



U.S. Department  
of Transportation  
**National Highway  
Traffic Safety  
Administration**



DOT HS 812 156

June 2015

# **Comparing the CRABI-12 And CRABI-18 for Infant Child Restraint System Evaluation**

## DISCLAIMER

This publication is distributed by the U.S. Department of Transportation, National Highway Traffic Safety Administration, in the interest of information exchange. The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Department of Transportation or the National Highway Traffic Safety Administration. The United States Government assumes no liability for its contents or use thereof. If trade or manufacturers' names or products are mentioned, it is because they are considered essential to the object of the publication and should not be construed as an endorsement. The United States Government does not endorse products or manufacturers.

### Suggested APA Format Citation:

Manary, M. A., Klinich, K. D., Orton, N. R., Reed, M. R., & Rupp, J. D. (2015, June). Comparing the CRABI-12 and CRABI-18 for infant child restraint system evaluation. (Report No. DOT HS 812 156). Washington, DC: National Highway Traffic Safety Administration.

**Technical Report Documentation Page**

|  |  |                                      |  |                            |           |
|--|--|--------------------------------------|--|----------------------------|-----------|
| 1. Report No.<br>DOT HS 812 156  |  | 2. Government Accession No.          |  | 3. Recipient's Catalog No. |           |
| 4. Title and Subtitle<br>Comparing the CRABI-12 and CRABI-18 for Infant Child Restraint System Evaluation  |  |                                      | 5. Report Date<br>June 2015  |                            |           |
|  |  |                                      | 6. Performing Organization Code  |                            |           |
| 7. Author(s)<br>Miriam A. Manary, Kathleen D. Klinich, Nichole R. Orton, Matthew P. Reed, Jonathan D. Rupp   |  |                                      | 8. Performing Organization Report No.  |                            |           |
| 9. Performing Organization Name and Address<br>University of Michigan Transportation Research Institute<br>2901 Baxter Road<br>Ann Arbor, MI 48109   |  |                                      | 10. Work Unit No. (TRAIS)  |                            |           |
|  |  |                                      | 11. Contract or Grant No.  |                            |           |
| 12. Sponsoring Agency Name and Address<br>National Highway Traffic Safety Administration<br>1200 New Jersey Avenue SE.<br>Washington, DC 29570   |  |                                      | 13. Type of Report and Period Covered<br>April 2012 – January 2013   |                            |           |
|  |  |                                      | 14. Sponsoring Agency Code   |                            |           |
| 15. Supplementary Notes  |  |                                      |  |                            |           |
| 16. Abstract<br>A preliminary study was performed to consider how evaluation of rear-facing-only child restraints might differ if the CRABI 18 month old crash test dummy was used instead of the CRABI 12 month old. In comparison to child anthropometry data, the CRABI-18 does a better job in representing the dimensions of children over 1 year old. Nineteen rear-facing-only child restraint systems (CRS) were measured, and both test dummies were installed in the CRSs for static evaluation. The CRABI-12 fit well in all the CRSs. Nine child restraints were too narrow for the CRABI-18 shoulders (including 7 CRSs for use with children at or over 18 kg [30 lb]), and 12 child restraints did not allow the recommended 25 mm head clearance. In dynamic FMVSS No. 213 testing with 3 CRSs (Graco Snuggly30, Chicco KeyFit, and Evenflo Embrace), the measured response of both test dummies was similar; both met all FMVSS No. 213 requirements. |  |                                      |  |                            |           |
| 17. Key Word<br>Child restraints, ATDs, anthropometry, crash test dummies  |  |                                      | 18. Distribution Statement<br>Document is available to the public from the National Technical Information Service <a href="http://www.ntis.gov">www.ntis.gov</a> |                            |           |
| 19. Security Classif. (of this report)   |  | 20. Security Classif. (of this page) |  | 21. No. of Pages<br>46     | 22. Price |

## Acknowledgments

This work was funded by the National Highway Traffic Safety Administration under cooperative agreement DTNH22-05-01020 with the University of Michigan. The views expressed in the report are those of the authors and do not reflect official positions of the NHTSA. The authors acknowledge the efforts of Brian Eby, Charles Bradley, Stewart Simonett, and David Hayashi on this project.

## Table of Contents

|  |     |
|--|-----|
| List of Figures .....                        | iv  |
| List of Tables .....                         | iv  |
| Introduction.....                            | 1   |
| Static Evaluation .....                      | 4   |
| Methods.....                                 | 4   |
| Results.....                                 | 6   |
| Dynamic Evaluation.....                      | 8   |
| Methods.....                                 | 8   |
| Results.....                                 | 9   |
| Discussion and Conclusions .....             | 14  |
| References.....                              | 15  |
| Appendix – Data From Static Fit Testing..... | A-1 |

## List of Figures

|   |    |
|---|----|
| Figure 1. An infant CRS with the measurement tool.....  | 5  |
| Figure 2. A single CRS model that provides good fit with the CRABI-12 (left) and tight fit with reduced head-to-CRS shell clearance with the CRABI-18 (right).. | 7  |
| Figure 3. Pre-test photos of the Graco SnugRide 30 with the CRABI-12 (top) and CRABi-18 (bottom).....   | 8  |
| Figure 4. Time-zero and maximum rotation video frames for each test conducted with the CRABI-18. ....   | 10 |
| Figure 5. Comparison of head and chest resultant acceleration histories for the Graco SnugRide 30 with both ATDs. ....  | 11 |
| Figure 6. Comparison of head and chest resultant acceleration histories for the Chicco KeyFit with both ATDs.....   | 12 |
| Figure 7. Comparison of head and chest resultant acceleration histories for the Evenflo Embrace 35 with both ATDs. ....   | 13 |

## List of Tables

|   |   |
|---|---|
| Table 1. Comparison of Selected Anthropometry Measures for Children and ATDs..... | 3 |
| Table 2. Rear-Facing CRS Measured .....   | 4 |
| Table 3. Information Collected .....  | 5 |
| Table 4. Key FMVSS No. 213 Criteria for Test Series .....                         | 9 |

## **Introduction**

In the United States, the minimum best practice for transporting infants in passenger vehicles requires children to face the rear of the vehicle while seated in harnessed child restraint systems (CRS) until they are both at least 1 year old and 9 kg (20 lb) body mass. Promising injury data from other countries where children remain rear-facing longer have promoted extended rear-facing use in the United States. Swedish data showing benefit for children rear-facing through age 4, with rear-facing restraints reducing AIS2+ injury by 90 percent compared with unrestrained children (Jakobsson, Wiberg, Isaksson-Hellman, & Gustafsson, 2007; Isaksson-Hellman, Jakobsson, Gustafsson, & Norin, 1997). U.S. crash data show that children up to 2 years old are 5.53 times safer in a rear-facing restraint than in a forward-facing restraints in side impacts and 1.23 times safer in frontal impacts (Henery et al., 2007). In early 2011, NHTSA and the American Academy of Pediatrics (AAP, 2011) modified their best practice recommendations to encourage infants to ride in rear-facing child restraints as long as possible. AAP has articulated a new goal of keeping children rear-facing up to age 2 when the child can be properly accommodated in a rear-facing restraint.

Over the past decade, rates of obesity and high body-mass index (BMI) among children in the United States have increased and mean that a greater proportion of children are heavier for their age/height. The goal of keeping all children rear-facing longer, possibly until age 2, means that child restraints should aim for accommodating children rear-facing to over 14 kg (32 lb). Traditionally, rear-facing only CRSs for infants have accommodated children up to 10 kg (22 lb). Parents were then advised to switch to a convertible child restraint used rear-facing. While the rear-facing convertibles usually have higher seatbacks and larger occupant spaces to accommodate larger children, rear-facing-only CRSs often have smaller overall dimensions and may fit more easily in smaller vehicles.

In response to the AAP recommendation to keep children rear-facing longer, CRS manufacturers have designed rear-facing CRSs that accommodate heavier children. The first rear-facing convertible CRSs were developed for use by children up to 13.6, 16, or 18 kg (30, 35, or 40 lb). Then rear-facing-only CRSs were also developed that accommodated children up to 13.6 and 16 kg (30 and 35 lb). The rear-facing-only CRSs usually have a shell with a handle that can be used to carry the infant, plus a base left in the vehicle for easier and quicker installation.

Although the development of these CRSs has had the positive outcome of allowing more children to remain rear-facing longer, there have also been some unintended issues with their development. As the child restraints accommodate larger children, the CRS become larger and require more open rear-seat volume in the vehicle to allow for proper installation and use. They have also become heavier, which can make installation more

challenging. Additionally, once children are above the age of 6 months, the combined mass of the infant seat and the child often make carrying the child in the CRS with a handle difficult or impractical, especially with the rear-facing only child restraints accommodating children up to 18 kg (35 lb). Finally, the occupant mass limit for the product is displayed on the label, but the best practice recommendation in the National Child Passenger Safety Certification Training Program (NHTSA, 2010) that the top of the child's head be at least 25 mm (1 in) below the top of the CRS shell is not required on the label, although it is often in the owner's manual. Some children outgrow rear-facing only seats by height before reaching the maximum rated mass. If the child restraint is designed to be strong enough to restrain the higher mass occupant, but does not account for the larger dimensions, misuse may occur with the child's head becoming too close to or extending past the top edge of the child restraint.

The FMVSS No. 213 family of anthropomorphic test devices (ATD) generally represents an average height and weight for a designated age. Currently the CRABI 12-month old (CRABI-12) ATD is used to represent a larger infant and the next-larger-sized ATD is the Hybrid III 3-year-old (HIII-3YO). CRS manufacturers also use the ATDs as a representation of typical anthropometry for size. There are concerns that neither the CRABI-12 nor the HIII-3YO are good representations of the 12- to 24-month-old child who has high weight for height/age. The CRABI 18-month old (CRABI-18) is another available ATD that has not been incorporated into Federal regulation.

Table 1 compares selected anthropometry for the three ATDs and 95th percentile 1 and 2-year-olds in the United States. The UMTRI anthropometry data provides more detailed measures, but was collected over 30 years ago. The current CDC data only provides height and weight. These data show that the CRABI-12 is smaller on every dimension than the 95th percentile 1-year-old child data from the United States. The CRABI-18 comes closer to the 95th percentile marks but is still low on some metrics. The HIII-3YO is larger than both the 95th percentile 1-year-old and 2-year-old on every dimension.



Table 1. Comparison of Selected Anthropometry Measures for Children and ATDs

|                             | <b>CRABI<br/>12</b> | <b>95%<br/>1YO<br/>UMTRI</b> | <b>95%<br/>1YO<br/>CDC</b> | <b>CRABI<br/>18</b> | <b>95%<br/>2YO<br/>UMTRI</b> | <b>95%<br/>2YO<br/>CDC</b> | <b>III<br/>3YO</b> |
|-----------------------------|---------------------|------------------------------|----------------------------|---------------------|------------------------------|----------------------------|--------------------|
| Mass<br>(kg)                | 10.1                | 11.7                         | 12.4                       | 11.2                | 13.2                         | 14.5                       | 16.1               |
| Standing<br>Height<br>(mm)  | 742                 | 790                          | 806                        | 818                 | 883                          | 930                        | 945                |
| Seated<br>Height<br>(mm)    | 470                 | 512                          | --                         | 500                 | 549                          | --                         | 546                |
| Shoulder<br>Breadth<br>(mm) | 208                 | 232                          | --                         | 224                 | 239                          | --                         | 244                |
| Hip<br>Breadth<br>(mm)      | 165                 | 184                          | --                         | 175                 | 191                          | --                         | 208                |

This study compares the CRABI-12 and CRABI-18 ATDs for suitability in evaluating rear-facing only CRS. Both ATDs were used to assess how the current range of commercial child restraints accommodates the two ATDs. Three models of rear-facing only CRS were then tested to compare the CRABI-12 and CRABI-18 ATDs responses under dynamic FMVSS No. 213 test conditions.

## Static Evaluation

### *Methods*

Nineteen rear-facing infant only child restraints were measured and evaluated by visiting local retailers and conducting in-store data collection. The seats measured are listed in Table 2. The Combi Shuttle 35 was measured twice using two different specimens but both yielded similar results. This model is listed twice in the table, to show the small differences but only counted once in the analysis. A set of simple physical dimensions was collected for each seat including: seatback height, seat pan length, harness slot heights, crotch slot locations, interior widths and exterior width. A tool made of two pieces of Plexiglass connected by a hinge, shown in Figure 1, was developed to make the measurement more repeatable and the definition of the bight of the seated area less subjective. Then the CRABI-12 and CRABI-18 were seated in each product. The distance between the top of the ATD's head and the top of the CRS shell was measured and any fit issues encountered while seating the ATDs were documented. A complete list of measures is shown in Table 3.

Table 2. Rear-Facing CRS Measured

| <i>Manufacturer</i> | <i>Model</i>      |
|---------------------|-------------------|
| BabyTrend           | FlexLock          |
| Britax              | B-Safe 30         |
| Britax              | Chaperone         |
| Chicco              | KeyFit            |
| Chicco              | KeyFit 30         |
| Combi               | Shuttle 35        |
| Cosco               | Comfy Carry       |
| Cosco               | Comfy Carry Elite |
| Evenflo             | Discovery         |
| Evenflo             | Embrace 35        |
| First Years         | Via               |
| Graco               | Snugride          |
| Graco               | Snugride 30       |
| Graco               | Snugride 35       |
| Graco               | Snugride CC 40    |
| Peg Perego          | Primo Viaggio     |
| Safety 1st          | onBoard 35        |
| Safety 1st          | onBoard 35 Air    |
| Summer              | Infant Prodigy    |



Figure 1. An infant CRS with the measurement tool.

Table 3. Information Collected

|   |
|---|
| Infant seat model name                          |
| Manufacturer                                    |
| Model number                                    |
| Date of manufacture                             |
| Height range                                    |
| Weight range                                    |
| Number of shoulder slots                        |
| Number of crotch slots                          |
| Seatback height (cm)                            |
| Seat length (cm)                                |
| Slot heights (cm)                               |
| Crotch strap from bight (cm)                    |
| Seat interior width at bight (cm)               |
| Seat interior width at harness slots (cm)       |
| Seat interior width at crotch straps slots (cm) |
| Max exterior width location (cm)                |
| Max exterior width (cm)                         |
| Top head to top shell with each ATD (cm)        |

## ***Results***

The full compiled results table and the photos of each product measured are provided in Appendix A. The CRABI-12 fit well in all 19 child restraints while 9 of the 19 child restraints fit the CRABI-18 tightly at the shoulder. Of the 9 CRSs with tight shoulder fit, 7 of them were rated for use with children up to or over 18 kg (30 lb). The top of the CRABI-12 ATD's head fell 25 mm or more below the top of the CRS shell in all child restraints, meeting the best practice fit guidelines, while 12 of the 19 seats tested did not allow a 25 mm head clearance for the CRABI-18. Of the 12 child restraints not allowing a 25 mm head clearance for the CRABI-18, 7 were rated for occupants who weigh 18 kg (30 lb) or more. Examples of contrasting fit with the two ATDs are shown in Figure 2. In one CRS the highest harness routing slots were higher than the shoulder height of the CRABI-18 ATD and the top of the head is not 25 mm below the top edge of the back support shell. This suggests potential for misuse, as the shoulder harness should be placed at or below the child's shoulders when rear-facing, to prevent the child from sliding up along the back and exposing the head to interior contact when in a frontal crash.

In one CRS rated for children up to 18 kg (40 lb), the CRABI-18 could not sit fully into the child restraint with the back of the ATD in full contact with the CRS back support surface. This was due to a relatively stiff head support feature that formed a raised surface on the upper part of the CRS seatback and was well aligned to support the CRABI-12 head but contacted the CRABI-18 ATD below the shoulder. When the CRABI-18 was seated in this CRS, either the shoulders were propped forward off of the seatback surface or the ATD's pelvis had to be pulled forward in the seat to drop the height of the ATD's shoulders below the head support.



Figure 2. A single CRS model that provides good fit with the CRABI-12 (left) and tight fit with reduced head-to-CRS shell clearance with the CRABI-18 (right).

## Dynamic Evaluation

### *Methods*

Six, FMVSS No. 213-type frontal impact tests were conducted using three models of commercial CRS: Graco SnugRide30, Chicco KeyFit, and Evenflo Embrace 35. Each model was run once with the CRABI-12 and again with the CRABI-18 using a new seat for each run. Each seat was set up per manufacturers' instructions and all seat adjustments for harness routing and recline were held constant between tests of the same model CRS. All signals were processed per SAE J211 and standard algorithms were used to calculate HIC36 and 3-ms-clip chest accelerations. High-speed digital video was recorded at 1,000 frames per second and analyzed to quantify CRS motion. Figure 3 shows pre-test photos with both ATDs.



Figure 3. Pre-test photos of the Graco SnugRide 30 with the CRABI-12 (top) and CRABI-18 (bottom)

## Results

Table 4 lists the relevant response criteria for the test series. None of the CRS sustained any structure damage and all child restraints met the dynamic requirements of FMVSS No. 213. Figure 4 shows the initial position and maximum forward rotation video frame for each test, indicating the motion of the head relative to the CRS shell. The acceleration response of the two ATDs was very similar, as shown by the close agreement of the resultant head and chest acceleration histories shown in Figures 5 to 7.

Table 4. Key FMVSS No. 213 Criteria for Test Series

| <b>Test ID</b> | <b>Seat/ATD</b> | <b>HIC-36</b><br>(213 limit<br>1000) | <b>3-ms<br/>Chest Clip</b><br>(g)<br>(213 limit<br>60 g) | <b>Pre-test<br/>Angle</b><br>(deg) | <b>Max<br/>Rotation</b><br>(deg)<br>(213 limit<br>70 deg) |
|----------------|-----------------|--------------------------------------|--|------------------------------------|---|
| NT1303         | Embrace - 12    | 482                                  | 45   | 35                                 | 59  |
| NT1306         | Embrace - 18    | 517                                  | 45   | 35                                 | 60  |
| NT1302         | KeyFit - 12     | 350                                  | 52   | 41                                 | 59  |
| NT1305         | KeyFit - 18     | 487                                  | 47   | 39                                 | 56  |
| NT1301         | Snugride - 12   | 596                                  | 50   | 34                                 | 59  |
| NT1302         | Snugride - 18   | 658                                  | 54   | 35                                 | 59  |

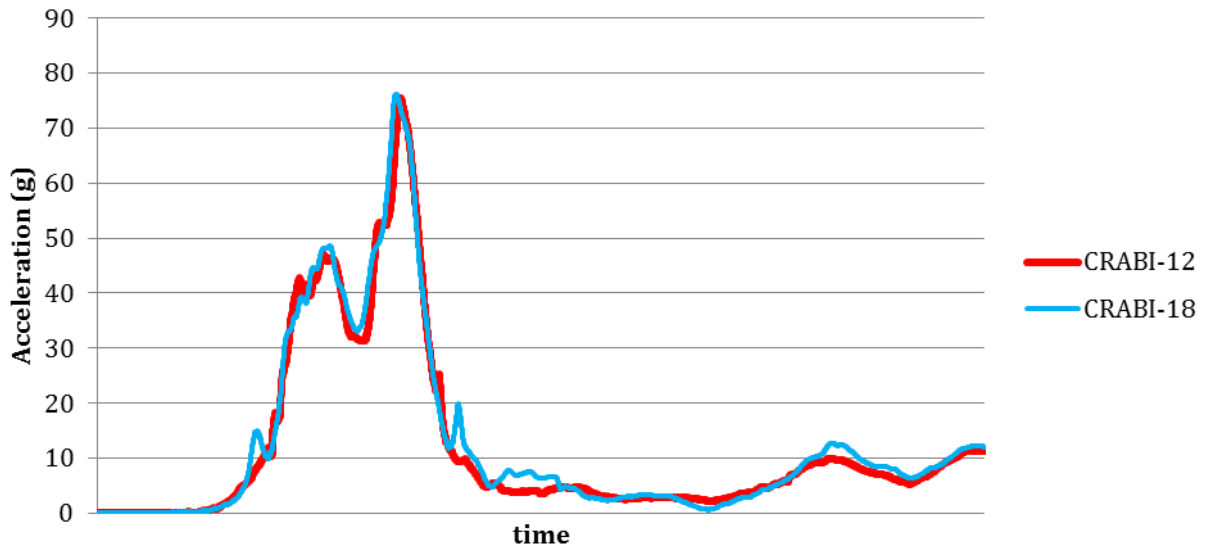




Figure 4. Time-zero and maximum rotation video frames for each test conducted with the CRABI-18.



## SnugRide Head Resultant Acceleration



## SnugRide Chest Resultant Acceleration

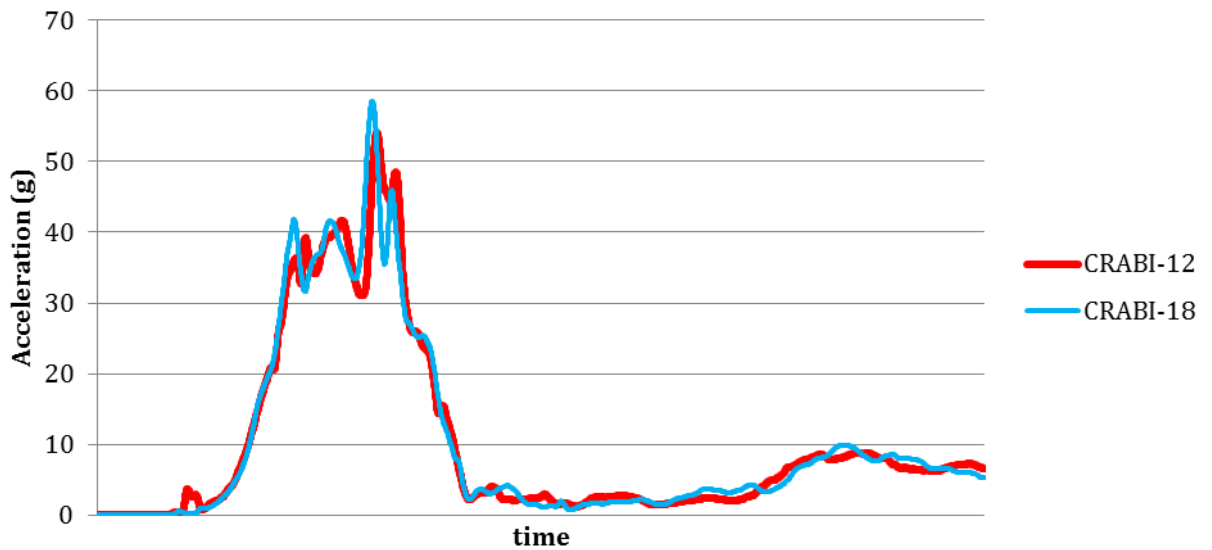
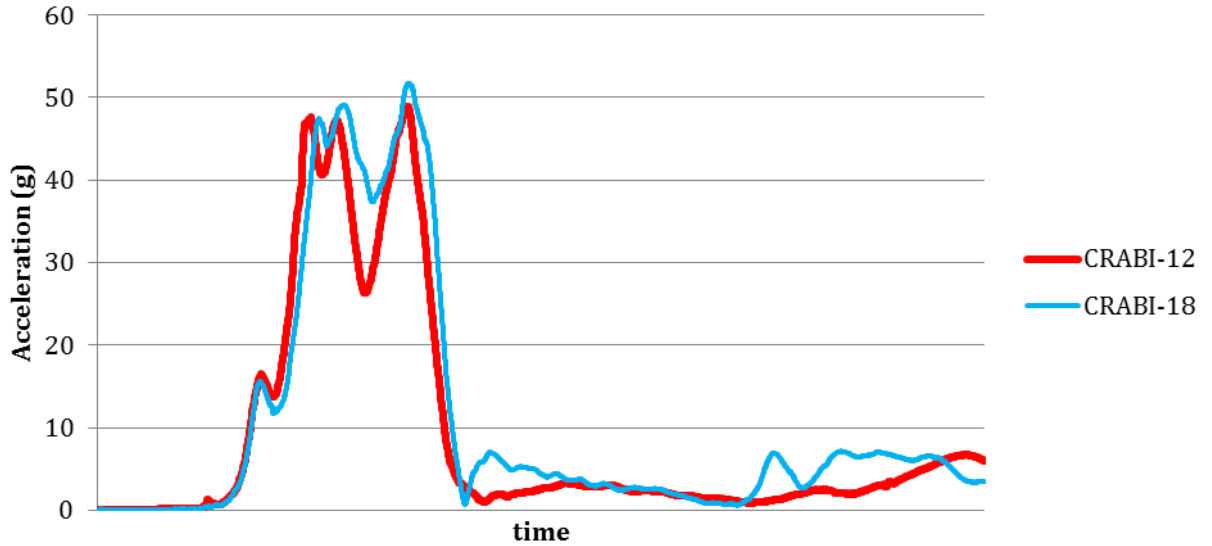


Figure 5. Comparison of head and chest resultant acceleration histories for the Graco SnugRide 30 with both ATDs.

## KeyFit Head Resultant Acceleration



## KeyFit Chest Resultant Acceleration

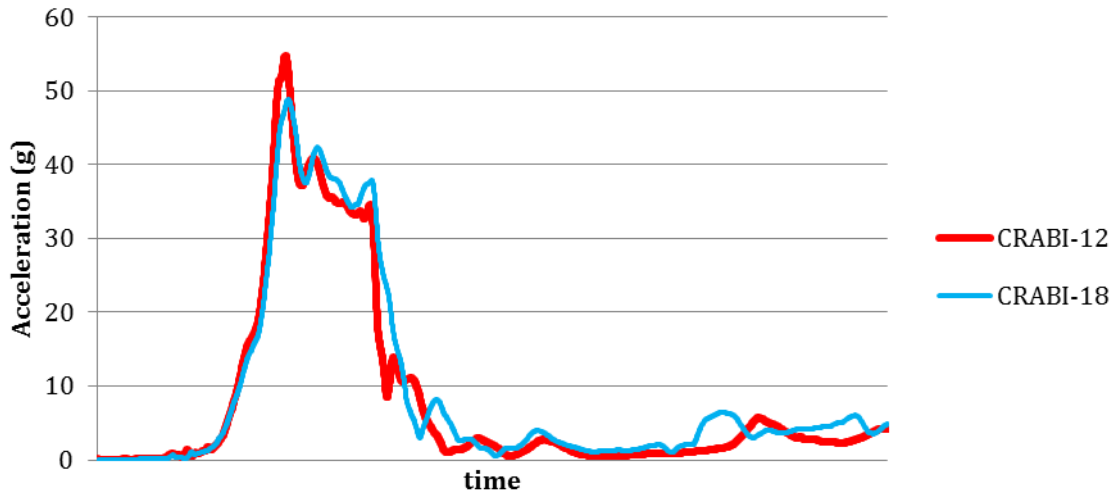
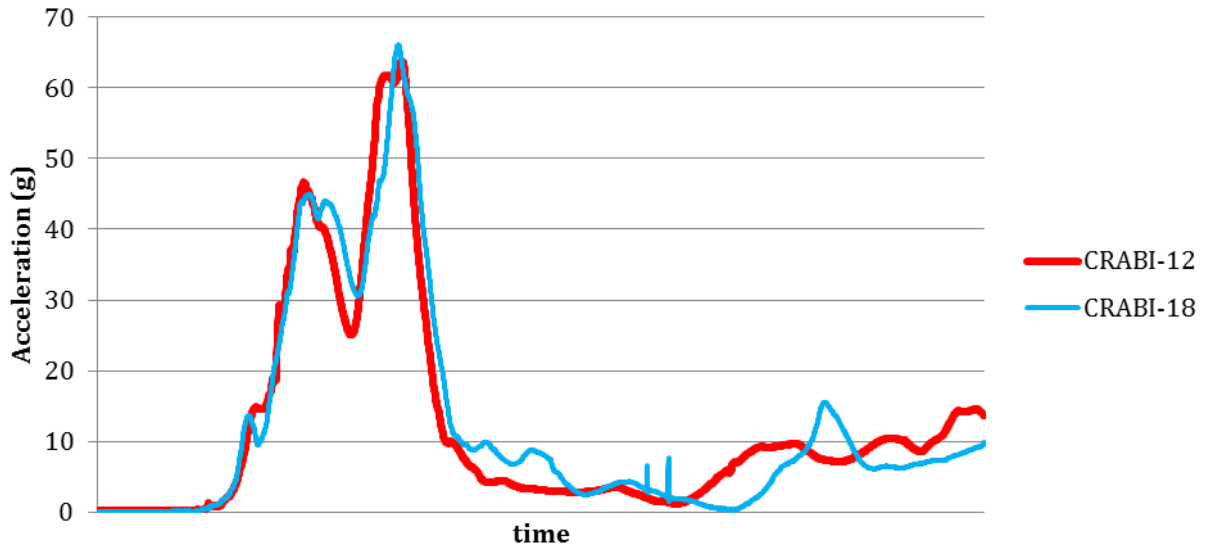


Figure 6. Comparison of head and chest resultant acceleration histories for the Chicco KeyFit with both ATDs.

## Embrace Head Resultant Acceleration



## Embrace Chest Resultant Acceleration

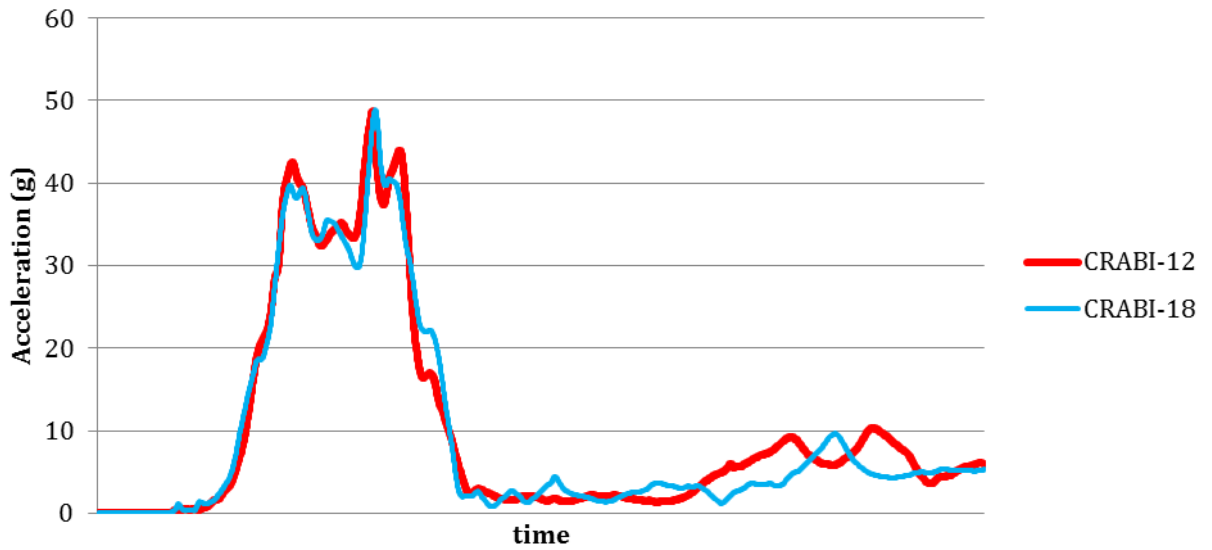


Figure 7. Comparison of head and chest resultant acceleration histories for the Evenflo Embrace 35 with both ATDs.

## **Discussion and Conclusions**

The anthropometry of the CRABI-18 is closer to that of a 95th percentile 1-year-old child than that of the CRABI-12. The static assessment showed that the CRABI-12 had no fit issues in the current set of commercially available rear-facing CRSs that were evaluated. In contrast, the CRABI-18 often did not have the best practice clearance of 25 mm between the top of the head and the top of the CRS shell. In addition, the shoulder width of the CRABI-18, though narrower than that of the 95th percentile 1-year-old, was not accommodated in about half of the rear-facing CRSs evaluated.

One explanation for the poor fit of the CRABI-18 in some CRSs is that the ATD is simply not widely available to CRS designers. Another potential source of this information is spacers or clearance tools that would indicate the volume needed for larger children.

The two ATDs performed similarly in FMVSS No. 213 sled testing and both passed all dynamic criteria. The current FMVSS No. 213 requirement for head containment demands that the CG of the ATD's head be kept within the CRS shell. The peak rotation photos from the tests of the CRABI-18 suggest that some CRS designs do not always keep the leading edge of the ATD's head fully protected. Evaluation of forward-facing child restraints requires tracking the leading edge of the ATD's head to measure excursion.

The key findings from this investigation are that the CRABI-18 does not fit well in a large portion of rear-facing only CRSs due to lack of accommodation of the ATD's shoulder width and the lack of a full 25 mm of clearance between the ATD's head and top of the CRS shell. The CRABI-12 and CRABI-18 perform very similarly in dynamic testing per FMVSS No. 213.

## References

- American Academy of Pediatrics, Committee on Injury, Violence, and Poison Prevention. (2011). Policy statement: Child passenger safety. *Pediatrics* 127:788-793.
- Henary, B., Sherwood, C. P., Crandall, J. R., Kent, R. W., Vaca, F. E., Arbogast, K. B., & Bull, M. J. (2007). Car safety seats for children: rear facing for best protection. *Injury Prevention* 13:398–402. doi: 10.1136/ip.2006.015115.
- Isaksson-Hellman, I., Jakobsson, L., Gustafsson, C., & Norin, H. (1997). Trends and effects of child restraint systems based on Volvo's Swedish accident database. (Report No. SAE 973299). In: Child Occupant Protection 2nd Symposium Proceedings, 43-54. Warrendale, PA: Society of Automotive Engineers.
- Jakobsson, L., Wiberg, H., Isaksson-Hellman, I., Gustafsson, J. (2007). Rear seat safety for the growing child—a new 2-state integrated booster cushion. (Paper Number 07-0322). Proceedings of the 20th International Technical Conference on the Enhanced Safety of vehicles, Lyon, France.
- National Highway Traffic Safety Administration. (2007, April; Revised, 2010, October). National Child Passenger Safety Certification Training student manual. (Report No. DOT HS 810 731) Washington DC: Author. Available at [www.cpsboard.org/pdf/techmanual/StudentManual\\_R1010\\_Complete\\_WebQuality.pdf](http://www.cpsboard.org/pdf/techmanual/StudentManual_R1010_Complete_WebQuality.pdf)

## **Appendix – Data From Static Fit Testing**

Table A.1 Static Data

|                                     | 1                   | 2                   | 3                                      | 4                                      | 5                     | 6                   |
|-------------------------------------|---------------------|---------------------|--|--|-----------------------|---------------------|
| Infant Seat Model Name              | <b>KeyFit30</b>     | <b>B-Safe 30</b>    | <b>Snugride 30</b>                     | <b>Via</b>                             | <b>onBoard 35 air</b> | <b>Snugride 35</b>  |
| Manufacturer                        | Chicco              | Britax              | Graco                                  | First Years/Lamazé                     | Safety 1st            | Graco               |
| Model Number                        | 00061472450070      | E9LE53C             | 1759021 JJ                             | I470-LMGY                              | 22395-MCK             | 1806993 JJ          |
| Date of Manuf                       | 01/2011             | 5/5/11              | 10/6/10                                | 4/20/11                                | 3/31/11               | 9/8/11              |
| Weight Range                        | 4-30 lb             | 4-30 lb             | 4-30 lb                                | 5-22 lb                                | 4-35 lb               | 4-35 lb             |
| Height Range                        | 30 in or less       | 32 in or less       | 30 in or less                          | 32 in or less                          | 32 in or less         | 32 in or less       |
| # of Shoulder Slots                 | 3                   | 4                   | 4                                      | Moving slots (5 Pos)                   | 4                     | 3                   |
| # of Crotch Slots                   | 1                   | 2                   | 2                                      | 1                                      | 3                     | 1                   |
| <i>All Measurements below in cm</i> |                     |                     |  |  |                       |                     |
| Seatback Height                     | 50                  | 48                  | 51                                     | 51                                     | 50                    | 49                  |
| Seat Length                         | 27                  | 31.5                | 25                                     | 27                                     | 30                    | 27                  |
| Slot Height:                        |                     |                     |  |  |                       |                     |
| (lowest) 1                          | 17.5                | 13                  | 17                                     | 18.5                                   | 11.5                  | 16                  |
| 2                                   | 22.5                | 18                  | 20                                     | -                                      | 16                    | 22.5                |
| 3                                   | 28                  | 22                  | 26                                     | -                                      | 21                    | 27                  |
| 4                                   | -                   | 27                  | 30.5                                   | -                                      | 26                    | -                   |
| (or highest) 5                      | -                   | -                   | -                                      | 31.5                                   | -                     | -                   |
| Crotch dist from bight:             |                     |                     |  |  |                       |                     |
| (closest) 1                         | 10                  | 9.5                 | 4                                      | 13                                     | 6.5                   | 13                  |
| 2                                   | -                   | 14                  | 12                                     | -                                      | 10                    | -                   |
| (farthest) 3                        | -                   | -                   | -                                      | -                                      | 14.5                  | -                   |
| Seat interior width at:             |                     |                     |  |  |                       |                     |
| bight                               | 24                  | 25                  | 23                                     | 26                                     | 26                    | 24                  |
| slot 1 (lowest)                     | 24.5                | 24                  | 24                                     | 26                                     | 26                    | 24                  |
| slot 2                              | 24                  | 24                  | 24                                     | -                                      | 26                    | 24                  |
| slot 3                              | 23                  | 24                  | 23                                     | -                                      | 24                    | 23                  |
| slot 4                              | -                   | 23                  | 19                                     | -                                      | 20                    | -                   |
| (or highest) 5                      | -                   | -                   | -                                      | 22                                     | -                     | -                   |
| crotch 1 (closest)                  | 24                  | 25                  | 23                                     | 26                                     | 27                    | 23                  |
| crotch 2                            | -                   | 25                  | 22                                     | -                                      | 27                    | -                   |
| crotch 3                            | -                   | -                   | -                                      | -                                      | 28                    | -                   |
| belt path                           | 22                  | 22                  | 25                                     | 39                                     | 23                    | 24                  |
| max exterior width location         | handle hub          | handle hub          | middle seat                            | lock-off clips on seat                 | handle hub            | handle hub          |
| max exterior width                  | 43                  | 45                  | 44                                     | 44                                     | 44                    | 48                  |
| height top head to top shell:       |                     |                     |  |  |                       |                     |
| 12-MO                               | 3.5                 | 3                   | 5                                      | 6.5                                    | 5                     | 6                   |
| 18-MO                               | 1                   | 1                   | 3                                      | 3.5                                    | 2                     | 3                   |
| Fit issues                          | None                | None                | Little tight at the shoulders for 18MO | Little tight at the shoulders for 18MO | None                  | None                |
| Location                            | BabiesRUs Ann Arbor | BabiesRUs Ann Arbor | BabiesRUs Ann Arbor                    | BabiesRUs Ann Arbor                    | BabiesRUs Ann Arbor   | BabiesRUs Ann Arbor |
| Date                                | 12/6/12             | 12/6/12             | 12/6/12                                | 12/6/12                                | 12/6/12               | 12/6/12             |
| Investigator                        | N. Orton            | N. Orton            | N. Orton                               | N. Orton                               | N. Orton              | N. Orton            |

Table A.1 Static Data (continued)

|                                     | 7                   | 8                   | 9  | 10   | 11                  |
|-------------------------------------|---------------------|---------------------|--|--|---------------------|
| Infant Seat Model Name              | <b>onBoard 35</b>   | <b>Snugride</b>     | <b>Flex-Loc</b>                            | <b>Snugride Click Connect 40</b>   | <b>Prodigy</b>      |
| Manufacturer                        | Safety 1st          | Graco               | BabyTrend                                  | Graco  | Summer Infant       |
| Model Number                        | IC-146 AWAD/GB1A2   | 1806996 JJ          | CS31705                                    | 1839195 JJ   | 21050               |
| Date of Manuf                       | 7/13/12             | 9/13/11             | 1/1/12                                     | 8/14/12  | 7/23/11             |
| Weight Range                        | 4-35 lb             | 5-22 lb             | 5-30 lb                                    | 4-40 lb  | 4-32 lb             |
| Height Range                        | 32 in or less       | 29 in or less       | 30 in or less                              | 35 in or less  | 32 in or less       |
| # of Shoulder Slots                 | 4                   | 2                   | moving slots (7 pos)                       | moving slots   | moving slots        |
| # of Crotch Slots                   | 3                   | 1                   | 1  | 2  | 2                   |
| <i>All Measurements below in cm</i> |                     |                     |  |  |                     |
| Seatback Height                     | 50                  | 49                  | 40-49                                      | 35-50.5  | 50                  |
| Seat Length                         | 30                  | 26.5                | 24   | 29   | 31                  |
| Slot Height:                        |                     |                     |  |  |                     |
| (lowest) 1                          | 12.5                | 19                  | 21   | 13.5   | 17                  |
| 2                                   | 17.5                | 25.5                | -  | -  | -                   |
| 3                                   | 22.5                | -                   | -  | -  | -                   |
| 4                                   | 27.5                | -                   | -  | -  | -                   |
| (or highest) 5                      | -                   | -                   | 29   | 29.5   | 30.5                |
| Crotch dist from bight:             |                     |                     |  |  |                     |
| (closest) 1                         | 6                   | 13.5                | 10   | 11 @HR bot / 12 @ HR top   | 6                   |
| 2                                   | 9                   | -                   | -  | 15 @HR bot / 16 @ HR top   | 11                  |
| (farthest) 3                        | 14                  | -                   | -  | -  | -                   |
| Seat interior width at:             |                     |                     |  |  |                     |
| bight                               | 27                  | 23                  | 23   | 24   | 22                  |
| slot 1 (lowest)                     | 26                  | 23.5                | 25   | 17   | 23                  |
| slot 2                              | 26                  | 23.5                | -  | -  | -                   |
| slot 3                              | 25                  | -                   | -  | -  | -                   |
| slot 4                              | 24                  | -                   | -  | -  | -                   |
| (or highest) 5                      | -                   | -                   | 24   | 17   | 20                  |
| crotch 1 (closest)                  | 27                  | 24                  | 23   | 24   | 23                  |
| crotch 2                            | 28                  | -                   | -  | 24   | 24                  |
| crotch 3                            | 29                  | -                   | -  | -  | -                   |
| belt path                           | 22                  | ? Wrong base        | 26   | 24   | 21                  |
| max exterior width location         | base                | handle hub          | handle hub                                 | handle hub   | handle hub          |
| max exterior width                  | 43                  | 43                  | 42   | 45   | 46.5                |
| height top head to top shell:       |                     |                     |  |  |                     |
| 12-MO                               | 4.5                 | 3                   | 3.5  | 4  | 4.5                 |
| 18-MO                               | 2                   | 1.5                 | 1  | 3.5  | 2                   |
| Fit issues                          | None                | None                | Shoulders of 18MO touch bottom of headrest | 12MO shoulders touch bottom of head rest, 18MO shoulders are crammed under HR forcing pelvis forward on seat | None                |
| Location                            | BabiesRUs Ann Arbor | BabiesRUs Ann Arbor | BabiesRUs Ann Arbor                        | BabiesRUs Ann Arbor  | BabiesRUs Ann Arbor |
| Date                                | 12/6/12             | 12/6/12             | 12/6/12                                    | 12/6/12  | 12/6/12             |
| Investigator                        | N. Orton            | N. Orton            | N. Orton                                   | N. Orton   | N. Orton            |



Table A.1 Static Data (continued)

|                                     | 12  | 13   | 14                                     | 15                 | 16  |
|-------------------------------------|---|--|--|--------------------|---|
| Infant Seat Model Name              | <b>Chaperone</b>  | <b>Primo Viaggio</b>   | <b>Discovery 5</b>                     | <b>Comfy Carry</b> | <b>Shuttle 35</b>   |
| Manufacturer                        | Britax  | Peg Perego   | Evenflo                                | Cosco              | Combi   |
| Model Number                        | E9L692K   | IMUN004535FG13PL46   | 30211248 PQ2                           | IC-021 AKT/GB1A2   | 8035116   |
| Date of Manuf                       | 7/2012  | 3/2/10   | 2/24/12                                | 6/5/12             | 9/3/11  |
| Weight Range                        | 4-30 lb   | 5-30 lb  | 5-22 lb                                | 4-22 lb            | 0-35 lb   |
| Height Range                        | 32 in or less   | 30 in or less  | 29 in or less                          | 29 in or less      | 33 in or less   |
| # of Shoulder Slots                 | moving slots  | moving slots   | 3                                      | 4                  | moving slots  |
| # of Crotch Slots                   | 2   | 1  | 2                                      | 3                  | 1   |
| <i>All Measurements below in cm</i> |   |  |  |                    |   |
| Seatback Height                     | 40-51   | 40-46.5 on HR / 50 on shell  | 50.5                                   | 47.5               | 44-54.5 on HR/ 47 on shell  |
| Seat Length                         | 23  | 25.5 @ HRbtm, 28 @ HRtop   | 24.5                                   | 28                 | 26 @ HRbtm, 27.5 @ HRtop  |
| Slot Height:                        |   |  |  |                    |   |
| (lowest) 1                          | 17  | 18   | 15.5                                   | 13                 | 19.5  |
| 2                                   | -   | -  | 20.5                                   | 18                 | -   |
| 3                                   | -   | -  | 26.5                                   | 23                 | -   |
| 4                                   | -   | -  | -                                      | 28                 | -   |
| (or highest) 5                      | 27.5  | 25   | -                                      | -                  | 36  |
| Crotch dist from bight:             |   |  |  |                    |   |
| (closest) 1                         | 5   | 12 @HRbtm / 14 @ HRtop   | 7.5                                    | 8.5                | 10.5 @HRbtm / 12 @ HRtop  |
| 2                                   | 8   | -  | 11.5                                   | 12.5               | -   |
| (farthest) 3                        | -   | -  | -                                      | 16.5               | -   |
| Seat interior width at:             |   |  |  |                    |   |
| bight                               | 22  | 25   | 24                                     | 26                 | 22  |
| slot 1 (lowest)                     | 24  | 25   | 23                                     | 26                 | 21  |
| slot 2                              | -   | -  | 23                                     | 25                 | -   |
| slot 3                              | -   | -  | 21                                     | 25                 | -   |
| slot 4                              | -   | -  | -                                      | 24                 | -   |
| (or highest) 5                      | 24  | 24   | -                                      | -                  | 21  |
| crotch 1 (closest)                  | 23  | 25   | 25                                     | 26                 | 25  |
| crotch 2                            | 23  | -  | 25                                     | 26                 | -   |
| crotch 3                            | -   | -  | -                                      | 24                 | -   |
| belt path                           | 23  | 25   | 24                                     | 21                 | 23  |
| max exterior width location         | handle hub  | handle hub   | handle hub                             | handle hub         | handle hub  |
| max exterior width                  | 48  | 44   | 42                                     | 43                 | 43  |
| height top head to top shell:       |   |  |  |                    |   |
| 12-MO                               | 5   | 3 @ HR, 5 @ shell  | 6.5                                    | 4                  | 8   |
| 18-MO                               | 3.5   | 1.5 above HR, 1 below shell  | 4                                      | 1.5                | 5.5   |
| Fit issues                          | 12MO shoulders touch bottom of head rest, 18MO shoulders are crammed against btm HR but pelvis fully back in seat | 12MO shoulders touch bottom of head rest, 18MO shoulders are crammed into HR but pelvis fully back in seat | Little tight at the shoulders for 18MO | None               | 18MO shoulders fit tight within head rest but pelvis fully back in seat, top slots are above 18MO shoulders |
| Location                            | BuyBuyBaby Canton   | BuyBuyBaby Canton  | Walmart Canton                         | Walmart Canton     | BabiesRUsNorthville   |
| Date                                | 12/7/12   | 12/7/12  | 12/7/12                                | 12/7/12            | 12/8/12   |
| Investigator                        | N. Orton  | N. Orton   | N. Orton                               | N. Orton           | N. Orton  |

Table A.1 Static Data (continued)

|                                     | 16  | 17                       | 18                                     | 19              |
|-------------------------------------|---|--------------------------|--|-----------------|
| Infant Seat Model Name              | <b>Shuttle 35</b>   | <b>Comfy Carry Elite</b> | <b>Embrace 35</b>                      | <b>KeyFit22</b> |
| Manufacturer                        | Combi   | Safety 1st               | Evenflo                                | Chicco          |
| Model Number                        | 8035123   | IC-096 BCR/GB1A2         | 48411392                               | 06060414930070  |
| Date of Manuf                       | 8/25/12   | 9/17/12                  | 10/26/12                               | 8/12            |
| Weight Range                        | 0-35 lb   | 4-22 lb                  | 4-35 lb                                | 4-22 lb         |
| Height Range                        | 33 in or less   | 29 in or less            | 17-30 in                               | 30 in or less   |
| # of Shoulder Slots                 | moving slots  | 4                        | 3                                      | 3               |
| # of Crotch Slots                   | 1   | 3                        | 2                                      | 1               |
| <i>All Measurements below in cm</i> |   |                          |  |                 |
| Seatback Height                     | 44-54.5 on HR/ 47 on shell  | 48                       | 48                                     | 49              |
| Seat Length                         | 26 @ HRbtm, 27.5 @ HRtop  | 27.5                     | 27.5                                   | 26              |
| Slot Height:                        |   |                          |  |                 |
| (lowest) 1                          | 20  | 14.5                     | 12.5                                   | 19              |
| 2                                   | -   | 18.5                     | 19                                     | 24              |
| 3                                   | -   | 23.5                     | 25                                     | 29              |
| 4                                   | -   | 28.5                     | -                                      | -               |
| (or highest) 5                      | 36  | -                        | -                                      | -               |
| Crotch dist from bight:             |   |                          |  |                 |
| (closest) 1                         | 10.5 @HRbtm / 12 @ HRtop  | 8                        | 10.5                                   | 9.5             |
| 2                                   | -   | 11.5                     | 16                                     | -               |
| (farthest) 3                        | -   | 15                       | -                                      | -               |
| Seat interior width at:             |   |                          |  |                 |
| bight                               | 23  | 25                       | 22                                     | 23              |
| slot 1 (lowest)                     | 21  | 26                       | 21                                     | 24              |
| slot 2                              | -   | 26                       | 22                                     | 23              |
| slot 3                              | -   | 25                       | 21                                     | 22              |
| slot 4                              | -   | 25                       | -                                      | -               |
| (or highest) 5                      | 20  | -                        | -                                      | -               |
| crotch 1 (closest)                  | 25  | 26                       | 24                                     | 24              |
| crotch 2                            | -   | 26                       | 24                                     | -               |
| crotch 3                            | -   | 25                       | -                                      | -               |
| belt path                           | 23  | 21                       | 23                                     | 23              |
| max exterior width location         | handle hub  | handle hub               | handle hub                             | handle hub      |
| max exterior width                  | 43  | 43                       | 48                                     | 43              |
| height top head to top shell:       |   |                          |  |                 |
| 12-MO                               | 8   | 3                        | 4.5                                    | 3.5             |
| 18-MO                               | 5.5   | 1.5 above shell          | 1                                      | 1.5             |
| Fit issues                          | 18MO shoulders fit tight within head rest but pelvis fully back in seat, top slots are above 18MO shoulders | None                     | Little tight at the shoulders for 18MO | None            |
| Location                            | UMTRI   | UMTRI                    | UMTRI                                  | UMTRI           |
| Date                                | 12/17/12  | 12/11/12                 | 12/19/12                               | 1/4/13          |
| Investigator                        | N. Orton  | N. Orton                 | N.Orton                                | N.Orton         |



**Seat**



**Measurement Tool**



**12 Month Old**



**18 Month Old**

**Figure A.1 Chicco KeyFit30**





**Seat**



**Measurement Tool**



**12 Month Old**



**18 Month Old**

**Figure A.2 Britax B-Safe 30**





**Seat**



**Measurement Tool**



**12 Month Old**



**18 Month Old**

**Figure A.3 Graco Snugride 30**





**Seat**



**Measurement Tool**



**12 Month Old**



**18 Month Old**

**Figure A.4 First Years/Lamaze Via**





**Seat**



**Measurement Tool**



**12 Month Old**



**18 Month Old**

**Figure A.5 Safety 1st onBoard 35 air**





**Seat**



**Measurement Tool**



**12 Month Old**



**18 Month Old**

**Figure A.6 Graco Snugride 35**





**Seat**



**Measurement Tool**



**12 Month Old**



**18 Month Old**

**Figure A.7 Safety 1st onBoard 35**





**Seat**



**Measurement Tool**



**12 Month Old**



**18 Month Old**

**Figure A.8 Graco Snugride**





**Seat**



**Measurement Tool**



**12 Month Old**



**18 Month Old**

**Figure A.9 Baby Trend Flex Loc**





**Seat**



**Measurement Tool**



**12 Month Old**



**18 Month Old**

**Figure A.10 Graco Snugride Click Connect 40**





**Seat**



**Measurement Tool**



**12 Month Old**



**18 Month Old**

**Figure A.11 Summer Infant Prodigy**





**Seat**



**Measurement Tool**



**12 Month Old**



**18 Month Old**

**Figure A.12 Britax Chaperone**





**Seat**



**Measurement Tool**



**12 Month Old**



**18 Month Old**

**Figure A.13 Peg Perego Primo Viaggio**





**Seat**



**Measurement Tool**



**12 Month Old**



**18 Month Old**

**Figure A.14 Evenflo Discovery 5**





**Seat**



**Measurement Tool**



**12 Month Old**



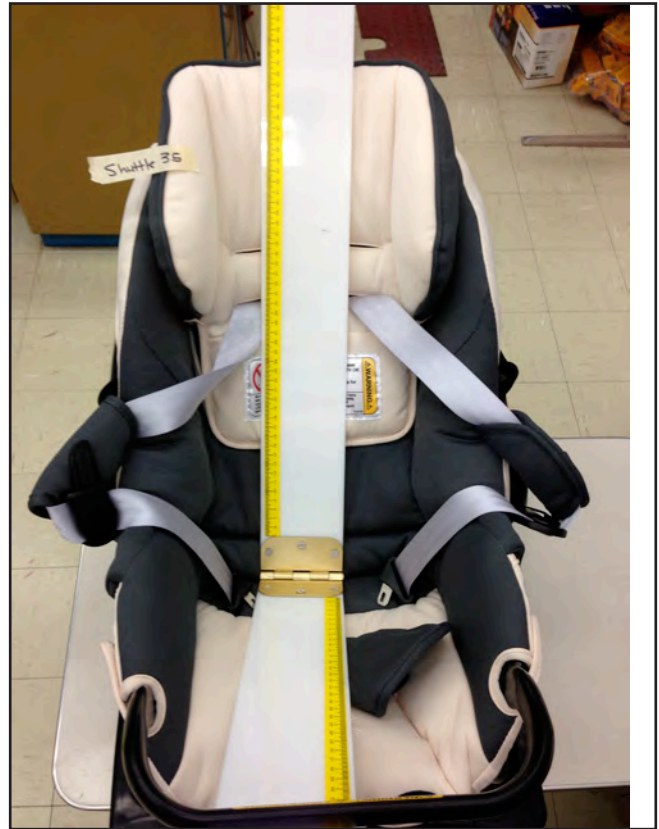
**18 Month Old**

**Figure A.15 Cosco Comfy Carry**





**Seat**



**Measurement Tool**



**12 Month Old**



**18 Month Old**

**Figure A.16 Combi Shuttle 35**





**Seat**



**Measurement Tool**



**12 Month Old**



**18 Month Old**

**Figure A.17 Safety 1st Comfy Carry Elite**





**Seat**



**Measurement Tool**



**12 Month Old**



**18 Month Old**

**Figure A.18 Evenflo Embrace 35**





**Seat**



**Measurement Tool**



**12 Month Old**



**18 Month Old**

**Figure A.19 Chicco KeyFit 22**

DOT HS 812 156  
June 2015



U.S. Department  
of Transportation  
**National Highway  
Traffic Safety  
Administration**

