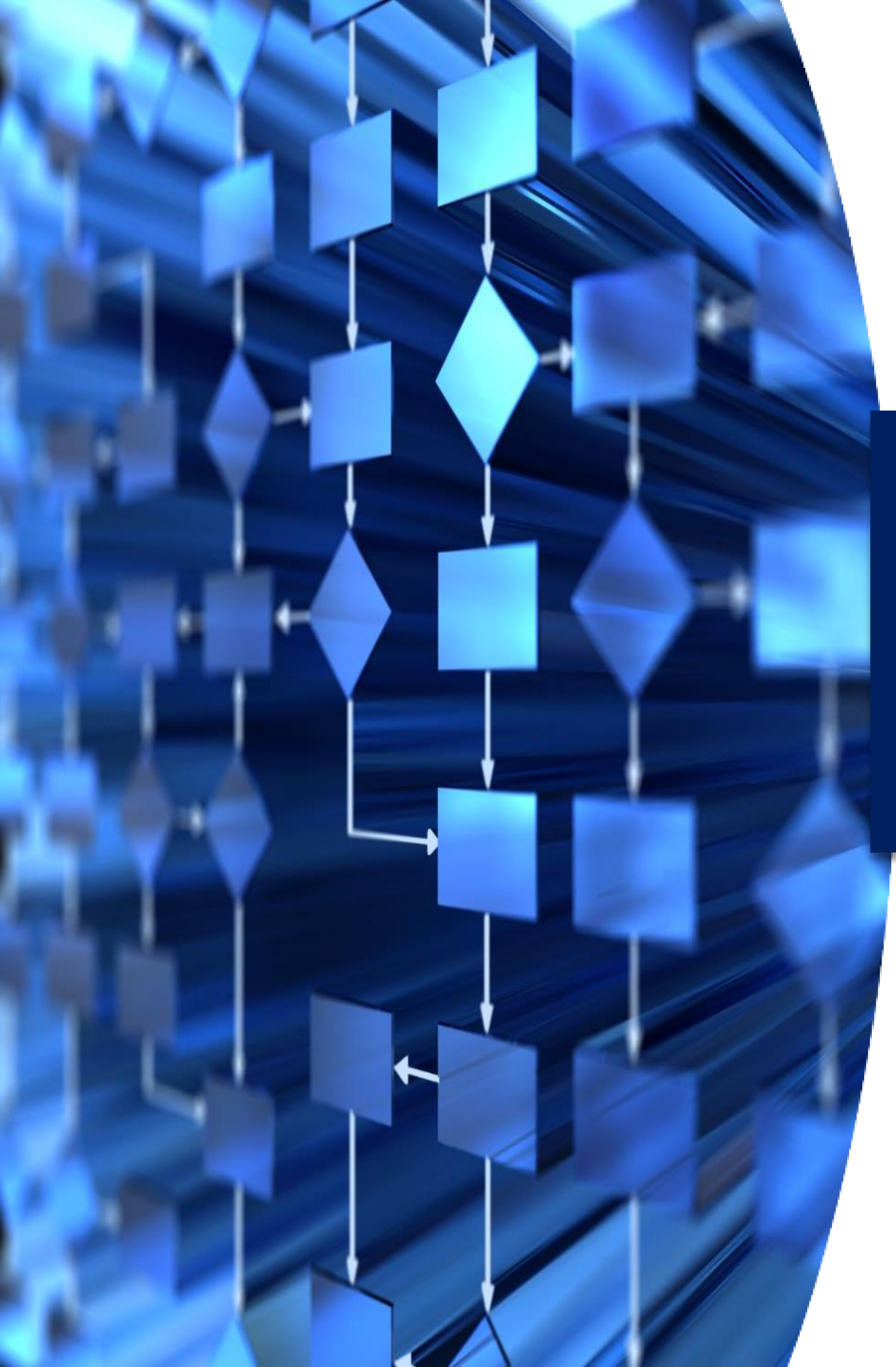


6th International Symposium on HIGHWAY GEOMETRIC DESIGN

Amsterdam - The Netherlands 26-29 June 2022

Featuring the 6th Urban Street Symposium

Development and Implementation of a Methodology for the Economic Appraisal of Road Infrastructure Safety Schemes

George Yannis, Anastasios Dragomanovits, Julia Roussou and Dimitrios Nikolaou

National Technical University of Athens

Department of Transportation Planning and Engineering

Introduction

- Economic assessment of road safety projects
  – increases the efficiency of decision makers' policies
  – maximizes the contribution of transport to the economy
  – safer and more balanced relationship between transport stakeholders, road users, society and the environment
- Limited funds for road safety
- Economic efficiency of measures is a widely used criterion to identify good policies

Scope (1/2)

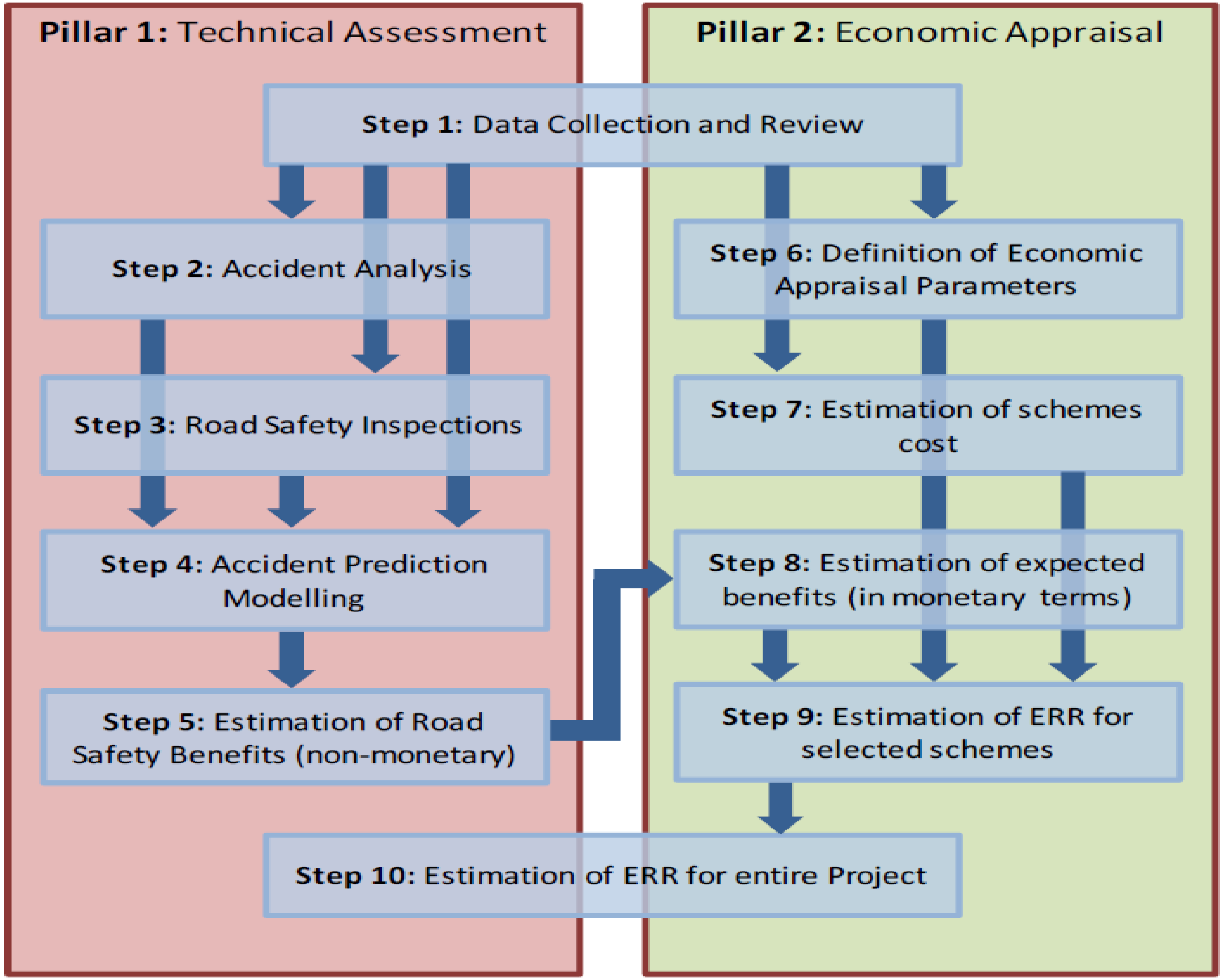
- Methodology for the economic assessment of road infrastructure safety projects using international crash prediction models, adjusted for local conditions and to account for limited data availability
- Assessment of the economic viability of large road safety project for the treatment of hazardous locations in the rural road network of Greece for Egnatia Odos SA (period 2012-2015)
- Project commissioned and funded by the European Investment Bank (EIB)

Scope (2/2)

- Technical and visual review of 15,000km of roads spreading over all 13 regions of Greece
- Rural two-lane two-way roads (excluding motorways and roads inside urban areas)
- ~7,000 hazardous locations (HL) identified spread over 2,500 km on 80 different roads
- Low cost road safety interventions were proposed (emphasis on quickly implemented measures)

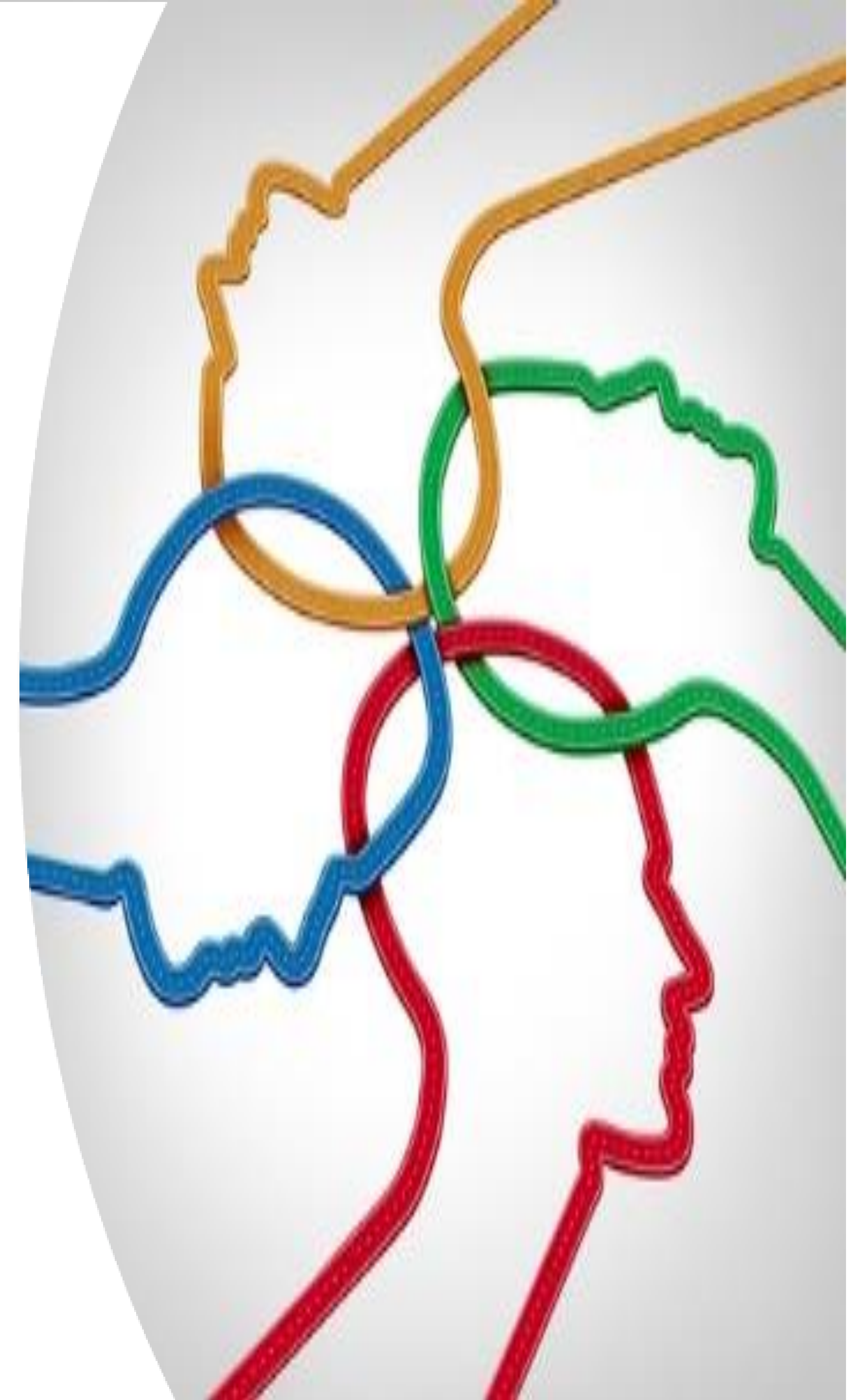
Methodological Approach

- Pillar 1 - Technical Assessment
  - Reactive approach
  - Proactive approach
  - Reduction in accident numbers, fatalities and injuries
- Pillar 2 - Economic Appraisal
  - Costs and benefits in monetary terms
  - Calculation of the project's Economic Rate of Return (ERR)
- No specific methodology systematically applied, in Greece or in Europe



Alternative Approaches

- **iRAP software (ViDA):** Star Rating Scores (SRS) - statistical/mathematical background not known and cannot be assessed
- **Highway Safety Manual (HSM) Predictive Method:** Observed crash data → Regression models → Safety Performance Functions (SPFs) → "base conditions" Crash Modification Factors (CMFs) → change in crash frequency due to a change in one specific condition Calibration Factor C for differences between "base" site and examined site
- **Interactive Highway Safety Design Module (IHSDM):** Requires detailed input data
- **PRACT Research Project Tool:** Based on HSM, allows user to calibrate models based on local accident data



Pilot Study

- Implementation in sub-regions of
  Imathia (northern Greece): 116 hazardous locations covering 38.6km of road network
  Viotia (central Greece): 111 hazardous locations covering 42.9km of road network

- Input data
  - Road geometry
  - Road equipment information
  - Traffic volumes
  - Historical crash data (for model calibration)

Treatments Commonly Proposed

- Construction of road markings (delineation)
- Installation of traffic signs & speed limit signage
- Construction of new asphalt pavement & anti-skid asphalt course
- Installation of roadside delineator posts
- Installation of centerline roadway deflectors
- Installation of transversal rumble strips
- Installation of safety barriers
- Installation of side roadway deflectors
- Improvement of roadside conditions (e.g. reconstruction of shoulders)
- Installation of road lighting

Accident Analysis & Site Inspections

- **Scenario 1:** only accidents for which the recorded road and station match those of the respective hazardous location
- **Scenario 2:** Scenario 1 + percentage of accidents with known road but unknown station
- **Under-reporting** correction coefficient (Hospitals/ ELSTAT) for fatalities
- **Site inspections** performed on 103 selected hazardous locations in Viotia and Imathia sub-regions to verify the suggested measures and identify any additional safety features needed.

Accident Prediction Modelling

- The HSM crash prediction methodology was implemented, calibrated according to actual crash data of the selected sites (for the years 2013-2017)
- The PRACT repository exploited for the identification of additional relevant CMFs
- Estimation of the number of accidents at the examined locations, for the period 2017-2032
  - without the project ("Business-As-Usual" scenario)
  - with implication of the suggested interventions

Topic	Value / Range of values
Roadway segments:	
Lane width	1.000 - 1.172
Shoulder width and type	0.987 - 1.287
Horizontal curvature	as in "Business As Usual" scenario
Superelevation	as in "Business As Usual" scenario
Grade	as in "Business As Usual" scenario
Driveway Density	as in "Business As Usual" scenario
Installation of centerline rumble strips	0.94
Passing lane	0.75
Road lighting	0.841 - 0.857 (calculated according to recorded night crash rates in each sub-region)
Improvement of vertical signage (including posting of speed limit)	0.87
Anti-skid asphalt wearing course	0.99 (national roads), 0.98 (regional roads)
Roadside improvements	exp(0.185*RHS), where RHS=change in Roadside Hazard Rating
Installation of EN-1317 compliant road safety barriers	0.78
Improvement - rehabilitation of road markings	0.94
Installation of roadside delineator posts	0.98 (calculated according to ratio of roadway departure crashes)
Installation of transverse rumble strips (as a measure for speed reduction)	0.66
Intersections:	
Skew angle	as in "Business As Usual" scenario
Left-turn lane	as in "Business As Usual" scenario
Right turn lane	as in "Business As Usual" scenario
Road lighting	0.892 - 0.919 (calculated according to recorded night crash rates in each sub-region)
Removal of sight obstructions	0.95
Anti-skid asphalt wearing course	0.94 - 0.98 (depending on number of intersection legs and ratio of crashes in wet conditions)

Estimation of Road Safety Benefits

- Estimation of benefits comparing the predicted number of accidents for assuming project implementation to the predicted number of accidents if the project is not implemented

- Severity indices used, based on 2008-2017 data:
  - number of fatalities per 100 crashes: 22.01
  - number of seriously injured per 100 crashes: 20.76
  - number of slightly injured per 100 crashes: 122.14

- Numbers in parentheses do not include adjustment for under-reporting

- Average reduction of accidents finally estimated at 40%

Time period 2017-2032

	Viotia sub-region		Imathia sub-region	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Reported accidents 2013-2017 (average per year)	(6,00)	(6,40)	(8,80)	(9,20)
Predicted accidents without project (final year)	(6,40)	(6,83)	(9,25)	(9,66)
Predicted accidents with project (final year)	(4,42)	(4,71)	(5,67)	(5,89)
Reduction in fatalities (total 2017-2032)	12 (10)	13 (11)	10 (9)	11 (9)
Reduction in seriously injured (total 2017-2032)	17 (10)	18 (10)	14 (8)	15 (9)
Reduction in slightly injured (total 2017-2032)	89 (58)	95 (62)	74 (48)	79 (51)

Economic Appraisal (1/2)

- Reference interest rate of 5%
- Average service life of 15 years
- Initial cost of road safety intervention (bidding documents)
- Annual maintenance cost
  0.5% of the construction costs annually first 5years,
  2.5% for the next 5years
  4.5% for the last 5years
- Valuation of human life in monetary terms

death:	2,148,034.20€
serious injury:	273,574.25€
slight injury:	51,372.70€

Economic Appraisal (2/2)

- ERR is *the interest rate at which the project's discounted benefits equal discounted costs*

ERR estimation Results

Scenario	Viotia	Imathia	Estimation for the whole Project in Greece
Scenario 1	25.2% (19.5%)	16.6% (11.6%)	16.7% (11.2%)
Scenario 2 (proposed)	27.1% (21.1%)	18.2% (13.1%)	18.2% (12.6%)

- Numbers in parentheses do not include adjustment for under-reporting

- Noticeable difference between ERRs in Viotia and Imathia
  Viotia: 0.19M€/km to be spent for treatment
  Imathia: 0.33M€/km to be spent for treatment

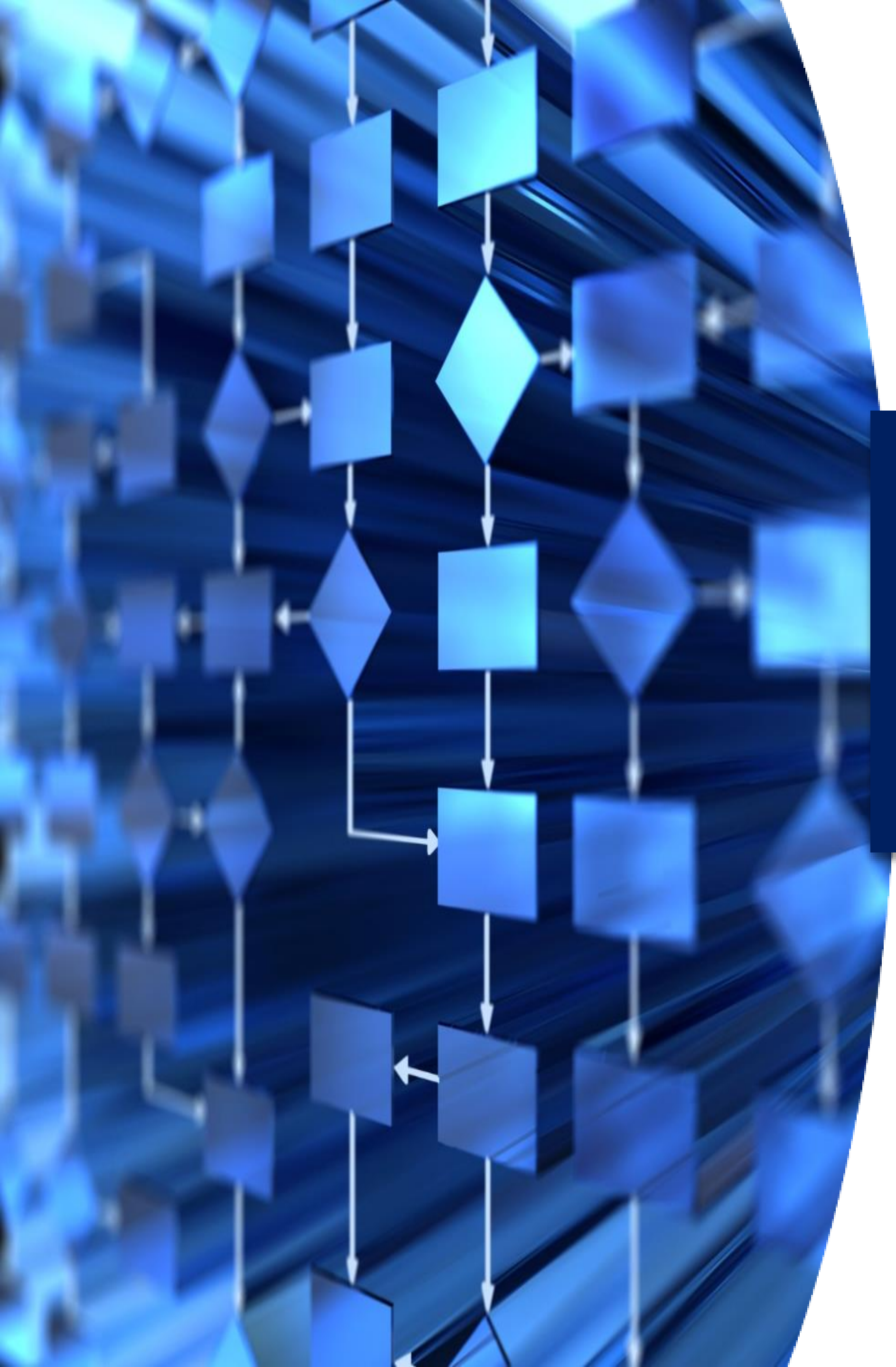
- Viotia → higher traffic volumes & higher estimated annual increase of AADT → more users are expected to benefit from the road safety interventions

Conclusions (1/2)

- Methodology is suitable for the economic assessment of road infrastructure safety improvements
- Road infrastructure safety investments and low cost measures are characterized by a very high ERR (25%)
- Combination of low implementation and maintenance costs with high valuation of their benefit (e.g. 2.15M€ for every fatality saved)
- Measures targeted to locations with serious safety deficiencies → significant impact on crash numbers

Conclusions (2/2)

- Reasonable results even in cases where input data is limited
- The results of the economic analysis are not sensitive to changes in the input data and assumptions
- Reliable information regarding crash numbers, AADT and geometric design elements of the road network is particularly important and necessary for the application of detailed quantitative methods



6th International Symposium on HIGHWAY GEOMETRIC DESIGN

Amsterdam - The Netherlands 26-29 June 2022

Featuring the 6th Urban Street Symposium

Development and Implementation of a Methodology for the Economic Appraisal of Road Infrastructure Safety Schemes

George Yannis, Anastasios Dragomanovits, Julia Roussou and Dimitrios Nikolaou

National Technical University of Athens

Department of Transportation Planning and Engineering