Team Name	Actuary the Best
Team ID #	16421
Proposal Topic Title	Skyward Bound: Risk Analysis of Overbooking Practices in Commercial Aviation

MTFC Scenario Quest Template Use Notes:

- *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

  One group that is at risk for loss because of climate change affecting ski resort times are the skiers and snowboarders who plan on attending the resort. The ski resort customers will rent or buy their equipment and potentially reserve housing. If the ski resort ends up not opening, the consumers will lose money by not being able to use the equipment and housing that they paid for. Another group that is at risk is the vendors that sell things at or near the ski resort. These include nearby restaurants, hotels, and vendors who sell equipment. They would lose profits with decreased customers coming to the resort.

- 1.2

  Some areas of risk include the net yearly profit, snowfall, number of customers, and number of employees. One way to measure risk is the net yearly profit, as a decrease in profit would represent a loss. As well, the number of customers will show how well the ski resort is doing. Snowfall can be a measure of risk as decreased snowfall results in a decrease in customers and the amount of time the resort can operate. The number of employees can be measured as an increase in layoffs would show a loss. Also, a decrease in wages could show loss too.

- 1.3

  Insurance would decrease the risk as if the resort paid a certain amount of money to the insurance company, their loss would be insured by the company, and it would not be as much as if they did not have insurance. A behavior change would reduce risk as if skiers are more conscious about protecting the mountain, the resort could stay open for longer. As well, if skiers just come for food instead of to ski, they could make revenue even when the mountain cannot be opened. Modifying Outcomes would decrease risk as the ski resort could take action to make snow.

Mission 1 - Team Project Proposal Prompt

- Our project will be on analyzing and defining the overbooking of airplane tickets. This problem is important because airline companies lose vast amounts of money while making payouts to passengers that they do not have enough seats on flight to fit. It is also important to passengers, as being removed from their flight can cause scheduling issues and cost the passenger a lot of time and money.
- The topic has seen a recent increase in popularity as videos and stories have gone viral on the internet detailing passengers who were forcibly removed from their flight, such as a doctor who was removed when his patients were in dire need of care.
- This topic affects all airline companies, as well as other businesses that rely on air travel or future space travel. Furthermore, it affect all passengers and customers who are refused their flight and are forced to take another flight at a later date.
- For airline companies, the risk would be the possibility of having to give payouts to passengers pushed out of their flights and a decrease in reputation and customer base. For customers, they can be pushed out of needed trips due to the overbooking of plane tickets. As a worst-case scenario, if everyone who bought a ticket showed up for the flight, it can cause people to miss important events, such as a wedding, funeral, surgery, business event, sports competition, and so on. This also causes airlines to lose money, as they have to compensate those who were bumped from their flight and also run the risk of being sued.
- Insurance: Airline companies could pay for insurance so that they don't have to pay as much money to passengers who are refused a flight. This would lessen the risk for loss.
- Behavior change: If less people book flights, airlines would be overbooked less often. Additionally, if more people did show up for their flights, airlines would have enough seats for all passengers more often.
- Modifying outcomes: Airline companies could offer less seats to purchase per flight. This would avoid overbooking and having to pay passenger who do not show up.

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
    - By how much is the snow decreasing each year
    - Ratio of skiers spend at the resort per year
    - How many skiers attend per year

- 2.2

1. Which of the five data types identified in the Actuarial Process Guide are provided in this dataset and what valuable information is the data able to tell us?
    - Data that defines historical trends
    - Data that separates potential outcomes
    - Data that defines the severity of potential losses
2. What additional data would be valuable in conducting a risk analysis and mitigation project for this scenario?
    - The number of skiers per year, snowfall rate and amount, and prices for admission.

- 2.3
    - N represents the sample size of the data. Categorical or numeric data represents whether the data is measuring numeric values or values that are classified as one type of thing or the other. The center of the data can be measured based on m
    - mean, and median, depending on whether or not the data is skewed. The spread can be measured based on standard deviation or range based on the data given and if the data is skewed or not.
    - Plotted graphs and charts help visualize the data, show the spread of data, and can show you which type of measure of center to use. It also can help you to see how different values are categorized and the percentage present of each value.

Mission 2 - Team Project Proposal Prompt

- Research questions that we need to mitigate the risk of Airplane overbooking payouts
    - How much do airlines lose each year because of removed passengers?
    - Are there any trends in the number of passengers that have been removed from their flight?
    - Are certain flights more likely to have cancellations?
-
- An ideal dataset would include profit for each major airline, how much each flight is overbooked, how many passengers had to be removed from a plane, payout amounts to the removed passengers, total profits, and removal frequency.

https://www.transportation.gov/sites/dot.gov/files/2023-10/October%202023%20ATCR_0.pdf page 41-43
https://www.transportation.gov/sites/dot.gov/files/2023-03/February%202023%20ATCR.pdf page 51
https://www.transportation.gov/sites/dot.gov/files/2023-01/December%202022%20ATCR.pdf July-Sept 2022, page 45
https://www.usatoday.com/story/travel/columnist/2023/05/10/airline-overbooking-bumped-flight-cruising-altitude/70199667007/

One data source is the department of transportation, as they give data on airline profits, passenger overbooking, and profit loss. This is a credible source because it comes from government reports. It defines historical trends and defines severity of losses. Another data source is The source shows how much payouts are for the passengers removed from their flights. It defines the severity of losses . 098
The other data source is USAtoday because they give data on how much airlines are required to pay passengers if they are overbooked. This is a credible source because it is a reputable news source.

Mission 3 Ski Resort Prompts

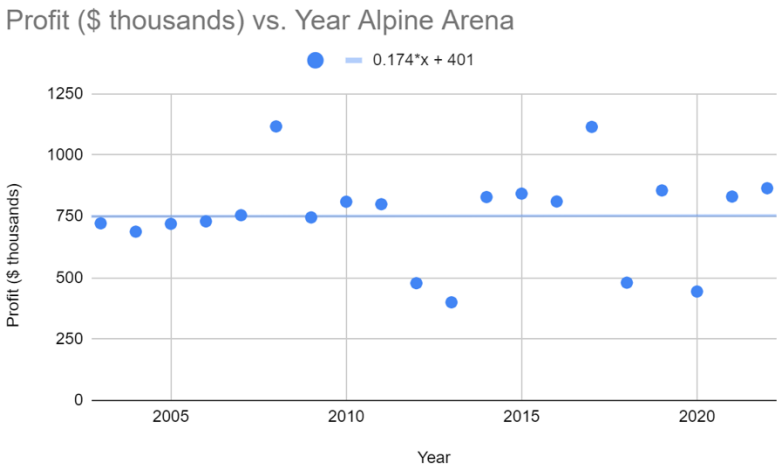
These prompts can be found on pages 24-26 of the Scenario Quest. Additional information on Data Identification and Analysis can be found on pages 30-31 of the Actuarial Process Guide.

Responses:

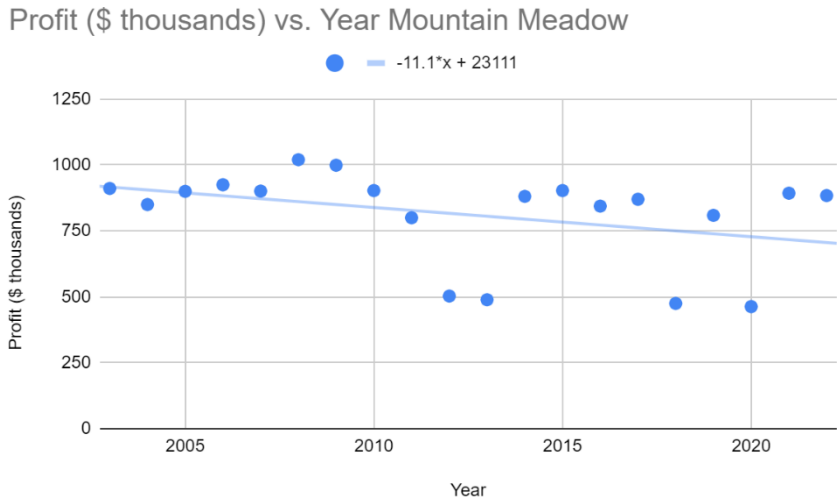
- 3.1
    - This provides a bunch of Research Articles. Some keywords provided are Ski tourism, Climate change, Internal climate variability, Large-ensemble, Snow modeling, Ski Areas, Regional Climate, Simulations, Meteorological parameters
    - Some of the mathematical concepts used are several different kinds of graphs, tables, maps. Flowcharts were also used.
    - It was helpful to look at what mathematical papers look like and the different kinds of techniques we can use for our project. Everything was comprehensible with our math levels.

- 3.2.1
    - Typical = 42/60 = 70% probability
    - Light = 12/60 = 20%
    - Heavy = 6/60 = 10%
- 3.2.2
    - Alpine Arena:
        - Typical: 786
        - Heavy: 1116
        - Light: 450
    - Mountain Meadows:
        - Typical: 886
        - Heavy: 945
        - Light: 482
    - White Haven:
        - Typical: 799
        - Heavy: 645
        - Light: 505
- 3.2.3
    - Alpine Airline: 822
    - Mountain Meadows: 868
    - White Haven: 800
    -

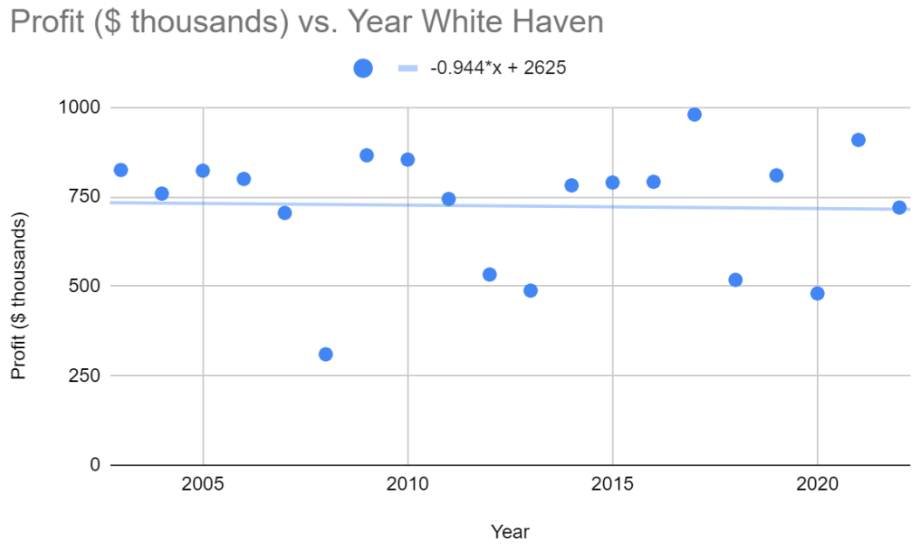
- 3.3
  Alpine Area



- **Mountain Meadows**



- **White Haven**



- Mountain Meadows seems to have a much more decreasing rate in profits, so it might be in a riskier profit projection than the others.

- Assumptions
    - We are assuming that the frequency of typical, heavy, and light snowfall years stays constant for the coming years, meaning that the same number of each type of snowfall that happened across thi time span will happen in the next time span
    - We are also assuming that the profit for typical, light, and heavy snowfall years respectivly stay constistant, meaning that the trend in profit decline stays consistant.

Mission 3 - Team Project Proposal Prompt

https://docs.google.com/spreadsheets/d/181_IkrOvlledjAIczgXYm2yS2H03XKN7OZq9Yg60vds/edit#gid=0

- **Airline overbookings**
    - 3.1. Most of our data is from official government transportation reports, since it is a credible source and contains lots of valuable information. Some helpful models we could use are graphs and charts.
- **What kind of results, published papers, and credible literature does this yield?**
    - It gives us equations and useful diagrams/graphs to help us envision our mathematical model. They also show us how other people went about tackling this problem and provide more background information in the abstract and introduction sections.
- **What are some keywords used in the articles you find?**
    - Booking level - the upper bound for reservations that minimizes expected costs
    - Bumping - term used for kicking passengers out when airlines overbook.
    - No-shows - Passengers who fail to show up to their flight with no notice or cancellations
    - Overbooking - The sale of more tickets than available seats
- **What is helpful in what you found? What was unfamiliar or beyond the math you are familiar with?**
    - It was helpful to see examples and gain more ideas about how we will create our model. It was also helpful to learn more background information on the current systems in place and the reasons why airlines overbook. Some of the math equations are very complex and would require us to do further research on them.
- **What kind of mathematical analysis seems to be fruitful to pursue in the Project Pase for your proposed topic.**
    - Graphing the potential profit of the airline. The graph shows more tickets will increase revenue, but eventually they will lose money as they have to compensate bumped passengers.
- **Provide a summary of your findings with links and identify how this informs your next steps in mathematical analysis**
    - They taught us mathematical methods to use to calculate the probabilities of everyone showing up for flights and the odds that someone will have to be paid out. It also taught us how to break down the overarching problem into sections that help us understand each aspect independently. We also learned distributions we can use to represent our data.
    - https://math.stackexchange.com/questions/2426604/binomial-probability-of-airline-overbooking
    - https://online.hbs.edu/blog/post/why-airlines-overbook-using-toy-models-to-maximize-revenues
    - https://www.jstor.org/stable/25767604?seq=1

- **Describe what you hope a mathematical model would be able to do for you? How could it help you identify the frequency & severity of risk and the changes over time or other elements that will help you characterize risk?**
    - A mathematical model should be able to provide a binomial probability distribution of expected profit produced by various plans of controlled overbooking so that we can determine which plan would yield the best average expected profit.

Mission 4 Ski Resort Prompts

These prompts can be found 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
    - Are there any significant outliers in atypical snowfall years?
        - Yes -310 is an outlier because it is significantly less than other heavy snowfall years, which are around 1,000.

    • If yes, what could be an explanation for this profit outlier in light of the snowfall? Does this outlier affect all ski resorts equally? Justify your explanation logically and mathematically.

        - It could be an unusual amount of snow that they get that year, so their profit will be different from typical years. There could also be other external factors, such as user preferences, competition, and malfunctions with the ski resort.

    • If no, explain why not and offer a logical and mathematical case for your reasoning.

        - There are outliers, so the answer is yes.

- 4.2.1: Consider the probabilities computed in Prompt 3.2.1 regarding Mountain Meadows.

    - Typical = 42/60 = 70% probability
    - Light = 12/60 = 20%
    - Heavy = 6/60 = 10%

    - Are these probabilities providing insight into the frequency or the severity of loss? Why? What does this tell you about the distribution of risks? Provide a logical and mathematical explanation in 1-2 sentences.

        - These probabilities show how often you should expect to have each type of snowfall per year. Lighter snowfall will result in a lower profit, while heavier snowfall will increase the profit. Using the probabilities for each type of snowfall, you can imagine the probability of having a typical, lower, or greater profit in a given year.

- 4.2.2: Consider the mean profits at Mountain Meadows computed in Prompt 3.2.2.

- Are these mean profits providing insight into the frequency or the severity of loss for Mountain Meadows? Why? What does this tell you? Explain in 1-2 sentences.

    - These mean profits provide insight into the severity of loss for Mountain Meadows because they show the differences in profits between light, typical and

heavy snowfall. When there is lighter snowfall, there is expected to be slightly more than half as much expected profit.

- 4.2.3: Consider the expected value of PROFITS for Mountain Meadows computed in Prompt 3.2.3

    - Alpine Airline: 822
    - Mountain Meadows: 868
        - White Haven: 800

    - Since Mountain Meadows did not report negative profits in any given year, what is a measure of "loss"? How can you define loss for a resort even when they have positive profits? Explain in 2-3 sentences.

        - You can consider a “loss” when the profit is less than the expected mean profit. This means that the ski resort made less money than they usually would, showing that they “lost” money that year.

Mission 4 - Team Project Proposal Prompt

To reduce the risk of airline companies having to pay out money to remove passengers because of overbookings, this mathematical model will identify the likelihood of having to remove a passenger from a plane based on the number of tickets sold and the number of the seats each airplane has available. The model will also find how much money airlines lose in proportion to the number of tickets sold greater than the number of seats on the flight. Using that information, it will calculate the optimal amount of overbookings to make as much of a profit as possible and reduce the losses at a maximum (modifying outcomes). We will also mitigate risk by finding the optimal way to compensate removed passengers while abiding to federal regulations and minimizing loss. We will mitigate risk by finding the optimal amount to charge passengers who do not show up for their flight and how this will affect the frequency in which passengers do not show up for their flight (behavior change). These statistics will be found out using the data provided to us by our sources which will tell us no show frequency, monetary loss, payout rates, and bumping frequency for different airlines.

We believe modifying outcomes to be the most viable system to prevent losses due to overbooking by airlines. This is because insurance requires payment by airline companies, which could further losses, and behavior change doesn't seem as viable as people have flights they must take and it would be difficult to deter people from taking flights. This does not really change our perspective on the approach as we were already leaning toward this solution path.
If no interventions are made to the airline booking system, airlines will continue to overbook flights and have to pay much more than they were paid for tickets. This will result in the airlines beginning to operate at a much lower window of income than possible. Our hope with our risk mitigation strategy is to lower the losses incurred by airline companies and the inconvenience on customer's behalf as they are pushed out of their seats.

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
    - Currently, Mountain Meadows is losing money each year, at an average rate of $11,000 of loss per year. This is seen through our trendline, which can be used to predict an estimated income for Mountain Meadows each year. With no intervention, Mountain Meadows will continue to lose $11,000 per year.
- 5.2
    - Risk Mitigation Strategy: Behavior Change
        - 3 Behavior changes that could be incorporated by Mountain Meadows to help reduce their loss in profits due to Global Warming are: a fine given to people who pollute the mountain, more sustainable packaging, and a mountain bus or encouraged carpooling to reduce the carbon footprint of everyone using cars to get to the mountain
        - Possible drawbacks to using the suggested methods to reduce pollution are that it is going to be hard to force people to pay if they pollute, and extra staff will have to be hired, which can cost more money. Also, having more sustainable packaging may be more expensive than the current packaging. Finally, having a Mountain Bus means drivers will need to be hired, as well as paying for fuel and other expenses. Furthermore, having to organize times and go to places far away will not be efficient.
    - Risk Mitigation Strategy: Modifying Outcomes
        - Things that Mountain Meadows could do to keep their profits is fabricate snow. They could have places to collect water each time it rains instead of snow and make snow out of it. Another way to modify the outcomes is by offering other activities like climbing, snowshoeing, hikes, etc.
    - Risk Mitigation Strategy: Insurance
        - Insurance would benefit Mountain Meadows by protecting the company from consumer injury, as well as the land and buildings on the property from excessive snowfall that could cause damages. These damages or injuries would be expensive for the resort to pay out of pocket, so a lack of insurance could bankrupt or cause severe losses to Mountain Meadows.
- 5.3

With Insurance	Mean Profit	Probability
Heavy	915	0.1
Typical	855.9285714	0.7
Light	552.5	0.2

WITH INSURANCE: Expected value = 801.15 Standard Deviation = 134.12057075632

WITHOUT INSURANCE: Expected Value = 799.12 Standard Deviation = 171.855542535

- The expected value with insurance is slightly higher with the insurance, meaning that the cost for buying the insurance every year as you will make money with the money the insurance company provides. Standard deviation is less when you have insurance, meaning that profit is more consistent with insurance and they are not losing as much money.
- It addresses the risks for Mountain Meadows by increasing their expected profit across all years and providing more consistent profit so that some years the resort is not short on money.

Mission 5 - Team Project Proposal Prompt

- The Risk Mitigation Strategy identified in Mission 4: Modifying Outcomes
    - 2 ways to modify outcomes are to offer fewer seats to purchase per flight. This would result in less chances for the flight having more passengers than seats. Another way to modify outcomes is by charging customers who do not show up for their flights. This would incite passengers to show up and would provide more money for the airline company if they don't show up because they'll have to pay for their ticket and the no-show fee.
    - Modifying outcomes is the most fruitful option as it will allow airlines to limit the out-of-pocket payments involved with the overbooking of flights, as well as the splitting up of passenger groups.

      When deciding which risk mitigation strategy to use, we needed to analyze which provided the most upside and least downside for the airline, as we are looking at this problem from their point of view. Insurance may not work very well as it would require a higher ticket payment for customers so airlines can cover the cost, resulting in fewer bookings for that airline company. Behavior change may not work well either as we would charge customers if they don't show up to their flights, causing fewer bookings from customers. For an alternative behavior change, we could pay customers who do show up to their flights, but this would require an even higher charge so this mitigation strategy is not one we should move forward with.
- A possible drawback to offering less seats to purchase per flight are that planes might not be full, which would result in less profit being made per flight and having to pay for the same amount of fuel for flights that are and are not full. Possible drawbacks to making passengers pay when they don't show up to their flight is having to charge them, and that people might be less likely to want to go with that certain airline.
- Hopefully, this model will recommend the optimal number of tickets to be sold per flight according to the number of seats on the plane and make airline companies lose less money. If airline companies follow this model, they will be able to maximize their profits by having the greatest number of passengers on each plane flight and minimize their losses because of not having to pay passengers who are denied access to their flight and maximizing the use of fuel. Additionally, this model will improve the overall quality of air travel for consumers by minimizing the number of passengers removed from flights.