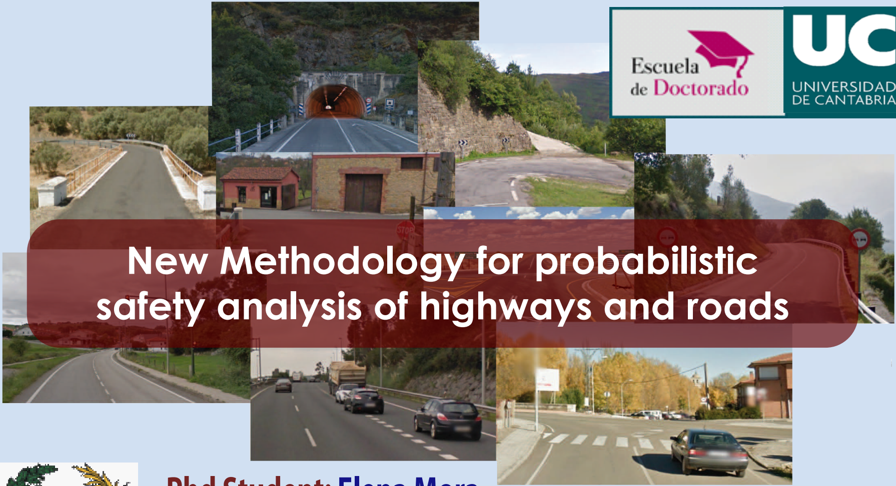

New Methodology for probabilistic safety analysis of highways and roads

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University of Cantabria

EIDEIC 2017

MOTIVATION

The main elements that have motivated the development of the following study for the **probabilistic safety assessment of highways and roads** are:

1. The concern on the **high number of traffic accidents** and the need for a reliable tool to evaluate specific highway and road segments and to reduce accident rates.
2. The **important advantages of the methodology based on Bayesian networks**, with respect to fault and event trees, which allow a better and simpler safety evaluation.
3. The experience cumulated in these methodologies in other fields of engineering such as **nuclear and railway fields**.

Model Description

The proposed model is a Bayesian network, which has two main components:

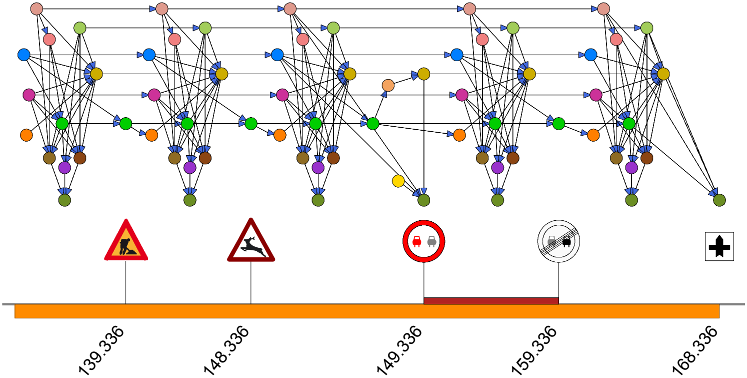
1. **An acyclic graph** to define the qualitative structure of the multidimensional variables.
2. **A set of conditional probability tables** to quantify the Bayesian network.

Construction of the Bayesian network can be based on the following steps:

- **Step 1. Selection of the items that have a relevant influence on traffic safety.** As items can be considered: light signals, stop signals, vehicle and pavement failures, intersections, curves, etc.).
- **Step 2. Identification of the variables related with these items.** Due to the great importance of the driver's behaviour variables related to this, such as driver's tiredness, driver's attention, and driver's type are considered in the model.
- **Step 3. Identification of the direct dependencies among the variables involved.**
- **Step 4. Definition of the conditional probability tables.**

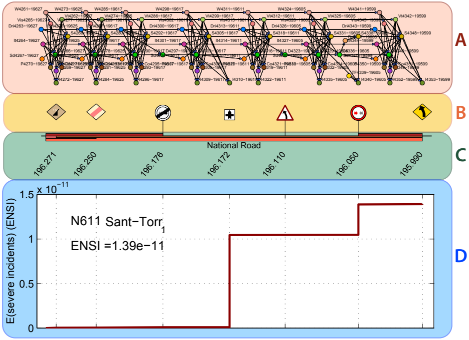
Model Description

The previously defined elements can be modelled as **different sub-Bayesian networks** with **a particular structure and associated variables with their corresponding conditional probabilities**.



MODEL DESCRIPTION

In order to **display the results in a useful way**, the following elements has been included divided by segments:



A) **The segment acyclic graph** of the Bayesian network.

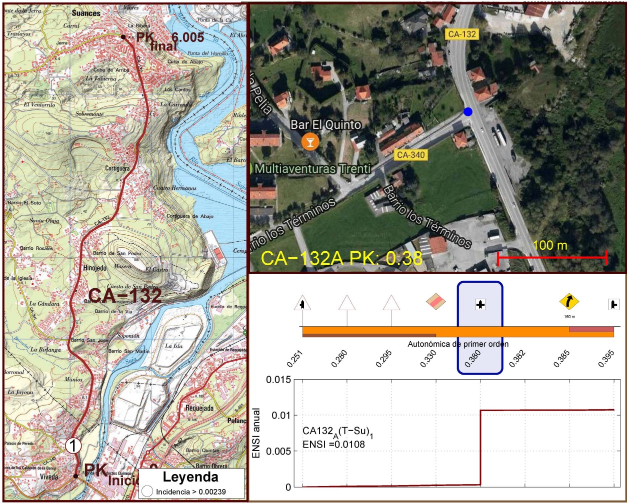
B) **The graphical representation of traffic signs and track elements.**

C) **The segment characteristics.**

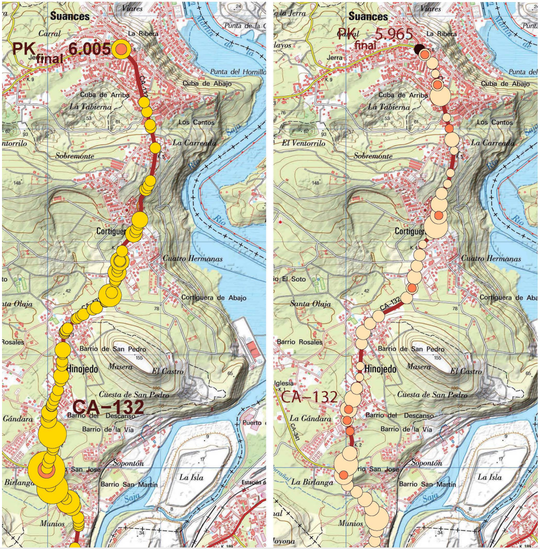
D) **A cumulated risk chart.**

The **whole line representation has been divided into short segments**, with the aim of obtaining a more detailed information.

Results (CA-132)

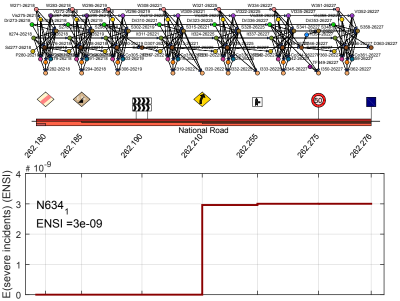


RESULTS (CA-132)



RESULTS (N-634)

The relative importance of the different items can be easily identified by comparing the discontinuities (jumps) in the graph.



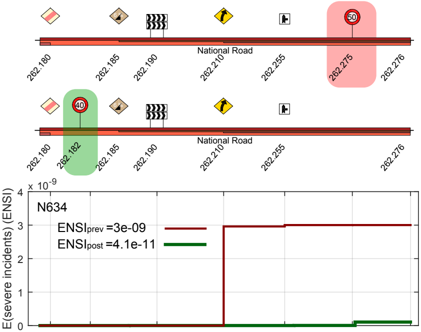
In the Table we give the ENSI events. It can be easily seen that *curves* and *lateral entries* are the most critical items.

item					ENSI	
Rank	**No**	**name**	**KP**	**node**	**Local**	**per year**
1	25	CurveIn	262.210	I320-262210Cv	**2.96e-09**	**0.00232**
2	35	LateralEntry	262.416	I456-262416LE	1.15e-10	8.98e-05
3	26	LateralEntry	262.255	I333-262255LE	4.07e-11	3.19e-05
4	49	LateralEntry	263.710	I635-263710LE	3.98e-11	3.12e-05
5	29	LateralEntry	262.278	I376-262278LE	3.85e-11	3.01e-05
6	15	LateralEntry	261.769	I192-261769LE	2.37e-11	1.85e-05
7	9	LateralEntry	261.524	I115-261524LE	2.13e-11	1.66e-05
8	8	CurveIn	261.060	I102-261060Cv	2.07e-11	1.62e-05
9	3	LateralEntry	260.965	I37-260965LE	2.05e-11	1.6e-05
10	12	LateralEntry	261.649	I154-261649LE	1.98e-11	1.55e-05

In order **to improve safety between KP 262,210 and KP 262,416, which is the worst segment of the line, we have moved the speed limit sign (50 Km/h) of KP 262,275 to KP 262,184 and reduced the speed limit in 10 km/h**.

RESULTS (N-634)

The plot shows how the **ENSI values can be reduced by changing the location of the current speed limit sign and its limit to 40 Km/h.** This change improves significantly the resulting ENSI as can be seen in the table. Moreover, the intervention is simple, easy and cheap.



	item				ENSI	
Rank	No	name	KP	node	Before	After
1	35	LateralEntry	262.416	I456-262416LE	**1.15e-10**	**1.11e-10**
2	49	LateralEntry	263.710	I635-263710LE	3.98e-11	3.98e-11
3	26	LateralEntry	262.255	I333-262255LE	**4.07e-11**	**3.58e-11**
4	29	LateralEntry	262.278	I376-262278LE	**3.85e-11**	**3.55e-11**
5	15	LateralEntry	261.769	I192-261769LE	2.37e-11	2.37e-11
6	9	LateralEntry	261.524	I115-261524LE	2.13e-11	2.13e-11
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8	3	LateralEntry	260.965	I37-260965LE	2.05e-11	2.05e-11
9	12	LateralEntry	261.649	I154-261649LE	1.98e-11	1.98e-11
-	25	CurveIn	262.210	I320-262210Cv	**2.96e-09**	**1.85e-14**

Alternatively,**other improvements could also reduce the risks. However, they can be more expensive and less effective**.

SCIENTIFIC ACTIVITY

1. **PUBLICATIONS**:

- **Highway And Road Probabilistic Safety Assessment Based On Bayesian Network Models** (2017). Computer-Aided Civil and Infrastructure Engineering (Q1, **N°1 in the ranking of Civil Engineering**).
- **Complexity Reduction And Sensitivity Analysis In Road Probabilistic Safety Assessment Bayesian Network Models** (2017). Computer-Aided Civil and Infrastructure Engineering (Q1, **N°1 in the ranking of Civil Engineering**).
- **Proactive, Backward Analysis And Learning In Road Probabilistic Bayesian Network Models**. Computer-Aided Civil and Infrastructure Engineering (Q1, **N°1 in the ranking of Civil Engineering**). In revision.
- **Reduction of Risk of Accident Through Self-explainig Roads. Analysis of Design Consistency Measures**. In process.

Scientific Activity

1. **INTERNATIONAL CONFERENCES**:

   - Participation in **Eurocast 2017**. Bayesian Networks Probabilistics Safety Analysis of Highways and Roads. 19-24 February. Las Palmas de Gran Canaria. **(Selected to be included in the Springer LNCS volumes)**.

   - Future attendance to the **TRA (Transport Research Arena)** conference. 16-19 April 2018 in Vienna (Austria).

2. **SEMINARS**:

   - RAIN (Risk Analysis Of Infrastructure Networks In Response To Extreme Weather) final event. Extreme Weather Events and Infrastructure: Assessing the Impacts, Mitigating the Consequences. 24th of March 2017. Trinity College Dublin (Ireland).

Scientific Activity

1. **TRAINING COURSES**:

   - **EDUC Basic course training**. 19 Sept-3 Nov 2016. 40 hours. EDUC.

   - **EDUC Advanced course on the future career of the PhD student** . 14 Nov- 2 Dec 2016. 40 hours. EDUC

   - **Programación Matemática en Ingeniería y Ciencia** . Oct 2016- Feb 2017. 75 hours. University of Cantabria.

2. **MOBILITY**:

   Currently in a 3-month internship at **Trinity College Dublin** (Ireland), working in RESILENS European Project in the Department of Civil, Structural and Environmental Engineering.

   March 1 to June 1, 2017.

MANY THANKS

THANKS

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