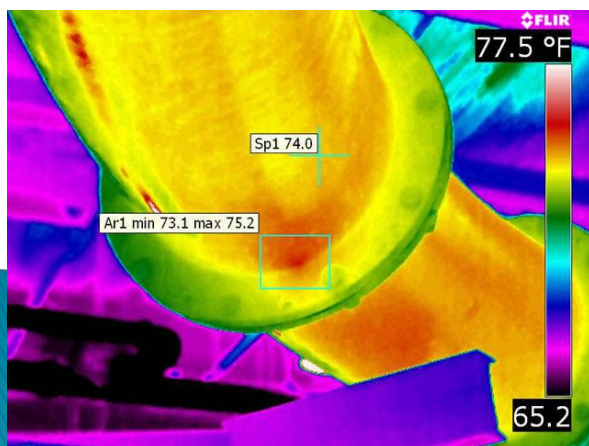


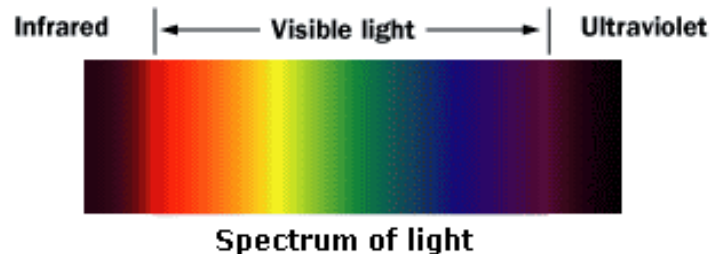


# Infrared Vision



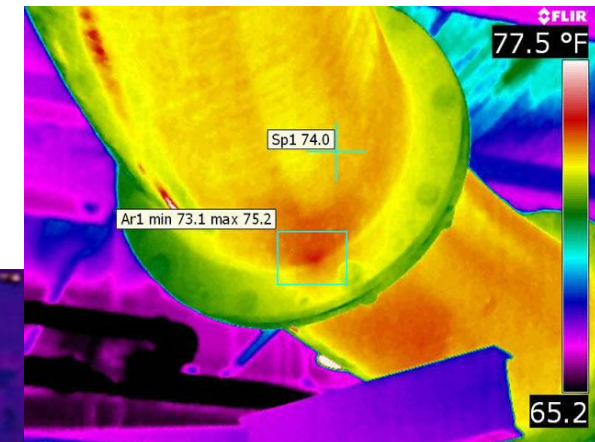
# Basic principles

- ▶ The infrared light can be separated into three ranges:
  - Near-infrared (near-IR) – around visible, has wavelengths ranging from 0.7 to 1.3 microns
  - Mid-infrared (mid-IR) – has wavelengths ranging from 1.3 to 3 microns. Both this range as the previous one are widely used in electronic devices, among them the remote commands.
  - Thermal-infrared (thermal-IR) – Occupies the largest range of the infra-red spectrum, with wavelengths ranging from 3 to 30 microns.
- ▶ The biggest difference between the thermal-IR and the other is that this is emitted by a subject, instead of reflected. Infrared light is emitted by an object due to atomic level phenomena.



# Applications

- ▶ Thermal vision equipment is ideal for:
  - Movement detectors
  - Vision in the near-absolute dark with very little or no ambient light.
  - Quality inspection
  - Temperature measurement
  - Materials characterization



# Equipment technologies

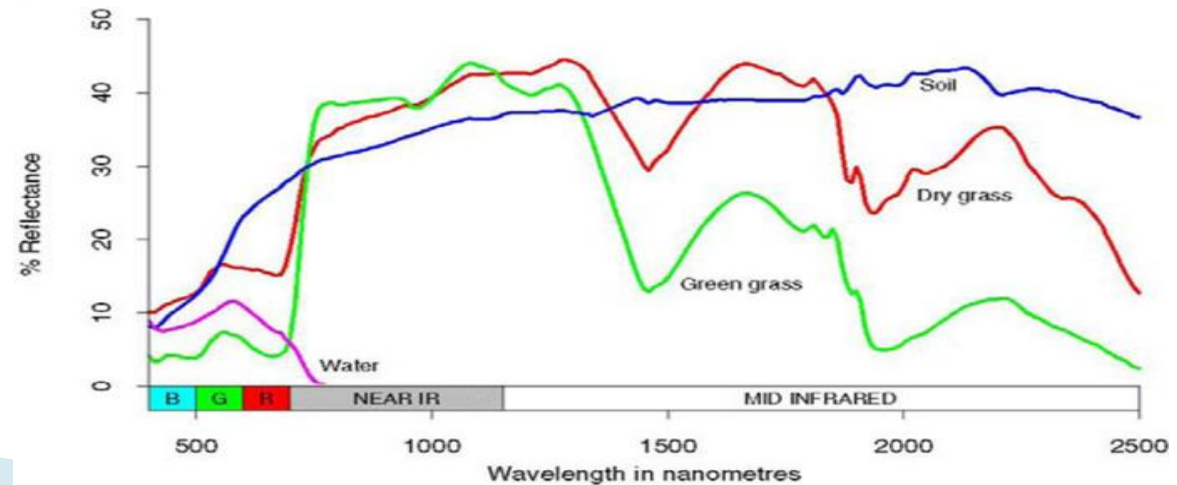
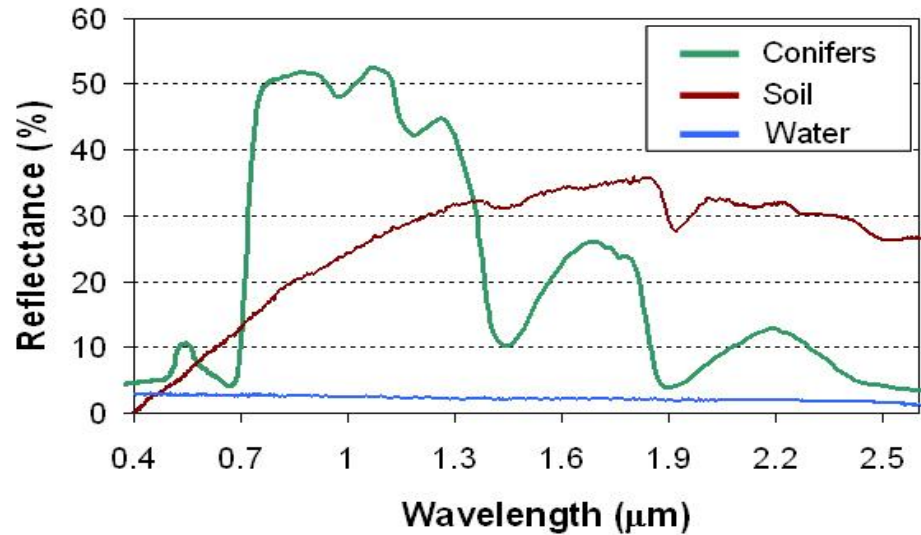
- ▶ Two technologies for infrared vision exists:
  - Image intensification( $I^2$ )
  - Thermal Image.
- ▶ Because the cost is lower and the images are easier to interpret, the **image intensification** is the most used in police equipment.
- ▶ The **thermal images** show a grayscale image depending on the temperature of the object



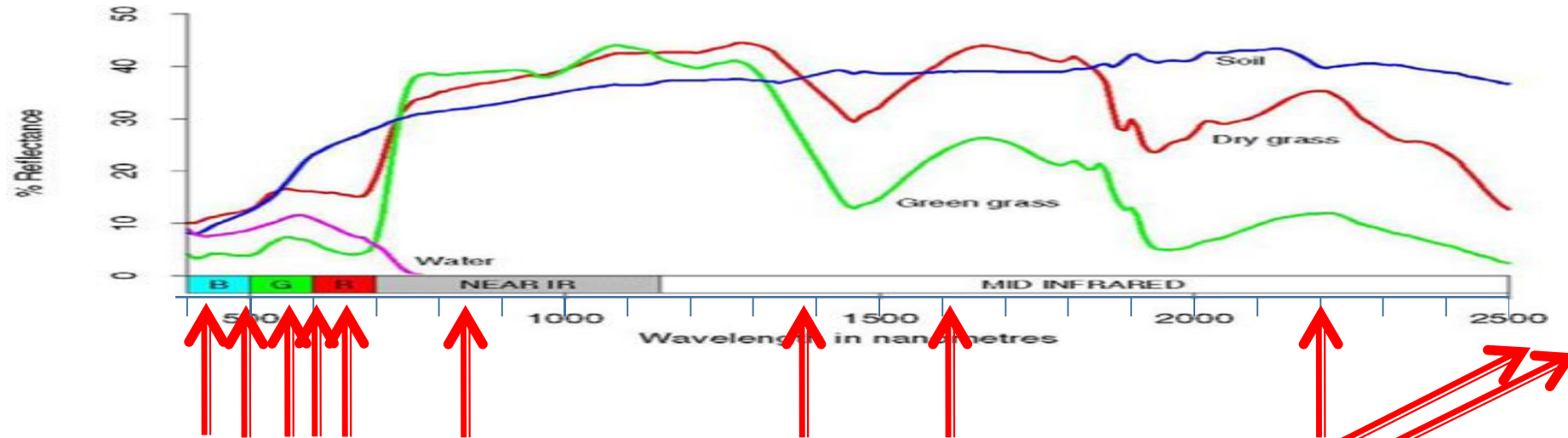
# Multi-spectral imaging



# Multispectral/ Hiperespectral analysis



# Satellite – Landsat 8

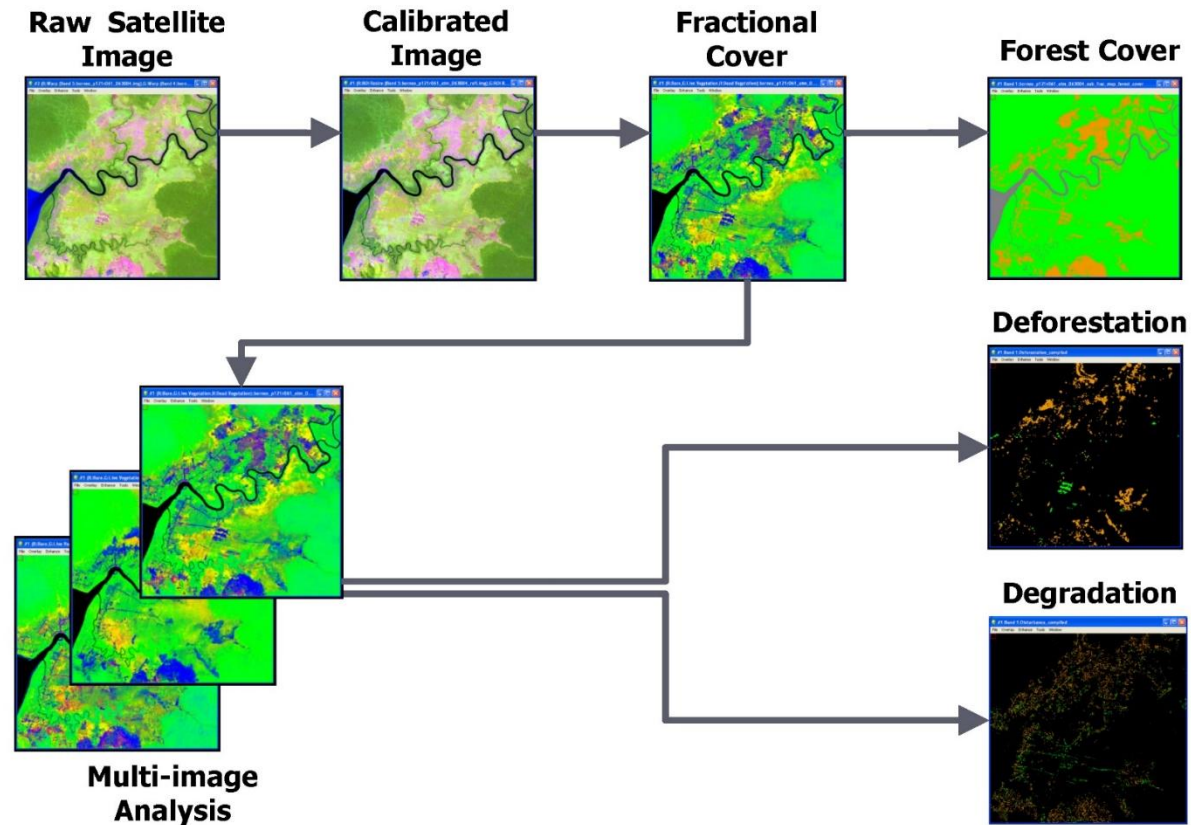


Revisit	Resolution
16 days	15 m/px – panchromatic 30 m/px – multispectral 100 m/px – thermal

Spectral Band	Wavelength	Resolution
Band 10 – Long Wavelength Infrared (Thermal)	10.30 – 11.30 $\mu\text{m}$	100 m
Band 11 – Long Wavelength Infrared (Thermal)	11.50 – 12.50 $\mu\text{m}$	100 m

7

# Example of application to forests



<http://claslite.carnegiescience.edu/en/about/software.html>

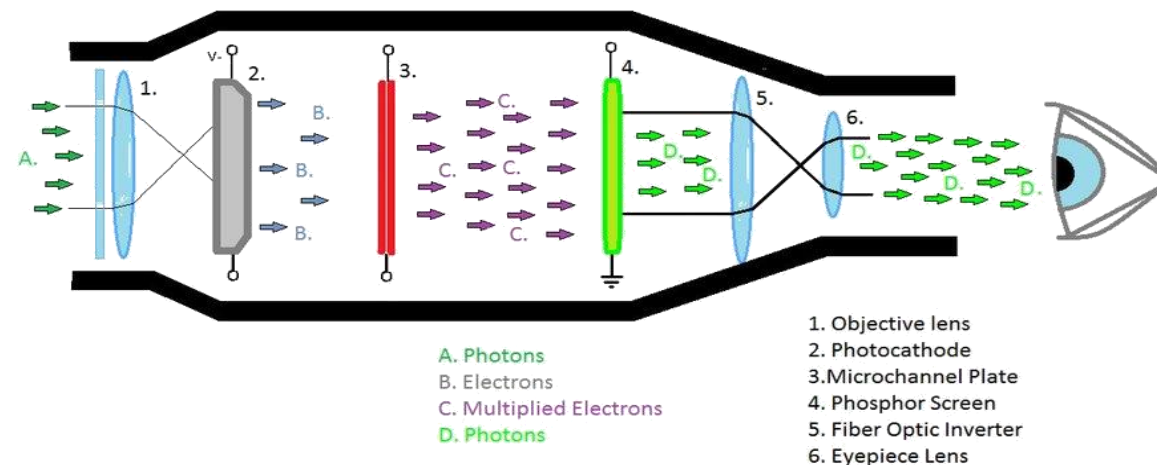


# Image intensifiers



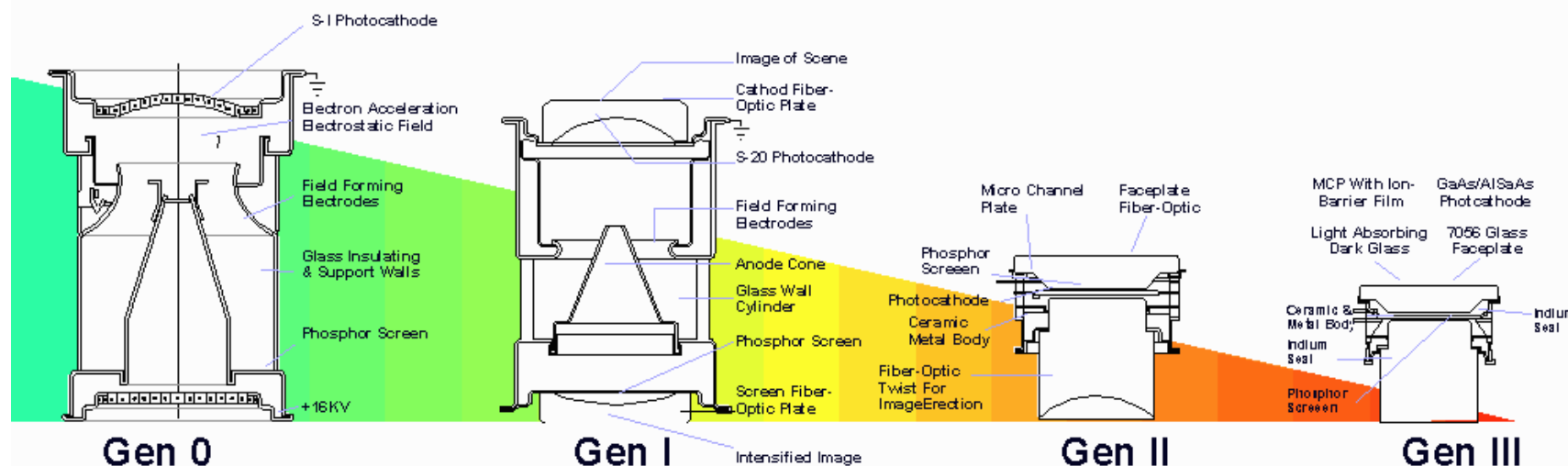
# Image intensifiers

- ▶ The light enters the lens through a device that directs to a photocathode powered by a high voltage source
- ▶ Electric charges are accelerated through a vacuum chamber until they reach a phosphor screen (identical to a TV screen) where the image is formed.



# Equipment Generations

## Image Intensification Tube Technology and Evolution



**Gen 0** - Typically uses an S-1 photocathode with peak response in the blue-green region (with a photosensitivity of  $60\mu\text{A/lm}$ ), electrostatic inversion, and electron acceleration to achieve gain. Consequently, Gen 0 tubes are characterized by the presence of geometric distortion and the need for active infrared illumination.

**Gen I** - Typically uses an S-20 photocathode (with a photosensitivity of  $180\text{--}200\mu\text{A/lm}$ ), electrostatic inversion, and electron acceleration to achieve gain. Because of higher photosensitivity, Gen I was the first truly passive image intensifier. Gen I is characterized by geometric distortion, performance at low light levels and blooming.

**Gen II** - Usually an S-25 (extended red) photo-cathode (with a photosensitivity of  $240\text{--}\mu\text{A/lm}$ ) and a micro-channel to achieve gain. Can be found with either electro-static or fiber optic-inversion. Gen II tubes provide satisfactory performance at low light levels and exhibit low distortion.

**Gen III** - Uses gallium-arsenide for the photocathode and a micro-channel plate for gain. The microchannel plate is also coated with an ion barrier film to increase tube life. Produces more than  $800\mu\text{A/lm}$  in the 450 to 950 nanometer (near infrared) region of the spectrum. Gen II Provides very good to excellent low-light-level performance, long tube life. Recent mil-spec tubes have no perceptible distortion.

# Generation 0

- ▶ The generation 0 consisted essentially by nocturnal sight used in World War II and in the Korean war.
- ▶ Were image converters that required IR lighting to illuminate the scene.





# Generation 1

- ▶ Equipment developed for the Vietnam war during the years 60, constituted the first generation image intensifiers.
- ▶ Consisting of three intensifiers in series, produced images of acceptable quality in the Center, but with significant distortion in the periphery.
- ▶ Currently, are used in low-cost equipments.



# Generation 2

- ▶ This generation is due to the development of microchannel plate (MCP) in the late 60.
- ▶ This technique allowed to accelerate and multiply the electrons providing a gain similar to the previous generation.
- ▶ With this technique it was possible to:
  - reduce the dimensions
  - reduce weight of the devices
  - increase image quality especially when bright lights are in the scene.



# Generation 3

- ▶ This generation was developed during the years 70 and was released in the early 80.
- ▶ Was the result of two technological advances: the photocathode of arsenate of gallium arsenide (GaAs) and filtering plate ion barrier "microchannel".
- ▶ This technology increased the lifetime of image tubes. GEN3 has more than 10000 hours of expected life, Gen2 between 2000 and 4000 hours.



# Thermal Image

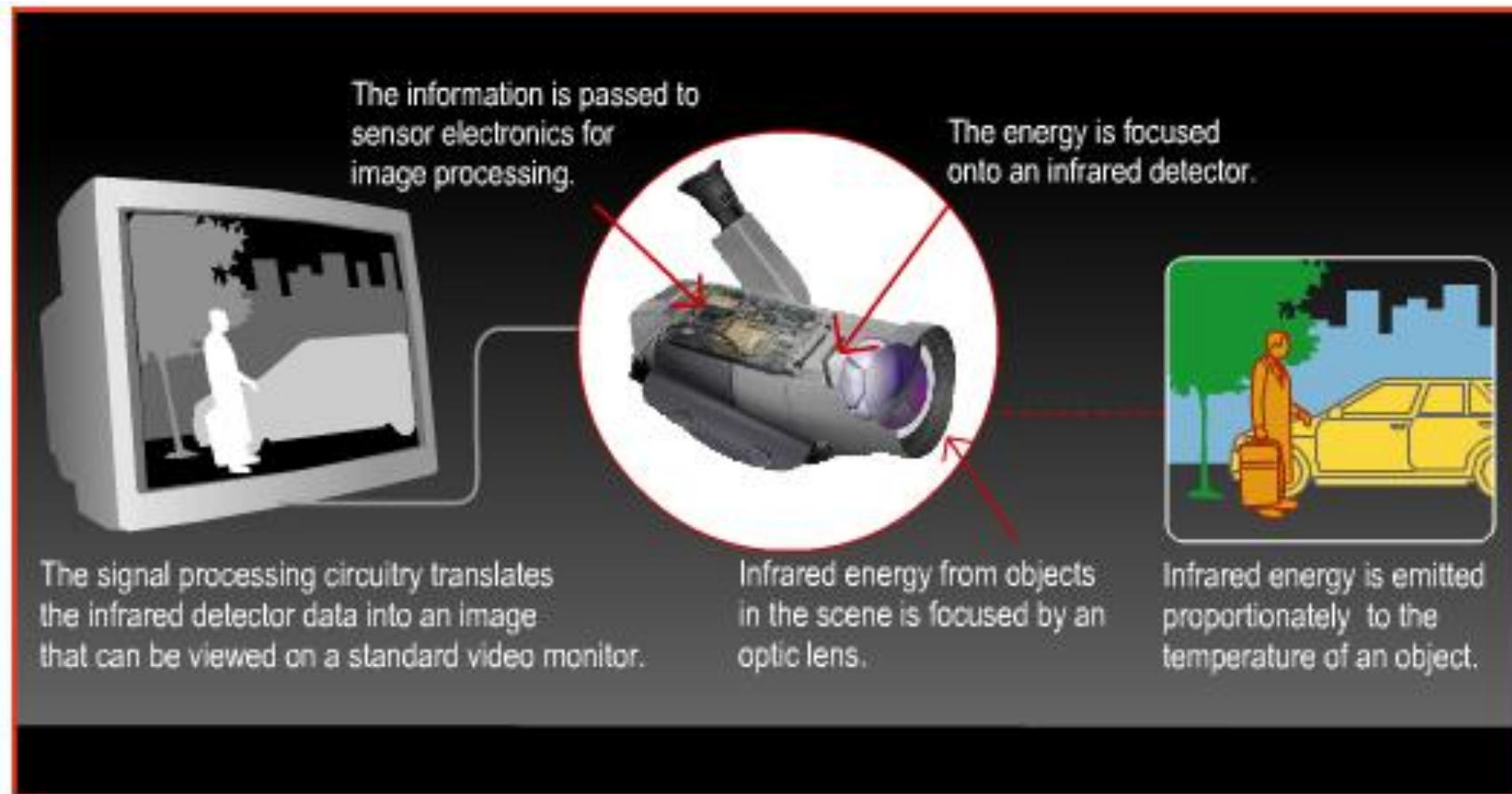




# Main Features

- ▶ Most thermal imaging devices:
  - Work at 30 frames per second
  - Low resolution (320 x 240, & 640 x 480 pixels)
  - Capture temperatures between  $-20/-40^{\circ}$  Celsius and  $2000^{\circ}$  Celsius with a precision of  $0.04^{\circ}$  Celsius /  $30^{\circ}\text{C}$
- ▶ Two basic types of equipments exist:
  - **Un-cooled:** most common.
    - Work at room temperature.
    - Silent, have instant turn-on and work with batteries.
  - **Cryogenically cooled:**
    - More expensive and sensitive, kept at zero degrees Celsius.
    - Good resolution and sensitive. (differences of  $0.1^{\circ}\text{C}$  at more than 300m distance)

# Working principle



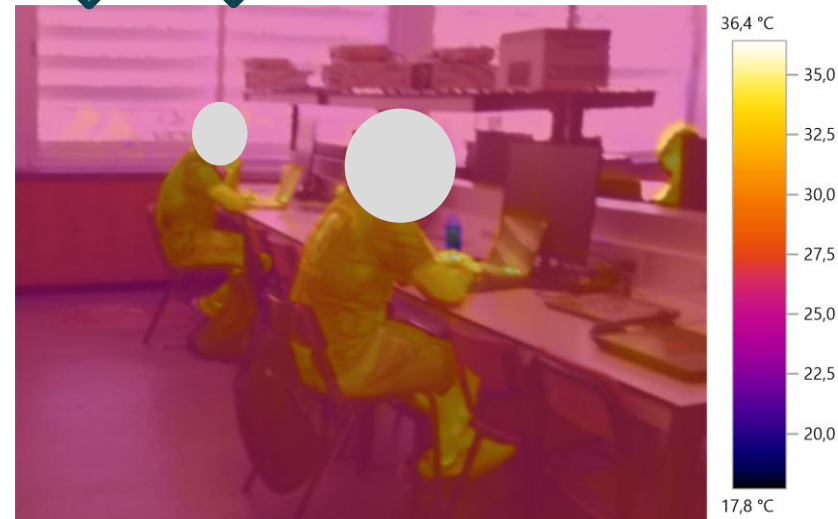
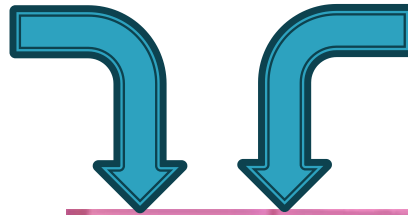
# Dahua TPC-BF2120 THERMAL CAMERA

- ▶ Dual Sensor
  - Thermal (160 x 120px)
  - Visible (2Mp)



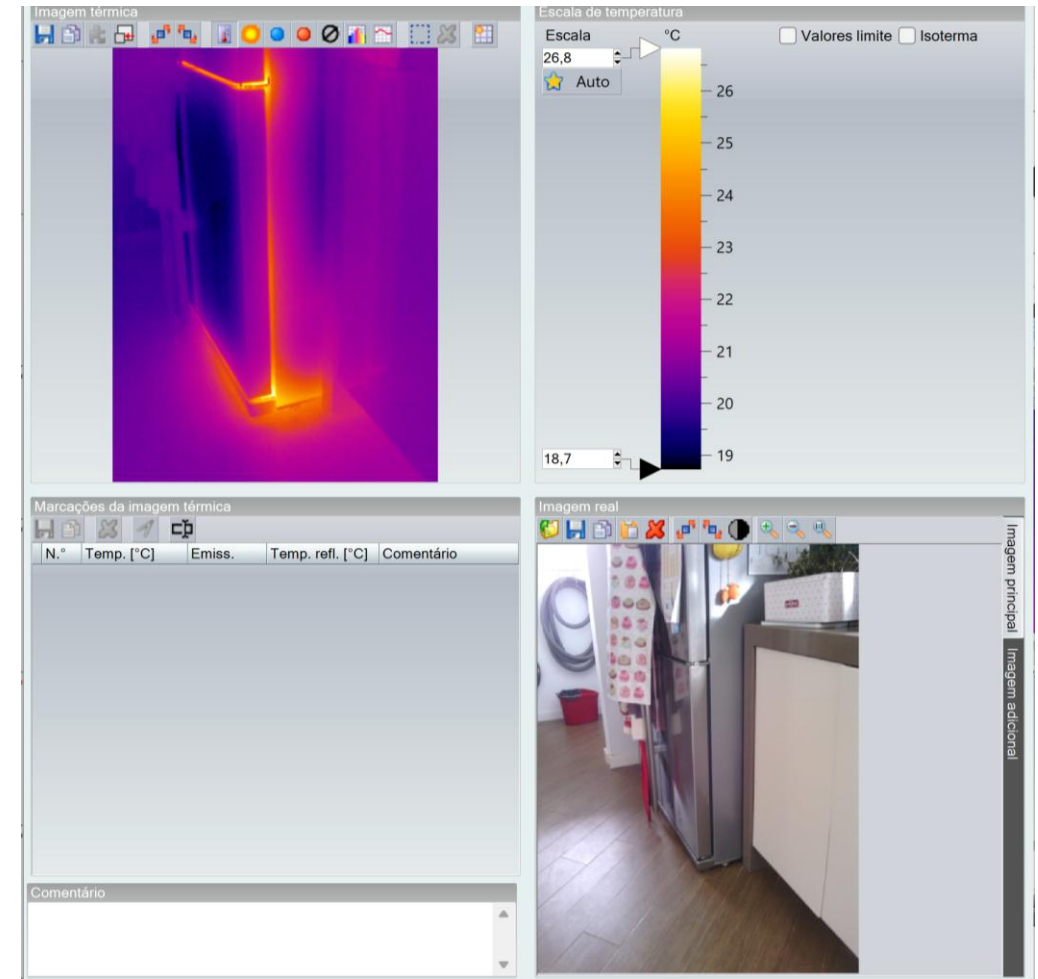
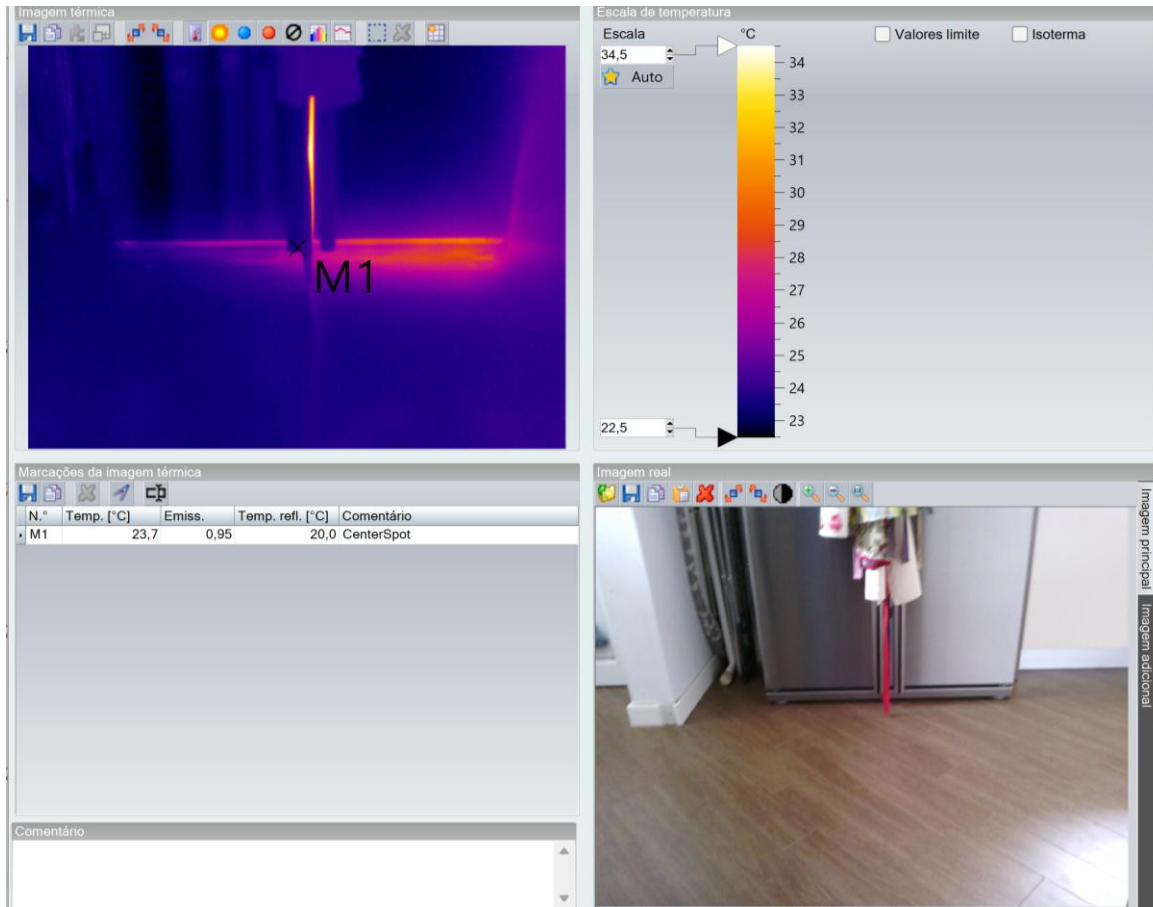
# Testo 872s

- ▶ Dual Sensor
  - Thermal (320 x 240px)
  - Visible (5Mp)

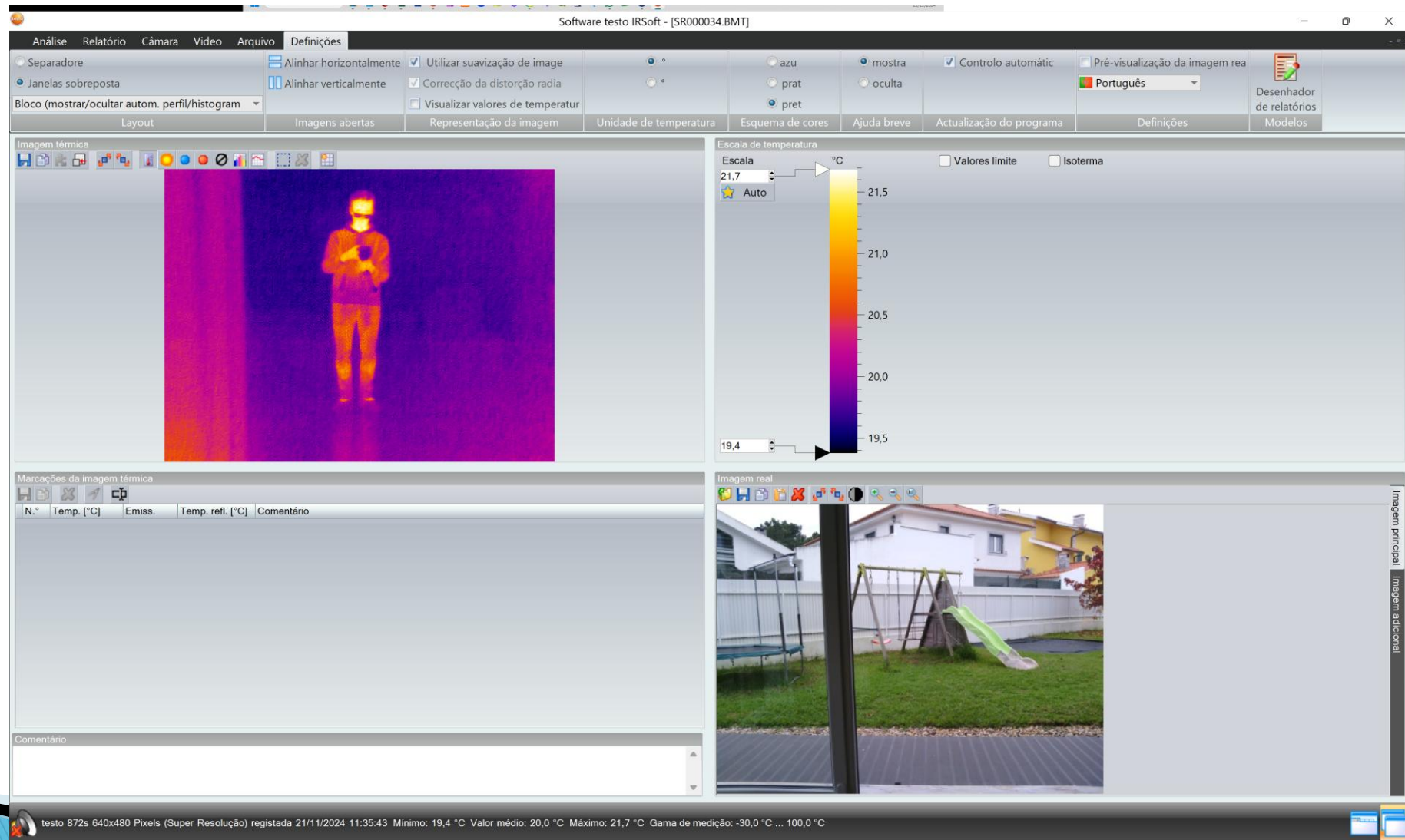




# Thermal behavior of the refrigerator door



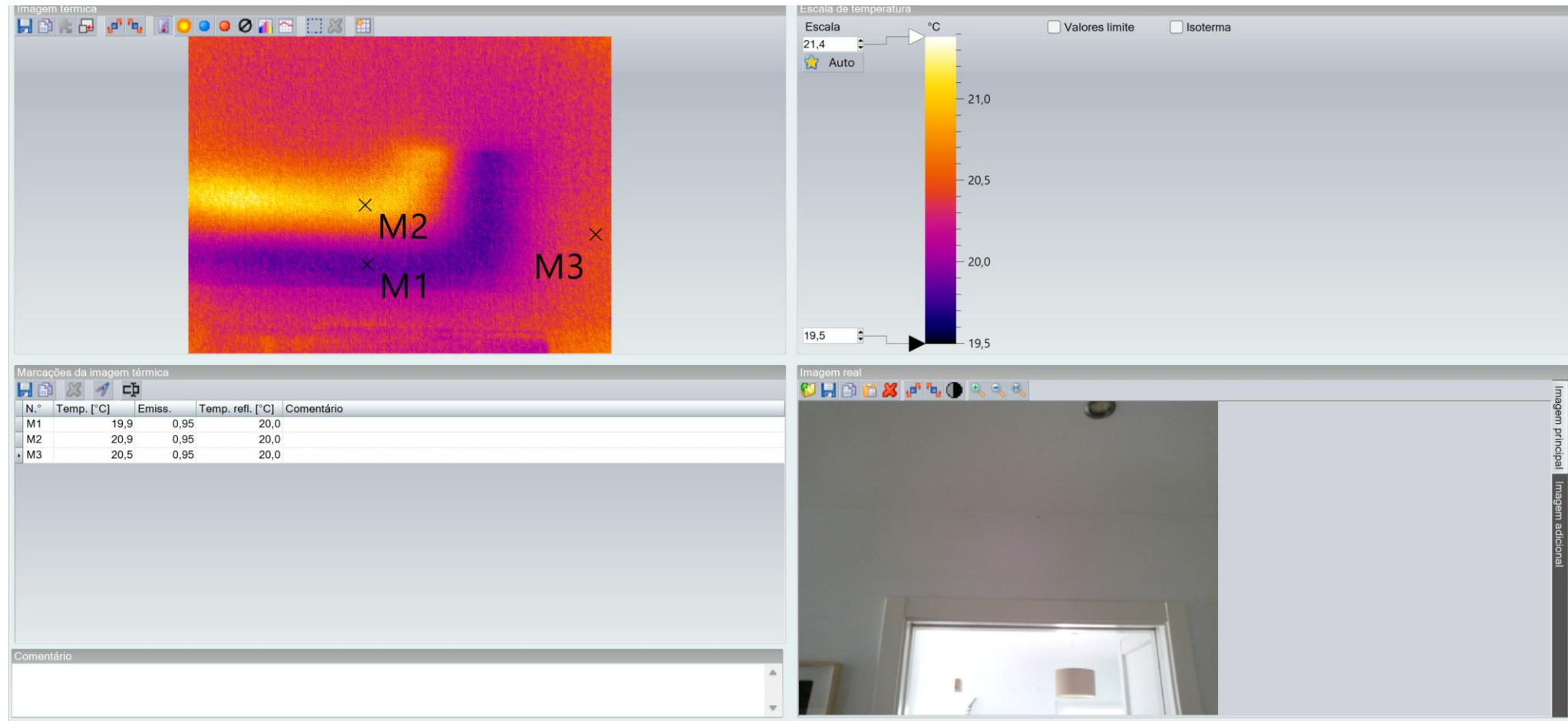
# Mirror effect



10/11/2025

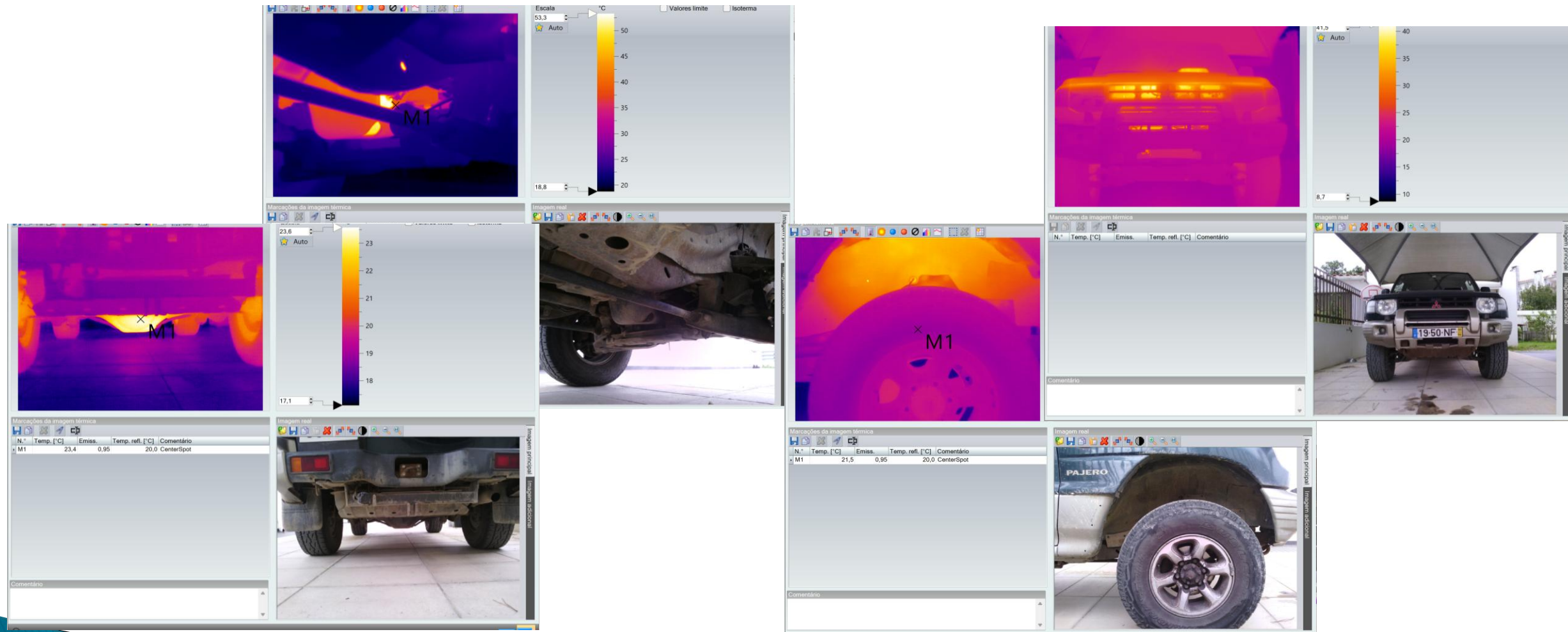
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# Hot and cold water piping





# Automotive Diagnostics / Maintenance

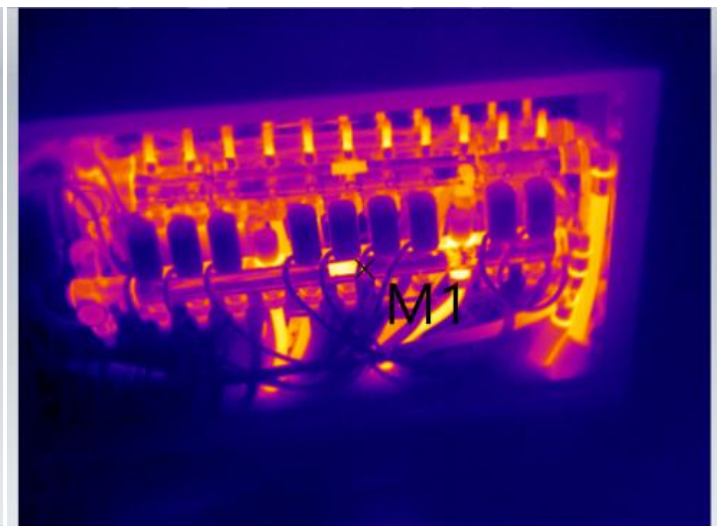
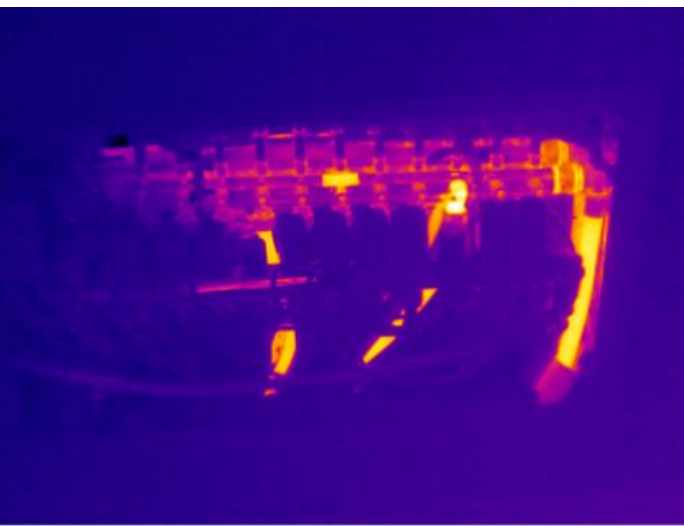
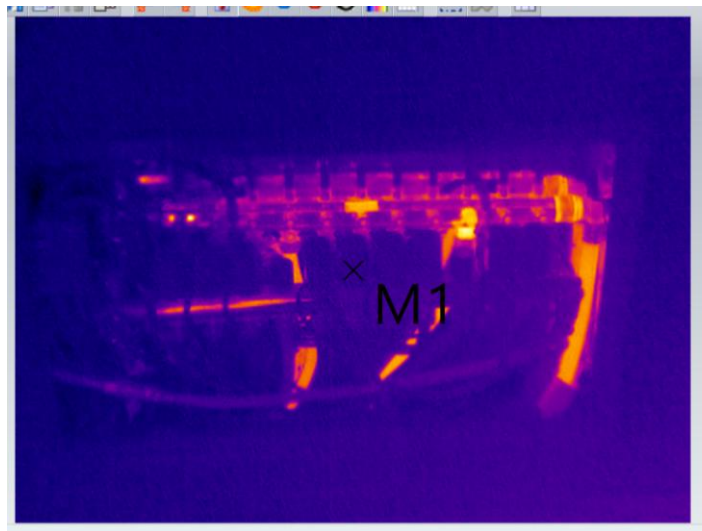
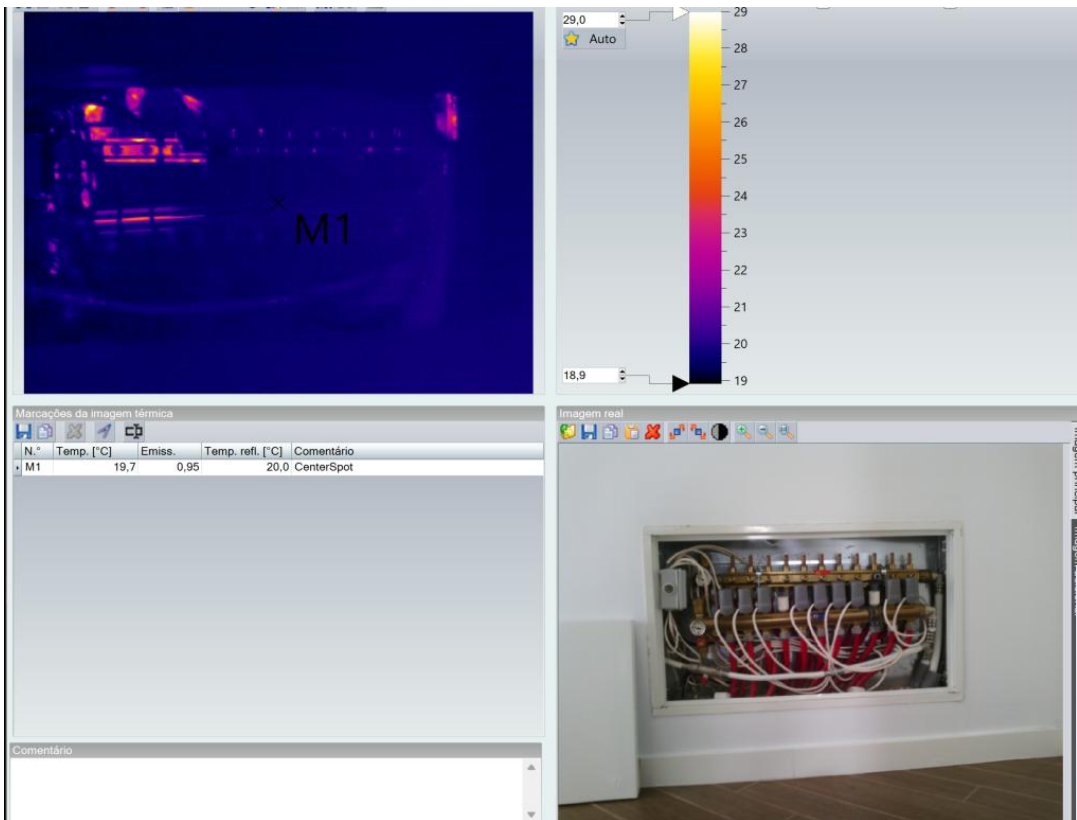


10/11/2025

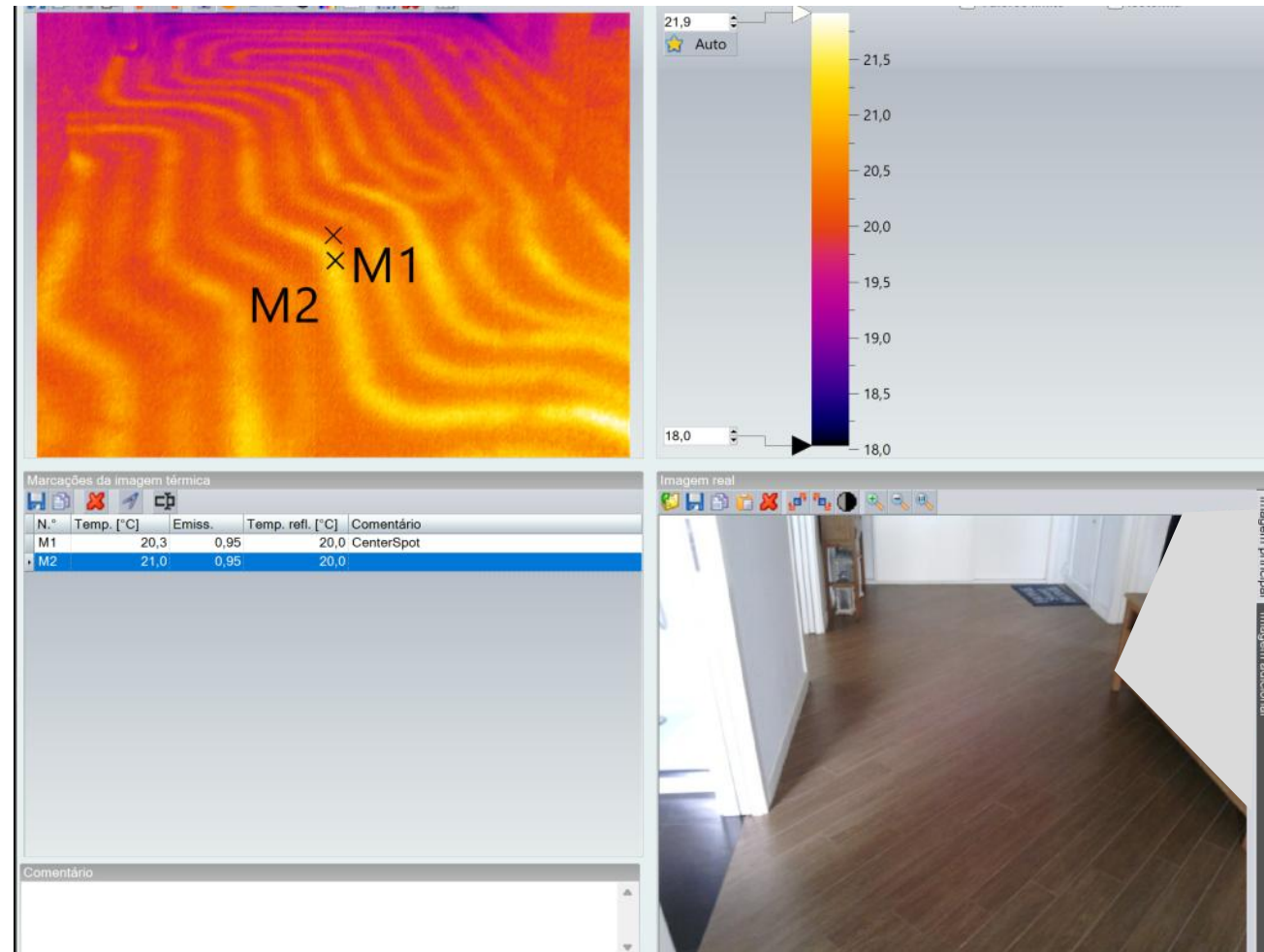
André D. Mora e José M. Fonseca  
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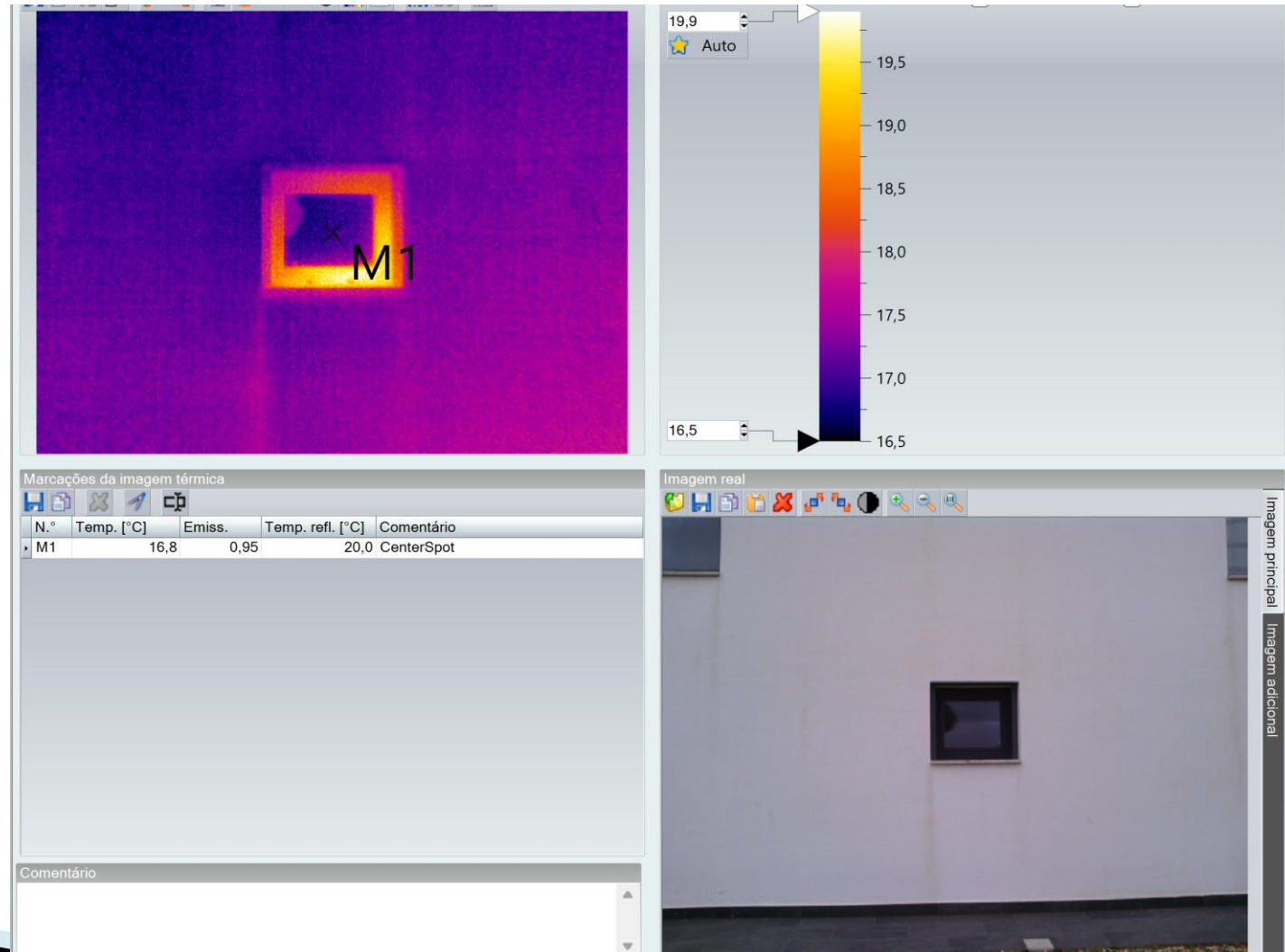
# Water Heating System Inspection



# Water Heating System Inspection



# Exterior Walls



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# Thermal cameras



Camera HT-175  
– 32x32 pixels –  
118€ (2020)



Camera FLIR T600-25  
– 480x360 pixels –  
±18000€ (2020)

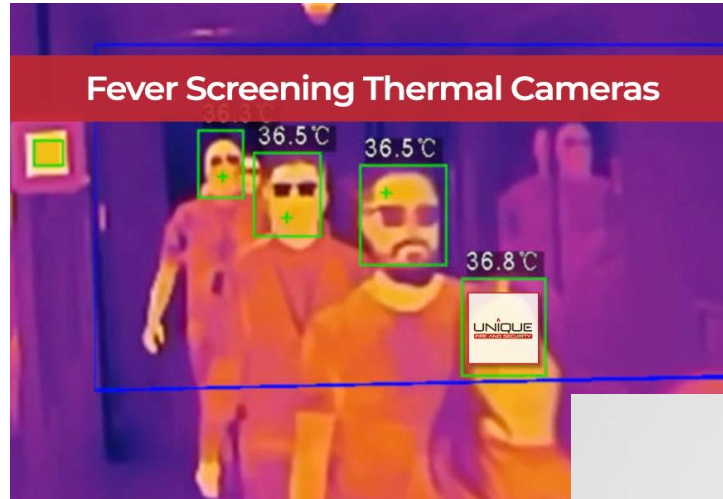
FLIR T1020-45  
– 1024x768 pixels –  
±40000€ (2020)

# Thermal Video





# Human Body Temperature System



# Digital thermometers without contact



*Technical use*



*Domestic Use*