Optimal Traffic Safety Resource Allocations
2023 Update 2017-2021 Data

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January 15, 2023

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1.0 Introduction: Why Optimization?

1.1 What is Optimization

In an age when extremes are believed to be the norm for more and more people, the concept of optimization is given little thought. We have been disturbed by the fact that some basic principles of optimization are not taught at the grade-school level, since the simplest aspects of optimization are actual life survival skills. This author did not have a good concept of it until he got into an Operations Research course at the University level. We will discuss the downsides of this ignorance in the next section. For now, we want to concentrate on the definition.

The simplest concept of optimization is in the word *balance*. To elaborate somewhat: it is balance for the purpose of achieving some well-defined goal (sometimes formulated mathematically). In this study report, the goal will be one of traffic safety: to save the maximum number of lives lost to traffic crashes (also commonly referred to as *accidents*). The word "accidents" was banned we believe by NHTSA several years ago because high-level decision-makers reasoned that the word accident inferred that the incident had no cause. AAA had been arguing for decades that there was no such thing as an accident without a cause. These causes are typically of human origin. Many honest and good traffic safety advocates have been chastised when they slipped and called a crash an accident. We know of absolute no lives that have been saved from this word control. However, if it made those involved in traffic safety to recognize that there are no crashes that do not have human causes, then it was not all bad. We will use the word *crash* to avoid this controversy and further wasted time debating over it.

Try to think of a crash not caused by human action or the lack thereof (usually driver but might also be other human error, such as that caused by pedestrians, or someone leaving an object in the roadway). We have tried ourselves to think of a crash without a cause, but the best we could do would be a vehicle struck by a meteorite, which, of course could involve other vehicles. Even crashes caused by defective vehicles can ultimately be traced to a lack of proper maintenance, or even an engineering error during manufacture.

Let us get back on the optimization track by redefining the goal: to obtain the maximum reduction in lives lost due to traffic crashes. Sometimes the goal of reducing human suffering it tacked on to the fatality reduction goal. This would create a compound goal, and we should immediately recognize that there could be internal competition between the two components of this goal. The maximum reduction of total suffering may not result in the maximum reduction in lives lost. So some additional qualifiers to establish priority may be necessary. Such as, to obtain the maximum reduction first in lives lost, and then in suffering experienced due to traffic crashes. Since we do not believe that any suffering can be a traumatic as the loss of life, we will just omit this second consideration.

Another issue with the vague concept of reducing suffering is that it is difficult to measure the extent to which that part of the goal is being met. Lives lost is the exception, and most states keep up with this metric year after year, and even daily. Total human suffering might also be measured by crashes of the various severities. Keeping track of these numbers year after year provides essential information as to the effectiveness of the overall traffic safety program. Subdividing these numbers by the various traffic safety programs is feasible, since there are usually specific types of crashes that each countermeasure deals with. However, usually several countermeasures are applied to the same traffic crash problem.

We will keep things simple by stating that, in this study, optimization within the traffic safety function will be accomplished by allocating resources to those countermeasures that collectively reduce the number of persons killed over a given period of time (usually one year). While this is not an easy problem to solve, it helps if all members of the traffic safety community understand the issues involved and work together to try to bring about the best total solution possible.

Before we get too far into this report, let us define some of the words we will commonly use:

- Countermeasure. An action by one or more traffic safety professionals to reduce the frequency and/or severity of traffic crashes and save lives.
- Fatality. The loss of life caused by a traffic crash. NHTSA Fatality Analysis Research System (FARS) has very detailed definitions that, for example, define the number of days after the crash that the death of an injured person takes place when it can still be considered a traffic crash fatality. The important thing to recognize is that their counting of these fatalities is both consistent and accurate.
- Issue. A fatality crash cause. In Table 1 below each line of the table is for a separate issue. There are 24 such issues in Table 1, and it is quite important to recognize that while an issue is only counted once, no one of them is mutually exclusive from the others. The one that is counted is the one that was most likely to have caused the fatality.
- Optimization goal. To avoid unnecessary complications, the simple goal in this report is to minimize the number of fatalities that will occur in the next future year period.
- Optimization approach. The general approach to be used is to balance the resources allocated to countermeasures for each given issue so that the total traffic safety program brings about the maximum reduction in traffic crash fatalities.
- Program. The total combination of traffic safety countermeasure projects that make up the state's funding allocation to traffic safety for one year.
- Project. The implementation of a countermeasure. The traffic safety program consists of all projects planned for that year.

1.2 What if Optimization is not Applied

If optimization considerations are not applied to traffic safety countermeasures, there will be a waste of valuable life-saving resources. To emphasize the seriousness of this statement, it means that some people will be unnecessary killed. This might come as a shock to those who feel that a major goal in their lives is in saving lives. To the extent that this optimization procedure is quantified, its accuracy and respective benefits will be increased. But even if it is impossible to quantify some of the costs and savings involved, just an appreciation for the need to consider optimization and the need for balance can result in major system benefits. Otherwise, there tends to be a skewing of the allocations toward upper management's favorites.

Display 1. The Reality of Traffic Safety Budget Allocations

- Reality of countermeasure (CM) constraints
  - Except in extremely special circumstances, total budgets to traffic safety are fixed for the period of time of the decision-making (usually one year due to federal allocations)
  - Once a fixed total budget is specified the objective is the maximum fatality reduction caused by the combination of particular traffic safety issues being addressed
- Major consideration in CM selection
  - Optimization is required within each CM strategy. Once that is accomplished, the following questions follow:
    - What is the potential fatality reduction that can be expected from this CM implemented at the level specified?
    - How many fatal crashes will be reduced by this CM?
    - How much will this CM cost?
    - What other CMs must be reduced if more resources are allocated to this one?
  - Usually the ignored and unspoken downside of any CM: Could these funds be better spent elsewhere? I have never heard that expressed in any discussions on the subject.

To emphasize the potential problems of ignoring optimization, consider the four points summarized in Display 1, which deal with the realities of the problem of employing traffic safety resources effectively:

- Some tend to act like there are infinite total resources that can be employed. If they are successful in getting more resources assigned to their particular favored projects, this will lead to over-spending in those areas for which this attitude exists. In reality, while there might be a few extraordinary situations in which a given countermeasure is seen to be so beneficial that additional non-traffic-safety resources are allocated to it, in most cases *the overall traffic safety budget is fixed* and tradeoffs have to be made among the various countermeasures under consideration. So, in the end, those involved must try to do the best that they can with the resources that are allocated to their project areas and issues for the given duration of the budget (usually one year).

- There are four major considerations for CM selection (assuming that the primary objective is fatality reduction):
    - What potential reduction in fatalities are possible by this countermeasure (if not known definitively, then a maximum and minimum would tend to sharpen the estimation process)?
    - How much of this potential can the countermeasure reasonably be expected to reduce (again, a range is generally better than a single figure)? It should never be assumed that a CM will eliminate 100% of any issue.
    - How much cost will this deduct from the total budget? – this is quite important because it dictates the degree to which other CM will be sacrificed.
    - Can giving up the resources consumed by the CM be justified?
- A failure to see (or recognize) the downside effect on other countermeasures virtually guarantees that the budget allocations will not attain the degree of fatality reduction possible for the entire program.

This final point is often neglected by "traffic safety advocates" who are focused only on one or a very limited number of CMs. We often hear the maxim: "If we only saved one life, it was all worth it." This is only true if there are no other competing CMs the effectiveness of which was not reduced by those resources going to the first CM. Most effective CMs will save more than one life, so this adage tends to be an admission that there is a chance that the CM they are supporting will only save one. We understand why people make this assertion and it is not our goal here to be word police. Let us say that to emphasize the value of one life, such statements are acceptable, but if the goal is to take resources from other CMs, such an adage should just not be believed.

1.3 The Analytics and Data Starting Points

It is essential, especially for those organizations that have not applied optimization in the past, to have a sense of where to begin. We believe that the first step is to set up what we are calling Table 1. It is a listing in reverse order of fatalities in every given traffic safety issue being considered. Table 1 for 2022 Alabama is given below.

Table 1 is a starting point for optimization. It is a listing for each traffic safety issue, along with the maximum number of fatalities that can be reduced by applying CMs to it. If all fatalities could be eliminated for every traffic safety issue, then this list would be in priority order. However, we recognize that some issues present more difficult problems than others, and generally we are not going to assume that we can totally eliminate all fatalities within any of the issues. Instead, the Table 1 listing is that maximum that a totally effective program can eliminate for each issue. It should go without saying that it is impossible to reduce more fatalities within any given issue than the maximum (i.e. the Table 1 value) indicates.

Two of the issues related to occupant restraints are stated in terms of the consequences of the CM (e.g., seatbelts) *not* being applied. This is because within these issues, the absence of the use of the CM does not cause the crash. However, if the CMs for all crashes are ignored, the resulting increases in fatalities can be expected. This puts restraints on a level playing field with all of the other issues.

Table 1. Top Fatality Causes Alabama in CY2021

CY20	CY21	Crash Type (Causal Driver)	Fatal Number	Fatal %	Injuries	Injury %	PDO No.	PDO %	Total
1	1	Belt Restraint Fault*	541	6.24%	4,476	51.62%	3,654	42.14%	8,671
2	2	Speed Involved	199	2.16%	2,785	30.29%	6,209	67.54%	9,193
3	3	ID/DUI All Substances	180	3.17%	1,953	34.40%	3,544	62.43%	5,677
4	4	Hit Roadside Obstacle	126	2.15%	1785	30.46%	3949	67.39%	5,860
9	5	Pedestrian Involved	126	17.14%	575	78.23%	34	4.63%	735
10	6	Wrong Way Items	113	3.19%	805	22.73%	2,623	74.08%	3,541
6	7	Large Truck Involved	112	1.17%	1,701	17.80%	7,741	81.02%	9,554
5	8	Fail to Yield-Ran (All)	111	0.38%	8,040	27.41%	21,184	72.21%	29,335
8	9	License Defect Causal	101	1.39%	2,127	29.22%	5,052	69.40%	7,280
13	10	Youth (16-20) Causal	82	0.38%	4,351	20.08%	17,233	79.54%	21,666
11	11	Mature (65 or Older)	81	0.61%	2,666	19.94%	10,621	79.45%	13,368
14	12	Motorcycle Involved	72	4.57%	1,044	66.33%	458	29.10%	1,574
12	13	Aggressive Operation	70	2.46%	792	27.89%	1,978	69.65%	2,840
15	14	Distracted Driving	45	0.33%	2,803	20.55%	10,794	79.12%	13,642
17	15	Drowsy Driving	33	0.97%	1,201	35.22%	2,176	63.81%	3,410
19	16	Vehicle Defects – All	29	0.64%	923	20.28%	3,600	79.09%	4,552
16	17	Utility Pole	26	1.03%	799	31.76%	1,691	67.21%	2,516
22	18	Child Restraint Fault*	22	0.85%	717	27.80%	1,840	71.35%	2,579
18	19	Work Zone Related	17	0.73%	420	18.07%	1,887	81.20%	2,324
20	20	Vision Obscured	12	0.97%	289	23.31%	939	75.73%	1,240
21	21	Bicycle	7	3.15%	174	78.38%	41	18.47%	222
24	22	Railroad Trains	6	9.84%	18	29.51%	37	60.66%	61
25	23	Roadway Defects – All	2	1.77%	22	19.47%	89	78.76%	113
23	24	School Bus Involved	1	0.18%	71	12.96%	476	86.86%	548

* This issue is measured in the number of each severity of crash that *resulted* from the failure to use the proper restraint, as opposed to other items that are measured by the number of crashes *caused by* or *related to* the involvement of the particular issue.

Table 1 columns. The first two columns indicate the Table 1 results for the current year and the previous year. Any change of positioning between years should be studied carefully and an explanation as to the reason for the change should be assigned. Sometimes this is just some minor circumstance, but other times it may either signal the value of a CM or the consequences for not having one effectively implemented. The third column is what we have been referencing as the issue. In some cases (e.g. Speed Involved) the fault (in this case of the driver) is spelled out. In other cases (e.g., Large Truck Involved) the item used to define the issue does not nail down who or what was at fault.

The ordering of the Table is given in the next column (number of fatalities). This is persons killed and not fatal crashes, although fatal (and other severity crashes) are often used for evaluation and policy implementation. Here the number killed is used in order to provide a consistent metric for all of the issues. The next column (Fatal %) is given to indicate on a per crash basis how lethal the absence of a CM is as measured over all such crashes with this issue during the previous full year. The same is true of Injuries, Injury %, and Property Damage Only (PDO) crashes, which come next. The total column provides an indication as to how many crashes within this issue occurred in the previous full year.

As explained above, the number of fatalities will provide the basis for optimization – the objective function being to reduce the numbers in this column to the greatest extent possible. All other columns to the right are to provide decision makers with additional supplementary information. [If they were not there, we would expect many participants in the process would be asking for them.]

Table 1 can be viewed as the first step in the optimization procedure. It answers the question, what should the ordering of CMs be if all other things were equal. The problem is: all other things *are not equal*. Right from the outset it should be recognized that the issues are not mutually exclusive. For example, a crash may occur where no one was properly restrained, that involve the driver speeding and being under the influence of intoxicating substances, where the vehicle runs off the road and hits a pedestrian. We could go on and on but the dependence among the various crash issues is of critical importance. For one thing, it established that the level of implementation of one CM can have a significant effect on many others.

2 Major Considerations

2.1 Some Concepts Often Ignored

See the items within Display 2, which is an attempt to document the continuous improvement culture that should be a part of every traffic safety program.

Display 2 – Some Things Often Ignored

- Table 1 should be viewed as the overall status of the total current traffic safety program
    - It was derived from results of the previous year's traffic safety program.
    - If nothing is changed it is what can again be expected in the coming year.
- Table 1 should be respected as the result of previous year's efforts
    - So should the traffic safety experts who planned last year's CMs.
    - In most cases great efforts were put forward previously to save lives.
    - If true, all new CMs proposed will have the downside of taking resources from this previous plan.
    - The fact that a CM is newly proposed does not make it better.
    - In other words, its implementation will not necessarily reduce total fatalities.
    - But on the other hand, it well could – no plan is perfect.
- Traffic Safety Culture – continuous improvement forever; never satisfied
    - New is not necessarily better – but something is
    - The new optimal solution should include:
        - Improving the current CMs that have demonstrated increased benefits
        - Eliminating those current CMs that have not
        - Using saved resources for promising new CMs
- With a fixed budget any new CM will diminish allocated resources of the former plan
- If new money is available, seek the following that will save additional lives:
    - Determine and improve current CMs, if necessary, with additional resources.
    - Eliminate those CMs for which it is obvious that better strategies exist.
    - Implement new CMs where proposed benefit-costs exceed those currently in the plan.

2.2 Concept of Diminishing Returns

Seatbelts (restraints) are at the top of Table 1 indicating that more people lose their lives by not "buckling up" than for any other issue. Some seatbelt advocates might be tempted to think: why do we not place the entire traffic safety budget in this issue. Hopefully most can see intuitively the reason this would be counter-productive. The reason is called the Diminishing Returns Concept, which is explained in Display 3. This concept applies in virtually every human endeavor and it can be summarized by the maxim: too much of anything is not good. Semantics can be argued here in that how can anything be "too" much if it is a good thing. While there could be exceptions to this adage (e.g., love), for the most possible part it applies to all practical applications.

Display 3. The Diminishing Returns (DR) Concept

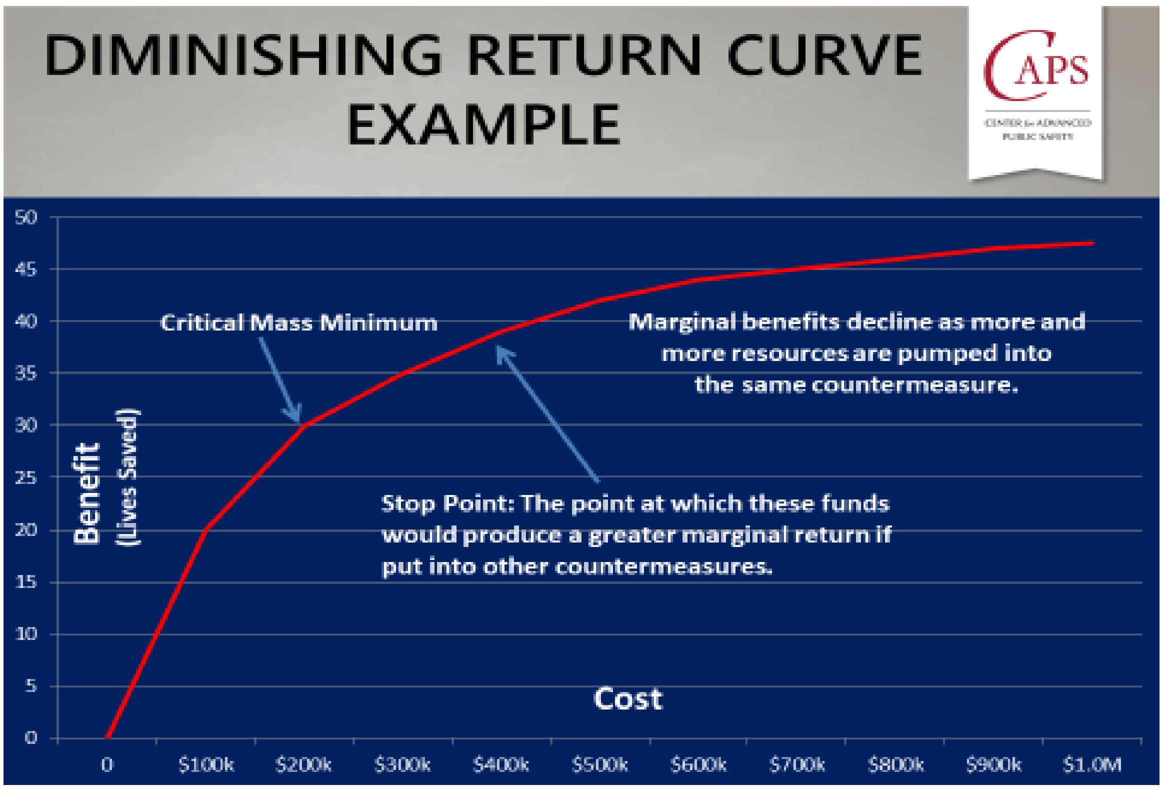
- Adding more and more funding to an exceedingly beneficial CM, generally increases the benefit to be obtained from it; however
  - At some point the *marginal benefit* declines, where
  - *Marginal benefit* is the net benefit derived from the last increment of funds invested in the CM
  - Every CM has a (generally different) Diminishing Returns (DR) curve.
- Creating the DR curve for any given CM
  - Costs can be obtained that are nearly perfect since we generally know what a CM will cost and the range of costs associated with it.
  - CMs that have not yet been implemented in the state will require additional research from other states, or publication for both costs and benefits. See immediately below for a highly-recommended publication: "Countermeasures that Work."
  - Benefits must be estimated to the best of the abilities of the analysts, including the following considerations:
    - Evaluations should be performed to the extent feasible for all CMs.
    - They should be guided by obtaining data for the DR curve.
    - Where data cannot be generated, the best estimates should be made.
    - While clearly this will not lead to a perfect optimization, the results will be considerably higher than that of ignoring the optimization and DR curve concepts.
    - Some approximation is essential in all measurements; this should not be an excuse for not doing the best that we can.
    - The purpose of the presentation in this section more to understand the concept of DR curves than it is to obtain a perfectly optimized solution.
  - Documentation is available from NHTSA on past evaluations of CMs that can help (e.g., Countermeasures that Work: Venkatraman, V., Richard, C. M., Magee, K., & Johnson, K. (2021, July). Countermeasures that

work: A highway safety countermeasures guide for State Highway Safety Offices, 10th edition, 2020 (Report No. DOT HS 813 097). National Highway Traffic Safety Administration.

2.2.1 Example Generalized Diminishing Return Curve

Display 4 presents a typical example of a Diminishing Return (DR) Curve.

Display 4. Example Diminishing Return Curve



Display 5. Components of the Diminishing Return Curve

The following should be clearly identified in any DR curve:

- Costs – plotted on the "X" scale, this should be a range of costs under consideration for this CM.
- Benefits (Lives Saved) – Plotted on the "Y" scale, the estimated benefit that this cost investment will generate.
- Critical Mass Minimum – the minimum investment that will produce any benefit at all.

- Stop point – the cost determined as the best investment for this CM in light of the funds required for other CMs.
- Remainder of the curve shows how ultimately the marginal benefits will diminish to zero.

2.2.2 Illogical Approaches to Avoid

Display 6 provides a listing of common errors that need to be avoided in striving toward a good optimal solution.

Display 6. Common Errors in Traffic Safety Budget Allocation

- The "Silver Bullet" approach. In one of our meetings over 20 years ago on the subject of CMs, an older respected and experienced individual asked the question: "what one CM should we implement?" Further discussion revealed that he was not asking about the best or most productive CM, he actually was thinking along the lines of what we are calling the silver bullet, where one shot solves all of the problems. My response was "There is none. Traffic safety can only be addressed by several, perhaps a large number of CMs implemented as a coordinated program"
- While we do not find many traffic safety professionals who believe there is a silver bullet, many traffic safety advocates promote their particular favored CM as if this were the case. And we have seen several cases throughout the years where a new director or other person of high authority, cut out all but a very few countermeasures thinking that this would result in more fatality reduction than all of the CM projects that had been functional for many years.
- Similar to the silver bullet approach are solutions at the extremes, where very little consideration is given to balance. Aristotle stated a long time ago: "All virtue is at the mean between extremes." Aristotle saw the error of not having a well-balanced program and/or thinking that all CMs in the program should be implemented on an "all-or-nothing" approach.
- We also now return to the problem of the common maxim: "if it only saves one life it will all be worth it." To say something like this might be good for public relations, but to believe it is extremely counter-productive. We do not speak against those publicly who make this statement, but we try to reason with them privately after the meetings. Clearly, several CMs competing fairly for the total pool of traffic safety resources is a much better way of perceiving traffic safety.
- Taking credit for recent successes. This is too much for some to give up. My question to them is "Did you accept the blame when the number of fatalities increased. It need not be a full-blown confession. Something along the lines of "We really need to do better next year" shows at least a recognition our part of the problems.
- Taking undue credit can validate a week program. Those who have the continual improvement forever culture will put special emphasis on identifying the reason that

things improved, similar to the analyses when things did not go as effectively as planned and working to eliminate the issues identified.

- Table 1 serves to assist in this endeavor in that the particular issues that are increasing in fatalities can be separated from those that are neutral or doing better.

2.2.3 Exceptions

We have been using Table 1 to get a first-case reading of the issues that will need to be addressed in the future. It should be recognized that exceptions to Table 1 are justified under certain circumstances. Among these are: (1) projects involving the safety and well-being of young children, such as child restraints; (2) projects involving older children, such as school bus security and safe walking; and (3) projects of which a major part of the cost will be provided outside of the traffic safety budget, by organizations such as bike clubs or MADD.

These exceptional programs will completely fall out of the optimization procedure because so few lives are considered by them. A traffic safety professional (or team) should be assigned to these exceptions, and supplementary funding should be sought in addition to what has traditionally been assigned to the in the past from the traffic safety budget.

3 The Need for a Systematic Approach?

3.1 What is a Systematic Approach to Traffic Safety Budget Allocations

Many states are already using some systematic approach to lead to a good if not optimal budget, or at least one that produces a greater return than if their approach were random or determined by a single decision-maker. Let us begin by defining what is not a systematic approach. One approach that is often used is to have a meeting of all who are interested in traffic safety and then go around the table and let each person give their opinion as to the best CMs. This usually results in those who have the most political clout getting their ways, and the result is no better than some of the flawed approaches discussed above. The goal of such a meeting is to make everyone happy with the results because supposedly everyone had input. But there is a difference between having a chance to provide input and actually providing that input. Many superior thinkers are too shy, and they feel it is best for them not to make waves especially in large meetings.

Display 7 presents the philosophical basis for a more systematic approach to traffic safety budget allocation.

Display 7. Philosophical Basis for the Systematic Approach

- *What is it*? It is an approach to traffic safety planning that is laid out step by step in a procedure based on known facts, to result in as nearly an optimal planned program as is possible.
- *Why is it needed*? To avoid the many flaws and shortcomings presented in several sections above.
- *What are its tenets*? Everyone must be aboard in providing the type of input that only they can provide because of their past and present commitments to various projects. These include the following:
    - We can do better, no matter how structured our approach was in the past.
    - All ideas need to be entertained even though it is realized that they cannot all be implemented.
    - No one should feel left out of the process; all should be encouraged to provide input in their areas of expertise.
    - Currently applied CMs need to be given precise evaluations with the goal of each evaluation to establish the benefit of that CM as applied in the previous year.
    - Make known that any current CM can be reduced (if necessary eliminated), maintained at its current level of funding, or increased to a higher level of funding.
    - In addition to the previous year's fatality results, estimates of benefit are required for incremental increases and decreases in funding. This should be recognized as the starting from the benefit point of the previous year on its DR curve, with the potential of moving in either direction. It should also be recognized as an imprecise estimate, and thus should draw upon one or more experts in the given issue to come up with estimates that are as accurate as possible.

3.2 Proposed Steps in a Systematic Approach

There are any number of ways to systematize the initial generation of all CMs, generally, at least one for each Table 1 issue.

Display 8. Steps in a Systematic Approach Toward Optimization

1. Research review. Perform a detailed web search for research on the issue. The objective here is to provide the participants with as much knowledge on the issue subjects as possible.
2. Brainstorming. This should be recognized as a formal procedure with the following rules:
   a. Absolutely no criticism. This is to facilitate the widest range of ideas possible and to stimulate other original thoughts.
   b. A totally infeasible idea may stimulate another participant to come up with one of exceedingly high benefit.
   c. Ideas are submitted orally to a meeting of as many traffic safety participants as possible.
   d. If you have a board, put the submitted ideas on it with enough words to get the idea. Photograph the idea list. If not, assign someone to take notes.
3. Document any reasonable new ideas.
4. Perform High-Level analysis for feasibility.
5. Establish data on costs and benefits for each CM still under consideration.
6. Rough out a DR curve for each of the alternatives.
7. Perform a cost-benefit analysis to get an initial rough priority for all CMs. Use it also to help with your DR curves. The initial rough cut will prioritize by maximum benefit to cost ratio first.
8. The end result should be at least one CM for each issue. If necessary, have subsequent meetings where the notes are used to break the ice.
9. The output of this process is a list of CMs in the order of the issues in Table 1. Other than the cost-benefit analysis, no other analytics should be applied at this point.

3.3 Proposed Approach to Implementation

Implementation is used here to refer to the actual optimization process, and the generation of a set of results that will provide a good estimate of the optimal set of CMs for the State's traffic safety program. It is presented in Display 9 in a similar stepwise sequence as the systematic approach given above.

Display 9. Proposed Approach to Implementation

1. Perform detailed research in your specialty area as they apply to the first tentative set of CMs output in the procedure of Section 3.2. A large number of references and reports are given on http://www.SafeHomeAlabama.gov and on NHTSA at Research | NHTSA. Focus on reports that contain CM costs and benefits.
2. Answer the question: "what have other states done (or are doing) to address the Table 1 issues, especially those for which I have been accepted special responsibility?
3. Look especially for quantitative evaluations that have been performed by NHTSA (FARS) or in other states.
4. Formulate alternative CMs for those issues for which you have assumed responsibility.
    a. This list should include the CMs currently implemented in your state.
    b. Others may arise from the brainstorming sessions, but if other states are doing additional CMs that look promising, feel free to include them.
5. Formulate any questions that you have about any of you list of CMs so far, and contact any practitioners that you believe can be of added assistance.
6. Formulate alternatives within your issues and to the extent possible optimize the alternatives within each issue area. This is non-quantitative and should be done by those with experience in each issue.
7. The following will be performed collectively once each participant has a good knowledge of the CMs available in their issue areas:
    a. Translate the results of Step 6 into cost and benefit data that can provide the input for optimization.
    b. Specify a first cut of the overall program, optimize the CM selection by eliminating all clearly sub-optimal CMs.
    c. To the extent possible, improve the chosen CMs by answering the who, what, where, when and why of their implementation. Also ages and any other demographics that can improve implementation.
    d. If possible, perform IMPACT runs over all relevant attributes.
8. See the next sections for example analytics that can be applied at this point.

4.0 Examples of Analytics Assistance

This section will consider some example analytics that have been applied to issues at or near the top of Table 1. The same principles can and should be applied to all issues as time allows. Those covered in this section will include (1) Restraint Use, (2) Speed Reduction, (3) Impaired Driving [DUI], and (4) Young Driver Risk Taking.

First some general principles regarding analytics, which is the science of turning data into useable information. Most people do not realize it when they cite statistics, but numbers tell us very little unless they are compared to other numbers. It does little good to state that 500 people died last year who were not using the proper restraints. Much more information is conveyed by stating that only 50 of these people would have died had they been properly restrained, and that the problem we had with this last year cost 450 lives. This last number is the comparison difference between the 500 and the 50. The overall principle is: generally available numbers (data) have to be compared with other (comparable) numbers in order to create productive information. This principle will be illustrated in detail by the example that will be given.

4.1 Restraint Use

For this example, we will compare time of day for when restraints are used against those times when they typically not used. This is just one example, and all relevant attributes in the database should be tested in this way (e.g., day of the week, ages of the drivers, the use of alcohol or drugs, and about 30 more that are commonly compared out of the nearly 300 attributes in the crash records database.

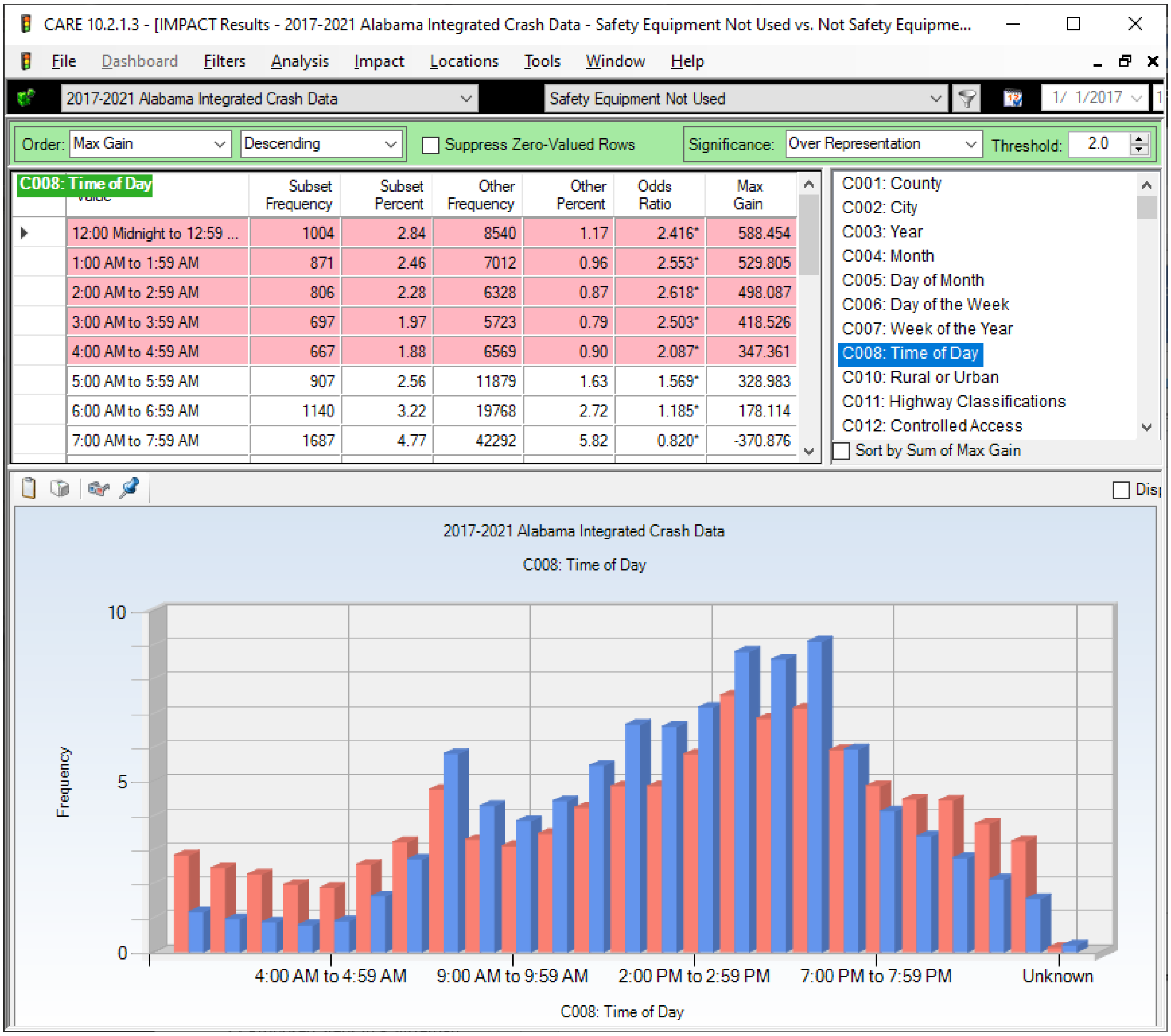
As a major part of this example we will demonstrate the CARE IMPACT capabilities, which automatically does the types of comparisons that are discussed above. Any attribute within the database can be compared, for this example it will be time of day that the crashes occur. The comparison for time of day is given in Display 10. Time of day distributions are particularly useful in directing the timing of selective enforcement activities to assure officers are assigned when most needed. The comparison is crash attribute values that result when seatbelts are worn against the same when not worn.

The following details the components of the IMPACT outputs:

- Top line – is informational showing what is being compared. We like to put the negative thing being tested as the "Subset," defined below.
- Second line – operations used to control IMPACT into its various capabilities. We are just going to consider the simplest of these, which is generated by IMPACT, under the Analysis tab. Any or all attributes can be specified at once.
- Third Line: (1) the specific database that is being processed, which can easily be changed by the drop-down; (2) a brief description of one of the subsets being compared – its

values will be displayed on the chart by red bars; particular records to be compared are determined by a *filter* that only allows the specified values through; in this case the only records allowed to form the *subset* to be compared are those crashes in which no safety equipment [e.g. seatbelts] were used; and (3) a variety of other information items and capabilities.

Display 10a. Example CARE Time of Day IMPACT Output



Components of IMPACT outputs referenced as given in Display 10 (continued):

- Fourth line – information that informs the user of (1) the item (column head) being used to order the outputs, (2) ordering: Ascending or Descending, (3) toggle, on and off indicator of whether user wants to suppress items that have zero crashes in the Subset

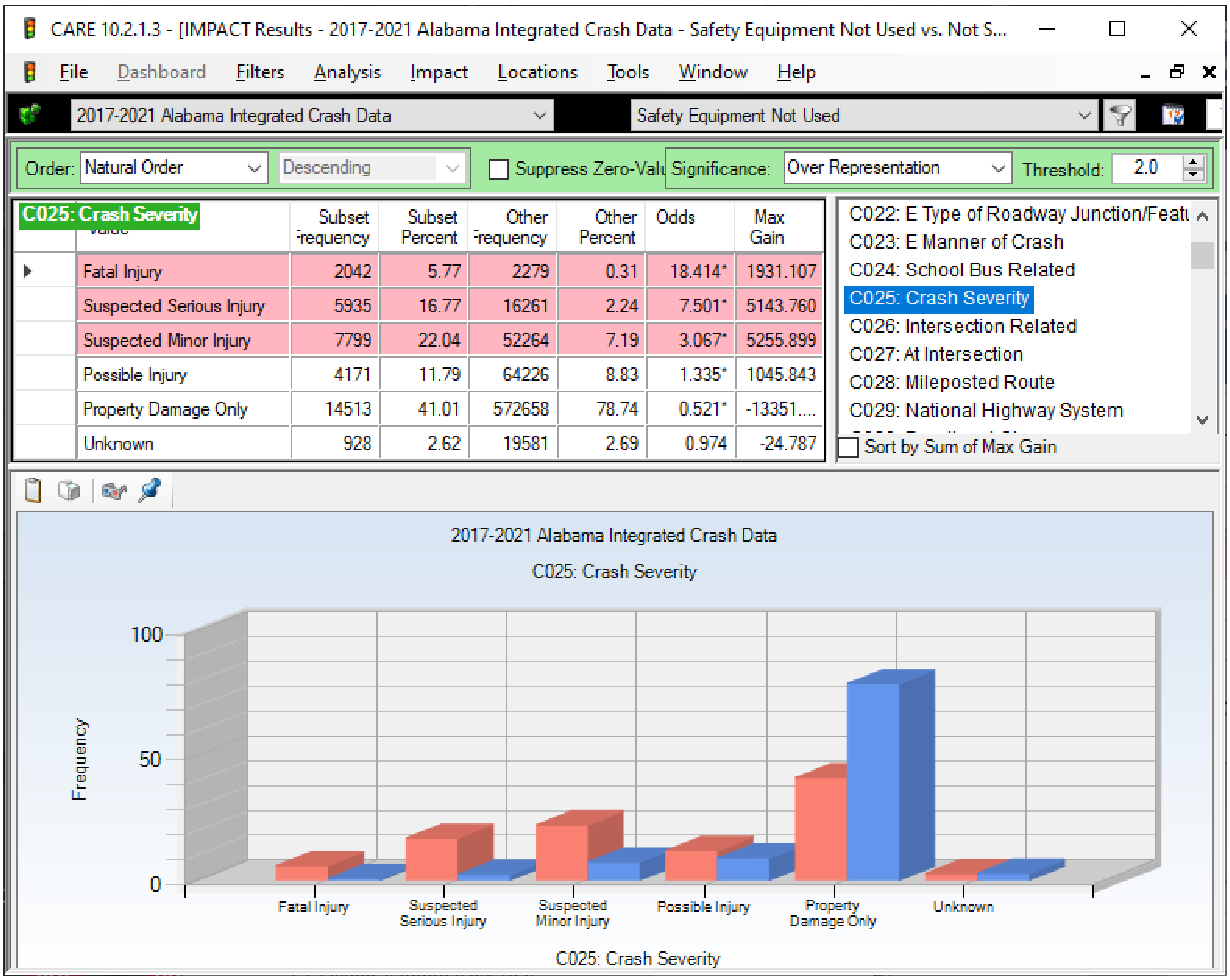
Frequency column, (4), table background control, which is currently set to the default of being red if the Odds Ratio is two or more.

- Fifth line – name of attribute being processed (redundant with the highlighted attribute in the attribute list to the right) followed by headings for the numeric columns, as follow:
  - Subset Frequency -- the subset is defined by the filter that is given on the third line. Users choose from a number of pre-defined filters, or they can create their own new ones. If new, the name they give it will appear on the third line, second item.
  - Subset Percent – the subset frequency column is totaled and each of the attribute value items is given its percent of that total.
  - Other Frequency – can be determined by the user setting up a filter for it, or by default the "Other" will be the complement of the subset filter. For this example, we have allowed it to default so the first item will be all crashes where Safety Equipment was Used in the time span between 12 Midnight and 12:59 AM. This is the "comparison number" described above. However, because of the discrepancy in size between the Subset and the Other, any reasonable comparison must be made between the respective proportions (Percents).
  - Other Percent. The same as the Subset Percent but calculated on values within the Other Percent. For this example, the Other Frequency and Other Percent are just complements, i.e., the specific percent of Safety Equipment is Not Used is compared against its complement, Safety Equipment is Used. This enables a complete comparison over all of the times.
  - Odds Ratio – this is the name of the ratio of the Subset Percent divided by the Other Percent. It tells to what extent these two percentages are different. An Odds Ratio of 1.0 would occur if they were the same. The greater the difference between the Subset Percent and the Other Percent, the greater the Odds Ratio. The Odds Ratio is 2.416 indicates that 2.84/1.17 = 2.416. Because this odds ratio in greater than 2, the background had been painted red. Also, an asterisk (*) on the Odds Ratio indicates that there is a statistically significant difference between these two percentages. As can be seen, some non-red items are still statistically significant in their differences.
- The chart shows graphically how each of the lines compare, with the red bars representing the Subset Percent and the blue bars representing the Other Percent. This enable users to view the results in a more collective manner. Since all hours from 7 PM until 6:59 PM clearly have red over-representations, we might conclude that there is a special problem with the use of restraints in the night time or darker hours. The reason for this cannot be determined just from these data, but the chart is amazingly comparable to that for Impaired driving, and further analyses have shown the relative reluctance of those who are intoxicated to be properly restrained. Of course we would expect other causes as well.

CARE IMPACT analyses can easily be performed for all attributes – in fact the example lists some of these attributes in its right column, indicating that all have been processed together within a matter of seconds. So users can easily go from one attribute to another to see how restraint use varies with the various attributes.

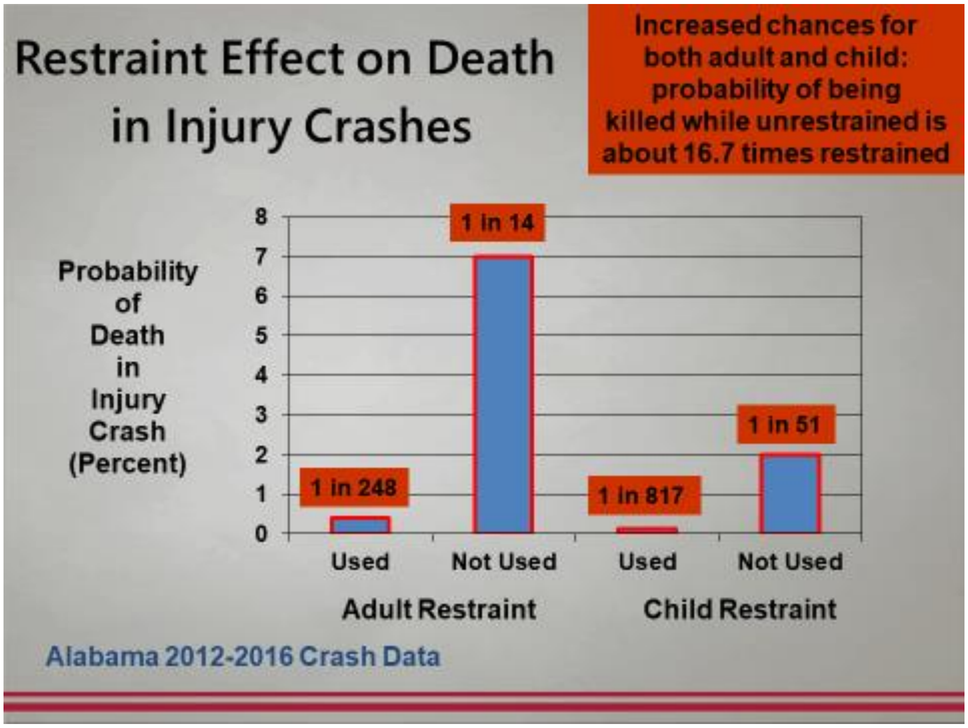
A second example will compare the severity of crashes where restraints were used against those where they were not. This output can be generate simply by going down the attribute on the very right of the first IMPACT output and selecting attribute 25, Crash Severity. This output has been arranged in natural order that puts the worst outcomes toward the top of the list. It is given immediately below:

Display 10b. Example CARE Severity IMPACT Output



As expected, the probability of the crash being fatal is 18.414 (Odds Ratio) times that of being restrained when not properly restrained. All three of the most severe injuries are over twice their probabilities of sever injury (Suspected Serious Injury 7.501, and Suspected Minor Injury 3.067). The only under-represented severity is Property Damage Only.

Display 11. Additional Presentations of Analytics Comparisons



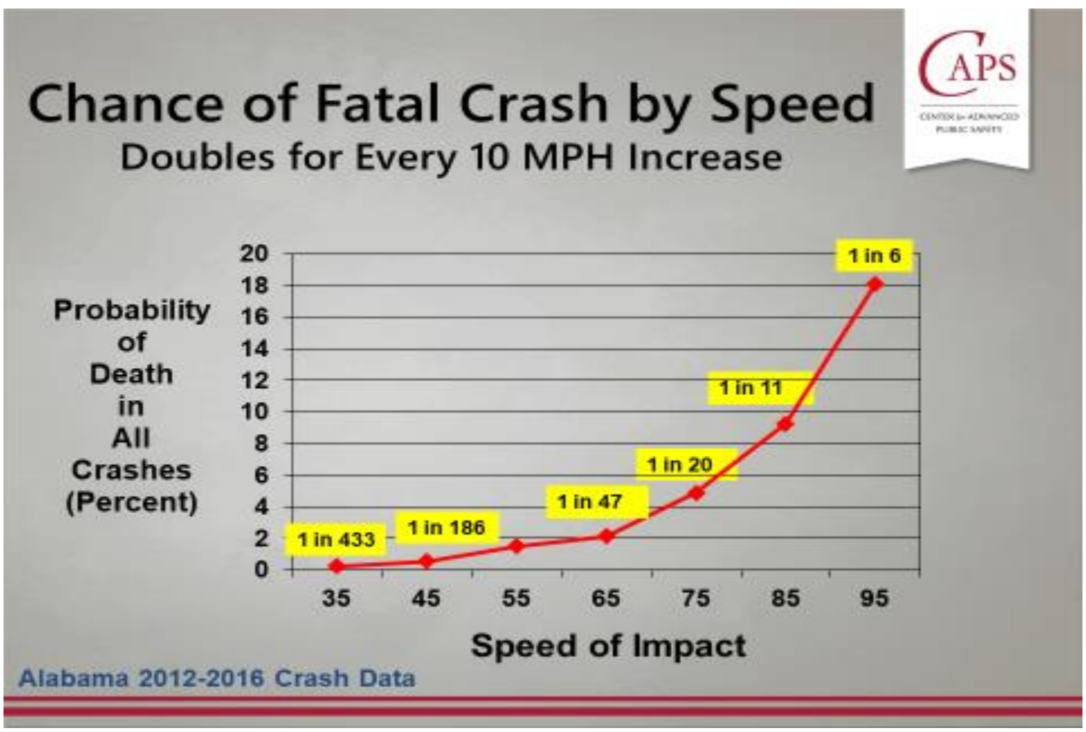
Display 11 presents a different view of information generated by the CARE IMPACT module. It has been re-formatted manually in order to give non-technical people a bottom line idea, i.e., the benefits of restraints. The presentation uses odds of being killed in an injury crash. It is divided into the effectiveness of adult restraints and child restraints, since the odds of death are quite different in the two. Adult restraints reduce the odds of death from one in every 14 crashes to on in 248; an effectiveness of 17.7 times fewer fatalities. For child restraints the odds are reduced from one death in every 51 crashes to one in 817, a favorable multiplier of 16.1, which is quite comparable to that of the adult multiplier.

4.2 Speed Reduction

Selective Enforcement (SE) has been found to be the largest life saver when it comes to speed reduction. On average studies repeated every year in Alabama have confirmed that if impact speeds can be reduced by 10 MPH, the result will cut the number of fatalities due to speed in half. This should be the goal of officers assigned to SE. There will, of necessity be some tickets issued. But the goal is far broader than just targeting those few vehicles that are caught. It should be a reduction of from 5 to 10 MPH of every driver who is exceeding the speed limit. Officer presence has been shown to produce such a speed change even when tickets are not given.

Display 12 illustrates how fatalities are dependent on Speed. As can be seen, the rule of thumb of exponentially doubling the number of fatalities for every10 MPH Increase of impact speed holds. This display is updated by Display 13 that gives the same information using more current data. An average of the multipliers shows that “doubling” may be a conservative estimate of the expected fatality increases. Displays 12 and 13 come directly from a cross-tabulation of crash severity by number of fatalities.

Display 12. Fatal Crash Probability as a Function of Impact Speed



Display 13. 2017-2021 Data are used to Update the Display 12 results

	Odds of Death	**Multiplier**
Speed	**1 in X**	**From 35 MPH**
35	534	1
45	181	3
55	74	2.4
65	53	1.4
75	32	1.7
85	12	2.7
95	5	2.4
Averages	127.29	2.267

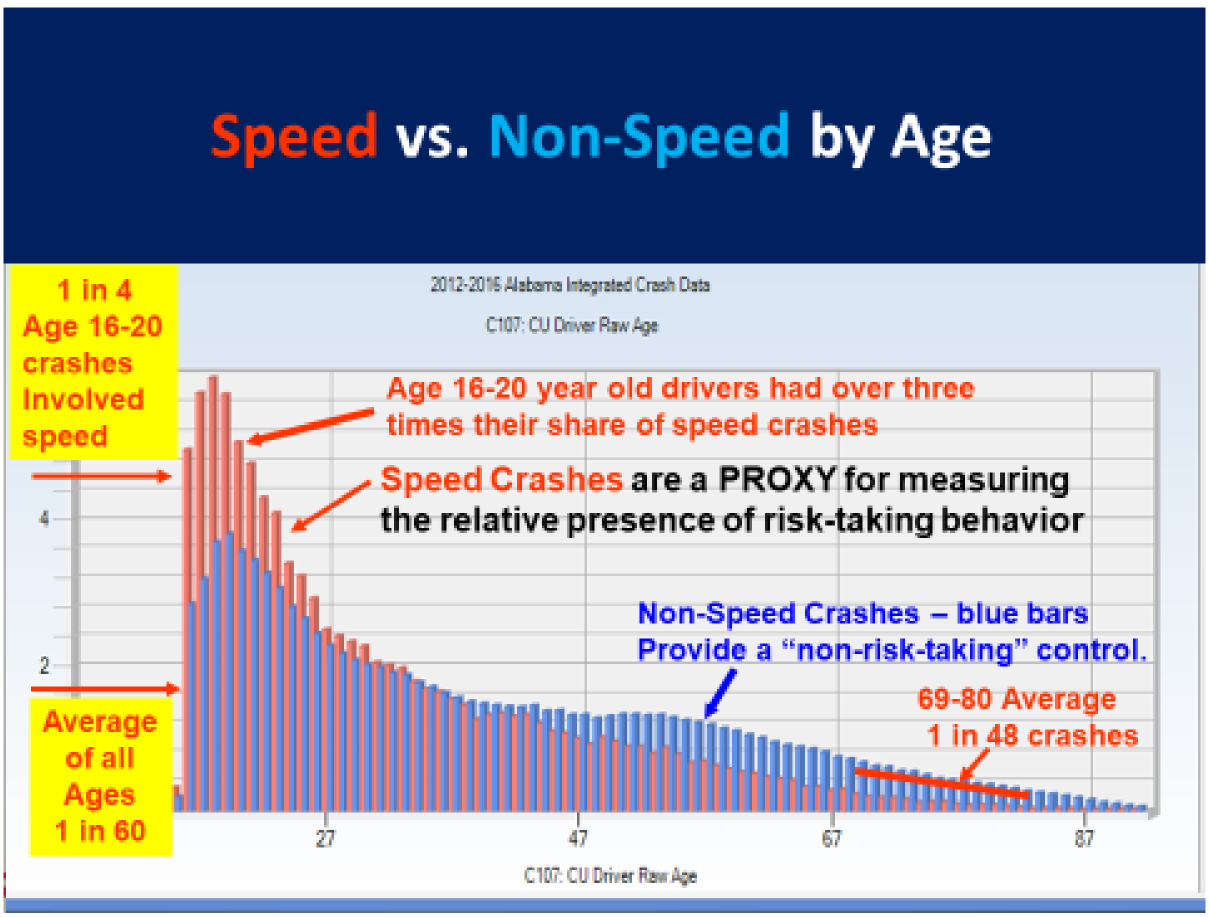
4.3 Young Drivers

A third example of the generation of data for crash fatality reduction involves those drivers who have shown their dramatic increase in crashes and fatalities, especially for those crash types that involve risk-taking or risk acceptance.

4.3.1 Risk Acceptance by Younger Drivers

This example will use impact speed as a proxy for risk taking. It is reasonable that the higher the speed of impact the greater the acceptance of risk. Display 14 plots this speed of all crashes for younger drivers (16-20) red bars, and all older drivers, represented by the blue bars. It should be noticed that this is just one of the IMPACT outputs in comparisons of the younger to the older drivers for all attributes.

Display 14 Youth Risk-Taking as measured by the Speed at Impact Proxy



Notations have been added within the Display 14 output using Word capabilities once the

The following give a more detailed explanation of these notes:

- One in four 16-20 year-old crashes involved speed. This means that according to law enforcement measurements, one out of four drivers who got in a crash was exceeding the speed limit. Notice the blue bars for this age group (the first four from left to right). What the high bars indicate is that in general (without considering speed or any other contributing factors, this age of driver has far more crashes than would be expected. Now, consider the red bars, which are well above the blue bars illustrating that speed-related crashes for this age group is a significantly higher proportion than their crashes in general. The over-representations becomes less with the higher ages, but it does not disappear completely until after age 33.
- Average of all ages 1 to 60. This is given here to illustrate where the average of all crashes are in the general age groups average out to. Those over 60 were excluded to prevent the average from being skewed lower than it is for most drivers' ages.
- Age 16-20 year-old drivers had over three times their share of speed crashes. This is calculated by comparing the proportion of non-speed crashes against the proportion of those that involved speed.
- Speed [involved] crashes are a PROXY for measuring the relative presence of risk-taking behavior. This statement is made so that readers will see that the only thing being determined here has to do with speed. Risk-taking involves much more than just speed. It could involve running red lights, cutting across oncoming lanes of traffic to make left turns, tail-gating and similar risky actions.
- Non-Speed Crashes – blue bars Provide a "non-risk-taking" control. The blue bars are quite useful as a contrast to those that are red. Without them in the chart we would have no idea as to whether any given actions are just expected and normal. We see the age at which non-risky behavior become significantly over-represented to be about 45 years of age.
- 69-80 Average 1 in 48 crashes. This emphasizes further the risk averse nature of older drivers. Generally, the older they are, the more risk averse they become. So the large contrast between the two extreme ages is 1 in 4 for the younger as opposed to 1 in 48 for the older drivers.

4.3.2 Younger Driver Countermeasures

The problem as to how to deal with and reduce crashes caused by young driver risk taking. The following findings were found by CARE IMPACT

- General findings
    - Over-represented items that are largely risk-taking behaviors are highly associated younger drivers: Driving too Fast for Conditions, Following too Close, Over the Speed Limit, Misjudge Stopping Distance, and Failure to Yield the Right of Way. These should be given emphasis in driver training and PI&E.

    - In all but a few exceptional cases the most severe crashes involve a very high level of risk acceptance, and in some cases the intentional increase of risk, usually by high speeds. Countermeasures to prevent these types of incidents have clearly not been as successful as traffic safety professionals would like, and research must continue in this area. It should be recognized that warning young drivers against specific risky behaviors is often not an effective countermeasure, especially for those who want to increase their risks. These warnings might have just the opposite effects.
        - A review of efforts to reduce young drivers' risk taking is in the following: http://www.safehomealabama.gov/wp-content/uploads/2019/10/Youth-Risk-Taking-Analysis-v08.pdf
        - Nearly 80% of young drivers' crashes involve two or more vehicles. However, their over-representation in single vehicle crashes show an excess of unforced errors and risk-taking as well.
        - Electronic devices have the highest causal rank among distracted driving types, of those items that are specifically defined. They were related to 1,497 additional crashes above what would be expected if their proportion of these crashes was the same as older drivers. Special emphasis should be given to avoiding these distractions on the part of younger drivers.
        - Rain was a particular issue for young drivers, their having 28.2% more than their expected number of crashes in the rain (in comparison with older drivers). Young drivers need to be given exercises in coming to a stop on wet pavement, especially on downslopes.
- Severity Factors
    - Several of the crashes with impact speeds over 70 MPH were over-represented for young driver caused crashes. Male younger drivers are especially prone to taking such risks.
    - Necessity for young-driver caused crashes to be towed is over-represented by 29.4%, indicating that these crashes are more severe in the physics involved than those caused by older drivers.
- Time Factors
    - Year. Younger drivers had a proportion that was significantly higher than the older drivers for 2017 and 2018, and they were very close in their proportion for 2019. The effects of the COVID pandemic are clear in 2020 and 2021, when their numbers dropped to slightly lower percentages that comparable older drivers.
    - Day of the Week. Fridays and the weekends are over-represented for crashes caused by young drivers.
    - Time of Day. Before and after school are significantly greater than the normal rush hours, and the significant afternoon over-representations continue through the midnight hour. The most over-represented hours are from 3 PM through to 11:59 PM.

- Time of Day by Day of the Week. Friday night, early Saturday morning, Saturday night, and early Sunday morning were over-represented hours. However, far more crashes occur in the before and after school hours. These hours should provide guidance for the most effective selective enforcement times, along with the County and Cities that are over-represented to provide guidance in the locations. Young driver selective enforcement needs to focus on those times when young-driver crashes are at their highest.
- Roadway and Vehicle Factors
  o Curve and Down Grades are particularly problematic for young drivers who have not yet experienced the fact that braking might take twice as long on a down slope. There is no substitute here for hands and feet on an operating vehicle.
- Over-represented vehicle maneuvers included Negotiating a Curve, Slowing/Stopping, Turning Left, and Entering Main Road.
- Young drivers on county highways had nearly 1.4 times (Odds Ration 1.375) the expected number of crashes. State routes were also over-represented. Interstates were under-represented indicating the tendency of younger drivers to drive locally. Some selective enforcement targeting younger male drivers is warranted on
  County roads.

The following references can provide further help in this extremely difficult problem. They are given as section headings to facilitate access via Word's or the web navigation bar.

1. Young people, risk-taking and improving risk communications to adolescents; Youth and Policy.
   https://www.youthandpolicy.org/articles/young-people-risk-taking/
2. Young People, Risk Taking and Risk Making: Some Thoughts for Social Work1); Forum, Qualitative Social Research.
   http://www.qualitative-research.net/index.php/fqs/article/view/56/115
3. Research in Practice; Strategic Briefing
   https://sscb.safeguardingsomerset.org.uk/wp-content/uploads/2016/06/CSE-Risk-taking-adolescents-and-child-protection.pdf
4. What is happening to children and young people's risk behaviors? UK Assets Publishing Service.
   https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/452059/Risk_behaviours_article.pdf
5. Risk behaviors and negative outcomes. UK Assets Publishing Service.
   https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/452169/data_pack_risk_behaviours_and_negative_outcomes.pdf.
6. Risk & Protective Factors. Youth.gov.
   https://youth.gov/youth-topics/substance-abuse/risk-and-protective-factors-substance-use-abuse-and-dependence
7. Does risky driving behavior increase young drivers' risk of crashing? George Institute, Australia.
   https://www.youngdriverfactbase.com/the-issues/behaviour1/

8. Why have different laws for new drivers? George Institute, Australia. https://www.youngdriverfactbase.com/the-issues/summary1/
9. Risk Taking Behavior. PrintableWorksheets.in. https://printableworksheets.in/worksheet/risk-taking-behaviour
10. Why Are Teen Brains Designed for Risk-taking? Psychology Today. https://www.psychologytoday.com/us/blog/the-wide-wide-world-psychology/201506/why-are-teen-brains-designed-risk-taking
11. Honoring the Teen Brain: A Conversation with Thomas Armstrong. Educational Leadership. http://www.ascd.org/publications/educational-leadership/may19/vol76/num08/Honoring-the-Teen-Brain@-A-Conversation-with-Thomas-Armstrong.aspx?utm_source=twitter&utm_cam-paign=Social-Organic&utm_medium=social
12. Teen Safety: What Every Parent Needs to Know. Dinner Table MBA. https://dinnertablemba.com/teen-safety/
13. Risk-taking and the Teen Brain. Parent Toolkit.com https://www.parenttoolkit.com/social-and-emotional-development/news/responsible-decision-making/risk-taking-and-the-teen-brain
14. Understanding Teen Behavior. TeenMentalHealth.org http://teenmentalhealth.org/learn/teen-behaviour/
15. Encourage Risk-Taking. Your Teen (two web pages). https://yourteenmag.com/health/teenager-mental-health/how-to-motivate-boys
    Raising Positive Risk Takers. Your Teen; https://yourteenmag.com/health/teenager-mental-health/raising-positive-risk-takers
16. Teen Risk-Taking: Tips for Parents. MyHealth.Alberta.ca https://myhealth.alberta.ca/Alberta/Pages/teen-risk-taking-tips-for-parents.aspx
17. The Teen Brain: How Schools Can Help Students Manage Emotions and Make Better Decisions. Education Week. https://www.edweek.org/ew/articles/2018/10/10/the-teen-brain-how-schools-can-help.html?pre-view=1&user_acl=0
18. Assessing Fatality Rates in Crash Involvement for Motorists and Non-Motorists in Teen Driver Crashes by Risk Factor. AAA Foundation for Traffic Safety. https://aaafoundation.org/wp-content/uploads/2018/10/FINAL-_18-0658_AAAFTS Everyones-at-Risk-Brief_1010-1.pdf
19. Teen Driver Risk in Relation to Age and Number of Passengers. AAA Foundation for Traffic Safety. https://aaafoundation.org/wp-content/uploads/2018/01/TeenDriverRiskAgePassengersReport.pdf
20. Characteristics of Fatal Crashes Involving 16- and 17-Year-Old Drivers with Teenage Passengers. AAA Foundation for Traffic Safety. https://aaafoundation.org/wp-content/uploads/2018/01/2012FatalCrashCharacteristicsTeenDriversAndPassengersReport.pdf

21. Analysis of the Most Critical Factors in Young (16-20 Year Old) Driver-Caused Vehicle Crashes. SafeHomeAlabama.gov. http://www.safehomealabama.gov/wp-content/uploads/2018/12/Young-Driver-IMPACT-2011-15-2016-Update-v03.pdf
22. GDL Compliance and Enforcement During Intermediate License Phase. Children's Hospital of Philadelphia, Center for Injury Research and Prevention. https://injury.research.chop.edu/teen-driving-safety/gdl-compliance-and-enforcement
23. Analysis of the Most Critical Factors in Young (16-20 Year Old) Driver-Caused Vehicle Crashes; Updated using CY2017-2021 Data; brown@cs.ua.edu, July 18, 2022
24. Base Study: CY2011-2015; Updated with CY2016 Data, October 8, 2017 http://www.safehomealabama.gov/wp-content/uploads/2018/12/Young-Driver-IMPACT-2011-15-2016-Update-v03.pdf
25. Mitigating the Problem of Young Driver Risk-Taking September 30, 2019 http://www.safehomealabama.gov/wp-content/uploads/2019/10/Youth-Risk-Taking-Analysis-v08.pdf

4.4 Impaired Driving (DUI Alcohol and Drugs)

NHTSA hs provided estimates of total fatalities and those caused by DUI (Alcohol and other drugs). The recent annual estimate for DUI (alcohol) is11,654 while the estimate for total fatalities is 42,915. This means that approximatly 27.2 of all traffic fatalities nationally were caused by DUI. NHTSA rounded this to 30%, and when non-alcohol drugs are added, this would seem to be a good fair estimate. A couple decades ago the common estimate was that over 50% of fatalities are cause by alcohol [non-alcohol drugs were just getting started back then]. Since that time a number of federal and state funded programs as well as several private and volunteer programs have caused a significant reduction in the proportion. However, 11,654 fatalities annually are not to be taken lightly.

The effort in this chapter will be to show how the ages for social drinking have changed over the years as well as that for the problem drinker. The goal is to impress the fact that established statistics during one era may not hold up in another, especially if they are far apart in time. Consider the folowing for each dis play:

- Display 15, 1993-2002. Determining the substance vulnerabity types (social user, transition, probem user) is a matter of looking at the distribution of the red bars. In some cases they divide themselve neatly into three groups. An analysis was run prior to 2002. The notes on the chart indicate that the distribution has spread out, so that now the three groupings appear to be 21-30 for social users, 41-43 for the transition (some still social but others becoming problem users), and 44-52 are confirmed to be problem users. The rationale for this last category is that if a user is above the age of 40 and still getting tickets for DUI, chances are excellent that he is a problem user (drinker in the case)
- Display 16, 2007- 2012. The red bars are now showing some more definitive groupings. Ages 21-30 show significant over-representations, which can be seen by the *-marked Odds Ratios in the table. There is a noticable drop after age 30 that would indicate their moving into a transition stage. There is a distinct rise after 43, which shows the number who are "graduating" into the problem drinker group.
- Display 17, 2012-2016. This shows a more pronounced three-bump distribution, where roughly 21-30 is social use, 31-43 is the transition stage, and 44-55 can be declared as problem users. The over-representations in the problem user category is getting wider and more pronounced.
- Display 18, 2017-2021. Table for ages 24-33 social users. Three displays have been generated for this most recent time span in order to provide access to the table numbers for each of the most current groups. The first display focuses on social using, which has seemed to have moved up about three years from its previous distribution in Display 17.
- Display 19, 2017-2021. Table for ages 34-43 transition users. The over-representations can clearly be seen in the transition users group.
- Display 20, 2017-2021. Table for agest 44-58 problem users. This group has gotten signivicantly large, perhaps at the inclusion of non-alcohol drugs in this display. See the section below for more information on these most recent displays.

4.4.1 Displays 18-20, 2017-2021 Data (3 IMPACT Runs)

The above has been repeated with 2017-2021 data. One major difference for this most current five years is that these displays are not only for alcohol, but include drugs as well. Alcohol is a drug, and the other drugs included any drugs that the recording officer considered to be detrimental to their driving. To give the amount that non-alcohol drugs contributed in the 2017-2021 time frame:

Coverage	**Number of Cases**	**Percent**
DUI Alcohol Only	21,719	74.0
DUI Non-alcohol Drugs	7,612	26.0
TOTAL	29,331	100.0

So the number and percent of non-alcohol drug cases is significant. However, the age range that showed over-representations was 23 to 55 for alcohol and 24 to 57 for non-alcohol drugs. Since these two age ranges are nearly identical, their combination for purposes of determining which vulnerability age group they are in is valid.

4.4.2 Conclusions on age groupings

The purpose of this section was not to nail down accurate age groupings for social, transition and problem users, although the results are quite convincing in that regard. It was to illustrate the flaws of locking into these age grouping without realizing that they are subject to change with the culture. Knowing the age-groupings as best we can is quite important to determining which countermeasures apply. Obviously, dealing with college age social users is considerably different from dealing with over-40 problem users.

We have not suggested any countermeasures, but the traffic safety literature contains many. There have been two major CM types that take the opposite approach. On the one side you have the early MADD approach of not distinguishing between the underlying problem, and for the most part the remedy proposed was to jail anyone guilty of DUI. When the jails got filled and the problems persisted, several other approaches were tried that appeared to have merit. Among these are various types of “diversion” programs that make an attempt to rehabilitate those who are given to substance abuse. Diversion here is from the strict application of the law’s punitive aspects toward evaluating each individual and applying the approach that is most likely to return the offender to society as a productive individual.

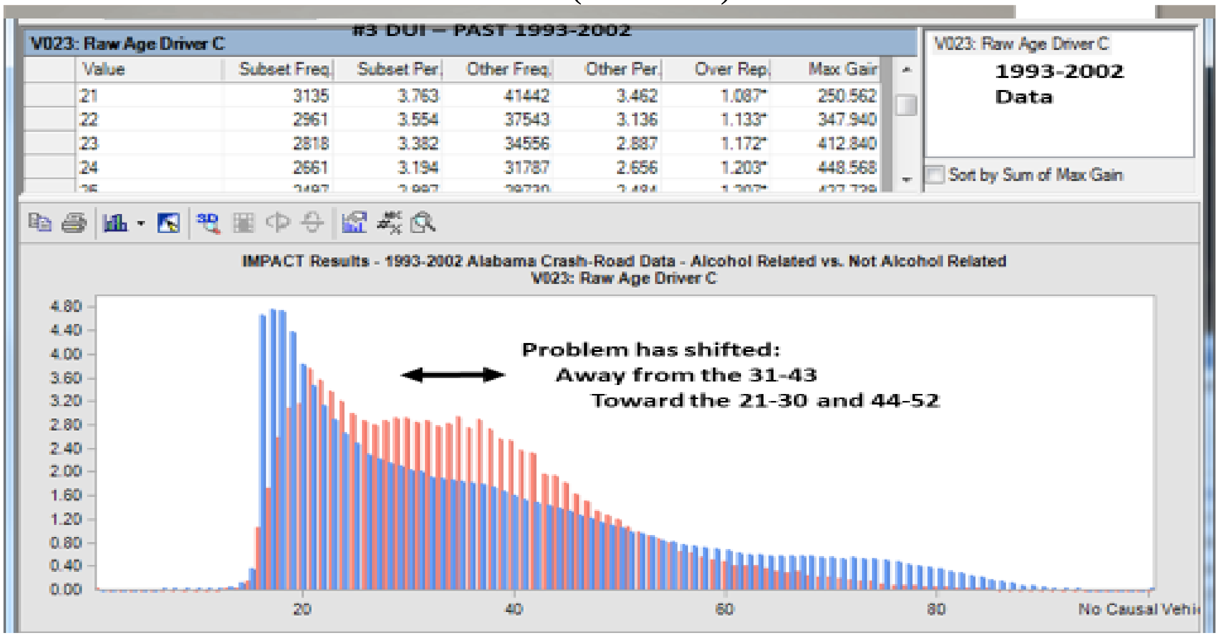
Reference:

NHTSA, Traffic Safety Facts (2020 Data); Alcohol Impaired Driving; contains several references at the end that are useful for countermeasure development and evaluation.

http://www.safehomealabama.gov/wp-content/uploads/2022/06/2020-ALCOHOL-IMPAIRED-DRIVING-Traffic-Safety-Fact-Sheet.pdf

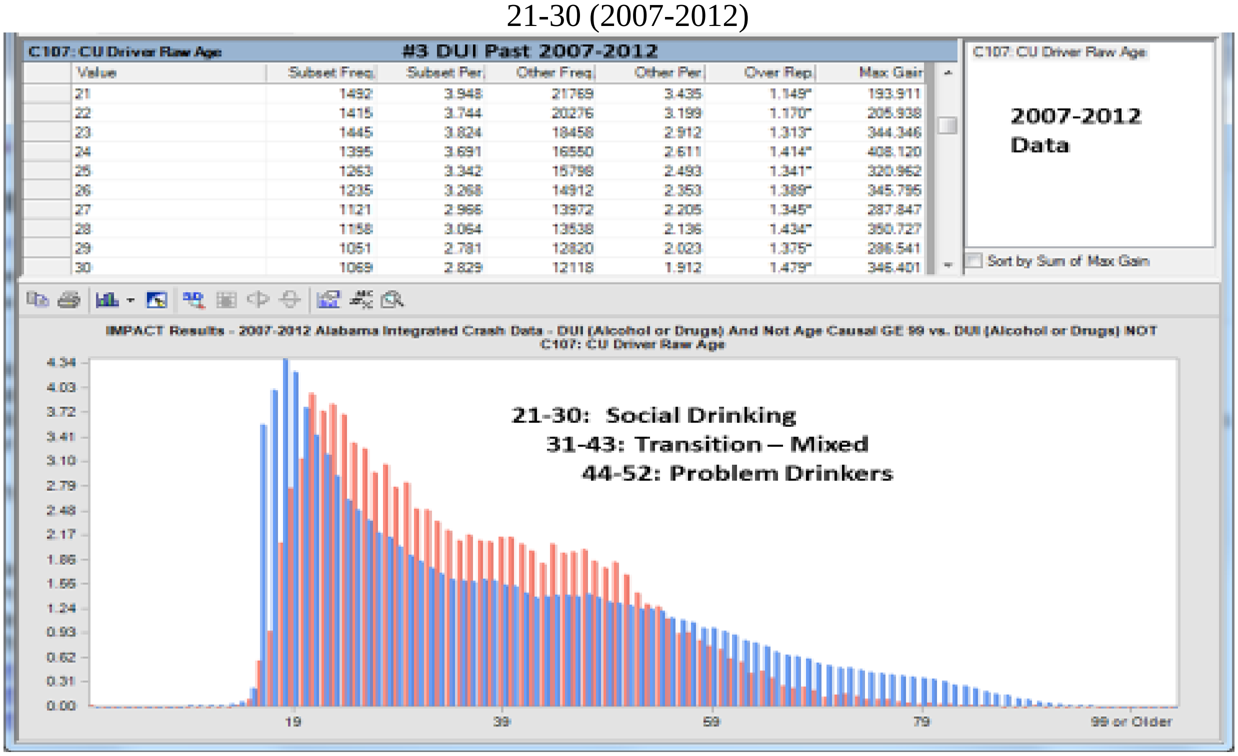
Display15 Problem age groups in 1993-2002

21-24 (1993-2002)



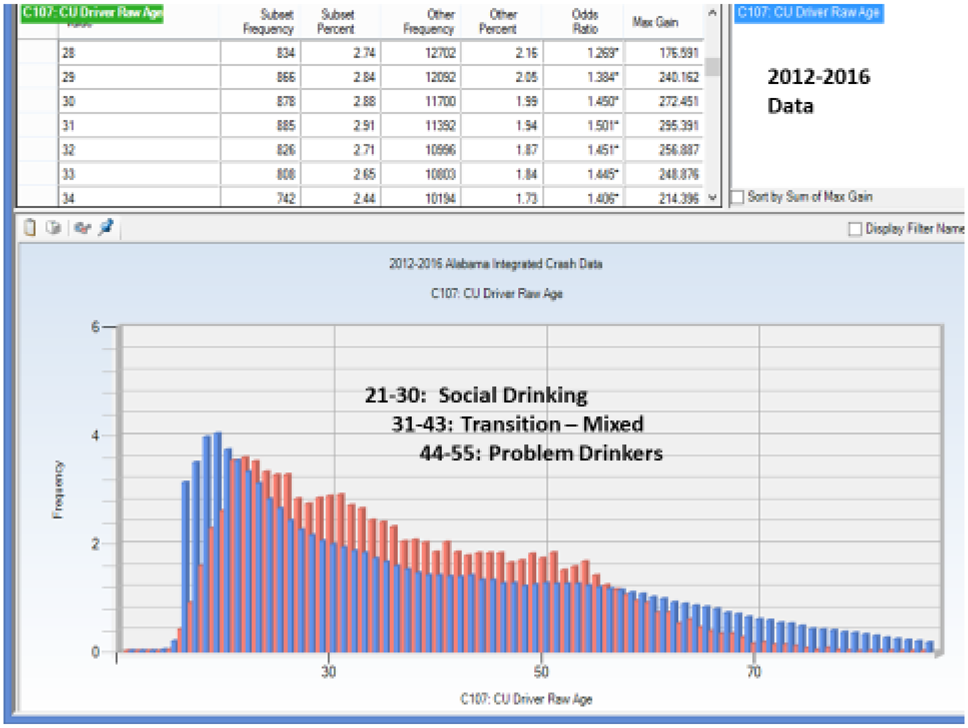
Display16 Problem age groups in 2007-2012

21-30 (2007-2012)



Display 17 Problem Age Groups in 2012-2016

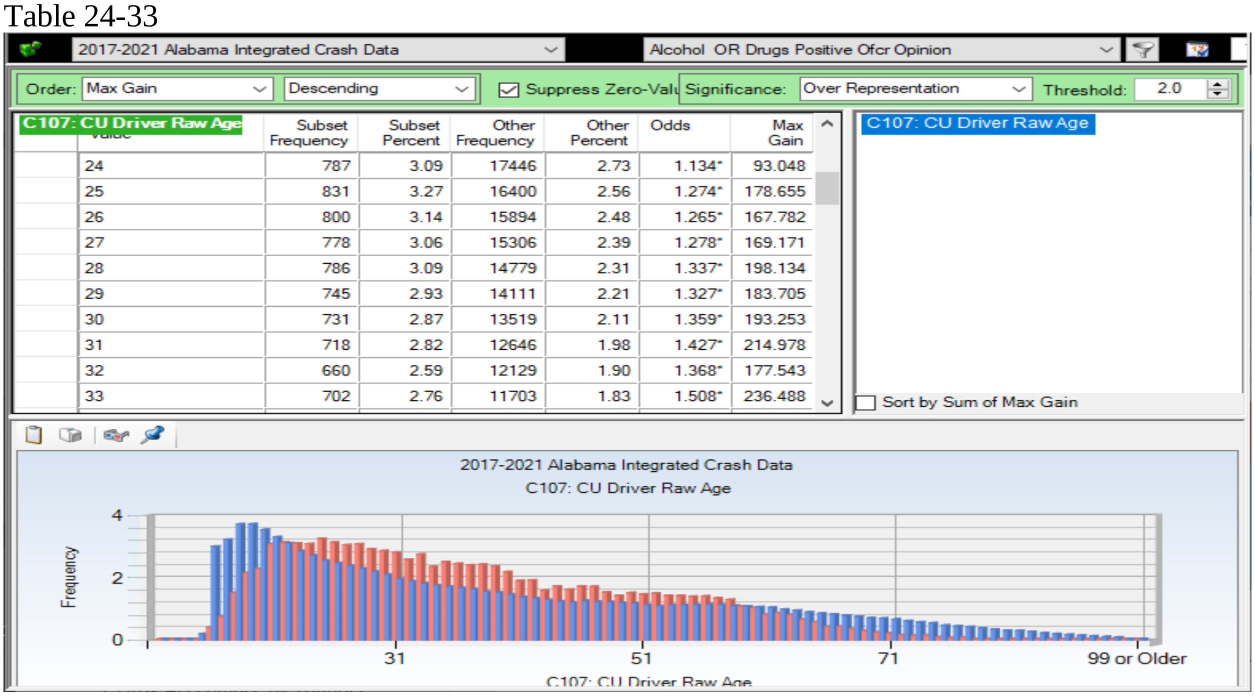
28-34



C107: CU Driver Raw Age Value	Subset Frequency	Subset Percent	Other Frequency	Other Percent	Odds Ratio	Max Gain
28	834	2.74	12702	2.16	1.269*	176.591
29	866	2.84	12092	2.05	1.384*	240.162
30	878	2.88	11700	1.99	1.450*	272.451
31	885	2.91	11392	1.94	1.501*	295.391
32	826	2.71	10996	1.87	1.451*	256.887
33	808	2.65	10803	1.84	1.445*	248.876
34	742	2.44	10194	1.73	1.406*	214.396

Display 18 Most Recent Data (2017-2021), Table for Ages 24-33

Table 24-33



C107: CU Driver Raw Age Value	Subset Frequency	Subset Percent	Other Frequency	Other Percent	Odds	Max Gain
24	787	3.09	17446	2.73	1.134*	93.048
25	831	3.27	16400	2.56	1.274*	178.655
26	800	3.14	15894	2.48	1.265*	167.782
27	778	3.06	15306	2.39	1.278*	169.171
28	786	3.09	14779	2.31	1.337*	198.134
29	745	2.93	14111	2.21	1.327*	183.705
30	731	2.87	13519	2.11	1.359*	193.253
31	718	2.82	12646	1.98	1.427*	214.978
32	660	2.59	12129	1.90	1.368*	177.543
33	702	2.76	11703	1.83	1.508*	236.488

Display 19 Most Recent Data (2017-2021), Table for Ages 34-43

Table 34-43

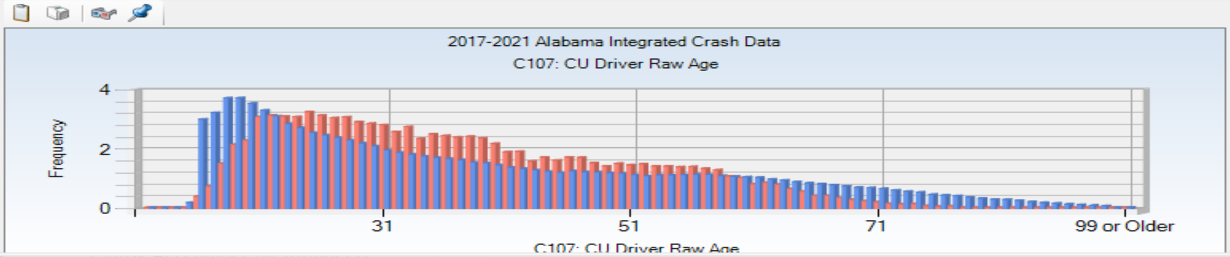
2017-2021 Alabama Integrated Crash Data | Alcohol OR Drugs Positive Ofcr Opinion

Order: Max Gain | Descending | ☑ Suppress Zero-Valu | Significance: Over Representation | Threshold: 2.0

C107: CU Driver Raw Age Value	Subset Frequency	Subset Percent	Other Frequency	Other Percent	Odds	Max Gain
34	601	2.36	11335	1.77	1.333*	150.126
35	640	2.52	11036	1.73	1.458*	201.020
36	626	2.46	10767	1.68	1.462*	197.720
37	613	2.41	10504	1.64	1.467*	195.181
38	619	2.43	9986	1.56	1.558*	221.786
39	605	2.38	9866	1.54	1.542*	212.559
40	558	2.19	9428	1.47	1.488*	182.981
41	486	1.91	8921	1.39	1.370*	131.148
42	490	1.93	8644	1.35	1.425*	146.166
43	406	1.60	8325	1.30	1.226*	74.855

C107: CU Driver Raw Age

☐ Sort by Sum of Max Gain



Display 20 Most Recent Data (2017-2021), Table for Ages 46-53

Table 44-53

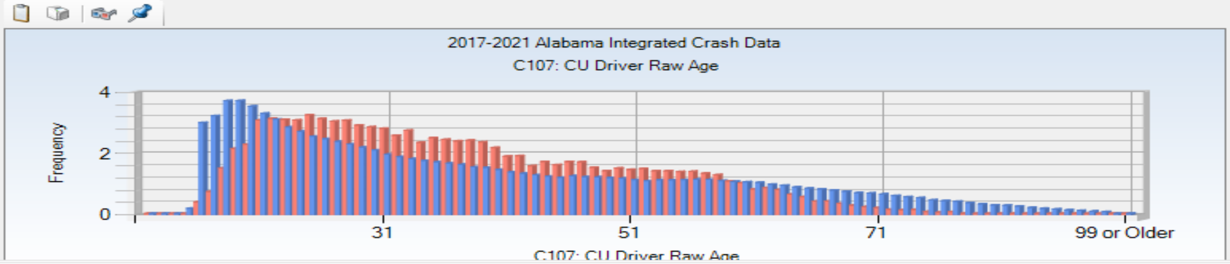
2017-2021 Alabama Integrated Crash Data | Alcohol OR Drugs Positive Ofcr Opinion

Order: Max Gain | Descending | ☑ Suppress Zero-Valu | Significance: Over Representation | Threshold: 2.0

C107: CU Driver Raw Age Value	Subset Frequency	Subset Percent	Other Frequency	Other Percent	Odds	Max Gain
44	441	1.73	8031	1.26	1.380*	121.550
45	415	1.63	7778	1.22	1.341*	105.613
46	441	1.73	8120	1.27	1.365*	118.010
47	439	1.73	7924	1.24	1.393*	123.806
48	393	1.54	7877	1.23	1.254*	79.676
49	365	1.43	7739	1.21	1.186*	57.165
50	387	1.52	7623	1.19	1.276*	83.779
51	375	1.47	7299	1.14	1.292*	84.667
52	383	1.51	7069	1.11	1.362*	101.815
53	364	1.43	7282	1.14	1.257*	74.343

C107: CU Driver Raw Age

☐ Sort by Sum of Max Gain



5.0 Ultimate Toward Zero Deaths (TZD)

Estimates from the traffic safety community claim that at least 80% and perhaps as many at 95% of crashes of all severities are caused by the human driver. Years have been spent in research to reduce this proportion, but as long as there is a human driver in the vehicle, the hope to get anywhere close to zero deaths is impossible. Clearly the recent increase in fatalities is moving in the opposite direction.

The only solution to the problem is to remove the primary cause. Is it possible that within 25 years we may have removed the necessity for a human driver for a significant number of vehicles to the point that a vehicle with a human drivers becomes as rare as a horse-drawn vehicle is today?

There is considerable research being done on this subject, and we recommend that those who have doubts consider the articles on SafeHomeAlabame.gov that discuss the wide variety of efforts that are being made. URLs to access these articles are given here:

http://www.safehomealabama.gov/page/2/?s=autonomous

http://www.safehomealabama.gov/tag/automated-vehicles/

5.1 Speeding up the TZD process

The traffic safety community should be at the forefront of promoting autonomous or automated vehicles. For those who are interested, there are over 100 articles on SafeHomeAlabama.gov, most of which have additional references for more information in the specialty areas for which you would like to contribute. The following is a list of Advanced Driver Assistance Systems (ADAS) and some additional references:

- Advanced Driver Assistance Systems (ADAS)
    - Adaptive Cruise Control (ACC)
    - Glare-free high beam and pixel light
    - Adaptive light control: swiveling curve lights
    - Anti-lock braking system
    - Automatic Driving Systems (ADS)
    - Automatic Emergency Braking (AEB),
    - Automatic parking
    - Automotive head-up display
    - Automotive navigation system with typically GPS and TMC for providing up-to-date traffic information
    - Automotive night vision

- Backup camera
- Blind spot monitor
- Blind Spot Warning (BSW),
- Collision avoidance system (Pre-crash system)
- Crosswind stabilization
- Cruise control
- Driver drowsiness detection
- Driver Monitoring System (DMS)
- Electric vehicle warning sounds used in hybrids and plug-in electric vehicles
- Electronic stability control
- Emergency driver assistant
- Forward Collision Warning (FCW)
- Intersection assistant
- Hill descent control
- Hill-Start Assist
- Intelligent Speed Adaptation or Intelligent Speed Advice (ISA)
- Lane centering
- Lane Departure Warning system (LDW)
- Lane change assistance
- Lane Keeping Assistance (LKA),
- Parking sensor
- Pedestrian AEB or Detection (PAEB/PD)
- Pedestrian protection system
- Rain sensor
- Rear Cross Traffic Warning (RCTW)
- Surround View system
- Tire Pressure Monitoring (TPM)
- Traction control system
- Traffic sign recognition
- Turning assistant
- Vehicular communication systems
- Wrong-way driving warning

- Additional References:
  - Lane Departure
    - https://www.sciencedirect.com/science/article/pii/S0386111217302091
  - Driver perceptions
    - https://www.sciencedirect.com/science/article/abs/pii/S0965856418315817?via%3Dihub
  - Improve user acceptance using Adaptive Naturalistic Data
    - https://www.sciencedirect.com/science/article/pii/S092575351732101X?via%3Dihub

5.2 Conclusions on ADAS and ADS

It is essential that traffic safety professionals and their organizations promote ADAS and other vehicle automation developments. This should be done by appealing to the traffic safety (life-saving) benefits that we expect to be obtained once these disciplines mature. In the meantime, expect that there will be resistance caused by liability and other litigation problems. Clearly there needs to be a cultural acceptance of Automated Driver Systems (ADS) that has already begun in the acceptance of many ADAS systems. It is important that the traffic safety community recognize the many legitimate issues that will slow down this transition, such as the vulnerabilities to malicious hacking.

The promotion of vehicle automation should not be made at the expense of the many excellent countermeasure that are currently directed primarily at drivers. This is not an either-or proposition. Advances need to be made on both fronts simultaneously, and hopefully the two innovation tracks will be complementary in nature. To the extent possible, the transition to driverless vehicles should follow the pattern that is currently evolving in the transition to electric vehicles (EVs).