Strategies for managing the effects of kinetic energy in crashes

Presented by:
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Berkeley SafeTREC

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Developing a Framework to Combine the Different Protective Features of a Safe System

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View Bio
Goal of the transportation system

Provide mobility.

Provide efficient, cost-effective, equitable, ..., sustainable, and safe mobility.
How do we measure if it’s Safe?

We commonly approximate safety in terms of crashes, which are a count, and represent lack of safety (i.e., how unsafe the system is as an empirical outcome).
Not safe in absolute or relative terms

### 2017 Fatalities
- California: 3,602
- USA: 37,133
- Globally: Over 1,300,000

First or Second Leading Cause of Death for ages > 1
Safety as a feature of the system

a system in which people cannot die despite human error.

Job, and Sakashita. 2016a
Policy innovation to move the needle

**THE SAFE SYSTEM APPROACH VS. TRADITIONAL ROAD SAFETY PRACTICES**

<table>
<thead>
<tr>
<th>Traditional</th>
<th>Safe System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevent crashes</td>
<td>Prevent deaths and serious injuries</td>
</tr>
<tr>
<td>Improve human behavior</td>
<td>Design for human mistakes/limitations</td>
</tr>
<tr>
<td>Control speeding</td>
<td>Reduce system kinetic energy</td>
</tr>
<tr>
<td>Individuals are responsible</td>
<td>Share responsibility</td>
</tr>
<tr>
<td>React based on crash history</td>
<td>Proactively identify and address risks</td>
</tr>
</tbody>
</table>

Whereas traditional road safety strives to modify human behavior and prevent all crashes, the Safe System approach also refocuses transportation system design and operation on anticipating human mistakes and lessening impact forces to reduce crash severity and save lives.
The Safe System Approach
Principles and Elements

- Safe Road Users
- Safe Vehicles
- Safe Roads
- Safe Speeds
- Post-Crash Care

DEATH/SERIOUS INJURY IS UNACCEPTABLE
REDUNDANCY IS CRUCIAL
SAFETY IS PROACTIVE
RESPONSIBILITY IS SHARED
HUMANS ARE VULNERABLE
HUMANS MAKE MISTAKES
U.S. Department of Transportation
Federal Highway Administration
Collaborative Sciences Center for
Road Safety
Berkeley SafeTREC
The Safe System Approach Principles and Elements

5 Safe System Action Elements

- Safe Road Users
- Safe Vehicles
- Safe Speeds
- Safe Roads
- Post-Crash Care

U.S. Department of Transportation
Federal Highway Administration
Collaborative Sciences Center for ROAD SAFETY
Berkeley SafeTREC
The Safe System Approach Principles and Elements

6 Safe System Principles

- Safe Road Users
- Safe Vehicles
- Safe Speeds
- Safe Roads
- Post-Crash Care
- Redundancy is Crucial
- Death/Serious Injury is Unacceptable
- Humans Make Mistakes
- Humans are Vulnerable
- Safety is Proactive
- Responsibility is Shared

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Can KE help us improve our safety efforts?

Kinetic energy (KE) is the energy associated with the movement of an object and is determined by a combination of velocity and mass.

\[ E_k = \frac{1}{2}mv^2 \]

- \( E_k \) = kinetic energy of object
- \( m \) = mass of object
- \( v \) = speed of object

KE is the focal variable, but by itself, it does not have the ability to determine safety.
How safe are these activities?

Fly on an airplane; High KE

Walk on wet crosswalk; Low KE

Very different levels of KE, but not necessarily indicative of safety
Define safety as the relationship between

Amount of Kinetic Energy carried by users during a trip

Capability of the system to control or contain Kinetic Energy, so that it is survivable (when things go wrong)
Define safety as the relationship between

Amount of Kinetic Energy carried by users during a trip < Capability of the system to control or contain Kinetic Energy, so that it is survivable (when things go wrong)
Define **safety** as the relationship between

Amount of Kinetic Energy carried by users during a trip

Capability of the system to control or contain Kinetic Energy, so that it is survivable (when things go wrong)
A pandemic natural experiment

Injury crash rate during COVID-19 show a decoupling of death + serious and minor injury

Death + serious rate went up, minor injury rate went down
A pandemic natural experiment

No real change in the system’s capability to control or contain KE.

Possibly an increase in the amount of KE carried by users during a trip.
Define safety as the relationship between

Amount of Kinetic Energy carried by users > Capability of the system to control

**Takeaway:** when we want to use KE we need to benchmark it relative to the system’s capability

**However,** in practice we also want a framework to understand how we can change the system attributes
Pedestrian Safety Considerations

We would want alert and compliant pedestrians, to make trips on safe street design with adequate separation from safe motorized traffic operated by alert and compliant users, all of which are governed by safe speeds, and supported by effective pedestrian protection, and the medical emergency system, when needed.
Protective Layers of any Safe System

<table>
<thead>
<tr>
<th>General</th>
<th>Purpose</th>
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<tbody>
<tr>
<td>Public space design</td>
<td>Changes to the built environment that would make the public space safer.</td>
</tr>
<tr>
<td>Public space operations</td>
<td>Guidelines that dictate how we move through space safely.</td>
</tr>
<tr>
<td>Individual Behavior</td>
<td>Individual actions to maintain safe environment around each of us</td>
</tr>
<tr>
<td>Early warning</td>
<td>Provide a warning about the level of risk.</td>
</tr>
<tr>
<td>Personal Protection</td>
<td>elements that can protect you or others from a hazard given exposure</td>
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<tr>
<td>Medical treatment</td>
<td>Reduce symptoms and reduce the probability of death given impact</td>
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## Protective Layers of a Transport Safe System

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<th>Purpose</th>
<th>Transportation</th>
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</thead>
<tbody>
<tr>
<td>Public space design</td>
<td>Changes to the built environment that would make the public space safer.</td>
<td>street design</td>
</tr>
<tr>
<td>Public space operations</td>
<td>Guidelines that dictate how we move through space safely.</td>
<td>street operations</td>
</tr>
<tr>
<td>Individual Behavior</td>
<td>Individual actions to maintain safe environment around each of us</td>
<td>street-user behavior</td>
</tr>
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<td>Early warning</td>
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<td>street-user warning</td>
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<td>street-user protection</td>
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<td>Medical treatment</td>
<td>Reduce symptoms and reduce the probability of death given impact</td>
<td>emergency medical services</td>
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# Ordinal Safety Considerations - Examples

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<tbody>
<tr>
<td>street design</td>
<td>Changes to the built environment that would make the public space safer.</td>
<td>Shoulder lane</td>
</tr>
<tr>
<td>street operations</td>
<td>Guidelines that dictate how we move through space safely.</td>
<td>Speed limits</td>
</tr>
<tr>
<td>street-user behavior</td>
<td>Individual actions to maintain safe environment around each of us</td>
<td>BAC limits</td>
</tr>
<tr>
<td>street-user warning</td>
<td>Provide a warning about the level of risk.</td>
<td>Lane departure warning</td>
</tr>
<tr>
<td>street-user protection</td>
<td>elements that can protect you or others from a hazard given exposure</td>
<td>Airbags</td>
</tr>
<tr>
<td>emergency medical services</td>
<td>Reduce symptoms and reduce the probability of death given impact</td>
<td>EMS</td>
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Combining with the KE safety definition

<table>
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<tr>
<th>Considerations</th>
<th>Trip Kinetic Energy</th>
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<td>street design</td>
<td>Roundabout (-)</td>
<td>Shoulder lane (+)</td>
</tr>
<tr>
<td>street operations</td>
<td>Speed limits (-)</td>
<td>Traffic signal (+)</td>
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Implications

• KE is a focal variable for studying system safety
• It is not practical to aggregate the additive capability of the system’s elements to control or contain KE
• It is valuable to evaluate the cumulative KE of the system
• There are potential benefits in monitoring KE along the system
• Using the proposed framework can support researchers and practitioners in better understanding the safety mechanism and identifying strategies that may have been overlooked.
If I Built a Car
by Chris Van Dusen

I’ll build a safe car, just as safe as I can.
’Cause safety is job number-one in my plan.
It may look like steel—from afar you can see,
But it’s actually made of a polymer gel—
A space-age concoction that I just invented.
So in a collision my car won’t get dented.
It simply absorbs what we happen to hit,
And folks would be fine in the seats where they sit.
I'll build a safe car just as safe as I can
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Thank you!

Offer Grembek, grembek@berkeley.edu

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Safe vehicles: How effective are pedestrian crash prevention systems?

Presenter: Asad Khattak
University of Tennessee, Knoxville

July 27, 2022
2:30-3:00 p.m. ET

Learn more/register here: www.roadsafety.unc.edu/profdev/webinars/