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Environmental Design and Operations for Persons with Low Vision

Abstract

"Low vision" is defined as a chronic visual impairment that causes functional limitations or disability. The prevalence of the low vision population in the U.S. has been estimated to be about 4.5 million but the number of people who currently have problems with their vision is estimated to be about 17 million, and is growing partially due to the increase of older adults in the general population. This population is comprised of people who have disease-related or age-related vision loss. The need to accommodate persons with low vision in the built environment is critical and must be addressed. This concept paper addresses and analyzes issues and knowledge gaps that were identified during a recent workshop on this subject, and proposes plans to address them through evidence-based improvements in designs and operational procedures for new and existing buildings. These plans present a unique opportunity to create a paradigm shift in the way facilities are designed and operated. By interfacing scientific investigations and advanced techniques for building performance evaluations, it is anticipated that significant advances can be made in the state-of-the-art of: 1) clinical and other professional health care for low vision patients; and 2) design and operations that improve accommodations for all occupants of the built environment, including those with low vision.

Introduction

We negotiate and appreciate the world around us – the natural and built environments – with all our senses, but for those of us with sight, it is our vision on which we most depend. Whether we are fully sighted or when vision is less than optimal, visual cues aid us in our interactions with our surroundings – supplemented by non-visual clues such as acoustic, thermal, olfactory, and tactile ones.

Any lack of clarity of the visual cues or defect in our ability to see can reduce our abilities to navigate the environment safely and to understand it. As low vision affects an increasing percentage of the population, the need to accommodate persons with low vision in the built environment is critical and must be addressed.

Glare, low contrast, and low illuminance levels are three of the strongest visual impediments in the built environment. Many modern buildings are designed with large areas of glass for daylight and views and with extensive artificial lighting. Glare from both sources of light is a major cause of distraction, discomfort and impediment to vision for many who use these buildings. Also, many newer or recently renovated building interiors have monochromatic or low-contrast treatments that are difficult for persons with low vision to negotiate.

While the pathologies and treatment of low vision disorders are medical issues, assuring optimal access to the built environment for persons with low vision is a design issue. Design of natural and artificial lighting to minimize glare is beneficial to all sighted persons, and the use of luminance, color and value contrast to improve visual clarity of the environment is especially helpful to persons with low vision.

Whereas many issues of accessibility have been addressed by the Americans with Disabilities Act (ADA) and the Architectural Barriers Act (ABA) for those who are legally blind, accessibility for persons with low vision, who are not legally blind, has not. It is the goal of the General Services Administration GSA, working through the National Institute of Building Sciences (NIBS) and with the U.S. Access Board, to begin a process of developing guidance for the design professions in improving the performance of buildings to better accommodate all types of sighted persons.

To that end, NIBS hosted a Workshop in Washington, D.C. in September 2010, with participants from the fields of medicine (specialists in optometry and low vision), architecture, engineering, interior design, lighting design, professional associations, government, academia, advocacy, research and development.

This concept paper is based on the findings and recommendations from that Workshop: "*Improving Building Design for Persons with Low Vision*." Proceedings of the Workshop, and related material, are available at the website: http://files.nibs.org/. The user name and password are both *lowvision* (one word, all lower case, not italicized).

Four major learning outcomes were expressed by the participants of that interdisciplinary Workshop:

1. Clinicians need a better understanding of lighting and accessibility *exposures* that "low vision" *patients* experience while in "built environments."
2. Designers need a better understanding of the lighting and accessibility *needs* of "low vision" *persons* while in "built environments."
3. A common vocabulary is needed for clinicians, design practitioners (e.g., architects, interior designers, lighting designers, engineers), building owners and managers, and policy makers for all built environments.
4. There is a need to balance federal and other mandates for reduced energy consumption against the needs of all building occupants, including people with low vision, to have adequate illumination.

The objective of this concept paper is to address these learning outcomes by: 1) analyzing the issues and knowledge gaps that were identified during the Workshop; and 2) proposing the development of plans for addressing these issues and knowledge gaps through evidence-based improvements in designs and operational procedures for new and existing buildings.

Issues and Knowledge Gaps

Twenty-four issues were identified in the Workshop.[1] They are summarized in this concept paper as two interactive sets of issues and knowledge gaps: 1) those that pertain to the psycho-

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[1] See Appendix E in the Proceedings.

physiology of vision; and 2) those that pertain to the performance of the buildings and their systems.

Low Vision and its Prevalence

"We don't see with our eyes, we see with our brains"[2]. Light from direct sources and from surface reflections comes into the eye and impacts the retina. The signal then goes from the retina to the brain, and the brain translates it into what we know as vision. We are all different, and our visual perceptions are different for different circumstances. It would be helpful for the clinician other health care professionals to be able to quantify the vision problem of each patient or care-receiver in terms of measurable parameters and values of light and of perception. Likewise, it would be helpful for those accountable for building performance to be able to quantify visual environments and occupant perceptions in terms of the same measurable parameters and values as those used by clinicians and other health care professionals.

> ***A fundamental knowledge gap exists in defining measurable parameters and values of visual environments and occupant perceptions in terms that mutually benefit clinicians and other health care professionals, and those accountable for building performance.***

Definitions

"Low vision" has both general and specific definitions. Generally, *low vision* means "*chronic visual impairments that cause functional limitations or disability*"[3] where:

- *Chronic* means that low vision cannot be corrected with medical or surgical intervention or refractive error correction;
- *Visual impairment* means loss of visual acuity, loss of contrast sensitivity, loss of peripheral vision, or the occurrence of central blind spots;
- *Functional limitations* means increased difficulty with reading, mobility, visual motor activities, interpreting visual information; and
- *Disability* means unable to perform usual or customary daily activities.

Technically, low vision is defined in terms of loss of *visual acuity* (i.e., a measure of the limit of a person's vision resolution):[4] In clinical practice, however, low vision includes disabling visual impairments, such as visual field or contrast sensitivity loss with or without visual acuity loss. The technical definitions of loss of visual acuity quantitatively *distinguish between legal blindness and low vision*:

- The World Health Organization defines low vision as corrected visual acuity that is less than 20/60, but greater than or equal to 20/200, and blindness as corrected visual acuity that is less than or equal to 20/400 in the person's better-seeing eye.

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[2] Quoted from Robert Massof, page 55 of the Proceedings.
[3] See keynote address by Robert Massof, page 24 of Workshop Proceedings.
[4] See discussions of Visual Acuity by Robert Massof, Dennis Siemsen, and Suleiman Alibhai in Workshop Proceedings.

- In the U.S., blindness is currently defined in the Social Security Act as corrected visual acuity in the better-seeing eye that is less than 20/100 (previously, 20/200 or less).
- Medicare defines low vision using ICD-9-CM codes:
    - *Mild low vision*, which Medicare does not pay for, is in the range of less than 20/40, but greater-than or equal to 20/60;
    - *Moderate low vision*, which Medicare pays for, is less than 20/60 and greater than 20/200 and/or if the visual acuity is greater than or equal to 20/60 but blind spots exist in the central field that interfere with the person's functioning. If a person can document these conditions, the person will still be classified as moderate, even though the visual acuity might not reach those particular limits; and
    - *Severe low vision* is anything less than or equal to 20/200, which qualifies as legal blindness as defined by the Social Security Act.

The distinction between low vision and legal blindness is important not only for the type of medical reimbursement provided for patient care, but also for accommodation requirements in the design and operations of the built environment in accordance with the Architectural Barriers Act of 1968 (ABA) and the Americans with Disabilities Act of 1990 (ADA).[5]

Whereas accommodations for legally blind persons must be addressed during design and operations of the built environment, in accordance with these acts, accommodations for persons with less severe cases of low vision are not addressed in these acts.

Moreover, there is a dearth of codes and standards that provide guidance for the design or operations of facilities that people with low vision occupy.

Prevalence and Incidence

The prevalence of the low vision population in the U.S. has been estimated to be about 4.5 million but the number of people who currently have problems with their vision is estimated to be about 17 million, and growing with the general population, but with an acceleration in the age groups above 75 years old.[6] The low vision population is comprised of people who have disease-related or age-related vision loss as well as people with eye conditions that affect vision temporarily or permanently.[7] Most of these individuals are used to having good vision and may not have adapted to reduced vision nor have most of them had low vision services. Most have not received skills-training such as orientation to the environment, trailing or self-protective techniques, or braille. Most do not use mobility canes. If traveling with others, most do not know proper sighted guide techniques.

Prevalence is projected to increase linearly by approximately 33% during the next 15 years,[8] primarily due to an aging population. However, *incidence* (i.e., number of new cases of low

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[5] See discussions by Marsha Mazz and Priscilla Rogers in the Workshop Proceedings.
[6] See Robert Massof's keynote presentation, beginning on page 27 of the Proceedings.
[7] See presentation by Priscilla Rogers, beginning on page 58 of the Proceedings.
[8] See Robert Massof's Slide 17 from his keynote address.

vision per year) is likely to accelerate during this same period. The difference between the growth in incidence and the growth in prevalence is that the numbers of new low vision cases are almost exactly balanced by the numbers of deaths among low vision patients, because the average low vision patient is more than 70 years old.

> ***These increasing amounts of prevalence and incidence will become critically important as the ages increase for retirement and Medicare support.***

Knowledge Gaps

> ***That occupants in the built environment have low vision is not always evident. Major knowledge gaps exist in data that could correlate the perceptions of persons with low vision to the physical characteristics (e.g., lighting, materials, assemblies, and systems) of the spaces they occupy (e.g., stationary work stations, indoor and outdoor public spaces such as walkways, plazas, entry ways, lobbies, atriums, and corridors), and to the functions that low vision occupants perform (e.g., occupants or visitors in public rights-of-way and in all building types, such as educational, office, public assembly, nursing, residential, health care, retail, research, manufacturing and recreational facilities).***

Availability of these data could advance the state-of-the-art for clinicians and other health care professionals providing treatment to patients and care receivers, and for those who are accountable for the design and operations of spaces that may be occupied by persons with low vision.

Design and Operational Issues

To provide for acceptable responses (i.e., perceptions and judgments) from occupants with normal and low vision in *destination* (e.g., workstations) and *circulation* spaces in which various functions are performed, an integrated approach is needed that involves building owners, planners and designers, contractors, and facility managers. Members of this interdisciplinary team should be responsible and accountable for the selection, assembly, commissioning, and operational performance of appropriate materials, assemblies, and systems during each phase of the building's life.[9]

Measurable Criteria and Requirements

Some standards and guidelines are available with which to design and evaluate the performance of visual environments that accommodate persons with low vision.[10] ***However, they are not based on measurable criteria (i.e., parameters and values) that have been validated for applications that include occupants with low vision or that are compatible with the needs of clinicians and other health care professionals.***

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[9] See comments by James E. Woods, page 68, Mark Mazz, page 80, Gregory Knoop, page 87, and Earle Kennett, Appendix F, page F-1, in Proceedings.
[10] See presentation and slide 2 by Eunice Noell-Waggoner, beginning on page 101, and comments by Kurt Knight on pages 109 and 135 of the Proceedings.

The most common lighting parameter in standards and guidelines is "*Illuminance*," which is a measure of light flux (i.e., lumens[11]) impinging on a surface area at a specified distance from the light source.[12] Common terms for Illuminance are *lux* (i.e., lumens per square meter of surface area) and *footcandles* (i.e., lumens per square foot of surface area). Unfortunately, this parameter only indirectly relates to the light flux impinging on the eye.

The parameter that is most commonly used to measure both direct and reflected light flux impinging on the eye is "*Luminance*," but it is seldom referenced in standards and guidelines. Confusingly, common terms for Luminance are also *lux* (i.e., lumens per square meter of a surface area perceived by the eye looking at the surface from a particular angle of view) and *footlamberts* (i.e., lumens per square foot of a surface area perceived by the eye). ***Luminance is often misunderstood as reflected Illuminance perceived by the eye.*** Rather, Luminance has two components: 1) the direct impingement on the eye from areas of natural and artificial light sources; and 2) the impingement on the eye from light reflected from areas of surrounding surfaces. Luminance is independent of distance.

The parameters that most closely characterize occupant vision, clinically and environmentally, are contrast, brightness, glare, and color; all of which are functions of Luminance rather than Illuminance. However, the parameters and recommended values for Luminance and these related parameters are not provided in current design standards and guidelines. A major discovery during the Workshop was that the methods of measuring these parameters are not consistent between the clinicians and those accountable for the performance of buildings.

Another finding from the Workshop is that the Illuminance values, which are currently recommended in standards and guidelines, are based on a study conducted more than 20 years ago.[13] This was a study of young, normally sighted people with which to develop the illumination levels recommended by the Illuminating Engineering Society at that time, and that are still referenced today. These Illuminance values are questionable because they were not studied from a perspective of a large portion of the population, from older people to younger people. And, as further described below, these values are being arbitrarily lowered in an effort to reduce building energy consumption.

Materials, Assemblies, and Systems

Luminance is a measure of *direct and reflected light* that impinges on the eye. The primary sources of *direct light* are electric lighting fixtures and lamps (e.g., for ambient, accent, and task lighting) and daylighting (e.g., windows and skylights indoors) within the occupant's *field of view*. Likewise, the sources of *reflected light* are all of the two and three dimensional surface areas within the occupant's *field of view*. The light impinging on the surfaces within the field of view may come from a combination of direct sources and other reflected surfaces of various colors that are outside of the field of view. ***Therefore, the values of Luminance, contrast,***

[11] A "lumen" is a measure of light emitted by a source: one lumen is the amount of light emitted by a "standardized" candle through one steradian solid angle.
[12] The Illuminance on a surface area follows the Inverse Square Law: Illuminance is inversely proportional to the square of the distance from the light source to the surface.
[13] See presentation by Robert Dupuy, beginning on page 98 of the Proceedings.

brightness, glare, and color are dynamic and change as a person moves, surfaces are modified, daylighting changes, or electric lights are switch on or off, or dimmed.

For persons with some types of low vision, the field of view is diminished, so design and operational accommodations are needed with regard to properties of the selected materials and assemblies to which these occupants are exposed:

- The selection, placement, and treatment of windows and skylights for daylighting significantly affect occupant perceptions of brightness, contrast, color and glare within the occupied spaces.[14] Daylighting is also likely to provide a positive impact on the circadian patterns of occupants with normal and low vision, by melatonin suppression.[15]
- The selection and placement of electric lighting fixtures and lamps also significantly affect occupant perceptions of brightness, contrast, color and glare within the occupied spaces.[16, 17] ***Some of the new, more energy efficient fixtures and lamps produce light at higher frequencies and tend to exacerbate glare.***
- Because light flux is a vector, the flux on a surface from all of its sources of lighting is additive. This property is important when the design or operations of the lighting systems involves both artificial and natural light sources, because the resultant values of contrast, brightness, color and glare will change as a function of daylight variability and the remote or proximate control of the electric lighting power (e.g., the movement of shadows[18, 19]).
- Reflectances of two and three-dimensional surfaces of materials, together with the location and placement of the light sources, determine contrast.[20] Polished horizontal surfaces can result in disability glare and can distort pathways.[21] Light Reflective Values (LRV) are provided for all paint chips and for other materials. It is important to specify these values early in the design process, before starting the detailed design.[22]
- Stairs, doorways, escalators, and elevators should provide “high definition environments” that include texture contrast and high contrast painting of edges.[23] ***The National Fire Protection Association allows the average Illuminance for emergency egress in stairwells of one footcandle (1 fc) with a ratio not to exceed 40 to 1. These values are likely to be low for the safety of persons with low vision.[24]***

[14] See presentations in Panel 3, beginning on page 62, and Panel 4, beginning on page 77 of the Proceedings.
[15] See presentation by Mariana Figueiro, beginning on page 82 of the Proceedings.
[16] See presentation by David Munson and open discussion on pages 49-51 of the Proceedings.
[17] See presentations in Panels 3 and 5 in the Proceedings.
[18] See presentation by Gregory Knoop, beginning on page 18 of the Proceedings.
[19] See presentation by Mark Mazz, beginning on page 80 of the Proceedings.
[20] See discussion by Robert Massof, page 31 of Proceedings.
[21] See presentation by Eunice Noell-Waggoner, page 112 of the Proceedings.
[22] See presentation and discussion by Jeanne Halloin, pages 121-126 of the Proceedings.
[23] See presentation by Gregory Knoop, beginning on page 17 of the Proceedings.
[24] See presentation by Eunice Noell-Waggoner, page 103 and slide 7 of the Proceedings.

- For wayfinding, color and design should be used to create architectural landmarks to aid in spatial orientation.[25]

Energy and Economic Pressures

To reduce energy consumption and costs, federal laws and regulations, codes, and standards are being revised to reduce the lighting power densities (LPD, in Watts/m^2 or Watts/ft^2 of floor area) for specific spaces in new and existing buildings.[26] Some of these standards (e.g., ANSI/ASHRAE/IESNA 90.1-2010) list LPDs without explicit consideration for the resultant Illuminance or Luminance values. Others (e.g., GSA/PBS P100-2010) list LPDs and Illuminance values, but without empirical or rational correlations between them. Examples of these arbitrary reductions in Illuminance values from the previous GSA/PBS P100-2005 are:

- 30 – 40% for offices, classrooms, and conference rooms;
- 16 – 61% for lobbies, atriums, restrooms, corridors/transition areas, stairs, and active storage areas;
- 61 – 75% for lounge/recreation areas; and
- 71 – 80% for inactive storage areas.

Because of the lack of evidence-based correlations between LPD and Illuminance values, there is little confidence in the claims that reduced Illuminance values will result in reductions in annual whole building energy consumption and corresponding costs in new or existing buildings (e.g., supplemental lighting may be used to compensate for the reduced Illumination; this is a variation of the Jevons Principle[27]), the percentages of energy reductions that can be attributed to the daylighting and/or electric lighting systems, or that acceptable occupant responses will be provided.

However, there is strong evidence that reductions in Illuminance values will result in lower Luminance values, which in turn will reduce <u>visual acuity</u> and <u>contrast sensitivity</u>. These reductions are likely to have adverse effects on the health, safety, accessibility and security of all occupants, especially those with low vision.

There is also some evidence that increased values of Lighting Efficacy (e.g., lumens/Watt), Luminance, and related values of contrast, brightness, and color can be used to achieve designs and operations that increase contrast sensitivity and reduce glare while reducing whole building energy consumption.

Knowledge Gaps

- ***A scientific basis for establishing parameters and values in lighting standards for the general population and for persons with low vision does not exist.***

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[25] See presentation by Erin Schambureck, beginning on page 113 of the Proceedings.
[26] See EISA-2007, ANSI/ASHRAE/IESNA Standard 90.1-2010, GSA/PBS P100-2010.
[27] "Jevons Principle" or the "Rebound Effect": As the efficiency of energy utilization increases, its consumption increases. See Owen, D. 2010. The energy dilemma: If our machines use less energy, will we just use them more? *The New Yorker*, December 20 and 27, 2010, pages 78-85.

- If credible standards pertaining to the visual environment are to be developed, empirical, scientifically designed laboratory and field studies are needed to affirm that the appropriate parameters have been defined for the mutual use of clinicians and other health care professionals, and those accountable for the performance of buildings.
- If the parameters are affirmed, studies should be designed to correlate *measured values* of Illuminance, Luminance, contrast, glare, color and brightness with *measured values of occupant perceptions and affective responses* from the general population and from the population of persons with low vision.[28]

- ***A database of standardized reflectance properties of materials does not exist.***
- ***The relationship between the visual environment and building energy consumption is misunderstood in the design community.***
  - The use of the LPD parameter and values by designers to *predict* building energy consumption, without evidence-based correlations to Illuminance, Luminance, and Occupant Perceptions, increases risk of discomfort and injury to occupants, loss of occupant performance and productivity, and liability to those accountable for the performance of the building.[29]
  - Empirical, scientifically designed laboratory and field studies (i.e., not only simulation studies) are needed to correlate the relationships between measures of the visual environment, measures of occupant responses, measures of whole building energy consumption, and measures to determine the percentages of energy consumption that are attributable to the daylighting and electrical lighting systems.
- ***A methodology for validating and verifying lighting designs by Post-Occupancy Evaluations does not exist.***
  - A validated and standardized methodology, which integrates the visual environment with other attributes in High Performance Buildings (HPB),[30] is needed to evaluate the design and operations of new and existing buildings for persons with low vision as well as for persons with normal vision.
- ***A database of buildings that integrates all of the attributes of HPBs, including the visual environment, does not exist.***
  - A robust and dynamic database should be created and maintained, possibly on the website of the NIBS Whole Building Design Guide (WBDG), to provide raw-data and analyses that would be mutually beneficial to clinicians and to those accountable for the performance of buildings.

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[28] See presentation and slide 5 by James E. Woods, beginning on page 94 of the Proceedings.
[29] See presentations by Robert Dupuy, beginning on page 98, Eunice Noell-Waggoner, beginning on page 101, Mary Ann Hay, beginning on page 103, and Open Discussion, beginning on page 105 of the Proceedings.
[30] See the definition of “High Performance Building” in EISA-2007 and in the NIBS Whole Building Design Guide.

Plans for Improved Designs and Operations

During the Workshop, there was general agreement that a *Committee on Low Vision* should be established to explore ways to move forward with the ideas expressed during the two days. The structure of the Committee was not defined, but it was agreed that NIBS would host the Committee, make its website available, and host conference calls as requested for Committee meetings.

As a result of the Workshop, three actions have been undertaken:

- A research proposal was submitted in February 2011 to the National Eye Institute of NIH, with Robert Massof as Principal Investigator. The title of that proposal is: *Computational Model of the Perception of Environments by People with Low Vision.* This proposed research would involve investigators from Johns Hopkins School of Medicine, NIBS, Virginia Tech, Indiana University, University of Texas at Austin, University of Maryland, and the University of California, Davis. The status of the proposal is that it is being revised and will be re-submitted in November 2011 in response to review comments.
- A review of the GSA/PBS P100-2010 edition was conducted by a "NIBS Subcommittee" consisting of Stuart L. Knoop, James E. Woods, Gregory Knoop, Bose Thomas, Earle Kennett, Eunice Noell-Waggoner, Priscilla Rogers, Stephanie Stubbs, Thomas Williams, Tom Sachs, and Vijay Gupta. Two deliverables were provided to GSA in June 2011:
    - A Chapter-by-Chapter review of the 2010 edition with "Track Changes" providing recommended additions, deletions, and revisions. These recommendations were intended to improve accessibility and lighting for all occupants, including persons with low vision. The 2010 edition is undergoing a major revision, which is being drafted by a NIBS Committee.
    - A brief document: "*Guidelines for Designing for Persons with Low Vision*" that was derived from the proposed revisions to the 2010 edition. The intent of the document was for immediate use.

      A copy of this document is attached as Appendix A.
- Discussions with potential sponsors for support of these plans have been initiated. It is anticipated that this concept paper will focus these discussions by extending the comments from the Workshop into a set of proposed plans for short-range, medium range, and long range activities.

Short-Range (1 – 2 years)

Some activities have already been conducted and others are in progress. Descriptions and ballpark cost estimates to achieve the short range plans are described below. The short-range plan includes seven Tasks, with subtasks:

Task 1: Organize the NIBS Committee

Task 2: Begin Development of a Memorandum of Understanding

Task 3: Begin Review of Existing Codes, Standards, and Regulations

Task 4: Develop Guidelines for Design and Operations based on Current Knowledge

Task 5: Design and Implement an Interactive Low Vision Repository

Task 6: Develop and Validate a Protocol for Post-Occupancy Evaluations (POE) including the Visual Environment in Public and Private Buildings

Task 7: Initiate an Outreach Program

Task 1: Organize the NIBS Committee

Although some activities have been conducted, an organizational structure for a *NIBS Committee on Low Vision* has not been established. This organization is now underway.

One of the early functions of this Committee will be identification of funding sources and development of a Committee budget.

The interdisciplinary committee members will include architects, engineers, lighting designers, interior designers, clinicians and other health care professionals, and researchers.

A ballpark estimate for organizing and holding an initial one-day meeting of the Committee, and conference calls as needed is $12,500 including compensation for staff support and travel expenses for some Committee members, but assuming that all members will serve without compensation.

Task 2: Begin Development of a Memorandum of Understanding

A suggestion was made during the opening of the Workshop that a Memorandum of Understanding (MOU) or a Memorandum of Agreement (MOA) be initiated for signature by lead Federal Agencies that are responsible for the design and performance of federal buildings. This MOU or MOA would focus on including provisions for persons with low vision as part of EISA-2007.[31]

A subcommittee should be appointed to draft such an MOU or MOA for approval of the Committee and potential signatories. Because of the nature of such documents, it is anticipated that the time to obtain agreement among the agencies will by extensive, but initiation of a draft document can begin immediately.

A ballpark estimate for beginning this work is $10,000 for staff support.

Task 3: Begin Review of Existing Codes, Standards, and Regulations

During the Workshop, a clear distinction was made between design and operational documents that *mandate* compliance (i.e., codes, regulations, and Federal Standards) and those that *provide guidance* (i.e., voluntary standards, practices, and guidelines). It was also noted that "voluntary" documents become mandatory when adopted into codes, regulations, and contract documents.

A literature search and initial reviews should be conducted of codes (e.g., International Building Code, fire and life/safety codes), mandatory standards (e.g., Department of Veterans

[31] See discussion on page 5 of the Proceedings.

Affairs, U.S. GSA, Department of Defense, Department of State), and federal regulations (e.g., U.S. Access Board Standards and Guidelines, Presidential Executive Orders, Department of Energy Rules) in which low vision issues should be addressed. The main objective of these initial reviews would be to identify and understand which existing documents affect the health, safety, or well-being of the low vision population and, more generally, the larger population with regard to vision issues. Based on these reviews, recommendations for revisions of the documents or inclusion in future editions of these documents should be prepared.

Subtask 3.1: Documents under Current Revision

Two documents, which are considered mandatory, are currently being revised. These documents will have significant impact on the health, safety, and well-being of the low vision population:

1. The 2010 *Guidelines for Design and Construction of Health Care Facilities* is being revised by the Facilities Guidelines Institute (FGI) for 2012. The revised Guidelines will be published as two volumes:

    - Volume 1, *Design and Construction of Health Care Facilities*, will continue to focus on Acute Care Facilities.
    - A new Volume 2, which will be entitled: *Design and Construction of Long Term Residential Health, Care, and Support Facilities*, will include requirements for Independent Living Facilities, Assisted Living Facilities, Nursing Homes, Hospice Facilities, Adult Day Care Facilities, Wellness, Diagnostic & Treatment Facilities, and Rehabilitation Facilities.

    The deadline for the first drafts of these two volumes is 31 October 2011. Comments to the first drafts will be received by FGI for a reasonable period after that date.

2. ANSI/IESNA RP-28-07: *Recommended Practices for Lighting and the Visual Environment for Senior Living* is scheduled by IESNA for review and revisions. This review and revision process will begin in October 2011 and will be due in the Spring of 2012.

This subtask should be completed with six months after receipt of funding. In addition to committee and staff time, compensation for two individuals would be needed to provide the detailed review and to propose revisions for these two documents within the scheduled deadlines. The ballpark estimate to review, to provide comments, and to propose recommendations for these two documents is $45,000, including staff time, compensation, and travel expenses.

Subtask 3.2: Other Documents

A literature search and initial reviews of other codes, standards, and regulations should be initiated to determine how these documents affect the health, safety, or well-being of the low vision population and, more generally, the larger population with regard to vision issues. The results of the search and initial reviews would be submitted by the committee to NIBS with recommendations for further action.

This subtask should be completed within 12 months after receipt of funding. In addition to committee and staff time, compensation for two individuals would be needed to organize and direct the search, to draft the reviews for committee discussion, and to prepare a report. The ballpark estimates for this subtask, including staff time, compensation and travel expenses, are: $25,000 for the literature search; $45,000 for the initial reviews; and $25,000 for preparation of the report.

Upon completion of these initial reviews, additional reviews and recommendations for inclusion of low vision design and operational requirements into other mandatory and voluntary documents should be prepared during the medium and long-range periods (see below).

Subtask 3.3: Coordination with the U.S. Access Board

Findings from Subtasks 3.1 and 3.2 should be evaluated for potential inclusion in the ADA and ABA Standards and Guidelines. Recommendations would be developed from these evaluations and submitted to the U.S. Access Board. It is anticipated that these recommendations would be discussed in meetings with the U.S. Access Board.

Initial coordination with the U.S. Access Board would begin immediately after the first organizational meeting of the Committee on Low Vision, and recommendations would be submitted within six months after completion of Subtask 3.2. The ballpark estimate for this subtask, including staff time, compensation and travel expenses is $25,000.

Coordination with the U.S. Access Board would be continued during the medium and long-range periods (see below).

Task 4: Develop Guidelines for Design and Operations based on Current Knowledge

Throughout the Workshop, comments were made that a comprehensive guideline on design and operations for persons with low vision was not currently available. It was generally agreed that such a guideline could be developed and adopted based on current knowledge and then updated as new evidence-based knowledge becomes available. This would be a stand-alone guidance document that could also be incorporated into, codes, standards, regulations, and contracts, directly or by reference.

An outline for this Guideline has been drafted and is included as Appendix B.

Work on developing this Guideline can begin as soon as funding becomes available. Publication of the initial edition is expected within one year. This Guideline would be structured to be suitable for adoption by reference into codes, standards, and regulations, especially for health care facilities such as senior living facilities and nursing homes, and for public buildings. It is anticipated that the initial edition of the Guideline would be based on current knowledge, evidence-based or experiential, and that subsequent editions would be based on new empirical data (see mid and long-range plans).

Subtask 4.1: First Draft

A first draft of the Guideline would be based on the outline in Appendix B. This subtask should be completed within three months after receipt of funding. In addition to committee and staff time, compensation for four individuals would be needed to prepare the draft for committee review. The ballpark estimate for this subtask, including staff time, compensation, and travel expenses is $100,000.

Subtask 4.2: Review by Committee

The first draft would be distributed to the committee for internal review, and comments will be collated by staff. This subtask should be completed within two months after completion of subtask 4.1. The ballpark estimate for staff time for this subtask is $10,000.

Subtask 4.3: Final Draft

The first draft would be revised to respond to the comments from the committee. This subtask should be completed within two months after completion of subtask 4.2. In addition to committee and staff time, compensation for four individuals will be needed to prepare the revised draft for industry review. The ballpark estimate for this subtask, including staff time, compensation and travel expenses is $45,000.

Subtask 4.4: Industry Review

The revised draft would be distributed to industry peer-reviewers for external review, and comments would be collated by staff. This subtask should be completed within two months after completion of subtask 4.3. The ballpark estimate for staff time for this subtask is $10,000.

Subtask 4.5: NIBS Publication

The revised draft would be finalized for publication by NIBS in response to the comments from the industry peer-reviewers. This subtask should be completed within two months after completion of subtask 4.4. In addition to committee and staff time, compensation for four individuals would be needed to finalize the draft for publication. The ballpark estimate for this subtask, including staff time, compensation and travel expenses is $45,000. Publication costs are not estimated here.

Task 5: Design and Implement an Interactive Low Vision Repository

Three interactive sets of issues and knowledge gaps have been described in this concept paper: 1) those that pertain to the psycho-physiology of vision; 2) those that pertain to the performance of buildings and their lighting systems, and 3) those that affect the persons' ability to navigate the built environment.

A framework for a repository of these evolving issues and potential resolutions should be developed for inclusion in the Whole Building Design Guide (WBDG) or an alternative repository. This framework should be interactive so that clinicians, scientists, and those accountable for building performance can contribute to this repository.

Subtask 5.1: Committee Interface with the WBDG or Alternative Repository

A study team of the committee would be identified and tasked with determining how a framework could be developed and interfaced with the WBDG or an alternative repository to incorporate the issues associated with low vision. A report of this feasibility study should be submitted to the committee within three months after receipt of funding.

The WBDG, which is managed by NIBS (http://www.wbdg.org/), is a web-based portal providing government and industry practitioners with one-stop access to up-to-date information on a wide range of building-related guidance, criteria and technology from a 'whole buildings' perspective. The WBDG is currently organized into three major categories: 1) Design Guidance; 2) Project Management; and 3) Operations & Maintenance. The WBDG web site is offered as an assistance to the building community by NIBS through funding support from the Department of Defense, the NAVFAC Engineering Innovation and Criteria Office, the Army Corps of Engineers, the U.S. Air Force, the U.S. General Services Administration (GSA), the Department of Veterans Affairs, the National Aeronautics and Space Administration (NASA), and the Department of Energy, and the assistance of the Sustainable Buildings Industry Council (SBIC). A Board of Direction and Advisory Committee, consisting of representatives from over 25 participating federal agencies guide the development of the WBDG.

In addition to committee and staff time, compensation for two individuals would be needed to focus on the feasibility and methodology of using the WBDG as a framework for the low vision repository or, if not feasible, to identify an alternative repository and framework. The ballpark estimates for this subtask, including staff time, compensation and travel expenses is $50,000.

Subtask 5.2: Validation of the Repository Documentation

Through methods similar those in Subtask 3.2, the documentation in the WBDG, or alternative repository, would be searched and reviewed to determine how this documentation affects the health, safety, or well-being of the low vision population and, more generally, the larger population with regard to vision issues. The results of the search and reviews, including identification of inconsistencies in the information, would be submitted by the committee to NIBS with recommendations for further action.

This subtask should be completed within twelve months after completion of subtask 5.1. In addition to committee and staff time, compensation for four individuals will be needed to organize and direct the search, to draft the reviews for committee discussion, and to prepare a report. The ballpark estimates for this subtask, including staff time, compensation and travel expenses, are: $25,000 for the literature search; $90,000 for reviews of the documentation, and $25,000 for preparation of the report.

Subtask 5.3: User Interface with the WBDG or Alternative Repository

A study team of the committee would be identified and tasked with developing interactive procedures for users to upload and download validated information to and from the repository. A report should be submitted to the committee within three months after completion of subtask 5.2. In addition to committee and staff time, compensation for two individuals would be needed to develop the procedures for committee discussion, and to prepare a report. The ballpark estimates for this subtask, including staff time, compensation and travel expenses, are: $25,000 for development of the procedures, and $25,000 for preparation of the report.

Task 6: Develop and Validate a Protocol for Post-Occupancy Evaluations (POE) including the Visual Environment in Public and Private Buildings

A basic need is valid and reliable data on the performance of buildings in terms of the HPB attributes[32] and the corresponding responses of the occupants, and more specifically with respect to the performance of the visual environments and the corresponding occupant responses. An important step toward fulfilling this need would be to integrate the procedures for evaluating the

[32] See definitions of attributes in EISA-2007 and in the WBDG website.

visual environment into the existing *NIBS Protocols for Post Occupancy Evaluation in Public and Private Buildings*.

Subtask 6.1: Draft POE Protocol

Currently, NIBS is developing protocols for evaluating the performance of federal buildings for the US GSA and for evaluating performance of health care facilities for the US Department of Veterans Affairs. In this subtask, those protocols would form the basis of a new protocol that would also include evaluations of occupant responses and system performance that are affected by: 1) the psycho-physiology of vision; 2) the luminous environment, and 3) the ability of occupants to navigate the built environment. This new protocol would include measurable parameters and values as defined in the Guideline (subtask 4.4).

This subtask should be completed within six months after completion of subtask 4.4. In addition to committee and staff time, compensation for two individuals would be needed to draft the new protocol for review by the committee, revise the draft protocol in response to the comments, and to prepare the protocol for validation. The ballpark estimate for this subtask, including staff time, compensation and travel expenses is $45,000.

Subtask 6.2: Validate the Draft POE Protocol in One or More Pilot Sites.

The draft protocol from subtask 6.1 would be validated in one or more facilities with known populations of persons with low vision. Likely sites for this validation would be senior living facilities, and medium to large size office buildings, where the low vision population could be identified and surveyed with permission. The objectives of this subtask would be to validate the reliability of POE with regard to:

1. New parameters and values in the draft protocol that pertain to the visual environment; and
2. The integration of the measures of the visual environment into the overall evaluation of the facility.

The selection and evaluation of each pilot site in this subtask should be completed within six months after completion of subtask 6.1. In addition to committee and staff time to select the site(s) and coordinate the logistics, compensation for four individuals would be needed to review the available project documentation, conduct the site visit, prepare a report for review by the committee, and revise the report based on comments from the committee. The ballpark estimate for completion of this subtask for each pilot site, including staff time, compensation and travel expenses is $50,000.

Subtask 6.3: Enter Validated Data into Repository and Publish Protocol

The validated results from the pilot site(s) would be entered into the repository in accordance with the procedures defined in subtask 5.3. In addition, the validated protocol from subtask 6.2 would be submitted to NIBS for publication as a companion document to the Guidelines for Design and Operations (subtask 4.5).

This subtask should be completed within three months after completion of subtask 6.2. In addition to committee and staff time to enter the data, compensation for one individual would be needed to provide quality assurance of the data entry. The ballpark estimate for completion of this subtask, including staff time and compensation is $15,000 for each pilot site. Publication costs are not estimated here.

Task 7: Initiate an Outreach Program

Knowledge gaps were identified throughout the Workshop. Several of these gaps are described above. Of particular note is the lack of knowledge that those accountable for building performance have regarding the measures of occupant responses and corresponding physical characteristics of the visual environment. Similarly, there was an expressed lack of knowledge by clinicians and scientists regarding the functional performance of buildings.

Subtask 7.1: Preparation of Awareness Articles

A study team of the committee would be identified and tasked with developing a series articles for potential constituency publications (e.g., American Foundation for the Blind, AARP, real estate and insurance industry journals), the general press (e.g., Wall Street Journal, Washington Post, Time, Newsweek), and the technical press (e.g., architectural and engineering journals). The objective of these articles would be to raise the awareness of various constituents regarding the needs of low vision persons in the built environment.

Preparation of these articles would begin immediately after receipt of funding. In addition to committee and staff time, compensation for individuals would be needed to develop these articles for committee approval and dissemination. The ballpark estimate for each article in this subtask, including staff time and compensation is: $12,000.

Subtask 7.2: Identification of an Educational Paradigm

A study team should be identified and tasked with developing the framework for an educational outreach program for professionals in practice, and for students of design, facilities management, and life-sciences. The focus of this educational paradigm would be to develop, at high school, higher education, and continuing education courses and curricula, a sensitivity to the needs of low vision persons and to the environmental methods that can be employed to accommodate these needs.

In addition to committee and staff time, compensation for individuals would be needed to develop these articles for committee approval and dissemination. A ballpark estimate for developing the framework for the educational outreach program is $50,000, including compensation and travel expenses.

Medium-Range (3 – 5 years)

As discovered during the Workshop, a major deficiency in providing for the needs of persons with low vision is the lack of empirical data pertaining to: 1) the design and performance of buildings; and 2) the resultant human responses. The focus of the medium range plan is to develop a credible base of empirical data with which advances in clinical practice and building performance can be achieved.

Task 3: Continue Review of Existing Codes, Standards, and Regulations

Review and recommendations for inclusion of low vision requirements in mandatory documents will be continued during medium-term period.

Task 4: Update Design and Operations Guidelines

Incorporate the findings and conclusions from the POEs and data from the clinical patients and residents of senior living and health care facilities into an update of the Design and Operations Guidelines.

Task 6: Continue to Obtain Post-Occupancy Evaluations (POE)

Based on the results of the Protocol development and validation, continue to obtain on-site empirical data and enter them into the framework of the WBDG repository.

Task 7: Update Outreach Program

Implement the educational outreach program as developed in the short range plan and to incorporate information obtained into the medium range plan. This outreach program would be offered to professionals in practice and to students of design, facilities management, and life-sciences.

Task 8: Correlate Clinical and Health Care Data with POEs

Correlate the field data from the POEs with data from clinical patients, and residents of senior living and health care facilities, who are either occupants of the evaluated buildings, or are matched to the low vision occupants. The protocol for acquiring these cross-cutting data would be designed and implemented by an interdisciplinary team. Validated results would be entered into the framework of the repository.

Long Range (5 years and longer)

The focus of the long range plan is to further enhance the empirical data with which advances in clinical and other health care practice, and building performance will continue.

Task 3: Continue Review of Existing Codes, Standards, and Regulations

Review and provision of recommendations for inclusion of low vision requirements in mandatory documents should be continued during long-term period. These recommendations should be based on evidence-based results, some of which will be obtainable for the medium and long-range projects described above.

Task 7: Continue to Update the Outreach Program

The Educational Outreach Program would continue to be updated as new information becomes available. It is envisioned that this Educational Outreach Program would incorporate “on-line” as well as on-site educational techniques for professionals and students, including hands-on experience with the design, operational, and POE procedures.

Task 8: Continue to Correlate Clinical and Experimental Data with POEs

Clinical data from patients who are either occupants in the enlarged set of evaluated buildings, or are matched to the low vision occupants, would continue to be used to update the Guidelines and the WBDG repository.

Task 9: Conduct Experimental Laboratory, Clinical, and Field Studies

Results from the interdisciplinary scientific research project on *Computational Model of the Perception of Environments by People with Low Vision* would be incorporated into the updated Guidelines and WBDG repository as they become available.

In addition, other available laboratory, clinical, and building performance studies would be coordinated by the Committee. It is envisioned that some of these studies would be conducted in response to Requests for Proposals generated by the Committee to address specific gaps in the Guidelines or the WBDG repository. It is also envisioned, that results from studies would also become available for the Guideline and WBDG repository through submissions by others who have used standardized protocols approved by the Committee.

Task 10: Apply POE Results to Design and Operations

Results from additional POEs of new and existing buildings, conducted by using the standardized protocols approved by the Committee, would also be integrated into the Guidelines and entered into the WBDG repository.

Conclusion

This concept paper describes a unique opportunity to create a paradigm shift in the way facilities are designed and operated. By interfacing scientific investigations, coordinating with the U.S. Access Board and other public and private agencies, and developing advanced techniques for building performance evaluations, it is anticipated that significant advances can be made in the state-of: 1) clinical and other professional health care for low vision patients; and 2) design and operations that improve accommodations for all occupants of the built environment, including those with low vision.

Appendix A

Guidelines for Designing for Persons with Low Vision

Building accessibility standards, which have been in effect since the 1970s, do not yet mandate requirements for accommodating persons with low vision, which is defined as "chronic visual impairments that cause functional limitations (such as increased difficulty with reading, mobility, visual motor activities, interpreting visual information) or disability." The National Eye Institute of the National Institutes of Health estimates that currently more than 38 million Americans age 40 and older experience blindness, low vision, and eye diseases such as macular degeneration, cone rod dystrophy, glaucoma, diabetic retinopathy, and cataracts—all of which can cause low vision. This number is expected to grow to more than 50 million people by year 2020.

To serve this growing population, the following supplementary guidelines are recommended for creating safer and more accommodating environments for people with low vision. These guidelines are offered in the spirit of broadening accessible facilities. As is true for many aspects of accessibility, designing for persons with low vision can create environments that are more universally user-friendly.

National Institute of Building Sciences

June 20, 2011

General Requirements

Visibility

Facilities should provide exterior and interior pathways and spaces that are safely illuminated and free from potentially hazardous visual obstacles, such as constructions or furnishings that may cause people to collide with them because they are not clearly distinguished from their surroundings by color, contrast or form.

Safety

Site paved areas should provide contrasts in surface treatment, texture and lighting that improve the clarity of the geometry of pedestrian circulation routes.

Site

Space and light should be used to enhance the intuitive quality of wayfinding on the site. Landscaping, bollards, and site furniture may be used as landmarks to help guide pedestrians in large, open paved spaces. Outdoor seating should be provided in appropriate locations such as bus stops and plazas and at approximately 50-M (55-yard) intervals along walkways.

Circulation: Circulation corridors should maintain constant widths where possible. Ramps and steps in circulation pathways should be clearly distinguished from the level areas by color value and texture.

Furnishings: Wall offsets, columns, furnishings, and other objects should be placed outside the paths of circulation and be clearly visible by contrasting color and value to avoid obstructing free and safe movement. . Illumination levels from artificial and natural lighting should be as constant as practicable, and vary gradually – not suddenly—along the path of travel, with a maximum contrast ratio of 10:1.

Paving and Curbs: Paving should be of medium color value and not glaringly reflective, especially in plazas, outdoor seating areas and other open spaces where reflections of sunlight into the building could add to glare and to the heat load. Pavement patterns and color changes **that won't be mistaken for steps** may be used where they cross paths of travel.

Curbs and edges: Curbs and other walkway edges should be a minimum of 100 mm (4 inches) and of contrasting color or value to be clearly visible to the pedestrian as a pavement boundary. (Pavement edge curbs generally are not needed where there are handrails.) Wheel stops at curbs should be of contrasting materials and colors to paving.

Drains: Drains and gratings should be placed to the sides rather than in the pathways in paved areas. Gratings bars should run perpendicular to the path of travel and be spaced no more than 13 mm (.5 inch) apart.

Landscaping: Trees should be placed so low-hanging branches won't project into paved walkways and plazas where they could present a hazard to pedestrians. Also, trees that drop fruit, nuts, or cones seasonally should be located to avoid creating a falling hazard on paved walkways. For safety reasons, water elements should be designed so that unwary pedestrians can't step into the water at the edge of pavement.

Outdoor Seating Areas: To the extent possible, provide shading for outdoor seating areas to help avoid glare. Also to minimize reflective glare from sunlight, care should be taken to select paving, table, and other surface colors with matte finishes and medium value.

Bollards: To avoid pedestrian collisions with bollards in pathways, bollards should be at least 1M (3.25 feet) in height. The color, form and other features of the bollards and other barriers should contrast with site surroundings. Bollards with ornamental horizontal projections linked with chain or rope should be avoided.

Exterior Design

Building orientation will affect the amount of direct and reflected solar penetration of interior spaces, as well as the need for controls to mitigate or prevent consequent glare.

External Stairs: The underside of stairs should be lighted after dark, and should be enclosed or protected to prevent pedestrians walking underneath from head injury on the sloping underside of the structure. Stair tread nosings, handrails and skirting should contrast with the treads in color and values, and should be abrasive in texture. Where steps cross grades, tapered risers to meet grade may be hazardous to the unwary pedestrian. Where possible, avoid tapering or use handrails to guide the pedestrian to the full step-and-riser section of the stair/steps. Open risers should be avoided.

Entrances: Entrances should be sheltered from the elements with overhangs or canopies. Where such shelter is constructed with columns, they should be clearly visible in all lighting conditions.

Entrances should be at least 1M (3.25 feet) away from steps or stairways. Entrance doors should be clearly visible and distinct from fixed glazing at the entrance.

Windows: Glare control should be considered when choosing window orientation as well as the number, size, and placement of windows. Light shelves on windows could redistribute daylight evenly across the building section, minimize glare and provide more comfortable, productive, daylit environments.

Skylights and Sloped Glazing: Skylights and sloped glazing should be used to provide the intended illuminance and luminance, and to prevent glare or overheating in the building interior. The potential for glare and high contrast caused by direct sunlight falling on task surfaces and/or causing confusing and hazardous shadow patterns should be evaluated. Consider the use of diffuse glazing or other sun control devices to reduce glare from skylights that serve office and other work areas. To reduce solar gain and glare, provide interior daylight control devices—and consider options for maintenance and cleaning as well as for repair and replacement.

Interior Design

The interior of the building should be planned to take advantage of views and daylight using an integrated design approach. In offices, workstations should not face directly into windows; in courtrooms and conference rooms, users should not be distracted by windows or glare. With few exceptions, daylighting should be controlled to adjust to seasons and time of day.

Public Spaces

High-contrast and low-glare materials should be selected for public areas, such as lobbies and vestibules that interface with the exterior environment. Information facilities should be located near and clearly visible from the entrance, waiting areas, and access to vertical transportation. Vestibules should provide transitional illumination levels between exterior and interior spaces.

Corridors: Public corridors should introduce as much natural light as possible without introducing excessive glare through windows, transoms, or borrowed light. Windows should not be placed at the ends of corridors or other pathways of travel where glare will cause discomfort and confusion.

Elevators: Passenger elevators should open to public circulation lobbies or corridors at each level with minimal change in illumination level from elevator cab to building space. Elevators should not open to face directly into sunlight and glare.

Doors: Door openings should be a minimum of 1200 mm (4 feet) wide to permit persons with escorts and seeing-eye dogs to pass through comfortably. Likewise, revolving doors should be sufficiently wide to accommodate a person with an escort.

Glazed doors should be used at building entrances and vestibules to facilitate orientation and safe movement. When revolving doors are needed, in addition to code requirements for egress, they should be accompanied with adjacent glazed swinging doors or be able to accommodate a person with an escort. When possible, use automatic sliding doors instead of automatic swinging doors. Swinging automatic doors should swing in the direction of traffic and incorporate safety devices to prevent a person from being struck by a swinging door.

Thresholds, floor mats and gratings all should be flush to avoid tripping hazards.

Tenant Spaces

In designing office space, all decisions should involve providing long-term flexibility for future floor plan changes. An open plan approach, however, gives individual workstations less visual privacy, less artificial and natural daylighting control and less environmental control than closed offices. Glazed partitions with glare control fronting the open area can help add to a feeling of spaciousness and should be used where appropriate. However, care is needed to prevent glazed partitions from being dangerously less visible in circulation pathways.

In laying out workstations, avoid long rows of cubicles, or creating mazes or confusing paths of travel among workstations.

Training and conference rooms should avoid having occupants face directly into potential glare, such as a conference tables with one long side facing the windows. Lighting control for these facilities should offer a wide range of illuminance and luminance, while minimizing glare (see the current edition of the Illuminating Engineering Society of North America's *IESNA Lighting Handbook* for criteria).

Support Spaces

Custodial Spaces, Storage Rooms, Stockrooms, and Janitor's Closets: Lighting in support spaces should be adequate for workers to read labels and written instructions. Walls should have a high light reflectance value to maximize lighting levels.

Toilet Rooms: Colors and values of finishes for plumbing fixtures, partitions and countertops should provide strong value contrast to improve their visibility for users. Matte finish walls and floor tile should be selected to avoid glare. Mirrors should be provided on walls in places other than over a lavatory in each public toilet. Lighting (not integral to the mirror) should be placed over the mirror itself.

Structured Parking Garages To avoid disability glare problems for drivers, avoid locating exits where they would face the rising or setting sun, if possible. Select garage light fixtures to produce minimal glare and choose ceiling surfaces with a high light reflectance value.

Finishes

Wall Coverings Wall coverings should be selected to provide medium contrast value with the flooring and with a spectral reflectance that will minimize glare.

Doors: Interior doors should contrast with walls in color and value. Doors on corridors should have a finish that is the same on both sides of the door and in contrast with wall surfaces on both sides.

Floors: Floor finishes should comply with Architectural Barriers Act Accessibility Standard (ABAAS) slip-resistant requirements in entrances, lobbies, and atriums, where reflections and glare from windows on the flooring can cause glare and visual confusion. Resilient flooring should be selected with a spectral reflectance to minimize glare, and wall bases should be contrasted with both the wall and the floor in color and value. If using carpet, avoid contrasting colors in patterns that suggest changes in level.

Stairways: Stair nosings should contrast with treads and risers in color and value. Make all thresholds flush to avoid a tripping hazard.

Lighting

Lighting is a critical and energy-intensive component of building design. Good lighting design is a careful integration of artificial lighting and daylighting principles to provide in an energy efficient manner for the health and safety of occupants; enhance the appearance of the space; and support the performance of the occupants. An energy efficient design should be the result of providing adequate lighting levels for people of all ages. Lighting designers should be added to the A/E team to ensure a high-quality workplace.

Definitions: For many spaces, lighting design uses a combination of ambient and task lighting to provide light levels that support occupant productivity. "Ambient Lighting" is defined in terms of luminance, contrast and glare, where:

- Illiuminance = light impinging on a surface
- Luminance = light impinging on the eye (i.e.-reflected illuminance and direct impingement from lighting sources.)
- Contrast = ratio of light to dark illuminance. Contrast ratios between a task and the immediate field of view and between the immediate field of view and the surrounding area (ambient) should be 2:1 or 3:1.
- Glare = reduction in visibility caused by intense light sources in the field of view. There are two primary measures of glare: *Disability glare* is a reduction in visibility due to intense light sources in the field of view; *Discomfort glare* is a sensation of irritation or pain from high luminances in the field of view. Glare from daylighting should be considered as a major issue to be resolved.
- Lighting power density (LPD) = lighting power per unit floor area (i.e., W/sf).

Criteria: The current edition of the Illuminating Engineering Society of North America's *IESNA Lighting Handbook* should be referenced for applicable values of illuminance, luminance, contrast and glare criteria, and color temperatures of ambient light lamps for interior and exterior lighting. The current edition of the American Society of Heating, Refrigerating and Air-Conditioning Engineers' *ANSI/ASHRAE/IESNA Standard 90.1 or Standard 189.1* should be referenced for the applicable values of LPD criteria for energy efficiency. Care should be taken to rationalize the values for these two sets of criteria.

Daylighting: For daylighting design, the most critical luminance relationships are those between the daylight opening, its immediately adjacent surfaces and the surfaces surrounding the work tasks. Understanding the geometry between sun, sky, daylight opening and interior space at different times of the day and throughout the seasons is the key to setting the stage for visual comfort. When providing daylighting, glare should be minimized in open spaces with shading devices. For instance, lightshelves, which divide a window into an upper (daylight segment) and lower view segment, distribute daylight deeper into the spaces while shading the lower view window from direct sunlight and glare.

Daylighting design must mitigate the adverse effects of glare and solar heat gain. Ask these questions:

- How is daylighting factored into the energy reduction requirements?
- Doe the use of daylighting also account for additional cooling loads caused by radiant heat gains from the daylighting?
- Does the use of daylighting account for the incremental heating loads caused by reduction in heating by the lighting system?

References for daylighting design include the *IESNA Lighting Handbook* and *IESNA RP-5, Recommended Practice of Daylighting*.

Task lighting: Task lighting (providing higher levels of light at specific locations, such as a desk top) may be employed to give users flexibility in creating their own custom illuminated environment. Some individuals prefer working in lower ambient environments and may choose not to use task lighting at all.

Accent Lighting: Color, illuminance, luminance and contrast ratios for accent lighting should be synchronized as described in the *IESNA Lighting Handbook.*

Exterior Lighting: To provide for the security and safety of the occupants and passersby, as well as to enhance the architectural aesthetics of the building, the exterior lighting system should provide the required contrast sensitivity as well as illumination levels.

To improve the quality of lighting:

- Control luminance and glare from both natural and artificial lighting sources to reduce high contrast (such as from deep shadows), prevent eyestrain, and to provide acceptable occupant contrast sensitivity and visual acuity.
- Use appropriate controls to balance daylighting, occupant needs and energy efficiency.
- Provide consistent levels of illumination in circulation zones.
- Provide increased task illumination.
- Consider "transition zones" for entry points to significantly higher or lower illumination levels.
- Provide vertical illumination on room surfaces for vantage point and space definition.
- Provide high color rendition sources.
- Avoid accent or spot lighting that creates high-contrast pools of light on dark surfaces.

Appendix B

Design Guidelines for Persons with Low Vision

Proposed Outline

DRAFT 07-08-11

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