Design Considerations of Compound Alignments Resulting from Visibility Restrictions by Median Jersey Barriers

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3D Highway Geometry

- 2 Independent and mostly uncorrelated 2D stages
  - horizontal alignment
  - vertical alignment

- 2D approach associated with design misconceptions affecting design performance adversely
  - typical case: SSD
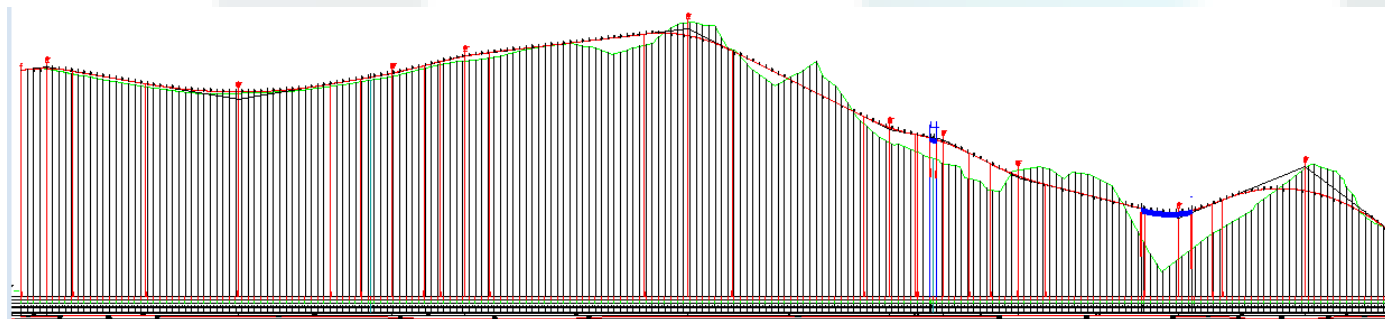
Current Practice

- 2D Approach
  - efforts to overcome this incorrect SSD determination
    - coordination between horizontal and vertical curve positioning

- not all design cases are addressed
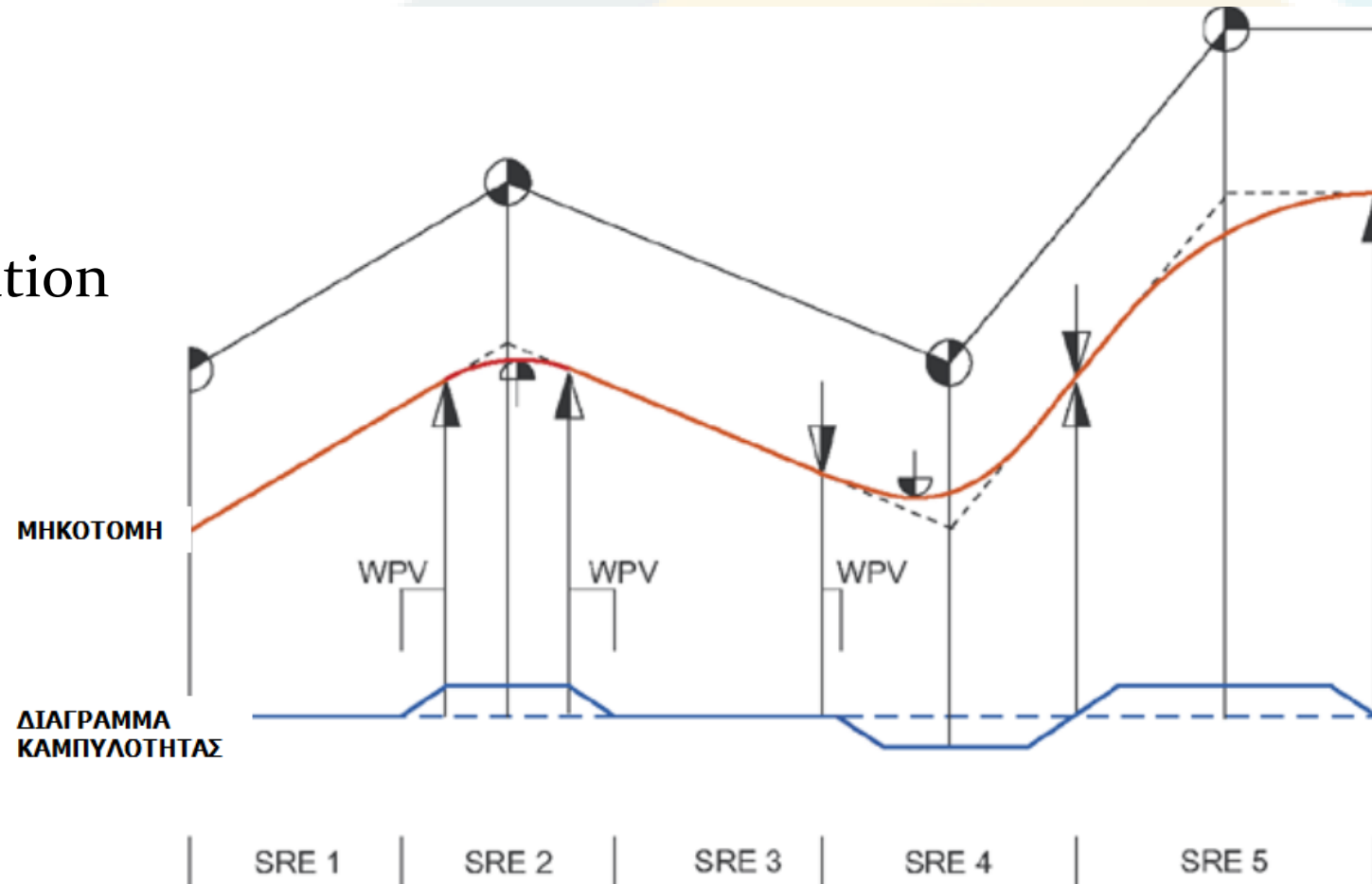
Left Curved Divided Highways

- Median barriers

  – increase level of safety

- Necessity for SSD adequacy

- No Explicit Process Provided

  – no assurance whether
  barrier height and/or vertical curve
  do not obstruct
  driver's line of sight

Left Curved Divided Highways – SSD Adequacy Breakpoint

$$SSD_{DEMANDED} \leq SSD_{AVAILABLE}$$

- Options
  - determine the examined curve's inferred safe speed
  - define the inner shoulder width for a desired speed

Objectives

- Deliver **analytical tool** for SSD assessments

- **Quantify safety impact** of median Jersey barriers during emergency braking conditions on compound alignments
  - left horizontal curves (R)
  - crest vertical curves (H_k)

- **Identify** areas of **interrupted vision lines** between driver and object
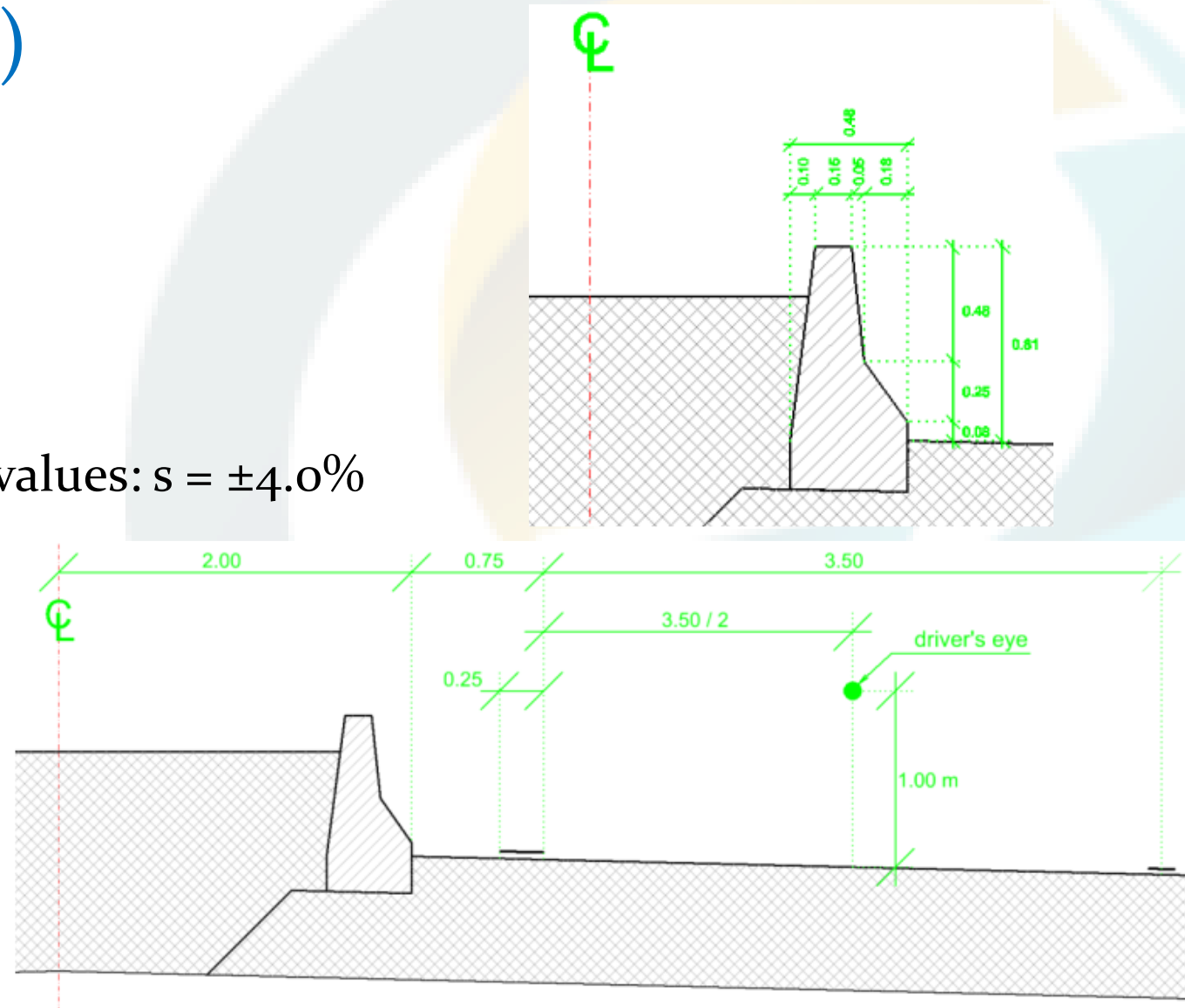
- Examine **interaction** of utilized **design parameters**

SSD Assessment (1/2)

- RAA 2008 Design Guidelines
  - V =130km/h
  - $t_{\text{perception-reaction}}$ = 2.0sec, a=3.7m/sec²
  - $h_{\text{driver's eye}} = h_{\text{object}}$ = 1.00m
 - crest vertical curve grade boundary values: s = ±4.0%

- Passing lane width = 3.50m

- Inner shoulder width = 0.75m

- NJ median barrier (0.90m high)
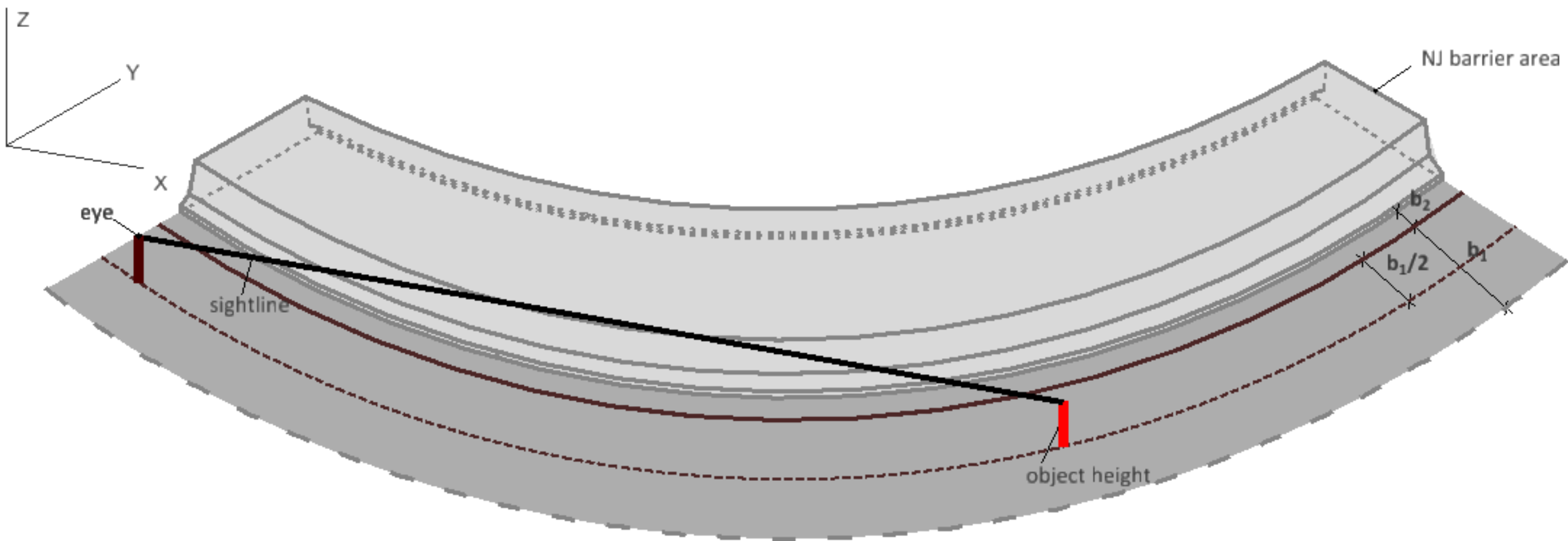
- Variety of horizontal – vertical parameters

SSD Assessment (2/2)
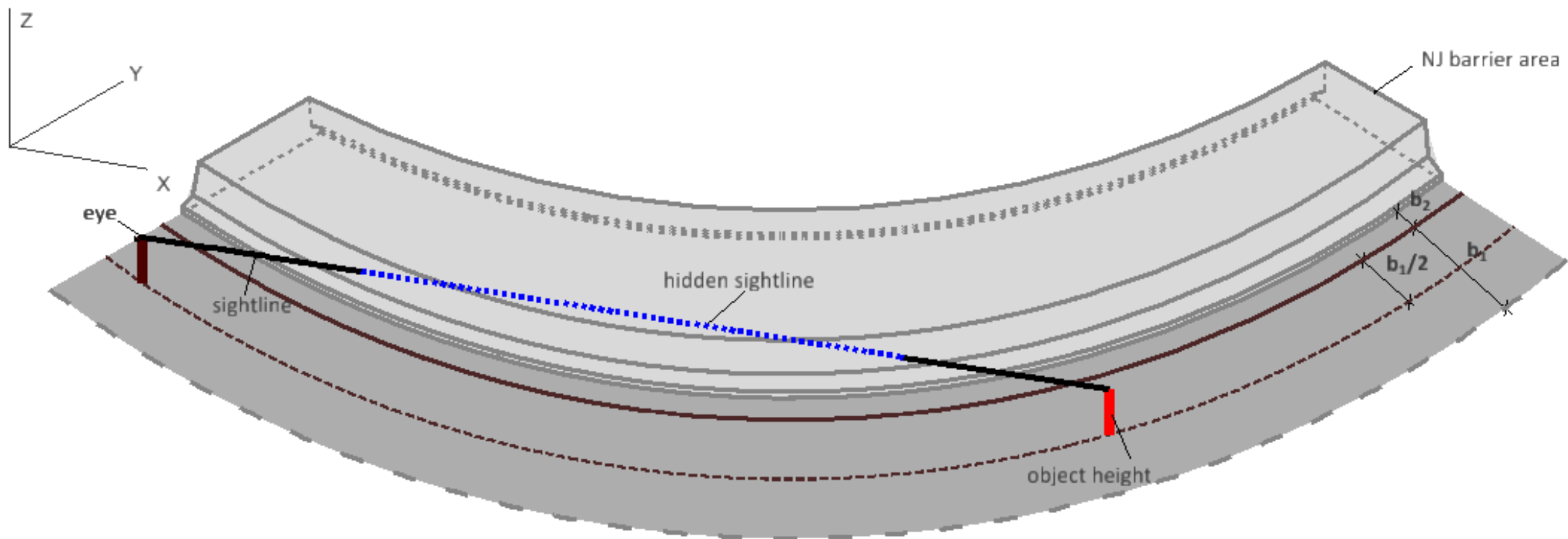
$$SSD_{DEMANDED} \leq SSD_{AVAILABLE}$$

- 3D $SSD_{DEMANDED}$
  - enriched point mass model
    - actual values of grade (vertical curves)
    - friction variation (vehicle cornering)

- 3D $SSD_{AVAILABLE}$
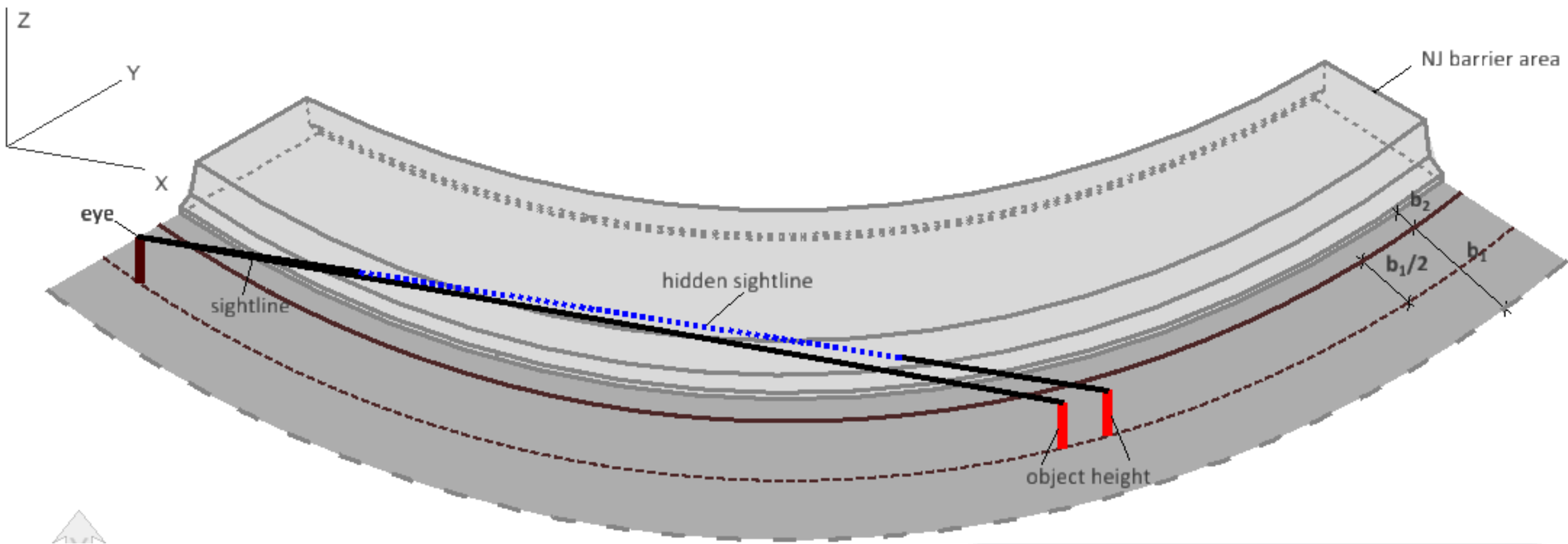 - driver's line of sight towards object height
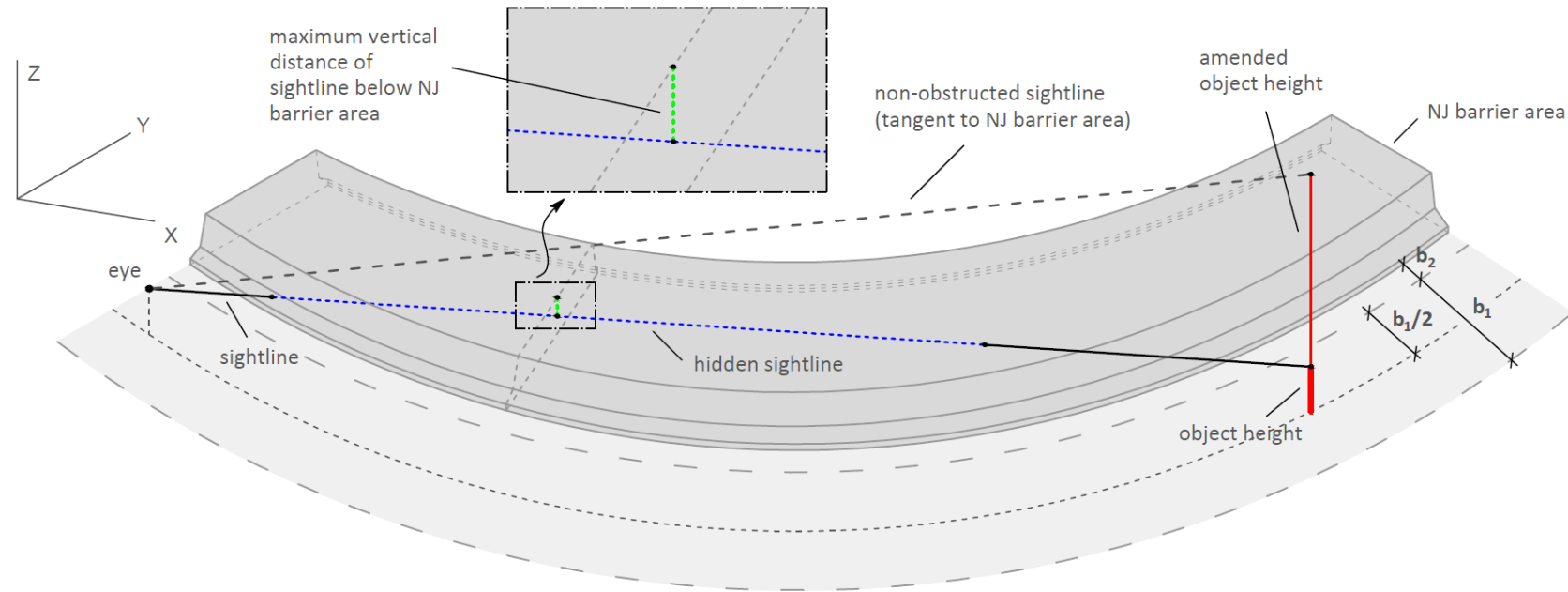
SSD~AVAILABLE~ (Station A)
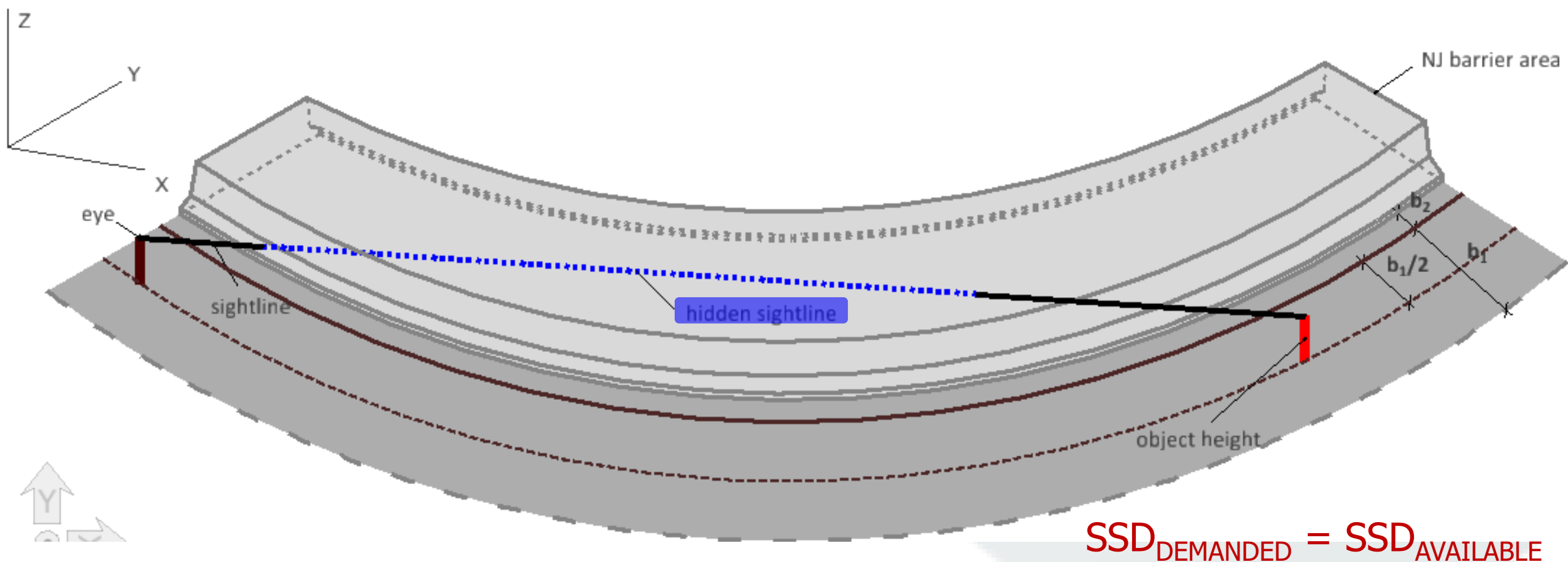
SSD_AVAILABLE (Station A + calc. step)

SSD~AVAILABLE~ (Station A) vs SSD~AVAILABLE~ (Station A + calc. step)

SSD Modeling Proposal (1/3)

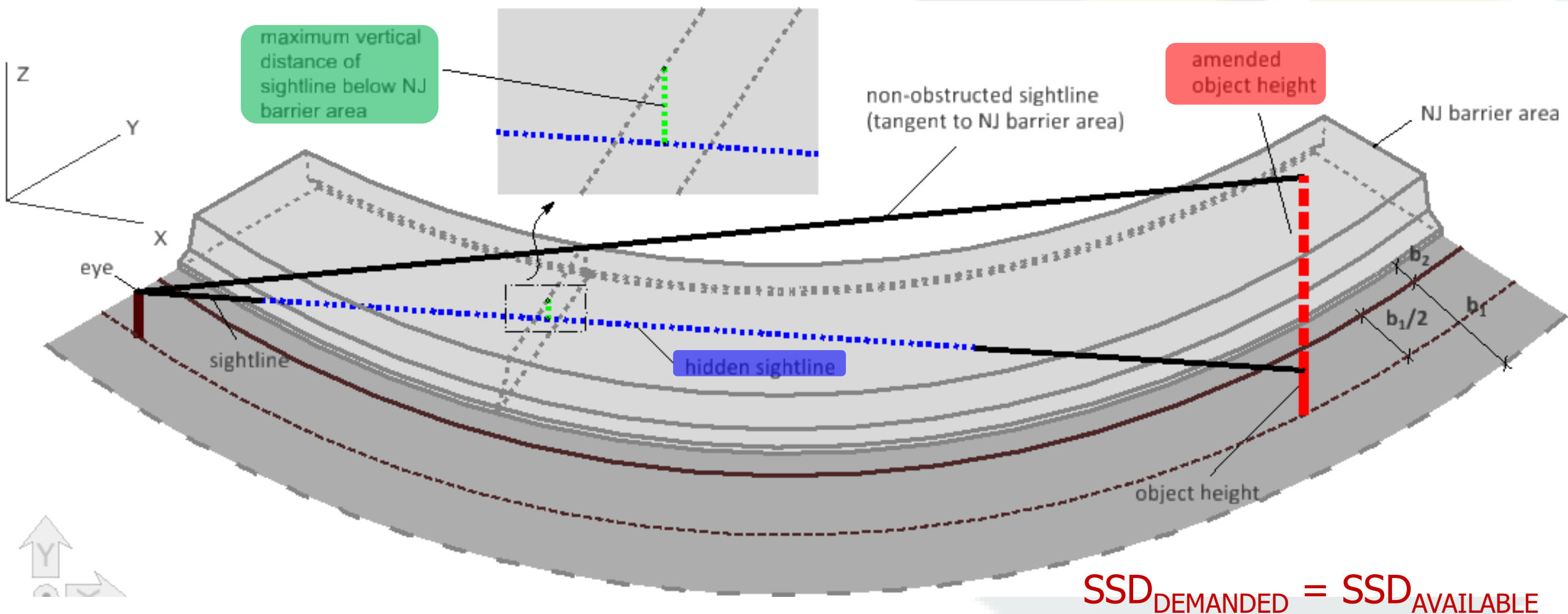$$SSD_{DEMANDED} = SSD_{AVAILABLE}$$

SSD Modeling Proposal (2/3)

maximum vertical distance of sightline below NJ barrier area

NJ barrier area

b_2

$b_1/2$

b_1

eye

sightline

hidden sightline

object height

$SSD_{DEMANDED} = SSD_{AVAILABLE}$

SSD Modeling Proposal (3/3)

maximum vertical distance of sightline below NJ barrier area

non-obstructed sightline (tangent to NJ barrier area)

amended object height

NJ barrier area

hidden sightline

eye

sightline

object height

b_2

$b_1/2$

b_1
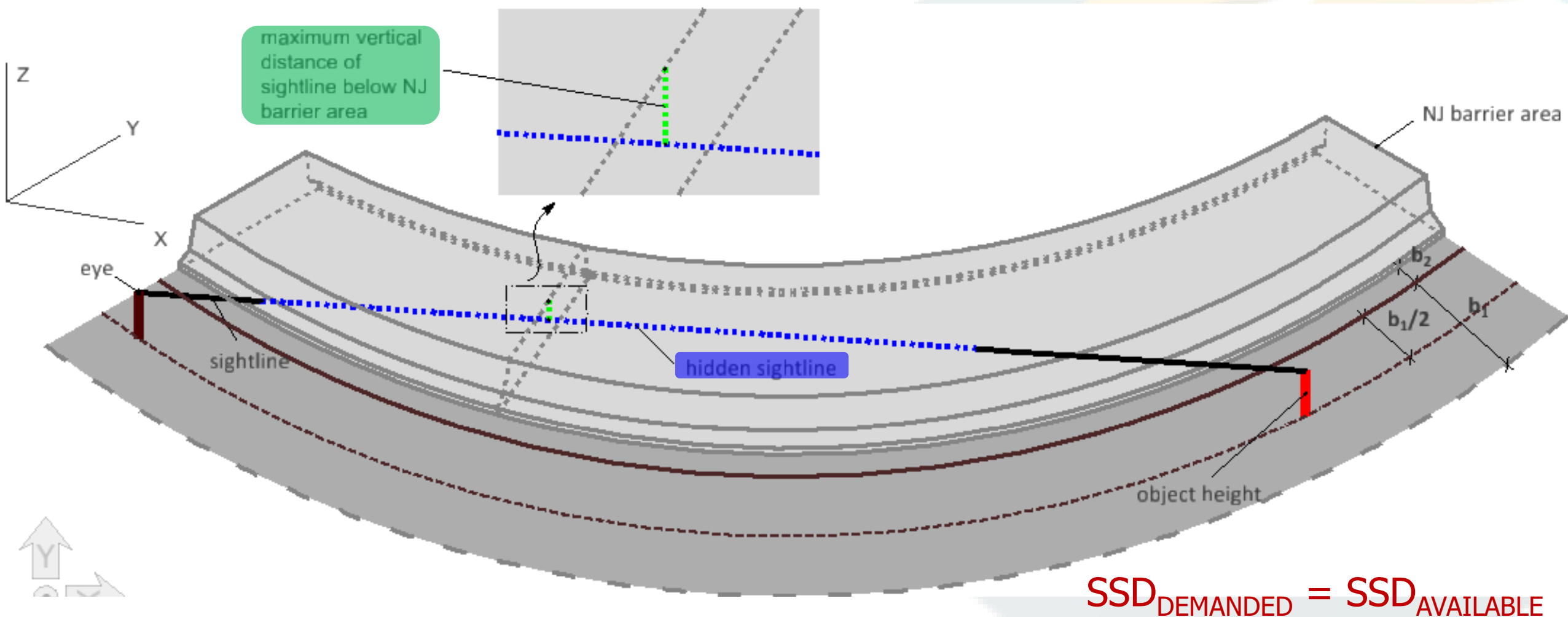
$SSD_{DEMANDED} = SSD_{AVAILABLE}$
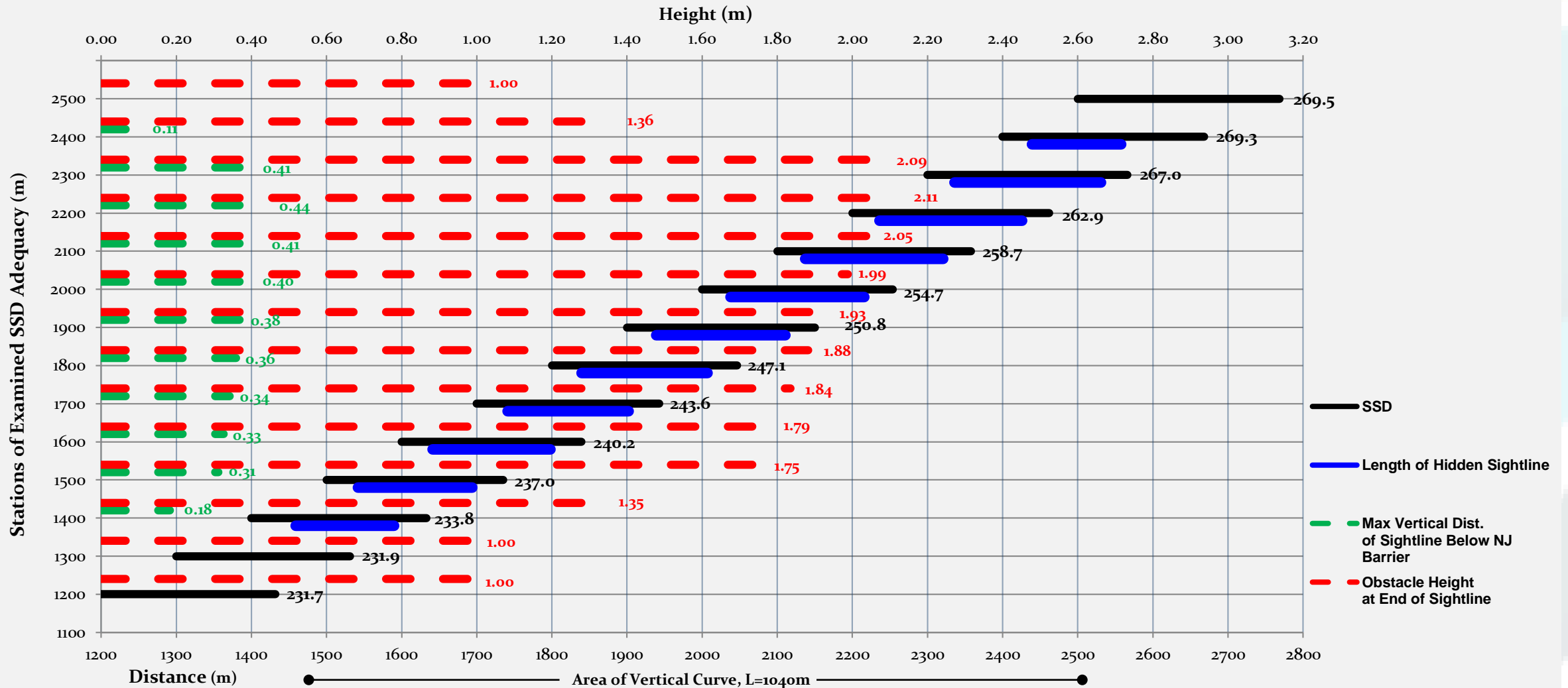
Output Data (R=1500m, H$_k$=13000m, s=±4.0%)

Output Data (R=1500m, H_k=13000m, s=±4.0%)
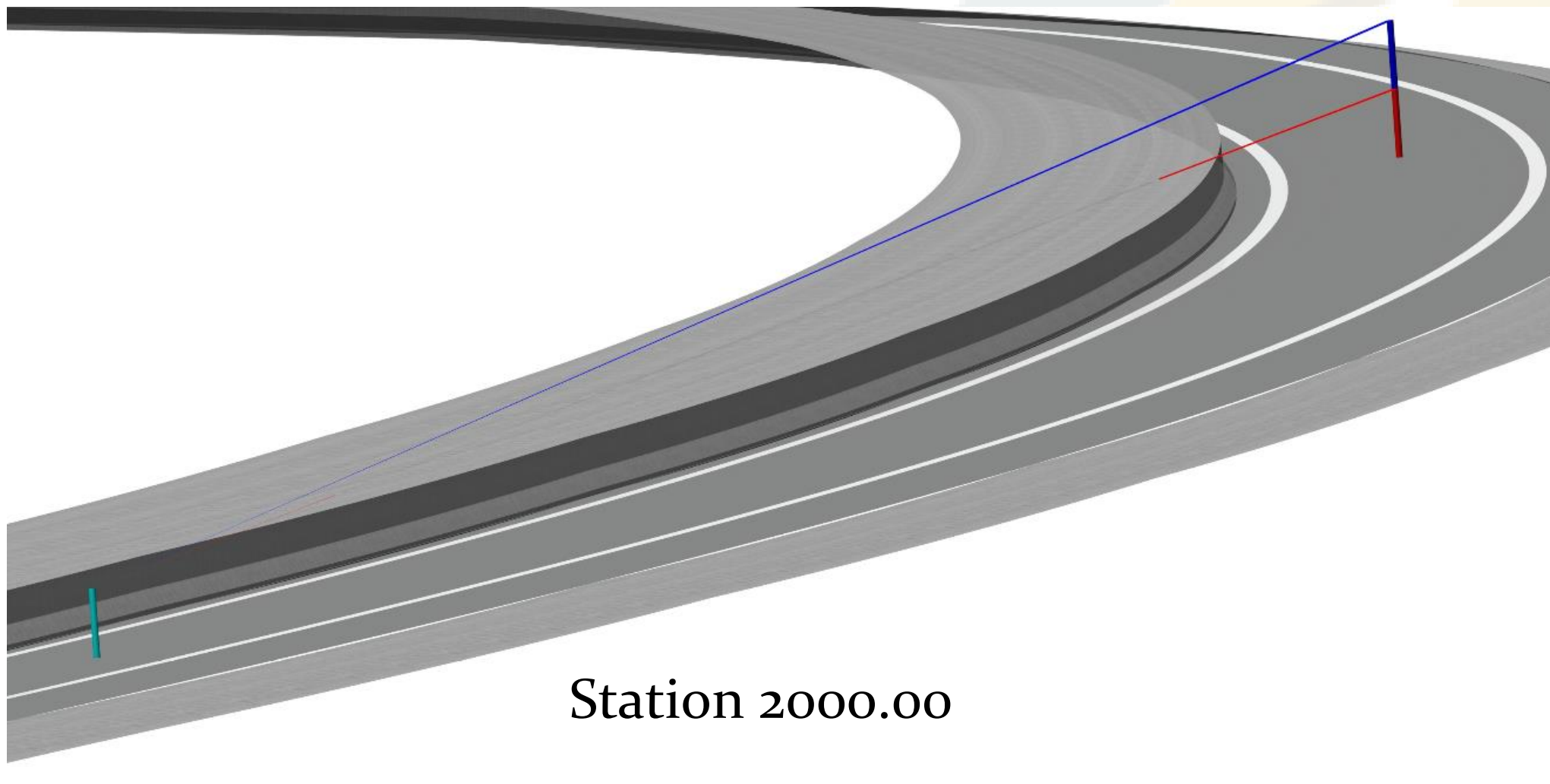
Station 2000.00

Output Data (R=1500m, H_k=13000m, s=±4.0%)
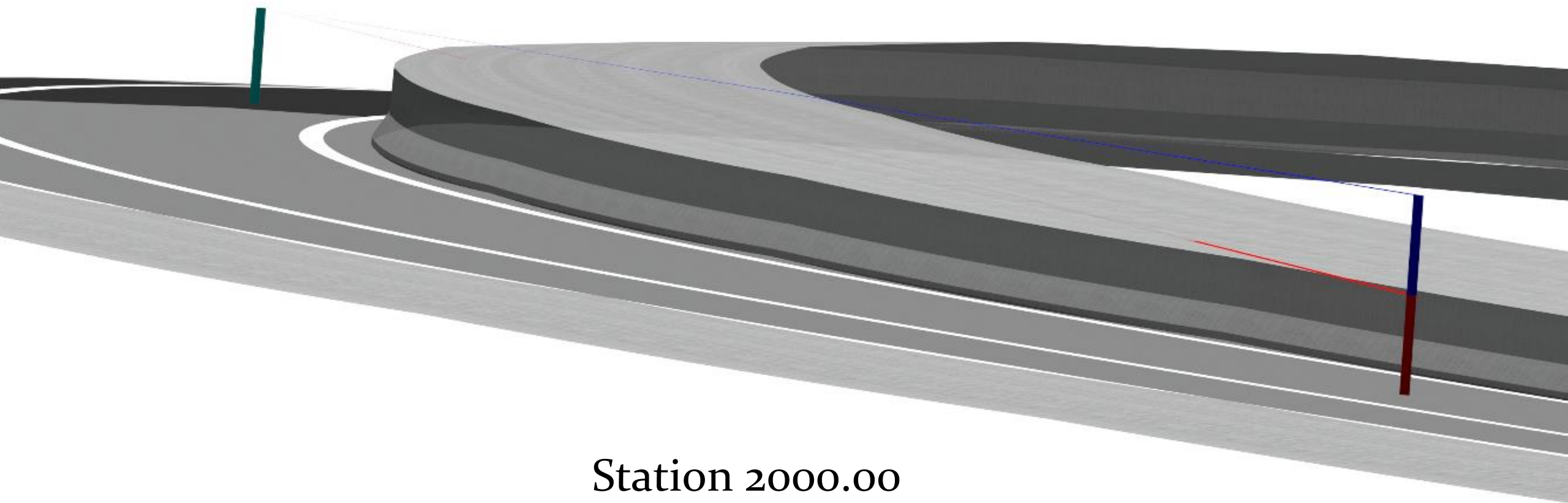
Station 2000.00

Output Data (R=1500m, H_k=13000m, s=±4.0%)

Station 2000.00
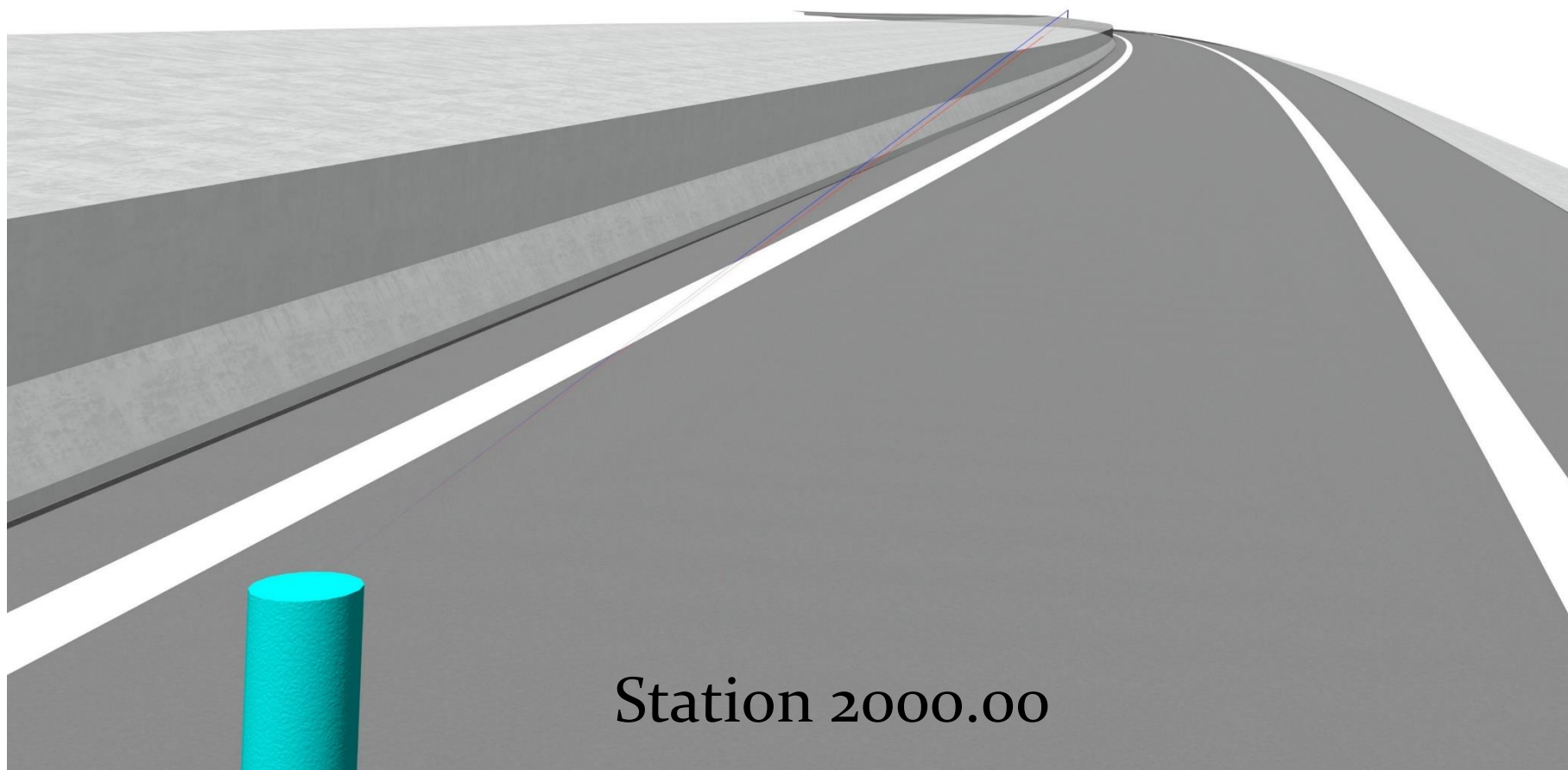
24 Examined Alignments

- $SSD_{DEMANDED}$ reduction (%)
  - $h_{object} = 1.00m$

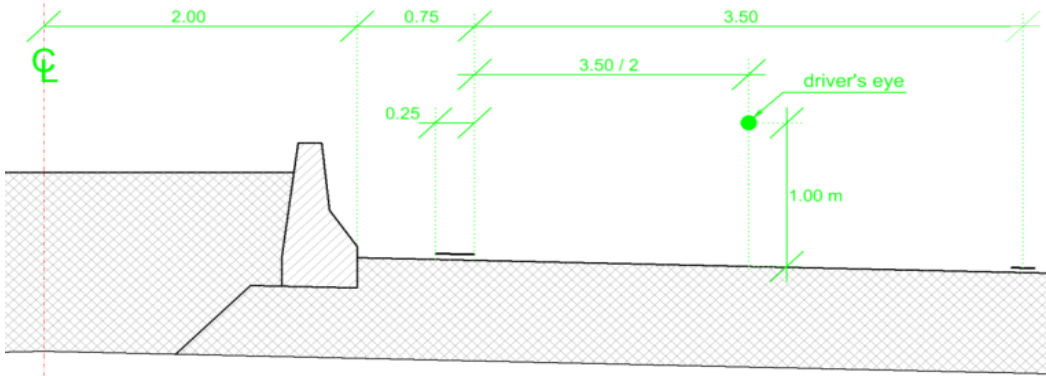|	CVCR (m)			
R (m)	**13000**	**20000**	**25000**	**40000**
900	>39%	>25%	>16%	0%
1500	>32%	>25%	>16%	0%
2000	>22%	>22%	>16%	0%
2500	>12%	>12%	>12%	0%
3000	4%	4%	4%	0%
3500	0%	0%	0%	0%

Can We Reduce SSD$_{DEMANDED}$?

- Introduction of:

  "tolerable road length not visible to the driver"

  - SSD$_{AVAILABLE}$ = SSD$_{DEMANDED}$ reduced by 9%-12%
    - deceleration rate 3.7m/sec^2 → 4.3m/sec^2

Acceptable Arrangements of Compound Alignments

- ## SSD Adequacy
  - V=130km/h
  - s=±4.0%
  - a=4.3m/sec²
  - $h_{driver's\ eye} = h_{object} = 1.00m$

Note:
- ✓ acceptable arrangements,
- ✓* acceptable arrangements for exit grades not bellow s= -2.5%,
- ✗ unacceptable arrangements

R (m)	CVCR (m)			
	13000	20000	25000	40000
900	✗	✗	✓*	✓
1500	✗	✗	✓*	✓
2000	✗	✗	✓*	✓
2500	✓	✓	✓	✓
3000	✓	✓	✓	✓
3500	✓	✓	✓	✓

Conclusions

- 24 compound alignments examined (V=130km/h)

- Extensive SSD shortage areas defined

- Introduction of:
  "tolerable road length not visible to the driver"

- Additional work
  – examine more speed values
  – optimize effect of additional parameters involved
    - inner shoulder width
    - median barrier type for certain cases (e.g. bridge – tunnels, etc.)
  – night time driving
  – issues associated to human factors

Thank you for your attention!!

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