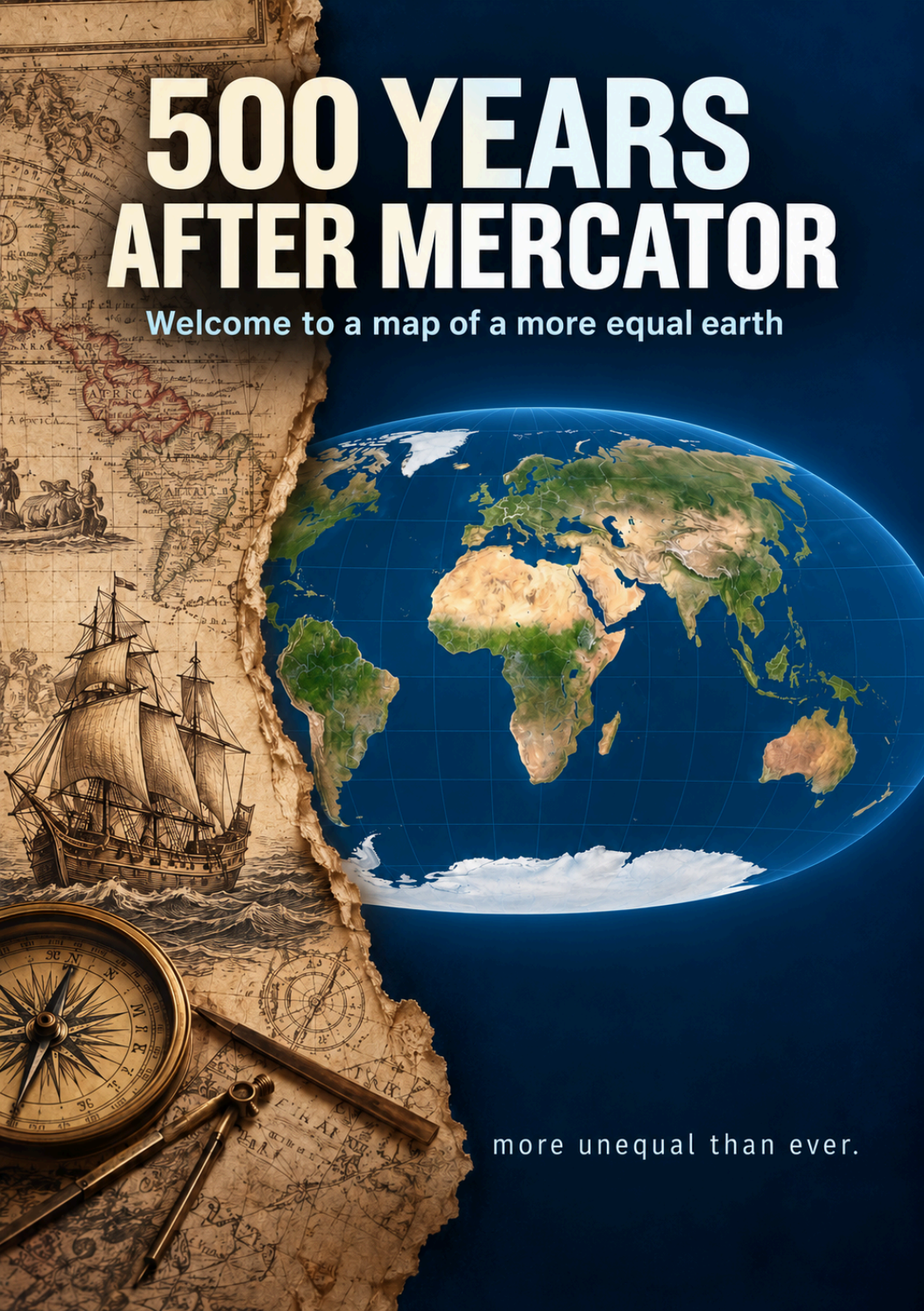
500 YEARS AFTER MERCATOR

Welcome to a map of a more equal earth



more unequal than ever.

Contents

Prologue: The Day the World Map Changed 3
Chapter 1: The Impossible Map 8
Chapter 2: The Sailor's Map 14
Chapter 3: When the Useful Map Became the World 21
Chapter 4: Who Gets the Middle? 28
Chapter 5: Draw a Line, Claim a World 35
Chapter 6: Survey After Conquest 42
Chapter 7: Maps Worth Stealing 49
Chapter 8: The Map Goes to War 57
Chapter 9: The Line That Survived the War 64
Chapter 10: Finding Yourself on Earth 70
Chapter 11: From Secret Satellites to the Phone in Your Pocket 76
Chapter 12: The Secret Numbers Behind Every Digital Map 84
Chapter 13: The Joke Code That Ate the Web 90
Chapter 14: Where the Database Cuts the World 97
Chapter 15: The Place the Web Map Cannot Show 105
Chapter 16: The Map Was Never Empty 111
Chapter 17: Africa Is Bigger Than You Think 130
Chapter 18: Greenland Is Big Enough 144
Chapter 19: Does a Map Change Your Mind? 150
Chapter 20: Designing a Different World Map 158
Chapter 21: The World, Redrawn 165
Epilogue: Choose Your Distortion 171
Endnotes 176
Bibliography 201
Image Credits and Licence Notes 214
Acknowledgements 215
About the Author 216
Colophon 217
Glossary 218

PROLOGUE

THE DAY THE WORLD MAP CHANGED

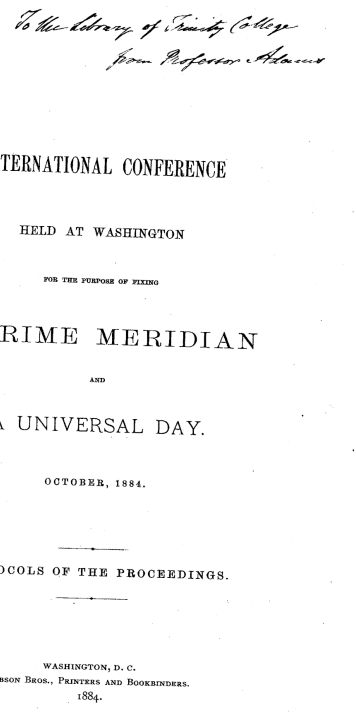


Figure P.1. Title page from the published record of the 1884 International Meridian Conference. Long before the events of 2026, governments had already gathered to negotiate a global cartographic convention and turn it into shared infrastructure. Wikimedia Commons scan of the conference proceedings. Public domain.

On Friday 4 September 2026, the United Nations General Assembly found itself voting on something most people never imagined becoming a matter for international diplomacy: how the world should be represented on a flat map.

The item appeared in the Assembly's 114th plenary meeting under the dry administrative language of Item 13. The draft resolution was A/80/L.104.[1] Its title was less dry: "Correct the Map". There are moments when bureaucracy accidentally writes a good book title.

Togo presented the initiative on behalf of the African Group, with the backing of the African Union.[2] Its immediate cartographic complaint could be explained without much jargon. On the familiar Mercator world map, places far from the equator expand dramatically in apparent area. Greenland, Canada, northern Europe and Russia receive much more map space per square kilometre than regions nearer the equator. Africa, which spans the equator and lies largely at low and middle latitudes, therefore appears much smaller beside them than it really is.

Campaigners wanted institutions to use world maps that represented relative land areas more faithfully. Equal Earth, a modern equal-area projection designed by Bojan Šavrič, Tom Patterson and Bernhard Jenny, had become the campaign's most visible alternative.[3][4] On an equal-area map, if one region covers twice as much of the Earth as another, it also occupies twice as much area on the page. That did not make Equal Earth perfect. It made it good at the property now under argument.

The resolution passed overwhelmingly.[5] The adopted text became General Assembly resolution A/RES/80/307.[6]

If history had been written by headline alone, this would have been the day the old world map was removed and a new one installed in its place. The actual change was stranger and more interesting.

No technician in California had to sprint across a server room and pull a large lever marked MERCATOR. Ships did not lose permission to use Mercator charts. School caretakers were not ordered to remove every rectangular world map before Monday morning. The resolution was non-binding.[7] It encouraged governments, schools, international organisations and technology companies to use Equal Earth or other equal-area maps when relative size mattered, and to teach the limitations of flat maps. The African Union welcomed the vote and called for progressive uptake by international institutions, schools, publishers and digital platforms.[8]

A map projection had become a diplomatic issue, a fact worth pausing over. Map projections usually live in the technical background. They are the machinery that turns the curved Earth into a flat image, often unnamed and largely unnoticed by the people looking at the result. Yet here were diplomats from almost every country in the world casting votes about one of those hidden choices.

The dispute did not begin because cartographers had suddenly discovered that Mercator distorts area. That has been known for centuries. Nor did it begin because Mercator had ceased to be useful. A projection that is poor for comparing continental area can still be excellent for another job. The argument arose because a specialised way of drawing the Earth had acquired a life far beyond the problem it was originally designed to solve.

Gerardus Mercator published his famous world map in 1569.[9] He was trying to make navigation easier on a curved planet. His projection allowed a sailor following a constant compass bearing to treat that route as a straight line on the chart. The result was ingenious. The price was a scale that grew rapidly towards the poles.

Five centuries later, the navigational solution had become one of the most recognisable pictures of Earth. It had travelled through atlases, classrooms, government offices and, in a related digital form,

into the architecture of web mapping. A technical choice had become familiar enough that many people no longer noticed it as a choice.

The larger story behind the vote begins with a set of harder questions. How does a tool become a convention, a convention become an institution, and an institutional design choice come to feel natural? What happens when people who dislike the consequences of that convention persuade governments to reconsider it?

Those questions are harder than asking whether Mercator is good or bad. They lead into navigation, printing, schools, surveying, law, war, satellites, databases and software. They also lead into politics, because maps do more than calculate positions. They are used to organise territory, teach geography, record ownership, define boundaries and present the world to people who may never stop to ask why the picture looks the way it does.

The 2026 campaign brought one particular consequence into public view: relative area. Africa did not need to become larger. Greenland did not need to become smaller. The Earth had not altered between one projection and another. What changed was how much flat space the map gave to different parts of the curved surface.

That distinction sounds simple once explained. Before explanation, the map can feel like the world itself.

A wall map is especially good at this illusion. It presents every continent and ocean inside one bounded frame. The centre looks like a natural centre. The top looks like a natural top. The places cut by the edge look as though they naturally belong there. Familiar outlines seem to confirm that nothing unusual has happened. The mathematical bargain disappears into the picture.

The United Nations vote made one of those bargains visible again. It did not abolish Mercator or produce a single official replacement map for every purpose. It did something subtler. It

turned an inherited cartographic choice into an international public question.

That question matters particularly from New Zealand and the Pacific, where the edges and seams of familiar world maps are hard to ignore. Aotearoa often sits near the margin of a Greenwich-centred world. The Pacific is frequently divided between two edges. None of that makes the map wrong by itself, but it is a useful reminder that a world map has been arranged by someone, for some purpose, according to some set of choices.

The book that follows is about those choices and what happened when they became useful enough, powerful enough or familiar enough to outlive the reasons that first produced them. It begins before the politics, before the software and before Mercator himself, with the awkward piece of geometry underneath every argument about a flat world map.

The Earth is curved. The page is not. Everything else follows from that.

CHAPTER 1

THE IMPOSSIBLE MAP

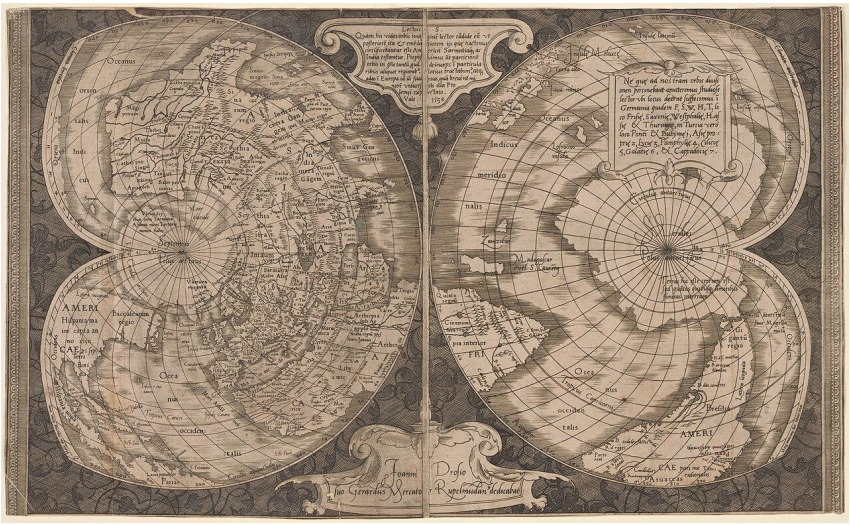


Figure 1.1. Gerardus Mercator's double-cordiform world map, 1538. Three decades before his famous navigational projection, Mercator was already experimenting with very different ways to flatten the Earth. New York Public Library Digital Collections. Public domain.

In the 1820s, Carl Friedrich Gauss spent part of his working life worrying about triangles. These were not the tidy triangles of a school geometry book. They stretched across the Kingdom of Hanover, their corners fixed by survey stations on distant hills, church towers and other points that could be sighted across the landscape.

Surveying a country requires a peculiar kind of confidence in geometry. Measure a baseline carefully, observe angles from one station to another, carry those measurements across the landscape, and a network begins to appear. Roads, fields, rivers and villages can be located inside that geometric skeleton. The method is power-

ful because the mathematics is dependable, but the surface beneath the network has one inconvenient property: the Earth is curved.

Gauss knew that problem intimately. His work in geodesy fed into his investigations of curved surfaces, and in 1827 he published a paper whose title, General Investigations of Curved Surfaces, concealed a result that later became known as the Theorema Egregium, the remarkable theorem. The mathematics is deep. Its consequence for maps can be stated plainly.

A curved surface and a flat surface do not have the same geometry. You cannot turn the whole Earth into a flat sheet without changing something.

An orange demonstrates the problem with less ceremony. Peel one carefully and try to press the skin flat on a table. If you force one part down, another buckles. Cut the peel and gaps appear. Overlap pieces and some areas cover others. Stretch it and the pieces may lie flatter, but their dimensions have changed. Cartography has spent centuries developing highly sophisticated versions of this kitchen experiment.

Some surfaces cooperate. A paper cylinder can be slit down one side and unrolled into a rectangle without stretching. A cone can be cut and opened into a sector. A sphere cannot be treated that way. The difficulty is not that nobody has yet invented the clever enough projection. A perfect flat world map preserving every area, distance, angle, direction and shape does not exist.[1]

That fact is the starting condition of map projection, not an accusation against it. Every flat world map changes something. The useful question is what it changes, how much, where, and what the map gains in return.

The word distortion can make this sound more sinister than it is. In ordinary language a distorted account is misleading, and a distorted photograph may have been manipulated. In cartography, distortion begins as geometry. Criticism becomes meaningful only

when the map's purpose is known. A distortion can be unavoidable and still be a poor choice for a particular job.

A famous map of London makes the point without showing the world at all. In 1933, passengers on the London Underground began encountering Harry Beck's diagram of the rail network.[2] It treated geography with extraordinary freedom. Curving lines became horizontal, vertical and diagonal strokes. Stations were spaced for legibility rather than literal distance. Central London expanded while the outer network contracted. The River Thames was simplified into a clean visual guide.

As a measured plan of London, the diagram was wrong in many ways. As a tool for answering "How do I get from this station to that station?", it was brilliant. A passenger usually needs to know which station comes next, where to change and how the lines connect. Beck sacrificed geographic distance to protect network structure. Nobody looks at the diagram and concludes that Paddington has been moved without planning permission.

World maps deserve the same first question: what job is this map trying to do? The difficulty is that a world map does not advertise its purpose as clearly as a transport diagram. A road map is visibly about roads. A weather map is visibly about weather. A cadastral map is visibly about parcels and boundaries. A world map can appear to be simply the world, as though the continents have arrived on the page without mediation.

The continents have not arrived on the page without mediation. The moment the curved surface becomes a plane, a bargain has been made.

Suppose a mapmaker decides that relative area matters most. If one region covers twice as much of the Earth as another, the map should give it twice as much area on the page. An equal-area projection does this.[3] It is an excellent property for maps where the reader is comparing territorial extent or quantities tied to surface

area. The price is that shapes must change somewhere. A continent may stretch, bend or compress while its area remains correct.

Suppose instead that local angles matter. A conformal projection preserves angles at sufficiently small scales, so tiny shapes remain locally similar even though their size may change across the map. This can be extremely useful where bearings and local angular relationships matter. The price can be severe area distortion.[4]

A third approach is compromise. Rather than preserving one property exactly, a compromise projection distributes several kinds of distortion so that the whole map looks reasonably balanced. This is not indecision. If a general reference map has several jobs at once, a carefully controlled compromise may be exactly the property the designer wants.

There are other possibilities. A projection can preserve distance from one chosen point. It can preserve direction from a centre. It can be designed around a particular region. It can cut the oceans to reduce distortion over land. Each choice protects something and spends the distortion somewhere else.

The principle is easier to remember than the vocabulary. Map projections have properties rather than moral scores.

Gauss helps explain why those trade-offs cannot be escaped. His theorem showed that curvature is intrinsic to a surface. A creature living entirely on that surface could, in principle, detect its curvature by making measurements without ever stepping outside it. A flat sheet has zero Gaussian curvature. Roll the sheet into a cylinder and it can still be unrolled without stretching because that kind of bending has not changed its intrinsic geometry. A sphere has positive curvature. Its geometry cannot be transferred intact to a plane.[5]

Something must give, and for a general reader that is enough mathematics to close the door on the perfect flat world map. The rest of projection design is what happens after accepting the loss.

Nineteenth-century cartographer Nicolas Auguste Tissot offered a particularly useful way to see where that loss goes. Imagine the globe covered with thousands of tiny identical circles, all the same size. Project the globe onto a flat map and watch what happens. On some maps the circles remain circular but grow or shrink from place to place. On others they become ellipses, stretched more strongly in one direction than another.

Those imaginary shapes reveal the local behaviour of the projection. A conformal projection keeps very small circles circular, although their size can vary dramatically. An equal-area projection keeps their area constant, although the circles may become stretched ellipses. No world map can keep every one of them identical everywhere.

Tissot's idea is valuable because it turns an abstract statement about distortion into a diagnostic habit. When a map looks strange, ask what it has chosen to preserve. When it looks normal, ask the same question.

The second question can be more revealing. Familiarity is one of cartography's best disguises. An unfamiliar projection announces itself because Africa looks wider, South America bends differently or the outer meridians curve. The map someone grew up with may feel neutral simply because its particular distortions have become visually ordinary.

That does not mean the familiar map has secretly rewritten the viewer's mind, or that an unfamiliar map is automatically better. It means appearance is learned as well as measured. A technically appropriate projection can still look odd because readers recognise the outlines of countries almost like logos. Change the projection and those mental shapes bend.

The result is a design problem as much as a mathematical one. A real map has to work for geometry and for people. It has to protect

the property that matters while remaining readable enough that users understand what they are seeing.

Asking for the "true" flat map therefore leads nowhere useful. A globe avoids flattening the whole Earth at once, but a page, wall map or static screen must choose what to protect. Once that choice is visible, criticism becomes more precise: area, angles, distance, direction or a deliberately balanced compromise can each matter for different jobs.

In 1569, Gerardus Mercator faced a particularly practical version of it. Sailors were trying to reason about direction on a curved Earth while working with a flat chart and a compass.[6] Mercator found a way to make one kind of route behave beautifully on paper. To do that, he accepted a distortion that would become spectacular toward the poles.

There was no perfect map waiting for Mercator to ruin, only an impossible problem in which he had to choose which part to solve.

CHAPTER 2

THE SAILOR'S MAP

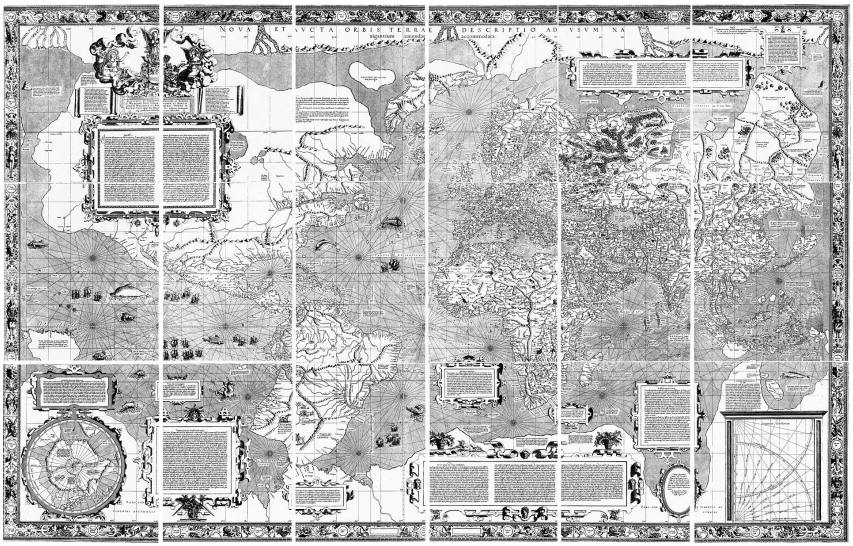


Figure 2.1. Gerardus Mercator's 1569 world map. The projection was designed so that a constant compass bearing could be represented as a straight line, an ingenious solution to a real navigational problem. Gerardus Mercator, 1569. Public domain.

In August 1569, Gerardus Mercator published a world map that was difficult to ignore.[1] Assembled from eighteen printed sheets, it measured roughly two metres across and more than a metre high. Coastlines, place names, notes and geometry crowded its surface. It was less a convenient atlas page than an object capable of taking command of a wall.

The best clue to what Mercator was trying to do was in the title. The map was made for navigation.[2]

That fact is easy to lose because Mercator's name now belongs to arguments he could not have imagined. It appears in debates about Africa, Greenland, classrooms and online maps. In 1569, however, the problem was much more practical. A sailor had a compass. The Earth was round. The chart was flat. Those facts did not cooperate neatly.

Mariners already possessed charts crossed by directional lines, and they had generations of accumulated practical knowledge about coastlines, winds, currents, stars and compass bearings. None of this made navigation easy. Longitude at sea remained difficult. Magnetic variation could make the compass less obedient than its clean dial suggested. A ship could be pushed off course by weather and current. Geographic knowledge was incomplete, and the ocean did not offer many fixed objects against which a navigator could check a mistake.

Mercator did not solve navigation. He solved one useful part of it. Suppose a navigator wished to keep a constant compass bearing. Follow a direction such as north-east and maintain that same bearing as the ship moved. On the curved Earth, such a path is called a rhumb line, or loxodrome. On a globe it usually curls toward a pole. On Mercator's map, it becomes a straight line.

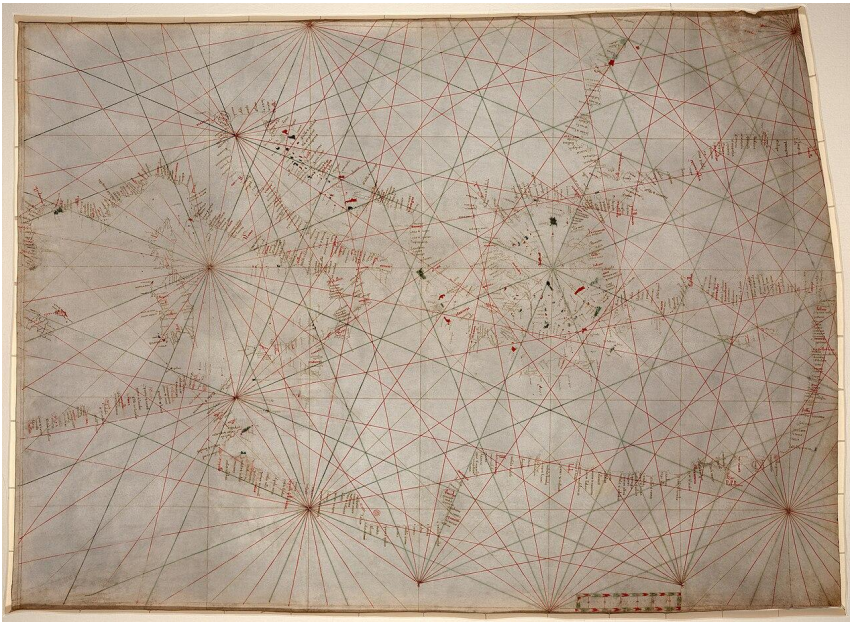


Figure 2.2. Anonymous Genoese portolan chart, c.1325–1350. Its dense network of compass-bearing lines shows that rhumb-line navigation was already central to Mediterranean seafaring long before Mercator's 1569 projection. Library of Congress. Public domain.

That was the trick, and its value is clearer if we forget modern navigation for a moment. A phone can now tell a driver where they are, where they are going and how to recover after a missed turn. A sixteenth-century chart sat on a table. The navigator supplied the intelligence.

Mercator made one part of that work easier. A constant compass bearing could be drawn as a straight line and handled with ordinary instruments on paper. The compass and chart could speak the same angular language. The sea remained difficult. The paper became easier.

That straightness did not make the route the shortest path across the Earth. The shortest route between two distant points on a sphere is generally a great-circle route, and its compass bearing usually changes as the journey proceeds. This is why long-distance air-

line routes can look curved on a rectangular map even when they are shorter than a straight-looking alternative. Mercator's achievement was different: he made constant bearing straight.[3]

To buy that convenience, he had to stretch the world. Lines of longitude converge toward the poles on a globe. On Mercator's projection they appear as straight, parallel vertical lines. The east-west scale therefore increases as latitude rises. To preserve local angles, the north-south scale increases by the same factor. Cartographers call the resulting property conformality.

The word is more complicated than the idea. Very small shapes preserve their local angles. A tiny compass direction on the chart behaves consistently even though the scale of the map changes from place to place. This is precisely why the projection works so well for the navigational problem Mercator chose to solve.

The price becomes obvious in area. On a simple spherical Mercator, local linear scale grows approximately with the secant of latitude.[4] At the equator the factor is one. At 60 degrees north or south it is about two, so a small feature is doubled in each linear direction and its local area on the map is roughly four times what the equatorial scale would suggest. At 75 degrees the local linear factor is nearly 3.9 and local area inflation approaches fifteenfold.

Countries do not occupy a single latitude, so no whole country can be assigned one neat inflation number without calculation. The broad effect is nevertheless unmistakable. High latitudes receive increasingly extravagant amounts of map space.

Greenland is the famous example because it stretches from roughly 60 degrees north deep into the Arctic. Africa lies largely at much lower latitudes and crosses the equator. Mercator does not apply a special shrinking operation to Africa. It enlarges high latitudes much more strongly, so Africa appears comparatively smaller beside Greenland, Canada, northern Europe and Russia than their true areas justify.

This distinction matters because it explains the map without inventing an intention. The distortion is not an error accidentally introduced after the useful part was finished. It is connected to the useful part. The same stretching that preserves local angles causes scale to grow toward the poles.

Eventually the stretching becomes infinite. A true Mercator projection cannot show the poles at any finite distance.[5] As latitude approaches 90 degrees, the projected coordinate runs away without bound. The map can approach a pole forever without arriving.

This sounds like a philosophical joke, but it follows directly from the mathematics. It also shows how specialised the design really is. A projection that sends the poles to infinity would be a strange candidate if its primary job were to give a balanced visual portrait of the entire planet. For a navigator interested in bearings over the parts of the ocean where ships actually travelled, the bargain could make excellent sense.

Mercator himself did not leave a modern derivation written in the notation used by projection software today. Historians of mathematics and cartography have reconstructed how he may have produced the map using the tables, mathematical knowledge and practical techniques available in the sixteenth century.[6] Joaquim Alves Gaspar and Henrique Leitão's work is especially useful here because it separates the clean equations familiar to modern students from the historical process by which a sixteenth-century mapmaker could reach the result.

This matters for another reason. It is tempting to tell the story as though Mercator discovered the formula, printed the map, and sailors immediately converted to a new system. Adoption was slower and more complicated.[7] Navigators already had established chart traditions and techniques. Charts were expensive objects. Knowledge circulated unevenly. A technically powerful idea still had to be reproduced, understood and fitted into practice.

The broad historical outcome is clear: Mercator's projection survived its inventor because other people could use it. Before following that afterlife, one technical distinction needs to be kept tidy. Gerardus Mercator's 1569 map, the mathematical family of Mercator projections used in later cartography, and the system commonly called Web or Pseudo-Mercator in modern online mapping are related, but they are not identical historical objects.[8] Modern Web Mercator, usually associated with EPSG:3857, belongs to a much later engineering story. Treating a twenty-first-century tile system as though Mercator designed it in Duisburg is rather unfair to both centuries.

The same caution applies to claims about motive. The surviving evidence supports a navigational purpose for the 1569 projection. There is no good historical basis for saying Mercator devised it to enlarge Europe for a later colonial or political agenda. That does not settle what later publishers, states, schools or software systems did with Mercator-style maps. It simply separates the inventor's problem from the afterlife of the invention.

That afterlife is where the argument becomes culturally interesting. A map can be born for one task and later become useful, familiar or convenient in settings where the original task matters much less. Once that happens, the projection is no longer explained only by the problem it first solved. It has entered institutions, markets and habits.

Mercator's own map offers a useful irony. The high-latitude enlargement criticised today was inseparable from the geometric property that made the projection valuable to navigators. For a sailor following a constant compass bearing, that bargain had a genuine advantage; for a reader comparing continental area, the same stretching is a genuine disadvantage. The geometry is the same. The job has changed.

Once a navigational projection entered atlases, shops and classrooms, the original navigational reason mattered less to the immediate user. Mercator's map had solved a sailor's problem. Its afterlife began when the map escaped the sailor.

CHAPTER 3

WHEN THE USEFUL MAP BECAME THE WORLD

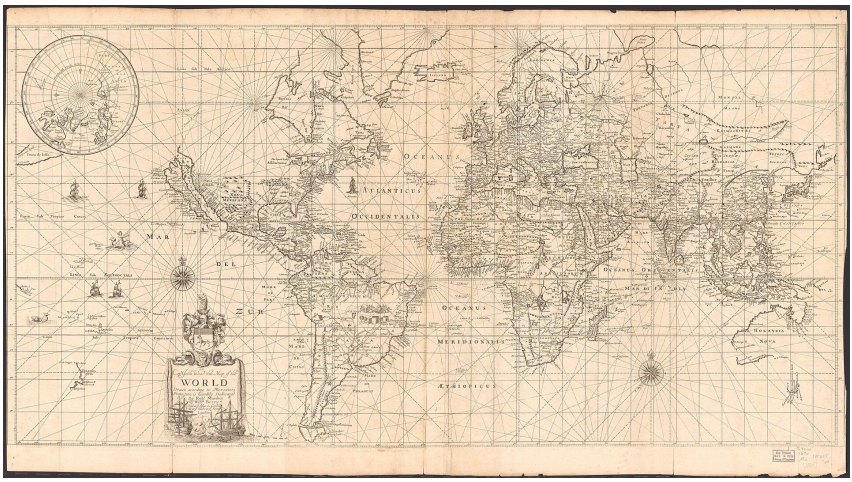


Figure 3.1. Robert Morden and William Berry's world map on Mercator's projection, c.1690. Rich decoration and general-world presentation show the projection moving beyond a specialist navigational solution into wider cartographic culture. Library of Congress, Geography and Map Division. Public domain.

On 17 January 1871, a Wellington bookseller advertised the equipment of education.[1] There were grammar books, copy books, histories, arithmetic texts, school atlases and wall maps. A teacher could order Europe, Palestine, New Zealand or the whole world. Then, tucked into the list, came a choice that would have sounded peculiar three centuries earlier.

The choices included "World in Hemispheres", 30 shillings, and "Maps of the World, or Mercator's Projection", 25 shillings.

The wording is almost comically ordinary. There is no announcement that one of the great technical inventions in cartography has reached a colony on the far side of the world. No explanation of rhumb lines or conformality accompanies the price. A projection created around a sixteenth-century navigation problem has become something a school can order from the newspaper, for five shillings less than the hemispheres.

The advertisement does not prove that every New Zealand classroom used Mercator. It immediately proves the opposite of that tidy story, because another world map was offered beside it. What it does show is more interesting: by 1871, "Mercator's Projection" was a recognisable commercial category. The projection had acquired a career independent of its inventor.



Figure 3.2. The world on Mercator's projection, 1818. Published by John Melish and Samuel Harrison; drawn by Hugh Bridport and engraved by George Murray. By the nineteenth century Mercator had

acquired a life far beyond its original navigational problem and had become an ordinary commercial map form. Library of Congress, Geography and Map Division. Free to use and reuse.

That career had been developing for generations. Around 1690, London cartographers Robert Morden and William Berry produced a world map described explicitly as being drawn according to Mercator's projection. The map still remembered the sea. It was dedicated to Captain John Wood, carried compass roses and rhumb lines, and included a north-polar inset. Yet it also demonstrated that projection and geographic knowledge are different problems. California appeared as an island.

Mercator's geometry could be reproduced correctly while the information placed inside it remained wrong. A projection transforms positions on a surface. It cannot correct a bad report, an incomplete survey or a fashionable geographical mistake. That distinction matters whenever an old map is judged as though every error visible on it were caused by the projection.

Morden and Berry's map revealed something else. Gerardus Mercator was no longer required. Once a technique is reproducible, it can detach from the person who created it. Other mapmakers can apply the same projection to new coastlines, new boundaries, new decorative styles and new audiences. The inventor's surname becomes an adjective, and the method enters the trade.

In 1818, John Melish published a large world map on Mercator's projection in the United States. It combined geography with practical instructions for finding distance and with statistical information. The projection still had a working life, but the context was widening. It was now a framework into which a commercial mapmaker could pour the changing geographic knowledge of a young republic.

By 1840, the Edinburgh firm A & C Black included The World, on Mercator's Projection in its General Atlas.[2] The map was mod-

est enough to turn in a book rather than dominate a wall. It belonged to readers at tables, not only navigators at sea.

The geographic content of such maps was still uneven. Coastlines had improved greatly in European cartography, while large continental interiors remained incompletely surveyed or confidently wrong. Antarctica was absent or poorly understood. Arctic geography was incomplete. Political boundaries could be uncertain, and place names reflected the languages and institutions of the people making the maps. The projection supplied a precise grid without guaranteeing that everything inside the grid was equally precise.

By the nineteenth century, Mercator had therefore acquired something more powerful than fame: routine. Publishers knew how to make the maps. Sellers knew how to list them. Readers recognised the format. Institutions could buy replacements from catalogues rather than commission an entirely new cartographic idea.

Routine is a quiet way for standards to spread. Nobody needs to announce that a convention has become normal. People build around what already exists, and what already exists becomes easier to keep using. The mechanism is not unique to maps. It is one of the ways technical choices acquire an institutional life.

That explanation must not become too neat. Mercator did not march from the sea into every atlas and classroom until it conquered the world. Hemisphere maps and globes remained common, regional maps used many projections, and publishers made different choices across places and decades. The Wellington advertisement catches that untidiness in one column: two different representations of the same planet were both for sale.

School records allow us to see what happened after the catalogue. In 1876, an inspection of Awanui School listed a world map on Mercator's projection among the equipment.[3]

These records belong to the broader history of the Native Schools system and colonial education in Aotearoa. An inventory entry cannot tell us how Māori pupils experienced a map or what a teacher said about it. For the narrower history of cartographic convention, the inventory establishes something concrete: Mercator had become ordinary school equipment.

The same system could also decide that Mercator was the wrong map for a particular room. In 1877, an inspector complained that a Mercator world map was "not suited to the school" and asked for a map of the Pacific instead.[4] The surviving wording does not state whether the objection concerned projection, centring, regional relevance, content or some combination of them. It does establish that a world map could be legitimate in general and still be unsuitable in a Pacific classroom.

Two years later, the judgement was blunter. At Waihou School in 1879 an inspector listed "Mercator's World (bad)" and requested hemisphere maps.[5] Other Native School inspections that year recorded Mercator maps alongside Europe, Australasia, New Zealand, hemisphere maps and Pacific charts. At Taumarere, the material included a Mercator world map, Europe, New Zealand and a hemispheric map, with further maps including the Pacific requested. At Te Ti, Mercator sat alongside Australasia and New Zealand. The school wall was not organised around one projection. It held an ecology of scales, regions and centres.

The archive becomes even more revealing when teacher examinations are added. In 1880, candidates were asked about the difficulty of representing the spherical Earth on a flat surface and about Mercator's projection. Similar questions appeared again in 1886 and 1888. The 1888 paper expected candidates to discuss both the projection's "special advantages" and its "characteristic defects".[6]

That wording deserves to survive because it is so refreshingly practical. Advantages and defects. The exam did not require the

candidate to declare Mercator a triumph or a fraud. It required an understanding that the same geometric design could be useful in one respect and costly in another.

This complicates a popular modern story in which generations of schoolchildren supposedly stared at Mercator without question until recent campaigners finally discovered that the map was distorted. The New Zealand record will not support that. Mercator maps were being sold and used, but their limitations were also being discussed. Teachers could be expected to understand projection trade-offs. Inspectors could ask for another map when the setting demanded it.

Familiarity and criticism can grow together. In 1890, another small piece of evidence shows how far the projection had travelled. A reporter visiting an exhibition of Native School pupils' work paused at hand-drawn maps. One pupil had drawn a world map on Mercator's projection, which the reporter praised for its legibility and correctness of drawing.[7]

The colonial setting needs care here as well. The Native Schools system was part of a much larger project of English-language schooling and state policy toward Māori communities. A newspaper reporter's praise tells us little about the pupil's own understanding or experience. For the history of maps, the scene establishes something narrower: Mercator had become a teachable form that a pupil could reproduce by hand.

That is a deeper level of circulation than a map hanging on the wall. An object can be seen. A form taught as geography can be recreated by the next generation. The convention begins to live not only in printed sheets but in skills and expectations.

The projection's journey ran through several kinds of normalisation. Other cartographers reproduced it, publishers put it in atlases, booksellers sold it as school equipment, teachers were examined on its advantages and defects, and pupils learned to draw it. At each

stage, the navigational problem of 1569 became less important to the immediate user.

This is how a technical choice becomes cultural scenery. Familiarity can make a particular arrangement feel natural even when alternatives remain available. A rectangular world map can begin to look like the world rather than one way of arranging the world. The distinction disappears not because nobody knows it exists, but because most ordinary uses do not require the user to think about it.

The historical evidence still does not justify saying that Mercator became the single map everyone used. That claim is too strong and obscures the more interesting process. Mercator became one of the most durable and recognisable ways of presenting the whole Earth, while globes, hemisphere maps and many other projections continued alongside it.

The Wellington advertisement captures that better than a slogan can. A school could buy one world for thirty shillings and another for twenty-five. The planet was the same. The presentation was not.

Once a world map becomes ordinary, other choices begin to hide inside it too. Projection is only one. A map must also choose where to place its centre, where to put the edge, how to orient the page and where to begin counting longitude. Those decisions can become familiar enough to look geographical rather than designed.

In 1884, one of them was taken into an international conference room in Washington. Delegates were not deciding which world projection was best. They were deciding where the world should begin counting.

CHAPTER 4

WHO GETS THE MIDDLE?



Figure 4.1. Delegates to the International Meridian Conference, Washington, October 1884. The meeting made Greenwich the shared prime meridian, turning a cartographic reference line into an international standard. U.S. Naval History and Heritage Command, NH 96688. Public domain.

On 1 October 1884, diplomats, astronomers, naval officers, engineers and surveyors filed into the Diplomatic Hall of the United States Department of State in Washington to settle a question that sounds almost too simple to require an international conference: where should zero longitude be?[1]

Latitude has a natural reference. The equator follows from the geometry of a rotating planet. Longitude is different. The Earth does not come with a line marked START COUNTING HERE. Every longitude system therefore needed an agreed beginning, and by the nineteenth century there were far too many.

France used Paris. Britain used Greenwich. Other charts and national systems referred to Cadiz, Naples, Ferro, Pulkova, Stockholm, Lisbon, Copenhagen, Rio de Janeiro and other meridians. A navigator could understand longitude perfectly and still need one extra piece of information before trusting a number: longitude from where?

Rear-Admiral C. R. P. Rodgers, the American chairman of the conference, described the problem from a seaman's point of view. Passing ships might exchange longitudes hurriedly, sometimes by figures written on a blackboard. If the figures referred to different prime meridians, confusion followed. At sea, confusion could be dangerous.

The conference was therefore trying to agree on a common zero and, through related resolutions, bring the world's clocks into a more orderly relationship with it. It was not choosing the best world projection. That distinction matters because a prime meridian, a map's central meridian, the place where a flat map is cut, and the direction placed at the top are separate choices even though they can interact.

The delegates mostly had the first of those choices in front of them. The gathering itself was an unusually literal collection of the world around one table. Austria-Hungary, Brazil, France, Britain, Japan, Hawaii, Russia, Spain, Mexico, Switzerland, Venezuela and many other states sent representatives. The American Secretary of State welcomed them with language about serving the "civilized world", a phrase carrying all the assumptions of its century.

Then they began arguing about Greenwich, where the practical case was formidable. A table presented to the conference counted 37,663 ships already using Greenwich longitude, about 65 per cent of the vessels surveyed and 72 per cent of the tonnage.[2] Paris accounted for about 10 per cent of ships and 8 per cent of tonnage. The remainder was divided among other national meridians.

This was standardisation's strongest argument: do not imagine that the world is beginning from zero. Ask which change will disrupt the fewest existing charts, almanacs, instruments, printing plates, observatories and trained users. Greenwich had not won a philosophical contest about where longitude ought naturally to begin. It had accumulated infrastructure.

France's delegates objected to turning practical dominance into universal scientific authority. The astronomer Jules Janssen argued that science itself had no reason to prefer Greenwich. Britain's maritime power, chart-making reach and the amount of shipping already using its meridian were historical advantages, not laws of nature. To make them universal could look like science following the strongest existing power rather than choosing a neutral reference.

Janssen did not simply demand that Paris replace Greenwich. He argued for a neutral meridian, one that did not run through a national observatory and therefore would not award symbolic priority to one state.[3] The proposal was attractive in principle and awkward in practice. A meridian in the middle of an ocean would still need to be defined from an observatory somewhere, while the world would still face the cost of changing charts and systems.

One proposed compromise has particular appeal from a New Zealand perspective. Instead of Greenwich, why not use the meridian exactly opposite it, running largely through the Pacific? The line belonged to the same great circle and could be defined precisely from Greenwich, while zero itself would no longer pass through

Britain. A speaker described such a Pacific meridian as potentially "international and in no respect national".

The part of the world often pushed toward the edge of a familiar map was briefly considered as the place from which longitude might begin counting.

It did not win. Greenwich had observatories, charts, navigational practice and users on its side. A neutral Pacific zero had conceptual elegance. Greenwich had a much lower switching cost.

The Greenwich resolution passed on 13 October. That session's roll call recorded twenty-one states in favour, San Domingo against, with Brazil and France abstaining.[4] When the conference adopted its Final Act on 22 October, the same resolution was recorded as 22–1–2, with Salvador included among the affirmative states.[5]

The conference had chosen a common reference, not moved the Earth. Governments still had to implement the decision, and France did not instantly abandon Paris longitude in every context. Standards acquire histories after the vote. What the conference established was an international answer to one question: where should east and west longitude begin?

It did not answer the more visible question of where the world should sit on a page. A familiar world map centred roughly on Greenwich keeps Europe and Africa continuous while dividing the Pacific between the left and right edges. New Zealand appears near one edge not because the planet puts it there, but because the map has been opened and arranged somewhere else. A Pacific-centred map reverses the emphasis. New Zealand, Australia, Asia, the Americas and the island Pacific can be seen around one continuous ocean, while the Atlantic takes the cut.

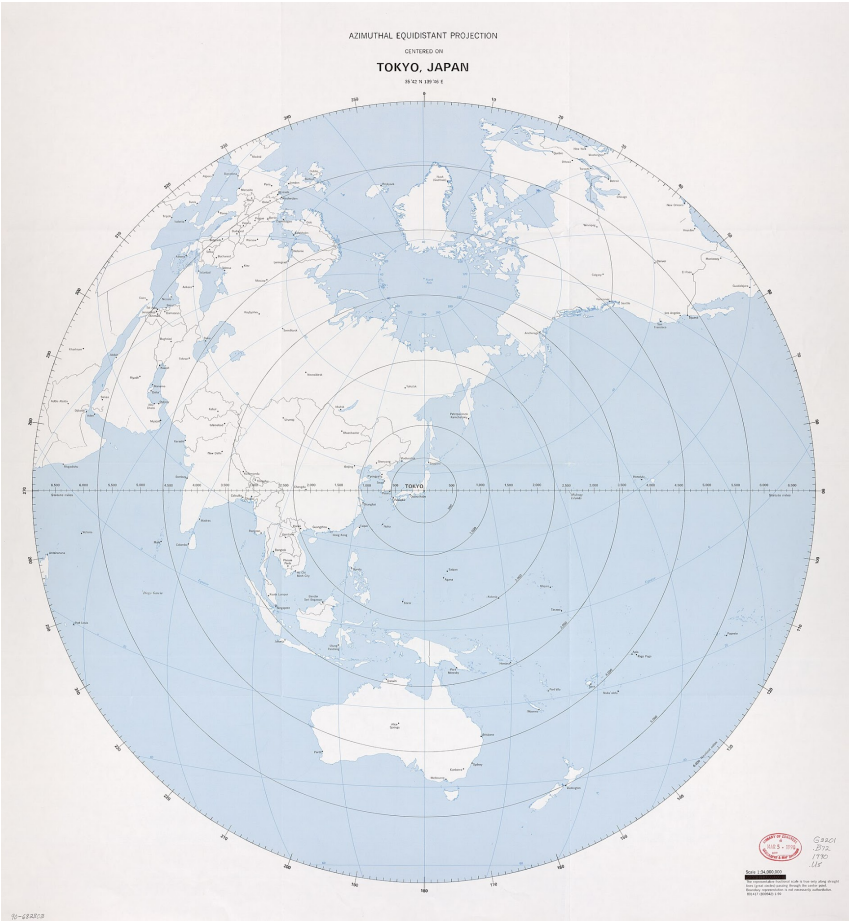


Figure 4.2. Azimuthal equidistant world map centred on Tokyo, 1990. Moving the centre changes the visual ordering of the world, while this projection also preserves distance from its chosen centre. U.S. Central Intelligence Agency / Library of Congress, Geography and Map Division. U.S. government public domain.

Nothing about Greenwich longitude has changed when the map is recentred. The prime meridian remains the reference from which longitude is counted.[6] The mapmaker has changed the central meridian of the display, the longitude chosen to sit near the middle of the picture.[7] The world's bookkeeping can remain Greenwich-based while the map turns to face the Pacific.

This is one of the simplest and most useful distinctions in world cartography. Moving the middle of a map no more relocates the prime meridian than turning a globe on a desk moves Greenwich. It changes what the reader sees continuously and what is divided by the edge.

For Pacific mapping that can matter a great deal. The ocean is not blank space separating important continents. It is route, environment, territory, resource and history. A map cut through the Pacific can make a connected region look like two margins. Recentring the map can improve the geographic story without claiming that one centre is morally or mathematically ordained.

There is no natural middle of the surface of a sphere. Any point can face you when you turn a globe. A flat world map has to choose.

Orientation is similar. North-up feels natural to readers accustomed to it, and that familiarity can be practically useful, but there is no physical law placing north at the top of a sheet. Other mapping traditions have used different orientations. A convention can be arbitrary in origin and still become useful once millions of people share it.

That is the deeper lesson of the Washington conference. Greenwich was selected because existing use, shipping, science, cost, national prestige and the desire for interoperability all mattered. British maritime power and chart-making reach plainly helped create the advantage. So did the practical benefit of not rebuilding the navigational world from scratch. The result was neither an inevitable scientific discovery nor a story that can be reduced to one political motive.

The delegates did not discover Greenwich. They selected it, and once that reference was widely adopted it became easy to treat as natural. That is what standards do when they work well enough for long enough. They reduce the number of questions users have to ask. A navigator can exchange longitude without first naming a

national observatory. A database can store geographic coordinates inside a shared reference. A clock can be related to a common time system. The price of that convenience is that the original choice becomes harder to see.

From New Zealand, the distinction between reference and presentation is especially useful. Greenwich can remain zero while the Pacific becomes the centre of a map. New Zealand can move from margin to middle without moving a metre on Earth. The edge is cartographic, not geographic.

The conference fixed one invisible line so ships, charts and clocks could speak a more common language. The next lines in this story were different. They were drawn to divide territory, and once political power attached itself to them, changing the line could mean changing who claimed the land on either side.

CHAPTER 5

DRAW A LINE, CLAIM A WORLD

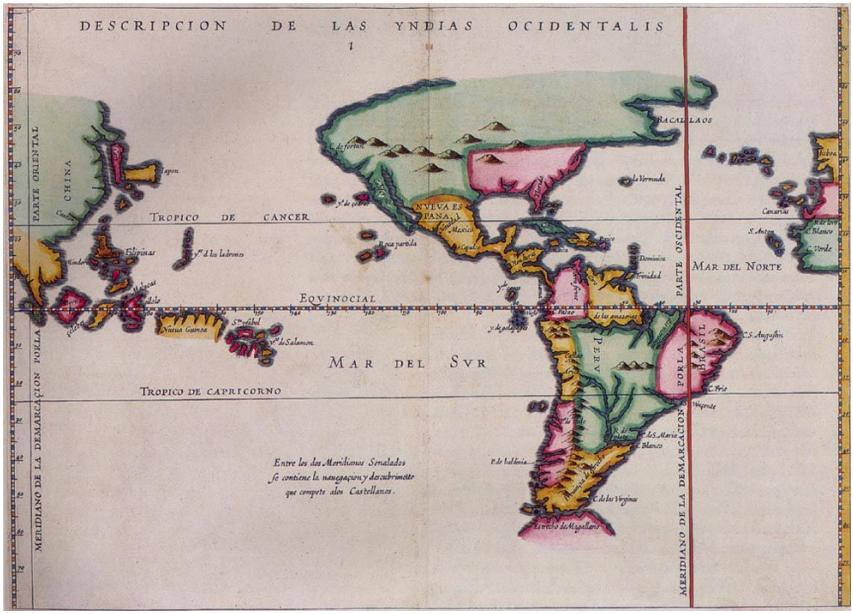


Figure 5.1. A seventeenth-century map showing the meridian associated with the Treaty of Tordesillas. The line is a reminder that an abstract division drawn on paper could be made to carry imperial claims across oceans and continents. Antonio de Herrera y Tordesillas, 1622. Public domain.

Long before anyone argued about Greenwich, people had discovered that a line could acquire an unusual authority once it was written down.

The British Museum holds dark boundary stones from ancient Babylonia known as kudurru.[1] They are not maps in the modern sense. They are legal objects recording grants, people, measurements and limits, sometimes surrounded by divine symbols. One

surviving inscription from the eleventh century BCE describes such a stone as establishing a boundary forever.

Forever is an ambitious word for any boundary. Rivers move, markers disappear, states collapse and neighbours disagree. Yet the desire behind the word is familiar. A spatial decision has been made, and somebody wants it to persist after the people who made it are gone.

Maps are very good at giving such decisions geometry. They can translate a treaty, conquest, grant or compromise into something that can be seen, copied and later surveyed. The line on the page is not the same thing as authority on the ground, but it can become the spatial form through which authority is implemented.

In 1494, Castile and Portugal attempted this on a scale that still sounds audacious after five centuries of imperial history. The Treaty of Tordesillas, signed on 7 June, established a demarcation line from pole to pole 370 leagues west of the Cape Verde islands.[2] Lands on one side would fall within the Spanish sphere, lands on the other within the Portuguese.

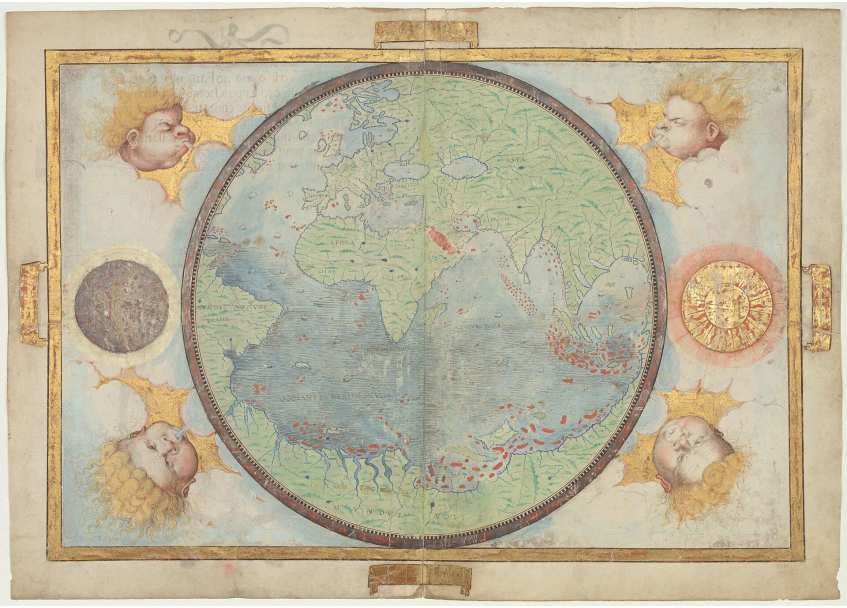


Figure 5.2. The Portuguese hemisphere from the Miller Atlas, 1519. The richly worked chart belongs to the imperial cartographic world created around voyages, claims and the attempt to divide newly encountered lands into rival spheres. Lopo Homem and collaborators / Bibliothèque nationale de France. Public domain.

The treaty had the confidence of geometry and the inconvenience of geography. Its negotiators were allocating rights across oceans and territories Europeans had not fully charted and, in many places, had never visited. The supposedly precise phrase "370 leagues west of the Cape Verde islands" immediately raised practical questions. Which island supplied the reference? How long was the league? How could longitude be measured accurately enough at sea in the late fifteenth century to place the line consistently?

The treaty did not make these problems disappear. It gave two rival states a geographic rule around which they could negotiate claims. That rule would have enormous consequences, including for Portugal's position in what became Brazil. It also rested on a po-

litical premise rejected by the people already living in the territories being assigned.[3]

Modern maps can make Tordesillas look more settled than it was. Draw a clean north-south line, colour one side Spanish and the other Portuguese, and five centuries of uncertainty collapse into a confident graphic. The people who signed the treaty had no such finished layer. They had incomplete charts, astronomical techniques, negotiation and disagreement over what the words meant in actual geography.

That is one of cartography's recurring powers and recurring dangers. A finished line can hide how hard it was to locate, who contested it and what authority made it consequential.

Three and a half centuries later, the Treaty of Guadalupe Hidalgo shows the process becoming more explicit. Signed on 2 February 1848, it ended the war between Mexico and the United States and transferred an immense territory to the United States. Article V described the new boundary in words, following the Rio Grande, the limits of New Mexico, the Gila River, the Colorado and a final straight line toward the Pacific. For the New Mexico portion, the treaty also referred specifically to an 1847 map published by John Disturnell.[4] A copy was attached and signed and sealed by the negotiators.

That sounds reassuring: if words are difficult, use a map. The Disturnell map, however, was not a perfect representation of the terrain the treaty was trying to divide. The boundary commission that followed had to reconcile the text, the mapped geography and the actual landscape. The treaty anticipated this by requiring each government to appoint a commissioner and surveyor. They were to meet, run and mark the boundary, keep records and produce plans whose agreed results would carry legal force.

The sequence is the important part. A political agreement defines a spatial relationship. A map helps represent it. Surveyors

take the description into the field. Physical monuments and observations connect the legal words to the land. Administrators and later surveyors maintain the result.[5]

The line does not leap from paper into the desert; people carry it there. From 1848 into the 1850s, boundary-survey parties worked across thousands of kilometres of difficult country. They used astronomical observations, field measurement, reconnaissance and monuments to turn treaty language into recoverable positions. The surviving records show something that the clean modern border cannot: heat, distance, imperfect prior maps, field decisions and the labour of making a line real.

Most political maps give us the finished line first. Two colours meet neatly. The border has no broken instruments, no diplomatic correspondence, no disputed coordinate, no shifting river channel and no surveyor trying to decide where a sentence written in a capital touches the ground. The final line hides the work and uncertainty that produced it.

Repetition then gives the line another kind of strength. The same geometry appears in atlases, deeds, official documents, signs and digital datasets. A once-contested decision becomes an ordinary reference. Later users may encounter only the current boundary, with no reason to know how uncertain or politically charged its creation was.

Law, however, does not allow every printed line to become sovereignty merely by looking official. In 1986, the International Court of Justice considered a frontier dispute between Burkina Faso and Mali.[6] Both sides had submitted many maps and sketches, yet no indisputable boundary emerged from the pile. The Court treated maps, in ordinary circumstances, as information and evidence whose value depended on their reliability and relationship to the legal record, not as territorial title merely because a line appeared on them.

That is a useful antidote to visual confidence. A map can record a claim, illustrate an agreement, support an argument or help locate a boundary. Its legal function depends on the instrument and context behind it.

Sometimes that function is deliberately strong. The 1995 Dayton Peace Agreement that ended the war in Bosnia and Herzegovina incorporated mapped boundary material into the settlement and gave it a controlling role in implementation.[7] In that case the map was not merely a later illustration of the agreement. It was part of the machinery by which the agreement became spatially operational.

These examples are enough to establish the principle without turning every political line into the same legal category. Geometry does not announce its own authority. A treaty line, an administrative boundary, a ceasefire line and a disputed claim can look almost identical at small scale while carrying very different meanings.

The most durable boundaries combine several things: words that describe the decision, maps or coordinates that locate it, physical or surveyed evidence that lets later users recover it, and institutions prepared to act on the result. Remove any one of these and the line may become harder to maintain. Add all of them and a decision can outlive the generation that made it.

Political power repeatedly reaches for cartography when it wants geography to hold still. A state administering territory across great distances needs descriptions, surveys, registers and maps that allow officials who cannot see the land to speak about it consistently. The map does not replace law or force. It gives those systems a portable spatial language.

For a modern GIS user, this history is easy to forget. Add a country-boundary layer and the world appears instantly divided into polygons. The interface conceals the treaty, survey, river change, court judgment, dispute and administrative history be-

neath the line. Different datasets may still disagree, and a boundary may be de jure, de facto, disputed, provisional or generalised for display, but the software prefers a geometry it can store.

The map user sees a line. The analyst sees metadata. The lawyer sees a claim or instrument. The person living beside the line may see a checkpoint, a tax authority, a land title, a school system or a barrier between relatives. The same geometry can belong to all these realities at once.

The Babylonian boundary stone, Tordesillas and the U.S.-Mexico survey are separated by millennia and political systems, but they share the same practical problem: how do you make a spatial decision persist when the decision-makers are absent?

The durable answer usually combines all three: write the rule, draw the line and mark the ground.

Once the line has been fixed, another task begins. Everything inside it can be measured, divided and entered into records. That is where the surveyor becomes central, and in colonial New Zealand the consequences could be immediate enough to provoke people to pull the survey pegs straight back out of the ground.

CHAPTER 6

SURVEY AFTER CONQUEST



Figure 6.1. Subdivision of a Native Reserve in Block XII, Waikouaiti Survey District, 1888. The survey map turns land into measured parcels, boundaries and numbered sections. New Zealand Railways Corporation, District Engineer's Office, Dunedin / Archives New Zealand, DABB D101 409/55 - R6619117. CC BY 2.0.

A survey peg is a very small object to carry so much argument.

In 1879, government surveyors were working across confiscated land on the Waimate Plain in south Taranaki. Their task was ordinary by the standards of a colonial administration: measure the land, mark boundaries, lay out roads and sections, and prepare the ground for settlement.

The work required an abstract scheme to become physical. A line in a plan or instruction had to touch the land somewhere. Survey pegs did that quietly, one point at a time.

The people of Parihaka understood what those pegs meant. Under the leadership of Tohu Kākahi and Te Whiti-o-Rongomai, Māori resisting the settlement of confiscated land disrupted the surveys, removed pegs, ploughed land occupied by settlers and built fences across roads cut through their cultivations. The resistance was deliberately non-violent, but it attacked government policy at the moment that policy was becoming recoverable geography.

A surveyor could replace a peg; the argument was about the authority behind it. That is one of the most useful things to understand about surveying. Measurement can be technically exact while the arrangement being measured remains politically contested. The angle, distance and traverse can all be correct. None of those observations decides who was entitled to order the survey. Once an institution has made that prior decision, however, surveying can make the decision durable.

Cadastral surveying does more than measure. It translates land into legal parcels that can be identified, recorded, sold, taxed, mortgaged, inherited, subdivided and disputed. In New Zealand, cadastral survey plans extend back into the nineteenth century and remain part of the infrastructure beneath property records. A modern title can feel like an obvious description of a patch of Earth, but a parcel is a legal and spatial object that had to be defined.

That distinction was especially consequential in a colonising society. Māori had long-established systems of land tenure, territory

and resource rights, with relationships grounded in whakapapa, occupation, cultivation, fisheries, forests, seasonal use and connections among whānau and hapū. Rights could overlap. The colonial state did not encounter an absence of land relationships. It sought to translate them into a system that its own courts, titles and land market could administer.

Law did part of that work and surveying did another. The Native Land Court became central to the transformation. In its nineteenth-century operation it converted customary interests into titles recognised by colonial law.[1] Before the court could investigate a block, land generally had to be surveyed, and owners were expected to meet the costs. A survey plan therefore did not merely illustrate the court's decision after the fact. It helped turn the land into an object that the court could identify and process.

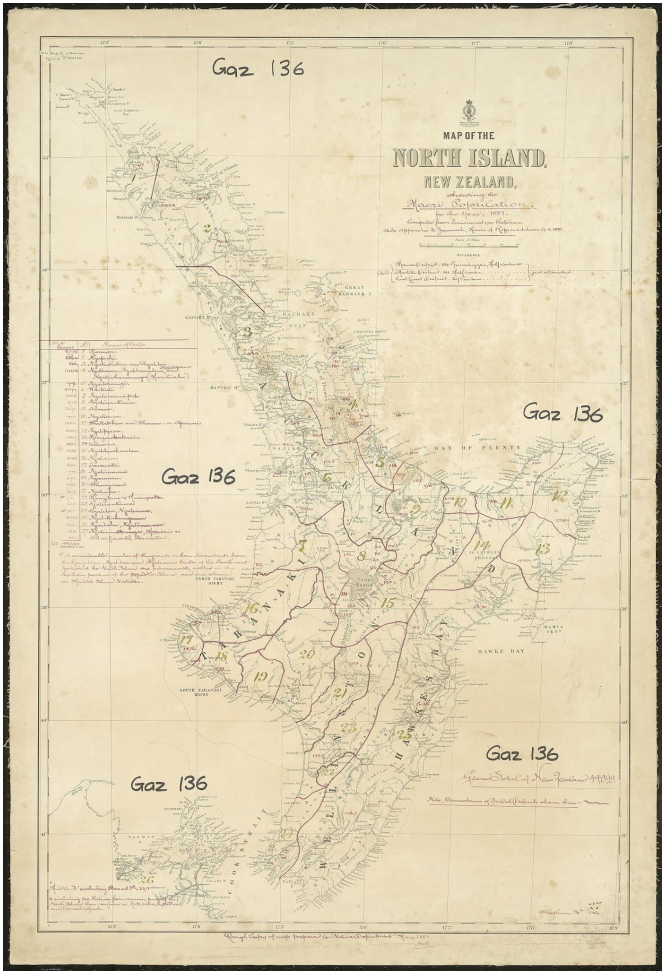


Figure 6.2. North Island map showing iwi boundaries and Māori population, 1881. This is a colonial-state cartographic classification, not an authoritative statement of iwi geography. It is useful here because it shows how Indigenous land and people were translated into administrative map categories. Archives New Zealand. CC BY-SA 2.0.

A place may be completely intelligible to the community that lives there through names, whakapapa, use, memory and relationships. A bureaucracy operating at distance wants something different: an object with a defined extent, an area, recognised owners and a

record that can be found again. Surveying helps create that administrative legibility.

An earlier Wellington episode makes the politics of the peg unusually clear. In 1840, when surveyors marked out the colonial town at Te Aro, Māori pulled up pegs because they disputed that the land had been sold.[2] Nearly four decades later, the same physical action appeared at Parihaka. The legal systems and circumstances were different, but the peg still marked the point where an external decision entered the ground.

By the 1870s, New Zealand's surveying system was itself becoming more organised. Early colonial surveys had been fragmented among provinces and practitioners of uneven quality. Expanding settlement and land transactions exposed overlapping boundaries, inconsistent records and surveys that could not be reconciled cleanly. In 1876 the provincial survey systems were brought into a national structure under a Surveyor-General, with professional regulation tightening over subsequent decades.[3]

This administrative story lacks the drama of Parihaka but explains why cadastral systems become so powerful in ordinary life. A land market needs confidence that the parcel sold this year can be found by another surveyor decades later. A mortgage needs a legally identifiable property. A road reserve needs recoverable edges. A town needs sections. The stronger the survey framework, the easier it becomes for institutions to act consistently on land records.

For Māori owners passing through the Native Land Court, the costs of this system could themselves become a mechanism of loss. Surveying had to be paid for. Te Ara notes cases where survey costs consumed twenty per cent or more of a block's value, alongside court, travel and other expenses.[4] Waitangi Tribunal research records instances in which land was surrendered to meet survey charges and reports nearly 40,000 acres associated with Ngāti Ma-

niapoto survey costs, while also showing why such figures must be handled carefully by district and evidence.[5][6]

The mechanism is more important than one national total. A community could need a survey for title recognition under the colonial system. The survey created a debt. That debt could then contribute to land being sold or surrendered. The process that made ownership legible to the state could therefore help place ownership under financial pressure.

Surveying is also indispensable to modern Māori land administration, Treaty settlement work, infrastructure, environmental management, housing and the protection of legal rights. Precision is useful. Its political meaning depends on the institutional decision that precision is being used to implement.[7]

At Parihaka, the answer was inseparable from confiscation and settlement. The government had confiscated large areas of Taranaki land during and after the wars of the 1860s. Promised reserves remained unresolved.[8] Survey work on the Waimate Plain accelerated in 1878 and 1879, and Te Whiti and Tohu's followers resisted the process through peg removal, ploughing and fencing.[9] The government responded with arrests. On 5 November 1881, a force of roughly 1,600 volunteers and Armed Constabulary entered Parihaka.[10] Te Whiti and Tohu were arrested, and the settlement was broken up.

The story is properly remembered as one of non-violent resistance and state violence. It is also a story about what happens after territory has been claimed. Conflict can move from armies into surveys, roads, reserves, titles and settlement. Surveying helps organise what happens next.

That administrative afterlife is visible in the records. A nineteenth-century peg may disappear while the line associated with it survives through survey plans, titles, coordinates and

later resurvey. The physical marker can be temporary. The administrative geometry can last for generations.

This is why cadastral records are such rich historical documents. They can preserve old place names, occupation lines, fences, streams, road proposals, reserves and the work of surveyors who could not have imagined a digital cadastre. They show land at the moment it is being fitted into a system of sections, blocks, lots, roads, reserves and titles.

Those categories are ordinary parts of a modern land system. They are also historical products. Once a parcel has a legally recognised boundary and record, it can enter institutions that depend on those things. It can be transferred, mortgaged, rated, partitioned, inherited or subdivided. The map does not perform those acts by itself. It gives the institutions a stable object on which to act.

A cadastral plan can therefore be more consequential to a person than a famous world map. The world map asks how the planet should be represented. The cadastral survey asks where this piece of land ends, and who the legal system recognises on either side.

At Parihaka, pulling out the pegs did not erase confiscation law or defeat the government. It revealed the machinery required to turn the state's decision into sections, roads and settler titles. Those outcomes did not emerge automatically from conquest. They had to be measured and recorded.

Precision also made geographic knowledge valuable. Detailed geographic knowledge could support administration, property and infrastructure, but it could also become an advantage worth guarding or stealing.

CHAPTER 7

MAPS WORTH STEALING

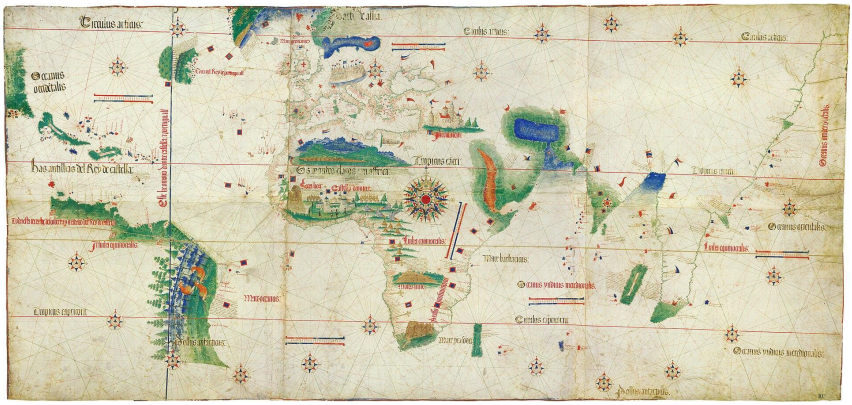


Figure 7.1. The Cantino Planisphere, 1502. Made by an anonymous Portuguese cartographer. This celebrated world map was covertly copied in Portugal for Alberto Cantino, making it an unusually literal example of geographic information worth stealing. Biblioteca Estense Universitaria, Modena. Public domain.

In 1502, Alberto Cantino had a problem familiar to intelligence officers in every century: the information he wanted belonged to somebody else.[1]

Cantino was in Lisbon working for Ercole I d'Este, Duke of Ferrara. Portugal was accumulating some of the most commercially valuable geographic knowledge in Europe. Portuguese voyages had rounded Africa, reached India by sea, crossed the Atlantic to Brazil and pushed into waters that remained uncertain on many European maps. Routes, ports, coastlines and discoveries were not merely interesting. They were advantages.

A coastline could be a commercial secret. A sailing route could be a state asset. A world map could be worth stealing.

The document that came to bear Cantino's name is now known as the Cantino Planisphere. The surviving original, held in Modena, is more than two metres across and drawn richly on parchment. It shows Europe and Africa, the Atlantic, recently charted parts of the Americas, the route around the Cape of Good Hope toward India, and geographic information that had reached Lisbon only recently from Portuguese voyages.

The precise circumstances of its creation require caution. Institutional accounts describe Cantino as an Italian agent who is believed to have bribed a Portuguese cartographer for a copy and sent it clandestinely to Ferrara. Modern scholarship is more careful about treating the surviving map as a simple copy of one perfectly controlled royal master chart. The larger point is much firmer: Cantino obtained privileged Portuguese geographic information for another court, and that information was valuable because it was difficult to acquire.[2]

Today a world map is among the least secret objects imaginable. A child can inspect coastlines, roads, ports and satellite imagery on a phone. In Lisbon in 1502, detailed knowledge of a recently explored coast could be the product of an expensive and dangerous voyage, collected by pilots and navigators, paid for by a crown and guarded because another state could use the same knowledge for trade and power.

Cartography was part of intelligence because a map could do something a pile of reports could not. It assembled information spatially.

A letter might say that Portuguese ships had reached India. A map could show the route around Africa. A report might describe a new coast. A map could place it relative to islands, ports and the line agreed at Tordesillas. Facts became relationships.

That is the peculiar value of geographic intelligence. A warehouse is information. A warehouse beside a navigable river, con-

nected to a road and close to a bridge with a known load limit, is a different kind of information. Location turns isolated facts into a system.

The expensive part of a map is often not drawing it. The expensive part is knowing enough to draw it.

For early navigators that knowledge came from voyages, observations, dead reckoning, soundings, local knowledge, coastal sketches and accumulated experience. For later survey departments it came from field crews and instruments. For intelligence agencies it could require aircraft, satellites, analysts and spies. The map is the compression format.

Cantino's map also had an extraordinary afterlife. Commissioned for Ercole I d'Este, the planisphere ultimately entered the collections now held by the Biblioteca Estense Universitaria in Modena, where it survives as one of the library's celebrated cartographic treasures. Later accounts disagree over some details of its nineteenth-century rediscovery, so the safer irony is simpler: information acquired for strategic advantage can outlive the political purpose that made it valuable.[3]

A map's value is not permanently stored in the parchment. It depends on who knows what the sheet contains and what can be done with the knowledge.

Four and a half centuries after Cantino, another government attempted a geographic intelligence project at an astonishing scale. During the Cold War, the Soviet Union produced topographic maps covering enormous areas outside Soviet territory and detailed plans of more than two thousand foreign towns and cities. Many city plans were made at scales such as 1:10,000 or 1:25,000 and marked СЕКРЕТНО: secret.

One of them was Dover, at the narrowest part of the English Channel, facing continental Europe. Harbour, railways, cliffs, tunnels, military history and transport infrastructure occupy a com-

pressed strategic geography. A Soviet military plan compiled in 1972 and printed in Saratov in February 1974 mapped the town at 1:10,000, listed twenty-nine strategically important objects and included a descriptive text of around a thousand words.[4]

Some of the detail is unsettlingly practical. The plan recorded transport and industrial facilities, showed the railway tunnel beneath Shakespeare Cliff, marked ventilation shafts, included harbour depths and soundings, and identified military, government, communications and industrial sites with a standardised system of numbers and colours.

It also made mistakes. A coal-handling aerial ropeway dismantled decades earlier survived on the Soviet plan. One industrial site appears to have been misclassified, perhaps because information had been inherited from an older German wartime source. Important underground facilities were absent.

The errors make the map more revealing. An intelligence map is not a magical view from nowhere. It is an argument assembled from sources. Some information is current, some old, some copied, some inferred and some wrong. The finished sheet can look far more certain than the process that produced it.[5]

Researchers comparing the Dover plan with British mapping have found evidence that Soviet cartographers were not simply tracing one Ordnance Survey source. Terrain, hydrography and strategic information were combined and reorganised for military purposes. Existing maps were inputs, not the final product.

This links Cold War Dover to Renaissance Lisbon. In both cases, the valuable thing is the combination. Geographic information gains power when separate observations share location and can be read together.

A modern GIS analyst recognises the logic immediately. Roads, bridges, slope, vegetation, ports and fuel depots can each exist as separate datasets created for ordinary civilian purposes. Combine

them and a new question becomes possible, one none of the original publishers needed to ask. The map becomes more than the sum of its layers.

This is also why geographic secrecy is difficult. A government can classify a report more easily than it can conceal a coastline. A bridge plan may be restricted while the bridge itself remains visible to travellers, photographers, planning records, shipping notices and sensors. The information needed for a map can leak through people, publications, commercial charts, engineers and observations made from somewhere else.

States still try. The Portuguese crown attempted to control sensitive charts. Twentieth-century militaries classified detailed mapping. Governments today continue to restrict some geospatial information and high-resolution imagery. The incentive is durable because where something is can still be valuable knowledge, especially when the other side does not know what you know about it.



Figure 7.2. Kunstmann II portolan chart, c.1502–1506. Anonymous, attributed to Amerigo Vespucci. Charts like this condensed newly valuable coastlines, routes and geographic intelligence into portable objects, helping explain why states tried to control cartographic knowledge. Wikimedia Commons reproduction of a public-domain work. Public domain.

The Soviet maps eventually escaped too. After the collapse of the Soviet Union, sheets that had been secret began appearing commercially. In the 1990s, Western cartographers and collectors could buy maps that had once been created to support Soviet military planning.[6]

A classified plan could become a research object, and the political system that produced it could disappear while the geographic information survived. The pattern recurs throughout cartographic history. Military surveys become civilian basemaps. Intelligence imagery becomes environmental or archaeological evidence. Colo-

nial surveys become sources for Treaty research. A map's second life may have almost nothing to do with the task that first justified its creation.

Cantino's plan now reveals the geographic knowledge Portugal possessed and another court's appetite to acquire it. The Dover plan reveals what Soviet military cartographers considered worth knowing about an English port and how successfully they could reconstruct it from afar.

Neither was created mainly to persuade a public audience. They were working instruments intended to support advantage. Propaganda maps try to influence what viewers feel or believe; intelligence maps often exist to help somebody act by navigating, trading, landing, moving troops, assessing terrain or choosing a route.

Operational usefulness can make the important parts of a map look almost boring. A bridge's load capacity may matter more than a dramatic national boundary. Harbour depth may matter more than an elegant coastline. War and logistics happen through details.

Maps are often most powerful when they stop being pictures of territory and become instructions for acting inside it.

There is a further caution. Secret cartography should not be told only as a story of clever state mapmakers and spies. Official maps have often depended on guides, pilots, interpreters and local communities whose knowledge disappeared beneath the names of institutions or surveyors. A place may be secret in a government archive while being thoroughly known to the people who live there. Secrecy is a relationship around recorded knowledge, not a property of the landscape itself.

A reef is not classified. A government's precise assessment of it might be. A city is visible to its residents. A compiled database of every road width, tunnel, depot and communications site is something else.

Cantino had to get a physical map out of Portugal. A modern dataset can be copied perfectly and cross the world without leaving the original owner with one fewer copy. The better geographic information becomes at travelling, the harder it becomes to contain.

The map Cantino obtained in Lisbon survived the empire that tried to guard the information behind it. The Soviet plan of Dover survived the Soviet Union. What began as advantage became archive.

Once geographic information is standardised, gridded and distributed through an army, it can become operational at the scale of metres.

CHAPTER 8

THE MAP GOES TO WAR

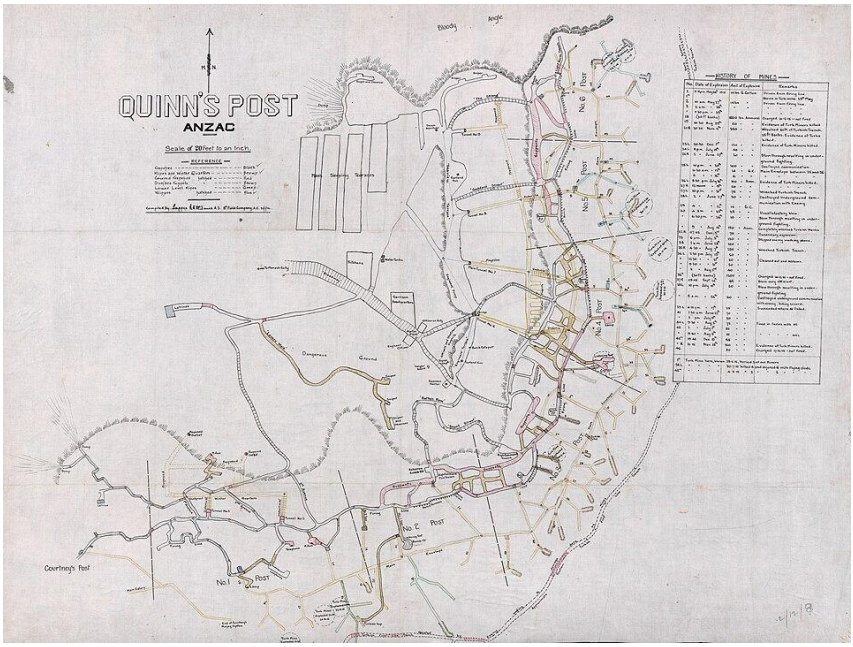


Figure 8.1. Quinn's Post trench and tunnel map, Gallipoli, December 1915. Made by Sapper (later Lieutenant) Ronald McInnis. The dense network of trenches, saps and tunnels shows the operational scale at which wartime mapping could become a matter of survival. Australian War Memorial, G7432.G1 S65 XII.8e. Public domain.

At a scale of 1:1,800, one centimetre on a map represents eighteen metres on the ground.[1]

A surviving New Zealand Expeditionary Force plan from Gallipoli is drawn at exactly that scale. It shows the Apex on Rhododendron Spur below Chunuk Bair. The sheet, about forty-one by fifty-six centimetres, is almost obsessively local. It has no interest in

explaining the Ottoman Empire or why armies had landed on the peninsula. It is interested in a patch of steep ground where a few dozen metres could matter.

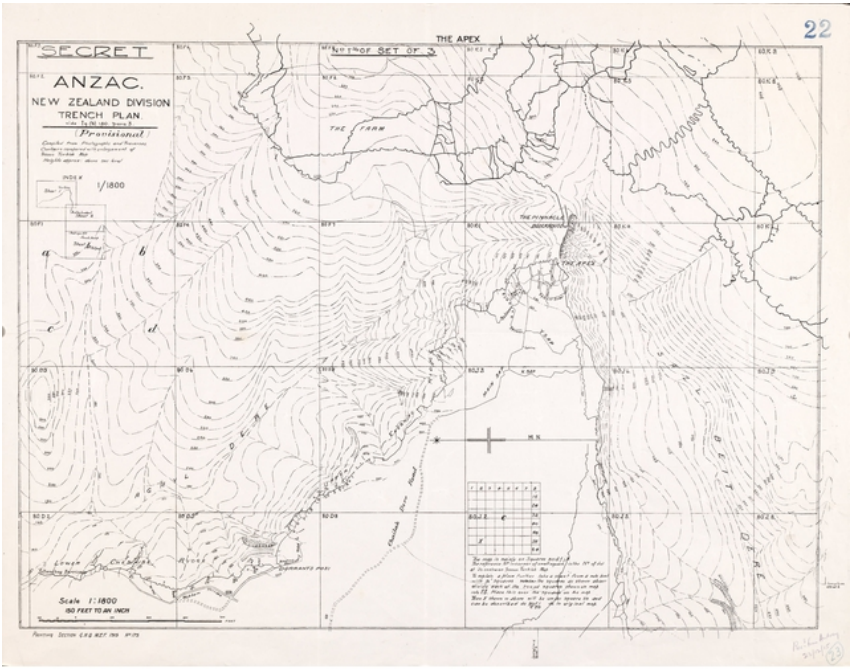


Figure 8.2. ANZAC New Zealand Division trench plan of The Apex, Gallipoli, 1915, scale 1:1,800. Made by the Printing Section, G.H.Q., Mediterranean Expeditionary Force. The map is almost obsessively local because a few dozen metres could matter. Australian War Memorial, RC04172. Copyright expired, public domain.

The plan survives in Auckland Libraries as one sheet in a 1915 ANZAC New Zealand Division trench-plan series.[2] Its value is broader than the provenance of any one surviving copy. It shows the cartographic environment in which New Zealand troops fought: an army enlarging small pieces of landscape because operational consequences had become concentrated inside them.

At the Apex in the early hours of 7 August 1915, Lieutenant-Colonel William Malone and the Wellington Infantry Battalion were living inside that kind of geography.[3]

The Allied August offensive was intended to break the stalemate at Anzac by seizing the heights of the Sari Bair Range, including Chunuk Bair. The ground between the beachhead and the summit was a maze of steep ravines, narrow spurs and scrub. Soldiers had given working names to places that now carried military meaning: Old No. 3 Post, Table Top, Rhododendron Spur, the Apex, the Pinnacle and Chunuk Bair.

The plan depended on units moving through that terrain at night and arriving at particular places on schedule. The terrain did not cooperate. Columns became lost or delayed, rendezvous failed and the offensive lost precious hours while Ottoman forces reinforced the heights. A route can be intelligible on a map and still be brutal to follow in darkness through unfamiliar ground.

Malone reached the Apex with the Wellington Battalion. After the Auckland Battalion suffered heavily in a daylight attack on 7 August, Malone resisted sending his men forward in the same conditions. The Wellingtons attacked before dawn on 8 August and reached Chunuk Bair, where they occupied and extended trenches under intense fire.[4] By the time the battalion was relieved that evening, about seventy of the 760 men who had advanced from the Apex were still standing. Malone was dead, killed at about 5 p.m. by an Allied shell, probably from supporting artillery.

The event contains a terrible lesson about increasingly precise warfare. Maps, grids and fire-control systems were intended to put violence in the intended place. Greater positional precision made coordination possible on a scale earlier armies could not manage. It also made errors of tens of metres consequential in ways that errors of kilometres were not.

The 1:1,800 Apex plan makes the scale visible. Five centimetres on the paper is ninety metres on the ground. A tiny movement of pencil or a slight misunderstanding of position can represent the distance between a trench and supporting fire.

This is where cartographic language becomes counter-intuitive. A 1:1,800 plan is a large-scale map because the fraction is large and the map shows a small area in great detail. A world map is small scale. Soldiers did not need the terminology to understand the practical difference. A world map could explain why armies were fighting across continents. A trench map helped determine which gully, junction or trench mattered next.

The First World War turned local precision into an industrial mapping system. The British military produced tens of millions of official maps, including an immense family of Western Front sheets at different scales. The National Archives describes 1:40,000 maps used for wider administrative purposes, 1:20,000 maps important for artillery, 1:10,000 trench maps for local operations, and 1:5,000 sheets for even more detailed work.[5]

This was cartography organised by consequence. Different jobs required different extents and detail.[6] The battlefield did not have one definitive scale any more than the world has one definitive projection.

The Western Front also developed a grid-reference language that let positions travel through messages. A location could be compressed into letters and numbers and passed among headquarters, observers, artillery and infantry. A grid reference might identify a square and then subdivide it to increasing precision. Add enough detail and a location could be narrowed to only a few yards.

A place no longer needed a memorable name before it could become operationally important; it could be a coordinate. The usefulness depended on a shared system. A grid reference without the correct sheet is nearly useless. Modern researchers still encounter

wartime diaries containing coordinates whose meaning has to be reconstructed from the map series the writer was using. The number belongs to a reference system, not to the landscape by itself.

That idea will matter later when this book reaches modern geodesy and GIS. For the battlefield, the immediate point is simpler: standard grids made position portable.

They also made currency important. Trenches moved. New positions were dug, batteries shifted and intelligence changed. The National Archives catalogue repeatedly records sheets with trenches "corrected to" a particular date. A beautifully printed map could become operationally stale while remaining perfectly legible.

A military user therefore needed the right place at the right scale and the right date. Security followed naturally. A map useful to your own army can help the enemy if captured. Larger-scale trench maps often emphasised enemy positions, while "Secret" editions could show Allied trenches as well. Operational users wanted detail; security officers wanted control; cartographers wanted consistent symbols; intelligence officers wanted the latest positions. One sheet could not serve every requirement.

Armies therefore produce families of maps. The New Zealand Apex plan belonged to one family of local operational sheets. Broader maps explained the Sari Bair offensive. Artillery grids, naval charts, aerial photographs and sketch maps answered other questions. Later official histories would draw the same ground again for readers who already knew how the battle ended.

That last category carries a trap. A clean retrospective map can make a battle look more coherent than it felt to the people inside it. Arrows move decisively, units have tidy labels and objectives sit still. A battalion commander in a gully did not possess the historian's complete aerial view. Reports arrived late, units were missing, terrain blocked sight and darkness erased landmarks.

Gallipoli reminds us that a map extends what people can know without turning them into omniscient observers. The plan had geometry. The men had geometry plus fatigue, uncertainty, enemy action and a clock.

After the fighting, the same ground changed cartographic jobs. In 1916, New Zealand's Department of Lands and Survey included a "Map of Anzac" in its annual report. The department said the map was prepared from information supplied by Private Waldo Thompson, a member of its Napier staff who had landed on 25 April 1915 and served for four months.

The episode creates a small loop in New Zealand's mapping history. A civilian survey employee went to war, returned with knowledge of a battlefield, and his department helped turn that knowledge into a map for readers at home.

The annual report tried to make the scale of Anzac understandable. It put the occupied area at about 1,000 acres, with the sea front extending about three miles and only about 1,100 yards between the sea and front trenches at the widest point. The campaign occupies a huge place in New Zealand memory. The actual Anzac position occupied a remarkably compressed piece of ground.

The 1916 map was no longer helping somebody attack a trench. The troops had withdrawn. Its job was explanation, record and memory. The same landscape had moved from operational geography into national history.

Maps of war often keep moving after the shooting stops. They become archival evidence, archaeological guides and clues for families and historians. Old grid references are decoded. Trench positions are compared with modern landscapes. A wartime sheet can become more historically valuable as its operational value disappears.

The First World War did not invent military cartography, but it demonstrated the scale at which mapping could become woven

into everyday operations: millions of sheets, standard grids, multiple scales, frequent revisions and security classifications. Paper had become part of an information system.

Some lines outlasted the operations that created them. A trench line might vanish into archaeology, while a ceasefire line could remain on the map and accumulate patrols, checkpoints, rules and institutions around it.

CHAPTER 9

THE LINE THAT SURVIVED THE WAR



Figure 9.1. Dayton Agreement map, Bosnia and Herzegovina, 24 November 1995. The settlement line is not merely described in words: the political arrangement is made visible and operational through a map. U.S. Central Intelligence Agency / Library of Congress, Geography and Map Division. Public domain.

On 30 November 1948, two military commanders sat down in Jerusalem with a map between them and tried to stop people killing one another.

The city had been fought over for months. Roads were cut, neighbourhoods divided and positions seized and lost. Israeli and Jordanian forces faced each other across a city that no longer functioned as one place. What they needed that day was not a final constitutional settlement or an internationally recognised frontier. They needed to establish where the troops would stop.

Moshe Dayan, commanding Israeli forces in Jerusalem, and Abdullah el-Tell, representing the Arab Legion and other Arab forces in the city, marked the positions held by their sides on an attached map with thick grease-pencil lines.[1] A Law Library of Congress review, using a copy from the Israel State Archives, records that the red and green strokes were 3–4 millimetres thick and could represent roughly 60–80 metres in the city; in places the lines were disconnected or unclear.[2]

The scene is almost too neat as a metaphor: two men, one map, coloured pencils, one divided city. Its importance lies in what happened next. The line was intended to help stop fighting. It was not designed to settle every political question beneath it. Yet a line that is observed, patrolled, copied and administered can accumulate a life far beyond the emergency that created it.

In 1949, Israel signed separate armistice agreements with Egypt, Lebanon, Jordan and Syria. The Israel-Jordan General Armistice Agreement, signed on 3 April, carefully defined military demarcation lines while stating that the arrangement was without prejudice to later territorial settlements or claims.[3]

That wording matters. An armistice line can tell armed forces where they may operate without becoming an ordinary sovereign boundary by that fact alone. The geometry on a small-scale map

may look similar, but legal status comes from the agreement and the history behind it, not from the thickness of the stroke.

The 1949 lines nevertheless became enormously important. Widely known as the Green Line, they structured movement, military positions and administration between 1949 and 1967.[4] In Jerusalem the division was physical. Barriers, no-man's land, fortified positions and controlled crossings cut through streets and neighbourhoods. A route that had once been ordinary could become impossible because the line now shaped daily life.

The line became lived geography without thereby becoming a complete answer to sovereignty. After the 1967 war, when Israel took control of territories beyond the 1949 armistice lines, the Green Line remained a powerful reference. It supplied a common before-and-after for diplomacy, law and public discussion. The military arrangement had outlived the military configuration that first gave it practical force.

Temporary lines become durable when institutions begin depending on them. Patrol instructions use the line. Checkpoints require locations. Governments issue maps. Property, roads, utilities and movement adapt. Diplomats need a shared geographic reference. Journalists need a short name for a complicated territorial situation. Each repetition gives the geometry another reason to survive.

Maps participate in that durability because they make the line easy to reproduce. They do not cause the conflict or create the political claims behind it. They give those claims and arrangements a stable spatial form that can be copied into the next document.

Korea offers an even clearer example of a provisional military geometry becoming institutional structure.

On 27 July 1953, representatives of the United Nations Command, the Korean People's Army and the Chinese People's Volunteers signed an armistice at Panmunjom. The Korean War had

devastated the peninsula and shifted front lines dramatically before fighting settled into a grinding contest near the middle. The armistice halted hostilities. It did not produce a comprehensive peace treaty or reunify Korea.

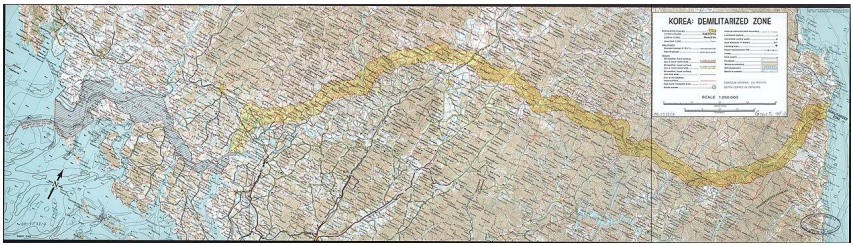


Figure 9.2. Korea Demilitarized Zone, 1969. The armistice line hardened into a mapped buffer that outlived the circumstances in which it was created. U.S. Central Intelligence Agency / Library of Congress, Geography and Map Division. U.S. government public domain.

Article I fixed a Military Demarcation Line on an attached map.[5] Each side was required to withdraw two kilometres, creating a Demilitarized Zone roughly four kilometres wide. The agreement required the line and the edges of the zone to be marked and created a supervisory system around the arrangement.

The sequence is almost laboratory-clean. First the line appears in the agreement. Then comes measurement, physical marking and withdrawal. Rules govern entry and crossing. A commission monitors the system. Geometry becomes administration.

The terminology needs care because simplified maps often turn the whole arrangement into one bold “border” line. The Military Demarcation Line is the line at the centre.[6] The DMZ is the wider zone created by withdrawals on both sides. The armistice remains an armistice rather than a final peace settlement. A general map may simplify this for legibility, but the simplification can change the history if the legend quietly turns a military arrangement into an ordinary treaty boundary.

More than seven decades later, the line and the DMZ remain central features of the peninsula's military and political geography. The larger political settlement anticipated by the armistice did not arrive. What was provisional in legal purpose became durable in institutional practice.

Jerusalem and Korea are very different histories and should not be collapsed into one model. The useful comparison is narrow. In both cases, military necessity created mapped lines with limited immediate purposes. Those lines remained long enough for systems and expectations to accumulate around them.

The line survives because institutions grow around it. Moving a boundary vertex in GIS is geometrically easy and politically difficult. A line may be attached to roads, property, water systems, military positions, administrative records, cultural sites and memory. The geometry is the visible tip of a much larger arrangement.

Eventually, durable lines acquire another life inside digital systems. A paper agreement map can be scanned. The line can be digitised into coordinates and stored as a feature. The geometry can enter national databases, humanitarian systems, academic datasets and online maps. Digital copying gives the line extraordinary persistence because the coordinates can be duplicated exactly, including any approximation or mistake inherited from the original source.

This makes provenance essential. A GIS line should carry more than geometry. What document defines it? What date does it represent? At what scale was it captured? Is it approximate, disputed or generalised? Is it a sovereign boundary, a line of control, an armistice line or some other administrative object?

A line with coordinates to six decimal places may still rest on a thick pencil mark drawn during a ceasefire.

That sentence captures the tension between numerical precision and historical origin. Digital coordinates can look far more exact than the source from which they were derived. The map becomes

dangerous when the precision of the storage format is mistaken for certainty about the status or original position of the line.

The Jerusalem story shows one route to durability. A rough emergency line can matter because later institutions repeatedly use it. Korea shows another. An armistice can build physical markers, withdrawal rules and supervisory arrangements around a mapped line from the beginning.

In both cases, the map is static while the durability is active. Political geography has to be maintained through patrolling, recording, negotiating, surveying, updating, crossing, preventing crossing and reproducing the line in official systems. The line has to be made real again every day.

Across these chapters, maps have moved from navigation and classrooms into treaties, surveys, intelligence, warfare and ceasefire administration. The common thread is operational: location becomes consequential when institutions can act on it. That raises a deceptively simple problem. Before a coordinate can guide a surveyor, soldier or phone, it has to answer a basic question: where are you on Earth?

CHAPTER 10

FINDING YOURSELF ON EARTH

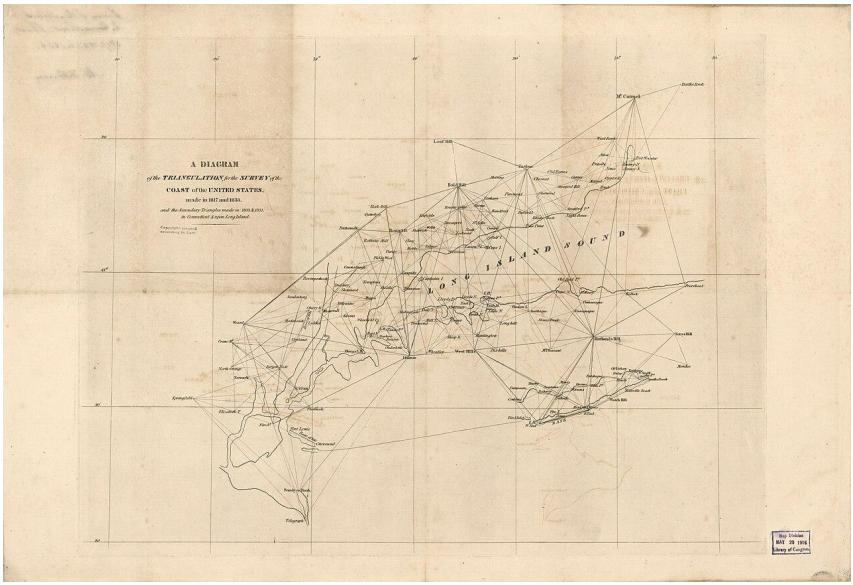


Figure 10.1. U.S. Coast Survey triangulation diagram, 1834. Position is built from networks of measured relationships: triangles spreading across the landscape until local measurements become a geographic reference framework. U.S. Coast Survey / Library of Congress, Geography and Map Division. Public domain.

In November 1761, a ship called the Deptford left Portsmouth for Jamaica carrying a watch.

Not an ordinary watch. John Harrison's H4 marine timekeeper had been completed after decades of work on clocks designed to keep reliable reference time while a ship pitched, rolled, heated, cooled and crossed an ocean. Harrison's son William carried H4 on the voyage as part of its formal trial.[1]

During the voyage, William Harrison used the timekeeper to predict that Madeira would appear sooner than the crew expected. He was right. The episode is usually told as a triumph of clockmaking, but the watch mattered because it answered a geographic question: where are we?

Latitude, the north-south part of the answer, had long been comparatively manageable at sea through observations of the Sun and stars. Longitude was harder. To know how far east or west a ship had travelled, the navigator needed local time and the time at an agreed reference meridian. The Earth rotates 360 degrees in about twenty-four hours, so one hour corresponds to fifteen degrees of longitude.[2] The arithmetic is easy. The hard part was carrying reference time accurately across the ocean.

A clock error became a position error. H4 did not make longitude effortless or instantly replace astronomical methods. Lunar distances developed alongside marine chronometers, accurate instruments remained expensive, and Harrison's dealings with the Board of Longitude became famously contentious. The larger change was nevertheless profound. A navigator could increasingly carry a stable reference with the ship. Position became easier to measure consistently rather than reconstruct only from dead reckoning and occasional astronomical fixes.

The same principle becomes more demanding on land when the required precision shrinks from kilometres to metres or centimetres. A coordinate looks like a property of a place, but it is really a description inside a reference system.

A survey mark makes the distinction physical. Imagine a brass disk set into concrete on a hill. The mark can be touched. An instrument can be placed above it. The coordinates assigned to that mark, however, depend on the geodetic framework being used. Change the datum and the brass disk does not move, yet the coordinate values can change.

The word datum often appears in software as an obstacle between the user and the map. The underlying idea is simpler. A geodetic datum provides the reference framework that connects coordinate numbers to the real Earth. It uses a defined coordinate system and a smooth mathematical model of the Earth, generally an ellipsoid. Modern systems may also include rules for movement over time.

The ellipsoid exists because the Earth is not a perfect sphere. It is slightly flattened at the poles, wider around the equator and irregular in ways that are awkward for calculation. Geodesists do not use an ellipsoid because they believe mountains and ocean trenches are imaginary. They use it because a precise mathematical surface makes a national or global coordinate system possible.

For much of surveying history, countries built their own reference frameworks from observations made on the ground. Surveyors measured baselines, observed angles and extended networks of triangles across landscapes. Triangulation is one of the great technologies hidden by simple geometry. Measure one distance exceptionally well, observe enough angles, and a connected network can spread position across a country without every distance being measured directly.

New Zealand's survey history shows why a national framework matters. European settlement and cadastral work did not wait for one complete geodetic network. Local and regional surveys grew first. As larger and more accurate triangulation networks developed, older work sometimes had to be reconciled with the newer framework.

High ground acquired trig stations because one survey point needed to see another. A trig was not there to improve the view; it was part of a national geometry. The first-order national triangulation is generally dated from measurement of the Wairarapa Baseline in 1909. The network took decades to complete. In 1949 New

Zealand adopted NZGD1949, a national geodetic datum based on astronomical observations, triangulation and the International 1924 ellipsoid.[3] Survey marks across much of the country could now be related to one national framework rather than a collection of regional systems.

That was an enormous practical achievement. A road project in Waikato, a boundary survey in Canterbury and topographic work in Otago could all refer to a common national geometry. The system gave surveyors a shared mathematical answer to where their control points were.

The answer was designed for the technology of its time. NZGD1949 was static. Once the defining coordinates were established, they did not continuously change. Over later decades, the limitations became more apparent. LINZ records regional distortions of up to about five metres, along with uneven densification, limited offshore coverage and increasing incompatibility with satellite-based positioning.[4]

Five metres is trivial on a world map, but not at a property corner or engineering site. The arrival of satellite geodesy exposed another assumption. Global satellite systems work most naturally with Earth-centred reference frames. New Zealand, meanwhile, sits across the boundary between the Australian and Pacific tectonic plates. The land itself moves relative to those global frames.

NZGD2000 was created for that world. Officially adopted in 1998, the New Zealand Geodetic Datum 2000 is aligned to an international terrestrial reference frame at a reference epoch of 2000.0 and uses the GRS80 ellipsoid.[5] The epoch is the conventional date at which the datum's coordinates are defined, not its adoption date. More unusually, NZGD2000 is semi-dynamic.

The phrase contains one of the stranger truths in modern mapping: New Zealand is moving. Relative to a global Earth-centred frame, points in New Zealand can move by around five centime-

tres a year as the tectonic plates move and deform.[6] Over twenty-five years, five centimetres a year accumulates to about 1.25 metres. LINZ has used that order of magnitude to explain why time-dependent transformations matter when relating NZGD2000 to dynamic global reference frames.

A fully dynamic coordinate can therefore change with time even if the survey mark remains attached to the same piece of ground. For a national cadastre or engineering system, allowing every familiar coordinate to drift a little each year would be inconvenient. NZGD2000 instead uses a deformation model so current observations can be related back to the datum's reference epoch. The model absorbs ordinary plate motion in a controlled way, giving users stable national coordinates while preserving a rigorous path to global frames.

Time has become part of position, which sounds abstract until the ground moves suddenly.

At 12.02 a.m. on 14 November 2016, the magnitude 7.8 Kaikōura earthquake ruptured a complex sequence of faults across the northeast South Island. Large parts of central New Zealand shifted. Survey marks moved with the land. Coordinates that had described the pre-earthquake geometry accurately enough for high-precision work no longer represented the post-earthquake ground in the same way.

This was not a database mistake. The country had moved, and geodesists responded with new observations and revisions to the national deformation model. In January 2018, LINZ released an updated NZGD2000 deformation model incorporating movement caused by the Kaikōura earthquake and subsequent deformation. In the most affected areas, resulting horizontal coordinate changes reached as much as about six metres, though most locations changed by much less.[7]

The distinction here is important. The earthquake caused physical ground displacement. Later model revisions changed the coordinates used to represent that altered geometry consistently. Those are related events, not identical ones.

After major earthquakes, precise positioning can therefore need more than latitude, longitude and height. Surveyors may need to record the datum, its version, the coordinate epoch and the observation source. The question "where?" becomes "where, relative to which framework, and when?"

A coordinate is not a permanent label nailed to the Earth. It is a position expressed inside a defined reference system. The better the measurement becomes, the more the reference matters.

Harrison's watch carried reference time across an ocean. Triangulation spread a reference network across a country. NZGD1949 gave New Zealand one national geodetic framework. Satellite geodesy made Earth-centred positioning ordinary. NZGD2000 added time and deformation because the New Zealand landmass would not remain still for the convenience of the coordinates.

The machinery is mostly invisible to ordinary map users, which is a sign that it works. A person opens a phone and sees a blue dot. They do not see the ellipsoid, reference epoch or deformation model beneath it.

The longitude problem began with carrying a clock across the ocean. By the twentieth century, reference time and position would be broadcast from machines moving through space.

CHAPTER 11

FROM SECRET SATELLITES TO THE PHONE IN YOUR POCKET

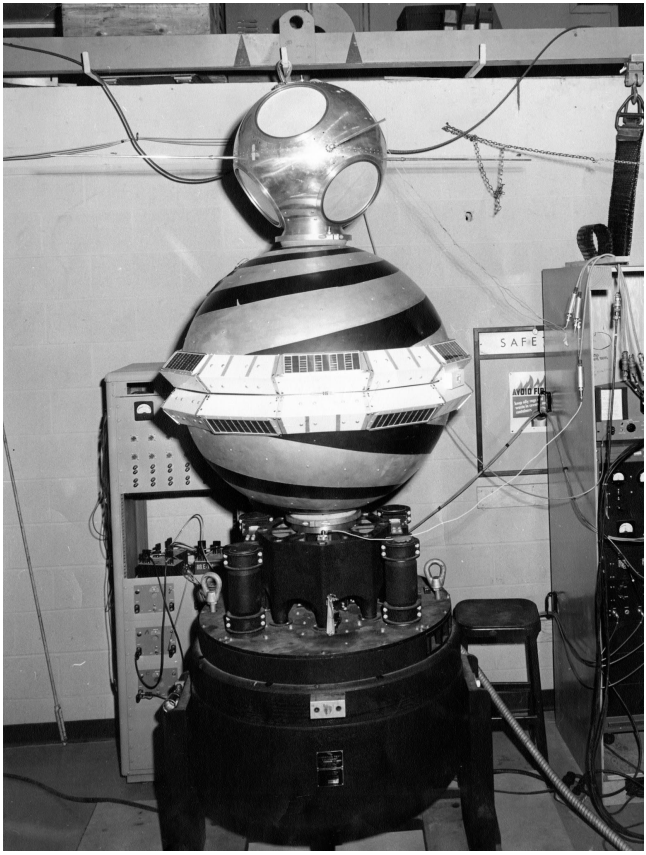


Figure 11.1. GRAB I mounted above the Transit IIA navigation satellite, 1960. Intelligence collection and satellite navigation were literally stacked together in this early space-era hardware, a striking precursor to the positioning infrastructure now taken for granted. National Reconnaissance Office / U.S. Naval Research Laboratory. Public domain.

On 19 August 1960, somewhere over the Pacific, an aircraft crew was waiting for a small object to fall out of space.

The object descended beneath a parachute. Captain Harold Mitchell and the crew of a modified C-119 had been sent to catch it in mid-air with a hook and winch. They missed twice. On the third pass, the aircraft snagged the parachute and hauled the capsule aboard. Inside was exposed photographic film that had orbited the Earth.

The mission had launched the previous day under the public name Discoverer XIV. Its real purpose belonged to CORONA, a secret American reconnaissance programme. The satellite photographed Soviet territory, ejected a film capsule and returned the physical roll through the atmosphere. The successful mission brought back roughly 3,000 feet of film covering about 1.65 million square miles of Soviet territory, more Soviet photographic coverage than all earlier U-2 missions combined, according to the National Reconnaissance Office.[1]

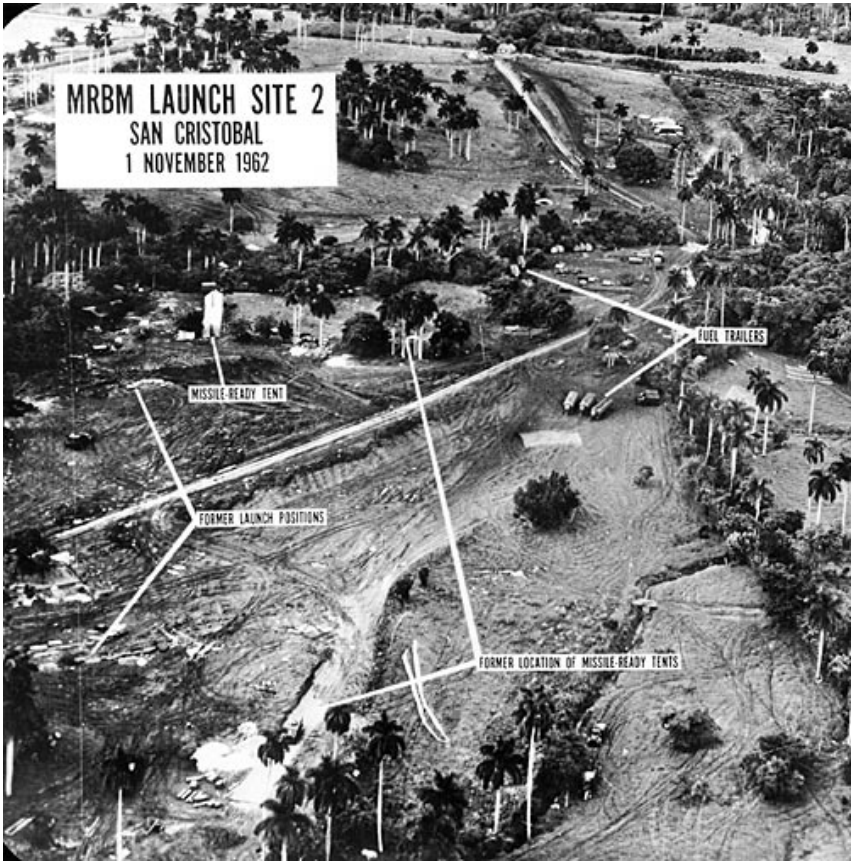


Figure 11.2. U-2 reconnaissance photograph of MRBM Field Launch Site No. 1 at San Cristobal, Cuba, 14 October 1962. Overhead imagery had become evidence at the centre of geopolitical decision-making. U.S. Department of Defense; John F. Kennedy Library; National Archives and Records Administration. Public domain, free of known copyright restrictions.

The recovery method now feels wonderfully mechanical. No digital camera streamed pixels to a server.[2] The United States had to catch the photograph.

What mattered was the new vantage point. A government could gather geographic information about places its aircraft and surveyors could not safely enter. The old story of map knowledge had moved into orbit.

CORONA grew from Cold War intelligence needs, especially after a Soviet missile brought down Francis Gary Powers's U-2 on 1 May 1960 and President Dwight Eisenhower stopped such overflights of the Soviet Union. The satellite programme continued until 1972 and eventually produced hundreds of thousands of images. Later, after declassification, photography collected for intelligence became useful for environmental research, archaeology and historical analysis.

CORONA is the opening rather than the main story. Reconnaissance satellites answered one question: what is down there? A second satellite revolution answered another: where am I?

That revolution began almost as soon as the space age itself. In October 1957, the Soviet Union launched Sputnik. At the Johns Hopkins University Applied Physics Laboratory, William Guier and George Weiffenbach listened to its radio signal and realised that Doppler shift could reveal the satellite's motion. As Sputnik approached, the received frequency changed; as it receded, the shift reversed. Their colleague Frank McClure recognised that the logic could be turned around. If the satellite's orbit were already known, a receiver on Earth could use the signal to determine its own position.

The idea became Transit, the United States Navy's satellite navigation system. A small constellation of low-orbit satellites broadcast predictable signals. Ships and submarines measured the Doppler shift and calculated a position when a suitable satellite passed overhead. The system was especially valuable for updating the inertial navigation of Polaris submarines. It eventually became useful well beyond the military, including merchant shipping, surveying and science, and was released for broad international use in 1967.

Transit was satellite navigation by appointment. A user could wait for a pass, take a fix and then continue. It was a remarkable improvement, but not yet the continuous blue dot.

During the late 1960s and early 1970s, different American military programmes explored more continuous forms of satellite navigation and precise timing. In 1973 these strands were brought together in the programme that became NAVSTAR GPS. The first developmental GPS satellites were launched in 1978.

The basic geometry can be explained without a page of equations. A GPS satellite broadcasts a message containing the time the signal was sent and information about its orbit. A receiver compares that time with the time of arrival. Because radio signals travel at the speed of light, the difference provides a measure of distance. One satellite gives a large set of possible positions. Several satellites narrow the possibilities until the receiver can solve for its position and its own clock error.

The system is a technological descendant of Harrison's longitude watch. Harrison carried accurate reference time aboard the ship. GPS put extraordinarily stable clocks in orbit and made the comparison electronic and continuous.

For much of its development, GPS remained military infrastructure.[3] The policy decision that pushed it toward a genuinely global civilian role followed a catastrophe.

On 1 September 1983, Korean Air Lines Flight 007 deviated far from its intended route between Anchorage and Seoul and entered Soviet airspace. A Soviet fighter shot the Boeing 747 down near Sakhalin Island. All 269 people aboard were killed. The precise chain of navigation and human failures remained the subject of investigation and controversy, but the disaster made the value of reliable civilian global positioning impossible to ignore.

On 16 September, the Reagan administration announced that the United States would make GPS available to civilian aircraft once

the system became operational. GPS had not been invented because of Flight 007.[4] The disaster accelerated and formalised the policy decision to open a military positioning system for civilian use.

That decision produced unusual infrastructure. The satellites remained owned and operated by the United States military, but civilian receivers around the world could use the signal. A fishing boat in the Pacific, a surveyor in New Zealand and eventually a phone in someone's pocket could listen to the same constellation.

Civil access did not initially mean full performance. During the 1990s, the United States deliberately degraded the standard civilian service through Selective Availability. Positions wandered more than the underlying system required. Civil users responded with differential techniques and other corrections that recovered much of the lost accuracy for applications prepared to do the extra work.

Then, shortly after midnight on 2 May 2000 in the eastern United States, the artificial wandering collapsed. President Bill Clinton had ordered Selective Availability switched off.[5] GPS.gov records civilian accuracy improving by roughly an order of magnitude. Receivers around the world became much more useful without their owners replacing the hardware.

A policy setting in a satellite system changed while coastlines and survey marks stayed where they were, and civilian positioning became markedly more precise overnight.

The timing was ideal. Receivers were becoming smaller, cheaper and less power-hungry. Satellite positioning moved through car navigation, surveying, agriculture and specialist handheld devices into mobile phones. By the late 2000s, location was becoming a background capability of a device people carried for many reasons other than navigation.

That difference changed the cultural position of maps. A handheld GPS receiver announced that the user was doing a geographic

task. A smartphone could invoke location while the person ordered food, found a bus, recorded a run, booked a ride, tagged a photograph or searched for a nearby shop. Positioning became an invisible service.

The blue dot is the visible symbol of that transition. A printed map usually required the reader to determine their own position from signs, landmarks, bearings or prior knowledge. A phone can place the reader on the map automatically and continually recalculate the map around them.

The dot is not produced by the map projection.[6] Satellite navigation provides position and time within a reference framework. The basemap, projection, road data, routing engine and application then use that position for other jobs. Those layers cooperate so smoothly that the user experiences them as one map.

The important change was social and infrastructural: precise global positioning escaped the specialist instrument, while the coordinate-system metadata beneath it remained largely invisible.

There is also a political history beneath the convenience. GPS is not a natural feature of the atmosphere. It arose from decades of American military research, spending and policy. Other global navigation satellite systems now provide alternatives and complements, including Europe's Galileo, Russia's GLONASS and China's BeiDou. Modern devices often combine several constellations, which is why specialists increasingly speak of GNSS rather than treating GPS as the whole category.

The signals are not infallible. They can be blocked, jammed or spoofed. Buildings, terrain and atmosphere affect reception. Accuracy depends on receiver quality, available satellites, corrections and method. A number displayed to six decimal places still does not guarantee six-decimal-place truth.

Even with those limitations, the historical change is extraordinary. In 1960, the United States needed an aircraft over the Pacific

to catch film returning from space. Early satellite navigation users could wait for a suitable pass. Four decades later, ordinary civilian receivers could determine position continuously to within metres, and soon the receiver disappeared inside the phone.

A technology built around submarines, missiles, reconnaissance and Cold War uncertainty became part of the ordinary geography of daily life.

That transformation also changed the volume of geographic data people could create. A navigator once wrote a fix in a logbook. A modern device can generate a continuous track. Photographs acquire coordinates. Vehicles generate histories. Wildlife collars transmit movement. Scientific instruments time-stamp observations against a common global reference. The user is not merely reading geography. Their device can continuously produce it.

The map on the phone hides this complexity extremely well. Open an unfamiliar street in Auckland or Seoul and a marker appears. The user does not need a chronometer, sextant, triangulation station or paper chart. They may not know which satellites the receiver heard.

The ease is real, as are the invisible standards underneath it. A satellite may know where the receiver is and the data can still appear in the wrong place if the computer has been given numbers without the rules that explain what those numbers mean.

CHAPTER 12

THE SECRET NUMBERS BEHIND EVERY DIGITAL MAP

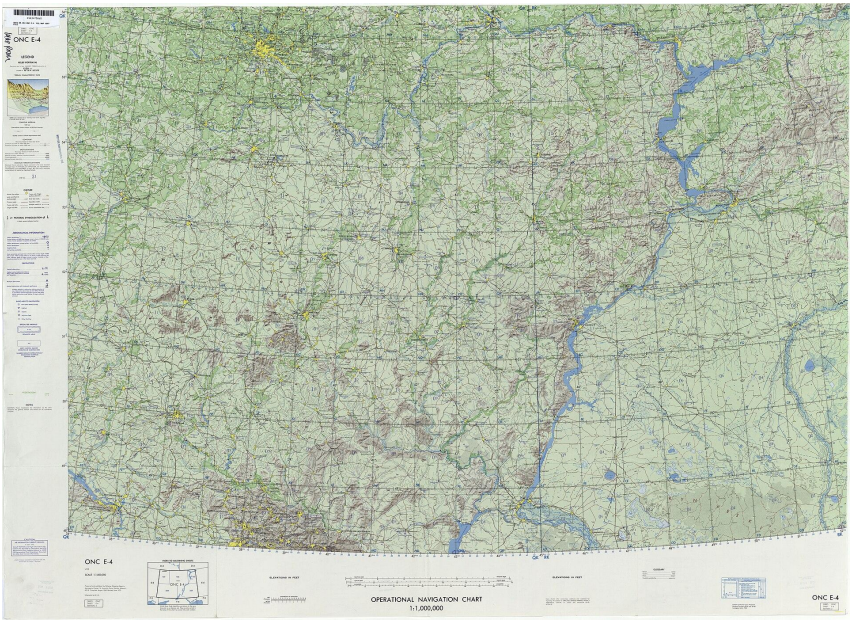


Figure 12.1. Operational Navigation Chart E-4, 1974. Its printed technical specification names the Lambert Conformal Conic projection, standard parallels and centre longitude, making the coordinate reference system part of the map's operational meaning. U.S. Defense Mapping Agency Aerospace Center. Public domain.

A coordinate can look wonderfully precise and still be useless.

Give a GIS user two numbers such as 174.7762 and -41.2865 and they may reasonably suspect longitude and latitude near Wellington. Give the same person numbers around 1,748,000 and 5,428,000 and they may suspect metres in a New Zealand projected

coordinate system. Give either pair to software without telling it what the numbers mean, however, and the confidence disappears.

The computer has no instinct for Wellington. It has numbers, and numbers need rules.

This is one of the least visible facts in digital mapping. Every point, line and polygon is interpreted inside a coordinate reference system. The system tells the software what the axes mean, which units are being used, what geodetic framework the coordinates belong to and, if the data have been projected, how the curved reference surface has been turned into a plane.

When those rules are correct, the result feels effortless. Layers line up. Roads meet bridges. Parcels sit under imagery. A user assumes the computer simply knows where everything is. When the rules are wrong, digital geography becomes surreal very quickly. A dataset can appear in the Atlantic instead of Auckland. Metres can be treated as degrees. Longitude and latitude can be swapped. Correct coordinates can be assigned the wrong reference and plotted faithfully in the wrong place.

The modern geospatial world deals with this through formal definitions and identifiers. Four codes recur throughout this book: EPSG:4326, EPSG:3857, EPSG:2193 and EPSG:8857. Two more become important when the world is turned towards the Pacific: EPSG:8858 and EPSG:8859.

They look like model numbers or versions. They are neither. A larger number is not more advanced. The codes are identifiers in a registry. Each points to a particular coordinate reference system definition.[1]

The registry's origins lie somewhere less romantic than astronomy or exploration: the petroleum industry.

In 1985, the European Petroleum Survey Group created a dataset of geodetic parameters for use by its members. Oil and gas companies worked across national borders and offshore areas where the

same physical location might be represented by different datums, projections, units and coordinate conventions. A well or seismic line described only by two numbers could be ambiguous, and ambiguity around expensive infrastructure is expensive ambiguity.

The dataset became public in 1993. When the European Petroleum Survey Group was later disbanded, maintenance continued within what is now the International Association of Oil and Gas Producers. The old initials survived. EPSG became one of the hidden pieces of infrastructure underneath modern GIS.

Start with 4326. EPSG:4326 is the WGS 84 geographic two-dimensional coordinate reference system.[2] It expresses position as angular latitude and longitude in degrees. It is global and common in geographic data exchange. It is frequently called a projection in casual conversation, but it is not a projected CRS. It describes geographic coordinates on WGS 84 rather than a particular flat map.

That distinction becomes practical when software has to transform coordinates. Telling software what CRS existing numbers already use is not the same as converting those numbers into another CRS.[3] The first operation assigns meaning. The second calculates new values.

Confusing the two is a classic GIS failure. If NZTM2000 metre coordinates are incorrectly labelled as WGS 84 latitude and longitude, the software generally trusts the label. The data may vanish or appear somewhere absurd. Correct reprojection requires the software to know the true source system first, then calculate coordinates in the target system.

A CRS is therefore not decorative metadata. It is part of the data's meaning.

EPSG:4326 also carries an axis-order trap. Formal EPSG definitions specify latitude then longitude, while many web and program-

ming conventions use longitude then latitude because they think in x then y. Software and standards have handled this differently over time. For New Zealand, values around 175 and -41 make the danger obvious: reverse them and the supposed latitude is impossible.

Standards work often consists of preventing this kind of afternoon.

Now take 3857. EPSG:3857 is WGS 84 / Pseudo-Mercator, the projected coordinate reference system underlying a large part of modern web mapping.[4] Its coordinates are expressed in projected metres, and its formal scope is web mapping and visualisation. It provides the square, Mercator-like world used by many slippy-map systems.

For this chapter, that is enough. EPSG:3857 is not a better version of 4326. The two often work together. A database may store global positions in 4326 while a web map transforms them into 3857 for display. The next chapter follows the engineering history that made 3857 so dominant.

Then there is 2193. EPSG:2193 is NZGD2000 / New Zealand Transverse Mercator 2000, usually shortened to NZTM2000.[5] It is a projected coordinate reference system in metres, designed for mainland New Zealand and recommended by Toitū Te Whenua for national mapping where local measurement and consistency matter.

The contrast with 3857 is useful. A global web map values compatibility with a worldwide tiling ecosystem. A survey, engineering or topographic job in New Zealand values a system designed around New Zealand. The same organisation can therefore use both. LINZ serves Web Mercator products for global interoperability and NZTM2000 products for New Zealand-focused work.

Using both is competent engineering rather than indecision. Finally, EPSG:8857 is WGS 84 / Equal Earth Greenwich. It is a projected CRS for very small-scale equal-area world mapping.[6] Very

small scale here means a map showing an enormous geographic extent, typically the world. Equal Earth preserves relative area, and the registered EPSG definition is centred on Greenwich.

Two details matter. First, the code predates the 2025–2026 political campaign. The United Nations did not create EPSG:8857. The projection was published years earlier and then registered as a formal CRS. Political attention gave the code visibility, not mathematical existence.

Second, 8857 is only one registered Equal Earth CRS. EPSG:8858 centres the Americas on 90 degrees west, while EPSG:8859 centres Asia-Pacific on 150 degrees east. The latter is the registered Pacific-facing variant most directly relevant to New Zealand.[7] A mapmaker can still choose another central meridian, but a custom definition is not automatically one of these registered CRSs. A projection family and a registered CRS are different layers.

The codes therefore describe different jobs rather than competitors. EPSG:4326 supplies global geographic coordinates in degrees; EPSG:3857 supports much web mapping; EPSG:2193 is the New Zealand projected CRS designed for mainland national work; and EPSG:8857, 8858 and 8859 are registered Equal Earth CRSs centred on Greenwich, the Americas and Asia-Pacific respectively. The numbers are database keys, not a ranking.

That point becomes even clearer with EPSG:4357. It is a real code, but it is not a slightly newer version of 4326. It refers to a deprecated Moznet three-dimensional CRS associated with Mozambique. One wrong digit can therefore point to an entirely different record.

The EPSG dataset matters because coordinates are not self-describing. A value such as 174.8 does not announce that it is longitude. A value such as 5,428,000 does not announce that it is a northing. A pair of values does not tell a computer which datum, axis order, units or projection produced them.

The code acts as a compact contract: interpret these numbers according to this definition. GIS professionals develop defensive habits around that fact. They inspect coordinate ranges. They check units. They look at the area of use. They verify whether a CRS was genuinely known or guessed. They distinguish assigning a CRS from transforming into one. They compare a known point. These habits are not paranoia. They are geospatial literacy.

The public almost never sees this machinery. A person opens a map and expects a blue dot to sit beside the correct road. They do not see axis order, a transformation pipeline or an EPSG identifier. Modern GIS succeeds when hidden conventions produce an obvious result.

The current Equal Earth debate makes one of those hidden identifiers unusually visible, and visibility can encourage the wrong conclusion. EPSG:8857 does not replace 4326, 3857 or 2193. It gives software a formal way to identify one particular Equal Earth world CRS when that is the job.

The most important lesson is therefore not memorising a list of numbers. It is learning that every coordinate arrives with assumptions, and that software needs those assumptions stated precisely.

CHAPTER 13

THE JOKE CODE THAT ATE THE WEB

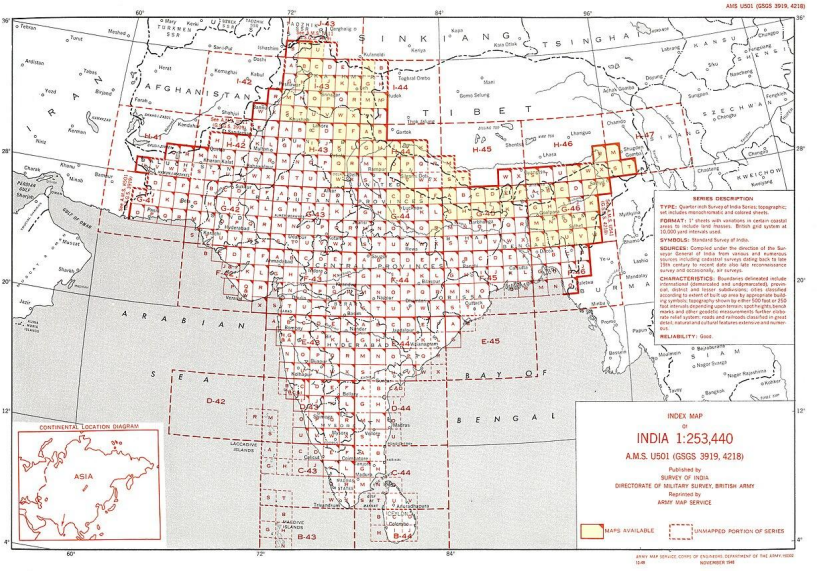


Figure 13.1. Survey of India sheet-index map, 1948. Long before global web-map tiles, large mapping systems were already divided into regular numbered sheets so users could retrieve a particular piece of a much larger geographic whole. Survey of India / Directorate of Military Survey. Public domain.

On the evening of 6 August 2007, Christopher Schmidt published a very short blog post about a very large problem.[1]

Schmidt was working with OpenLayers, the open-source web-mapping library. Google Maps had already changed what people expected a map on a computer screen to do. Instead of clicking an arrow, waiting for a new page, clicking again and waiting again, users could grab the map and drag it. Roads slid beneath the mouse.

New imagery arrived around the edges. Zoom in and more detail appeared. Zoom out and the world reassembled itself.

Developers wanted other services to behave the same way. They wanted their own data to line up with Google-style maps, map servers to return the right pieces at the right scale, and software libraries to agree about where every coordinate belonged. For that, they needed a common name for the coordinate system underneath the new web map.

There was a difficulty. No tidy official EPSG identifier yet described exactly what these systems were using. Some existing Mercator definitions were close, but not quite the same. Close is a dangerous word in geodesy. A coordinate system can be close enough to draw something recognisable and wrong enough to make overlaid data drift apart.

OpenLayers therefore needed a label. Schmidt's post proposed 900913, a deliberately unofficial piece of leetspeak for GOOGLE. It was memorable and immediately useful. A month later the number was in OpenLayers code.

The number did not create the projection. It revealed that the projection had become important enough to need a common language, which is the more interesting story.

Google Maps had launched in February 2005 with an interface that now feels ordinary and at the time felt startlingly fluid. A user could drag the map without forcing the whole page to reload. The illusion of continuity depended on a simple engineering idea: the browser did not receive one enormous image of the planet. It received only the rectangular pieces it needed.

Those pieces were tiles. At the broadest zoom, imagine the usable world reduced to one square tile.[2] Zoom in once and that square becomes four. Zoom again and it becomes sixteen. Each level doubles the number of tiles along each side. The browser asks

only for the small set visible on screen, and those tiles can be cached, reused and served by different machines.

A planetary map had become a filing system.

The server no longer needed to think about the whole world whenever somebody looked at Wellington. It needed to know the zoom level and the x and y address of the required tile. The mathematics beneath that filing system had to behave in a predictable way from one side of the planet to the other.

The Mercator family was attractive because its local angular behaviour suited street-scale display, but Web Mercator is not the ellipsoidal conformal Mercator used in geodesy. EPSG:3857 applies spherical Mercator equations, using the WGS 84 semi-major axis, to WGS 84 geodetic latitude. That approximation simplifies the global tile mathematics but does not preserve conformality exactly on the ellipsoid. At ordinary street-map scales the difference is usually visually small. Technically, the modern name matters: WGS 84 / Pseudo-Mercator, EPSG:3857.[3]

Web Mercator is therefore not simply Gerardus Mercator's 1569 map moved into a browser. It belongs to the same family and inherits the dramatic enlargement towards high latitudes, but it is a modern computational variant built around web visualisation.

It also has one feature computers adore: between about 85.051 degrees north and south, the projected world can be made square.[4]

A true Mercator projection never reaches the poles. The scale grows without bound as latitude approaches ninety degrees. For the web, the answer was practical rather than philosophical. Stop before infinity becomes a software problem. Clip the world at the latitude that makes the projected height equal its width, then divide the square again and again into tiles.

That square was a gift to the web. It could be halved cleanly. Each half could be halved again. Adjacent tiles could be found

with simple arithmetic. Cache keys could be predictable. Browsers could request only what they needed. A user could pan apparently without end while the system quietly swapped rectangular pieces beneath the cursor.

The history of Web Mercator should therefore not begin with Greenland.[3]

Greenland's exaggerated apparent area is real. So is the enlargement of Canada, Russia, Scandinavia and Antarctica as latitude rises. But those distortions do not explain why the projection became infrastructure. The decisive attraction was that the geometry suited the engineering of a fast, global, tiled, interactive map.

The projection protected what the application valued. At neighbourhood scale, users wanted roads to cross correctly, street geometry to look familiar and adjacent map tiles to meet cleanly. At world scale, the same system produced the area distortion already familiar from Mercator maps. The advantage and the sacrifice came from the same choice.

The next step was repetition.

Once a company has a global tile grid, it can cache the results. Once it has cached millions or billions of tiles, continuity becomes valuable. Once libraries understand that grid, data providers gain an incentive to use the same one. Once providers use it, more developers adopt compatible libraries. A different projection is no longer merely a different equation. It becomes an interoperability decision.

This is where 900913 becomes more than a joke.[5]

OpenLayers needed a label because software components had to talk to each other. A map service needed to know what spatial reference a request used. A Google-compatible layer and another service needed to meet in the same projected space. The number was an adapter between systems moving faster than formal standards.

Then the standards machinery caught up. EPSG introduced an official Popular Visualisation CRS / Mercator entry as EPSG:3785 in 2008.[6] That identifier was later deprecated, and EPSG:3857 became the formal code for WGS 84 / Pseudo-Mercator in 2009.

The genealogy is untidy. The result is simple. A de facto convention became formal infrastructure.

By the 2010s, this was no longer meaningfully a Google-only story. OpenStreetMap used the same broad slippy-map logic. Microsoft and other platforms used compatible approaches. GIS software supported it. OGC standardised the WebMercatorQuad tile matrix set. Apple developer documentation describes custom map tiles in EPSG:3857. Even the formal name GoogleMapsCompatible survived in standards language.

Compatibility had become a feature in its own right.

New Zealand's national mapping agency provides a useful reality check. LINZ serves Web Mercator tiles because they plug easily into the global mapping ecosystem. It also serves NZTM2000 tiles in EPSG:2193 because New Zealand-focused mapping has different requirements. The same organisation uses both because the jobs differ.

The persistence of 3857 does not require a conspiracy. It requires accumulated usefulness.

There was no meeting at which the internet voted to make Mercator permanent. There was a sequence of practical decisions. Google built an unusually effective interactive map. Developers imitated and extended the approach. Open-source libraries needed compatible formulas and identifiers. Tile conventions spread. Standards bodies formalised common practice. Data providers valued interoperability. Users came to expect smooth panning, predictable zooming and familiar basemaps.

The system acquired weight.

That is path dependence in its least dramatic form. A decision that is cheap at the beginning can become expensive to reverse after enough other things depend on it. Railway gauges do this. File formats do it. Keyboard layouts do it. Spatial reference systems do it too.

The cost of changing Web Mercator is not mainly the cost of reprojecting coordinates. GIS software can do that routinely. The cost is systemic. Tile servers, caches, APIs, application code, vector and raster products, documentation, third-party services and user expectations may all assume a particular geometry.

Imagine a warehouse filled with millions of square pieces from one enormous jigsaw puzzle. Somebody proposes a better-shaped final picture. The new picture may be excellent, but the old pieces were cut for another frame. They cannot all be snapped into the new outline without some work.

That is what lock-in looks like in cartography.

Lock-in is not permanence. Modern digital mapping can support globes, alternate display projections and regional coordinate systems without requiring every underlying dataset to be stored in the display CRS. A printed sheet commits to one projection, while software can increasingly change representation with scale and task. That flexibility matters later in the book; here it is enough to note that Web Mercator's installed infrastructure is substantial without being mathematically compulsory.

That is also why Web Mercator deserves a fair history. Its weaknesses at world scale are genuine. So are its achievements. It helped make interactive mapping cheap enough, fast enough and standardised enough to become ordinary infrastructure. Restaurants, buses, property listings, emergency dashboards, weather systems, hiking apps, delivery services and government portals could all build on a common spatial platform.

The web did not adopt 3857 because engineers wanted Greenland to dominate the planet. It adopted a geometry that solved a practical interface problem very well, then kept using it because compatibility accumulated around the solution.[7]

The joke code records the moment when that accumulation became visible.

In 2007 the formal registry had not quite caught up with practice, so a developer community invented a memorable name. Later the standards became sober, the software became enormous and 900913 survived as a fossil from an unusually informal stage in the construction of global infrastructure.

Gerardus Mercator received immortality through a surname; Google briefly received calculator text. The joke became serious because the map beneath it became serious.

The square tiled world created another problem. A square has edges. On screen, horizontal wrapping can make one edge almost disappear. In the underlying data, however, a feature crossing from 179 degrees east to 179 degrees west can still become spectacularly confused. At that seam sits Fiji.

CHAPTER 14

WHERE THE DATABASE CUTS THE WORLD



Figure 14.1. Aaron Arrowsmith's Reduced Chart of the Pacific Ocean, 1798. The Pacific is treated as a continuous geographic space, with Cook's routes crossing it, rather than as two fragments pushed against opposite edges of a database or world map. Library of Congress, Geography and Map Division. Free to use and reuse.

In August 2016, the authors of one of the internet's most important geographic data standards needed an example of a place where ordinary map logic becomes strange. They chose Fiji.

The document was RFC 7946, the specification for GeoJSON. The format is intentionally simple. A point is a pair of numbers. A line is a list of points. A polygon is a ring of coordinates. A bounding box records the smallest rectangular extent containing a feature. The simplicity is one reason GeoJSON became so useful for moving geometry between databases, browsers and mapping applications.

Then the standard reaches the Pacific. Imagine points spread through the Fiji archipelago between roughly sixteen and twenty degrees south. Some lie just west of the 180-degree meridian. Others lie just east. On a globe they are neighbours. In the usual longitude convention, however, one group has coordinates near 177 degrees east and the other near 178 degrees west.

RFC 7946 gives the bounding box as a western edge of 177 and an eastern edge of minus 178.[1][2] Read geographically, that is a narrow box crossing the Pacific seam, only five degrees of longitude wide.

Read as an ordinary minimum-to-maximum range, it looks backwards.[3]

Reorder the values numerically from minus 178 to plus 177 and the box suddenly spans 355 degrees. Fiji has not expanded. The data structure has simply gone the long way around the Earth.

The antimeridian problem appears in four numbers, revealing something a smooth digital map is very good at hiding. When a continuous planet is stored as coordinates, the coordinate system has a join.

Longitude is circular. Most data structures are not.

Starting from Greenwich, longitudes increase eastward towards 180 and decrease westward towards minus 180. At the far side of the planet, 180 degrees east and 180 degrees west refer to the same meridian. On a globe, nothing dramatic happens there. The surface continues.

In an array of numbers, something dramatic happens. A value close to +180 can be followed by one close to -180 even though the two locations are a few kilometres apart.

A human sees neighbours. A naïve Cartesian algorithm sees a jump of almost 360 degrees.

Suppose a route runs from 170 degrees east to 170 degrees west. The intended route may cross only twenty degrees of longitude over the Pacific. If software connects the endpoint values as ordinary x-coordinates, it may draw a line across Asia, Europe, the Atlantic and the Americas before reaching the other point.

The endpoints are valid. The interpretation of the connection is wrong.

GeoJSON deals with this explicitly. For interoperability, RFC 7946 recommends cutting geometries that cross the antimeridian so that the resulting pieces do not cross it.[4] A line can become two segments, one ending at +180 and one beginning at -180. A polygon can become a MultiPolygon with matching edges on opposite sides of the coordinate seam.

The Earth has not been cut. The polygon has.

That is where cartography becomes data engineering. A paper mapmaker can draw a feature to the edge of the sheet and continue it on the other side. A database must decide exactly how the geometry is represented. That choice affects bounding boxes, spatial indexes, centroids, intersections, clipping, measurements and rendering.

For many developers in Europe or North America, this problem remains comfortably remote. A municipal road layer in Berlin or Boston can live its entire life without approaching 180 degrees longitude. Software can be written under the quiet assumption that the western coordinate will always be numerically smaller than the eastern coordinate, and the assumption may survive for years.

Fiji breaks it immediately, as do the Aleutians, parts of Russia and Alaska, Pacific shipping routes, cyclone tracks, satellite paths, maritime boundaries and global datasets that cannot politely stop at the edge of a conventional map.

The wider geography of New Zealand belongs to the same world. Mainland Aotearoa lies in east longitudes. The Chatham Islands lie beyond the 180-degree meridian in west-longitude notation. New Zealand's maritime interests and Pacific relationships extend across the part of the coordinate system where the sign changes. A dataset that treats the region as a coherent whole therefore encounters the same problem as the GeoJSON example.

There are several ways to survive the seam. One is to split the geometry. GDAL, one of the foundational open-source libraries beneath modern GIS software, includes a '-wrapdateline' option in its ogr2ogr tool for exactly this purpose. Natural Earth, the widely used global map dataset, requires linework crossing 180 degrees to be clipped there and to resume with matching geometry on the opposite edge.

Another approach is to change the longitude convention. Instead of storing longitudes from -180 to +180, a system can use 0 to 360. A point written as 170 degrees west becomes 190 degrees east. A feature spanning 170 east to 190 east is then numerically continuous across the Pacific. PROJ supports this kind of wrapping, and global maritime datasets are sometimes distributed in explicit 0-to-360 variants for precisely this reason.[5]

The numerical convention has changed, not the locations.

This is the kind of problem GIS practitioners learn from symptoms. A modest island chain becomes a polygon covering most of the world. A route between neighbouring islands swings across continents. A spatial index says two nearby features are extremely far apart. A centroid turns up near Greenwich because coordinates

on either side of the sign change were averaged as ordinary numbers.

The screenshot can be funny; the same error is less amusing when the geometry represents a cyclone warning, an exclusive economic zone, a cable route, a fisheries closure or a search-and-rescue area.

The Pacific is not unusually difficult geography. It is unusually inconvenient geography for a set of global conventions whose join happens to run through it.

That join is often confused with another famous Pacific line: the International Date Line.[6]

They are related, but they are not the same thing. The antimeridian is the meridian 180 degrees from Greenwich. It follows from the longitude framework. If Greenwich is zero, the opposite meridian is 180 degrees. Its mathematical location does not bend around islands or governments.

The International Date Line is a timekeeping convention. It runs broadly through the Pacific because changing calendar date near 180 degrees is convenient, but it bends around states and island groups. Governments can alter which side of the calendar divide they choose to occupy.

Samoa demonstrated the difference dramatically in 2011.

That year Samoa legislated a change to its standard time and moved, for Samoan civil purposes, from the eastern side of the International Date Line to the western side.[7] Thursday 29 December 2011 was followed by Saturday 31 December. Friday the 30th disappeared from Samoa's civil calendar. The legislation had to deal with pay, deadlines and other ordinary consequences of removing a date. It also explicitly addressed maps, charts and atlases.

The law did not move longitude 180; it changed Samoa's relationship to the calendar convention drawn near it.

Kiribati had already made a comparable move in the 1990s so that its widely scattered island groups could share the same calendar day. The resulting date-line convention reaches well east of the antimeridian.

Several different lines can occupy roughly the same part of a familiar world map while doing entirely different jobs: the antimeridian belongs to the longitude system, the International Date Line is a civil time convention, and a projected map's seam depends on where the mapmaker chooses to cut the display.

A Greenwich-centred rectangular world map often places its seam near 180 degrees, which makes all three seem more closely connected than they are. Recentre the map on the Pacific and the visual seam can move into the Atlantic. Greenwich longitude has not changed. The antimeridian has not changed. Samoa's legal time has not changed. Only the map's frame has moved.

Digital mapping adds another twist to the distinction between reference and display: even if the display seam moves, the underlying data may still be stored in a coordinate range that jumps from +180 to -180.

A Pacific-centred map can therefore look continuous while its database still contains an antimeridian problem.

That is why experienced GIS developers become careful about words such as split, wrap, clip, normalise and repeat. They are not synonyms.

A Web Mercator map may repeat the world horizontally, so dragging east beyond 180 degrees simply reveals another copy of the tiled world. The display feels continuous. The feature geometry underneath may still be stored as a ring that crosses the sign change, as multiple parts split at the seam, or as coordinates expressed in another longitude range. A renderer, spatial database and tile generator may each have different rules for handling it.

When all the rules agree, the user notices nothing. That invisibility is the achievement.

The Fiji example is useful because it makes the whole problem visible without a border dispute, political campaign or exotic mathematics. A bounding box is enough. Four numbers that appear to be in the wrong order are correct once the reader remembers that longitude is circular.

The absurdity exists only after the planet has been mentally converted into a rectangle.

There is no edge of Earth at Fiji. There is no natural break at the Chathams. There is no gap between Russia and Alaska. The edge belongs to the representation.

Once the representation becomes infrastructure, however, the edge acquires practical consequences. Data formats describe it. Libraries add flags for it. Dataset publishers maintain alternate versions. GIS analysts test for it. Governments legislate nearby time conventions. The seam becomes real in the same sense that standards generally become real: systems must agree about what happens there.

Once the convention is embedded in formats and software, its consequences are measurable without requiring a larger theory about maps constructing reality.

For global data, the practical question is straightforward. When geometry approaches 180 degrees longitude, stop assuming the rectangle is ordinary. Check the bounding box. Check whether the software understands antimeridian-spanning geometry. Check whether the feature needs to be split or wrapped. Check the longitude convention. Check whether a calculation is planar or geodesic. And do not confuse a date-line map with the mathematical antimeridian.

The phone hides all of this extremely well. A user swipes across the Pacific and sees a continuous world. Longitudes wrap. Tiles re-

peat. Polygons split. Coordinates transform. The software spends considerable effort making the seam disappear.

Horizontal wrapping cannot hide Web Mercator's other edge. Travel far enough north or south and the coordinate world simply stops, while the planet continues.

CHAPTER 15

THE PLACE THE WEB MAP CANNOT SHOW

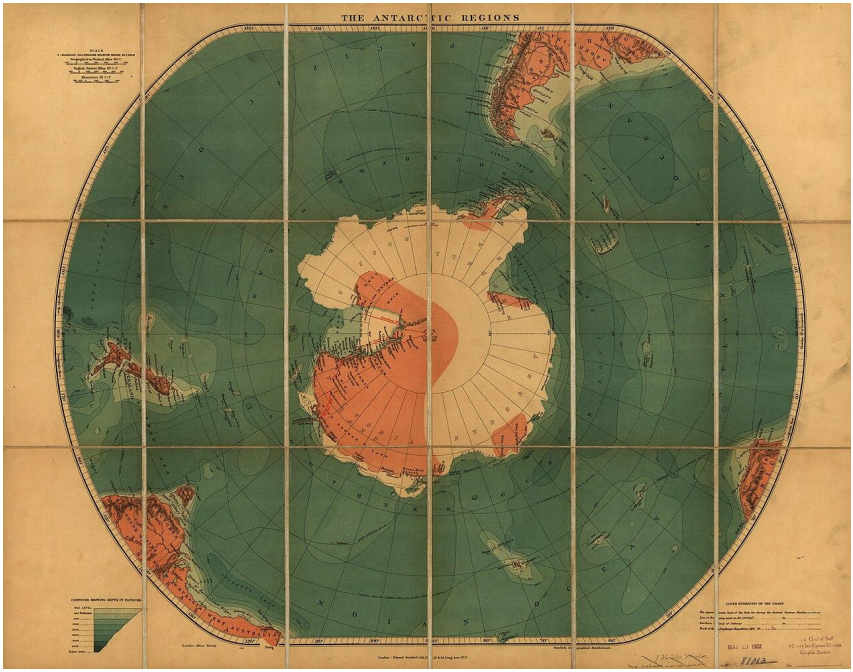


Figure 15.1. The Antarctic Regions, Edward Stanford Ltd., c.1900. The South Polar view makes Antarctica a coherent centre rather than the unreachable edge of a cylindrical world map. Library of Congress, Geography and Map Division. Free to use and reuse.

Open a familiar web map and begin dragging south.

At first, nothing seems unusual. New Zealand slides upward. The Southern Ocean expands. Antarctica approaches. Coastlines redraw, labels appear and imagery sharpens. The interface gives

every impression that the world will continue indefinitely beneath the cursor.

Then, at about 85 degrees south, the map stops.

Not the Earth. The map.

In the Web Mercator coordinate system used by much of the modern web, the standard square world ends at about 85.0511 degrees north and south. The South Pole lies roughly five degrees farther on. It still supports ice, instruments, scientists, buildings, vehicles, survey marks and decades of geographic data. But it does not fit inside the ordinary Web Mercator tile world.

That is a strange discovery in a technology that feels universal.

The explanation comes directly from the projection. Mercator stretches latitude more and more as it approaches the poles. At ninety degrees the projected coordinate runs to infinity. The pole is not merely distorted. It cannot be placed at a finite distance on a true Mercator plane.

The web needed a finite world, so engineers clipped it. The familiar limit near 85.0511 degrees is the latitude that makes the projected world fit into a square suitable for the tile pyramid described in the previous chapter.[1] The same decision that made the global slippy map neat, cacheable and interoperable removed the poles from its planar coordinate world.[2]

That engineering bargain is elegant from a computer's perspective and an awkward frame from Antarctica.

Antarctica is not an expendable white margin. It covers roughly fourteen million square kilometres, depending on how ice shelves and islands are counted. It contains the geographic South Pole, mountain ranges, volcanoes, research stations, protected areas, traverse routes and one of Earth's most closely studied climate systems. New Zealand has maintained a permanent scientific presence there since Scott Base opened in 1957.

Antarctic scientists do not wait for Web Mercator to become more accommodating. A major modern answer is Antarctic Polar Stereographic, EPSG:3031.[3] It places the South Pole directly on the plane and arranges the continent around it. Longitudes radiate outwards. The geography that appeared as a stretched strip along the bottom of a rectangular world map becomes a coherent working region.

This is projection choice in its most practical form. The British Antarctic Survey's Antarctic Digital Database uses Antarctic Polar Stereographic for operational geographic data.[4] Coastline, rock outcrops, ice features and other layers are not being arranged that way to make a philosophical statement about world maps. They are being arranged so scientists and mapmakers can work with Antarctica as Antarctica.

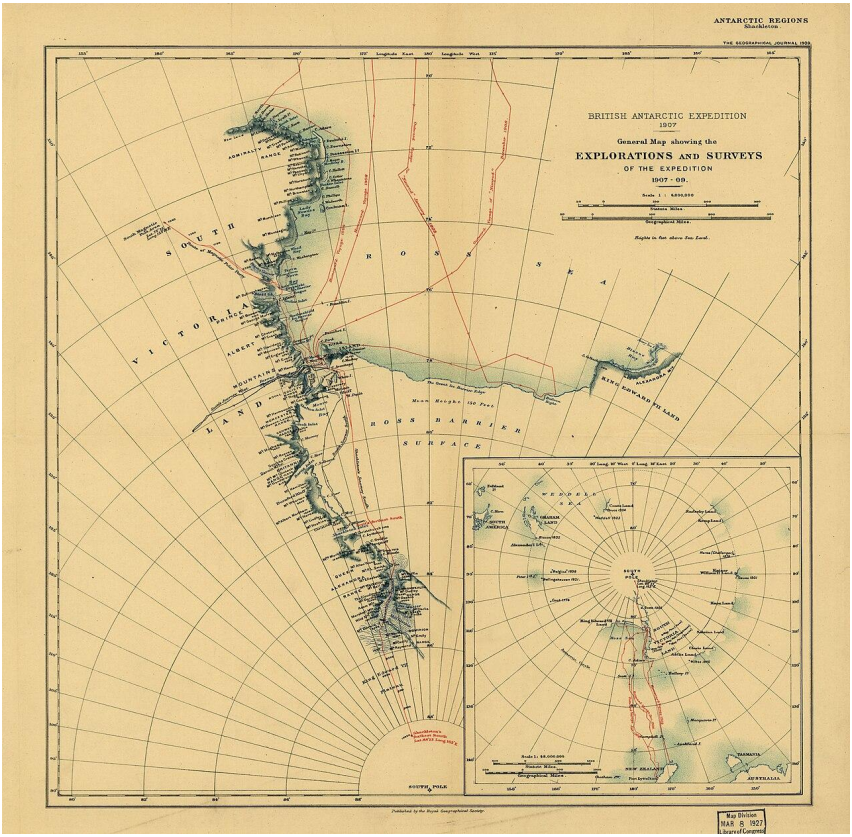


Figure 15.2. General map of Ernest Shackleton's Antarctic expedition and surveys, 1907–09. Long before digital polar databases, Antarctic exploration already demanded maps that treated the continent as a coherent working geography. Ernest Shackleton / Library of Congress. Public domain.

The map changes because the job changes. A world map needs to show the relationship of the entire planet at once. An Antarctic research map needs to make the pole, ice sheet, coast and surrounding ocean usable. A logistics map between Christchurch and Scott Base may need yet another treatment because its question is not how to map all Antarctica, but how to show a long regional connection across the Southern Ocean.

Antarctic mapping makes the point concrete: EPSG:3031 exists because polar work requires different geometry.[5][6]

The South Pole also exposes a visual habit created by rectangular world maps. Antarctica often appears as a long white band across the bottom of the page. Every longitude meets at the pole, yet a cylindrical map has to spread those meridians across a horizontal edge. The continent can therefore look less like a place than like the map's lower border.

Turn to a polar map and the relationship changes immediately. The coast becomes a recognisable form around the centre. The Ross Sea, Weddell Sea and Antarctic Peninsula occupy positions that are easier to compare. The Southern Ocean circles the continent rather than falling apart along the bottom edge. New Zealand's route south becomes part of a southern geographic system rather than a journey towards the bottom of a rectangle.

The polar view makes the subject legible on its own terms.

For Aotearoa, that matters. A standard Greenwich-centred world map often places New Zealand near the lower-right margin. A polar view reveals another geography. Christchurch is one of the main gateways to Antarctica. The Ross Sea is not beyond the bottom of the world. It lies south of New Zealand across an ocean connected by science, weather, logistics and history.

A 1922 map of the south polar regions held by the National Library of New Zealand already understood the principle. Long before EPSG identifiers and tile matrices, mapmakers recognised that polar geography demanded a different geometry.

Digital mapping added invisibility. A printed map usually announces its frame simply by existing as a sheet. The edge is obvious. A web map encourages the opposite sensation. Dragging feels continuous. Zooming feels limitless. The projection disappears beneath the interface.

The 85-degree cutoff is therefore more interesting than it first appears. It is where a hidden default becomes visible.

Web Mercator's inability to include the poles belongs to the same mathematical structure that made it convenient for the tiled web. It succeeds spectacularly at a rectangular, global, zoomable interface across most inhabited latitudes. Antarctica asks another question and therefore needs another geometry.

Digital mapping makes this flexibility easier than paper ever could. A platform can retain existing services while changing the display for another scale or specialist task. Antarctica makes the point obvious: a specialist polar system can be the correct answer to a specialist polar problem without becoming a prescription for every other map.

The South Pole makes the distinction impossible to miss: in Web Mercator it is mathematically unreachable, while in Antarctic Polar Stereographic it can sit at the centre.

At the pole, the hidden assumptions of a universal-looking web map become visible. A deeper question sits underneath them: who gets to define geography, names and evidence before any projection is chosen?

CHAPTER 16

THE MAP WAS NEVER EMPTY

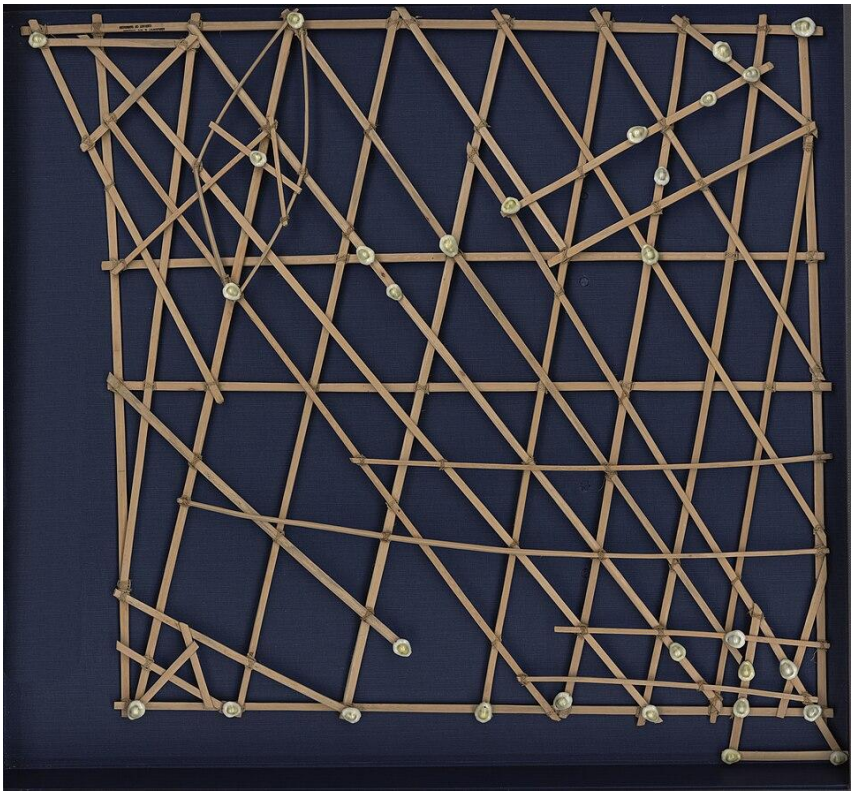


Figure 16.1. Marshall Islands stick chart, Rebbelib type, 1920s. The sticks and shells encode islands, wave patterns, swells and navigational relationships, demonstrating a cartographic tradition built around ocean knowledge rather than a European coordinate grid. Library of Congress, Geography and Map Division. Free to use and reuse.

Long before anyone in Aotearoa worried about coordinate systems, datums or EPSG codes, people were mapping the world around

them. They did not always make maps in forms that a modern GIS professional would immediately recognise. There were no obligatory north arrows, neatlines, projection notes or scale bars, and in many cases there was no sheet of paper at all.

Geographic knowledge could be held in stories, place names, whakapapa, tracks, stars, winds, currents, reefs, mountains, food-gathering places and relationships between people and land. A map might be carried in memory rather than in a case, learned through repeated travel, recited or taught from one generation to the next. It could tell someone not only where a place was, but why it mattered, who was connected to it, what resources were found there, when they could be gathered and what had happened there generations before.

This presents a problem for any history of cartography that treats mapping as a steady progression from crude sketches towards increasingly accurate scientific maps. Told that way, the familiar characters arrive in an orderly sequence: Ptolemy, Mercator, astronomical navigation, Cook, triangulation, the surveyor, the national mapping agency and eventually the satellite. Indigenous peoples tend to enter the story later, often as guides, informants or names recorded in somebody else's notebook. Yet the geography was already known before the notebook appeared. In Aotearoa, Māori had named mountains, rivers, harbours, settlements, fishing grounds, tracks and countless other features over many generations. Te Ara describes this body of geographical knowledge as forming an extensive oral map of the landscape, expressed through narratives, whakapapa and place names. The absence of a European-style planimetric map did not mean the absence of geography.[1]

There is no single Indigenous way of mapping, and it would be a mistake to invent one. It is also unnecessary to force every form of geographic knowledge into the modern category of a map. Different peoples developed different systems for navigation, territorial

knowledge, memory and spatial representation. Some used physical diagrams or carved objects; others relied more heavily on oral traditions, memorised routes, environmental signs, genealogies, place names or combinations of these. The point is not that one tradition was purer than scientific cartography, or that one should replace another. The question that matters for this book is what happens when one particular way of representing geography becomes the version that governments, courts, property systems, schools and eventually computers treat as authoritative.

Maps begin to acquire a different kind of power when institutions act on them. A map used to find a fishing ground or navigate between islands does not carry the same authority as a survey plan recognised by a court. A place name remembered in a community does not have the same institutional status as a name recorded in an official national gazetteer. A customary boundary negotiated through relationships between neighbouring groups does not operate in the same way as a cadastral line registered in a land-title system. The difference is not simply one of accuracy. It is a difference in what institutions are prepared to recognise and act upon.

The navigation traditions of the Pacific make this clear. The islands of Micronesia and Polynesia are separated by enormous stretches of ocean, and to a reader accustomed to a printed chart, navigation without one can seem improbable. Pacific navigators developed sophisticated systems based on stars, winds, currents, birds, cloud formations, ocean swells and the way islands altered patterns in the sea. In the Marshall Islands, the objects commonly grouped together as stick charts were not all doing the same job. A mattang is commonly described as a teaching model for swell behaviour, while a rebbelib represents a broader network of islands and navigational relationships.[2] Curved and straight strips could encode wave patterns and relationships, and shells could mark particular islands or atolls. These were not simply European charts

made from different materials. Some were learned from before a voyage rather than consulted continuously at sea. The navigator studied the representation, then read the ocean itself.

Asking what projection such an object used, what its scale was or how closely its geometry matched measured positions can miss the purpose of the representation. A swell chart was not trying to reproduce the ocean as a miniature topographic surface. It was preserving information needed to understand movement across it. Modern cartography makes the same kind of selection all the time. A road map discards geology, family histories, underground utilities, bird migration and most buildings because those things are irrelevant to its immediate purpose. Every useful map throws information away. The revealing question is what it chooses to preserve.

Pacific navigation also exposes an assumption embedded in many conventional maps. Land tends to become the subject while water becomes the background. Political maps colour countries and leave the oceans comparatively empty. Cadastral maps divide land into parcels and usually treat water as boundary or obstacle. Nautical charts reverse that relationship and make the sea intensely detailed; weather maps make the atmosphere the subject; geological maps make rock visible. Each representation brings one part of geography forward and pushes others back. No map can show everything, and no useful map should try.

The same point appears in a very different physical form on the east coast of Greenland. In 1885, an Inuit hunter named Kunit made a small set of carved wooden representations of coast, offshore islands and a peninsula near Ammassalik. The surviving objects could be handled as tactile geographic representations rather than read as north-up sheets.[3] Their precise use should not be overgeneralised: a Greenland National Museum curator has described the known examples as storytelling or explanatory aids rather than practical navigation charts. Their significance here is

narrow but powerful. A geographic representation does not have to be flat, visual or organised around latitude and longitude to preserve useful spatial relationships. Maps can encode movement, shape, relationships or phenomena, depending on what their makers need to know.

One of the most remarkable encounters between different systems of geographic knowledge occurred aboard James Cook's Endeavour in 1769. Tupaia, a Raʻiātean priest, political figure and highly skilled navigator, joined the expedition and became an important intermediary between Cook's crew and the peoples they encountered. The chart associated with him has fascinated historians because it does not behave like a conventional European chart. Islands do not always appear where a reader trained in latitude and longitude expects them. Earlier interpretations could therefore treat it as a failed attempt to copy European cartography. More recent work by Lars Eckstein and Anja Schwarz argues that it is better understood as an act of translation between navigational and representational systems.[4] The chart emerged from a collaborative encounter between Tupaia and members of the Endeavour expedition, and its unusual structure shows the difficulty of fitting a large body of Pacific wayfinding knowledge into a European graphical form.

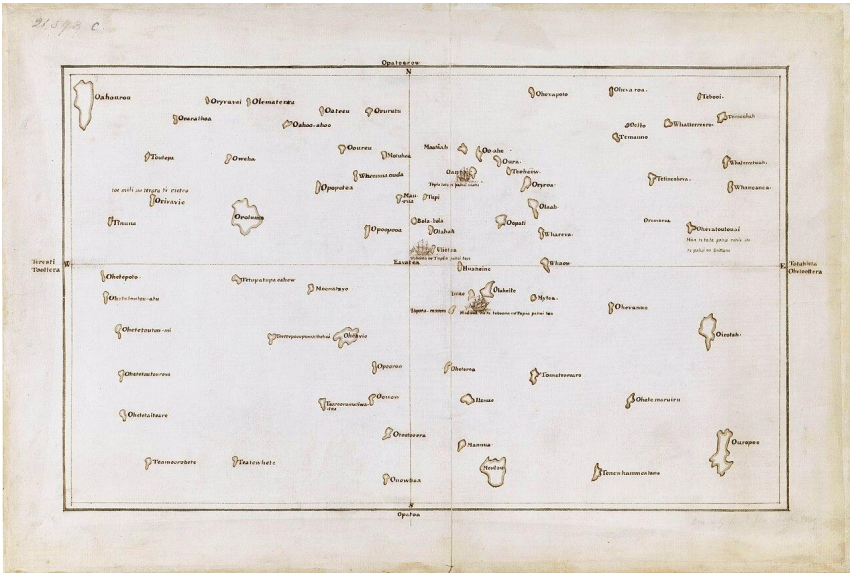


Figure 16.2. Tupaia's chart of Pacific islands, c.1769. The chart emerged from a difficult act of translation between Pacific wayfinding knowledge and a European graphical form, and should not be read simply as a failed latitude-and-longitude map. James Cook and Tupaia / British Library, Add MS 21593 C. Public domain.

Tupaia knew a vast geography of islands and relationships extending across thousands of kilometres of ocean. Cook's officers had astronomical instruments, charts and a different mathematical tradition. Both could contain valid geographic knowledge while organising it in very different ways. Anyone who has worked with spatial data knows a faint modern echo of the problem: two datasets can describe the same place and appear irreconcilable when their reference rules differ. Tupaia's chart is not a coordinate-reference-system problem, but it makes the broader point unusually vivid. Geographic knowledge and the graphical system used to represent it are not the same thing.

A still more direct example survives from Aotearoa. In 1793, Tuki Te Terenui Whare Pirau, usually called Tuki, and another Māori rangatira from northern New Zealand were forcibly taken

to Norfolk Island.[5] Europeans hoped they could teach convicts how to process harakeke into flax fibre, but the scheme rested on a basic misunderstanding because preparing and using flax was largely women's work. Accounts preserved by the National Library describe Tuki first drawing New Zealand in chalk on the floor of a room, after which the delineation was transferred to paper. A version based on the map appeared in David Collins's 1798 history of New South Wales. It does not resemble Cook's chart of the coastline. The far north, the part of the country Tuki knew best, is given striking prominence, while other regions are compressed. The map also carries social and spiritual geography, including a double-dotted pathway ending at Te Rēinga that represents the route taken by wairua towards the underworld.[6]

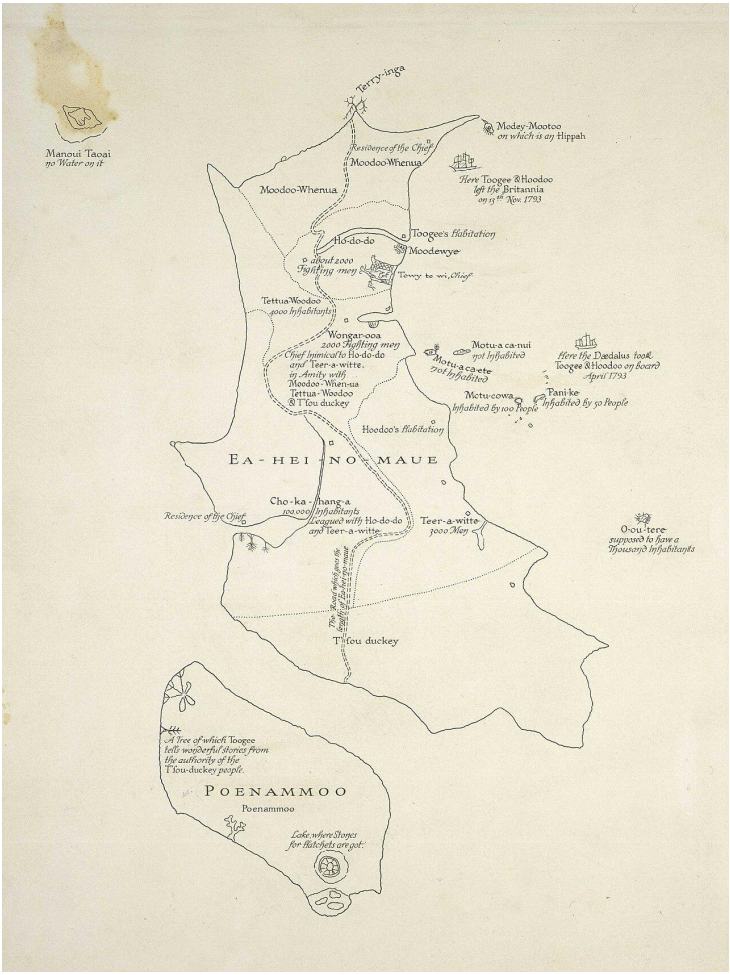


Figure 16.3. Map of New Zealand based on Tuki Te Terenui Whare Pirau's geographic knowledge, drawn in 1793 and published in 1798. Its emphases and its social and spiritual geography follow a different cartographic logic from a European coastal survey. Alexander Turnbull Library, MapColl-CHA-2/1/9-Acc.36440. Public domain.

Judged as a hydrographic survey, Tuki's map is geometrically distorted. Judged according to what he was trying to communicate, that is not a sufficient description of it. Cartography always chooses which relationships deserve protection. Mercator preserves local angles and sacrifices area at high latitudes. Equal Earth preserves

relative area and necessarily gives up other geometric properties. A schematic rail map moves stations and straightens routes because connectivity matters more than exact position. Tuki's map followed another set of priorities. Its proportions reflected knowledge, importance and relationship rather than a uniform mathematical scale. The useful question is not whether every coastline is proportioned correctly, but what the map makes legible.

Chapter 6 showed how survey geometry acquired force through the Native Land Court, titles and state institutions. Here the important contrast is what that system displaced or subordinated: a landscape already structured by Māori names, whakapapa, occupation, cultivation, fisheries, routes and relationships. The difference was not knowledge versus an empty landscape. It was between forms of geographic evidence and the institutions empowered to recognise them.

Maps rarely exercise political power by themselves. Their power comes from the institutions that act upon them. A boundary in an atlas cannot stop anybody crossing it, but a state can enforce the boundary. A cadastral polygon cannot evict someone, but a legal system can recognise ownership based on it. A geographic name in a database cannot force people to forget another name, but the cumulative effect of schools, signs, legislation, search engines and official maps can make one name dominant and another increasingly difficult to find. Cartographic authority therefore sits not only in geometry but in the network of institutions that agree to treat the geometry, label or classification as consequential.

Naming deserves as much attention as surveying because a place name may preserve an ancestor, event, journey, environmental characteristic, resource or story. In that sense, a name can function as a compressed archive. When one name is replaced by another, the mountain, river or harbour remains physically unchanged, but information has been displaced. Colonial mapping across the world

produced vast numbers of new names. Explorers and governments named places after monarchs, politicians, ships, patrons, military victories, distant towns and themselves. Sometimes existing Indigenous names survived, sometimes they were modified through spelling or pronunciation, and sometimes a new name became so dominant that later generations were unaware another had existed.

The contemporary process in Aotearoa shows that this authority can change. Ngā Pou Taunaha o Aotearoa, the New Zealand Geographic Board, operates within a framework in which te reo Māori names, consultation with iwi and hapū, and names restored through Treaty settlements form part of the official naming system.[7] The Board's tangata whenua place-name maps incorporate names corrected or restored through research, Treaty settlement processes and direct consultation. Names that once existed outside the dominant official map can therefore move back into formal geographic systems. The physical place does not move when this happens. What changes is the authority surrounding its names. A name may begin as oral knowledge, appear imperfectly in a colonial record, survive in an archive, be recovered through research, receive official recognition, enter a national gazetteer and eventually appear in the databases used by digital maps.

The same movement from knowledge to archive and back into living geography can be seen in the history of Ngāi Tahu mapping. In 1880 Ngāi Tahu leader Hori Kerei Taiaroa gathered information from kaumātua about settlements, camps and mahinga kai across Canterbury and Otago.[8] The work was connected to longstanding efforts to document grievances arising from major South Island land purchases. More than a thousand place names were recorded, many relating to places where food and other resources had traditionally been gathered. Mahinga kai were not picturesque cultural annotations that could simply be added to a conventional land map. They were essential to movement, economy, food gathering and

social relationships, so recording them preserved evidence of how Ngāi Tahu used and understood the landscape.

The resulting map did not disappear after the political circumstances that produced it had passed. Its information survived through archival records. More than a century later, the map and associated lists were used as evidence during the Ngāi Tahu Claim before the Waitangi Tribunal, and they subsequently became important sources for Kā Huru Manu, the Ngāi Tahu cultural mapping project. The sequence is remarkable because knowledge held by kaumātua became testimony, testimony became recorded place names, those names became a map, the map entered an archive, the archive later became evidence, and the historical evidence then became part of a contemporary digital geographic system. Cartography had not ceased to be powerful. The authority directing its use had changed.

This history complicates any simple claim that cartography belongs to one political side. The same technologies that can support colonial administration can later be used to document Indigenous rights and histories. Surveying mathematics can assist land acquisition or Treaty settlement. GIS software can support mining, conservation, emergency response, cultural mapping, military planning or Indigenous land management. A coordinate has no politics by itself. The institutions, purposes and relationships surrounding the coordinate are what give it political meaning.

The same tension appears in the global movement often described as counter-mapping. The term became influential through work such as Nancy Peluso's 1995 study of forest territories in Kalimantan, Indonesian Borneo. State forestry maps classified land according to administrative and economic categories that could fail to recognise Indigenous occupation and customary territorial relationships. Communities and activists responded by producing maps of their own, using cartography to assert claims that had been

poorly represented or omitted by official maps. A state had created a cartographic language through which territory was administered, and communities learned that language well enough to use it against the state's own representation.

Similar approaches have since been used in many parts of the world to document tenure, support land claims, record cultural knowledge and manage natural resources. Techniques range from hand-drawn participatory maps to GPS field surveys, satellite imagery and sophisticated GIS databases. A major review by Mac Chapin, Zachary Lamb and Bill Threlkeld documented the rapid expansion of Indigenous mapping across regions and purposes.[9] The appeal is clear: information that is politically invisible can become visible in a form governments, courts and conservation agencies understand. Yet this is not a straightforward story in which the official map is bad, the community map is good and the problem is solved.

To become legible to governments or courts, communities may have to express territorial relationships in forms those institutions recognise. A flexible or seasonal relationship with land may become a polygon. A boundary understood through negotiation may become a fixed line. Overlapping interests may have to be simplified. A landscape understood relationally may acquire precise coordinates. A map can strengthen a political claim while altering the form of the claim itself, because once a boundary is drawn questions about who falls inside or outside it become difficult to avoid. Once a sacred place receives an exact coordinate, that coordinate can be copied. Once a community GIS exists, someone will ask whether its data should be made public, and once a spatial layer has been created it can be combined with other datasets for purposes its creators never intended.

These questions become especially difficult in the age of open data. GIS professionals have good reasons to value accessibility.

Open government data can support research, reduce duplication, improve accountability and let communities examine public decisions. Interoperability and reuse are central to modern geospatial systems. Yet openness is not automatically ethical. In Aotearoa, Te Mana Raraunga has articulated Māori Data Sovereignty principles asserting Māori rights to govern Māori data and the systems through which it is collected, stored, interpreted, shared and reused. Internationally, the CARE Principles for Indigenous Data Governance emphasise Collective Benefit, Authority to Control, Responsibility and Ethics.[10] Both challenge the easy assumption that technically open and reusable data is necessarily socially appropriate.

For a GIS practitioner, this creates an uncomfortable but useful limit to technical thinking. A spatial database can be exemplary and still be wrong in ways no geometry validation will detect. Every polygon can close, every coordinate can be valid, the metadata can be complete, the server can conform to standards and the projection can be appropriate, while the project still violates the authority or expectations of the people whose knowledge it contains. There is no coordinate system for consent. Sometimes the responsible map is the one that reveals less.

This idea runs against a technological culture in which progress is often associated with greater precision, higher resolution and broader access. Satellite imagery becomes sharper, positioning becomes more accurate, databases become larger, storage becomes cheaper and governments release increasingly detailed information. The underlying assumption is that more geographic knowledge available to more people must represent progress. Frequently it does. Sometimes, however, responsible governance means deciding that certain information should not be made public at all. This does not represent a rejection of mapping. It recognises that maps

operate within social relationships and that visibility itself can have consequences.

The history of cartography is frequently presented as a history of expanding visibility. Blank coastlines are filled in, longitude becomes measurable, triangulation spreads, aerial photography reveals landscapes from above, satellites observe the planet, GPS provides near-instantaneous position, LiDAR records surfaces in extraordinary detail and global databases accumulate billions of geographic features. The apparent direction of travel is from ignorance towards complete knowledge. Yet many supposedly blank spaces on historical European maps were blank only for the people drawing those maps. A forest described as unknown might have contained generations of local geographic knowledge. A coastline appearing for the first time on a European chart may have been named and navigated for centuries. A mountain described as discovered by an explorer may have been central to the identity and cosmology of people living beside it. To say that a place was unmapped often means only that it had not been mapped within a particular cartographic tradition.

Scientific cartography remains an extraordinary achievement. Cook's charting of New Zealand's coastline demanded remarkable observation and hydrographic skill; geodesy created global reference frameworks of extraordinary precision; surveying, mapping and geographic information science transformed what people can measure and build. The error comes only when one highly successful representation of the world is confused with the world itself.

Modern cartographic scholarship has spent decades examining this distinction. J. B. Harley and other scholars helped broaden the history of cartography beyond the idea of a sequence of increasingly accurate scientific documents. Maps could be examined as cultural objects produced by particular societies for particular purposes, without abandoning geometry or measurement. Somebody

always decides what will be shown, what will be omitted, what will be named, which boundaries count and which categories will organise the result. That observation applies to a colonial survey plan and to a digital map in 2026 alike.

A software developer chooses a basemap. A government chooses an authoritative boundary dataset. A naming authority determines official names. A database designer creates the schema. A cartographer selects the projection. An algorithm determines which labels appear at which zoom levels. A product team decides which settings users will encounter by default. Most people viewing the finished map will never know that any of these decisions were made. This is one reason cartographic power can be harder to recognise today than it was during the age of colonial surveying. A nineteenth-century surveyor standing on disputed land with instruments and pegs is visibly engaged in territorial measurement. A default setting in software looks almost invisible, yet defaults can influence what hundreds of millions of people see.

A projection becomes normal because it is preselected. A disputed boundary becomes familiar because it arrives with the basemap. One name dominates another because a search engine lists it first. The modern exercise of cartographic power often works not by forcing people to use a particular map, but by ensuring that they rarely need to make an active choice. This brings the story back to contemporary Indigenous GIS. The important feature of a project such as Kā Huru Manu is not simply that Indigenous communities have adopted modern mapping software. Framing the story that way would make the technology the protagonist again. The more significant change concerns authority: decisions about what is mapped, how features are described, which stories accompany them, who governs the data and which information becomes public can remain with the people whose geography is being represented.

For much of colonial history, Indigenous knowledge entered maps controlled by others. A guide identified a route, a community supplied a name, an elder described a boundary, a surveyor recorded it, a cartographer determined how it appeared and a government archive stored the resulting document. Contemporary Indigenous mapping can reorganise that relationship. Communities can commission the work, determine categories, hold the database, define access rules, correct records and decide that some information will never appear in a public layer. The coordinates may use exactly the same national datum or global geodetic system as a government map, while the politics can nevertheless be entirely different.

Kā Huru Manu also demonstrates that the past does not need to be discarded to achieve this change. Historical surveys, archival documents, oral histories, traditional place names and modern spatial technologies can be combined. Colonial records can be interrogated rather than simply accepted. A document produced within one political system can become evidence within another. Taiaroa's 1880 map is valuable partly because it translated knowledge into a documentary form that survived within institutions capable of preserving it. Colonial archives can therefore preserve evidence later used to challenge colonial decisions. Military maps become historical sources, property plans can reveal patterns of dispossession, old aerial photographs document environmental transformation, and survey plans may preserve Indigenous place names that disappeared from later maps. Maps are exceptionally good at surviving the political intentions of their makers.

For that reason, it is too simple to describe cartography merely as propaganda or an instrument of domination. Maps can serve power and expose it. They can erase information and preserve it. They can facilitate dispossession and help document claims for redress. They can simplify a landscape in damaging ways, or simplify

it in precisely the way required to make an important relationship visible. A map can be meticulously accurate and still mislead, and it can be geometrically distorted while being entirely appropriate for the purpose for which it was created.

This book is centred on a change in projection, which makes projection an obvious place to look for politics. Indigenous mapping shows that many of the most consequential decisions occur much earlier. Before a projection is chosen, somebody has already decided what will be mapped. Before a line is rendered, somebody has decided that a boundary exists. Before a label is placed, somebody has chosen a name. Before a database is published, somebody has determined who is entitled to see it. Before a coordinate is transformed, someone has decided that the thing being represented can usefully be reduced to a coordinate in the first place.

EPSG:8857 answers a much narrower question. An equal-area projection can preserve relative area on a world map; it cannot resolve sovereignty, return land, restore language, judge the legitimacy of a boundary or govern sensitive knowledge. That matters, but it matters within a much larger history of deciding who represents geography and whose representation becomes authoritative. The geometry of a projection is objective enough to calculate precisely while the meaning attached to that geometry is social and historical. We can calculate how much Mercator enlarges a region at a given latitude, but we cannot calculate with the same precision what generations of seeing a particular world map have meant for public perceptions of geography.

Keeping those different kinds of claim apart makes the case for better cartography stronger. When the purpose of a map is to compare the relative sizes of countries and continents, preserving area matters. When the purpose is marine navigation, other properties may matter more. When the purpose is documenting an Indigenous relationship with land, a conventional cadastral polygon may

be inadequate. When the purpose is protecting culturally sensitive information, not placing the information on a public map may be the most responsible cartographic decision. A good map begins with a clear understanding of what it is for.

Tuki knew what his map was for. Tupaia knew what his geographic knowledge was for. Marshallese navigators knew what swell patterns were for. The makers of the east Greenland carved coastlines knew which shape needed to be remembered by hand.[11] Colonial surveyors knew what land parcels were for. Hori Kerei Taiaroa knew why Ngāi Tahu place names and mahinga kai needed to be recorded. The point is not that all purposes are equivalent. It is that every map has one. Selection and abstraction are unavoidable, and somebody chooses what to include, how to classify it, what to call it and how to display it.

The modern GIS profession inherits this history along with an extraordinary amount of capability. A single analyst can now combine in an afternoon what once required entire government departments: cadastral parcels, census statistics, high-resolution satellite imagery, elevation models, property information, road networks, hydrology, ecological data and historical maps. A cloud service can publish the result worldwide almost immediately, while machine-learning systems can discover patterns across datasets too large for any human cartographer to inspect feature by feature. The technology has changed dramatically, but the underlying questions have not. Who supplied the data, who defined the categories, who benefits from the map, who is missing, who decided that a boundary exists, who selected the name, who is allowed access and who can correct an error?

Maps have power because they are useful to governments, communities, scientists, navigators, emergency services and Indigenous organisations. The task is to recognise where authority enters that usefulness. For several centuries, European scientific cartography

expanded alongside European political and economic power. European states possessed ships, military forces, survey organisations, printing systems, bureaucracies and educational institutions capable of making their geographic representations authoritative far beyond Europe itself. Other forms of spatial knowledge did not cease to exist; they became easier for those institutions to ignore.

That relationship is changing. Indigenous peoples are producing and governing their own geographic databases, recovering traditional names, challenging official classifications, mapping cultural landscapes and determining when information should remain restricted. Historical maps are being read against the purposes for which they were created, archives are being combined with oral histories, and survey plans are being used as evidence. Cartography has not become less scientific through these developments. The range of people able to direct its scientific and institutional power has widened.

The map was never empty. The world did not wait to be discovered, named, surveyed or entered into a database before it became geography. European scientific cartography developed powerful techniques for representing that world, and colonial governments gave some representations extraordinary legal and institutional authority. The contemporary change is not rejection of those techniques but a widening of who can decide how they are used. At global scale, the same question returns: who decides what the world should look like, which properties a flat map should preserve, and which inherited defaults still deserve authority?

CHAPTER 17

AFRICA IS BIGGER THAN YOU THINK

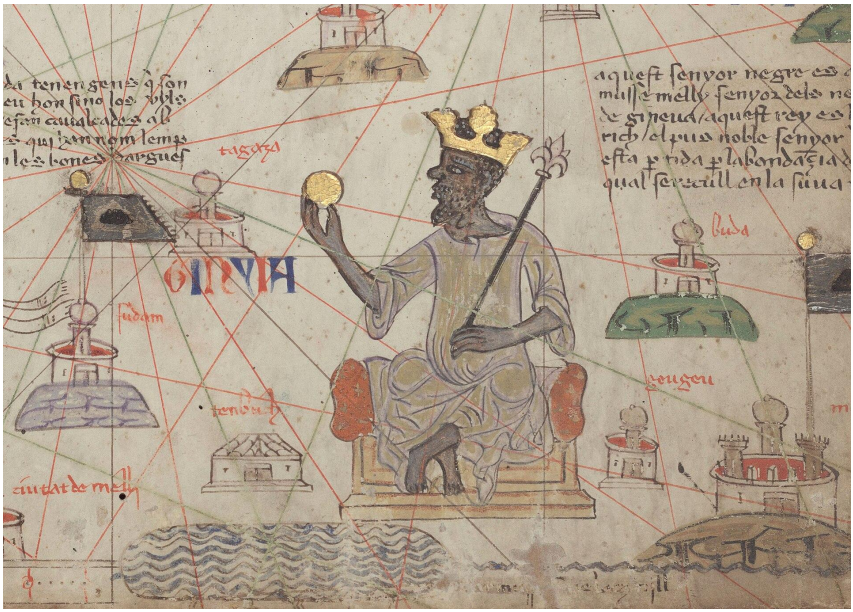


Figure 17.1. Mansa Musa in the Catalan Atlas, 1375, attributed to Abraham Cresques. The image places a powerful West African ruler and the wealth of Mali within a medieval cartographic world centuries before the colonial partition of Africa. Bibliothèque nationale de France, Département des manuscrits, Espagnol 30. Public domain.

On 4 September 2026, the United Nations General Assembly found itself debating a map projection. Togo had introduced the issue on behalf of the African Group, and the resolution before delegates carried an unusually direct message: the familiar visual proportions of the world map did not represent land area fairly, particularly for Africa. The final institutional story belongs near the end of this book, where the resolution, the vote and its practi-

cal consequences are examined in detail. What matters here is the historical question behind that moment. How did the apparent size of one continent become a subject of diplomacy, and why did a mathematical choice made in the sixteenth century become entangled with arguments about empire, representation and political power nearly five hundred years later?

The starting point is simple. Africa covers a little over 30 million square kilometres and Greenland a little over 2 million, making Africa roughly fourteen times larger.[1] On a Mercator world map Greenland can look remotely comparable. As Chapter 2 explained, this is a latitude effect: Mercator progressively enlarges higher latitudes rather than applying a special shrinking rule to Africa.[2] The later political question is what happened when that visual consequence met Africa's political history.

Africa's cartographic history did not begin with Mercator, and it certainly did not begin with the Scramble for Africa. Long before nineteenth-century partition, maps made around the Mediterranean and beyond contained information about African kingdoms, trade routes, cities and rulers.[3] The fourteenth-century Catalan Atlas famously depicted Mansa Musa of Mali holding a gold object, while the fifteenth-century Fra Mauro map represented an Africa dense with names, routes and reported places. These were not neutral or complete portraits of the continent, and they were produced outside the African societies they depicted. They were filtered through the knowledge, conventions and interests of their makers. Their value here is simpler: Africa was already part of a wide geography of states, commerce, travel and political imagination centuries before European colonial partition.



Figure 17.2. Africa in the Fra Mauro world map, c.1450. The continent is dense with names, reported places and routes, a reminder that Africa's cartographic history long predates nineteenth-century colonial partition. Fra Mauro / Biblioteca Nazionale Marciana, Venice. Public domain.

The relationship between Africa, mapping and power is therefore much older and better documented than any theory about Mercator causing colonial attitudes. European colonial states later used maps directly as instruments of exploration, negotiation, military planning, administration, resource extraction and territorial con-

trol. They did not arrive with complete geographic knowledge and impose it on a blank continent. Explorers, officials and mapmakers repeatedly depended on African guides, interpreters, political authorities and local knowledge.[4] Rivers, routes, settlements, kingdoms and environmental conditions were already known by the people who lived among them. What changed was the growing institutional power of European states to select, translate and circulate geographic knowledge in forms that acquired administrative and diplomatic force.



Figure 17.3. Abraham Ortelius's Africae Tabula Nova, 1570. Published in the first edition of Theatrum Orbis Terrarum, it shows the early-modern European atlas tradition taking shape long before nineteenth-century colonial partition. Abraham Ortelius / University of Texas at Arlington Libraries. Public domain.

A place could appear blank on one map while being deeply known to the people living there. In nineteenth-century Africa, expanding colonial institutions gained an increasing ability to turn incomplete

knowledge into political claims. Military reconnaissance, surveying, printing, treaties and bureaucratic records made it possible to administer territory from a distance. Roads and rivers became networks, mineral areas became concessions, administrative districts acquired names and colours, and a claim could appear far more complete on paper than control actually was on the ground.

Few episodes symbolise this relationship more strongly than the Scramble for Africa, and few have acquired a more misleading cartographic shorthand. The familiar story imagines the Berlin Conference of 1884 and 1885 as the moment when European leaders spread a map across a table, took out rulers and divided Africa into the borders that still exist today. The image captures something real about imperial power: African sovereignty was frequently ignored, European competition drove the partition and communities were incorporated into colonial territories without their consent.[5] Yet as a description of how the continent's actual borders were formed, the image is too simple.

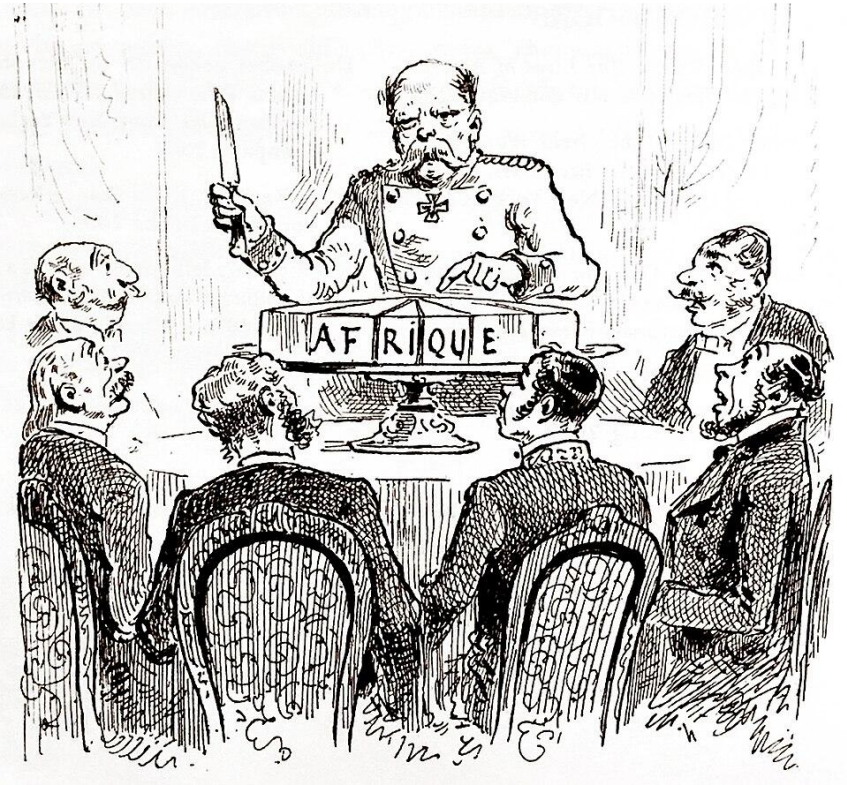


Figure 17.4. An anonymous political cartoon published in L'Illustration on 3 January 1885 depicts Otto von Bismarck cutting an 'Africa' cake while other delegates watch. It is a contemporary satirical image of the Berlin Conference, not a literal record of the negotiations. Public domain.

Recent systematic research by Jack Paine, Xiaoyan Qiu and Joan Ricart-Huguet examined the formation of 107 bilateral colonial borders in Africa and found that most were not fixed at Berlin.[6] The median year of initial border formation in their dataset was 1891, with major revisions continuing later. Their analysis also found that precolonial political frontiers directly influenced many boundaries, alongside rivers, lakes, topography, settlement patterns and the practical information colonial states acquired after the Berlin Conference. Straight geometric lines were important, particularly in sparsely populated or poorly known regions, but the

detailed partition emerged through decades of treaties, bargaining, military expansion, surveys, local knowledge and revision.

This correction makes the process more historically useful without making colonial border-making benign. Power rarely becomes geography in one dramatic act. A government announces a claim, diplomats negotiate, surveyors locate features, administrators gather information, local rulers bargain or resist, soldiers enforce decisions and maps are revised as control changes. The line eventually becomes difficult to move because institutions accumulate around it. Roads lead to border posts, administrative districts are organised around it, legal systems recognise it and successive maps reproduce it. The apparent certainty of the finished boundary hides the years of negotiation and coercion through which it became certain.

Colonial maps could therefore function both as records of control and as instruments for creating it. An atlas coloured a territory as British, French, German, Belgian, Portuguese or Italian even when colonial administration remained thin across large areas. The colour translated a claim into a visual fact for audiences in Europe and elsewhere. Over time, the claim was followed by surveying, taxation, transport systems, district administration and military force. Mapping was one component of the machinery through which empire became organised and legible.

The end of formal colonial rule introduced one of the great paradoxes of African political geography. Newly independent states inherited boundaries associated with European imperial competition, yet most chose to defend those boundaries rather than reopen the entire territorial settlement. The reasons were practical as well as political. Precolonial kingdoms had expanded and contracted, communities overlapped, languages crossed frontiers and many different historical criteria could be invoked to justify different maps. Redrawing the continent according to ethnicity, historical king-

dom, language or precolonial political authority would not have produced one obvious answer. It could instead have generated widespread territorial conflict.

The Organisation of African Unity confronted this problem directly in 1964. At its first ordinary Assembly of Heads of State and Government in Cairo, member states adopted a resolution on border disputes that committed them to respect the borders existing at the time they achieved national independence.[7] That decision is often described as the principle of uti possidetis in the African context, although the political logic mattered more than the Latin terminology: inherited borders might be deeply imperfect, but reopening all of them could be far more dangerous.

The result is a useful warning against assigning a permanent ideology to a line on a map. A boundary created through colonial bargaining can later become the internationally defended boundary of an independent African state. The coordinates may remain similar while the political authority behind them changes completely. Maps inherit histories, but they do not dictate one meaning forever. The same is true of Mercator. A projection created for sixteenth-century navigation could later become a classroom convention, then a symbol in arguments about colonial representation, and eventually a target of African diplomatic action.

The modern political argument about the apparent size of Africa began long before 2026. In the 1970s, German historian and filmmaker Arno Peters promoted a cylindrical equal-area world map as an ethical alternative to Mercator. His argument travelled well beyond professional cartography because the visual contrast was immediate. Africa and South America occupied far more of the sheet, while Greenland, Canada, Europe and Russia lost much of the high-latitude enlargement familiar from Mercator. Development organisations, churches, educators and campaigners adopted

the map because it gave a simple visual form to a much larger argument about representation.

Professional cartographers objected to parts of Peters' historical and technical case. The projection was essentially the same as one described by James Gall in the nineteenth century, so claims of novelty were disputed.[8] More importantly, equal area did not mean no distortion. Gall-Peters preserves relative area but stretches and compresses shapes conspicuously. Many cartographers were not defending Mercator as a universal world map; they were rejecting the idea that one equal-area projection was uniquely truthful or morally correct.

The Peters dispute became one of cartography's best-known public arguments because the two sides were often answering different questions. Cartographers focused on projection properties, history and design quality. Campaigners focused on what a familiar world map appeared to say about the relative scale of the Global North and Global South. Technical expertise could explain the distortion perfectly, but it could not make the political interpretation disappear once the public had learned to see it.

For maps comparing territory, an equal-area projection is simply better suited than Mercator. Maps of forest cover, agriculture, population or territorial extent can mislead if high-latitude regions receive far more display area than their geographic area warrants. Equal-area projections preserve the relationship that matters for those tasks.

Peters also exposed a design problem. A map does not become a successful general-purpose world map merely because one mathematical property is appropriate. People notice shape. Gall-Peters preserved area but changed familiar continental forms so strongly that many readers disliked it. The political critique had found a wide audience, but its best-known proposed replacement had not become an obvious visual standard.

In 2018, Bojan Šavrič, Tom Patterson and Bernhard Jenny introduced Equal Earth, an equal-area projection intended to combine correct relative area with a more balanced general-world appearance than Gall-Peters.[9] By the time the political campaign arrived, the design was already implemented in mainstream geospatial software and a Greenwich-centred WGS 84 definition had been registered as EPSG:8857. That chronology matters: African diplomacy did not invent the projection or the CRS. It selected an existing, technically deployable alternative for a political campaign about world-map representation.

By the time African advocates began pushing for Equal Earth, the technical alternative was therefore mature. In April 2025, Africa No Filter and Speak Up Africa launched the Correct the Map campaign.[10] Their message was intentionally direct: the familiar Mercator world map made Africa appear much smaller relative to northern regions than it really was, and institutions should adopt equal-area alternatives such as Equal Earth in contexts where area representation mattered. The campaign framed this as part of a broader problem of African representation, linking cartographic proportions to questions of narrative power and inherited global conventions.

The campaign's political language went beyond what projection mathematics alone can prove. It is straightforward to demonstrate that Mercator inflates high-latitude area and that Equal Earth preserves relative area. It is much harder to demonstrate exactly how repeated exposure to a particular projection affects political judgement, self-perception or attitudes towards a continent. That psychological step requires empirical evidence of its own, so the levels must remain separate here. The campaign's larger claims should be attributed as political arguments rather than presented as consequences proved by geometry.

That caution does not reduce the political significance of what happened next. African organisations had taken a technical property of map projections and turned it into a question of continental representation. More importantly, the issue moved from civil-society advocacy into African state diplomacy. Togo became the central government actor, and the campaign increasingly connected with African Union debates over historical justice, representation and what officials described as narrative sovereignty.

At the African Union's 39th Ordinary Session on 14 and 15 February 2026, leaders adopted the Equal Earth projection and urged member states to revise national curricula in accordance with it.[11] The decision, proposed by Togo, transformed Correct the Map from a campaign into an intergovernmental African position and provided for a champion to promote the initiative with the African Union Commission. Togo then carried the proposal into the wider international system, and by April Foreign Minister Robert Dussey was publicly confirming that the country intended to seek support at the United Nations.[12]

There is an important historical reversal in this sequence. In the 1970s, Arno Peters was a European telling audiences that Africa and the developing world were misrepresented by conventional maps. In 2026, African organisations and African governments were defining the issue themselves, deciding how to frame it and choosing the diplomatic institutions through which to pursue it. Whatever one thinks of the campaign's broader rhetoric, that change in authorship matters. The argument was no longer simply about outsiders deciding how Africa ought to appear. African states were asserting their own preference about the representation of the continent within global cartography.

Togo's leadership also demonstrates a form of power that is easy to miss in a book dominated by large states and famous empires. A comparatively small country can sometimes exercise disproportion-

ate diplomatic influence by choosing an issue that is easy to understand, symbolically strong and technically difficult to refute. The area comparison between Africa and Greenland can be shown in seconds. Equal Earth already existed. The African Union provided institutional support. The proposed change did not require renegotiating a border, transferring money or surrendering sovereignty. It asked governments to support a different default for particular kinds of maps.

That made the issue politically efficient. A government supporting the campaign could present its vote as backing geographic accuracy, African representation and a modest modernisation of mapping practice. A government opposing it had to explain why. The underlying geometry placed critics in an awkward position because nobody could plausibly argue that Greenland actually deserved almost as much visual area as Africa on a map intended to compare territorial size. Opposition therefore centred not on the mathematics but on whether the United Nations should turn a projection choice into a political programme.

The United States ultimately made that argument. At the General Assembly, its representative objected to the ideological framing of the initiative and argued that the organisation had more pressing responsibilities. That position deserves to be stated fairly. It was not a declaration that Africa ought to look small. It was an argument that the UN should be cautious about treating a technical cartographic choice as part of a programme of historical or representational justice. The African position was equally clear: inherited conventions are not neutral simply because they are familiar, and a general world map that misrepresents relative area has no special claim to remain the default when an appropriate alternative exists.

On 4 September, the General Assembly adopted the resolution overwhelmingly.[13] Projection choice had moved from specialist cartography into international diplomacy.

For Africa, the most durable achievement is narrower than some of the campaign rhetoric. A world map intended to represent relative continental area no longer needs to reproduce the familiar Mercator imbalance. Equal Earth and other equal-area projections make Africa's share of global land area visible without requiring the conspicuous shape distortions associated with Gall-Peters. A school, news organisation or international institution can make that choice for straightforward cartographic reasons before entering any argument about psychology or symbolism.

That achievement should remain separate from the history of colonial conquest.[14] European empires did not conquer Africa because Mercator made Europe look large. Colonial states used maps much more directly, to claim, survey, administer, tax, transport, extract and govern. Their boundaries emerged through unequal political and military relationships, though not through the simple ruler-at-Berlin story so often repeated. After independence, African states inherited many of those lines and deliberately stabilised them. The 2026 campaign addressed a different cartographic inheritance: not where Africa's borders were, but how much visual space the continent occupied when the world was flattened onto a page.

Changing that visual space cannot undo the earlier history. Equal Earth does not repair colonial borders, settle conflicts or redistribute power. It does one measurable thing well: it preserves relative area. Its political significance comes from the fact that African organisations and governments decided that this measurable property was worth making visible, then built enough diplomatic support to turn that preference into a United Nations resolution.

The route to the vote is what makes the story more than a dispute over graphic design. An existing equal-area alternative moved from software into civil-society advocacy, then through Togo into African Union diplomacy and finally the United Nations. The

mathematics did not change during that journey. The authority surrounding the map did.

The result was not the defeat of Mercator. It was a shift in what could pass without explanation. Once equal-area alternatives are readily available, using a Mercator world map for continental size comparison becomes an active design choice rather than an inherited inevitability.

That theme links Africa back to the Indigenous mapping of the previous chapter. A map acquires power when institutions treat its representation as authoritative, whether the issue is a survey boundary, a place name, a customary territory or the apparent area of a continent. In each case, the political question begins when one representation becomes normal enough to disappear from view as a choice. The contemporary shift is not that maps have suddenly become political. It is that more people are recognising where the choices are and claiming a role in making them.

Africa's measured area never changed. What changed was the willingness of institutions to question a familiar picture of the world. Greenland is the obvious counterpoint: correcting Mercator reduces its visual size beside Africa, but not its geopolitical importance.

CHAPTER 18

GREENLAND IS BIG ENOUGH



Figure 18.1. Hans Egede's Map of Greenland, 1737. Seen in its own geographic frame, Greenland is a place of coasts, fjords, routes and communities rather than an oversized silhouette near the top of a rectangular world map. Royal Library, Denmark / World Digital Library. Free to use and reuse.

Correct the area distortion and Greenland becomes much smaller, but it does not become unimportant.

On Mercator, Greenland is famously enlarged. An equal-area map substantially reduces its visual share of the world.[1] The correction is real, but the political geography remains.

On 4 January 2026, Donald Trump told reporters aboard Air Force One that the United States needed Greenland for national security, described the island as strategically important and invoked Russian and Chinese activity around it.[2]

The two facts invite an easy inference: Greenland looks huge on Mercator, Greenland attracts geopolitical attention, so perhaps the map made powerful people imagine the island as more important than it really is. Greenland does not need the projection's help. Its strategic value begins with position.

At Pituffik Space Base in north-west Greenland, the United States operates infrastructure for missile warning, space surveillance, satellite communications and control.[3] The base's extreme latitude is not an inconvenience to be corrected on a map. It is part of the reason the location is useful. Polar-orbiting satellites pass over high latitudes repeatedly. A northern tracking station can see them often. U.S. Space Force material in 2026 described Pituffik as the northernmost station in its Satellite Control Network and noted the frequency with which polar-orbiting spacecraft can come into view.



Figure 18.2. U.S. Air Force C-123J at Thule Air Base, Greenland, 1958. Greenland's strategic importance rests partly on its high-latitude position, not on how large it appears in Mercator. U.S. Air Force / National Museum of the U.S. Air Force. Public domain.

A corrected equal-area world map does nothing to that geometry. Shrink Greenland on the page until its area relationship with Africa is right and Pituffik stays where it is. The satellites still pass overhead. The Arctic remains between North America, Europe and Russia. Long-range aviation still crosses northern routes. Sea ice, undersea infrastructure and military surveillance still make the region operationally important.

For those questions, the useful map may not be a world map at all. It may be a polar projection showing Arctic states around the North Pole, or a specialised map of radar horizons, satellite ground tracks, sea approaches, military installations or great-circle routes. A Mercator rectangle is a poor instrument for understanding the real strategic geography even when its oversized Greenland happens to catch the eye.

Map size and strategic importance are different variables, and that distinction becomes even more important when Greenland is discussed as territory rather than geography.[4]

A large blank shape on a world map encourages an old habit: talking about land as though it were an object whose future is decided elsewhere. Greenland's political status is much less simple.

Greenland has extensive self-government within the Kingdom of Denmark. The 2009 Self-Government Act recognises the people of Greenland as a people with a right to self-determination under international law and sets out a process under which a decision on independence belongs to the Greenlandic people, followed by negotiations and democratic approval.[5]

That legal fact matters more to Greenland's political future than the size of its polygon on a world map, a point that became especially visible during the political arguments of January 2026. Green-

landic leaders repeatedly insisted that Greenland's future must be decided by Greenlanders. A joint statement from major political parties placed Greenlandic agency at the centre, and Prime Minister Jens-Frederik Nielsen rejected the idea that Greenland should be owned or governed by the United States while also affirming cooperation within existing security relationships.[6]

The political map can therefore distort in a way projection mathematics cannot measure. If a news graphic reduces the situation to arrows between Washington and Copenhagen, Nuuk can disappear from its own story. That is not a Mercator problem but a framing problem.

The same caution applies to minerals. Greenland attracts international attention because of its geology and the possibility of resources important to modern industry. But a map covered in mineral symbols can make potential look like production. A deposit is not a mine.[7] A geological occurrence is not a commercially recoverable reserve. Infrastructure, energy, regulation, finance, environment and local political decisions determine what can actually be developed. Greenland's own mineral authorities maintain detailed licensing and geological information precisely because the word resources is not enough.

Correcting Greenland's visual area changes none of that. The island's ice sheet remains enormous, its settlements remain concentrated around the margins, its population remains small relative to its territory, its geology remains specific, its sovereignty remains politically complex and its latitude remains extreme.

The Arctic itself reinforces the point. Recent American and NATO strategy documents describe a high north shaped by military activity, alliance geography, climate change, new operating conditions and closer attention to Russian and Chinese activity.

Those strategic concerns exist on a globe, an equal-area map, a polar map and a Mercator map. The projection may affect how the region looks, but it does not create the region's location.

Greenland is therefore a useful test for claims about map power. It contains a spectacular visual distortion and an abundance of real-world reasons for attention. Any argument that jumps directly from the first to the second has to pass through too many alternative explanations.

The alternative explanations are substantial. Pituffik and polar-orbit geometry exist independently of the projection, as do Arctic approaches to North America, Russian Arctic capabilities, alliance geography, mineral prospects, climate-driven changes in access and Greenland's own constitutional and independence debate. A map can contribute to how people imagine these facts, but it cannot substitute for them.

Projection may still matter psychologically, but Greenland provides a clean way to separate two questions: what makes the island strategically important, and whether a distorted map changes how people judge that importance. The first belongs to geography and politics; the second can be tested.

Here Greenland's role is simpler: it shows what remains after the projection is corrected.

Correcting Greenland's area does not make political importance proportional to size. An equal-area map is excellent for seeing how much territory the island occupies relative to Africa, but not necessarily for asking which satellites Pituffik can see, how Arctic states relate around the pole, where sea routes pass or how ice affects operations. Area is one geographic property among many.

Draw Greenland at the right relative area and it is still positioned between continents and oceans, still connected to Arctic security, still governed through its own political institutions and still home to people whose decisions matter more to its future than any out-

sider's map. That leaves a narrower question: once geometry and real geography have been separated, what evidence do we have that the picture itself changes what a viewer thinks?

CHAPTER 19

DOES A MAP CHANGE YOUR MIND?

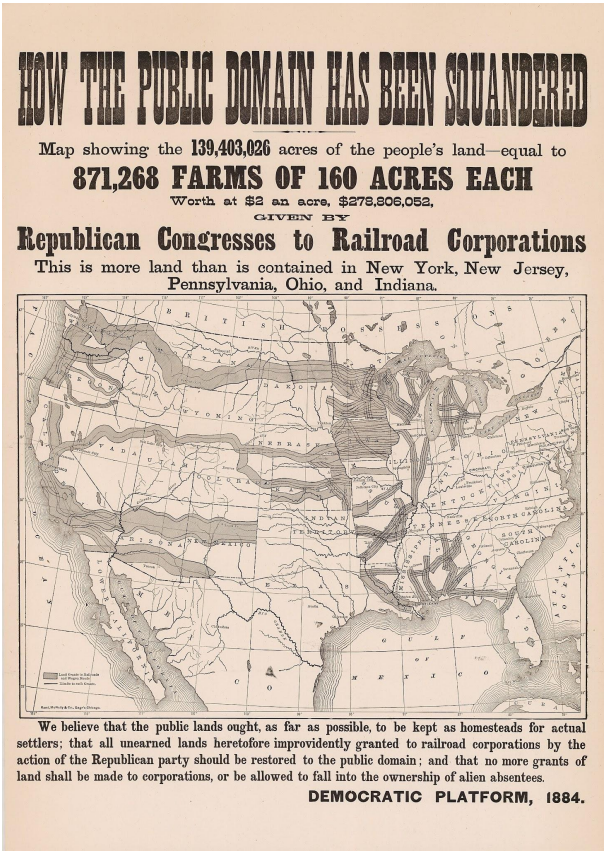


Figure 19.1. How the Public Domain Has Been Squandered, 1884. Published by the Democratic Party. This campaign map uses geography as an argument, not merely as a locator, showing how mapped framing can be designed to persuade. Cornell University Library, Persuasive Cartography: The PJ Mode Collection, 1088.01. Public domain.

A student sits down with a page of questions and is asked to estimate the size of the world from memory.

Suppose Greenland is 1,000 units. How large is Canada? Russia? India? New Zealand? The student is not being asked for exact square kilometres. The researchers want something more interesting: the shape of the world that remains after the map is gone.

Then the task changes. Imagine standing in California and pointing toward a distant city by the shortest route across the surface of the Earth. Tokyo. Moscow. Cape Town. Which direction would you point?

These were the kinds of questions used by geographer Daniel Montello and cartographer Sarah Battersby in a long-running attempt to test one of the most persuasive claims in projection politics: does repeated exposure to the Mercator map distort the world in our heads?

The claim is easy to believe because Mercator enlarges high latitudes dramatically. Greenland looks enormous, Russia and Canada expand, and Africa looks comparatively smaller. If people see this picture often enough, perhaps they store its proportions and later reproduce them without the map present.

The first half of that argument is mathematics; the second is psychology. The psychological result cannot be read off the projection equations.

Battersby and Montello tested the area question directly in 2009.[1] Participants estimated the relative areas of world regions from memory. If a strong Mercator effect existed, places at high latitudes should have been systematically overestimated in something like the pattern produced by the projection.

That was not the pattern they found. People were imperfect at estimating area, as people generally are when asked to compare large magnitudes from memory, and small regions tended to be overestimated relative to large ones. But participants' estimates related

more closely to actual geographic area than to Mercator's latitude-driven enlargement. A person can therefore be wrong about geography without being wrong in the particular way Mercator predicts.

Perhaps the study had caught the wrong generation. Those participants had grown up with printed atlases and a mixture of projections. What about younger people immersed in digital mapping and years of Web Mercator?

Researchers tested that possibility too. A 2019 study of young people in Belgium and the United States looked for a Mercator-like imprint in estimates of countries and continents.[2] Again, the expected projection signature was difficult to find. Education and individual knowledge appeared more important than simple exposure to one projection.

Then the sample became enormous. A worldwide study published in 2020 gathered more than 130,000 responses.[3] If a strong global Mercator effect on remembered area were common, this was a good place to see it.

The results again resisted the slogan. Participants did not reproduce the systematic latitude-driven area pattern that a simple Mercator-memory theory predicted. Europe was often overestimated, but the broader pattern followed other human judgement effects more strongly, including the tendency to overestimate small regions and underestimate very large ones.[4] In some comparisons, Mercator did not even produce worse estimates than Gall-Peters.

Mercator remains a poor map for comparing global area, and Greenland remains visually too large on it. The experiments show that an objectively distorted display does not necessarily leave the exact long-term memory effect critics expect.

Mathematical distortion, immediate perception and later memory are different questions. A viewer can see Greenland enlarged while the map is present and may misunderstand its size at that mo-

ment, yet later draw on other knowledge such as numbers learned at school, globes, other projections, travel, news, geographic facts and reasoning. The mind is not a screenshot folder or a single internally consistent miniature atlas.

That became even clearer when researchers turned from area to direction. In 2022, Montello and Battersby again found little evidence for the expected Mercator effect on remembered areas, but they asked participants another question: from a given place, in what direction lies a distant city along the shortest route over the globe?

A rectangular world map becomes deceptive here in a different way. Great-circle routes can begin in directions that look surprising on a flat map, because the shortest route on a sphere does not behave like a straight line drawn across a familiar rectangle. Participants were explicitly told to think about the shortest route over Earth's surface, the way a jet might fly, yet their answers often followed the flat-map intuition. Where the correct spherical direction and the Mercator-like planar direction differed substantially, average estimates were far closer to the planar answer than to the spherical one.

The directional result was consistent with an effect from Mercator or familiar rectangular mapping, but not with the famous remembered-area claim.[5] Instead of asking whether a projection enters the mind, the better question is which properties enter which kinds of judgement.

A person may know that Africa is much larger than Greenland and still imagine the direction to Europe as though the world were a flat rectangle. They may know New Zealand is far from Britain and still draw the Pacific badly from memory. They may understand that Mercator distorts area and still be unable to mentally correct the distortion region by region.

Cognitive geography is fragmented. Montello and Battersby suggest something more like a cognitive atlas than a single mental map: remembered facts, directions, routes, images and relationships learned from different sources and not necessarily geometrically consistent with one another.

That idea fits ordinary experience. Most people can navigate their neighbourhood without knowing its exact area. They can know two countries are neighbours without knowing their relative size. They can understand that Japan lies north of New Zealand and still fail to draw the coastlines accurately.

The knowledge is useful without being one perfect picture, and projection literacy does not automatically solve the problem. Research has found that people may know in general that world projections distort while struggling to apply that knowledge to a specific judgement.[6] Novices often use familiar continental shapes as clues to whether a projection looks trustworthy, while more experienced readers may use the graticule and other systematic cues.

That creates a practical problem for reform. An equal-area projection can be mathematically better for comparing territory and still look wrong to someone who has learned that familiar shapes are evidence of accuracy. Gall-Peters is the obvious example: its stretched equatorial forms preserve area exactly, yet many viewers read the unfamiliar shapes as distortion without understanding which property has been protected. Changing the map therefore works better when the reader is also told what changed.

The story becomes more political when maps are combined with words because people rarely encounter maps in isolation. A news map arrives with a headline, a school map with a lesson, a military map with a briefing and a social-media map with a caption. The projection is one cue among labels, colours, framing and prior beliefs.

A 2024 experiment tested exactly this interaction. Participants considered a hypothetical United States purchase of Greenland while viewing different projections and different verbal frames, including economic and national-security framing.

The projection did not produce one uniform response. Under the national-security frame, however, the Mercator view changed some judgements relative to Gall-Peters, including perceived importance associated with Russia, which then related to attitudes toward the hypothetical purchase. Under the economic framing, the same pattern did not appear in the same way. That conditional result is a more plausible model of how political maps can influence people than any claim of a universal projection effect.

Maps are not hypnotic devices. They are part of an information environment in which a large-looking Russia may become more salient when the accompanying words already tell the viewer to think about military threat. Under another framing, the same visual size may matter less. The picture and the argument can reinforce each other.

The result supports a smaller, testable claim: projection can interact with framing to influence judgement under some conditions.[7] It does not establish a general causal account of real-world policy.

Smaller claims are useful because they can survive evidence. A 2024 review of research on cognition and map projections reached a similarly cautious conclusion: the evidence base is real but thinner and more uneven than public claims often imply.[8] Samples are frequently narrow, projection properties are sometimes misunderstood, and studies test different psychological outcomes that cannot simply be merged into one assertion that maps shape worldview.

Taken together, the evidence is uneven rather than null: Mercator visibly enlarges high latitudes; simple remembered-area effects

are weak; directional effects appear stronger; and projection can interact with verbal framing. Those are different psychological outcomes and should not be collapsed into a single "Mercator effect".

The distinctions make map politics less dramatic and more credible, and they give educators a better goal. Simply replacing one wall map with another cannot carry the whole burden of geographic literacy. A student can look at Equal Earth without knowing why it differs, memorise the phrase "Mercator distorts" without understanding area, direction or scale, and learn that Greenland is smaller than it appears while still imagining great-circle routes as straight paths across a rectangle.

Projection education should therefore teach questions rather than slogans: what property is preserved, what is distorted, what comparison the map asks the reader to make, what visual and verbal cues accompany it, and what evidence supports any claim about how viewers respond.

Those questions are more useful than calling a projection innocent or guilty. The failure to find a strong long-term Mercator area effect does not make projection choice psychologically irrelevant: immediate area differences remain visually obvious, directional effects have been measured, projection and framing can interact, and familiarity influences what looks trustworthy.[9] Maps can influence thought without controlling it, which is the conclusion the evidence supports best.

The practical consequence is liberating. A cartographer does not need to prove a grand psychological theory before choosing an equal-area map for an area-comparison task. The map can simply be better for the stated purpose; any claim that the design changes beliefs must then earn its place through evidence.

This evidence narrows the design question. If no projection preserves everything and readers respond in more complicated ways than slogans suggest, how should a cartographer design a general

world map? Equal Earth began with dissatisfaction over the alternatives already in public view.

CHAPTER 20

DESIGNING A DIFFERENT WORLD MAP

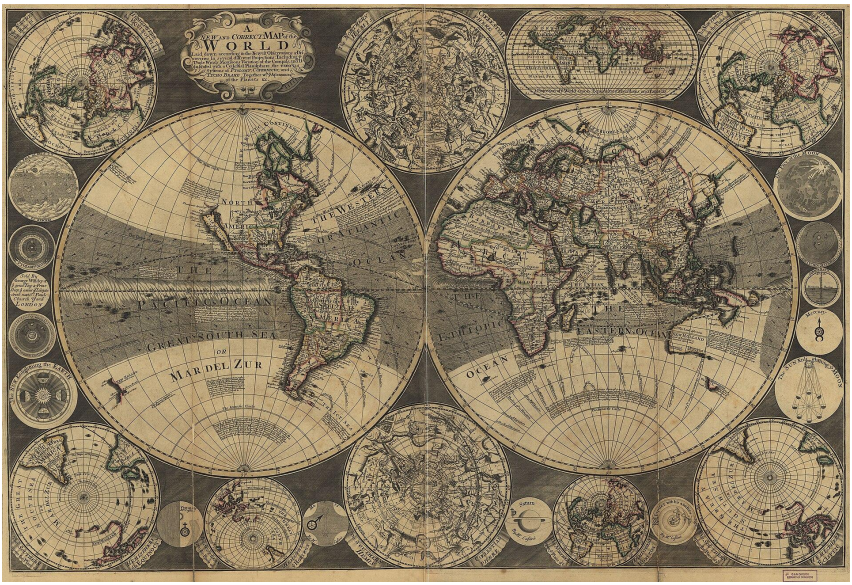


Figure 20.1. W. Godson's A New and Correct Map of the World in Several Different Projections, 1702. The sheet makes visible a fact that predates modern projection arguments by centuries: there has never been only one plausible way to draw the world. Library of Congress, Geography and Map Division. Public domain.

In March 2017, teachers in Boston were handed a different-looking world.

The city's public schools had begun introducing Gall-Peters maps into social-studies classrooms.[1] The change attracted attention because the proportions were impossible to ignore. Africa occupied much more of the page than on a Mercator map. Greenland contracted. Europe lost visual bulk. The continents remained

recognisable, but many of their shapes looked stretched or compressed.

The map was doing exactly what it was designed to do. Gall-Peters is equal-area, so a square kilometre receives the same amount of map space wherever it lies.[2][3] That fixes the relative-area problem directly, while the cost appears in shape.

The political history of Gall-Peters had already been running for decades, but the design lesson exposed in Boston was simpler. Equal area solved the continental-size problem decisively while creating a conspicuous shape and familiarity problem for many readers.

The quarrel became a warning about what happens when a world-map problem is reduced to two options. Mercator protected properties useful for navigation at the cost of relative area; Gall-Peters protected area at the cost of conspicuous shape distortion. The design space was much larger than either choice.

Three cartographers watching the Boston debate thought there should be another answer. Tom Patterson, Bojan Šavrič and Bernhard Jenny wanted a general-purpose world map that preserved area without producing the elongated forms that made Gall-Peters so difficult for many readers to accept. Their design problem had two parts: area had to be correct, but the continents also needed to look balanced and familiar enough that ordinary map readers might actually want to use the result.

The visual requirement places Equal Earth inside a much older tradition of projection design. Arthur Robinson had faced a related problem in the early 1960s when Rand McNally asked him to create a projection for general world maps. Robinson did not begin by selecting one mathematical property to preserve exactly. He began with appearance, sketching the kind of world he wanted to see and then building the numerical scheme needed to produce it.

The Robinson projection, introduced in 1963, is neither equal-area nor conformal.[4] It is a compromise. High latitudes are enlarged, but far less than on Mercator. Shapes remain broadly familiar. The curved sides and shortened polar lines give the map a rounded appearance rather than a hard rectangular frame.

Robinson's idea was that a general reference map might be better if it looked moderately wrong in several ways rather than disastrously wrong in one.

After using Van der Grinten for its signature world maps until 1988, National Geographic adopted Robinson.[5] It first published a Winkel Tripel world map as a National Geographic Magazine supplement in April 1995. The favourable response helped lead to a later decision, implemented in 1998, to replace Robinson with Winkel Tripel as the projection for its standard world maps.

The sequence shows that even a major institutional world map can change when its designers reach a different judgement about the best compromise.

Winkel Tripel, devised by Oswald Winkel in 1921, is another compromise projection. It does not preserve area exactly and it does not preserve local angles exactly. Its appeal lies in reducing several forms of overall distortion at once. The word tripel refers to that threefold balancing ambition, usually described in terms of area, direction and distance.

For a general reference map, compromise can be a design virtue; for a thematic map comparing land area, it may be the wrong choice. That was the tension Patterson, Šavrič and Jenny were trying to resolve. They wanted an equal-area map whose overall appearance borrowed some of the visual moderation that made compromise projections popular.[6]

Equal Earth emerged from that search. The designers experimented with existing equal-area projection forms and adjusted the mathematics until they reached a shape they considered both tech-

nically sound and visually persuasive. The finished projection has straight horizontal parallels, curved meridians and relatively short polar lines. Africa retains its correct area relationship without the extreme vertical stretching seen in Gall-Peters. The edges curve inward, so the world looks recognisably like a modern compromise map while preserving area exactly.

Equal Earth did not discover equal-area mapping. Cartographers had been designing equal-area projections for centuries, including Mollweide, Eckert IV and Goode's interrupted homolosine. Its innovation was a particular aesthetic solution to the old problem: keep true relative area while making the result easier for general audiences to accept.



Figure 20.2. Jean Cossin's cosmographical world map, 1570. Equal Earth belongs to a much older history of cartographers searching for visually persuasive ways to flatten the world while accepting different distortions. Bibliothèque nationale de France / Gallica. Public domain.

The projection appeared publicly in 2018 and moved into software unusually quickly. NASA's G.Projector added it. PROJ implemented it. Major GIS systems and web-rendering tools followed.

That rapid adoption separated Equal Earth from many mathematically interesting projections that remained specialist curiosities. It moved quickly from paper into open-source libraries, desktop GIS and web rendering, and a Greenwich-centred WGS 84 implementation later entered the EPSG dataset as EPSG:8857. For the design story, the important point is simple: Equal Earth was deployable rather than merely theoretical.

The word Greenwich in that name matters because it is one registered orientation, not a requirement of Equal Earth itself. The EPSG registry also defines EPSG:8858, centred on 90 degrees west for the Americas, and EPSG:8859, centred on 150 degrees east for Asia-Pacific. PROJ permits other central meridians as well, but those custom definitions are not automatically one of the registered CRSs.[7]

For New Zealand, EPSG:8859 changes the practical conclusion. A Pacific-facing Equal Earth does not require an improvised custom definition. The registered Asia-Pacific variant places Aotearoa, Australia and much of the island Pacific within a continuous regional view while preserving the equal-area property. The Atlantic takes the seam.

Projection is therefore only part of world-map design. Two maps can preserve the same mathematical property and still tell different visual stories because they use different centres, seams, labels or orientations.

The designers of Equal Earth were also interested in what readers actually preferred. Earlier preference studies involving Šavrič and colleagues found no universal visual winner. Familiar compromise projections such as Robinson performed well, as did several other designs. Mercator was less preferred by trained cartographers, but reader preference varied.[8]

A technically appropriate map can fail socially if readers reject its appearance. Visual acceptance therefore belongs inside the design problem without becoming the only criterion.

Gall-Peters demonstrated the cost of ignoring that problem. Its area property is excellent for the task. Its shape distortion is so visually assertive that discussion often shifts from the area relationship to whether the continents look strange. Equal Earth was designed to preserve the same key property while reducing that distraction.

The contrast among these projections is really a contrast among priorities. Mercator began with navigation and accepted high-latitude area distortion to preserve local angles; Robinson distributed distortion to create a balanced general reference map; Winkel Tripel pursued a compromise among several global errors; Gall-Peters made area non-negotiable and accepted conspicuous shape distortion; Equal Earth also made area non-negotiable but treated appearance as a second design objective rather than an afterthought.

Each projection records a set of priorities. Even compromise is a choice about which errors are acceptable and where.

The modern digital world makes those choices more flexible than they were in Robinson's day. A printed atlas page commits to one projection. A digital renderer can support several. A globe can appear at small scale. A Pacific-centred view can be offered alongside a Greenwich-centred one. A local application can use a national projection without changing the world overview.

Software can now support more than one world-map answer.[9]

Equal Earth is a strong option when a general world map needs to preserve relative area; specialist polar, engineering, navigational and interactive tasks can continue to use other systems.

By the time Equal Earth acquired a political role, the design and much of the technical implementation were already in place. The

design story therefore ends with an available alternative and the institutional story begins with a different question: what happens when governments decide that alternative should change public practice?

CHAPTER 21

THE WORLD, REDRAWN

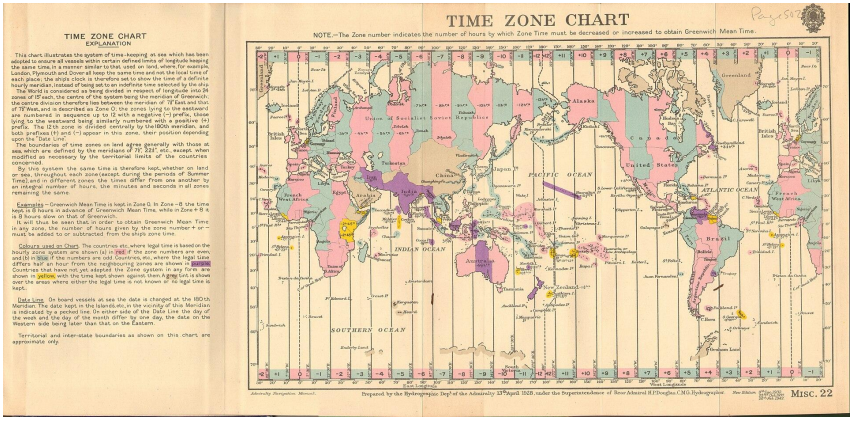


Figure 21.1. Time Zone Chart of the World, first published in 1928 and reproduced in a 1942 edition. A once-new international convention became ordinary infrastructure. United Kingdom Hydrographic Office. Public domain.

On the morning after the vote, Google Maps still worked. Ships still navigated. GIS analysts still opened projects whose layers were labelled 4326, 3857 and 2193, and EPSG:8857 meant exactly what it had meant the day before. The Earth had not acquired a new shape overnight. Yet something had changed.

On Friday 4 September 2026, the United Nations General Assembly's 114th plenary meeting took action on draft resolution A/80/L.104, "Correct the Map: Rebalancing global cartographic representation and promoting equitable representation of the world's regions, particularly Africa." Togo presented the initiative on behalf of the African Group. The vote was 164 in favour, one against and six abstentions. The United States cast the sole vote

against; Estonia, Georgia, Lithuania, the Republic of Moldova, Serbia and Ukraine abstained.[1] The adopted text became General Assembly resolution A/RES/80/307.[2]

That was an overwhelming political endorsement of an argument that, about seventeen months earlier, had largely belonged to campaigners, cartographers and African institutions.[3] It belonged to the political layer of mapping, not to a global software update. Projection invention, software support, standards registration, government endorsement and implementation are different events, and the 2026 vote did not make them happen at once.

Public discussion after the vote often compressed those layers into one dramatic sentence: the United Nations had replaced Mercator with Equal Earth. The resolution was more limited. It encouraged governments, schools, international organisations and technology companies to use Equal Earth and other equal-area maps when relative size matters, and to teach the limitations of flat maps. It neither prohibited Mercator nor changed navigational charts, national coordinate systems, web-tile infrastructure or the status of other EPSG-defined systems.

Togo's own diplomatic framing had been more careful than the headlines. The initiative was presented as a challenge to inherited defaults and a call for more appropriate cartographic representation, not as a claim that one projection should serve every conceivable map.

The African Union had already taken a stronger internal step. At its thirty-ninth ordinary session on 14–15 February 2026, Assembly/AU/Dec.959(XXXIX) adopted Equal Earth and urged Member States to revise national curricula accordingly.[4] The same decision provided for a champion and annual implementation reporting through collaboration with the African Union Commission. Its wider language linked the initiative to historical justice and colo-

nial cartography, claims that belong to the AU's political framing rather than to projection mathematics.

By June, implementation had moved beyond discussion. The African Union Commission said it had established an interdepartmental working group to coordinate rollout and, with Togo, would convene a continental workshop to develop an implementation roadmap involving Member States, educators, geospatial specialists, media, civil society and other partners.[5] It said engagement with technology companies, mapping providers, publishers and educational institutions was already under way. After the UN vote, Commission chairperson Mahmoud Ali Youssouf encouraged international institutions, educational systems, publishers and digital platforms to progressively promote cartographic representations that better reflect actual land areas. The word progressively matters.

A map can be changed in seconds; a mapping culture cannot. A school ministry replacing a Mercator wall map immediately faces further choices: which equal-area projection to use, where to centre the world, whether navigation lessons should still show Mercator, whether Antarctica needs a polar view, whether a digital atlas should change projection with scale, and whether students should see several projections side by side so the trade-offs are explicit. If the old map is removed without explaining why, one invisible default may simply be replaced by another.

France offered a useful example of a more purpose-driven response. On 4 September, its foreign ministry announced that it would abandon Mercator in its diplomatic uses in favour of cartographic representations adapted to purpose and more faithful to actual areas.[6] The official announcement did not frame the decision as allegiance to one mandatory replacement. It framed the change around use.

That purpose-driven language is consistent with professional cartographic guidance. The International Cartographic Associa-

tion has stressed that no single flat world projection is correct for all purposes, that equal-area projections are appropriate when area matters, and that Mercator is a poor default for global area comparison. The political significance of the UN vote did not depend on Equal Earth being perfect; it lay in making an inherited convention negotiable.

Equal Earth entered the political debate with the technical groundwork already in place. Šavrič, Patterson and Jenny published it in 2018; software support followed; and the EPSG dataset registered the Greenwich-centred WGS 84 implementation as EPSG:8857 before the 2026 vote.[7] That chronology matters because EPSG registration, political endorsement and implementation are different layers of the mapping system.[8]

The vote did not trigger an immediate technical migration. Two days later, major mapping platforms were still operating on their existing architectures, with Web Mercator deeply embedded in tile pyramids, caches, APIs, libraries and applications.[9] Political endorsement had changed faster than infrastructure.

Modern mapping increasingly allows the display projection to change without forcing every underlying data system to change with it. A platform can offer a globe or an Equal Earth overview while retaining existing coordinate and tile infrastructure in other layers. A national agency can use a specialist projected CRS for engineering and an equal-area projection for a world graphic. A map service can transform data between systems automatically.

The modern map is already plural, and the political debate is catching up with that technical reality. A public world graphic can change projection without requiring national engineering, Antarctic mapping or existing web services to adopt the same system. The vote concerned the general world map, not every map.

There was never one universal world map to replace. Even the United Nations had long used multiple projections for different

products. The Secretariat's geospatial guidance described a variety of world-map choices rather than one mandated Mercator default. The political slogan was simpler than the institution's actual cartographic practice.

The institutional chain was now visible: African Union bodies had adopted the issue, Togo had carried it into the General Assembly, a large majority of governments supported the resolution, France announced an immediate diplomatic-policy response, and the AU called for progressive implementation across education, publishing and digital platforms.[10] That was consequential even though the world's map interfaces looked almost identical the next morning.

Defaults are powerful partly because they require no explanation. For decades, a general world map could use Mercator-like proportions because the template was already there, the audience recognised it or the software defaulted to it. After 4 September 2026, that choice became easier to question: if the purpose is comparing countries and continents, why use a projection that badly distorts their relative areas? The answer can no longer simply be that this is what a world map looks like. The vote changed the burden of explanation.

This is a quieter change than the headline "UN changes world map", but it may last longer. School publishers revise slowly, government templates persist, newsrooms inherit graphics and software defaults survive because users expect them. Reform will therefore be uneven: some institutions will adopt Equal Earth, others will choose another equal-area projection, some will use several projections, and some will barely change at all. Like other infrastructure, mapping standards spread through adoption, compatibility, education and habit rather than decree alone.

By 2026, the technical choices beneath world maps were already layered through navigation, standards, software and specialist prac-

tice. The General Assembly vote did something different: it made one familiar default openly negotiable.

On 4 September 2026, the General Assembly supplied an answer to a question that had been accumulating for centuries: can a technical convention become a political issue simply because people decide the default no longer serves them? Yes. The next morning the geometry was unchanged, but the assumption that the familiar picture required no defence had weakened. The final task is not to crown a permanent new map of the world. It is to decide more consciously which distortion belongs to which job.

EPILOGUE

CHOOSE YOUR DISTORTION

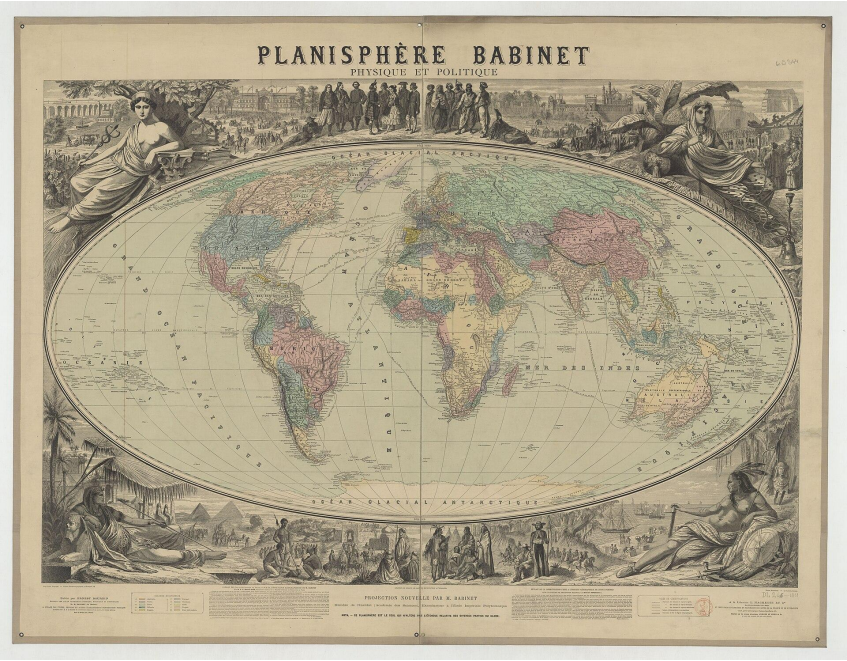


Figure E.1. Planisphère Babinet, 1864, a wall map on the Mollweide/Babinet equal-area projection. Its elaborate nineteenth-century design shows that arguments over how to flatten the world long predate today's projection debates. Jacques Babinet; Bibliothèque nationale de France (Gallica). Public domain.

The next time a world map appears in front of you, resist the first temptation to decide whether it is right or wrong. Ask a more useful question: what is this map trying to do?

That question changes how the map should be judged. A flat map cannot carry every property of the curved Earth onto a page

or screen intact. It protects some relationships and damages others. The useful test is therefore not whether distortion exists, but whether the distortion suits the job.[1] A map that is excellent for one purpose may be poor for another without either judgement being contradictory.

The phrase that has run beneath this book can now be stated in full: Accurate for what purpose? If the map asks the reader to compare the size of countries or continents, relative area matters. If it asks about a route, the geometry of distance or direction matters.[2] If it shows a polar region, the way the pole is represented matters. If it is a local engineering map, the requirements are different again. The map should be judged against the task it has been given.

That habit makes criticism more precise. Instead of stopping at the familiar claim that every projection distorts, ask what property has been preserved and what has been sacrificed to preserve it. Look at the parts of the map where the distortion becomes most visible. Check whether the projection is appropriate to the comparison the map is encouraging you to make. A world map can look familiar and still be badly matched to its purpose. It can look unfamiliar and still be technically appropriate.

Projection is only one layer of the choice. Ask where the map is centred and where it is cut. The centre determines what the reader meets first. The seam determines what is divided, pushed to the edges or made awkward for software and the eye. For readers in Aotearoa New Zealand and across the Pacific, that question is especially revealing because a region that so often appears at the edge of one conventional world view can move towards the middle simply by changing the frame. Nothing about the planet has moved. The audience has.

Then ask what the map leaves out. Every map omits more than it shows. A political map may hide topography. A climate map may simplify borders. A military map may make infrastructure promi-

nent and everyday life almost invisible. A data dashboard may display countries as clean polygons while concealing uncertainty, disputed boundaries or gaps in the underlying data. Omission is not automatically a flaw. It becomes a problem when the reader mistakes selection for completeness.

The same discipline applies to authority. Who selected the projection, the centre, the labels, the boundary lines, the categories and the data? Was the choice made by a cartographer, a software library, a government agency, a publisher, a teacher, a campaigner or an inherited template that nobody recently reconsidered? The answer does not tell you whether the map is good or bad, but it tells you where to look for the reasoning behind it.

Defaults deserve particular attention because they often arrive without an argument. A projection can become familiar through repetition, software support, institutional habit and accumulated infrastructure. Once it is familiar, its choices become harder to see. The most useful response is not to assume that every inherited standard is suspect. It is to ask whether the reasons that once made it useful still match the present task.

This is also where evidence matters. Maps can affect what people notice, remember and infer, but those effects should not be asserted more strongly than research allows. If somebody claims that a projection changes political beliefs, produces a particular bias or causes a policy choice, the psychological step needs evidence of its own. Mathematical distortion can be measured directly. Human interpretation has to be tested.

That distinction prevents the debate from collapsing into moral labels. A projection can be overused without being a villain, and another can be valuable without being perfect. Cartographic, historical and psychological claims should each carry the evidence appropriate to them.

Seen this way, a map is less like a verdict and more like a tool with a specification. The reader's job is not to demand that one representation solve every problem. It is to understand what the tool was designed to protect, what it gives up and whether those choices are visible enough for the task at hand.

Digital mapping makes those choices more flexible because a screen can change representation with scale, location and purpose.[3] That flexibility increases the responsibility to reveal enough of the method for the user to understand what has changed. Sometimes a projection label is enough; sometimes the map needs a note about scale or uncertainty, or a comparison that makes the trade-off visible.

There is a simple reading habit that helps with almost every world map: look at the centre, then look at the edge. The centre tells you what has been given prominence. The edge often reveals the machinery. It is where the seam appears, where regions are divided, where longitude wraps, where polar limits become obvious and where the chosen frame stops pretending to be the whole Earth.

Then return to the map's purpose. Does the property it preserves match the question being asked? Does the distortion matter to the message? Does the map's framing make one comparison easier while making another harder? What has been omitted? Who chose the design? What evidence supports any claim about how viewers respond to it? These questions do not make map reading cumbersome. With practice, they become as ordinary as checking the scale bar or reading the legend.

Five centuries of projection history do not end with one generation discovering the correct flat world map. They show how a familiar representation can accumulate technical, cultural and political authority without becoming inevitable. The useful outcome is not to replace one unquestioned picture with another, but to make readers more capable of seeing what a map asks them to accept.

Once the choices are visible, disagreement can move from slogans to properties, purposes and evidence.

So the final habit is not a preference for one projection. It is a sequence of questions. What is this map for? What does it preserve? What does it distort? What does it omit? Where are the centre and the seam?[4] Who selected those choices? What evidence supports any claim about how the map affects the people who see it?

A map that answers those questions well does not need to be perfect. It needs to be fit for purpose and honest enough about its compromises.

Distortion is unavoidable. The choice of distortion is not. Once you can see the choice, the world map becomes more informative, not less trustworthy.

ENDNOTES

PROLOGUE

THE DAY THE WORLD MAP CHANGED

1. The date, 114th plenary meeting, agenda context and draft symbol A/80/L.104 are controlled by the official General Assembly schedule and draft text. Sources: United Nations, "80th General Assembly schedule - 114th plenary meeting"; United Nations General Assembly, "A/80/L.104 - Correct the map".

2. The African Union's backing predates the UN vote; Assembly/AU/Dec.959(XXXIX) adopted Equal Earth for the AU initiative and urged curriculum revision. Sources: African Union Assembly, "Decision on 'Correcting the Map of Africa on the Globe'".

3. Equal Earth was introduced in 2018 by Bojan Šavrič, Tom Patterson and Bernhard Jenny as an equal-area pseudocylindrical world projection. Sources: Bojan Šavrič; Tom Patterson; Bernhard Jenny, "The Equal Earth map projection".

4. EPSG:8857 is WGS 84 / Equal Earth Greenwich and predates the 2026 political endorsement. Sources: EPSG / IOGP, "WGS 84 / Equal Earth Greenwich - EPSG:8857".

5. The 164–1–6 vote, the United States as the sole vote against, the six abstentions and Togo's presentation on behalf of the African Group are recorded in official UN meeting coverage. Sources: United Nations Meetings Coverage and Press Releases, "General Assembly Adopts 'Correct the Map' Resolution at 114th Plenary Meeting".

6. The adopted resolution symbol is A/RES/80/307. Sources: United Nations General Assembly, "Correct the map: rebalancing global cartographic representation and promoting equitable representation of the world's regions, particularly Africa".

7. The resolution is non-binding and encourages equal-area representations, especially where comparative area matters; it does not ban Mercator or compel a universal technical migration. Sources: United Nations General Assembly, "A/80/L.104 - Correct the map"; United Nations General Assembly, "Correct the map: rebalancing global cartographic representation and promoting equitable representation of the world's regions, particularly Africa".

8. The AU's immediate post-vote statement explicitly called for progressive uptake, reinforcing the distinction between political endorsement and completed imple-

mentation. Sources: African Union Commission, “Communiqué of the Chairperson on the adoption of the Correct the Map resolution”.

9. Mercator’s 1569 wall map and its explicit navigational purpose are supported by the BnF catalogue and modern historical reconstruction; the rhumb-line and scale-growth explanation is technical rather than political. Sources: Gerardus Mercator, “Nova et aucta orbis terrae descriptio ad usum navigantium emendate accomodata”; Joaquim Alves Gaspar; Henrique Leitão, “Squaring the Circle: How Mercator Constructed His Projection in 1569”; PROJ contributors, “Mercator - PROJ documentation”.

CHAPTER 1

THE IMPOSSIBLE MAP

1. The general projection trade-off discussion follows standard cartographic treatment: no flat world map preserves area, angle, distance, direction and shape everywhere at once. Sources: John P. Snyder, “Map Projections: A Working Manual”; Michael T. Gastner; Krisztián Kerkovits, “Choosing World Map Projections: When Equal-Area Is Appropriate (and Why There Is No Single “Correct” Projection)”.

2. Harry Beck’s diagrammatic Underground map was introduced in 1933 and deliberately prioritised network legibility over geographic distance. Sources: Transport for London, “Harry Beck’s Tube map”.

3. Equal-area projections preserve relative area, conformal projections preserve local angles, and compromise projections distribute rather than eliminate distortion. Sources: John P. Snyder, “Map Projections: A Working Manual”; U.S. Geological Survey Educational Resources, “Map Projections educational PDF”.

4. Tissot’s indicatrix is the diagnostic device used here to explain local angular and area distortion. Sources: Aileen Buckley, “Tissot’s indicatrix helps illustrate map projection distortion”; John P. Snyder, “Map Projections: A Working Manual”.

5. Gauss’s 1827 work on curved surfaces supplies the mathematical background for the claim that intrinsic curvature cannot be transferred unchanged from a sphere to a plane. Sources: Carl Friedrich Gauss, “General Investigations of Curved Surfaces of 1827 and 1825”.

6. Sources: Gerardus Mercator, “Nova et aucta orbis terrae descriptio ad usum navigantium emendate accomodata”; PROJ contributors, “Mercator - PROJ documentation”.

CHAPTER 2

THE SAILOR'S MAP

1. The 1569 Nova et aucta orbis terrae descriptio was an eighteen-sheet wall map published at Duisburg in August 1569; surviving copies vary slightly in assembled dimensions. Sources: Gerardus Mercator, "Nova et aucta orbis terrae descriptio ad usum navigantium emendate accomodata".

2. Mercator's title explicitly identifies navigation as the intended use of the map. Sources: Gerardus Mercator, "Nova et aucta orbis terrae descriptio ad usum navigantium emendate accomodata".

3. A rhumb line is a path of constant bearing and appears as a straight line on the Mercator projection; great-circle routes are generally shorter over long distances. Sources: PROJ contributors, "Mercator - PROJ documentation"; John P. Snyder, "Map Projections: A Working Manual".

4. Mercator is conformal: local linear scale increases with latitude. The secant-latitude examples are spherical approximations, not country-wide inflation factors. Sources: PROJ contributors, "Mercator - PROJ documentation"; John P. Snyder, "Map Projections: A Working Manual".

5. A true Mercator projection cannot represent the poles at finite projected coordinates. Sources: PROJ contributors, "Mercator - PROJ documentation".

6. Gaspar and Leitão reconstruct how Mercator could have constructed the 1569 projection with sixteenth-century mathematical and practical methods, avoiding anachronistic assumptions about modern formulas. Sources: Joaquim Alves Gaspar; Henrique Leitão, "Squaring the Circle: How Mercator Constructed His Projection in 1569".

7. Evidence for nautical adoption after 1569 shows a slower and more complicated process rather than instant universal uptake. Sources: Joaquim Alves Gaspar; Henrique Leitão, "Squaring the Circle: How Mercator Constructed His Projection in 1569"; Mark Monmonier, "Rhumb Lines and Map Wars: A Social History of the Mercator Projection".

8. Gerardus Mercator's 1569 map, later Mercator projection practice and modern Web/Pseudo-Mercator are related but distinct historical and technical objects. Sources: Gerardus Mercator, "Nova et aucta orbis terrae descriptio ad usum navigantium emendate accomodata"; EPSG / IOGP, "WGS 84 / Pseudo-Mercator - EPSG:3857"; PROJ contributors, "Web Mercator / Pseudo Mercator - PROJ documentation".

CHAPTER 3

WHEN THE USEFUL MAP BECAME THE WORLD

1. An 1871 Wellington bookseller advertisement offered both hemisphere maps and world maps on Mercator's projection, evidence that Mercator was one format among several in the New Zealand market. Sources: Bookseller advertisement, "1871 New Zealand bookseller advertisement listing school maps including 'Maps of the World, or Mercator's Projection'".

2. Historical Mercator world maps from the eighteenth and nineteenth centuries document the projection's broader atlas and display afterlife. Sources: Robert Morden; William Berry, "To Capt. John Wood this map of the world, drawn according to Mercators projection"; John Melish; Samuel Harrison; Hugh Bridport; George Murray, "The world on Mercator's projection"; A & C Black, "The World, on Mercator's Projection"; Unknown manuscript cartographer, "Map of the world on the Mercator projection".

3. Awanui Native School equipment records in 1876 included a Mercator world map. Sources: New Zealand education inspecting officers, "Native Schools inspection reports: Awanui School equipment included World on Mercator's projection".

4. In 1877 a Native Schools inspector wrote that the Mercator world map was "not suited to the school" and requested a Pacific map. Source: New Zealand education inspecting officer, "Native Schools report: inspector says the Mercator world map 'is not suited to the school'".

5. The 1879 Waihou School inspection recorded "Mercator's World (bad)" and requested hemisphere maps; other Native School inspections record Mercator maps alongside regional and hemisphere maps. Sources: New Zealand education inspecting officer, "Waihou School inspection: 'Mercator's World (bad)' and hemisphere maps requested"; New Zealand education inspecting officers, "Native Schools inspection report listing Mercator maps at Taumarere, Te Ti and other schools".

6. Teacher examinations in 1880, 1886 and 1888 required knowledge of Mercator's projection, its construction or its characteristic advantages and defects. Sources: New Zealand Department of Education, "New Zealand teacher examination, Class D Geography: explain Mercator projection advantages and disadvantages"; New Zealand Department of Education, "New Zealand teacher examination, Class D Geography: explain how flat maps represent Earth and the nature of Mercator projection"; New Zealand Department of Education, "New Zealand teacher examination: principle, advantages and characteristic defects of Mercator projection".

7. An 1890 exhibition report described a Māori pupil's hand-drawn world map on Mercator's projection. Source: Evening Star reporter, "1890 exhibition report

on map drawing by Native school pupils, including a world map on Mercator's projection".

CHAPTER 4

WHO GETS THE MIDDLE?

1. The 1884 International Meridian Conference proceedings are the primary source for the shipping-use table, delegate arguments and formal resolutions. Sources: International Meridian Conference, "International Conference Held at Washington for the Purpose of Fixing a Prime Meridian and a Universal Day - Protocols".

2. Greenwich's prior practical prevalence in navigation is reflected in the conference shipping table and provided an important political and technical advantage. Sources: International Meridian Conference, "International Conference Held at Washington for the Purpose of Fixing a Prime Meridian and a Universal Day - Protocols"; Royal Observatory Greenwich historical project, "The adoption of a Prime Meridian and the International Meridian Conference of 1884".

3. French and other delegates proposed alternatives, including neutral-meridian ideas; the proceedings demonstrate that the choice was negotiated. Sources: International Meridian Conference, "International Conference Held at Washington for the Purpose of Fixing a Prime Meridian and a Universal Day - Protocols".

4. The session record on 13 October shows 21 votes for Greenwich, San Domingo against, with Brazil and France abstaining. Sources: International Meridian Conference, "International Conference Held at Washington for the Purpose of Fixing a Prime Meridian and a Universal Day - Protocols".

5. The Final Act adopted on 22 October records the Greenwich resolution as 22–1–2, with Salvador included among the affirmative states; this differs from the earlier roll-call record. Sources: International Meridian Conference, "International Conference Held at Washington for the Purpose of Fixing a Prime Meridian and a Universal Day - Protocols"; International Meridian Conference, "International Conference Held at Washington for the Purpose of Fixing a Prime Meridian and a Universal Day".

6. A prime meridian is a geographic longitude reference; it is not the same concept as the central meridian chosen for a particular projected map. Sources: PROJ contributors, "Equal Earth - PROJ documentation"; PROJ contributors, "Cartographic projection - PROJ longitude wrapping and prime meridian documentation".

7. EPSG:8857 is specifically Greenwich-centred. An Equal Earth map can use a different central meridian without thereby becoming another EPSG:8857 instance. Sources: EPSG / IOGP, "WGS 84 / Equal Earth Greenwich - EPSG:8857"; PROJ contributors, "Equal Earth - PROJ documentation".

CHAPTER 5

DRAW A LINE, CLAIM A WORLD

1. British Museum kudurru objects support the opening discussion of Mesopotamian boundary records and the ambition to make land grants and limits durable. Sources: Babylonian state / British Museum, "Kassite kudurru recording land transfer and boundaries"; Babylonian state / British Museum, "Kudurru of Marduk-nadin-ahhe".

2. The Treaty of Tordesillas was signed on 7 June 1494 and specified a pole-to-pole line 370 leagues west of the Cape Verde islands; practical placement remained difficult. Sources: Crowns of Castile/Aragon and Portugal / UNESCO, "Treaty of Tordesillas".

3. The treaty's line allocated European imperial claims over territories that were incompletely mapped by the signatories and inhabited by peoples outside the agreement. Sources: Crowns of Castile/Aragon and Portugal / UNESCO, "Treaty of Tordesillas".

4. Article V of the Treaty of Guadalupe Hidalgo referred to John Disturnell's 1847 map and required commissioners and surveyors to run and mark the boundary. Sources: United States and Mexico / U.S. National Archives, "Treaty of Guadalupe Hidalgo (1848)".

5. The Agreement → Map → Survey → Monument → Administration sequence is a synthesis of the treaty's textual, cartographic and field-survey machinery. Sources: United States and Mexico / U.S. National Archives, "Treaty of Guadalupe Hidalgo (1848)".

6. In the Burkina Faso/Mali frontier case, the International Court of Justice treated maps in ordinary circumstances as information/evidence rather than territorial title in themselves. Sources: International Court of Justice, "Frontier Dispute (Burkina Faso/Republic of Mali), Judgment of 22 December 1986".

7. Dayton Annex 2 gave mapped Inter-Entity Boundary material a controlling role; the 1:50,000 mapped line was accepted as controlling and definitive for implementation. Sources: Bosnia and Herzegovina parties, "General Framework Agreement for Peace in Bosnia and Herzegovina, Annex 2: Agreement on Inter-Entity Boundary Line and Related Issues".

CHAPTER 6

SURVEY AFTER CONQUEST

1. The Native Land Court's role in converting customary interests into titles recognised by colonial law is supported by Te Ara's institutional history. Sources: New Zealand History, "Native Land Court created".

2. The 1840 Te Aro comparison is supported by Te Ara's account that Māori pulled up survey pegs after New Zealand Company surveyors began marking a town site on land they said had not been sold. Sources: Te Ara - The Encyclopedia of New Zealand, "Māori and maps of colonisation".

3. The abolition of the provinces in 1876 led to a central Department of the Surveyor-General and a more unified national surveying framework under John Turnbull Thomson. Sources: Te Ara - The Encyclopedia of New Zealand, "Government surveying and mapping, 1870–1900".

4. Survey requirements and survey costs were integral to Native Land Court processes; Te Ara records cases where survey costs consumed roughly 20 per cent or more of a block's value. Sources: Te Ara - The Encyclopedia of New Zealand, "Surveying and other costs, 1880–1900".

5. Sources: Te Ara - The Encyclopedia of New Zealand, "Surveying and other costs, 1880–1900".

6. Sources: Crown and Taranaki Iwi, "Taranaki Iwi Deed of Settlement"; Te Kotahitanga o Te Āti Awa, "Parihaka historical material".

7. The distinction between technical precision and political authority is analytical: accurate measurement does not itself decide whether the legal or political order being implemented is legitimate. Source: J. B. Harley, "Deconstructing the Map".

8. The source balance for the Waimate Plain is strengthened by the Taranaki Iwi Deed of Settlement and Te Kotahitanga o Te Āti Awa material concerning promised reserves, cultivations, burial places and peaceful eviction of surveyors. Sources: Crown and Taranaki Iwi, "Taranaki Iwi Deed of Settlement"; Te Kotahitanga o Te Āti Awa, "Parihaka historical material".

9. Government survey activity on the Waimate Plain in 1879, peg removal, ploughing and fencing by Parihaka followers, and the wider non-violent resistance chronology are supported by New Zealand public-history sources. Sources: New Zealand History, "Parihaka ploughing campaign begins".

10. The 5 November 1881 invasion/entry into Parihaka, arrests of Te Whiti-o-Rongomai and Tohu Kākahi, and state suppression are part of the established Parihaka chronology. Source: New Zealand History, "Parihaka ploughing campaign begins".

CHAPTER 7

MAPS WORTH STEALING

1. The Cantino Planisphere dates to 1502 and is associated with Alberto Cantino's acquisition of privileged Portuguese geographic information for Ercole I d'Este. Sources: Portuguese state cartography, copied for Alberto Cantino, "Cantino Planisphere".

2. Portuguese secrecy around nautical and cartographic information provides the institutional context for the Cantino episode; the exact bribery mechanics remain attributed rather than eyewitness evidence. Source: Portuguese state cartography, copied for Alberto Cantino, "Cantino Planisphere".

3. Institutional and curatorial accounts support the surviving narrative of Cantino's acquisition and the map's later history. Source: Portuguese state cartography, copied for Alberto Cantino, "Cantino Planisphere".

4. Alexander J. Kent's peer-reviewed study of the Soviet 1:10,000 plan of Dover supports the 1972 compilation, 1974 printing, strategic-object detail and discussion of errors/inherited information. Sources: Alexander J. Kent, "The Soviet Military 1:10,000 City Plan of Dover, UK (1974)".

5. The Soviet Dover material shows that highly detailed military mapping could contain both extraordinary intelligence value and mistakes. Sources: Alexander J. Kent, "The Soviet Military 1:10,000 City Plan of Dover, UK (1974)".

6. The post-Soviet commercial circulation of formerly secret Soviet military maps is part of the documented afterlife of that mapping programme. Sources: Alexander J. Kent, "The Soviet Military 1:10,000 City Plan of Dover, UK (1974)".

CHAPTER 8

THE MAP GOES TO WAR

1. The 1:1,800 scale means one centimetre on the map represents eighteen metres on the ground. Source: New Zealand Expeditionary Force / Auckland Libraries, "ANZAC New Zealand Division trench plans at Gallipoli".

2. The Auckland Libraries NZEF trench plan of the Apex on Rhododendron Spur is a 1915 sheet at 1:1,800, about 41 × 56 cm. Source: New Zealand Expeditionary Force / Auckland Libraries, "ANZAC New Zealand Division trench plans at Gallipoli".

3. Lieutenant-Colonel William Malone was killed by an Allied shell at about 5 p.m.; the source does not securely identify a particular firing battery. Source: Manatū Taonga / New Zealand History, "Wellington Battalion captures Chunuk Bair".

4. The Wellington Battalion occupied Chunuk Bair before dawn on 8 August 1915; by relief that evening only 70 of 760 men were still standing. Source: Manatū Taonga / New Zealand History, "Wellington Battalion captures Chunuk Bair".

5. The UK National Archives records production of about 34 million official British military maps for the Western Front and documents the scale hierarchy used for administration, artillery, trench work and local operations. Sources: British War Office / UK National Archives, "First World War trench-map grid system".

6. The relationship between wartime map scale and what becomes actionable is grounded in the documented military-map scale hierarchy. Sources: British War Office / UK National Archives, "First World War trench-map grid system"; New Zealand Expeditionary Force / Auckland Libraries, "ANZAC New Zealand Division trench plans at Gallipoli".

CHAPTER 9

THE LINE THAT SURVIVED THE WAR

1. The 30 November 1948 Jerusalem ceasefire-map episode involved Moshe Dayan and Abdullah el-Tell; the surviving map evidence is connected to Israel State Archives material reviewed by the Law Library of Congress. Sources: Ruth Levush, "International Law: November 30, 1948, Cease-Fire Agreement and Demarcation of No-Man's-Land in the Jerusalem Area"; United Nations, "Israel-Jordan General Armistice Agreement - Cablegram from UN Acting Mediator, Map (Green Line)".

2. The red and green grease-pencil strokes were 3–4 mm wide and could represent roughly 60–80 metres in the city; the current text does not rely on an unsupported exact map scale. Sources: Ruth Levush, "International Law: November 30, 1948, Cease-Fire Agreement and Demarcation of No-Man's-Land in the Jerusalem Area".

3. The Israel–Jordan General Armistice Agreement of 3 April 1949 defined armistice demarcation lines without prejudice to later territorial settlements or claims. Sources: United Nations, "Israel-Jordan General Armistice Agreement - Cablegram from UN Acting Mediator, Map (Green Line)".

4. The 1949 armistice lines became known as the Green Line and structured military and administrative geography without becoming, by that fact alone, a final sovereign boundary. Sources: United Nations, "Israel-Jordan General Armistice Agreement - Cablegram from UN Acting Mediator, Map (Green Line)".

5. The Korean Armistice Agreement of 27 July 1953 established the Military Demarcation Line, required two-kilometre withdrawals by each side and thereby created the roughly four-kilometre-wide DMZ. Sources: United Nations Command; Korean People's Army; Chinese People's Volunteers, "Korean War Armistice Agreement".

6. The armistice distinguishes the central Military Demarcation Line from the wider DMZ and is not itself a peace treaty. Sources: United Nations Command; Korean People's Army; Chinese People's Volunteers, "Korean War Armistice Agreement".

CHAPTER 10

FINDING YOURSELF ON EARTH

1. John Harrison's H4 was carried by William Harrison on the 1761 Jamaica trial; Royal Museums Greenwich provides the institutional account used for the voyage and Madeira-prediction episode. Sources: Royal Museums Greenwich, "Longitude found - the story of Harrison's timekeepers".

2. Longitude from time difference follows the Earth's approximately 360-degree rotation in twenty-four hours. Sources: John P. Snyder, "Map Projections: A Working Manual".

3. Institutional histories identify 1909 as the beginning of the national geodetic triangulation programme and 1949 as the completion and implementation era associated with NZGD49. Sources: National Library of New Zealand, "Surveying and the cadastre"; Toitū Te Whenua LINZ, "New Zealand Geodetic Datum 2000 (NZGD2000)".

4. LINZ records that NZGD1949 used the International 1924 ellipsoid, was static and accumulated regional distortions of up to about five metres relative to later geodetic needs. Sources: Toitū Te Whenua LINZ, "New Zealand Geodetic Datum 2000 (NZGD2000)"; Toitū Te Whenua LINZ, "Understanding datums and projections".

5. NZGD2000 was implemented in 1998, uses GRS80, aligns to ITRF96 at epoch 2000.0 and includes a deformation model. Source: Toitū Te Whenua LINZ, "New Zealand Geodetic Datum 2000 (NZGD2000)".

6. LINZ's dynamic-datum guidance supports the approximate five-centimetre-per-year tectonic-motion explanation. Source: Toitū Te Whenua LINZ, "New Zealand Geodetic Datum 2000 (NZGD2000)".

7. The post-Kaikōura deformation-model update produced horizontal coordinate changes of up to about six metres in the most affected areas. Source: Toitū Te Whenua LINZ, "New Zealand Geodetic Datum 2000 (NZGD2000)".

CHAPTER 11

FROM SECRET SATELLITES TO THE PHONE IN YOUR POCKET

1. CORONA/Discoverer XIV launched on 18 August 1960 and its film capsule was recovered on 19 August; the successful mission returned roughly 3,000 feet of film and extensive coverage of Soviet territory. Sources: National Reconnaissance Office, "CORONA".

2. CORONA's physical film-return system and mid-air recovery illustrate the pre-digital mechanics of satellite reconnaissance. Sources: National Reconnaissance Office, "CORONA".

3. The GPS development sequence distinguishes the military origins of satellite positioning from later civilian availability. Source: Ronald Reagan / White House, "Statement by Deputy Press Secretary Speakes on the Soviet Attack on a Korean Civilian Airliner".

4. The 1983 destruction of Korean Air Lines Flight 007 accelerated and formalised the U.S. commitment to make GPS available for international civil use when operational. Source: Ronald Reagan / White House, "Statement by Deputy Press Secretary Speakes on the Soviet Attack on a Korean Civilian Airliner".

5. Selective Availability was discontinued in May 2000, producing the familiar improvement in unaugmented civilian GPS accuracy. Sources: U.S. Government / GPS.gov, "Selective Availability".

6. A GNSS position, its datum/CRS, the projected basemap and the display projection are different layers; GPS does not itself determine which world map projection a screen uses. Sources: Toitū Te Whenua LINZ, "Understanding datums and projections"; Toitū Te Whenua LINZ, "Geospatial data types".

CHAPTER 12

THE SECRET NUMBERS BEHIND EVERY DIGITAL MAP

1. EPSG identifiers are database identifiers for coordinate reference systems and related objects, not versions or rankings of the Earth. Sources: EPSG / IOGP, "WGS 84 / Equal Earth Greenwich - EPSG:8857"; EPSG / IOGP, "WGS 84 / Pseudo-Mercator - EPSG:3857"; EPSG / IOGP, "WGS 84 - EPSG:4326"; EPSG / IOGP, "NZGD2000 / New Zealand Transverse Mercator 2000 - EPSG:2193".

2. EPSG:4326 is WGS 84, a geographic 2D CRS; its formal axis order is latitude then longitude even though many applications display or accept longitude-latitude conventions. Sources: EPSG / IOGP, "WGS 84 - EPSG:4326"; Toitū Te Whenua LINZ, "Axis ordering in LINZ web services".

3. Assigning a CRS tells software how existing numbers should be interpreted; transforming coordinates computes new numbers in another CRS. Sources: QGIS Project, "Working with Projections - QGIS 3.44 documentation"; QGIS Project, "Lesson: Reprojecting and Transforming Data".

4. EPSG:3857 is WGS 84 / Pseudo-Mercator, a projected CRS widely used for web mapping and visualisation. Sources: EPSG / IOGP, "WGS 84 / Pseudo-Mercator - EPSG:3857"; PROJ contributors, "Web Mercator / Pseudo Mercator - PROJ documentation".

5. EPSG:2193 is NZGD2000 / New Zealand Transverse Mercator 2000, a projected CRS used for New Zealand mapping. Sources: EPSG / IOGP, "NZGD2000 / New Zealand Transverse Mercator 2000 - EPSG:2193"; Toitū Te Whenua LINZ, "New Zealand Transverse Mercator 2000 (NZTM2000)".

6. EPSG:8857 is WGS 84 / Equal Earth Greenwich, a projected CRS for very-small-scale equal-area world mapping. Source: EPSG / IOGP, "WGS 84 / Equal Earth Greenwich - EPSG:8857".

7. EPSG:8857 is Greenwich-centred; EPSG:8858 is Americas-centred at 90 degrees west; and EPSG:8859 is Asia-Pacific-centred at 150 degrees east. Other central meridians can be defined without inheriting one of these identifiers. Sources: EPSG / IOGP, "WGS 84 / Equal Earth Greenwich - EPSG:8857"; EPSG / IOGP, "WGS 84 / Equal Earth Americas - EPSG:8858"; EPSG / IOGP, "WGS 84 / Equal Earth Asia-Pacific - EPSG:8859"; PROJ contributors, "Equal Earth - PROJ documentation".

CHAPTER 13

THE JOKE CODE THAT ATE THE WEB

1. Christopher Schmidt's 6 August 2007 post records the OpenLayers/community use of 900913 as a humorous GOOGLE-like identifier for the emerging web-map projection. Sources: OpenStreetMap contributors, "Web Mercator - history".

2. Google's tile-coordinate documentation supports the square tile-pyramid logic: one world tile at zoom zero and a doubling of the tile matrix along each axis at each zoom level. Source: Google, "Map and Tile Coordinates - Maps JavaScript API".

3. Web/Pseudo-Mercator differs from classic ellipsoidal Mercator and belongs to the engineering history of web mapping. Sources: EPSG / IOGP, "WGS 84 / Pseudo-Mercator - EPSG:3857"; PROJ contributors, "Web Mercator / Pseudo Mercator - PROJ documentation"; Sarah E. Battersby; Michael P. Finn; E. Lynn Usery; Kristina H. Yamamoto, "Implications of Web Mercator and Its Use in Online Mapping".

4. The practical Web Mercator world is clipped near ±85.0511 degrees to form a finite square tile extent. Sources: Google, "Map and Tile Coordinates - Maps JavaScript API"; EPSG / IOGP, "WGS 84 / Pseudo-Mercator - EPSG:3857".

5. 900913 was unofficial and was never an EPSG-issued code. Source: OpenStreetMap contributors, "Web Mercator - history".

6. The EPSG sequence moved through Popular Visualisation CRS / Mercator (EPSG:3785) before the modern EPSG:3857 identifier; the former was deprecated in 2009. Sources: OpenStreetMap contributors, "Web Mercator - history"; EPSG / IOGP, "WGS 84 / Pseudo-Mercator - EPSG:3857".

7. Compatibility, tile geometry and network effects help explain the persistence of Web Mercator as infrastructure. Sources: Sarah E. Battersby; Michael P. Finn; E. Lynn Usery; Kristina H. Yamamoto, "Implications of Web Mercator and Its Use in Online Mapping"; Toitū Te Whenua LINZ, "WGS 84 / Web Mercator tile scale set definition".

CHAPTER 14

WHERE THE DATABASE CUTS THE WORLD

1. RFC 7946 defines GeoJSON and supplies the Fiji antimeridian-crossing bounding-box example. Sources: Howard Butler et al., "RFC 7946 - The GeoJSON Format".

2. A known RFC erratum changes a corner-label description in the Fiji example. Source: Howard Butler et al., "RFC 7946 - The GeoJSON Format".

3. The bounding box [177.0, -20.0, -178.0, -16.0] is a compact five-degree antimeridian-crossing extent; interpreting the longitudes as an ordinary minimum-to-maximum interval gives the approximately 355-degree complement. Source: Howard Butler et al., "RFC 7946 - The GeoJSON Format".

4. RFC 7946 recommends cutting geometries at the antimeridian for interoperability. Source: Howard Butler et al., "RFC 7946 - The GeoJSON Format".

5. Longitude can also be represented in 0–360 form without changing the underlying datum; software wrapping and display seams are representation choices. Sources: GDAL contributors, "ogr2ogr - wrapdateline"; PROJ contributors, "Cartographic projection - PROJ longitude wrapping and prime meridian documentation".

6. The mathematical antimeridian at 180 degrees is distinct from the civil/political International Date Line, whose deviations respond to national and administrative choices. Sources: U.S. Naval Observatory, "The International Date Line"; Legislative Assembly of Samoa, "International Date Line Act 2011".

7. Samoa's 2011 legislation is an example of a state changing its civil date-line relationship without moving the geometric antimeridian. Source: Legislative Assembly of Samoa, "International Date Line Act 2011".

CHAPTER 15

THE PLACE THE WEB MAP CANNOT SHOW

1. Mercator cannot place the poles at finite coordinates; Web/Pseudo-Mercator therefore uses a practical latitude cutoff near ±85.0511 degrees for its square tiled world. Sources: EPSG / IOGP, "WGS 84 / Pseudo-Mercator - EPSG:3857"; PROJ contributors, "Web Mercator / Pseudo Mercator - PROJ documentation"; Google, "Map and Tile Coordinates - Maps JavaScript API".

2. The cutoff is a property of the coordinate/display system, not a natural or political boundary. Sources: EPSG / IOGP, "WGS 84 / Pseudo-Mercator - EPSG:3857".

3. EPSG:3031 is the official WGS 84 / Antarctic Polar Stereographic projected CRS definition. Source: EPSG / IOGP, "WGS 84 / Antarctic Polar Stereographic - EPSG:3031".

4. The British Antarctic Survey Antarctic Digital Database uses WGS 84 / Antarctic Polar Stereographic, EPSG:3031, for its datasets. Source: British Antarctic Survey / SCAR community, "Antarctic Digital Database".

5. Different Antarctic mapping tasks use different polar systems and parameters. Sources: EPSG / IOGP, "WGS 84 / Antarctic Polar Stereographic - EPSG:3031"; National Snow and Ice Data Center, "A Guide to NSIDC's Polar Stereographic Projection".

6. The polar example demonstrates why a projection appropriate to one global web-map architecture may be inappropriate for detailed polar work. Sources: British Antarctic Survey / SCAR community, "Antarctic Digital Database"; EPSG / IOGP, "WGS 84 / Antarctic Polar Stereographic - EPSG:3031".

CHAPTER 16

THE MAP WAS NEVER EMPTY

1. Te Ara documents early Māori geographic knowledge beyond European-style planimetric sheets. Sources: Te Ara - The Encyclopedia of New Zealand, "Māori and maps of colonisation".

2. Marshallese chart traditions demonstrate physical representations of swell and island relationships learned differently from European paper charts. Source: Smithsonian National Museum of Natural History, "Stick Navigation Chart".

3. The 1885 east Greenland wooden representations are used narrowly as examples of tactile geographic representation; curatorial evidence indicates that surviving objects may have served explanatory or storytelling rather than routine navigation functions. Source: Greenland National Museum & Archives, "Mapping NUNAAT: Rethinking Greenlandic Cartographic Heritage".

4. Eckstein and Schwarz interpret Tupaia's chart as an encounter and translation between navigational systems. Sources: Lars Eckstein; Anja Schwarz, "The Making of Tupaia's Map: A Story of the Extent and Mastery of Polynesian Navigation, Competing Systems of Wayfinding on James Cook's Endeavour, and the Invention of an Ingenious Cartographic System".

5. The Tuki episode is dated to 1793, including forced removal to Norfolk Island, the chalk-to-paper sequence and the disproportionate emphasis on the far north in the surviving representation. Source: Te Ara - The Encyclopedia of New Zealand, "Māori and maps of colonisation".

6. Archival evidence supports the depiction of a wairua path towards the underworld in Tuki's map; preferred tikanga-sensitive terminology remains for specialist review. Source: Te Ara - The Encyclopedia of New Zealand, "Māori and maps of colonisation".

7. Ngā Pou Taunaha o Aotearoa / New Zealand Geographic Board material supports the discussion of Māori place names entering official geographic systems through research, consultation and Treaty settlement processes. Sources: Ngā Pou Taunaha o Aotearoa / New Zealand Geographic Board, "Tangata whenua place-name maps - Te Waipounamu and Te Ika-a-Māui, second edition 2023".

8. Kā Huru Manu documents Hori Kerei Taiaroa's 1880 gathering and collation of Ngāi Tahu place-name and mahinga-kai knowledge and its later relationship to archive, claim evidence and contemporary GIS. Sources: Kā Huru Manu, "Ngāi Tahu 1880 Mahinga Kai Map".

9. Peluso's 1995 article is the source for 'counter-mapping' in Kalimantan; Chapin, Lamb and Threlkeld document the wider expansion and diversity of Indigenous mapping practices. Sources: Nancy Lee Peluso, "Whose Woods Are These?

Counter-Mapping Forest Territories in Kalimantan, Indonesia"; Mac Chapin; Zachary Lamb; Bill Threlkeld, "Mapping Indigenous Lands".

10. Te Mana Raraunga supplies the Māori Data Sovereignty principles; the CARE Principles supply Collective Benefit, Authority to Control, Responsibility and Ethics. Sources: Te Mana Raraunga, "Principles of Māori Data Sovereignty"; Global Indigenous Data Alliance, "CARE Principles for Indigenous Data Governance".

11. Sources: Lars Eckstein; Anja Schwarz, "The Making of Tupaia's Map: A Story of the Extent and Mastery of Polynesian Navigation, Competing Systems of Wayfinding on James Cook's Endeavour, and the Invention of an Ingenious Cartographic System"; Te Mana Raraunga, "Principles of Māori Data Sovereignty"; Global Indigenous Data Alliance, "CARE Principles for Indigenous Data Governance".

CHAPTER 17

AFRICA IS BIGGER THAN YOU THINK

1. The Africa–Greenland area comparison is deliberately rounded: authoritative area figures support the statement that Africa is roughly fourteen times Greenland's area. Sources: United Nations, "UNData Africa regional profile"; Statistics Greenland, "Greenland in Figures 2026".

2. Mercator enlarges scale increasingly with latitude; it does not apply a special shrinking operation to Africa. Mercator's 1569 design was navigational. Sources: PROJ contributors, "Mercator - PROJ documentation"; Gerardus Mercator, "Nova et aucta orbis terrae descriptio ad usum navigantium emendate accomodata".

3. The 1375 Catalan Atlas and the fifteenth-century Fra Mauro map are used as external evidence that substantial information about African polities, routes and trade circulated before nineteenth-century partition; they are not presented as internally African-authored maps. Sources: Bibliothèque nationale de France, "Atlas catalan, 1375: catalogue and contextual material"; Biblioteca Nazionale Marciana, "Il mappamondo di Fra Mauro".

4. Recent scholarship on colonial cartography supports the point that European mapping depended on African guides, intermediaries, rulers and local geographic knowledge while imperial institutions controlled much of the printing, surveying and bureaucratic circulation. Sources: Lindsay Frederick Braun, "Cartography in Colonial Africa".

5. The Berlin Conference remains important to imperial competition and the exclusion of African sovereignty. Source: Jack Paine; Xiaoyan Qiu; Joan Ricart-Huguet, "Endogenous Colonial Borders: Precolonial States and Geography in the Partition of Africa".

6. Paine, Qiu and Ricart-Huguet analyse 107 bilateral colonial borders and show that precolonial political geography and African agency influenced many boundary outcomes. Source: Jack Paine; Xiaoyan Qiu; Joan Ricart-Huguet, "Endogenous Colonial Borders: Precolonial States and Geography in the Partition of Africa".

7. OAU resolution AHG/Res.16(I), Cairo 1964, pledged respect for borders existing at independence. Sources: Organisation of African Unity, "AHG/Res.16(I) - Border Disputes Among African States".

8. The Gall-Peters controversy involved an equal-area cylindrical projection associated with James Gall and later promoted by Arno Peters; political claims and technical properties should remain distinct. Sources: Dhananjayan Sriskandarajah, "Long Underwear on a Line? The Peters Projection and Thirty Years of Cartocontroversy"; Jeremy W. Crampton, "Cartography's Defining Moment: The Peters Projection Controversy, 1974–1990".

9. Equal Earth was introduced in 2018 and EPSG:8857 existed before the 2026 campaign's UN success. Sources: Bojan Šavrič; Tom Patterson; Bernhard Jenny, "The Equal Earth map projection"; EPSG / IOGP, "WGS 84 / Equal Earth Greenwich - EPSG:8857".

10. Africa No Filter and Speak Up Africa launched Correct the Map in Dakar on 7 April 2025. Claims about subconscious, economic or political effects are campaign claims unless independently supported by cognition research. Sources: Africa No Filter; Speak Up Africa, "The Biggest Lie in Geography Is About Africa — And It's Time to Correct It".

11. Assembly/AU/Dec.959(XXXIX) adopted Equal Earth for the AU initiative, urged member states to revise curricula and established implementation machinery; the AU's colonial, cognitive-justice and reparatory language remains attributed to the AU. Sources: African Union Assembly, "Decision on 'Correcting the Map of Africa on the Globe'".

12. Togo's sponsorship and diplomatic role are documented in AU/Togolese records; interpretations about why the strategy was effective remain authorial analysis. Sources: Ministry of Foreign Affairs, Togo, "Correct The Map - Togo diplomacy project page"; Robert Dussey, "Briefing to African Group before UN consideration of Correct the Map".

13. The UN vote and final resolution symbol are recorded in official United Nations sources. Sources: United Nations Meetings Coverage and Press Releases, "General Assembly Adopts 'Correct the Map' Resolution at 114th Plenary Meeting"; United Nations General Assembly, "Correct the map: rebalancing global cartographic representation and promoting equitable representation of the world's regions, particularly Africa".

14. Sources: Jack Paine; Xiaoyan Qiu; Joan Ricart-Huguet, "Endogenous Colonial Borders: Precolonial States and Geography in the Partition of Africa"; Organisation of African Unity, "AHG/Res.16(I) - Border Disputes Among African States".

CHAPTER 18

GREENLAND IS BIG ENOUGH

1. Greenland covers a little over two million square kilometres. Sources: Statistics Greenland, "Greenland in Figures 2026"; United Nations, "UNData Africa regional profile".

2. Donald Trump's 4 January 2026 remarks are limited to source-supported statements that the United States needed Greenland for national security, that the island was strategically important, and that he invoked Russian and Chinese activity. Sources: Donald J. Trump / Office of the Federal Register, "DCPD-202600005 - Trump remarks on Greenland and Arctic security".

3. Pituffik Space Base's high-latitude location supports satellite-control, missile-warning and space-surveillance missions; U.S. Space Force material explains the value of repeated access to polar orbits. Sources: U.S. Space Force Combat Forces Command Public Affairs, "Satellite Control Network operations at Pituffik Space Base"; Staff Sgt. Jaime Sanchez, "Pituffik Space Base change of command and current mission".

4. The Arctic-strategy context comes from current defence and NATO material; strategic importance is grounded in geography and policy. Sources: U.S. Department of Defense, "2024 Department of Defense Arctic Strategy"; NATO, "NATO Arctic security topic page".

5. Greenland's 2009 Self-Government Act recognises Greenlanders' right of self-determination and establishes a process in which a decision on independence belongs to the people of Greenland. Source: Danish Government / Greenland, "Act on Greenland Self-Government".

6. Greenlandic political statements place Greenlandic agency at the centre rather than framing the island solely as an object of U.S.–Danish competition. Sources: Jens-Frederik Nielsen; Pele Broberg; Múte B. Egede; Aleqa Hammond; Aqqalu C. Jerimiassen, "Greenland political-party leaders: We stand together as a people"; Jens-Frederik Nielsen, "Greenland Prime Minister Jens-Frederik Nielsen press conference remarks"; Mette Frederiksen, "Statement by Danish Prime Minister Mette Frederiksen on Greenland".

7. Greenland's mineral-resource discussion distinguishes geological or resource potential, licences and regulation from operating or profitable mines. Sources: Naalakkersuisut, "Greenland Mineral Resources Authority"; Ministry of Business and Minerals / Rambøll, "Greenland mining-industry sustainable energy report".

CHAPTER 19

DOES A MAP CHANGE YOUR MIND?

1. Battersby and Montello's 2009 study tested remembered area estimates and found little support for the simple latitude-driven Mercator effect predicted by popular claims. Sources: Sarah E. Battersby; Daniel R. Montello, "Area Estimation of World Regions and the Projection of the Global-Scale Cognitive Map".

2. A 2019 Belgium/U.S. study of young people likewise did not find a simple Mercator-exposure signature dominating country/continent area estimates. Sources: Lieselot Lapon; Philippe De Maeyer; Nina Vanhaeren; Sarah Battersby; Kristien Ooms, "Evaluating Young People's Area Estimation of Countries and Continents".

3. The 2020 worldwide study gathered more than 130,000 responses; its filtered analytic sample was smaller. Sources: Lieselot Lapon; Kristien Ooms; Philippe De Maeyer, "The Influence of Map Projections on People's Global-Scale Cognitive Map: A Worldwide Study".

4. The 2020 results were more nuanced than a 'Mercator imprints area memory' slogan and included strong general magnitude-estimation effects. Sources: Lieselot Lapon; Kristien Ooms; Philippe De Maeyer, "The Influence of Map Projections on People's Global-Scale Cognitive Map: A Worldwide Study".

5. Montello and Battersby's 2022 work again found little support for a remembered-area Mercator effect but found a much stronger directional pattern consistent with familiar rectangular-map geometry. Sources: Daniel R. Montello; Sarah E. Battersby, "Another Look at the "Mercator Effect" on Global-Scale Cognitive Maps: Not in Areas but in Directions".

6. Research on projection cues shows that users can know projections distort while still relying on familiar shapes, graticules and other cues inconsistently. Sources: Sarah E. Battersby; Fritz C. Kessler, "Cues for Interpreting Distortion in Map Projections".

7. The 2024 Greenland experiment found a conditional interaction between projection and verbal framing in a hypothetical U.S. purchase scenario; it does not establish that projection caused real-world U.S. policy. Sources: Adam S. Richards; Evan Cooley; Jalen Miller; Ronald Watterson, "Testing the Mercator Effect: Global Map Projections Persuade Differently According to the Emphasis Frames Used to Contextualize Them".

8. Kessler and Battersby's literature review was published online in 2023 and in the 2024 volume/issue; it describes a real but relatively sparse and methodologically uneven body of cognition/perception research on map projections. Sources: Fritz

C. Kessler; Sarah E. Battersby, "Cognition and perception of map projections: a literature review".

9. The cited studies distinguish immediate visual distortion, remembered area, directional judgement and projection-plus-framing effects as different psychological outcomes. Sources: Sarah E. Battersby; Daniel R. Montello, "Area Estimation of World Regions and the Projection of the Global-Scale Cognitive Map"; Daniel R. Montello; Sarah E. Battersby, "Another Look at the "Mercator Effect" on Global-Scale Cognitive Maps: Not in Areas but in Directions"; Adam S. Richards; Evan Cooley; Jalen Miller; Ronald Watterson, "Testing the Mercator Effect: Global Map Projections Persuade Differently According to the Emphasis Frames Used to Contextualize Them"; Fritz C. Kessler; Sarah E. Battersby, "Cognition and perception of map projections: a literature review".

CHAPTER 20

DESIGNING A DIFFERENT WORLD MAP

1. Boston Public Schools' 2017 introduction of Gall-Peters maps supplies the contemporary opening context for the design discussion. Sources: National Geographic Education, "A Whole New World in Boston Public Schools"; Bob Shaffer, "Boston Public Schools Gall-Peters introduction - contemporary local report".

2. Gall-Peters is equal-area and therefore preserves relative area while producing conspicuous shape distortion; equal-area does not mean distortion-free. Sources: Dhananjayan Sriskandarajah, "Long Underwear on a Line? The Peters Projection and Thirty Years of Carto-controversy"; John P. Snyder, "Map Projections: A Working Manual".

3. The Gall-Peters projection belongs to the Gall Orthographic/cylindrical equal-area tradition associated with James Gall and later promoted by Arno Peters; it must not be confused with the separate Gall Stereographic projection. Sources: Jeremy W. Crampton, "Cartography's Defining Moment: The Peters Projection Controversy, 1974–1990".

4. Arthur Robinson's design is a compromise projection rather than equal-area or conformal. Sources: Esri, "Robinson projection - ArcGIS Pro documentation"; John P. Snyder, "Map Projections: A Working Manual".

5. National Geographic used Robinson for its standard world maps from 1988. A Winkel Tripel world-map supplement appeared in April 1995; Kessler's contemporary account records that favourable response contributed to a 1998 decision to use Winkel Tripel for National Geographic's standard world maps. Sources: National Geographic Society, "Selecting a Map Projection"; Fritz C. Kessler, "A Visual Basic Algorithm for the Winkel Tripel Projection".

6. Šavrič, Patterson and Jenny introduced Equal Earth in 2018 as an equal-area pseudocylindrical world projection inspired in visual character by compromise maps such as Robinson. Source: Bojan Šavrič; Tom Patterson; Bernhard Jenny, "The Equal Earth map projection".

7. The EPSG dataset registers three WGS 84 Equal Earth orientations relevant here: Greenwich as EPSG:8857, Americas at 90 degrees west as EPSG:8858, and Asia-Pacific at 150 degrees east as EPSG:8859. Other central meridians require their own parameterisation. Sources: EPSG / IOGP, "WGS 84 / Equal Earth Greenwich - EPSG:8857"; EPSG / IOGP, "WGS 84 / Equal Earth Americas - EPSG:8858"; EPSG / IOGP, "WGS 84 / Equal Earth Asia-Pacific - EPSG:8859"; PROJ contributors, "Equal Earth - PROJ documentation".

8. User-preference research finds meaningful differences in how readers respond aesthetically to world projections; preference is not the same as geometric accuracy. Source: Bojan Šavrič; Bernhard Jenny; Denis White; Daniel R. Strebe, "User preferences for world map projections".

9. Modern software can support multiple projections or globe views, weakening the technical necessity for one universal flat default even though institutional and compatibility choices still matter. Sources: Mapbox, "Globe and Atmosphere - Mapbox GL JS"; Jennifer Wrightsell-Hughes, "Changing the map projection in ArcGIS Online"; MapLibre contributors, "MapLibre GL JS globe support and projection toggle"; Bernhard Jenny, "Adaptive Composite Map Projections".

CHAPTER 21

THE WORLD, REDRAWN

1. Togo introduced the initiative for the African Group; 164 states voted in favour, the United States against, and Estonia, Georgia, Lithuania, Republic of Moldova, Serbia and Ukraine abstained. Source: United Nations Meetings Coverage and Press Releases, "General Assembly Adopts 'Correct the Map' Resolution at 114th Plenary Meeting".

2. The formal UN action on 4 September 2026 is controlled by the 114th-plenary schedule, draft A/80/L.104, official meeting coverage and final A/RES/80/307 record. Sources: United Nations, "80th General Assembly schedule - 114th plenary meeting"; United Nations General Assembly, "A/80/L.104 - Correct the map"; United Nations Meetings Coverage and Press Releases, "General Assembly Adopts 'Correct the Map' Resolution at 114th Plenary Meeting"; United Nations General Assembly, "Correct the map: rebalancing global cartographic representation and promoting equitable representation of the world's regions, particularly Africa".

3. The interval from the 7 April 2025 campaign launch to the 4 September 2026 vote is about seventeen months. Sources: Africa No Filter; Speak Up Africa, "The Biggest Lie in Geography Is About Africa — And It's Time to Correct It"; United Nations Meetings Coverage and Press Releases, "General Assembly Adopts 'Correct the Map' Resolution at 114th Plenary Meeting".

4. Assembly/AU/Dec.959(XXXIX) in February 2026 adopted Equal Earth for the AU initiative and urged curriculum revision. Source: African Union Assembly, "Decision on 'Correcting the Map of Africa on the Globe'".

5. By June 2026 the African Union Commission had announced an interdepartmental working group and a continental implementation-roadmap process, with engagement aimed at technology, mapping, publishing and education sectors. Source: African Union Commission, "AU leaders adopt historic initiative to correct the Map of Africa, advancing implementation and global repositioning of the Continent".

6. France's 4 September 2026 foreign-ministry statement announced a move away from Mercator in diplomatic uses toward representations adapted to purpose and more faithful to area. Source: Ministère de l'Europe et des Affaires étrangères, France, "Cartographie : pourquoi dépasser la projection de Mercator ?".

7. The resolution is political and institutional endorsement, not a technical act of inventing Equal Earth or registering EPSG:8857. Sources: Bojan Šavrič; Tom Patterson; Bernhard Jenny, "The Equal Earth map projection"; EPSG / IOGP, "WGS 84 / Equal Earth Greenwich - EPSG:8857"; United Nations General Assembly, "Correct

the map: rebalancing global cartographic representation and promoting equitable representation of the world's regions, particularly Africa".

8. The chronology distinguishes projection invention, software implementation, EPSG registration, political endorsement and practical rollout. Sources: Bojan Šavrič; Tom Patterson; Bernhard Jenny, "The Equal Earth map projection"; EPSG / IOGP, "WGS 84 / Equal Earth Greenwich - EPSG:8857"; African Union Assembly, "Decision on 'Correcting the Map of Africa on the Globe'"; United Nations General Assembly, "Correct the map: rebalancing global cartographic representation and promoting equitable representation of the world's regions, particularly Africa".

9. Major platform documentation current through 6 September 2026 continued to describe existing Web Mercator and globe-based mapping infrastructure. Sources: Google, "Map and Tile Coordinates - Maps JavaScript API"; Mapbox, "Globe and Atmosphere - Mapbox GL JS"; Jennifer Wrightsell-Hughes, "Changing the map projection in ArcGIS Online"; Apple, "Apple Maps - Interactive Globe".

10. The AUC's post-vote response called for progressive uptake. Source: African Union Commission, "Communiqué of the Chairperson on the adoption of the Correct the Map resolution".

EPILOGUE

CHOOSE YOUR DISTORTION

1. The epilogue restates the book's central cartographic principle: every flat projection preserves some properties and distorts others; the relevant standard is fitness for purpose rather than the absence of distortion. Sources: John P. Snyder, "Map Projections: A Working Manual"; Michael T. Gastner; Krisztián Kerkovits, "Choosing World Map Projections: When Equal-Area Is Appropriate (and Why There Is No Single "Correct" Projection)".

2. Equal-area, conformal, distance/direction-preserving and compromise properties are technical choices suited to different tasks, not a hierarchy of moral correctness. Sources: John P. Snyder, "Map Projections: A Working Manual"; Miljenko Lapaine; E. Lynn Usery, editors, "Choosing a Map Projection".

3. Modern globe and multi-projection software demonstrates that digital mapping need not use one flat projection for every scale and task. Sources: Mapbox, "Globe and Atmosphere - Mapbox GL JS"; MapLibre contributors, "MapLibre GL JS globe support and projection toggle"; Bernhard Jenny, "Adaptive Composite Map Projections".

4. The centre and seam of a world map are design choices distinct from the prime meridian and from the International Date Line. Sources: PROJ contributors, "Cartographic projection - PROJ longitude wrapping and prime meridian documentation"; U.S. Naval Observatory, "The International Date Line".

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Figure 6.1. Subdivision of a Native Reserve in Block XII, Waikouaiti Survey District, 1888. New Zealand Railways Corporation, District Engineer's Office, Dunedin. Archives New Zealand reference DABB D101 409/55, R6619117. Source: https://commons.wikimedia.org/wiki/File:Map_of_Block_XII,_Waikouaiti_Survey_District_-_Being_Subdivision_of_Native_Reserve_(1888).jpg. Licence: Creative Commons Attribution 2.0 Generic (CC BY 2.0), https://creativecommons.org/licenses/by/2.0/. Reproduced without substantive modification; display size changed only.

Figure 6.2. Map of the North Island, with iwi boundaries and Māori population, 1881. Archives New Zealand, AAFV 997 Box 77/GAZ136. Source: https://commons.wikimedia.org/wiki/File:Map_of_the_North_Island,_with_iwi_boundaries_and_Māori_population,_1881_(29010155165).jpg. Licence: Creative Commons Attribution-ShareAlike 2.0 Generic (CC BY-SA 2.0), https://creativecommons.org/licenses/by-sa/2.0/. Reproduced without substantive modification; display size changed only.

Figure 17.4. Anonymous political cartoon of the Berlin Conference, published in L'Illustration, 3 January 1885. Source: https://commons.wikimedia.org/wiki/File:Berlin_Conference,_1884%E2%80%9385.jpg. Wikimedia Commons lists the file under the Creative Commons CC0 1.0 Universal Public Domain Dedication, https://creativecommons.org/publicdomain/zero/1.0/. Reproduced without substantive modification; display size changed only.

ACKNOWLEDGEMENTS

This book depends on the work of cartographers, surveyors, historians, archivists, librarians, standards bodies, public agencies and researchers whose records and scholarship are cited throughout. Duane Wilkins is especially grateful to the institutions and collections named in the endnotes, bibliography and figure captions for making historical maps, technical documentation and public records accessible.

This book was developed with significant assistance from OpenAI's ChatGPT. Duane Wilkins used ChatGPT extensively for research support, source discovery and organisation, drafting and rewriting, structural and line editing, bibliography and source-management work, and production quality assurance. The final selection, interpretation and responsibility for the published text remain with the author.

The Māori and Pacific material is grounded in the sources identified in the text, endnotes and bibliography. Its inclusion should not be read as a claim to speak for the communities concerned. Responsibility for the interpretation and for any remaining errors rests with Duane Wilkins.

ABOUT THE AUTHOR

Duane Wilkins is a New Zealand geospatial professional and project/programme manager with long experience in GIS across public-sector, consulting and international environments. His work has included geospatial leadership, advisory and project roles, as well as practical GIS education.

This book brings Wilkins's professional perspective to a wider history of how maps, standards and software shape the way the world is represented.

COLOPHON

This A5 edition was prepared in 2026 at a trim size of 148 × 210 mm. Body text is set in EB Garamond, with Nimbus Sans used for headings, captions and navigational elements.

Figure captions identify source institutions and rights status, with additional licence and provenance information provided in Image Credits and Licence Notes. Coordinate reference system identifiers follow the EPSG Geodetic Parameter Dataset, and technical terminology follows the standards and documentation cited in the endnotes and bibliography.

Research, writing and production were substantially assisted by OpenAI's ChatGPT, including source discovery and organisation, synthesis, drafting, revision, citation management and production quality assurance. Duane Wilkins made the final editorial decisions and accepts responsibility for the published text. The cover artwork was developed using ChatGPT image generation. Web references were reviewed during the final source-control passes in September 2026.

GLOSSARY

Definitions below explain terms as they are used in this book. They are intended as a reading aid rather than as a replacement for the formal standards and source documents listed in the bibliography and endnotes.

A/RES/80/307. The United Nations General Assembly resolution adopted on 4 September 2026 after consideration of the Correct the Map initiative. In the book it is treated as political and institutional endorsement of more equitable world-map representation, not as the invention of Equal Earth, the creation of EPSG:8857, or a binding technical replacement of Mercator for every use.

Adaptive composite projection. A digital mapping approach that changes projection behaviour according to scale or viewing context instead of forcing one flat projection to serve every task. The book uses this as evidence that modern software can reduce the need for a single universal flat-map default, especially when a map can move between globe and planar views.

African Group. The group of African states at the United Nations on whose behalf Togo presented the Correct the Map initiative. In the 2026 episode described in the book, the African Group framed map representation as a question of institutional practice and equitable depiction, particularly where familiar world maps exaggerate high-latitude regions relative to Africa.

Antimeridian. The longitude opposite the chosen prime meridian, commonly associated with 180 degrees when Greenwich is the zero reference. A world map often places a display seam near this longitude, but the book stresses that the seam, the prime meridian, and the International Date Line are separate choices and should not be treated as the same thing.

Area distortion. Change in the relative size of regions when the curved Earth is flattened. Mercator is useful for preserving local angles but greatly enlarges high-latitude areas on the page. Equal-area projections make a different bargain: if one region is twice the area of another on Earth, it receives twice the area on the map, although its shape may still be altered.

Axis order. The order in which coordinate values are expected. The manuscript highlights a common GIS trap: formal EPSG definitions for EPSG:4326 specify latitude then longitude, while many programming and web conventions use longitude then latitude as x then y. Correct numbers in the wrong order can therefore place data in an impossible or absurd location.

Azimuthal equidistant projection. A projection that can preserve distance from a chosen centre. Its visual ordering changes when the centre changes. The book uses a Tokyo-centred example to show that moving a map centre can put Asia, the Americas and the Pacific into a different visual relationship without changing the underlying geography.

Berlin Conference. The 1884–1885 meeting often used as a shorthand for the European partition of Africa. The book cautions against the simplified image of delegates literally drawing every modern African border at one table. It uses the conference instead to examine how imperial power, diplomacy, surveying and later boundary-making interacted over time.

Cadastre. A system for recording parcels, boundaries, ownership or related land interests. In the New Zealand chapters, cadastral mapping is shown as practical infrastructure for administration and land markets, but also as a historical mechanism through which land was divided into legally recognisable sections, blocks, lots, roads, reserves and titles.

Cantino Planisphere. A world map of 1502 made by an anonymous Portuguese cartographer and covertly copied for Alberto Cantino. The book uses it as an unusually literal example of geographic information treated as strategically valuable knowledge, showing that maps could be guarded, acquired or stolen long before digital geospatial data.

CARE Principles. The CARE Principles for Indigenous Data Governance: Collective Benefit, Authority to Control, Responsibility and Ethics. The manuscript places them beside Māori Data Sovereignty principles to challenge the assumption that making data technically open and reusable is automatically socially appropriate.

Central meridian. The longitude chosen to sit near the middle of a projected map or display. It is not the same as the prime meridian used as the zero reference for longitude. A map can remain Greenwich-referenced while being visually recentred on the Pacific, the Americas or another longitude.

Conformal projection. A projection that preserves local angles at sufficiently small scales, so tiny shapes remain locally similar even when their size varies across the map. Mercator is conformal. The property is useful where direction and local angular relationships matter, but it can produce severe area distortion, especially towards the poles.

Coordinate. A numerical description of position. The book repeatedly stresses that coordinate numbers are not self-describing: values do not reveal their datum, units, axis order or projection. A coordinate becomes operationally meaningful only when software and users know the coordinate reference system that gives the numbers their interpretation.

Coordinate reference system (CRS). A formal framework that tells software how coordinate values relate to the Earth. A CRS can be geographic, using angular coordinates such as latitude and longitude, or projected, using planar coordinates such as metres. In the book, EPSG identifiers act as compact contracts that point to these definitions.

Coordinate transformation. A calculation that converts coordinates between reference systems or datums when the relationship between them is known. The manuscript distinguishes transformation or reprojection from merely assigning a CRS label. Labelling numbers with the wrong CRS changes their stated meaning without correctly calculating new coordinates.

Correct the Map. The title of the 2026 United Nations initiative introduced by Togo on behalf of the African Group, with African Union backing. Its argument centred on the persistent public use of world maps that make Africa appear smaller relative to high-latitude regions. The book treats the campaign as a political intervention in map choice, not as an order abolishing Mercator.

Counter-mapping. The use of mapping by communities or activists to challenge official representations of territory. The book discusses the term through work on forest territories in Kalimantan, where state classifications could omit Indigenous occupation and customary relationships. Counter-mapping turns the administrative language of maps into a means of asserting claims that official cartography has neglected.

Datum. See Geodetic datum. In the manuscript, datum is the reference framework that connects coordinate numbers to the real Earth. Changing the datum can change coordinate values even though the physical survey mark or location itself has not moved.

Distortion. The unavoidable change produced when a curved surface is represented on a flat one. The book uses distortion as a technical term rather than a moral judgement. Different projections preserve different properties, so the useful question is not whether a flat map distorts, but which properties it protects and which changes are acceptable for the map's purpose.

Eckert IV. An equal-area world projection mentioned as part of the longer history that predates Equal Earth. Its presence in the book is a reminder that equal-area mapping is not a new invention of the 2020s campaign. Equal Earth belongs to an established cartographic tradition while offering its own balance of area fidelity and visual appearance.

Ellipsoid. A smooth mathematical model used in geodesy because the Earth is not a perfect sphere. The manuscript explains that the real planet is slightly flattened at the poles and irregular in ways that are inconvenient for calculation. Datums

therefore use defined ellipsoids as part of the framework connecting coordinates to the Earth.

Endnotes. The source notes collected after the narrative chapters. They document the evidence behind historical, technical and political claims in the manuscript and are separate from the bibliography, which lists sources as full bibliographic entries.

EPSG code. A numeric identifier used in the EPSG geodetic parameter dataset. The manuscript emphasises that an EPSG number is a database key, not a version or a ranking. A larger number is not more modern or more accurate by virtue of being larger. The code points to a formal definition of a CRS or related geodetic object.

EPSG Registry. The geodetic parameter registry that underlies the EPSG identifiers used throughout the book. It provides formal definitions for coordinate reference systems and related parameters. The manuscript treats the registry as part of the largely invisible infrastructure that allows GIS software and datasets to agree on what coordinates mean.

EPSG:2193. NZGD2000 / New Zealand Transverse Mercator 2000, usually called NZTM2000. It is a projected CRS in metres designed for mainland New Zealand and recommended for national mapping where local measurement and consistency matter. The book contrasts its national engineering purpose with global systems such as EPSG:4326 and EPSG:3857.

EPSG:3031. Antarctic Polar Stereographic. The manuscript uses it to show that polar science does not depend on forcing Web Mercator to perform a job for which it is poorly suited. The South Pole is placed directly on the plane and Antarctic geography is arranged coherently around it.

EPSG:3857. WGS 84 / Pseudo-Mercator, the projected CRS underlying much modern web mapping. Its coordinates are expressed in projected metres and its formal scope is web mapping and visualisation. It supports the square Mercator-like world used by many tiled slippy-map systems, but it is not the same historical object as Mercator's 1569 map.

EPSG:4326. The WGS 84 geographic two-dimensional CRS. It expresses position as angular latitude and longitude in degrees and is common in global geographic data exchange. The manuscript stresses that it is often casually called a projection, but it is not a projected CRS. It also carries the well-known axis-order complication between formal and programming conventions.

EPSG:8857. WGS 84 / Equal Earth Greenwich, a projected CRS for very small-scale equal-area world mapping. The registered definition is centred on Greenwich. The book stresses that the code predates the 2025–2026 political campaign: the

United Nations increased its visibility but did not create the projection or register the CRS.

EPSG:8858. A registered WGS 84 / Equal Earth CRS centred on 90 degrees west, giving an Americas-facing orientation. It demonstrates that Equal Earth is not inherently tied to a Greenwich-centred display. It is one registered member of the Equal Earth CRS family.

EPSG:8859. A registered WGS 84 / Equal Earth CRS centred on 150 degrees east, giving an Asia-Pacific-facing orientation. The manuscript identifies it as the registered Equal Earth variant most directly relevant to New Zealand and the Pacific. Other custom central meridians are possible, but they are not automatically EPSG:8859.

Equal Earth. A modern equal-area world projection designed by Bojan Šavrič, Tom Patterson and Bernhard Jenny. It preserves relative area while also treating the overall appearance of continents as an explicit design concern. In the book it becomes the main alternative associated with the 2026 Correct the Map campaign, while remaining one projection among several legitimate choices.

Equal-area projection. A projection that preserves relative area across the map. If one region covers twice as much of the Earth as another, it occupies twice as much area on the map. Equal area does not mean zero distortion: shape, angle, distance or direction can still change. Gall-Peters, Mollweide, Eckert IV and Equal Earth are discussed as examples.

Gall-Peters projection. A cylindrical equal-area world projection promoted prominently by Arno Peters in the 1970s as an ethical alternative to Mercator. The book notes its connection to earlier work by James Gall and stresses that equal area is not the same as no distortion. Gall-Peters preserves relative area but produces conspicuous stretching and compression of shapes.

Geodesy. The science and practice of measuring and modelling the Earth and establishing reference frameworks for position. The book connects geodesy to surveying, datums, ellipsoids, satellite positioning and the problem of describing locations precisely on a curved, moving planet.

Geodetic datum. The reference framework that connects coordinate numbers to the real Earth. It uses a defined coordinate system and usually a smooth ellipsoid, and modern datums may also account for movement through time. In New Zealand, the book contrasts older national frameworks with NZGD2000, which was designed for a tectonically active country.

Geographic coordinate reference system. A CRS that represents position using angular coordinates on a reference surface rather than planar x and y values. EPSG:4326 is the main example in the book: WGS 84 latitude and longitude in

degrees. Geographic coordinates can later be projected into a flat CRS for mapping or measurement.

GIS. Geographic information system. In the manuscript, GIS refers both to software and to the wider practice of storing, analysing, transforming and displaying geographic data. The narrative emphasises that modern GIS depends on hidden agreements about CRSs, datums, axis order, units and transformation rules.

Goode's interrupted homolosine. An equal-area world projection mentioned as part of the established history of equal-area mapping. Its interrupted layout cuts the oceans in several places to reduce distortion of the land masses. The book cites it to show that preserving area has long been possible through many different visual strategies.

GPS. The satellite positioning system that grew from earlier military navigation and timing programmes and became NAVSTAR GPS. A receiver estimates its position from timed satellite signals and orbital information. The book follows GPS from restricted and degraded civilian performance to a technology embedded in everyday phones and GIS workflows.

Great-circle route. The shortest route between two distant points on a spherical Earth, in the simplified geometric sense used in the book. It generally appears curved on a Mercator chart. This differs from a rhumb line, which keeps a constant compass bearing and appears straight on Mercator.

Green Line. The name widely used for the 1949 armistice lines associated with Israel and its neighbours. The book uses the example to show how lines drawn through negotiation and military agreement can become durable structures of movement, administration and political geography. Their significance comes from institutions and history, not from the visual thickness of the line on a map.

Greenwich prime meridian. The zero-longitude reference adopted internationally through the 1884 International Meridian Conference. The book distinguishes this global bookkeeping reference from the central meridian of a particular map display. A Pacific-centred world map can therefore remain referenced to Greenwich longitude.

GRS80. The ellipsoid used by NZGD2000. In the manuscript it appears as part of the geodetic framework supporting modern New Zealand coordinates. Its role is mathematical: it provides a smooth reference surface within a datum that must also deal with the country's position across active tectonic plates.

International Date Line. A civil timekeeping convention running broadly through the Pacific. It bends around countries and island groups and can change when governments alter their time arrangements. The book uses Samoa's 2011

change of date to show that the Date Line is neither identical to the antimeridian nor simply a fixed cartographic seam.

International Meridian Conference. The 1884 conference in Washington that established Greenwich as the shared prime meridian. The manuscript uses it as an early example of governments negotiating global cartographic and temporal infrastructure. It was not a conference choosing the best map projection; it standardised a longitude reference and related time conventions.

Latitude. Angular position north or south of the equator. Latitude matters strongly to Mercator distortion because scale increases towards the poles. The book repeatedly contrasts low- and middle-latitude Africa with high-latitude regions such as Greenland, Canada and northern Eurasia to explain why relative visual size changes so dramatically on Mercator.

Longitude. Angular position east or west of a prime meridian. Longitude also provides the raw material for several different design choices: which longitude is zero, which one is placed at the centre of a map, and where the map is cut. The book emphasises that these choices can be separated.

Longitude wrapping. The software and display handling that allows longitude values to be represented across a chosen range and wrapped around the globe. The manuscript notes that longitudes can be expressed in forms such as 0–360 without changing the underlying datum. Wrapping and display seams are representation choices, not new geography.

Loxodrome. Another name for a rhumb line: a path that maintains a constant compass bearing. On a globe it usually curves towards a pole, while on Mercator it appears as a straight line. This property is central to understanding why Mercator's projection was valuable for navigation.

Map projection. A mathematical or systematic method for representing the curved Earth on a flat surface. No flat world projection can preserve every geometric property at once. The book therefore treats projection choice as a problem of purpose: area, local angle, distance, direction, appearance or some compromise among them.

Mercator projection. The conformal cylindrical projection associated with Gerardus Mercator's 1569 world map. It makes constant compass bearings straight on the chart and preserves local angles, which was valuable for navigation. Its scale increases rapidly towards the poles, producing very large high-latitude area distortion and making the poles unreachable at any finite projected distance.

Mollweide. An equal-area world projection included in the manuscript's discussion of the long history of equal-area cartography. Like Eckert IV and Goode's inter-

rupted homolosine, it shows that preserving relative area is an established technical option rather than an innovation created by the 2026 campaign.

Māori Data Sovereignty. Principles asserting Māori rights to govern Māori data and the systems through which it is collected, stored, interpreted, shared and reused. In the manuscript this framework complicates a simple "open data is always good" assumption and places authority, context and responsibility alongside technical interoperability.

Native Land Court. A nineteenth-century New Zealand institution that converted customary interests into titles recognised by colonial law. The book places surveying and mapping alongside the court's legal work, showing how land had to be measured and fitted into administrative categories before it could function inside the colonial title and land-market system.

NZGD2000. New Zealand Geodetic Datum 2000. Adopted in 1998, it is aligned to an international terrestrial reference frame at reference epoch 2000.0 and uses the GRS80 ellipsoid. The manuscript describes it as semi-dynamic, reflecting the reality that New Zealand moves across the boundary between the Australian and Pacific tectonic plates.

NZTM2000. New Zealand Transverse Mercator 2000, the national projected mapping system represented by EPSG:2193. It uses metres and is designed for mainland New Zealand. The book uses it to show why a country can sensibly use a local projected CRS for national work while also using global CRSs for exchange and web mapping.

Pacific-centred map. A world map whose display is recentred so the Pacific sits near the middle rather than being split across the left and right edges. This is a visual orientation choice, not a change to the Greenwich prime meridian. The book uses Pacific-centred maps to show how centre and seam affect the perceived ordering of the world.

Polar stereographic projection. A stereographic projection arranged around a pole. The manuscript uses Antarctic Polar Stereographic, EPSG:3031, as an example of matching projection to task. Where Web Mercator clips the polar regions, a polar stereographic CRS gives Antarctic science and mapping a coherent working plane.

Portolan chart. A medieval and early-modern nautical chart characterised by dense networks of compass-bearing lines and practical coastal information. The book uses a fourteenth-century Genoese example to show that rhumb-line navigation and sophisticated maritime charting existed long before Mercator's 1569 projection.

Prime meridian. The longitude chosen as the zero reference from which longitudes are counted. Since the 1884 international agreement, Greenwich has served as

the shared prime meridian. The book repeatedly separates this reference line from a map's visual centre, seam and orientation.

PROJ. Widely used geospatial software for coordinate transformations and map projections. The manuscript refers to PROJ documentation when discussing projection definitions, Equal Earth, Mercator, Web Mercator, central meridians and longitude wrapping. Its role illustrates how mathematical projection choices become executable infrastructure inside GIS software.

Projected coordinate reference system. A CRS in which positions are represented as coordinates on a flat plane, commonly in linear units such as metres. EPSG:3857, EPSG:2193 and EPSG:8857 are examples used in the manuscript. A projected CRS combines a projection with the other reference information needed to interpret coordinates operationally.

Projection seam. The line or edge where a continuous globe is cut to make a bounded flat world map. A seam can be placed in different locations and can divide the Pacific, Atlantic or another region depending on the map's centre. The book stresses that the seam is a cartographic design choice, separate from the prime meridian and International Date Line.

Pseudo-Mercator. The name used in EPSG:3857, the web-mapping CRS commonly called Web Mercator. It resembles the Mercator projection and keeps the square tiled world convenient for online mapping, but the manuscript carefully distinguishes it from Gerardus Mercator's 1569 map and from the broader historical family of Mercator constructions.

QGIS. Open-source GIS software cited in the manuscript for practical work with projections, reprojection and coordinate transformations. QGIS stands as an example of the software layer where abstract CRS definitions become operational decisions about how data is labelled, transformed and displayed.

Raster. A geographic data model based on a grid of cells or pixels. The term appears in the book alongside vector data as one of the common forms handled by modern GIS. Raster data must still be associated with appropriate georeferencing and a CRS if its pixels are to correspond to real locations.

Reference epoch. The conventional date at which coordinates in a time-aware geodetic datum are defined. The manuscript stresses that an epoch is not the same as the date a datum was adopted. NZGD2000 uses reference epoch 2000.0 because New Zealand's coordinates must be understood in a tectonically moving world.

Reprojection. The process of calculating new planar or geographic coordinates so data can be represented in another CRS. The book warns that reprojection is not the same as merely assigning a different CRS label. Correct reprojection requires software to know the true source CRS first.

Rhumb line. A path of constant compass bearing, also called a loxodrome. On Mercator it appears as a straight line, which made the projection particularly useful for traditional navigation with paper charts and ordinary drawing instruments. A rhumb line is generally not the shortest route over long distances.

Robinson projection. A compromise world projection created by Arthur Robinson for general reference mapping. It was developed with visual balance as a design goal rather than by preserving one mathematical property exactly. The book contrasts it with Mercator, Gall-Peters, Winkel Tripel and Equal Earth to show different priorities in world-map design.

Scale factor. The local ratio between distance on a map and corresponding distance on the Earth, expressed within the mathematics of a projection. In Mercator, scale increases with latitude and grows without bound as the poles are approached. The concept helps explain why high-latitude regions become so enlarged.

Selective Availability. The deliberate degradation of the standard civilian GPS service by the United States during the 1990s. The manuscript describes how civilian users developed differential corrections and how the policy was turned off in 2000, allowing ordinary receivers to benefit from substantially better accuracy.

Slippy map. The interactive web-map model in which users pan and zoom through tiled map imagery. The book connects the slippy map to Web Mercator, square global tile pyramids, caching and interoperability. The apparent simplicity of dragging a map hides a large amount of CRS and tiling infrastructure.

Standard parallel. A latitude used as a defining parameter in some projections, including conic projections such as Lambert Conformal Conic. The manuscript mentions standard parallels as part of the technical specification that gives a projected CRS its operational meaning, beyond a projection name alone.

Stick chart. A Marshall Islands navigational chart made from sticks and shells to encode islands, swells, wave patterns and navigational relationships. The book uses the Rebbelib example to demonstrate a cartographic tradition organised around ocean knowledge rather than a European coordinate grid, expanding the meaning of what a map can be.

Theorema Egregium. Gauss's "remarkable theorem" on the intrinsic curvature of surfaces. In the book it provides the mathematical reason a curved Earth cannot be flattened into a plane while preserving all geometry. The theorem closes the door on the idea of a perfect flat world map before politics or design preference enters the discussion.

Tile pyramid. The multilevel structure of map tiles used by many web-mapping systems. At each zoom level the world is divided into a regular grid of image or

vector tiles. Web Mercator's clipped, square world made this structure easy to cache and combine, helping EPSG:3857 become deeply embedded in web infrastructure.

Tissot's indicatrix. A diagnostic method associated with Nicolas Auguste Tissot that imagines small circles distributed across the globe and examines how a projection changes them. Their stretching, compression or enlargement reveals local distortion. The book uses the indicatrix to turn abstract projection properties into a visible way of asking what a map preserves.

Transverse Mercator. A projection in the Mercator family whose cylinder is conceptually turned so the projection is suited to regions extending mainly north-south rather than to the whole world. The manuscript's main national example is New Zealand Transverse Mercator 2000, the projection used in EPSG:2193.

Van der Grinten. A compromise-style world projection used by National Geographic before its adoption of Robinson in 1988. The book mentions it in the sequence of changing institutional world-map choices, showing that even very familiar publishers have revised projection defaults over time.

Vector. A geographic data model representing features as points, lines and polygons rather than a pixel grid. The book treats vector and raster data as ordinary GIS data types whose usefulness still depends on correct coordinate reference information when they are positioned, combined or transformed.

Web Mercator. The web-mapping system commonly associated with EPSG:3857 and also called Pseudo-Mercator. It supports a square tiled world, fast caching and consistent zoom levels, which helped make it a global engineering default. It clips the planet near 85.0511 degrees latitude, so the poles do not exist inside its finite planar tile world.

WGS 84. The global geodetic reference system used by GPS and many geographic datasets. In the book it appears in both EPSG:4326, which expresses geographic latitude and longitude, and several projected CRSs whose names begin "WGS 84 /". WGS 84 is part of the reference framework, not a synonym for one particular map projection.

Winkel Tripel. A compromise world projection devised by Oswald Winkel in 1921. It does not preserve area exactly or preserve local angles exactly; instead it seeks to reduce several forms of global distortion at once. National Geographic adopted it for its standard world maps after using Robinson, illustrating how institutions change projection choices.