



The Value of Overhead, High Resolution IR Thermal Imagery

Ellis Freedman

Serious Science, LLC

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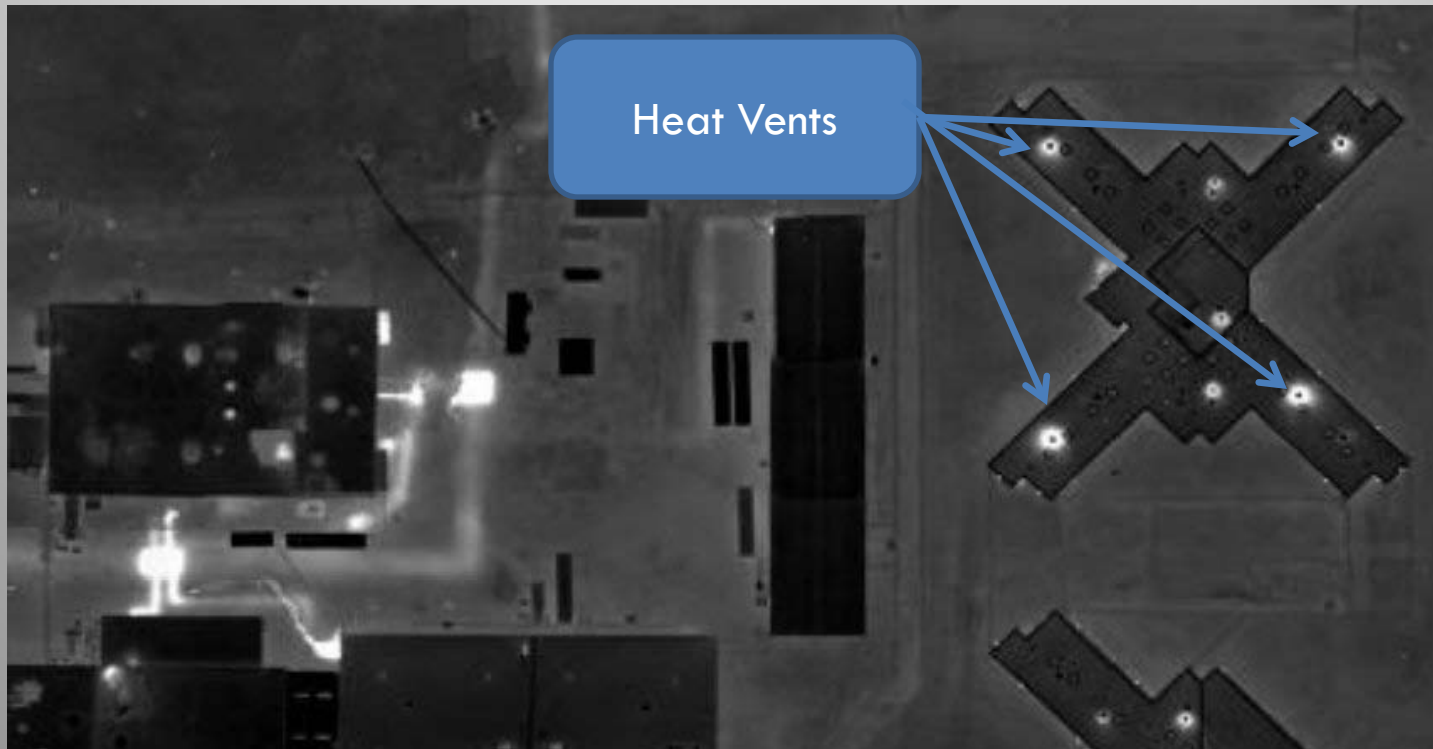
IR Imagery Provides Information Unavailable in Visible Imagery



- Heat loss or suppression
- Short term variations over time
- Power generation or activity
- Hidden or covert activities
- Easy water detection
- Absolute temperature estimates

Heat Loss

Prison



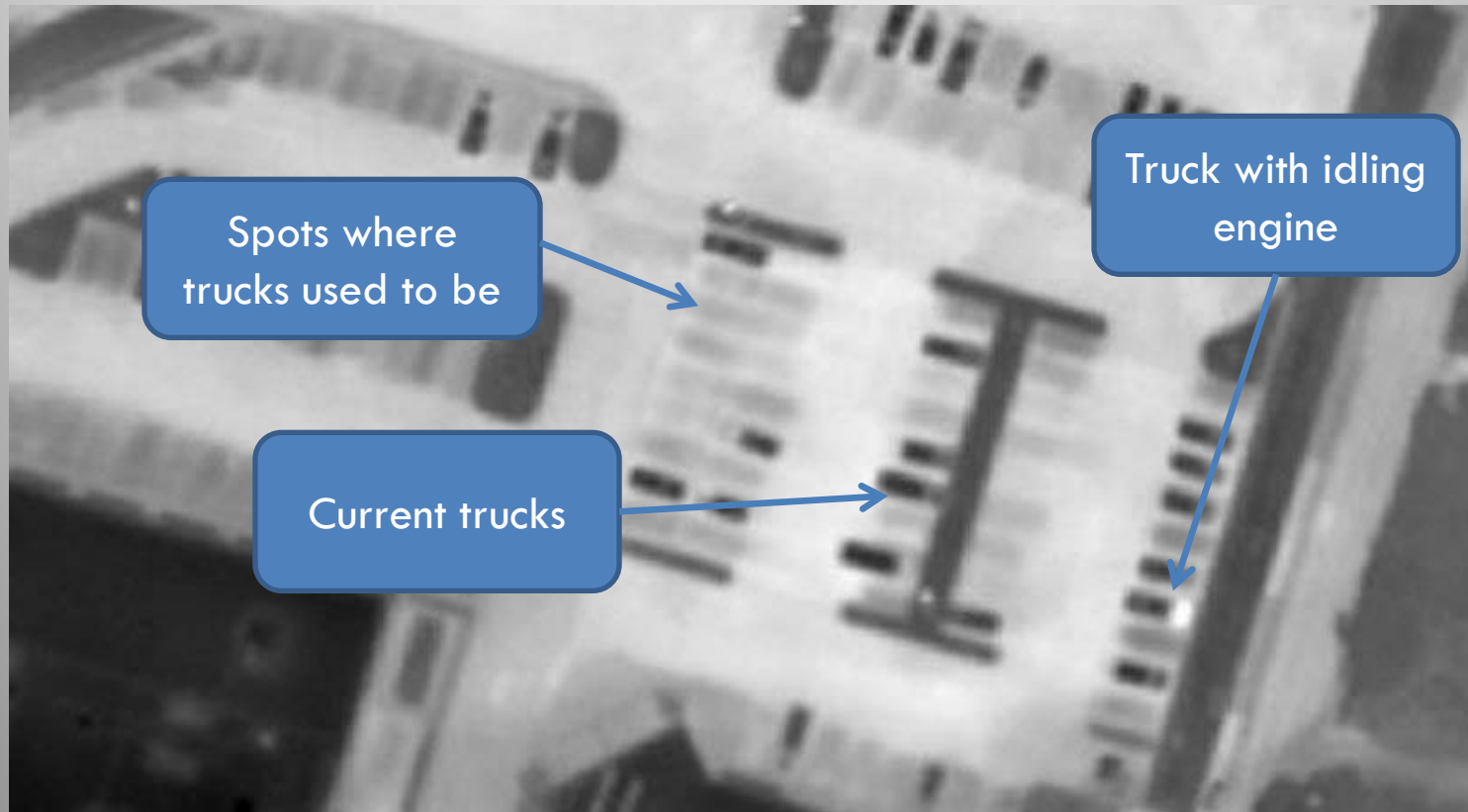
Temperature estimates from the image and weather data enable the estimation of BTU loss

(All images courtesy of Stockton Infrared Thermographic Services (www.stocktoninfrared.com))



Temporal Activity

Truck Depot



Temperature estimates from the image, surface models, and weather data allow the derivation of the time since the vehicle left

(All images courtesy of Stockton Infrared Thermographic Services (www.stocktoninfrared.com))

Power Generation

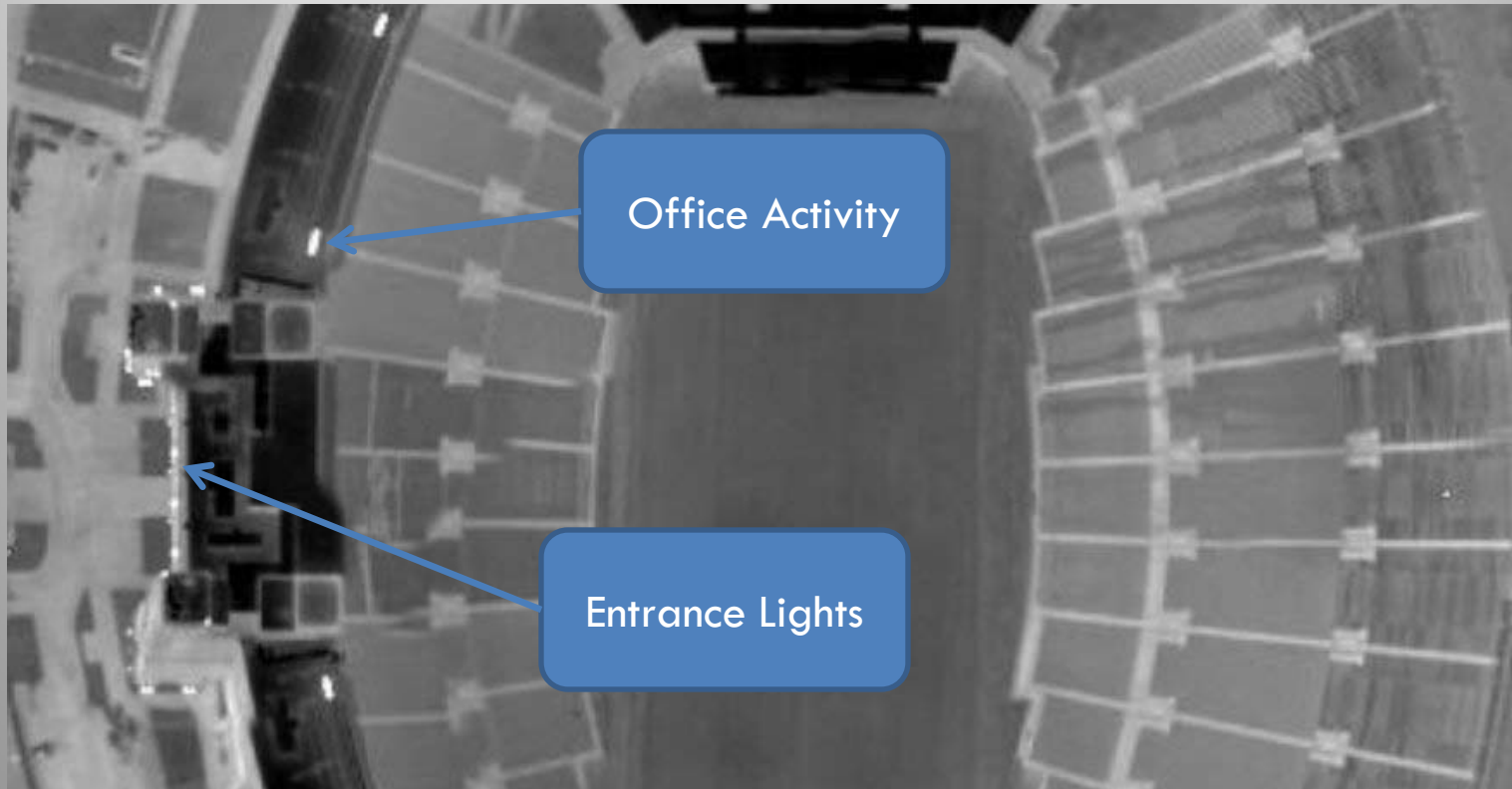


Hot spots on a high voltage transmission line

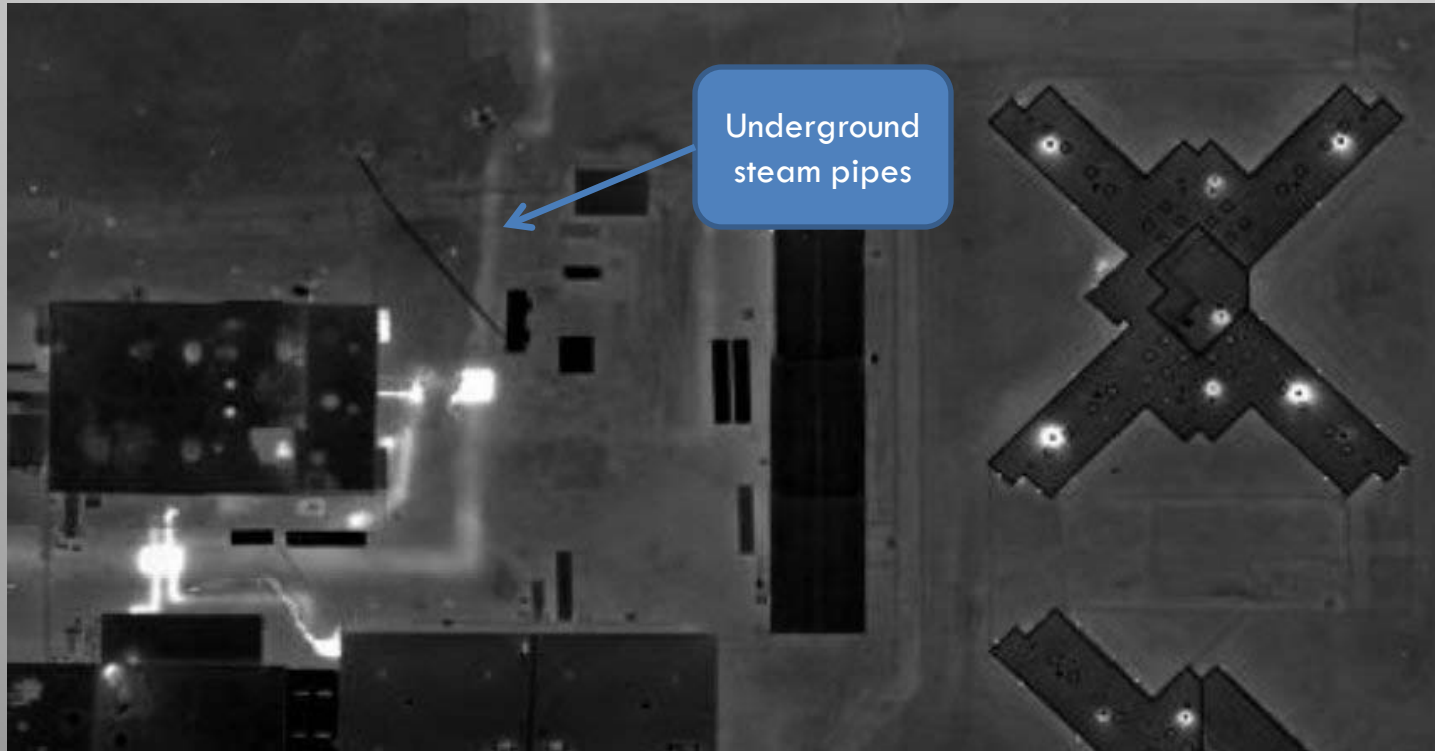
Otherwise, Non-Visible Activity



Empty Stadium



Hidden Activity





Open Water Detection and Tracking

Stream winding through housing developments and under roads



(All images courtesy of Stockton Infrared Thermographic Services (www.stocktoninfrared.com))



Absolute Temperature Estimates

- Absolute temperature measurements are not necessary for detection of activity
- It is necessary for quantitative evaluations
 - BTUs
 - Power loss estimates
 - Time since a vehicle has moved
- Absolute temperature requires absolute radiometric calibration through a combination of,
 - On-board blackbody calibrator
 - Vicarious ground calibration
 - Accurate nearfield (self emission from telescope/sensor) calibration



Potential Sources of Revenue

- Detection and assessment of power generation and transmission problems
 - Problem power lines and transformers will be highlighted
- Detecting the activity of vehicles and aircraft
 - Parking lot and airport activity
 - Are mall customers continuously shopping or did the mall only see activity early in the day?
 - Which cars and aircraft are running their engines?
- Large scale estimation of energy efficiency in large buildings and factories
- Determination of nighttime activity vs. daytime
- Mapping of underground steam pipes and other activities
- Theft of natural gas
- Easier mapping of rivers, streams flooding and runoff
- Rapid and detailed mapping of fires
- Monitoring of illegal burn exhausts
- Animal and human detection and location
- Military, security and intelligence



What High Res IR Imagery Isn't

- Competition or replacement for civil/scientific satellite IR imagery
 - High res is $> 20X$ better resolution
 - Civil/scientific imagery is useful for thematic or climatic evaluations, not for sensing most manmade objects
- A spatial or visual competitor for visible imagery
 - IR senses thermal phenomenology in a contextual format
 - It can be registered, overlaid and sharpened with visible images to provide better context, geospatial and geodetic accuracy



What Would Such a Sensor Look Like?

- Assume that it would be a secondary payload on a commercial, high resolution visible imaging satellite
 - 400 nmi orbit, 1.1 meter aperture, F# 12, 8 μ m visible sensor
- Operate in the long wave IR (LWIR) region (8 – 12 μ m)
- Two most common approaches
 - Uncooled IR Sensor (microbolometer)
 - Works by sensing actual changes in temperature changes in the detector
 - Inexpensive, no cooler required, no vibrations from cryo-cooler, space qualified, very insensitive to shot noise
 - Low sensitivity, slow response, limited area collecting capability
 - Cryo-cooled IR sensor (HgCdTe)
 - Photoelectric device
 - High sensitivity, large area collecting capability, straightforward to space qualify
 - More expensive to manufacture, requires some form of cryo-cooling, care must be taken to minimize vibrations from cooler, sensitive to shot noise, especially from nearfield



Microbolometer Imager

- Very common in hand held IR thermal imagers
 - Also used in space (THEMIS)
- Maximum line/frame rate = 100/sec
- Assume a 50um detector pitch and f# 12
 - GSD = 2.6m
 - Q = 2.4
 - Would require ≈ 200 TDI (or registered line co-adds) for sufficient SNR
 - Small target restoration could be used to increase resolution
- A 25um detector and f# 6 would give similar results with about 1/5 the number of TDI
- Both versions would be limited in swath width to minimize smear at the edges of the image

HgCdTe IR Imager



- More traditional IR thermal imager
- Cooled photoelectric device
- Same expected GSD and Q
- Line rate at least 10X faster than microbolometer
- Much more sensitive
 - May not need TDI at all
- Sensitive to shot noise
 - Care must be taken to control and calibrate the contributing nearfield components
- Should not be difficult to build a focal plane 1000 – 2000 detectors across and collect at least 10^6 pixels/s

Other Options



- QWIP (Quantum Well Infrared Photodetector)
 - Newer cooled LWIR technology
 - Relies heavily upon InGaAs
 - More expensive
 - Tunable wavelength sensitivity
 - Useful for multispectral IR
 - Low thermal and $1/f$ noise
- MWIR
 - Operate in the 3.5 – 4.1 μ m range instead of the 8 – 12 μ m bandpass
 - Pros
 - GSD improves by more than 2.5X
 - Cons
 - Less accurate absolute temperature estimates
 - Still need TDI (≈ 16)
 - Probably more expensive than LWIR HgCdTe
 - Could also use InSb detectors

Summary



- High resolution overhead thermal imagery has valuable utility for many missions
 - It can be combined with other sources of imagery to provide a better GIS solution
- There are many potential sources of revenue
- Well established technologies are available for the cameras
 - Resolutions only a few times greater than visible systems can be achieved