Mapping: Methods & Tips

Matrix Projection
"A true equal area map of the world"

Abbas Bazeghi
Architect; Cartographer
Goleta, CA
jonablelight@cox.net

A Brief History of Map Projections

Maps have been prepared by men since ancient times. Babylonians of 2500 BC. Romans of Jesus' time and feudals of the middle ages all prepared local maps showing natural features such as rivers, mountains, shorelines and forests; and man made features such as roads, bridges, property lines and structures. Since the real size and shape of the world was not commonly known until as late as the 16th century, all earlier world maps were incomplete and inaccurate. By the end of the 16th century real world maps were being produced in Europe.

The following is a brief history of world map design from the 16th century to the present. It will be followed by some examples of known world maps and series of new designs by Abbass Bazeghi in more detail.

Before Ferdinand Magellan's explorations, by 1520 AD, and Nicolaus Copernicus publishing his hypothesis of the heliocentric nature of the known universe in 1543 AD, the earth was assumed by most people to be flat; with the exception of very few, including Columbus, Magellan and Copernicus who had read about Eratosthenes of Greece, residing in Alexandria, Egypt around the third century BC.

Eratosthenes, by measuring heights and shadows of obelisks in Aswan, Egypt at the Tropic of Cancer, and Alexandria some 800 kilometers north of Aswan, geometrically proved that the earth is spherical and showed that the circumference of the Earth is 50 times longer than the 800 kilometer distance between Aswan and Alexandria. This is very close to the actual distance by current measurements. Eratosthenes' discovery remained unknown by most people for many centuries. But the myth of a spherical world continued.

By 1492 AD Christopher Columbus had convinced Queen Isabella of Spain to finance an exploratory voyage to find a route to the east and India by sailing west. If the earth is indeed round, then one will reach India by sailing west in addition to an eastern route involving difficult and often dangerous roads over many lands.

Columbus finally reached land further west in the Atlantic Ocean. He assumed that he had reached the shores of India and did not realize that he had found a new unknown land "America". Consequently, he grossly miscalculated the size of the earth.

Ferdinand Magellan, the Portuguese explorer, was the first to circumnavigate the earth by 1520 AD. He provided more accurate data than ever before to prove the spherical shape and size of the earth.

By 1543 AD, Nicolaus Copernicus of Poland had correctly described the earth as a sphere rotating around its axis with one moon orbiting around it. The earth with its moon and all observable planets and even fixed stars were assumed to be orbiting the sun as the center of the universe. Copernicus' theory was perfected by Johannes Kepler of Germany about 50 years later.

By the 1560's the earth was accepted by most intellectuals, scholars and scientists to be spherical. However, the dispute over the heliocentric theory of Copernicus and earlier geocentric theory still continued even to the time when Galileo Galilei of Italy was experimenting with telescopes verifying Copernicus' theory by providing more proofs as late as 1616 AD. He was forced by the powerful governing church to stop teaching Copernicus' theory or roundness of the

---

Abbas Bazeghi graduated from the University of California, Berkeley, class of 1968, with a 5 year professional degree in architecture. He has completed hundreds of architectural projects during the last 36 years. He is presently practicing in Santa Barbara, California as an architect/cartographer.

He worked as a cartographer in Iran from 1955 to 1962 and was trained by three master cartographers. He came to San Francisco in February 1962 and attended San Francisco State College for one year, then transferred to UC Berkeley in 1963 to study architecture.

He has continued his cartographic work and has spent a great amount of time during the last 15 years in pursuit of designing the ultimate "equal area projection". He has designed 6 original world maps, the best and the last one being "Matrix Projection".

earth. By 1623, with a new Pope in office, Galileo was left alone to do his work.

Nevertheless, by 1570 AD new world maps based on the spherical shape of the earth began to appear in Europe. By 1569 AD a new view of the earth was presented by a leading cartographer, the Flemish Gerhardus Mercator. This new map, known as the Mercator projection, is still the most familiar world map in use. The genius of Mercator's projection is the rectangular grid. Although the earlier versions were only partial maps of known places and shorelines, with lots of guess work on size and extent of land masses, nevertheless, the Mercator projection provided a grid to expand on and refine as more accurate surveys of shorelines and land masses were prepared in the following years. The basic design of the grid remained unchanged.

The Mercator projection was invented to provide a tool for navigation and charting routes for voyages on the high seas. This is achieved by assuming the meridians as straight, vertical and parallel lines, equally spaced along the equator. The parallels are presented as straight horizontal lines, parallel to the equator, spaced to provide the best geometric proportion and compensate for the distortions caused by parallel meridians. Although the Mercator projection has been a very useful tool for navigators, it has not been a good viewing map. It depicts the earth grossly distorted and not equal to the areas in comparison.

Other earlier attempts were made by 17th century cartographers to present the world, visually, more realistic than the Mercator projection. The most well known example was introduced around 1660 by Andreas Cellarius, where the world is shown as two perfect circles side by side. The map is an artistic presentation and is not based on scientific or mathematical rules. The earth map in this design is grossly distorted with a great deal of guess work and many missing or obscure parts of land and seas. This projection is now used as decoration, often seen in gold paper prints.

From the 16th century to the 20th century the world was well traveled and mapped. During the last 400 years almost all places have been accurately surveyed and most places aerial photographed. But the Mercator projection as the standard world map remained unchanged and supreme until very recently.

The National Geographic Society, since 1922, had been using a revised version of the Mercator projection which was developed by an American engineer, Alphons Van der Grinten. This projection, much like the Mercator, was also grossly distorted visually, depicting Greenland 554% larger than it is. The ex-Soviet Union was depicted 223% larger and the USA 68% larger. The Robinson projection has been their official map since 1988.

Since there have been repeated complaints about visual distortions of the Mercator's design, despite its geometric and mathematical correctness, many attempts have been made to improve it visually.

By 1963, Arthur H. Robinson, professor emeritus of cartography and geography at the University of Wisconsin-Madison, introduced a new design in which he has reduced the visual distortions of the Mercator projection by bringing the meridians closer together as they approach the north and south poles. The distance from north pole to south pole is also made equal in length, at (0)° meridian, to actual length. Where in the Mercator projection, the (0)°, as well as all the meridians, are presented 2 times longer than they are.

The Robinson projection is less distorted visually than the Mercator projection. Never-the-less, it is not free of distortion and it is not an equal area map. Alaska, Russia and Greenland are skewed and bent out of shape. However, it is graphically well balanced and looks very attractive. It would have been a great projection if the earth really looked like that or was that size.

There are about 200 projections that have been designed, mostly in the 20th century, of which only very few have been widely used. Many of these projections are not known by most people.

I have developed a new innovative method of designing original and geometrically precise equal area world maps. The method does not involve projecting the grid of meridians and parallels to a cylindrical or conical, two dimensional, planes. Rather, it involves sizing and designing each segment of the globe, formed by the cross sections of the meridians and parallels, individually.

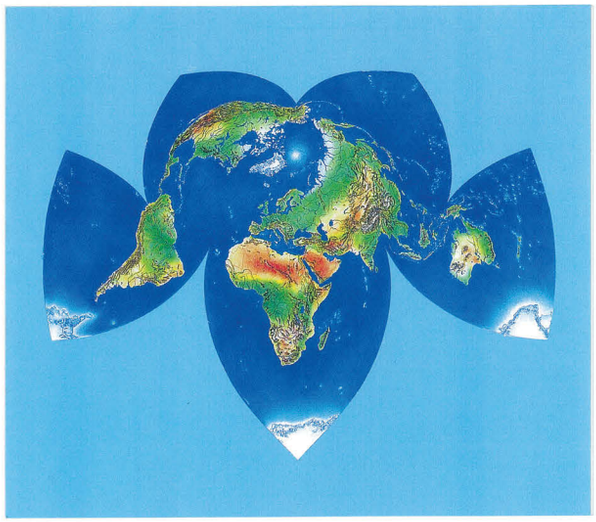
The overall design of the world map is first conceived by carefully selecting the interruptions and creating a grid where the shapes of the segments and distortions are controlled by design to achieve the best relevant size and shape of each segment as close to the real size and shape on the globe as possible. Once the overall design is conceived, a hand drawn schematic line drawing is prepared, scanned and imported to AutoCad. (AutoCad is a software product developed by AutoDesk for architects and engineers for drafting and rapidly calculating geometric sizes and areas of surfaces among many other useful drafting tools).

On a 15 degree grid, the globe is covered by a total of 288 segments. There are only 6 typical segments. It takes 48 of each of the 6 segments to cover the entire surface area of the globe. These segments on a given world map design are then individually shaped and enclosed by geometrically definable arcs of circles. The main challenge is to keep the curves in alignment from segment to segment to maintain a visually smooth and attractive overall design. The process is really an effort

in combining art and mathematically precise geometry; it is a marriage of art and science. The next step is to calculate the surface area of each enclosed segment. Fortunately, it is rather easy to calculate the exact surface area of any segment enclosed by arcs of circles using AutoCad. Each segment can be fine tuned by changing the radii of the arcs and recalculating until the exact required area is achieved. Without the right software, such as AutoCad, it would be impossible or extremely difficult to complete the work. Any change of shape or size of any segment has a domino effect and involves changing many neighboring segments. Even using AutoCad does not eliminate the tedious and time consuming process of fine tuning to achieve the final desired precision, but it is doable.

After completing a geometrically precise grid, coordinates of any point on the grid may be obtained instantly from the AutoCad file. These coordinates then can be used to formulate the map for interpolating inputs from satellites or compliance with other scientific methods of designing equal area world maps.

A few of these existing projections are shown with a series from the publication: Jon Able Light, Matrix Projection "A true equal area map of the world. Copyright 2006 by Abbass Bazeghi.

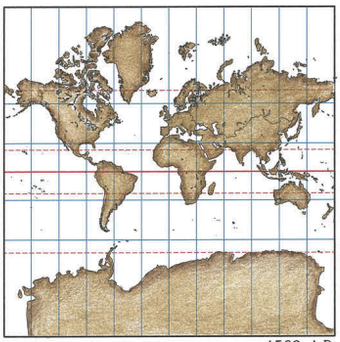


Jon Able Light

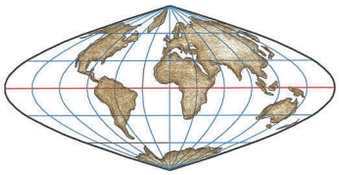
MATRIX PROJECTIONS

"True equal area world maps"

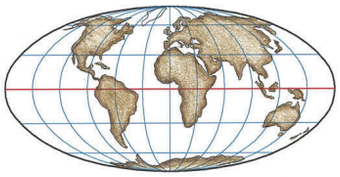
EqualAreaMaps.com
jonablelight@cox.net



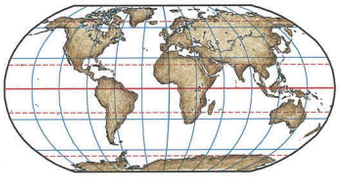
MERCATOR PROJECTION 1569 A.D.



SINUSOIDAL EQUAL AREA PROJECTION
1950'S

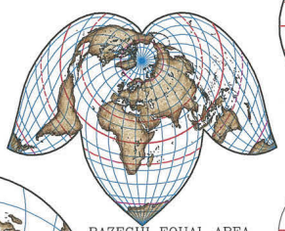


MOLLEWEIDE HOMOLOGRAPHIC PROJECTION
1960'S

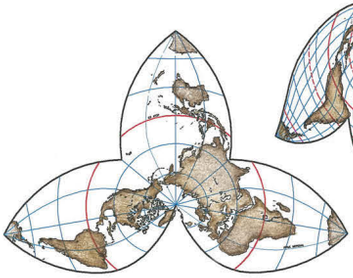


ROBINSON PROJECTION 1963

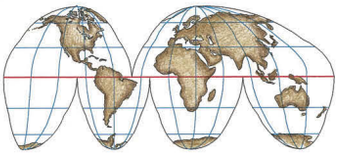
BAZEGHI EQUAL AREA PROJECTION ② 2001



BAZEGHI EQUAL AREA
PROJECTION ⑤ 2004

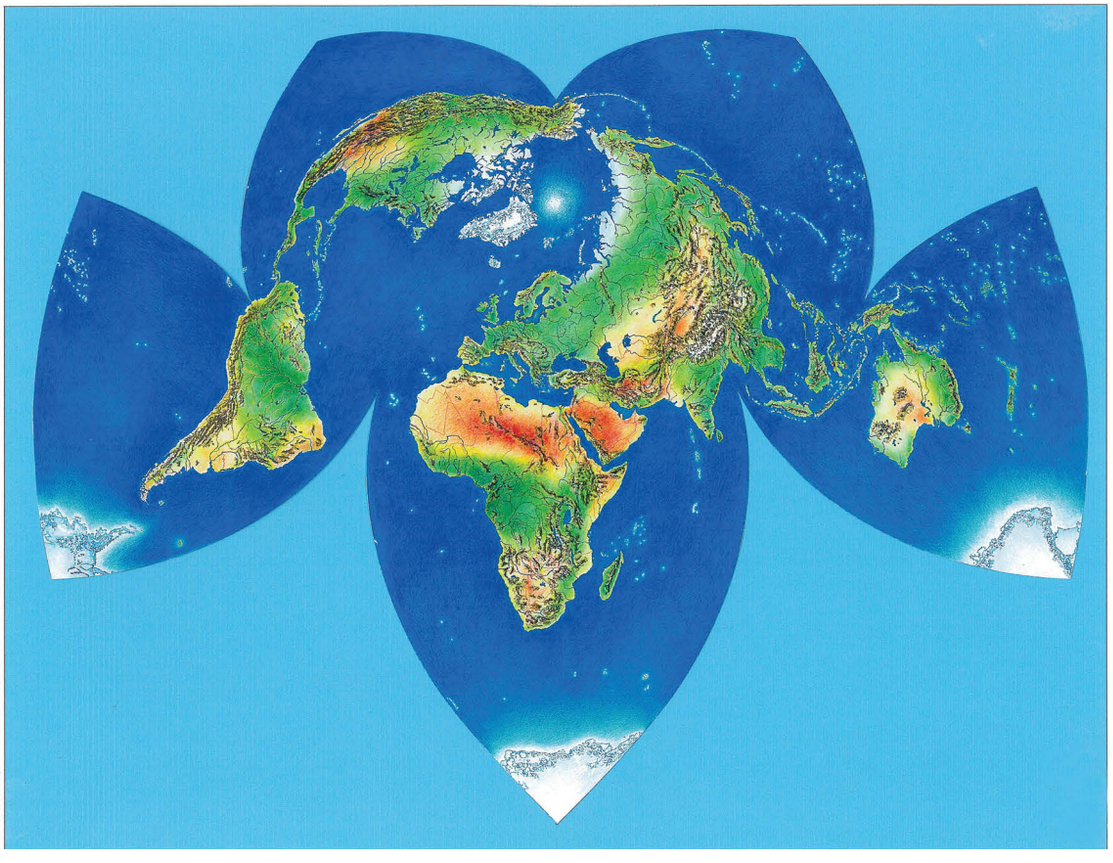


BAZEGHI EQUAL AREA PROJECTION ① 1996



GOODE'D EQUAL AREA PROJECTION 1970'S

330 Moreton Bay Ln. Goleta, CA 93117 e-mail: jonablelight@cox.net

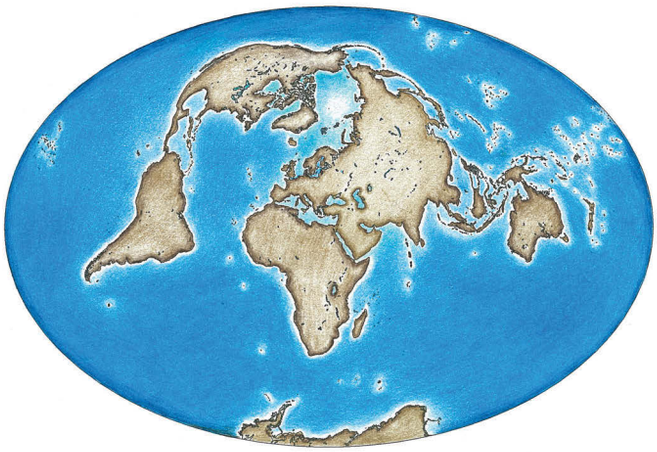


Physical map of
THE WORLD

Presented on the
International edition of:
JON ABLE LIGHT
MATRIX PROJECTION
"Truest map of the world ever created"

A mathematically precise direct equal area polar projection.
Copyright©2006, Abbass Bazeghi. All rights reserved.

EqualAreaMaps.com
jonablelight@cox.net



JON ABLE LIGHT
OVAL MATRIX PROJECTION
2007

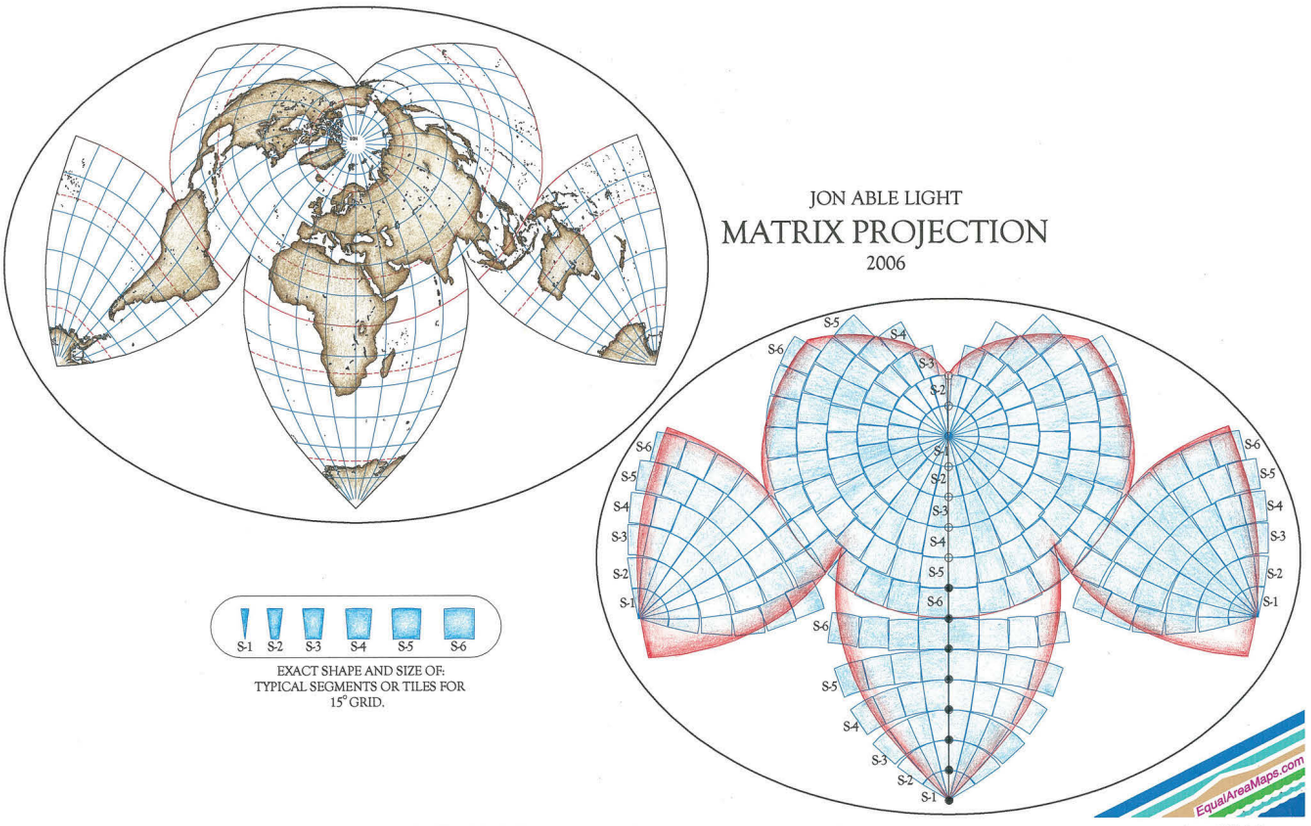
330 Moreton Bay Ln. Goleta, CA 93117 e-mail: jonablelight@cox.net

NORTHERN HEMISPHERE

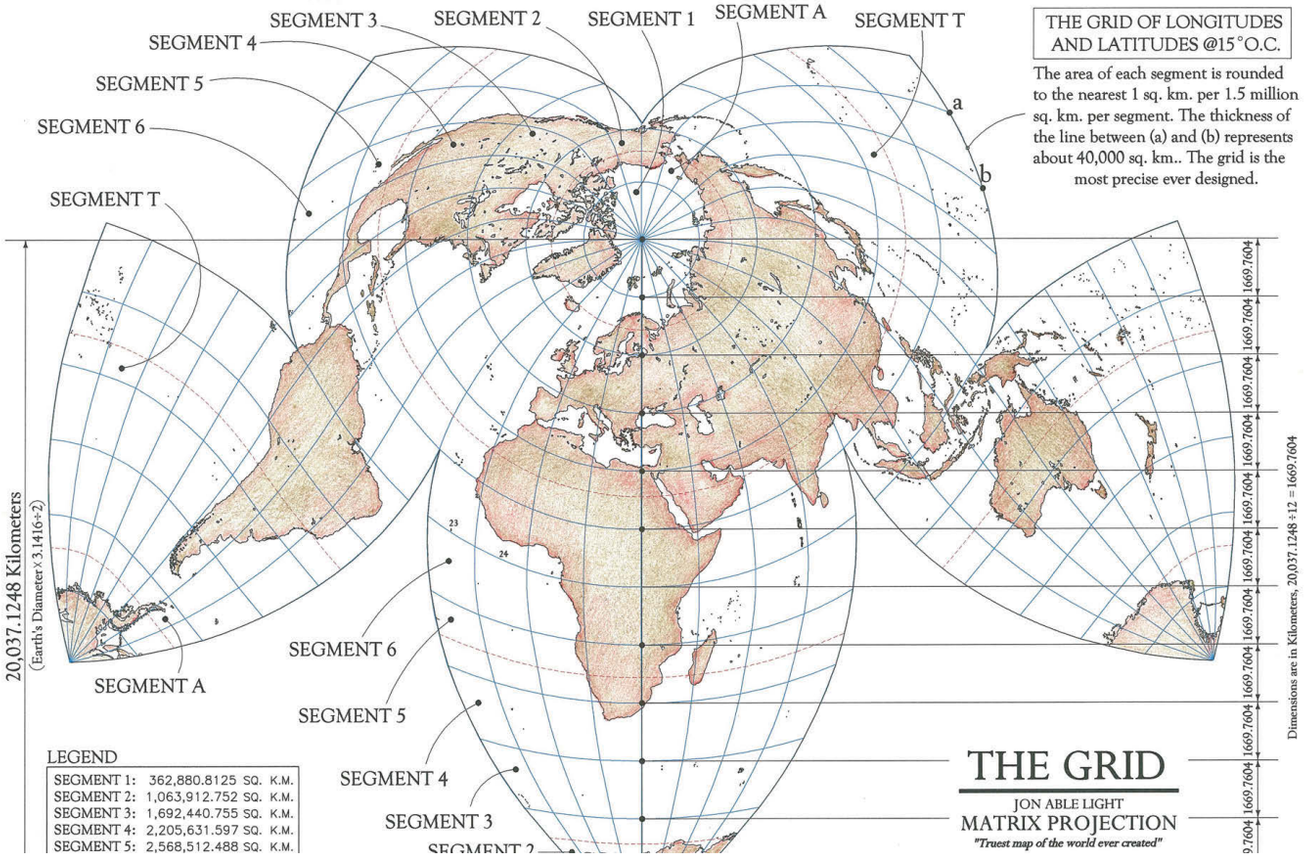
Presented on the
International edition of:
JON ABLE LIGHT
MATRIX PROJECTION
"Truest map of the world ever created"

A mathematically precise direct equal area polar projection.

EqualAreaMaps.com
jonablelight@cox.net



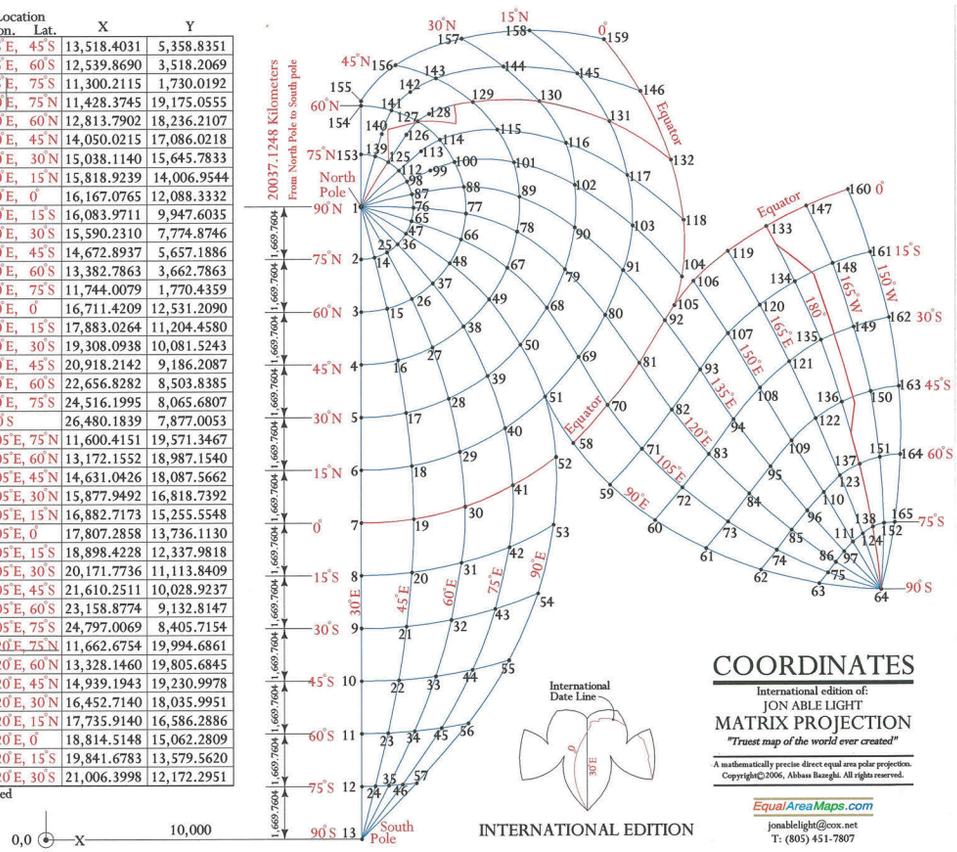
330 Moreton Bay Ln. Goleta, CA 93117 e-mail: jonablelight@cox.net



#	Location Lon.	Lat.	X	Y
1	90°	N	10,000.0000	20,037.1284
2	30°	E, 75° N	10,000.0000	18,367.3680
3	30°	E, 60° N	10,000.0000	16,697.6076
4	30°	E, 45° N	10,000.0000	15,027.8472
5	30°	E, 30° N	10,000.0000	13,358.0868
6	30°	E, 15° N	10,000.0000	11,688.3264
7	30°	E, 0°	10,000.0000	10,018.5660
8	30°	E, 15° S	10,000.0000	8,348.8056
9	30°	E, 30° S	10,000.0000	6,679.0452
10	30°	E, 45° S	10,000.0000	5,009.2848
11	30°	E, 60° S	10,000.0000	3,339.5244
12	30°	E, 75° S	10,000.0000	1,669.7604
13	90°	S	10,000.0000	0
14	45°	E, 75° N	10,422.2973	18,422.6693
15	45°	E, 60° N	10,825.5684	16,802.4935
16	45°	E, 45° N	11,167.4960	15,170.2763
17	45°	E, 30° N	11,423.2299	13,498.0619
18	45°	E, 15° N	11,605.4312	11,818.3391
19	45°	E, 0°	11,666.5011	10,135.7090
20	45°	E, 15° S	11,605.3631	8,447.0219
21	45°	E, 30° S	11,432.2134	6,732.9138
22	45°	E, 45° S	11,187.9720	5,036.0984
23	45°	E, 60° S	10,838.0470	3,357.3707
24	45°	E, 75° S	10,427.2173	1,679.9536
25	60°	E, 75° N	10,820.4869	18,580.9285
26	60°	E, 60° N	11,609.5519	17,108.5945
27	60°	E, 45° N	12,267.4195	15,567.6082
28	60°	E, 30° N	12,780.3158	13,947.0298
29	60°	E, 15° N	13,129.8845	12,260.3893
30	60°	E, 0°	13,298.7206	10,525.3363
31	60°	E, 15° S	13,177.5121	8,754.5401
32	60°	E, 30° S	12,856.0300	6,938.1593
33	60°	E, 45° S	12,362.7710	5,155.2028
34	60°	E, 60° S	11,680.3348	3,416.6592
35	60°	E, 75° S	10,860.5983	1,699.6433
36	75°	E, 75° N	11,161.5762	18,839.9944
37	75°	E, 60° N	12,277.4113	17,598.3855
38	75°	E, 45° N	13,249.0668	16,228.1268
39	75°	E, 30° N	14,002.4370	14,661.7721
40	75°	E, 15° N	14,557.4068	13,006.4951
41	75°	E, 0°	14,802.8828	11,198.3978
42	75°	E, 15° S	14,689.5838	9,235.4790
43	75°	E, 30° S	14,237.1634	7,282.9169

#	Location Lon.	Lat.	X	Y
44	75°	E, 45° S	13,518.4031	5,358.8351
45	75°	E, 60° S	12,539.8690	3,518.2069
46	75°	E, 75° S	11,300.2115	1,730.0192
47	90°	E, 75° N	11,428.3745	19,175.0555
48	90°	E, 60° N	12,813.7902	18,236.2107
49	90°	E, 45° N	14,050.0215	17,086.0218
50	90°	E, 30° N	15,038.1140	15,645.7833
51	90°	E, 15° N	15,818.9239	14,006.9544
52	90°	E, 0°	16,167.0765	12,088.3332
53	90°	E, 15° S	16,083.9711	9,947.6035
54	90°	E, 30° S	15,590.2310	7,774.8746
55	90°	E, 45° S	14,672.8937	5,657.1886
56	90°	E, 60° S	13,382.7863	3,662.7863
57	90°	E, 75° S	11,744.0079	1,770.4359
58	90°	E, 0°	16,711.4209	12,531.2090
59	90°	E, 15° S	17,883.0264	11,204.4580
60	90°	E, 30° S	19,308.0938	10,081.5243
61	90°	E, 45° S	20,918.2142	9,186.2087
62	90°	E, 60° S	22,656.8282	8,503.8385
63	90°	E, 75° S	24,516.1995	8,065.6807
64	90°	S	26,480.1839	7,877.0053
65	105°	E, 75° N	11,600.4151	19,571.3467
66	105°	E, 60° N	13,172.1552	18,987.1540
67	105°	E, 45° N	14,631.0426	18,087.5662
68	105°	E, 30° N	15,877.9492	16,818.7392
69	105°	E, 15° N	16,882.7173	15,255.5548
70	105°	E, 0°	17,807.2858	13,736.1130
71	105°	E, 15° S	18,898.4228	12,337.9818
72	105°	E, 30° S	20,171.7736	11,113.8409
73	105°	E, 45° S	21,610.2511	10,028.9237
74	105°	E, 60° S	23,158.8774	9,132.8147
75	105°	E, 75° S	24,797.0069	8,405.7154
76	120°	E, 75° N	11,662.6754	19,994.6861
77	120°	E, 60° N	13,328.1460	19,805.6845
78	120°	E, 45° N	14,939.1943	19,230.9978
79	120°	E, 30° N	16,452.7140	18,035.9951
80	120°	E, 15° N	17,735.9140	16,586.2886
81	120°	E, 0°	18,814.5148	15,062.2809
82	120°	E, 15° S	19,841.6783	13,579.5620
83	120°	E, 30° S	21,006.3998	12,172.2951

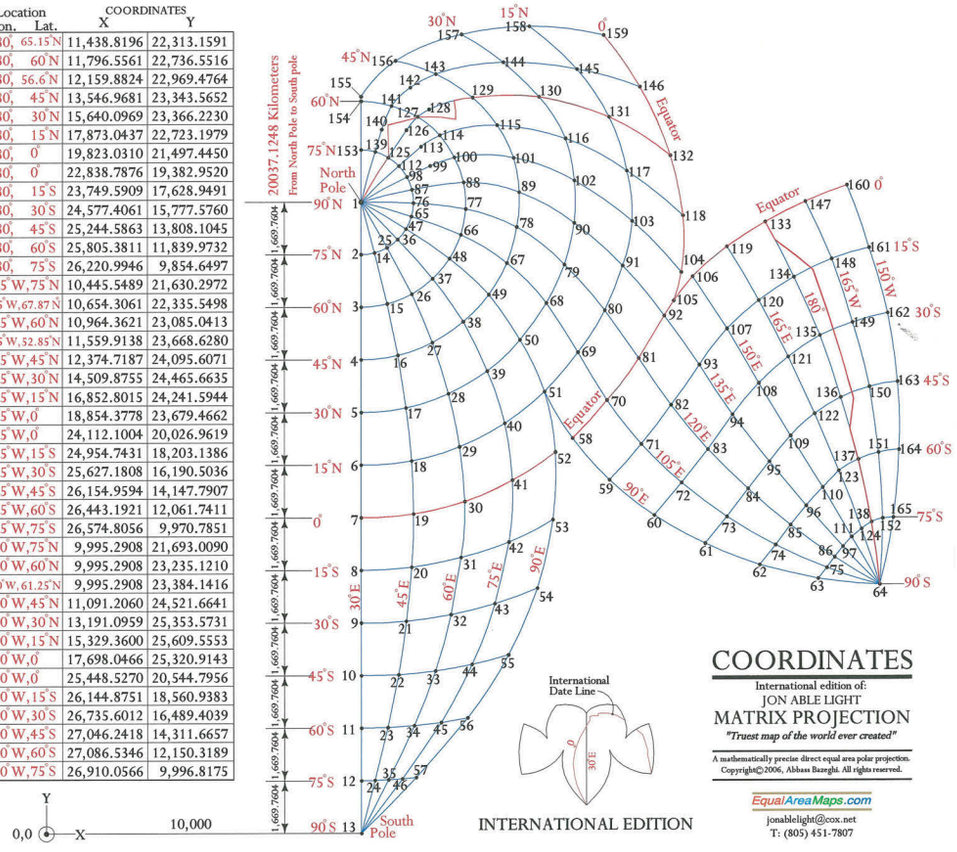
Continued

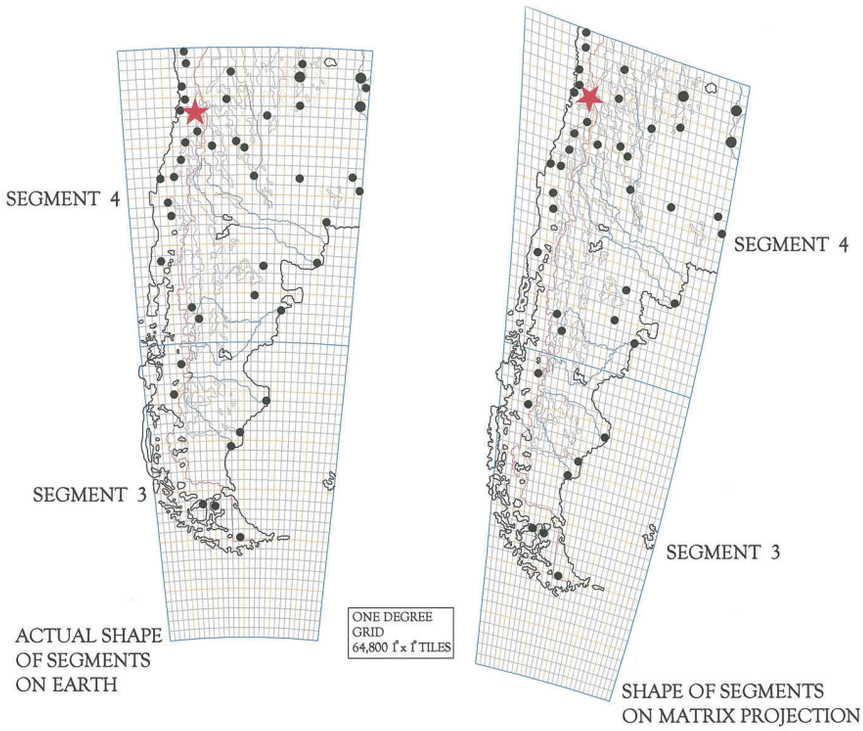


#	Location Lon.	Lat.	COORDINATES X	Y
84	120°	E, 45° S	22,282.6175	10,914.6895
85	120°	E, 60° S	23,637.4988	9,765.9042
86	120°	E, 75° S	25,045.5263	8,739.7363
87	135°	E, 75° N	11,616.4479	20,423.4905
88	135°	E, 60° N	13,263.6539	20,651.2115
89	135°	E, 45° N	15,013.7779	20,335.8222
90	135°	E, 30° N	16,769.1553	19,355.1093
91	135°	E, 15° N	18,306.3534	17,998.4539
92	135°	E, 0°	19,627.4487	16,413.2061
93	135°	E, 15° S	20,737.0269	14,853.0681
94	135°	E, 30° S	21,789.7831	13,271.3980
95	135°	E, 45° S	22,966.5310	11,776.3680
96	135°	E, 60° S	24,136.6638	10,372.8335
97	135°	E, 75° S	25,308.5346	9,075.8876
98	150°	E, 75° N	11,459.2179	20,827.8142
99	150°	E, 67.5° N	12,197.9167	21,173.9391
100	150°	E, 60° N	12,966.5926	21,433.3269
101	150°	E, 45° N	14,840.1279	21,426.6837
102	150°	E, 30° N	16,771.2041	20,703.5389
103	150°	E, 15° N	18,609.2537	19,418.9455
104	150°	E, 0°	20,167.1463	17,791.8046
105	140.5°	E, 0°	19,926.7016	16,888.1849
106	150°	E, 0°	20,525.8235	17,653.6299
107	150°	E, 15° S	21,620.0350	15,995.4311
108	150°	E, 30° S	22,632.5633	14,268.8684
109	150°	E, 45° S	23,638.7596	12,593.1392
110	150°	E, 60° S	24,666.8225	10,952.8857
111	150°	E, 75° S	25,594.9592	9,378.9407
112	165°	E, 75° N	11,200.8177	21,177.9318
113	165°	E, 66.5° N	11,907.0144	21,786.8825
114	165°	E, 60° N	12,507.9060	22,150.9039
115	165°	E, 45° N	14,314.4450	22,464.3096
116	165°	E, 30° N	16,491.4763	22,040.3088
117	165°	E, 15° N	18,439.7316	21,015.7466
118	165°	E, 0°	20,221.6893	19,588.6155
119	165°	E, 0°	21,615.9810	18,599.9481
120	165°	E, 15° S	22,631.0258	16,889.5481
121	165°	E, 30° S	23,566.2241	15,096.3079
122	165°	E, 45° S	24,410.4480	13,296.5702
123	165°	E, 60° S	25,181.0512	11,483.4929
124	165°	E, 75° S	25,901.2933	9,636.7302
125	180°	75° N	10,861.1650	21,442.7742

#	Location Lon.	Lat.	COORDINATES X	Y
126	180°	65.15° N	11,438.8196	22,313.1591
127	180°	60° N	11,796.5561	22,736.5516
128	180°	56.6° N	12,159.8824	22,969.4764
129	180°	45° N	13,546.9681	23,343.5652
130	180°	30° N	15,640.0969	23,366.2230
131	180°	15° N	17,873.0437	22,723.1979
132	180°	0°	19,823.0310	21,497.4450
133	180°	0°	22,838.7876	19,382.9520
134	180°	15° S	23,749.5909	17,628.9491
135	180°	30° S	24,577.4061	15,777.5760
136	180°	45° S	25,244.5863	13,808.1045
137	180°	60° S	25,805.3811	11,839.9732
138	180°	75° S	26,220.9946	9,854.6497
139	165° W,	75° N	10,445.5489	21,630.2972
140	165° W,	67.87° N	10,654.3061	22,335.5498
141	165° W,	60° N	10,964.3621	23,085.0413
142	165° W,	52.85° N	11,559.9138	23,668.6280
143	165° W,	45° N	12,374.7187	24,095.6071
144	165° W,	30° N	14,509.8755	24,465.6635
145	165° W,	15° N	16,852.8015	24,241.5944
146	165° W,	0°	18,854.3778	23,679.4662
147	165° W,	0°	24,112.1004	20,026.9619
148	165° W,	15° S	24,954.7431	18,203.1386
149	165° W,	30° S	25,627.1808	16,190.5036
150	165° W,	45° S	26,154.9594	14,147.7907
151	165° W,	60° S	26,443.1921	12,061.7411
152	165° W,	75° S	26,574.8056	9,970.7851
153	150° W,	75° N	9,995.2908	21,693.0090
154	150° W,	60° N	9,995.2908	23,235.1210
155	150° W,	61.25° N	9,995.2908	23,384.1416
156	150° W,	45° N	11,091.2060	24,521.6641
157	150° W,	30° N	13,191.0959	25,353.5731
158	150° W,	15° N	15,329.3600	25,609.5553
159	150° W,	0°	17,698.0466	25,320.9143
160	150° W,	0°	25,448.5270	20,544.7956
161	150° W,	15° S	26,144.8751	18,560.9383
162	150° W,	30° S	26,735.6012	16,489.4039
163	150° W,	45° S	27,046.2418	14,311.6657
164	150° W,	60° S	27,086.5346	12,150.3189
165	150° W,	75° S	26,910.0566	9,996.8175

Continuation

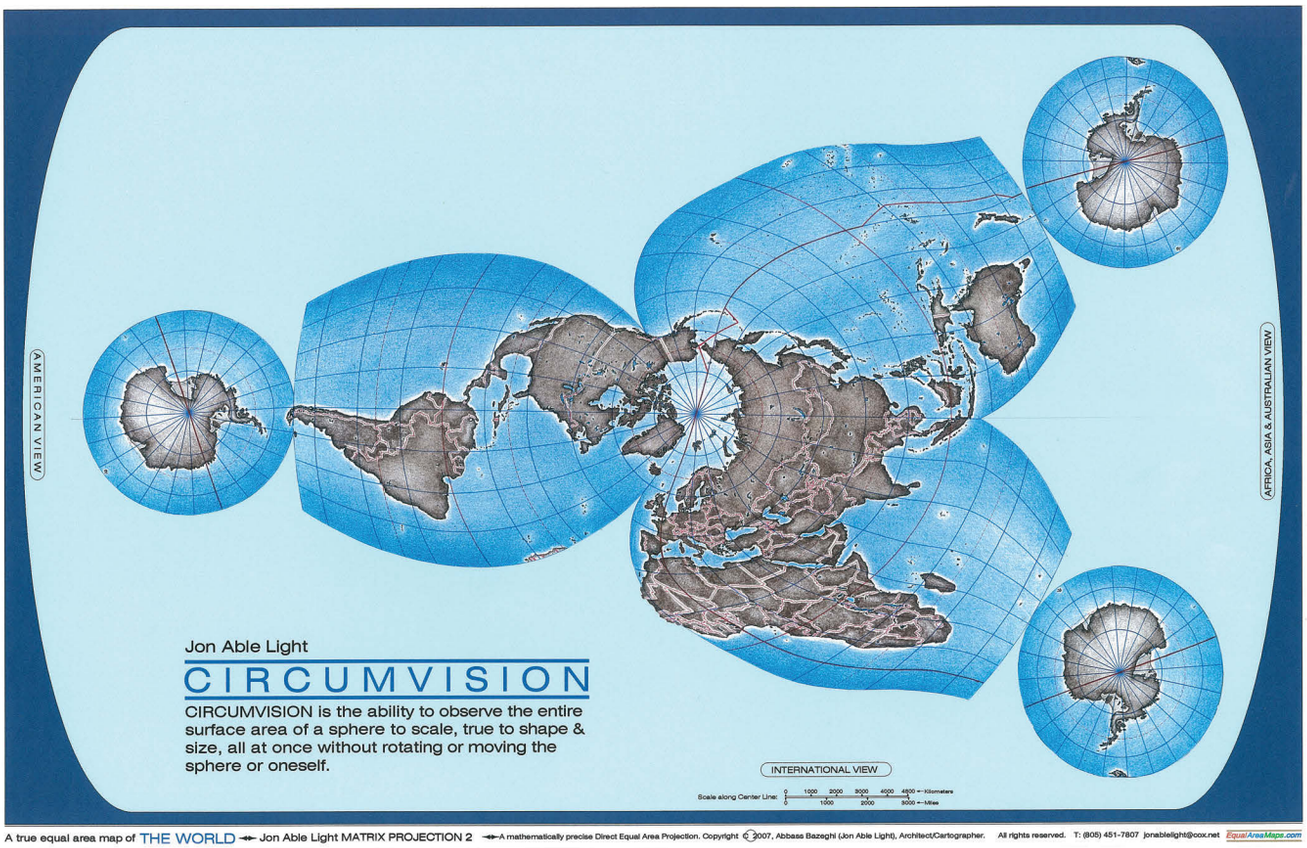




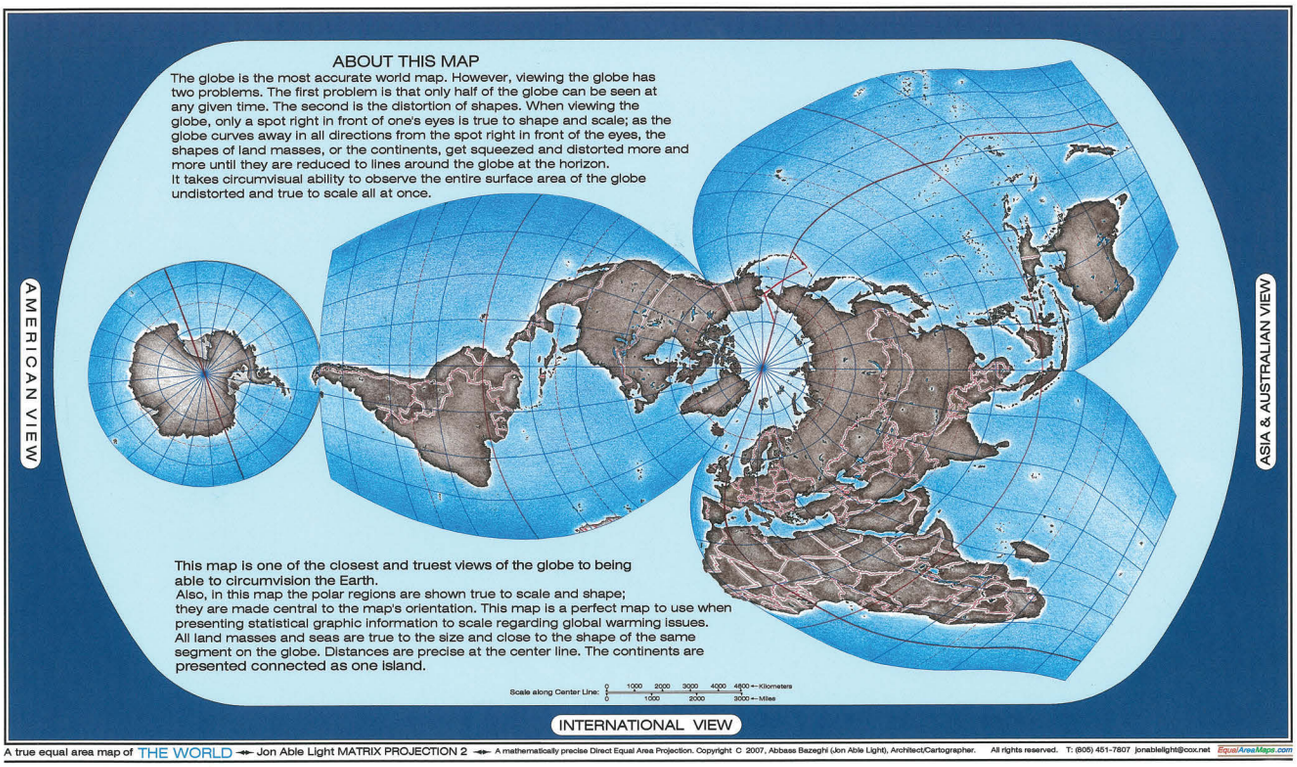
Jon Able Light

MATRIX PROJECTION, INTERPOLATION RESOLUTION

330 Moreton Bay Ln. Goleta, CA 93117 e-mail: jonablelight@cox.net

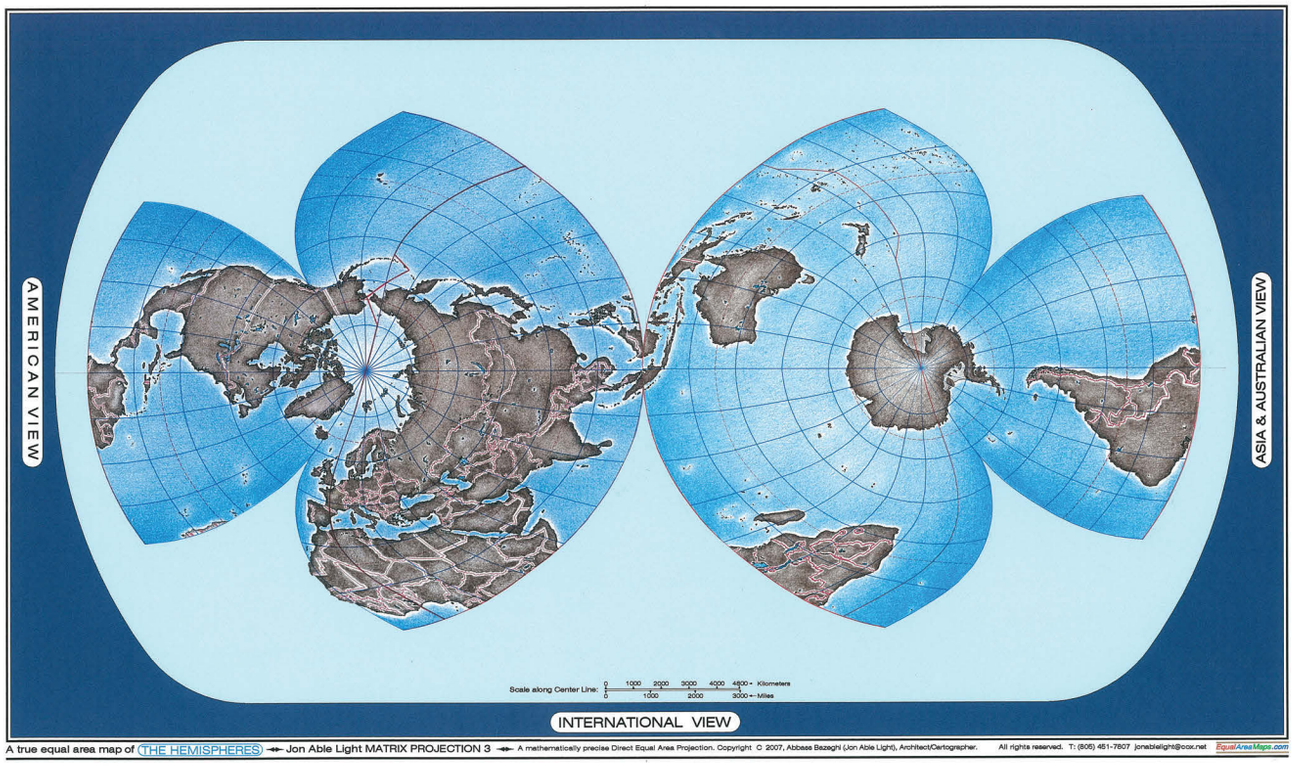


A true equal area map of THE WORLD ⇥ Jon Able Light MATRIX PROJECTION 2 ⇥ A mathematically precise Direct Equal Area Projection. Copyright © 2007, Abbass Bazeghi (Jon Able Light), Architect/Cartographer. All rights reserved. T: (805) 451-7807 jonablelight@cox.net EqualAreaMaps.com



A true equal area map of THE WORLD ⇻ Jon Able Light MATRIX PROJECTION 2 ⇻ A mathematically precise Direct Equal Area Projection. Copyright © 2007, Abbass Bazeghi (Jon Able Light), Architect/Cartographer. All rights reserved. T: (805) 451-7807 jonablelight@cox.net EqualAreaMaps.com

ABOUT THE EARTH Total surface area of the Earth: 197,370,457.1 Sq. Miles (511,187,127.9 Sq. Kilometers). Diameter at the equator: 7,926.2 Miles (12,756.0 Sq. Kilometers)
Total area of the oceans and seas is about 71%, and the land area is about 29% of the total surface area of the Earth. Distance from the Sun: 93 million Miles (149.6 million Kilometers)
World population is about 6.5 Billion by mid 2007, it is increasing at a rate of .14% per year. (about 90 million in 2007) . As much as USA population every 3 years. August 2007



A true equal area map of THE HEMISPHERES ⇻ Jon Able Light MATRIX PROJECTION 3 ⇻ A mathematically precise Direct Equal Area Projection. Copyright © 2007, Abbass Bazeghi (Jon Able Light), Architect/Cartographer. All rights reserved. T: (805) 451-7807 jonablelight@cox.net EqualAreaMaps.com

ABOUT THE EARTH Total surface area of the Earth: 197,370,457.1 Sq. Miles (511,187,127.9 Sq. Kilometers). Diameter at the equator: 7,926.2 Miles (12,756.0 Sq. Kilometers)
Total area of the oceans and seas is about 71%, and the land area is about 29% of the total surface area of the Earth. Distance from the Sun: 93 million Miles (149.6 million Kilometers)
World population is about 6.5 Billion by mid 2007, it is increasing at a rate of .14% per year. (about 90 million in 2007) . As much as USA population every 3 years. August 2007