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# Robust Aircraft Squadron Scheduling in the Face of Absenteeism

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**ROBUST AIRCRAFT SQUADRON SCHEDULING IN THE FACE OF ABSENTEEISM**

THESIS

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AFIT/GOR/ENS/08-06

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## Abstract

Air Force fighter aircraft squadrons the world over share a unique problem. Each requires complex training schedules coupling aircraft to pilots, the duo to missions and airspaces, and then the entire combination to a feasible time slot. Creating daily and weekly flight schedules that include shifts around the clock every day of the year with a set number of pilots is a time consuming job for manual schedulers within a squadron. Complicating matters is absenteeism. If one or more pilots are unable to perform their previously assigned tasks, due to sickness, aircraft failure, or reassignment, those tasks must be performed by pilots that were not previously scheduled. These changes can not conflict with the rules of Air Force regulations, squadron policy, the squadron commander, operations officer or flight training officer's direction. Given these constraints, the goal of a new re-rostered schedule, in the event of absenteeism, should be to affect the previous schedule as little as possible. This research will develop a weekly flight schedule. The goal of this reformulated schedule is robustness to absenteeism. In order to find a robust schedule, a comparison will be done to select the most robust schedule from among 17 candidate schedules. The expected values for the number of changes for each schedule are compared, and a general conclusion will be provided using a new objective function to create a model that yields a robust schedule on the first attempt.

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*To Father and Mother*

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Gokcen , Osman B

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# ANALYSIS OF SEARCHING ROBUST SCHEDULES FOR FIGHTER SQUADRONS

## I. Introduction

### Background

Fighter squadron schedulers face major problems when disruptions occur to an already prepared weekly schedule.  At first review, a schedule may be satisfactory and acceptable to both schedulers and commanders.  As the flying period progresses, however, disruptions in the schedule, such as weather difficulties (WX), maintenance problems (MX), and pilot absenteeism, can lead to non-effective missions, low productivity rates, or further absenteeism.  In addition, the changes required to address these disruptions tend to lower the morale of flying personnel because of the uncertainty of being able to fly or because of the impact on family life.  Traditional scheduling methods are not concerned with the impact on the personal lives of flying personnel. Such lack of concern can lead personnel to the conclusion that the squadron does not care about them.  The scheduler's need is for a robust schedule that can handle these tough and costly situations and promote the well-being of the squadron's flying personnel.

A robust schedule should be proactive in dealing with the uncertainties in flying. Therefore, instead of preparing a schedule many times, a robust schedule should handle these uncertainties without requiring schedules to be created over and over. A robust schedule will not allow a large number of changes in a new schedule which is built as a result of disruptions. It will rather minimize the number of changes in the new schedule when compared to the previous schedule. Robust scheduling would thus find its place at the top of a scheduler's desires, and frequent disruptions to the schedule could face fewer changes compared to the other scheduling models.

Since changes cause huge time, money, and personnel losses; even a new schedule may not be feasible because of insufficient personnel, aircraft, or parts. Such cases guide the fighter squadron schedulers to think deliberately and prepare proactive schedules to guard against disruptions rather than using all available resources to handle the situation. Therefore, a proactive, robust scheduling model should be the most beneficial model for the squadron flight schedulers.

**Problem Statement**

In this research a conventional fighter squadron schedule will be prepared. It will be modified in order to make it more robust with the goal of minimizing the number of changes in the updated schedule in case of various disruptions. Thus, a robust schedule will be designed to be less vulnerable than a conventional schedule in the case of a number of disruptions.

Fighter squadron schedules have the first objective of flying as much as possible. On the other hand, the number of aircraft, the number of missions, and specifically the number of pilots are limited, so maximizing flights is an objective that makes schedulers very sensitive to even minimum changes on the schedule since they have already used all of the resources for the flight schedule.

However, the objective of over-planning for contingencies by keeping many aircraft and pilots on the ground is over-cautious and costly. A robustness option is given to provide some insight on the subject. Other robustness options will be used as well, but comparing the objective of flying as much as possible with the over-cautious objectives shows that there is a trade off between these two options. From a multi-objective perspective, it can be said that these two objectives are actually two conflicting objectives. However, there is a need for a model which will handle both of the objective functions.

**Fighter Squadron Schedule**

A fighter squadron training section prepares daily and weekly flight schedules and arranges its training with respect to these flight schedules consisting of A/C numbers, names of pilots, missions, training areas and times for takeoff and landing. A fighter squadron flight schedule is a different and more complex type of a personnel schedule, and it is vulnerable to possible disruptions as well. Each aspect of the schedule that is mentioned previously may change because of a number of unexpected reasons such as weather, sickness, maintenance problems etc.

This research will focus on pilot absenteeism as part of this problem. Personnel absenteeism is one of the biggest deviation factors in personnel schedules. It may take a long time to re-fix a schedule after a certain number of absentees, so it has a cost for the scheduler and it has another cost for the commander as well.

Absent pilots will add an additional load on present and available pilots. In order to fulfill the already planned missions, present pilots will have to do more than their assigned tasks. For instance, some missions require one day or two days of preparation time, four or five times longer than the flying period of the mission. In such cases, newly assigned pilots may not adapt themselves well to the current situation. Eventually this condition may cause such a critical sortie to be non-effective. Unexpected mission assignments at the very last moment may cause non-effective or unsuccessful missions. Thus the time and effort for that specific pilot would be ineffective or useless. Even though they are trained for such cases, pilots don't like unexpected changes.

Regularly, it takes about 10 hours for a fighter squadron scheduler to prepare a weekly flight schedule. The necessity to re-arrange the schedule can easily be a nightmare to the scheduler. Utilizing all the pilots available to make the schedule doesn't leave any slack for the schedule to be robust; however leaving some pilots as alternates, makes the schedule more robust. This is an option to create a robust schedule.

Robust schedules are more long-lasting than traditional schedules. Therefore, schedulers work on manually preparing robust schedules, resistant to changes on paper without any computer help. They try to manually preserve the balance between maximizing the number of sorties and maximizing the robustness of a schedule. They provide the robustness of the schedule by assigning a number of pilots as alternate pilots for each specific task.

The Turkish Air Force uses a database network for flight schedules which is called HVBS(Hava Kuvvetleri Bilgi Sistemi (Air Force Data Network)) HVBS is a comprehensive network not only consisting of the flight database, but also other databases as well. However, the flight database is only used to check if pilots are qualified to fly specific missions or if pilots are available to fly. But flight schedulers are still assigned to prepare a feasible flight schedule on paper. Schedulers desire to prepare a weekly robust schedule by the mean of a scheduling model. The desire is for a robust schedule from paper to a computer, thus preparing a robust model will help the schedulers prepare a robust schedule with the help of a mathematical model. The objective is to go further from the present point and use the benefit of a scheduling model.

**Specifications of a Flight Schedule**

There are different positions that are required to be fulfilled daily during each block in a squadron. The specific pilot status positions are IP (Instructor Pilot), FL (Flight Lead), and P (Wingman) and the specific pilot qualifications are Top3 and SOF (Supervisor of Flight). Top3 are the top three pilots in the squadron; squadron commander, director of operations, and training officer. No other officers can be assigned to substitute for them in performing Top3 duties. There must be one Top3 pilot assigned to be on duty in the squadron for each day. There must be one SOF on duty for each block. There must be a number of IPs, FLs and Ps for specific missions.

In addition, a squadron has a certain number of pilots and a limited number of aircraft to fulfill required total flight hours for each pilot. Therefore, the scheduler tries to maximize the number of flight hours. The goal of maximizing the total number of sorties is preserved while producing a more robust schedule. As the compromise between two objectives shifts in time during a flight year, sometimes maximizing the number of sorties becomes the only objective function. (Sometimes maximizing the robustness objective appears.) However, maximizing the robustness objective doesn't become the only objective at any time, because of flight hours that the pilots should reach by the end of the year. Flight hours are very important for a squadron since they show the success of the squadron, and these are essential indicators of the squadron training level.

Some duties can be shared between squadrons such as SOF duty. For example while AM block (the first flight block) and PM block (the second flight block) SOF duties are taken by one squadron, N block (the third flight block) SOF duty is taken by the other squadron. Pilots who are qualified to be SOF are senior pilots like IPs and FLs. Thus the number of pilots who are available to be SOF is small, similar to the number of Top3 pilots. Additionally, one of the other groups which are small and hard to schedule is IPs. Since the IP set consists both of the Top3 and the SOF pilot set, IPs are one of the busiest groups in the squadron.

The aircraft composition for missions can vary. If six aircraft are scheduled, there can be two plus two plus two, or there can be a four ship plus two. The number of IPs and FLs will be less than or equal to six whereas since Ps can't fly in any position in a wing other than their own position, the number of Ps will be less than three.

The scheduler should take care of the crew rest requirements of the pilots while preparing a weekly or daily schedule. For example, a night flyer shouldn't fly the following AMGO. Furthermore, an AMGO flyer shouldn't fly at NGO on the same day.

## Purpose and Research Question

How can a scheduling model be made robust? Is there a feasible, inexpensive way to build an operational model that will produce robust schedules while providing as many sorties as possible? How can robustness of a schedule be evaluated? Can a mathematical model be made more robust by finding only the most proper objective function coefficients without assigning a set of alternate pilots?

## Significance

Even though the commander desires as many sorties as possible to be flown, there will be a number of cancelled flights, MX based aborts, and WX based aborts. Such discrepancies affect the effectiveness or the success rate of the schedule. The commander desires a high mission success rate as well as a maximum number of sorties flown. Discrepancies tend to decrease mission success rate which is not desired. The way to increase success rate is to use robustness measures in the schedules.

There exists a compromise between maximizing the total number of sorties and maximizing robustness. Maximizing the total number of sorties objective is the higher objective. This research will focus on ways of making a scheduling model more robust without assigning any alternate pilots. It will also yield a mathematical model with a robust objective function as well as maximizing the number of sorties. In addition to the model, an application to fighter squadron schedules will be made and analyzed to select the most robust schedule by using statistical analysis. Eventually, a final objective function will be produced to prepare robust schedules on the first attempt.

## II. Literature Survey

This research will concentrate on developing a robust scheduling model. A robust model will prepare a schedule that makes the least changes possible in the case of disruptions. As a part of literature review related to robustness, questions of how the researchers have handled robustness problems and what kind of methods they have used lead to numerous articles in this area are addressed. These articles that address robust schedules are related to areas such as hospitals, manufacturing plants, airports and others. Scheduling techniques are becoming very popular around the business and industrial arena. However, much work still needs to be done in this area.

### Terminology and Classifications

Before starting a general review on robust scheduling, a review of robustness-related terms will be cited from Herreoelen et.al. (2004). This article aggregates research related to project scheduling and reviews robust scheduling methodologies while mentioning robust scheduling terms as well. However, robust scheduling and scheduling related terms will focus on an introduction to the question of what makes a schedule robust and what are some schedule types. A baseline schedule, which is known as a pre-schedule or predictive schedule, assumes deterministic or complete information and neglects uncertainty. A baseline schedule tries to optimize the objective function while fulfilling all subject constraints and allocating resources. The next term cited from the article is robustness. Robustness is proportional flexibility or built in *slack* in a schedule. If a schedule is optimum while having slackness and flexibility, then it is robust as well. Proactive or robust scheduling handles a baseline schedule which anticipates variability, or which has precautions or tactics against uncertainties and disruptions. Another term to review is reactive scheduling. Reactive scheduling is used in dynamic scheduling. Mostly, reactive scheduling doesn't require pre-schedules. Reactive schedules are referred to as predictive-reactive schedules as well. Reactive schedules re-optimize the baseline schedule after a number of disruptions occur. For more review on robustness, the reader is referred to the article. (Herreoelen et.al., 2004) One other review paper related to personnel scheduling belongs to Ernst et.al. (2004) They made a comprehensive bibliography and review on personnel scheduling which categorizes the work as classifications, application areas and solution methods. The article is a complete and comprehensive study so that the reader is referred to the article for more review on robust schedules. (Ernst et.al., 2004)

There are many classifications related to robust schedules. Loo et.al. (2007) classified the solution approach to robustness into two categories. The first group of research tends to minimize the insensitivity of the schedule to external disturbances. The second tries to create schedules with greater flexibility so that, when a disruption occurs, recovery can be achieved with minimal alteration to the disrupted schedule. (Loo et.al, 2007)

Ahmed et.al. (2008) made a classification of the robust scheduling research methods that have been used before and have been found popular in the area, giving the names of the authors and article titles. They classified the methods as neighborhood search (heuristic), multi-objective genetic algorithm (heuristic), simulation approach (heuristic), multi-criteria approach (heuristic), delay perturbation (heuristic), just-in-time approach (heuristic), modeling integration (modeling), degradable airline schedule (modeling) flight schedule re-timing (modeling), and integrating FAM (Fleet Assignment Model) and rerouting problem (hybrid).

Two classifications will be made concerning robust schedules relative to the solution methodology and application area where they are used or going to be used. The stochastic and multi objective nature of the schedules will be the first classification. The other articles will be listed relative to their application areas, such as manufacturing, airlines, and personnel scheduling, as the second classification. All of these areas are related to robustness by different objective functions. Manufacturing has the objective of minimizing the number of disruptions affecting their plant schedules. Airlines have the objective of minimizing the number of disruptions (delays) affecting the flight schedules. Fixing a flight schedule which is less vulnerable to time disruptions is the robustness criteria for airliners. As to the last topic, personnel scheduling has the objective of minimizing the number of disruptions that affect the schedule. Therefore, researchers make robust schedules that are more insensitive to disruptions, and they make models allowing rescheduling with a minimum number of changes compared to old versions of the schedule.

**Using Stochastic Procedures to Build Robust Schedules and Stochastic Nature of Robust Schedules**

Some researchers believe that if they are thinking about unexpected incidents, they can use stochastic methods to find out how they can construct models having robust schedules. One article related to this belongs to Ran Ding et.al. (2006)

Ran Ding et al.(2006) offered "the idea of robust scheduling with recourse." "The objective of robust optimization is to find the equilibrium between feasibility and optimization." (Ran Ding et.al., 2006) Their starting point was that a deterministic model presents a suboptimal schedule which can be infeasible in some cases; thus, they represented a stochastic model by taking advantage of stochastic tools. They mentioned that there are many solution methods to different problems in presenting a robust schedule. This means that when the problem changes, the solution method to be applied can or should also be changed, and new techniques are applied in the area. (Ran Ding, 2006)

Ran Ding et al. mentioned that different than the "worst-case" analysis method, some constraints can be violated, but these constraints are compensated by recourse in case of violations. They used scenario-based uncertainty and implemented the uncertainty values as stochastic values to the objective function. They let some constraints be applied as soft constraints; however, they applied recourse in case of violations. In this case the schedule is still feasible despite the violations. Namely, the schedule is improved by the violations on the constraints which were caused by uncertainty, so uncertainty makes the schedule dynamic. Furthermore, they used four stochastic metrics to measure how robust the schedule is that is produced by the model that they introduced: variance in the objective function, extent of violations of the objective, extent of violations of constraints, and frequency of rescheduling. They introduced stochastic variables stemming from a uniform distribution and then run an example to demonstrate the model's effectiveness. (Ran Ding, 2006)

**Multi-objective Nature of Robust Scheduling**

"In the process of planning, design, operation, or evaluation of large-scale systems, often more than one objective function seems to be both desirable and essential for a meaningful analysis. However, because there is a lack of such conceptual schemes available, most analysts sacrifice more realistic modeling for a simplified optimization scheme. " (Haimes et.al., 1971)

Robust scheduling has a multi-objective nature; however, there aren't many articles mentioning this aspect. Other research that is described belongs to Surico et.al. (2007). Surico et.al. mentioned an important and non-negligible aspect of robust schedules. Much research which has been done relative to robust scheduling shows an intuitive or clear trade off between two objectives. One is minimizing cost or maximizing profit, and the other is maximizing robustness. Namely, increasing the robustness of a schedule increases costs or decreases the profit. However, increasing robustness is more beneficial and useful in the long run. In real life for most cases, both of the objectives are conflicting. When it comes to this problem, both of the objectives are conflicting objective functions. Surico et.al.'s (2007) research is most accurate at the moment. They considered the problem as a bi-objective problem as described above. They stated that robustness of the problem should be considered along with minimizing the cost objective. The group had an approach to the robust schedule by qualifying two objectives via the bi-objective genetic algorithm. (Surico et.al., 2007)

Ehrgott and Ryan (2002) have solved the same problem as Loo et.al. (2007) did, concentrating on evaluating multi-objectives. In this case there are two objectives so it's called bi-objective optimization. They mentioned that airlines are both interested in cost effective solutions and robust solutions which are less vulnerable to disruptions than other conventional schedules. They developed a bi-criteria optimization framework to generate Pareto optimal schedules for domestic airlines that don't allow an improvement in cost and robustness at the same time. (Ehrgott & Ryan, 2002)

The problem is described as a ToD planning problem. The set partitioning problem provided an underlying mathematical model for ToD planning and for rostering sub-problems of the aircrew scheduling problem. Measuring cost is trivial compared to other problems, but measuring robustness is more complex. They use the total delay for each tour as a non-robustness penalty. Using these two objective functions doesn't seem trivial since they are conflicting; namely there is a trade-off between cost and robustness. (Ehrgott & Ryan , 2002) Adding the minimizing non-robustness objective, the problem became a 2SPP (Bi-objective Set Partitioning Problem). They applied an iterative methodology to solve the problem. In addition they made a comparison among multi-objective function methods such as the weighted sum method, the ε constraint method, and the elastic constraint method. For more review related to multi-objective problem solutions reader is referred to the article. (Ehrgott&Ryan, 2002)

**Manufacturing Related Articles**

Kentaro et.al. solved a job shop problem by a robust scheduling method. They described unexpectedly changing situations as uncertainty. They mentioned that in real production, information for scheduling in a scheduling division is uncertain and incomplete, so that the generated schedule is often not executable in a production division. Researchers are looking for ways of preparing a schedule which is executable without any modification in production such as putting spare time between each process. (Kentaro et al., 2004:1464) They stated that there exists a trade off between improving productivity and enhancing a robust schedule that is not vulnerable against environmental changes. Both of these are literal objectives desired by manufacturers. (Kentaro et al., 2004:1464)

In their research, an environmental change probability model is introduced, and the model is used to fix schedules for any conditions to be met. These schedule sets are kept in data carriers. In case any of the changes occur, the schedules that are kept in those data carriers for such cases are used directly. (Kentaro et al., 2004:1464) They came up with an innovative comment that a robust schedule can be a basis for the next robust schedule which generates an iterative improvement through an iterative manner. (Kentaro et al., 2004:1467)

One other article in the area belongs to Hart et al. (1998). They worked on solution techniques on robust schedules via an "artificial immune system". They used a genetic algorithm method to improve the "artificial immune system method" to obtain robust schedules. Hart et al. stated that the biological immune system consists of antibodies against foreign molecules, namely antigens. In case an antibody discovers an antigen, it physically binds to it and finally eliminates it. Antibodies build up an antigen library in time so that they recognize more antigens if the body encounters more intruder incidents. The human immune system has evolved in a manner that allows it to successfully deal with an enormous range of antigens, reacting quickly both to those antigens it has encountered before as well as to entirely new ones. Hart et al. solved the problem in an m machine job-shop environment. The objective function is defined as the minimization of $T_{max}$ (maximum tardiness) (Hart et al., 1998)

Hart et.al. (1999) worked on a heavily constrained scheduling problem for a local chicken factory. Chickens are caught live by teams who work for a local firm. Around 1.3 million birds are caught from the farms in a specific region and carried to the factories by trucks. Since there are strict regulations about waiting time for the trucks in front of the factory, it requires an effective schedule to meet the related requirements. The authors define the problem as a job scheduling problem and used a genetic algorithm to solve it. The algorithm yields a robust schedule in seconds which generally takes one or more days by hand. Constructing a robust schedule by hand depends on the experience of the scheduler, and it takes a long time for the scheduler to be successful at preparing such a schedule. (Hart et.al. , 1999)

Dr. Carla Gomes from Rome Laboratory did research which focuses on the real-world problem of multiple resource-constrained project management. The problem is in planning outages for nuclear plants and is defined as a job-shop scheduling problem. An outage is considered as a planned shutdown for refueling, repair, and maintenance. Safety is of paramount importance so management of a nuclear plant's outage is planned considering the safety issues. Since scheduling is an intractable problem, the problem is solved by heuristic methods in order to get quick but feasible results. However related methodology that the author has contributed supplies infinite feasible solutions and is used to obtain robust schedules. She used KIDS software as the base software platform. She also used transformational approaches and AI (artificial intelligence) technology to solve real-world planning and scheduling problems involving complex constraints such as planning outages for nuclear plants. The problem is modeled as a constraint satisfaction problem combining a global search tactic with constraint propagation. The derivation of very specialized constraints to perform efficient propagation is a key aspect for the generation of very fast schedules. (Gomes, 1996)

**Airline Related Articles**

An important area for which robust models are constructed is the airlines. In MIT there is a course related to airline scheduling. (Airline Schedule Planning) Airlines are trying to increase the effectiveness of airline schedules to both decrease costs and increase profit in the long run.

Airline planners build schedules for aircraft and crew members as well as taking care of the passenger itineraries which are concerned mostly with connecting flights. These schedules affect each other from a time perspective, so a minor delay in one local point can affect the whole schedule nationwide. "In fact, such *local* delays can impact network operations *globally*." (Ball et.al, 2006) The economic impact of disruptions is great. 116.5 million system delay minutes (up five percent from 2005) drove an estimated $7.7 billion in direct operating costs for U.S. airlines (up 11 percent from 2005) according to the data taken from U.S. Department of Transportation in 2006.

Table 2.1: Delay Related Costs

| **Direct (Aircraft) Operating Costs Calendar Year 2006** | **$ Per Block Minute** | **Annual Delay Costs** ($ millions) |
|---|---|---|
| Fuel | $28.31 | $3,296 |
| Crew - Pilots/Flight Attendants | 14.25 | 1,659 |
| Maintenance | 10.97 | 1,277 |
| Aircraft Ownership | 9.18 | 1,069 |
| Other | 3.10 | 361 |
| **Total DOCs** | **$65.80** | **$7,663** |

Notes:
1. Costs based on data reported by U.S. passenger and cargo airlines with annual revenues of at least $100 million.
2. Arrival delay minutes taken from the FAA Aviation System Performance Metrics (ASPM 75) database.

(27)

Thus, airline planners have to handle their schedules in a timely manner to decrease the costs. In order to address this issue, robust scheduling has become very popular. In addition, such scheduling can minimize time disruptions for each step in the schedule. Operating costs are expected to increase dramatically, with air traffic forecast to double in the next 10-15 years (Ball et al., 2006). Planners are looking for tactical and strategic plans to use to address this situation.

Kontogiorgis et.al. (1999) did research related to automating weekend fleet assignment in US Airways. First, they mention two conflicting objective functions to show that they have to solve the problem by balancing them. Airliners have to meet the passenger demand as much as possible while minimizing the costs related to realigning airport facilities and personnel that would be incurred by changing the flight patterns too much. In order to solve this problem they have modeled a schedule which supplies a safe, profitable and robust schedule. (Kontogiorgis et.al. ,1999)

Loo et.al.(2007) from National University of Singapore did research on a multi-objective genetic algorithm for robust scheduling using simulation. The problem was modeled as a case of deterministic variables in this research. An algorithm was developed to solve the problem. Loo et.al. mentioned that since every change of a flight schedule affects revenue, it is of paramount importance that a quality flight schedule be constructed, but developing one is a very intricate task. Are the flight schedules deterministic so that they can be carried out as planned without uncertainties?

Whereas the flight schedules encounter frequent disruptions by unexpected external events, such as bad weather, crew absences or equipment failure, delays caused in earlier flights of the day, without sufficient slack time between flights, may propagate along the flight network to the remaining flights and cause widespread disruptions in the schedule. Crews and passengers often miss their connections due to these disruptions. These environmental conditions necessitate cost effective, robust flight schedules. This research is based on a multi-objective decision space since different airlines use different robustness measures, such as on-time performance, percentage of flights delayed, number of legs cancelled per day, etc. (Loo et al., 2007)

One other research similar to airliner scheduling considers ground transportation scheduling. Alfieri et.al. (2007) solved a problem of scheduling train drivers on a railway subnetwork. Alfieri's train driver scheduling problem refers to airliners ToD (tours-of-duty) scheduling problems. Each train driver has a duty, and each duty consists of a sequence of trips. Each trip is covered by at least one duty, and each duty meets related constraints. A feasible train driver schedule has a feasible set of duties. The objective function is to minimize the number of duties while maximizing the robustness of the schedule from outside disruptions. The authors apply a heuristic method, implicit column generation approach. They start with an initial feasible solution which they obtained with a heuristic method and then apply a heuristic branch and price algorithm based on a dynamic programming algorithm to price out the columns. Alfrieri et.al. applied heuristic methodology to obtain a quick and robust solution. (Alfieri et. Al. ,2007)

**Personnel Scheduling**

There are numerous articles in the literature about robust schedules; however, when one focuses on personnel scheduling, it is hard to find articles. This shows that not much research has been done in this area.

Moz and Pato expressed the need for arranging a robust schedule more specifically so that nurses could organize their private lives in accordance with their expected duties. Any change in the announced schedules may create personal inconveniences to some of them. Therefore, in order to increase personnel motivation and work productivity, a rerostering problem arises that aims to minimize shift changes with regard to the current one. (Moz&Pato, 2004: 668) While Moz&Pato don't address robust schedules, the problem they mention could be reduced by robust schedules. Robust schedules supply the flexibility and durability that personnel need.

Mercier et.al.(2005) solved the integrated aircraft routing and crew scheduling problem while determining a minimum cost aircraft route set and crew pairings. They propose a robust model to handle the linking constraints that they have introduced to the model and then compare two Benders decomposition methods. The first one takes the aircraft routing problem while the second one takes the crew pairing part of the problem. (Mercier et.al. ,2005)

Kroon et.al. (2000) worked on an already existing model, called TURNI system that is used by the Dutch railway operator NS Reizigers for supporting its internal planning processes of generating efficient and robust duties for train drivers and guards. The TURNI system is a set-covering model which is solved by applying dynamic column generation techniques, Lagrangean relaxation and powerful heuristics, using additional constraints. They run the Noord-Oost case which was carried out with the objective of obtaining an efficient schedule for the drivers and guards with a high robustness with respect to the transfer or delay of trains. The Noord-Oost case contains different scenarios. These scenarios are additional constraints which are injected into the model. They consist of more specific conditions and narrow the schedule to a more specific one. Kroon et.al. (2000) compare the output of these scenarios and choose the most robust one. Even though this problem had not been feasible to solve using a set-covering problem since the number of cells to be scheduled is greater than those on an airline schedule, newly developed algorithms make such a solution possible.

It is worth mentioning Laporte's model since it builds a constraint programming (CP) algorithm which fixes a robust schedule. Laporte et.al. (2004) have done research which focuses on multi-shift schedules. They took a cyclic system which has repeating, periodic schedules. They solved the problem with a constraint programming algorithm of rotating schedules. This is the main contribution of this article. My motivation for using this approach is that CP offers at the same time the flexibility, robustness and speed required for this problem. Their model efficiently filters out inconsistent variable assignments. (Laporte et.al. ,2004)

Warner et.al. (1997) addressed worker assignments in implementing manufacturing cells. They modeled the problem as an assignment problem and made the model robust against small changes on the worker skills, absenteeism or firing. The work includes the development of contingent solutions for the cellular system as well. (Warner et.al. , 1997)

One of the other authors who have worked on robust personnel schedules is Tower. Tower constructed five nurse scheduling models based on Knighton's Mathematical Network Flow Program (2005). Five models are constructed on five different scenarios. He compared the resistance of the models against disruptions. Models are constructed by assigning a different number of personnel as alternates from each qualification set. Each model is evaluated based on the number of disruptions it can receive before becoming invalid. (Tower, 2006)

Personnel scheduling is a very specific area in the robust scheduling research study. Similarly, a fighter squadron flight schedule can be included in the personnel scheduling area as well. In this research a fighter squadron schedule will be used and made more robust against possible disruptions using specific modeling techniques.

### Fighter Squadron Scheduling Models

Fighter squadron schedules can be categorized as personnel scheduling problems. As a pilot who has flown in a fighter squadron, It can be said that fighter squadron schedules have a large number of constraint types which make them heavily constrained. Such conditions make a schedule very hard to build and solve. One of the schedules built in this area belongs to Nguyen (2002) who has built a fighter pilot training schedule.

**An Interactive Decision Support System for Scheduling Fighter Pilot Training**

The schedules that best meet the squadron's needs must be flexible and robust and be able to allow changes to occur without significantly affecting the original schedules. (Nguyen, 2002:48) Nguyen (2002) built a software program which makes a robust flight schedule for flight training squadrons. Software design and implementation take advantage of the existing tools/software to speed up the creation process. The existing tool was created in Excel. Inherent in Excel is the VBA (Visual Basic for Applications) programming language. Therefore, VBA was used to extend the existing tool by programming additional capabilities using VBA codes. (Nguyen, 2002:49-50)

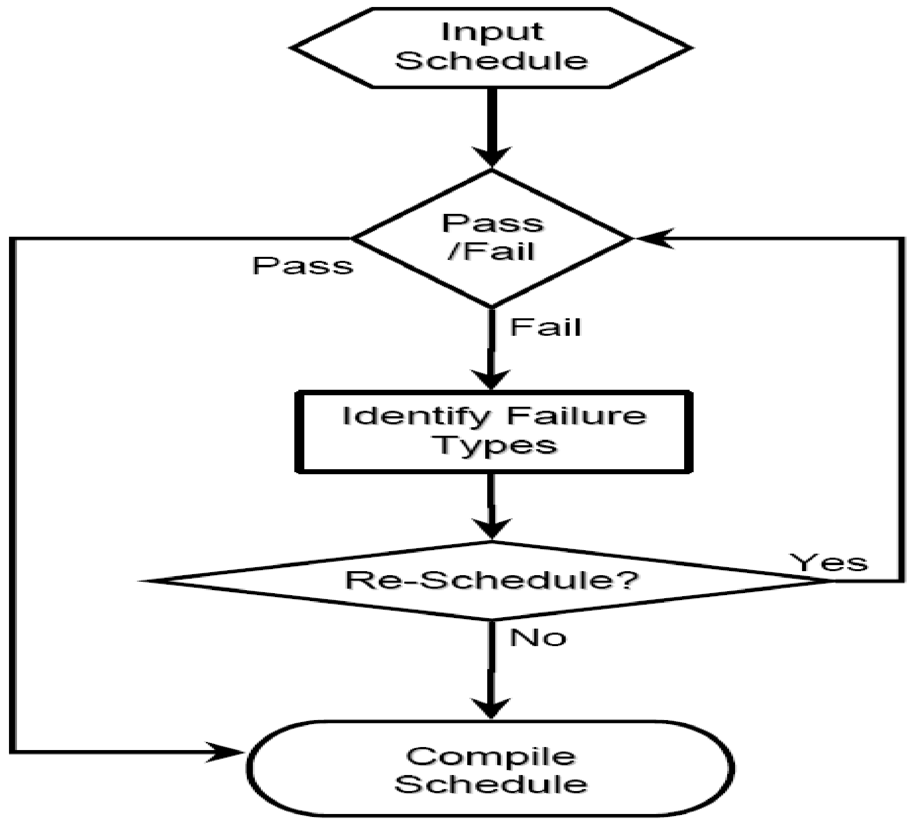



**Figure 2.1 Post-Scheduling Attrition Model (Nguyen, 46:2002)**

A scheduling algorithm is applied. One of the priorities ("Largest Number of Requests, Flight Behind the Training Schedule the Most, and Class Seniority") is selected by the scheduler and used in the algorithm as the objective function. There are many feedback cycles used in the algorithm, and then a draft schedule is prepared. (Nguyen, 2002) In addition, the draft schedule is evaluated by an attrition model which implements changes to the schedule depending on the probabilities of weather, maintenance, operations and the other unexpected events depending on historical data. The attrition model is used to simulate the attrition of sorties that can typically be found in a training environment. Using the 15.9% attrition rate, the squadron scheduler planned for sortie attrition by adding additional sorties to the base sortie rates. Depending on the quality of the output, a new schedule is built by the post-attrition model, or the existing schedule is modified to obtain a new schedule. Nguyen mentions that re-scheduled sorties are affected by attrition at the same rate as the original sorties scheduled. (Nguyen, 2002: 57) Nguyen's method is an iterative and continuously improving schedule which supplies a robust schedule at the end. (Nguyen, 2002)

Nguyen's robustness idea depends on the validation of the final schedule following the implementation of the simulated disruptions. If the output of the schedules is still valid and effective after the implementation of the attrition model, the entire model supplies a robust schedule for a 120 day training calendar. He proves the robustness of all three objective functions in his model.

**Network Flow Model for Optimizing Fighter Squadron Scheduling**

The research belongs to Boyd et.al. 2006. They made a network flow model of a fighter squadron schedule. Boyd et.al mentioned details about the complexity and heavy constraints of a fighter squadron schedule. They prepared an applicable fighter squadron schedule by using the data which belong to an Air Force Base in Germany. The model was constructed as an acyclic network flow problem such as a transshipment problem with multiple supply and demand points. The model that they provide doesn't consider any robust solution.

**Newlon's Mathematical Model for Fighter Squadron Scheduling**

Additional research related to fighter squadron schedules belongs to Newlon, 2007. Newlon made a scheduling model which presents a VBA-based graphical user interface which has a formulation built on an Excel based solver platform. The model is an improved version of the fighter squadron scheduling model which was built by Boyd et.al. (2006). The model has been divided into hourly parts compared to Boyd et.al. 's model. Newlon divided the problem into sub-problems and solved some of them by using heuristic methods. Newlon's model didn't provide any robust solutions. In other words, it doesn't consider robustness in the schedules. However, these models can provide pre-schedules or initial baseline schedules to develop robust schedules.

A baseline scheduling model will be developed in this research and be looked for robust schedules among a set of optimal schedules. The next chapter will provide the methods of constructing a baseline schedule and re-scheduling model.

# III. Methodology

## Chapter Overview

The objective of this methodology is to find robust schedules for fighter aircraft squadrons and, to make a generalization for further research related to robustness. In order to obtain a robust schedule, first a basic scheduling model will be created. Following the creation of the basic scheduling model, a rescheduling model will be created. Schedules created by the basic scheduling model will be tested by 10 different disruption types. Then the disrupted schedules are rescheduled, minimizing the total number of changes with respect to the previous schedule's objective function. Output schedules are ordered from min to max mean value of the total number of changes. The schedules which have the least mean value of the total number of changes are the most robust schedules. Final comments are made on the obtained robust schedules in order to reach a general recommendation about robust schedules. Specified models don't take advantage of using alternate pilots to obtain robust schedules. Rather, the opportunity of changing the objective function coefficients of the current basic scheduling model will be utilized to obtain the most robust schedules and come to a general conclusion using the results.

Fighter squadron schedules include different types of qualifications and flight statuses. The qualifications which are used in the model are Top3, and SOF (Supervisor of Flight). IP (Instructor Pilot), FL (Flight Lead), and P (Wingman) are the three flight statuses in the squadron. Top3 is the duty type that only the top three highest ranking personnel in the squadron can perform. SOF is the duty type that only SOF qualified pilots can perform. SOF qualified pilots are the pilots who have the highest flying status in the squadron such as IP and FL. IP status allows those in the squadron to fly as instructor pilots. Instructor pilots fly to re-qualify pilots for specific mission types. An instructor pilot can fly as FL and P in a flight other than in IP status. FL is a 4-ship flight lead status. A FL can fly as P other than in FL status. P status is the lowest status in a flight and can fly only as a wingman. A wingman needs either an IP or a FL to fly a specific mission.

Before mentioning the basic scheduling model, assumptions related to both the basic scheduling model and the rescheduling model will be introduced. These assumptions are given conditions to the models; however, they can be changed without affecting the model's operability.

**Assumptions**

(1) Even though the total number of sorties flown changes daily, it is assumed to be at the maximum level of 6 in each flight block.

(2) It is assumed that there are three blocks of flights to be scheduled for each weekday even though night missions are flown only on specific days, such as Monday and Wednesday.

(3) The squadron doesn't have D model aircraft. D models are indeed present at all of the squadrons. They are used for training and requalification purposes, so they are required and necessary for the squadrons.

(4) FL position refers to 4 ship leadership. All of the flight leads in the squadron are 4 ship leaders. 2 ship leads aren't used in the model. 2 ship leads can only be used in 2-ship flights or number three in 4-ship flights.

(5) This research assumed that this squadron will take over 2 SOF duties a day according to the agreement between two squadrons.

**Basic Scheduling Model**

A basic model is constructed to prepare a weekly flight schedule. There are three types of cells to fill in the schedule. The first one is the Top3 cell, the second one is the SOF who will be assigned for a specific block, and the third one is the assigned flights for each pilot. The data for the flight scheduling model is taken from the Letter of X's from a current operational F-16 fighter squadron at Spangdahlem Air Base, Germany, in order to present a realistic set of pilot qualifications. A **Letter of X is** a form that shows which pilots are qualified for which kind of missions for how many days**.** Appendix A shows a sample fighter squadron Letter of X's. (Boyd & Cunningham, 2006)

A basic model is constructed for fifteen pilots. There will be 6 sorties flown each block. Three blocks are scheduled each weekday, AMGO (AM Block), PMGO (PM Block), and NGO (Night Block). Thus, the total number of blocks is fifteen for one week. Specific scheduling slots are referred to as cells. The total number of cells for flights to be scheduled is 225. Since the Top3 mission is the entire day, the total number of cells to be scheduled is 3 each day for each pilot, and the total number of cells to be scheduled is 15 each week for each pilot. There are 4 pilots qualified for SOF duty. Since there are 3 blocks each day and 15 blocks a week for each pilot, the total of 60 SOF cells are to be scheduled each week for qualified pilots. Finally the total number of cells to be scheduled is 300 for a weekly flight schedule.

**Basic Scheduling Model Problem Formulation**

$$\text{MAX } c_{IP} * \sum_m \sum_j \sum_t x'_{mj_t} + c_{FL} * \sum_n \sum_j \sum_t x'_{nj_t} + c_P * \sum_o \sum_j \sum_t x'_{oj_t} - 100 * \sum_i \sum_j l'^{-}_{ij}$$

Where, $c_{IP}$, $c_{FL}$, $c_P$ are coefficients for IPs, FLs, and Ps.

Subject to

$\sum_j \sum_t x'_{ij_t} = 6 \quad i \in I$ (1)

where, $x'_{ij_t}$ = whether or not the $i^{th}$ pilot will fly in the $j_t^{th}$ block

I= {set of all pilots} , J= {set of weekdays} , K= {set of Top3 pilots}

T= {set of all possible blocks for each day} , F= {set of available pilots for SOF}

$x'_{ij_t} \in$ Binary i= 1, 2, … , 15 $\in$ I , j= 1 , … ,5 $\in$ J t= 1,2,3 $\in$ T

$\sum_m x'_{mj_t} + \sum_n x'_{nj_t} >= \sum_o x'_{oj_t}$ (2)

Where, $m \in M \subset I$ M= {set of IP's}, $n \in N \subset I$ N= {set of FL's}, $o \in O \subset I$ O= {set of P's}

$x'_{ij_3} + x'_{i(j+1)_1} <= 1 \quad \forall \quad i \in I, j \in J$ (3)

$x'_{ij_1} + x'_{ij_3} - 1 + l'^{-}_{ij} - l'^{+}_{ij} = 0 \quad \forall \quad i \in I, j \in J$ (4)

Where, $l'^{-}_{ij}$, $l'^{+}_{ij}$ >= 0, Goal variables belong to the 2nd Rest Constraint

$\sum_t x'_{ij_t} <= 2 \quad \forall \quad i \in I, j \in J$ (5)

$\sum_k p'_{kj} = 1 \quad j \in J$ (6)

Where, $p'_{kj}$ = whether or not the k^th Top3 pilot will be on duty as Top3 for the entire j^th day

k= 1, 2, 3 ∈ K ⊂ I  $\mathbf{p'_{kj}}$ ∈ Binary

$$\sum_f s'_{fjt} = \mathbf{a} \quad \mathbf{j \in J, t \in T} \tag{7}$$

Where, $s'_{fjt}$ = whether or not the $f^{th}$ pilot will be SOF on the $j^{th}$ day

**a** is the vector consisting of either 1 or 0 for each block depending on the agreement between the squadrons. f=3, 4, 5, 6 ∈ F ⊂ I  $s'_{fjt}$ ∈ Binary

$$x'_{ijt} + p'_{kj} + s'_{fjt} <= 1 \quad \forall \quad k, f, i \tag{8}$$

**Constraints of the Basic Scheduling Model**

(1) The first constraint is related to the number of pilots to fly each block. This constraint of the model limits the number of sorties to be flown in each block to 6, since there are 6 aircraft designated to the squadron.

(2) The second constraint is related to compositions of pilot's flight status for each block. Before explaining the second constraint, some information must be given about the composition of the flights.

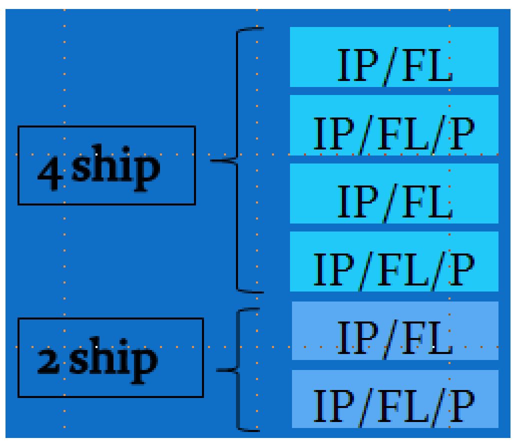



**Figure 3.1 : 6-ship Compositions**

Considering that IPs and FLs can occupy various positions in a flight, the total number of cells to be scheduled in a flight block for IPs should be less than or equal to 6. The total number of FLs should be less than or equal to 6, and the total number of Ps should be less than or equal to 3. Figure 3.1 shows the possible positions for the pilot groups. As a consequence, the second constraint is developed related to the type of pilot for all these flight compositions. The total sum of the scheduled IPs and FLs should be more than the total number of scheduled Ps. This constraint presents a more relaxed and realistic condition rather than limiting each pilot group to a specific number of sorties each bock.

(3) The third constraint is interested in the crew rest of the pilots. A pilot should not fly on the AM GO if he has flown on a NGO the previous day.

(4) The fourth constraint is a second crew rest constraint. If a pilot is assigned to fly in the AMGO, he/she shouldn't fly in the NGO on the same day. The constraint is constructed as a soft constraint; namely, violations on the constraint are penalized in the objective function. $x'_{ij1} + x'_{ij3}$ -1 on the left hand side of the constraint can be -1 and 0; however, it is not intended to be 1. Thus, the total sum of $t'^{+}_{ij}$ will be penalized in the objective function.

(5) The fifth constraint limits the total number of sorties flown by a specific pilot for one flying day to 2. A pilot shouldn't fly 3 sorties a day. Therefore, a pilot can't fly all the blocks in a given flight day.

(6) The sixth constraint is related to Top3 duty. One Top3 pilot should be on duty in the squadron during all the blocks in a flight day.

(7) The seventh constraint is related to the number of SOFs. According to flight regulations, there must be a SOF who starts, observes and ends the flying activity during each block. Therefore, for each block, the number of SOFs should be equal to 1. However, this duty is shared by two or more squadrons. The first squadron, which this research is scheduling, will take 2 SOF duties a day. The third SOF duty will be taken by the other squadron.

(8) The eighth constraint is related to the type of missions that one pilot can perform at a time. Some pilots are responsible for fulfilling more than one mission type in

the squadron. For example, all of the Top3 pilots are IPs. One of the pilots is both Top3 and SOF qualified, so that he/she can be either Top3 or SOF, or he/she can fly. Thus, an additional constraint will limit such pilots to only one of these missions at a time.

**Objective Function of the Basic Scheduling Model**

The main objective is to maximize the robustness of the flight schedule. Thus the objective function is arranged to balance the total number of sorties among the pilot groups: IP s, FL s, P s. The second objective function, maximizing the total number of sorties, is set as a constraint. Namely, the epsilon constraint method is applied to search for a robust scheduling model. Top3 and SOF duties are not a concern. Namely, no coefficients are used for SOF and Top3 duties. The objective function attempts to balance the total number of sorties for the pilot groups while fulfilling SOF and Top3 duty requirements. The basic model thus builds a weekly flight schedule.

Since all of the variables are binary, either 1 or 0, the problem is formulated as an integer programming problem. In addition to this, the problem is formulated as a 0-1 set-covering problem.

Robust schedules will yield fewer changes on a new schedule in the event of disruptions. Since fewer changes are the indication of the robustness, a rescheduling model will be constructed to measure the robustness. The rescheduling model will then produce a new schedule when disruptions occur on the previous schedule.

## Rescheduling Model

The rescheduling model will re-roster a previous schedule with a minimum number of changes. Goal programming will be used in the rescheduling model. In order to have a schedule with a minimum number of changes, additional goal constraints will be used in addition to the constraints of the basic scheduling model,. . Then these depict the total number of changes with respect to the previous schedule should be equal to zero. These then should be added to the model. Thus, additional constraints narrow the same region when compared to the feasible region of the basic scheduling model. Such goal constraints are used for flight cells, Top3 duty cells and SOF cells which mean three constraints are used to minimize the number of changes. The rescheduling problem is formulated as a mixed integer 0-1 set covering problem when the additional goal constraints are added.

**Rescheduling Model Problem Formulation**

$$MIN \sum_i \sum_j \sum_t (v^-_{ijt} + v^+_{ijt}) + \sum_k \sum_j (u^-_{kj} + u^+_{kj}) + \sum_i \sum_j \sum_t (w^-_{fjt} + w^+_{fjt}) - 3 * \sum_i \sum_j (l''^-_{ij})$$

Subject to

$$\sum_j \sum_t x''_{ijt} = 6 \quad \forall\, i \in I \qquad (1)$$

Where, $x''_{ijt}$ = whether or not the i[th] pilot will fly in the j[th] block

$x''_{ijt} \in binary$ i=1,2,…,15 ∈ $I$ , j=1,2,…,5 ∈ $J$ , t=1,2,3 ∈ $T$

I= {set of all pilots} , J= {set of weekdays} , K= {set of Top3 pilots}
T= {set of all possible blocks for each day} , F= {set of available pilots for SOF}

$$\sum_m x''_{mjt} + \sum_n x''_{njt} \geq \sum_o x''_{ojt} \qquad (2)$$

$m \in M \subset I$, M= {set of IP's} , $n \in N \subset I$, N= {set of FL's} ,

$o \in O \subset I$, O= {set of P's}

$$x''_{ij3} + x''_{i(j+1)1} \leq 1 \quad \forall\, i \in I, j \in J \qquad (3)$$

$$x''_{ij1} + x''_{ij3} - 1 + l''^-_{ij} + l''^+_{ij} = 0 \quad \forall\, i \in I, j \in J \qquad (4)$$

Where, $l''^-_{ij}$ - $l''^+_{ij}$ >= 0, Goal variables belong to the 2[nd] Rest Constraint

$$\sum_t x''_{ijt} \leq 2 \quad \forall\, i \in I, j \in J \qquad (5)$$

$$\sum_k p''_{kj} = 1 \quad \forall\, j \in J \qquad (6)$$

Where, $p''_{kj}$= whether or not the k[th] Top3 pilot will be on Top3 duty on the j[th] day

$$\sum_f s''_{fjt} = a \quad \forall\, j \in J, t \in T \qquad (7)$$

Where $s''_{fjt}$=whether or not the f[th] pilot will be SOF on the j[th] day

f=3,4,5,6 ∈ F ⊂ I $s''_{fjt} \in binary$

**a** is a vector of $(\quad)_{3\times1}$ which depicts whether SOF duty is to be performed by the squadron or not.

$$x''_{ijr} + p''_{kj} + s''_{fjr} \leq 1 \quad (8)$$

$$x''_{ijr} - x'_{ijr} + v^{-}_{ijr} - v^{+}_{ijr} = 0 \quad (9)$$

Where, $v^{-}_{ijt} \geq 0,\ v^{+}_{ijt} \geq 0,$ Goal variables related to flight constraints

$$p''_{kj} - p'_{kj} + u^{-}_{kj} - u^{+}_{kj} = 0 \quad (10)$$

Where, $u^{-}_{kj} \geq 0, u^{+}_{kj} \geq 0,$ Goal variables related to Top3 duties

$$s''_{fjr} - s'_{fjr} + w^{-}_{fjr} - w^{+}_{fjr} = 0 \quad (11)$$

Where, $w^{-}_{fjt} \geq 0, w^{+}_{fjt} \geq 0,$ Goal variables related to SOF duties

**Constraints of the Rescheduling Model**

The presented constraints are equivalent to the basic scheduling model's constraints up to the eighth constraint, whereas the ninth, tenth and eleventh constraints are additional constraints particular to the rescheduling model.

**(9)** The change in a flight cell should be zero. (GOAL 1)

**(10)** The change in a Top3 scheduling cell should be zero. (GOAL 2)

**(11)** The change in a SOF scheduling cell should be zero. (GOAL 3)

## Objective Function of the Rescheduling Model

The rescheduling function has an objective of minimizing the total number of changes compared to the previous schedule. Screenshots belonging to both the basic scheduling model and rescheduling model which is built in Excel Premium Solver are shown in Appendix B.

The Excel Premium Solver which is a special commercial add-in for Microsoft Excel was used to formulate and prepare the basic scheduling model and the rescheduling model. The basic model consists of 450 variables and 486 constraints. The rescheduling model consists of 1050 variables and 786 constraints. The Standard LP/Quadratic solver engine of the Premium Solver Platform was used to run both of the models. The Standard LP/Quadratic solver engine can solve models up to 8000 variables and 8000 constraints. Current models are out of limits of basic solver in the Microsoft Excel.

## Construction of a Robust Schedule

After the schedule has been rostered by the basic scheduling model, it faces a number of disruptions and becomes inapplicable. In order to make a new schedule, the rescheduling model is run, and a new schedule is re-rostered with a minimum number of changes. If the previous schedule is robust, the number of changes which the rescheduling model yields will be minimal. In order to understand which schedule is the most robust schedule, a search method will be applied.

The basic scheduling model can generate a large number of distinctly optimum schedules by changing the coefficients of $c_{IP}$, $c_{FL}$, $c_P$ with respect to IPs, FLs, and Ps. A small subset will be taken and classified. After the classification, only selected distinct schedules among the groups will be checked to see which is most robust.

**Selection of Objective Function Coefficients in the Basic Scheduling Model**

In order to be used as objective function coefficients, 11 numbers are selected for each objective function coefficient from 0 to 100 in increments of 10. The total number of possible schedules is 1331; thus 1331 schedules can be made by only using permutation of the numbers as the coefficients. The output data of 1331 schedules, which includes coefficients of each objective function and the total number of sorties with respect to each coefficient array, will be presented in Appendix C.

**Proposition:** The same cardinal order of the objective function coefficients will yield the same total number of sorties for IPs, FLs, and Ps.

26 Scheduling Rules which are derived from the proposition above are listed in Figure 3.2. As an example of the proposition, for the small-big-bigger rule, 10-20-30 coefficients yield 10-35-45 sorties with respect to IP, FL, and P sets. However, 50-70-90 coefficients yield 10-35-45 sorties, as well.

| | IP | FL | P | | IP | FL | P |
|---|---|---|---|---|---|---|---|
| 1 | Z | Z | Z | 6.1 | S | B | BE |
| 2.1 | Z | S | B | 6.2 | S | BE | B |
| 2.2 | Z | B | S | 6.3 | B | S | BE |
| 2.3 | Z | E | E | 6.4 | B | BE | S |
| 3.1 | S | Z | B | 6.5 | BE | S | B |
| 3.2 | B | Z | S | 6.6 | BE | B | S |
| 3.3 | E | Z | E | 7.1 | S | BE | BE |
| 4.1 | B | S | Z | 7.2 | BE | S | BE |
| 4.2 | S | B | Z | 7.3 | BE | BE | S |
| 4.3 | E | E | Z | 8 | E | E | E |
| 5.1 | Z | Z | S | 9.1 | B | R | R |
| 5.2 | Z | S | Z | 9.2 | R | B | R |
| 5.3 | S | Z | Z | 9.3 | R | R | B |

| LEGEND | | |
|---|---|---|
| Z | ZERO | 0 |
| B | BIG | >0 |
| E | EQUAL | >0 |
| S | SMALL | >0 |
| BE | BIGGER | >0 |
| R | SMALLER | >0 |

**Figure 3.2 Cardinal Order Rules**

This research will focus on the effect of the balance among the total number of sorties flown in a week for each IP, FL, P set to robustness. Eventually, a number of prominent and distinct schedule types will be selected among 1331 schedules which have a different total number of sorties.

After selecting a number of different schedule types in order to choose the most robust schedule, 10 different types of disruptions will be homogeneously applied to each of the selected schedules. 10 different disruption types can be presented as follows;

1) 1 Top3 absent;
2) 1 SOF absent;
3) 1 IP absent;
4) 1 FL absent;
5) 1Top3 and 1 SOF absent;
6) 1 IP and 1 FL absent;
7) 1 IP, 1 FL, and 1 P absent;
8) 2 IP and 1 P absent;

9) 1 IP, 2 FL and 1 P absent;

10) 2 IP, 1 FL and 1 P absent. The specific disruptions which will be applied to the schedules will be produced by the random function of Microsoft Excel.

Since the schedules will be inapplicable after facing the disruptions, they will be rescheduled by the rescheduling model. The number of changes obtained from each re-rostered schedule will be collected each time as a sample. 15 samples will be taken for each disruption set which makes a total of 150 samples for each schedule. The same specific disruptions will be applied to each of the selected schedules. A statistical analysis will show which schedule is the most robust. Analysis and results will be presented in the results section.

## IV. Analysis and Results

### Chapter Overview

The ultimate goal is to discover one or more robust schedules among a set of schedules to reach a general conclusion about such schedules. A set of schedules was selected among 1331 schedules. The specific feature of the selected schedules was a different total number of sorties when comparing one to the other. The number of selected schedules is 17, and the list of 17 different schedule types is presented in Table 4.1. The description of the way of selecting schedules will be given in the following lines.

### Selection of Objective Function Coefficients

Following the production of 1331 schedules by the basic scheduling model, the total number of sorties belonging to IPs, FLs, and Ps were taken as output. Whether the schedules are the same or not was not a concern for the output data. The outputs to be evaluated are the total number of sorties for IPs, FLs, and Ps. The outputs were grouped with respect to each cardinal order rule of objective function coefficients such as presented in Figure 3.2.

After the output schedule sets were grouped with respect to the proposition in chapter 3, it is observed that the total number of flights for IPs, FLs, and Ps are the same for each of the proposed rules. However, after the schedule types were grouped with respect to the rules mentioned in Figure 3.2, since the total number of sorties are the same for some groups, they were re-grouped with respect to the total number of sorties as seen in the last three columns of Table 4.1. The total number of distinct and unique schedule types among 1331 schedules was decreased to 17. The list of schedule types is presented in Table 4.1. Since they yield different schedules 5.3x was added which refers to coefficients of 100-0-0, and 3.2x refers to coefficients of 100-0-50, and 2.3x refers to coefficients of 0-100-100.

Table 4.1: 17 Different Schedule Types

| | SCHEDULE TYPE | IP | FL | P |
|---|---|---|---|---|
| 1 | 1 | 29 | 35 | 26 |
| 2 | 2.1 | 10 | 35 | 45 |
| | 2.3 | | | |
| | 6.1 | | | |
| | 7.1 | | | |
| 3 | 2.2 | 10 | 40 | 40 |
| | 6.2 | | | |
| 4 | 3.1 | 30 | 15 | 45 |
| | 3.2 | | | |
| | 3.3 | | | |
| | 6.3 | | | |
| | 6.5 | | | |
| | 7.2 | | | |
| 5 | 4.1 | 30 | 35 | 25 |
| | 6.6 | | | |
| 6 | 4.2 | 25 | 40 | 25 |
| | 6.4 | | | |
| | 7.3 | | | |
| 7 | 4.3 | 26 | 39 | 25 |
| 8 | 5.1 | 27 | 18 | 45 |
| 9 | 5.2 | 21 | 40 | 29 |
| 10 | 5.3 | 30 | 31 | 29 |
| 11 | 8 | 12 | 33 | 45 |
| 12 | 9.1 | 30 | 17 | 43 |
| 13 | 9.2 | 15 | 40 | 35 |
| 14 | 9.3 | 26 | 19 | 45 |
| 15 | 5.3x | 29 | 16 | 45 |
| 16 | 3.2x | 30 | 32 | 28 |
| 17 | 2.3x | 9 | 36 | 45 |

**Statistical Analysis**

Following the selection of 17 different schedule types in order to find out the most robust schedule, 10 different types of disruptions were applied to each schedule as mentioned in Chapter 3. The disruption types were 1 Top3 absent; 1 SOF absent; 1 IP absent; 1 FL absent; 1 Top3 and 1 SOF absent; 1 IP and 1 FL absent; 1 IP, 1 FL, and 1 P absent; 2 IP and 1 P absent; 1 IP, 2 FL, and 1 P absent; 2 IP, 1 FL and 1 P absent. The specific disruptions which have been applied to the schedules were produced by the random function of Microsoft Excel. Random disruptions are presented at Appendix D.

330 samples were taken for schedule 1,2,3,4,5,8,12,14,15, and 180 samples were taken for schedule 6,7,9,10,13,16,17 since the standard deviations were high for the first group. The same specific disruptions have been applied to all of the schedules, so the total number of samples to be taken will be 4410. Output data which belong to the 17 schedules are presented in Appendix E. After each schedule faces the specific disruptions and rescheduling occurs, the number of changes has been collected to generate the output data. After the output data was obtained, the mean and standard deviation of the number of changes were taken for each schedule.

The mean value formula for each disruption type for each schedule and each disruption type is;

$$\sum_i \frac{\varepsilon_{i_j}}{n_j} \qquad \forall j \in J$$

J= {the set of disruptions: j=1, 2… 10}

where, $n_j$ is the sample size for $j^{th}$ disruption type and $\varepsilon_{i_j}$ is the number of changes for $i_j^{th}$ sample. I= {Number of samples: i=1, 2… 15}

The standard Deviation formula for each disruption type for each schedule is;

$$S^2{}_j = \frac{\sum_i (\varepsilon_{i_j} - \overline{\varepsilon_{i_j}})^2}{n_j - 1}$$

However, the statistic value which is needed to compare the schedules is the mean and standard deviations for each schedule. Before mentioning the mean for each schedule, the probability of each disruption should be found. 4 of the disruption types are related to the absenteeism of one personnel, 2 of the disruptions are related to the absenteeism of 2 persons at the same time. 2 of the disruptions are related to the absenteeism of 3 persons at a time, and 2 of the disruptions are related to the absenteeism of 4 persons at a time.

The probability of having one absent pilot is given as 0.05; a representative low probability value was selected. The probability of having 1 Top3 pilot can be found by using a binomial probability distribution. This distribution was used for the other disruption types as well. Furthermore, the probability of having two or three different absents which belong to different sets is independent.

P (1 Top3 pilot is absent) = $\binom{3}{1} * (0.05)^1 * (0.95)^2$ = 0.1354

P (1 SOF pilot is absent) = $\binom{4}{1} * (0.05)^1 * (0.95)^3$ = 0.1714

P (1 IP pilot is absent) = $\binom{4}{1} * (0.05)^1 * (0.95)^3$ = 0.1714

P (1 FL pilot is absent) = $\binom{4}{1} * (0.05)^1 * (0.95)^3$ = 0.1714

P (1 Top3 and 1 SOF pilot is absent) = $\binom{3}{1} * (0.05)^1 * (0.95)^2 * \binom{4}{1} * (0.05)^1 * (0.95)^3$ = 0.0232

P (1 IP and 1 FL pilot is absent) = $\binom{4}{1} * (0.05)^1 * (0.95)^3 * \binom{4}{1} * (0.05)^1 * (0.95)^3 =$ 0.0232

P (1 IP and 1 FL and 1 P pilot is absent) =

$\binom{4}{1} * (0.05)^1 * (0.95)^3 * \binom{4}{1} * (0.05)^1 * (0.95)^3 * \binom{7}{1} * (0.05)^1 * (0.95)^6 =$ 0.0232

P (1 IP and 1 FL pilot is absent) = $\binom{4}{2} * (0.05)^2 * (0.95)^2 * \binom{4}{1} * (0.05)^1 * (0.95)^3 =$ 0.0023

P (1 IP and 2 FL and 1 P pilot is absent) =

$\binom{4}{1} * (0.05)^1 * (0.95)^3 * \binom{4}{2} * (0.05)^2 * (0.95)^2 * \binom{7}{1} * (0.05)^1 * (0.95)^6 =$ 0.0006

P (2 IP and 1 FL and 1 P pilot is absent) =

$\binom{4}{2} * (0.05)^2 * (0.95)^2 * \binom{4}{1} * (0.05)^1 * (0.95)^3 * \binom{7}{1} * (0.05)^1 * (0.95)^6 =$ 0.0006

All the probabilities related to the selected disruption types are determined. Then, they will be converted to weights. After obtaining the weights using these probabilities, weighted mean values for each schedule will be obtained.

$$W_1 = \frac{0.1384}{(0.1384 + 0.1714 + 0.1714 + 0.1714 + 0.0232 + 0.0232 + 0.0232 + 0.0023 + 0.0006 + 0.0006)} = \frac{0.1384}{0.7227} = 0.19$$

$W_2 = \frac{0.1714}{0.7227} = 0.24$, and

$W_3$=0.24, $W_4$=0.24, $W_5$=0.033, $W_6$=0.041, $W_7$=0.011, $W_8$=0.003, $W_9$=0.001, $W_{10}$=0.001

The weighted mean for each schedule should be;

$$\mu_{W_j} = \sum_j \sum_t W_t * \frac{s_{t_j}}{n_j} \qquad \forall j \in J$$

And the weighted standard deviation for each schedule should be;

$$\widehat{\sigma_{w_j}}^2 = \sum_j \left(\frac{w^2{}_j}{n_j} * S^2{}_j\right)$$

Table 4.2 shows the weighted mean and weighted standard deviations related to each schedule in order from min mean to max mean. The objective function coefficients and total number of sorties are presented as an output of each schedule.

Table 4.2: Weighted Mean and Standard Deviations of 17 Schedules

| Schedule | OBJECTIVE FUNC. COEFFICIENTS | | | IP SORTIES | FL SORTIES | P SORTIES | Weighted Mean | Weighted Stdev |
|---|---|---|---|---|---|---|---|---|
| 14 | 40 | 40 | 60 | 26 | 19 | 45 | 0.957174 | 0.199602 |
| 8 | 0 | 0 | 50 | 27 | 18 | 45 | 0.994247 | 0.122255 |
| 15 | 100 | 0 | 0 | 30 | 32 | 28 | 1.029552 | 0.11447 |
| 11 | 30 | 30 | 30 | 12 | 33 | 45 | 1.074048 | 0.18753 |
| 12 | 80 | 70 | 70 | 30 | 17 | 43 | 1.074048 | 0.132604 |
| 2 | 0 | 10 | 100 | 10 | 35 | 45 | 1.164104 | 0.128894 |
| 13 | 30 | 100 | 30 | 15 | 40 | 35 | 1.215863 | 0.166793 |
| 10 | 90 | 0 | 0 | 30 | 31 | 29 | 1.233264 | 0.184088 |
| 1 | 0 | 0 | 0 | 29 | 35 | 26 | 1.234886 | 0.129584 |
| 7 | 70 | 70 | 0 | 26 | 39 | 25 | 1.307197 | 0.173322 |
| 16 | 100 | 0 | 50 | 29 | 16 | 45 | 1.349972 | 0.22293 |
| 9 | 0 | 30 | 0 | 21 | 40 | 29 | 1.459894 | 0.224398 |
| 3 | 0 | 30 | 20 | 10 | 40 | 40 | 1.472087 | 0.143707 |
| 4 | 30 | 0 | 90 | 30 | 15 | 45 | 1.609605 | 0.146497 |
| 6 | 30 | 60 | 0 | 25 | 40 | 25 | 1.690929 | 0.247783 |
| 5 | 90 | 20 | 0 | 30 | 35 | 25 | 1.825494 | 0.163072 |
| 17 | 0 | 100 | 100 | 9 | 36 | 45 | 3.130708 | 0.165524 |

**Obtaining the Most Robust Schedules**

The first two schedules have the closest mean values and the most consistent results compared to the rest of the results. Thus an essential conclusion can be made by interpreting the outcomes of the first two schedules followed by conclusions about the rest of the outcomes. The scheduling rule of the schedule 14 is equal-equal-bigger. The scheduling rule of the schedule 8 is zero-zero-small. Therefore, since these two rules yield very close results, they can be combined under a general rule of equal-equal-bigger. The weighted means of the first three schedules are very close to each other, but for the other schedule types it gets bigger. Thus the third schedule can be added to the evaluation as well.

Table 4.3: Total number of sorties and Sortie Differences

| Schedule | OBJECTIVE FUNC. COEFFICIENTS | | | IP SORTIES | FL SORTIES | P SORTIES | Weighted Mean | Weighted Stdev | Sortie Difference between IP and FL | Total Number of Sorties for IP and FLs |
|---|---|---|---|---|---|---|---|---|---|---|
| 14 | 40 | 40 | 60 | 26 | 19 | 45 | 0.957174 | 0.199602 | 7 | 45 |
| 8 | 0 | 0 | 50 | 27 | 18 | 45 | 0.994247 | 0.122255 | 9 | 45 |
| 15 | 100 | 0 | 0 | 30 | 32 | 28 | 1.029552 | 0.11447 | 2 | 62 |
| 11 | 30 | 30 | 30 | 12 | 33 | 45 | 1.074048 | 0.18753 | 21 | 45 |
| 12 | 80 | 70 | 70 | 30 | 17 | 43 | 1.074048 | 0.132604 | 13 | 47 |
| 2 | 0 | 10 | 100 | 10 | 35 | 45 | 1.164104 | 0.128894 | 25 | 45 |
| 13 | 30 | 100 | 30 | 15 | 40 | 35 | 1.215863 | 0.166793 | 25 | 55 |
| 10 | 90 | 0 | 0 | 30 | 31 | 29 | 1.233264 | 0.184088 | 1 | 61 |
| 1 | 0 | 0 | 0 | 29 | 35 | 26 | 1.234886 | 0.129584 | 6 | 64 |
| 7 | 70 | 70 | 0 | 26 | 39 | 25 | 1.307197 | 0.173322 | 13 | 65 |
| 16 | 100 | 0 | 50 | 29 | 16 | 45 | 1.349972 | 0.22293 | 13 | 45 |
| 9 | 0 | 30 | 0 | 21 | 40 | 29 | 1.459894 | 0.224398 | 19 | 61 |
| 3 | 0 | 30 | 20 | 10 | 40 | 40 | 1.472087 | 0.143707 | 30 | 50 |
| 4 | 30 | 0 | 90 | 30 | 15 | 45 | 1.609605 | 0.146497 | 15 | 45 |
| 6 | 30 | 60 | 0 | 25 | 40 | 25 | 1.690929 | 0.247783 | 15 | 65 |
| 5 | 90 | 20 | 0 | 30 | 35 | 25 | 1.825494 | 0.163072 | 5 | 65 |
| 17 | 0 | 100 | 100 | 9 | 36 | 45 | 3.130708 | 0.165524 | 27 | 45 |

The difference between the total number of sorties for IP and FL is low for the top two schedules compared to the other schedules, thus demonstrating that there is a balance between total IP sorties and FL sorties in the most robust schedules. When the other schedules are checked, it can be noticed that the difference gets bigger after the first three schedules except for schedule 10, schedule 1 and schedule 5. However, schedule 10 has the same rule as schedule 15, thus schedule 10 can be eliminated. The difference between IP sorties and FL sorties is less than 9 for the first three schedules. The presence of schedule 10, schedule 5 and schedule1 shows that the robustness of the top two schedules does not depend on the balance of the total number of sorties among IPs and FLs, but there also must be some other criteria that provide the robustness. Total number of IP and FL sorties is at the minimum level for the top two schedules as well.

A generalization can be made by evaluating both the relationship between the total number of sorties for IPs and FLs and the sum of the total number of sorties for IPs and FLs. In order to increase the robustness of the schedules the total number of sorties for IPs and FLs must be close to each other, so that the difference between each number should be small. P sorties were not a concern in the analysis, since there was already a constraint related to the total number of sorties for IPs and FLs versus those for Ps. The sum of the total number of sorties for IPs and FLs should be more than the total number of P sorties (or it can be equal as well.) (Constraint 2)

The busiest pilots in the schedules are IPs and FLs since 3 of the 4 IPs have qualifications for Top3 duty, as well. And 1 of the IPs can be assigned as Top3 and SOF. 3 of the 4 FLs are SOF qualified in addition to flying missions. Both mission types have to be fulfilled as ground requirements for flight activity. Eventually, the busiest pilots are IPs and FLs in the squadron. Thus, keeping the busiest pilots as free as possible will yield the maximum flexible schedule.

Consequently, a robust schedule should have the maximum flexibility while having a balance between total sorties. In order to provide the maximum flexibility in a schedule, the total sorties for IPs and FLs must be minimized while keeping a balance between them. The objective of minimizing the total sorties for IPs and FLs without violating the IP, FL and P comparison constraint (Constraint 2) should yield 45 sorties a week, given that the total scheduled sorties for a week are 90. The first two schedules support the predicted results. The third schedule does not provide the minimum number of total sorties; however, it provides a balance between pilot groups.

The proposed objective function is

$$\text{MIN} \sum_m \sum_j \sum_t x'_{mjt} + \sum_n \sum_j \sum_t x'_{njt} + k^-_{ij} - k^+_{ij} + 5 * \sum_i \sum_j l'^{-}_{ij}$$

Where $k^-_{ij}, k^+_{ij} \in R^+$

And a new goal constraint is added to the other constraints in the basic scheduling model.

$$\sum_m \sum_j \sum_t x'_{mjt} - \sum_n \sum_j \sum_t x'_{njt} + k^-_{ij} - k^+_{ij} = 0$$

Where $k^-_{ij}, k^+_{ij}$ $R^+$ and goal variables for the balancing constraint.

Table 4.4: The location of the modified schedule in the list

| Schedule | OBJECTIVE FUNC. COEFFICIENTS | | | IP SORTIES | FL SORTIES | P SORTIES | Weighted Mean | Weighted Stdev | Sortie Difference between IP and FL | Total Number of Sorties for IP and FLs |
|---|---|---|---|---|---|---|---|---|---|---|
| 14 | 40 | 40 | 60 | 26 | 19 | 45 | 0.96 | 0.200 | 7 | 45 |
| 8 | 0 | 0 | 50 | 27 | 18 | 45 | 0.99 | 0.122 | 9 | 45 |
| 15 | 100 | 0 | 0 | 30 | 32 | 28 | 1.03 | 0.114 | 2 | 62 |
| 11 | 30 | 30 | 30 | 12 | 33 | 45 | 1.07 | 0.188 | 21 | 45 |
| 12 | 80 | 70 | 70 | 30 | 17 | 43 | 1.07 | 0.133 | 13 | 47 |
| **Mod** | | | | **23** | **22** | **45** | **1.10** | **0.150** | **1** | **45** |
| 2 | 0 | 10 | 100 | 10 | 35 | 45 | 1.16 | 0.129 | 25 | 45 |
| 13 | 30 | 100 | 30 | 15 | 40 | 35 | 1.22 | 0.167 | 25 | 55 |
| 10 | 90 | 0 | 0 | 30 | 31 | 29 | 1.23 | 0.184 | 1 | 61 |
| 1 | 0 | 0 | 0 | 29 | 35 | 26 | 1.23 | 0.130 | 6 | 64 |
| 7 | 70 | 70 | 0 | 26 | 39 | 25 | 1.31 | 0.173 | 13 | 65 |
| 16 | 100 | 0 | 50 | 29 | 16 | 45 | 1.35 | 0.223 | 13 | 45 |
| 9 | 0 | 30 | 0 | 21 | 40 | 29 | 1.46 | 0.224 | 19 | 61 |
| 3 | 0 | 30 | 20 | 10 | 40 | 40 | 1.47 | 0.144 | 30 | 50 |
| 4 | 30 | 0 | 90 | 30 | 15 | 45 | 1.61 | 0.146 | 15 | 45 |
| 6 | 30 | 60 | 0 | 25 | 40 | 25 | 1.69 | 0.248 | 15 | 65 |
| 5 | 90 | 20 | 0 | 30 | 35 | 25 | 1.83 | 0.163 | 5 | 65 |
| 17 | 0 | 100 | 100 | 9 | 36 | 45 | 3.13 | 0.166 | 27 | 45 |

The current basic scheduling model already supplies the maximum number of sorties for one week. Namely, changing the objective function coefficients supplies the distribution of sorties among each pilot set: IPs, FLs, and Ps, depending on the distribution of the total number of sorties among pilot groups, the robustness of the schedule was changed, and the robustness of the schedule was clearly observed from the output results.

By the newly suggested objective function and the additional goal constraint, keeping the busiest pilots as free as possible and trying to preserve sortie balance among the pilot groups yielded a schedule near the middle of the list. The reason for this was to adjust the right hand side of the additional goal constraint to zero, namely assuming both IP and FL groups have the same busyness levels.

However, a general conclusion can be derived from the current results, and a heuristic can be suggested to the flight schedulers in the squadrons. Whether or not scheduling manually, the scheduler must start with the least busy pilot group and then progressively pass to the busier groups. The final conclusion will be provided in the next chapter. In addition, Recommendations for further research will be mentioned as well.

# V. Conclusions and Recommendations

## Conclusions of Research

A fighter squadron scheduling model has been prepared to obtain a weekly schedule. A great number of schedules can be prepared by only using different objective function coefficients. Eventually, 1331 schedules have been prepared by using a small set of objective function coefficients. 17 different and unique schedules have been selected among 1331 schedules.

When a schedule faces a number of disruptions, it becomes inapplicable, thus, it requires rescheduling. However, a new schedule should be obtained with a minimum number of changes, so that rescheduling-sourced side effects on the personnel would be decreased. In other words, to minimize the total number of changes is the objective function of the rescheduling model.

A robust schedule has insensitivity to disruptions. Namely, after a number of disruptions, a robust schedule requires fewer changes to obtain a feasible schedule compared to previous schedules. In order to search for robustness, 17 different schedule types have been selected among 1331 schedules. Robustness was analyzed by statistical analysis taking 4410 total number of samples from the selected schedules. The samples consist of the number of changes after rescheduling. Weighted means and standard deviations were obtained for each schedule depicting the expected weighted number of changes in case of disruptions. A general conclusion was made evaluating the robustness of the schedules from the ordered list of 17 schedules.

As a conclusion, a new objective function was developed to create the most robust schedule just by adjusting the sortie balance among the pilot groups by evaluating the *busyness level* of them. The general conclusion is to keep the busiest personnel as free as possible while fulfilling all of the requirements. And the suggested heuristic is to begin scheduling from the least busy pilot to the busiest.

**Recommendations for Future Research**

The effects of *busyness level* of the personnel on the robustness of the schedule have been observed from this paper. Even if new constraints are added to the model, the solution space of the model changes and the model does not provide the same schedules. However, the same conclusion related to the *busyness level* of the pilots works. Thus, a new objective function can be added to the basic scheduling model in order to make the schedule more sensitive against the *busyness level* of the personnel. A new heuristics can keep the sortie number of the busy personnel at the minimum level without violating any of the current constraints. The heuristics can be developed in order to measure the *busyness level* for each pilot, so that the model can schedule each pilot with respect to these predetermined levels of each personnel. The proposed model as a dynamic model would work in an iterative manner for a certain time or until the desired robustness have been reached.

The current basic scheduling model started to schedule the first pilot first, second pilot second and so on. This caused the first pilots of each group to be over scheduled, especially Ps. Thus the next scheduling model should be concerned with the homogeneous distribution of sorties to pilots. This allows each pilot to be considered equally in the schedule.

The only soft constraint being used in the model was the 2nd rest constraint. The rest of the constraints are hard constraints since the conditions presented with them are to be in accordance with flight regulations. However, the effect of soft constraints may increase the robustness of the model.

The flight missions, training areas and aircraft numbers are not considered in the model. In addition, D model can be considered in the new model. The new model can be more detailed and consisting of the flight missions. However, this will increase the number of variables and the computational time of the problem

The other thing that needs to be taken into consideration is three flight blocks. One flight day is divided into three blocks, however, if a pilot is not available about 2 hours at the intersection of AM GO and PM GO it must be evaluated as absent for two blocks in the current model. However, he can fly at the beginning of the AM GO or towards the end of PM GO. Thus, dividing a day to evaluate the presence of the personnel would be better solution. Even if this may cause a big increase on the number of the variables and may yield a model which can not be run in the Premium Solver Platform due to software limitations, it would be a satisfying model. Specified model can be setup in LINDO or VBA in Excel by getting the support of Solver.

In case of larger number of variables Large Scale Premium Solver can be used. This can solve up to 32000 variables. Increasing the number of variables will be helpful identifying the problem more detailed; however it will increase the computational time.

Thus, using heuristic algorithms will be very helpful on to obtaining good results in a reasonable amount of time.

**Summary**

This research concentrated on obtaining robust schedules without keeping alternate pilots on the ground. A scheduling model was used to obtain robust schedules. After selecting the most robust schedules among a set, general conclusion have been reached to obtain robust schedules on the first attempt.

# Appendix A: Letter of X's

| | Rank | Assigned | Position | RAP | V/IP | DEROS | API | FLT | VX CAT | MSN CC | FLT LD | FCF | SOF | SEFE | Top 3 | EGHH Instr | NVG | IRC | Rear CPT | SEAD | Maverick | TGT Pod | Link 16 | HMCS | RCO | FECOC | 30/60/90 | SOF 30 | 30 Day Required | Restrictions/Unaccomplished tasks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | LTC | Specht, John | EPCE | CMR | | | 6 | | B | X | IP | | | X | X | | IP | | | IP | IP | IP | IP | IP | | | # | | 27 | |
| 2 | LTC | Youtsey, David | EPCE | CMR | X | | 6 | | B | X | IP | | | X | X | | IP | | | IP | IP | IP | IP | IP | | | # | | 27 | |
| 1 | Capt | Cockrum, Jason | IPCE | CMR | | | 1 | | B | X | IP | | X | | X | | IP | | | IP | IP | | IP | IP | | | 35 | 12 | 27 | |
| 2 | Capt | Cole, Tim | MPCE | CMR | | | 1 | | B | T | 4 | | X | | | | 4 | | | 4 | | | X | X | | | 41 | 3 | 27 | NAAR |
| 3 | Capt | Friedel, Jesse | EPCE | CMR | X | | 1 | | B | X | IP | | X | X | | | IP | | | IP | IP | IP | IP | IP | | | # | 5 | 27 | |
| 4 | Capt | Garrison, Matt | IPCE | CMR | | | 1 | | B | X | IP | | X | | | | IP | | | IP | IP | | IP | IP | | | 45 | 6 | 27 | |
| 5 | Capt | Gump, James | MPCN | CMR | | | 1 | | B | | | | | | | | X | | | X | | | X | X | | | 31 | | # | |
| 6 | Capt | Johnston, Mike | MPBE | CMR | | | 1 | | B | T | 4R | X | X | | | | X | | | 4R | X | | X | X | | | # | 4 | 27 | Day only FL, NAAR, FLUG-11 |
| 7 | Capt | Kopacek, Chris | MPCE | CMR | | | 1 | | B | | T | | | | | | X | | | X | X | 4T | X | X | | | # | | 27 | |
| 8 | Capt | Locke, Joseph | IPCE | CMR | | | 1 | | B | X | IP | | X | | | | IP | | | IP | X | | IP | IP | | | 31 | 5 | 27 | |
| 9 | Capt | Lord, Kevin | MPCN | CMR | | | 1 | | B | | | | | | | | X | | | X | | | X | X | | | # | | # | |
| 10 | Capt | Mann, Sam | IPCE | CMR | X | | 1 | | B | X | IP | | | | | | IP | | | IP | IP | IP | IP | IP | | | # | | 27 | |
| 11 | Capt | Murray, Rich | FPCE | MQT | | | 1 | | C | | | | | | | | T | | | T | | | T | T | | | 15 | | 27 | |
| 12 | Capt | Penrod, Sean | MPCN | CMR | | | 1 | | B | | T | | | | | | X | | | X | | | X | X | | | # | | # | |
| 13 | Capt | Perkins, Chris | MPCN | CMR | | | 1 | | B | | T | | | | | | XR | | | X | | | X | X | | | # | | # | NON-NVG-SEAD WG |
| 14 | Capt | Reed, Jeremiah | MPCN | CMR | | | 1 | | B | | | | | | | | X | | | X | | | X | X | | | 35 | | # | |
| 15 | Capt | Sabia, Jay | MPCE | CMR | | | 1 | | B | X | IPT | | X | | | | 4 | | | X | X | 4 | X | X | | | # | 3 | 27 | |
| 16 | Capt | Shultz, Johathan | MPCE | CMR | | | 1 | | B | T | 4R | | X | | | | XR | | | 4R | X | | X | X | | | # | 2 | 27 | NAAR |
| 17 | Capt | Willingham, Paul | MPCN | CMR | | | 1 | | B | | 4 | | X | | | | 4 | | | 4 | | 4T | X | X | | | # | 1 | # | |
| 18 | LT | Connellan, Pat | MPCN | CMR | | | 1 | | B | | | | | | | | T | | | X | | | X | X | | | 35 | | # | |
| 19 | LT | Gaona, Joey | MPCN | CMR | | | 1 | | B | | | | | | | | X | | | X | | | X | X | | | # | | # | |
| 20 | LT | Johnston, Cheryl | FPMN | MQT | | | 1 | | E | | | | | | | | | | | T | | | | | | | 0 | | # | |
| 21 | LT | Jones, Dave | MPCN | CMR | | | 1 | | B | | | | | | | | X | | | X | | | X | X | | | # | | # | |
| 22 | LT | Kellam, Brian | FPMN | MQT | | | 1 | | C | | | | | | | | T | | | T | | | T | T | | | 14 | | # | |
| 23 | LT | McCarthy, Mike | MPCN | CMR | | | 1 | | B | | | | | | | | X | | | X | | | X | X | | | # | | # | |
| 24 | LT | Moeller, Chris | FPMN | MQT | | | 1 | | C | | | | | | | | T | | | T | | | T | T | | | 12 | | # | |
| 25 | LT | Reynolds, Matthev | MPCN | CMR | | | 1 | | B | | | | | | | | X | | | X | | | X | X | | | 25 | | # | |
| 1 | GEN | Foglesong, Robert | MPBE | BMC | | | 8 | | B | | | | | | | | | | | X | | | | | | | 2 | | 15 | |
| 2 | LTC | Bishop, Scott | IPBE | NBMC | X | | 8 | | B | X | IP | | | | | | | | | 4 | IP | | IP | | | | 2 | | 15 | MQT-10 |
| 3 | MAJ | Boyd, Jay | EPBE | BMC | | | 8 | | B | X | IP | | | X | | | IP | | | IP | IP | IP | | | | | 3 | | 15 | |
| 1 | COL | Goldfein, Dave | EPCE | BMC | X | | 6 | | B | X | IP | | | X | | | IP | | | IP | IP | IP | X | X | | | # | | 15 | |
| 2 | LTC | Berghoff, Tom | IPCE | NBMC | | | 6 | | B | X | IP | | | | | | IP | | | 4 | IP | IP | X | X | | | 31 | | 15 | Non-SEAD IP |
| 3 | LTC | Bowen, Scott | MPBE | BMC | | | 6 | | B | | T | | | | | | | | | X | | | X | X | | | # | | 15 | |
| 4 | LTC | Neumann, Brian | IPBE | NBMC | | | 6 | | B | X | IP | | | | | | IP | | | IP | X | | IP | IP | | | # | | 15 | |
| 5 | LTC | Woodcock, Bill | IPBE | NBMC | | | 6 | | B | X | IP | | | | | | IP | | | IP | IP | IP | IP | IP | | | # | | 15 | |
| 6 | MAJ | Forkner, William | MPBE | NBMC | | | 6 | | B | | | | | | | | X | | | X | X | X | X | X | | | # | | 15 | |
| 7 | MAJ | Mcatee, Thomas | IPBE | BMC | X | | 6 | | B | X | IP | | X | | | | IP | | | IP | IP | IP | IP | IP | | | 41 | 2 | 15 | |
| 8 | MAJ | Nichols, Ryan | EPCE | CMR | | | 6 | | B | X | IPR | | T | X | | | X | | | IPR | IP | | IP | IP | | | # | | 27 | Day Only FL/IP |
| 9 | CAPT | Rassas, Sean | IPCE | CMR | | | 6 | | B | X | IP | | X | | | | IP | | | IP | X | IPT | IP | IP | | | # | 4 | 27 | |
| 10 | CAPT | Lyons, Dave | IPCE | CMR | | | 6 | | B | X | IP | | X | | | | IP | | | IP | IP | IP | IP | IP | | | # | 2 | 27 | |

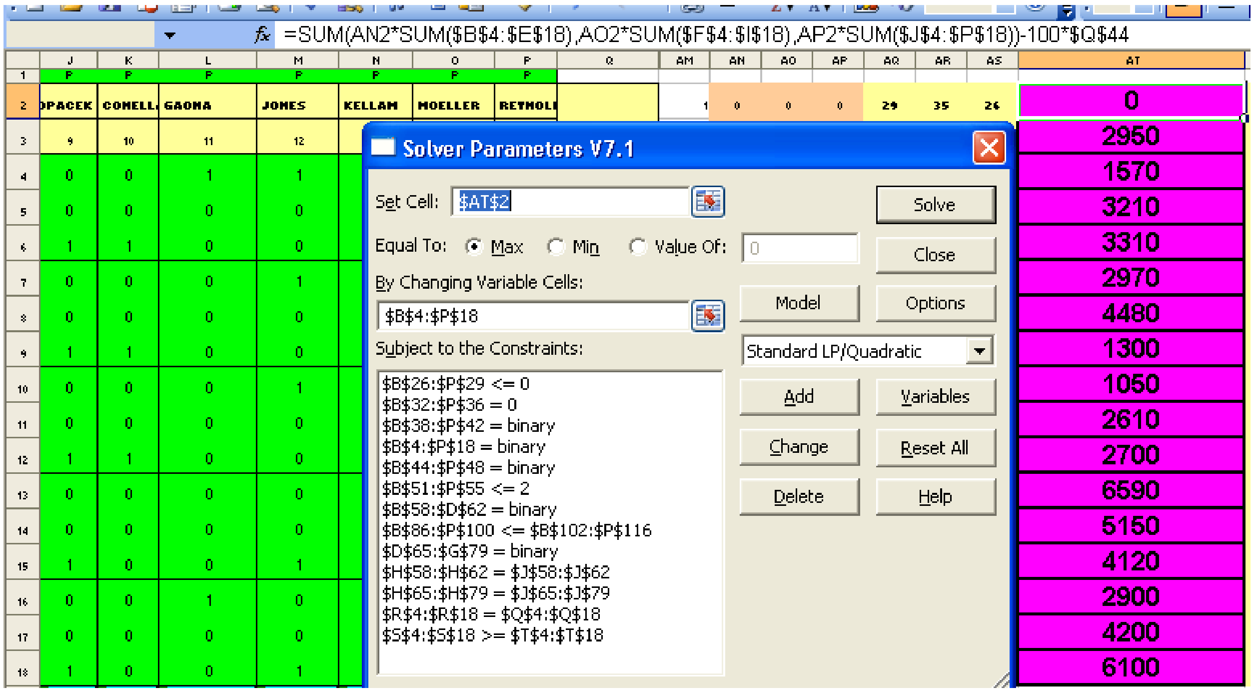
# Appendix B: Screenshots of Basic Scheduling Model and Rescheduling Model

| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | SOF | SOF | SOF | SOF | | | P | P | P | P | P | P | P |
| 2 | | SPECHT | TOUTSEY | COCKRUM | FRIEDEL | COLE | SABIA | SHULTZ | WILLINGHA | PACEK | CONELL | GAONA | JONES | KELLAM | MOELLER | REYNOLI |
| 3 | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 4 | MONAM | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| 5 | MONPM | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | MONN | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 7 | TUEAM | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| 8 | TUEPM | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | TUEN | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| 10 | WEDAM | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| 11 | WEDPM | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | WEDN | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 13 | THURAM | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 14 | THURPM | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | THURN | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 16 | FRIAM | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 |
| 17 | FRIPM | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | FRIN | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 19 | TOTAL | 6 | 6 | 7 | 10 | 9 | 9 | 9 | 8 | 5 | 3 | 2 | 5 | 5 | 4 | 2 |

**Sample Weekly Flight Schedule**

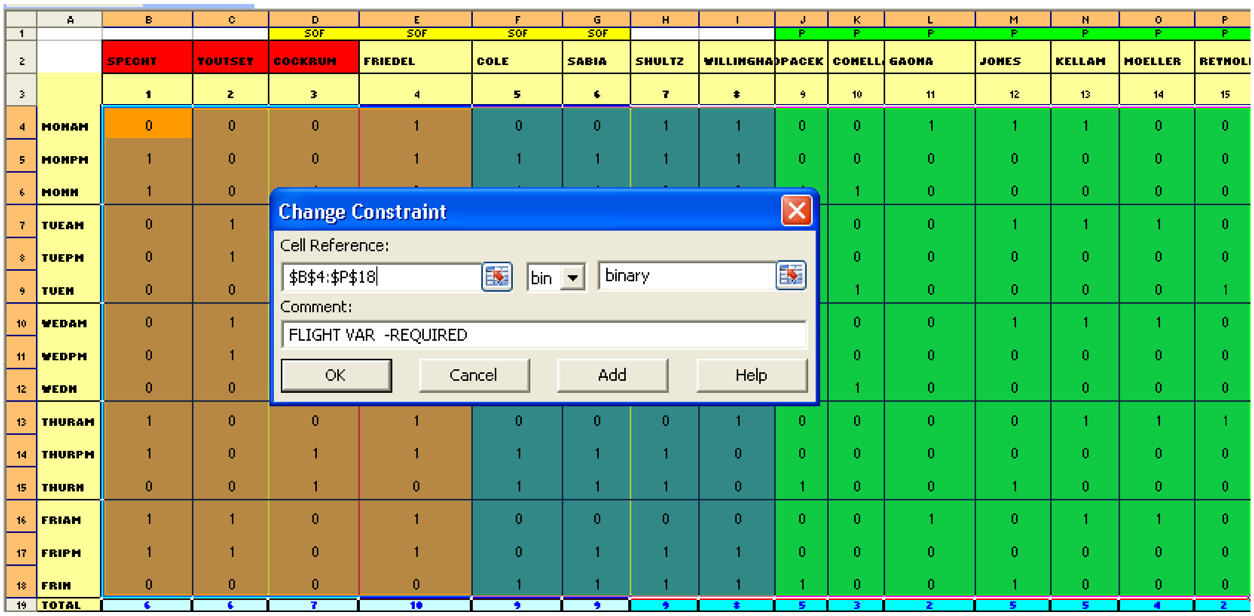
| | | | | SOF | SOF | SOF | SOF |
|---|---|---|---|---|---|---|---|
| | | SPECHT | YOUTSEY | COCKRUM | FRIEDEL | COLE | SABIA |
| | | 1 | 2 | 3 | 4 | 5 | 6 |
| T3 | | 0 | 1 | 0 | x | x | x |
| | | 1 | 0 | 0 | x | x | x |
| | | 1 | 0 | 0 | x | x | x |
| | | 0 | 1 | 0 | x | x | x |
| | | 0 | 0 | 1 | x | x | x |
| SOF | MONAM | | | 1 | 0 | 0 | 0 |
| | MONPM | | | 1 | 0 | 0 | 0 |
| | MONN | | | 0 | 0 | 0 | 0 |
| | TUEAM | | | 1 | 0 | 0 | 0 |
| | TUEPM | | | 0 | 0 | 0 | 0 |
| | TUEN | | | 0 | 1 | 0 | 0 |
| | WEDAM | | | 1 | 0 | 0 | 0 |
| | WEDPM | | | 0 | 0 | 0 | 1 |
| | WEDN | | | 0 | 0 | 0 | 0 |
| | THURAM | | | 1 | 0 | 0 | 0 |
| | THURPM | | | 0 | 0 | 0 | 0 |
| | THURN | | | 0 | 1 | 0 | 0 |
| | FRIAM | | | 0 | 0 | 1 | 0 |
| | FRIPM | | | 0 | 0 | 1 | 0 |
| | FRIN | | | 0 | 0 | 0 | 0 |

**Sample Top3 and SOF duty schedule**

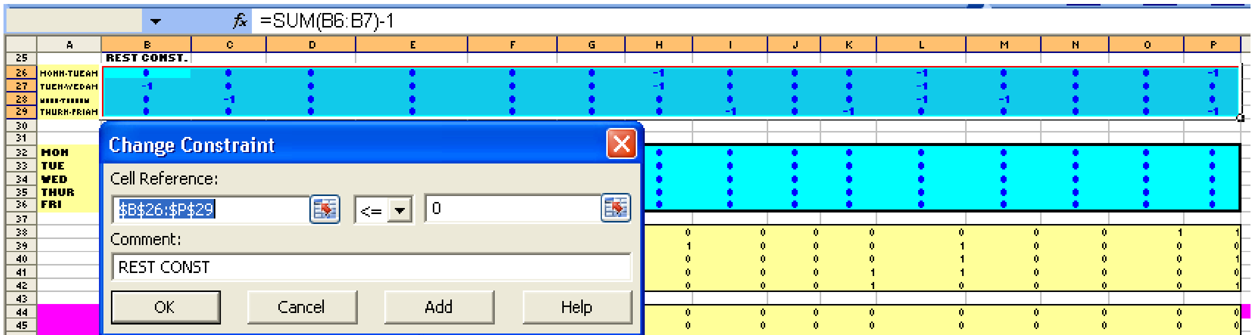



**OBJECTIVE FUNCTION AND CONSTRAINTS OF BASIC SCHEDULING MODEL**

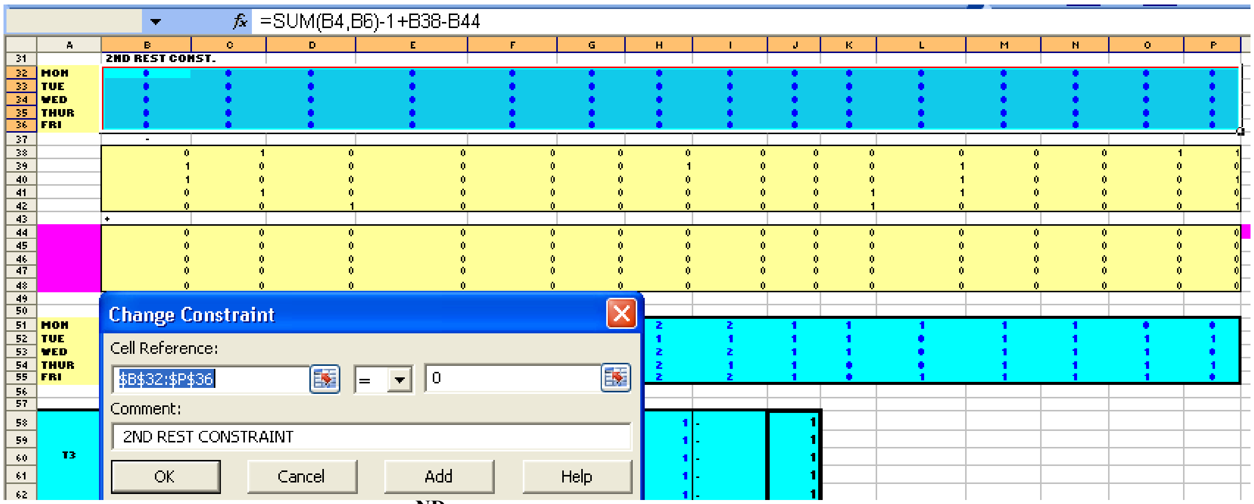
AN2: OBJ. FUNC. COEFFICIENT FOR IPS
AO2:OBJ. FUNC. COEFFICIENT FOR FLS
AP2:OBJ. FUNC. COEFFICIENT FOR PS
SUM($B$4:$E$18): Total sum of IP sorties
SUM($F$4:$I$18): Total sum of FL sorties
SUM($J$4:$P$18): Total sum of P sorties
Q44: + GOAL VARIABLE FOR SECOND REST CONSTRAINT



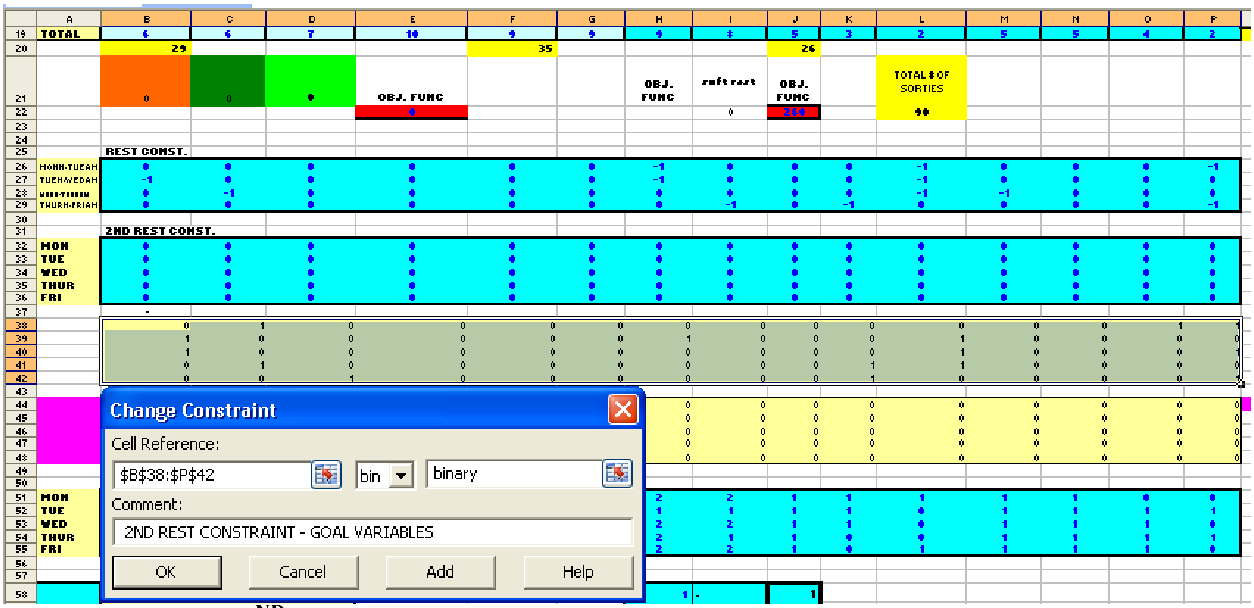

FLIGHT CELLS VARIABLES



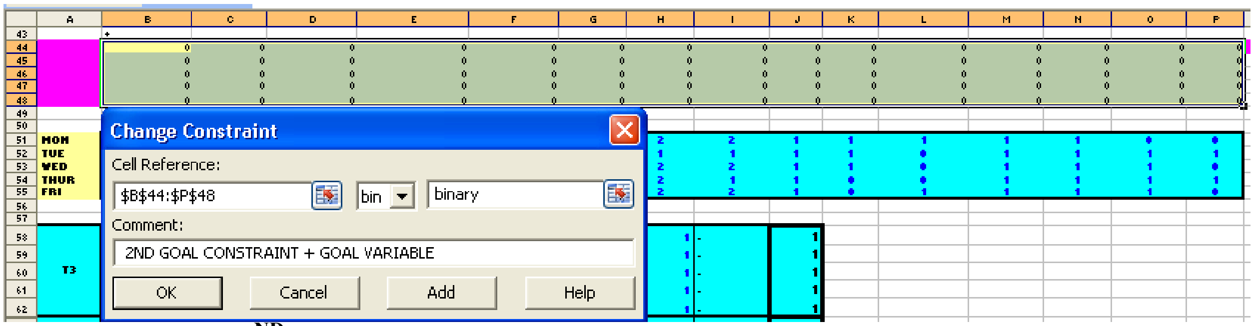

**1ST REST CONSTRAINT**



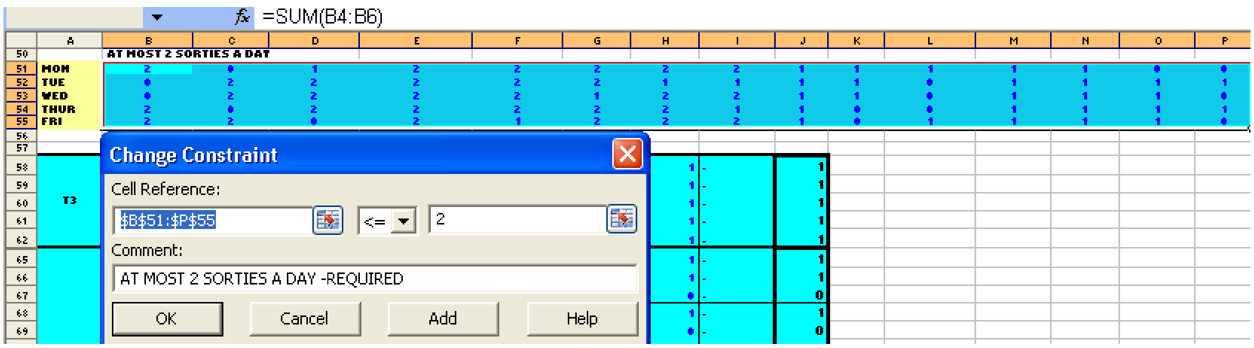

**2$^{ND}$ REST CONSTRAINT**



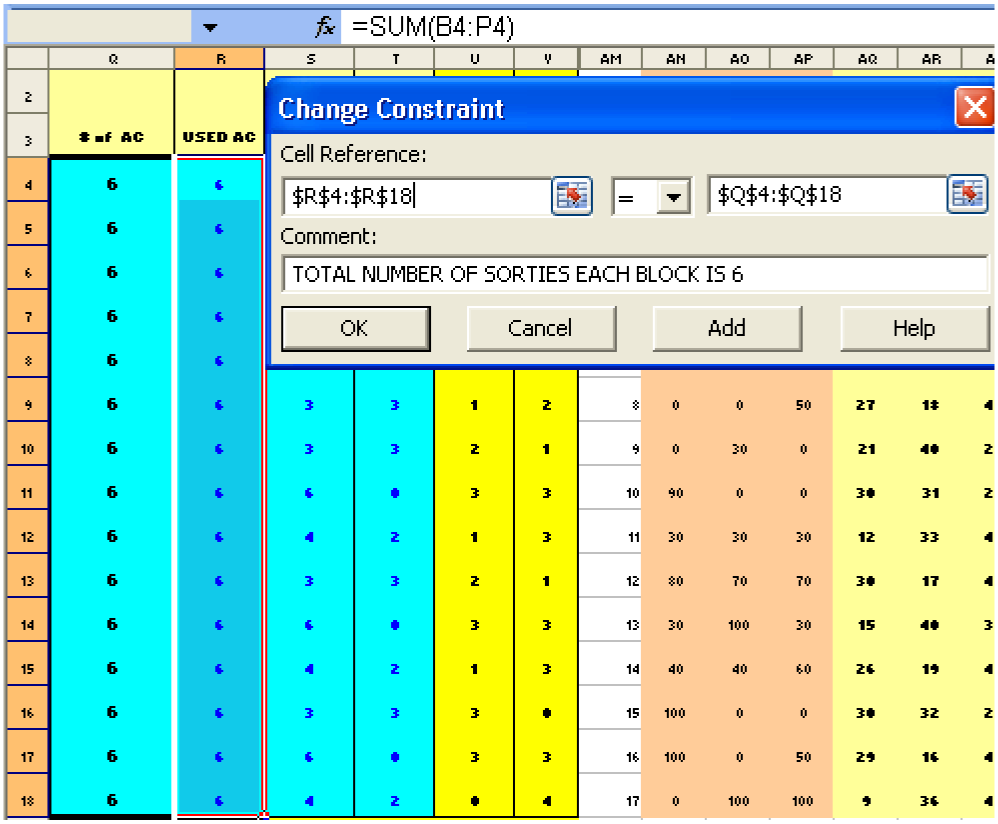

**2ND REST CONSTRAINT – GOAL VARIABLES**



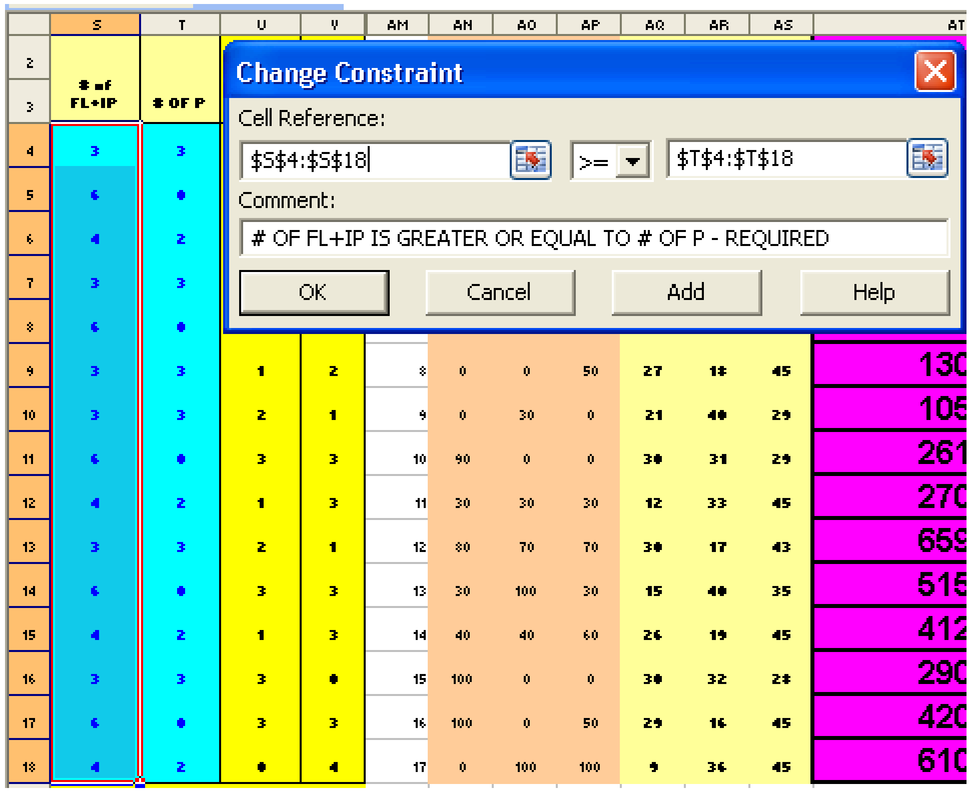

**2ND REST CONSTRAINT + GOAL VARIABLES**



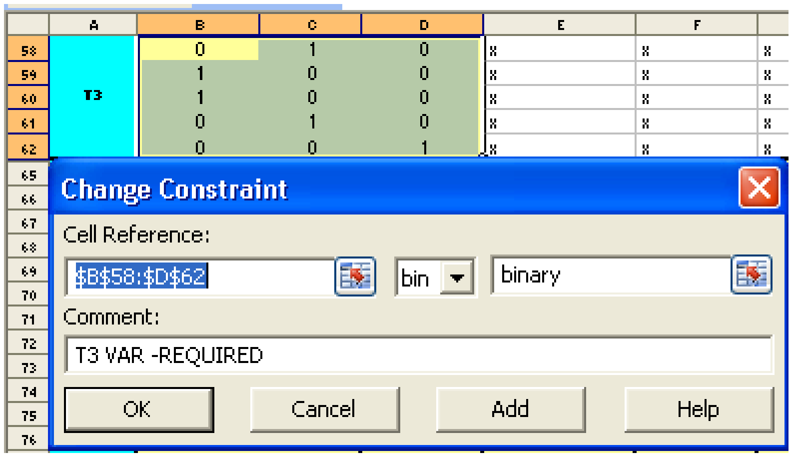

**AT MOST 2 SORTIES A DAY FOR EACH PILOT**



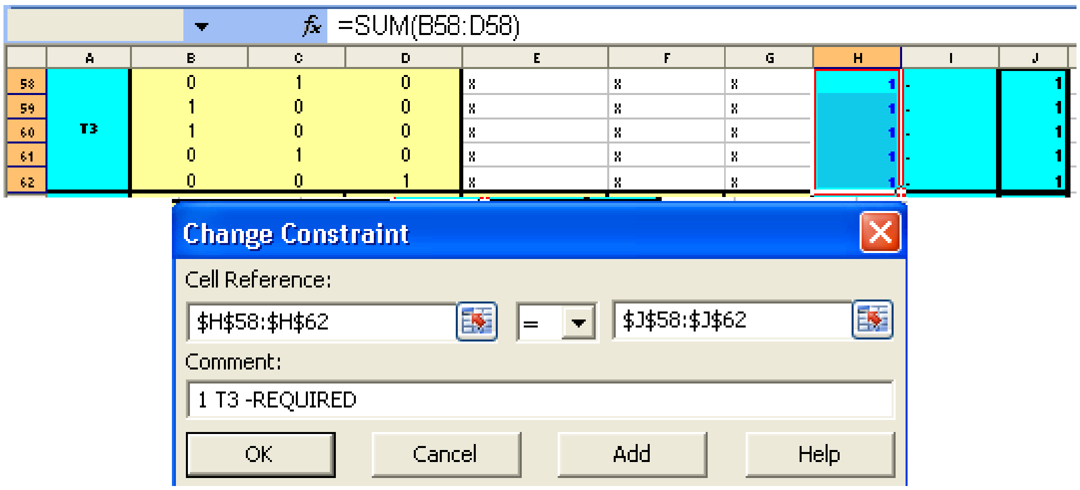

**THE TOTAL NUMBER OF SORTIES FOR EACH BLOCK TO BE 6**



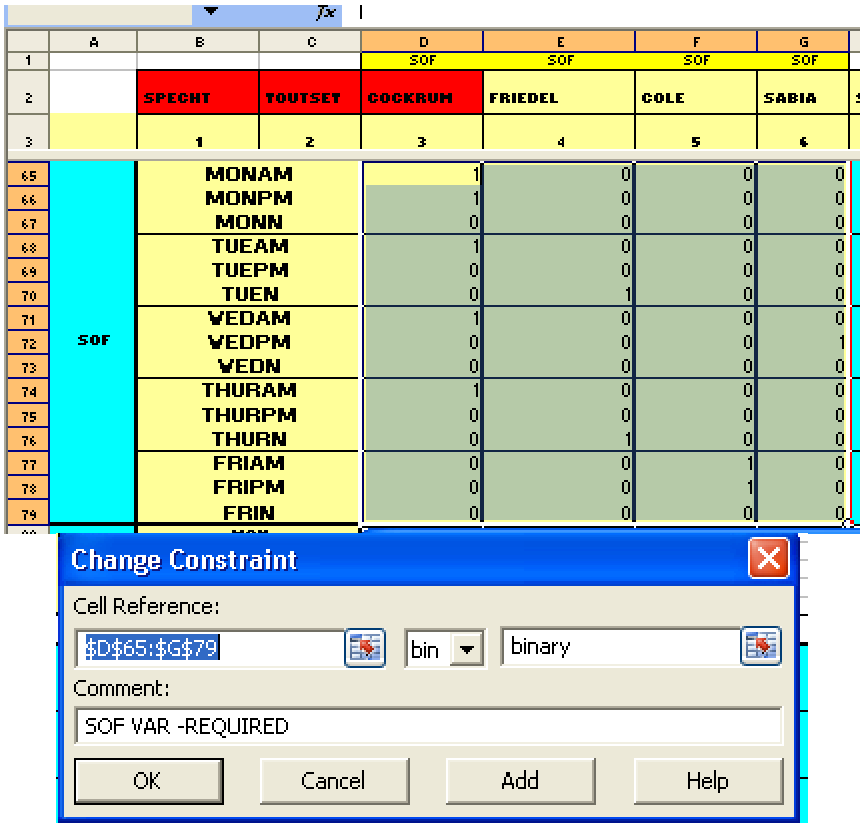

**TOTAL NUMBER OF IP AND FL SORTIES IS GREATER THAN TOTAL NUMBER OF P SORTIES**



TOP3 VARIABLES



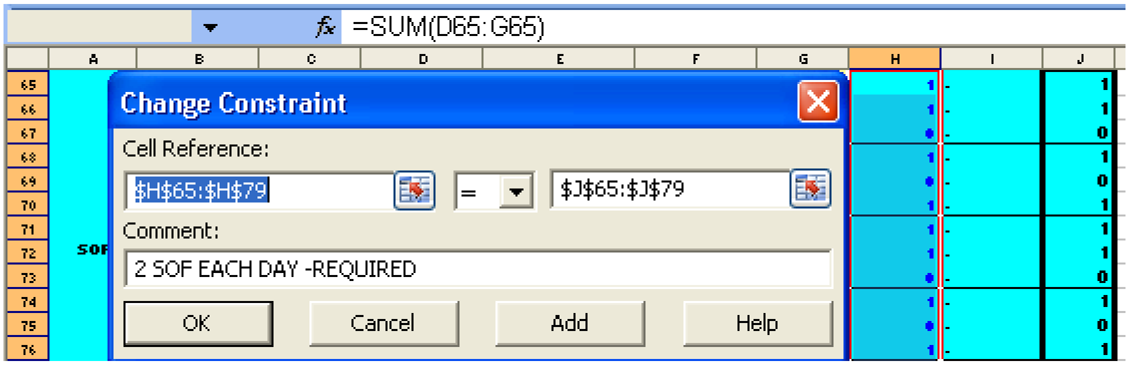

**Each day 1 Top3 required**



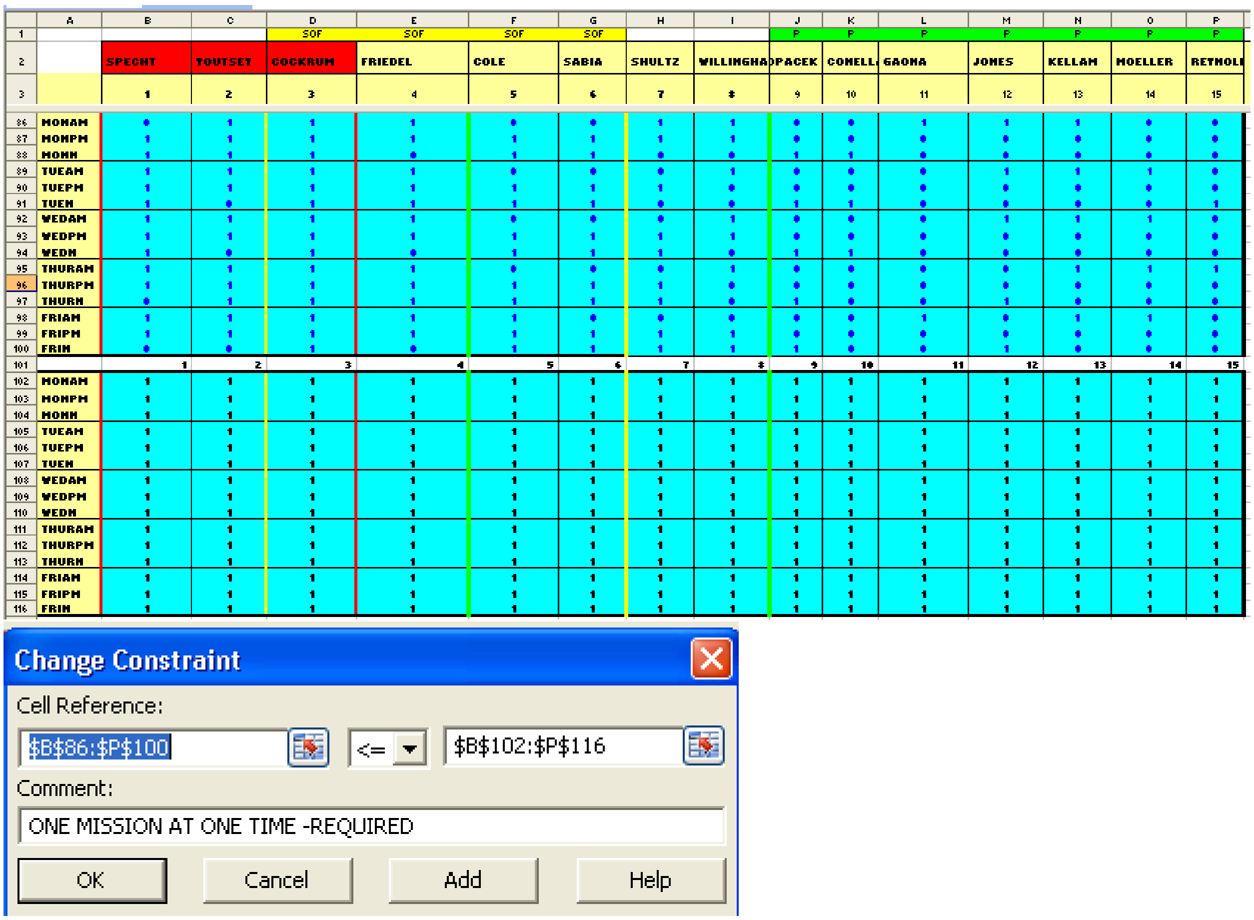
| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 1 | | | | SOF | SOF | SOF | SOF |
| 2 | | SPECHT | TOUTSET | COCKRUM | FRIEDEL | COLE | SABIA |
| 3 | | 1 | 2 | 3 | 4 | 5 | 6 |
| 65 | SOF | MONAM | | 1 | 0 | 0 | 0 |
| 66 | | MONPM | | 1 | 0 | 0 | 0 |
| 67 | | MONN | | 0 | 0 | 0 | 0 |
| 68 | | TUEAM | | 1 | 0 | 0 | 0 |
| 69 | | TUEPM | | 0 | 0 | 0 | 0 |
| 70 | | TUEN | | 0 | 1 | 0 | 0 |
| 71 | | WEDAM | | 1 | 0 | 0 | 0 |
| 72 | | WEDPM | | 0 | 0 | 0 | 1 |
| 73 | | WEDN | | 0 | 0 | 0 | 0 |
| 74 | | THURAM | | 1 | 0 | 0 | 0 |
| 75 | | THURPM | | 0 | 0 | 0 | 0 |
| 76 | | THURN | | 0 | 1 | 0 | 0 |
| 77 | | FRIAM | | 0 | 0 | 1 | 0 |
| 78 | | FRIPM | | 0 | 0 | 1 | 0 |
| 79 | | FRIN | | 0 | 0 | 0 | 0 |



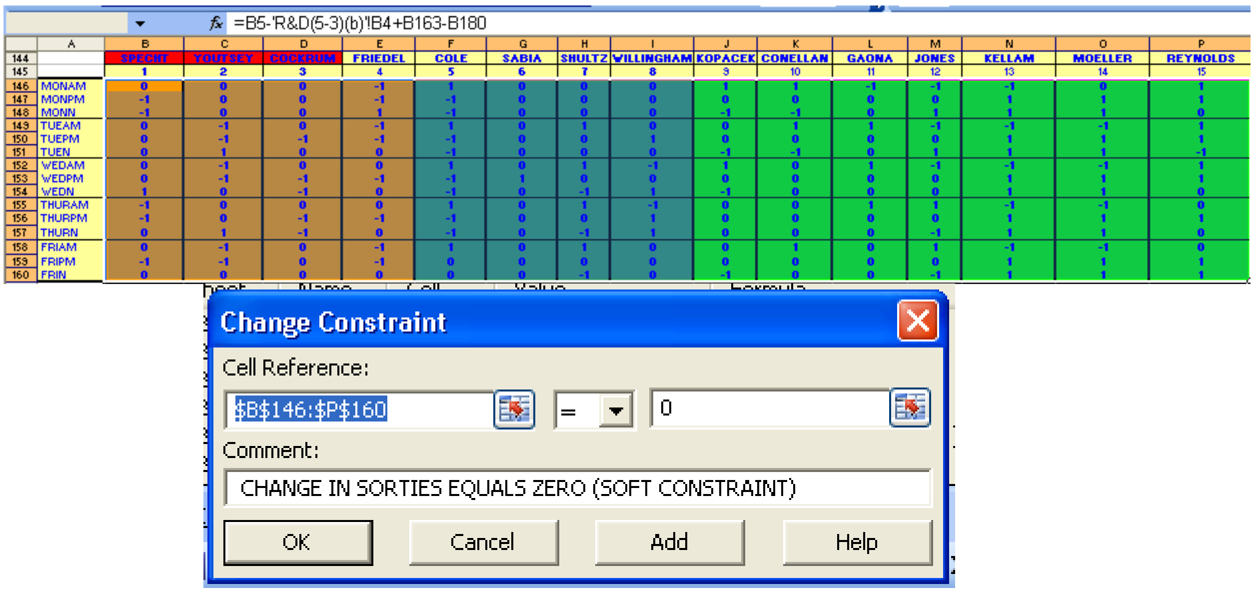
SOF VARIABLES




**EACH DAY 2 SOF TO BE ASSIGNED**




**ONE MISSION AT A TIME**

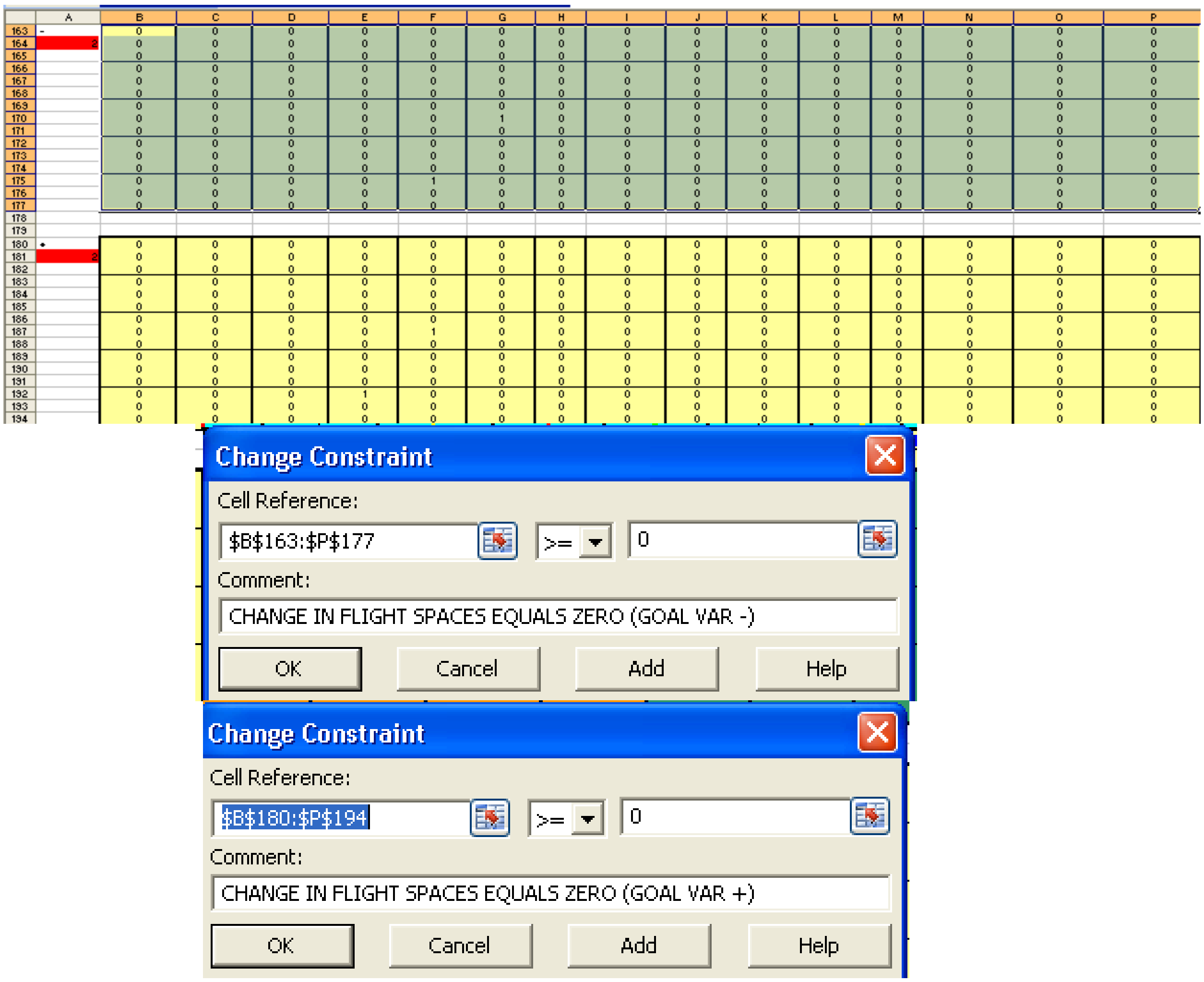


=B5-'R&D(5-3)(b)'!B4+B163-B180

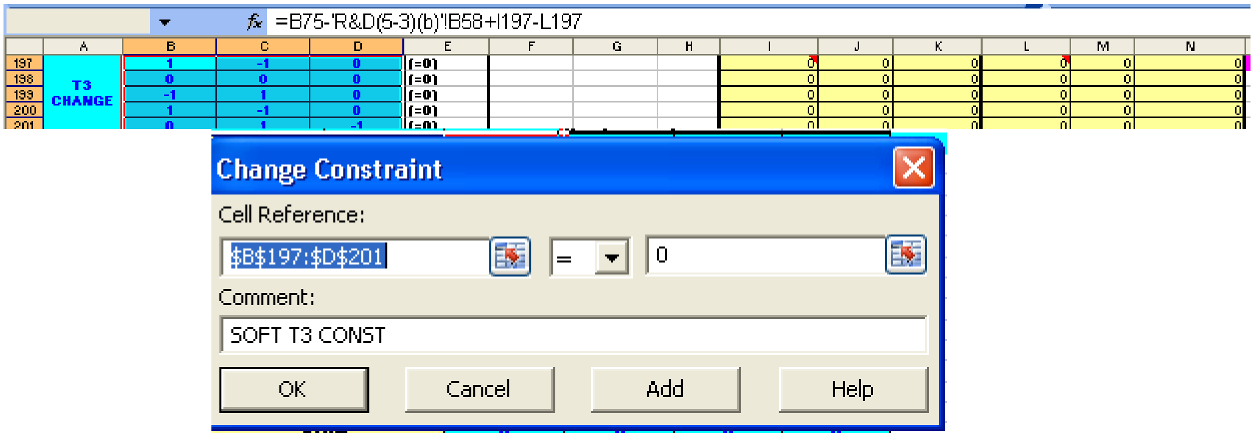
| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 144 | | SPECHT | YOUTSEY | COCKRUM | FRIEDEL | COLE | SABIA | SHULTZ | WILLINGHAM | KOPACEK | CONELLAN | GAONA | JONES | KELLAM | MOELLER | REYNOLDS |
| 145 | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 146 | MONAM | 0 | 0 | 0 | -1 | 1 | 0 | 0 | 0 | 1 | 1 | -1 | -1 | -1 | 0 | 1 |
| 147 | MONPM | -1 | 0 | 0 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 148 | MONN | -1 | 0 | 0 | 1 | -1 | 0 | 0 | 0 | -1 | -1 | 0 | 1 | 1 | 1 | 0 |
| 149 | TUEAM | 0 | -1 | 0 | -1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | -1 | -1 | -1 | 1 |
| 150 | TUEPM | 0 | -1 | -1 | -1 | -1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 151 | TUEN | 0 | 1 | 0 | 0 | -1 | 0 | 0 | 0 | -1 | -1 | 0 | 1 | 1 | 1 | -1 |
| 152 | WEDAM | 0 | -1 | 0 | 0 | 1 | 0 | 1 | -1 | 1 | 0 | 1 | -1 | -1 | -1 | 1 |
| 153 | WEDPM | 0 | -1 | -1 | -1 | -1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 154 | WEDN | 1 | 0 | -1 | 0 | -1 | 0 | -1 | 1 | -1 | 0 | 0 | 0 | 1 | 1 | 0 |
| 155 | THURAM | -1 | 0 | 0 | 0 | 1 | 0 | 1 | -1 | 0 | 0 | 1 | 1 | -1 | -1 | 0 |
| 156 | THURPM | -1 | 0 | -1 | -1 | -1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 157 | THURN | 0 | 1 | -1 | 0 | -1 | 0 | -1 | 1 | 0 | 0 | 0 | -1 | 1 | 1 | 0 |
| 158 | FRIAM | 0 | -1 | 0 | -1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | -1 | -1 | 0 |
| 159 | FRIPM | -1 | -1 | 0 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 160 | FRIN | 0 | 0 | 0 | 0 | 0 | 0 | -1 | 0 | -1 | 0 | 0 | -1 | 1 | 1 | 1 |



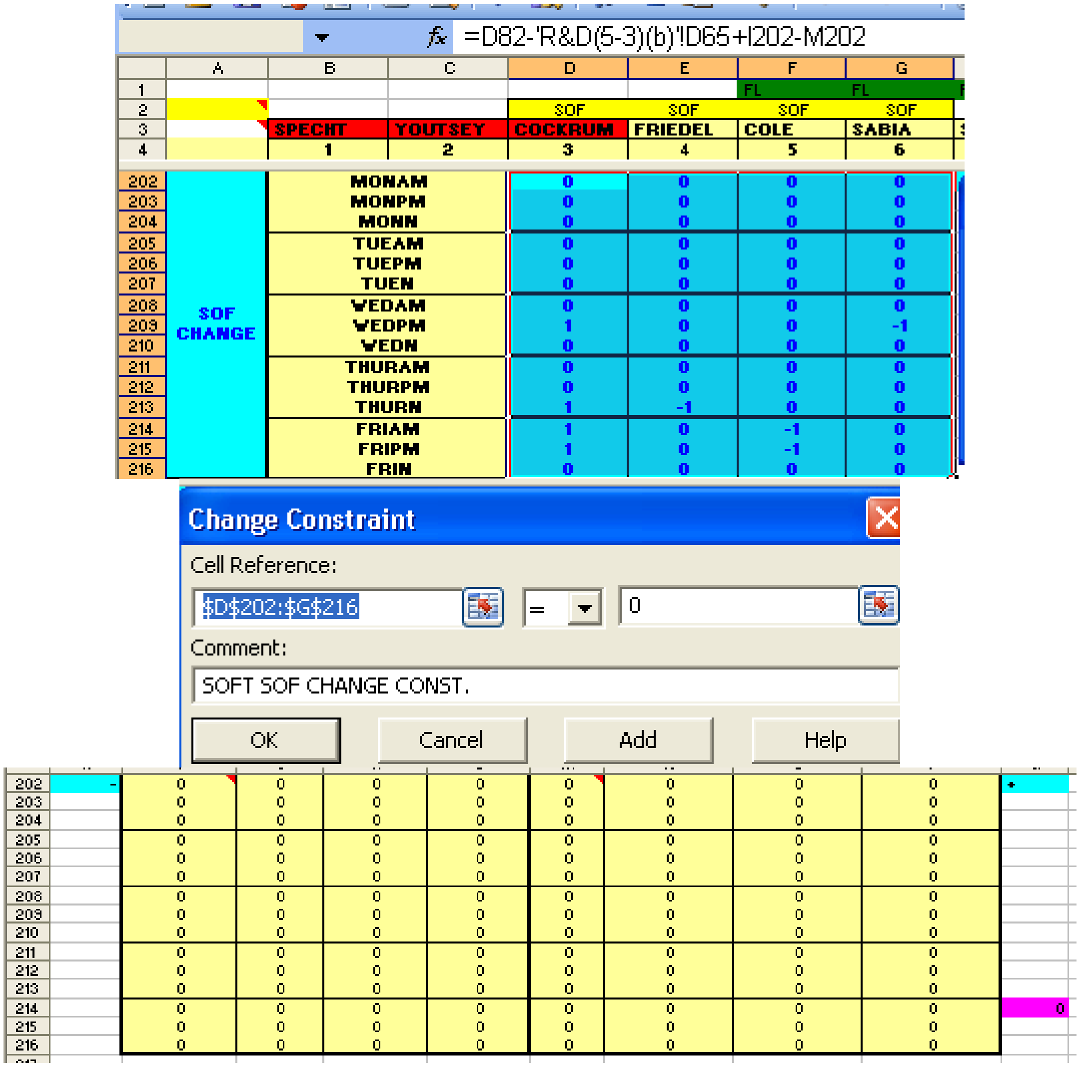
**ADDITIONAL GOAL CONSTRAINT**
**CHANGE IN FLIGHT SCHEDULING CELLS IS ZERO**




**CHANGE IN FLIGHT CELLS IS ZERO GOAL VARIABLES (-) AND (+)**




**ADDITIONAL GOAL CONSTRAINT AND VARIABLES CHANGE IN Top3 CELLS IS ZERO**




**ADDITIONAL GOAL CONSTRAINT AND VARIABLES CHANGE IN SOF CELLS IS ZERO**

## Appendix C: The Output List of 1331 Schedules

| TYPE | IP coefficient | FL Coefficient | P coefficient | Total IP Sorties | Total FL Sorties | Total P Sorties | TYPE | IP coefficient | FL Coefficient | P coefficient | Total IP Sorties | Total FL Sorties | Total P Sorties |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 29 | 35 | 26 | 6.4 | 20 | 30 | 10 | 25 | 40 | 25 |
| 2.1 | 0 | 10 | 20 | 10 | 35 | 45 | 6.4 | 20 | 40 | 10 | 25 | 40 | 25 |
| 2.1 | 0 | 10 | 30 | 10 | 35 | 45 | 6.4 | 20 | 50 | 10 | 25 | 40 | 25 |
| 2.1 | 0 | 10 | 40 | 10 | 35 | 45 | 6.4 | 20 | 60 | 10 | 25 | 40 | 25 |
| 2.1 | 0 | 10 | 50 | 10 | 35 | 45 | 6.4 | 20 | 70 | 10 | 25 | 40 | 25 |
| 2.1 | 0 | 10 | 60 | 10 | 35 | 45 | 6.4 | 20 | 80 | 10 | 25 | 40 | 25 |
| 2.1 | 0 | 10 | 70 | 10 | 35 | 45 | 6.4 | 20 | 90 | 10 | 25 | 40 | 25 |
| 2.1 | 0 | 10 | 80 | 10 | 35 | 45 | 6.4 | 20 | 100 | 10 | 25 | 40 | 25 |
| 2.1 | 0 | 10 | 90 | 10 | 35 | 45 | 6.4 | 30 | 40 | 10 | 25 | 40 | 25 |
| 2.1 | 0 | 10 | 100 | 10 | 35 | 45 | 6.4 | 30 | 50 | 10 | 25 | 40 | 25 |
| 2.1 | 0 | 20 | 30 | 10 | 35 | 45 | 6.4 | 30 | 60 | 10 | 25 | 40 | 25 |
| 2.1 | 0 | 20 | 40 | 10 | 35 | 45 | 6.4 | 30 | 70 | 10 | 25 | 40 | 25 |
| 2.1 | 0 | 20 | 50 | 10 | 35 | 45 | 6.4 | 30 | 80 | 10 | 25 | 40 | 25 |
| 2.1 | 0 | 20 | 60 | 10 | 35 | 45 | 6.4 | 30 | 90 | 10 | 25 | 40 | 25 |
| 2.1 | 0 | 20 | 70 | 10 | 35 | 45 | 6.4 | 30 | 100 | 10 | 25 | 40 | 25 |
| 2.1 | 0 | 20 | 80 | 10 | 35 | 45 | 6.4 | 30 | 40 | 20 | 25 | 40 | 25 |
| 2.1 | 0 | 20 | 90 | 10 | 35 | 45 | 6.4 | 30 | 50 | 20 | 25 | 40 | 25 |
| 2.1 | 0 | 20 | 100 | 10 | 35 | 45 | 6.4 | 30 | 60 | 20 | 25 | 40 | 25 |
| 2.1 | 0 | 30 | 40 | 10 | 35 | 45 | 6.4 | 30 | 70 | 20 | 25 | 40 | 25 |
| 2.1 | 0 | 30 | 50 | 10 | 35 | 45 | 6.4 | 30 | 80 | 20 | 25 | 40 | 25 |
| 2.1 | 0 | 30 | 60 | 10 | 35 | 45 | 6.4 | 30 | 90 | 20 | 25 | 40 | 25 |
| 2.1 | 0 | 30 | 70 | 10 | 35 | 45 | 6.4 | 30 | 100 | 20 | 25 | 40 | 25 |
| 2.1 | 0 | 30 | 80 | 10 | 35 | 45 | 6.4 | 40 | 50 | 10 | 25 | 40 | 25 |
| 2.1 | 0 | 30 | 90 | 10 | 35 | 45 | 6.4 | 40 | 60 | 10 | 25 | 40 | 25 |
| 2.1 | 0 | 30 | 100 | 10 | 35 | 45 | 6.4 | 40 | 70 | 10 | 25 | 40 | 25 |
| 2.1 | 0 | 40 | 50 | 10 | 35 | 45 | 6.4 | 40 | 80 | 10 | 25 | 40 | 25 |
| 2.1 | 0 | 40 | 60 | 10 | 35 | 45 | 6.4 | 40 | 90 | 10 | 25 | 40 | 25 |
| 2.1 | 0 | 40 | 70 | 10 | 35 | 45 | 6.4 | 40 | 100 | 10 | 25 | 40 | 25 |
| 2.1 | 0 | 40 | 80 | 10 | 35 | 45 | 6.4 | 40 | 50 | 20 | 25 | 40 | 25 |
| 2.1 | 0 | 40 | 90 | 10 | 35 | 45 | 6.4 | 40 | 60 | 20 | 25 | 40 | 25 |
| 2.1 | 0 | 40 | 100 | 10 | 35 | 45 | 6.4 | 40 | 70 | 20 | 25 | 40 | 25 |
| 2.1 | 0 | 50 | 60 | 10 | 35 | 45 | 6.4 | 40 | 80 | 20 | 25 | 40 | 25 |
| 2.1 | 0 | 50 | 70 | 30 | 15 | 45 | 6.4 | 40 | 90 | 20 | 25 | 40 | 25 |
| 2.1 | 0 | 50 | 80 | 10 | 35 | 45 | 6.4 | 40 | 100 | 20 | 25 | 40 | 25 |
| 2.1 | 0 | 50 | 90 | 10 | 35 | 45 | 6.4 | 40 | 50 | 30 | 25 | 40 | 25 |
| 2.1 | 0 | 50 | 100 | 10 | 35 | 45 | 6.4 | 40 | 60 | 30 | 25 | 40 | 25 |
| 2.1 | 0 | 60 | 70 | 10 | 35 | 45 | 6.4 | 40 | 70 | 30 | 25 | 40 | 25 |
| 2.1 | 0 | 60 | 80 | 10 | 35 | 45 | 6.4 | 40 | 80 | 30 | 25 | 40 | 25 |
| 2.1 | 0 | 60 | 90 | 10 | 35 | 45 | 6.4 | 40 | 90 | 30 | 25 | 40 | 25 |
| 2.1 | 0 | 60 | 100 | 10 | 35 | 45 | 6.4 | 40 | 100 | 30 | 25 | 40 | 25 |
| 2.1 | 0 | 70 | 80 | 10 | 35 | 45 | 6.4 | 50 | 60 | 10 | 25 | 40 | 25 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2.1 | 0 | 70 | 90 | 10 | 35 | 45 |
| 2.1 | 0 | 70 | 100 | 10 | 35 | 45 |
| 2.1 | 0 | 80 | 90 | 10 | 35 | 45 |
| 2.1 | 0 | 80 | 100 | 10 | 35 | 45 |
| 2.1 | 0 | 90 | 100 | 10 | 35 | 45 |
| 2.2 | 0 | 20 | 10 | 10 | 40 | 40 |
| 2.2 | 0 | 30 | 10 | 10 | 40 | 40 |
| 2.2 | 0 | 30 | 20 | 10 | 40 | 40 |
| 2.2 | 0 | 40 | 10 | 10 | 40 | 40 |
| 2.2 | 0 | 40 | 20 | 10 | 40 | 40 |
| 2.2 | 0 | 40 | 30 | 10 | 40 | 40 |
| 2.2 | 0 | 50 | 10 | 10 | 40 | 40 |
| 2.2 | 0 | 50 | 20 | 10 | 40 | 40 |
| 2.2 | 0 | 50 | 30 | 10 | 40 | 40 |
| 2.2 | 0 | 50 | 40 | 10 | 40 | 40 |
| 2.2 | 0 | 60 | 10 | 10 | 40 | 40 |
| 2.2 | 0 | 60 | 20 | 10 | 40 | 40 |
| 2.2 | 0 | 60 | 30 | 10 | 40 | 40 |
| 2.2 | 0 | 60 | 40 | 10 | 40 | 40 |
| 2.2 | 0 | 60 | 50 | 10 | 40 | 40 |
| 2.2 | 0 | 70 | 10 | 10 | 40 | 40 |
| 2.2 | 0 | 70 | 20 | 10 | 40 | 40 |
| 2.2 | 0 | 70 | 30 | 10 | 40 | 40 |
| 2.2 | 0 | 70 | 40 | 10 | 40 | 40 |
| 2.2 | 0 | 70 | 50 | 10 | 40 | 40 |
| 2.2 | 0 | 70 | 60 | 10 | 40 | 40 |
| 2.2 | 0 | 80 | 10 | 10 | 40 | 40 |
| 2.2 | 0 | 80 | 20 | 10 | 40 | 40 |
| 2.2 | 0 | 80 | 30 | 10 | 40 | 40 |
| 2.2 | 0 | 80 | 40 | 10 | 40 | 40 |
| 2.2 | 0 | 80 | 50 | 10 | 40 | 40 |
| 2.2 | 0 | 80 | 60 | 10 | 40 | 40 |
| 2.2 | 0 | 80 | 70 | 10 | 40 | 40 |
| 2.2 | 0 | 90 | 10 | 10 | 40 | 40 |
| 2.2 | 0 | 90 | 20 | 10 | 40 | 40 |
| 2.2 | 0 | 90 | 30 | 10 | 40 | 40 |
| 2.2 | 0 | 90 | 40 | 10 | 40 | 40 |
| 2.2 | 0 | 90 | 50 | 10 | 40 | 40 |
| 2.2 | 0 | 90 | 60 | 10 | 40 | 40 |
| 2.2 | 0 | 90 | 70 | 10 | 40 | 40 |
| 2.2 | 0 | 90 | 80 | 10 | 40 | 40 |
| 2.2 | 0 | 100 | 10 | 10 | 40 | 40 |
| 2.2 | 0 | 100 | 20 | 10 | 40 | 40 |
| 2.2 | 0 | 100 | 30 | 10 | 40 | 40 |
| 2.2 | 0 | 100 | 40 | 10 | 40 | 40 |
| 2.2 | 0 | 100 | 50 | 10 | 40 | 40 |
| 2.2 | 0 | 100 | 60 | 10 | 40 | 40 |
| 2.2 | 0 | 100 | 70 | 10 | 40 | 40 |
| 2.2 | 0 | 100 | 80 | 10 | 40 | 40 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 6.4 | 50 | 70 | 10 | 25 | 40 | 25 |
| 6.4 | 50 | 80 | 10 | 25 | 40 | 25 |
| 6.4 | 50 | 90 | 10 | 25 | 40 | 25 |
| 6.4 | 50 | 100 | 10 | 25 | 40 | 25 |
| 6.4 | 50 | 60 | 20 | 25 | 40 | 25 |
| 6.4 | 50 | 70 | 20 | 25 | 40 | 25 |
| 6.4 | 50 | 80 | 20 | 25 | 40 | 25 |
| 6.4 | 50 | 90 | 20 | 25 | 40 | 25 |
| 6.4 | 50 | 100 | 20 | 25 | 40 | 25 |
| 6.4 | 50 | 60 | 30 | 25 | 40 | 25 |
| 6.4 | 50 | 70 | 30 | 25 | 40 | 25 |
| 6.4 | 50 | 80 | 30 | 25 | 40 | 25 |
| 6.4 | 50 | 90 | 30 | 25 | 40 | 25 |
| 6.4 | 50 | 100 | 30 | 25 | 40 | 25 |
| 6.4 | 50 | 60 | 40 | 25 | 40 | 25 |
| 6.4 | 50 | 70 | 40 | 25 | 40 | 25 |
| 6.4 | 50 | 80 | 40 | 25 | 40 | 25 |
| 6.4 | 50 | 90 | 40 | 25 | 40 | 25 |
| 6.4 | 50 | 100 | 40 | 25 | 40 | 25 |
| 6.4 | 60 | 70 | 10 | 25 | 40 | 25 |
| 6.4 | 60 | 80 | 10 | 25 | 40 | 25 |
| 6.4 | 60 | 90 | 10 | 25 | 40 | 25 |
| 6.4 | 60 | 100 | 10 | 25 | 40 | 25 |
| 6.4 | 60 | 70 | 20 | 25 | 40 | 25 |
| 6.4 | 60 | 80 | 20 | 25 | 40 | 25 |
| 6.4 | 60 | 90 | 20 | 25 | 40 | 25 |
| 6.4 | 60 | 100 | 20 | 25 | 40 | 25 |
| 6.4 | 60 | 70 | 30 | 25 | 40 | 25 |
| 6.4 | 60 | 80 | 30 | 25 | 40 | 25 |
| 6.4 | 60 | 90 | 30 | 25 | 40 | 25 |
| 6.4 | 60 | 100 | 30 | 25 | 40 | 25 |
| 6.4 | 60 | 70 | 40 | 25 | 40 | 25 |
| 6.4 | 60 | 80 | 40 | 25 | 40 | 25 |
| 6.4 | 60 | 90 | 40 | 25 | 40 | 25 |
| 6.4 | 60 | 100 | 40 | 25 | 40 | 25 |
| 6.4 | 60 | 70 | 50 | 25 | 40 | 25 |
| 6.4 | 60 | 80 | 50 | 25 | 40 | 25 |
| 6.4 | 60 | 90 | 50 | 25 | 40 | 25 |
| 6.4 | 60 | 100 | 50 | 25 | 40 | 25 |
| 6.4 | 70 | 80 | 10 | 25 | 40 | 25 |
| 6.4 | 70 | 90 | 10 | 25 | 40 | 25 |
| 6.4 | 70 | 100 | 10 | 25 | 40 | 25 |
| 6.4 | 70 | 80 | 20 | 25 | 40 | 25 |
| 6.4 | 70 | 90 | 20 | 25 | 40 | 25 |
| 6.4 | 70 | 100 | 20 | 25 | 40 | 25 |
| 6.4 | 70 | 80 | 30 | 25 | 40 | 25 |
| 6.4 | 70 | 90 | 30 | 25 | 40 | 25 |
| 6.4 | 70 | 100 | 30 | 25 | 40 | 25 |
| 6.4 | 70 | 80 | 40 | 25 | 40 | 25 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.2 | 0 | 100 | 90 | 10 | 40 | 40 | 6.4 | 70 | 90 | 40 | 25 | 40 | 25 |
| 2.3 | 0 | 10 | 10 | 10 | 35 | 45 | 6.4 | 70 | 100 | 40 | 25 | 40 | 25 |
| 2.3 | 0 | 20 | 20 | 10 | 35 | 45 | 6.4 | 70 | 80 | 50 | 25 | 40 | 25 |
| 2.3 | 0 | 30 | 30 | 10 | 35 | 45 | 6.4 | 70 | 90 | 50 | 25 | 40 | 25 |
| 2.3 | 0 | 40 | 40 | 10 | 35 | 45 | 6.4 | 70 | 100 | 50 | 25 | 40 | 25 |
| 2.3 | 0 | 50 | 50 | 10 | 35 | 45 | 6.4 | 70 | 80 | 60 | 25 | 40 | 25 |
| 2.3 | 0 | 60 | 60 | 10 | 35 | 45 | 6.4 | 70 | 90 | 60 | 25 | 40 | 25 |
| 2.3 | 0 | 70 | 70 | 10 | 35 | 45 | 6.4 | 70 | 100 | 60 | 25 | 40 | 25 |
| 2.3 | 0 | 80 | 80 | 10 | 35 | 45 | 6.4 | 80 | 90 | 10 | 25 | 40 | 25 |
| 2.3 | 0 | 90 | 90 | 10 | 35 | 45 | 6.4 | 80 | 100 | 10 | 25 | 40 | 25 |
| 2.3 | 0 | 100 | 100 | 9 | 36 | 45 | 6.4 | 80 | 90 | 20 | 25 | 40 | 25 |
| 3.1 | 10 | 0 | 20 | 30 | 15 | 45 | 6.4 | 80 | 100 | 20 | 25 | 40 | 25 |
| 3.1 | 10 | 0 | 30 | 30 | 15 | 45 | 6.4 | 80 | 90 | 30 | 25 | 40 | 25 |
| 3.1 | 10 | 0 | 40 | 30 | 15 | 45 | 6.4 | 80 | 100 | 30 | 25 | 40 | 25 |
| 3.1 | 10 | 0 | 50 | 30 | 15 | 45 | 6.4 | 80 | 90 | 40 | 25 | 40 | 25 |
| 3.1 | 10 | 0 | 60 | 30 | 15 | 45 | 6.4 | 80 | 100 | 40 | 25 | 40 | 25 |
| 3.1 | 10 | 0 | 70 | 30 | 15 | 45 | 6.4 | 80 | 90 | 50 | 25 | 40 | 25 |
| 3.1 | 10 | 0 | 80 | 30 | 15 | 45 | 6.4 | 80 | 100 | 50 | 25 | 40 | 25 |
| 3.1 | 10 | 0 | 90 | 30 | 15 | 45 | 6.4 | 80 | 90 | 60 | 25 | 40 | 25 |
| 3.1 | 10 | 0 | 100 | 30 | 15 | 45 | 6.4 | 80 | 100 | 60 | 25 | 40 | 25 |
| 3.1 | 20 | 0 | 30 | 30 | 15 | 45 | 6.4 | 80 | 90 | 70 | 25 | 40 | 25 |
| 3.1 | 20 | 0 | 40 | 30 | 15 | 45 | 6.4 | 80 | 100 | 70 | 25 | 40 | 25 |
| 3.1 | 20 | 0 | 50 | 30 | 15 | 45 | 6.4 | 90 | 100 | 10 | 25 | 40 | 25 |
| 3.1 | 20 | 0 | 60 | 30 | 15 | 45 | 6.4 | 90 | 100 | 20 | 25 | 40 | 25 |
| 3.1 | 20 | 0 | 70 | 30 | 15 | 45 | 6.4 | 90 | 100 | 30 | 25 | 40 | 25 |
| 3.1 | 20 | 0 | 80 | 30 | 15 | 45 | 6.4 | 90 | 100 | 40 | 25 | 40 | 25 |
| 3.1 | 20 | 0 | 90 | 30 | 15 | 45 | 6.4 | 90 | 100 | 50 | 25 | 40 | 25 |
| 3.1 | 20 | 0 | 100 | 30 | 15 | 45 | 6.4 | 90 | 100 | 60 | 25 | 40 | 25 |
| 3.1 | 30 | 0 | 40 | 30 | 15 | 45 | 6.4 | 90 | 100 | 70 | 25 | 40 | 25 |
| 3.1 | 30 | 0 | 50 | 30 | 15 | 45 | 6.4 | 90 | 100 | 80 | 25 | 40 | 25 |
| 3.1 | 30 | 0 | 60 | 30 | 15 | 45 | 6.5 | 30 | 10 | 20 | 30 | 15 | 45 |
| 3.1 | 30 | 0 | 70 | 30 | 15 | 45 | 6.5 | 40 | 10 | 20 | 30 | 15 | 45 |
| 3.1 | 30 | 0 | 80 | 30 | 15 | 45 | 6.5 | 40 | 10 | 30 | 30 | 15 | 45 |
| 3.1 | 30 | 0 | 90 | 30 | 15 | 45 | 6.5 | 40 | 20 | 30 | 30 | 15 | 45 |
| 3.1 | 30 | 0 | 100 | 30 | 15 | 45 | 6.5 | 50 | 10 | 20 | 30 | 15 | 45 |
| 3.1 | 40 | 0 | 50 | 30 | 15 | 45 | 6.5 | 50 | 10 | 30 | 30 | 15 | 45 |
| 3.1 | 40 | 0 | 60 | 30 | 15 | 45 | 6.5 | 50 | 10 | 40 | 30 | 15 | 45 |
| 3.1 | 40 | 0 | 70 | 30 | 15 | 45 | 6.5 | 50 | 20 | 30 | 30 | 15 | 45 |
| 3.1 | 40 | 0 | 80 | 30 | 15 | 45 | 6.5 | 50 | 20 | 40 | 30 | 15 | 45 |
| 3.1 | 40 | 0 | 90 | 30 | 15 | 45 | 6.5 | 50 | 30 | 40 | 30 | 15 | 45 |
| 3.1 | 40 | 0 | 100 | 30 | 15 | 45 | 6.5 | 60 | 10 | 20 | 30 | 15 | 45 |
| 3.1 | 50 | 0 | 60 | 30 | 15 | 45 | 6.5 | 60 | 10 | 30 | 30 | 15 | 45 |
| 3.1 | 50 | 0 | 70 | 30 | 15 | 45 | 6.5 | 60 | 10 | 40 | 30 | 15 | 45 |
| 3.1 | 50 | 0 | 80 | 30 | 15 | 45 | 6.5 | 60 | 10 | 50 | 30 | 15 | 45 |
| 3.1 | 50 | 0 | 90 | 30 | 15 | 45 | 6.5 | 60 | 20 | 30 | 30 | 15 | 45 |
| 3.1 | 50 | 0 | 100 | 30 | 15 | 45 | 6.5 | 60 | 20 | 40 | 30 | 15 | 45 |
| 3.1 | 60 | 0 | 70 | 30 | 15 | 45 | 6.5 | 60 | 20 | 50 | 30 | 15 | 45 |
| 3.1 | 60 | 0 | 80 | 30 | 15 | 45 | 6.5 | 60 | 30 | 40 | 30 | 15 | 45 |
| 3.1 | 60 | 0 | 90 | 30 | 15 | 45 | 6.5 | 60 | 30 | 50 | 30 | 15 | 45 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.1 | 60 | 0 | 100 | 30 | 15 | 45 | 6.5 | 60 | 40 | 50 | 30 | 15 | 45 |
| 3.1 | 70 | 0 | 80 | 30 | 15 | 45 | 6.5 | 70 | 10 | 20 | 30 | 15 | 45 |
| 3.1 | 70 | 0 | 90 | 30 | 15 | 45 | 6.5 | 70 | 10 | 30 | 30 | 15 | 45 |
| 3.1 | 70 | 0 | 100 | 30 | 15 | 45 | 6.5 | 70 | 10 | 40 | 30 | 15 | 45 |
| 3.1 | 80 | 0 | 90 | 30 | 15 | 45 | 6.5 | 70 | 10 | 50 | 30 | 15 | 45 |
| 3.1 | 80 | 0 | 100 | 30 | 15 | 45 | 6.5 | 70 | 10 | 60 | 30 | 15 | 45 |
| 3.1 | 90 | 0 | 100 | 30 | 15 | 45 | 6.5 | 70 | 20 | 30 | 30 | 15 | 45 |
| 3.2 | 20 | 0 | 10 | 30 | 15 | 45 | 6.5 | 70 | 20 | 40 | 30 | 15 | 45 |
| 3.2 | 30 | 0 | 10 | 30 | 15 | 45 | 6.5 | 70 | 20 | 50 | 30 | 15 | 45 |
| 3.2 | 30 | 0 | 20 | 30 | 15 | 45 | 6.5 | 70 | 20 | 60 | 30 | 15 | 45 |
| 3.2 | 40 | 0 | 10 | 30 | 15 | 45 | 6.5 | 70 | 30 | 40 | 30 | 15 | 45 |
| 3.2 | 40 | 0 | 20 | 30 | 15 | 45 | 6.5 | 70 | 30 | 50 | 30 | 15 | 45 |
| 3.2 | 40 | 0 | 30 | 30 | 15 | 45 | 6.5 | 70 | 30 | 60 | 30 | 15 | 45 |
| 3.2 | 50 | 0 | 10 | 30 | 15 | 45 | 6.5 | 70 | 40 | 50 | 30 | 15 | 45 |
| 3.2 | 50 | 0 | 20 | 30 | 15 | 45 | 6.5 | 70 | 40 | 60 | 30 | 15 | 45 |
| 3.2 | 50 | 0 | 30 | 30 | 15 | 45 | 6.5 | 70 | 50 | 60 | 30 | 15 | 45 |
| 3.2 | 50 | 0 | 40 | 30 | 15 | 45 | 6.5 | 80 | 10 | 20 | 30 | 15 | 45 |
| 3.2 | 60 | 0 | 10 | 30 | 15 | 45 | 6.5 | 80 | 10 | 30 | 30 | 15 | 45 |
| 3.2 | 60 | 0 | 20 | 30 | 15 | 45 | 6.5 | 80 | 10 | 40 | 30 | 15 | 45 |
| 3.2 | 60 | 0 | 30 | 30 | 15 | 45 | 6.5 | 80 | 10 | 50 | 30 | 15 | 45 |
| 3.2 | 60 | 0 | 40 | 30 | 15 | 45 | 6.5 | 80 | 10 | 60 | 30 | 15 | 45 |
| 3.2 | 60 | 0 | 50 | 30 | 15 | 45 | 6.5 | 80 | 10 | 70 | 30 | 15 | 45 |
| 3.2 | 70 | 0 | 10 | 30 | 15 | 45 | 6.5 | 80 | 20 | 30 | 30 | 15 | 45 |
| 3.2 | 70 | 0 | 20 | 30 | 15 | 45 | 6.5 | 80 | 20 | 40 | 30 | 15 | 45 |
| 3.2 | 70 | 0 | 30 | 30 | 15 | 45 | 6.5 | 80 | 20 | 50 | 30 | 15 | 45 |
| 3.2 | 70 | 0 | 40 | 30 | 15 | 45 | 6.5 | 80 | 20 | 60 | 30 | 15 | 45 |
| 3.2 | 70 | 0 | 50 | 30 | 15 | 45 | 6.5 | 80 | 20 | 70 | 30 | 15 | 45 |
| 3.2 | 70 | 0 | 60 | 30 | 15 | 45 | 6.5 | 80 | 30 | 40 | 30 | 15 | 45 |
| 3.2 | 80 | 0 | 10 | 30 | 15 | 45 | 6.5 | 80 | 30 | 50 | 30 | 15 | 45 |
| 3.2 | 80 | 0 | 20 | 30 | 15 | 45 | 6.5 | 80 | 30 | 60 | 30 | 15 | 45 |
| 3.2 | 80 | 0 | 30 | 30 | 15 | 45 | 6.5 | 80 | 30 | 70 | 30 | 15 | 45 |
| 3.2 | 80 | 0 | 40 | 30 | 15 | 45 | 6.5 | 80 | 40 | 50 | 30 | 15 | 45 |
| 3.2 | 80 | 0 | 50 | 30 | 15 | 45 | 6.5 | 80 | 40 | 60 | 30 | 15 | 45 |
| 3.2 | 80 | 0 | 60 | 30 | 15 | 45 | 6.5 | 80 | 40 | 70 | 30 | 15 | 45 |
| 3.2 | 80 | 0 | 70 | 30 | 15 | 45 | 6.5 | 80 | 50 | 60 | 30 | 15 | 45 |
| 3.2 | 90 | 0 | 10 | 30 | 15 | 45 | 6.5 | 80 | 50 | 70 | 30 | 15 | 45 |
| 3.2 | 90 | 0 | 20 | 30 | 15 | 45 | 6.5 | 80 | 60 | 70 | 30 | 15 | 45 |
| 3.2 | 90 | 0 | 30 | 30 | 15 | 45 | 6.5 | 90 | 10 | 20 | 30 | 15 | 45 |
| 3.2 | 90 | 0 | 40 | 30 | 15 | 45 | 6.5 | 90 | 10 | 30 | 30 | 15 | 45 |
| 3.2 | 90 | 0 | 50 | 30 | 15 | 45 | 6.5 | 90 | 10 | 40 | 30 | 15 | 45 |
| 3.2 | 90 | 0 | 60 | 30 | 15 | 45 | 6.5 | 90 | 10 | 50 | 30 | 15 | 45 |
| 3.2 | 90 | 0 | 70 | 30 | 15 | 45 | 6.5 | 90 | 10 | 60 | 30 | 15 | 45 |
| 3.2 | 90 | 0 | 80 | 30 | 15 | 45 | 6.5 | 90 | 10 | 70 | 30 | 15 | 45 |
| 3.2 | 100 | 0 | 10 | 30 | 15 | 45 | 6.5 | 90 | 10 | 80 | 30 | 15 | 45 |
| 3.2 | 100 | 0 | 20 | 30 | 15 | 45 | 6.5 | 90 | 20 | 30 | 30 | 15 | 45 |
| 3.2 | 100 | 0 | 30 | 30 | 15 | 45 | 6.5 | 90 | 20 | 40 | 30 | 15 | 45 |
| 3.2 | 100 | 0 | 40 | 30 | 15 | 45 | 6.5 | 90 | 20 | 50 | 30 | 15 | 45 |
| 3.2 | 100 | 0 | 50 | 29 | 16 | 45 | 6.5 | 90 | 20 | 60 | 30 | 15 | 45 |
| 3.2 | 100 | 0 | 60 | 30 | 15 | 45 | 6.5 | 90 | 20 | 70 | 30 | 15 | 45 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.2 | 100 | 0 | 70 | 30 | 15 | 45 | 6.5 | 90 | 20 | 80 | 30 | 15 | 45 |
| 3.2 | 100 | 0 | 80 | 30 | 15 | 45 | 6.5 | 90 | 30 | 40 | 30 | 15 | 45 |
| 3.2 | 100 | 0 | 90 | 30 | 15 | 45 | 6.5 | 90 | 30 | 50 | 30 | 15 | 45 |
| 3.3 | 10 | 0 | 10 | 30 | 15 | 45 | 6.5 | 90 | 30 | 60 | 30 | 15 | 45 |
| 3.3 | 20 | 0 | 20 | 30 | 15 | 45 | 6.5 | 90 | 30 | 70 | 30 | 15 | 45 |
| 3.3 | 30 | 0 | 30 | 30 | 15 | 45 | 6.5 | 90 | 30 | 80 | 30 | 15 | 45 |
| 3.3 | 40 | 0 | 40 | 30 | 15 | 45 | 6.5 | 90 | 40 | 50 | 30 | 15 | 45 |
| 3.3 | 50 | 0 | 50 | 30 | 15 | 45 | 6.5 | 90 | 40 | 60 | 30 | 15 | 45 |
| 3.3 | 60 | 0 | 60 | 30 | 15 | 45 | 6.5 | 90 | 40 | 70 | 30 | 15 | 45 |
| 3.3 | 80 | 0 | 80 | 30 | 15 | 45 | 6.5 | 90 | 40 | 80 | 30 | 15 | 45 |
| 3.3 | 70 | 0 | 70 | 30 | 15 | 45 | 6.5 | 90 | 50 | 60 | 30 | 15 | 45 |
| 3.3 | 90 | 0 | 90 | 30 | 15 | 45 | 6.5 | 90 | 50 | 70 | 30 | 15 | 45 |
| 3.3 | 100 | 0 | 100 | 30 | 15 | 45 | 6.5 | 90 | 50 | 80 | 30 | 15 | 45 |
| 4.1 | 20 | 10 | 0 | 30 | 35 | 25 | 6.5 | 90 | 60 | 70 | 30 | 15 | 45 |
| 4.1 | 30 | 10 | 0 | 30 | 35 | 25 | 6.5 | 90 | 60 | 80 | 30 | 15 | 45 |
| 4.1 | 30 | 20 | 0 | 30 | 35 | 25 | 6.5 | 90 | 70 | 80 | 30 | 15 | 45 |
| 4.1 | 40 | 10 | 0 | 30 | 35 | 25 | 6.5 | 100 | 10 | 20 | 30 | 15 | 45 |
| 4.1 | 40 | 20 | 0 | 30 | 35 | 25 | 6.5 | 100 | 10 | 30 | 30 | 15 | 45 |
| 4.1 | 40 | 30 | 0 | 30 | 35 | 25 | 6.5 | 100 | 10 | 40 | 30 | 15 | 45 |
| 4.1 | 50 | 10 | 0 | 30 | 35 | 25 | 6.5 | 100 | 10 | 50 | 30 | 15 | 45 |
| 4.1 | 50 | 20 | 0 | 30 | 35 | 25 | 6.5 | 100 | 10 | 60 | 30 | 15 | 45 |
| 4.1 | 50 | 30 | 0 | 30 | 35 | 25 | 6.5 | 100 | 10 | 70 | 30 | 15 | 45 |
| 4.1 | 50 | 40 | 0 | 30 | 35 | 25 | 6.5 | 100 | 10 | 80 | 30 | 15 | 45 |
| 4.1 | 60 | 10 | 0 | 30 | 35 | 25 | 6.5 | 100 | 10 | 90 | 30 | 15 | 45 |
| 4.1 | 60 | 20 | 0 | 30 | 35 | 25 | 6.5 | 100 | 20 | 30 | 30 | 15 | 45 |
| 4.1 | 60 | 30 | 0 | 30 | 35 | 25 | 6.5 | 100 | 20 | 40 | 30 | 15 | 45 |
| 4.1 | 60 | 40 | 0 | 30 | 35 | 25 | 6.5 | 100 | 20 | 50 | 30 | 15 | 45 |
| 4.1 | 60 | 50 | 0 | 30 | 35 | 25 | 6.5 | 100 | 20 | 60 | 30 | 15 | 45 |
| 4.1 | 70 | 10 | 0 | 30 | 35 | 25 | 6.5 | 100 | 20 | 70 | 30 | 15 | 45 |
| 4.1 | 70 | 20 | 0 | 30 | 35 | 25 | 6.5 | 100 | 20 | 80 | 30 | 15 | 45 |
| 4.1 | 70 | 30 | 0 | 30 | 35 | 25 | 6.5 | 100 | 20 | 90 | 30 | 15 | 45 |
| 4.1 | 70 | 40 | 0 | 30 | 35 | 25 | 6.5 | 100 | 30 | 40 | 30 | 15 | 45 |
| 4.1 | 70 | 50 | 0 | 30 | 35 | 25 | 6.5 | 100 | 30 | 50 | 30 | 15 | 45 |
| 4.1 | 70 | 60 | 0 | 30 | 35 | 25 | 6.5 | 100 | 30 | 60 | 30 | 15 | 45 |
| 4.1 | 80 | 10 | 0 | 30 | 35 | 25 | 6.5 | 100 | 30 | 70 | 30 | 15 | 45 |
| 4.1 | 80 | 20 | 0 | 30 | 35 | 25 | 6.5 | 100 | 30 | 80 | 30 | 15 | 45 |
| 4.1 | 80 | 30 | 0 | 30 | 35 | 25 | 6.5 | 100 | 30 | 90 | 30 | 15 | 45 |
| 4.1 | 80 | 40 | 0 | 30 | 35 | 25 | 6.5 | 100 | 40 | 50 | 30 | 15 | 45 |
| 4.1 | 80 | 50 | 0 | 30 | 35 | 25 | 6.5 | 100 | 40 | 60 | 30 | 15 | 45 |
| 4.1 | 80 | 60 | 0 | 30 | 35 | 25 | 6.5 | 100 | 40 | 70 | 30 | 15 | 45 |
| 4.1 | 80 | 70 | 0 | 30 | 35 | 25 | 6.5 | 100 | 40 | 80 | 30 | 15 | 45 |
| 4.1 | 90 | 10 | 0 | 30 | 35 | 25 | 6.5 | 100 | 40 | 90 | 30 | 15 | 45 |
| 4.1 | 90 | 20 | 0 | 30 | 35 | 25 | 6.5 | 100 | 50 | 60 | 30 | 15 | 45 |
| 4.1 | 90 | 30 | 0 | 30 | 35 | 25 | 6.5 | 100 | 50 | 70 | 30 | 15 | 45 |
| 4.1 | 90 | 40 | 0 | 30 | 35 | 25 | 6.5 | 100 | 50 | 80 | 30 | 15 | 45 |
| 4.1 | 90 | 50 | 0 | 30 | 35 | 25 | 6.5 | 100 | 50 | 90 | 30 | 15 | 45 |
| 4.1 | 90 | 60 | 0 | 30 | 35 | 25 | 6.5 | 100 | 60 | 70 | 30 | 15 | 45 |
| 4.1 | 90 | 70 | 0 | 30 | 35 | 25 | 6.5 | 100 | 60 | 80 | 30 | 15 | 45 |
| 4.1 | 90 | 80 | 0 | 30 | 35 | 25 | 6.5 | 100 | 60 | 90 | 30 | 15 | 45 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4.1 | 100 | 10 | 0 | 30 | 35 | 25 | 6.5 | 100 | 70 | 80 | 30 | 15 | 45 |
| 4.1 | 100 | 20 | 0 | 30 | 35 | 25 | 6.5 | 100 | 70 | 90 | 30 | 15 | 45 |
| 4.1 | 100 | 30 | 0 | 30 | 35 | 25 | 6.5 | 100 | 80 | 90 | 30 | 15 | 45 |
| 4.1 | 100 | 40 | 0 | 30 | 35 | 25 | 6.6 | 30 | 20 | 10 | 30 | 35 | 25 |
| 4.1 | 100 | 50 | 0 | 30 | 35 | 25 | 6.6 | 40 | 20 | 10 | 30 | 35 | 25 |
| 4.1 | 100 | 60 | 0 | 30 | 35 | 25 | 6.6 | 40 | 30 | 10 | 30 | 35 | 25 |
| 4.1 | 100 | 70 | 0 | 30 | 35 | 25 | 6.6 | 40 | 30 | 20 | 30 | 35 | 25 |
| 4.1 | 100 | 80 | 0 | 30 | 35 | 25 | 6.6 | 50 | 20 | 10 | 30 | 35 | 25 |
| 4.1 | 100 | 90 | 0 | 30 | 35 | 25 | 6.6 | 50 | 30 | 10 | 30 | 35 | 25 |
| 4.2 | 10 | 20 | 0 | 25 | 40 | 25 | 6.6 | 50 | 30 | 20 | 30 | 35 | 25 |
| 4.2 | 10 | 30 | 0 | 25 | 40 | 25 | 6.6 | 50 | 40 | 10 | 30 | 35 | 25 |
| 4.2 | 10 | 40 | 0 | 25 | 40 | 25 | 6.6 | 50 | 40 | 20 | 30 | 35 | 25 |
| 4.2 | 10 | 60 | 0 | 25 | 40 | 25 | 6.6 | 50 | 40 | 30 | 30 | 35 | 25 |
| 4.2 | 10 | 50 | 0 | 25 | 40 | 25 | 6.6 | 60 | 20 | 10 | 30 | 35 | 25 |
| 4.2 | 10 | 70 | 0 | 25 | 40 | 25 | 6.6 | 60 | 30 | 10 | 30 | 35 | 25 |
| 4.2 | 10 | 80 | 0 | 25 | 40 | 25 | 6.6 | 60 | 30 | 20 | 30 | 35 | 25 |
| 4.2 | 10 | 90 | 0 | 25 | 40 | 25 | 6.6 | 60 | 40 | 10 | 30 | 35 | 25 |
| 4.2 | 10 | 100 | 0 | 25 | 40 | 25 | 6.6 | 60 | 40 | 20 | 30 | 35 | 25 |
| 4.2 | 20 | 30 | 0 | 25 | 40 | 25 | 6.6 | 60 | 40 | 30 | 30 | 35 | 25 |
| 4.2 | 20 | 40 | 0 | 25 | 40 | 25 | 6.6 | 60 | 50 | 10 | 30 | 35 | 25 |
| 4.2 | 20 | 50 | 0 | 25 | 40 | 25 | 6.6 | 60 | 50 | 20 | 30 | 35 | 25 |
| 4.2 | 20 | 60 | 0 | 25 | 40 | 25 | 6.6 | 60 | 50 | 30 | 30 | 35 | 25 |
| 4.2 | 20 | 70 | 0 | 25 | 40 | 25 | 6.6 | 60 | 50 | 40 | 30 | 35 | 25 |
| 4.2 | 20 | 80 | 0 | 25 | 40 | 25 | 6.6 | 70 | 20 | 10 | 30 | 35 | 25 |
| 4.2 | 20 | 90 | 0 | 25 | 40 | 25 | 6.6 | 70 | 30 | 10 | 30 | 35 | 25 |
| 4.2 | 20 | 100 | 0 | 25 | 40 | 25 | 6.6 | 70 | 30 | 20 | 30 | 35 | 25 |
| 4.2 | 30 | 40 | 0 | 25 | 40 | 25 | 6.6 | 70 | 40 | 10 | 30 | 35 | 25 |
| 4.2 | 30 | 50 | 0 | 25 | 40 | 25 | 6.6 | 70 | 40 | 20 | 30 | 35 | 25 |
| 4.2 | 30 | 60 | 0 | 25 | 40 | 25 | 6.6 | 70 | 40 | 30 | 30 | 35 | 25 |
| 4.2 | 30 | 70 | 0 | 25 | 40 | 25 | 6.6 | 70 | 50 | 10 | 30 | 35 | 25 |
| 4.2 | 30 | 80 | 0 | 25 | 40 | 25 | 6.6 | 70 | 50 | 20 | 30 | 35 | 25 |
| 4.2 | 30 | 90 | 0 | 25 | 40 | 25 | 6.6 | 70 | 50 | 30 | 30 | 35 | 25 |
| 4.2 | 30 | 100 | 0 | 25 | 40 | 25 | 6.6 | 70 | 50 | 40 | 30 | 35 | 25 |
| 4.2 | 40 | 50 | 0 | 25 | 40 | 25 | 6.6 | 70 | 60 | 10 | 30 | 35 | 25 |
| 4.2 | 40 | 60 | 0 | 25 | 40 | 25 | 6.6 | 70 | 60 | 20 | 30 | 35 | 25 |
| 4.2 | 40 | 70 | 0 | 25 | 40 | 25 | 6.6 | 70 | 60 | 30 | 30 | 35 | 25 |
| 4.2 | 40 | 80 | 0 | 25 | 40 | 25 | 6.6 | 70 | 60 | 40 | 30 | 35 | 25 |
| 4.2 | 40 | 90 | 0 | 25 | 40 | 25 | 6.6 | 70 | 60 | 50 | 30 | 35 | 25 |
| 4.2 | 40 | 100 | 0 | 25 | 40 | 25 | 6.6 | 80 | 70 | 10 | 30 | 35 | 25 |
| 4.2 | 50 | 60 | 0 | 25 | 40 | 25 | 6.6 | 80 | 70 | 20 | 30 | 35 | 25 |
| 4.2 | 50 | 70 | 0 | 25 | 40 | 25 | 6.6 | 80 | 70 | 30 | 30 | 35 | 25 |
| 4.2 | 50 | 80 | 0 | 25 | 40 | 25 | 6.6 | 80 | 70 | 40 | 30 | 35 | 25 |
| 4.2 | 50 | 90 | 0 | 25 | 40 | 25 | 6.6 | 80 | 70 | 50 | 30 | 35 | 25 |
| 4.2 | 50 | 100 | 0 | 25 | 40 | 25 | 6.6 | 80 | 70 | 60 | 30 | 35 | 25 |
| 4.2 | 60 | 70 | 0 | 25 | 40 | 25 | 6.6 | 80 | 20 | 10 | 30 | 35 | 25 |
| 4.2 | 60 | 80 | 0 | 25 | 40 | 25 | 6.6 | 80 | 30 | 10 | 30 | 35 | 25 |
| 4.2 | 60 | 90 | 0 | 25 | 40 | 25 | 6.6 | 80 | 30 | 20 | 30 | 35 | 25 |
| 4.2 | 60 | 100 | 0 | 25 | 40 | 25 | 6.6 | 80 | 40 | 10 | 30 | 35 | 25 |
| 4.2 | 70 | 80 | 0 | 25 | 40 | 25 | 6.6 | 80 | 40 | 20 | 30 | 35 | 25 |

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| 4.2 | 70 | 90 | 0 | 25 | 40 | 25 |
| 4.2 | 70 | 100 | 0 | 25 | 40 | 25 |
| 4.2 | 80 | 90 | 0 | 25 | 40 | 25 |
| 4.2 | 80 | 100 | 0 | 25 | 40 | 25 |
| 4.2 | 90 | 100 | 0 | 25 | 40 | 25 |
| 4.3 | 10 | 10 | 0 | 26 | 39 | 25 |
| 4.3 | 20 | 20 | 0 | 26 | 39 | 25 |
| 4.3 | 30 | 30 | 0 | 26 | 39 | 25 |
| 4.3 | 40 | 40 | 0 | 26 | 39 | 25 |
| 4.3 | 50 | 50 | 0 | 26 | 39 | 25 |
| 4.3 | 60 | 60 | 0 | 26 | 39 | 25 |
| 4.3 | 70 | 70 | 0 | 26 | 39 | 25 |
| 4.3 | 80 | 80 | 0 | 26 | 39 | 25 |
| 4.3 | 90 | 90 | 0 | 26 | 39 | 25 |
| 4.3 | 100 | 100 | 0 | 26 | 39 | 25 |
| 5.1 | 0 | 0 | 10 | 27 | 18 | 45 |
| 5.1 | 0 | 0 | 20 | 27 | 18 | 45 |
| 5.1 | 0 | 0 | 30 | 27 | 18 | 45 |
| 5.1 | 0 | 0 | 40 | 27 | 18 | 45 |
| 5.1 | 0 | 0 | 50 | 27 | 18 | 45 |
| 5.1 | 0 | 0 | 60 | 27 | 18 | 45 |
| 5.1 | 0 | 0 | 70 | 27 | 18 | 45 |
| 5.1 | 0 | 0 | 80 | 27 | 18 | 45 |
| 5.1 | 0 | 0 | 90 | 27 | 18 | 45 |
| 5.1 | 0 | 0 | 100 | 27 | 18 | 45 |
| 5.2 | 0 | 10 | 0 | 21 | 40 | 29 |
| 5.2 | 0 | 20 | 0 | 21 | 40 | 29 |
| 5.2 | 0 | 30 | 0 | 21 | 40 | 29 |
| 5.2 | 0 | 40 | 0 | 21 | 40 | 29 |
| 5.2 | 0 | 50 | 0 | 21 | 40 | 29 |
| 5.2 | 0 | 60 | 0 | 21 | 40 | 29 |
| 5.2 | 0 | 70 | 0 | 21 | 40 | 29 |
| 5.2 | 0 | 80 | 0 | 21 | 40 | 29 |
| 5.2 | 0 | 90 | 0 | 21 | 40 | 29 |
| 5.2 | 0 | 100 | 0 | 22 | 40 | 28 |
| 5.3 | 10 | 0 | 0 | 30 | 31 | 29 |
| 5.3 | 20 | 0 | 0 | 30 | 31 | 29 |
| 5.3 | 30 | 0 | 0 | 30 | 31 | 29 |
| 5.3 | 40 | 0 | 0 | 30 | 31 | 29 |
| 5.3 | 50 | 0 | 0 | 30 | 31 | 29 |
| 5.3 | 60 | 0 | 0 | 30 | 31 | 29 |
| 5.3 | 70 | 0 | 0 | 30 | 31 | 29 |
| 5.3 | 80 | 0 | 0 | 30 | 31 | 29 |
| 5.3 | 90 | 0 | 0 | 30 | 31 | 29 |
| 5.3 | 100 | 0 | 0 | 30 | 32 | 28 |
| 6.1 | 10 | 20 | 30 | 10 | 35 | 45 |
| 6.1 | 10 | 20 | 40 | 10 | 35 | 45 |
| 6.1 | 10 | 20 | 50 | 10 | 35 | 45 |

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|---|---|---|---|---|---|---|
| 6.6 | 80 | 40 | 30 | 30 | 35 | 25 |
| 6.6 | 80 | 50 | 10 | 30 | 35 | 25 |
| 6.6 | 80 | 50 | 20 | 30 | 35 | 25 |
| 6.6 | 80 | 50 | 30 | 30 | 35 | 25 |
| 6.6 | 80 | 50 | 40 | 30 | 35 | 25 |
| 6.6 | 80 | 60 | 10 | 30 | 35 | 25 |
| 6.6 | 80 | 60 | 20 | 30 | 35 | 25 |
| 6.6 | 80 | 60 | 30 | 30 | 35 | 25 |
| 6.6 | 80 | 60 | 40 | 30 | 35 | 25 |
| 6.6 | 80 | 60 | 50 | 30 | 35 | 25 |
| 6.6 | 90 | 20 | 10 | 30 | 35 | 25 |
| 6.6 | 90 | 30 | 10 | 30 | 35 | 25 |
| 6.6 | 90 | 30 | 20 | 30 | 35 | 25 |
| 6.6 | 90 | 40 | 10 | 30 | 35 | 25 |
| 6.6 | 90 | 40 | 20 | 30 | 35 | 25 |
| 6.6 | 90 | 40 | 30 | 30 | 35 | 25 |
| 6.6 | 90 | 50 | 10 | 30 | 35 | 25 |
| 6.6 | 90 | 50 | 20 | 30 | 35 | 25 |
| 6.6 | 90 | 50 | 30 | 30 | 35 | 25 |
| 6.6 | 90 | 50 | 40 | 30 | 35 | 25 |
| 6.6 | 90 | 60 | 10 | 30 | 35 | 25 |
| 6.6 | 90 | 60 | 20 | 30 | 35 | 25 |
| 6.6 | 90 | 60 | 30 | 30 | 35 | 25 |
| 6.6 | 90 | 60 | 40 | 30 | 35 | 25 |
| 6.6 | 90 | 60 | 50 | 30 | 35 | 25 |
| 6.6 | 90 | 70 | 10 | 30 | 35 | 25 |
| 6.6 | 90 | 70 | 20 | 30 | 35 | 25 |
| 6.6 | 90 | 70 | 30 | 30 | 35 | 25 |
| 6.6 | 90 | 70 | 40 | 30 | 35 | 25 |
| 6.6 | 90 | 70 | 50 | 30 | 35 | 25 |
| 6.6 | 90 | 70 | 60 | 30 | 35 | 25 |
| 6.6 | 90 | 80 | 10 | 30 | 35 | 25 |
| 6.6 | 90 | 80 | 20 | 30 | 35 | 25 |
| 6.6 | 90 | 80 | 30 | 30 | 35 | 25 |
| 6.6 | 90 | 80 | 40 | 30 | 35 | 25 |
| 6.6 | 90 | 80 | 50 | 30 | 35 | 25 |
| 6.6 | 90 | 80 | 60 | 30 | 35 | 25 |
| 6.6 | 90 | 80 | 70 | 30 | 35 | 25 |
| 6.6 | 100 | 20 | 10 | 30 | 35 | 25 |
| 6.6 | 100 | 30 | 10 | 30 | 35 | 25 |
| 6.6 | 100 | 30 | 20 | 30 | 35 | 25 |
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| 6.6 | 100 | 40 | 30 | 30 | 35 | 25 |
| 6.6 | 100 | 50 | 10 | 30 | 35 | 25 |
| 6.6 | 100 | 50 | 20 | 30 | 35 | 25 |
| 6.6 | 100 | 50 | 30 | 30 | 35 | 25 |
| 6.6 | 100 | 50 | 40 | 30 | 35 | 25 |

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| 6.1 | 10 | 20 | 60 | 10 | 35 | 45 |
| 6.1 | 10 | 20 | 70 | 10 | 35 | 45 |
| 6.1 | 10 | 20 | 80 | 10 | 35 | 45 |
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| 6.1 | 10 | 20 | 100 | 10 | 35 | 45 |
| 6.1 | 10 | 30 | 40 | 10 | 35 | 45 |
| 6.1 | 10 | 30 | 50 | 10 | 35 | 45 |
| 6.1 | 10 | 30 | 60 | 10 | 35 | 45 |
| 6.1 | 10 | 30 | 70 | 10 | 35 | 45 |
| 6.1 | 10 | 30 | 80 | 10 | 35 | 45 |
| 6.1 | 10 | 30 | 90 | 10 | 35 | 45 |
| 6.1 | 10 | 30 | 100 | 10 | 35 | 45 |
| 6.1 | 10 | 40 | 50 | 10 | 35 | 45 |
| 6.1 | 10 | 40 | 60 | 10 | 35 | 45 |
| 6.1 | 10 | 40 | 70 | 10 | 35 | 45 |
| 6.1 | 10 | 40 | 80 | 10 | 35 | 45 |
| 6.1 | 10 | 40 | 90 | 10 | 35 | 45 |
| 6.1 | 10 | 40 | 100 | 10 | 35 | 45 |
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| 6.1 | 10 | 50 | 80 | 10 | 35 | 45 |
| 6.1 | 10 | 50 | 90 | 10 | 35 | 45 |
| 6.1 | 10 | 50 | 100 | 10 | 35 | 45 |
| 6.1 | 10 | 60 | 70 | 10 | 35 | 45 |
| 6.1 | 10 | 60 | 80 | 10 | 35 | 45 |
| 6.1 | 10 | 60 | 90 | 10 | 35 | 45 |
| 6.1 | 10 | 60 | 100 | 10 | 35 | 45 |
| 6.1 | 10 | 70 | 80 | 10 | 35 | 45 |
| 6.1 | 10 | 70 | 90 | 10 | 35 | 45 |
| 6.1 | 10 | 70 | 100 | 10 | 35 | 45 |
| 6.1 | 10 | 80 | 90 | 10 | 35 | 45 |
| 6.1 | 10 | 80 | 100 | 10 | 35 | 45 |
| 6.1 | 10 | 90 | 100 | 10 | 35 | 45 |
| 6.1 | 20 | 30 | 40 | 10 | 35 | 45 |
| 6.1 | 20 | 30 | 50 | 10 | 35 | 45 |
| 6.1 | 20 | 30 | 60 | 10 | 35 | 45 |
| 6.1 | 20 | 30 | 70 | 10 | 35 | 45 |
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| 6.1 | 20 | 30 | 90 | 10 | 35 | 45 |
| 6.1 | 20 | 30 | 100 | 10 | 35 | 45 |
| 6.1 | 20 | 40 | 50 | 10 | 35 | 45 |
| 6.1 | 20 | 40 | 60 | 10 | 35 | 45 |
| 6.1 | 20 | 40 | 70 | 10 | 35 | 45 |
| 6.1 | 20 | 40 | 80 | 10 | 35 | 45 |
| 6.1 | 20 | 40 | 90 | 10 | 35 | 45 |
| 6.1 | 20 | 40 | 100 | 10 | 35 | 45 |
| 6.1 | 20 | 50 | 60 | 10 | 35 | 45 |
| 6.1 | 20 | 50 | 70 | 10 | 35 | 45 |
| 6.1 | 20 | 50 | 80 | 10 | 35 | 45 |

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| 6.6 | 100 | 60 | 10 | 30 | 35 | 25 |
| 6.6 | 100 | 60 | 20 | 30 | 35 | 25 |
| 6.6 | 100 | 60 | 30 | 30 | 35 | 25 |
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| 6.6 | 100 | 60 | 50 | 30 | 35 | 25 |
| 6.6 | 100 | 70 | 10 | 30 | 35 | 25 |
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| 6.6 | 100 | 70 | 30 | 30 | 35 | 25 |
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| 6.6 | 100 | 70 | 50 | 30 | 35 | 25 |
| 6.6 | 100 | 70 | 60 | 30 | 35 | 25 |
| 6.6 | 100 | 80 | 10 | 30 | 35 | 25 |
| 6.6 | 100 | 80 | 20 | 30 | 35 | 25 |
| 6.6 | 100 | 80 | 30 | 30 | 35 | 25 |
| 6.6 | 100 | 80 | 40 | 30 | 35 | 25 |
| 6.6 | 100 | 80 | 50 | 30 | 35 | 25 |
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| 6.6 | 100 | 80 | 70 | 30 | 35 | 25 |
| 6.6 | 100 | 90 | 10 | 30 | 35 | 25 |
| 6.6 | 100 | 90 | 20 | 30 | 35 | 25 |
| 6.6 | 100 | 90 | 30 | 30 | 35 | 25 |
| 6.6 | 100 | 90 | 40 | 30 | 35 | 25 |
| 6.6 | 100 | 90 | 50 | 30 | 35 | 25 |
| 6.6 | 100 | 90 | 60 | 30 | 35 | 25 |
| 6.6 | 100 | 90 | 70 | 30 | 35 | 25 |
| 6.6 | 100 | 90 | 80 | 30 | 35 | 25 |
| 7.1 | 10 | 20 | 20 | 10 | 35 | 45 |
| 7.1 | 10 | 30 | 30 | 10 | 35 | 45 |
| 7.1 | 10 | 40 | 40 | 10 | 35 | 45 |
| 7.1 | 10 | 50 | 50 | 10 | 35 | 45 |
| 7.1 | 10 | 60 | 60 | 10 | 35 | 45 |
| 7.1 | 10 | 70 | 70 | 10 | 35 | 45 |
| 7.1 | 10 | 80 | 80 | 10 | 35 | 45 |
| 7.1 | 10 | 90 | 90 | 10 | 35 | 45 |
| 7.1 | 10 | 100 | 100 | 10 | 35 | 45 |
| 7.1 | 20 | 30 | 30 | 10 | 35 | 45 |
| 7.1 | 20 | 40 | 40 | 10 | 35 | 45 |
| 7.1 | 20 | 50 | 50 | 10 | 35 | 45 |
| 7.1 | 20 | 60 | 60 | 10 | 35 | 45 |
| 7.1 | 20 | 70 | 70 | 10 | 35 | 45 |
| 7.1 | 20 | 80 | 80 | 10 | 35 | 45 |
| 7.1 | 20 | 90 | 90 | 10 | 35 | 45 |
| 7.1 | 20 | 100 | 100 | 10 | 35 | 45 |
| 7.1 | 30 | 40 | 40 | 10 | 35 | 45 |
| 7.1 | 30 | 50 | 50 | 10 | 35 | 45 |
| 7.1 | 30 | 60 | 60 | 10 | 35 | 45 |
| 7.1 | 30 | 70 | 70 | 10 | 35 | 45 |
| 7.1 | 30 | 80 | 80 | 10 | 35 | 45 |
| 7.1 | 30 | 90 | 90 | 10 | 35 | 45 |

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| 6.1 | 20 | 50 | 90 | 10 | 35 | 45 | 7.1 | 30 | 100 | 100 | 10 | 35 | 45 |
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| 6.1 | 20 | 60 | 70 | 10 | 35 | 45 | 7.1 | 40 | 60 | 60 | 10 | 35 | 45 |
| 6.1 | 20 | 60 | 80 | 10 | 35 | 45 | 7.1 | 40 | 70 | 70 | 10 | 35 | 45 |
| 6.1 | 20 | 60 | 90 | 10 | 35 | 45 | 7.1 | 40 | 80 | 80 | 10 | 35 | 45 |
| 6.1 | 20 | 60 | 100 | 10 | 35 | 45 | 7.1 | 40 | 90 | 90 | 10 | 35 | 45 |
| 6.1 | 20 | 70 | 80 | 10 | 35 | 45 | 7.1 | 40 | 100 | 100 | 10 | 35 | 45 |
| 6.1 | 20 | 70 | 90 | 10 | 35 | 45 | 7.1 | 50 | 60 | 60 | 10 | 35 | 45 |
| 6.1 | 20 | 70 | 100 | 10 | 35 | 45 | 7.1 | 50 | 70 | 70 | 10 | 35 | 45 |
| 6.1 | 20 | 80 | 90 | 10 | 35 | 45 | 7.1 | 50 | 80 | 80 | 10 | 35 | 45 |
| 6.1 | 20 | 80 | 100 | 10 | 35 | 45 | 7.1 | 50 | 90 | 90 | 10 | 35 | 45 |
| 6.1 | 20 | 90 | 100 | 10 | 35 | 45 | 7.1 | 50 | 100 | 100 | 10 | 35 | 45 |
| 6.1 | 30 | 40 | 50 | 10 | 35 | 45 | 7.1 | 60 | 70 | 70 | 10 | 35 | 45 |
| 6.1 | 30 | 40 | 60 | 10 | 35 | 45 | 7.1 | 60 | 80 | 80 | 10 | 35 | 45 |
| 6.1 | 30 | 40 | 70 | 10 | 35 | 45 | 7.1 | 60 | 90 | 90 | 10 | 35 | 45 |
| 6.1 | 30 | 40 | 80 | 10 | 35 | 45 | 7.1 | 60 | 100 | 100 | 10 | 35 | 45 |
| 6.1 | 30 | 40 | 90 | 10 | 35 | 45 | 7.1 | 70 | 80 | 80 | 10 | 35 | 45 |
| 6.1 | 30 | 40 | 100 | 10 | 35 | 45 | 7.1 | 70 | 90 | 90 | 10 | 35 | 45 |
| 6.1 | 30 | 50 | 60 | 10 | 35 | 45 | 7.1 | 70 | 100 | 100 | 10 | 35 | 45 |
| 6.1 | 30 | 50 | 70 | 10 | 35 | 45 | 7.1 | 80 | 90 | 90 | 10 | 35 | 45 |
| 6.1 | 30 | 50 | 80 | 10 | 35 | 45 | 7.1 | 80 | 100 | 100 | 10 | 35 | 45 |
| 6.1 | 30 | 50 | 90 | 10 | 35 | 45 | 7.1 | 90 | 100 | 100 | 10 | 35 | 45 |
| 6.1 | 30 | 50 | 100 | 10 | 35 | 45 | 7.2 | 20 | 10 | 20 | 30 | 15 | 45 |
| 6.1 | 30 | 60 | 70 | 10 | 35 | 45 | 7.2 | 30 | 10 | 30 | 30 | 15 | 45 |
| 6.1 | 30 | 60 | 80 | 10 | 35 | 45 | 7.2 | 40 | 10 | 40 | 30 | 15 | 45 |
| 6.1 | 30 | 60 | 90 | 10 | 35 | 45 | 7.2 | 50 | 10 | 50 | 30 | 15 | 45 |
| 6.1 | 30 | 60 | 100 | 10 | 35 | 45 | 7.2 | 60 | 10 | 60 | 30 | 15 | 45 |
| 6.1 | 30 | 70 | 80 | 10 | 35 | 45 | 7.2 | 70 | 10 | 70 | 30 | 15 | 45 |
| 6.1 | 30 | 70 | 90 | 10 | 35 | 45 | 7.2 | 80 | 10 | 80 | 30 | 15 | 45 |
| 6.1 | 30 | 70 | 100 | 10 | 35 | 45 | 7.2 | 90 | 10 | 90 | 30 | 15 | 45 |
| 6.1 | 30 | 80 | 90 | 10 | 35 | 45 | 7.2 | 100 | 10 | 100 | 30 | 15 | 45 |
| 6.1 | 30 | 80 | 100 | 10 | 35 | 45 | 7.2 | 30 | 20 | 30 | 30 | 15 | 45 |
| 6.1 | 30 | 90 | 100 | 10 | 35 | 45 | 7.2 | 40 | 20 | 40 | 30 | 15 | 45 |
| 6.1 | 40 | 50 | 60 | 10 | 35 | 45 | 7.2 | 50 | 20 | 50 | 30 | 15 | 45 |
| 6.1 | 40 | 50 | 70 | 10 | 35 | 45 | 7.2 | 60 | 20 | 60 | 30 | 15 | 45 |
| 6.1 | 40 | 50 | 80 | 10 | 35 | 45 | 7.2 | 70 | 20 | 70 | 30 | 15 | 45 |
| 6.1 | 40 | 50 | 90 | 10 | 35 | 45 | 7.2 | 80 | 20 | 80 | 30 | 15 | 45 |
| 6.1 | 40 | 50 | 100 | 10 | 35 | 45 | 7.2 | 90 | 20 | 90 | 30 | 15 | 45 |
| 6.1 | 40 | 60 | 70 | 10 | 35 | 45 | 7.2 | 100 | 20 | 100 | 30 | 15 | 45 |
| 6.1 | 40 | 60 | 80 | 10 | 35 | 45 | 7.2 | 40 | 30 | 40 | 30 | 15 | 45 |
| 6.1 | 40 | 60 | 90 | 10 | 35 | 45 | 7.2 | 50 | 30 | 50 | 30 | 15 | 45 |
| 6.1 | 40 | 60 | 100 | 10 | 35 | 45 | 7.2 | 60 | 30 | 60 | 30 | 15 | 45 |
| 6.1 | 40 | 70 | 80 | 10 | 35 | 45 | 7.2 | 70 | 30 | 70 | 30 | 15 | 45 |
| 6.1 | 40 | 70 | 90 | 10 | 35 | 45 | 7.2 | 80 | 30 | 80 | 30 | 15 | 45 |
| 6.1 | 40 | 70 | 100 | 10 | 35 | 45 | 7.2 | 90 | 30 | 90 | 30 | 15 | 45 |
| 6.1 | 40 | 80 | 90 | 10 | 35 | 45 | 7.2 | 100 | 30 | 100 | 30 | 15 | 45 |
| 6.1 | 40 | 80 | 100 | 10 | 35 | 45 | 7.2 | 50 | 40 | 50 | 30 | 15 | 45 |
| 6.1 | 40 | 90 | 100 | 10 | 35 | 45 | 7.2 | 60 | 40 | 60 | 30 | 15 | 45 |
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| 6.1 | 50 | 60 | 80 | 10 | 35 | 45 |
| 6.1 | 50 | 60 | 90 | 10 | 35 | 45 |
| 6.1 | 50 | 60 | 100 | 10 | 35 | 45 |
| 6.1 | 50 | 70 | 80 | 10 | 35 | 45 |
| 6.1 | 50 | 70 | 90 | 10 | 35 | 45 |
| 6.1 | 50 | 70 | 100 | 10 | 35 | 45 |
| 6.1 | 50 | 80 | 90 | 10 | 35 | 45 |
| 6.1 | 50 | 80 | 100 | 10 | 35 | 45 |
| 6.1 | 50 | 90 | 100 | 10 | 35 | 45 |
| 6.1 | 60 | 70 | 80 | 10 | 35 | 45 |
| 6.1 | 60 | 70 | 90 | 10 | 35 | 45 |
| 6.1 | 60 | 70 | 100 | 10 | 35 | 45 |
| 6.1 | 60 | 80 | 90 | 10 | 35 | 45 |
| 6.1 | 60 | 80 | 100 | 10 | 35 | 45 |
| 6.1 | 60 | 90 | 100 | 10 | 35 | 45 |
| 6.1 | 70 | 80 | 90 | 10 | 35 | 45 |
| 6.1 | 70 | 80 | 100 | 10 | 35 | 45 |
| 6.1 | 70 | 90 | 100 | 10 | 35 | 45 |
| 6.1 | 80 | 90 | 100 | 10 | 35 | 45 |
| 6.2 | 10 | 30 | 20 | 10 | 40 | 40 |
| 6.2 | 10 | 40 | 20 | 10 | 40 | 40 |
| 6.2 | 10 | 40 | 30 | 10 | 40 | 40 |
| 6.2 | 10 | 50 | 20 | 10 | 40 | 40 |
| 6.2 | 10 | 50 | 30 | 10 | 40 | 40 |
| 6.2 | 10 | 50 | 40 | 10 | 40 | 40 |
| 6.2 | 10 | 60 | 20 | 10 | 40 | 40 |
| 6.2 | 10 | 60 | 30 | 10 | 40 | 40 |
| 6.2 | 10 | 60 | 40 | 10 | 40 | 40 |
| 6.2 | 10 | 60 | 50 | 10 | 40 | 40 |
| 6.2 | 10 | 70 | 20 | 10 | 40 | 40 |
| 6.2 | 10 | 70 | 30 | 10 | 40 | 40 |
| 6.2 | 10 | 70 | 40 | 10 | 40 | 40 |
| 6.2 | 10 | 70 | 50 | 10 | 40 | 40 |
| 6.2 | 10 | 70 | 60 | 10 | 40 | 40 |
| 6.2 | 10 | 80 | 20 | 10 | 40 | 40 |
| 6.2 | 10 | 80 | 30 | 10 | 40 | 40 |
| 6.2 | 10 | 80 | 40 | 10 | 40 | 40 |
| 6.2 | 10 | 80 | 50 | 10 | 40 | 40 |
| 6.2 | 10 | 80 | 60 | 10 | 40 | 40 |
| 6.2 | 10 | 80 | 70 | 10 | 40 | 40 |
| 6.2 | 10 | 90 | 20 | 10 | 40 | 40 |
| 6.2 | 10 | 90 | 30 | 10 | 40 | 40 |
| 6.2 | 10 | 90 | 40 | 10 | 40 | 40 |
| 6.2 | 10 | 90 | 50 | 10 | 40 | 40 |
| 6.2 | 10 | 90 | 60 | 10 | 40 | 40 |
| 6.2 | 10 | 90 | 70 | 10 | 40 | 40 |
| 6.2 | 10 | 90 | 80 | 10 | 40 | 40 |
| 6.2 | 10 | 100 | 20 | 10 | 40 | 40 |
| 6.2 | 10 | 100 | 30 | 10 | 40 | 40 |

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| 7.2 | 80 | 40 | 80 | 30 | 15 | 45 |
| 7.2 | 90 | 40 | 90 | 30 | 15 | 45 |
| 7.2 | 100 | 40 | 100 | 30 | 15 | 45 |
| 7.2 | 60 | 50 | 60 | 30 | 15 | 45 |
| 7.2 | 70 | 50 | 70 | 30 | 15 | 45 |
| 7.2 | 80 | 50 | 80 | 30 | 15 | 45 |
| 7.2 | 90 | 50 | 90 | 30 | 15 | 45 |
| 7.2 | 100 | 50 | 100 | 30 | 15 | 45 |
| 7.2 | 70 | 60 | 70 | 30 | 15 | 45 |
| 7.2 | 80 | 60 | 80 | 30 | 15 | 45 |
| 7.2 | 90 | 60 | 90 | 30 | 15 | 45 |
| 7.2 | 100 | 60 | 100 | 30 | 15 | 45 |
| 7.2 | 80 | 70 | 80 | 30 | 15 | 45 |
| 7.2 | 90 | 70 | 90 | 30 | 15 | 45 |
| 7.2 | 100 | 70 | 100 | 30 | 15 | 45 |
| 7.2 | 90 | 80 | 90 | 30 | 15 | 45 |
| 7.2 | 100 | 80 | 100 | 30 | 15 | 45 |
| 7.2 | 100 | 90 | 100 | 30 | 15 | 45 |
| 7.3 | 20 | 20 | 10 | 25 | 40 | 25 |
| 7.3 | 30 | 30 | 10 | 25 | 40 | 25 |
| 7.3 | 40 | 40 | 10 | 25 | 40 | 25 |
| 7.3 | 50 | 50 | 10 | 25 | 40 | 25 |
| 7.3 | 60 | 60 | 10 | 25 | 40 | 25 |
| 7.3 | 70 | 70 | 10 | 25 | 40 | 25 |
| 7.3 | 80 | 80 | 10 | 25 | 40 | 25 |
| 7.3 | 90 | 90 | 10 | 25 | 40 | 25 |
| 7.3 | 100 | 100 | 10 | 25 | 40 | 25 |
| 7.3 | 30 | 30 | 20 | 25 | 40 | 25 |
| 7.3 | 40 | 40 | 20 | 25 | 40 | 25 |
| 7.3 | 50 | 50 | 20 | 25 | 40 | 25 |
| 7.3 | 60 | 60 | 20 | 25 | 40 | 25 |
| 7.3 | 70 | 70 | 20 | 25 | 40 | 25 |
| 7.3 | 80 | 80 | 20 | 25 | 40 | 25 |
| 7.3 | 90 | 90 | 20 | 25 | 40 | 25 |
| 7.3 | 100 | 100 | 20 | 25 | 40 | 25 |
| 7.3 | 40 | 40 | 30 | 25 | 40 | 25 |
| 7.3 | 50 | 50 | 30 | 25 | 40 | 25 |
| 7.3 | 60 | 60 | 30 | 25 | 40 | 25 |
| 7.3 | 70 | 70 | 30 | 25 | 40 | 25 |
| 7.3 | 80 | 80 | 30 | 25 | 40 | 25 |
| 7.3 | 90 | 90 | 30 | 25 | 40 | 25 |
| 7.3 | 100 | 100 | 30 | 25 | 40 | 25 |
| 7.3 | 50 | 50 | 40 | 25 | 40 | 25 |
| 7.3 | 60 | 60 | 40 | 25 | 40 | 25 |
| 7.3 | 70 | 70 | 40 | 25 | 40 | 25 |
| 7.3 | 80 | 80 | 40 | 25 | 40 | 25 |
| 7.3 | 90 | 90 | 40 | 25 | 40 | 25 |
| 7.3 | 100 | 100 | 40 | 25 | 40 | 25 |
| 7.3 | 60 | 60 | 50 | 25 | 40 | 25 |

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| 6.2 | 10 | 100 | 40 | 10 | 40 | 40 | 7.3 | 70 | 70 | 50 | 25 | 40 | 25 |
| 6.2 | 10 | 100 | 50 | 10 | 40 | 40 | 7.3 | 80 | 80 | 50 | 25 | 40 | 25 |
| 6.2 | 10 | 100 | 60 | 10 | 40 | 40 | 7.3 | 90 | 90 | 50 | 25 | 40 | 25 |
| 6.2 | 10 | 100 | 70 | 10 | 40 | 40 | 7.3 | 100 | 100 | 50 | 25 | 40 | 25 |
| 6.2 | 10 | 100 | 80 | 10 | 40 | 40 | 7.3 | 70 | 70 | 60 | 25 | 40 | 25 |
| 6.2 | 10 | 100 | 90 | 10 | 40 | 40 | 7.3 | 80 | 80 | 60 | 25 | 40 | 25 |
| 6.2 | 20 | 40 | 30 | 10 | 40 | 40 | 7.3 | 90 | 90 | 60 | 25 | 40 | 25 |
| 6.2 | 20 | 50 | 30 | 10 | 40 | 40 | 7.3 | 100 | 100 | 60 | 25 | 40 | 25 |
| 6.2 | 20 | 60 | 30 | 10 | 40 | 40 | 7.3 | 80 | 80 | 70 | 25 | 40 | 25 |
| 6.2 | 20 | 70 | 30 | 10 | 40 | 40 | 7.3 | 90 | 90 | 70 | 25 | 40 | 25 |
| 6.2 | 20 | 80 | 30 | 10 | 40 | 40 | 7.3 | 100 | 100 | 70 | 25 | 40 | 25 |
| 6.2 | 20 | 90 | 30 | 10 | 40 | 40 | 7.3 | 90 | 90 | 80 | 25 | 40 | 25 |
| 6.2 | 20 | 100 | 30 | 10 | 40 | 40 | 7.3 | 100 | 100 | 80 | 25 | 40 | 25 |
| 6.2 | 20 | 50 | 40 | 10 | 40 | 40 | 7.3 | 100 | 100 | 90 | 25 | 40 | 25 |
| 6.2 | 20 | 60 | 40 | 10 | 40 | 40 | 8 | 10 | 10 | 10 | 12 | 33 | 45 |
| 6.2 | 20 | 70 | 40 | 10 | 40 | 40 | 8 | 20 | 20 | 20 | 12 | 33 | 45 |
| 6.2 | 20 | 80 | 40 | 10 | 40 | 40 | 8 | 30 | 30 | 30 | 12 | 33 | 45 |
| 6.2 | 20 | 90 | 40 | 10 | 40 | 40 | 8 | 40 | 40 | 40 | 12 | 33 | 45 |
| 6.2 | 20 | 100 | 40 | 10 | 40 | 40 | 8 | 50 | 50 | 50 | 12 | 33 | 45 |
| 6.2 | 20 | 60 | 50 | 10 | 40 | 40 | 8 | 60 | 60 | 60 | 12 | 33 | 45 |
| 6.2 | 20 | 70 | 50 | 10 | 40 | 40 | 8 | 70 | 70 | 70 | 12 | 33 | 45 |
| 6.2 | 20 | 80 | 50 | 10 | 40 | 40 | 8 | 80 | 80 | 80 | 12 | 33 | 45 |
| 6.2 | 20 | 90 | 50 | 10 | 40 | 40 | 8 | 90 | 90 | 90 | 12 | 33 | 45 |
| 6.2 | 20 | 100 | 50 | 10 | 40 | 40 | 8 | 100 | 100 | 100 | 12 | 33 | 45 |
| 6.2 | 20 | 70 | 60 | 10 | 40 | 40 | 9.1 | 20 | 10 | 10 | 30 | 17 | 43 |
| 6.2 | 20 | 80 | 60 | 10 | 40 | 40 | 9.1 | 30 | 10 | 10 | 30 | 17 | 43 |
| 6.2 | 20 | 90 | 60 | 10 | 40 | 40 | 9.1 | 30 | 20 | 20 | 30 | 17 | 43 |
| 6.2 | 20 | 100 | 60 | 10 | 40 | 40 | 9.1 | 40 | 10 | 10 | 30 | 17 | 43 |
| 6.2 | 20 | 80 | 70 | 10 | 40 | 40 | 9.1 | 40 | 20 | 20 | 30 | 17 | 43 |
| 6.2 | 20 | 90 | 70 | 10 | 40 | 40 | 9.1 | 40 | 30 | 30 | 30 | 17 | 43 |
| 6.2 | 20 | 100 | 70 | 10 | 40 | 40 | 9.1 | 50 | 10 | 10 | 30 | 17 | 43 |
| 6.2 | 20 | 90 | 80 | 10 | 40 | 40 | 9.1 | 50 | 20 | 20 | 30 | 17 | 43 |
| 6.2 | 20 | 100 | 80 | 10 | 40 | 40 | 9.1 | 50 | 30 | 30 | 30 | 17 | 43 |
| 6.2 | 20 | 100 | 90 | 10 | 40 | 40 | 9.1 | 50 | 40 | 40 | 30 | 17 | 43 |
| 6.2 | 30 | 50 | 40 | 10 | 40 | 40 | 9.1 | 60 | 10 | 10 | 30 | 17 | 43 |
| 6.2 | 30 | 60 | 40 | 10 | 40 | 40 | 9.1 | 60 | 20 | 20 | 30 | 17 | 43 |
| 6.2 | 30 | 70 | 40 | 10 | 40 | 40 | 9.1 | 60 | 30 | 30 | 30 | 17 | 43 |
| 6.2 | 30 | 80 | 40 | 10 | 40 | 40 | 9.1 | 60 | 40 | 40 | 30 | 17 | 43 |
| 6.2 | 30 | 90 | 40 | 10 | 40 | 40 | 9.1 | 60 | 50 | 50 | 30 | 17 | 43 |
| 6.2 | 30 | 100 | 40 | 10 | 40 | 40 | 9.1 | 70 | 10 | 10 | 30 | 17 | 43 |
| 6.2 | 30 | 60 | 50 | 10 | 40 | 40 | 9.1 | 70 | 20 | 20 | 30 | 17 | 43 |
| 6.2 | 30 | 70 | 50 | 10 | 40 | 40 | 9.1 | 70 | 30 | 30 | 30 | 17 | 43 |
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| 6.2 | 30 | 90 | 50 | 10 | 40 | 40 | 9.1 | 70 | 50 | 50 | 30 | 17 | 43 |
| 6.2 | 30 | 100 | 50 | 10 | 40 | 40 | 9.1 | 70 | 60 | 60 | 30 | 17 | 43 |
| 6.2 | 30 | 70 | 60 | 10 | 40 | 40 | 9.1 | 80 | 10 | 10 | 30 | 17 | 43 |
| 6.2 | 30 | 80 | 60 | 10 | 40 | 40 | 9.1 | 80 | 20 | 20 | 30 | 17 | 43 |
| 6.2 | 30 | 90 | 60 | 10 | 40 | 40 | 9.1 | 80 | 30 | 30 | 30 | 17 | 43 |
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| 6.2 | 30 | 80 | 70 | 10 | 40 | 40 | 9.1 | 80 | 50 | 50 | 30 | 17 | 43 |
| 6.2 | 30 | 90 | 70 | 10 | 40 | 40 | 9.1 | 80 | 60 | 60 | 30 | 17 | 43 |
| 6.2 | 30 | 100 | 70 | 10 | 40 | 40 | 9.1 | 80 | 70 | 70 | 30 | 17 | 43 |
| 6.2 | 30 | 90 | 80 | 10 | 40 | 40 | 9.1 | 90 | 10 | 10 | 30 | 17 | 43 |
| 6.2 | 30 | 100 | 80 | 10 | 40 | 40 | 9.1 | 90 | 20 | 20 | 30 | 17 | 43 |
| 6.2 | 30 | 100 | 90 | 10 | 40 | 40 | 9.1 | 90 | 30 | 30 | 30 | 17 | 43 |
| 6.2 | 40 | 60 | 50 | 10 | 40 | 40 | 9.1 | 90 | 40 | 40 | 30 | 17 | 43 |
| 6.2 | 40 | 70 | 50 | 10 | 40 | 40 | 9.1 | 90 | 50 | 50 | 30 | 17 | 43 |
| 6.2 | 40 | 80 | 50 | 10 | 40 | 40 | 9.1 | 90 | 60 | 60 | 30 | 17 | 43 |
| 6.2 | 40 | 90 | 50 | 10 | 40 | 40 | 9.1 | 90 | 70 | 70 | 30 | 17 | 43 |
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| 6.2 | 40 | 70 | 60 | 10 | 40 | 40 | 9.1 | 100 | 10 | 10 | 30 | 17 | 43 |
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| 6.2 | 40 | 90 | 60 | 10 | 40 | 40 | 9.1 | 100 | 30 | 30 | 30 | 17 | 43 |
| 6.2 | 40 | 100 | 60 | 10 | 40 | 40 | 9.1 | 100 | 40 | 40 | 30 | 17 | 43 |
| 6.2 | 40 | 80 | 70 | 10 | 40 | 40 | 9.1 | 100 | 50 | 50 | 30 | 17 | 43 |
| 6.2 | 40 | 90 | 70 | 10 | 40 | 40 | 9.1 | 100 | 60 | 60 | 30 | 17 | 43 |
| 6.2 | 40 | 100 | 70 | 10 | 40 | 40 | 9.1 | 100 | 70 | 70 | 30 | 17 | 43 |
| 6.2 | 40 | 90 | 80 | 10 | 40 | 40 | 9.1 | 100 | 80 | 80 | 30 | 17 | 43 |
| 6.2 | 40 | 100 | 80 | 10 | 40 | 40 | 9.1 | 100 | 90 | 90 | 30 | 17 | 43 |
| 6.2 | 40 | 100 | 90 | 10 | 40 | 40 | 9.2 | 10 | 20 | 10 | 15 | 40 | 35 |
| 6.2 | 50 | 70 | 60 | 10 | 40 | 40 | 9.2 | 10 | 30 | 10 | 15 | 40 | 35 |
| 6.2 | 50 | 80 | 60 | 10 | 40 | 40 | 9.2 | 10 | 40 | 10 | 15 | 40 | 35 |
| 6.2 | 50 | 90 | 60 | 10 | 40 | 40 | 9.2 | 10 | 50 | 10 | 15 | 40 | 35 |
| 6.2 | 50 | 100 | 60 | 10 | 40 | 40 | 9.2 | 10 | 60 | 10 | 15 | 40 | 35 |
| 6.2 | 50 | 80 | 70 | 10 | 40 | 40 | 9.2 | 10 | 70 | 10 | 15 | 40 | 35 |
| 6.2 | 50 | 90 | 70 | 10 | 40 | 40 | 9.2 | 10 | 80 | 10 | 15 | 40 | 35 |
| 6.2 | 50 | 100 | 70 | 10 | 40 | 40 | 9.2 | 10 | 90 | 10 | 15 | 40 | 35 |
| 6.2 | 50 | 90 | 80 | 10 | 40 | 40 | 9.2 | 10 | 100 | 10 | 15 | 40 | 35 |
| 6.2 | 50 | 100 | 80 | 10 | 40 | 40 | 9.2 | 20 | 30 | 20 | 15 | 40 | 35 |
| 6.2 | 50 | 100 | 90 | 10 | 40 | 40 | 9.2 | 20 | 40 | 20 | 15 | 40 | 35 |
| 6.2 | 60 | 80 | 70 | 10 | 40 | 40 | 9.2 | 20 | 50 | 20 | 15 | 40 | 35 |
| 6.2 | 60 | 90 | 70 | 10 | 40 | 40 | 9.2 | 20 | 60 | 20 | 15 | 40 | 35 |
| 6.2 | 60 | 100 | 70 | 10 | 40 | 40 | 9.2 | 20 | 70 | 20 | 15 | 40 | 35 |
| 6.2 | 60 | 90 | 80 | 10 | 40 | 40 | 9.2 | 20 | 80 | 20 | 15 | 40 | 35 |
| 6.2 | 60 | 100 | 80 | 10 | 40 | 40 | 9.2 | 20 | 90 | 20 | 15 | 40 | 35 |
| 6.2 | 60 | 100 | 90 | 10 | 40 | 40 | 9.2 | 20 | 100 | 20 | 15 | 40 | 35 |
| 6.2 | 70 | 90 | 80 | 10 | 40 | 40 | 9.2 | 30 | 40 | 30 | 15 | 40 | 35 |
| 6.2 | 70 | 100 | 80 | 10 | 40 | 40 | 9.2 | 30 | 50 | 30 | 15 | 40 | 35 |
| 6.2 | 70 | 100 | 90 | 10 | 40 | 40 | 9.2 | 30 | 60 | 30 | 15 | 40 | 35 |
| 6.2 | 80 | 100 | 90 | 10 | 40 | 40 | 9.2 | 30 | 70 | 30 | 15 | 40 | 35 |
| 6.3 | 20 | 10 | 30 | 30 | 15 | 45 | 9.2 | 30 | 80 | 30 | 15 | 40 | 35 |
| 6.3 | 20 | 10 | 40 | 30 | 15 | 45 | 9.2 | 30 | 90 | 30 | 15 | 40 | 35 |
| 6.3 | 20 | 10 | 50 | 30 | 15 | 45 | 9.2 | 30 | 100 | 30 | 15 | 40 | 35 |
| 6.3 | 20 | 10 | 60 | 30 | 15 | 45 | 9.2 | 40 | 50 | 40 | 15 | 40 | 35 |
| 6.3 | 20 | 10 | 70 | 30 | 15 | 45 | 9.2 | 40 | 60 | 40 | 15 | 40 | 35 |
| 6.3 | 20 | 10 | 80 | 30 | 15 | 45 | 9.2 | 40 | 70 | 40 | 15 | 40 | 35 |
| 6.3 | 20 | 10 | 90 | 30 | 15 | 45 | 9.2 | 40 | 80 | 40 | 15 | 40 | 35 |
| 6.3 | 20 | 10 | 100 | 30 | 15 | 45 | 9.2 | 40 | 90 | 40 | 15 | 40 | 35 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.3 | 30 | 10 | 40 | 30 | 15 | 45 | 9.2 | 40 | 100 | 40 | 15 | 40 | 35 |
| 6.3 | 30 | 10 | 50 | 30 | 15 | 45 | 9.2 | 50 | 60 | 50 | 15 | 40 | 35 |
| 6.3 | 30 | 10 | 60 | 30 | 15 | 45 | 9.2 | 50 | 70 | 50 | 15 | 40 | 35 |
| 6.3 | 30 | 10 | 70 | 30 | 15 | 45 | 9.2 | 50 | 80 | 50 | 15 | 40 | 35 |
| 6.3 | 30 | 10 | 80 | 30 | 15 | 45 | 9.2 | 50 | 90 | 50 | 15 | 40 | 35 |
| 6.3 | 30 | 10 | 90 | 30 | 15 | 45 | 9.2 | 50 | 100 | 50 | 15 | 40 | 35 |
| 6.3 | 30 | 10 | 100 | 30 | 15 | 45 | 9.2 | 60 | 70 | 60 | 15 | 40 | 35 |
| 6.3 | 30 | 20 | 40 | 30 | 15 | 45 | 9.2 | 60 | 80 | 60 | 15 | 40 | 35 |
| 6.3 | 30 | 20 | 50 | 30 | 15 | 45 | 9.2 | 60 | 90 | 60 | 15 | 40 | 35 |
| 6.3 | 30 | 20 | 60 | 30 | 15 | 45 | 9.2 | 60 | 100 | 60 | 15 | 40 | 35 |
| 6.3 | 30 | 20 | 70 | 30 | 15 | 45 | 9.2 | 70 | 80 | 70 | 15 | 40 | 35 |
| 6.3 | 30 | 20 | 80 | 30 | 15 | 45 | 9.2 | 70 | 90 | 70 | 15 | 40 | 35 |
| 6.3 | 30 | 20 | 90 | 30 | 15 | 45 | 9.2 | 70 | 100 | 70 | 15 | 40 | 35 |
| 6.3 | 30 | 20 | 100 | 30 | 15 | 45 | 9.2 | 80 | 90 | 80 | 15 | 40 | 35 |
| 6.3 | 40 | 10 | 50 | 30 | 15 | 45 | 9.2 | 80 | 100 | 80 | 15 | 40 | 35 |
| 6.3 | 40 | 10 | 60 | 30 | 15 | 45 | 9.2 | 90 | 100 | 90 | 15 | 40 | 35 |
| 6.3 | 40 | 10 | 70 | 30 | 15 | 45 | 9.3 | 10 | 10 | 20 | 26 | 19 | 45 |
| 6.3 | 40 | 10 | 80 | 30 | 15 | 45 | 9.3 | 10 | 10 | 30 | 26 | 19 | 45 |
| 6.3 | 40 | 10 | 90 | 30 | 15 | 45 | 9.3 | 10 | 10 | 40 | 26 | 19 | 45 |
| 6.3 | 40 | 10 | 100 | 30 | 15 | 45 | 9.3 | 10 | 10 | 50 | 26 | 19 | 45 |
| 6.3 | 40 | 20 | 50 | 30 | 15 | 45 | 9.3 | 10 | 10 | 60 | 26 | 19 | 45 |
| 6.3 | 40 | 20 | 60 | 30 | 15 | 45 | 9.3 | 10 | 10 | 70 | 26 | 19 | 45 |
| 6.3 | 40 | 20 | 70 | 30 | 15 | 45 | 9.3 | 10 | 10 | 80 | 26 | 19 | 45 |
| 6.3 | 40 | 20 | 80 | 30 | 15 | 45 | 9.3 | 10 | 10 | 90 | 26 | 19 | 45 |
| 6.3 | 40 | 20 | 90 | 30 | 15 | 45 | 9.3 | 10 | 10 | 100 | 26 | 19 | 45 |
| 6.3 | 40 | 20 | 100 | 30 | 15 | 45 | 9.3 | 20 | 20 | 30 | 26 | 19 | 45 |
| 6.3 | 40 | 30 | 50 | 30 | 15 | 45 | 9.3 | 20 | 20 | 40 | 26 | 19 | 45 |
| 6.3 | 40 | 30 | 60 | 30 | 15 | 45 | 9.3 | 20 | 20 | 50 | 26 | 19 | 45 |
| 6.3 | 40 | 30 | 70 | 30 | 15 | 45 | 9.3 | 20 | 20 | 60 | 26 | 19 | 45 |
| 6.3 | 40 | 30 | 80 | 30 | 15 | 45 | 9.3 | 20 | 20 | 70 | 26 | 19 | 45 |
| 6.3 | 40 | 30 | 90 | 30 | 15 | 45 | 9.3 | 20 | 20 | 80 | 26 | 19 | 45 |
| 6.3 | 40 | 30 | 100 | 30 | 15 | 45 | 9.3 | 20 | 20 | 90 | 26 | 19 | 45 |
| 6.3 | 50 | 10 | 60 | 30 | 15 | 45 | 9.3 | 20 | 20 | 100 | 26 | 19 | 45 |
| 6.3 | 50 | 10 | 70 | 30 | 15 | 45 | 9.3 | 30 | 30 | 40 | 26 | 19 | 45 |
| 6.3 | 50 | 10 | 80 | 30 | 15 | 45 | 9.3 | 30 | 30 | 50 | 26 | 19 | 45 |
| 6.3 | 50 | 10 | 90 | 30 | 15 | 45 | 9.3 | 30 | 30 | 60 | 26 | 19 | 45 |
| 6.3 | 50 | 10 | 100 | 30 | 15 | 45 | 9.3 | 30 | 30 | 70 | 26 | 19 | 45 |
| 6.3 | 50 | 20 | 60 | 30 | 15 | 45 | 9.3 | 30 | 30 | 80 | 26 | 19 | 45 |
| 6.3 | 50 | 20 | 70 | 30 | 15 | 45 | 9.3 | 30 | 30 | 90 | 26 | 19 | 45 |
| 6.3 | 50 | 20 | 80 | 30 | 15 | 45 | 9.3 | 30 | 30 | 100 | 26 | 19 | 45 |
| 6.3 | 50 | 20 | 90 | 30 | 15 | 45 | 9.3 | 40 | 40 | 50 | 26 | 19 | 45 |
| 6.3 | 50 | 20 | 100 | 30 | 15 | 45 | 9.3 | 40 | 40 | 60 | 26 | 19 | 45 |
| 6.3 | 50 | 30 | 60 | 30 | 15 | 45 | 9.3 | 40 | 40 | 70 | 26 | 19 | 45 |
| 6.3 | 50 | 30 | 70 | 30 | 15 | 45 | 9.3 | 40 | 40 | 80 | 26 | 19 | 45 |
| 6.3 | 50 | 30 | 80 | 30 | 15 | 45 | 9.3 | 40 | 40 | 90 | 26 | 19 | 45 |
| 6.3 | 50 | 30 | 90 | 30 | 15 | 45 | 9.3 | 40 | 40 | 100 | 26 | 19 | 45 |
| 6.3 | 50 | 30 | 100 | 30 | 15 | 45 | 9.3 | 50 | 50 | 60 | 26 | 19 | 45 |
| 6.3 | 50 | 40 | 60 | 30 | 15 | 45 | 9.3 | 50 | 50 | 70 | 26 | 19 | 45 |
| 6.3 | 50 | 40 | 70 | 30 | 15 | 45 | 9.3 | 50 | 50 | 80 | 26 | 19 | 45 |

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|---|---|---|---|---|---|---|
| 6.3 | 50 | 40 | 80 | 30 | 15 | 45 |
| 6.3 | 50 | 40 | 90 | 30 | 15 | 45 |
| 6.3 | 50 | 40 | 100 | 30 | 15 | 45 |
| 6.3 | 60 | 10 | 70 | 30 | 15 | 45 |
| 6.3 | 60 | 10 | 80 | 30 | 15 | 45 |
| 6.3 | 60 | 10 | 90 | 30 | 15 | 45 |
| 6.3 | 60 | 10 | 100 | 30 | 15 | 45 |
| 6.3 | 60 | 20 | 70 | 30 | 15 | 45 |
| 6.3 | 60 | 20 | 80 | 30 | 15 | 45 |
| 6.3 | 60 | 20 | 90 | 30 | 15 | 45 |
| 6.3 | 60 | 20 | 100 | 30 | 15 | 45 |
| 6.3 | 60 | 30 | 70 | 30 | 15 | 45 |
| 6.3 | 60 | 30 | 80 | 30 | 15 | 45 |
| 6.3 | 60 | 30 | 90 | 30 | 15 | 45 |
| 6.3 | 60 | 30 | 100 | 30 | 15 | 45 |
| 6.3 | 60 | 40 | 70 | 30 | 15 | 45 |
| 6.3 | 60 | 40 | 80 | 30 | 15 | 45 |
| 6.3 | 60 | 40 | 90 | 30 | 15 | 45 |
| 6.3 | 60 | 40 | 100 | 30 | 15 | 45 |
| 6.3 | 60 | 50 | 70 | 30 | 15 | 45 |
| 6.3 | 60 | 50 | 80 | 30 | 15 | 45 |
| 6.3 | 60 | 50 | 90 | 30 | 15 | 45 |
| 6.3 | 60 | 50 | 100 | 30 | 15 | 45 |
| 6.3 | 70 | 10 | 80 | 30 | 15 | 45 |
| 6.3 | 70 | 10 | 90 | 30 | 15 | 45 |
| 6.3 | 70 | 10 | 100 | 30 | 15 | 45 |
| 6.3 | 70 | 20 | 80 | 30 | 15 | 45 |
| 6.3 | 70 | 20 | 90 | 30 | 15 | 45 |
| 6.3 | 70 | 20 | 100 | 30 | 15 | 45 |
| 6.3 | 70 | 30 | 80 | 30 | 15 | 45 |
| 6.3 | 70 | 30 | 90 | 30 | 15 | 45 |
| 6.3 | 70 | 30 | 100 | 30 | 15 | 45 |
| 6.3 | 70 | 40 | 80 | 30 | 15 | 45 |
| 6.3 | 70 | 40 | 90 | 30 | 15 | 45 |
| 6.3 | 70 | 40 | 100 | 30 | 15 | 45 |
| 6.3 | 70 | 50 | 80 | 30 | 15 | 45 |
| 6.3 | 70 | 50 | 90 | 30 | 15 | 45 |
| 6.3 | 70 | 50 | 100 | 30 | 15 | 45 |
| 6.3 | 70 | 60 | 80 | 30 | 15 | 45 |
| 6.3 | 70 | 60 | 90 | 30 | 15 | 45 |
| 6.3 | 70 | 60 | 100 | 30 | 15 | 45 |
| 6.3 | 80 | 10 | 90 | 30 | 15 | 45 |
| 6.3 | 80 | 10 | 100 | 30 | 15 | 45 |
| 6.3 | 80 | 20 | 90 | 30 | 15 | 45 |
| 6.3 | 80 | 20 | 100 | 30 | 15 | 45 |
| 6.3 | 80 | 30 | 90 | 30 | 15 | 45 |
| 6.3 | 80 | 30 | 100 | 30 | 15 | 45 |
| 6.3 | 80 | 40 | 90 | 30 | 15 | 45 |
| 6.3 | 80 | 40 | 100 | 30 | 15 | 45 |

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|---|---|---|---|---|---|---|
| 9.3 | 50 | 50 | 90 | 26 | 19 | 45 |
| 9.3 | 50 | 50 | 100 | 26 | 19 | 45 |
| 9.3 | 60 | 60 | 70 | 26 | 19 | 45 |
| 9.3 | 60 | 60 | 80 | 26 | 19 | 45 |
| 9.3 | 60 | 60 | 90 | 26 | 19 | 45 |
| 9.3 | 60 | 60 | 100 | 26 | 19 | 45 |
| 9.3 | 70 | 70 | 80 | 26 | 19 | 45 |
| 9.3 | 70 | 70 | 90 | 26 | 19 | 45 |
| 9.3 | 70 | 70 | 100 | 26 | 19 | 45 |
| 9.3 | 80 | 80 | 90 | 26 | 19 | 45 |
| 9.3 | 80 | 80 | 100 | 26 | 19 | 45 |
| 9.3 | 90 | 90 | 100 | 26 | 19 | 45 |

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|---|---|---|---|---|---|---|
| 6.3 | 80 | 50 | 90 | 30 | 15 | 45 |
| 6.3 | 80 | 50 | 100 | 30 | 15 | 45 |
| 6.3 | 80 | 60 | 90 | 30 | 15 | 45 |
| 6.3 | 80 | 60 | 100 | 30 | 15 | 45 |
| 6.3 | 80 | 70 | 90 | 30 | 15 | 45 |
| 6.3 | 80 | 70 | 100 | 30 | 15 | 45 |
| 6.3 | 90 | 10 | 100 | 30 | 15 | 45 |
| 6.3 | 90 | 20 | 100 | 30 | 15 | 45 |
| 6.3 | 90 | 30 | 100 | 30 | 15 | 45 |
| 6.3 | 90 | 40 | 100 | 30 | 15 | 45 |
| 6.3 | 90 | 50 | 100 | 30 | 15 | 45 |
| 6.3 | 90 | 60 | 100 | 30 | 15 | 45 |
| 6.3 | 90 | 70 | 100 | 30 | 15 | 45 |
| 6.3 | 90 | 80 | 100 | 30 | 15 | 45 |

# Appendix D: Specific Random Disruptions

| | 1Top3 | | 1SOF | | 1IP | | 1FL | | 1Top3 | | 1SOF | | 1IP | | 1FL | | 1IP | | 1FL | | 1P | | 1IP | | 1IP | | 1FL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 2 | 9 | 3 | 10 | 1 | 3 | 4 | 1 | 2 | 3 | 2 | 1 | 4 | 3 | 1 | 13 | 3 | 4 | 3 | 2 | 2 | 5 | 3 | 7 | 3 | 13 | 4 |
| 2 | 5 | 2 | 11 | 2 | 13 | 2 | 11 | 3 | 4 | 2 | 1 | 2 | 9 | 2 | 2 | 3 | 8 | 4 | 8 | 4 | 3 | 6 | 13 | 3 | 14 | 1 | 14 | 2 |
| 3 | 2 | 2 | 14 | 2 | 8 | 3 | 1 | 1 | 2 | 1 | 9 | 2 | 6 | 4 | 7 | 2 | 7 | 2 | 3 | 3 | 9 | 5 | 2 | 4 | 13 | 3 | 3 | 2 |
| 4 | 2 | 1 | 5 | 3 | 10 | 2 | 3 | 2 | 2 | 2 | 10 | 2 | 8 | 1 | 5 | 3 | 10 | 3 | 9 | 1 | 8 | 2 | 1 | 1 | 6 | 3 | 1 | 2 |
| 5 | 4 | 1 | 12 | 4 | 10 | 3 | 12 | 3 | 2 | 2 | 8 | 2 | 15 | 4 | 14 | 3 | 14 | 3 | 2 | 1 | 10 | 2 | 3 | 1 | 4 | 3 | 11 | 1 |
| 6 | 5 | 3 | 11 | 3 | 2 | 1 | 9 | 3 | 4 | 2 | 5 | 1 | 4 | 3 | 9 | 4 | 3 | 2 | 2 | 1 | 10 | 2 | 2 | 3 | 4 | 4 | 11 | 1 |
| 7 | 4 | 3 | 4 | 2 | 2 | 4 | 9 | 4 | 2 | 2 | 14 | 2 | 5 | 4 | 4 | 2 | 11 | 3 | 10 | 2 | 2 | 2 | 4 | 1 | 5 | 4 | 11 | 2 |
| 8 | 5 | 2 | 9 | 3 | 6 | 4 | 5 | 3 | 3 | 1 | 13 | 3 | 6 | 3 | 5 | 2 | 12 | 2 | 4 | 2 | 8 | 5 | 11 | 3 | 12 | 3 | 11 | 3 |
| 9 | 4 | 1 | 2 | 2 | 10 | 4 | 2 | 3 | 4 | 2 | 12 | 3 | 8 | 3 | 7 | 4 | 6 | 3 | 8 | 2 | 11 | 3 | 13 | 1 | 8 | 4 | 6 | 2 |
| 10 | 3 | 3 | 14 | 3 | 15 | 2 | 2 | 4 | 3 | 2 | 2 | 2 | 4 | 4 | 7 | 1 | 13 | 1 | 8 | 1 | 9 | 3 | 7 | 3 | 4 | 1 | 14 | 3 |
| 11 | 1 | 1 | 4 | 4 | 4 | 1 | 2 | 3 | 4 | 2 | 11 | 2 | 6 | 3 | 2 | 1 | 7 | 2 | 9 | 2 | 2 | 1 | 10 | 2 | 13 | 1 | 4 | 1 |
| 12 | 4 | 3 | 1 | 3 | 3 | 3 | 6 | 3 | 4 | 3 | 3 | 3 | 12 | 2 | 8 | 3 | 2 | 3 | 13 | 2 | 13 | 3 | 5 | 4 | 11 | 4 | 9 | 3 |
| 13 | 1 | 1 | 13 | 2 | 1 | 1 | 9 | 2 | 5 | 1 | 5 | 3 | 14 | 1 | 5 | 4 | 3 | 1 | 9 | 2 | 9 | 6 | 9 | 4 | 13 | 3 | 9 | 3 |
| 14 | 4 | 1 | 6 | 2 | 6 | 2 | 14 | 2 | 4 | 1 | 6 | 4 | 10 | 2 | 9 | 4 | 6 | 2 | 10 | 2 | 4 | 6 | 1 | 4 | 13 | 3 | 13 | 1 |
| 15 | 5 | 1 | 11 | 3 | 5 | 1 | 13 | 2 | 5 | 2 | 3 | 2 | 2 | 4 | 5 | 3 | 10 | 2 | 3 | 2 | 5 | 1 | 1 | 2 | 13 | 2 | 1 | 4 |
| 16 | 3 | 2 | 1 | 2 | 11 | 2 | 2 | 2 | 4 | 2 | 2 | 4 | 4 | 1 | 12 | 2 | 3 | 1 | 11 | 2 | 4 | 2 | 7 | 2 | 3 | 2 | 8 | 2 |
| 17 | 2 | 2 | 1 | 2 | 1 | 4 | 2 | 1 | 1 | 1 | 2 | 3 | 5 | 3 | 12 | 2 | 5 | 1 | 7 | 3 | 14 | 3 | 15 | 2 | 10 | 2 | 13 | 1 |
| 18 | 5 | 2 | 11 | 4 | 4 | 1 | 14 | 2 | 1 | 2 | 7 | 3 | 3 | 2 | 1 | 2 | 3 | 4 | 7 | 2 | 13 | 4 | 13 | 2 | 9 | 2 | 7 | 4 |
| 19 | 4 | 2 | 14 | 3 | 9 | 3 | 7 | 2 | 3 | 2 | 2 | 4 | 8 | 3 | 10 | 2 | 6 | 4 | 13 | 3 | 6 | 4 | 4 | 2 | 2 | 2 | 7 | 1 |
| 20 | 1 | 1 | 10 | 2 | 5 | 3 | 10 | 2 | 5 | 3 | 7 | 1 | 5 | 3 | 6 | 4 | 2 | 4 | 9 | 1 | 10 | 6 | 10 | 4 | 9 | 2 | 9 | 4 |
| 21 | 2 | 1 | 10 | 3 | 13 | 3 | 1 | 1 | 4 | 2 | 12 | 1 | 15 | 4 | 6 | 2 | 4 | 3 | 13 | 3 | 8 | 3 | 10 | 3 | 1 | 2 | 13 | 3 |
| 22 | 3 | 2 | 9 | 3 | 10 | 3 | 13 | 3 | 4 | 3 | 3 | 3 | 4 | 2 | 11 | 1 | 4 | 3 | 8 | 3 | 14 | 1 | 1 | 2 | 11 | 3 | 3 | 2 |
| 23 | 1 | 1 | 1 | 2 | 12 | 4 | 9 | 4 | 2 | 2 | 6 | 3 | 7 | 1 | 5 | 1 | 13 | 4 | 10 | 4 | 9 | 4 | 12 | 3 | 8 | 2 | 7 | 4 |
| 24 | 5 | 2 | 6 | 3 | 11 | 2 | 5 | 3 | 4 | 2 | 13 | 2 | 1 | 3 | 5 | 1 | 9 | 1 | 9 | 1 | 3 | 3 | 1 | 3 | 14 | 3 | 2 | 3 |
| 25 | 3 | 2 | 10 | 3 | 3 | 1 | 4 | 1 | 1 | 3 | 10 | 4 | 13 | 2 | 13 | 4 | 2 | 1 | 5 | 2 | 11 | 1 | 1 | 2 | 14 | 4 | 2 | 3 |
| 26 | 2 | 2 | 14 | 2 | 15 | 3 | 8 | 4 | 3 | 2 | 11 | 4 | 2 | 3 | 2 | 3 | 6 | 1 | 5 | 4 | 14 | 4 | 11 | 3 | 3 | 2 | 10 | 2 |
| 27 | 5 | 1 | 9 | 3 | 4 | 1 | 14 | 3 | 2 | 1 | 8 | 3 | 7 | 3 | 12 | 1 | 14 | 4 | 7 | 3 | 3 | 4 | 9 | 1 | 3 | 4 | 11 | 1 |
| 28 | 2 | 2 | 4 | 3 | 3 | 4 | 9 | 1 | 2 | 2 | 15 | 3 | 7 | 2 | 10 | 2 | 3 | 2 | 12 | 3 | 7 | 6 | 1 | 2 | 5 | 2 | 9 | 2 |
| 29 | 3 | 2 | 14 | 2 | 8 | 3 | 9 | 4 | 4 | 1 | 4 | 2 | 8 | 1 | 12 | 3 | 9 | 2 | 10 | 2 | 4 | 2 | 7 | 3 | 8 | 2 | 14 | 4 |
| 30 | 5 | 1 | 15 | 3 | 11 | 3 | 13 | 4 | 1 | 2 | 3 | 2 | 15 | 3 | 3 | 4 | 10 | 3 | 7 | 2 | 1 | 5 | 10 | 4 | 11 | 3 | 6 | 3 |

| | 1 IP | | 1FL | | 1FL | | 1P | | 1IP | | 1FL | | 1FL | | 1P | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 11 | 3 | 13 | 4 | 4 | 2 | 6 | 6 | 13 | 3 | 7 | 2 | 13 | 3 | 1 | 3 |
| 2 | 4 | 2 | 7 | 1 | 2 | 2 | 8 | 6 | 9 | 2 | 8 | 1 | 15 | 1 | 14 | 6 |
| 3 | 7 | 3 | 3 | 2 | 3 | 4 | 12 | 3 | 10 | 3 | 6 | 3 | 10 | 3 | 12 | 4 |
| 4 | 5 | 4 | 7 | 3 | 7 | 2 | 15 | 2 | 14 | 3 | 3 | 3 | 9 | 3 | 13 | 5 |
| 5 | 8 | 1 | 3 | 3 | 9 | 4 | 11 | 4 | 5 | 2 | 12 | 2 | 15 | 3 | 10 | 6 |
| 6 | 10 | 1 | 12 | 2 | 10 | 3 | 7 | 6 | 8 | 2 | 5 | 3 | 5 | 1 | 7 | 4 |
| 7 | 4 | 2 | 2 | 1 | 14 | 3 | 14 | 4 | 14 | 2 | 4 | 3 | 12 | 1 | 9 | 3 |
| 8 | 8 | 3 | 5 | 2 | 8 | 3 | 3 | 5 | 11 | 3 | 13 | 2 | 6 | 3 | 9 | 3 |
| 9 | 2 | 3 | 15 | 1 | 11 | 2 | 2 | 2 | 4 | 3 | 8 | 4 | 13 | 2 | 6 | 6 |
| 10 | 12 | 2 | 14 | 3 | 9 | 3 | 10 | 4 | 14 | 2 | 12 | 4 | 14 | 3 | 4 | 6 |
| 11 | 12 | 3 | 14 | 3 | 5 | 4 | 7 | 1 | 13 | 4 | 3 | 1 | 8 | 1 | 10 | 2 |
| 12 | 1 | 2 | 8 | 3 | 6 | 1 | 15 | 2 | 15 | 4 | 9 | 3 | 1 | 2 | 8 | 4 |
| 13 | 1 | 1 | 6 | 2 | 15 | 1 | 9 | 5 | 9 | 3 | 11 | 2 | 2 | 2 | 6 | 2 |
| 14 | 6 | 2 | 10 | 4 | 3 | 3 | 11 | 4 | 7 | 4 | 6 | 1 | 14 | 2 | 2 | 5 |
| 15 | 6 | 3 | 7 | 4 | 14 | 1 | 15 | 4 | 5 | 3 | 3 | 3 | 14 | 1 | 14 | 3 |
| 16 | 13 | 1 | 7 | 3 | 9 | 4 | 1 | 7 | | | | | | | | |
| 17 | 2 | 2 | 4 | 3 | 8 | 2 | 5 | 2 | | | | | | | | |
| 18 | 11 | 1 | 9 | 2 | 12 | 4 | 13 | 5 | | | | | | | | |
| 19 | 3 | 4 | 4 | 3 | 12 | 2 | 10 | 1 | | | | | | | | |
| 20 | 4 | 2 | 13 | 2 | 3 | 2 | 10 | 4 | | | | | | | | |
| 21 | 10 | 2 | 9 | 1 | 8 | 3 | 11 | 2 | | | | | | | | |
| 22 | 8 | 2 | 15 | 2 | 5 | 1 | 13 | 6 | | | | | | | | |
| 23 | 12 | 3 | 6 | 1 | 7 | 3 | 3 | 2 | | | | | | | | |
| 24 | 8 | 2 | 13 | 3 | 3 | 4 | 6 | 1 | | | | | | | | |
| 25 | 9 | 2 | 12 | 1 | 10 | 4 | 4 | 4 | | | | | | | | |
| 26 | 13 | 4 | 2 | 2 | 12 | 3 | 5 | 2 | | | | | | | | |
| 27 | 12 | 2 | 7 | 3 | 3 | 3 | 13 | 2 | | | | | | | | |
| 28 | 12 | 2 | 9 | 1 | 5 | 2 | 12 | 5 | | | | | | | | |
| 29 | 9 | 3 | 14 | 3 | 7 | 2 | 4 | 4 | | | | | | | | |
| 30 | 8 | 3 | 7 | 3 | 2 | 2 | 14 | 2 | | | | | | | | |

| | 1 IP | | 1 IP | | 1FL | | 1P | | 1 IP | | 1 IP | | 1FL | | 1P | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 13 | 4 | 12 | 4 | 14 | 3 | 4 | 3 | 9 | 2 | 14 | 3 | 1 | 3 | 14 | 4 |
| 2 | 12 | 1 | 8 | 3 | 11 | 3 | 4 | 4 | 5 | 3 | 5 | 2 | 3 | 4 | 2 | 5 |
| 3 | 4 | 4 | 4 | 2 | 6 | 1 | 13 | 7 | 15 | 3 | 3 | 3 | 6 | 3 | 3 | 2 |
| 4 | 3 | 2 | 7 | 1 | 11 | 1 | 7 | 6 | 5 | 1 | 2 | 2 | 5 | 1 | 10 | 1 |
| 5 | 8 | 3 | 12 | 3 | 5 | 2 | 3 | 6 | 13 | 2 | 8 | 3 | 12 | 2 | 8 | 5 |
| 6 | 10 | 2 | 11 | 4 | 3 | 3 | 1 | 4 | 13 | 3 | 10 | 4 | 10 | 2 | 7 | 4 |
| 7 | 9 | 2 | 14 | 4 | 10 | 3 | 6 | 7 | 14 | 2 | 13 | 3 | 5 | 2 | 9 | 4 |
| 8 | 5 | 2 | 5 | 3 | 3 | 3 | 9 | 4 | 5 | 2 | 14 | 3 | 3 | 4 | 9 | 4 |
| 9 | 8 | 2 | 14 | 2 | 10 | 4 | 3 | 2 | 9 | 1 | 11 | 4 | 8 | 3 | 12 | 5 |
| 10 | 8 | 4 | 14 | 2 | 8 | 4 | 4 | 6 | 12 | 3 | 7 | 2 | 12 | 3 | 5 | 2 |
| 11 | 12 | 2 | 2 | 2 | 15 | 3 | 13 | 5 | 8 | 2 | 13 | 3 | 7 | 1 | 4 | 3 |
| 12 | 6 | 1 | 3 | 3 | 8 | 4 | 1 | 2 | 6 | 3 | 15 | 2 | 3 | 3 | 8 | 2 |
| 13 | 5 | 2 | 7 | 4 | 11 | 1 | 14 | 3 | 12 | 1 | 8 | 2 | 9 | 1 | 6 | 5 |
| 14 | 9 | 1 | 5 | 1 | 13 | 2 | 11 | 2 | 4 | 3 | 6 | 2 | 4 | 2 | 9 | 2 |
| 15 | 5 | 1 | 7 | 3 | 4 | 4 | 7 | 5 | 2 | 1 | 2 | 3 | 8 | 2 | 13 | 6 |
| 16 | 2 | 3 | 11 | 2 | 9 | 1 | 13 | 6 | | | | | | | | |
| 17 | 3 | 2 | 7 | 3 | 12 | 4 | 12 | 5 | | | | | | | | |
| 18 | 15 | 3 | 8 | 2 | 12 | 2 | 6 | 3 | | | | | | | | |
| 19 | 12 | 2 | 10 | 2 | 3 | 2 | 10 | 3 | | | | | | | | |
| 20 | 9 | 3 | 10 | 1 | 5 | 3 | 6 | 1 | | | | | | | | |
| 21 | 6 | 2 | 13 | 2 | 15 | 3 | 8 | 2 | | | | | | | | |
| 22 | 9 | 2 | 6 | 2 | 10 | 3 | 2 | 6 | | | | | | | | |
| 23 | 11 | 2 | 13 | 3 | 13 | 4 | 3 | 5 | | | | | | | | |
| 24 | 8 | 3 | 6 | 3 | 9 | 1 | 6 | 6 | | | | | | | | |
| 25 | 9 | 2 | 7 | 3 | 1 | 1 | 6 | 3 | | | | | | | | |
| 26 | 12 | 2 | 9 | 3 | 12 | 3 | 5 | 2 | | | | | | | | |
| 27 | 6 | 2 | 7 | 2 | 9 | 2 | 4 | 6 | | | | | | | | |
| 28 | 3 | 4 | 12 | 1 | 6 | 3 | 8 | 4 | | | | | | | | |
| 29 | 9 | 3 | 2 | 3 | 13 | 1 | 5 | 4 | | | | | | | | |
| 30 | 2 | 4 | 2 | 2 | 6 | 2 | 1 | 1 | | | | | | | | |

# Appendix E: Output data as a Result of Disruptions

| SCHEDULE | OBJECTIVE FUNC. COEFFICIENTS | | | SAMPLING | 1Top3 | 1SOF | 1IP | 1FL | 1Top3 1SOF | 1IP 1FL | 1IP 1FL 1P | 2 IP 1FL | 1 IP 2 FL 1P | 1 IP 2 FL 1P | 2IP 1FL 1P | 2IP 1FL 1P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 1 | 0 | 0 | 6 | 0 | 6 | 4 | 0 | 2 | 2 | 2 | 6 | 3 |
| 1 | 0 | 0 | 0 | 2 | 0 | 0 | 4 | 2 | 6 | 2 | 4 | 4 | 4 | 4 | 6 | 4 |
| 1 | 0 | 0 | 0 | 3 | 0 | 0 | 2 | 0 | 5 | 0 | 4 | 4 | 2 | 2 | 12 | 6 |
| 1 | 0 | 0 | 0 | 4 | 5 | 0 | 0 | 2 | 0 | 2 | 2 | 2 | 2 | 4 | 4 | 2 |
| 1 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 2 | 0 | 2 | 2 | 4 | 0 | 8 | 6 | 8 |
| 1 | 0 | 0 | 0 | 6 | 8 | 0 | 2 | 2 | 6 | 0 | 2 | 4 | 10 | 8 | 4 | 8 |
| 1 | 0 | 0 | 0 | 7 | 0 | 0 | 2 | 0 | 0 | 2 | 2 | 4 | 4 | 4 | 4 | 4 |
| 1 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 2 | 6 | 4 | 0 | 6 | 6 | 2 | 4 | 2 |
| 1 | 0 | 0 | 0 | 9 | 0 | 0 | 6 | 2 | 6 | 6 | 2 | 8 | 4 | 2 | 12 | 4 |
| 1 | 0 | 0 | 0 | 10 | 0 | 4 | 0 | 2 | 0 | 2 | 6 | 2 | 4 | 6 | 6 | 10 |
| 1 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 2 | 6 | 4 | 6 | 4 | 4 | 8 | 4 | 2 |
| 1 | 0 | 0 | 0 | 12 | 0 | 0 | 2 | 0 | 0 | 2 | 2 | 6 | 4 | 2 | 4 | 2 |
| 1 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 2 | 0 | 2 | 4 | 2 | 4 | 8 | 8 | 4 |
| 1 | 0 | 0 | 0 | 14 | 0 | 4 | 0 | 2 | 0 | 0 | 2 | 4 | 6 | 8 | 0 | 2 |
| 1 | 0 | 0 | 0 | 15 | 0 | 0 | 0 | 0 | 0 | 4 | 2 | 7 | 10 | 2 | 4 | 4 |
| 1 | 0 | 0 | 0 | 16 | 0 | 0 | 0 | 2 | 6 | 2 | 4 | 4 | 4 | | 4 | |
| 1 | 0 | 0 | 0 | 17 | 0 | 0 | 4 | 2 | 0 | 4 | 0 | 0 | 0 | | 0 | |
| 1 | 0 | 0 | 0 | 18 | 0 | 0 | 0 | 2 | 6 | 0 | 0 | 8 | 6 | | 4 | |
| 1 | 0 | 0 | 0 | 19 | 6 | 4 | 2 | 0 | 0 | 2 | 0 | 2 | 2 | | 2 | |
| 1 | 0 | 0 | 0 | 20 | 0 | 0 | 2 | 0 | 10 | 2 | 8 | 6 | 4 | | 12 | |
| 1 | 0 | 0 | 0 | 21 | 5 | 0 | 2 | 0 | 6 | 2 | 0 | 0 | 4 | | 6 | |
| 1 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 4 | 2 | 4 | 8 | | 0 | |
| 1 | 0 | 0 | 0 | 23 | 0 | 0 | 0 | 0 | 0 | 2 | 10 | 8 | 6 | | 0 | |
| 1 | 0 | 0 | 0 | 24 | 0 | 0 | 0 | 2 | 6 | 2 | 2 | 2 | 4 | | 6 | |
| 1 | 0 | 0 | 0 | 25 | 0 | 0 | 2 | 0 | 0 | 6 | 4 | 4 | 8 | | 0 | |
| 1 | 0 | 0 | 0 | 26 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 2 | 0 | | 4 | |
| 1 | 0 | 0 | 0 | 27 | 0 | 0 | 0 | 2 | 5 | 2 | 2 | 2 | 0 | | 8 | |
| 1 | 0 | 0 | 0 | 28 | 0 | 0 | 0 | 2 | 0 | 4 | 4 | 4 | 4 | | 0 | |
| 1 | 0 | 0 | 0 | 29 | 0 | 0 | 2 | 0 | 0 | 2 | 0 | 4 | 6 | | 2 | |
| 1 | 0 | 0 | 0 | 30 | 0 | 0 | 2 | 0 | 6 | 0 | 2 | 8 | 4 | | 4 | |

| SCHEDULE | OBJECTIVE FUNC. COEFFICIENTS | | | SAMPLING | 1Top3 | 1SOF | 1IP | 1FL | 1Top3 1SOF | 1IP 1FL | 1IP 1FL 1P | 2 IP 1FL | 1 IP 2 FL 1P | 1 IP 2 FL 1P | 2IP 1FL 1P | 2IP 1FL 1P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 0 | 10 | 100 | 1 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 2 | 0 | 10 | 2 |
| 2 | 0 | 10 | 100 | 2 | 4 | 0 | 0 | 2 | 0 | 1 | 4 | 2 | 7 | 4 | 6 | 2 |
| 2 | 0 | 10 | 100 | 3 | 6 | 0 | 0 | 2 | 0 | 0 | 4 | 4 | 4 | 4 | 6 | 12 |
| 2 | 0 | 10 | 100 | 4 | 0 | 0 | 3 | 4 | 6 | 2 | 0 | 0 | 0 | 2 | 2 | 6 |
| 2 | 0 | 10 | 100 | 5 | 3 | 0 | 0 | 4 | 6 | 2 | 1 | 6 | 2 | 6 | 5 | 6 |
| 2 | 0 | 10 | 100 | 6 | 0 | 0 | 0 | 2 | 0 | 2 | 1 | 8 | 4 | 7 | 6 | 8 |
| 2 | 0 | 10 | 100 | 7 | 0 | 0 | 0 | 2 | 6 | 0 | 0 | 2 | 3 | 0 | 0 | 2 |
| 2 | 0 | 10 | 100 | 8 | 4 | 0 | 0 | 2 | 6 | 1 | 2 | 2 | 8 | 4 | 0 | 0 |
| 2 | 0 | 10 | 100 | 9 | 3 | 0 | 4 | 1 | 0 | 0 | 2 | 8 | 2 | 2 | 4 | 6 |
| 2 | 0 | 10 | 100 | 10 | 0 | 0 | 0 | 0 | 0 | 10 | 6 | 1 | 10 | 6 | 0 | 6 |
| 2 | 0 | 10 | 100 | 11 | 0 | 0 | 0 | 1 | 0 | 1 | 4 | 14 | 1 | 6 | 2 | 8 |
| 2 | 0 | 10 | 100 | 12 | 0 | 0 | 4 | 4 | 0 | 2 | 2 | 2 | 2 | 2 | 8 | 0 |
| 2 | 0 | 10 | 100 | 13 | 0 | 0 | 0 | 2 | 0 | 0 | 12 | 2 | 6 | 3 | 6 | 2 |
| 2 | 0 | 10 | 100 | 14 | 3 | 0 | 0 | 2 | 3 | 6 | 0 | 8 | 0 | 8 | 0 | 2 |
| 2 | 0 | 10 | 100 | 15 | 0 | 0 | 0 | 0 | 4 | 2 | 8 | 2 | 1 | 2 | 4 | 2 |
| 2 | 0 | 10 | 100 | 16 | 0 | 0 | 0 | 2 | 4 | 6 | 4 | 6 | 4 | | 2 | |
| 2 | 0 | 10 | 100 | 17 | 6 | 0 | 0 | 2 | 6 | 0 | 0 | 0 | 6 | | 12 | |
| 2 | 0 | 10 | 100 | 18 | 4 | 0 | 6 | 2 | 0 | 6 | 6 | 4 | 4 | | 2 | |
| 2 | 0 | 10 | 100 | 19 | 0 | 0 | 0 | 4 | 4 | 4 | 0 | 0 | 0 | | 4 | |
| 2 | 0 | 10 | 100 | 20 | 0 | 0 | 0 | 4 | 2 | 4 | 2 | 8 | 8 | | 6 | |
| 2 | 0 | 10 | 100 | 21 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 4 | | 5 | |
| 2 | 0 | 10 | 100 | 22 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 2 | | 2 | |
| 2 | 0 | 10 | 100 | 23 | 0 | 0 | 0 | 2 | 6 | 6 | 4 | 0 | 4 | | 2 | |
| 2 | 0 | 10 | 100 | 24 | 4 | 0 | 0 | 2 | 4 | 1 | 4 | 2 | 0 | | 4 | |
| 2 | 0 | 10 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 4 | 2 | 2 | 6 | | 2 | |
| 2 | 0 | 10 | 100 | 26 | 6 | 0 | 0 | 2 | 4 | 2 | 2 | 8 | 0 | | 4 | |
| 2 | 0 | 10 | 100 | 27 | 0 | 0 | 6 | 2 | 0 | 4 | 0 | 2 | 2 | | 0 | |
| 2 | 0 | 10 | 100 | 28 | 6 | 0 | 0 | 2 | 6 | 4 | 8 | 0 | 8 | | 4 | |
| 2 | 0 | 10 | 100 | 29 | 0 | 0 | 0 | 2 | 0 | 4 | 6 | 2 | 8 | | 0 | |
| 2 | 0 | 10 | 100 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 8 | 2 | | 0 | |

| SCHEDULE | OBJECTIVE FUNC. COEFFICIENTS | | | SAMPLING | 1Top3 | 1SOF | 1IP | 1FL | 1Top3 1SOF | 1IP 1FL | 1IP 1FL 1P | 2 IP 1FL | 1 IP 2 FL 1 P | 1 IP 2 FL 1 P | 2 IP 1FL 1P | 2 IP 1FL 1P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 0 | 30 | 20 | 1 | 4 | 0 | 4 | 0 | 0 | 4 | 0 | 0 | 8 | 4 | 6 | 2 |
| 3 | 0 | 30 | 20 | 2 | 0 | 0 | 4 | 2 | 4 | 2 | 3 | 2 | 4 | 5 | 4 | 0 |
| 3 | 0 | 30 | 20 | 3 | 6 | 0 | 0 | 0 | 0 | 4 | 2 | 0 | 0 | 4 | 8 | 8 |
| 3 | 0 | 30 | 20 | 4 | 0 | 0 | 0 | 0 | 6 | 1 | 2 | 2 | 4 | 2 | 10 | 2 |
| 3 | 0 | 30 | 20 | 5 | 0 | 0 | 0 | 4 | 6 | 2 | 6 | 2 | 2 | 2 | 3 | 4 |
| 3 | 0 | 30 | 20 | 6 | 0 | 0 | 0 | 2 | 4 | 2 | 10 | 8 | 4 | 7 | 2 | 14 |
| 3 | 0 | 30 | 20 | 7 | 0 | 0 | 0 | 2 | 6 | 6 | 4 | 8 | 4 | 4 | 0 | 1 |
| 3 | 0 | 30 | 20 | 8 | 0 | 0 | 0 | 2 | 0 | 1 | 6 | 2 | 6 | 8 | 0 | 0 |
| 3 | 0 | 30 | 20 | 9 | 0 | 0 | 4 | 2 | 4 | 0 | 2 | 0 | 4 | 7 | 0 | 6 |
| 3 | 0 | 30 | 20 | 10 | 0 | 0 | 0 | 2 | 4 | 6 | 2 | 8 | 10 | 6 | 2 | 1 |
| 3 | 0 | 30 | 20 | 11 | 6 | 0 | 6 | 2 | 4 | 2 | 0 | 0 | 4 | 13 | 2 | 0 |
| 3 | 0 | 30 | 20 | 12 | 0 | 0 | 4 | 4 | 0 | 2 | 4 | 2 | 6 | 4 | 8 | 0 |
| 3 | 0 | 30 | 20 | 13 | 6 | 0 | 0 | 0 | 3 | 2 | 2 | 2 | 4 | 4 | 6 | 4 |
| 3 | 0 | 30 | 20 | 14 | 0 | 0 | 0 | 2 | 0 | 2 | 4 | 0 | 0 | 10 | 4 | 6 |
| 3 | 0 | 30 | 20 | 15 | 3 | 0 | 0 | 4 | 0 | 2 | 0 | 6 | 2 | 2 | 0 | 1 |
| 3 | 0 | 30 | 20 | 16 | 4 | 0 | 0 | 2 | 4 | 6 | 4 | 6 | 4 | | 2 | |
| 3 | 0 | 30 | 20 | 17 | 6 | 0 | 0 | 2 | 6 | 0 | 0 | 0 | 6 | | 12 | |
| 3 | 0 | 30 | 20 | 18 | 0 | 0 | 6 | 2 | 0 | 6 | 6 | 4 | 4 | | 2 | |
| 3 | 0 | 30 | 20 | 19 | 4 | 0 | 0 | 4 | 4 | 4 | 0 | 0 | 0 | | 4 | |
| 3 | 0 | 30 | 20 | 20 | 6 | 0 | 0 | 4 | 2 | 4 | 2 | 8 | 8 | | 6 | |
| 3 | 0 | 30 | 20 | 21 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 4 | | 5 | |
| 3 | 0 | 30 | 20 | 22 | 4 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 2 | | 2 | |
| 3 | 0 | 30 | 20 | 23 | 6 | 0 | 0 | 2 | 6 | 6 | 4 | 0 | 4 | | 2 | |
| 3 | 0 | 30 | 20 | 24 | 0 | 0 | 0 | 2 | 4 | 1 | 4 | 2 | 0 | | 4 | |
| 3 | 0 | 30 | 20 | 25 | 4 | 0 | 0 | 0 | 0 | 4 | 2 | 2 | 6 | | 2 | |
| 3 | 0 | 30 | 20 | 26 | 6 | 0 | 0 | 2 | 4 | 2 | 2 | 8 | 0 | | 4 | |
| 3 | 0 | 30 | 20 | 27 | 3 | 0 | 6 | 2 | 0 | 4 | 0 | 2 | 2 | | 0 | |
| 3 | 0 | 30 | 20 | 28 | 6 | 0 | 0 | 2 | 6 | 4 | 8 | 0 | 8 | | 4 | |
| 3 | 0 | 30 | 20 | 29 | 4 | 0 | 0 | 2 | 0 | 4 | 6 | 2 | 8 | | 0 | |

| SCHEDULE | OBJECTIVE FUNC. COEFFICIENTS | | | SAMPLING | 1Top3 | 1SOF | 1IP | 1FL | 1Top3 1SOF | 1IP 1FL | 1IP 1FL 1P | 2 IP 1FL | 1 IP 2 FL 1 P | 1 IP 2 FL 1 P | 2 IP 1FL 1P | 2 IP 1FL 1P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 30 | 0 | 90 | 1 | 6 | 0 | 0 | 0 | 0 | 8 | 0 | 4 | 4 | 4 | 6 | 2 |
| 4 | 30 | 0 | 90 | 2 | 6 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 2 | 2 | 4 |
| 4 | 30 | 0 | 90 | 3 | 6 | 0 | 2 | 0 | 0 | 2 | 4 | 6 | 4 | 6 | 10 | 8 |
| 4 | 30 | 0 | 90 | 4 | 0 | 0 | 0 | 4 | 6 | 2 | 4 | 4 | 4 | 11 | 6 | 8 |
| 4 | 30 | 0 | 90 | 5 | 4 | 0 | 0 | 2 | 6 | 0 | 2 | 0 | 8 | 2 | 4 | 4 |
| 4 | 30 | 0 | 90 | 6 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 8 | 2 | 0 | 6 | 11 |
| 4 | 30 | 0 | 90 | 7 | 0 | 0 | 2 | 0 | 6 | 2 | 6 | 8 | 0 | 0 | 2 | 3 |
| 4 | 30 | 0 | 90 | 8 | 6 | 0 | 0 | 0 | 0 | 4 | 4 | 4 | 4 | 8 | 9 | 5 |
| 4 | 30 | 0 | 90 | 9 | 4 | 0 | 4 | 0 | 0 | 2 | 4 | 2 | 2 | 2 | 6 | 2 |
| 4 | 30 | 0 | 90 | 10 | 0 | 2 | 0 | 0 | 6 | 6 | 0 | 6 | 6 | 4 | 4 | 9 |
| 4 | 30 | 0 | 90 | 11 | 5 | 0 | 6 | 0 | 0 | 4 | 0 | 0 | 4 | 6 | 8 | 4 |
| 4 | 30 | 0 | 90 | 12 | 0 | 2 | 0 | 4 | 0 | 2 | 6 | 7 | 6 | 3 | 0 | 8 |
| 4 | 30 | 0 | 90 | 13 | 5 | 0 | 0 | 0 | 0 | 2 | 0 | 3 | 0 | 9 | 2 | 7 |
| 4 | 30 | 0 | 90 | 14 | 4 | 2 | 0 | 0 | 4 | 0 | 8 | 2 | 10 | 8 | 4 | 4 |
| 4 | 30 | 0 | 90 | 15 | 0 | 0 | 2 | 2 | 6 | 2 | 6 | 4 | 4 | 6 | 6 | 2 |
| 4 | 30 | 0 | 90 | 16 | 6 | 0 | 2 | 0 | 0 | 6 | 0 | 0 | 2 | | 7 | |
| 4 | 30 | 0 | 90 | 17 | 6 | 0 | 2 | 0 | 7 | 2 | 2 | 0 | 6 | | 0 | |
| 4 | 30 | 0 | 90 | 18 | 6 | 0 | 6 | 0 | 0 | 0 | 2 | 0 | 2 | | 2 | |
| 4 | 30 | 0 | 90 | 19 | 0 | 2 | 3 | 2 | 6 | 6 | 4 | 2 | 4 | | 10 | |
| 4 | 30 | 0 | 90 | 20 | 5 | 0 | 2 | 4 | 2 | 2 | 6 | 4 | 6 | | 3 | |
| 4 | 30 | 0 | 90 | 21 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 3 | | 2 | |
| 4 | 30 | 0 | 90 | 22 | 6 | 0 | 0 | 0 | 0 | 0 | 2 | 6 | 0 | | 2 | |
| 4 | 30 | 0 | 90 | 23 | 5 | 0 | 0 | 2 | 6 | 2 | 9 | 2 | 8 | | 6 | |
| 4 | 30 | 0 | 90 | 24 | 6 | 0 | 2 | 0 | 0 | 2 | 4 | 4 | 0 | | 10 | |
| 4 | 30 | 0 | 90 | 25 | 6 | 0 | 0 | 0 | 0 | 2 | 0 | 4 | 4 | | 0 | |
| 4 | 30 | 0 | 90 | 26 | 6 | 0 | 2 | 0 | 6 | 2 | 0 | 6 | 0 | | 10 | |
| 4 | 30 | 0 | 90 | 27 | 0 | 0 | 6 | 0 | 2 | 0 | 2 | 0 | 6 | | 4 | |
| 4 | 30 | 0 | 90 | 28 | 6 | 0 | 0 | 4 | 6 | 4 | 4 | 2 | 6 | | 4 | |
| 4 | 30 | 0 | 90 | 29 | 6 | 0 | 2 | 2 | 4 | 4 | 4 | 0 | 8 | | 7 | |
| 4 | 30 | 0 | 90 | 30 | 0 | 0 | 2 | 2 | 0 | 2 | 2 | 10 | 2 | | 4 | |

| SCHEDULE | OBJECTIVE FUNC. COEFFICIENTS | | | SAMPLING | 1Top3 | 1SOF | 1IP | 1FL | 1Top3 1SOF | 1IP 1FL | 1IP 1FL 1P | 2 IP 1FL | 1 IP 2 FL 1P | 1 IP 2 FL 1P | 2IP 1FL 1P | 2IP 1FL 1P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 90 | 20 | 0 | 1 | 6 | 0 | 0 | 4 | 0 | 0 | 2 | 0 | 8 | 10 | 6 | 2 |
| 5 | 90 | 20 | 0 | 2 | 0 | 0 | 4 | 2 | 4 | 2 | 6 | 4 | 2 | 2 | 4 | 6 |
| 5 | 90 | 20 | 0 | 3 | 0 | 0 | 2 | 2 | 0 | 8 | 0 | 2 | 4 | 4 | 0 | 0 |
| 5 | 90 | 20 | 0 | 4 | 0 | 0 | 5 | 0 | 0 | 4 | 2 | 2 | 10 | 0 | 8 | 4 |
| 5 | 90 | 20 | 0 | 5 | 5 | 6 | 0 | 0 | 0 | 4 | 0 | 0 | 4 | 2 | 10 | 6 |
| 5 | 90 | 20 | 0 | 6 | 8 | 0 | 0 | 0 | 0 | 2 | 4 | 2 | 4 | 2 | 6 | 4 |
| 5 | 90 | 20 | 0 | 7 | 0 | 4 | 2 | 2 | 0 | 4 | 6 | 6 | 6 | 8 | 10 | 4 |
| 5 | 90 | 20 | 0 | 8 | 0 | 0 | 6 | 2 | 0 | 2 | 2 | 8 | 6 | 2 | 2 | 6 |
| 5 | 90 | 20 | 0 | 9 | 5 | 0 | 0 | 2 | 0 | 2 | 2 | 5 | 6 | 6 | 2 | 4 |
| 5 | 90 | 20 | 0 | 10 | 0 | 4 | 0 | 2 | 6 | 0 | 4 | 4 | 4 | 8 | 4 | 4 |
| 5 | 90 | 20 | 0 | 11 | 4 | 0 | 2 | 2 | 0 | 0 | 0 | 11 | 10 | 0 | 2 | 0 |
| 5 | 90 | 20 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 4 | 2 | 4 | 2 | 0 |
| 5 | 90 | 20 | 0 | 13 | 4 | 2 | 0 | 0 | 0 | 4 | 2 | 2 | 2 | 6 | 2 | 2 |
| 5 | 90 | 20 | 0 | 14 | 5 | 0 | 6 | 2 | 5 | 7 | 10 | 0 | 6 | 2 | 2 | 8 |
| 5 | 90 | 20 | 0 | 15 | 0 | 0 | 2 | 0 | 0 | 4 | 5 | 4 | 0 | 0 | 4 | 6 |
| 5 | 90 | 20 | 0 | 16 | 6 | 4 | 2 | 2 | 0 | 2 | 4 | 6 | 12 | | 8 | |
| 5 | 90 | 20 | 0 | 17 | 0 | 4 | 0 | 0 | 8 | 0 | 6 | 5 | 4 | | 8 | |
| 5 | 90 | 20 | 0 | 18 | 0 | 0 | 2 | 2 | 2 | 6 | 10 | 4 | 4 | | 0 | |
| 5 | 90 | 20 | 0 | 19 | 0 | 4 | 2 | 4 | 6 | 6 | 14 | 2 | 6 | | 7 | |
| 5 | 90 | 20 | 0 | 20 | 4 | 0 | 0 | 4 | 8 | 6 | 4 | 2 | 2 | | 4 | |
| 5 | 90 | 20 | 0 | 21 | 0 | 0 | 4 | 2 | 0 | 2 | 4 | 4 | 6 | | 10 | |
| 5 | 90 | 20 | 0 | 22 | 6 | 0 | 0 | 4 | 0 | 0 | 2 | 2 | 4 | | 10 | |
| 5 | 90 | 20 | 0 | 23 | 4 | 4 | 4 | 2 | 2 | 4 | 0 | 4 | 8 | | 2 | |
| 5 | 90 | 20 | 0 | 24 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 8 | | 8 | |
| 5 | 90 | 20 | 0 | 25 | 6 | 0 | 0 | 2 | 0 | 4 | 2 | 4 | 4 | | 2 | |
| 5 | 90 | 20 | 0 | 26 | 0 | 0 | 0 | 2 | 6 | 4 | 2 | 10 | 0 | | 2 | |
| 5 | 90 | 20 | 0 | 27 | 0 | 0 | 2 | 2 | 4 | 4 | 8 | 4 | 6 | | 6 | |
| 5 | 90 | 20 | 0 | 28 | 0 | 0 | 4 | 2 | 0 | 4 | 4 | 2 | 4 | | 4 | |
| 5 | 90 | 20 | 0 | 29 | 6 | 0 | 2 | 2 | 9 | 2 | 6 | 2 | 6 | | 4 | |
| 5 | 90 | 20 | 0 | 30 | 0 | 0 | 2 | 0 | 0 | 4 | 4 | 2 | 8 | | 6 | |

| SCHEDULE | OBJECTIVE FUNC. COEFFICIENTS | | | SAMPLING | 1Top3 | 1SOF | 1IP | 1FL | 1Top3 1SOF | 1IP 1FL | 1IP 1FL 1P | 2 IP 1FL | 1 IP 2 FL 1P | 1 IP 2 FL 1P | 2IP 1FL 1P | 2IP 1FL 1P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 30 | 60 | 0 | 1 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 10 | 3 | 4 | 0 |
| 6 | 30 | 60 | 0 | 2 | 6 | 0 | 0 | 2 | 4 | 2 | 8 | 4 | 6 | 2 | 2 | 2 |
| 6 | 30 | 60 | 0 | 3 | 0 | 0 | 0 | 2 | 3 | 8 | 8 | 2 | 6 | 8 | 0 | 9 |
| 6 | 30 | 60 | 0 | 4 | 3 | 0 | 4 | 0 | 2 | 4 | 0 | 2 | 6 | 14 | 6 | 8 |
| 6 | 30 | 60 | 0 | 5 | 6 | 0 | 0 | 2 | 0 | 4 | 2 | 6 | 10 | 6 | 8 | 2 |
| 6 | 30 | 60 | 0 | 6 | 0 | 0 | 0 | 2 | 0 | 4 | 7 | 2 | 2 | 4 | 14 | 0 |
| 6 | 30 | 60 | 0 | 7 | 0 | 6 | 2 | 0 | 0 | 6 | 2 | 4 | 4 | 0 | 2 | 2 |
| 6 | 30 | 60 | 0 | 8 | 6 | 0 | 7 | 2 | 0 | 2 | 4 | 6 | 4 | 10 | 10 | 2 |
| 6 | 30 | 60 | 0 | 9 | 6 | 0 | 0 | 2 | 4 | 4 | 2 | 8 | 2 | 5 | 4 | 5 |
| 6 | 30 | 60 | 0 | 10 | 0 | 0 | 0 | 2 | 6 | 4 | 8 | 6 | 10 | 2 | 2 | 6 |
| 6 | 30 | 60 | 0 | 11 | 4 | 0 | 0 | 2 | 0 | 2 | 0 | 12 | 6 | 2 | 6 | 4 |
| 6 | 30 | 60 | 0 | 12 | 0 | 0 | 0 | 7 | 0 | 2 | 0 | 4 | 2 | 6 | 4 | 8 |
| 6 | 30 | 60 | 0 | 13 | 4 | 2 | 0 | 0 | 0 | 4 | 4 | 8 | 0 | 6 | 4 | 0 |
| 6 | 30 | 60 | 0 | 14 | 6 | 0 | 5 | 2 | 6 | 4 | 4 | 6 | 15 | 2 | 3 | 13 |
| 6 | 30 | 60 | 0 | 15 | 0 | 0 | 0 | 0 | 6 | 4 | 4 | 2 | 6 | 10 | 10 | 2 |

| SCHEDULE | OBJECTIVE FUNC. COEFFICIENTS | | | SAMPLING | 1Top3 | 1SOF | 1IP | 1FL | 1Top3 1SOF | 1IP 1FL | 1IP 1FL 1P | 2 IP 1FL | 1 IP 2 FL 1P | 1 IP 2 FL 1P | 2IP 1FL 1P | 2IP 1FL 1P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 70 | 70 | 0 | 1 | 0 | 0 | 3 | 3 | 6 | 0 | 4 | 8 | 8 | 12 | 3 | 4 |
| 7 | 70 | 70 | 0 | 2 | 0 | 0 | 4 | 1 | 8 | 6 | 6 | 6 | 10 | 8 | 3 | 7 |
| 7 | 70 | 70 | 0 | 3 | 0 | 0 | 0 | 2 | 5 | 10 | 3 | 6 | 9 | 10 | 2 | 8 |
| 7 | 70 | 70 | 0 | 4 | 5 | 0 | 0 | 0 | 4 | 0 | 2 | 5 | 8 | 7 | 1 | 2 |
| 7 | 70 | 70 | 0 | 5 | 0 | 0 | 2 | 1 | 0 | 4 | 2 | 3 | 7 | 8 | 4 | 4 |
| 7 | 70 | 70 | 0 | 6 | 0 | 0 | 2 | 4 | 4 | 6 | 2 | 1 | 3 | 6 | 6 | 10 |
| 7 | 70 | 70 | 0 | 7 | 0 | 4 | 2 | 4 | 0 | 4 | 3 | 3 | 4 | 6 | 6 | 8 |
| 7 | 70 | 70 | 0 | 8 | 0 | 0 | 4 | 0 | 7 | 2 | 2 | 3 | 4 | 13 | 7 | 5 |
| 7 | 70 | 70 | 0 | 9 | 0 | 0 | 0 | 2 | 6 | 0 | 2 | 2 | 3 | 12 | 6 | 4 |
| 7 | 70 | 70 | 0 | 10 | 0 | 0 | 0 | 2 | 0 | 6 | 6 | 8 | 6 | 5 | 4 | 1 |
| 7 | 70 | 70 | 0 | 11 | 0 | 0 | 0 | 2 | 4 | 2 | 0 | 2 | 6 | 2 | 2 | 8 |
| 7 | 70 | 70 | 0 | 12 | 0 | 0 | 0 | 4 | 0 | 2 | 6 | 7 | 2 | 8 | 2 | 3 |
| 7 | 70 | 70 | 0 | 13 | 0 | 2 | 2 | 0 | 4 | 2 | 0 | 14 | 4 | 7 | 3 | 2 |
| 7 | 70 | 70 | 0 | 14 | 0 | 0 | 0 | 2 | 0 | 4 | 2 | 7 | 3 | 2 | 4 | 10 |
| 7 | 70 | 70 | 0 | 15 | 4 | 0 | 0 | 4 | 0 | 2 | 0 | 4 | 2 | 7 | 4 | 6 |

| SCHEDULE | OBJECTIVE FUNC. COEFFICIENTS | | | SAMPLING | 1Top3 | 1SOF | 1IP | 1FL | 1Top3 1SOF | 1IP 1FL | 1IP 1FL 1P | 2 IP 1FL | 1 IP 2 FL 1P | 1 IP 2 FL 1P | 2IP 1FL 1P | 2IP 1FL 1P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 0 | 0 | 50 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 10 | 10 | 4 | 6 | 0 |
| 8 | 0 | 0 | 50 | 2 | 0 | 0 | 6 | 0 | 2 | 0 | 4 | 0 | 2 | 6 | 2 | 4 |
| 8 | 0 | 0 | 50 | 3 | 6 | 0 | 0 | 0 | 0 | 2 | 4 | 4 | 4 | 4 | 2 | 2 |
| 8 | 0 | 0 | 50 | 4 | 0 | 0 | 2 | 2 | 8 | 0 | 6 | 0 | 2 | 0 | 0 | 4 |
| 8 | 0 | 0 | 50 | 5 | 5 | 0 | 2 | 0 | 6 | 2 | 4 | 2 | 0 | 4 | 2 | 8 |
| 8 | 0 | 0 | 50 | 6 | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 0 | 4 | 4 | 6 | 2 |
| 8 | 0 | 0 | 50 | 7 | 0 | 2 | 2 | 0 | 6 | 2 | 2 | 4 | 2 | 8 | 4 | 2 |
| 8 | 0 | 0 | 50 | 8 | 0 | 0 | 2 | 0 | 6 | 0 | 2 | 2 | 0 | 2 | 2 | 0 |
| 8 | 0 | 0 | 50 | 9 | 5 | 0 | 0 | 0 | 0 | 2 | 0 | 4 | 2 | 6 | 6 | 4 |
| 8 | 0 | 0 | 50 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 2 | 2 | 2 | 2 |
| 8 | 0 | 0 | 50 | 11 | 4 | 0 | 2 | 0 | 0 | 2 | 6 | 2 | 0 | 6 | 2 | 2 |
| 8 | 0 | 0 | 50 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 4 | 2 | 0 | 0 |
| 8 | 0 | 0 | 50 | 13 | 4 | 0 | 0 | 2 | 5 | 0 | 4 | 6 | 6 | 0 | 0 | 4 |
| 8 | 0 | 0 | 50 | 14 | 5 | 0 | 0 | 0 | 5 | 2 | 0 | 0 | 2 | 4 | 2 | 2 |
| 8 | 0 | 0 | 50 | 15 | 5 | 0 | 2 | 0 | 0 | 2 | 4 | 12 | 4 | 4 | 6 | 0 |
| 8 | 0 | 0 | 50 | 16 | 0 | 2 | 2 | 0 | 0 | 6 | 2 | 2 | 2 | | 4 | |
| 8 | 0 | 0 | 50 | 17 | 6 | 2 | 0 | 2 | 4 | 6 | 2 | 2 | 2 | | 4 | |
| 8 | 0 | 0 | 50 | 18 | 0 | 0 | 2 | 0 | 0 | 0 | 4 | 8 | 2 | | 8 | |
| 8 | 0 | 0 | 50 | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 2 | 6 | | 6 | |
| 8 | 0 | 0 | 50 | 20 | 4 | 2 | 2 | 0 | 0 | 2 | 4 | 0 | 4 | | 2 | |
| 8 | 0 | 0 | 50 | 21 | 0 | 0 | 0 | 0 | 6 | 4 | 6 | 10 | 6 | | 6 | |
| 8 | 0 | 0 | 50 | 22 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 6 | 2 | | 2 | |
| 8 | 0 | 0 | 50 | 23 | 4 | 2 | 6 | 0 | 6 | 0 | 2 | 7 | 2 | | 8 | |
| 8 | 0 | 0 | 50 | 24 | 0 | 0 | 2 | 0 | 0 | 2 | 4 | 2 | 8 | | 4 | |
| 8 | 0 | 0 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 4 | 10 | | 2 | |
| 8 | 0 | 0 | 50 | 26 | 6 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | | 0 | |
| 8 | 0 | 0 | 50 | 27 | 5 | 0 | 2 | 0 | 0 | 8 | 2 | 2 | 2 | | 6 | |
| 8 | 0 | 0 | 50 | 28 | 6 | 0 | 2 | 2 | 6 | 2 | 0 | 4 | 4 | | 2 | |
| 8 | 0 | 0 | 50 | 29 | 0 | 0 | 0 | 0 | 7 | 0 | 2 | 4 | 2 | | 0 | |

| SCHEDULE | OBJECTIVE FUNC. COEFFICIENTS | | | SAMPLING | 1Top3 | 1SOF | 1IP | 1FL | 1Top3 1SOF | 1IP 1FL | 1IP 1FL 1P | 2 IP 1FL | 1 IP 2 FL 1P | 1 IP 2 FL 1P | 2IP 1FL 1P | 2IP 1FL 1P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 0 | 30 | 0 | 1 | 6 | 0 | 3 | 4 | 0 | 0 | 0 | 2 | 6 | 6 | 8 | 2 |
| 9 | 0 | 30 | 0 | 2 | 0 | 0 | 4 | 2 | 0 | 2 | 4 | 2 | 10 | 2 | 4 | 8 |
| 9 | 0 | 30 | 0 | 3 | 0 | 0 | 0 | 2 | 4 | 8 | 0 | 2 | 8 | 4 | 4 | 10 |
| 9 | 0 | 30 | 0 | 4 | 4 | 0 | 6 | 0 | 2 | 4 | 0 | 2 | 6 | 2 | 12 | 4 |
| 9 | 0 | 30 | 0 | 5 | 0 | 0 | 0 | 5 | 0 | 2 | 4 | 2 | 4 | 7 | 2 | 8 |
| 9 | 0 | 30 | 0 | 6 | 0 | 0 | 0 | 2 | 0 | 2 | 4 | 2 | 7 | 8 | 8 | 4 |
| 9 | 0 | 30 | 0 | 7 | 8 | 0 | 2 | 2 | 0 | 6 | 0 | 2 | 4 | 4 | 6 | 4 |
| 9 | 0 | 30 | 0 | 8 | 0 | 0 | 4 | 2 | 0 | 2 | 6 | 2 | 4 | 6 | 4 | 6 |
| 9 | 0 | 30 | 0 | 9 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 2 | 2 | 2 | 6 | 2 |
| 9 | 0 | 30 | 0 | 10 | 0 | 0 | 0 | 2 | 6 | 6 | 4 | 2 | 6 | 9 | 4 | 5 |
| 9 | 0 | 30 | 0 | 11 | 3 | 0 | 0 | 2 | 0 | 2 | 0 | 12 | 4 | 8 | 4 | 8 |
| 9 | 0 | 30 | 0 | 12 | 8 | 0 | 4 | 4 | 8 | 2 | 0 | 2 | 2 | 4 | 6 | 0 |
| 9 | 0 | 30 | 0 | 13 | 3 | 0 | 0 | 0 | 4 | 2 | 0 | 6 | 0 | 10 | 4 | 0 |
| 9 | 0 | 30 | 0 | 14 | 0 | 0 | 0 | 2 | 0 | 6 | 0 | 7 | 0 | 2 | 0 | 6 |
| 9 | 0 | 30 | 0 | 15 | 4 | 0 | 0 | 0 | 0 | 4 | 6 | 4 | 2 | 4 | 4 | 4 |

| SCHEDULE | OBJECTIVE FUNC. COEFFICIENTS | | | SAMPLING | 1Top3 | 1SOF | 1IP | 1FL | 1Top3 1SOF | 1IP 1FL | 1IP 1FL 1P | 2 IP 1FL | 1 IP 2 FL 1P | 1 IP 2 FL 1P | 2IP 1FL 1P | 2IP 1FL 1P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 90 | 0 | 0 | 1 | 0 | 0 | 0 | 4 | 0 | 0 | 4 | 6 | 7 | 4 | 6 | 2 |
| 10 | 90 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 2 | 2 | 4 | 6 | 6 | 0 | 10 | 6 |
| 10 | 90 | 0 | 0 | 3 | 8 | 0 | 0 | 0 | 0 | 4 | 10 | 6 | 4 | 2 | 4 | 2 |
| 10 | 90 | 0 | 0 | 4 | 0 | 0 | 2 | 0 | 10 | 4 | 0 | 2 | 6 | 6 | 6 | 6 |
| 10 | 90 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 8 | 4 | 2 | 7 | 6 | 6 | 2 | 4 |
| 10 | 90 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 4 | 8 | 10 | 10 | 8 |
| 10 | 90 | 0 | 0 | 7 | 6 | 6 | 2 | 0 | 8 | 5 | 0 | 4 | 4 | 2 | 4 | 8 |
| 10 | 90 | 0 | 0 | 8 | 0 | 0 | 4 | 2 | 0 | 2 | 3 | 2 | 4 | 0 | 6 | 6 |
| 10 | 90 | 0 | 0 | 9 | 0 | 0 | 0 | 2 | 6 | 0 | 2 | 2 | 4 | 8 | 8 | 8 |
| 10 | 90 | 0 | 0 | 10 | 6 | 4 | 2 | 2 | 0 | 4 | 0 | 2 | 4 | 8 | 8 | 6 |
| 10 | 90 | 0 | 0 | 11 | 4 | 0 | 0 | 2 | 0 | 0 | 6 | 6 | 2 | 0 | 4 | 10 |
| 10 | 90 | 0 | 0 | 12 | 6 | 0 | 0 | 0 | 6 | 2 | 6 | 4 | 4 | 4 | 5 | 6 |
| 10 | 90 | 0 | 0 | 13 | 4 | 2 | 0 | 4 | 5 | 0 | 4 | 8 | 0 | 6 | 2 | 6 |
| 10 | 90 | 0 | 0 | 14 | 0 | 0 | 0 | 2 | 0 | 2 | 4 | 8 | 6 | 2 | 6 | 13 |
| 10 | 90 | 0 | 0 | 15 | 5 | 0 | 2 | 0 | 0 | 4 | 2 | 2 | 0 | 6 | 6 | 4 |

| SCHEDULE | OBJECTIVE FUNC. COEFFICIENTS | | | SAMPLING | 1Top3 | 1SOF | 1IP | 1FL | 1Top3 1SOF | 1IP 1FL | 1IP 1FL 1P | 2 IP 1FL | 1 IP 2 FL 1P | 1 IP 2 FL 1P | 2IP 1FL 1P | 2IP 1FL 1P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 30 | 30 | 30 | 1 | 0 | 0 | 0 | 2 | 0 | 2 | 8 | 5 | 0 | 6 | 4 | 4 |
| 11 | 30 | 30 | 30 | 2 | 0 | 0 | 3 | 2 | 2 | 2 | 2 | 6 | 8 | 2 | 4 | 4 |
| 11 | 30 | 30 | 30 | 3 | 0 | 0 | 0 | 0 | 3 | 6 | 7 | 6 | 12 | 4 | 7 | 2 |
| 11 | 30 | 30 | 30 | 4 | 3 | 0 | 4 | 2 | 2 | 2 | 4 | 0 | 0 | 4 | 2 | 4 |
| 11 | 30 | 30 | 30 | 5 | 3 | 0 | 4 | 2 | 0 | 2 | 0 | 4 | 0 | 4 | 2 | 7 |
| 11 | 30 | 30 | 30 | 6 | 0 | 0 | 0 | 4 | 0 | 4 | 0 | 0 | 4 | 4 | 6 | 6 |
| 11 | 30 | 30 | 30 | 7 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 4 | 2 | 6 |
| 11 | 30 | 30 | 30 | 8 | 0 | 0 | 6 | 2 | 3 | 2 | 2 | 2 | 6 | 0 | 0 | 2 |
| 11 | 30 | 30 | 30 | 9 | 3 | 0 | 0 | 2 | 0 | 4 | 2 | 6 | 2 | 6 | 2 | 4 |
| 11 | 30 | 30 | 30 | 10 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 7 | 10 | 6 | 4 | 5 |
| 11 | 30 | 30 | 30 | 11 | 3 | 0 | 0 | 2 | 0 | 0 | 4 | 3 | 4 | 2 | 2 | 6 |
| 11 | 30 | 30 | 30 | 12 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 4 | 10 | 4 | 2 | 0 |
| 11 | 30 | 30 | 30 | 13 | 3 | 2 | 0 | 6 | 3 | 2 | 6 | 14 | 10 | 6 | 0 | 2 |
| 11 | 30 | 30 | 30 | 14 | 3 | 0 | 0 | 2 | 3 | 4 | 2 | 9 | 0 | 8 | 0 | 8 |
| 11 | 30 | 30 | 30 | 15 | 3 | 0 | 0 | 0 | 0 | 2 | 6 | 6 | 4 | 0 | 5 | 2 |

| SCHEDULE | OBJECTIVE FUNC. COEFFICIENTS | | | SAMPLING | 1Top3 | 1SOF | 1IP | 1FL | 1Top3 1SOF | 1IP 1FL | 1IP 1FL 1P | 2 IP 1FL | 1 IP 2 FL 1P | 1 IP 2 FL 1P | 2IP 1FL 1P | 2IP 1FL 1P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 80 | 70 | 70 | 1 | 6 | 0 | 0 | 0 | 6 | 6 | 2 | 4 | 4 | 9 | 6 | 2 |
| 12 | 80 | 70 | 70 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 2 | 8 | 6 |
| 12 | 80 | 70 | 70 | 3 | 0 | 0 | 2 | 0 | 4 | 5 | 2 | 2 | 0 | 2 | 6 | 6 |
| 12 | 80 | 70 | 70 | 4 | 4 | 0 | 0 | 0 | 4 | 2 | 0 | 8 | 13 | 2 | 2 | 0 |
| 12 | 80 | 70 | 70 | 5 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 4 | 2 | 4 | 2 | 4 |
| 12 | 80 | 70 | 70 | 6 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 4 | 4 | 2 | 2 | 4 |
| 12 | 80 | 70 | 70 | 7 | 6 | 2 | 2 | 0 | 0 | 4 | 2 | 2 | 2 | 4 | 8 | 2 |
| 12 | 80 | 70 | 70 | 8 | 0 | 0 | 0 | 0 | 0 | 6 | 10 | 0 | 6 | 2 | 4 | 4 |
| 12 | 80 | 70 | 70 | 9 | 0 | 0 | 0 | 0 | 2 | 8 | 6 | 2 | 2 | 2 | 4 | 8 |
| 12 | 80 | 70 | 70 | 10 | 0 | 2 | 2 | 0 | 6 | 2 | 0 | 0 | 8 | 4 | 4 | 0 |
| 12 | 80 | 70 | 70 | 11 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 4 | 6 | 0 |
| 12 | 80 | 70 | 70 | 12 | 6 | 2 | 4 | 0 | 6 | 6 | 6 | 4 | 8 | 4 | 6 | 8 |
| 12 | 80 | 70 | 70 | 13 | 0 | 2 | 0 | 0 | 4 | 0 | 4 | 4 | 2 | 8 | 2 | 10 |
| 12 | 80 | 70 | 70 | 14 | 0 | 2 | 6 | 0 | 0 | 0 | 9 | 2 | 8 | 8 | 6 | 9 |
| 12 | 80 | 70 | 70 | 15 | 4 | 0 | 0 | 2 | 6 | 2 | 0 | 2 | 9 | 2 | 2 | 6 |
| 12 | 80 | 70 | 70 | 16 | 6 | 0 | 2 | 0 | 0 | 0 | 4 | 0 | 5 | | 6 | |
| 12 | 80 | 70 | 70 | 17 | 0 | 0 | 2 | 0 | 2 | 2 | 5 | 2 | 2 | | 2 | |
| 12 | 80 | 70 | 70 | 18 | 0 | 0 | 0 | 0 | 8 | 2 | 7 | 5 | 2 | | 2 | |
| 12 | 80 | 70 | 70 | 19 | 0 | 2 | 4 | 5 | 6 | 4 | 2 | 0 | 2 | | 6 | |
| 12 | 80 | 70 | 70 | 20 | 0 | 4 | 2 | 2 | 0 | 2 | 4 | 0 | 4 | | 6 | |
| 12 | 80 | 70 | 70 | 21 | 4 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 0 | | 0 | |
| 12 | 80 | 70 | 70 | 22 | 6 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 2 | | 10 | |
| 12 | 80 | 70 | 70 | 23 | 0 | 0 | 6 | 0 | 0 | 0 | 2 | 5 | 8 | | 8 | |
| 12 | 80 | 70 | 70 | 24 | 0 | 0 | 2 | 0 | 2 | 0 | 6 | 2 | 2 | | 8 | |
| 12 | 80 | 70 | 70 | 25 | 6 | 0 | 4 | 0 | 0 | 2 | 2 | 2 | 2 | | 0 | |
| 12 | 80 | 70 | 70 | 26 | 0 | 0 | 2 | 0 | 6 | 2 | 0 | 2 | 0 | | 8 | |
| 12 | 80 | 70 | 70 | 27 | 4 | 0 | 0 | 0 | 6 | 0 | 12 | 4 | 9 | | 7 | |
| 12 | 80 | 70 | 70 | 28 | 0 | 2 | 0 | 0 | 0 | 2 | 2 | 2 | 8 | | 6 | |
| 12 | 80 | 70 | 70 | 29 | 6 | 0 | 2 | 0 | 0 | 2 | 2 | 0 | 10 | | 6 | |
| 12 | 80 | 70 | 70 | 30 | 4 | 0 | 0 | 2 | 6 | 2 | 5 | 0 | 8 | | 2 | |

| SCHEDULE | OBJECTIVE FUNC. COEFFICIENTS | | | SAMPLING | 1Top3 | 1SOF | 1IP | 1FL | 1Top3 1SOF | 1IP 1FL | 1IP 1FL 1P | 2 IP 1FL | 1 IP 2 FL 1P | 1 IP 2 FL 1P | 2IP 1FL 1P | 2IP 1FL 1P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | 30 | 100 | 30 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 6 | 4 | 8 | 8 | 0 |
| 13 | 30 | 100 | 30 | 2 | 0 | 0 | 2 | 2 | 2 | 2 | 2 | 4 | 4 | 8 | 2 | 0 |
| 13 | 30 | 100 | 30 | 3 | 4 | 0 | 0 | 0 | 0 | 8 | 8 | 2 | 4 | 5 | 3 | 3 |
| 13 | 30 | 100 | 30 | 4 | 0 | 0 | 2 | 0 | 6 | 2 | 4 | 4 | 4 | 6 | 4 | 2 |
| 13 | 30 | 100 | 30 | 5 | 4 | 0 | 2 | 6 | 4 | 6 | 2 | 4 | 2 | 4 | 2 | 2 |
| 13 | 30 | 100 | 30 | 6 | 0 | 0 | 0 | 4 | 0 | 2 | 4 | 2 | 0 | 8 | 4 | 8 |
| 13 | 30 | 100 | 30 | 7 | 0 | 0 | 0 | 0 | 4 | 2 | 2 | 4 | 4 | 6 | 2 | 4 |
| 13 | 30 | 100 | 30 | 8 | 0 | 0 | 3 | 2 | 3 | 2 | 2 | 2 | 6 | 5 | 2 | 0 |
| 13 | 30 | 100 | 30 | 9 | 4 | 0 | 0 | 2 | 0 | 4 | 2 | 0 | 6 | 6 | 2 | 4 |
| 13 | 30 | 100 | 30 | 10 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 8 | 12 | 4 | 4 | 10 |
| 13 | 30 | 100 | 30 | 11 | 4 | 0 | 2 | 2 | 0 | 2 | 4 | 2 | 8 | 4 | 4 | 2 |
| 13 | 30 | 100 | 30 | 12 | 0 | 0 | 0 | 3 | 0 | 2 | 2 | 4 | 5 | 12 | 2 | 2 |
| 13 | 30 | 100 | 30 | 13 | 4 | 2 | 0 | 0 | 4 | 2 | 2 | 13 | 6 | 4 | 2 | 6 |
| 13 | 30 | 100 | 30 | 14 | 4 | 0 | 0 | 2 | 4 | 2 | 4 | 2 | 4 | 5 | 2 | 14 |
| 13 | 30 | 100 | 30 | 15 | 4 | 0 | 0 | 2 | 0 | 2 | 2 | 6 | 6 | 4 | 6 | 2 |

| SCHEDULE | OBJECTIVE FUNC. COEFFICIENTS | | | SAMPLING | 1Top3 | 1SOF | 1IP | 1FL | 1Top3 1SOF | 1IP 1FL | 1IP 1FL 1P | 2 IP 1FL | 1 IP 2 FL 1P | 1 IP 2 FL 1P | 2IP 1FL 1P | 2IP 1FL 1P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 | 40 | 40 | 60 | 1 | 0 | 0 | 0 | 0 | 6 | 2 | 4 | 2 | 8 | 4 | 2 | 12 |
| 14 | 40 | 40 | 60 | 2 | 6 | 0 | 0 | 0 | 6 | 5 | 4 | 2 | 2 | 10 | 6 | 6 |
| 14 | 40 | 40 | 60 | 3 | 0 | 2 | 0 | 0 | 8 | 8 | 6 | 2 | 0 | 3 | 4 | 4 |
| 14 | 40 | 40 | 60 | 4 | 8 | 0 | 0 | 0 | 0 | 2 | 5 | 4 | 12 | 2 | 3 | 4 |
| 14 | 40 | 40 | 60 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 5 | 2 | 4 | 2 |
| 14 | 40 | 40 | 60 | 6 | 0 | 0 | 2 | 0 | 6 | 4 | 0 | 2 | 6 | 6 | 4 | 11 |
| 14 | 40 | 40 | 60 | 7 | 0 | 0 | 2 | 4 | 2 | 6 | 5 | 2 | 3 | 6 | 5 | 0 |
| 14 | 40 | 40 | 60 | 8 | 6 | 0 | 4 | 0 | 0 | 0 | 6 | 4 | 2 | 4 | 4 | 4 |
| 14 | 40 | 40 | 60 | 9 | 0 | 0 | 4 | 0 | 6 | 0 | 0 | 2 | 4 | 4 | 4 | 4 |
| 14 | 40 | 40 | 60 | 10 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 2 |
| 14 | 40 | 40 | 60 | 11 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 6 | 4 | 0 | 2 |
| 14 | 40 | 40 | 60 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 4 | 4 | 3 | 0 | 0 |
| 14 | 40 | 40 | 60 | 13 | 0 | 0 | 0 | 0 | 0 | 2 | 8 | 0 | 7 | 0 | 2 | 9 |
| 14 | 40 | 40 | 60 | 14 | 0 | 0 | 4 | 0 | 0 | 3 | 7 | 0 | 4 | 6 | 2 | 10 |
| 14 | 40 | 40 | 60 | 15 | 0 | 0 | 0 | 2 | 6 | 2 | 0 | 3 | 2 | 4 | 4 | 4 |
| 14 | 40 | 40 | 60 | 16 | 0 | 0 | 0 | 0 | 6 | 0 | 2 | 0 | 8 | | 8 | |
| 14 | 40 | 40 | 60 | 17 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 0 | 4 | | 2 | |
| 14 | 40 | 40 | 60 | 18 | 6 | 0 | 0 | 0 | 6 | 4 | 6 | 5 | 2 | | 6 | |
| 14 | 40 | 40 | 60 | 19 | 6 | 0 | 0 | 2 | 0 | 3 | 6 | 0 | 12 | | 4 | |
| 14 | 40 | 40 | 60 | 20 | 0 | 0 | 2 | 3 | 0 | 2 | 8 | 7 | 6 | | 0 | |
| 14 | 40 | 40 | 60 | 21 | 8 | 0 | 2 | 0 | 6 | 0 | 2 | 2 | 6 | | 0 | |
| 14 | 40 | 40 | 60 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | | 13 | |
| 14 | 40 | 40 | 60 | 23 | 0 | 0 | 0 | 4 | 0 | 3 | 2 | 2 | 10 | | 2 | |
| 14 | 40 | 40 | 60 | 24 | 6 | 0 | 0 | 0 | 6 | 0 | 5 | 2 | 4 | | 7 | |
| 14 | 40 | 40 | 60 | 25 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 12 | | 8 | |
| 14 | 40 | 40 | 60 | 26 | 0 | 2 | 2 | 0 | 0 | 2 | 0 | 5 | 2 | | 0 | |
| 14 | 40 | 40 | 60 | 27 | 0 | 0 | 0 | 0 | 10 | 2 | 2 | 2 | 2 | | 4 | |
| 14 | 40 | 40 | 60 | 28 | 0 | 0 | 2 | 6 | 0 | 3 | 0 | 4 | 7 | | 4 | |
| 14 | 40 | 40 | 60 | 29 | 0 | 2 | 0 | 4 | 0 | 2 | 5 | 2 | 6 | | 2 | |
| 14 | 40 | 40 | 60 | 30 | 0 | 0 | 2 | 0 | 6 | 2 | 2 | 6 | 2 | | 4 | |

| SCHEDULE | OBJECTIVE FUNC. COEFFICIENTS | | | SAMPLING | 1Top3 | 1 SOF | 1 IP | 1 FL | 1Top3 1SOF | 1IP 1FL | 1IP 1FL 1P | 2 IP 1FL | 1 IP 2 FL 1 P | 1 IP 2 FL 1 P | 2 IP 1FL 1P | 2 IP 1FL 1P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 100 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 6 | 10 | 4 | 4 | 2 |
| 15 | 100 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 11 | 2 | 4 | 2 | 10 | 0 | 8 | 6 |
| 15 | 100 | 0 | 0 | 3 | 0 | 0 | 2 | 3 | 6 | 10 | 6 | 2 | 2 | 0 | 6 | 4 |
| 15 | 100 | 0 | 0 | 4 | 6 | 0 | 0 | 0 | 0 | 2 | 0 | 6 | 8 | 10 | 6 | 4 |
| 15 | 100 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 4 | 2 | 4 | 2 | 4 | 6 | 2 |
| 15 | 100 | 0 | 0 | 6 | 0 | 0 | 2 | 4 | 6 | 0 | 0 | 2 | 4 | 10 | 6 | 7 |
| 15 | 100 | 0 | 0 | 7 | 0 | 0 | 2 | 0 | 0 | 6 | 5 | 4 | 2 | 2 | 2 | 4 |
| 15 | 100 | 0 | 0 | 8 | 0 | 0 | 2 | 2 | 4 | 4 | 4 | 6 | 6 | 6 | 6 | 6 |
| 15 | 100 | 0 | 0 | 9 | 0 | 0 | 0 | 2 | 8 | 2 | 4 | 2 | 2 | 6 | 10 | 4 |
| 15 | 100 | 0 | 0 | 10 | 0 | 4 | 2 | 2 | 0 | 4 | 0 | 2 | 8 | 6 | 6 | 12 |
| 15 | 100 | 0 | 0 | 11 | 0 | 0 | 0 | 2 | 6 | 2 | 4 | 4 | 4 | 0 | 6 | 6 |
| 15 | 100 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 8 | 8 | 9 | 2 | 6 |
| 15 | 100 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 5 | 0 | 2 | 8 | 0 | 10 | 4 | 4 |
| 15 | 100 | 0 | 0 | 14 | 0 | 0 | 0 | 2 | 0 | 0 | 5 | 4 | 5 | 2 | 4 | 6 |
| 15 | 100 | 0 | 0 | 15 | 5 | 0 | 0 | 4 | 0 | 4 | 0 | 3 | 2 | 4 | 4 | 4 |
| 15 | 100 | 0 | 0 | 16 | 0 | 5 | 0 | 2 | 6 | 0 | 4 | 6 | 0 | | 0 | |
| 15 | 100 | 0 | 0 | 17 | 0 | 5 | 0 | 0 | 4 | 2 | 0 | 4 | 4 | | 0 | |
| 15 | 100 | 0 | 0 | 18 | 0 | 0 | 0 | 2 | 0 | 3 | 8 | 0 | 4 | | 6 | |
| 15 | 100 | 0 | 0 | 19 | 6 | 4 | 4 | 4 | 0 | 5 | 2 | 10 | 2 | | 4 | |
| 15 | 100 | 0 | 0 | 20 | 0 | 0 | 2 | 3 | 0 | 4 | 2 | 0 | 11 | | 4 | |
| 15 | 100 | 0 | 0 | 21 | 6 | 0 | 2 | 3 | 6 | 2 | 0 | 3 | 2 | | 2 | |
| 15 | 100 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 6 | 2 | 4 | 4 | | 0 | |
| 15 | 100 | 0 | 0 | 23 | 0 | 5 | 2 | 0 | 2 | 2 | 3 | 2 | 4 | | 4 | |
| 15 | 100 | 0 | 0 | 24 | 0 | 2 | 0 | 2 | 6 | 2 | 0 | 4 | 6 | | 4 | |
| 15 | 100 | 0 | 0 | 25 | 0 | 0 | 2 | 4 | 6 | 4 | 4 | 7 | 6 | | 5 | |
| 15 | 100 | 0 | 0 | 26 | 0 | 0 | 2 | 2 | 0 | 2 | 0 | 5 | 2 | | 4 | |
| 15 | 100 | 0 | 0 | 27 | 5 | 0 | 0 | 2 | 10 | 0 | 2 | 4 | 2 | | 6 | |
| 15 | 100 | 0 | 0 | 28 | 0 | 0 | 2 | 0 | 0 | 6 | 4 | 4 | 2 | | 4 | |
| 15 | 100 | 0 | 0 | 29 | 0 | 0 | 2 | 0 | 0 | 0 | 3 | 4 | 13 | | 8 | |
| 15 | 100 | 0 | 0 | 30 | 5 | 0 | 2 | 4 | 0 | 4 | 6 | 2 | 4 | | 4 | |

| SCHEDULE | OBJECTIVE FUNC. COEFFICIENTS | | | SAMPLING | 1Top3 | 1 SOF | 1 IP | 1 FL | 1Top3 1SOF | 1IP 1FL | 1IP 1FL 1P | 2 IP 1FL | 1 IP 2 FL 1 P | 1 IP 2 FL 1 P | 2 IP 1FL 1P | 2 IP 1FL 1P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | 100 | 0 | 50 | 1 | 6 | 0 | 3 | 0 | 0 | 4 | 4 | 6 | 6 | 2 | 3 | 3 |
| 16 | 100 | 0 | 50 | 2 | 4 | 0 | 0 | 0 | 2 | 0 | 4 | 2 | 2 | 1 | 4 | 4 |
| 16 | 100 | 0 | 50 | 3 | 0 | 0 | 2 | 0 | 0 | 6 | 0 | 6 | 6 | 0 | 2 | 2 |
| 16 | 100 | 0 | 50 | 4 | 0 | 0 | 0 | 4 | 2 | 2 | 4 | 2 | 4 | 6 | 2 | 8 |
| 16 | 100 | 0 | 50 | 5 | 0 | 0 | 0 | 6 | 0 | 2 | 8 | 0 | 2 | 2 | 4 | 4 |
| 16 | 100 | 0 | 50 | 6 | 0 | 0 | 2 | 4 | 0 | 0 | 6 | 0 | 3 | 2 | 4 | 8 |
| 16 | 100 | 0 | 50 | 7 | 6 | 2 | 2 | 0 | 0 | 2 | 6 | 8 | 0 | 8 | 4 | 0 |
| 16 | 100 | 0 | 50 | 8 | 4 | 0 | 2 | 0 | 0 | 0 | 5 | 0 | 2 | 8 | 2 | 4 |
| 16 | 100 | 0 | 50 | 9 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 2 | 0 | 6 | 4 | 6 |
| 16 | 100 | 0 | 50 | 10 | 0 | 3 | 0 | 0 | 6 | 0 | 4 | 7 | 9 | 0 | 0 | 6 |
| 16 | 100 | 0 | 50 | 11 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 5 | 0 |
| 16 | 100 | 0 | 50 | 12 | 6 | 0 | 0 | 0 | 6 | 3 | 6 | 8 | 4 | 6 | 2 | 0 |
| 16 | 100 | 0 | 50 | 13 | 0 | 2 | 2 | 0 | 0 | 0 | 4 | 8 | 2 | 0 | 2 | 4 |
| 16 | 100 | 0 | 50 | 14 | 0 | 0 | 4 | 2 | 6 | 0 | 10 | 3 | 8 | 6 | 5 | 4 |
| 16 | 100 | 0 | 50 | 15 | 0 | 0 | 2 | 4 | 4 | 2 | 4 | 4 | 0 | 0 | 10 | 2 |

| SCHEDULE | OBJECTIVE FUNC. COEFFICIENTS | | | SAMPLING | 1Top3 | 1 SOF | 1 IP | 1 FL | 1Top3 1SOF | 1IP 1FL | 1IP 1FL 1P | 2 IP 1FL | 1 IP 2 FL 1 P | 1 IP 2 FL 1 P | 2 IP 1FL 1P | 2 IP 1FL 1P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | 0 | 100 | 100 | 1 | 6 | 2 | 2 | 2 | 2 | 2 | 6 | 2 | 6 | 4 | 5 | 4 |
| 17 | 0 | 100 | 100 | 2 | 6 | 2 | 2 | 4 | 2 | 4 | 6 | 4 | 9 | 4 | 4 | 4 |
| 17 | 0 | 100 | 100 | 3 | 2 | 2 | 2 | 4 | 5 | 2 | 4 | 4 | 4 | 4 | 2 | 4 |
| 17 | 0 | 100 | 100 | 4 | 5 | 2 | 2 | 4 | 2 | 4 | 2 | 7 | 5 | 2 | 2 | 2 |
| 17 | 0 | 100 | 100 | 5 | 8 | 2 | 2 | 2 | 2 | 4 | 2 | 2 | 4 | 6 | 6 | 7 |
| 17 | 0 | 100 | 100 | 6 | 2 | 2 | 2 | 2 | 2 | 4 | 2 | 2 | 10 | 4 | 2 | 6 |
| 17 | 0 | 100 | 100 | 7 | 2 | 2 | 2 | 4 | 2 | 2 | 2 | 4 | 8 | 6 | 6 | 4 |
| 17 | 0 | 100 | 100 | 8 | 6 | 2 | 2 | 4 | 2 | 8 | 7 | 4 | 8 | 2 | 2 | 2 |
| 17 | 0 | 100 | 100 | 9 | 8 | 2 | 6 | 4 | 2 | 2 | 9 | 10 | 4 | 7 | 2 | 10 |
| 17 | 0 | 100 | 100 | 10 | 2 | 2 | 2 | 4 | 6 | 5 | 4 | 3 | 10 | 8 | 4 | 2 |
| 17 | 0 | 100 | 100 | 11 | 4 | 2 | 2 | 4 | 2 | 7 | 4 | 8 | 10 | 2 | 6 | 7 |
| 17 | 0 | 100 | 100 | 12 | 2 | 2 | 4 | 2 | 2 | 7 | 4 | 2 | 3 | 2 | 8 | 7 |
| 17 | 0 | 100 | 100 | 13 | 4 | 2 | 2 | 4 | 2 | 4 | 6 | 2 | 10 | 6 | 5 | 6 |
| 17 | 0 | 100 | 100 | 14 | 8 | 4 | 6 | 3 | 8 | 4 | 5 | 2 | 6 | 10 | 4 | 7 |
| 17 | 0 | 100 | 100 | 15 | 2 | 2 | 2 | 2 | 6 | 4 | 4 | 6 | 7 | 2 | 6 | 4 |

## Appendix F: Acronyms

**AM GO:** Daily flying schedules are broken in to three separate sections. Each section is referred to as a "Go" AM GO refers to the 1st section of the schedule and associated events.

**FL**: 4 ship Flight Lead

**IP**: Instructor Pilot

**Letter of X:** A form that shows which pilots are qualified which kind of missions for how many days

**N GO:** N GO refers to the 3rd section of the schedule and associated events.

**P:** Wingman who is not qualified to fly by himself/herself, however can be a part of a flight.

**PM GO:** Daily flying schedules are broken in to three separate sections. Each section is referred to as a "Go" PM GO refers to the 2nd section of the schedule and associated events.

**SOF:** Supervisor of Flight duty. Only SOF qualified pilots can do this duty.

**Top3:** Top3 duty. Only highest top 3 personnel are qualified to do this duty

## Appendix G: Compact Disc

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**14. ABSTRACT**
Air Force fighter aircraft squadrons the world over share a unique problem. Each requires complex training schedules coupling aircraft to pilots, the duo to missions and airspaces, and then the entire combination to a feasible time slot. Creating daily and weekly flight schedules that include shifts around the clock every day of the year with a set number of pilots is a time consuming job for manual schedulers within a squadron. If one or more pilots are unable to perform their previously assigned tasks, due to sickness or aircraft failure, those tasks must be performed by previously not scheduled pilots. These changes can not conflict with the rules of Air Force regulations, squadron policy, the squadron commander, operations officer or flight training officer's direction. Given these constraints, the goal of a new re-rostered schedule, in the event of absenteeism, should be to affect the previous schedule as little as possible. This research will develop a weekly flight schedule. The goal of this reformulated schedule is robustness to absenteeism. In order to find a robust schedule, a comparison will be done to select the most robust schedule from among 17 candidate schedules. The expected values for the number of changes for each schedule are compared, and a general conclusion will be provided using a new objective function to create a model that yields a robust schedule on the first attempt.

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