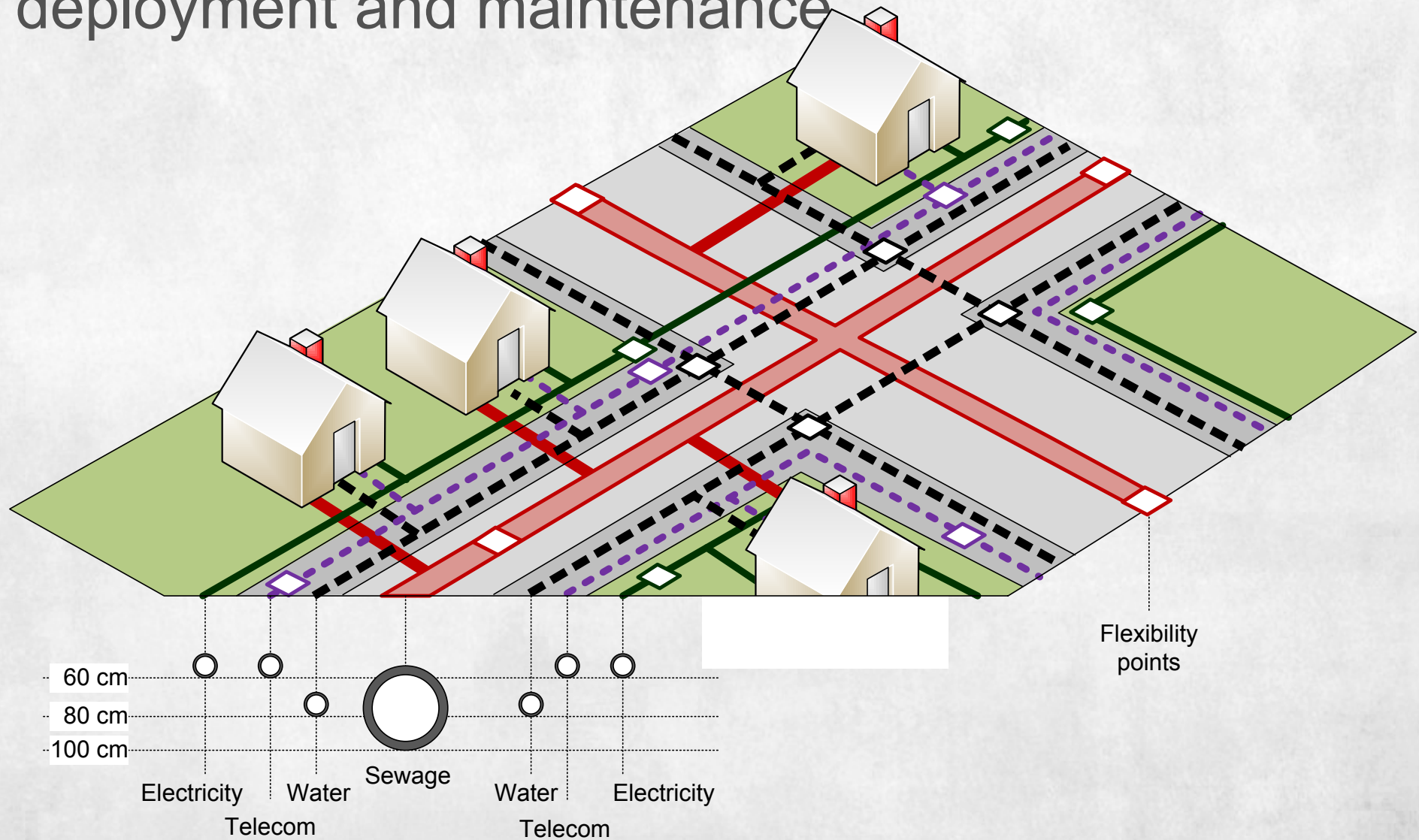




# Optimized synergy in networked infrastructure deployment and maintenance

Jonathan Spruytte

# Optimized synergy in networked infrastructure deployment and maintenance





# Optimized synergy in networked **infrastructure** deployment and maintenance



- + **Robust  
invisible**
- **Expensive road works  
Nuisance to inhabitants**

**€50/m**



- + **~ Cheap &  
Install if used**
- **Ducts available  
Not for solid tubes**

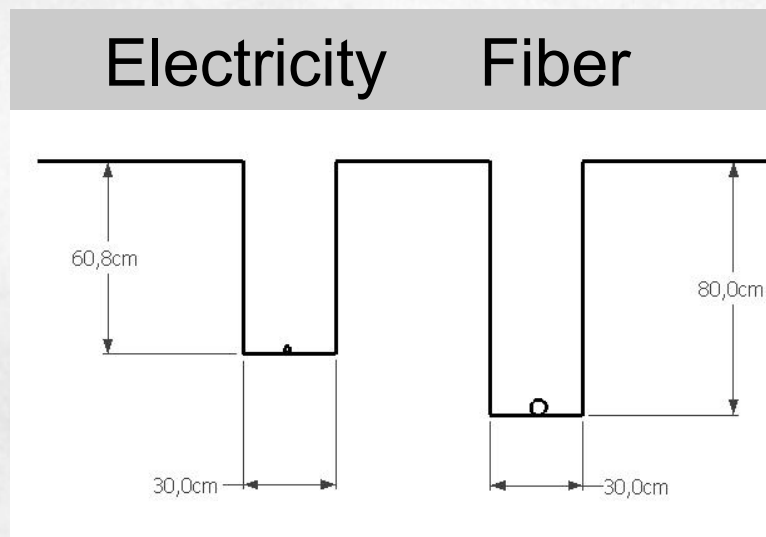
**€15/m**



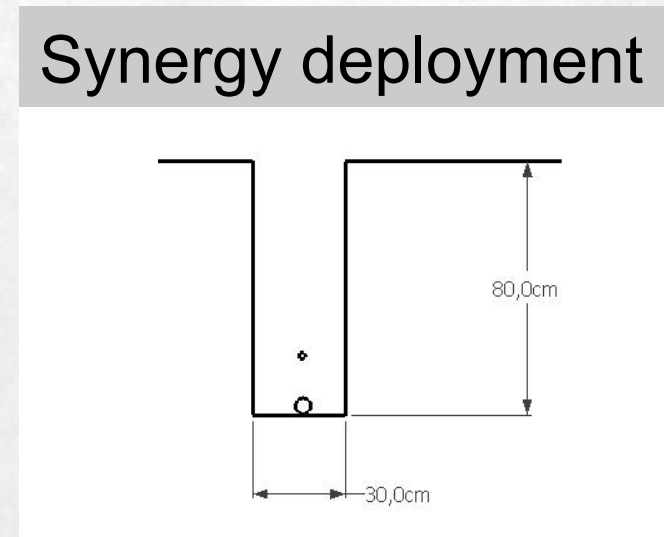
- + **Fast  
Cheap**
- **Vulnerable  
Ugly  
Often prohibited**

**€10/m**

# Optimized synergy in networked infrastructure deployment and maintenance



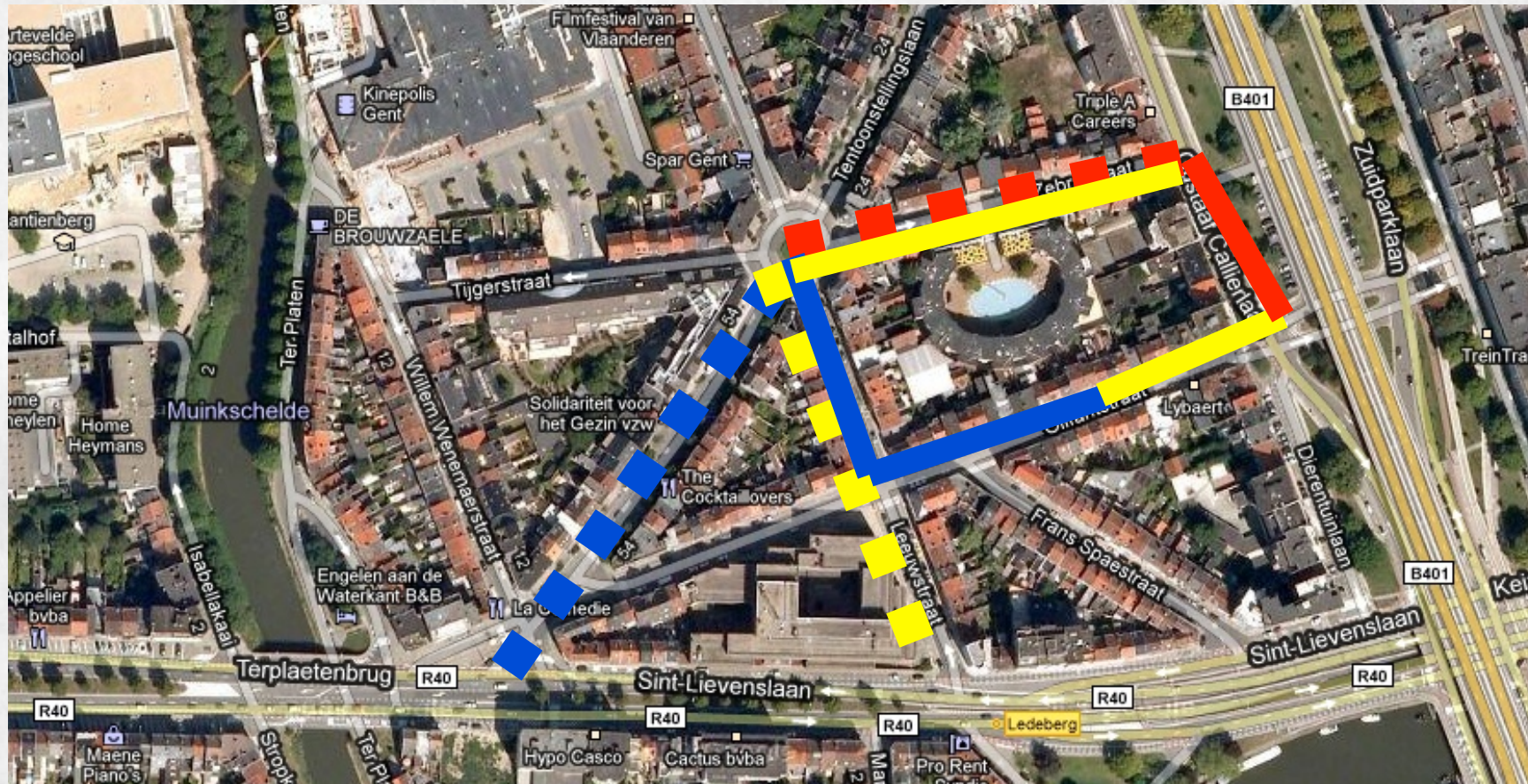
**€50/m + €50/m**



**< €100/m**



# Optimized synergy in networked infrastructure deployment and maintenance

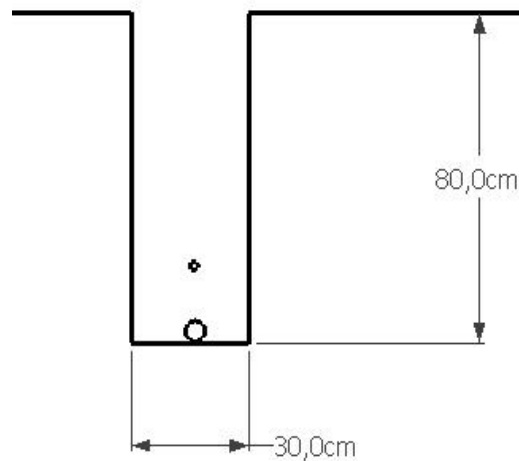


**January 2014**   **February 2014**   **March 2014**



# Optimized synergy in networked infrastructure deployment and maintenance

## Trench Optimization



## Network Planning

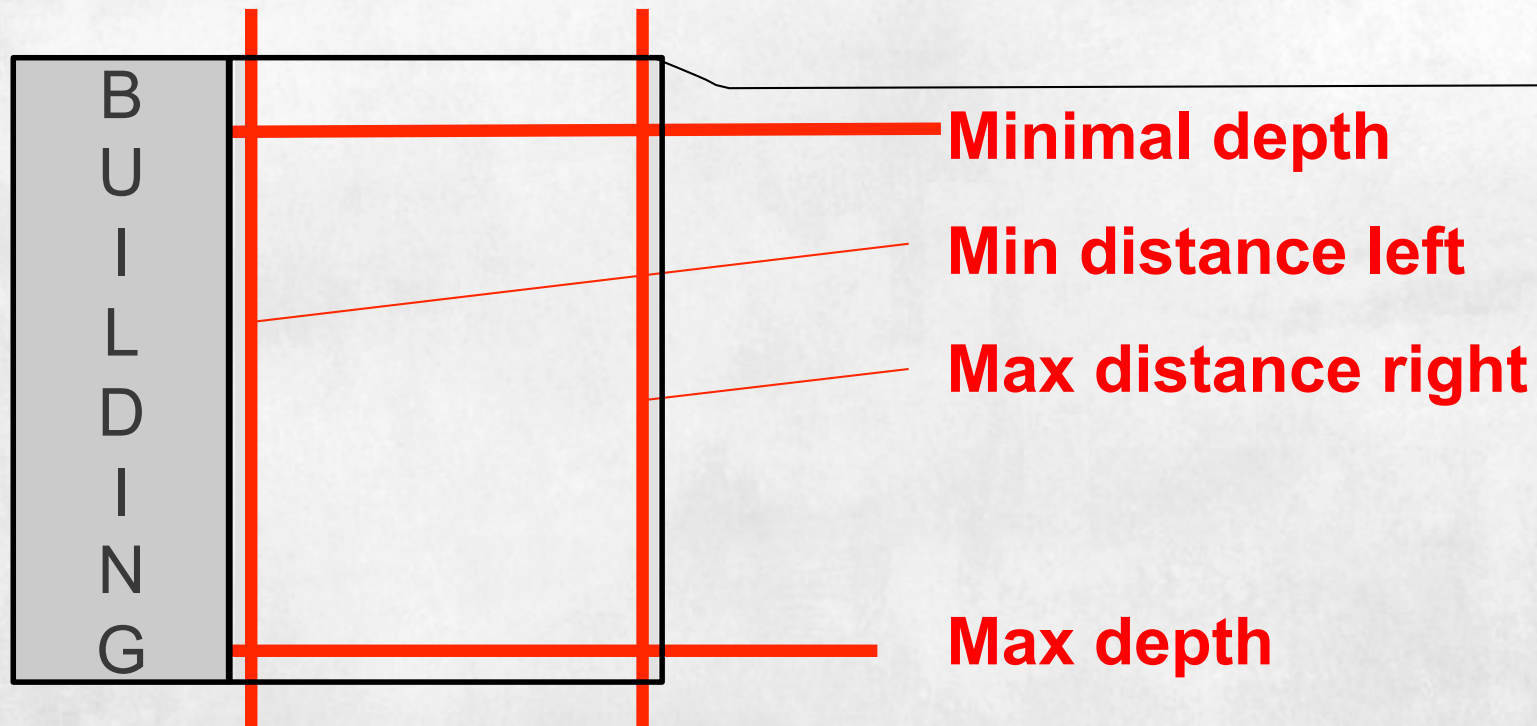


# Infrastructure alignment in trench

- Optimal cost-based
  - Pavement replacement  $\leftrightarrow$  dig cost
  - Constraint driven

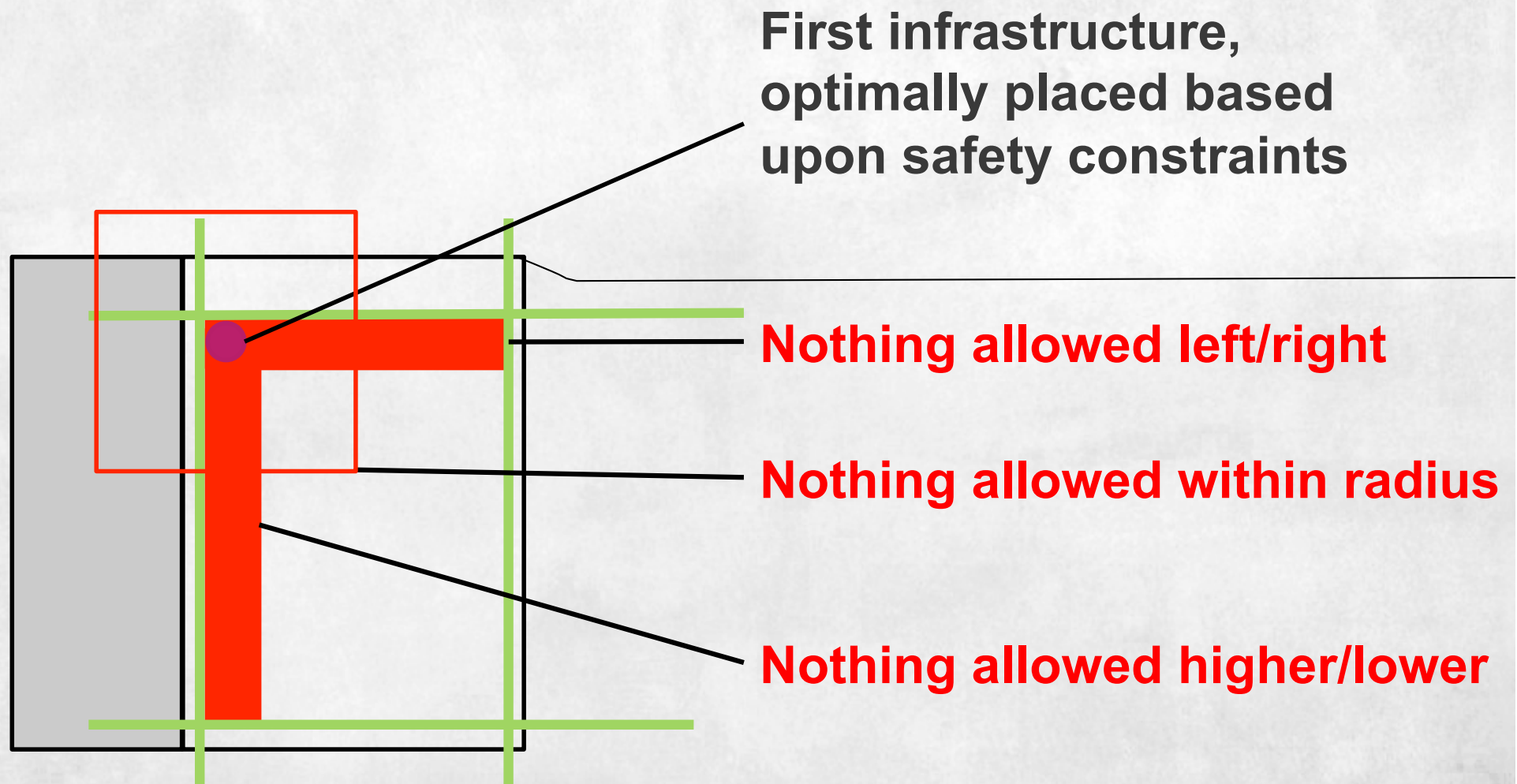
Infrastructure type	Depth (m)	Distance to wall of trench (m)	Distance to other cables (m)
Electricity	0.6	0.05	0.06
Gas low pressure	0.8	0.1	0.2
Gas medium pressure	1	0.1	0.2
Telecom	0.75	0.05	0
Drinking water	1.10	0.1	0.2

# Used approach

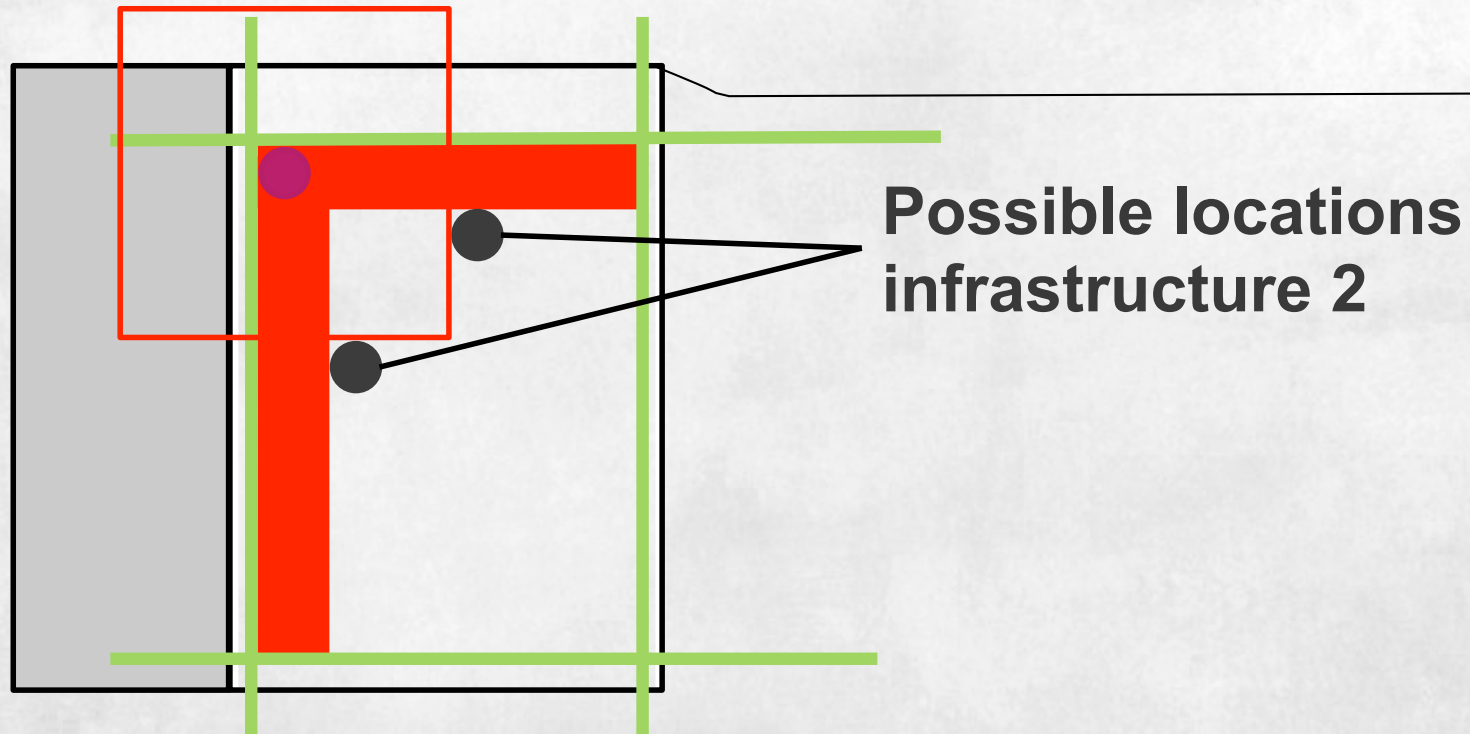




# Used approach

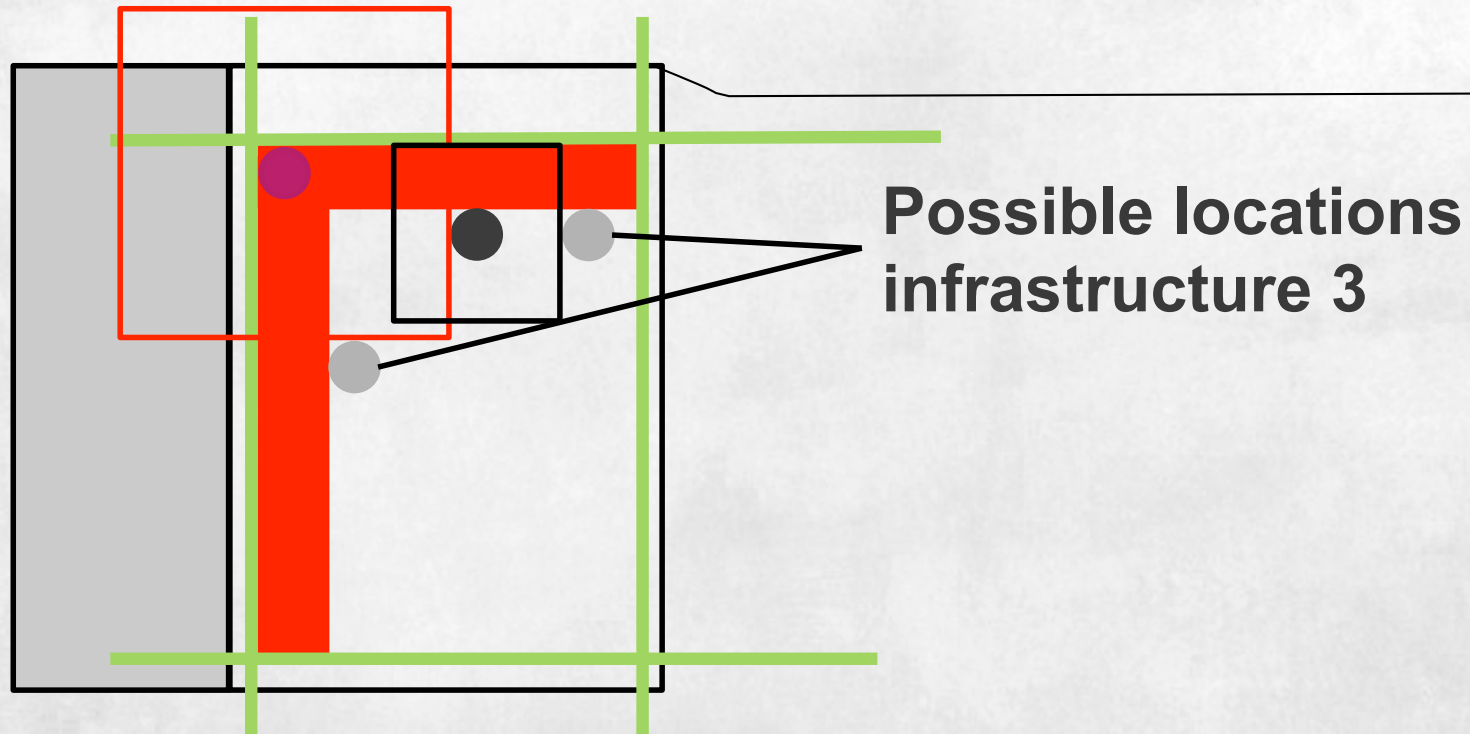


# Used approach

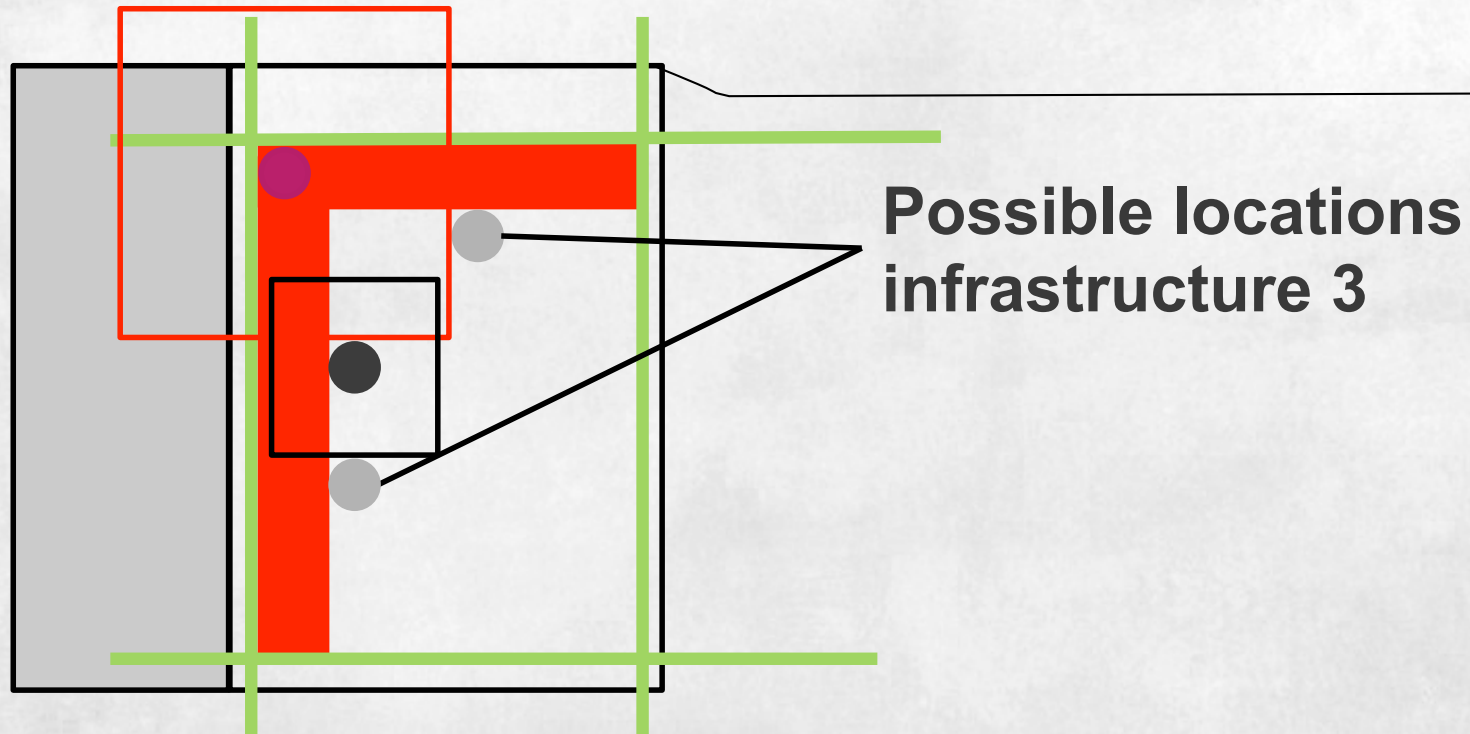




# Used approach

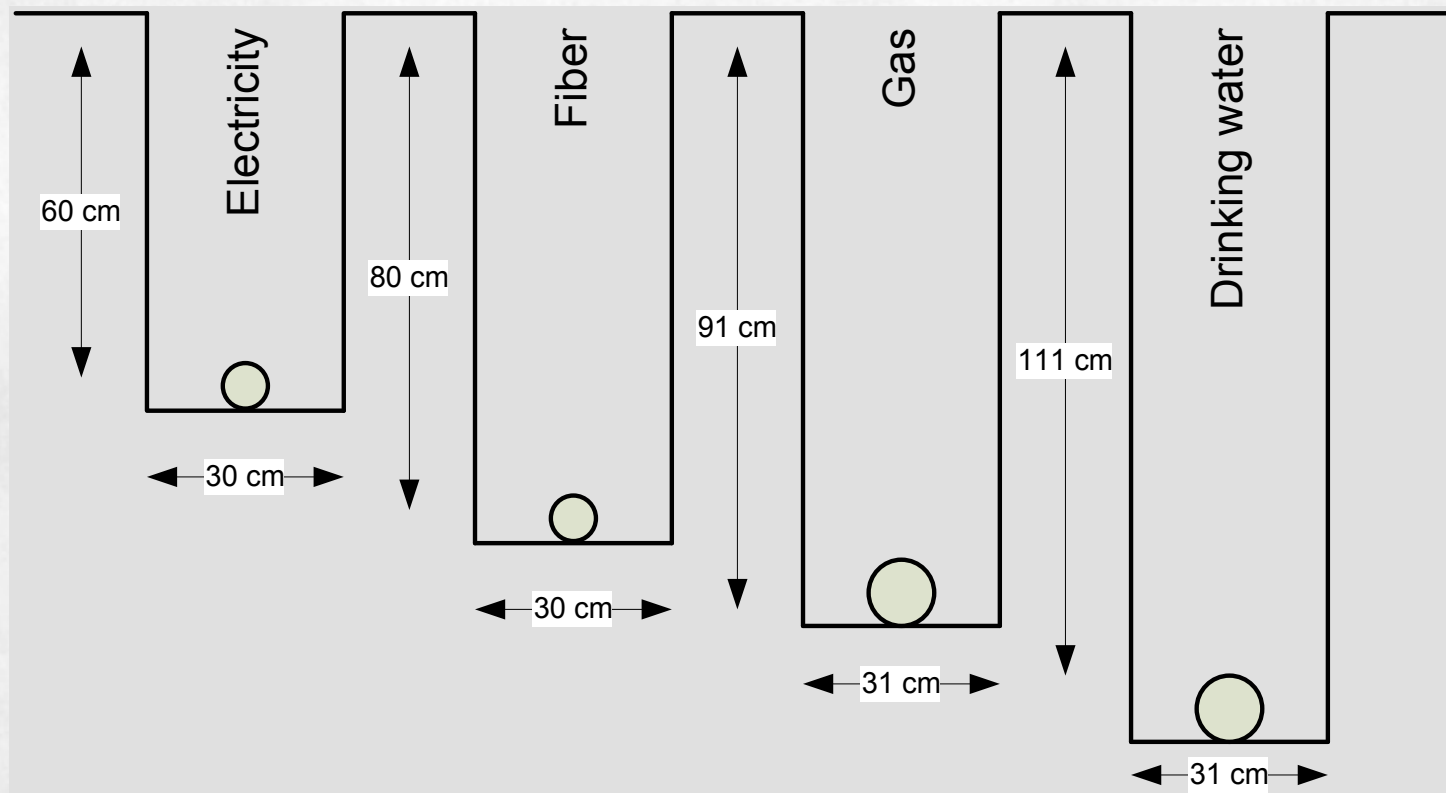


# Used approach

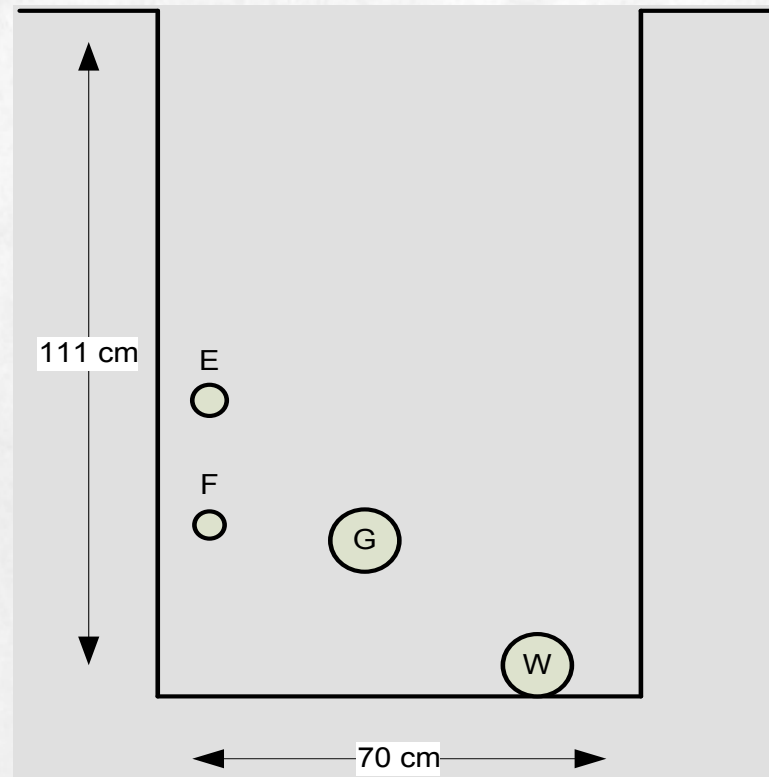




# Case example: not optimized



# Case example: optimized



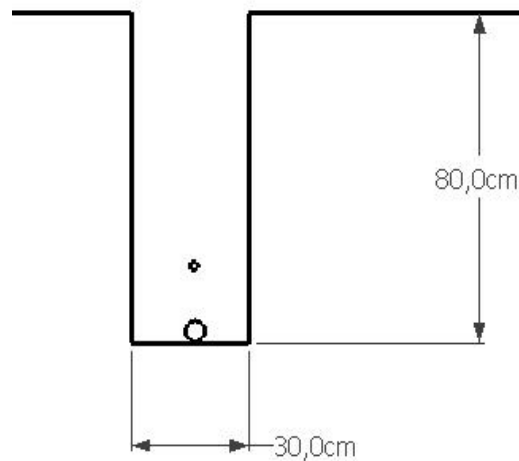


# Case example: results

	Electricity	Fiber	Gas	Drinking water	Total
<b>Individual</b>					
Digging cost	82 €	91 €	98 €	107 €	378 €
Installation cost	113 €	114 €	117 €	118 €	462 €
Equipment cost	266 €	265 €	268 €	268 €	1,067 €
<b>Total cost</b>	<b>461 €</b>	<b>470 €</b>	<b>483 €</b>	<b>493 €</b>	<b>1,907 €</b>
<b>Cooperation</b>					
Digging cost	38 €	42 €	45 €	49 €	174 €
Installation cost	90 €	91 €	93 €	95 €	369 €
Equipment cost	266 €	265 €	268 €	268 €	1,067 €
<b>Total cost</b>	<b>€ 394</b>	<b>€ 398</b>	<b>€ 406</b>	<b>€ 412</b>	<b>€ 1,610</b>
<b>Comparison</b>					
<b>Digging cost reduction</b>	<b>-54%</b>	<b>-54%</b>	<b>-54%</b>	<b>-54%</b>	<b>-54%</b>
<b>Total cost reduction</b>	<b>-15%</b>	<b>-15%</b>	<b>-16%</b>	<b>-16%</b>	<b>-16%</b>

# Optimized synergy in networked infrastructure deployment and maintenance

## Trench Optimization



## Network Planning

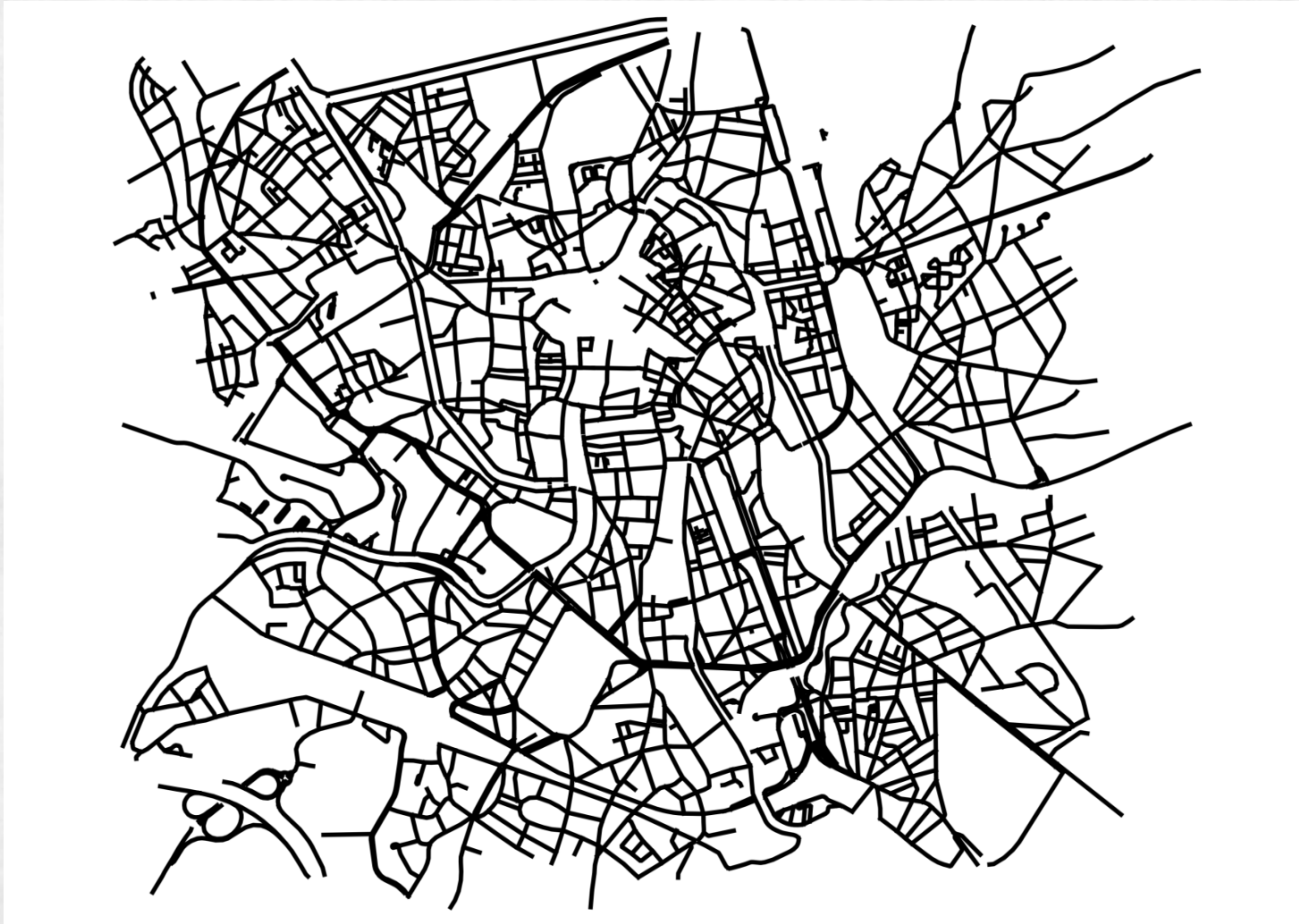


# Scheduling of infrastructure works

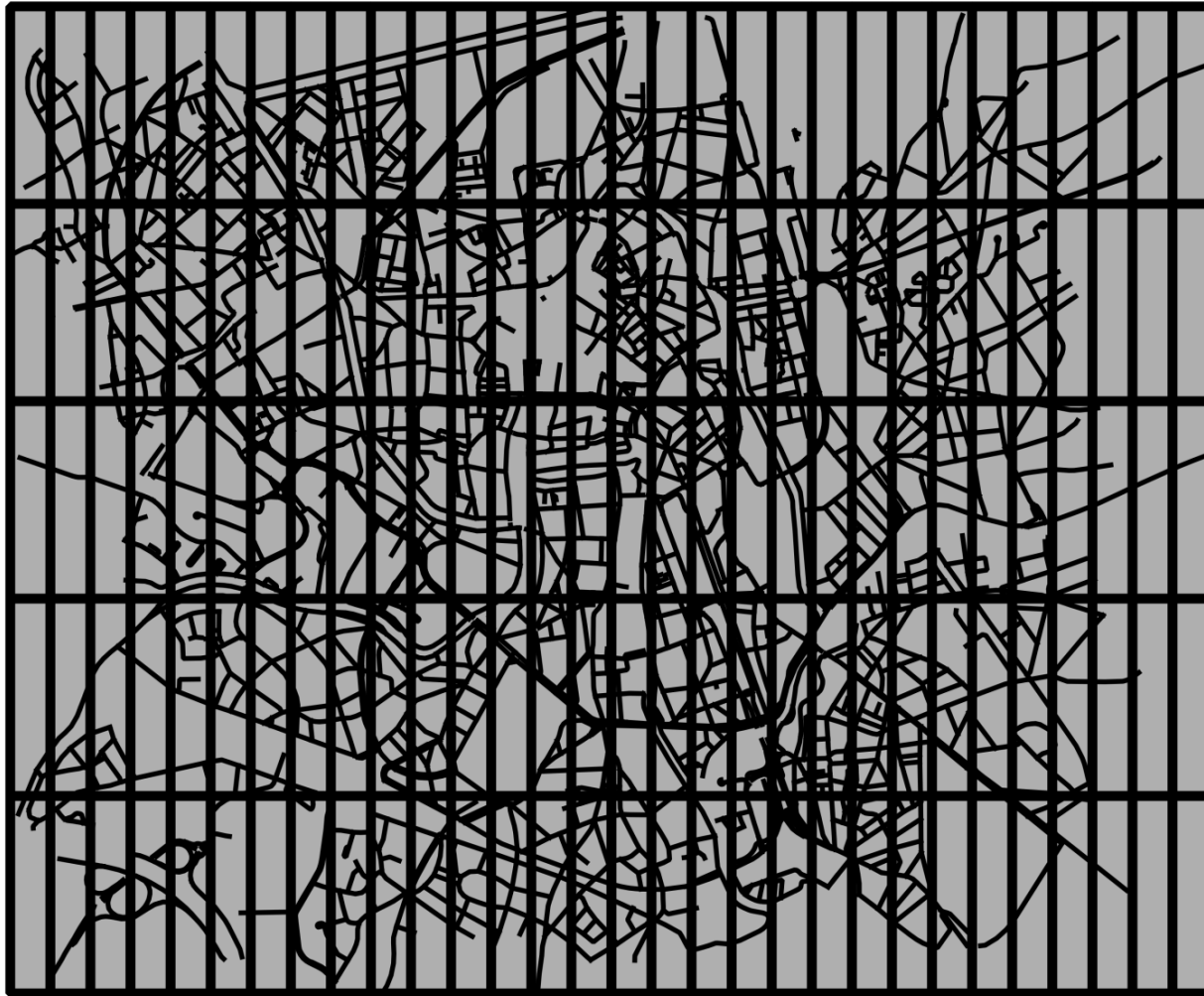
- Multi-actor multi-period planning
- Proof of concept scheduler
  - GIS-data from OpenStreetMap
  - Infrastructure works = fictitious
  - Generated test case
  - Point-based evaluation (actual cost = future work)



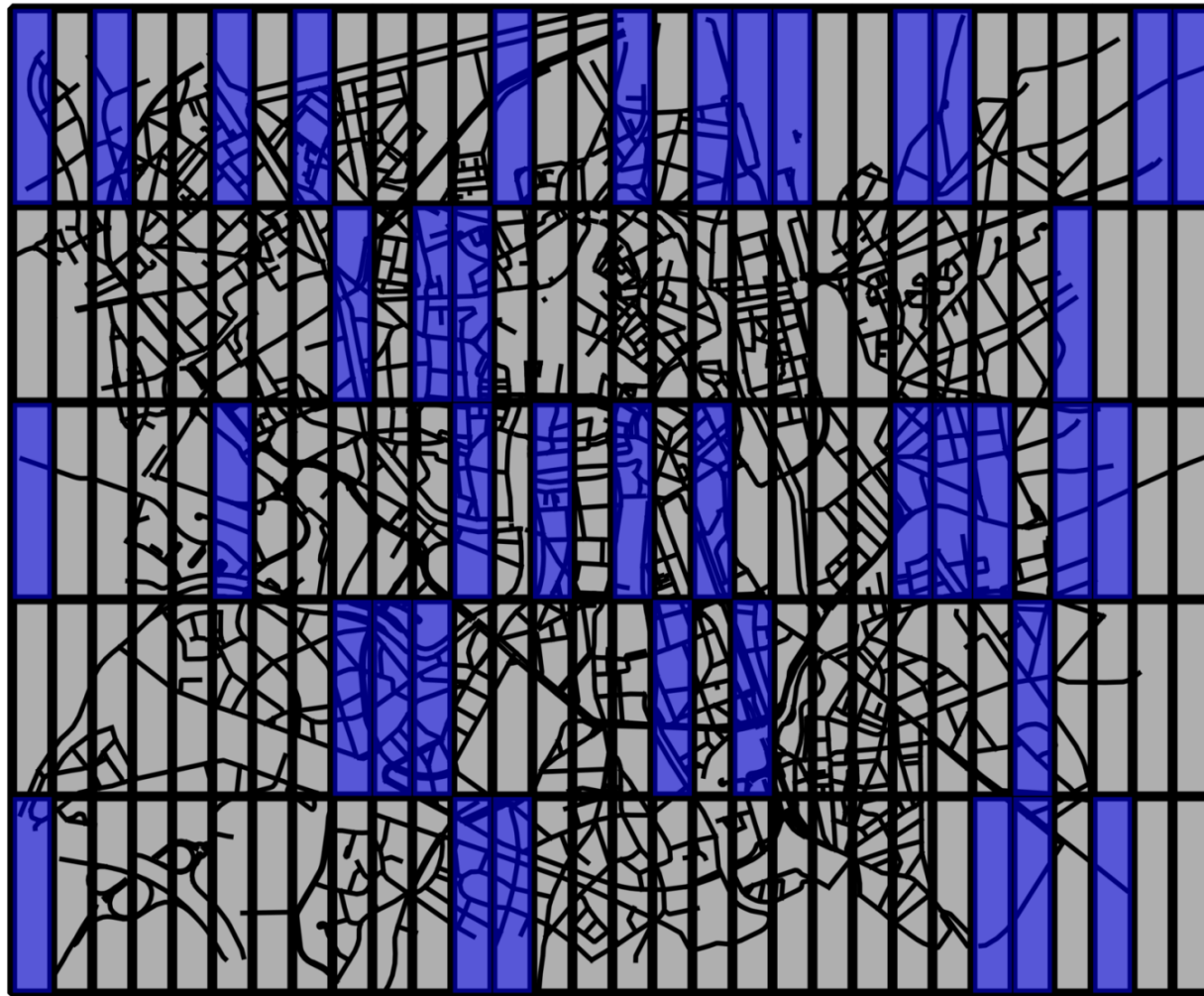
# Test case



# Test case

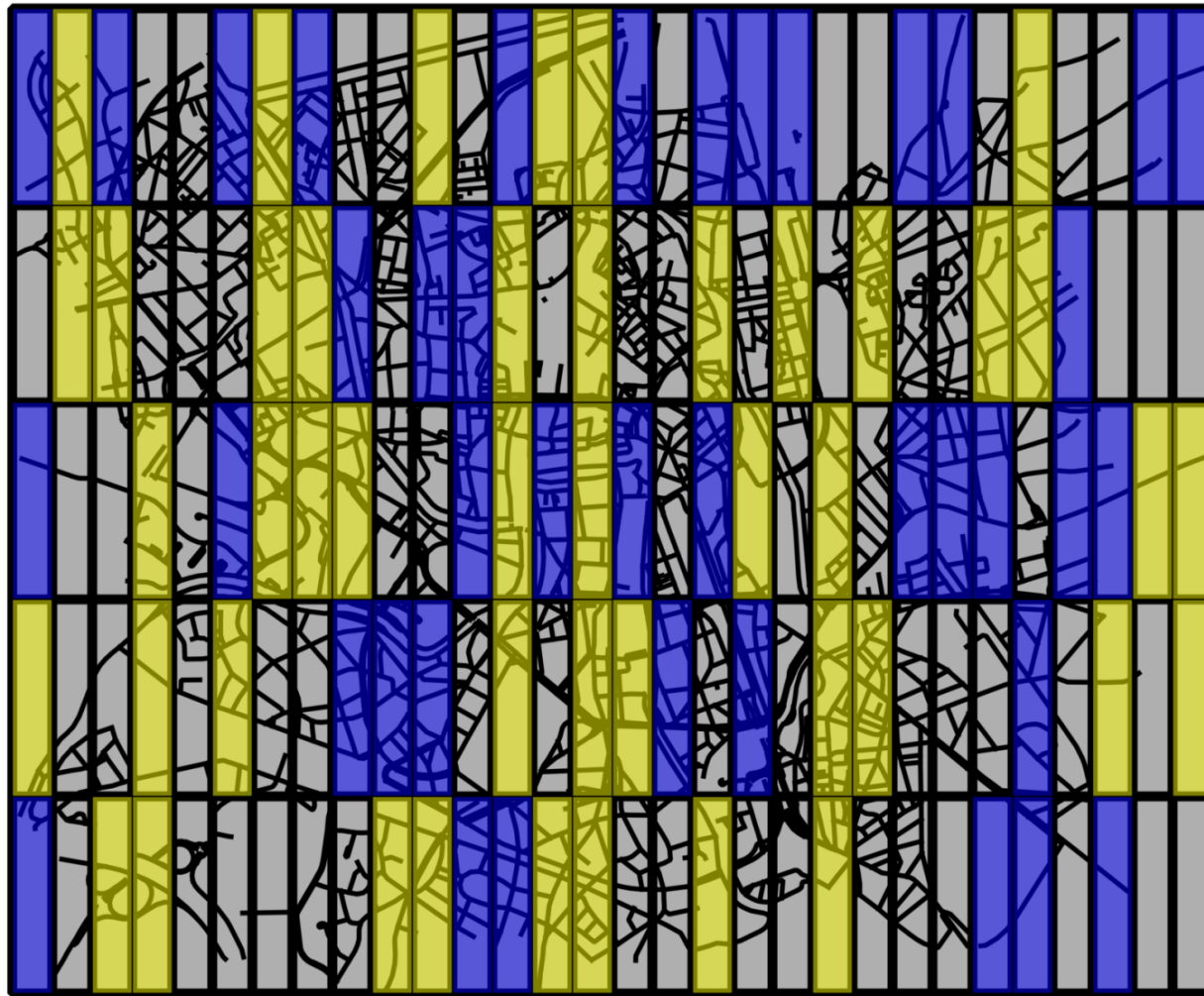


# Test case

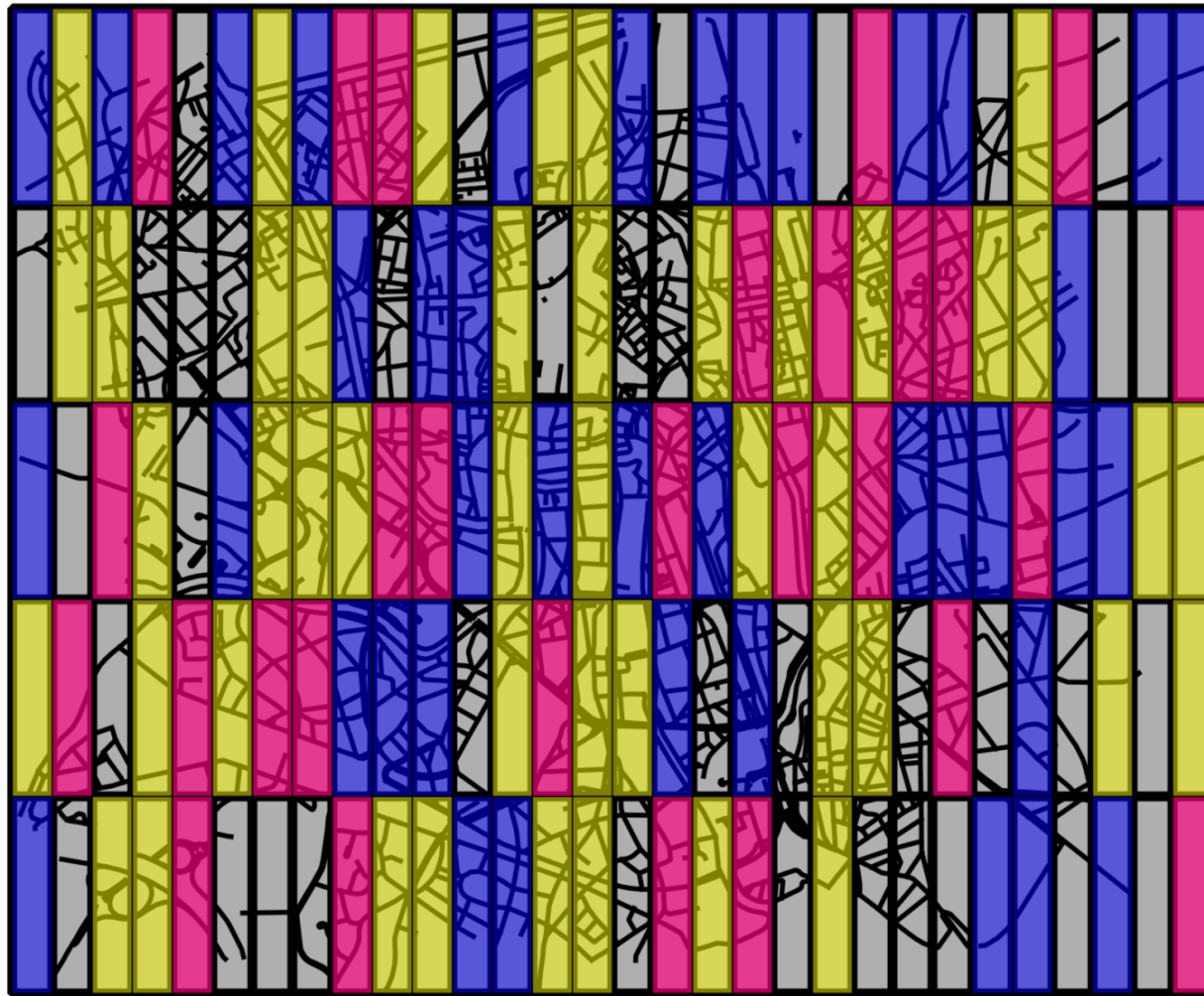




# Test case

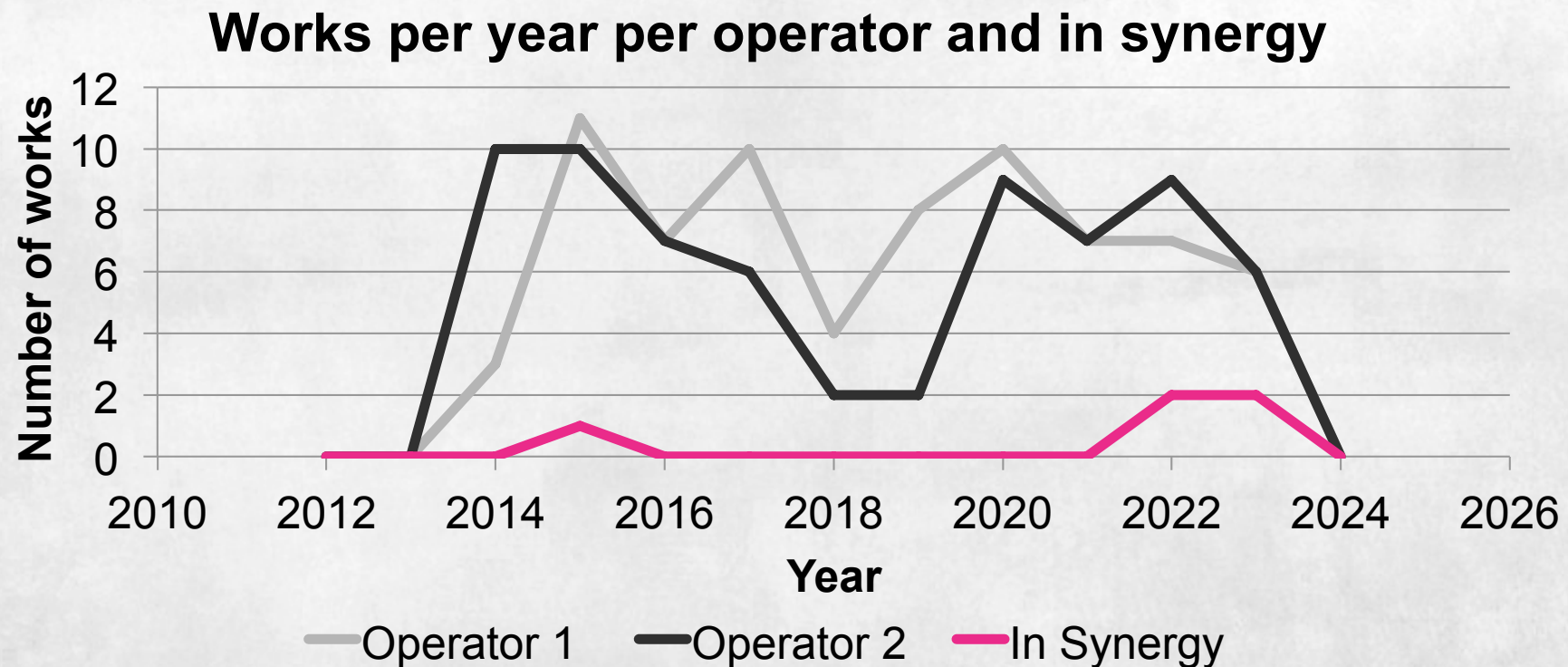


# Test case



# Random scheduling

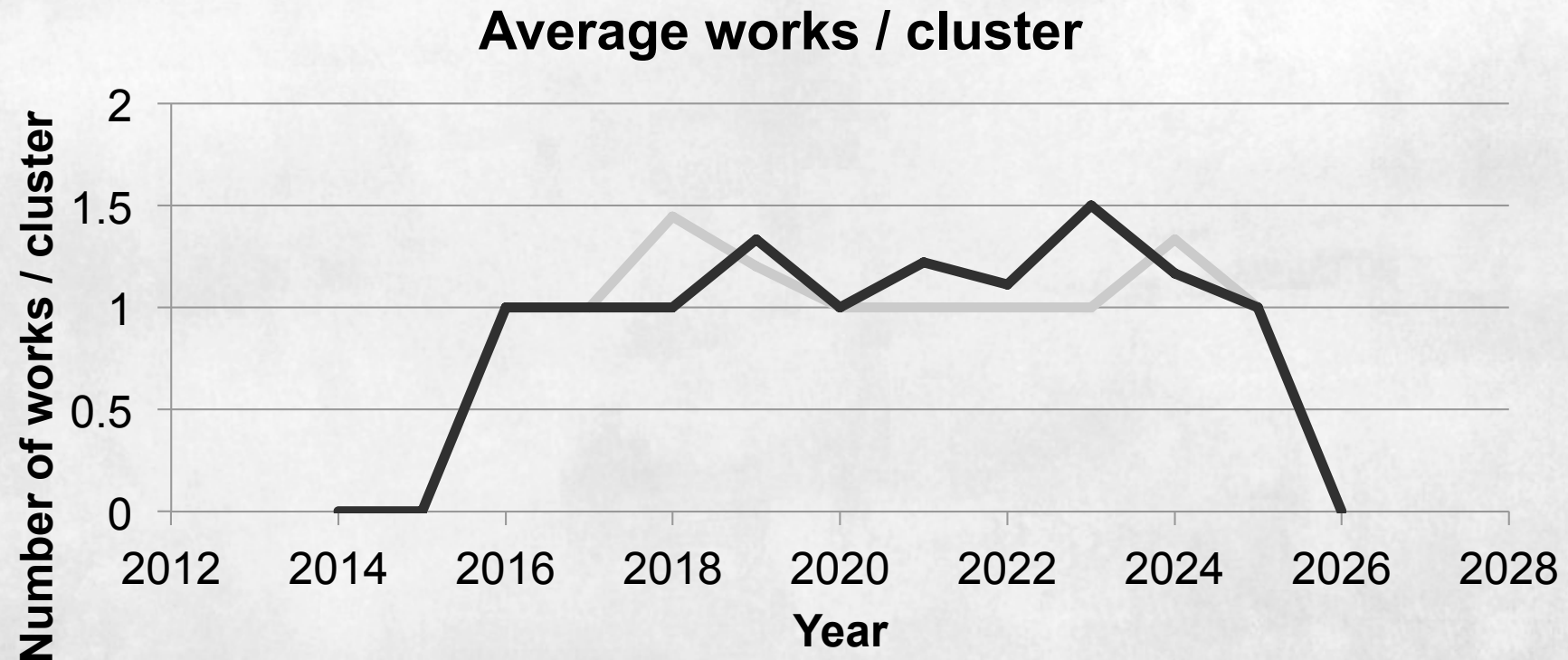
- Almost non-existing synergy (~7%)
- 20% executed within allowed date range





# Random scheduling

- Adjacent works are executed independently (only 9% profit of economies of scale)



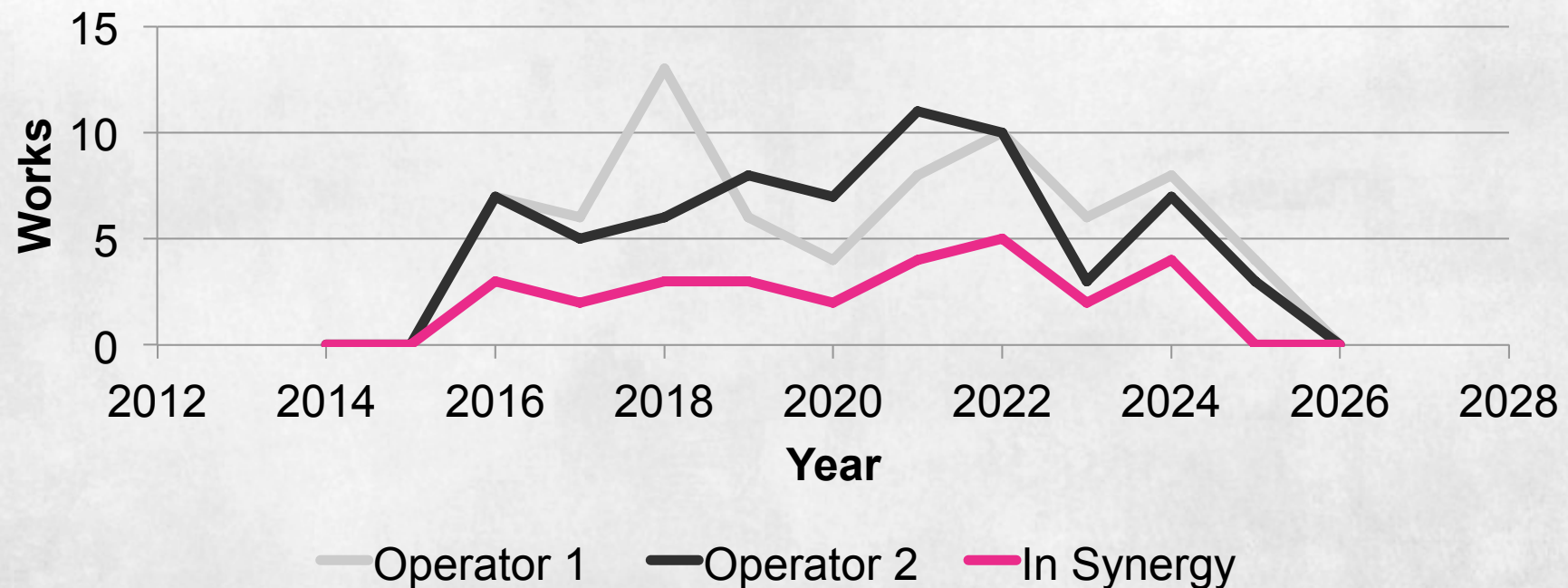
# Optimizations

- Multi-actor multi-period planning
- In synergy
- Economy of scale
- Within allowed date range
- Max budget / year

# Optimization 1/4

- Focus synergy: synergy increase to 38-41%
- 24% executed within allowed date range

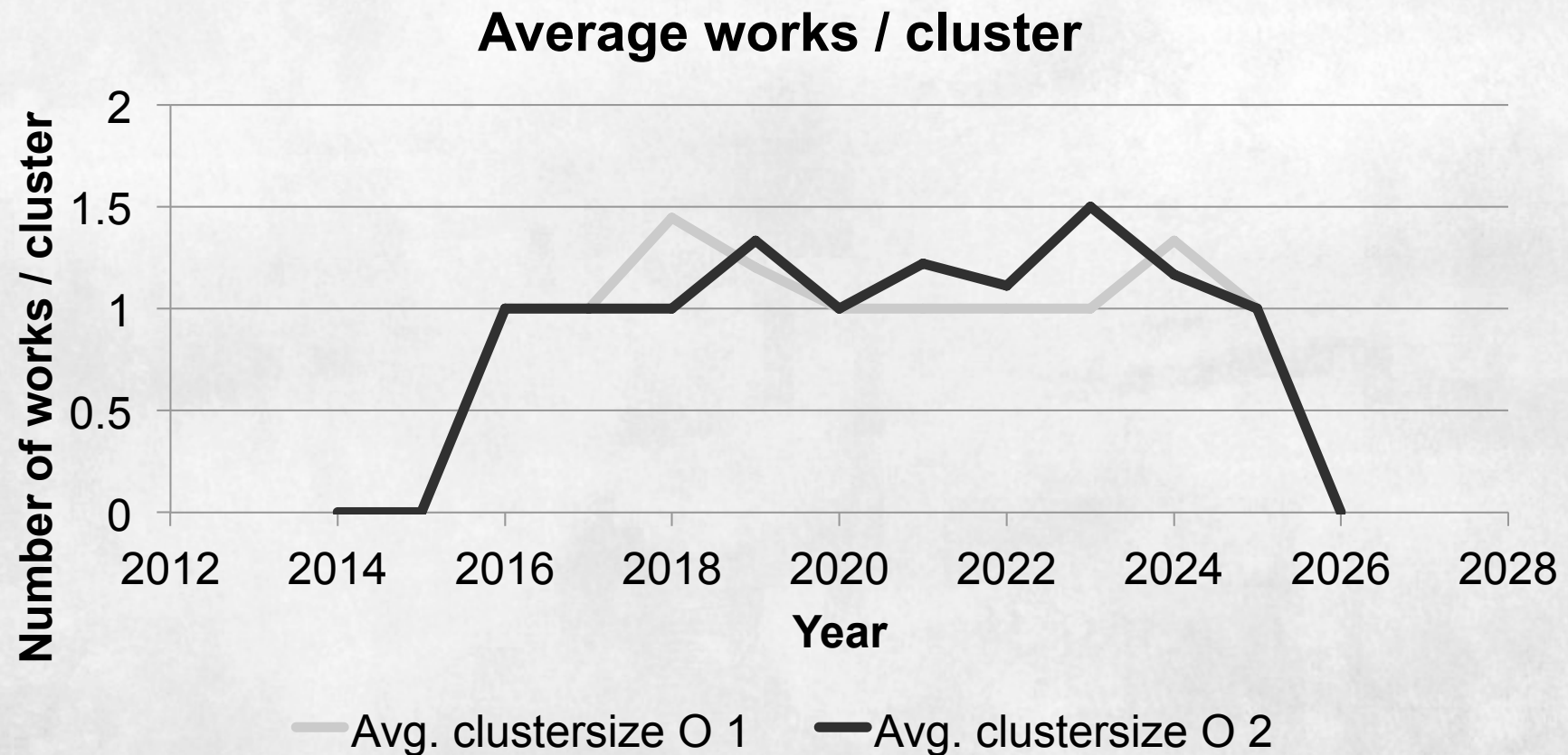
**Works per year per operator and in synergy**





# Optimization 1/4

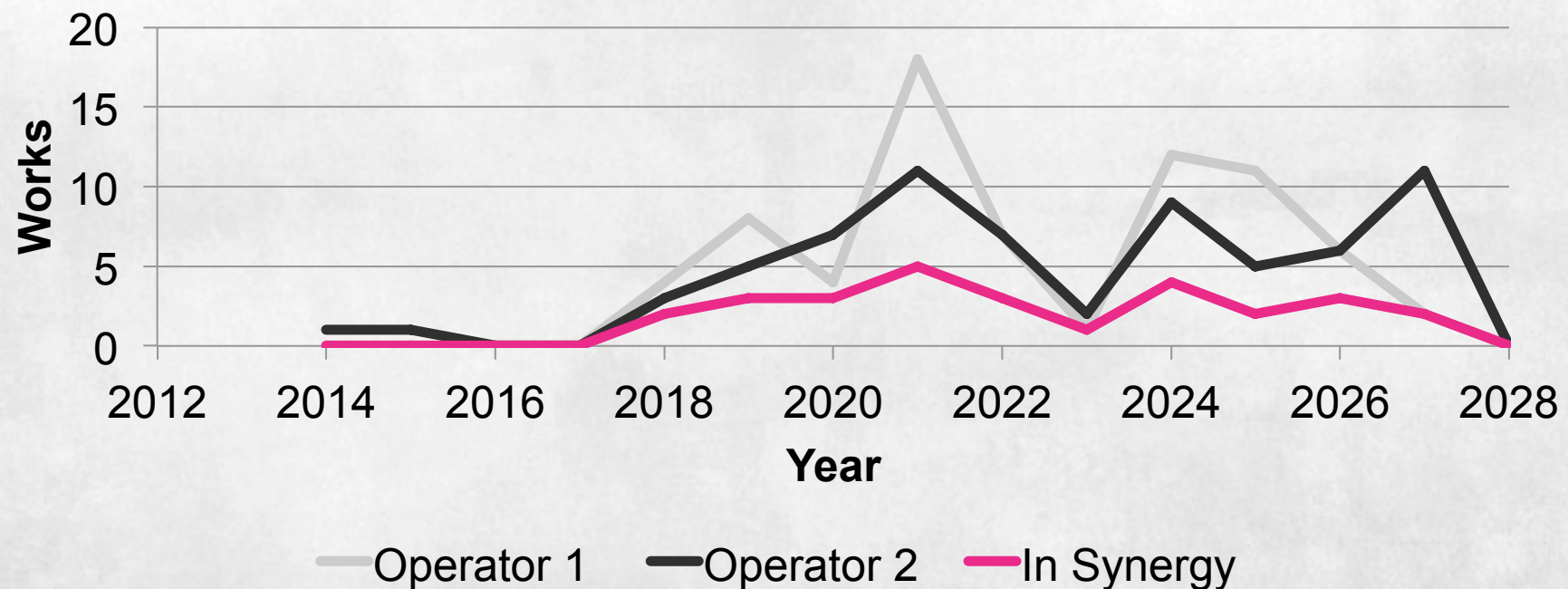
- Adjacent works only 10% clustered



# Optimization 2/4

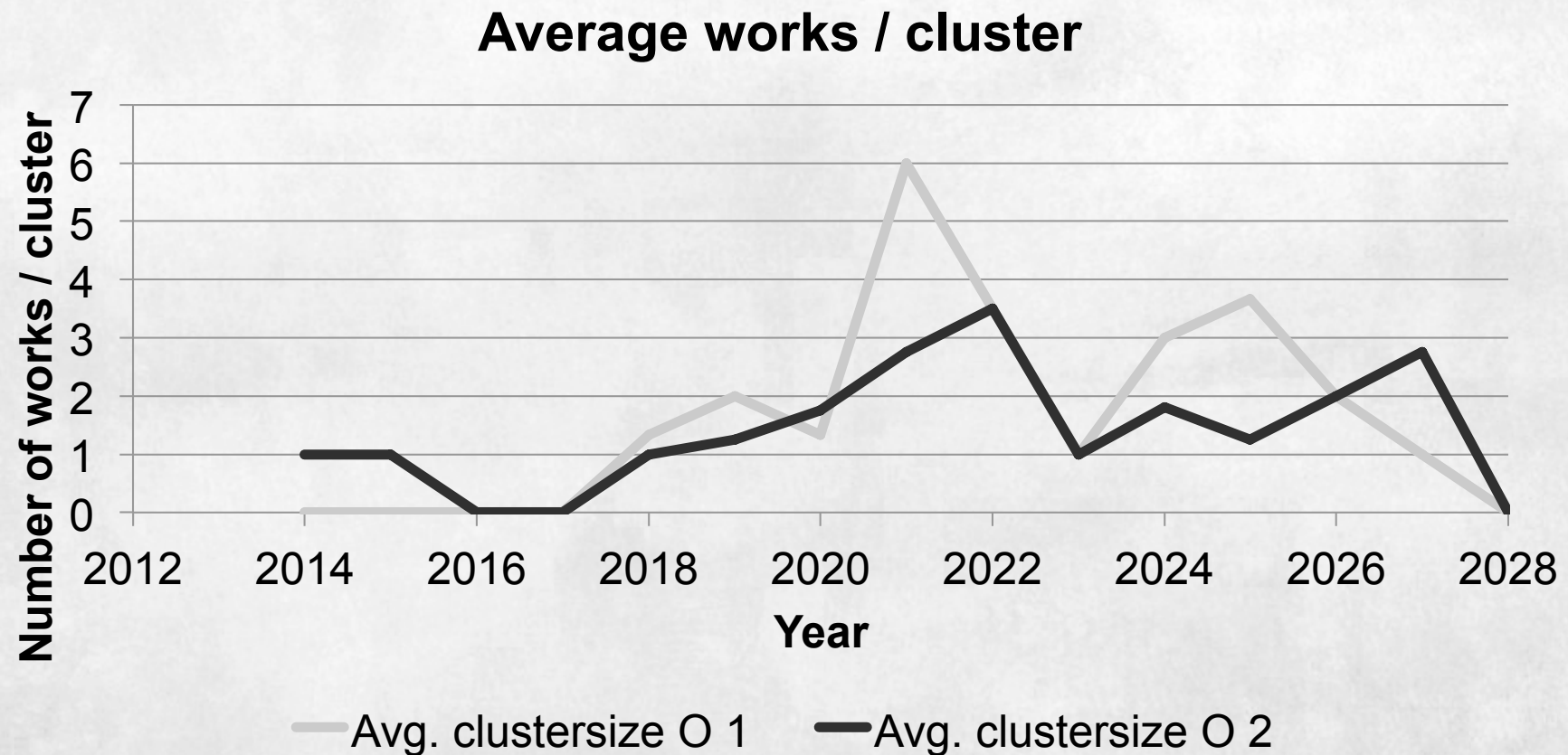
- + economies of scale
- 21% executed within allowed date range

**Works per year per operator and in synergy**



# Optimization 2/4

- 46-61% of works are joined with a larger work

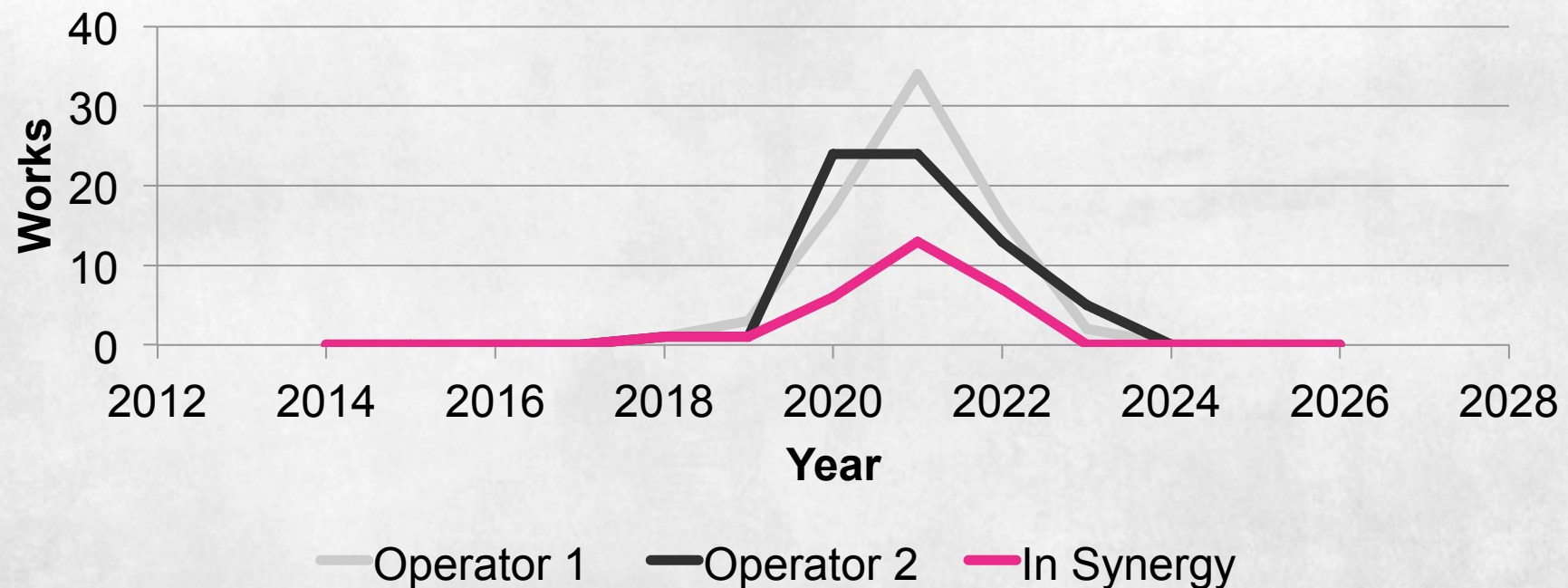




# Optimization 3/4

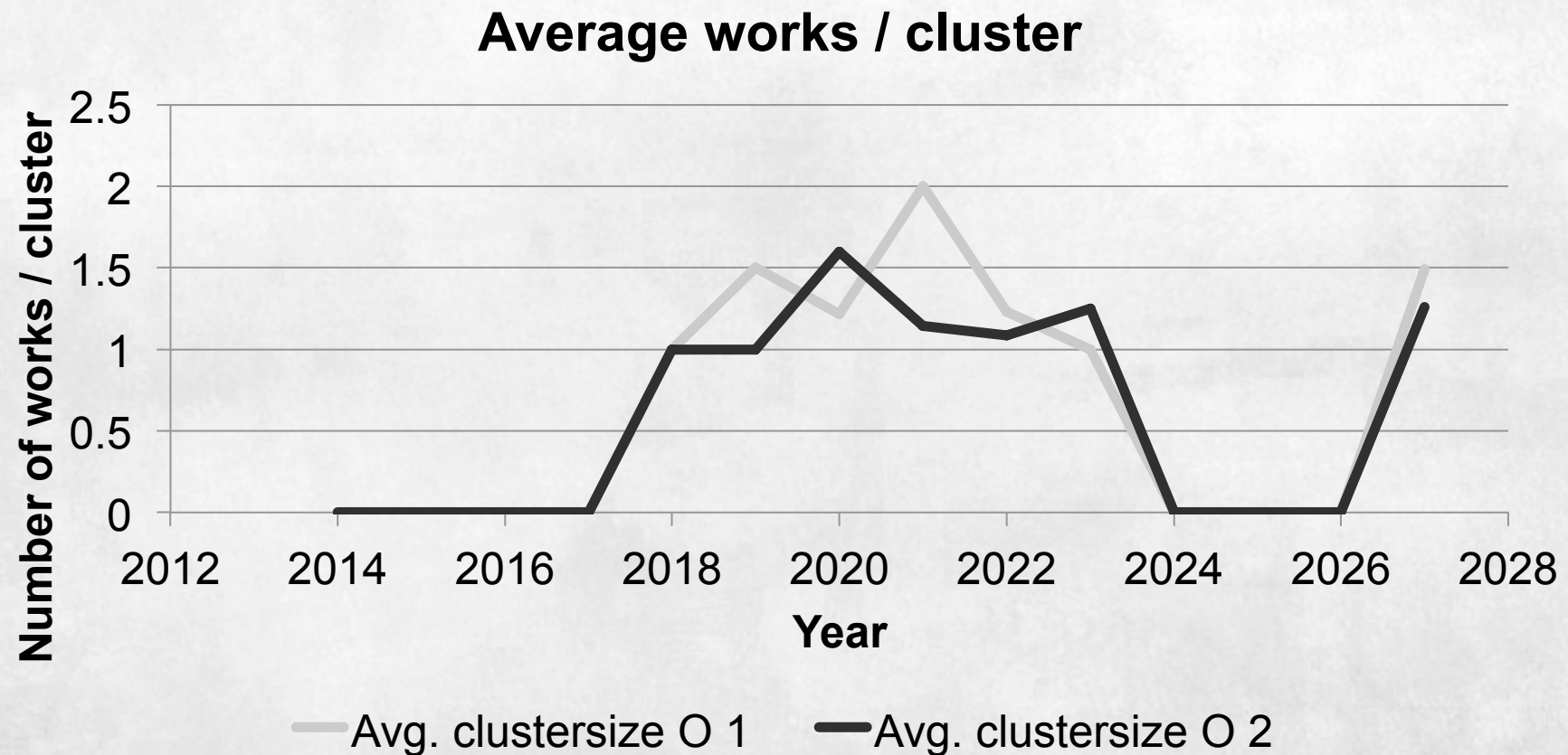
- + within allowed date range
- 85% executed within allowed date range

**Works per year per operator and in synergy**



# Optimization 3/4

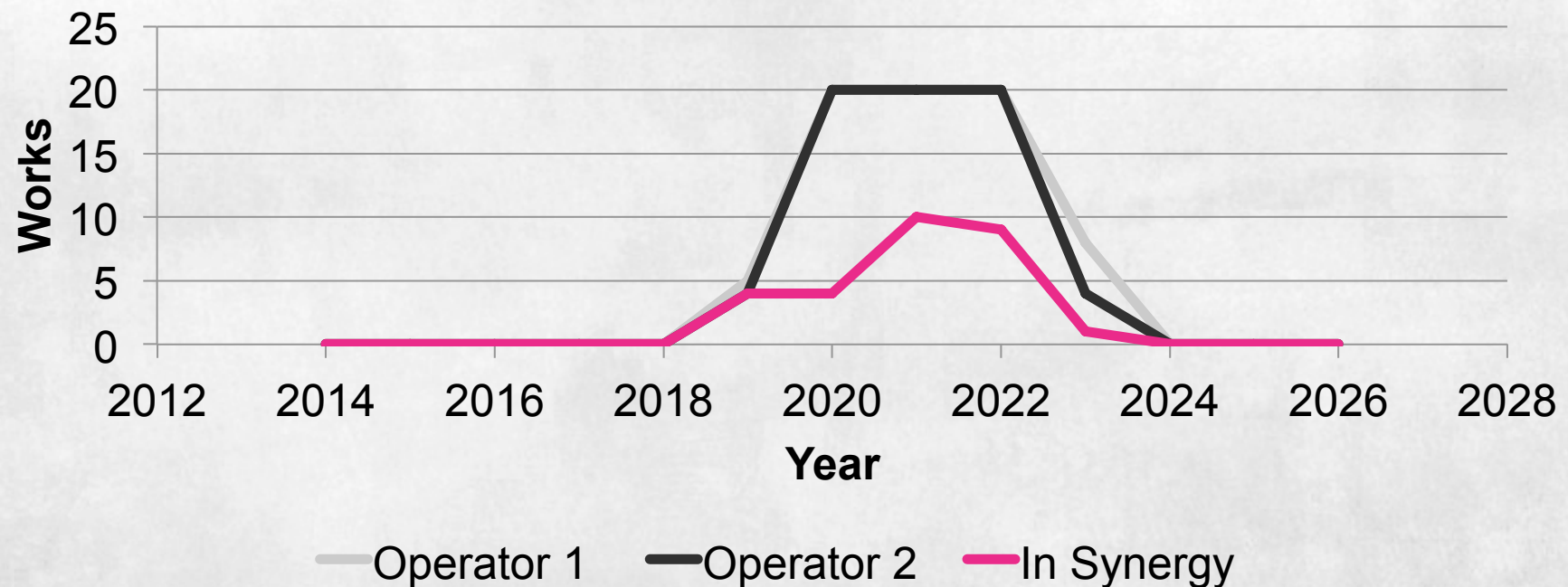
- Clustering lowers to 20-35%



# Optimization 4/4

- + Max budget / year
- 80% executed within allowed date range

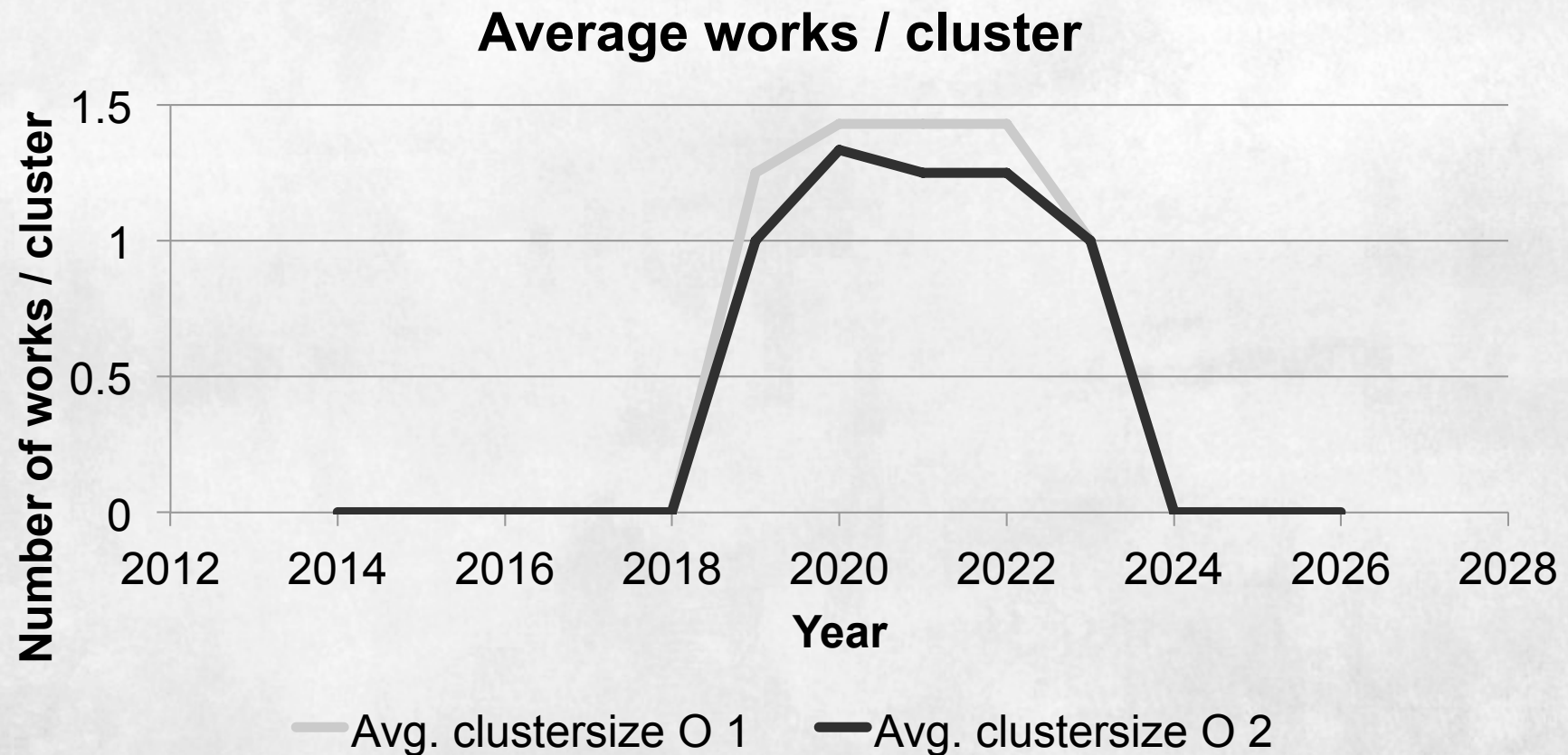
**Works per year per operator and in synergy**





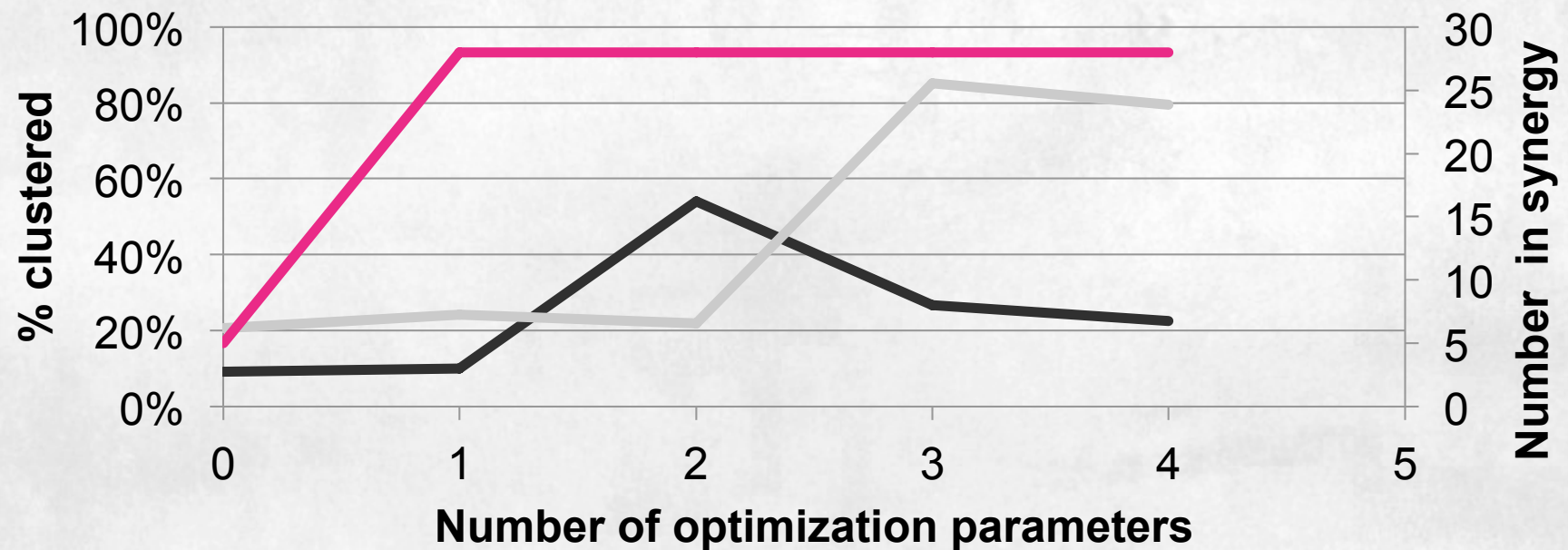
# Optimization 4/4

- Clustering at around 20-25%



# Conclusions

## Optimization results



- Average clustered
- Executed within allowed date range
- In Synergy

# Conclusions

- Trench optimization
  - Can lead to a cost reduction up to 54% for digging cost and 16% overall (highly influenced by type of pavement)
- Multi-actor multi-period planning
  - requires multiple optimization parameters
  - 38-41% of works executed in synergy
  - 20% of works profit of scaling methods
  - (Results can be influenced by setting the parameters)



# Future work

- Scaling
  - Larger cases (=more operators)
  - More detailed cases (=smaller grid size / street level)
- Combination of both optimizations (trench + scheduling)
- Extra optimization parameters
  - All parts of a city accessible
  - Total nuisance for certain streets
- Further evaluation of the relative importance of each parameter

# Questions?

