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ADVANCING ROAD SAFETY THROUGH TWINNING

PhD SEMINAR SESSIONS

Web Page: https://twin-safe.com/

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The presenter

- Name: Zhankun Chen (a.k.a Alex)
- Age: Prefer not to say
- Career: Two more years to go

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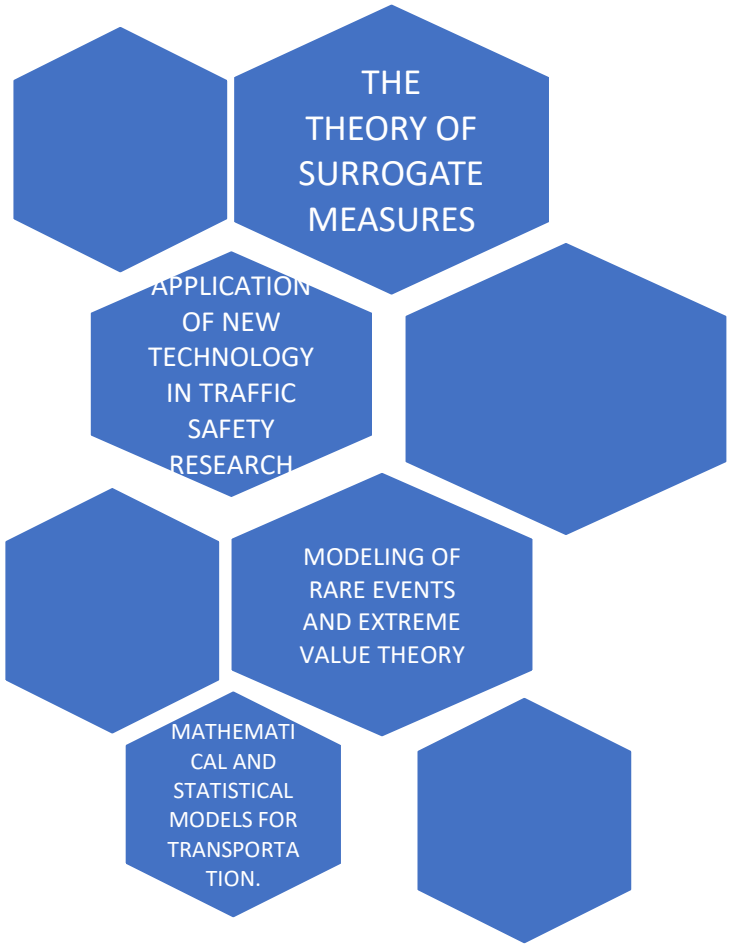
Research interest



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SUperSAFE

SUrrogate measures for SAFE autonomous and connected mobility

ERC Starting Grant 2021

Carmelo D'Agostino - Carl Johnsson - Zhankun Chen - Hampus Norén

supersafe

LUND UNIVERSITY

erc

European Research Council

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Research question:

to develop a new crash prediction method based on non-accident indicators to evaluate the effect of infrastructure on the safety of interaction between CAVs and conventional road users when they share the same physical space.

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Break down the RQ

to develop a new crash prediction method based on non-accident indicators to evaluate the effect of infrastructure on the safety of interaction between CAVs and conventional road users when they share the same physical space.

Advance the theory of SMoS by exploring the possibility of Extreme Value Theory

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Behavioral model on conflict causation, using simulator

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Break down the RQ

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Advance the theory of SMoS by exploring the possibility of Extreme Value Theory

Behavioral model on conflict causation, using simulator

Previous knowledge + microsimulation

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Methods

Theoretical development

- Advances in Extreme Value Theory application in SMoS theory
- Development of behavioral models
- Development of microsimulation model

Hands-on activities:

- Driving simulator experiment
- Micro-simulation ”experiment”

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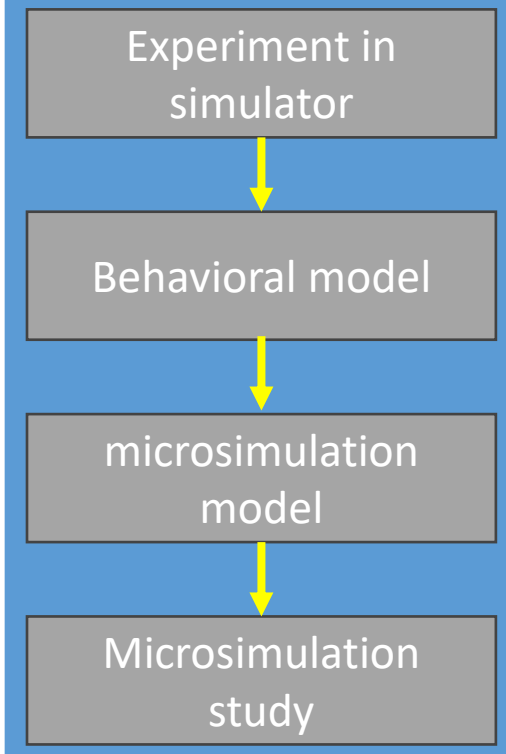
Roadmap, more chronological



- Under the framework of SMoS
- EVT serves as a measurement tool

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Feasible SMoS framework

Zhankun Chen, Transport and Roads, Lund University

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Overview

- **What are SMoS and EVT**
- Why SMoS + EVT
- Some discussion of the methodology

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Surrogate Measure of Safety

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Fundamental questions:

To what extent can we measure traffic safety with events other than crashes?

What are the essential elements that assemble such “interactions”?

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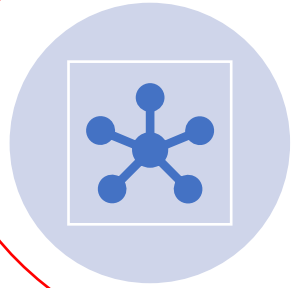
Fundamental questions:

To what extent can we measure traffic safety with events other than crashes?



What are the essential elements that assemble such “interactions”?

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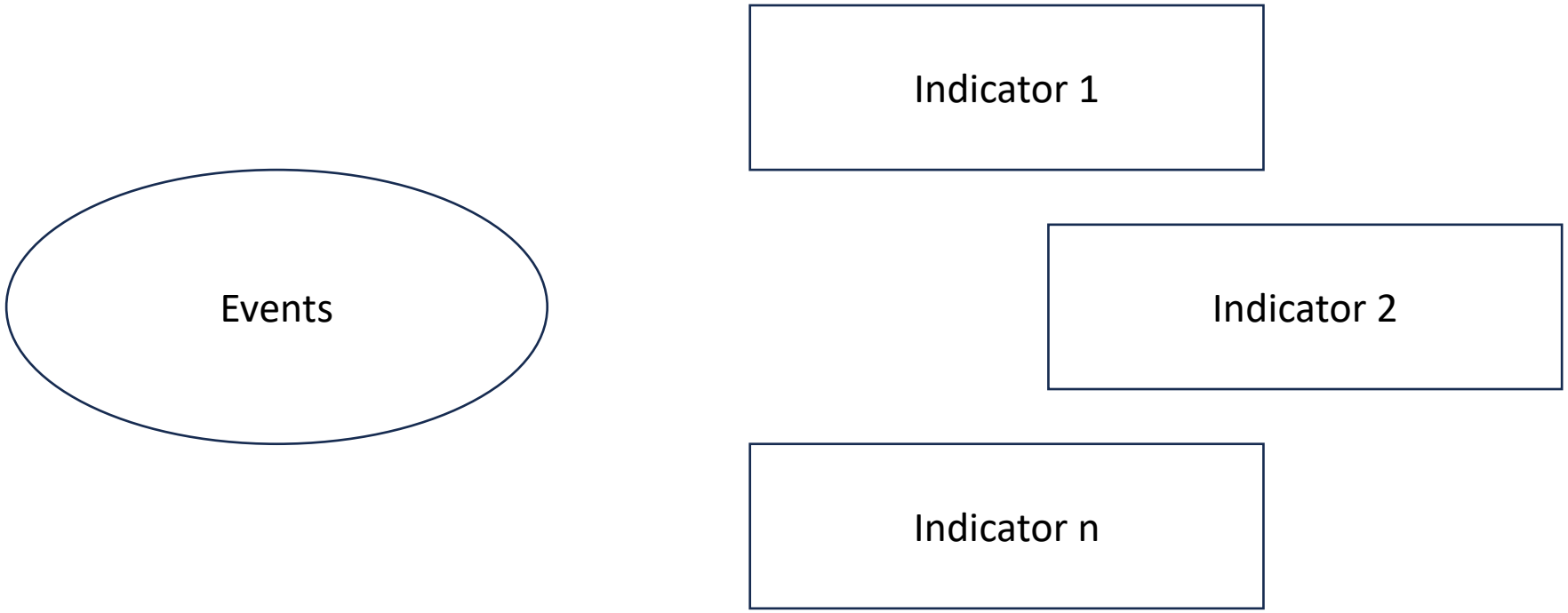
How to quantify



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How to quantify

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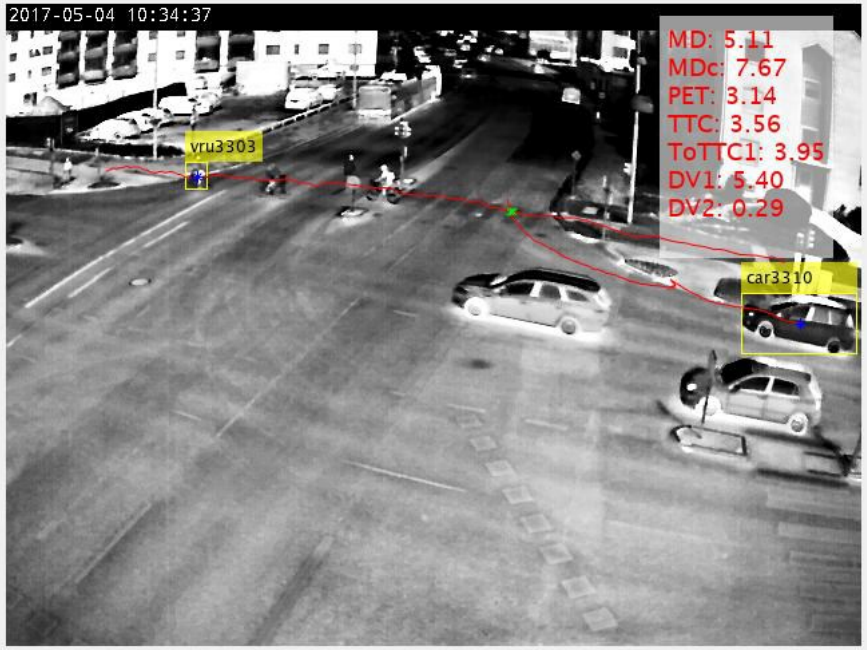
How to quantify



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Interaction severity

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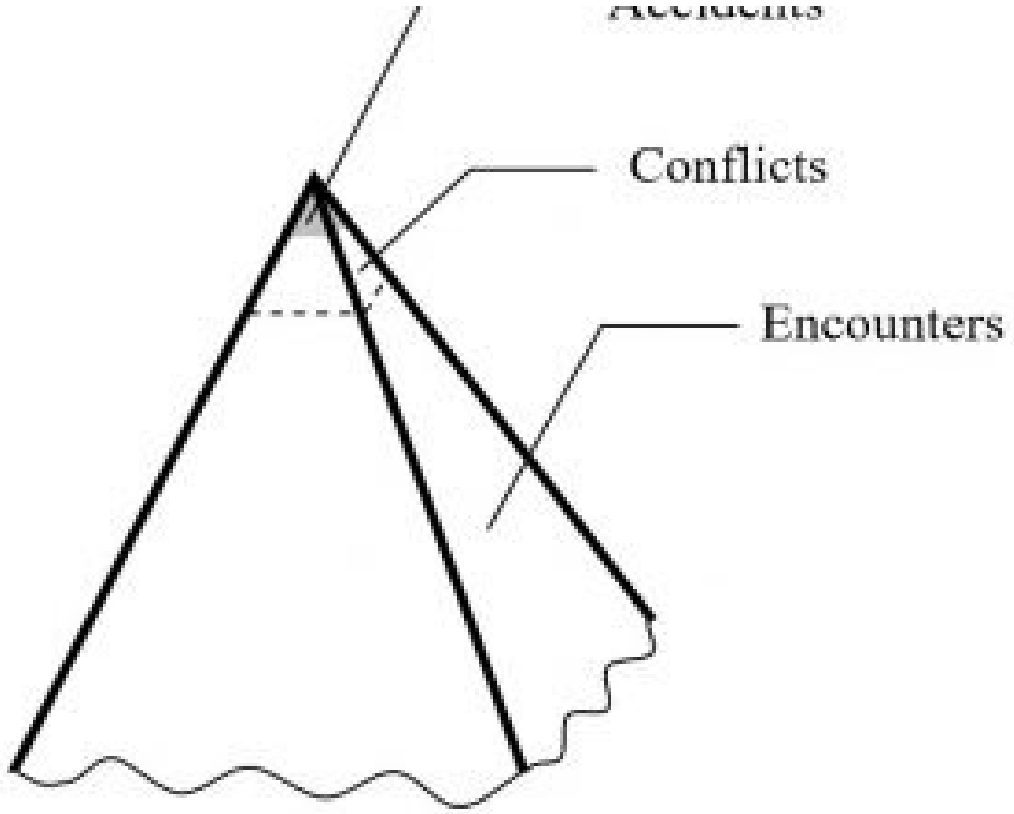
Conflict Severity

Conceptually, the severity of different interactions are comparable

The shape is pyramid because the frequency decreases as severity increases



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Informal definition

Oh Sh*t!!!!

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Formal definition

- *A traffic conflicts is an observable situation in which two or more road users approach each other in space and time to such an extent that there is a risk of collision if thier movements remain unchanged.*

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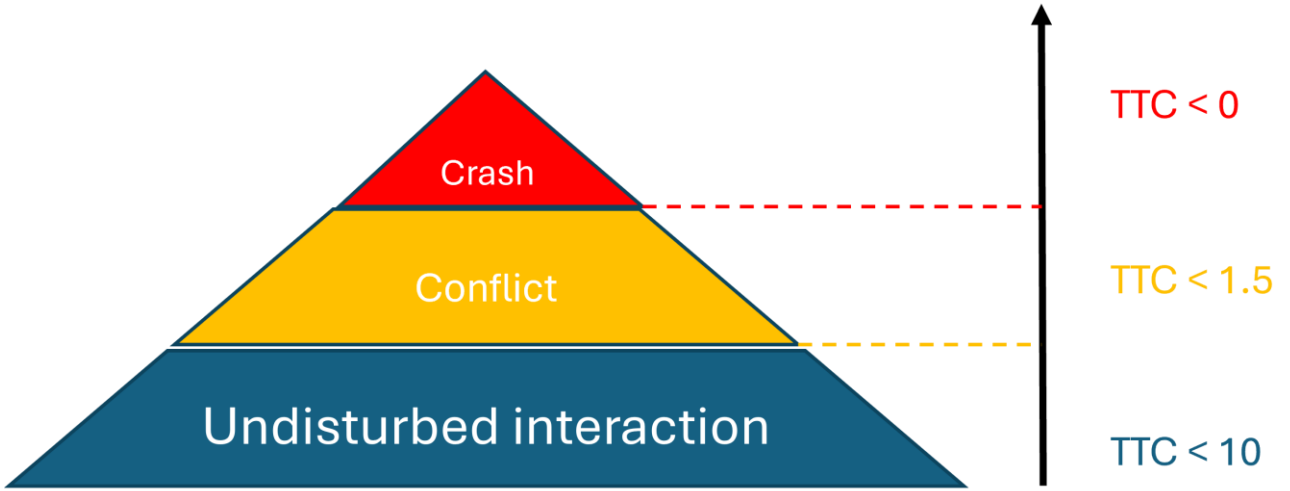
SMoS and severity

When only one indicator is used, the severity is quantified by the thresholds of the indicator.



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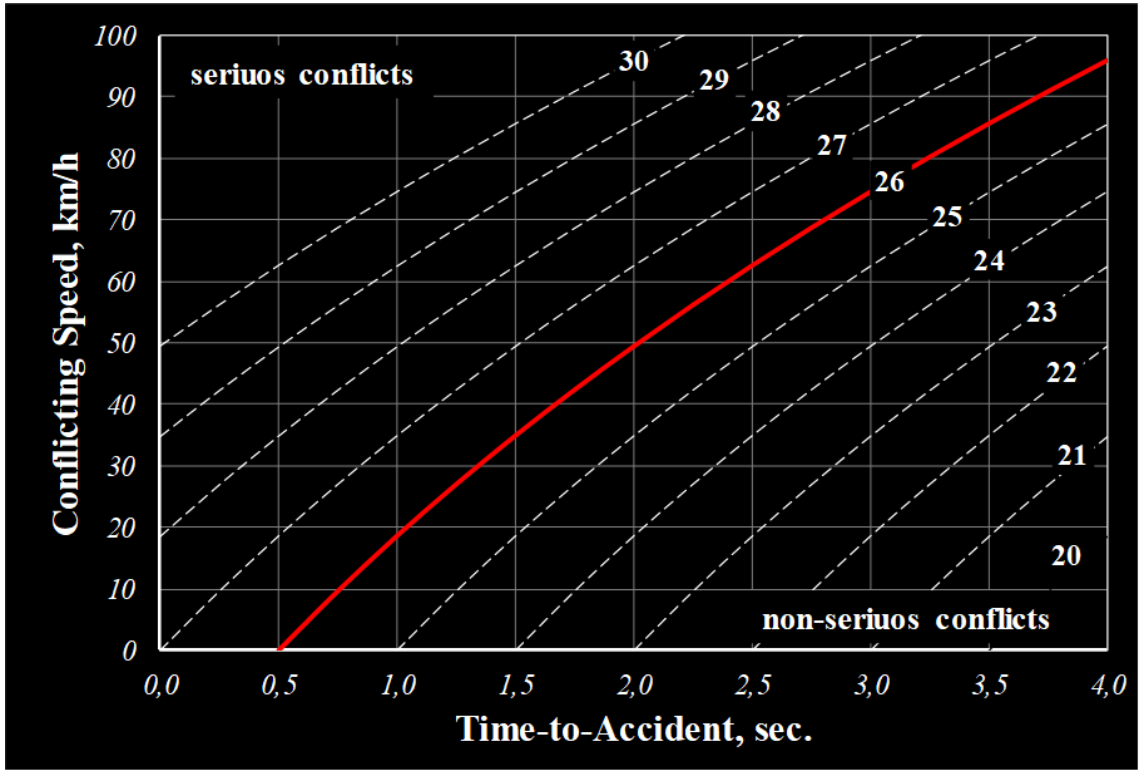
SMoS and severity



When more than one indicator is used, the severity is determined by the combination of indicators.

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Summary: What is SMoS framework

- Using non-crash to measure safety
- A quantification of traffic interaction on microscopic scale
- SMoS characterize all events continuously, including crashes, in theory.
- Enable numerical comparison of the conceptual severity.

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Selection of “extreme” events

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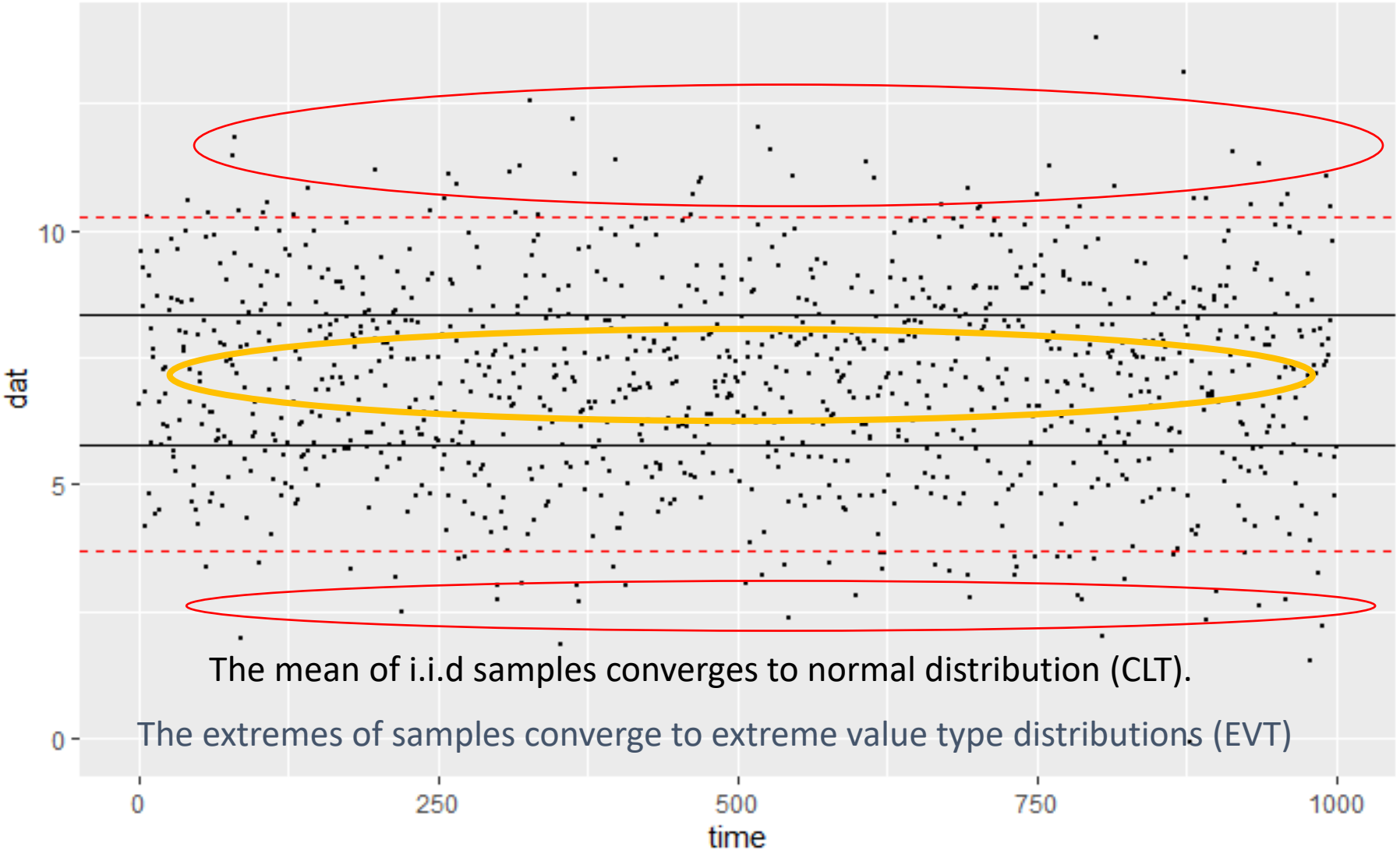
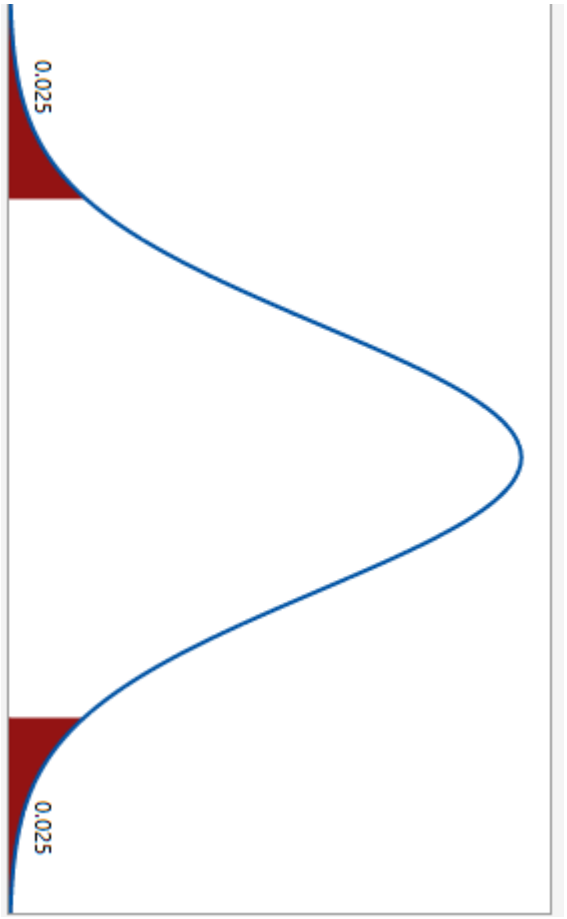
Extreme in statistical sense



The mean of i.i.d samples converges to normal distribution (CLT).

The extremes of samples converge to extreme value type distributions (EVT)



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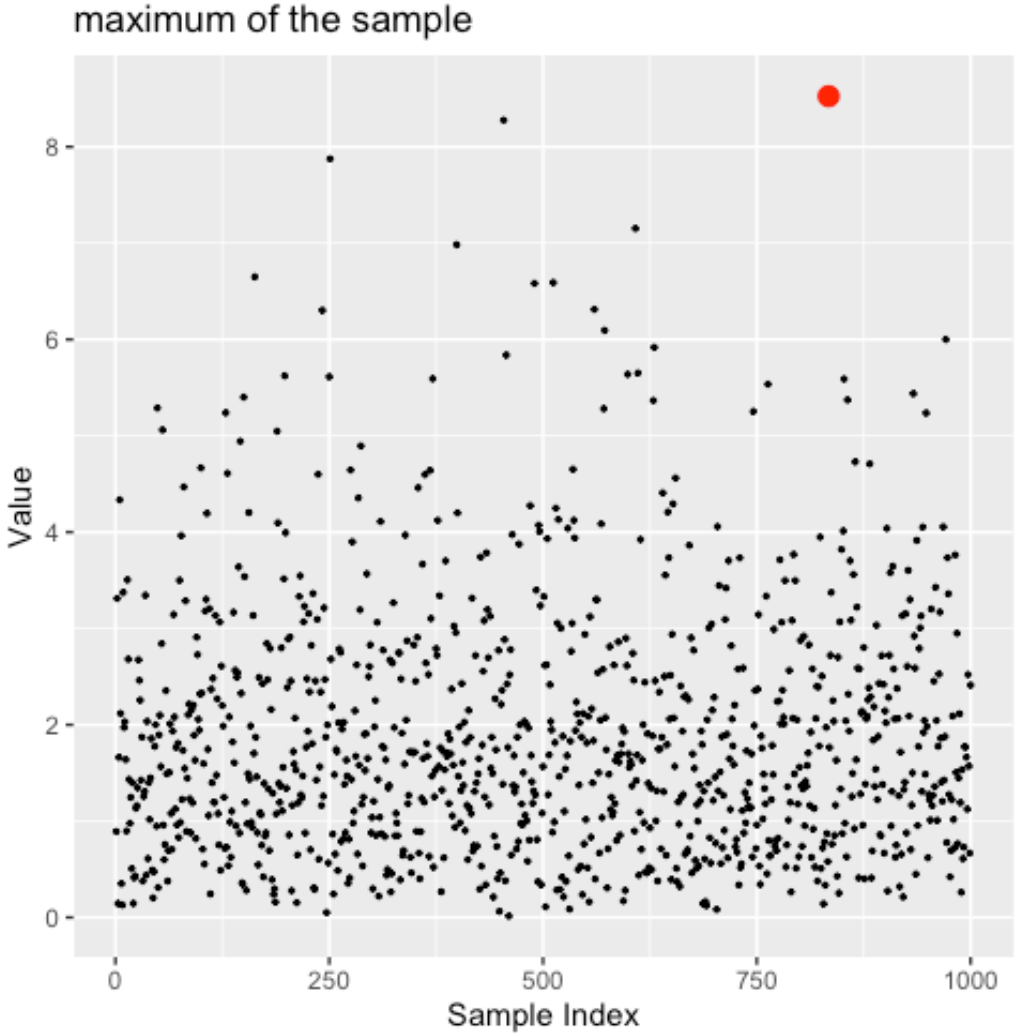
Two ways of selecting extremes (1)



What is the probability distribution of the maximum of the sample?

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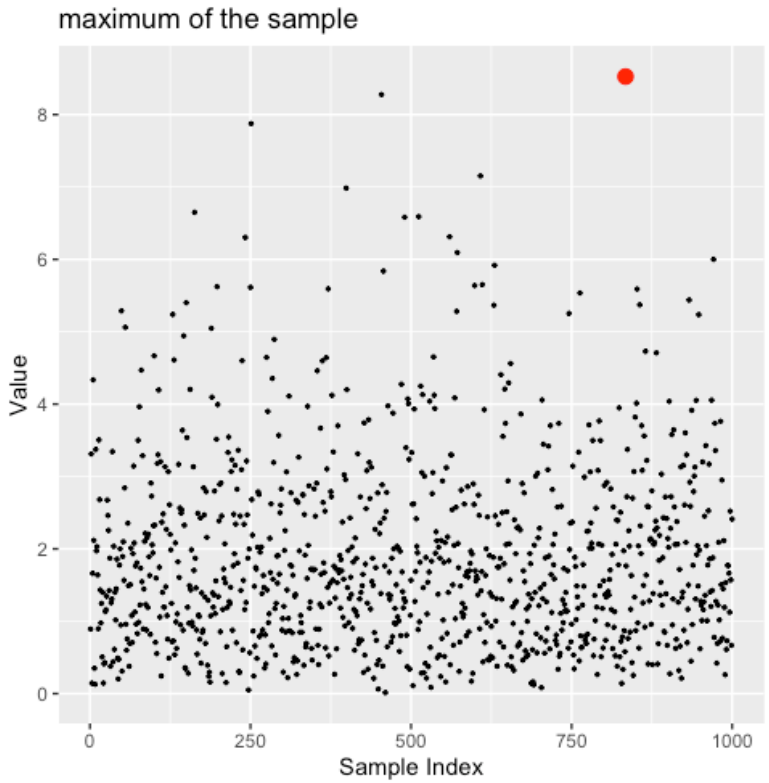
Two ways of selecting extremes (1)



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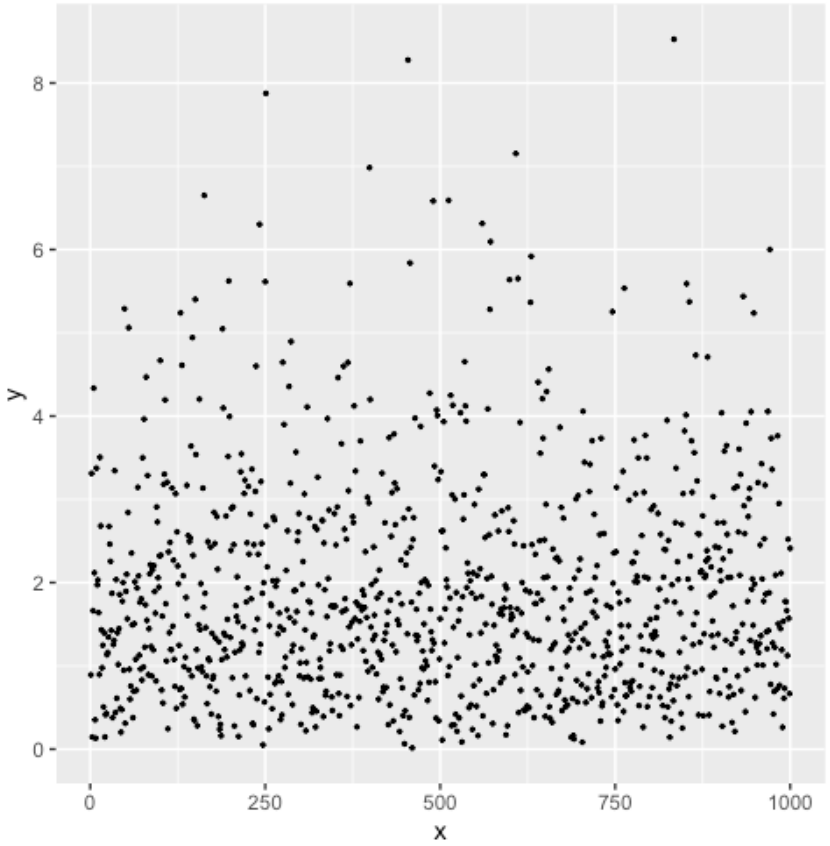
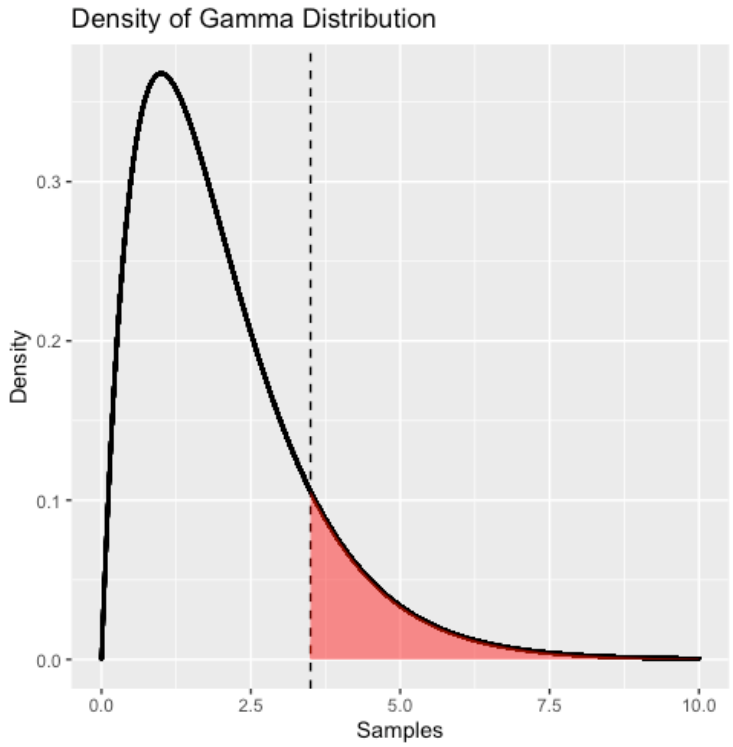
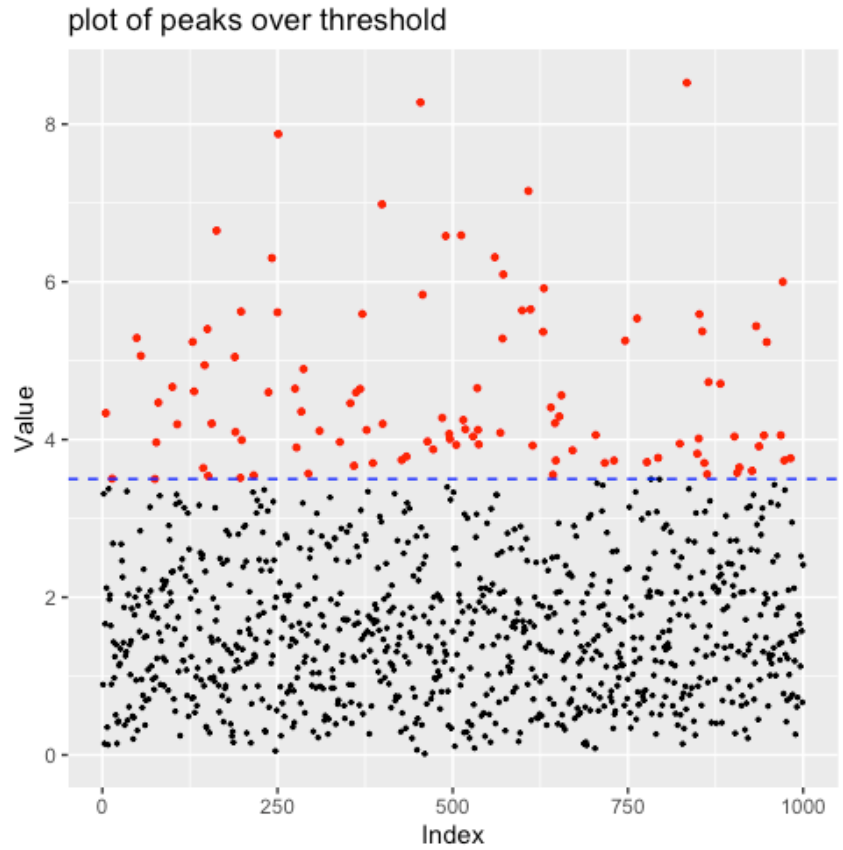
Two ways of selecting extremes (2)







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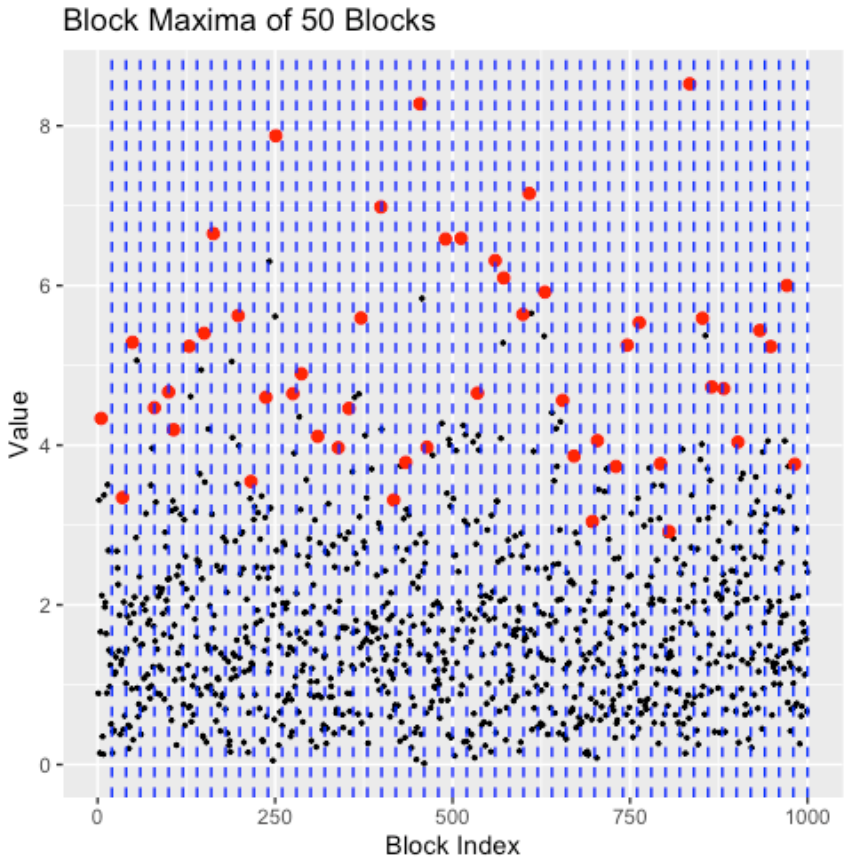
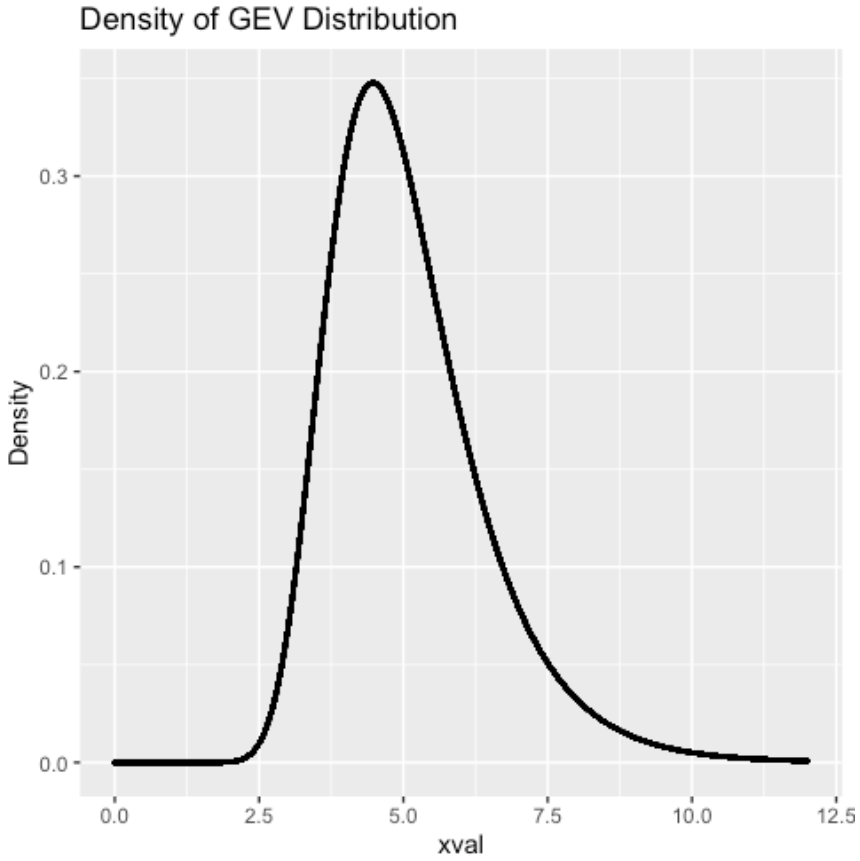
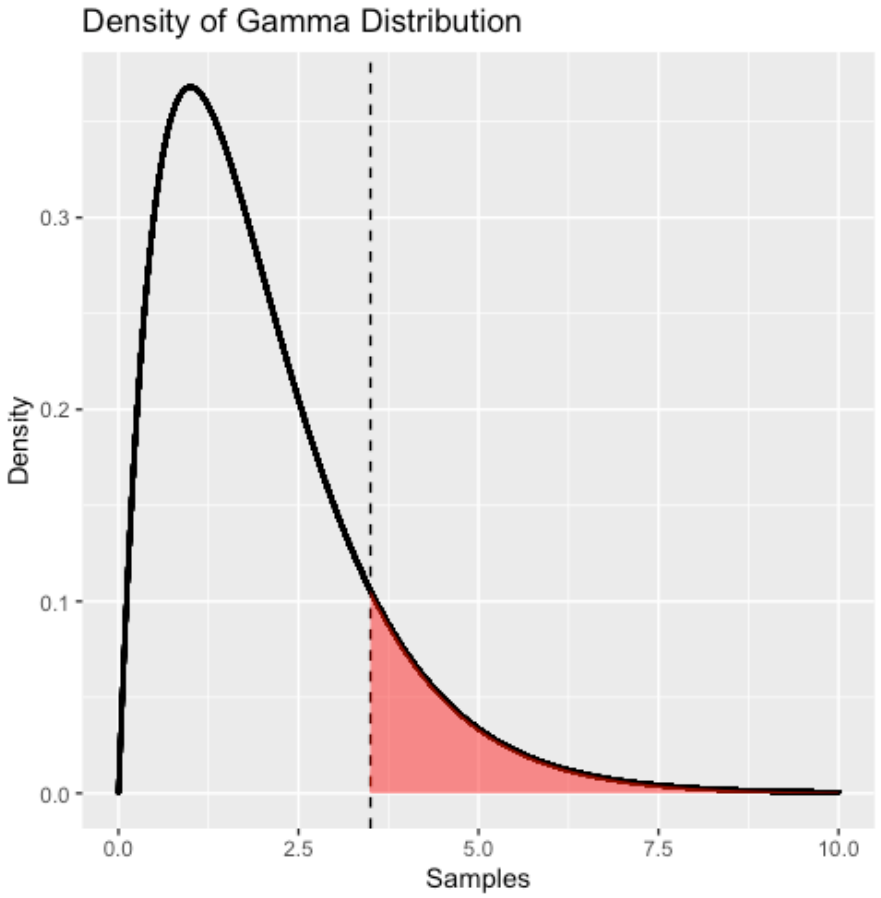
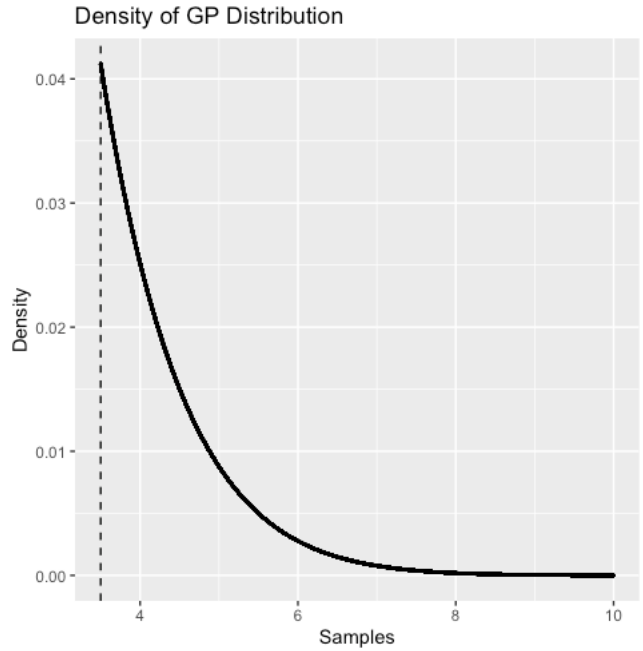




This is the approximated distribution of the maximum of a block (red dots).

Two ways of selecting extremes (2)





This is the approximated conditional upper tail distribution

Overview

- What are SMoS and EVT
- **Why SMoS + EVT**
- Some discussion of the methodology

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EVT + SMoS

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A theoretical comparison

SMoS

- SMoS values and severity of interaction are monotone. Extreme is of interest.
- SMoS characterize all events continuously, including crashes

EVT

- EVT fits well with the continuous characterization of interactions.

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A theoretical comparison

SMoS

- SMoS values and severity of interaction are monotone. Extreme is of interest.
- SMoS characterize all events continuously, including crashes

EVT

- EVT fits well with the continuous characterization of interactions.
- Extrapolation of unobserved events from observation

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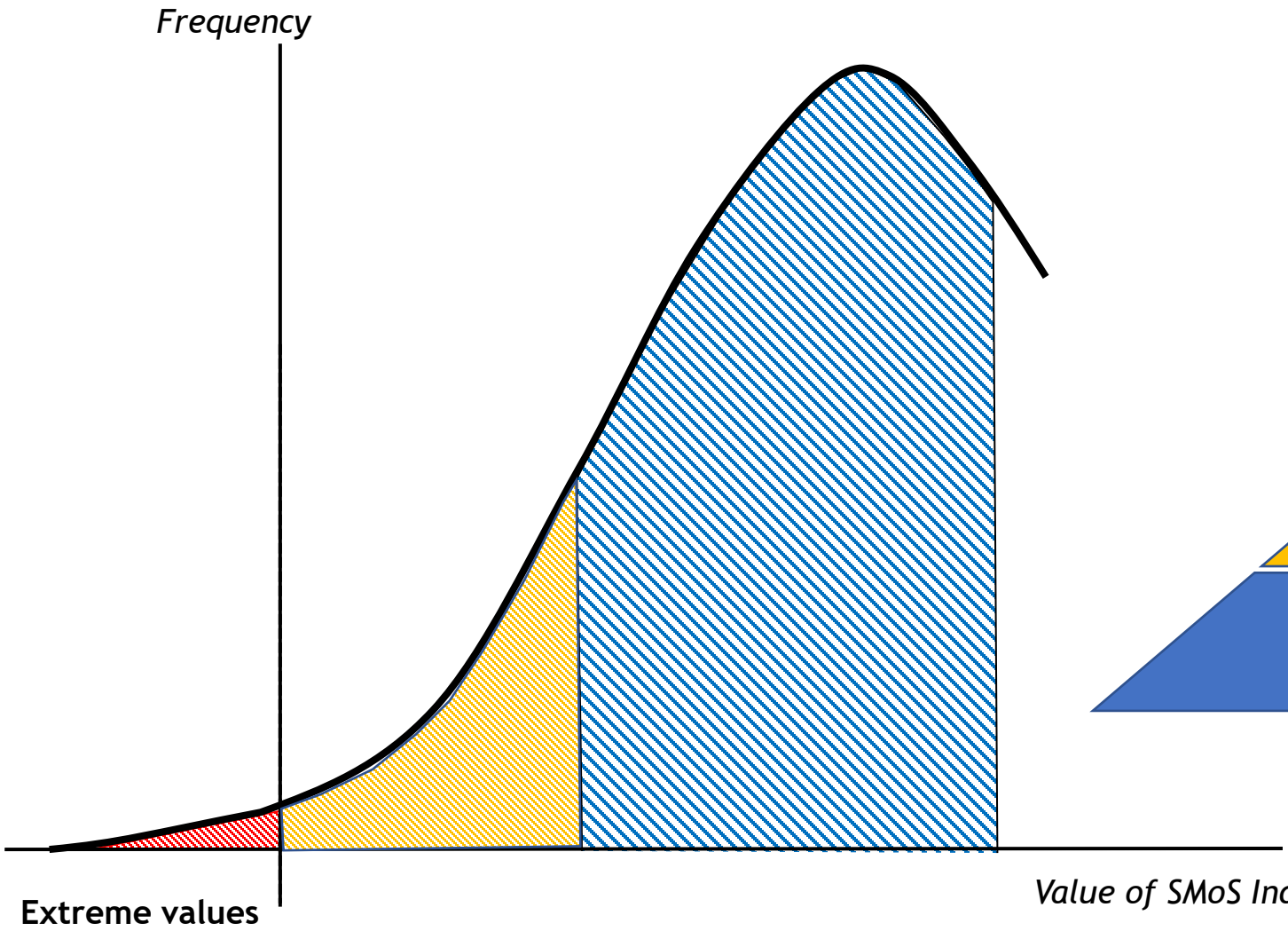

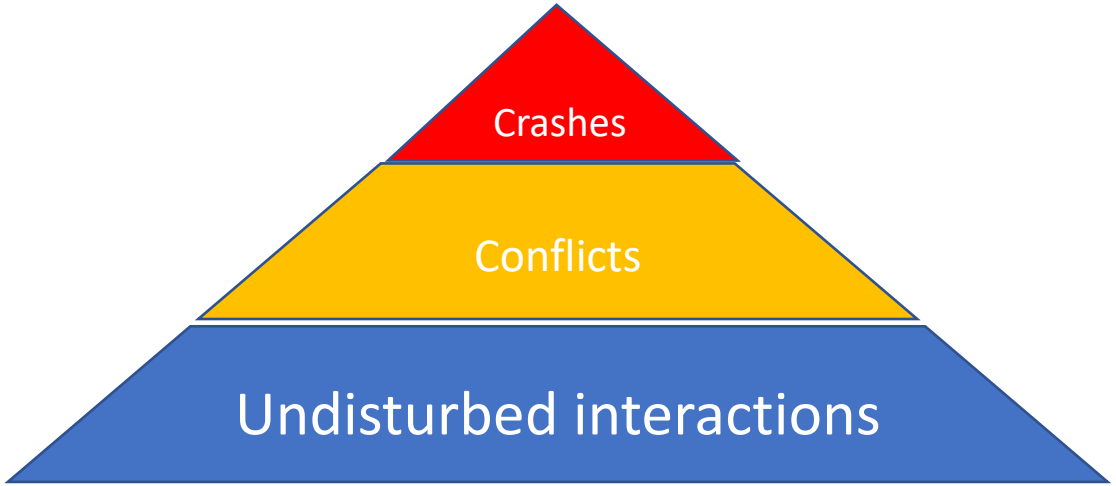

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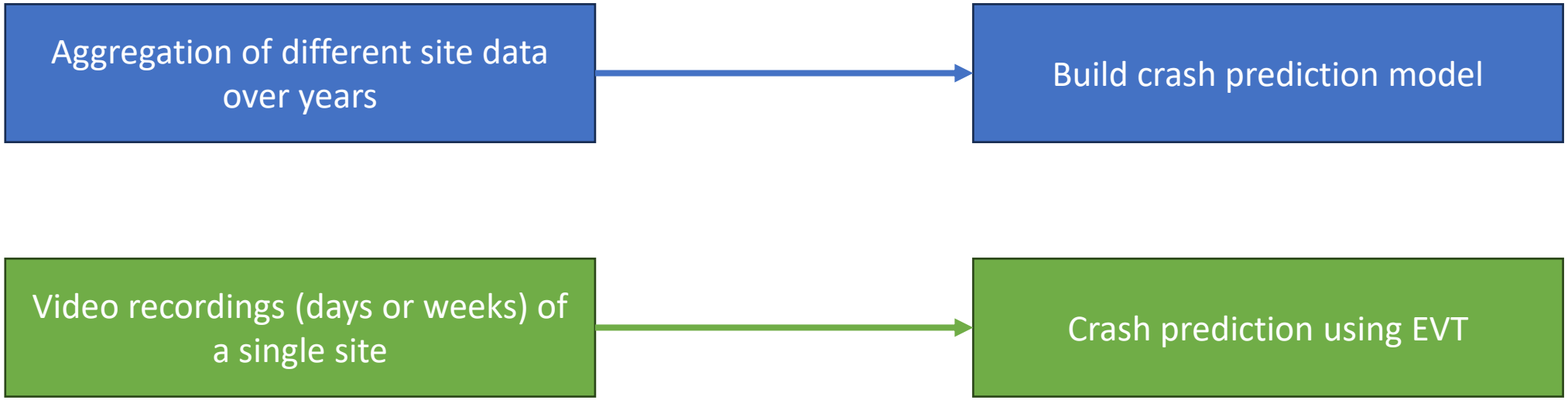
EVT paradigm in road safety (why)

The golden standard: Safety Performance function



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Summary: Why SMoS+EVT?

- Short data collection area
- Detailed information
- Evaluation of minor details
- No need for site aggregation
- Assessment of new measures

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Overview

- What are SMoS and EVT
- Why SMoS + EVT
- **Some discussion of the methodology**

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Some considerations

How to interpret EVT result?

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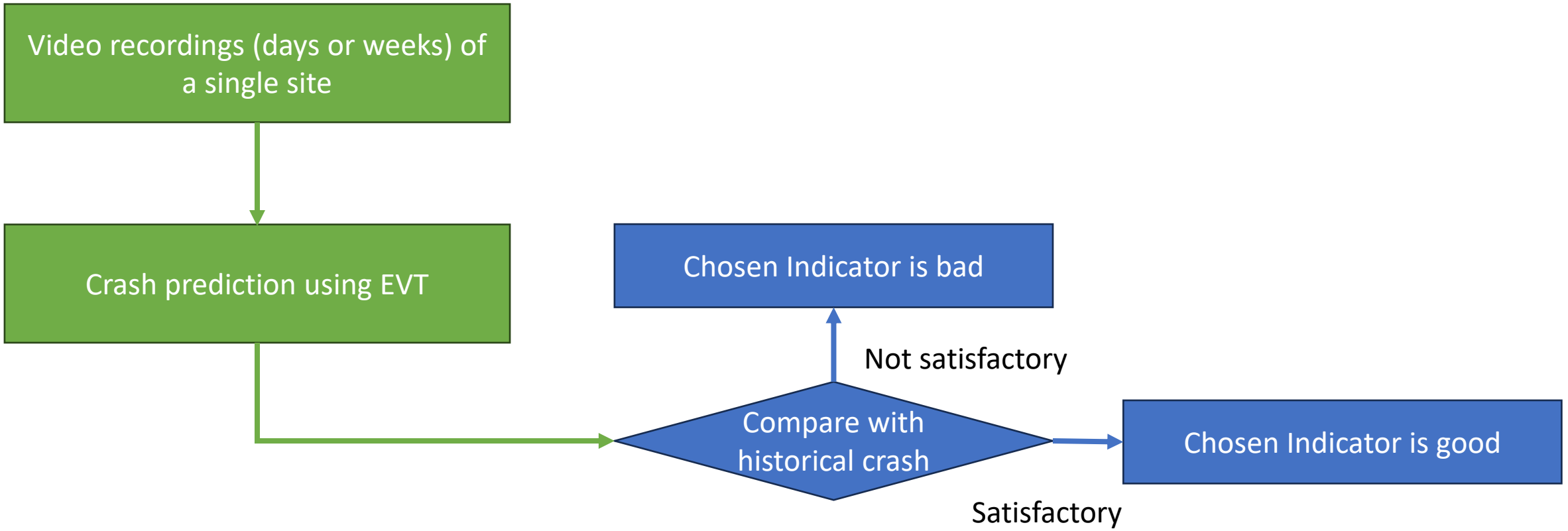
EVT paradigm in road safety



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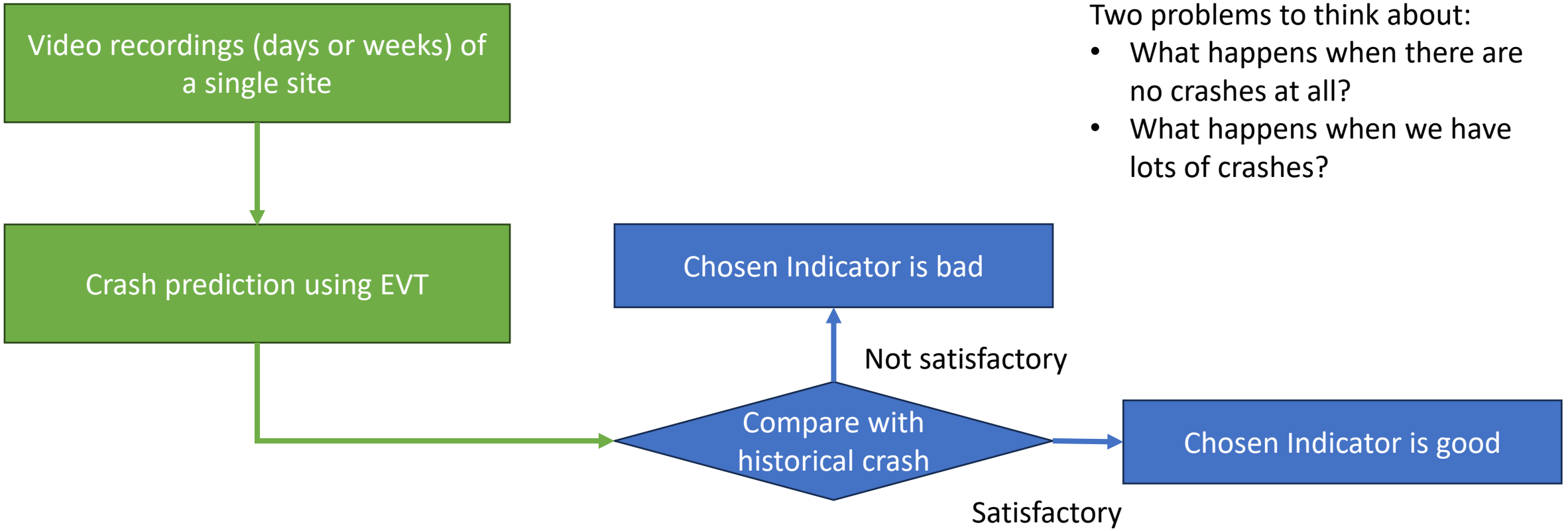
EVT paradigm in road safety



Two problems to think about:

- What happens when there are no crashes at all?
- What happens when we have lots of crashes?

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Some considerations

Is EVT appropriate for modeling conflicts?

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Generalizability

As far as the laws of mathematics refer to reality, they are not certain; and as far as they are certain, they do not refer to reality

As far as EVT concerns SMoS in general sense (that is, regardless of indicator choice), **making cross-comparison makes no sense**; and as far as EVT is concerning a specific type of SMoS, the conclusion is only limited to this definition.

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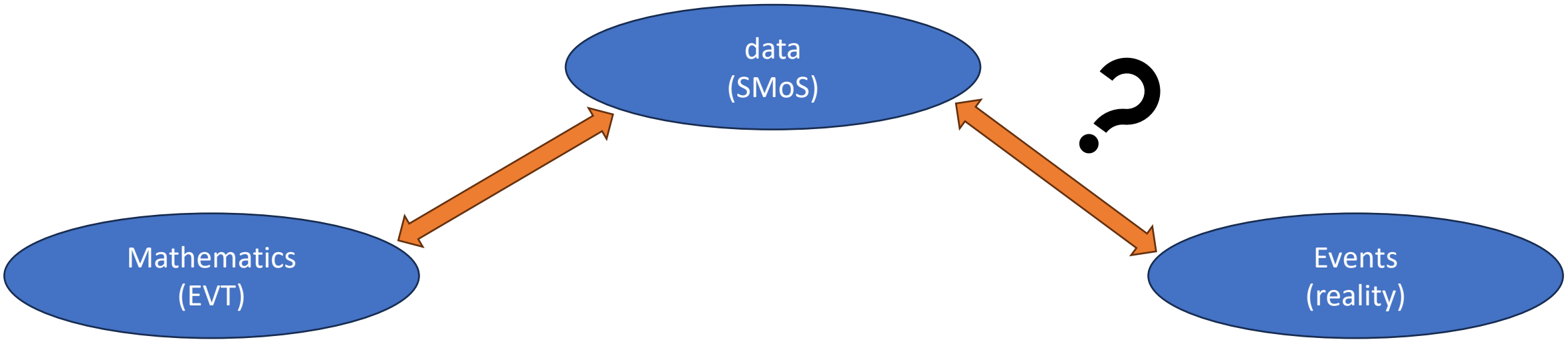
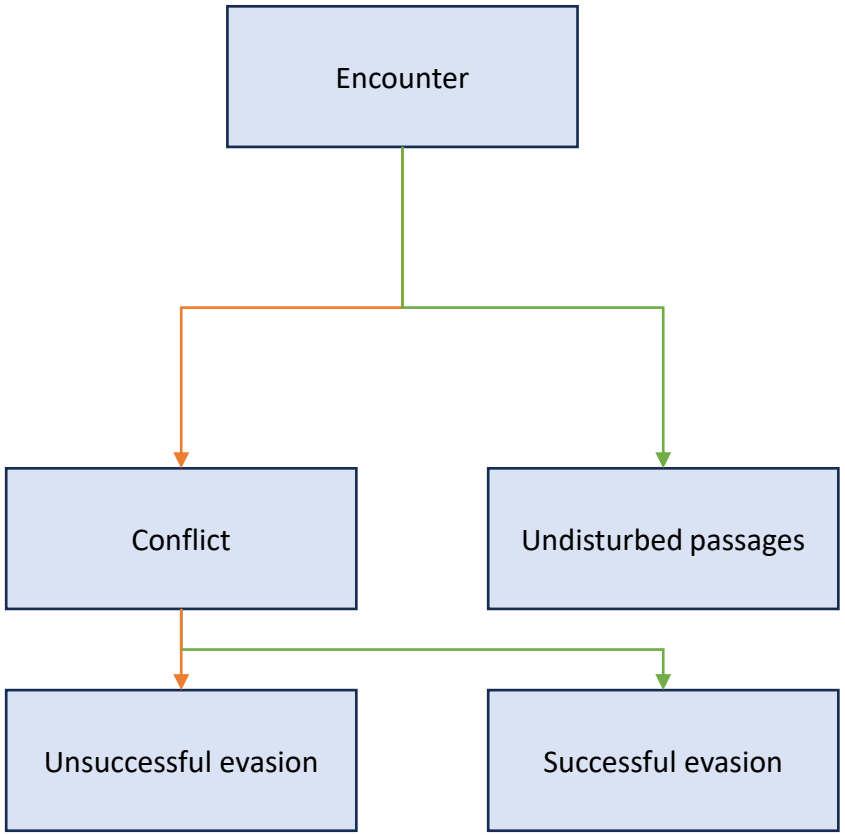
Some epistemology





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More on the continuity assumption

Ideal world

- Conflicts and crashes are “essentially the same”.
- Normal interaction should NOT be a part of continuity.

Real world

- Conflicts are identified by indicator values
- Indicators are “quantitative values, rather than an interpretation
- Normal interactions tend to be treated as conflicts

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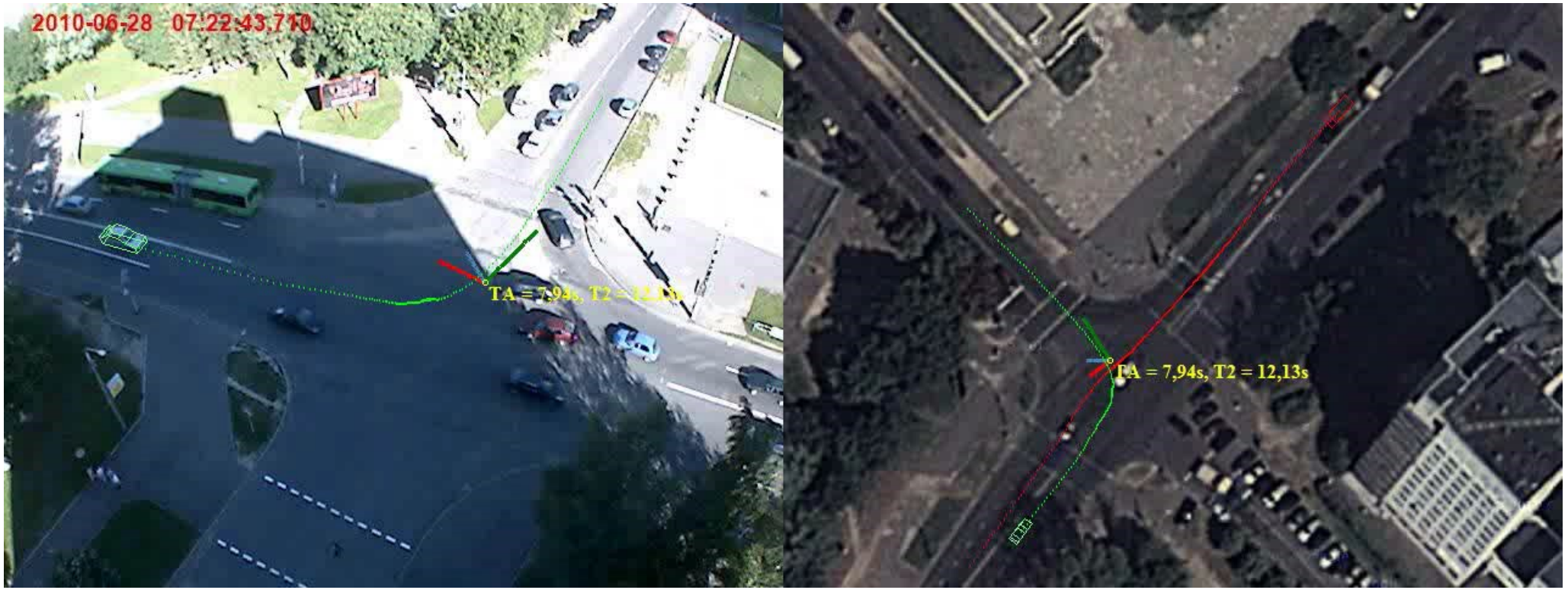
Example



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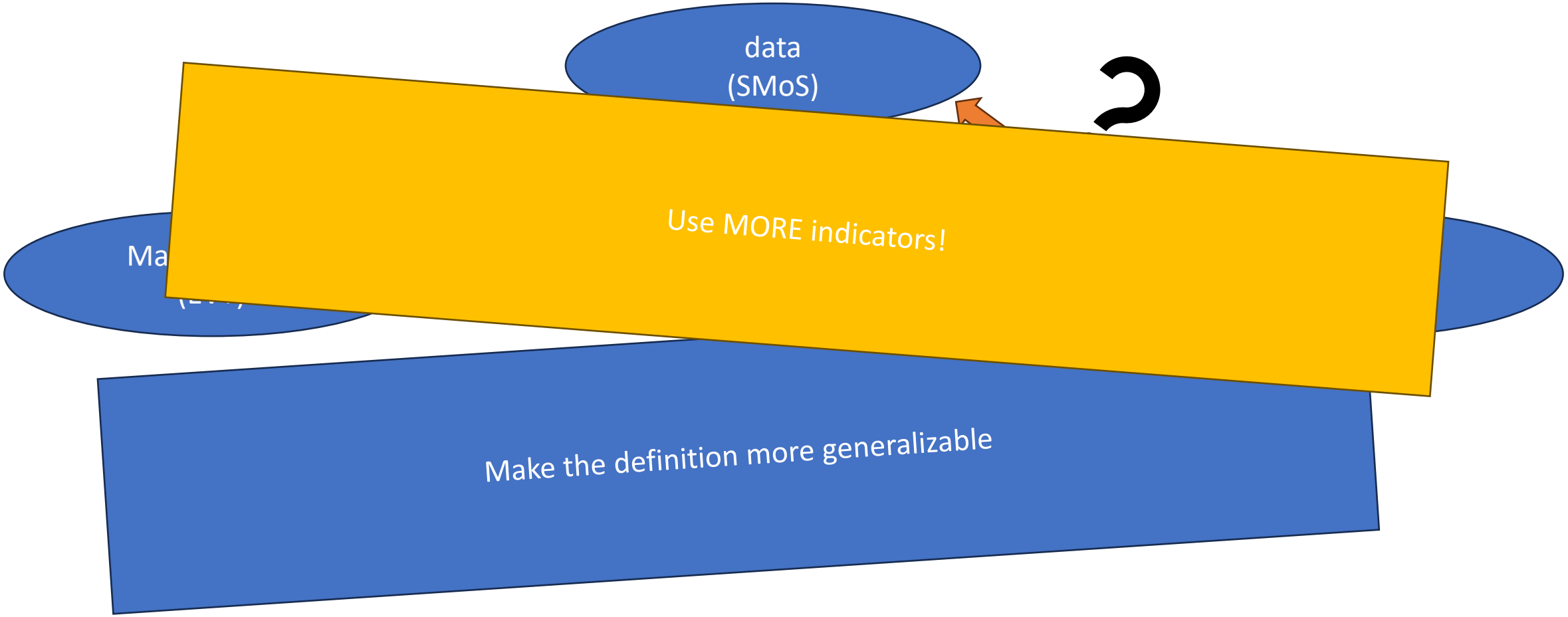
Some epistemology



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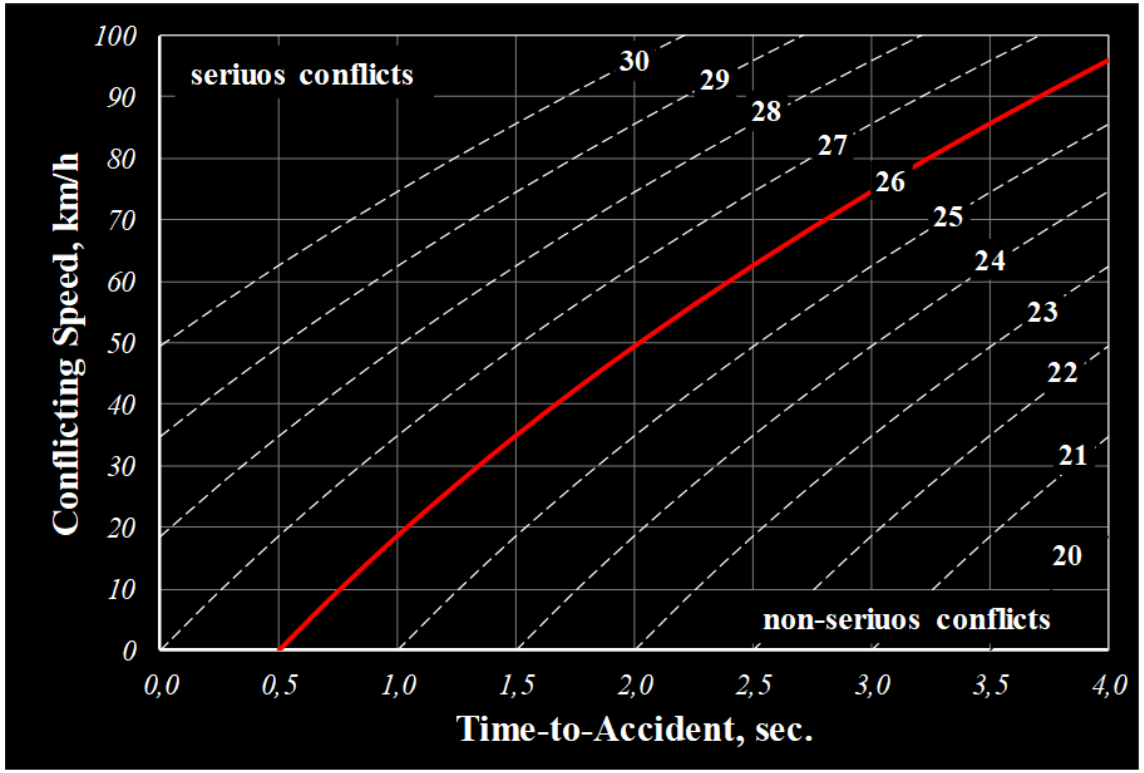
Example: Swedish TCT



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Aggregation of indicators

- Decrease false positive

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Aggregation of indicators

- Decrease false positive
- Insights in other dimensions

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Aggregation of indicators

- Decrease false positive
- Insights in other dimensions
- Possibility to model injury crashes

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Some considerations

How to model injury crash?

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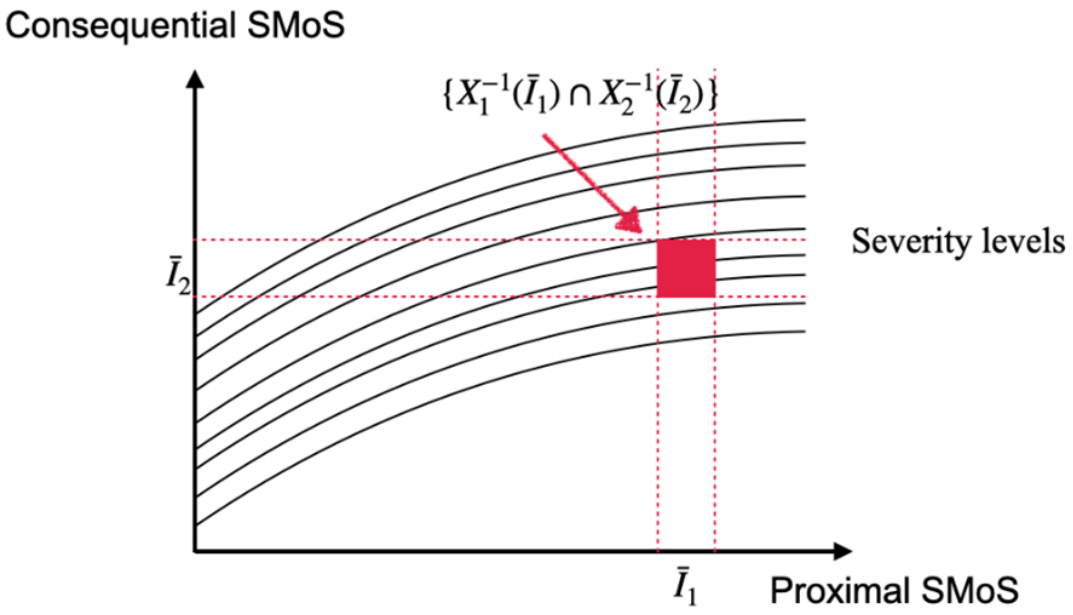

Possibility to estimate the severity of a crash.

Higher severity is more likely to result in injury

Bivariate EVT can estimate severe crashes

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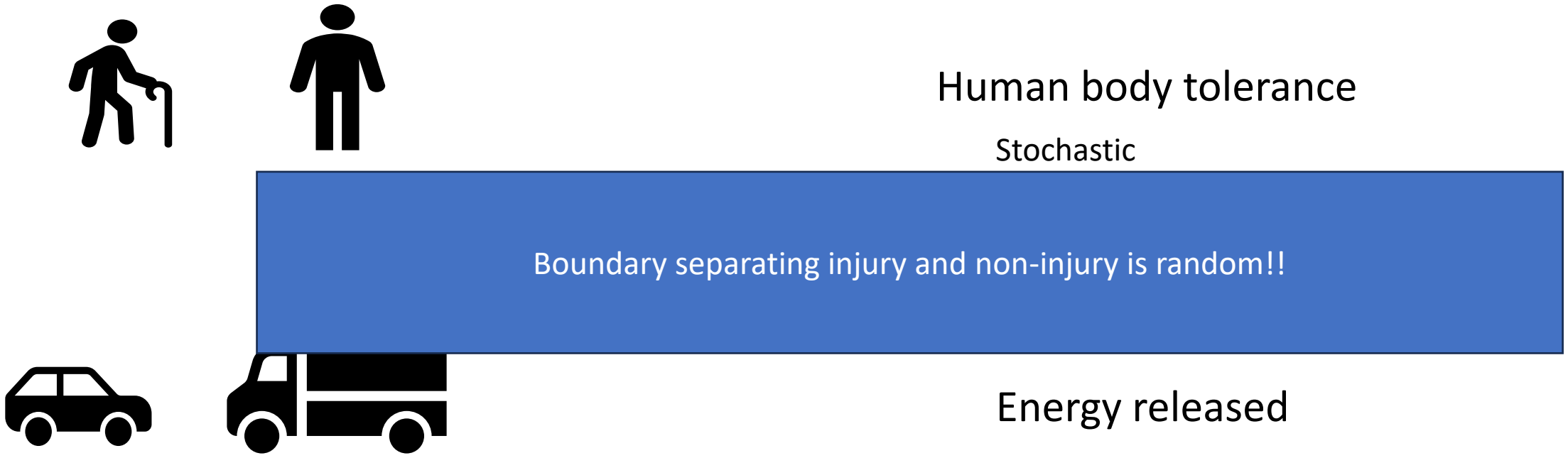
Relation between crash severity and injury



Human body tolerance

Stochastic

Boundary separating injury and non-injury is random!!

Energy released

Can be modelled by SMoS

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Summary

Old paradigm

- Surrogate of all crashes
- Composite indicator
- Emphasis on Absolute validity
- Dichotomous injury/severity classification

New paradigm

- Surrogate of injury crashes
- Aggregation of simple indicators
- Emphasis on process validity
- Entire span of severity

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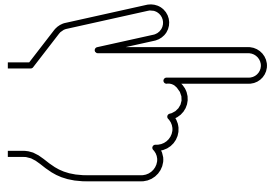
Method for the new paradigm



- Multivariate modeling of indicators
- Proximal indicator + Consequential indicator
- Use convenience of Extreme Value Theory in defining critical events
- Mathematically described the behavior of road user as interplay of indicators

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