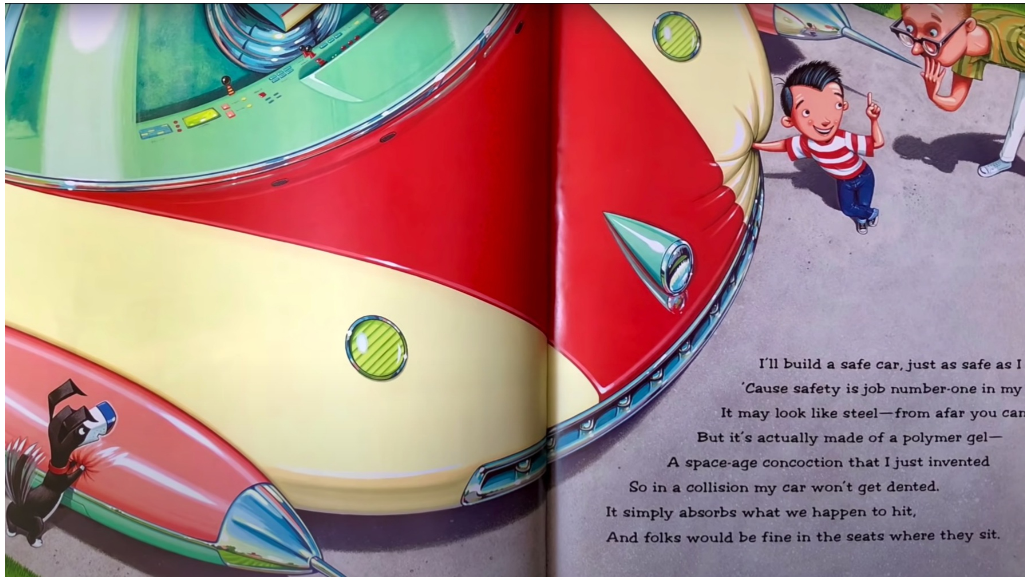
Strategies for managing the effects of kinetic energy in crashes



Presented by:

Dr. Offer Grembek

Berkeley SafeTREC

Collaborative Sciences Center for ROAD SAFETY

Presented at:

CSCRS Research to Practice

June 22, 2022

CSCRS Research Project R24

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

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University of California, Berkeley

View Bio

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Goal of the transportation system

Provide mobility.

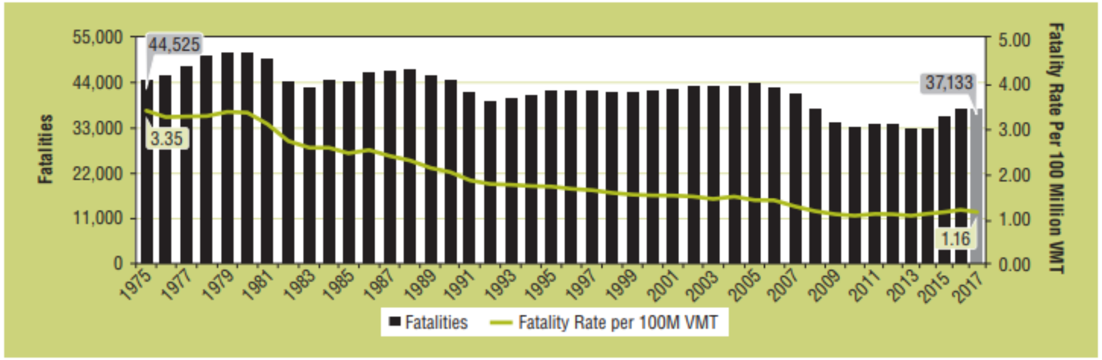
Provide efficient,
cost-effective,
equitable, …, sustainable, and
safe mobility.

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

Fatalities and Fatality Rate per 100 Million VMT, by Year, 1975–2017



Sources: FARS 1975–2016 Final File, 2017 ARF; Vehicle Miles Traveled (VMT): FHWA.

10 Leading Causes of Injury Deaths by Age Group Highlighting Unintentional Injury Deaths, United States – 2017

	Age Groups										
Rank	<1	1-4	5-9	10-14	15-24	25-34	35-44	45-54	55-64	65+	Total
1	Unintentional Suffocation 1,106	Unintentional Drowning 424	Unintentional MV Traffic 327	Unintentional MV Traffic 428	Unintentional MV Traffic 6,697	Unintentional Poisoning 16,478	Unintentional Poisoning 15,032	Unintentional Poisoning 14,707	Unintentional Poisoning 10,581	Unintentional Fall 31,190	Unintentional Poisoning 64,795
2	Homicide Unspecified 139	Unintentional MV Traffic 362	Unintentional Drowning 125	Suicide Suffocation 280	Unintentional Poisoning 5,030	Unintentional MV Traffic 6,871	Unintentional MV Traffic 5,162	Unintentional MV Traffic 5,471	Unintentional MV Traffic 5,584	Unintentional MV Traffic 7,667	Unintentional MV Traffic 38,659
3	Unintentional MV Traffic 90	Homicide Unspecified 129	Unintentional Fire/Burn 94	Suicide Firearm 185	Homicide Firearm 4,391	Homicide Firearm 4,594	Suicide Firearm 3,098	Suicide Firearm 3,937	Suicide Firearm 4,219	Suicide Firearm 5,996	Unintentional Fall 36,338
4	Homicide Other Spec., Classifiable 76	Unintentional Suffocation 110	Homicide Firearm 78	Homicide Firearm 126	Suicide Firearm 2,959	Suicide Firearm 3,458	Suicide Suffocation 2,562	Suicide Suffocation 2,294	Unintentional Fall 2,760	Unintentional Unspecified 5,125	Suicide Firearm 23,854
5	Undetermined Suffocation 56	Unintentional Fire/Burn 95	Unintentional Suffocation 36	Unintentional Drowning 110	Suicide Suffocation 2,321	Suicide Suffocation 3,063	Homicide Firearm 2,561	Suicide Poisoning 1,604	Suicide Suffocation 1,631	Unintentional Suffocation 3,920	Homicide Firearm 14,542

Data Source: National Center for Health Statistics (NCHS), National Vital Statistics System.
Produced by: National Center for Injury Prevention and Control, CDC using WISQARS™.

<u>2017 Fatalities</u>

California: 3,602

USA: 37,133

Globally: Over 1,300,000

First or Second Leading Cause of Death for ages > 1

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Safety as a feature of the system

a system in which people cannot die despite human error.

Job, and Sakashita. 2016a

safe system

Policy innovation to move the needle

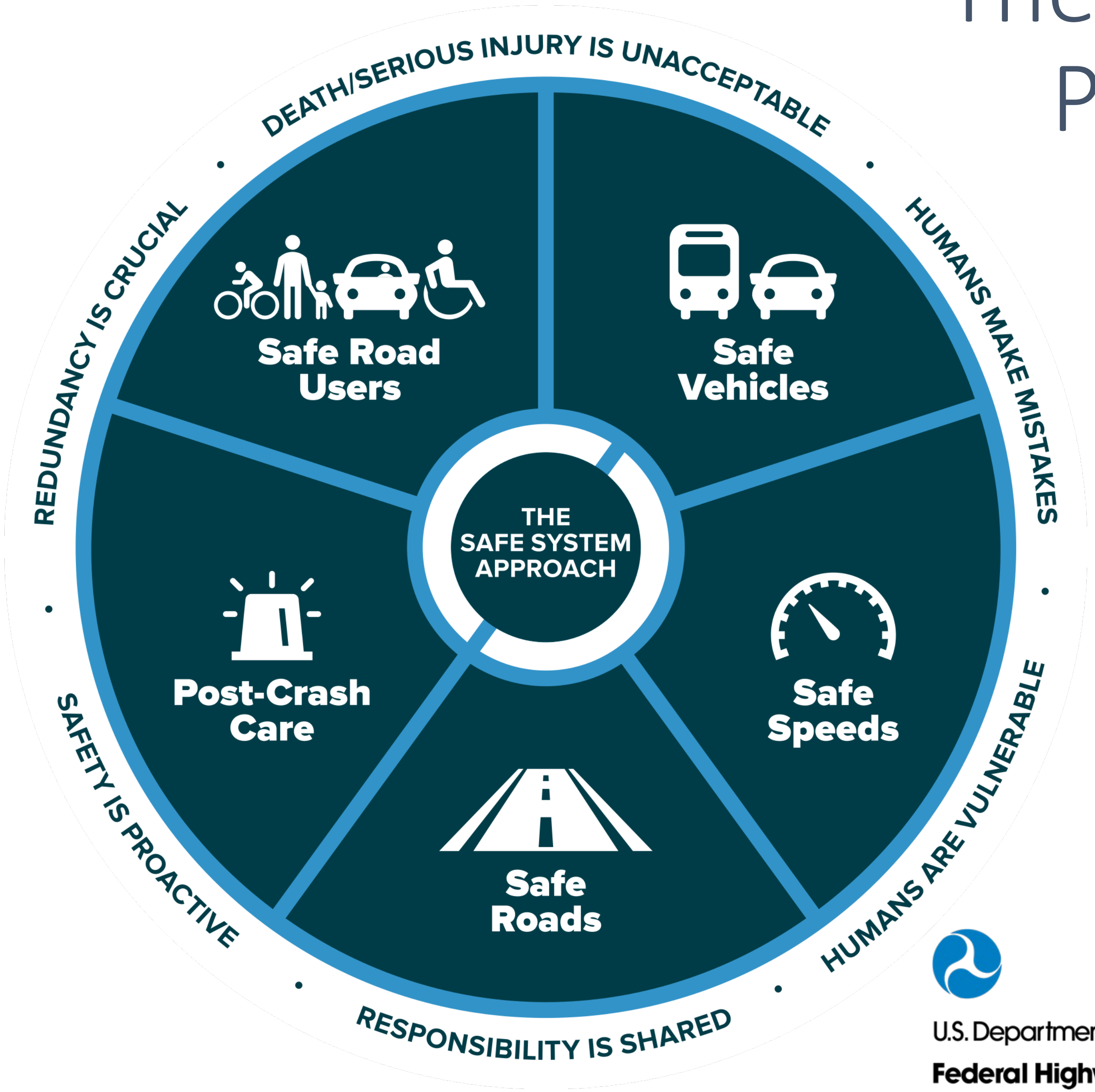
THE SAFE SYSTEM APPROACH VS. TRADITIONAL ROAD SAFETY PRACTICES

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

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.

U.S. Department of Transportation
Federal Highway Administration

The Safe System Approach Principles and Elements



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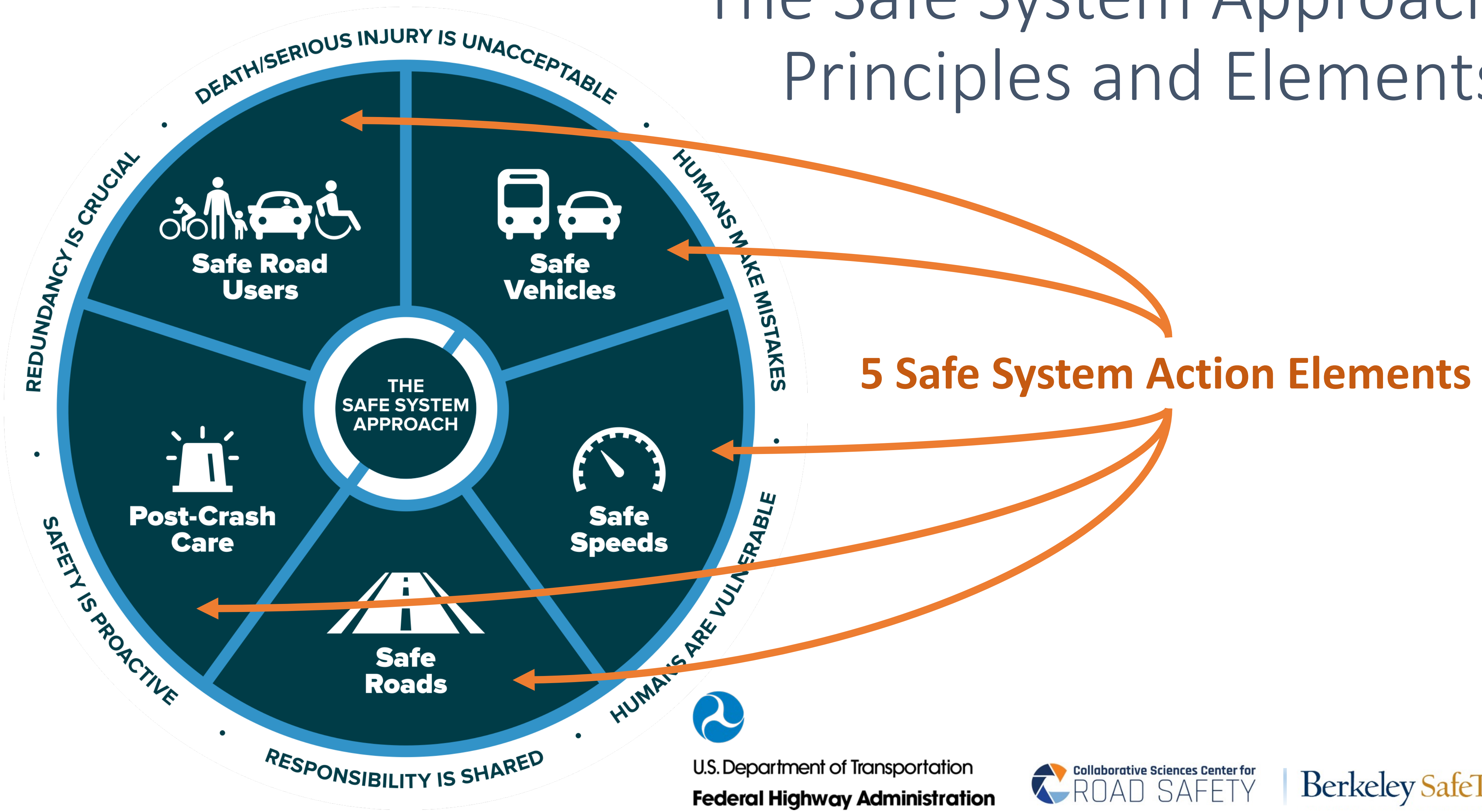
The Safe System Approach Principles and Elements



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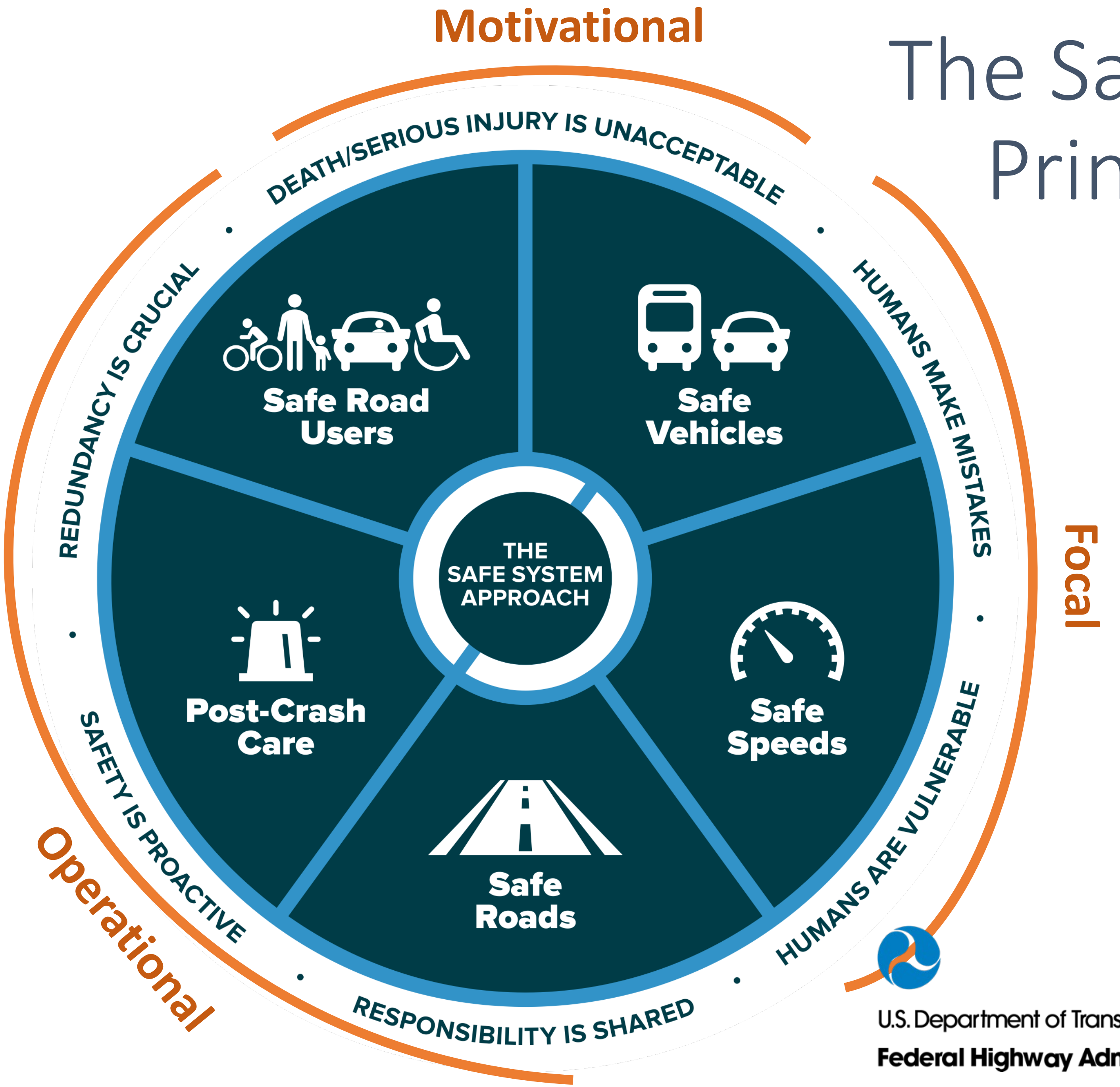
The Safe System Approach Principles and Elements



6 Safe System Principles

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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

By Danielkang7744 at English Wikipedia

Walk on wet crosswalk; Low KE

By Danielkang7744 at English Wikipedia

Very different levels of KE, but not necessarily indicative of safety

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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)

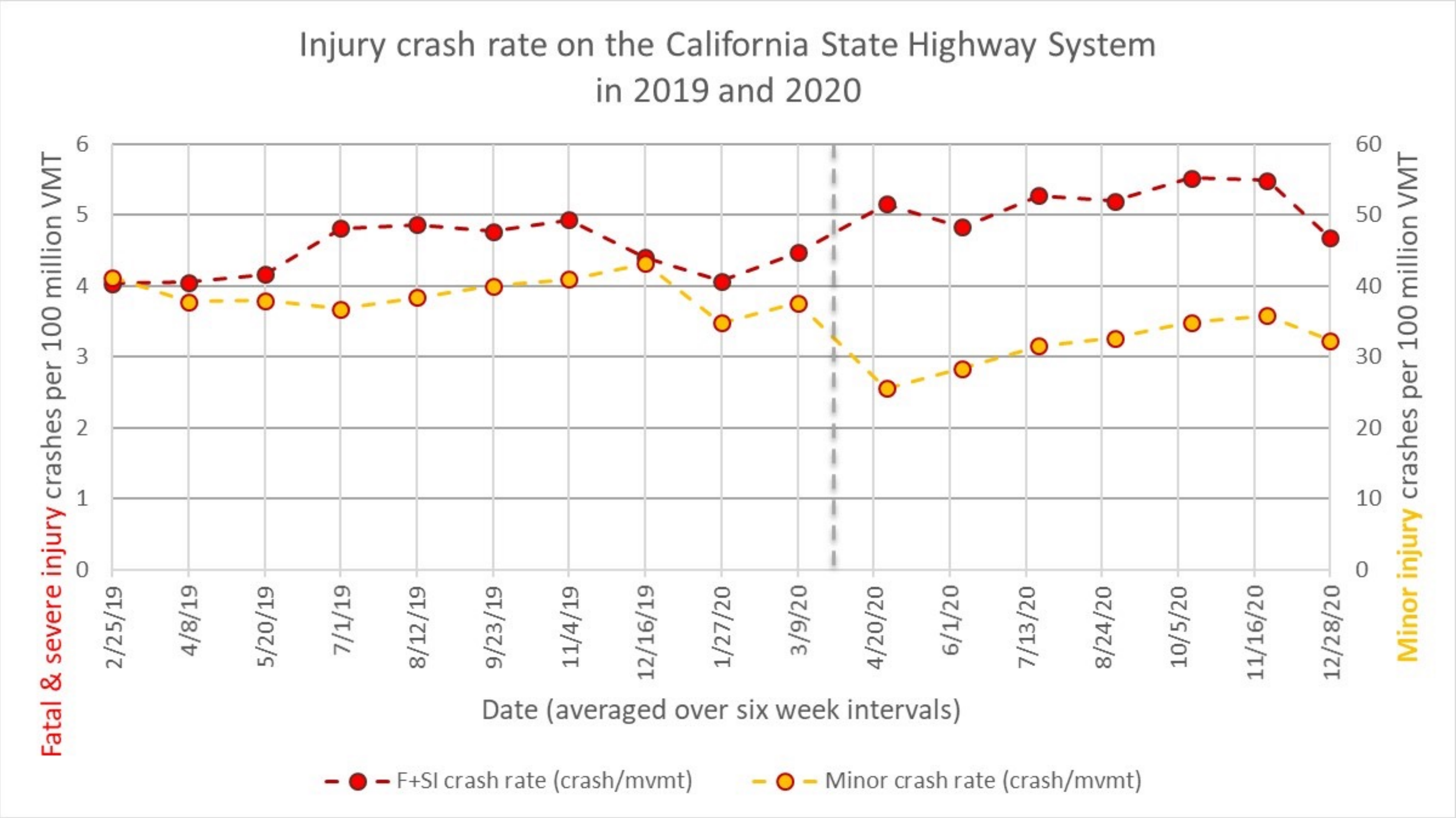
Define safety as the relationship between

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)

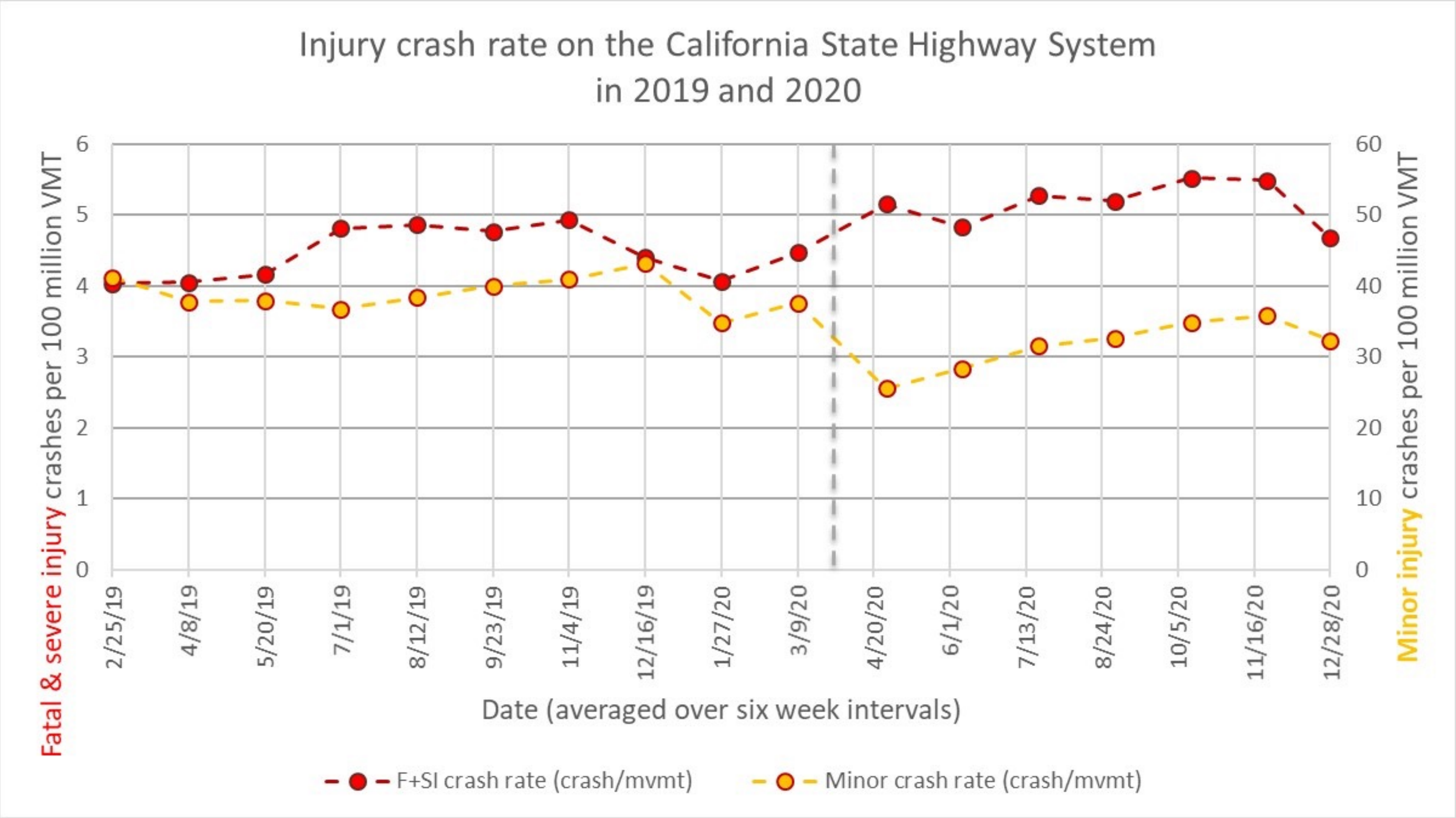
A pandemic natural experiment



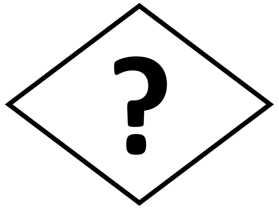
Injury crash rate during COVID-19 show a decoupling of **death + serious** and **minor** injury

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.

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Define safety as the relationship between

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

<u>Takeaway</u>: when we want to use KE we need to benchmark it relative to the system's capability

<u>However</u>, 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

E

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

S

Protective Layers of a Transport Safe System

E

General	Purpose	Transportation
Public space design	Changes to the built environment that would make the public space safer.	**street design**
Public space operations	Guidelines that dictate how we move through space safely.	**street operations**
Individual Behavior	Individual actions to maintain safe environment around each of us	**street-user behavior**
Early warning	Provide a warning about the level of risk.	**street-user warning**
Personal Protection	elements that can protect you or others from a hazard given exposure	**street-user protection**
Medical treatment	Reduce symptoms and reduce the probability of death given impact	**emergency medical services**

S

Ordinal Safety Considerations - Examples

E

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

S

Combining with the KE safety definition

E

Considerations
street design
street operations
street-user behavior
street-user warning
street-user protection
emergency medical services

S

Trip Kinetic Energy ? System Capability

Combining with the KE safety definition

Considerations
street design
street operations
street-user behavior
street-user warning
street-user protection
emergency medical services

E

S

Trip Kinetic Energy ? System Capability

+ +

+ +

+ +

Combining with the KE safety definition

E → S

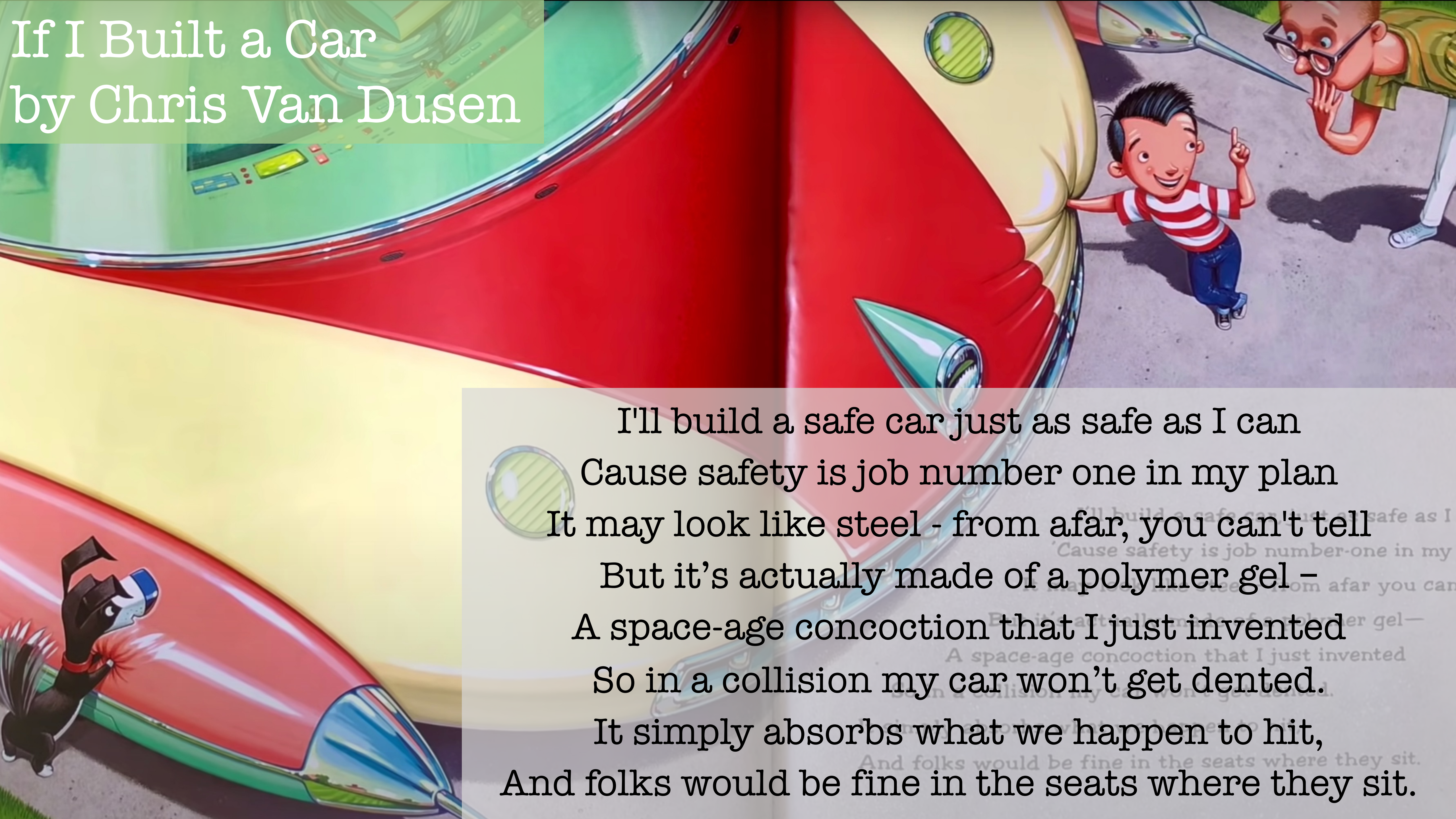
Considerations	Trip Kinetic Energy	?	System Capability
street design	Roundabout (-)		Shoulder lane (+)
street operations	Speed limits (-)		Traffic signal (+)
street-user behavior	-		+
street-user warning	-		+
street-user protection			
emergency medical services	-		+

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 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
'Cause safety is job number-one in my
It may look like steel—from afar you can
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.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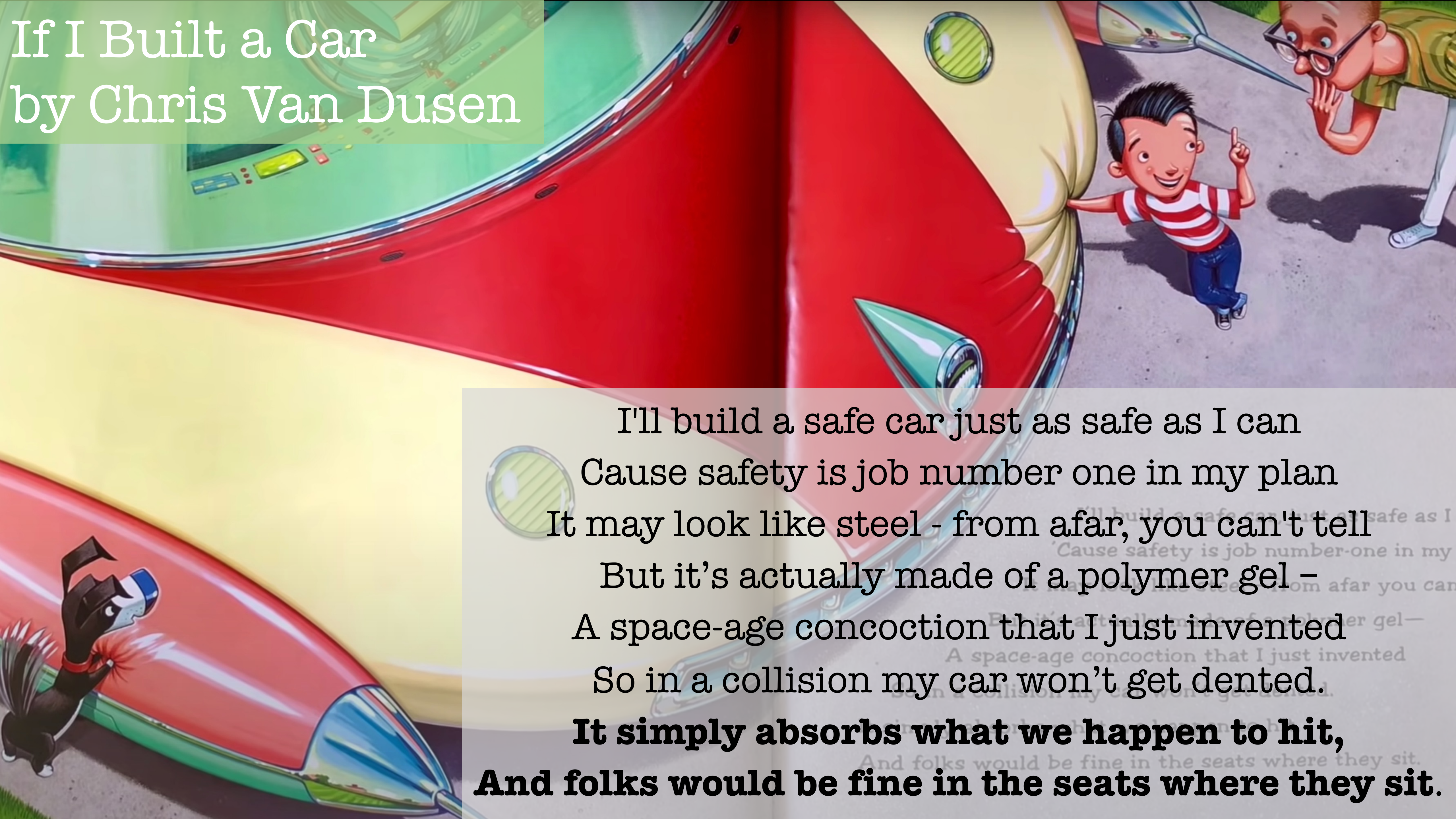

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And folks would be fine in the seats where they sit.

Thank you!

Offer Grembek, grembek@berkeley.edu

Research presented is based on various efforts funded by:

Collaborative Sciences Center for ROAD SAFETY

ITS Berkeley Institute of Transportation Studies

SB1

Caltrans

Berkeley SafeTREC

RESEARCH TO PRACTICE BYTES

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

Collaborative Sciences Center for
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