Why 80 West? Effect of Viewing Geometry on West Coast Pixel Size

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West Coast urban areas and wildfires are of special interest. A spacecraft stationed at 80W longitude is farther away from these locations than a spacecraft stationed at 98W.

Calculation of Footprint Dimensions

The Earth E is considered to be a rigid sphere, and a spacecraft B is assumed to be in geostationary orbit; in other words, B is fixed in E.

When the latitude and longitude of a point T on the surface of E is provided, one may calculate the position vector (boresight) from $B^\star$, the center of B, to T, as well as the position vectors to four points $T_1, \ldots, T_4$ at which the corners of an instrument's square field of view intersect the surface of E. It is then a simple matter to determine the position vectors $\mathbf{r}^{E^\star T_r}$ from $E^\star$, the center of E, to each of T_r $(r = 1, 2, 3, 4)$.

The four-sided patch of the surface of E having vertices $T_1, \ldots, T_4$ is referred to as the instrument's spatial footprint (Instantaneous Field of View, or IFOV). Each of the four sides is an arc on the surface of E, and the length s of the arc is given by

$$s = R_E\,\theta$$

where R_E is the radius of E, and θ is the angle between two of the position vectors $\mathbf{r}^{E^\star T_r}$; for example,

$$\cos\theta = \frac{\mathbf{r}^{E^\star T_1} \cdot \mathbf{r}^{E^\star T_2}}{{R_E}^2}$$

For the purposes of calculating area, the footprint can be regarded as two spherical triangles that share a common side (a diagonal of the footprint). Subtended angles a, b, and c of each spherical triangle can be obtained from relationships having the preceding form, and the angles A, B, and C of the spherical triangle are then determined by employing the familiar law of cosines

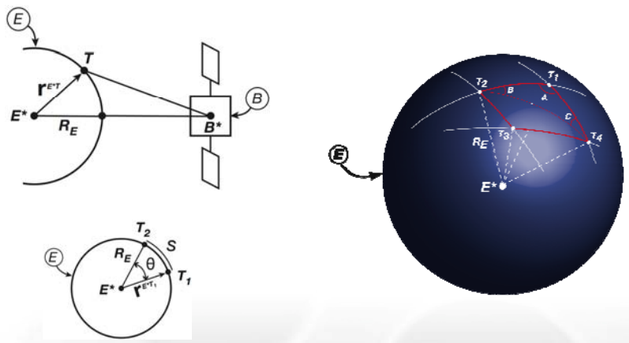
$$\cos a = \cos b \cos c + \sin b \sin c \cos A$$

together with the law of sines

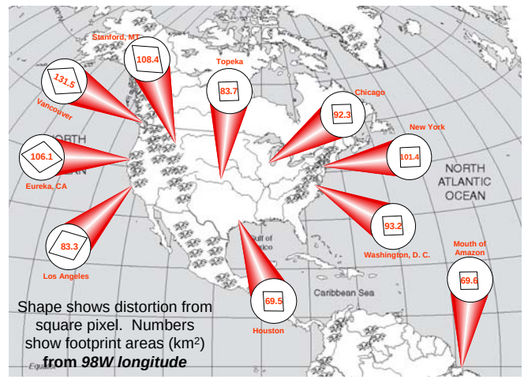
$$\frac{\sin a}{\sin A} = \frac{\sin b}{\sin B} = \frac{\sin c}{\sin C}$$

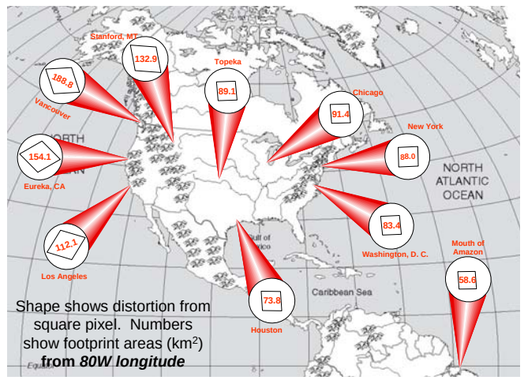
The area $\mathcal{A}$ of the spherical triangle is given by

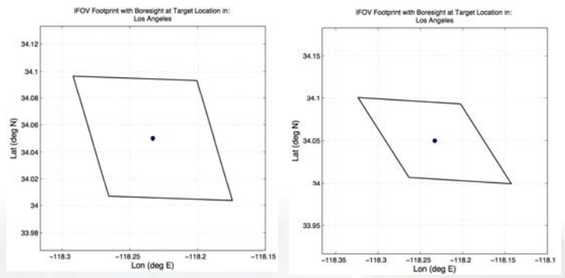
$$\mathcal{A} = (A + B + C - \pi){R_E}^2$$



Relative Footprint Sizes







Location	NE_NW (km)	NW_SW (km)	SW_SE (km)	SE_NE (km)	Area (km²)	Area ratio
98W						
Los Angeles, CA	8.430	10.294	8.426	10.289	83.384	0.996
Houston, TX	7.553	9.204	7.552	9.205	69.481	0.830
Washington D.C.	8.596	11.448	8.590	11.455	93.237	1.114
Chicago, IL	7.930	11.804	7.927	11.808	92.325	1.103
New York, NY	8.965	12.228	8.957	12.238	101.375	1.211
Vancouver B.C.	9.375	15.801	9.359	15.778	131.468	1.570
Mexico City	7.426	8.053	7.425	8.053	59.796	0.714
Rio de Janeiro	17.662	11.486	17.713	11.529	157.038	1.876
Amazon (mouth)	8.776	8.055	8.778	8.057	69.581	0.831
Topeka, KA	7.685	10.903	7.683	10.904	83.724	1.000
Eureka, CA	9.260	12.622	9.250	12.609	106.047	1.267
Stanford, MT	8.135	13.665	8.131	13.658	108.404	1.295
Nadir	7.336	7.336	7.336	7.336	53.818	0.643
80W						
Los Angeles, CA	11.220	11.809	11.202	11.790	112.126	1.259
Houston, TX	7.999	9.396	7.997	9.394	73.826	0.829
Washington D.C.	7.687	10.855	7.686	10.856	83.356	0.936
Chicago, IL	7.848	11.746	7.846	11.743	91.398	1.026
New York, NY	7.775	11.375	7.773	11.376	88.019	0.988
Vancouver B.C.	13.721	20.557	13.635	20.460	188.820	2.120
Mexico City	8.127	8.227	8.125	8.225	66.023	0.741
Rio de Janeiro	10.579	9.281	10.587	9.288	91.062	1.022
Amazon (mouth)	7.515	7.808	7.516	7.808	58.601	0.658
Topeka, KA	8.172	11.227	8.168	11.222	89.060	1.000
Eureka, CA	13.457	15.905	13.405	15.849	154.055	1.730
Stanford, MT	10.075	15.550	10.054	15.523	132.914	1.492
Nadir	7.336	7.336	7.336	7.336	53.818	0.604

Conclusions

The Decadal Survey-assigned GEO-CAPE satellite longitude of 80W is not optimal for urban or wildfire areas in the western U.S.

Footprint areas for western locations from a satellite positioned at a more optimal 98W are smaller by as much as 32%, as compared to the same areas viewed from 80W. (Smaller is better).

At 98W, the average footprint area (of these selected western locations) is 15% larger than at mid-continent. From 80W, the average is 26% larger.

The increased footprint size variation from 80W can adversely affect measurement variability and the overall error budget.