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GTR7-02-08

# Rear Impact Dummy Biofidelity

## Status Update

Rear Impact/Head Restraint Meeting
Tokyo, Japan
3 February 2010

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Vehicle Research and Test Center
National Highway Traffic Safety Administration

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# Objectives & Tasks

- Evaluate biofidelity of available RIDs (BioRID II, RID3D)
  - Choose biofidelity test condition
  - Develop experimental seat for rear impact sled testing
  - Conduct sled tests
    - PMHS (Post-Mortem Human Subjects)
    - Dummies (BioRID II, RID3D, Hybrid III)
  - Assess biofidelity of dummies

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- Investigate the mechanism of injury
  - Develop and validate 3-D cervical spine kinematic instrumentation
  - Identify injurious kinematics (if possible)

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  - Assess biofidelity of dummies
- Investigate the mechanism of injury
  - Develop and validate 3-D cervical spine kinematic instrumentation
  - Identify injurious kinematics (if possible)
- Choose appropriate dummy & injury criterion
  - Assess efficacy of various ICs (if possible)

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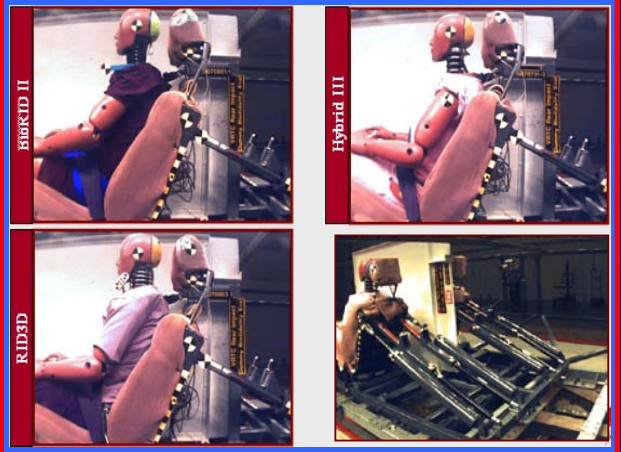
# Project Overview

## PMHS Tests

## NHTSA BioRank

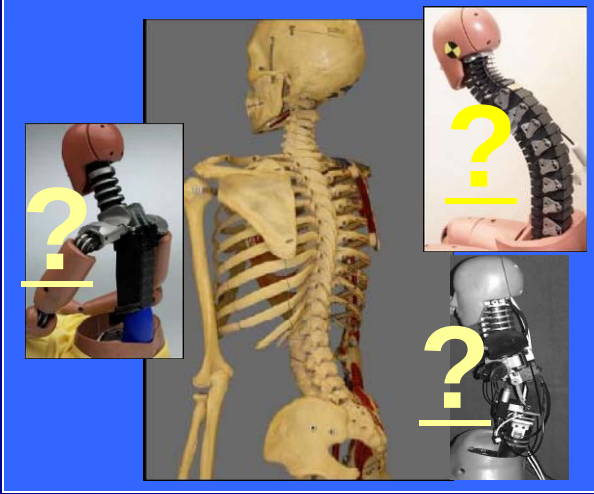
## Dummy Tests




## Intervertebral Kinematics

## Comparison of Neck Injury Criteria

## Biofidelity



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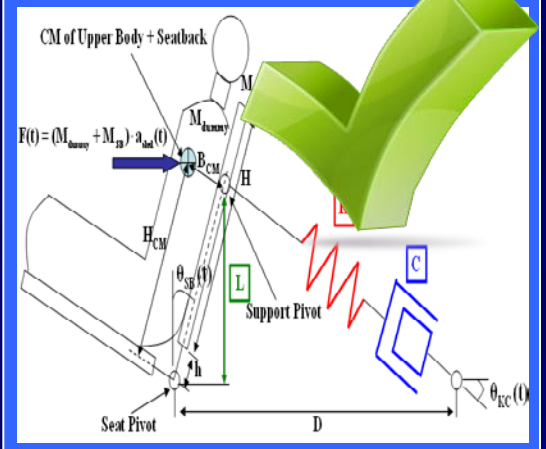
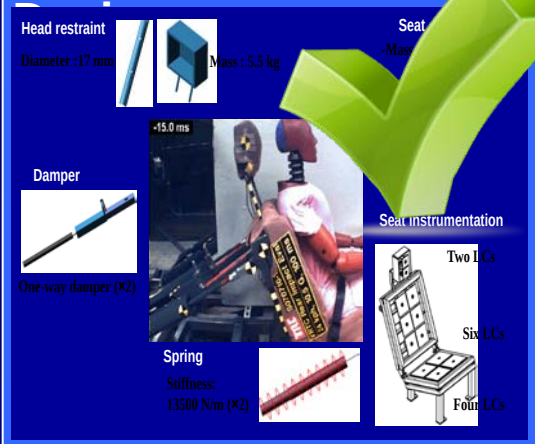
# Project Overview

## Dynamic Analysis

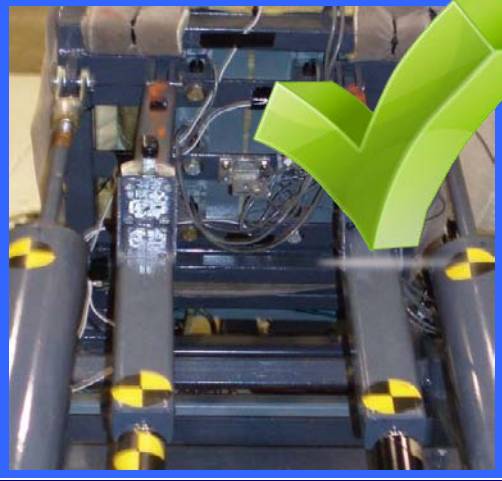



## Experimental Seat

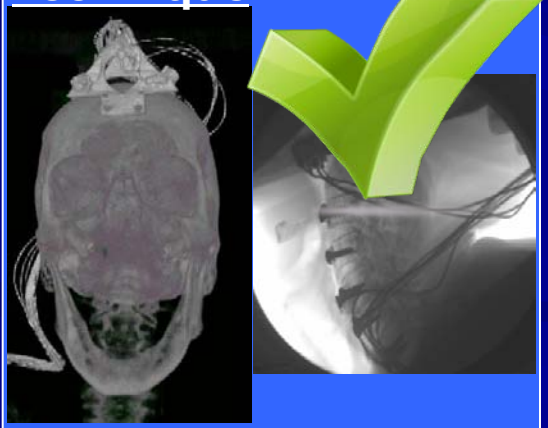



## Dummy Tests


## Design Improvement



## Instrumentation Technique



## PMHS Tests

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# Added Low Speed PMHS Tests

- In support of the Head Restraint Working Group – GTR 7
- Added seven low speed (8.5 g, 16.7 kph) PMHS tests
- Two tests per subject, low→mid speed
- Verified no damage at low speed
- Biofidelity at low & mid speed
- Kinematic cervical vertebrae analysis

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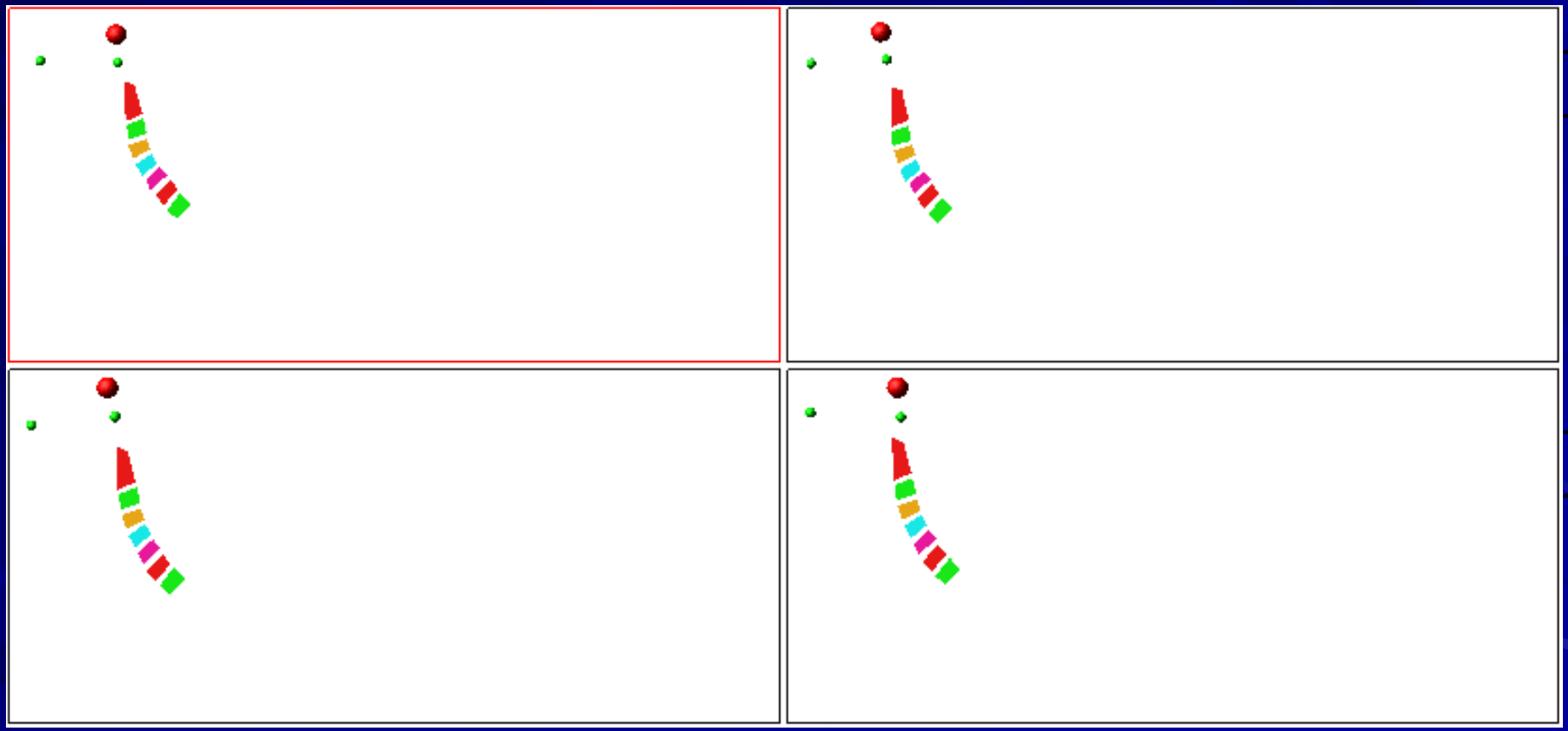
# Four Repeat Low Speed Tests



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# Test Matrix

## Dummy Tests

| Test Number | Test Speed | Driver Side Dummy | Passenger Side Dummy |
|---|---|---|---|
| 1 | L | Hybrid III 50th | BioRID II |
| 2 | L | Hybrid III 50th | BioRID II |
| 3 | L | RID3D | BioRID II |
| 4 | L | RID3D | BioRID II |
| 5 | L | RID3D | Hybrid III 50th |
| 6 | M | RID3D | Hybrid III 50th |
| 7 | M | RID3D | Hybrid III 50th |
| 8 | M | RID3D | BioRID II |
| 9 | M | RID3D | BioRID II |
| 10 | M | Hybrid III 50th | BioRID II |

## PMHS Tests

| Test Number | Test Speed | Subject |
|---|---|---|
| 1 | M | PMHS01 |
| 2 | L | PMHS02 |
| 3 | L/M | PMHS03 |
| 4 | L/M | PMHS04 |
| 5 | L/M | PMHS05 |
| 6 | L/M | PMHS06 |
| 7 | L/M | PMHS07 |
| 8 | L/M | PMHS08 |

L = Low Speed (8.5 g, 16.7 kph FMVSS 202)

M = Moderate Speed (10.5 g, 24 kph)

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| 4 | L | RID3D | BioRID II |
| 5 | L | RID3D | Hybrid III 50th |
| 6 | M | RID3D | Hybrid III 50th |
| 7 | M | RID3D | Hybrid III 50th |
| 8 | M | RID3D | BioRID II |
| 9 | M | RID3D | BioRID II |
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| 8 | L/M | PMHS08 |

L = Low Speed (8.5 g, 16.7 kph FMVSS 202)

M = Moderate Speed (10.5 g, 24 kph)

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# Rear Impact Sled Test

## Low Speed

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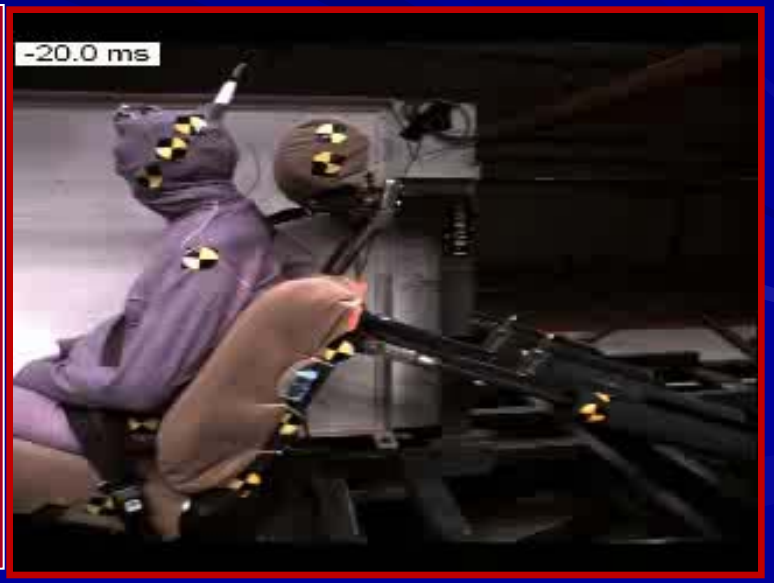
BioRID II


Hybrid III


RID3D


PMHS01



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# Rear Impact Sled Test

## Moderate Speed

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BioRID II

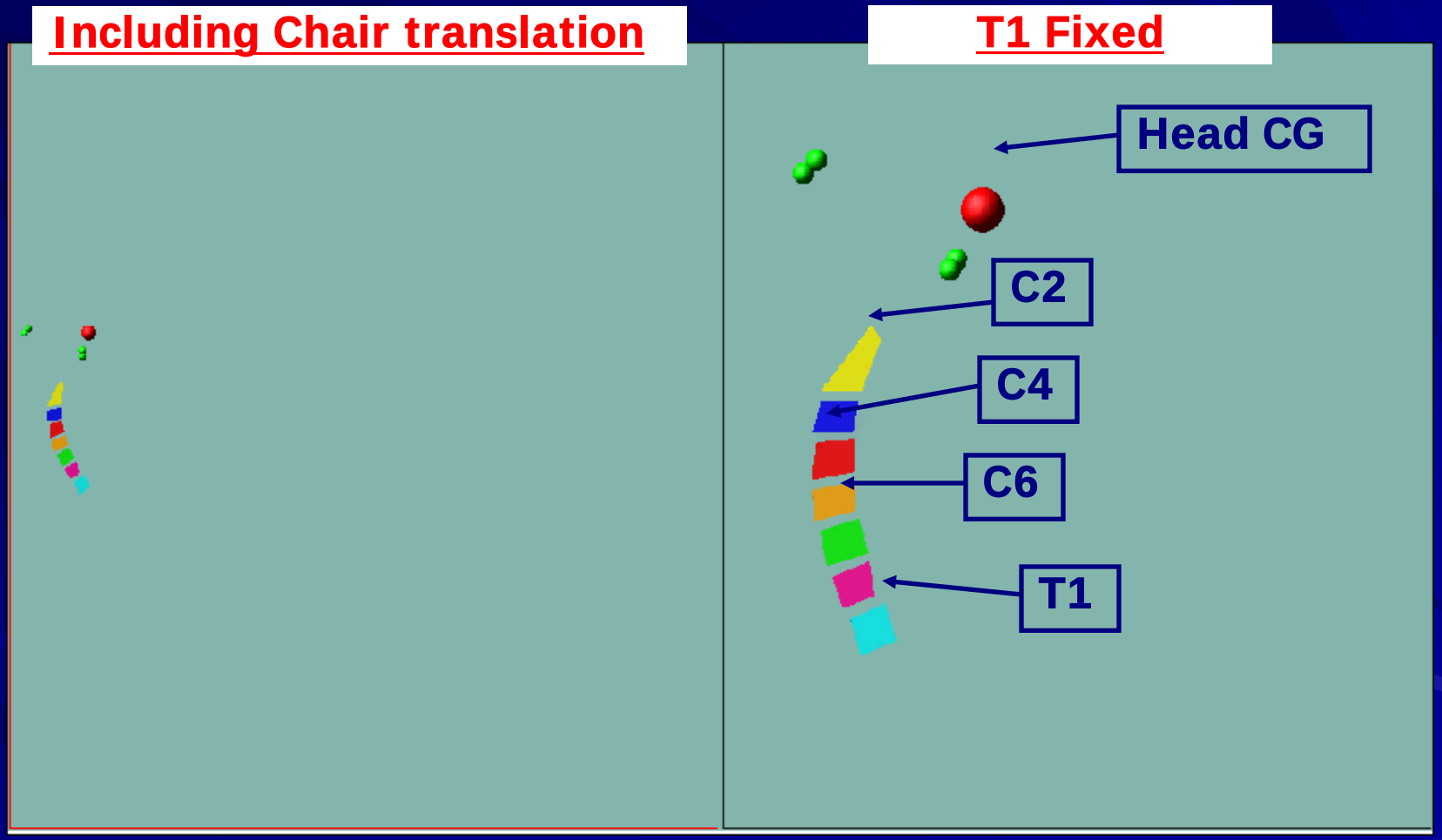

Hybrid III


RID3D

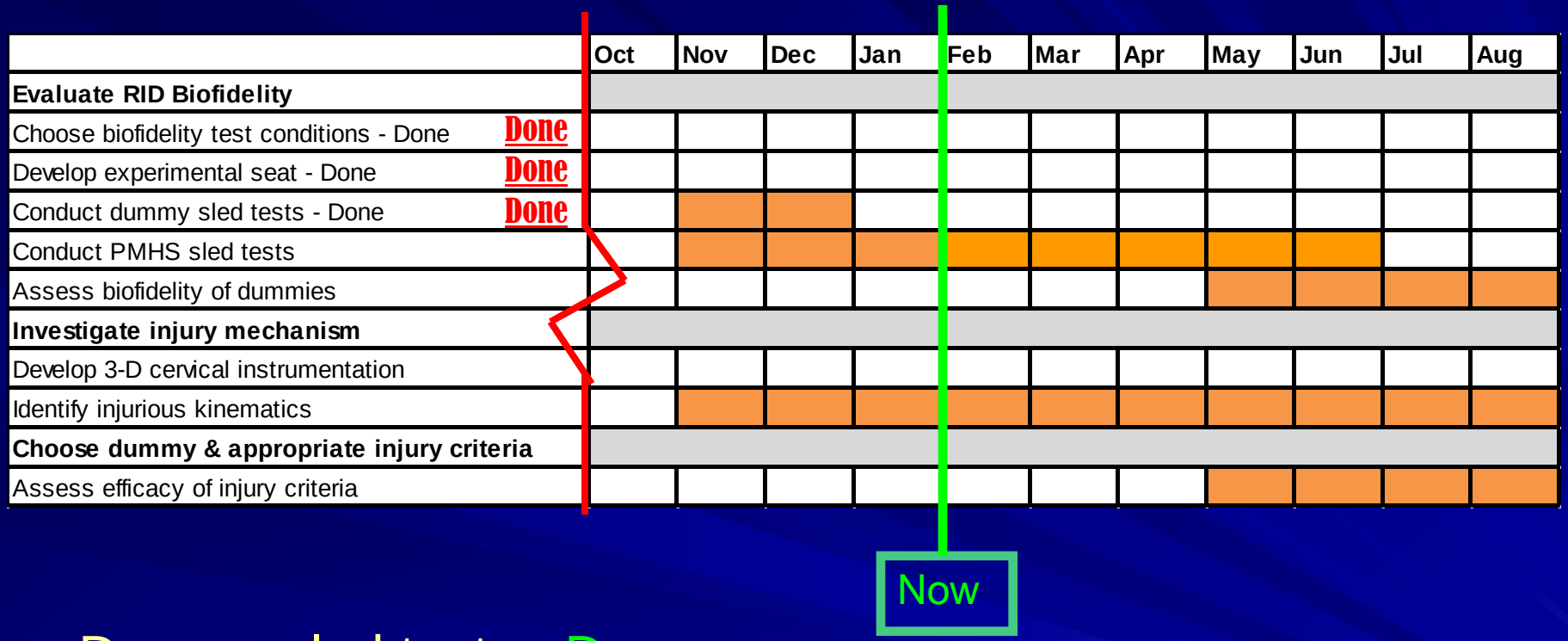

PMHS01

# Cervical Spine Instrumentation

- Sled test (24 kph, 10.5 g)



# Schedule & Status




- Dummy sled tests - Done
  - 6 exposures each dummy (3x each speed)
  - Sufficient for repeatability
- Conduct PMHS sled tests - 3 Done, 5 Remaining
  - 8 PMHS (7 at low-speed, 7 at moderate-speed)

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# Thank you

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# Cervical Spine Instrumentation

- Identify injurious kinematics
  - Determine likelihood and mode of injury at each vertebral level
  - Relative displacements and rotations measured
  - Compare with values of non-injurious physiologic ROM
    (Panjabi et al, 1998; Panjabi et al, 2005)
    - Shear and axial displacements
    - Flexion and extension rotations

- Compare to various injury criteria and look for best predictor
  - NIC, $N_{ij}$, $N_{km}$, $N_{te}$, ND criterion, LNL index
  - Head-to-Torso rotation, upper & lower extension moment
  - IV-NIC
  - Other??

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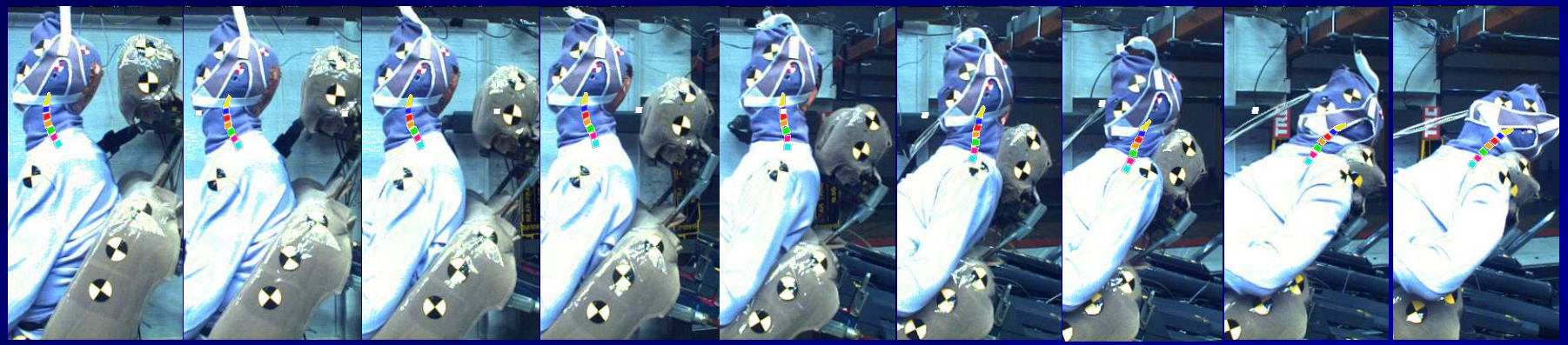
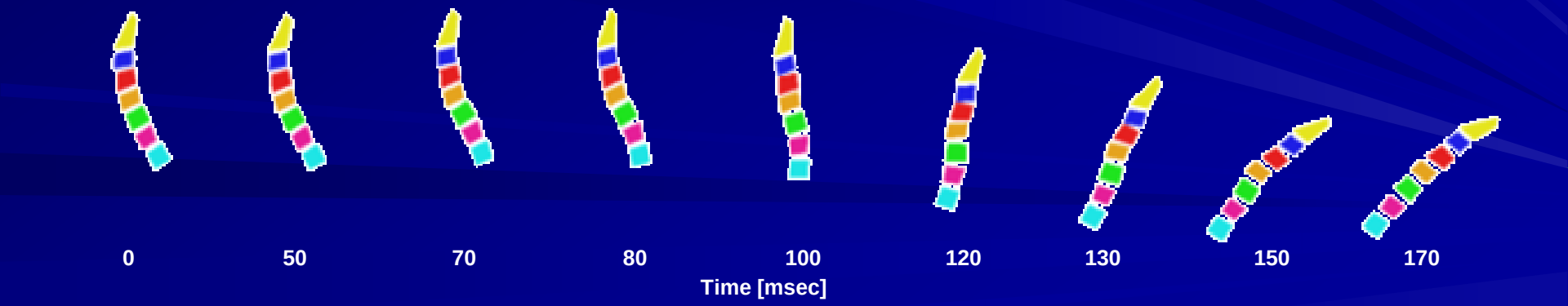
# Cervical Spine Instrumentation

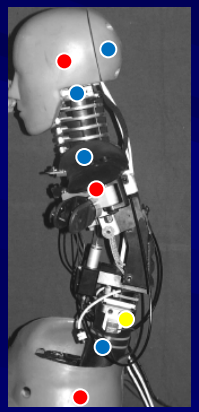
- Sled Test (24 kph, 10.5 g)



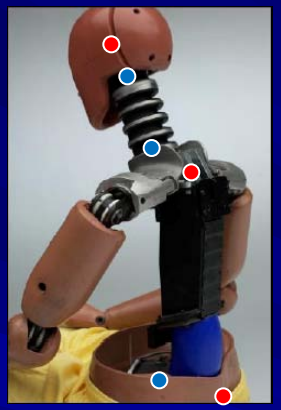
# Internal Biofidelity

## Instrumentation - ATDs vs. PMHS



<RID3D>

<BioRID II>



<Hybrid III>

- Accelerometers (x, z)
- Accelerometers (x, z) & angular rate sensor (y)
- 3 accelerometers & 3 ARS (3aw)
- Load cell
- Aluminum tetrahedron - 6aω

<PMHS>

| ● ● | RID 3D | BioRID II | Hybrid III | PMHS |
|---|---|---|---|---|
| Head | Two Acc (x, z) One ARS (y) | Two Acc (x, z) One ARS (y) | Two Acc (x, z) One ARS (y) | 6aw |
| T1 | Two Acc (x, z) One ARS (y) | Two Acc (x, z) One ARS (y) | Two Acc (x, z) One ARS (y) | 3aw |
| T8 | None | Two Acc (x, z) | None | 3aw |
| T12 | Two Acc (x, z) | None | None | 3aw |
| L1 | None | Two Acc (x, z) | None | |
| Pelvis | Two Acc (x, z) One ARS (y) | Two Acc (x, z) One ARS (y) | Two Acc (x, z) One ARS (y) | 3aw |

| ○ | RID 3D | BioRID II | Hybrid III | PMHS |
|---|---|---|---|---|
| Skull Cap | Fx, Fz | Fx, Fz | None | None |
| Upper neck | Fx, Fz, My | Fx, Fz, My | Fx, Fz, My | None |
| Lower neck | Fx, Fz, My | Fx, Fz, My | Fx, Fz, My | None |
| Lumbar | Fx, Fz, My | Fx, Fz, My | Fx, Fz, My | None |
| Muscle Substitute (front) | None | Fx | None | None |
| Muscle Substitute (rear) | None | Fx | None | None |

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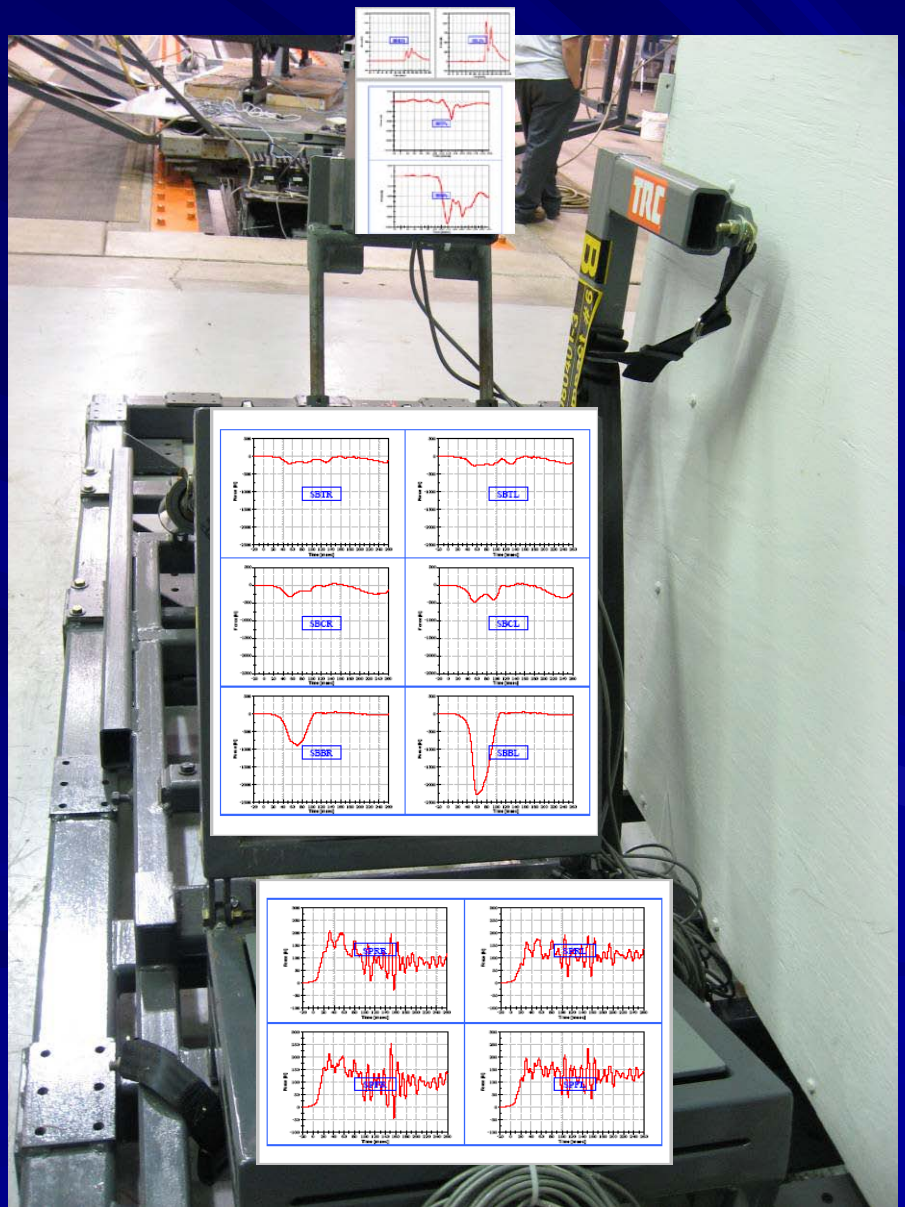
# External Biofidelity

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