GERHARD MERCATOR – INGENIOUS CARTOGRAPHER HOW ACCURATE IS HIS MAP OF THE WORLD FROM 1569?

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Abstract
Long before people were able to write, maps have been used to visualise reality or fantasy. Their content influenced the way people realized the world. From studying maps conclusions can be drawn how visualized regions are experienced, imagined, or meant to be perceived.
The article will deal with the brief and concise history and development of the world image in the maps from the Old Ages to Gerhard Mercator (1512 – 1594). Mercator was a teacher of the humankind and one of the greatest cartographers who revolutionised cartography. Astounding is the accuracy of the coastline in his Map of the World (1569), which will be presented as well as the reasons why the line-deformation, in comparison to the today's line-construction of continents in the maps (the same projection and scale), was generate.

1 Introduction
Maps combine yesterday's, today's, and tomorrow's view of our world, other planets, and the whole universe. The history of mapmaking, i.e. cartography, resembles the history of mankind.
The brief and concise history (author's option) of the appearance and development of topographic representations, from Old Ages (6th century B.C.) to the first World Atlas from Gerhard Mercator (1512 – 1594) with his proposal of conformal cylindrical projection will be presented. This period was an important period for the development of cartography.

2 A walk through the history of cartographic representations
Activities such as surveying the Earth's surface, mapping gathered data as well as defining the coordinates of an arbitrary location anywhere on the surface of the Earth belong to current activities of cartography. But, historically, the determination of coordinates was the utopia of many astronomers, geographers and cartographers, and it was accompanied by much speculation, delusion and ingenious inventions. The next sections outline the historical events.

2.1 The Greek Antique period – Claudius Ptolemy
Claudius Ptolemy (87 – 150), one of the greatest scientists of the Greek Antique period, presented in his lifetime work *Megale syntaxis* the Earth in the centre of the planetary system, relying on the theory by Plato and Aristotle. In his work *Geographia* (eight

volumes), Ptolemy provided a list of all known settlements, their positions defined using geographic coordinates, *Map of the World* (Fig. 1) as well as maps of various areas. The first printed edition of Ptolomey's work without maps was published in Venice in 1475, the first printed editions with maps was done in Bologna (Italy) in 1477, and the prettiest one in Ulm (Germany) in 1482 (see "First edition of Ptolemy's *Map of the World* Ulm 1482", in: Clark et Black 2005, p. 181) (note that the Cape of Good Hope is not presented). Unfortunately, no originals of Ptolemy's maps were preserved.

Figure 1: Nicolaus Germanius: Copy of Ptolemy's *Map of the World*[1](*Geographia* 1st/2nd Century A.D.) from 1467, size: 25.3 x 34.5 cm. (http://commons.wikimedia.org/wiki/Image:Ptolemy_Cosmographia_1467_-_world_map.jpg, *this image is in the public domain because its copyright has* ***expired***.)

From Ptolemy and Marinus of Tyrus (70~130), sprang the revolutionary idea (around the year 100) of introducing a geographical grid into cartographic representations, as well as the notion about how important is mapping adjusted to scale. Ptolemy's *Map of the World* was the first attempt to project the surface of a sphere onto a plane – the mantle of a cone. The projection grid consisted of meridians which cut the equator into equal segments and converged towards the North Pole. Parallels were depicted as

[1] National Digital Library of Poland

circles of varying circumferences, which had a mutual centre in the same pole. Ptolemy's scientific works affected cartographic activities authoritatively for centuries. Namely, in the lack of knowledge and the verification of mathematical sources and computing technique the author did not compute needed values or use the correct value of the Earth's circumference, which was already provided the Greek Antique period geographer and historian Eratosthenes. However, he employed the measurement (i.e. computation results) of the voyager, geographer and historian Strabo of Amaseia (60 – 20 B.C.). Ptolemy's degree was shorter by almost a third. Consequently, his world image was therefore a third shorter in a north-south direction and the equator was drawn too far north. Due to the incorrect length of the Mediterranean Sea (62 instead of 42 degrees) and stretching of Asia to the east (50 degrees more than its true value) there was not enough space left between western European coast and the Asian eastern coast. This would later deceive Columbus (1451 – 1506) in his conclusions that he could reach Asia relatively quickly by sea, sailing in a westerly direction from Europe.
There is no doubt that Ptolomy's work advanced cartography, however his assumptions inhibited its further development. Up until the end of the Middle Ages, geographers and cartographers overlooked his fatal error.

2.2 Roman Antique Age

The further development of the mathematical foundations of maps stagnated during the Roman period. *Tabula Peutingeriana*[2] (Leithäuser 1958, Clark and Black 2005, Bricker and Tooley 1969) consists of 11 maps is exceptionally important for geography and not so much for cartography, because its geometry of rivers, road networks, settlements and the most important mountain chains do not reflect reality . Its special value lies in the 3,500 toponyms on the map which describe the world of that time.

2.3 The Middle Ages

During the Middle Ages, cartographic issues were addressed in particular by the Arabs who directed Christian scientists to Aristotle's works, and do not possess great value.
In the 9th Century they calculated the circumference of the Earth more precisely than Eratosthenes (276 – 195 B.C.). The humanist, geographer and cartographer Abu Abdallah Mohammad al-Sharif al-Idrisi (1100 – 1172) contributed to the development of cartography with his great work *Tabula Rogeriana*, whose collection also contains a *Map of the World*[3] from 1154 whit application of circular parallels, what was a great novelty in cartography of that time.

2.4 Centuries of great discoveries and the development of cartography

The survival of the Christian image of the world became doubtful due to the information being added by explorers about newly discovered lands and the new natural-scientific understandings in the 14th, 15th and 16th Centuries.

2.4.1 Christopher Columbus

[2] Austrian National Library, Vienna, http://commons.wikimedia.org/wiki/Image:Part_of_Tabula_Peutingeriana.jpg
[3] http://commons.wikimedia.org/wiki/Image:Al-Idrisi-s_world_map.jpg

Christopher Columbus (1451 – 1506), an eminent sailor who discovered America, and his brother Bartholomew Columbus (1460 – 1514), also a sailor and cartographer, employed their own measurements for their maps, but also discoveries, itineraries, reports and fantasies of other sailors (Marco Polo (1254 – 1324)). In August 1492, Columbus set sail with his Spanish fleet west to the Atlantic, seeking a sea route to (magically described) India. In the same year he discovered a land in the far west – the Bahamas. He thought that it was just an island before the Indian coast. Thus Columbus was the first Spaniard to step on American soil. He set sail for the third time in 1498, sailing around the Caribbean Islands and following the eastern coast of South America.

Figure 2: Henricus Martellus Germanus: *Map of the world*[4] from 1489.
(http://commons.wikimedia.org/wiki/Image:Henricus_Martellus%27_World_Map.jpg
this image is in the public domain because its copyright has ***expired****.)*

In 1487 – 1488 Bartolomeo Diaz (1450 – 1500), a Portuguese sailor, was the first to sail the south of the African continent – The Cape of Good Hope. Those discoveries enabledthe inclusion of new geographical content in the maps, but they still refuted the theory and authority of Ptolemy (87 – 150) (Fig. 2).

2.4.2 Quarta orbis pars

[4] British Library

When the Italian sailor Amerigo Vespucci (1451 – 1512) returned from the west in 1504, he wrote that the Columbus discovery wasn't related to India and Asia, which were already known continents, but to a new continent.
In 1507, cartographer Martin Waldseemüller (1470 – 1518) published in his work *Cosmographiae Universalis Introductio* a *Map of the World*[5] from 1507. Presenting the fourth continent, he named it *America sive Americi terra,* celebrating Vespucci's discovery.
The image of the world changed again when the Pacific was discovered. Ferdinand Magellan (1480 – 1521) sailed around South America, proving that 'beyond the horizon' there is another new ocean not included in maps of that time, and that the Earth was round. He also proved that *Terra Nova*, *Terra Incognita* or *Brasil* wasn't a part of Asia, but indeed a new continent, *America*. This gave true meaning to Columbus discovery in 1492.
Thus, only in a few years, the known and mapped world doubled in size and lost its old borders. During this period, a young scientist, humanist, astronomer and cartographer appeared, desiring knowledge and full of new ideas that revolutionized cartography as science. His name was Gerhard Mercator.

3 Gerhard Mercator – ingenious cartographer

Gerhard Mercator (actually Gerhard Kremer) was born in the small town of Rupelmonde in Belgium in 1512. At 20 he completed a Master of Philosophy degree. He quickly changed his profession, wanting to work on map production, globe construction and building astronomical instruments for surveying the Earth, applying his great knowledge of mathematics. Mercator was a cartographer, drawer and copper-engraver, penman, publisher, printer of his maps, constructor of his own globes of the Earth and the celestial sphere and a precise machinist in production of measuring instruments. His lifetime opus and deserved fame of a great cartography reformer resulted from the combination of practical experience and ingenious mathematical talent.

3.1 Lifetime opus of Gerhard Mercator

In 1538, under the influence of Frisius' school and his work *Cosmography*, Mercator published his first *Map of the World* in a very complex "heart-like projection"(see "*Map of the World* from 1538 by Gerhard Mercator", in: Leithäuser 1958, p. 280),dividing the whole world at the equator into two heart-like forms. The representation and name of South and North America are historically important.
Shortly after he published a book (in Antwerp) about map lettering, entitled *Lettering Booklet*. This revolutionized cartographic lettering. He used, instead of fractured lettering, very fine small and legible italic lettering, which takes less space on maps. In 1554 he published his first *Map of Europe* (wall-map consist of fifteen sheets), the first ever to deserve that name (2). He had been working on it since 1538, precisely drawing

[5] Library of Congress, Washington
http://commons.wikimedia.org/wiki/Image:Martin_waldseemuller_map_1507_m_2.jpg

positions of cities according to his calculations, carefully correcting incorrect positions that were attributed to Ptolemy, which were still present on maps.
In 1569, he finished working on his great *Map of the World – „ad usum navigantium*"(Fig. 3, 4), produced in the normal aspect of a cylindrical conformal projection – *Mercator's projection* (Kretschmer 1986). This started another new period in cartography, the period of mathematically correct maps, which formed the foundations of *new cartography.*

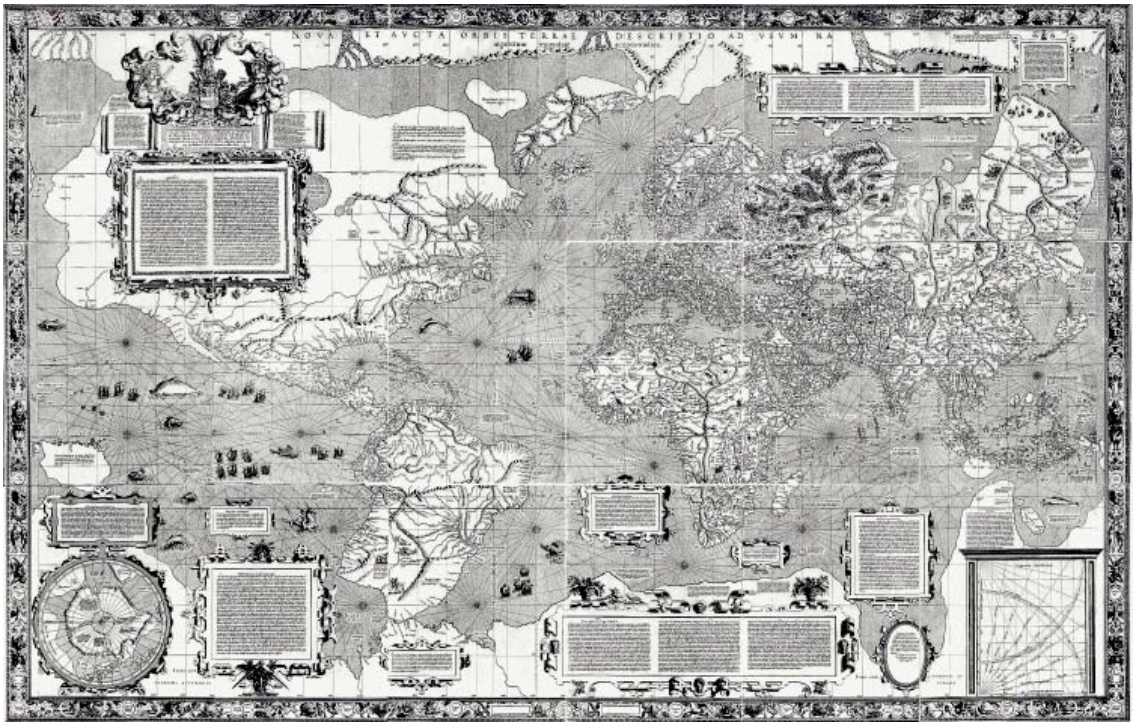

Figure 3: Gerhard Mercator: *Map of the World* from 1569.
(http://commons.wikimedia.org/wiki/Image:Mercator_1569.png, *this image is in the public domain because its copyright has* ***expired****.)*

In the *Map of the World*, Mercator inserted the newest continent border geometry with accurate verification, detail and precision (the coasts of seas and oceans). For its production, he employed all his past works, for example his and not Ptolemy's geometry of the *Map of Europe*, and therefore the Mediterranean area. He also included a huge, imaginary south continent *Continens australis*.
Mercator's cylindrical conformal projection is represented by a grid of meridians and parallels that intersect at an angle of 90^{o}. The distance between the parallels gets larger, the closer they are to the poles. Therefore the represented area becomes more and more deformed. The poles can't be mapped. This projection was the first one that could be used to connect two points on the surface of the Earth by a straight line on the map – rhumb lines. A rhumb line cuts all meridians at the same angle. It is not difficult to imagine what kind of help that was in navigation.

Figure 4: *Europe*, as a part of the Mercator's wall-map – *Map of the World* from 1569 (Scandinavia is disproportionately large),
(http://commons.wikimedia.org/wiki/Image:MercatormapFullEurope16thcentury.jpg,
this image is in the public domain because its copyright has ***expired****.)*

Map of the World from 1569 is 1.31m x 2.08 m in size and consists of 18 relatively large sheets, an unpractical format for sailors. An unknown sailor prepared three Mercator's maps reducing them to 29 sheets for his route (Leithäuser 1958). This opened the way for the first printed maritime atlas in a book.
Many cartographers adopted the idea. The first among them was Abraham Oertelius (1527 – 1598), Mercator's friend. His published atlas *Theatrum Orbis Terrarum*[6] comprised 70 maps on 53 sheets (see also "*Map of the World* 1570 by Abraham Oertelius from his atlas *Theatrum Orbis Terrarum", in:* Clark and Black 2005, p. 107). This work continued to be updated even after the author's death.
For years, when Oertelius atlas continued to gain recognition, Mercator worked relentlessly and in much detail on his idea. He wanted to realize his lifetime idea, his *Opus magnum* in five parts (Leithäuser 1958, Monmonier 2004). In the first, he wanted to represent the creation of the world, in the second to describe the celestial sphere, in

[6] http://commons.wikimedia.org/wiki/Image:OrteliusWorldMap.jpeg

the third a representation of all countries and seas, in the fourth to represent the political history, and in the fifth to give a conclusive representation from the beginning of the world to his days.
The third part of his *Opus magnum*, he called *Tabula Geographicae.* He engraved a total of 102 new maps in copper, all in the same format. He controlled all astronomic calculations, determined geographic coordinates and distances between individual points, gathered newest geographic reports and transferred that data into his projection of 'increasing widths'. For the whole work, he chose the name *Atlas*, the name of the mythological Maori king Atlas, who was interested in astronomy and allegedly produced the first celestial sphere globe (Leithäuser 1958). In reality, however, regardless of the model, the term 'atlas' as a collection of maps has its true source in Mercator's work (Monmonier 2004, Lechthaler and Stadler 2006).
In 1585, he published 51 maps belong to *Tabulae Geographicae* of western and middle Europe (France, Belgium and Germany). Four years later, he published the last group of 23 maps of *Tabulae Geographicae* (Italy and Greece) (Monmonier 2004). In 1590, weak from a heart attack, he couldn't work on maps any more, being paralyzed. He worked without pause from 1568 to his death on December 2, 1594. Unfortunately, his *Opus magnum* with 123 books wasn't completed.
In 1587 Mercator's son Rumold finished and published the *Map of the world*[7]. The map was engraved in copper and colored by hand (Wolf 1995). In 1595 Rumold published the *Tabula Geographica*[8] as a complete work, with tied maps in the form of a book. He titled it *Atlas sive Cosmographicae Meditationes de Fabrica Mundi et Fabricati Figura.* Rumold stated that this was the title Mercator chose. He added to the atlas a title sheet, genealogic table and a picture of god Atlas, who carries the entire celestial sphere on his back at the beginning of the work (Leithäuser 1958, Monmonier 2004).

4 Mercator – the greatest cartographer

Various reasons caused that the *Atlas* did not immediately gain the success it deserved: the slow publishing progress and then the development and use of Mercator's projection itself, which wasn't accepted at first. Neither Mercator himself nor his son Rumold got recognition during their lifetimes. They did not experience or learned the extraordinary work became famous and influenced the entire development of *modern cartography*. From 1595 to the present day, 31 editions of *Atlas Gerardi Mercatoris* have been published, translated to five languages, as well as the so called *Atlas minor* in a smaller format.
With his suggestion of conformal cylindrical projection, he left as heritage a work on which all navigation maps (maritime and aerial) are based on. And that is not all! State coordinate systems of numerous European and non-European countries are based on the Gauß-Krüger as well as on the worldwide used UTM (Universal Transversal Mercator)

[7] http://commons.wikimedia.org/wiki/Image:Mercator_World_Map.jpg
[8] Some maps from *Tabula geographica*:
http://commons.wikimedia.org/wiki/Image:Mercator_Africa_037.jpg,
http://commons.wikimedia.org/wiki/Image:Mer%D1%81ator_north_pole_1595.jpg,

projection. Both of them are modified versions of Mercator's projection from 16th century.

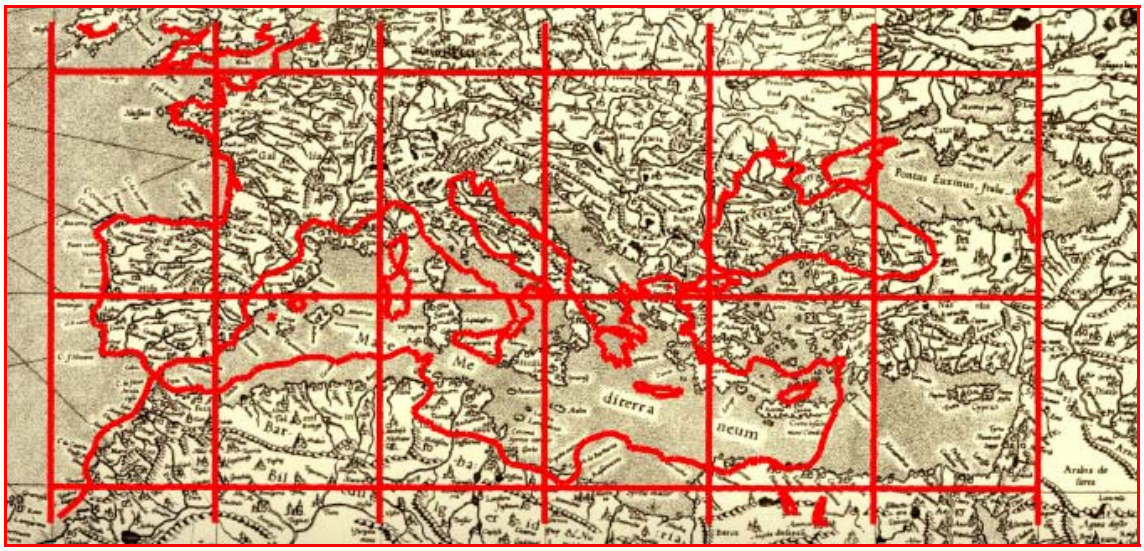

Figure 15: Mediterranean area – combination of Mercator's Map of the World and actually coastline (Mesenburg 2004)

Cartometric data gathering from Mercator's Map of the World (1569) points to extraordinary accuracy whereby the author carried out surveys, computing and mapping of geographical network with regard to existing mathematical notions and repro-technical possibilities of the 16th century. After comparison Mercator's map geometry with the geometry of actually world map, Mesenburg (2004) points that the network's accuracy is astounding, in opposite to continents coastline representation (Fig. 5).
For the continent boundaries Mercator devotes heterogeneous sources. Trusting and leaning on scientific authority of his predecessor Claudius Ptolemy (87 – 150), he employed a part of Ptolemy's geometry (see chapter 2.1) instead of taking relatively precise geometry from Portolan maps (Lechthaler 2008, 2009). The regions without Ptolemy' coastline geometry data (Northern Europe, Africa or America) were presented more accurately as the Mediterranean areas.

Despite this fact, Mercator's maritime maps and the Map of the World, which the author published under the name *as usum navigantium*, as well as his main and greatest work *Atlas*, which was published after author's death, contain numerous analogous information of the time they were produced in. Today his lifework mystifies us with his respectable accuracy and precision. His maps are historical documents about technical skills, which were used at that time to produce the cartographic originals, as well to copy them.

5 Concluding thoughts

Maps combine yesterday's, today's, and tomorrow's view of our world, other planets, and the whole universe – from the perspective of people, sciences, and arts. The history of mapmaking – cartography – resembles the history of mankind. Long before people were able to write, maps were used to visualise human reality or fantasy. The centuries of great expeditions led to today's view and mapping of the world.
One of the greatest cartographers of all times was undoubtedly Gerhard Mercator. His extraordinary life's work *Opus magnum* in five parts (the third part he called *Tabula Geographicae*, called from his son *Atlas sive Cosmographicae Meditationes de Fabrica Mundi et Fabricati Figura)* became famous and influenced the entire development of *modern cartography*.

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(1) http://commons.wikimedia.org/wiki/Category:T_and_O_map, accessed August 2009.

(2): http://www.bl.uk/onlinegallery/ttp/mercator/accessible/introduction.html, accessed August 2009.