Scenario Analysis, Decision Trees and Simulation for Cargo Screening

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Background

Introduction
- Cargo screening at seaports
- Looking for stowaways
- Efficiency is not known

Tools for evaluating different policies
- Trade-Off Analysis
- Cost-Benefit Analysis
- Pareto Analysis

Evaluation methods used in tools
- Scenario analysis
- Decision trees
- Simulation (Monte Carlo and DES)

Aim and Focus

Aim: To examine different probabilistic methods that are frequently used for conducting Cost-Benefit Analysis of different cargo screening policies

Focus:
- Comparison between techniques
- Data requirements
- Use in security research

Case Study - Calais

- Stowaways (clandestines)
- 900,000 lorries/year
- 0.4% are positive detected lorries

Scenarios

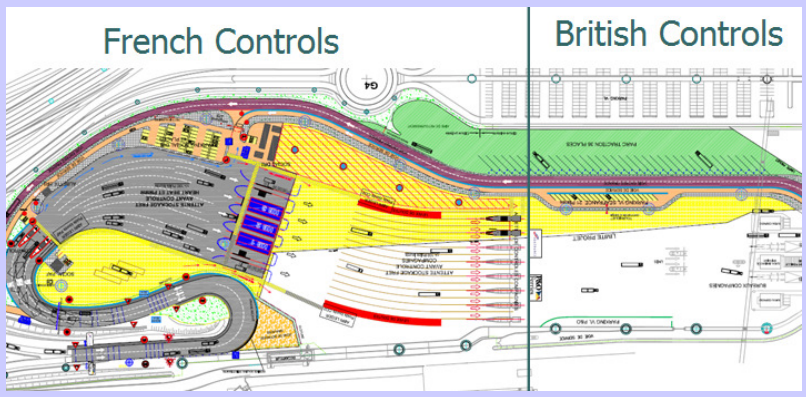
Traffic Growth (TG)	p (TG)	Clandestine Growth (CG)	p (CG)	Search Growth (SG)
0%	0.25	-50%	0.33	0%
10%	0.5	0%	0.33	10%
20%	0.25	25%	0.33	20%

Table 1: Two factors with three scenarios and one decision variable with three options

	-50% CG	0% CG	+25% CG
0% TG	0.083	0.083	0.083
10% TG	0.167	0.167	0.167
20% TG	0.083	0.083	0.083

Table 2: Combined probabilities assuming independence of probabilities

Conceptual Model



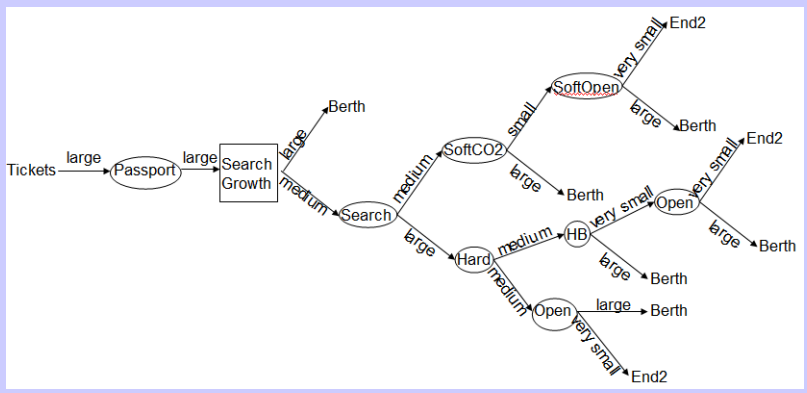
Scenario Analysis

- % of vehicles searched
- # of positive lorries stopped
- Comparison with base scenario CG=0%
- # of positive lorries missed
- Cost of extra searches
- Relative # of positive lorries missed vs. CG=0%

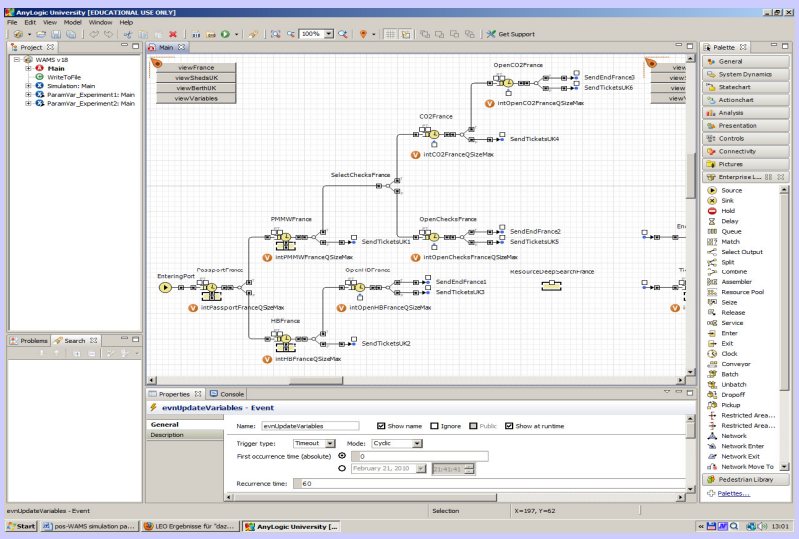
TG vs. SG	SG 0%	SG +10%	SG +20%
TG 0%	£60,000,000	£59,545,455	£60,000,000
TG 10%	£66,000,000	£65,000,000	£65,000,000
TG 20%	£72,000,000	£70,454,545	£70,000,000

Table 3: Expected costs excluding SG costs for CG = 0%

Decision Trees



Simulation (using AnyLogic)



- Monte Carlo Simulation
- DES 0: basic (incl. times and resources)
- DES 1: DES 0 & seasonal arrival rates
- DES 2: DES 0 & queue size restrictions (UK controls)
- DES 3: DES 1 & queue size restrictions (UK controls)

Results and Conclusions

Option	Total expected costs 1: SG=0%	2: SG=10%	3: SG=20%	Cheapest option
SA	£60,500,000	£60,000,000	£60,416,667	2
DT	£60,497,446	£60,000,000	£60,418,795	2
MCS	£60,335,818	£60,058,184	£60,461,341	2
DES 0	£60,797,873	£60,250,740	£60,350,102	2
DES 1	£60,881,284	£60,017,602	£60,406,308	2
DES 2	£60,714,953	£60,166,442	£60,857,915	2
DES 3	£59,817,382	£60,116,618	£61,624,835	1

Table 4: Overall cost comparisons of all methodologies

- Scenario analysis, decision trees and simulation are useful for cost benefit analysis of static systems
- In dynamic environments simulation is more flexible (e.g. seasonal arrivals rates and queue restrictions)
- Further comparison of methods can be found in Table 5.

		SA	DT	MC	DES
Risk type	Discrete / Continuous	D	D	C	C
	Correlated / Independent	C	I	both	both
	Sequential / Concurrent	C	S	both	both
Decision process	Strategic / Operational	S	S	S	O
	Broad / Detailed	B	B	B	D
Model Characteristics: Low, Medium, High	Complexity	L	M	H	H
	Data requirements	L	L	M	H
	Tool costs	L	L	M	H
	Training costs	L	L	H	H
	Assumptions	H	M	L	L

Table 5: Factors to take into consideration before making decisions

Future Research

- How useful is simulation for analysing the impact of rare events?
- Looking at standard deviation in the context of rare events: How can it be used to assess risk when events get rarer?
- Comparison of probabilistic (top down) with object oriented (bottom-up) routing in simulation models

The Research Team

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