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DESIGN, ANALYSIS AND PRODUCTION OF THE DIFFERENT SUB-UNITS OF THE ROCKET THAT ARE TO BE DEVELOPED WITHIN THE SCOPE OF TEKNOFEST ROCKET COMPETITION

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ABSTRACT

Rockets are widely used in aerospace and defense with their speed and improved mechanical properties. Another important feature is that the mechanical properties and skills of rockets can be improved act upon their works. Structural properties can be increased to a higher level by design methods and manufacturing methods, as well as many parameters in the rocket modeling process and each of these parameters has an effect on structural properties. In this study, the effects of major design variables (nose cone wall thickness, nose cone length, nose cone shape parameter, payload weight, motor body tube wall thickness, motor gripper system total weight, middle body tube wall thickness, middle body tube length, fin top length, fin bottom length, fin height, fin thickness, fin location and the distance between fin bottom length to fin top length) on the rocket modeling were investigated. The study was conducted in two stages as experimentally and numerically. In the experimental part, in order for the data collection, the scenarios determined by using Design of Experiment (DoE) approach. These scenarios were carried out through the OpenRocket. MacroRecorder app was used to speed up to process applied tries on the OpenRocket and all outputs(stability, maximum speed, apogee, velocity off-road, ground hit velocity) were recorded. In the numerical part, different regression models were created to define the phenomena by using the multiple non- linear regression analysis with combining neuro regression method. The coefficient of determination (R^2), adjusted coefficient of determination ($R^2_{adjusted}$) also $R^2_{training}$ and $R^2_{testing}$ values were calculated for each model, to see how well the models define the phenomena. While the Wolfram Mathematica was used for numerical operations, the experimental operations were studied on the OpenRocket app. As a design-oriented solution, the values of the process parameters for stability, maximum speed, apogee, velocity off-road, the velocity at deployment, and ground hit velocity values, have been optimized by using stochastic optimization algorithms. It was aimed to increase the rocket modeling process efficiency.

ÖZET

Roketler, hızları ve geliştirilmiş mekanik özellikleri ile uzay ve savunmada yaygın olarak kullanılmaktadır. Bir başka önemli özellik de roketlerin mekanik özelliklerinin ve becerilerinin çalışmalarına göre geliştirilebilmesidir. Yapısal özellikler, tasarım yöntemleri ve üretim yöntemleri ile daha yüksek bir seviyeye çıkarılabilir ve ayrıca roket modelleme sürecindeki birçok parametre ve bu parametrelerin her birinin yapısal özellikler üzerinde etkisi vardır.

Bu çalışmada, ana tasarım değişkenlerinin (burun konisi duvar kalınlığı, burun konisi uzunluğu, burun konisi şekil parametresi, faydalı yük ağırlığı, motor gövdesi tüp duvar kalınlığı, motor tutucu sistemi toplam ağırlığı, orta gövde tüp duvar kalınlığı, orta gövde tüp uzunluğu) etkileri , kanat üst uzunluğu, kanat alt uzunluğu, kanat yüksekliği, kanat kalınlığı, kanat yeri ve kanat alt uzunluğu ile kanat üst uzunluğu arasındaki mesafe) roket modelinde araştırılmıştır. Çalışma deneysel ve sayısal olarak iki aşamada gerçekleştirilmiştir. Deneysel bölümde, veri toplama amacıyla, senaryolar Deney Tasarımı (DoE) yaklaşımı kullanılarak belirlenmiştir. Bu senaryolar OpenRocket aracılığıyla gerçekleştirildi. OpenRocket üzerinde uygulanan denemeleri hızlandırmak için MacroRecorder uygulaması kullanıldı ve tüm çıkışlar (kararlılık, maksimum hız, apogee, off-road hızı, açılmadaki hız, yere isabet hızı) kaydedildi. Sayısal bölümde, nöron regresyon yönteminin birleştirilmesiyle çoklu doğrusal olmayan regresyon analizi kullanılarak fenomenleri tanımlamak için farklı regresyon modelleri oluşturulmuştur. Modellerin fenomenleri ne kadar iyi tanımladığını görmek için her bir model için belirleme katsayısı (R^2), düzeltilmiş belirleme katsayısı (R^2 ayarlı) da R^2 eğitim ve R^2 test değerleri hesaplanmıştır. Wolfram Mathematica sayısal işlemler için kullanılırken, deneysel işlemler OpenRocket uygulaması üzerinde incelenmiştir. Tasarım odaklı bir çözüm olarak, kararlılık, maksimum hız, zirve, yol dışı hız, açılmadaki hız ve yer isabet hızı değerleri için proses parametrelerinin değerleri stokastik optimizasyon algoritmaları kullanılarak optimize edilmiştir. Roket modelleme işlem verimliliğinin arttırılması hedeflenmiştir.

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ACRONYMS

BEK	Nose Cone Wall Thickness
BU	Nose Cone Length
FYA	Weight of Payload
KAU	Fin Bottom Length
KEK	Fin Thickness
KK	Fin Location
KP	Fin Position
KÜU	Fin Top Length
KY	Fin Height
MGEK	Motor Body Tube Wall Thickness
MSTA	Motor Holder System Total Weight
OGEK	Middle Body Tube Wall Thickness
OGU	Middle Body Tube Length
PD	Power Variable
SSE	Sum of square errors
SST	Total sum of squares R^2
R^2	Coefficient of Determination
$R^2_{adjusted}$	Adjusted Coefficient of Determination
$R^2_{training}$	Training Coefficient of Determination
$R^2_{testing}$	Testing Coefficient of Determination
TON	Third Order Multiple Nonlinear Model
SON	Second Order Multiple Nonlinear Model

Chapter 1: Introduction

1.1. Model rocketry

Rocket science is a combination of top rings of many disciplines and many technologies. So it is an extremely expensive, dangerous and difficult science. However, with simpler materials and techniques, a rocket science that brought a less payload to shorter distances than commercial/military rockets developed and was called 'model rocketry'. Model aviation science, pyrotechnic materials, and modern rocket technologies are the cornerstones of this model science. Model rocketry became a safer and more attractive science with the establishment of an authoritarian institution (National Association of Rocketry - NAR) in 1957[1].

1.2. Parts of the model rocket

Although rockets need different parts depending on the purpose they will serve, there are some basic components they have[1].

Tablo 1.1 Parts of model rocket

Parts of model rocket
1.Nose cone
2.Payload
3.Body
4.Rocket Motor
5.Fixed Fins
6.Recovery System
7.Separation System

1.2.1. Nose Cone

The nose cone is the first component that meets the air in model rockets. Thanks to its shape, it can reduce the drag of the rocket. Therefore, it should be designed according to the speed profile of the rocket will fly.

One of the biggest factors affecting the drag in the air is the geometry of the structure exposed to the air. Assuming the cross-section of the nose is spherical and concentric to the rocket body, it can be said that the largest radius of the rocket and the shape of the nose are very important for flight performance. Nose cone geometries can have spherical, conical or more complex shapes. A spherical nose is aerodynamically more efficient at subsonic speeds. Pointed and conical geometries should be preferred at the speeds above the sound.

The noses should be durable to preserve rocket integrity, lightweight to minimize the effect on the center of gravity and keep up overall flight performance.

1.2.2. Payload

The main purpose of the model rockets is to send the necessary equipment to the target point. These equipment are called payloads and they have various tasks. Scientific research tools or experimental equipment are often used as a payload. These researches are mostly about atmosphere or space, as rockets are preferred in altitude missions. Since the rocket can face many different and high forces, the safety standards of the payload must be provided and designed so that it does not break during the rocket's mission.

1.2.3. Body

The body ensures the integrity of the rocket and includes most equipment. In order for the rocket to complete its mission successfully, the placement and integration of these equipment must be done properly. The body is the surface of the rocket in contact with the outer atmosphere. Therefore, the body must be designed to withstand all conditions to complete the task. In situations where the atmosphere exists, aerodynamic effects are observed on the rocket. Therefore, almost all elements should be stored inside the body. Otherwise, parts located outside the body aerodynamically affect the rocket. Another situation to consider when designing the body and integrating is the center of gravity. Equipment should be designed and located so as not to change the center of gravity during flight.

1.2.4. Rocket Motor

The motors serve to deliver the payload to the desired location. To put it simply, the motors operate with the discharge of gases with high temperature and pressure in a closed environment. Unlike air-breathing motors, rocket motors store fuel and oxidizer inside the vehicle. In this way, they can be used in places where the air is thin or absent. The motor does not need speed to start up. Rocket motors can move the rocket with high acceleration and reach very high speeds.

1.2.5. Fixed Fins

During their mission, rockets encounter many factors that will disrupt the flight. In such cases, the rocket is expected to recharge itself. Otherwise, the flight becomes unstable and will likely follow an unexpected route.

One of the simplest ways to ensure the stability of rockets uses fixed fin. Fixed fins create aerodynamic forces during flight, and properly designed and positioned fins help stabilize the rocket when the order of the flight is disturbed. Fixed fins create aerodynamic forces during flight, and properly designed and positioned fins help stabilize the rocket when the flight order is disturbed.

1.2.6. Recovery System

Model rockets need to be recovered to be reusable. Recovering of rockets both reduces costs and prevents negative damage to the environment. The recovery process is usually carried out with a parachute stored inside the body. Preferably, the rocket is expected to open parachute after it has reached apogee. Parachutes opened earlier may adversely affect the performance of the rocket, or if the rocket has a high speed, it may damage the structure. The parachutes that open late after the downfall, can damage the structure as the structure or structures will still have high speed.

1.2.7. Separation System

There must be a separation system in the rocket for evacuating the payload. When the rocket reaches the desired altitude, the separation system should work and disconnect the payload from the rocket. The separation system can be hot or cold , can start with a timer or sensor. Separation systems are generally based on the principle of pressurizing the body for model rockets.

Timer systems are usually activated by delaying the flame after the combustion of the engine has finished. Another fuel at the end of the fuel, which has a slow-burning rate, ignites when the motor thrust profile is finished. This slow-burning fuel is connected to another fuel and this fuel is activated after the retarder is finished and pressurizes the environment. The delay time can be calculated by making ballistic calculations. In timer and cold systems, when slow-burning fuel runs out, it activates a pressurized tube and the environment is pressurized cold.

Systems with sensors, on the other hand, operate according to the desired data - pressure, acceleration, speed, altitude, etc. - using appropriate sensors. When the flight arrives at the desired profile, the sensors activate the separation system, which can be cold or hot.

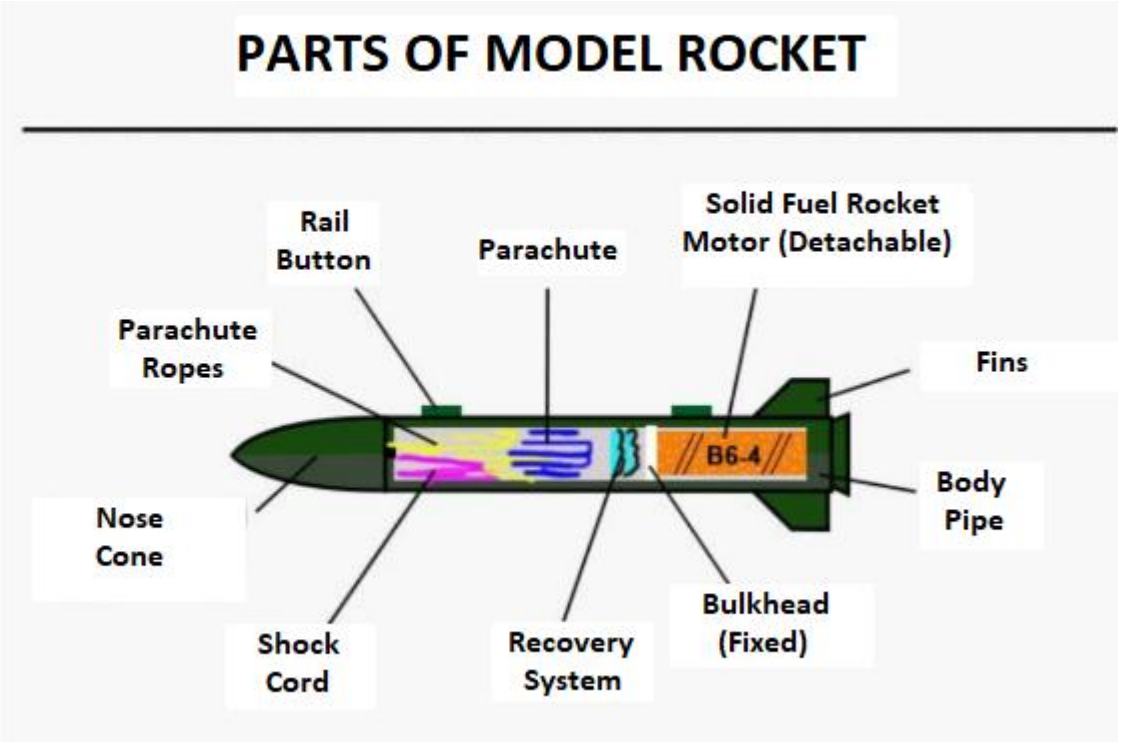


Figure 3.1 Parts of model rocket

1.3. Design of the Model Rocket

Design is always a process that should be carried out systematically. The main purpose of product design is to reach a capability that is not already possessed due to need. Rocket design can also be evaluated from this perspective. However, the materials are not any products, they are high quality and energetic materials. The environment is not sea level, but every environment from deep seas to distant stars.

For this reason, errors must be eliminated in the initial stages while designing. The best way to do this is to learn and store any information that is available and used in design before starting design. This information includes design requirements, capabilities, geometric criteria, fuel science, thermodynamics, etc. covers many topics.

During the design process, the subsystems of the design should be researched separately. However, these subsystems cannot be considered independently while designing. The output of a subsystem may be the input of another subsystem, or a subsystem may restrict another subsystem. As an example, the temperature of the engine is a warning for other systems, and how it affects the environment of the engine should be considered at every stage. [1]

1.3.1. Motor Design

The heart of rockets is motors. Simply put, rocket motors are closed environments that contain gas at high pressure and temperature during their operation. The main topics to be known in order to understand and analyze the operation of rocket engines are; are mechanical, thermodynamic, and chemistry. Since the rocket motor to be used in this study will be selected from a Teknofest catalog, no motor design research has been made.

1.3.2. Body Design

The body is the element that contains almost all the subsystems of the rocket, provides structural integrity, and protects the subsystems from the external environment. Since complex subsystems are not required in model rocketry, the most important factor that helps shape the body can be called the rocket motor. The motor and assembly method geometrically decides the diameter of the body. The thing to be considered in the motor assembly method is that it consists of strong structures that will meet the load from the motor and share it equally and keep the motor stable. After these systems are designed, important information about the body is revealed.

Another factor that should not be forgotten in the body design is that the body will be exposed to the atmosphere. Therefore, calculations should be made carefully when determining the body diameter and larger diameter should not be used as necessary. Excess diameters will return as drag, and degrade performance.

The length-radius ratio is a ratio used when designing the body, and it can be seen as a major step in deciding shape of the body in model rocketry. Even if there is information about the range of this ratio in the sources, the best method to determine this ratio is to compare the values used in similar rockets in the preliminary design stage. Because body length directly affects important values such as the center of gravity and pressure center.

While designing the body, the working conditions of the systems should be taken into consideration. Sensors that collect flight data should be stored in an environment where they can operate. Sensors collecting atmospheric data should not be stored in closed environments. Sensitive, electronic units that need to be protected should be isolated from the external environment if necessary. Since vibration is a problem occurred in rockets, the units must be well fixed.

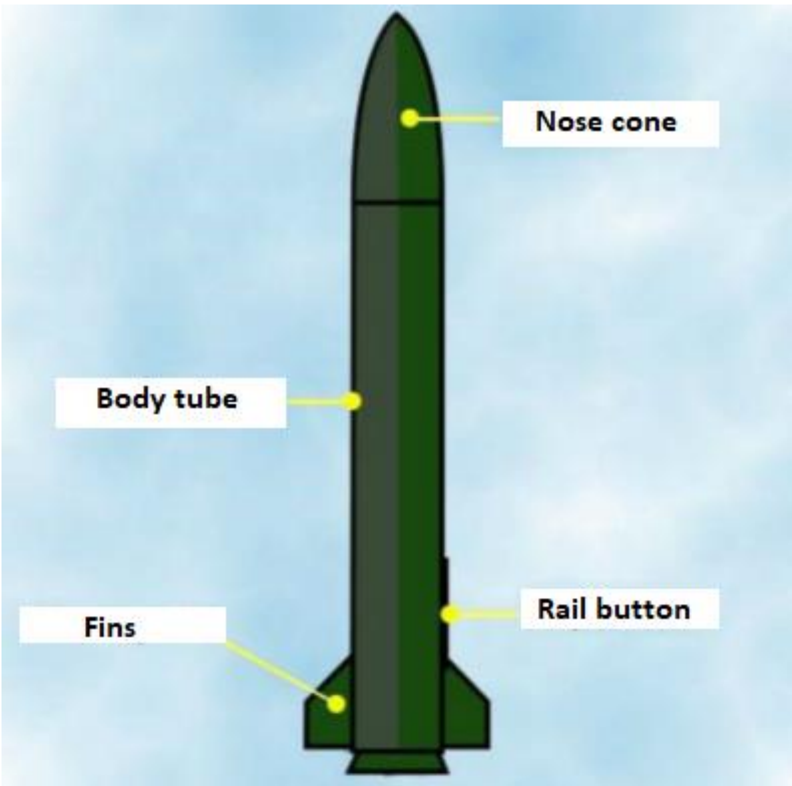


Figure 1.4 Parts of rocket outside body

1.3.3. Fin Design

The fins are of most importance for the rocket to fly stable. For the stable flight, the center of pressure (CP) must be behind the center of gravity (CG). Unguided, altitude rockets do not need to have the fins moving and the cross-sectional areas to be airfoil; Because stability can be achieved sufficiently with fixed fins and fixed fins are much simpler and cheaper than fins with the movable control surface.

A conventional fin design, which brings the distance between the pressure center and the center of gravity to the desired value, is sufficient for altitude rockets. Calculation of the pressure center which considers the geometry of the fins takes place with the help of Barrowman equations,

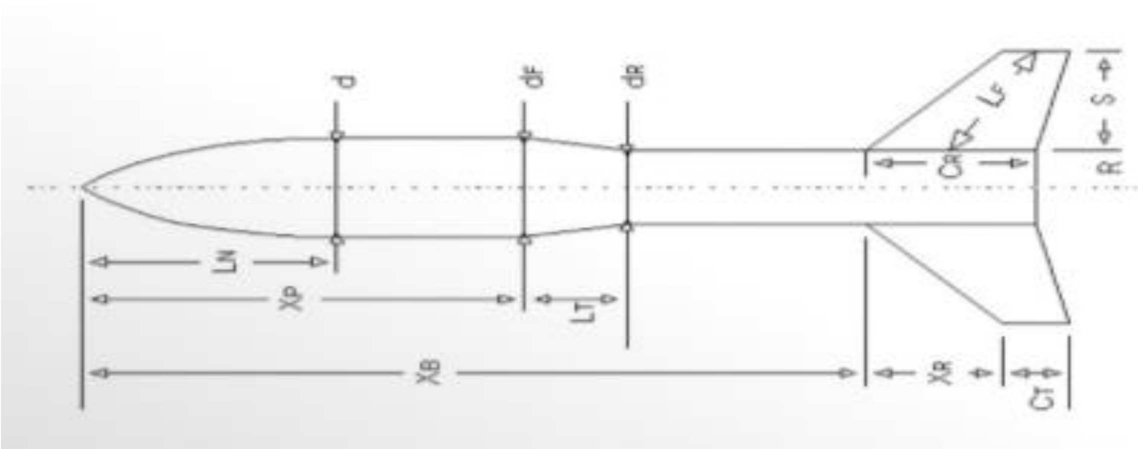


Figure 1.3 Barrowman equations values on a model rocket

$$L_F = \sqrt{S^2(\frac{C_T+C_R}{2} + \frac{S}{tan\theta})^2} \quad \text{(Equation1)}$$

The longitudinal length of the fin cross-section is determined by Equation1, where S is fin semi-clearance, C_T is fin tip-section, C_R is fin root-section, θ is wind pitch angle.

The distance of the center of pressure of the rocket from the nose of the rocket is found with the help of the following equation where R is radius at the end of the rocket body;

$$X = \frac{(C_N)_N X_N + (C_N)_T X_T + (C_N)_F X_F}{(C_N)_R} \quad \text{(Equation2)}$$

In this equation, C_N is an uncertain coefficient determined by geometry. N-indexed variables are used for the nose, T-indexed variables are used for cross-section transitions and F-indexed variables are used for fins. $(C_N)_N$, X_N, $(C_N)_T$, X_T, $(C_N)_F$, X_F, $(C_N)_R$ values are defined in under tittles.

1.3.3.1. N-indexed variables

Barrowman equations consider the structure of the nose. There is a difference between a conical nose and an ogive-shaped nose. The X_N variables are shown in Table 1.2, where L_N is nose length;

Tablo 1.2 $\boldsymbol{X_N}$ values for different nose types

For conical noses	$X_N = 0.666L_N$
For ovig shaped noses	$X_N = 0.466L_N$
For parabolic noses	$X_N = 0.5L_N$

$(C_N)_N = 2$ is generally used regardless of shape for the noses.

1.3.3.2. T-indexed variables

$$(C_N)_T = 2[(\frac{d_R}{d})^2 - (\frac{d_F}{d})^2] \quad \text{(Equation3)}$$

$$X_T = X_P + \frac{L_T}{3}[1 + \frac{1-\frac{d_F}{d_R}}{1-(\frac{d_F}{d_R})^2}] \quad \text{(Equation4)}$$

The T-indexed variables are shown in the Equation3 and Equation 4, where d_R is diameter of the back part of rocket body transition, d_F isdiameter of the front part of rocket body transition, d isthe widest diameter of the nose, L_T is longitudinal length of the rocket body transition, X_P islongitudinal distance between the nose tip and body transition.

1.3.3.3. F-indexed variables

$$(C_N)_F = (1 + \frac{R}{R+S})(\frac{4N(\frac{S}{d})^2}{1+\sqrt{1+(\frac{2L_F}{C_R+C_T})^2}}) \quad \text{(Equation5)}$$

$$X_F = X_B + \frac{X_R}{3}(\frac{C_R+2C_T}{C_R+C_T}) + \frac{1}{6}(C_R + C_T - \frac{C_R C_T}{C_R+C_T}) \quad \text{(Equation6)}$$

The F-indexed variables are shown in Equation 5 and Equation6, where N is fin number, X_B is longitudinal distance between the tip of the nose and the fin root attack edge, X_R is longitudinal distance between the fin attack edge and root attack edges.

1.3.3.4. Rocket

$$(C_N)_R = (C_N)_N + (C_N)_F + (C_N)_T \quad \text{(Equation7)}$$

by using these equations, fins that can keep the pressure center at the desired margin can be designed.

1.3.4. Recovery system design

The purpose of the recovery system is to safely bring down precious subsystems in air-space vehicles. Recovery systems can consist of the parachute, wing, or vertical landing systems. In this design, it will be mentioned on parachute recovery systems.

The forces on the parachute are created by the effect of the atmosphere surrounding the world. For this reason, the characteristics of the atmosphere should be defined accurately, and if necessary, the changes should not be taken into consideration according to the altitude. The main features to be considered are;

- Density
- Static pressure
- Temperature
- Gravity
- Velocity of Sound
- Kinematic Viscosity

These values can change with altitude. It can be predicted whether this change is important by looking at the flight profile.

The recovery system serves to save the rocket and the payload on the rocket using aerodynamic drag. When designing a recovery system, the operational strength of the objects, the environment exposed during the flight, and the recovery requests should be evaluated. The criteria resulting from this evaluation should be compiled and the design should be suitable for them. Criteria that an exemplary criterion collection may contain are given below;

- Determination of the descent velocity of the recovery system
- Determination of the maximum weight of the recovery system
- Determining at what height atmospheric conditions the recovery system will withstand
- The diameter of the rocket where the recovery system will be stored
- The weight of the load to be recovered
- The safety factor of the recovery system
- Determination of the maximum force to which the main parachute will be exposed

An approach to design should be determined after evaluating the found criteria. This approach is at the initiative of the designer. The information, demands, and constraints possessed are the factors that change the design approach. However, aerodynamic equations and gravity are common for all conditions. Candidate designs can be created by evaluating the weight of the systems to be recovered, the surface area and air permeability of the parachute, and the atmospheric conditions to which the parachute will be exposed to landing.

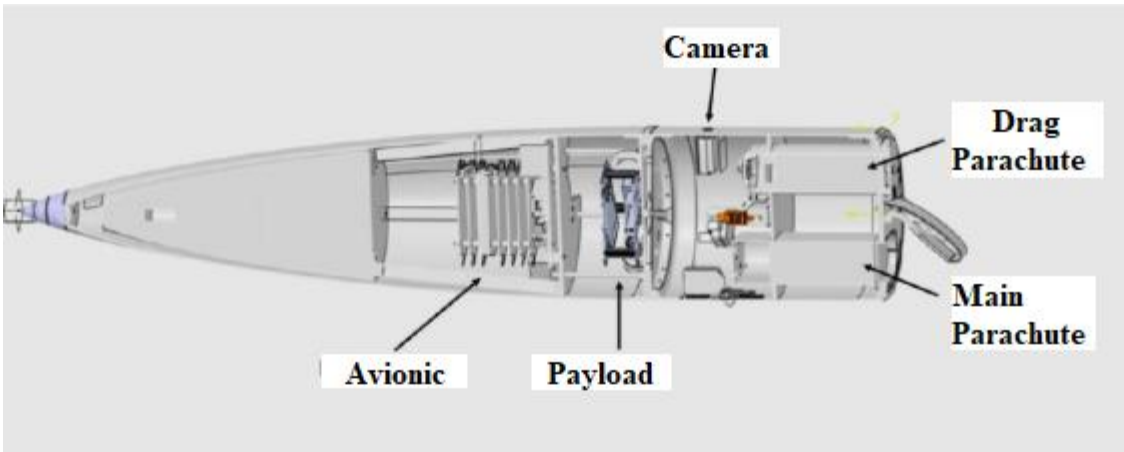


Figure 1.4 A sample recovery system

The most important factor in the design of the parachute is the drag in the air; because the main purpose of the parachute is to slow down the systems it is connected to by using this drag. [1]

In this study, parachute design is not made, the positioning of parachutes in the rocket is considered. Parachute design is the subject of another study.

1.4. TEKNOFEST Aviation, Space and Technology Festival

TEKNOFEST is a technology festival that was organized for the first time in January 2017. It is organized under the leadership of the Technology Team Foundation (T3 Foundation) and T.C. Ministry of Industry and Technology. The model rocket competition organized within the scope of this festival consists of 3 different categories. There are different design criteria for model rockets to be designed in each category. In this study, TEKNOFEST medium-altitude rocket competition criteria are taken as reference values. [2]

Chapter 2: Meterials & Methods

2.1. Materials

Since the type of material to be used directly affects flight performance, the selection of the material from which the rocket will be produced has been an important step in rocket design. The choice of material to be used should be made by considering factors such as the height of the rocket, the external forces it will be exposed to, the rocket integration strategy, and the rocket mounting strategies of the rocket systems. Aluminum, carbon fiber and fiber glass are commonly preferred structural body materials in model rockets. Each material has different advantages and disadvantages to the other. [3]

2.1.1. Aluminium

The main properties of aluminum and its alloys are their strength-weight ratio,their high thermal and electrical conductivity and their resistance to corrosion. Its density is about 2770 kg/m3 (0.10 lbf/in3), compared with 7750 kg/m3 (0.28 lbf/in3) for steel. The tensile strength of pure aliminium of about 90 MPa (13 kpsi), but this can be improved by cold working or by alloying with other materials. The modulus of elasticity of aluminum and its alloys, is 71.7 GPa (10.4 Mpsi), this means that it is one-third the stiffness of steel.

Aluminium and its alloys are among the maximum versatile substances from the viewpoint of fabrication with considering strength and cost. Aluminum can be processed by variety methods. For example: diecasting, sand casting, cold or hot working, or extruding. In addition to this its alloys can be machined, press operation, brazed, soldered, or welded. Pure aluminum melts at 660°C (1215°F), and this makes it very desirable for using permanent or sand-mold castings methods. In addition, it is available in the form of plates, rods, sheets, foils, rods and pipes, and in structural and extruded shapes, often used for commercial purposes.

The corrosion resistance of the aluminum alloys depends upon the formation of a thin oxide coating. Aluminum is very reactive. This film forms spontaneously because of its high reactivity. Stable erosion or abrasion removes this film then allows corrosion to take surface.

The anodizing process the specimen is made to become the anode in an electrolyte, which may be chromic acid, oxalic acid, or sulfuric acid.An heavy oxide film may be produced by this process. It makes possible to control the color of the resulting film very accurately. [4]

2.1.2. Carbon Fiber

Carbon fibers increase the strength properties of these materials by adding them as reinforcements to polymers, metals, and ceramics which normally exhibit brittle properties [5]. The electrical and thermal conductivity of the composite produced by the incorporation of electrically and thermally conductive carbon fibers as a reinforcing element into the non-conductive polymer matrix is increased. At the same time, the thermal expansion coefficient of carbon fibers reduces the thermal expansion of the material. Due to the combination of high thermal conductivity and expansion, carbon fiber-based polymeric matrix composites can be used in electronic applications and space vehicles where dimensional stability is required [6]. Carbon fiber-based polymeric matrix composites are widely used in spacecraft, automobiles, construction, biomedical and other industries. Due to this situation, there is a great demand for the research and development of such composites [5].

Carbon Fiber Properties [6];

- high tensile modulus and strength, high thermal conductivity
- low density, low electrical resistivity, low thermal expansion coefficient
- thermal stability in the presence of oxygen above 3000 ° C
- excellent creep resistance
- better chemical stability in strong acids
- biocompatibility

2.1.3. Fiber Glass

The first scientific and engineering studies on composite materials consisting of organic matrices reinforced with fibers have been developed as a result of research conducted with glass fiber (fiberglass). Glass fiber has been used in the manufacture of highly structural elements such as rocket motors as well as in non-structural panels in aircraft. The main reasons why glass fiber is widely used in composite material manufacturing are; it is cheap, ease of availability, and high strength.

However, it is the biggest disadvantage that glass fiber is very sensitive to moisture. As is known, glass is a silicon dioxide-based chemical. The physical, chemical, and mechanical properties of the glass can be changed by adding different oxide components to this structure. Although many different types of glass fiber are produced, advanced composites mostly use E-glass, S-glass, Quartz, and C-glass type glass fibers. E-glass type glass fiber is used in composite materials in areas where strength and high electrical conductivity are required. E-glass glass fiber is cheaper than other glass fibers. The amount of alumina contained in S-glass glass fiber is higher than E-glass. Its strength is 40% bigger than E-glass. In addition, S-glass can better maintain its mechanical, physical, and chemical properties even at high temperatures. If strength is the most important condition in advanced composite material, S-glass glass fiber should be used. The most important usage areas of quartz materials are parts such as antenna and radar, where low electrical properties are required. C-glass glass fiber is not used in aviation. When formulating composite materials, attention is paid to their mechanical and chemical properties. Tensile strength is significantly dependent on faults that may exist on the surface. Moisture has a negative effect on the strength of the glass fiber. As the temperature increases, the decrease in strength is much more evident in E-glass glass fiber compared to S-glass. The decrease in the module is almost the same for both types of glass fiber.

The advantages of composite materials formulated with glass fiber can be listed as corrosion protection, many binder elements not being used, low mold cost, and design flexibility. [7]

2.2. Methods

2.2.1. Regression Analysis

Regression analysis is a technique this is used to take a look at the purposeful relationship among two or more variables and forming a predictive modeling technique that investigates the connection. The regression approach is used to study modifications in the established variable with adjustments in the independent variables in different phrases this approach is used for estimating, finding, and modeling the causative results to the relationships among the variables. It has extensive applications in much subject research. In regression analysis, the independent variable represents the inputs make the changes in the dependent variable and the dependent variable represents the output based on the values of the independent variable.[8]

The regression technique can be categorized as two part. These are linear regression and nonlinear regression. While linear regression is used to investigate the linear relationship between independent and dependent variable, Non-linear regression is used to investigate the non-linear relationship among two or more variables [9].

The problem is first modeled by way of the use of the proper model. For modeling of the problem rational model, polynomial model, trigonometric model, logarithmic model, and many others may be select on. After the modeling operation, the coefficient of determination value (R^2) is calculated to peer how near the equipped version outcomes to the experimental statistics [10]. For that reason, it's miles crucial to boom R^2 value by changing model types or degrees of the model. However this is not which means that increasing the degree of the model usually will increase the R^2 value, can also decreases. The aim is to make R^2 value exceed 0.85 and the R^2 is calculated by means of using the following equation Equation 8 [11].

$$R^2 = 1 - \frac{SSE}{SST} \quad \text{(Equation 8)}$$

Equation 2 includes Sum of SquareErrors (SSE) and Total Sum of Squares (SST). So earlier than the calculation of R^2, the SSE and SST are calculated. Equation 9 and Equation 10 shown the method of these calculations.

$$\text{SSE} = \sum_{i=1}^{n}(fi - fi')^2 \quad \text{(Equation 9)}$$

$$\text{SST} = \sum_{i=1}^{n}(fi - \bar{f})^2 \quad \text{(Equation 10)}$$

In these formulations, f_i is the measured function value at the ith design point, f' is the function value calculated from the model at the ith design point, and $\bar{f}$ is the mean value of f_i.

$$R^2_{adjusted} = 1 - (1 - R^2)\frac{(n-1)}{(n-k-1)} \quad \text{(Equation 11)}$$

The increased R^2 value is not enough to recall good modeling. The main concept of the determination of R^2 value is identifying the physical phenomena as actual as feasible. Because of that, $R^2_{adjusted}$ (R^2_{adj}) needs to be calculated in order to test the suitability of the model and Equation 11 is used to calculate the R^2_{adj}.

2.2.2. Design of Experiment (DoE):

DOE (design of test) is a tool of data collection and analysis that can be utilized in experimental conditions and engineering problem-fixing. A strategically planned and performed experiment can provide a great deal of information about the effect on a response variable because of one or extra factors. There exist 3 aspects of DoE. These are; Factors, Levels and Response. Factors represent the inputs of the process, Levels represents the setting of the factors and Response represents the output of the system. The aim of this DoE takes a look at is amassing statistics for a selected study below the constraint of minimum expenditure of engineering runs, time, and money [12].

The design of experiment has a look at may be accomplished by way of the usage of alternative methods, which include; Box Banken, Taguchi, Genaral Factorial, D-Optimal, etc. By specifying all factors, levels and responses each method offers an exclusive variety of test situations.

2.2.3. Optimization

Optimization may be defined as making something the best as a whole lot as viable by using the use of any to be had assets. With optimization via the usage of the mathematical feature, outcomes can be maximized or minimized with recognize to the desired scenario, by way of changing with design parameters [13].

To make optimization research associated with a subject, first, we must have sure information set composed of parameters that's referred to as design variables. After that with recognition to regression analysis type the mathematical model that's referred to as ‘Objective Function’ of the problem has to be defined. After that, by using the objective function the problem can be minimized or maximized by optimization study. For the usage of optimization look at, there exist many methods which might be called as optimization algorithms.

2.2.3.1. Differential Evolution Algorithms (DE)

Differential Evolution is an iterative optimization method and it presents alternative answers for the complex machining problems that's primarily based on a genetic algorithm in phrases of its operation. The Differential Evolution Algorithms found by Price and Storn in 1995 [14]. The Differential Evolution is a populace-based totally derivative-free stochastic optimization method and the purpose is to analyze the best method to all of the constraints of the problem.

Differential Evolution algorithm considers a set of the solution instead of a single solution at each iteration. It is expensive in terms of calculation due to this. Using DE is efficient to find the global optimum of the objective function. However, it does not guarantee to find the global optima [13].

2.2.3.2. Nelder-Mead Algorithm (NM)

The Nelder-Mead set of rules is a derivative-free direct search optimization technique that's designed for unconstrained optimization issues and additionally called Simplex search. Nelder-Mead approach of optimization is broadly desired to solve statistical issues and making parameter estimation. It is appropriate for issues that don't have many local minimal. The adjustment of the NM alternatives is controlled through 4 basic parameters like the DE algorithm. They are reflection, expansion, contraction, and shrinkage. NM algorithms important specifications are sufficient results that can be obtained first few iterations.

In each iteration, the algorithm wishes one or two function evaluations and it's far clearly rare in practice because every evaluation is very steeply-priced or time-consuming. Besides this, NM has high flexibility in exploring complicated search areas [13].

2.2.3.3. Random Search Algorithm (RS)

The random search (RS) algorithm which can be known as the Monte Carlo method is based on the stochastic technique. RS method additionally referred to as clean to adopted to complicated problems. This method is an algorithm that achieves the optimum result depending on the number of iterations. The Random search method begins from a preliminary search point or set of points, to search for accepting random points inside the search area until it reaches the optimum result.

RS algorithm is possible to reach the global optimum for non-convex, non-differentiable objective functions including continuous, discrete domains or mixed of them for large scale problems [13].

2.2.4. Wolfram Mathematica

In present study the numerical procedures including regression and optimization studies were made by using ‘Wolfram Mathematica’ software.

Mathematical operations with mathematics, equations, integrals, matrices, arrays, functions, vectors may be made with a few simple Wolfram Language instructions. Wolfram Mathematica, with its capabilities in mathematics, provides answers in a completely brief time.

Wolfram Mathematica consists of the Wolfram Notebook report type, which has an .nb extension so that it will do any type of procedure or project, which includes mathematical operations. In this record type, you can write your commands into In cells and show the output of your codes in Out cells. The command that used inside the present study by using Mathematica, delivered below [15].

2.2.5. OpenRocket

The OpenRocket simulation software turned into originally evolved as the Master's thesis project of Sampo Niskanen, containing its written part "improvement of an Open supply model rocket simulation software" [16]. The thesis is used as the basis of this technical documentation, that is updated to account for later development within the software program.

This file often still refers to itself as a thesis, as no systematic updating of this truth has not been actualized. At the same time as the unique thesis is available online under a Creative Commons no derivatives license, this document is available a freer share-alike license. The present-day version of the technical documentation is to be had at the OpenRocket internet site,

http://openrocket.Sourceforge.Net/.

The software advanced as part of the thesis is the OpenRocket project [17]. It's an open-source rocket development and simulation surroundings written absolutely in Java. The program structure has been designed to make full use of object-oriented programming, permitting one to without difficulty expand its functions. The software program additionally consists of a framework for growing user-made listener additives that can concentrate on and have interaction with the simulation while it's running. These permits an effective and simple manner of interacting with the simulation and permits simulating as an example of a guidance system. One possible future enhancement that has also especially been considered at some point in the improvement is calculating the aerodynamic properties of the use of computational fluid dynamics (CFD). CFD calculates the exact airflow in a discretized mesh across the rocket. This will permit even more correct calculation of the aerodynamic forces for odd-shaped rockets, for which the techniques explained herein do no longer absolutely perform. It's far anticipated that the software program will allow extra hobbyists the possibility of simulating their rocket designs prior to constructing them and experimenting with a one-of-a-kind configuration, therefore giving them deeper know-how of the aerodynamics of rocket flight. It will additionally offer a more versatile academic tool because the simulation strategies are open and all people could be capable of "look under the hood" and see how the software carries out the calculations.

2.2.6. Weighted Decision Matrix

A decision matrix is a technique of evaluating competing principles by way of ranking the design criteria with weighting factors and scoring the point to which each design concept meets the criterion. To do this it's far necessary to transform the values acquired for distinctive design criteria into a consequent set of values. The easiest manner of managing design standards expressed in an expansion of approaches is to apply a point scale. A 5-point scale is used when the instructions about the standards are not very detailed. An 11-point scale (0–10) is used when the information is extra detailed (Table 2.1). It is first-class if several informed people beings participate on this evaluation.

Table 2.1 Evaluation Scheme for Design Altrenatives or Objects

Evaluation Scheme for Design Alternatives or Objectives

11-point Scale	Description	5-point Scale	Description
0	Totally useless solution	0	Inadequate
1	Very inadequate solution		
2	Weak solution	1	Weak
3	Poor solution		
4	Tolerable solution		
5	Satisfactory solution	2	Satisfactory
6	Good solution with a few drawbacks		
7	Good solution	3	Good
8	Very good solution		
9	Excellent (exceeds the requirement)	4	Excellent
10	Ideal solution		

Identification weighting factors for criteria is an inexact manner. Intuitively we understand that a valid set of weighting factors has to sum to 1. Consequently, when n is the number of assessment standards and w is the weighting element,

$$\sum_{i=1}^{n} w_i = 1.0 \quad \text{and} \quad 0 \leq w_i \leq 1 \qquad \text{(Equation 12)}$$

Systematic methods can be followed for determining weighting factors. Three are listed below.

● Direct Assignment: The group makes a decision on how to assign 100 points between the distinct criteria in step with their significance. Dividing every criterion's score through 100 normalizes the weights. This method is most effective for design groups in which there are numerous years of practice in designing an identical product line.

● Objective Tree: Weighting factors may be determined via the use of a hierarchical goal. Higher decisions regarding alternatives might be made when the comparisons are made on the same level within the hierarchy because you will be comparing "apples with apples and oranges with oranges". Again, this approach is predicated on a few experiences with the significance of the criteria in the design process.

● Analytic Hierarchy Process (AHP): AHP is the least arbitrary method for determining weighting factors.[18]

Chapter 3: Experiments & Data Collection

3.1. Problem Definition

Optimization means improving the performance of a system, process, or product to get the maximum help from the system. For this purpose, the data obtained by using the mathematical program and experimental methods, optimization process in this thesis has been realized. In this thesis, the aim is to determine the model rocket sizes suitable for the desired reference values by optimization method. The effects of the data obtained as a result of optimization on the flight profile were investigated. The determined results are stated in Chapter 4.

3.1.1. Determination of Ouputs

The values in Teknofest mid-altitude rocket competition are based on for determining the outputs. These restrictions are as follows:

• Ground hit velocity 9 m / s,

• Velocity off rod 25 m / s,

• Maximum Altitude being the closest value to 3000 meters (2400m -3600m, 20% tolerance range)

• Maksimum speed is 270 m / s (0.8 Mach number),

• Stability value is between 1.5 and 3.

Thus, the 5 outputs that will be used in optimization are determined as the rocket's ground hit velocity with the main parachute effect, the rocket's velocity off rod from the ramp, the apogee of the rocket, the maximum velocity that the rocket can reach throughout the flight, and the average stability value throughout the flight.

3.2. Data Collection

In the rocket flight profile, as mentioned in the literature section, there are many factors that affect the rocket's flight characteristics. Therefore, the parameters to be examined were determined and other parameters were kept constant. System parameters to be examined on the effects of flight features are given in 3.2.2.

3.2.1. Motor Selection

In order to select the motor suitable for the required thrust force, the rocket's rough weight calculation had to be made. In order to calculate the weight, firstly, the average size of the motor bearing suitable for the medium altitude engines in the catalog was calculated, and it was found to be 100cm. Considering the parts to be placed in the middle body length (payload, payload gps, payload parachute, two separation mechanisms, main parachute, drift parachute, avionic system, shock cords), the length was found about 120 cm for the required space in the middle body For the nose (the source of the quote in the wiki will be written), the nose type power series that was most suitable for the speed of the rocket (0.8 mach) was chosen. Then, the CAD drawing of the outer body was made in SolidWorks and Fiberglass was assigned, which we would use as a material. With the help of Solidworks program tools, the outer body weight of the rocket was approximately 11 kg. As a result of adding the parts and the motor to be placed inside, the total weight was found to be 20kg. The motor with the thrust that matches the estimated weight of the rocket was chosen from the catalog (M1675).

3.2.1.1. Backup Motor Selection

For the selection of the spare engine, it was decided by placing the other engines on the sample draft rocket and analyzing them on OpenRocket. The M2020 was chosen as the backup engine, taking into account the OpenRocket results, engine diameters, thrust time and total thrust.

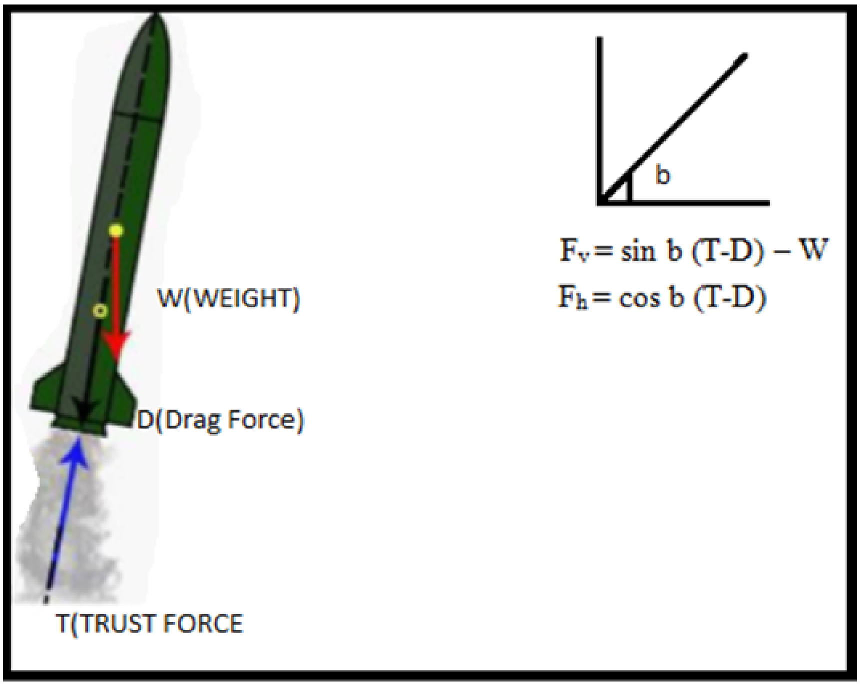


Figure 3.1 Forces acting on rocket

3.2.2. Determining the Inputs

Firstly, it was decided to determine the rocket diameter. When determining this, the diameter of the two engines selected was taken into account.

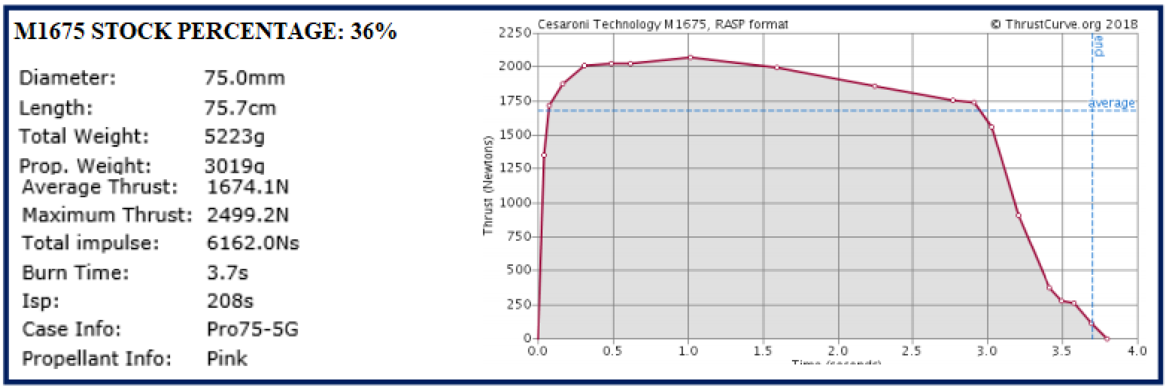


Figure 3.2 Main motor properties

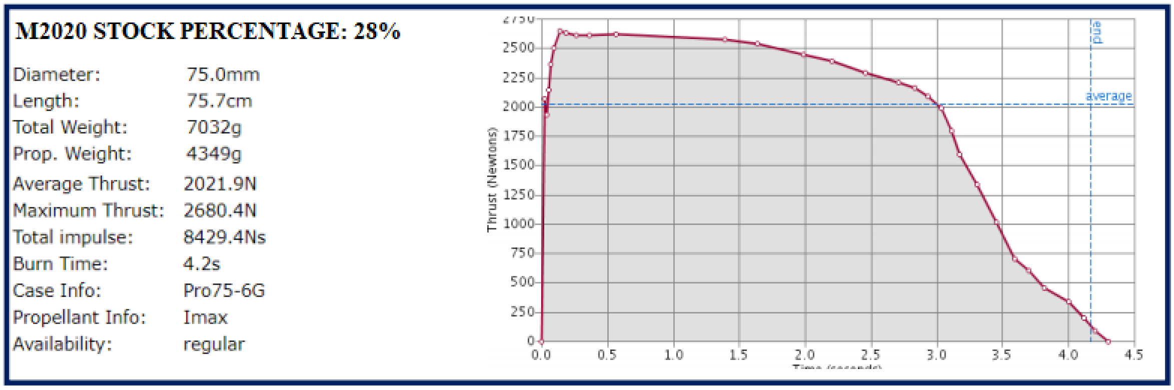


Figure 3.3 Backup motor properties

As can be seen in the figures, both motor diameters are the same. Considering the motor bearing system suitable for 75.0mm motor diameter, and the parts to be placed inside (especially the electronic system and payload that cannot be easily changed in diameter), the ideal rocket diameter was determined as 120mm.

In order to determine the inputs affecting the output values, a sample rocket design with this diameter was made in the OpenRocket application. Model rockets made in this category were taken into consideration when deciding the values for the sample design.

Accordingly, it was decided that the model size of the sample design was 100 cm in length, 22.5 cm in length, and the power variable chosen for the nose type was 0.5. For the wall thicknesses; nose and middle body wall thickness is 0.6cm, fin wall thickness is 0.55cm, and motor body wall thickness is decided as 0.65cm for easy assembly of bulkheads to be used for motor fixing.

In our variables as mass, the total weight of the engine system was decided to be approximately 2200gr. It was decided that the weight of the payload that will be separated from the rocket system with the separation system at the maximum altitude is 4500gr with the GPS to be mounted and its own parachute. Then the bottom length was determined as 25cm, the top length as 15cm and the height as 12 cm for the shape of the fin. The position of the fin is estimated at -5 cm, and it was decided to start 5 cm from the bottom surface of the rocket. The horizontal difference between the bottom surface and the top surface for the fin position was determined as 0cm for the start.

In addition to these, 4 of our rocket position variables were determined.These are,

- Payload position
- Avionic system location
- Main parachute position
- Drift parachute location

After the OpenRocket trial tests, these four location variables were determined to change only Stability of the outputs and removed from the input list to be used for optimization.

Table 3.1 Inputs values of first try

1	Nose length	22.5cm
2	Nose wall thickness	0.6cm
3	Power variable	0.5cm
4	Middle body lenght	100cm
5	Middle body wall thickness	0.6cm
6	Payload weight	4500gr
7	Motor body wall thickness	0.65cm
8	Motor body weight	2200gr
9	Fin wall thickness	0.55cm
10	Fin location	0cm
11	Fin bottom edge length	25cm
12	Fin top edge length	15cm
13	Fin height	12cm
14	Fin position	-5cm

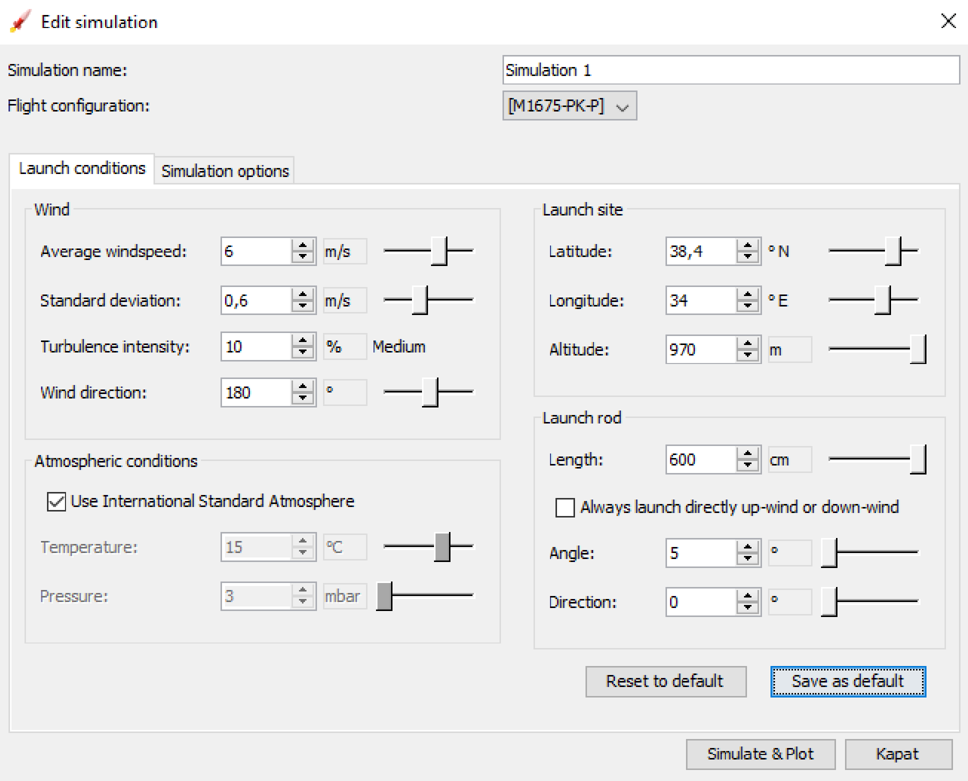


Figure 3.4 Screenshot of used surroundings properties from OpenRocket

When the data was entered into OpenRocket and the flight was analyzed, it was observed that only the altitude was not within the desired range of the outputs obtained. Optimization process will be started to ensure that all of these values are within the desired value ranges.

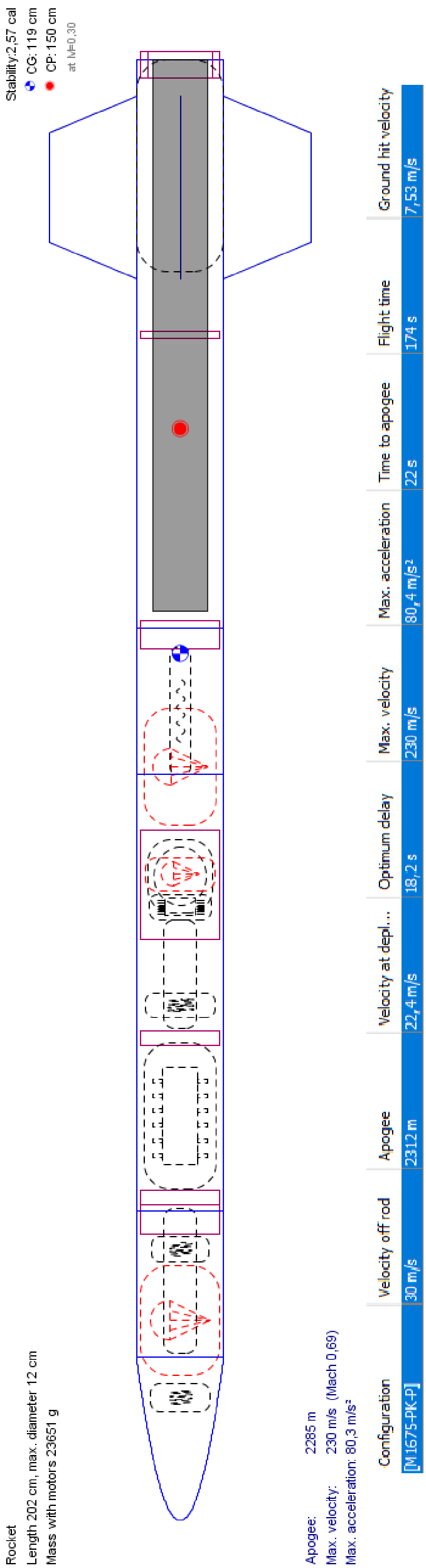


Figure 3.5 Screenshot of result of first try from OpenRocket

Before using the Design of Experiment application, which is the first step for optimization, there are two things that we need to determine before we can use this application, they are a importance index for each input and maximum and minimum values depending on this importance index, and if necessary, medium values.

3.2.2.1. Determining the Importance Indexes of Inputs

While determining importance indexes of the inputs, the A 5-Point scale technique in the 'Weighted Decision Matrix' method was used. While determining the importance index, the effect of inputs on the outputs was taken into consideration.

Accordingly, their degree of importance;

Table 3.2 Importance index of inputs

1	Nose length	3
2	Nose wall thickness	2
3	Power variable	3
4	Middle body lenght	2
5	Middle body wall thickness	3
6	Payload weight	2
7	Motor body wall thickness	3
8	Motor body weight	2
9	Fin wall thickness	2
10	Fin location	3
11	Fin bottom edge length	3
12	Fin top edge length	3
13	Fin height	3
14	Fin position	3

3.2.2.2. Determining the Limits of Inputs

While determining the maximum and minimum values of the inputs, the previous test values and whether the outputs obtained under these values are within the desired limits, in addition, it was assessed whether the rocket’s flight profile has damaged or not. In addition, another main factor is manufacturability for this part.

3.2.3. Design of Experiment

With the Design of Experiment 12 application, it was learned how many trials should be made using which values. For this, respectively,

A new design was created and D-Optimal was chosen.

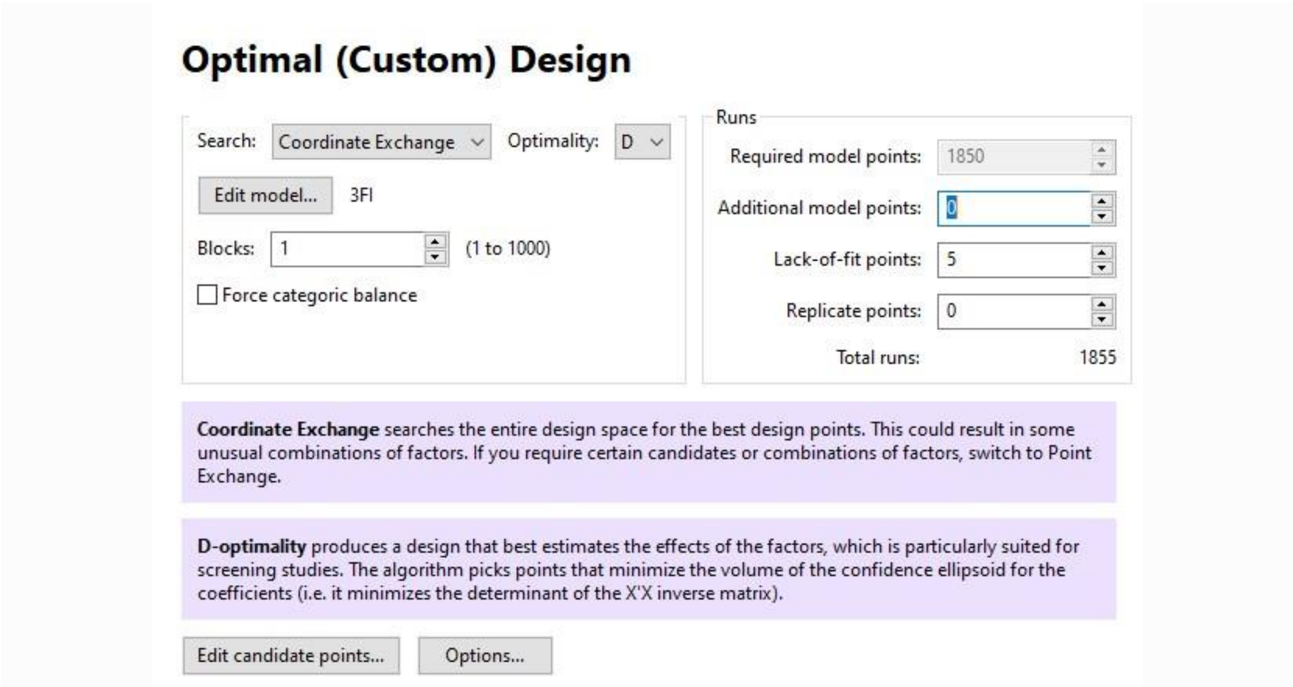


Figure 3.6 Screenshot of design type selection step from Design of Experiment

Covering arrays detect interactions among factors by providing that every combination of levels for at most t factors is tested in at least one run (the strength t is the maximum number of interacting factors examined). In addition D-optimal designs provide orthogonality rather than just coverage. Because of this, D-optimal designs lend themselves to measurement of interactions, while covering arrays may alias some of the interactions of strength at most t. This lack of estimation capability leads to a significant difference in the number of runs, with Designs D-premier for energy t entailing ways more runs for electricity t that does a masking array. [19]

Then the number of inputs was entered as categoric factor. Importance levels of each input are given. The importance level was determined as 3 for 9 inputs and 2 for the other 5 inputs.

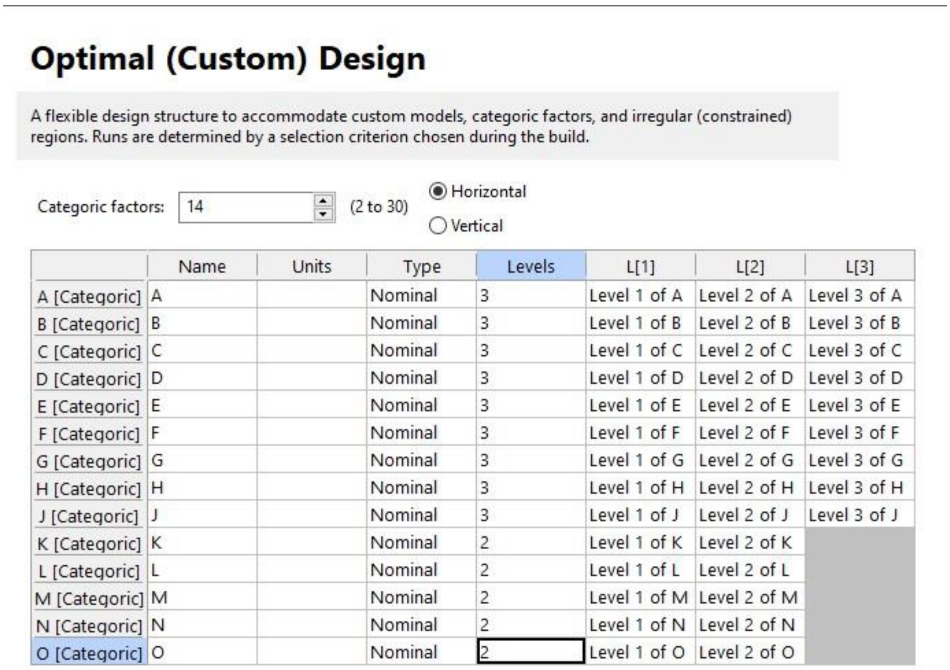


Figure 3.7 Screenshot of input enterance page from Design of Experiment

Then output number was entered.

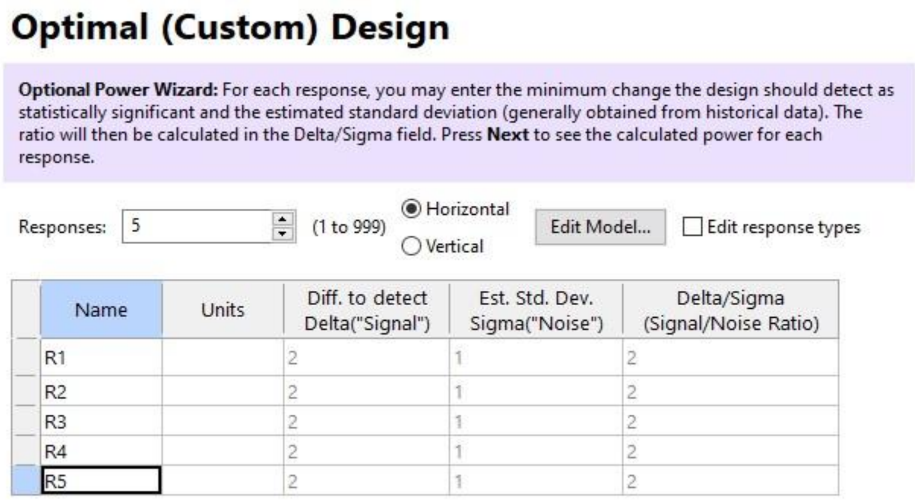
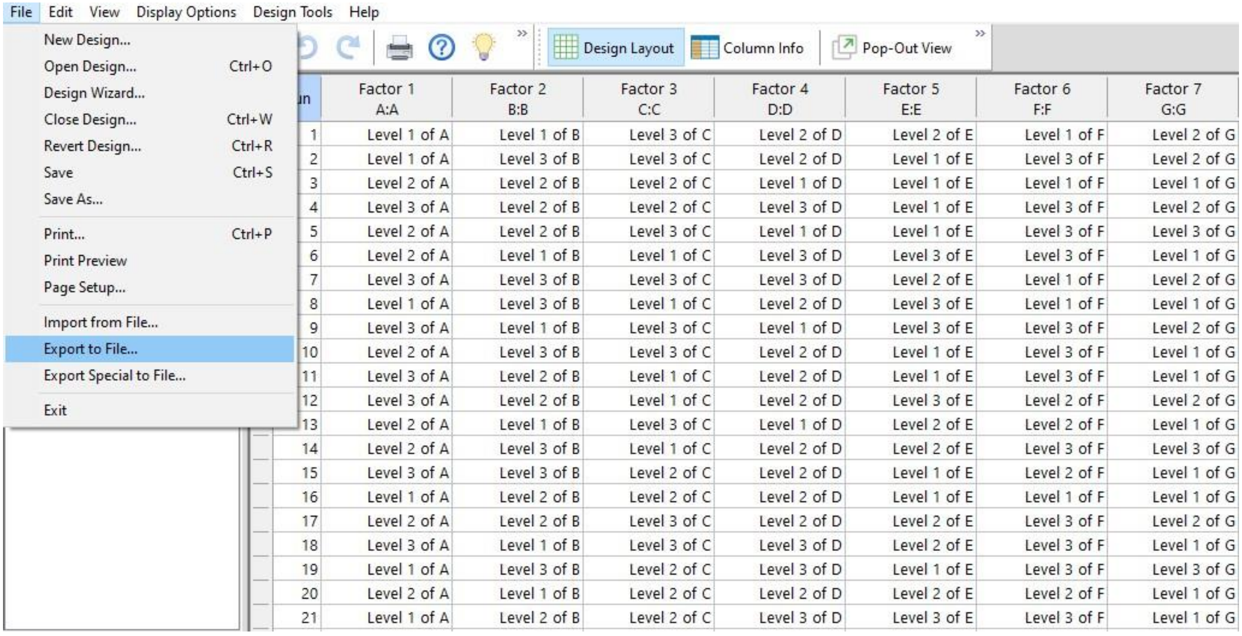


Figure 3.8 Screenshot of output enterance page from Design of Experiment

A table with 505 rows was obtained and exported as an excel file.



un	Factor 1 A:A	Factor 2 B:B	Factor 3 C:C	Factor 4 D:D	Factor 5 E:E	Factor 6 F:F	Factor 7 G:G
1	Level 1 of A	Level 1 of B	Level 3 of C	Level 2 of D	Level 2 of E	Level 1 of F	Level 2 of G
2	Level 1 of A	Level 3 of B	Level 3 of C	Level 2 of D	Level 1 of E	Level 3 of F	Level 2 of G
3	Level 2 of A	Level 2 of B	Level 2 of C	Level 1 of D	Level 1 of E	Level 1 of F	Level 1 of G
4	Level 3 of A	Level 2 of B	Level 2 of C	Level 3 of D	Level 1 of E	Level 3 of F	Level 2 of G
5	Level 2 of A	Level 2 of B	Level 3 of C	Level 1 of D	Level 1 of E	Level 3 of F	Level 3 of G
6	Level 2 of A	Level 1 of B	Level 1 of C	Level 3 of D	Level 3 of E	Level 3 of F	Level 1 of G
7	Level 3 of A	Level 3 of B	Level 3 of C	Level 3 of D	Level 2 of E	Level 1 of F	Level 2 of G
8	Level 1 of A	Level 3 of B	Level 1 of C	Level 2 of D	Level 3 of E	Level 1 of F	Level 1 of G
9	Level 3 of A	Level 1 of B	Level 3 of C	Level 1 of D	Level 3 of E	Level 3 of F	Level 2 of G
10	Level 2 of A	Level 3 of B	Level 3 of C	Level 2 of D	Level 1 of E	Level 3 of F	Level 1 of G
11	Level 3 of A	Level 2 of B	Level 1 of C	Level 2 of D	Level 1 of E	Level 3 of F	Level 1 of G
12	Level 3 of A	Level 2 of B	Level 1 of C	Level 2 of D	Level 3 of E	Level 2 of F	Level 2 of G
13	Level 2 of A	Level 1 of B	Level 3 of C	Level 1 of D	Level 2 of E	Level 2 of F	Level 1 of G
14	Level 2 of A	Level 3 of B	Level 1 of C	Level 2 of D	Level 2 of E	Level 3 of F	Level 3 of G
15	Level 3 of A	Level 3 of B	Level 2 of C	Level 2 of D	Level 1 of E	Level 2 of F	Level 1 of G
16	Level 1 of A	Level 2 of B	Level 2 of C	Level 2 of D	Level 1 of E	Level 1 of F	Level 1 of G
17	Level 2 of A	Level 2 of B	Level 3 of C	Level 2 of D	Level 2 of E	Level 3 of F	Level 2 of G
18	Level 3 of A	Level 1 of B	Level 3 of C	Level 3 of D	Level 2 of E	Level 3 of F	Level 1 of G
19	Level 1 of A	Level 3 of B	Level 2 of C	Level 3 of D	Level 1 of E	Level 3 of F	Level 3 of G
20	Level 2 of A	Level 1 of B	Level 2 of C	Level 2 of D	Level 2 of E	Level 2 of F	Level 1 of G
21	Level 1 of A	Level 2 of B	Level 2 of C	Level 3 of D	Level 3 of E	Level 3 of F	Level 1 of G

Figure 3.9 Screenshot of obtained table from Design of Experiment

Table 3.3 Input names of obtained table from Design of Experiment

A	Nose length
B	Nose wall thickness
C	Power variable
D	Middle body lenght
E	Middle body wall thickness
F	Payload weight
G	Motor body wall thickness
H	Total weight of the engine system
I	Fin location
J	Fin wall thickness
K	Fin bottom edge length
L	Fin top edge length
M	Fin height
N	Fin position

Then all values are written instead. For Excel values, the level3 value, which is shown in table 3.4, has been written instead of level 2.

Table 3.4 Input levels and level values

	Input name	Level 1	Level 2	Level 3
1	Nose length (cm)	10	22.5	35
2	Nose wall thickness (cm)	0.2	--------	1
3	Power variable	0.3	0.5	0.7
4	Middle body lenght (cm)	75	--------	120
5	Middle body wall thickness (cm)	0.2	0.6	1
6	Payload weight (gr)	4000	--------	5000
7	Motor body wall thickness (cm)	0.3	0.65	1
8	Total weight of the engine system (gr)	1500	--------	3000
9	Fin wall thickness (cm)	0.4	--------	0.7
10	Fin location (cm)	-10	0	10
11	Fin bottom edge length (cm)	10	25	40
12	Fin top edge length (cm)	0	15	30
13	Fin height (cm)	9	12	15
14	Fin position (cm)	-10	-5	0

And the final data table was obtained (Figure 3.10) and trials were started.

Figure 3.10 Screenshot of part of final data table from Excel

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1		Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12	Factor 13	Factor 14
2	Run	A:BU	B:BEK	H:PD	D:OGU	E:OGEK	F:FYA	K:MGEK	C:MSTA	J:KK	G:KEK	L:KAU	M:KÜU	N:KY	O:KP
3		3 Level	2 Level	3 Level	2 Level	3 Level	2 Level	3 Level	2 Level	3 Level	2 Level	3 Level	3 Level	3 Level	3 Level
4															
5	1	35	1	0,3	120	0,6	4000	1	1500	10	0,4	25	0	9	-5
6	2	35	0,2	0,7	75	1	5000	0,65	3000	10	0,4	40	0	15	-5
7	3	10	0,2	0,5	75	1	5000	0,3	3000	10	0,7	25	0	15	-10
8	4	35	1	0,7	120	0,2	5000	0,3	1500	10	0,4	40	15	9	-10
9	5	10	1	0,5	75	0,6	4000	1	1500	0	0,7	25	0	9	0
10	6	10	0,2	0,7	75	0,6	5000	1	1500	-10	0,7	25	15	12	-10
11	7	22,5	0,2	0,3	75	0,2	5000	1	1500	0	0,7	40	15	15	-5
12	8	35	1	0,3	75	0,6	5000	1	3000	-10	0,4	25	0	12	-10
13	9	10	1	0,7	75	1	5000	0,65	3000	10	0,4	25	0	12	-5
14	10	10	1	0,7	120	0,2	4000	1	1500	-10	0,4	10	15	9	0
15	11	35	1	0,5	120	0,6	4000	0,3	3000	-10	0,7	40	0	15	0
16	12	35	1	0,5	120	0,6	4000	0,3	1500	0	0,4	40	30	15	-10
17	13	35	1	0,7	120	0,6	5000	1	1500	0	0,7	25	15	12	0
18	14	22,5	1	0,3	75	1	5000	0,65	3000	-10	0,7	10	0	12	-10
19	15	22,5	0,2	0,5	75	0,6	4000	0,3	3000	10	0,7	25	30	12	-10
20	16	35	1	0,3	120	0,6	5000	0,65	3000	0	0,7	25	15	9	-5
21	17	35	1	0,3	120	1	5000	0,65	3000	10	0,7	40	0	9	0
22	18	10	1	0,3	75	0,6	4000	1	3000	0	0,4	40	15	15	-10
23	19	10	1	0,7	120	0,6	4000	0,65	1500	0	0,7	40	0	9	-5
24	20	35	1	0,5	75	0,6	4000	0,65	3000	0	0,7	10	30	12	-5

3.2.4. OpenRocket Tries

The 505 trial data series obtained with the Design of Experiment program was tested on the OpenRocket with the help of the bot system. And the outputs of all trials were recorded for use in optimization. And an excel file with input-ouput values was created and shown in Appendix A – 1.

The experimental part of this study was completed with the acquisition of data. In the numerical section, these steps are defined as follows:

1. Define the Objective Function, Design Variables and Constraints

2. Modeling of the problem

3. Optimization

First, regression analysis was performed. The data in this analysis were obtained from the experimental study. In regression analysis, the Objective Function, Design Variables and Constraints of this study are given in Table 3.5.

Table 3.5 Objective Function, Design Variables and Constraints of the process

Objective Function	Closest value to 3000m AP
Design Variables	BU, BEK, PD, OGU, OGEK, FYA, MGEK, MSTA, KK, KEK, KAU, KÜU, KY, KP
Constraints	GHV < 9 m / s, VOR > 25 m / s, 2400m < AP < 3600m MV < 272 m/s 1.5 < ST < 3

The R^2 and R^2_{adj} values were calculated for each model. Then models with a value above 0.85 were selected . The next phase of study started with appropriate model. The all of the data obtained up to this step was used for modeling.

3.2.5. Models

Second Order Multiple Non-Linear (SON) general formula is given Appendix A-2 and Third Order Multiple Non-Linear (TON) general formula is given Appendix A-3.

At this point, % 80 of the obtained data selected spontaneously. Using stochasticly chosen datas, a training model is occured and $R^2_{training}$ value is calculated for this model. After that, %20 datas is applied in training model and outputs calculated.

%20 of the datas which is calculated by training model and outputs of orginal data and correlation between them and the coeffcient of determination value between these outputs is named as $R^2_{testing}$. The main objective is obtain $R^2_{testing}$ value as high as posible. This numerical method called as neuro regression. The higher $R^2_{testing}$ value examine that the model created using a certain part of the data for the same problem provides physical phenomena for the remaining data.

Chapter 4: Results And Discussion

In this thesis, a try on OpenRocket was performed for each of the 505 scenarios that obtained as a result of the design of experiment study. In order to increase the accuracy of the data, it was more logical to do these try by a macro program. Thus, the human error rate is minimized in the processing of the data into the program. However, a few randomly selected scenarios were repeated for check the values.

Table 4.1 Datas of Experiment 80

Try	80
[BU]	10
[BEK]	1
[PD]	0.5
[OGU]	75
[OGEK]	1
[FYA]	5000
[MGEK]	1
[MSTA]	3000
[KK]	-10
[KEK]	0.7
[KAU]	25
[KÜU]	15
[KY]	15
[KP]	0

Table 4.2 Results of Experiment 80

Try	80
Velocity Off Rod	28.3
Apogee	1855
Maximum Velocity	196
Ground Hit Velocity	9.61
Stability	2.24

Table 4.3 Datas of Experiment 108

Try	108
[BU]	35
[BEK]	0.2
[PD]	0.7
[OGU]	75
[OGEK]	0.2
[FYA]	5000
[MGEK]	0.3
[MSTA]	1500
[KK]	10
[KEK]	0.4
[KAU]	25
[KÜU]	0
[KY]	12
[KP]	0

Table 4.4 Results of Experiment 80

Try	108
Velocity Off Rod	36.6
Apogee	3593
Maximum Velocity	336
Ground Hit Velocity	7
Stability	2.01

Table 4.5 Datas of Experiment 456

Try	456
[BU]	10
[BEK]	1
[PD]	0.5
[OGU]	75
[OGEK]	0.6
[FYA]	5000
[MGEK]	0.65
[MSTA]	1500
[KK]	10
[KEK]	0.4
[KAU]	40
[KÜU]	0
[KY]	12
[KP]	-10

Table 4.6 Results of Experiment 456

Try	456
Velocity Off Rod	32.8
Apogee	2979
Maximum Velocity	268
Ground Hit Velocity	8.27
Stability	1.19

These trials repeated for the check, and same values found again.

4.1. Modelling

Regression models can be used to define the phenomena. In this context, many different regression models have created for VOR, AP, MV, GHV, and ST. Among the created models, the ones with greater R^2, $R^2_{adjusted}$, $R^2_{training}$ and $R^2_{testing}$ values, were selected for identification of the system more appropriately (Table 4.7).

Table 4.7 Model types and coefficient and determination values for outputs

Outputs	Model	$R^2_{training}$	$R^2_{testing}$
VOR	SON	0.9999541	0.9890273
AP	TON	0.9999998	0.9999998
MV	SON	0.9997208	0.9858698
GHV	SON	0.9958873	0.9996981
ST	SON	0.9948837	0.9813841

4.1.1. Modelling of VOR

Regression model used for VOR (SON) is given Appendix A-4.

The second order multiple non-linear model was chosen to describe the physical phenomena at the output for VOR (velocity off rod) value.

4.1.2. Modelling of AP

Regression model used for AP (TON) is given Appendix A-5.

The third order multiple non-linear model was chosen to describe the physical phenomena at the output for AP (apogee) value.

4.1.3. Modelling of MV

Regression model used for MV (SON) is given Appendix A-6.

The second order multiple non-linear model was chosen to describe the physical phenomena at the output for MV (maximum velocity) value.

4.1.4. Modelling of GHV

Regression model used for GHV (SON) is given Appendix A-7.

The second order multiple non-linear model was chosen to describe the physical phenomena at the output for GHV (ground hit velocity) value.

4.1.5. Modelling of ST

Regression model used for ST (SON) is given Appendix A-8.

The second order multiple non-linear model was chosen to describe the physical phenomena at the output for ST (stability) value.

4.2. Optimization

In this study, the optimization operation has done for 5 different parameters in order to find the optimum design parameters of the model rocket to provide the constraints. The optimization process is systematically and sequentially performed as mentioned in the method section. The optimization process was done separately for the problems specified in the problem definition section. And all of the constraints provided.

After optimization operation, the input values found as ;

- BEK – 0.975 mm
- BU – 10 cm
- FYA – 4858 gram
- KAU – 19.4 cm
- KEK – 0.402 cm
- KK – 8.577 cm
- KP – -7.92 cm
- KÜU – 10.493
- KY – 9
- MGEK – 0.8
- MSTA – 1500
- OGEK – 0.602
- OGU – 107
- PD – 0.521

Output values for given input values;

- Apogee = 2697m
- Maximum Velocity = 246 m/s
- Ground Hit Velocity = 7.28 m/s
- Velocity Off Rod = 30.9 m/s
- Stability = 1.88

Chapter 5: Conclusion

In this study, the effects of nose length,nose wall thickness, nose type variable, body lenghts and thichness, payload weight, fin thichness, geometry and fin location on fligt properties were investigated. All parameters were kept constant except for these 14 parameters. The data used in the study were obtained as a result of experiments formed by using design of experiment study. By giving different values to the rocket parameters, the flight profile was obtained under stable weather conditions. As a result, it was observed that 14 inputs affect 5 outputs.

In addition, it has been observed that the increase in wall thicknesses and weights decrease altitude, decrease the velocity off rod, decrease the maximum velocity but increase the velocity of hitting the ground.

This study also proposed that different regression models can identify the engineering problem and suggested that it can also be used to obtain flight profile.

In addition to multiple regression analysis, neuro regression was applied to enrich the study. The data were divided into as training and testing data. By using trainnig data training model was created. Then, the testing data were put in the training model and R^2 values were calculated. In the engineering approach, when R^2 values are greater than 0.85, the results are suitable for real-life applications. Modeling results indicate that more than one regression model can define an engineering problem. When R^2 is less than 0.85, we can say that this model is not sufficient to describe the engineering problem. At this point, the model is needed to change. The same procedure were made for GHV, VOR , AP, MV, ST values, then appropriate models were selected.

As a result of this study, it has been observed that the values in the flight profile can be brought to the desired range under suitable conditions. Based on the sample flight profile, altitude increased by 25%. With this increase, other values remained intact and remained within the desired range. It should be noted that the results of this study are obtained under certain weather conditions. For this reason, it should be known that the changes in the weather conditions and the materials to be used may differ in the results.

APPENDICES

A–1 All data table with inputs and outputs

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12	Factor 13	Factor 14	Response 1	Response 2	Response 3	Response 4	Response 5
Run	A:BU	B:BEK	H:PD	D:OGU	E:OGEK	F:FYA	K:MGEK	C:MSTA	J:KK	G:KEK	L:KAU	M:KÜU	N:KY	O:KP	VOR	AP	MV	GHV	ST
1	35	1	0,3	120	0,6	4000	1	1500	10	0,4	25	0	9	-5	30,3	2402	229	8,97	1,58
2	35	0,2	0,7	75	1	5000	0,65	3000	10	0,4	40	0	15	-5	29,9	2369	226	9,02	2,01
3	10	0,2	0,5	75	1	5000	0,3	3000	10	0,7	25	0	15	-10	31	2542	245	8,63	2,34
4	35	1	0,7	120	0,2	5000	0,3	1500	10	0,4	40	15	9	-10	34,2	3227	299	7,74	1,28
5	10	1	0,5	75	0,6	4000	1	1500	0	0,7	25	0	9	0	32,1	2838	261	8,35	1,03
6	10	0,2	0,7	75	0,6	5000	1	1500	-10	0,7	25	15	12	-10	31,1	2365	237	8,73	0,88
7	22,5	0,2	0,3	75	0,2	5000	1	1500	0	0,7	40	15	15	-5	31	2256	239	8,63	0,87
8	35	1	0,3	75	0,6	5000	1	3000	-10	0,4	25	0	12	-10	29,8	2168	218	9,2	1,15
9	10	1	0,7	75	1	5000	0,65	3000	10	0,4	25	0	12	-5	29,9	2522	233	8,94	2,16
10	10	1	0,7	120	0,2	4000	1	1500	-10	0,4	10	15	9	0	33,4	3117	285	7,96	0,96
11	35	1	0,5	120	0,6	4000	0,3	3000	-10	0,7	40	0	15	0	30	2173	228	8,93	3,16
12	35	1	0,5	120	0,6	4000	0,3	1500	0	0,4	40	30	15	-10	31,5	2383	244	8,57	3,04
13	35	1	0,7	120	0,6	5000	1	1500	0	0,7	25	15	12	0	29,1	1999	207	9,36	3,21
14	22,5	1	0,3	75	1	5000	0,65	3000	-10	0,7	10	0	12	-10	29,9	2133	222	9,06	1,13
15	22,5	0,2	0,5	75	0,6	4000	0,3	3000	10	0,7	25	30	12	-10	32,8	2604	261	8,26	1,35
16	35	1	0,3	120	0,6	5000	0,65	3000	0	0,7	25	15	9	-5	28,6	2038	209	9,39	1,77
17	35	1	0,3	120	1	5000	0,65	3000	10	0,7	40	0	9	0	27,1	1813	187	9,91	1,94
18	10	1	0,3	75	0,6	4000	1	3000	0	0,4	40	15	15	-10	30,5	2112	224	8,94	1
19	10	1	0,7	120	0,6	4000	0,65	1500	0	0,7	40	0	9	-5	31,9	2703	253	8,53	1,1
20	35	1	0,5	75	0,6	4000	0,65	3000	0	0,7	10	30	12	-5	30,8	2405	236	8,82	2,25
21	10	0,2	0,3	75	0,6	5000	0,65	3000	-10	0,7	25	0	15	-5	31,1	2061	235	8,67	1,73
22	10	1	0,5	75	1	4000	0,65	1500	-10	0,4	40	15	15	-10	31,1	2429	242	8,62	1,32
23	35	0,2	0,5	120	0,6	5000	1	1500	10	0,4	40	15	12	-5	29,5	2314	222	9,14	2,21
24	10	1	0,5	120	0,6	5000	0,3	1500	0	0,4	10	15	9	-5	32,8	2885	272	8,15	2,83
25	35	0,2	0,3	120	0,2	4000	0,3	1500	10	0,7	10	15	9	-5	36,8	3062	326	7,2	1,46
26	22,5	1	0,7	120	1	5000	0,65	1500	0	0,7	40	15	12	-10	27,9	1902	195	9,66	2,44
27	22,5	1	0,5	75	0,2	5000	1	3000	10	0,4	10	0	15	-5	32	2721	254	8,56	1,79
28	35	1	0,5	120	0,2	5000	0,65	3000	-10	0,7	10	15	12	-5	31,5	2537	247	8,58	2,43
29	22,5	0,2	0,5	75	1	4000	1	3000	-10	0,7	40	0	9	-10	29,7	661	201	9,17	-0,4
30	10	0,2	0,3	75	1	4000	1	1500	0	0,7	25	15	9	-5	30,5	2178	230	8,8	0,91
31	22,5	1	0,3	120	1	5000	0,3	1500	-10	0,7	10	15	12	0	29,5	2148	219	9,1	4,21
32	22,5	0,2	0,5	75	0,6	5000	1	3000	-10	0,7	10	15	15	0	30	2251	224	9	2,34
33	35	1	0,7	120	1	5000	0,65	1500	10	0,7	25	30	12	-5	27,4	1819	191	9,8	3,62
34	35	0,2	0,7	75	0,6	4000	1	1500	-10	0,4	40	30	15	-5	30,8	2386	240	8,65	0,87
35	35	1	0,3	120	0,2	4000	0,65	1500	10	0,7	40	0	15	-5	32,5	2554	259	8,31	2,71
36	10	0,2	0,5	75	0,2	5000	1	3000	-10	0,4	25	0	12	-5	32	2730	259	8,36	0,777
37	10	0,2	0,5	120	1	4000	0,65	3000	-10	0,7	40	15	12	0	28,2	1847	195	9,63	2,17
38	10	0,2	0,7	75	0,2	5000	0,65	1500	0	0,4	40	30	15	-10	32,9	2699	275	8,01	0,73
39	35	0,2	0,3	75	0,6	4000	0,65	1500	0	0,4	25	30	9	-5	33,8	2799	277	8	0,56
40	35	1	0,5	75	0,6	5000	0,65	1500	0	0,7	10	0	15	-5	31,9	2439	253	8,38	2,62
41	10	0,2	0,7	75	0,2	5000	0,3	1500	-10	0,4	10	15	15	0	36,7	3225	326	7,21	2,58
42	22,5	1	0,3	120	0,2	5000	0,65	1500	0	0,7	10	0	9	-5	33,5	2683	278	7,92	1,12
43	10	0,2	0,7	120	0,2	5000	1	3000	10	0,7	25	30	12	0	30,6	2238	227	8,92	2,05
44	10	1	0,7	75	0,2	4000	0,65	3000	-10	0,7	40	30	12	-10	31,7	511	163	22,7	-0,27
45	35	1	0,3	75	0,2	5000	0,3	3000	-10	0,7	10	15	15	-10	32,9	2574	266	8,18	2,13
46	22,5	0,2	0,7	75	0,2	5000	0,3	3000	10	0,4	10	30	15	0	34,1	2890	292	7,72	3,1
47	22,5	0,2	0,5	120	0,6	5000	0,3	3000	0	0,7	25	15	12	-5	31	2303	235	8,79	2,8
48	10	0,2	0,7	75	0,2	4000	1	3000	0	0,7	40	15	9	0	31,7	504	156	22,7	-0,25
49	35	1	0,5	120	1	4000	1	1500	-10	0,7	10	30	15	-10	27,4	1796	187	9,88	3,52
50	10	0,2	0,7	75	1	5000	0,65	1500	-10	0,7	25	0	9	0	31,5	2542	248	8,58	1,13
51	22,5	1	0,3	75	0,2	5000	1	1500	-10	0,4	40	30	15	-10	31	2276	239	8,63	0,56
52	35	1	0,7	120	0,2	5000	1	1500	0	0,4	10	0	12	-10	32,2	2725	260	8,32	1,85
53	35	0,2	0,5	120	0,6	4000	1	1500	0	0,7	25	0	15	-10	30,1	2244	230	8,88	2,63
54	10	0,2	0,3	120	0,2	4000	1	1500	10	0,4	40	30	9	-5	33,2	2471	267	8,05	0,12
55	35	0,2	0,3	75	1	4000	0,3	3000	0	0,7	10	30	12	-10	31,5	2433	245	8,65	1,99
56	35	0,2	0,7	120	0,2	4000	0,65	3000	-10	0,4	25	0	9	-5	33,2	2731	278	7,97	2,1
57	22,5	0,2	0,3	120	1	5000	0,3	3000	-10	0,4	10	0	15	-5	29,7	2131	221	9,03	3,27
58	35	0,2	0,7	75	0,6	4000	1	3000	10	0,7	25	15	15	-5	30,2	2256	225	8,98	2
59	22,5	0,2	0,7	75	1	5000	0,65	1500	10	0,7	10	15	15	-10	31,3	2329	237	8,72	3,02
60	10	1	0,7	75	0,2	5000	1	1500	10	0,7	40	15	12	-5	31,8	2668	251	8,54	0,8
61	22,5	0,2	0,3	75	0,2	4000	0,3	1500	0	0,4	10	15	12	-10	38,1	3053	340	6,93	1,69
62	10	0,2	0,7	75	0,2	4000	1	3000	0	0,7	40	15	9	0	31,7	523	167	22,7	-0,25
63	10	1	0,7	120	1	4000	1	1500	0	0,7	40	30	15	0	27,2	1626	180	10	2,89
64	22,5	1	0,5	120	0,6	5000	0,65	3000	-10	0,7	25	30	15	-10	28	1898	199	9,55	2,5
65	22,5	0,2	0,5	75	0,6	5000	0,65	3000	0	0,4	40	30	15	-5	30,4	2298	232	8,85	1,31
66	10	1	0,3	75	0,2	5000	0,65	1500	0	0,7	40	15	12	0	32,7	2394	260	8,2	1,05
67	10	1	0,5	75	0,6	5000	1	1500	10	0,7	25	30	15	-5	29,4	2093	218	9,09	2,18
68	22,5	1	0,5	120	1	5000	0,65	3000	0	0,4	10	15	15	-10	28	1904	196	9,65	4,28
69	22,5	1	0,5	75	0,6	5000	0,3	1500	-10	0,4	25	30	9	-5	33,2	3128	285	7,98	0,93
70	10	0,2	0,7	75	0,6	4000	0,3	3000	-10	0,7	10	0	12	0	33,9	2733	287	7,78	2,07
71	10	1	0,3	75	0,2	4000	1	3000	10	0,7	10	30	12	0	31,9	2176	241	8,54	2,08
72	35	0,2	0,7	75	1	4000	0,3	1500	-10	0,7	40	15	12	-5	32,2	2475	255	8,38	1,13
73	35	0,2	0,7	75	0,2	5000	0,65	3000	10	0,7	10	30	9	-5	32,4	2698	266	8,2	0,85
74	10	1	0,3	120	1	5000	1	3000	0	0,7	10	15	9	0	27,2	1679	184	9,9	2,57

75	22,5	1	0,7	75	1	5000	0,3	1500	-10	0,7	25	0	12	-10		31,9	2525	254	8,4	1,82
76	22,5	1	0,3	120	0,2	5000	0,3	3000	10	0,4	25	30	9	-5		33,5	2715	273	8,07	1,65
77	35	1	0,3	120	0,6	5000	0,65	1500	10	0,4	25	30	9	0		30,3	2316	227	8,97	2,59
78	10	0,2	0,5	75	0,6	4000	0,65	3000	10	0,7	10	30	15	-10		31,3	2292	241	8,59	2,35
79	22,5	1	0,7	120	0,2	5000	0,3	3000	0	0,7	40	30	12	-5		32	2377	247	8,5	1,54
80	10	1	0,5	75	1	5000	1	3000	-10	0,7	25	15	15	0		28,3	1855	196	9,61	2,24
81	35	0,2	0,3	120	0,2	5000	0,3	1500	-10	0,4	40	30	15	0		34,6	2594	282	7,82	2,37
82	35	0,2	0,5	75	0,6	4000	1	1500	-10	0,7	25	30	12	0		31,2	2445	239	8,71	1,14
83	22,5	1	0,5	75	0,6	4000	0,65	1500	-10	0,7	10	15	12	-10		32,7	2828	270	8,18	1,63
84	35	0,2	0,3	75	1	5000	0,65	1500	0	0,7	40	0	15	-10		30,5	2232	227	8,93	1,48
85	22,5	0,2	0,5	75	0,6	4000	0,3	1500	0	0,7	40	15	9	-5		34,1	3148	297	7,73	0,28
86	10	0,2	0,5	120	0,2	5000	1	3000	10	0,7	25	15	9	-5		30,7	2589	244	8,68	0,67
87	10	0,2	0,7	75	0,2	4000	0,3	3000	-10	0,7	25	30	15	-5		33,7	2699	279	7,92	1,03
88	35	1	0,7	120	0,6	4000	1	3000	10	0,4	40	30	9	-5		29,1	2156	210	9,41	0,95
89	35	1	0,5	75	0,6	4000	1	1500	10	0,7	10	15	15	-10		31,2	2315	236	8,74	2,81
90	35	1	0,3	120	0,6	4000	0,65	3000	10	0,4	10	15	15	-10		30	2204	223	9,01	4,16
91	22,5	0,2	0,7	120	1	4000	1	3000	0	0,4	40	0	12	-10		27,9	1916	196	9,66	1,23
92	35	0,2	0,5	75	1	4000	0,65	3000	10	0,7	25	30	9	0		30,4	2370	229	9	1,14
93	10	1	0,7	120	0,6	4000	0,65	1500	10	0,7	10	15	12	0		31,4	2527	251	8,5	3,78
94	10	0,2	0,7	120	0,6	4000	1	3000	0	0,7	10	30	9	-5		29,2	2276	220	9,15	1,43
95	22,5	1	0,5	120	1	4000	1	3000	10	0,7	25	15	15	-5		26,9	1682	179	10,1	3,72
96	35	1	0,5	75	1	4000	0,3	1500	10	0,7	10	0	9	-10		33,1	3072	277	8,13	0,794
97	35	0,2	0,5	120	0,2	4000	0,65	3000	0	0,7	40	15	15	-10		31,7	2370	245	8,54	1,22
98	35	0,2	0,5	120	1	4000	0,3	3000	-10	0,4	25	30	12	-5		29,4	2270	221	9,1	2,75
99	35	1	0,7	120	1	4000	0,65	1500	-10	0,4	25	15	15	0		28,8	2065	210	9,3	4,27
100	22,5	1	0,7	120	1	5000	1	3000	-10	0,4	25	15	12	0		27,3	1759	183	10	3,07
101	35	1	0,3	75	0,6	4000	0,3	1500	-10	0,7	40	15	12	0		32,9	2420	257	8,27	1,55
102	35	1	0,3	120	0,2	4000	0,65	1500	0	0,7	25	30	12	0		32,1	2338	251	8,35	2,6
103	10	1	0,5	75	0,2	4000	1	1500	-10	0,7	10	0	9	-5		33,8	575	217	21	-0,515
104	10	0,2	0,5	75	0,2	4000	0,3	1500	10	0,7	40	15	15	-10		35,8	3032	305	7,58	0,93
105	35	0,2	0,3	120	1	5000	0,3	1500	-10	0,7	40	0	9	-5		30,2	2276	225	9	1,42
106	22,5	1	0,7	75	0,6	5000	1	3000	10	0,7	10	0	9	0		30	2552	234	8,89	0,436
107	10	1	0,7	120	0,6	5000	0,65	1500	-10	0,7	10	0	15	-10		31,5	2358	244	8,57	2,61
108	35	0,2	0,7	75	0,2	5000	0,3	1500	10	0,4	25	0	12	0		36,6	3593	336	7	2,01
109	10	1	0,7	75	1	5000	0,65	1500	-10	0,4	10	15	12	-5		31,4	2720	249	8,55	2,34
110	35	0,2	0,7	120	1	5000	1	3000	10	0,4	10	15	9	0		27,9	1935	192	9,76	2,43
111	35	1	0,7	120	0,6	4000	0,65	3000	10	0,7	25	0	12	-10		30,2	2382	227	8,98	2,46
112	35	1	0,3	75	1	4000	0,3	3000	10	0,7	40	30	15	-5		28,8	1985	208	9,33	2,12
113	35	1	0,3	75	0,6	4000	1	3000	-10	0,7	25	30	9	-10		29,5	563	186	45,8	-0,07
114	35	0,2	0,3	75	1	5000	1	1500	10	0,4	10	30	15	-5		29,6	2151	220	9,07	3,25
115	10	1	0,5	120	0,2	5000	0,3	3000	-10	0,4	25	30	15	-10		33,4	2753	273	8,08	2,26
116	10	0,2	0,7	120	1	5000	0,65	1500	0	0,7	25	15	15	-5		28,4	1881	201	9,48	3,85
117	35	0,2	0,7	75	0,2	4000	1	3000	0	0,7	10	30	15	-10		31,5	2404	245	8,56	1,5
118	10	1	0,5	120	0,6	4000	0,65	3000	10	0,4	25	0	15	-5		31,1	2552	240	8,75	3,38
119	22,5	0,2	0,3	120	1	5000	0,65	3000	10	0,4	25	0	12	-10		28,4	2040	203	9,49	2,77
120	10	1	0,3	120	1	5000	0,3	1500	10	0,4	40	15	15	-5		29,4	2048	217	9,1	4,06
121	35	1	0,7	120	0,2	4000	0,3	3000	-10	0,4	10	30	12	0		34,3	3090	291	7,88	2,97
122	22,5	1	0,5	75	0,6	5000	0,3	3000	-10	0,4	40	15	12	-10		31,7	2621	255	8,37	0,82
123	10	1	0,7	120	0,2	4000	0,3	3000	0	0,4	25	0	15	0		35,5	3050	303	7,58	3,23
124	22,5	0,2	0,7	120	0,2	5000	0,3	1500	0	0,7	25	15	9	-10		34,8	3007	306	7,6	1,04
125	35	0,2	0,3	120	1	4000	1	1500	-10	0,4	10	0	12	0		29,1	2135	213	9,26	2,03
126	35	1	0,7	75	0,2	5000	0,65	1500	-10	0,7	40	30	15	0		30,7	2215	236	8,79	1,2
127	10	1	0,3	120	0,6	5000	1	1500	10	0,4	10	30	12	-10		29,7	2043	218	9,06	3,28
128	35	0,2	0,7	120	1	4000	0,65	3000	10	0,7	10	15	9	-10		28,6	2142	211	9,3	1,87
129	22,5	1	0,3	120	1	4000	0,3	3000	-10	0,7	40	15	9	-10		28,5	1970	207	9,38	1,02
130	10	0,2	0,5	120	0,6	4000	0,65	1500	0	0,7	25	0	12	-10		31,9	2649	256	8,39	2,31
131	10	0,2	0,5	120	0,6	5000	1	1500	10	0,7	10	30	9	0		29,9	2231	223	9,04	2,31
132	10	1	0,3	120	0,2	4000	1	3000	-10	0,7	40	30	15	-5		29,3	1847	212	9,15	0,98
133	22,5	1	0,3	75	0,2	5000	1	3000	10	0,7	25	15	9	-10		30,9	2430	237	8,77	0,25
134	10	0,2	0,3	120	1	5000	0,65	1500	10	0,7	10	0	9	-5		29,5	2139	219	9,11	1,24
135	10	0,2	0,3	120	0,6	4000	0,65	3000	10	0,4	25	30	12	-5		30,6	2158	230	8,81	2,65
136	35	1	0,3	75	0,2	4000	0,65	3000	-10	0,4	25	30	15	0		31,9	2529	254	8,39	1,97
137	22,5	1	0,3	75	1	4000	1	1500	-10	0,7	10	0	15	0		30,2	2153	228	8,93	2,36
138	35	1	0,3	75	1	5000	0,3	3000	-10	0,4	25	0	9	0		30,8	2456	237	8,8	1,4
139	35	0,2	0,3	75	0,2	5000	1	1500	10	0,7	10	0	15	0		33,5	2693	272	8,07	1,81
140	35	0,2	0,5	75	0,6	5000	0,3	3000	0	0,7	40	30	9	0		32	2544	250	8,48	0,26
141	35	0,2	0,7	75	0,6	4000	0,3	3000	0	0,4	40	0	12	-10		33,6	3131	287	7,92	0,827
142	35	1	0,5	75	0,6	4000	0,65	3000	-10	0,4	40	15	9	0		31,1	2592	246	8,65	0,39
143	22,5	0,2	0,3	120	0,2	5000	0,3	1500	10	0,7	40	0	12	-10		34,8	2882	295	7,67	1,63
144	10	0,2	0,3	120	0,6	5000	0,3	1500	0	0,4	10	0	9	0		33	2579	272	8,04	2,15
145	10	0,2	0,5	75	0,2	4000	0,65	3000	0	0,4	10	15	9	-5		34,5	3230	301	7,74	0,77
146	35	1	0,3	120	0,2	5000	0,3	3000	0	0,7	10	0	9	0		33,8	2713	274	8,04	1,58
147	22,5	1	0,5	120	0,2	4000	0,65	1500	-10	0,4	40	30	12	0		32,9	2753	276	8,02	1,6
148	22,5	0,2	0,5	120	0,2	4000	1	3000	-10	0,7	25	15	12	-10		31,4	2381	244	8,62	0,725
149	22,5	0,2	0,5	75	1	5000	1	1500	0	0,4	40	15	12	0		29,6	2336	223	9,07	1,62
150	35	0,2	0,5	120	0,6	4000	0,65	1500	-10	0,7	40	30	9	-10		31,1	2347	238	8,7	-0,02
151	10	0,2	0,5	75	0,2	5000	0,65	3000	-10	0,4	40	0	15	0		32,9	2803	271	8,15	1,2
152	35	1	0,3	120	0,2	4000	1	3000	-10	0,7	40	0	9	0		30,6	2350	234	8,81	0,216
153	22,5	0,2	0,3	120	0,2	4000	0,3	3000	10	0,7	25	15	15	0		33,8	2553	276	7,91	3,01
154	35	0,2	0,5	75	1	5000	0,3	1500	10	0,4	40	30	9	-10		32,4	2867	263	8,38	0,617
155	22,5	0,2	0,3	75	0,6	5000	0,65	1500	0	0,4	25	0	12	0		33	2768	270	8,13	2,11
156	10	1	0,7	120	1	4000	0,3	1500	0	0,7	10	0	12	0		31,5	2456	245	8,58	3,74
157	10	0,2	0,5	75	0,6	4000	1	3000	0	0,4	40	30	12	-5		30,3	2379	233	8,85	0,645
158	10	1	0,5	75	0,2	5000	0,3	3000	10	0,4	40	30	9	0		34,5	3219	295	7,83	0,535
159	10	0,2	0,5	120	1	5000	0,3	1500	0	0,7	40	30	12	-10		28,8	1994	208	9,32	2,33
160	22,5	1	0,5	75	0,6	4000	0,65	1500	10	0,4	10	30	9	0		33,3	2954	276	8,1	2,05
161	35	1	0,7	120	1	4000	1	3000	0	0,4	25	15	12	-10		27,3	1811	187	9,9	2,77
162	10	0,2	0,7	120	1	4000	0,65	1500	10	0,4	40	0	12	-10		30	2416	227	9,05	2,51
163	22,5	1	0,5	75	1	5000	0,65	1500	0	0,7	25	15	9	0		30,2	2406	233	8,86	1,64
164	10	0,2	0,5	120	1	5000	1	1500	10	0,4	25	15	12	0		27,9	2045	201	9,55	3,71
165	22,5	0,2	0,5	75	0,6	5000	1	1500	0	0,4	40	0	9	-10		31,8	551	199	23	-0,122
166	10	1	0,3	120	0,6	4000	0,65	3000	0	0,4	40	0	12	0		29,8	2083	216	9,18	2,16
167	10	1	0,5	120	1	4000	0,65	3000	0	0,7	40	0	15	-5		28	1917	196	9,65	2,97
168	35	0,2	0,3	120	1	5000	0,65	3000	0	0,4	10	15	12	-5		28,3	1905	197	9,63	3,81
169	22,5	0,2	0,7	75	1	5000	1	3000	0	0,4	25	15	15	-10		28,5	2084	209	9,33	1,97
170	10	0,2	0,5	75	1	4000	1	1500	10	0,7	40	0	15	-5		30	2357	226	9,03	1,77
171	35	1	0,3	75	0,6	4000	1	1500	0	0,4	10	30	9	0		31	2591	245	8,62	1,72
172	22,5	1	0,3	75	0,6	5000	0,65	1500	-10	0,7	40	30	12	-5		30	2126	226	8,88	0,77
173	35	1	0,3	120	1	5000	0,65	3000	-10	0,4	40	30	12	-10		27,2	1698	181	10	2,07
174	22,5	1	0,3	120	0,2	4000	0,65	3000	10	0,4	10	15	12	-5		33	2646	268	8,15	2,9
175	22,5	1	0,3	120	0,2	4000	0,65	1500	0	0,7	10	30	15	-10		32,7	2385	260	8,14	3,04
176	22,5	0,2	0,5	75	0,2	4000	1	1500	0	0,7	25	30	15	0		31,9	2342	250	8,41	1,55
177	22,5	0,2	0,3	75	1	4000	0,3	3000	0	0,7	40	0	15	0		31	2363	241	8,64	2,09
178	35	0,2	0,3	75	1	5000	0,3	1500	0	0,4	40	15	15	0		31,5	2505	251	8,45	2,45

179	35	1	0,3	75	0,2	5000	1	1500	0	0,7	40	30	9	-5	30,7	478	173	23,7	-0,127
180	10	1	0,3	120	0,2	5000	0,65	1500	-10	0,4	25	0	9	-10	34,4	2582	280	7,82	0,566
181	22,5	1	0,5	75	1	4000	0,65	3000	10	0,7	40	0	12	0	29,6	2384	224	9,07	1,84
182	22,5	0,2	0,3	75	0,2	4000	0,65	1500	10	0,7	25	30	12	-5	34,1	2594	279	7,86	1,16
183	10	0,2	0,5	120	0,6	4000	0,3	1500	-10	0,7	10	15	15	-5	31,8	2389	246	8,54	3,72
184	35	1	0,3	75	1	5000	1	1500	10	0,7	25	15	12	-10	28,6	2027	204	9,47	2,05
185	35	0,2	0,3	120	1	5000	0,65	3000	-10	0,7	10	30	15	0	27,6	1781	188	9,84	3,92
186	35	1	0,3	75	0,6	5000	1	3000	10	0,4	40	30	15	0	28,4	1971	202	9,5	2,2
187	10	1	0,5	120	0,2	5000	1	3000	0	0,7	40	0	9	-10	31	605	216	8,75	-0,122
188	10	0,2	0,5	75	0,6	5000	0,65	3000	10	0,4	25	15	9	0	32,1	2863	256	8,5	1,28
189	35	0,2	0,5	120	0,2	4000	1	1500	10	0,7	40	30	12	-10	31,4	2466	246	8,54	0,674
190	35	0,2	0,7	75	1	5000	1	1500	0	0,4	25	30	12	-5	29,5	2249	221	9,09	1,81
191	22,5	1	0,3	75	0,6	5000	0,65	3000	10	0,7	10	15	15	-5	30,4	2162	228	8,85	3,13
192	10	0,2	0,7	120	1	4000	1	3000	-10	0,7	25	0	15	0	27,5	1773	191	9,74	3,26
193	22,5	0,2	0,3	120	0,6	5000	0,3	3000	-10	0,4	40	30	9	-10	30,9	2380	241	8,71	0,418
194	10	0,2	0,7	120	0,2	4000	1	1500	0	0,4	10	0	12	-5	34,4	3025	290	7,84	1,48
195	22,5	0,2	0,3	120	0,6	5000	1	3000	-10	0,7	25	0	9	-5	29	2029	211	9,34	5,81
196	10	1	0,5	120	0,6	5000	0,65	3000	0	0,7	40	15	15	0	28,6	1950	203	9,43	2,84
197	35	0,2	0,5	120	0,2	5000	0,65	1500	0	0,4	40	0	12	-5	33,7	3044	286	7,93	1,71
198	35	1	0,5	75	0,2	4000	1	3000	0	0,7	10	15	12	0	31,2	2335	237	8,72	2,28
199	35	0,2	0,5	120	0,6	4000	0,65	3000	-10	0,4	10	0	9	-5	31,4	589	218	45,9	-0,199
200	10	1	0,7	75	0,6	4000	0,65	1500	-10	0,4	25	30	12	0	33,1	2924	274	8,14	1,66
201	35	1	0,5	75	0,2	4000	1	1500	-10	0,4	25	15	9	-10	33	2884	274	8,14	-0,035
202	10	1	0,7	75	1	5000	1	1500	0	0,4	10	15	9	-10	29,9	2486	232	8,9	1,43
203	10	0,2	0,5	75	1	5000	0,65	3000	0	0,4	10	0	9	0	31	2640	241	8,77	1,32
204	22,5	0,2	0,7	120	0,2	5000	1	1500	-10	0,7	10	30	12	-5	31,4	2653	254	8,43	1,85
205	10	0,2	0,7	120	0,6	4000	0,65	3000	10	0,7	40	30	15	-5	28,6	1998	208	9,34	2,25
206	22,5	1	0,5	120	1	4000	0,3	1500	0	0,4	25	0	9	-10	30,6	2643	243	8,7	2,4
207	35	1	0,5	75	0,2	5000	0,3	3000	0	0,4	25	15	15	-5	33,6	2763	274	8,07	2,42
208	10	1	0,7	75	0,2	5000	0,65	3000	10	0,4	25	15	15	-10	32,3	2829	268	8,21	1,8
209	22,5	0,2	0,7	75	0,6	4000	0,65	3000	-10	0,7	25	15	12	-5	31,3	2337	237	8,72	1,17
210	35	0,2	0,5	75	0,6	5000	1	3000	0	0,7	10	15	9	-10	29,9	2351	230	8,91	0,635
211	10	0,2	0,3	75	1	4000	0,65	3000	-10	0,4	40	30	9	0	30,7	2226	232	8,81	0,293
212	10	0,2	0,7	120	0,6	5000	1	1500	10	0,4	40	0	15	0	30	2370	226	9,06	3,21
213	22,5	1	0,7	75	0,6	5000	0,3	1500	10	0,4	25	15	15	0	33	2940	280	8,06	3,37
214	35	1	0,5	75	1	5000	1	1500	-10	0,4	40	15	15	-5	28,9	2019	206	9,42	1,77
215	22,5	1	0,3	75	0,6	4000	0,3	3000	0	0,4	10	0	12	-5	33,5	2801	280	5,02	1,96
216	10	0,2	0,7	120	0,2	5000	0,65	3000	0	0,7	10	0	12	-10	33,3	2686	271	8,12	1,4
217	22,5	1	0,3	75	1	4000	1	3000	0	0,4	25	30	15	-5	28,7	1933	203	9,43	2,31
218	10	1	0,7	120	0,6	4000	0,3	3000	0	0,7	10	15	15	-10	31,3	2335	247	8,45	3,66
219	35	1	0,7	120	0,2	5000	1	3000	-10	0,4	25	30	15	-5	29,9	2247	224	9,02	2,41
220	22,5	1	0,7	120	0,6	5000	0,65	3000	0	0,4	25	0	9	-5	30,3	2468	230	8,98	1,74
221	10	1	0,7	120	0,6	5000	0,3	1500	0	0,4	40	30	12	0	31,5	2546	252	8,48	2,92
222	22,5	0,2	0,5	120	0,6	4000	0,65	1500	10	0,4	25	15	9	-10	32,3	2865	263	8,34	1,42
223	35	1	0,7	75	0,2	4000	0,3	1500	0	0,4	40	0	15	-5	36,2	3296	320	7,4	1,84
224	10	0,2	0,5	75	1	4000	0,3	3000	-10	0,7	10	15	9	0	32,8	2926	266	8,31	1,43
225	22,5	1	0,5	120	0,2	5000	0,3	1500	0	0,7	40	0	15	0	33,5	2795	280	7,95	3,11
226	35	0,2	0,7	120	0,6	4000	0,3	1500	10	0,7	10	0	15	0	33,9	2835	283	7,9	3,64
227	35	1	0,7	120	0,6	4000	1	3000	-10	0,7	40	15	12	-5	28,3	1851	196	9,66	1,49
228	22,5	0,2	0,3	75	0,6	4000	1	3000	-10	0,7	10	30	9	-5	30,8	2447	237	8,78	0,309
229	22,5	1	0,7	120	0,2	5000	0,65	1500	10	0,7	40	30	9	0	32,1	2728	260	8,34	0,961
230	35	0,2	0,7	120	1	5000	1	3000	-10	0,7	10	0	12	-5	27,3	1827	191	9,81	1,71
231	22,5	1	0,5	120	0,2	4000	0,3	1500	10	0,4	25	0	12	-10	35,9	3455	329	7,31	2,52
232	35	1	0,5	75	0,6	4000	0,3	1500	10	0,4	25	15	12	-5	34,3	3134	291	7,91	2,61
233	22,5	0,2	0,5	120	0,6	5000	0,65	1500	10	0,7	10	0	12	-5	32	2650	252	8,47	2,21
234	10	1	0,3	75	0,6	5000	0,65	3000	0	0,7	10	30	9	-10	30,5	2287	237	8,68	0,95
235	10	0,2	0,7	75	0,6	5000	1	1500	-10	0,7	25	15	12	-10	31,1	2365	237	8,72	0,884
236	10	1	0,7	75	1	4000	0,3	3000	-10	0,4	40	0	15	-10	31,5	2638	254	8,45	1,45
237	22,5	1	0,5	75	1	5000	0,65	1500	0	0,7	25	15	9	0	30,2	2406	233	8,93	1,64
238	35	0,2	0,3	120	0,6	5000	0,3	1500	-10	0,7	10	30	12	-10	31,5	2546	252	8,45	2,7
239	22,5	0,2	0,7	120	0,6	5000	0,65	1500	0	0,7	25	30	9	-10	30,6	2333	234	8,8	1,18
240	10	0,2	0,5	120	1	4000	0,3	3000	10	0,4	40	0	9	0	29,9	2528	233	8,94	2,01
241	10	1	0,5	120	1	4000	0,3	1500	10	0,7	25	30	15	0	29,7	2033	214	9,18	4,45
242	10	0,2	0,5	120	0,2	5000	1	1500	0	0,7	10	15	15	-10	32,2	2386	253	8,35	2,75
243	22,5	0,2	0,7	120	0,2	4000	1	1500	10	0,7	10	0	9	-10	34,1	444	164	21,3	-0,721
244	35	1	0,7	75	0,6	4000	0,65	1500	0	0,7	25	15	15	-10	31,9	2349	246	8,58	2,08
245	35	1	0,5	120	1	5000	0,3	3000	10	0,4	25	30	12	0	28,1	1995	201	9,62	4,3
246	35	0,2	0,5	75	0,2	4000	0,3	1500	-10	0,4	10	0	15	-10	38,7	3345	353	6,94	1,17
247	35	1	0,7	75	1	4000	1	3000	0	0,7	25	0	9	-5	28,8	2237	213	9,38	0,995
248	35	1	0,3	120	1	4000	0,3	3000	0	0,4	40	15	9	-5	28,8	2146	212	9,32	1,89
249	10	1	0,7	120	0,6	4000	0,65	1500	10	0,7	10	15	12	0	31,4	2528	251	8,47	3,78
250	10	1	0,7	75	0,6	5000	0,3	3000	-10	0,4	40	30	9	-5	32,8	2817	265	8,28	0,103
251	10	0,2	0,3	75	0,2	4000	1	1500	10	0,4	25	15	15	0	33,5	2539	274	7,93	2,2
252	35	0,2	0,5	120	1	4000	0,3	1500	0	0,7	10	15	15	0	30,9	2195	232	8,78	4,99
253	10	1	0,3	120	0,6	4000	0,3	3000	-10	0,4	10	30	15	0	31,3	2327	246	8,51	3,99
254	35	1	0,3	75	0,2	5000	0,3	3000	-10	0,7	10	15	15	-10	32,9	2573	266	8,2	2,13
255	22,5	1	0,7	75	1	5000	0,3	3000	0	0,4	40	0	9	0	30,7	2727	245	8,66	1,25
256	10	1	0,5	75	1	4000	1	3000	10	0,4	25	30	9	-10	29,8	2332	220	9,16	0,82
257	35	0,2	0,7	75	0,6	5000	0,65	1500	10	0,4	10	15	9	-5	33,2	3062	277	8,1	1,47
258	22,5	0,2	0,3	120	1	4000	0,65	1500	0	0,7	40	30	12	-5	28,3	1846	200	9,5	2,14
259	10	0,2	0,3	120	0,6	5000	0,65	1500	-10	0,7	40	15	15	-10	29,6	1870	214	9,05	1,99
260	10	1	0,7	120	0,2	4000	0,65	1500	0	0,4	10	30	9	-10	35,1	3201	304	7,65	1,22
261	22,5	1	0,3	75	1	4000	0,65	1500	10	0,4	10	0	9	-10	31,8	2742	257	8,39	0,509
262	22,5	0,2	0,5	120	0,2	4000	0,3	3000	0	0,4	10	30	9	-10	35	3304	313	7,56	1,04
263	35	0,2	0,5	120	0,2	5000	1	1500	-10	0,7	25	0	15	-5	31,8	2352	250	8,37	2,17
264	35	0,2	0,7	120	0,6	4000	1	1500	0	0,4	10	15	12	-10	30,6	2473	240	8,69	2,68
265	35	0,2	0,7	120	0,6	5000	0,3	3000	-10	0,7	25	15	9	0	30,8	2461	242	8,66	1,52
266	22,5	1	0,7	75	0,2	4000	1	3000	-10	0,4	10	15	15	-10	32,2	2767	261	8,36	1,52
267	35	0,2	0,7	75	1	5000	0,65	3000	-10	0,4	25	15	9	-10	29,9	2460	232	8,89	0,36
268	35	0,2	0,5	120	0,2	5000	0,3	1500	0	0,4	25	15	9	0	35,8	3246	317	7,43	1,74
269	22,5	0,2	0,5	120	0,2	4000	0,3	3000	-10	0,7	10	0	12	0	35,7	2938	310	7,43	1,27
270	22,5	0,2	0,7	75	1	5000	1	1500	10	0,7	40	30	9	-5	29,1	2230	215	9,26	0,4
271	22,5	1	0,5	75	1	5000	0,3	3000	10	0,4	10	15	9	-5	31,2	2725	248	8,6	2,08
272	22,5	0,2	0,3	75	1	5000	1	3000	10	0,4	25	0	15	0	29,1	2164	213	9,26	2,73
273	10	1	0,3	120	1	4000	1	1500	-10	0,7	25	30	12	-5	27,5	1742	190	9,73	2,4
274	35	0,2	0,7	75	0,2	5000	1	3000	-10	0,4	40	15	12	0	31,3	2518	246	8,65	0,49
275	35	0,2	0,7	120	1	5000	0,3	1500	0	0,4	10	0	9	-10	31,3	2585	242	8,68	1,92
276	22,5	0,2	0,7	120	0,2	4000	0,65	1500	-10	0,4	40	0	15	-10	34,4	2931	295	7,7	2,46
277	35	1	0,3	75	0,2	5000	0,3	1500	-10	0,4	10	0	12	-5	35,3	3074	310	7,55	1,42
278	22,5	1	0,5	120	0,2	5000	1	1500	10	0,4	25	30	12	0	31,7	2553	248	8,54	2,84
279	22,5	1	0,3	120	0,6	4000	0,65	1500	-10	0,7	25	0	9	0	31,5	2363	244	8,6	1,59
280	22,5	0,2	0,5	120	0,2	5000	0,65	3000	0	0,7	40	30	9	-5	31,5	493	300	23,1	-0,074
281	22,5	1	0,7	120	0,6	5000	1	1500	0	0,7	10	30	15	0	29,1	1978	206	9,38	4,17
282	10	1	0,3	120	1	4000	0,65	1500	10	0,4	25	15	9	0	29,7	2160	221	9,04	2,71

283	35	0,2	0,5	120	0,6	5000	0,3	3000	10	0,4	25	15	15	-10	30,8	2495	242	8,64	3,56
284	35	0,2	0,3	75	0,2	4000	1	3000	0	0,4	10	0	15	-5	33	2697	269	8,13	1,36
285	22,5	0,2	0,7	75	0,6	4000	0,3	1500	-10	0,4	40	15	9	0	34,8	3198	309	7,55	0,464
286	10	0,2	0,3	120	1	4000	0,65	3000	0	0,4	25	30	15	-10	28,4	1806	199	9,48	3,17
287	35	0,2	0,3	75	0,6	4000	0,65	1500	10	0,4	40	15	12	-10	33,2	2835	273	8,07	0,91
288	10	1	0,3	75	0,6	5000	1	1500	-10	0,4	40	15	9	0	30,8	2280	238	8,63	0,317
289	10	1	0,3	75	0,2	4000	0,65	3000	10	0,7	10	0	9	-5	33,9	544	185	20,9	-0,181
290	10	1	0,5	120	0,2	5000	0,65	1500	0	0,4	25	30	12	-5	33,6	2761	275	8,1	2,33
291	10	1	0,7	120	1	5000	0,65	3000	10	0,4	10	30	15	0	28,1	1891	196	9,65	5,11
292	22,5	0,2	0,7	75	1	4000	0,65	1500	0	0,4	10	0	15	-5	32,2	2784	266	8,27	2,57
293	10	0,2	0,3	75	0,6	4000	0,3	1500	-10	0,4	40	0	12	-5	35	2706	298	7,55	1,08
294	10	1	0,7	120	0,6	4000	0,3	3000	0	0,7	10	15	15	-10	31,3	2336	247	8,46	3,66
295	10	1	0,3	75	0,6	5000	0,3	1500	10	0,4	10	0	15	-10	34,6	2702	290	7,71	2,35
296	22,5	1	0,7	120	0,6	4000	0,65	1500	0	0,4	40	15	15	-5	31,3	2425	239	8,77	2,99
297	10	1	0,5	120	0,6	5000	1	3000	-10	0,4	10	0	12	0	29,5	2031	213	9,23	1,85
298	35	0,2	0,5	120	0,6	5000	0,65	3000	0	0,4	10	30	12	0	30,2	2347	227	8,99	3,48
299	10	0,2	0,3	75	0,6	5000	1	3000	10	0,7	10	15	12	-5	29,8	2100	224	8,92	2,16
300	10	1	0,5	75	0,6	5000	1	1500	10	0,7	25	30	15	-5	29,4	2093	218	9,12	2,18
301	22,5	0,2	0,7	75	0,6	4000	0,65	3000	10	0,7	40	0	9	-10	31,8	507	184	22,7	-0,161
302	22,5	0,2	0,3	120	0,6	4000	0,65	3000	0	0,7	10	15	9	0	31,1	2420	242	8,63	1,62
303	22,5	0,2	0,7	120	0,6	5000	0,65	3000	-10	0,7	40	0	12	0	29,3	2189	219	9,14	1,97
304	35	0,2	0,5	75	0,6	5000	0,65	1500	10	0,7	40	15	15	0	31,2	2434	239	8,71	1,95
305	22,5	0,2	0,7	75	0,2	4000	1	3000	10	0,4	40	0	12	-5	33	2978	269	8,26	0,551
306	10	0,2	0,5	120	0,6	5000	0,3	3000	10	0,4	10	30	15	-5	31,2	2423	243	8,61	4,47
307	10	1	0,7	120	1	5000	0,3	3000	-10	0,7	25	15	9	-5	28,8	2119	211	9,31	1,92
308	35	1	0,7	75	1	5000	0,3	3000	0	0,7	25	30	15	-10	29,1	1970	210	9,26	2,24
309	22,5	1	0,5	75	0,2	4000	0,65	3000	0	0,7	25	0	15	-10	32,9	2698	269	8,14	1,48
310	10	1	0,5	120	0,2	4000	0,65	3000	0	0,7	25	30	9	0	32,8	2604	261	8,27	0,79
311	22,5	0,2	0,3	75	1	5000	0,3	1500	10	0,7	25	15	9	0	32,5	2682	260	8,29	1,72
312	10	0,2	0,3	120	0,2	5000	1	1500	-10	0,7	40	0	12	0	31,5	2251	246	8,42	1,3
313	22,5	0,2	0,7	75	0,6	5000	1	3000	10	0,4	25	30	12	-5	30,1	2343	226	8,96	1,68
314	10	0,2	0,7	75	1	4000	0,3	3000	0	0,4	10	30	9	-5	32,9	2977	268	8,22	1,7
315	35	0,2	0,3	75	0,2	5000	0,65	3000	0	0,7	25	15	12	-10	32,3	2451	255	8,34	0,76
316	10	0,2	0,5	75	1	4000	0,3	1500	0	0,4	25	0	15	-5	33,8	3027	286	7,97	2,8
317	10	0,2	0,3	75	1	5000	0,65	1500	10	0,4	40	30	12	0	30,8	2228	232	8,78	1,94
318	35	1	0,3	120	0,6	4000	1	3000	0	0,7	10	0	15	-5	28,8	1954	208	9,34	3,04
319	10	1	0,5	120	0,6	5000	1	3000	-10	0,7	40	0	12	-5	28,2	1986	202	9,49	1,56
320	10	0,2	0,5	75	0,2	5000	1	1500	10	0,4	10	15	9	-10	33,2	3154	285	7,99	0,7
321	22,5	0,2	0,7	120	0,2	5000	1	3000	0	0,4	10	15	9	-5	32	2667	252	8,5	1,1
322	22,5	0,2	0,3	75	1	4000	0,3	1500	-10	0,4	25	30	12	-10	33,3	2708	271	8,12	1,42
323	35	0,2	0,3	120	1	4000	0,3	3000	-10	0,7	25	0	12	-10	29,8	2095	220	9,16	2,35
324	22,5	0,2	0,7	75	0,2	4000	0,3	1500	0	0,4	40	30	12	0	36,4	3130	325	7,34	0,98
325	10	1	0,3	120	1	4000	1	3000	-10	0,4	10	0	9	-10	28,5	1885	198	9,61	0,13
326	10	0,2	0,7	75	0,6	5000	0,3	1500	0	0,7	40	0	15	-5	33,5	2812	274	8,06	1,72
327	22,5	0,2	0,5	75	1	4000	1	1500	0	0,7	10	30	9	-10	30,4	2496	235	8,91	0,98
328	22,5	0,2	0,5	120	1	5000	1	1500	-10	0,4	10	0	15	-10	28,7	2050	205	9,43	2,64
329	35	0,2	0,5	75	1	4000	1	3000	10	0,4	10	0	12	-10	30,4	2507	231	8,95	0,99
330	10	0,2	0,3	120	1	4000	0,65	3000	0	0,4	25	30	15	-10	28,4	1808	199	9,52	3,17
331	35	1	0,3	120	0,2	5000	1	1500	10	0,4	10	15	15	0	31,4	2420	244	8,58	4,46
332	35	1	0,3	75	1	5000	0,3	1500	0	0,7	25	0	12	-5	31,3	2483	245	8,66	2,63
333	35	0,2	0,5	75	0,2	5000	0,3	1500	0	0,7	10	30	12	-5	34,9	3029	306	7,52	1,87
334	10	1	0,5	75	1	4000	0,65	1500	10	0,7	40	30	9	-5	31	2555	239	8,76	0,66
335	35	1	0,5	120	1	4000	1	1500	10	0,7	40	15	9	0	27,8	1917	192	9,81	1,82
336	22,5	1	0,3	75	0,6	4000	1	3000	0	0,4	25	15	12	0	30	2282	229	8,9	2
337	22,5	0,2	0,5	120	0,2	4000	0,3	3000	-10	0,4	40	15	15	-5	33,9	2759	288	7,75	1,71
338	35	1	0,5	120	1	5000	0,65	3000	-10	0,4	40	0	15	-10	29,9	1814	188	9,85	2,93
339	22,5	0,2	0,3	120	0,2	5000	1	3000	0	0,4	10	30	12	0	31	2408	242	8,64	1,6
340	22,5	1	0,3	120	0,6	5000	1	1500	-10	0,4	10	15	9	-5	29,7	2281	223	9,07	0,72
341	10	0,2	0,5	120	0,6	5000	0,3	3000	-10	0,7	25	0	9	-10	31,9	2537	250	8,5	0,997
342	35	1	0,5	75	1	4000	0,3	3000	0	0,7	40	15	12	-10	30,4	2316	228	8,95	0,51
343	22,5	0,2	0,3	75	1	4000	1	3000	-10	0,4	40	15	12	-5	29,6	537	179	44	0
344	35	1	0,3	75	1	5000	0,65	3000	10	0,4	10	15	12	0	29,6	2205	217	9,18	2,46
345	35	1	0,7	75	0,2	4000	0,3	3000	10	0,7	25	15	9	0	33,9	569	218	21	0,16
346	10	1	0,7	120	1	5000	1	1500	10	0,7	25	0	9	-10	28,5	2080	201	9,58	1,62
347	35	1	0,5	120	1	5000	0,65	1500	-10	0,7	10	0	12	0	29	2025	207	9,36	2,9
348	22,5	1	0,5	120	0,6	4000	1	3000	0	0,4	40	0	9	0	29,6	2323	219	9,18	1,11
349	22,5	1	0,7	75	0,6	4000	1	1500	0	0,7	40	30	12	-10	30,2	2192	225	8,96	0,64
350	22,5	0,2	0,3	120	0,2	4000	1	1500	0	0,4	25	0	9	0	33,7	2823	283	7,93	0,8
351	35	0,2	0,3	120	0,2	5000	0,65	3000	10	0,4	10	0	9	-10	33,3	434	172	42,9	-0,67
352	22,5	1	0,3	120	0,2	5000	0,65	3000	0	0,4	40	15	15	0	31	2327	240	8,66	1,78
353	10	1	0,5	75	0,2	5000	0,3	1500	-10	0,7	25	15	12	0	35,7	2890	302	7,56	0,36
354	22,5	1	0,3	120	0,6	5000	0,3	1500	10	0,7	40	30	9	-5	31,1	2362	237	8,72	0,69
355	35	0,2	0,5	120	1	5000	0,3	1500	-10	0,4	10	15	12	-10	30,5	2486	235	8,78	3,39
356	35	1	0,7	75	0,2	5000	1	3000	10	0,7	40	0	15	-10	30,1	2360	227	9,01	1,08
357	10	0,2	0,5	75	0,6	4000	0,3	1500	10	0,4	10	30	12	0	35	3132	309	7,59	2,94
358	35	0,2	0,3	120	0,2	4000	1	1500	-10	0,4	25	15	12	-5	33,3	2655	271	8,09	0,73
359	35	0,2	0,3	75	0,6	5000	1	3000	0	0,7	40	0	12	0	29,3	2235	220	9,13	1,03
360	22,5	1	0,7	120	1	4000	0,65	3000	-10	0,7	10	15	9	-5	28,7	2125	207	9,47	1,36
361	10	0,2	0,3	75	1	5000	1	3000	-10	0,4	10	30	15	-10	28,6	1989	207	9,33	2,01
362	22,5	1	0,7	75	1	4000	0,65	1500	10	0,7	25	0	15	0	31,1	2577	245	8,67	3,1
363	35	1	0,5	75	0,2	5000	0,65	1500	10	0,7	25	0	9	-10	33,1	3164	284	8,02	0,5
364	10	1	0,3	75	0,2	4000	1	1500	0	0,4	40	0	12	-10	33,3	2631	275	7,98	0,36
365	10	0,2	0,7	120	0,2	5000	0,65	1500	-10	0,4	40	15	9	-5	34,1	408	162	21,2	-0,62
366	10	0,2	0,3	75	1	5000	0,3	3000	10	0,4	40	15	12	-10	31	2335	240	8,67	0,67
367	35	0,2	0,7	75	0,2	4000	0,65	1500	-10	0,7	10	0	12	-5	36,4	3032	316	7,4	0,5
368	22,5	0,2	0,5	120	1	5000	1	3000	0	0,7	25	0	12	0	27,2	1821	187	9,9	3,07
369	35	0,2	0,3	75	0,2	5000	0,3	3000	-10	0,7	40	15	9	-5	33,6	434	156	21,4	-0,68
370	35	0,2	0,3	120	1	5000	1	1500	0	0,7	25	30	9	-10	27,9	1788	190	9,79	0,82
371	22,5	0,2	0,5	120	0,6	4000	0,65	1500	10	0,4	25	15	9	-10	32,3	2865	263	8,35	1,42
372	35	0,2	0,3	120	0,6	5000	1	1500	0	0,7	40	30	15	-5	28,2	1747	193	9,63	2,13
373	10	1	0,3	75	0,2	5000	0,65	3000	0	0,4	10	30	15	-5	32,1	2391	257	8,25	2,39
374	22,5	1	0,7	120	1	5000	0,3	1500	0	0,4	10	30	15	-5	29,6	2232	221	9,05	5,14
375	35	1	0,7	75	1	4000	1	1500	10	0,4	40	0	12	0	30,1	2471	228	8,98	2,05
376	35	0,2	0,7	120	0,6	5000	0,3	1500	-10	0,4	25	0	12	-5	32,8	2770	270	8,19	2,89
377	22,5	1	0,5	120	0,6	4000	1	3000	-10	0,4	40	30	15	-5	28,3	1932	201	9,49	2,02
378	22,5	0,2	0,7	120	1	4000	0,3	3000	10	0,7	25	0	9	-5	30,4	2479	231	8,94	1,92
379	22,5	1	0,3	75	0,2	4000	0,65	3000	0	0,4	40	30	9	-10	32,8	444	161	22	-0,46
380	35	1	0,5	120	0,6	5000	1	3000	0	0,4	25	30	9	-10	27,9	2004	201	9,54	1,2
381	35	0,2	0,3	120	1	4000	0,3	1500	10	0,4	25	0	15	-10	30,9	2490	243	8,65	3,97
382	10	0,2	0,3	75	0,6	5000	0,3	3000	0	0,7	25	30	15	0	31,1	2040	233	8,61	2,23
383	35	0,2	0,7	120	1	5000	0,65	1500	0	0,4	40	30	9	0	28,6	2134	211	9,37	1,76
384	22,5	1	0,7	75	0,2	4000	0,65	1500	0	0,4	25	15	9	-5	35,5	3271	309	7,61	0,686
385	10	1	0,3	120	0,2	5000	0,3	1500	-10	0,7	25	0	15	-5	35	2308	281	7,63	2,96
386	10	0,2	0,3	75	0,2	4000	0,3	3000	0	0,7	25	0	9	-10	36,4	2799	310	7,37	0,06

387	35	1	0,5	75	0,6	4000	0,3	3000	10	0,7	40	0	9	-5		32,7	2959	267	8,31	0,65
388	10	0,2	0,7	120	1	4000	0,3	1500	-10	0,7	10	30	15	-10		29,9	2312	229	8,97	3,7
389	10	1	0,7	75	0,2	5000	1	1500	0	0,4	25	30	9	0		32,5	2875	270	8,24	0,705
390	22,5	0,2	0,3	120	0,6	4000	0,65	1500	10	0,4	40	0	15	0		31,4	2526	251	8,44	3,27
391	35	0,2	0,7	120	0,2	4000	0,65	3000	10	0,4	40	15	12	0		33	2898	273	8,12	1,69
392	10	0,2	0,3	120	0,2	4000	0,3	3000	0	0,7	40	15	12	-5		33,6	2422	272	7,89	1,18
393	10	0,2	0,5	120	1	5000	1	1500	-10	0,4	25	30	9	-5		27,9	2060	201	9,61	1,51
394	10	0,2	0,5	120	0,6	5000	0,65	1500	-10	0,4	25	30	15	0		30,9	2392	236	8,75	3,38
395	22,5	0,2	0,7	120	0,6	4000	0,65	3000	-10	0,4	10	30	12	-10		31,1	2565	240	8,77	2,19
396	10	0,2	0,7	75	1	5000	1	3000	10	0,7	40	30	12	-10		27,7	1908	194	9,87	0,85
397	10	1	0,5	120	0,2	4000	1	3000	10	0,4	40	15	12	-10		31,7	2662	250	8,55	0,999
398	10	0,2	0,7	75	0,6	4000	0,3	1500	10	0,4	25	30	9	-10		35	3257	310	7,52	0,935
399	35	1	0,7	75	0,6	4000	0,65	3000	0	0,4	10	0	9	0		32	2873	233	8,38	1,12
400	35	0,2	0,3	75	0,6	4000	0,3	3000	10	0,4	10	15	9	0		34,5	3048	291	7,83	1,56
401	35	0,2	0,7	75	0,6	5000	0,65	3000	-10	0,4	10	30	15	-10		31	2604	245	8,63	1,86
402	10	1	0,3	120	0,6	5000	0,3	3000	10	0,7	25	0	12	0		31,9	2439	247	8,53	2,19
403	10	1	0,3	75	1	5000	1	3000	0	0,4	40	0	9	-5		28,8	2079	210	9,31	0,551
404	35	1	0,5	75	1	4000	0,65	1500	0	0,4	25	30	12	-10		30,9	2423	237	8,79	1,94
405	22,5	1	0,7	75	1	5000	0,65	3000	-10	0,7	25	30	15	-5		28,2	1936	200	9,53	1,93
406	22,5	0,2	0,7	75	0,2	5000	0,3	3000	-10	0,7	10	0	9	-10		35,1	481	160	20,2	-0,65
407	22,5	1	0,5	120	1	5000	1	3000	10	0,7	10	30	12	-10		26,3	1605	175	10,2	3,41
408	10	0,2	0,3	75	0,6	4000	0,65	1500	0	0,7	10	30	15	0		32,1	2262	254	8,22	2,79
409	35	1	0,5	120	0,2	4000	1	3000	10	0,4	25	0	15	0		31	2602	245	8,63	3,2
410	22,5	0,2	0,3	120	1	5000	0,3	3000	10	0,7	10	30	9	-10		29	2008	210	9,26	2,4
411	35	1	0,7	75	0,6	5000	0,3	3000	0	0,4	10	15	12	-5		32,5	2752	262	8,33	2,76
412	22,5	1	0,7	75	0,6	4000	1	1500	-10	0,4	25	0	15	-5		31,5	2796	257	8,49	2,4
413	10	0,2	0,5	120	0,2	4000	0,65	3000	10	0,7	10	0	15	0		34	2859	285	7,93	2,32
414	10	1	0,3	120	0,2	4000	1	1500	0	0,7	25	15	15	-10		31,8	2114	243	8,44	2,08
415	22,5	1	0,5	75	1	4000	0,3	3000	-10	0,4	10	30	15	0		31,5	2643	248	8,55	3,2
416	35	0,2	0,3	120	0,2	5000	0,65	3000	10	0,4	10	0	9	-10		33,3	449	180	21,9	-0,673
417	22,5	1	0,7	120	0,6	4000	0,3	3000	0	0,7	25	30	9	0		30,7	2402	240	8,68	1,87
418	22,5	0,2	0,3	75	0,2	5000	0,65	1500	-10	0,4	25	15	15	-5		34,5	2671	283	7,8	1,53
419	22,5	1	0,7	120	0,6	4000	0,3	1500	-10	0,4	10	0	9	-10		33,6	3202	288	7,93	1,02
420	22,5	0,2	0,3	120	1	4000	0,3	1500	10	0,4	10	30	12	0		30,8	2330	239	8,68	4,67
421	10	0,2	0,3	75	0,2	4000	0,3	3000	0	0,7	25	0	9	-10		36,4	2796	310	7,37	0,062
422	10	0,2	0,3	120	0,2	4000	0,3	1500	-10	0,7	25	30	9	0		36,1	2658	304	7,36	0,76
423	22,5	1	0,7	75	0,2	5000	0,65	1500	-10	0,4	10	0	12	0		34,5	3170	300	7,7	1,31
424	10	0,2	0,7	120	0,2	4000	0,3	1500	10	0,7	25	15	12	-10		36,3	3060	314	7,34	2,04
425	22,5	1	0,7	120	0,2	4000	1	1500	-10	0,7	40	15	15	0		30,7	2192	236	8,71	1,82
426	22,5	1	0,7	120	1	5000	1	1500	-10	0,4	40	30	9	-10		27,3	1896	192	9,76	0,84
427	35	1	0,5	75	0,2	5000	1	3000	-10	0,4	10	30	9	-5		31,3	2691	244	8,69	0,541
428	10	1	0,7	75	0,2	4000	0,65	3000	-10	0,7	40	30	12	-10		31,7	511	163	22,7	-0,278
429	35	1	0,7	75	0,6	5000	1	1500	-10	0,7	40	0	9	-10		30	743	226	8,89	-0,163
430	10	1	0,5	120	1	4000	0,3	1500	-10	0,4	40	0	12	-5		31,3	2517	240	8,71	2,88
431	22,5	0,2	0,3	120	0,6	4000	0,3	1500	0	0,4	25	30	15	-5		32,6	2432	261	8,17	3,55
432	22,5	1	0,5	75	0,2	4000	0,65	1500	-10	0,7	40	15	9	-5		34	469	176	21,3	-0,322
433	22,5	0,2	0,7	120	1	4000	0,3	1500	10	0,4	25	15	12	-5		30,9	2585	244	8,66	3,84
434	22,5	0,2	0,3	75	0,6	4000	0,3	1500	-10	0,7	25	15	15	-10		34,2	2448	275	7,85	1,54
435	35	1	0,3	75	0,2	4000	0,3	3000	10	0,4	25	30	12	-10		33,9	2806	282	7,9	1,67
436	35	1	0,5	120	0,2	4000	0,3	1500	0	0,7	25	30	9	-5		34,2	2832	292	7,71	1,44
437	22,5	1	0,5	120	1	4000	1	1500	0	0,4	10	15	12	-5		28	1992	200	9,53	3,89
438	22,5	0,2	0,5	75	0,2	5000	0,3	1500	10	0,4	25	0	9	-5		37,2	3746	342	7,16	0,69
439	35	1	0,7	120	1	5000	0,3	3000	10	0,7	10	0	15	-5		28,7	2095	210	9,31	3,99
440	35	0,2	0,5	75	0,2	5000	0,65	3000	-10	0,4	25	30	12	-10		32,2	2831	268	8,21	0,416
441	10	1	0,3	75	0,6	4000	0,3	3000	-10	0,4	25	15	9	-5		33,6	2615	277	7,94	0,673
442	22,5	1	0,7	75	0,2	4000	0,3	1500	10	0,7	10	30	15	-5		35	2678	298	7,62	2,81
443	35	0,2	0,3	120	0,6	4000	1	3000	-10	0,4	25	15	15	0		29,6	2079	215	9,18	2,87
444	22,5	0,2	0,5	75	0,2	5000	0,65	1500	-10	0,7	10	30	9	-10		34,5	3204	295	7,83	0,079
445	10	1	0,7	75	1	4000	1	3000	10	0,4	10	15	15	-5		29,5	2285	222	9,11	3,18
446	10	0,2	0,7	120	1	5000	1	3000	-10	0,4	40	15	15	-5		27,2	1704	181	10,1	2,56
447	22,5	1	0,5	120	0,6	4000	0,3	3000	10	0,4	40	15	12	0		31,3	2621	247	8,61	3
448	35	0,2	0,5	120	1	4000	1	3000	0	0,4	40	30	15	0		26,9	1713	183	9,98	2,9
449	22,5	1	0,5	75	1	4000	0,65	3000	-10	0,4	25	0	12	-5		30,6	2462	235	8,79	1,74
450	22,5	0,2	0,7	75	1	4000	0,65	3000	0	0,7	10	30	12	0		29,9	2347	230	8,89	2,52
451	10	1	0,7	75	1	5000	0,3	3000	10	0,7	40	15	15	0		29,9	2279	224	9,03	2,39
452	22,5	0,2	0,3	120	1	4000	1	1500	10	0,4	10	15	15	-10		29,6	2251	222	9,08	4,08
453	22,5	1	0,5	120	0,6	5000	0,3	1500	10	0,7	10	15	9	-10		32,2	2711	259	8,35	2,53
454	10	0,2	0,7	75	1	4000	0,3	3000	0	0,4	25	15	12	0		32,4	2749	261	8,33	2,45
455	35	1	0,3	120	1	4000	0,65	1500	-10	0,4	10	30	9	-5		28,9	2186	213	9,32	2,39
456	10	1	0,5	75	0,6	5000	0,65	1500	10	0,4	40	0	12	-10		32,8	2979	268	8,27	1,19
457	10	1	0,3	120	0,6	5000	0,3	1500	0	0,4	25	15	12	-10		32,6	2353	254	8,33	3,16
458	22,5	0,2	0,3	75	0,6	4000	1	1500	10	0,7	10	0	12	-10		32,2	2671	264	8,23	0,821
459	35	0,2	0,3	75	0,2	4000	0,65	1500	-10	0,7	10	15	9	0		35	3048	301	7,64	0,745
460	22,5	0,2	0,7	75	0,2	4000	1	3000	-10	0,4	25	30	9	0		32,9	535	182	22,3	-0,077
461	10	1	0,3	75	1	4000	0,65	3000	10	0,7	25	15	12	-10		30,2	2127	223	8,95	1,79
462	10	0,2	0,7	75	0,6	5000	1	3000	0	0,4	10	0	15	0		31,1	2503	239	8,74	2,34
463	10	1	0,5	120	1	4000	0,3	3000	10	0,7	10	30	12	-5		29,5	2058	213	9,23	4
464	22,5	1	0,3	75	0,2	5000	0,3	3000	-10	0,7	25	30	12	0		32,9	2529	260	8,32	1,36
465	22,5	1	0,7	75	0,6	5000	0,3	1500	10	0,4	25	15	15	0		33	2939	280	8,01	3,37
466	35	1	0,7	75	1	5000	0,65	3000	0	0,7	40	15	9	-5		28,5	2178	211	9,35	0,608
467	10	1	0,3	120	0,2	5000	0,65	3000	10	0,7	40	30	15	-10		30,2	1978	219	8,98	1,66
468	22,5	1	0,5	120	0,2	5000	0,65	3000	-10	0,4	10	15	9	0		32,6	2899	265	8,31	1,36
469	22,5	0,2	0,7	120	0,6	5000	1	3000	10	0,7	40	15	15	-10		27,6	1871	193	9,72	2,1
470	10	1	0,3	75	1	4000	0,3	1500	0	0,7	10	15	15	-5		32,1	2095	240	8,47	3,36
471	35	0,2	0,5	120	0,2	4000	0,65	1500	10	0,4	10	30	15	-5		34,2	2809	290	7,75	3,53
472	35	0,2	0,7	120	0,2	5000	0,65	3000	0	0,7	25	0	15	0		32,1	2525	255	8,4	2,88
473	22,5	1	0,3	120	0,6	5000	0,3	3000	0	0,7	40	0	15	-10		29,8	2137	221	9,01	2,81
474	35	1	0,7	75	1	4000	0,3	1500	-10	0,7	10	30	9	0		32,5	2918	265	8,31	1,84
475	22,5	1	0,3	75	0,2	4000	0,3	1500	10	0,4	40	0	9	0		36,7	3301	331	7,18	0,801
476	10	0,2	0,3	75	0,2	4000	0,65	1500	10	0,4	25	0	12	0		36,3	2879	311	7,36	1,66
477	35	1	0,7	75	0,6	5000	0,3	1500	10	0,7	10	30	12	-10		32,2	2548	261	8,27	2,66
478	10	1	0,7	120	0,2	5000	0,3	1500	10	0,4	10	0	9	-5		35,9	3437	326	7,28	0,77
479	22,5	1	0,7	120	1	4000	0,3	3000	10	0,4	40	30	15	-10		29,1	2051	207	9,36	3,27
480	22,5	1	0,5	75	1	5000	0,65	1500	10	0,4	40	30	15	-10		29,7	2255	222	9,03	1,95
481	10	1	0,3	75	1	5000	0,3	1500	-10	0,7	40	30	9	-10		31,2	2225	239	8,6	0,161
482	22,5	0,2	0,5	75	0,6	4000	0,3	3000	-10	0,4	25	0	15	0		34,2	2893	286	7,86	2,26
483	10	0,2	0,7	120	0,6	5000	0,65	3000	0	0,4	40	15	9	-10		30,5	2446	230	8,94	0,682
484	22,5	1	0,7	75	0,2	5000	1	3000	0	0,7	25	0	12	-5		30,9	2560	244	8,64	1,27
485	35	1	0,3	120	1	5000	0,65	1500	0	0,4	25	0	15	0		28,2	1980	202	9,5	4,84
486	35	0,2	0,7	120	0,2	4000	1	1500	10	0,4	25	30	15	-10		32,1	2594	262	8,24	2,27
487	35	1	0,7	120	0,6	4000	0,65	3000	10	0,7	25	0	12	-10		30,2	2383	227	8,97	2,46
488	35	0,2	0,5	75	0,2	4000	0,65	1500	0	0,4	40	0	9	0		35,6	3476	321	7,51	0,076
489	35	0,2	0,7	120	0,2	4000	0,3	3000	-10	0,7	40	30	9	-10		33,5	371	171	35,6	-0,631
490	22,5	0,2	0,5	120	1	5000	0,65	3000	10	0,4	40	15	9	-5		27,9	2073	202	9,58	1,54

491	10	1	0,3	120	0,6	4000	1	1500	10	0,7	40	15	9	-10		30	2144	222	9,02	0,621
492	22,5	1	0,5	75	0,2	4000	0,3	1500	0	0,4	10	15	15	0		37	3152	329	7,13	3,26
493	35	0,2	0,3	75	1	4000	1	3000	10	0,4	40	15	9	-10		29,2	616	200	9,14	-0,037
494	22,5	1	0,3	120	1	5000	1	1500	10	0,4	40	0	12	-5		27,4	1887	192	9,74	2,92
495	10	0,2	0,7	120	0,6	4000	1	3000	-10	0,4	25	0	9	-10		30,4	2398	230	8,99	0,331
496	10	0,2	0,3	120	0,2	4000	0,65	3000	-10	0,4	10	15	12	-10		33,8	2583	277	7,9	1,46
497	35	0,2	0,5	75	1	4000	0,65	1500	-10	0,7	25	15	15	-5		24,9	1314	152	10,9	3,25
498	22,5	0,2	0,5	120	1	5000	0,3	1500	-10	0,7	40	30	15	0		21,2	778	109	12,5	4,65
499	22,5	0,2	0,3	120	0,6	4000	1	3000	10	0,7	40	30	12	0		28	1896	199	9,59	1,76
500	22,5	0,2	0,5	75	0,2	5000	0,65	3000	10	0,7	10	15	12	0		33	2741	270	8,14	2,19
501	35	0,2	0,5	120	0,2	5000	0,3	3000	10	0,7	40	0	12	-5		33,6	2930	277	8,04	1,67
502	10	1	0,5	75	0,2	5000	0,3	3000	0	0,4	10	0	12	-10		34,8	3274	310	7,5	1,24
503	35	1	0,5	75	1	5000	1	3000	-10	0,7	40	30	12	0		26,8	1700	182	10	1,12
504	10	0,2	0,5	75	1	5000	0,65	1500	-10	0,7	10	30	12	-5		30,8	2522	238	8,78	2,03
505	10	1	0,5	75	0,6	5000	0,65	1500	10	0,4	40	0	12	-10		32,8	2978	268	8,26	1,19

A–2 Second Order Multiple Non-Linear (SON) Genel Formula

Y = 1 + 2 x1 + x1^2 + 2 x10 + 2 x1 x10 + x10^2 + 2 x11 + 2 x1 x11 + 2 x10 x11 + x11^2 + 2 x12 + 2 x1 x12 + 2 x10 x12 + 2 x11 x12 + x12^2 + 2 x13 + 2 x1 x13 + 2 x10 x13 + 2 x11 x13 + 2 x12 x13 + x13^2 + 2 x14 + 2 x1 x14 + 2 x10 x14 + 2 x11 x14 + 2 x12 x14 + 2 x13 x14 + x14^2 + 2 x2 + 2 x1 x2 + 2 x10 x2 + 2 x11 x2 + 2 x12 x2 + 2 x13 x2 + 2 x14 x2 + x2^2 + 2 x3 + 2 x1 x3 + 2 x10 x3 + 2 x11 x3 + 2 x12 x3 + 2 x13 x3 + 2 x14 x3 + 2 x2 x3 + x3^2 + 2 x4 + 2 x1 x4 + 2 x10 x4 + 2 x11 x4 + 2 x12 x4 + 2 x13 x4 + 2 x14 x4 + 2 x2 x4 + 2 x3 x4 + x4^2 + 2 x5 + 2 x1 x5 + 2 x10 x5 + 2 x11 x5 + 2 x12 x5 + 2 x13 x5 + 2 x14 x5 + 2 x2 x5 + 2 x3 x5 + 2 x4 x5 + x5^2 + 2 x6 + 2 x1 x6 + 2 x10 x6 + 2 x11 x6 + 2 x12 x6 + 2 x13 x6 + 2 x14 x6 + 2 x2 x6 + 2 x3 x6 + 2 x4 x6 + 2 x5 x6 + x6^2 + 2 x7 + 2 x1 x7 + 2 x10 x7 + 2 x11 x7 + 2 x12 x7 + 2 x13 x7 + 2 x14 x7 + 2 x2 x7 + 2 x3 x7 + 2 x4 x7 + 2 x5 x7 + 2 x6 x7 + x7^2 + 2 x8 + 2 x1 x8 + 2 x10 x8 + 2 x11 x8 + 2 x12 x8 + 2 x13 x8 + 2 x14 x8 + 2 x2 x8 + 2 x3 x8 + 2 x4 x8 + 2 x5 x8 + 2 x6 x8 + 2 x7 x8 + x8^2 + 2 x9 + 2 x1 x9 + 2 x10 x9 + 2 x11 x9 + 2 x12 x9 + 2 x13 x9 + 2 x14 x9 + 2 x2 x9 + 2 x3 x9 + 2 x4 x9 + 2 x5 x9 + 2 x6 x9 + 2 x7 x9 + 2 x8 x9 + x9^2

A–3 Third Order Multiple Non-Linear (TON) Genel Formula

Y = 1 + 3 x1 + 3 x1^2 + x1^3 + 3 x10 + 6 x1 x10 + 3 x1^2 x10 + 3 x10^2 + 3 x1 x10^2 + x10^3 + 3 x11 + 6 x1 x11 + 3 x1^2 x11 + 6 x10 x11 + 6 x1 x10 x11 + 3 x10^2 x11 + 3 x11^2 + 3 x1 x11^2 + 3 x10 x11^2 + x11^3 + 3 x12 + 6 x1 x12 + 3 x1^2 x12 + 6 x10 x12 + 6 x1 x10 x12 + 3 x10^2 x12 + 6 x11 x12 + 6 x1 x11 x12 + 6 x10 x11 x12 + 3 x11^2 x12 + 3 x12^2 + 3 x1 x12^2 + 3 x10 x12^2 + 3 x11 x12^2 + x12^3 + 3 x13 + 6 x1 x13 + 3 x1^2 x13 + 6 x10 x13 + 6 x1 x10 x13 + 3 x10^2 x13 + 6 x11 x13 + 6 x1 x11 x13 + 6 x10 x11 x13 + 3 x11^2 x13 + 6 x12 x13 + 6 x1 x12 x13 + 6 x10 x12 x13 + 6 x11 x12 x13 + 3 x12^2 x13 + 3 x13^2 + 3 x1 x13^2 + 3 x10 x13^2 + 3 x11 x13^2 + 3 x12 x13^2 + x13^3 + 3 x14 + 6 x1 x14 + 3 x1^2 x14 + 6 x10 x14 + 6 x1 x10 x14 + 3 x10^2 x14 + 6 x11 x14 + 6 x1 x11 x14 + 6 x10 x11 x14 + 3 x11^2 x14 + 6 x12 x14 + 6 x1 x12 x14 + 6 x10 x12 x14 + 6 x11 x12 x14 + 3 x12^2 x14 + 6 x13 x14 + 6 x1 x13 x14 + 6 x10 x13 x14 + 6 x11 x13 x14 + 6 x12 x13 x14 + 3 x13^2 x14 + 3 x14^2 + 3 x1 x14^2 + 3 x10 x14^2 + 3 x11 x14^2 + 3 x12 x14^2 + 3 x13 x14^2 + x14^3 + 3 x2 + 6 x1 x2 + 3 x1^2 x2 + 6 x10 x2 + 6 x1 x10 x2 + 3 x10^2 x2 + 6 x11 x2 + 6 x1 x11 x2 + 6 x10 x11 x2 + 3 x11^2 x2 + 6 x12 x2 + 6 x1 x12 x2 + 6 x10 x12 x2 + 6 x11 x12 x2 + 3 x12^2 x2 + 6 x13 x2 + 6 x1 x13 x2 + 6 x10 x13 x2 + 6 x11 x13 x2 + 6 x12 x13 x2 + 3 x13^2 x2 + 6 x14 x2 + 6 x1 x14 x2 + 6 x10 x14 x2 + 6 x11 x14 x2 + 6 x12 x14 x2 + 6 x13 x14 x2 + 3 x14^2 x2 + 3 x2^2 + 3 x1 x2^2 + 3 x10 x2^2 + 3 x11 x2^2 + 3 x12 x2^2 + 3 x13 x2^2 + 3 x14 x2^2 + x2^3 + 3 x3 + 6 x1 x3 + 3 x1^2 x3 + 6 x10 x3 + 6 x1 x10 x3 + 3 x10^2 x3 + 6 x11 x3 + 6 x1 x11 x3 + 6 x10 x11 x3 + 3 x11^2 x3 + 6 x12 x3 + 6 x1 x12 x3 + 6 x10 x12 x3 + 6 x11 x12 x3 + 3 x12^2 x3 + 6 x13 x3 + 6 x1 x13 x3 + 6 x10 x13 x3 + 6 x11 x13 x3 + 6 x12 x13 x3 + 3 x13^2 x3 + 6 x14 x3 + 6 x1 x14 x3 + 6 x10 x14 x3 + 6 x11 x14 x3 + 6 x12 x14 x3 + 6 x13 x14 x3 + 3 x14^2 x3 + 6 x2 x3 + 6 x1 x2 x3 + 6 x10 x2 x3 + 6 x11 x2 x3 + 6 x12 x2 x3 + 6 x13 x2 x3 + 6 x14 x2 x3 + 3 x2^2 x3 + 3 x3^2 + 3 x1 x3^2 + 3 x10 x3^2 + 3 x11 x3^2 + 3 x12 x3^2 + 3 x13 x3^2 + 3 x14 x3^2 + 3 x2 x3^2 + x3^3 + 3 x4 + 6 x1 x4 + 3 x1^2 x4 + 6 x10 x4 + 6 x1 x10 x4 + 3 x10^2 x4 + 6 x11 x4 + 6 x1 x11 x4 + 6 x10 x11 x4 + 3 x11^2 x4 + 6 x12 x4 + 6 x1 x12 x4 + 6 x10 x12 x4 + 6 x11 x12 x4 + 3 x12^2 x4 + 6 x13 x4 + 6 x1 x13 x4 + 6 x10 x13 x4 + 6 x11 x13 x4 + 6 x12 x13 x4 + 3 x13^2 x4 + 6 x14 x4 + 6 x1 x14 x4 + 6 x10 x14 x4 + 6 x11 x14 x4 + 6 x12 x14 x4 + 6 x13 x14 x4 + 3 x14^2 x4 + 6 x2 x4 + 6 x1 x2 x4 + 6 x10 x2 x4 + 6 x11 x2 x4 + 6 x12 x2 x4 + 6 x13 x2 x4 + 6 x14 x2 x4 + 3 x2^2 x4 + 6 x3 x4 + 6 x1 x3 x4 + 6 x10 x3 x4 + 6 x11 x3 x4 + 6 x12 x3 x4 + 6 x13 x3 x4 + 6 x14 x3 x4 + 6 x2 x3 x4 + 3 x3^2 x4 + 3 x4^2 + 3 x1 x4^2 + 3 x10 x4^2 + 3 x11 x4^2 + 3 x12 x4^2 + 3 x13 x4^2 + 3 x14 x4^2 + 3 x2 x4^2 + 3 x3 x4^2 + x4^3 + 3 x5 + 6 x1 x5 + 3 x1^2 x5 + 6 x10 x5 + 6 x1 x10 x5 + 3 x10^2 x5 + 6 x11 x5 + 6 x1 x11 x5 + 6 x10 x11 x5 + 3 x11^2 x5 + 6 x12 x5 + 6 x1 x12 x5 + 6 x10 x12 x5 + 6 x11 x12 x5 + 3 x12^2 x5 + 6 x13 x5 + 6 x1 x13 x5 + 6 x10 x13 x5 + 6 x11 x13 x5 + 6 x12 x13 x5 + 3 x13^2 x5 + 6 x14 x5 + 6 x1 x14 x5 + 6 x10 x14 x5 + 6 x11 x14 x5 + 6 x12 x14 x5 + 6 x13 x14 x5 + 3 x14^2 x5 + 6 x2 x5 + 6 x1 x2 x5 + 6 x10 x2 x5 + 6 x11 x2 x5 + 6 x12 x2 x5 + 6 x13 x2 x5 + 6 x14 x2 x5 + 3 x2^2 x5 + 6 x3 x5 + 6 x1 x3 x5 + 6 x10 x3 x5 + 6 x11 x3 x5 + 6 x12 x3 x5 + 6 x13 x3 x5 + 6 x14 x3 x5 + 6 x2 x3 x5 + 3 x3^2 x5 + 6 x4 x5 + 6 x1 x4 x5 + 6 x10 x4 x5 + 6 x11 x4 x5 + 6 x12 x4 x5 + 6 x13 x4 x5 + 6 x14 x4 x5 + 6 x2 x4 x5 + 6 x3 x4 x5 + 3 x4^2 x5 + 3 x5^2 + 3 x1 x5^2 + 3 x10 x5^2 + 3 x11 x5^2 + 3 x12 x5^2 + 3 x13 x5^2 + 3 x14 x5^2 + 3 x2 x5^2 + 3 x3 x5^2 + 3 x4 x5^2 + x5^3 + 3 x6 + 6 x1 x6 + 3 x1^2 x6 + 6 x10 x6 + 6 x1 x10 x6 + 3 x10^2 x6 + 6 x11 x6 + 6 x1 x11 x6 + 6 x10 x11 x6 + 3 x11^2 x6 + 6 x12 x6 + 6 x1 x12 x6 + 6 x10 x12 x6 + 6 x11 x12 x6 + 3 x12^2 x6 + 6 x13 x6 + 6 x1 x13 x6 + 6 x10 x13 x6 + 6 x11 x13 x6 + 6 x12 x13 x6 + 3 x13^2 x6 + 6 x14 x6 + 6 x1 x14 x6 + 6 x10 x14 x6 + 6 x11 x14 x6 + 6 x12 x14 x6 + 6 x13 x14 x6 + 3 x14^2 x6 + 6 x2 x6 + 6 x1 x2 x6 + 6 x10 x2 x6 + 6 x11 x2 x6 + 6 x12 x2 x6 + 6 x13 x2 x6 + 6 x14 x2 x6 + 3 x2^2 x6 + 6 x3 x6 + 6 x1 x3 x6 + 6 x10 x3 x6 + 6 x11 x3 x6 + 6 x12 x3 x6 + 6 x13 x3 x6 + 6 x14 x3 x6 + 6 x2 x3 x6 + 3 x3^2 x6 + 6 x4 x6 + 6 x1 x4 x6 + 6 x10 x4 x6 + 6 x11 x4 x6 + 6 x12 x4 x6 + 6 x13 x4 x6 + 6 x14 x4 x6 + 6 x2 x4 x6 + 6 x3 x4 x6 + 3 x4^2 x6 + 6 x5 x6 + 6 x1 x5 x6 + 6 x10 x5 x6 + 6 x11 x5 x6 + 6 x12 x5 x6 + 6 x13 x5 x6 + 6 x14 x5 x6 + 6 x2 x5 x6 + 6 x3 x5 x6 + 6 x4 x5 x6 + 3 x5^2 x6 + 3 x6^2 + 3 x1 x6^2 + 3 x10 x6^2 + 3 x11 x6^2 + 3 x12 x6^2 + 3 x13 x6^2 + 3 x14 x6^2 + 3 x2 x6^2 + 3 x3 x6^2 + 3 x4 x6^2 + 3 x5 x6^2 + x6^3 + 3 x7 + 6 x1 x7 + 3 x1^2 x7 + 6 x10 x7 + 6 x1 x10 x7 + 3 x10^2 x7 + 6 x11 x7 + 6 x1 x11 x7 + 6 x10 x11 x7 + 3 x11^2 x7 + 6 x12 x7 + 6 x1 x12 x7 + 6 x10 x12 x7 + 6 x11 x12 x7 + 3 x12^2 x7 + 6 x13 x7 + 6 x1 x13 x7 + 6 x10 x13 x7 + 6 x11 x13 x7 + 6 x12 x13 x7 + 3 x13^2 x7 + 6 x14 x7 + 6 x1 x14 x7 + 6 x10 x14 x7 + 6 x11 x14 x7 + 6 x12 x14 x7 + 6 x13 x14 x7 + 3 x14^2 x7 + 6 x2 x7 + 6 x1 x2 x7 + 6 x10 x2 x7 + 6 x11 x2 x7 + 6 x12 x2 x7 + 6 x13 x2 x7 + 6 x14 x2 x7 + 3 x2^2 x7 + 6 x3 x7 + 6 x1 x3 x7 + 6 x10 x3 x7 + 6 x11 x3 x7 + 6 x12 x3 x7 + 6 x13 x3 x7 + 6 x14 x3 x7 + 6 x2 x3 x7 + 3 x3^2 x7 + 6 x4 x7 + 6 x1 x4 x7 + 6 x10 x4 x7 + 6 x11 x4 x7 + 6 x12 x4 x7 + 6 x13 x4 x7 + 6 x14 x4 x7 + 6 x2 x4 x7 + 6 x3 x4 x7 + 3 x4^2 x7 + 6 x5 x7 + 6 x1 x5 x7 + 6 x10 x5 x7 + 6 x11 x5 x7 + 6 x12 x5 x7 + 6 x13 x5 x7 + 6 x14 x5 x7 + 6 x2 x5 x7 + 6 x3 x5 x7 + 6 x4 x5 x7 + 3 x5^2 x7 + 6 x6 x7 + 6 x1 x6 x7 + 6 x10 x6 x7 + 6 x11 x6 x7 + 6 x12 x6 x7 + 6 x13 x6 x7 + 6 x14 x6 x7 + 6 x2 x6 x7 + 6 x3 x6 x7 + 6 x4 x6 x7 + 6 x5 x6 x7 + 3 x6^2 x7 + 3 x7^2 + 3 x1 x7^2 + 3 x10 x7^2 + 3 x11 x7^2 + 3 x12 x7^2 + 3 x13 x7^2 + 3 x14 x7^2 + 3 x2 x7^2 + 3 x3 x7^2 + 3 x4 x7^2 + 3 x5 x7^2 + 3 x6 x7^2 + x7^3 + 3 x8 + 6 x1 x8 + 3 x1^2 x8 + 6 x10 x8 + 6 x1 x10 x8 + 3 x10^2 x8 + 6 x11 x8 + 6 x1 x11 x8 + 6 x10 x11 x8 + 3 x11^2 x8 + 6 x12 x8 + 6 x1 x12 x8 + 6 x10 x12 x8 + 6 x11 x12 x8 + 3 x12^2 x8 + 6 x13 x8 + 6 x1 x13 x8 + 6 x10 x13 x8 + 6 x11 x13 x8 + 6 x12 x13 x8 + 3 x13^2 x8 + 6 x14 x8 + 6 x1 x14 x8 + 6 x10 x14 x8 + 6 x11 x14 x8 + 6 x12 x14 x8 + 6 x13 x14 x8 + 3 x14^2 x8 + 6 x2 x8 + 6 x1 x2 x8 + 6 x10 x2 x8 + 6 x11 x2 x8 + 6 x12 x2 x8 + 6 x13 x2 x8 + 6 x14 x2 x8 + 3 x2^2 x8 + 6 x3 x8 + 6 x1 x3 x8 + 6 x10 x3 x8 + 6 x11 x3 x8 + 6 x12 x3 x8 + 6 x13 x3 x8 + 6 x14 x3 x8 + 6 x2 x3 x8 + 3 x3^2 x8 + 6 x4 x8 + 6 x1 x4 x8 + 6 x10 x4 x8 + 6 x11 x4 x8 + 6 x12 x4 x8 + 6 x13 x4 x8 + 6 x14 x4 x8 + 6 x2 x4 x8 + 6 x3 x4 x8 + 3 x4^2 x8 + 6 x5 x8 + 6 x1 x5 x8 + 6 x10 x5 x8 + 6 x11 x5 x8 + 6 x12 x5 x8 + 6 x13 x5 x8 + 6 x14 x5 x8 + 6 x2 x5 x8 + 6 x3 x5 x8 + 6 x4 x5 x8 + 3 x5^2 x8 + 6 x6 x8 + 6 x1 x6 x8 + 6 x10 x6 x8 + 6 x11 x6 x8 + 6 x12 x6 x8 + 6 x13 x6 x8 + 6 x14 x6 x8 + 6 x2 x6 x8 + 6 x3 x6 x8 + 6 x4 x6 x8 + 6 x5 x6 x8 + 3 x6^2 x8 + 6 x7 x8 + 6 x1 x7 x8 + 6 x10 x7 x8 + 6 x11 x7 x8 + 6 x12 x7 x8 + 6 x13 x7 x8 + 6 x14 x7 x8 + 6 x2 x7 x8 + 6 x3 x7 x8 + 6 x4 x7 x8 + 6 x5 x7 x8 + 6 x6 x7 x8 + 3 x7^2 x8 + 3 x8^2 + 3 x1 x8^2 + 3 x10 x8^2 + 3 x11 x8^2 + 3 x12 x8^2 + 3 x13 x8^2 + 3 x14 x8^2 + 3 x2 x8^2 + 3 x3 x8^2 + 3 x4 x8^2 + 3 x5 x8^2 + 3 x6 x8^2 + 3 x7 x8^2 + x8^3 + 3 x9 + 6 x1 x9 + 3 x1^2 x9 + 6 x10 x9 + 6 x1 x10 x9 + 3 x10^2 x9 + 6 x11 x9 + 6 x1 x11 x9 + 6 x10 x11 x9 + 3 x11^2 x9 + 6 x12 x9 + 6 x1 x12 x9 + 6 x10 x12 x9 + 6 x11 x12 x9 + 3 x12^2 x9 + 6 x13 x9 + 6 x1 x13 x9 + 6 x10 x13 x9 + 6 x11 x13 x9 + 6 x12 x13 x9 + 3 x13^2 x9 + 6 x14 x9 + 6 x1 x14 x9 + 6 x10 x14 x9 + 6 x11 x14 x9 + 6 x12 x14 x9 + 6 x13 x14 x9 + 3 x14^2 x9 + 6 x2 x9 + 6 x1 x2 x9 + 6 x10 x2 x9 + 6 x11 x2 x9 + 6 x12 x2 x9 + 6 x13 x2 x9 + 6 x14 x2 x9 + 3 x2^2 x9 + 6 x3 x9 + 6 x1 x3 x9 + 6 x10 x3 x9 + 6 x11 x3 x9 + 6 x12 x3 x9 + 6 x13 x3 x9 + 6 x14 x3 x9 + 6 x2 x3 x9 + 3 x3^2 x9 + 6 x4 x9 + 6 x1 x4 x9 + 6 x10 x4 x9 + 6 x11 x4 x9 + 6 x12 x4 x9 + 6 x13 x4 x9 + 6 x14 x4 x9 + 6 x2 x4 x9 + 6 x3 x4 x9 + 3 x4^2 x9 + 6 x5 x9 + 6 x1 x5 x9 + 6 x10 x5 x9 + 6 x11 x5 x9 + 6 x12 x5 x9 + 6 x13 x5 x9 + 6 x14 x5 x9 + 6 x2 x5 x9 + 6 x3 x5 x9 + 6 x4 x5 x9 + 3 x5^2 x9 + 6 x6 x9 + 6 x1 x6 x9 + 6 x10 x6 x9 + 6 x11 x6 x9 + 6 x12 x6 x9 + 6 x13 x6 x9 + 6 x14 x6 x9 + 6 x2 x6 x9 + 6 x3 x6 x9 + 6 x4 x6 x9 + 6 x5 x6 x9 + 3 x6^2 x9 + 6 x7 x9 + 6 x1 x7 x9 + 6 x10 x7 x9 + 6 x11 x7 x9 + 6 x12 x7 x9 + 6 x13 x7 x9 + 6 x14 x7 x9 + 6 x2 x7 x9 + 6 x3 x7 x9 + 6 x4 x7 x9 + 6 x5 x7 x9 + 6 x6 x7 x9 + 3 x7^2 x9 + 6 x8 x9 + 6 x1 x8 x9 + 6 x10 x8 x9 + 6 x11 x8 x9 + 6 x12 x8 x9 + 6 x13 x8 x9 + 6 x14 x8 x9 + 6 x2 x8 x9 + 6 x3 x8 x9 + 6 x4 x8 x9 + 6 x5 x8 x9 + 6 x6 x8 x9 + 6 x7 x8 x9 + 3 x8^2 x9 + 3 x9^2 + 3 x1 x9^2 + 3 x10 x9^2 + 3 x11 x9^2 + 3 x12 x9^2 + 3 x13 x9^2 + 3 x14 x9^2 + 3 x2 x9^2 + 3 x3 x9^2 + 3 x4 x9^2 + 3 x5 x9^2 + 3 x6 x9^2 + 3 x7 x9^2 + 3 x8 x9^2 + x9^3

A–4 Regression model used for VOR (SON)

VOR = (-2.0951009705158293`*10^13 + 4.340745956373227`*10^13 [BEK] - 3.608431842352215`*10^13 [BEK]^2 - 3.3967216339284814`*10^11 [MGEK] + 4.23767704111145`*10^10 [BEK] [MGEK] + 2.3721021775271667`*10^10 [MGEK]^2 + 5.060457121695314`*10^10 [MSTA] + 2.7169003737415448`*10^7 [BEK] [MSTA] + 5.678541058711201`*10^7 [MGEK] [MSTA] - 1.124551493321809`*10^7 [MSTA]^2 - 1.63133290297773`*10^12 [OGEK] - 2.0522016699487674`*10^11 [BEK] [OGEK] - 2.1218941281786716`*10^11 [MGEK] [OGEK] - 1.817544262605129`*10^7 [MSTA] [OGEK] + 3.814661354636895`*10^10 [OGEK]^2 - 1.0617434776075471`*10^11 [OGU] -2.292047215820363`*10^9 [BEK] [OGU] - 5.199724639634311`*10^9 [MGEK] [OGU] - 1.8638103501519773`*10^6 [MSTA] [OGU] + 1.2837529056109915`*10^10 [OGEK] [OGU] + 4.883041748556605`*10^8 [OGU]^2 - 1.719058654584833`*10^10 [PD] - 9.567022794572754`*10^10 [BEK] [PD] - 9.766786592194006`*10^10 [MGEK] [PD] + 3.1195766898668937`*10^7 [MSTA] [PD] - 3.833880800518143`*10^11 [OGEK] [PD] - 5.0501490086159115`*10^9 [OGU] [PD] + 7.463297079698893`*10^11 [PD]^2 - 2.164776061804013`*10^10 [BU] + 8.046830532349296`*10^9 [BEK] [BU] + 2.721576619823895`*10^9 [MGEK] [BU] + 1.5375330291521836`*10^6 [MSTA] [BU] - 4.271823448399746`*10^9 [OGEK] [BU] + 3.721887720606793`*10^7 [OGU] [BU] + 4.0168105502260327`*10^9 [PD] [BU] - 1.0446831050140606`*10^8 [BU]^2 + 2.9238700718493433`*10^9 [FYA] + 1.0280374305899236`*10^7 [BEK] [FYA] + 3.443100099712413`*10^7 [MGEK] [FYA] - 11610.909234682325` [MSTA] [FYA] - 5.99615273517188`*10^7 [OGEK] [FYA] - 2.793343298657149`*10^6 [OGU] [FYA] + 2.7607897745389414`*10^8 [PD] [FYA] + 2.916425304780165`*10^6 [BU] [FYA] - 295325.81782333506` [FYA]^2 - 3.947743127710481`*10^10 [KAU] - 9.202455488928279`*10^8 [BEK] [KAU] + 1.9618869154693828`*10^9 [MGEK] [KAU] - 736936.4252920175` [MSTA] [KAU] - 5.691095888183844`*10^8 [OGEK] [KAU] + 3.471499913503778`*10^7 [OGU] [KAU] + 1.3981398418847363`*10^9 [PD] [KAU] + 1.3658495242483214`*10^8 [BU] [KAU] - 515218.1678837271` [FYA] [KAU] + 2.0325780454159945`*10^8 [KAU]^2 - 1.2744722755690272`*10^14 [KEK] + 1.5230313721046011`*10^9 [BEK] [KEK] + 2.1198391170217508`*10^11 [MGEK] [KEK] - 1.7248831043948125`*10^7 [MSTA] [KEK] - 3.2328647578336005`*10^11 [OGEK] [KEK] + 7.605447338959344`*10^9 [OGU] [KEK] - 3.8590681911971954`*10^11 [PD] [KEK] - 9.520715461896194`*10^9 [BU] [KEK] - 2.170998995425437`*10^7 [FYA] [KEK] + 8.113253635772294`*10^9 [KAU] [KEK] + 1.1368735825637933`*10^14 [KEK]^2 + 3.3710715704405853`*10^10 [KK] + 2.8960716468633356`*10^9 [BEK] [KK] - 1.8574406562573354`*10^9 [MGEK] [KK] - 731477.0208716816` [MSTA] [KK] - 5.790434721700892`*10^9 [OGEK] [KK] - 7.514241147090124`*10^7 [OGU] [KK] + 3.031039275775126`*10^9 [PD] [KK] - 1.0224638465754372`*10^8 [BU] [KK] - 793146.6405272804` [FYA] [KK] - 1.33042374967059`*10^8 [KAU] [KK] - 4.529840888859495`*10^8 [KEK] [KK] + 2.0568809642460752`*10^8 [KK]^2 - 1.596351849534589`*10^10 [KP] + 2.9374515831142053`*10^7 [BEK] [KP] + 1.0966255044451235`*10^10 [MGEK] [KP] - 1.4488977544294172`*10^6 [MSTA] [KP] - 1.139365325273034`*10^10 [OGEK] [KP] + 1.5019263139286244`*10^8 [OGU] [KP] + 2.3827042033794415`*10^10 [PD] [KP] - 2.716113711278824`*10^8 [BU] [KP] - 2.4573363084699363`*10^6 [FYA] [KP] + 6.941275907133919`*10^7 [KAU] [KP] + 2.3201434297610683`*10^10 [KEK] [KP] - 747471.7091178085` [KK] [KP] + 8.378096018183143`*10^8 [KP]^2 - 2.1762570525809155`*10^10 [KÜU] + 8.549404107618804`*10^8 [BEK] [KÜU] + 2.21145691941551`*10^9 [MGEK] [KÜU] - 360800.4519868893` [MSTA] [KÜU] - 7.000952055360344`*10^9 [OGEK] [KÜU] - 2.8456123916004892`*10^7 [OGU] [KÜU] + 6.532496798749869`*10^9 [PD] [KÜU] + 1.0936152424876485`*10^6 [BU] [KÜU] - 1.2637425578057955`*10^6 [FYA] [KÜU] - 9.763184427049585`*10^7 [KAU] [KÜU] + 1.4650358781477634`*10^10 [KEK] [KÜU] + 2.4738981068400303`*10^8 [KK] [KÜU] - 1.7375501142566103`*10^8 [KP] [KÜU] + 1.2622863964822683`*10^7 [KÜU]^2 - 2.1544506322999377`*10^11 [KY] + 1.0011982586528418`*10^9 [BEK] [KY] - 1.0240340664620543`*10^10 [MGEK] [KY] + 6.009878319793221`*10^6 [MSTA] [KY] + 2.2390733836839075`*10^9 [OGEK] [KY] + 4.5351221179457885`*10^8 [OGU] [KY] - 1.8409873641168053`*10^10 [PD] [KY] -3.883516912104602`*10^8 [BU] [KY] - 1.6190209972998877`*10^6 [FYA] [KY] + 1.0609952121257688`*10^9 [KAU] [KY] + 2.5236596218993053`*10^10 [KEK] [KY] + 26.581203298151341`*10^7 [KK] [KY] - 4.430425969851679`*10^8 [KP] [KY] +1.2501456173596623`*10^9 [KÜU] [KY] + 2.627056253641043`*10^9 [KY]^2)/(2.0882479478178772`*10^12 - 8.058372808679385`*10^10 [BEK] + 7.357040624862796`*10^10 [BEK]^2 + 2.171672579702279`*10^10 [MGEK] + 8.99523156765468`*10^8 [BEK] [MGEK] - 1.5922860925548887`*10^9 [MGEK]^2 - 2.5570572544556317`*10^9 [MSTA] + 730130.2062469507` [BEK] [MSTA] + 948858.5056706788` [MGEK] [MSTA] + 569490.8903875554` [MSTA]^2 - 4.7767975343043785`*10^9 [OGEK] - 7.66769221268621`*10^9 [BEK] [OGEK] - 1.5717470568372864`*10^10 [MGEK] [OGEK] - 2.107938151971071`*10^6 [MSTA] [OGEK] - 6.028638789690496`*10^9 [OGEK]^2 - 1.4610979760088326`*10^10 [OGU] - 8.988151365621656`*10^7 [BEK] [OGU] - 2.522172071191369`*10^8 [MGEK] [OGU] - 76100.42340998005` [MSTA] [OGU] +3.385613185369979`*10^8 [OGEK] [OGU] + 7.490109901242067`*10^7 [OGU]^2 - 1.9286463557651787`*10^10 [PD] - 3.2583682181877403`*10^9 [BEK] [PD] - 2.2012593184840712`*10^8 [MGEK] [PD] + 1.6486943273958121`*10^6 [MSTA] [PD] - 8.277889430489897`*10^9 [OGEK] [PD] - 1.335335491725561`*10^8 [OGU] [PD] + 2.6101582287296104`*10^10 [PD]^2 - 5.133244783622768`*10^8 [BU] + 2.799475508415474`*10^8 [BEK] [BU] + 5.345999264198902`*10^7 [MGEK] [BU] + 42133.748711610504` [MSTA] [BU] - 1.9789137048017636`*10^8 [OGEK] [BU] + 728194.0931557558` [OGU] [BU] + 1.6246647163204503`*10^8 [PD] [BU] -3.583160066380253`*10^6 [BU]^2 + 4.5912415985378355`*10^8 [FYA] +.66387794784` [BEK] [FYA] + 1.0282887956534828`*10^6 [MGEK] [FYA] - 404.7100370745733` [MSTA] [FYA] - 2.485014612604869`*10^6 [OGEK] [FYA] - 102057.51462197248` [OGU] [FYA] + 9.477324201447692`*10^6 [PD] [FYA] + 96938.53254800114` [BU] [FYA] - 49711.951225827834` [FYA]^2 - 1.0191681214323043`*10^9 [KAU] - 4.118372647538454`*10^7 [BEK] [KAU] + 1.0609749952980658`*10^7 [MGEK] [KAU] - 31753.47206938325` [MSTA] [KAU] - 1.0306270007843879`*10^8 [OGEK] [KAU] + 418191.01499995764` [OGU] [KAU] + 7.077302970874152`*10^7 [PD] [KAU] + 4.241126600112407`*10^6 [BU] [KAU] - 23462.072548361943` [FYA] [KAU] + 6.6580562480604295`*10^6 [KAU]^2 + 1.1068425913195706`*10^12 [KEK] - 1.2403709121239145`*10^9 [BEK] [KEK] - 4.6938439727795535`*10^8 [MGEK] [KEK] - 1.955759261059881`*10^6 [MSTA] [KEK] - 2.1362919312968365`*10^10 [OGEK] [KEK] + 1.5620340408912316`*10^8 [OGU] [KEK] - 8.846730968676884`*10^9 [PD] [KEK] - 3.4983782776963484`*10^8 [BU] [KEK] - 1.7376742119510383`*10^6 [FYA] [KEK] + 2.3827017300832573`*10^8 [KAU] [KEK] - 1.0458468976188181`*10^12 [KEK]^2 + 7.583816900859382`*10^8 [KK] + 1.0676549662841734`*10^8 [BEK] [KK] + 9.60422996733389`*10^6 [MGEK] [KK] - 10456.031253292747` [MSTA] [KK] - 9.095422894343452`*10^7 [OGEK] [KK] - 1.7496794774162872`*10^6 [OGU] [KK] + 9.251637725606567`*10^7 [PD] [KK] - 3.21019744218384`*10^6 [BU] [KK] - 12387.11578468707` [FYA] [KK] -3.9167886788446093`*10^6 [KAU] [KK] + 1.7417304962516576`*10^7 [KEK] [KK] + 5.848377976961323`*10^6 [KK]^2 - 3.217034136882967`*10^8 [KP] + 1.798858527149548`*10^6 [BEK] [KP] + 3.332956679591181`*10^8 [MGEK] [KP] - 63824.782325682834` [MSTA] [KP] - 4.1491568494832087`*10^8 [OGEK] [KP] + 4.475699387080379`*10^6 [OGU] [KP] + 7.991921462527481`*10^8 [PD] [KP] - 9.222625190540675`*10^6 [BU] [KP] - 97445.69154353149` [FYA] [KP] + 2.630107300567772`*10^6 [KAU] [KP] + 7.227173693787031`*10^8 [KEK] [KP] + 254348.06183101126` [KK] [KP] + 2.5785669440851867`*10^7 [KP]^2 - 4.737053179155084`*10^8 [KÜU] + 2.5533768912481416`*10^7 [BEK] [KÜU] + 1.9136353973558966`*10^7 [MGEK] [KÜU] - 19913.410816200932` [MSTA] [KÜU] - 3.051703311556186`*10^8 [OGEK] [KÜU] - 1.629899475243863`*10^6 [OGU] [KÜU] + 2.4227498869384447`*10^8 [PD] [KÜU] - 412409.6294283219` [BU] [KÜU] - 41499.1491379316` [FYA] [KÜU] - 3.5780239879180305`*10^6 [KAU] [KÜU] + 4.538778959167255`*10^8 [KEK] [KÜU] + 8.750557828186678`*10^6 [KK] [KÜU] - 6.007007499430087`*10^6 [KP] [KÜU] + 199152.42745664399` [KÜU]^2 - 5.492561322726513`*10^9 [KY] - 1.0251618867370784`*10^7 [BEK] [KY] - 6.229657730839468`*10^8 [MGEK] [KY] + 141829.94804819347` [MSTA] [KY] - 3.677524050945533`*10^8 [OGEK] [KY] + 1.130366809560762`*10^7 [OGU] [KY] - 4.9851472336520284`*10^8 [PD] [KY] - 1.592695962197429`*10^7 [BU] [KY] - 88843.3715630223` [FYA] [KY] + 3.382420093989005`*10^7 [KAU] [KY] + 6.292717384309503`*10^8 [KEK] [KY] + 3.2690113960994673`*10^6 [KK] [KY] - 1.4385947355576348`*10^7 [KP] [KY] + 4.014750081826567`*10^7 [KÜU] [KY] + 8.09661714345044`*10^7 [KY]^2)

A–5 Regression model used for AP (TON)

AP = 491.73462528631615` + 77.30238138839243` [BEK] - 98.94628106079907` [BEK]^2 - 134.98632439008696` [BEK]^3 - 1645.7575009364634` [MGEK] - 93.5305796178528` [BEK] [MGEK] +
540.4254915104696` [BEK]^2 [MGEK] - 460.6972969898086` [MGEK]^2 + 499.06032023826594` [BEK] [MGEK]^2 + 1948.1219097854807` [MGEK]^3 + 0.1778858144313324` [MSTA] -
0.17275325301664385` [BEK] [MSTA] - 0.2858847075902887` [BEK]^2 [MSTA] - 0.4875309382196566` [MGEK] [MSTA] - 0.1112266870541 7764` [BEK] [MGEK] [MSTA] + 0.14358286464206083`
[MGEK]^2 [MSTA] + 0.00005337084505373463` [MSTA]^2 - 0.00010941784766977414` [BEK] [MSTA]^2 - 0.0001155790569390612` [MGEK] [MSTA]^2 + 1.5774182182413007`*10^-8 [MSTA]^3
+ 715.0027209133513` [OGEK] + 2183.6673208171633` [BEK] [OGEK] + 2436.7029781388137` [BEK]^2 [OGEK] - 1252.2873192135535` [MGEK] [OGEK] - 388.65193498996564` [BEK] [MGEK]
[OGEK] - 61.918202175572134` [MGEK]^2 [OGEK] + 0.6023656750637291` [MSTA] [OGEK] - 0.029950622004328818` [BEK] [MSTA] [OGEK] - 0.9303615023928837` [MGEK] [MSTA] [OGEK] +
0.0002790775694384997` [MSTA]^2 [OGEK] - 596.5914474461889` [OGEK]^2 - 1201.6013985008126` [BEK] [OGEK]^2 - 346.26896021638186` [MGEK] [OGEK]^2 + 0.41286543390419733`
[MSTA] [OGEK]^2 - 1871.582372195774` [OGEK]^3 + 2.4688359262143242` [OGU] + 0.8636751340208566` [BEK] [OGU] + 0.09163165023382963` [BEK]^2 [OGU] - 0.3973192945161398`
[MGEK] [OGU] + 0.7300010167046544` [BEK] [MGEK] [OGU] - 4.089528759206513` [MGEK]^2 [OGU] - 0.0014985490933202663` [MSTA] [OGU] + 0.005765874493114294` [BEK] [MSTA]
[OGU] - 0.003286618855791845` [MGEK] [MSTA] [OGU] - 1.1378618185060295`*10^-6 [MSTA]^2 [OGU] - 6.565257799059847` [OGEK] [OGU] - 3.7718013685184726` [BEK] [OGEK] [OGU] +
15.626914512988119` [MGEK] [OGEK] [OGU] 0.008872851431562509` [MSTA] [OGEK] [OGU] + 12.420930647046` [OGEK]^2 [OGU] + 0.003332535914363329` [OGU]^2 + 0.008288464162134216`
[BEK] [OGU]^2 + 0.11812282092879567` [MGEK] [OGU]^2 - 0.00003798939564274211` [MSTA] [OGU]^2 - 0.1611028102331722` [OGEK] [OGU]^2 - 0.0000914310108540717` [OGU]^3 +
1513.5744879035449` [PD] - 70.34579933149875` [BEK] [PD] - 690.9377947624318` [BEK]^2 [PD] + 355.6453801373233` [MGEK] [PD] + 1194.721942630169` [BEK] [MGEK] [PD] -
5395.682491550831` [MGEK]^2 [PD] + 0.6679085254065726` [MSTA] [PD] + 0.33674943269309365` [BEK] [MSTA] [PD] + 0.15161397141816094` [MGEK] [MSTA] [PD] +
0.0002350217430744199` [MSTA]^2 [PD] - 2027.265037512855` [OGEK] [PD] - 303.332791443105` [BEK] [OGEK] [PD] + 2628.762622412346` [MGEK] [OGEK] [PD] - 0.11976072157249756`
[MSTA] [OGEK] [PD] - 792.1771255338228` [OGEK]^2 [PD] - 1.3610956333244382` [OGU] [PD] + 0.7313015118557677` [BEK] [OGU] [PD] - 25.81901386900472` [MGEK] [OGU] [PD] +
0.004160264295367666` [MSTA] [OGU] [PD] - 0.23614471301100212` [OGEK] [OGU] [PD] - 0.1361725190349938` [OGU]^2 [PD] - 130.47097839103407` [PD]^2 - 1644.2044126272353` [BEK]
[PD]^2 + 9170.413785522625` [MGEK] [PD]^2 - 1.3965980968336198` [MSTA] [PD]^2 + 3755.2778892891793` [OGEK] [PD]^2 + 18.49565216788009` [OGU] [PD]^2 - 5955.918855371317` [PD]^3 +
10.171063149384628` [BU] + 42.37930373734521` [BEK] [BU] + 48.74295078289225` [BEK]^2 [BU] + 18.666884030247896` [MGEK] [BU] + 4.173806792889273` [BEK] [MGEK] [BU] -
43.02477027698121` [MGEK]^2 [BU] - 0.008906446491251059` [MSTA] [BU] + 0.003385125298984927` [BEK] [MSTA] [BU] + 0.011126454756294445` [MGEK] [MSTA] [BU] -
6.261845299524419`*10^-6 [MSTA]^2 [BU] - 54.60531585155797` [OGEK] [BU] - 40.738878234590665` [BEK] [OGEK] [BU] - 45.1150399893565` [MGEK] [OGEK] [BU] + 0.004908959301915616`
[MSTA] [OGEK] [BU] - 19.351557335255286` [OGEK]^2 [BU] - 0.008600700170161393` [OGU] [BU] - 0.12108819842559107` [BEK] [OGU] [BU] - 0.8622254584231066` [MGEK] [OGU] [BU] +
0.00008685285905422264` [MSTA] [OGU] [BU] + 0.7973773502557217` [OGEK] [OGU] [BU] - 0.0009085490182502768` [OGU]^2 [BU] + 48.62108634806176` [PD] [BU] + 12.750241956134317`
[BEK] [PD] [BU] + 44.87846244114565` [MGEK] [PD] [BU] + 0.006427674847824426` [MSTA] [PD] [BU] + 0.05601759532822863` [OGEK] [PD] [BU] + 0.05601759532822863` [OGU] [PD] [BU] -
59.69942236856194` [PD]^2 [BU] + 0.7962949453189605` [BU]^2 - 0.966873868599968` [BEK] [BU]^2 - 1.141405352906669` [MGEK] [BU]^2 + 0.0001876681907576767` [MSTA] [BU]^2 -
0.2475328355314455` [OGEK] [BU]^2 + 0.003687325716879089` [OGU] [BU]^2 - 0.4090271829441712` [PD] [BU]^2 + 0.041125625255021316` [BU]^3 + 0.03282131830907915` [FYA] +
0.08210501332615486` [BEK] [FYA] + 0.08924496977539925`[BEK]^2 [FYA] - 0.0731159097017077` [MGEK] [FYA] + 0.21178453337818515` [BEK] [MGEK] [FYA] + 0.4033056569074282`
[MGEK]^2 [FYA] + 0.00004307865200285124` [MSTA] [FYA] - 0.00010831570486590772` [BEK] [MSTA] [FYA] + 0.00011944374637464072` [MGEK] [MSTA] [FYA] + 2.187997105992782`*10^-
8 [MSTA]^2 [FYA] + 0.044443794498788006` [OGEK] [FYA] - 0.5900133883393777` [BEK] [OGEK] [FYA] - 0.6112560918509315` [MGEK] [OGEK] [FYA] - 0.00015654987619400095` [MSTA]
[OGEK] [FYA] + 0.7898728576081595` [OGEK]^2 [FYA] + 0.0002783583387325286`[OGU] [FYA] - 0.0011181830856607203` [BEK] [OGU] [FYA] + 0.000981327854073356` [MGEK] [OGU] [FYA]
- 2.248671505950342`*10^-7 [MSTA] [OGU] [FYA] + 0.00548080637568015` [OGEK] [OGU] [FYA] + 2.0763381532450675`*10^-6 [OGU]^2 [FYA] + 0.17111101286206365` [PD] [FYA] -
0.36243707828254895` [BEK] [PD] [FYA] - 0.23442001624469755` [MGEK] [PD] [FYA] - 0.00016832121156878246` [MSTA] [PD] [FYA] - 1.5440150710012164` [OGEK] [PD] [FYA] -
0.004116760330392223` [OGU] [PD] [FYA] + 0.7860433406271276` [PD]^2 [FYA] - 0.008711257593040372` [BU] [FYA] - 0.007281259057961759` [BEK] [BU] [FYA] + 0.012352308713042824`
[MGEK] [BU] [FYA] - 8.134084755067217`*10^-8 [MSTA] [BU] [FYA] + 0.0021336731894860883` [OGEK] [BU] [FYA] + 0.00004000777649117183` [OGU] [BU] [FYA] + 0.01986351494542911`
[PD] [BU] [FYA] + 0.00009790959981757576` [BU]^2 [FYA] - 8.566169018865844`*10^-6 [FYA]^2 + 0.0000308006469210647` [BEK] [FYA]^2 + 0.000043811254467102674` [MGEK] [FYA]^2 +
9.967967492667126`*10^-9 [MSTA] [FYA]^2 - 0.000013713637569929888` [OGEK] [FYA]^2 + 4.481027132017477`*10^-9 [OGU] [FYA]^2 + 3.0399952044025783`*10^-6 [PD] [FYA]^2 -
4.106800682831765`*10^-6 [BU] [FYA]^2 - 4.806700039579709`*10^-9 [FYA]^3 + 48.880722544213185` [KAU] - 13.515805943632497` [BEK] [KAU] - 35.95417945467851` [BEK]^2 [KAU] -
16.125917124063427` [MGEK] [KAU] + 40.18783389992044` [BEK] [MGEK] [KAU] - 4.8501243953152064` [MGEK]^2 [KAU] + 0.0004490893610132236` [MSTA] [KAU] - 0.006199442042041198`
[BEK] [MSTA] [KAU] - 0.004088834548921128` [MGEK] [MSTA] [KAU] - 4.824795709650471`*10^-6 [MSTA]^2 [KAU] - 7.975695991252769` [OGEK] [KAU] - 1.839633285723478` [BEK]
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- 0.05085646920728562` [BEK] [OGU] [KAU] - 0.05870555749281491` [MGEK] [OGU] [KAU] + 0.0003776843925374084` [MSTA] [OGU] [KAU] + 0.18196812892399916` [OGEK] [OGU] [KAU] -
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1.286463581107217 1` [PD] [BU] [KÜU] + 0.038298229563711025` [BU]^2 [KÜU] + 0.004169753020538643` [FYA] [KÜU] + 0.01344843484363591` [BEK] [FYA] [KÜU] - 0.02433738353099967 2` [MGEK] [FYA] [KÜU] + 0.000010977944553118141` [MSTA] [FYA] [KÜU] + 0.00586587918656957` [OGEK] [FYA] [KÜU] - 0.00012485470481924795` [OGU] [FYA] [KÜU] + 0.038942852101985406` [PD] [FYA] [KÜU] + 0.00003369565284392971` [BU] [FYA] [KÜU] + 9.061286968417172`*10^-7 [FYA]^2 [KÜU] - 1.3904037632658106` [KAU] [KÜU] + 0.16256792719113194` [BEK] [KAU] [KÜU] + 1.443648969479252` [MGEK] [KAU] [KÜU] - 0.0005225516377711643` [MSTA] [KAU] [KÜU] + 1.1136689178046457` [OGEK] [KAU] [KÜU] -0.011942275077733306` [OGU] [KAU] [KÜU] - 2.047130169248` [PD] [KAU] [KÜU] -0.01876434469598304` [BU] [KAU] [KÜU] - 0.0002979058558509732` [FYA] [KAU] [KÜU] +0.056890281488812526` [KAU]^2 [KÜU] + 32.792257034486646` [KEK] [KÜU] -47.98948411154116` [BEK] [KEK] [KÜU] - 40.63613765160685` [MGEK] [KEK] [KÜU] +0.034451869837271644` [MSTA] [KEK] [KÜU] - 124.70399443056343` [OGEK] [KEK] [KÜU] -0.778128241339383` [OGU] [KEK] [KÜU] + 6.479185450476843` [PD] [KEK] [KÜU] -3.5069379301586228` [BU] [KEK] [KÜU] + 0.005525209769901344` [FYA] [KEK] [KÜU] - 1.7458420562255144` [KAU] [KEK] [KÜU] + 49.24241635017352` [KEK]^2 [KÜU] -4.654969615755689` [KK] [KÜU] + 0.35794998936154754` [BEK] [KK] [KÜU] +0.0817749976309840 7` [MGEK] [KK] [KÜU] + 0.0008300314647031043` [MSTA] [KK] [KÜU] -1.2529892702537924` [OGEK] [KK] [KÜU] + 0.015492755330093373` [OGU] [KK] [KÜU] +1.6975230460087156` [PD] [KK] [KÜU] + 0.017898074103807515` [BU] [KK] [KÜU] -0.0002028929169530722` [FYA] [KK] [KÜU] - 0.0060172938466286595` [KAU] [KK] [KÜU] -0.1199001513787746` [KEK] [KK] [KÜU] + 0.05031603280667816 5` [KK]^2 [KÜU] -8.8704085939811` [KP] [KÜU] + 5.658808056999329` [BEK] [KP] [KÜU] -2.052507090362103` [MGEK] [KP] [KÜU] - 0.0002659357228630291` [MSTA] [KP] [KÜU] +0.5997806027432873` [OGEK] [KP] [KÜU] + 0.0008714985019748217` [OGU] [KP] [KÜU] -3.8764403013302546` [PD] [KP] [KÜU] + 0.07346528062685785` [BU] [KP] [KÜU] +0.000309961806915099` [FYA] [KP] [KÜU] - 0.006301477619464864` [KAU] [KP] [KÜU] +2.9482478546643582` [KEK] [KP] [KÜU] + 0.16262250562545835` [KK] [KP] [KÜU] - 0.09342330938687277` [KP]^2 [KÜU] - 0.20308444977461704` [KÜU]^2 +0.3980528669683487` [BEK] [KÜU]^2 - 1.0712924841207354` [MGEK] [KÜU]^2 +0.0001539137003066925 6` [MSTA] [KÜU]^2 + 0.5597670599566923` [OGEK] [KÜU]^2 +0.0009826156865345552` [OGU] [KÜU]^2 - 1.1632630993521058` [PD] [KÜU]^2 +0.02165035881566635 5` [BU] [KÜU]^2 - 0.0005499553849266079` [FYA] [KÜU]^2 +0.01841223827033742` [KAU] [KÜU]^2 + 2.3767549208728775` [KEK] [KÜU]^2 +0.0199126568341 3356` [KK] [KÜU]^2 - 0.1097577166609122 2` [KP] [KÜU]^2 -0.023395670505586573` [KÜU]^3 + 51.484913449219746` [KY] -8.36852986664869` [BEK] [KY] - 30.82984308044678` [BEK]^2 [KY] -59.19480815822273` [MGEK] [KY] - 75.62347151489914` [BEK] [MGEK] [KY] -133.2778440931193` [MGEK]^2 [KY] + 0.002223065175356515` [MSTA] [KY] +0.047634371461842226` [BEK] [MSTA] [KY] + 0.03174674227860157` [MGEK] [MSTA] [KY] -4.036474879239835`*10^-6 [MSTA]^2 [KY] - 37.12984548391699` [OGEK] [KY] +108.91321209530912` [BEK] [OGEK] [KY] + 254.1088288912774 3` [MGEK] [OGEK] [KY] -0.07969320595150074` [MSTA] [OGEK] [KY] + 282.86481790813446` [OGEK]^2 [KY] +0.4634654951065276` [OGU] [KY] - 1.8028048067896827` [BEK] [OGU] [KY] +0.8385618761227855` [MGEK] [OGU] [KY] + 0.0002892609146584914` [MSTA] [OGU] [KY] -1.105499522882396` [OGEK] [OGU] [KY] + 0.0036930924417875504` [OGU]^2 [KY] +181.54722355760813` [PD] [KY] - 200.77736774003236` [BEK] [PD] [KY] +101.1025222751888` [MGEK] [PD] [KY] + 0.0623923811366787` [MSTA] [PD] [KY] -214.20727003648443` [OGEK] [PD] [KY] - 0.7932707098887049` [OGU] [PD] [KY] +146.98365117060257` [PD]^2 [KY] + 3.5622145130214244` [BU] [KY] -1.7602813484929984` [BEK] [BU] [KY] + 8.161245996585436` [MGEK] [BU] [KY] +0.0003606490973885938` [MSTA] [BU] [KY] - 2.4969055941046845` [OGEK] [BU] [KY] -0.05196708714872919` [OGU] [BU] [KY] - 13.16006697411153` [PD] [BU] [KY] -0.1571055550723123 6` [BU]^2 [KY] + 0.002785784128396383 3` [FYA] [KY] +0.028855378316778597` [BEK] [FYA] [KY] - 0.007155639843683802` [MGEK] [FYA] [KY] -0.000010302316044483163` [MSTA] [FYA] [KY] +0.02525486949779473` [OGEK] [FYA] [KY] + 6.8566971067793315`*10^-6 [OGU] [FYA] [KY] +0.011843346494543733` [PD] [FYA] [KY] + 0.00018931928098109166` [BU] [FYA] [KY] - 1.169962678531036`*10^-6 [FYA]^2 [KY] + 3.09288225112003` [KAU] [KY] -5.646602089101414` [BEK] [KAU] [KY] + 6.9565250784402455` [MGEK] [KAU] [KY] +0.000302231030459248 3` [MSTA] [KAU] [KY] - 8.628892066740859` [OGEK] [KAU] [KY] -0.01300483425013452` [OGU] [KAU] [KY] + 0.4453610414089153` [PD] [KAU] [KY] -0.054567518906120605` [BU] [KAU] [KY] + 0.00006323973420109405` [FYA] [KAU] [KY] +0.1779934203359249` [KAU]^2 [KY] + 79.01028237401079` [KEK] [KY] +138.30713712866466` [BEK] [KEK] [KY] + 61.05974300873871` [MGEK] [KEK] [KY] -0.02742661362802714` [MSTA] [KEK] [KY] - 429.9537908291927` [OGEK] [KEK] [KY] -2.1935213443821957` [OGU] [KEK] [KY] + 291.342608297547` [PD] [KEK] [KY] - 8.107617931854259` [BU] [KEK] [KY] + 0.002441261834297782` [FYA] [KEK] [KY] -1.5600117282846155` [KAU] [KEK] [KY] + 104.03972849151054` [KEK]^2 [KY] -24.874221321253966` [KK] [KY] - 6.0291358834712625` [BEK] [KK] [KY] -7.32014667901413` [MGEK] [KK] [KY] + 0.005131109379576986` [MSTA] [KK] [KY] +2.278085881763965` [OGEK] [KK] [KY] + 0.015479079637485653` [OGU] [KK] [KY] +12.86648148416898` [PD] [KK] [KY] - 0.036347468009358605` [BU] [KK] [KY] -0.0055204380911722415` [FYA] [KK] [KY] - 0.11085240231497198` [KAU] [KK] [KY] +8.052146718005625` [KEK] [KK] [KY] + 0.4264995222871919` [KK]^2 [KY] -3.0833894269307587` [KP] [KY] - 11.747476575920706` [BEK] [KP] [KY] -5.737989152770366` [MGEK] [KP] [KY] - 0.0072310481460742` [MSTA] [KP] [KY] +8.229549558960219` [OGEK] [KP] [KY] + 0.16809689557626203` [OGU] [KP] [KY] -24.715027440969624` [PD] [KP] [KY] - 0.7886363389630906` [BU] [KP] [KY] -0.0005666397545519067` [FYA] [KP] [KY] - 0.2559661472698881` [KAU] [KP] [KY] -48.96404700203952` [KEK] [KP] [KY] - 0.28893569422757803` [KK] [KP] [KY] -0.7368929334957819` [KP]^2 [KY] - 0.7684054296475551` [KÜU] [KY] +4.104621893731057` [BEK] [KÜU] [KY] + 2.9094894711805486` [MGEK] [KÜU] [KY] -0.000281545443297853` [MSTA] [KÜU] [KY] - 1.3366770155115457` [OGEK] [KÜU] [KY] +0.013289469680125551` [OGU] [KÜU] [KY] + 0.8958481379230306` [PD] [KÜU] [KY] -0.11915191391490046` [BU] [KÜU] [KY] - 0.0014517053397587896` [FYA] [KÜU] [KY] +0.17020437569388291` [KAU] [KÜU] [KY] + 5.3969030756223315` [KEK] [KÜU] [KY] +0.1220127834231284 1` [KK] [KÜU] [KY] + 0.4560885753902377` [KP] [KÜU] [KY] +0.12268175397111333` [KÜU]^2 [KY] + 1.5673509334509825` [KY]^2 +1.6043517280683557` [BEK] [KY]^2 - 15.29869710123912` [MGEK] [KY]^2 - 0.0017552906965530447` [MSTA] [KY]^2 + 11.790275422372138` [OGEK] [KY]^2 +0.11776546071903042` [OGU] [KY]^2 - 17.734585729960962` [PD] [KY]^2 +0.5721258137560298` [BU] [KY]^2 + 0.00019617028860912652` [FYA] [KY]^2 -0.31389767068860963` [KAU] [KY]^2 - 4.177896936240541` [KEK] [KY]^2 +1.3555606664021773` [KK] [KY]^2 + 2.337011800579165` [KP] [KY]^2 - 0.15072679108977424` [KÜU] [KY]^2 - 0.20364608206745033` [KY]^3

A–6 Regression model used for MV (SON)

MV = (1.15439*10^12 + 3.9285*10^12 [BEK] - 3.12085*10^12 [BEK]^2 - 2.78886*10^11 [MGEK] - 5.21546*10^10 [BEK] [MGEK] + 7.77098*10^10 [MGEK]^2 - 1.37502*10^8 [MSTA] - 5.96196*10^7 [BEK] [MSTA] - 5.76109*10^7 [MGEK] [MSTA] + 7526.9 [MSTA]^2 + 1.00772*10^12 [OGEK] + 1.45868*10^11 [BEK] [OGEK] + 1.30757*10^11 [MGEK] [OGEK] + 8.37259*10^7 [MSTA] [OGEK] - 3.39081*10^11 [OGEK]^2 - 7.21216*10^10 [OGU] - 8.35322*10^8 [BEK] [OGU] + 5.82266*10^8 [MGEK] [OGU] - 382334. [MSTA] [OGU] + 4.43997*10^8 [OGEK] [OGU] + 4.47805*10^8 [OGU]^2 - 6.1154*10^9 [PD] + 5.81287*10^10 [BEK] [PD] + 2.55042*10^11 [MGEK] [PD] + 7.43446*10^7 [MSTA] [PD] + 1.0808*10^11 [OGEK] [PD] - 4.13403*10^9 [OGU] [PD] + 9.98163*10^10 [PD]^2 - 2.85559*10^10 [BU] + 2.1862*10^9 [BEK] [BU] - 2.72887*10^9 [MGEK] [BU] + 590835. [MSTA] [BU] - 4.28691*10^9 [OGEK] [BU] + 9.38491*10^7 [OGU] [BU] - 7.51766*10^9 [PD] [BU] + 1.04251*10^8 [BU]^2 -1.63558*10^9 [FYA] + 56864. [BEK] [FYA] - 1.12969*10^8 [MGEK] [FYA] +10882.6 [MSTA] [FYA] + 7.82786*10^7 [OGEK] [FYA] - 1.93353*10^6 [OGU] [FYA] +8.34034*10^7 [PD] [FYA] + 1.45207*10^6 [BU] [FYA] + 207926. [FYA]^2 +2.02705*10^10 [KAU] + 1.26238*10^9 [BEK] [KAU] + 1.63082*10^9 [MGEK] [KAU] +256448. [MSTA] [KAU] - 2.33163*10^9 [OGEK] [KAU] - 8.60477*10^6 [OGU] [KAU] -4.32393*10^9 [PD] [KAU] + 7.24609*10^7 [BU] [KAU] - 2.51121*10^6 [FYA] [KAU] -1.54641*10^6 [KAU]^2 + 1.83208*10^13 [KEK] + 3.18745*10^10 [BEK] [KEK] +7.93979*10^9 [MGEK] [KEK] + 4.23447*10^6 [MSTA] [KEK] -3.54772*10^11 [OGEK] [KEK] -1.02116*10^9 [OGU] [KEK] - 1.00985*10^11 [PD] [KEK] - 7.98414*10^8 [BU] [KEK] +6.81448*10^6 [FYA] [KEK] - 2.70267*10^9 [KAU] [KEK] - 1.58956*10^13 [KEK]^2 +3.18841*10^7 [KK] - 3.709*10^9 [BEK] [KK] - 4.20317*10^9 [MGEK] [KK] - 1.42878*10^6 [MSTA] [KK] + 7.90322*10^9 [OGEK] [KK] - 2.48042*10^7 [OGU] [KK] +5.76195*10^9 [PD] [KK] - 3.37046*10^7 [BU] [KK] - 1.04491*10^6 [FYA] [KK] +2.45042*10^7 [KAU] [KK] - 3.45959*10^9 [KEK] [KK] - 2.81232*10^8 [KK]^2 +4.94537*10^10 [KP] + 2.58848*10^9 [BEK] [KP] + 5.64148*10^9 [MGEK] [KP] +6.22573*10^6 [MSTA] [KP] - 4.58599*10^9 [OGEK] [KP] - 1.80496*10^8 [OGU] [KP] +1.3876*10^10 [PD] [KP] - 2.20038*10^8 [BU] [KP] - 3.76082*10^6 [FYA] [KP] +1.36491*10^8 [KAU] [KP] - 5.21727*10^9 [KEK] [KP] - 2.9036*10^8 [KK] [KP] +9.01175*10^8 [KP]^2 + 2.87051*10^10 [KÜU] - 5.2027*10^8 [BEK] [KÜU] +4.0599*10^9 [MGEK] [KÜU] + 571561. [MSTA] [KÜU] - 3.58481*10^9 [OGEK] [KÜU] -1.68611*10^7 [OGU] [KÜU] - 2.57937*10^9 [PD] [KÜU] + 1.39126*10^8 [BU] [KÜU] -3.33425*10^6 [FYA] [KÜU] - 6.75396*10^7 [KAU] [KÜU] - 1.29672*10^10 [KEK] [KÜU] +5.69982*10^7 [KK] [KÜU] + 1.22897*10^8 [KP] [KÜU] + 5.75592*10^7 [KÜU]^2 +4.94005*10^10 [KY] + 5.56922*10^9 [BEK] [KY] + 2.97772*10^10 [MGEK] [KY] +4.42495*10^6 [MSTA] [KY] - 4.96467*10^10 [OGEK] [KY] - 1.67058*10^8 [OGU] [KY] -2.81401*10^10 [PD] [KY] + 2.75268*10^8 [BU] [KY] + 2.32648*10^6 [FYA] [KY] -9.14633*10^8 [KAU] [KY] - 3.37728*10^10 [KEK] [KY] + 1.15238*10^9 [KK] [KY] -2.13237*10^9 [KP] [KY] - 4.09257*10^8 [KÜU] [KY] +2.22465*10^9 [KY]^2)/(3.29322*10^10 - 1.67005*10^10 [BEK] +1.37894*10^10 [BEK]^2 - 9.541*10^8 [MGEK] - 6.16641*10^7 [BEK] [MGEK] +6.7467*10^7 [MGEK]^2 - 5.01566*10^7 [MSTA] - 204594. [BEK] [MSTA] -296619. [MGEK] [MSTA] + 11041.7 [MSTA]^2 + 6.71392*10^8 [OGEK] +8.87352*10^8 [BEK] [OGEK] + 7.33191*10^8 [MGEK] [OGEK] + 418760. [MSTA] [OGEK] -8.43745*10^8 [OGEK]^2 + 3.06332*10^8 [OGU] - 1.02142*10^6 [BEK] [OGU] +4.8576*10^6 [MGEK] [OGU] - 726.544 [MSTA] [OGU] + 1.51465*10^7 [OGEK] [OGU] -1.36002*10^6 [OGU]^2 + 7.36398*10^8 [PD] + 1.30603*10^8 [BEK] [PD] +7.39893*10^8 [MGEK] [PD] + 227514. [MSTA] [PD] - 4.92252*10^7 [OGEK] [PD] -1.95204*10^7 [OGU] [PD] + 8.05527*10^8 [PD]^2 - 1.03637*10^8 [BU] +1.06224*10^7 [BEK] [BU] - 1.65231*10^7 [MGEK] [BU] + 2082.62 [MSTA] [BU] -2.07859*10^7 [OGEK] [BU] + 355342. [OGU] [BU] - 2.72894*10^7 [PD] [BU] +424880. [BU]^2 + 1.9126*10^6 [FYA] + 46937.8 [BEK] [FYA] - 425154. [MGEK] [FYA] +46.5156 [MSTA] [FYA] + 487519. [OGEK] [FYA] - 6157.21 [OGU] [FYA] +299102. [PD] [FYA] + 5279.97 [BU] [FYA] - 138.542 [FYA]^2 + 8.94038*10^7 [KAU] +4.68518*10^6 [BEK] [KAU] + 1.31817*10^6 [MGEK] [KAU] + 245.991 [MSTA] [KAU] -1.12326*10^7 [OGEK] [KAU] - 34622.4 [OGU] [KAU] - 1.83081*10^7 [PD] [KAU] +295196. [BU] [KAU] - 10727.4 [FYA] [KAU] - 25054.6 [KAU]^2 + 2.22207*10^9 [KEK] +2.20255*10^8 [BEK] [KEK] - 2.68103*10^7 [MGEK] [KEK] - 66923.2 [MSTA] [KEK] -1.27082*10^9 [OGEK] [KEK] - 3.22615*10^6 [OGU] [KEK] - 3.00342*10^8 [PD] [KEK] -3.03279*10^6 [BU] [KEK] + 17928.8 [FYA] [KEK] - 1.09665*10^7 [KAU] [KEK] +5.19886*10^8 [KEK]^2 - 2.43394*10^7 [KK] - 1.24348*10^7 [BEK] [KK] -1.09546*10^7 [MGEK] [KK] - 4274.07 [MSTA] [KK] + 3.77519*10^7 [OGEK] [KK] -57157.1 [OGU] [KK] + 2.54954*10^7 [PD] [KK] - 121514. [BU] [KK] -2305.06 [FYA] [KK] + 64966.7 [KAU] [KK] - 1.48066*10^7 [KEK] [KK] -1.17291*10^6 [KK]^2 + 1.86926*10^8 [KP] + 1.29994*10^7 [BEK] [KP] +2.16014*10^7 [MGEK] [KP] + 26200.6 [MSTA] [KP] - 1.48124*10^7 [OGEK] [KP] -689952. [OGU] [KP] + 4.98143*10^7 [PD] [KP] - 885290. [BU] [KP] -14185.8 [FYA] [KP] + 616180. [KAU] [KP] - 1.94419*10^7 [KEK] [KP] -1.00339*10^6 [KK] [KP] + 3.26764*10^6 [KP]^2 + 8.63462*10^7 [KÜU] +653832. [BEK] [KÜU] + 1.9051*10^7 [MGEK] [KÜU] + 3389.6 [MSTA] [KÜU] -5.75739*10^6 [OGEK] [KÜU] - 17497.7 [OGU] [KÜU] - 1.45524*10^7 [PD] [KÜU] +513407. [BU] [KÜU] - 12346.2 [FYA] [KÜU] - 244163. [KAU] [KÜU] -4.52913*10^7 [KEK] [KÜU] + 275897. [KK] [KÜU] + 450145. [KP] [KÜU] +238177. [KÜU]^2 - 6.58484*10^7 [KY] + 3.40423*10^7 [BEK] [KY] +1.63621*10^8 [MGEK] [KY] + 28335.5 [MSTA] [KY] - 1.18994*10^8 [OGEK] [KY] -229120. [OGU] [KY] - 1.33378*10^8 [PD] [KY] + 1.04978*10^6 [BU] [KY] +17576.9 [FYA] [KY] - 3.20678*10^6 [KAU] [KY] - 7.63296*10^7 [KEK] [KY] +4.57728*10^6 [KK] [KY] - 8.87698*10^6 [KP] [KY] - 783178. [KÜU] [KY] +1.09129*10^7 [KY]^2)

A–7 Regression model used for GHV (SON)

GHV = (-8.25565*10^9 - 1.24534*10^11 [BEK] + 1.04092*10^11 [BEK]^2 - 4.77294*10^8 [MGEK] + 1.08256*10^9 [BEK] [MGEK] - 8.32564*10^8 [MGEK]^2 + 2.14023*10^7 [MSTA] - 376049. [BEK] [MSTA] - 3662.83 [MGEK] [MSTA] - 5070.53 [MSTA]^2 + 1.71331*10^9 [OGEK] + 4.50641*10^8 [BEK] [OGEK] + 1.63335*10^9 [MGEK] [OGEK] + 331708. [MSTA] [OGEK] - 8.37387*10^8 [OGEK]^2 - 4.05588*10^8 [OGU] - 1.51565*10^6 [BEK] [OGU] + 6.21034*10^6 [MGEK] [OGU] - 4647.8 [MSTA] [OGU] + 2.30804*10^7 [OGEK] [OGU] + 2.57015*10^6 [OGU]^2 + 3.84922*10^9 [PD] + 1.72562*10^8 [BEK] [PD] + 1.2317*10^9 [MGEK] [PD] + 80612.9 [MSTA] [PD] + 2.46771*10^9 [OGEK] [PD] - 4.06832*10^7 [OGU] [PD] - 1.1159*10^9 [PD]^2 - 2.34998*10^8 [BU] - 9.89729*10^6 [BEK] [BU] - 5.15363*10^7 [MGEK] [BU] + 1395.68 [MSTA] [BU] - 3.1638*10^7 [OGEK] [BU] + 625748. [OGU] [BU] - 3.38212*10^7 [PD] [BU] + 1.37858*10^6 [BU]^2 - 251324. [FYA] + 76953.5 [BEK] [FYA] - 597638. [MGEK] [FYA] + 255.261 [MSTA] [FYA] + 780840. [OGEK] [FYA] - 15229.7 [OGU] [FYA] + 746947. [PD] [FYA] + 11308.2 [BU] [FYA] + 224.313 [FYA]^2 + 2.27087*10^8 [KAU] + 2.56261*10^7 [BEK] [KAU] - 2.65554*10^7 [MGEK] [KAU] - 5120.13 [MSTA] [KAU] - 2.37354*10^7 [OGEK] [KAU] + 48115.1 [OGU] [KAU] - 4.702*10^7 [PD] [KAU] + 918388. [BU] [KAU] - 29369.9 [FYA] [KAU] - 641445. [KAU]^2 + 9.03105*10^10 [KEK] + 3.57739*10^8 [BEK] [KEK] - 3.42306*10^8 [MGEK] [KEK] + 611573. [MSTA] [KEK] - 2.29159*10^9 [OGEK] [KEK] + 1.55465*10^6 [OGU] [KEK] - 3.64847*10^9 [PD] [KEK] + 2.50934*10^7 [BU] [KEK] - 118333. [FYA] [KEK] - 93785. [KAU] [KEK] - 7.97449*10^10 [KEK]^2 - 2.38826*10^7 [KK] - 2.75928*10^7 [BEK] [KK] + 3.19514*10^7 [MGEK] [KK] - 5242.5 [MSTA] [KK] + 8.16459*10^7 [OGEK] [KK] - 184276. [OGU] [KK] + 5.59882*10^7 [PD] [KK] - 1.35062*10^6 [BU] [KK] + 1556.9 [FYA] [KK] - 60119.5 [KAU] [KK] - 4.94489*10^7 [KEK] [KK] - 97008. [KK]^2 + 2.96348*10^8 [KP] + 4.14366*10^7 [BEK] [KP] + 1.30268*10^8 [MGEK] [KP] + 51974.8 [MSTA] [KP] - 3.24329*10^7 [OGEK] [KP] - 926319. [OGU] [KP] + 6.17265*10^6 [PD] [KP] - 2.67924*10^6 [BU] [KP] - 41573.6 [FYA] [KP] + 713957. [KAU] [KP] - 6.18248*10^7 [KEK] [KP] - 2.61003*10^6 [KK] [KP] + 4.90158*10^6 [KP]^2 + 2.13928*10^8 [KÜU] + 8.9745*10^6 [BEK] [KÜU] + 1.51058*10^7 [MGEK] [KÜU] + 8870.27 [MSTA] [KÜU] - 1.4327*10^7 [OGEK] [KÜU] - 330848. [OGU] [KÜU] - 8.00796*10^6 [PD] [KÜU] + 1.11102*10^6 [BU] [KÜU] - 26916.9 [FYA] [KÜU] - 933884. [KAU] [KÜU] - 9.1259*10^7 [KEK] [KÜU] + 1.2539*10^6 [KK] [KÜU] - 743394. [KP] [KÜU] + 146381. [KÜU]^2 - 2.04997*10^8 [KY] - 6.56459*10^6 [BEK] [KY] + 3.38507*10^8 [MGEK] [KY] + 38025.5 [MSTA] [KY] - 2.61836*10^8 [OGEK] [KY] + 155412. [OGU] [KY] + 1.17429*10^7 [PD] [KY] + 684177. [BU] [KY] + 31756.5 [FYA] [KY] - 4.75307*10^6 [KAU] [KY] - 1.05808*10^8 [KEK] [KY] + 8.18717*10^6 [KK] [KY] - 4.07829*10^6 [KP] [KY] - 135795. [KÜU] [KY] + 1.5072*10^7 [KY]^2)/(-2.63783*10^9 - 8.88368*10^8 [BEK] + 8.64275*10^8 [BEK]^2 + 1.75*10^7 [MGEK] + 1.10096*10^8 [BEK] [MGEK] - 8.72339*10^7 [MGEK]^2 - 395053. [MSTA] - 46607.3 [BEK] [MSTA] + 5247.31 [MGEK] [MSTA] + 52.1371 [MSTA]^2 + 5.90932*10^8 [OGEK] + 2.39173*10^7 [BEK] [OGEK] + 1.59519*10^8 [MGEK] [OGEK] + 32703.6 [MSTA] [OGEK] - 1.5548*10^8 [OGEK]^2 + 2.84921*10^7 [OGU] - 409688. [BEK] [OGU] + 321397. [MGEK] [OGU] - 635.158 [MSTA] [OGU] + 1.26975*10^6 [OGEK] [OGU] - 77076.5 [OGU]^2 + 5.12843*10^8 [PD] + 2.16768*10^7 [BEK] [PD] + 1.36359*10^8 [MGEK] [PD] + 11253. [MSTA] [PD] + 2.85435*10^8 [OGEK] [PD] - 4.72546*10^6 [OGU] [PD] - 1.31944*10^8 [PD]^2 - 3.10388*10^7 [BU] - 1.20271*10^6 [BEK] [BU] - 5.04865*10^6 [MGEK] [BU] + 313.54 [MSTA] [BU] - 2.81728*10^6 [OGEK] [BU] + 77548.4 [OGU] [BU] - 4.26288*10^6 [PD] [BU] + 165818. [BU]^2 + 660497. [FYA] + 854.236 [BEK] [FYA] - 81341.4 [MGEK] [FYA] + 28.0221 [MSTA] [FYA] + 62225.6 [OGEK] [FYA] - 1985.58 [OGU] [FYA] + 84005.2 [PD] [FYA] + 1439.7 [BU] [FYA] - 44.5111 [FYA]^2 + 2.58451*10^7 [KAU] + 2.93042*10^6 [BEK] [KAU] - 2.57524*10^6 [MGEK] [KAU] - 503.379 [MSTA] [KAU] - 2.40463*10^6 [OGEK] [KAU] + 6017.31 [OGU] [KAU] - 5.53812*10^6 [PD] [KAU] + 112150. [BU] [KAU] - 3402.77 [FYA] [KAU] - 76463.9 [KAU]^2 - 8.9672*10^8 [KEK] + 3.78407*10^7 [BEK] [KEK] - 4.10915*10^7 [MGEK] [KEK] + 81445.4 [MSTA] [KEK] - 2.7488*10^8 [OGEK] [KEK] + 87789.2 [OGU] [KEK] - 4.63583*10^8 [PD] [KEK] + 3.13629*10^6 [BU] [KEK] - 15684.3 [FYA] [KEK] - 42507. [KAU] [KEK] + 1.13689*10^9 [KEK]^2 + 3.76454*10^6 [KK] - 3.70692*10^6 [BEK] [KK] + 2.0961*10^6 [MGEK] [KK] - 936.268 [MSTA] [KK] + 7.63649*10^6 [OGEK] [KK] - 32493.4 [OGU] [KK] + 6.36581*10^6 [PD] [KK] - 160676. [BU] [KK] - 202.011 [FYA] [KK] - 14305.1 [KAU] [KK] - 5.94586*10^6 [KEK] [KK] - 7663.91 [KK]^2 + 3.93849*10^7 [KP] + 4.48176*10^6 [BEK] [KP] + 1.41788*10^7 [MGEK] [KP] + 5787.54 [MSTA] [KP] - 4.75804*10^6 [OGEK] [KP] - 117985. [OGU] [KP] + 1.38078*10^6 [PD] [KP] - 320346. [BU] [KP] - 5142.76 [FYA] [KP] + 67623.3 [KAU] [KP] - 6.91296*10^6 [KEK] [KP] - 326083. [KK] [KP] + 613857. [KP]^2 + 2.91557*10^7 [KÜU] + 670043. [BEK] [KÜU] + 1.1992*10^6 [MGEK] [KÜU] + 907.266 [MSTA] [KÜU] - 2.83046*10^6 [OGEK] [KÜU] - 45918.9 [OGU] [KÜU] - 1.00072*10^6 [PD] [KÜU] + 137300. [BU] [KÜU] - 3345.05 [FYA] [KÜU] - 110562. [KAU] [KÜU] - 1.12264*10^7 [KEK] [KÜU] + 136876. [KK] [KÜU] - 94233.7 [KP] [KÜU] + 11718.7 [KÜU]^2 - 1.89074*10^6 [KY] - 1.92972*10^6 [BEK] [KY] + 3.49156*10^7 [MGEK] [KY] + 3727.44 [MSTA] [KY] - 3.7217*10^7 [OGEK] [KY] - 13188.6 [OGU] [KY] + 444606. [PD] [KY] + 118875. [BU] [KY] + 3007.66 [FYA] [KY] - 600540. [KAU] [KY] - 1.62801*10^7 [KEK] [KY] + 945456. [KK] [KY] - 472031. [KP] [KY] - 95911.4 [KÜU] [KY] + 1.60451*10^6 [KY]^2

A–8 Regression model used for ST (SON)

ST = (3.38259*10^14 + 7.87254*10^14 [BEK] - 6.57452*10^14 [BEK]^2 +3.76022*10^12 [MGEK] - 3.90958*10^11 [BEK] [MGEK] - 1.1023*10^11 [MGEK]^2 -4.1975*10^11 [MSTA] + 1.36042*10^8 [BEK] [MSTA] - 4.63732*10^7 [MGEK] [MSTA] +9.31076*10^7 [MSTA]^2 - 1.89594*10^12 [OGEK] + 4.42418*10^11 [BEK] [OGEK] -6.71568*10^11 [MGEK] [OGEK] + 4.94522*10^7 [MSTA] [OGEK] +1.6704*10^11 [OGEK]^2 + 5.30592*10^12 [OGU] + 4.29442*10^9 [BEK] [OGU] -1.40161*10^10 [MGEK] [OGU] - 190608. [MSTA] [OGU] + 1.26763*10^10 [OGEK] [OGU] -2.72804*10^10 [OGU]^2 - 3.26849*10^12 [PD] - 7.90843*10^11 [BEK] [PD] +1.19466*10^12 [MGEK] [PD] - 1.25391*10^8 [MSTA] [PD] +1.58421*10^12 [OGEK] [PD] - 7.85951*10^8 [OGU] [PD] +7.33703*10^11 [PD]^2 - 3.61482*10^10 [BU] + 1.03904*10^10 [BEK] [BU] -2.09693*10^10 [MGEK] [BU] + 4.94919*10^6 [MSTA] [BU] - 8.44146*10^9 [OGEK] [BU] +1.09841*10^6 [OGU] [BU] + 1.47133*10^10 [PD] [BU] - 2.74412*10^8 [BU]^2 -1.44722*10^11 [FYA] + 1.30838*10^8 [BEK] [FYA] - 3.88241*10^8 [MGEK] [FYA] +126477. [MSTA] [FYA] - 6.26109*10^7 [OGEK] [FYA] + 232086. [OGU] [FYA] +2.81472*10^8 [PD] [FYA] + 5.59338*10^6 [BU] [FYA] + 1.60428*10^7 [FYA]^2 +4.25068*10^10 [KAU] + 7.63071*10^9 [BEK] [KAU] + 5.78959*10^9 [MGEK] [KAU] -1.99263*10^6 [MSTA] [KAU] + 2.3256*10^9 [OGEK] [KAU] + 2.02205*10^7 [OGU] [KAU] -2.36365*10^9 [PD] [KAU] - 7.48733*10^7 [BU] [KAU] - 1.00575*10^6 [FYA] [KAU] -6.21207*10^8 [KAU]^2 + 1.04491*10^14 [KEK] - 4.22306*10^11 [BEK] [KEK] +1.54846*10^12 [MGEK] [KEK] - 5.41938*10^6 [MSTA] [KEK] -5.77875*10^11 [OGEK] [KEK] + 1.19338*10^10 [OGU] [KEK] -1.3656*10^12 [PD] [KEK] + 9.03623*10^7 [BU] [KEK] - 3.61225*10^8 [FYA] [KEK] -6.99929*10^9 [KAU] [KEK] - 9.36513*10^13 [KEK]^2 - 1.22669*10^11 [KK] +5.93959*10^8 [BEK] [KK] - 1.46036*10^10 [MGEK] [KK] - 3.51637*10^6 [MSTA] [KK] +3.38989*10^10 [OGEK] [KK] + 1.13899*10^8 [OGU] [KK] -1.36158*10^10 [PD] [KK] - 4.10502*10^7 [BU] [KK] + 1.20305*10^7 [FYA] [KK] +4.95229*10^8 [KAU] [KK] - 7.97899*10^9 [KEK] [KK] - 5.46641*10^8 [KK]^2 -6.39056*10^10 [KP] + 2.28704*10^9 [BEK] [KP] - 4.98883*10^9 [MGEK] [KP] +5.43259*10^6 [MSTA] [KP] + 5.42049*10^10 [OGEK] [KP] - 6.14891*10^7 [OGU] [KP] -5.14312*10^10 [PD] [KP] - 7.69462*10^8 [BU] [KP] + 3.94018*10^6 [FYA] [KP] +1.71654*10^8 [KAU] [KP] - 1.00734*10^11 [KEK] [KP] + 1.45839*10^9 [KK] [KP] +4.59089*10^8 [KP]^2 - 6.38604*10^10 [KÜU] + 9.67908*10^9 [BEK] [KÜU] -6.82091*10^9 [MGEK] [KÜU] - 2.55843*10^6 [MSTA] [KÜU] + 2.80438*10^10 [OGEK] [KÜU] +3.80071*10^8 [OGU] [KÜU] + 2.14033*10^10 [PD] [KÜU] - 8.0607*10^7 [BU] [KÜU] +2.20715*10^6 [FYA] [KÜU] - 1.09643*10^9 [KAU] [KÜU] - 2.33814*10^10 [KEK] [KÜU] +1.20906*10^9 [KK] [KÜU] + 1.09262*10^9 [KP] [KÜU] - 1.56085*10^8 [KÜU]^2 -7.71608*10^10 [KY] + 1.04085*10^11 [BEK] [KY] - 1.75727*10^11 [MGEK] [KY] +1.84528*10^7 [MSTA] [KY] + 1.83199*10^11 [OGEK] [KY] + 1.13731*10^9 [OGU] [KY] +4.29787*10^10 [PD] [KY] + 1.55536*10^9 [BU] [KY] + 3.45425*10^7 [FYA] [KY] -2.4104*10^8 [KAU] [KY] - 1.49727*10^11 [KEK] [KY] + 8.71371*10^9 [KK] [KY] +1.49294*10^10 [KP] [KY] + 8.02919*10^9 [KÜU] [KY] +2.63453*10^9 [KY]^2)/(-5.87646*10^13 + 6.31681*10^14 [BEK] -5.26217*10^14 [BEK]^2 + 2.33118*10^11 [MGEK] - 1.17959*10^11 [BEK] [MGEK] -1.97921*10^11 [MGEK]^2 - 1.66261*10^10 [MSTA] + 7.01113*10^7 [BEK] [MSTA] -7.01671*10^7 [MGEK] [MSTA] + 3.63911*10^6 [MSTA]^2 + 6.75556*10^11 [OGEK] +5.14714*10^10 [BEK] [OGEK] + 7.10112*10^10 [MGEK] [OGEK] +5.12071*10^7 [MSTA] [OGEK] - 2.8505*10^10 [OGEK]^2 - 1.0017*10^12 [OGU] -1.69982*10^9 [BEK] [OGU] - 2.2099*10^8 [MGEK] [OGU] - 410457. [MSTA] [OGU] -6.69648*10^8 [OGEK] [OGU] + 5.18833*10^9 [OGU]^2 - 2.53726*10^12 [PD] -3.15167*10^11 [BEK] [PD] + 7.00645*10^11 [MGEK] [PD] -6.66679*10^7 [MSTA] [PD] + 7.83441*10^11 [OGEK] [PD] +2.24457*10^8 [OGU] [PD] + 5.23318*10^11 [PD]^2 - 2.33892*10^10 [BU] -1.63124*10^9 [BEK] [BU] - 6.73654*10^9 [MGEK] [BU] + 2.67623*10^6 [MSTA] [BU] -2.07494*10^9 [OGEK] [BU] + 3.59535*10^7 [OGU] [BU] + 1.20727*10^10 [PD] [BU] -1.69533*10^8 [BU]^2 + 2.82081*10^9 [FYA] + 2.2224*10^7 [BEK] [FYA] - 1.22966*10^8 [MGEK] [FYA] + 50968.2 [MSTA] [FYA] - 1.26735*10^8 [OGEK] [FYA] -2.03353*10^6 [OGU] [FYA] + 1.48355*10^8 [PD] [FYA] + 3.95686*10^6 [BU] [FYA] -276893. [FYA]^2 + 1.514*10^10 [KAU] + 6.10611*10^9 [BEK] [KAU] +9.77102*10^7 [MGEK] [KAU] + 1.67564*10^6 [MSTA] [KAU] + 6.80052*10^8 [OGEK] [KAU] -1.86397*10^8 [OGU] [KAU] - 6.76676*10^8 [PD] [KAU] - 1.21858*10^8 [BU] [KAU] +558462. [FYA] [KAU] + 2.08668*10^8 [KAU]^2 + 4.10457*10^13 [KEK] -4.36468*10^10 [BEK] [KEK] + 5.4043*10^11 [MGEK] [KEK] - 7.75325*10^7 [MSTA] [KEK] -6.67409*10^10 [OGEK] [KEK] + 1.00137*10^10 [OGU] [KEK] -3.28612*10^11 [PD] [KEK] - 3.40086*10^9 [BU] [KEK] - 2.937*10^8 [FYA] [KEK] -5.22346*10^9 [KAU] [KEK] - 3.65605*10^13 [KEK]^2 + 5.23919*10^9 [KK] -7.92168*10^9 [BEK] [KK] + 1.70071*10^9 [MGEK] [KK] - 2.49055*10^6 [MSTA] [KK] +3.07776*10^9 [OGEK] [KK] - 1.27126*10^8 [OGU] [KK] - 1.33177*10^10 [PD] [KK] -9.29474*10^7 [BU] [KK] + 1.55789*10^6 [FYA] [KK] + 5.29981*10^8 [KAU] [KK] +8.87741*10^9 [KEK] [KK] - 5.73936*10^7 [KK]^2 - 1.1695*10^10 [KP] +2.21047*10^8 [BEK] [KP] + 1.41295*10^10 [MGEK] [KP] + 4.78119*10^6 [MSTA] [KP] -5.11962*10^8 [OGEK] [KP] - 7.53998*10^7 [OGU] [KP] - 3.0637*10^10 [PD] [KP] -2.84222*10^8 [BU] [KP] + 4.28983*10^6 [FYA] [KP] - 1.88977*10^8 [KAU] [KP] -4.02545*10^10 [KEK] [KP] - 1.66149*10^6 [KK] [KP] + 1.33657*10^8 [KP]^2 +1.83617*10^10 [KÜU] - 9.07166*10^8 [BEK] [KÜU] + 8.55242*10^9 [MGEK] [KÜU] +176515. [MSTA] [KÜU] - 3.11963*10^9 [OGEK] [KÜU] - 1.10518*10^8 [OGU] [KÜU] +6.54042*10^9 [PD] [KÜU] - 1.07821*10^8 [BU] [KÜU] - 948496. [FYA] [KÜU] +3.20476*10^8 [KAU] [KÜU] - 1.95985*10^9 [KEK] [KÜU] + 3.15846*10^7 [KK] [KÜU] -3.7628*10^8 [KP] [KÜU] + 2.47957*10^8 [KÜU]^2 - 1.22025*10^9 [KY] +8.33256*10^9 [BEK] [KY] - 1.10562*10^10 [MGEK] [KY] + 9.58501*10^6 [MSTA] [KY] -4.15227*10^9 [OGEK] [KY] - 2.10846*10^8 [OGU] [KY] + 3.41371*10^10 [PD] [KY] +5.97408*10^8 [BU] [KY] + 317645. [FYA] [KY] - 4.37754*10^8 [KAU] [KY] -5.40034*10^10 [KEK] [KY] + 1.45961*10^9 [KK] [KY] + 4.01117*10^9 [KP] [KY] +3.1544*10^8 [KÜU] [KY] + 3.38602*10^9 [KY]^2)

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