RESILIENT TRANSPORTATION SYSTEMS COMPARATIVE CASE STUDY:

Amsterdam Metro North-South Line// Cityringen Nordhavn Extension, Copenhagen

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CONTENTS

BUILT PROJECT

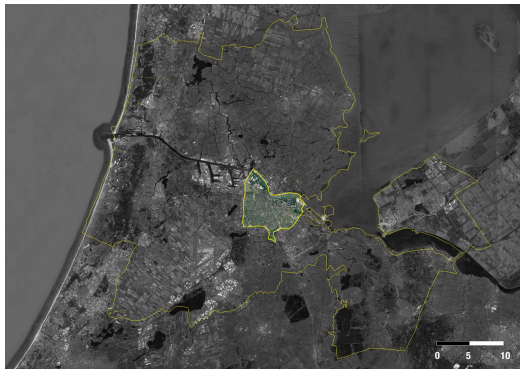
Amsterdam Metro North-South Line

BUILT PROJECT
CONTEXT

GEOGRAPHIC CONTEXT

THE NETHERLANDS
Area: 41,543 km^2
GDP: $826 billion
Population: 17,000,000
People/km^2: 409
% growth since 2000: 7
Avg. Age: 42.1
Household Size: 2.16
% HH with children: 33
% Dutch: 78
Gini Index (WB): .29

AMSTERDAM METROPOLITAN AREA
Area: 2,580.26 km^2
GRP: $156.94 billion
Population: 2,400,000
People/km^2: 930.14



GREATER AMSTERDAM
Area: 219.32 km^2
Population: 833,624
People/km^2: 3,801.3
Avg. Age: 37.55 years
% HH with children: 27.4%
% Dutch: 86.2%
Cars: 8,100,000

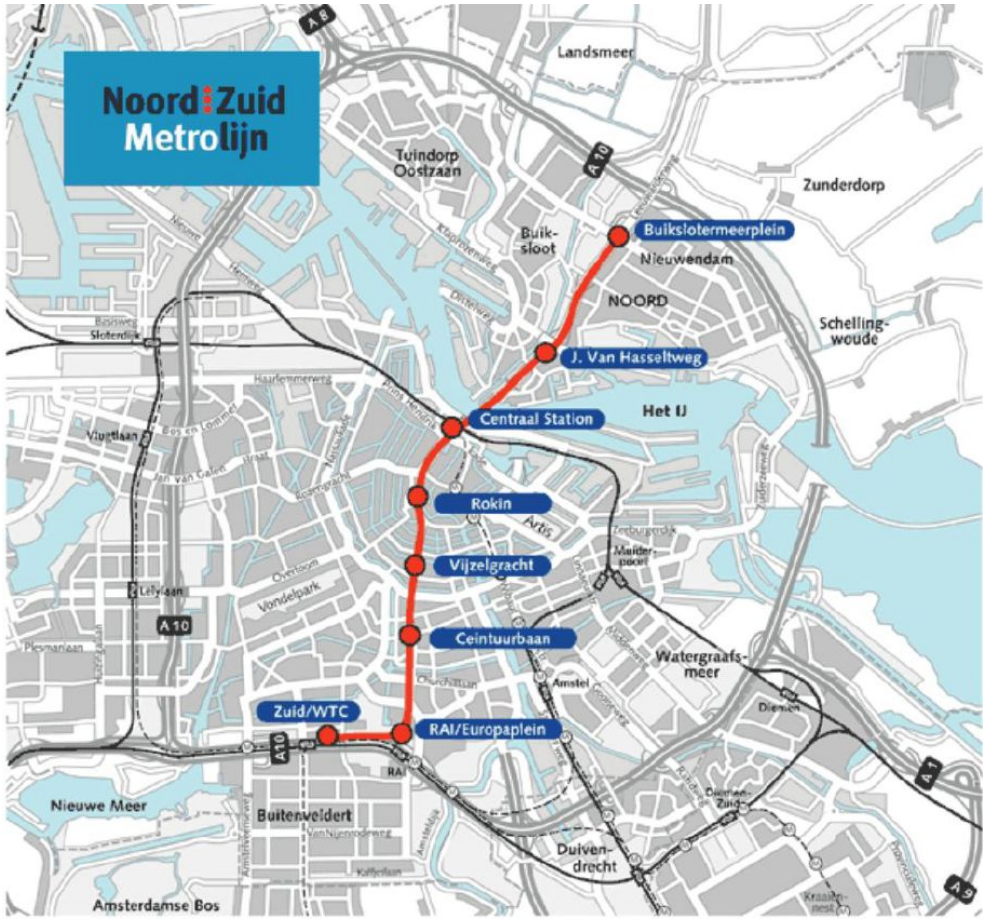
Sources: Wikipedia, https://ugeo.urbistat.com/AdminStat/en/nl/demografia/popolazione/amsterdam/23055764/4

METROPOLITAN TRANSIT

North-South Line

Project Overview

- **What:** A 9.8km long route extension of which a total of 6km will be underground. The route is expected to be 16 minutes. A 4 minute interval service is planned for peak times, reducing 5 minutes during the day, and 10 in the evening.
- **Who:** Dutch Government, Amsterdam Municipality, MTA (GVB)
- **Where:** Between the suburbs north of the River Ij and the Amsterdam Zuid (south) transport interchange.
- **When:** In project since 1968. Construction from 2003-July 22nd, 2018
- **How:** €1.7bn (from Municipal Government)
- **Why:** The new line will provide more direct journey possibilities and provide connections with Amsterdam Centraal hub station and South/WTC railway station by extending line 52 to 80km.



Regional Railway & Roads

3,223 km of track nationwide

408 stations nationwide

11 stations citywide

438 million passengers/year

Tram System

200 km of rail

First opened 1900

500 stops

15 lines

310,958 daily passengers

Metro System

42.7 km of track

5 lines

39 stations

194,000 passengers/day

Cars & Buses

44 bus routes

545 stops

4,808 km of road

About 200,000 cars

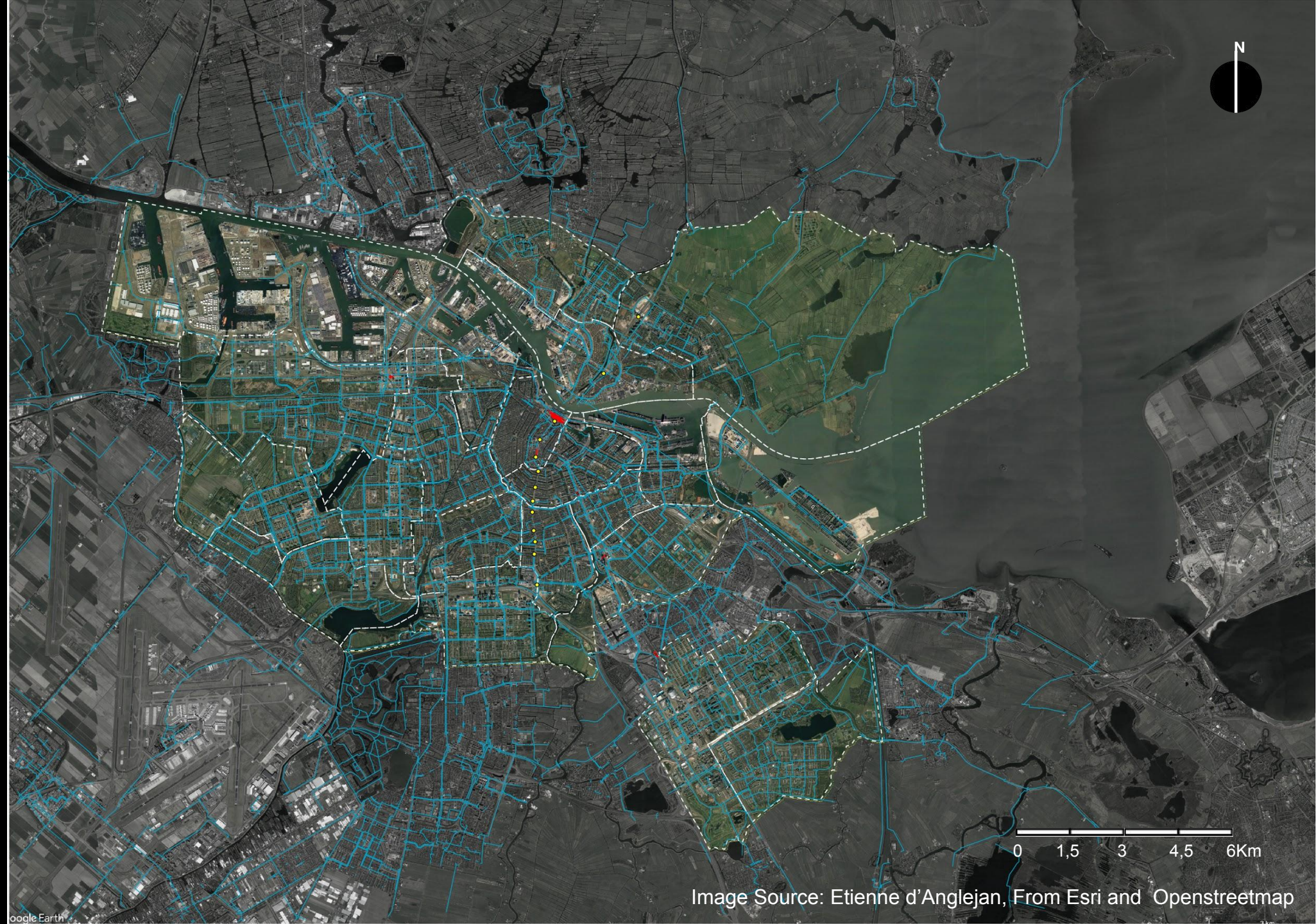
Bikes

767 km of bike lanes/paths

881,000 bikes

Distance: 2,000,000 km/day

Trips: 250-300 cycle trips/year per person



BUILT PROJECT
OVERVIEW

Nord Lijnen:
a metropolitan metro ?

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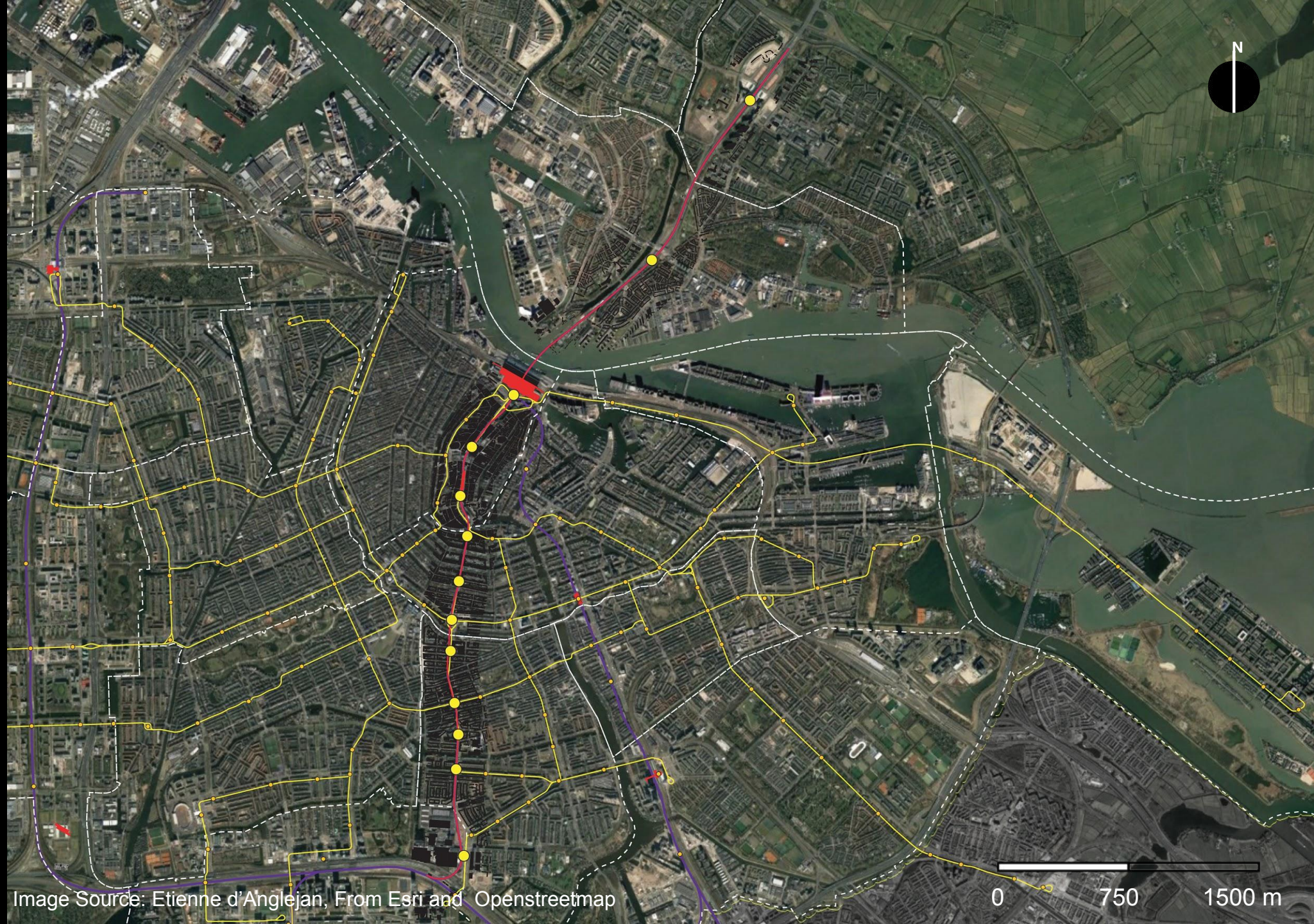
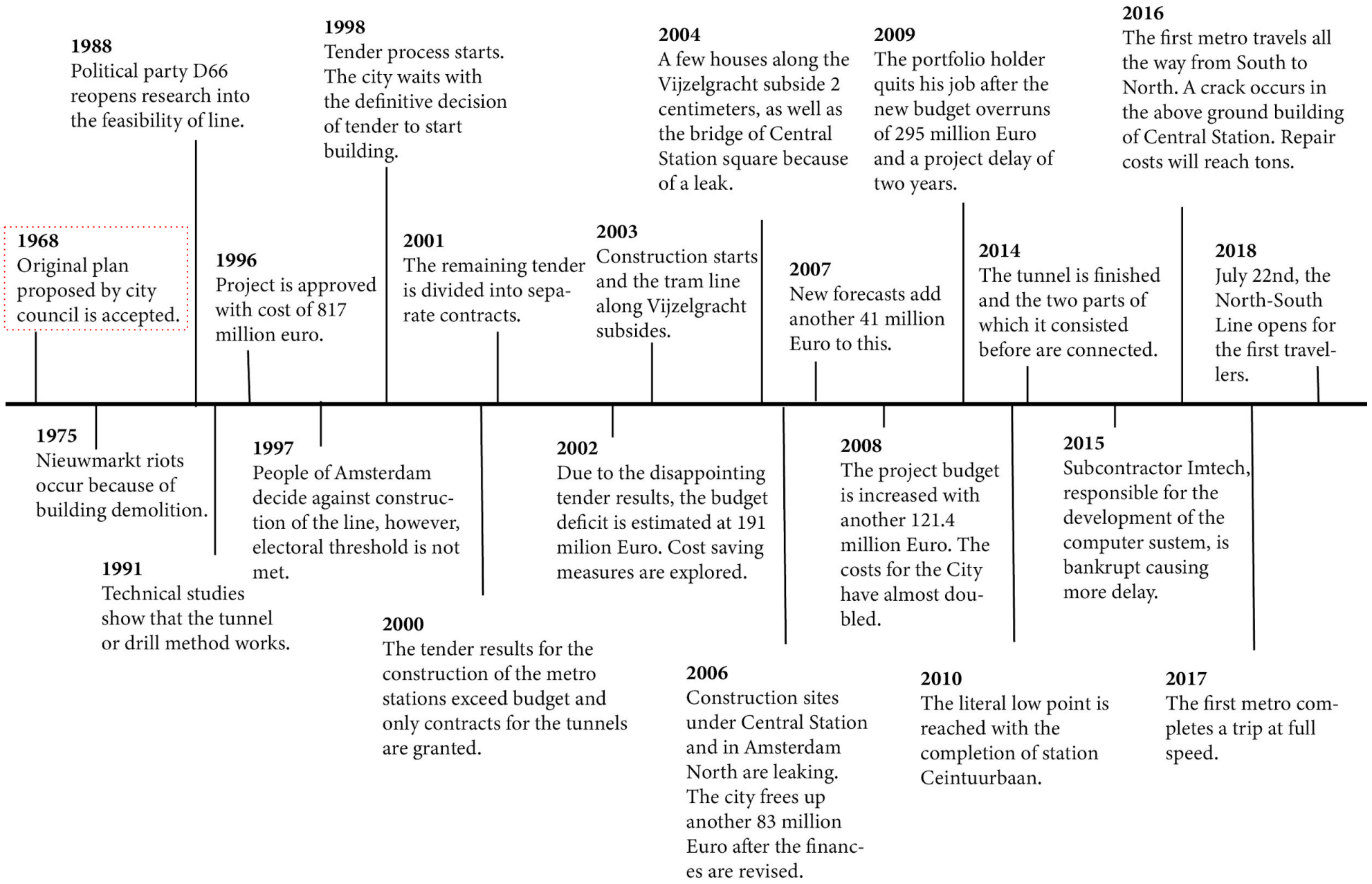


BUILT PROJECT
(UN) FACILITATING ENVIRONMENT

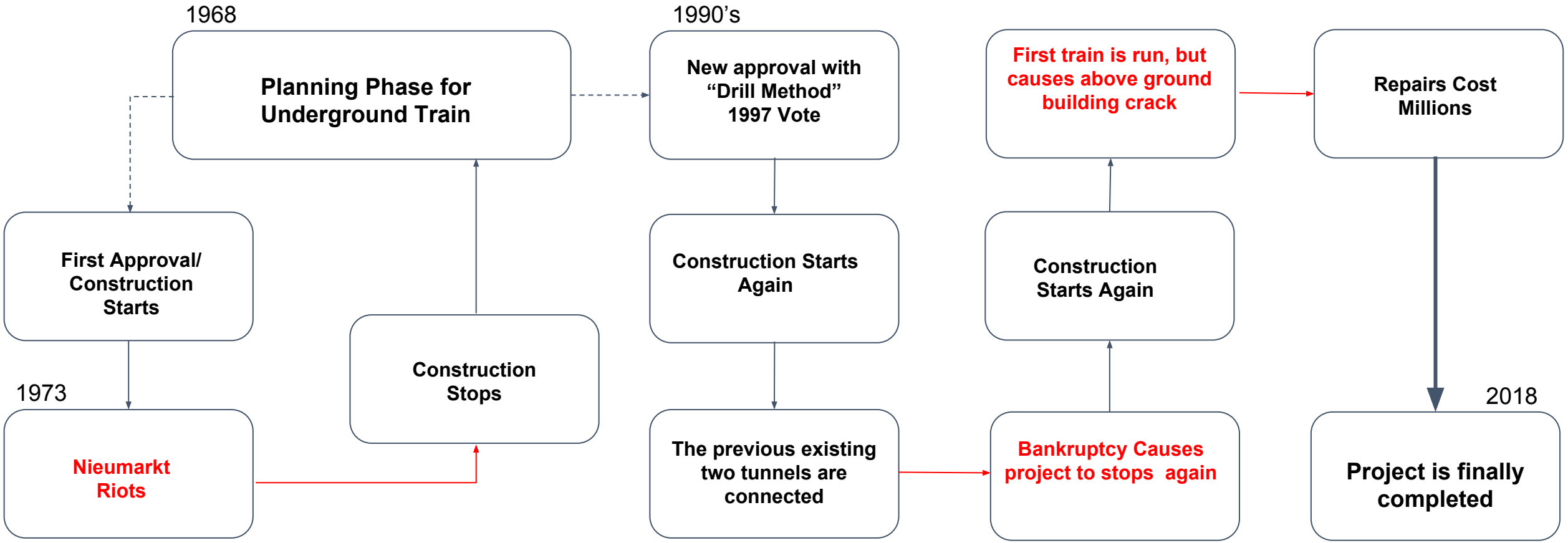
TIMELINE



The planning process took about 35 years, and construction another 15.

PROJECT DELIVERY

Organizational Flow Chart of Major Events



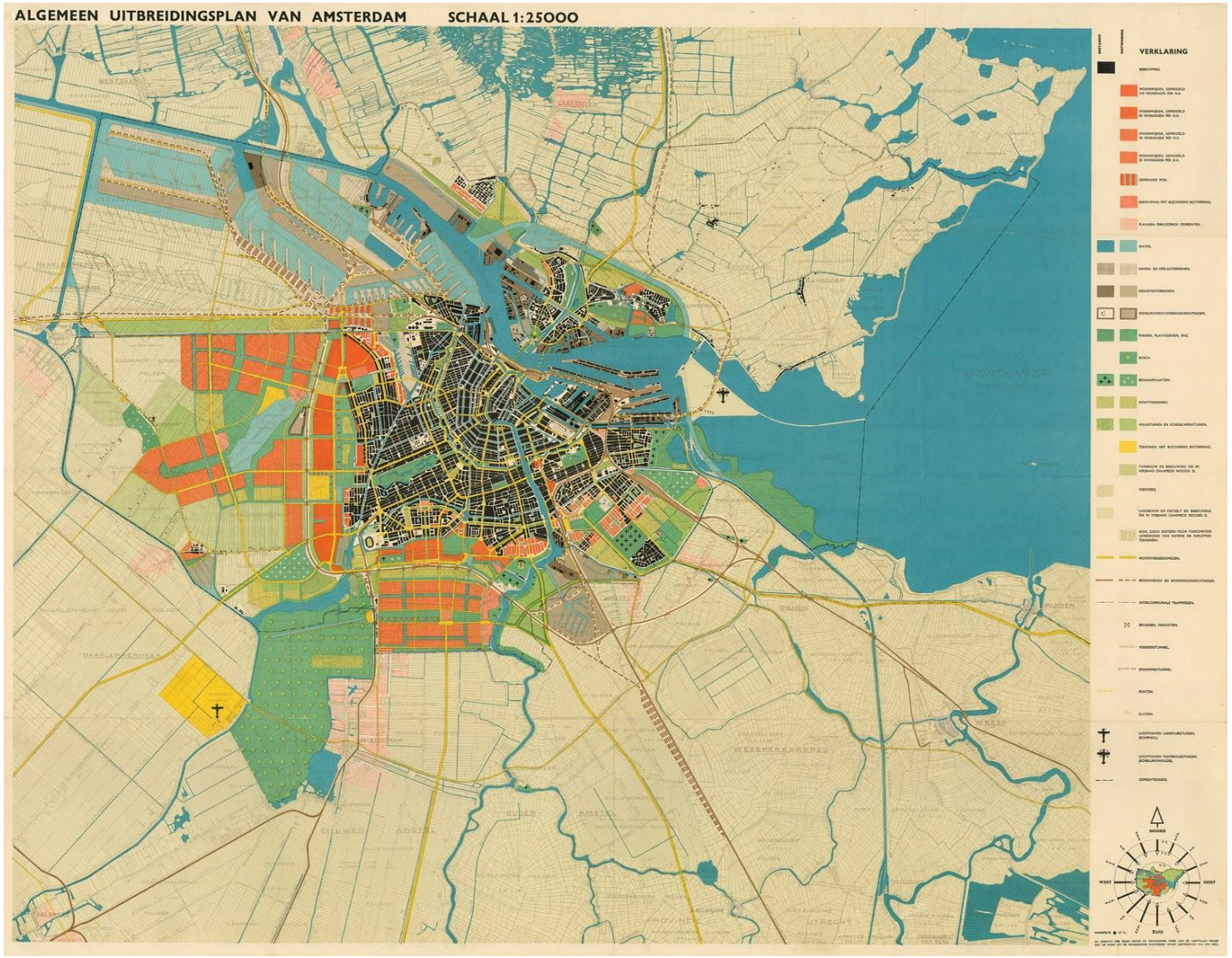
STAKEHOLDERS

View of Affected Stakeholders in Project

1935 EXTENSION PLAN

1935: ‘Deconcentrated concentration” and regional transportation plan

- **Algemeen Uitbreidingsplan Amsterdam, 1935, Cornelis Van Eesteren and Theo van Lohuizen**
    - From the XIXth century, Amsterdam municipality controls urban development thanks to long term leases. Viabilize the soggy soil then lease it to owners and developpers for 100 years. Increased control over city
    - **Modernist plan:**
        - Link urban cores of the country:Rotterdam, Amsterdam, Utrecht et The Hague
        - **building in the direct city fringe rather than building from scratch in the hinterland or with tabula rasa**
        - prospective approach: build the city, **as the population grows**, around housing units of 10.000 inhabitants.
        - **includes a massive amount of natural land within the city** -> Bos woods 980 acres, each neighbourhood unit separated by natural corridor.
        - Centralized “garden city” ?



Sources: http://burobreidablik.blogspot.com/2011/02/structural-vision-2040-of-amsterdam.html
https://nl.wikipedia.org/wiki/Bestand:Algemeen_Uitbreidingsplan_Amsterdam_-_General_Expansion_Plan_for_Amsterdam_(8157209840).jpg

HISTORIC URBAN TRANSFORMATION

1945 -1968: post war coming city facing several disruptions and housing shortage.

- At the end of WW2, Amsterdam, which unlike Rotterdam wasn't destroyed at during the war, faces cruel housing shortage while the port economy faces strong structural disruptions: competition of Rotterdam and Hamburg, economic obsolescence of Amsterdam's canals, transport economy facing decolonization, and difficulties in providing housing for new populations coming from from rural areas.

- In 1953: Zuiderzeee flooding, more than 2000 deads, and monumental destructions. **Delta Plan** across the netherlands, massive investment within impacted areas, promethean protections and land development, agricultural modernization, road connections between cities, and protection of natural areas…

- Construction of new social housing in the outskirts of the city begins in the 60's

Sources: "The Politics of Urban Water….."
https://laboratoireurbanismeinsurrectionnel.blogspot.com/2017/09/amsterdam-en-luttes.html

SHOCKS AND STRESSES

1950-1968: a fast growing city facing several disruptions and housing shortage.

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- **The sixties are a period of strong social contestations**, leading to massive protests in 1968. In Amsterdam left-wing protesters (anarchists, leninists..), street conter-culture movements (hippie boathouse, squatters..) as well as ecological activism are on the rise.

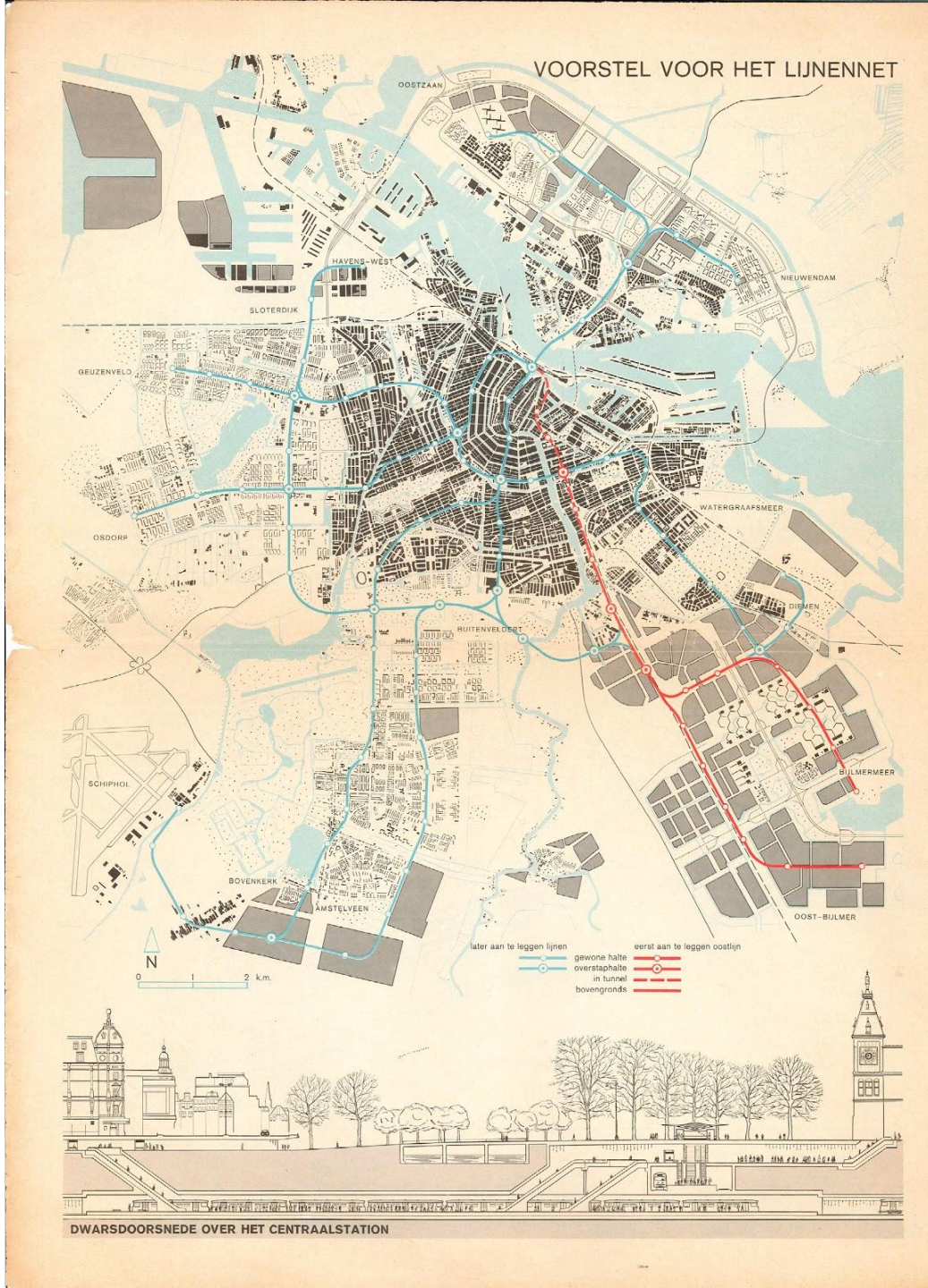
- The city begins the building of new social housing projects, in the fringe of the city, while developping a masterplan for public transportation.

Sources: http://burobreidablik.blogspot.com/2011/02/structural-vision-2040-of-amsterdam.html
https://nl.wikipedia.org/wiki/Bestand:Algemeen_Uitbreidingsplan_Amsterdam_-_General_Expansion_Plan_for_Amsterdam_(8157209840).jpg

1968 TRANSPORT PLAN

Urban Renewal, Standardized Housing, and Metro Transit

- While the city sorely lacks housing, and Amsterdam port suffers the economic backlash of decolonisation,and precoce obsolescence from increased competition with other european port ports, **the city engages in an ambitious politic of urban transformation that includes**:
    - the urban renewal of the historical center
    - massive social housing construction
    - the development of a CBD in the heart of the city
    - the development of transports within the city and at regional scale
- **The project of the the North Line transportation is central to that plan.**
- All of the pre-war buildings that used to be in this area are now gone from Central Station to Amstel station.



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SHOCKS AND STRESSES

1968 - 1975: Housing Crisis and Urban Renewal

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Bijlmermeer | 1975

Bijlmermeer | 1975

Source: https://medium.com/whichway/north-south-timeline-669e5199eeb9
https://laboratoireurbanismeinsurrectionnel.blogspot.com/2017/09/amsterdam-en-luttes.html

SHOCKS AND STRESSES

1968 - 1975: Social Turmoil and Urban Riots

- **The late sixties are a period of profound social contestations and civic claims over the city space in Amsterdam. Social movements crystallize in their opposition to modernist planning and urban renewal.** It leads to massive protests in 1968, in the 70's left-wing protesters (anarchists, squatters…) street counter-culture movements (*nozems,* boathouse hippies...) as well as ecological activism are on the rise in the city.

- **Originally in order to build the underground portion of the North South line, central historic buildings had to be demolished** in order to place the large tunnels under the ground where the future train would run, and develop a business district in the hsitoric popular city center. Outraged citizens, many of whom saw no point to destroying part of the historic city of Amsterdam to construct an underground train protested, this led to the **Nieuwmarkt Riots.**

- Oil Crisis in the seventies (25% of unemployment between the end of 1979 and 1983) the city engages in an ambitious politic of urban renewal, and begin the construction of the North Line transportation systems.

Source: https://medium.com/whichway/north-south-timeline-669e5199eeb9

"Geen Buizen Maar Huizen!" - "not a subway houses"

Nieuwmarkt RIots in the City Center, 1973

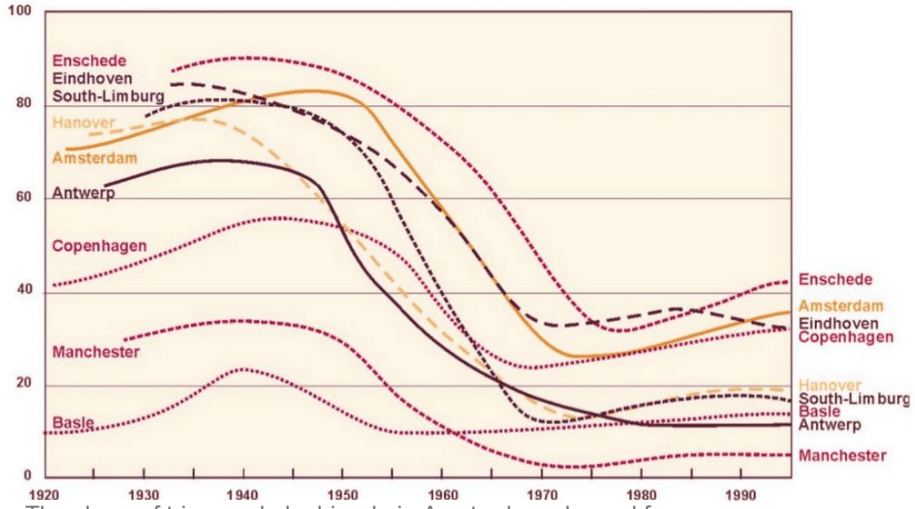
SHOCKS AND STRESSES

1970's: Ecological Activism: the case of "Stop de Kindermoord"

Stop de Kindermoord happening 1972

- While Amsterdam is generally seen as a bycicle friendly city, the modernist plan radically transformed mobilities. "Stop de Kindermoord" (literally "Stop the death of our children" is a movement that rises from strong concern about cars dangers.

- Birth of "urban environmentalism" in Amsterdam.



The share of trips made by bicycle in Amsterdam plunged from 80% to 20% between the 1950s and 70s

Source: https://medium.com/whichway/north-south-timeline-669e5199eeb9
https://www.theguardian.com/cities/2015/may/05/amsterdam-bicycle-capital-world-transport-cycling-kindermoord#img-2

SHOCKS AND STRESSES

1970's - 2000's: Claims over city space: Squatters and 'hippie boats"

"Fight for your housing rights. Stop the squatting ban", Amsterdam, 2006

A former barge converted to houseboat duty along a canal in Amsterdam

Sources: https://www.oapen.org/view?docId=608061.xhtml
http://www.bbc.com/autos/story/20160601-welcome-aboard-your-next-home

BOUNCING FORWARD

The soggy soil issue: technological Improvement and the North Metro Connection

- Since the city of Amsterdam decided that it would follow through with building no more new metro lines after 1975 due to the Nieuwmarkt riots, it was a long time before the North-South Line could be completed. The city was facing a major technological challenge: how to drill within the underground without putting the city at risk.

- The city needed a new way to build the underground that didn't involve any above ground demolition.
- This new way of building finally came about with the development of the **"tunnel"** or **"drill method"** in 1991.
    - With the new method however, there was still worry that drilling below ground would still cause demolition to what was above ground.
    - After further investigation however, it was found that 90-95% of the homes would not need new foundations.

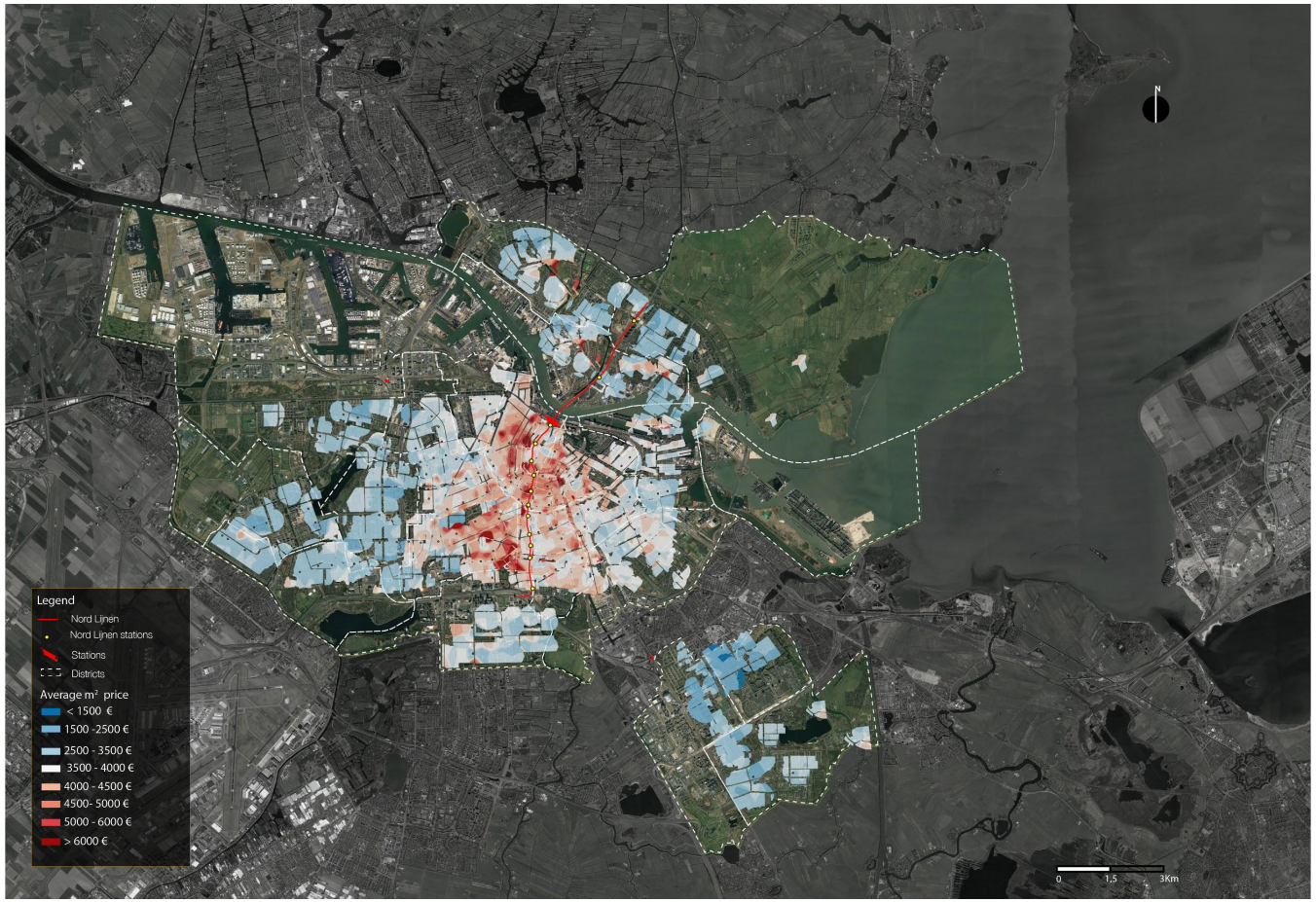
Tunnel in soggy soil

Source: https://medium.com/whichway/north-south-timeline-669e5199eeb9

BOUNCING FORWARD

The 2000's:
Cheap Land and opportunities: brownlands, waterfront redevlopment and the "rent - gap"

- **While the state finally sell his public housing park to social landlords, and while P.P.P in funding and developping urban project are on the rise, cheap land development in outskirts and in the industrialized neighbourhoods appear as an increasingly interesting investment for new urban projects: CBD, mixed used neighbourhoods programs, cultural institutions.**



Average land price in 2017 in Amsterdam

Sources: OSM/GoogleSat/Amsterdam Open Geo Data/ BBGA (Census Data)

BOUNCING FORWARD

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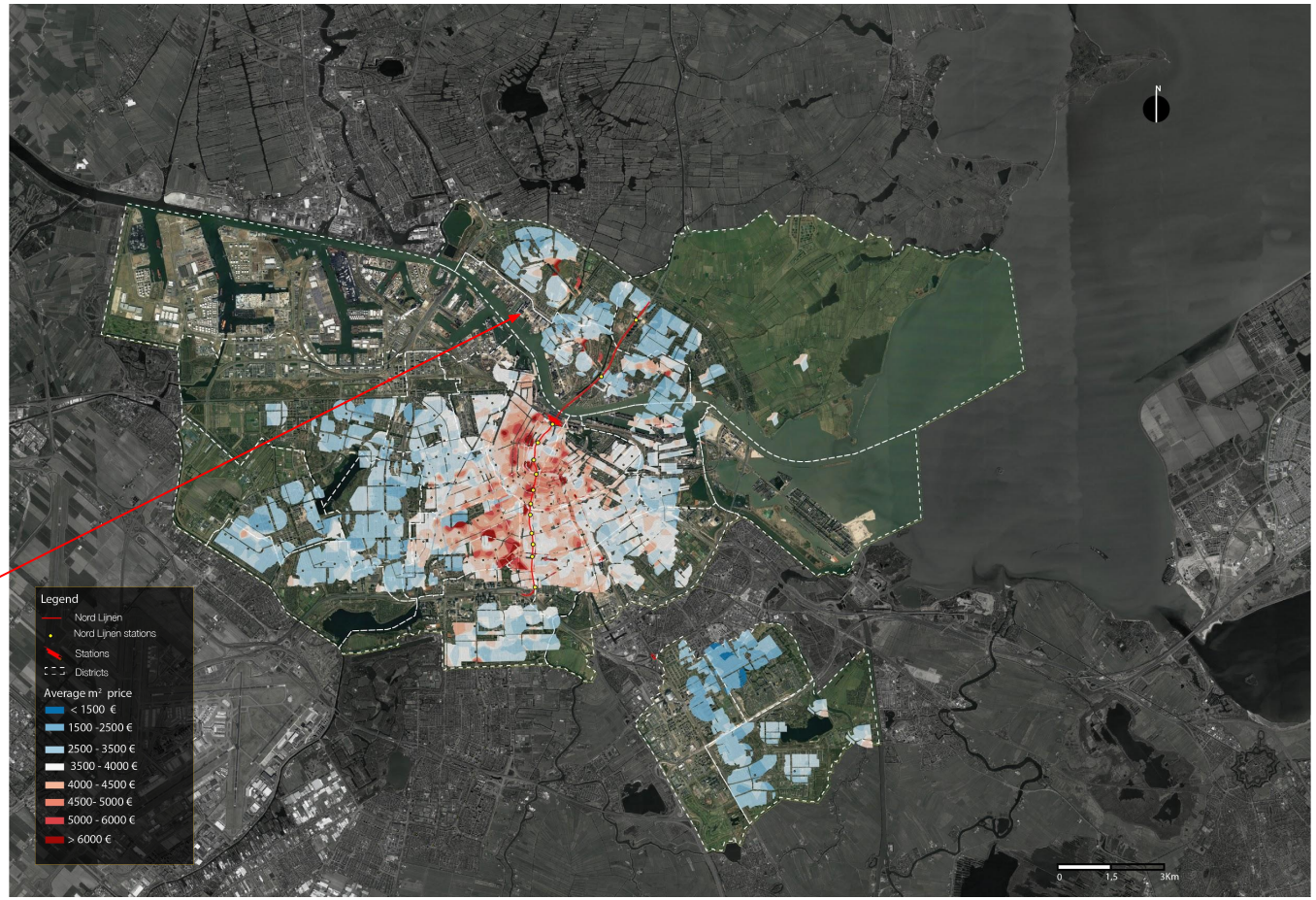
NDSM Mixed Use Neighbourhood,
around a former shipyard.



Average land price in 2017 in Amsterdam

Sources: OSM/GoogleSat/Amsterdam Open Geo Data/ BBGA (Census Data)
https://www.parool.nl/amsterdam/onderzeeer-foxtrot-moet-nu-echt-weg-bij-ndsm-werf~a4508042/

BOUNCING FORWARD

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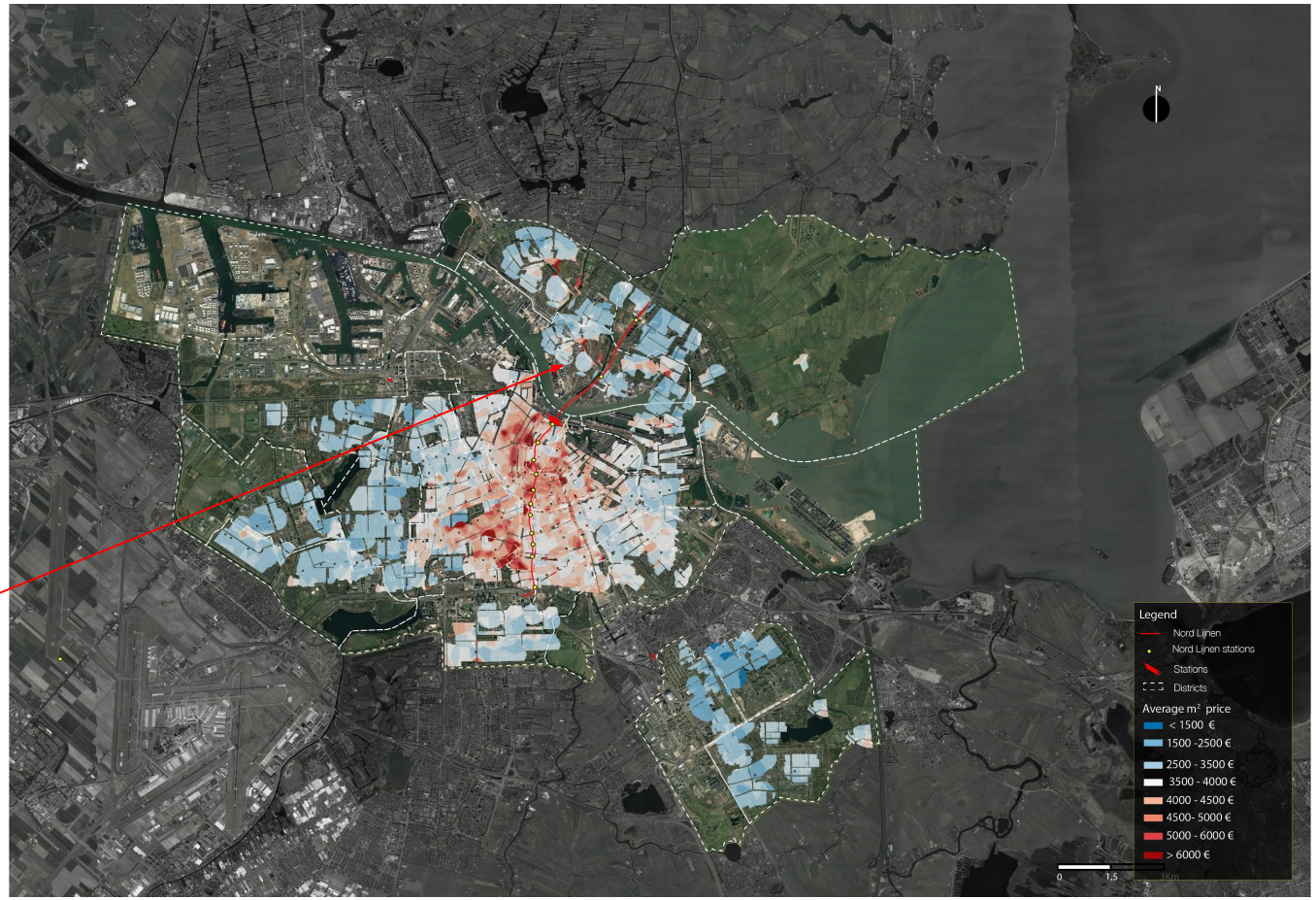
The Eye Film Institute



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Sources: OSM/GoogleSat/Amsterdam Open Geo Data/ BBGA (Census Data)
https://www.timeout.com/amsterdam/cinemas/eye-film-institute

BOUNCING FORWARD

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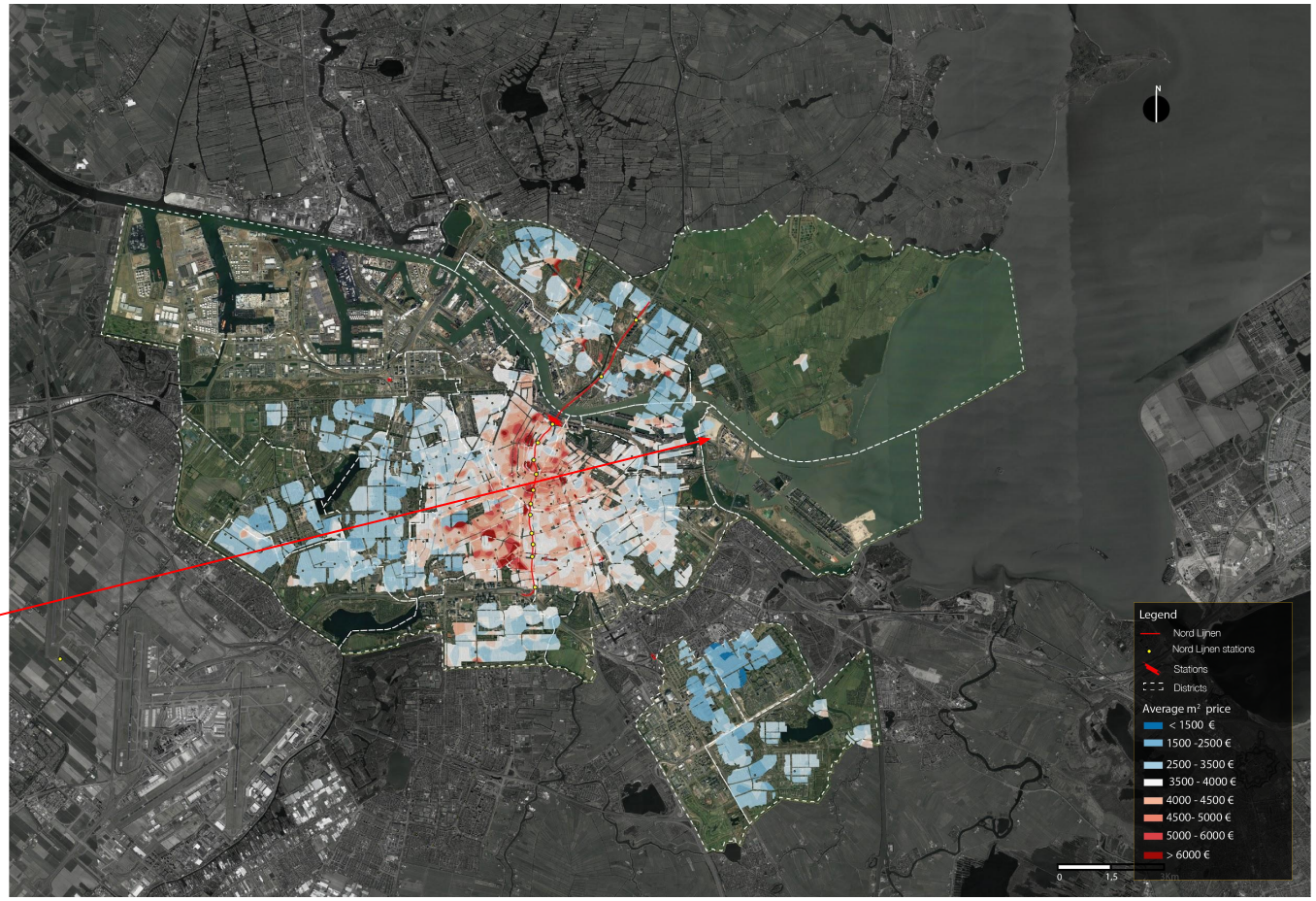
Ijburg Floating Neighbourhood



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BOUNCING FORWARD

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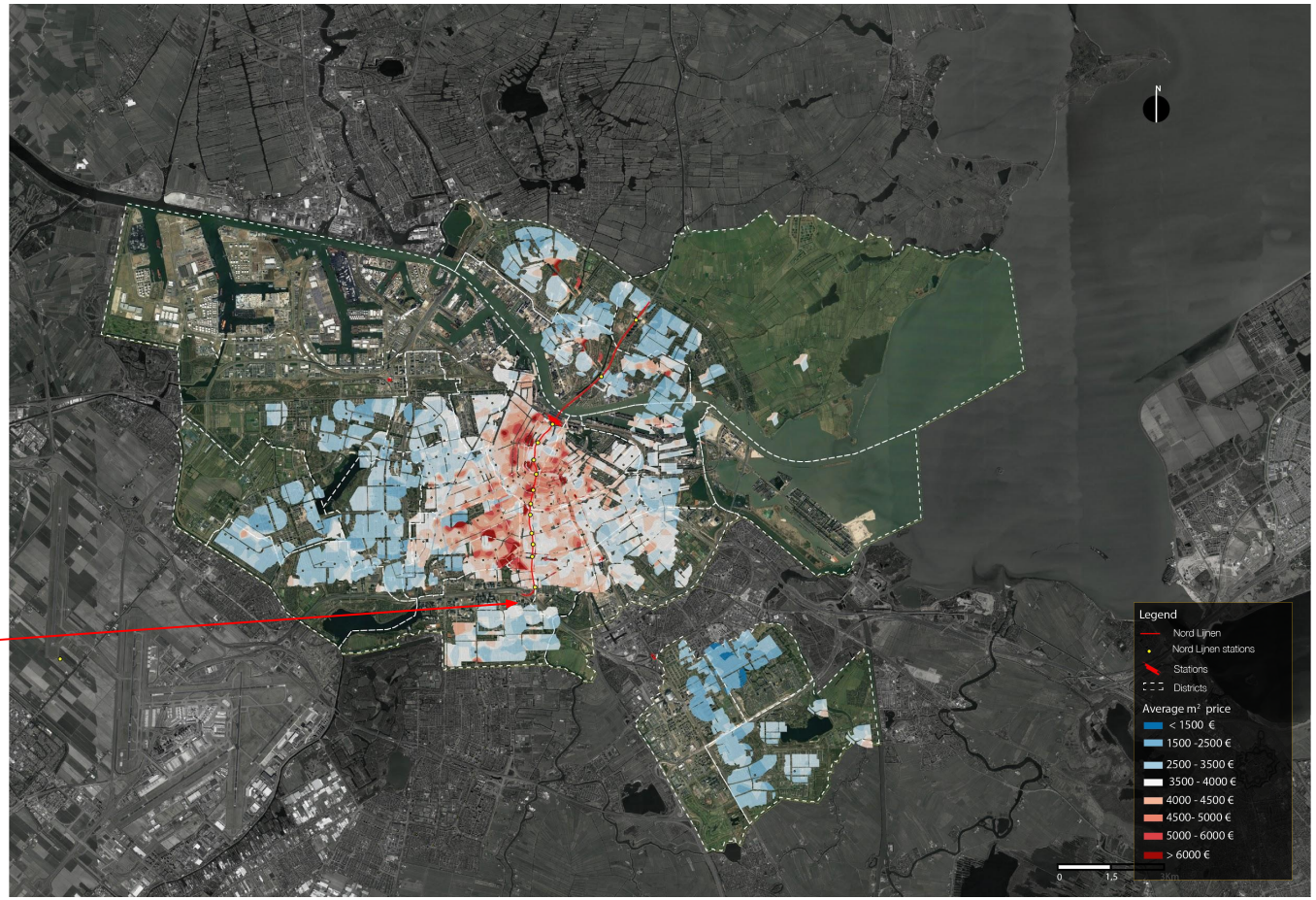
Zuidas CBD



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BOUNCING FORWARD

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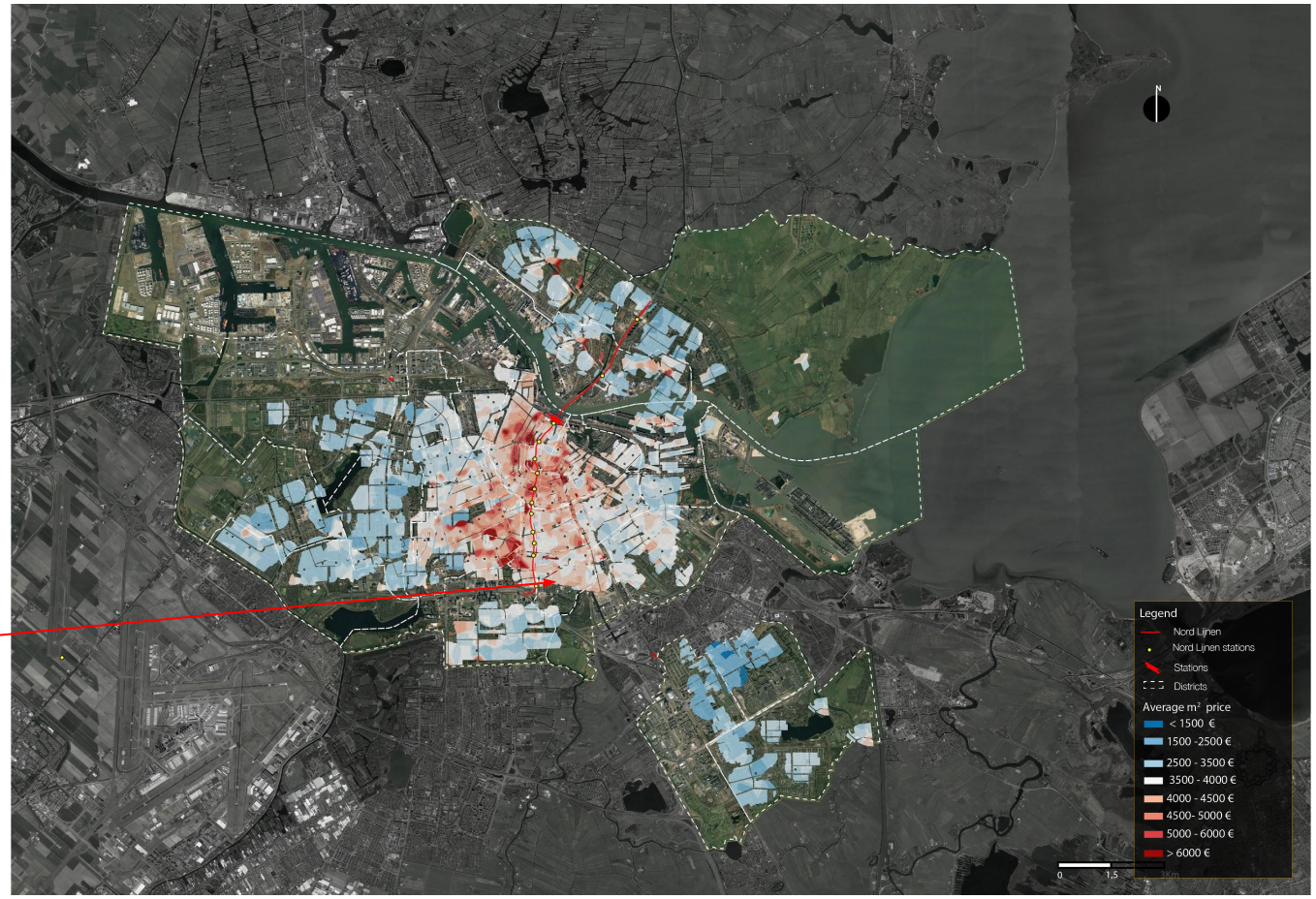
RAI Center + Amstel District



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https://www.archdaily.com/147339/elicium-rai-benthem-crouwel-architekten/5014c18828ba0d58280002b8-elicium-rai-benthem-crouwel-architekten-image

BOUNCING FORWARD

Ecological Activists, Right to the City and Redevlopment.

- **Culture of “consensus:” large representation of the citizens, vote as tool of approval.**

- Paradoxically, by pushing against car transportation and defending the historical center, ecological activists subsequently made it easier for the city to justify the new North Line transportation project. It allows the project process to “bounce forward” at the beginning of the 2000’s, as this would allow lower car traffic and easier bikers commutes, **besides a strong opposition 1997’s vote open the path to the completion of the North Line Transportation Project.**

- Squatters as well as boat dwellers (initially installed on boats because canal weren’t subject to land use restriction) developed new ways of living and relating to the des-industrialized neighbourhoods, along the de-sindustrialised banks… and involuntarily created the opportunity for transformation and new developments, among those neighbourhoods.**Those development increased the necessity for a robust and efficient transportation system.**

The Ijselburg district and natural reserve, eastward of the city center. Planned in 1997, initially criticised for destroying natural infrastructures, consensus over the creation of a natural reserve, and now place of experientation of floating houses dwellings.

Sources: https://www.parool.nl/amsterdam/amsterdam-onbewolkt-de-tweede-fase-van-ijburg~a4350352/

K. Kimber, “The politics of Urban Water - Changing Waterscapes in Amsterdam” The University of Georgia Press, Athens (Ge. U.S), 2015

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BOUNCING FORWARD

Citizens involvement and urban redevolpment: from “riots” to counter-cultural vibrancy.

- Post industrialized squatted neighbourhoods become the home of a vibrant counter cultures, and a fertile ground for creative/intellectual professions, and home to talented designers and artists.
- The city conserved historic center, object of a sharp citizen stewardship, becomes a major tourist attraction in the wake of globalization, that movement gained momentum in the past 20 years: increased investments, massive congestion and “bnbfication” of the city center.
- Amsterdam’s enhanced tolerance becomes an attractor: for instance during the 1990’s, queer and LGBT movements start to appropriate the waterscape through barge parades.
- **Renewed interest in developping those neighbourhoods: from cultural contestation to land devlopment.**

Gay prides in Amsterdam

Image sources; https://www.coffeeshopdirect.com/forum/viewtopic.php?t=35702
https://goo.gl/images/UTxedj
https://www.iamsterdam.com/en/see-and-do/whats-on/gayamsterdam/areas

BOUNCING FORWARD

Historical Findings from Drilling in Oil Soil

- Drilling in the historic center of Amsterdam implied dealing with historic remnants: buildings built on wood piles as well as object found in the construction process. One can consider such finding an additional stress in an already complicated process.
- 700,000 objects were found during the construction processArchaeologists dug up everything from pot shards to hash pipes and from Nokia 3310’s to coins. These objects emerged from the construction pits on Damrak and Rokin.
- These items have since been preserved as seen to the right.You can see these objects in two displays containing 10,000 objects that have been integrated to the stations.

NZD1.00540KST009
LxW:85x54

NZD1.00009KST001 L:47
0:28


NZD1.00418MTL072 0:18


NZD1.00374MIX001
LxWxH:110x65x30

NZD1.00469MTL116 0:18


NZD1.00029CER042

NZD1.00613GLS003 H:203

NZR2.00052CER013 H:45
0:30


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NZD1.00637MTL033
LxWxH:120x25x9


NZD1.00047KSC001


NZD1.00043MTL015
LxWxT:55x20x14


NZD1.00095KSC001


NZR2.00516MTL119
LxWxH:43x41x22

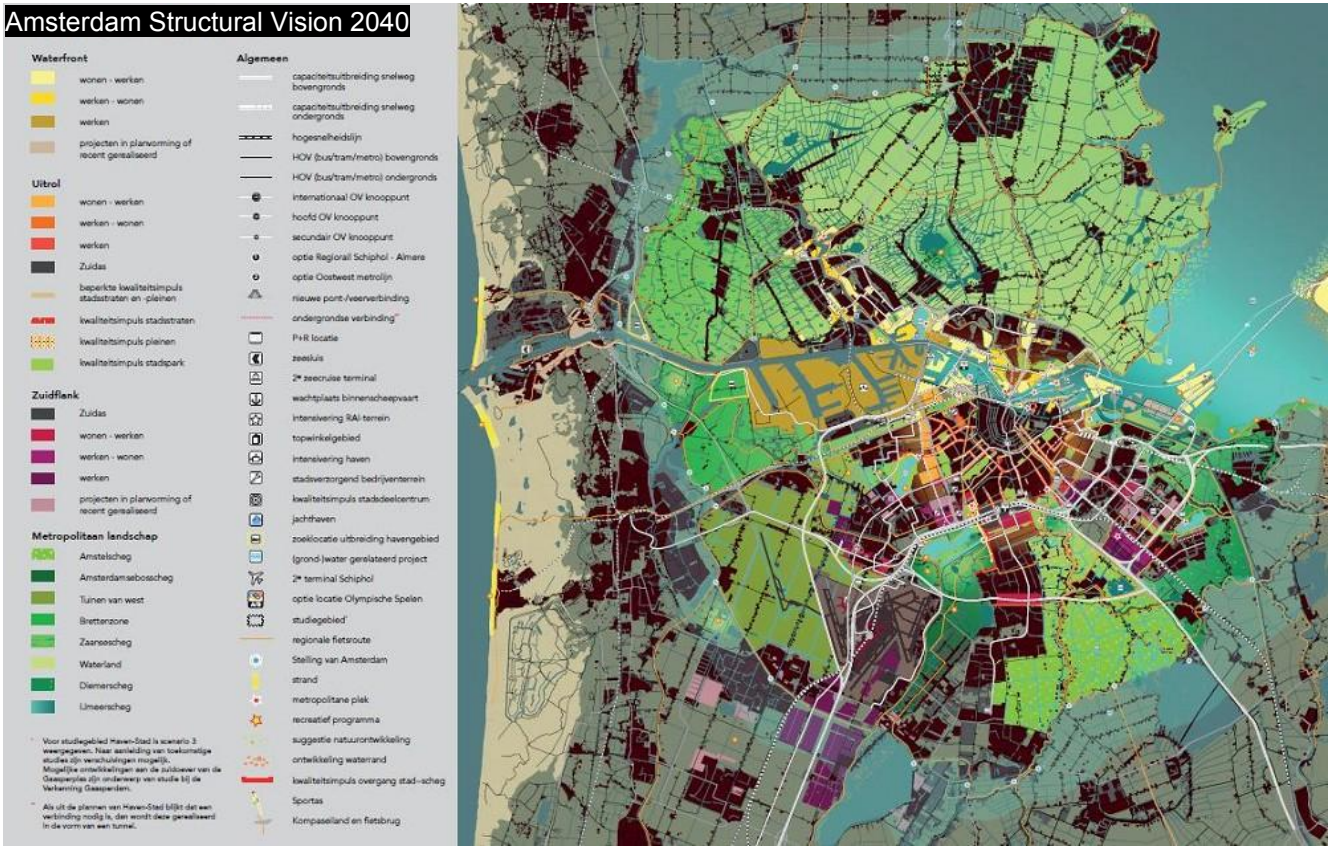

NZD1.00393PLT002
LxWxT:39x30x21

Source: https://heavenly-holland.com/north-south-line-amsterdam/

FACILITATING ENVIRONMENT

A Strategic Master Plan: Amsterdam Structural Vision 2040

- From the modernist Masterplan based on fonctionnal zoning (working,living, leisure), to peri-urban sprawl, to a strategic plan aiming to densify, redevelop and repurpose the city around the historic center and includes:
  - **Plan for a Compact metropolis within the A10 ring:** (“Rolling out the City Center”)
  - **Keep on redevelopping the waterfront and particularly the industrial brownlands** inherited from functionnalist planning around mix-use neighbourhoods: work and live, live and work.
  - **Enhance the link between the metropolis and its ecological infrastructures** (which means densification instead of Sprawl)
  - **Develop and internationalize Zuidas Neighbourhood**, providing it fast public and local/global transport connection (RandStadt, Schipol Airport, and North Metro Line: Infrastructure corridor.



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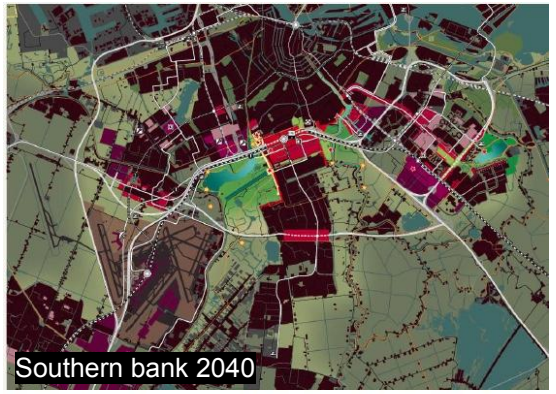
FACILITATING ENVIRONMENT

A Strategic Master Plan: 6 axes of Structural Vision 2040

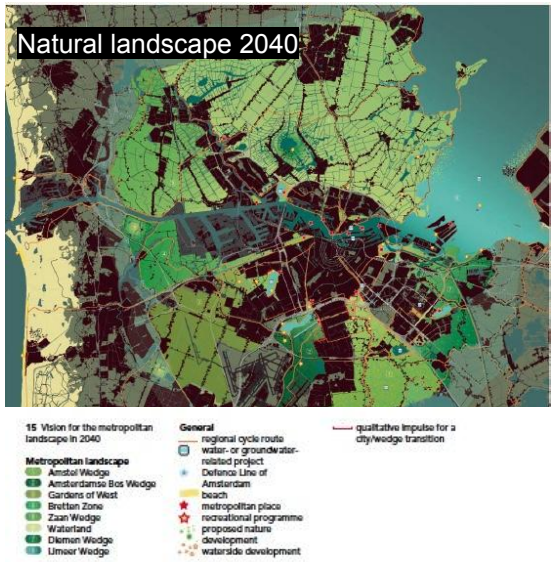


6 POINTS

1. **Densify**
2. **Transform**
3. **Public transport on a regional scale**
4. **High quality layout of public space**
5. **Invest in the recreational use of green space and water**
6. **Converting to sustainable energy**

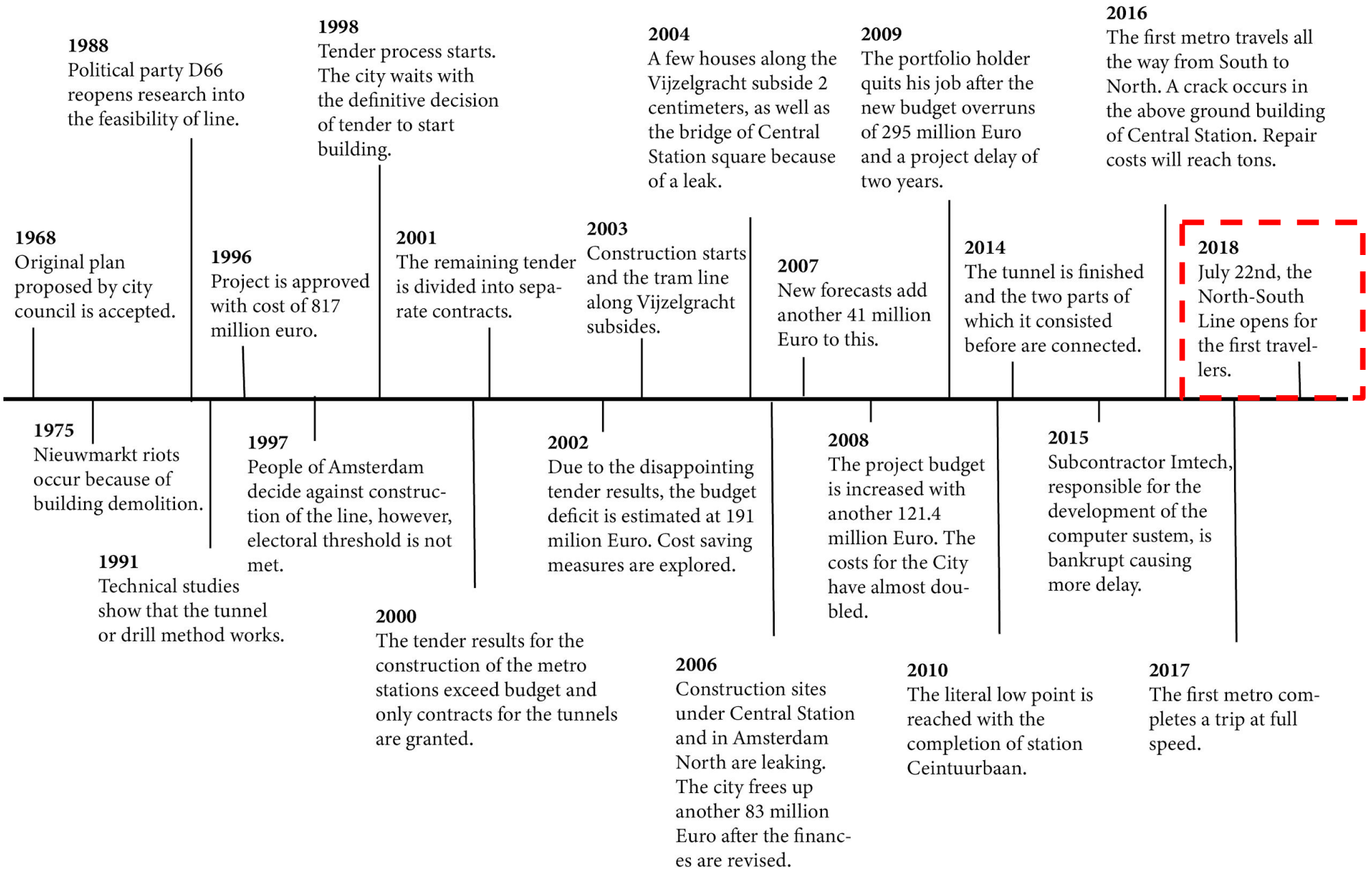
City Council Approach:

"The Structural Vision is not a book of pipe dreams, but articulates the ambitions of Amsterdam City Council, which sees opportunities for the city to grow and become stronger even in less prosperous times. Ambitions can, however, only be fulfilled if they result in concrete plans, in the awareness that it is impossible to do everything everywhere all at once."



Sources: http://burobreidablik.blogspot.com/2011/02/structural-vision-2040-of-amsterdam.html
https://nl.wikipedia.org/wiki/Bestand:Algemeen_Uitbreidingsplan_Amsterdam_-_General_Expansion_Plan_for_Amsterdam_(8157209840).jpg

TIMELINE

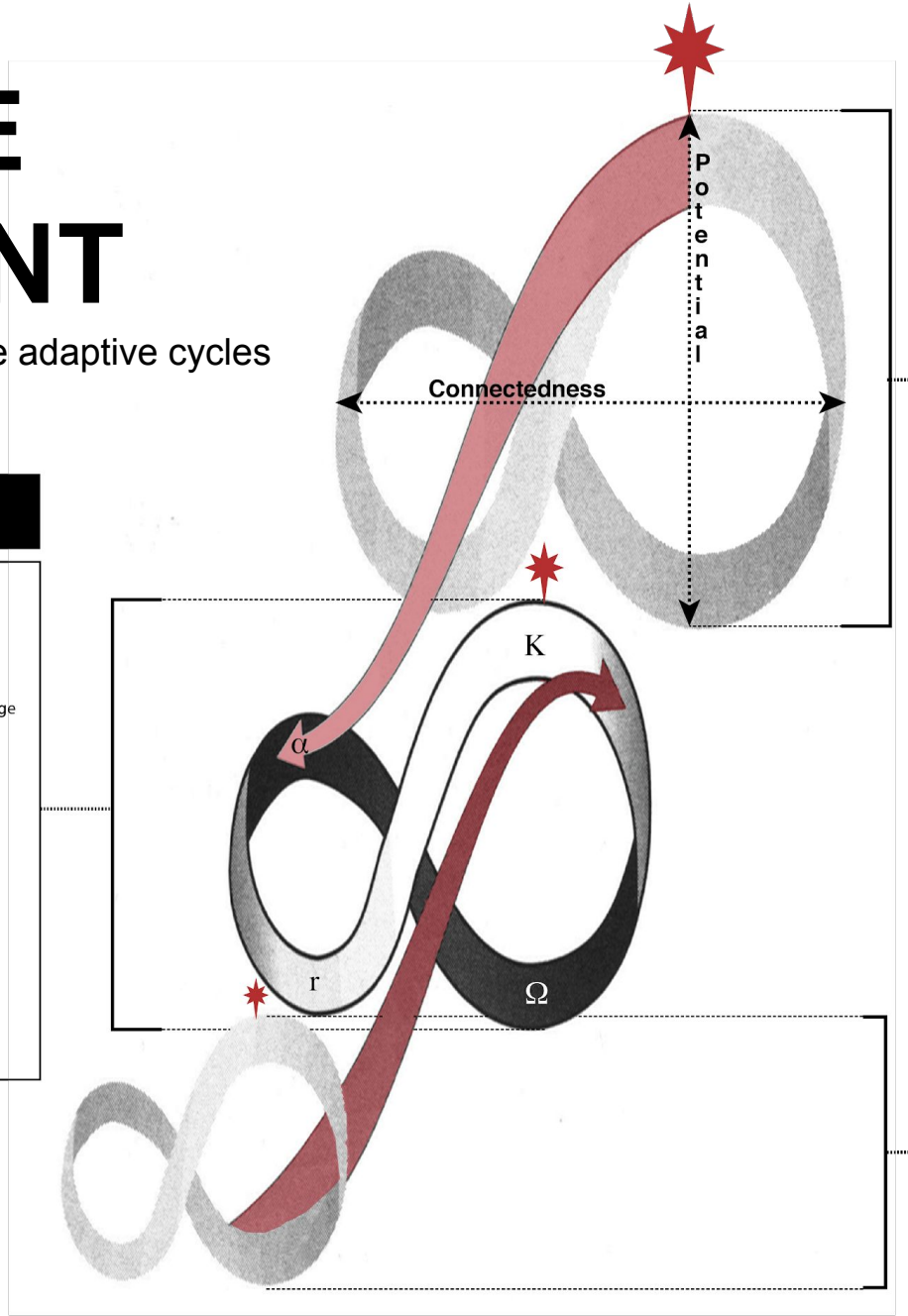


The planning process took about 35 years, and construction another 15.

BUILT PROJECT
RESILIENCE ASSESSMENT

RESILIENCE ASSESSMENT

Project Implementation, shocks and the adaptive cycles



North Line Metro Construction
1968 - 2018

- α **Reorganisation Phase**
  - 1968 Plan
- r **Exploitation Phase:**
  - Social Housing construct° in the fringe
  - Massive public investment
- K **Conservation Phase:**
  - Urban Renewal
  - Hegemonic roads importance
  - 1968 plan unfolds
- ✸ **Rigidity Trap / «Collapse»**
  - Historic center at risk
  - Technological mismatch
  - Buildings collapse
  - Construction stops
- Ω **Release Phase**
  - Social turmoil
  - Counter culture & new land uses
  - Technological Improvements

Amsterdam Evolution
1945 - 2018

- r **Exploitation Phase:**
  - Modernist Plan
  - Industrialisation
- K **Conservation Phase:**
  - Post War City Growth
  - Ind. Port Obsolescence
- ✸ **Rigidity Trap / «Collapse»**
  - Housing Shortage
  - Desindustrialistation
  - Congestion
- Ω **Release Phase**
  - 1968 Plan; transport + dwelling
  - Destruction + Reconstruction
  - Civic protest/ eco. stewardship
- α **Reorganisation Phase**
  - Consensus
  - Cheap Land: rent gap
  - P.P.P. and redevelopment

Civic and ecological involvment
1973 - 2000

- Ω **Release Phase**
  - Nieuwmarkt Riots
- α **Reorganisation Phase**
  - Squats, boat dwellers
  - Ecological stewardship
  - Transportat° contestation
- r **Exploitation Phase:**
  - New uses in desindustrialised areas along the North Line
  - Counter culture & creativeness
- K **Conservation Phase:**
  - Neighbourhoods vibrancy
  - Culture of consensus in U. P.
  - Redevlopment
- ✸ **Rigidity Trap / «Collapse»**
  - Gentrification
  - Mass tourism in city cenetr

RESILIENCE ASSESSMENT

Project profile

REDUNDANT	+ Efficient multi-modal system,wide of transp (metro, ferries, bus, bycicle ..): i. e. if failure, a + Parking allow to parks cars in the fringes of
RESOURCEFUL	+ Building technique is astonishing, and allo implement an efficient transportation syste + Historical findings and parks were integrate
REFLECTIVE	+As an historical and politica process, the me tion process took into account the initial sy tion, top down agenda..) + This allowed the system to bounce forward
FLEXIBLE	+ Mainly Hard Infrastructure but also integra functions: museum for instance. + Important Socio Ecological infrastructures a
ROBUST	+ The drilling method appears adaptated anc ground. + Yet by allowing an increased development a the project coul mechanically augment bioph
INCLUSIVE	+/- Yet to be determined. Will it benefit to sma the most vulnerables population ?
INTEGRATED	+ Economic development + Zuidas and Noor at regional and international level. +/- will this development integrate the inhabi

BUILT PROJECT
IMPACTS/LESSONS LEARNED

9.8 km Length of Extension

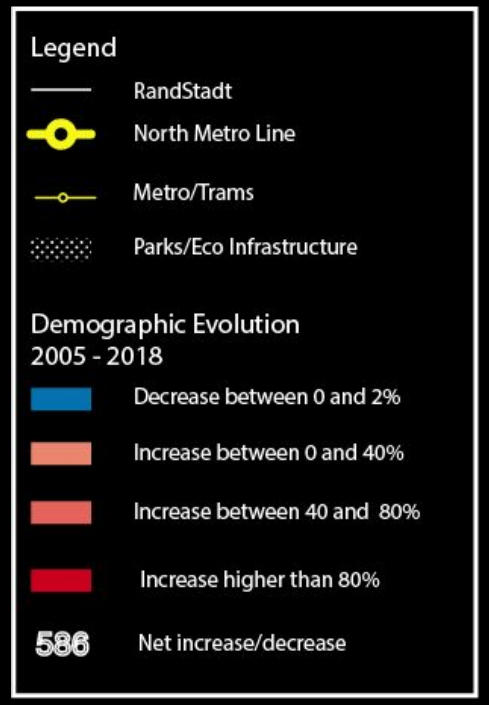
16 minutes Trip Length

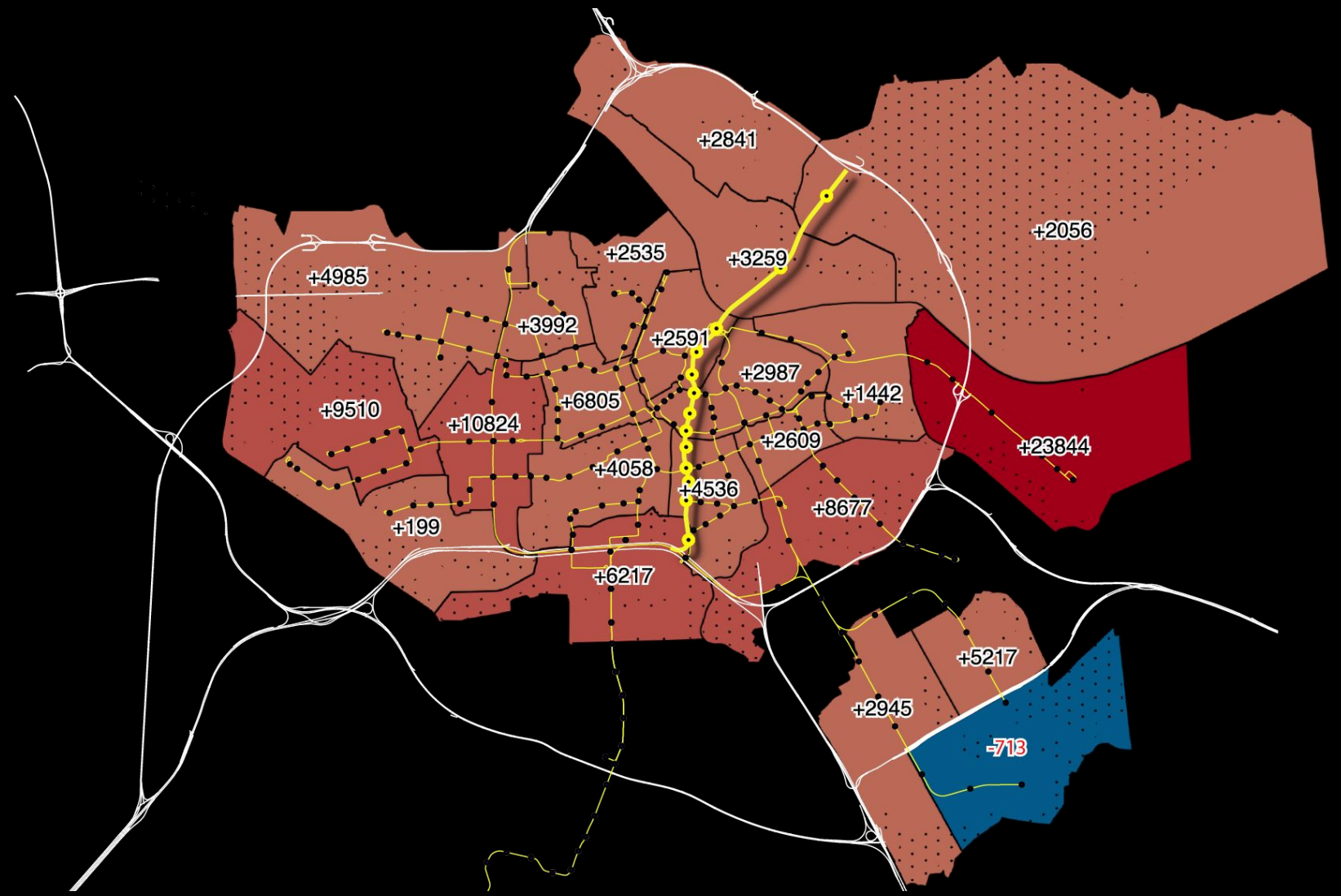
4, 5, 10 minutes Interval between trains for Peak, Daytime, and Evening

€1.7 bn Project Costs

IMPACT

Nord Lijnen as a Compact City Enhancer





Demographic evolution from 2005 to 2015: Amsterdam is expected to grow (only) from 100,000 to 150,000 inhabitants between 2011 and 2040.

0 1,5 3Km

Source: Amsterdam Open Geodata / OSM / BBGA Database (Census from 2005 on)

IMPACT

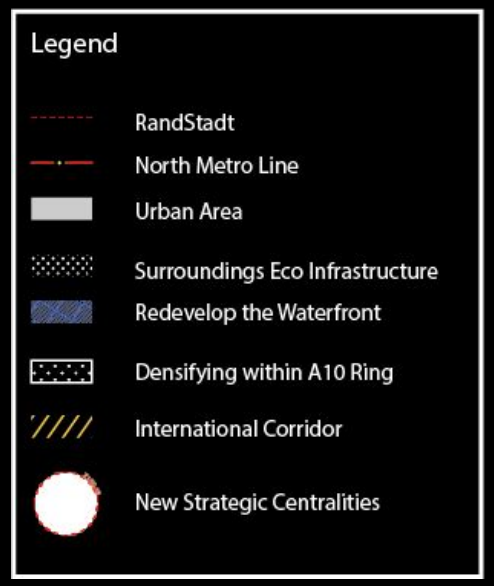
Nord Lijnen as a Compact City Enhancer

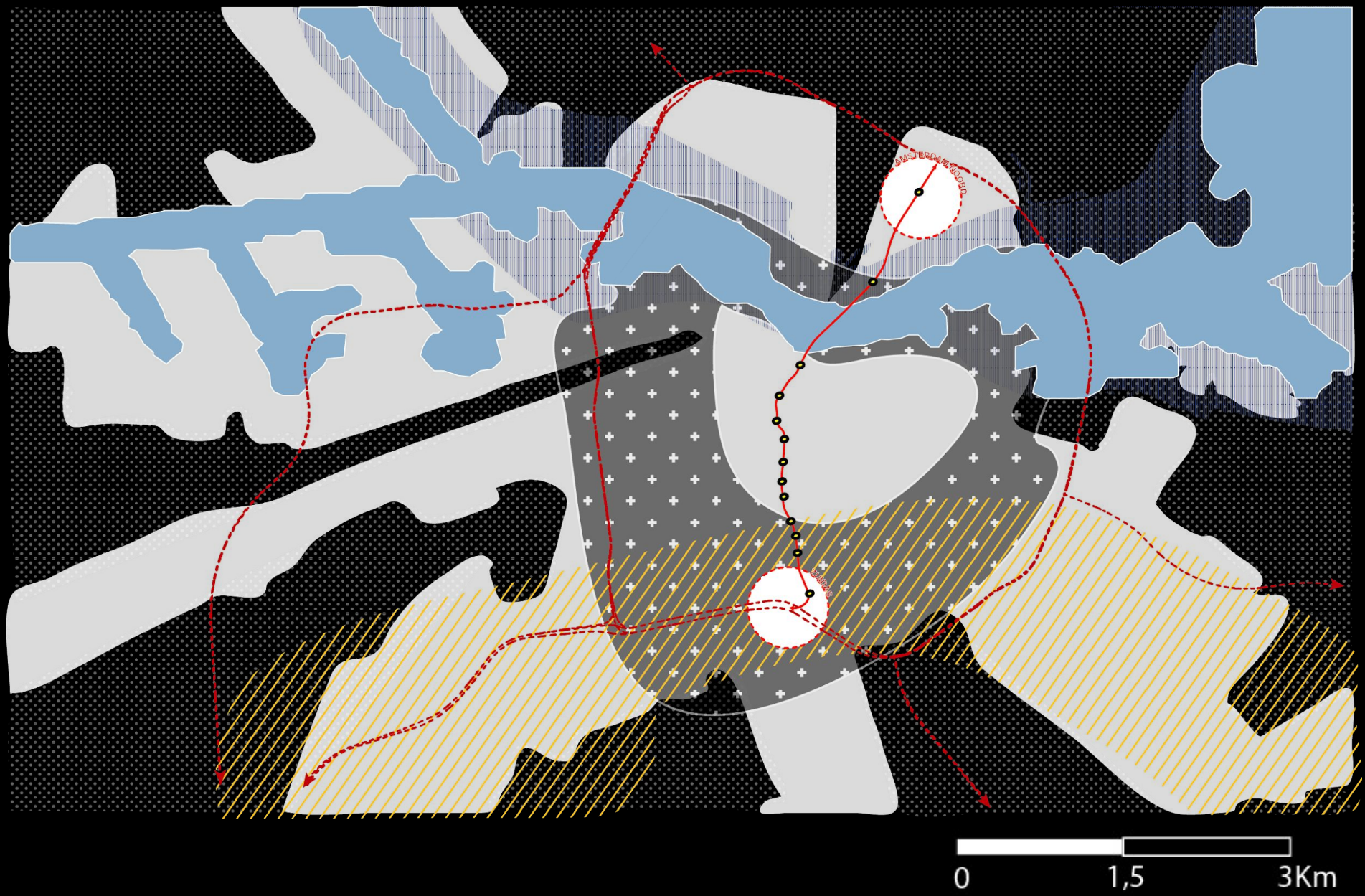
« Amsterdam has deliberately opted for densification of the city centre. The city has not chosen for growth by increasing its surface area but for intensification of the existing urban territory and for transformation of business zones. By building 70,000 new dwellings with accompanying amenities within the city's existing boundaries we can expand the city centre milieu that makes the city so attractive. **That is only feasible if we simultaneously invest in the public space, public transport and greenery"**

Source: Amsterdam Structural Vision 2040, Amsterdam Department of Physical Planning (DRO)

IMPACTS

Nord Lijnen as a Compact City Enhancer





Source: Amsterdam Open Geodata / OSM / Amsterdam Structural Vision 2040

LESSON LEARNED

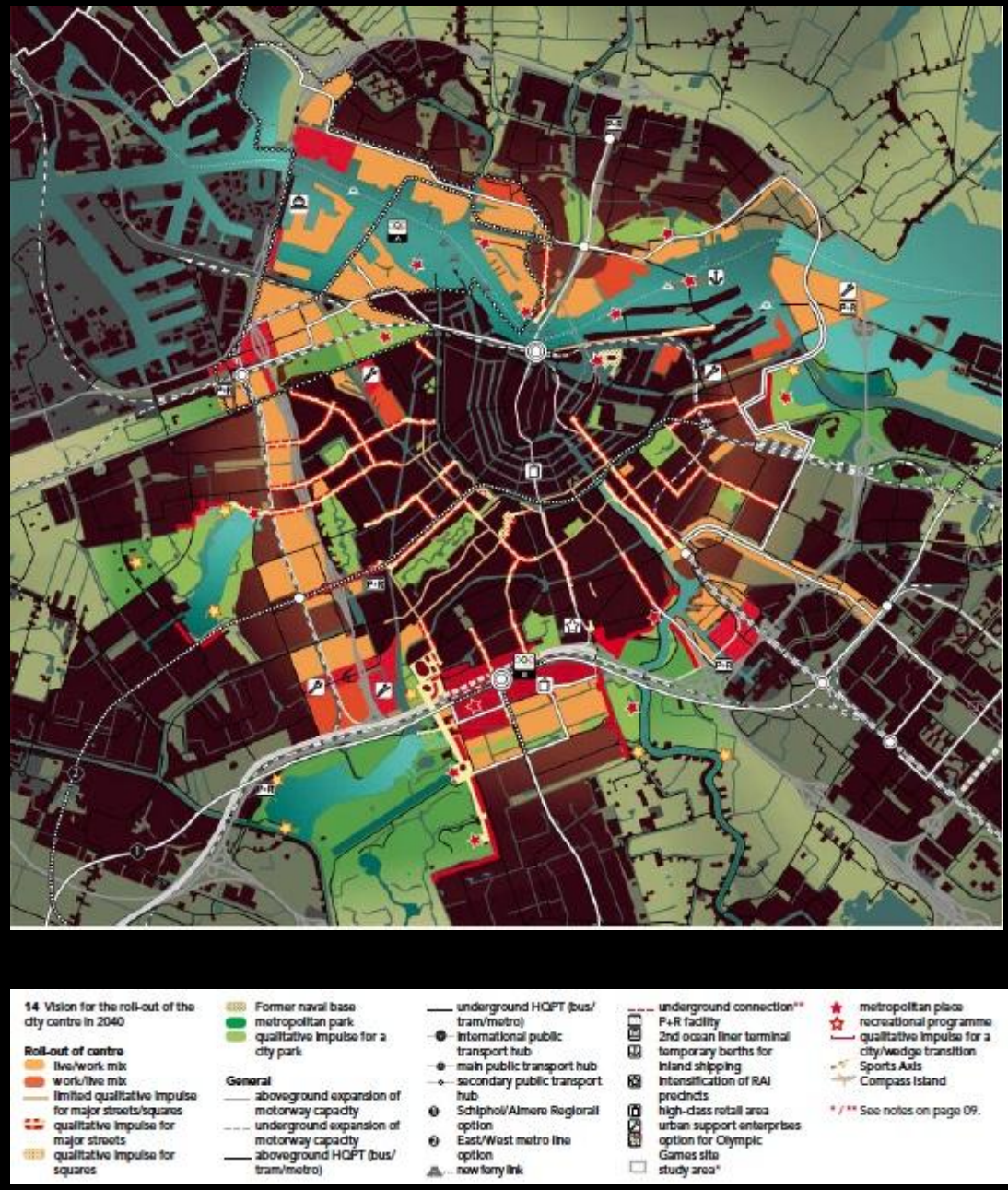
Nord Lijnen as a Compact City Enhancer

- With hindsight, the North Line Project in allows to re-connect the Northermost Part of Amsterdam, to redevelop a vibrant waterfront on former brownlands and densify the city within the A10 ring, and around major infrastructures (sprawling vs. the compact city)

- Benefiting from relatively low land prices, an ambitious waterfront redevelopment has been led from the 2000's, through numerous public-private partnerships the former (des)-industrialized parts of Amsterdam has been transformed by cutting edge building (the Eye film institute etc...), mixed-use neighbourhoods redevelopment around former industrial areas (former naval construction site NDSM redevelopment), and innovative dwellings built on water (Ijburg).

- The North Line, and the North Line Sations are critical infrastructure in that it participates in building up resilience (and getting its dividend) in the face of desindustrialisation, land devaluation and mass unemployment. The trasnsportation system enhances the neighbourhood vibrancy, and allows for future investments in mix-used neighbourhood, around the Noord hub and along the riverbanks.

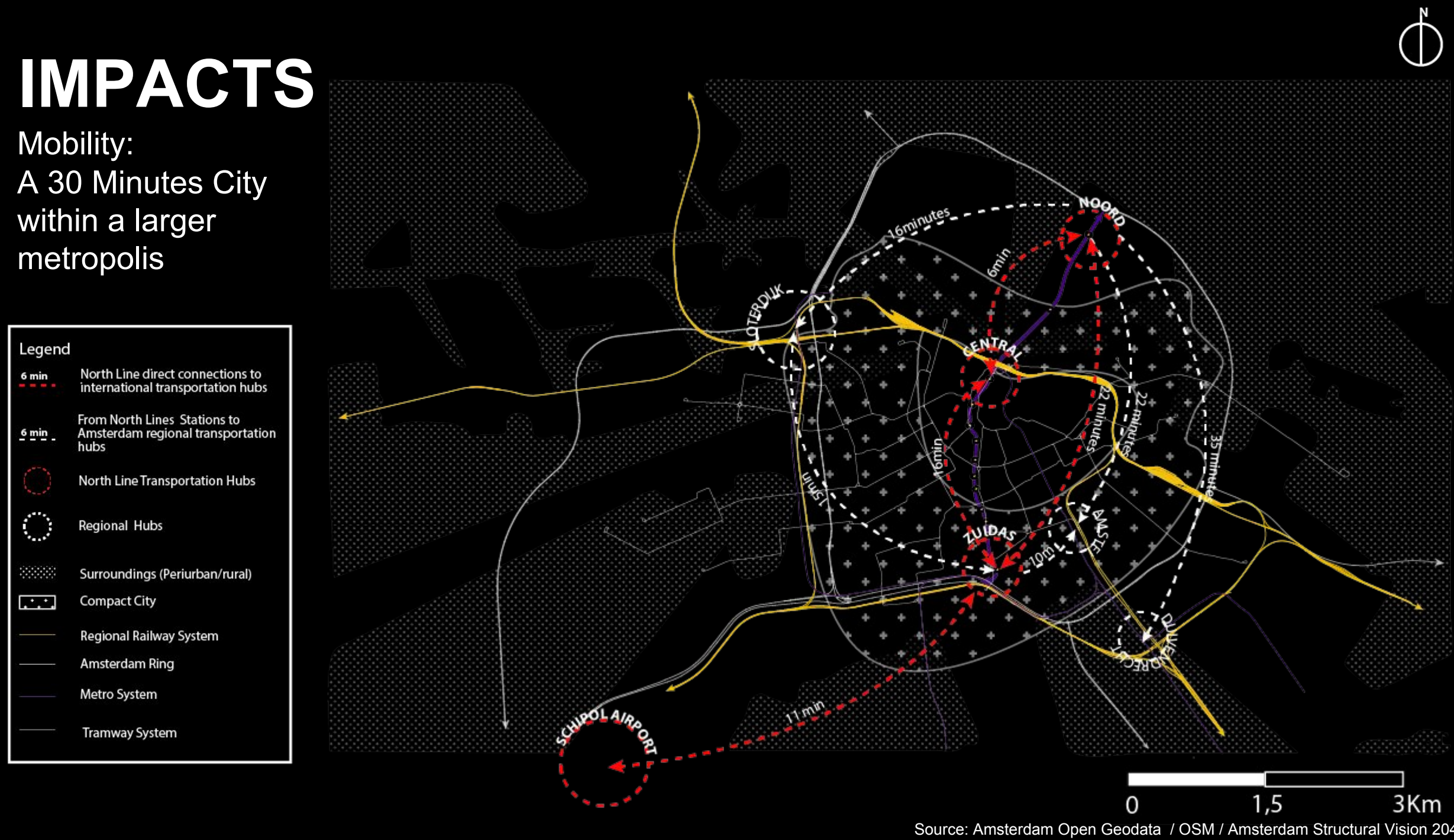
- **A question yet to asked is how will the inhabitants will benefit from those developments ?**



Source: Amsterdam Structural Vision 2040, Amsterdam Department of Physical Planning (DRO)

IMPACTS

Mobility:
A 30 Minutes City within a larger metropolis



Source: Amsterdam Open Geodata / OSM / Amsterdam Structural Vision 2040

LESSON LEARNED

A 30 minutes city:
metropolitan, regional and international commutes.

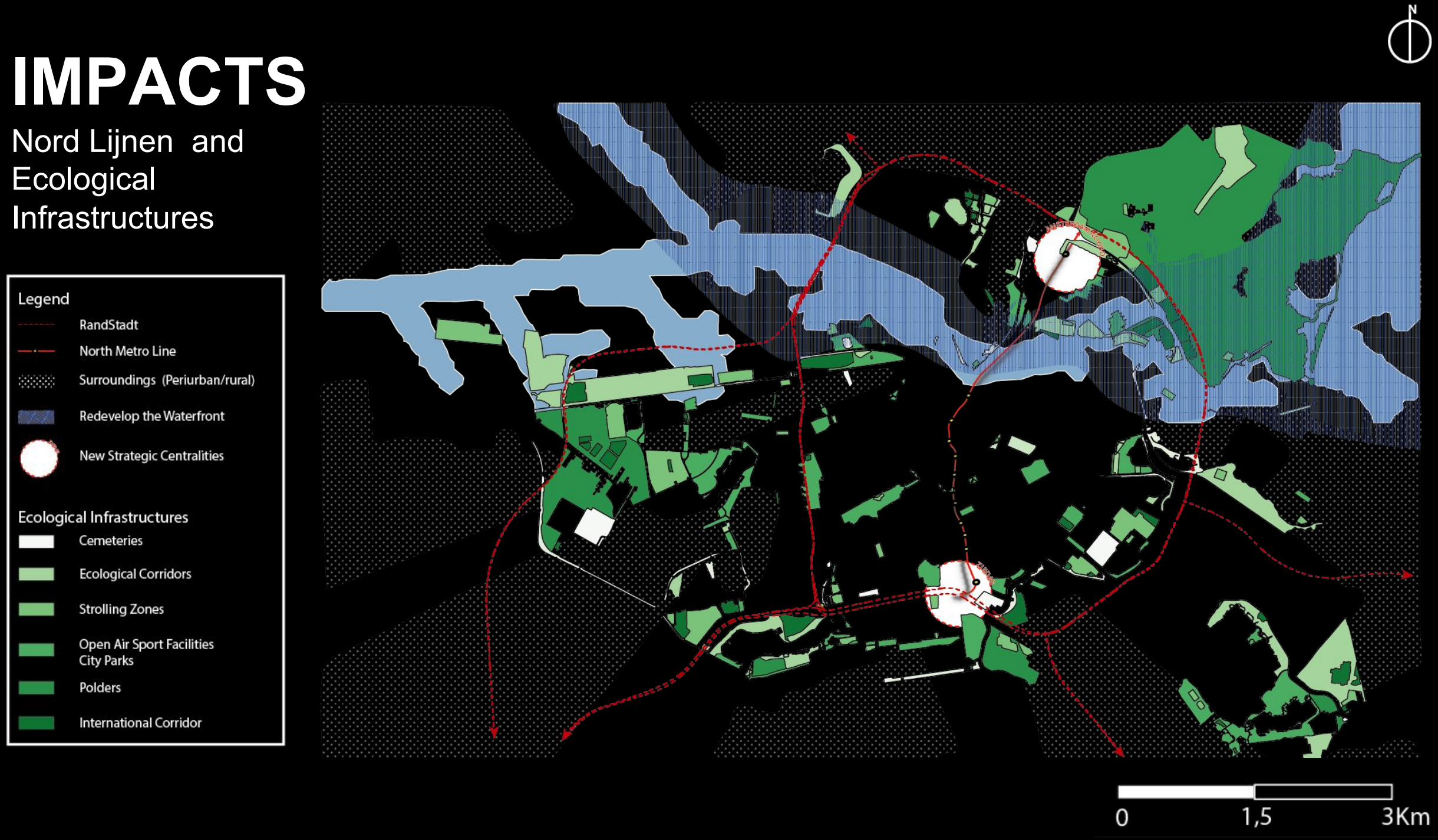
- Rapid Connection to regional and international hubs.
- From Noord To Zuidas in 22 min, From Zuidas to Schipol in 11 min.
- In the Sourthern Part of the city, the Zuidas business center, will widely beneficiate from the transportation project, 10 minutes away from the Schipol Airport, and minutes away from regional and international station: no doubt it will benefit from that situation, in a context of widespred competition among europeans cities to attract businesses, and particularly those leaving London with the Brexit.
- The Northernmost part of Amsterdam, which was not as well connected as the Southern Part **will be transformed by this project,** hopefully the northernmost part of the city, where social housing built in the 70's and 80's starkly lacked connection and suffered economical backlash, will benefit from this new connection as it should allows faster commutes and economic development.
- **A question yet to asked is how will the inhabitants will benefit from those developments ?**

Noord Station

Zuidas Station

IMPACTS

Nord Lijnen and Ecological Infrastructures



LESSON LEARNED

Nord Lijnen and Ecological Infrastructures

- Amsterdam's hinterland comprises a wide array of critical ecological infrastructure and buffer zones (polders, wetlands, parks…) critical for the climate resiliency of the city. By choosing to enhance those natural areas the city effectively works toward a more resilient urban metabolism.

- On the North bank the developmnent of the North Line goes along with the maintining of a vast natural area transforme in park. The North Line also connects the inhabitants to the NorthEast IjPolder, a wide natural area in the direct outskirt of the city.

- This plan, aiming to develop the "city over the city" rather than periurban extension in the fringes allow to protect natural areas and buffer zones.

- In that regard we can underline the similarities between this masterplan and the 1935 plan: prospective, aiming at a denser urban core, and successfully integrating natural landscapes in the city.

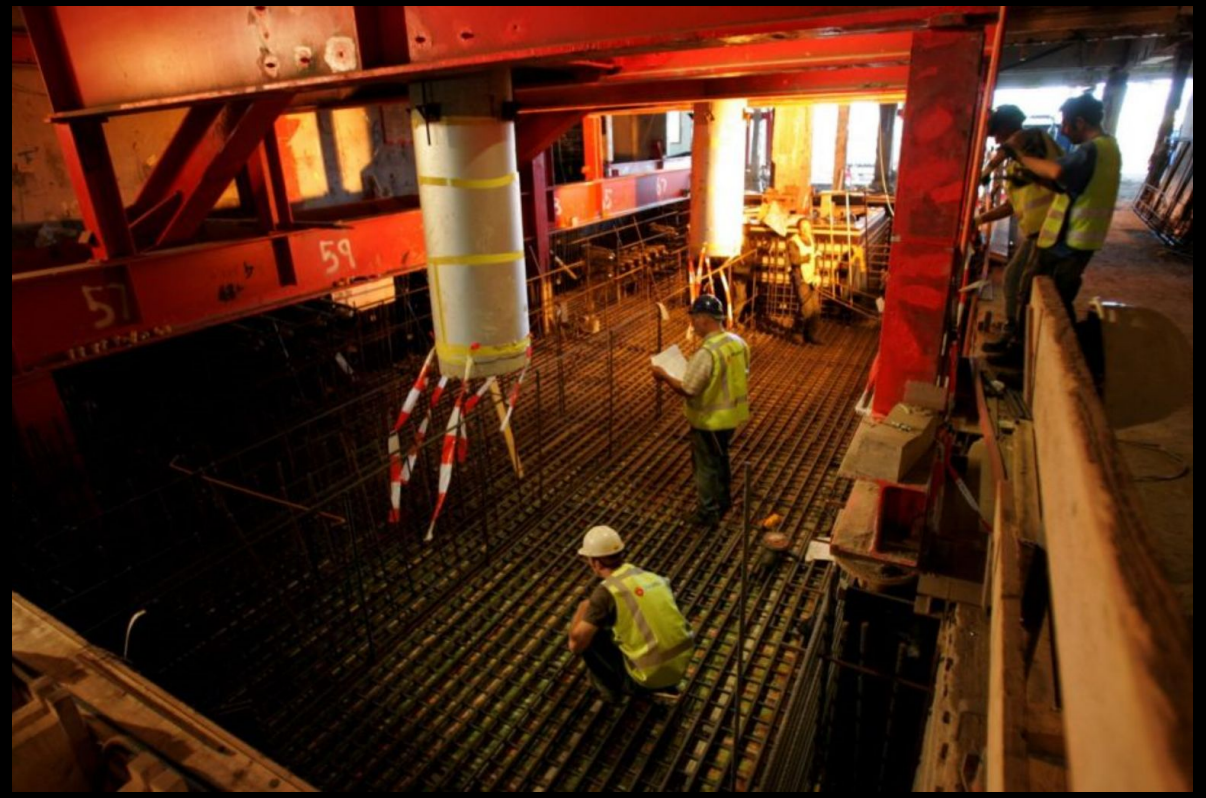
NoordPark

Noderpop, in the cinty fringes

Source: http://www.dutchamsterdam.nl/991-amsterdam-noord-zuid-north-south-metro-line-52

LESSONS LEARNED

- Engineering an underground metro 25m deep in the soggy soil of historical Amsterdam is quite a feat.
  - The project was originally conceived in the 1960s, started in 2003, and not completed until this year, 2018!
- The new tunnel drilling technique developed in the 1990s is what made this task possible.
  - They were able to drill up to 30m deep within the unstable ground without affecting the city too much.
  - This method involved freezing the ground around the tunnel to stabilize it before excavating the tunnel using tunnel-boring machines.
- The sections beneath Amsterdam's historic centraal railway station and the river itself runs through submerged boc tunnels.
- Delays and setbacks like this are COSTLY
  - The project started out at 1.4 billion euro in 2003 and ended up being 3.1 billion euro.



Source: https://nextcity.org/daily/entry/amsterdams-north-south-metro-line-finally-opens

QUESTIONS

Questions for Primary Source of North-South Line:

i. What are some of the reasons for the lengthy and extended timeframe of the project since 1968?
ii. How did the Nieumarkt riots affect the view of the Amsterdammers on metro lines being built in their city?
iii. How did residents of Amsterdam react when told about the completion plan for the project in the early 2000s?
    a. How did they react when building the project had so many setbacks?
    b. Did they end up happy upon completion of the project?
iv. What was the most costly event that increased the overall cost of the project after 2003?
v. Were there any specific metro systems in other countries that had built through soggy soil previously, and did you look to them for guidance as a type of case study?

PROPOSED PROJECT

Cityringen Nordhavn Extension, Copenhagen

PROPOSED PROJECT
CONTEXT

GEOGRAPHIC CONTEXT

DENMARK
Area: 42,924 km^2
GDP: $324.9 billion
Population: 5.77 million
People/km^2: 134.42
% growth since 2000: 7
Avg. Age: 41.6
Household Size: 2.16
% HH with children: 28%
% Danish: 86.9
Gini Index (WB): 28.2

COPENHAGEN METROPOLITAN AREA
Area: 2,778 km^2
GRP: $102 billion
Population: 2,400,000
People/km^2: 863.93

COPENHAGEN
Area: 88.25 km^2
Population: 602,481
People/km^2: 6,826.98
Avg. Age: 35.9 years
% HH with children: 31.71%
% Danish: 76%
Cars: 252,600

METROPOLITAN TRANSIT

Metro System

43 km of track

4 lines

40 stations

137,000 passengers/day

Regional Railway

3,223 km of track nationwide

408 stations nationwide

11 stations citywide

438 million passengers/year

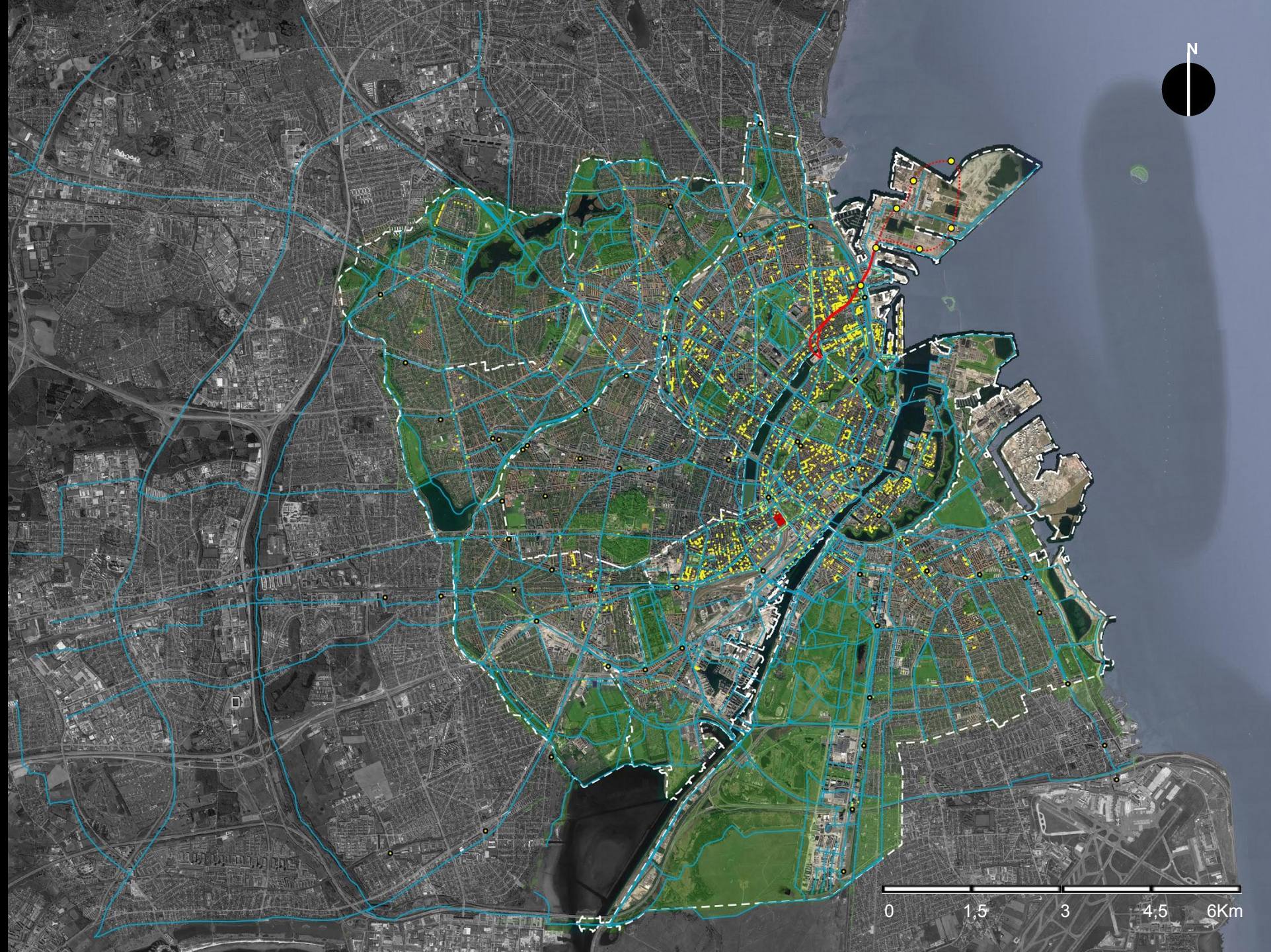
Bikes

416 km of bike lanes/paths

265,700 bikes

Distance: 1,400,000 km/day

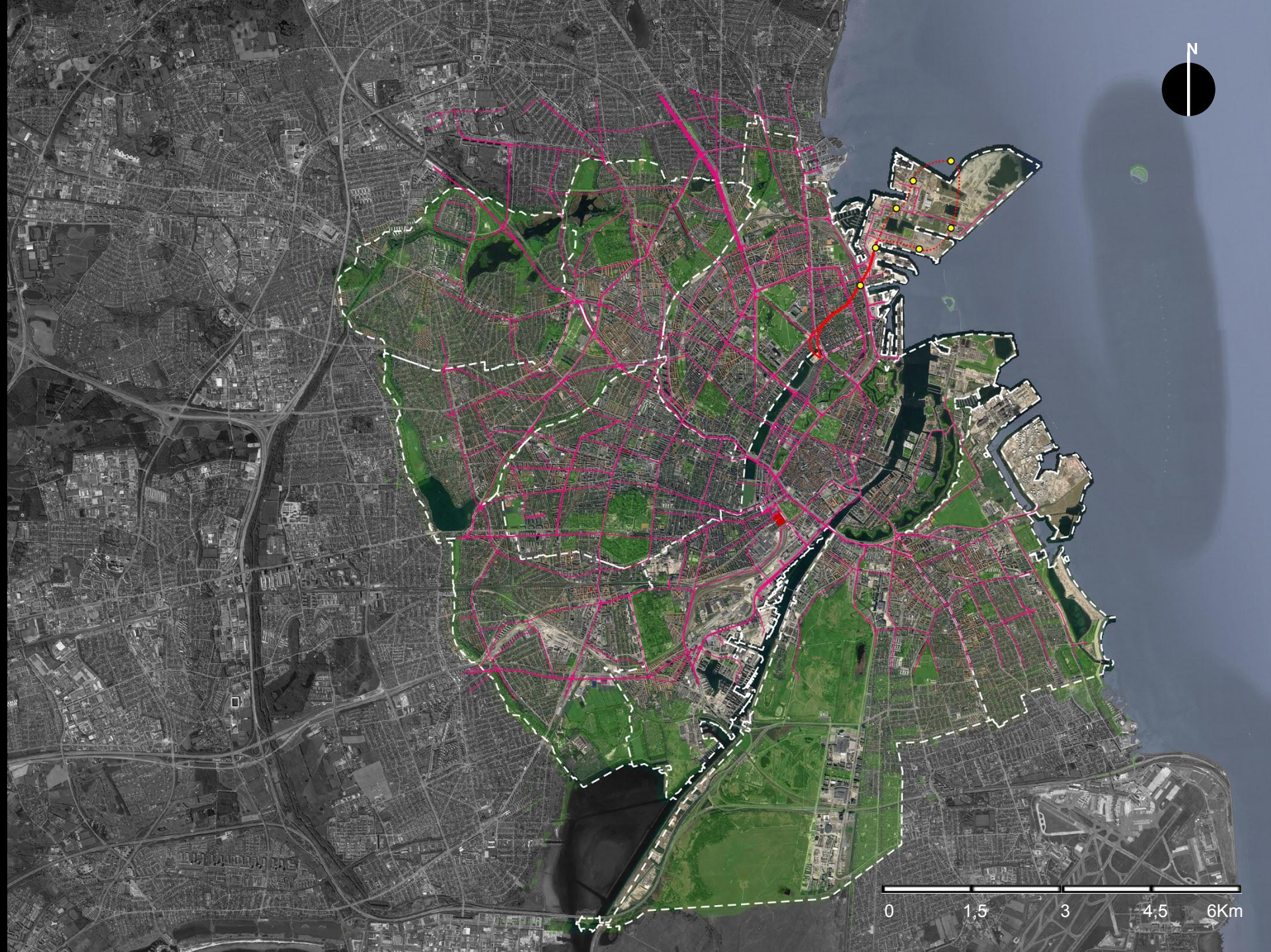
Trips: 171.55 cycle trips/year per person



Cars & Buses

15 bus routes

About 252,600 cars on the roads



Tram System

99.8 km of rail

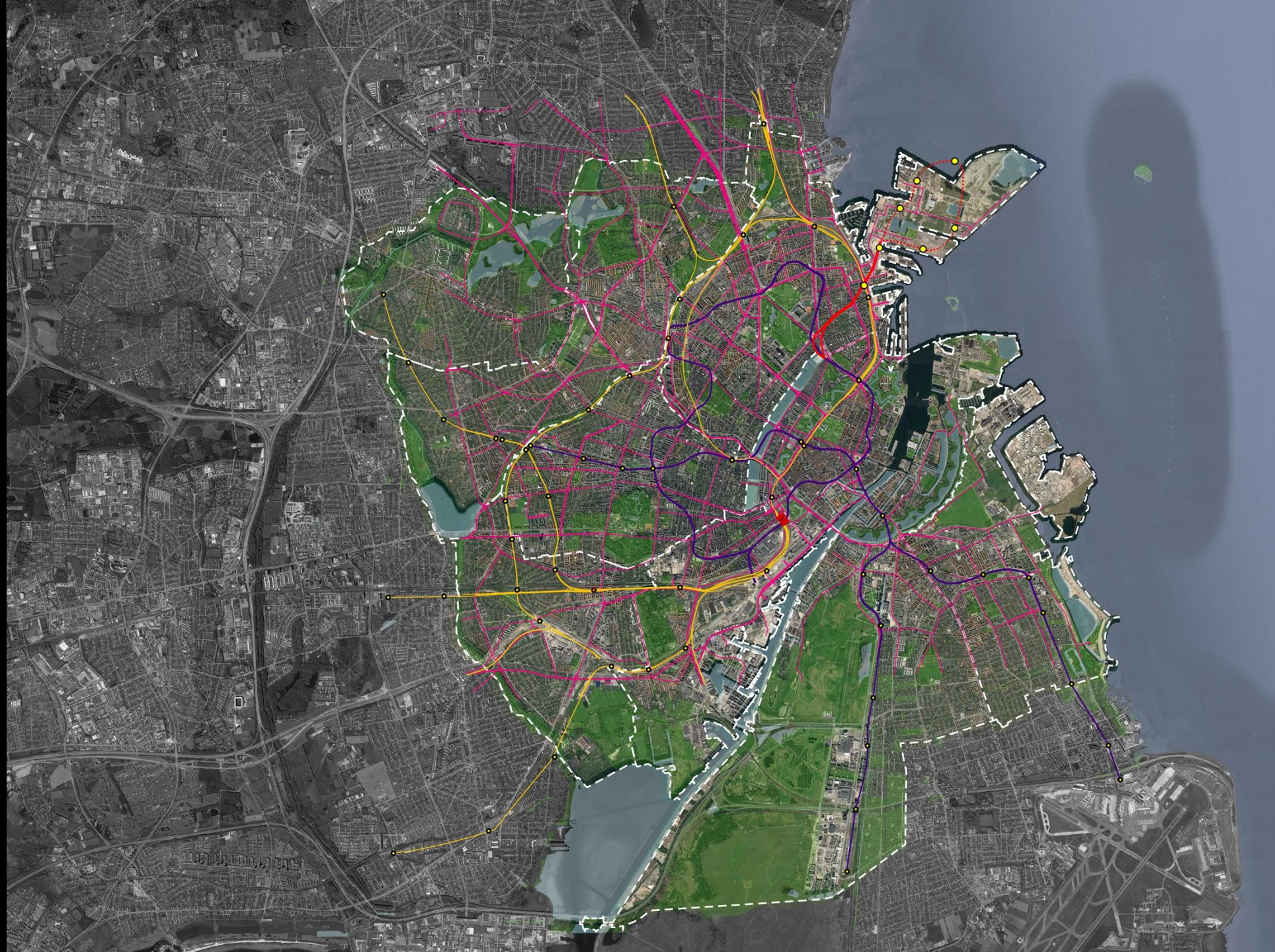
First opened 1863

1972 closed

18 lines

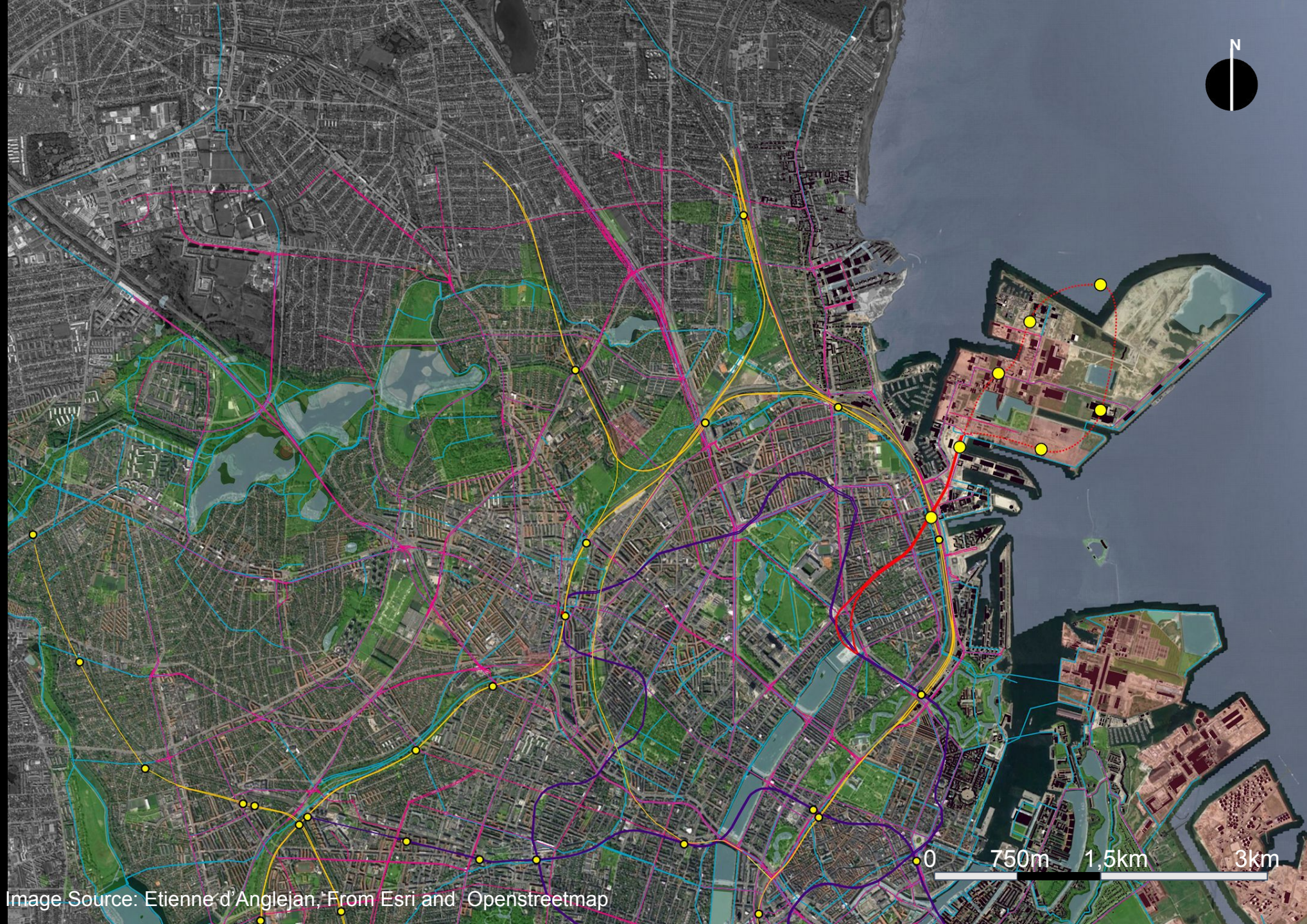
PROPOSED PROJECT
OVERVIEW

NordHavn:
a metropolitan metro ?



NordHavn

a metropolitan metro ?

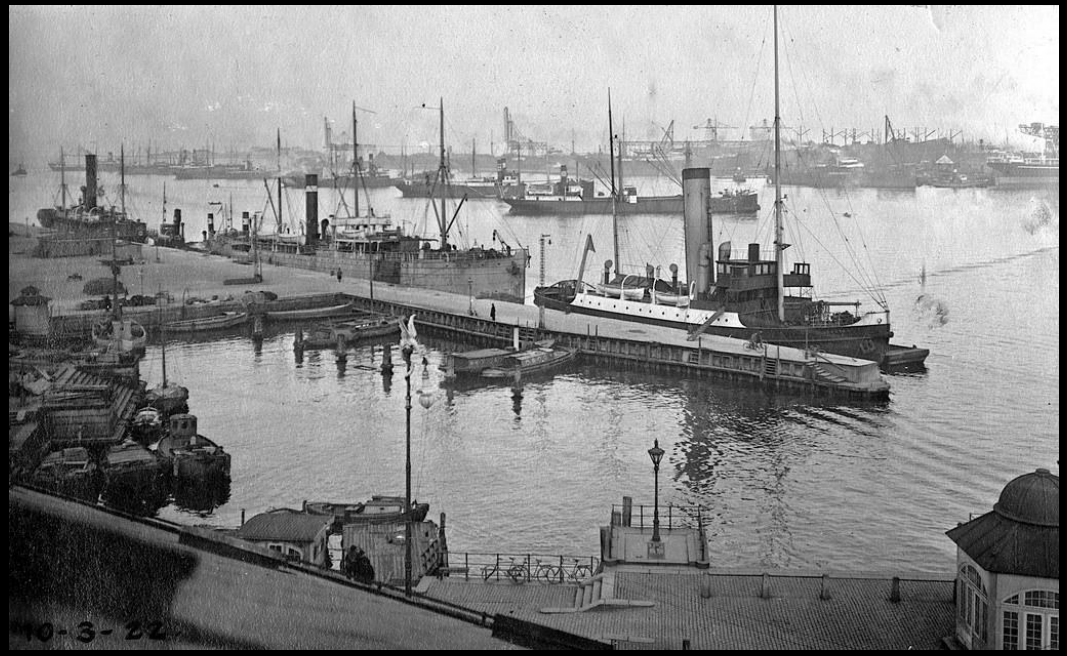


PROPOSED PROJECT
OVERVIEW

Historic Snapshot

The inner part xof Nordhavn (Århusgade, Redmolen and Sundmolen) was not developed until the end of the 1800. Then it was reclaimed along with other large areas of Copenhagen harbour in order to meet in order to make more space for harbour industries and large shipping volumes.

NordHaven 1928



NordHaven at the beginning of the XXth century

Source: http://www.nordhavnen.dk/english/uk-nh-experiencenordhavnen/uk-nh-history.aspx

City Ringen Nordhavn Extension

A proposed new transit line between Copenhagen and Nordhavn

- Two new stations will branch off of the metro circle line to connect to the sustainable city district, ‘Nordhavn’.
- A pedestrian tunnel will make it easy to change to the S-train, and gives potential for more green areas.
- One of the Stations, the Orientkaj metro station will be an above-ground station on an elevated section of the line.
- There is political consensus to build more stations in Nordhavn, but these have not been decided yet.

Cityringen extension maps

Source: https://plh.dk/en/projects/metro-cityring-nordhavn-extension/

CINTYRINGEN LINK

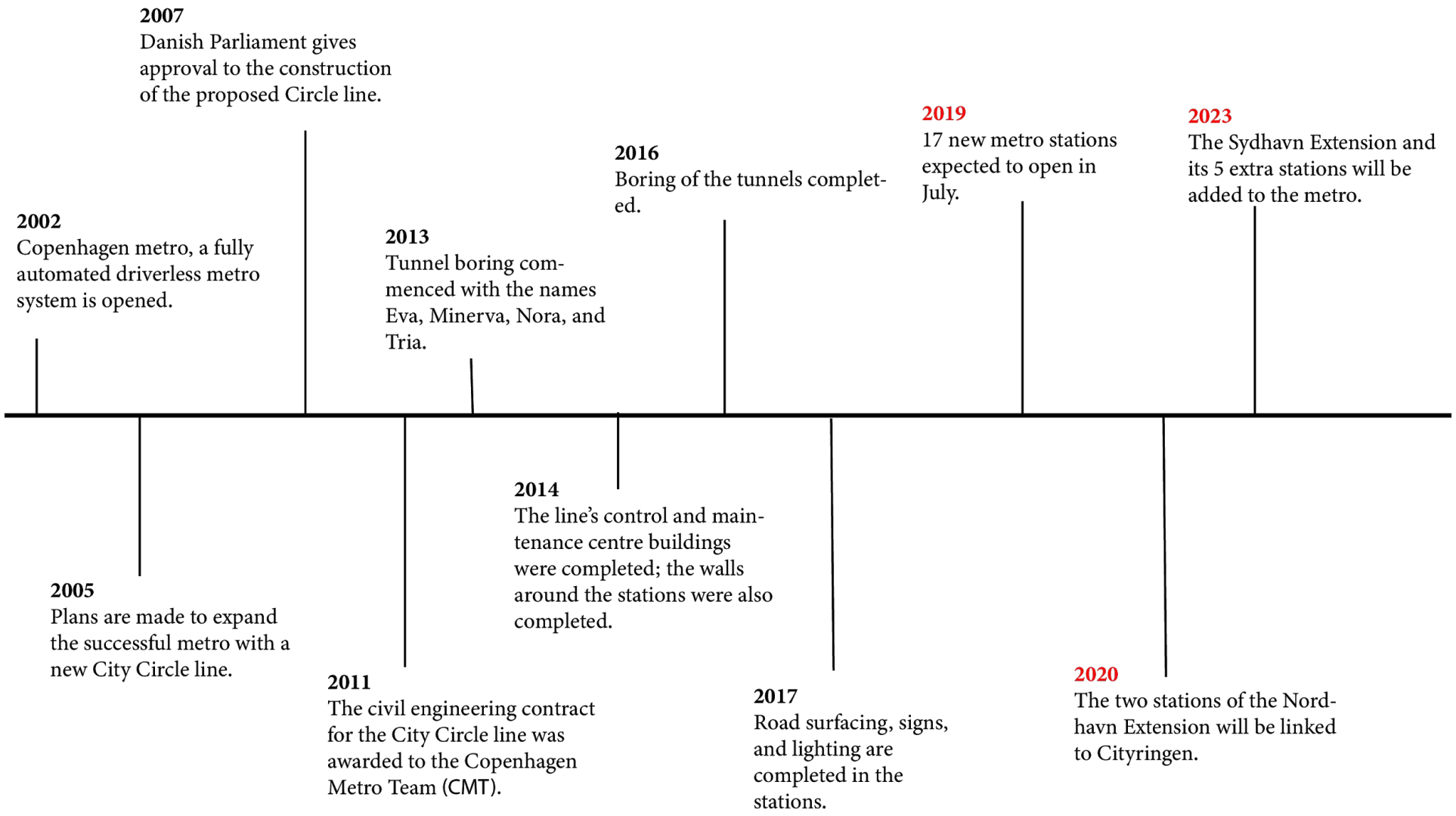
Overview

- **What:** The completely new metro circle line will have two stations that branch off and connect to the new sustainable city district, “Nordhavn”. Track length: 2,5 km; Lines: 1; Stations: 2
- **Who:** A collaboration between the municipal authorities of Copenhagen and Frederiksberg and the Danish government, Port Authorithy
- **Where:** Copenhagen, Denmark
- **When:** 2017-2020
- **How:** DKK 21.3 bn, from the municipal government
- **Why:** To make it “easy” to change to the S train and to give potential for new development.

Proposed Cityringen line to connect the Copenhagen metro system.

TIMELINE

History and Future of the Danish Metro



A Green Transformation ?

Nordhavn, Copenhagen

What was previously an active industrial port, will now be a “modern” and accessible residential and business quarter.

So what will be included?

- **40,000** new residents and an equal number of workplaces.
- **165,000** meters squared of residential space
- **140,000** meters squared of commercial space
- **1,100** meter long quay big enough for 3 cruise ships.

Proposed Waterfront project

Source: http://www.@nordhavnen.dk/english/uk-nh-transformation2/uk-nh-nordhavnen.aspx

Source:

Today’s situation: what’s the issue?

Development in NordHavn: International Business School

Today’s situation: what’s the issue?

Development in NordHavn: Park’n Play Jaja Architects

Stressors & Building Towards Sustainability

Nordhavn, Copenhagen

- **Economic/structural stresses:**
  An old harbour hit by desindustrialisation and soil pollution…
- **Development stress:**
  Development can be considered as a stress as well, by concentrating more assets in a risky coastal area, it mechanically worsen vulnerability
- **Coastal area environmental stresses:**
  Sandy beach is at risk from erosion, area at risk from rising sea and oceanic storm. One may argue that developing this natural harbour was not a good idea from the beginning: such a natural harbour indeed constitutes a critical buffer zone from coastal storms, therefore protecting the whole city.
- **Social Equity and Development:**
  The price of depolluting contaminated industrial area is high, and involves huge investments, adding the Metro Construction the costs of the overall project will certainly lead to an increase in dwelling prices, mechanically excluding population from this neighbourhood.

Source:

Stressors & Building Towards Sustainability

Nordhavn, Copenhagen

Wind

- Denmark has a large amount of wind and studies show that especially around tall buildings, wind may be particularly strong.
- This was considered when taking into consideration each building's design.
- In order to protect urban spaces from the wind specific vegetation was placed in certain urban areas.

Robust Materials

- Consistent robust materials such as **concrete, asphalt, hard wood, and steel** were used in order to be consistent with the harbour's history.

Lighting

- Since Denmark experiences only **7 hours** of daylight during the winter, in the streets, alleyways and promenades, there is an emphasis on street lighting for pedestrian safety.
- Additionally, the lighting is aimed at highlighting the qualities of the neighborhood and presenting a pleasant mood.

252,600 private cars in Copenhagen (2017)

24 minutes to travel all the way around the Cityringen line

130 million passengers expected to take the metro by 2025

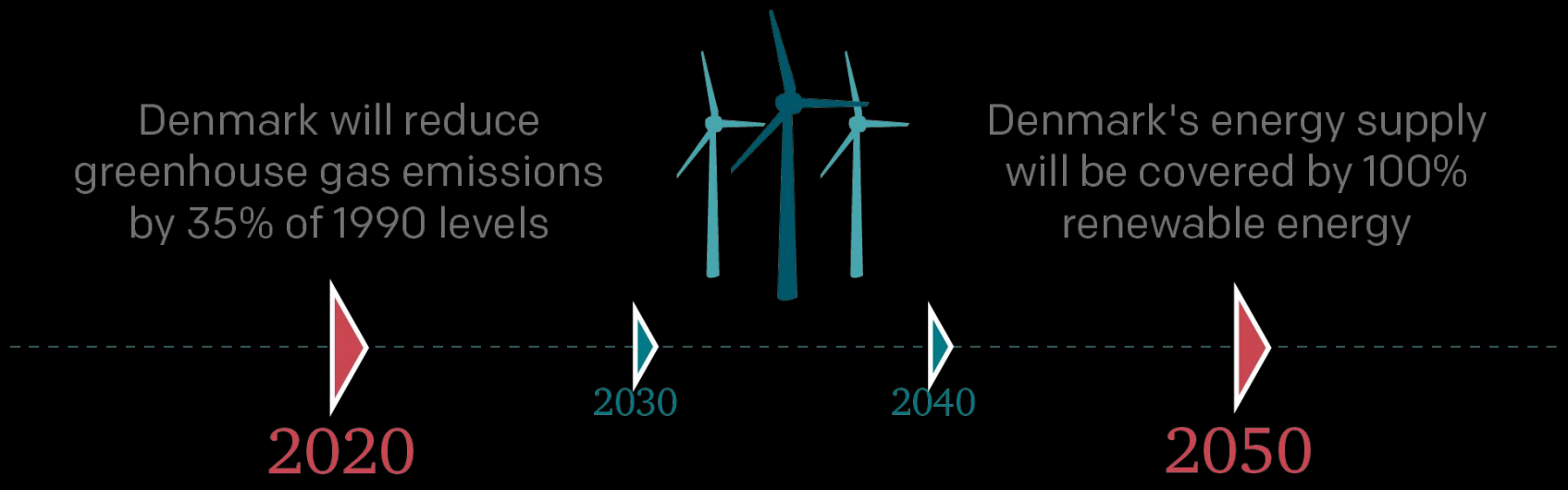
40 km/hour speed on metro

DKK 21.3bn project cost

PROPOSED PROJECT
RESILIENCE ASSESSMENT AND RECOMENDATIONS

RESILENCE ASSESSMENT - SYSTEMS

Is the Cityringen line in line with goals to make **Denmark** more resilient?



Transportation, energy and energy consumption are the top items on the country's **Carbon Neutral Plan**. Denmark gets more than **20%** of its energy from renewable energy, most of which is generated from wind turbines. The country goal is to increase that amount to **100%** by 2050. The new stations will enable easy access to the city without the use of cars, a major source of power and energy.This is in line with the country of Denmark's overall goals to reduce carbon emissions and utilize renewable energy. So on a very theoretical plan the development of a new metro line further decreases the uses of cars in Copenhagen metropolis, which reinforce the country "path" to carbon neutrality.

RESILENCE ASSESSMENT - SOCIAL

Will the Nordhavn Extension make the **neighborhood** more resilient?

By transforming a de-industrialised neighbourhood into a mixed used neighbourhood, the project enhances the neighbourhood resilience to a major structural/economic change.

By proposing new public spaces, as well as a university the neighbourhood engages in a transformation from a former industrial cluster to a vibrant metropolitan neighbourhood: enhancing its relation with the rest of the city. In short Nordhavn is on the brink of experiencing new residential and business growth, and Nordhavn is critical for that redevelopment.

On the other hand, in terms of inclusiveness and sustainability the project ought to be criticized:
Will it manage inclusive development ?
Does development goes with hand with buffer zone protection ?
How will this neighbourhood will cope with sea water rise ?

Source: https://intl.m.dk/#!/about+the+metro/metro+expansion/the+nordhavn+extension

RESILIENCE ASSESSMENT - ECOLOGICAL

Will the Cityringen Line make **the city** more resilient?

- The most advanced technology will allow for fully automated, its **driverless** trains that will run round the clock along two single track tunnels. Each track is about 16 km in length.
- Once it is up and running, Cityringen is expected to serve up to **240,000** passengers per day, or **72 million** per year. Along the edge of the platforms at each station will be screen doors to prevent anyone from falling in front of harm's way.
- The city ringen does make the city more resilient to desindustrialisation, on the other hand this harbour is a critical asset in term of coastal risk protection for the city.

Source: https://www.webuildvalue.com/en/stories-behind-projects/cityringen-copenhagen-s-ring.html

RECOMMENDATIONS

SYSTEMS

- Redundancy of the systems: emphasis should be put on the redundancy of the system, which alternative mode to the metro line ?
- The development of this system should come with strategies towards others mode of transportation: so far the neighbourhood suffers a lack of public bikes parking/rental.
- The future development of the transportation should be questioned on its environmental impacts: how the new ring will impact (drilling, mineralizing…) the shore ?
- Monitor the project's impacts.

SOCIAL

- A critical aspect of our social recommendations would be to take into account the urban green public space that can be utilized in the absence of excessive roads.
- The development of the two new stations for the Nordhavn extension should include a plan to limit parking surrounding the metro stations in order to encourage cycling and walking.
- Finally, we recommend utilizing inclusionary housing to maximize the health of all social classes of Danes and not just those that can afford higher prices to live a newly developed neighborhood.

ECOLOGICAL

- A critical aspect of our ecological recommendations would be to take into account the advantages of a natural buffer zone on the coast.
- How does a sandy harbour can be considered as both an ecological and social infrastructure ?
- And how will the redevelopment allowed by the transportation system will impact that ecological asset ?
- We also have have concerns about the cruise ships that are supposed to call in that part of the city: as it will generate more emissions and will have strong ecological impacts on the shore line (cf. Venise).