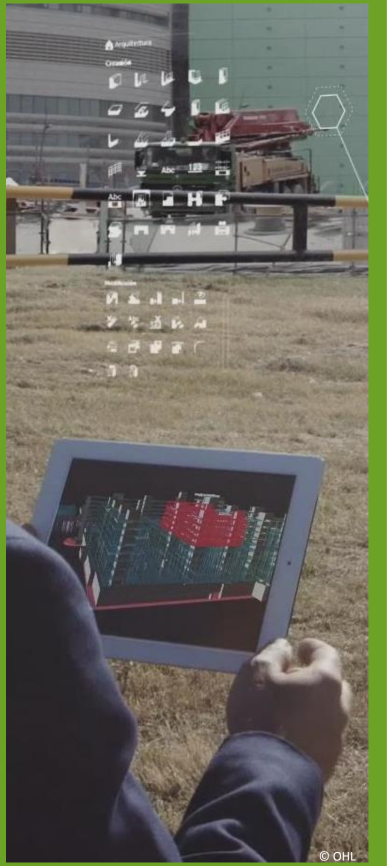

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Tools for the 21st Century Construction Worksite

Exploring Low Cost Infrared Cameras to Reduce Energy Performance Gap in Buildings: *Using the Flir One Thermal Imaging Camera*

Colin Pearson , BSRIA Ltd. UK

29 June 2017| Sustainable Places Conference 2017| Middlesbrough

www.built2spec-project.eu

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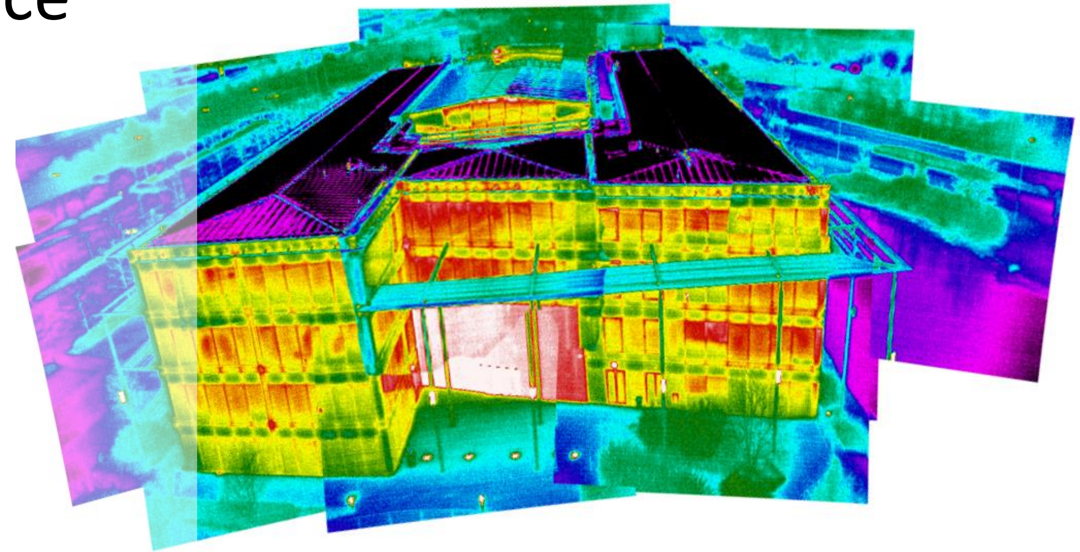
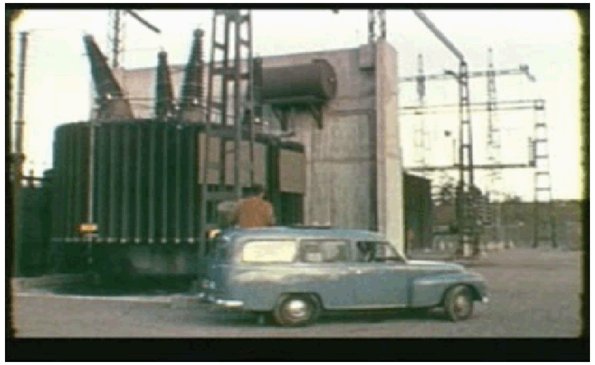
Thermal Imaging

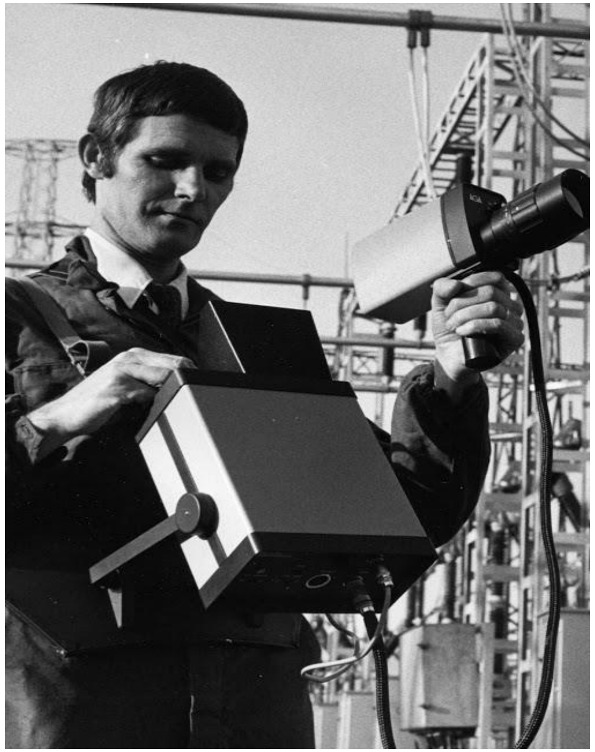
- Produces a map of radiant heat from a surface
- Uses infrared radiation
- Usually presented as a temperature map
- A non-contact temperature measurement
- Wide range of applications
- Works on anything that is a different temperature from its environment



Thermal Imaging - History

- Since 1968
- Insulation effectiveness
- Mechanical services diagnostics
- Electrical connection checks
- Barriers to entry:
  - Price: €40,000
  - Weight: 30 kg
  - Complexity:





Thermal imaging - Recent

- Same applications
- Widely accessible
  - Price: €1000
  - Weight: 600g
  - Complexity:

Thermal imaging - Today

- More applications
- Everybody can have one
  - Price: €200
  - Weight: 32g
  - Complexity:

Performance

- Checked in BSRIA calibration laboratory

	Typical IR Camera	Smartphone Camera 1	Smartphone Camera 2	Smartphone Camera 3	Units
Purchase Date	2007	2015	2016	2017	year
Price	10,000	135	165	200	UK Pounds
Weight	880	220	144	140	g
Pixels	320 x 240	80 x 60	160 x 120	160 x 120	No.
Sensitivity	0.05	0.1	0.1	0.1	K
Field of View	25 x 19	50 x 39	46 x 35	55 x 43	Angular degrees
Temperature Range	-20 to 650	-10 - 120	-20 - 120	-20 - 400	°C
Wavelength	8 to 14	8 to 14	8 to 14	8 - 14	µm
Minimum Focus	400	150	150	150	mm
Specified Accuracy	± 2	± 2	± 2	± 2	K
Measured Accuracy	± 0.83	± 1.25	± 0.98	NA	K

Additional Features on the Smartphone Camera

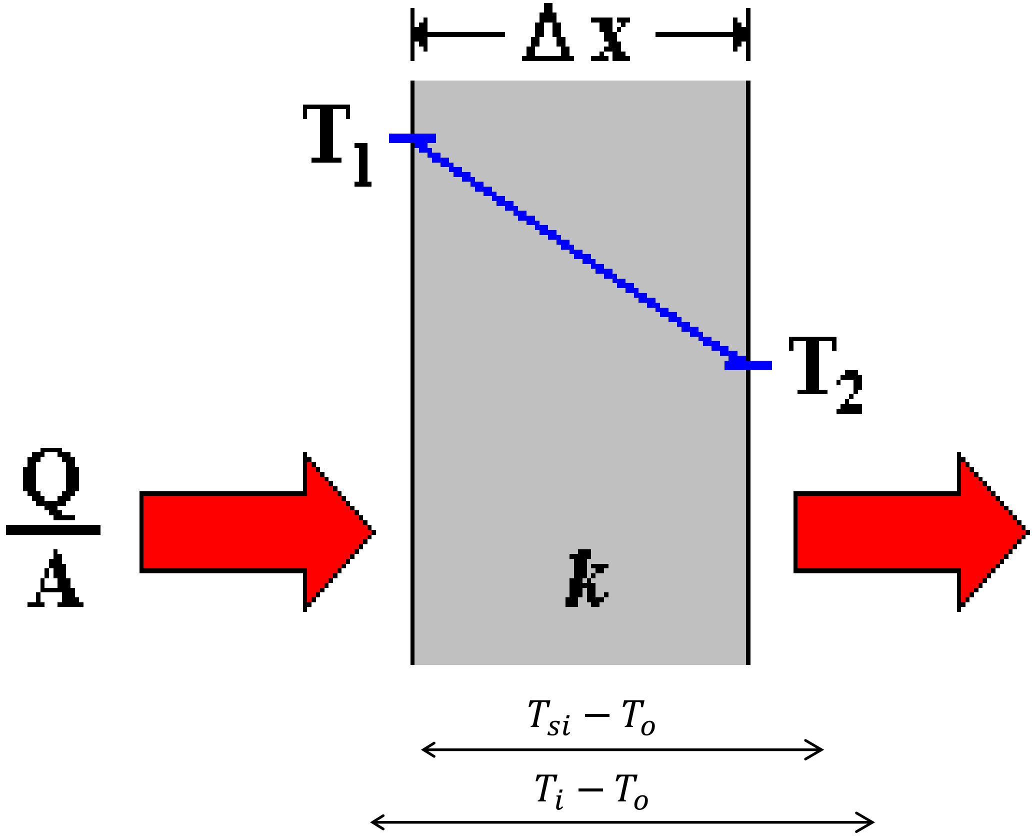
- GPS location
- 3G, Wi-Fi & Bluetooth communication
- Image analysis app
- Fits in your pocket
- You can make phone calls on it!

It’s Easy, Isn’t it?

- It’s easy to get a thermal image
- How do you? understand what’s going on?
  - Is there enough temperature difference?
  - Has it been constant for long enough?
  - What surface temperature should I expect?
  - What is the emissivity of the surface?
  - What is an acceptable variation?

Thermal Index

$$\frac{\text{Difference between internal surface and external temperature}}{\text{Difference between internal and external environmental temperatures}}$$

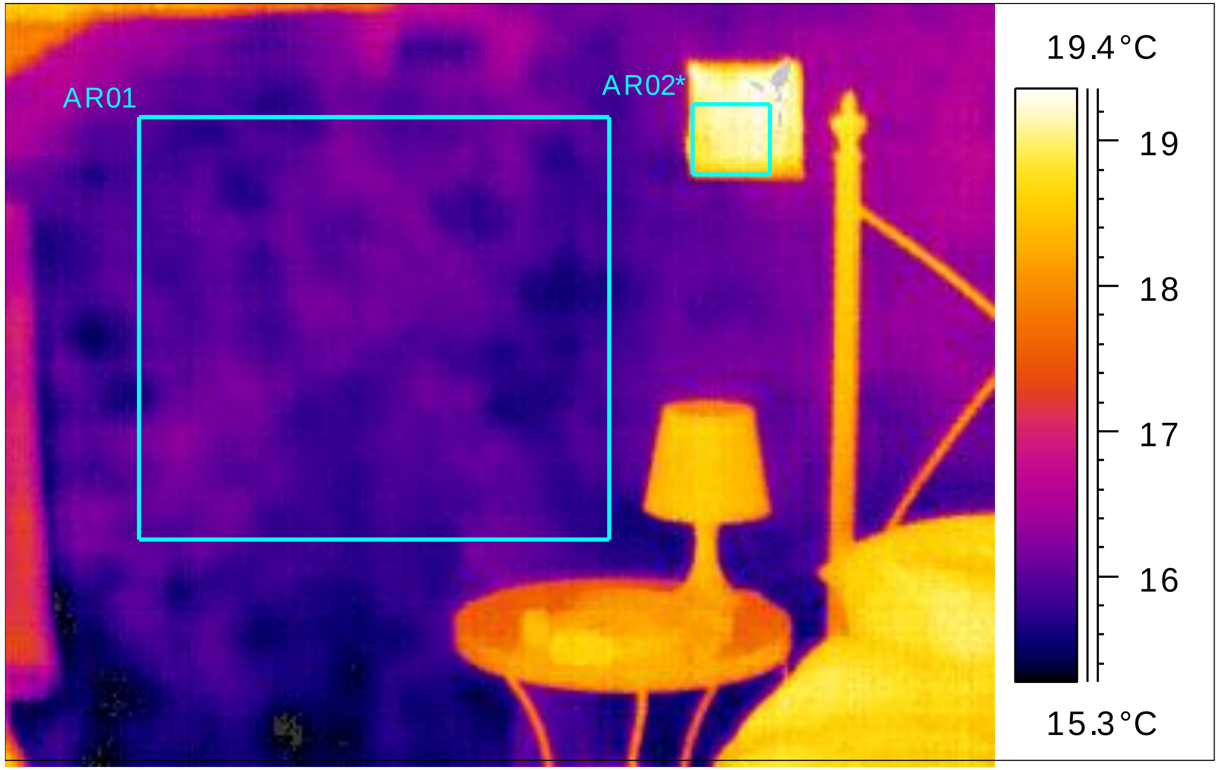


$$Thermal\ Index, TI = \frac{(T_{si} - T_o)}{(T_i - T_o)}$$

Insulation Effectiveness – Example using TI

- External temperature 9.0°C
- Accurate room temperature measurement =

  AR02∗ : avg19.0°C
- AR01 : avg15.9°C
- Thermal Index calculated for area AR01



$$Thermal\ Index, TI = \frac{(15.9-9.0)}{(19.0-9.0)} = 0.69$$

Co-relation between TI and U-value

Thermal Index	0.69	0.75	0.9	0.97	
U Value	2.38	1.92	0.77	0.23	W/m^2K

- $U = (1 - TI) / R_{si}$ (R_{si} = Inside surface resistance = 0.13 m^2K/W for internal vertical surface)
- Uncertainty of measurement depends on ΔT
- Depends on air movement
- Only applies at the point where measured
- Only applies at the time when measured

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Some Answers

In ideal conditions with suitable:

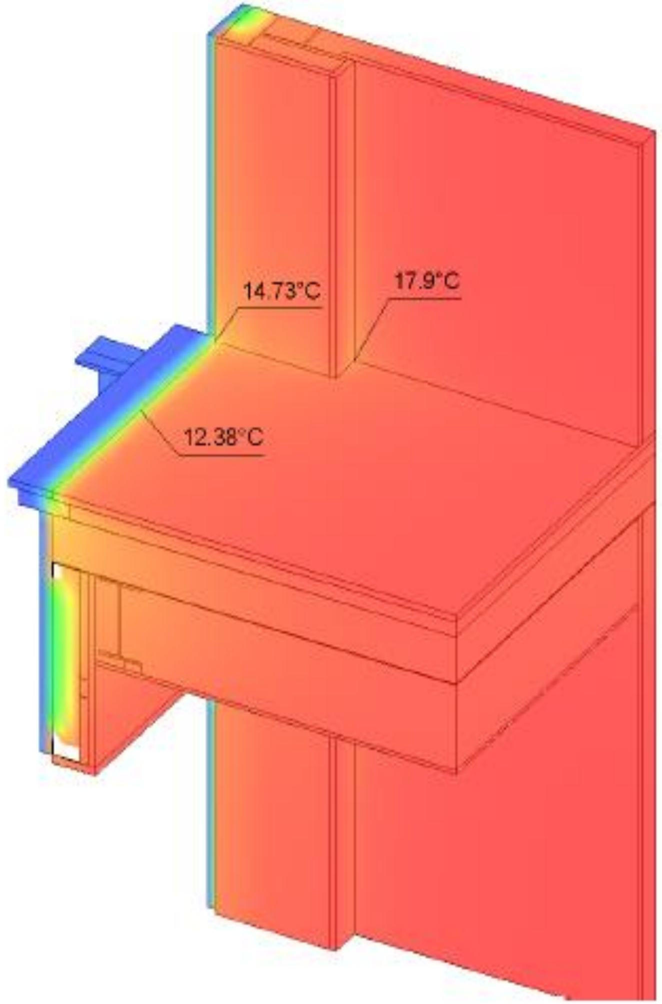
- External and internal air temperatures
- External and internal radiant temperatures
- Known high surface emissivity
- Constant for long enough to reach equilibrium
- Low wind speed
- No precipitation
- You can calculate U value

- But this never happens!

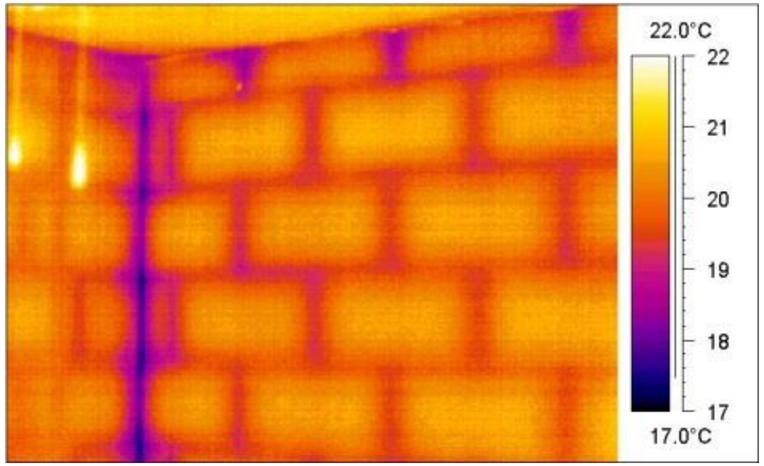
The Solution

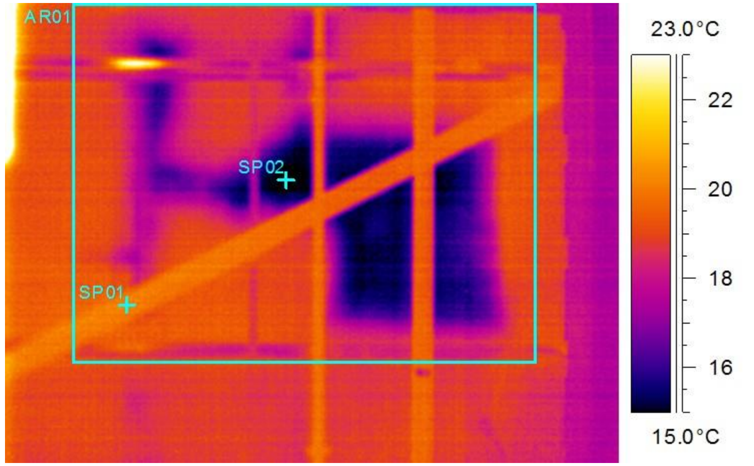
Thermal Modelling

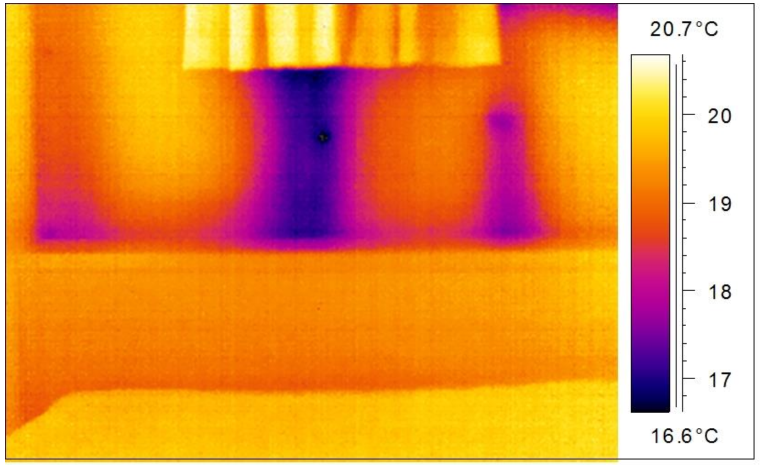
- Simple Finite Element Analysis of structure
- Based on temperature history
- Uses design thermal properties
- Tests for difference between measured and expected temperatures

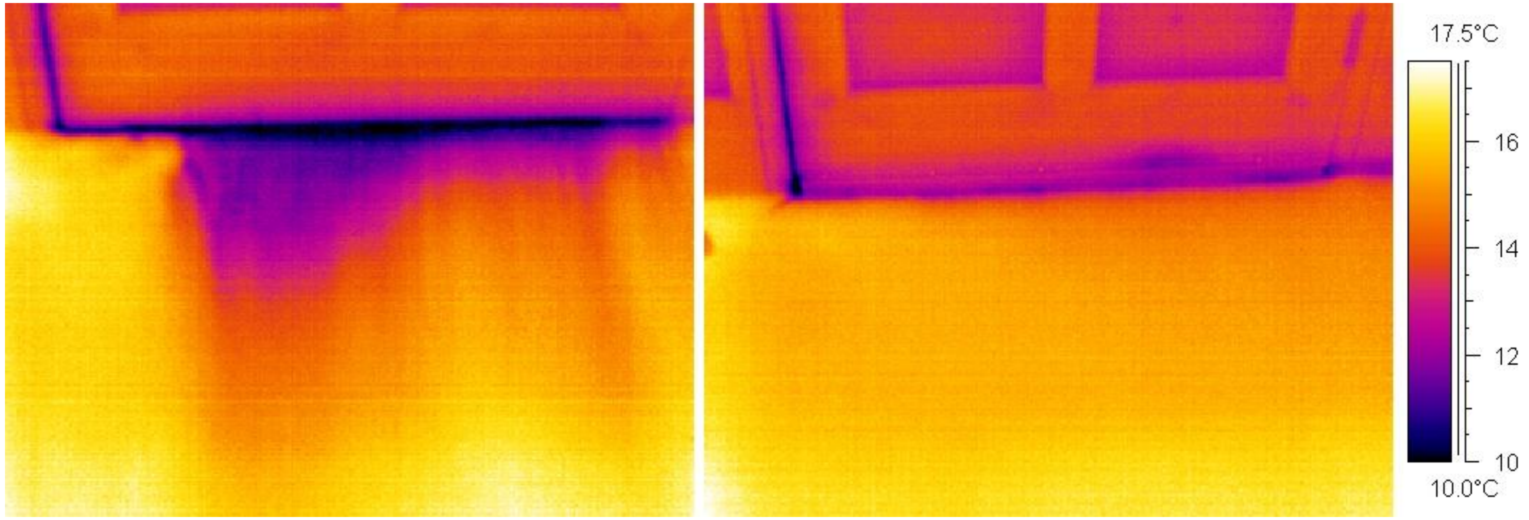


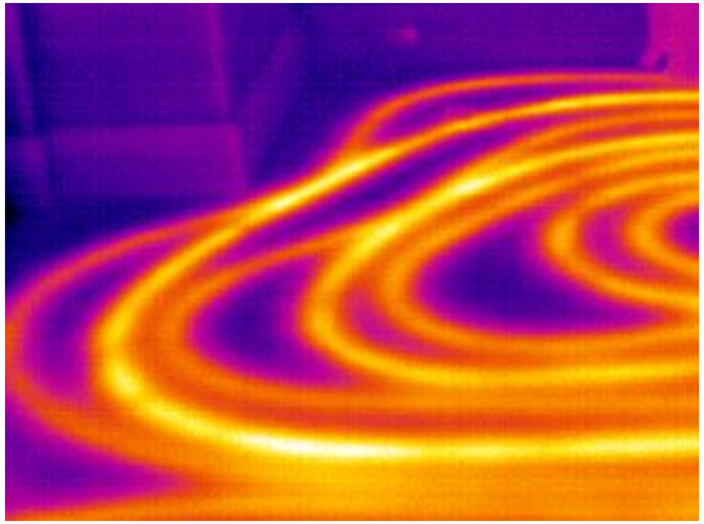
Examples


22.0°C
22
21
20
19
18
17
17.0°C


AR01
SP02
SP01
23.0°C
22
20
18
16
15.0°C


20.7°C
20
19
18
17
16.6°C

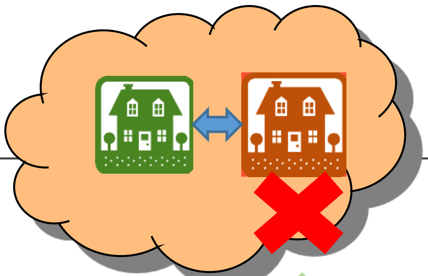

17.5°C
16
14
12
10
10.0°C



Built2Spec

- EU research project with 20 partners finishing in Dec 2018, aimed at ensuring build quality by making the process of building checks easier with research on :
  - Energy Efficiency Quality Checks
  - Indoor Air Quality Tools
  - **Thermal Imaging Tools**
  - Smart Building Components
  - Building Information Modelling
  - Airtightness Test Tools
  - Acoustic Tools
  - 3D and Imagery Tools
  - Virtual Construction Management Platform

Built2Spec Thermal Imaging



- Checking thermal performance of structure using a suitable infrared camera and networked processing
  - Measure site conditions for suitable period [BMS, sensor network etc.]
  - Position the camera and data collector in front of the area to be assessed
  - Collect location data [BLE, Tango or other] Match 3D location and model
  - Collect thermal image
  - Send data and thermal image to building model in the cloud
  - Compare thermal image with result of dynamic thermal model [model maps expected internal surface temperatures]
  - Move to new location and repeat

Conclusion

- Smartphone infrared cameras help to ensure quality in insulation
- Every project manager should have one
  - BSRIA don’t sell them!
  - But you can get them through websites:
    - www.flir.com/flirone
    - http://therm-app.com (Therm-App)
    - www.thermal.com (Seek Thermal)
    - www.i3-thermalexpert.com
    - www.catphones.com/ (Caterpillar brand)

THANK YOU

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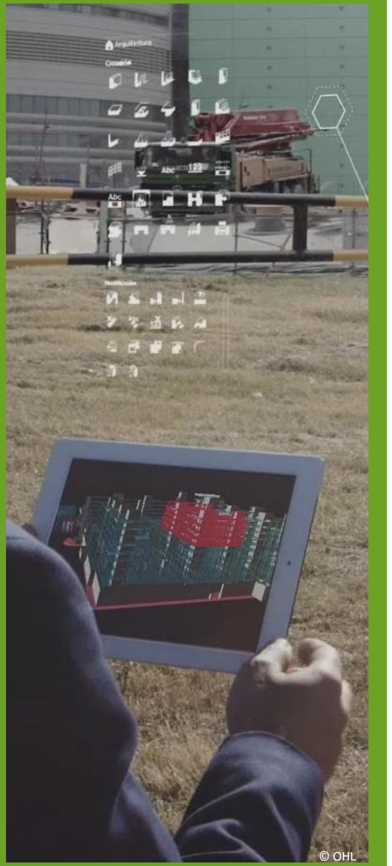

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Colin Pearson, BSRIA

BSRIA Ltd, Old Bracknell Lane West,
Bracknell, Berkshire, UK

RG127AH

Tel. : +44-01344 465523

Fax : +44-01344 465626

Email : ian.wallis@bsria.co.uk

Website : www.bsria.co.uk

www.built2spec-project.eu

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