Apply "STEAMS" Methodology on Managing Europe Travel

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Abstract
This paper adopts STEAMS (Science, Technology, Engineering, Artificial Intelligence, Math, Statistics) methodology. The objectives of this paper are to introduce the benefits of integrating all 6 "STEAMS" elements, especially living in the Big Data World. Managing Europe Travel case study was demonstrated to present this novel "STEAMS" concept as compared to current "STEM" or" STEAM" approach. This paper was addressing travel cost & time while visiting five major cities in Europe. The main objective was to build a robust route which can meet both time & expense requirements. The input variables used were the intra-city time & expense while the response variables were the total time & expense. There are three core visions of this "STEAMS" methodology: (1) replace "Art" with "Artificial Intelligence", (2) separate "Statistics" from "Math", and (3) integrate all six "STEAMS" elements. Adding the "Artificial Intelligence" Black-Box element can trigger and enhance the effectiveness of "Scientific" Research and "Math" algorithms. Separating the "Statistics" element from "Math" can conduct more effective risk management and draw practical conclusions. "Engineering" DOE can validate the "Artificial Intelligence" algorithm. The "STEAMS" approach can enhance the cross-linking and becoming a natural critical thinking way for most scientists and engineers striving in the modern Big Data era. It's critical and urgent for educators and teachers to migrate from their traditional STEM approach to the new "STEAMS" approach to educate our next generations in their early school learning and career development.

Key Words: Science, Technology, Engineering, Artificial Intelligence, Math, Statistics

1. Introduction

Many people like travelling but have three constraints on Time Management, Expense Budget, and Travel Quality. The objectives of this paper are: (1) manage travel in Europe, (2) build a statistical model to predict travel duration and expense, and (3) conduct a Robust Design to optimize the travel plan. A great way to save time and money when travelling across Europe is by taking the trains. Eurostar is more convenient and economic than taking Flights. However, Eurostar only has direct trains among major cities such as London, Paris, Brussel, Lyon, Avignon… Taking trains among other cities in Europe may not be a better choice than taking a Flight.

"STEM" (Science, Technology, Engineering, Math) or "STEAM" (Science, Technology, Engineering, Art, Math) are popular in School Education is a term used to group together these academic disciplines [1,2]. This term is typically used when addressing education policy and curriculum choices in schools to improve competitiveness in science and technology development. It has implications for workforce development, national security concerns and immigration policy. The acronym came into common use shortly after an interagency meeting on science education held at the US National Science Foundation. In the early 1990's, a summer program called STEM Institute is arranged for talented under-represented students in the Washington, DC area. Based on the program's recognized success and expertise in STEM education [3], that NSF was first introduced to the acronym STEM. In this paper, a new "STEAMS" approach will be introduced.

1.1 Design Europe Travel Package

This paper would design a summer travel package on visiting five major European cities: London, Paris, Amsterdam, Prague and Munich as shown in Figure 1. The starting and ending destination will be at the Paris Charles de Gaulle CDG Airport applicable for most Visitors. CDG airport is the largest international airport in France and the second largest in Europe. This paper would only consider the travelling time and expense of taking either train or/and flight among five destinations. It won't consider the other travel duration and expense during visiting each city.

Figure 1: travel among five major European cities

1.2 Criticism of STEM

The focus on increasing participation in STEM fields has attracted many criticisms:

(1) The efforts of the U.S. government to increase the number of STEM graduates, the science and engineering occupations have been flat or slow-growing, and unemployment as high or higher than in many comparably-skilled occupations [4].

(2) The STEM Crisis Is a Myth": there was a "mismatch between earning a STEM degree and having a STEM job in the United States, with only around ¼ of STEM graduates working in STEM fields, while less than half of workers in STEM fields have a STEM degree [5].

(3) Based on the data, science should not be grouped with the other three STEM categories, because, while the other three generally result in high-paying jobs, "many sciences, particularly the life sciences, pay below the overall median for recent college graduates [6].

(4) Efforts to remedy the perceived domination of STEM subjects has led to intense efforts to diversify the STEM workforce. Some critics feel that this practice in higher education, as opposed to a strict meritocracy, causes lower academic standards [7].

1.3 STEAM and Artificial Intelligence

STEAM fields are Science, Technology, Engineering, Art[8] , and Math [9]. STEAM is designed to integrate STEM subjects into various relevant education disciplines. These programs aim to teach students innovation, to think critically and use engineering or technology in imaginative designs or creative approaches to real-world problems while building on students' mathematics and science base [10]. STEAM programs add art to STEM curriculum by drawing on design principles and encouraging creative solutions. [11-14].

In the modern Big Data Society, Artificial intelligence (AI) is becoming a new dominant Data Science. AI sometimes called machine intelligence or machine learning, is intelligence demonstrated by machines, in contrast to the natural intelligence displayed by humans. In computer science AI research is defined as the study of "intelligent agents": any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goals [15].

Digital art is an artistic work or practice that uses digital technology as an essential part of the creative or presentation process. Since the 1970s, various names have been used to describe the process, including computer art and multimedia art [16-17]. Recently, a lot of articles are about AI in art and design: a lot of the feature imagery, unsurprising as they're largely created by people from a science rather than arts background. And their research is often presented in the ultra-detailed format of scientific papers - heavy on words and, strangely to us. This digital art application of AI is being referred to as 'generative'. Generative AI will drive the next generation of apps for auto-programming, content development, visual arts, and other creative, design, and engineering activities. In Generative graphics**:** AI can abstract visual patterns from artwork and then apply those patterns in the fanciful re-rendering of photographic images with the hallmark features of that artwork [18].

2. Introduce “STEAMS” Methodology

Instead of using classical STEM or STEAM, here, a new holistic “STEAMS” methodology is introduced in this paper. There are several novel concepts embedded in this new “STEAMS” methodology: (1) replace “Art” with “Artificial Intelligence”, (2) separate “Statistics” from “Math”, and (3) integrate all six “STEAMS” elements. “STEAMS” (Science, Technology, Engineering, Artificial Intelligence, Math, Statistics) methodology would be demonstrated through managing a Europe Travel project as shown in Figure 2 “STEAMS” Diagram.

The Aircraft Flying Kinetics Physics “Science” was studied to compare transportation speed and duration between train and flight. “Technology” is understanding the Europe train system. Systematic “Engineering” problem solving techniques such as Decision Flow Chart and Design Constraints are utilized to optimize the travel package. Neural “Artificial Intelligence” algorithm was conducted to discover the sensitivity patterns. Monte Carlo “Math” random simulation can help study the Noise factors and impact on meeting the two travel requirements. JMP DOE Design was used to optimize the travel package. All 6 "STEAMS" elements are critical to making this project successful [19-20].

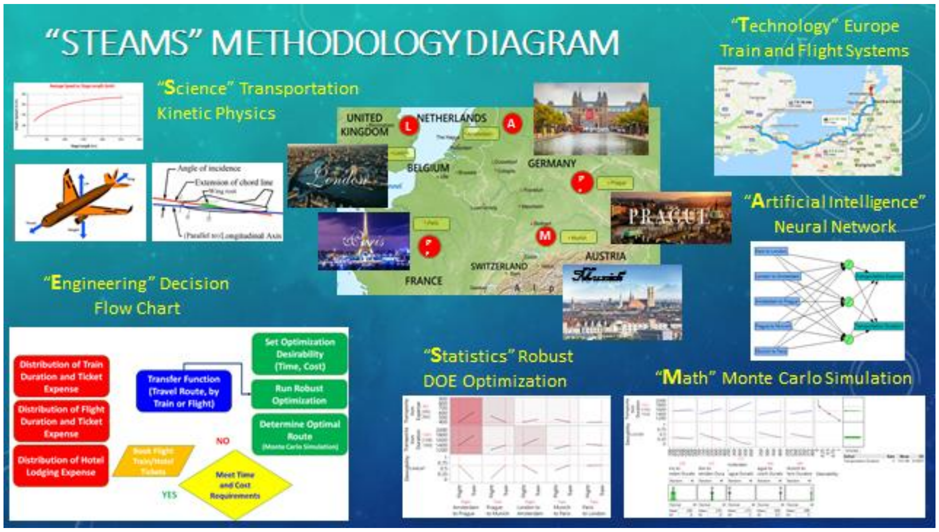

Figure 2: "STEAMS" Diagram

2.1 "Science"

Depending on the length of the aircraft, it may then take 15-20mins for the plane to climb to its cruising altitude and another 15-20mins for preparing landing. There are four forces acting upon an aircraft: (1) Weight (Gravity), (2) Lift – acting perpendicular to the direction of relative motion, (3) Thrust – acting along the direction of motion, generated by engines to move the aircraft forward, and (4) Drag – acting opposite to the relative motion of the aircraft, generated by the air resistance. The lift force "holding" a plane up is generated by airflow over the wings. Lift is only possible if the relative air speed must be large enough. Train acceleration physics is much simpler, and it typically takes 5mins to reach the full speed.

In aerodynamics, airplane wings are called airfoils. They have a cambered shape which enables them to produce lift, even for angles of attack (α) equal to zero [21-22]. The figure below shows a cross-sectional view of an airfoil, with nomenclature shown in Figure 3.

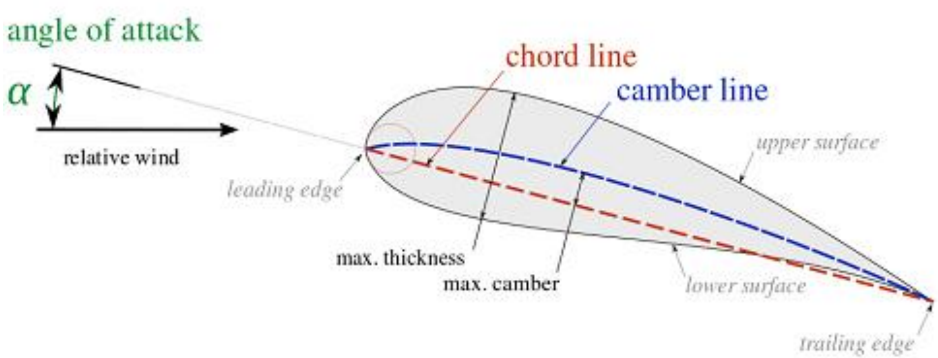

Figure 3: Aerodynamics of Airplane

According to the Eurostar Train service, train line speeds are 300 km per hour except within the Channel Tunnel, where a reduced speed of 160 km per hour applies for safety reasons. Based on 80% (full)-20% (Reduced) ratio, the estimated average Eurostar train speed is around 265km/hour. As shown in Figure 4, the average flight speed is drawn vs. stage length [23]. The average flight speed will be significant lower with shorter length due to significant portion of take-off and landing. Section 2.1 “Science” module is critical to lay out the foundation of “STEAMS” methodology.

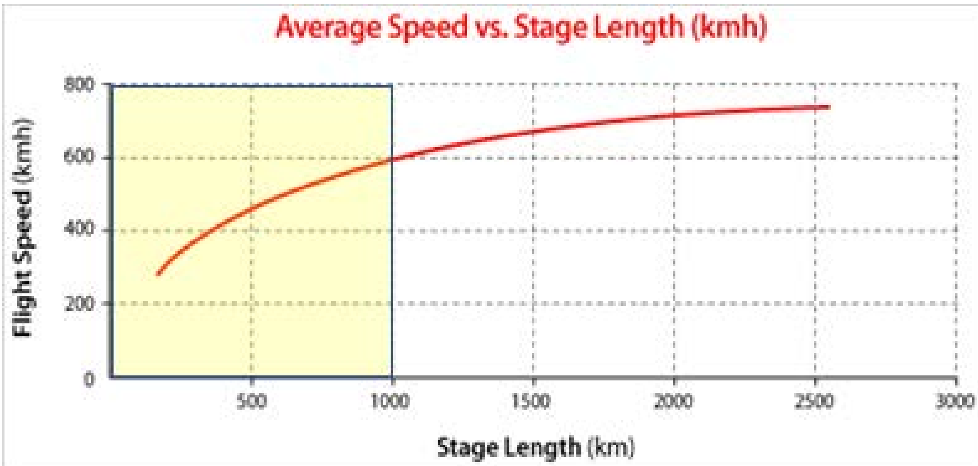

Figure 4: Flight Speed vs. Stage Length

2.2 “Technology”

There are two most popular transportation technologies among major Europe Cities: train or flight. We won’t consider the other choices like Bus, Ferry, Taxi… To design the shortest transportation duration among five destination cities, both the driving distance and the flying distance information are provided in the Figure 5 diagram. There are two distance numbers in each intra-city pair. The first number is the Driving Distance and the second one is the Flying Distance. For example, for L (London) – A (Amsterdam) pair, the driving distance is 550km, and the flying distance is 358 km. The Shortest Green Route is by Train 3123km, and by Flight 2359km. The distance ratio factor of Driving/Flying is ~ 1.3. The transportation duration ratio will depend on this Distance Ratio and Speed Ratio. Apparently, we will only consider the Green shortest route (3123km Driving Distance, 2359km Flying Distance).

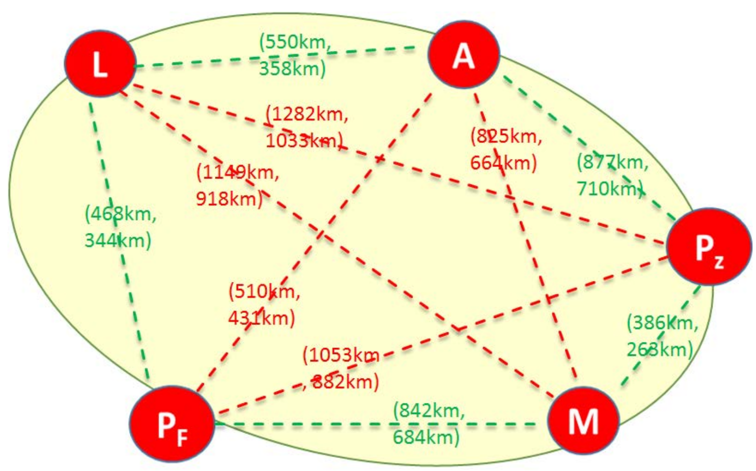

Figure 5: Driving and Flying Distance among five major cities

When considering the transportation selection, the Geometry factor may play a role. As shown in Figure 6, from London to Amsterdam, taking the Flight will be much shorter cross the Great Atlantic Ocean. Taking train would need to cross English Straight First. Section 2.2" Technology "module would consider the appropriate technology applicable in the real world.

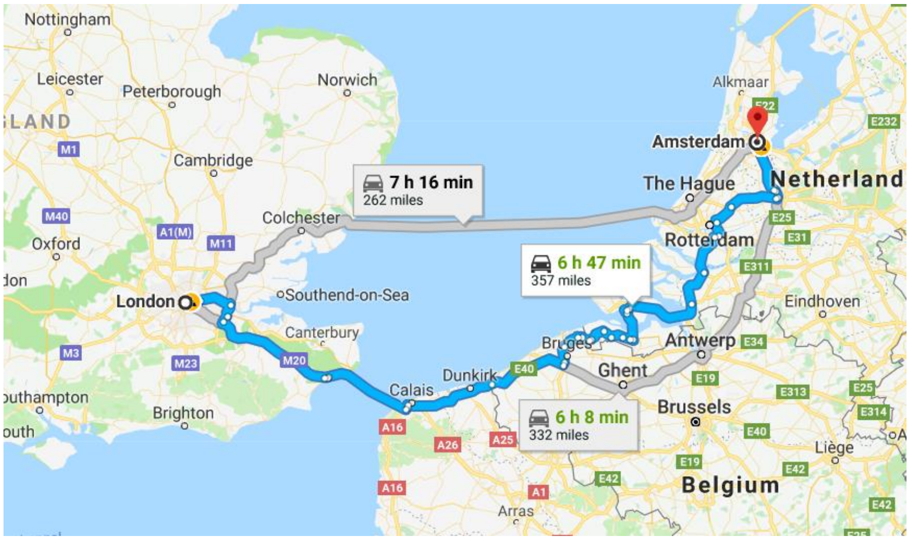

Figure 6: "Technology" selection between Flight and Train

2.3 "Engineering"

To build a regression model, two Response Variables are: (1) Total Intra-City Transportation Time and (2) Total Intra-City Transportation Expense. Three project Input Variables are: (1) Travel Route (Sequence), (2) Each Intra-City Transportation Time, and (3) Each Intra-City Transportation Expense.

In addition, to simplify the regression model, the following Design Constraints would be considered throughout this paper**:**

- Collect all transportation raw data on July 11, 2018 and book tickets by May 26, 2018
- Start and End at Paris CDG Airport or Train Main Station
- Add 3 hours Check-In/out Time for flight, and 1hour Check-In/out Time for Euro Star Train
- Take Economic Flight Seat or 2nd Class Train Seat (all one-way ticket)
- Only consider direct flight or direct train if available. Otherwise, take one stop in transition
- Only consider flight or train after 9am and arrive by 9pm within the same day
- Won't consider driving or ferry transportation among five cities
- Won't consider Flight/Train Delay Factor

Set Travel Transportation Requirements

To manage this special travel package among five major cities in Europe, two reasonable travel requirements are set as following:

(1) Total Intra-City Transportation Duration < 28.8 Hours:

- Total 12 Travel Days, 9am-9pm, 12 hours*12 Days= 144 Hours
- Less than 20% of 144 Hours is allocated to intra-city transportations < 28.8 Hours

- Other local transportation duration won't be included in this first requirement.

(2) Total Intra-City Transportation Expense < $500 USD:
- Total Budget: < $5,000 USD
- 12 Hotels = $2,400 USD ($200/Night)
- Meals: $900 USD ($75/Day)
- Other Tour/Local Transportations: $1,200 USD ($100/Day)
- Total Intra-City Transportation Expense Budget ~ $500 USD

To manage this travel task systematically, a project management flow chart was made as shown in Figure 7. The flow chart starts with red zone by collecting all the raw data of train/flight duration and ticket expense. The lodging expense won't be included in this paper. The Blue Zone would build a transfer function of all input variables which will contribute to two Reponses (total transportation duration and expense). The Green Zone would conduct sensitivity analysis and Robust optimization to determine the Optimal Route. The optimal route would be validated against two requirements and decide whether to book tickets. Adding "Engineering" module can manage Project Risk Trilogy "Schedule, Cost, Quality" in a transparent and objective way. Such kind of "Engineering" critical thinking can stimulate the Section 2.1 "Scientific Thinking", and make "Technology (train, flight)" working in the real world. Without blending "Science, Technology, Engineering" well, most projects may stay in the "Ideal" case and produce "Not-Practical, or Not-User Friendly" technology. After completed the first more "Subjective" "STE" modules, we will move to more "Objective" "AMS" modules which are heavily Data-Driven and Modeling-Oriented. The second half will start with "Artificial Intelligence" Neural Network Modeling which can discover the patterns of how to optimize the travel package.

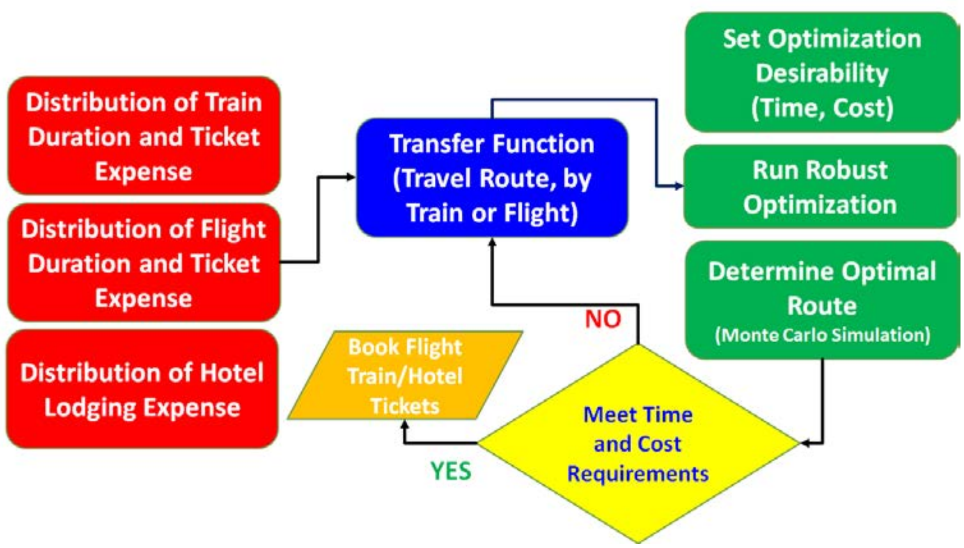

Figure 7: Project Management Flow Chart

2.4 "Artificial Intelligence"

How could the Neural Network algorithm predict the Travel Duration and Expense. As shown in Figure 8 Neural Network Diagram, between the output variable Transportation Expense and Duration, and the other Intra-City transportation input variables, a hidden layer of three Perceptron nodes is added acting as activation functions from Inputs to hidden nodes and then hidden nodes to Outputs. Neural network algorithm would search the optimal Hyperbolic Tangent (TanH) activation functions in order to fit the Transportation responses the best.

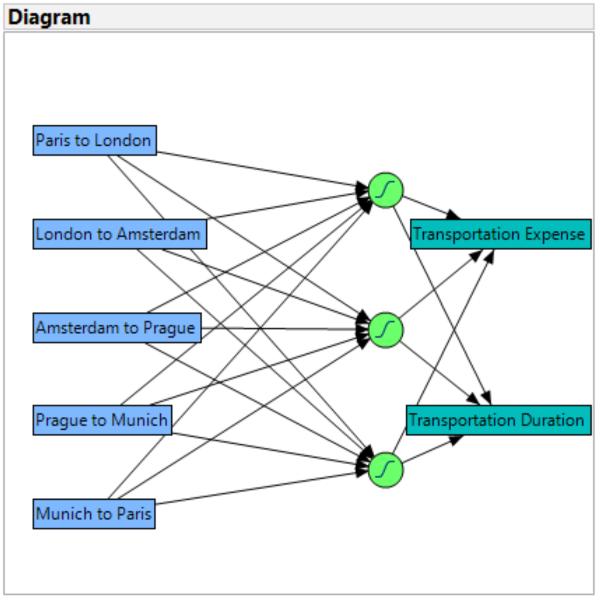

Figure 8: Neural Network Diagram

Based on the Neural Network algorithm, the Profiler Sensitivity analysis would rank which Intra-City segment is making more impact to either Expense or Duration as shown in Figure 9. The Amsterdam-to-Prague segment has shown the highest sensitivity to both transportation responses. The sensitivity is not just determined by the Intra-City distance factor only but also by the other factors such as the availability of Eurostar train, Direct Train, and Demanding (Ticket Price). It's not surprised that Amsterdam-Prague segment is the most sensitive one by taking flight over taking train. There is no Eurostar and no direct train from Amsterdam to Prague. Train ticket price is very expensive too due to low demanding (lower passenger rate- cost, and fewer train available). Neural Network modeling can help discover some key patterns. Though, it may not be sufficient to build a reliably predictive model. The following two "Math", and "Statistics" modules can further expand its function and benefits.

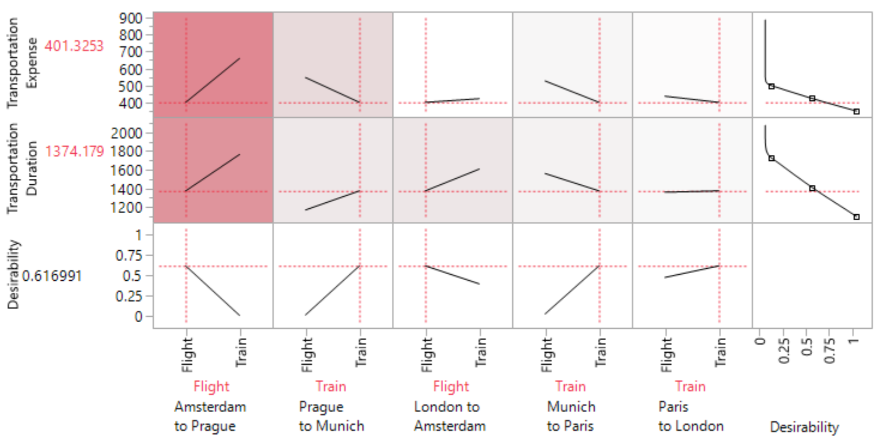

Figure 9: Neural Network Profiler Sensitivity

2.5 Math

Section 2.4 Neural Network algorithm would not consider the noise factors such as duration distribution and ticket price distribution. Even within the same day at the same station, the transportation duration and the ticket price may be different from peak hours to off-peak hours. In order to accurately estimate the total transportation duration and expense, there is a need to consider all these uncertain noise factors. JMP Profiler Monte Carlo simulator is very powerful to simulation these random noise factors.

Monte Carlo simulation, or probability simulation, is a technique used to understand the impact of risk and uncertainty in financial, project management, cost, and other forecasting models. Their essential idea is using randomness to solve problems that might be deterministic in principle. They are often used in physical and mathematical problems and are most useful when it is difficult or impossible to use other approaches. Monte Carlo methods are mainly used in three problem classes [24-25] optimization, numerical integration, and generating draws from a probability distribution. Monte Carlo Simulation enables you to discover the distribution of model outputs as a function of the random variation in the factors and model noise. The simulator in the profilers provides a way to set up the random inputs and run the simulations, producing an output table of simulated values.

As shown in Figure 10a and 10b, JMP Profiler Simulators use Normal Distribution to simulate the two responses by including the variability of flight duration and ticket price. The distribution standard deviation was determined by calculating from the real duration/ticket price data. The two requirements are also input as upper specific limit (USL) in order for JMP Profiler to estimate the non-conforming defect rate. The Monte Carlo Simulation results have shown 0% probability of not meeting the 28.8hours duration requirement and 8% probability of not meeting $500 USD transportation budget. Even though the predicted expense is $392 (seems enough buffer from $500), when considering the noise ticket price distribution, there is still 8% chance that the total transportation expense may exceed $500 USD. In order to avoid this 8% risk, it may need to book the flights/trains earlier and not scheduled during the peak hours.

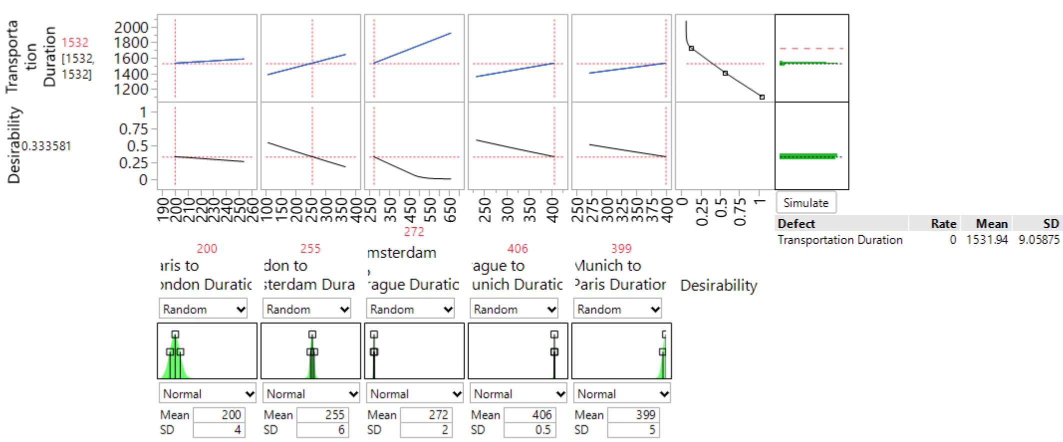

Figure 10a: Monte Carlo Simulation of Transportation Duration

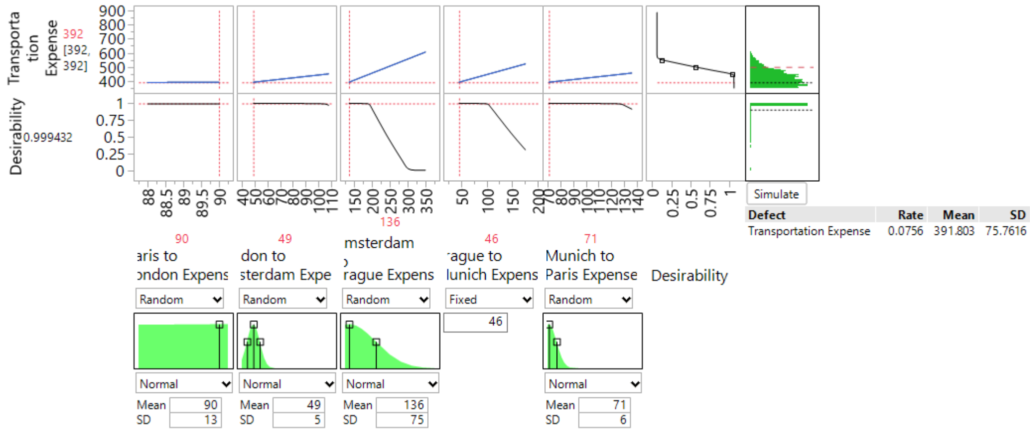

Figure 10b: Monte Carlo Simulation of Transportation Expense

2.6 Statistics

Section 2.5 Monte Carlo Simulation is based on the Section 2.4 Neural Network algorithm. In order to further improve the model accuracy, a special design of experiment (DOE) methodology was utilized to determine the optimal route: (1) Design a Structured DOE, (2) DSD Optimization Result, and (3) Monte Carlo Simulation. A special JMP Definitive Screen Design (DSD) was conducted in order optimize the transportation route. A "definitive screening design" (DSD) would be conducted to optimize the "Neural" algorithm. Here are areas where definitive screening designs are superior to standard screening designs: (1) identify the causes of nonlinear effects by fielding each continuous factor at three levels and (2) avoid confounding between any effects up through the second order [26-30]. There are five one-way transportation segments of categorical input variables (Flight or Train), total 18 DSD runs.

The objective of this DSD is to demonstrate the optimal transportation route in order to minimize two intra-city transportation goals: total duration and total expense. The DOE results were shown in Figure 11 DSD Profiler Analysis. Among five transportation segments, Amsterdam to Prague segment has shown the biggest impact to both Expense and Duration responses which is matching well with Neural Network algorithm in Section 2.4. Overall, the Section 2.4 sensitivity ranking of Neural Network algorithm is matching well with Section 2.6 DSD algorithm. This is the power of integrating objective "AMS" modules in "STEAMS" to validate the predictive models through "Artificial", "Math", and "Statistics" elements.

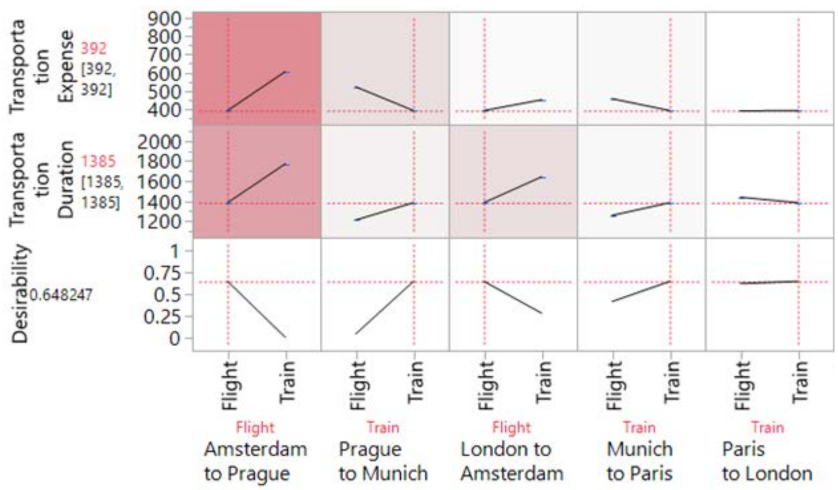

Figure 8: DSD Profiler Sensitivity and Optimization

Next, there are two competing patterns between two responses on: (1) Prague to Munich, and (2) London to Amsterdam. Prague to Munich segment has more impact on the expense and taking direct train would significantly reduce the expense around $100 USD as compared to taking a flight. Instead, for the London-Amsterdam segment, taking a flight can shorten the transportation duration time by more than 200 minutes. The driving/flying distance ratio of London-Amsterdam route is 550km/358km ~ 1.54 higher than the typical 1.3 ratio in Europe. From London-Amsterdam, train needs to pass Paris first. The flight can be across Ocean. The fourth sensitive segment Munich to Paris also favors train choice in order to meet the expense requirement more. The last segment Paris to London favors train to meet the duration requirement more. There is no wonder most visitors would take Euro Star train across English Straight. The optimal design can achieve the expected expense at $392 USD (below $500 USD) and duration $1,385mins (below 2,880mins). Though, the overall optimal design can only meet both requirements at 65% desirability.

3. Conclusions

This paper has demonstrated an effective "STEMS" methodology of managing Travel in Europe by integrating (1) Study the "Aerodynamic Physics Science", (2) Explore "Transportation Technology Systems in Europe", (3) Take "Systematic Engineering Problem Solving", (4) Adopt "Artificial Intelligence Neural Network" algorithm, (5) Simulate "Monte Carlo Math", and (6) Designed a structured "DSD Statistics" in order to build and validate the predictive models of minimizing both the travel duration and expense. Still observed 8% risk probability of not meeting the transportation expense budget. The same methodology can be applied to travel in China, Japan, Taiwan where the High Speed Train system is well established.

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