measured 87 by 117 cm and contained no less than 1000 locations, justifying the title he gave it: *Exactissima Flandriae Descriptio—*an accurate description of Flanders.

Like his tutor, Mercator did not confine himself to his chosen area of expertise. Following his matriculation he studied philosophy and theology, learned the science and art of instrument-making and taught himself the script used by ecclesiastical secretaries in Italy (now known as italic), whose clarity and compression he considered ideal for use on maps and globes. His progress as an engraver was so impressive that Frisius invited him to collaborate on a printed globe which was completed in 1536. In 1537, Mercator published a map of the Holy Land – his first-- to be followed by a heart-shaped world map in 1538 and the self-surveyed Flanders map in 1540 . One year later he produced his first globe. Its 420 mm diameter made it the largest and most detailed printed globe constructed until that time.

The mid-16th century was a period of religious and political turmoil in the Low Countries, as Mercator was to experience first-hand. In 1543 he turned up on a list of suspected heretics and was imprisoned early the following year in Rupelmonde, his birthplace, which he was visiting at the time. Fortunately Mercator had influential friends, who helped secure his release after a seven-month period of captivity. Several of his co-captives did not make it out alive. In fact, with the Inquisition regularly torturing and executing its prisoners, this dark period probably contributed to Mercator’s decision to leave Flanders. It may also have contributed to a reduced output. It is true that Mercator never was highly productive – for that he was far too much of a perfectionist who preferred to do much work himself (rather than delegate it), but in the six years following his release he apparently produced only one globe – a magnificent celestial companion piece to the terrestrial globe completed before his captivity. Aside from this globe, it appears Mercator also devoted a considerable amount of time to the construction of scientific instruments, including quadrants and astronomical ring dials, at least one of which commissioned for or by the Emperor Charles V (1500-1558).

During the early 1550s Mercator left the Low Countries for Duisburg at the invitation of the Duke of Cleves. Here and for another forty years he focused on a series of maps, globes and written works that would establish his reputation as the foremost mapmaker and cosmographer of his time. In 1590 Mercator suffered a stroke which affected his speech and partially paralyzed him, but to the extent possible he continued his work until his death in 1594.

Walter Ghim, mayor of Duisburg as well as Mercator’s friend and neighbor, wrote an extensive obituary which remains the only contemporary biography of Mercator. It was published in 1595, a year after Mercator’s death. He described his friend as a “remarkable and distinguished man,” who was known for his “mild character and honest way of life.” This is the kind of language one would expect in an obituary but from all accounts it appears that this was not just a description reserved for the dead. Others too – his peers, colleagues and collaborators-- described him as honest, calm, sincere and peaceable. Mercator, in short, was admired not only as a brilliant scientist and humanist, but just as much as an honest and humble man (Fig. 1).

**The Globes**

Mercator had the opportunity to observe globe construction firsthand when Gemma Frisius in 1536 invited him to engrave maps for a terrestrial globe commissioned by the Emperor Charles V. Though globe construction was a painfully slow process, he apparently enjoyed the task because there would be many more globes to leave his workshop in the years to come. In fact, with the first one he constructed single-handedly, he immediately set very high standards. Completed in 1541, its 420 mm diameter provided 28.85 percent more surface area than the Frisius globe, allowing it to become the most detailed terrestrial globe ever produced. It also displayed an exceptional knowledge of magnetism, with the north magnetic pole clearly located away from the geographical pole (Fig. 2).

Globe construction was a time-consuming and complicated process. First there was the construction of the sphere itself, consisting of two half-spherical molds, usually made out of paper mache, which were balanced and weighed and subsequently glued together. Once dried the resulting sphere would be covered with gypsum and carefully sanded down to obtain a near-perfect surface. A terrestrial or celestial map could then be pasted or glued onto it to complete the globe. Prior to the invention of printing, each globe had a hand-drawn map pasted onto the sphere, making it a unique (and expensive) specimen. Printing did away with the hand-drawn maps, allowing the production of a number of identical globes at a lower cost.

Of course, there still remained the difficulty of transferring or transposing a two-dimensional hand-drawn or printed map onto a three-dimensional globe. The solution was to draw or print the map in tapering segments or gores (Fig. 3) which could be glued onto the sphere. Though simple in theory, this was by far the most intricate part of the process, involving a good bit of sliding and stretching to make sure the gores would be glued perfectly aligned. The more gores, the more difficult the process. Some globe makers settled on 16 gores for their creations whereas Mercator relied on a mathematical system that included 12 gores along with separate circular caps (or calottes) for the polar regions.

Once the transfer of the map was completed, the surface area was hand-colored and subsequently varnished. A globe was only useful if it could easily be turned, so it was set into an innovative four-legged stand with an attached horizon and meridian rings. Marked with degrees, these allowed for a latitude and longitude reading for any place on the globe, though the latter was at best approximate, since accurate (and practical) longitude determination would only became available in the late 18th century with the introduction of the marine chronometer.

Mercator’s 1541 globe also featured a number of innovations. Aside from its clear distinction between the magnetic and geographical poles, it included a number of *loxodromes* or rhumb lines which plot a course of constant compass bearings, reflecting Mercator’s early interest in navigational issues. Mercator also addressed and refined the issue of including written information on globes. Using copper plates rather than woodcuts for the maps allowed for much smaller yet legible lettering, but Mercator went beyond that by developing a lettering or rather font convention for globes and maps, including the use of italic script. Finally like his maps, his globe and its many successors married science with art, including the latest geographical knowledge with superbly drawn text cartouches and fanciful depictions of marine life.

Due to high demand, it is estimated that hundreds of these globes left his workshop in the course of his long life, often sold in pair with the celestial globe that was completed ten years later, at the end of his stay in Flanders (Fig. 4). A good number of these Mercator would assemble single-handedly, in part because he was a noted perfectionist, but possibly also because globes made considerably more money that maps or gores. Antwerp printer Plantin, for instance, charged 25 carolus guilders for a pair of Mercator globes in 1570 –between 2000 and 2500 euro in modern currency. Given their quality and importance that may seem like a steal today but it was considered a small fortune at the time. Only 22 sets of globes survive to this day. Naturally it would take more than a small fortune to purchase one of these today, if they can be purchased at all.

**The Maps and the Atlas**

Though Mercator produced the finest globes of his time, it is mapmaking that he is best known for. Mercator published his first map – a map of the Holy Land – in 1537. It was designed, according to its subtitle, “for a better understanding of the Bible”, reflecting his interest in theology. The world map that appeared a year later similarly demonstrated an interest in combining or even uniting the scientific and the spiritual. Rather than using the customary oval or conic projection, Mercator developed a double, heart-shaped (or cordiform) projection (Fig. 5). It was based on advanced mathematics, but the resulting distortions created a somewhat unfamiliar world image, limiting its use as a practical map. In fact, seen from hindsight, its principal contribution was its clear division of America into two separate continents – the first time this had been done. He called them *Americae pars septentrionalis*  (North America) and *Americae pars meridionalis* (South America), expanding and solidifying the use of the term America for the continent “discovered” nearly half a century earlier. Mercator next turned his attention to his homeland, publishing his influential Flanders map in 1540. Compared to earlier efforts, it turned out to be extremely useful, not only as a depiction of his homeland but quite possibly also as a political tool.

The three maps were significant achievements for a young cartographer, but the best was yet to come, following Mercator’s move to Duisburg during the early 1550s. First to be released from his Duisburg workshop was a six-panel wall map of Europe (1554), followed one year later by a map of the British Isles. Drawing on his experience surveying Flanders, he also surveyed the city of Duisburg and the surrounding area. In 1564 he was appointed court cosmographer to the Duke of Cleves and set out on surveying trip of the Duchy of Lorraine which, according to one contemporary source, severely weakened him. Following that experience, Mercator seldom left Duisburg, focusing on his globes, maps and a strong desire to write a multi-part cosmography that was to include a revision of the Creation account, a section on astronomy, a chronology of world events and geography section containing new maps.

 Though that ambition was never fully realized, it did include an enormous world map, consisting of no less than 18 sheets (Fig. 6). Assembled it measured 123.5 by 202.5 cm but it was not its size that made it so remarkable. It was the way he converted a spherical three-dimensional world onto a two-dimensional surface by progressively increasing the space between his lines of latitude north and south of the Equator. While this caused progressive areal distortion as one moved away from the equator, it permitted constant compass bearings to be drawn as straight lines (rhumbs or loxodromes) on the map, making it uniquely suited for navigation. Mercator explained its navigational purpose in the map’s title and emphasized it by drawing intersecting rhumbs in every ocean, but his contemporaries failed to grasp the map’s significance. In fact, it would take another thirty years, after English mathematician and cartographer Edward Wright published an in-depth explanation of Mercator’s techniques, that these were used and accepted by nautical cartographers. Even more astounding is the fact that the underlying mathematical framework for the projection included calculus, differential geometry and logarithms that were not even developed when Mercator developed his techniques. It took, in other words, an extremely gifted mathematician and superb cartographer to work out the map projection justly named after him.

 Mercator realized that the navigational benefits of his projection came at the expense of areal reality. Although the resulting map was angle-true and conveyed the correct shape of the continents (at least so on a limited scale), there was no way of escaping the fact that landmasses further north of south of the equator were shown progressively larger (Fig. 7). Polar regions occupied the full width of the map, as would the poles themselves, explaining why these are never depicted on a standard Mercator projection. Since no one was sailing anywhere near the poles at that time, this created no practical limitation on a navigational map. Like anything Mercator made, the map was a piece of outstanding workmanship and sold well. Though there are no precise figures, hundreds of them probably left the printers of which only one survived into the 20th century. That specimen was in turn destroyed during the bombing of Wroclaw, Poland in 1945. Fortunately several precise copies had been made in Berlin at the end of the 19th century, giving us a faithful impression of one of the most important and revolutionary maps in world history.

During Mercator’s lifetime, Ptolemy’s *Geographia* or *Geography,* as translated and updated time after time, remained an influential source of geographical information. Mercator saw it as his task to complete a final version, not only updated with new information and new maps but also properly edited, to remove the many inaccuracies that had crept into the many translations of the past. It too proved a long-term effort, with Mercator spending years collecting the information needed to complete the task. Mercator’s *Tabulae geographicae Cl. Ptolemaei* was published in 1578 and contained newly engraved and updated versions of Ptolemy’s maps. Though this type of work had by then become somewhat of an antiquarian endeavour, Mercator would continue to refine it, releasing a full edited text edition six years later. Distribution was limited but to Mercator all of this had a clear purpose. One could not understand modern geography, he asserted, without respect for historical geography. Mercator’s revision certainly showed this respect, and would undoubtedly have been approved by his illustrious predecessor.

Mercator also published many modern maps, especially regional maps of Europe and North America, responding to the growing demand for accurate renditions of these areas. North America in particular intrigued him and Mercator spent a good deal of time naming and trying to fill in the blanks on that map. Every voyage of exploration, even many trading voyages across the Atlantic, returned with new information. Mercator sought to obtain it at the earliest convenience through his contacts in other cities, enabling him to draw progressively more accurate maps of the Americas. In fact, his consistent use of the terms North and South America solidified Martin Waldseemüller’s first use of the term America, making him at least partially responsible for the naming of the western hemisphere.

The business of collecting the needed geographical information and then transferring it onto maps left little time for the business of distribution. Fortunately Mercator had excellent contacts to handle that aspect. Noted Antwerp printer Christoffe Plantin is known to have ordered hundreds of maps from Mercator for resale but by far the most important collaborator was engraver Abraham Ortelius (1527 – 1598), also based in Antwerp. Together, they formed a perfect pair: Mercator as the brain behind the world’s best maps and Ortelius with the commercial and creative savvy to increase their distribution.

 Initially Ortelius collected maps and re-engraved them, after having added newly available information. But whereas Mercator’s clientele included emperors and archbishops, Ortelius had to deal with sailors and traders. They asked him for a practical, more user-friendly format; a map (or maps) that could be taken along on board, for instance. Or at least smaller maps, which did not have to be rolled and unrolled all the time. Their request led Ortelius to develop a standard map format of approximately 70 by 60 cm, very near the largest format paper manufacturers could supply in quantity at the time. Next he decided to publish the maps in a book, allowing him to cover the then-known world in one single publication. To achieve this ambitious task, he worked closely with Mercator in assembling the best maps to be updated and re-engraved in his standard format. The result was first published in 1570 and sold out in a matter of months. Entitled *Theatrum Orbis Terrarum* (*Theater of the World*) and printed in Antwerp, it contained seventy maps on 53 sheets, along with extensive descriptions. Given its popularity, it was quickly translated into Dutch, French, Spanish, Italian and English. These editions too turned out to be a success, causing new and updated printings to be released year after year. By the time of Ortelius’ death in 1598, the *Theatrum* had gone through 28 printings.

 Mercator was pleased and impressed by Ortelius work, praising him for the faithfulness of his map renditions. His own maps would in turn be published in book format as well, starting with a three-part volume covering France, Germany and the Low Countries in 1585. An updated edition followed in 1589 and added maps of Greece and the Balkans, but Mercator was far too much of a perfectionist for the publication to be fully completed within his lifetime. Only in 1595, a year after his death, was the volume he had in mind published. Edited by his son Rumold, it was entitled *Atlas sive Cosmographicæ Meditationes de Fabrica Mundi et Fabricati Figura* (*Atlas - Cosmographical Meditations Upon the Creation of the Universe, and the Universe as Created*). Though a splendid work (Fig. 8), it could not compete commercially with Ortelius’ constantly reprinted *Theatrum*, but Mercator was the first to use the term Atlas – a term we still use today for a collection of maps in a volume. More importantly it was Mercator’s Atlas which defined the principles of such publications. His ordering, italic lettering, identical map overlaps, coverage of regions at more than a single scale, and use of grids of latitude and longitude would in due time become cartographic standards.

Ten years after his death Mercator’s heirs decided to sell his estate, including all his reference works, atlases, maps and – most importantly – the engraved copper plates. Joos Dhondt, a Flemish cartographer who had fled to Amsterdam because of religious intolerance at home, acquired the estate and quickly set to work updating Mercator’s atlas. In 1606, just two years later, he published the first Latin edition of the Mercator-Hondius Atlas. To Mercator’s original 100 maps he added 37 new maps, releasing a more complete and up to date volume than the original. It sold so successfully that already one year later a second updated edition was published.

Unlike the original, the Mercator-Hondius atlas could compete with Ortelius’ Theatrum, with no less than 14 editions appearing between 1606 and 1633. Its popularity caused the center of cartography to move from Antwerp to Amsterdam, giving Dutch cartographers the opportunity to supply the never-ending demand for accurate charts and maps. Among them, the father-son team of Willem and Johan Blaeu would emerge as the best cartographers of the 17th century. Their magnificent work quickly overtook anything their Flemish predecessors had created, though they realized and honored the debt owed them, and Mercator in particular. In fact, their Atlas Major, first published in 1630, included a world map in Mercator projection, a fitting tribute to the genius who first mapped heaven and earth.

**Mercator and East Asia**

 In comparison to Europe and even Africa or North America, Mercator’s maps of East Asia are quite rudimentary if not speculative. Of course, when Mercator started work on his globes and maps, geographical information on this part of the world was relatively limited. Mercator’s 1541 terrestrial globe, for instance, relies indirectly on Marco Polo’s account for its depiction of China, with a text cartouche referring to Kublai Khan’s attempted invasion of Zipangri, as Polo called it. By then his account was more than 250 years old but it remained one of the most wide-spread narratives on the Far East, used frequently by earlier mapmakers. Zipangri, or rather Cipangu was Japan, which remained a mostly mythical land to Europeans. Two years later three Portuguese would literally wash ashore there, but it would be several more years before reliable information made it back to the West. Korea similarly remained unknown and the Korean peninsula is, as a consequence, not shown on the globe.

 Throughout the following years the map of Asia would fill in rapidly. From the early 15th century onward Portuguese explorers and traders were travelling throughout South and Southeast Asia, much the same way they had done earlier in Africa. Their tales, observations and accounts would filter back to Goa and from there to Lisbon and Antwerp, from whence the Portuguese operated their main European distribution network, giving Mercator and his colleagues rapid access to the latest information.

 This information was subsequently included in maps. Mercators 1569 world map (Fig. 6), as a result, shows considerably more Asian detail than the terrestrial globe or the heart-shaped world map published 25 years earlier. Even so, once past Vietnam and the South Chinese coast, the map grows more speculative. There still is no sign of the Korean peninsula though an embryonic form of Japan is beginning to appear. A year later Ortelius Theatrum appeared and from then onward, driven by market demand and supplied by a steadily growing flow of information, the map of Asia quickly became more detailed. Initially the detail extended mostly to South and Southeast Asia – the region from which Europe obtained its much sought after spices. China and East Asia in general were less accessible and lag behind in terms of reliable geographical data, as Mercator’s 1587 world map reveals (Fig. 9). Engraved by his son Rumold, it still shows no more than a rudimentary form of Japan, while the Korean peninsula remains absent.

 Cartographers in Antwerp had access to more up-to-date information, and Ortelius 1589 map of the Pacific Ocean (Fig. 10), printed just two years later, reflects major progress, with Japan now showing the four major islands, though not in proper shape or proportion. The textual information is less precise, stating *Iapan insula, nuper ad Fidem Christianam conversa* which translates to “the Island of Japan, recently converted to the Christian faith”. There were a good many Christians there at the time, especially in the southern island of Kyushu, but it wouldn’t take much longer for Christianity to be banned. Also of interest on the map is the detailed depiction next to South America of the Victoria, the first ship to sail around the world. The map is dedicated to Nicolas Rockox, past mayor and a distinguished Antwerp citizen.

 Korea never made onto a Mercator map. It is only after Hondius updated the Mercator Atlas with a number of newly commissioned maps in 1606 that Korea first appears, shown as an island (Fig. 11). The text insert within the island states *Corea… an sit insula an pars continentis nondum constat. Indigenae candidi sunt … et in bello sunt strenui sed crudeles et barbari* or “*It has not yet been established whether Korea is an island or part of the mainland. The natives are honest and in war determined but also cruel and brutal*”. Hondius probably obtained the geographical information from Petrus Plancius’ map of 1594, which included Korea for the first time in a European map. Two years later Plancius depicted Korea correctly as a peninsula, explaining the uncertainty raised in the text insert. The source of the quote on the Koreans themselves is unknown and possibly made up, since no European had visited or returned from Korea at the time. Interesting also is the naming of Jeju, shown very small at the southern tip, as the Ilha dos Ladrones – the island of thieves, predating its role as a tourist destination by hundreds of years.