

ANSI/INFOCOMM V202.01:2016

Display Image Size for 2D Content in Audiovisual Systems

InfoComm International Standard

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11242 Waples Mill Road, Suite 200
Fairfax, VA 22030
infocomm.org
+1.703.273.7200
1.800.659.7469
+1.703.278.8082 FAX



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InfoComm International Standard

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Abstract

This Standard determines required display image size and relative viewing positions according to two defined viewing needs: Basic Decision Making and Analytical Decision Making. The Standard can be used to design a new space or to assess/modify an existing space, from either drawings or the space itself. It applies to both permanently installed systems and temporary systems. The Standard applies to the overall system and not the performance or efficiency of any component.

Keywords

Analytical decision making; audiovisual; audiovisual standard; AV; AV system performance; basic decision making; contrast; contrast ratio; detail; digital signage; display; farthest viewer; front projection; image contrast; image size; InfoComm; information; informational display; inspection; presentation; projected image; projection screen; rear projection; system contrast ratio; videoconferencing; viewing angle; viewing distance; visual acuity

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Foreword

The use of displays to convey information is widespread. Displays are essential to the working process in many environments, and viewers depend on the displayed image to convey information in adequate detail. Methods of calculating appropriate image size currently used by audiovisual professionals are not attributable to any particular source and appear to be based on precedent. Therefore, the task group developing this Standard established new methods and metrics to determine image size.

The Standard recognizes that displays are used for different purposes and identifies these purposes according to two viewing categories derived from *ANSI/INFOCOMM 3M-2011 Projected Image System Contrast Ratio* (PISCR). Having determined the categories within which the system will fall, users of this Standard can determine suitable image size or identify suitable viewing locations within existing installations.

When planning a display, audiovisual designers often encounter limitations with dimensions and layout in relation to optimal displayed image size. For instance, a large room size might dictate a large display size that limited ceiling height will restrict. This Standard provides formulas to design and display suitable content.

Displays are available in a wide variety of ever-increasing resolutions. At one end of the scale, viewers may be unable to discern required content due to displays that lack sufficient resolution. At the other end of the scale, high resolutions can negatively affect the viewing experience by rendering objects too small for viewing from typical viewing distances.

This Standard addresses image height, image resolution, and the size of image content as prescriptive elements when determining required image size. The Standard addresses closest and farthest viewing distances, as well as relative horizontal and vertical viewer locations.

Image size requirements for a display are determined by the application, the nature of the content, and the significance of the content to the viewer. Image size is but one element of a system-based approach that includes the display, its resolution, the image size relative to viewing positions, and both the viewing requirements and the visual acuity of the viewer.

The ability to perceive and assimilate visual information (visual acuity) is a defining factor in determining image size. Visual acuity is expressed in subtended arc minutes, which is the metric that describes the perceived size of an object relative to viewing distance. Individual visual acuity varies and decays with age.

Users of the Standard should note that proper display image size will not correct a negative viewing experience if content has unsuitable viewing element height (e.g., font size) or degraded images.

This Standard is limited to displayed image size determination and does not include testing and measurement of related display factors, including display luminance, contrast, display resolution, or other factors relating to the resultant condition of the displayed image.

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InfoComm International maintains a Standards Steering Committee that provides oversight to the standards development task groups responsible for specific standards. The Standards Steering Committee is the consensus body that reports to the InfoComm International Board of Directors.

At the time of this Standard's development and approval, contributors' names and affiliations are as shown:

DISPLAY IMAGE SIZE FOR 2D CONTENT IN AUDIOVISUAL SYSTEMS TASK GROUP

Greg Jeffreys, Visual Displays Ltd., Moderator

Michael Bialas, Anadarko Petroleum

Michael Comiskey, CTS, AECOM

Steven Douglas, Central Washington University

Mitch Dudman, CTS, CBCI Telecom Canada

Michael Field, M.Ed., CTS, ACE, Temple University

Steve Mills, CTS-D, CTSI

Peter Pekurar, CQE, CET, Christie Digital Systems

Dick Tollberg, CTS-D, AVI-SPL

INFOCOMM INTERNATIONAL STANDARDS STEERING COMMITTEE

Jason Brameld, BSc (Hons) ARCS, MInstSCE, Torpedo Factory Group, Chair

Jason Antinori, CTS-D, TELUS Communications Company

John Bailey, CTS-D, CTS-I, Whitlock

David Barnett, CTS-D, The Sextant Group

Greg Bronson, CTS-D, DMC-E, Cornell University

John Monitto, Meyer Sound

Richard Morrison, BE (Computer Systems), Prince2, CPEng, AECOM

Donald Palmer, Administrative Office of the United States Courts

Read Wineland, CTS, Biamp Systems

INFOCOMM INTERNATIONAL STANDARDS STAFF

Ann Brigida, CTS, CStd, Director of Standards

Michelle Streffon, CTS, Standards Manager

Page Mori, Standards Developer

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1. Scope, Purpose, and Application

1.1. Scope

This Standard defines the calculations required to determine minimum image size relative to viewing locations in both new and existing installations whether fixed or temporary.

This Standard applies to the overall system and not the performance or efficiency of any component.

This Standard uses two out of four viewing categories defined in ANSI/INFOCOMM 3M-2011, *Projected Image System Contrast Ratio* as further described in the Application section below.

This Standard should be used in conjunction with related standards for displayed images where applicable.

1.2. Purpose

This Standard provides measurement and reporting methodologies for the assessment, documentation, and categorization of new and existing audiovisual systems.

The Standard will assist professionals engaged in the design of audiovisual systems determine appropriate displayed image sizes. The Standard provides a calculation/assessment tool for determining proper display image size based upon viewer needs as defined under two main categories.

When planning a display, audiovisual designers often encounter limitations with dimensions and layout in relation to optimal displayed image size. This Standard provides formulas to design and display suitable content.

1.3. Application

This Standard can be used to:

- Plan and design new displayed image systems
- Determine image size relative to space and viewing requirements
- Determine Closest and Farthest Viewer Positions
- Determine horizontal angles of view
- Provide metrics for content design

Use of this Standard is intended for display images in fixed and temporary installations.

Exceptions are noted below.

This Standard uses two viewing requirement categories: Basic Decision Making and Analytical Decision Making. These categories are defined in ANSI/INFOCOMM 3M-2011, *Projected Image System Contrast Ratio* and have been expanded. Users select corresponding calculations to determine the required image size and conforming viewing locations. A chart defining both viewing categories in greater detail can be found in Annex 6.3.

1.4. Exceptions

This Standard does not:

- Consider quality and aesthetic issues with regard to content (e.g., focus, color, contrast).
- Include factors such as contrast, luminance, color rendition, and video motion rendition.
- Apply to personal viewing displays (e.g., cell/mobile phones and tablets).
- Apply to single-user displays (e.g., computer monitors, laptop screens).
- Apply to 3D images.
- Apply to screens that are not in the vertical plane (e.g., tilted screen).

- Apply to Full Motion Video and Passive Viewing categories identified in ANSI/INFOCOMM 3M-2011, *3M Projected Image System Contrast Ratio (PISCR)*.
- Apply to images outside of single-image landscape format.
- Apply to curved displays.
- Apply to systems where viewers can move as close to the image as they choose. However, the formulas provided in the Standard may be used for guidance.
- Apply to displays used in an interactive manner. However, the formulas provided in the Standard may be used for guidance.

2. Referenced Publications

2.1. Normative References

The following standards contain provisions that, through reference in this text, constitute provisions of this document. At the time of approval, the editions indicated below were valid. Because standards are periodically revised, users should consult the latest revision approved by the sponsoring Standards Developing Organizations:

There are no normative references for this Standard.

2.2. Informative References

The following publications contain information that support the design and application of this Standard, but are not required provisions of the Standard:

ANSI/INFOCOMM 3M-2011, *Projected Image System Contrast Ratio*

ANSI/HFES 100-2007, *Human Factors Engineering of Computer Workstations*

Peter G.J. Barten – Knegsel, Contrast Ratio Sensitivity of the Human Eye and its Effects on Image Quality, (HV Press, 1999)

Hongyi Cai, Ph.D., and Paul A. Green, Ph.D., Legibility Index for Examining Common Viewing Situations: A New Definition Using Solid Angle

Peter G. Engeldrum, Psychometric Scaling: A Toolkit for Imaging Systems Development, (Imcotek Press, 2009)

MIL-STD-1472G, DEPARTMENT OF DEFENSE DESIGN CRITERIA STANDARD: HUMAN ENGINEERING (United States Government, 2012)

Herman Snellen, Eye Chart (Amsterdam, 1862)

3. Definitions

3.1. Abbreviations

For the purposes of this Standard, the following abbreviations apply:

%EH	Percent Element Height
ADM	Analytical Decision Making
BDM	Basic Decision Making
CV	Closest Viewer Distance
FV	Farthest Viewer Distance
IH	Image Height
IO	Image Offset

IR	Vertical Image Resolution
IW	Image Width
VF	Vertical Viewing Factor

3.2. Definitions

All equations are expressed following ISO/IEC DIR 2, *Rules for the structure and drafting of International Standards*, Edition 6.0 2011-04.

For the purposes of this Standard, the following definitions apply:

- 3.2.1. **%Element Height:** The height of an element in relation to the overall Image Height. The BDM %Element Height factor represents the ratio of element height to screen height expressed as a percentage (e.g., 1% represents an element height of 1 unit relative to 100 units screen height). The Standard provides a range of percentages; users of the Standard should vary this percentage according to the content.
- 3.2.2. **Acuity Factor:** A constant derived from the Visual Acuity standards formulas. The Acuity Factor for Analytical Decision Making and Basic Decision Making are different constants, as the formulas to calculate each are different. The Acuity Factor for Basic Decision Making is 200. The Acuity Factor for Analytical Decision Making is 3438. See Annex 1 for a detailed discussion of these factors.
- 3.2.3. **Closest Viewer Distance:** The horizontal distance between the display image and viewer.
- 3.2.4. **Conforming Viewing Area:** The area bounded by the closest and farthest viewer calculations in conformance for viewing the specified content.
- 3.2.5. **Display Image:** The active image area displaying the user's content.
- 3.2.6. **Element:** This term is used in relation to Basic Decision Making. It refers to a group of pixels conveying an item of information (e.g., a character at a given font size). Users of this Standard shall ensure that the display has sufficient resolution to render an element at its smallest prescribed size.
- 3.2.7. **Farthest Viewer Distance:** Viewer positioned at the farthest distance from the screen as defined by the viewing area.
- 3.2.8. **Horizontal Viewing Area:** The area bounded by a line drawn 60 degrees from the perpendicular of each edge of the image to determine Closest Viewer.
- 3.2.9. **Image Offset:** The difference in height between the floor to the bottom of the image against the Viewing Height. The calculation is expressed as a positive number if the bottom of the image is above the Viewing Height and a negative number if the bottom of the image is below the Viewing Height.
- 3.2.10. **Vertical Viewing Factor:** A value derived from the sum of the Image Height and the Image Offset. The Vertical Viewing Factor shall be undefined if the calculation results in a factor that is less than 50 percent of the Image Height. In this case, the closest viewer cannot be defined by the standard, but the farthest viewer still can be defined.
- 3.2.11. **Viewer:** An observer with normal/corrected vision, or normal visual acuity of 20/20 as defined in *The International Council of Ophthalmology 'Visual Acuity Measurement Standard' 1984*.
- 3.2.12. **Viewing Area Plan:** Plan view drawing of the viewing environment.
- 3.2.13. **Viewing Height:** The distance from the floor to the eye of the viewer.
- 3.2.14. **Viewing Ratio:** The ratio found by dividing the Viewing Distance by the Image Height.
- 3.2.15. **Visual Acuity:** The ability to discern details and shapes of objects.

4. Requirements

4.1. Planning or Assessing Displayed Image System Requirements for the Space

The user shall:

1. Determine applicable viewing based on intended use of the space, selecting the category(ies) according to the descriptions in section 4.2. Refer to Annex 6.3 for a chart describing the viewing categories in greater detail.
2. Follow the steps for calculations described within the selected category (4.3, 4.4, or 4.5) below.

4.2. Viewing Category Descriptions

4.2.1. Basic Decision Making

The viewer can make basic decisions based on the displayed image. The decisions are not dependent on critical details within the image, but the viewer can assimilate and retain information. The viewer is actively engaged with the content (e.g., information displays, presentations containing detailed images, classrooms, boardrooms multi-purpose rooms, product illustrations). Graphic images and text are legible to the extent that the viewer can make decisions based on what is being seen. Decisions are made by comprehending the informational content itself and are not dependent on the resolution of every element of detail.

4.2.2. Analytical Decision Making

The viewer is fully engaged with minute detail present in the content and needs to be able to resolve every element of the displayed image. Analytical decision-making environments support critical assessments, including but not limited to examination of medical imaging, fine arts, engineering or architectural drawings, electrical schematics, photographic image inspection, forensic evidence, or failure analysis.

System design criteria may include one or both of these viewing categories based on the needs of the viewer.

4.3. Basic Decision Making Only

If Basic Decision Making is selected:

Users of the Standard have multiple factors or variables to consider. Users who opt to use the formulas below should note that the processes of determining display image size and viewing positions may be iterative while all design factors are considered.

The following variables are employed:

1. %Element Height. Basic Decision Making (BDM) incorporates consideration of image content, specifically element height, the prime example being font size. The BDM %Element Height factor represents the ratio of element height to screen height expressed as a percentage (e.g., 1.0% represents an element height of 1 unit relative to 100 units screen height). The Standard provides a default percentage of x; users of the Standard should vary this percentage according to the content.
2. BDM Acuity Factor (200). This variable relates to visual acuity, specifically 20/20 vision, and provides the user with an easy-to-use method to relate perceived Element Height relative to viewing distance by providing an alternative to the trigonometric calculations otherwise required.

3. Vertical Viewing Factor and Image Offset. These variables relate to the vertical position of the displayed image. *The Vertical Viewing Factor shall be undefined if the calculation results in a factor that is less than 50 percent of the Image Height.*

Users shall execute the following steps as appropriate:

4.3.1. Determine Minimum Image Height if Farthest Viewer Distance and %Element Height are known

To determine (user-required) minimum Image Height, the formula is:

$$IH = \frac{FV}{200 \times \%EH}$$

Where:

- IH is the minimum Image Height for the space
- FV is the farthest distance a viewer will be from the image
- %EH is the Element Height, which is the height of the element being viewed expressed as a percentage of overall image height
- 200 is the Acuity Factor for Basic Decision Making

Note that the display shall have sufficient resolution to render an element at its smallest prescribed size.

Farthest Viewer Distance shall be determined either by physical measurement in an existing space or from the architectural layouts.

4.3.2. Determine Farthest Viewer Distance if Minimum Image Height and %Element Height are known

To determine Farthest Viewer Distance, the user shall make the following calculation:

$$FV = IH \times \%EH \times 200$$

Where:

- FV is the Farthest Viewer Distance
- IH is the Image Height
- %EH is the percent Element Height
- 200 is the Acuity Factor for BDM

4.3.3. Determine Closest Viewer Distance

The Closest Viewer Distance for Basic Decision Making is determined by two factors:

1. a viewing angle restriction of 30 degrees above the eye position for the Closest Viewer, and
2. a viewing angle restriction such that no viewing position in the horizontal plane exceeds 60 degrees at any part of the displayed image. This is to ensure viewers at the widest viewing positions can adequately view the entire image.

To determine Closest Viewer Distance:

First, determine the Vertical Viewing Factor for both Closest Viewer and Image Height. The user shall make the following calculations:

To determine the Vertical Viewing Factor:

$$VF = IH + IO$$

Where:

VF is the vertical viewing factor

IH is the image height

IO is the image offset

To determine the Closest Viewer:

$$CV = VF \times 1.732$$

Where:

CV is the closest viewer distance

VF is the vertical viewing factor. Note: The Vertical Viewing Factor shall be undefined if the calculation results in a factor less than 50 percent of the Image Height.

Next, determine the Horizontal Closest Viewer Distance:

$$\text{Horizontal Distance from Display Image to CV} = 6 \times VF - IW$$

Where:

CV is the closest viewer distance

VF is the vertical viewing factor

IW is the image width

The result of this calculation may be wider than the room. In this case, the room width determines the overall length of the closest viewer boundary.

The output of the formulas for Closest and Farthest Viewer Distance shall be shown on a viewing area drawing (plan view) per the example in Section 5.3.4 to inform clients and architects during the design process, as well as to guide users of the facility to specify content size appropriate to the space.

The output for the Closest Viewer Distance shall be shown on an elevation or section drawing (side view) per the example in Section 5.3.4. Elevation and section drawings are used to inform clients and architects during the design process.

4.3.4. Determine Minimum %Element Height

To determine the appropriate minimum %Element Height for a given Image Height and Farthest Viewer Distance, the user shall make the following calculation:

$$\%EH = \frac{FV}{IH \times 200}$$

Where:

%EH is the percent element height

FV is the farthest viewer distance

IH is the image height

4.4. Analytical Decision Making Only

IF Analytical Decision Making (ADM) is selected:

Users of the Standard have multiple factors or variables to consider. When using the formulas below, the processes of determining display image size and viewing positions may be iterative while all design factors are considered.

The following variables are employed:

- A. ADM Acuity Factor (3438). This factor relates to visual acuity, specifically 20/20 vision, and provides the user with an easy-to-use method to relate image resolution (pixel height) relative to viewing distance by providing an alternative to the trigonometric calculations otherwise required.
- B. Vertical Image Resolution (e.g., 1080)
- C. Vertical Viewing Factor and Image Offset. These factors relate to the vertical position of the displayed image.

Users shall execute the following steps as appropriate:

To determine (user-required) minimum Image Height, the user shall make the following calculation:

$$IH = \frac{(IR \times FV)}{3438}$$

Where:

IH is the image height

IR is the vertical image resolution

FV is the farthest viewer distance

3438 is the Acuity Factor for ADM

To determine the Farthest Viewer distance when image height is fixed, the user shall make the following calculation:

$$FV = \left(\frac{IH}{IR} \right) \times 3438$$

Where:

FV is the Farthest Viewer distance

IR is the Vertical Image Resolution

IH is the Image Height

3438 is the Acuity Factor for ADM

Closest Viewer Distance

Analytical Decision Making is considered a specialist viewer category relative to Basic Decision Making. In some instances, the viewers can move very close to the image to view it in detail. Additionally, very high-resolution displays may be used. Therefore, Closest Viewer calculations for ADM are limited to horizontal viewing restrictions only.

The Closest Viewer Distance for Analytical Decision Making is determined by a viewing angle restriction such that no viewing position in the horizontal plane exceeds 60 degrees at any part of the displayed image. This is to ensure viewers at the widest viewing positions can adequately view the entire image. See Figure 1 and Figure 2 in section 5.3.

The output of the formulas for Closest and Farthest Viewer Distance shall be shown on a viewing area drawing (plan view) per the example in section 6.5.

4.5. Both Basic and Analytical Decision Making

IF Basic Decision Making (BDM) AND Analytical Decision Making (ADM) are BOTH selected:

1. When viewing requirements dictate use of both BDM and ADM, the image size and viewing distances shall be determined by the ADM formulas in section 4.4.
2. Once these calculations have been made, the user shall calculate the %Element Height and Closest Viewer boundaries as described in sections 4.3.3 and 4.3.4.

Users will note that in the case of high resolution displays selected for enhanced viewing requirements of ADM, it is theoretically possible to display elements (e.g., fonts) of impractically small size relative to viewer needs. Therefore, it is necessary to calculate the %Element Height appropriate for the display image size chosen for ADM viewing needs.

5. Verification of Conformance

5.1. Conformance

Verification of conformance to this Standard shall include:

1. Completion of Verification Sheet detailing all calculation results and key system data.
2. Completion of Plan View Drawing according to Section 5.3.
3. Completion of Elevation or Section View Drawing according to Section 5.3.3 for BDM only.

If a space is used for both ADM and BDM content, a separate plan view drawing for each viewing category shall be provided.

5.2. Verification Sheet

The Verification Sheet shall include, as appropriate:

- Displayed image width
- Displayed image height
- Displayed image resolution
- %Element Height
- Room layout and dimensions, including ceiling height and any space features affecting sightlines
- Closest viewer distance
- Farthest viewer distance
- Distance between the bottom of the image and the finished floor
- Eye height of viewers
- Room description
- Any available or relevant data concerning system application or content to be displayed

5.3. Drawings

Measurements shown on the drawings shall include:

5.3.1. Plan view for BDM

Display image width

Room layout and dimensions

Horizontal viewing angles as lines drawn from either edge of the image at a 60-degree angle toward the opposite side of the image.

Line showing Closest Viewer, parallel to the screen

Arc showing Farthest Viewer Distance

(See section 5.3.5)

5.3.2. Plan view for ADM

Display image width

Room layout and dimensions

Horizontal viewing angles as lines drawn from either edge of the image at a 60-degree angle toward the opposite side of the image.

Arc showing Farthest Viewer Distance

(See section 5.3.5)

5.3.3. Elevation view for BDM

Elevation dimensions, including ceiling height, room length, and any features that affect viewing positions

Display image height

Distance between the bottom of the image and the finished floor

Line drawn at 30 degrees from top of image

Seated and/or standing eye height of viewers

5.3.4. Elevation view for ADM

No elevation drawing is required for ADM as vertical viewing distances are not considered.

5.3.5. Both plan and elevation view

Conforming viewing area.

Indicate the areas that conform with the viewing category(ies) selected, according to the calculations made.

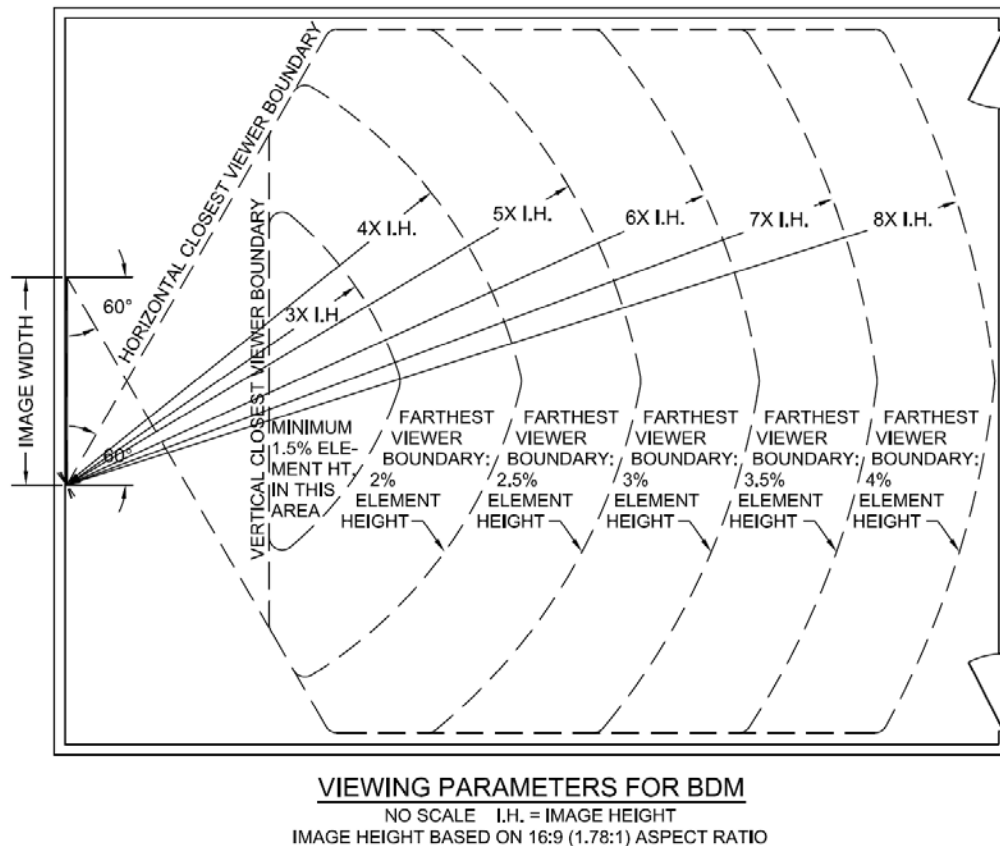
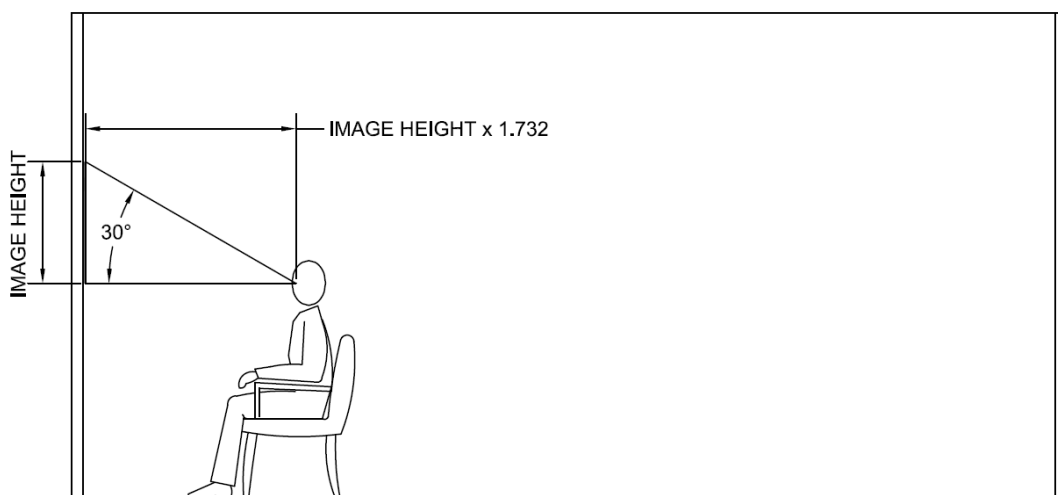


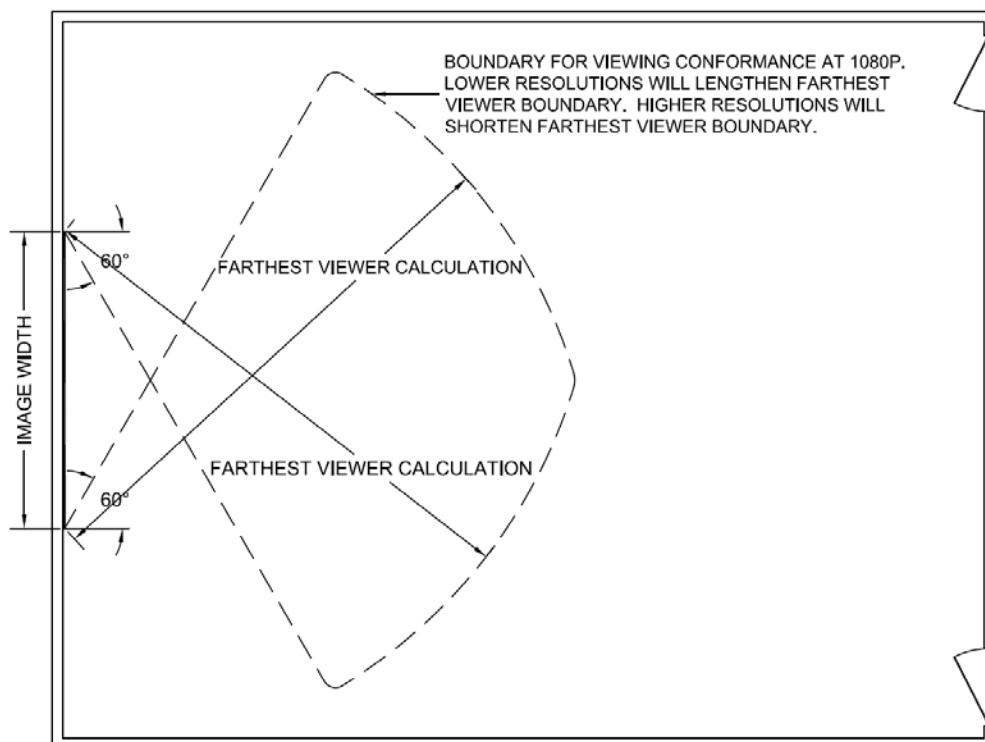
Figure 1 Showing Farthest Viewer Boundaries based on content size (%EH)



CLOSEST VIEWER CALCULATION FOR BDM

NO SCALE
IMAGE HEIGHT BASED ON 16:9 (1.78:1) ASPECT RATIO

Figure 2 Showing Closest Viewer Elevation Drawing for BDM



VIEWING PARAMETERS FOR ADM

NO SCALE
IMAGE HEIGHT BASED ON 16:9 (1.78:1) ASPECT RATIO

Figure 3 Example showing boundary conformance at 1080 and parameters for ADM

6. Informative Annexes

6.1. Derivation of Acuity Factors

The Acuity Factors for both Analytical Decision Making (ADM) and Basic Decision Making (BDM) are constants derived to simplify the calculation of the minimum image height recommended for a given space. The factors are based on the trigonometric portion of each formula, shown in Figure 4. The only requirement is that the agreed upon visual acuity for both Analytical and Basic Decision Making is being utilized, as the constants will change if the desired visual acuity changes.

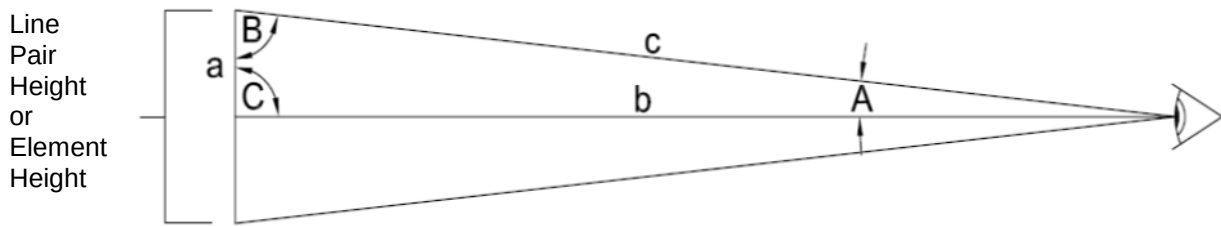


Figure 4 Depiction of Viewing Angle

For ADM, a represents the height of one pixel. $2*a$ represents the height of a line pair.

For BDM, $2*a$ represents the height of an element.

A represents $\frac{1}{2}$ the visual acuity in degrees.

A minute of arc (MOA) is $\frac{1}{60}$ of a degree.

b represents the viewing distance.

Note that $b = a / \tan(A)$.

For ADM, note that *Image Height* = # Vertical Pixels * Pixel Height.

For BDM, note that *Image Height* = $1 / (\text{Element Height} * \% \text{Element Height})$.

6.1.1. Deriving the Acuity Factor for Analytical Decision Making

The formula for determining minimum image height for Analytical Decision Making is:

$$\text{Minimum Image Height} = \text{Maximum Viewing Distance} * \# \text{ Vertical Pixels} * \tan \left(\frac{\text{MOA}}{2} \right)$$

Where:

Minimum Image Height = the recommended minimum image height for the space.

Maximum Viewing Distance = the maximum distance a viewer will be from the image.

Vertical Pixels = the number of vertical pixels comprising the image height.

MOA = visual acuity required for a line pair expressed in minutes of arc.

The equation may also be expressed as:

$$\text{Minimum Image Height} = (\text{Maximum Viewing Distance} * \# \text{ Vertical Pixels}) / (1 / \tan\left(\frac{\text{MOA}}{2}\right))$$

as $a = b * c$ can also be written as $a = b / (\frac{1}{c})$.

While $\tan\left(\frac{\text{MOA}}{2}\right)$ can be calculated to a constant where MOA is stated, the resultant number is significantly less than one and is very small, making it cumbersome to use. Utilizing the result from $(1 / \tan\left(\frac{\text{MOA}}{2}\right))$ yields a constant that can be rounded to a whole number while still providing the accuracy required for the calculation. This constant is the Acuity Factor for Analytical Decision Making or ADM_{AF} . The formula now becomes:

$$\text{Minimum Image Height} = \frac{\text{Maximum Viewing Distance} * \# \text{ Vertical Pixels}}{ADM_{AF}}$$

Where $ADM_{AF} = (1 / \tan\left(\frac{\text{MOA}}{2}\right))$.

Let's consider the following calculation of ADM_{AF} . The Snellen eye chart line listed as 20/20 contains an E character which subtends 5 minutes of arc for a viewer 20 feet from the chart. The letter E is comprised of 2-1/2 line pairs, which calculates to a required visual acuity of 2 minutes of arc to read the letter. If this number is applied to the expression above, ADM_{AF} is calculated to be 3437.75, which can be rounded to 3438 without sacrificing any meaningful accuracy.

6.1.2. Deriving the Acuity Factor for Basic Decision Making

The formula for determining image height for Basic Decision Making is:

$$\text{Minimum Image Height} = 2 * \frac{\text{Maximum Viewing Distance} * \tan\left(\frac{\text{MOA}}{2}\right)}{\%Element}$$

Where:

Minimum Image Height = the recommended minimum image height for the space.

Maximum Viewing Distance = the maximum distance a viewer will be from the image.

%Element = the height of the element being viewed expressed as a percentage of overall image height.

MOA = visual acuity required for an element expressed in minutes of arc.

The equation above may also be expressed as:

$$\text{Minimum Image Height} = 2 * \frac{\text{Maximum Viewing Distance}}{1 / \tan\left(\frac{\text{MOA}}{2}\right) * \%Element}$$

The equation can be multiplied by one in the form of 0.5/0.5, which yields the expression:

$$\text{Minimum Image Height} = \frac{\text{Maximum Viewing Distance}}{0.5 / \tan\left(\frac{\text{MOA}}{2}\right) * \%Element}$$

Where MOA is stated for Basic Decision Making, the expression $(0.5 / \tan\left(\frac{\text{MOA}}{2}\right))$ can be calculated to a constant. This constant shall be called the Acuity Factor for Basic Decision Making or BDM_{AF} . The expression now becomes:

$$\text{Minimum Image Height} = \frac{\text{Maximum Viewing Distance}}{BDM_{AF} * \%Element}$$

where $BDM_{AF} = (0.5 / \tan\left(\frac{\text{MOA}}{2}\right))$.

Using an MOA of 17.25, we calculate BDM_{AF} to be 200.

6.2. Derivation of Width for Closest Viewer Calculations

The Closest Viewer is determined by a combination of factors, including vertical and horizontal viewing angles. As the maximum vertical and horizontal angles for closest viewer are already determined, those angles can be applied into the calculations and derive an easy-to-use formula that will allow the designer to determine closest viewer accurately without using trigonometry.

6.2.1. Deriving the Vertical Viewing Factor

This factor is simply rendered:

$$\text{Vertical Viewing Factor} = (\text{Image Height} + \text{Image Offset})$$

Where:

Image Height = the image height for the space.

Image Offset = the distance from eye level to the bottom of the image.

Note that the Image Offset is a positive number if the bottom of the image is above eye level and is a negative number if the image is below eye level. If the bottom of the image is at eye level, the offset goes away. Also note that eye level is not specified here as the formula will apply to typical seated or standing positions or any variance in the average eye level for a special application.

6.2.2. Deriving the Closest Viewer based on the Vertical Viewing Factor

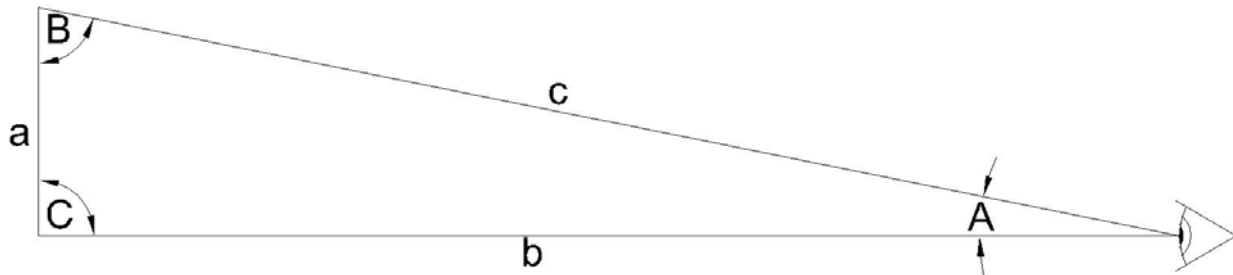


Figure 5 Vertical Viewing Factor

If “a” in Figure 5 represents the Vertical Viewing Factor and the maximum recommended viewing angle above eye level is 30 degrees (“A”), “b” can be solved as the distance to the closest viewer:

$$b = a / \text{TAN}(A)$$

If “a” represents the Vertical Viewing Factor, then “b” represents the distance to the closest viewer based on vertical viewing. The formula becomes:

$$\text{Closest Viewer} = \text{Vertical Viewing Factor} / \text{TAN}(30)$$

Solving this equation by assigning a Vertical Viewing Factor of 1 yields a closest viewer of 1.732 units. This means that for every unit height of the Vertical Viewing Factor, multiplying the Vertical Viewing Factor by 1.732 will yield the closest viewer based on vertical viewing.

6.2.3. Deriving the Closest Viewer based on the Horizontal Viewing

The concept for the closest viewer based on horizontal viewing is depicted in Figure 6.

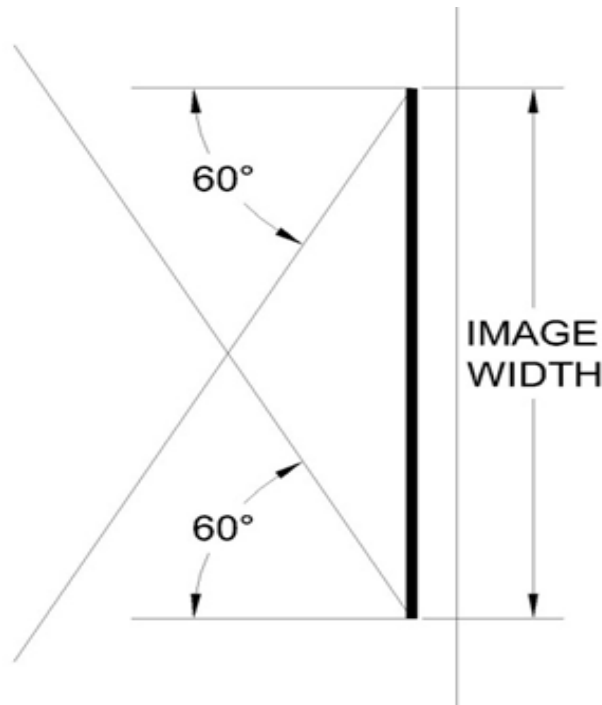


Figure 6 Closest viewer based on horizontal viewing

The good viewing area is defined as an angle that is drawn from each edge of the image 60 degrees inward. Any viewer who is inside of the area defined by the two intersecting lines can be considered within the good viewing area. The closest viewer can be closest when they are centered on the image. As they move off-center of the image, the closest viewer gradually moves farther from the image.

The two different aspects of determining the closest viewer must now be combined to get an accurate determination of the recommended closest viewing within a space. This combination is depicted in Figure 7.

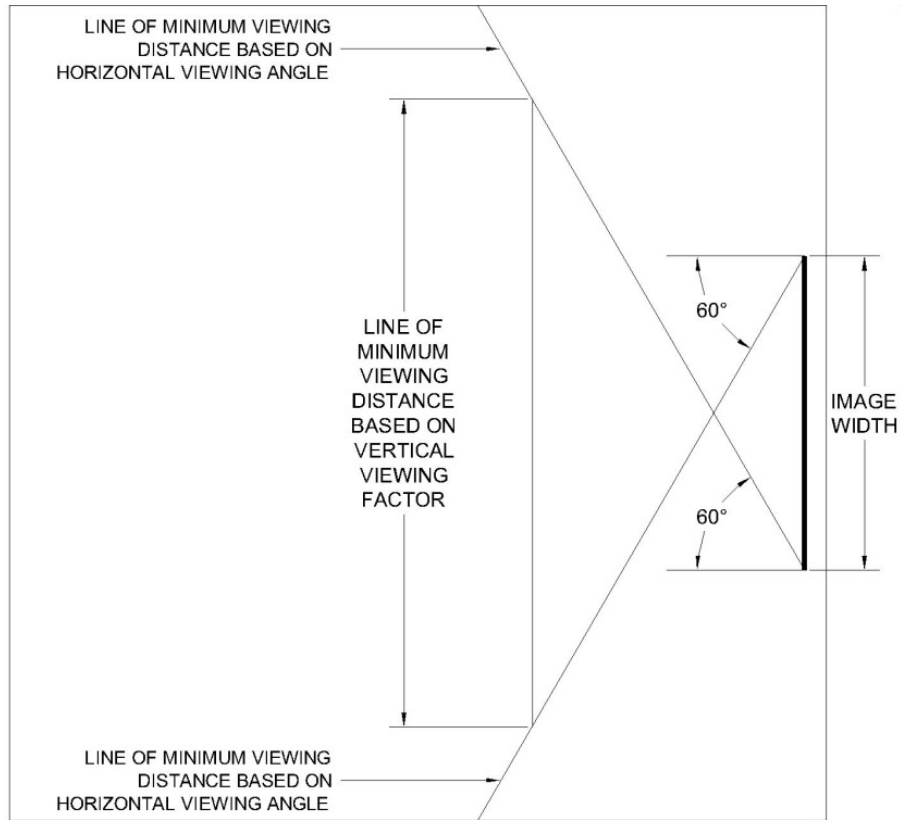


Figure 7 Closest viewer based on horizontal viewing and vertical viewing factor

The closest viewer calculations must take both calculations into account and apply whichever calculation is most stringent to a given area. In the figure above, the vertical component of the calculation dominates the solution until you get to the edges of the room, where the horizontal component takes over. In truth, the depiction of the closest viewer area takes both calculations into account where the ratio of the Image Width to the Vertical Viewing Factor is less than 6:1. For images greater than 6:1, the vertical viewing component does not come into play. This will be shown later.

There is an easy way to calculate the line of minimum viewing distance based on Vertical Viewing Factor. Let's refer back to the vertical calculation again:

$$\text{Closest Viewer} = \text{Vertical Viewing Factor} / \text{TAN}(30)$$

Now, let's look at Figure 8. It is the same as Figure 7 except some notes have been deleted and labels have been added to make the following calculations a bit easier to follow.

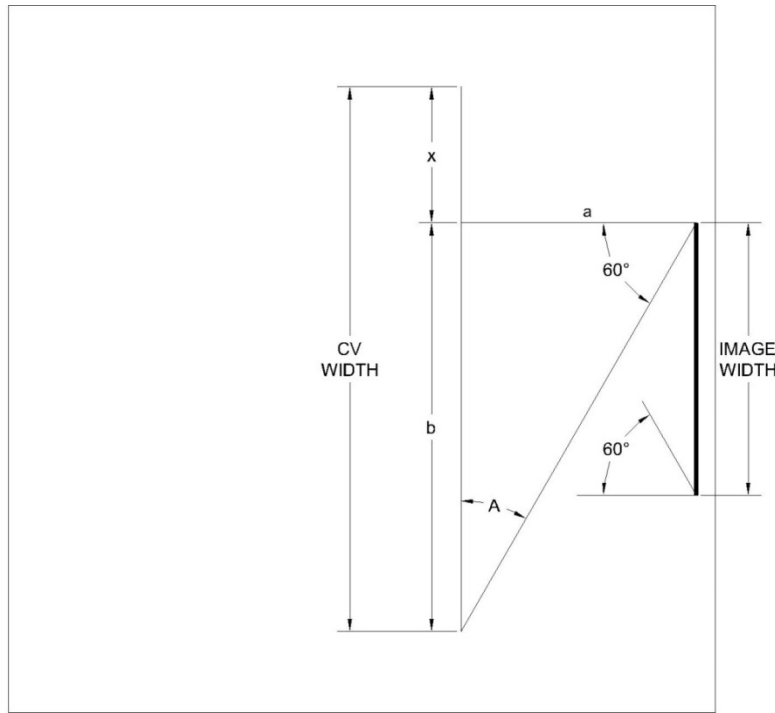


Figure 8 Simplified closest viewer

In Figure 8, “a” can be expressed as the Vertical Viewing Factor/TAN(30). We can also see, by inspection that the CV (Closest Viewer) Width can be expressed as (2 * x) + Image Width. Let’s look at solving for “b”:

$b = a / \text{TAN}(A)$, which can also be written as $b = a * 1 / \text{TAN}(A)$

So: $b = \left(\text{Vertical Viewing Factor} * \frac{1}{\text{TAN}(30)} \right) * \frac{1}{\text{TAN}(30)}$

And, further: $b = \text{Vertical Viewing Factor} * \left(\frac{1}{\text{TAN}(30)} \right)^2$

Now, we also can see that: $b = \text{Image Width} + x$

So: $\text{Image Width} + x = \text{Vertical Viewing Factor} * \left(\frac{1}{\text{TAN}(30)} \right)^2$

And: $x = \text{Vertical Viewing Factor} * \left(\frac{1}{\text{TAN}(30)} \right)^2 - \text{Image Width}$

And, we know that: $\text{CV Width} = \text{Image Width} + 2 * x$

So, the result is:

$\text{CV Width} = \text{Image Width} + 2 * \left(\text{Vertical Viewing Factor} * \left(\frac{1}{\text{TAN}(30)} \right)^2 - \text{Image Width} \right)$

This also can be expressed as:

$\text{CV Width} = \text{Image Width} + 2 * \left(\text{Vertical Viewing Factor} * \left(\frac{1}{\text{TAN}(30)} \right)^2 \right) - 2 * \text{Image Width}$

And:

$\text{CV Width} = 2 * \left(\text{Vertical Viewing Factor} * \left(\frac{1}{\text{TAN}(30)} \right)^2 \right) - \text{Image Width}$

Finally, we can calculate that: $\left(\left(\frac{1}{\text{TAN}(30)} \right)^2 \right) = 3$

So, the final result is:

$$CV\ Width = 6 * Vertical\ Viewing\ Factor - Image\ Width$$

This solution will allow the designer to calculate and draw out the closest viewer of a given space without having to do the trigonometry. Note that when the image width increases to a width of 6 times or greater than the Vertical Viewing Factor, this formula zeros out, which means that only the horizontal viewing calculation has any meaning for the closest viewer.

The end result of this exercise is depicted in Figure 9.

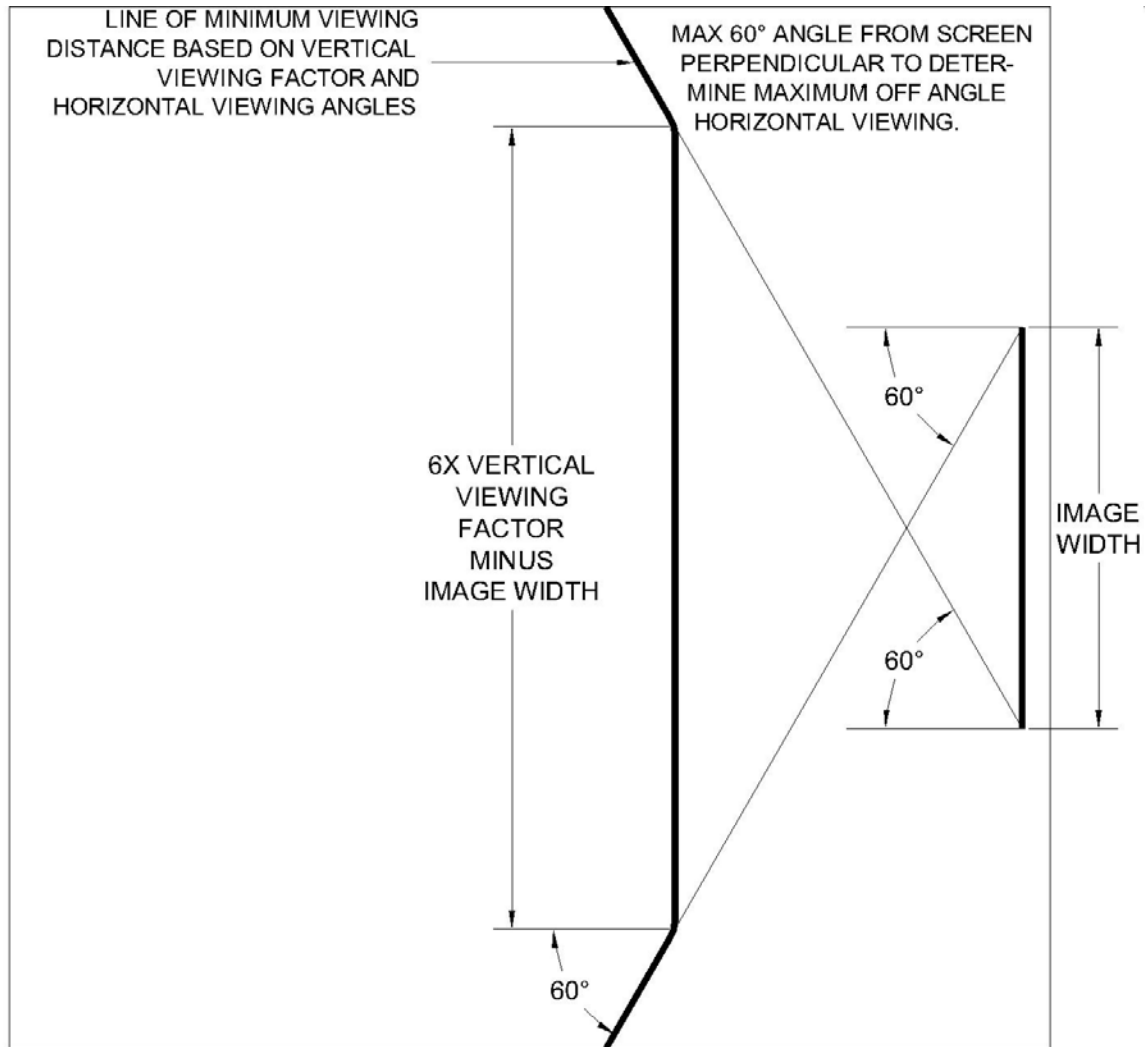


Figure 9 Closest Viewing Area

6.3. Expanded Viewing Categories

Basic and Analytical Decision Making Chart

The viewing categories described in this Standard originated in ANSI/INFOCOMM 3M-2011, *Projected Image System Contrast Ratio*.

	Basic Decision Making (BDM)	Analytical Decision Making (ADM)
Definition	15:1 Minimum Contrast Ratio The viewer can make basic decisions from the displayed image. Images and text are legible to the extent that basic decisions can be made Decisions based on content itself, not resolution of detail Non-analytical viewing The viewer is actively engaged with the content (e.g., information displays, presentations containing text and images, classrooms, boardrooms, multi-purpose rooms, product illustrations).	50:1 Minimum Contrast Ratio The viewer can make critical decisions with the ability to analyze details within the displayed image. The viewer is analytical and fully engaged with the content's details. This category requires that the finest detail available in an image is evident down to one line pair (e.g., art history classrooms, medical imaging, architectural/engineering drawings, forensic evidence, image inspection).
Communication Level	Basic information is retained Line-pair level detail in image not required	Analyze (fine) detail to make critical decisions Line-pair detail in image is required
Description	Ability to discern elements that are a certain percentage of the overall image height, relative to viewing distance Ability to absorb information within time constraints	Based on visual acuity to discern a line pair Placing as much information on the screen as possible and be able to discern all of the intended detail Ability to view analytical material for extended period of time Ability to view analytical material for extended period of time Comfort not a significant factor
Environment	Typical office environment, meeting rooms, classrooms Unpredictable ambient light Possible task lighting	Highly controlled environment Controlled ambient light Focused task lighting No ambient light directly affecting screen, black-out window treatments

6.4. Example Verification Sheet

This Annex shows an example Verification Sheet per items in Section 5.2.

Display Image Size Verification Sheet	
Location:	Date of Test:
Viewing Requirement Category:	
%Element height of content	
Room layout and dimensions, including ceiling height and any space features affecting sightlines	
Display image width	
Display image height	
Display image resolution	
Closest viewer distance	
Farthest viewer distance	
Distance between the bottom of the image and the finished floor	
Eye height of viewers	
Any available or relevant data concerning system application or content to be displayed	
Measurements taken by:	

6.5. Example Plan View and Elevation Drawings

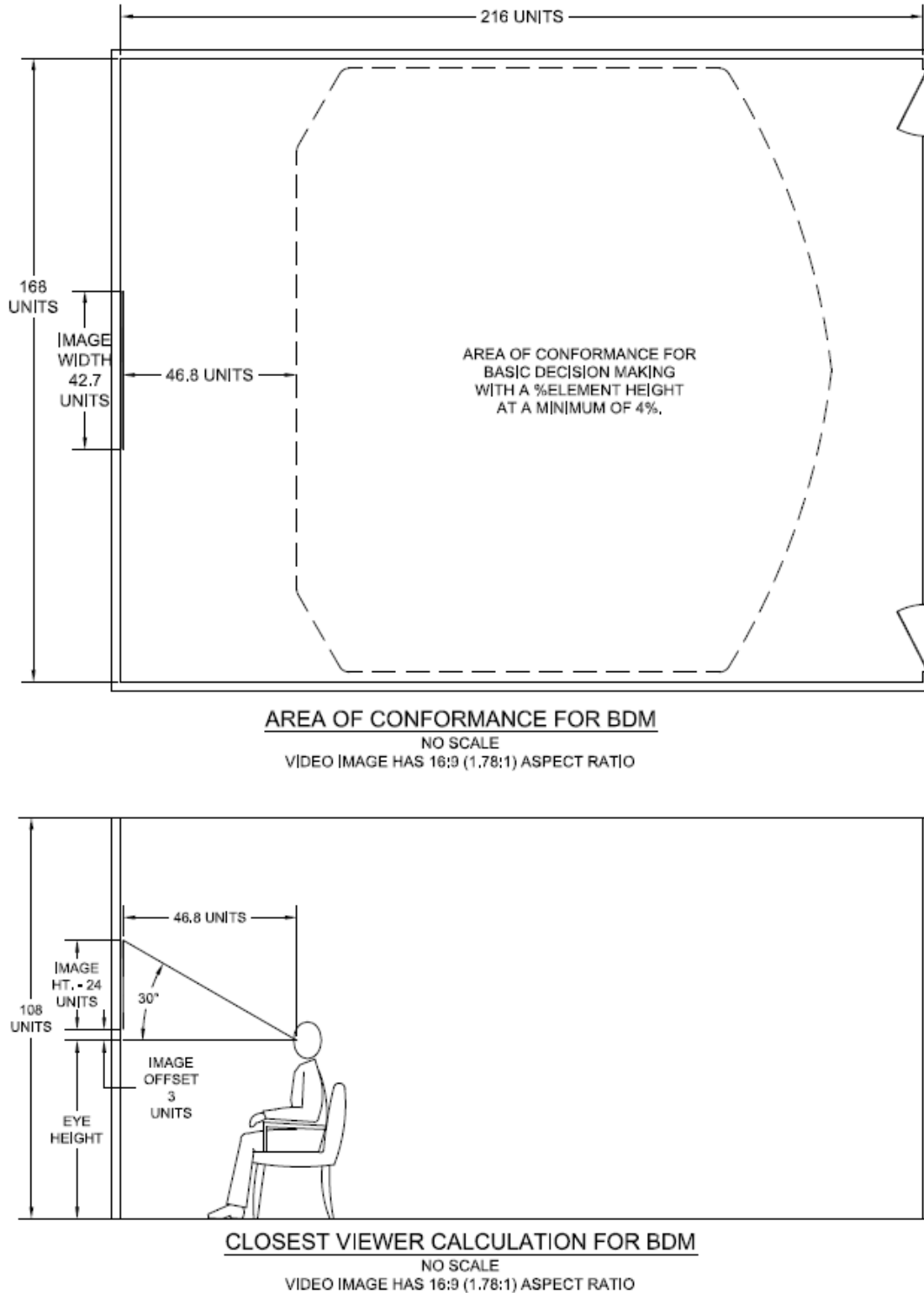


Figure 10 Example of Plan View and Elevation Drawing showing required measurements

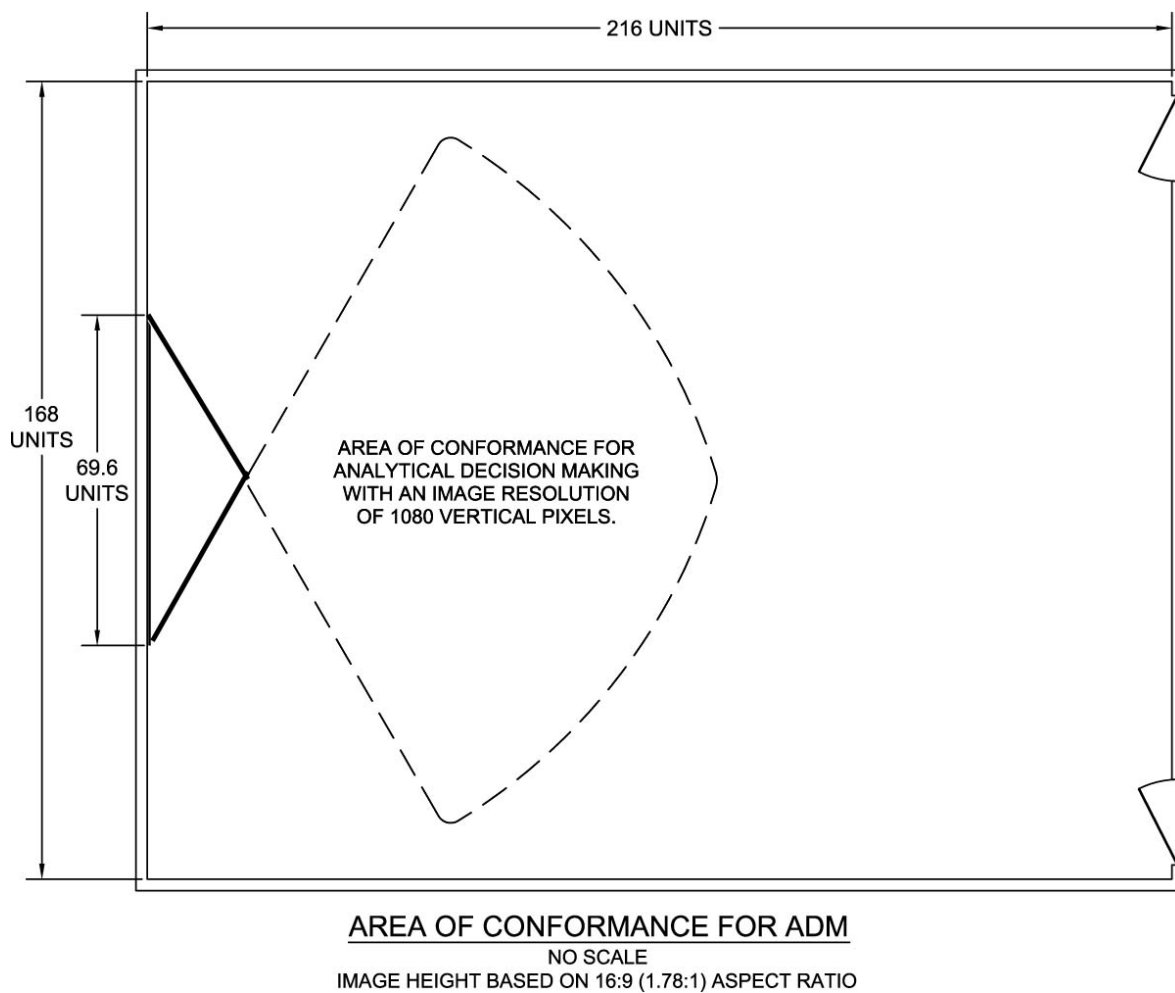


Figure 11 Example of Plan View Drawing showing required measurements

6.1. Vocabulary and Terms

- 6.1.1. **Image Aspect Ratio:** The ratio found by dividing the image width by the image height.
- 6.1.2. **Closest Viewer:** The minimum distance a viewer shall be positioned relative to a displayed image based on the standard calculations.
- 6.1.3. **Farthest Viewer:**
- 6.1.4. The maximum distance a viewer shall be positioned relative to a displayed image based on the standard calculations.
- 6.1.5. The farthest attainable distance between the displayed image and a viewer in a given space.
- 6.1.6. **Displayed image:** The image being referenced.
- 6.1.7. **Image Height:** The measured height of the displayed image.
- 6.1.8. **Image Width:** The measured width of the displayed image.
- 6.1.9. **Viewer:** A person viewing an image.
- 6.1.10. **Viewing Distance:** The measured distance between the viewer and the displayed image.

APPROVAL VERIFICATION



Ann E. Brigida, CTS, CStd
Director of Standards
InfoComm International



Jason Brameld, BSc (Hons) ARCS, MInstSCE
Chair, Standards Steering Committee
InfoComm International