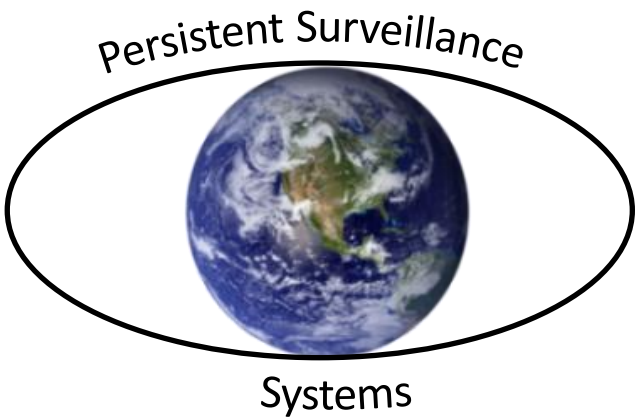
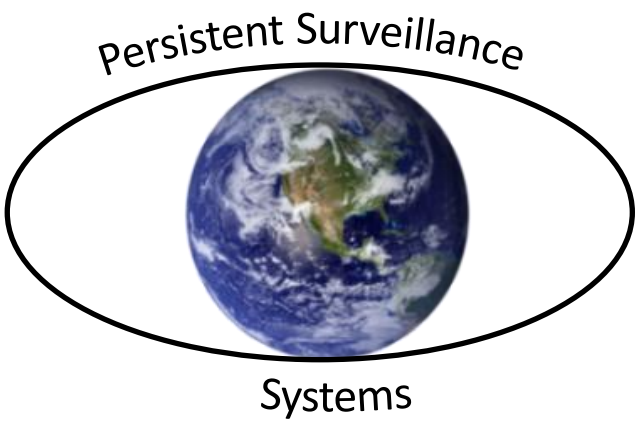


Wide Area Motion Imagery Technical Overview

Dr Ross McNutt

Technical Aspects of Wide Area Surveillance

- Pixels, Pixels, and more Pixels
- Coverage
  - Look Angles, Orbits, and Altitude
- Georectification and Orthorectification
  - Elevation Maps, Camera Models, and IMUs
- Data, Data, and more Data
  - Compression
  - Data Links
  - Data Storage
- Color Images



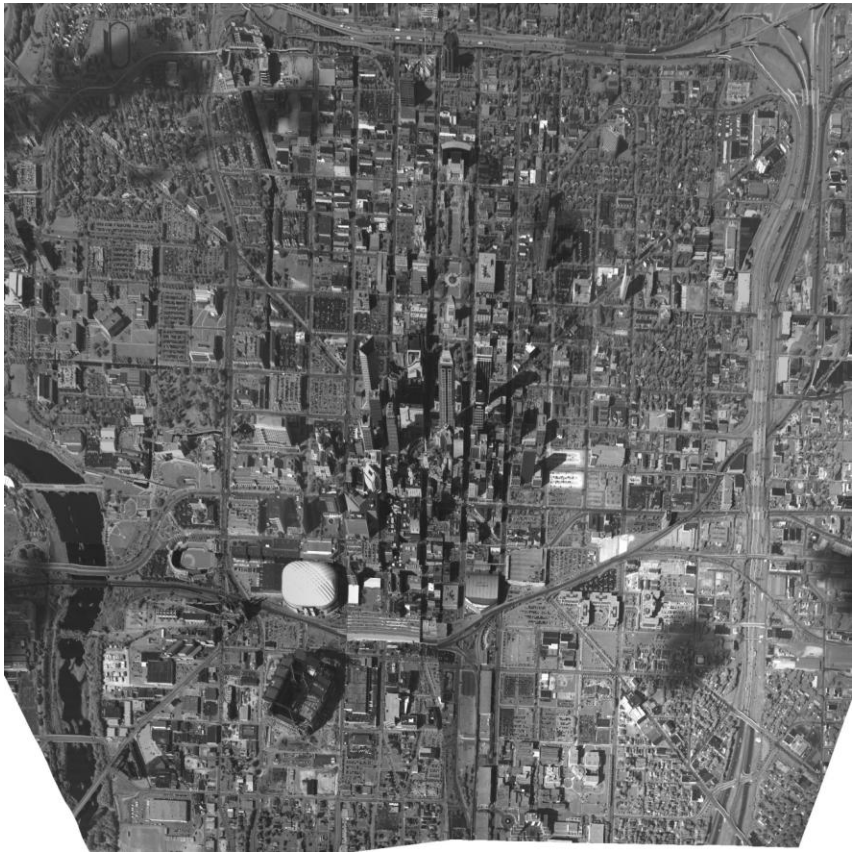
Pixels, Pixels, and More Pixels

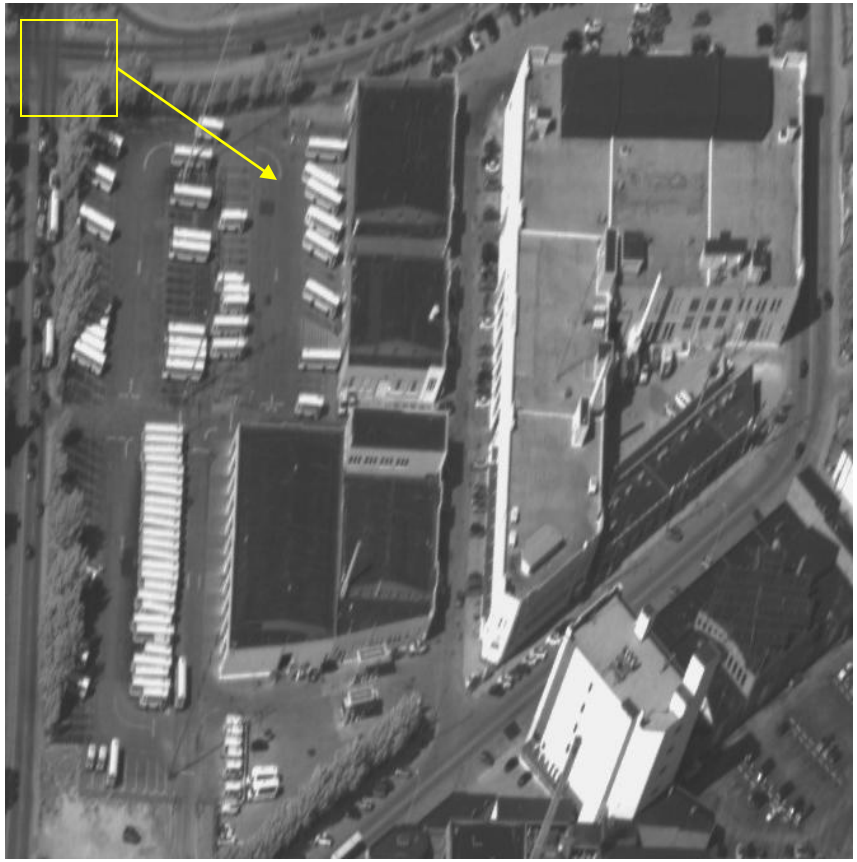
Resolution and Area

PSS Wide Area Surveillance

How many cameras would it take to cover this areas?

Indianapolis Downtown





Megapixels
Our Experts

- http://www.youtube.com/watch?v=i9r7BUzKMGY&feature=related

- http://www.youtube.com/watch?v=R0PM5sZQztg&NR=1

Resolution

- Pixels
- Resolution
- Ground Sampling Distance (GSD)

http://www.youtube.com/watch?v=i9r7BUzKMGY&feature=related

http://www.youtube.com/watch?v=R0PM5sZQztg&NR=1

Samples of Pixels

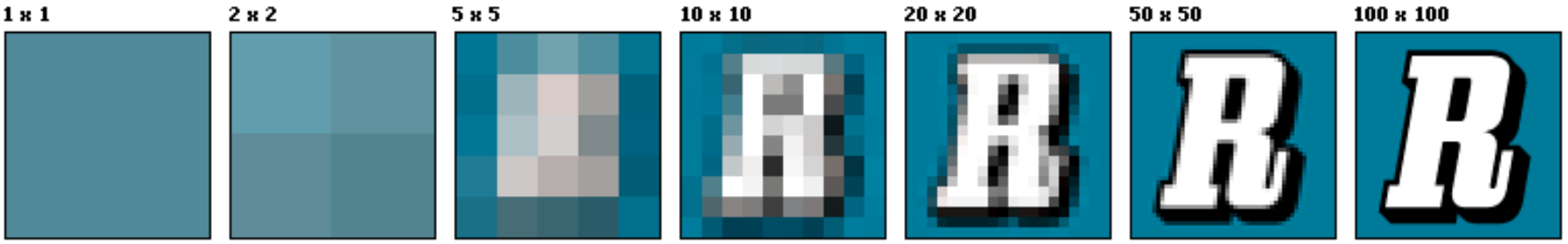
Typical Security Camera	320 x 240	0.08 MP
Standard TV	640 x 480	0.31 MP
HD TV 720P	1280 x 720	0.92 MP
HD 1080	1920 x 1080	2.07 MP
Digital Cinema 2K	2048 x 1080	2.21 MP
Imax Digital Cinema 4k	4096 x 2160	8.84 MP
PSS Hawkeye		99 MP
PSS Hawkeye II		192 MP

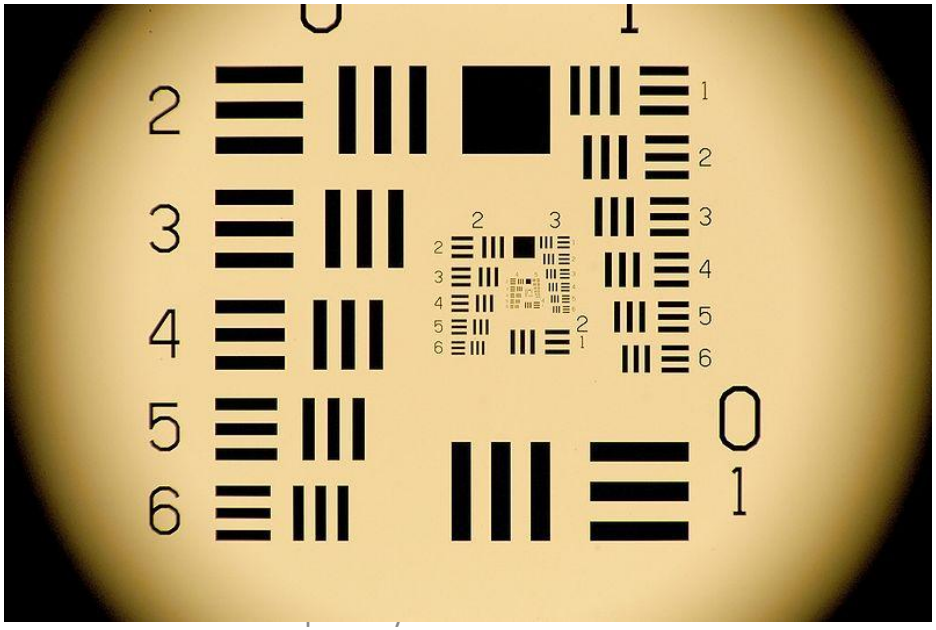
GSD

Ground Sample Distance (**GSD**) is the spacing of areas represented by each pixel in a digital photo (such as an orthophoto) of the ground from air or space. For example, in an image with a one-metre GSD, each pixel represents a ground area of 1 square metre.[1] GSD is a measure of one limitation to image resolution, that is, the limitation due to sampling.[2]

Google and or PSS Example

Resolution Required





Our Resolution Objectives

- Be able to track humans from areas of interest to vehicles
- Be able to track vehicles from areas of interest to place of origin and place of destination
- Maximize coverage area

NIIRS

National Image Interpretability Rating Scales

NIIRS 1	> 9 meters	Ports and Runways
NIIRS 2	4.5 to 9	Large Hangers
NIIRS 3	2.5 to 4.5	Large Aircraft Wing Configuration
NIIRS 4	1.2 to 2.5	Identify Fighters
NIIRS 5	.75 to 1.2	Identify radar as vehicle mounted
NIIRS 6	.4 to .75	Identify Spare tire on truck
NIIRS 7	.2 to .4	detect details of the silo door hinges
NIIRS 8	.1 to .2	Identify rivet lines on Bombers
NIIRS 9	less then .1	Distinguish screw heads on AC skin

Track a Car

Track a Human

Event Locations 27 Feb 10

Part I Crime

Victim Shot at 13:40:42 - 27 Feb 2010

Part I Crime

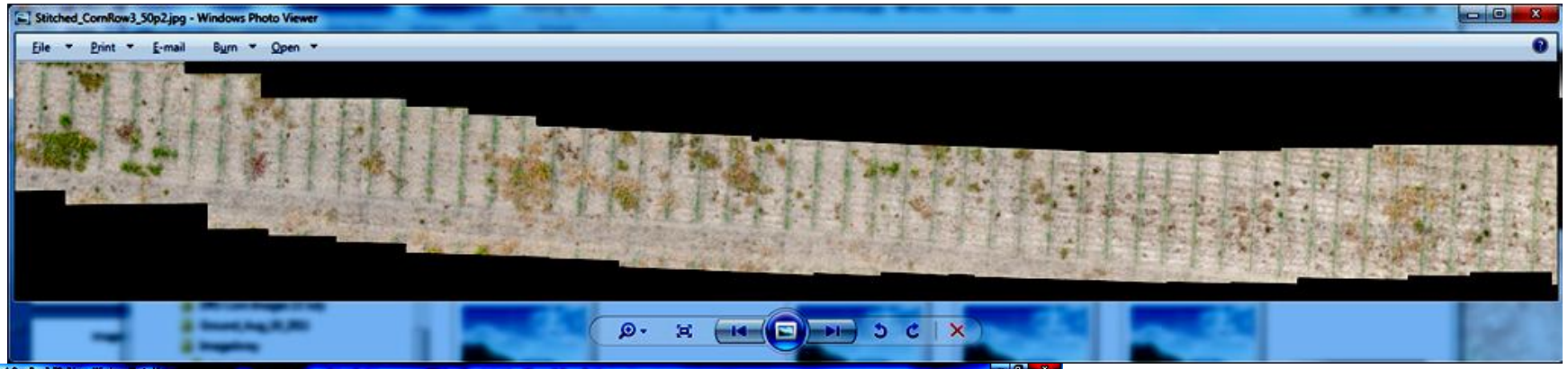
Victim Shot at 13:56:16 – 27 Feb 10

Shot of actual shooter, victim and getaway car
Accomplice car 2 (left) also shown waiting around the corner

Not Our Resolution Objectives

- Identify vehicles specific type of vehicle
  - 6 inch resolution
- Read License Plates
  - 3 cm resolution - wrong look angle
- Identify people
  - 1 cm resolution
- Determine if someone is armed
  - 2 cm resolution
- If I had more pixels would want to cover more area
- Use secondary higher resolution systems

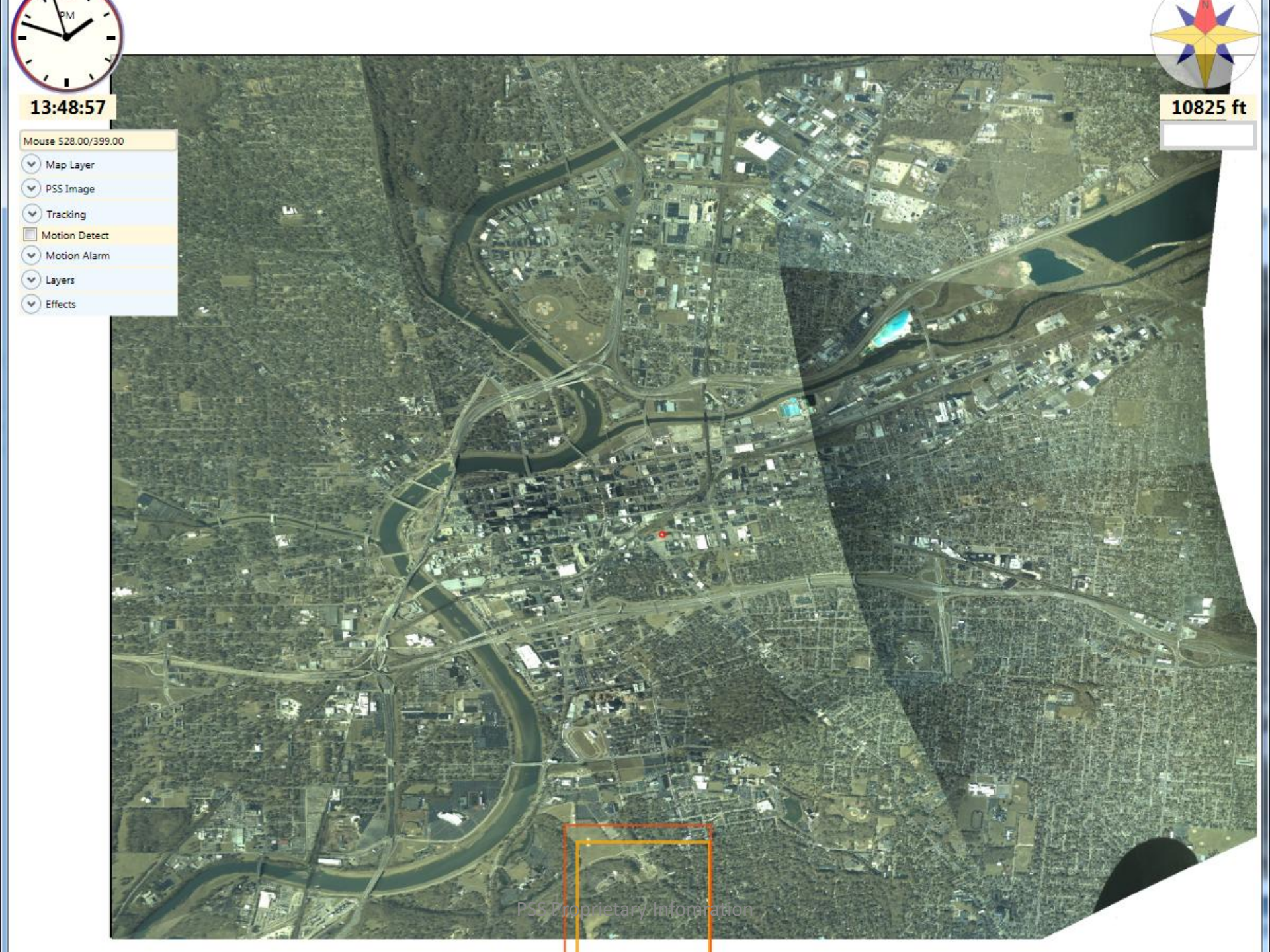
Stitched 200mm Imagery



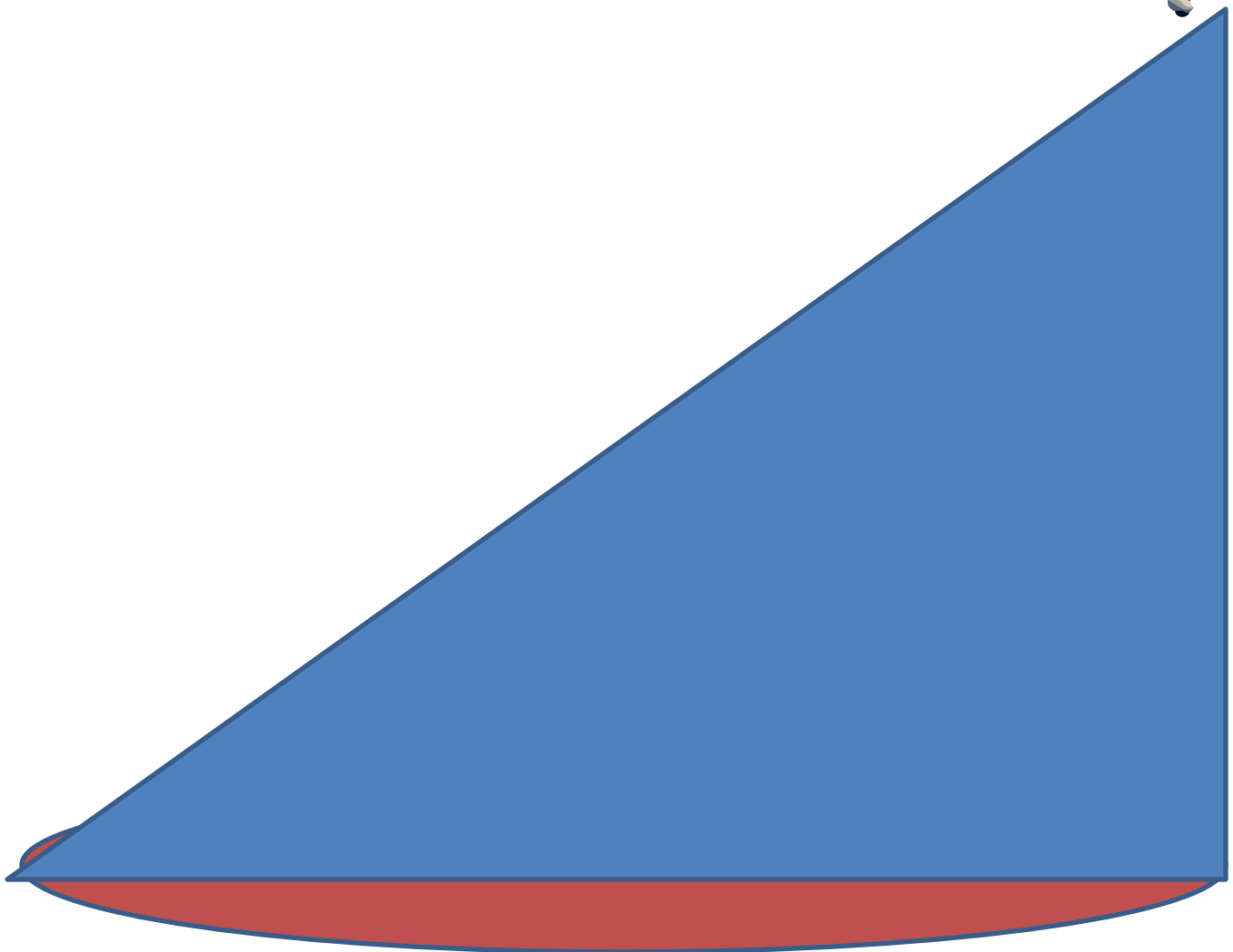
Sample Stitching

Sample Seams

Sample Resolution

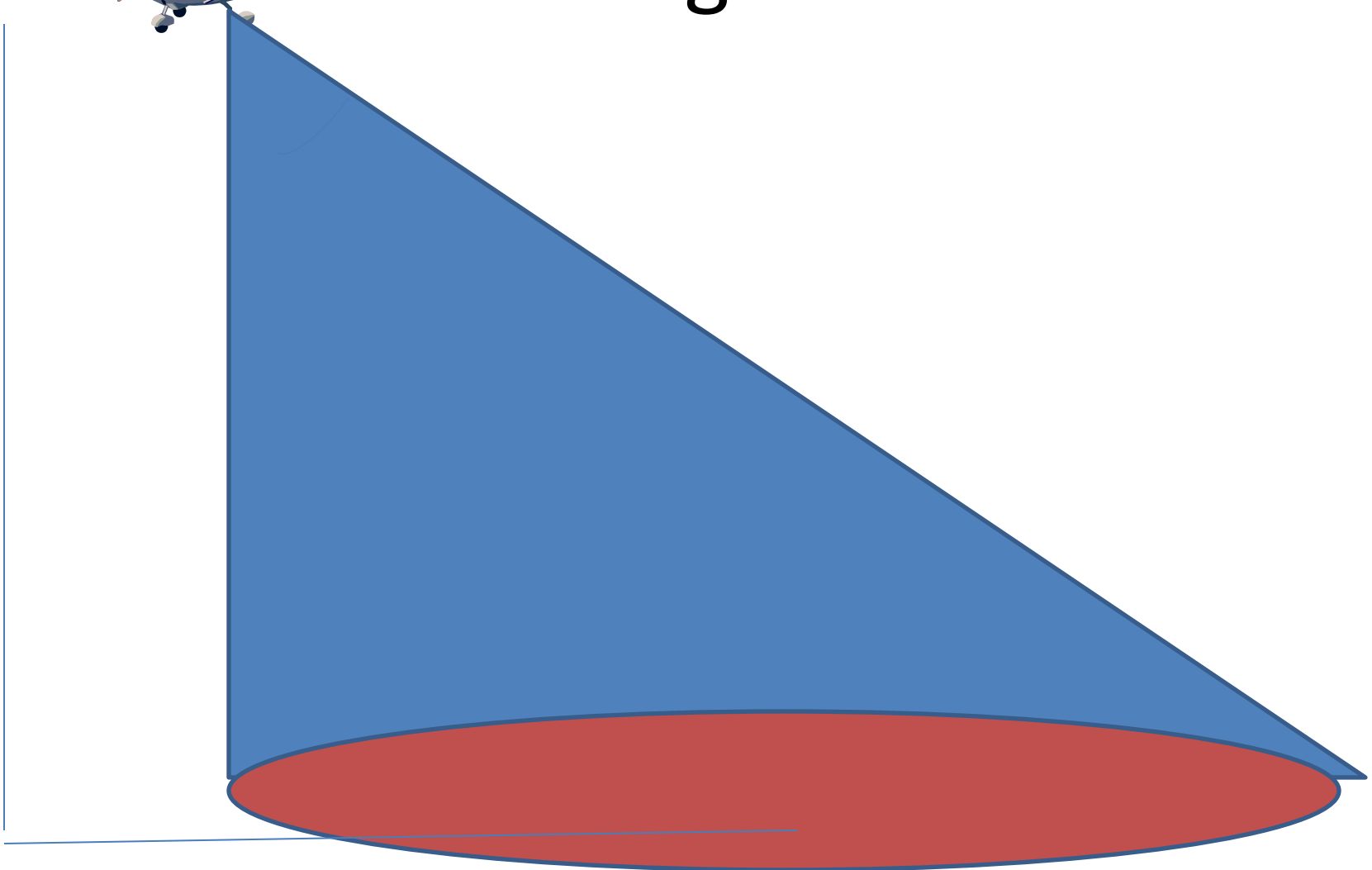

PM
13:48:57
Mouse 528.00/399.00
Map Layer
PSS Image
Tracking
Motion Detect
Motion Alarm
Layers
Effects
10825 ft
PSS Proprietary Information

Coverage Area

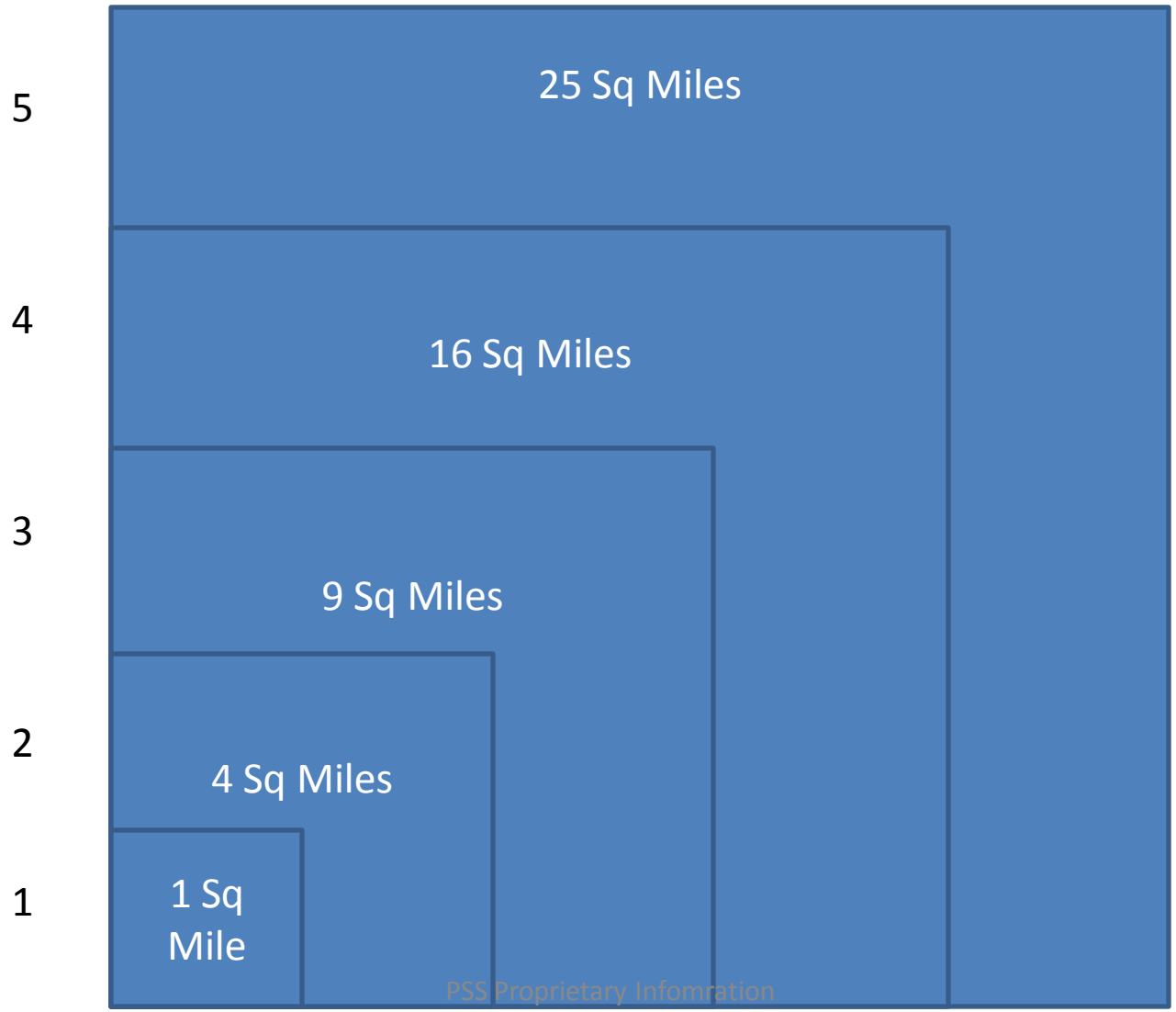


Persistent Surveillance Systems

Coverage Area



Coverage Area

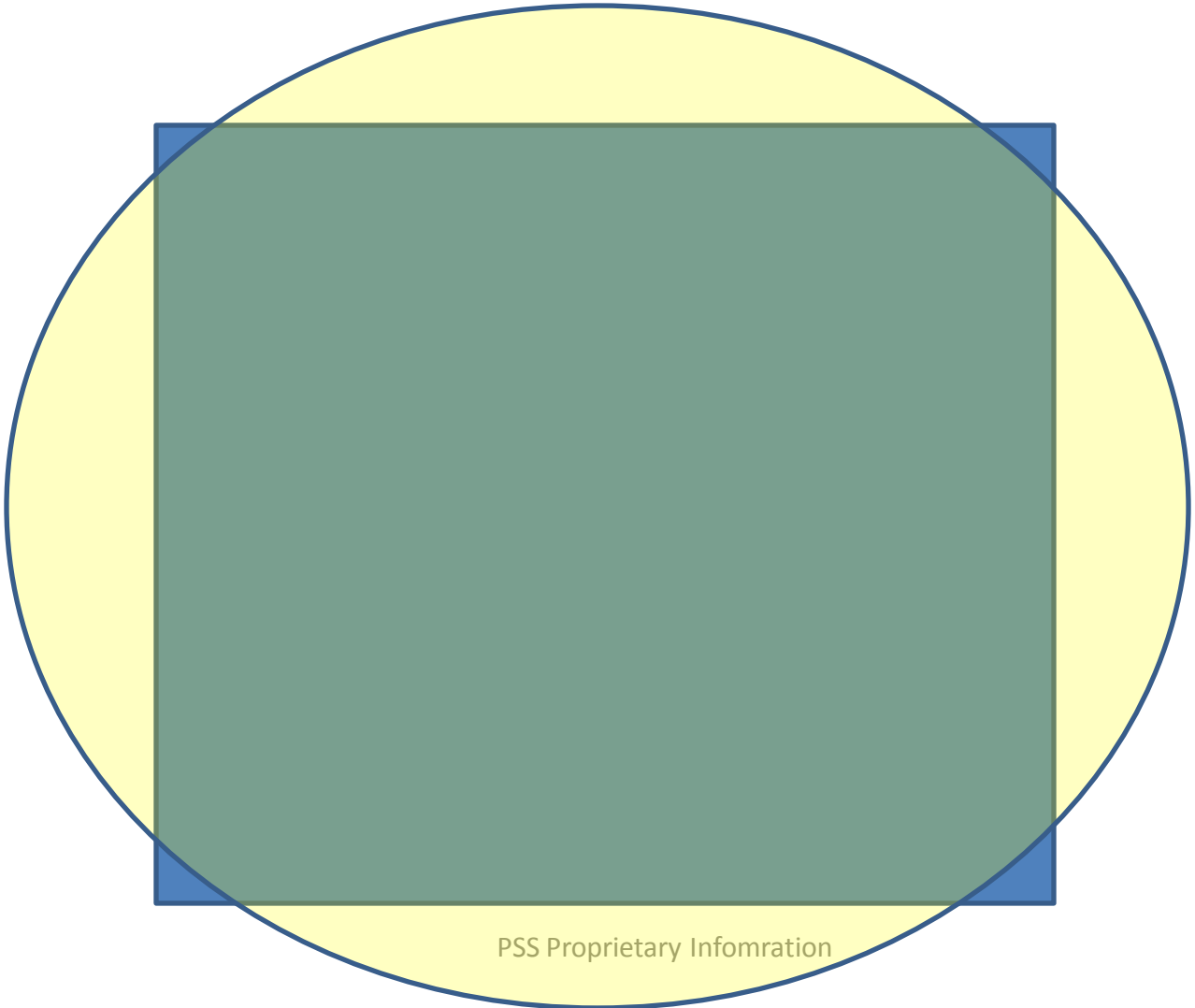


Resolution and Area

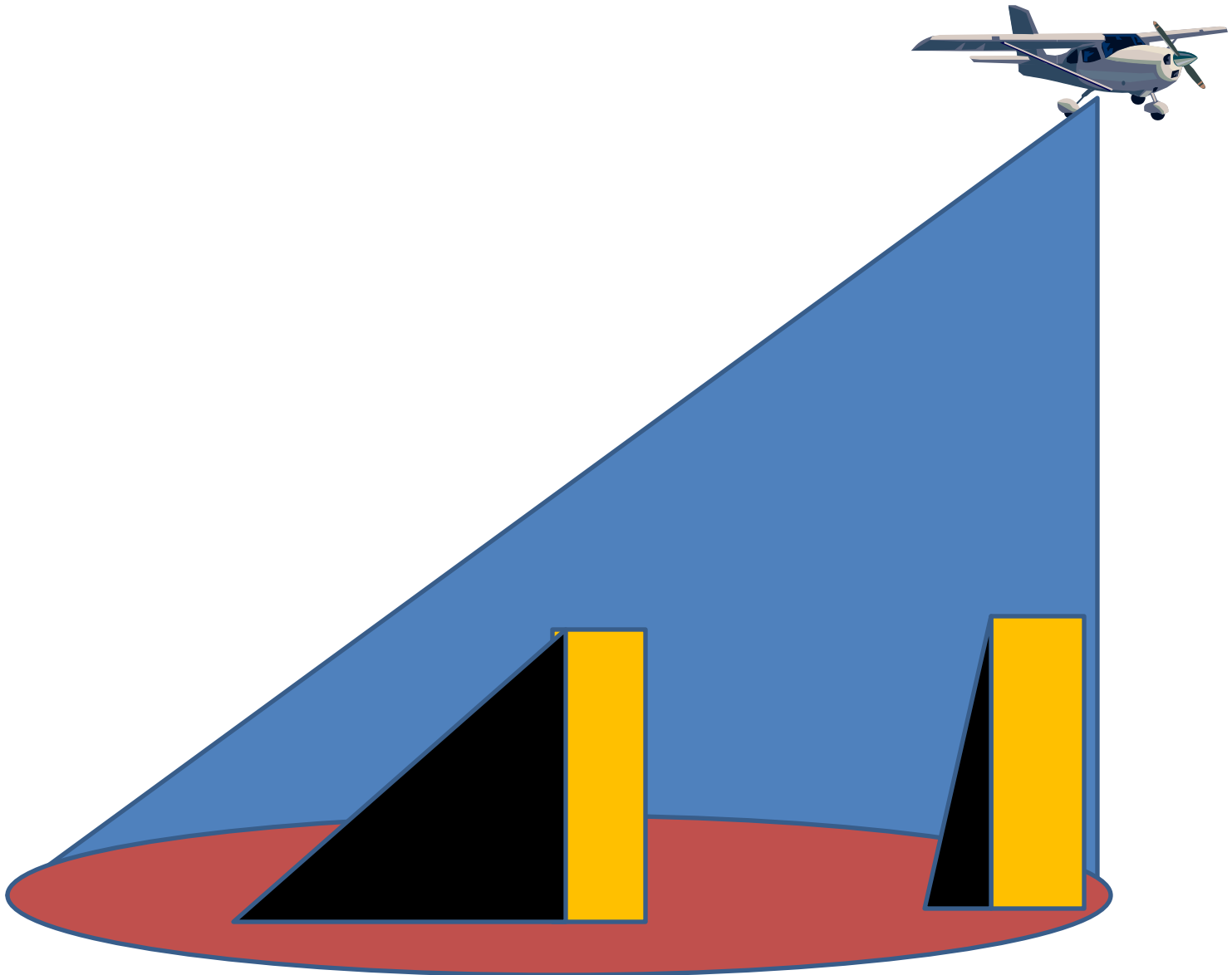
1 Square Mile

	Feet	1 yard	1 foot	6 inches	3 inches	1 inch	.5 inch	.25 inch
	5280	3	1	0.5	0.25	0.083333333	0.041666667	0.02083333
	5280	1760	5280	10560	21120	63360	126720	25344
1 yard	3	1760	3,097,600	9,292,800	18,585,600	37,171,200	111,513,600	223,027,200	446,054,400
1 foot	1	5280	9,292,800	27,878,400	55,756,800	111,513,600	334,540,800	669,081,600	1,338,163,200
6 inchs	0.50	10560	18,585,600	55,756,800	111,513,600	223,027,200	669,081,600	1,338,163,200	2,676,326,400
3 inches	0.25	21120	37,171,200	111,513,600	223,027,200	446,054,400	1,338,163,200	2,676,326,400	5,352,652,800
1 inch	0.08333 3	63360	111,513,600	334,540,800	669,081,600	1,338,163,200	4,014,489,600	8,028,979,200	16,057,958,400
.5 inch	0.04166 7	126720	223,027,200	669,081,600	1,338,163,200	2,676,326,400	8,028,979,200	16,057,958,400	32,115,916,800
.25 inch	0.02083 3	253440	446,054,400	1,338,163,200	2,676,326,400	5,352,652,800	16,057,958,400	32,115,916,800	64,231,833,600

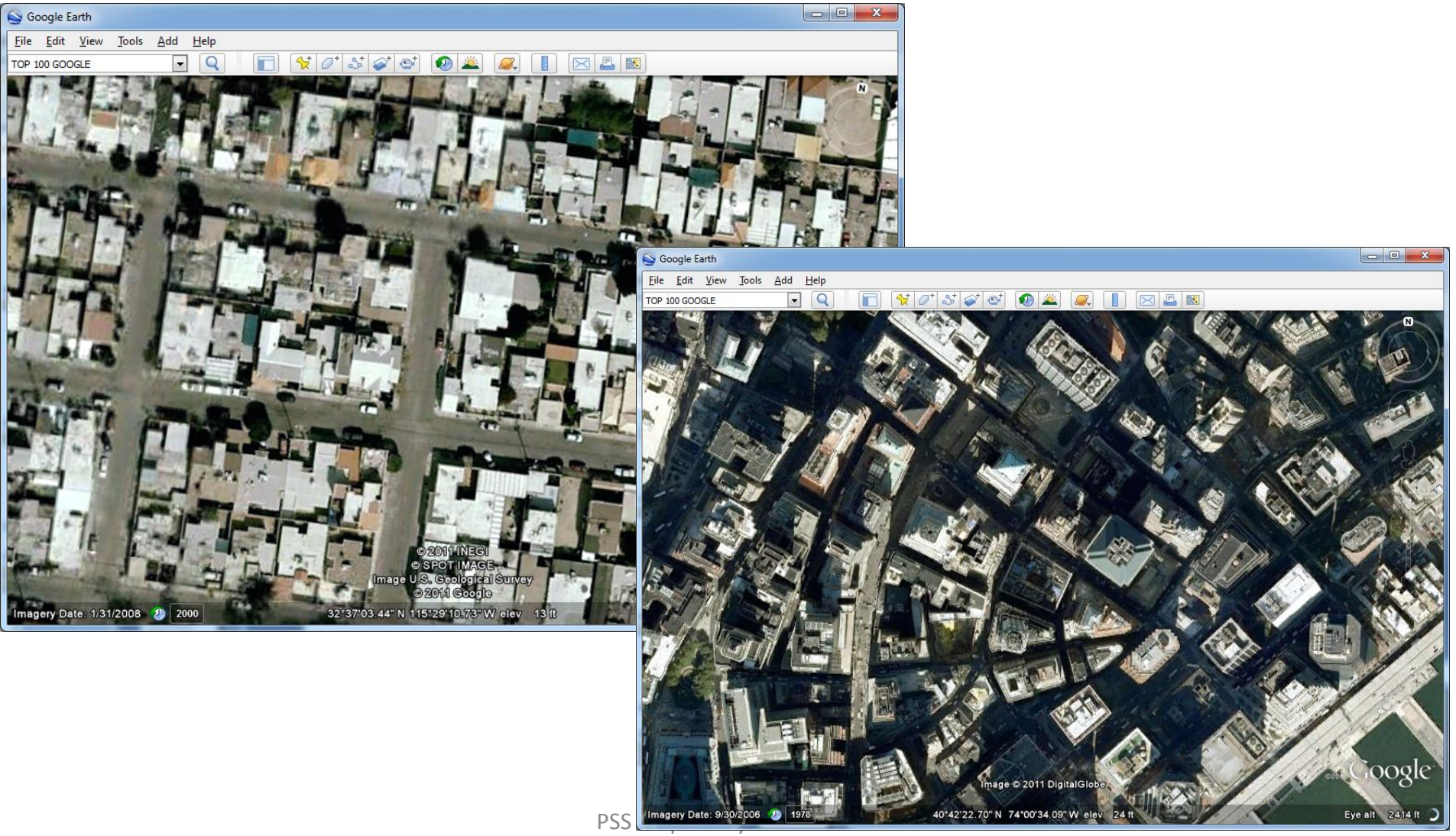
Continuous Coverage Area



Look Angles and Shadowing



Terrain


Google Earth
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TOP 100 GOOGLE
© 2011 INEGI
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Image U.S. Geological Survey
© 2011 Google
Imagery Date: 1/31/2008 2000
32°37'03.44" N 115°29'10.73" W elev 13 ft
Google Earth
File Edit View Tools Add Help
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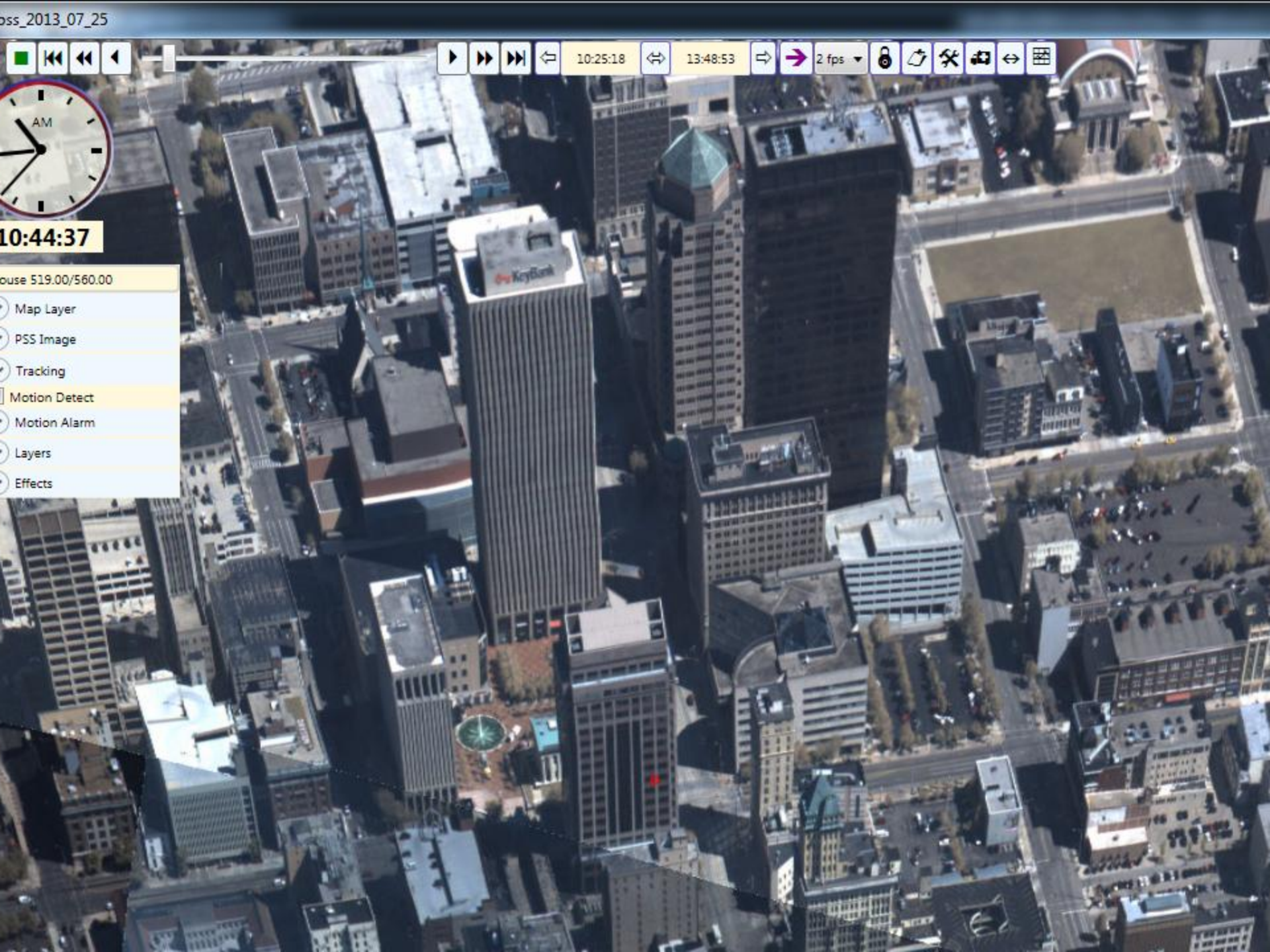
40°42'22.70" N 74°00'34.09" W elev 24 ft
Eye alt 2414 ft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2 fps
AM
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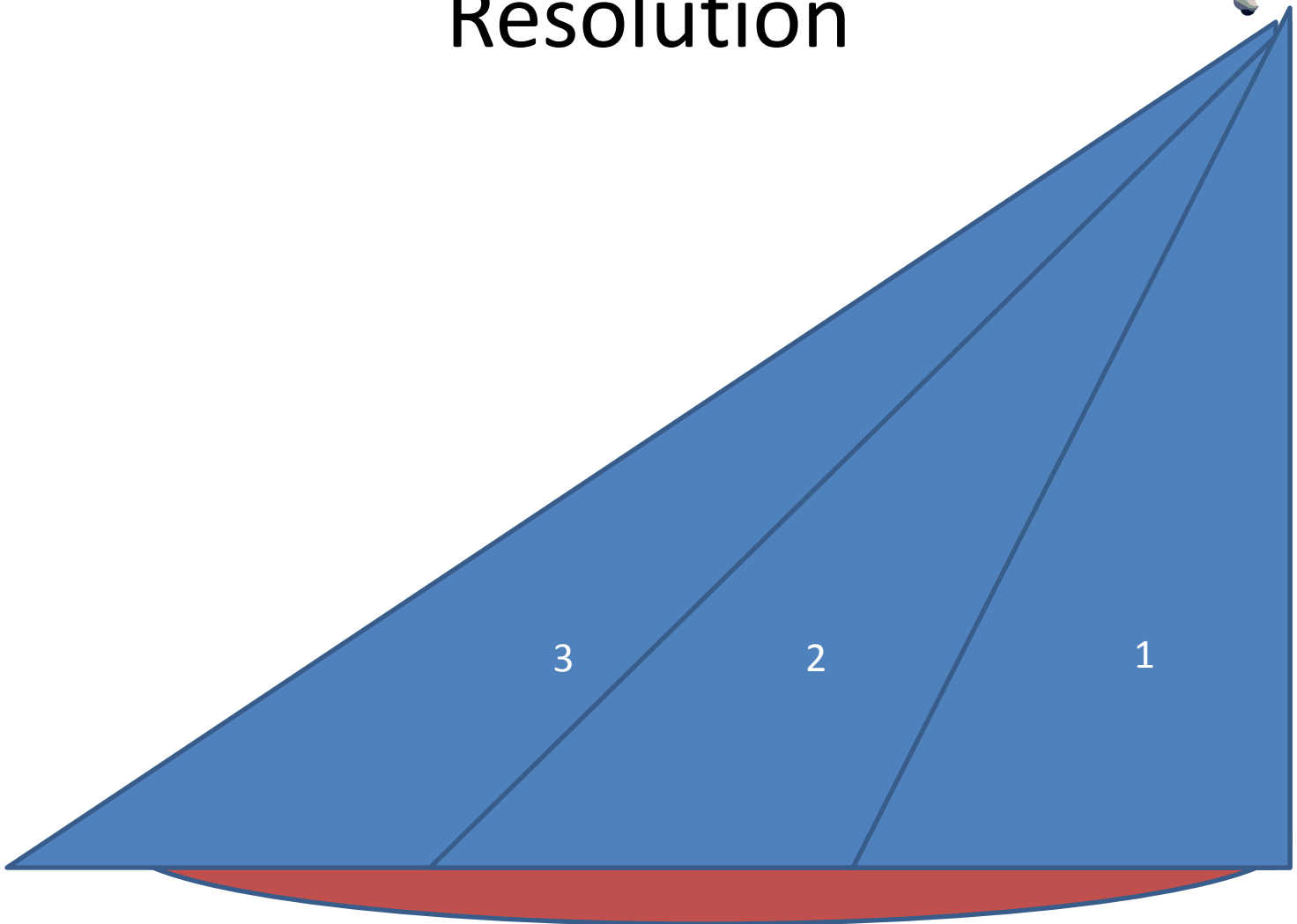
ouse 519.00/560.00
Map Layer
PSS Image
Tracking
Motion Detect
Motion Alarm
Layers
Effects
KeyBank

Coverage Area Resolution



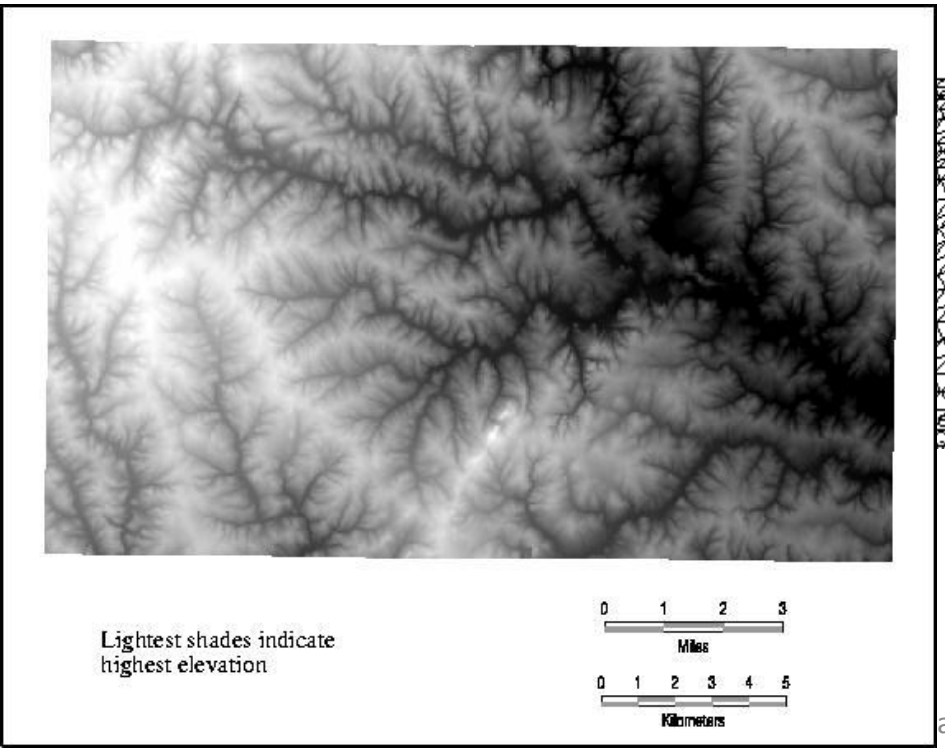
OrthoRectification

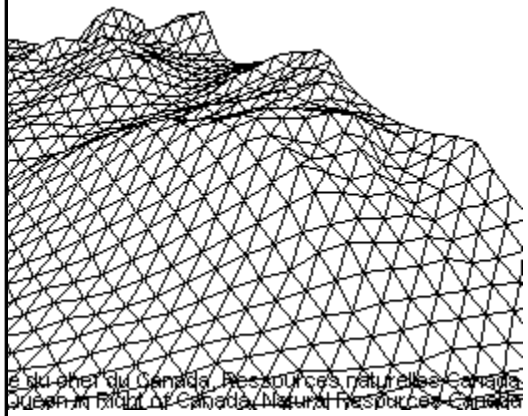
An **orthophoto, orthophotograph** or **orthoimage** is an aerial photograph geometrically corrected ("orthorectified") such that the scale is uniform: the photo has the same lack of distortion as a map. Unlike an uncorrected aerial photograph, an orthophotograph can be used to measure true distances, because it is an accurate representation of the Earth's surface, having been adjusted for topographic relief[1], lens distortion, and camera tilt.

Inertial Measurement Unit

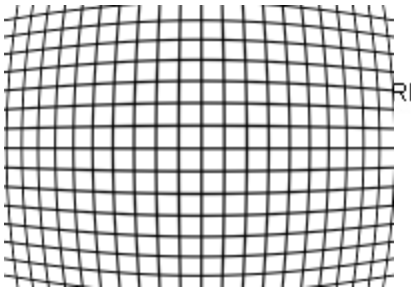
- Where your camera is
  - Latitude, Longitude, Altitude
- Where your camera is looking
  - Roll, Pitch, and Yaw angles
- Errors
  - Offset – Misalignment
  - Random Shot to Shot

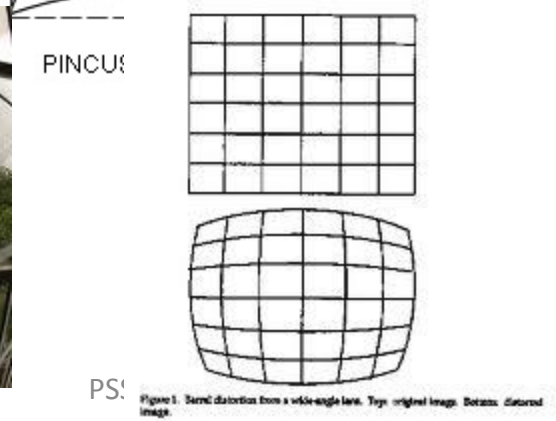
Digital Elevation Maps





Lens Distortion





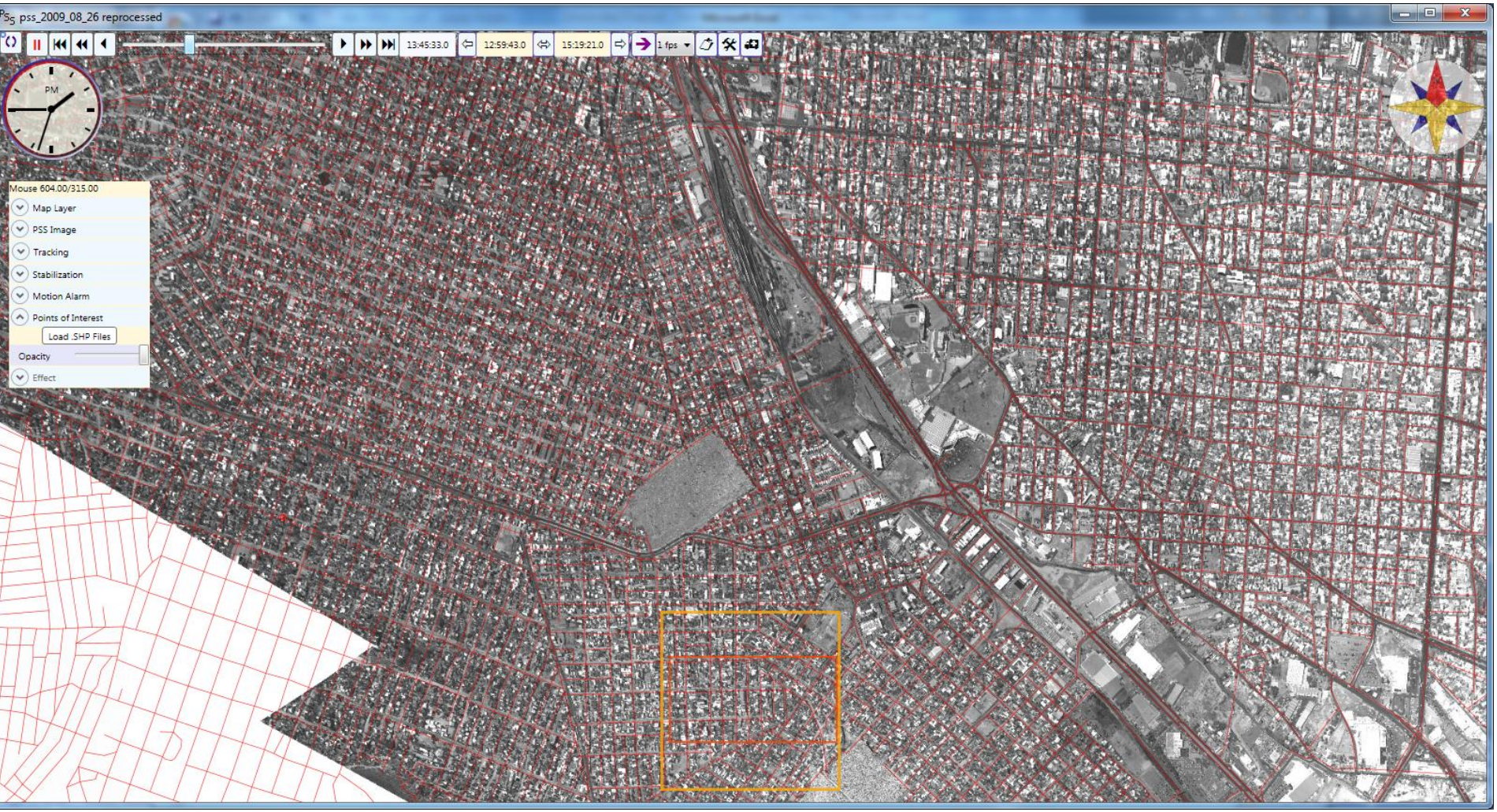
Camera Model

- Location
- Overlap
- 11 elements per camera
- 9 to 12 cameras

132 parameters to optimize

Image quality and location

Objective getting images where they are supposed to be on the map



Data, Data, and More Data

Sample

- PSS Image File ~60 MB
- 3600 images per hour
- 6 hour mission

- 6 Hours x 3600 Sec/Hour x 60 MB/Sec = 1.29 TB

- 150 day storage = 194 TB

Data Management and Distribution Data Storage and Server Systems

- PSS 200 TB Affordable Disk Array
  - Up to 180 days of data
  - Portable (small bar fridge sized on wheels)
  - Raid 6 dual failure data protection
  - Easily expandable
  - Up to 10 Gbps Interface

- Integrated PSS Servers
  - PSS Image Server
  - PSS Investigation Data Base Server
    - Incident based information tracks,
    - imagery, records
  - PSS Incident Locator Server
  - PSS Locate Server
  - Map Server
    - GIS information , Comm Imagery,
    - Shape Files

Image Compression

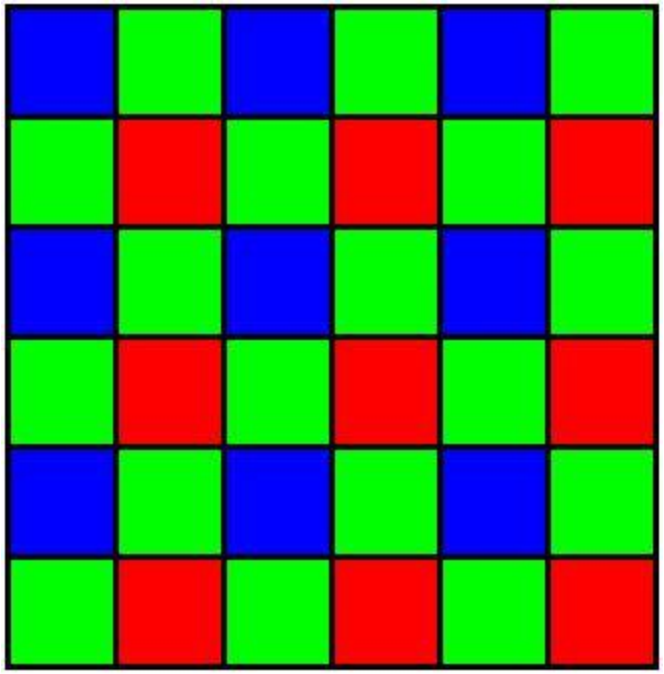
- Processed Imagery 495 MB/Image
- JPEG Compression 5-10 to 1 ~60 MB/Image
- Also cuts bandwidth per user by factor of 5 to 10

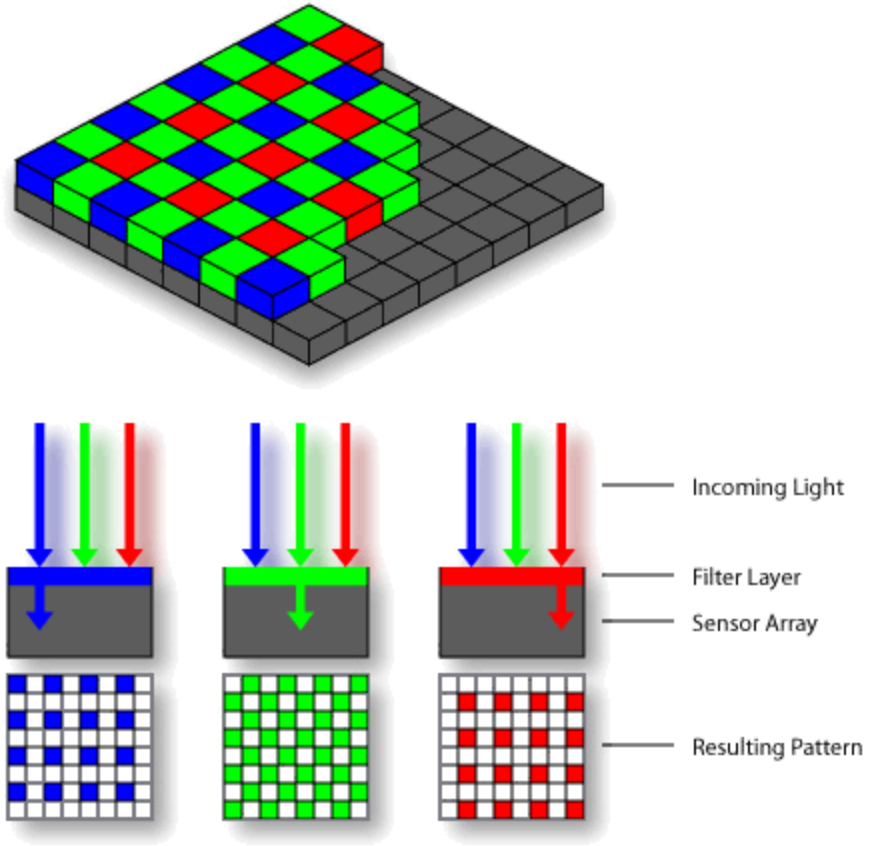
JPEG Artifacts

Color vs. Monochrome

Monochrome	Color
8 bits per pixel	24 bits per pixel
256 shades of grey	16 mil colors
Medium color car	Blue, red, green Car

Bayer Pattern - Color





http://www.youtube.com/watch?v=2-stCNB8jT8&NR=1&feature=fvwp


AM
10:44:48
Mouse 972.00/405.00
Map Layer
PSS Image
Tracking
Motion Detect
Motion Alarm
Layers
Effects
PSS Proprietary Information