Flex-GTR Testing

Transportation Research Center
NHTSA Vehicle Research & Test Center

Flex-TEG Meeting
Dec. 1-2, 2009

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Overview

- History of VRTC Testing with Flex-PLI
- Objectives
- Test Setup & Procedure
- Test Matrix
- Results
  - Repeatability
  - Durability
  - SLICE

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History of VRTC Testing with Flex

- **Flex-G tests**
  - ESV 2005
  - Durability issues identified
- **Flex-GT tests**
  - Presented @ Flex-TEG (March 2008) & SAE Govt.-Industry Meeting (May 2008)
  - Less durability problems but still some issues
    - Still haven't tested any very stiff cars
- **Flex-GTR tests (2009)**
  - This presentation

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Objectives: Flex-GTR Tests (2009)

- Provide Flex-TEG with feedback on
  - Repeatability
  - Durability
  - SLICE onboard data acquisition

Test Procedure

- **GTR conditions (40 km/h, 75 mm height)**
  - Laser speed-traps to measure impact velocity
- **Center impacts**
- **Overhead and lateral video**
  - Monitor alignment during flight
- **DTS Onboard SLICE Nano DAS**

Laser speed-traps

SLICE disconnect

Disconnect anchor point
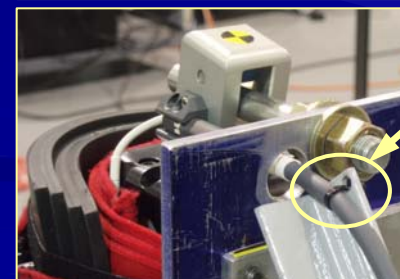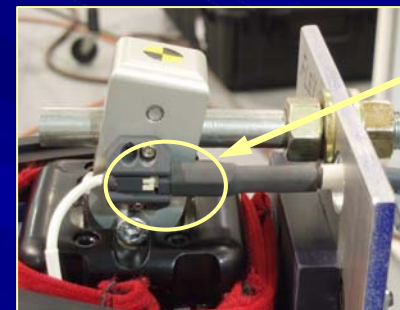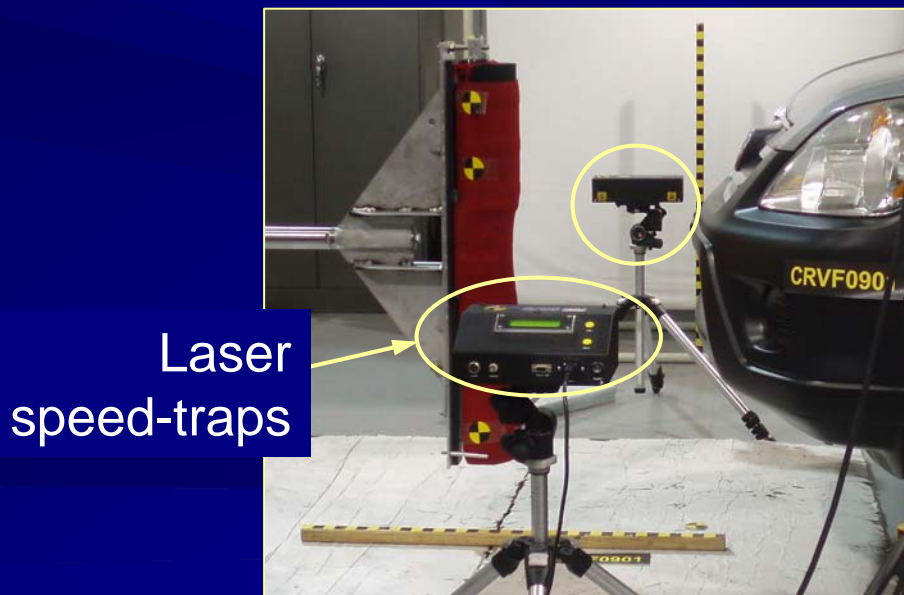
Test Matrix

- Selection Criteria
  - Vehicle location did reasonably well in TRL tests (Mallory, ESV 2009 & more recent testing)

| Vehicle	Tibia Acceleration (GTR: 170 g)	Bending Angle (GTR: 19 deg)	Shear Displacement (GTR: 6 mm)
2005 Honda CR-V	Pass	Pass	Pass
2002 Mazda Miata	Pass	Pass	Pass
2006 Infiniti M35 (with Nissan Fuga bumper)	Pass	Pass	Pass
2006 Volkswagen Passat	Pass	Fail	Pass
2001 Honda Civic	Fail (marginal)	Fail (marginal)	Fail (marginal)
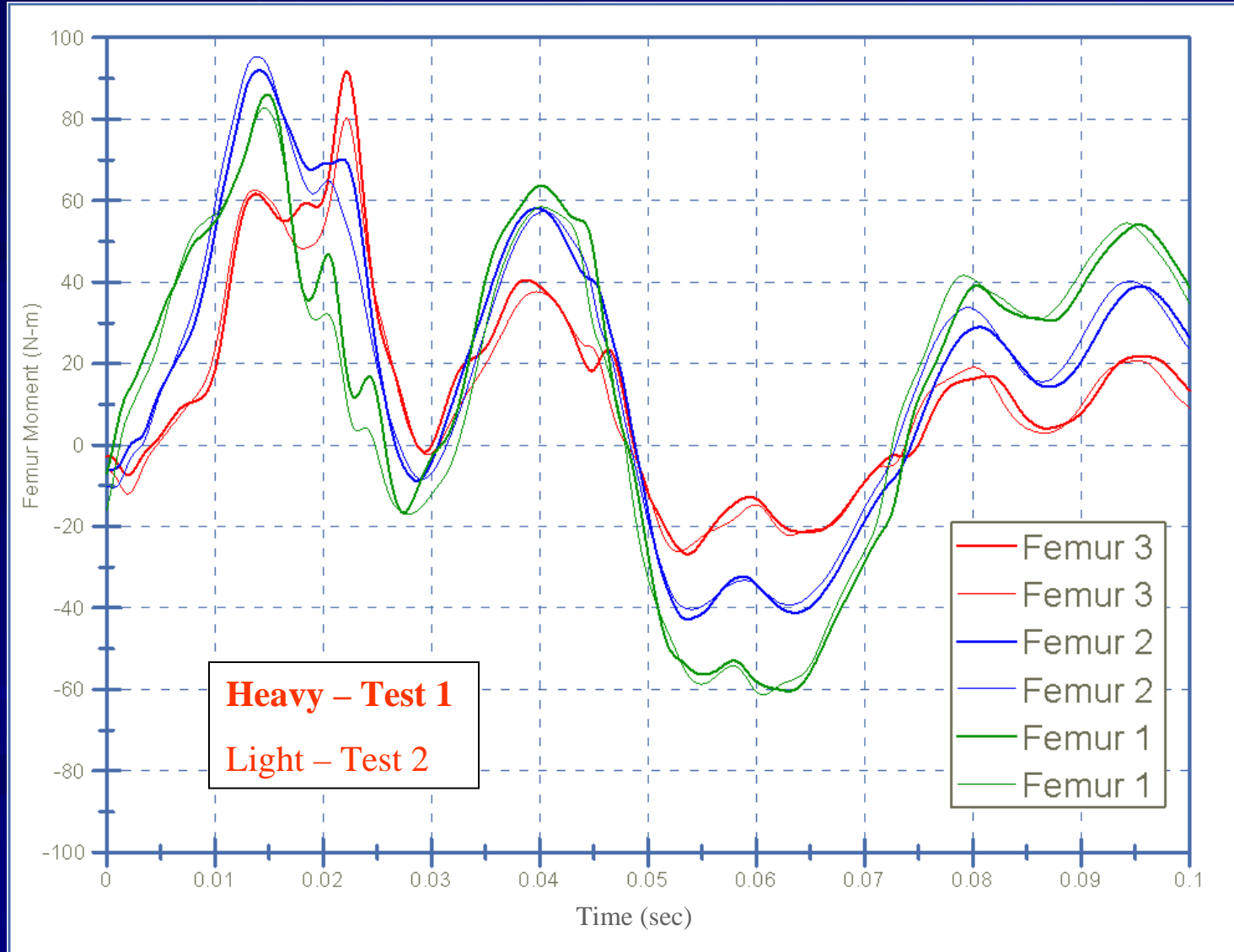
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Repeatability
Honda CR-V

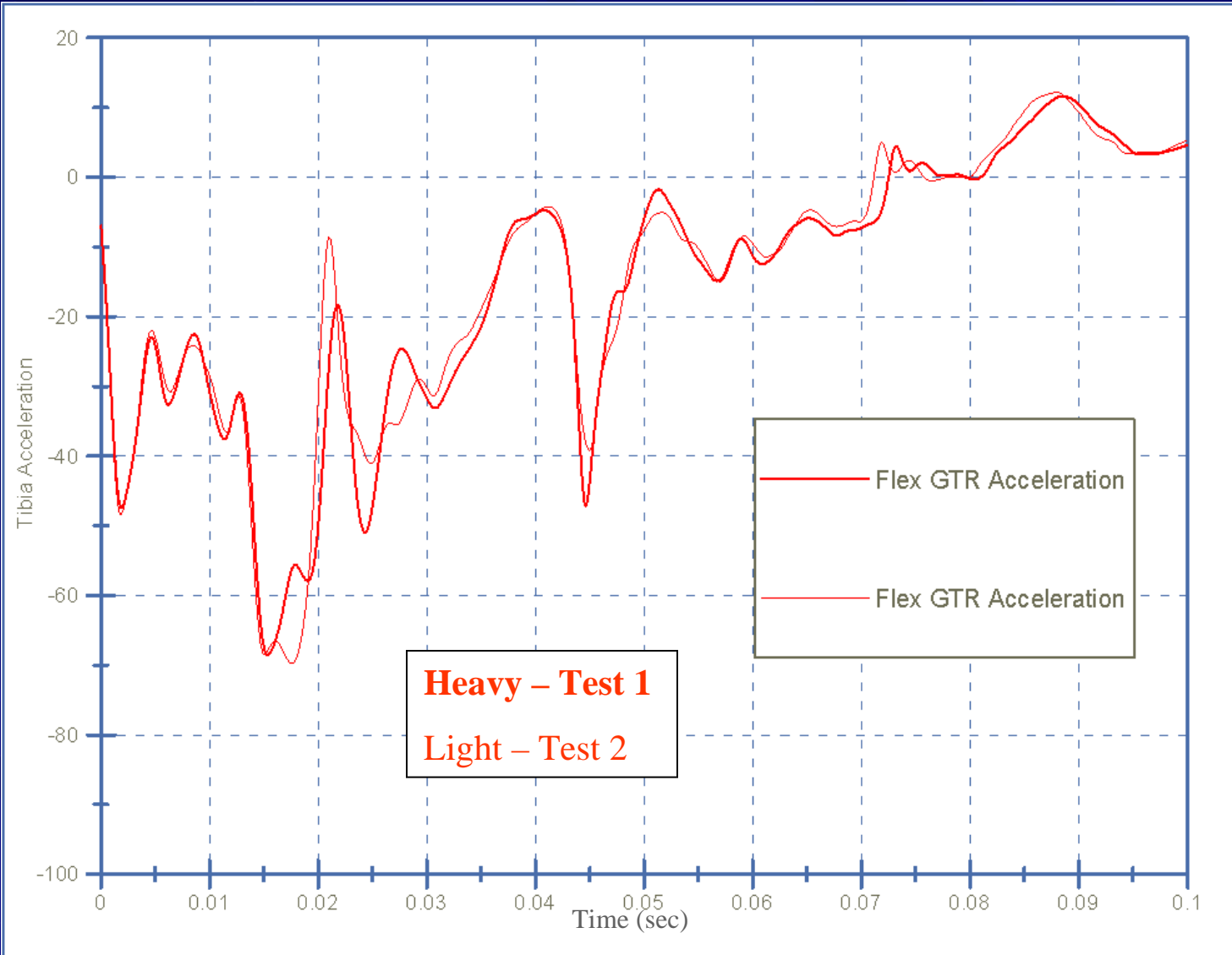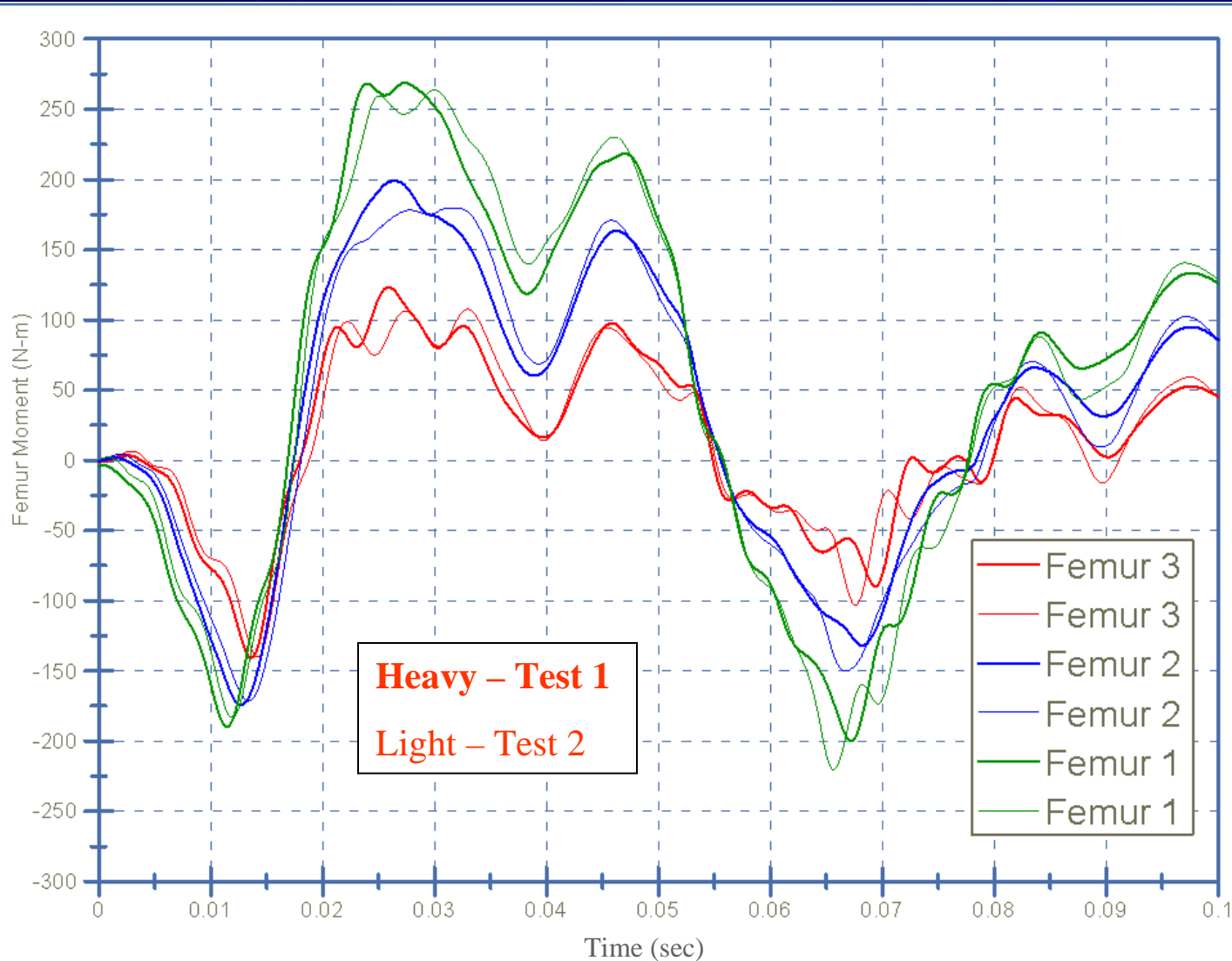# Repeatability
Honda CR-V
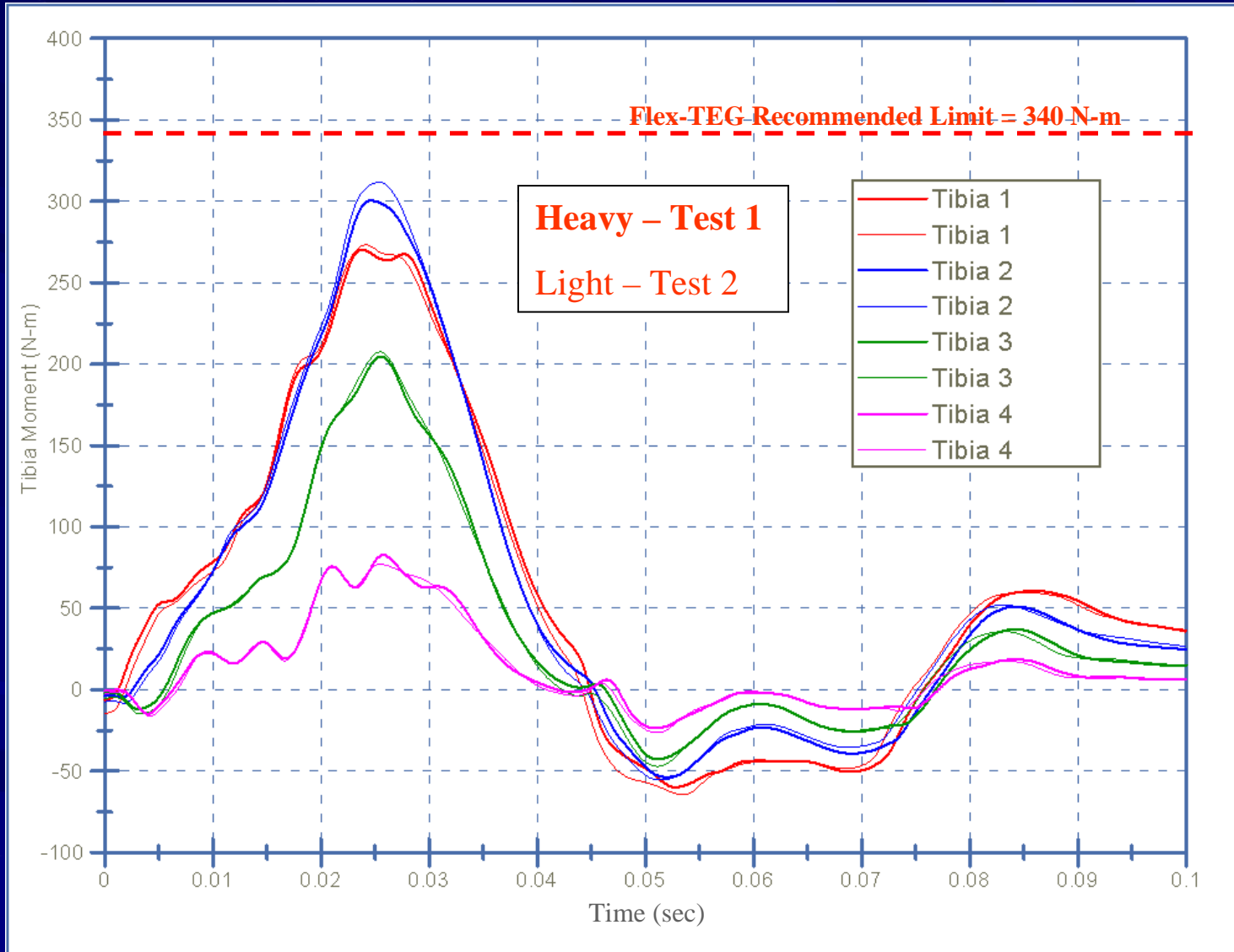
Repeatability
Honda CR-V
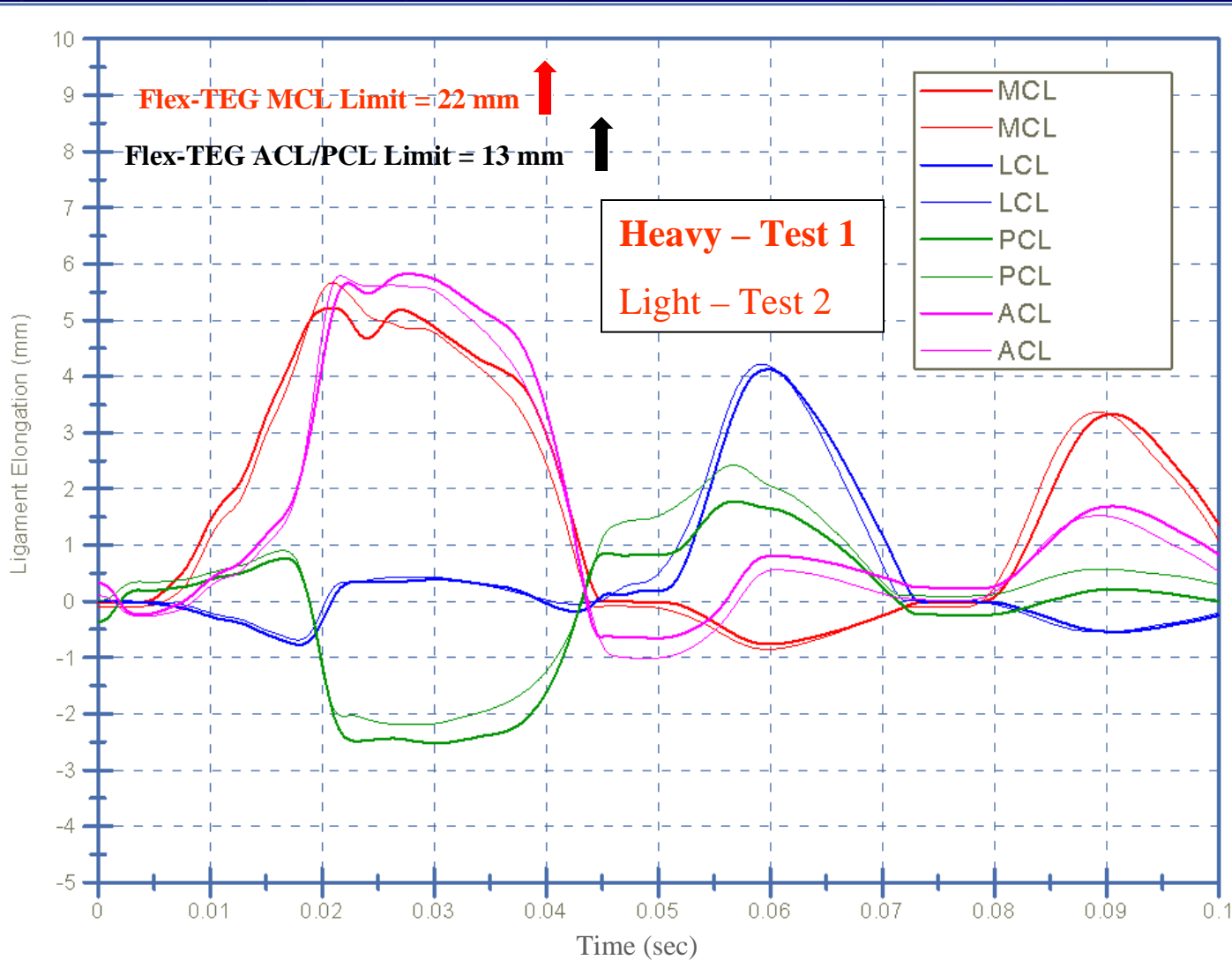
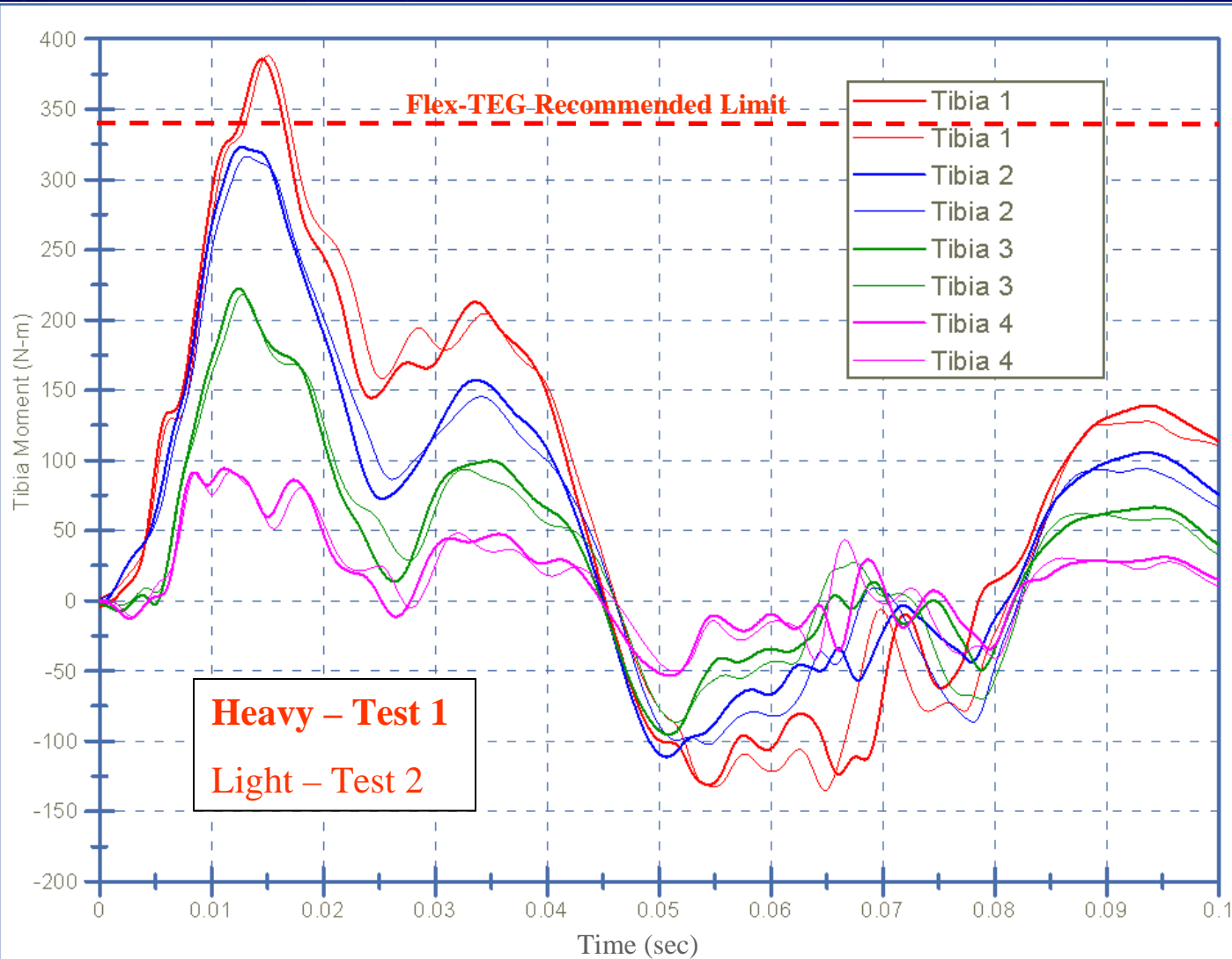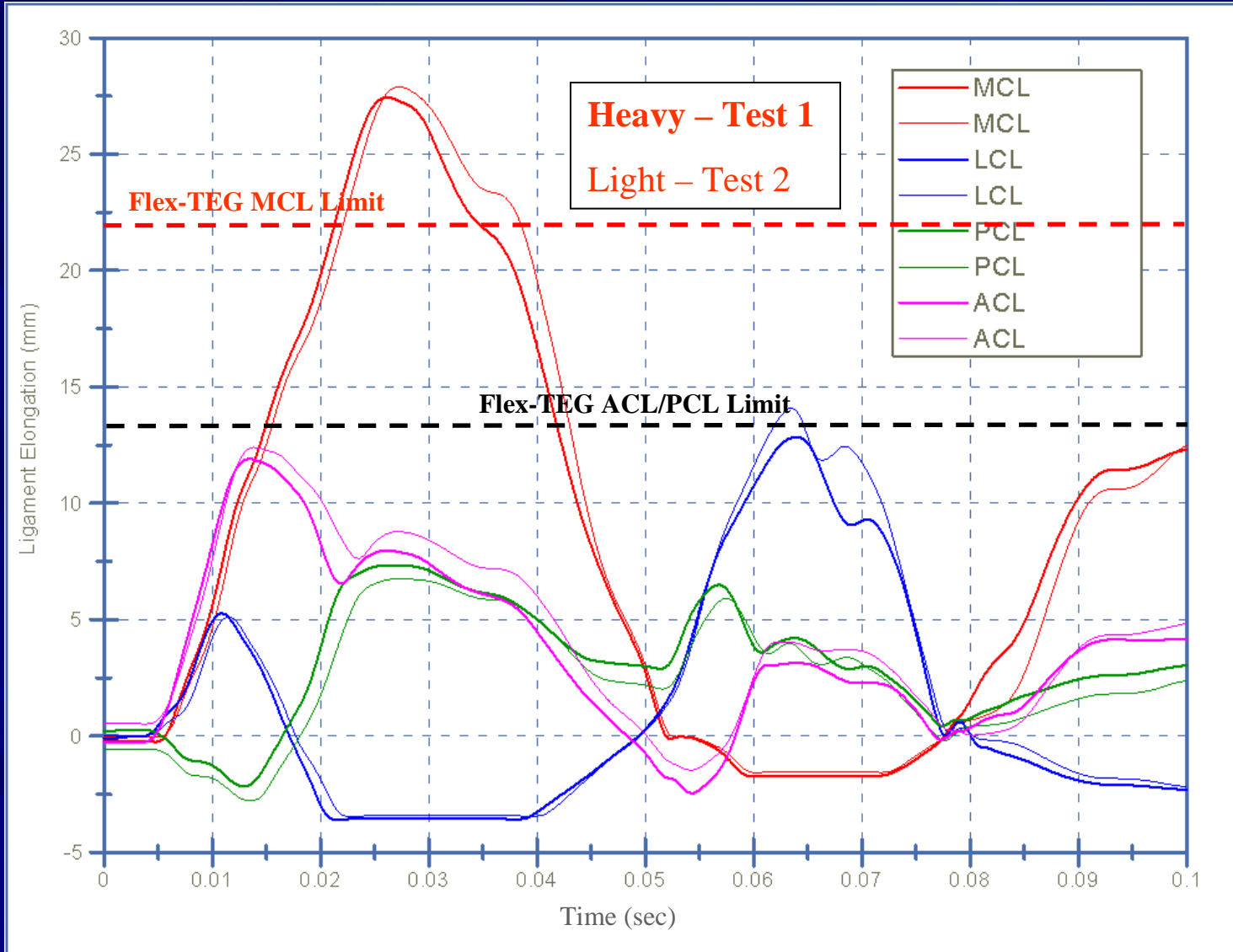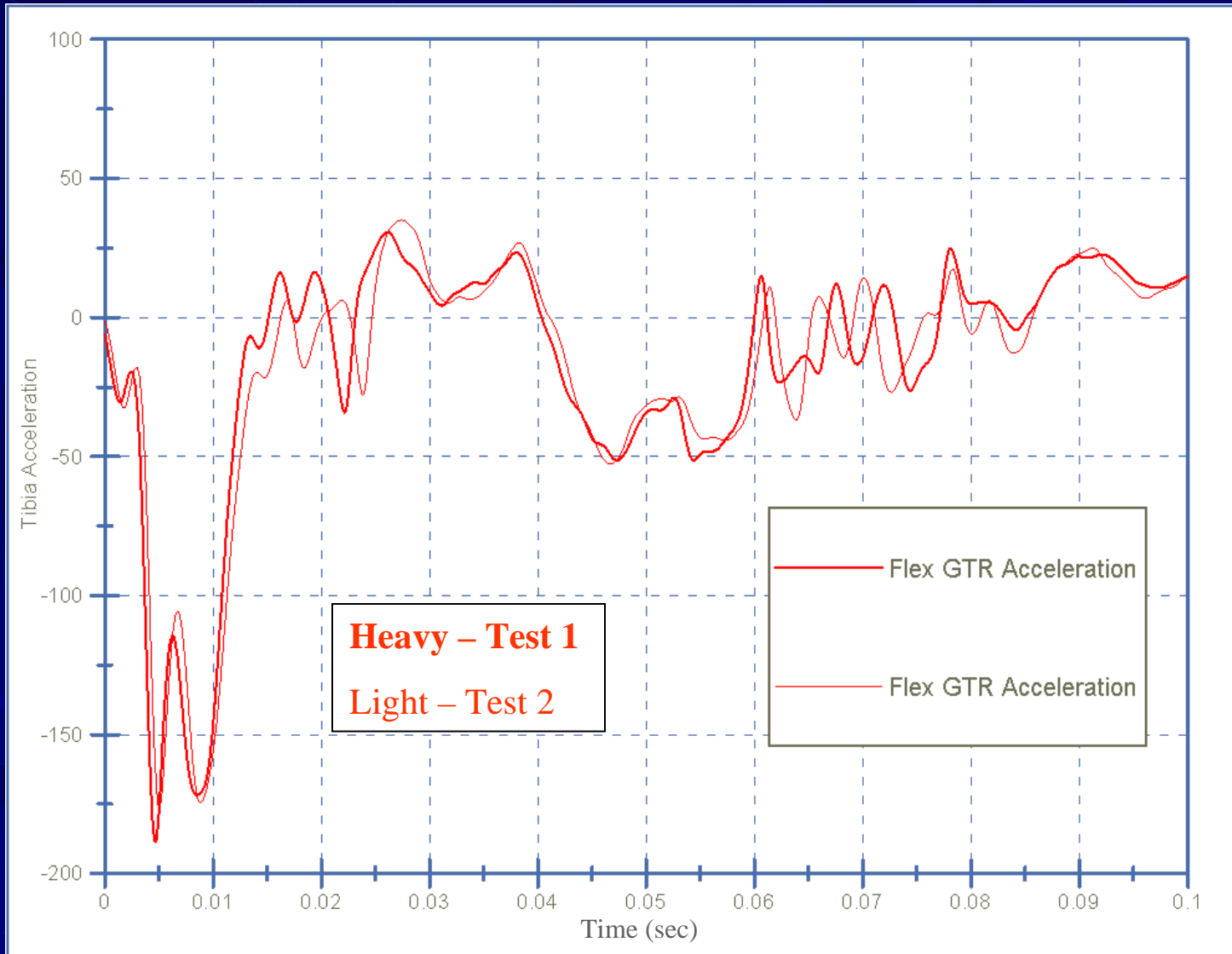# Repeatability
Honda CR-V

Repeatability
Mazda Miata

Repeatability
Mazda Miata
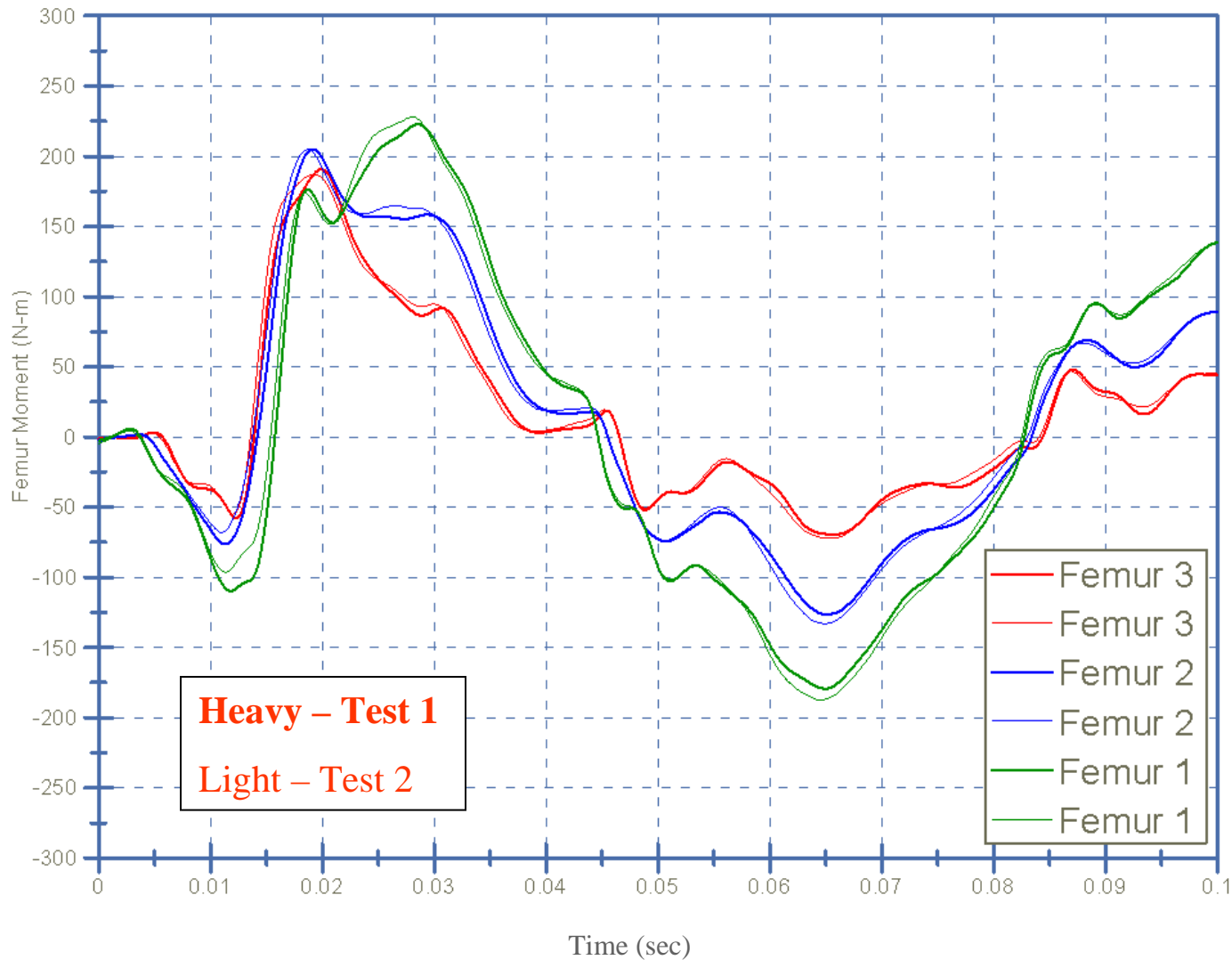
Repeatability
Mazda Miata
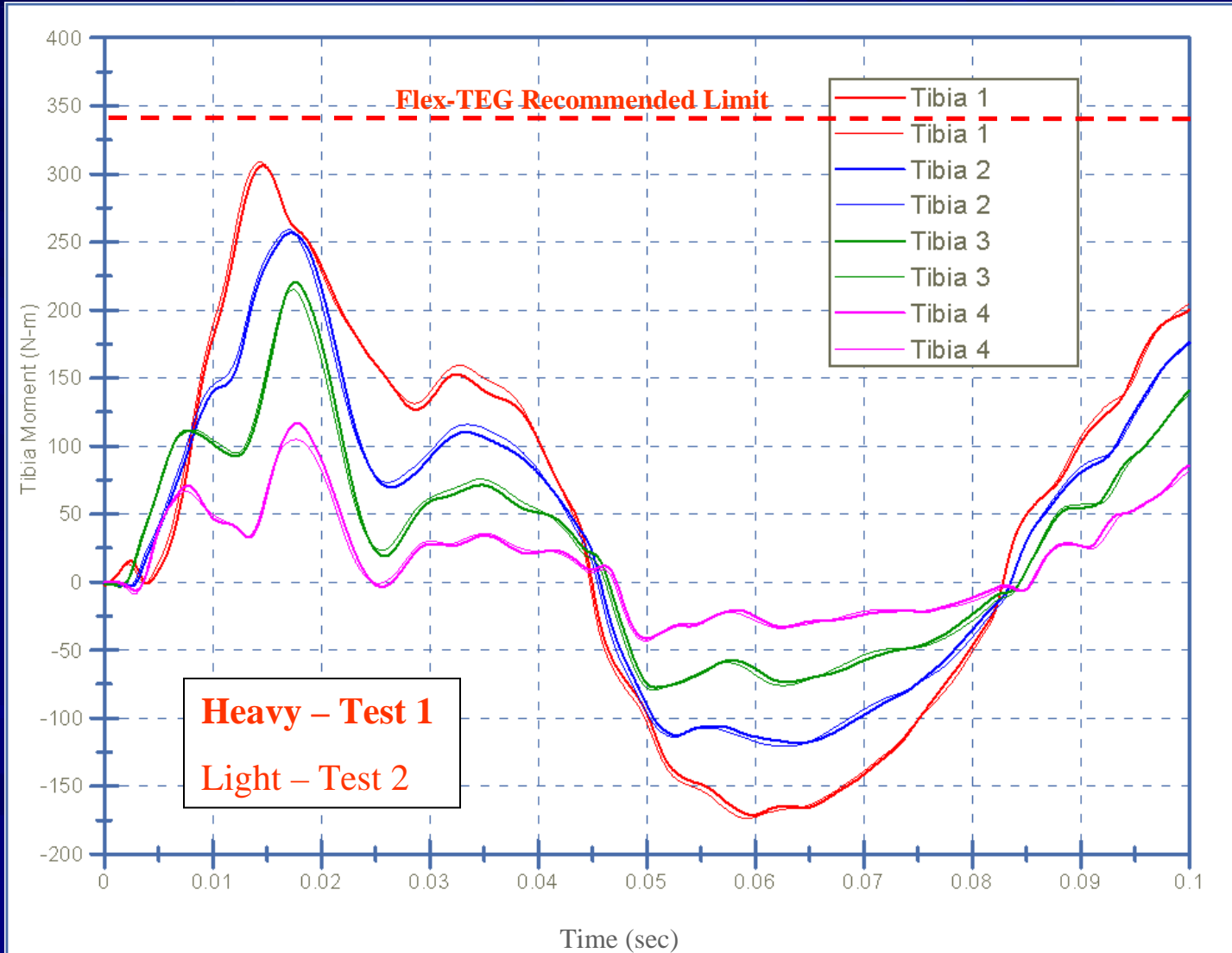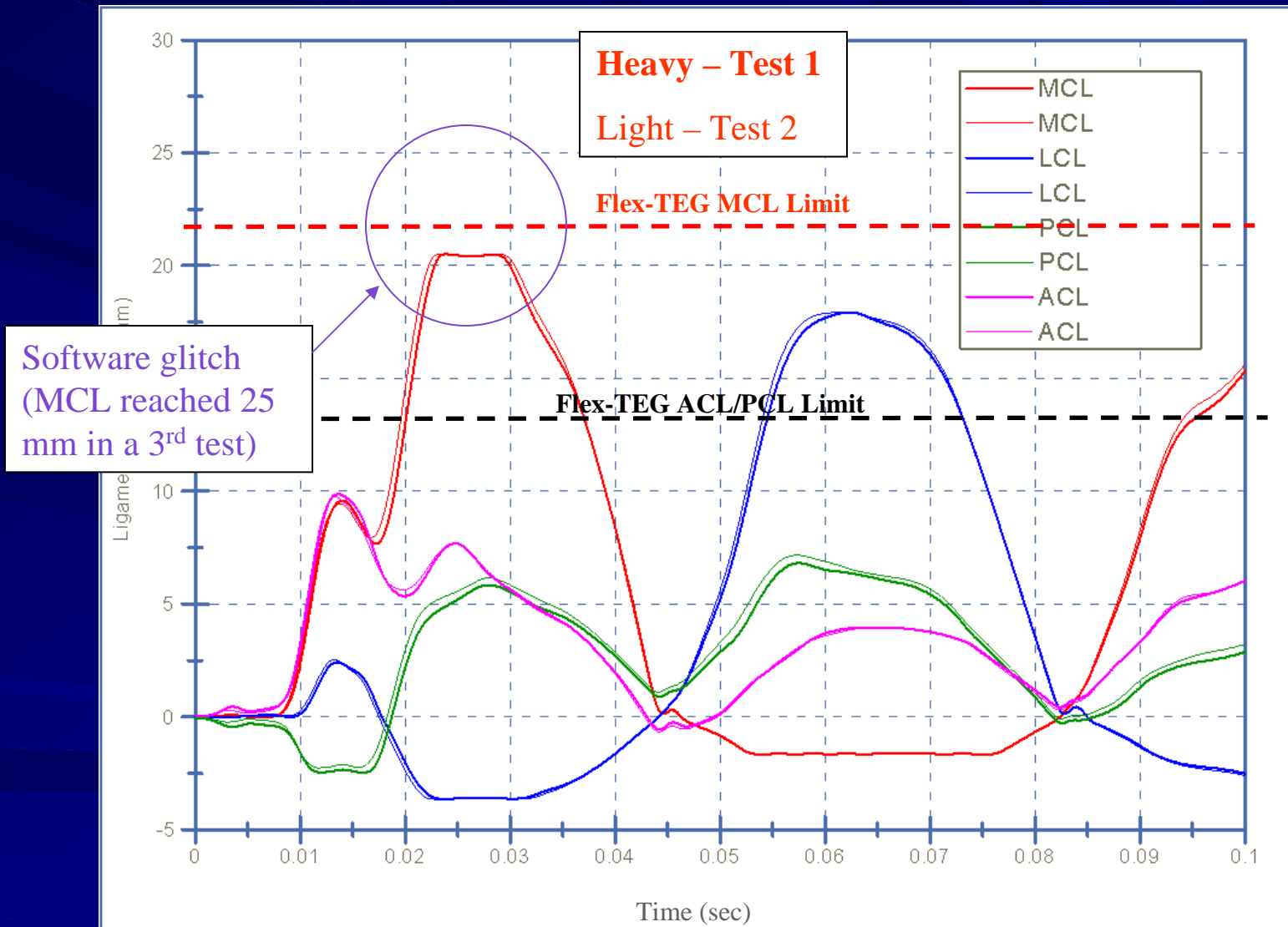
Repeatability
Mazda Miata

Repeatability
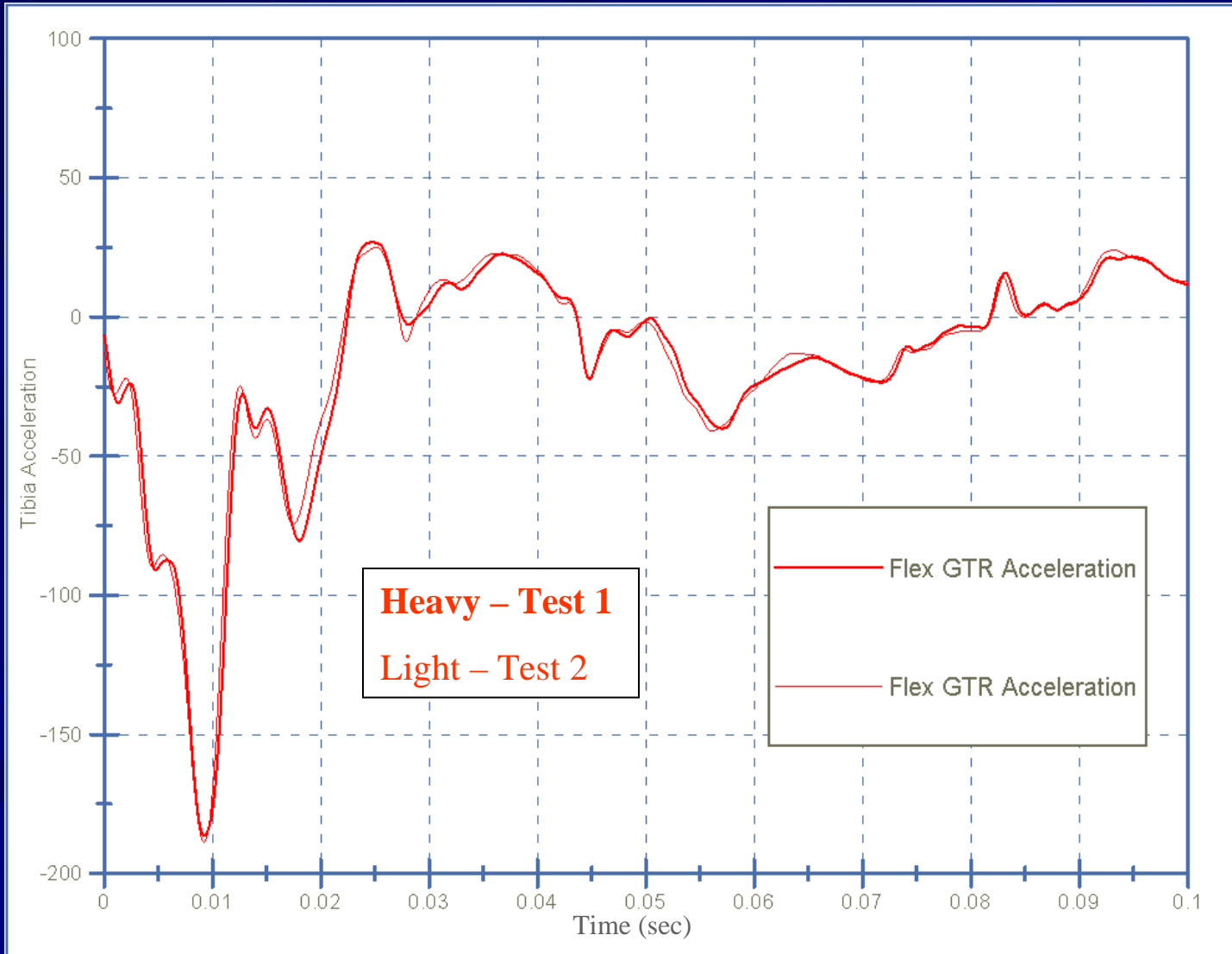## Nissan Fuga

Repeatability
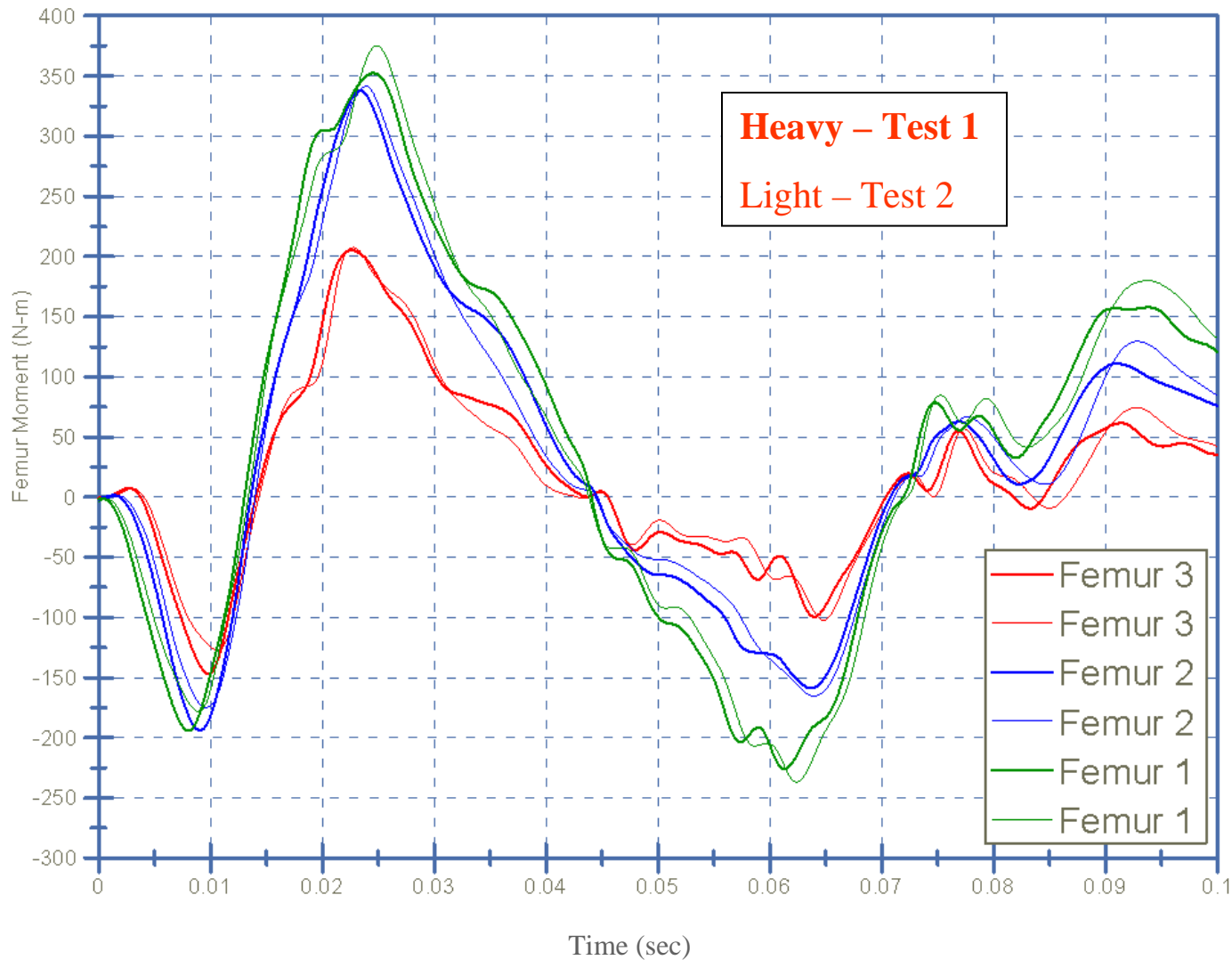## Nissan Fuga

Repeatability
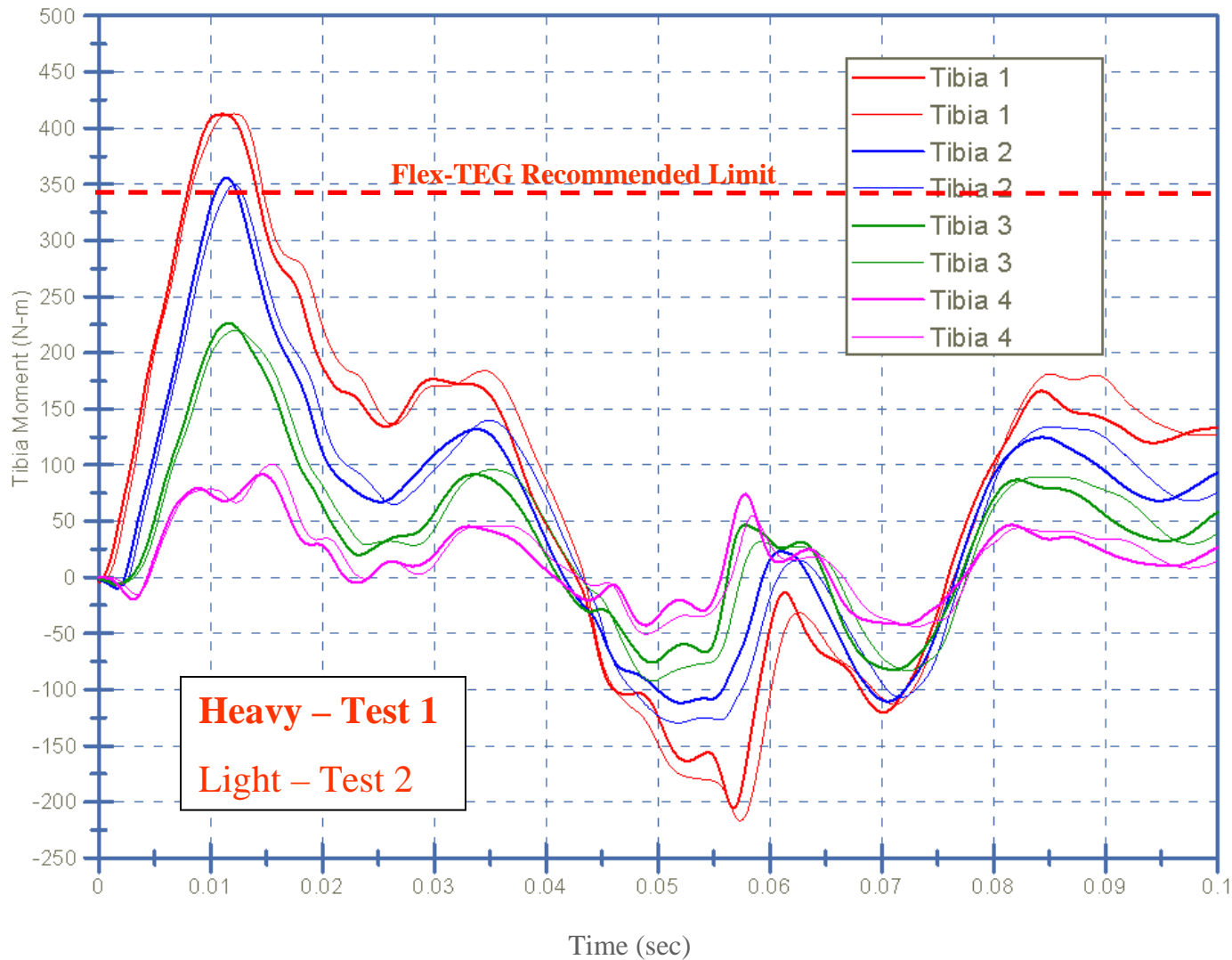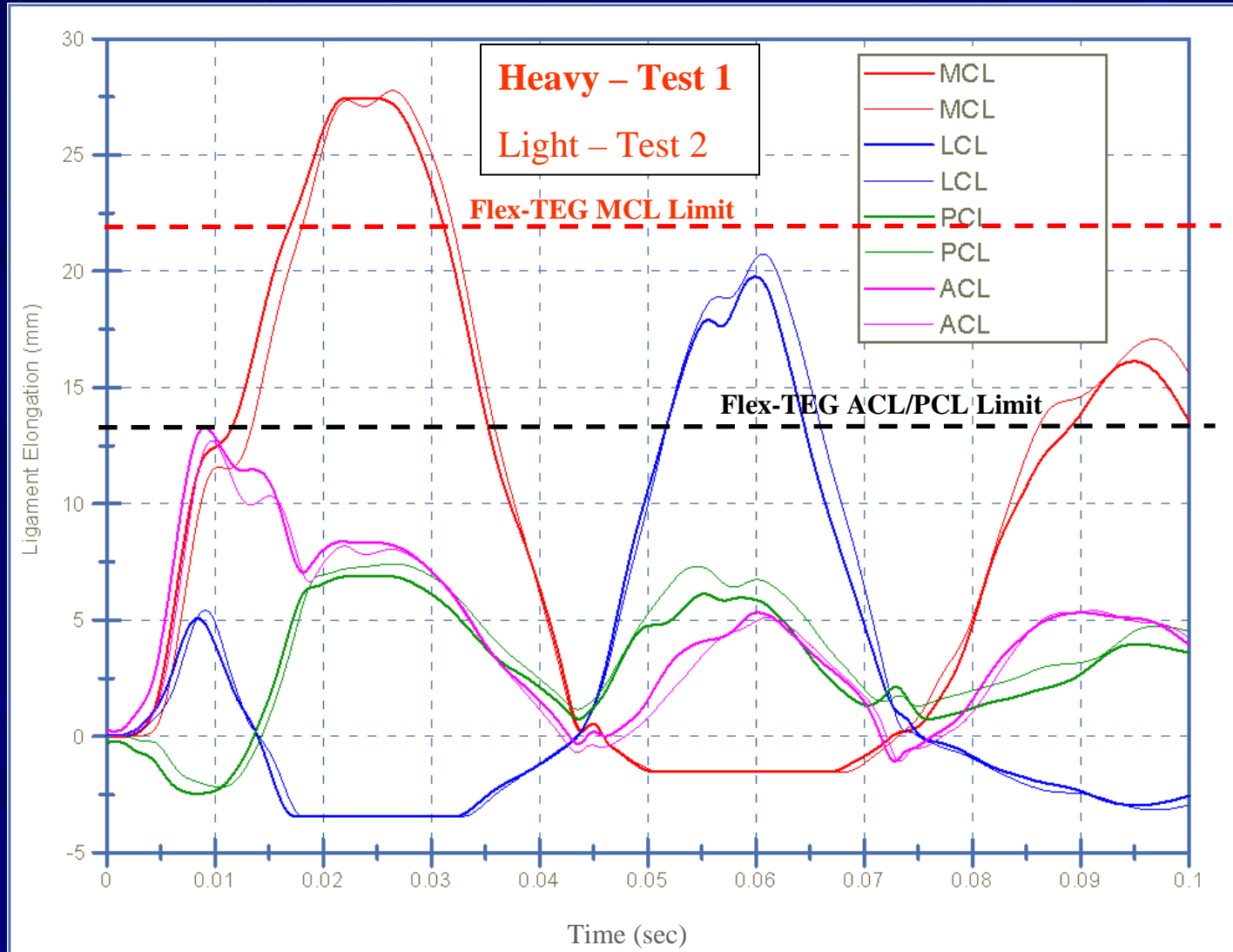## Nissan Fuga

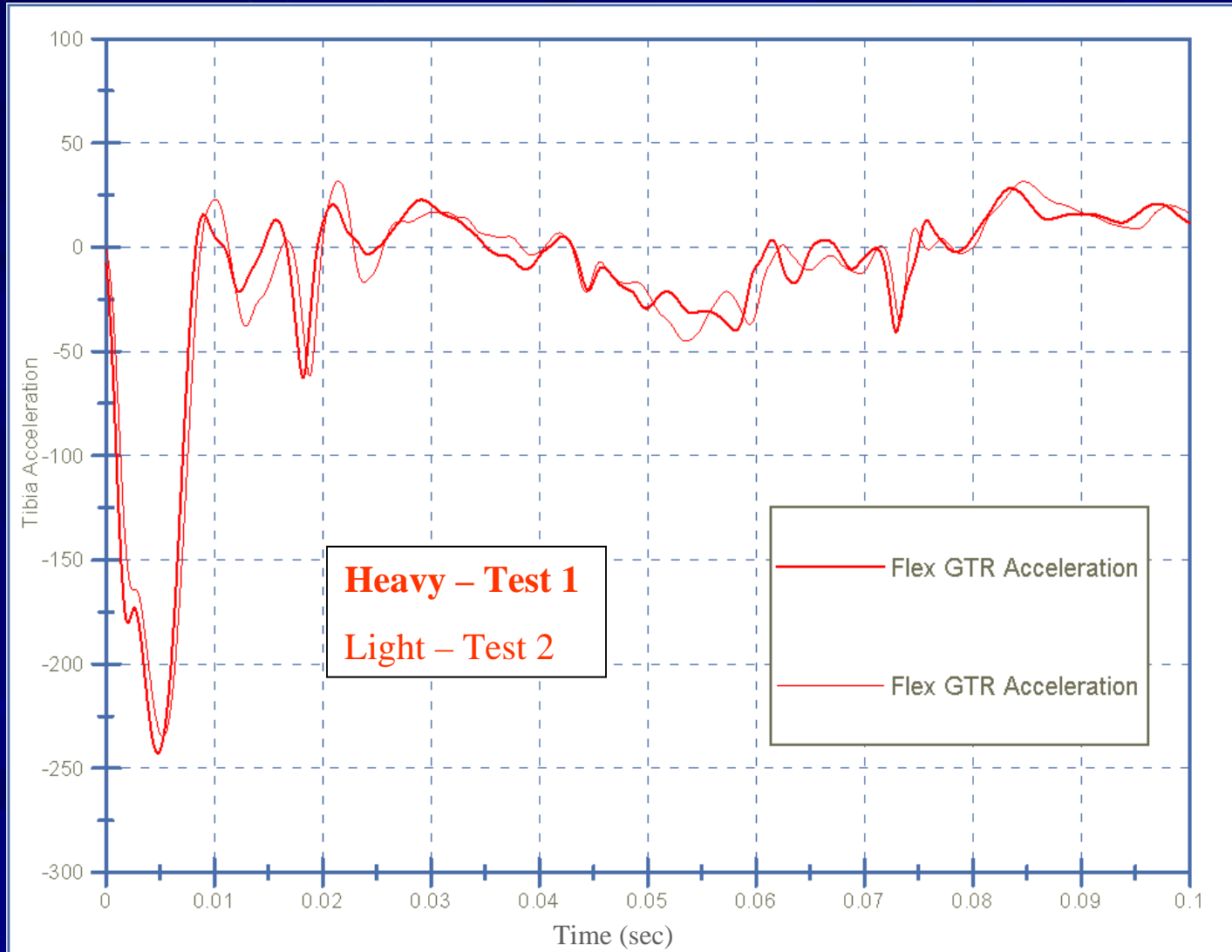# Repeatability
Nissan Fuga

Repeatability
Volkswagen Passat

Repeatability
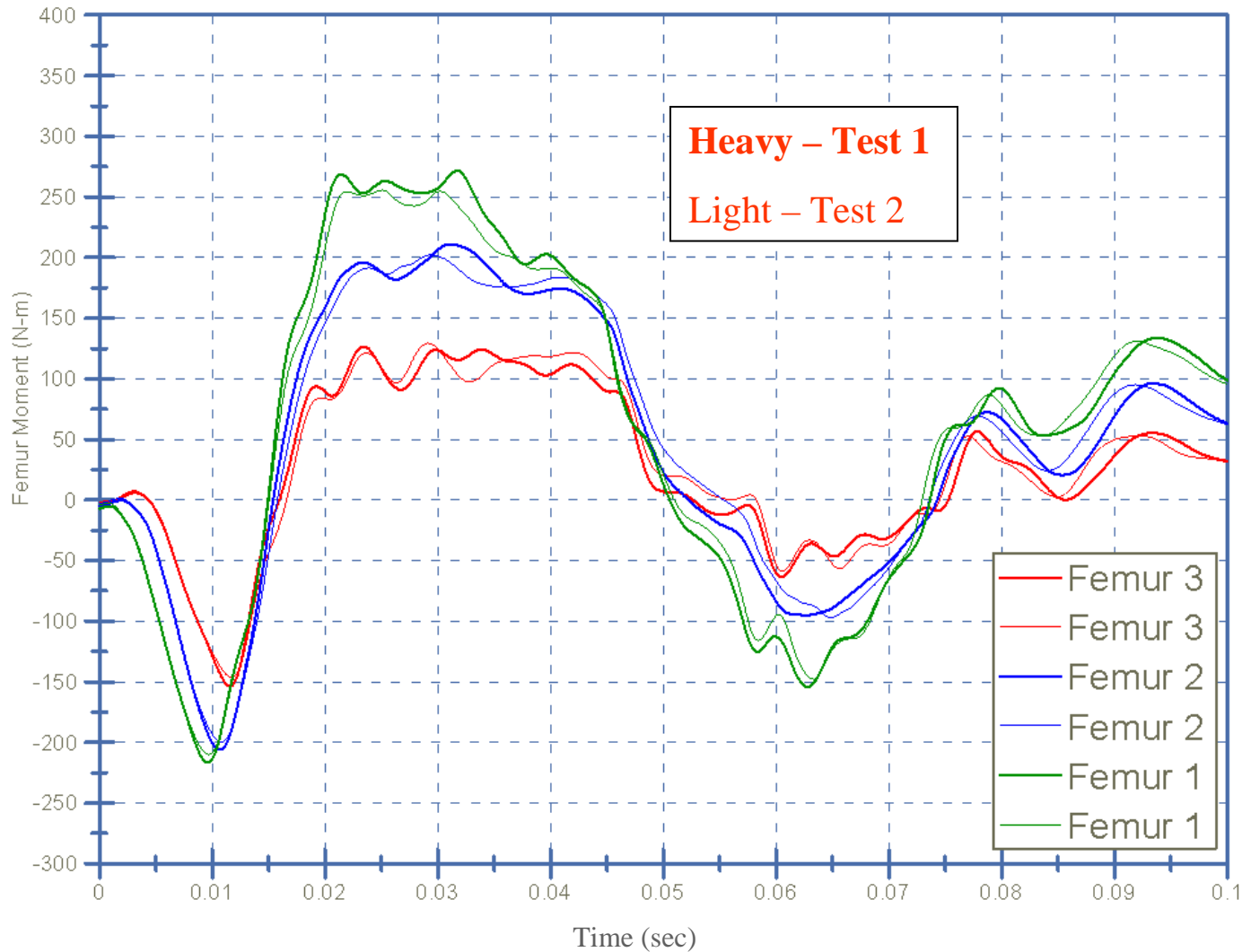## Volkswagen Passat

Repeatability
Volkswagen Passat

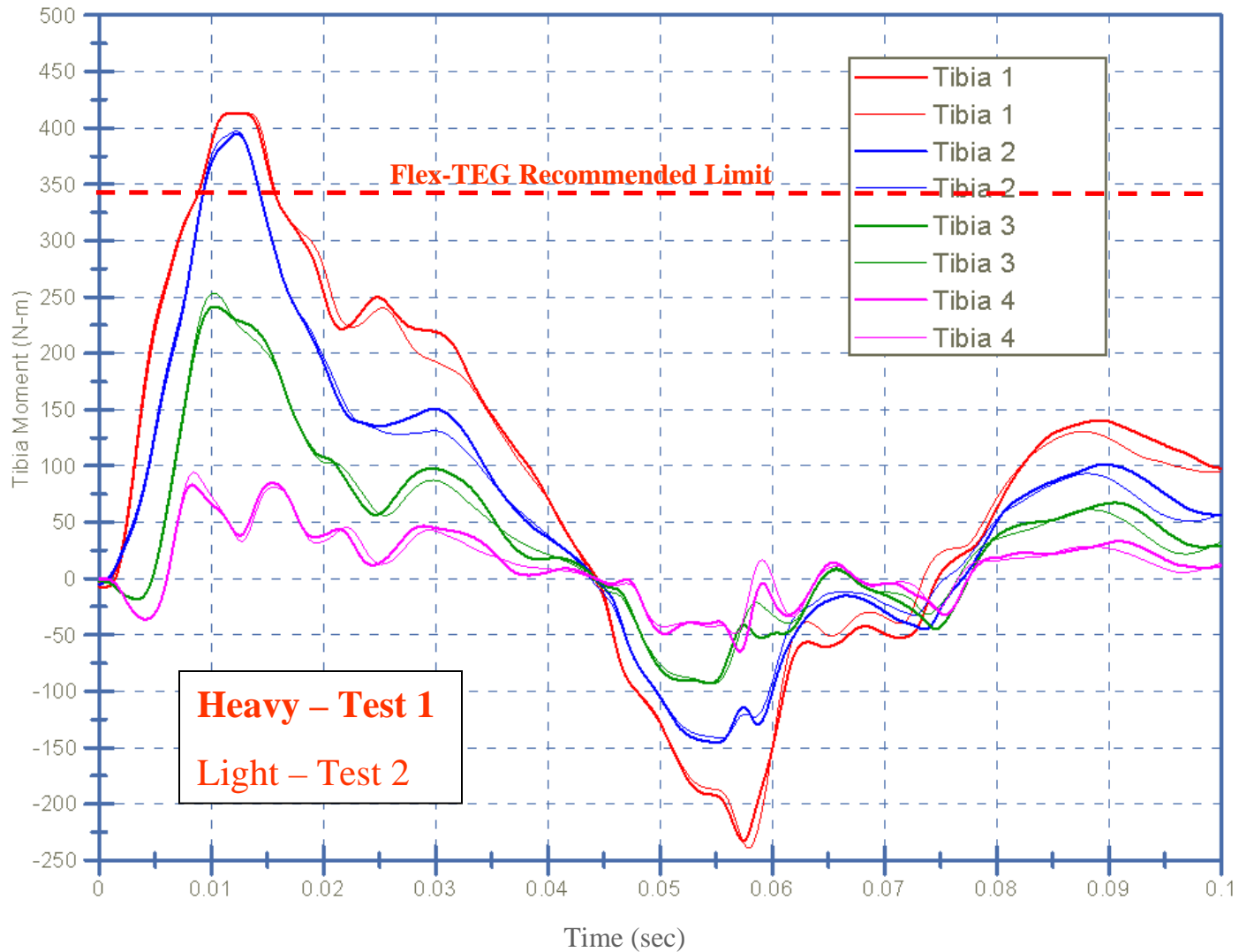# Repeatability
Volkswagen Passat
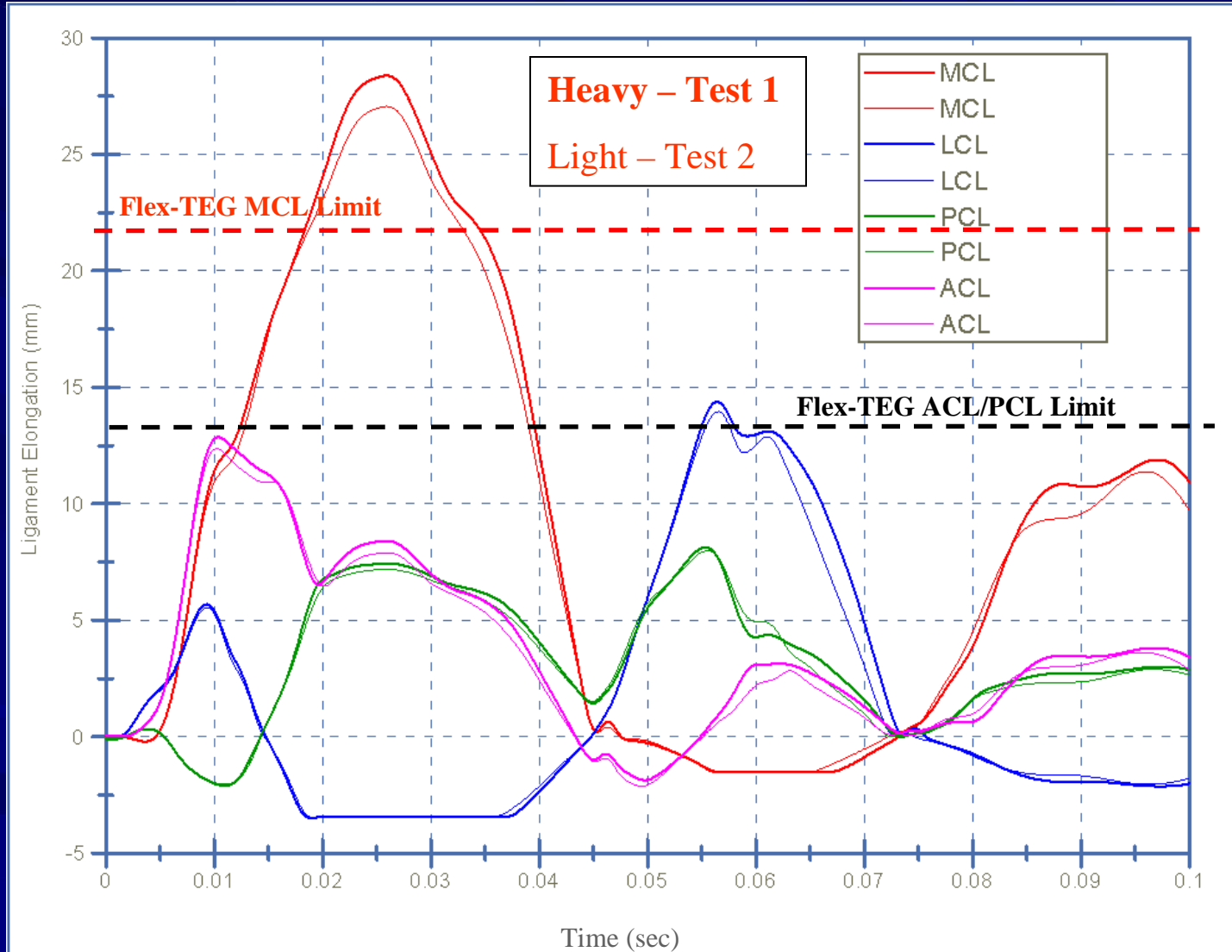
Repeatability
Honda Civic

Repeatability
Honda Civic

Repeatability
Honda Civic

Repeatability
Honda Civic
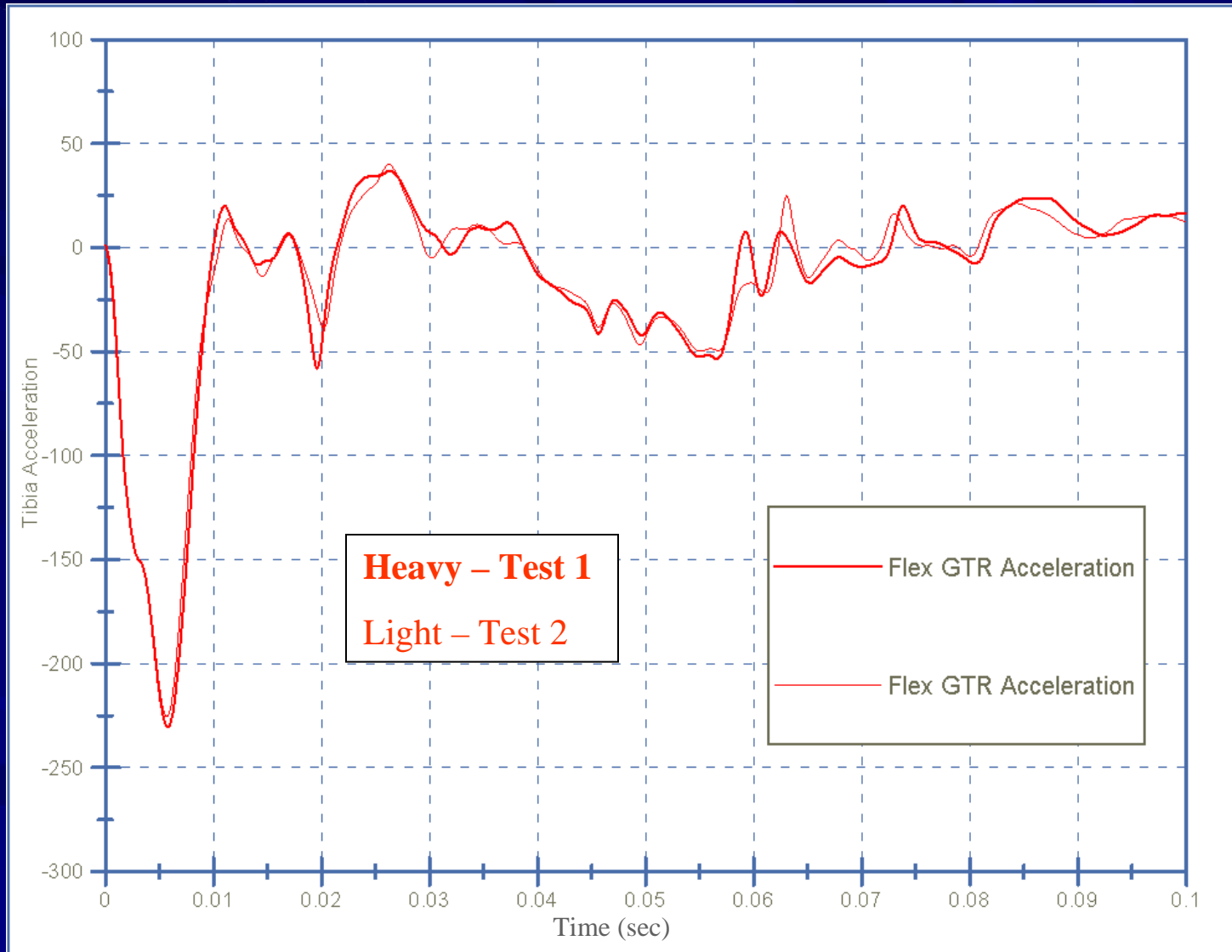
Summary

	TRL Legform			Flex-GTR Legform		
	Tibia Acceleration	Bending Angle	Shear Displacement	Tibia Bending Moment	MCL Elongation	ACL/PCL Elongation
Limit (GTR value for TRL or 9th Flex-TEG recommendation for Flex-GTR)	**170 g**	**19 deg**	**6 mm**	**340 N-m**	**22 mm**	**13 mm**
2005 Honda CR-V	Pass	Pass	Pass	Pass	Pass	Pass
2002 Mazda Miata	Pass	Pass	Pass	Fail	Fail	Pass
2006 Infiniti M35 with Nissan Fuga bumper	Pass	Pass	Pass	Pass	Fail	Pass
2006 Volkswagen Passat	Pass	Fail	Pass	Fail	Fail	Fail (marginal)
2001 Honda Civic	Fail (marginal)	Fail (marginal)	Fail (marginal)	Fail	Fail	Pass (marginal)

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Durability
Flex-GT (2008)
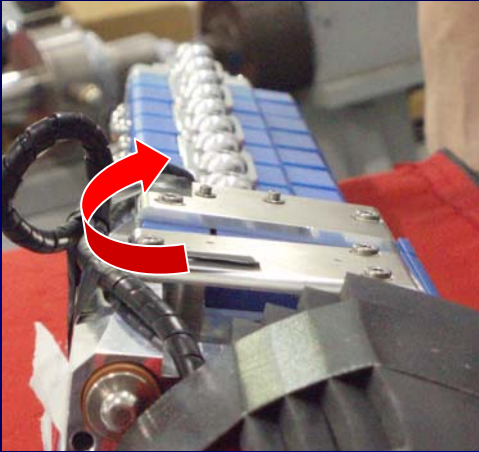
Knee Twist
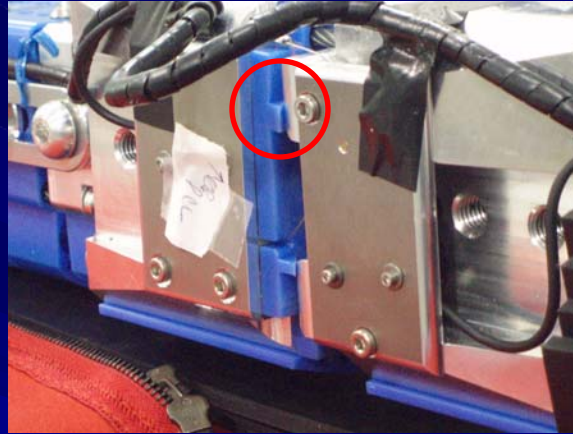
Bent Tabs

Rubber Spacer

Damaged Casings

Seized Bolt/Sleeve

Face Plate Rotation

Durability
Flex-GTR (2009)
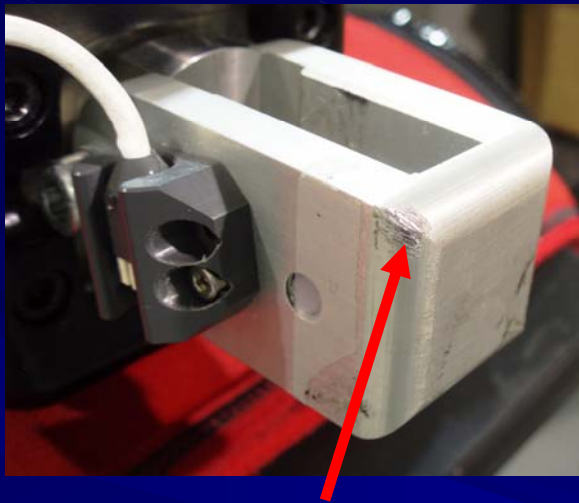
Scuffing but no deformation
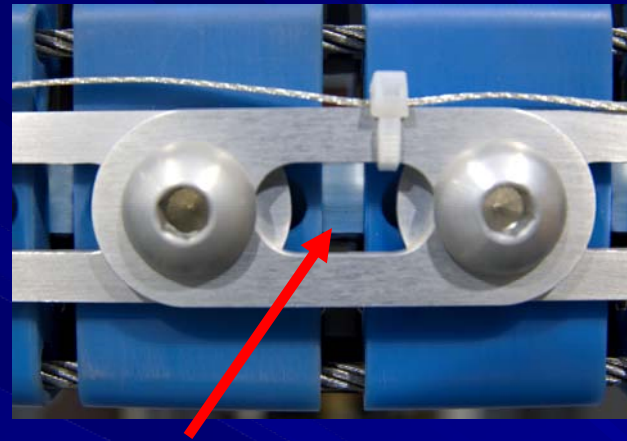
Longitudinal lines looked like material lamination not cracks

Blue segment face detached - easily re-attached

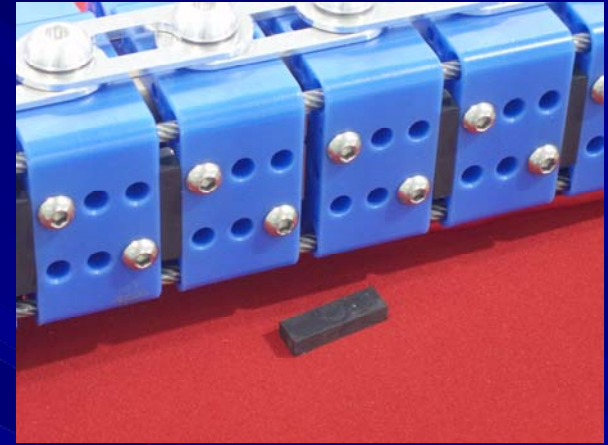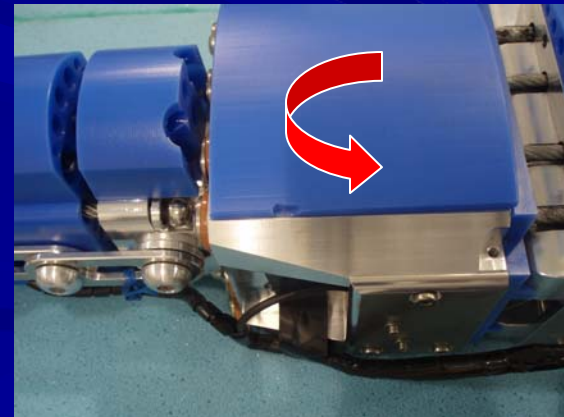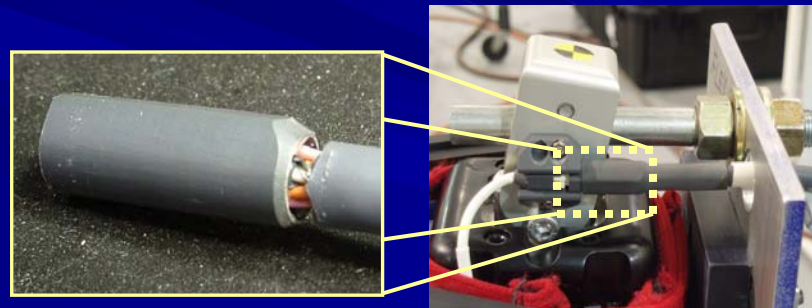Separated cable casing - no data loss

No Functional Damage

Durability Comparison
Flex-GT vs. Flex-GTR

	Flex-GT (2008)	Flex-GTR (2009)
Knee Twist (Needed Manual Fix)	X	
Bent Tabs	X	
Rubber Spacer Fell Out	X	
Damaged Cable Casings	X	
Seized Bolt Sleeves	X	
Broken Zipper Ring	X	
Cut/Pulled Instrumentation Cables	X (sensors)	X (SLICE)
Scuffing of Support Piece		X
Blue Cap Came Off	X (easily replaced)	X (easily replaced)
Longitudinal Lamination Lines on Bone?		Not considered damage (?)

SLICE

Advantages

- Wire-free system improved flight alignment
- Sensor ID streamlined setup
- Contact switch ***concept*** good

SLICE

Functional Issue

- ***<u>However</u>*, contact switch only functional when legform still connected to system**

System connection

Double-tape contact switch

SLICE

Usability Issues (Communicated to FTSS/DTS)

- **Software bugs**
  - Ligament full scale: 20 mm limit (workaround: no offset removal)
  - Viewer: Multiple channels plotted to different scales
  - Export: Cannot export to DIADEM channels with single character units (g)
  - Collection: If connection status monitored up to release, errors occur when disconnected.
  - Software freezes: Needed frequent re-start of software/computer if left without activity for several minutes prior to testing.
- **Ligament polarity inconsistent**
  - LCL, MCL → Elongation (+)
  - ACL, PCL → Elongation (-)

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Summary

- Very good repeatability
  - In two repeat tests, center impact, 5 vehicles
- Improved durability
  - But we have not tested vehicles that were poor performers in TRL legform tests
- SLICE is functional & improvement over conventional DAS
  - But does have some bugs that need to be worked out

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Future Work

- NHTSA still needs to evaluate:
  - Biofidelity
  - Reproducibility (do multiple Flex-GTR legforms produce similar results?)
  - Poorly performing vehicles
  - Larger vehicles (for example, pickup trucks)

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