Design of Footbridges

Dutch solutions for bicycle and pedestrian bridges

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ipv Delft

- infrastructure
- urban furniture
- architecture
- lighting


footbridge


footbridge

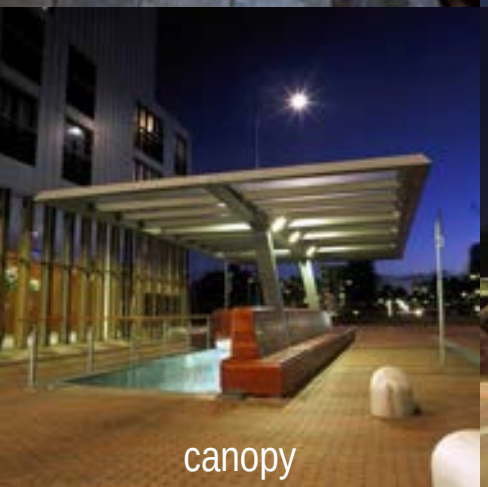

aquaduct

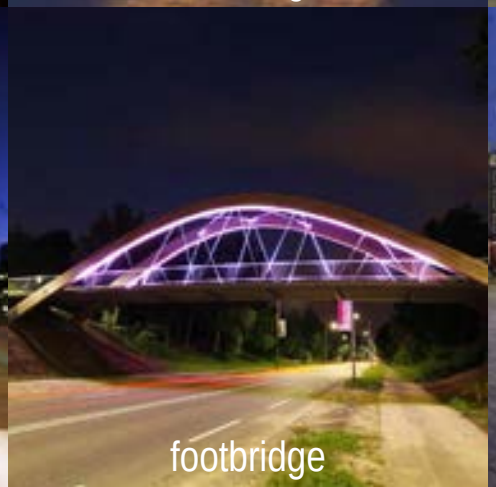

bench


footbridge

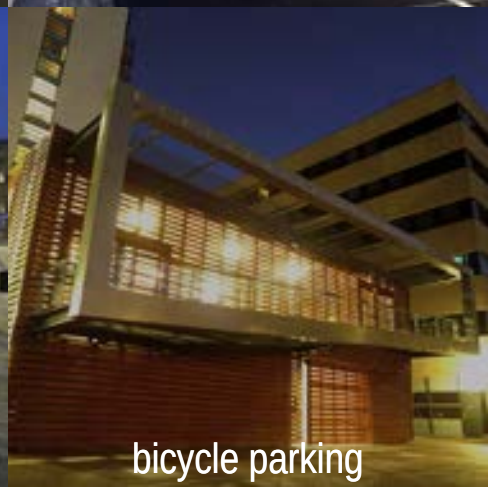

footbridge


tunnel


canopy


footbridge


lamp shade

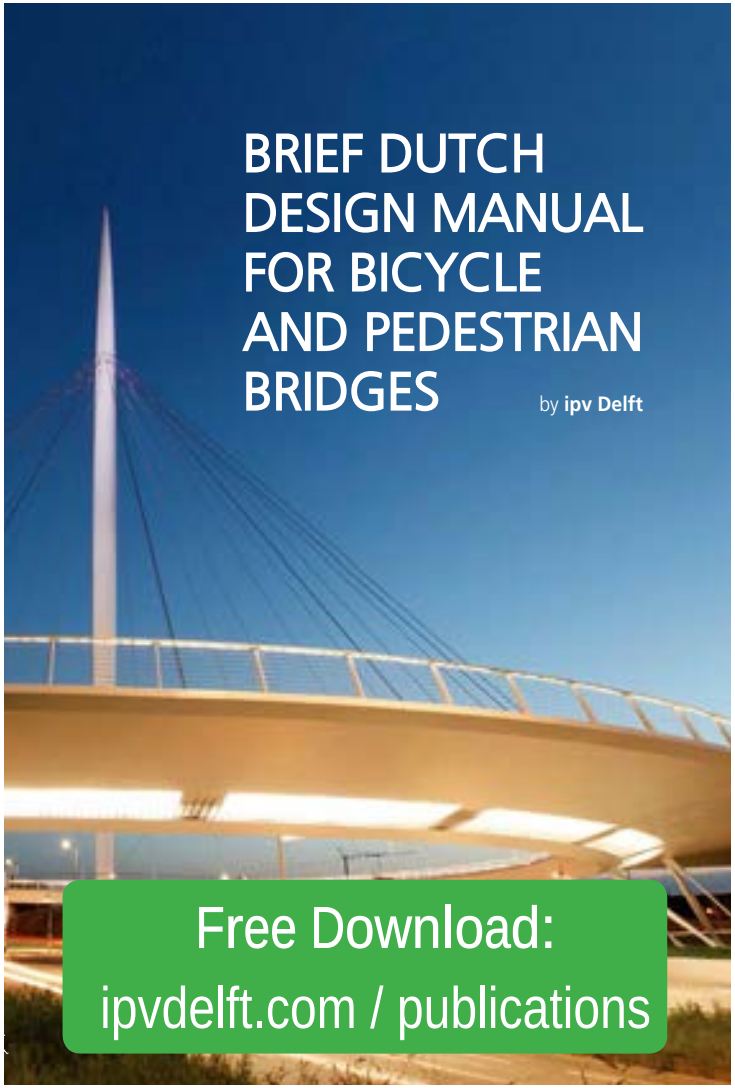

bicycle parking

CROW publication 342

Dutch, by ipv Delft

Summary CROW publication 342

English, by ipv Delft



Dutch Design Manual

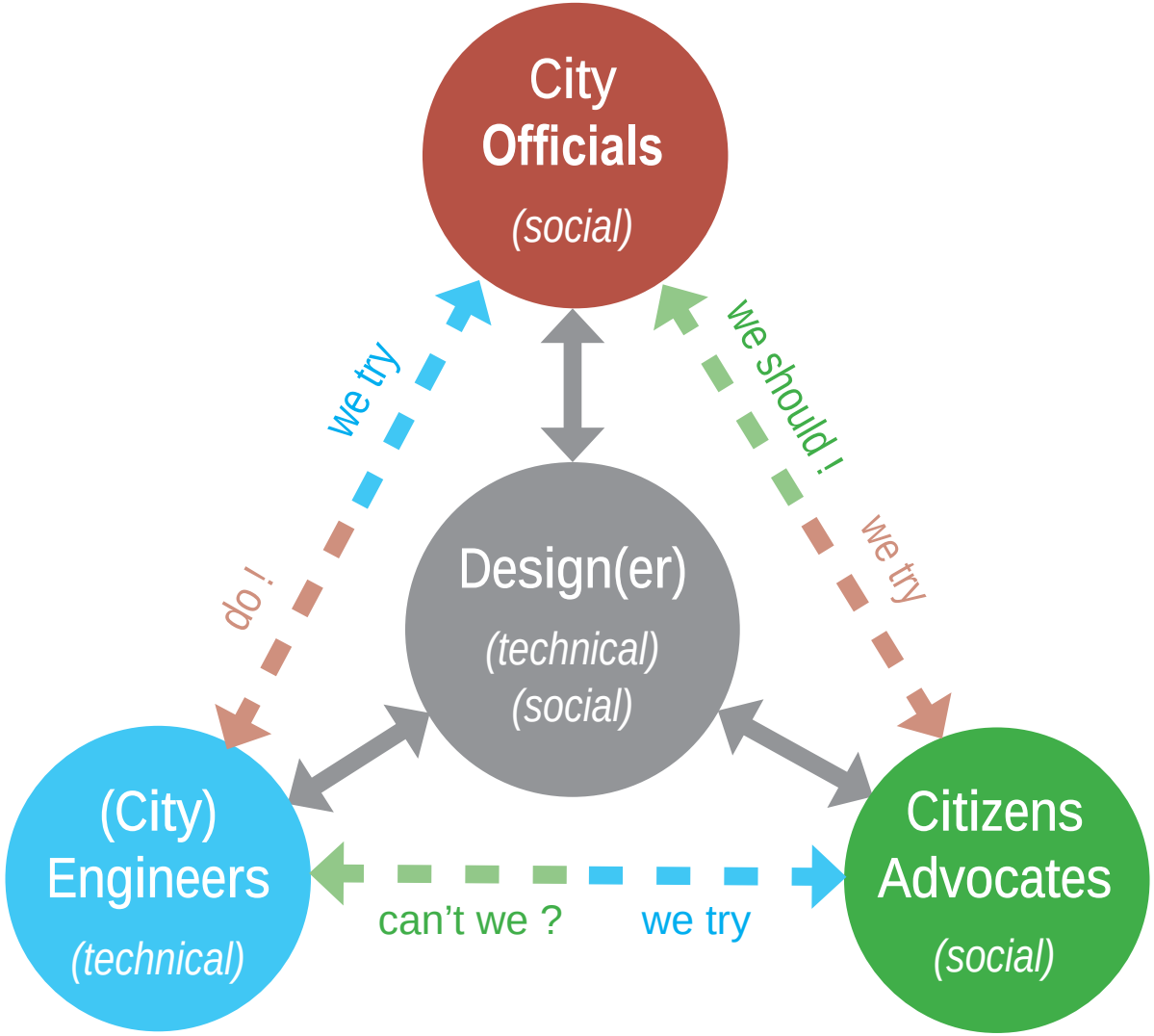
Intended Users: All involved disciplines & stakeholders

- Management
- Urban Planning
- Architects
- Structural engineering
- Traffic engineering
- Maintenance
- Contractors
- *Advocates*
- *Local stakeholders*

Dutch Design Manual

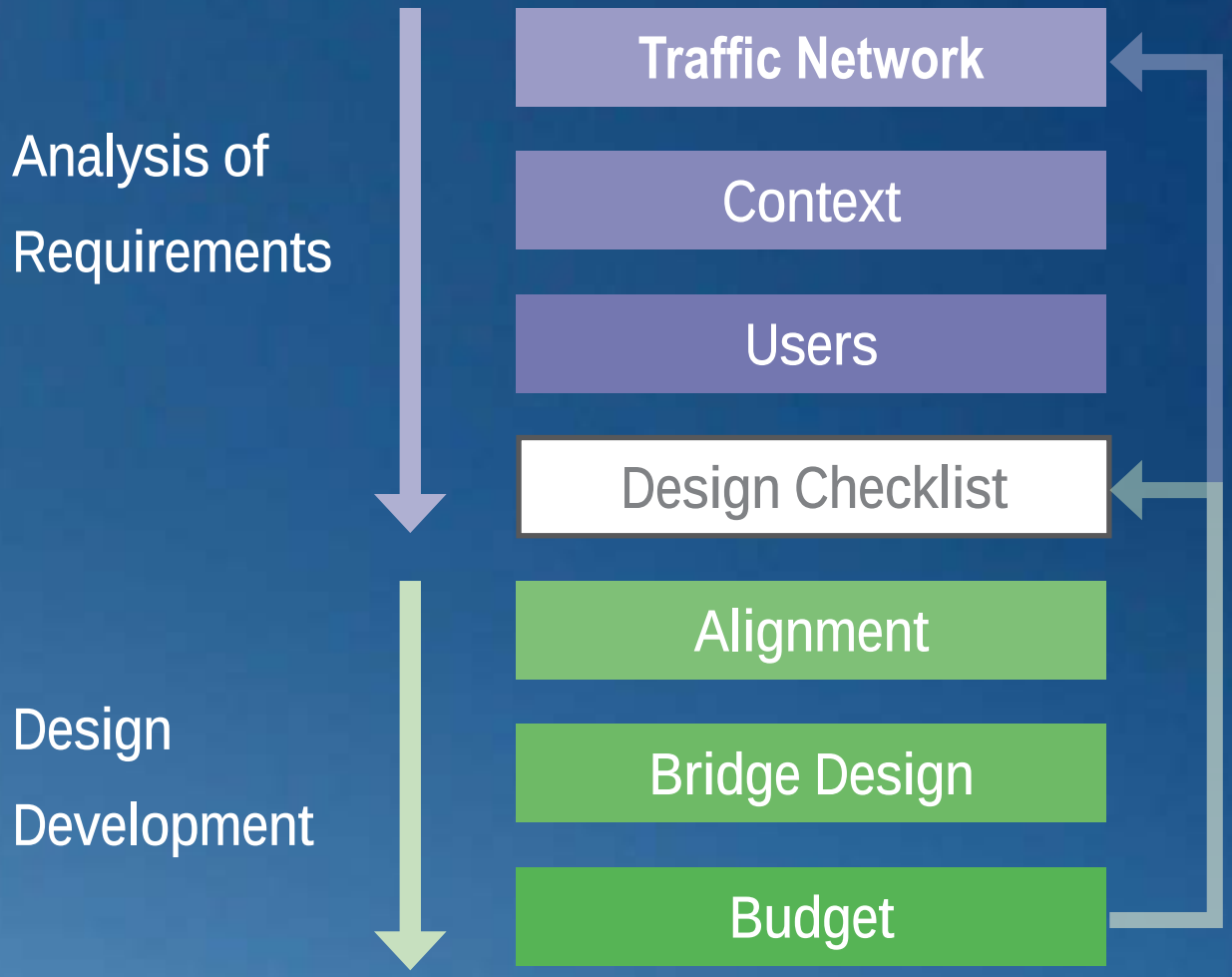
Intended Goal: Create Understanding

Between representatives of Technical & Social requirements



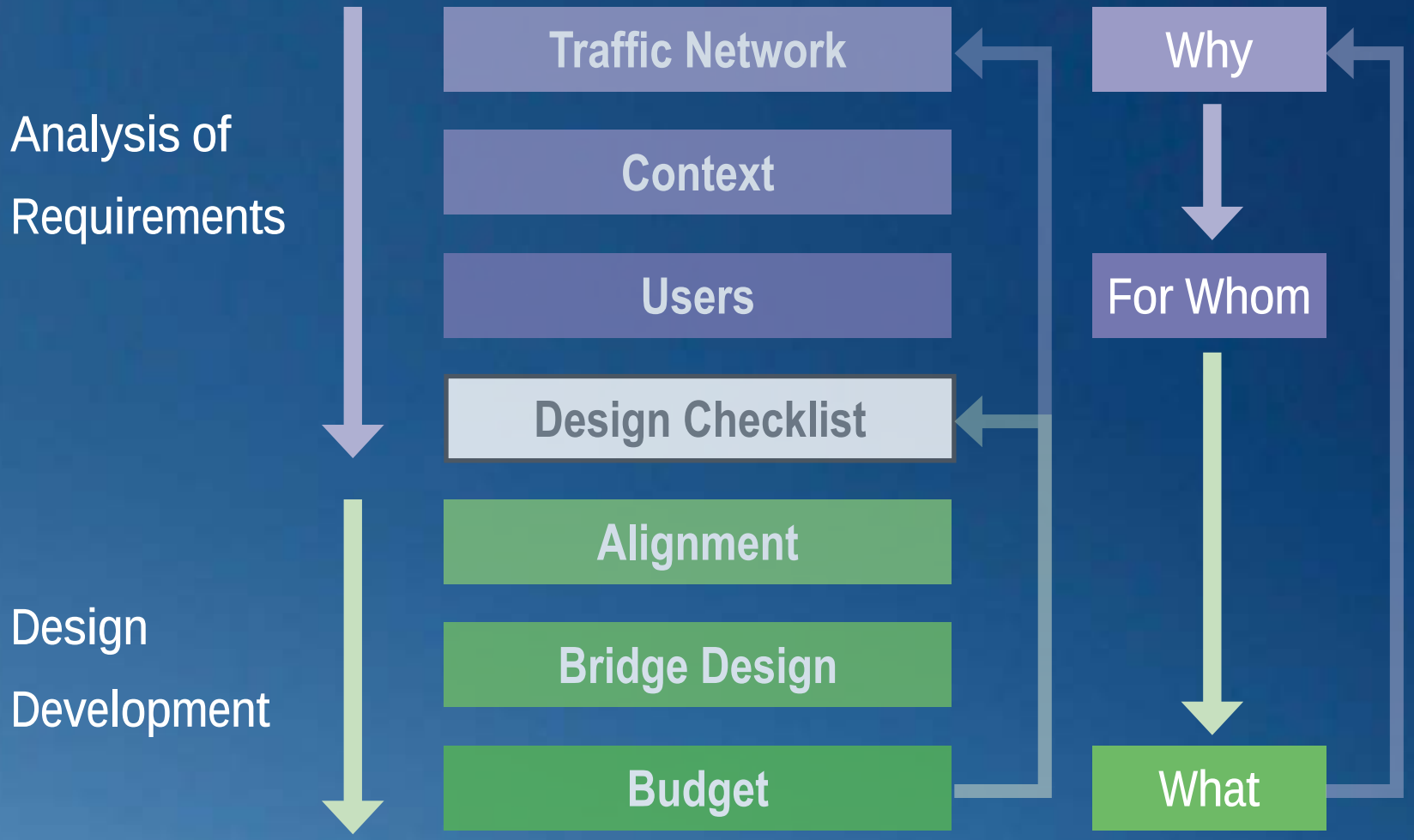
Dutch Design Manual

Structure: Follows the Development Process

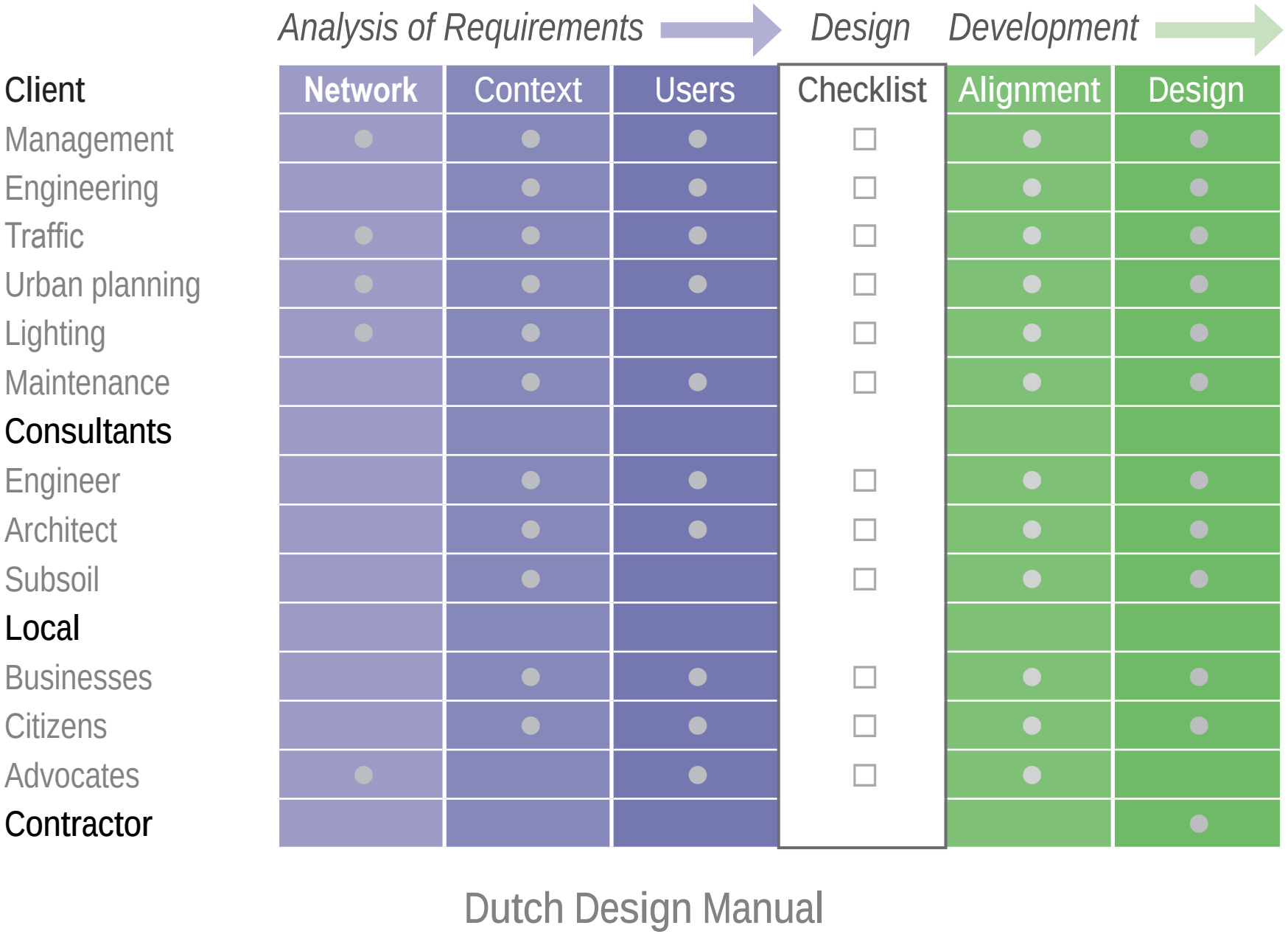


Dutch Design Manual

Structure: Follows the Development Process



Involvement of disciplines & stakeholders: *Optimal*



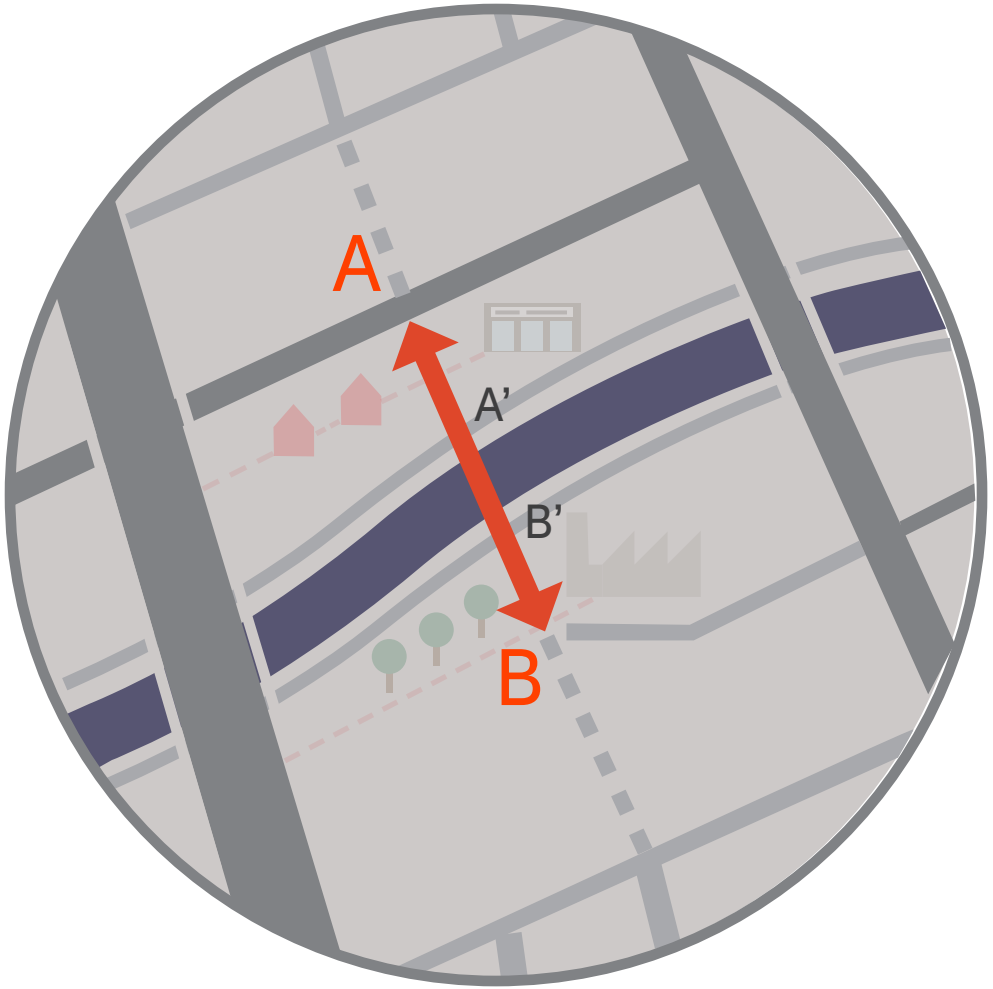
Dutch Design Manual

Traffic Network

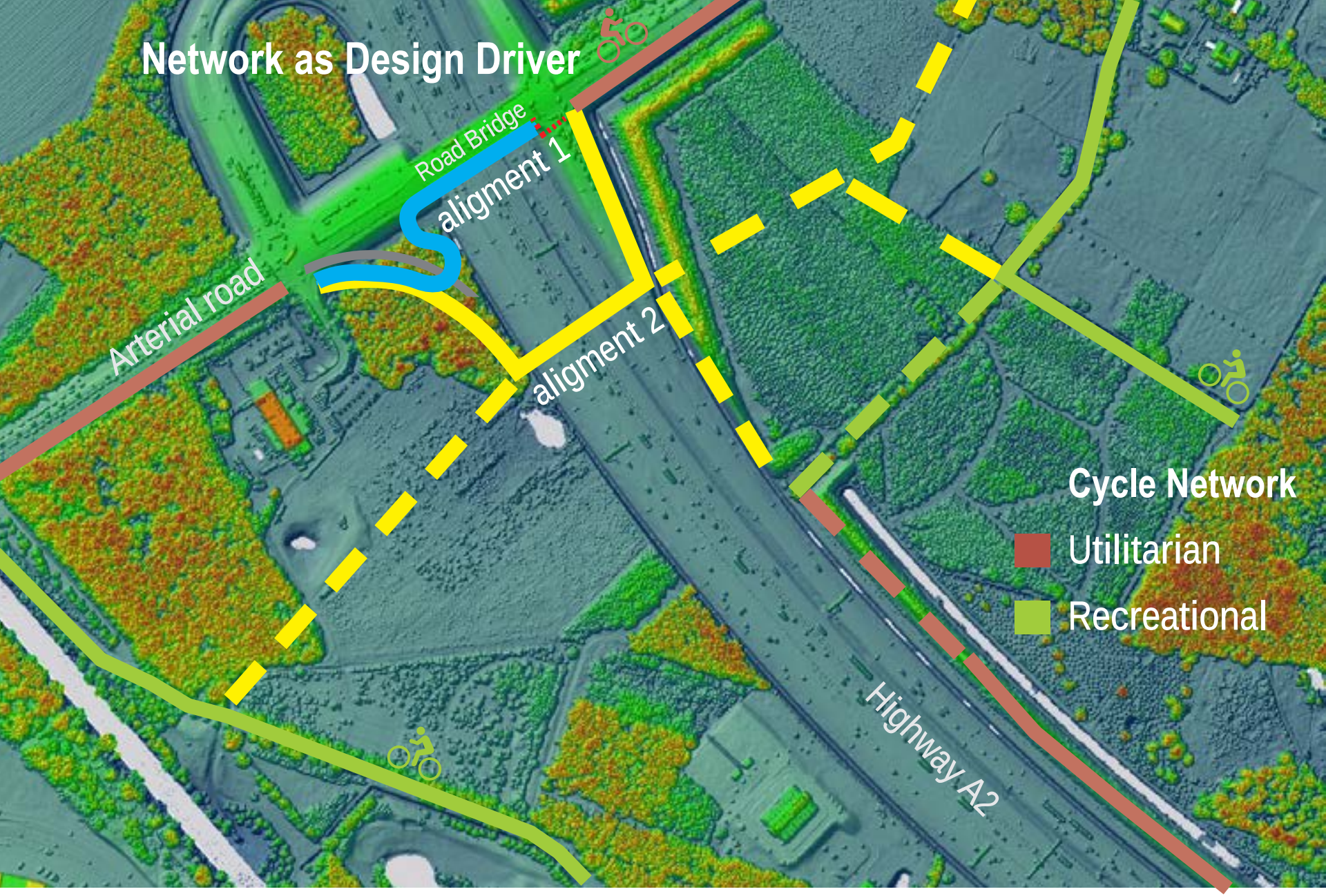
Finding the best bridge location

Analyse

- Network demand
  - regular users
  - number of users
- Route restrictions
- Adjacent route (A', B')

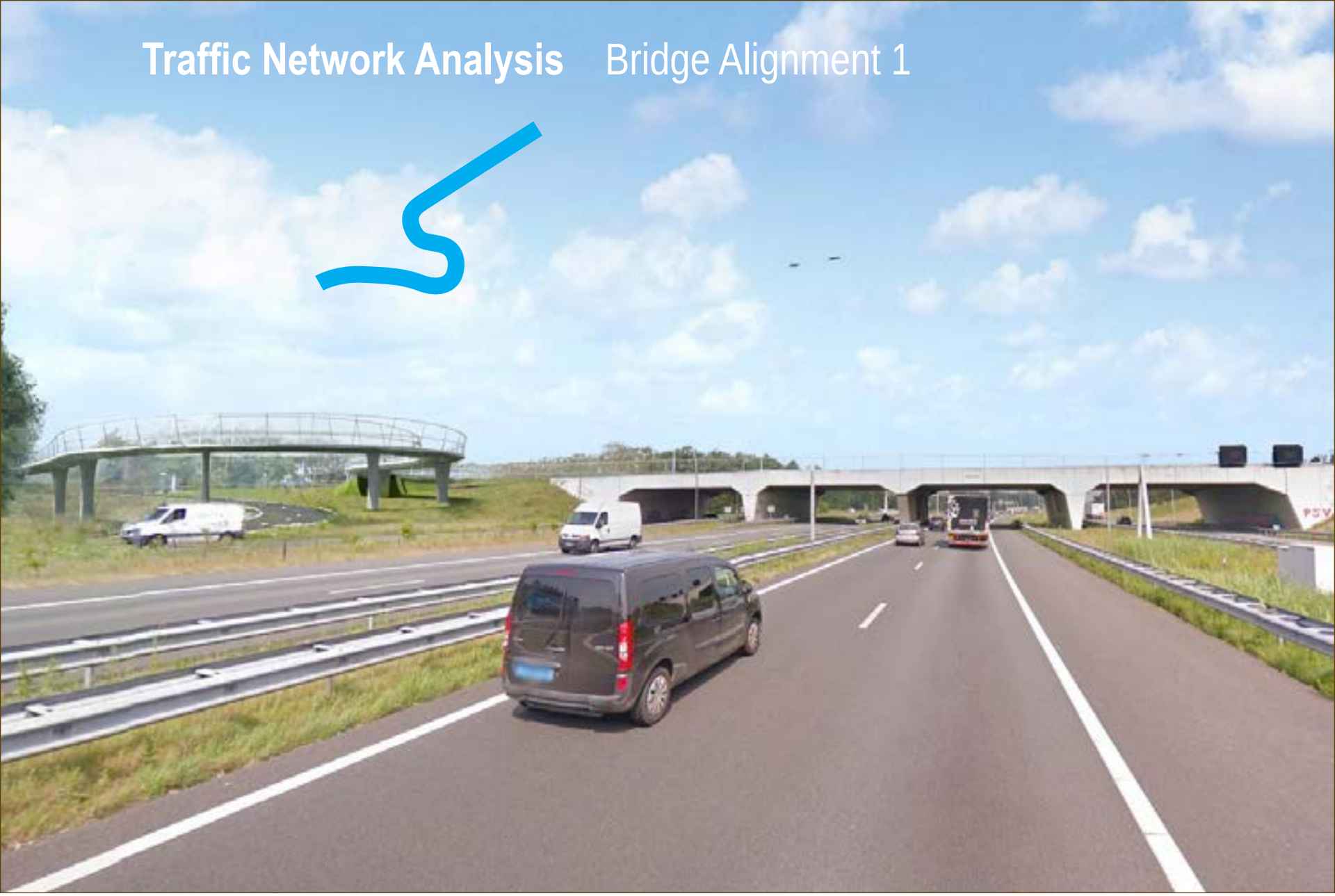


Dutch Design Manual



Dutch Design Manual

Traffic Network Analysis Bridge Alignment 1



Dutch Design Manual

Traffic Network Analysis Bridge Alignment 2

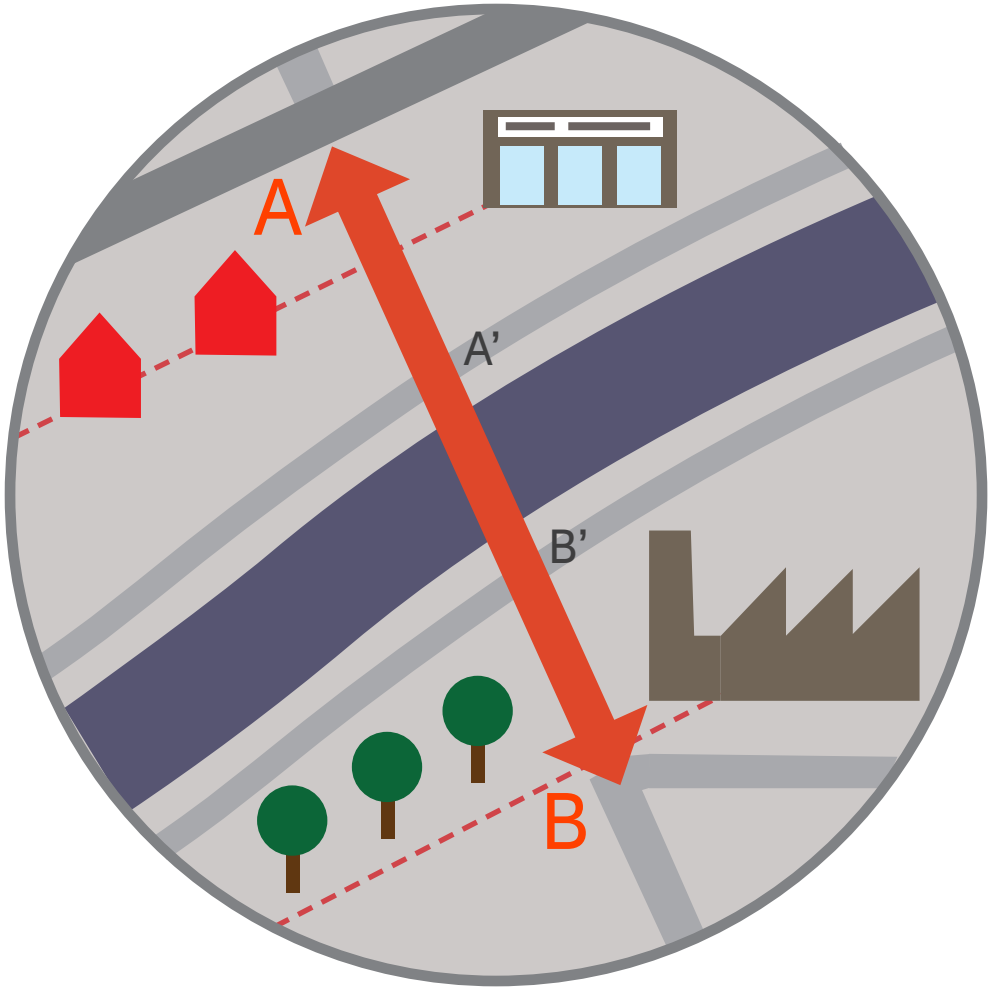
- **structurally / cost efficient**
- no piers in highway :
  - no obstruction of sightlines
  - minimal constuction hindrance

Context

Location specific requirements & potential benefits

Analyse

- Urban Planning
- Local Wishes
- Ecology
- Land Ownership
- Cables and Pipelines
- Subsurface Conditions
- Potential Benefits



Context: History

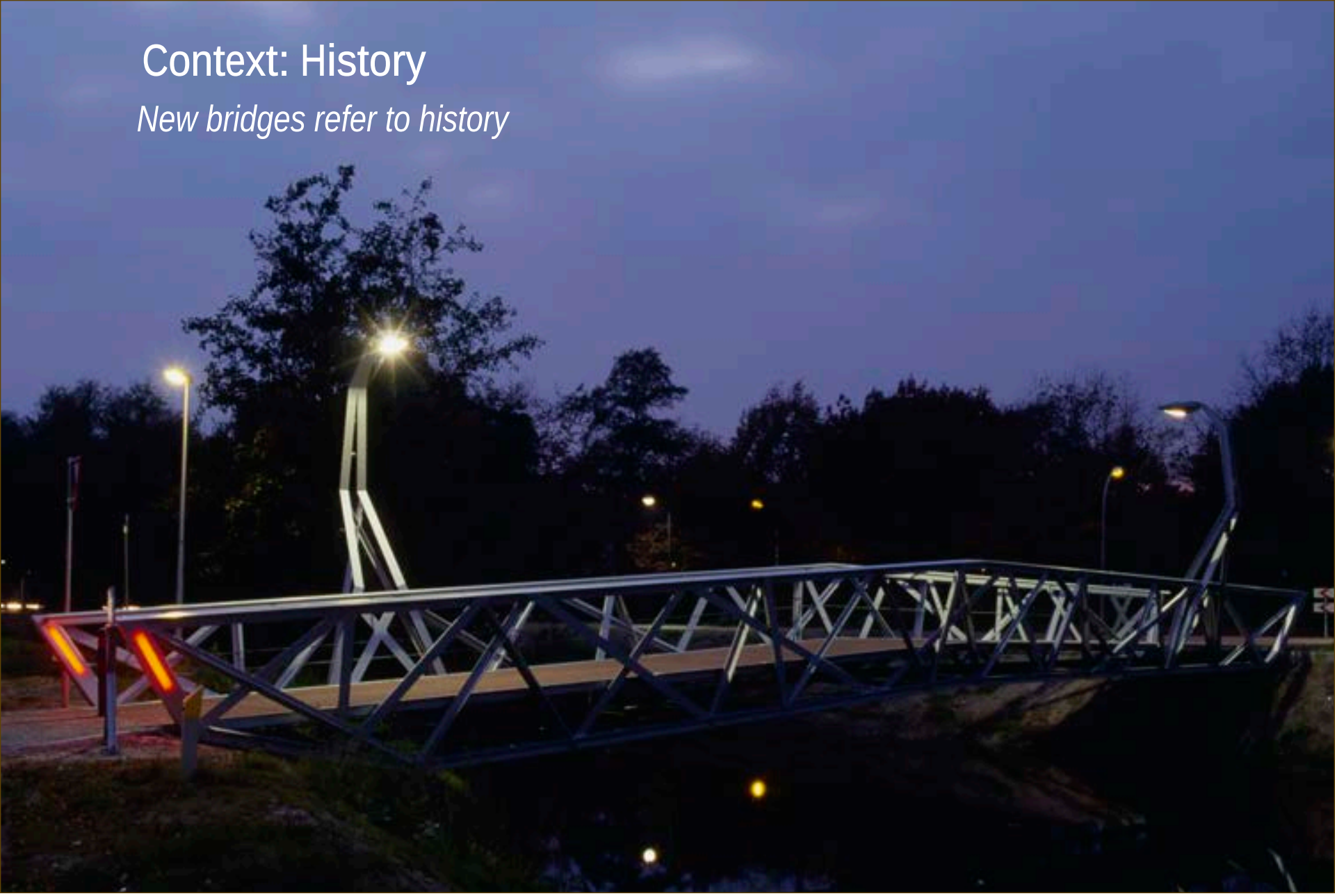
Historic railroad truss bridge

Context: History

New bridges refer to history

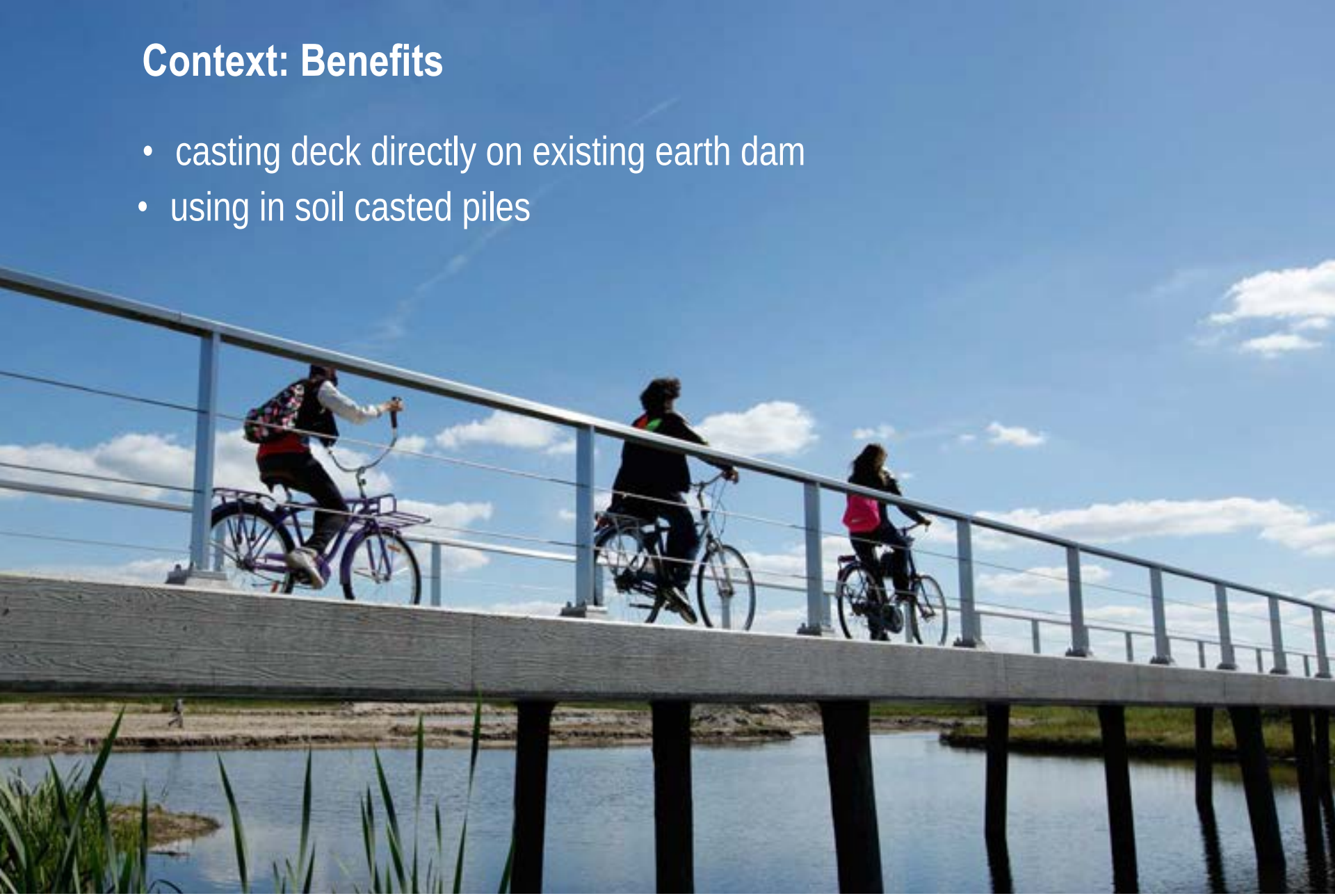
Context: History

New bridges refer to history



Context: Benefits

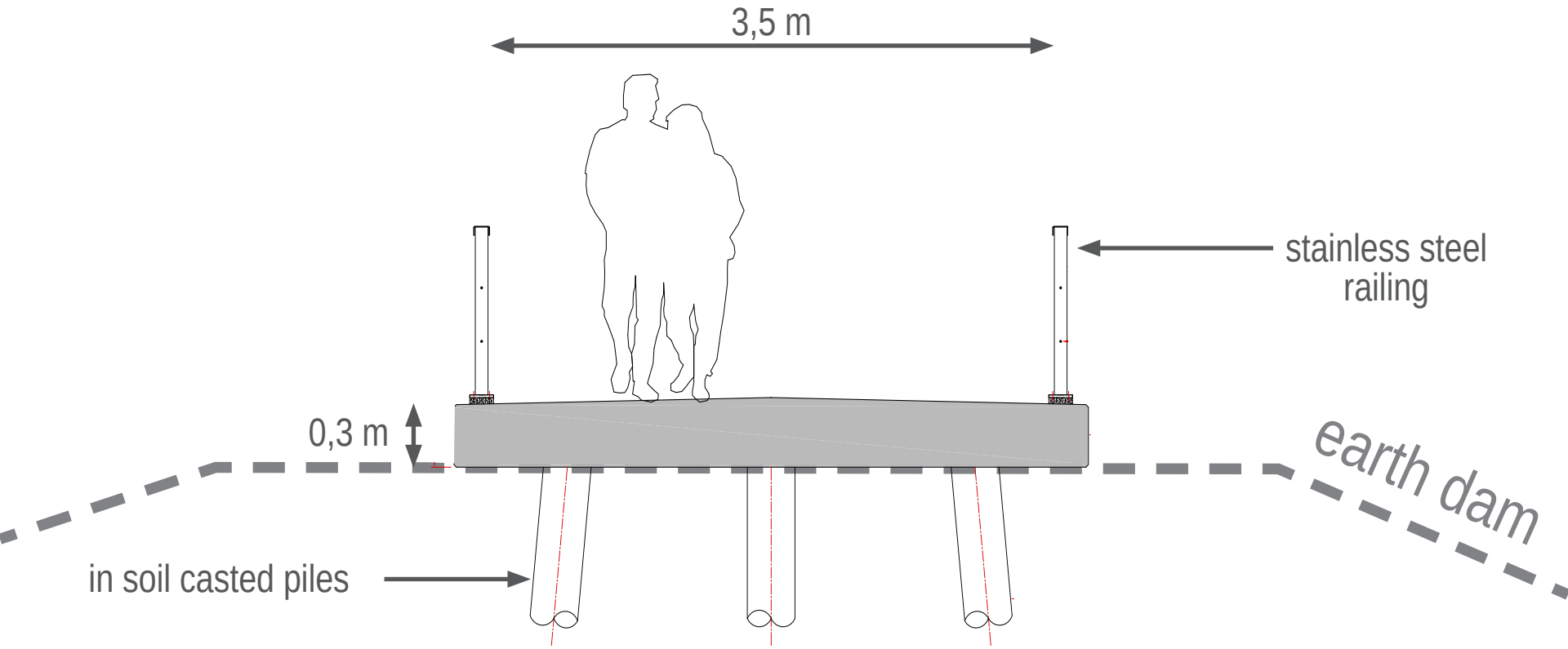
- casting deck directly on existing earth dam
- using in soil casted piles



Dutch Design Manual

Context: Benefits

- casting deck directly on existing earth dam
- using in soil casted piles

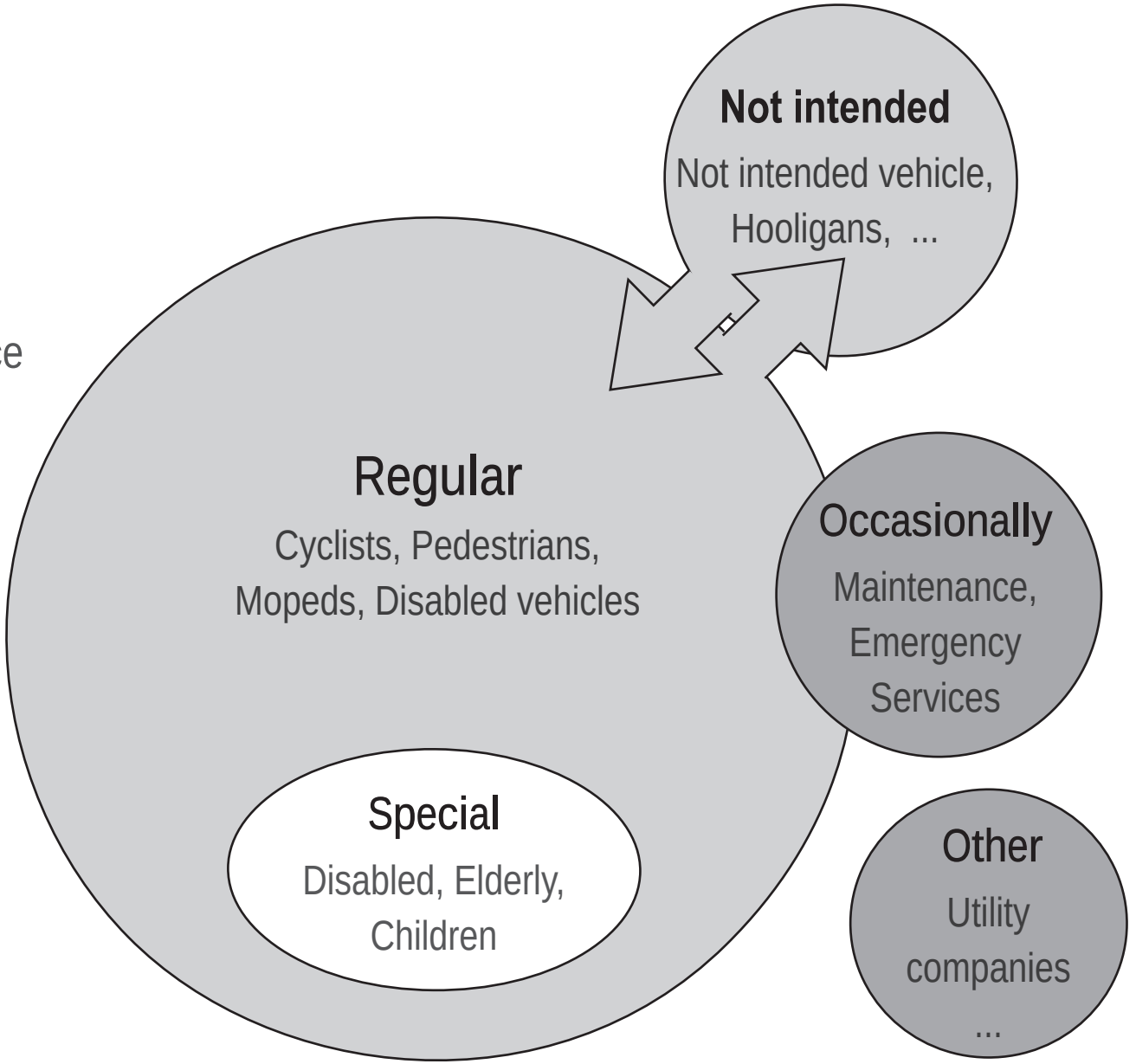


Dutch Design Manual

Users

Determine

- Required Space
- Road Planning
- Loads
- Abuse Prevention

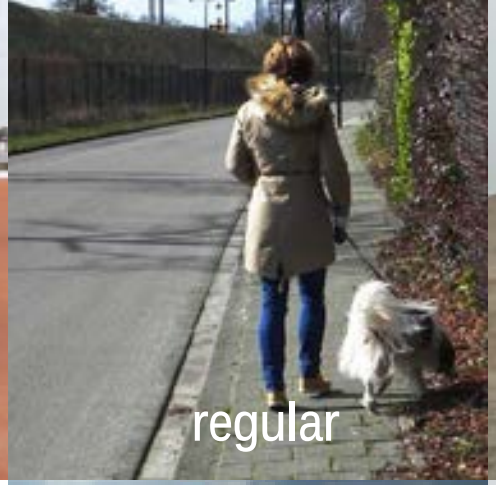


Dutch Design Manual

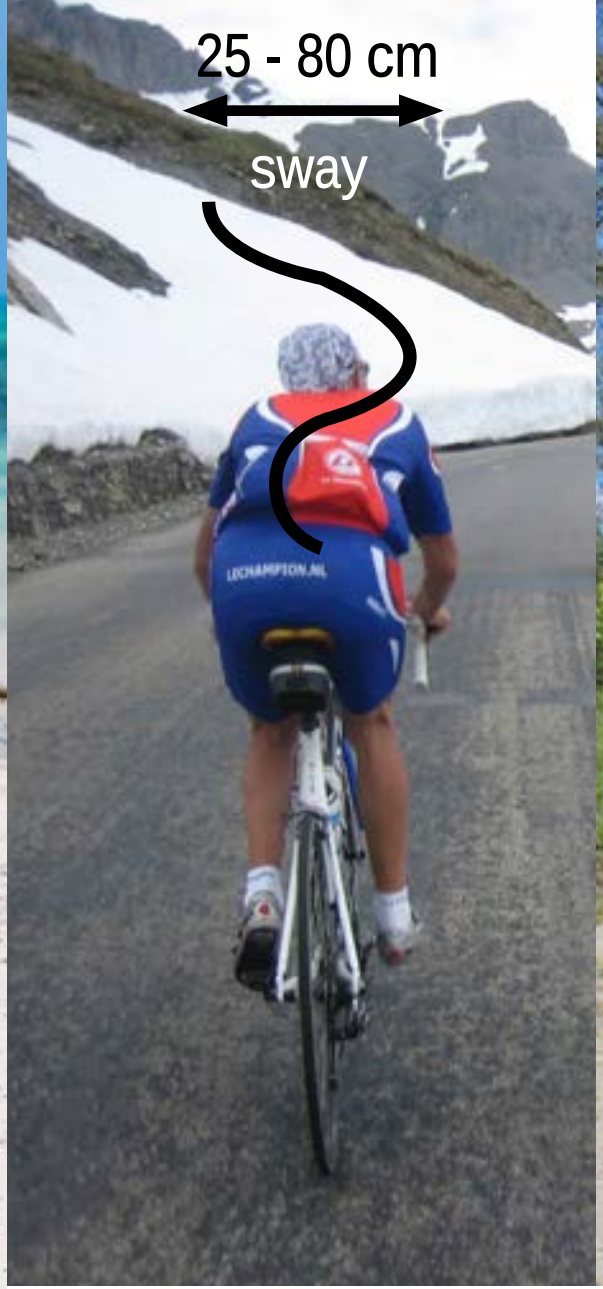
Users

Bridge &

Intersecting



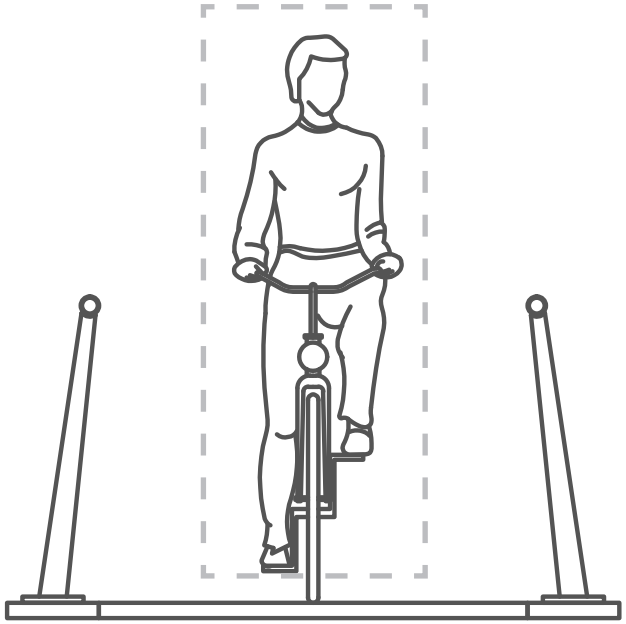

75 cm
width
2,5 m vertical
clearance

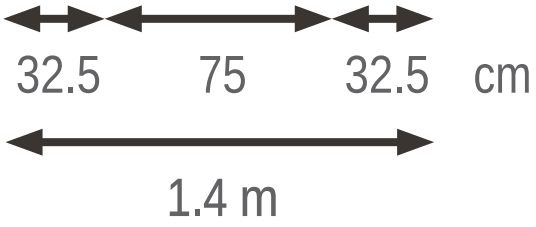

25 - 80 cm
sway


25 cm
distance

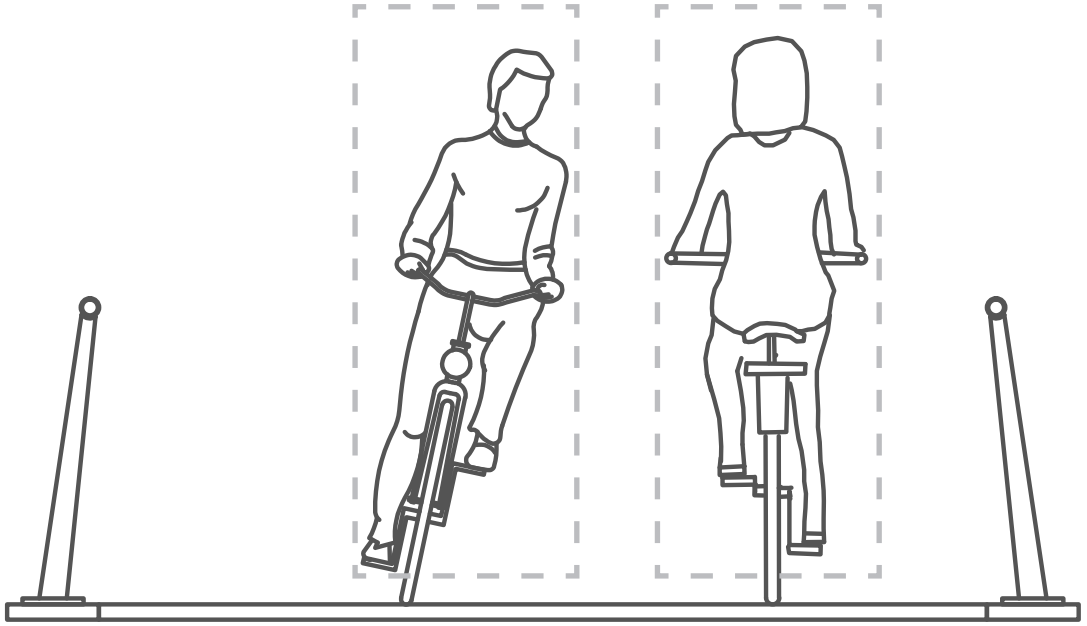
Dutch Design Manual cyclist distance to objects

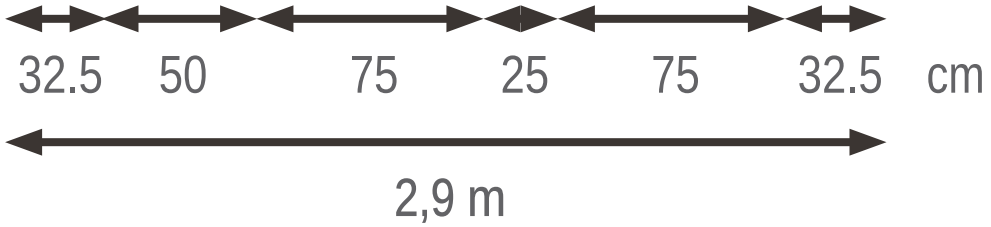
minimum one way





minimum two way in curve





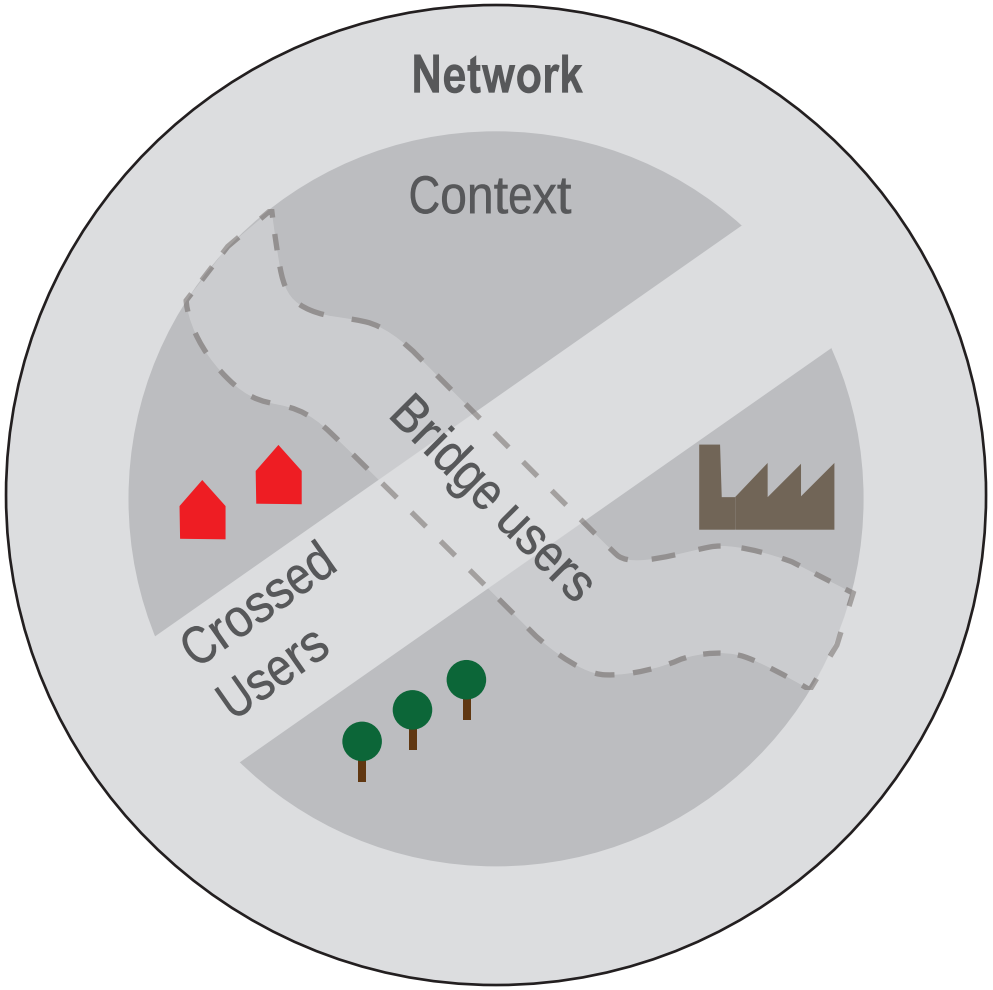
Dutch Design Manual cyclist deckwidth

List of requirements

Gathering all requirements

Design Checklist

- Network ✔
- Context ✔
- Users ✔
- Regulations ✔
- Building Codes ✔

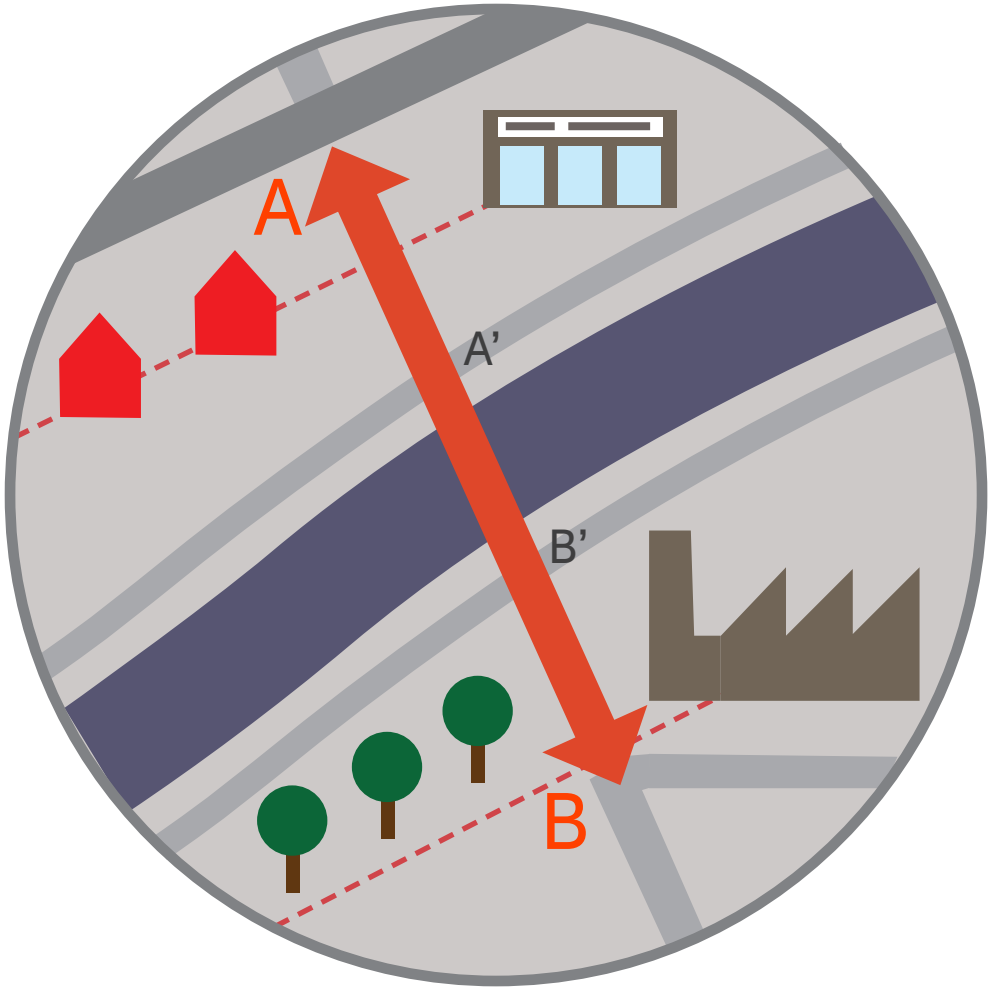


Alignment

Finding the best contextual fit, alignment with the contextual requirements

Taking into account

- Network
- Context
- Users
  - comfort
  - safety



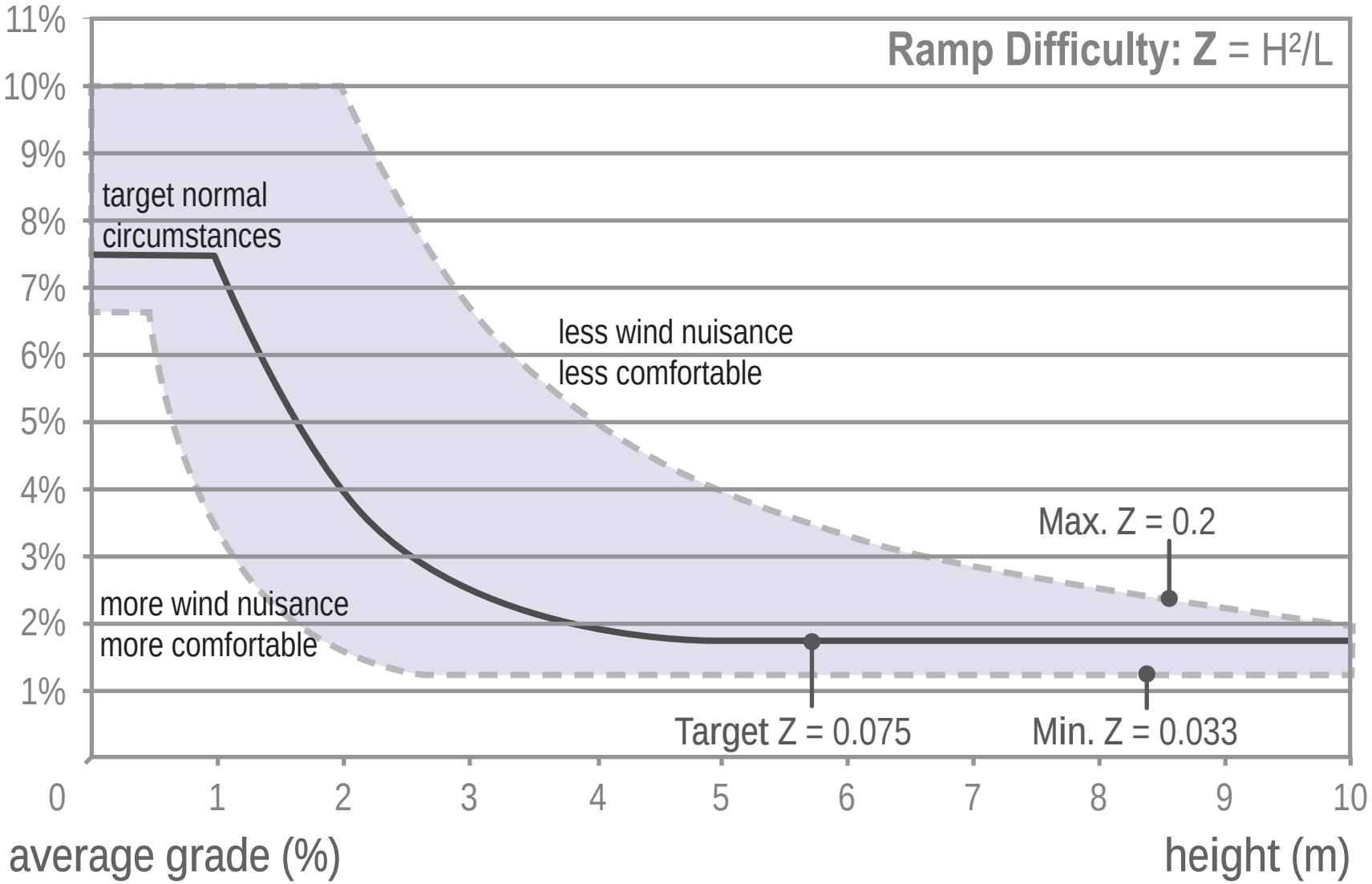
Dutch Design Manual

Alignment

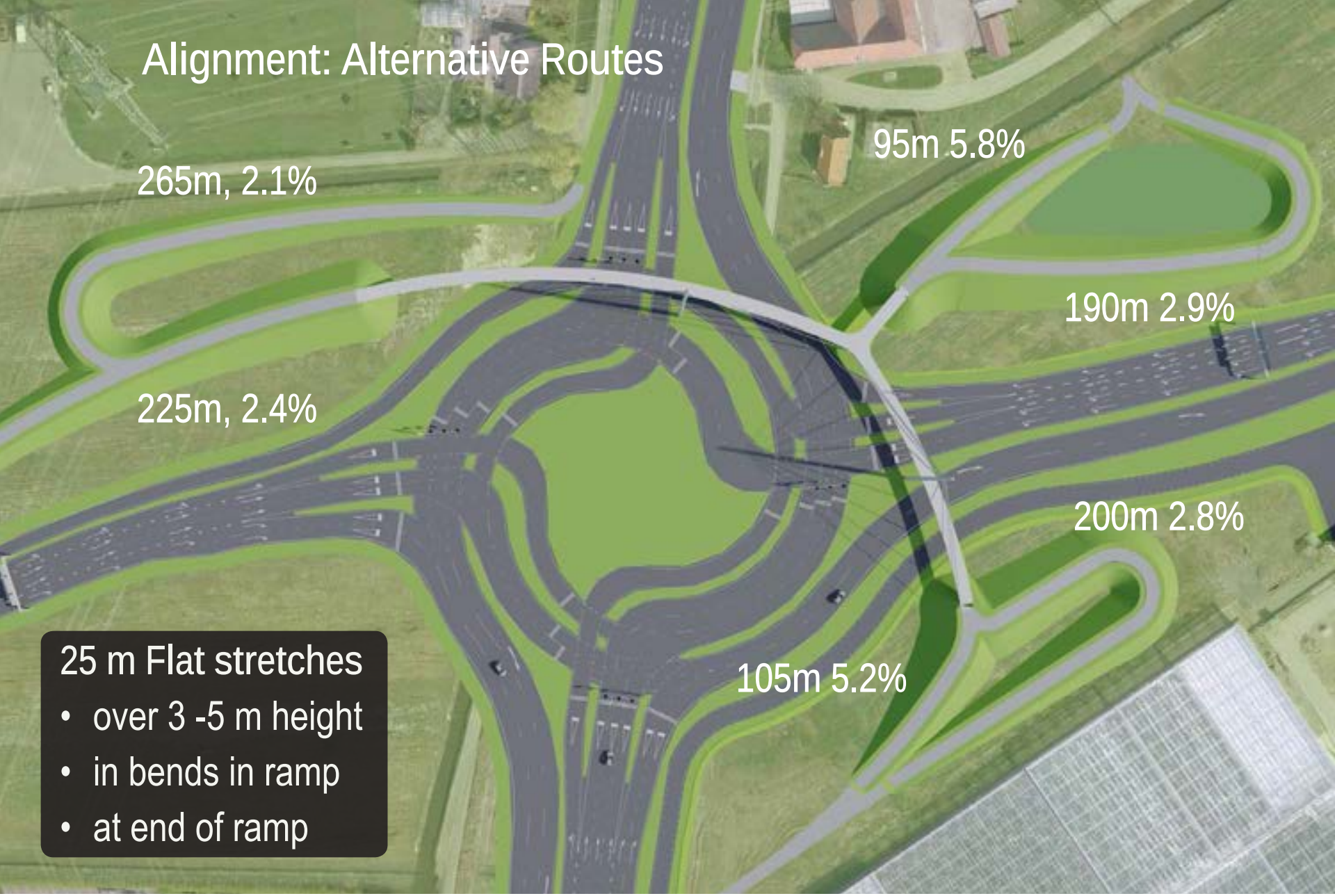
Ramp aspects

- Grade
- Directness
- Alternatives
- Flat stretches

Alignment: Grade



Dutch Design Manual



Dutch Design Manual

Bridge Design

Designing for the requirements

Requirements

Network, context & Users

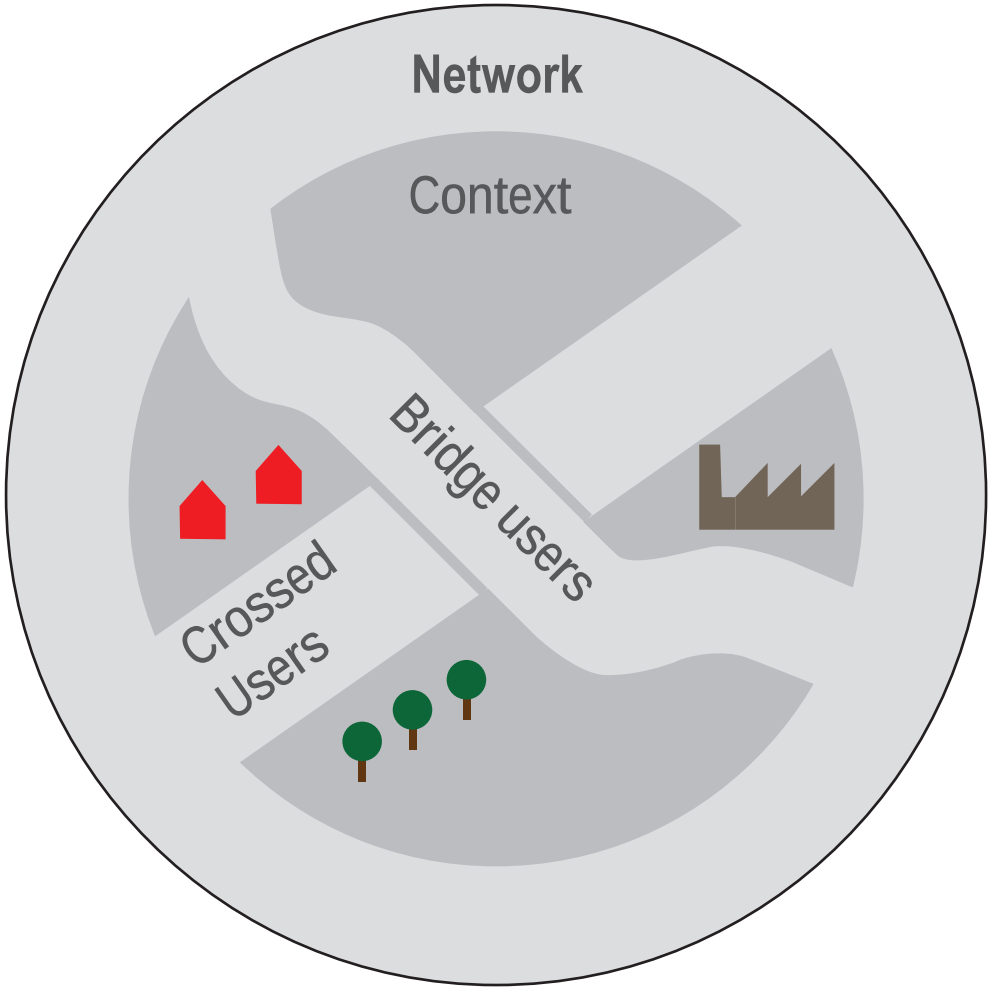
Determine

Best Alignment &

Spatial Integration

Starting Point

Detailed Bridge Design

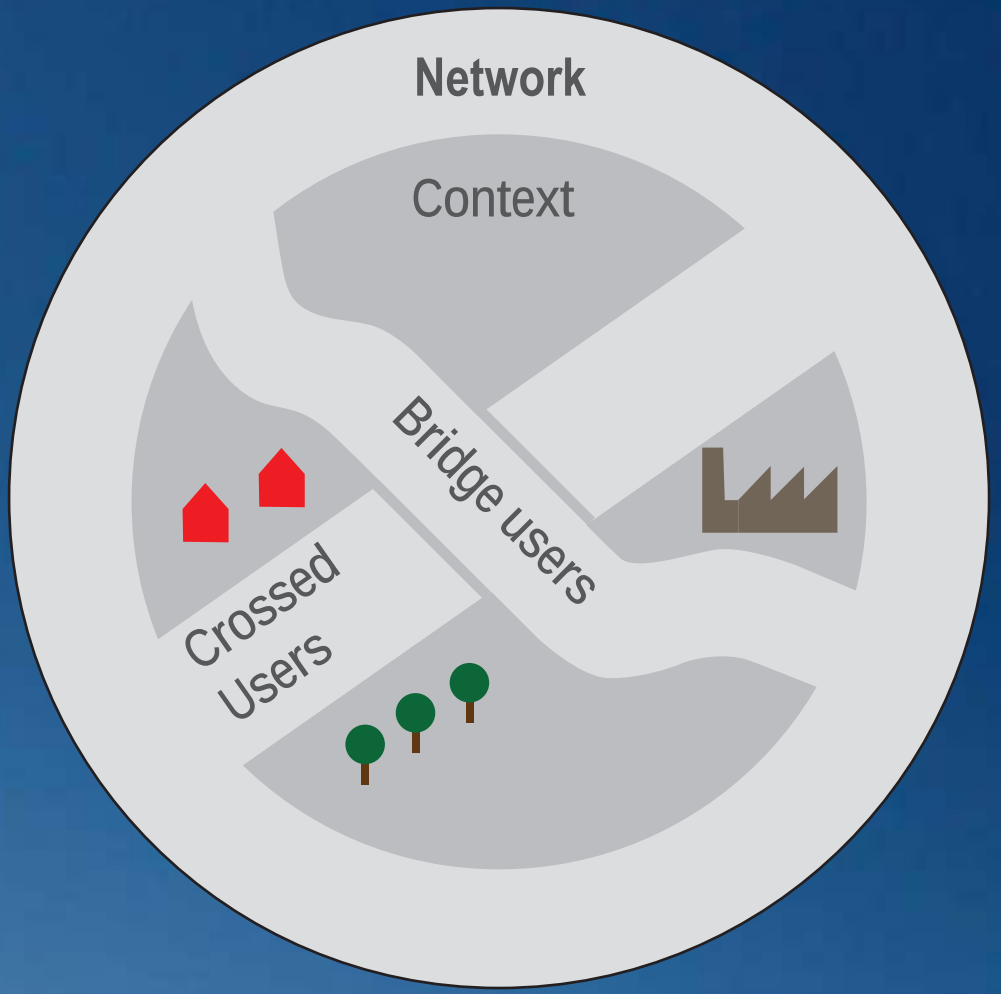


Structure: Follows the Development process

Analyse

Design

- Traffic Network
- Context
- Users
- Design Checklist
- Alignment
- Bridge Design
- Budget



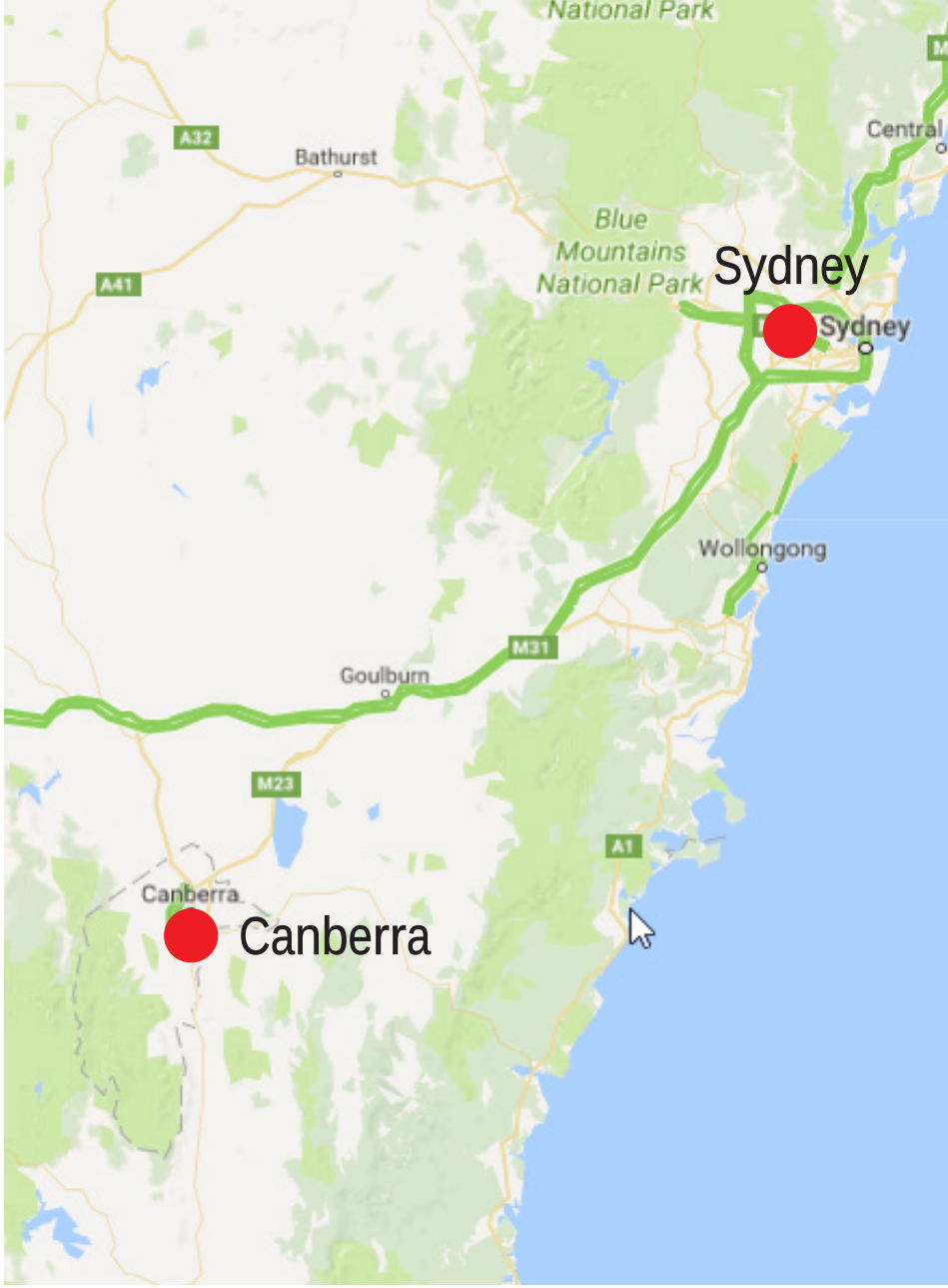
Hovenring, Eindhoven

Context (national) Eindhoven - population 220.000

Context (international) The Netherlands in Europe

Context (international) The Netherlands compared to Australia

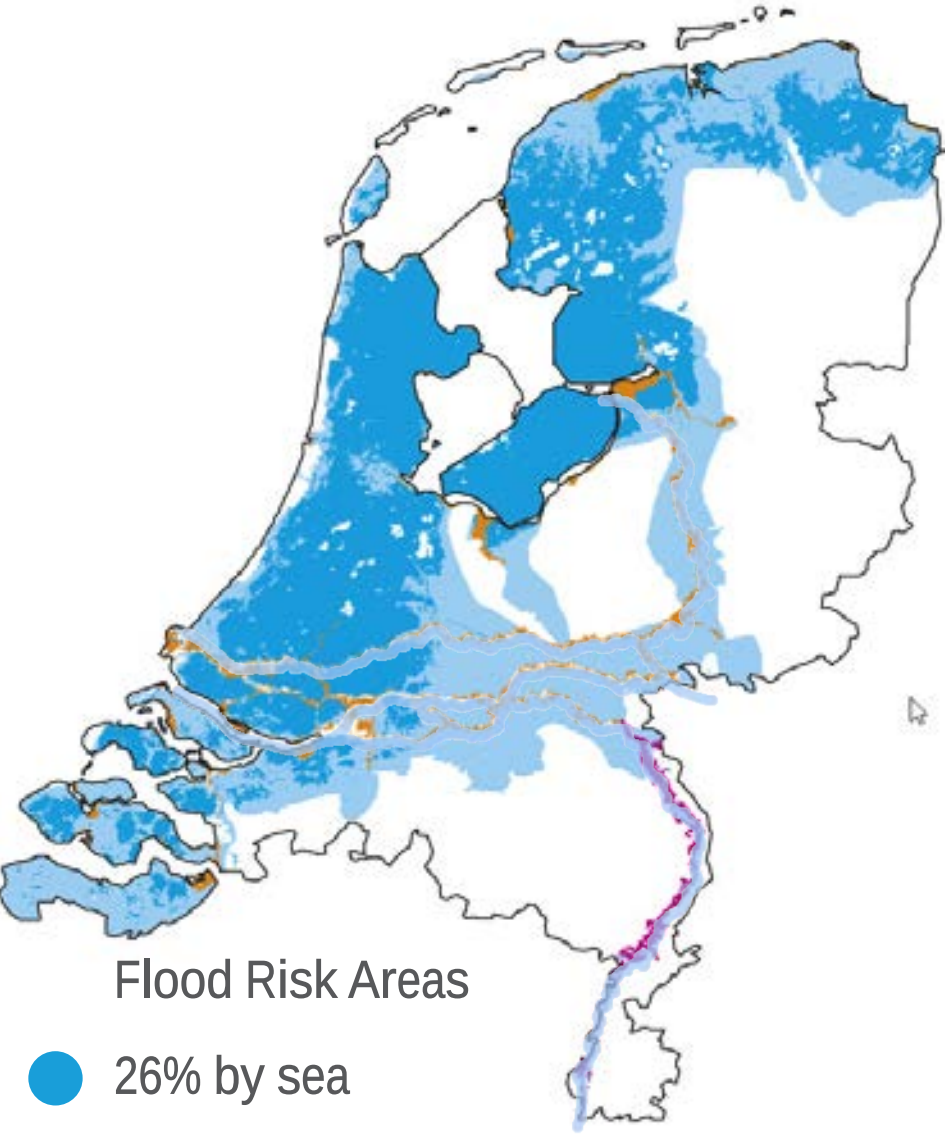
Context (national) The Netherlands compared to Sydney - Canberra Region



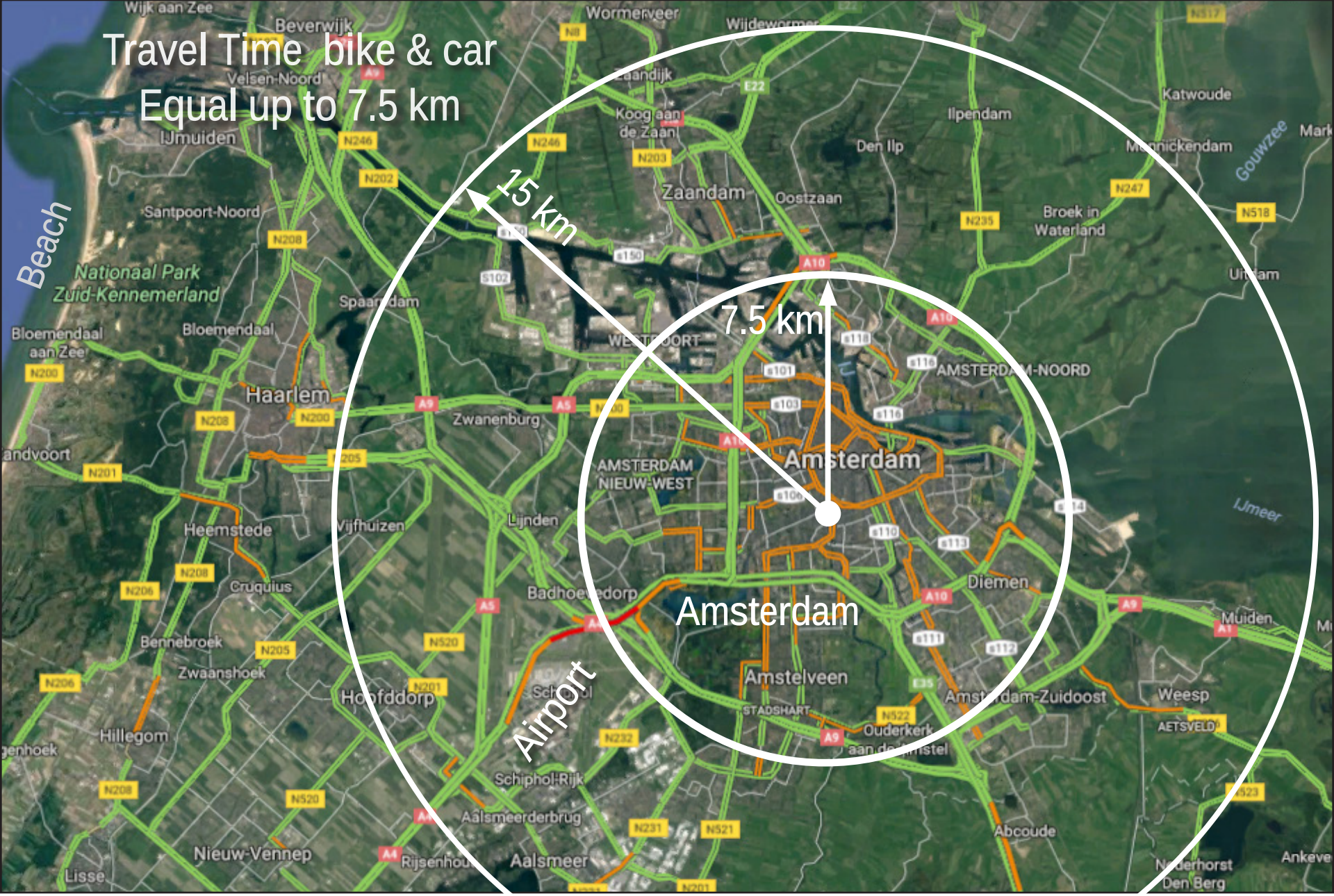
Network (national) Dutch network compared to Sydney - Canberra Region

Network (national) transport over water and road

Network (international) The Netherlands, a hub for Europe



Context (national) flooding risk



Network (regional) travel time in dense populated areas

Network (national) travel time in dense populated areas

18 million bikes

- > 14 million trips / day
- 35.000 km bike path

- 2500 km highway
- 8 million cars

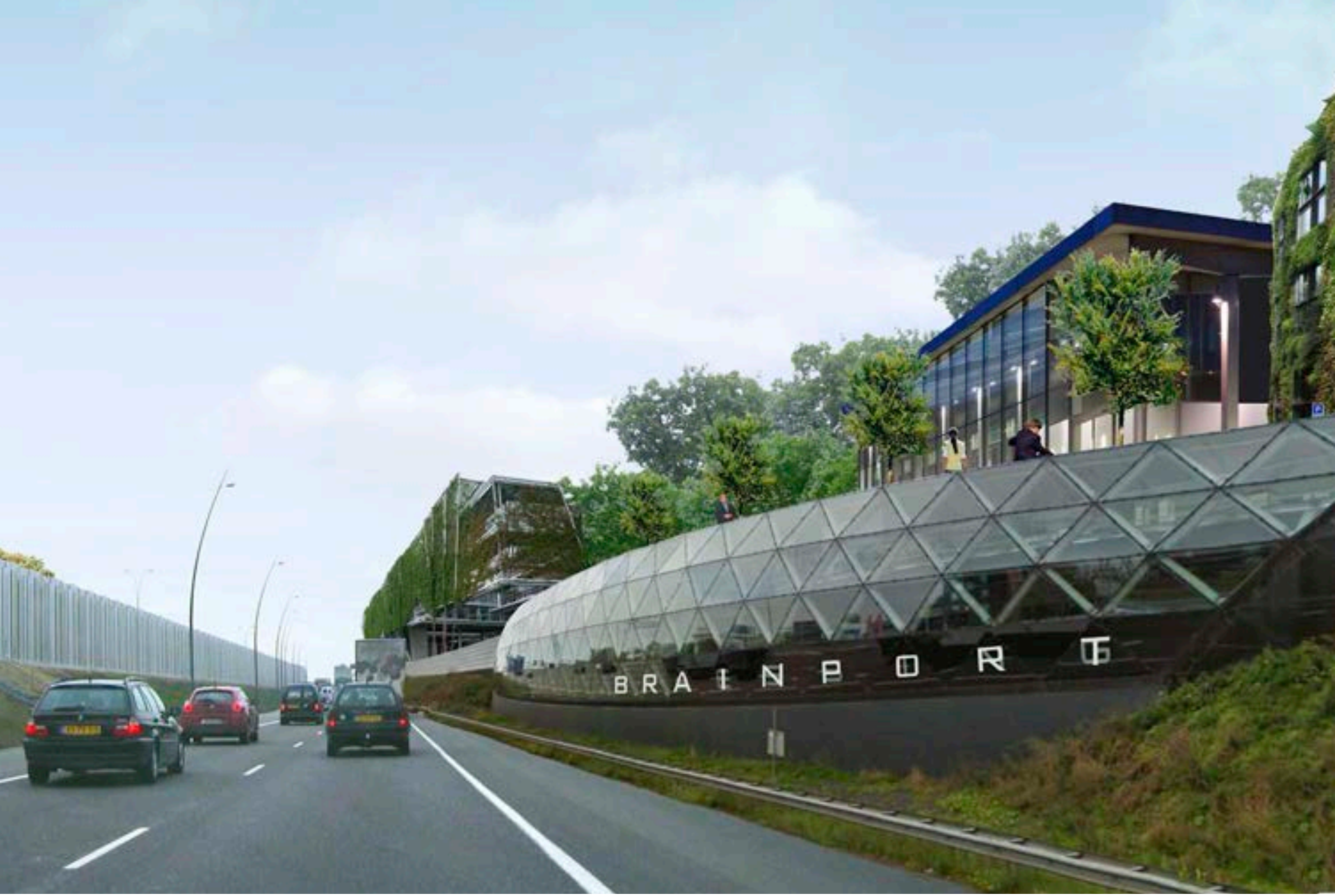
Network (national) Cycling Facts

Context (regional) Eindhoven - Brainport of the netherlands

Context (regional) Eindhoven - technology and innovation

Network (regional) Project Location in the region

Context (regional) Eindhoven - Brainport Avenue (highway A2)

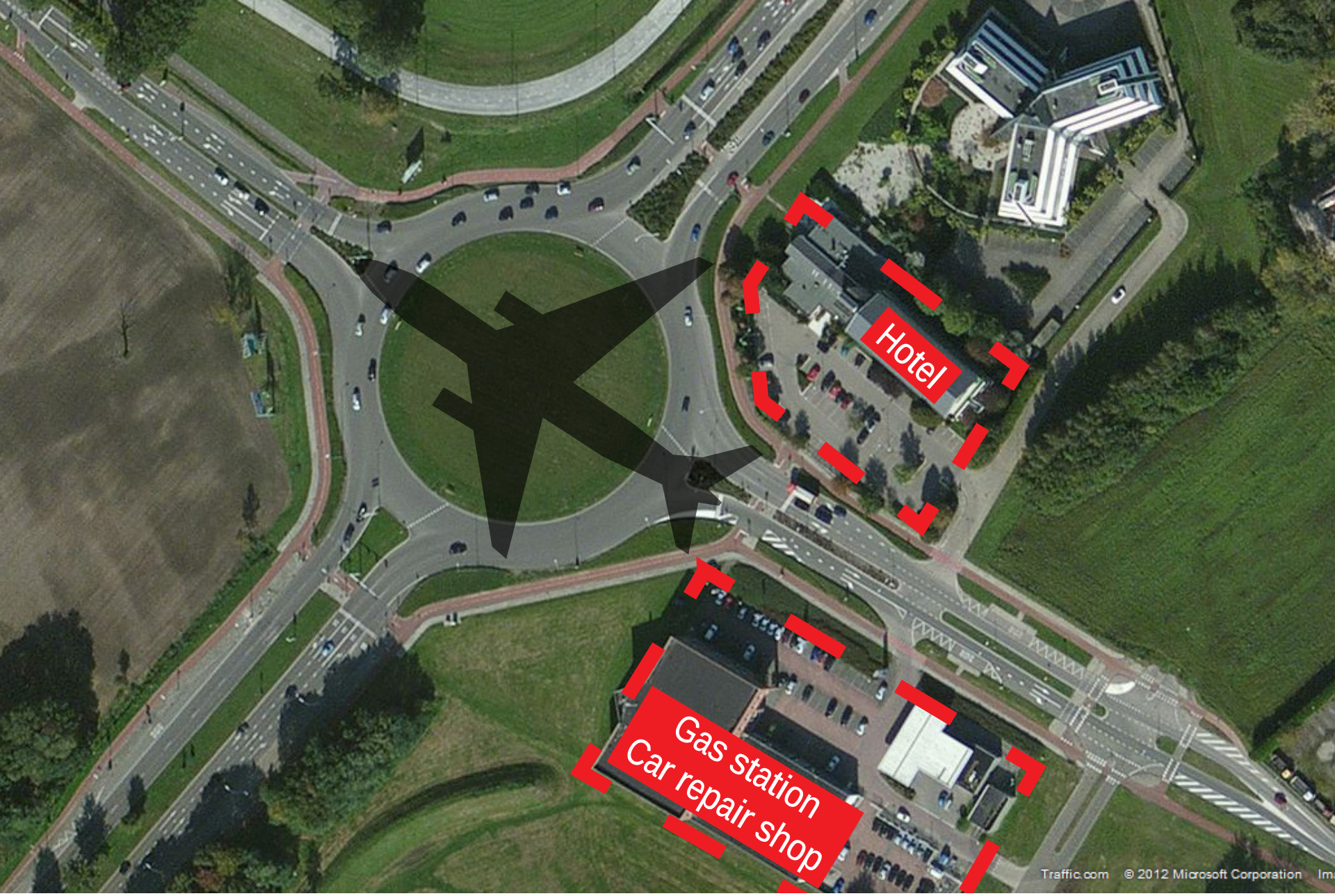


Context (regional) Eindhoven - Impression Brainport Avenue (highway A2)

Network (local) Project Location - old situation

Network (local) Traffic Situation

Network, Context (local) New Developments



Context (local) Commercial and Safety Requirements

?

landmark bridge

future technology museum

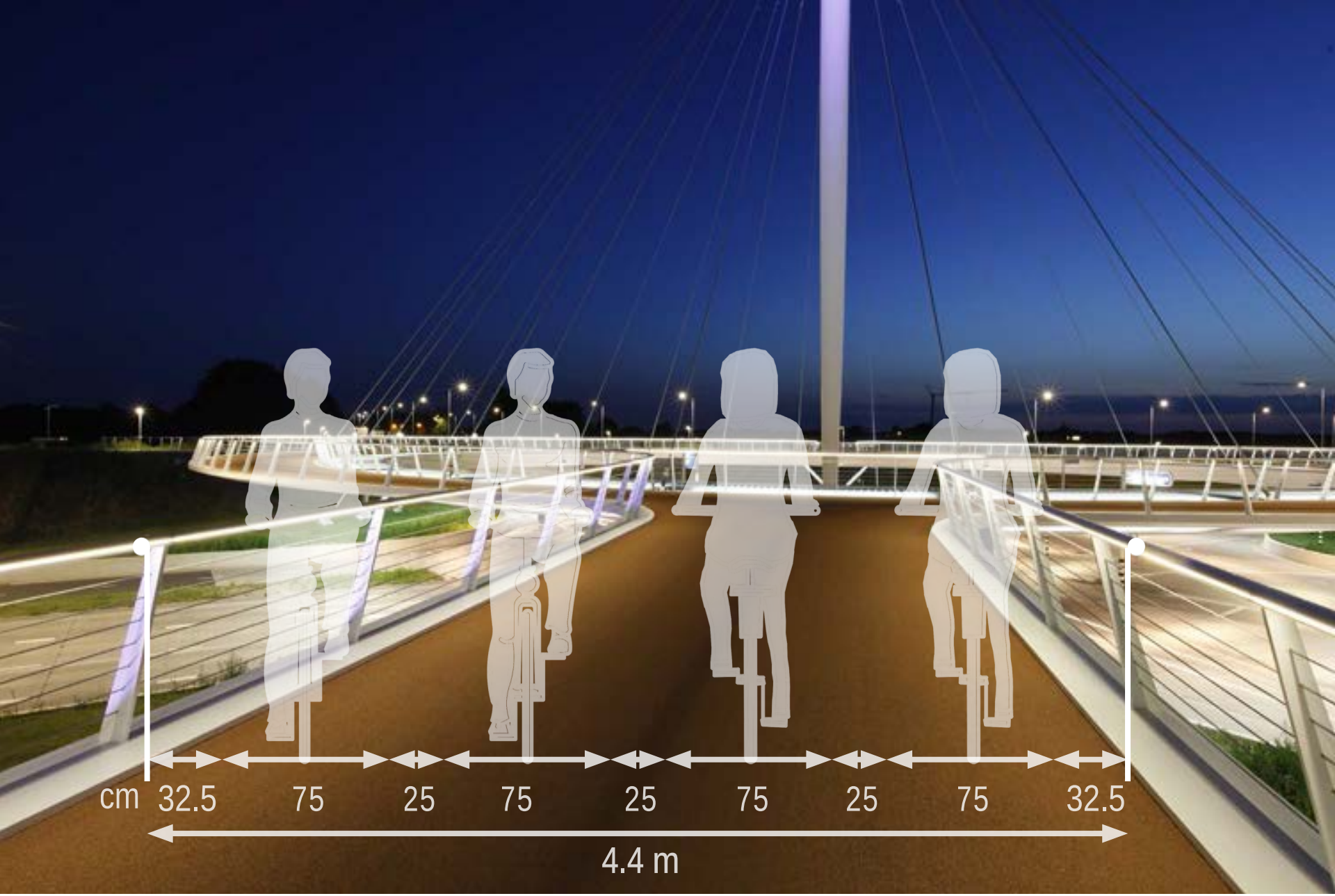
Hovenring

Evoluon

Light Needle

Westcorridor Eindhoven

Context (regional) Existing landmarks



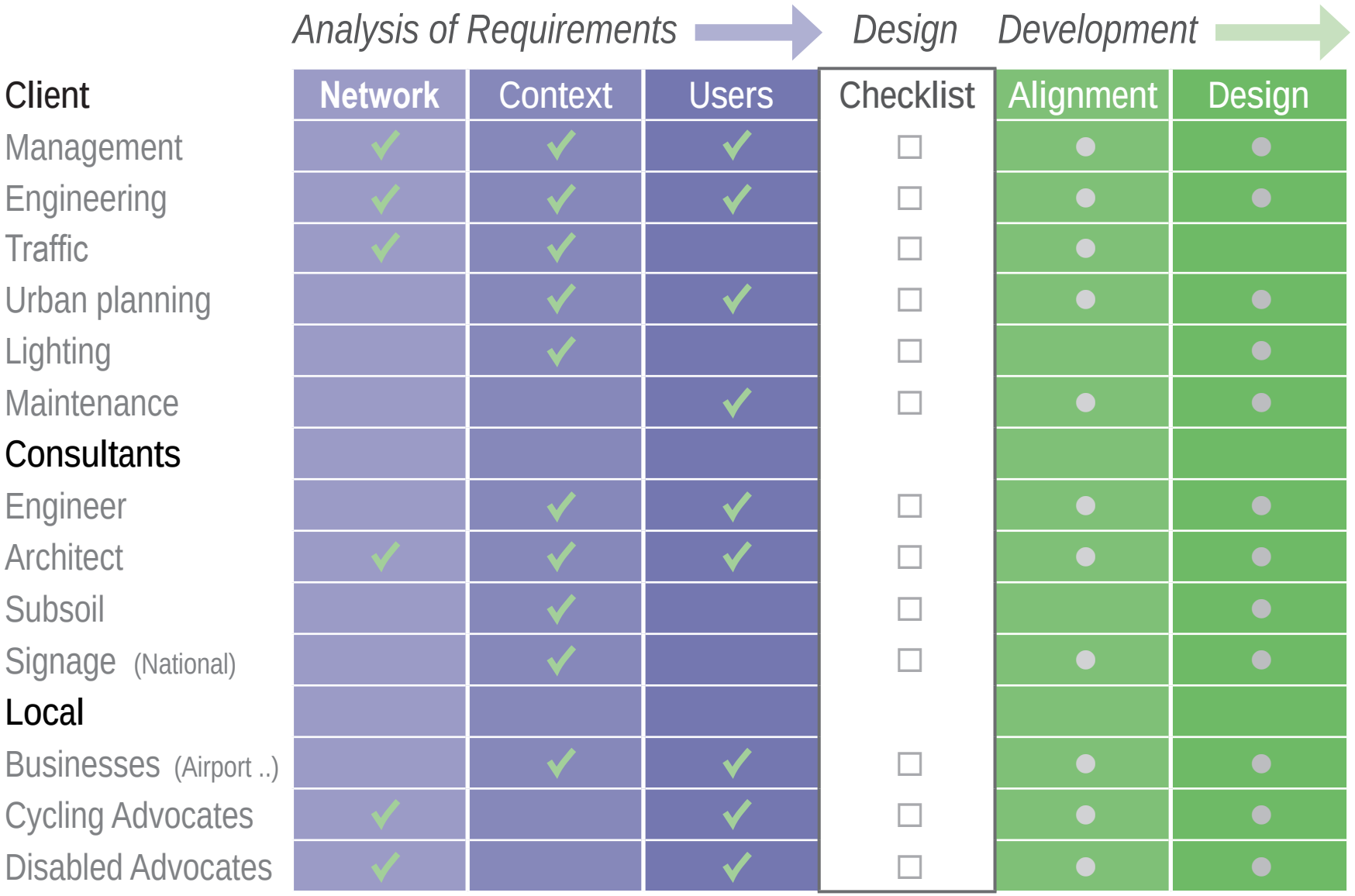
Users Deck Width

Users Not intended visitors (Latin American mayor delegation 2017)

Users Maintenance

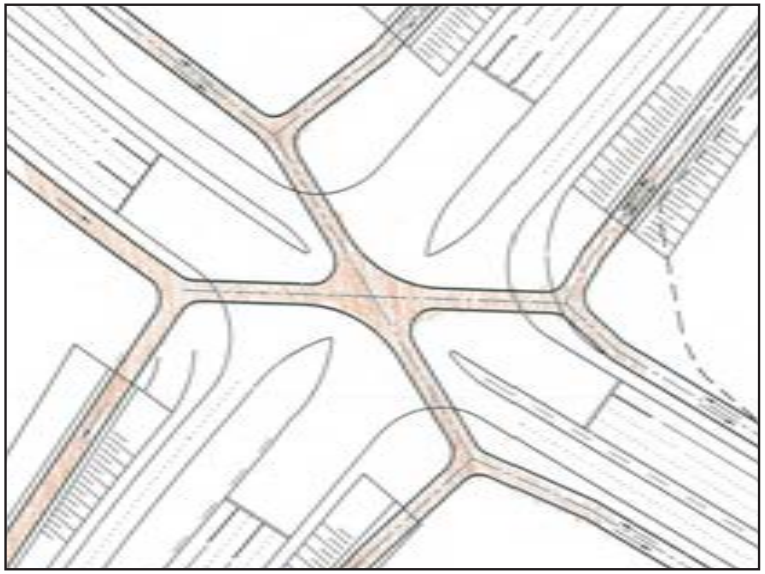
Users Intersecting Infrastructure

Hovenring

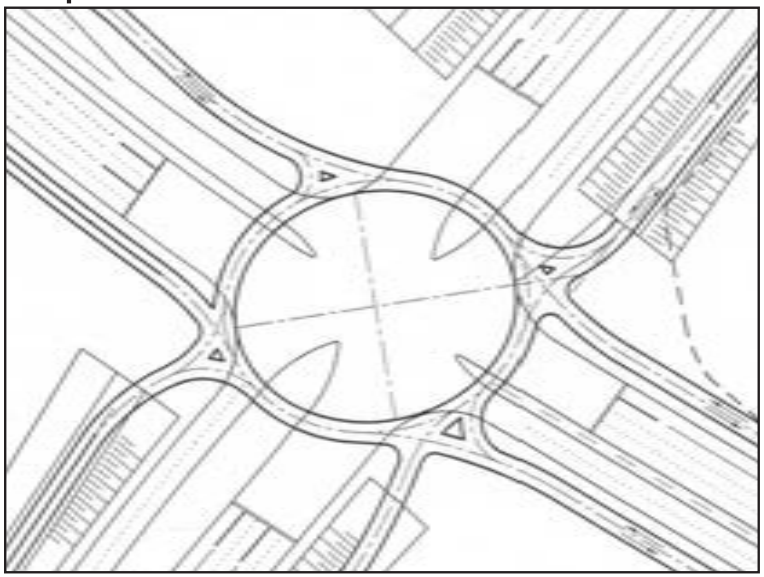


Analysis of Requirements Involvement of all Disciplines & Stakeholders

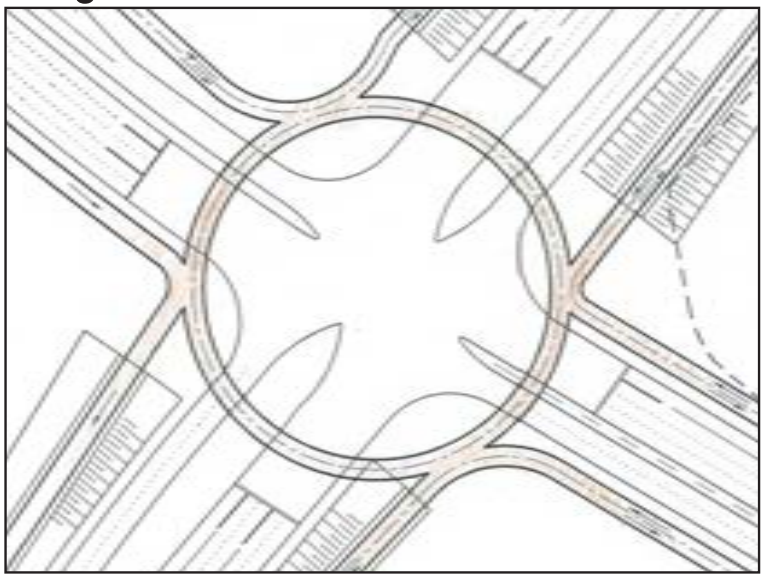
Cross



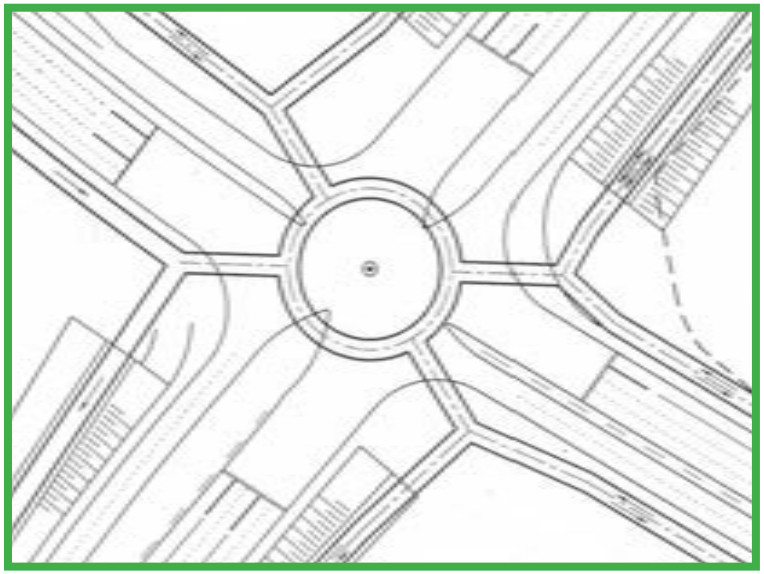
Ellipse



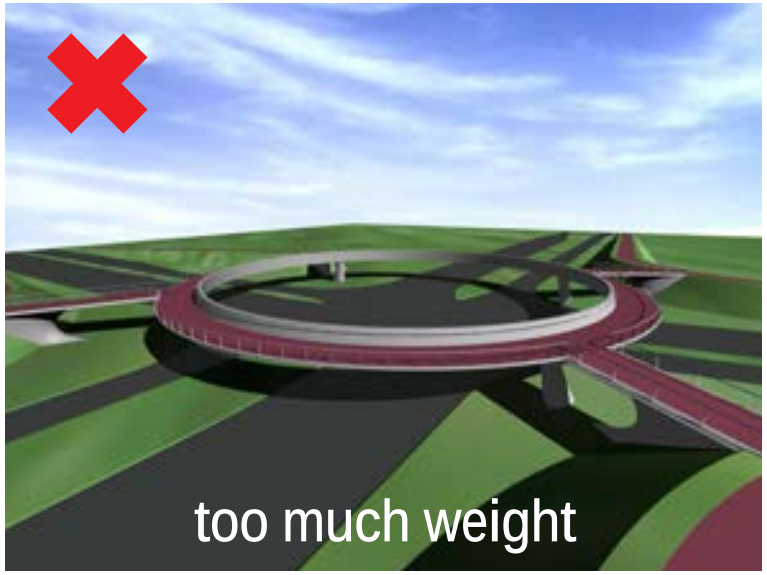
Large roundabout

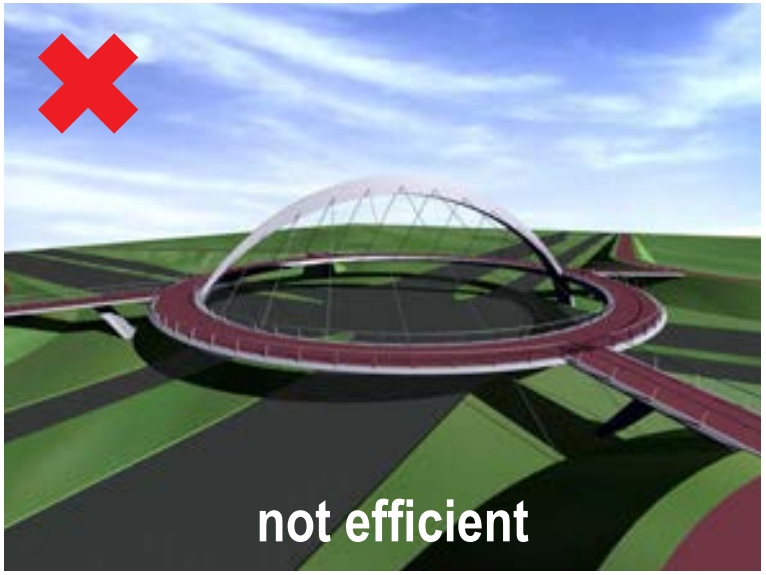


Small roundabout



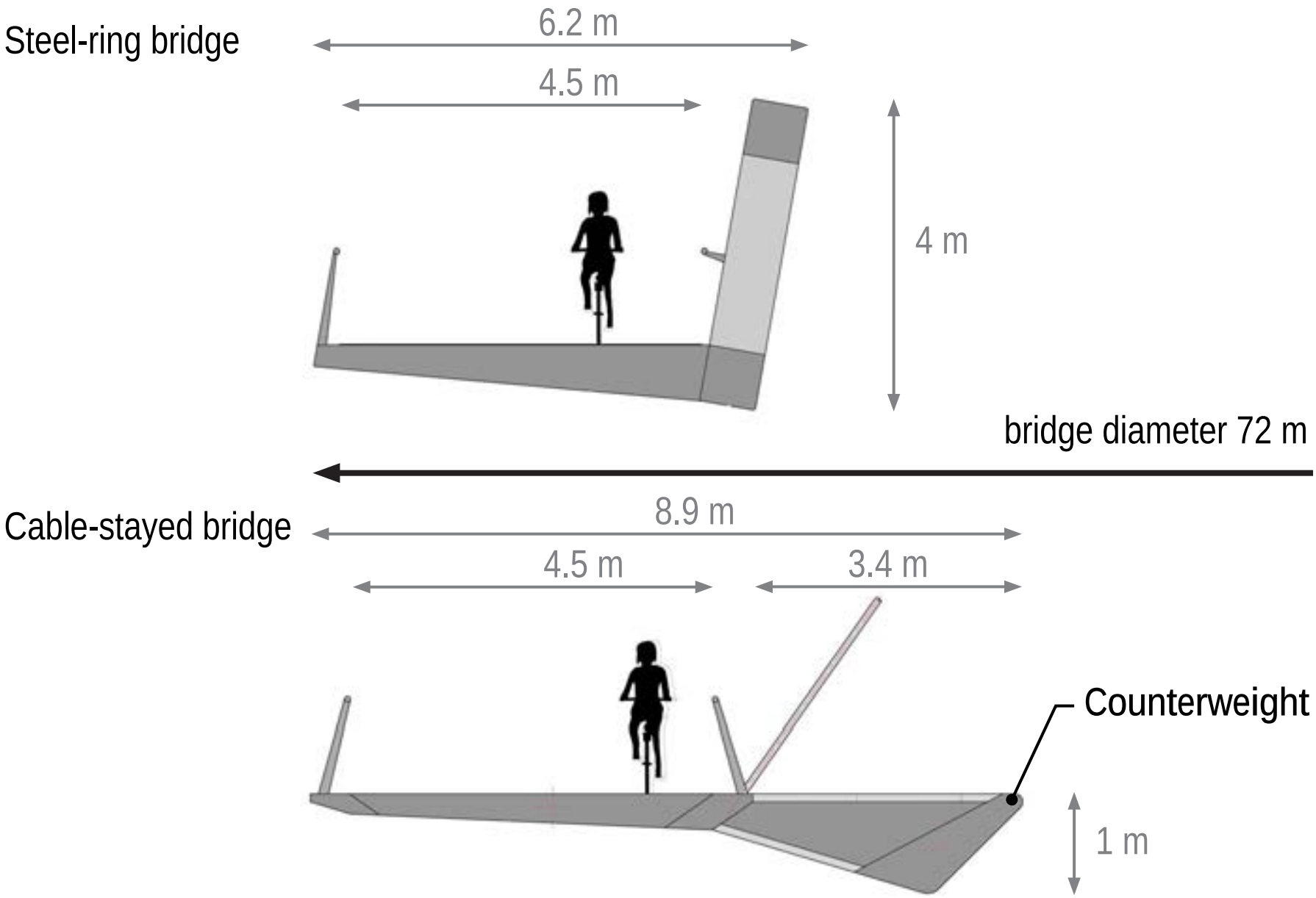
Alignment Route and Bridgeform Study

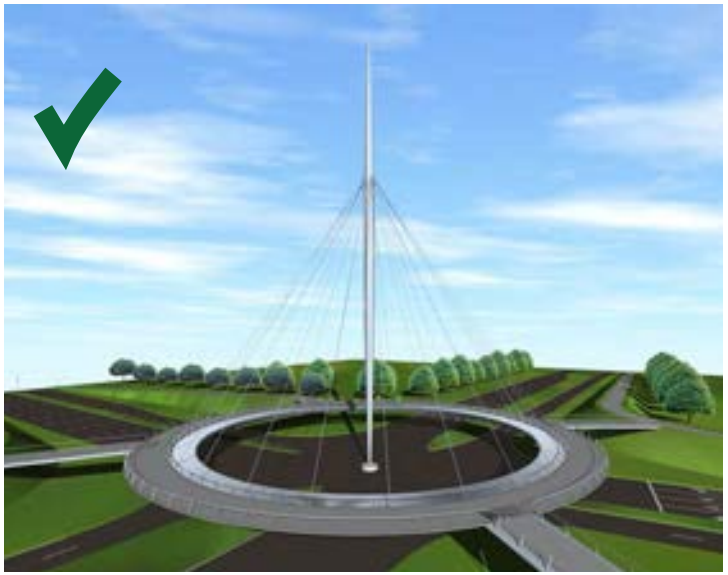

too much weight

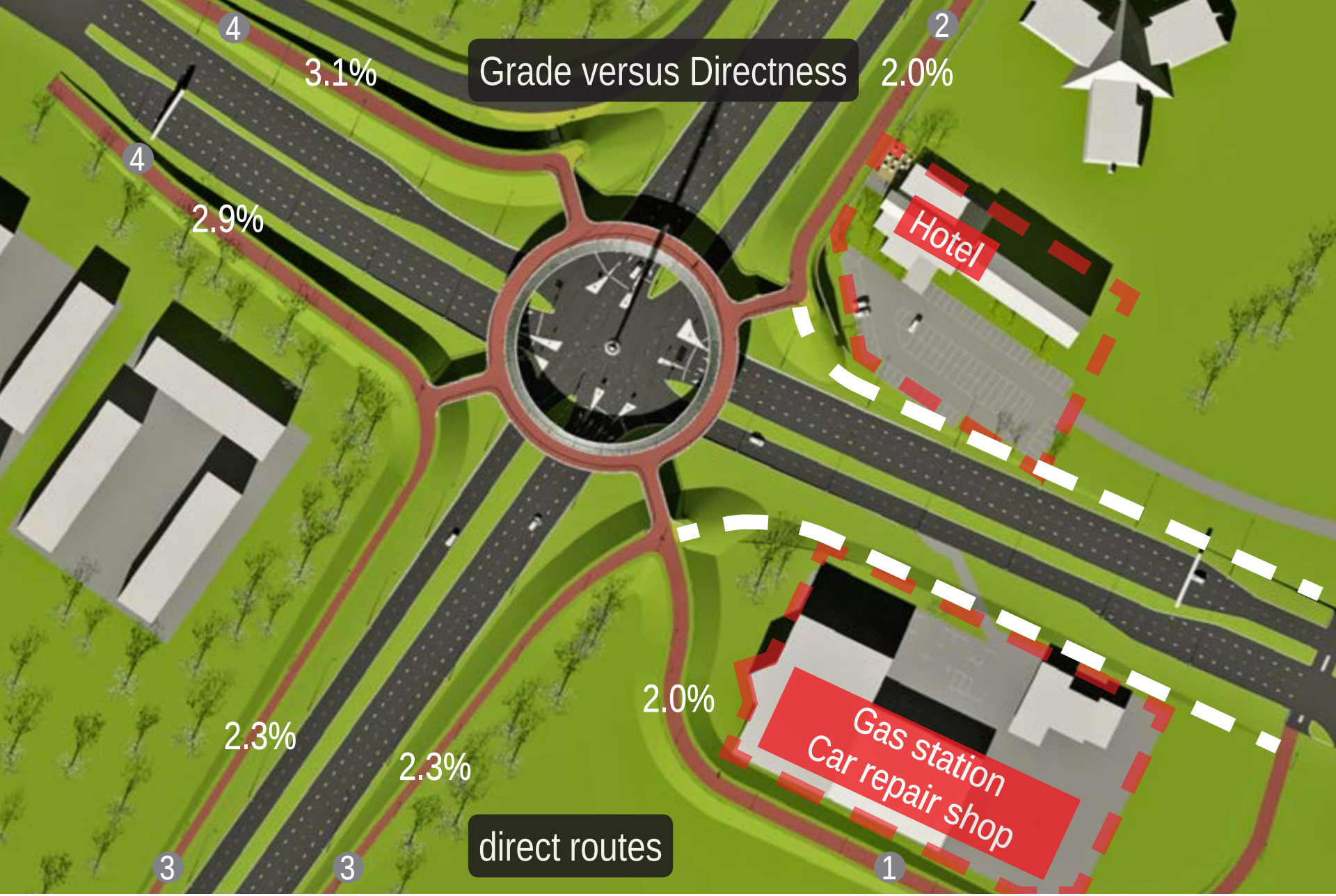

not efficient


reasonably efficient

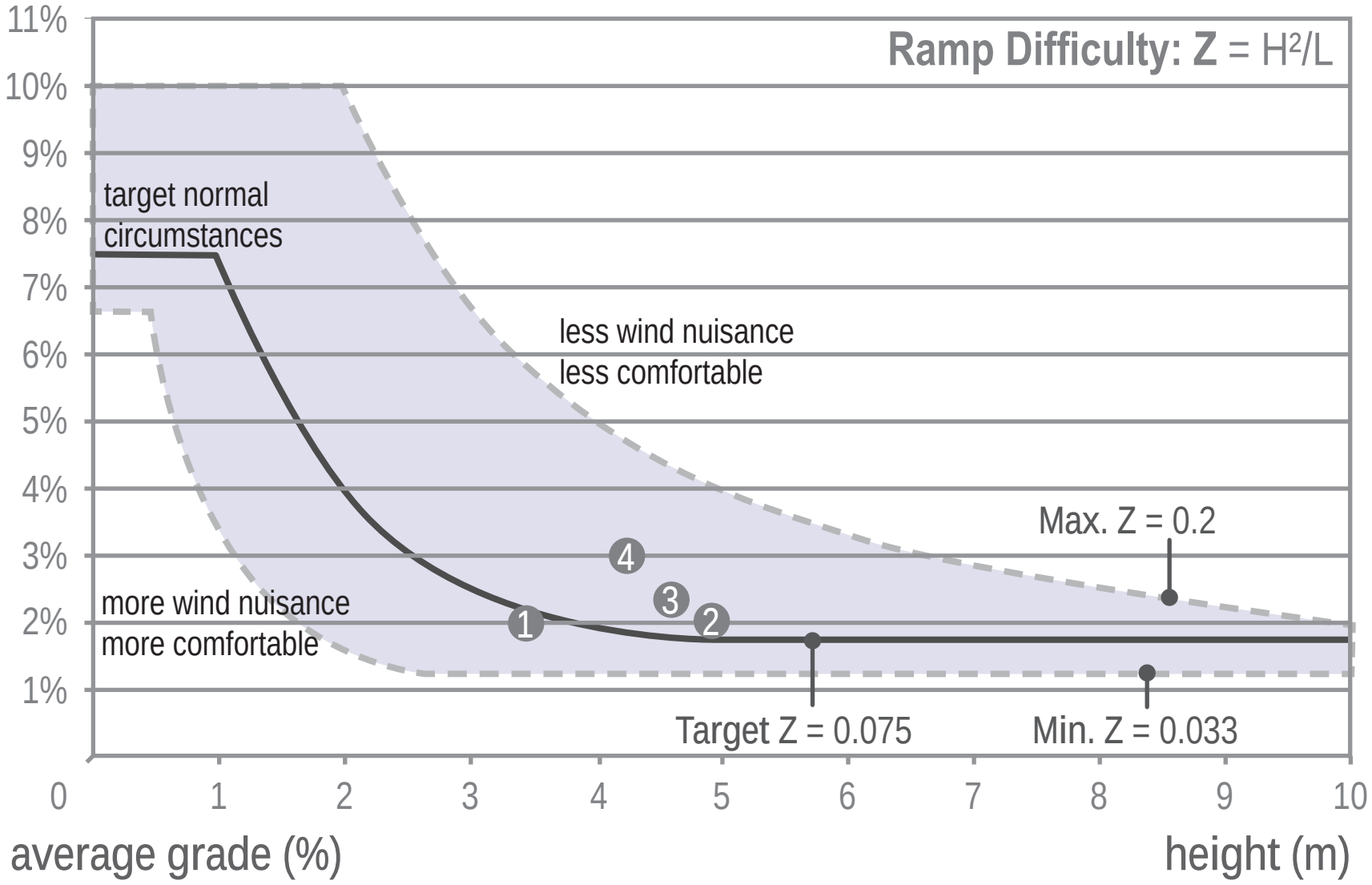

efficient

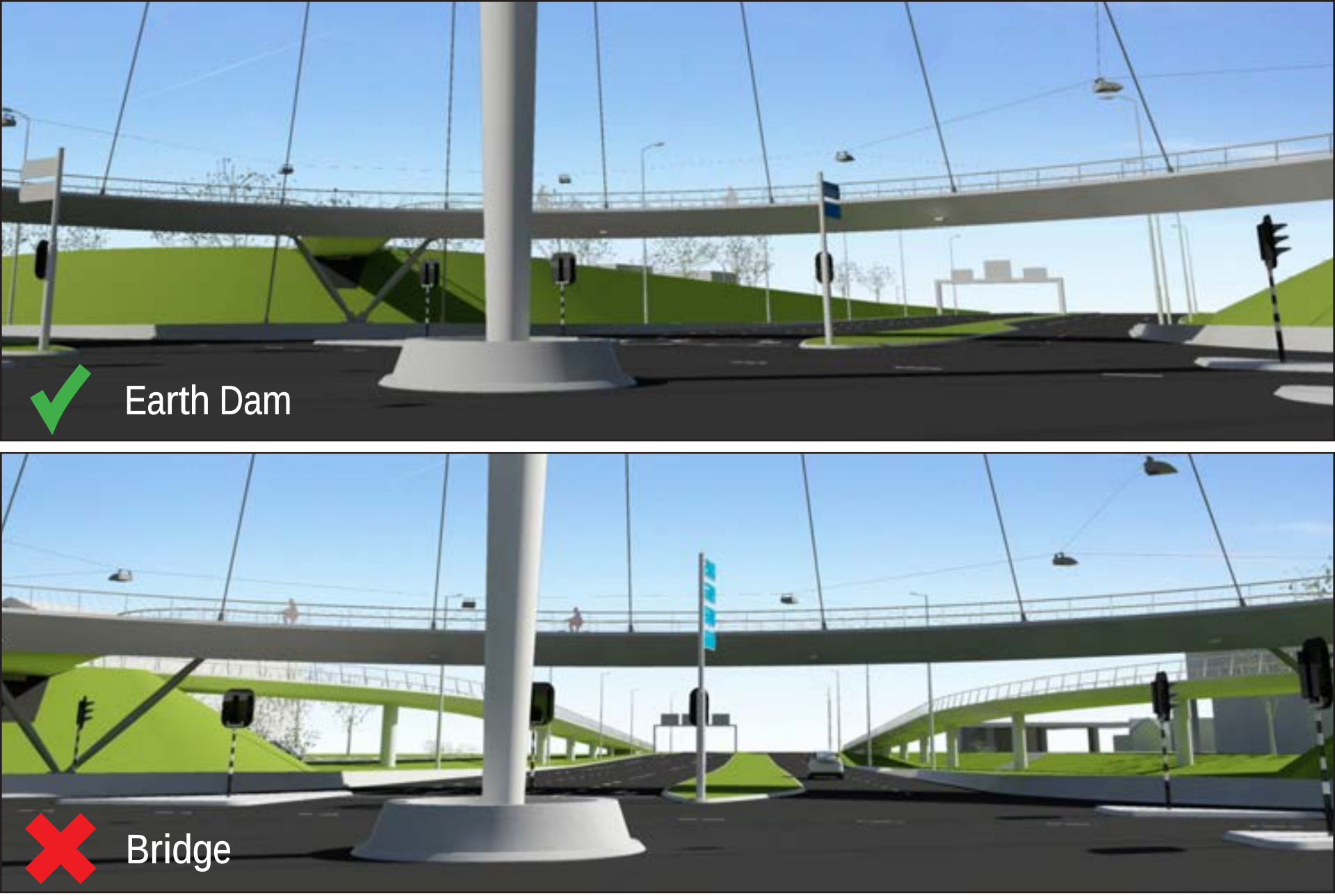

Steel-ring bridge
6.2 m
4.5 m
4 m
bridge diameter 72 m
Cable-stayed bridge
8.9 m
4.5 m
3.4 m
Counterweight
1 m

	Steel-ring bridge	Cable-stayed bridge
		
Appearance	spectacular and distinct landmark visible form vicinity	spectacular and subtle landmark visible form afar
Structural Efficiency	poor	optimal
Costs	not distinctive	not distinctive



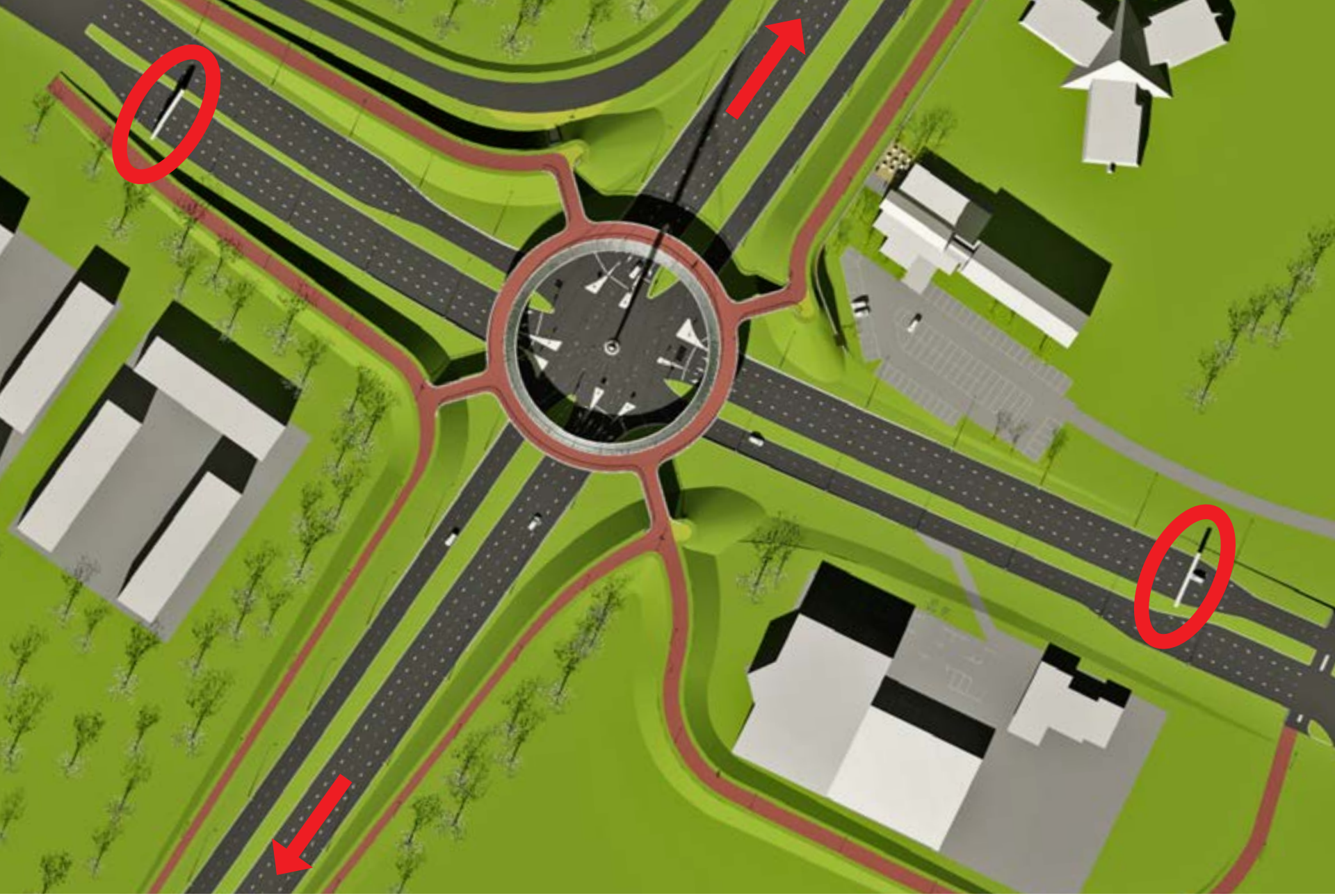
Alignment Optimization


Ramp Difficulty: Z = H²/L
target normal circumstances
less wind nuisance
less comfortable
more wind nuisance
more comfortable
Max. Z = 0.2
Target Z = 0.075
Min. Z = 0.033
1
2
3
4
11%
10%
9%
8%
7%
6%
5%
4%
3%
2%
1%
0
1
2
3
4
5
6
7
8
9
10
average grade (%)
height (m)



Alignment Ramp Type

Collision Loads



Collision Loads Signage Portals as Anti-Collison Portals

Collision Loads Commonly used Signage Portals

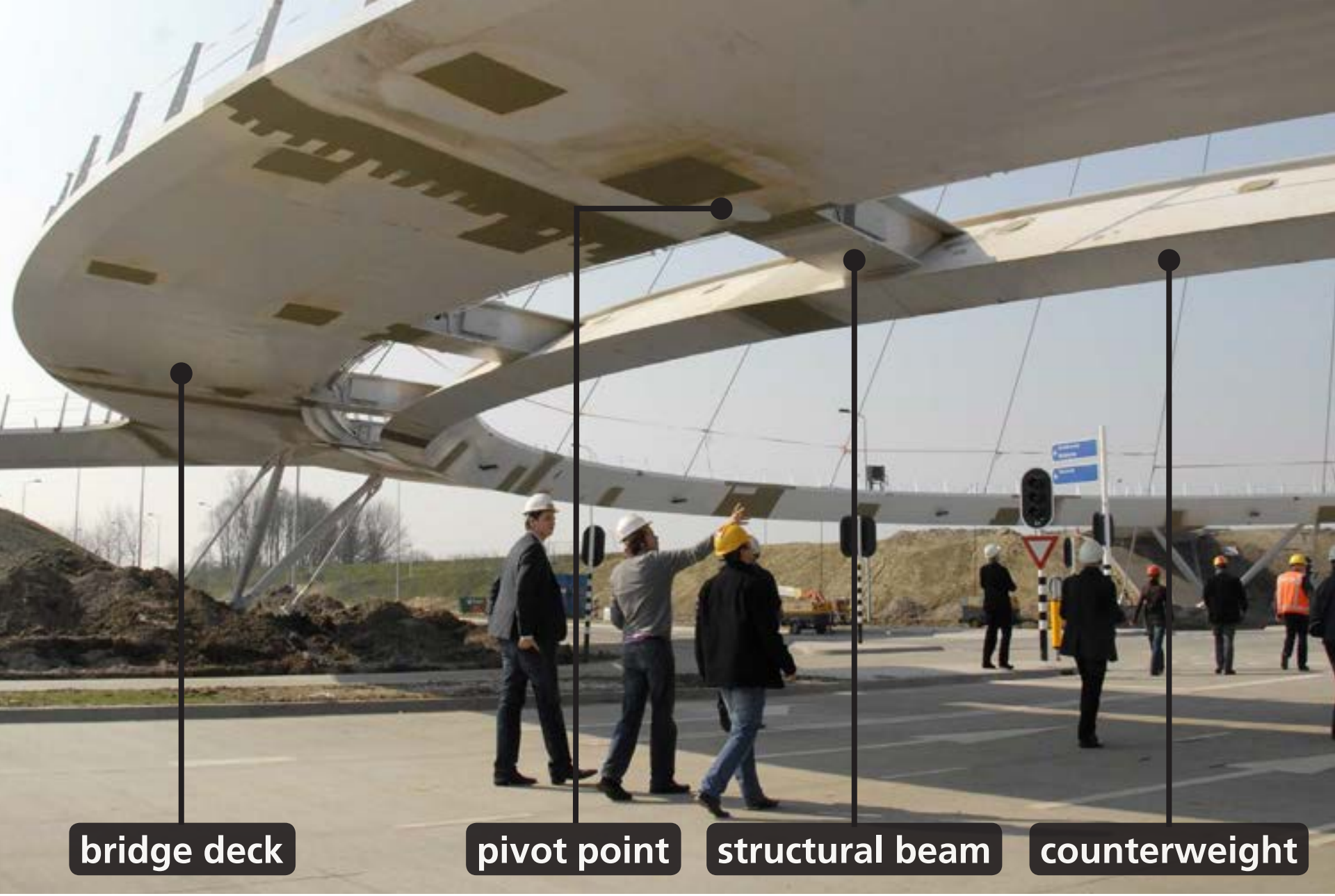
Collision Loads Custom designed Anti-Collision Portals

Collision Loads Anti-Collision Portals proven usefull

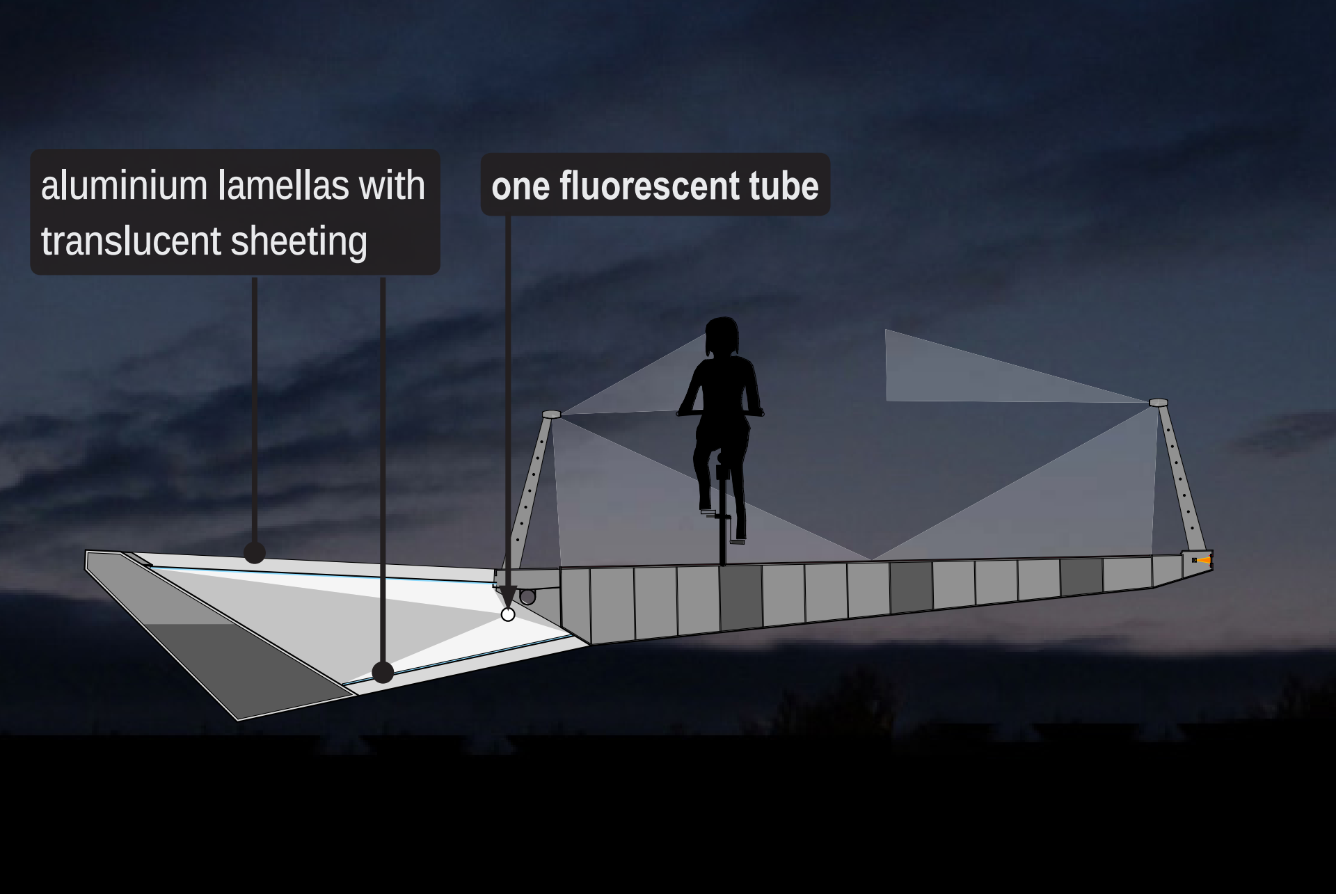
Collision Loads Anti-Collision Portals - Cost-saving Filters

Collision Loads Concrete Barrrier Pylon Foot

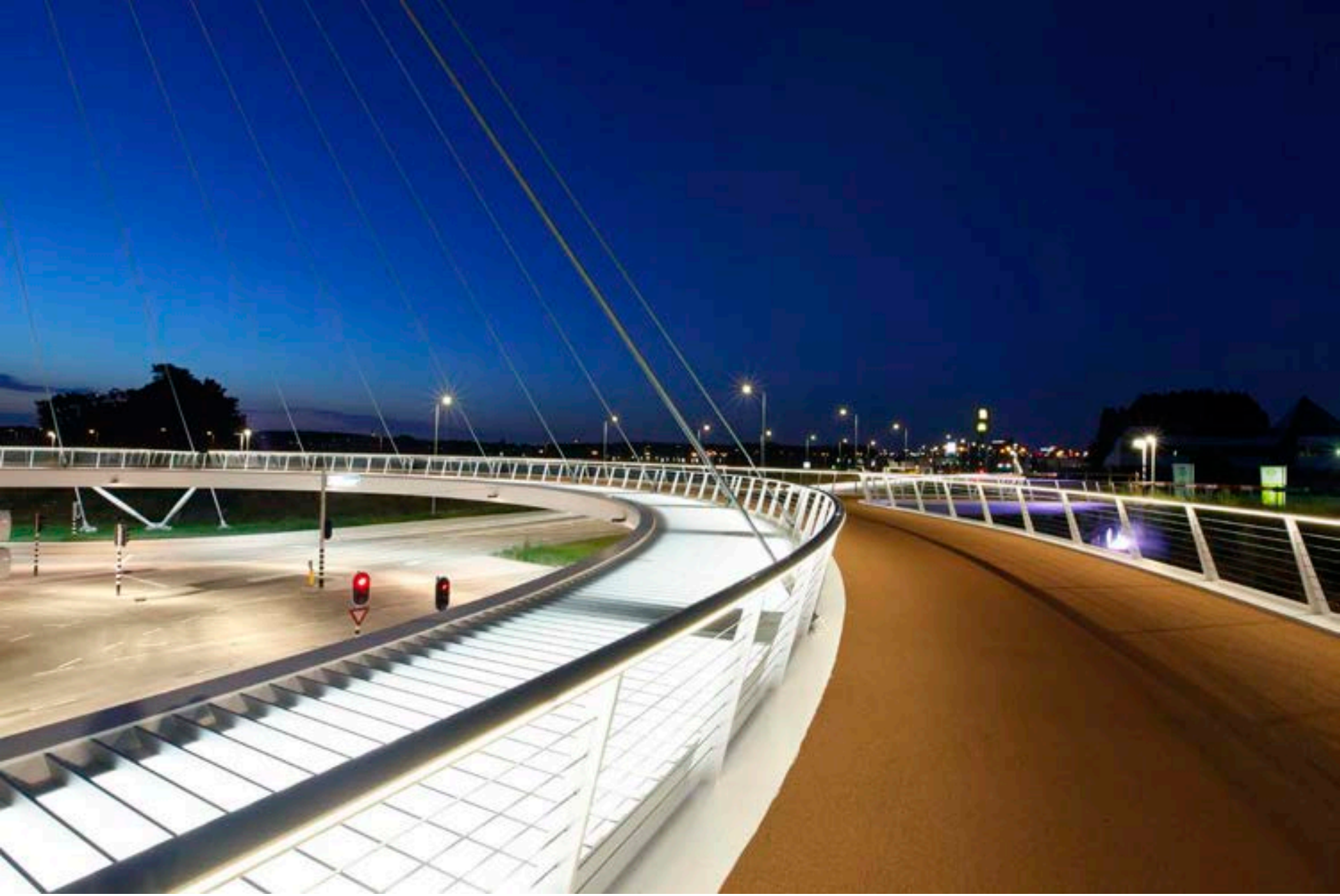
Collision Loads Concrete Barrriers protect supports



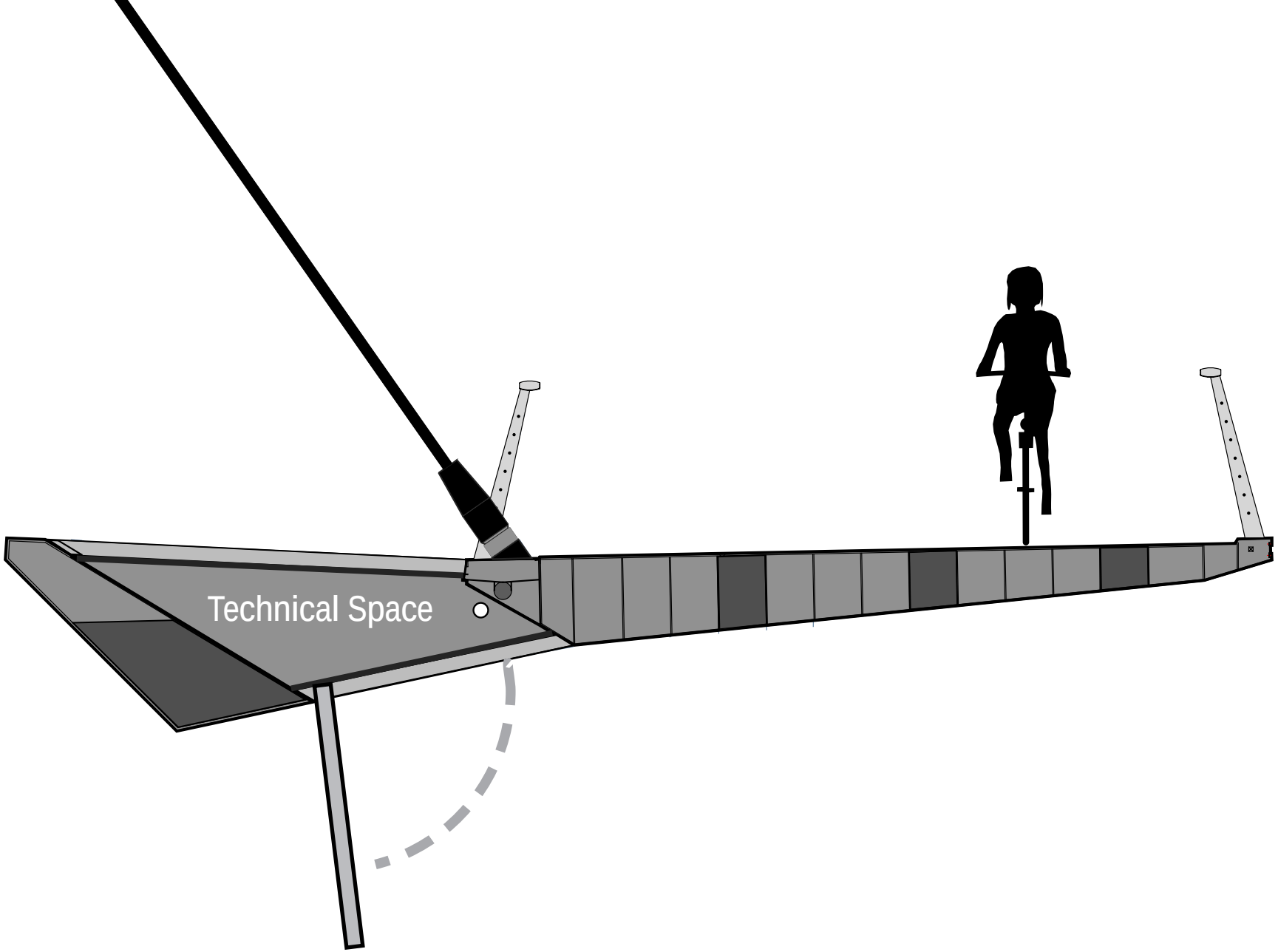
Structural Design Bridge Deck and Counterweight


aluminium lamellas with translucent sheeting
one fluorescent tube


aluminium lamellas with translucent sheeting
structural beam

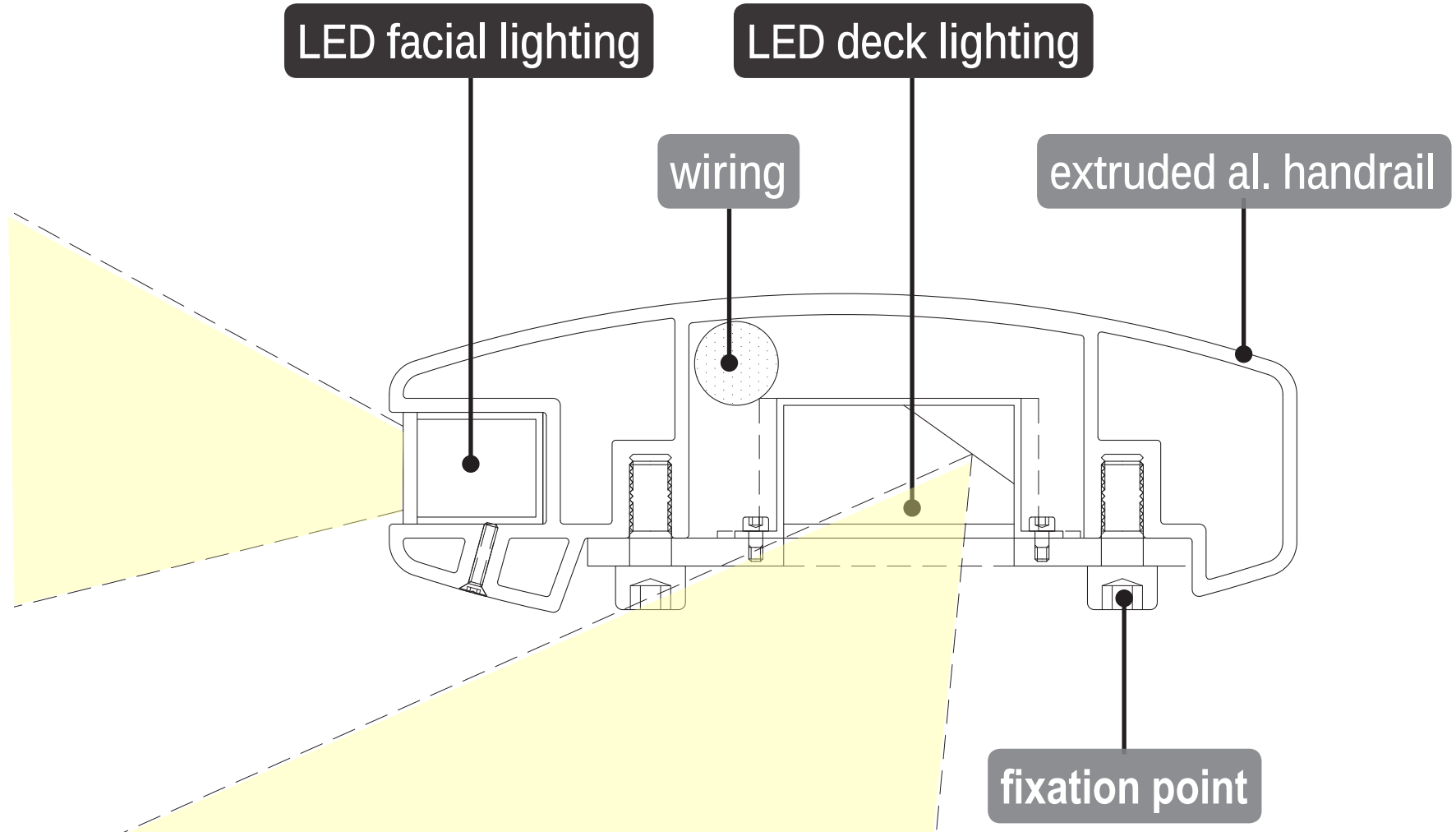


Lighting Design Architectural Lighting



Bridge Design Integrated Technical Space

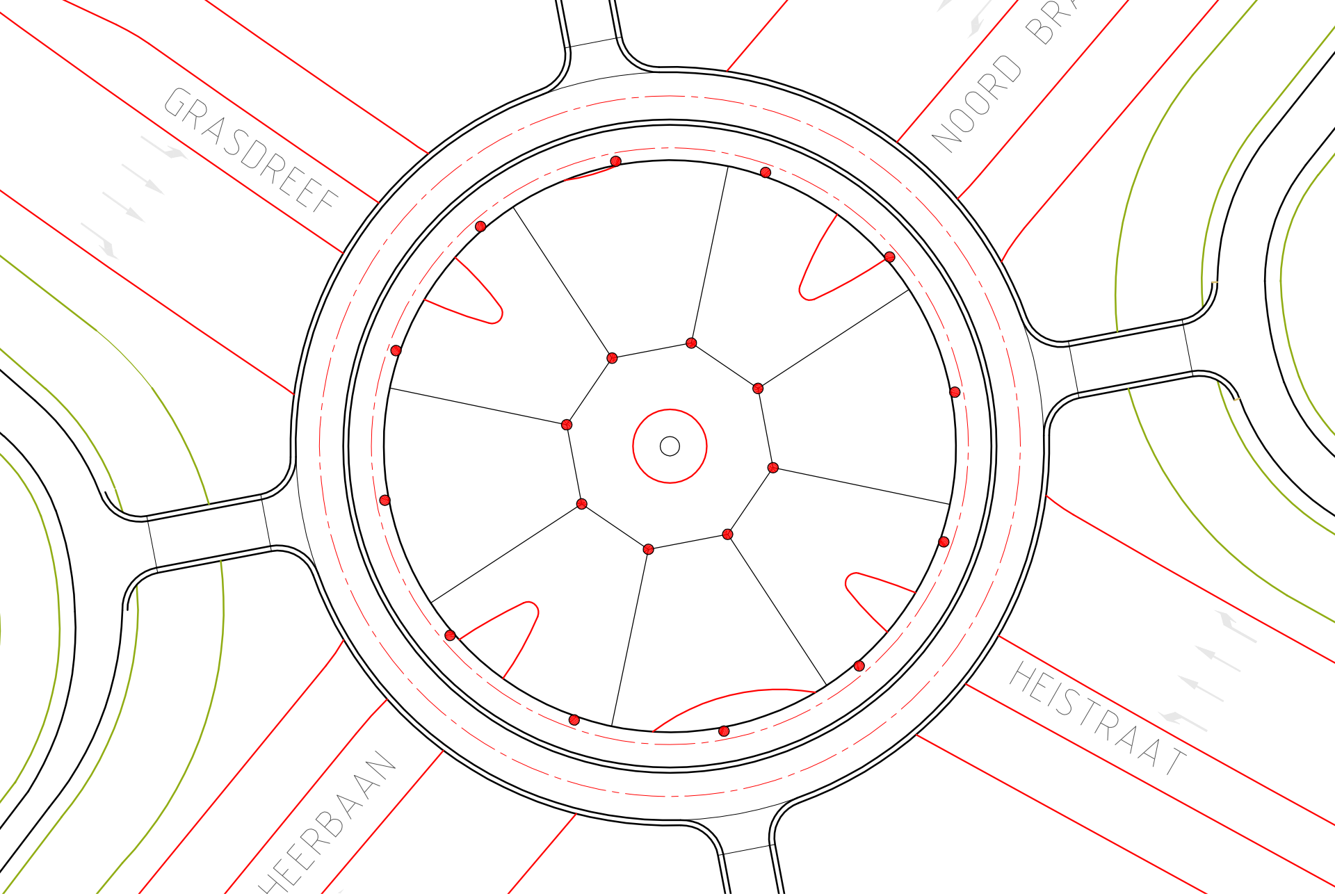
Lighting Design Deck & Facial Lighting



Lighting Design Custom Handrail with Integrated Lighting

Lighting Design Custom Handrail with Integrated Lighting

Lighting Design Intersection Lighting

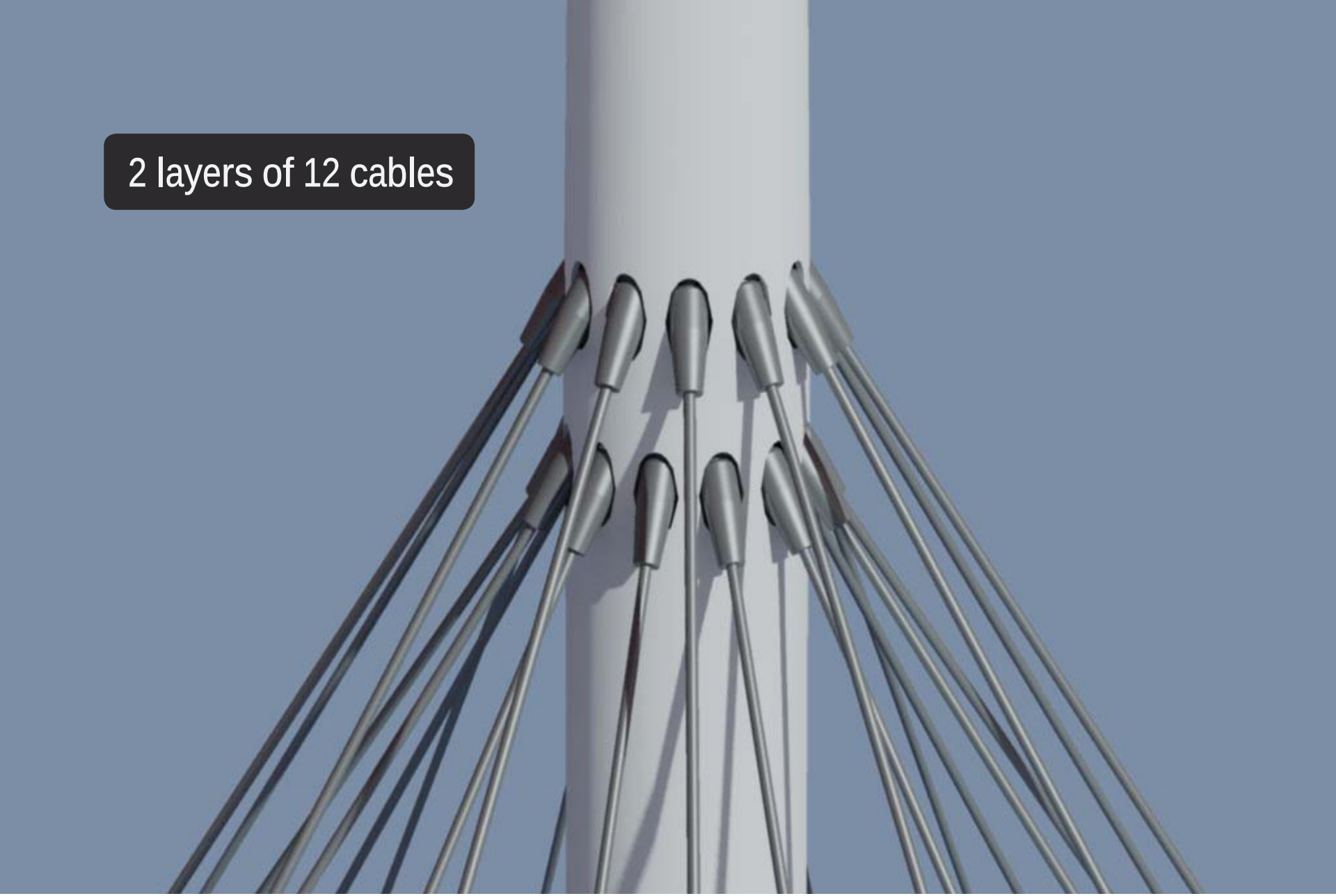


Lighting Design Intersection Lighting

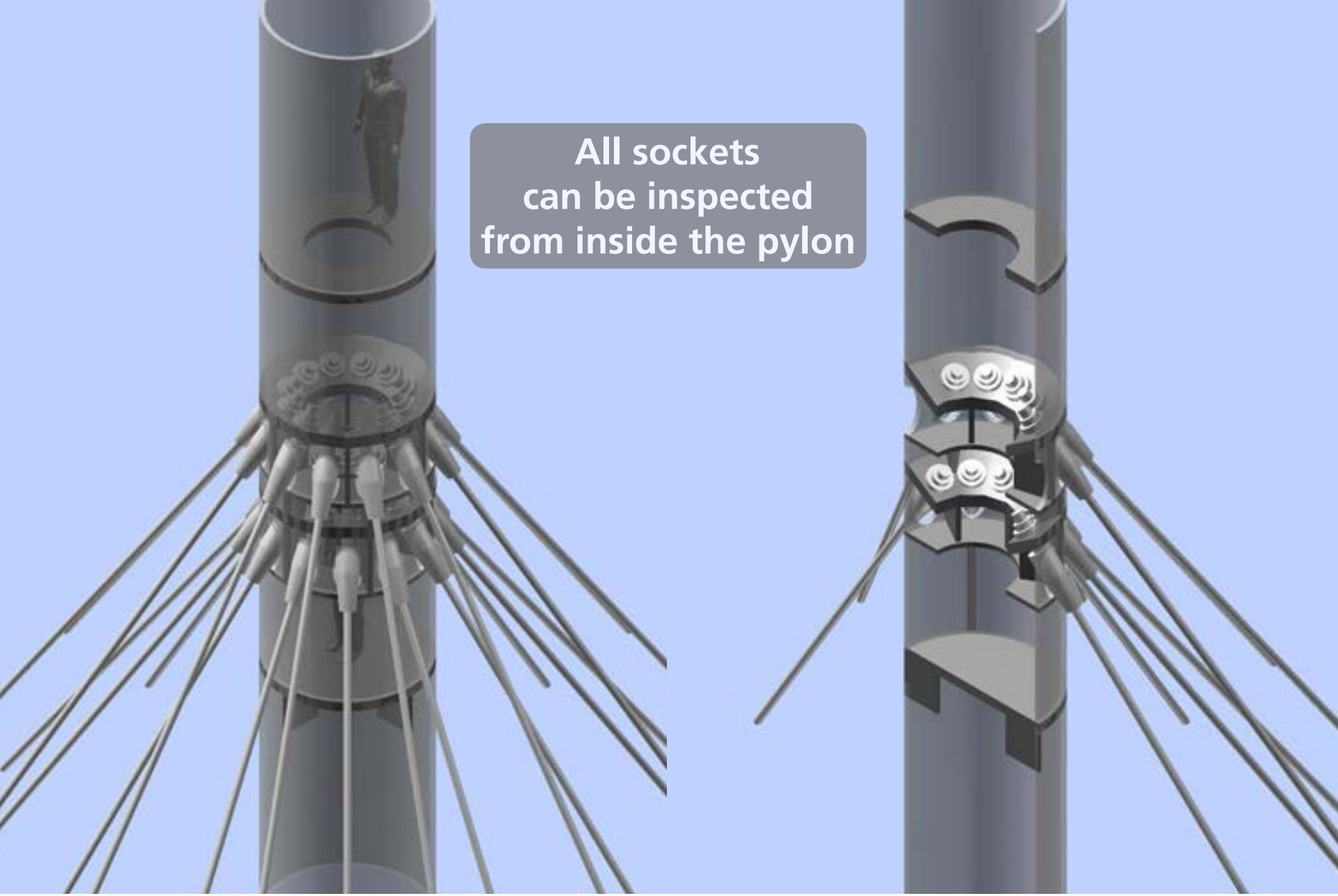
Lighting Design Intersection Lighting

Lighting Design Intersection Lighting

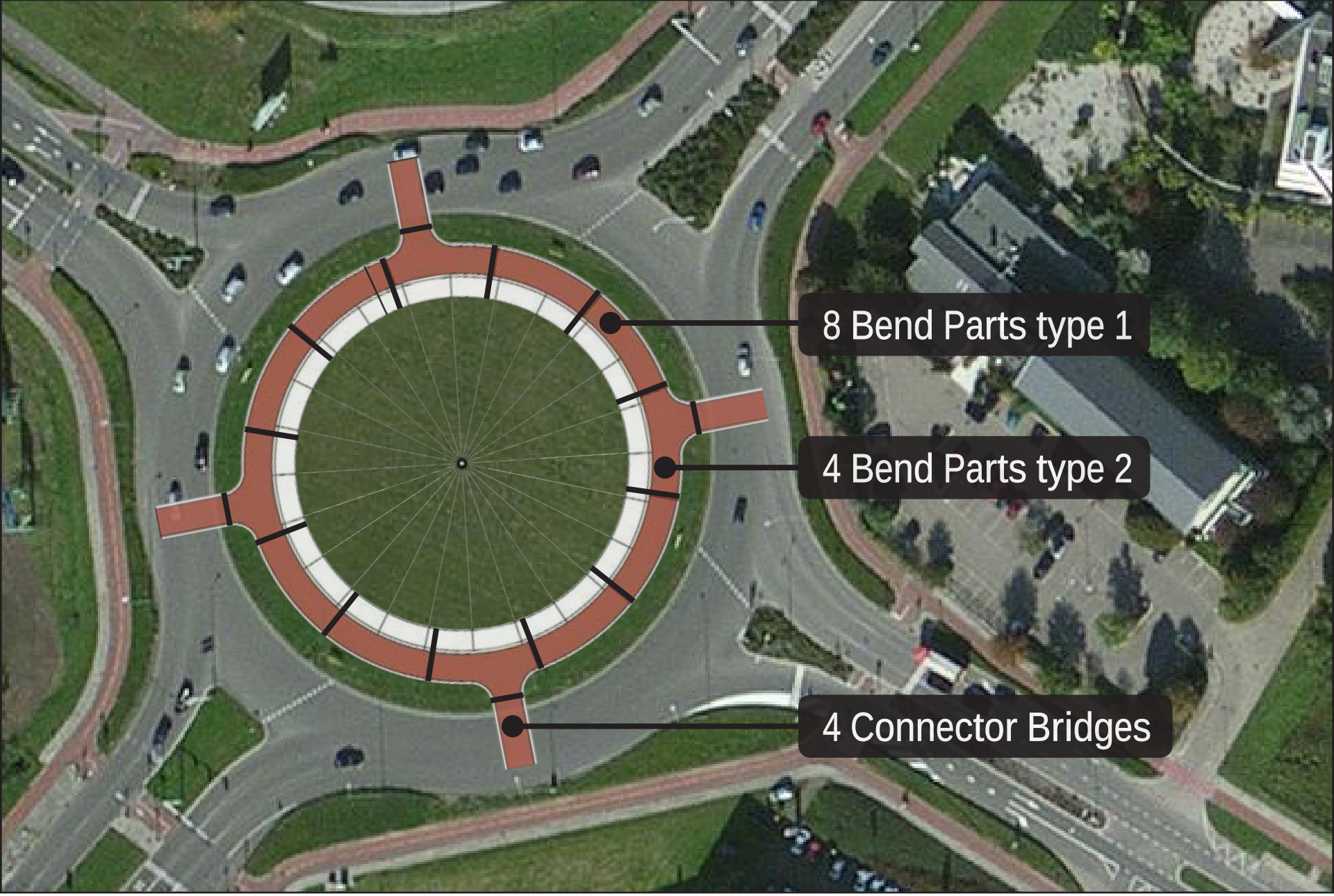
Integral Design Integration of traffic lights, lighting and signage



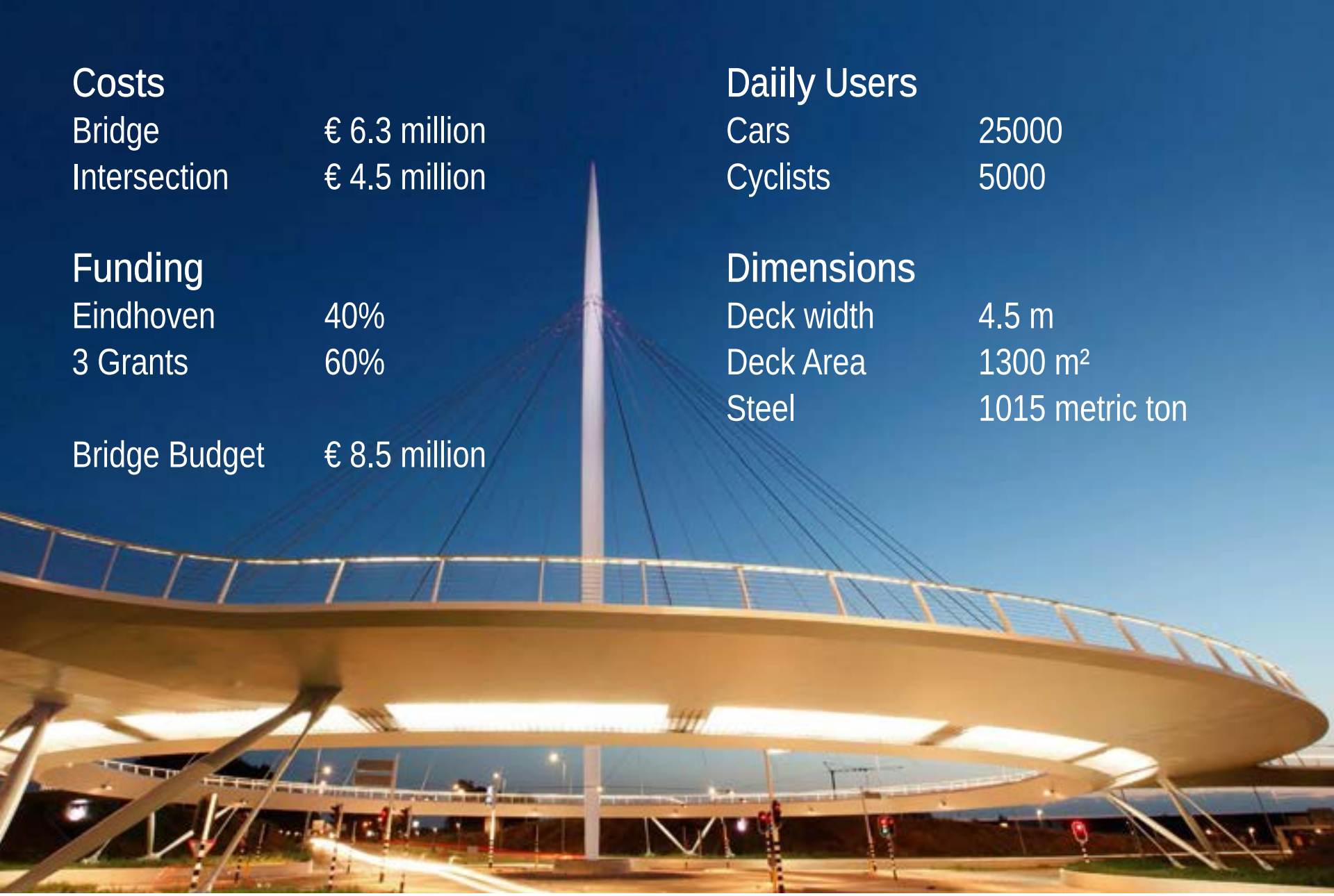
Design details Pylon Cable Anchorage



Design details Pylon Cable Anchorage



Construction Modularity



Costs

Bridge	€ 6.3 million
Intersection	€ 4.5 million

Funding

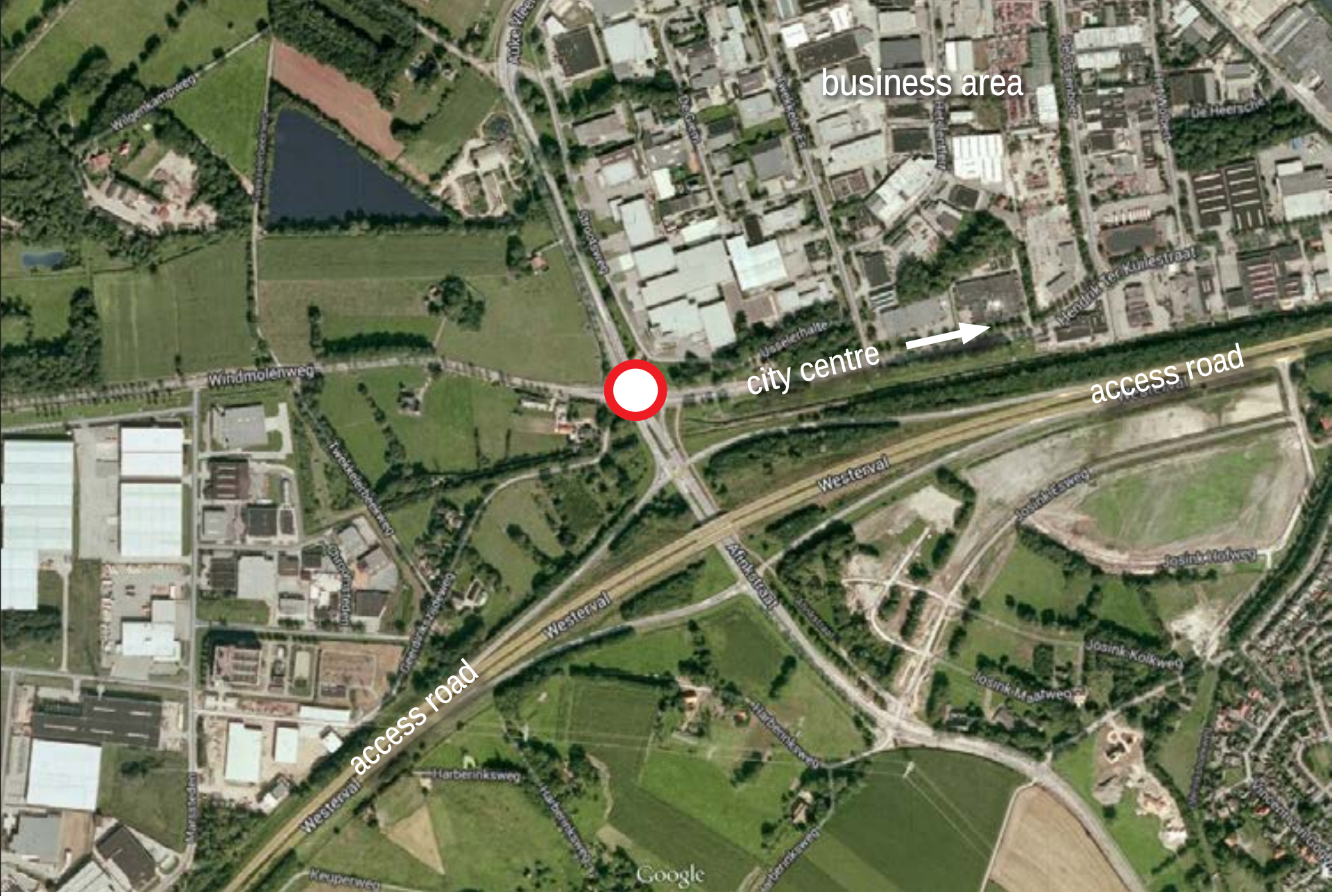
Eindhoven	40%
3 Grants	60%
Bridge Budget	€ 8.5 million

Daiily Users

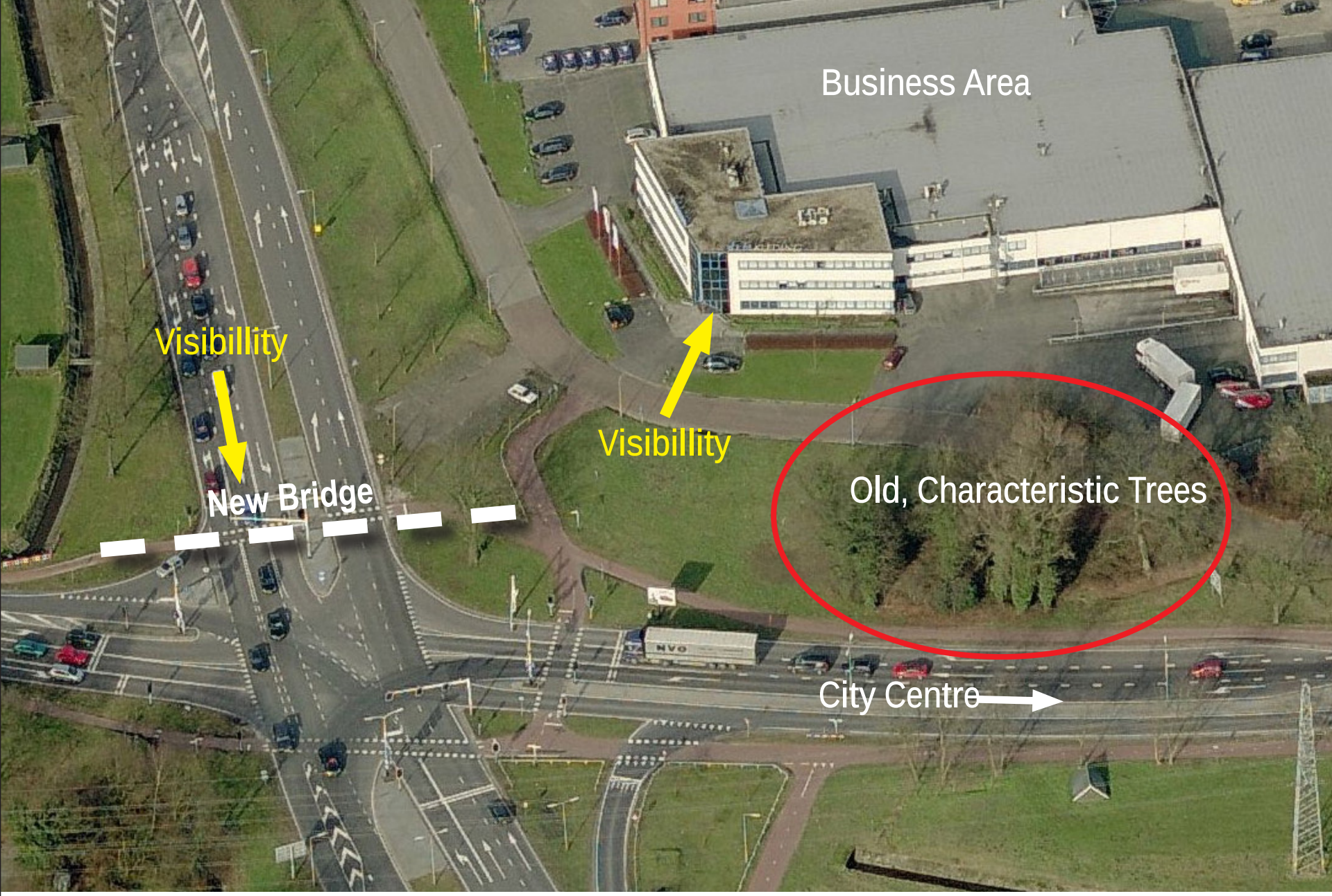
Cars	25000
Cyclists	5000

Dimensions

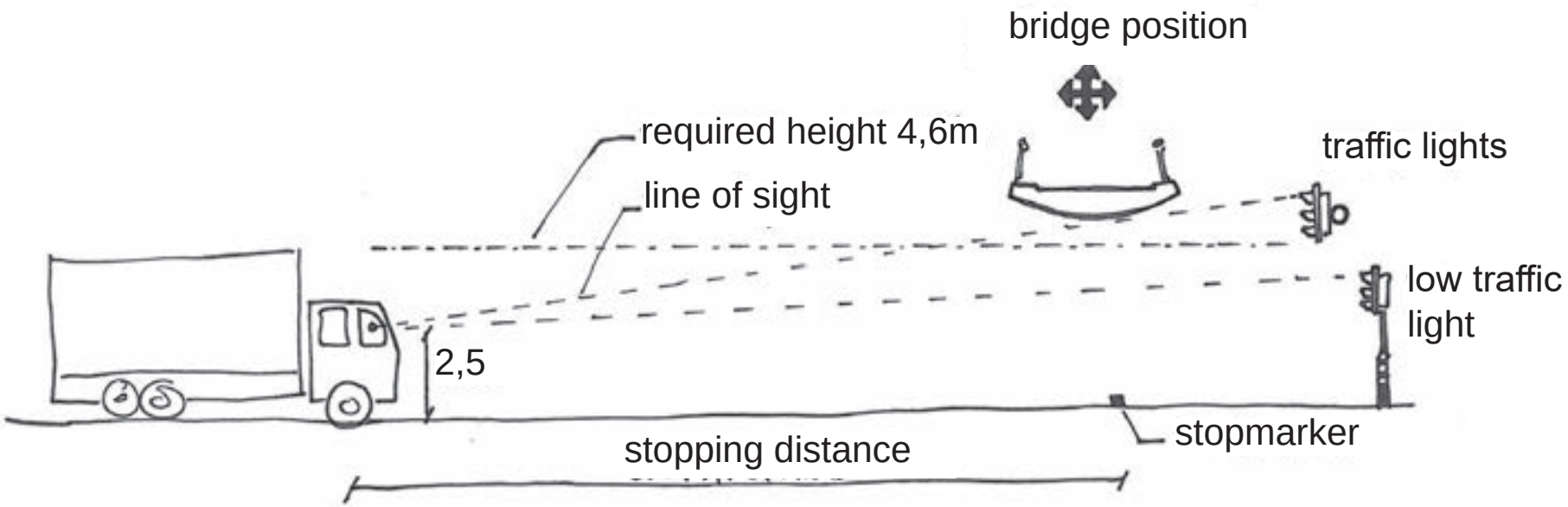
Deck width	4.5 m
Deck Area	1300 m^2
Steel	1015 metric ton

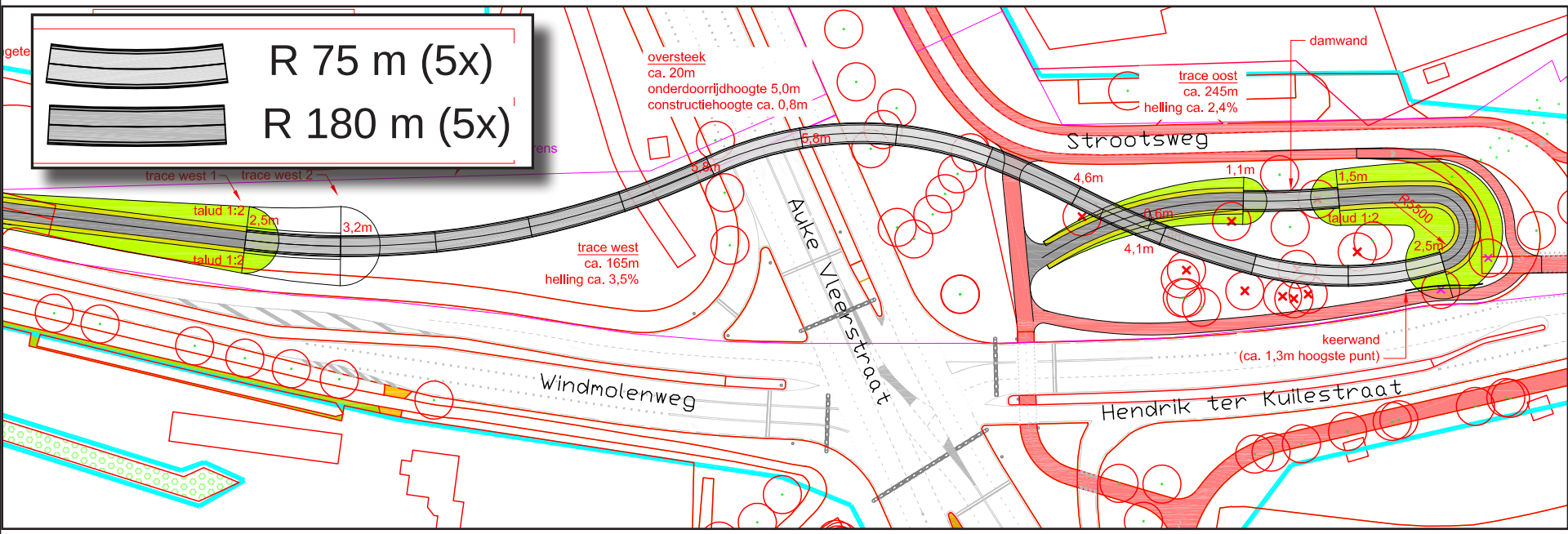


Enschede Bridge Context



Enschede Bridge Context - Alignment Constraints





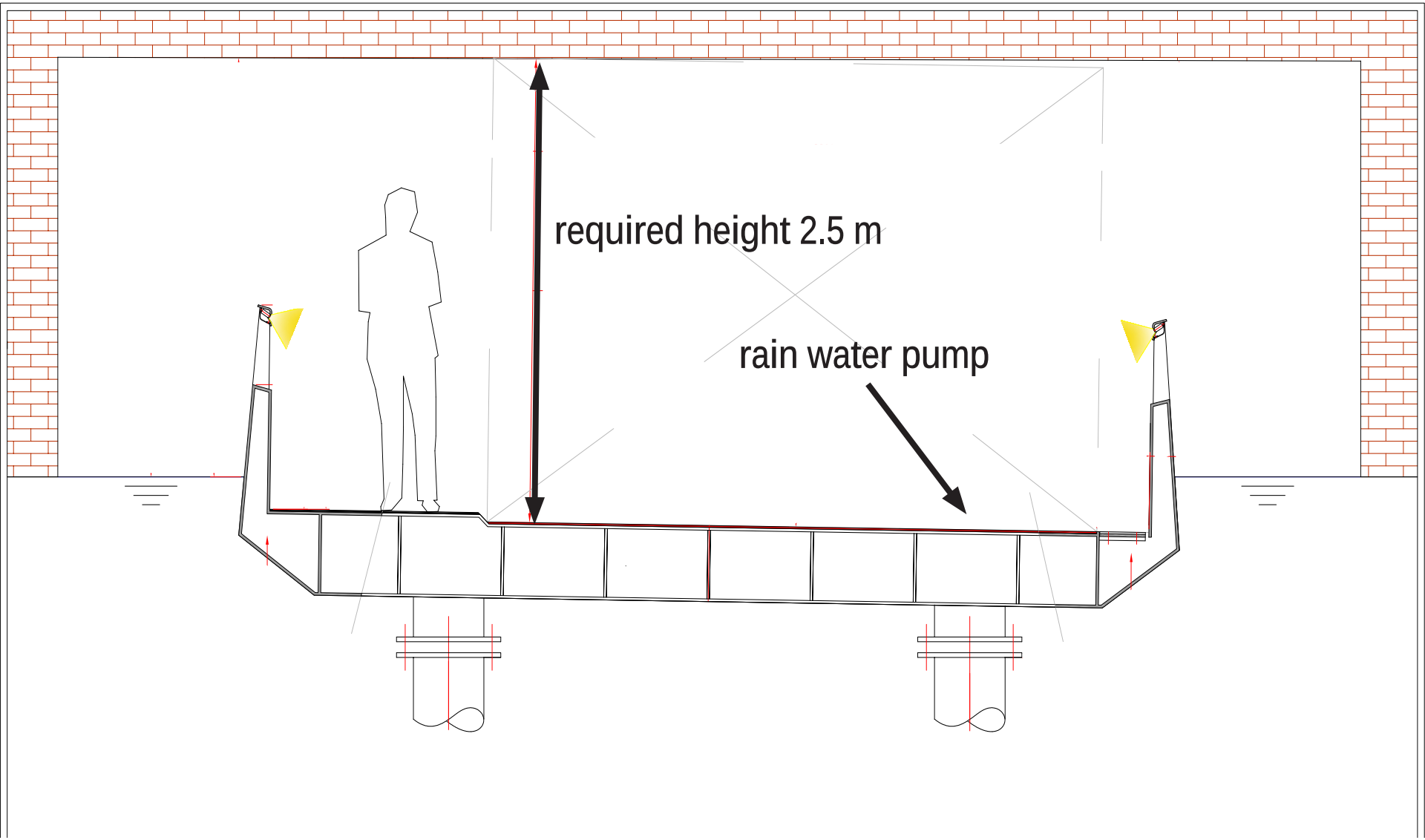
Enschede Bridge Final Alignment

Enschede Bridge Modular Construction

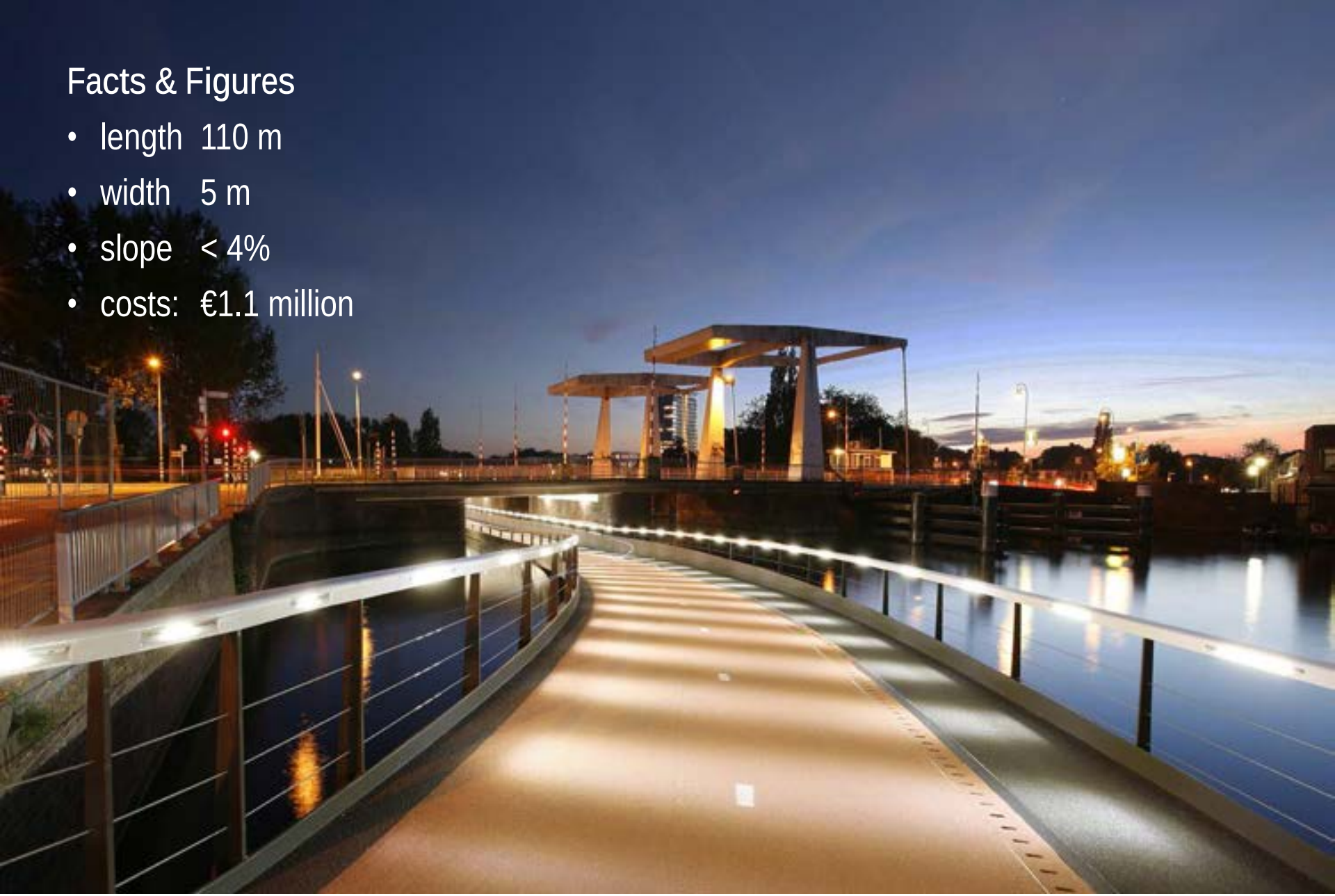
Facts & Figures

- bridge length 280 m
- ramp length 150 m
- width 3.5 m
- lightingelement
- budget: €2.0 million
- costs: €1.4 million

Haarlem submerged bridge Context



Haarlem submerged bridge Cross Section

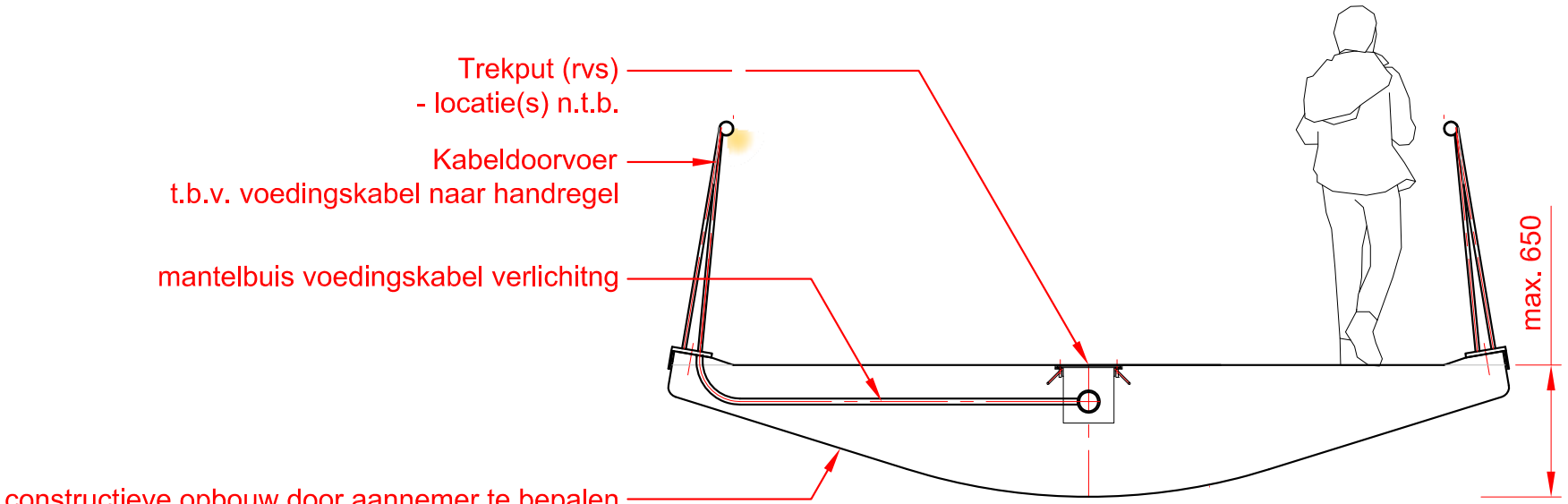


Haarlem submerged bridge Result

Heerhugowaard Station bridge Alignment Fitting in the Contect

Possible main span materials

	bonus
• steel	no bonus
• stainless steel	€ - 125.000,-
• high performance concrete	€ - 175.000,-
• fiber re-inforced composite	€ - 175.000,-



main span contour

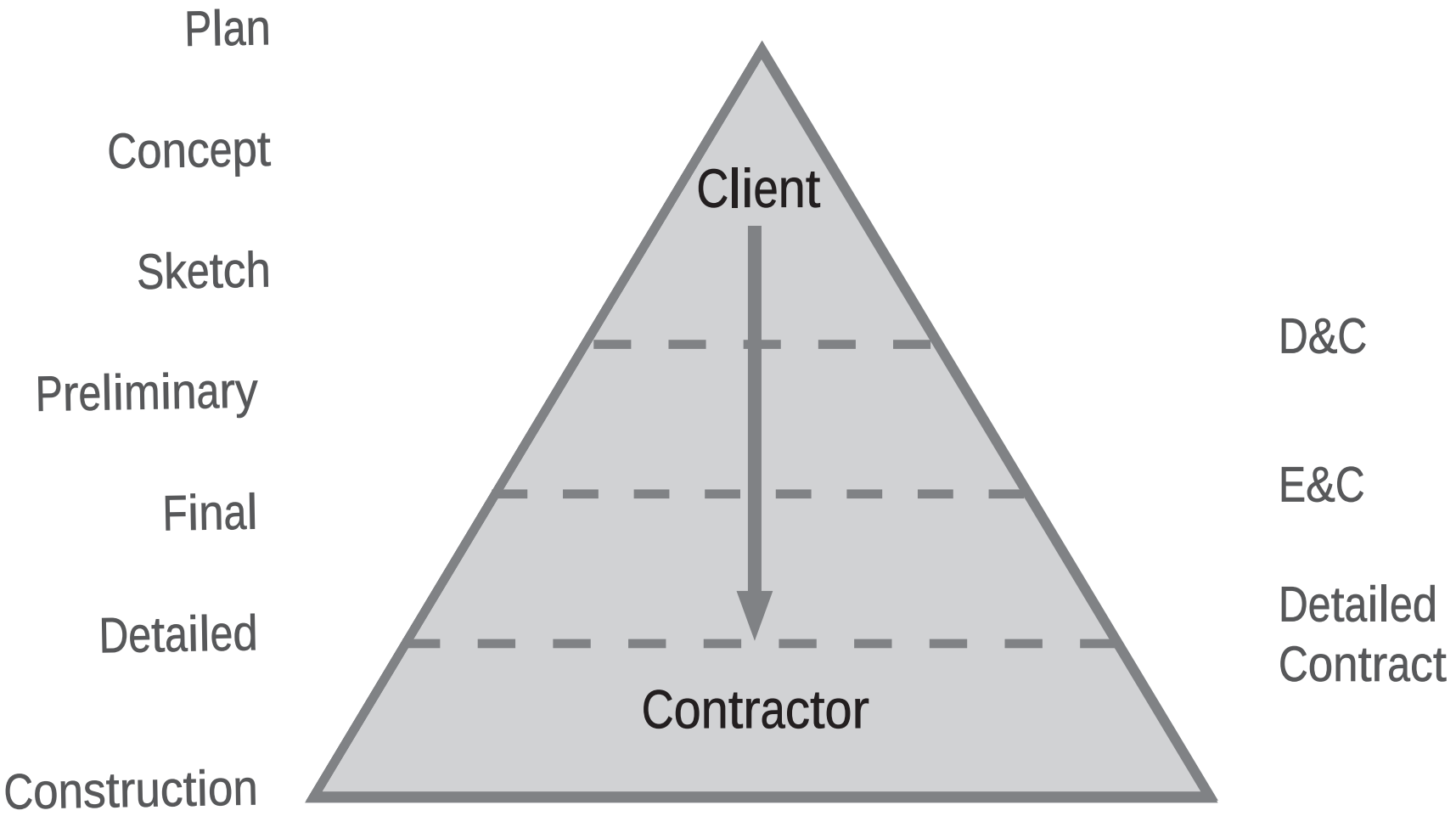
Facts & Figures

- bridge length 154 m
- ramp length 120 m
- width 3.5 m mainspan, 4m straight slopes, 6 m corners
- costs: €1.7 million

Heerhugowaard Station bridge Maintenance Free Main Span

Tender Type: Client side development

Contract type



Budget

Tender & Contract format

Tender Type: Market orientated development

Contract type

Plan

Concept

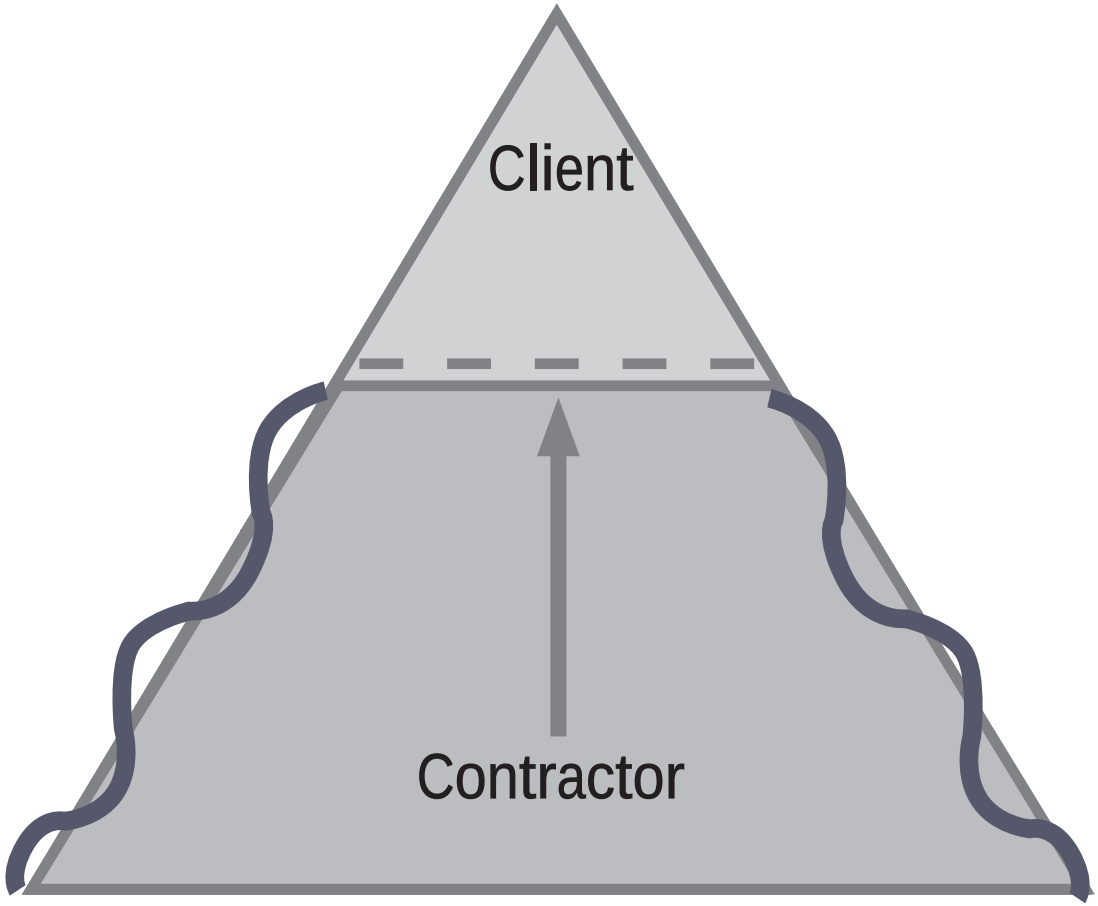
Sketch

Preliminary

Final

Detailed

Construction



D&C

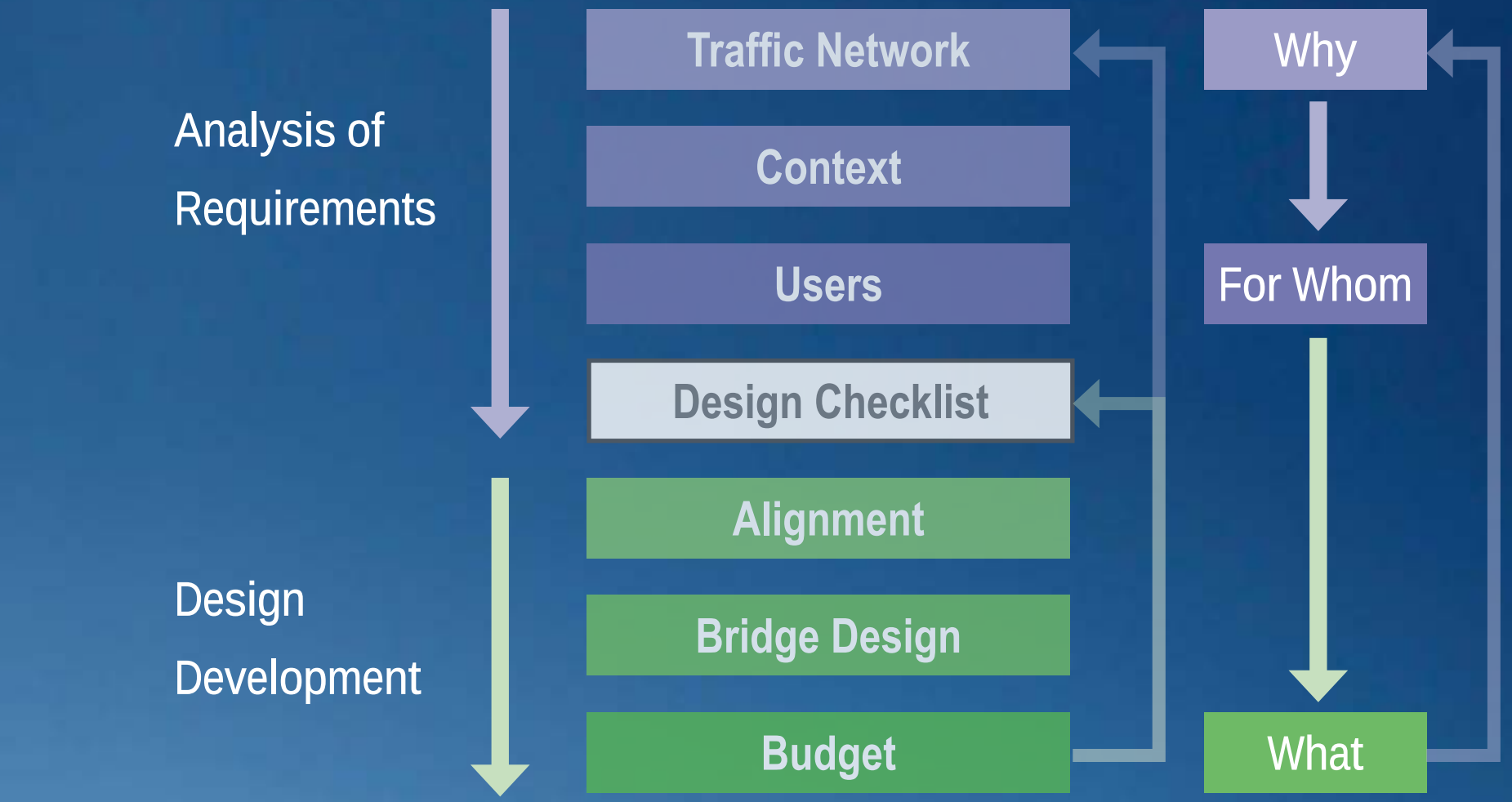
E&C

Detailed Contract

Budget

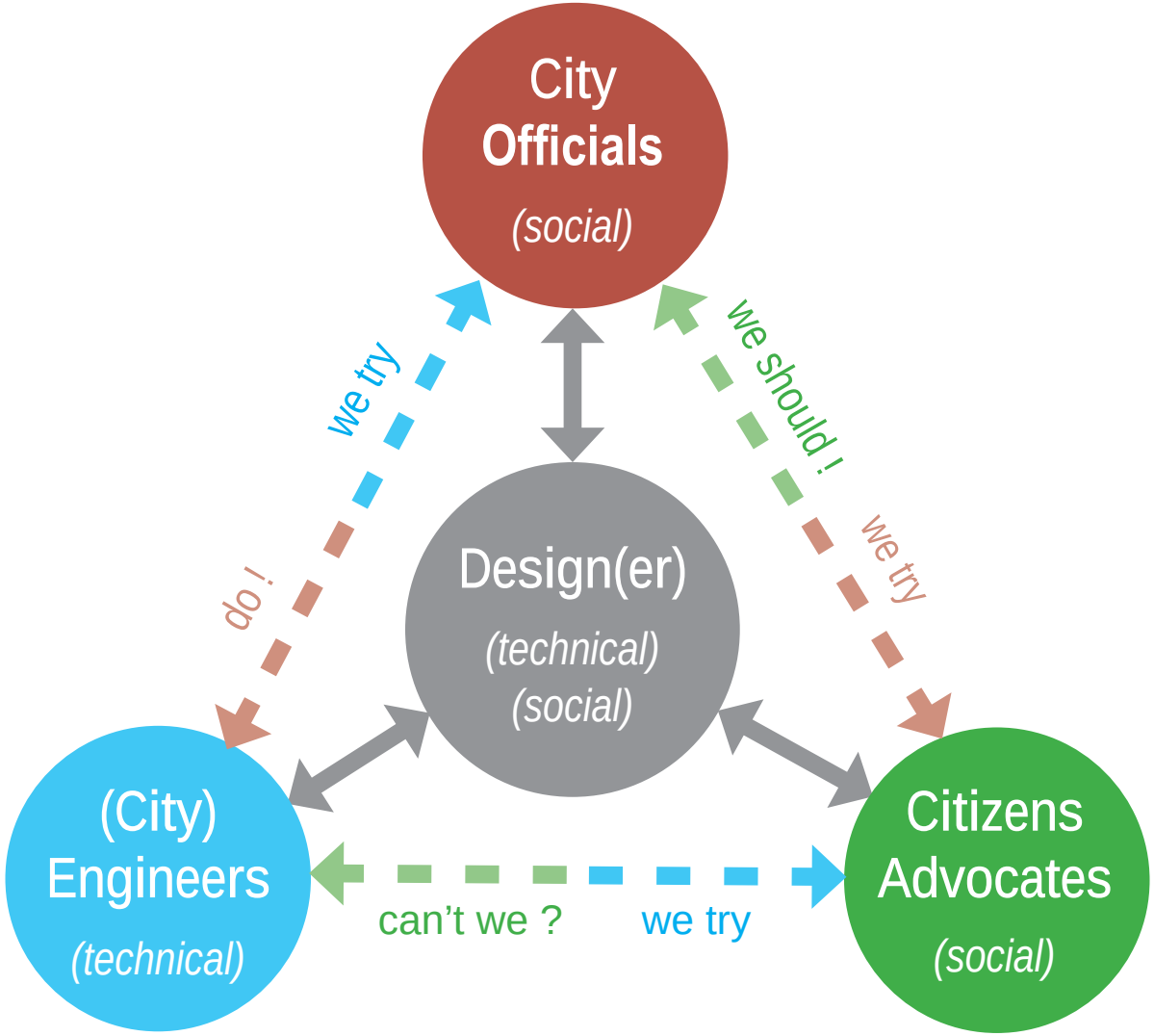
Tender & Contract format

A Thorough Analysis



Create Understanding

Between representatives of Technical & Social requirements



Dutch Design Manual

Start with the Crossings

Because Crossings are:

- Hard to Integrate
- Hard to Upgrade
- Advertisers / Kickstarters
- Gapclosers

Dutch Design Manual

Eindhoven Hovenring benefits from the context

Contextual Benefits

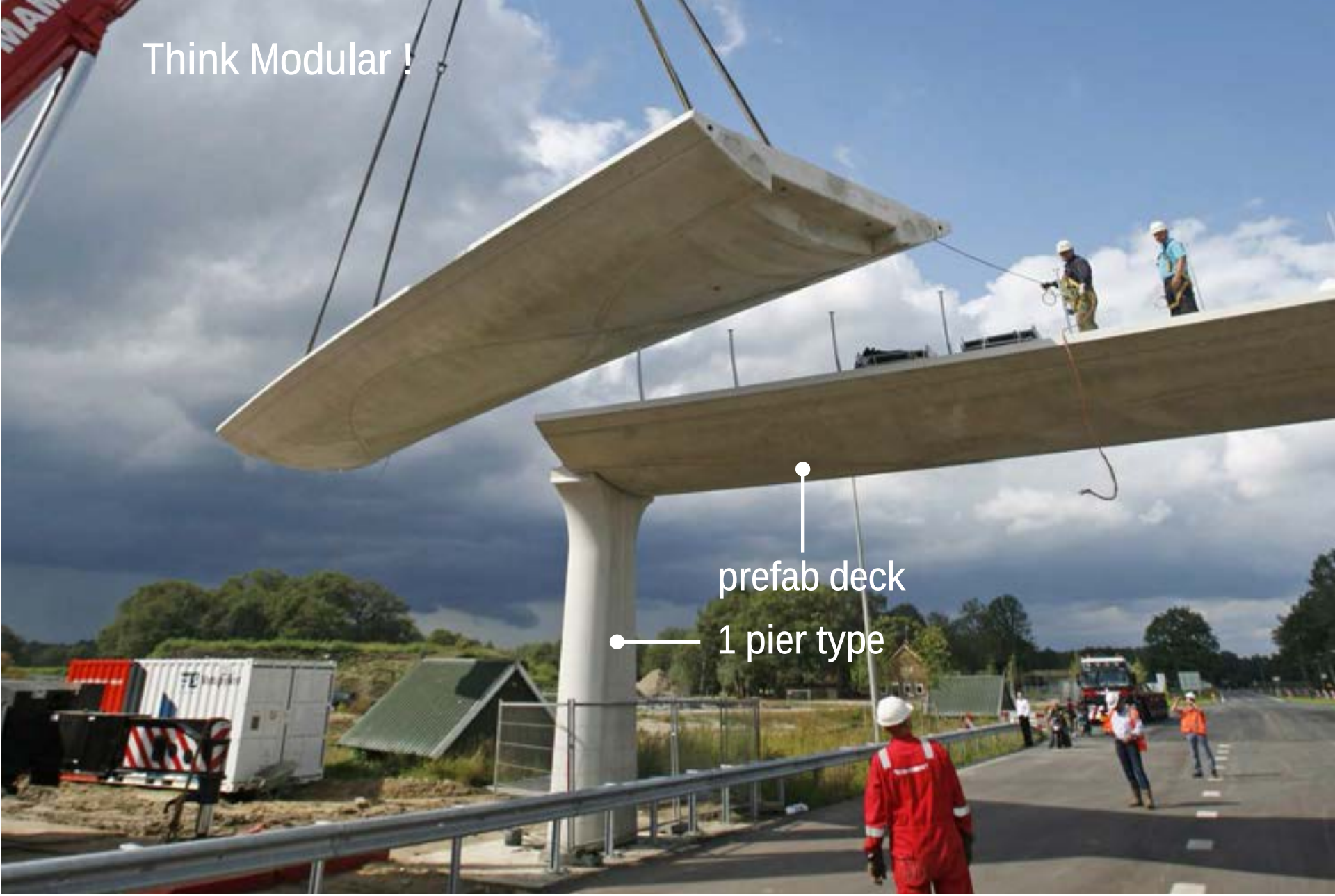
- **Signage portals as high traffic filter**

Eindhoven Hovenring benefits from the context

Contextual Benefits

- bridge deck casted directly on existing earth dam
- Using in soil casted piles

Breda Werkdonken bridge benefits from the context

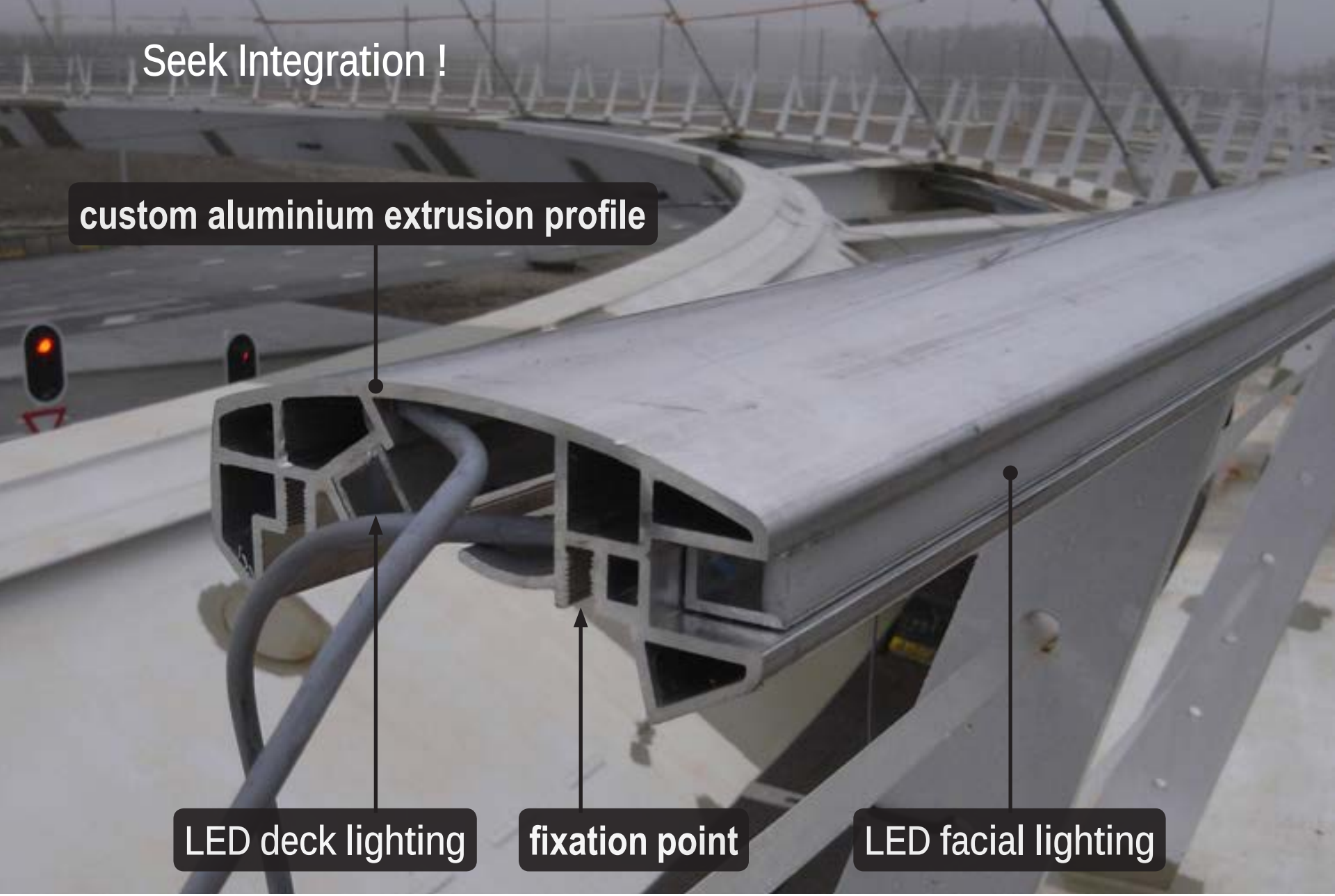


Enschede Bridge Modular Construction

Collision Loads Anti-Collision Portals - Cost-saving Filters

Think Filter !

Users Unauthorized vehicle loads - use a filter



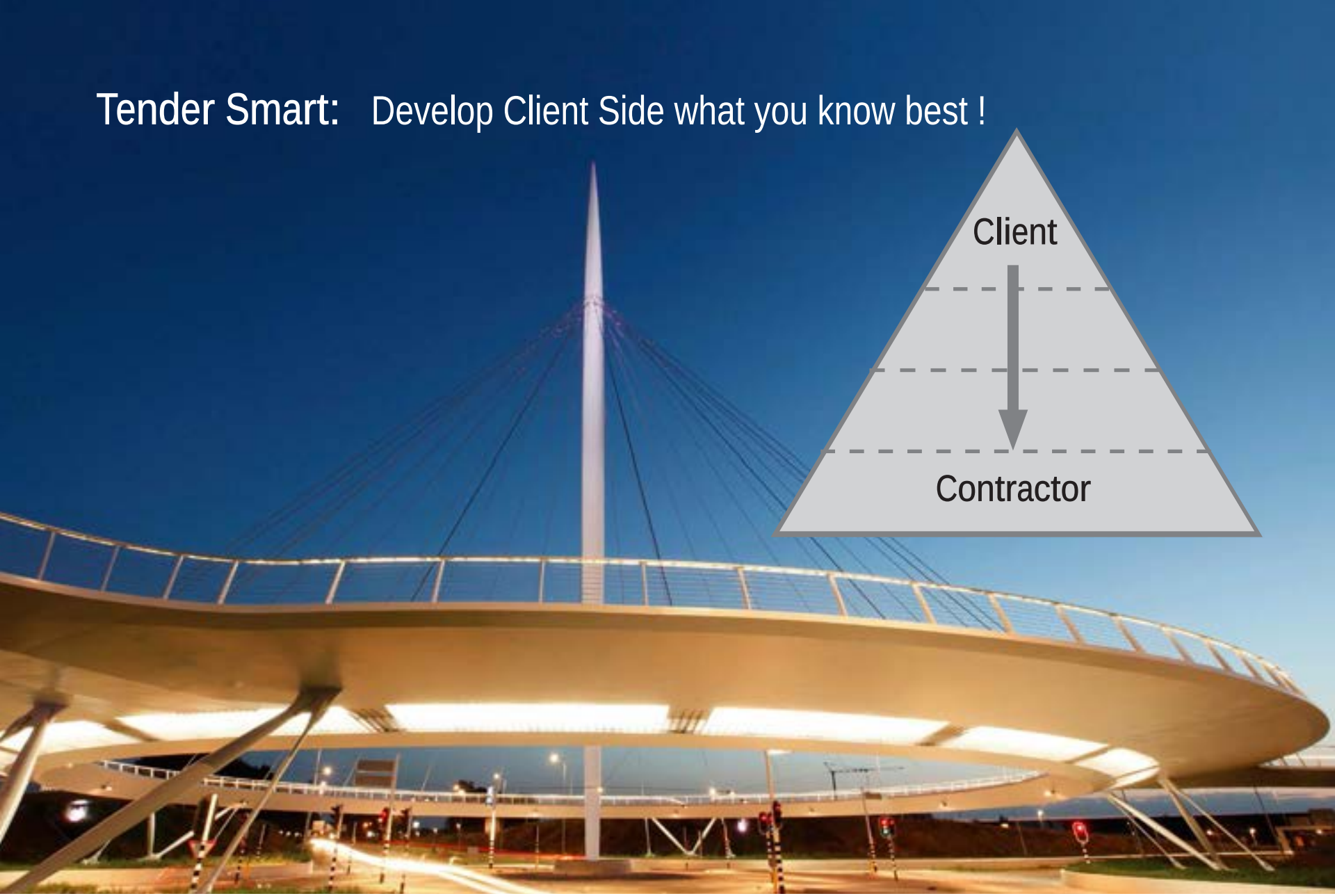
Lighting Design Custom Handrail with Integrated Lighting

Seek Integration !

Users Not intended visitors (Latin American mayor delegation 2017)

Integral Design Integration of traffic lights, lighting and signage

Tender Smart: Develop Client Side what you know best !



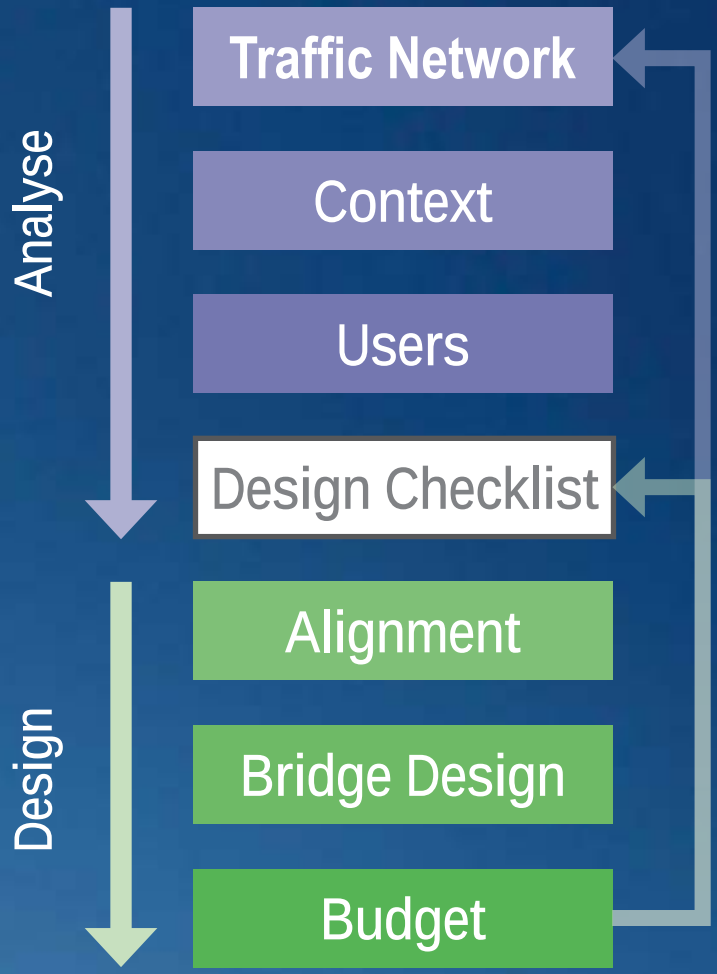
Budget Tender & Contract format

Conclusions

To develop bridges that satify all involved and their requirements:

- Analyse requirements thouroughly
- Involve all from the start
- Create understanding & openess
- Start with the crossings
- Seek Modularity
  Contextual Benefits
  Filters
  Integration
- Outsource Only what you can't do yourself

Be open to practical custom new solutions.
Bridges are almost never standard solutions.
A custom solution can be best and cheapest.



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