Taking a systems approach to road safety

The UK DfT funded Road Collision Investigation Project

Elizabeth Box
Head of Research
@elizabethcbox
11 April 2019
Outline

• Background and history
• Purpose and approach taken to the Road Collision Investigation Project (RCIP)
• Model and method selection
• A case study example
• Current work and next steps
• A note on some related PhD research…
• Final observations
government announces bold package of measures to improve road safety
measures include £350,000 for a competition to bring a new mobile breathalyser to the market
£480,000 for the RAC Foundation to trial an innovative new approach to road casualty investigation, looking more closely at what is really causing road collisions

Road Collision Investigation Project (RCIP) - Announced
Road Collision Investigation Project (RCIP)

- Project run by the RAC Foundation
- In collaboration with, and supported by the DfT, Highways England, National Police Chiefs Council and others
Purpose

- To establish whether there is a business case for putting more resource into the investigation of road crashes based on a comparison with the approach to crash investigation used for other modes (Rail, Air and Sea) and safety critical industries (Oil & Gas)
Purpose cont...

- Establishing how feedback from investigation of individual incidents can better inform policy development.
- Developing new approaches to harvesting and analysing of data from different sources, including information from police investigations beyond that captured in STATS19.
The story so far...

RAC Foundation Road Crash Investigation Project – The top-down/bottom-up picture

RAC Foundation

- Commission new 'systems-thinking' approach for interrogating the causes of road crashes
- Subject the draft to peer review, publish and share with local analysts for deployment
- Devise protocol for selection/prioritisation of crashes to be re-investigated
- Train local analysts to apply the 'systems thinking' framework
- Subject the package of map, framework and selection criteria to local review before deployment

Local intelligence could lead directly to identification and development of interventions

Development of interventions, e.g., police resource deployment, actions for third parties, changes to reporting processes etc...

RACF continues to pursue leads, and seek ideas from other sectors, potentially bringing in Cabinet Office 'nudge' unit to advise on successful interventions

Local intelligence is the key to tracing back the full social/economic cost of road crashes

The cost of road crashes

Local intelligence is used to inform development of selection criteria and of the interested parties/data map

Local analysts identify ‘missing’ elements, in patterns of causation + severity factors

Highways England data is key to tracing back the causes, incidence, severity and congestion impact of crashes on the motorway/strategic road network

Local analysts conduct interviews, take informal soundings and explore local crash records

Experience/results fed back, compared across the three forces, refined and re-applied, and feed identification and development of interventions

NPCC/NRPIF

Map all interested parties/known sources of relevant data

NRPIF lead analyst input
The Safe Systems approach is based on a kinetic energy model where road safety outcomes are achieved by separating sources of kinetic energy in moving vehicles in order that it is not transferred to road users.
Conceptualisation of the safe system

UN Decade of Action for Road Safety 2011-2020

Pillar 1
Road safety management

Pillar 2
Safer roads and mobility

Pillar 3
Safer vehicles

Pillar 4
Safer road users

Pillar 5
Post-crash response

Source: NRSS (2016)
Models and Methods for Collision Analysis
A guide for policymakers and practitioners

Prof Neville Stanton, University of Southampton, UK

Expert review:

Prof Paul Salmon, USC, Australia
Prof Guy Walker, Heriot-Watt, UK
Methods

- Time and Motion (1911)
- FTA (Watson, 1961)
- Bow-Tie (ICI, c. 1979)
- STEP (Hendrick & Benner, 1987)
- Accimap (Rasmussen, 1997)
- STAMP-CAST (Leveson, 2004)
- EAST-BL (Stanton & Harvey, 2017)

Behaviourism

- Scientific Management (Taylor, 1911)
- Domino Model (Heinrich, 1931)
- General Systems Theory (Von Bertalanffy, 1950)
- Safety Management Systems (Kysor, 1973)

Cognitivism

- Safety Management Systems (Kysor, 1973)
- Sociotechnical Systems Theory (Trist & Bamforth, 1951)
- Soft Systems (Checkland, 1981)
- Normal Accident Theory (Perrow, 1984)

Systemism

- Swiss Cheese Model (Reason, 1990)
- Risk Management Framework (Rasmussen, 1997)
- STAMP (Leveson, 2004)

Models

Note: (a) Watson’s work on FTA for Bell Laboratories in 1961 is referenced by ScienceDirect, undated;
(b) EAST-BL: Event Analysis of Systemic Teamwork – Broken Links;
FTA: Fault Tree Analysis;
FRAM: Functional Resonance Analysis Method;
HFACS: Human Factors Analysis and Classification Scheme;
STAMP–CAST: Systems-Theoretic Accident Model and Processes – Causal Analysis using Systems Theory;
STEP: Sequential Timed Event Plotting.
### Table 3.1: List of methods and corresponding models

<table>
<thead>
<tr>
<th>Method</th>
<th>Model type</th>
<th>Pioneer(s)</th>
<th>Date</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>AcciMap*</td>
<td>Heterarchy</td>
<td>Rasmussen</td>
<td>1997</td>
<td>Safety Science</td>
</tr>
<tr>
<td>Bow-Tie</td>
<td>Tree structure</td>
<td>ICI</td>
<td>c. 1979</td>
<td>ICI</td>
</tr>
<tr>
<td>EAST–BL</td>
<td>Networks</td>
<td>Stanton and Harvey</td>
<td>2017</td>
<td>Ergonomics</td>
</tr>
<tr>
<td>FTA*</td>
<td>Tree structure</td>
<td>Watson</td>
<td>1961</td>
<td>Bell Laboratories</td>
</tr>
<tr>
<td>FRAM</td>
<td>Network</td>
<td>Hollnagel</td>
<td>2012</td>
<td>Book (Ashgate)</td>
</tr>
<tr>
<td>HFACS*</td>
<td>Taxonomic</td>
<td>Shappell and Wiegmann</td>
<td>2001</td>
<td>Human Factors and Aerospace Safety</td>
</tr>
<tr>
<td>STAMP–CAST*</td>
<td>Control structure</td>
<td>Leveson</td>
<td>2004</td>
<td>Safety Science</td>
</tr>
<tr>
<td>STEP</td>
<td>Multilinear</td>
<td>Hendrick and Benner</td>
<td>1987</td>
<td>Book (Marcel Dekker)</td>
</tr>
</tbody>
</table>

Source: Author’s own

Notes: (a) *methods specified in RCIP call for proposals;
(b) Watson's work on FTA for Bell Laboratories in 1961 is referenced by ScienceDirect, undated.;
(c) EAST–BL: Event Analysis of Systemic Teamwork – Broken Links;
FTA: Fault Tree Analysis;
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STEP: Sequential Timed Event Plotting

RAC Foundation

Source: Rasmussen (1997); Leveson (2011)
Case Study – Uber Collision with Cyclist

Slide by: Prof. N Stanton
Automated driving

How a Self-Driving Car Works

**LIDAR UNIT**
Constantly spinning, it uses laser beams to generate a 360-degree image of the car's surroundings.

**RADAR SENSORS**
Measure the distance from the car to obstacles.

**CAMERAS**
Use parallax from multiple images to find the distance to various objects. Cameras also detect traffic lights and signs, and help recognize moving objects like pedestrians and bicyclists.

**ADDITIONAL LIDAR UNITS**

**MAIN COMPUTER (LOCATED IN TRUNK)**
Analyzes data from the sensors, and compares its stored maps to assess current conditions.

Slide by: Prof. N Stanton
Timeline 18th March 2018

- **6:30 p.m.**: 44-year-old Rafaela Vasquez arrives for work at the Uber facilities in Tempe, Arizona.
- **9:14 p.m.**: Vasquez leaves the Tempe facilities in a self-driving 2017 Volvo XC90 operated by Uber to run an established test route through downtown Tempe.
- **9:39 p.m.**: The vehicle is switched to autonomous mode.
- [A report from Tempe police states Vasquez begins streaming "The Voice" on the Hulu app on a cellphone. During this time, the Tempe police state that Vasquez can be seen frequently looking down at the lower center console area near her knee and frequently smirking and laughing. Her hands are not visible in the frame of the surveillance footage. Police determine she looks down 204 times over the course of 11.8 miles. Her eyes were off of the road for 6 minutes and 47 seconds during this period (i.e., over 25% of time)]. *This report is not yet substantiated by NTSB.*
- **9:58 p.m.**: Vasquez looks up while driving northbound on Mill Avenue toward Curry Road, approximately 0.5 seconds before the crash. She attempts to swerve left before striking 49-year-old Elaine Herzberg at 39 mph (speed zone posted at 45 mph) as she crosses the street mid-block. Hulu’s records also show the streaming of the show ended at this time.
- Vasquez calls 911 and is released later that night after speaking to police. She stated she was monitoring the self-driving system interface and neither her business or personal phones were in use.

Slide by: Prof. N Stanton
Video Footage

Slide by: Prof. N Stanton
Figure 2. View of the self-driving system data playback at about 1.3 seconds before impact, when the system determined an emergency braking maneuver would be needed to mitigate a collision. Yellow bands are shown in meters ahead. Orange lines show the center of mapped travel lanes. The purple shaded area shows the path the vehicle traveled, with the green line showing the center of that path.
Paths of cyclist and vehicle

Slide by: Prof. N Stanton
Junction approach (daytime)
Paved median (no crossing sign)
The AcciMap Model

Source: Svedung & Rasmussen (2002)
## Actor Map

<table>
<thead>
<tr>
<th>International influences</th>
<th>International Organization for Standardization</th>
</tr>
</thead>
<tbody>
<tr>
<td>National committees</td>
<td>Society of Automotive Engineers</td>
</tr>
<tr>
<td>Regulatory bodies and associations</td>
<td>California regulators</td>
</tr>
<tr>
<td>Company management and local area government</td>
<td>Uber</td>
</tr>
<tr>
<td>Technical and operational management</td>
<td>Uber engineers</td>
</tr>
<tr>
<td>Driving processes</td>
<td>Driver</td>
</tr>
<tr>
<td>Equipment and environment</td>
<td>Automated vehicle</td>
</tr>
</tbody>
</table>

Source: Author's own
Selection of method

- Systems levels addressed (Top: AcciMap, STAMP-CAST)
- 7 Tenets of Accidents (Rasmussen, 1997)
  - Multiple contributory factors, multiple actors, interactions between contributory factors, vertical integration, communications and feedback, migration of performance to safe to unsafe, triggering events (Top: AcciMap)
- Criteria ratings
  - Evidence of reliability & validity, complexity, reliance on SMEs, audit of system influences, applicability to road traffic safety, in-built classification (Top: AcciMap & Fault tree)
  - Ease of use, application time, training demand, simplicity of interpretation, tools required, evidence of practical impact (Top: AcciMap)
Recommendations - Method

- AcciMap method (incorporating Actor Maps) appears to be ‘best’ approach in terms of coverage across theoretical, methodological and practical criteria
- A classification scheme needs to be developed to help with consistency and aggregation of data (identifying systemic factors in collisions)
- Tablet-based data collection at road scene followed by desktop analysis with database (Actor and AcciMap)
Recommendations - Training

- Development and roll-out of training in data collection with Actor Map and AcciMap classification scheme (which needs to be developed)
- Studies of reliability and validity during training
- Studies of adherence to methods at intervals across the lifetime of the RCIP
Next steps for implementation

• Develop classification scheme for Actor Maps and AcciMaps
• Matrix for linking of events in AcciMaps
• Development of training materials for Actor Maps and AcciMaps
• Pilot study conducting training in Actor Maps and AcciMaps
• Revision of training materials
• Roll-out of training for RCIP study
Participant Information Sheet – RCIP Interviews

Road Collision Investigation Project

You are invited to take part in an interview to inform the Road Collision Investigation Project (RCIP)

- Please take the time to read the following information carefully.
- You are free to decide whether or not to take part in this study and to withdraw from the project at any stage.
- Please do ask if anything is not clear or you would like more information.

Key information

- This study is being run, with £480,000 of Government funding, to develop and trial, in a number of police force areas a different approach to identifying and understanding common themes and patterns that result in road collisions.

Contents

1. Study purpose
2. Interview format
3. Your invitation to participate
4. More information

Contact details

If you have any questions about this study, please talk to the RCIP Project Director, Steve Gooding
steve.gooding@racfoundatio
n.org Tel no: 020 7747 3485
Local Analyst Recruitment
More systems...

Framework of individual, social and environmental factors intervening in young novice drivers’ risk using an ecological systems (Bronfenbrenner, 1979).

*Note: Arrows indicate links between factors within and between systems*

Observations on the project
THANK YOU

elizabeth.box@racfoundation.org