Thesis (1)

- A nation's patrimony is an essential component of the nation's identity
- The built heritage and other cultural resources (such as the contents of buildings) are key parts of this
- The destruction of cultural resources (whether by accident or design) is a crime against humanity especially where the deliberate destruction of cultural resources forms part of an attempt at ethnic cleansing

Thesis (2)

- The most effective way of destroying cultural resources is by fire and its aftermath
- We do not own our patrimony we are merely its stewards
- While the protection of people is mandated by law, there is little compulsion on owners to protect their property. It's critical to consider the needs of the building and its contents as well as the occupants
- A structured fire safety management approach to the protection of traditional buildings is key to the protection of built heritage

Antithesis

- Traditional buildings derive their value from context and method of construction/fabric
- Any changes to these can negate the value of the structure
- Loss of context and heritage fabric through adaptive reconstruction is often as unacceptable as demolition of the structure
- Buildings can be reconstructed; contents can be replaced

Synthesis (1)

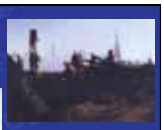
- Loss of authenticity is as serious as destruction
- Empty and 'unloved' buildings are at high risk from intrusion, vandalism as well as wind and weather
- Adaptive reconstruction may be undesirable from a strict conservation perspective but finding a new use for an old building may be its only hope for continuing survival
- Experience suggests that eventually, most empty and unused buildings burn to destruction

Synthesis (2)

- Adaptive reconstruction means compliance with modern building standards and legislation
- However, sympathetic implementation of sensible, structural improvements undertaken in accordance with a set of peer-reviewed protocols can serve to provide a building that it not only fit for purpose in its new use in respect of legislation compliance but also retains its value as a cultural resource
- Consider: 'Use it or lose it' in this context as a driver. Consider also whether there should be mandatory protection standards for some properties

The Risks

- The past informs the present
- We do not own our cultural patrimony, we are only its caretakers
- Fire is the best way to destroy historic buildings and their content. It's so effective it's used in ethnic cleansing
- A nation that fails to protect its heritage fails as a society





Protection of Heritage

- The full armoury of fire safety management should be employed:
  - Fire risk assessment
  - Detection
  - Compartmentation
  - Staff training
  - Mitigation
  - Audit and Review
- But not heritage fire fighting…

Let's not confuse collection items with the real thing !


Historic Scotland: Guide for Practitioner's No 7: *Fire Safety Management in Traditional Buildings*

- Replaces Technical Advice Notes 11,14,22 and 28
- The Guide (which has ACOP status in Scotland) makes it clear that automatic fire suppression systems are a major asset in adaptive reconstruction
- Part 2 of the Guide provides extensive information on the use of fire suppression systems in older buildings
- ISBN 978-1-84917-035-2
- www.historic-scotland.gov.uk/v1/product_detail.htm?productid=1788
- Refer also to NFPA 909:2013 *Code for the Protection of Cultural Resources*

Some Protected UK Heritage Buildings









Small Scale Protection

- 'A La Ronde', Exmouth
- Unique 16-sided, domestic property dating from late 18th Century
- 'A tiny jewel in the NT crown'
- Structure is subordinate to contents
- Seashell Gallery is very fragile – viewed by video
- 2008 FRA noted: 'that although desirable…any improved compartmentation would severely impact on vulnerable fabric. Upper structure and stairs are timber. Consideration should be given to an AFSS'
- Sprinkler protected since 2012

Large Scale Protection (1)

- Schönbrunn Palace
- World Heritage Site
- Most visited attraction in Austria
- Sprinklers form key part of its fire protection programme
- Roof spaces, basements, ground floor and utility areas are protected
- Underground tank and pumps

Large Scale Protection (2)

Heritage Buildings: The Risks

The differences are obvious:

- Fires spread more easily where there is insufficient compartmentation and where there are unstopped shafts, ducts, voids and flues
- The age of the building will usually determine its type of construction – and the inherent fire risk
- No other external impact can totally destroy a cultural asset as effectively as fire
- Many heritage buildings are unoccupied for long periods and located where there water supply problems and difficult access
- Loss or damage of heritage fabric and authenticity by making inappropriate changes is a cultural crime, but:
  - If buildings are not used, they cannot pay their way and are likely to be abandoned and eventually vandalised and destroyed by arsonists
  - Risk assessments matter as for any building – but should also include consideration of the impact of fire service intervention and property/ contents protection considerations as well as life (including firefighter) safety

Awareness of Value of Heritage Tourism

- All European countries recognise the significant contribution to national economies of tourism of which heritage tourism is a key part
- The built heritage is a key part of this
- These buildings are assets not liabilities and as such deserve intervention when necessary

Fires in Scottish Heritage Buildings 2008/9

Service	A Listed	B Listed	C Listed	Total
Central	4	12	1	17
Dumfries & Galloway	2	8	2	12
Fife	2	8	9	19
Grampian	5	43	12	60
Highlands & Islands	2	11	6	19
Lothian & Borders	30	130	71	249
Strathclyde		*No Data Available*		
Tayside	8	23	11	42
Totals	62	244	112	428

Source: Scottish Historic Buildings National Fire Database 2010

Causes of Fires in Scottish Historic Buildings 2008/2009

Cooking	120
Electrical Appliances/Installations	119
Deliberate	71
Smoking Materials	36
Heating Appliances	31
External Sources	12
Hot Work	10
Unknown	8
Candles	7
Chemical Reaction	4

Source: Scottish Historic Buildings National Fire Database 2010

Fire Risk Assessment in Heritage Context

The purposes of risk assessment should be to:
- Identify people especially at risk (including firefighters)
- Eliminate/mitigate hazards where possible
- Control by identifying appropriate measures
- Avoid and prevent fires
- Transfer the risk of financial loss where feasible
- Accept the residual risk
- **Consider the heritage, aesthetic and cultural value of the building and its contents**
- **Consider the potential impact of firefighting activities**

The Principles of Conservation Work (After Maxwell 1998)

- Listed building consent will invariably be required
- Alternative approaches should be considered
- All 'improvements' in/to historic buildings must be:
  - Minimally invasive
  - Reversible
  - Essential
  - Sensitive
  - Appropriate
  - Compliant

Not Just Life Safety but Property Risks

- Statutory risk assessments are only concerned with the safety of the 'relevant persons'
- However, one risk assessment can cover both life and property
- In heritage or historic buildings the process is complicated by the need to consider the impact on buildings and/or contents
- So consideration must also be given to the impact of fire/heat/smoke/firefighting water on historic fabric and collection items
- For business continuity planning, it is essential to consider property and contents in the FRA

The Fire Engineering Approach

- Assess the risks
  - Especially when there is a proposed change of use
- Identify those at risk
- Manage the hazards
  - Ignition sources
  - Fuel load
  - Staff
  - External/arson
- Improve levels of protection
  - Compartmentation
  - Detection
  - Intervention and staff fire fighting
  - Automatic fire suppression
  - Ventilation and smoke control
  - Salvage/Damage Limitation

Constraints and Problems

- Fires respect only walls and water
- In historic buildings, compartmental integrity is rare
- Introducing segregation can result in unwanted impact on building micro-climate
- Who will respond to alarms? What will be the response time/weight of attack by F&RS?
- Water in quantities used by F&RS can have serious side effects
- Major post-fire impact on structural stability, stonework, timber and foundations
- Supply of fire fighting water for F&RS may be limited – invariably a problem in rural areas

What Systems are Available?

Automatic Suppression

- For a wholly independent view refer to BS 5306 Part 0: 2011
- Gas systems
  - Inert gases
  - Halocarbon gases
  - New generation gases
- Powder systems
- Air inerting/oxygen reduction
- Water based systems
  - Sprinklers
  - Water mist
  - Foam

Alternatives: Gas Systems

- Offer significant benefits in reduction of impact of fire fighting agent on most historic fabric/contents. But: consider impact of halocarbon agents which can generate hydrogen fluoride when discharged into compartments where there is a fire.
- HFC-227ea (FM-200) with its higher design concentrations also may be inappropriate for normally occupied compartments.
- Inert gases may require significant storage space; this may create floor loading problems in some older buildings.
- The compartmental integrity required to retain gas concentrations to achieve extinction is rarely possible in heritage and traditional buildings.
- Newer agents such as Novec 1230 (FK- 5-12) look promising (although still generating some fluorides). Novec design concentrations are stated to be much lower than HFC-227ea or HFC-125 (FE-25).
- There is debate that some HCFC's may be subject to a future ban as is the case in some Nordic countries.

Gases for Fire Suppression

Inert Gas Name	Trade Names	Chemical Composition
IG-01	Argotec®, Argonfire®	Argon 100%
IG-55	Argonite®	Argon 50%, Nitrogen 50%
IG-541	Inergen®*	Argon 40%, Nitrogen 52% CO_2 8%

*NB: Patent on Inergen (Tyco) has now expired

Chemical Gas Name	Trade Names	Chemical Composition
HFC-227ea	FM-200®, FE-227, Solkflam 227, MH-227	C_3HF_7
HFC-236a	FE-36®	$C_3H_2F_6$
FK-5-1-12	NOVEC 1230®	$C_6F_{12}O$

Alternatives: Powder Systems

- In a word, NO !
- In two words, please, NO, NO !
- Powder is hygroscopic and will bake on to stone, wood, brass, glass and fabric
- Powder has no place in buildings with heritage fabric and fine objects
- Spalding Parish Church
  - Willful discharge of one 6kg dry powder extinguisher resulted in cleanup costs of £350,000 – and litigation

Other Alternatives

Air Inerting (Hypoxic) Systems

- Reduces oxygen levels to below 16/17% to prevent combustion
- Superficially attractive for heritage protection
- Can be used for large new book/art storage buildings
- But:
  - Compartmental integrity?
  - Energy costs?
  - Life safety?
  - Noise issues?

Foam

- Offers no benefits over water (sprinklers and mist)
- Still requires water supply, pumps and pipework and visible discharge heads
- Some foam compounds are slightly acidic
- Foam compound costs have increased significantly
- Some foam compounds may cause environmental damage when discharged into drains or watercourses

Sprinklers – Pro's

- Detect, warn, report and suppress fires - automatically
- Very low probability of false alarms/spurious actuation
- Ideal for properties which are often left vacant for long periods
- All parts of the building are normally protected
- Not reliant on finite number of cylinders
- Will compensate for inadequate compartmentation
- Will compensate where fire service response is restricted due to weather or terrain or poor water supply
- Protect means of escape so ideal solution when there is only one escape route/staircase
- Very effective at enabling old buildings to meet intent of modern regulations

Sprinklers – Con's

- Potential for water damage can be an issue in premises which are left empty for long periods – waterflow alarms are essential, interconnected to an Alarm Receiving Centre. However this will **always** be less than volume of water used in intervention by the f&rs.
- Frost problems, particularly in roof spaces – trace heating/lagging and anti-freeze may be needed.
- Tanks and pumps will be required in many cases where service mains flow/pressure is low.
- Pipework may have to be surface run if floor boards above cannot be lifted. Boxing in may be possible. Where possible, existing voids/ducts should be used
- Care should be taken when notching timber

Watermist

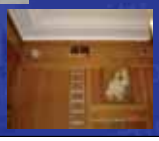
- Systems are very similar to sprinklers employing water propelled through pipes and projected onto a fire through heads
- Due to the greater heat absorption capacity of very small water droplets less water is employed than in a sprinkler system and therefore less water is discharged
- Systems operate at much higher pressures
  - Sprinklers: 3 - 9 bars
  - Low Pressure Mist: 12 - 20 bars
  - High Pressure Mist: 200 - 225 bars
- High pressure systems have critical requirements to allow correct functioning (pipework, water quality, pumps)
- More HP mist heads are required than sprinkler heads
- Low pressure mist may compare favourably on price with sprinklers, not likely to be the case for HP
- While sprinklers can be designed using tables, the design of mist systems demands that each application be either proven by reference to a test or computer simulation

Sprinklers and Mist

- Historic Scotland had previously expressed and interest in installing a watermist system in one of its properties
- At Corgarff Castle, a project to install automatic fire suppression invited bids for sprinklers and mist but the additional costs of mist (>25%) precluded its use at this location
- The Stirling Castle project therefore offered the chance to try out a mist installation

Pipework Choices

- Black steel
- Stainless steel
- Copper
- Listed CPVC



- CPVC Benefits
  - Smaller diameters
  - Flexible for insertion in voids etc
  - Cleaner cutting
  - No need for heated jointing
- But:
  - Should only be used in wet systems
  - In UK, should only be used in R&D/ Light Hazard & OH 1 systems
  - Jointing/solvent is critical
  - Should only be installed by trained operatives using approved handbook
  - Restrictions on unprotected use
  - See TB 227 of LPC Sprinkler Rules
  - New LPS 1260 will cover installation standards including training

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Case Studies

Corgarff Castle
Royal Apartments, Stirling Castle

Corgarff: The Problems

- Remote location
- Poor access –often impossible often between December and March
- Restricted fire and rescue service response
- Poor site utilities and services
- Single wooden staircase extends height of building
- Crown Fire Inspector's Report proposed restrictions on use of building and exclusion of upper floors as education resource
- Scheduled Ancient Monument status restricted opportunities for changes/improvements and excavation

Corgarff: Consultant's Conclusions

- There is little more that can be done to improve detection or passive fire protection
- Management of fire safety is of a high standard
- Installation of an automatic fire suppression system would:
  - Provide acceptable alternative compliance for the requirements of the Fire (Scotland) Act 2005
  - Greatly enhance the levels of property protection
  - Provide alternative intervention as there is a possibility of delayed fire service response
  - Compensate for poor site access/total lack of easily accessible firefighting water

The Results (1)

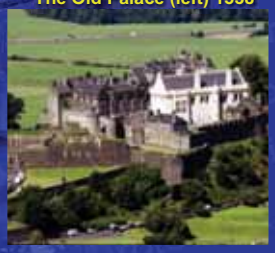
The Results (2)

Corgarff: The Lessons

- Installations *are* feasible in such premises
- Standards may have to be used as a guide rather than a rule book
- Single phase (220v AC) power supply can work
- High level of coordination between owner, consultant and installer is essential
- Using owner's craftspeople for penetrations and chasing is highly effective
- Modular tanks are better than sliced bread
- Joint commissioning/handover with the fire service is essential

Royal Apartments, Stirling Castle 2011

The Old Palace (left) 1538



Spot the mist head !

The oldest UK building to be fully protected by an automatic fire suppression system.

May be the oldest in Europe/the world as while there are slightly older protected buildings in Venice, these have partial systems in roof spaces only

Water Mist: Stirling Castle (1)

- At the time the specification was drawn up, the only European guidance available was EN TS 14972:2007 which had not been approved for use in the UK
- The tender enquiry document therefore used a performance-based specification which required the bidders to offer a system which would provide an equivalent level of coverage to an Ordinary Hazard I sprinkler system designed to BS EN 12845:2009
- Both low pressure and high pressure systems were considered
- The client's final decision was based on a combination of cost and ease of installation and maintenance
- Today, the system would be specified to Parts 1 and 7 of BS 8489:2015

Water Mist: Stirling Castle (2)

- LPCB-Approved CVPC pipe was specified both for ease of installation and for its size as the space available within the new ceiling structure was limited
- CPVC lends itself to installation in existing structures using cavities, voids and ducts
- However, this material is only suitable for wet systems in low hazard occupancies
- The red pipe visible is for the air aspiration (fire detection) system
- Using CPVC eliminates some of the hazards associated with traditional materials but it must only be installed by trained operatives

Water Storage and Power Supply Controls

$6m^3$ storage = 30 minutes approx.

2 x 220v AC duty pumps

Water Mist Heads

Actuation temperature = 57 C°

Grills can be coloured

Low Visibility of Mist Heads

Stirling Head Replicas and Mist Head !

The Real Things
Artifacts of major importance

Water Mist: Stirling Castle

Additional Benefits

- Active fire suppression systems can usually provide additional compensatory benefits
- In this case, primary purpose is property protection (fabric and contents)
- But levels of life safety are also improved
- Additionally, Crown Inspector accepted mist as compensation for the introduction of large tapestries where Class '0' ratings could not be achieved

Thesis Sustained?

- It is possible to install AFSS in even very old buildings given proper planning and coordination
- Property protection systems will always also provide enhanced life safety for occupants - and firefighters
- Close liaison with the client and architect can pay huge dividends - eg client provision of craftsmen to make penetrations, chase plaster and making good, as well as preplanning of pipe runs
- Mist and sprinkler heads can be sited for minimal visual intrusion and visible heads can be camouflaged
- Pumps and tanks can be shoehorned into very small spaces and pumps can be powered by single phase electricity supplies
- Joint commissioning approach involving the f&rs can be very effective in resolving minor issues
- Both Project Objectives satisfied:
  - A very expensive refurbishment of an internationally-important historic building is now protected by automatic suppression system
  - A second, nationally-significant heritage building and educational resource remains open, accessible and protected 24/7

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COTAC

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COTAC Conference 20 November 2014

Fire and Flood in the Built Environment: Keeping the Threat at Bay

Selection of Fire Suppression Systems for Cultural Resources

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1 November 2014