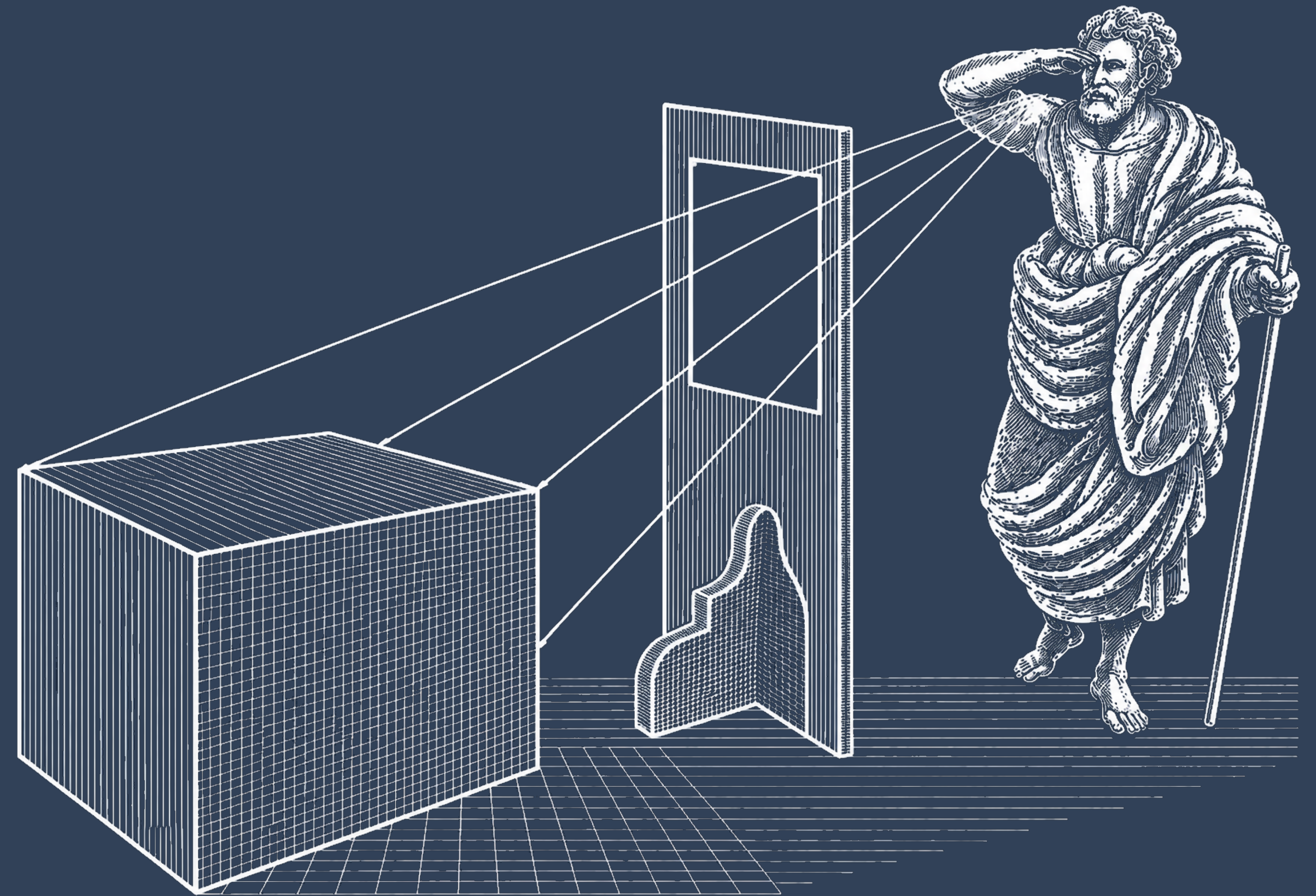


Perspective

Past, Present and Future

Alan S. Radley

Perspective Research Centre



In this talk...

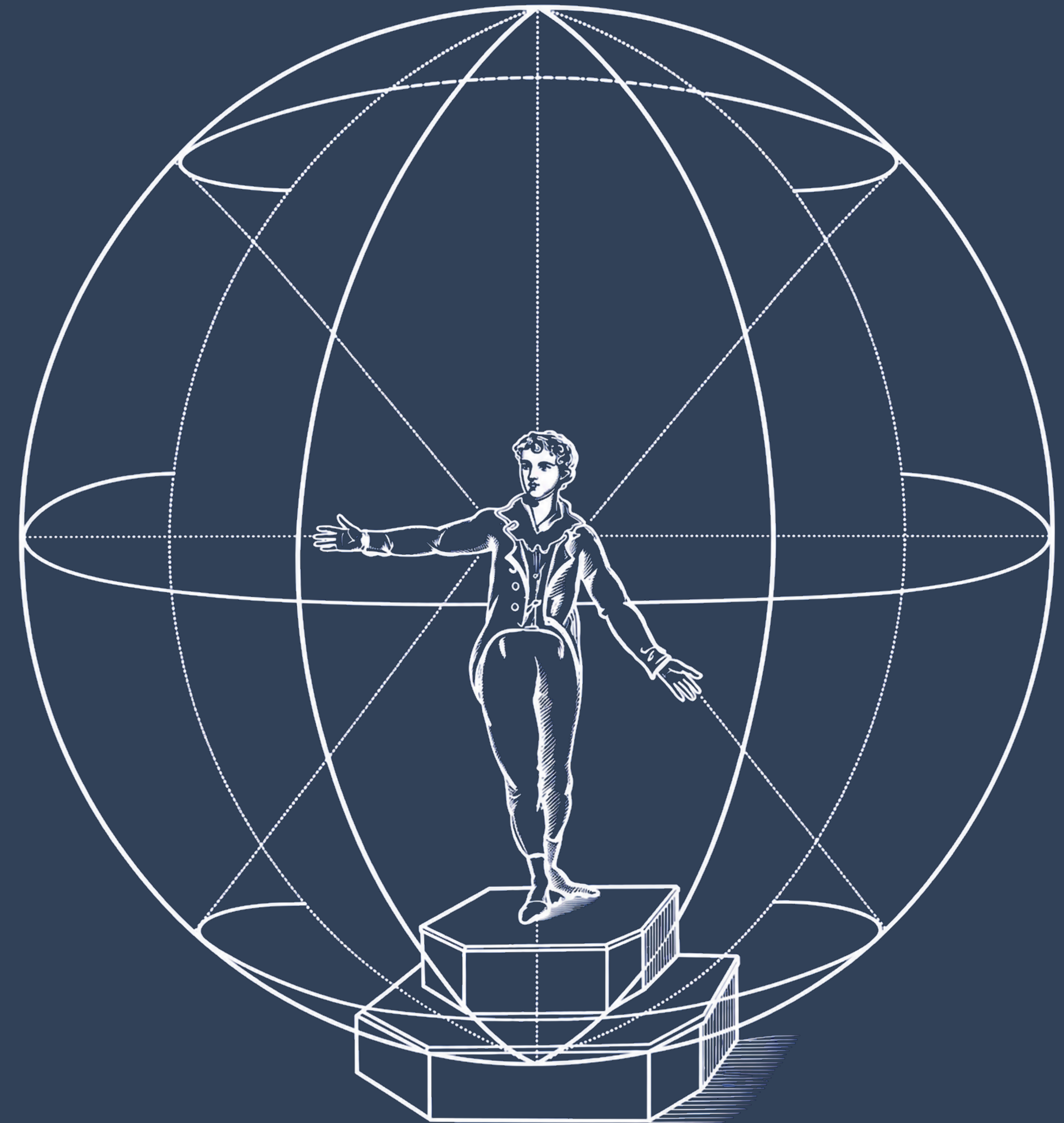
I will explore the mysteries, complexities,
and unanswered questions
that first drew me to perspective

Perhaps, like me,
you have found perspective fascinating –
but surprisingly difficult to understand

Visual Perspective

A visual language for
viewing, representing,
interpreting, and shaping space

Across technologies and disciplines



What is Visual Perspective?

Perspective is concerned with visual images, views and appearances—whether naturally seen, optically formed, represented, projected or technologically produced.

It includes:

- natural visual appearance and human vision
- optical and instrumental imaging
- drawings, paintings, photography and film
- projected and screen-based images
- computer-generated and virtual imagery



AI-generated illustration

Two Kinds of Visual Perspective

Type 1: The broad visual-image domain

Type 2: Human visual perception

—a subclass within Type 1

1000 TYPES / FORMS OF PERSPECTIVE

Selected directly from the Dictionary of Perspective index

Exactly 1,000 unique names • alphabetically ordered • every entry individually written

[illegible]

1,000 INDIVIDUALLY WRITTEN AND NUMBERED ENTRIES — NO HIDDEN CONTINUATIONS

Source: Alan Stuart Radley, Dictionary of Perspective, Second Edition 2.1 (2026), Index of Perspective.

A0 landscape • 1189 x 841 mm • infinitely scalable vector artwork

M • CONTINUED

- 0501 Multi-Mirror Perspective
- 0502 Multi-Ocular Perspective
- 0503 Multi-Plane Perspective (1) - Multi-Object Plane Perspective, Multi-Plane Perspective (Paolo Uccello)
- 0504 Multi-plane Perspective (Theatre)
- 0505 Multi-Plane/Stacked-Plane Perspective - Defined
- 0506 Multi-Plane/Stacked-Plane Perspective - Technology
- 0507 Multi-Point Perspective (Linear Perspective)
- 0508 Multi-Scale Perspective, 280
- 0509 Multi-View Flat Perspective
- 0510 Multi-View Mirror Perspective
- 0511 Multi-View Perspective (1, 2, 3, 4)
- 0512 Multi-View Stationary Perspective
- 0513 Multiple Aspect Perspective/Composite Viewing Angle Perspective
- 0514 Multiple Cone of Vision Perspective
- 0515 Multiple Lens/Eye Perspective
- 0516 Multiple Perspective
- 0517 Multiple Plane Perspective
- 0518 Multiscopic Perspective (1, 2)
- 0519 Multiview Drawing Perspective
- 0520 Mutoscope Perspective

- 0521 Narrative Perspective
- 0522 Narrow Field Perspective
- 0523 Natural Perspective
- 0524 Nautical Perspective
- 0525 Naval Perspective
- 0526 Nearby Perspective
- 0527 Negative Perspective (2) - Photographic Negative
- 0528 Negative Perspective - Synonyms
- 0529 New Media and Multi-View Perspective
- 0530 New Media Perspective
- 0531 New Perspective (1, 2)
- 0532 Non-Compound-Eye Perspective
- 0533 Non-Euclidean Perspective
- 0534 Non-Linear Perspective (1,2,3)
- 0535 Non-Participation Perspective (1)
- 0536 Non-Perspective (1)
- 0537 Non-Perspective (2)
- 0538 Non-Picture Space Perspective
- 0539 Non-planar Projection Surface Perspective
- 0540 Normal Perspective
- 0541 Northern Perspective
- 0542 Numbers, dimensions and perspective space
- 0543 Näherer Weg Perspective (Dürer's Construction M

- 0544 O ce Perspective Method
- 0545 Object Perspective (1, 2)
- 0546 Object Source Colour Perspective
- 0547 Objective Perspective
- 0548 Oblique Parallel Perspective
- 0549 Oblique Perspective (1: A, B)
- 0550 Oblique Perspective (2)
- 0551 Oblique Perspective - Graphics Method
- 0552 Oblique Perspective - Mathematical Method
- 0553 Oblique Perspective Method
- 0554 Oblique Perspective of a Cube
- 0555 Obscured Perspective
- 0556 Occlusion Perspective
- 0557 Ocular Perspective
- 0558 Oculling Perspective
- 0559 Old Perspective
- 0560 Olfactory Perspective
- 0561 Omni-Directional Perspective
- 0562 One Axis Horizontal Perspective
- 0563 One Axis Vertical Perspective

W

0987 Walking/Running Perspective

0989 Warped/Violent Perspective

0991 Wide-Angle Perspective

0992 Window Figure/Windowpane Perspective
0993 Window Perspective (1, 2)

0994 Wire-Frame Perspective
0995 Wobbly Perspective (1, 2)

0996 Worm's Eye Perspective

0997 X-Ray Perspective

**** **Topic: Point Derivatives (8)**

0999 Zero-Point Perspective (B)

Zooming Perspective - Types (1, 2, 3, 4)

100

APPLICATIONS OF PERSPECTIVE BY DISCIPLINE AND GOAL

How perspective is viewed, matched, represented, creates illusion and delivers immersion across fields.

DISCIPLINE	VIEW	MATCH	REPRESENT	ILLUSION	IMMERSION
 Anatomy / Medicine	CT, MRI, X-ray, electron, nuclear and ultrasound imaging. 	Kinaesthetic modelling; prosthetics; oncology; ophthalmology; AI. 	Medical illustration; brain imaging; radiology; education; robotic surgery. 	Internal-body visualisation; cardiology; radiotherapy; gastroenterology. 	Stereography; VR/AR operations; remote and keyhole surgery. 
 Archaeology / Natural Sciences	Remote sensing; active, passive and microwave. 	Photogrammetry; metrology; surveying; AI. 	NeRF, LiDAR, topography and sedimentary mapping. 	Radar and VR imaging; GNSS, IMU and Earth maps. 	Built-environment VR; AR/XR/MR surveying. 
 Architecture / Environment	Buildings, columns, fountains, gardens and environments. 	CAD and multi-modal building simulations; AI. 	Idealised buildings, interiors and furniture. 	Future-building VR and building-reality experience. 	Environmental walk-throughs; lighting simulations; AI. 
 Astronomy	Ground- and space-based telescopes; optical, gravity and particle views. 	Survey telescopes; universe modelling; star atlases; AI. 	Astronomical seasons, planetary orbits and eclipses. 	Virtual star atlases and solar-system fly-throughs. 	Planetariums; IMAX and sphere theatres. 
 Artistic Subjects	2-D and 3-D art, drawing, painting, sculpture and installation. 	Modelling; light shows; visibility maps; large installations. 	Intarsia, lettering, marquetry, polyhedra and sculpture. 	Light and night-scapes; stage lighting; projection mapping. 	Sphere and IMAX theatres; drone light shows; fireworks. 
 Cinema	2-D cinema, large format, HFR and time-lapse. 	3-D photogrammetry; digital filmmaking; virtual production. 	Motion capture; practical/CGI blending; animation. 	Digital filmmaking; SFX; widescreen and practical effects. 	Stereoscopic cinema; virtual production; volume screens. 
 Computing	Generative AI; hypergrams and visualisation. 	Computer vision; GIS, GPS and AI. 	Computer graphics, CGI, animation, VFX and CAD. 	3-D, volumetric and holographic displays; simulation. 	Digital metaverse; VR, AR, MR, XR and AI. 
 Information Visualisation	Cosmograms; visual relationships; global viewpoint and focus. 	World trees and types; spatialisation; biosphere modelling. 	Multi-view and multi-time representation; false perspective. 	Social and cultural modelling; ecological relations. 	VR/AR information visualisation; Tree of Life; cognitive media. 
 Crystals / Gems / Symmetry	Natural crystals and gemstone optics. 	Atomic, molecular and facet symmetry modelling. 	Microstructure and modal-structure representation. 	Gemstone simulation; light scattering and dispersion. 	Atomic and sub-atomic structural visualisation. 
 Drones	Aerial and sky photography; aerial movies. 	Photogrammetry; metrology and surveying. 	Panoramic and 360-degree spherical views. 	Bird's-eye views and panoramic fly-throughs. 	VR trips; panoramas and volume displays. 



From the invisible to the immersive: perspective enables how we see, understand, create and experience the world.

It matches methods to meaning, represents reality, reveals illusion and delivers immersion across every field of human activity.

Visual Perspective

Every perspective image is produced through one or more systems

But which systems produced this view?

- 3-D Scene
- Glass ball
- Photographic camera
- Conference-room projector
- Viewer's eye



AI-simulated
photograph

The *Appearance Problem* of Perspective

Size changes primarily with distance

Position changes with viewpoint and object position

Shape / Aspect changes with viewpoint and object orientation

Perspective translates

3D spatial relationships into 2D appearance

How Knowledge of Perspective Helps

Perspective enables us to understand, represent and create spatial experience

Functions of perspective

- **View** – depth, scale, position and viewpoint
- **Match** – maps, surveys, models and instruments
- **Represent** – art, science, engineering, media, AI
- **Illusion** – art, photography, cinema and CGI
- **Immersion** – VR / AR, IMAX and Sphere

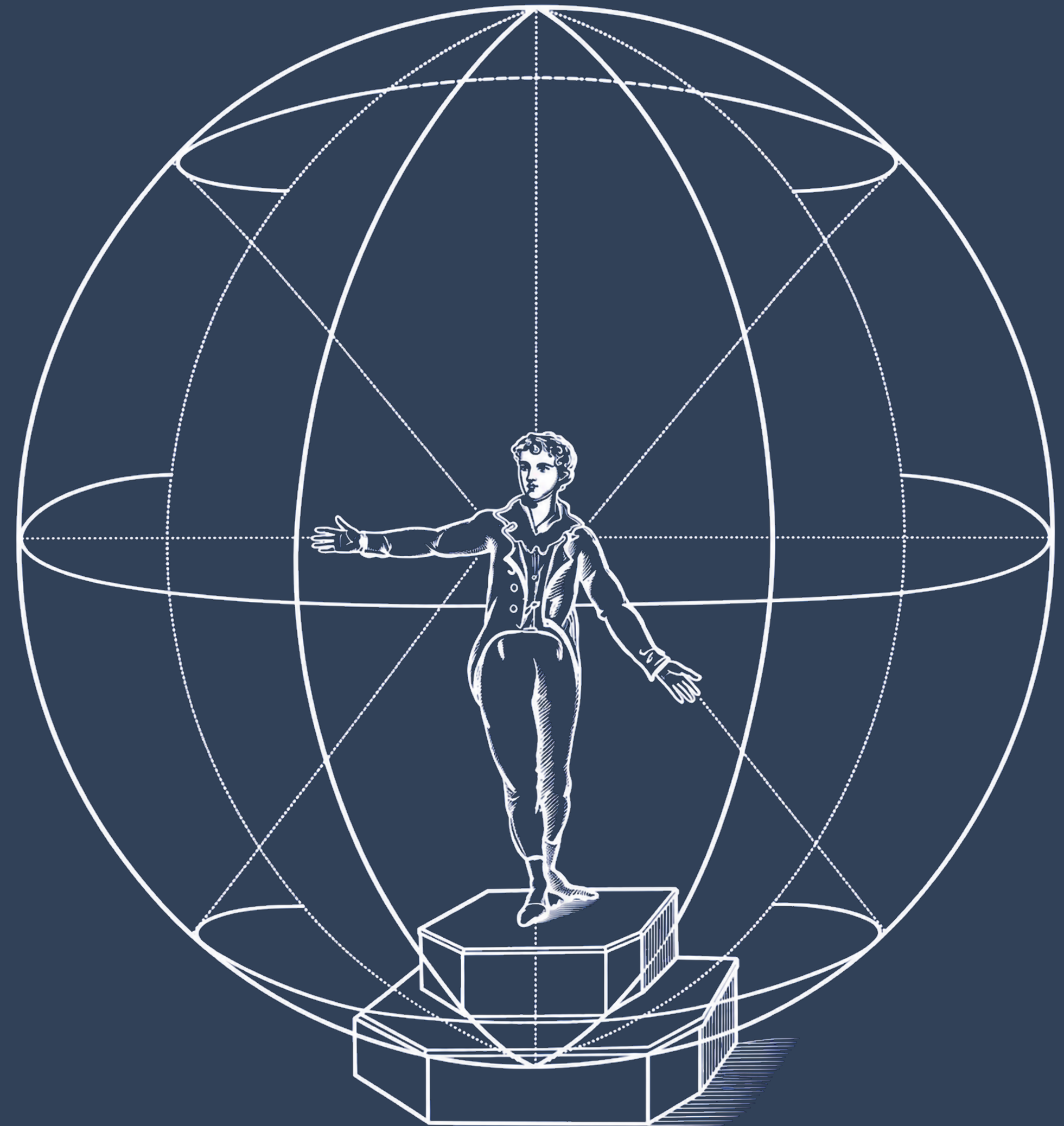
AI-generated illustration



Central Questions

What kinds of "space" and "form" are we talking about?

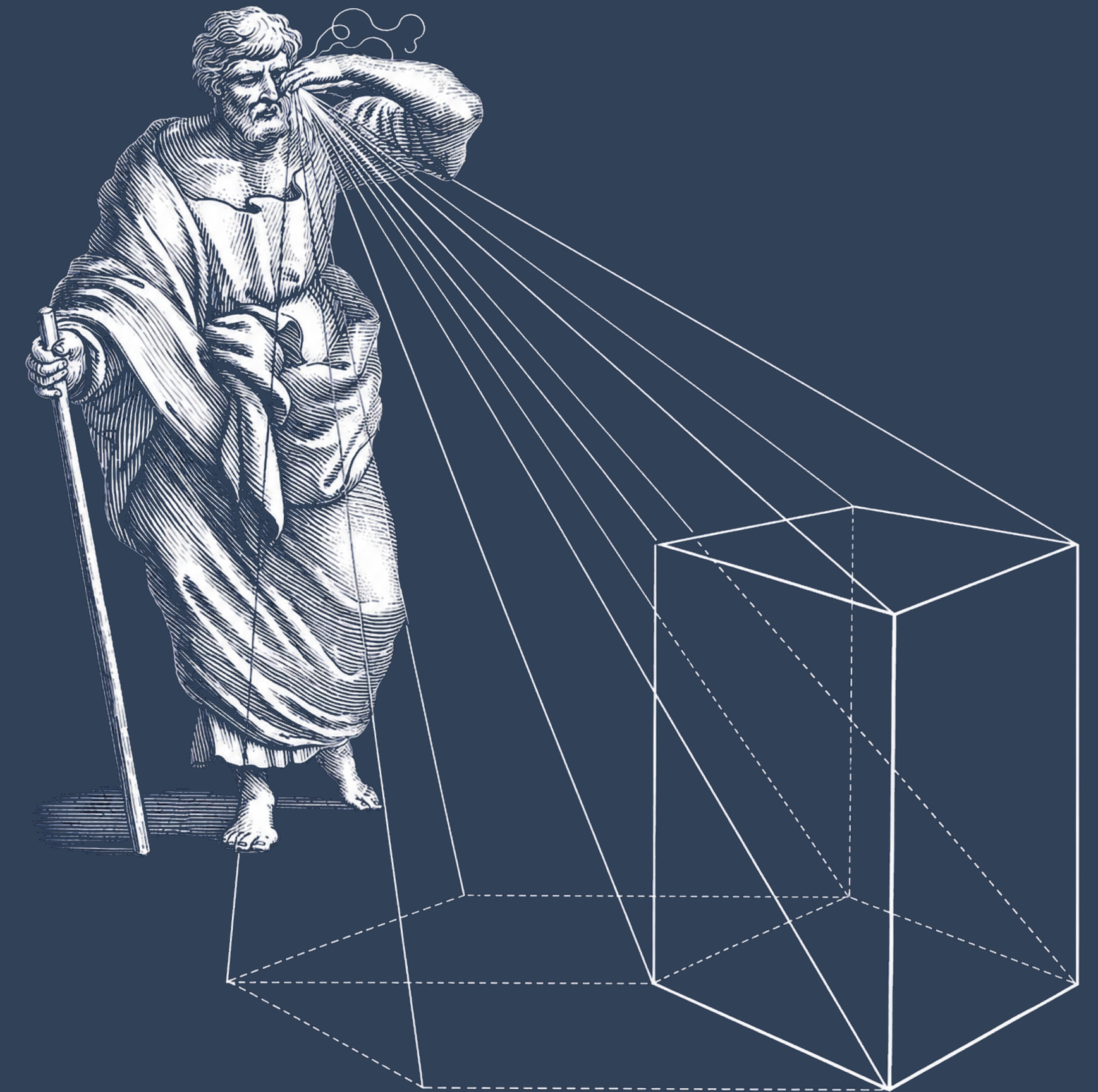
Perspective deals fundamentally with spatial form and depth.



Kinds of Space

Perspective involves different kinds of space – and these do not always coincide

- **Physical / Object** – real objects and environments
- **Optical / Visual** – space formed or experienced through vision and optical systems
- **Image / Represented** – depth on a surface or screen
- **Perceived / Imaginary** – depth inferred by vision or illusion
- **Synthetic / Immersive** – simulated virtual, or mixed spaces



A perspective view may involve several kinds of space at once.

Form in Perspective: Meaning and Kinds

Form: **Classified Output**

Classified perspective output
(**characteristic appearance: generalised
visual and geometric features**)

Examples

- **Photographic Form**
- **Linear Perspective Form**
- **Spherical Perspective Form**

Conceptual Clarification
Meanings and Kinds of Perspective Form

Form: **Particular Scene Structure**

The shape, or structure of a spatial thing
(**particular geometric features**)

Three kinds

- **Physical Form** = shape of real object
- **Apparent Form** = object appearance
- **Modelled Form** = idealised geometric form used for analysis or construction

Example

- Cube: **physical form**, **apparent form**, **modelled form**

Relationships Among the Three Forms

Physical Form exists; Apparent Form is its perspective appearance; Modelled Form is the assumed geometrical approximation by which that relationship is analysed. Their correspondence varies across scale and geometry.

The arrows indicate relations of dependence and interpretation, not a temporal causal sequence.

Production / appearance

Physical Form + Modelled Form → Apparent Form

Interpretation / reconstruction

possible

appropriate

Apparent Form → Physical Form + Modelled Form

A single apparent form does not always determine one unique physical form.

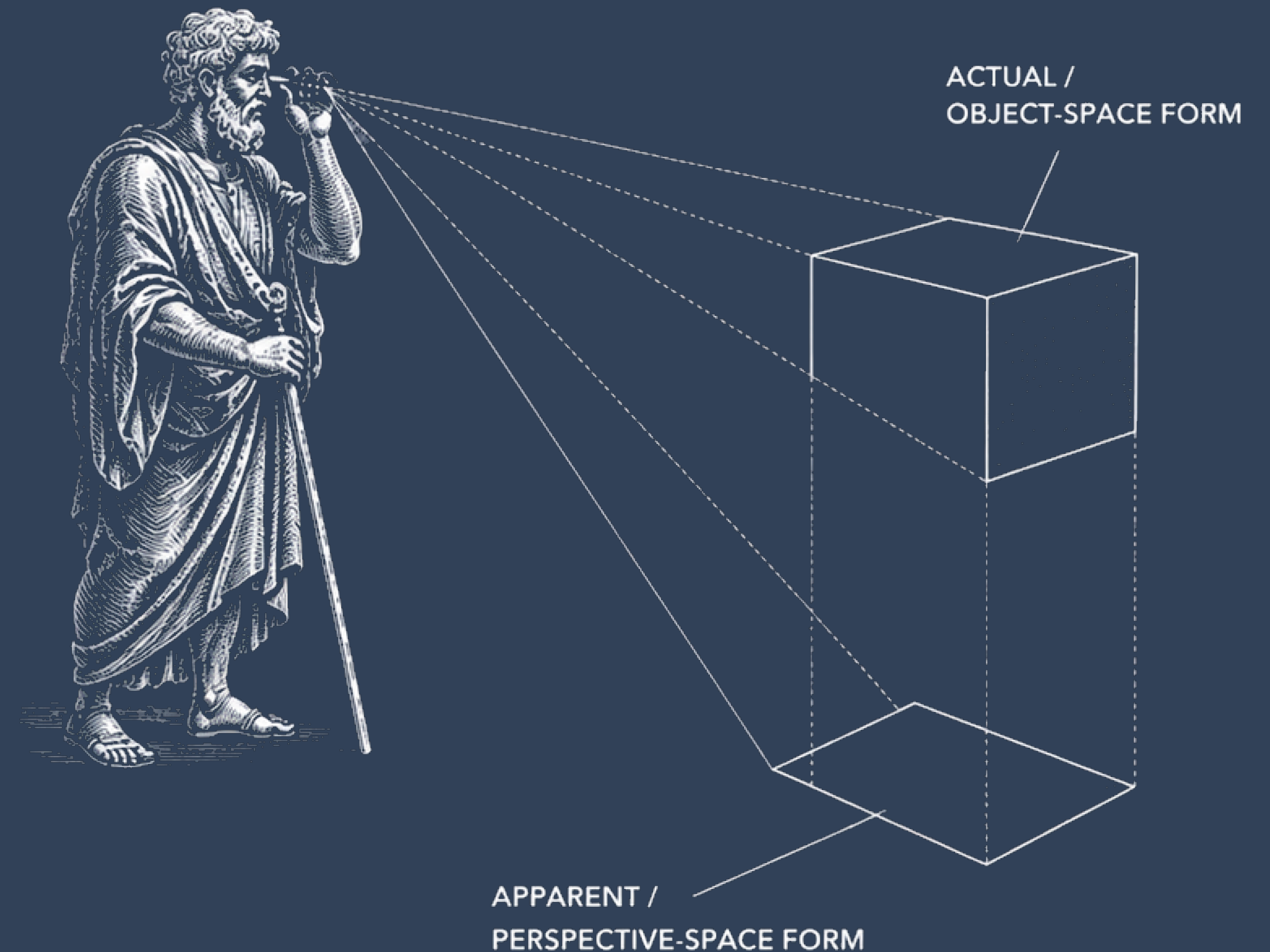
Perspective works in both directions: producing appearance and interpreting appearance.

Physical and Apparent Form

Physical form appears through perspective as apparent form

- **Physical / Object-Space Forms** – actual structure of objects and environments
- **Apparent / Perspective-Space Forms** – appearance from a particular viewpoint

Physical and apparent forms do not always coincide.



Perspective distinguishes between **physical form** and **apparent form**.

Perspective Phenomena Shaping Apparent Scene Form

Apparent scene form is shaped by several kinds of perspective phenomenon.
Linear perspective is only one of them.

Main focus of this talk → Linear Perspective

1. Perspective of Form – GEOMETRICAL FACETS

LINEAR PERSPECTIVE – edges, outlines, planes, vanishing

2. Gradient of Colour Perspective – OPTICAL FACETS

aerial / atmospheric colour change with distance

3. Gradient of Acuity Perspective –
OPTICAL + GEOMETRICAL FACETS

clarity, sharpness, detail and resolution diminish

4. Gradient of Chiaroscuro Perspective – OPTICAL FACETS

light-dark contrast and tonal gradients

Depth Cues: Visual Information for Spatial Depth

Using visual information to infer depth and spatial relationships.

Depth cues help interpret
apparent form and infer
possible scene/object
structure and possible
physical form.

Monocular / Pictorial cues

- Overlapping contours / occlusion
- Relative size and height in visual field
- Texture gradients
- Linear convergence
- Aerial colour, contrast and acuity changes

Motion cues

- Motion parallax
- Optic flow
- Viewpoint change

Binocular cues

- Retinal disparity → stereopsis
- Convergence

Contextual / perceptual cues

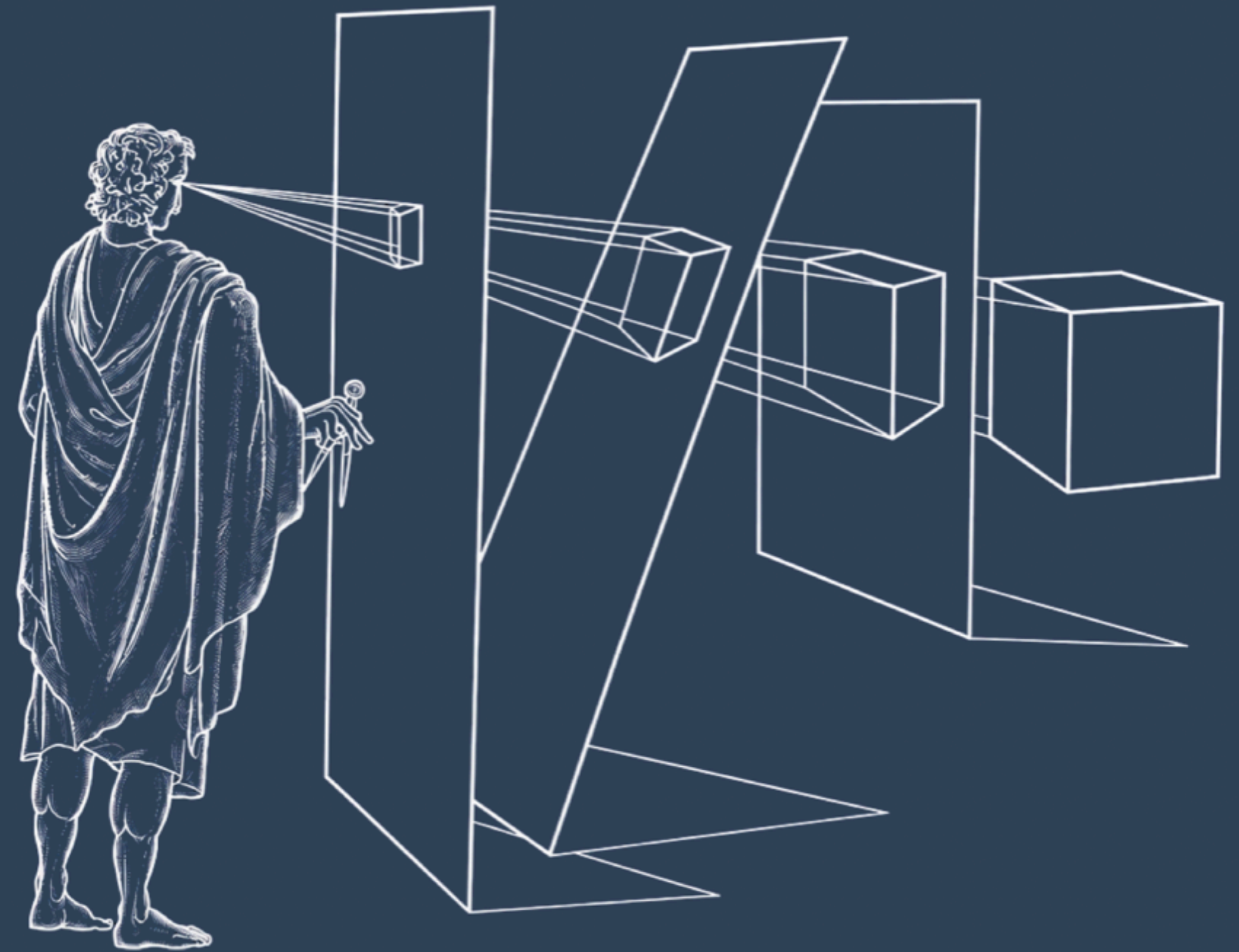
- Familiar size and object recognition
- Scene structure and spatial relations
- Image invariants and affordances

phenomena → visual cues → depth interpretation

Why space and form matter

Understanding perspective views and images involves fundamental problems of space and form...

- Image space is not object space
- Apparent form is not physical form
- Depth, position and form may be ambiguous
- One image may correspond to more than one possible spatial reality

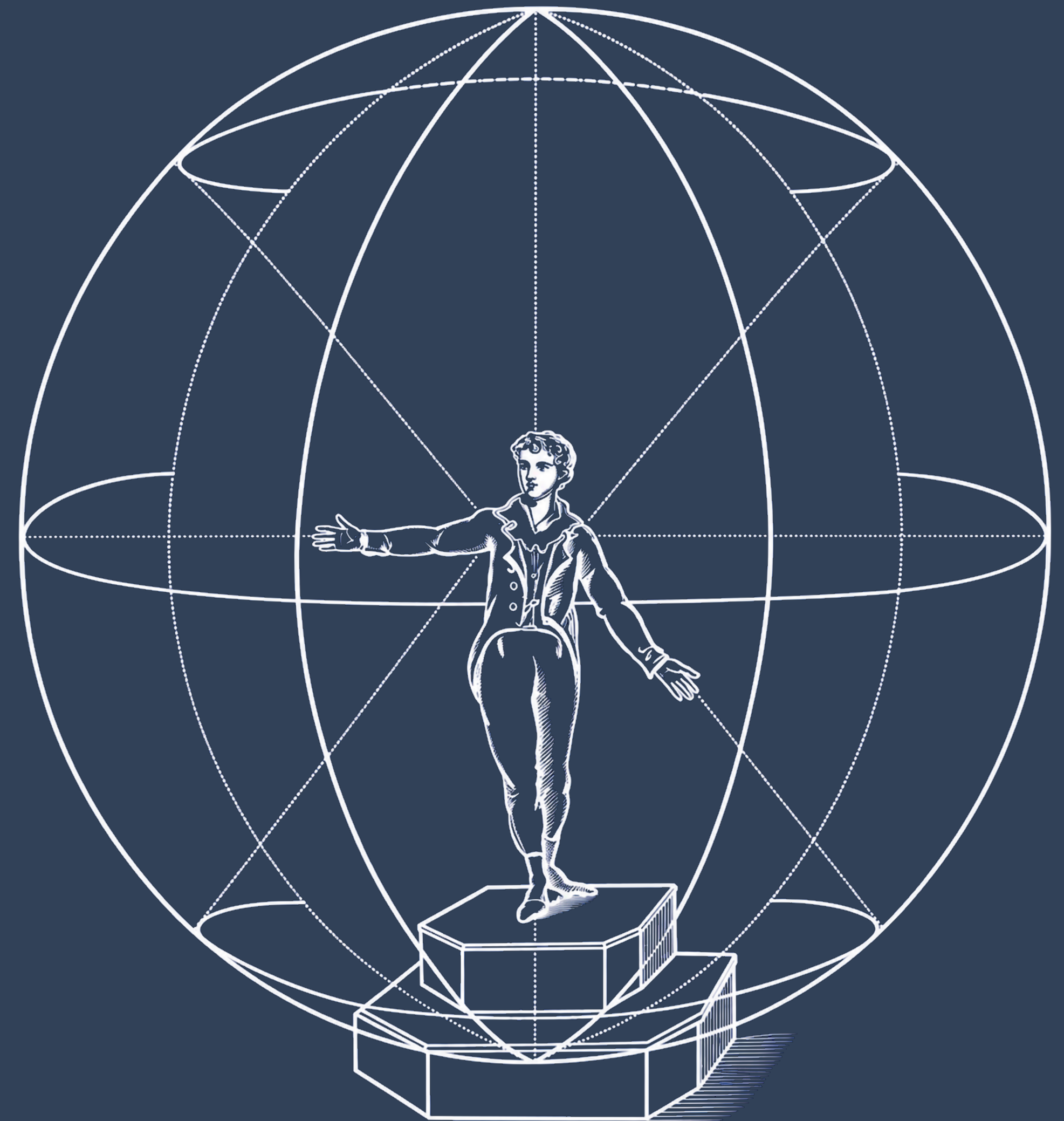


Perspective helps relate image space and **apparent form** to possible scene structure and **physical form**

Problems and Solutions

A perspective image does not uniquely determine the spatial reality that produced it

Perspective presents fundamental problems – and possible solutions.



Recurring Problems of Perspective

These problems recur across disciplines

- **Space** — how spatial structure is organised
- **Scale** — how size and detail change with distance
- **Time** — how perspective freezes, links, or unfolds time
- **Viewpoint** — how each position gives a partial view
- **Reality** — how appearance equates to spatial reality

Next: scale and viewpoint...



AI-generated illustration

Scale – How Long is the Coast of Britain?

Measured length depends on measuring unit, resolution and map scale

- Smaller measuring units follow more bays, inlets and irregularities
- As the measuring scale becomes finer, the measured coastline becomes longer
- There is no single fixed coastline length independent of method or resolution

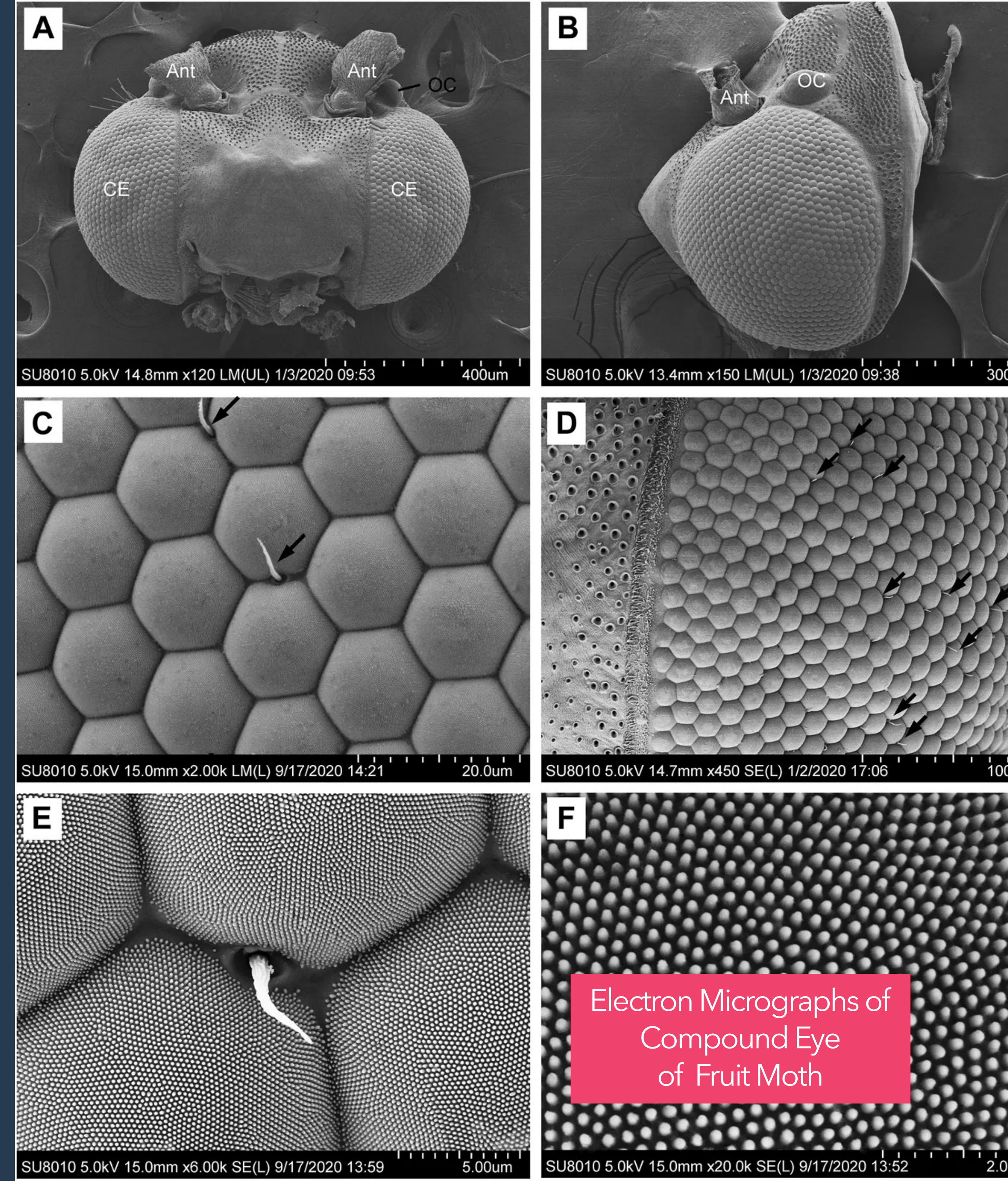


Smaller measuring unit =
longer distance

Scale – Shape – Size < Problem >

Shape and size depend on the scale and resolution of observation

- Apparent size depends on viewpoint, geometry, scale and measurement.
- Changing scale reveals or obscures structural detail.
- No single observed shape represents every scale.
- This is why perspective must distinguish **physical**, **apparent** and **modelled** form.



Shape Sufficiency Problem

Form = particular scene structure
Physical · Modelled · Apparent Form.

At what *range of scales* do **Modelled Form** and **Apparent Form** approach **Physical Form** sufficiently closely for the perspective system to remain valid?

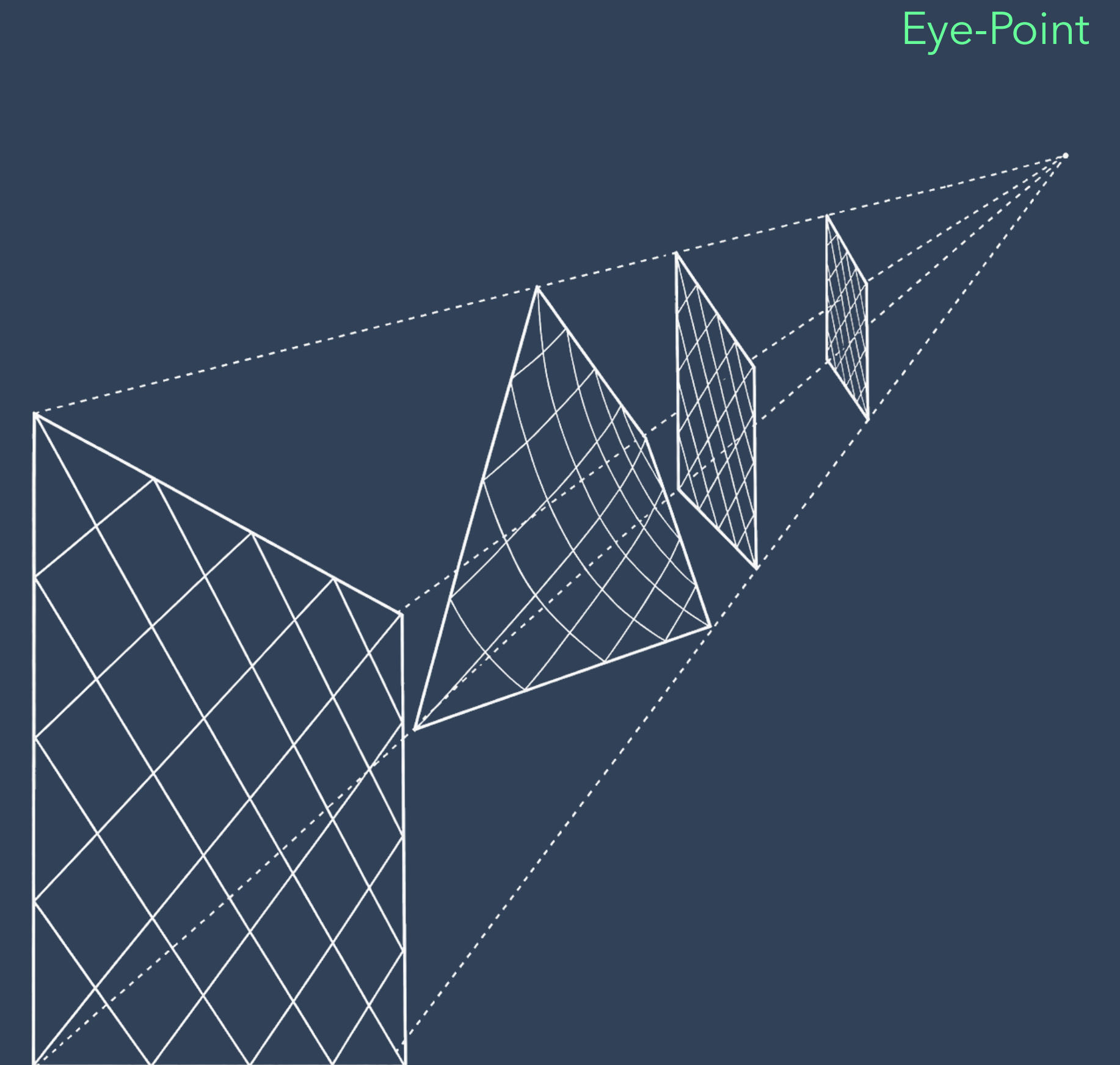
Perspective validity depends on the assumed geometry remaining sufficiently close to physical reality across the relevant scale range.

- **Example** – Linear Perspective remains valid while physical surfaces and edges are sufficiently approximated as flat, straight and parallel.
- **Principle** – **Physical Form** is the limiting reality; **Modelled Form** and **Apparent Form** with differing degrees of adequacy across scale.

Viewpoint – Correspondence Problem

One **Apparent Form** can correspond to many possible **Physical Forms**.

- Depth, shape and position are underdetermined by **Apparent Form** alone.
- Additional views or constraints can narrow the possible **Physical Forms**.
- **Modelled Form** provides the geometrical framework for analysing the relationship between **Apparent Form** and **Physical Form**.



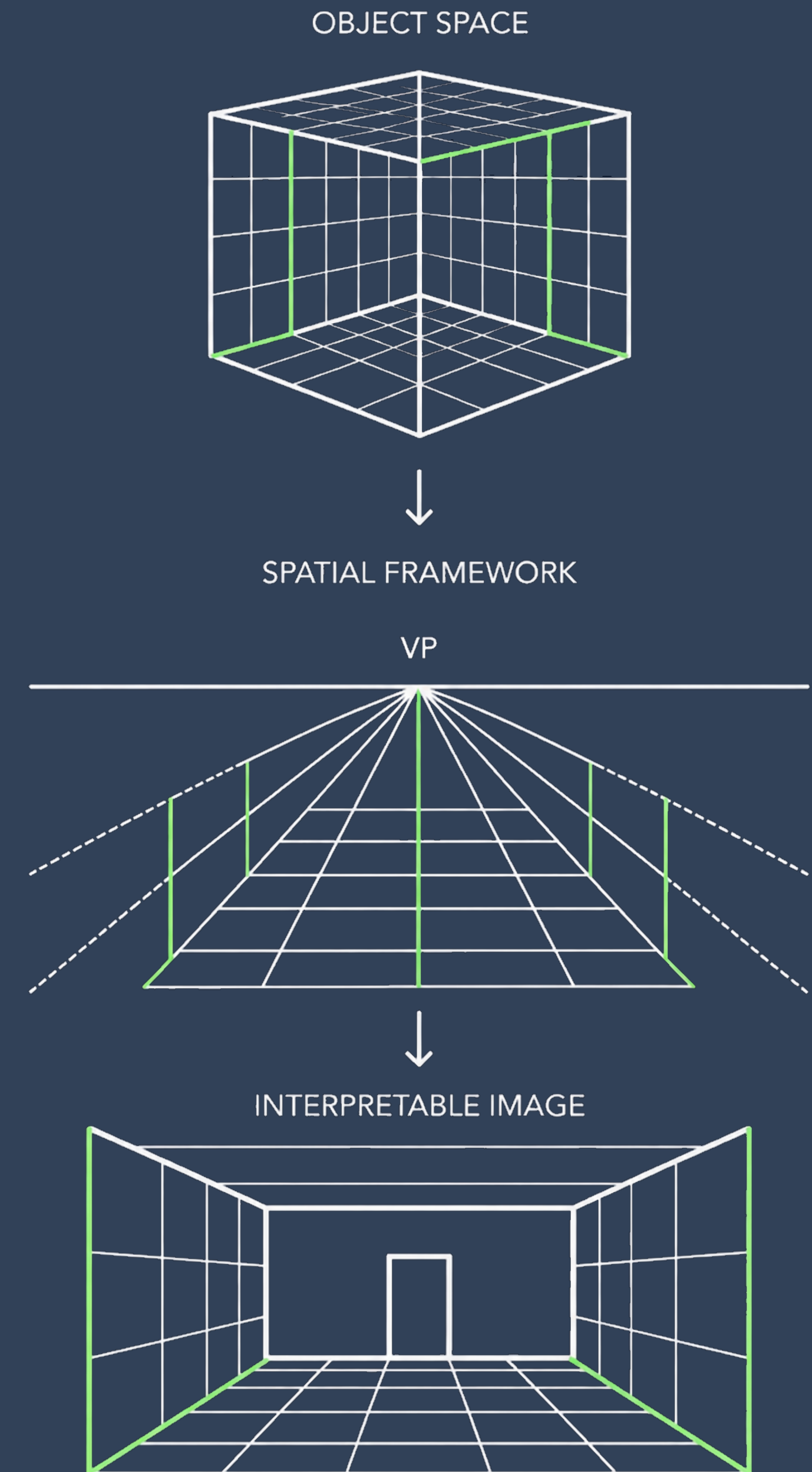
Why Parallel Lines Matter

Parallel lines make spatial structure legible

They help us...

- **Structure space** – establish directions, planes and surfaces
- **Contextualise depth** – show how forms extend into space
- **Generate perspective cues** – establish vanishing points and horizons
- **Support interpretation** – reveal shape, scale and position

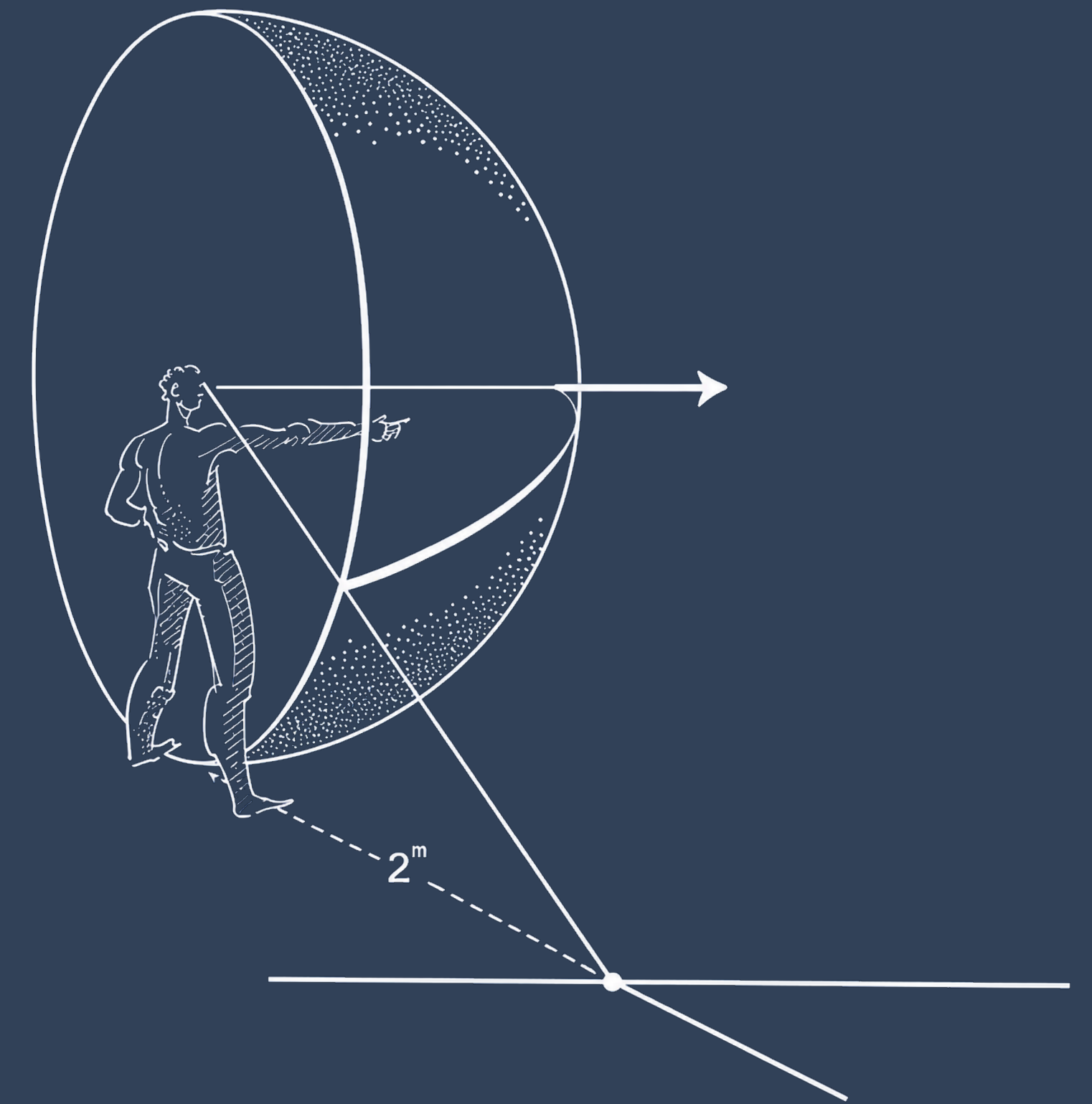
Without known spatial relations, different 3D scenes can produce the same 2D image



Towards a Science of Perspective

Perspective provides a shared spatial framework across disciplines:

- **Seeing** – viewpoint and appearance
- **Representing** – turning space into images and models
- **Measuring** – resolving scale, depth, and position
- **Simulating** – constructing artificial and virtual spaces
- **Interpreting** – understanding what images reveal or distort

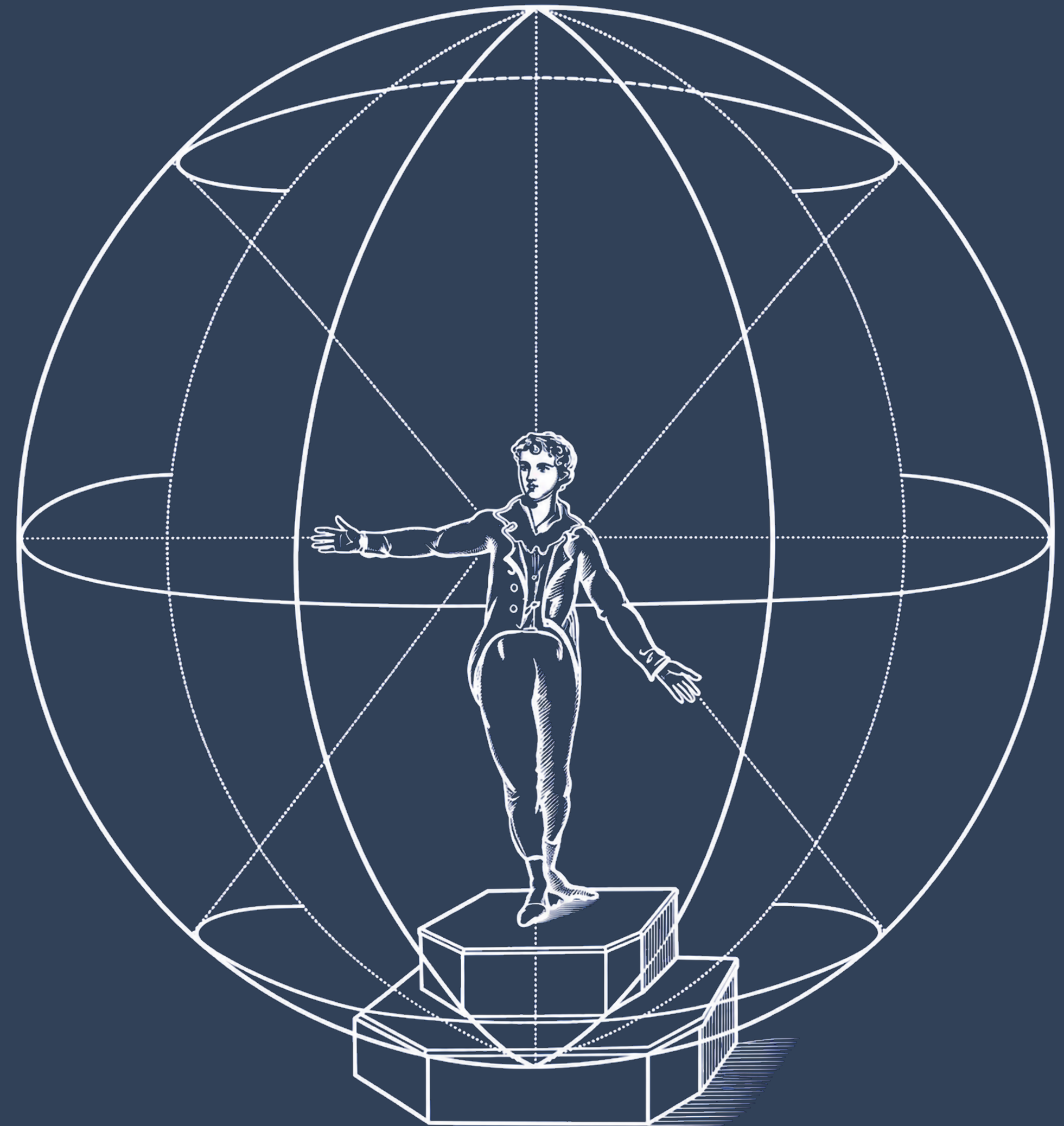


Together, these form the
basis of a science of
perspective

Perspective Theory

From visual appearance to
underlying structure

Connecting perception, geometry,
representation and visual construction





Reality → image = Viewing or Imaging Class



Image/light → reality = Projecting Class

Natural, Artificial, and Synthetic Perspective

Three modes of perspective

Seeing, Representing, Synthesising

- **Natural perspective** – perspective as seen
- **Artificial perspective** – perspective as represented
- **Synthetic perspective** – perspective as computationally generated or reconstructed

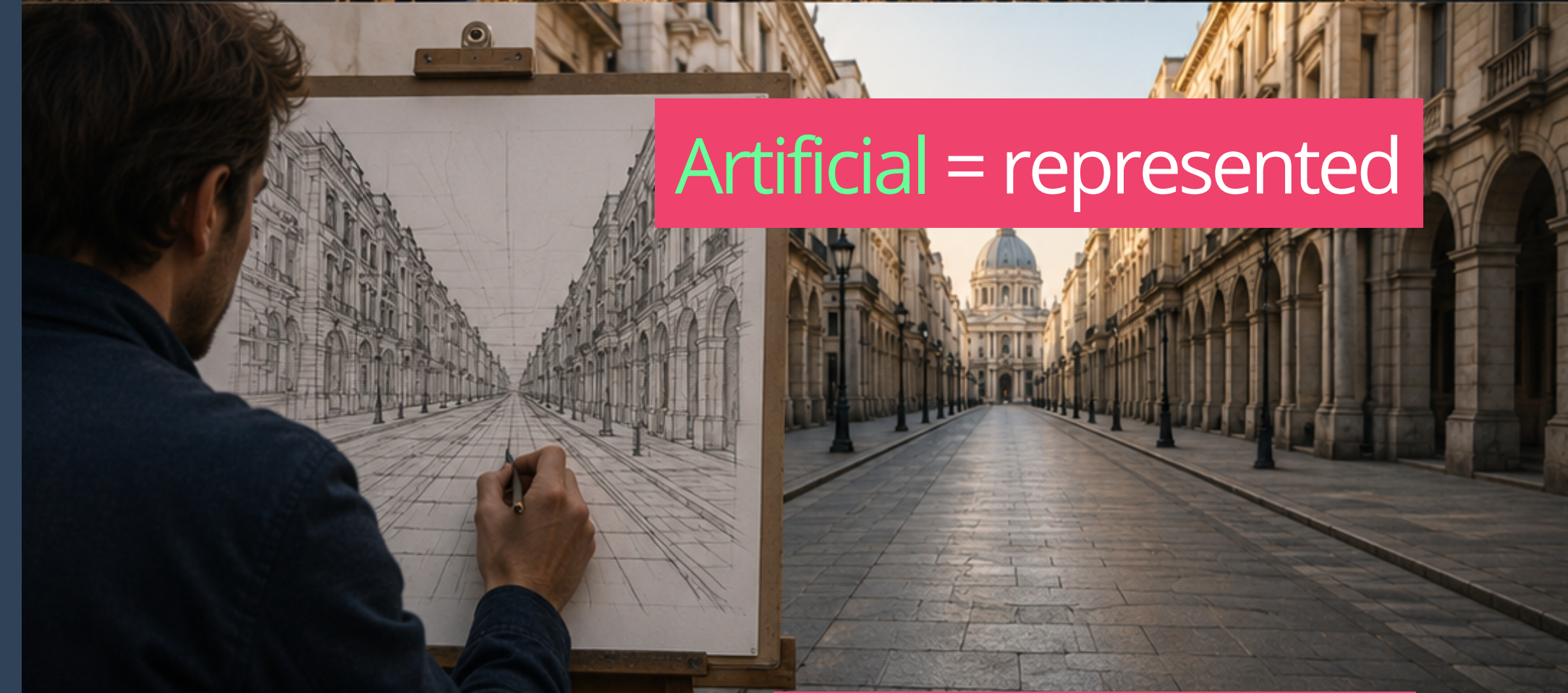
Conceptual Clarification

Synthetic = production mode · **Simulated** = altered appearance

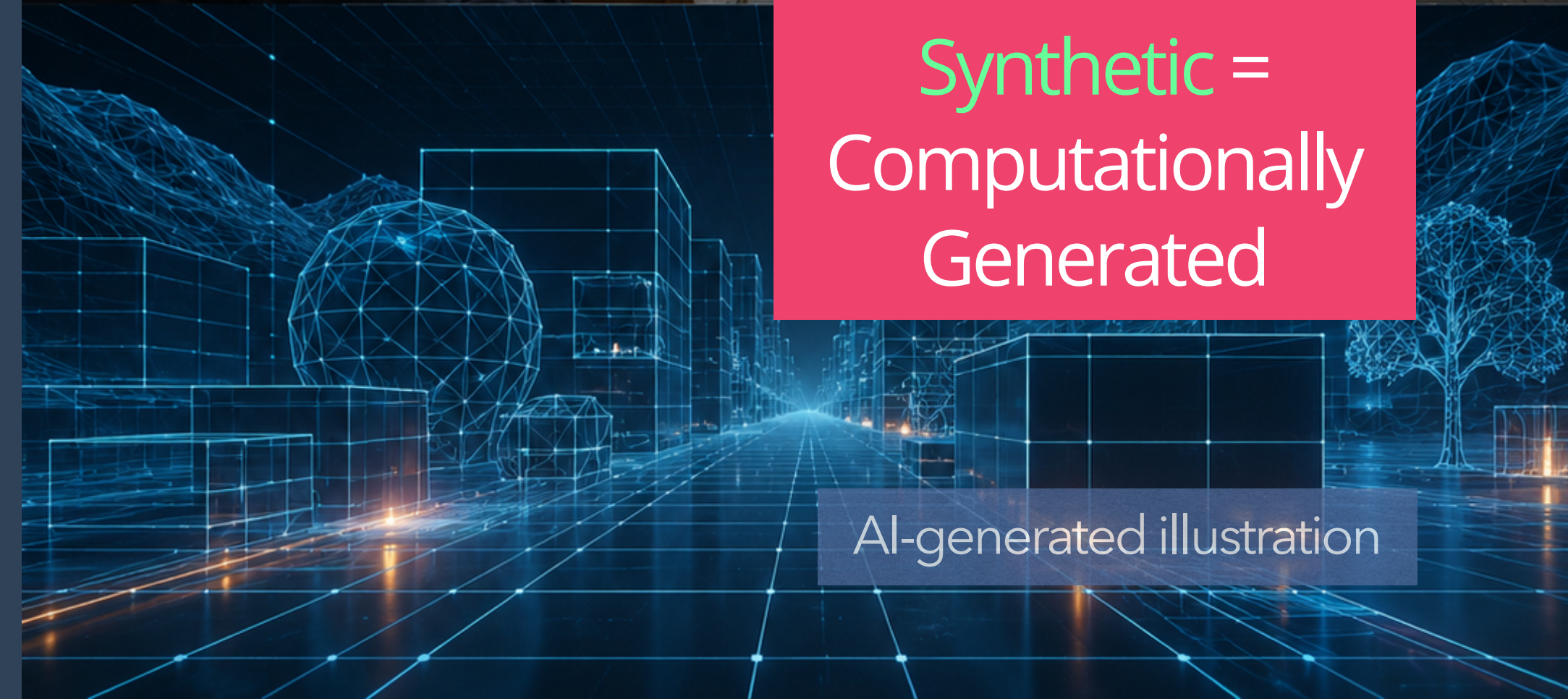
Combined = multiple spaces · **Blended** = combined spaces made continuous



Natural = as seen



Artificial = represented



Synthetic =
Computationally
Generated

AI-generated illustration

Type = the production system

Object-Image-Space Schematic
Graphical / Mathematical Perspective

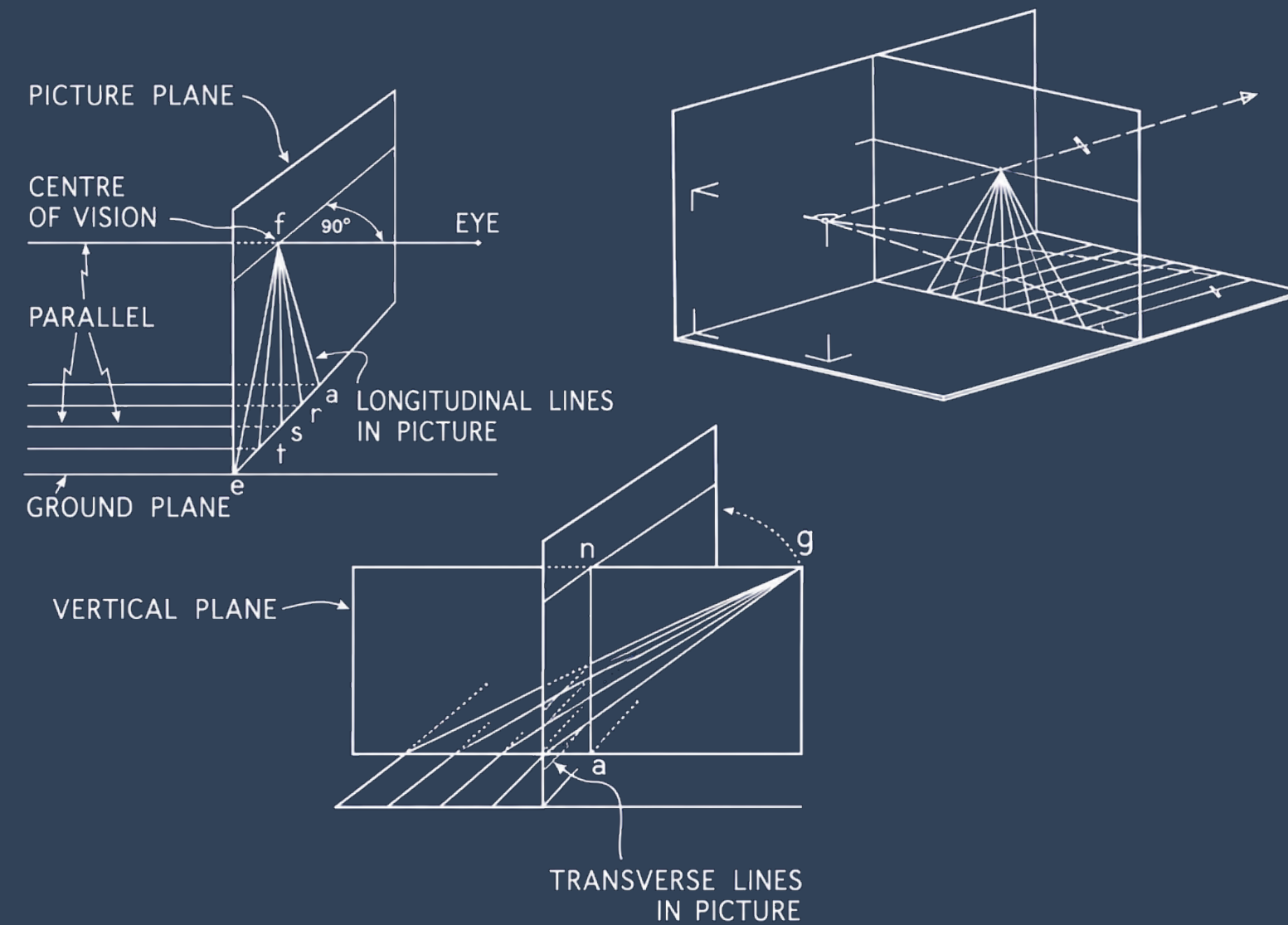
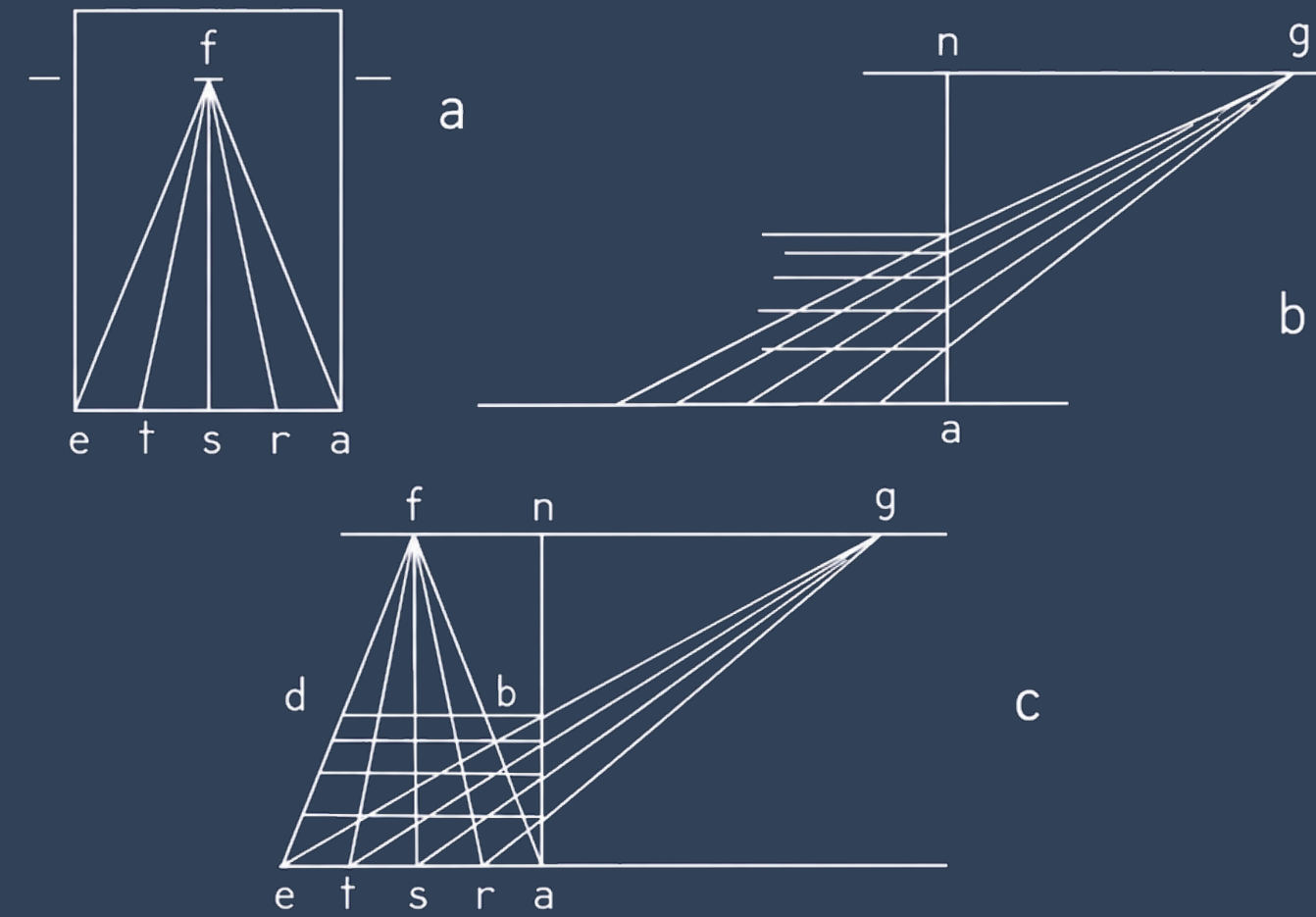
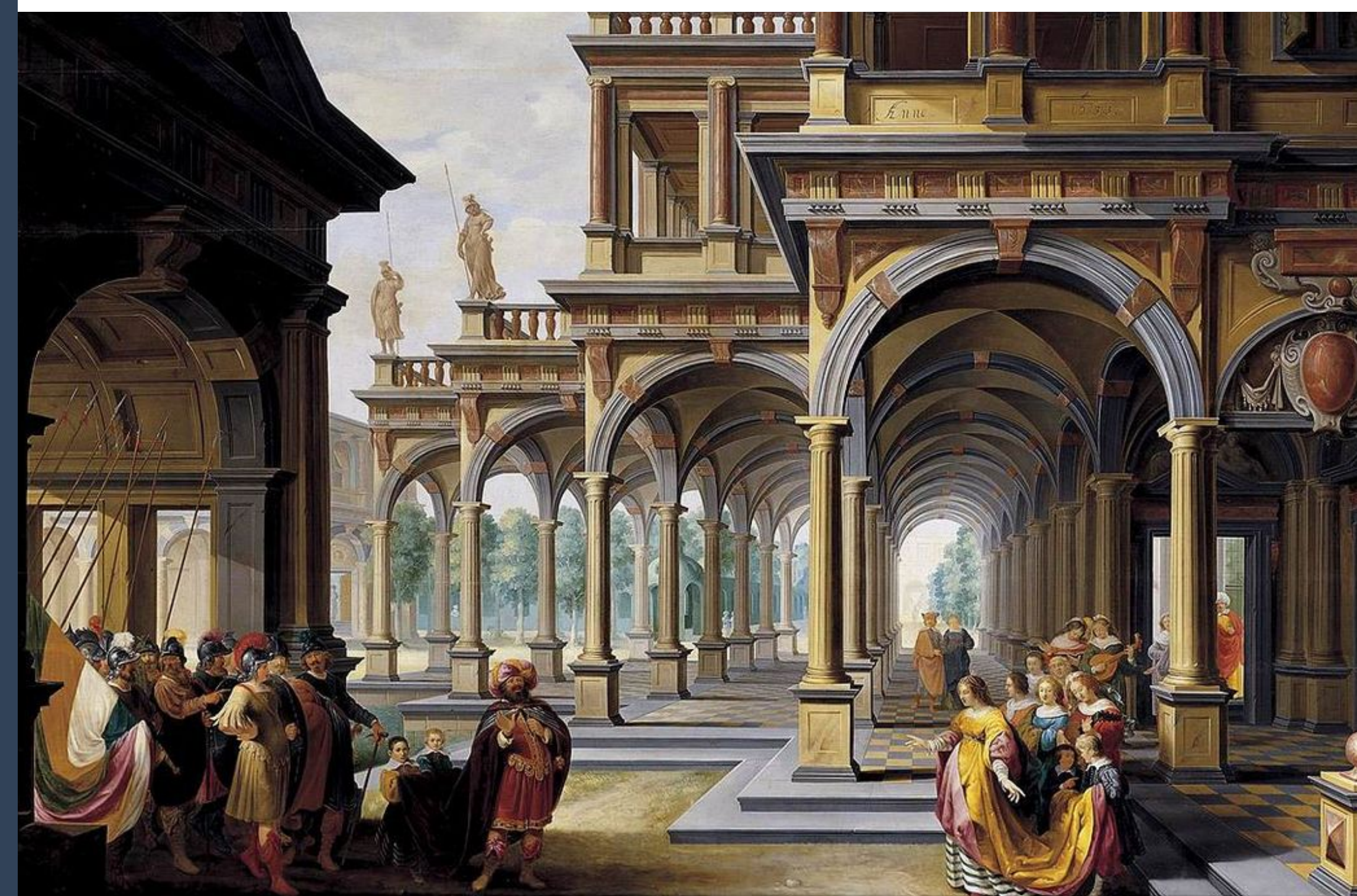
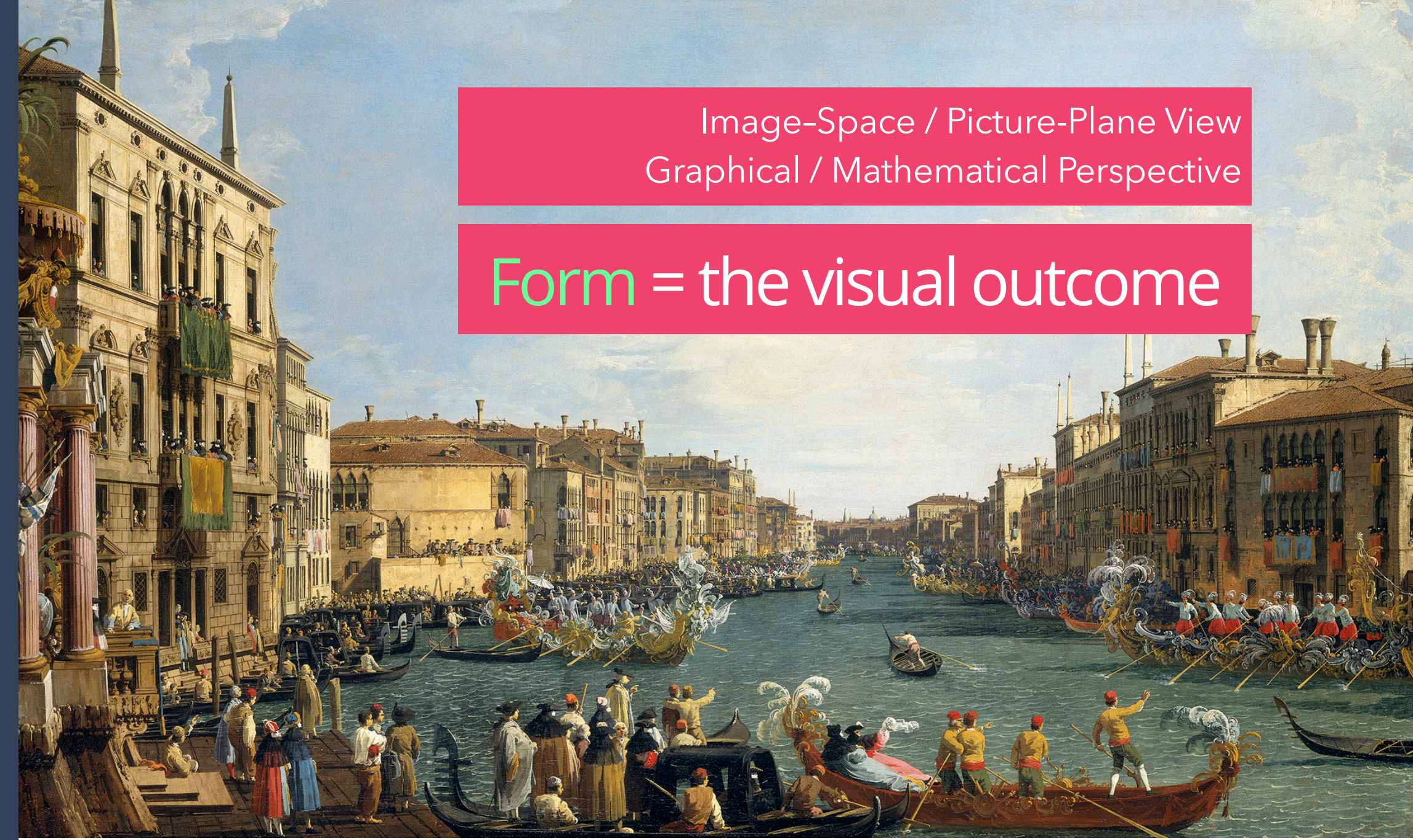


Image-Space / Picture-Plane View
Graphical / Mathematical Perspective

Form = the visual outcome

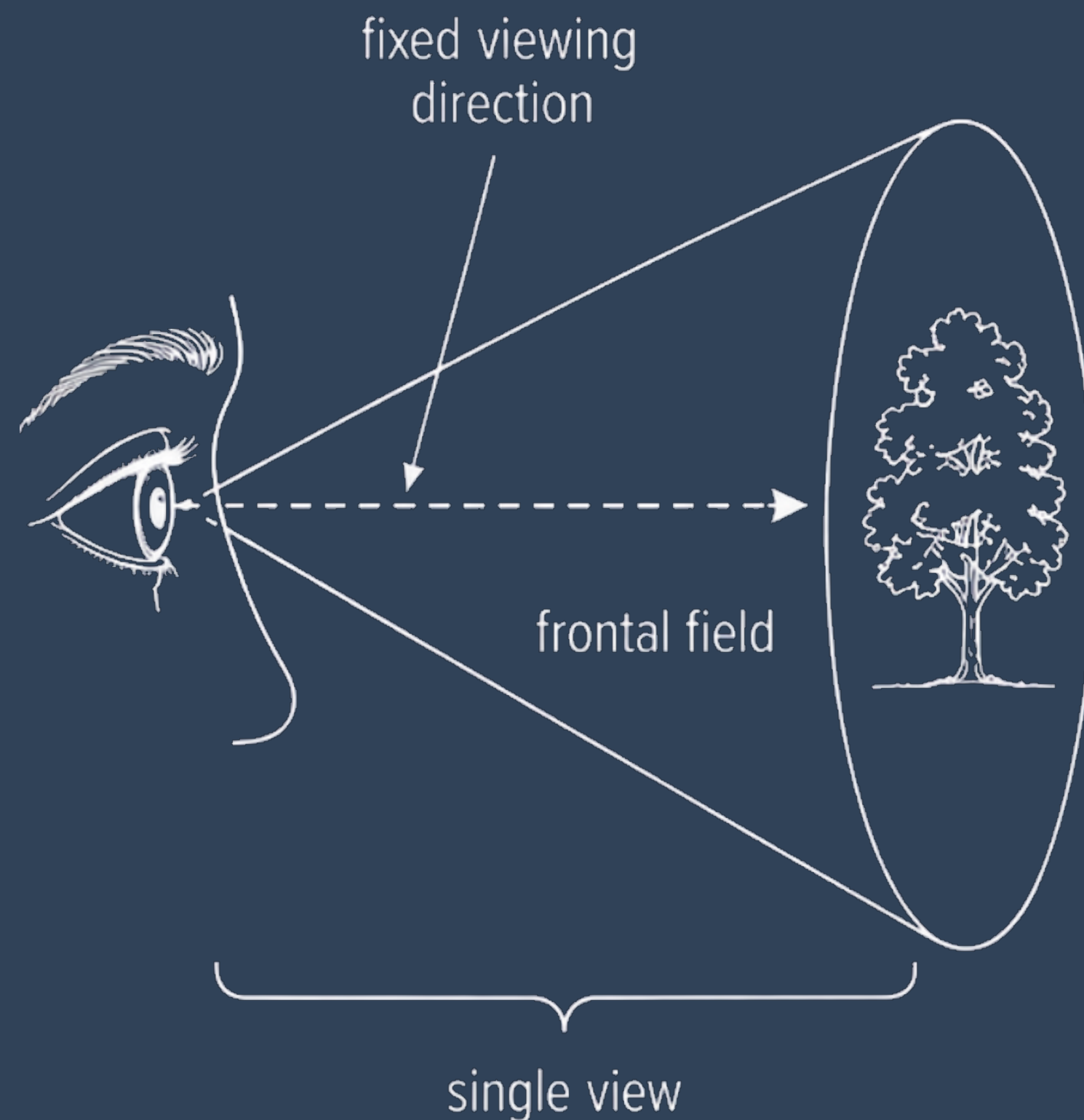


Two kinds of Looking

Object-Space Schematic
Visual / Optical Perspective

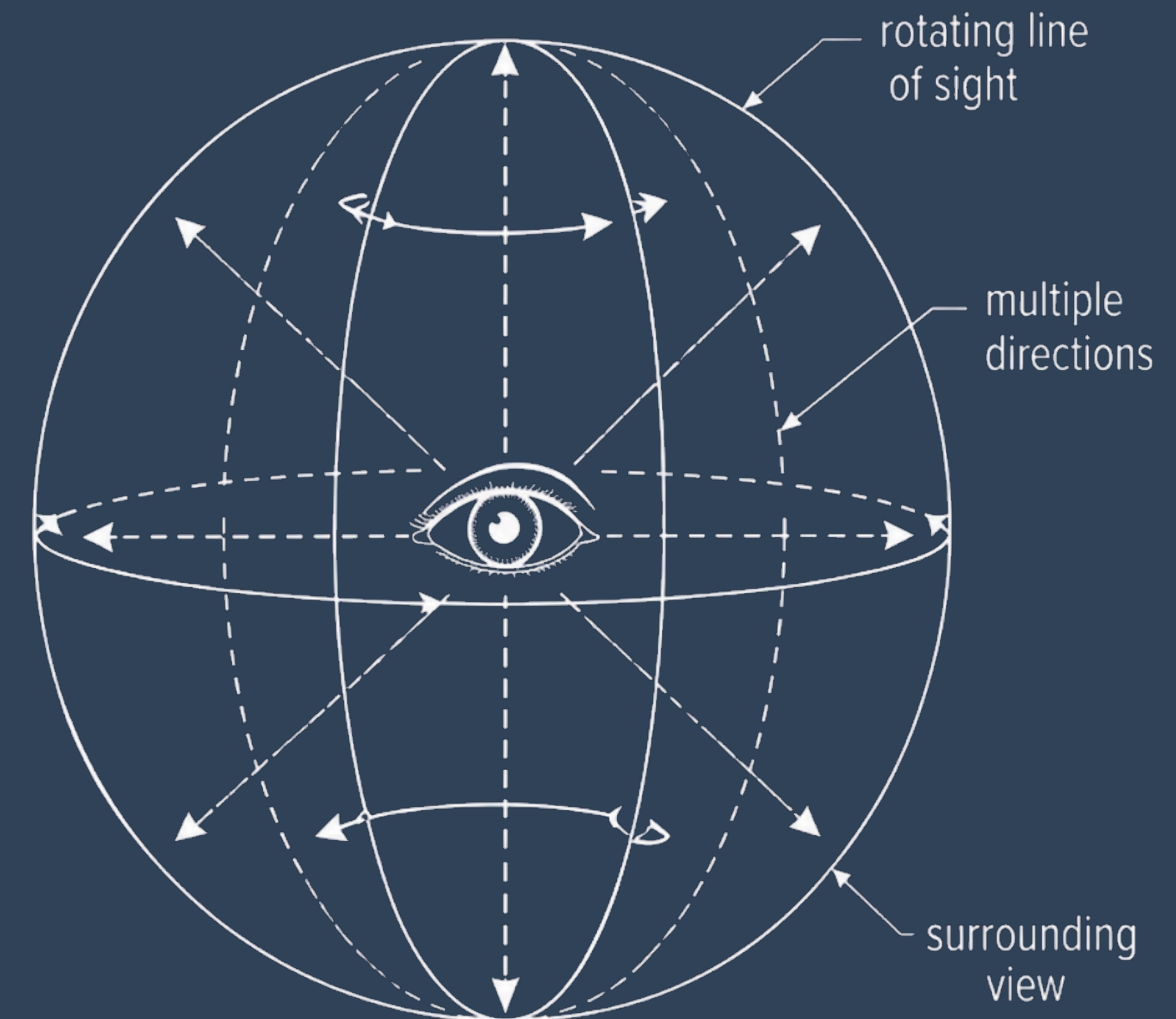
LOOKING AT

Sphere of Revolution
(potential moving station point)



LOOKING AROUND

Sphere of Vision



Looking Around

Sphere of Vision



Looking Around = Sphere of Vision



Perspective 3-D Panorama Drawing Machine, Ryan and Trevor Oakes. 2020.

Natural, Artificial, and Synthetic Perspective

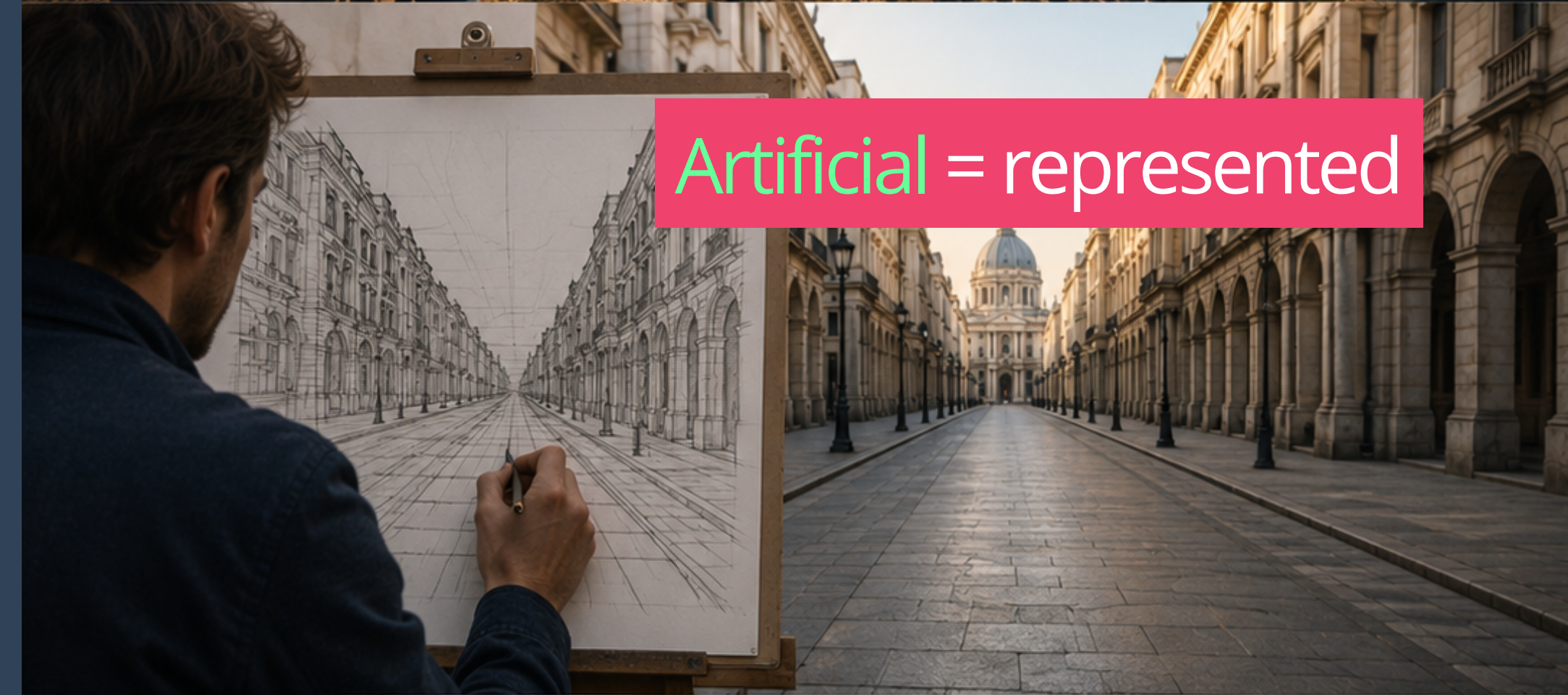
Three modes of perspective

Seeing, Representing, Simulating

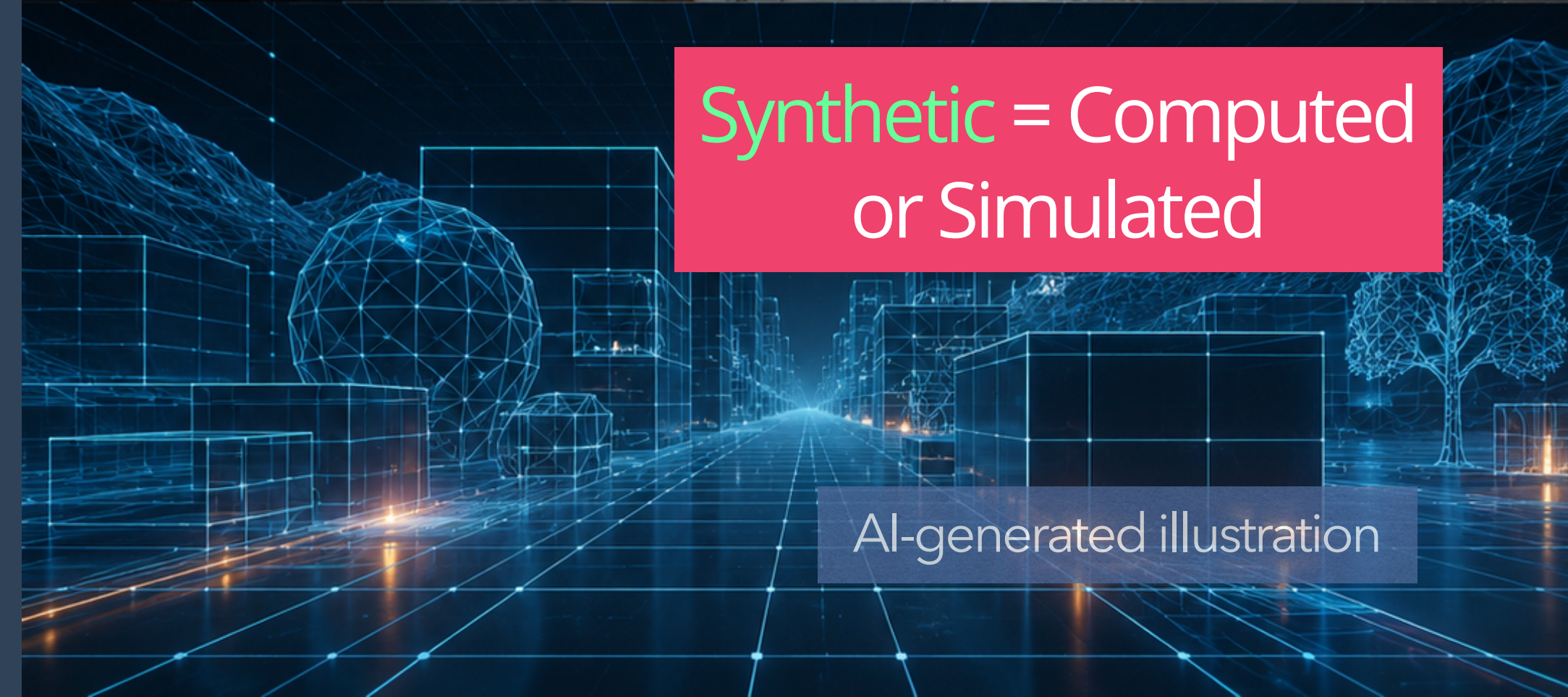
- **Natural perspective** – perspective as seen
- **Artificial perspective** – perspective as represented
- **Synthetic perspective** – perspective as computed or simulated



Natural = as seen



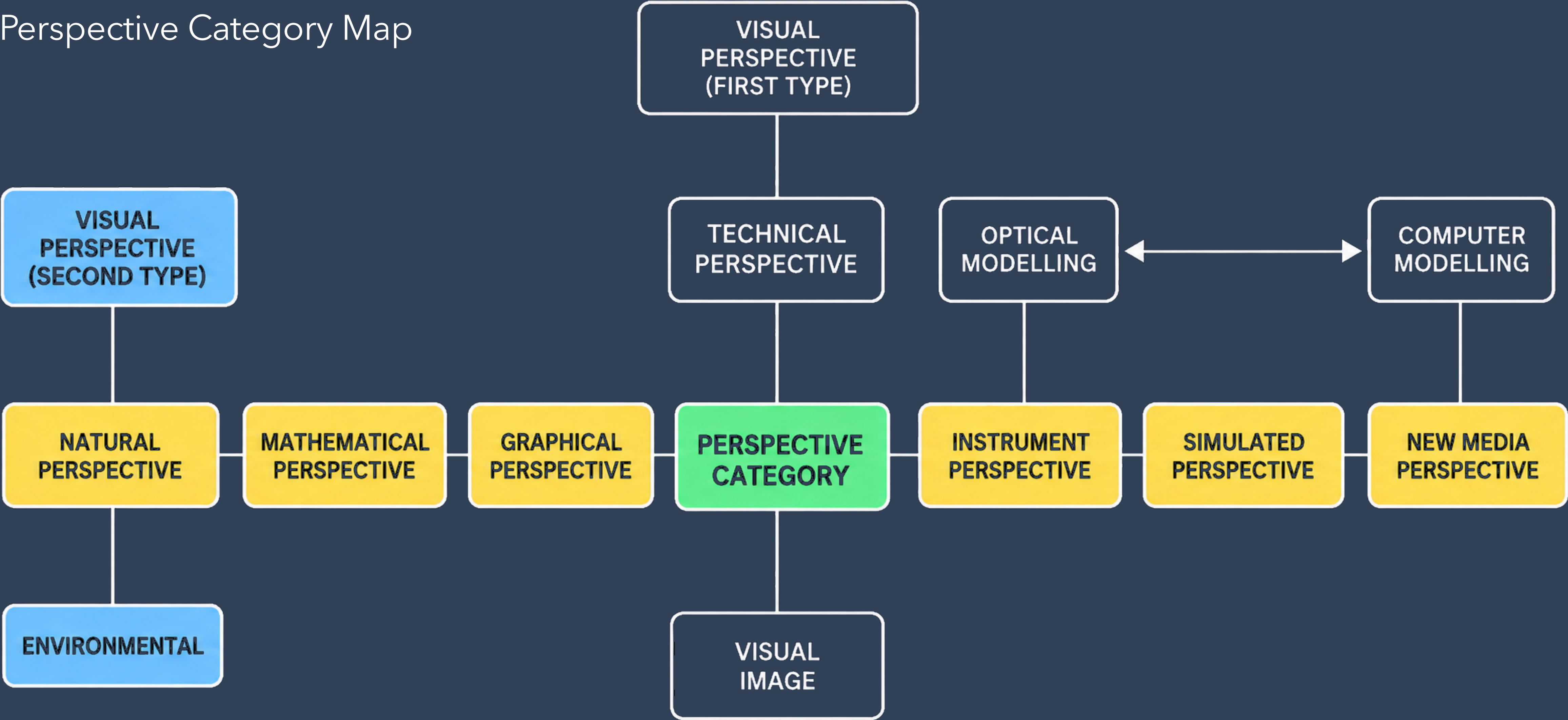
Artificial = represented



Synthetic = Computed
or Simulated

AI-generated illustration

Perspective Category Map



The Seven Analytical Levels of Perspective

Levels of Analysis

- **Category** — source / mode
- **Class** — fundamental direction
- **Type** — system or process
- **Form** — resulting appearance
- **Phenomenon** — visible effect
- **Function** — what it does
- **Product** — what is produced

A single perspective view can be analysed at seven distinct levels.

AI-generated illustration

Two Classification Ambiguities

When perspective types or terms do not fit neatly into one meaning

Category Overloading

One perspective type belongs to more than one category

- A single type may fit two or more categories
- Different systems may contribute to the same image
- Graphical, optical, mathematical, or computational aspects may overlap

Type / Form Ambiguity

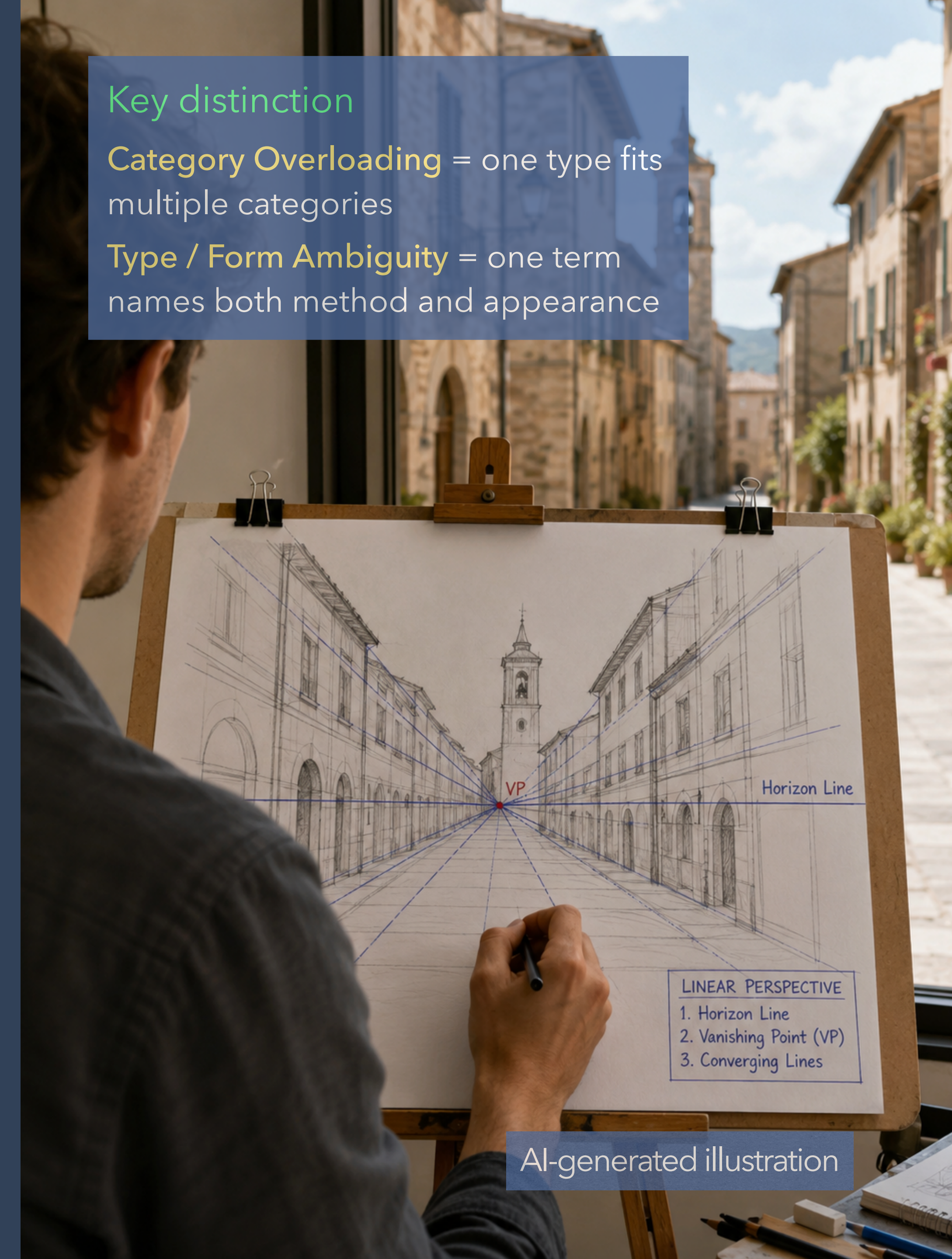
One term describes both method and appearance

- **Type** = the method or system
- **Form** = the visual result
- **Example:** “linear perspective” can name both a method and a visual result

Key distinction

Category Overloading = one type fits multiple categories

Type / Form Ambiguity = one term names both method and appearance



LINEAR PERSPECTIVE
1. Horizon Line
2. Vanishing Point (VP)
3. Converging Lines

AI-generated illustration

Composite Perspective

Multiple systems contribute to producing one perspective image

Composite perspective asks:

What systems or categories produced this image

Example of “Category Chaining”

A scene (natural perspective) is photographed (camera perspective), displayed on a screen (instrument perspective), possibly altered by New Media perspective, and viewed with visual perspective (Type 2).



Photograph

Combined and Blended Perspective

Layered spaces vs fused spaces

Combined Perspective

Multiple spatial domains function together within one view.

- Real, represented, projected or digital spaces may coexist
- Each may retain its own spatial identity
- Example: AR overlay aligned with real space

Blended Perspective / Blended Scene Perspective

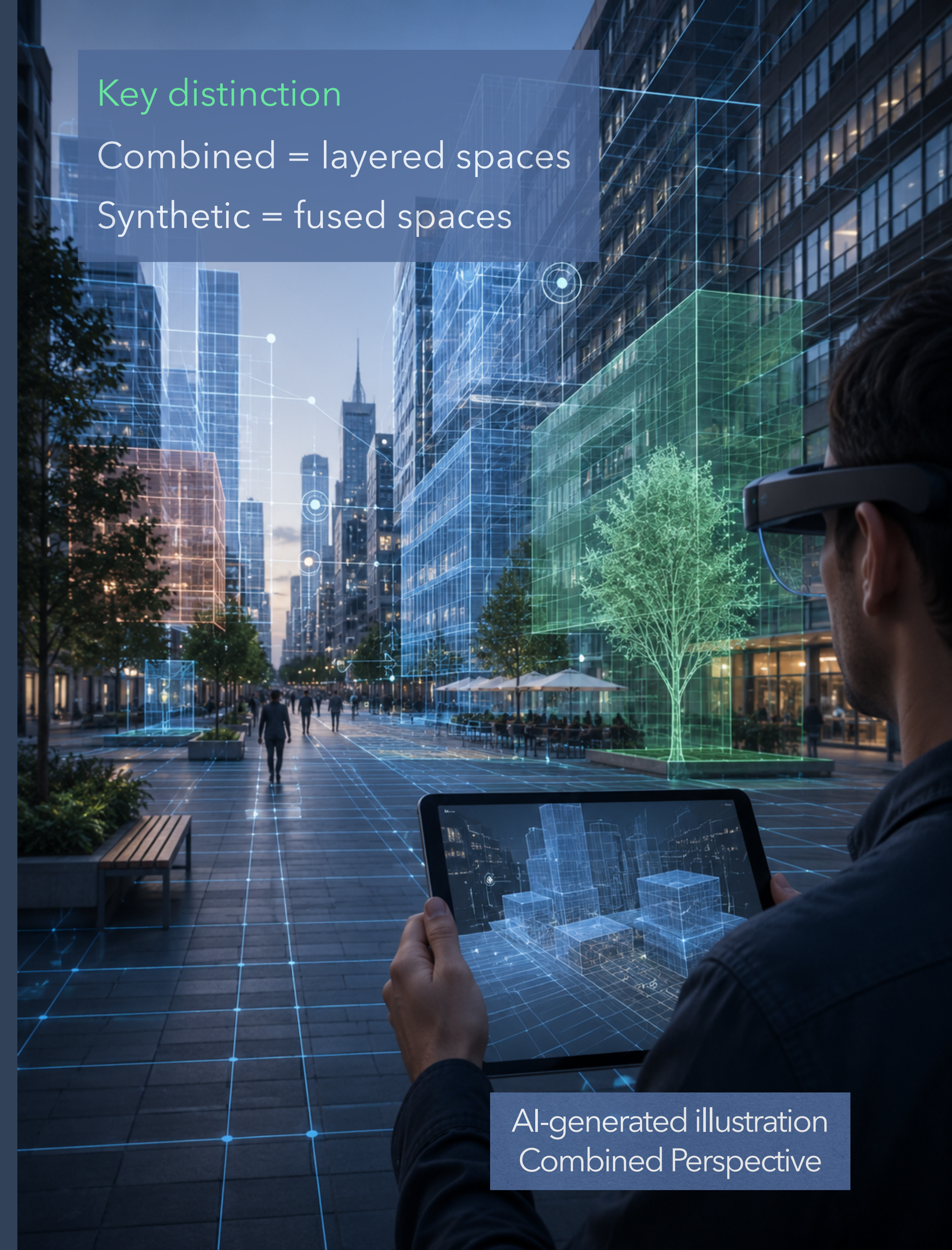
Combined spaces are made to appear spatially continuous.

- Boundaries between component spaces become visually integrated
- The result appears as one continuous spatial field
- Example: virtual production

Key distinction

Combined = layered spaces

Synthetic = fused spaces



AI-generated illustration
Combined Perspective

Blended Scene Perspective

Real and artificial spaces made to appear continuous

- Blends physical, represented, and digital space
- Integrates component spaces into one continuous scene
- Common in CGI, VFX, spatially integrated AR, and virtual production



Simulated Perspective

Creates a spatial appearance that differs from physical spatial reality.

Key Idea

- Produced through visual illusion, optical adjustment, or false scene geometry

Examples

- Forced perspective + trompe-l'œil effects
- Anamorphic perspective

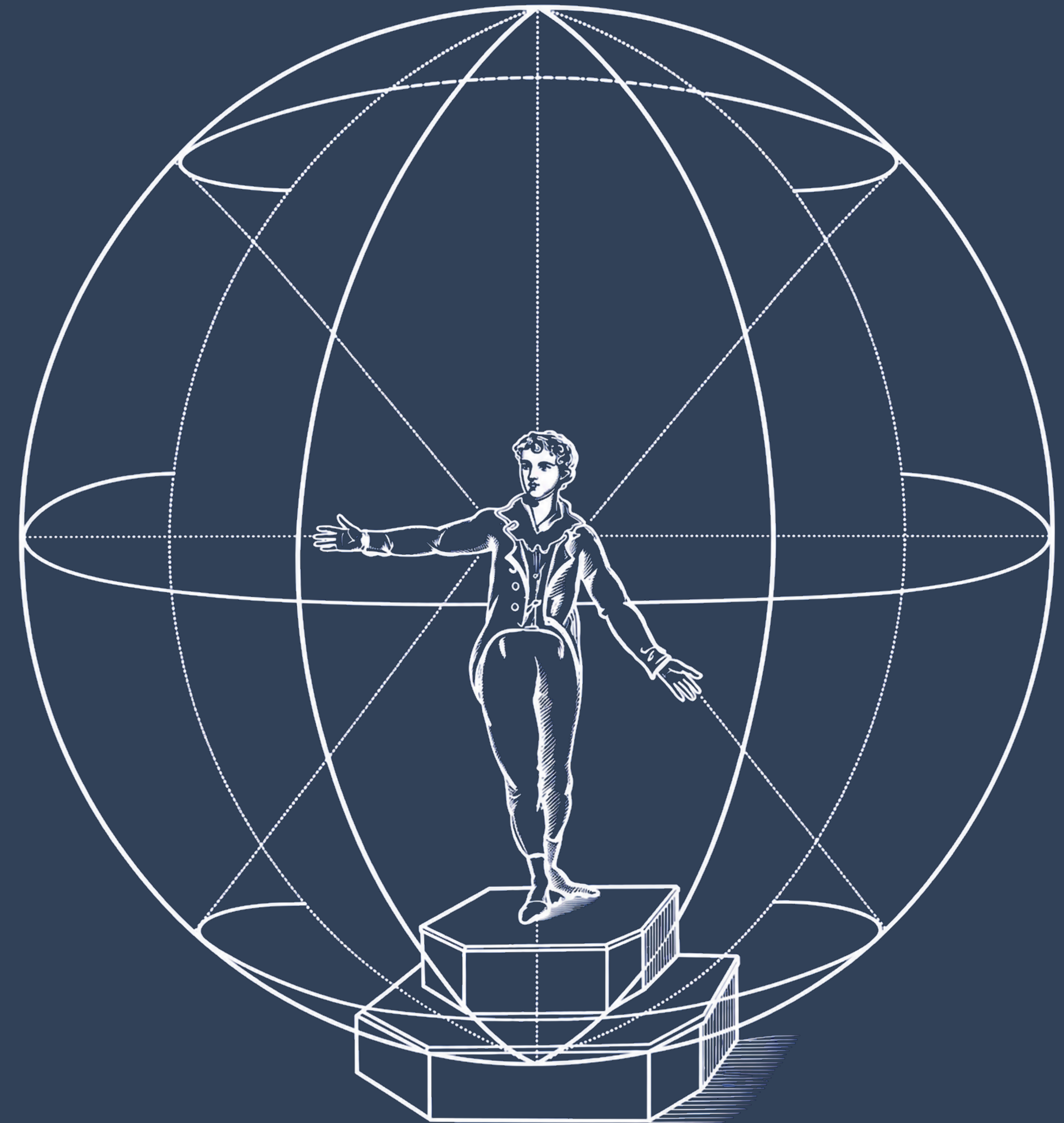


Photograph

Origins of Perspective

Perspective emerges from:
optics, geometry, art,
instruments, and culture

A field shaped by vision,
measurement, and image-making



A Landmark in Linear Perspective

An early example of coherent projection

Unified Vanishing Point

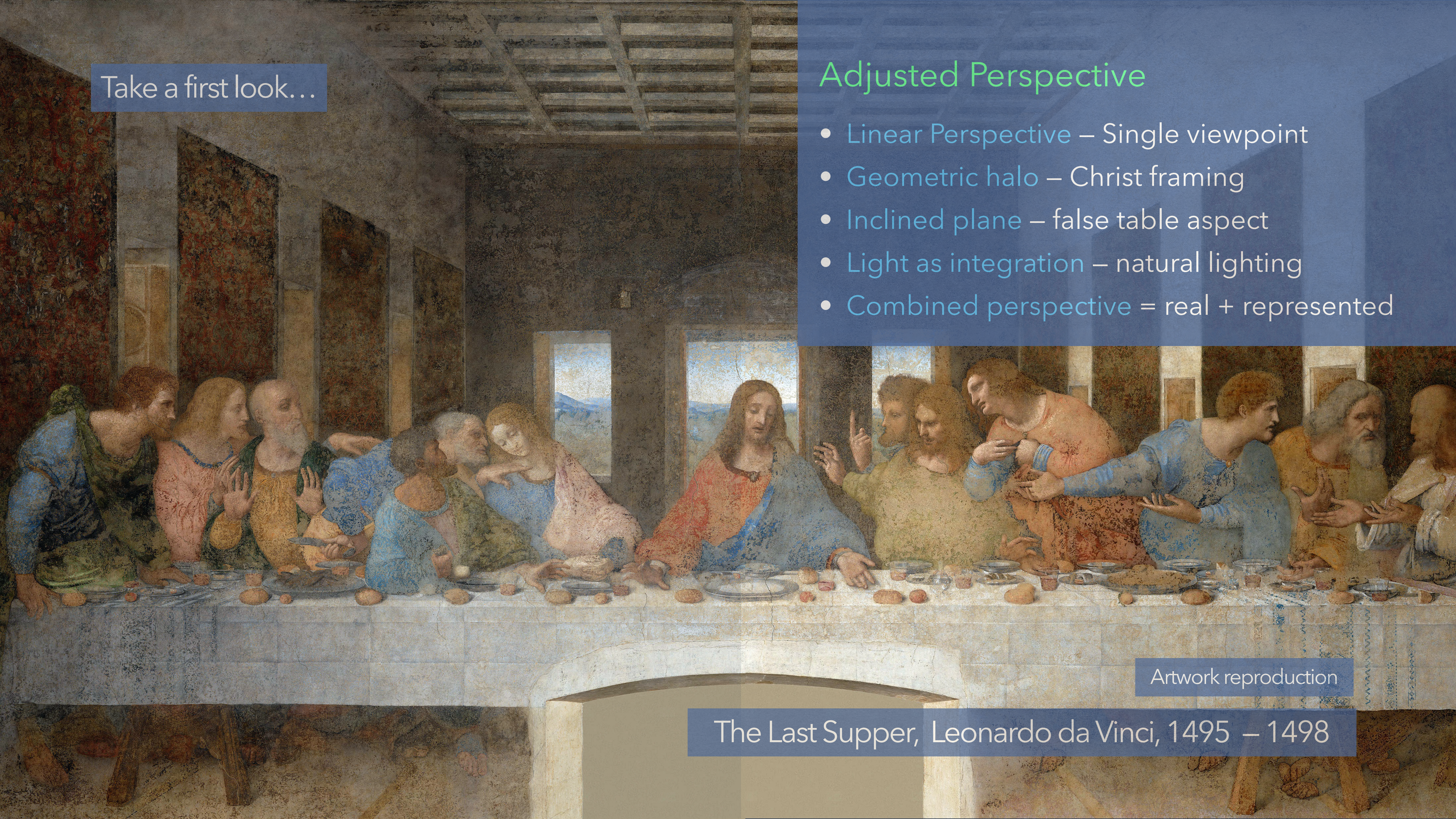
- Receding parallels converge on the VP
- Architectural edges share the same system
- A single-viewpoint image unifies space
- Linear perspective helped define modern visual theory



Take a first look...

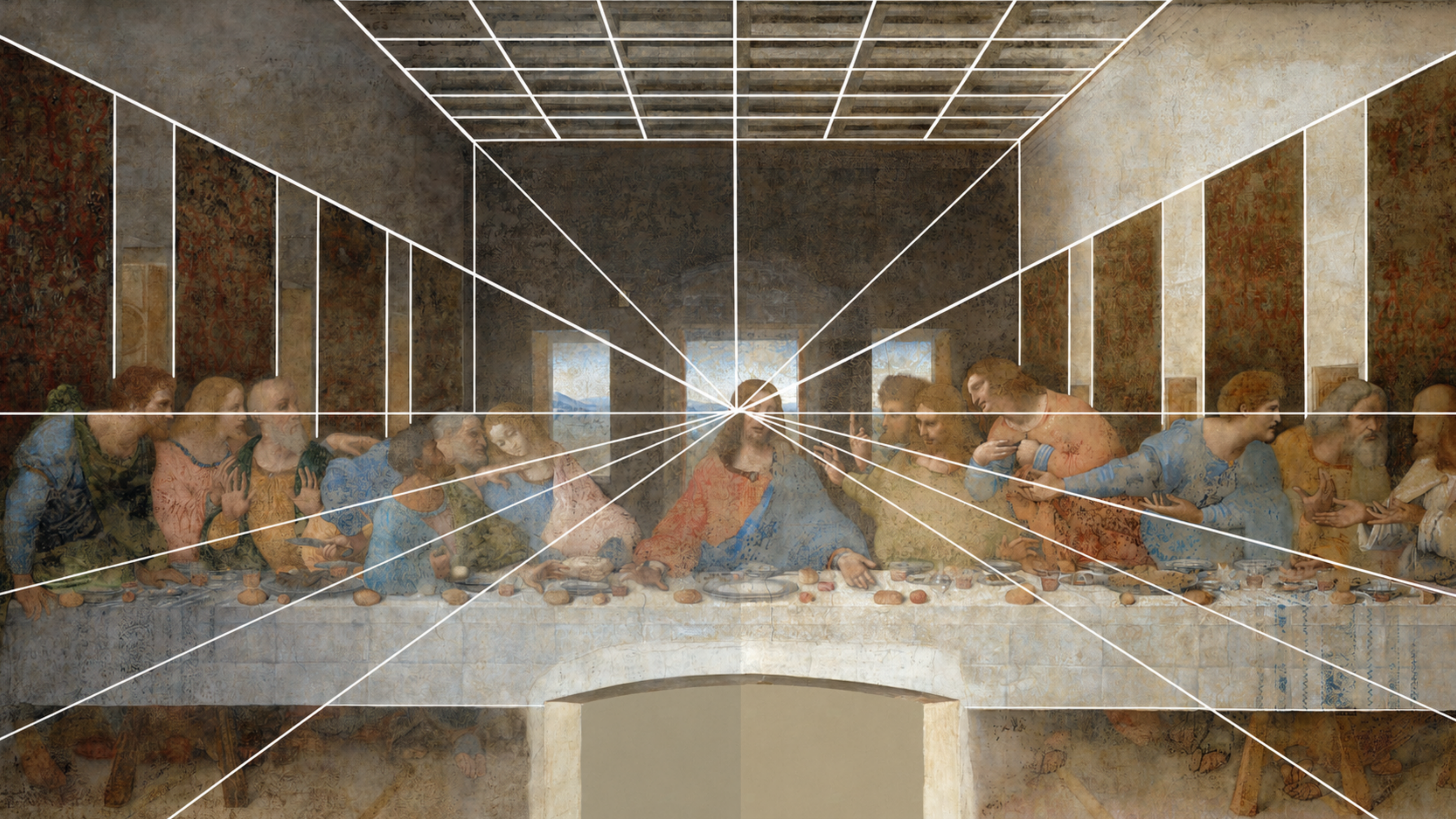
Adjusted Perspective

- Linear Perspective – Single viewpoint
- Geometric halo – Christ framing
- Inclined plane – false table aspect
- Light as integration – natural lighting
- Combined perspective = real + represented



Artwork reproduction

The Last Supper, Leonardo da Vinci, 1495 – 1498

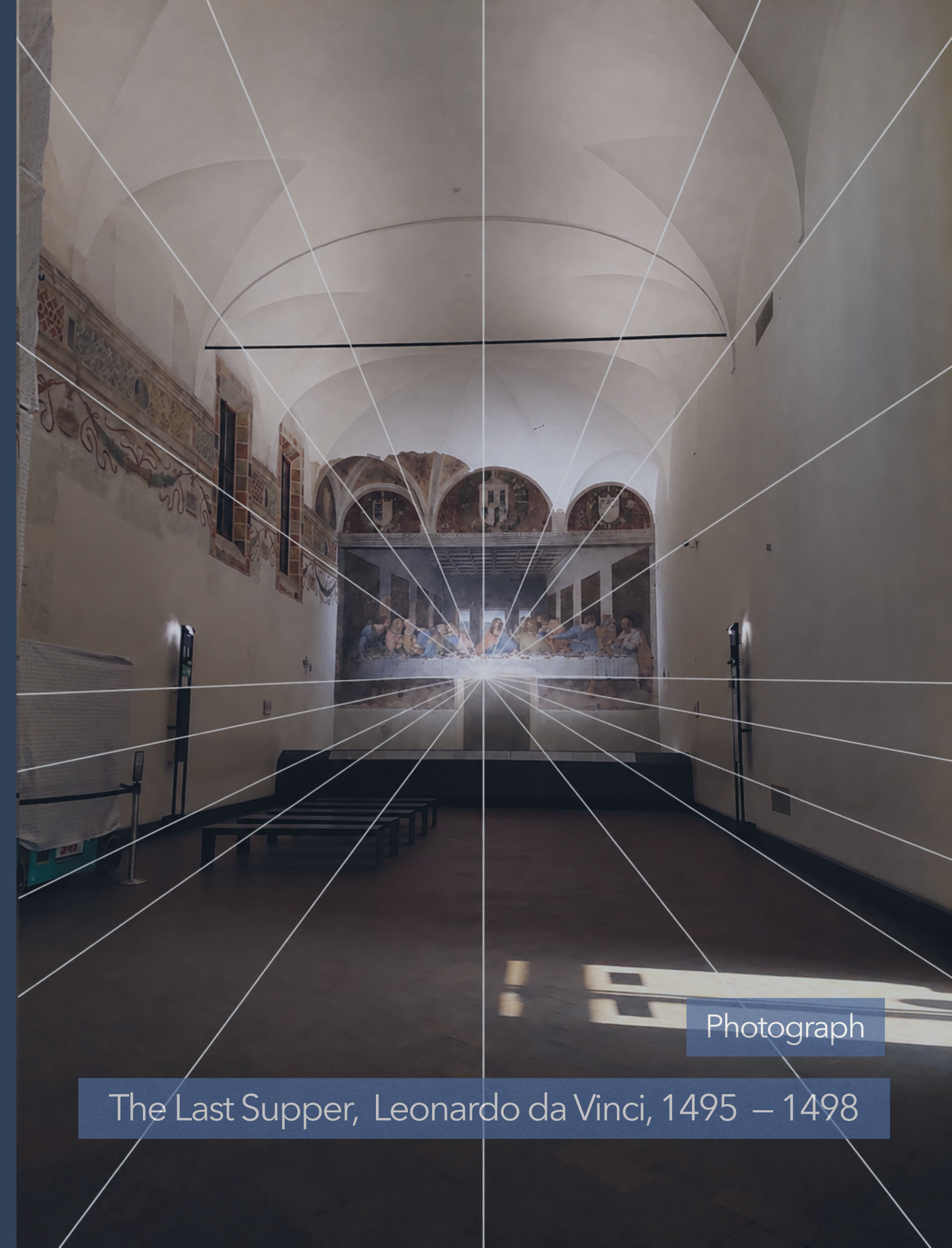


Leonardo da Vinci

One-point perspective creates...
the illusion of a room extending
from the dining hall

More than one-point perspective

Leonardo visually extends the real refectory into a represented architectural space. In PRC terms, this creates a form of **Combined Perspective**—real and represented space functioning together to produce a unified **synthetic spatial illusion**.



Photograph

The Last Supper, Leonardo da Vinci, 1495 – 1498

WHAT the perspective system contains.

Elements of Graphical Linear Perspective

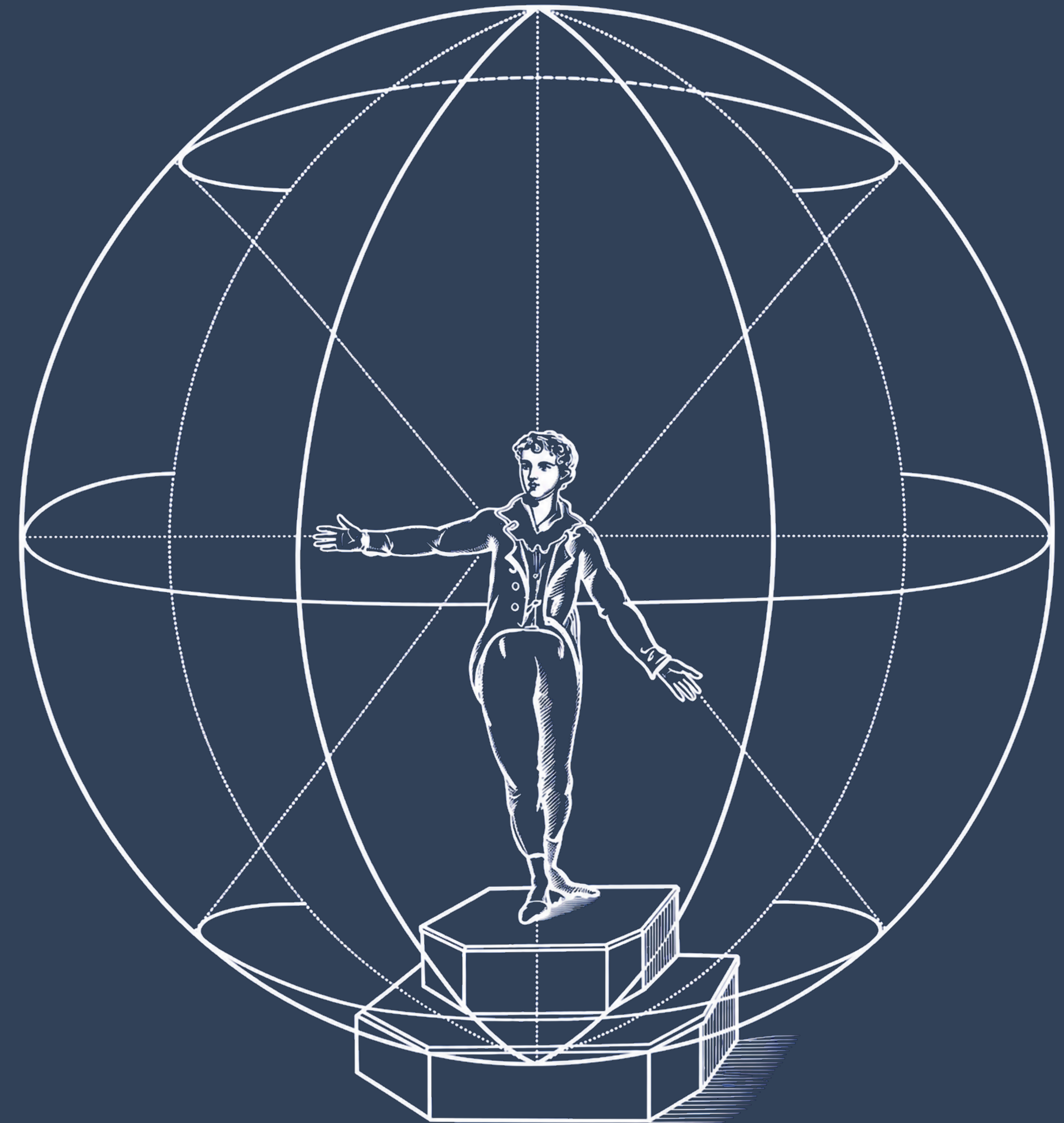
A linear perspective system contains five basic elements:

- **Eye / Camera** – Establishes a single viewpoint or projection centre.
- **Spatial Object / Scene** – The subject or spatial forms extending into depth.
- **Visual Rays / Visual Cone** – The sight-lines connecting the spatial scene with the viewpoint.
- **Picture / Projection Plane** – The two-dimensional surface on which the perspective view is formed
- **Pyramid of Spatial Recession** – The spatial depth structure within which recession, diminution and vanishing occur.

Axioms of Perspective

Perspective is governed by:
viewpoint, projection,
convergence, and scale

How space becomes visual form

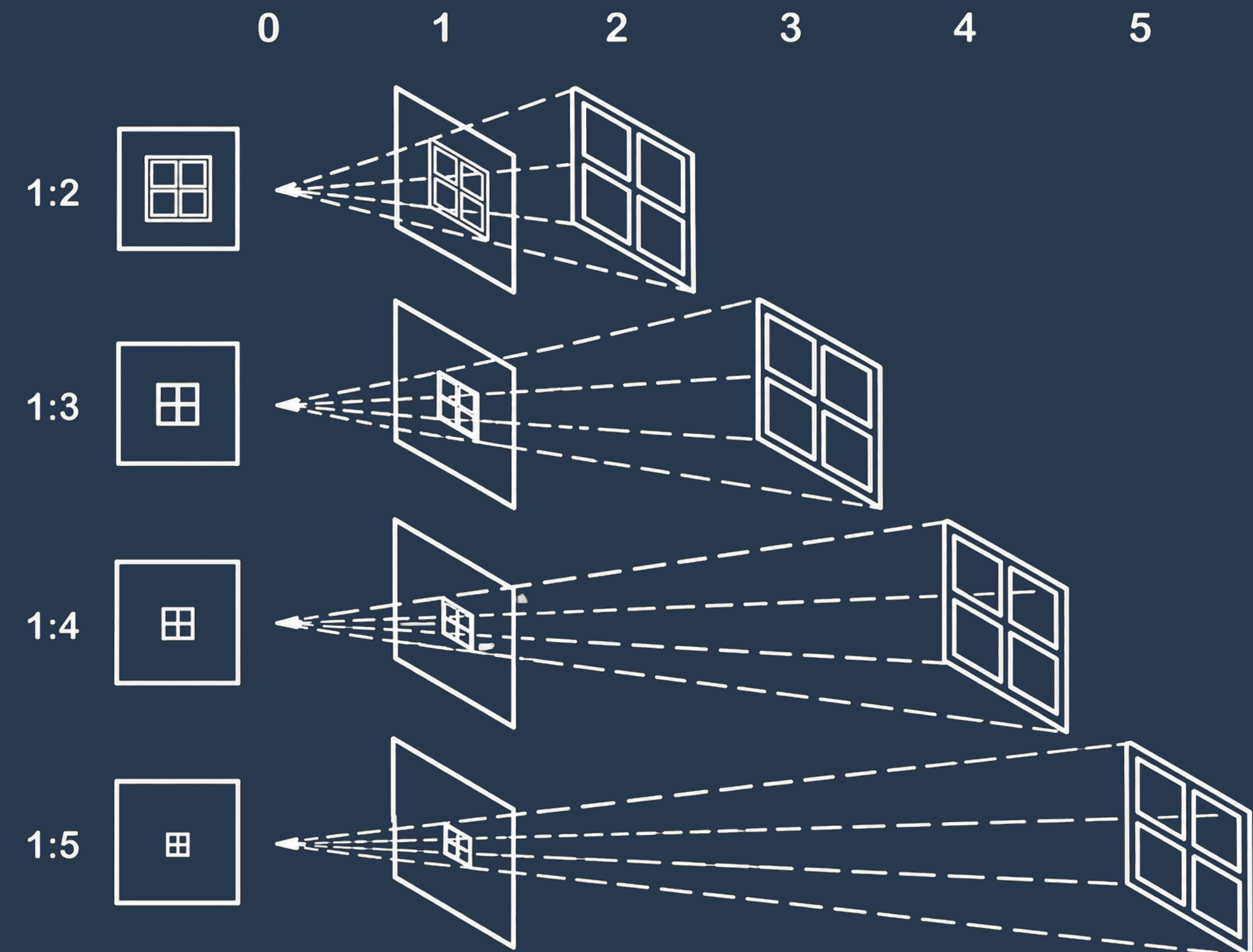


Size-Distance Law

Projection geometry explains why distant objects appear smaller

Apparent size decreases with distance

- Doubling the distance halves apparent size
- Receding parallel lines appear to converge
- A key fact of vision and drawing
- Applies to photography and projection



Two Kinds of Plane

Planes themselves – not their picture-plane appearances.

Original Plane - Extending into Depth (exists in Object Space)

- **Original Plane → seen at an angle** – An object-space plane, such as a ground plane, wall, ceiling or road. **Visible as a two-dimensional surface.**
- **Original Plane → seen Edge-On** – An object-space plane whose extension passes through the eye-point. **Visible as a line.**

Imaginary Plane - Extending into Depth (in Object Space)

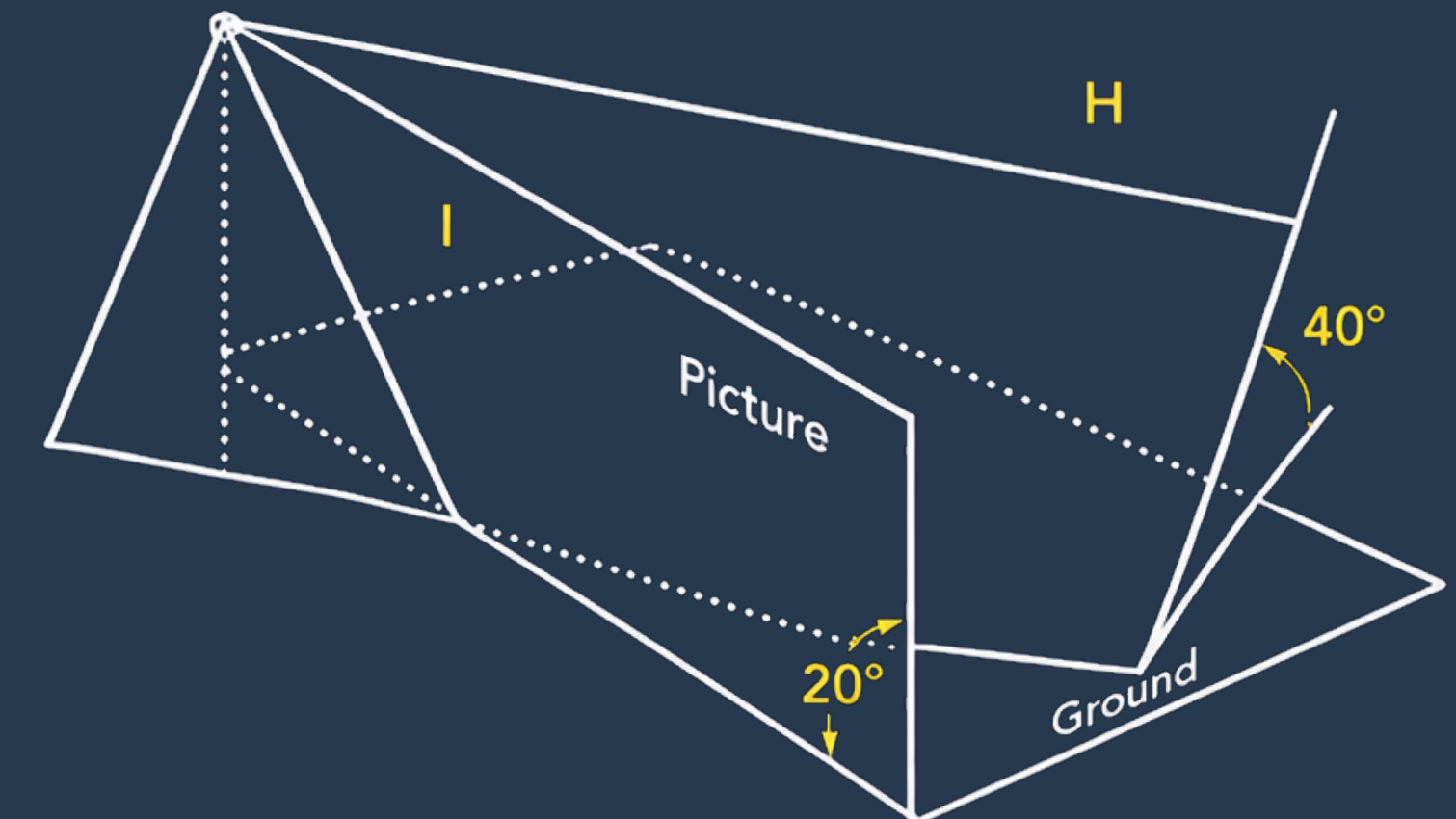
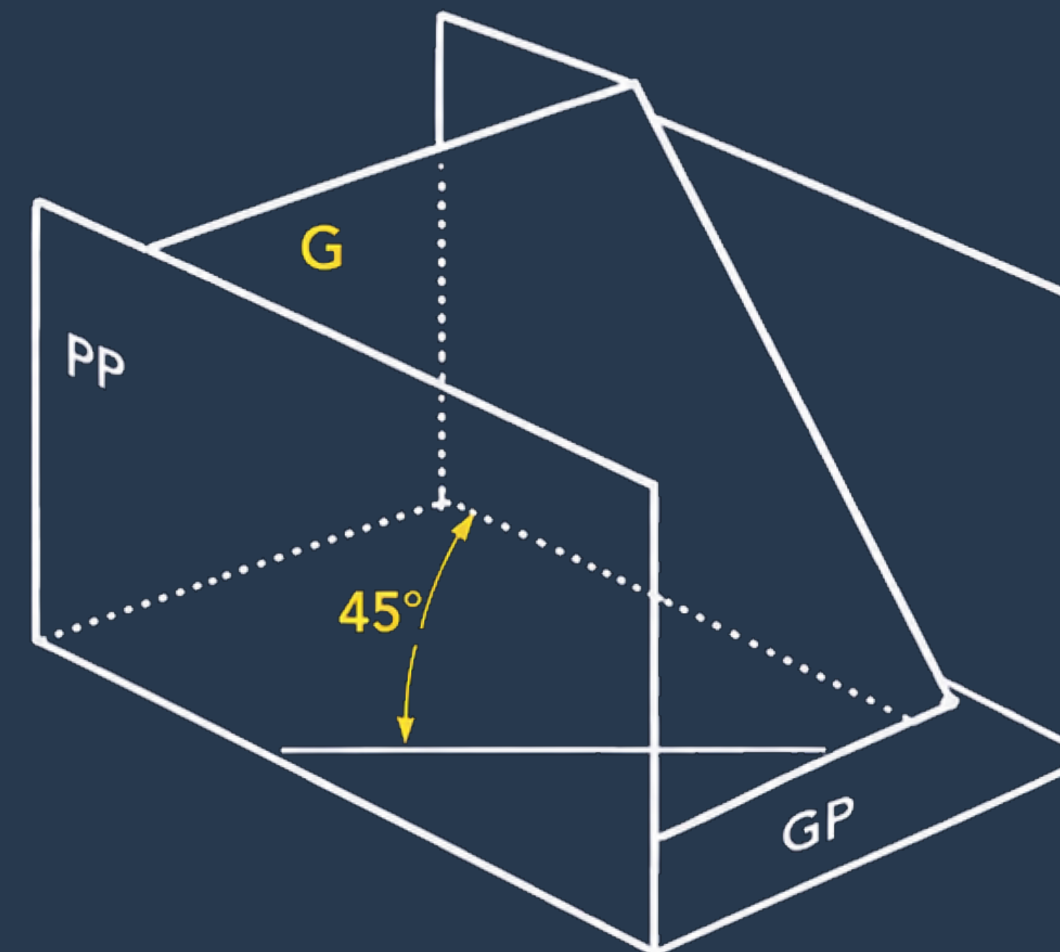
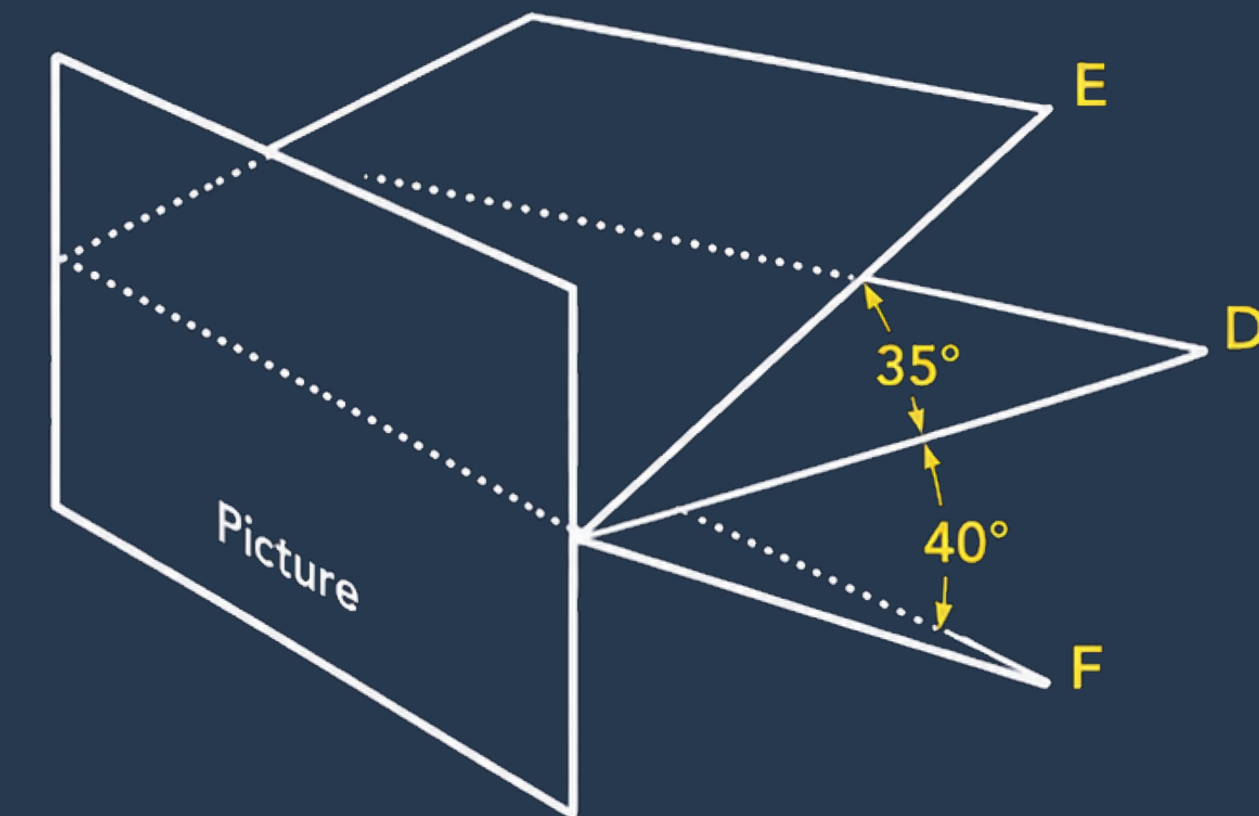
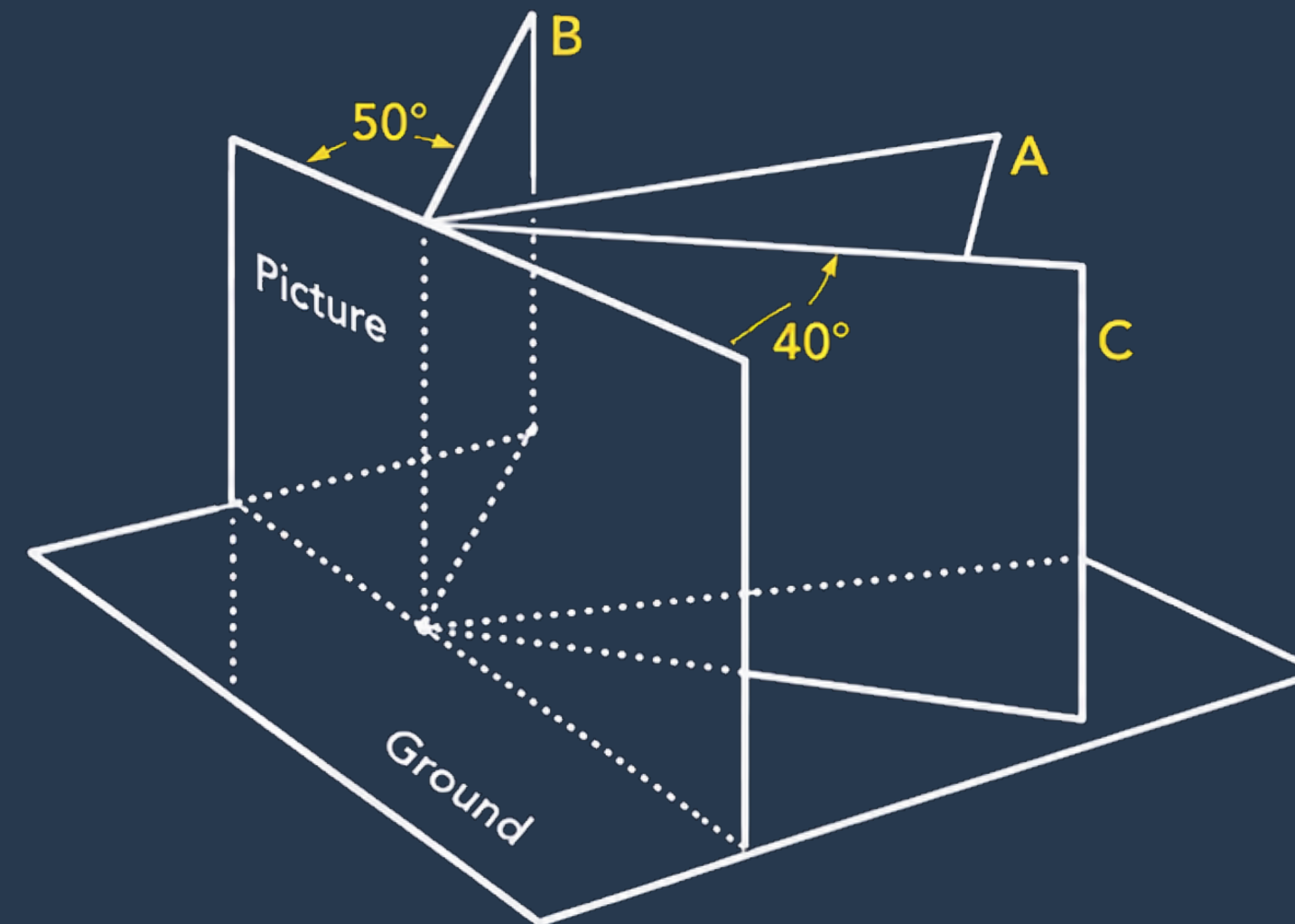
- **Visual Plane** – Imaginary plane passing through the eye-point and extending across the visual field. **Represented by crossed lines centred on the sight line.**
- **Reference Plane** – Directional reference plane passing through the eye-point and extending across the visual field.

Plane Positions

Object Space Planes

- 1) Parallel to the picture plane (I)
- 2) Horizontal (D)
- 3) Vertical (A)
- 4) Inclined - along sight line (G)
- 5) Directly Ascending or Descending (E or F)
- 6) Vertical Angled (B or C)
- 7) Obliquely Ascending or Descending (H)

The Seven Positions of Planes



Visual Plane

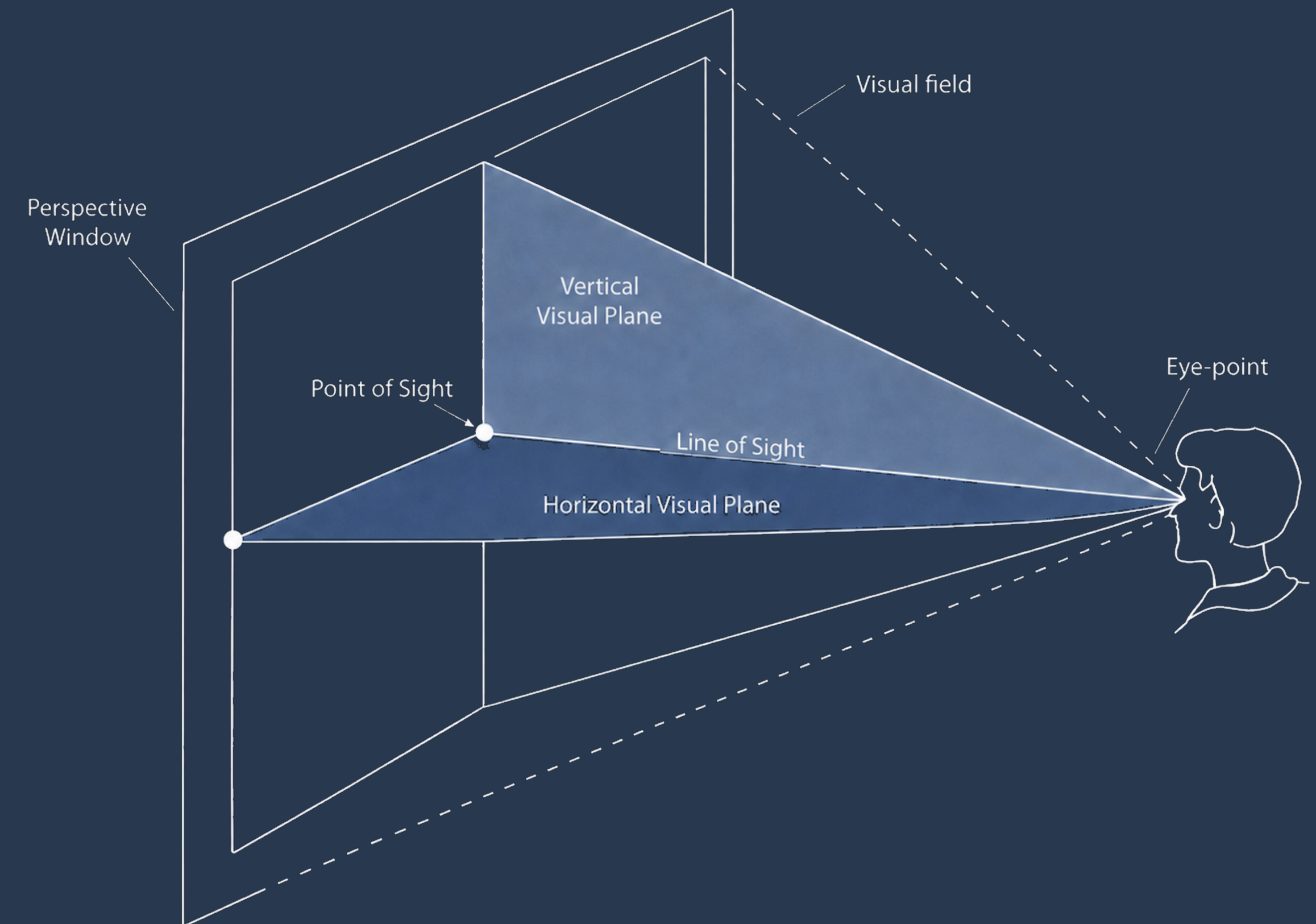
An observer-centred imaginary reference plane passing through the eye-point and extending across the visual field

Facets

- **Seen Edge-on** – the Visual Plane appears as a line.
- **Two Planes** – Vertical / Horizontal.

Explains

- **Sight Line + Point of Sight** – establish **visual direction** and **centre of view**.



Real Eye or Camera - Image Plane

A real eye or camera forms the image behind the effective projection centre.

Object → lens / aperture → projection centre → retina / sensor

- **Ray Sorting** – Rays from each object point fall at a single image point.
- **Inverted Image** – The physical image is inverted.
- **Image Plane Shape** – Eye: curved retina. Camera: planar sensor or film.

Two Related Configurations:

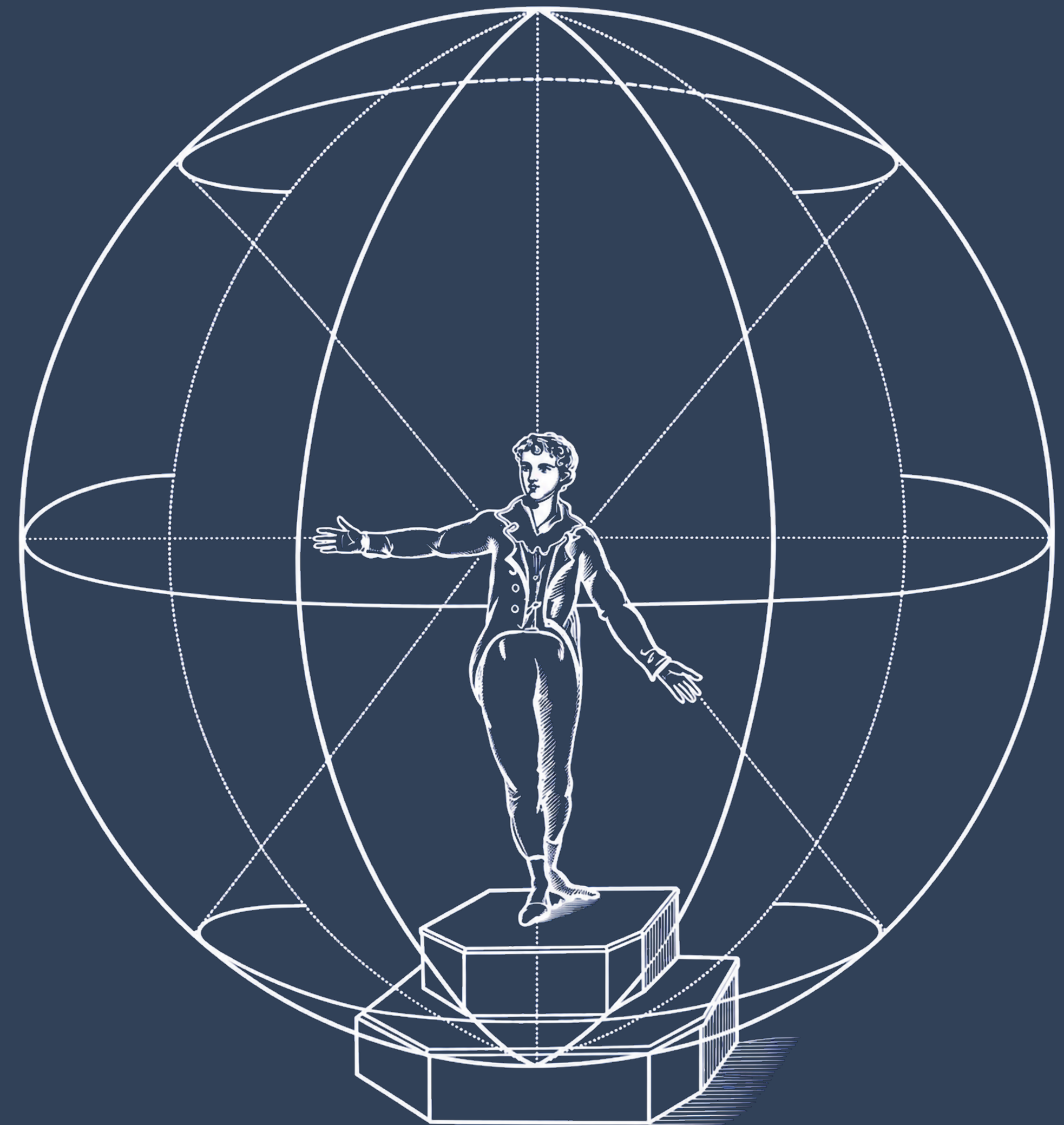
- **Conventional Picture Plane** – the conventional geometrical projection plane in front of the eye-point.
- **Rear Image Plane** – physical imaging surface; inverted image.

Picture Plane $\neq$ Physical Image Plane / Retina / Sensor

The Visual Element and Vanishing

The Visual Element connects spatial direction and plane orientation to vanishing

From spatial direction → to vanishing point, vanishing trace and plane collapse



Parallel Systems in Object Space

Perspective begins with two basic organised systems in object space: systems of parallel lines and systems of parallel planes.

Parallel Line System

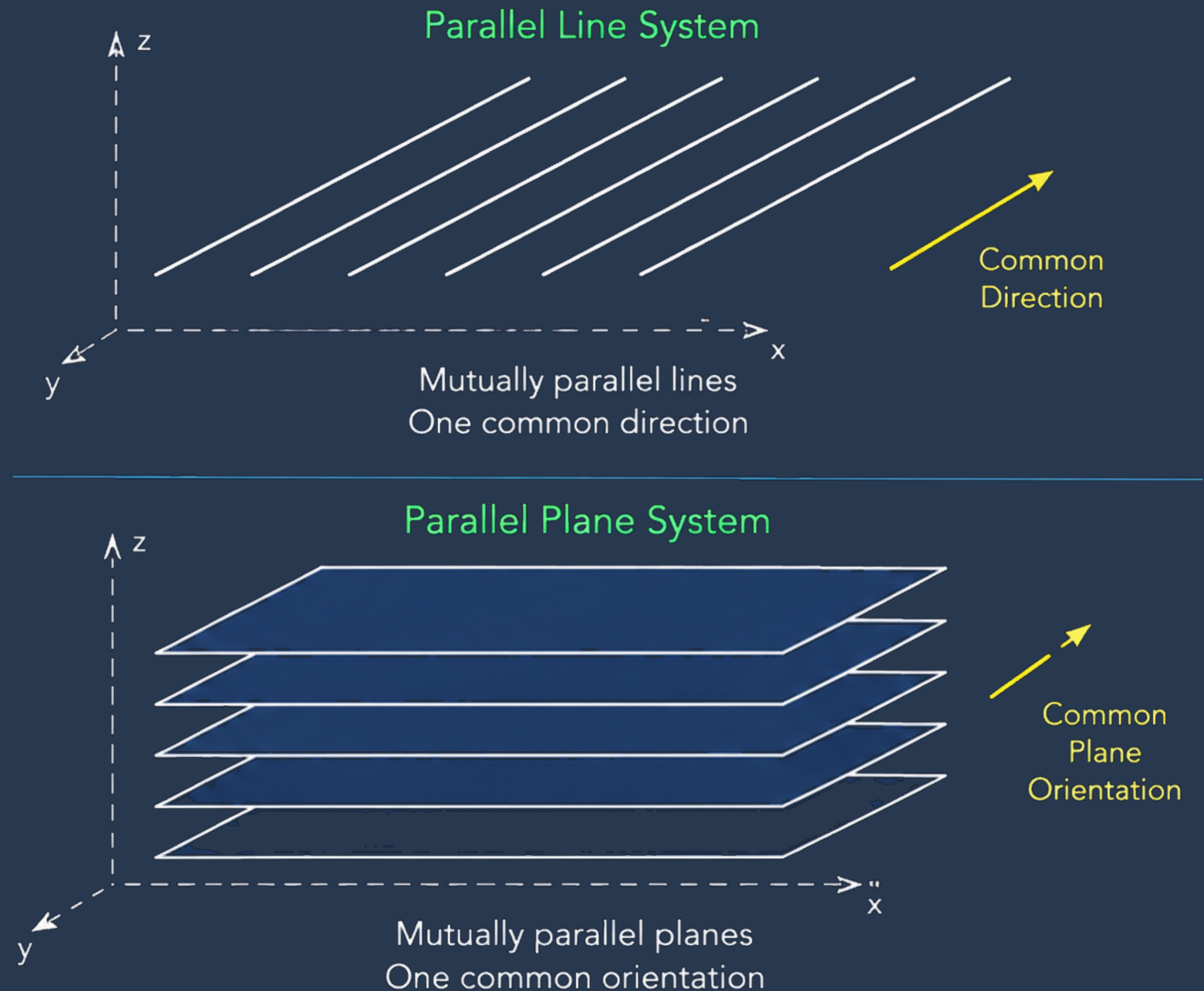
A family of lines that remain mutually parallel in object space and share one common direction.

Parallel Plane System

A family of planes that remain mutually parallel in object space and share one common plane orientation.

Key Idea

These are object-space systems. Parallel in object space; converging or vanishing in projection.



Visual Element of the System

A system-specific geometrical reference defined through the eye-point by the direction or orientation of a particular parallel-line or parallel-plane system in object space.

Components

- **Line system** – The Visual Element is directed **parallel to the line system**, establishing a **Directional Reference Line** through the **eye-point** and parallel to that system.
- **Plane system** – The Visual Element is directed **parallel to the plane system**, establishing a **Directional Reference Plane** through the **eye-point** and parallel to that system.

Key idea

The Visual Element belongs to the spatial system being analysed. Each family of parallel lines or planes therefore has its own Visual Element, defined relative to the eye-point.

There are potentially an infinite number of different line directions and plane orientations present and each one associated with a unique Visual Element.

It is distinct in function from the observer's sight line or optical axis, although the two may geometrically coincide in the special central one-point case.

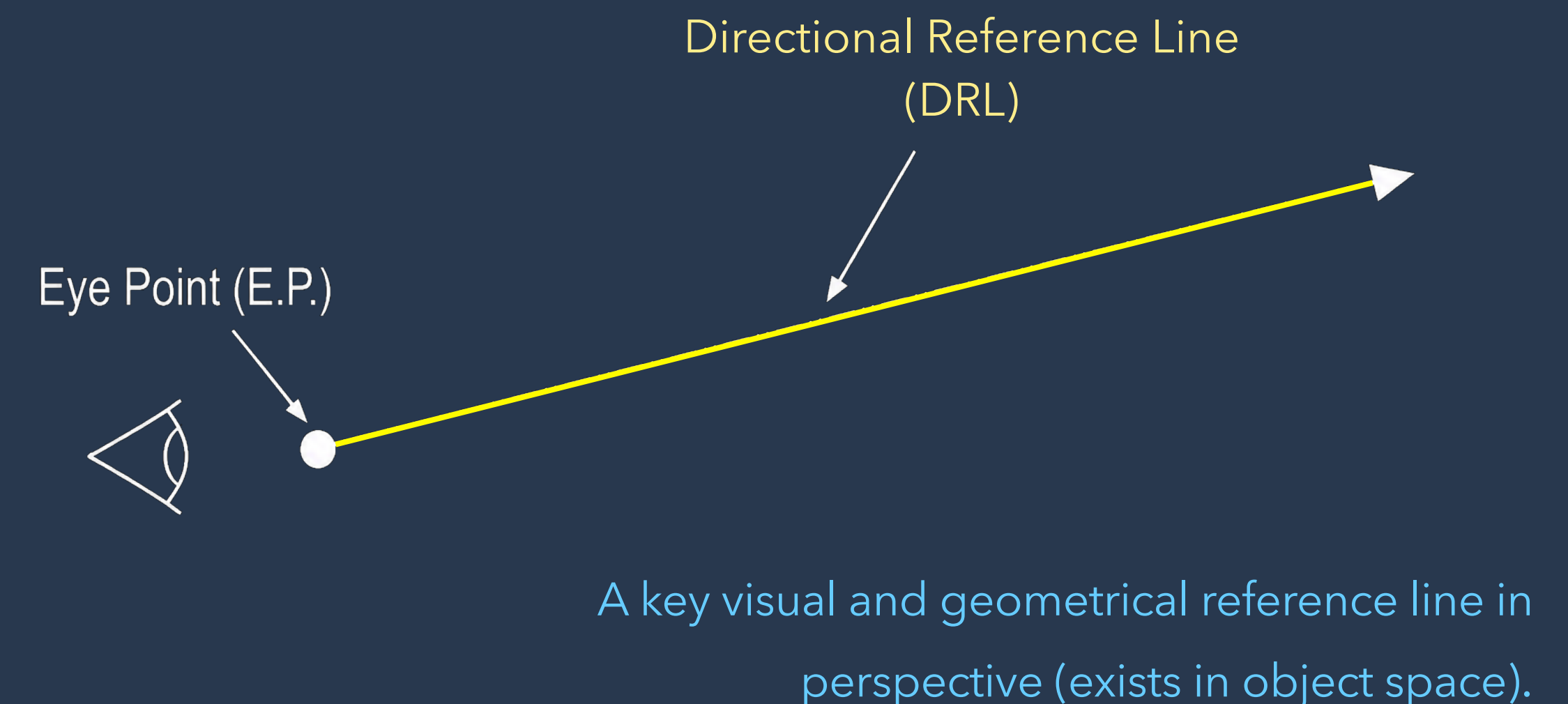
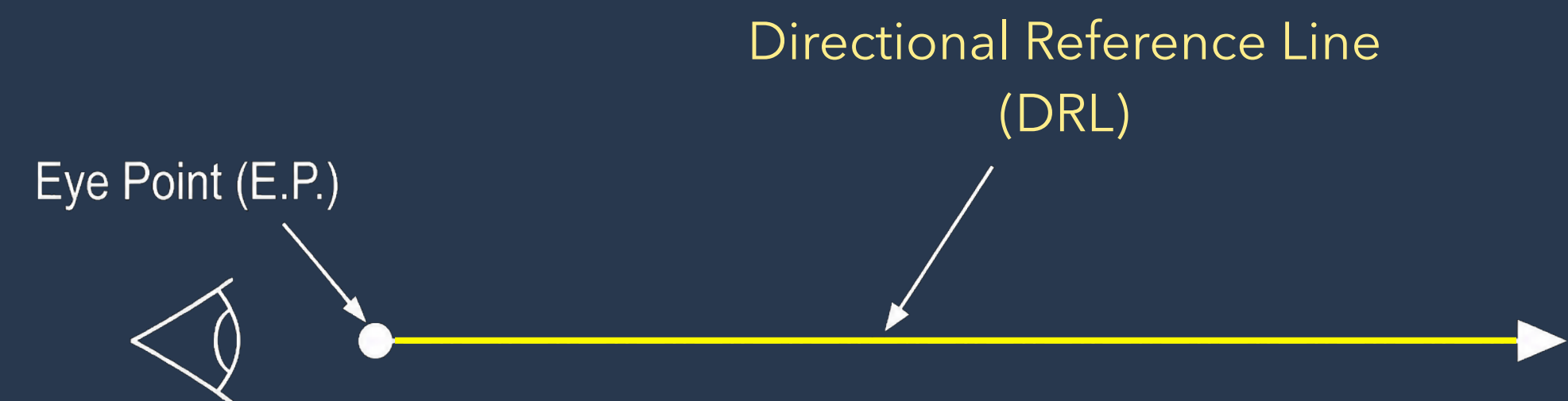
Directional Reference Line

An imaginary line that passes through the **eye-point** and represents the reference direction of a given directional system.

It provides the geometrical basis by which the directional and vanishing behaviour of that system can be understood.

Key Points

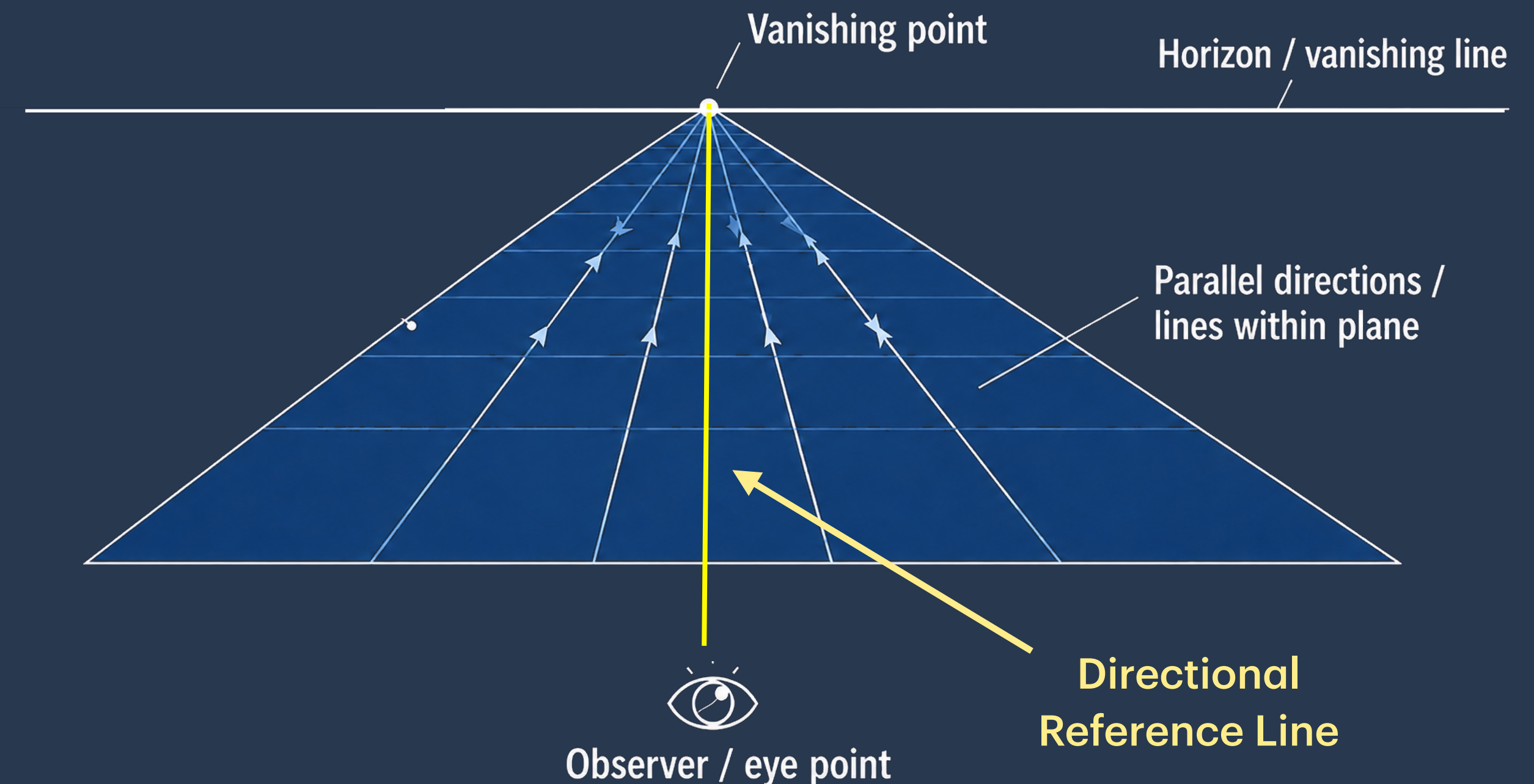
- Passes through the eye-point
- Defines the reference direction of the system
- Provides the basis for understanding directional vanishing



Directional 'Line' Vanishing

Parallel lines in object space that are parallel to a corresponding Directional Reference Line project towards the Vanishing Point established where that DRL intersects the picture plane.

- **Key Idea** – Plane remains visible (extension does not pass through eye-point).
- **What Vanishes** – Parallel depth-directions and lines within the plane.
- **Formula** – Directional Reference Line → Vanishing Point.
- **Explains** – Roads, floors, ceilings and walls where the plane remains visible while its internal directions converge.



The lines remain parallel in object space; only their projected images converge.

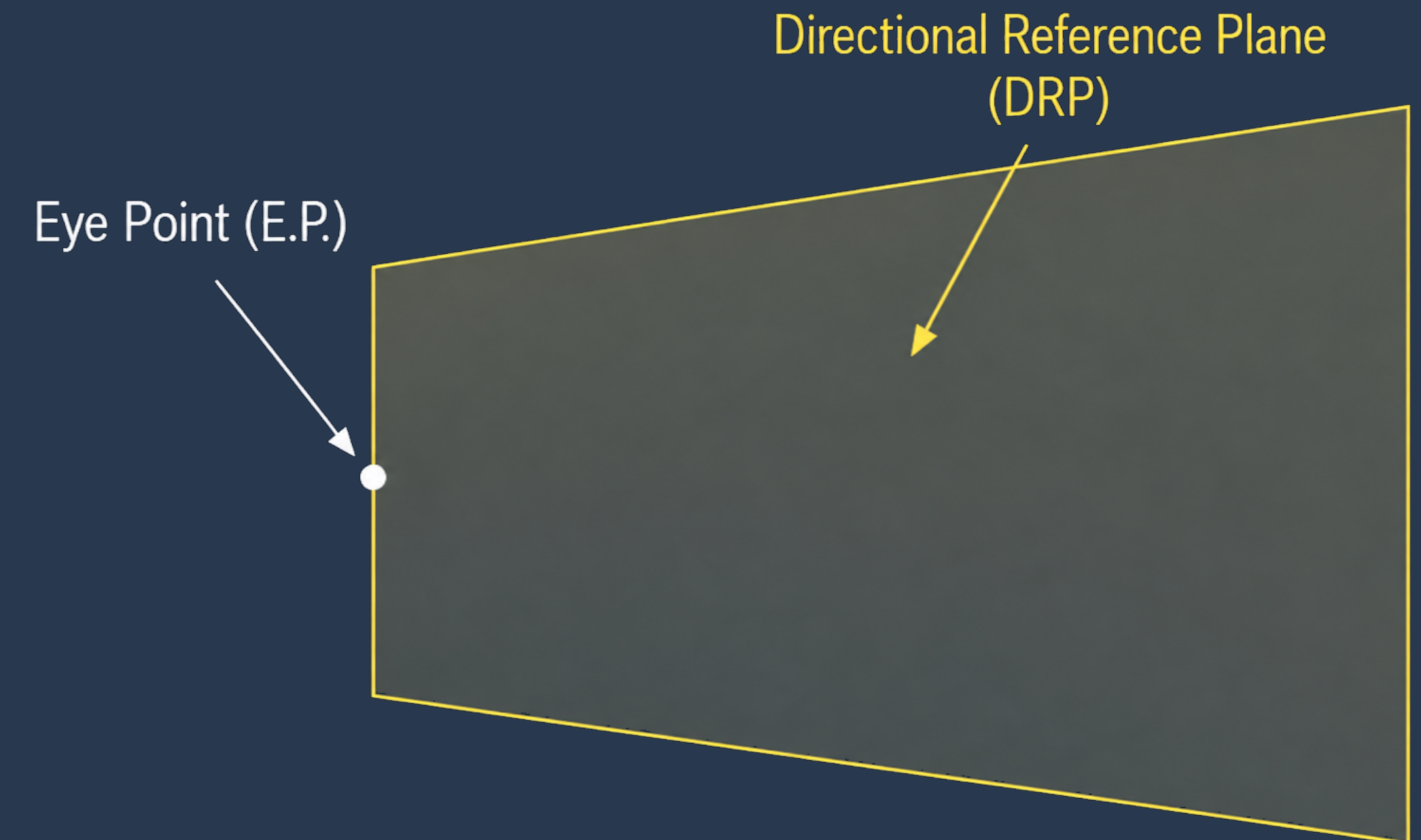
Directional Reference Plane

An imaginary plane in object space that passes through the eye-point and has the orientation of a given system of parallel planes.

It provides the geometrical reference by which directional plane vanishing and aspect vanishing can be understood.

Key Points

- Passes through the eye-point
- Directional Reference Plane projects edge-on as a line
- Defines the reference orientation of the system
- Helps explain directional plane vanishing and aspect vanishing

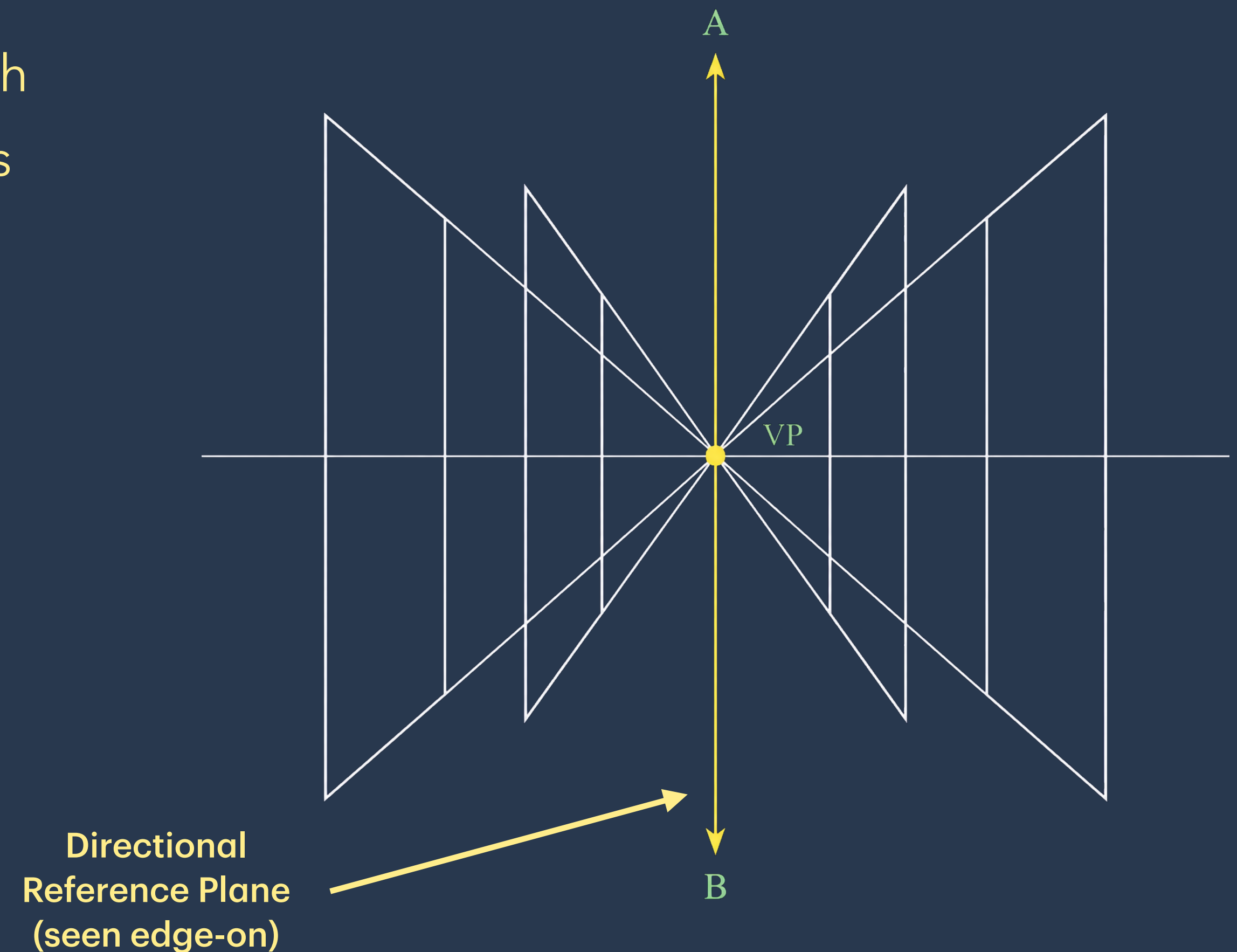


A key visual and geometrical reference plane in perspective (in object space).

Directional 'Plane' Vanishing

A plane has a parallel Directional Reference Plane through the eye-point. Its intersection with the picture plane forms the Vanishing Trace, containing the vanishing points of directions within that plane.

- **Key Idea** – The object plane and the Directional Reference Plane are parallel and distinct.
- **What Vanishes** – Line directions within the plane generate vanishing points aligned on one common trace.
- **Formula** – Directional Reference Plane projects edge-on → Vanishing Trace.
- **Explains** – apparent convergence of parallel wall planes.



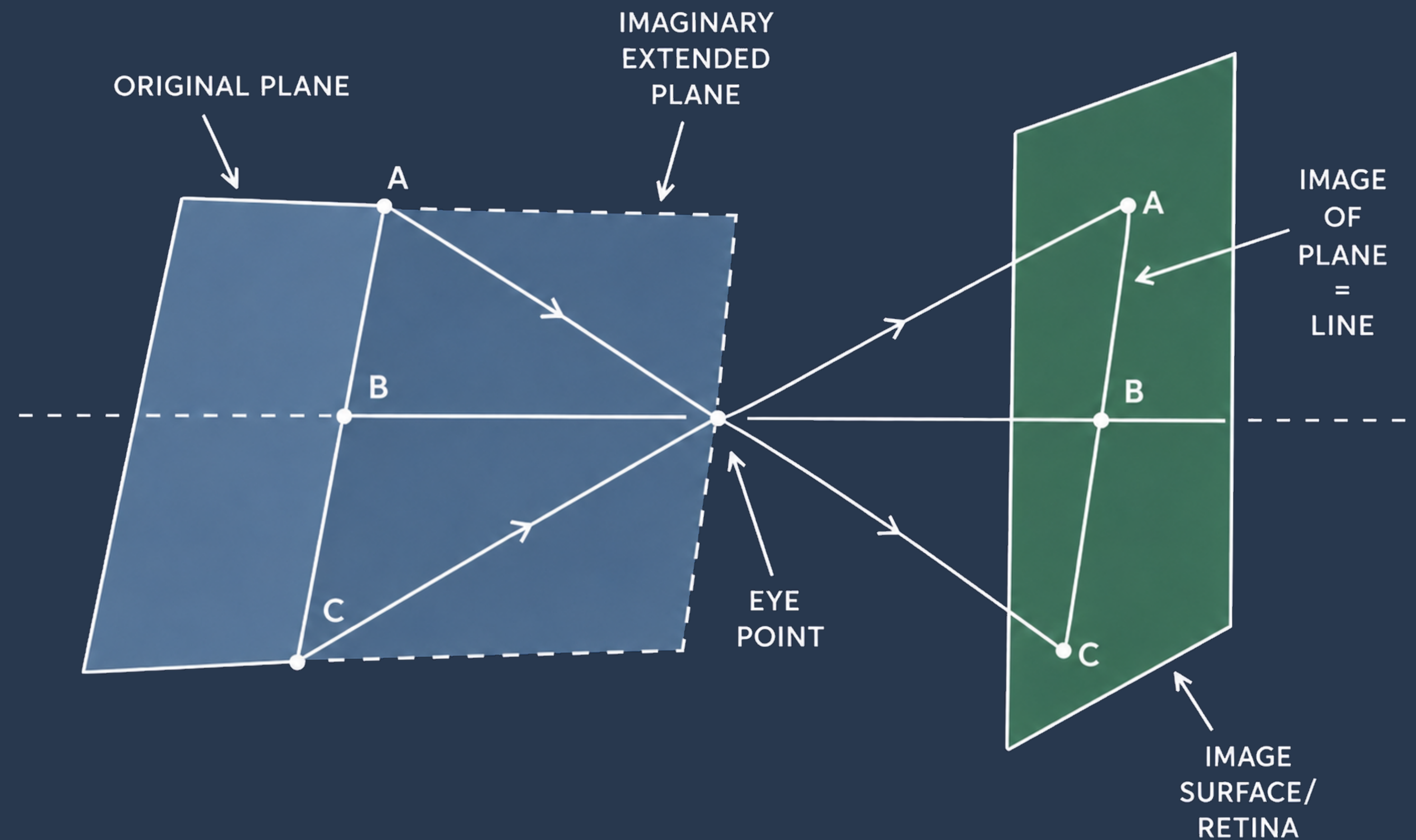
The planes' horizontal edges also converge to their VP;
plane vanishing does not replace line vanishing.

Plane Collapse Condition: Plane Whose Extension Passes Through the Eye-Point

The limiting condition of **Aspect Vanishing**, reached when the extended plane of an object-space plane becomes geometrically coincident with its corresponding **Directional Reference Plane** and therefore passes through the eye-point.

Geometrical Limiting Condition

- **Original Plane** – Its imaginary extension in object space passes through the eye-point.
- **Image of Plane is a Line** – The plane projects as a line on the image surface.



Visual Effects of the Visual Element

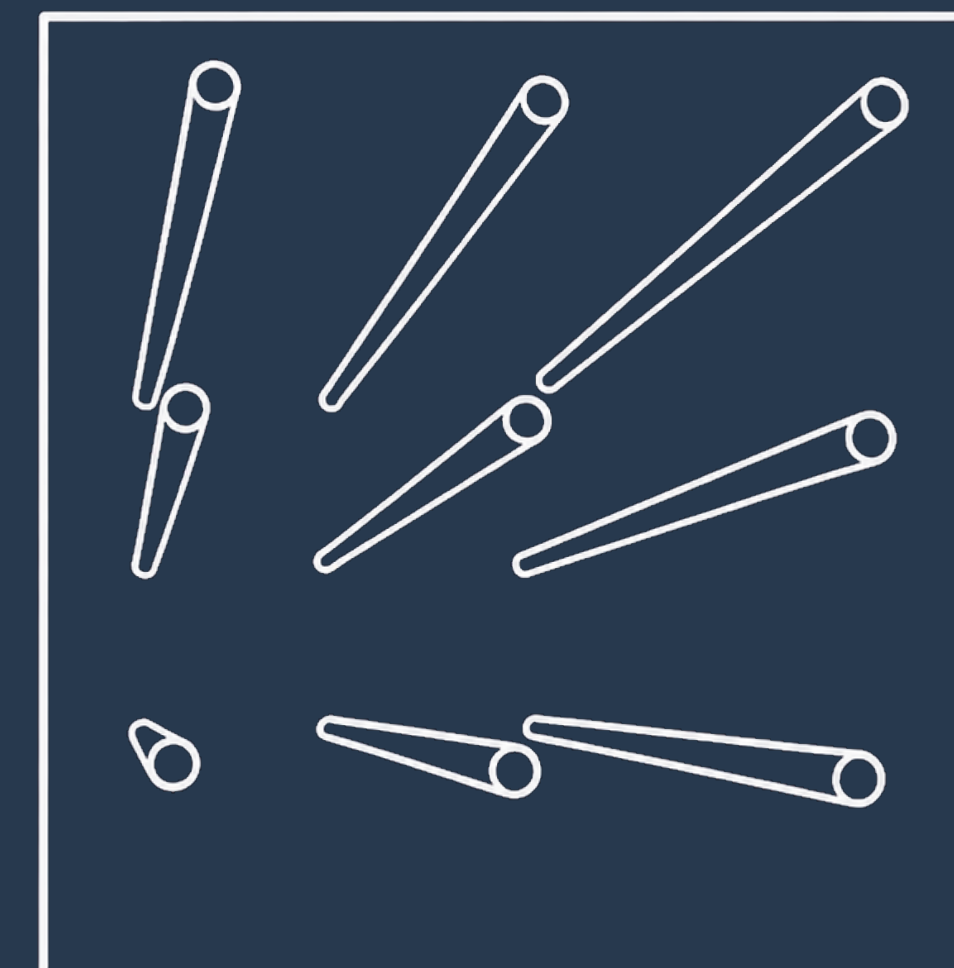
Each parallel line or plane system has its own Visual Element, defining its geometrical relationship to the eye-point.

- **Line system** — the Visual Element extends from the eye-point along the direction of the parallel lines and defines their directional vanishing relationship.
- **Plane system** — represented by a Directional Reference Plane passing through the eye-point and parallel to the corresponding plane system.
- **Vanishing condition** — Directional Line or Aspect Vanishing depends on the eye-point/system projection angle. Changing sight line or optical axis leaves the Visual Element fixed, but may shift the projected vanishing element.

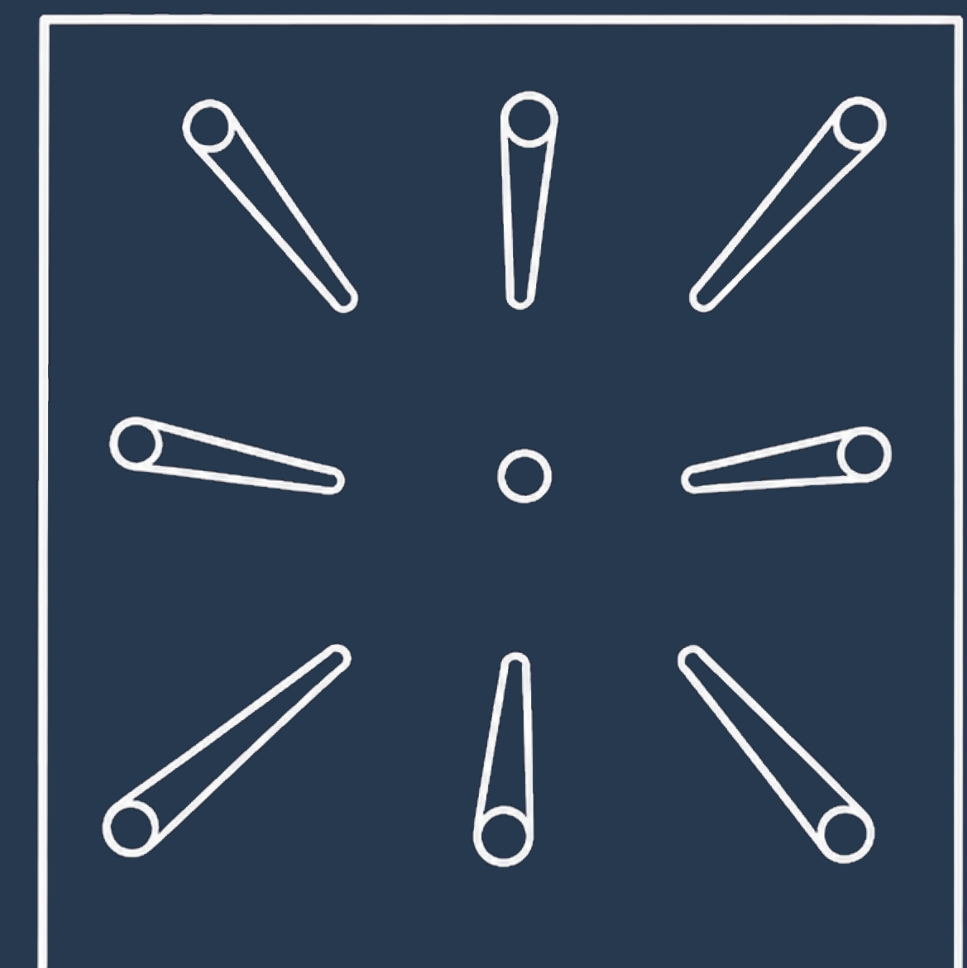
System-Specific Visual Elements

Different parallel line and plane systems establish different Visual Elements from the same eye-point.

C: Middle Plane



A: Bottom Left Pole



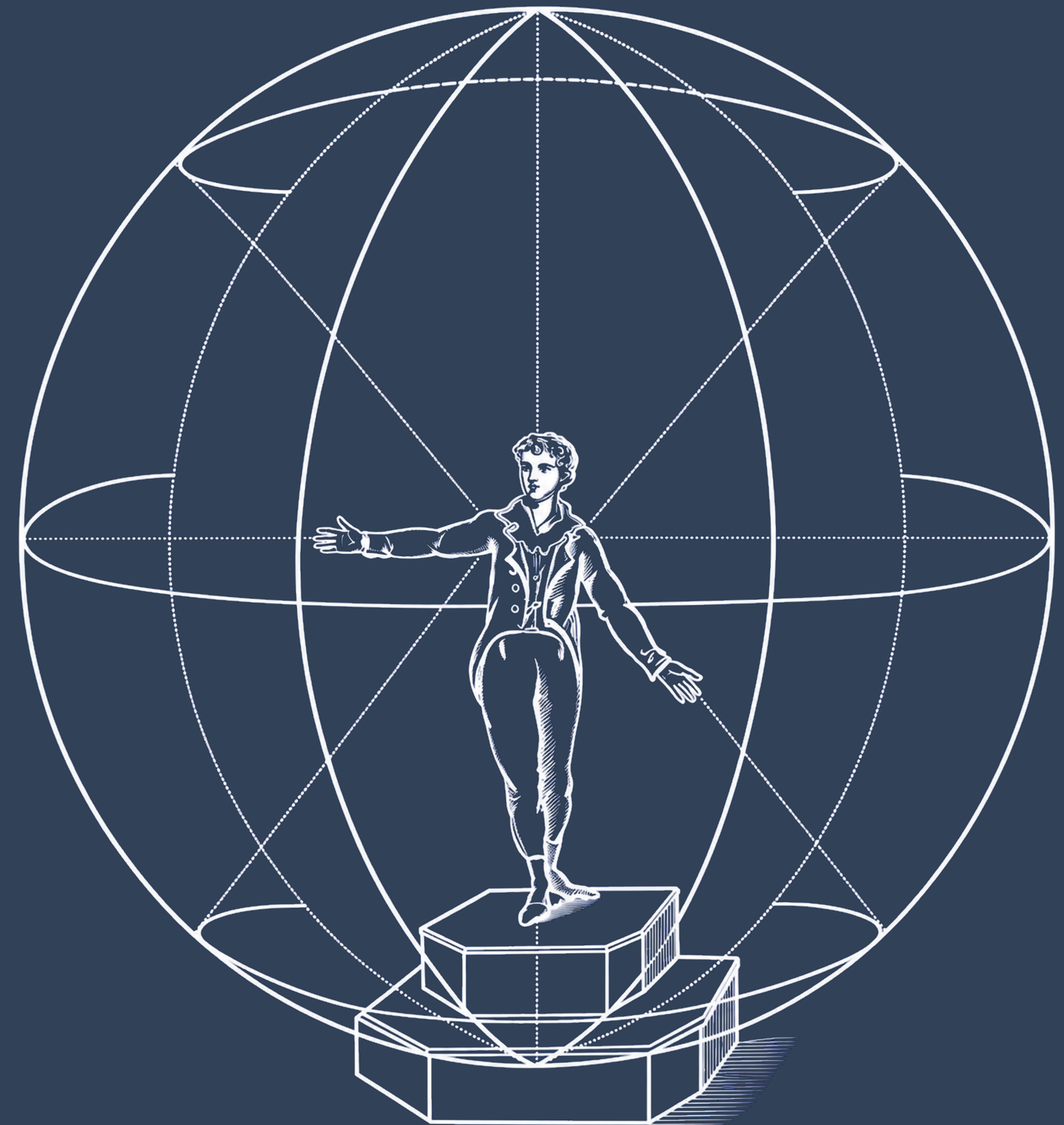
B: Middle Pole

Principles of Graphical Linear Perspective

Linear perspective is structured
by parallels, planes, vanishing
structures, and horizon lines

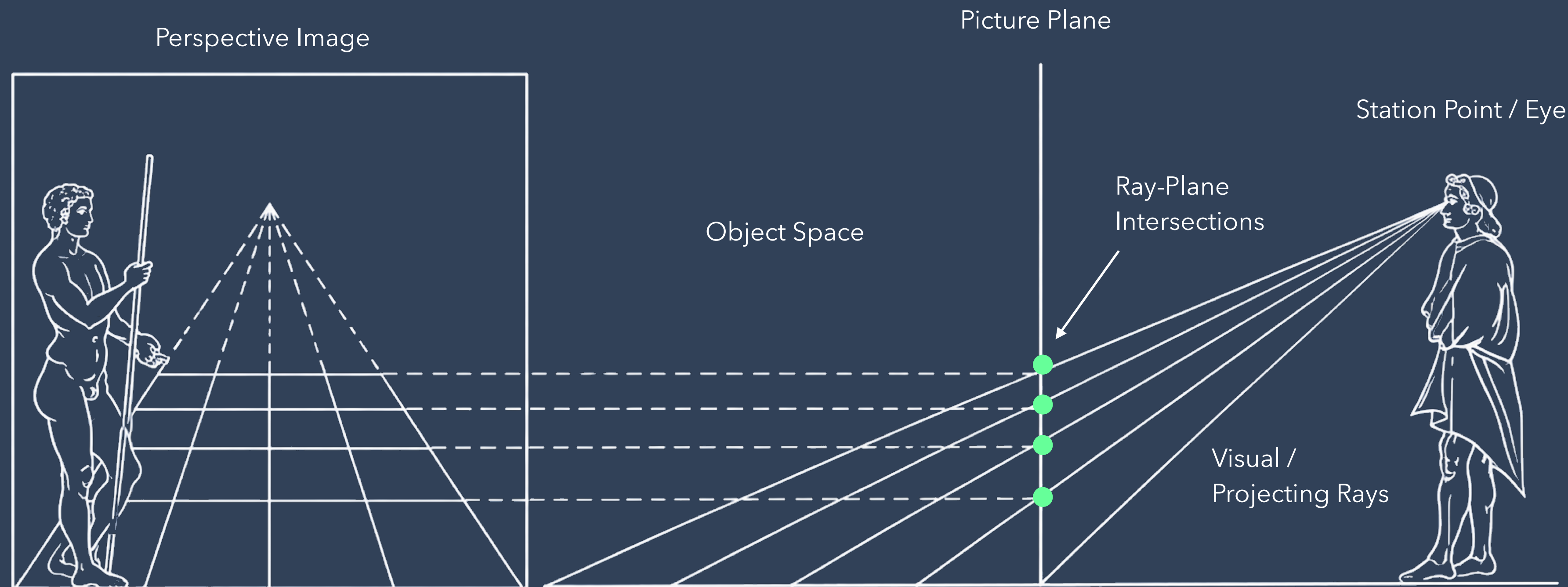
How spatial form appears

This section considers the Perspective of Form—
especially linear perspective, involving lines,
planes and geometrical vanishing.



Exact Geometrical Construction of Linear Perspective

ONE-POINT EXAMPLE



Geometrical Construction

- Establish the station point, object space and picture plane
- Project **visual rays** from spatial points to the station point
- **Ray-plane intersections** determine the image points

Image points are fixed where visual rays intersect the picture plane.

Orthogonal Lines

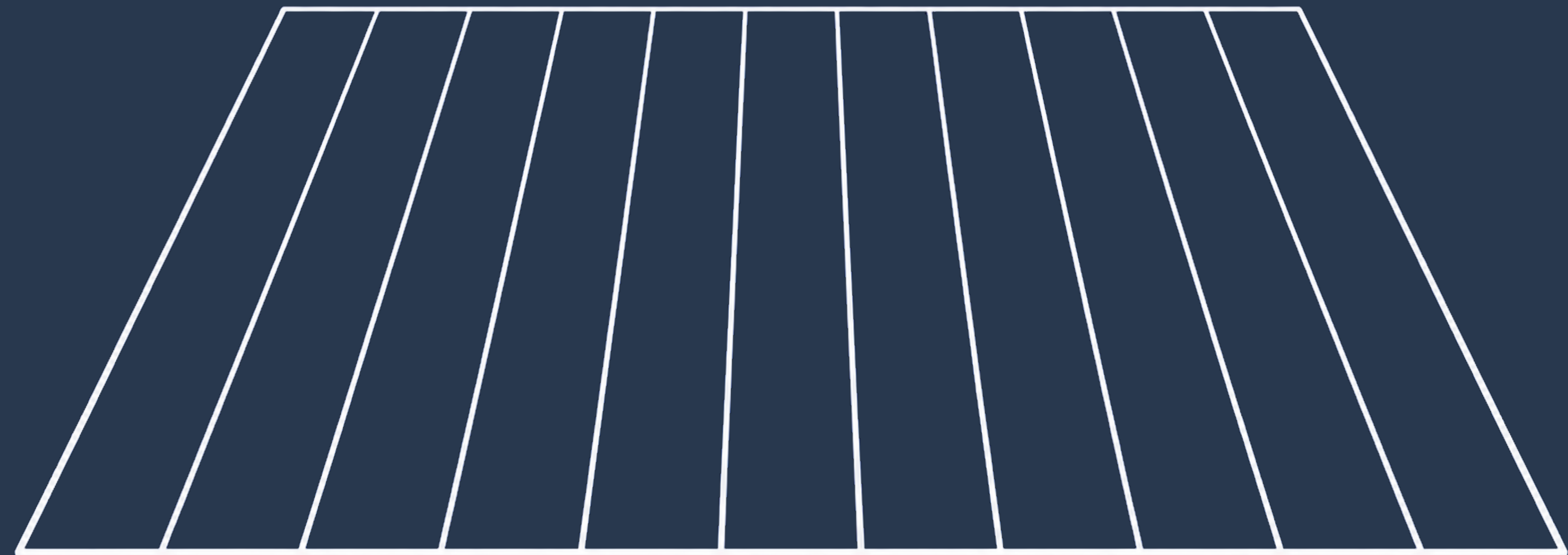
Ground-plane parallel lines that
run directly away from the viewer

Set of Parallels

Lines that extend through
space while remaining
mutually parallel

Orthogonal Lines on the Ground Plane

Like railway tracks, they are parallel in reality but
appear to converge in perspective



Depiction of Original Plane geometry: slight convergence suggests depth

Horizon Plane

The Horizon Plane is the horizontal reference plane passing through the eye-point.

Geometrical Relationship

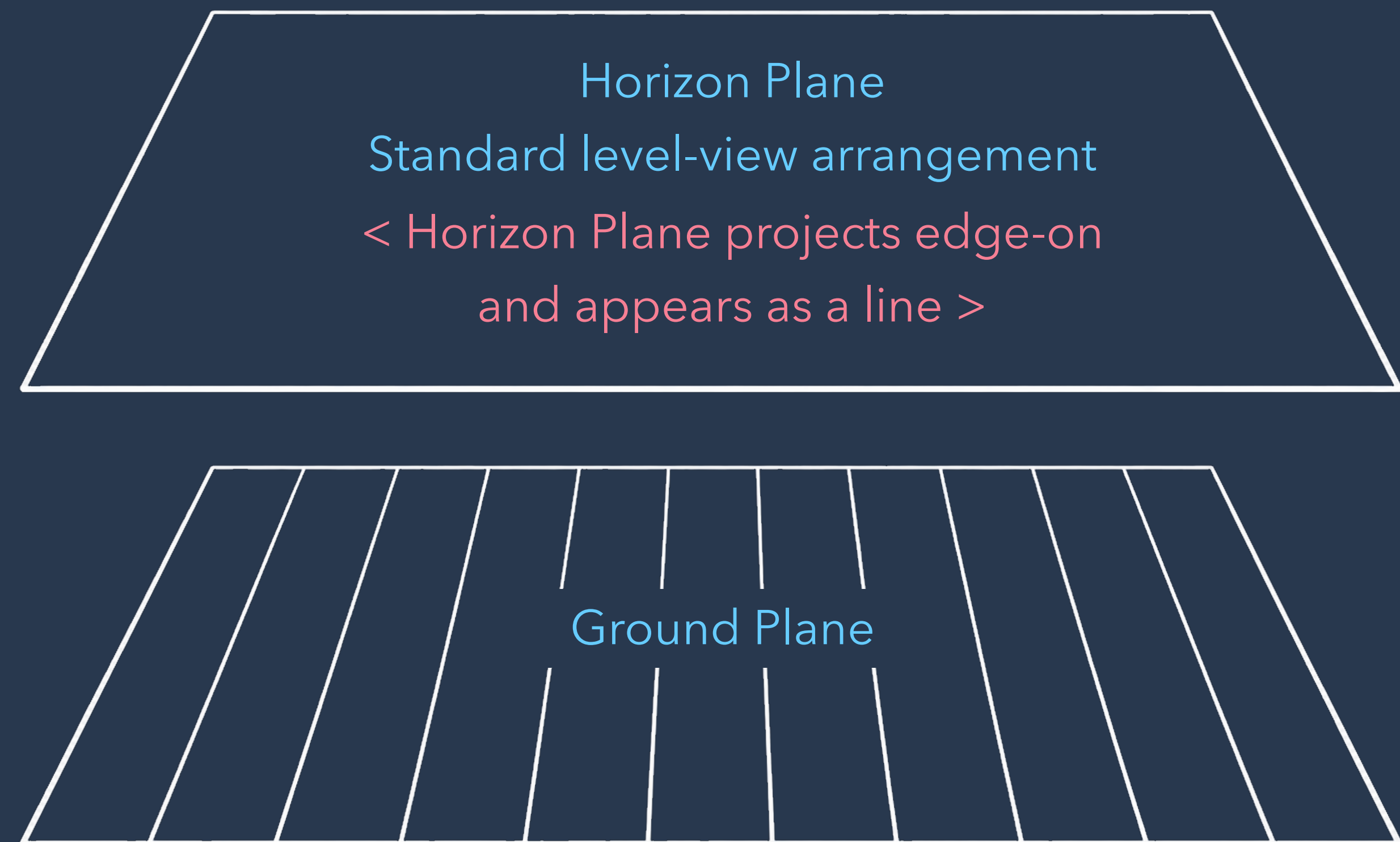
The horizon plane passes through the eye point

The horizon plane and ground plane are horizontal and parallel

Their physical separation remains constant with distance

Horizon plane and ground plane are parallel

In the standard level-ground configuration, the Horizon Plane is parallel to the ground plane and acts as its Directional Reference Plane



The Horizon Plane is the Directional Reference Plane for a horizontal ground-plane system.

One-Point Recession and Vanishing Point

A flat ground-plane grid diminishes in depth as receding parallels converge to a vanishing point

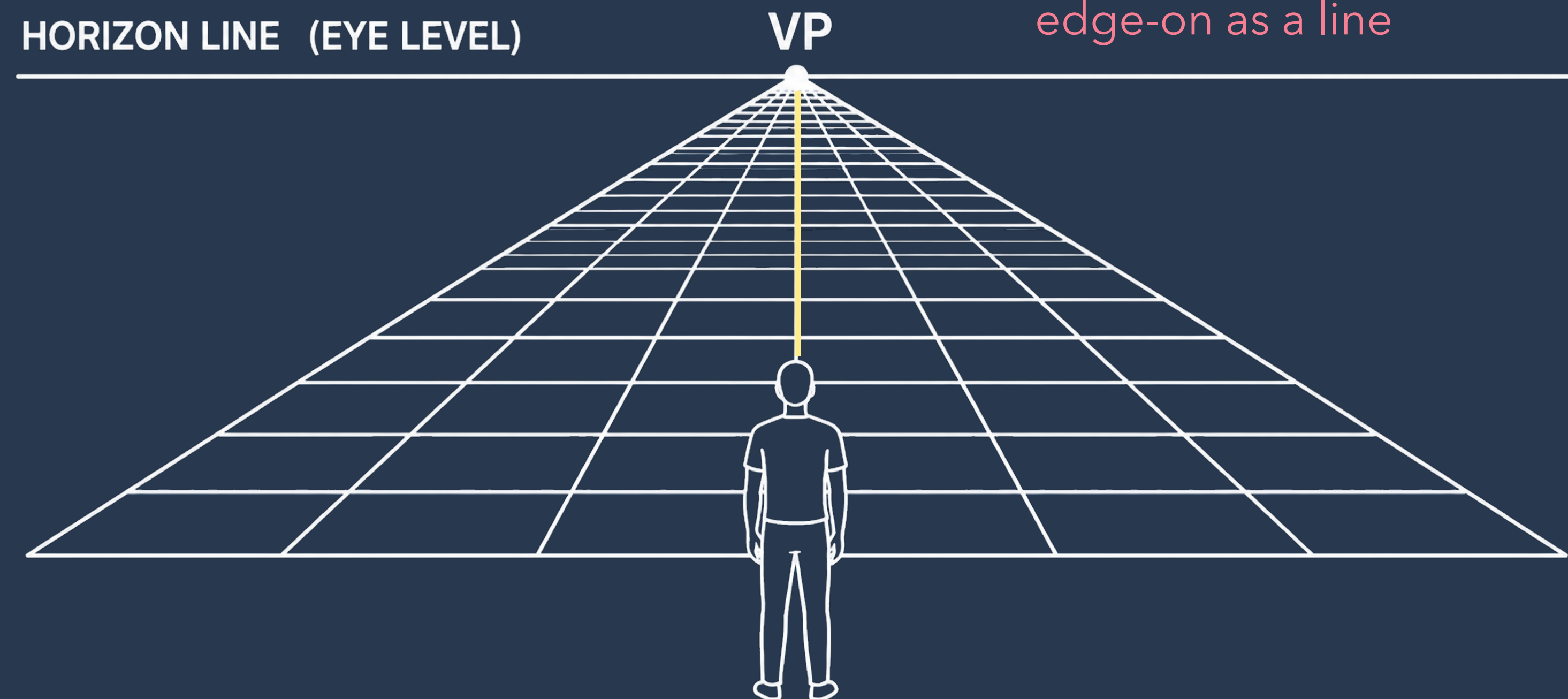
Key Ideas

- **Horizon Plane** – an imaginary plane through the eye-point, parallel to the ground plane
- **Horizontal Recession** – receding parallels form a wedge that signals spatial depth
- **Vanishing Point** – the common visual meeting point of the receding parallels

What is a Vanishing Point?

Where receding parallels visually meet
Horizontal line spacing becomes indistinguishable

Horizon Plane – projects edge-on as a line



Horizon Line = Line of Vanishing Points

The ground-plane horizon contains all vanishing points for horizontal directions.

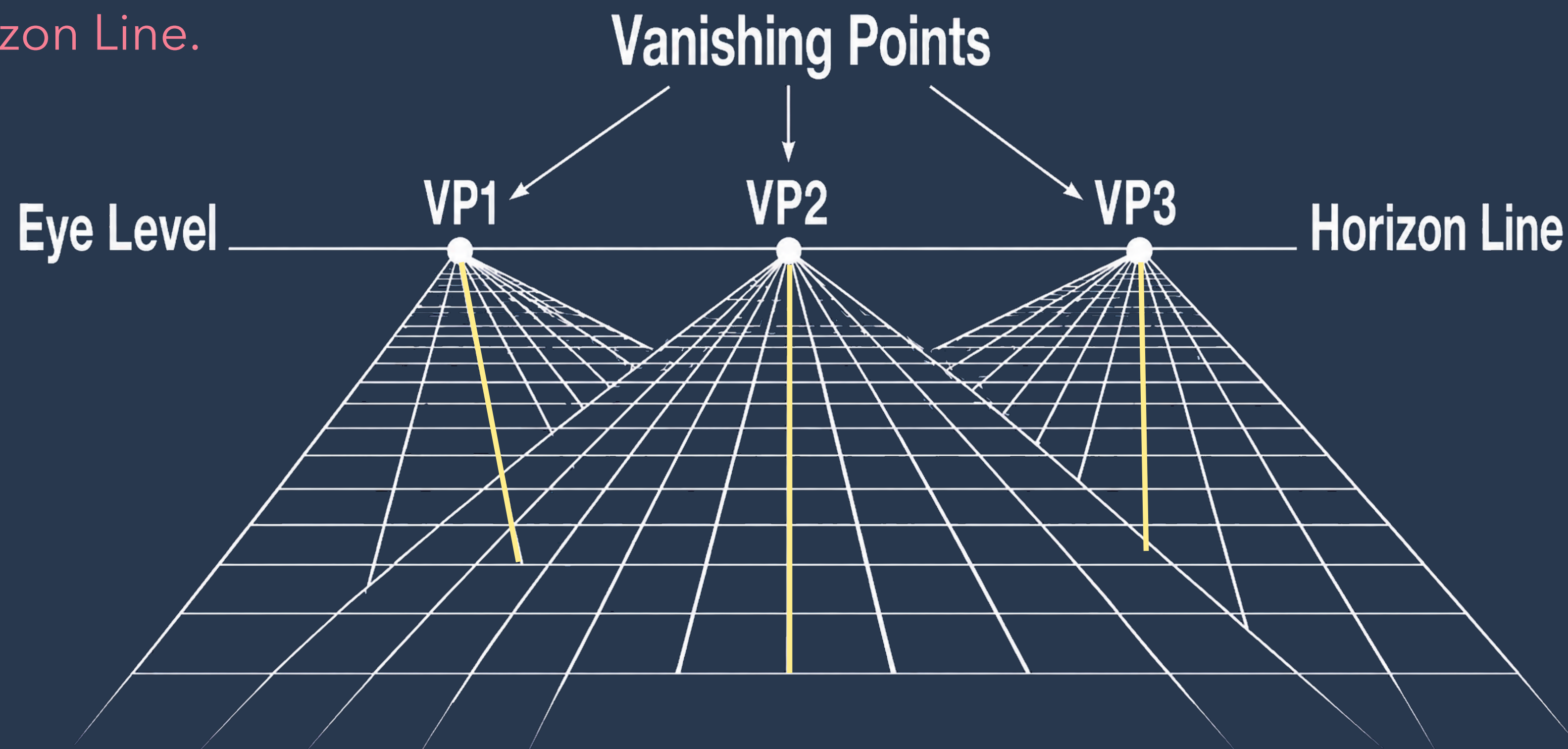
The Horizon Plane projects edge-on; its trace on the Picture Plane is the Horizon Line.

Vanishing Line
(Vanishing Trace)

A line containing all vanishing points for one plane

The horizon line is the vanishing line of the ground plane

Every plane orientation
has a corresponding
vanishing line



Horizon Line: Trace of the Horizon Plane

The horizon line is where the Horizon Plane intersects the picture plane.

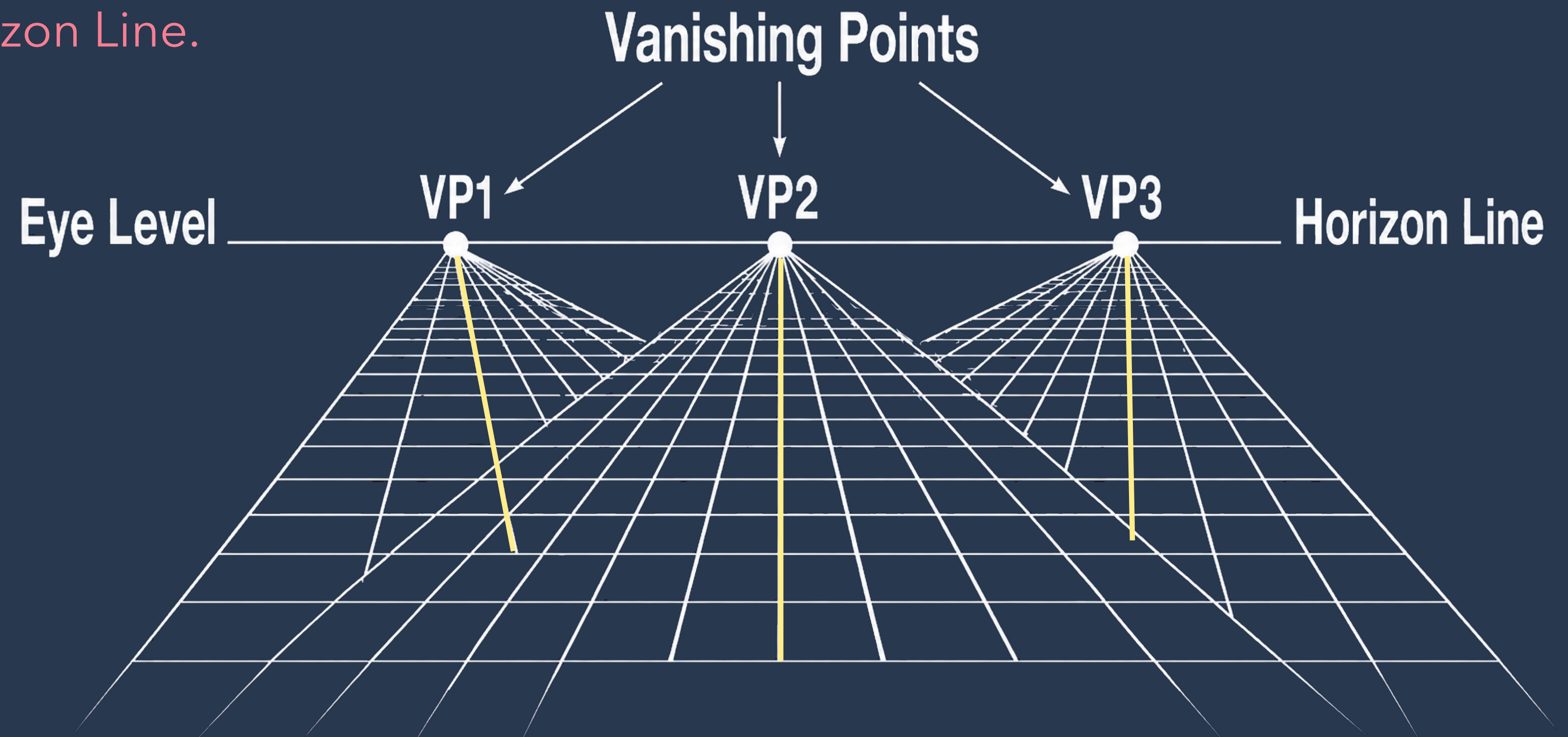
The Horizon Plane projects edge-on; its trace on the Picture Plane is the Horizon Line.

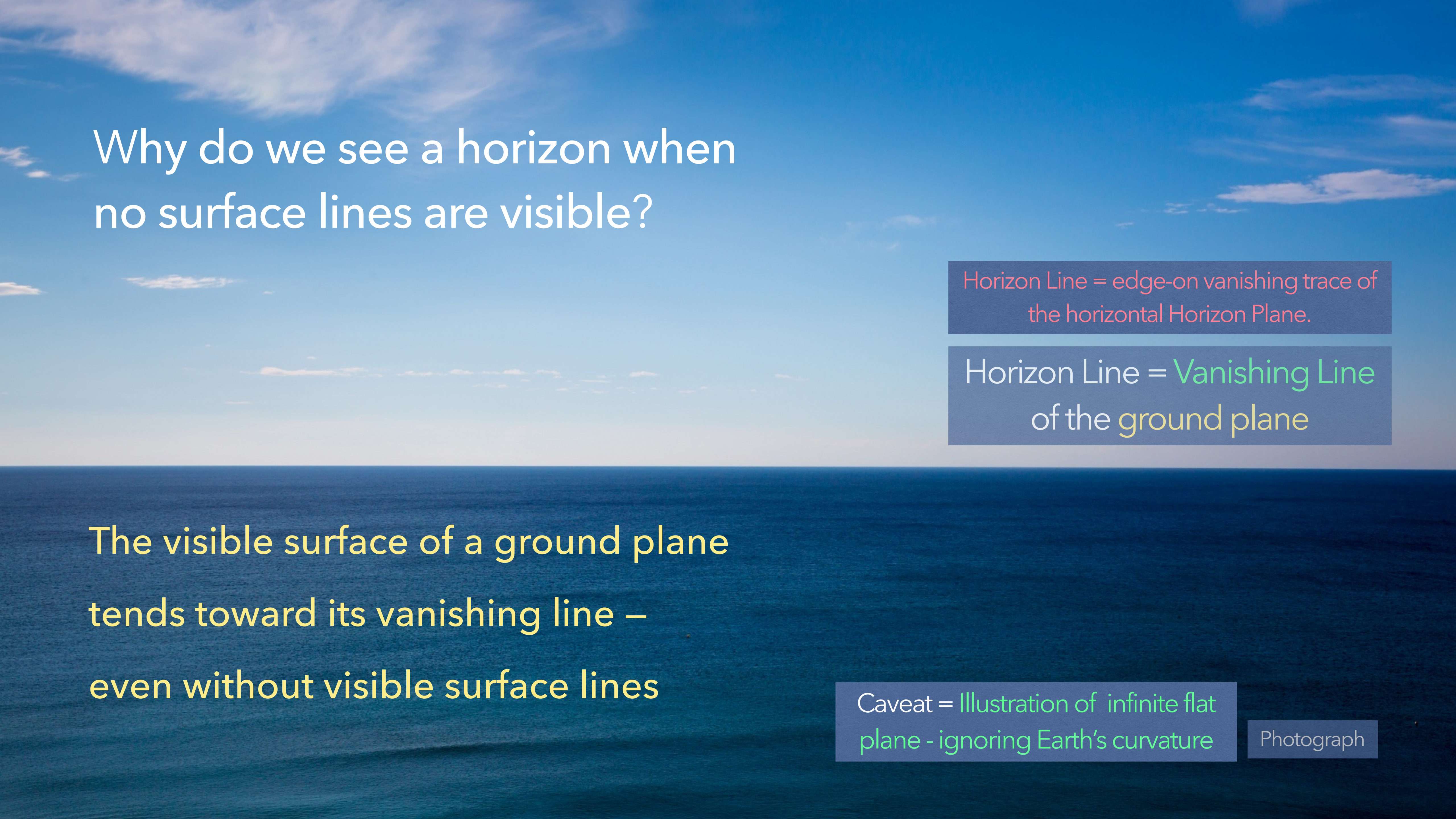
Ground-Plane
Vanishing Line

For a horizontal ground plane, the horizon line contains the vanishing points of all horizontal directions.

It contains these VPs; it does not cause their convergence.

Horizon plane has fixed orientation, horizon line position can change with sight line





Why do we see a horizon when no surface lines are visible?

Horizon Line = edge-on vanishing trace of
the horizontal Horizon Plane.

Horizon Line = Vanishing Line
of the ground plane

The visible surface of a ground plane
tends toward its vanishing line –
even without visible surface lines

Caveat = Illustration of infinite flat
plane - ignoring Earth's curvature

Photograph

Why the Horizon Line Appears at Eye-Level

In a level view, the horizon line appears at eye level

Vertical Diminution

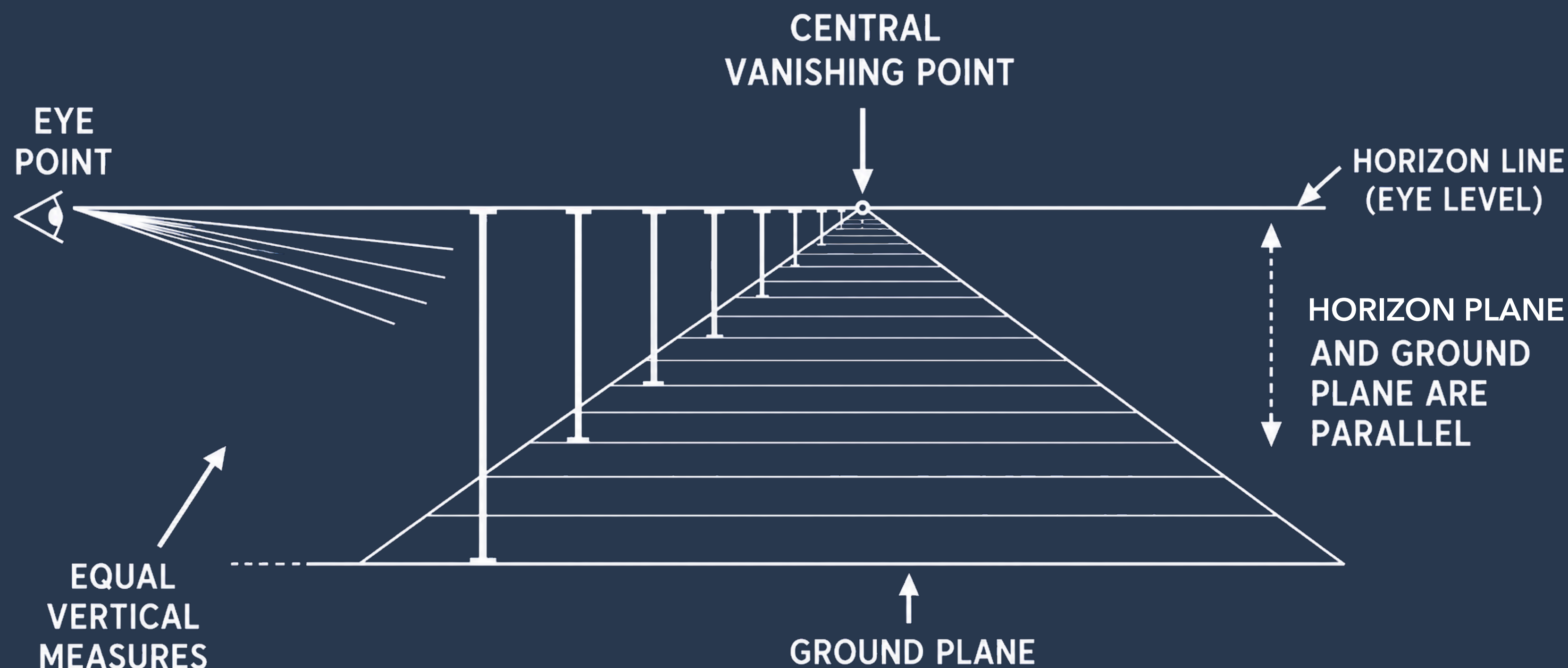
Equal vertical measures receding in depth diminish toward the horizon

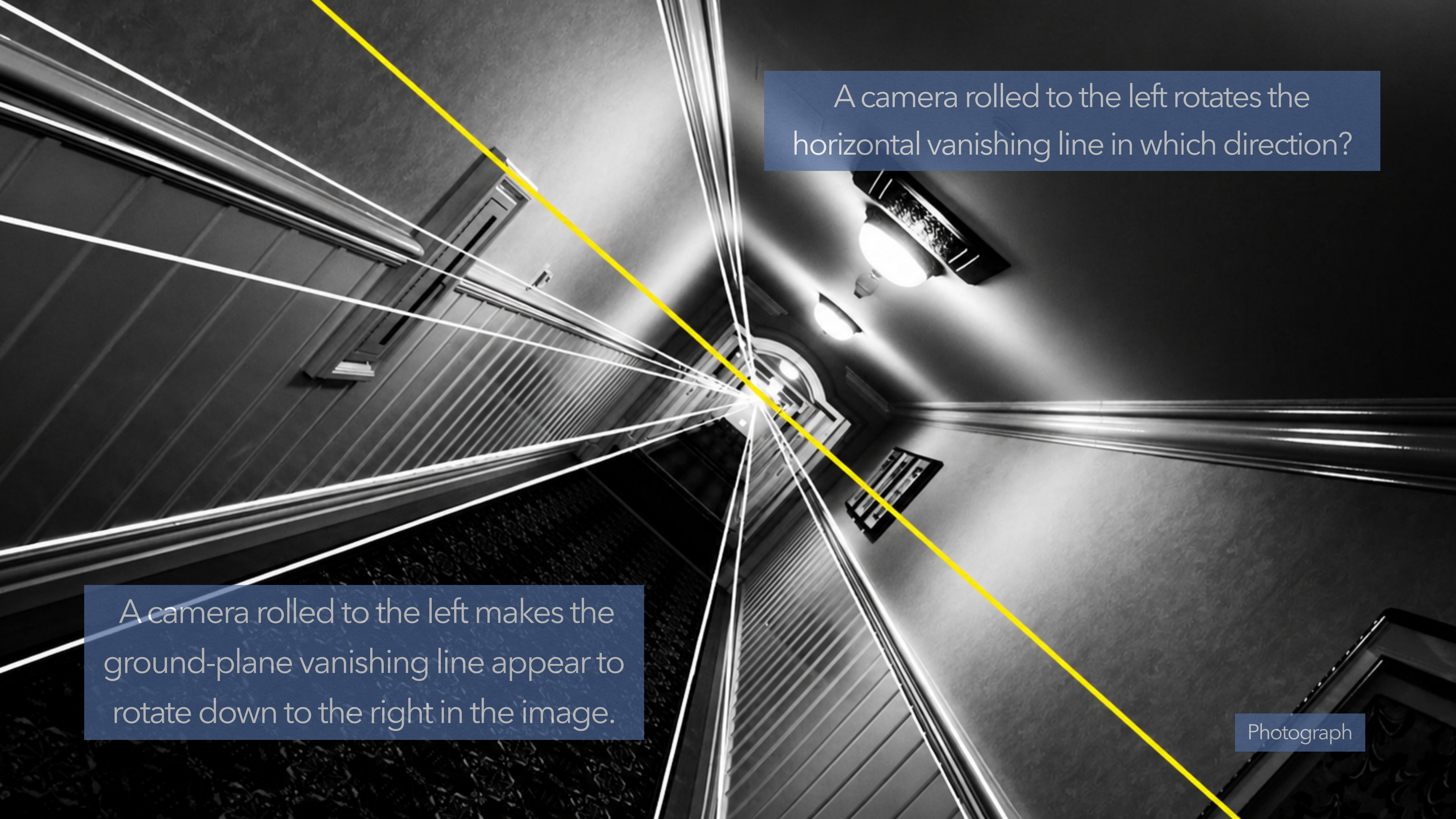
Horizon Plane

A horizontal plane through the eye, parallel to the ground plane

Horizon Line = Horizon Plane on Picture Plane

In this level configuration, also the ground-plane vanishing line.





A camera rolled to the left rotates the horizontal vanishing line in which direction?

A camera rolled to the left makes the ground-plane vanishing line appear to rotate down to the right in the image.

Photograph

Perspective Phenomena

Visible changes that reveal perspective

Geometrical Phenomena

- Diminution of size
- Foreshortening of form
- Receding parallels / vanishing points
- Horizon / depth direction

Optical Phenomena

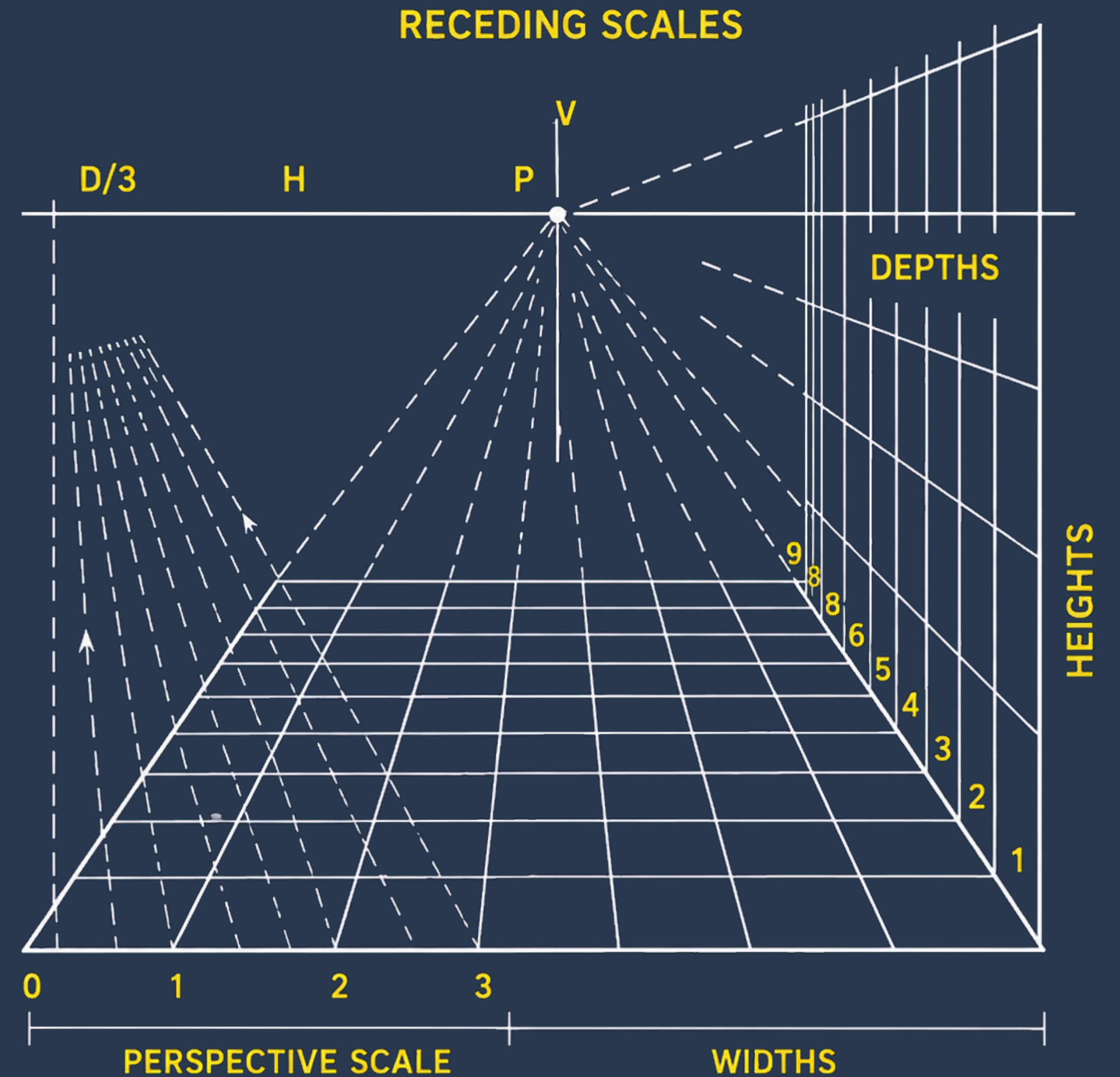
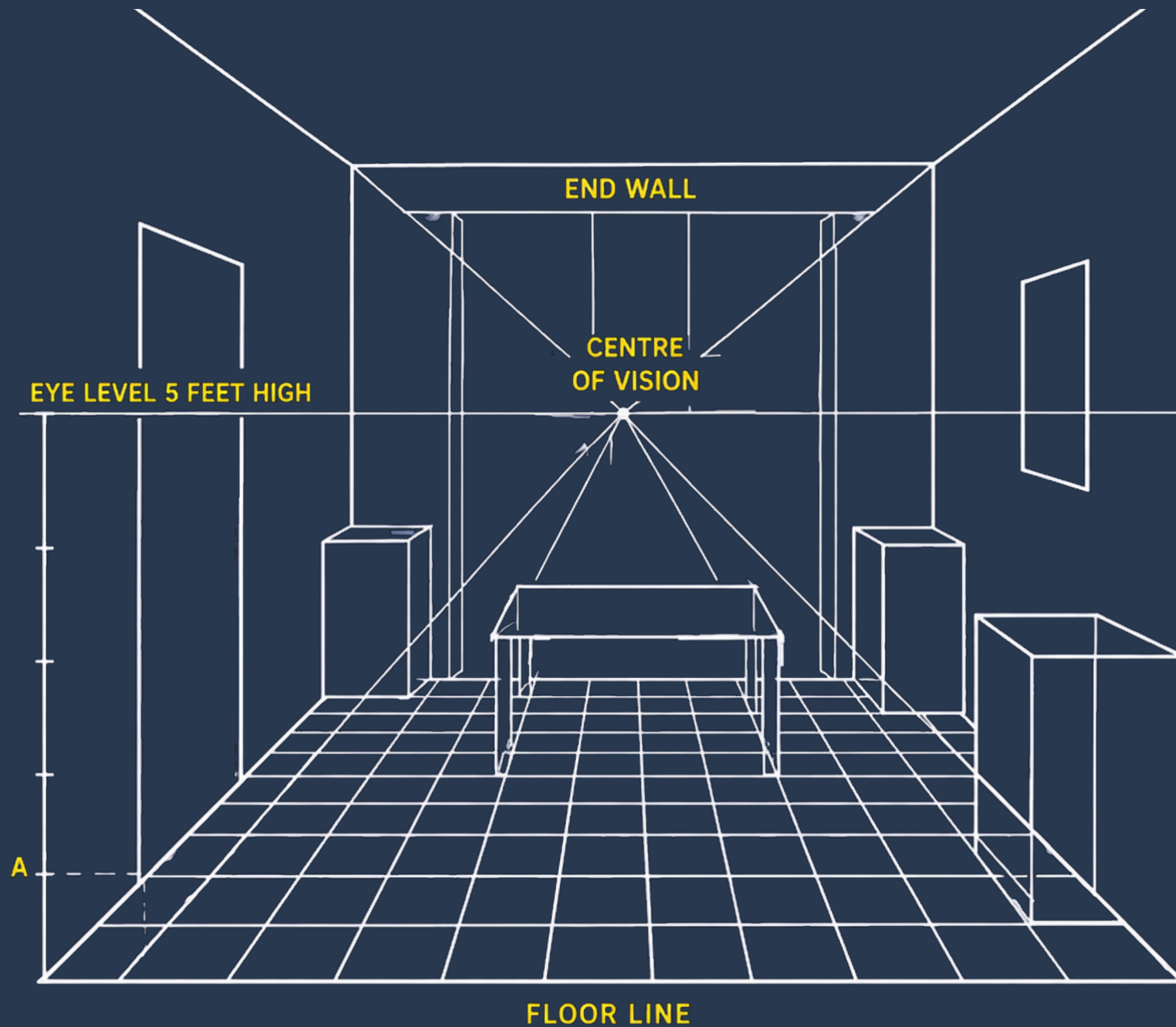
Loss of colour
Loss of contrast
Atmospheric depth
Light-dark gradients

Optical + Geometrical Phenomena

Acuity (loss of detail) =
Optical + Geometrical facets

AI-generated illustration

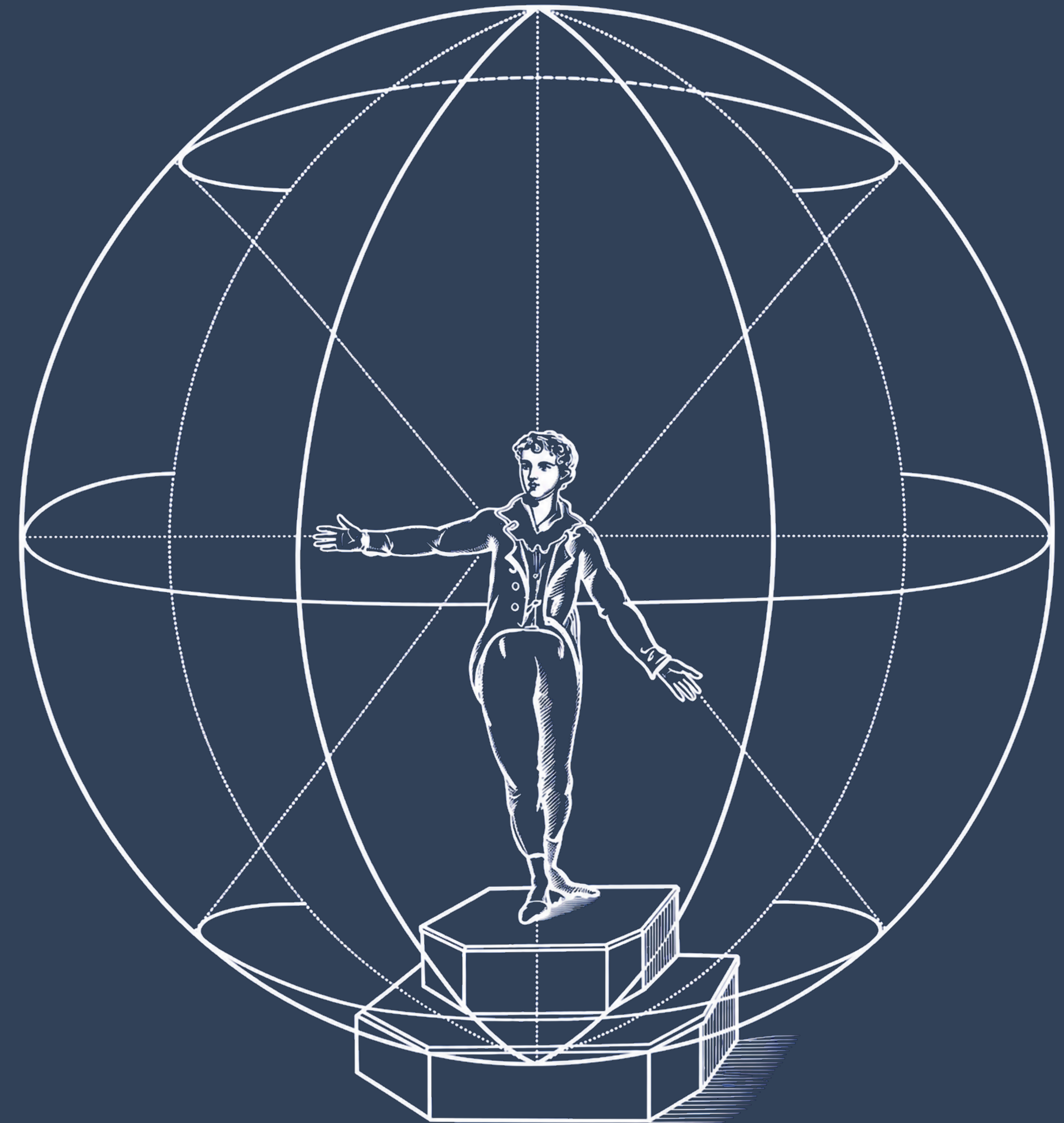
Graphical Linear Perspective



Vanishing Structures

Vanishing occurs through
both geometrical projection
and optical limitation

From geometrical vanishing to
optical vanishing



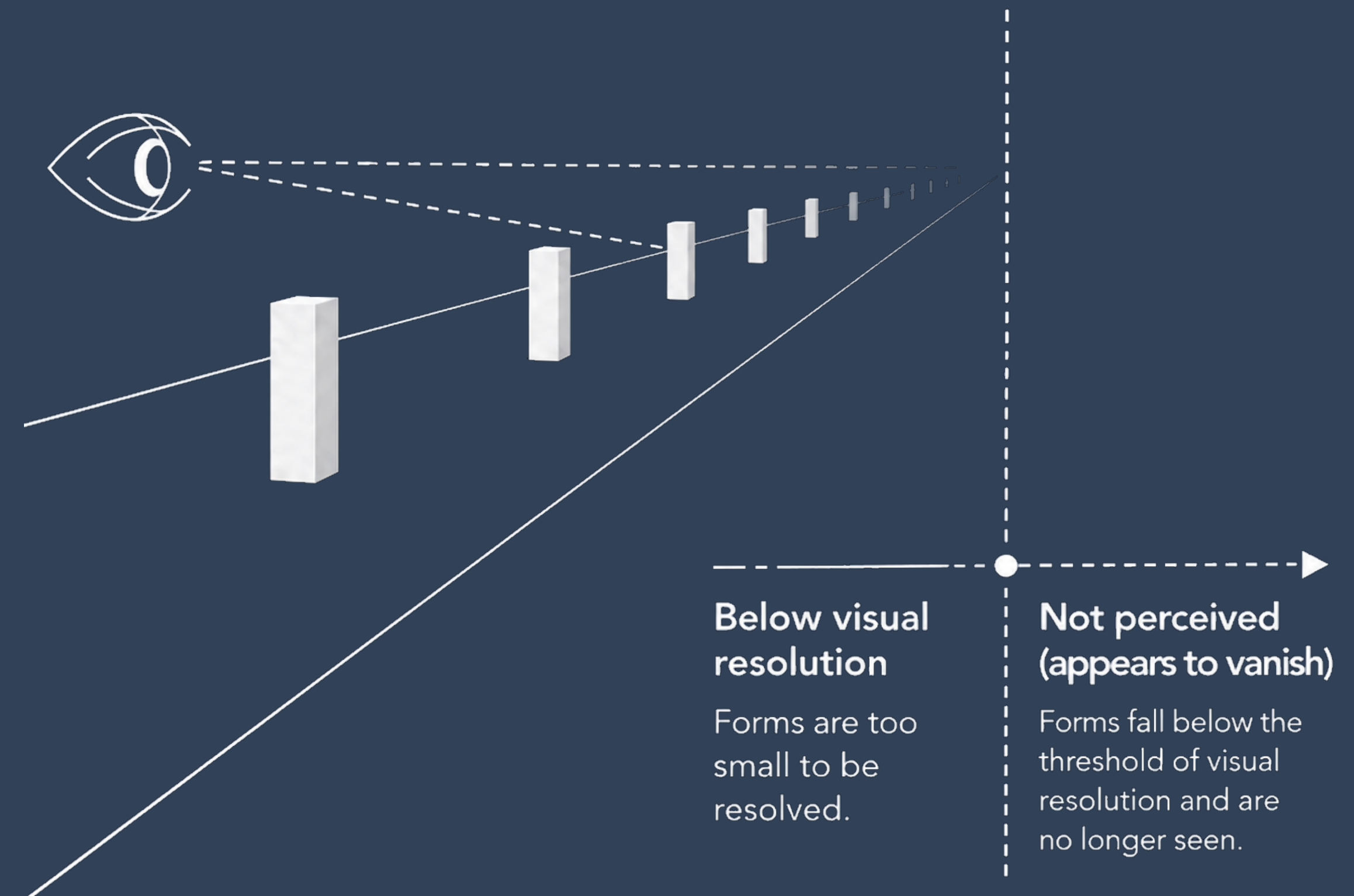
Optical and Geometrical Vanishing

Beyond Geometrical Vanishing

Vanishing is not only geometrical, it can also depend on the resolving power of the eye or camera

Two kinds of Vanishing

- **Geometrical Vanishing** – where projected directions converge
- **Optical / Resolution-Limited Vanishing** – when forms disappear below the threshold of visual perception

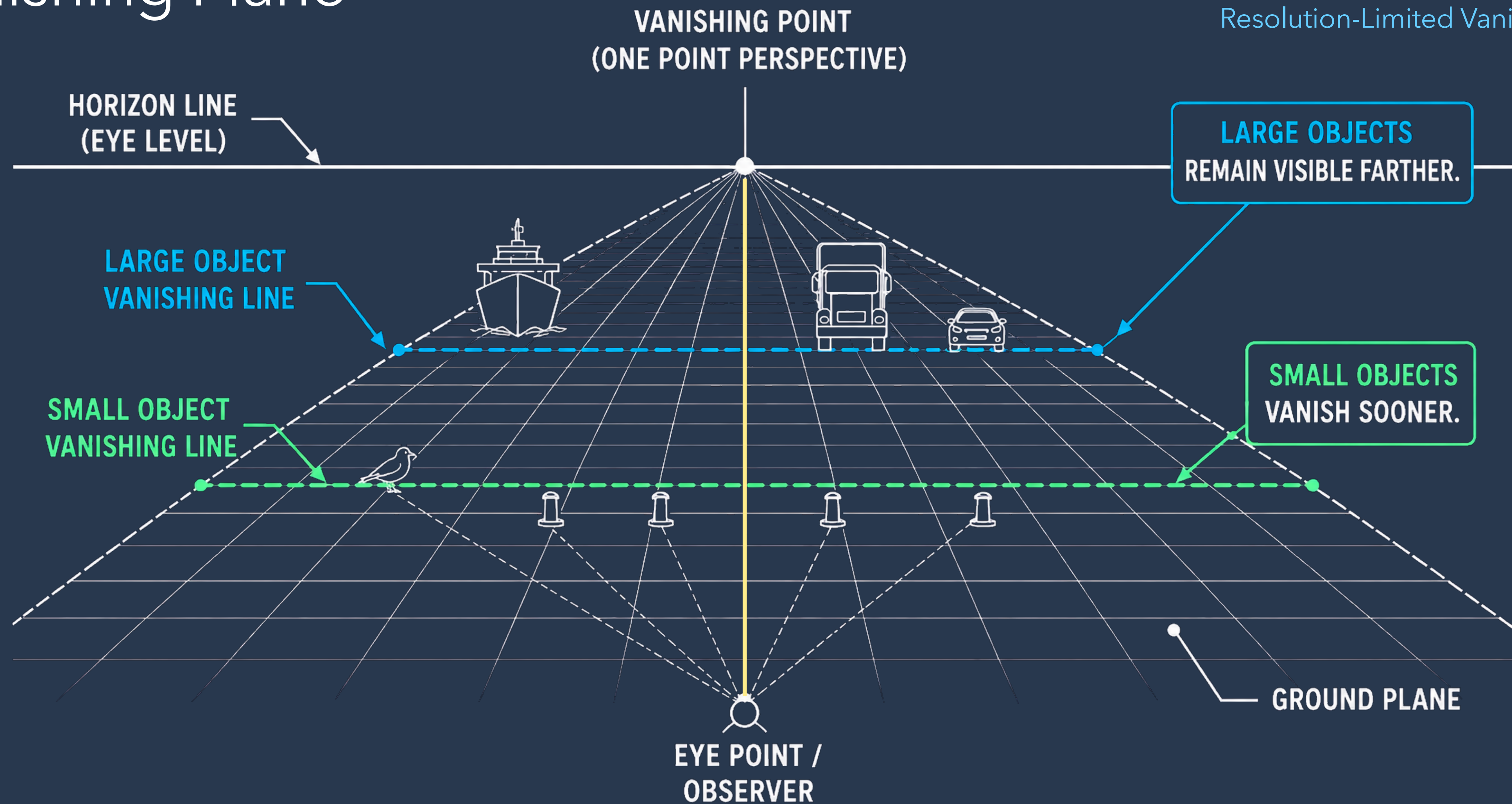


Resolution-Limited Vanishing Plane

Image-Space Schematic
Visual / Optical Perspective

Limit of Optical Resolution

Resolution-Limited Vanishing

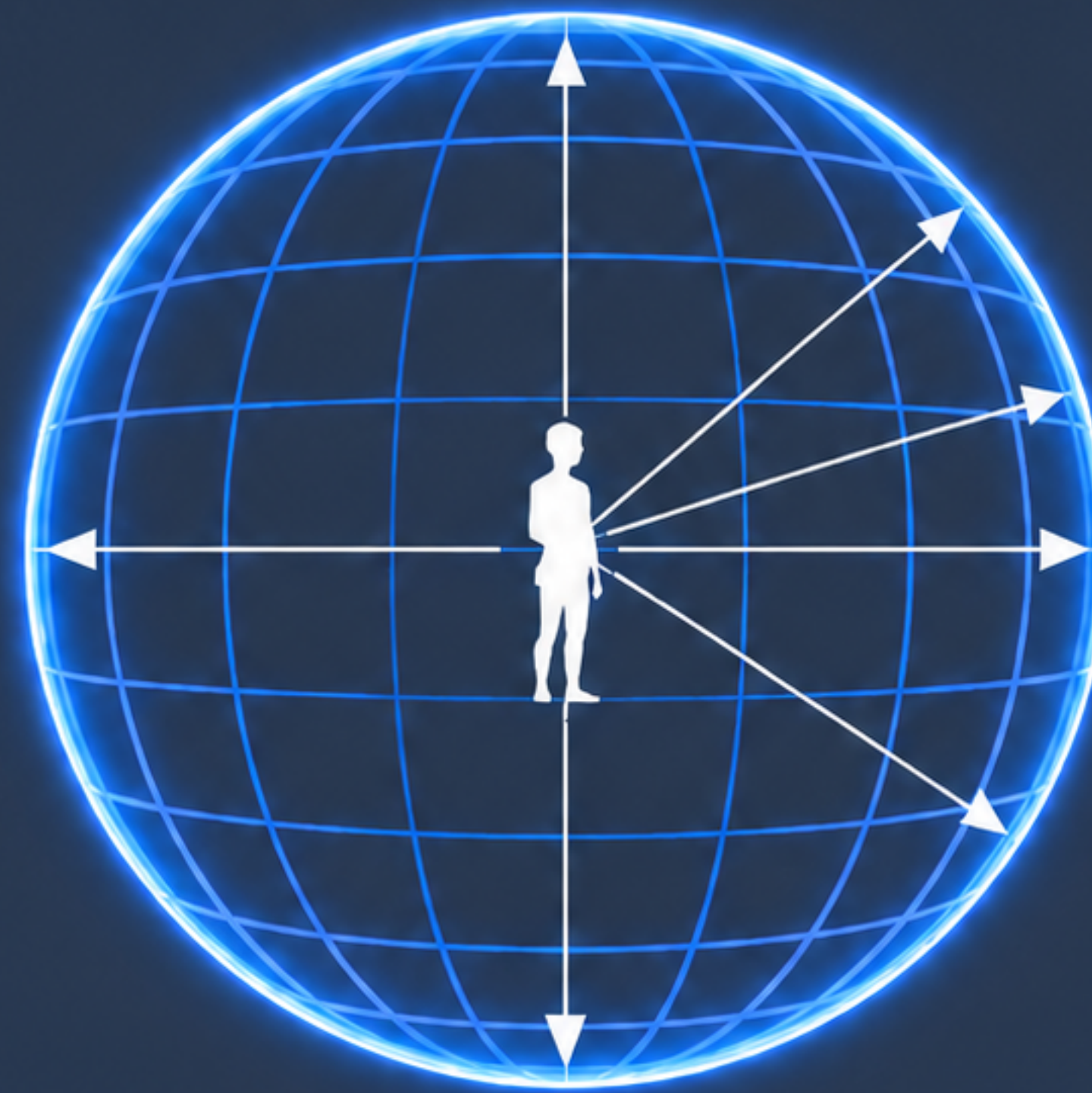


Resolution-limited Vanishing Sphere

Spherical / all-direction model

Object-Space Schematic
Visual / Optical Perspective

Resolution-Limited Vanishing



 Tiny Bird

Small objects
vanish sooner

Directional Reference Planes in All Directions

Directional reference planes may occur at every orientation around the eye-point

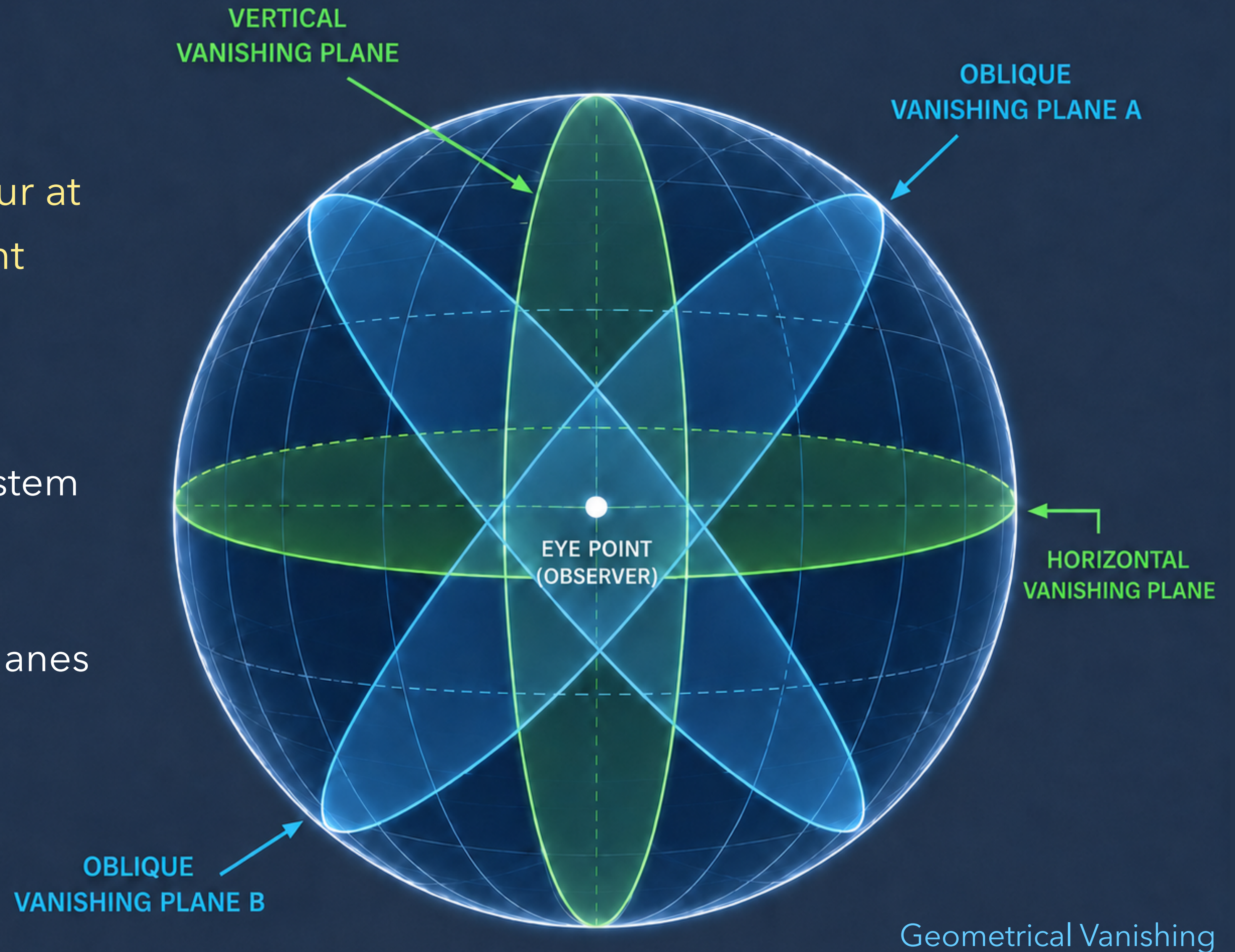
Directional Reference Plane

- passes through the eye-point.
- parallel to the object-space plane system it represents.
- projects edge-on as a line.
- it is the vanishing plane for related planes

Vanishing Trace

The line formed where the Directional Reference Plane intersects the picture planes.

Object-Space Schematic
Graphical / Mathematical Perspective



Vanishing Points in all Directions

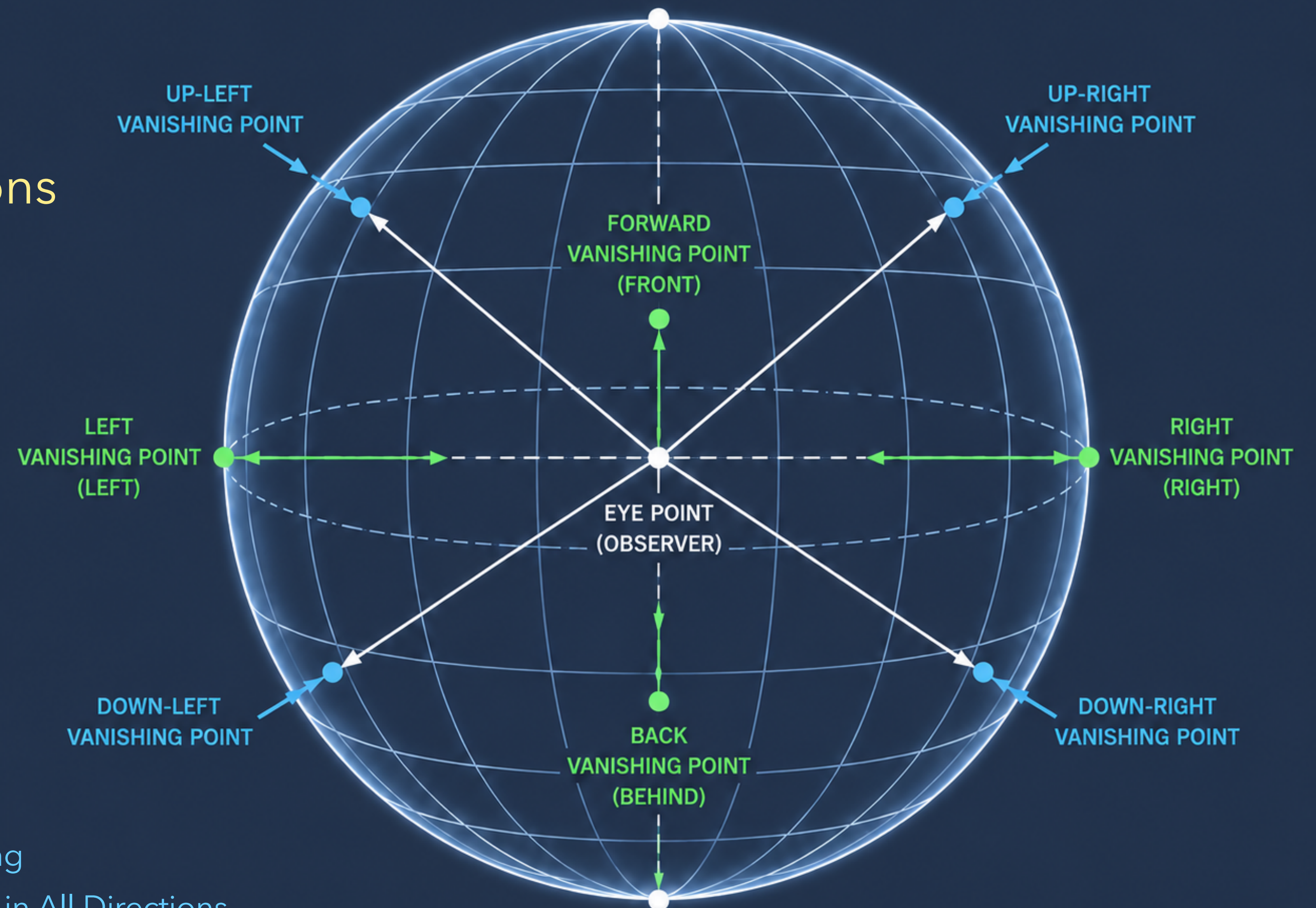
A sphere of vanishing directions
centred on the eye-point

Viewing Direction

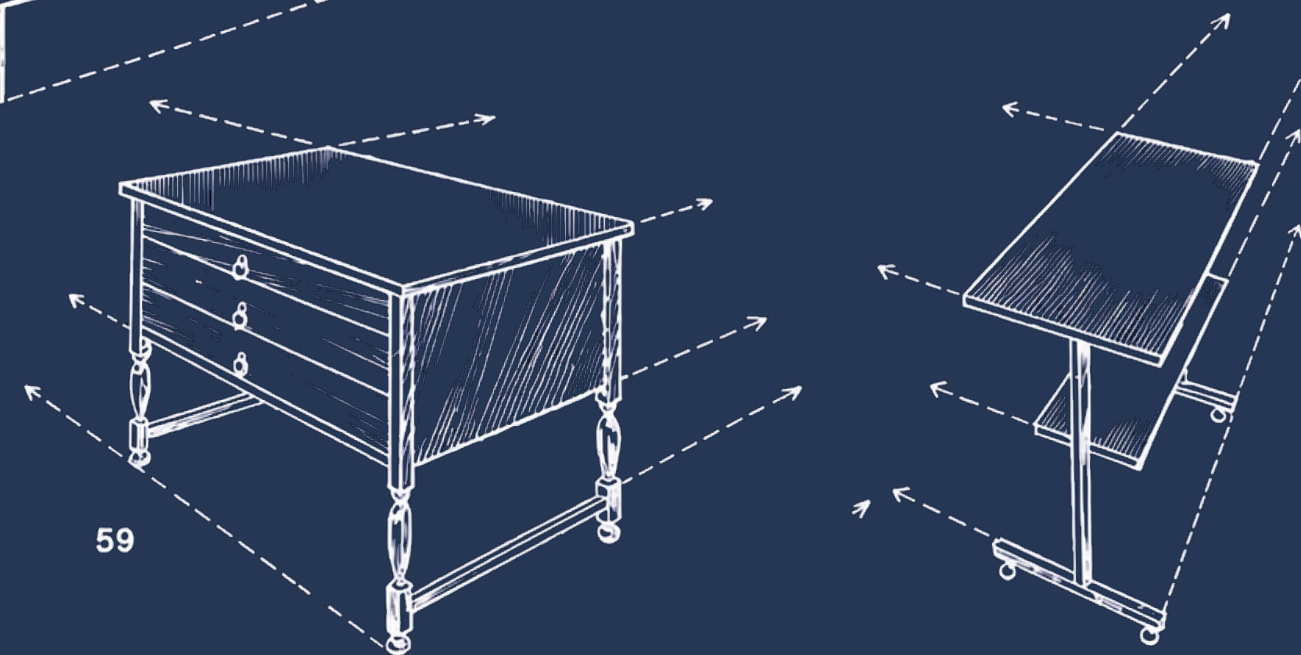
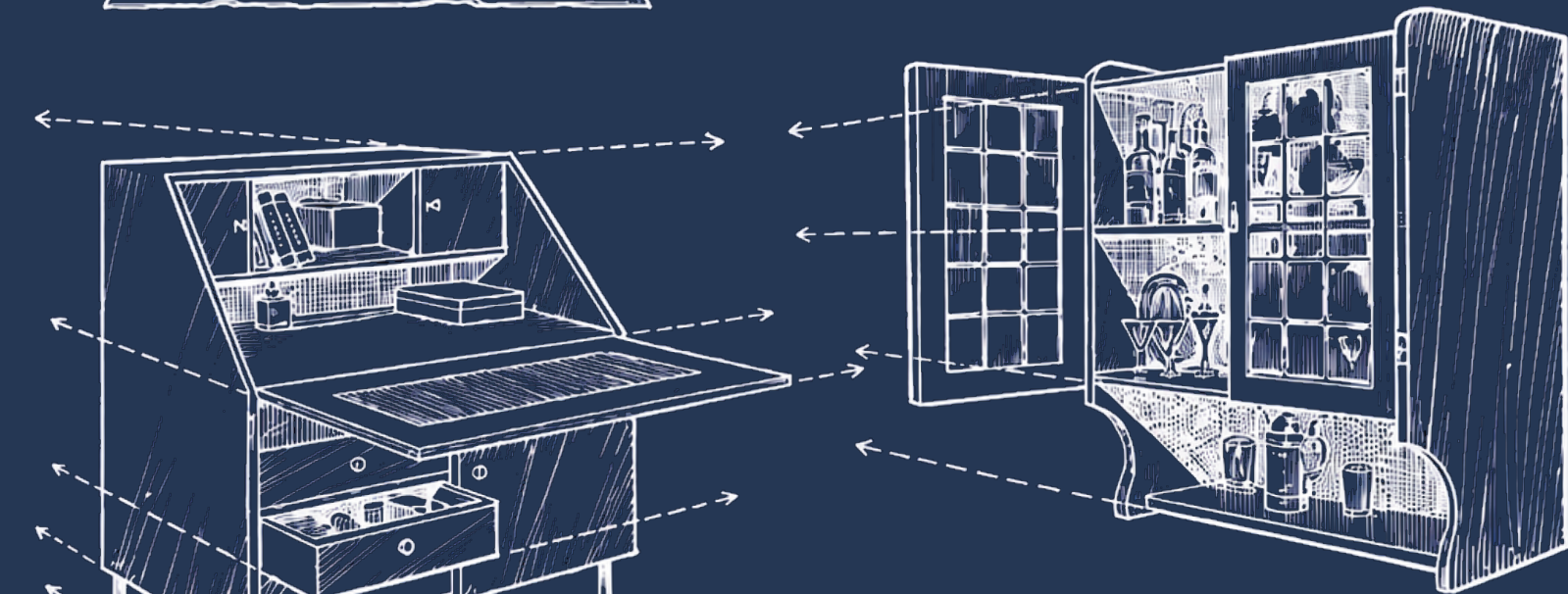
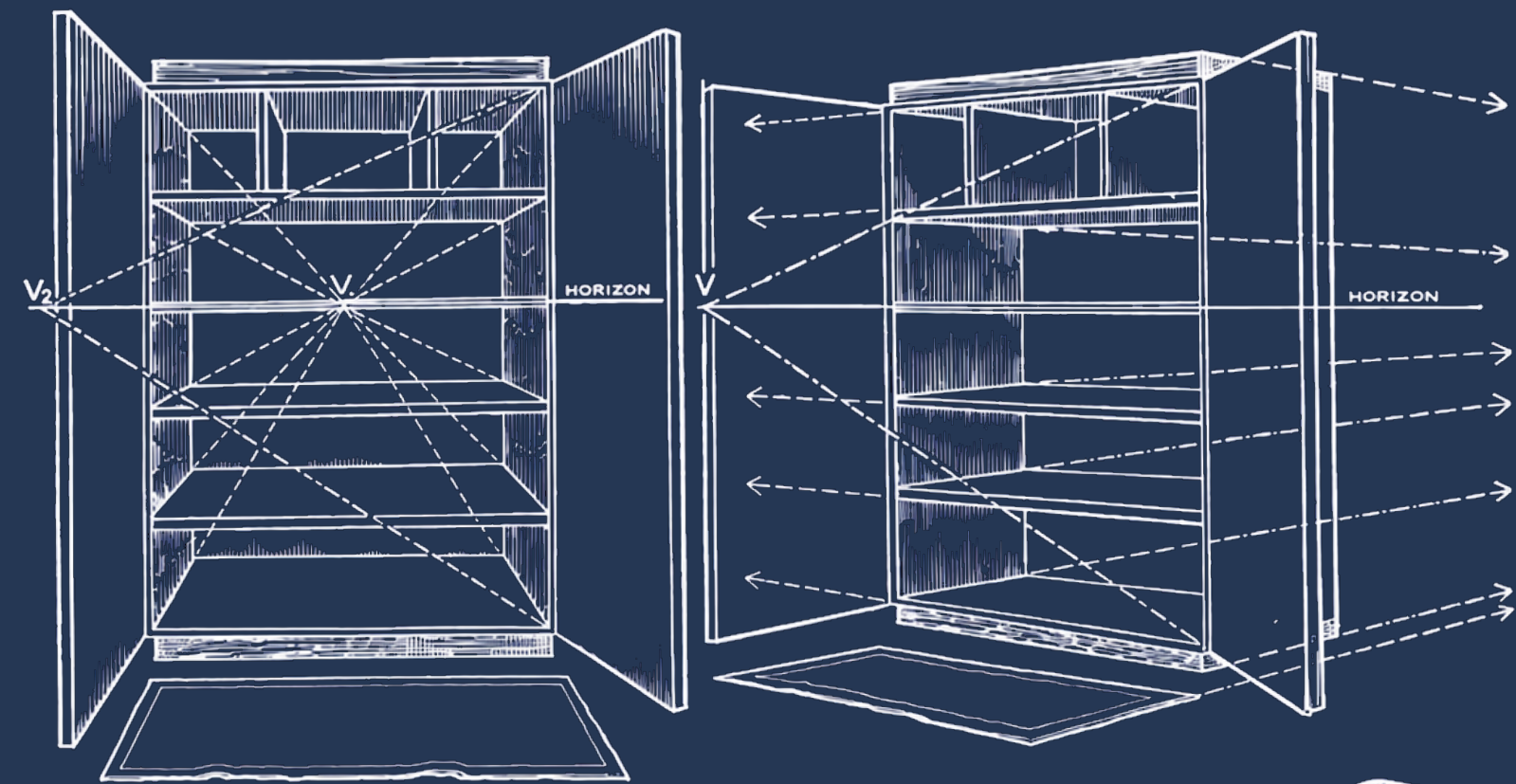
Each point on the sphere represents
a viewing direction in space

Each point corresponds to the
vanishing point of a family of
parallel lines.

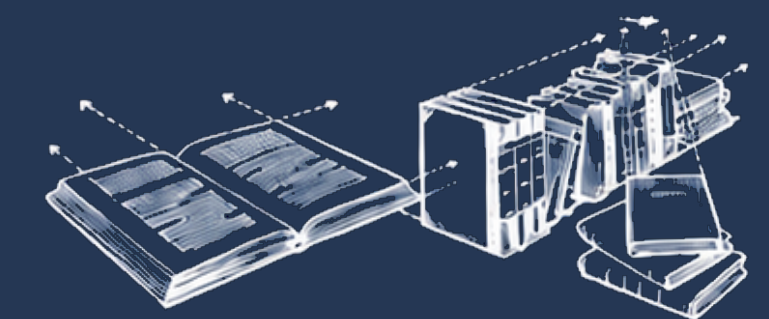
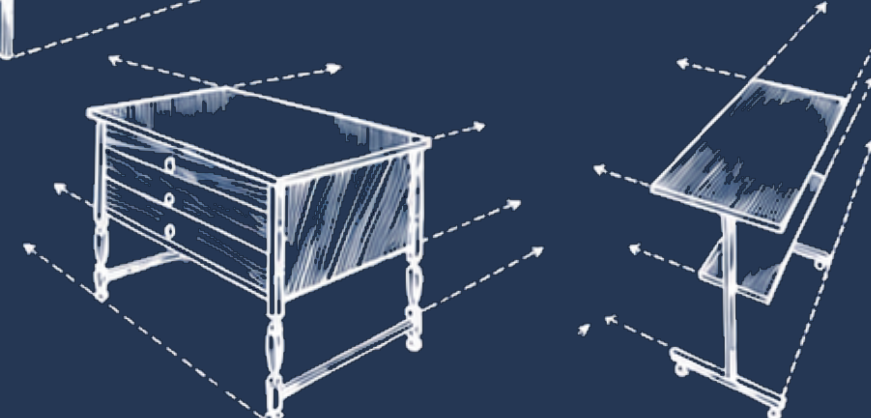
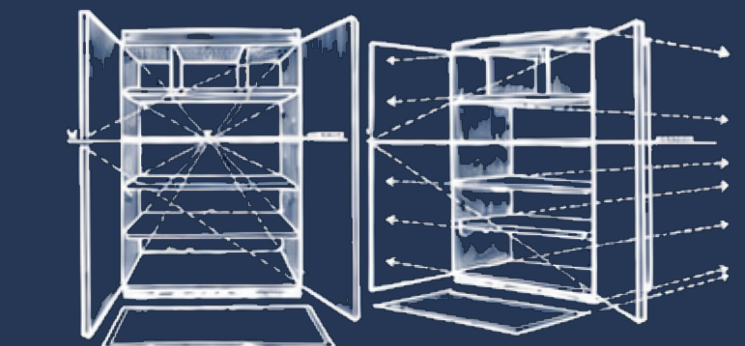
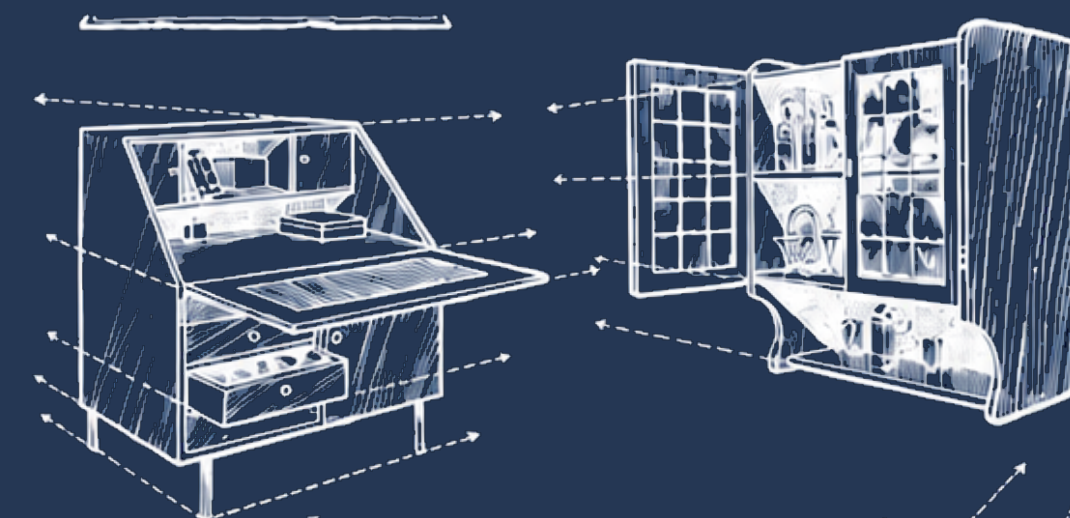
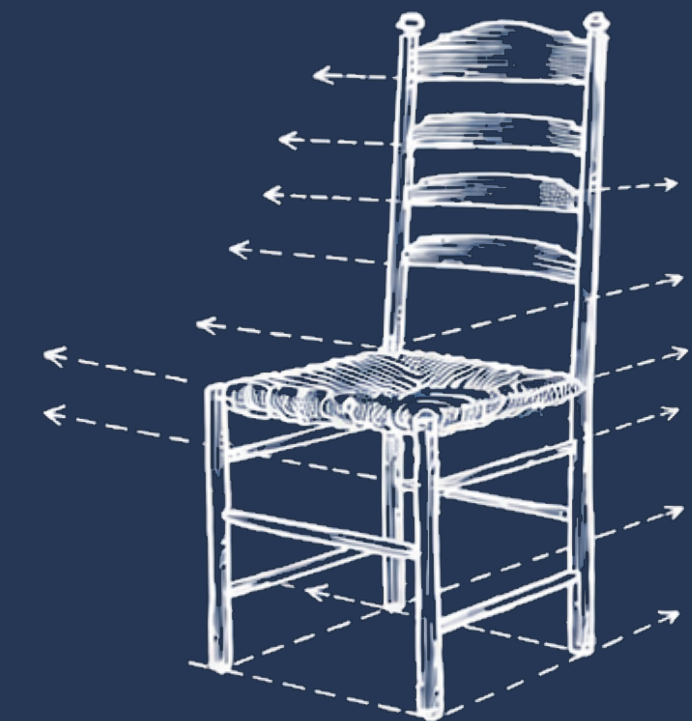
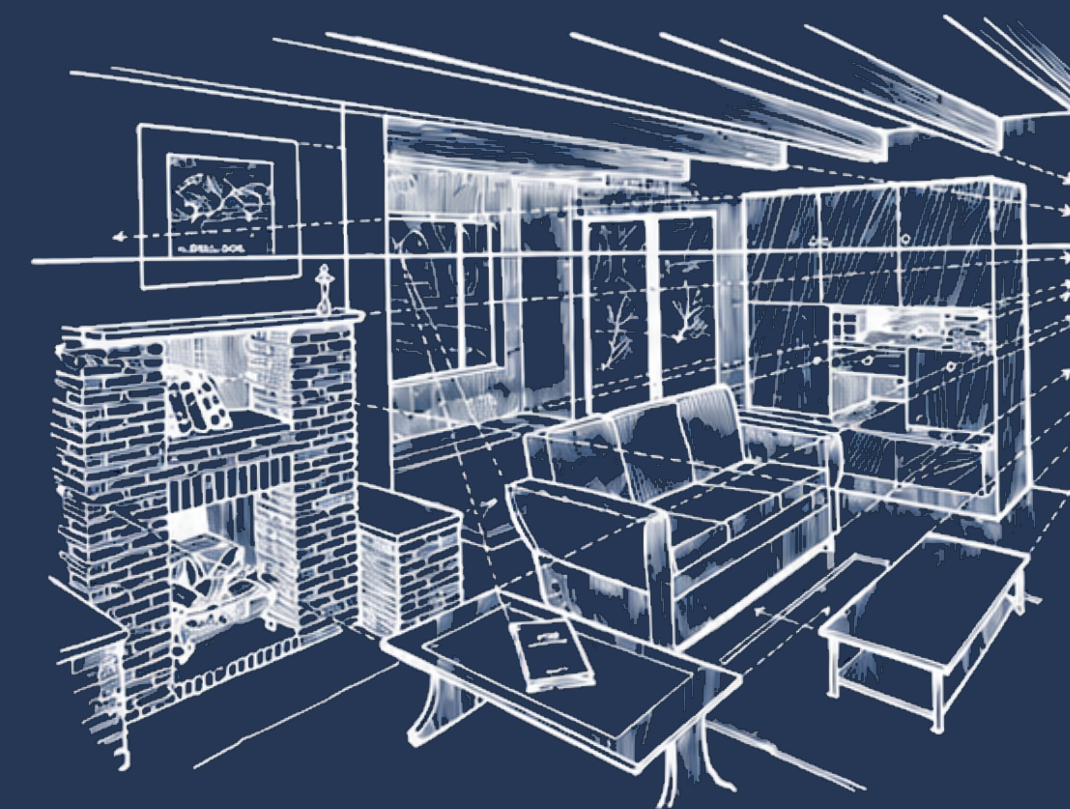
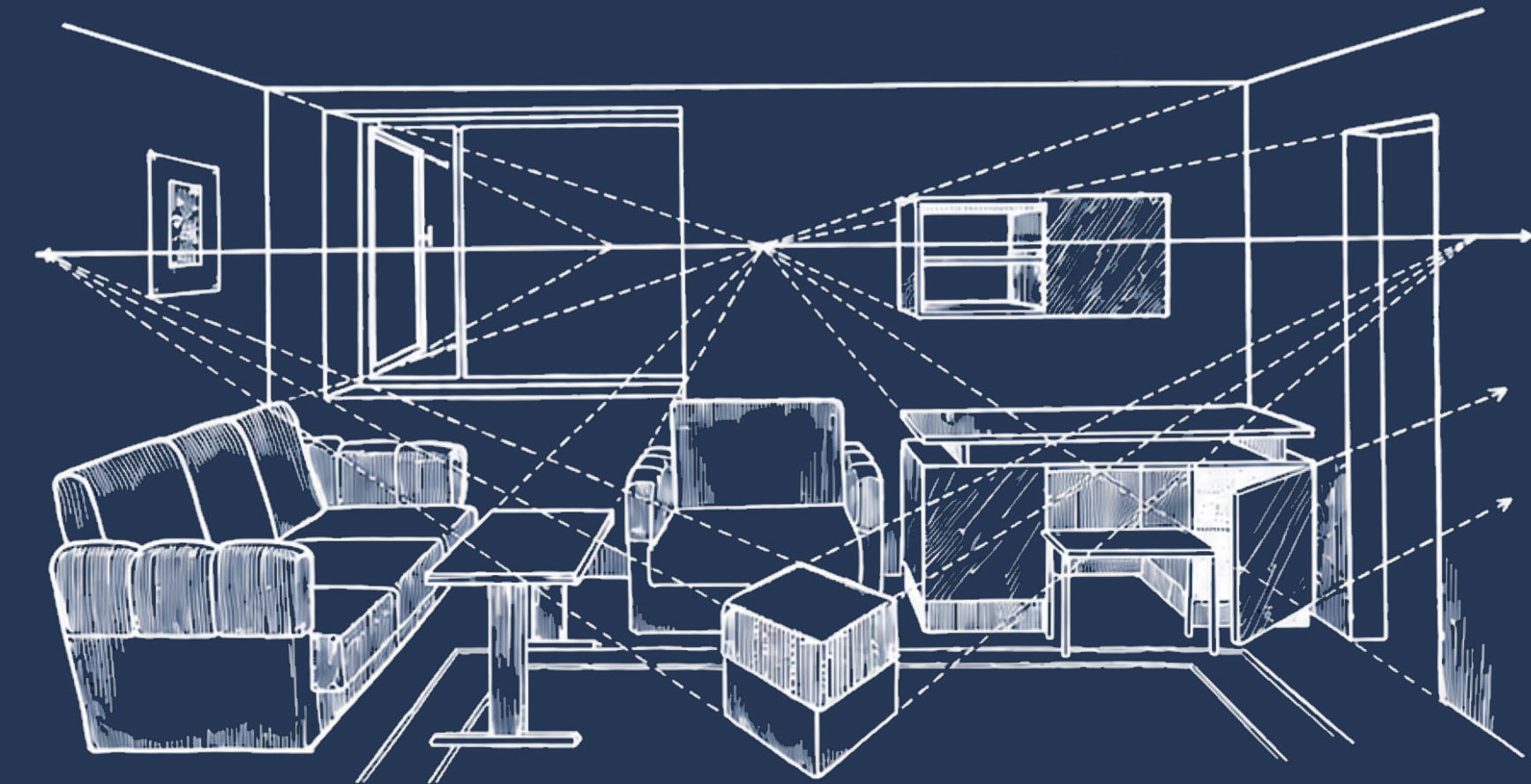
Geometrical Vanishing - Directional Line Vanishing
Directional Reference Lines and Vanishing Points in All Directions



Vanishing Points are Everywhere



59



Types and Forms of Perspective

Perspective is not one system –
but a family of systems

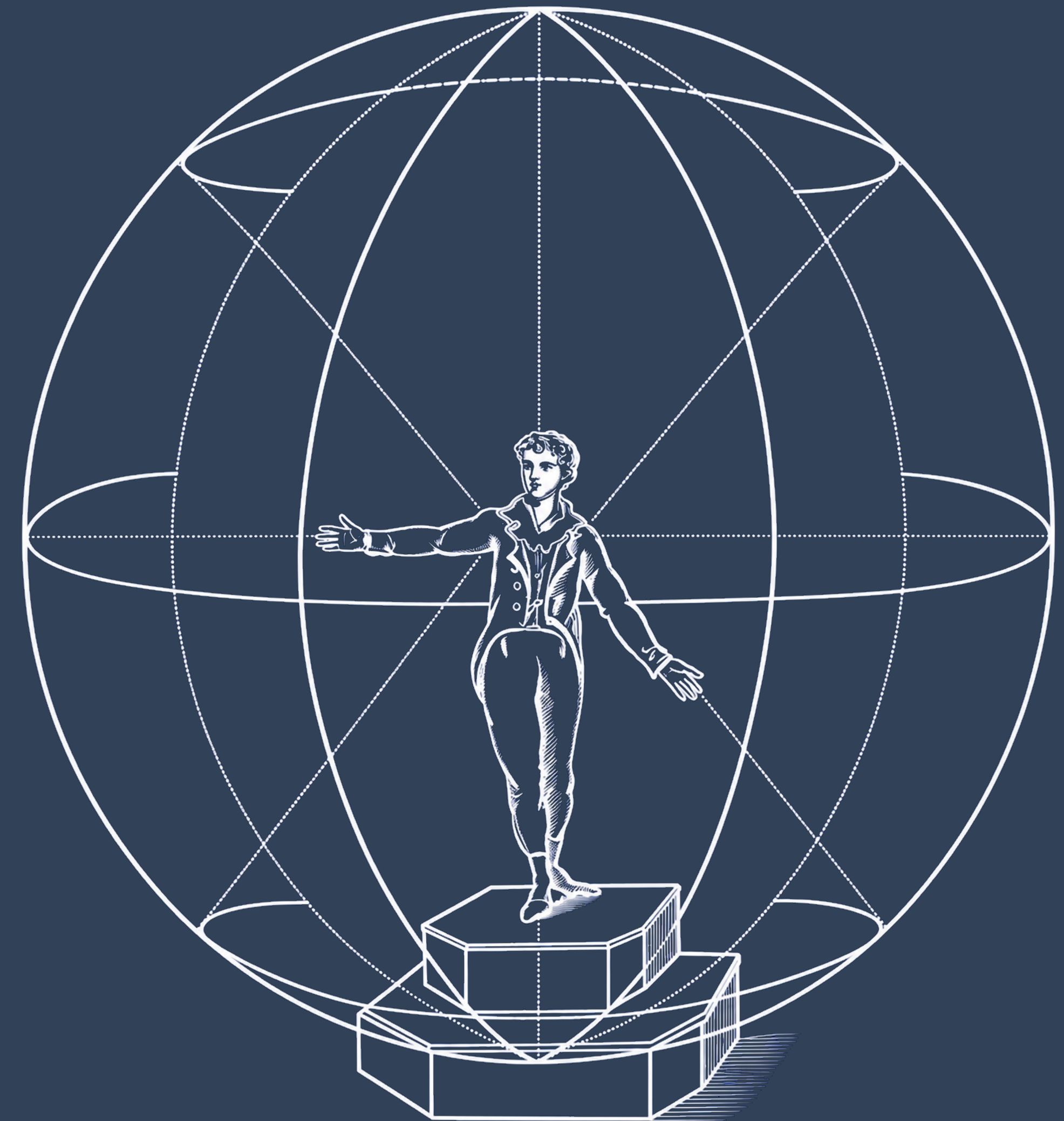
Types – define how space is produced

Forms – define how space appears

Form has two related meanings:

Form = classified output

Form = particular scene structure / appearance

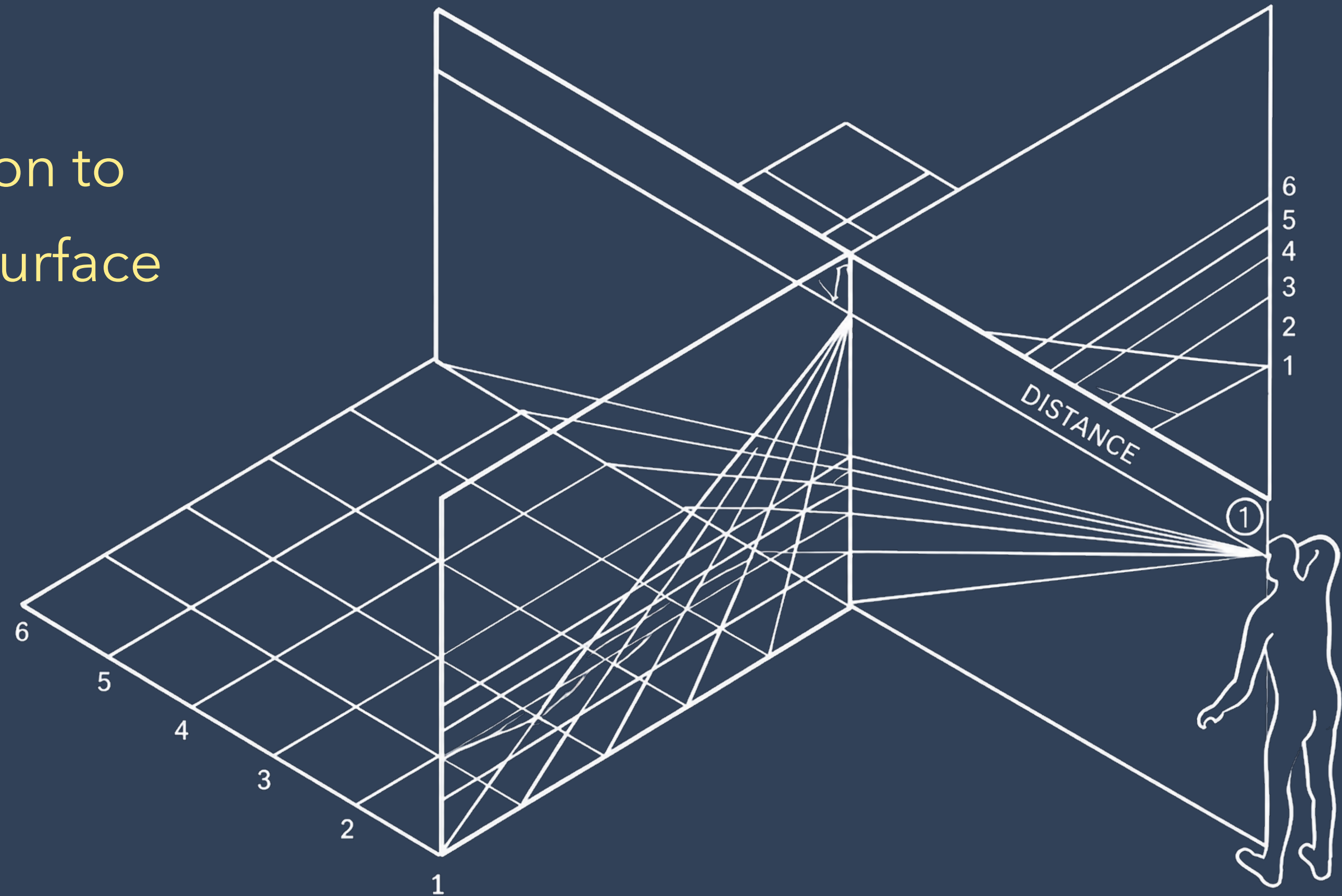


Graphical Perspective

Uses drawing or pictorial construction to represent spatial appearance on a surface

Technical Types

- Linear
- Cylindrical
- Curvilinear / Spherical
- Parallel
- Non-standard

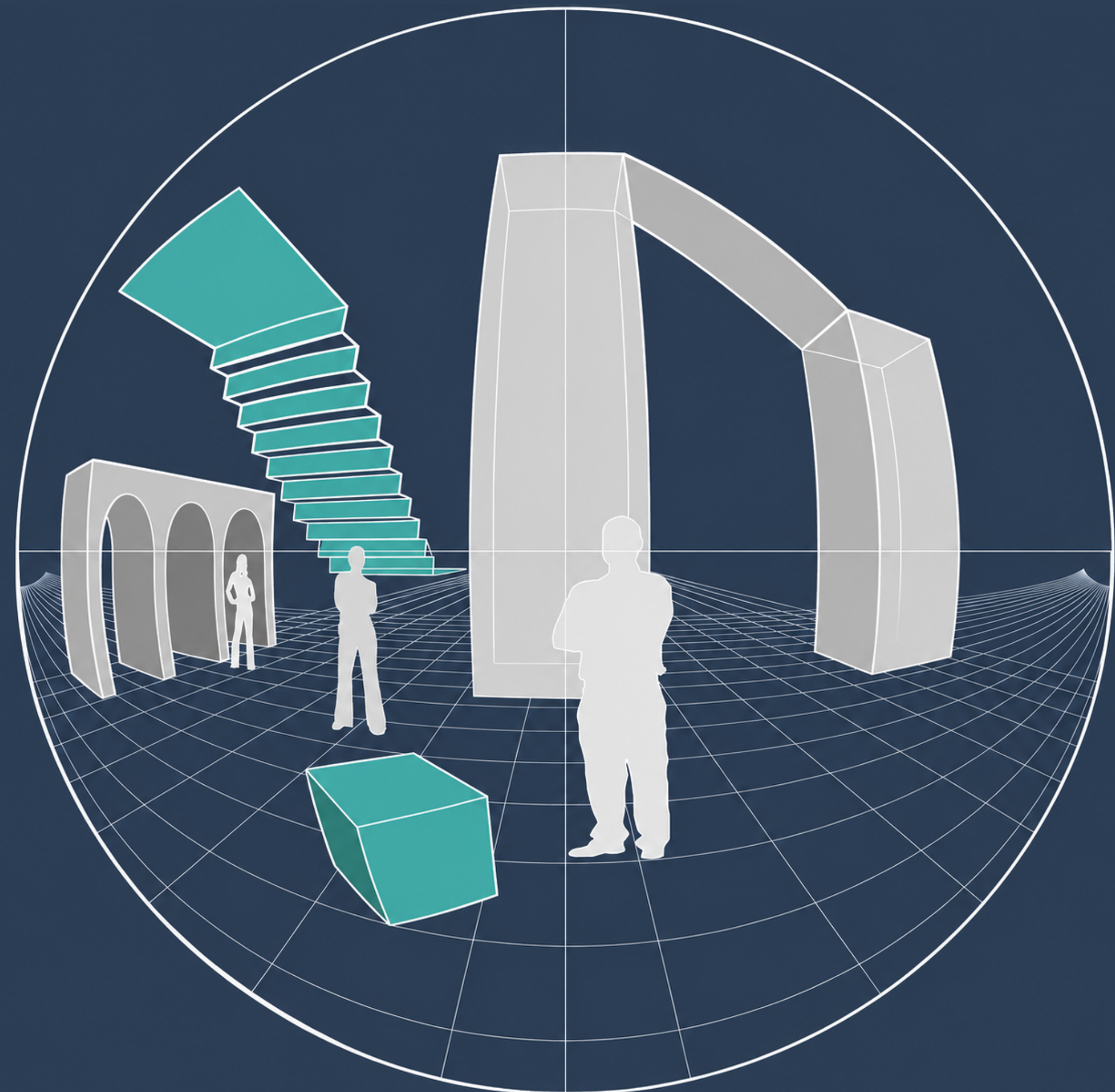


Curvilinear Perspective

Wide-field perspective beyond the central viewing direction

Features

- Curved projection system
- Wide field of view
- Fisheye / five-point appearance
- Straight lines may bend toward the edges
- Peripheral space is compressed
- Links to panoramic, spherical, etc.

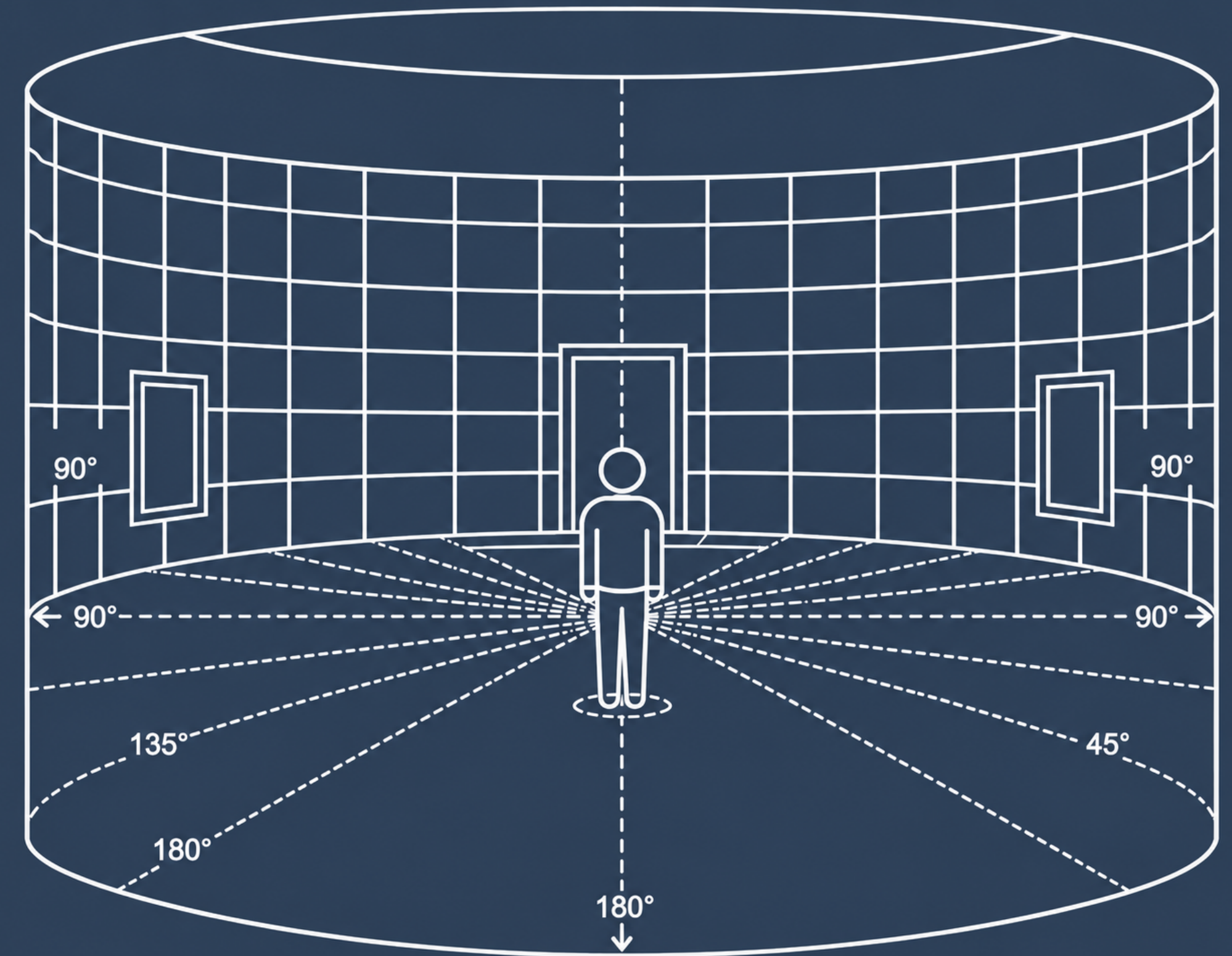


Cylindrical Perspective

Projects space on a curved vertical surface

Features

- Uses a curved vertical picture plane
- Keeps verticals straight
- Curves horizontals around the viewer
- Expands the field of view
- Useful for panoramas and immersive spaces
- Shows perspective beyond the flat picture plane



Panoramic Perspective

A wide-field view of a spatial scene

Extends vision beyond a single frame

- Expands space laterally
- Combines multiple directions
- Connects photography, mapping, VR, and immersion

Hong Kong Island from the air: 360 photograph panorama
Lok Yiu Cheung

Photograph



Cinerama widescreen cinema, 1952



Film Frame: Immersive / Panoramic Projection Perspective

Spherical Perspective

Spherical View Types

- **Glass / metal ball - unfolding projection**

Reflects or refracts a miniature panoramic scene that changes as the ball moves.

- **Globe / digital model - unfolding view**

Reveals changing views through rotation, zoom, or viewpoint shift.

- **Multi-view 6-point sphere**

Maps multiple directions into one spherical image.



Glass Ball - Type 1
Spherical Perspective View

Unfolding Globe Ball - Type 2
Spherical Perspective View

Photograph

Sphere of Revolution



Spherical Perspective - Type 3

Projects spatial appearance onto a spherical field, allowing wide-angle, panoramic, or 360° views

Sphere of Vision

- Spherical field of view
- Space seen in all directions
- Six-point perspective structure
- Opposite paired vanishing points
- Projected onto flat or spherical displays



6-Point Sphere - Type 3
Spherical Perspective System

Termespheres

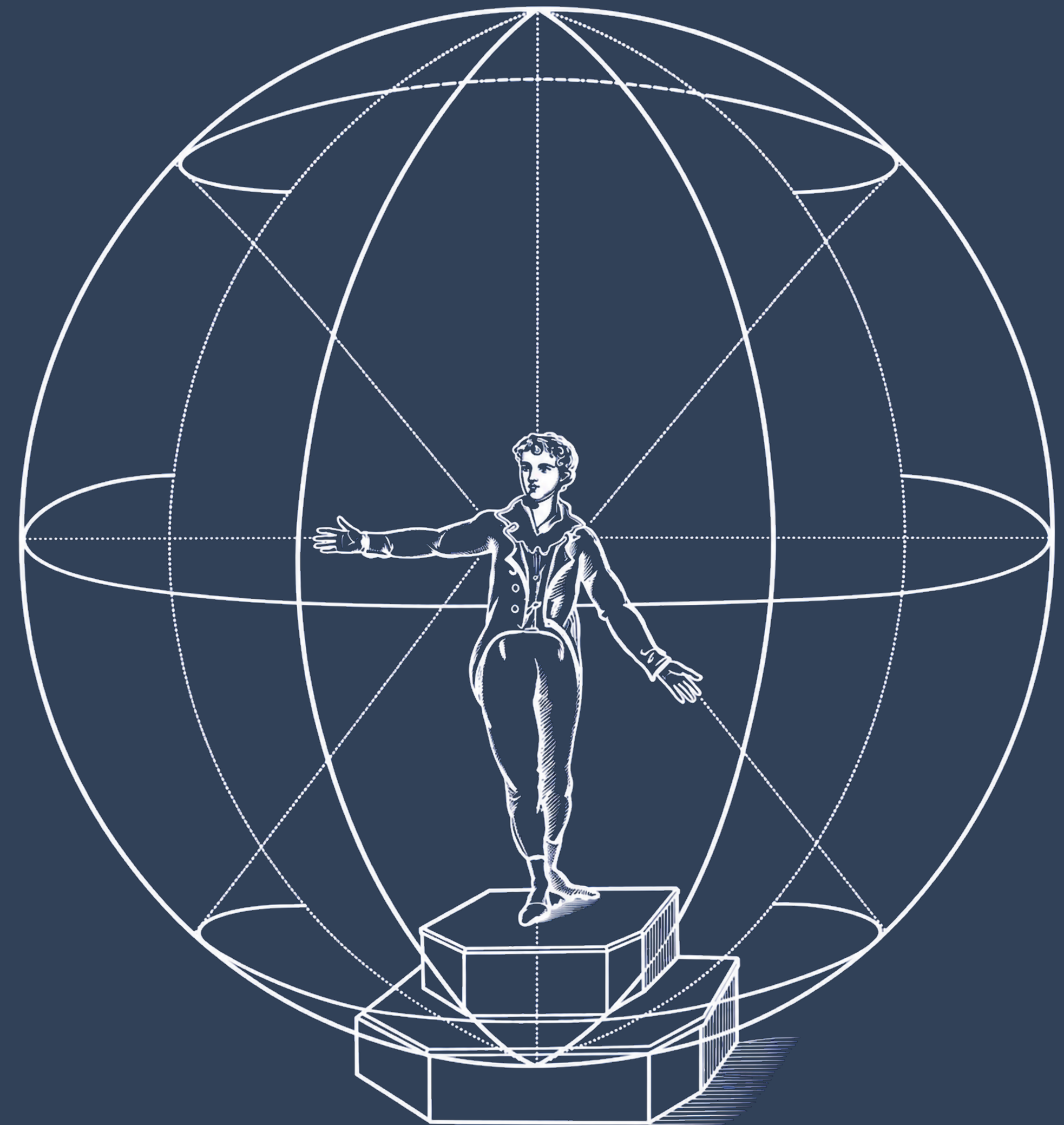
Spherical / Total-View Perspective



3D Illusions and Immersion

Perspective can make
space appear altered

Illusions of size, depth, distance,
position, and transparency

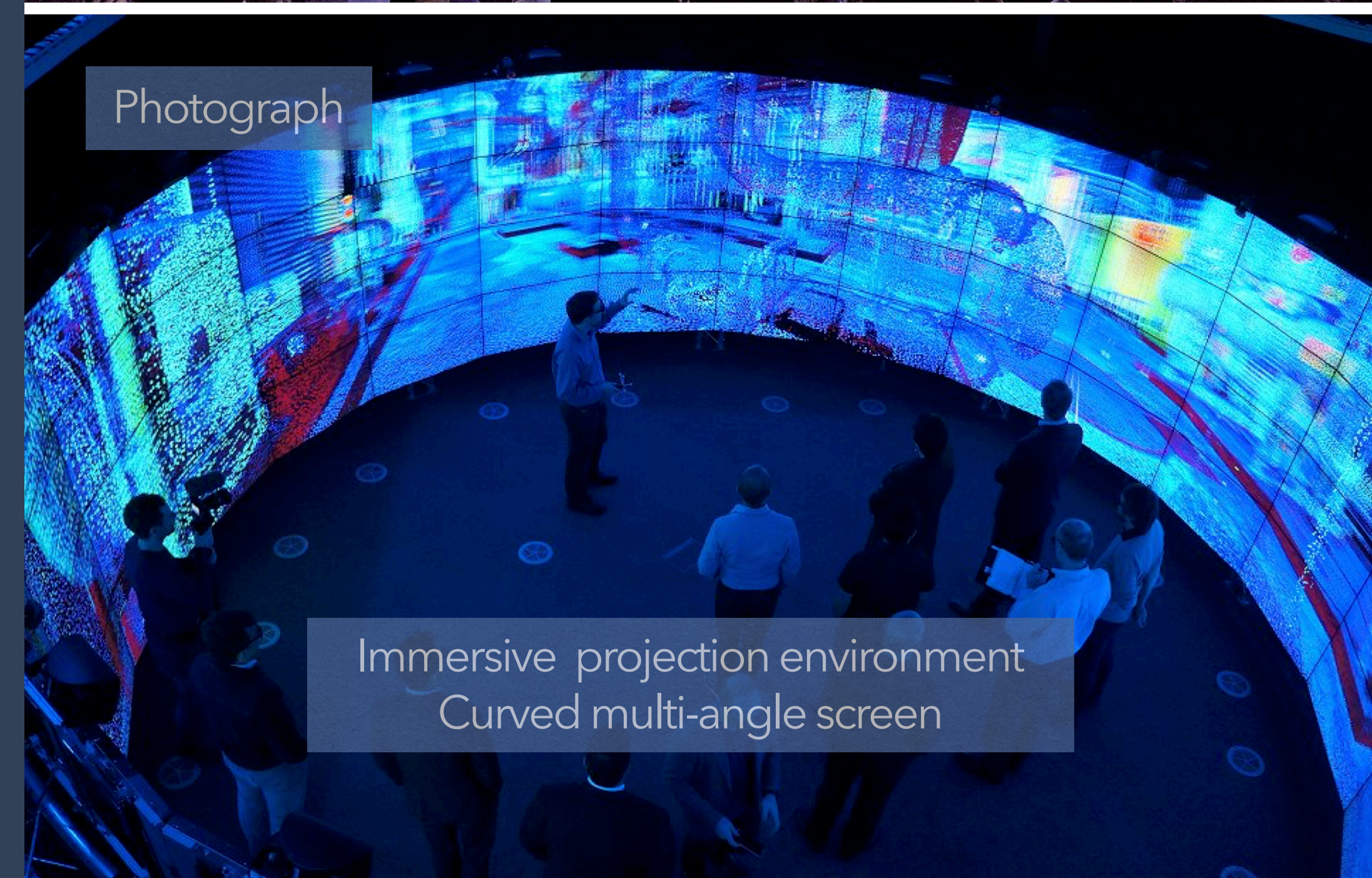


Perspective and Immersion

Perspective becomes an environment

Merging digital and physical worlds

- Images no longer stay inside a frame
- Projection and digital media surround the viewer
- Space is experienced from within, not only observed from outside

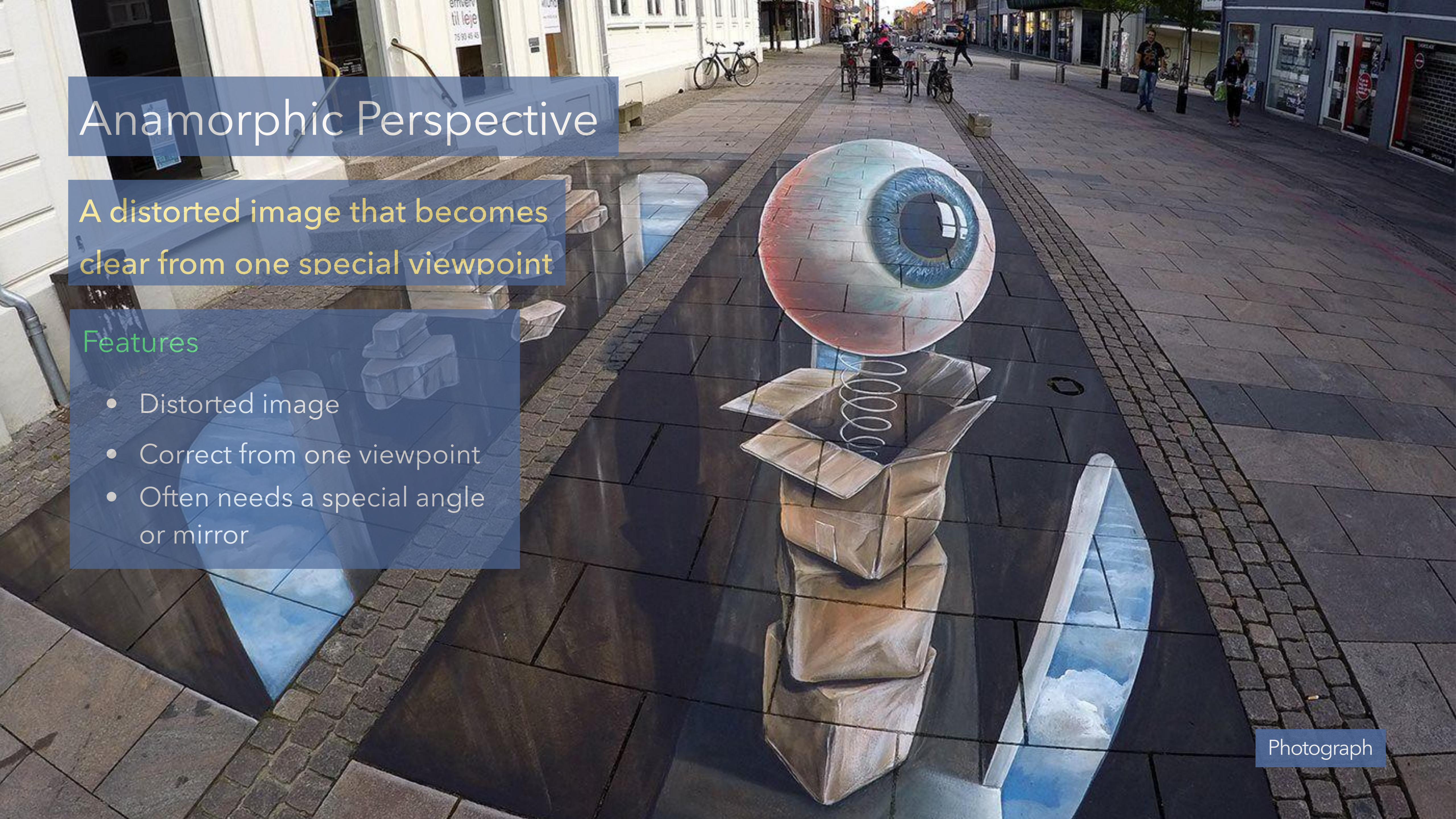


Anamorphic Perspective

A distorted image that becomes clear from one special viewpoint

Features

- Distorted image
- Correct from one viewpoint
- Often needs a special angle or mirror



Photograph

Virtual Production

Blends physical space, digital space, and camera perspective

Blended Scene / Synthetic Perspective

- Camera movement is matched to digital perspective
- LED volumes place actors inside responsive virtual scenes
- Physical and computer-generated space blend in real time



AI-generated illustration

Forced Perspective

Altered space made convincing from a controlled viewpoint

Accelerated Perspective

- Compresses real space
- Exaggerates apparent depth
- Makes distant objects appear smaller

Decelerated Perspective

- Expands real space
- Reduces apparent depth
- Makes distant objects appear larger

Accelerated Perspective

What the eye sees: long corridor

What the body reveals: shortened, tapered space



Photograph

Borromini's Palazzo Spada Gallery in Rome, c. 1653

Perspective makes spatial reality measurable

-
- Media-Enhanced Photograph
- New York
- 40.71°N, 74.01°W
- The High Line
- Whitney Museum of American Art
- Manhattan Community College
- Charging Bull
- Battery Park
- FDR Drive
- St. Paul's Chapel of Trinity Church Wall...
- Foley Square
- Murry Bergtraum High School For...
- Tenement Museum
- United Nations Headquarters
- Google



Inside and Outside of the Image

Expanding cognition through perspective

Turning images into spatial experience

- Perspective becomes a world you live inside
- Stereo, parallax, projection and head-tracking create spatial depth
- Digital multiverse cross-matches reality
- From stereoscopes to VR, domes and holographic displays



Sphere, Las Vegas

Perspective as immersive architecture

Turns perspective into a total spatial experience

- 16K-by-16K wraparound interior LED display
- 875,000 sq ft (516 ft wide) exterior screen
- Spatial audio and sensory effects surround the viewer
- Image, architecture, sound, and viewpoint merge
- Perspective becomes environment, not just image

Photograph

Artificial Intelligence Perspective

From computer vision to immersive spatial intelligence

Perspective becomes
computational, adaptive, and
generative

AI infers depth and viewpoint

Images are reconstructed

Spatial structure is generated

Human and machine vision converge

AI-generated illustration

Instrument Perspective

1 LOOKING

observing reality, appearances, and illusions



- lens, mirror, window
- camera obscura
- spectacles / binoculars
- microscope
- refracting telescope
- reflecting telescope

2 CAPTURING

recording views and images



- pinhole camera
- stereo camera
- film camera
- movie camera
- television / digital camera
- astronomical satellite telescopes
- earth-observation satellite telescopes

(camera techniques: zoom, pan, tilt, dolly, focus, position, angle)

3 PROJECTING / DISPLAYING

showing images and views



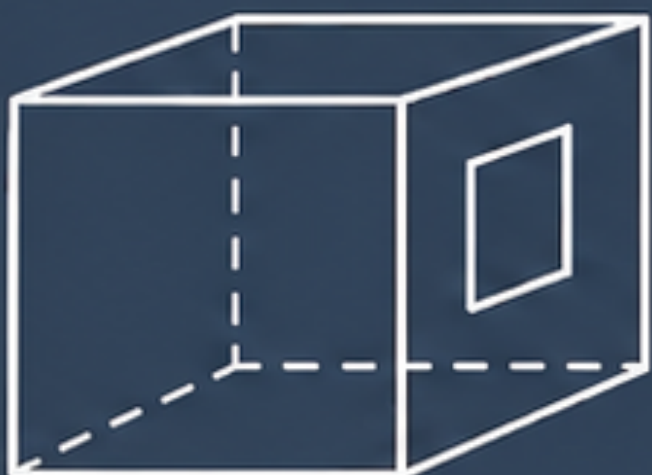
- zoetrope, kinetoscope
- film projector (*moving / still*)
- digital projector (*moving / still*)
- panoramas / television
- 3D display techniques
- computer + display
- Cinerama, IMAX / OMNIMAX

projective techniques

- picture-in-picture
- full-partial frame views
- multi-frame / interactive
- angle/sliced frame views

4 REPRESENTING

copying or constructing appearances



- pantograph
- camera lucida
- perspective window
- perspective box

Instrument Perspective

6 SIMULATING

creating an illusion of, or immersion into, a false reality



- optical illusions
- stereoscope
- projection mapping
- VR / AR / XR systems
- hologram
- Ames room
- kaleidoscope
- catadioptric cistula

5 MEASURING / MODELLING

prescribing, indexing, mapping, analysing, and modelling



Measuring & Calculating

- rule, calipers, set-square
- protractor
- slide rule, *nautical slide rule*
- flight computer
- sextant, quadrant
- theodolite, sundial
- compass (*all types*)

Astronomy & Modelling

- astrolabe
- armillary
- orrery
- planisphere

Mapping & Charting

- map (global, plane)
- chart (2D, 3D)
- globe (3D)

Imaging & Analysis

- spectrograph
- hyperspectral imaging

Surveying & Geospatial

- surveying
- topography
- cartography
- remote sensing

Toward a Unified Future

Perspective becomes immersive,
interactive and intelligent.

Space 360

Photograph

Spherical projection theatre at
the Gwangju National Science
Museum, South Korea.



Converging Modes of Perspective

From looking at and around to
looking through

- **Looking-at/in** – focused views
- **Looking-around** – wide-field views
- **Looking-through** – transparent and immersive views

Digital systems increasingly combine
these modes



AI-generated illustration

Why Perspective Matters

Perspective is the visual infrastructure for representing, measuring and constructing space

A keystone of spatial knowledge

- **Visualises** – depth, scale, position, and viewpoint
- **Measures** – maps, surveys, models, and instruments
- **Underpins** – art, science, media, AI, and spatial computing



AI-generated illustration

My thesis is that...

Perspective is the science of spatial appearance –
unifying optics, geometry, vision, and representation
across disciplines

It deserves recognition as a major field of study