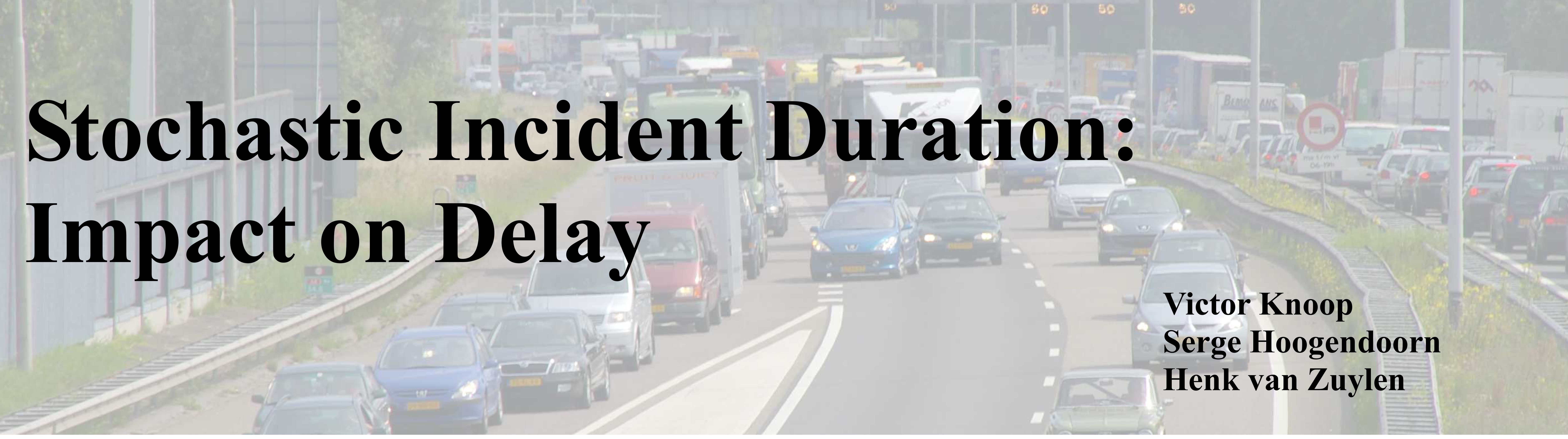

Stochastic Incident Duration: Impact on Delay

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Abstract

The delay caused by an incident depends on many variables. This paper introduces an analytical expression for the delay, describing the location and length of the queue by shockwave theory. As long as the congestion remains on the same link, delay is proportional to the square of the duration, even in case the outflow is reduced by a junction downstream. This gives an elegant expression for the expected delay. Once the queue grows to other links (spillback or blocking back), the influence of duration becomes even larger. Therefore, it is useful to avoid spillback by network design or reduce incident times as much as possible.

Introduction

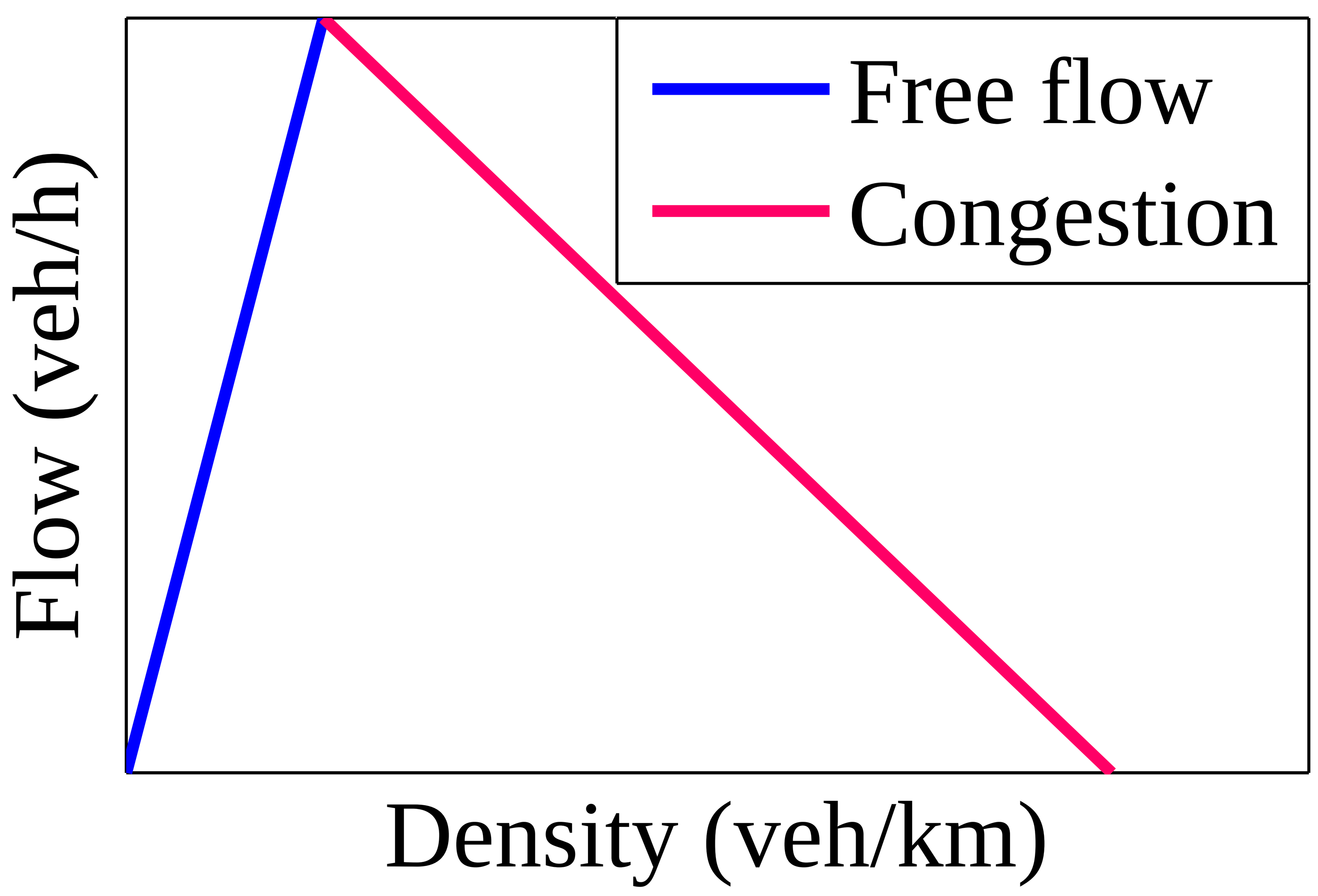
It is important to know the delay caused by incidents, both for operations and planning purposes. The average duration of the incident is not a good indicator for the average delay. The variance of the duration also has an influence on the average delay.
This paper shows an equation to calculate the benefit that can be obtained by reducing the duration of an incident. This can be used to assess the value of measures to reduce the handling time of an incident.

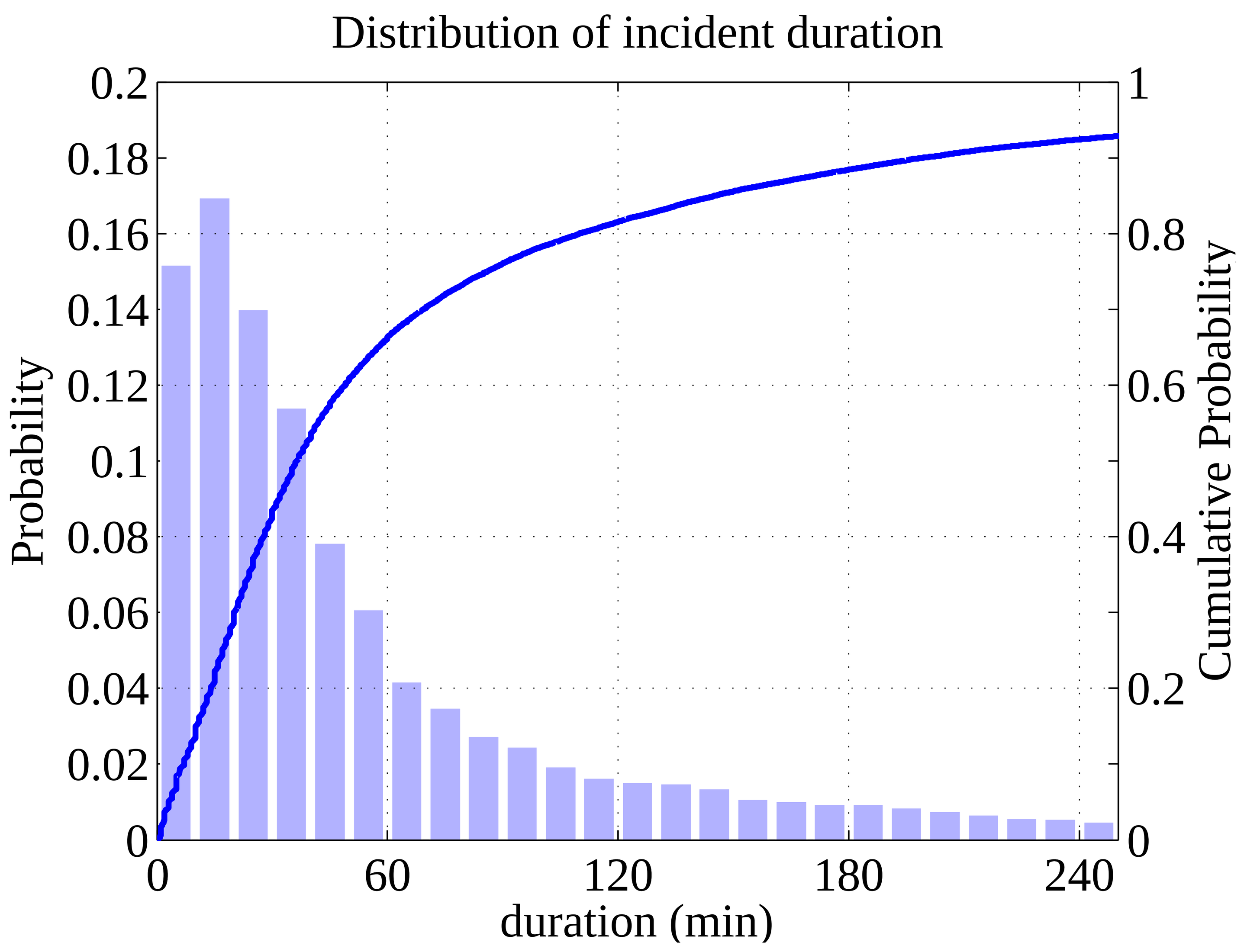
Traffic flow description

- Variables:
  - Incident duration (ΔT) and location
  - Capacities
- Analytical description
- Shock wave theory
- Triangular fundamental diagram

} => *Closed delay expression*

=> *Analytical modeling is possible*





Practical relevance

- Calculate the magnitude of the effect in practice

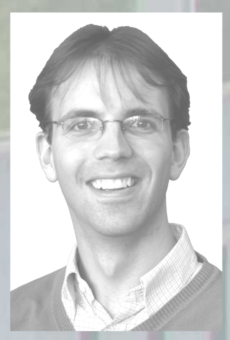
=> duration of the blockades on the Dutch motorway

- Variance is 32% of the average incident duration

=> Underestimation of the average delay by 24% if calculated using the average incident duration

- In case of spillback larger error

- Reducing incident duration important, more than increasing capacity, or decreasing demand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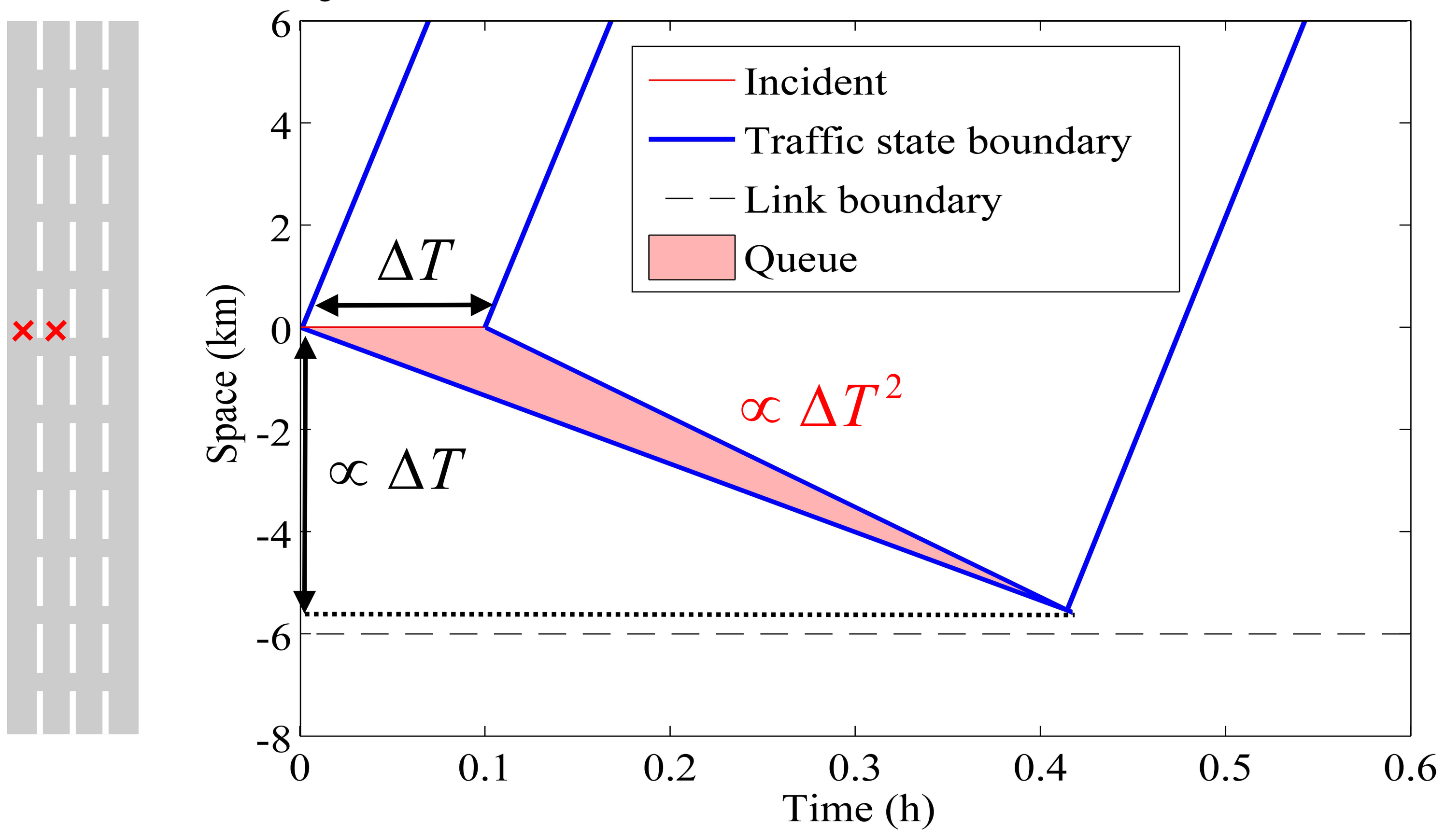
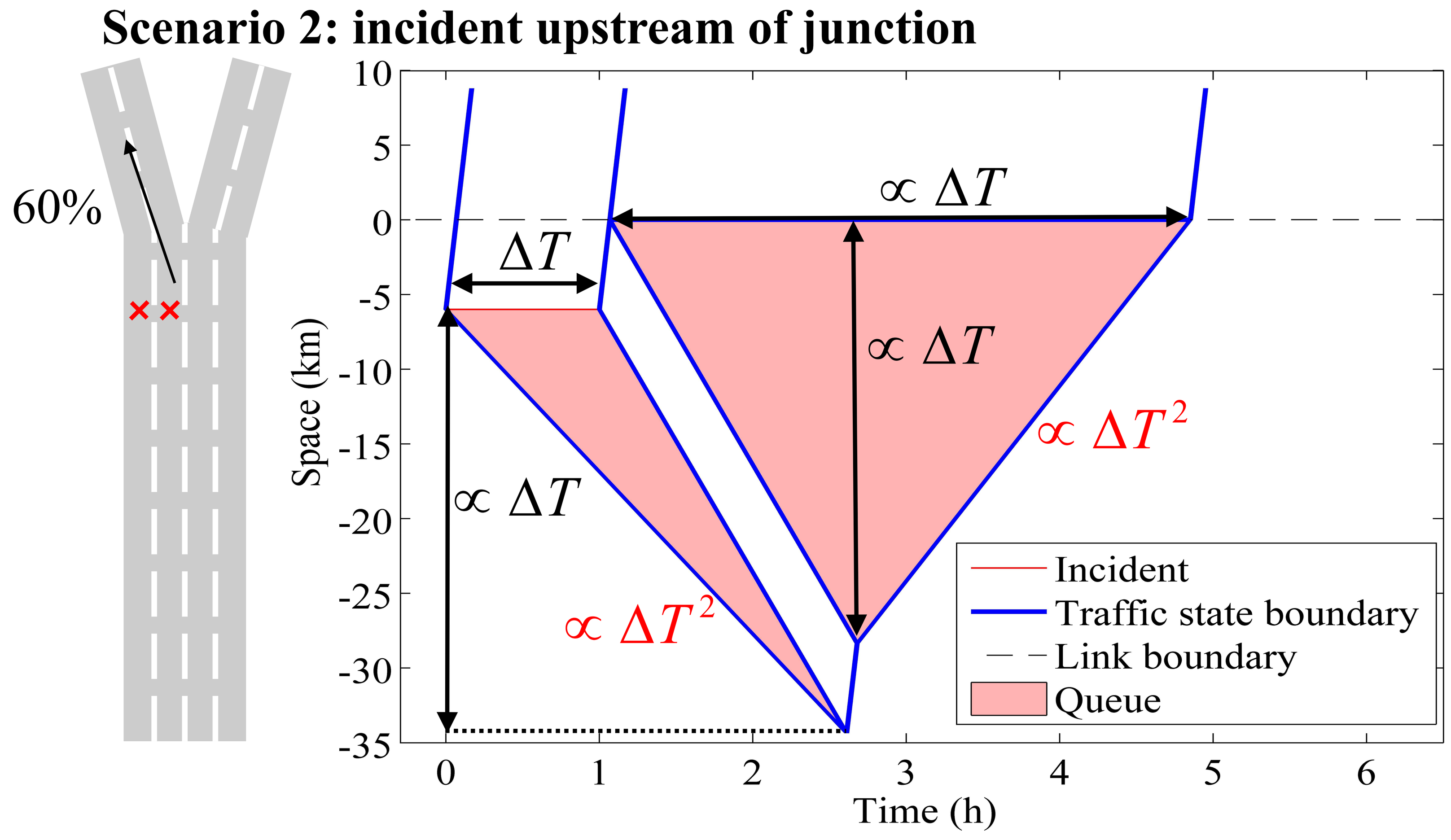
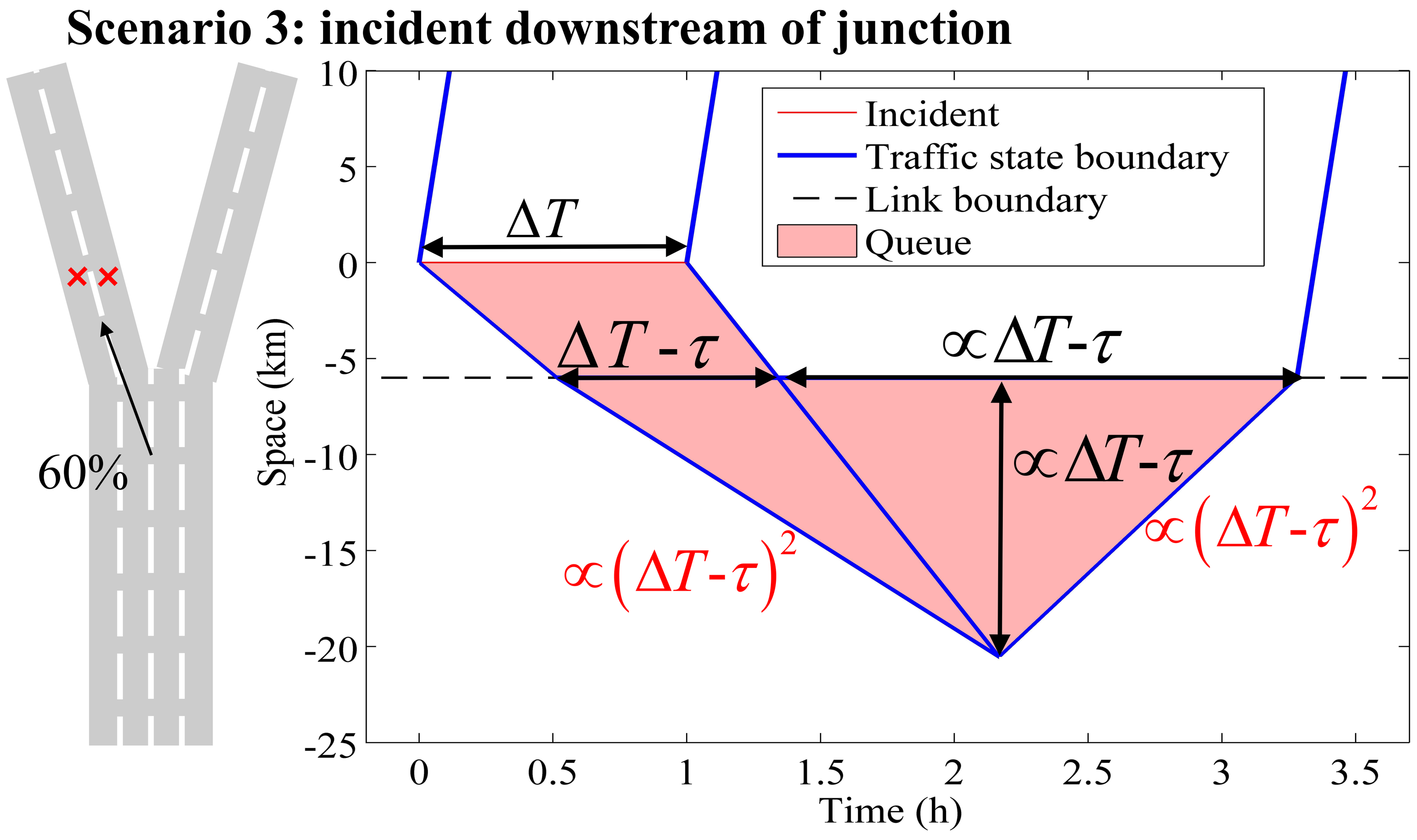
Scenario 1: no junction



Scenario 2: incident upstream of junction



Scenario 3: incident downstream of junction



Stochastic duration

Without spillback the total delay D equals $D=c\Delta T^2$.
The variance of incident duration ΔT equals

$$\mathrm{Var}(c\Delta T) = \left\langle (c\Delta T)^2 \right\rangle - \langle c\Delta T\rangle^2$$

Then, the expected delay, $\langle D\rangle$, is

$$\langle D\rangle = c\left\langle \Delta T^2\right\rangle = c\left(\langle \Delta T\rangle^2 + \mathrm{Var}(\Delta T)\right)$$

Delay is formulated as closed expression with 2 parts:
1) *the delay of an incident with a mean duration,* $\langle \Delta T\rangle$
2) *a part with the variance of the incident duration.*

If a deterministic mean duration is used instead, the error is:

$$\text{error} = c\left\langle \Delta T\right\rangle^2 - \left\langle c\Delta T^2\right\rangle = c\mathrm{Var}\left(\Delta T\right)$$

Influence of duration & spillback

No blockade of upstream link:

- *Delay is proportional to the square of the incident duration.*

=> Reducing indicent time has large impact on delays

Blockade of upstream link:

- Congested duration τ shorter than ΔT
- τ depends on the speed of the waves and the distance to the junction.
- *Delay increases more than proportional to the square of the duration .*

=> Reducing the incident time is even more effective if there is a risk of spillback

Conclusions

It is possible to analytically describe the total delay caused by an incident, leading to a closed formula. It shows that under a wide range of conditions, even including downstream bottlenecks, the delay is proportional to the square of the duration. This shows the importance of the reduction of the incident duration. Once the queue spills back, the delay increases sharply and the duration is even more important. It therefore is best to prevent spillback if possible.