Hazard Proximity Zone Design for Heavy Construction Equipment

Ibukun Awolusi
Eric Marks, P.E., Ph.D.

Department of Civil, Construction and Environmental Engineering
University of Alabama

June 9, 2015

Outline

- Proximity problem in construction
- Current methods of mitigating human-equipment interaction
- Hazard zone creation and testing
- Results of implementation
- Conclusion and future research

Equipment-Worker Proximity Problem

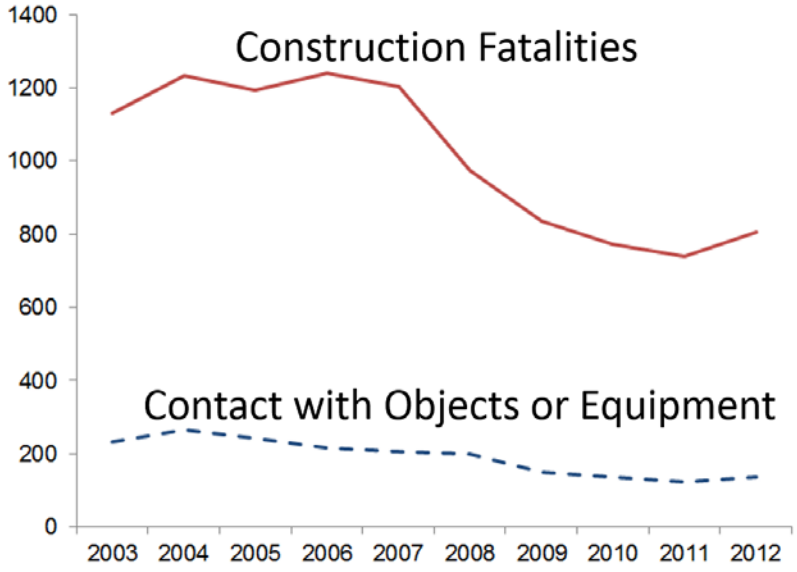
Causes

Construction Site Conditions

- Vary in size and scope
- Multiple resources involved in dynamic work tasks
- Outdoor environment: day/night, noise, dust/dirt, weather conditions

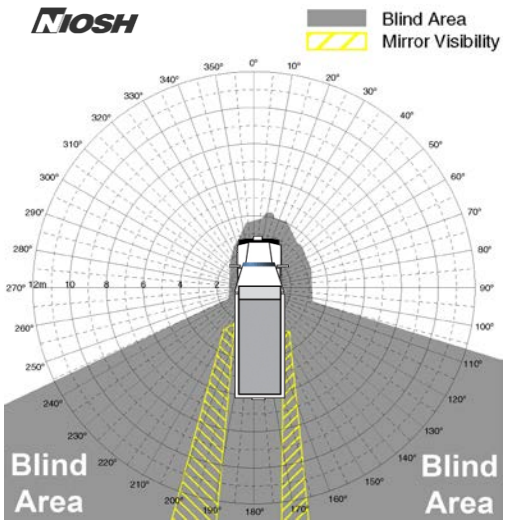
Workers Struck by an Object or Construction Equipment (BLS 2015)

Year	Fatalities
2013	140 (17%)
2012	136 (17%)
2011	122 (17%)



Current Practices

1) Rear-view mirrors



2) Flagger

3) Field modification

4) Back-up alarm

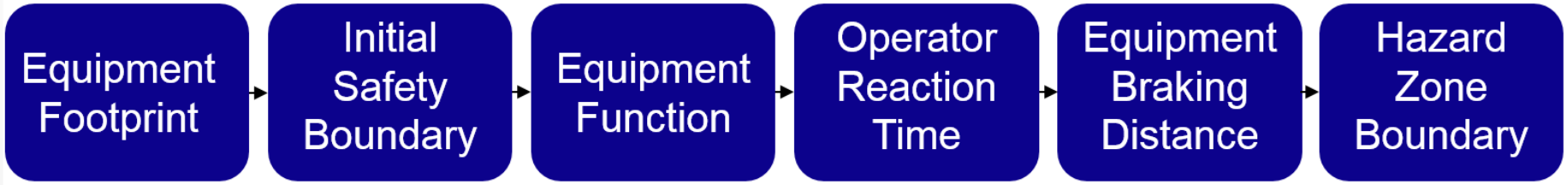
5) Back-up camera

6) Proximity sensing

Research Objective and Scope

Objective: Create a tool to automatically design a hazard zone around a piece of construction equipment

Scope:
- Construction sites and equipment at a horizontal grade
- Hazardous situations between heavy construction equipment and pedestrian workers



Step 1: Equipment Information

Equipment specifications

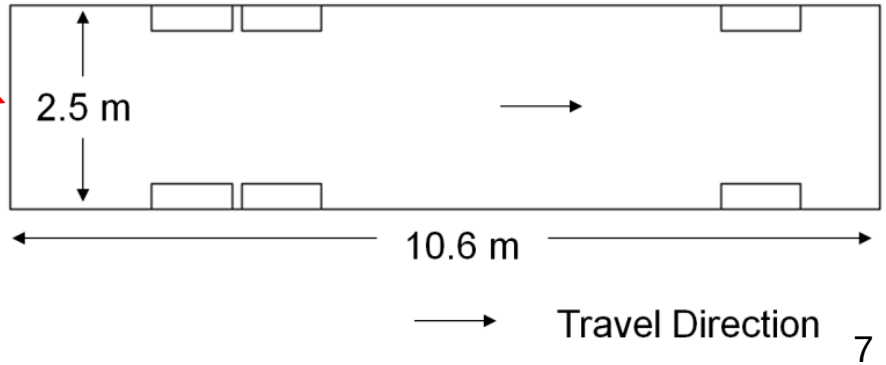
MAKE		Eaton Fuller
MODEL		FR-13210B 10-speed
NUMBER OF FORWARD GEARS		10
HIGH GEAR RATIO		
LOW GEAR RATIO		
Wheelbase Option (CCT) 1		
WHEELBASE	139 in	3531 mm
OVERALL LENGTH	19.2 ft in	5852 mm
LENGTH FROM BACK OF CAB TO END OF FRAME	117 in	2972 mm
LENGTH FROM CENTER OF REAR AXLE(S) TO END OF FRAME	41 in	1041 mm
TOTAL CHASSIS WEIGHT	11678 lb	5297.1 kg
Dimensions		
OVERALL WIDTH	7.9 ft in	2410 mm
HEIGHT TO TOP OF CAB	9.4 ft in	2857 mm
NUMBER OF REAR AXLES		1
TIRE SIZE		295/75R22.5

User-interface

Construction Equipment Hazard Zone

Equipment type	dump truck
Overall width (m)	2.5
Overall length (m)	10.6
Maximum turning radius (m)	13.1
Safety boundary (m)	2
Estimated velocity (m/s)	7
Operator reaction time (s)	2.5

Equipment footprint

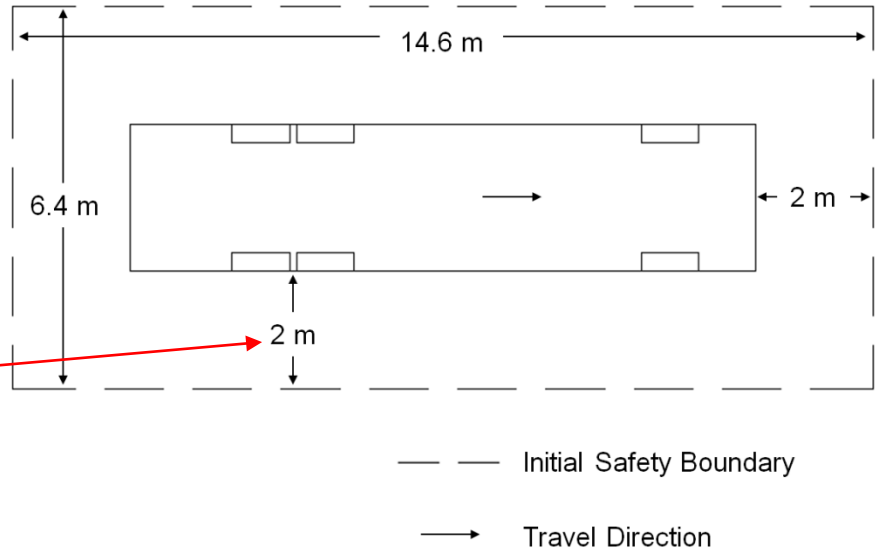


Step 2: Initial Safety Boundary

User-interface

Construction Equipment Hazard Zone

Equipment type	dump truck
Overall width (m)	2.5
Overall length (m)	10.6
Maximum turning radius (m)	13.1
Safety boundary (m)	2
Estimated velocity (m/s)	7
Operator reaction time (s)	2.5

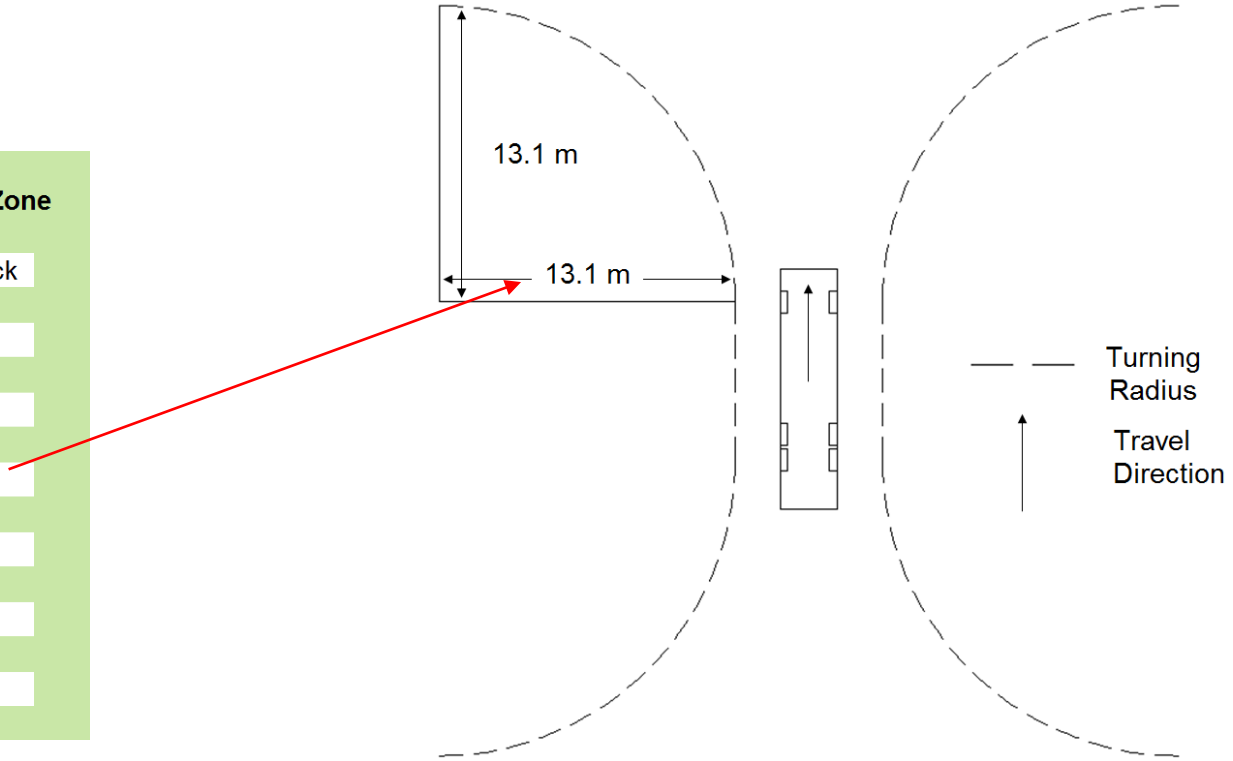


Step 3: Equipment Function

User-interface

Construction Equipment Hazard Zone

Equipment type	dump truck
Overall width (m)	2.5
Overall length (m)	10.6
Maximum turning radius (m)	13.1
Safety boundary (m)	2
Estimated velocity (m/s)	7
Operator reaction time (s)	2.5



Step 4-5: Finalize Hazard Zone

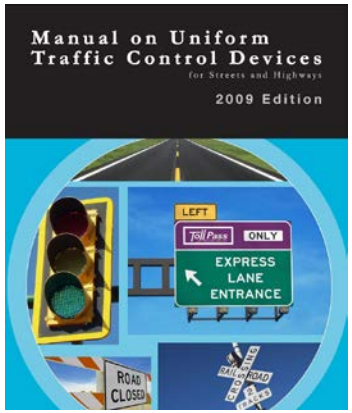
User-interface

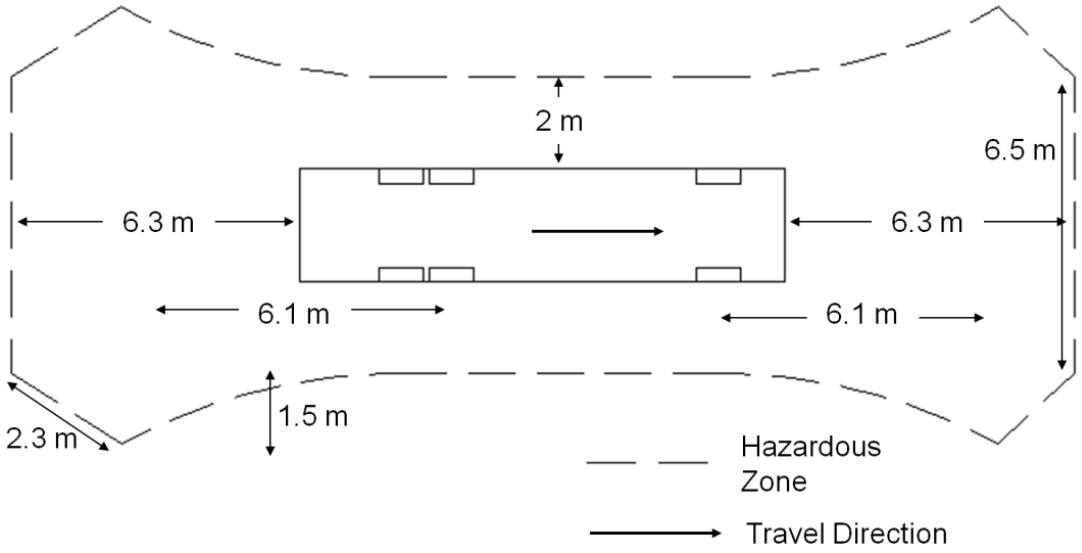
Construction Equipment Hazard Zone

Equipment type	dump truck
Overall width (m)	2.5
Overall length (m)	10.6
Maximum turning radius (m)	13.1
Safety boundary (m)	2
Estimated velocity (m/s)	7
Operator reaction time (s)	2.5

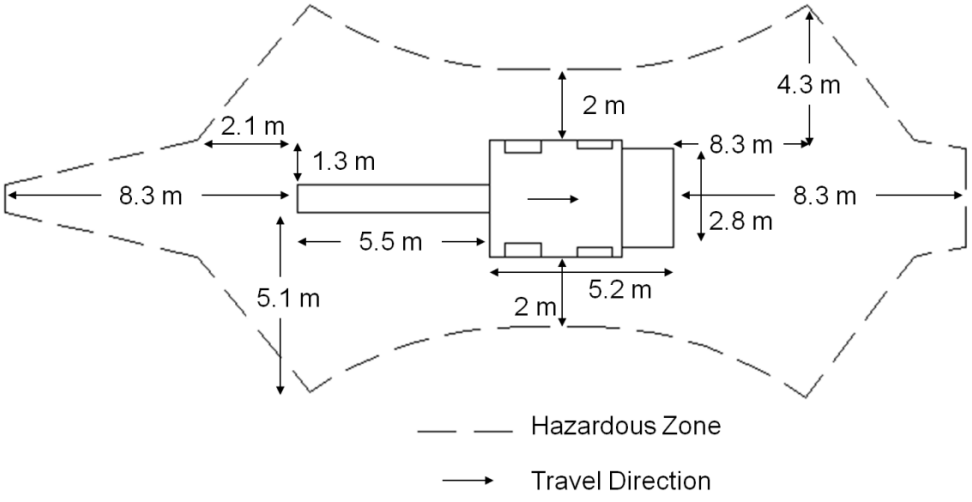
Step 4: Operator Reaction Distance

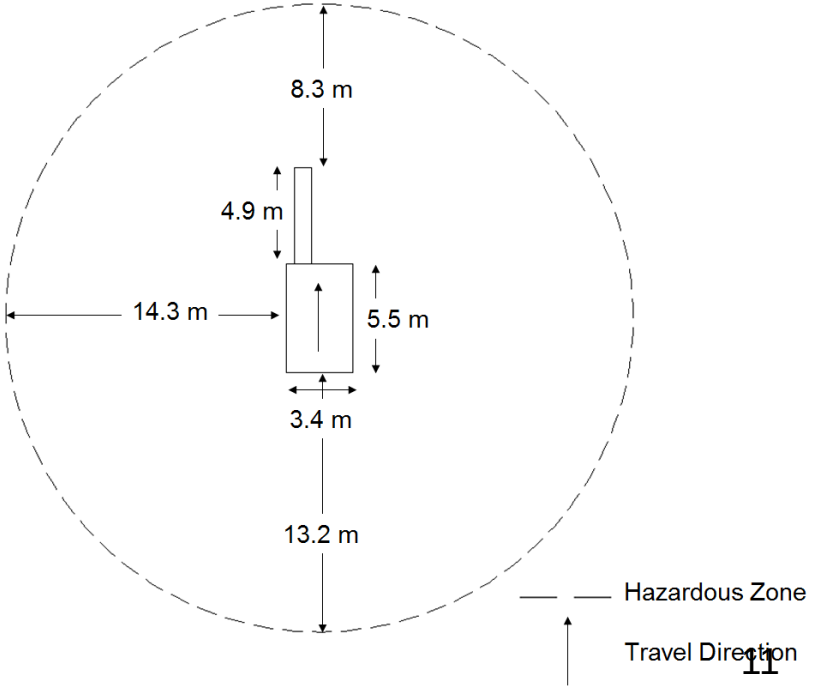
Step 5: Equipment Braking Distance





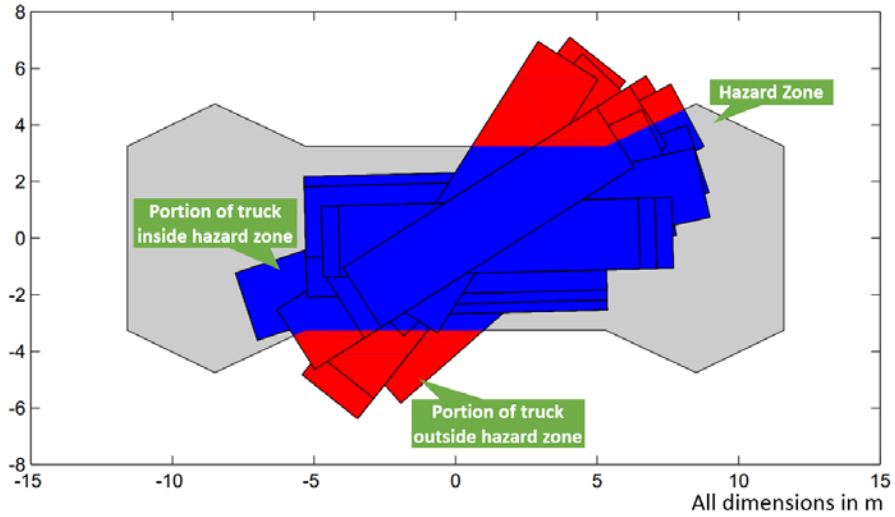
Equipment Hazard Zones





Hazard Zone Implementation

- 2/3 of truck movements were in hazard zone
- Sharp right turns at minimum speed were not captured



Conclusions and Future Research

Conclusions

- Current safety practices are inadequate
- Hazard zones identify areas that have a higher potential for injury and should be avoided
- Created hazard zones can be used in site planning and safety education for construction workers

Future Research

- Implementation of hazard zone information
- Equipment malfunction and environmental conditions

Contact Information

Eric Marks, Ph.D., P.E.
University of Alabama
Department of Civil, Construction
and Environmental Engineering
E-mail: eric.marks@eng.ua.edu

Ibukun Awolusi
University of Alabama
Department of Civil, Construction and
Environmental Engineering
E-mail: igawolusi@crimson.ua.edu

Nipesh Pradhananga, Ph.D.
Florida International University
College of Engineering and Computing
E-mail: npradhan@fiu.edu

Tao Cheng, Ph.D.
ExxonMobil Upstream Research Company
Senior Research Engineer