

he NIKE missile was the first operational supersonic surface-to-air missile. The Nike Ajax and Hercules versions were l-weather weapons with a range of 30-90 miles to altitudes from 60,000 to greater than 100,000 feet. Nike sites onsisted of an Integrated Fire Control facility (IFC) and a separate Launch Facility located relatively nearby. Between 1954 to as late as 1979, operational Nike anti-aircraft missiles sites surrounded numerous cities and Defense Areas in he United States to protect them from attack by Soviet long-range bombers such as the Tupolev Tu-95 Bear. Site Summit in Alaska and site HM-40 in Florida were the last sites to close, closing in 1979.

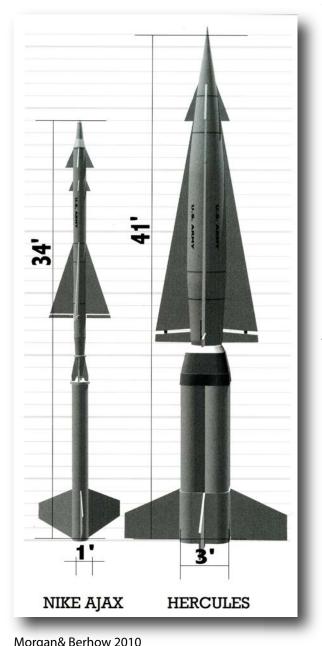
xpanding the original Patterned Ground project that I began in 2013, Patterned Ground II adds georeferenced historical aerial imagery to a new base map of the NIKE missile launch sites located around major urban centers and Defense Areas in the United States. I downloaded from the USGS EarthExplorer site historic aerial photographs from the 1950s, 1960s and 1970s showing operational sites. Metadata associated with these images provide lat/long coordinates for the image corners, but georeferencing is difficult when the corner marks are obscured in the scans and/or the imagery has been rotated such that the values do not reflect the correct corner positions.

Using the new Arc2Earth extension for ArcGIS, Google Earth imagery can be loaded directly into ArcMap and used as a base map for visually georeferencing these historic images. The Arc2Earth imagery provides seamless, high resolution coverage eliminating the need to download individual recent orthoimages, as previously needed, to visually georeference a historic image. The Google Earth imagery allows for easy comparison between land use/land cover when the site was operational and the current land use/land cover of the same area.

In order create composite KMZ files for use by the NIKE Historical Society and others, I needed to do additional processing. Raster data exported as KMZ files directly from ArcMap do not display well in Google Earth. To improve the quality of the KMZ file, I exported the georeferenced image files from ArcMap as TIFFs, opened them in Global Mapper and exported them using Global Mapper's KMZ export function, which creates a "super overlay" allowing Google Earth to display a quality raster image of the spatially located historic airphoto.

# <u>The Nike Defense System</u>

The NIKE defense system was de signed to replace World War II era anti-aircraft batteries, becomir operational in the mid to late 1950s and remaining operationa until the late 1970s. The initial installations used the liquid fueled NIKE-AJAX missile. This was a two stage missile with a conventional high-explosive warhead and limited range. It was soon recognized that the NIKE-AJAX was inadequate for stopping the develop ing Soviet bomber threat and these missiles were replaced with the more powerful solid fueled two stage NIKE-HERCULES missile. These missiles had a longer range, could achieve a higher altitude and were capable of carrying a high explosive or nuclear warhead NIKE AJAX HERCULES of varying yields.



A NIKE missile site consisted of two operational sections, the Integrated Fire Control (IFC) and a launch area where the mis siles were stored and launched. The IFCs were not located far from the launch areas (minimum o direct "line of sight" contact with the launch areas.

lorgan& Berhow 201

The target: 2008 photo of an RAF

fighter escorting a Russian Bear air-

craft over the North Atlantic. The

AN602 Tsar Bomba (Царь-бомба) the

most powerful nuclear weapon ever

1961 remains the most powerful arti-

ficial explosion in human history. The

mated the yield at 50-60 megatons or

power of the bombs dropped on Hi-

Atomic Energy Commission esti-

1350 -1570 times the combined

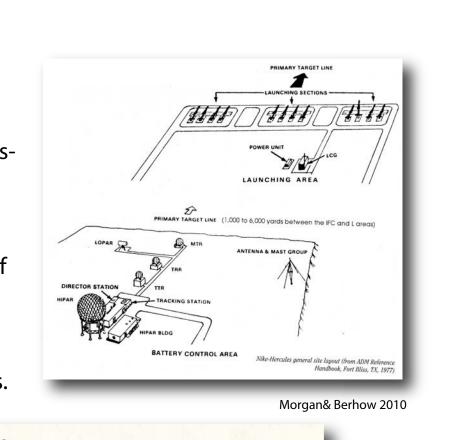
roshima and Nagasaki.

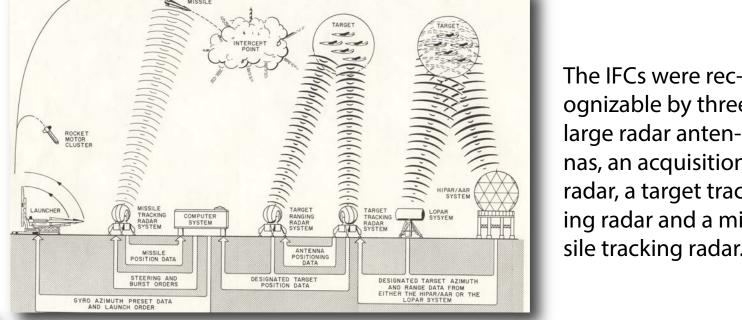
(http://en.wikipedia.org/wiki/Tsar\_Bomb

detonated. The test on October 30,

TU-95 carried and dropped the

QRA (Quick Reaction Alert) Typhoon





ognizable by three large radar antennas, an acquisition radar, a target track ing radar and a missile tracking radar.



Western Electric PDF

tp://nikemissile.org/Ajax.shtml tp://nikemissile.org/IFC/nike\_hercules.shtm Nike Ajax (left) and Hercules (right) during test launches



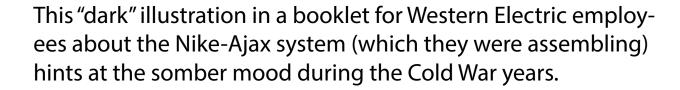
From the same publication, this illustration of the Nike-Ajax and Hercules system shows all the major components of the system with the IFC and radars on the hill in the background, the launch area with the distinctive earthen berms around the fueling and war head placement area and the complex underground bunker system lying below the visible launch pads with the missile storage area and elevators to raise the missiles to the launching rails. Each of these underground bunkers are 5,000 square feet in area.

Notice the city skyline on the horizon labeled as the "DEFENDED AREA".

### One of the first operational sites was in Lorton, Virginia. Construction began in March of 1954 and site was operational in 1955. Secretary of the Army, Charles C. Finucane labeled it the "National NIKE Site" and hosted visits by foreign dignitaries and national and local politicians.

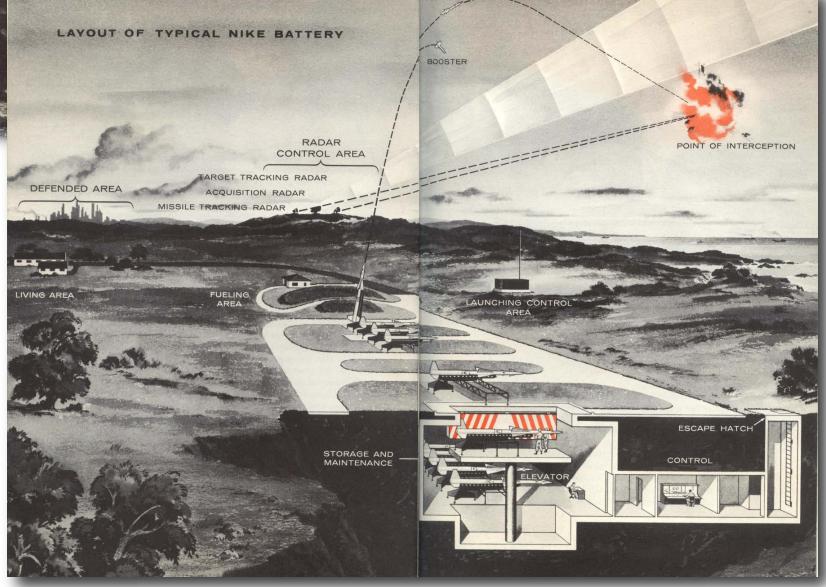


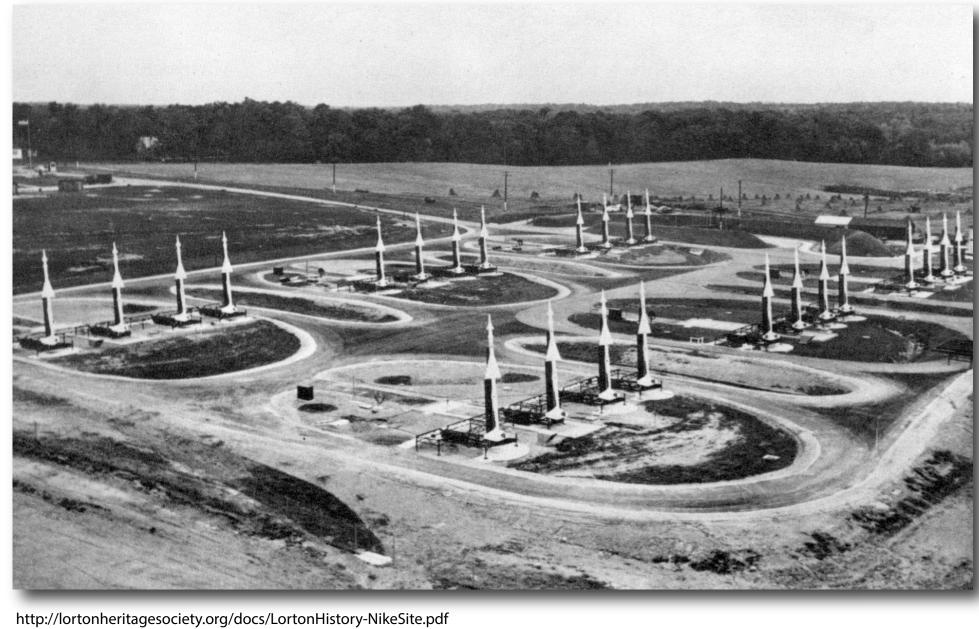
http://www.hmdb.org/marker.asp?marker=2092



Although the Ajax missiles only carried conventional high explosive warheads, these missiles were soon replaced by the Nike-Hercules missiles that were capable of carrying nuclear warheads and had not only surface-to-air capability but some ere modified to be surface-to-surface capable as well.

http://nikemissile.org/AJAX/PDFAJAX.pdf (both)

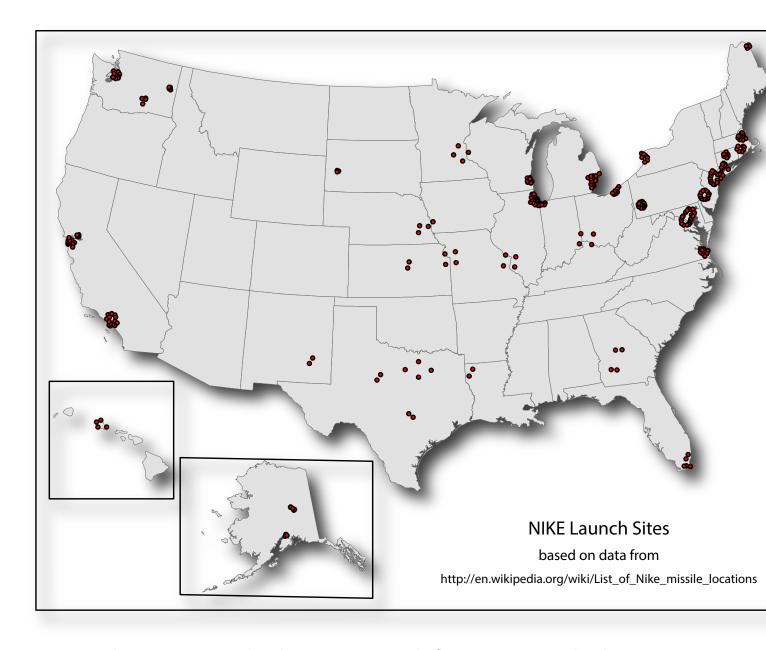




# <u>Previous work</u>

Mapping and Visualizing the NIKE Site Location

A number of websites including Wikipedia have listings for the nearly 300 locations of both the IFC and launch sites associated with the NIKE Defense System. I constructed spreadsheet with coordinates for both the IFCs and associated launch sites, converting DMS to decimal degrees, and importing the data into ArcGIS to visualize the locations throughout the United States. The distribution of the sites immediately explained Morgan & Berhow's book title "Rings of Supersonic Steel".



The sites were built to protect "defense areas" which were major US cities and selected USAF Strategic Air Command bases.

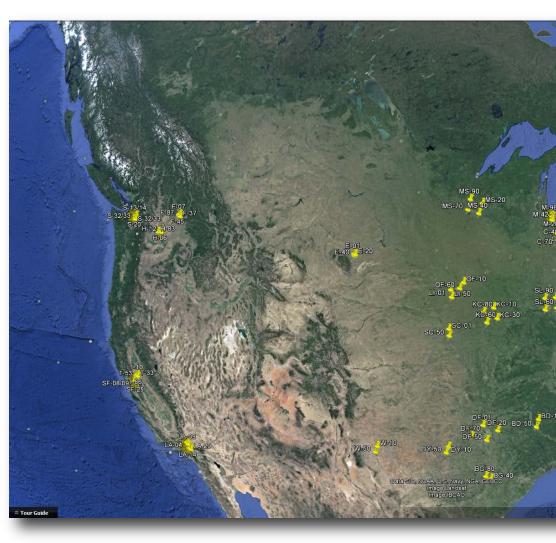
Anchorage Defense Area, Ak Barksdale Defense Area, LA Bergstrom AFB Defense Area, TX Boston Defense Area. Mr Bridgeport Defense Area, C. Chicago-Gary Defense Area, IL-IN Cincinnati-Davton Defense Area, OH-IN Cleveland Defense Area, OH Dallas-Fort Worth Defense Area, Detroit Defense Area, MI Dyess AFB Defense Area, TX Ellsworth AFB Defense Area, SI Fairbanks Defense Area, AK Fairchild AFB Defense Area, WA Hanford Defense Area, WA Hartford Defense Area. CT Homestead-Miami Defense Area, F Kansas City Defense Area, KS-MO Lincoln AFB Defense Area, NE Loring AFB Defense Area, ME

Minneapolis-St.Paul Defense Area, MN New York Defense Area, NY Niagara Falls-Buffalo Defense Area, NY Norfolk Defense Area, VA Oahu Defense Area, HI Offutt AFB Defense Area, NE Philadelphia Defense Area, PA-NJ Pittsburgh Defense Area, PA Providence Defense Area, RI-MA Robbins AFB Defense Area, GA St. Louis Defense Area, MO San Francisco Defense Area, CA Schilling AFB Defense Area, KS Seattle Defense Area, WA Travis AFB Defense Area, CA Turner AFB Defense Area, GA Walker AFB Defense Area, NM Washington-Baltimore Defense Area, MD-V

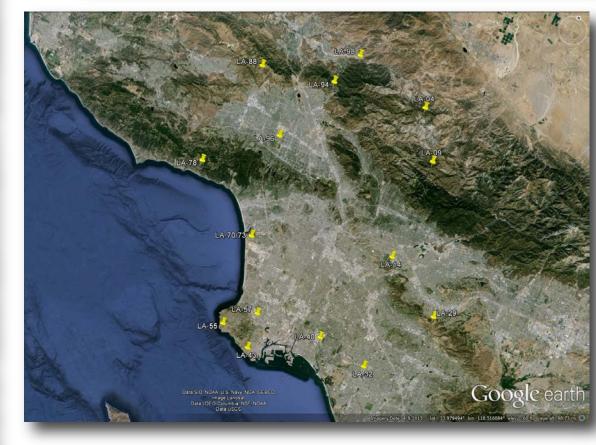
Los Angeles Defense Area, CA

Milwaukee Defense Area, WI

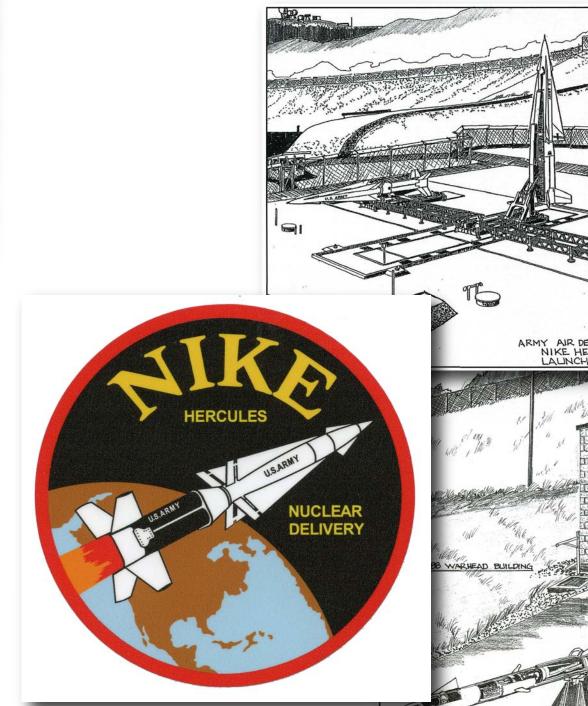
Shapefile exported out of ArcMap as a KMZ and opened in Google Earth to examine the sites with current high resolution imagery.







Google Earth screen shots of launch sites surrounding New York City, Los Angeles and Detroit.

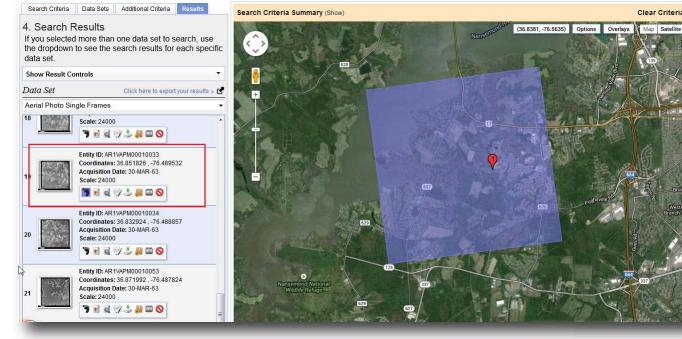


http://nikemissile.org/ (all three)

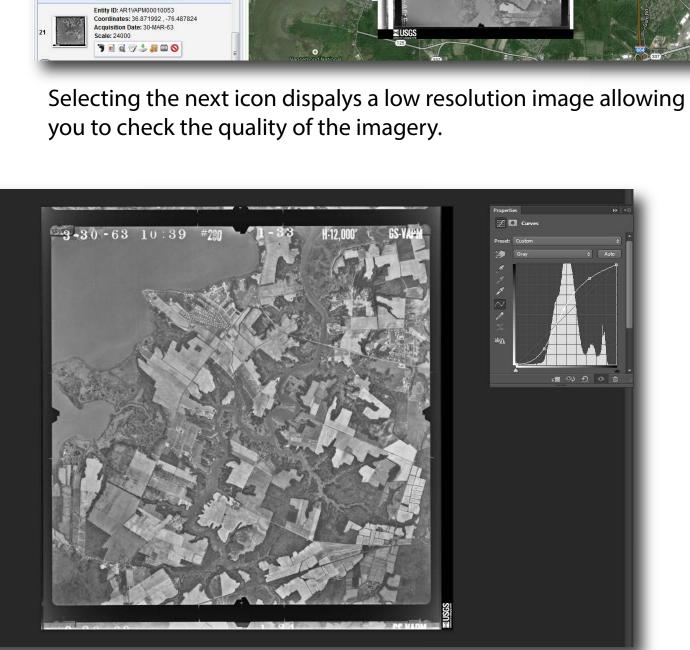
Freating Quality KML/KMZ Imagery from Historic Aerial Photographs

Coordinates Predefined Area Shapefile KML

oordinates for a specific placemark created in the initial Patterned Ground proje entered into the search field in Earth Explorer (earthexplorer.usgs.gov) with single frame aerial photos selected as the data set to search.



Search results display as a list. Selecting an individual image footprint icon zooms the view to display the footprint for that image.



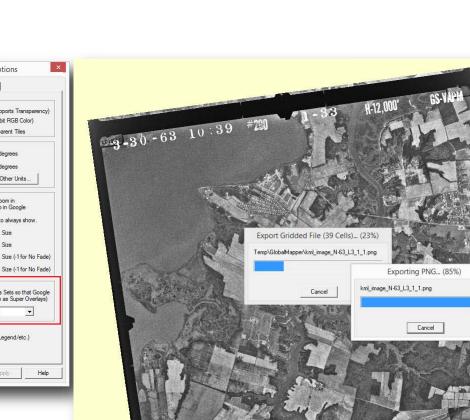
In Photoshop a curves adjustment layer is added and curve is mod



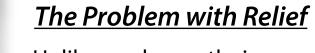








Global Mapper's extensive export options include KML/KMZ with the creation of a "super overlay" builds varying resolution layers resulting is a smooth display and zoom when opened in Google Earth.



Unlike modern orthoimagery which is processed to account for elevation differences within the image, these air photos are simply "pictures" and the scale within an individual image varies depending on the difference in elevation between the aircraft and the ground surface at any given point.

- \* You cannot measure distances on an air photo, it is not a map \* An orthophoto has uniform scale, it is a photo map
- \* Because orthophotos have a uniform scale they can serve as a base
- map, and other map information can be overlain on it.
- \* Dramatic elevation differences in a scene may make it impossible to georeference all parts of an air photo to the underlying orthophoto without severely distorting the air photo.

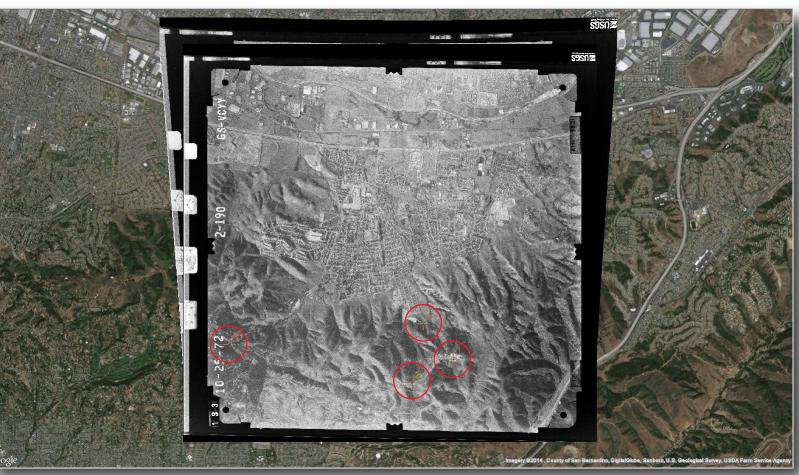


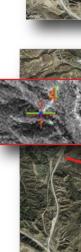


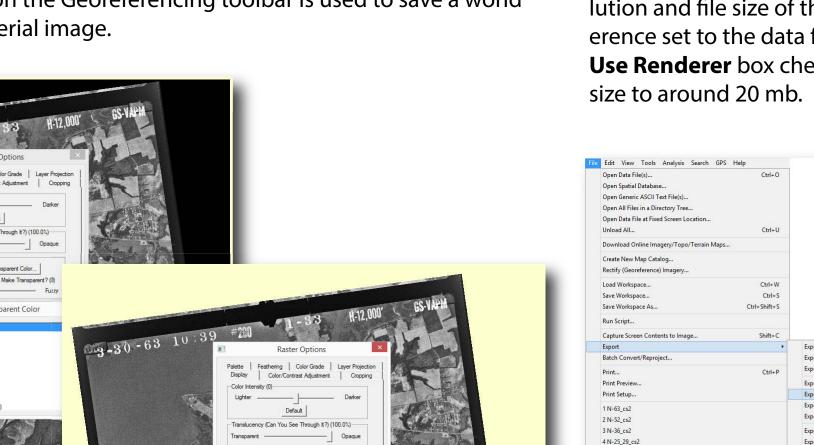
Image at left has control points selected for a very narrow range of elevation resulting in an undistorted georeferenced image. Examining the quality of the georeferencing shows the area in the foothills is well matched to the underlying ortho imagery, but the urban area in the valley is poorly matched due to scale differences.

Image above shows the effect of adding control points in the low elevation urban area to the north of the foothills and updating the georeferencing. The image is stretched, changing the scale of the lower elevation area to more closely match the scale in the foothills portion of the image.

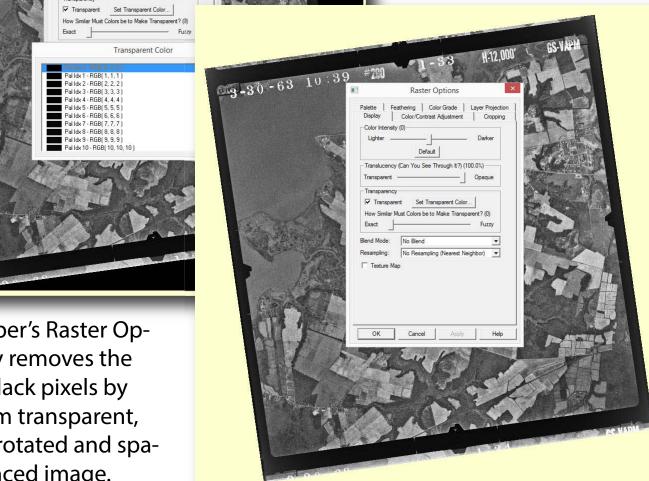
Because the elevation changes are gradual and consistent, changing from foothills to flat valley floor, the image remains rectilinear but stretched along the upper border. Imagery, at right, shows the effect in a more complex setting of elevation differences.



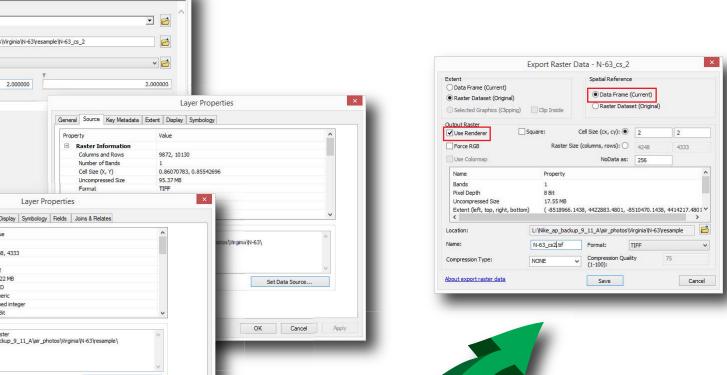




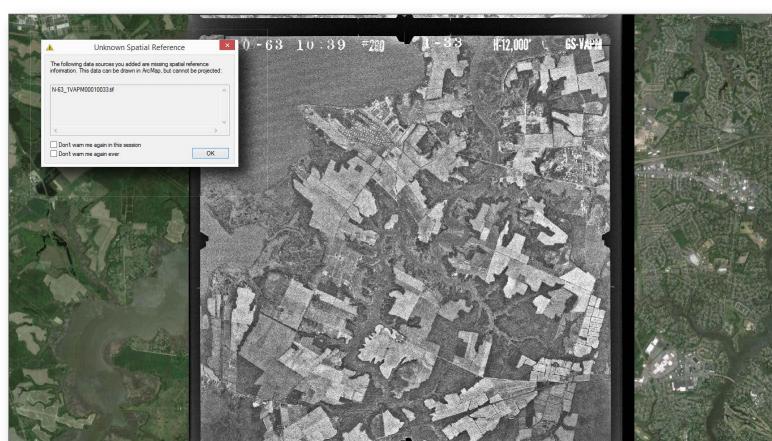
Global Mapper's Raster Op ions cleanly removes the bounding black pixels b naking them transparen eaving the rotated and spa ially referenced image.



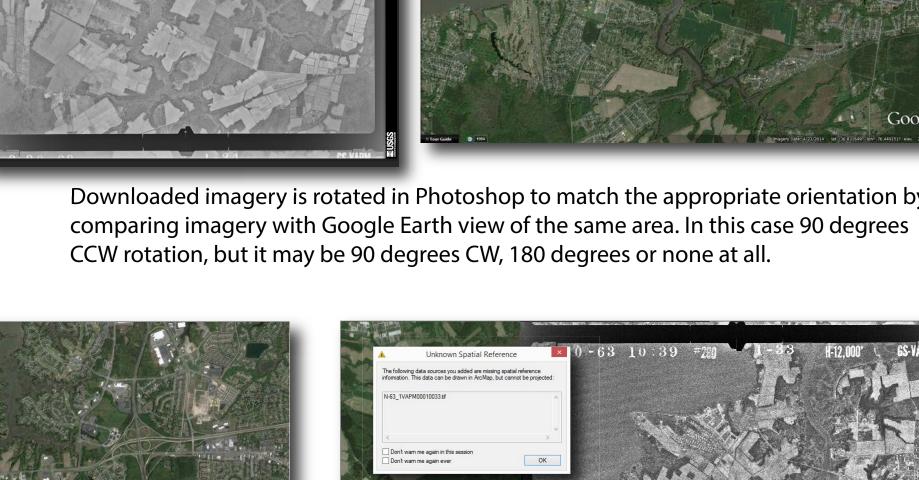
ery is displayed. General Source Key Metadata Extent Display Symbol

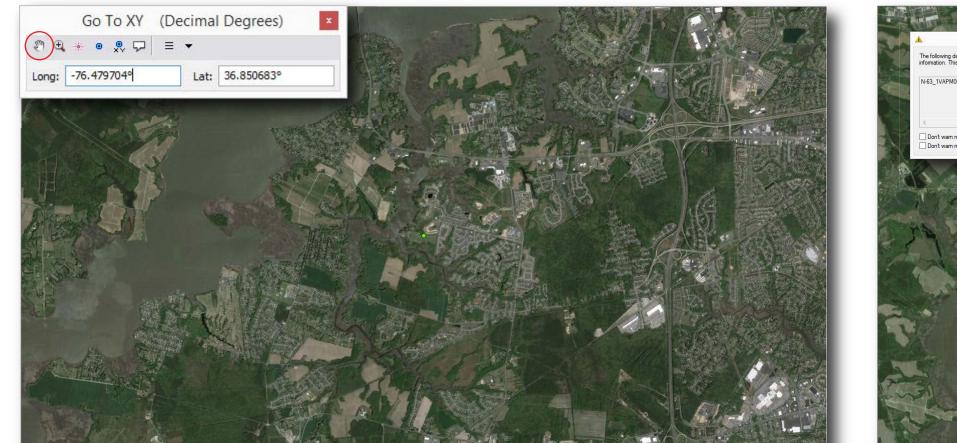


**Resample** tool (Data Management > Raster > Raster Processing > Resample) is used to reduce the resolution and file size of the original raster. Raster is then exported with the spatial reference set to the data frame, which is defined by the Google Earth imagery, and the **Use Renderer** box checked to reduce the image to 8 bit further reducing the file



Imagery is brought into the ArcMap document with a warning that it has no spatial reference. Using **Fit to Display** in the Georeferencing toolbar, the imag-





New ArcMap document is opened and Arc2Earth high resolution Google Earth imagery layer is added. Placemark coordinates are entered in the GoTo window and **pan to location** (circled) is used to center the view on the correct location.

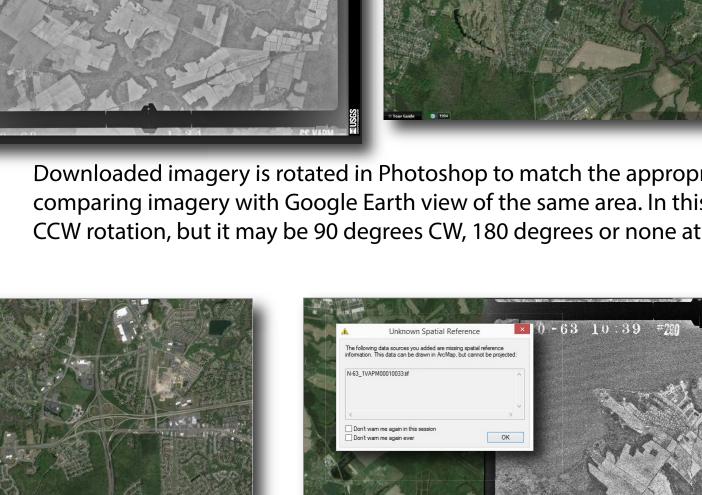
Downloaded imagery is opened in Photoshop.

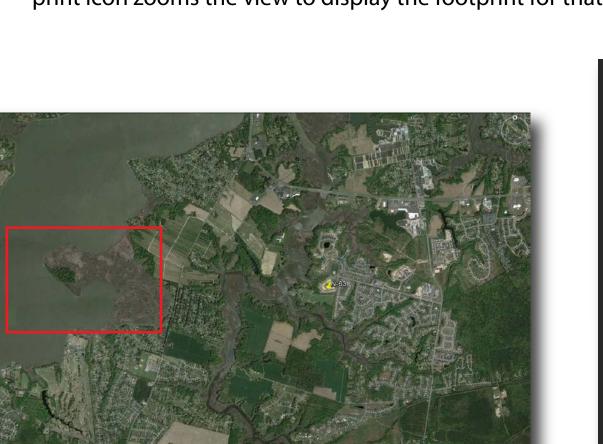
Imagery may come in any orientation with

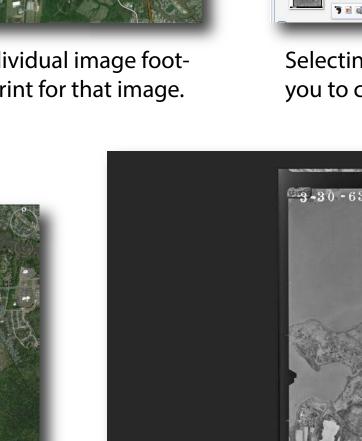
various levels of contrast and/or brightness





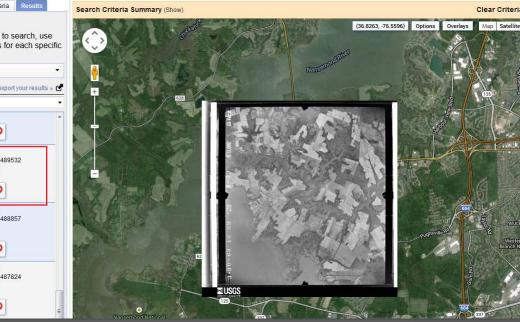




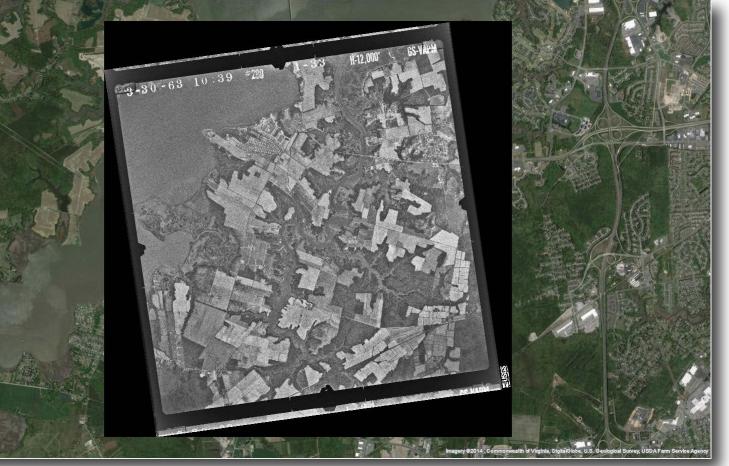




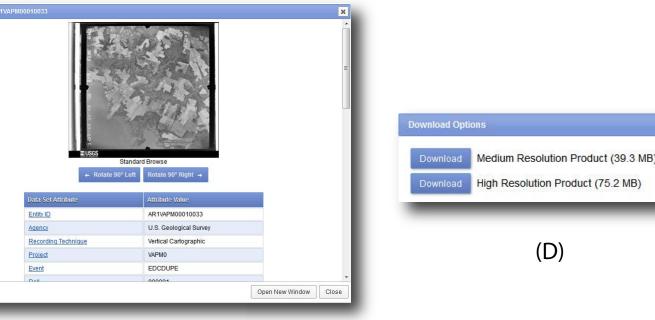
aster images exported as KML/KMZ files from ArcMap do not display well in Google Earth, presenting as coarsely pixelated versions as you zoom in. The method ned below can be used to create KML/KMZ files that display well in Google Earth. The starting raster can be anything from an air photo to a topographic eologic map. Maps are easier because they do not require Photoshop adjustments and can be georeferenced using the coordinates in the collar marginalia



vpically three to four control points, linking the same point on both the aerial photo and the underlying Google Earth imagery, can be used to accurately georeference an image. Images captured at an angle or areas with large elevation differences in the scene require more control points and may be impossible to accurately georeference across the entire image.



ne exported raster is added as a new layer to the ArcMap document. Note the black border created to fit the rotated image in a square 2 meter x 2 meter/pixel raster. This layer must be removed from the ArcMap TOC before proceeding to

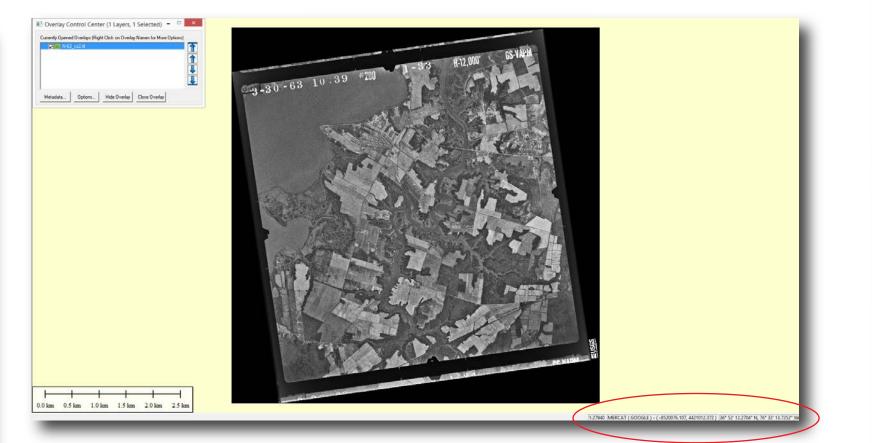


The fourth icon in opens a metadata file for the image and the next icon with the green arrow opens the download dialog box (D).

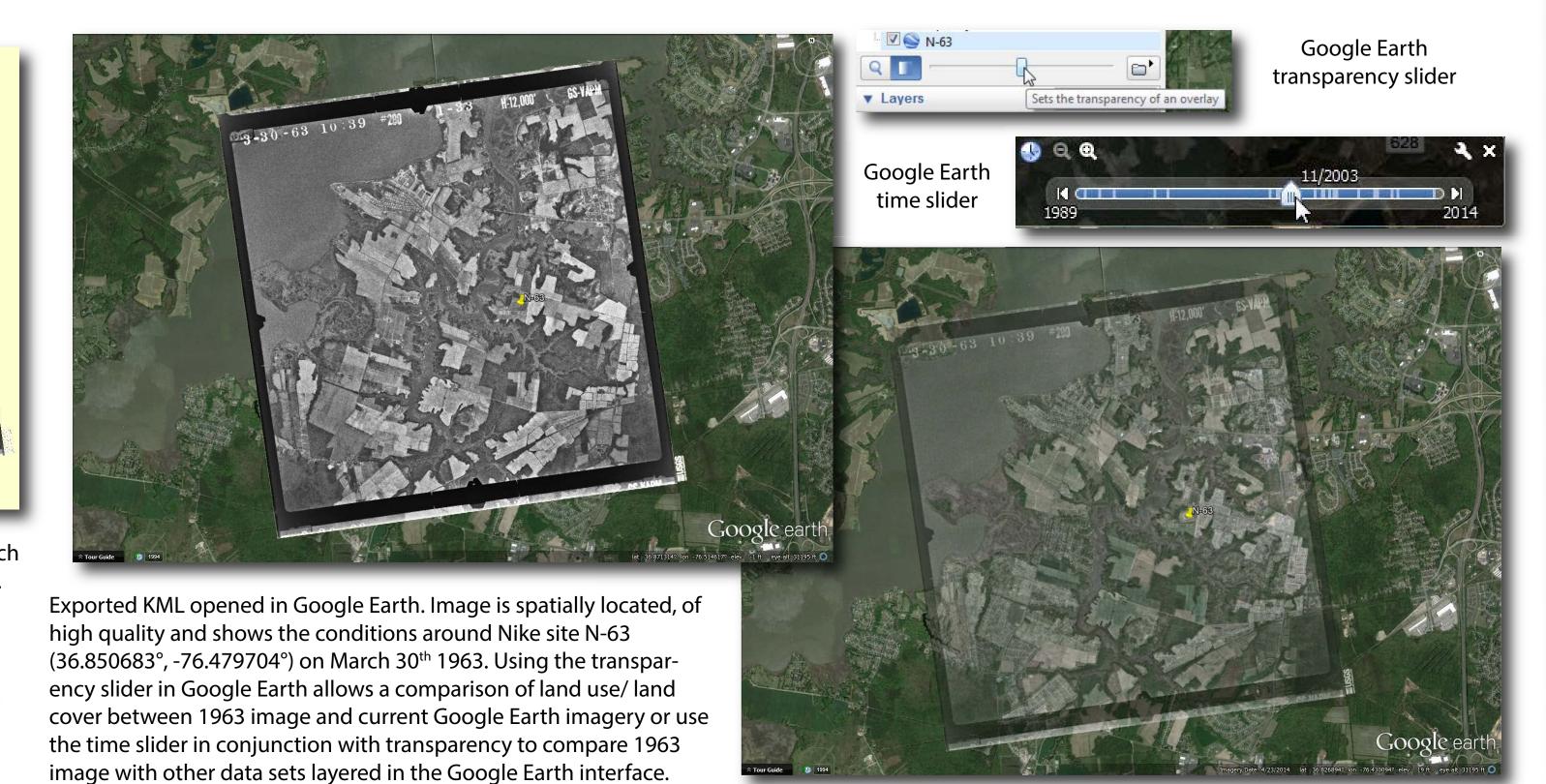


Unsharp masking is applied as needed. Multiple applications of "weak" unsharp

Jsing the **reveal tool** in the Effects toolbar, the georeferencing can be QCd on various scales to confirm quality across the image.



The exported raster opened in Global Mapper. Note the data is spatially located Global Mapper has tools to automatically crop the black collar from the image. In addition there are tools to automatically crop collars from topo maps allowing you to create seamless maps when your field location falls at the intersection of 2 or more quads.

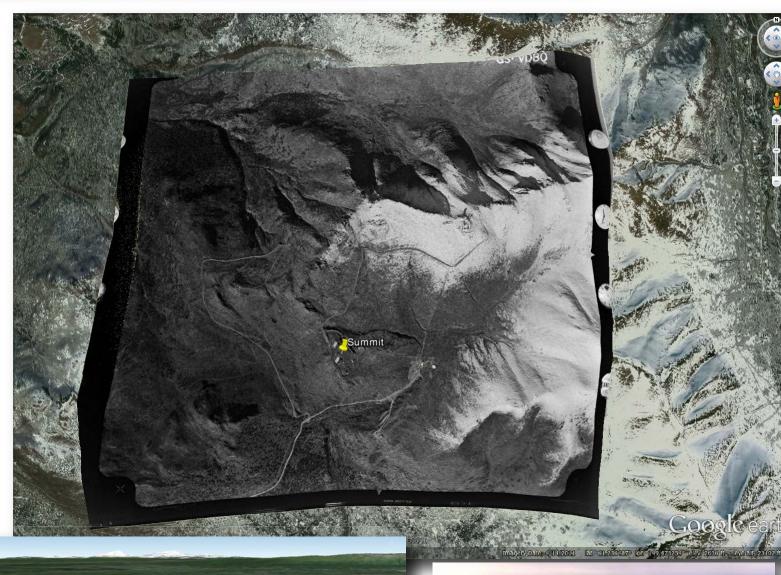


ArcMap's georeferencing algorithms attempt to align control points that link location between the non-georeferenced image and the underlying map or orthoimage. Site LA-94 is located in the mountains north of the city of Los Angeles. This image contains the site in the mountains as well as low elevation valleys and flatlands. Dramatic differences in scale occur within this image due to these elevation differences. ArcMap's first order algorithm aligns the overall image, but close examination of control points show large error bars trying to connect points of similar locations. Second order algorithm attempts to minimize scale differences to attain a better match between points but distorts the image as it attempts to maintain scale across the whole image.



At right is site Summit in the Chugach nountains, over 4000 feet above An chorage Alaska. In this case georeferencing only the critical portion of the image was the only approach to take and it still resulted in a very distorted image in Google Earth. The basic georeferencing for the site is good and the

image drapes well on the Google Earth elevation data. Lowering transparency would show poor registration with features in the underlying imager

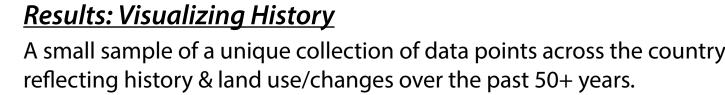


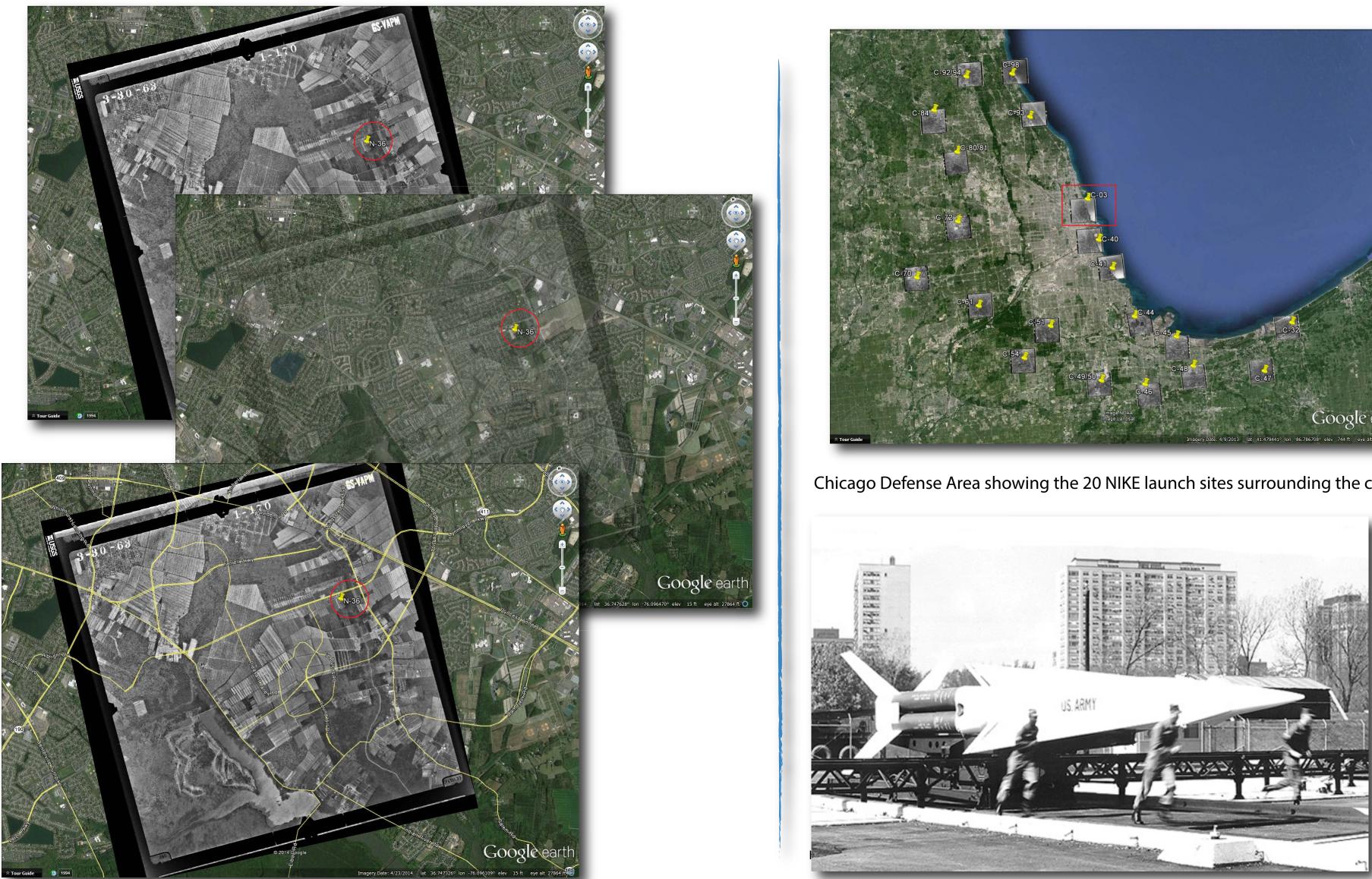
Test launch of NIKE Hercules missile

from site Summit November 196









**N-36** (36.787500°, -76.129444°) in the Norfolk Defense Area, is a good example of significant land use change between 1963 and the 2013 Google Earth imagery. Top image shows the georeferenced 1963 air photo, middle image shows the 1963 air photo semi-transparent to show the current land use. Bottom image shows the 1963 air photo with Google Earth roads layer added.

**Point** (61.247778, -149.548333) Located next to Anchorage airport southwest of Elmendorf Air Force

During the Cuban Missile Crisis in October 1962 crews at Alaskan NIKE sites (and those in Florida) were on "five minute status" with missiles carrying nuclear warheads ready to fire in 5 minutes. Crews remained in this status for more than 30 days while President Kennedy dealt with the crisis. (Raichle, 2012)

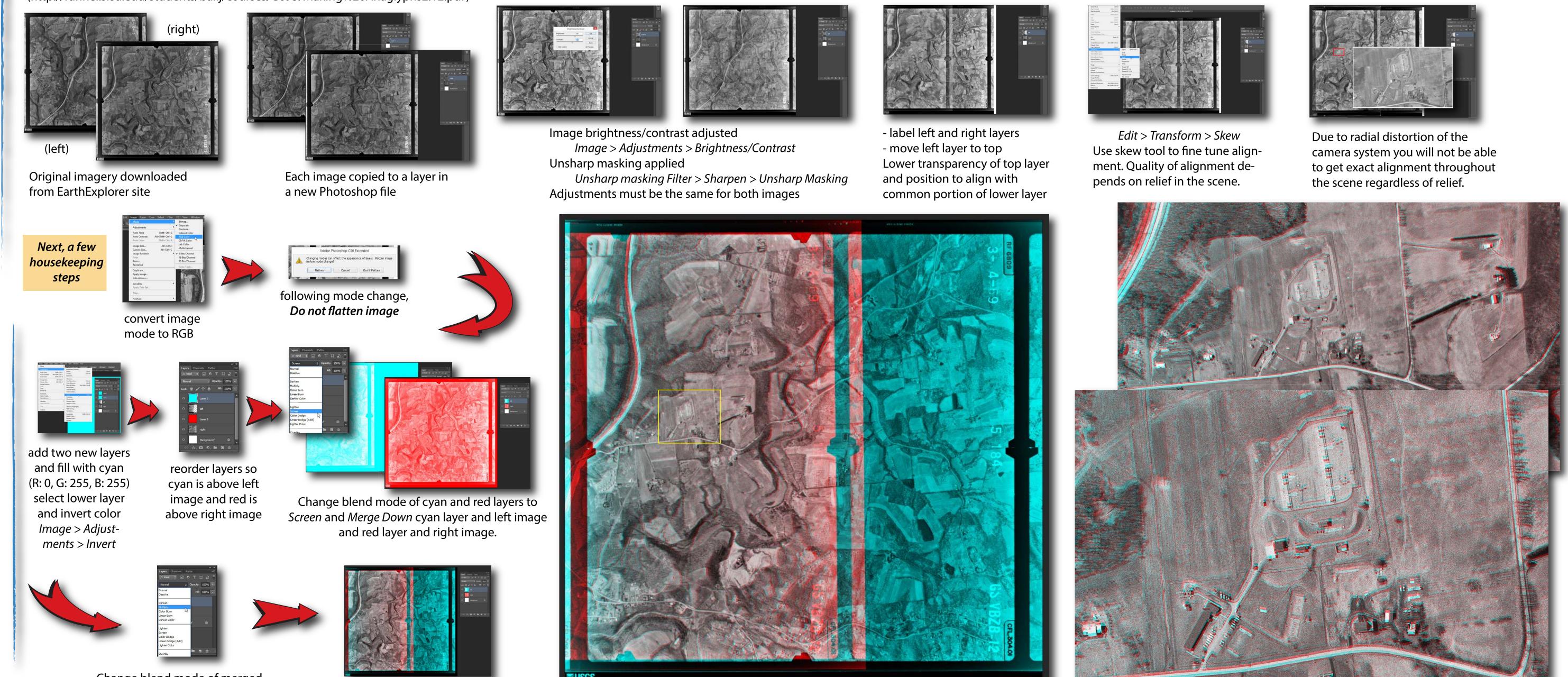
All three of the Anchorage Defense Area sites, Bay, Point and Summit fel the impact of the 9.2 magnitude Good Friday earthquake on March 27, 1964. Documentation from both

Point and Summit highlight the fact that earth movement knocked nuclear missiles from their launchers and storage racks. The warheads were not armed, no radiation leaks occurred, but missiles had to be rendered safe, inspected and secured. (Raichle, 2012)

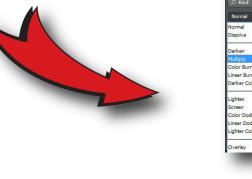
## <u>at site Point</u>

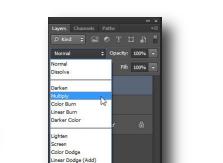
"We went inside the first launcher section of the fire unit on 'hot status' after prying open the blast doors. It was a big mess. No complete missile round was intact on the tracked launchers or handling rails. All the yoke structures ha been sheared. The skins were gouged open; fins bent in all directions. Solid propellants cracked and the rock motor covers were off. Strong stench from the exposed rocket propellant. Arming lanyards were pulled, energizing the on-board battery operated electrical power systems and gyros were spinning. Large components strung across the handling rails and launchers and on the floor, in all directions. Each missile representing upwards of 5 tons of high explosive just waiting for the initial spark to set off the entire lot... [After 40 years] I still have nightmares about what I saw in the first launcher section immediately after the earthquake." (http://nikealaska.org/aadcp/aadcp.html))

<u>Creating Red/Cyan Stereo Imagery from Historic Aerial Photographs</u> (http://funnel.sfsu.edu/students/ballj/courses/G695/Making%20Anaglyphs2.12.pdf)



(use red/cyan glasses to view processed images in 3D)



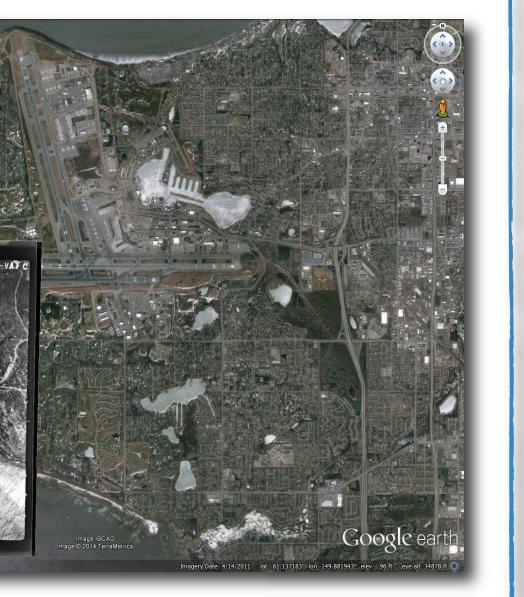


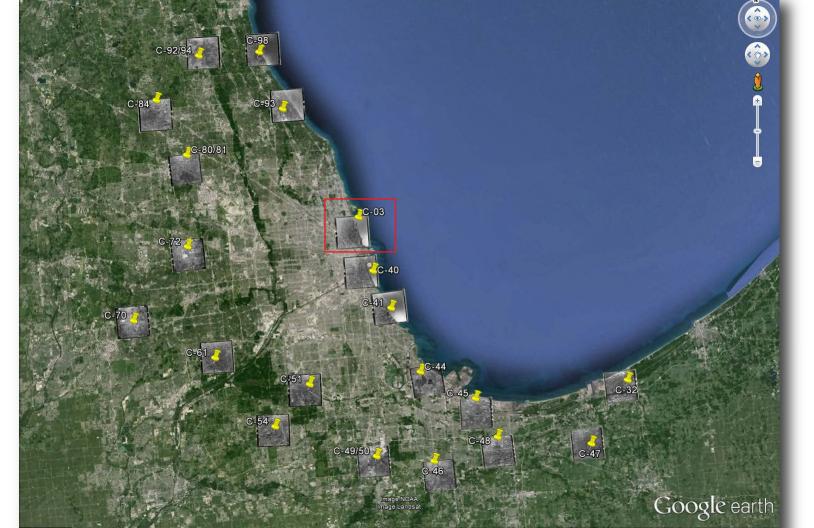


Change blend mode of mergec. cyan/left image to Multiply

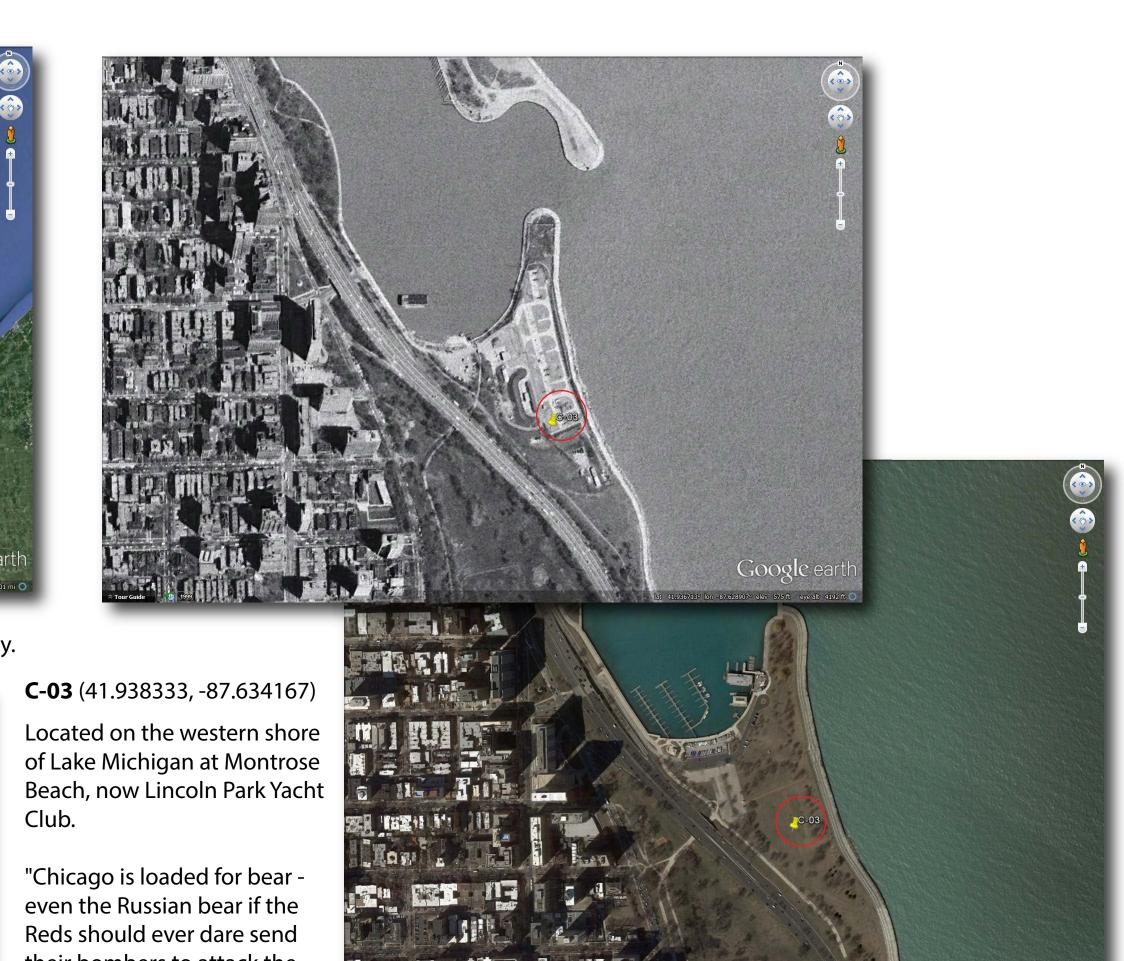
# Patterned Ground II: Creating Google Earth KMZ Files of Georeferenced Historic NIKE Missile Launch Site Aerial Photographs Using Global Mapper and the New Arc2Earth Extension for ArcMap

Dave Tewksbury - Geosciences - Hamilton College - Clinton, NY - USA



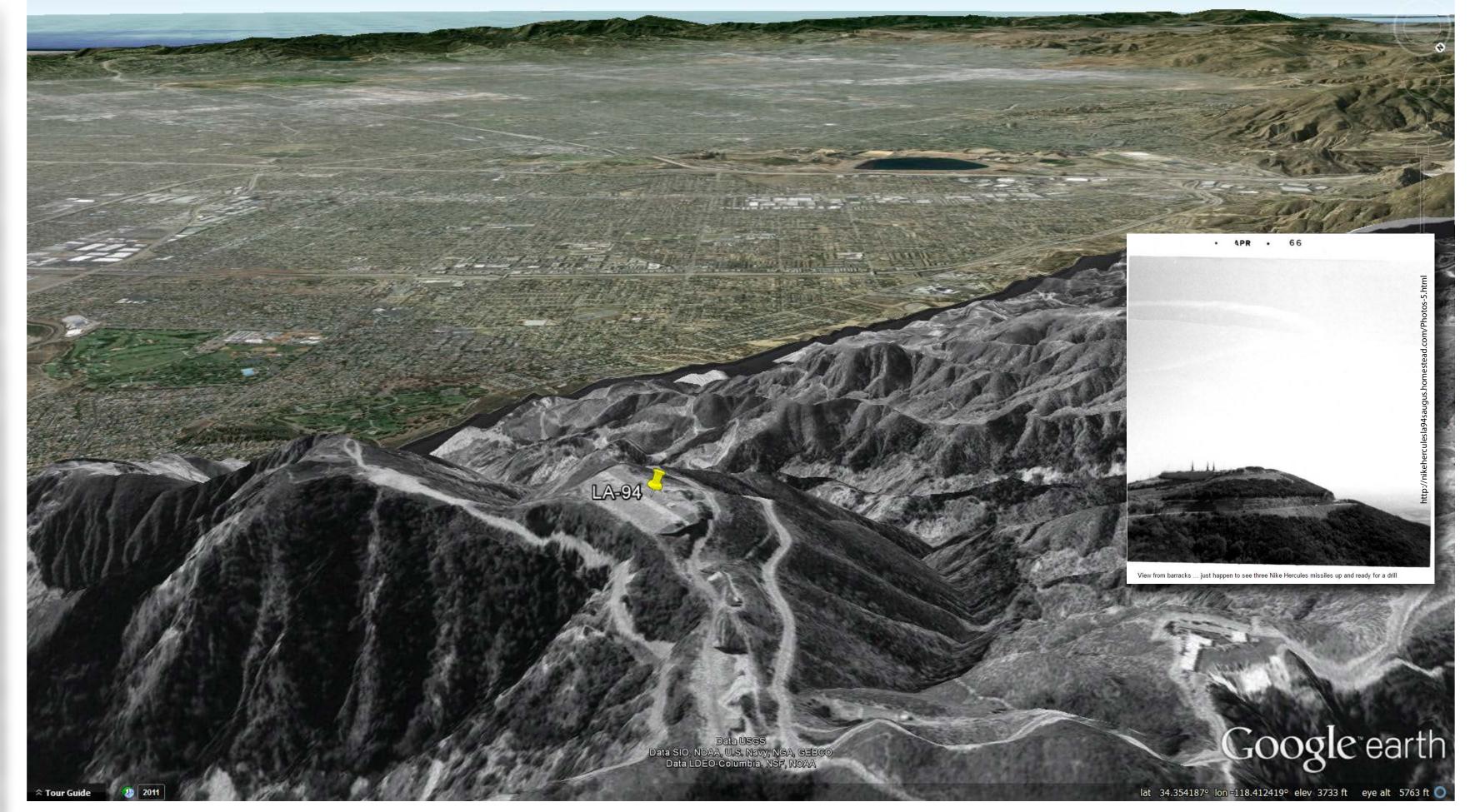


hicago Defense Area showing the 20 NIKE launch sites surrounding the city.



heir bombers to attack the puided missiles called the Nike - revealed for the first time today - stands ready to send sudden death belting into the sky to meet any enemy head on." "They are inescapable by any air maneuver now known to aviation..." "The thing you ought to remember is that the Nike's presence hereabouts should enable you to sleep a lot more soundly." "They

make nice neighbors." --Chicago American http://pruned.blogspot.com/2011/04/sunday-in-park-with-chicagos-cold-war.htm



LA-94 (34.347392°, -118.408875°) in the Los Angeles Defense Area. 1972 air photo viewed in perspective in Google Earth. Georeferencing is biased to the area around the launch site. The 90 meter per pixel SRTM elevation data used in Google Earth masks georeferencing errors created by the relief in the area. Insert photo shows three NIKE Hercules missiles raised at the launch site during a test in 1966. LA-94 was constructed in 1954, upgraded to support Hercules missiles in the late 1950's and closed in 1968. LA-94 complex is now Los Angeles County Fire Suppression Camp #9 housing both air attack and air rescue squads.

In some cases you can find adjacent images of the same scene to download from the EarthExplorer site. These can be used to create red/cyan anaglyphs to view in 3D. Many ways to do this can be found online. This method is modified from J. Caskey.





Site PI-03, Pittsburgh PA Defense Area (40.598333°, -79.891944°)