Computer Modelling of a Test Device for Investigating Injury Causes in Vehicle Rollovers

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2013 ACRS National Conference

November 7-8, 2013 - Adelaide

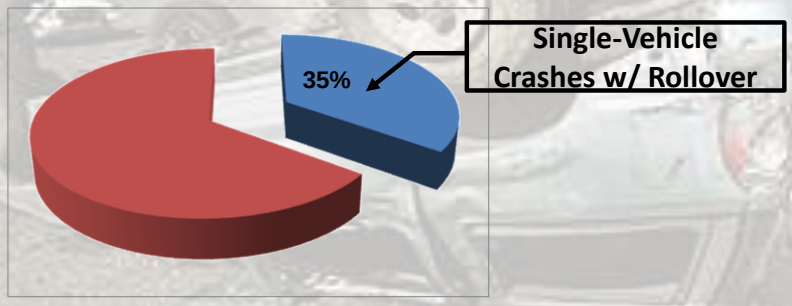
Outline

- INTRODUCTION
- COMPUTER MODELLING
- CONCLUSIONS

INTRODUCTION

Rollover Crashes - Background

- Rollover crashes are unforgiving events
  - Small percentage compared to all crashes
  - But, high Fatality and Serious-injury rate

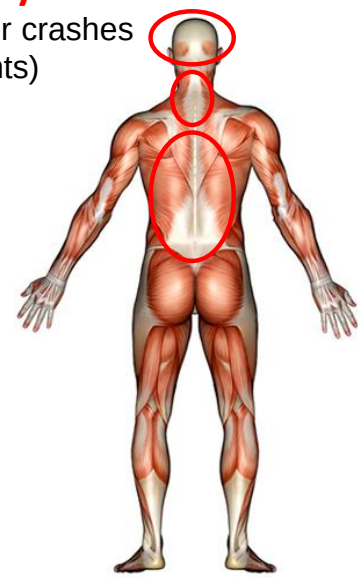


- Societal cost of rollover crashes in Australia ≈ 3Bil/year

INTRODUCTION

Rollover Crashes - Injury Modes

- Three main injury modes in rollover crashes (contained and restrained occupants)
  - Head
  - Neck
  - Chest & Spine



Source: http://medicalanatomy.net/

INTRODUCTION

Vehicle Rollover Testing

- So far, only a mandatory static test to measure roof crush strength

Stiffer vehicle roof not sufficient!

- Need for a dynamic rollover crash test
  - Identify root causes for the 3 injury modes
  - Assess performance of countermeasures to prevent/mitigate rollover injuries
  - Rate vehicle rollover safety through standard testing

INTRODUCTION

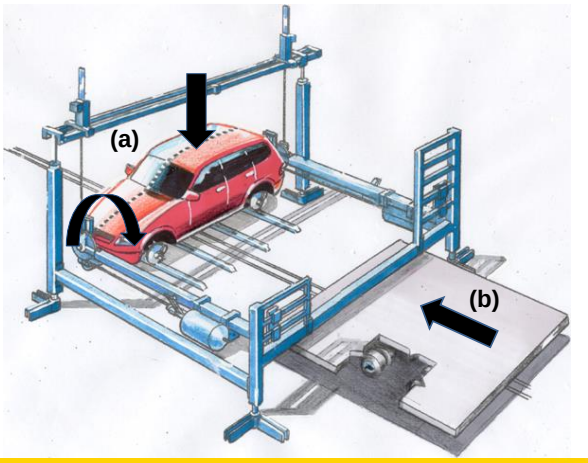
Rollover Dynamic Testing

- Desired characteristics
  - **Reliability**: Replicate injuries observed in real-world rollover crashes
  - **Repeatability/Reproducibility**: consistent and repeatable results
  - **Flexibility**: Reproduce different rollover scenarios

INTRODUCTION

UNSW Jordan Rollover System (JRS)- 1/3

- Test rig for repeatable dynamic testing of vehicle rollover
  a) **Spinning** and **dropping** vehicle
  b) Approaching **roadbed**



INTRODUCTION

UNSW Jordan Rollover System (JRS)- 2/3

- JRS capable of replicating real-world rollover crashes?

- Major phenomena to compare
  - Vehicle **kinematics** & **deformation**
  - Occupant **injury** modes

Comparison of testing outcomes and actual rollover crashes

- Related issue: uncertainty in reconstruction of initial rollover conditions!
  - Consider various initial conditions in the uncertainty range

INTRODUCTION

UNSW Jordan Rollover System (JRS)- 3/3

- Simulations are feasible method to investigate multiple scenarios
  - Various initial conditions within uncertainty range
  - Identify potential problems before testing
- Further, simulations can be invaluable in helping to:
  - Investigate root causes for injuries
  - Assess effectiveness of potential countermeasures

INTRODUCTION

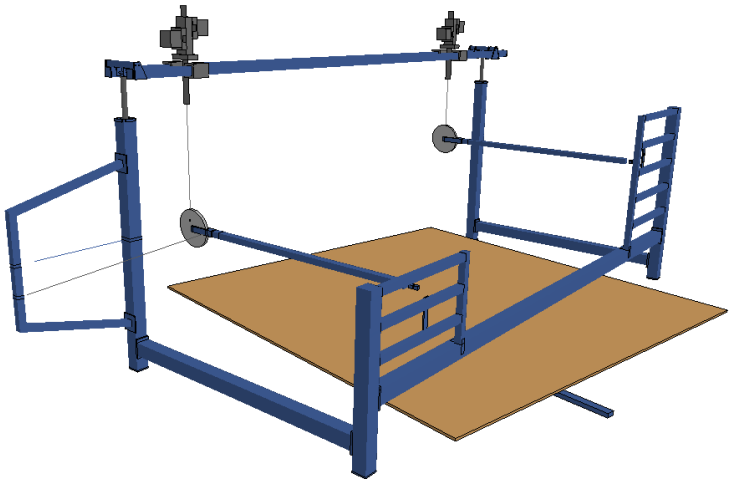
Objective/Methods

- **Objective:** Simulate dynamic rollover testing w/ UNSW JRS
- **Methods:** FE modelling (LS-DYNA)
  - Create accurate model of JRS rig
  - Validate model against a crash test

COMPUTER MODELLING

FE Model

- Accurate modelling of JRS structure & kinematics



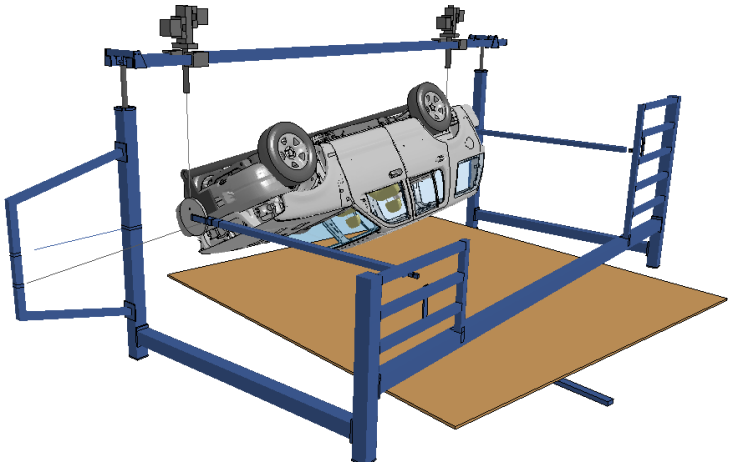
COMPUTER MODELLING

FE Model

- Accurate modelling of JRS structure & kinematics
- Replicate JRS testing w/ SUV
  - Combination w/ validated model of SUV (Ford Explorer)
  - Focus on vehicle kinematics, roof deformation, and impact loads
    (No model of ATD considered at this stage!)

COMPUTER MODELLING

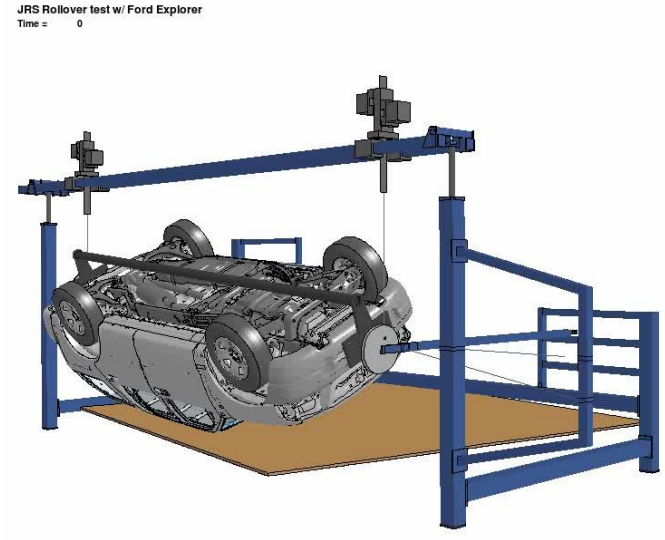
FE Model



COMPUTER MODELLING

Simulation results

- Realistic vehicle kinematics and deformations



COMPUTER MODELLING

Model Validation 1/2

- ❑ No test results available w/ Ford Explorer

- ❑ Test w/ Toyota LandCruiser used instead (similar vehicle)
  - ➢ Similar inertial properties
  - ➢ Still some difference expected (potentially different roof structure)
    - FE Model (Ford Explorer) SWR≈2.2 (stiffer roof)
    - Test (Toyota LandCruiser) SWR <1.5

COMPUTER MODELLING

Model Validation 1/2

- ❑ Test w/ Toyota LandCruiser
  - ➢ Initial Conditions
    - Roll Angle: 153 deg
    - Pitch Angle: 5.1 deg
    - Yaw Angle: 10 deg
    - Roll Rate: 181 deg/sec
    - Drop Height: 117 mm
    - Roadbed Speed: 24 km/h

COMPUTER MODELLING

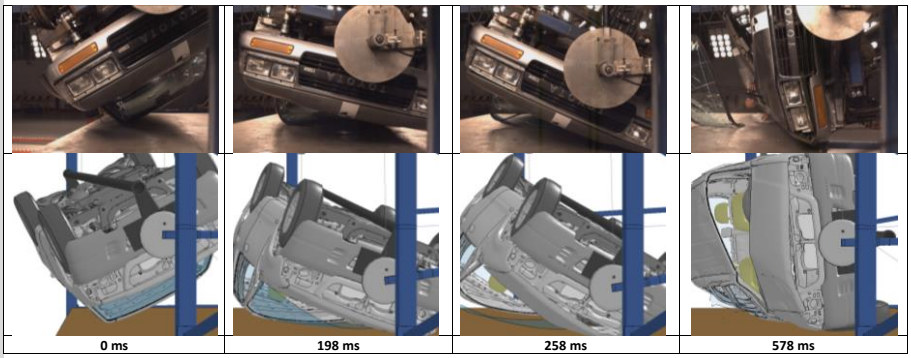
Model Validation 1/2

- Test w/ Toyota LandCruiser

COMPUTER MODELLING

Model Validation 2/2

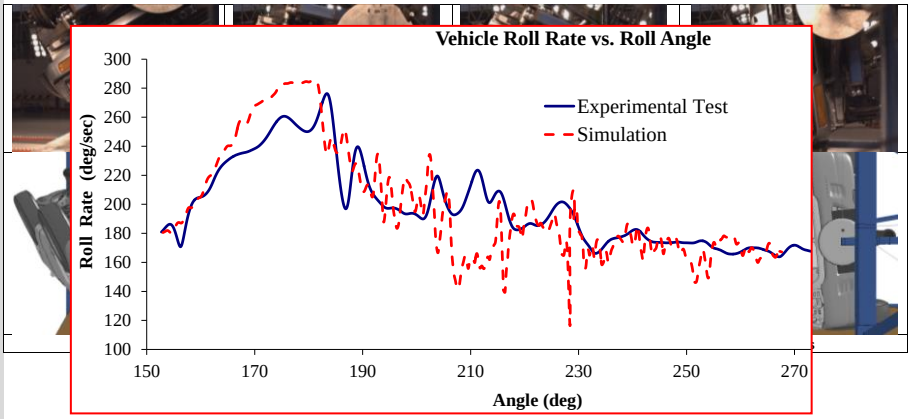
- Physical phenomena compared:
  - Vehicle kinematics



COMPUTER MODELLING

Model Validation 2/2

- Physical phenomena compared:
  - Vehicle kinematics
    - Very similar Roll Rate



COMPUTER MODELLING

Model Validation 2/2

- Physical phenomena compared:
  - Vehicle kinematics
  - Vehicle roof deformation
    - Smaller simulated crush (due to Explorer stiffer roof)
    - Same failure mode (i.e., roof buckling w/ plastic hinge)

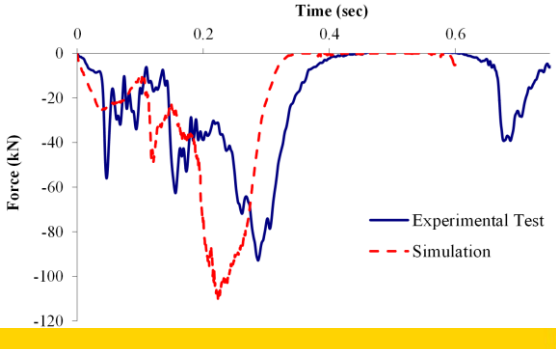
Roof Crush Measurements

	Test	Sim.
Horizontal component (mm)	*220*	*200*
Vertical component (mm)	*395*	*239*

COMPUTER MODELLING

Model Validation 2/2

- Physical phenomena compared:
  - Vehicle kinematics
  - Vehicle roof deformation
  - Roadbed load
    - Earlier and larger peaks for simulated load (due to Explorer stiffer roof)



CONCLUSIONS

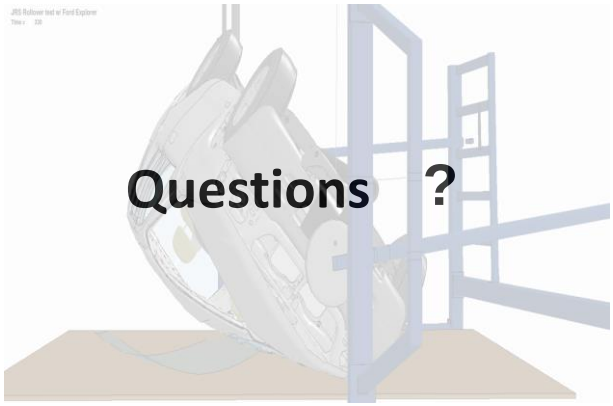
Conclusions

- Developed FE model can reproduce JRS testing w/ reasonable accuracy
  - Similar vehicle kinematics
  - Smaller roof deformation & higher roadbed load justified by stiffer roof than the tested vehicle)
- Computer modelling will be beneficial for tuning and assessing the JRS rig:
  - Sensitivity analysis for critical test parameters (e.g., roadbed mass or friction)
  - Identification of extreme testing conditions for the rig
  - Identification of critical configurations @ which typical real-world crash injuries occur
    (focus testing on identified critical scenarios)

Acknowledgments

- Funding sources
  - DROP Project funded by Australian Research Council (LIEF Project No. LE0989476)
  - Monash University
  - Industry partners
  - Centre for Road Safety at Transport for NSW
  - NSW Motor Accident Authority (MAA)
  - Office of Road Safety at Main Roads WA
  - Center for Injury Research (CfIR) – USA

- Technical and logistical support
  - CrashLab at TfNSW
  - Acen Jordan (Jordan & Co), and Josh Jeminez, Susie Bozzini and Don Friedman (CfIR)



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