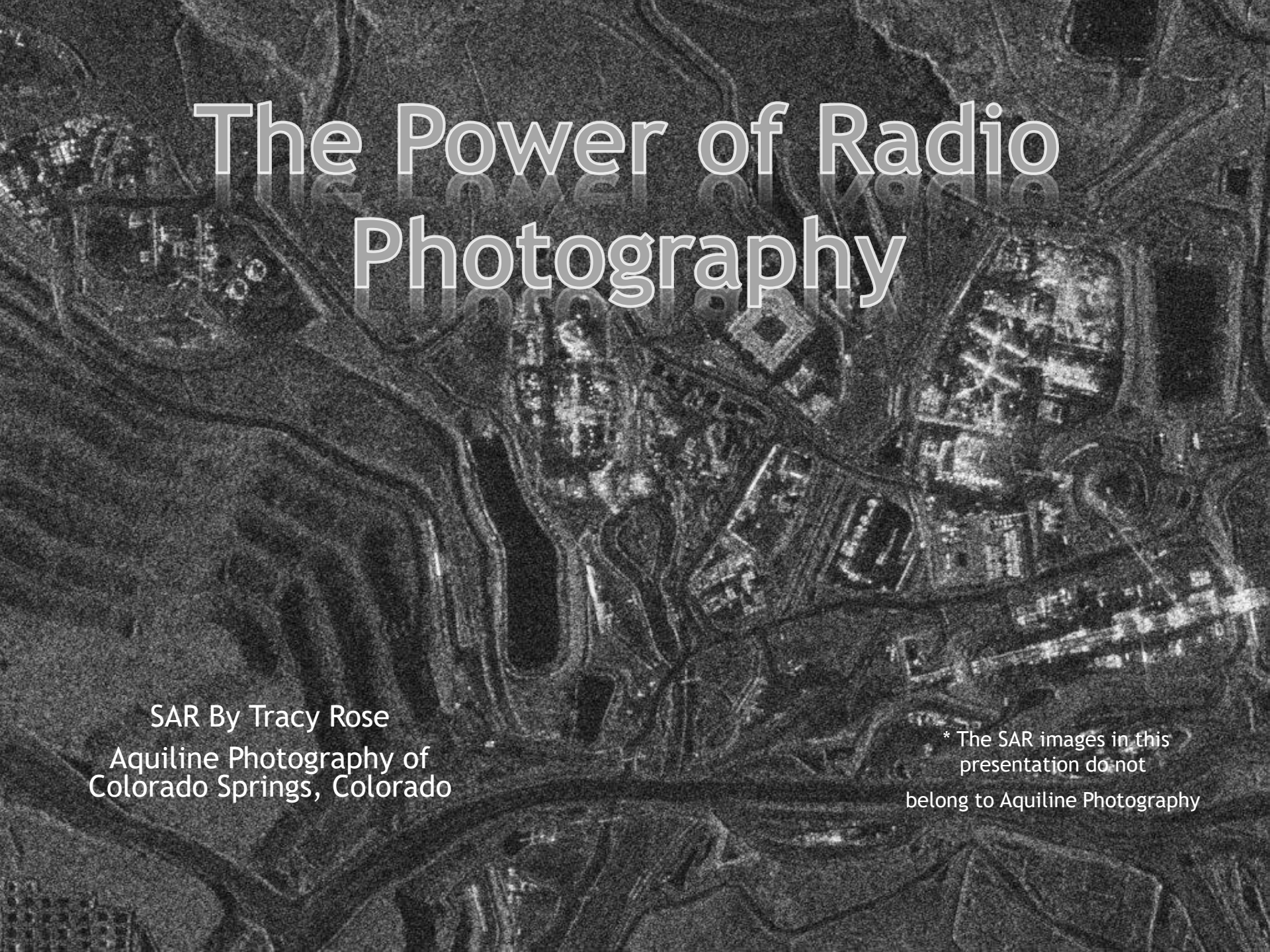
The Power of Radio Photography



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* The SAR images in this presentation do not belong to Aquiline Photography

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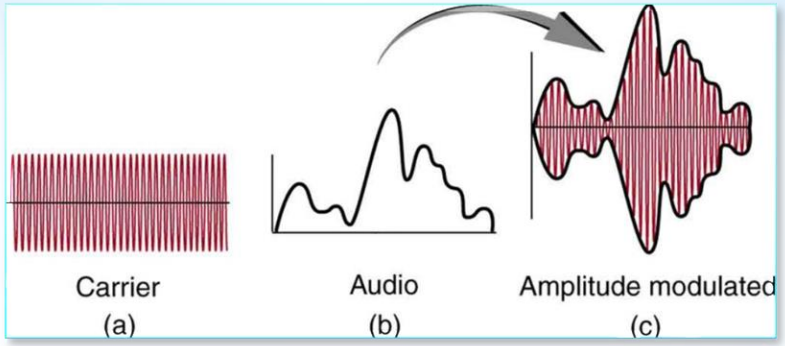
http://aess.cs.unh.edu/radar%20se%20Lecture%2018%20B.html

Did You Know Radio is Light?

When we think of radio we consider music playing from our car audio systems. However, radio is light waves using frequency or amplitude change to carry information. In this case the information is music. The change in amplitude or frequency is referred to as modulation.

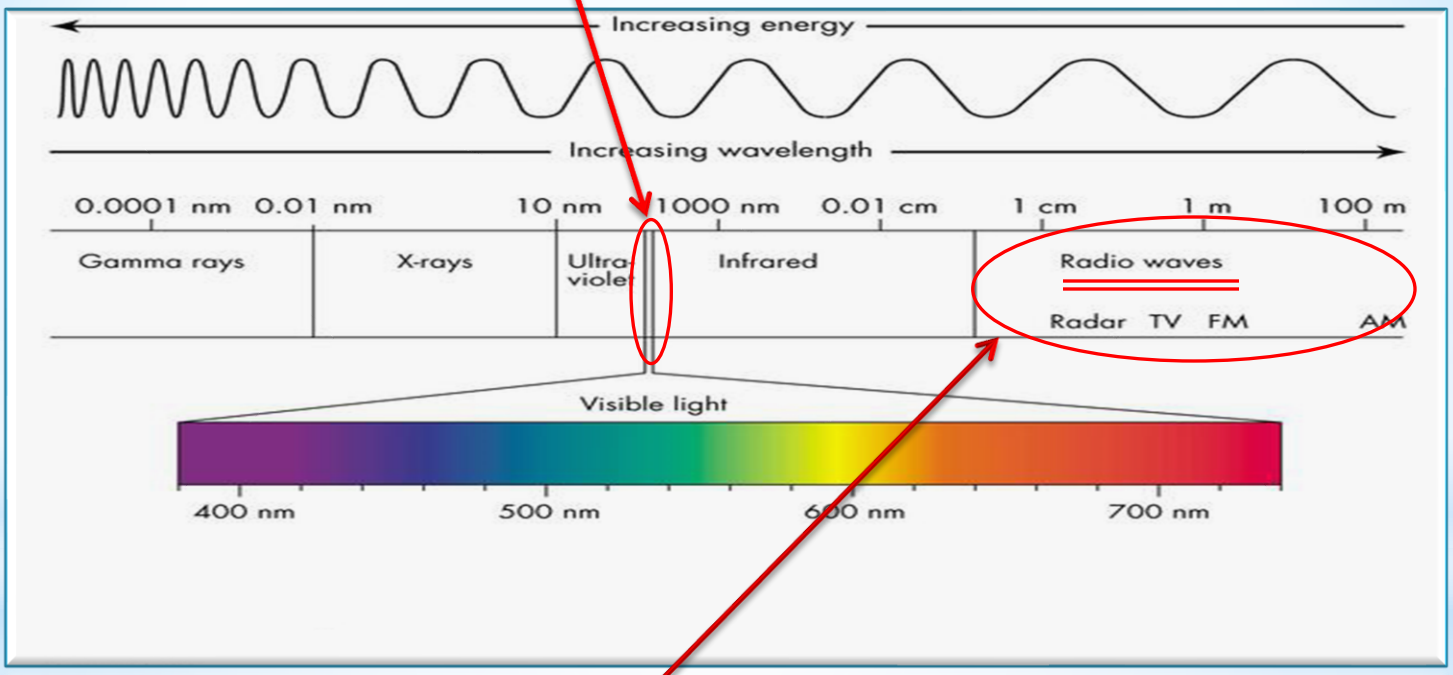
Many aircraft and satellites use radio to create beautiful images. This is often called SAR or synthetic aperture radar. SAR is an acronym within an acronym because as you may recall, RADAR stands for **RA**dio **D**etecting **A**nd **R**anging and as indicated by the name, it is based on the use of radio waves. SAR stands for **S**ynthetic **A**perture **RADAR** because a moving antenna acts as a camera synthesizing the aperture to create an image



SAR imagery from the Sandia National Laboratory's
Ka band airborne SAR imaging system.

It might help to visualize below where radio occurs in the spectrum…

Humans see from 400 to 700 nanometers wavelength



Radio is approximately from 1cm - 100m

Imagine a light wave 100 meters long or 300 feet. This makes for a large camera to receive it

Radio Photography Clichés

- Radio is an incredibly long wave that is much longer than all infrared and longer in wavelength than normal true-color vision. Unlike normal photography, the sun does not emit a great deal of radio waves to illuminate these photographic subjects. Because of this fact, a photographer would need his own light to do radio imaging

- In the 1930's Karl Jansky observed radio coming from the Milky Way galaxy naturally. Selective and weak radio waves are received from space due to cosmic events such as neutron stars collapsing as well as other space phenomena

- Radio is indeed light but is also known as groups of different frequencies to include microwaves, VHF (very high frequencies), UHF (ultra high frequencies), Citizens band HF, and many others. Microwaves do cook food but this is because of high power. Low power microwaves are for communications

- The internet Wi-Fi router most people use is also microwave but uses lower power that falls off quickly. Early versions of radar imaging were at 3 GHz. Later the higher resolution machines went on to 10 and 26 GHz

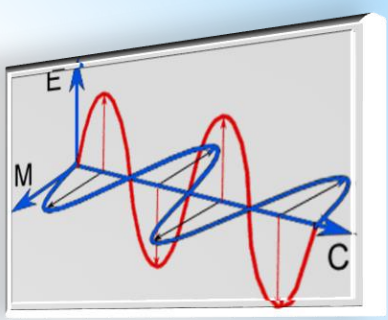
http://www.mathworks.com/matlabcentral/fileexchange/screenshots/22325/original.jpg

- The larger the synthetic aperture, the better the resolution of the image. In these images the sensor sends out the radio waves (often microwaves). Since the radio wave is very large , the SAR sensor receives many images from the same target while along it's moving path and stitches them together for better clarity

- Despite appearing as sun shadows, the image above could have been taken at 3 a.m. in the darkness because it relies entirely upon radio waves to create the image

- The shadows are opposite where the radio waves were sent out and the darkness indicates lack of radio wave returns to the synthetic aperture

Radio Polarimetry



- Light spins in all directions. When light doesn't spin, it is traveling but oriented in one direction and is called polarized. It then moves like a snake in one axis or another

- Said another way, light is a bit like whipping a jump rope in all directions. If that jump rope were intentionally moved only up and down, so that the wave traveling down the rope were just vertical, then this would be like polarized light.

- Radar waves have a polarization and this can be used to match the same signals when they are sent out and measured on their return. Some complex radar can use a mixture of vertically polarized and horizontally polarized radar waves to create a false color appearance for use in an image.

Radio Photography Brief History

- An Australia group laid out the principles of aperture synthesis in their revolutionary paper in 1946 and published in 1947.

- During the late 1960s and early 1970s, computers became capable of handling the computationally intensive “Fourier transform inversions” math required to use aperture synthesis to create a 'One-Mile' effective aperture

http://www.thespacereview.com/archive/790a.jpg

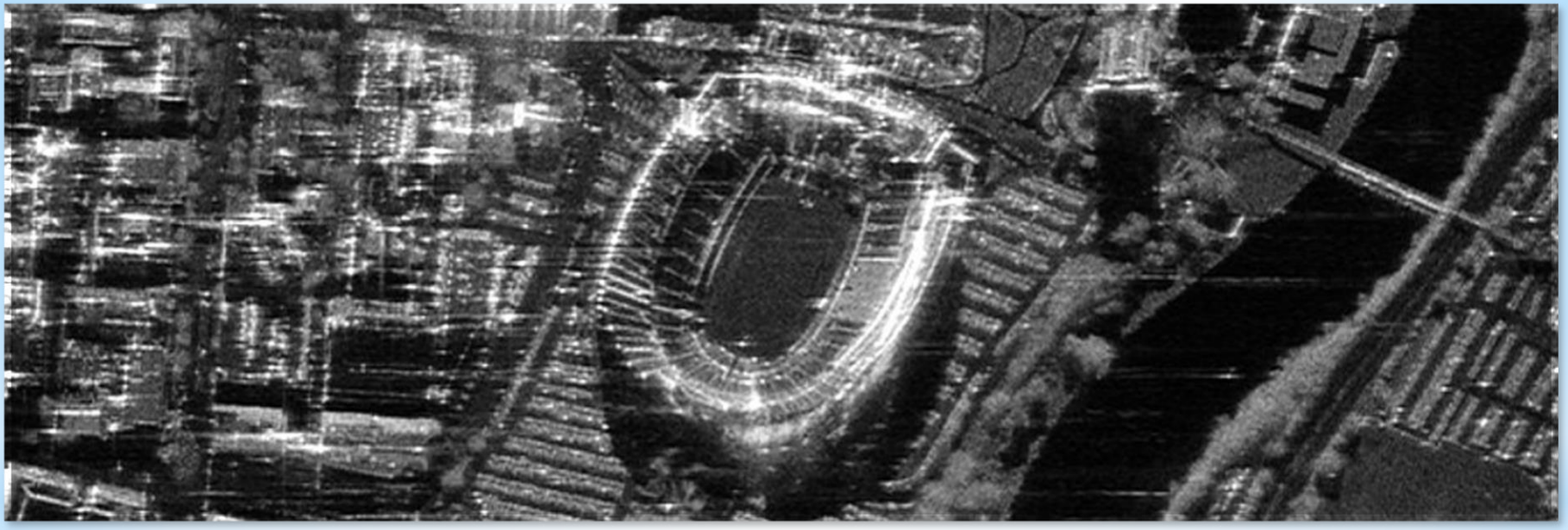
Radio Interferometry

- Taking radio images from two different cameras separated by an entire continent can actually be done. For space imaging many sites around the earth can combine radio images to make one clear image

- Since radio is a light wave, one can use interferometry to help combine the images. Interferometry is the use of interference. Consider if someone captured waves of light for two images. If the image crests and peaks match, then this would mean they were in phase

- If these waves of radio were opposite they would be out of phase. Like the ocean waves, if two waves of light in the image are the same phase the wave gets bigger. If the waves are opposite they cancel each other out.

- This is the basis of interferometry to help combine images and use the interference to help achieve clarity



http://www2.ece.ohio-state.edu/ips/images/OSUshoe_banner.jpg

RADAR Image of a Ohio Football Stadium

Radio Photography in Practice

- The larger the dish used for make-shift aperture, the more finely detailed the image. This is why there are giant dishes used for creating radio images of space. RADAR images are usually a compilation of several images mathematically combined together for more clarity

- By sending out radio waves in order to image, one can detect motion because moving objects will alter the speeds of the radio wave returns to the sensor and smudge the appearance within the image

- A wave of radio is so large it can penetrate clouds and storms. This makes it ideal to image during poor weather were one's subject is located.

https://directory.eoportal.org/web/eoportal/satellite-missions/t/tecsar

- RADAR is absorbed by water leaving an often featureless dark region.
- Really bright spot and glints are often caused by metal structures or sides of a ground elevation that got a great deal of radio energy
- Trees and bushes scatter radio waves and look fractal or bushy like even in radar imagery

Radio Photography in Near Future

- Why don't we have hand-held cameras that take radio pictures? The answer is probably the incredibly long wave. One might have to have a large receiving dish. One might also have to take many images and compile them via interferometry to get the best clarity.

- Can modern circuit chips in cameras handle the required math in a hand-held device? Maybe and of course this would all be complicated for a camera one has to walk around using. Could your hobby camera have a flash-like unit that sends out soft radio waves and then displays the radio image?

- Imagine yet another mode. By clicking the button on your unusual hobby camera a soft umbrella antenna pops out with many little dipoles. In the back you tune the digital display to a frequency of your local music radio stations. Then in the view finder seeing this wondrous image painted by music radio waves

AQ has covered these topics….

+ Did You Know Radio is Light?
+ Visualizing Radio's Place in the Electromagnetic Spectrum
+ Radio Photography Clichés
+ Radio Polarimetry
+ Radio Photography Brief History
+ Radio Interferometry
+ Radio Photography in Practice
+ Radio Photography in Near Future

End

any questions?

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