


European Cooperation in the field of Scientific and Technical Research






Building Integration of Solar Thermal Systems – TU1205 – BISTS

BISTS testing under a Solar Simulator


[Dr Mervyn Smyth](#)
[Dr Aggelos Zacharopoulos](#)

Centre for Sustainable Technologies
University of Ulster, UK







Centre for Sustainable Technologies




COST is supported by the EU RTD Framework Programme

ESF provides the COST Office through an EC contract






European Cooperation in the field of Scientific and Technical Research



Building Integration of Solar Thermal Systems – TU1205 – BISTS


Overview


- The CST Solar Simulator
- Uniformity, collimation and spectral output
- Light incident at non-normal angles
- Experimental set-ups



COST is supported by the EU RTD Framework Programme


ESF provides the COST Office through an EC contract







European Cooperation in the field of Scientific and Technical Research

Building Integration of Solar Thermal Systems – TU1205 – BISTS




- Solar energy system testing procedures which are conducted outdoors have large uncertainties due to the non-controllable insolation conditions.
- Indoor solar simulator facilities allow insolation conditions to be both limited and controllable.






COST is supported by the EU RTD Framework Programme


ESF provides the COST Office through an EC contract






European Cooperation in the field of Scientific and Technical Research


Building Integration of Solar Thermal Systems – TU1205 – BISTS



A solar simulator should provide:


- **Uniform illumination** over a given test area
- **Collimated light**
- **Spectral output** similar to that of the sunlight






COST is supported by the EU RTD Framework Programme


ESF provides the COST Office through an EC contract





European Cooperation in the field of Scientific and Technical Research


Building Integration of Solar Thermal Systems – TU1205 – BISTS



Solar Simulator Requirements (illumination)


The CST solar simulator was required to produce:


- continuous,
- highly uniform,
- collimated light,
- with a spectral output matching the AM 1.5 spectrum
- allow testing at non-normal incidence angles of illumination



COST is supported by the EU RTD Framework Programme


ESF provides the COST Office through an EC contract





European Cooperation in the field of Scientific and Technical Research


Building Integration of Solar Thermal Systems – TU1205 – BISTS



Solar Simulator Requirements (testing flexibility)


For testing building integrated technologies which are mounted vertically on a test rig (as on a building façade) the simulator needed a suitable mounting frame that would allow height adjustment from ground level to 6m and tilt adjustment from horizontal to vertical.


The simulator was also required to be mobile as to facilitate testing of the various technologies investigated within the CST laboratory.




COST is supported by the EU RTD Framework Programme


ESF provides the COST Office through an EC contract





European Cooperation in the field of Scientific and Technical Research






www.cost.esf.org

Building Integration of Solar Thermal Systems – TU1205 – BISTS


Unique Feature


- Solar simulators are unable to simulate sunlight incident at other than the normal angle on a large area test plane. The CST solar simulator was designed to achieve highly uniform illumination at non-normal incidence angles.
- This is particularly important for the experimental characterisation of solar concentrators and evacuated glazing




COST is supported by the EU RTD Framework Programme


ESF provides the COST Office through an EC contract





European Cooperation in the field of Scientific and Technical Research






www.cost.esf.org

Building Integration of Solar Thermal Systems – TU1205 – BISTS

The Lamp Array


- It generates the simulator light.
- 35 lamps - arranged in 7 rows of 5 lamps each. Includes lamp reflectors.
- All components are housed in a 2750 mm x 2020 mm x 350 mm aluminum box.
- Two ducts at the ends of the aluminum housing contain fans which cool the lamps by forcing air through it at ambient temperature.
- The lamp arrangement was carefully selected by the manufacturer with the aim of producing the required highly uniform light output.

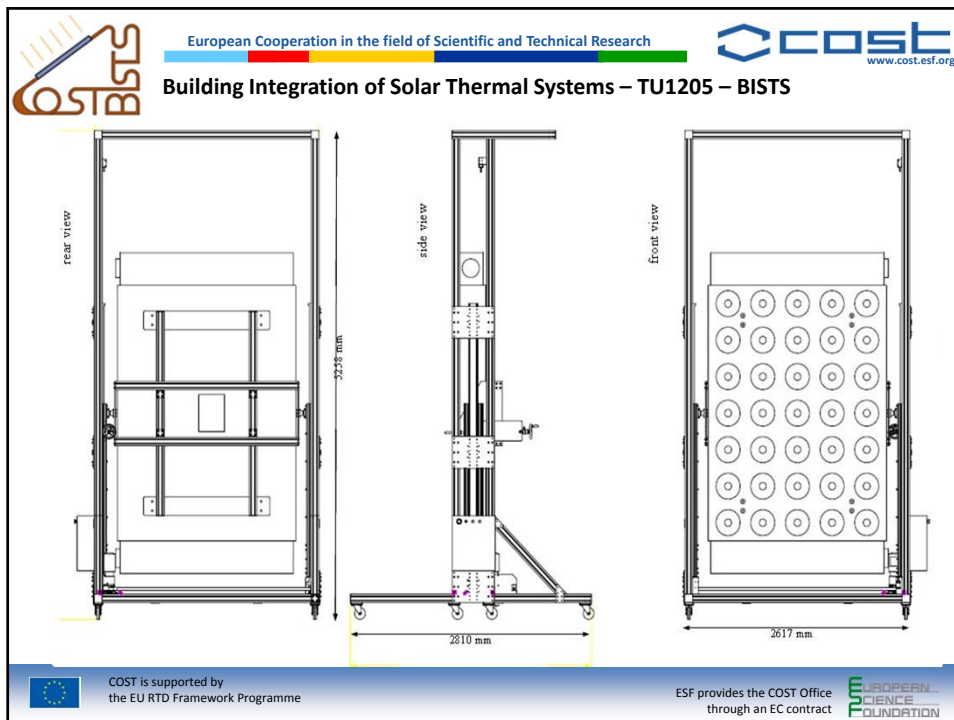
It weighs approximately 500 kg (including cables) and is connected to the control unit via heavy duty cabling



COST is supported by the EU RTD Framework Programme

ESF provides the COST Office through an EC contract





European Cooperation in the field of Scientific and Technical Research

BIST

cost
www.cost.esf.org

Building Integration of Solar Thermal Systems – TU1205 – BISTS

Technical - Electrical Data	
Wattage	575 W
Voltage	95 V
Current	6.7 A

Technical - Geometries	
Light centre length (LCL)	70 mm
Electrode gap cold	7.0 mm
Bulb diameter	30.00 mm
Length	145 mm
Diameter	30 mm

Technical - other	
Cooling	Convection
Lifespan	1000 h
Colour temperature	6000 K

Metal halide (Osram HMP 575W)


Spectral output

Graph showing Spectral output (Rel. Intensity vs Wavelength/nm). The x-axis ranges from 250 to 780 nm, and the y-axis ranges from 0.0 to 1.0. The curve shows a broad spectrum with peaks around 400 nm, 500 nm, and 600 nm.


COST is supported by the EU RTD Framework Programme

ESF provides the COST Office through an EC contract

EUROPEAN SCIENCE FOUNDATION




European Cooperation in the field of Scientific and Technical Research




www.cost.esf.org

Building Integration of Solar Thermal Systems – TU1205 – BISTS





The completed solar simulator in operation at the CST laboratory at the University of Ulster




COST is supported by the EU RTD Framework Programme

ESF provides the COST Office through an EC contract






University of ULSTER



Centre for Sustainable Technologies



www.cost.esf.org


Building Integration of Solar Thermal Systems – TU1205 – BISTS

Infra-Red (IR) filter

Purpose of the filter is to reduce excess IR radiation produced by the metal halide lamps at wavelengths above 740 nm.


The filter is important for testing PV technologies where IR radiation can increase temperature and reduce electrical conversion efficiency

Two 4 mm thick low-iron glass panes are mounted on a purpose built frame which creates a 50 mm gap between them. Fans integrated within the frame provide forced air circulation to keep glass cool and reduce IR re-radiation



COST is supported by the EU RTD Framework Programme

ESF provides the COST Office through an EC contract





European Cooperation in the field of Scientific and Technical Research






www.cost.esf.org

Building Integration of Solar Thermal Systems – TU1205 – BISTS





The solar simulator with the IR filter in operation




COST is supported by
the EU RTD Framework Programme


ESF provides the COST Office
through an EC contract





European Cooperation in the field of Scientific and Technical Research






www.cost.esf.org


Building Integration of Solar Thermal Systems – TU1205 – BISTS


Achieving uniformity on the test target



COST is supported by
the EU RTD Framework Programme


ESF provides the COST Office
through an EC contract



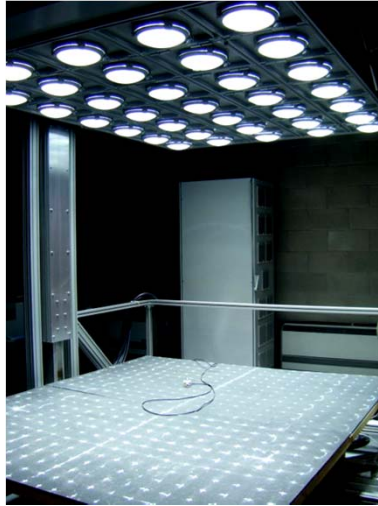


European Cooperation in the field of Scientific and Technical Research

Building Integration of Solar Thermal Systems – TU1205 – BISTS




www.cost.esf.org




Normal Incidence


The light is perpendicular on the test plane



COST is supported by the EU RTD Framework Programme


ESF provides the COST Office through an EC contract



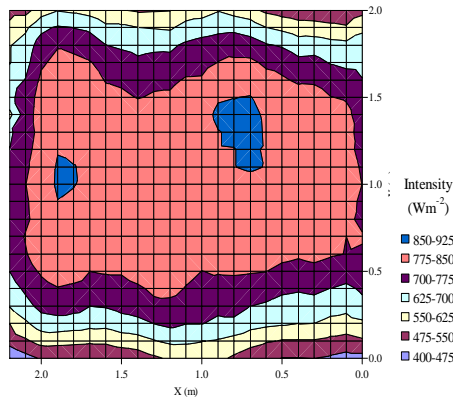


European Cooperation in the field of Scientific and Technical Research


Building Integration of Solar Thermal Systems – TU1205 – BISTS



www.cost.esf.org





Distance	Standard deviation (average intensity)		
Area ->	2.2 m x 2.0 m	2.2 m x 1.5 m	1.5 m x 1.5 m
1.8 m	13.7% (738 Wm ⁻²)	5.7% (791 Wm ⁻²)	4.7% (802 Wm ⁻²)
2.2 m	14.4% (644 Wm ⁻²)	9.8% (684 Wm ⁻²)	8.7% (699 Wm ⁻²)




COST is supported by the EU RTD Framework Programme

ESF provides the COST Office through an EC contract






European Cooperation in the field of Scientific and Technical Research




www.cost.esf.org

Building Integration of Solar Thermal Systems – TU1205 – BISTS




Non-normal Incidence


The light is incident at an angle on the test plane




COST is supported by the EU RTD Framework Programme

ESF provides the COST Office through an EC contract



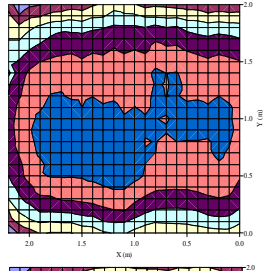


European Cooperation in the field of Scientific and Technical Research



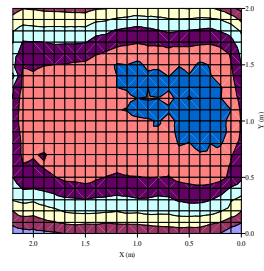
www.cost.esf.org

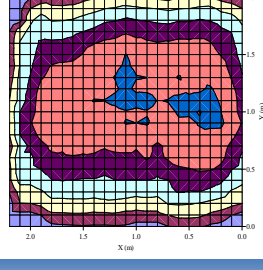
Building Integration of Solar Thermal Systems – TU1205 – BISTS




Intensity (Wm^{-2})

- 850-925
- 775-850
- 700-775
- 625-700
- 550-625
- 475-550
- 400-475






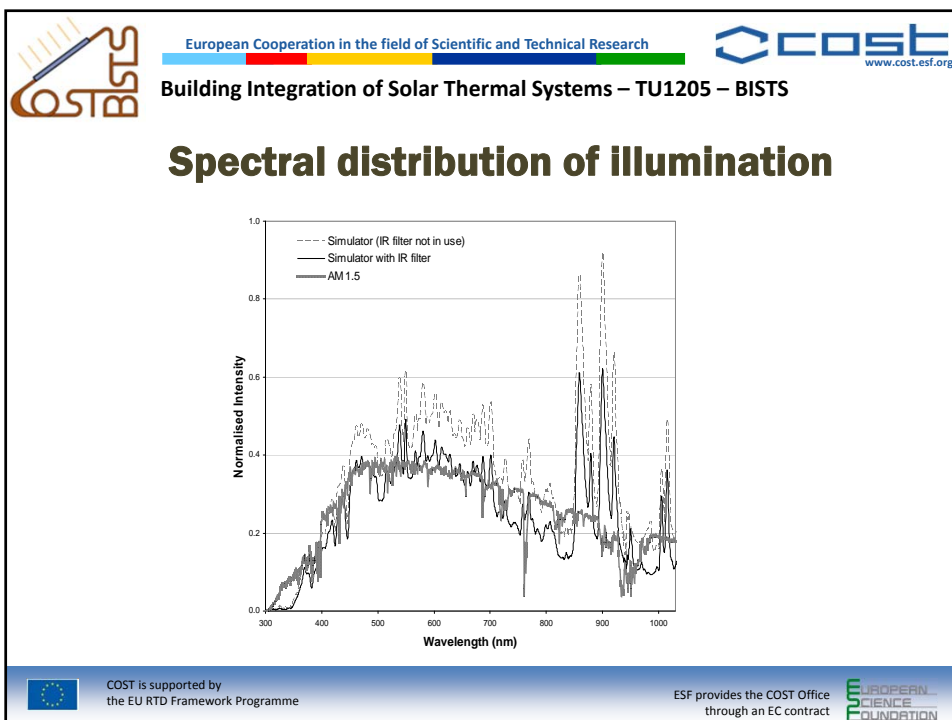
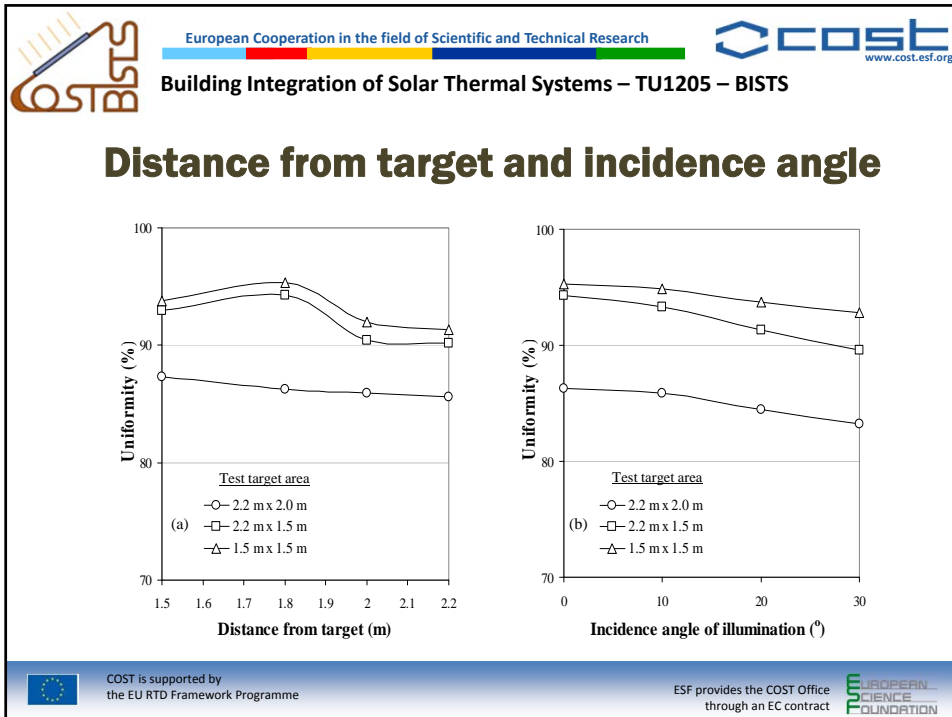
Incidence	Standard deviation (average intensity)		
	Area -> 2.2 m x 2.0 m	2.2 m x 1.5 m	1.5 m x 1.5 m
10°	14.1% (763 Wm^{-2})	6.7% (814 Wm^{-2})	5.1% (829 Wm^{-2})
20°	15.5% (735 Wm^{-2})	8.7% (785 Wm^{-2})	6.3% (808 Wm^{-2})
30°	16.8% (709 Wm^{-2})	10.4% (758 Wm^{-2})	7.2% (790 Wm^{-2})




COST is supported by the EU RTD Framework Programme

ESF provides the COST Office through an EC contract








European Cooperation in the field of Scientific and Technical Research


Building Integration of Solar Thermal Systems – TU1205 – BISTS



www.cost.esf.org


Testing under the Solar Simulator

(Components and full systems)



COST is supported by
the EU RTD Framework Programme

ESF provides the COST Office
through an EC contract




EUROPEAN
SCIENCE
FOUNDATION



European Cooperation in the field of Scientific and Technical Research

Building Integration of Solar Thermal Systems – TU1205 – BISTS



www.cost.esf.org



Proprietary solar collector testing

- Evacuated tube
 - HP
 - DF
 - Concentrated
- Flat plate






COST is supported by
the EU RTD Framework Programme


ESF provides the COST Office
through an EC contract




EUROPEAN
SCIENCE
FOUNDATION

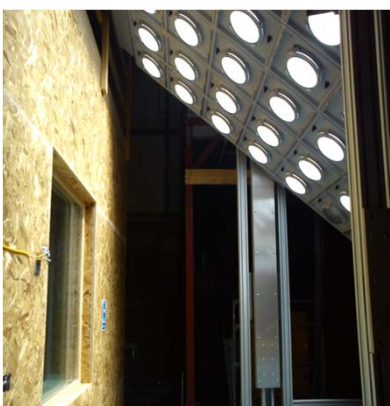


European Cooperation in the field of Scientific and Technical Research







Building Integration of Solar Thermal Systems – TU1205 – BISTS



Building elements


- Insulating panels
- Evacuated glazing
- Evacuated PV glazing







COST is supported by the EU RTD Framework Programme


ESF provides the COST Office through an EC contract






European Cooperation in the field of Scientific and Technical Research







Building Integration of Solar Thermal Systems – TU1205 – BISTS



One-off collector testing


- NCT asphalt BISTS collector
- Unglazed polymer collector






COST is supported by the EU RTD Framework Programme

ESF provides the COST Office through an EC contract



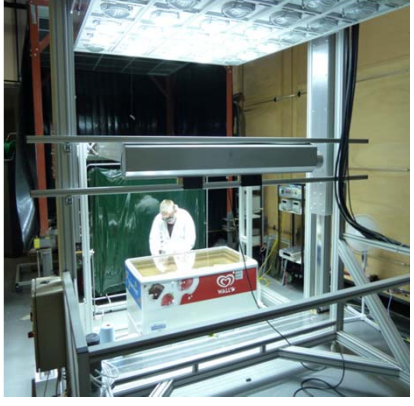


European Cooperation in the field of Scientific and Technical Research



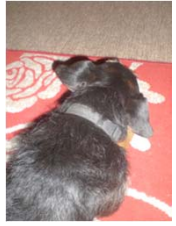




Building Integration of Solar Thermal Systems – TU1205 – BISTS



Commercial products

- Unilever Ice-cream cabinets
- PV dog collars
- Solar/air heat recovery AHU
- SolaSiphon
- SolaPlug

COST is supported by the EU RTD Framework Programme

ESF provides the COST Office through an EC contract





European Cooperation in the field of Scientific and Technical Research





Building Integration of Solar Thermal Systems – TU1205 – BISTS

Integrated Collector Storage systems

- Façade collector
- Small scale AD
- Reflector augmentation









COST is supported by the EU RTD Framework Programme

ESF provides the COST Office through an EC contract






European Cooperation in the field of Scientific and Technical Research



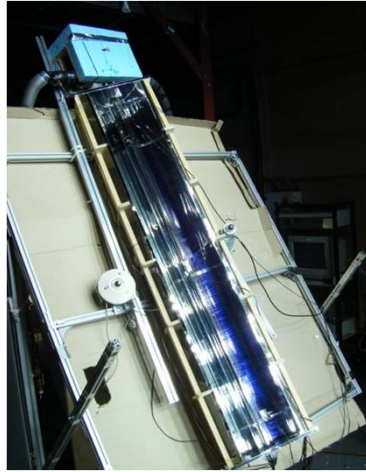
www.cost.esf.org


Building Integration of Solar Thermal Systems – TU1205 – BISTS

Concentrating PV




Evacuated tube collectors







COST is supported by the EU RTD Framework Programme

ESF provides the COST Office through an EC contract





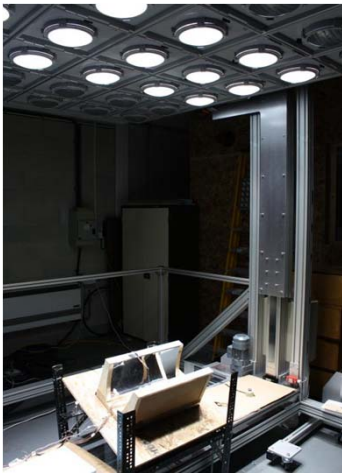
European Cooperation in the field of Scientific and Technical Research



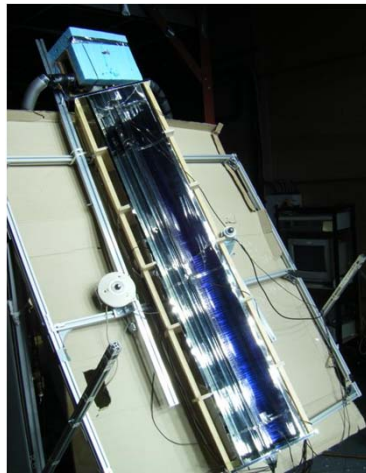
www.cost.esf.org


Building Integration of Solar Thermal Systems – TU1205 – BISTS

Concentrating PV




Evacuated tube collectors







COST is supported by the EU RTD Framework Programme

ESF provides the COST Office through an EC contract





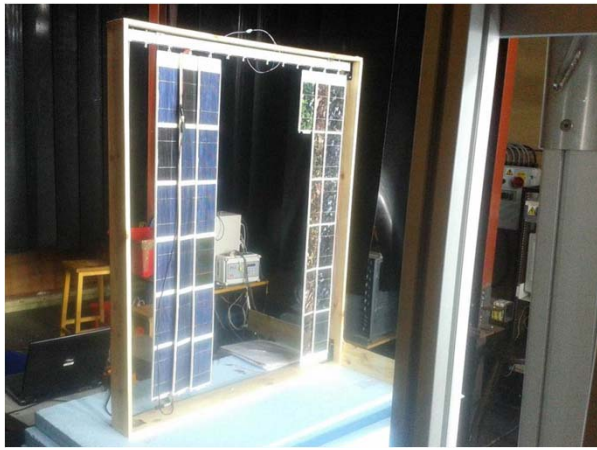
European Cooperation in the field of Scientific and Technical Research




www.cost.esf.org

Building Integration of Solar Thermal Systems – TU1205 – BISTS


Novel PV blind







COST is supported by
the EU RTD Framework Programme

ESF provides the COST Office
through an EC contract





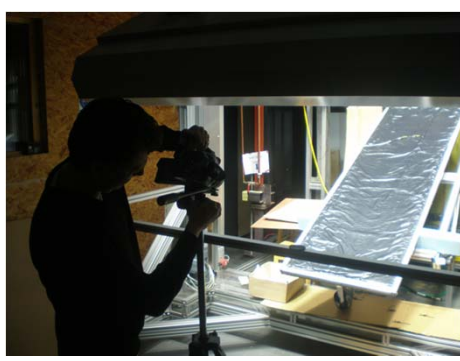
European Cooperation in the field of Scientific and Technical Research

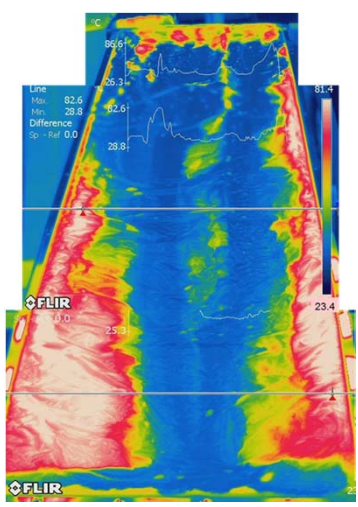



www.cost.esf.org

Building Integration of Solar Thermal Systems – TU1205 – BISTS

IR Visualisation testing







COST is supported by
the EU RTD Framework Programme

ESF provides the COST Office
through an EC contract

