Advanced Car Seating Restraint Systems

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Project Description

This project, proposed through OSU's Center for Automotive Research & Intelligent Transportation (CAR-IT) and funded by NHTSA seeks to:

- improve the convenience, effectiveness and use of restraint systems (seat belts) in cars and light trucks.
- emphasis is on belt systems integrated into seats, but does include the evaluation and design of alternative restraints and seating, both ergonomically and structurally.

The interdisciplinary research team began working in Autumn 03
- delivered its findings, recommendations, and
- concepts in Spring 05, plus
- conducted tests of the concepts until Spring 07

Briefings by representatives from NHTSA and VRTC at the Vehicle Research and Test Center in East Liberty, Ohio, clarified the agencys' primary interests and objectives in regard to approach and expectations (e.g deliverables).

Research Overview of Completed Phases

1.0 Pertinent Context and Synergetic Effects

2.0 Project Structure and Approach

3.0 Design Concept Generation & Evaluation

4.0 Design Studies

5.0 Assessment and Pursuit of Selected Concept(s)

6.0 Pilot Testing

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2.1 Findings Based on Reference Material & Provided Studies

2.1.3 Rana Balci and Aicia Vertiz, Delphi Automotive Systems (SAE)
Comfort and Usability of the Seat Belts, SAE 2001 World Congress Detroit, Michigan
Problems:
- seat belt trapping in the door
- awkward negotiation with clothes
• belt twisting
- belt locking up
• difficulties to locate the buckle
- 40+ (age) drivers have more complaints than younger drivers
- 55+ (age) pulling force too strong
- 55+ (age) inappropriate & loose fitting
- females have more complaints than males
- short statured drivers need both hands to pull & guide the retracting of the belt
- over 66th perc. in terms of their weight: complaints about belt twisting
- the coupe type of vehicles have the least comfortable seat belts
- the most comfortable seat belts are found in sedan & SUV type vehicles

2.1.4 Motor Industry Research Association, 1981
Areas of improvement:
- 84% were dissatisfied with one or more ergonomic aspects of the sb design
• location & accessibility of the buckle
- the levels of retraction forces
- perceptiveness to webbing extraction
- susceptibility of webbing tangling & twisting
> Conclusion: Designers need criteria for ergonomic design of the seat belts!

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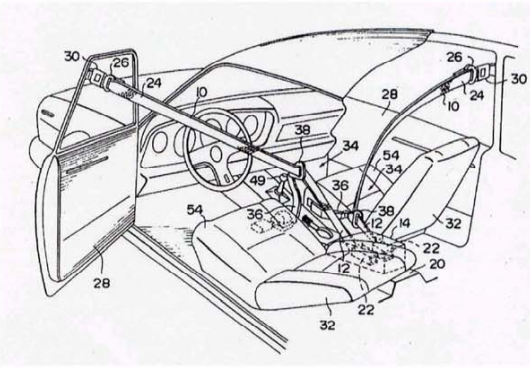
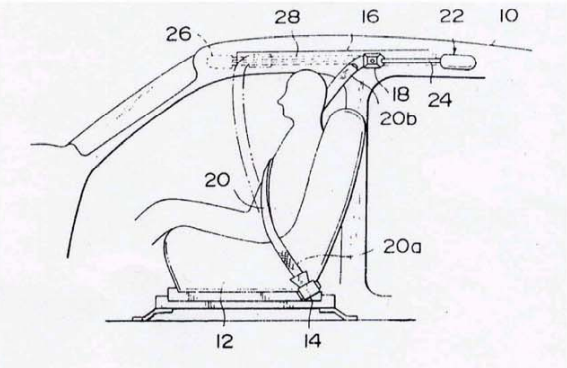
2.2 Patent Research of Seat Restraint Systems

2.2.2 Search Results

Example of door mounted shoulder strap design



Example of frame mounted retractable shoulder strap design



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2.3 Selected Conceptual Car Seat Design Examples

2.3.1 Salon Geneva 2002 to Detroit 2004

Restraint systems are typically either conventional, or afterthoughts, or even totally neglegted.

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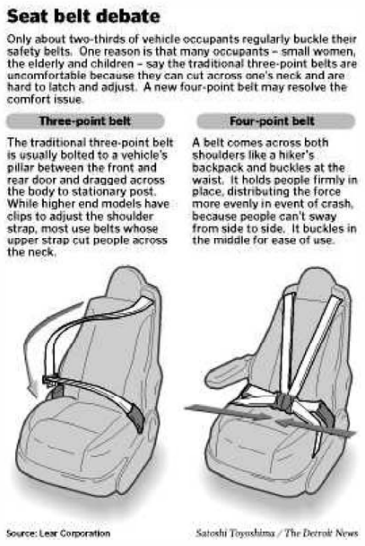
2.3 Selected Conceptual Car Seat Design Examples

2.3.3 Experimental Harness Solution by Suppliers



Lear Corp.

http://www.ezonpro.com/boy.jpg

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2.4 Examples of Related Seat Restraint Systems

2.4.2 Coasters and Joy Rides

Shoulder restraint

Lab restraint

Full body restraint

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2.5 Initial Attempt to Establish Design Criteria

2.5.1 User Profiles

Considerations to be extended to include more than typicals and ideals in terms of:

Range ◄——————————►

Gender	Male			Female
Hight	Short	Below Average	Above Average	Tall
Weight	Obese	Heavy	Average	Skinny
Body Types	Athletic			Pyknic
Age	Elderly	Middle Aged		Young
Condition	Fully Abled	Temporarily “Impaired”		Impaired

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2.5 Initial Attempt to Establish Design Criteria

2.5.3 Realities of Seat Belt Use



Affect of clothing and other factors on access and reach of restraint system buckles



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2.5 Initial Attempt to Establish Design Criteria

2.5.4 Preliminary List of Considerations, Issues and Factors
(Not in terms of importance)

- Integration into seat to eliminate dependency on vehicle structures (e.g. B-pillar)
- Independent function from airbag systems
- Consideration of driver's familiarity with popular systems (MAYA)
- Adjustability to major variations of driver size, body types, etc.
- Avoidance of "punishment" in favor of gentle reminders
- Ease of accessability of handles (tongue and buckle)
- Avoidance of webbing twisting and tangling
- Consideration of full range of accident dynamics (e.g. side impact)
- Optimizations of wearing comfort (e.g. extreme climatic conditions)
- Simplicity and reliability of engineering design
- Unobstructed egress and ingress
- Self-evidence of interaction with the system
- One-step operation of the entire system
- etc.

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3.1 Belt Restraint System Addressing Lower Buckle Access

3.1.0 Evaluation of Conceptual Solutions

Outside,
interference with clothing

Outside,
interference with obesity and clothing

Inside,
interference with center console

Advanced Seating Restraint System Development

3.1 Belt Restraint System Addressing Lower Buckle Access

3.1.6 Ideation of Concept Principle 6

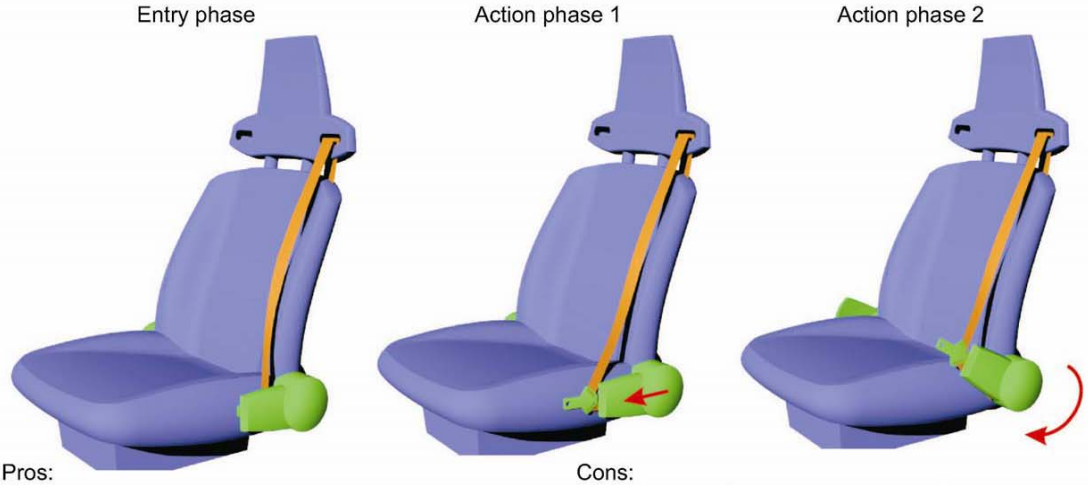
Pros:
- Seat belt upper part & head rest adjustability in one

Cons:
- Search for location of tongue
- Uncomfortable location of D-ring
- Restriction of sight

Advanced Seating Restraint System Development

3.1 Belt Restraint System Addressing Lower Buckle Access

3.1.7 Ideation of Concept Principle 7



Pros:
- Easy ingress
- Convenient reach of activated lab presenter
- Head rest and D-ring adjustment in one

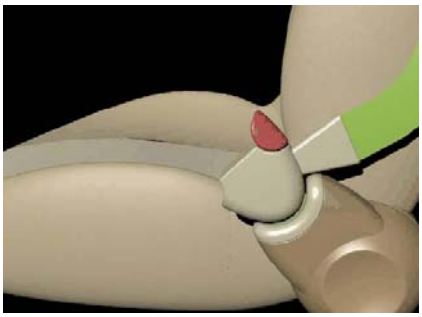
Cons:
- Possible interference with loose clothing
- Added overall width requirement
- Strong head rest mount needed

Advanced Seating Restraint System Development

3.1 Belt Restraint System Addressing Lower Buckle Access

3.1.7 Animation Based on Concept 7





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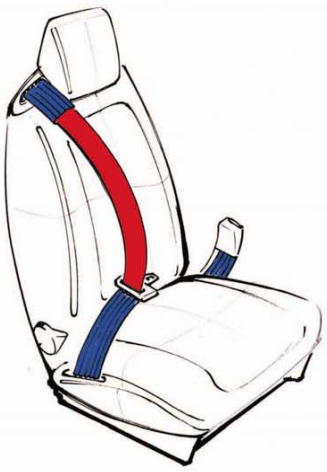
3.1 Belt Restraint System Addressing Lower Buckle Access

3.1.9 Ideation of Concept Principle 9


Pros:
• Inflatable and retractable belt presenter sections

Cons:
• Requires air compressor and special webbing

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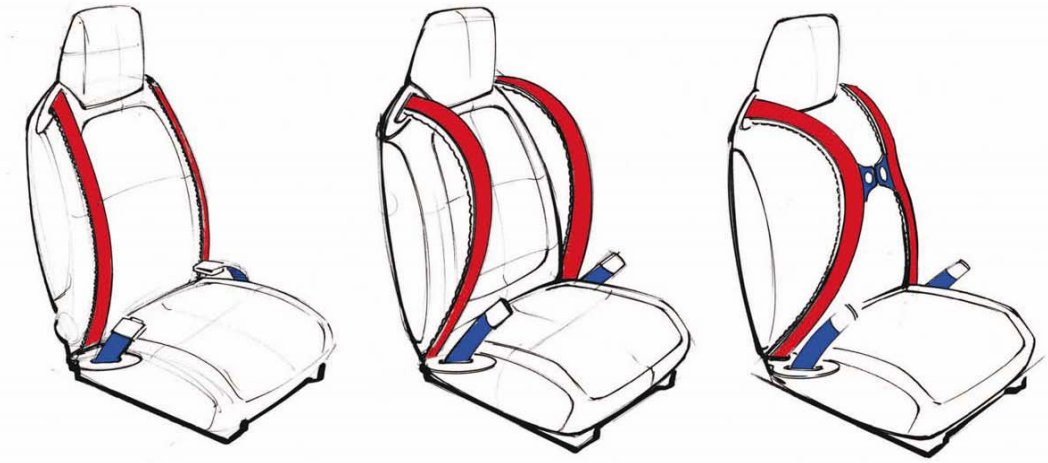
3.1 Belt Restraint System Addressing Lower Buckle Access

3.1.10 Ideation of Concept Principle 10



Pros:
- Inflatable and retractable belt presenter sections
- Enhanced applying function

Cons:
- Requires buckling in two steps

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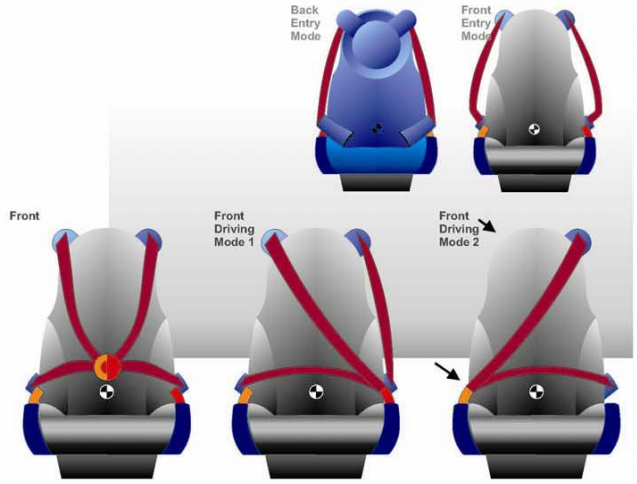
3.1 Belt Restraint System Addressing Lower Buckle Access

3.1.11 Ideation of Concept Principle 11



Pros:
- 3 different modes of belt application (4-point, 3-point left, 3-point right)

Cons:
- Complex buckle design
- Not self-evident

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3.2 Belt Restraint System Addressing Upper Buckle Access

3.2.0 Evaluation of Conceptual Solutions



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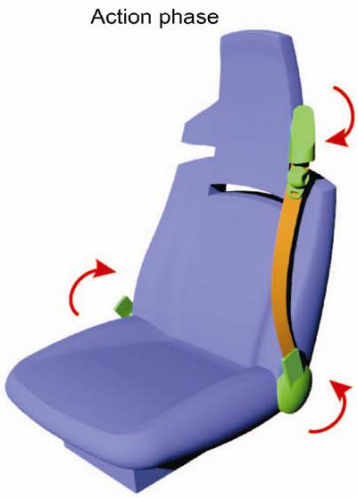
3.2 Belt Restraint System Addressing Upper Buckle Access

3.2.1 Ideation of Concept Principle 13



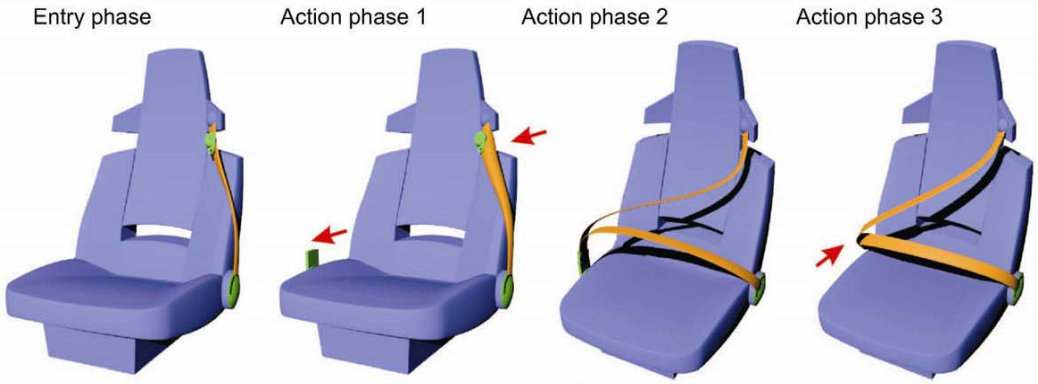
Pros:
- Easy ingress
- Convenient buckle location
- Subtle reminder

Cons:
- Forces management because of flapping headrest mounted ‘presenter’
- Lack of guidance for vertical head rest movement

Advanced Seating Restraint System Development

3.2 Belt Restraint System Addressing Upper Buckle Access

3.2.2 Ideation of Concept Principle 14



Pros:
- Stationary ear section (minimized structural issues)
- Elongated back support
- Inflatable webbing (for easy grip)

Cons:
- Varying adjustment of backrest sections (see anthropometric diagram)

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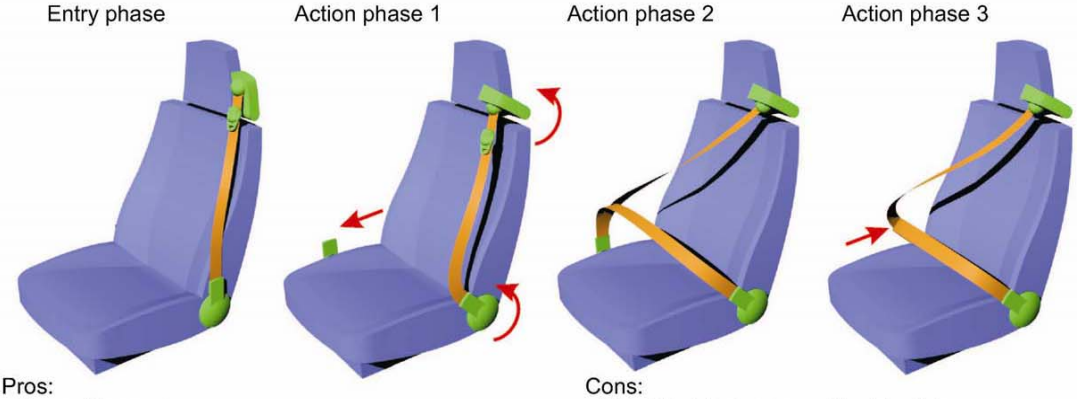
3.2 Belt Restraint System Addressing Upper Buckle Access

3.2.3 Ideation of Concept Principle 15a



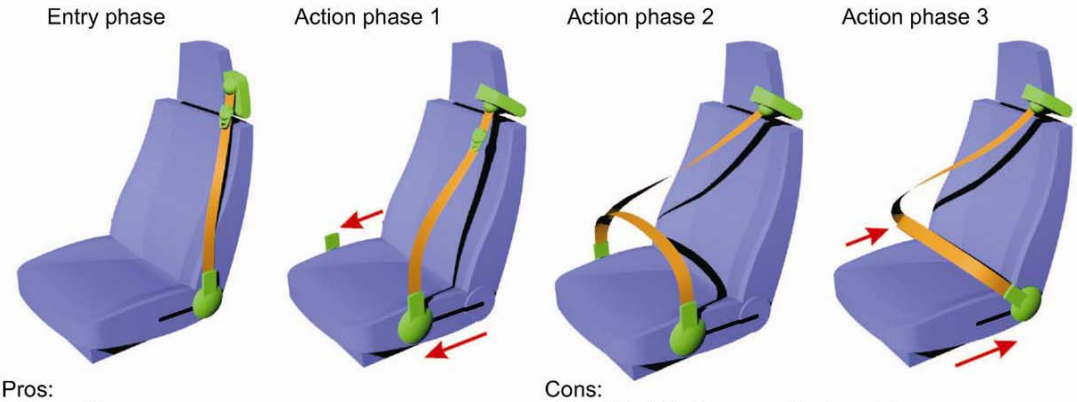
Pros:
- Ease of ingress
- Convenient buckle location
- Subtle reminder
- Convenient lower presenter location

Cons:
- Possible interference with side vision
- Forces management because of rotating headrest mounted ‘presenter’ & sliding seat mounted presenter

Advanced Seating Restraint System Development

3.2 Belt Restraint System Addressing Upper Buckle Access

3.2.4 Ideation of Concept Principle 15b



Pros:
- Ease of ingress
- Convenient buckle location
- Subtle reminder
- Convenient lower dual presenter location

Cons:
- Possible interference with side vision
- Forces management because of rotating headrest mounted 'presenter' & sliding seat mounted dual presenter

5.1.0 Focused research of crucial concept components:

To recap the reasons for the selection of the pursued concepts the following parameters were briefly discussed:

- Lap presenters
- Belt configuration and buckling
- Headrest with integrated D-rings
- Ergonomics of seat contours

A breadboard model demonstrated the basic configuration, dimensions, and mechanical functions of the four above listed features.

The model was to be further refined, finished, and photographically documented for future presentations, and/or the report.

5.2.1 Principal lap presenter solutions

Concept 1 - curved sliding pusher

Presenter/buckle in position for easy access and egress

Presenter/buckle in position for easy reach

5.2.1 Principal lap presenter solutions

Concept 1 - curved sliding pusher

Initial assessment of buckling procedure (with ca. 95 percentile user)

1

2

3 >>

5.2.1 Principal lap presenter solutions (continued)
Concept 1 - curved sliding pusher

Initial assessment of buckling procedure (with ca. 95 percentile user)

>> 4

5

6 >>

5.2.1 Principal lap presenter solutions (continued)
Concept 1 - curved sliding pusher

Initial assessment of buckling procedure (with ca. 95 percentile user)

>> 7

8

9

5.2.1 Principal lap presenter solutions

Concept 3 - pivoting arm

Optional concept based on mechanically simple non-sliding action

Horizontal resting position (vertical belt hindering accsess/egress)

Vertical resting position (vertical belt twisting problem)

5.2.2 Headrest with integrated or synchronized D-rings

Concept 1 - fully integrated D-rings

D-rings positioned in adjustable headrest allow for optimal location regardless of users' height

e.g. tall male

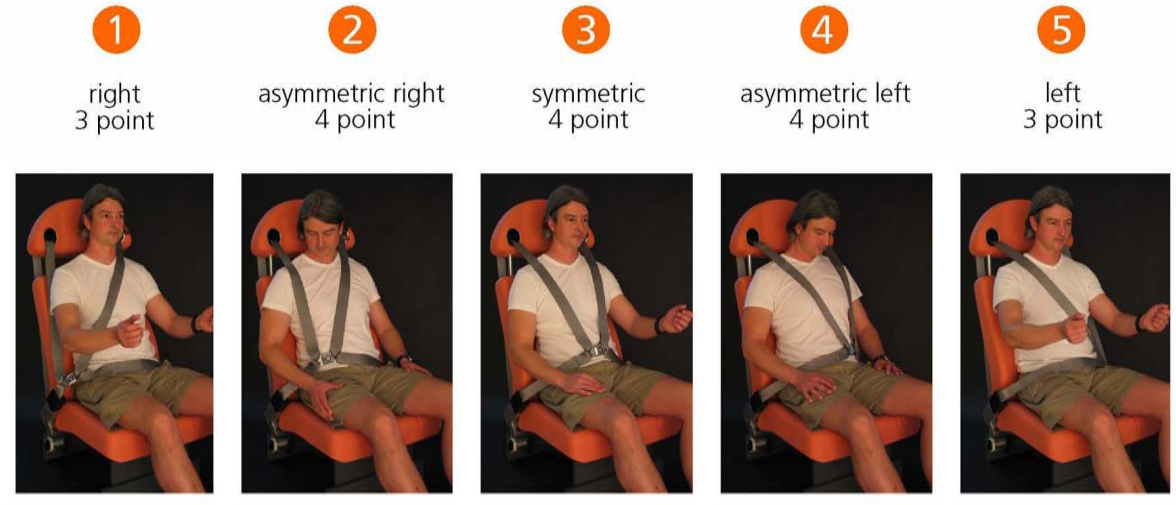
e.g. tall female

5.2.3 Generic belt configurations

Five different buckling options, depending on users' wearing preferences and safety needs.
(Position two and four possibly advantageous for females).

5.2.3 Generic belt configurations

Initial assessment of buckling options (with ca. 95 percentile user)



5.2.5 Ergonomic seat cushion considerations

- Seat-pan flattening towards front
- Backrest flattening towards top
- Total width 20 inch minimum
- Generously dimensioned headrest

Project Assessment and Recommendations for Continuation

The project as tentatively completed still requires safety and convenience oriented testing in actual settings. A separate proposal is being submitted to allow the study to be prepared and conducted starting in Summer 2005.

Independent of this testing phase a number of sub-projects were identified with the benefit of adding to the significance and usefulness of the current outcome of the study.

- One specific example for such project centers around the subject of belt buckles, both in terms of mechanical configuration and user-friendly design. The purpose of the various buckle concepts as shown in this report is only proof of possibilities, still requiring intense ergonomic research and design refinement.

- Another example worth investigating is the layout and form of seat cushions for an emerging generation of different bodied users, and the functional integration of safer seats into future car interiors (e.g. crossover vehicles).

6.0 Pilot Testing

6.1.0 Test Mock-ups

System A: traditional, non-presenter 3-point seat belt

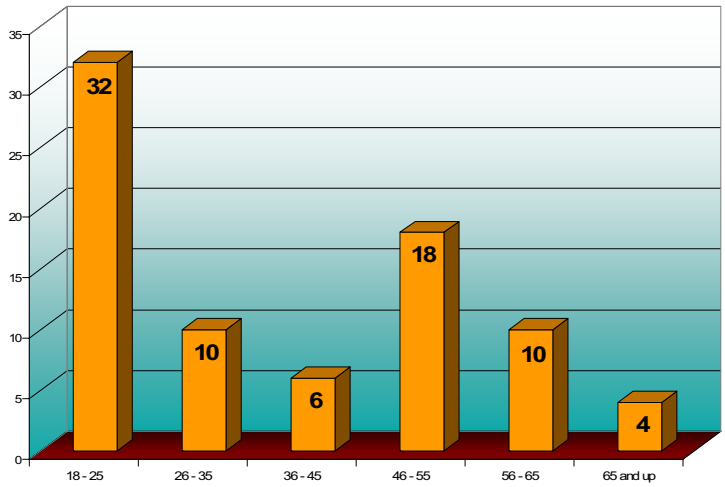
System B: 3-point seat belt with presenter

System C: 4-point seat belt with presenter

6.2.0 Test Questionnaire

Total of 43 questions

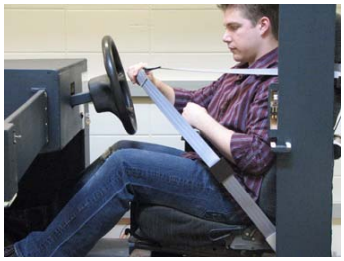
Number of participants 80



Age distribution (skewed towards future users)

6.3.0 Test procedure

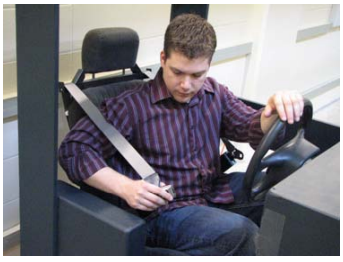
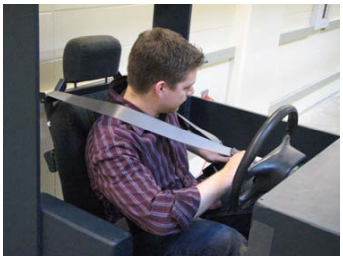
Sequence of buckling according to suggested procedure (3-point system)

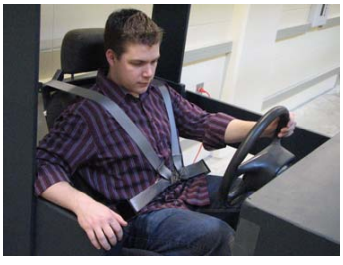
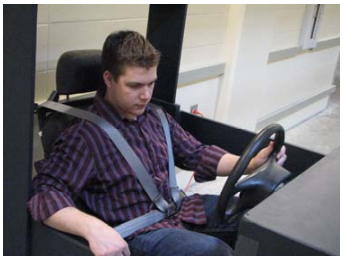




Presenter activated by ignition key

6.3.0 Test procedure

Sequence of buckling according to suggested procedure (4-point system)


6.4.0 Preliminary Test Results

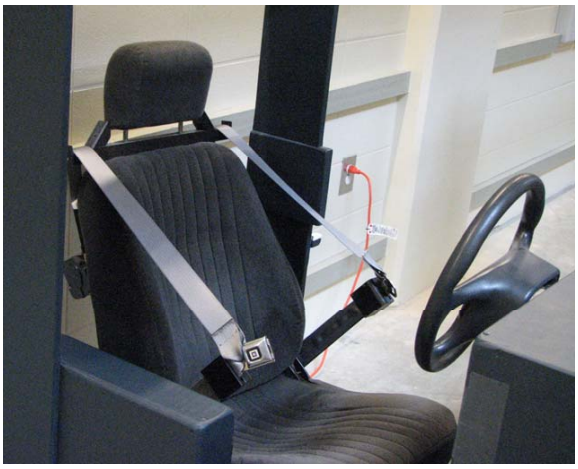
Comprehensive analysis of pilot testing with 80 subjects revealed a number of compelling insights and recommendations for further research and development in automotive seating:

- Majority of subjects prefer 4-point belt with presenter over 3-point belt with and without presenter
- Majority expects 4-point belt in future cars
- Subjects with high BMI, back pain, and/or arthritis preferred C, over B, over A
- Majority would be willing to pay extra for system of choice
- Added cost between $100 and $200 is acceptable
- Consistently low choice of system A indicates appreciation of presenter concept
- Presenter system does encourage buckling up and thus facilitates safety
- Etc.

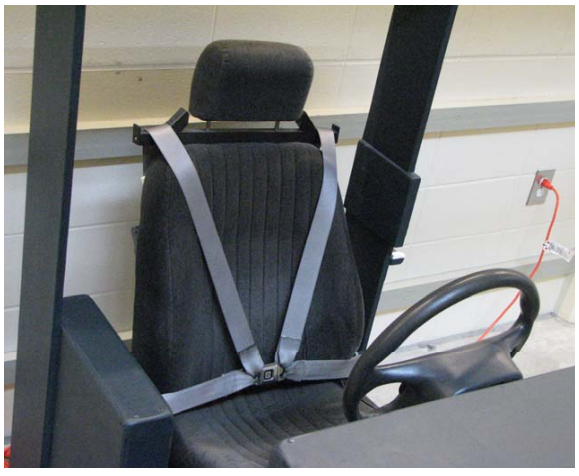
(Statistical data available upon request)

6.4.0 Test Results

The future of automotive seating?



Presenter system



4-point belt