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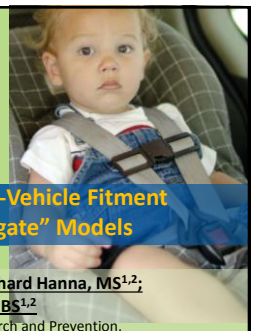

Quantifying CRS-to-Vehicle Fitment - "Virtual Surrogate" Models

Aditya Belwadi, PhD[1]; Richard Hanna, MS[1,2]; Evan Bisirri, BS[1,2]

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Then and Now: Looking Forward
Saturday, April 2nd 2016, Long Beach CA

"Technical solutions" for rear seat

- During 2012, there were a total of 33,561 traffic fatalities in the United States (Traffic Safety Facts, NHTSA)
- Children 14 and younger accounted for 1,168 (3%) of those traffic fatalities
  - About 70% of rear seat occupants are children
- How can we optimize rear seat for its most common occupant – Children?
  - Continue to improve vehicle-to-CRS fitment in the rear seat

"There is great opportunity for the United States to further reduce child occupant injury and death by focusing on the rear seat safety design."
--CPS Issue Report: Optimizing the Rear Seat for Children, April 2013

Background

- Car Seat and Vehicle Compatibility issues contribute to misuse of car seats by caregivers
- Simply fitting a car seat into the vehicle can sometimes be a challenge
- Consumers seldom purchase their vehicle and car seat at the same time

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Background

- When optimizing the design of the rear seat environment, vehicle manufacturer's must balance the following items with CRS accommodation:
  - occupant protection
  - spaciousness
  - comfort and appearance
  - regulations and consumer metrics
  - industry standards (e.g. SAE)

- It is important to understand the range of CRS dimensions so that this balance can be even more successfully negotiated

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Background

- Assess fit of Virtual car seat "fixtures" like SAE J1819
  - An envelope developed to improve fitment of car seats using seat belts
  - Does not include LATCH attachments
  - Does not represent the real shape, footprint or volume of current CRSs

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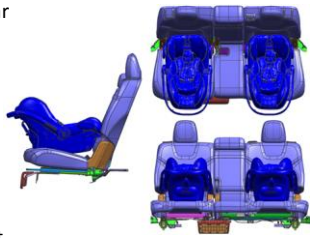
Current Compatibility Assessments

Assess fit of Scanned Car Seats

- Cannot model every available car seat
- Vehicle manufacturer access to car seat models is limited
- Does not insure that future car seats will fit



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Current Compatibility Assessments

Test Physical Car Seats in Vehicles

- Difficult to determine representative car seat samples
- Time consuming process
- Does not insure that future car seats will fit in vehicles

Average U.S. -- 280 vehicles X 290 CRSs = 81,200 Combinations

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Research Question / Aims

How can we collectively establish and better define requirements upfront, early in the design process, to better optimize CRS/Vehicle interfaces to improve CRS fitment and ease of installation?

The specific aim of this line of research is

"To develop virtual surrogate models of Rear Facing, Forward Facing and Booster Child Restraint Systems"

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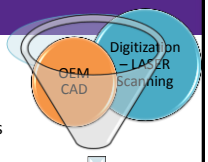
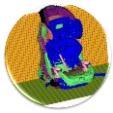
Methods

- **Step 1:** Scan and digitize a selection of CRSs
  + CAD models from CChIPS CRS members (Evenflo, Britax, and Graco CRSs)
- **Step 2:** Use established digitization techniques to quantify the overall geometric footprint of CRSs
  – Virtual Surrogate



Virtual Surrogate



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Scanning and Reconstruction Microsoft Xbox Kinect Sensor

- Xbox Kinect
  - Motion sensing input device by Microsoft for the Xbox Console

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Scanning and Reconstruction

- CRSs installed as per recommendations
- Setup on a flat table
- Cup holders/LATCH
  - Not retracted
- Scanned in their smallest and largest configurations
  - Eg: Head rest pulled out

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Child Restraints Included

- Comprehensive list from www.healthychildren.org
  - Infant seats
  - Convertibles
  - Forward Facing
  - Combination
  - High Back Booster
  - Low Back Booster

291 CRSs Represented - as of Jan 2016

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Development of the Small RF Virtual Surrogate

- More than one "size" of Rear Facing Car Seat model has been developed – Small, Medium, Large
- First model was the "small size" which would be expected to fit into the smallest motor vehicles
- CRSs Selected to Represent Small Size Rear Facing Car Seats
  1. Britax B-Safe
  2. Comfy Carry
  3. Graco Snugride

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Steps to create the Model

- Overlay the group of child seats
  - Match up their rear-most point
  - Include a range of position angles
  - Center the seats over one another
- "Shrink Wrap" the models to get a generic envelope
  - Simplify the shape by "filling in" areas in the volume that don't affect fit in the vehicle

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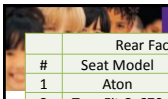
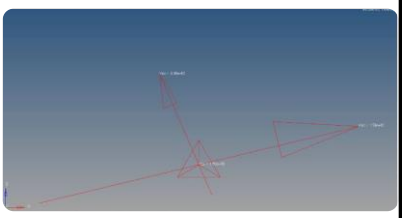


	Rear Facing CRS	
#	Seat Model	Manufacturer
1	Aton	Cybex
2	True Fit C_670	The First Years
3	Flex Loc	Baby Trend
4	Mia Moda	Dream on Me
5	Peg Perego SIP 30/30	Peg Perego
6	Peg Perego SIP 5/70	Peg Perego
7	Via Lamaze L470	The First Years
8	T-Tario 35	Teutonia
9	Foonf	Clek
10	Anti Shuttle Rebound	Combi
11	Keyfit 30	Chicco
12	Bsafe	Britax
13	Chaperone	Britax
14	Comfy Carry	Dorel
15	Comfortsport	Graco

	Rear Facing CRS	
#	Seat Model	Manufacturer
16	Embrace	Evenflo
17	My Ride	Graco
18	Snug 22	Graco
19	Secure Ride	Evenflo
20	Symphony	Evenflo
21	HWY	Britax
22	Roundabout 50	Britax
23	Titan	Evenflo
24	Aquos	Dorel
25	Alpha Elite	Dorel
26	Scenera	Dorel
27	Sure Ride	Evenflo
28	Tribute	Evenflo
29	Triumph	Evenflo
31	Alpha Omega	Dorel
32	Comfortsport	Graco
33	Doona	Simple Parenting

Development of the Virtual Surrogate Example : Rear Facing CRSs

- Seat Back Angle – 110°
- Seat Pan Angle – 13.5°
  - Angles consistent with data from published literature
  - Reed et al. 2004, 2008 (UMTRI)



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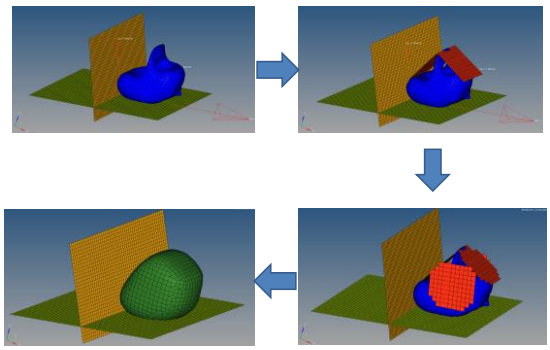

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CChIPS - Virtual Surrogates for CRS-to-Vehicle Fitment

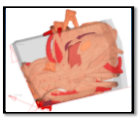

Fig. 1: Smallest RF Surrogate

Fig. 2: Largest RF Surrogate

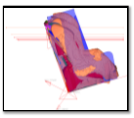

Fig. 3: Smallest FF Surrogate

Fig. 4: Largest FF Surrogate

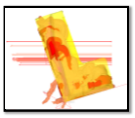

Fig. 5: HBB Surrogate

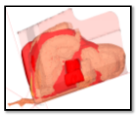

Fig. 6: LBB Surrogate

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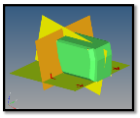
CChIPS - Virtual Surrogates for CRS-to-Vehicle Fitment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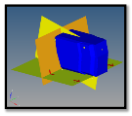
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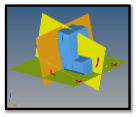
Fig. 3: Smallest FF Surrogate

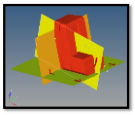
Fig. 4: Largest FF Surrogate

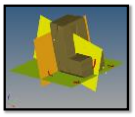
Fig. 5: HBB Surrogate

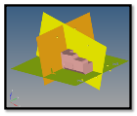
Fig. 6: LBB Surrogate

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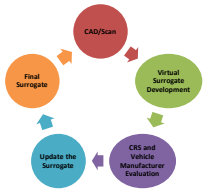
Vehicle and Child Seat Manufacturers' Evaluation

Evaluation material consisted of

1. FE Model of the Rear Facing Surrogate
2. Surface model (CAD)
3. PowerPoint Presentation
4. Material Transfer Agreement / Feedback Form



We thank all the vehicle and CRS manufacturers for their detailed feedback/input on the virtual surrogate models

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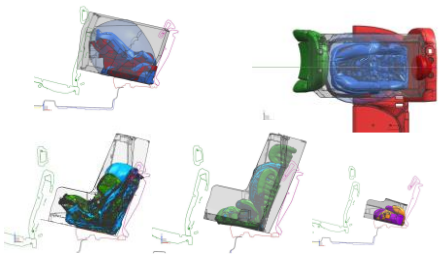
Manufacturer's Evaluation Summary 1)Virtual Installations Sub-Compact Sedan



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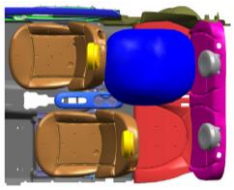
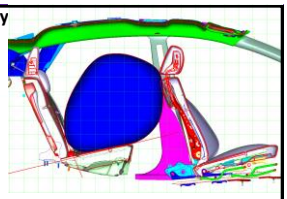
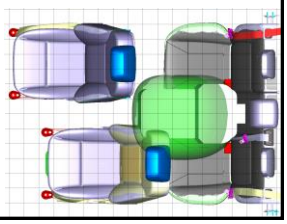
Manufacturer's Evaluation Summary
1)Virtual Installations
Sub-Compact Sedan



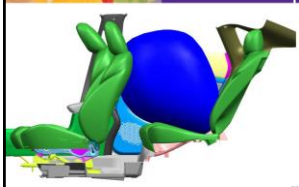
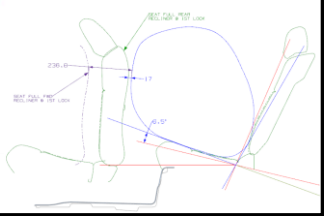
Manufacturer's Evaluation Summary
2) Physical Installations
Sub-Compact Sedan

Graco Infant Seat - Rear Outboard Position

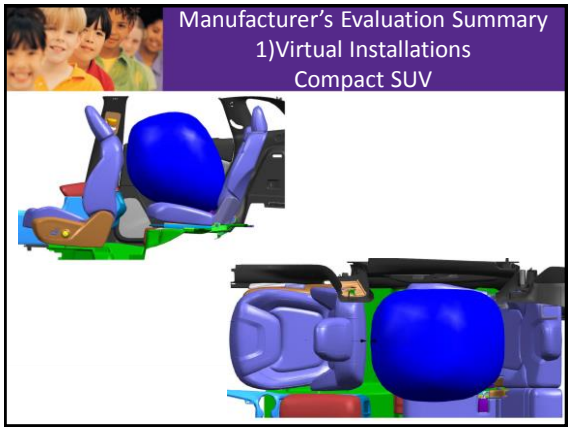
Britax Infant Seat - Rear Outboard Position

Safety First Infant Seat - Rear Outboard Position

Manufacturer's Evaluation Summary
1)Virtual Installations
Compact Passenger Car


Manufacturer's Evaluation Summary
2) Physical Installations
Compact Passenger Car Evaluation
Graco Infant Seat – Rear Outboard Position
(Driver)
Britax Infant Seat – Rear Outboard Position
(Driver)
Safety First Infant Seat – Rear Outboard Position
(Driver) – Bottom Raised to Level


Manufacturer's Evaluation Summary
1)Virtual Installations
Compact SUV


Manufacturer's Evaluation Summary
2) Physical Installations
Compact SUV Evaluation
Graco Infant Seat – Rear Outboard Position
Britax Infant Seat – Rear Outboard Position
Safety First Infant Seat – Rear Outboard Position

Conclusions

- 102 CAD models, representing 291 CRSs in the market as of Jan 2016, scanned
  - This process was made possible by the unique pre-competitive relationship afforded by CChIPS
- Evaluated in Detail by Manufacturers (Vehicle and CRS)
- Six CRS surrogate models developed
  - RF (2), FF(2), HBB (1) and LBB (1)

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What's Next

- Work-in-progress
  - Finalizing the volumes –shapes, details, naming, Vehicle manufacturers, Child Seat Manufacturers, Consumer Reports
  - To integrate these surrogate models early in their design cycle → as an example: 2018, 19 model year onwards
  - Interior design optimization

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Industry Relevance / Conclusions

- Largest CRS Digitization study ever conducted in the U.S.
- The line of work will help define the CRS-Vehicle fitment characteristics for future makes/models
- Helps reduce a significant amount of physical installations and evaluations thus saving time and costs
- *Enabling better CRS-to-vehicle fitment to the end consumer!*

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Action for CPS Techs?

- **Stay current with the research**
  - **–Injury.research.chop.edu**
    - Subscribe to *Research in Action* Blog
  - **–Cchips.research.chop.edu**

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Acknowledgements

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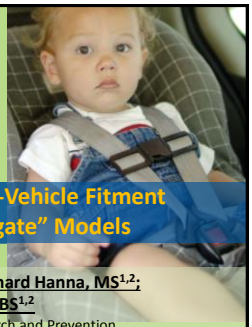

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