

# Development of a Surrogate Seatbelt Retractor for Use in Child Restraint Testing

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# Booster Seats in the Field

- Booster seats are used in the field with vehicle production 3-point belts that have shoulder belt retractors.
- Retractor systems spool small amounts of webbing out during a crash event
  - some at initial lock up
  - some due to tightening of webbing spool
  - potentially with load limiting



# Booster Seats in the Lab

- FMVSS No. 213 evaluates booster seat dynamic performance using a static 3-point belt with no spool out
- Booster seat designs could be improved if tested using more realistic belt systems
- Why not use real retractors?
  - Expense
  - Variation among manufacturers
  - Repeatability



# Objectives

Develop hardware and procedures for a surrogate seatbelt retractor for potential use with dynamic evaluation of belt-positioning booster seats



# Commercial Hardware Survey

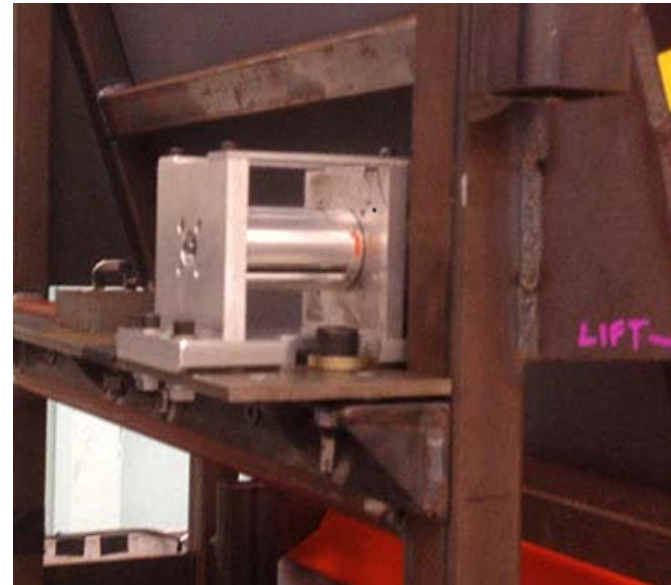
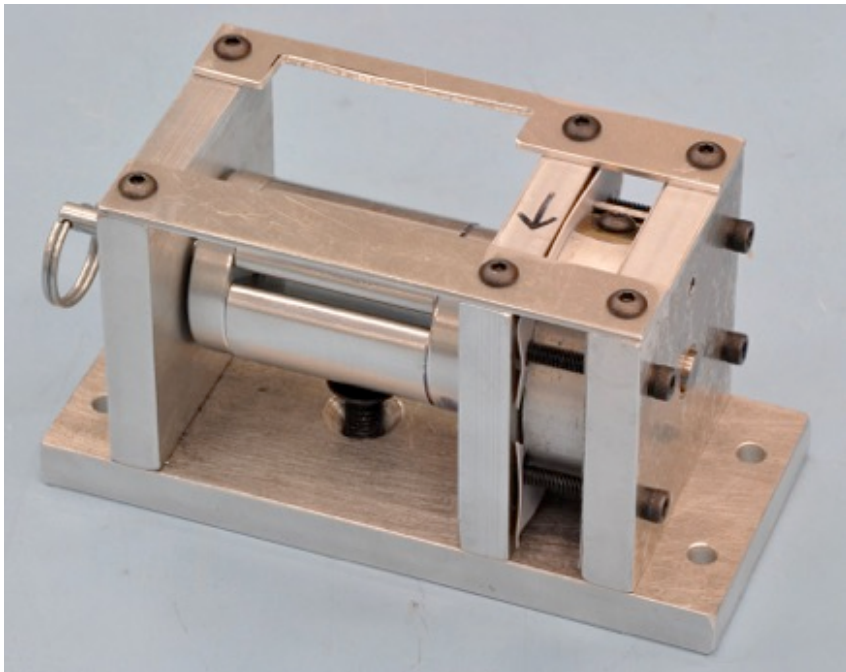
- Measured convenience sample of 20+ UMTRI staff vehicles
- Phone survey of manufacturers
- Determined resting belt tension
- Determined amount of spoolout with belt jerk
- Established targets of 1-2 inches of spool out and 2-4 lbf resting tension





# Surrogate retractor

- Resting tension of 9-14 N
- Spoolout can be adjusted to different levels



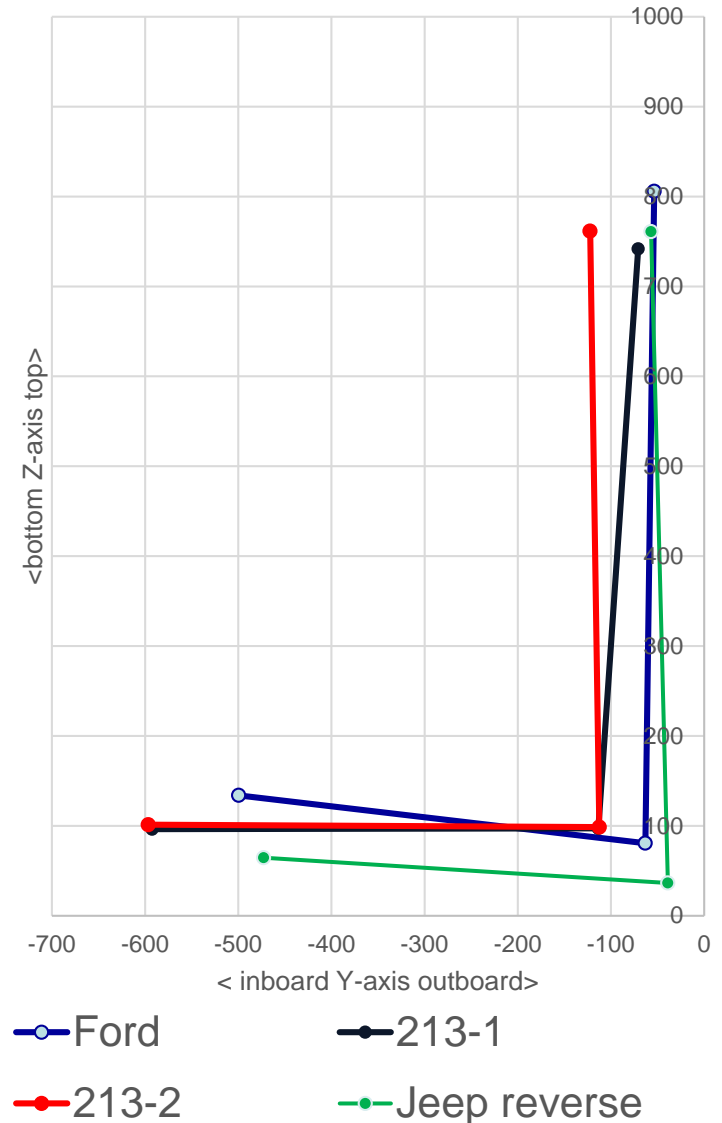
# Test bench

- Drawings from May 17, 2015  
Federal Docket No. NHTSA-2013-0055-0002
- Lower anchors lowered 40 mm
- Back extended upwards 50 mm
- Midway through testing, shoulder belt anchor moved inboard according to the drawings posted in docket NHTSA-2013-0055-0008 (Aug. 25, 2015)



# Vehicle Seats

- Kinematics depend on
  - Vehicle seat stiffness
  - Belt anchor geometry
  - Retractor
- Vehicle systems
  - Ford Explorer
  - Jeep Grand Cherokee





# ATD and Instrumentation

- Hybrid III 6YO ATD
- Instrumentation
  - Head, chest, pelvis triaxial accelerometers
  - Load cells in upper neck, lower neck, lumbar spine, upper and lower ASIS
  - Angular rate sensors in spine and pelvis to measure rotation about y-axis
- Current FMVSS No. 213 seating procedures



# CRS Selection



B1: Graco Turbo booster



B2: Evenflo AMP



B3: Safety 1<sup>st</sup> Incognito



B4: Bubble Bum Inflatable



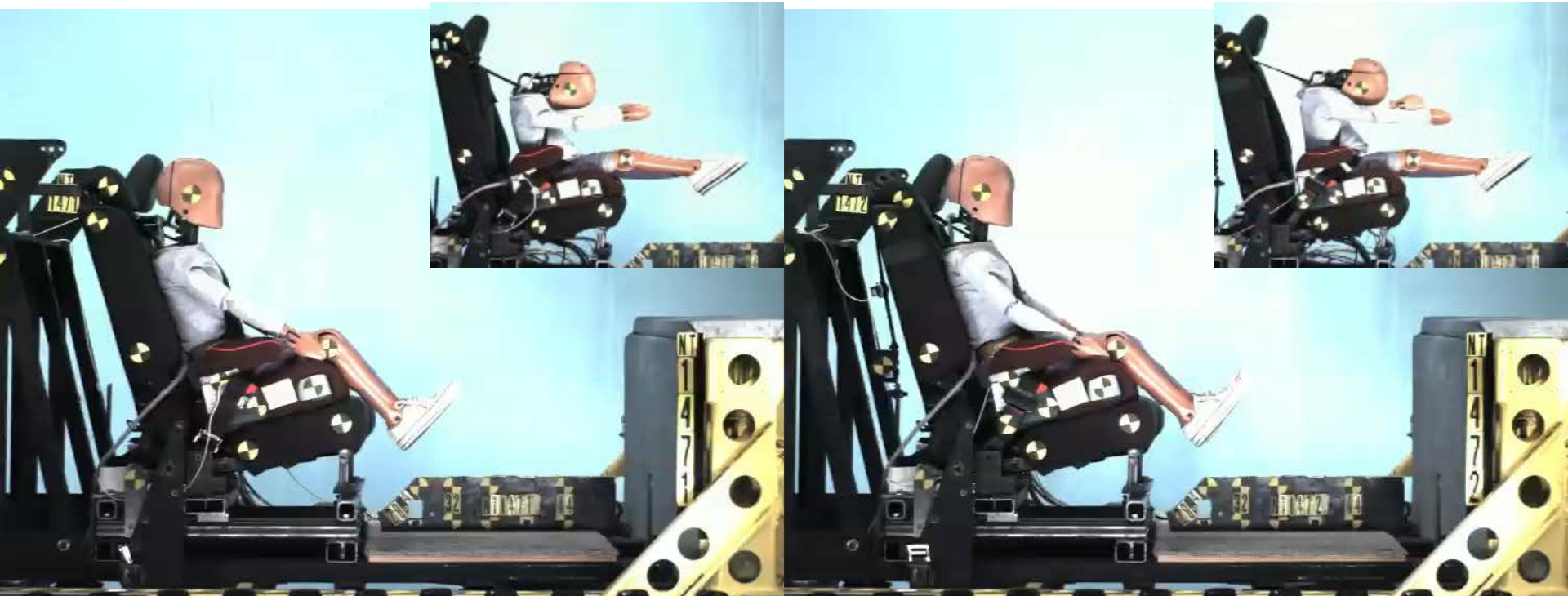
# Sled Test Matrix

Seat	Belt	None	B1	B2	B3	B4
Jeep	Jeep		X		X	
Jeep	Static		X		X	
Explorer	Explorer			X		X
Explorer	Static			X		X
NewBuck	Static	X X	X X	X	X	X
NewBuck	Commercial	X	X X	X		X
NewBuck	Surrogate	X	X XXX	X X	X	XX

Series 1: several tests damaged ATD because of error in shoulder belt anchor location

Series 2: testing run using shoulder belt location included in August 2015 drawing revision that resolved error

# Static vs Production on Vehicle Seats (3 comparisons – 6 tests)

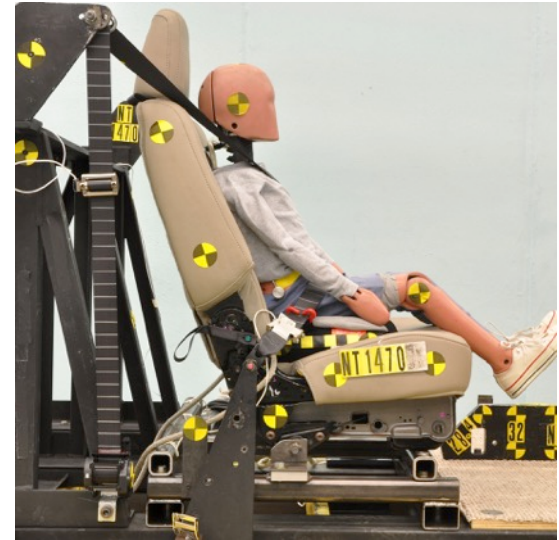


Static Belt produces:

- Higher HIC (up 85), Neck Force (up 148 N)
- Lower Torso Angle (down 20 deg),  
Head Ex (down 55 mm), Knee Ex (16 mm)

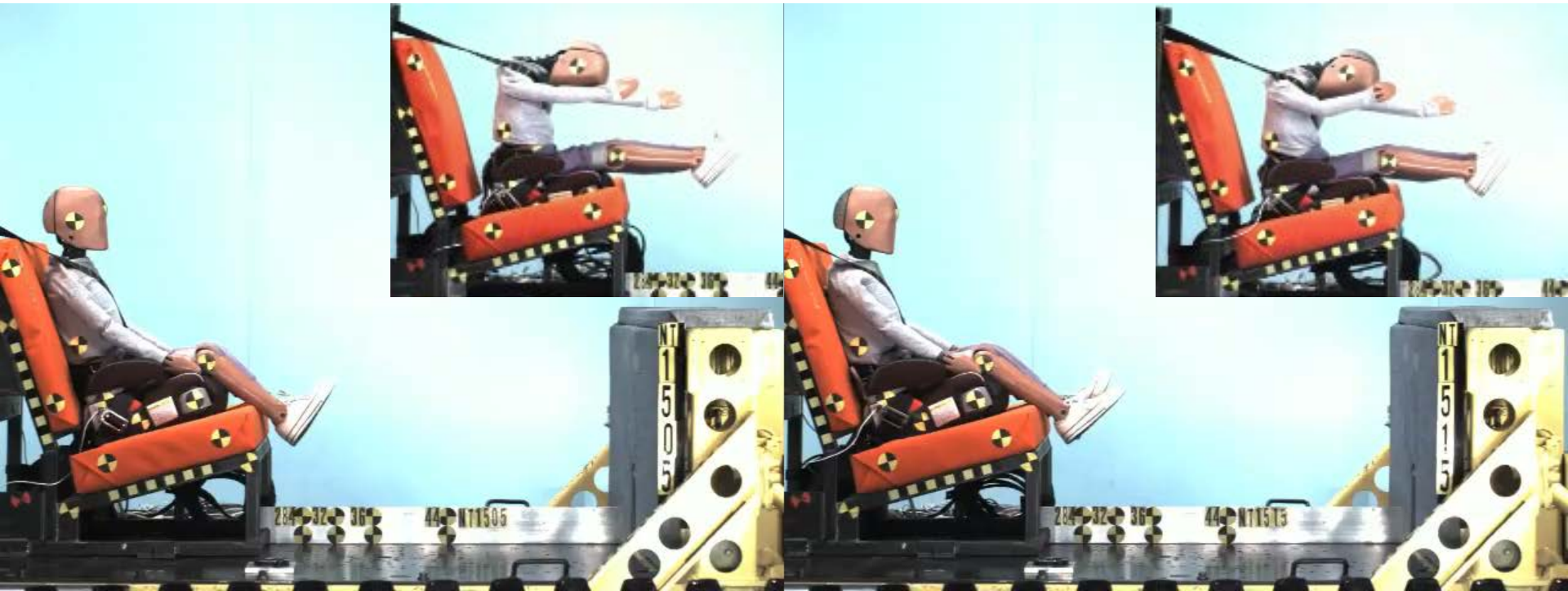
# Vehicle Seats vs. Test Bench

- Compare kinematics between vehicle seat and test bench
  - Static belts
  - Production belts
  - Using same booster
- Preliminary 213 test bench kinematics closer to tests run with Ford seat than Jeep seat
- Design of surrogate retractor tuned to match Ford retractor





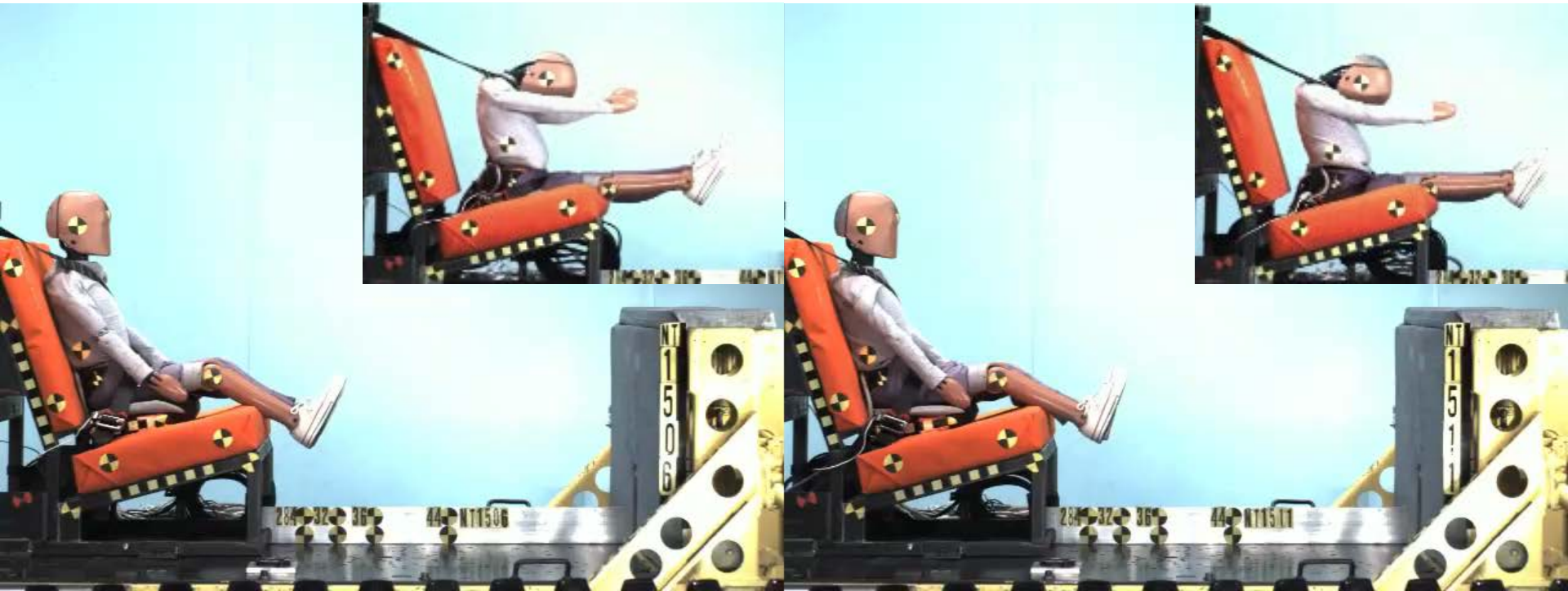
# Comparison of surrogate vs production



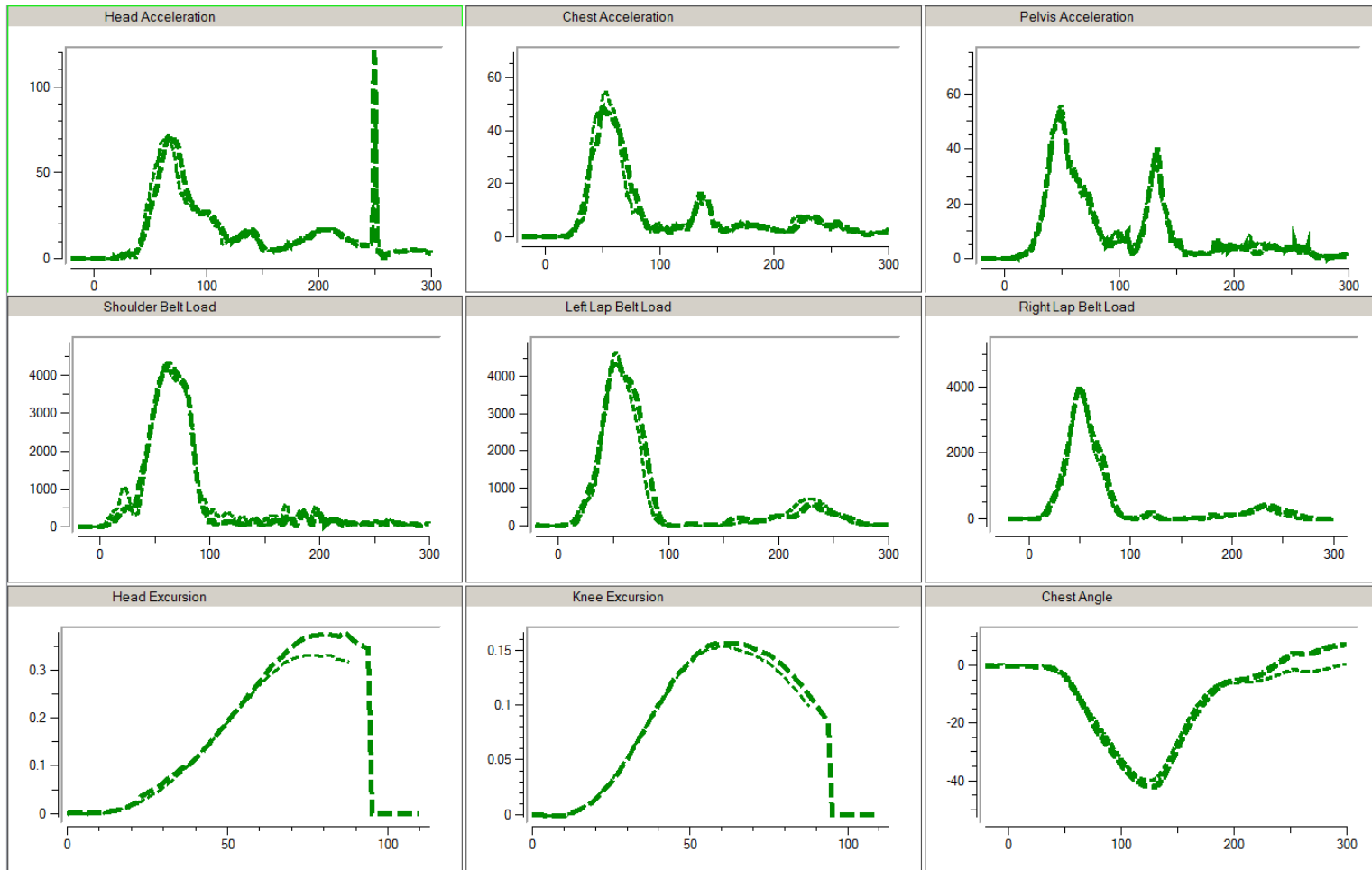
Surrogate Belt produces kinematics similar to production belt:

- Lower HIC (down 11), Neck Force (down 148 N)
- Lower Torso Angle (down 2 deg), Head Ex (down 12 mm), Knee Ex (15 mm)

# Comparison of surrogate vs production



# Comparison of surrogate v production – Booster 1



# Summary and Continuing Research

- Surrogate retractor produces realistic kinematics compared to production belts
- Assess surrogate retractor performance with a greater range of booster seats, including high back boosters
- Assess durability of surrogate retractor using Hybrid III 10YO
- Assess repeatability of surrogate retractor



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Thank you for your attention.