Summit on the Museum Preservation Environment

March 5, 2013, National Museum of the American Indian

March 22, 2013, Donald W. Reynolds Center

Cover photo: Summit speakers and planning committee members

Front (L-R): Mary Rogers, Kendra Gastright, Jane Passman, Wendy Jessup, Kathryn Makos

Middle (L-R): Richard Barden, Scott Rosenfeld, Luanne Greene, Cecily Grzywacz, Fiona Cousins, Sarah Stauderman, Catharine Hawks, Paula DePriest

Back (L-R): William Tompkins, Ann Trowbridge, R. Robert Waller, Jonathan Ashley-Smith, David Hauk, Michael C. Henry, Paul Tintle, James M. Reilly, Stefan Michalski

Planning Team members not pictured: Michael Carrancho, Susan Cary, Malcolm Collum, Kathy Ernst, Joshua Gorman, Gail Joice, Sharon Park

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Background

In fall 2012, the Smithsonian's National Collections Program, along with the Collections Space Steering Committee, formed a working group on the preservation environment for Smithsonian collections. The group recognized that the Smithsonian's overarching collections management policy, SD 600, does not include guidance with respect to environmental controls for collections areas. Moreover, they acknowledged that the controlled environments for many of the Institution's collections and buildings were based on commonly held notions of environmental "standards" that are at odds with current (and even historical) research findings. They further recognized that establishing environments for long-term preservation of collections must take into account mandated and socially responsible energy saving and sustainability goals.

The objective of the working group was three-fold:

- Organize a symposium where experts from within and without the Smithsonian would provide information on the best practices and standards in preservation environment;
- Finalize a draft policy document to be discussed with Smithsonian collections representatives; and
- Determine the best method of encoding the policy at the Institution.

To these ends, the working group formulated a DRAFT *Smithsonian Institution Declaration on Environmental Controls for Collections Areas including Exhibition and Display* (see Appendix C), and planned the Smithsonian Preservation Environment Summit (PES), to be held over two days, March 5-6, 2013[1]. The Summit program agenda is found in Appendix B.

The goal of the Summit was to familiarize Smithsonian staff and other audience members with the current thinking on the role of the environment in the long-term preservation of collections, and to provide a forum for discussion and adoption of the "Declaration" that spells out the Smithsonian's perspective regarding environmental controls for collections areas, including exhibition areas. The Summit was conceived as a two part program with the first day devoted to learning and understanding the issues and the second day devoted to sharing knowledge, experiences, and challenges in adopting environment policy for collections at the Smithsonian. Ultimately, the point of the Summit was to inculcate the collaborative process stakeholders must employ to establish environmental parameters, and not to debate the technical details of set points.

The Summit's target audience was Smithsonian and non-Smithsonian professionals responsible for planning, establishing, and maintaining museum environment settings – conservators, collections managers, registrars, and exhibition designers; building managers, systems, and engineering staff; and design managers, architects, and engineers.

[1] Day 2 of the Summit was postponed until March 22, 2013 due to the closing of the Federal government for a snowstorm.

Attendance on Day one, with 264 in-person visitors, was near capacity for the Rasmuson Theater at the National Museum of the American Indian. In addition, over 400 unique virtual visitors to the webcast were counted. Close to one-third of the in-person attendees were from non-Smithsonian organizations such as architectural and engineering firms and local cultural institutions. A smaller audience of 120 primarily Smithsonian staff attended Day 2.

The Preservation Environment Summit was deemed a success by a variety of measures – the high numbers and tangible enthusiasm of the physical and virtual audiences, level of interest of upper Smithsonian management, positive assessment by the invited speakers, and ripple effect on listservs and blogs throughout allied organizations and industries of the collections preservation world.

Such success is owing to the commitment of the 21-member working group, led by Sarah Stauderman of Smithsonian Institution Archives, along with Bill Tompkins and Mary Rogers of the National Collections Program. This interdisciplinary group, spanning the spectrum of collections care, facilities management, and conservation science, exemplified the foremost pillar of the DRAFT *Declaration on Environmental Controls for Collections Areas including Exhibition and Display* – that collaboration is the foundation to establish environmental parameters.

Preservation Environment Summit Attendees

Invited Speakers

Dr. Jonathan Ashley-Smith, Independent teacher and consultant (formerly Head of Conservation, Victoria and Albert Museum)

Fiona Cousins, PE, LEED AP BD+C, Principal, Arup

Luanne Greene, Principal, Ayers/Saint/Gross

Cecily Grzywacz, Facilities Scientist, National Gallery of Art

Michael C. Henry, PE, IIA, Watson & Henry Associates/University of Pennsylvania

Stefan Michalski, Senior Conservation Scientist, Canadian Conservation Institute

Jim Reilly, Director, Image Permanence Institute

R. Robert Waller, PhD, CAPC, FIIC, President and Senior Risk Analyst, Protect Heritage Corp.

Smithsonian Leadership

Wayne Clough, Secretary

Scott Miller, Deputy Under Secretary for Collections and Interdisciplinary Support

Nancy Bechtol, Director, Office of Facilities Engineering and Operations (OFEO)

Working Group Members

Richard Barden, Supervisory Conservator, National Museum of American History

Michael Carrancho, Associate Director, Office of Engineering Design and Construction (OEDC), OFEO

Susan Cary, Archives Specialist, Archives of American Art

Malcolm Collum, Supervisory Conservator, National Air and Space Museum

Paula DePriest, Deputy Director, Museum Conservation Institute

Kathy Ernst, Senior Research Analyst, Office of Policy and Analysis

Kendra Gastright, Director, Office of Facilities Management and Reliability (OFMR), OFEO

Joshua Gorman, Collections Manager, Anacostia Community Museum

David Hauk, Supervisory Electrical Engineer, Energy Management, OFMR, OFEO

Catherine Hawks, Conservator, National Museum of Natural History

Wendy Jessup, Consultant

Gail Joice, Museum Specialist, National Museum of the American Indian

Kathy Makos, Office of Safety Health and Environmental Management, OFEO

Sharon Park, Associate Director, Architectural History and Historic Preservation, OFEO

Jane Passman, Senior Facility Master Planner, OFEO

Mary Rogers, Collections Program Specialist, National Collections Program

Scott Rosenfeld, Exhibit Lighting Specialist, Smithsonian American Art Museum

Sarah Stauderman, Collections Care Manager, Smithsonian Institution Archives

Paul Tintle, Office of Facilities Management and Reliability, OFEO

Bill Tompkins, Director, National Collections Program

Ann Trowbridge, Associate Director for Planning, Office of Planning and Project Management, OFEO

Other Smithsonian introducers and presenters

Paul Drake, Technical Services Division, OEDC, OFEO

Robert Koestler, Director, Museum Conservation Institute

Andy Smith, Zone Manager at Smithsonian American Art Museum, OFMR, OFEO

Summit Proceedings Day 1 – March 5, 2013

Introduction to the Summit

Scott Miller, Deputy Under Secretary for Collections and Interdisciplinary Support

Long term care of collections objects and—hopefully—saving things forever is a priority as well as a challenge for museums. This is certainly true at the Smithsonian. Secretary Wayne Clough feels strongly about the importance of collections and created the new position of Deputy Under Secretary for Collections and Interdisciplinary Support as part of his commitment to raise the profile of collections to the senior management level.

Collections and their stewardship are core activities and the intellectual base for museum programs – scholarship, discovery, exhibition, and education. Smithsonian collections are global resources that are accessed by millions of visitors and researchers who use them for a variety of traditional purposes, and increasingly by applying new technologies to get at different layers of information content. This presents new challenges; for example, extracting DNA and chemical isotopes from old biological specimen collections raises new questions: How did the preservation environment and preservatives impact them? How should we be preserving those objects going forward?

The last reauthorization of the America Competes Act recognized that federally owned collections represent the national and global infrastructure for research. Holders of these collections have a significant responsibility to care for them and make them available to help address such societal challenges as climate change, spread of invasive species, changing patterns of epizootic disease, and loss of biological and cultural diversity.

Stewardship of collections is not easy, in part because the Smithsonian and museums in general have a tremendous diversity of characteristics, properties, ages, and kinds of material in their collections, as well as a whole variety of discipline-based care standards and the constant demand of managing use versus preservation over time.

The exciting thing about the Summit is bringing together an interdisciplinary dialogue and approach to the museum preservation environment. There is tremendous diversity represented in the audience – conservators, scientists, architects, engineers, curators, registrars, collections managers, and facilities managers from different disciplines and units across the Smithsonian, but also from outside of the Smithsonian and outside of the United States.

It is hoped that this process will reinforce the commitment to further understand the museum preservation environment and spread that knowledge so that long term care of collections objects can be done in a way that that is pragmatic and responsible, balances the various factors involved, makes financial sense, and is environmentally sustainable. From the Smithsonian's standpoint, this event will help address its own collections issues in a way that is informed by the best of community standards and knowledge. Invited experts to this Summit will address: how we got here and where the cutting edge research is headed; environmental management of the museum environment; the role of risk management in establishing environmental parameters; striking a balance between collections preservation and green building goals; the importance of collaboration; and moving from what constituted "urban legend" to evidence-based decision making.

The Smithsonian Museum Conservation Institution (MCI) has historically taken a leadership role in this area. Marion Mecklenburg, now retired from MCI, is a hero of the evidence-based approach to the museum preservation environment. Mecklenburg and his collaborators produced a body of scientific evidence that challenged assumptions about the environment necessary to preserve cultural heritage materials, finding that many of these materials were more resistant to temperature and humidity changes than was generally thought. In 2004, Smithsonian Facilities began implementing these findings and found considerable cost savings. That has sparked discussion at the Smithsonian and in the community and this Summit is part of that continuing process.

The Smithsonian has made significant progress in raising the level of collections care, storage and digitization with a set of strategic initiatives in those areas. This Summit comes out of the Collections Space Planning initiative, a pan-Institutional steering committee led by Bill Tompkins in collaboration with the OFEO facilities group that surveyed 2.1 million sq. ft. of collections space – more than 1800 individual spaces representing over 18% of the Smithsonian's total building space. For the first time, the Institution has a handle on the location and condition of collections storage space and how to prioritize getting it up to the standards going forward. This of course requires a firm understanding of what those standards ought to be.

One of the challenges across the broad range of disciplines is vocabulary – getting everyone to speak the same language. This requires being open minded on the one hand and also willing to define terms. It is important to recognize that we have a shared responsibility for the sustainable future of collections and museums.

Climate Guidelines for Heritage Collections: How We Got Here, and Where We Are Today

Stefan Michalski, Senior Conservation Scientist, Canadian Conservation Institute

> ***This talk explores the origin of the 70°F/50% RH model presented in Thomson's* The Museum Environment *and the research over decades such as the isoperm method of identifying performance standards for the long-term storage of paper materials; microclimates as a preservation environment; and recent research leading to the PAS 198.***

An unfortunate underlying theme of this selective overview of major contributions to the scientific study of environmental effects on collections materials is the slowness with which the cultural heritage field has picked up on relevant discoveries, both from its own practitioners and from practitioners in related fields. Scientific knowledge has sometimes taken decades to be widely incorporated into practice, and some basic ideas have had to be rediscovered several times.

Three other important threads in this brief primer are:

- Recognition of damage phenomena related to relative humidity (RH) and temperature;
- Exploration of the feasibility of control over these phenomena; and
- Precise quantification of these phenomena.

These threads are presented in approximately the historical order in which they occurred: people first noted bad things happening to their collections; they then thought about how to control them; and only much later did they set about understanding the basic mechanisms at work.

To do this subject justice would take far more time than this presentation allows. For greater depth, a good historical survey is J.P. Brown and William Rose, "Development of humidity recommendations in museums and moisture control in buildings," in JAIC, 1997.

Earliest Years

A.H. Church (1872) offered a concise early description of how paintings respond to humidity changes, noting how what we would now call RH fluctuations caused cracks. A few years later, in **1890**, Church hit upon the concept of using microenvironments to control RH and pollutants, by way of his observations about protecting paintings with glass covering.

Russell and Abney (1888) noted how the presence of moisture (high RH) and oxygen accelerated light damage to watercolors, while pigments exposed to light in a vacuum appeared to be unaffected. **Rathgen (1905)** rediscovered Church's findings about the value of microenvironments in a different context, demonstrating that the rapid corrosion known as "bronze disease" could be stopped by housing bronze objects in airtight, moisture-control display cases.

McCabe (1908)[2] was the first to define acceptable RH levels as a band. McCabe, an engineer, worked on a central humidification and air washing system for the Huntington Building of the Boston Museum of Fine Arts that was installed in 1908. He suggested winter humidification of 55%-60% RH as appropriate for the artworks in that building. This began a pattern often repeated on both sides of the Atlantic, in which engineers rather than cultural heritage professionals themselves take the lead in setting guidelines for collections environments.

One of these engineers was **McIntyre (circa 1929-1934)**, who worked for His Majesty's Office of Works at the National Gallery London. He recognized the depth of ignorance in his time about the factors that affect collections materials, admitting that "optimum conditions for any particular class of paintings must be more or less arbitrary." Despite this admission, he suggested winter targets of 55%-60% for RH and 60˚ F for temperature, based more on what was practically feasible in the climate of London than on any deeper scientific basis. He also stressed the reliability of building systems as an important part of what would later come to be known as collections risk management, noting the need to look at how systems function not just on a normal day-to-day basis, but over long time frames and under extreme conditions. As he put it: "The maintenance of the plant and control gear cannot be left to the ordinary attendant."

Around the same time, the **National Gallery of Canada (1934)** published drawings for an airtight brass case to house wood panels. This invention was motivated by the realization that, in cold climates, it is not feasible to maintain moderate RH in interior spaces during the winter, and that micro-environments are needed. The design for such cases is substantially the same today as it was in those original plans.

Learning, Re-Learning, and Failing to Learn

The National Gallery London's **Weaver Report (1947)** provides an example of the field's resistance to learning from important discoveries. Many decades after Church established that glass coverings on paintings constitute an important conservation measure, Keeley and Rawlins noted in the Report the "great importance" that continued to be attached to "removing the glass from paintings, thus eliminating the irritating reflections."

Not only did the cultural heritage field ignore or forgot many important discoveries by its own practitioners, but it often overlooked relevant scientific discoveries from other fields. For example, a paper by **Nelson and Rundel (1923)** of the New Jersey Zinc White Company addressed the question of why zinc white house paint was prone to cracking. In it, they carefully studied the effects of RH and sunlight (UV aging) on the elasticity and strength of linseed oil paints similar to those used in fine arts paintings. The failure of this paper to have an impact on the cultural heritage field is but a single illustration of an underlying theme repeated in many examples not cited here: throughout the 20th century, the field was slow to recognize and borrow from findings in other fields.

Rawlins (1942) was the first to note that many materials can acclimatize to a fairly wide range of conditions, provided that large fluctuations in RH and temperature are avoided. Like McIntyre, Rawlins was honest about the lack of a firm basis for establishing temperature and RH guidelines, but

[2] Information published in 1931.

nonetheless offered 60˚ F and 60% RH as acceptable and "easy to remember" (his words) rules of thumb. On the question of precisely how environmental requirements differ for different types of materials, **Buck (1964)** came up with specific RH tolerance bands for a variety of collections materials, including paper, parchment, velum, fabric, bone, ivory, and wood. Most of these bands fell within the range of 45%-65% RH that McLeod later identified (see below).

Much of what has been said so far concerns art collections, but what about archival materials? By the 1970s, it was widely understood that chemical deterioration of paper and photographic materials could be mitigated through cold storage. Yet it was not until **1985** that **Reilly** formed the Image Permanence Institute; more generally, collecting institutions did not begin to act on this knowledge until the 1980s. However, the Smithsonian, where **Wallace** spearheaded the creation of cold storage facilities for photographic assets in the mid-1970s, was ahead of the curve.

Toward a More Scientific Approach

The Canadian Conservation Institute's **McLeod (1975)** noted in the CCI's first technical bulletin that at 65% RH, some molds may still grow on wood, so he proposed this as the upper limit of the RH tolerance band.[3] He suggested a lower limit of 45% RH, although this figure was based on practical experience rather than any specific scientific findings. McLeod was also the first to suggest the need for seasonal adjustment in light of the realities of maintaining conditions within buildings in cold climates, proposing 35%-55% RH as an acceptable compromise if the preferred 45%-65% RH was not practically feasible.

The first edition of **Thomson (1978)** described various phenomena and noted what some credible institutions were doing to cope with them. Whether he was making recommendations is unclear; he provided numbers that particular organizations were using without necessarily endorsing them. His second edition **(1986)** introduces the Class 1 and Class 2 designations in a summary appendix.

In CCI Technical Bulletin #5, **Lafontaine (1979)** offered the first published use of environmental targets specified as set points with tolerances indicated in ± notation, as well as a formal definition of seasonal setback. He suggested RHs of 50% ± 3% (summer) and 38% ± 3% (winter). In retrospect, his ranges—which were based on "best available technology" rather than published scientific findings—are impractically narrow. Lafontaine also suggested temperature set points of 25˚C ± 1.5˚C (summer) and 20˚C ± 1.5˚C (winter).

The Smithsonian's **Mecklenburg** is regarded as one of the leading figures in conservation science of the past few decades, but it is beyond the scope of this presentation to review more than a few of his many contributions. Perhaps his single most influential work was not a published paper. "Some Aspects of the Mechanical Behavior of Fabric Supported Paintings," an unpublished internal Smithsonian report of **1982**, formulated a damage-function model for stretched canvas that introduced the now-famous "hockey stick" diagram plotting RH against material shrinkage tension.

[3] His conclusions rested on scientific evidence dating back to the 1930s and 1940s; by the 1950s, very detailed plots of mold growth under various environmental conditions were available.

Seberra (1986) used isoperm diagrams to discuss how RH affects mold growth. While a critical contribution, his analysis was also a reminder that the cultural heritage field still held a simplistic understanding of mold growth—especially considering data allowing a better understanding were 50 years old at the time. Sebarra was one of the first to draw boxes on isoperms to indicate environmental zones of acceptability for different types of collections. By contrast to some later efforts that tended to over-simplify, he noted the inherent uncertainty about how materials are affected by mold phenomena.

Progress in the 1990s

Mecklenberg's 1991 handbook *Art in Transit* introduced computer-based finite element modeling (FEM) to the field. Oddly, this approach was not further developed, although it is just now beginning to re-emerge in Europe as a useful tool for understanding how environmental factors affect individual collections pieces.

Michalski (1993) demonstrated that the "hockey stick" stress curve applied to a variety of materials, not just stretched canvas. However, he also noted that if one looks at risk-of-fracture (cracking) rather than material stress itself, the smooth "hockey stick" curve is replaced by a "bathtub" curve that shows negligible risk of damage over a wide RH range, coupled with sudden and dramatic increases when certain thresholds for unusually high or low RH are crossed. This is a better representation of the actual loss of value to collections than looking at stress, which in most cases does not translate into detectable damage. He also made the important observation that the ability of older objects to withstand RH fluctuations in the present is predicated on the range of fluctuations to which it has been exposed in the past.

The **1994 Smithsonian** press release "Work of Smithsonian Scientists Revises Guidelines for Climate Control in Museum and Archives," which discussed the relative resilience of many materials to fluctuations previously deemed dangerous, provided another reminder of how slowly information has been disseminated in the field. Although the announcement was seen by many in the United States as a revelation, Michalski and his colleagues had been presenting similar ideas to Canadian audiences for a decade; these ideas simply had not spread south.

In the same year, **Michalski** further explored how the size of fluctuations affects the risk of fracture, noting that while the "bathtub" curve holds for individual objects, it does not hold for whole collections. When looking at whole collections, one needs to think in terms of probabilities of damage associated with different fluctuations in RH, not discontinuous jumps.

Also in 1994, **Erhardt and Mecklenburg** provided a reminder of the variety of material science phenomena affected by RH, identifying white (safe), amber (caution), and red (avoid) RH zones with respect to several of these phenomena.

In 1999, the **American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) Handbook (1999)** presented its guidelines for collections environments. These were based on the concept of different levels of control for different levels of risk, with classes of control designated AA, A, B, C, and D.

The Present: A Trend toward Wider Tolerances

In **2004**, **Erhardt and Mecklenburg** identified unified RH (45% ± 8%) and temperature (70˚ ± 4˚F) tolerances for building interiors designed to minimize overall risks across a variety of phenomena. These allowed collections organizations to achieve considerable energy and cost savings over the alternative of accommodating highly material-specific tolerances. The resulting environment was similar to ASHRAE class A control for RH, and class AA control for temperature.

Things got busy in **2008** with the **U.K. National Museum Directors' Conference (NMDC); Bizot Group; Environmental Guidelines, Opportunities, and Risks (EGOR); etc.** Under the leadership of Tate Director Nicolas Serota, the NMDC formulated a set of guiding principles for reducing museum carbon footprints, a consideration any organization receiving public funding in Europe cannot ignore. These accepted wider RH tolerances in the interest of reduced energy consumption, albeit with the stipulation that sensitive materials need tighter controls through the use of micro-climates. These guidelines recommended RH in the range of 40%-60% and temperature in the range of 16˚-25˚C. **Saunders (2009)** of the British Museum identified materials that can tolerate the recommended RH range, and materials that need more stringent controls.

A conference organized by the **Boston Museum of Fine Arts** in **2010** brought the conversation about wider RH tolerances to the United States. At it, a number of practitioners attested to the acceptability of the 40%-60% RH guideline based on their own experience, as well as to the practical difficulties of doing any better than this.

Risk Assessment and Assignment of Environment Parameters

R. Robert Waller, PhD, CAPC, FIIC, President and Senior Risk Analyst, Protect Heritage Corp.

This talk concerns how materials may be categorized as robust and tolerant of a host of indoor and outdoor climates or categorized as special or intolerant, i.e., they require specialized environments. It reviews three key factors in risk assessment—source path, and effect of hazards to collections, and how facilities management, collections care, and conservation science must work together to characterize and manage risks.

The programmatic activities of any museum inevitably expose its collections to risks of deterioration, damage, and loss. Risk assessment is therefore a principal component of sound collections environment. It should be approached in an informed, deliberate, and scientific manner.

Drawing on his own background with mineral collections, Dr. Waller showed a time-lapse video of a rare mineral, tachyhydrite, exposed to conditions of 70°F and 50% relative humidity (RH) for a few hours. By the end of the clip, the object had completely dissolved, demonstrating the dangers to collections posed by poor environmental control. While this demonstration was staged, Waller has actually witnessed cases of parts of collections destroyed in weeks or months from inappropriate levels of humidity and other environmental issues.

Different collections risk assessment methods exist. Most are designed for a particular purpose or to emphasize a particular perspective, and work best when applied to similar situations. Examples include the following:

The approach of **English Heritage** combines collections risk, condition, and significance audits, yielding a combined measure of conservation priority.

The **Canadian Conservation Institute (CCI)** uses ABC Scales that prioritize recommendations for reducing risks in conservation reports.

Heritage Preservation provides a guide to identifying potential disasters and reducing their effects; it is designed mainly to connect collections care staff to the emergency preparedness and management field.

The University of California at Berkeley Library places library risks within an overall enterprise risk-management system.

The CPRAM (Cultural Property Risk Analysis Method) of the Canadian Museum of Nature embeds risk awareness and competence throughout collection-holding institutions.[4]

An underlying principle of such models is that risk assessment must mesh with other collections and institutional systems if it is to be effective. For example, CPRAM is based on a systems understanding of

[4] While the discussion in this presentation is at a basic level that is broadly applicable to most risk assessment models, in any specifics it draws largely upon the CPRAM model.

collections management that comprises collections development (acquisition, cataloging, etc.), preservation, and use (for research, education, exhibitions, etc.).

In application, risk assessment must embrace uncertainty in four dimensions: model structure, variability, ignorance, and randomness.

Model Structure

The first dimension of uncertainty, model structure, tends to be the largest. At the most fundamental level, an implicit assumption in model structures is that the future will resemble the past, and that the past can serve as a guide to the future. This assumption arises naturally because all of our empirical evidence comes from the past. But it is important to bear in mind that it *is* an assumption, and the future may in some respects diverge substantially from expectations based on past experience.

The most important aspect of a risk model is a **goal**. Risk models posit a long-term goal, and define risk as deviation from that goal. For example, consider a hypothetical collection of 25 objects: 5 ceramics; 5 prints; 5 textiles; 5 natural history specimens; 5 works of art. The goal for this collection is defined as moving it forward undamaged and intact 100 years into the future. Of course, reality usually has other plans: some objects will be damaged; some are lost; some will fade or deteriorate. There is even a small chance of a catastrophic event that will affect the whole collection. These risks can all be thought of as departures from the goal.

This definition of risk can be broken down into three parts: **sources, paths,** and **effects** of departures from a goal. For purposes of illustration, we will talk about RH, but the concepts discussed here can apply to any type of environmental hazard. In the case of RH, we can think of the three elements of risk as follows:

- **Source:** What is the original problem that could lead to departure from the goal? For example, it could be a set point that is not achieved, a temperature gradient, or an HVAC failure.
- **Path:** What parts of the collection are sensitive to RH, and thus potentially at risk? How are they, or can they be, protected? For example, some vulnerable objects could be given additional protection through storage within cabinets or containers.
- **Effect:** What kind of damage is done to the collection as a result of departures from the goal (for example: mold, hydrolysis, corrosion, fracture)?

In general, understanding the **source** of risk is the domain of facilities management. Understanding the **path** to damage is the domain of collections care. And understanding the **effect** of a hazard is the domain of conservation science. How do the three domains work together in risk assessment and management?

- **Facilities management staff** are responsible for seeing that set points are achieved, that temperature gradients are controlled, and that plans are in place for when HVAC systems fail.

- **Collections care personnel** are responsible for knowing which collections are sensitive to moisture, and for mitigating risks to them—for example, by housing them in cabinets, containers, or other protective micro-environments.

- **Conservation scientists** are responsible for understanding and quantifying the effects (damage) RH may have on vulnerable collections.

Variability, Ignorance, and Randomness

Embracing uncertainty also means coming to terms with the variability, ignorance, and randomness of risk, and capturing these in a risk model. Again, it is helpful to think in terms of **sources, path,** and **effects,** and of the three professional domains respectively associated with them.

- Facilities management can conduct periodic intensive environmental audits to characterize short-term RH variability through time and space. Collections care can combine this information with its ongoing monitoring to get a better picture of environmental variations across and within storage spaces.

- It is also for facility management to characterize the expected frequency and severity of environmental excursions over years and decades—for example, cases of load exceeding capacity because of a run of unusually damp days, or control system interruptions that cause spikes in RH. In risk assessment, thinking about such long-term expected departures is at least as important as looking at short-term data.

- Collections care identifies the most sensitive objects and the overall distribution of sensitivity across objects. For example, within a collection of panel paintings, you have a range of sensitivities from paintings on wood, which are among the most vulnerable, to paintings on honeycomb aluminum substrates, which are highly stable. Likewise, after two hours of exposure to high RH, most pyrite crystals remain stable, but some do not. In a collection in which some parts are more vulnerable, those parts may need special protection at the object level or case level—which is different from approaching environmental risk mitigation strategy at the building or even the room level. Of course, the distribution of vulnerability varies among collections; in some, practically all objects will be similarly vulnerable.

- Collections care also needs to characterize controls on environmental exposures at the collection and object levels. Problems at these levels can thwart the best efforts of facilities management. For example, if a rock gets wet, it takes weeks to completely dry; and if you place a damp rock in a cabinet, it can raise the RH level and damage other objects that are sensitive to moisture. Collections care should not blame facilities management if this happens!

- Conservation science characterizes damage functions for representative sensitive objects, defining the range of stability for a particular type of material.

- Conservation science also can take the lead in working with collections care staff, facilities management personnel, and risk analysts to bring all these analyses together to create an overall risk model.

To pull the whole model together:

1. Look at sources of deviations in RH (and other environmental factors) and express them as distributions;

2. Consider what parts of a collection are susceptible to these deviations and the damage functions in the case of a deviation, adjusting for distributed collection-level controls (such as objects receiving special protective measures/storage);

3. Pull together expertise from across the fields of facilities, collections, and materials science to devise appropriate strategies.

Conclusion

In sum, the three key factors in risk assessment are the **source, path,** and **effect** of hazards to collections. Each of these is primarily associated with one of the three major collections management functions: **facilities management, collections care,** and **conservation science**, respectively. These professions must work together to characterize and manage risks.

Risk assessment means establishing a systematic process for characterizing risks and developing strategies to address them. Because we work with scarce and incomplete knowledge, risk assessment can never be foolproof; but it will improve over time as more data is gathered and our understanding deepens.

Risk managers need to do the best they can in any given state of knowledge, and be open to adjustments as new knowledge becomes available. They need to listen to all relevant subject matter experts—otherwise risks will be missed or misunderstood. And they should systematically document everything they do; if not, lessons learned this week will be forgotten by next week.

It is not easy, but it is easier than you think if you have a clear path.

Conservation Environments, Museum Buildings, and Sustainability

Michael C. Henry, PE, AIA, Watson & Henry Associates/University of Pennsylvania

This talk explains the ASHRAE chapter pertaining to museums (Chapter 23: Museums, Galleries, Archives, and Libraries) to non-engineers, especially collection managers and conservators. The presentation focuses on the relationship between collections environmental control and envelopes—that is, the structures that protect interior environments from external conditions, and specifically from the damaging forces of thermal energy and moisture.

"Geography is Preservation Destiny." Excursions in the external climate drive changes within a building that can affect collections; the broad outlines of these excursions are dictated by geography.

From a building engineering perspective, there are 17 climate zones in the United States, defined by their characteristic long-term regional statistics for temperature, moisture, precipitation, and other climatic factors. Moisture zones vary from East to West, and are designated by letters A-B; thermal zones vary from South to North and are designated by numbers 1-7. Some examples:

- Washington, D.C. is in Zone 4A—mixed/humid. To keep interior environments safe for most collections, structures in this zone need de-humidification throughout much of the year, especially in summer. They also need cooling for at least three months out of the year, as well as added moisture during the winter.
- Boston is in Zone 6A—cold/humid. Collections structures here do not need as much cooling, but require de-humidification in the summer.
- Phoenix is in Zone 2B—hot/dry. The climate here is mainly dry, but there is an annual spike in moisture during the summer, which creates the need for some de-humidification of collections spaces.
- Miami is in Zone 1A—very hot/ humid. The need for de-humidification of collections structures here is constant, even during the winter months when the cooling load is less.

Expected Changes

Global climate change adds new complications, because it means the frequency and severity of climatic excursion may differ in the future from what we have come to expect from the past. For example, we generally use historical temperature and moisture data to size an HVAC system with a 20-35 year life span, or to design a building envelope meant to last 50-100 years or more, as in the case of monumental buildings such as those at the Smithsonian. But climate change means the future may, relative to our historical data, hold the prospect of increased duration and frequency of extreme conditions; increased thermal and moisture loads; greater risk of flooding; and other associated changes. Climate change projections for the northeast United States, for instance, suggest that over the next several decades, we may see: substantial increases in average temperatures; shorter winters with fewer cold days and more precipitation; more extremely hot days; longer, hotter summers; and sea level rises.

These changes have implications for structures that house collections, such as longer periods of heavy cooling loads; greater risk of power interruptions; increased de-humidification needs (but possibly less need for humidification in winter); and more storms, with associated increases in moisture load and collateral effects.

The Building Envelope

The building envelope is a collection's first line of defense against climate. It creates the interior environment space, provides some protection when systems fail, and, when properly designed, can reduce the need for and expense of temperature and humidity modification. The envelope consists of any structure exposed to the exterior climate, both above and below grade: roofs, walls, floors, doors, windows, eaves, gables, and so on. Thermal and moisture effects mediated by the building envelope include:

- Thermal gains from solar radiation, and thermal losses from night de-radiation;
- Absorbed water from rain;
- Water vapor drying to inside or outside;
- Thermal losses and gains due to conduction;
- Thermal/water-vapor losses and gains from infiltration (leaks in the envelope);
- Thermal losses to soil at frost line; and
- Water (liquid + vapor) gains from soil moisture.

Building occupancy adds to thermal and moisture loads within the envelope through mechanisms such as thermal gains from lights and equipment; thermal/water-vapor losses and gains from ventilation systems; thermal/water-vapor gains from occupants themselves; and thermal and moisture gains from building systems. Another consequence of occupation is the need for constant re-introduction of external air, with associated concerns about thermal and moisture loads.

The building envelope sets the basic parameters for what can be achieved in the internal environment. Common sources of guidance for collections-environment building envelopes include jurisdictional codes (building, fire, systems, and energy conservation codes) and ASHRAE Applications Chapter 23 ("Museums, Galleries, Archives, and Libraries"). Additional guidance for historic and monumental buildings comes from the following sources:

- NPS—Standards for the Treatment of Historic Properties, 1995
- AIC—Code of Ethics and Guidelines for Practice
- APT/AIC—New Orleans Charter for Joint Preservation of Historic Structures & Artifacts

ASHRAE 23

ASHRAE 23 is the definitive source for the information on building envelopes and collections environments, although this may not be widely known in the community of building engineers and architects, where museum work is not a day-to-day activity for most. It is a living document that is constantly being revised. It provides information and guidance, but not implementation methodology, which must be worked out in each case by architects, engineers, and collections personnel, based on the unique climate, envelope, and collections in question.

ASHRAE 23 breaks down building envelopes into several classes, based on broad structural characteristics that influence what is realistically achievable in internal environmental control. The following three classes are offered for illustrative purposes:

- Class IV: Heavy masonry, composite walls, storm windows. Performance characteristics include low-to-moderate air and moisture exchange, high thermal mass, moderate moisture buffering mass, and solar radiant gain at windows.
- Class V: Insulated, vapor retardant, double glazed, with vestibules. Thin and light compared to Class IV. Performance characteristics include low air and moisture exchange rates, low-to-moderate thermal mass, low moisture buffering mass, and solar radiant gain on dark surfaces, especially roofs.
- Class VI: Tight construction, perimeter buffer, limited occupancy. Purpose-built museum storage facilities might fall into this class. Performance characteristics include low air and moisture exchange rates, low-to-moderate thermal mass, low moisture buffering mass, and interior spaces buffered from exterior surfaces by cavities or corridors.

Some specialized envelope types sometimes used for collections storage are not covered by ASHRAE 23. These include sub-grade structures and vaults, and glass structures such as greenhouses, which some modern museums may resemble.

ASHRAE 23 defines five different classes (AA–D) of environmental control for museums, galleries, libraries, and archives, based on risks and benefits to collections. Most purpose-build museums perform in classes AA, A, or B. Temperature control in such structures is typically very tight (AA), but moisture control may be closer to B (+/– 10 percent), because it is easier to control temperature fluctuations than relative humidity.

Non-Mechanical Strategies for Improving Envelope Performance

There is a widespread tendency to focus on operating components of environmental control systems. However, interior environments can also be influence by “passive” strategies for improving envelope performance.

Although the term “passive” is common in this context, “non-mechanical” is perhaps more accurate, since the strategies in question require commissioning and maintenance, just like mechanical systems. These strategies can help to reduce stresses on interior environments, moderate fluctuations, and keep a building operating near peak efficiency more often. The employment of non-mechanical envelope strategies can also reduce the required size and capacity of mechanical systems. Some essential non-mechanical strategies include:

- Installing vapor retarders in walls;
- Eliminating moisture at the source through mechanisms such as roof drainage and other strategies to keep surface and subsurface water out.
- Minimizing uncontrolled air and moisture exchange at windows, doors, flues, and envelope perforations. (Keep the doors and windows closed!)
- Minimizing or controlling direct and indirect solar gain through strategies such as landscaping for shade, shades/blinds/filters on windows and skylights, and cool roofs.
- Zoning interiors according to environmental needs, with more stable needs in inner spaces, and less stable needs along perimeters and under roofs.
- Separating collections zones from people zones. (Collections and people don't mix well, as the conditions that promote human comfort may clash with the needs of collections. Collections and food *really* don't mix well!)
- Managing peak visitor counts, especially on peak cooling days.

Thermal mass is an important non-mechanical factor for achieving stability in interior environments. It affects the exchange of thermal energy between interior and exterior, and can buffer swings in relative humidity as well. However, there are limits on what can be done with thermal mass, especially in buildings with large interior volume, which include many newer museums. The volume-to-mass ratio must be exactly right to gain major benefits, and this is hard to achieve with large, voluminous buildings.[5] More promisingly, new building materials – both phase-change materials and moisture-absorbing materials – hold out the prospect of more effective moisture buffering as well as thermal stability.

Multiple envelopes ("box-in-box" enclosures, such as an inner collections storage area surrounded by perimeter corridors) are an effective way of controlling interior environmental zones. Cascading envelopes make inner spaces more stable, because such spaces are removed from direct exposure to the exterior environment.

Pushing this concept one step further, it is often useful to think about temperature and moisture conditions at the level of micro-envelopes—for example, within cabinets or boxes that house collections—rather than at the level of whole interior spaces. To illustrate, Henry recounted experimental trials conducted at a "passive" collections-storage building near Ahmednaggar, India that applies multiple envelopes and micro-envelopes. The trial involved looking at the responses of proxy

[5] To the extent structures are below grade (bermed), it is like having infinite thermal mass around the building, so such structures are very thermally stable. The down side is that moisture is a huge concern for below-grade structures, so they must be water and vapor-tight.

materials (textiles and paper), initially stored in Coroplast boxes within metal cabinets in a stable but unconditioned room, as various layers of passive protection were removed. For paper collections at least, conditions within the immediate storage environment remained quite stable even when the collections were moved to an unstable room and the cabinet doors were opened. Textiles, by contrast experienced modest deterioration in RH conditions when moved to an unstable room, and major deterioration when cabinet doors were subsequently opened—although swings in RH within the storage boxes remained buffered relative to conditions outside of them.

Data and Simulations

Envelope damage and the resulting hazards to collections can arise from the interaction of liquid water, water vapor, temperature, materials, and other factors in various, extremely complex ways. Understanding these risks requires a dynamic simulation of heat and moisture effects, such as the one provided by the WUFI computer model (http://www.wufi-pro.com). But a note of caution is required: while a program like WUFI can be very useful, even the most sophisticated simulations should be applied with awareness that the assumptions on which the model is based may not hold in any given real-world case.

More generally, data are invaluable for monitoring temperature and moisture conditions faced by collections. But again, but it is important to think about what these data mean and how they might be misleading. Do not simply print out data logger charts and look at the trend line; analyze the data, parse them by season, and look at ranges and fluctuations with respect to both long- and short-term time frames.

Building Systems

Finally, while most of the presentation has focused on envelopes rather than building systems, a few closing words on systems are in order:

- Keep it simple and comprehensible;
- Make them resilient;
- Separate dehumidification from cooling;
- Minimize outside air; if you need a lot, pre-condition it, especially for moisture reduction;
- Prioritize RH control over temperature control;
- Provide ample space for service and repair;
- Commission the system;
- More is not always better.

Choosing Standards and Best Practices for Environmental Design and Operation

Jim Reilly, Director, Image Permanence Institute

> ***In this talk, Reilly compares "risk management" (e.g. the isoperm method or PAS 198) with established standards (such as ISO 18911). The term "standard" is discussed in the context of understanding by engineers, scientists, and collections managers: what does it mean and when should it be used?***

A shrunken head from the National Museum of Denmark in Copenhagen illustrates the complexity and diversity of real world collections. Its collections managers must prioritize among chemical, biological, and mechanical hazards in conducting risk assessments and setting environmental standards.

Museum environmental standards are our guideposts and they arose for good reasons—to meet the need for guidance when planning museums or thinking about the adequacy of conditions, and for some form of authority. Standards have become concise statements of best practices, and have grown to be more reference, with few or no tables.

Standards play an important role at two points in the life of an institution—the design/retrofit stage and operations stage:

- Design/retrofit is a time-bound project, done by external architecture and engineering firms and overseen by construction managers who are project-oriented and have a capital budget. At this stage, standards serve the purpose of authority documents (what others have thought and done), and represent normative definitions of best practice for both the client (the museum administrator and collections manager) and the designer. Environment is seen in the context of architectural programming—what the building is for, who will work in it, what they will do, and what parts are for storage, exhibits, research, etc. The design professionals are trying to understand what is wanted and what they have to do, keeping in mind code conformance such as how much outside air is minimal for a building that people will be in.

- By contrast, the operations stage is continuous. Once the institution takes control of operating the building and systems on a day to day basis, standards serve as guidance to collections care and facilities managers and upper management as to how to actually go about it. Operations have become a collaborative, cross-disciplinary process. Since it impacts fiscal health, it is essential that these disciplines that traditionally have not known each other's business work together.

In the operations stage, one must diagnose the quality of the environment with respect to preservation and manage the performance of systems while meeting goals of sustainability and fiscal responsibility. To do that well, "industrial strength" data gathering and analysis are needed to translate the ideas behind best practices and standards to decision making. The bottom line is that if you are going to be concerned with the goals of stewardship, sustainability, fiscal management, and global responsibility, you need monitoring and analysis tools in the operations stage.

Standards have tended to reflect more the needs of design/retrofit than operations. With that in mind, it is important to “drive a stake through the heart of the zombie” that is the notion that there is an ideal environment for museums such as 70°F-50% RH.

Standards have evolved away from simplistic “received wisdom” embodied in short tables of numbers. Now, standards are a management strategy where hard numbers have disappeared and in their place is a continuum of risk. The PAS 198 specification has no tables at all. Rather than telling us what to do, standards now tell us what *not* to do. We all agree that at the extremes of relative humidity there are increased risks to collections, but the challenge now lies in where to be in the middle. PAS 198 and Chapter 23 of the ASHRAE applications volume provide much information to guide us.

To paraphrase Dr. Martin Luther King, Jr., “The arc of the environmental standards universe is long but it bends toward sustainable operations.” We have gone from seeing standards as prescriptive to being part of a coherent design and operating philosophy.

It is important to understand where the idea of an ideal environment for museums came from. Tight temperature and RH control originated in UK galleries, where people came to visit collections that were always on view, and where, consequently, human comfort temperatures were a given. Standards for an ideal museum environment came out of the fact that UK galleries had to control temperature tightly in order to achieve the desired RH, not because of a particular need with regard to preservation of collections.

The people who did the work that informs our notions of an ideal standard – Garry Thomson (1978, 1986) and prior to him, Harold Plenderleith (1956)—were concerned with UK museums in large masonry buildings without elaborate mechanical systems and with collections of mechanically-sensitive objects such as paintings and composite wooden objects. Garry Thomson, who was a giant of preventive conservation and called for investigation and understanding of the real behavior of environmental limits, is considered to be the source of the tightly controlled 70°F-50% RH ideal or “standard”.

Like the famous Garry Larson cartoon “What we say to dogs and what they hear,” despite what Garry Thompson *actually* wrote and other conservation scientists have been saying for years, what we hear is: “blah blah blah temperature 70° +/- 2° and blah blah blah humidity 50% +/- 2%.”

What Thomson actually said about *temperature* is that it is only important in so far as it begins to influence RH and the mechanical or physical sensitivity of objects. Pressed to give recommendations, he suggested different summer and winter levels: 67°F+/- 2° in winter and up to 75°F +/- 2° in summer. In addition, he noted:

- Temperature must be controlled to control RH, but the level is dictated by human comfort. For fuel economy, different summer and winter levels are suggested.

- In storage areas or buildings closed to the public in winter, temperatures can be allowed to fall, but not to the point where condensation may occur on cold or unventilated surfaces. A lower limit of 50°F is suggested. So really, the ideal temperature from the "horse's mouth" is anywhere from 50°F to 77°F.

What Thomson actually said about *relative humidity* is that it can be 50% or 55% +/- 5% day and night throughout the year, adding that the level may be fixed higher or lower but for mixed collections a range of 45% to 60% is recommended. Thomson noted that the "plus/minus" in RH control is based more on what we can reasonably expect the equipment to do than on any deep knowledge of the effect of small variations on the exhibit.

Moving ahead a quarter century, new research by Mecklenburg and Michaelski undermined and explained the old "ideal" of 70°F/50% RH and began to explore true safe limits for even very mechanically sensitive objects. They also explored the forgotten dynamic of temperature and how temperature driving chemical reactions is a major factor for all sorts of collections. For example, there are many organic collections with spontaneously deteriorating materials even in antiquities. Mecklenburg and his colleagues used finite element analysis to study component materials of objects (e.g., cottonwood used in art objects) and the end point where risk begins to understand RH tolerances. They found wider variations in RH tolerance than was the accepted wisdom.

This and other research helped move the standards, including:

- De-emphasizing tight RH control and need for +/-5% for most materials;

- A closer look at the function of decay and how much risk is generated by one type of environment or another based on kind of material, climate, risk tolerance, architectural design, and sustainability considerations;

- Active environmental management that is more data driven with a more collaborative team approach.

ASHRAE Chapter 23 2011 was written primarily for heating, refrigerating and air conditioning engineers with a bias toward design, but is more modern in that it has much information not found in other kinds of standards.

PAS 198: 2012 from the UK has less about design and more about management and operations, in particular Section 3, General, which includes these nuggets:

- Good management is about accountability—it must be somebody's job to look after the environment and the institution itself is accountable for the environment it provides.

- More on sustainability, with an emphasis on monitoring.
- Every organization defines its own environmental specifications.

In other words, the answer to “What is the best environment for your museum?” is “You’ve got to figure it out for yourself.” Furthermore, the modern understanding of how decay works and how we understand the notions of risk and costs for different environments in different climates are on continua—there is no ideal. The ideal is different for different parts of your collection and you must prioritize among them. You are choosing from a continuum of preservation quality/degree of risk and energy savings.

You prioritize among mechanisms of decay. Going back to the shrunken head, are you more worried about chemical decay (leading to cooler temperatures), biological decay (mold or insects) or mechanical or metal corrosion? Which is most important to you and what can you provide in an economical way?

PAS 198 has color bands to show continua of risk depending on conditions and the nature of collections objects. For example, the temperature chart helps you find the sustainability point that you want. If you allow for wider drift, and adapt to the building and climate you have, you can achieve sustainability in various ways. In sum, standards today such as PAS 198 do not specify environmental choices that are optimal; at best they define scenarios of excessive risk and it is up to you to decide what is optimal.

At a large institution such as the Smithsonian, there is an inherent managerial limitation in taking the approach of an institution-wide range of allowable temperature and RH values. That is, within any given range there will be better and worse choices in terms of preservation quality, stewardship, energy consumption, and incremental improvement.

A performance based approach with “industrial-strength” data gathering allows you to bring together and leverage expertise within the organization, quantify risk, and get real world feedback information. You cannot manage what you cannot measure.

British Publicly Available Specification (PAS) 198, "Specification for managing environmental conditions for cultural collections"

Dr. Jonathan Ashley-Smith, independent teacher and consultant (formerly Head of Conservation, Victoria and Albert Museum)

This talk provides an overview of the purpose of PAS 198 and the philosophy of the writing committee; origins and development of the PAS; style and content of the finished product; feedback after one year; and takeaway for the Smithsonian.

A primer on the British Standards Institute and the PAS 198 Steering Group includes understanding the vocabulary it uses, and the implications of selected auxiliary verbs:

- "Shall" denotes requirements—what we insist you do
- "Should" expresses a recommendation—what it would be good if you did do
- "Nay" is used to express permissibility
- "Can" is used to express possibility

The important thing to know about a PAS is that the process enables standards to be developed rapidly, which is why it was chosen in this particular instance. The difference between a PAS and a standard is the degree of consensus—in a British Standard, all stakeholders have to reach consensus on the technical content, whereas a PAS can be open for comment. A PAS may be considered for further development as a British Standard, or it could become part of the UK's input into development of a European or International Standard.

There are several caveats associated with a PAS:

- A PAS may take the form of a code of practice, lending guidance and recommendations. However, it should not be quoted as a "specification," with special care to avoid misleading claims of compliance.
- If you want to claim compliance with a PAS, you must justify any action that deviates from its recommendations.
- Compliance with a PAS does not confer immunity from legal obligations.

An early draft in 2011 titled PAS 198 as a specification for environmental conditions suggested that one "should" have "50 +/- 5." It later became a specification for *managing* environmental conditions, where the "shoulds" refer to what you must do to manage, and the 50 +/- 5 is something that you "may" do.

Leading up to PAS 198:2012, the British heritage sector was used to the idea of PAS 197:2009, which was a code of practice that said cultural collections management *should* have a collections development policy, collections information policy, collections access policy, and collections care and conservation policy, all documented and approved by top management.

Between PAS 197 and 198, two UK research funding bodies began funding heritage research clusters including the Environmental Guidelines: Opportunities and Risks (EGOR). EGOR, led by Nancy Bell, Head of Collection Care at The National Archives, held three workshops that looked at the ramifications of existing environmental standards on collections, buildings, and users. EGOR generated a list of six research priorities: science of material tolerances; modeling the built environment; energy use; bio-deterioration; new technologies; and values and human adaptation. Members of EGOR went on to the Working and Steering Groups for PAS 198.

In particular, EGOR findings enabled Nancy Bell to call for a review of British Standard 5454:2000, "Recommendations for the storage/exhibition of archival documents." The standard was considered "rubbish" since you cannot meet its stringent environmental requirements without introducing invasive or expensive and "un-green" energy consuming HVAC systems. If the standard had allowed for the temperature to drift, it would have been easy to control the RH within the guidelines.

This led to the call for a PAS that would allow examination of more agents of deterioration and a wider range of collections. PAS 198:2012 states:

- The organization *shall* develop an environmental management strategy for the collection. The strategy *shall* include a statement of the expected collection lifetime and the energy demand arising from the environmental conditions needed to achieve this, taking into account the sensitivity, significance and use of the individual collection items.
- The strategy *should* make clear the balance the organization intends to aim for between preservation requirements, usage and display, and energy economy.

This balance is the most difficult thing, in other words, the need to optimize four competing and interconnected outcomes—stability, cost, sustainability, and accessibility. In such a complex system, the optimal solution will probably be sub-optimal to at least one of the components.

The PAS uses a diagram of concentric rings with cultural collection as the inner circle. The outer circle represents environmental considerations (temperature, RH, light, pollution). Between the two are collection considerations (material sensitivity, intended use, expected lifetime, energy economy). One weakness of the diagram is that because cultural collection is in the center, the building envelope and existing hardware were not considered as part of the subject.

The project organization for the PAS, while appearing to be logical and systematic from the flowchart, was in fact complicated and bureaucratic. At the top were the project manager, project director, and technical author, and below them the steering and working groups and a review panel. All iterations went to the technical author, whose job it was to decide what version would go in the final document.

In terms of structure, following Section 3 (General) are four sections on Temperature, Relative Humidity, Light, and Pollution, with many "shall" statements on how these should be considered. Then come the Annexes, and Notes give further guidance.

The PAS was written as a textbook aimed at reader understanding, as compared to a terse standard, and as such has full descriptions that can engulf key points, for example:

- Light: specification of illuminance is always a compromise between preserving the collection item and making it clearly visible.

The Pollution section is different in that it advocates an "evaluate-monitor-mitigate" approach; in other words, do not flood the place with monitors before you know you actually need them.

The Annex informative charts give advice on how it is possible to drift within ranges and minimize energy considerations; however this is constrained by human comfort, UK law, and common sense (i.e., you may not freeze employees and would not want to freeze your water pipes.)

Once the PAS was ready for publication, there was a delay of several months as some influential people attempted to modify or ban its use. During the hiatus, The National Gallery in London published its own environmental and sustainability policy with a standard attributed to Garry Thomson: RH: 55% +/- 5% and temperature 21° +/- 1°C (winter); 23° +/- 1°C (summer). The rationale included that easel paintings are *exceptionally* complex in their material construction and that *unusually* stringent demands of environmental control are required to ensure their preservation. The policy undermined all the work of Mecklenburg and other conservation scientists to date, stating:

> Real paintings are very much more fragile than experimental test models which significantly over-simplify the nature of the problem, particularly with regard to their complex mechanical behavior.

The National Gallery asked an interesting question: "Is active environmental control in museums responsible use of energy?" The answer is that it is a matter of definition. In this case, the policy states that "Only ducted air-conditioning systems can provide safe conditions for long-term preservation of real paintings, and these systems will consume a proportion of the Gallery's energy budget." It is a fair point to make because you are trying to balance two non-renewable resources – Old Master paintings and a lifestyle that people in the West have become accustomed to. The PAS is meant to generate that sort of debate, asking "Which of these is the most important?"

The PAS was published one year ago with the following feedback:

- It doesn't tell us what to do!
- The concept of "lifetime" is difficult
- The concept of "lifetime" is dangerous
- The PAS is difficult to use in teaching
- Scientific experiments do not reflect the real world.

The concept of collections lifetime does not have to be a difficult if you are prepared to be a bit arbitrary and choose a planning horizon of 50, 100, or 200 years. You need to understand your collections and the **point at which they will fade out under the current environmental control systems**:

- Early in the planning horizon: you have the choice of doing something about it, or if resources don't allow, accepting that is the collection lifetime.
- Beyond the planning horizon: you do not have to do anything.
- Near the end of the planning horizon, you still do not have to do anything because a review at set intervals may involve new information and a new starting point.

With respect to scientific experiments, PAS 198 notes that:

> Alongside empirical research, it continues to be important to take account of the experience of, and data collected by, conservation professionals who witness first-hand the changes to objects over time.

Some key takeaway points about PAS 198:2012 are:

- It is very libertarian—it doesn't tell you what to do.
- It gives you a framework for thinking about what to do.
- It gives you the best set of tools that is available at the moment.
- It empowers you to follow your own local philosophy on sustainability or collections use and stay within your financial means. You can develop your own local compliance without being subservient to external normative pressures. You can devise your own conditions or your own criteria for different collections within your organization.

"Compliance without subservience" could be a new slogan for collections care. Some improvements to PAS 198 would be to simplify the procedure and incorporate energy considerations more fully. As for the Smithsonian, it should certainly use the framework, some of the text and visual aids, and the tools which are publicly available.

Sustainability: Climate for Culture

Fiona Cousins, PE, LEED AP BD+C, Principal, Arup

This lecture shows inspiring solutions in museum lighting, temperature and relative humidity control, pollutant control, and monitoring. It addresses both collections preservation and green building goals.

From the perspective of a designer, the 70° 50% +/- design standard is fairly ubiquitous in the museum world. It is the "capital expenditure point"—if you have to meet that standard you must buy the equipment to make it happen. The designer has to know if you decide to operate at a lower or different condition as well. You have to make sure you can operate both at the design condition and at the conditions that occur more frequently—"if the suit is too big it actually doesn't fit."

Cousins had design experience and learned lessons about environments and systems in a wide range of buildings.

- Sainsbury Wing of the National Gallery, London, 1985-86. During the commissioning stage they had to fake load the mechanical systems. They used electric kettles and light bulbs strung across chairs to load the mechanical system, and a smoke machine and video camera to see where the air would go at a certain load. Since it was in the UK, they were trying to simulate a busload of tourists getting off the bus with umbrellas and going straight into the gallery space.
- Fawcett Archive, London. As long as you don't open the door and let either a person or fresh air in, an archive stays stable and works well for quite a long time—it is a low energy, self-sustaining system and the materials themselves and the mass help maintain the humidity. As soon as you want to look at something in the archive or put in base ventilation you have all sorts of energy problems.
- Ashmolean Museum, London. You have to be careful about the historic fabric of a building if you are going to install an air conditioning system. One problem is that you cannot maintain the conditions that you need because moisture comes in through the non-waterproof, non-vapor type materials. Another is that moisture comes in and you cannot maintain the humidity without using a lot of energy.
- San Diego Museum of Contemporary Art. The architecture of this building with its big open space meant that design choices had to be made. They could not afford to put 70-50 space into the big hall; however, some 70-50 space in the building was needed to meet the requirements of insurers and lending institutions. They did not intend to keep the open space to anything other than 65-80 depending on whether the sun was shining – any more would have been difficult for an AC system.
- Blanton Museum of Art. This was a purpose built museum with big spaces and long galleries, about half custom built around the collections of Latin American art and casts of antiquities

found in Europe and taken to Texas. Some ideas have not changed—the Blanton Museum borrows many of its design features from the Grande Gallery of the Louvre.

Cousins has worked within the LEED system and energy saving for her entire career and thinks of sustainability as more than just energy saving. ARUP has a sustainability approach that it tries to incorporate in all of its building designs based on six distinct areas of sustainability:

- Carbon neutrality, which is a proxy for energy saving;
- Collecting and reusing water;
- Sustainable materials;
- Adaptation to future climate change (looking at the science of climate change and localizing it);
- Being a positive contributor to the community and the built environment; and
- Sustainable operations.

Three of the sustainability areas are significantly different for museums and galleries. Positive contribution to the community and built environment are what museums, galleries and archives are all about, but getting people to visit is more of a design problem than, say, for an office building. Carbon neutrality and sustainable operations are mainly about money spent on energy. Museums are different than other buildings in this regard because they run 24/7, 365 days a year, they are humidified, and they have a tight temperature control band to control humidity.

Another thing about designing a museum is that there tends to be a lot of stakeholders—e.g., politicians, donors, directors, curators, conservators, and visitors—whose purposes may be at odds. For example, directors often want to invite donors in the evening to eat and drink in the museum gallery space, which is not a good idea in a close controlled environment. Depending on the program, it will involve a balance of different requirements or space types.

The first question to ask in a sustainability framework is “what do you want your building to do?” Is it an **iconic building or an art centric space?** The Centre Pompidou, Paris, started the debate about what is more important—the building or what is inside it. The Royal Ontario Museum (ROM), Centre Pompidou, Metz, and Paul Klee Museum in Berne are all examples of museums that are very much about the iconic architecture and drawing people to make a social connection with the building as well as what is inside it.

The second question is “what do you want your visitor to get from the visit?”—a **curated or naturalistic experience?** This depends in large part on whether you have electric or natural light. The European approach is to have a large open room with enough natural daylight to see the pictures. The North American approach has dark rooms with highlighted objects and a focus on individual works. Having natural light and additional openness make a big difference in terms of the solar load within the space—if you want to be carbon neutral and save energy you need to make sure that your HVAC systems run as little as possible. To control the load you must keep the sun out, insulate the building properly, and allow the conditions to be as flexible as possible for the material that is within that gallery space.

Environments will also differ depending on what you are trying to exhibit. The New Acropolis Museum in Athens would have a different type of environment than the Los Angeles County Museum of Art (LACMA). One question is whether a Jeff Koons sculpture requires the same conditions as a classical sculpture.

The De Young Museum in San Francisco takes a slightly different approach of having a close conditioned space with the addition of "boxes" within that space for greater stability. You can reduce energy if you have a box in a room instead of just a room.

In the design world they tend to design for, and museum operators tend to operate at, the tightest conditions, e.g., the 70-50. An explanation for this is that when the default standard is questioned, the designers turn to the conservation department. The conservation department lacks guidance (before PAS 198) and punts in turn. When it comes back to the designers, they say, "The only thing we can do that won't get us sued is 70-50."

This perpetuation of the default standard is very energy wasteful, is hard to design to, and has effects on every piece of the building including the envelope, pressurization, airflow, whether you need to operate 24/7, etc. You can, however, design the system for 70-50 and then operate at something else; for example, you can choose not to run the dehumidifiers, or run them less, and still get very good temperature control. There is a whole series of things that you can do to hold design conditions more loosely and keep energy costs lower.

Another design question has to do with **authenticity of experience vs. technology-mediated**. Beyond traditional exhibits, the museum experience is moderated more and more by electronic devices such as phones or interactives, which typically are high energy use and don't require stringent environmental conditions. So, what you put into the space affects your loads and how to maintain appropriate conditions. One solution is zoning and having the control intelligence, maintenance team, and curatorial team in sync that will allow different conditions in different spaces. This is operationally very difficult and museums typically do not do it well.

Another big issue for sustainability is the tradeoff between **flexibility and low cost**. On one end of the spectrum is the Richelieu Wing of the Louvre, a large, non-flexible gallery where everything—how it is used, how the light falls, how the exhibits are shown—is mostly fixed. At the other end is the Institute of Contemporary Art (ICA), Boston, where you can put anything anywhere on the grid system and nothing about the layout is fixed. The ICA does not even try to achieve 70-50, it has no or minimal humidification.

This same open approach was used in the expansion of the High Museum of Art, which did have a 70-50 design condition. That space was designed with moveable partitions to give flexibility; however, the extreme modularity of the High only allows partitions to be placed horizontally between the air supply grills in the floor. In order to assure that light goes everywhere in such a building you have to change the mechanical system when you want to move a wall so the lighting will come through skylights. You can only have the flexibility that you design for—putting 800 skylights on the top of a museum building is not a good idea. Another important consideration from a sustainability standpoint is the material chosen since the embodied energy of the materials can account for 10% of annual carbon emissions.

Another design question is whether to go with a **designed space or "as found" space.** While it is often less expensive, there are often issues with the envelope of found spaces. The University Of Michigan Museum of Art is a designed space that is also very naturalistic with lots of daylight. The Dia Beacon, which occupies a former Nabisco factory on the Hudson River, cannot have an oil painting exhibit because there is no intention of trying to maintain conditions at "70-50." Another famous found space is the Turbine Hall of the Tate Modern, London, which displays the gigantic work *Marsyas* by Anish Kapoor and begs the conservation question, "will this ever go anywhere else?"

A final design consideration is **art conservation vs. low energy**. The things that we design for that cost energy are stable temperature (a must for stable humidity), control of pollutants (such as use of carbon filters), protection from ultra-violet radiation, and limited illumination exposure.

There some things that you can do to change the way a building behaves without the normal method of throwing in air, moving it around, and taking it out to achieve 70-50. The Brandhorst Museum, Munich, is a top-lit flexible space gallery with under floor air. It has activated slabs and pipes running through the walls and ceiling with chilled or hot water that fake thermal mass. This allows you to put in less air and thus have less duct work and less capital cost. A second approach at the Kimbell Art Museum, Texas is putting the air in from the bottom through an under-floor system. This approach usually helps save energy but galleries get hot at the top, which concerns conservators. If you have a high space this is the right way to get people comfortable and also have the right conditions for the art.

Another thing is keeping the sun out of the building. At the Nasher Sculpture Center, Dallas, a ceiling plane of angled components is a shading device designed to keep out direct solar radiation. Keeping out solar radiation is a heat question, not a conservation or lighting question—it allows you to keep your system sizes small and stop getting peaks in the load.

There are three things you need to do for sustainability, i.e., art conservation and low energy, once you get away from 70-50 or are working within it:

1. Make sure that you have reduced the loads by keeping the sun out;
2. Look at thermal mass to deal with what happens when the busload of wet tourists go into your gallery; and
3. Look at different types of systems that can be more energy efficient, for example an under-floor air system, high levels of heat recovery, and lower levels of fresh air during unoccupied hours.

Panel | Relationships, Respect, and Trust: Collaboration among Museum and Facility Professionals

Moderator: Cecily Grzywacz, Facilities Scientist, National Gallery of Art

Panelists: Stefan Michalski, R. Robert Waller, Michael C. Henry, James Reilly, Jonathan Ashley-Smith, and Fiona Cousins

Grzywacz, a senior research scientist at the National Gallery of Art, introduced the panel topic of collaboration among facilities, conservation and collections management professionals.

Collaboration is built upon relationships, trust and respect. If you are on the collections side, how do know when to go to the facilities people if there is a possible problem with the collection and vice versa? We need to stop worrying about asking people needless questions because we will eventually learn what we can help each other with. We have different areas of expertise such as science, art, and management, with different professional languages, so it is hard to interweave our conversations (and the acronyms are insane!)

In terms of preservation environments for museums, it takes a team if not a village. Some of the stakeholders are museum directors, collection managers, building engineers, conservators, facility managers, curators, architects, designers, registrars, operations staff, patrons, visitors, lenders, and benefactors. At NGA they liaise with the industrial hygienist / risk management people for health and safety who look at the material safety data sheets for human health safety while she reviews them from the perspective of the art.

Preservation environments are unique to the location, geography, climate, type of museum and building and particular artifact or collection. At NGA they are fortunate to have air washers—a 1910 technology installed in the gallery in 1940, and they have managed to maintain 1940s technology to control the environment.

> *Grzywacz to Robert Waller (referring to his presentation on risk management where facilities managers are responsible for **source**; collections personnel for **path**; and conservation science for helping us understand what the **effect** could be): We each perceive risk differently, so how can we make sure that we each understand the risks, which are very different in the three branches?*

Waller: We absolutely perceive these risks differently and there are many common perceptual biases in risk. One is voluntariness of risk—if collections managers are able to control a risk by themselves, they will perceive it as much lower than if they had to rely on facilities personnel to deliver the protection. The trick is to come up with rational predictive numbers (e.g. we expect that 5% of the collection will experience loss). That provides a concrete common understanding, even though it may be difficult to achieve. As long as we only rely on our passion or intuitive sense of the risk there will always be big differences depending on our perspective. We want to get to concrete numbers, even if they are approximate.

Grzywacz to Waller: If I'm the collection manager and I believe that I can handle that risk and don't share that with facilities, how will facilities learn about that potential for risk?

Waller: We strive to be comprehensive in identifying and defining risks. To do that requires very good documentation so that it is clear to everyone if there is risk of an excursion to a high RH and how that is interpreted for each of the collections, i.e., what are the most vulnerable objects and what is the median object, is it low vulnerability or is it also quite high? In that way you construct a profile based on the variability of the collection and the nature of the materials.

Audience: On a collaboration continuum, with facilities, collections, and science, where do vendors (e.g. HVAC components), contractors, and leased building managers fit in?

Reilly: It varies; each one is a different case. For example, in leased space people feel they have little control over things, making for what is often a fraught situation. Vendors operate a lot of buildings and they should feel comfortable getting together with conservators; likewise, the management of the institution should feel comfortable having conservators talk to whoever is running the building to work things out. It does become more difficult when the parties involved don't report to the same organization. At his university, for example, the Provost is the highest academic officer and the Vice President for Administration is the boss of the facilities organization, so the onus goes to the top to facilitate that cross disciplinary conversation.

Henry: If you know you are going to put a collections environment in leased space, the owner/operator of the building has to be brought into a collaborative discussion before the lease is signed rather than after wards when the cost, profit and lease rates are set. With respect to vendors, if a major specialized piece of equipment is being put in such as a dehumidification system, the vendor needs to be brought in during design and made aware of what the expectations are for that equipment once the project moves into operation.

Cousins: As Reilly said, the problem with operations is that it is not a project. When you are designing a building, making a lease, or doing a renovation you have a project and you know how to deal with vendors or manufacturers because it is part of the design process. It becomes an issue when they are not part of the design process; at that point there needs to be more collaboration than she currently sees.

Grzywacz: How can you zone or isolate areas within a building that are all on view and that have different exterior wall construction?

Cousins: In order to get close control you have to respond to what's happening in the part that you are influencing. So, you must have a zone for every room, sometimes multiple zones in a room. We are always dealing with controlling temperature and RH separately for spaces that are interior, exterior, east facing, south facing, north facing, brick, aluminum panel, glass—it is just part of the design work.

Henry: You can design for that, but he often goes into a museum after a few years and sees that doors intended to maintain zone separations are propped open for various reasons. It is virtually impossible to maintain that separate zone performance.

Grzywacz: Is it an education process—explaining the reason why we keep this door closed? We are all so busy running around and with new people coming on that we don't take the time to do that. It's a challenge to understand how each building works for collections preservation.

Cousins: Within the project process there are two stages of information handover. The first is where the institution says what it wants and the design team runs with it. In the second stage the designers deliver the building design and instructions on how it will operate. Neither of the stages of information transfer is done very well. Moreover, in new buildings, the facilities maintenance people often have not been hired yet, so there is no one to give that information to. It is not part of the design handover or standard services and takes greater effort to propagate that institutional knowledge.

Reilly: The building design process is complicated in that it disaggregates into ducting, piping, electrical, etc. and there are only a few people with an overall holistic sense of how it is supposed to work, making the first handover doubly hard. In addition, the commissioning process can be misleading in that the Commissioners have to verify that piece x, y or z is working, but that does not provide the essential knowledge of how to operate. By the time it is fully handed over the holistic understanding is lacking.

Grzywacz: *How do we maintain and continue that knowledge in existing buildings?*

Cousins: Universities do this best. Because they have a large number of existing buildings that they manage over time, they have a facilities team that does technical review for every project and makes sure it is something they know how to maintain and complies with their standards. The facilities team's role is to make sure there is an ongoing dialogue with the designers so that they understand what is wanted.

Reilly: There is a strong need for documenting how everything is working on the facilities side. You know things are working well if you walk into a mechanical room and can immediately tell what is what—like an organized versus a messy bedroom.

Grzywacz: At the National Gallery of Art they do a lot of documentation but it is kept in the file cabinets of facilities people. How do we get that documentation out to the collections and science people so that all can make use of it?

Question: How is the amount/need for outside air determined? Is it based on a formula or actual oxygen and carbon dioxide levels in the building? Wouldn't it make sense to base the need for fresh air on actual levels of CO2, particularly in high air volume, low occupancy areas such as storage?

Cousins: Carbon dioxide is difficult to measure; you need a lot of sensors in different areas. The amount of fresh air in gallery space is determined by outside and inside conditions and the number of people. It is usually kept to a minimum based on code. Sometimes during unoccupied times it goes lower and is based on pressurization.

Henry: In storage areas, you can go to low levels of outside air but need to be aware of the potential for off-gassing of collections, for example industrial collections or natural history collections in solutions.

Question: In mixed material collections, what is the recommended process for determining appropriate temperature and RH levels?

Michalski: Use a risk approach—if you are looking for a single magic number, you will get frustrated. It is better to ask where the most damage is happening for certain conditions and try to avoid that. If a sweet spot emerges, you're lucky. There will probably be several sweet spots where you have to trade off one collection or issue against another and you have to have a meta-criterion to determine which one you prefer.

Within any risk assessment you need to think about significance. There are two components that make a risk large: one is the material science and the probabilities it suggests and the other is whether it is a precious object relative to other things. If you know that your collection's significance resides to a greater degree in some objects than in others, and the material risks are similar, then clearly the priority is to avoid damage to the more precious objects. So, you start with the sensitivities / susceptibilities of the collection and where, if it pertains, you have a higher percentage of your whole collection value. If that is not an issue you can focus on the material science. It can become a feasibility issue, and some decisions based on resource constraints can generate more risk. In summary, do not look for a magic bullet that hits the bull's eye for all collections. You need to ask where the big, red, nasty spots are – identify and avoid the red danger zones rather than try to find the greenest zones.

Question re: thermal comfort versus collection preservation. Explain to a non-collection staff member why preservation environments may not always be equivalent to human comfort?

Reilly: Collections are dead, they don't feel hot and cold and like being cold because it slows down chemical reactions (though the point is conceded with regard to Zoo collections).

Ashley-Smith: The National Gallery went from 19°C to 21°C as its basis for human comfort, whereas the Medieval Gallery of the Victoria and Albert Museum has temperatures in the winter of 16°C and lower and nobody complains. We have to define human comfort in a different way than traditionally where people are accustomed to being able to wander around in t-shirts.

Reilly: There is an ISO standard to calculate the probability that a given individual will be comfortable, taking into account level of activity, what they are wearing, the mean radiant temperature, humidity, etc. You get a probability that x% of people will feel comfortable in y set of circumstances.

Henry: We know less about how to define what range of temperature and RH is appropriate for human thermal comfort than we do for collections. ASHRAE has studied this—the initial presumption was human thermal comfort in the heating season; then with the onset of air conditioning it became how to define comfort in the cooling season. There is now a tremendous amount of research on adaptive behavior in human thermal comfort where there is either no air conditioning or less due to energy saving. The research is showing that the tolerance span is larger than previously thought.

Reilly: The Library of Congress Fort Mead facility is 50°F/30%RH. People were basically wearing moon suits of inch thick fleece. People working at a similar 50°F/30%RH facility at Cornell University in Ithaca, NY are more adapted, wearing sweaters with some people running fork lifts in t-shirts.

Ashley-Smith: To some extent it has to do with training. If you say to people that the temperature is for the good of the collection they've come to see, you will get a lot more tolerance.

Cousins: Yes, if you go to a greenhouse you expect it to be hot and humid because that is what plants need.

Michalski: It would be rather pathetic if, at a moment when human comfort standards are relaxing or getting broader and more sophisticated, the heritage business would stick to a narrowly defined temperature that was historically driven by human comfort. One hopes that given sustainability targets like energy and carbon savings, the conversation is not so much about humidity or seasonal adjustment – that is more about savings in non-purpose buildings. Temperature seasonal setback is where the big savings will be. We do not want to be the obstacle to serious carbon footprint savings due to seasonal adjustments in average temperature. You may have heard that now temperature control is necessary because of its interaction with relative humidity. That plays out over periods of a few hours with the air mixing over and the fact that if the building buffers, it does so to RH rather than to dew point. Outside of a day there is no reason not to be playing with temperature adjustments for sustainability.

> *Cousins: What about rate of change of temperature and humidity? They are asked to control the rate as well as the actual value.*

Michalski: Tracking down the history of where that mythology emerged is difficult. To a large extent it is exaggerated. When Marion [Mecklenburg] presented "the box" at the Boston Museum meeting with 50 chiefs of conservation from across North America, much of the discussion was focused on the rate of change issues. Marion would say to his facilities people, I want you to stay inside the box, how you ping pong around in there is up to you. The good news is that they tend to ping pong around one side of the box in one season. To turn it around and have someone say, 'we can't do that; we are going to bounce around day by day—is that bad?' Within the kinds of boxes we are talking about, the answer is 'no'. To the extent that he has tried modeling, he hasn't found any plausible stress gradients that would emerge. The classic argument is that there is a gradient through the object; it has thermal inertia or humidity inertia so that those gradients lead to internal stresses.

Reilly: That was the mechanical answer; the chemical answer is that there is no penalty in terms of the rate of spontaneous chemical decay, mostly hydrolytic oxidative reactions, from moving from one temperature and moisture content condition to another. What changes is the rate of reaction. Precisely, there's no extra penalty just from changing from one condition to another. Every condition has a rate associated with it; what matters is the way the rates all integrate. It is unlike mechanical damage where there could be a plausible mechanism of deterioration that is related to the rate of moisture content change. On the chemical side it's better to be colder because it slows things and it's better to withdraw moisture (but not get too dry due to physical or mechanical concerns). Basically you can move around as much as you want and what will matter is how much time the object spent at each condition. Each condition has a rate, and if you properly integrate those rates then you can come up with an overall effective rate of decay or rate of preservation.

The pharmaceutical industry does something similar with mean kinetic temperature. That is how it ensures drugs are not ineffective by the time you get them because somebody stored them at too high a temperature. It must be 25°C or less; if it gets to 30°C your pharmaceutical is compromised. If the concern is chemical decay, you can move around in temperature and achieve sustainable savings that way. One underused sustainable method is duty cycling. Having the same temperature and humidity 24 hours/day, all year long is not effective or sustainable.

Michalski: What about loans determining guidelines? The ASHRAE guidelines say the set point can be the historic average for your collection, but notes that many lenders will require AA conditions centered on 70/50, so to meet contractual obligations you will need an exhibits room. Part of the reason he sits on international committees and panels is because whatever the Smithsonian settles on is going to trickle down – what credible organizations do sets precedent. (And this field is about precedents that get encrusted.) It is better to be at the beginning of those precedents and steer them in a good direction than to wait and deconstruct them. It takes longer to deconstruct a myth than to be there and give birth to the right story. If we can get the international community to change the specification, that has huge trickle-down effect. The single most stringent requirement for museum projects is not for their own collections—it is about contractual obligations and wanting to be on the loan circuit. This spans mega museums to small house museums. The extent to which we can get fundamental restrictions from the world of international loans to go in the same direction we are trying to go will have a huge effect on architectural projects.

Waller: Rates of change of temperature and humidity within a box probably don't affect many collections; however, we can't say categorically that they don't affect anything. For example, mineral collections are the most vulnerable of all and certain opal specimens are extremely vulnerable to crazing. So, there are always exceptions and we can improve communications between conservation science, collections care, and facilities by encouraging collections care professionals to identify the most vulnerable objects to any particular issue and work with conservation science to get an idea of how susceptible they are.

Henry: This Panel has been about collaboration. Ashley-Smith talked about empowerment and we have talked about decision-making. Question to the audience: "How many of you feel that you are basically empowered, or have some fundamental knowledge to move forward on a different path rather than saying, I want 70/50?"

[There was a sweeping show of hands across the audience.]

Smithsonian Institution Collections Space Prototypes: Project and Principles

Speaker: Luanne Greene, Principal, Ayers/Saint/Gross

This presentation reviews the Smithsonian Institution Collections Space Framework Plan, the result of a pan-Institutional planning exercise.

Greene began her career as an architect designing buildings in the traditional sense and for the last 20 years has focused on long range planning for facilities. Design is very different from planning. When you are designing you know what you want, an end product of the building or renovation. With planning you want a document and recommendations, but planning is a process as well. This process has been complex in part because it is pan-Institutional, cutting across many entities and people who don't normally work together. The goals were as broad as strengthening stewardship to developing shared solutions. It was not just "shooting for the moon"—it had to have a bold vision but also be rooted in reality and the fact that cost matters.

This is not an idealized plan that exists in a vacuum—it is rooted in the considerable work on the Collections Space Database, a fantastic tool that will continue to grow in strength and connection to the work of the Institution. The Database covers 2.1 million square feet of space, which is 18% of the Smithsonian's built space.

The planning team looked at this foundational work of the types of collections space, and then began to determine the biggest problems facing the space. Besides having a wide variety of space types, there are a wide variety of conditions. It quickly became clear that condition was an issue but also whether the collections were paired with the right type and condition of space. They arrived at the result that more space was needed, but also saw that better efficiency and long-term effectiveness of operations could be gained through shared resources. They needed both renovation and new construction.

An interim phase ensued where values and goals were clarified: improve conditions, allow decompression of overcrowded collections, reduce overly spread out locations of collecting units, accommodate future growth, increase efficiency through shared resources, plan for high performance facilities (especially with new construction), and reduce dependency on leased space.

They did not begin design of the 2.1 million sq. ft. needed to address conditions, but rather created prototype designs that theoretically embody shared values. They were looking for the sweet spot between best practices and the realities of construction and costs. A big piece of the process was communication—developing a common language to avoid being stressed or threatened. They found that they could talk broadly about the 80% of projects that were more typical or common. They struggled with the 20% that were the more unique pieces of the collection.

They developed three prototypes:

- Existing building that were "keepers" with renovation in the future

- New construction for majority (but not exclusively) large objects
- New construction for majority (but not exclusively) small and medium objects

Prototype 1, existing buildings, includes the spectacular collection of buildings on the Mall – they are part of the collection and what is iconic about the organization. They often house the highest value or most frequently accessed collections, and include processing and lab space in addition to storage. They also need to remain open as active facilities serving many audiences. The team examined three types of collections space at the National Museum of American History to represent different conditions: spaces that were vulnerable to conditions (e.g., in a basement or below the flood plain) that needed to be phased out; spaces that needed major renovation; and spaces that needed minor renovation. The high level takeaway that could be applied to other locations was that:

- While you could plan for gains in quality of the space, gains in efficiency, and reduction in overall risk, it was less clear that a result would be more quantity, or volume of space—it might be a wash or even diminished. However, there were great opportunities to gain capacity through stabilization or improvement of conditions or reconfiguration of equipment. Swing space was a concern, and overall net capacity would vary by unit. So master plans for each unit would guide the issue of capacity.

The team "draped" idealized drawings over drawings of existing space to see where modifications could best meet the idealized diagram—how to reconfigure walls and space, how different types of equipment could fit in, etc. It gave them enough detail to get some pricing and come up with a catalog of likely future conditions so that planning could be "smarter" and more informed.

The new construction prototypes roughly divided large from small and medium objects but the categories were broad. The large object prototype was for collections with similar: physical characteristics such as size, weight, and materials; environmental controls; specialized materials handling equipment (such as forklifts); and stewardship and research opportunities.

The starting point was around risk. They devised a collections storage module of 30,000 sq. ft. per floor —a 150 by 200 foot box—to minimize the risk of fire and smoke damage. They wanted an efficient design where security management figured highly. They tested a grouping of ten modules around a linear spine with a multi-story configuration due to the high cost of real estate in the DC area. The test grouping had centralized access, loading, and utilities plant for security purposes and to the extent possible shared or reduced the redundancy of critical elements such as freight elevators. At the end of the day you might get 900,000 sq. ft. of collections storage out of these ten modules – a very robust facility with high bay collections storage space.

The focus was on having a secure, robust and flexible capacity. They discussed at length module size, column grid for large objects, ceiling height, and ways to accommodate different heights for a variety of equipment.

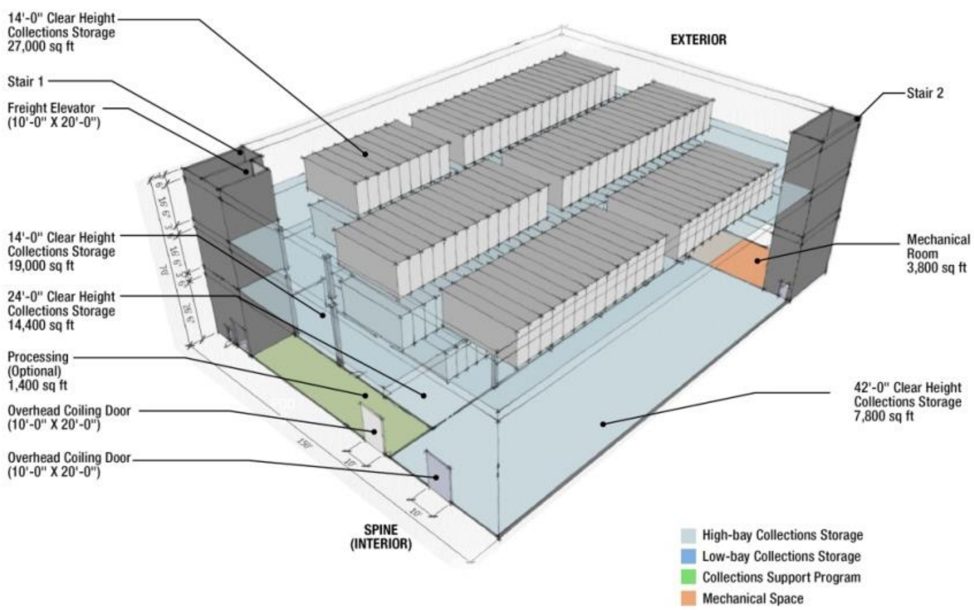
The prototype drawings addressed how to efficiently, safely, appropriately house the 80%, but also what were tools in the toolbox to address the 20% that needed an extra high door, etc. Much of the discussion was on how to subdivide the space to achieve a wide variety of environmental conditions appropriate to the collections. Other design considerations were security, sustainability, building performance, and a very thermally stable envelope, resulting in such features as one door at the loading dock and no windows.

The diagram for a Large Object Prototype shows a three-story module with a two-story high area for unique objects, a common spine for access, vertical circulation elements, and mechanical space on the outside for separation from the collections.

The team considered how the prototype would organize itself on the site, for example, how to gain efficiency from site utilities, low impact strategies such as storm water management, and phasing building over time.

The Small and Medium Object Prototype is similar in many ways. Differences are in the dimensions of the column grid, different “clear heights,” a mix of low and high bay spaces, and pairing with more collections support programs such as processing labs.

In summary, they did not invent a lot of new things, but they organized a lot of materials. Many individual thoughts came together and coalesced into a strong vision along with a very practical starting point, because the point is action – to improve the conditions you need to create a strong argument for getting going.



Summit Proceedings Day 2—March 22, 2013

Opening Remarks by Secretary Wayne Clough

The Summit brings together folks from different elements of the Smithsonian to address this topic that is at the core of our Institution. The Smithsonian Strategic Plan involved 1,500 people and the Summit exemplifies several parts of the Plan including emphasis on the quality of collections and collections care, and mission enabling excellence—being the very best at what we do, not only on the programmatic side but in every way we do business. The Summit also represents the Institution's ambition to be seen as a leader that emphasizes collaborations and partnerships. For example, many of the 177 affiliated museums and cultural institutions in the Smithsonian Affiliations Program participated on Day One via the webcast. The Summit is to be commended for thinking about our national leadership role with these great institutions that we call our affiliates, as well as many others who can work with us.

Collections stewardship is both a high priority and one of our greatest challenges due to the volume, characteristics, complexity, and age of Smithsonian collections, as well as the variety of discipline-specific standards that apply to their care. Management is as challenging and complex as the collections themselves, ranging from postage stamps to the Shuttle Discovery; the Allende meteorite that is more than 4 billion years old to the clouded leopard cubs born last month; cryo-collections of nearly one million samples of frozen tissue, germ-plasma, embryos, and DNA to digital art, images, and time-based media.

Smithsonian collections are priceless; they represent the collective memory of our nation and provide a timeless resource to understand life on our planet and the changes that are occurring to it. While the collections are now an essential resource to our own researchers, the public, and the thousands of scholars who use them, they will become an even greater source of information and innovation as they are digitized. Digitization of collections is one of the keys to improve preservation, accountability, and accessibility; however, the process, requiring each object to be digitized individually, is difficult and there is the added challenge of including metadata. A major accomplishment was the identification of 14 million priority objects for digitization comprising 10% of the total holdings of 137 million objects, artworks, artifacts, and specimens plus two million library volumes. However, it is estimated that even with digitizing one object per minute it will take over 100 years to complete the task.

More progress has been made with archival material—63% of the 137,000 cubic feet of personal papers, business records, photographs, recordings and film is prioritized for digitization, with 28% of that prioritized collection digitized. Even still, completion will take over 60 years.

As the Institution ramps up its digital efforts, it is important not to shrink away from investment in the physical task of caring for collections. And given the impact of global change and increasing need to adopt green technologies and achieve energy and costs savings, the Institution must strike the right balance between collections and environmental stewardship. These are not contradictory goals.

Museums should serve by example, preserving the collections entrusted to our care, being energy and cost efficient, and educating the public about the effects of global change and our options to adjust to such change.

The Smithsonian has invested $550 million in improving physical collections facilities since 2003. Notable projects include construction of Pod 5 and the renovation of Pod 3 at the Museum Support Center; leasing and development of the Pennsy Drive Collections and Support Center; construction of Hazy I and II; move of the collections at Cooper-Hewitt to an off-site storage facility in Newark, New Jersey; and other revitalization projects at Mall museums and the Zoo. Creating Scott Miller's position was another significant move to give collections care and facilities higher visibility. The current collections space planning initiative and survey has yielded data that gives the Institution its first realistic picture of the current state and environmental conditions of its collections spaces. We now know more about how big the job ahead is; this has in turn led to the development over the past two years of a Collections Space Framework Plan.

The Executive Order mandating energy use reductions tied to promoting sustainable operating practices across the Federal government is important given that controlling the environment for collections requires a 24/7 use of energy. The Institution can claim energy saving accomplishments such as the annual savings of half a million gallons of petroleum based fuel through use of alternative energy sources for the vehicle fleet, and the National Museum of the American Indian being awarded Silver certification under the LEED rating system. More than 18 other planned projects are designed to achieve LEED certification, including many projects involving collections.

In conclusion, this Summit, and the discussions you will be having today in relation to the draft Declaration on Environmental Controls, affords us an opportunity to assess and validate the state of current environmental research and guidelines, and permits us to define the process of how we decide to implement environmental best practices within the Smithsonian.

Overview of Proposed Smithsonian Institution Declaration on the Museum Preservation Environment

Sarah Stauderman, Collections Care Manager, Smithsonian Institution Archives

This talk provides a brief overview of the Smithsonian Declaration on Environmental Controls for Collection Areas (including Exhibition and Display), illustrated with images from the Smithsonian Institution Archives.

Why a declaration? Why not a statement, a policy, or a proclamation? The reason is that the declaration embodies the combined motivational, aspirational and inspirational aspects of all Smithsonian collecting unit plans, and a statement or policy is premature at this point. That is the task for Day 2 of the Summit and on-going discussions afterward.

The Declaration is a pan-institutional, cross-disciplinary effort of a group of Smithsonian collections and facilities professionals that came out of the deliberations of the Collections Space Steering Committee (CSSC). As CSSC moved forward with plans to create state-of-the-art prototypes for collection spaces, it became clear that there are gaps in the Institutions' procedural and policy activities as they pertain to the preservation environment.

The Declaration, which consists of a preamble and eight points, is intended to be a benchmark for future discussion and implementation of a system of processes that will improve the Smithsonian's approach to producing environmental set points in collections spaces. The committee recognizes the challenges of establishing and maintaining set points, especially because the Smithsonian's historic and other existing buildings may not be compatible with desired or required temperature, humidity, lighting, ventilation or pollution controls. It is important to consider performance of buildings in establishing set points and mediate this information with the requirements for collections.

While building guidelines from the facilities design standards at the Institution do indicate parameters for developing and building out designs with regard to the environment, the committee believes that the proper place for policy guidance on the environment for collections is within the Smithsonian Directive 600 collections management policy. The committee identified the five categories that should pertain to the preservation environment: temperature and allowable ranges, humidity, lighting, pollutants, and ventilation. Part of our task is to consider whether these are the exhaustive categories, or if more areas should exist under the Declaration, such as integrated pest management.

Part II of the Declaration focuses on coordination and collaboration. The Declaration is clear that individual units are responsible and accountable for establishing their own environmental set points; however, this cannot be done in a vacuum. The units have institutional expertise at their disposal to assist in developing set points in remediating existing spaces.

The Declaration introduces two important groups: the integrated facility team (IFT) and exhibition design team. The IFT, a cross-functional team of facilities personnel established to coordinate with museum and research staff, should be the primary mechanism for establishing environmental parameters within collections storage, galleries, research, and laboratory spaces. Engineers, curators, conservators, collections managers, scientists, administrators, and others are expected to be involved in the process of establishing environmental parameters. Similarly, exhibition design teams have coordinating roles to play in establishing exhibition environmental parameters. Part II establishes that research and study is key to success, and that specialists must be included for their expertise.

Part III of the Declaration asserts that monitoring is an essential element of the preservation environment. Part IV pertains to education and training. In order to comprehensively consider all the factors that go into deciding environmental parameters, one must have knowledge not only of the collections but also of the buildings they are in, and be aware of options such as micro-climate control, zoned areas, and relocations to better areas. These ideas are only developed through a trained workforce.

Part V of the Declaration states that standards and best practices documents are a tool for establishing, monitoring and maintaining preservation environment parameters. For example, The Museum Support Center was built as a state-of-the-art museum storage facility and promoted to Congress as a new museum standard, exemplifying the best practices known in the 1970's and 1980's. Part VI promotes risk management models as very important to developing preservation environment parameters. And Part VII of the Declaration establishes a default performance specification—a target for a conditioned environment in the absence of any other specification. In other words, if the collaboration, training, and discussion have not occurred then, at the very least, a conditioned environment is prescribed.

Part VIII says that the preservation environment is dependent on sustainability activities and vice versa. The Institution should seek to develop successful examples of systems that promote energy conservation *and* optimize preservation environments.

Smithsonian Institution Tools and Models for Successful Collaboration

Moderator: Michael Carrancho, Associate Director, Office of Engineering Design and Construction

In this section, three speakers describe current tools for managing preservation environments, and two speakers present case studies of models for success.

Part 1. What Smithsonian tools exist to assist the museum and facilities professionals achieve and maintain the desired outcome of an established environment?

Paul Drake: SI Explorer 2.0 and Collections Space Database

Paul Drake, Technical Services Division of the Office of Engineering, Design and Construction (OEDC), demonstrates the capabilities of SI Explorer 2.0, a web-based floor plan and space viewer, and the Collections Space Database, a pan-Institutional collections space management program.

SI Explorer 2.0 enables viewing Smithsonian facilities in a geo-spatial sense. The audience was shown the nuts and bolts of running the SI Explorer 2.0 web application.

The Collections Space Database is an evolving tool designed to help assess conditions of an individual space, or a room's suitability to house a particular item or collection. The database committee established five major condition factor categories: Construction, Envelope Integrity, Envelope Hazards, Envelope Systems, and Environment; and three minor condition factor categories: Storage Equipment, Safety, and Security.

Data collection efforts are shared by collection managers and OFEO staff, as well as safety and security professionals of the Institution. One of the challenges in maintaining the collections space dataset is that collections are often mobile—they may be in various stages of conservation and/or exhibition, making some spaces dual purpose or transient in nature. Exhibition spaces are excluded from the dataset, but conservation labs and work rooms are included.

Many factors are involved in space considerations where a collection may be priceless, be irreplaceable, have inherent hazards, have special handling standards, have special storage requirements, or need additional conservation. In terms of how the database works, each collection manager receives a report that shows the condition of their respective spaces, broken down by the five major condition factor categories with an overall condition score using "traffic signal" methodology of red, yellow or green. Storage density and space utilization are also reported.

- A condition of Red indicates there may be a significant issue that needs to be addressed.
- A condition of Yellow indicates there may be minor impacts that caution the use of the space.
- A condition of Green signals there are no apparent concerns for this area.

The Environmental Factor Report that each collection manager receives for their respective spaces takes into account normalized conditions, temperature controls, humidity controls, lighting controls, and special environmental requirements. The dataset is a tool that provides management with a clearer picture and better understanding of collections space, and helps them answer three critical questions:

- Is the space ADEQUATE for the use intended?
- Is the space RELEVANT to the needs of the collection?
- Is the space USEFUL in meeting the goals of the Institution?

Paul Tintle: OFMR/System Engineering Division monitoring reports and automated systems

Paul Tintle, Office of Facilities Maintenance and Reliability (OFMR), discusses the capabilities to monitor and troubleshoot environmental conditions within the Institution's facilities.

Both labs and museums have 24/7 operations and it is necessary to maintain space conditions at all times with the consequence of high energy usage. The difference lies in their missions—labs focus on the safety of workers in the labs and the surrounding spaces while museums focus on the safety of collections. Preservation is the guiding philosophy of museums.

The Smithsonian has two main partners in the area of Building Automation System (BAS) and data logger services. Siemens is the preferred BAS provider and Vaisala (formerly Veriteq) is the preferred data logger provider (accessed through ViewLinc software). The Smithsonian has approximately 80 data loggers in seven of its facilities.

Siemens has been associated with the Institution since 1987. Siemens' APOGEE system is very customizable—an important feature when your collections have special requirements or requirements that change over time because of exhibit or collection changes. While some applications can provide wireless sensing, OFMR generally uses Siemens in construction or renovation projects where the points or sensors are wired back to a Building Level Network field panel. At last count, there were nearly 41,000 points associated with 536 Siemens field panels at the Smithsonian, including the Zoo.

The Siemens network is monitored 24 hours a day, 7 days a week either by OFMR staff or by the OFEO Help staff. OFMR can set up prioritized alarming so that the appropriate people are notified in the event of a prolonged excursion of temperature or relative humidity, or if a critical fan or system is malfunctioning. Based on the criticality of the alarm or failure, OFMR uses its Computerized Maintenance Management System to create work orders to have the problem investigated and the system corrected. Such services can also be requested by calling OFEO Help at 3-1560.

OFMR also offers "trending services" that poll data in a requested area (if properly equipped) on a daily, weekly, or monthly basis, and generate reports that are emailed to the user. Services include setting up any trend interval, whether by change of value or time, and providing the raw data for any number of points in a single report. They are currently looking into ways to send data in graph form automatically. Not counting the data loggers, they are currently trending 13,795 points at the Smithsonian.

OFMR's Remote Notification application, RENO, allows users to be notified—either by email or voice mail—when a sensor fails or falls out of established parameters. RENO has an "escalation list" feature so that if the first person on the list fails to respond to the alarm within a set time, the next person on the escalation list is notified.

To improve system performance, OFMR often writes, diagnoses, or modifies the code that controls HVAC equipment. OFMR's Building Automation System (BAS) uses a Graphical User Interface to monitor alarms and building conditions. With over 3,100 graphics being used in the system, OFMR staff can "dig down" to the system level and see what each system in a building is doing.

When hard wiring a sensor is not feasible or when there is only a temporary need, Vaisala data loggers are used to monitor temperature and relative humidity. Vaisala loggers offer Ethernet Connectivity, long battery life, and extensive memory. They will hold up to a year and a half of both temperature and relative humidity data if samples are taken every hour. ViewLinc software is used to access the Veriteq/Vaisala data loggers. The application allows monitoring in real time and points can be set up to provide visual and/or email alarm notification.

With respect to energy consumption, being more eco-conscious is the right thing to do, but it is also good to increase cost avoidance so that the Institution has more money for other projects. The Smithsonian abides by the spirit of the Energy Independence and Security Act of 2007, which requires Federal agencies to reduce energy intensity 30 percent by 2015, compared to a FY 2003 baseline, as well as reduce water intensity and achieve other sustainability goals. While the Institution is diligently trying to be a good conservator of its resources, it may fall short of the 30% reduction mark in the interest of collections needs. Ultimately, the goal is to become more efficient than it has been, and the Institution has been able to reduce its energy intensity by 8.7% overall as compared to 2003.

Executive Order 13514 requires agencies to measure, manage and reduce greenhouse gas emissions, as well as improve water efficiency and increase the amount of recycling. Projected benefits include cost savings through energy reduction and avoided costs from improved efficiency.

At the Institution level, SD 422, Sustainable Design of Smithsonian Facilities, affirms the Institution's commitment to responsible stewardship through consideration of the environment in its facilities operations. The intent of this directive is to ensure that sustainable design is integrated into existing buildings and exhibit design, new construction, and building operations and maintenance processes so that Smithsonian facilities are eligible for LEED certification. The ultimate goal is more efficient operation of all facilities including offices, service areas, and collection areas.

Facilities staff have been working on communication skills, learning to speak and hopefully become fluent in the language of the conservator. They hope to continue the dialogue and try new approaches together, such as night setbacks for temperature, ventilation based on CO_2 levels rather than a constant volume, reduced lighting when an exhibit space has no one in it, and using LED lighting instead of the more conventional methods, knowing that any approach will be taken with the safety of the collections in mind. In the end, facilities and conservation are working toward the same goal—preservation of our nation's most precious treasures that have been placed in our care.

Paula DePriest: Museum Conservation Institute services and specialized equipment

Three types of work are performed by the Museum Conservation Institute (MCI):

- Conservation hands-on treatment to assist any of the Smithsonian museums, research centers or collections;
- Technical studies using MCI's sophisticated instrumentation to develop new information about objects and provide a context for their understanding (whether for scholarship or exhibit); and
- Application of scientific research to design guidelines for museum environments.

MCI is synonymous with the temperature and humidity debate because of the work of MCI scientist Marion Mecklenburg. His early 1990's book, *Art in Transit,* was a ground-breaking study that looked at the shipping conditions for moving art. He and his collaborators were concerned about panel paintings and other very sensitive and precious artworks. They moved forward from the transit area to the HVAC retrofit area and this informed the ASHRAE Supplement, which became the guidelines—the default standards—discussed earlier.

DePriest used a picture of Mecklenburg's lab to show the tensile testers, humidity chambers, and fatigue stressing equipment that he used for studying dimensional responses to changes in relative temperature and humidity. Mecklenburg, using that very equipment, looked at the components that would be in a painting and found that the high glue sizing responded differently to humidity than all of the other components. DePriest then used a chart to show the area above 70% relative humidity where the glue becomes softened, and how at that stage there is flaking of the component.

Mecklenburg defined a safe zone and within that he defined parameters that he graphically represented across a number of different factors – he put the "bounce" on the relative humidity (45°+/- 8°) that we currently use as a default setting. He also expressed this in a psychometric chart with the original Smithsonian settings of 50° +/- 5°. Mecklenburg expanded that to the 45°+/- 8° and 70°+/- 4° that have been discussed in this Summit. Now, the community is really discussing a wider range. So, even Mecklenburg's work was quite conservative.

Moving to the subject of monitoring, MCI has an ongoing project with the insect collection at Natural History. Monitoring showed that there was deviation out of the default setting for humidity and temperature in winter; however, by closing the doors on the cabinets they could affect the relative humidity inside the desired zone that was protective of the collections. The temperature, of course, remained the same inside and outside of the cabinets, but through monitoring MCI could reassure staff in the insect collection that the humidity controls they desired could be achieved in a simple way.

Besides humidification, MCI is currently working on violet light, normal light, and infrared light in museum environments. MCI's scientific equipment includes a microfadeometer, which tests fading of materials, LSac units that measure light levels, and a weatherometer, which can be used for accelerated aging under light, humidity, and temperature conditions.

Mecklenburg and his student Julio Del Hoyo worked on a project in the Lincoln Gallery of the Reynolds Center. They determined that they were within the cutoff point of 150 lux even with UV spikes in the middle of the day and the summer. However, they identified that accumulation over time needs to be looked at more closely, especially the times that lights are on and how that accumulates over the year. Even if it is only 35 lux in the room, there is brighter light in the spotted areas. Lighting design experts try to ensure that those spots don't get higher light than is allowed on those surfaces. The recent LED workshop looked at creative ways to protect the art, even while illuminating it for visitor comfort.

MCI also looks at chemical degradation including metal corrosion in sculpture, textile degradation, glass weeping and crizzling, polymer brittling, and rubber hardening and cracking. While they haven't done it yet, they could look at mineral dissolving. All of these are aging issues that involve an interaction with temperature, light, and relative humidity. A good example is the airplane recognition models falling off the wall at the Air and Space Museum, which MCI believes may be caused by the migration of triphenyl phosphates, the plasticizers, under these aging conditions. The industrial collections at both American History and Air and Space are a real problem, where untested materials often came right out of the production lines and there are many things that can happen to them.

Another area of MCI study is pollutants and toxins. On one project they are looking for the presence of arsenic and other substances once used to hold down insect collections that actually make the collections dangerous to people. One such substance is naphthalene and they are looking at procedures for airing out naphthalene.

MCI is very concerned about changes in environments. After super storm Sandy, MCI assisted the Martha Graham Dance Company, whose flooded basement was full of props and costumes for important American ballets such as Appalachian Spring. They had been floating for about a week, then drying out and were beginning to mold. MCI recommended an oxy treatment to suffocate insects and fungi and germicidal lights to reduce the spoil load.

In sum, MCI is one of the Smithsonian's central organizations that is ready to help in any way it can, whether through consultation, finding the right people, providing assistance directly, or providing information in publications.

Part 2. What models exist at the Smithsonian that highlight collaborative work for establishing environment in exhibition space design and preparation, and new long-term storage spaces?

Andy Smith – Donald W. Reynolds Center case study

> ***This case study concerns the museum environment around the Nam June Paik exhibit* Megatron *at the Smithsonian American Art Museum (SAAM).***

Staff from SAAM approached Smith, the OFMR Zone Manager at the Reynolds Center, saying that the room was extremely hot. Smith responded that there were 214 TV's in a 15 x 20 sq. ft. room—it was going to be warm. But there were greater problems—TV units in the exhibit were failing and there were crazy temperature and humidity swings. In addition, some spaces across from the *Megatron* room were freezing cold. Again, Smith pointed out that with 214 units, the system was doing what it could. The two sides went back and forth with SAAM insisting there was a problem that needed OFMR's help.

Following his code of practice, Smith asked OFMR to look at the building automation system (BAS) and was told that it was working fine. There are differences in orientation that lend to misunderstanding—while collections people look at space conditions, facilities people look at conditions from the return temperatures and humidities. In other words, sensors on the data logger units sense the air and temperature that are returned back from areas that are often very large, and that is not necessarily what the space conditions are. It is a challenge. The two sides continued to parry back and forth for many months with OFMR saying it was SAAM's problem of having too many TV's in a display that has too much heat load for what facilities can do, and SAAM saying, no; we need you to do something.

Part of the difficulty was poor communication—at first primarily via email—and lack of trust. The two sides started making some progress when they sat down in the same room and talked about the situation and possible fixes. Some problems take more than phone calls and tickets sent to the Help Center—they need "face to face" contact. Without good communication you can never get to the point of understanding the situation from a collections point of view as well as the limitations that facilities people face.

The *Megatron* exhibit is in one corner of the room but the air handler serves multiple areas. So, there is a huge heat load in a very small area, but the data logger unit gets return temperatures and humidities from other areas of that corridor of the building. When the return information from cold and more humid areas combines with that dry and hotter area, the system says "everything's fine" but of course it is not fine. This characteristic is seen in many Smithsonian locations.

The historic Patent Office Building had been through a major renovation and they had to be very mindful of where to put ductwork, return grills, etc. When the Art Tec engineers built the spaces they tried to do as little damage as possible. Unfortunately, in this particular case it meant that three of the four return registers were directly behind the TV wall with its 214 units producing a tremendous amount of heat. Due to the placement of the return vents, and with the data loggers in other spaces of the area, they got readings of low humidity and high temperature when they walked into the space with handhelds, but the BAS readings were okay. When the display was turned off, the temperature and humidity levels normalized, so they knew the TV's were causing the problem but they did not have a plan as to how to fix it.

The two parties began to discuss possible solutions. The suggestion to move the exhibit out of that space did not go over well with SAAM staff. Another approach to "throw money at it" with installation of more ductwork and an additional cooling unit was not optimal. Then, one engineering tech came up with the idea of putting in sensors that give a climate reading for that particular zone or space and then using those readings to control the discharge set points. This approach will not work in every case because the units in most museums do not serve single areas; rather, they serve multiple spaces, so anything you do to one space will affect another. However, in the *Megatron* case, considering all other options, they decided to install the sensors in the TV wall.

The solution worked to the extent that the temperature was better in the other spaces and they did not have frozen visitors, but there was still a problem with possible static issues and high temperatures that were the main cause of the TV units burning out. They needed to find a way to get cooler air from the other locations behind the very hot units. So, they installed very low tech (but very effective) grates below the exhibit. They then installed small in-line fans and space temperature and humidity sensors. They used the controlled space temperature and humidity readings to reset the discharge set points. The fix came in at under $2,000 with some of the earlier cost estimates in excess of $25,000.

The “fancy” solution is a Home Depot five-inch duct with an in-line fan that runs off 120v. There are five of them installed behind the grills underneath the wall. They draw cooler air from the adjacent spaces and force it up through the back of the TV's where the heat is generated. That accomplishes two things—cooling the TVs, which has prevented more failures; and providing a better mix of air across the different areas. The end result was reduction of excessive heat behind the displays by over 14°, elimination of heat-related failures, preservation of collections by stabilizing both temperature and humidity, and savings of over $20,000 in possible costs.

Smith credits the persistence of SAAM curators, registrars and collections managers. Despite thinking that facilities management should always takes the lead, there is much to be learned from collections staff. Collaboration between the two groups was most important, sitting down face-to-face and together coming up with a solution that would work. The physical work was done with a combination of the skills sets of the exhibits and facilities staff.

If a problem is bigger than can be handled in a museum’s immediate building or zone, the IFT (Integrated Facilities Team) groups mentioned in the Declaration are available as a tool to solve problems. Contact with the IFT groups can be made through the building or zone manager.

Kendra Gastright – Leased Facilities Case Study

Kendra Gastright, Director of the Office of Facilities Maintenance and Reliability’s (OFMR), presents a case study on leased facilities.

Not everything is so simple if you are in a leased facility, where there are no tools or building management staff to turn to, no zone manager, and just a random phone number that you are supposed to call when you have a problem.

In general, the Smithsonian is moving toward the norm that collections should NOT be in leased facilities. However, the reality is that the Institution does have collections in leased facilities, either for a short period or accidentally over time.

The Smithsonian has a robust lease portfolio. Looking at the weekly report on the portfolio, it may come as a surprise to see what is considered “general office space” and what is *not* considered “museum” and/or “specialty” space. The report shows that SI collecting units are in office spaces. The units have perhaps augmented these leased spaces with specialized security and a BAS system to monitor temperature and humidity. They may have installed a Liebert, but that is the extent of the specialized equipment; there is not anything really robust.

When thinking of using a lease, it is important to talk to the person who is developing the lease and make sure that it will take care of what is going to be in the space. In this case study, that was not done from the get-go, despite all good intentions.

The Archives of American Art (AAA) in New York was in multiple buildings at a very high cost. Unable to sustain these high cost leases, AAA came to OFEO Real Estate for a solution. AAA tried to state all of its needs and what its requirements were, and told OFEO that it would store archival papers in the space intermittently. OFEO was able to secure a better lease that could be sustained by AAA at Park Avenue South. This is an example of the client discussing what it needed but not necessarily asking the right questions such as what the temperature and humidity is in the space—if it is only office level temperature and humidity, it may need something to boost that in the summer months. As it was, OFEO Real Estate agreed to help AAA get specialized equipment installed and AAA walked away happy.

Part of the problem in a leased facility is that you cannot walk up and find a facilities manager who can take care of things for you. In general, lease agreements are written in such a way that they are a bureaucratic nightmare when something needs to be tweaked. What happened at Park Avenue South was that a Liebert unit—the specialized equipment that was needed—was installed as agreed upon. However, Gastright received a phone call from AAA saying that it was not turned on. It was sitting there and not doing anything.

While that would seem to be an easy fix, it was not so easy because it was not the building owner's Liebert unit. There was no agreement for the care of that Liebert unit and no arrangement to deal with the fact that it was not working. Even though it seemed to be something as simple as touching the ON switch, the owner of the building was not willing to go in and touch that equipment because it was under warranty and doing so could void the warranty. To check on it, Gastright had to send OFMR staff to see if it was turned on. Because the lease was written without the Liebert in place, it meant extra work for the Real Estate unit and for whoever might care for the facilities.

In general, collections should not be in leased facilities because they need specialized care; however, when leased space is necessary, collections staff need to follow up and make sure that the care they need is in place through the lease agreement. They need to communicate *full service* to the Real Estate unit. This means the expectation that there will be a facilities person who can provide what is needed, or if not, a phone number to call. Collections staff should be able to rest assured that something as simple as investigating a temperature and humidity request can be taken care of in an acceptable time frame. But it has to be written into the lease and there has to be an understanding that a new requirement is beyond a standard office lease.

In the AAA case study the Liebert unit was installed and was not working. No one owned the paperwork for the warranty, which would normally be in a Smithsonian facilities office; however, there is no SI facilities presence for AAA in New York. The problem sounds simple yet it took from November when AAA asked, "Why is my Liebert not working?" until the end of March to get the warranty in place and get service to the Liebert unit. All of the negotiation that took place during that time needs to happen on the front end and be understood at the outset.

When the time comes for collecting units to renegotiate their lease or talk about whether to lease space in the first place, their first consideration should be how *not* to be in a leased facility. After that, they should ask what tools are in place that will allow for care of the collection just as if it were in Smithsonian property.

Collecting units need to be very clear about what their needs are. In most cases when the OFEO Real Estate unit negotiates a lease it is looking for the lowest possible cost out the door. However, adding retrofits or installing a Building Automation System (which will be ripped out when the SI unit moves out of that facility) is not a cost-effective solution. Further, the responsiveness of a leased facility is just not the same as an owned facility.

Panel | Tools and Models

Moderator: Michael Carrancho

Panelists: Paul Drake, Paul Tintle, Paula DePriest, Andy Smith, Kendra Gastright

> *Carrancho: Is the collections space data viewable through SI Explorer 2.0 and if not are there any future plans to make it available?*

Drake: Collections space data is currently not available through the viewer. The development life-cycle of the SI Explorer application is at its end and he is not aware of any future plans to include that.

> *Carrancho: What effects did the August 2011 earthquake have on mechanical systems at our various facilities, and were the monitoring capabilities helpful in troubleshooting and coping with the aftermath?*

Tintle: The BAS systems fared remarkably well, with the exception of one at MSC where the buildings actually shifted, causing a break in the communication line that goes from panel to panel. That was difficult to find because it was behind a wall and behind an electrical box, but for the most part we did really well and were able to keep an eye on all of the collections. Once we found that one wire that was broken we replaced the wire and everything was back up to normal.

> *Carrancho: How do you and OFMR coordinate and team with your various equipment and expertise on troubleshooting and dealing with room environment issues?*

DePriest: The most important thing is to know people—to have a personal relationship and be in the same room with them. MCI benefited from Marion Mecklenburg knowing many people at OFEO, and over the years they established a group of people in facilities that they could contact when they saw an issue. For example, when they started the insect study, Marion called Paul Tintle and Paul was on-site with them when they did the walk-through the first time and put in the monitoring devices.

The more people MCI knows, the better it is able to put together groups around room environment issues. MCI has a coordinating role—it can listen to questions that collections people don't know how or who to ask and communicate that to OFEO so that all are on the same page. Better coordination is needed between MCI and OFEO with respect to instrumentation and services; for example MCI needs to be running the same monitoring system. MCI can assist the units with reading and monitoring environmental data together with OFEO, which has the expertise on how to reset the systems and make adjustments.

> *Carrancho: What is the best advice you could give both facilities and collections staff on resolving environmental problems in their spaces?*

Smith: Building management should be the first point of contact. Each building has a building manager or zone manager associated with it and hopefully they are doing their job you know who that person is. If you are not getting the response you need from the zone manager, the next step is contacting OFEO HELP at #3-1560, which is available 24 hours/day to respond to emergencies.

Gastright: If you are in a leased facility and don't have an OFEO building manager to call upon, you can still start your question at OFEO HELP.

DePriest: For collections management and conservation staff, an important tool is to meet the people who are coming on-site to do work, such as building engineers, and develop a relationship with them. Also, educate yourselves about the systems capabilities and understand what you can reasonably ask for and what can reasonably be done.

Carrancho: With respect to the Reynolds case study and the back and forth via email where they were conversing but not communicating: How long did it take to realize that was not working and decide to sit down face-to-face?

Smith: It took longer than it should have—months of emails saying, "This space is hot," and sending engineers to look at it who would respond that it was okay or that it was hot and they would make some adjustments. Nothing was resolved until they got together and started talking about what the problem really was. If you have a recurring problem with your collections space or office environment, emails should be discontinued and a conversation needs to take place about what is really happening.

Carrancho: What was the hardest aspect of solving the problem presented in the Reynolds case study, since it was a combination of exhibit and facility challenges?

Smith: The hardest aspect was the different orientations as to whose problem it was. His initial reaction was that it was SAAM's problem since it was putting an exhibit in a space that was creating a tremendous amount of heat that was more than the system could handle. OFMR's concern was the overall building condition, not necessarily an individual space's condition. Looking back, that was not the correct approach. It is easier to say "it is your problem" in an email than when you sit across the table from someone and get to know them. After they got together, had some conversations and better understood the situation they could say 'how can we fix it together?'

Carrancho: What is the biggest challenge facing the Institution with regard to leased spaces meeting Smithsonian environmental requirements?

Gastright: The biggest challenge is that most leased spaces are not outfitted—they are mostly for general office use. As such, they are not appropriate for collections storage. The solution is to get the Smithsonian out of leased facilities for collections within the next 5 to 10 years.

Carrancho: How do you get access to the collections space information and how do you add to or correct existing information? Please explain the updating process and procedures and what kind of cycle that is on.

Drake: Email him for the collections space data at drakep@si.edu—that information is not available through the SI Explorer web application. The update cycle was originally quarterly and is now done on an annual basis. Each space is broken down by unit, then by facility, so each collection manager receives a report broken into different configurations. Managers receive the report in PDF format as well as data format that they can use to make updates. These are sent back to Drake and initiate a conversation about the additions, deletions or any other corrections to the dataset.

Carrancho: Please comment on any issues with monitoring room environment through the OFMR systems versus in-room monitoring.

Tintle: With respect to the Reynolds case study, they are not doing a good job of determining that monitoring is being done where it needs to be done. OFMR systems control to readings that come back, which requires a central location, usually in the ductwork, and that does not necessarily tell you what is happening in the spaces. He is trying to address that through the SD 410 process. In-room monitoring is more expensive because of the sensing and wiring involved, but it is a better indicator of what is going on in the space. It is easier to control what is happening in the spaces when monitoring is done in the places where the collections actually are.

One of the benefits of the data logger systems is that they do not control the building automation system (BAS), which is for monitoring purposes only. OFMR is trying to figure out a good, economical way to do both. They are exploring CO_2 sensing rather than ventilating outside air all the time. When you bring in outside air you have to re-condition it with heating, cooling, re-humidifying, and de-humidifying. They are looking at the need in the space—if nobody is there, you don't necessarily need to ventilate as much. It is collections driven; they want to do what is best for the collections with respect to temperature and relative humidity, and would like to do it at the exhibit level rather than the duct level.

Audience question: In this building (the POB) they use Hanwell sensors. Is there a way to tie the BAS to the Hanwell system?

Tintle: Vaisala is the preferred system and at this point it is not tied in to the BAS. However, any opportunity to marry the two and be able to control based on actual room condition is desirable. He would be more than willing to talk about it and have an advocate at the museum level.

Andy Smith: In this building they have been provided access to monitor through the Hanwell system. While that does not necessarily change how they control conditions, it does give them good information to back-check against what they are seeing on the BAS. For example, when the engineers are looking at a problem, they have the Hanwell space readings and can compare them against the BAS to get down to the time of day that the problem happened.

Debbie Smith, OFEO Real Estate: In fall 2012, the Capital Planning Board, OFEO and other parties instituted real estate points of contact within each individual unit. The real estate points of contact are typically directors, associate directors, financial managers, or others that are knowledgeable of both the leasing transactions within their own unit portfolio and the funding requirements. Any questions should go first to the unit point of contact and then to OFEO Real Estate for discussion. There is a “critical path chart” with leases; for example:

- It could be the responsibility of the tenant to not only correct any problems but to go further in tenant improvements.
- It could be something that falls under the scope of the existing agreement with the landlord.

- It could be something that needs to be negotiated; for example if it is a long-term lease and they are transacting the improvement and then negotiating that within the rent.
- It could be something else that requires a specialty negotiation process.

The lease lingo in certain markets is "all expenses are passed on to the tenant," while in many situations the landlord does not want to monitor a collections environment on a 24/7 basis. Collections more appropriately belong in owned facilities versus leased facilities.

> *Audience question: SI Explorer 2.0 is an incredibly powerful system. Is the GIS mapping actually satellite mapping and updated in real time? Also, is the system layered with OPS data to determine immediate environmental threats or disaster scenarios?*

Drake: SI Explorer 2.0 is currently not a real-time system. It is not integrated with OPS at this time with respect to emergency scenarios. The facility information is updated in the geo-spatial database as well as the facility centers on a monthly cycle.

> *Audience question: In his case study he mentioned that one of the responses during the email communication phase was, "Well, you put something in that space that it wasn't designed to accommodate." As we think about communication and collaboration, at what point would you have wanted to be involved in the exhibition concept development cycle, or otherwise at what point would you have wanted to be involved?*

Smith: That question comes up often and the answer is "as early as possible, and certainly before the point where a final decision has been made." While the *Megatron* exhibit had temperature and humidity implications, there are many other implications in exhibit installation that OFEO can help with such as power issues, particularly with interactive exhibits, and egress and safety issues. Smith has been involved with exhibit change-outs where they talked with the exhibit designers about what could make the project go smoother, for example simply moving a temporary wall avoided egress lamping, exhibit exit sign, and smoke detector issues.

Paula DePriest: It is not only exhibits—MCI's zone and building managers have asked to be informed before MCI purchases heat-generating, power using equipment for exactly the same reason.

> *Audience question: How do the number and placement of the data loggers get determined?*

Tintle: The biggest consideration for a data logger that ties into the data logger system is whether OFMR can run an ethernet drop. There is a wireless communication between the module and the sensor itself. In older buildings such as POB there is an issue getting through the thick walls but in most other facilities the walls aren't nearly as dense. The number of data loggers depends on customer demand. They have some in-stock and can always order more, so it depends on how many data loggers the unit needs to cover its space and how many it is willing to buy. Because of the Ethernet there is no issue with quantity.

Audience question: How do you balance the seemingly contradictory imperatives to do more sophisticated, interactive things that use more power and at the same time cut down on electricity, save emissions, etc.?

Smith: We will always have to walk a fine line, but in the end we have to give the visitors what they want—it is why we are here, to diffuse knowledge. At the same time we are mindful of sustainability with the types of displays used, use of low-energy consumption units, etc.

Gastright: There are ways to balance the two. Many of the new exhibits draw more power than the original displays due to the lighting alone or interactive modules. However, energy use overall at the Smithsonian has dropped since 2005. This is due to working together and making changes in operations that make energy-efficient sense; for example, having the "Marion Mecklenburg band" in administrative areas and getting used to wearing a sweater in the winter. Looking at the color quality of LED lights in displays has also helped drop energy use. There are now more power receptacles and we are plugging in more, but at the same time we are getting smarter and using more energy-efficient products. Even though energy-efficient products have higher costs initially, we need to look at the life-cycle cost and energy use anytime we are considering a new display or anything else in a building.

Smith: Expanding the "box" of acceptable ranges is going to reduce the huge energy consumption from running the chillers and boilers. This will of course require conversations with unit management on what their collections can tolerate.

Afternoon Working Group Report-outs and Conclusions

Group 1—Environment and Collections Preservation: Sarah Stauderman, SIA, and Kathy Makos, OSHEM

The Declaration is going to be very useful to all endeavors on all sides of the isle. It is *not* a rigid standard yet, nor a regulation; rather it is a work in progress that is going to challenge the community to continue to find best practices and ways.

A major strength of the Declaration is that it adds to the design and construction SOW's (Statement of Work). Also, giving the document to upper management will highlight the importance of the preservation environment when it comes to budget and management support. Another positive is the emphasis on collaboration.

The Declaration gives all stakeholders a common foundation of "what to talk about." It enables a systematic process, making work easier by providing a checklist for collection use particularly, but also for OFEO to be able to address these issues in a systematic fashion across the board.

With respect to making the Declaration better, stronger, or more meaningful, it is important to add pests as an external factor to a policy document.

Going forward, each of the factors should have a working group that will 1. expand the definitions of each of those areas; 2. begin to develop standard procedures, tools or checklists for establishing the parameters for each of the factors; and 3. provide education at the unit level.

Another task will be to identify where in the document to put the "outliers" such as what happens in an emergency and what happens in an external loan situation, and how these should be addressed in a policy document.

There is a strong sense that more research by conservation scientists is needed so that there are better tools at our disposal and research-based information for decision making.

Also going forward, the document needs both an index and definitions; for example, what is meant by "unit"? Are we talking about divisions? Collecting units? Finally, the type of meeting that we had today as well as other training meetings and collaborations need to be encouraged and occur more frequently or regularly.

Group 2—Collaboration with Diverse Professional Specialists: Michael Carrancho, OFEO

The Declaration creates a framework for discussion at a high level—it is a single document that is flexible and inclusive and where all stakeholders can start to develop a common language to discuss these topics.

Several people in the group did not know what an IFT is or what its functions are—there needs to be more education on IFTs and other groups or organizations mentioned in the document.

There needs to be more discussion about accountability. In general, accountability tended to fall to the units and there should be more consideration of shared responsibility. For example, the document says that unit directors are responsible for maintaining and controlling temperature and humidity, but that is also an OFEO issue.

While the document is flexible and inclusive, it lacks detail and an implementation plan; as one person said, "Here's a good idea, but not a lot of discipline or structure on how to go about doing it." The Declaration needs a glossary of terms. It is a good start and a place to begin to develop a common language but more definitional work is needed on both the facilities and collections sides.

A gap is the lack of discussion regarding contingency operations. For example, how does collaboration happen in advance of an event like Hurricane Sandy? More work is needed on defining collaboration and communication before, during and after an event. And more research is needed on how to bring a building back on-line after being off two or three days and what are the impacts on collections.

There is a need for regular meetings, for example having a large meeting once a year, quarterly meetings at a lower level, and annual reports to keep abreast of what the different groups, museums and collecting units are experiencing.

More resources are needed to attend such meetings as this one. Concerns are how to charge time for attending these meetings and coverage in your absence. Other resource issues are training and additional staff.

There are three types of training: continuing education, cross-training, and advanced training. Add something to the Declaration highlighting the importance of continuing education both for facilities and collections staff. While engineers and architects have requirements to stay current, collections staff do not have the same requirement.

Emphasize the benefit of cross-training—collections staff teaching facilities staff about collections and how they respond to the environment, and facilities staff teaching collections staff about mechanical systems and how building elements work. One person said that if facilities staff explain what the limitations of a HVAC system are, how the feedback mechanism works, and how the system controls temperature and humidity to collections staff, that will help them understand what the mechanical system is trying to do. And if facilities staff understand how collections respond to those environments, that will help them understand the parameters that we are trying to maintain and why.

Finally, advocate for training to advance knowledge in the respective disciplines. For example, a technician knows how a system works but may not know the theory and science behind how temperature and humidity interact and what happens to humidity when the temperature drops or rises.

Group 3—Monitoring, Data Collection, and Data Interpretation: Paul Tintle, OFEO

A strong point of the Declaration is its emphasis on collaborative discussion. This aspect is refreshing as it is something they have been trying to do. Another strength is identification of who the responsible parties are and the role of the IFTs (Integrated Facilities Teams).

The Declaration is a tool. It permits us to be more proactive, especially when talking about leased facilities. It uses common language that can be understood no matter who is reading it; for example we can hand it over to someone managing a leased facility and say, "These are our requirements."

There needs to be more in the document about how to interpret the data; in other words, we collect data from different facilities and areas but then what do we do with that data? How do we interpret the data in support of decisions we have to make?

A weakness of the Declaration is vague language, in particular with respect to roles and stakeholders. It is unclear who exactly 'stakeholders' refers to. (One participant said, "the ultimate stakeholder is the collection itself.") In other words, the collection can't speak for itself, so we have to do the 'speaking' for it—we have to be able to interpret what its needs are and assure they are being met.

Integrated pest management (IPM) was missed completely and should be included.

A glossary is needed. In particular, sustainability and sustainable environments need to be defined.

Top-down delegation for adoption of the Declaration and its implementation are necessary. Clearly there is support at the top from Dr. Clough and senior managers such as Scott Miller and from the "people down here," but there is a gap in the middle. Some have supervisors and bosses who are very supportive of training and collaborative efforts such as this.

A solution with respect to monitoring is to establish the methodology for where and how to collect data. Questions to be answered include: Are we collecting data from the ductwork or from the rooms? How do we situate the sensors where we are trying to collect data? And as mentioned above, how do we interpret the data once it has been collected?

Echoing the other groups, there is a gap in stating the need for more education.

Group 4—Risk Management: Cathy Hawks, NMNH

Smithsonian unit directors should make decisions about risk based on consistent and verifiable data. The Smithsonian should establish holistic, quantitative risk assessment and risk management methodologies, as well as provide resources, including professional staff, required for implementation. The Declaration should explicitly state that the Smithsonian recognizes the role of environmental risks in preservation of collections and actively manages environments to promote preservation.

There is a need for definitions. Tweak the wording of the risk management section to take the onus for risk management off of collections managers and put it back into a collaborative context.

With respect to implementation, first define and assign roles and responsibilities for risk management. Second, develop a working group to assess the extant risk assessment methodologies and training. Third, develop a comprehensive training program in risk assessment and management for all staff tiered to their roles and responsibilities.

Group 5—Performance Specifications: David Hauk, OFEO

The Declaration is useful. With regard to performance specifications, it is important to realize the constraints related to particular buildings; for example, preservation environment criteria may have an impact on historic building fabric.

Conservators, building operators and other stakeholders do not necessarily understand what the others do. This can be addressed with cross-training and other training recommendations mentioned by the other groups.

A concern is that a default standard might discourage people from careful evaluation and creativity in meeting requirements of the collections. There should be greater emphasis on the process to follow when we see requirements or needs that fall outside of those defaults. Both lighting and contaminant preservation standards in that section of the document need to be strengthened. Also, the default standards should require periodic review.

Due to resource constraints, we need to consider the practicality of supporting the maintenance of the preservation standards. For example, in the collaboration area, the requirement for each collecting unit to annually review standards with the participation of stakeholders would involve staff from many different units—not all of those units would be staffed or able to fully participate in the annual reviews.

The default conditions should acknowledge micro-climates and how those fit within a space that may otherwise be operated under defaults. The Smithsonian should look at the overall building inventory and the different capabilities and collection environments that currently exist, then consider moving collections from one place to another if it is determined that environments are more suitable.

Training will be needed on the new Declaration. Perhaps what is needed is a new unit and/or resources dedicated to maintaining preservation environment standards.

> *The audience was asked to vote on the Declaration. The vast majority of the audience indicated, by show of hands, overwhelming support for the Declaration "with its promised new iteration" (the suggestions everyone heard from the groups.)*

Q&A and Discussion

> *Audience question: Will the Declaration continue to be a guidance document as it develops and as more tools are added to the toolkit, or is the ultimate goal to develop a substantial document similar to the PAS 198 that other museums can use as a model?*

Stauderman: It is going to be multi-phased. The first thing is to get a document that people more or less agree on for delivery as the Declaration and then move that document into policy. After that, the intention is to develop more specific, technical documents similar to what the PAS has incorporated into it. Even though the process will never be completely done due to the evolving nature of our understanding and changing situations, the Smithsonian *needs* to have a policy on preservation environment.

Audience question: What are data metrics for collections preservation and risk management? Libraries and archives have metrics for circulation statistics such as number of items pulled for researchers – can that be applied to other kinds of collections? The audience member was particularly interested in the possibility of an anthropological/behavior study of circulation and staff use of collections including "time out of storage" such as long-term excursions from storage areas into labs, research reading rooms, etc., and the impact on collections. This might be accomplished with statistical data mining of existing sources in the museum.

Stauderman: I like the idea of using fellows or other people to test the "time out of storage" concept if that area of research is established as a priority. The Working Group had discussed not just cross-training but detailing staff to different areas to learn more. At the unit level, they hope to provide the tools necessary to make decisions about appropriate uses for their collections. It would be good to have metrics for the amount of time things sit out in a hallway, but latitude must be given to collections people and researchers because there may be a good reason why things don't automatically go back into storage.

Audience member: There has been talk about the building envelope and external environment, but the Declaration does not provide for emergencies related to climate change. We need to consider that there is a good chance that the external environment will not be constant, and that there is an increased risk of more frequent storms, variations in temperature, flooding, etc. There are real costs associated with climate change. The Declaration should include a statement to the effect of "We recognize that climate change will impact our resources to protect the collections over the next 100 years."

Email question: Has SI started to re-think its policies for emergency response after Hurricane Sandy, and how does the Institution plan to deal with underground collections storage given that sea levels might be rising?

Hauk: Executive Order #13514 mandates federal agencies to begin planning for climate change adaptation, as differentiated from mitigation. Many federal agencies have publicly released adaptation plans and the Smithsonian recently kicked off a team to do the same thing. The Institution has contacted other federal residents of the downtown DC area that share common risks related to storm water and weather and is reaching out to NASA, a major climate change modeling and research advisor, to help understand particular risks that could occur at SI locations.

Carrancho: The Federal Facilities Council is hosting a government-wide discussion on the resiliency of federal facilities in view of future climate change that OFEO staff will be attending.

Hauk: We need collections representation on the climate change adaptation planning team. There will be much work to understand the risks and the actions that we should take including funding estimates.

Audience member: The section on sustainability, which did not have a separate breakout group, needs fleshing out. The section seems to focus on energy reductions, but there are other things such as awareness of increasing energy needs that will be imposed on us by the changing environment. Perhaps another working group can be assembled to beef up and broaden that section to include best practices for collections control in terms of sustainability.

Stauderman: They can convene a group to spend an hour and a half looking directly at sustainability.

Tompkins: The Smithsonian can serve as a leader in this area with the Declaration, our best practices, and our approach to sustainability beyond just being energy-efficient and cost-saving. While museums are tackling this in Europe, SI could be at the forefront of establishing a movement among museums in the U.S.

Closing Remarks: Scott Miller and Nancy Bechtol

Scott Miller, Deputy Under Secretary for Collections and Interdisciplinary Support

The collaboration that took place throughout the Summit and the collections space planning process has really started to bring together the diverse expertise within the Smithsonian.

One of Miller's favorite phrases from the first day of the Summit is "encrusted precedents" —a reminder for the Smithsonian to rethink its own precedents, consider what is evidence based, and think out of the box going forward.

This is an ongoing process—no one should wait for a set of next steps coming from the Castle or the leadership group; rather, they should begin implementing the ideas they have heard here at their various units and in their own collaborative circles.

It is anticipated that highlights of the Summit will come out in a book, a website, or whatever reaches the broader community. The Smithsonian is positioned to take a leadership role in these areas in the same way as it has with respect to collections policy for federal scientific collections: During the last presidential administration, a presidential science advisor took a couple tours of SI collections. Discussions in those tours led to the creation of the Inter Agency Working Group on Scientific Collections (IWGSC). The IWGSC issued a report on the condition of federal scientific collections, and recommendations from the report ultimately were written into law in the America Competes Act. The President's Office of Science and Technology Policy then asked the IWGSC to implement certain recommendations, which was done through government inter-agency processes, and the result is a document that lays out the basic standards for collections policy for federal scientific collections that will be issued out of the White House. The set of standards is very heavily rooted in SD 600 as a model, and the work that the Smithsonian has put into these kinds of activities over the years.

Collections are central to Smithsonian operations and the work of the Summit serves to fulfill the promise that our collections hold. Summit organizers Bill Tompkins, Mary Rogers and Sarah Stauderman provided the conceptual framework that many other people have worked within.

Nancy Bechtol, Director, Office of Facilities Engineering and Operations

It has been wonderful to have two entire days to step outside of all of our work and be able to dialogue about this very important topic, not just within the Smithsonian Institution but with our entire profession. That, itself, is a best practice.

There is tremendous energy around this topic. On the first day at NMAI there wasn't a seat left in that auditorium, and "how fabulous was that!" Even with the second day being a Friday and only having Smithsonian staff present there is palpable energy in the room.

Bechtol enthusiastically supports and encourages taking a leadership role on this topic. The Institution has every type of collection as well as the facilities and research staff expertise to do the job.

Because the excitement and the energy are so great, the biggest challenge will be not marching out too fast. Everyone should take time in building the specifics because what they are doing has the potential of leading this profession for the next 50 years.

Appendix A: Invited Speaker and Presenter Biographies

Day 1 Invited Speakers

Stefan Michalski

Stefan Michalski is a Senior Conservation Scientist at the Canadian Conservation Institute. In 1989, he developed the CCI Light Damage slide rule, which was recently replaced by a Light Damage Calculator on the CCI web site. He provided all the colorant sensitivity tables used in publications on museum lighting from both the CIE and the Illuminating Engineers Society of North America.

In 1993 he published an article, "Relative humidity: A discussion of correct and incorrect values," which was recently selected for a book of selected historical readings in preventive conservation. In 1994, he coined the "nine agents of deterioration and stages of control," and initiated the CCI poster "Framework for Preservation of Museum Collections."

In 1999, he authored the section on humidity and temperature specifications in the Museums, Libraries, and Archives chapter of the ASHRAE Handbook. In 2000, he authored the CCI *Guidelines for Humidity and Temperature for Canadian Archives.*

Between 2003 and the present, in partnership with ICCROM and Instituut Collectie Nederland, he developed and taught at the three week course, Reducing Risks to Collections, which has been held in Ottawa, Rome, Sibiu, Beijing, Quito, and Istanbul. Currently he is finalizing a manual and a software tool for the risk assessment method developed during that partnership, and now used by CCI in its risk assessments.

In 2005, at the invitation of ICOM and UNESCO, he wrote the "Collection Preservation" chapter in *Running a museum: a practical handbook*, available now in five languages. Also in 2005, he received the Harley J. McKee Award from the Association for Preservation Technology International, given to "individuals who have made outstanding contributions to the field of preservation technology." This was primarily for work on minimizing humidity risks to the frequent combination of collection plus historic building. He was on the steering committee, as well as a contributing writer, for the British Standards document called PAS 198, published in 2012.

His primary foci now are two projects: A computerized prediction model for crack risk in a varied collection, and a book on the museum environment to be coauthored with Jim Druzik of the Getty Conservation Institute.

Robert Waller

Robert Waller is currently President and Senior Risk Analyst with Protect Heritage Corporation, a firm dedicated to helping institutions and organizations improve heritage management. His career includes 33 years with the Canadian Museum of Nature, serving as Chief of the Conservation Section and Managing Director of the Collection Services Division. Waller holds appointments as a Research Associate at the Canadian Museum of Nature and as adjunct professor in the Art Conservation Program at Queen's University. He holds a Ph. D. in Cultural Property Risk Analysis from Goteborg University and professional accreditation with the Canadian Association of Professional Conservators. His research interests center on risk analysis approaches to rational decision-making for collections management and preservation. Waller has taught, lectured, and served as a consultant at museums and universities throughout North America, Europe, Asia, Australia, and New Zealand. He is a fellow of the International Institute for Conservation and has recently received the Carolyn L. Rose Award for lifetime achievement from the Society for the Preservation of Natural History Collections.

Michael C. Henry

Michael C. Henry, PE, AIA is Principal Engineer/Architect with Watson & Henry Associates. For the past 27 years, he has specialized, nationally and internationally, in the preservation of historic buildings, in engineered stabilization of large artifacts, and in analysis and design of environments for cultural heritage collections. He is a registered Profession Engineer in New Jersey and several other states and is a registered Architect in New Jersey.

Henry received a Bachelor of Science in Mechanical Engineering from the University of Houston and a Master of Science in Engineering from the University of Pennsylvania. He is Adjunct Professor of Architecture in the graduate program in Historic Preservation at the University of Pennsylvania, and is a guest lecturer and independent study supervisor for the graduate program in Art Conservation at the University of Delaware/Winterthur. From 2005 to 2009, he taught Sustainable Strategies at the Centre for Sustainable Heritage at University College London, UK. In 2006, he received a Fulbright Distinguished Scholar award to teach and research on the topic of low energy collections environments in historic buildings. Henry has been an instructor and consultant for the Getty Conservation Institute in North Africa and Latin America.

His recent environmental management projects and consultations range from Ernest Hemingway's *Finca Vigia* near Havana, Cuba to the renovations of the subterranean archives at the Harriett Beecher Stowe Center in Hartford, Connecticut.

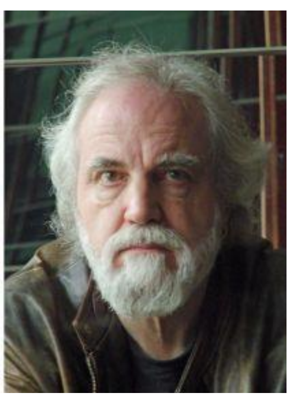
James M. Reilly

James M. Reilly is the founder and director of the Image Permanence Institute (IPI) at Rochester Institute of Technology in New York, a world leader in preservation research since 1985. He is well known for his own research on deterioration of 19th-century photographic prints. Under his guidance, IPI has made important contributions to image preservation, management of film archives, environmental monitoring and control, and sustainable preservation practice. He oversaw the creation of the Preservation Environment Monitor datalogger and Climate Notebook software, which were supported by the National Endowment for the Humanities, the Mellon Foundation, and the Institute of Museum and Library Services.

Reilly was Co-director, during its tenure, of the Advanced Residency Program in Photographic Conservation, a program co-managed by the George Eastman House International Museum of Photography and Film. He is the author of numerous publications, including *Care and Identification of 19th-Century Photographic Prints; New Tools for Preservation: Assessing Long-Term Environmental Effects on Library and Archives Collections; IPI Storage Guide for Acetate Film;* and *Storage Guide for Color Photographic Materials*.

Reilly is a consultant to many cultural institutions and is sought after worldwide as a teacher and seminar speaker. He is the recipient of many awards including an Academy Award for Technical Achievement in 1998.

Jonathan Ashley Smith



Jonathan Ashley Smith studied chemistry to the post-doctoral level at the Universities of Bristol and Cambridge. He joined the Victoria and Albert Museum (V&A) in 1973 as scientist and trainee conservator, becoming Head of Conservation in 1977. It will surprise no one who knows Jonathan to hear that he has played both Osama Bin Laden and Saddam Hussein in the annual V&A Christmas pantomimes.

In 1988, he became actively involved with the Royal College of Art/V&A postgraduate programme of training and research, and was Visiting Professor at the Royal College from 2000 to 2010. During that period he also served as Secretary-General of the International Institute for Conservation.

In 1994, Ashley Smith published *Let's be honest—realistic environmental parameters for loaned objects,* still an essential reading on the topic. That same year, he was awarded a Leverhulme Fellowship to study risk methodologies, resulting in the book *Risk Assessment for Object Conservation,* published in 1999. He has run risk assessment workshops for students and professionals throughout Europe as well as supervising research students in projects related to risk, ethics, and ethnography at a number of UK universities. In 2000, Ashley Smith received the prestigious Plowden medal for his contributions to the conservation profession.

Ashley Smith is now an independent teacher, researcher and consultant. He is currently serving as a "Work Package Leader" within the European Commission-funded research project "Climate for Culture," where his major focus is on damage functions that might help predict risks for collections in historic buildings in which environments may be affected by climate change. Jonathan recently co-organized the international conference "Climate for Collections: Standards and Uncertainties" with the Doerner Institut in Munich. In addition, he was a member of both the Steering Group and the Working Group for the 2012 publication, *British Publicly Available Standard 198: Specification for Managing Environmental Conditions for Cultural Collections*.

Fiona Cousins

Fiona Cousins is a mechanical engineer and sustainability consultant. She is a Principal with the firm Arup, since 1985. Cousins leads the sustainability team in Arup's New York office and is one of the leaders of the mechanical engineering team. She directs technical investments for Arup's Americas Region, and is a member of the Arup Americas Board.

Ms. Cousins has participated in design of museums including the High Museum of Art in Atlanta; the Jack S. Blanton Museum of Art in Austin; the Museum of Contemporary Art in San Diego; and others in the United States, the United Kingdom, and beyond.

Here in Washington, she recently served as Project Director and Project Manager for engineering on the Southwest Ecodistrict Initiative. For the Smithsonian, she provided a design for a new education center at the National Zoo.

Ms. Cousins has served as a board member of the U.S. Green Building Council since 2011. She has taught at Yale University and at Columbia University. She attended the University of Cambridge where she achieved a Masters degree in Interdisciplinary Design for the Built Environment.

Cecily Grzywacz

Cecily Grzywacz is currently Facilities Scientist in the Facilities Management Sustainability Department at the National Gallery of Art, where she is responsible for reviewing the operation and maintenance of facilities management to ensure the preservation of NGA collections. Previously, Ms. Grzywacz worked at the Getty Conservation Institute of the J. Paul Getty Trust from 1985 until 2010 as a research scientist. She developed protocols that reduced energy consumption while maintaining a preservation environment at the Getty Center Museum, conducting research to understand the deterioration of cultural heritage. In 2006, she authored the book *Monitoring for Gaseous Pollutants in Museum Environments,* a summation of her experience of air quality monitoring for both outdoor and indoor-generated pollutants. As the Getty prepared for relocation of its collections from the Getty Villa in Malibu to the Getty Center in Los Angeles, Ms. Grzywacz oversaw the Museum Monitoring Project funded by the President of The J. Paul Getty Trust, a collaborative project where she developed a reputation of collaborating and working with conservation, facilities, and science.

Ms. Grzywacz is a senior research scientist with nearly 30 years of professional experience in environmental monitoring and analytical chemistry, specializing in the study of the potential risk of pollutants to cultural heritage, especially for preservation microclimates and the evaluation of air monitoring technologies and passive sampling devices. Since 2003, she has been a primary reviewer of the ASHRAE guidelines for designing, heating, ventilation, and air-conditioning systems for museums, archives, and libraries and is fondly referred to as "museum lady" by the current President of ASHRAE. In 2010, she received the ASHRAE Distinguished Service Award from the American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

Luanne Greene

Architect and LEED accredited professional Luanne Goodson Greene specializes in long-range planning for colleges, universities and cultural institutions. With 25 years of design and planning experience, she is a strong advocate for smart, innovative and sustainable planning strategies. Her approach to planning has helped many institutions develop successful solutions for development that balance a bold vision with practical implementation issues.

Ms. Greene has worked with numerous institutions including: Johns Hopkins University, University of North Carolina at Chapel Hill, Wake Forest University, Carnegie Mellon University, University of Richmond, Washington University in St. Louis, and the Wildlife Conservation Society. Over the past eight years, she has worked with the Smithsonian Institution on numerous planning and building projects including: the National Zoological Park Comprehensive Facilities Master Plan, the Smithsonian Conservation Biology Institute Academic Center, the National Air and Space Museum Comprehensive Facilities Master Plan, and the Smithsonian Institution Collections Space Framework Plan.

In addition to her work with Ayers Saint Gross, Greene is an active member of the Society for College and University Planning, the American Institute of Architects, and the local Baltimore community. She received both her bachelor of science in architecture and master of architecture degrees from the University of Virginia.

Day 2 Smithsonian Presenters

Paul Drake

Paul Drake joined the Smithsonian team in 2012, and is a native of Florida. He is a 2003 combat veteran of the 124th Infantry Regiment serving as the NCB Non Commissioned Officer for Enduring Freedom and Iraqi Freedom. During his tour in Iraq, he worked with the Library of Congress in securing Iraq's national treasures. Paul has a bachelor's degree in Physical Science from Troy University with a minor in Sociology and Criminology; he is a certified Law Enforcement Officer and former State Trooper.

Paul Tintle

Paul Tintle has been with the Institution since 2006. He began his career in 1986 in the mechanical field as a Testing and Balancing tradesman in the relatively new field of Direct Digital Control. Prior to joining the Smithsonian, Paul worked with Siemens Building Technologies and spent most of his years there working with the National Institutes of Health and the U.S. Department of Agriculture commissioning laboratory facilities. Paul is a National Environmental Balancing Bureau qualified supervisor in both air and hydronic systems.

Paula DePriest

Paula DePriest is Deputy Director of the Museum Conservation Institute. Paula is first and foremost a scientist whose early research focused on the systematics and evolution of lichens. Her research has been published in over 75 professional papers and has been featured in several prominent journals and newspapers. Paula has traveled extensively and conducted field work throughout Europe, the Americas and Asia. She completed her Ph.D. in Botany at Duke University in 1992 and has been adjunct professor at both Duke and George Mason Universities.

Andy Smith

Andy Smith has been with the Institution for 11 years, and in the facility management career field for over 20. During his 20 year career Andy has worked in both the federal and private sectors and specifically with the State Department and the National Archives. He is currently the Zone Manager for the Off Mall Zone which includes the Reynolds Center, Postal Museum, and Renwick Gallery.

Kendra Gastright

Kendra Gastright is the Director of the Office of Facilities Management and Reliability (OFMR). Kendra joined the organization as a Museum Facilities Manager in 2004 and became Associate Director for the Systems Engineering Division in 2006. Kendra has been a leader of OFEO's expanding initiatives in sustainability, energy management, and a new centralized customer service center. She previously led staff and managed maintenance operations at various Naval facilities. Kendra holds a master's degree in civil and environmental engineering from The George Washington University and a bachelor's degree in Oceanography from the U.S. Naval Academy, Annapolis.

Appendix B: Summit Program Agenda

Appendix C: Declaration