DEVELOPMENT OF ADAPTIVE SUPPLEMENTAL RESTRAINT SYSTEM

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ABSTRACT

The article relates to methods of mitigating results of improper value of force applied to the occupant's body at a time of an imminent front vehicle collision and preventing fatalities as well as injuries that may be caused. More particularly, the present article relates to a new method of accurately weighing vehicle occupants that eliminates obstacles to improve their safety in the event of a collision.

The statistics show that the number of victims is indirectly proportional to their weight. It means that to significantly improve safety of the vehicle occupants, it is necessary to put stress on controlling the forces applied to the occupants' bodies by more accurately measuring their weights. It is noted in [1] that the weight of an occupant measured by an air bag system is not the entire weight of the occupant since some of the occupant's weight will be supported by feet which are resting on the floor or pedals. As result, there is overlapping of weight classes in the Passenger Classification System that creates malfunction of the air bag and decreases the number of properly working weight classes to 3 instead of 5. This is a problem that does not allow to accurately weigh a vehicle occupant in a supplemental restraint system to provide the possibility of an accurate control of the air bag inflation force depending on the real value of the occupant's weight (mass) and eliminate extra force applied to the occupant's body at the time of collision. NHTSA, Department of Transportation, published in August 2004 requirements of the final rule of Section §571.208 Standard No. 208; "Occupant crash protection" [2] to improve the security of the air bags for children and light women. An object of the article is to find ways to improve the accuracy of the safety system for differentiating the weight of older children from the weight of the light women passengers and support the documents provided by NHTSA that say the modern safety systems should provide improved protection for occupants of different sizes.

The method described in the present article provides the possibility to extend the current Passenger Classification System by accurately measuring occupant's weight and more accurately controlling the force applied to lighter weighing people and youngsters in case of accident. The article provides a method of accurately weighing occupants of different weights by employing an ADaptive MUlti-force Safety (ADMUS) system that improves the Passenger Classification System for minimizing the risk of injury or death from a possible improper extra force applied to them by air bags in case of accident especially for light adults in contemporary and self-driving or autonomous vehicles

The ADMUS system, with its accurate innovative occupant weight measuring KEF method [3, 4], provides higher protection to occupant bodies of different weights by keeping an extra force from them in case of accident. The weighing error of a vehicle occupant weight measuring drastically decreased in applications [5, 6] by employing the occupant weighing innovative KEF method and using this weighing method and technology based on it to eliminate the weighing error.

Research Question/Objective.

Practically all American cars are equipped by safety systems such as Supplemental Restraint System (SRS) comprising an air bag. When the vehicle includes an occupant safety restraint device arranged to protect the occupant during a crash involving the vehicle, it is connected to the weight measuring system and arranged to provide a variable deployment depending on the determined weight of the occupant. During a crash event, the vehicle's crash sensor and other sensors provide crucial information to the air bag Electronic Computing and Control Unit (ECU), including weight and position of an occupant, usage of the seat belt, severity of impact, etc. Using this information, the air bag ECU's crash algorithm determines if the crash event meets the criteria for air bag deployment and triggers various firing circuits to deploy one or more air bag modules within the vehicle.

THE WAYS TO IMPROVE AIR BAG TECHNOLOGY

To improve safety of passengers in case of a possible crash, adaptive and advanced duel-depth air bag systems and, according to them, the Passenger Classification Systems were designed. Adaptive air bag systems may utilize multi-stage air bags to adjust the pressure within the air bag. Information regarding the occupants and the severity of the crash are used by the air bag control unit, to determine whether air bags should be suppressed or deployed, and if so, at various calculated output levels**.** In the advanced duel-depth air bag, the first and second chambers of the air bag are selectively pressurized with a gaseous fluid. The design of the advanced duel-depth air bag system shows that the car manufacturers try to improve the vehicle occupant safety employing the Passenger Classification System [7] by multiplying the number of stages of an air bag.

STATISTIC OF CASUALTIES.

The present article relates to a problem of mitigating results of improper value of force applied to the occupant's body at a time of an imminent vehicle collision on the road by preventing fatalities as well as injuries that may be caused. More particularly, the present article relates to a new method of accurately weighing vehicle occupants that provides elimination of obstacles to improve their safety in the event of a collision. The problem of vehicle occupant safety has now become a nation-wide problem for the USA and other countries. The air bag by itself may cause injuries if it doesn't work properly. From 1990 to 2000, the United States National Highway Traffic Safety Administration (NHTSA) identified 175 fatalities caused by air bags. Most of these (104) have been children, while the rest were adults. 262 deaths from1990 to 2006 reportedly have been caused by air bags inflating in low severity crashes, most of them in older model vehicles. These deaths include 87 drivers, 13 adult passengers, 138 children, and 24 infants. In 2016 alone, 37,461 people died in motor vehicle crashes. In 2016 publication [8], NHTSA provided overall crash population for a period of 2010-2013. Today's cars and trucks come with driver assistance technologies. The driver assistance technologies that include sensors, radars, cameras, GPS will help support Automated Driving Systems (ADS), more commonly referred to as "self-driving" [9] (SDV) or autonomous vehicles. These 2 types of vehicles in contrast to the contemporary vehicles might be able to take over all aspects of driving and may predict imminent crashes on the road and reduce vehicle crashes and resulting fatalities and injuries. The Table 1 was generated by this data.

Table 1.
Crashes in 2010 - 2013 and their results

	2010 - 2013 Annually				2010 - 2013 total costs	
	Crashes	Fatalities	1-5 Injuries	Property damage	Costs for society	Total costs
1	Registered crashes for all vehicles					
	5.5 M	33,020	2.7 M	6.3 M	$195 B	$721 B
2	Related to the V2V technology (2 cars crashes - 69%)					
	3.8 M	13,329	2.1 M	5.2 M		
3	For LV2LV vehicles only (62% of all crashes) - that a new technology may save					
	3.4 M	7,325	1.8 M	4.7 M	$109 B	$319 B
4	Crashes and their results that will be not covered by the V2V technology					
	2.1 M	25,695	0.9 M	1.6 M	$86 B	$402 B

In the row 1 of the Table 1, is given the data published by NHTSA. Based on 2010-2013 General Estimates System (GES) and Fatality Analysis Reporting System (FARS), of the 5.5 million annually crashes, which would translate to 33,020 fatalities, 2.7 million Maximum Abbreviated Injury Scale (MAIS) 1-5 injuries, and 6.3 million property damage only vehicles (PDOVs). NHTSA estimated that safety applications enabled by self-driving technology could eliminate or mitigate the severity of up to 80 percent of crashes, including crashes at intersections or while changing lanes. Most of the automobile companies, technology companies, component makers, and organizations have begun developing or forming partnerships around self-driving technology to decrease the number of crashes, fatalities, and injuries on the roads.

The Tesla's hardware [10] for self-driving model S electrical car employed in the SDV to make driving vehicles safer . The V2V (vehicle-to-vehicle) communication technology described by NHTSA. Detailed information about DSRC-based V2V vehicle communication system see in [8]. As the statistics show, the number of the victims is indirectly proportional to their weight. The sensors have to measure weight of a vehicle occupant but not the size of the occupant because the energy accumulated by the occupant's body in the moving vehicle and which a restraint system has compensate during the crash, is proportional to the mass but not to the size of the body. In the contemporary Passenger Classification Systems, the force applied by an air bag to the adult occupant, especially to the driver, in the air bag system is the same as applied to the person whose weight is 102 Lb and applied to the person whose weight is even 215 Lb or higher. A light occupant in such situation may be injured and a heavy occupant may be not protected enough. This is the reason that it is necessary to provide more classes in the Passenger Classification System to differentiate the forces applied to children and adult occupants in case of collision according to their weight.

Methods and data sources

OCCUPANT WEIGHING ERROR

As was mentioned before, the weight of an occupant measured by an air bag system is not the entire weight of the occupant since some of the occupant's weight will be supported by his or her feet which are resting on the floor or pedals. Contribution of the lost weight of the foot part of the body to a total weight of a person during measurement may be evaluated very easily, and it is about 15 -30%% or more of the whole body weight. This is a problem that does not allow to accurately weigh a vehicle occupant in supplemental restraint system to provide the possibility of an accurate control of the air bag inflation force depending on the real value of the occupant’s weight (mass) and eliminate extra force applied to the occupant’s body at the time of collision. So, to accurately weigh a vehicle occupant, it is necessary to weigh the whole body of a vehicle occupant including the weight of a foot part of his/her body. NHTSA published in [2] requirements of the final rule of Section § 571.208 Standard No. 208; "Occupant crash protection" to improve the security of the air bags for children and light passengers. It is not made in the on-board vehicle safety system yet. It is a goal of the methods of the present article to improve the occupant safety system by more extensive preparations for overcoming an imminent vehicle collision on the road and preventing fatality as well as injuries of the occupants that may be caused by an unsafe force applied to their bodies by the restraint system in the event of a collision. A principal object of the present article is to improve the accuracy of the safety system for differentiating the weight of older children from the weight of the light women passengers and support the documents provided by NHTSA that say the modern safety systems should provide improved protection for occupants of different sizes. So, it is the object of the present article to provide a safety system for controlling the force applied to the occupant's body measuring not the size, but with the accurately measured weight of the occupant. An object of the present article is to provide an accurate measuring weight of the vehicle occupants in a safety system of the contemporary, self-driving and autonomous vehicles by an accurate occupant weighing technology because the statistics show that the number of the accident victims depends on their weight. This provides the possibility to extend also the current Passenger Classification System and more accurately control the force applied to lighter weighing people and youngsters in case of accident.

ADMUS SYSTEM

This article provides a safety method for protection of the different weight occupants of the self-driving or autonomous vehicle by applying different forces to their bodies at the moment of an accident that are more accurately controlled through the control signals depending on their weights that are modified depending on the morphological data and factors of the car trip in the current situation that influence the force applied to the occupant's body. The article provides method of accurately weighing occupants of different weights by employing an ADaptive MUlti-force Safety (ADMUS) system that improves the Passenger Classification System for minimizing the risk of injury or death from a possible improper extra force applied to them by air bags in case of accident especially for children and light adults in contemporary and self-driving or autonomous vehicles. The ADMUS system, with its accurate innovative occupant weight measuring KEF method [3, 4], provides higher protection to occupant bodies of different weights from applying an extra force to them in case of accident by more extensive preparations for overcoming possible negative consequences of an imminent vehicle collision on the road and preventing fatal accidents as well as injuries of the occupants that may be caused by an unsafe force applied to their bodies by the restraint system.

KEF METHOD

The weighing error of a vehicle occupant weight measurement may be drastically decreased by employing the occupant weighing innovative KEF method and using this weighing method and technology based on it to eliminate all the weighing error. In this case, the energy generated by the occupant's body at the time of collision may be accurately measured before the collision and used for safety purposes in the vehicle air bag system. Using the KEF method is important to provide effectiveness and accuracy for occupant weighing. It is based on a horwest (horizontal weighing stability) effect that states: the value of a weight measurement of an object located in a closed system on a weighing unit doesn't change while this object provides a bi-directional force in a horizontal direction of a predetermined value to a vertical surface of another object, which is a predetermined distance away [see 3,4]. The horwest effect can be used to implement the simplified weighing apparatus for accurate vehicle occupant weighing. Moreover, the innovative KEF method can provide a simplified and accurate occupant's weight measurement in a car or a motor vehicle, especially a passenger vehicle such as an automobile, a van, a self-driving car, a corporate vehicle, a limousine, or a truck equipped with an occupant safety device such as air bag Supplemental Restraint System (SRS) by employing a weighing unit (weight sensors) connected to the seat of the vehicle occupant, whose output is connected to the computing and control unit of the SRS, by pushing horizontally a switch of the weighing moderator, located above the waist of the occupant on a substantially vertical surface of the vehicle (for example, on a steering wheel, an instrument panel, or a dash board) at the beginning of the trip, and simultaneously, conveniently lifting feet above the floor and keeping them up during the weight measurement, measuring occupant's weight by the weighing unit. Subsequent processing of the collected weight of the vehicle's occupant by the computing and control unit while receiving the signal from the switch of the weighing moderator, modifying this original weight measurement of the vehicle occupant by the current values of the morphological data and factors of the car trip situation and transmitting this processed value of the vehicle occupant's weight to the air bag control unit to apply, in case of a collision, an appropriate force to the occupant's body, whose value will be calculated according to the modified and accurately measured occupant's original weight.

SOURCES

The accuracy of weighing a vehicle's occupant and, accordingly, providing an accurate value of the force applied to the different weights of the occupants' bodies may be improved up to 20-30% by employing KEF method. It is further noted that the priority documents of the current article, namely U.S. Pat. No. 9,566,877 [3], issued on Feb. 14, 2017, **allowed** U.S. Divisional patent application Ser. No. 15/430,219 [4] filed on Feb. 10, 2017, U.S. Pat. No. 10,131,308 [6] issued on Nov. 20 , 2018 and U.S. Provisional Application No. 61/956,059 [11] filed on May 30, 2013, can provide a more detailed description of the novel horwest effect and KEF method. The present article provides a method for a contemporary or a self-driving or autonomous vehicle having an air bag safety system to communicate with an innovative weighing KEF technology for use in the accurate weighing of an occupant based on a weighing moderator to prevent extra force applied to the occupant’s body in case of collision. The present article provides modification of the occupant's original weight accurately measured by the innovative weighing technology in a contemporary or a self-driving or autonomous vehicle before the beginning of a trip in accordance with the values of such parameters as the severity of the crash, position of the occupant, using a seat belt.

Results

As was noted above, the measured weight of an occupant is not the entire original weight of the occupant since some of the occupant's weight will be supported by his or her feet which are resting on the floor or pedals. This effect creates a weighing error. The value of this error in a total original weight of a person may be evaluated very easily, and it is about 15-30% or more of the whole body weight. In [12] this loss of the occupant's weight was given as 20%. Some data for the weighing error provided in the current article have been received in experiments and shown in Tables 2 , 3, and 4. The whole picture of the weight lost by a vehicle occupant during measuring his/her weight while one is sitting in the car seat and the feet are resting on floor or pedals and supporting the body, may be clear after receiving a statistical data. The weighing error is a problem that does not allow to accurately weigh a vehicle occupant in on-board vehicle safety restraint system to provide the possibility of an accurate control of the air bag inflation force depending on the real original value of the occupant's weight (mass). The weighing error does not allow also to eliminate improper force applied to the occupant's body at the time of collision by improving the Passenger Classification System and providing an improved accuracy of the safety system for differentiating occupants by weight, especially children from the light women. The weight measurements of occupants of different groups age, sex, positions were made by the author and provided in Table 2.

Table 2.

The occupant's weighing error

	Date	Weight (Lb)					
		Original weight, sex, age	Horizontal distance D (cm) from feet on the floor to the torso on the scale	Feet position (torso on the scale)			Percentage of the occupant's weighing error
				Hands are on the groins	Hands down in the air	Hands on the knees	
1	3.29.2018	151 Man, 82	70 max	128	126	115	15.2-23.8 %
			55 mid	121	114	112	19.9-25.8 %
			40 min	114	109	107	24.5-29.1 %
2	3.30.2018	182 Female, 77	60 max	155	154	150	14.8-17.6 %
			50 mid	150	149	147	17.6-19.2 %
			40 min	143	140	138	21.4-24.2 %
3	3.29.2013	148, Man, 77	D min			109	25.8-26.4 %
4	7.25.2014	151 Man, 78	D min			110	27.2%
5	9.24.2016	144, Man, 80	D min			120	16.7%
6	7.14.2018	221 Man, 45	D max	197	193	188	10.9 - 14.9 %
			D mid	189	178	173	14.5 - 19.5 %
			D min	173	166	160	21.7 - 27.6 %
7	11.10.2018	134 F 15	D min			93	30.6%
8	11.10.2018	91 F 11	D min			65	28.6 %

As we may see from Table 2, the value of an error of measuring weight of an occupant sitting in a seat of the contemporary on-board vehicle SRS air bag safety system may reach around 30% of original occupant's weight. For example, in the Table 2 in the range from 144 to 221 Lb of the original weights of occupants, the value of the mistake of occupant weight measurement reaches 29.1%. This means that some two classes in the Occupant Classification System SRS may be overlapped. In the Fig.1,a is given the Table S7.1.4 "Weights and dimensions of the vehicle occupants referred to in Standard § 571.208: Occupant crash protection"[2].

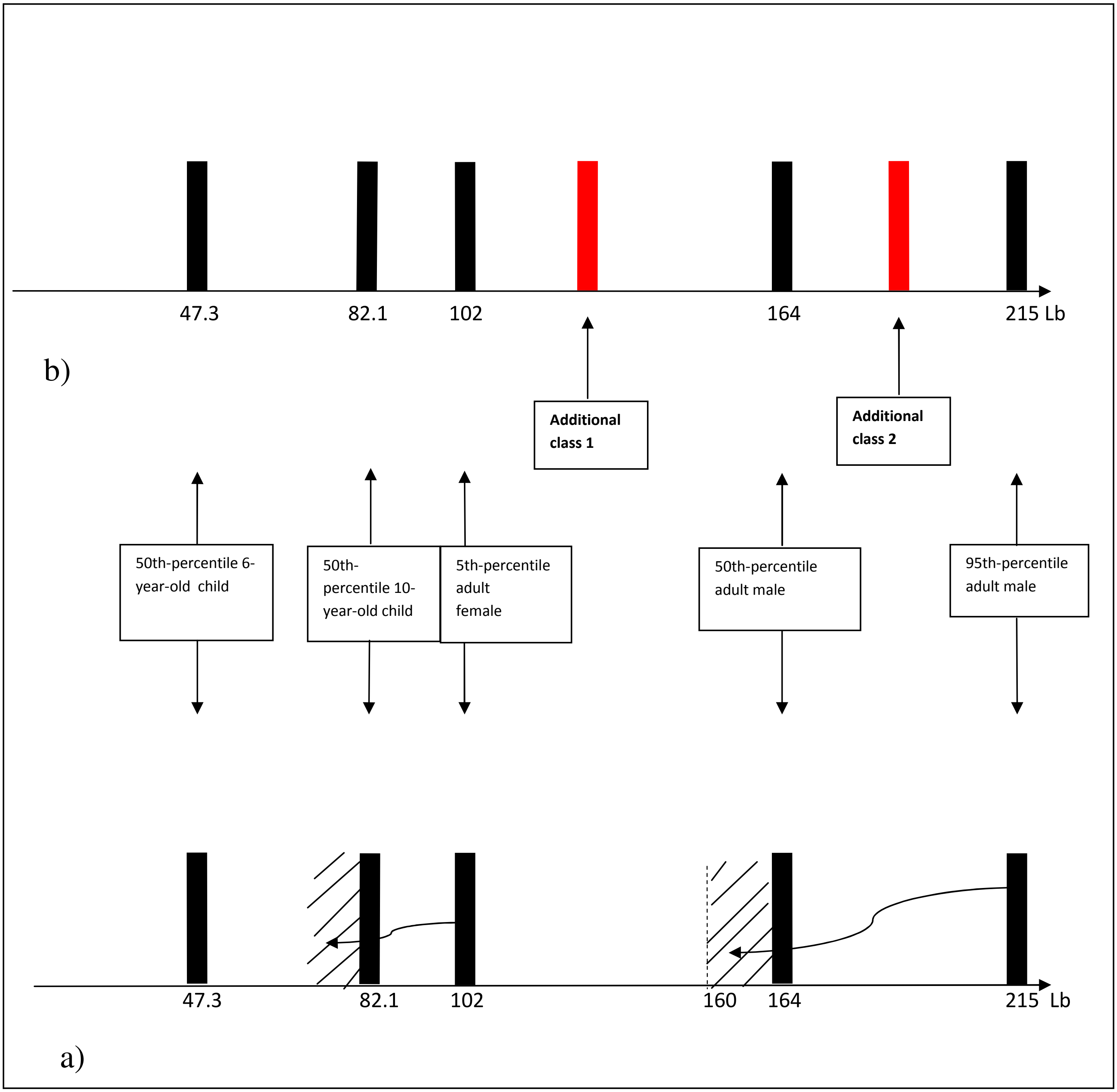

Fig.1. b) KEF method based Passenger Classification System
Fig.1. a) Overlapping in the Standard 208 Passenger Classification System

OVERLAPPING IN THE STANDARD §571 208

There are 5 classes of occupants in the Table S7.1.4 "Weights and dimensions of the vehicle occupants referred to in Standard § 571.208" [2] showed as 5 black bars in FIG.1,a:

50th-percentile 6-year-old child (47.3 Lb), 50th-percentile 10-year-old child (82.1 Lb), 5th-percentile adult female (102 Lb), 50th-percentile adult male (164 Lb), and 95th-percentile adult male (215 Lb). As we see from Table 2, in case of the 95th-percentile adult male whose original weight 221 Lb (that is close to the range 215 Lb) and its maximum variable weighing error value is 27.6%, 50th-percentile adult male class will be overlapped by the measured weight of the 95th-percentile adult male class**,** and the SRS air bag safety system will not recognize whom it is necessary to treat: 50th-percentile or 95th-percentile adult male, although the force applied to the bodies of these two different weight occupants should be different. For now it seems the worst case of overlapping is on the border of 50th-percentile 10-year-old child and 5th-percentile adult female. As in the previous example, in case of the 5th-percentile adult female whose original weight around 102 Lb (according to the Table S7.1.4 "Weights and dimensions of the vehicle occupants referred to in Standard § 571.208") and if its maximum variable weighing error value is more than 20%, the 50th-percentile 10-year-old child class will be overlapped by the measured weight of the 5th-percentile adult female class (see FIG 1, a). In this case, the air bag safety system will malfunction. It will suppress the air bag when it should be deployed because the 5th-percentile adult female is in the seat.

OVERLAPPING BY THE MEASURED DATA

Malfunction case was found in Table 3 when a group of adult people was checked for their value of weighing error. The weight measurement of this group of six adult women was provided by "ResCare" Adult Day Care Community Center, Hamden, CT. As we may see from Table 3, women ##5 and 6 may be related to the 5th-percentile adult females. Woman #5 has original weight of 113 Lb, and her measured weight in the simulator of the vehicle seat while her feet are on the floor, is 84 Lb. Her calculated weighing error is 25.7%. In case of the vehicle collision, the air bag system will recognize her as adult (84 Lb >82.1 Lb) and her air bag will be deployed. Woman #6 has original weight of 108 Lb, and her measured weight in the simulator of the vehicle seat while her feet on the floor, is 78 Lb. Her calculated weighing error is 27.8%. In case of her vehicle collision, the air bag system will malfunction by recognizing her as the 50th-percentile 10-year-old child (78 Lb <82.1 Lb), and her air bag will not be deployed.

Table 3.

The adult occupant's weighing error

No.	Date	Name	age	sex	Weight (Lb)			Percentage of the occupant's weighing error
					Original weight	Hands on the knees	Difference	
1	10.30.2018	Maya	82	F	154	110	44	28.6%
2	10.30.2018	Galina	79	F	148	101	47	31.8%
3	10.30.2018	Bella	81	F	135	103	32	23.7%
4	10.30.2018	Sophia	81	F	140	109	31	22.1%
5	10.30.2018	Angela	95	F	113	84	29	25.7%
6	10.30.2018	Inness	85	F	108	78	30	27.8%

The third such malfunction case was found in Table 4 when a group of 5th-percentile adult females was checked for their value of weighing error. The weight measurements in the Table 4 were provided by National Music Teachers Association (New Haven Chapter), a music studio in Woodbridge, CT.

As we may see from Table 4, women ##7 and 9 may be related by weight to the 5th-percentile adult females. Woman #7 has original weight of 105 Lb, and her measured weight in the simulator of the vehicle seat while her feet are on the floor, is 74 Lb. Her calculated weighing error is 29.5%. In case of her vehicle collision, the air bag system will malfunction by recognizing her as the 50th-percentile 10-year-old child (74 Lb <82.1 Lb) and her air bag will not be deployed.

Table 4.

The 5th-percentile adult females weighing error

No.	Date	Name	age	sex	Weight (Lb)			Percentage of the occupant's weighing error
					Original weight	Hands on the knees	Difference	
1	10.22.2018	Libby	12	F	77	54	23	29.8%
2	10.22.2018	Nell	13	F	83	59	24	28.9%
3	10.22.2018	Sienna	15	F	138	98	40	28.98%
4	10.22.2018	Mei	16	F	118	97	21	17.8%
5	10.23.2018	Sofia	15	F	158	108	50	31.6%
6	10.24.2018	Veronica	16	F	149	111	38	25.5%
7	10.24.2018	Sophia	13	F	105	74	31	29.5%
8	10.24.2018	Leila	14	F	158	105	53	33.54%
9	10.25.2018	Devin	12	F	102	74	28	27.45%
10	10.26.2018	Sophia	13	F	80	55	25	31.25%

Woman #9 in Table 4 has original weight of 102 Lb, and her measured weight in the simulator of the vehicle seat with her feet on the floor, is 74 Lb. Her calculated weighing error is 27.45%. In case of her vehicle's collision, the air bag system will malfunction because it will recognize her as 50th-percentile 10-year-old child (74 Lb <82.1 Lb), and her air bag will not be deployed.

The variable weighing error may be used to predict, find, and eliminate by KEF method a malfunction of an air bag safety system (especially for 5th-percentile adult females) in a contemporary, self-driving, and autonomous vehicle where an accurate weight measuring KEF technology of an occupant will be employed.

As we may see from FIG. 1,a and Tables 2-4, to mitigate the negative consequences of a crash on a road for a 5th - percentile woman sitting in the contemporary, self-driving, or autonomous vehicle, it is necessary to know in advance or measure it at the beginning of the trip by KEF method an accurate original weight of this occupant and her measured weight when she/he is sitting in the seat. This last weight will be less than original weight because the feet are resting on the floor or pedals. If this weight overlaps a closest child weight range, it is necessary to eliminate the possible suppression of the air bag of the 5th -percentile woman before the vehicle's imminent crash during a trip. The time interval for regular weighing error measuring has to be established for contemporary, self-driving, and autonomous vehicles where the KEF weight measuring technology of an occupant is available.

FIG.1,b shows additional occupant's weight classes proposed in this ADMUS adaptive safety SRS system employing the accurate KEF occupant weighing technology. In the FIG.1,b seven weight classes proposed referred to ADMUS safety SRS system. Among these classes, there are all 5 classes (including children) that exist in the Table S7.1.4 "Weights and dimensions of the vehicle occupants referred to in Standard § 571.208: Occupant crash protection"[2]. The accuracy of KEF method and elimination of the weighing error, protects weight classes of Admus system from an overlapping that in turn provides room for at least 2 additional weight classes (red bars in the FIG.1,b).

The two additional classes may be used for the same purposes of applying different forces to the bodies of different (for example 125 and 190 Lb) weight occupants at the moment of an accident that are controlled through the control signals depending on their accurately measured weights and factors of the car trip in the current situation.

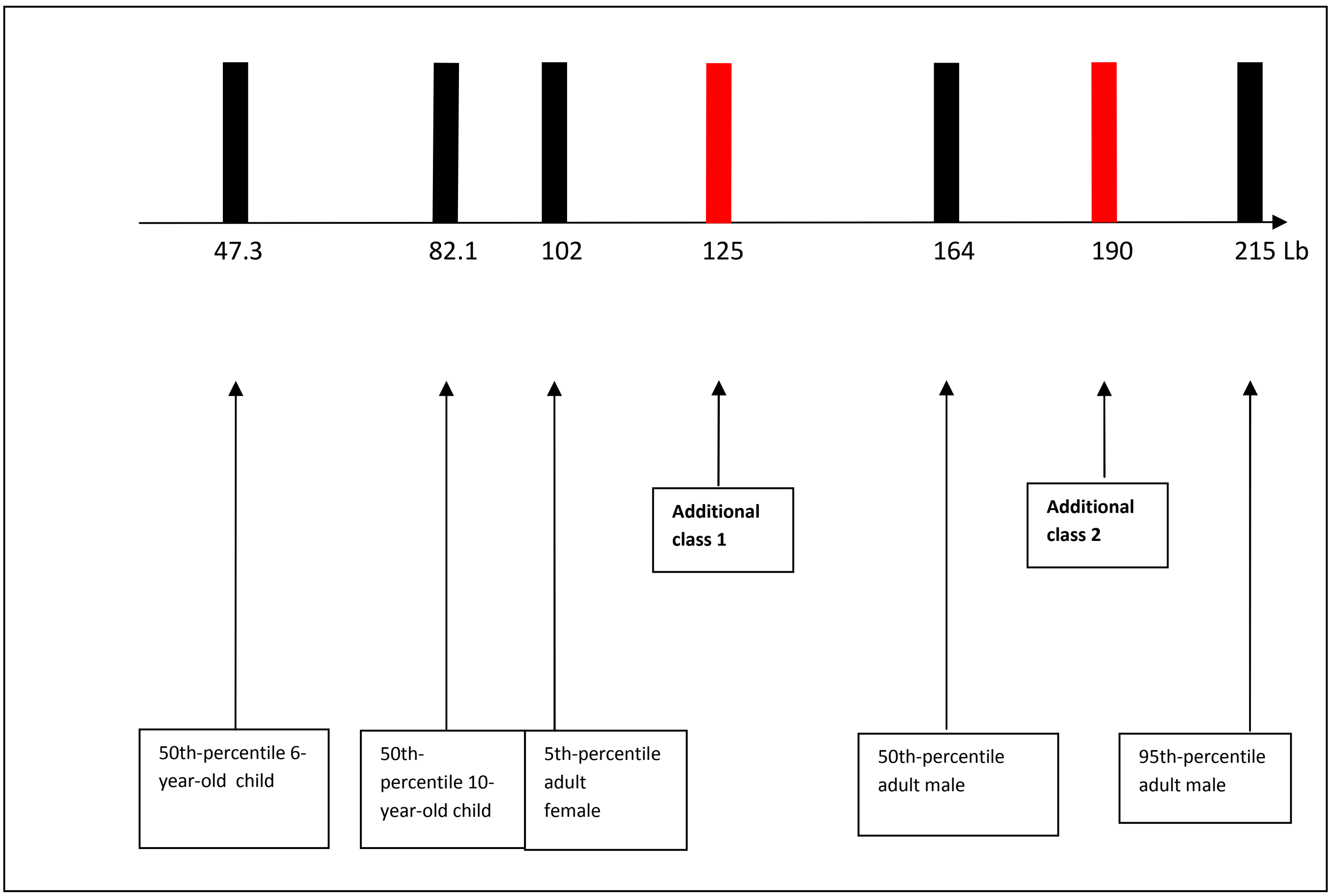

Fig.2. ADMUS Passenger Classification System

FIG.2 represents the proposed Passenger Classification System (PCS) based on accurate occupant's weight measuring KEF method and based in turn on this method the KEF technology that provide more accurate differentiation of different weight occupants and a safer restraint system. In Table 2 of [13], the number of passenger vehicles occupants that have been killed in crashes in 2016 is provided by age groups and restraint devices use. The ratio of the number of restrained passengers to the number of unrestrained passengers killed in the younger age groups such as <4 years old and 4-7 years old, and in the older aged groups 65 -74 and 75 + years old passengers, is 2-3 times higher than in other age groups despite that the percentage of known restrained was higher than the percentage of known unrestrained people killed in 2016. So, it seems that younger children group needs a more gentle restraint support during a crash, and proposed KEF method may help in this case also by extend the PCS.

Discussion and Limitations

Due to the of existence of the described above problem of overlapping and weighing error high value up to 30%, the number of properly functioning weight classes in the vehicles for adults in the Table S7.1.4 "Weights and dimensions of the vehicle occupants referred to in Standard § 571.208"[2] may really not be more than 3 classes that drastically decreases the accuracy of weighing occupants of a vehicle and their safety. This means it is necessary to provide a safety system for protection of the different weight occupants of the contemporary and self-driving or autonomous vehicles by applying different forces to their bodies that are more accurately controlled at the moment of an accident. The accuracy of the KEF technology of an occupant weighing improves safety system for differentiating the weight of older children from the weight of the light women passengers and supports the documents provided by NHTSA. The additional occupant's weight classes proposed in this ADMUS adaptive safety SRS system employing the accurate KEF occupant weighing technology that enhances safety (7 accurate weighing classes instead of 5) of the vehicle. These additional classes help to solve a problem of applying different forces to the bodies of different weight occupants by measuring weight of occupants accurately at a beginning of a trip and using these measurements at the moment of an accident to control the forces applied to the occupants' bodies depending on occupants' weights that are in the aftermath modified depending on the morphological data and factors in the current car trip.

Conclusions and Relevance to Session Submitted

Experimental data provided in the article clearly testifies that a weighing error of a vehicle occupants significantly reduces their safety by not restraining them by an accurate forces applied to their bodies. Additionally, weighing error, as shown in the article, leads to malfunction of the air bag for the 5th percentile of light women and for light old men. A simple KEF method of accurately weighing vehicle occupants provided in the article may help to avoid the weighing error in frontal and other types of crashes and enhance safety of vehicles. It is necessary to add that horrific numbers of child mortality provided in [13] forces us to make progress in this direction.

References.

1. U.S. Pat. No. 7,330,784. Johnson .W. et al. Weight measuring systems and methods for vehicles. February 12, 2008.
2. Final rule of Section § 571.208 Standard No. 208; Occupant crash protection. NHTSA. August 2004.
3. U.S. Pat. No. 9,566,877. Kriger Y. Technology and methods of on-board vehicle occupant accurate weighing by a simplified weighing apparatus based on weighing moderator and its applications in on-board occupant weighing systems, February 14, 2017.
4. U.S. Allowed Patent Application No.15/430219. Kriger Y. Technology and methods of on-board vehicle occupant accurate weighing by a simplified weighing apparatus based on weighing moderator and its applications in on-board occupant weighing systems, June 1, 2017
5. U.S. Pat. No. 10,017,078. Kriger Y. Relocatable/replaceable pad for accurate vehicle occupant weight measurement. July 10, 2018
6. U.S. Pat. No. 10,131,308. Kriger Y. Safety on-board vehicle multi-force restraint system employing a weighing moderator. November 20, 2018
7. U.S. Pat. No. 5,564,743. Marchant; Brent R. Multiple stage air bag inflator system. October 15, 1996.
8. Notice of Proposed Rulemaking. DOT of transportation NHTSA. 49 CFR Part 571 [Docket No. NHTSA-2016-0126] RIN 2127-AL55 Federal Motor Vehicle Safety Standards; V2V Communications.
9. NHTSA, " Driver assistance technologies". January 2018.
10. Tesla's Autopilot: The smart person's guide. By Hope Reese, TechRepublic, August 4, 2017.
11. U.S. Provisional Application No. 61/956,059. Kriger Y. filed on May 30, 2013
12. Development of occupant classification system. Tsutomu Takano, Nissan Motor Co., LTD 18 International ESV conference, Nagoya, May, 2003. Paper Number 206.
13. Traffic safety facts. 2016 data. DOT HS 812494. February 2018. NHTSA.