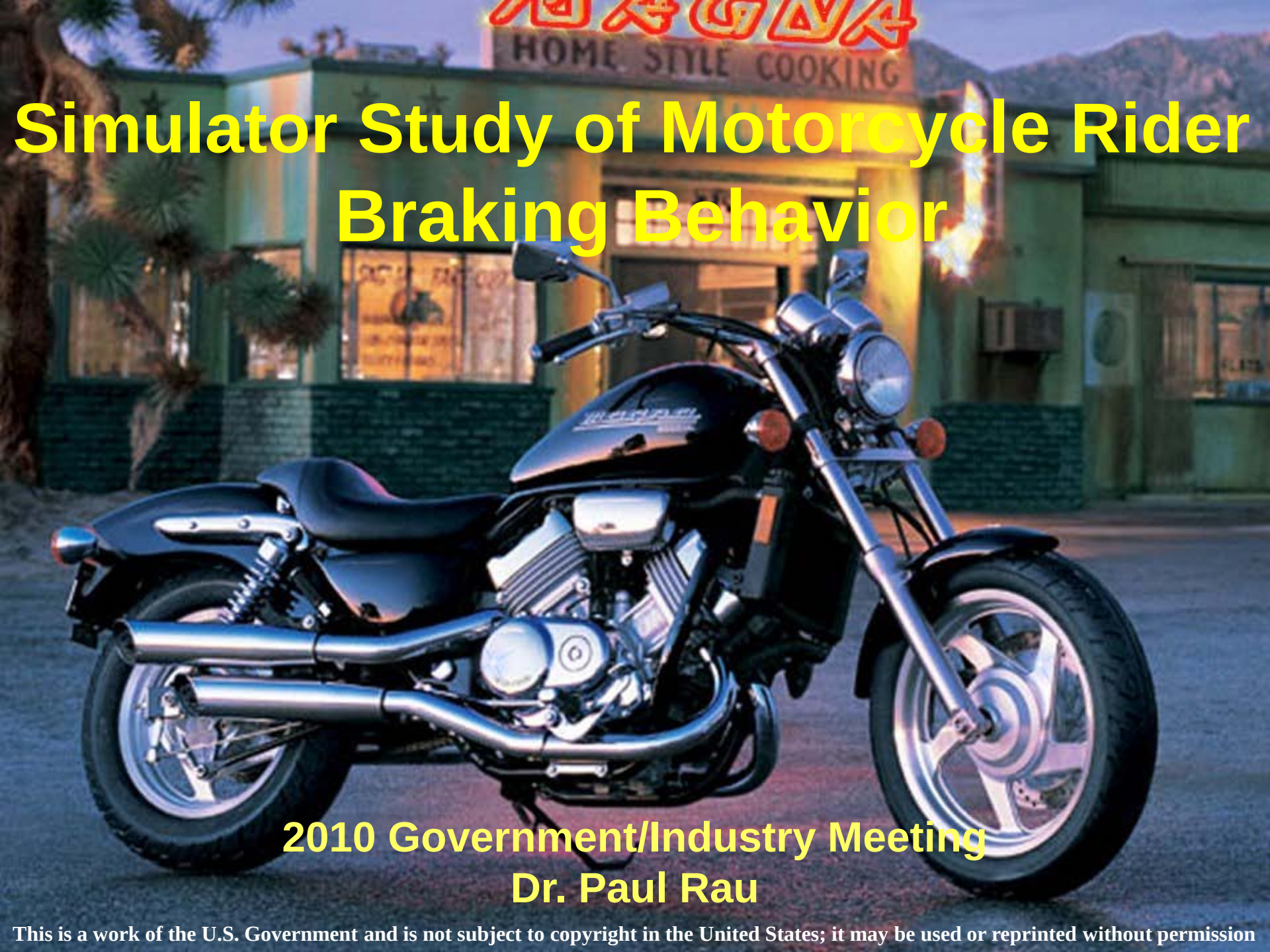


Simulator Study of Motorcycle Rider Braking Behavior

2010 Government/Industry Meeting

Dr. Paul Rau

Objectives

The objective of this study is to gain a better understanding of how non-expert motorcycle riders use their brakes in various emergency stopping and maneuvering situations.

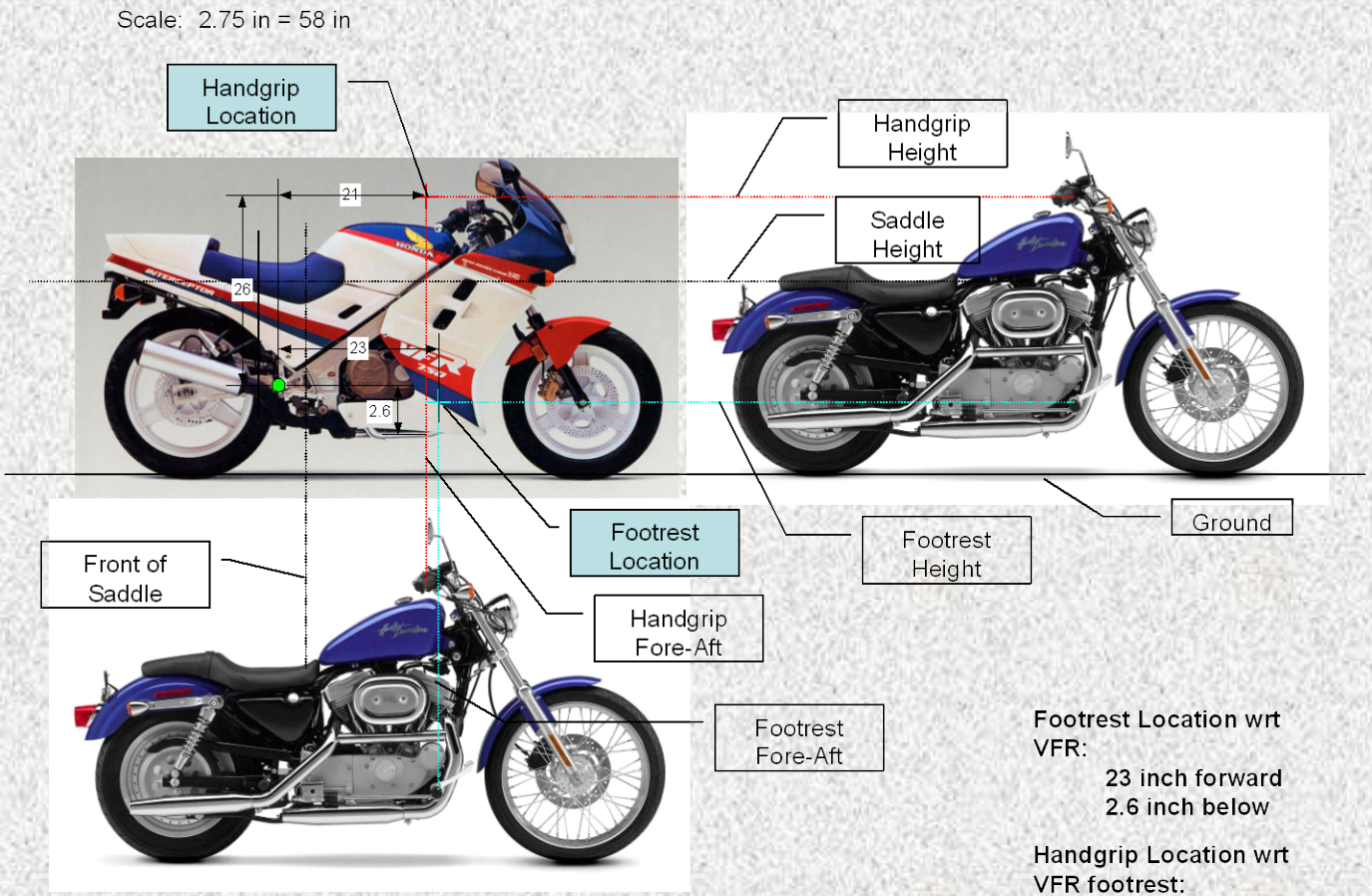
- Which brakes do riders use in an emergency – front, rear, or both?
- Does braking behavior predict whether riders crash or not?
- Do rider factors of age, experience, motorcycle preference, and rider training influence braking behavior?

Experimental Design

- The Dynamic Research Inc. (DRI) driving simulator is a dynamically realistic, moving base, "driver-in-the-loop" research device.
- 68 male subjects completed two 30 minute runs, each involving 14 braking events categorized as traffic (braking not required), normal braking (.1 -.2g), urgent braking (.3 -.5g), or emergency braking (.55 - .7g).
- Two motorcycle frame types were used, i.e. sport-touring and cruiser.
- 39 km ride included a suburban portion (intersections every 760 m, posted speed 40 mph) and rural portion (intersections every 3050 m, posted speed 65 mph).

Motorcycle Frame Types

1987 Honda VFR700F and 2008 Harley-Davidson Sportster XL883 Custom



Footrest Location wrt VFR:
23 inch forward
2.6 inch below

Handgrip Location wrt VFR footrest:
21 inch forward
26 inch above

Motorcycle Frame Types

Imagery: Suburban Intersection

Simulator Vehicle Measures

- Rider steer torque and steer angle inputs
- Rider hand lever and foot pedal brake force inputs
- Corresponding front and rear wheel brake torques
- Corresponding front and rear longitudinal slip values
- Other hand and foot control inputs, such as clutch and shift lever
- Accelerator position
- Motorcycle pitch, roll, and yaw angles and angular rates
- Path angle
- Motorcycle lateral and longitudinal acceleration
- Forward speed
- Stopping distance
- Lateral lane deviation
- Position and motion of obstacle and other interacting vehicles
- Video recording of rider head, arms, and legs

Rider Variables

- Time delay between the initial visual stimulus and the rider's initial control response (braking RT),
- Rise time (slope) of rider's initial control response,
- Peak control force of rider's initial control response,
- Peak control force overall,
- Duration of control input (time from initial control response to end of braking maneuver; either point at which control is released or speed goes to zero, whichever comes first),
- Mean control force over duration of control input,
- Mean square deviation of control force about the mean control force over the duration of control input,
- Energy spectrum (FFT) of the control input waveform providing a center frequency, spectral width, and perhaps a "spectral shape" metric.

Rider Principal Components

Rider Factors	Component		
	1	2	3
Miles Ridden in 2008	**.969**	-.042	.182
Group Riding Miles in 2008	**.967**	-.083	-.096
Avg. Miles / Year 2006-2008	**.778**	.128	.515
Age	-.106	**.946**	-.073
Total Years Riding	.035	**.945**	-.100
Skill Rating	.023	**.394**	.305
Ride Frequency Rating	.175	-.009	**.824**
Commuting Miles in 2008	.018	-.015	**.823**
Aggressiveness Rating	.202	-.199	**.242**

Simulator Study Findings

- In emergencies most riders used a combination of front and rear brakes. No rider used only the rear brake.
- In general, riders used a front brake bias. The remaining few riders mostly used the front brake only.
- The speed reduction at 2 seconds is a better predictor of collision than the total speed reduction; initial braking strongly determines the outcome (95% correct, R^2=.859).
- As more force is developed in either lateral or longitudinal axes there is a reduced capacity to produce force in the other.
- There were overall weak correlations between collision probability and rider factors. Rider Aggressiveness Rating was significant, but the correlation was low.

Simulator Study Conclusions

- Cruiser riders and sport touring riders have similar braking behavior, and neither is more or less likely to use only the rear brake in an emergency.
- Rider factors such as age, years experience, recent riding experience, etc. are not good indicators of probability of an in-path collision.

- End -