

FAKULTET TEHNIČKIH NAUKA UNIVERZITETA NOVI SAD  
SPECIALISTICKE STUDIJE "ENERGETSKA EFikasnost"

## SAVREMENE METODOLOGIJE DETEKCIJE ENERGETSKIH GUBITAKA OBJEKATA URBANIH SREDINA

II deo - Termalna snimanje

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### Infrared termografija i njena primena u urbanim sredinama

Infrared termografija kao nedestruktivna metoda obezbedjuje veliki broj inženjerskih podataka o konstruktivnim detaljima građevinskih objekata i značajnim karakteristikama objekata vezanih za energetska stanja i gubitke energije u zavisnosti od spoljnih uslova.



Chicago At Night

### Infrared Termografija i fasade objekata

Termografija je tehnologija koriscenja uređaja za proizvodnju infracrvenih snimaka na kojima se detektuje emitovanje termalne energije svakog objekta

Termalna ili infracrvena energija je deo elektromagnetnog spektra nevidljivog za ljudsko oko a koji se vezuje za izvor



Za razliku od vidljive svetlosti u infracrvenom svetu svaki objekat sa temperaturom iznad apsolutne nule emituje energiju

Visoke temperature fasada objekata na infracrvenom snimku se manifestuju tamnijom bojom - veći gubici

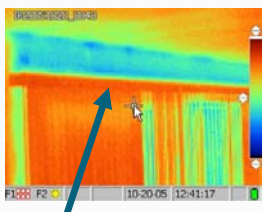
Iako nije očekivano visok stepen gubitaka energije je kroz temelje objekata.

### Infrared termografija i fasade objekata (2)

Glavni problemi:

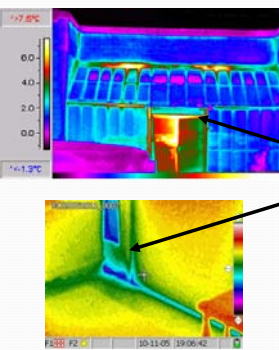
- Prekomerno trošenje energije do gubitka ili oštećenja izolacije ili prekomerni gubitak vazduha duž termalnih perimetara.
- Oštećenja izazvana vlagom
- Oštećenja izazvana ledom
- Neadekvatno izvođenje radova ili greske u projektu
- Raslojavanje materijala fasade

### Infrared Termografija i fasade (3)



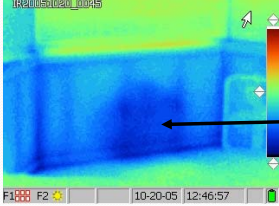
When conditions are right, it is possible to locate missing or damaged insulation, such as this poorly insulated area over a patio door

### Lociranje gubitaka toplog vazduha




- Excessive air leakage can account for up to half of the energy consumed to condition buildings.
- The problems can be as straightforward as a failed door weather seal or as complex as an air pathway through a plumbing chase in an interior wall.

### Air Leakage Location




Interior view of wall at base of bay window.



Exterior view of suspect wall detail

### New Construction

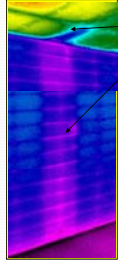


All the framing and insulation is clearly visible in this commercial building.

Normal pressure differences on the top floor result in air leaking past the envelope through various pathways.

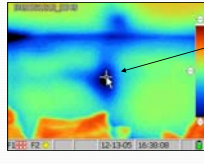
### Uticaj vlage ili kondenzacije

- As building designs and techniques produce tighter thermal envelopes, moisture has created more and more problems.
- The water can intrude through a small crack but is then trapped between the relatively impermeable building materials.
- Good building techniques typically must deal with both air sealing and moisture retarders to keep moisture from accumulating inside the wall sections.

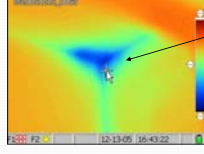


Leak from roof and down wall

### Detection and Cause of a Roof Leak




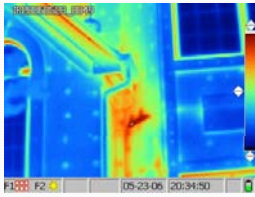
Roof leak on a closet ceiling and wall




On the opposite side of the wall and under a valley termination

### Detekcija gubitaka na fasadama





Here the infrared image shows wet areas behind the wall. Note the fastening pattern in the photo.



Suspect wall

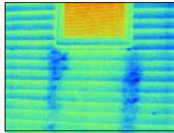

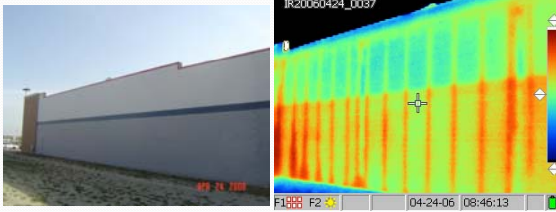


Image consistent with water damage



Fungal contamination and rot

### CMU



Painted Concrete Block Wall

Grouted Cells Filled At Regular Intervals

IR20060424\_0037

F1: F2 04-24-06 08:46:13


### Detekcija gubitaka preko krovova

Detekcija energetske gubitaka preko krovova omogućava izradu optimalnim projekata sanacije kojom se smanjuju gubici a i smanjuju proskovi rekonstrukcije

Studije detekcije energetske gubitaka pokazuju da preko 50% svih krovova mogu biti popravljene uz trosak koji se vrlo brzo nadoknadjuje uštedama na energetske gubicima

Problemi na detekciji lokacije energetske gubitaka i pronalaznje optimalnog rešenja rehabilitacije krova se resavaju multi disciplinarnim pristupom analizi podataka sadrzanih na infrared snimku ( Infrared snimatelj, gradjevinski inzenjer, arhitekta,...)

### Roofing



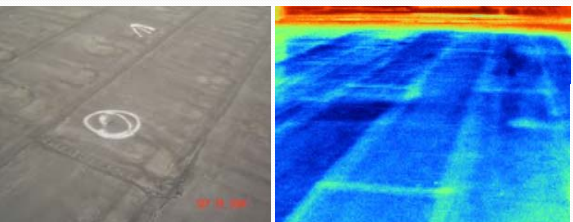
This roof didn't leak

The roof scan discovered the roof was saturated and didn't leak because of a 2 ply vapor barrier beneath the roof.

FLIR 82.8 F 86 68

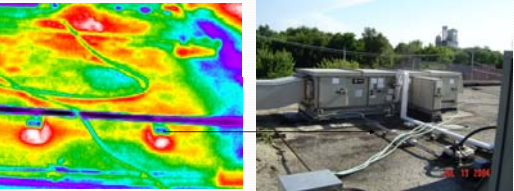
04:22 p c=0.86 Tref=68

### Roofing



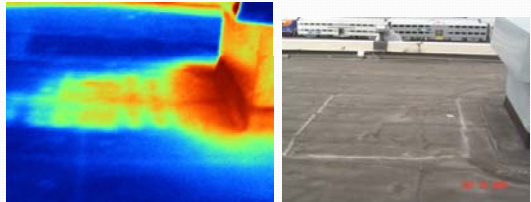
Overlap Pattern and Leaks

### Roofing



Roof leaks caused by improper pipe supports

### Roofing

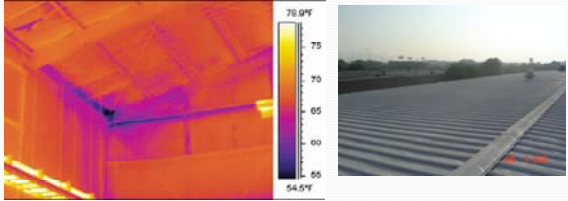


Roof Curb Leak


## Interior Roofing Inspection



## Metal Roofs




## System Performance



Poor circulation of air is shown in this room. Notice the warm air at the top of the room and the cool floors, blue. Commonly referred to as the "Stack Effect".

## Savremena Infra red kamera TABI 1800



The TABI-1800 is a thermal broadband imager which offering new technologies which improve sensitivity and increase the swath from 320 pixels to 1800 pixels. TABI-1800 has excellent sensitivity due to its stirling cycle cooled MCT (mercury cadmium telluride) detector, allowing users to distinguish temperature differences as low as one tenth of a degree while diminishing thermal drift as compared to bolometer-based systems. This new imager's 1800-pixel swath allows users to map large areas in a very small time frame.

## Primena TABI 1800

**Applications for TABI-1800**  
detection of underground tunnels, pipeline mapping, corridor mapping, **heat loss surveys**, and many other applications where there are even the subtlest temperature differences.

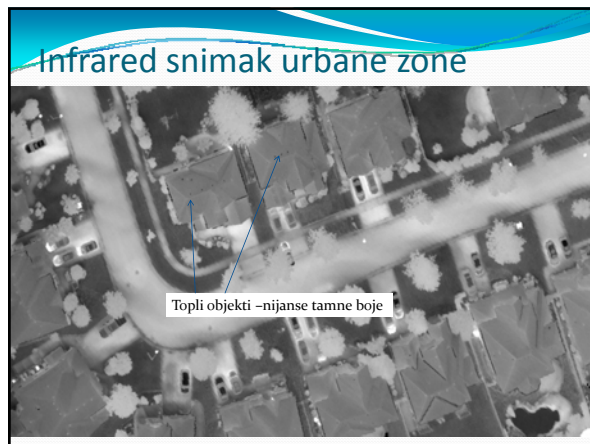
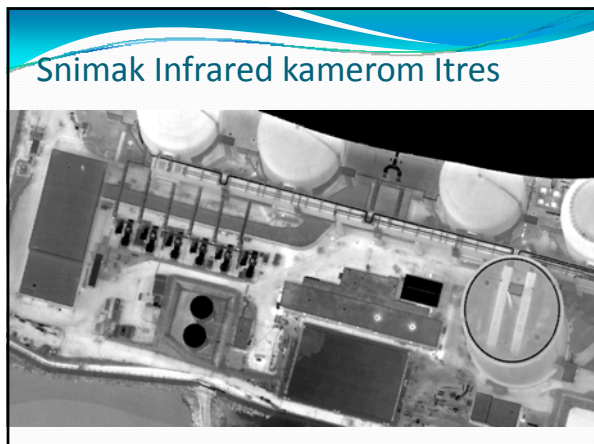
The TABI-1800 is a new breed of high-resolution airborne thermal mapper. It combines the following class-leading characteristics in a broadband thermal imaging package that can't be matched:

**Features**  
The industry's widest achievable pixel resolution range (10 cm to 1.25 m possible with typical unpressurized fixed-wing aircraft; ~2 cm resolution using a helicopter);  
High thermal resolving power (0.05 degrees Celsius);  
Wide imaging array (1800 pixels);  
Our trademark high-performance custom optics which are truly diffraction-limited with sub-pixel optical spot size for superb focus; and  
Simplified installation as the controller, digital recording system, and precision GPS/IMU are all built into the sensor head.

## TABI-1800 SPECIFICATIONS

|  |   |
|--|---|
| ACROSS TRACK PIXELS                    | 1800 ± 5%   |
| FIELD OF VIEW                          | 40° ± 2%  |
| IFOV                                   | 0.023° (0.405 mrad)   |
| NEDT                                   | < 0.05° C   |
| SPECTRAL RANGE                         | Midwave Infrared (3,700 - 4,800 nm)                               |
| NUMBER OF SPECTRAL BANDS               | One (1)   |
| COOLING                                | Stirling Cycle Cooler   |
| THERMAL REFERENCE                      | Internal black body measurements - collected on every flight line |
| THERMAL DRIFT                          | Minimal   |
| DYNAMIC RANGE                          | 14 bit  |
| DATA RATE (MB/SEC)                     | 3-38  |
| FRAME RATE                             | ≥ 80fps   |
| OPTICAL DISTORTION                     | < 0.05%   |
| STANDARD TEMPERATURE MEASUREMENT RANGE | -20 to 150°C  |





TAB-1800 Thermal Imagery (15 cm)  
Batzac, Alberta, Canada

itres

Prikaz infrared ortofoto karte u koordinatnom sistemu ortofoto planova urbanih zona omogućavaju:

- prostornu integraciju entiteta termalnog snimaka sa entitetima istog prostora
- klasifikaciju entiteta po stepenu zagrejanosti
- generisanje izotermi vazduhalinije iste temperature
- izrada baze energetski znacajnih podataka o entitetima prostoraobuhvacenih snimkom