



A Decision Support System for preventive evacuation of people

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Threat of Flooding in the Netherlands

Sea level rise and heavier storms

Sinking land surface due to gas extraction



9 million people
65% Gross National Product
70% Surface

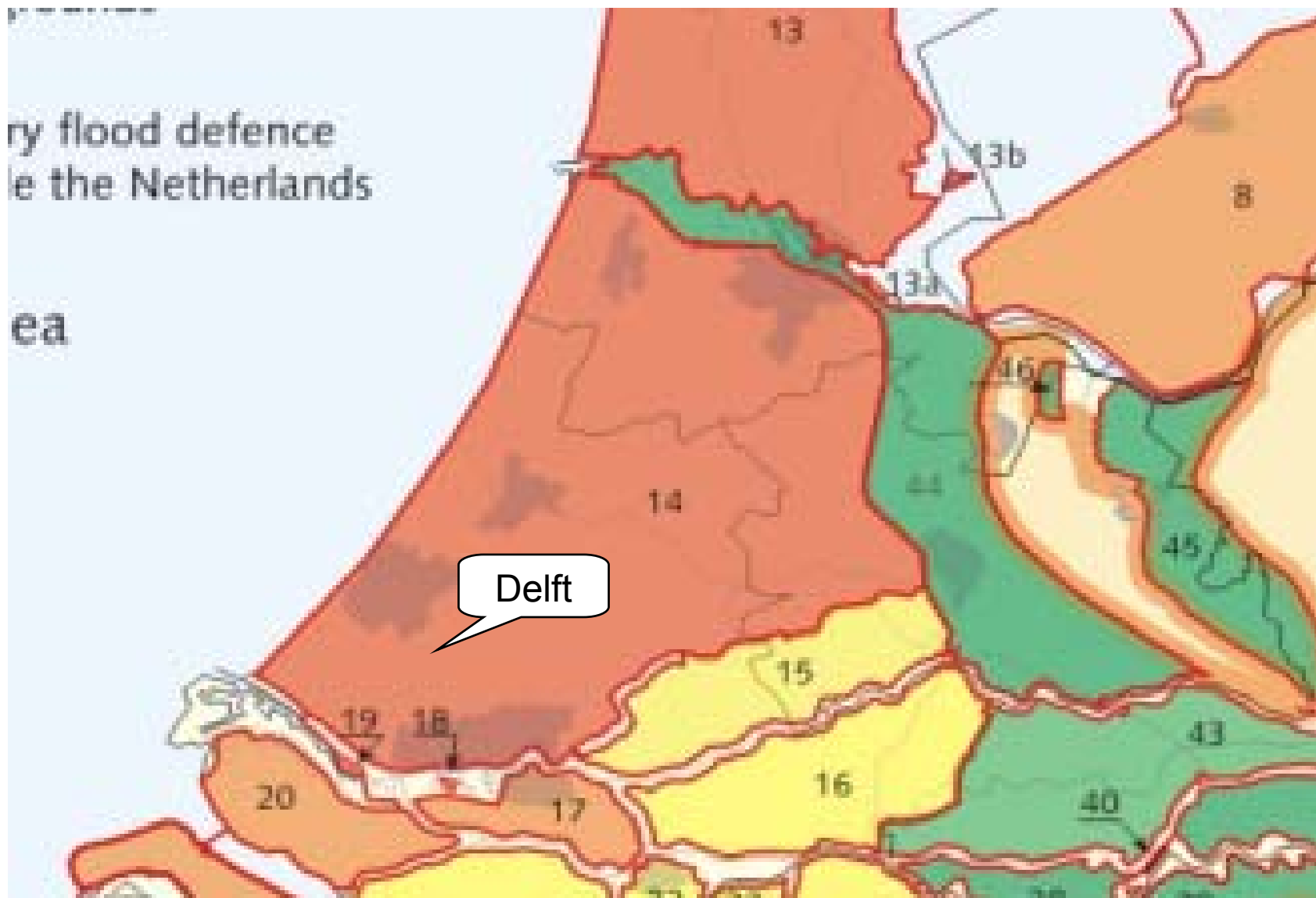
Sinking land surface due to reducing ground water level

More and heavier rainfall

ry flood defence
le the Netherlands

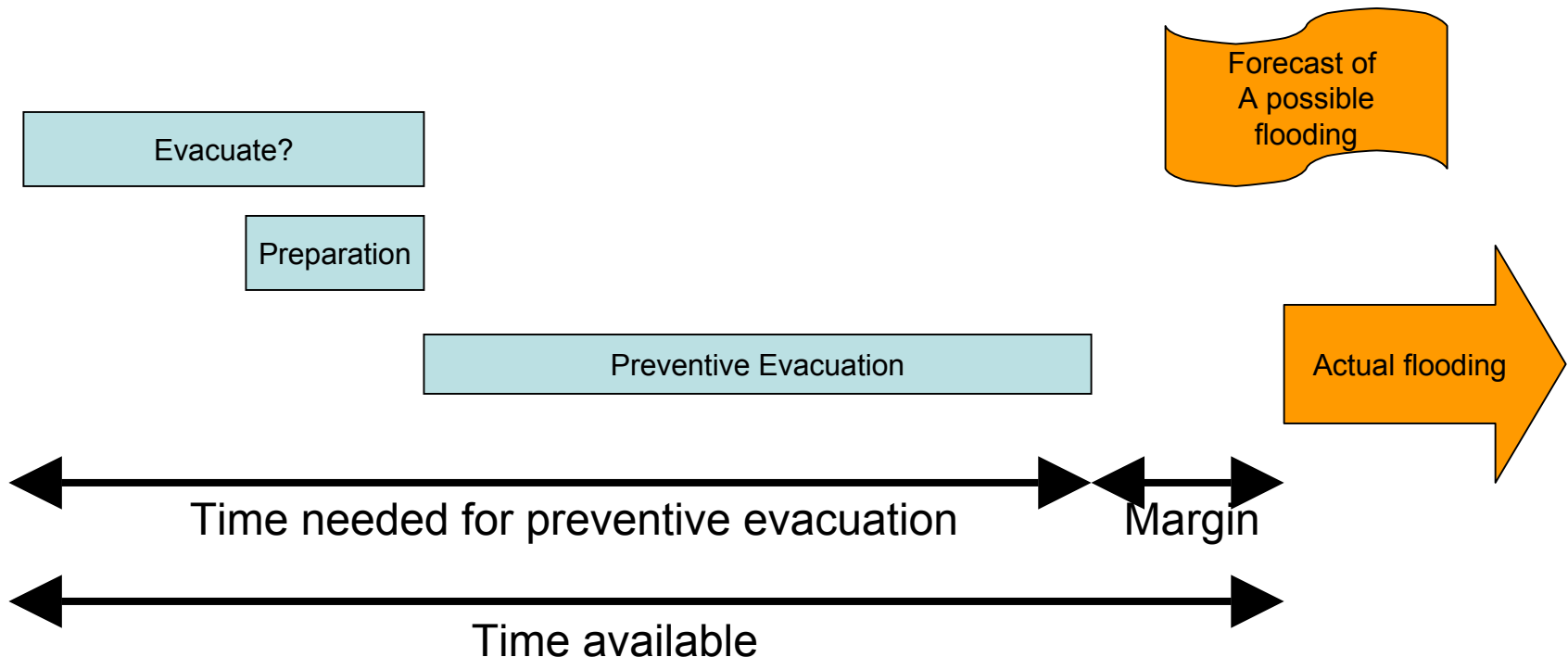
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Delft

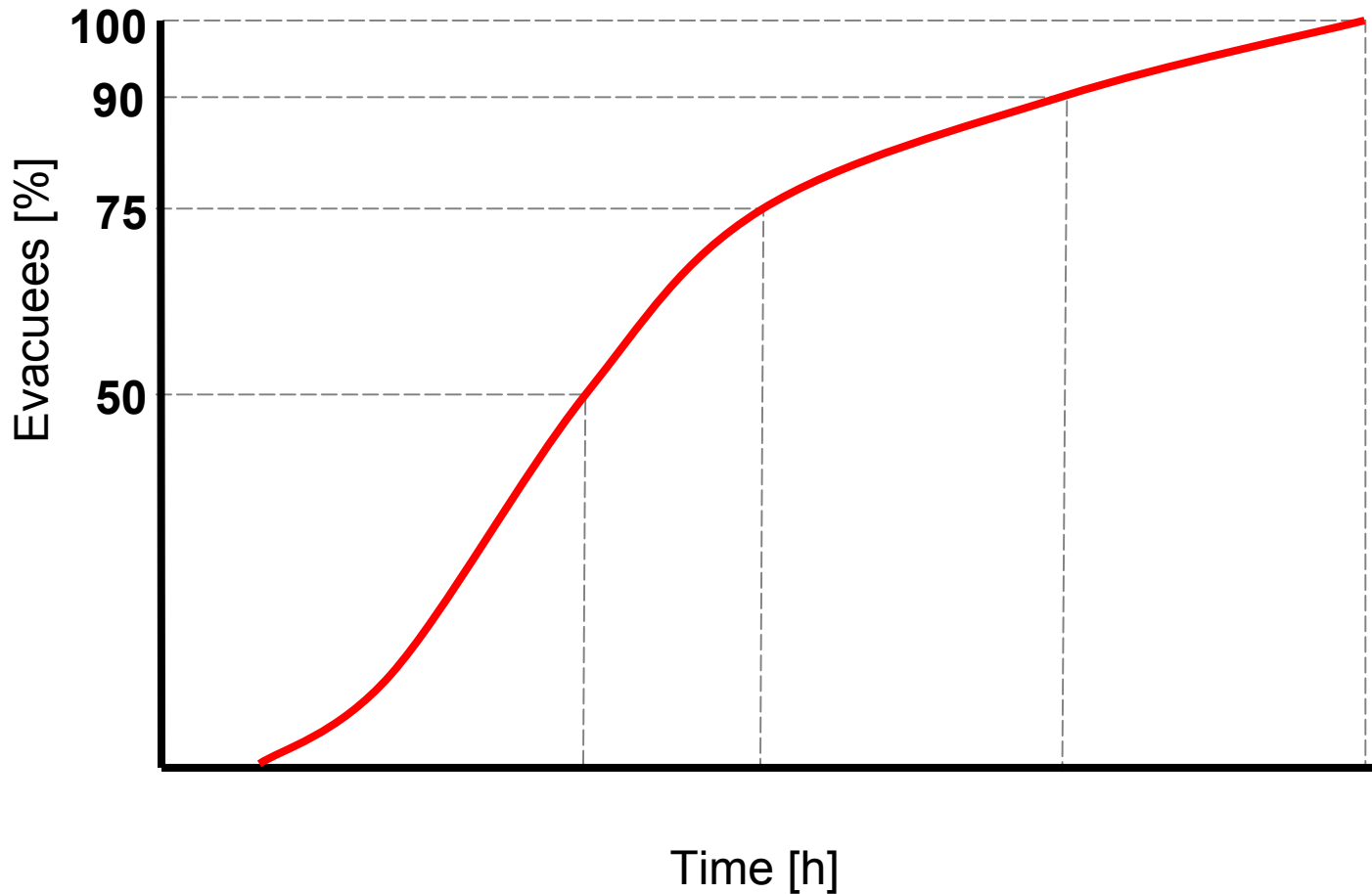


Aim of a preventive evacuation

- Secure lives of people and cattle before actual flooding, by means of an organized, fast and efficient evacuation.



Flood Risk and Safety in the Netherlands (Floris): Relationship between evacuees and evacuation time



Flood Risk and Safety in the Netherlands (Floris): Relationship between evacuees and evacuation time

- Does available time determine the organisation of the evacuation?

Or:

- Does the organisation of the evacuation determine the evacuation time?

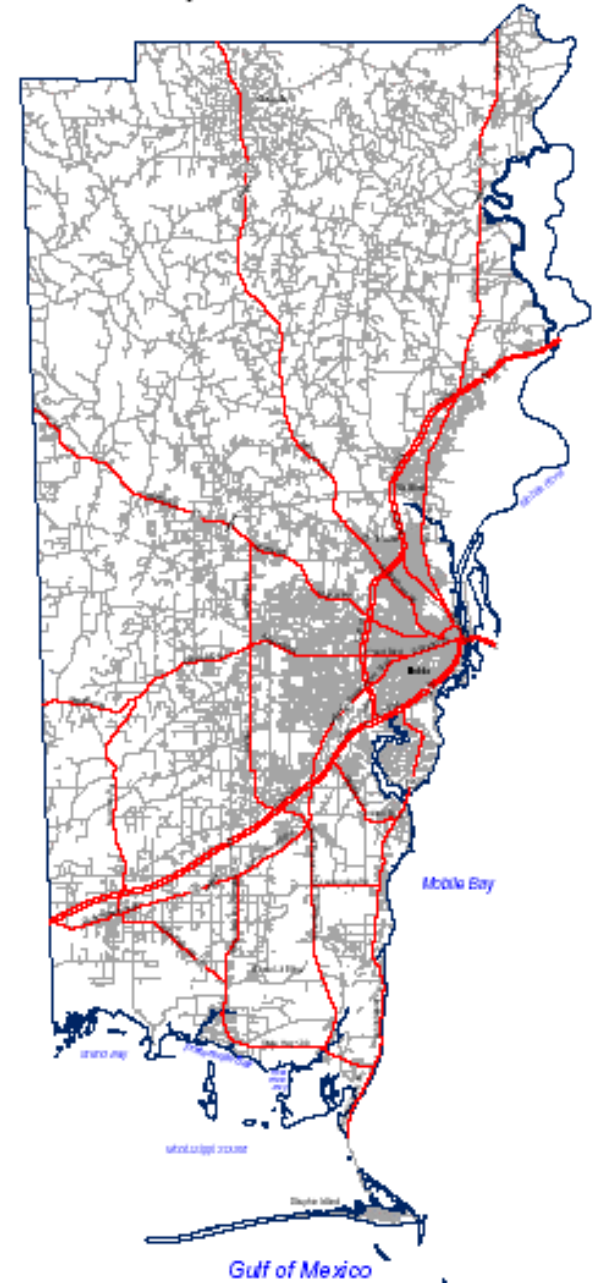
Organisation → Evacuation time

What if we make a mistake?

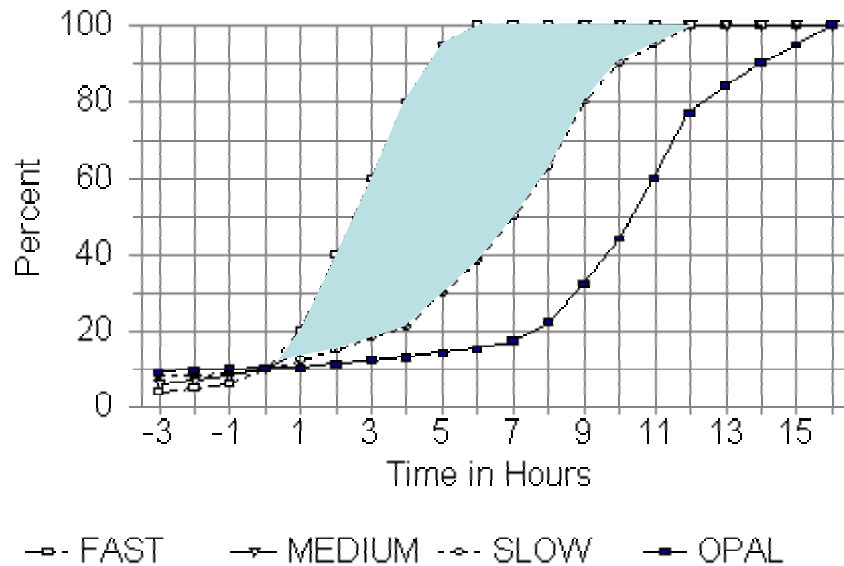
	Evacuation faster than predicted	Evacuation slower than predicted
Efficient traffic flow	++	-
Troublesome traffic flow	+/-	--

Alabama hurricane evacuation

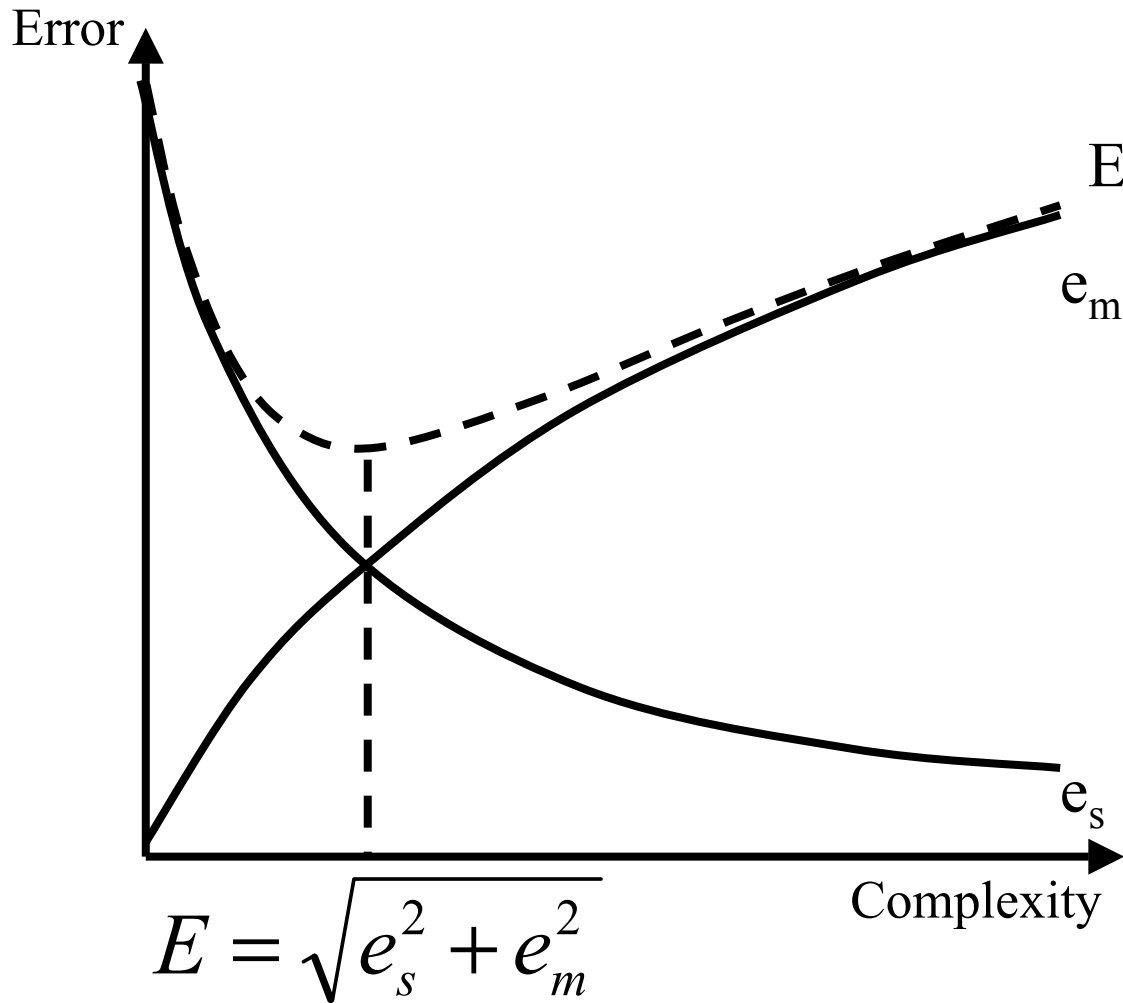
Mobile County Evacuation Routes



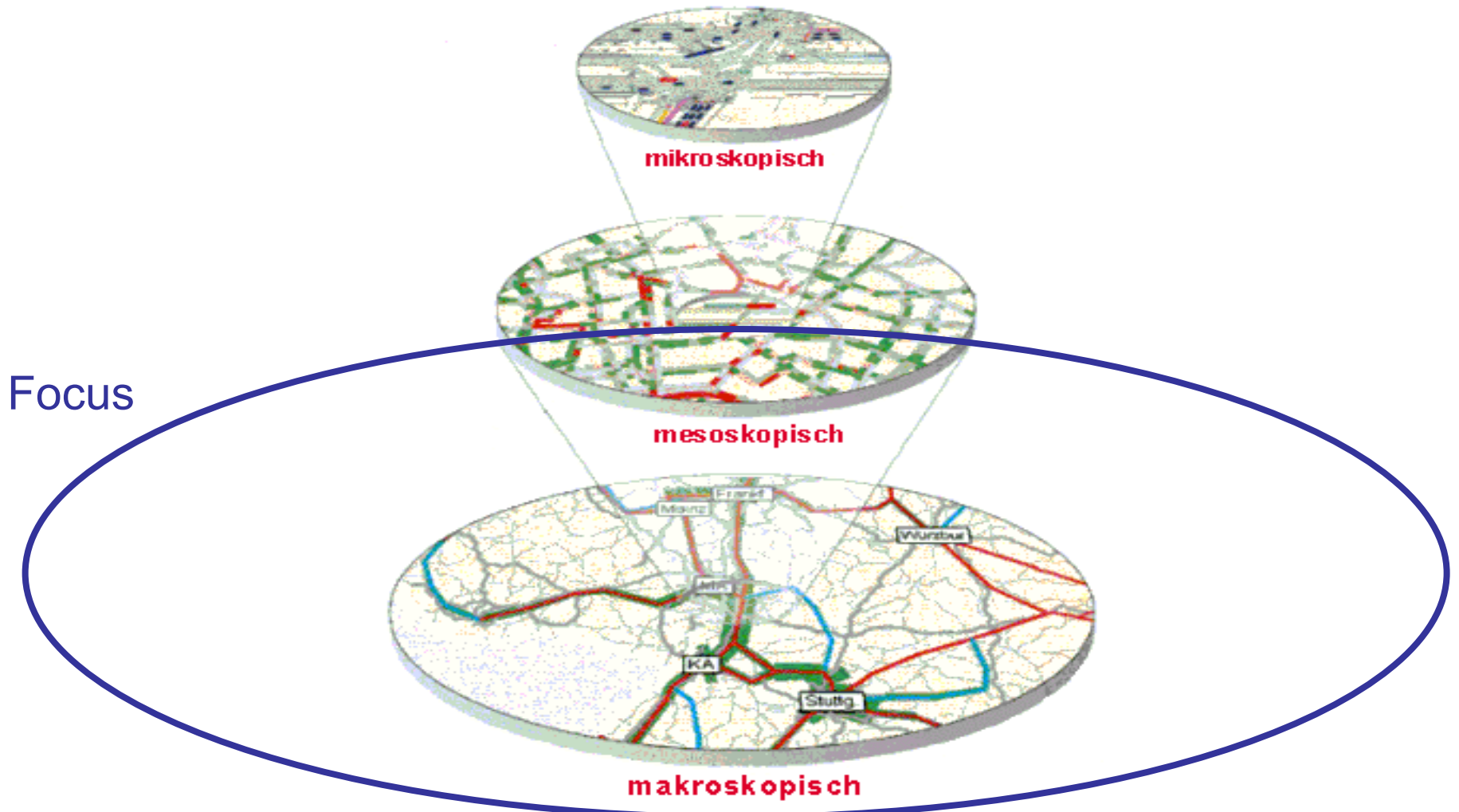
Evacuation Response Rates



Variation of error with complexity



Level of detailing



Do's and Don'ts

- Early notification
 - Converging traffic flows
 - Minimising of total km travelled
 - Reduction of weavings on crossings
 - No usage of vulnerable infrastructure
 - Assignment of people to exits
 - Monitoring of the process
- Late and unclear notification
 - Freedom of route choice
 - Diverging traffic flows
 - Crossing traffic flows
 - Usage of vulnerable infrastructure

Modelling approach

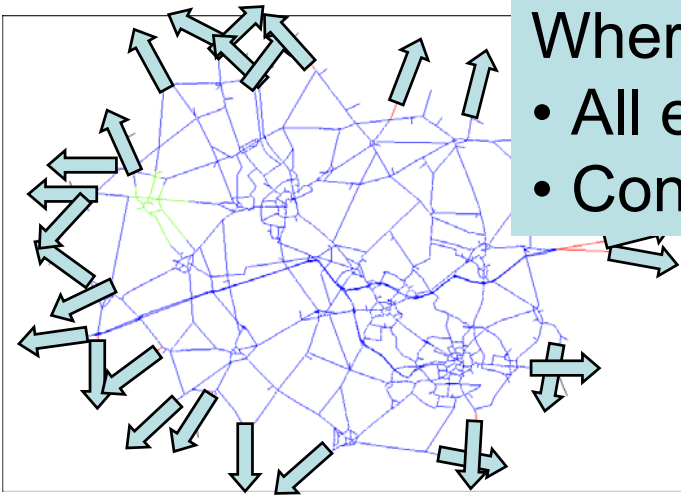
- Formal objective function
- Optimal (given constraints and modal structure)
- Not labour-intensive
- Result independent of operator

Objective function: Min(Max(Out-flow time))

Minimizing of the out-flow time of the slowest exit

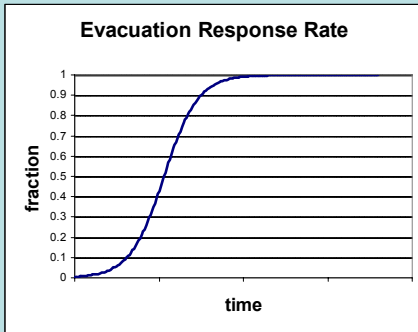
Where:

- All evacuees will leave the dike-ring
- Converging traffic flows





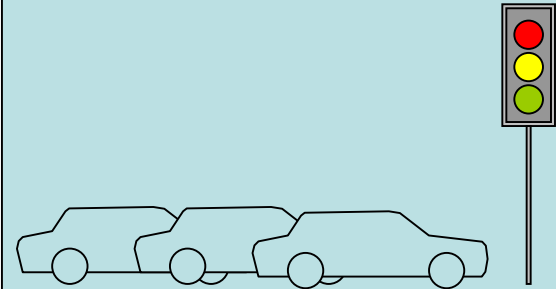
Departure



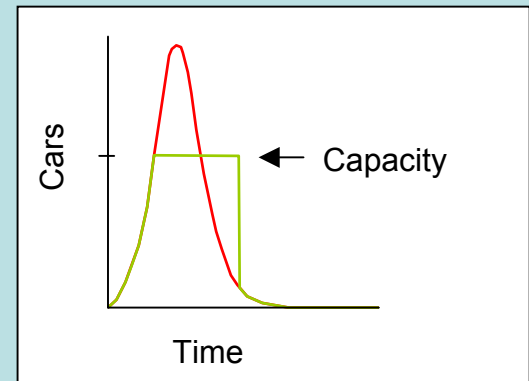
Travelling



$$\text{Time} = \text{Distance} / \text{Speed}$$



Leaving exit



Results for a reference case (do nothing) 1

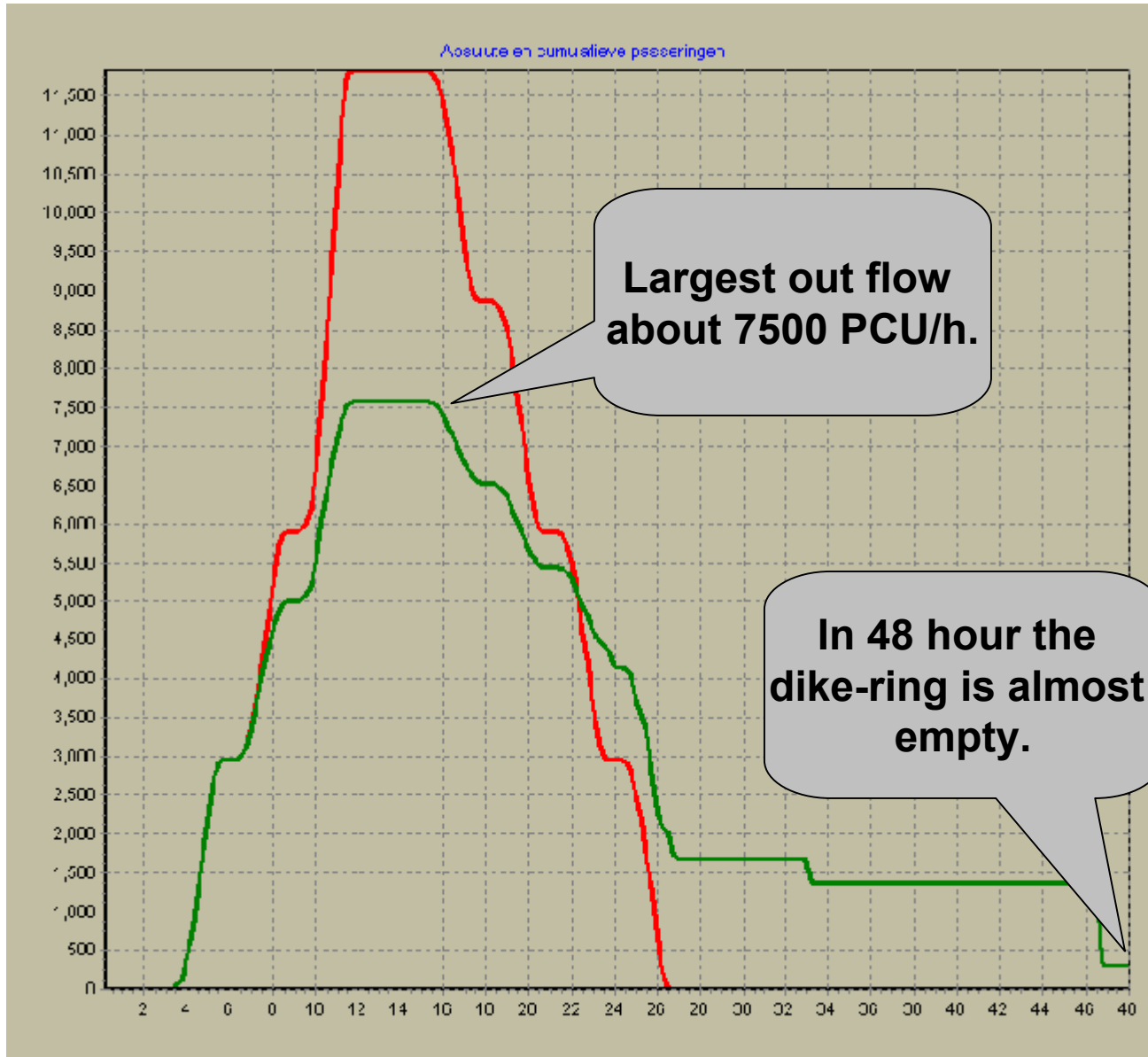
Free choice of destination



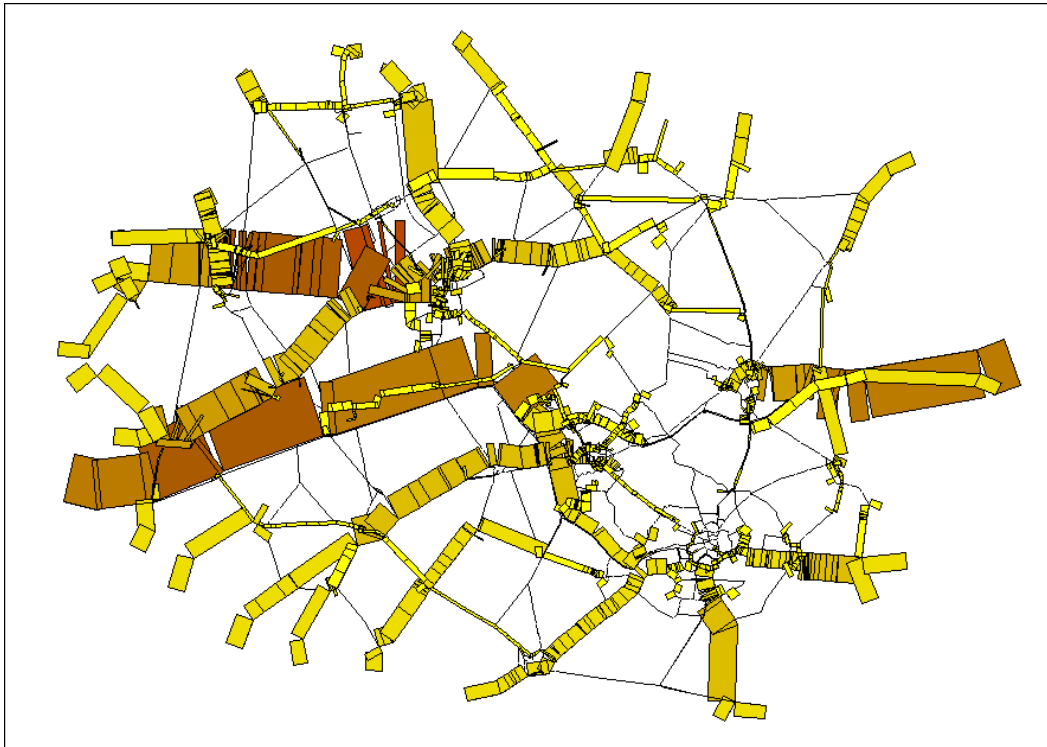
- (Late and unclear notification)
- Freedom of route choice
- Diverging traffic flows
- Crossing traffic flows
- (Usage of vulnerable infrastructure)

Results for a reference case (do nothing) 2

Free choice of destination

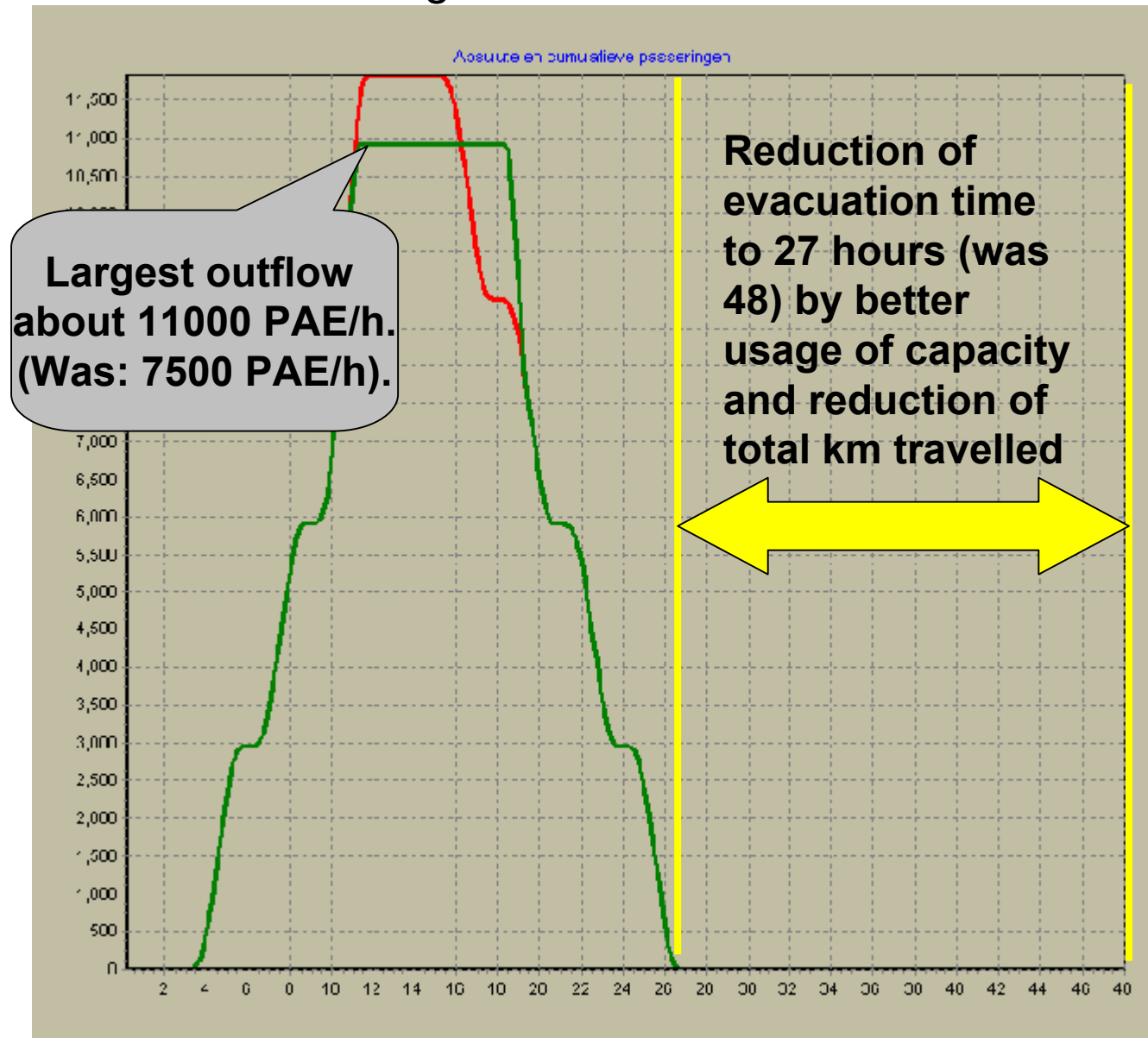


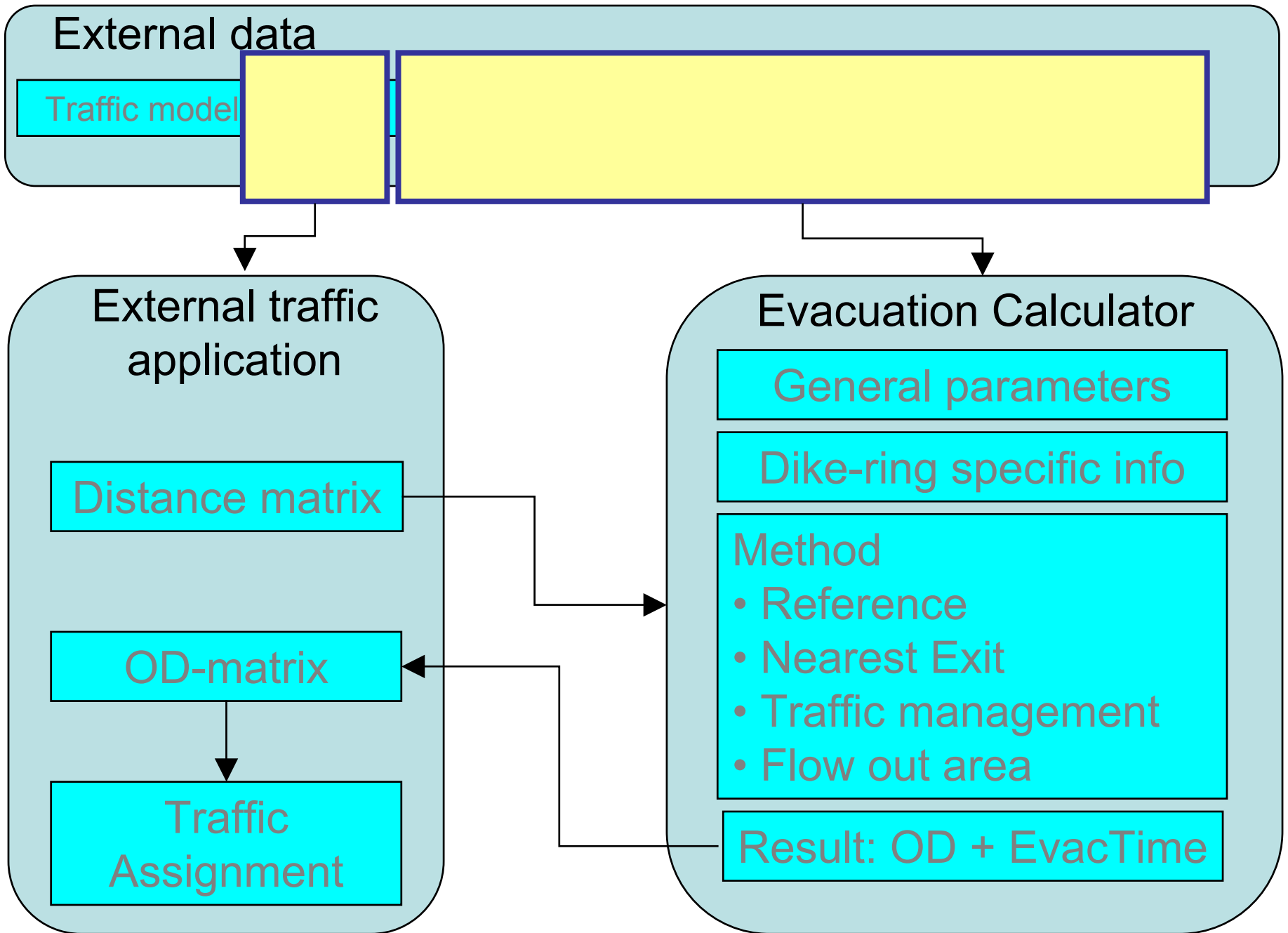
Use of the objective function: $\text{Min}(\text{Max}(\text{Out-flow time}))$ 1
by proportional usage of the capacity of exits together with
minimizing of total vehicle distance

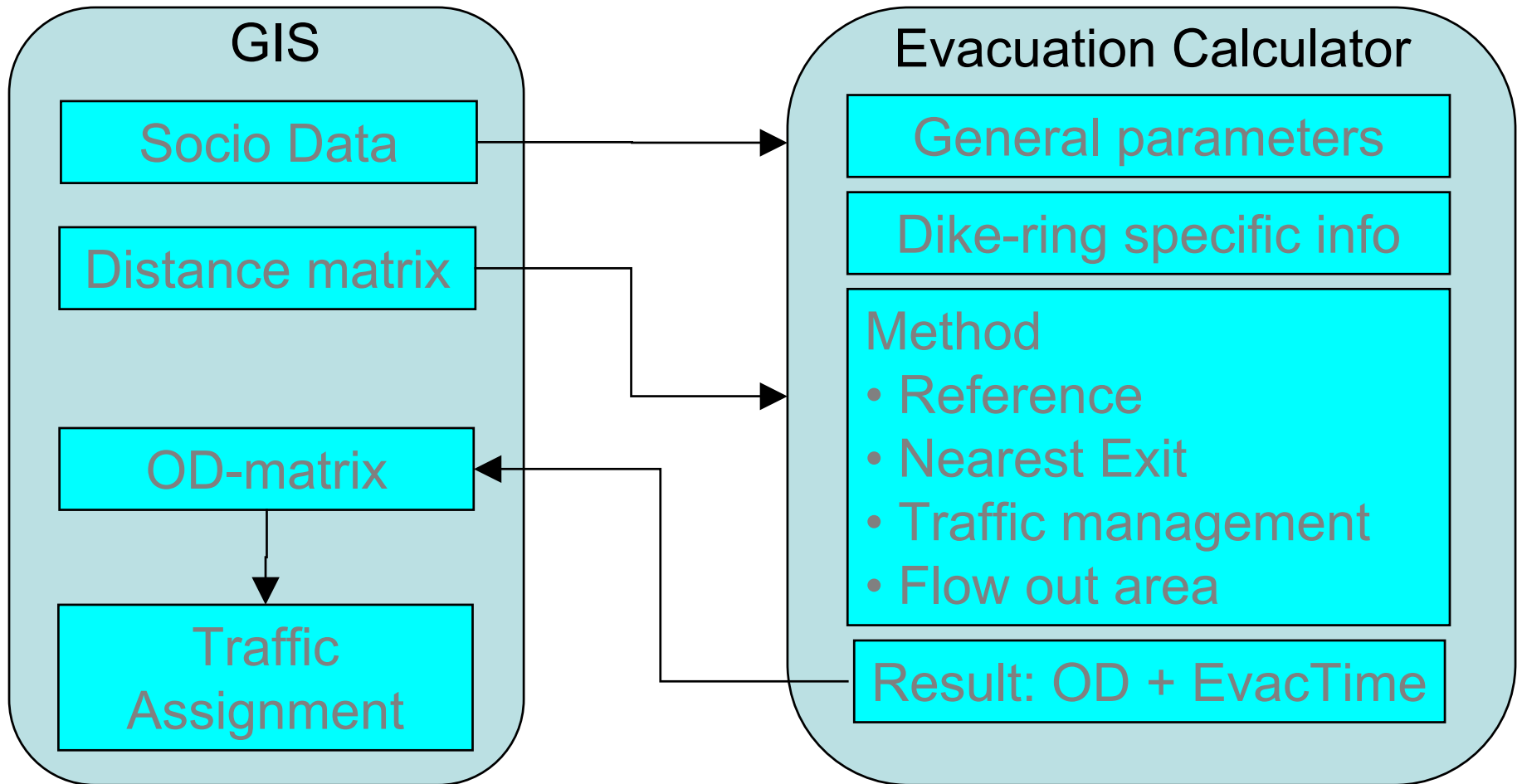


- Converging traffic flows
- Minimizing of total vehicle distance
- (Reduction of weavings on crossings)
- (No usage of vulnerable infrastructure)
- Assignment of people to exits
- (Monitoring of the process)

Use of the objective function: $\text{Min}(\text{Max}(\text{Out flow-time}))$ 2
by proportional usage of the capacity of exits together with
minimizing of total vehicle distance







Conclusions

- Formal objective function
- Optimal solution for the distribution of evacuees within the capabilities of the authorities
- Simple method for calculation the evacuation times
- Worst-case methods for upper bounds of evacuation time
- Modest data need