A Safe System Approach

Potential contributions from adapting road infrastructure

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Where are we and where are we going to in road safety?
Effective interventions in traditional areas (‘evidence based interventions’)

- Human behaviour (legislation + enforcement)
  - Speed, alcohol, seat belts and safety helmets
  - Driver education, schools, mass-media campaigns
- Infrastructure: planning, black spots, safe designs,
- Safe vehicles, crashworthiness, inspection, special attention for trucks/buses and motorised two wheelers
- Post-crash response
- Always new developments: such as drugs, mobile phones, ageing society

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<th>Pillar 1</th>
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<th>Pillar 3</th>
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<tr>
<td>Road safety management</td>
<td>Safer roads</td>
<td>Safer vehicles</td>
<td>Safer road users</td>
<td>Post-crash response</td>
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Traditional, reactive and, effective approach: ‘data driven’
Go fishing where the fish are, but ....

- Look for high risks, high proportions, high increases
  - e.g. novice drivers, elderly road users, powered two-wheelers, high-risk locations, distraction
- Road crashes can occur and will occur everywhere
- We were (relatively) successful in fishing where the fishes are (NL-fatalities: 80% reduction in 40 years)
- But, fishes are more and more everywhere
- How to respond?
High-speed train derailment in the north of Spain, 24 July 2013
What happened?

• High-speed train derailed on a sharp curve: 80 passengers were killed, 144 were injured
• The train was travelling at twice the permitted speed limit of 80 km/h
• The driver was reported to have been on the phone talking to colleagues just prior to the crash
• An official investigative report determined that this crash was *completely preventable*
• Official findings: driver was ‘*exclusively*’ responsible
The cause(s)?

• The facts primes us to believe the driver was to blame:

  - train driver inattention
  - excess speed
  - excess speed on curve
  - derailment and crash

• If you dig a little bit deeper, another picture emerges:

  ‘Upstream’ risk landscape: no driver alerts, no last line of defence (e.g. European Train Control System ETCS had consciously been switched off)
Safe System thinking: ‘upstream’ risk landscape to identify possible causal factors and points for interventions

- A crash like the high-speed derailment could be prevented by installing multiple layers of prevention, by redundant safety systems and a pro-active safety culture
Two approaches to the human fallibility

- Person approach versus System approach
Person approach: ‘Bad things happen to bad people’

- This approach focusses on unsafe acts by individuals: errors and (procedural) violations:
  - Forgetfulness, moral weakness, inattention, poor motivation, carelessness, negligence, recklessness

- Management response: campaigns that appeal to people's sense of fear, writing another procedure (or adding to existing ones), disciplinary measures, threat of litigation, retraining, naming, blaming, and shaming
System approach: humans are fallible and errors are to be expected

- Errors are seen as consequences rather than causes, having their origins not so much in the perversity of human nature, but in “upstream” systemic factors.

- Countermeasures are based on the assumption that, though we cannot change the human condition, we can change the conditions under which humans work. (“not fitting the person to the job, but the job to the person”)
Person approach vs. System approach (James Reason, 1990)

- The human fallibility can be explained by using these two approaches
- **Person**: errors of individuals because of forgetfulness, inattention, moral weakness, poor motivation, carelessness, recklessness, negligence, braking the law
- **System**: avert errors (or mitigate their effects) by defences, barriers, and safeguards
Road traffic today is *inherently* dangerous
Our fundamental road safety problem are *basic risk factors (not just risk increasing factors)*

- Today’s road traffic is *inherently* unsafe.
- The road system of today has not been designed with safety in mind, as is the case with air transport or rail transport (sic).
- Which means we are almost fully dependent on whether a road user makes a mistake or error in preventing a crash.
- We face too high levels of kinetic energy in crashes (above tolerable human levels).
- Another approach is needed: *Safe System Approach*.
Safe System approach

- Similar names are around, that accept the same principles (human beings make mistakes, the human body has a limited physical ability, there is a shared responsibility amongst stakeholders and road users, all parts of the system should be strengthened in combination)
  - Vision Zero
  - Towards Zero
  - Sustainable Safety
  - Safe System
- Safe System is not cast in concrete, but a living concept
Safe System approach

- A vision
- A set of principles
- A set of tools
Road safety vision = a product of underlying community values

- No one should be killed or seriously injured in road crashes
- Protecting vulnerable road users, such as children
- Limit disadvantage due to actions by other road users
- Mobility should be maximised within the limits of safe operations
Safe System (‘Sustainable Safety’) principles in the Netherlands, 2005 (I)

• Ethical
  • We don’t want to hand over a traffic system to the next generation with current casualty levels, but considerably less: *Towards zero*

• A proactive approach
  • There is no need to wait for crashes before to act; ‘we’ have enough knowledge to be applied; adapt knowledge to local conditions

• People are the measure of all things
  • Human capacities and limitations are the guiding factors (physically and psychologically)
Safe System (‘Sustainable Safety) principles in the Netherlands, 2005 (II)

• An integrated/holistic approach
  • Integrate man, vehicle and road into a safe system
  • Covers the whole network, all vehicles, all road users
  • Align with other policy areas: infrastructure, planning, health, etc.
  • Shared responsibility between ‘system’ and users

• Reducing latent errors (system gaps) of the system
  • Which means we will not be fully dependent on whether a road user makes a mistake or an error in preventing a crash

• Use criterion of preventable injuries
  • If we know the causes, if we know how to cure, if interventions are cost-beneficial
Safe System tools: implemented differently in different countries

• The Netherlands, e.g. rural traffic calming
• Sweden, e.g. 2+ 1 road
• Australia, e.g. speed management
People are the measure of all things

1. The road system should be designed to expect and accommodate *human error*, because it is inevitable that road users make mistakes and sometimes violate the law (and crashes occur); this concept has been accepted and implemented in other sectors of transportation.

2. In a crash, interaction between vehicle – roadway – human body must be managed so that serious injury likelihood is minimized, if not eliminated.
Proactive safe system approach

- System approach: prevention of latent errors (system gaps) based on the Swiss Cheese Model (Reason, 1997)
  - Intervene as early in chain as possible
  - Make unsafe actions less dependent from choices of individual road users
Proactive safe system approach

- System approach: prevention of latent errors (system gaps) based on the Swiss Cheese Model (Reason, 1997)
  - Intervene as early in chain as possible
  - Make unsafe actions less dependent from choices of individual road users
Don’t blame the driver

Proactive reducing of system gaps (latent errors)

Who or what caused the crash?

How could this happen?

Making road safety less dependent on choices of individual road users

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Aims of a Safe System

1. Preventing (serious) crashes, simply by eliminating conditions/circumstances where serious crashes can occur
2. Reducing the probability of serious injury, when crashes cannot be prevented (MAIS3+ or permanent disability)
How to avoid crashes by preventing errors and violations?

• Adjust the environment to the human measure in such a way that man commits fewer errors and, consequently, runs a lower risk
  • 1. Make potentially dangerous situations less frequent or even eliminate them
  • 2. Design an environment resulting in fewer errors
  • 3. If errors are committed, let the environment being forgiving for errors
• Deal effectively/efficiently with violations: ‘normal road users’, novice drivers and excessive behaviour/recidivists/‘delinguents’
Safe System approach characteristics (OECD/ITF, 2008 and 2016)

- Crashes will occur and road users will remain fallible, notwithstanding prevention efforts
- Road safety is a shared responsibility of road users and system designers/operators: ‘don’t blame the victim’
- Road safety decisions should be aligned with broader transportation decisions
- It shapes interventions to meet ambitious long term goals, rather than relying on ‘traditional’ interventions
Safe System approach: an example is NL Sustainable Safety
How the Safe System approach developed in the Netherlands

1991
Introduction of Sustainable Safety vision

1995
Start of sustainable safe demonstration projects

1997
Start-up programme Sustainable Safety

2001
Official ending of Start-up programme

2005
Launch of the advanced vision
25 April 2018: launch of 3rd version

- **DV3 - a strategic and operational system approach for safe road traffic**
- More than a decade after *Advancing Sustainable Safety* the time came for an updated, risk-based system approach for safe road traffic in the Netherlands. SWOV has named the new system approach it has been working on DV3 and aims to present a useful and inviting system approach that will find support and provides guidance to policy makers and road authorities for concrete measures.
## Five Sustainable Safety principles

1. **Functionality** of roads

2. **Homogeneity** of masses and/or speed and direction

3. **Predictability** of road course and road user behaviour by a recognizable road design

4. **Forgivingness** of the environment
1. FUNCTIONALITY (I)
(Based on Buchanan, 1960s):

Functional categorization of roads (road hierarchy):
- Flow function
- Access function

Ideally, roads only have one of these functions (monofunctionality)
1. FUNCTIONALITY (II)
Traditional approach (1965) vs. tri-partition in Sustainable Safety

- Motorway
- Urban motorway
- Area distributor
- Local distributor
- Shopping street
- Residential area road
- Residential street
- Woonerf

Traffic function
Access function
Capacity

Through road
Distribution road
Access road
1. FUNCTIONALITY (III)

Functional road hierarchy

- **Through roads**
  - Traffic should flow

- **Distributor roads**
  - Flow function on road sections
  - Exchange of traffic at intersections

- **Access roads**
  - Residence and exchange of traffic is central
FUNCTIONALITY (IV)
Road classification plans (concerted action by all road authorities!)
Golden triangle for safe road design

- If Function and Form are not attuned, higher Risk

Diagram showing the relationships between Function, Form, and Behaviour.
2. HOMOGENEITY (I)

- Prevention of conflicts
  - Separate driving lanes for different types of traffic (speed or mass)
    - Cycle paths and sidewalks
  - Opposite driving directions with high speed
    - physical separation
  - Conflict/crash unavoidable? Reduce speed!
    - Lower speed limit
    - Speed reduction at intersections
      - Roundabouts, plateaus
  - Run-off-road: obstacles shielded or obstacle free
2. HOMOGENEITY (II)

Proposal for critical impact speed (max. 10% probability of MAIS3+)

• Based on impact speeds, angles, mass, protection, obstacle-free zones and injury probability (MAIS 3+)

• (not based on Wamborg and Tingvall&Haworth, but on Jurewicz et al. and Sustainable Safety 3rd edition!)

<table>
<thead>
<tr>
<th>Crash type</th>
<th>Critical impact speed (km/h)</th>
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<tbody>
<tr>
<td>Pedestrian - vehicle</td>
<td>20-30</td>
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<tr>
<td>Head-on</td>
<td>30</td>
</tr>
<tr>
<td>Side impact</td>
<td>30</td>
</tr>
<tr>
<td>Rear-end</td>
<td>55</td>
</tr>
<tr>
<td>Run-off-road</td>
<td>Depends on shoulder</td>
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3. PREDICTABILITY (I)

- Preventing errors by:
  - Recognizable situations: consistency in road design
  - Predictable road course: continuity in road design

- Anticipated result:
  - More routine traffic behaviour → fewer errors
  - More predictable behaviour of other road users
3. PREDICTABILITY (II)
How the principle is supposed to work

- Recognisable road layout
- Homogeneous and predictable behaviour

**Expectations**

- Preferred or required behaviour:
  - Maximum speed
  - Range of safe behaviour
  - Allowed manoeuvres
- Other road users
  - Type of road users allowed
  - Maximum speed
  - Possible manoeuvres
- Road course and transitions between roads

**Routine behaviour**

**Mental categorisation**
Requirements for distinction:
- sufficient differences among categories
- sufficient uniformity within a category

**Reduction of dangerous errors**

**Reduction of probability of crash**

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5. PHYSICAL FORGIVINGNESS

- Forgiving road (side) environment
  - Matted (hard and semi-hard) shoulders
  - Obstacle-free zones
  - Shielded obstacles
Potential contributions from adapting road infrastructure

- Safe(r) roads by including road safety in decision making on new roads and, when rehabilitating or redesigning existing roads, using a minimum safety level, coming from up-to-date design guidelines, used by well-trained professional engineers/designers and planners (in cities, for rural roads and motorways)
- So:
  - Transparant decision making
  - Design guidelines based on Safe System approach
  - Well-trained professionals
## Expanding traffic calming schemes (inside/outside urban areas)

<table>
<thead>
<tr>
<th>Road lengths in kilometres</th>
<th>1998</th>
<th>2003</th>
<th>2008</th>
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<tr>
<td><strong>Inside urban areas</strong></td>
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<tr>
<td>30km/hour</td>
<td>8.900 (15%)</td>
<td>29.000 (45%)</td>
<td>50.300 (70%)</td>
</tr>
<tr>
<td>50km/hour</td>
<td>50.600 (85%)</td>
<td>36.500 (55%)</td>
<td>21.600 (30%)</td>
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<tr>
<td>Total inside urban areas</td>
<td>59.600 (100%)</td>
<td>66.400 (100%)</td>
<td>71.900 (100%)</td>
</tr>
<tr>
<td><strong>Outside urban areas</strong></td>
<td></td>
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<tr>
<td>60km/hour</td>
<td>2100 (3%)</td>
<td>+/- 10.000 (15-20%)</td>
<td>35.400 (57%)</td>
</tr>
<tr>
<td>80km/hour</td>
<td>63.300 (97%)</td>
<td>54.000 (80-85%)</td>
<td>25.500 (43%)</td>
</tr>
<tr>
<td>Total outside urban areas (excl. motorways)</td>
<td>65.400 (100%)</td>
<td>64.000 (100%)</td>
<td>62.100 (100%)</td>
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Effects of “Ten years Sustainable Safety”

- The number of fatalities decreased by an average of more than 5% per year (1998-2007); a more than two times faster decrease than in the ten years before (1988-1997)
- Implemented measures have with a large degree of probability contributed to this 1998-2007-decrease
- This resulted in a decrease of 300-400 fatalities in 2007, which is more than a 30% reduction
- We invested € 530 million per year; € 350 million on road infrastructure
- The benefits to society exceed the costs by a factor of 4
Some final observations (I)

• Safe System approach is a combination of a good understanding of causes of crashes, a vision to tackle problems fundamentally (*basic risk factors*), backed by evidence and a political will to implement.

• Safe System is 1) a vision, 2) set of principles and 3) set of tools.

• Safe System approach is somewhat different in different countries, e.g. Vision Zero in Sweden, Sustainable Safety in the Netherlands, but the fundamentals are the same.

• Design your own Safe System approach.
Some final observations (II)

• In NL: not effective in bringing down the number of serious injuries (cyclists); you need two different strategies!
• Sustainable Safety energized the professional community, resulted in more action, gave more focus to actions and improved efficiency of interventions
• However, we had to gain professional and political support continuously
• Vision remains, principles remain, tools differ (anticipation on a changing ‘environment’ is required), and priority for road safety is not guaranteed
Is a Safe System approach also applicable in Spain?

- How to create support for a Safe System approach?
- How to define your version of Safe System (vision + principles + tools)?
- How to bring Safe System approach to implementation in your country?