

MTFC Scenario Quest 2023-24

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|----------------------|------------------------------------|
| Team Name | Scheme Team |
| Team ID # | 16419 |
| Proposal Topic Title | Drowsy Driving Induced Car Crashes |

MTFC Scenario Quest Template Use Notes:

In 3-5 sentences, summarize what is the topic your team is proposing to investigate and why it is important.

Provide a statement on what the topic is and why it is important.

Has it seen a sudden or recent change that brings it to the forefront?

Who does it affect, where is it prevalent, is it tied to any other areas of impact?

- Refer to the official MTFC Scenario Quest 2023-24 for the prompts for each of the 5 Missions.
- The use of this template is NOT required for MTFC Scenario Quest submissions. It is provided as an optional resource for teams to keep their Scenario Quest response organized. Teams who wish to use this template should make a copy in order to edit.
- The final version of the MTFC Scenario Quest should be downloaded as a PDF or Word document to submit on the ICS Dashboard. A single file will be submitted.
- Additional resources can be found on the Modeling the Future Challenge website:
 - The Actuarial Process Guide <https://www.mtfchallenge.org/the-actuarial-process/>
 - Data Sources <https://www.mtfchallenge.org/data-sources/>
 - Sample Project Topics for Proposal Ideas <https://www.mtfchallenge.org/example-projects/>
 - Video Resources <https://www.mtfchallenge.org/video-resources/>

Please direct any questions to challenge@mtfchallenge.org.

Mission 1 Ski Resort Prompts

These prompts can be found on pages 11-12 of the Scenario Quest. Additional information on Data Identification and Analysis can be found on pages 11-22 of the [Actuarial Process Guide](#).

Responses:

- 1.1 - In addition to the ski resorts, large companies that manufacture ski-related items would be affected. For example, the companies that produce skis, poles, ski boots, snow goggles, etc. would suffer and have lower incomes. Small businesses that also sharpen and wax skis may also experience less store activity. Other attractions (restaurants, hotels, etc.) near the ski resorts would also have decreased activity. m
- 1.2 - The number of ski resorts would decrease, the number of people out of jobs due to ski resorts closing would increase, and the number of guests attending ski resorts whether it be just for skiing as well as booked resorts would decrease, *The ski resorts might be desperate to stay in business and buy more snow machines, increasing profits for those companies.
- 1.3- In an effort to manage the risks stated above, the three types of risk mitigation strategies would be able to mitigate these losses in several ways. Ski resorts paying a premium to an insurance agency will help prevent these resorts from going bankrupt when they have low revenue due to the weather, and if many ski resorts pay this premium then the insurance agency will also make a profit. One incentive that can be given to skiers/snowboarders is that if climate change worsens in the upcoming, skiing/snowboarding will not be an available activity; therefore, people should be encouraged to do it now.

Mission 1 - Team Project Proposal Prompt

- 1 - Drowsy Driving Car Crashes
- 1.1 - Drivers are the main group at risk from these crashes. On top of that, the other passengers in the car are at risk of being affected by the drowsy driver. Additionally, third party groups who aren't necessarily part of the crash, such as car companies, ambulances, etc.
- 1.2 - Population of cars on the road at late night and early morning times when people are more prone to be tired, the percentage of workers who need to work for long hours and then commute at unconventional times, typical hours of sleep for people living in a certain area.
- 1.3 -
 - Insurance: less coverage for drowsy driving incidents, increased insurance post-accident,
 - Behavior Change: Programs that must be taken on how to prevent animal induced crashed before getting your license are crucial to the overall safety of all drivers.
 - Modifying Outcomes: drowsy driving detection, more rest stops

Mission 2 Ski Resort Prompts

These prompts can be found on pages 18-19 of the Scenario Quest. Additional information on Data Identification and Analysis can be found on pages 23-29 of the [Actuarial Process Guide](#).

Responses:

- 2.1 –What are the constant expenses of the ski resort, regardless of profit? What are the other expenses that are proportional to number of guests / profit? Which expenses can be reduced in order to keep the resort open, even if the quality of experience is reduced? How have changes in climate been proportional to profit in the past years?
- 2.2 – The type of data identified here is projecting future trends given the scenario’s dataset. The data tells us the report on each resort’s snowfall and profit each year which helps to project future trends. Some additional data that would be valuable in conducting a risk analysis and mitigation project for this scenario would be the percentage of turnout in comparison to the first year (2003), as well as months that customers came the each resort the most each year.
- 2.3 – The sample size can be used to find the average. The identification of data types can be analyzed against each other to make further observations. The center of the data, especially when compared against each other, can help to show where a lot of the population is populated and shifted. The spread shows the consistency of the data, and how reliable it is for future patterns.

Mission 2 - Team Project Proposal Prompt

- 2 - Drowsy Driving Car Crashes
- 2.1 - What hours of the day is there the highest risk of drowsy driving? When is there the greatest traffic throughout the day? Is high traffic associated with high risk of drowsy driving? What preventative solutions have been attempted so far? What about caffeine in particular? How often are rest stops made? How does daylight savings / hours of sunlight affect drowsy driving accidents?
- 2.2 - The perfect data sets would include dates and times of drowsy driving accidents, locations of drowsy driving accidents, and working hours of the people who get in drowsy driving accidents (or at least the typical working hours of employees in the region). These would be mainly frequencies and locations. Additionally, it would be interesting to see government reports about actions taken so far to mitigate drowsy driving accidents.
- 2.3 -
- <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812446>
- <https://www-fars.nhtsa.dot.gov/Main/index.aspx>
- <https://www.mass.gov/traffic-safety#:~:text=Traffic%20safety%20is%20of%20outmost,of%20the%20Commonwealth%20of%20Massachusetts.>

The first data source shows the number and percentage of crashes involving drowsy driving, including the percentage of fatal crashes. It also identifies two main factors involved in this accident. This is very helpful because it helps us to put into perspective the percentage of drowsy driving crashes that result in fatalities, which can help us decide if we should plan more around mitigating the crashes in the first place versus preventing the fatalities. The second data source will bring data on statistics for various car crash scenarios with varying amounts of people. Providing statistics for the past twenty-five years, this source will allow us to make trends and model the changes in different crash scenarios over the years. This is beneficial information as it also includes national fatalities, which helps to broaden our research to different populations. In our analysis, this data will help us determine how likely car crashes versus motorcycle crashes are and give us an estimate of the fatalities involved.

Mission 3 Ski Resort Prompts

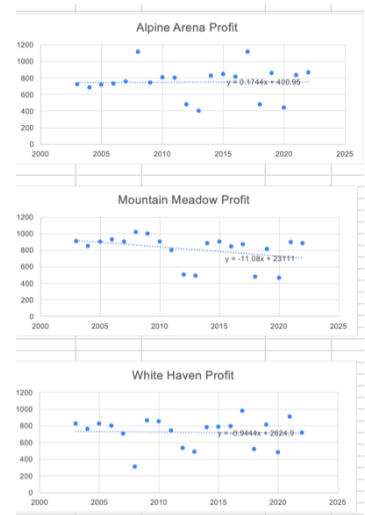
These prompts can be found on pages 24-26 of the Scenario Quest. Additional information on Data Identification and Analysis can be found on pages 30-31 of the [Actuarial Process Guide](#).

Responses:

- 3.1:
 - <https://www.mathmodels.org/Problems/2017/HIMCM-B/index.html>
 - https://www.researchgate.net/publication/267790078_Mathematical_modelling_of_the_inrun_profile_of_a_ski_jumping_hill_with_the_controlled_track_reaction_force
 - <https://journals.ametsoc.org/view/journals/hydr/24/6/JHM-D-22-0182.1.xml>
 - The results published in these papers were ones on how snowfall rates and their effects on ski resorts have become an increasing problem over the recent decade, as well as how there has been an overall decrease in snow in the Northern Hemisphere over the last half-century. In these mathematical models, linear regression, confidence intervals, and tables were used to display the decrease in snowfall. Overall these sources helped determine what type of graphs we may be able to use in our project, as well as give us more insight on this global issue's effects.

- 3.2
 - 3.2.1: As our calculation in Excel displayed, the probability for light, typical, and heavy snowfall is 0.2, 0.7, and 0.1, respectively.
 - 3.2.2: As our calculations in Excel displayed, the overall average profit for Alpine Arena, Mountain Meadows, and White Haven were 752, 811.15, and 724.4, respectively. In the Alpine arena, the mean profit for light, typical, and heavy snowfall is 360.4, 786.14, and 1116, respectively. In Mountain Meadows, the mean profit for light typical and heavy snowfall is 482.5, 885.93, and 945, respectively. White Haven's mean profit for light typical and heavy snowfall is 504.75, 798.5, and 645, respectively.

- 3.3: Linear regression graphs and equations for each ski resort.
 - 3.3.1: The Mountain Meadow ski resort is expected to have the riskiest profit. This is because their line of regression is negative from 2003 to 2022. Therefore, it is expected that their profits will continue to decline.
 - We assume that the same ratio and frequency of snowfall will occur in the coming years. We expect the ratio of snowfall to profit to stay the same. Additionally, we expect the Alpine Arena will continue to have the most profit, and Mountain Meadows will have the least.



Mission 3 - Team Project Proposal Prompt

- 3.1 -
- Most of the literature found was analyzing the causes most closely related to drowsy driving, as many of them are often unreported or accounted for, but rather just precited through police observations, as well as detection or drowsy driving through machine learning, as well as overall review papers going over different factors known to be correlated with the issue. Some of the key words we found we “alertness”, “fatalities”, “behaviors”, and “fatigue”. Finally, this was helpful because we did not realize how many drowsy driving crashes went under the radar, so we were able to become aware of the fact that the numbers we found online may be less than the actual number of crashes. It also brought to our attention about the underlying factors/causes the influence the drowsiness in the drivers in the first place.
- 3.2 - We expect to mathematically model the risks for our project by creating a linear regression model with the total number of drowsy driving crashes per year, compared to the number of fatal drowsy driving crashes. This will be helpful for us to decide if we should focus more on preventing drowsy driving crashes in general or prevent the impact that the passengers receive in the crash. We would also use a scatter plot to plot the times that the drowsy driving crashes occurred so that we can identify the most high-risk periods of the day and create risk mitigation strategies around those periods. We can also try to run a Monte Carlo Simulation based on the physiological factors and correlating data obtained from studies observing causing factors for drowsy driving crashes. This can help us brainstorm risk mitigation strategies.
- 3.2 - We hope that the mathematical model will help us to quantify the frequency of the risk based on the times that it occurs most throughout the day, and its overall frequency over the past years, so we can look for any trends. Additionally, we hope to standardize the severity of the risk of car crashes as well by identifying how many of drowsy driving crashes are fatal, and looking into the average cost of hospital bills and other data regarding post-crash challenges for the people involved.

Mission 4 Ski Resort Prompts

These prompts are on pages 31-32 of the Scenario Quest. Additional information on Data Identification and Analysis can be found on pages 32-33 of the [Actuarial Process Guide](#).

Responses:

- 4.1: There is one significant outlier in atypical snowfall years, in 2009 at Mountain Meadows ski resort. While the average profit for most years during typical snowfall was around \$850,000, this year it had a profit of \$1,069,00 which was larger than any other. One possible explanation for this outlier was that this was one of the earlier years in which the prolonged effects of climate change were less severe than in the coming years. In other words, in comparison to the more recent years such as 2019 and 2020, the effects of climate change were less severe ten years ago hence the increased snowfall. This outlier would likely not affect all ski resorts equally, as each resort's location plays a major role in its annual snowfall rates.
- 4.2
 - 4.2.1: The probabilities provide the frequency of loss as the probability of each type of snowfall describes how often the correlating profits will occur. The probability of typical snowfall is much higher than low or high snowfall, so most of the risks are clustered in that range.
 - 4.2.2: The mean profits help to gauge the severity of loss in terms of how much money the ski resort can make based on the different amounts of snowfall. For example, although all the mean profits are in positives, the mean profit for high snowfall is notably higher than the mean profit for typical snowfall, both of which are significantly higher than the mean profit for low snowfall, showing that the extent of the earnings is different for each situation.
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Mission 4 - Team Project Proposal Prompt

- 4.1 - The risk mitigation strategies that will be evaluated with a focus on drowsy driving include insurance, behavior change, and modifying outcomes. In terms of insurance, we will evaluate the effects of less coverage for drowsy driving accidents and increased insurance post-accident. In other words, we want to gauge if drivers would be deterred from driving while tired if they knew that their insurance would increase or if there was less coverage for those who do experience crashes due to this. Behavior change could be incorporated by implementing specific drowsy driving precautions into driving schools so that individuals are aware of these hazards before getting their licenses. This crucial aspect of driving will ultimately aid the overall safety of all drivers on the road. In terms of modifying outcomes, drowsy driving detection technology and more rest stops will aid in reducing the fatality rate.
- 4.2 - As hours of sleep duration for the common population has been generally decreasing over the past years and people have been relying more on self-driving systems in cars, drowsy driving has become more of a prevalent issue. So, without any interventions, the number of drowsy driving accidents is hypothesized to increase in the coming years. Our goal is to lower the amount of drowsy driving accidents and fatalities a significant amount by providing incentives to drivers to be more alert on roads in general and also finding ways to prevent the crashes right before they are about to occur.

Mission 5 Ski Resort Prompts

These prompts can be found on pages 36-38 of the Scenario Quest. Additional information on Data Identification and Analysis can be found on pages 34-35 of the [Actuarial Process Guide](#).

Responses:

- 5.1: The profit for typical snowfall is approximately twice that during light fall. The difference in profit between heavy and typical is significantly smaller than the profit between typical and light. If there are no interventions or mitigation strategies implemented, the projection for risk of loss is high because global temperatures continue to increase and light snowfall will become more common.
- 5.2: One strategy would be making the transition to utilizing snow pump technology that has a smaller carbon footprint. Another strategy would be targeting the electricity-powered ski lifts. By shifting to a renewable energy source, like wind turbines for example. One initial drawback would be the higher cost of implementing these new technologies. Not only that but shifting to wind turbines as a renewable energy source would create noise pollution, which would disrupt the people living in the local area. Some additions the ski resort could make to minimize losses are things like restaurants and gift shops to gain revenue. An insurance policy would be beneficial, specifically for the years where there is lighter snowfall, and they have less revenue from skiers. In specific, insurance companies could offer a fallback for the resort where there is a set amount the ski resort will receive each year because of buying the policy. This will give them a little cushion in the years when the resort doesn't do as well.
- 5.3:

| With Insurance | Mean Profit | Probability |
|----------------|--------------|-------------|
| Light | \$482,500.00 | 20% |
| Typical | \$885,930.00 | 70% |
| Heavy | \$945,000 | 10% |

| | |
|--|-----------|
| Expected Outcomes without Insurance Policy: | |
| Light Snowfall | \$96,500 |
| Typical Snowfall | \$620,151 |
| Heavy Snowfall | \$94,500 |
| Standard Deviation of Expected Profits without Insurance Policy: | |
| Light Snowfall | \$169,175 |
| Typical Snowfall | \$175,897 |
| Heavy Snowfall | \$144,721 |

| With Insurance | Mean Profit | Probability |
|----------------|--------------|-------------|
| Light | \$552,500.00 | 20% |
| Typical | \$955,929.00 | 70% |
| Heavy | \$1,015,000 | 10% |

| | |
|--|-----------|
| Expected Outcomes with Insurance Policy: | |
| Light Snowfall | \$110,500 |
| Typical Snowfall | \$669,150 |

| | |
|---|-----------|
| Heavy Snowfall | \$101,500 |
| Standard Deviation of Expected Profits with Insurance Policy: | |
| Light Snowfall | \$151,916 |
| Typical Snowfall | \$193,497 |
| Heavy Snowfall | \$181,423 |

- From the numbers, more profit is attained with the insurance policy regardless of the amount of snowfall in that particular year. Even though it would mean paying a set amount per year for insurance, this would still result in a higher profit value as the insurance would offer a high amount of additional money to the ski resort per year. In terms of addressing issues regarding Mountain Meadows and the profit attained, having the insurance policy, even in the years when there is heavy snowfall and there should be less profit, the insurance policy helps with this.

Mission 5 - Team Project Proposal Prompt

- 5.1 - We could write a speech to address the Massachusetts government, as well as major insurance companies about the issue regarding drowsy driving accidents. We would start by highlighting major statistics about crashes caused by drowsy driving, especially in recent years, and then provide our hypothesized major causes of the issue. Next, we would talk about the various risk mitigation strategies we came up with, such as increasing the emphasis on drowsy driving in driver's ed (behavior), improving drowsy driving detection in cars, and adding more rest stops to highways (modifying outcomes), and lowering coverage for drowsy driving accidents for the driver (insurance). Finally, we would encourage the government, driving schools, and major insurance companies to consider this issue and begin implementing changes to their systems.
- 5.2.1 - Although most of the strategies would not have negative consequences, the drowsy driving detection system is the most complex which could potentially cause more self-driving car accidents, and lowering insurance on drowsy driving accidents may make it more difficult for people in those accidents to pay for their medical fees. Additionally, building new rest stops could have large costs and they may also require some deforestation, negatively affecting the environment.
- 5.2.2 - The drowsy driving detection system is the most complex; therefore, it is likely to take a long time and lots of effort to develop, and if it doesn't work properly, it could potentially lead to more driving accidents caused by the car's self-driving technology. Additionally, the lowered insurance for drowsy drivers would create a financial incentive to be alert on the roads, but it may also cause people with financial difficulties to be unable to pay for their medical bills. At a large scale, this could decrease the quality of life for drivers overall and potentially even lower the life expectancy for drivers in the future.
- 5.3 - Our group hopes that through the strategies recommended in our proposal, there will be a lower number of drowsy driving accidents on the road. Some of our risk mitigation ideas target prevention of drowsiness on the road overall, while others target prevention of accidents right before it occurs. For example, increased emphasis on drowsy driving in driver's ed and lowered insurance coverage for drowsy drivers creates more awareness about the issue and encourages increased general alertness on the road. On the other hand, strategies such as increased rest stops and drowsy driving detection systems in cars help to avert the crash right before it is about to happen.