NATO Flying Training in Canada (NFTC) – Course Duration and Schedule

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Technical Report

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Abstract

Originally, the NATO Flying Training in Canada (NFTC) schedules were developed for all flight training phases until Calendar Year (CY) 2005. A1 Training officers are responsible for the creation and management of the NFTC schedules. They requested the assistance of the Operational Research and Analysis Directorate to build a new and more optimized schedule. During the first years of operation (2001-2004), NFTC has had problems graduating their students on time, especially in Phases III and IV. This was primarily caused by the inefficiencies of the method used to determine the course duration. In order to overcome these frequently occurring graduation problems, a more realistic approach was developed to determine the course duration of the serials in Phases III and IV. The new scheduling method is based on a thorough analysis of weather requirements necessary to fly each mission. This report presents the new approach and how it was integrated into a more complex model used to create all NFTC phases start/end dates until CY 2011. All the assumptions made and the different constraints faced are enumerated in the document. Finally, the report demonstrates the impacts of the new schedule on all NFTC participating nations. The impacts are expressed in terms of number of calendar days spent in Canada.

Résumé

À l'origine, les horaires de cours de toutes les phases du Programme d'Entraînement de Vol de l'OTAN au Canada (EVOC) avaient été construits jusqu'à la fin de 2005. Ce sont des officiers de A1 Instruction qui ont la responsabilité de créer et de gérer les horaires de l'EVOC. Ils ont demandé l'aide de la Direction de l'Analyse et de la Recherche Opérationnelle pour l'élaboration des nouveaux horaires. Pendant les premières années d'opérations de l'EVOC (2001-2004), le Programme a eu des problèmes à graduer les étudiants à temps, et ce, plus particulièrement pour les Phases III et IV. Ces problèmes ont surtout été causés par le fait que la méthode pour évaluer la date de fin des cours contenait plusieurs déficiences. Dans le but de remédier à ces problèmes de graduation, une nouvelle approche plus réaliste pour prédire la date de fin des cours a été développée. Celle-ci est basée sur une analyse détaillée des facteurs météorologiques requis pour voler chacune des missions. Ce rapport décrit la nouvelle approche et la façon dont elle a été intégrée dans un modèle plus complexe qui a été utilisé pour le développement des nouveaux horaires de l'EVOC jusqu'en 2011. Toutes les hypothèses émises ainsi que les contraintes rencontrées sont énumérées dans ce document. Finalement, ce rapport démontre les impacts qu'aura le nouvel horaire sur les pays participant au Programme. Les impacts sont exprimés en fonction du nombre de jours passés au Canada.

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Executive Summary

Since 2000, the Canadian Forces (CF) has provided all Basic Flying Training (BFT), advanced jet, and Fighter Lead-In Training (FLIT) for future fighter pilots through the NATO Flying Training in Canada (NFTC) Program. The program is a 20-year contract between the Government of Canada (Canadian Air Force) and Bombardier Aerospace Military Aviation Training (BA MAT). The program is also available to international air forces through direct government-to-government agreements.

NFTC is a three-phased program that offers undergraduate and post-graduate jet pilot training at 15 Wing Moose Jaw and 4 Wing Cold Lake, respectively. Phase IIA, BFT, is common to all prospective CF pilots and is conducted through the NFTC at 15 Wing. Graduates are then streamed into Phase IIB (for future fighter pilots), multi-engine, or rotary wing pilot training programs. Advanced jet pilot training (Phase III) continues under the NFTC banner at 15 Wing. Phase IV, post-graduate FLIT, is conducted under NFTC at 4 Wing. NFTC Phases IIA and IIB are conducted using the Harvard CT-156 and Phases III and IV use the Hawk CT-155 aircraft. Thus far, nations participating in NFTC include: Denmark, Italy, Canada and Hungary in all phases, Singapore in Phases III and IV, and the United Kingdom (UK) in a portion of Phase III (conversion) and fully in Phase IV.

During the first four years of operation, NFTC has had many problems graduating the students on time. This was particularly apparent at Phase IV where, of the last 24 serials that started, 18 did not graduate on time. Phase III has also experienced its share of graduation problems, 58.3 per cent of the serials loaded had students graduating late or being recoursed because they would not have met the graduation date. This was primarily caused by the inefficiencies of the method used for estimating Phases III and IV course duration, which is based on a fixed flying training day calendar (FTrgD Cal) containing 192 flying days. The main inefficiencies of the old method are: not enough non-flying days in the summer months, no consideration that a mission has different probabilities of being completed depending on the time of the year, and no history of how non-flying days in the 192-FTrgD Cal were determined.

Originally, the NFTC schedules were developed for all phases until Calendar Year (CY) 2005. A1 Training Officers are responsible for creating and managing the NFTC schedules. In June 2004, they requested the assistance of the Operational Research and Analysis Directorate to help address the graduation problems experienced at Phases III and IV, and to develop a new and more optimized NFTC schedule up to 2011. The project was divided into three objectives:

- For NFTC Phases III and IV, analyze historical weather data and the Integrated Training Plan course syllabus to determine a scientific method of estimating course duration;
- Using the new method for Phases III and IV and the current Phase II method, build the course start/end dates for all NFTC Phases until CY 2011; and

- Demonstrate the impact of the new method and the new schedules on each phase and on the participating NFTC nations.

A new approach for estimating the duration of Phase III and Phase IV serials was developed to address the disadvantages that the old method presented. The new method is based on a thorough analysis of weather requirements necessary to fly each mission. The following meteorological factors were considered: temperature, cloud ceiling, visibility, wind speed, wind chill, and James Brake Index (JBI).

A total of 21 weather conditions for Phase III, and 13 for Phase IV were identified by NFTC Subject Matter Experts to cover all the missions. A weather condition is characterized by seven values: minimum and maximum temperatures, minimum cloud ceiling, minimum visibility, maximum wind speed, minimum wind chill index, and a threshold for the JBI.

Thirty years of weather data (1973-2002) for each location was used to build tables containing the likelihood that Phase III and IV weather conditions would be met for each month of the year. A new algorithm, using the tables and expected values of geometric distributions, was developed to determine Phase III and IV course duration. The new approach was validated when applied to past NFTC schedules when the serials that had problems graduating on time in 2003 and 2004 were also identified with the new approach. Table ES.1 shows the average difference, expressed in calendar days, between the real schedule used and the expected duration calculated from the algorithm. For Phase III, the new model predicted that the serials were on average, approximately one week too short (seven and nine days). Similar results were obtained for Phase IV, except for CY 2004 where the difference was about four days.

Table ES.1: *Average Difference between Reality and Model Predictions*

Phase	2003	2004
III	-9 days	-7 days
IV	-7 days	-4 days

The new Phase III and IV approach for determining course duration was incorporated into a more complex model used to develop the new NFTC schedule. Due to assumptions made and constraints faced by the Program, the search space of the problem was reduced enough to perform an exhaustive search of all the possible schedules. The criterion used to evaluate the quality of a schedule was the total number of conflicts, which was based on the fact that a maximum of five Phase IIA, four Phase III and three Phase IV serials could be on the flightline simultaneously. The optimal solution showed that, every year, Phase IIA starts should happen on weeks: #1, #8, #12, #15, #20, #26, #32, #36 and #43. The final schedule was obtained after the transition period was added into the schedule to accommodate the serials that had already started, and once a final review from A1 Training, proposing minor changes, was completed. The total number of conflicts associated with the final schedule was 216, which equated to 36 conflicts for Phase IIA, 179 for Phase III and 11 for Phase IV.

There was insufficient time within the scope of this study to perform an extensive weather and missions analysis for Phase II, similar to the one done for Phases III and IV. For this reason, the Phase II serial duration was determined using the current method, i.e. based on a 175-FTrgD Cal. However, the last four years of experience have proven that the 175-FTrg Cal did not provide enough non-flying days in the summer period, and on the other hand, there are too many non-flying days in the winter. Consequently, before the generation of the new schedules, a redistribution of the 175-FTrgD Cal was done in order to better allocate the non-flying days during the year. Following a recommendation of 2 Canadian Forces Flying Training School, eight non-flying days in the winter months were changed to flying days, and eight flying days in the summer months were made non-flying days. This kept the total number of flying days throughout the year constant at 175. The impact of the redistribution on the duration is negligible as some Phase II serials were shortened and others were lengthened, but on average, the serials were shortened by only 0.11 day per year.

In order for the new schedules to be implemented by the Program, it had to be demonstrated that there would be very little impact on the participating nations. The metric used to determine the impact of the new schedule on all the nations was the *time in Canada*, expressed in terms of calendar days. For each nation, the time the students spent in Canada during 2002, 2003 and 2004 was compared with how long the students are expected to stay in Canada for future courses. This assumes that, when the new schedule is implemented, the nations will send their students through the same phase(s) and in the same serial(s). Table ES.2 presents the impact on each nation involved in NFTC.

Table ES.2: *Impact on the Nations*

	Canada	Denmark	Hungary	Italy	Singapore	UK
New Schedule	606	622	615	587	306	116
2002-2004	594	616	621	559	288	108
Difference (in Calendar Days)	13	6	-7	27	18	8

The impact, in terms of calendar days spent in Canada, is relatively minor. The time in Canada varies from staying 7 days less in Canada (for Hungary) to extending the stay in Canada by 27 days for Italy. The incremental cost incurred by keeping a student in the country longer by one week, two weeks, or even a month, is marginal compared to the money it costs to send students through NFTC. However, a more significant impact on the nations may be in relation to the new start and end dates, as the dates may no longer be synchronized with their respective in-country training that occurs immediately before or after NFTC. This could potentially create exceedingly long Pilot Awaiting Training (PAT) pools for some nations, which is undesirable in any pilot training system. The impact regarding PAT pools will have to be determined separately by each nation.

Minor contractual issues between the Government of Canada and BA MAT may arise from the implementation of the new schedule. The contract was built such that nine serials of each phase are loaded every year. This is how BA MAT is being remunerated: nine starts per year. However, in the new schedule, there are some years where there are only only eight Phase IIA starts. On the other hand, there are years where ten serials are loaded, which equates to an average of exactly nine per year. Some deliberations will have to take place in order to accommodate this issue.

Before the start of the project, some individuals were worried that if the courses were to be lengthened, like the case for the Phases III and IV, the Program might not be capable of graduating the contracted number students at the end of 2020. However, this should not be a concern since there will be on average, nine Phase IIA serials loaded every year, and therefore, the required number of students will be trained.

Culture shock may be incurred from the new method for calculating course duration introduced for Phases III and IV. Thus far, the Program has been using flying days as a reference, but the new approach does not consider flying days. Now, the idea is no longer to separate working and flying days (245 working days with 192 of them being flying days) in a year but rather, consider all 245 working days as possible flying days. The difference is that the likelihood of accomplishing a mission on any given day is now determined based on the weather condition associated with the mission to be flown and the time of the year. This is an important philosophical change since the Program is built with an average number of sorties per day, obtained considering 192 flying days.

Finally, it is assumed that, with the new schedule, as some courses have been lengthened, NFTC will increase its chances of meeting the graduation dates because the method for the duration of the course is based on rigorous weather analysis. Obviously, a monitoring period is recommended in order to validate that assumption, and minor modifications may be required as the Program evolves.

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1 Introduction

1.1 NATO Flying Training in Canada

Since 2000, the Canadian Forces (CF) has provided all Basic Flying Training (BFT), advanced jet, and Fighter Lead-In Training (FLIT) for future fighter pilots through the NATO Flying Training in Canada (NFTC) Program[1]. In addition, BFT for multi-engine and rotary wing pilots has also been accomplished at NFTC.

NFTC is a 20-year contract [1] between the Government of Canada (Canadian Air Force) and Bombardier Aerospace Military Aviation Training (BA MAT). The program is also available to international air forces through direct government-to-government agreements. The Canadian Air Force contributes to: the training syllabus, training plans, management of standards, the air bases, air traffic control, airspace, and accommodation facilities. BA MAT provides: academic and Flight Training Device (FTD) instructors, new and upgraded facilities, training equipment, training support equipment, infrastructure maintenance, equipment maintenance, and food services. Finally, participating air forces provide: international program management, flight instructors, students and quality control.

NFTC is a three-phased program that offers undergraduate and post-graduate jet pilot training at 15 Wing Moose Jaw and 4 Wing Cold Lake, respectively. Phase IIA, BFT, is common to all prospective CF pilots and is conducted through the NFTC at 15 Wing. Graduates are streamed into Phase IIB (for future fighter pilots), multi-engine, or rotary wing pilot training programs[2]. Advanced jet pilot training (Phase III) continues under the NFTC banner at 15 Wing. Phase IV, post-graduate FLIT, is conducted under NFTC at 4 Wing. NFTC Phases IIA and IIB are conducted using the Harvard CT-156 and Phases III and IV use the Hawk CT-155 aircraft.

Thus far, nations participating in NFTC include: Denmark, Italy, Canada and Hungary in all phases, Singapore in Phases III and IV, and the United Kingdom (UK) in a portion of Phase III (conversion) and fully in Phase IV.

1.2 Definitions

It is important to start with some key definitions. As stated earlier, NFTC is comprised of four distinct phases: IIA, IIB, III, and IV. At each phase, different courses may be offered. A course is characterized by a series of ground school lessons, flying and FTD missions. For the purpose of this study, only the courses of the regular students were considered. A serial is defined as a

[1] Hereafter throughout the report the abbreviation NFTC or Program may be used interchangeably to refer to the NATO Flying Training in Canada Program.

[2] Advanced multi-engine and rotary wing pilot training is given by the Canadian Air Force at Portage la Prairie, Manitoba. Phase I pilot training is given under a separate contract to the Canadian Air Force, also at Portage la Prairie, Manitoba. This contract also provides the aircraft and support for multi-engine and rotary wing training.

instance of a course, i.e. as a group of students who trained together following a predetermined course flow. There are typically nine serials loaded every year in each phase. A serial is identified by a phase and four digits *xx*0*y*, which corresponds to the *y*th serial that started Phase IIA in 20xx. For instance, Serial 0503 of Phase IV corresponds to a Phase IV serial that was the third serial to start Phase IIA in 2005.

1.3 Background

As of February 2005, there have been 24 serial starts for Phase IV. Of these 24 starts, 18 have not graduated on time. Similarly, the on-time graduation rate for Phase III has not been much better where 14 of 24 (58.3 per cent) serials either graduated late or had students recoursed because they would not have met the graduation date. Unlike Phases III and IV, Phase II has not experienced late graduations as frequently since the Canadian student throughput, which makes up the largest fraction of the Phase II student population, has been well below the original contracted values. In the Statement of Work (SOW) [2], the Government of Canada contracted for 131 Canadian (CA) starts per year between 2001 and 2003, however, never more than 112 starts occurred (74, 99 and 112 starts, respectively).

The fact that Phases III and IV serials consistently graduate late has become a major concern for the Program; mainly because graduating students on time is the primary measure of success used by the participating nations to evaluate the training provided to them by NFTC. Any delay associated with the graduation of a foreign student results in added cost to that particular nation due to additional time spent in Canada. It may potentially also have an impact on that nation's pilot replacement and rotation plan, which is based on the contracted number of students and dates agreed upon at the beginning of the program.

As a result of the aforementioned graduation problems, the Department of National Defence (DND) started to question the initial number of resources, aircraft and simulators, purchased by BA MAT to support the Program. In 2003, two Tiger Teams (TTs), one for Phase II and one for Phases III/IV, were tasked to explore all aspects of training in order to optimize NFTC student production. Part of their mandate was to verify all factors that affect the ability of 2 Canadian Forces Flying Training School (CFFTS) located at 15 Wing, and 419 Squadron (4 Wing) to fly a sufficient amount of aircraft sorties allowing them to meet contracted student graduation times.

Most of the TT efforts were put towards determining the number of aircraft and simulators required to meet student graduation dates. The Operational Research and Analysis Directorate (ORAD), formally known as the Centre for Operational Research and Analysis, was actively involved with the different TTs in the development of a Resource Allocation Model (RAM). Several scenarios were created and various runs using the model were performed to analyze the resources available to the Program. The results of these studies were documented in [3]. One conclusion that emerged from the report was that all NFTC phases should have had enough resources to support the past

(2001, 2002 and 2003), and also the current student loads[3].

In the mean time, 419 Squadron did an analysis and produced a report [4] on the effect of weather on Phase IV flying operations in Cold Lake. Preliminary results showed that from 2001 to 2003, there were consistently less than 192 flying days per year[4]. Their initial recommendation was to use a 172 Flying Training Day Calendar (FTrgD Cal) for Phase IV, in Cold Lake. This was presented by A1 Training to the NFTC Steering Committee during [5]. The participating nations were reluctant to accept these findings, stating that the courses are already longer than what was originally agreed upon, and the proposition (reducing the number of flying days from 192 to 172) would lengthen the courses substantially. The NFTC Steering Committee henceforth tasked the NFTC Operations Working Group (OpsWG) to study alternative methods to determine course lengths.

In June 2004, A1 Training requested the assistance of ORAD [6] to help address the graduation problems experienced at Phases III and IV during the first few years of operation, and to build the new NFTC schedules, as originally, they were developed only until Calendar Year (CY) 2005. The aim of the project was divided into three objectives:

- For NFTC Phases III and IV, analyze historical weather data and the Integrated Training Plan (ITP) course syllabus to determine a scientific method of estimating course duration;
- Using the new method for Phases III and IV and the current Phase II method, build the course start/end dates for all NFTC Phases until CY 2011; and
- Demonstrate the impact of the new method and the new schedules on each phase and on the participating NFTC nations.

In an attempt to satisfy the aforementioned objectives, this report consists of five distinct sections. Section 1 briefly describes the NFTC Program and provides some key definitions and background on the project. Section 2 presents the assumptions made, and the methodology used to determine the duration of the Phase III and Phase IV courses. It also includes a comparison of the CY 2003 and CY 2004 schedules versus the new method. An overview of the approach employed to build the new course start/end dates is shown in Section 3. Section 4 demonstrates the impact of the new methodology on all the countries involved in NFTC. Lastly, Section 5 summarizes the main conclusions.

[3]Note that the report also stated that NFTC was built with the minimum number of aircraft and simulators, limiting the ability to surge when required. Also, it is obvious that more resources would help graduating students on time, however, the number of resources should not have been the primary reason why the serials have been consistently late.

[4]Since the beginning of the contract, Phases III and IV course durations have been based on a 192 flying training day calendar. On the other hand, Phase II uses a calendar with 175 flying days.

2 Phase-by-Phase Duration

The method presented in this section is very similar to the approach presented in a previous study [7]. Several concepts that were introduced in that research note were adapted to the methodology described below.

2.1 Current Method

Presently, the course dates of all NFTC phases are based on a fixed FTrgD Cal composed of a set of predetermined flying days. The number of flying days in the calendars are: 175 for Phase II, and 192 for Phases III and IV. Figure 1 corresponds to the 192-FTrgD Cal used in 2004 for Phases III and IV. The white cells represent flying days, the green cells, non-flying days (when only ground school and FTD missions can be accomplished), and the gray cells are either weekends, statutory holidays or Christmas leave.

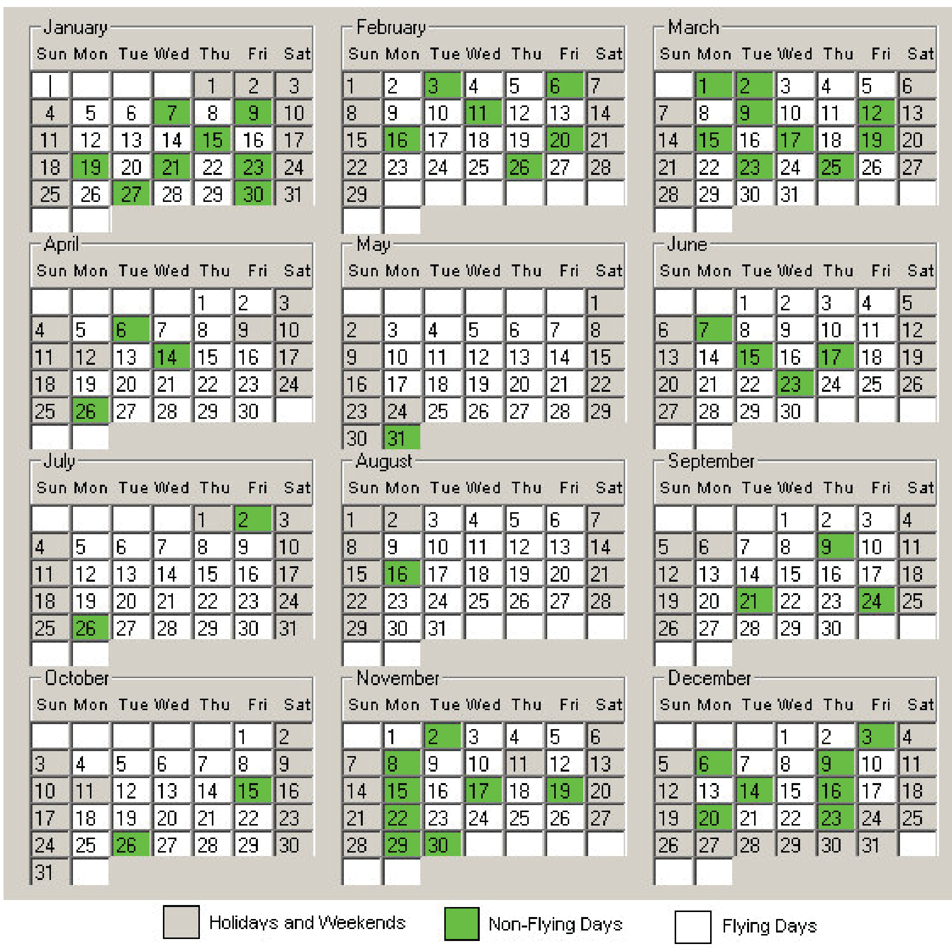

Figure 1: *2004 – 192-FTrgD Cal*

The current procedure for obtaining the end date of a serial, given a particular start date, is as follows:

Step 1 From the start date, allow one working day[5] for each day of ground school that has to be completed at the beginning of the course;

Step 2 Then, in the FTrgD Cal, count *n* flying days (white cells), where *n* is the total number of Cockpit Procedures Training (CPT), FTD and flying missions to be completed by the students; and

Step 3 Finally, for all phases but IIA, if the end date is not already a Friday, the official end date becomes the Friday following the completion date of the last mission.

Table 1 contains the information concerning all NFTC Phases. For example, if one uses the values in Table 1 and the calendar presented in Figure 1, a serial that starts Phase IV on Monday, 5 January 2004, would end its ground school portion on Friday, 9 January 2004 and the official serial end date would be Friday, 30 April 2004.

Table 1: *Number of Missions per Phase*

Phase	Number of Full Days of Ground School	Cockpit Procedures Training (CPT)	FTD Mission	Flying Mission
IIA	15	5	28	66
IIB	0	0	5	28
III	9	3	26	55
IV	5	0	15	38

2.1.1 Disadvantages of the Current Method

The current method presents several disadvantages. Firstly, the bad weather days in the FTrgD Cal are fixed and predetermined, and do not consider the different weather requirements of the various training phases within the syllabus. A predicted bad weather day for a particular serial may not be a bad weather day for another serial. For instance, in Phase IV, the likelihood that all weather conditions will be met for an Airborne Intercept (AI) mission, which requires a ceiling of 19,000 feet, is much lower than an Air-to-Surface Tactics (AST) mission, which requires a ceiling of only 2,000 feet. This is a very important aspect that is not taken into account in the current way of calculating the ending date.

Secondly, the 192-FTrgD Cal is not representative of the weather conditions experienced in the past years, especially during the summer months. For instance, using the current method, a course starting Phase IV on 20 June 2005 would end on 16 September 2005. This means that the serial

[5] Note that working days include both flying and non-flying days (green and white cells in Figure 1).

would be allotted only four bad weather days. It is unrealistic to expect such a low number of non-flying days during three summer months. The fact that the schedules were built with so few non-flying days during the summer months was one of the areas of concern highlighted in [4], as a flaw with the current 192-FTrgD Cal used for Phase IV. Table 2 summarizes the predicted, versus the actual number of non-flying days at Cold Lake during the months of June, July, August and September for 2002 and 2003. These significant variations were one of the main factors for the late graduations experienced during the past years, especially considering the limited surge capability in Cold Lake during the summer months (due to MAPLE FLAG EXERCISE, Instructors rotation, etc.).

Table 2: *Predicted versus Actual Non-Flying Days in Cold Lake for Summers 2002 and 2003*

Year	Predicted (in days)	Actual (in days)	Difference
2002	8.0	14.2	+6.2
2003	8.0	18.8	+10.8

Thirdly, there is no history of how bad weather days in the calendars were determined. The authors of this report and of [7] have unsuccessfully searched for the programs and data used to develop the current set of FTrgD Cal, which were created in the mid-1970s. Furthermore, before the beginning of NFTC, the only CF flying training school that used the 192-FTrgD Cal was the Advanced Flying Training - Rotary Wing (AFT-RW) at Portage La Prairie, Manitoba. There are also no obvious reasons why NFTC selected the 192-FTrgD Cal for its flying operations at Cold Lake and Moose Jaw.

Finally, a question worth asking is: Why use the same FTrgD Cal for Phase III and Phase IV? Although both phases use the same aircraft, there are differences between the missions flown at each location, the student pilots' skills and experience, and the weather conditions at each location.

2.2 New Method for Phases III and IV

Initially, the intent was to continue to use a fixed FTrgD Cal for Phases III and IV; a calendar with a different number of flying days (less than 192) including a better distribution of the bad weather days (more non-flying days in the summer months than what is currently used). However, because of all the 192-FTrgD Cal disadvantages noted, the author decided to use a more scientific method, greatly inspired by the approach presented in [7], for Phases III and IV. The approach is based on the following three simple rules:

- Because of its corresponding weather requirements, a flying mission has different probabilities of being completed depending on the time of the year and the geographic location;
- Each flying mission for a specified course syllabus can only be flown on a given day, if and only if, all the corresponding weather requirements are satisfied; and

- A given day might be a flying day for one serial but a non-flying day for another serial, depending upon where the serials are in their respective course flow.

2.2.1 Factors Affecting Course Duration

There are various factors that have an impact on the course duration. The first factor that comes to mind is the number of resources available at the schools, which include: aircraft, simulators, classrooms, flying instructors, FTD operators and ground school instructors. As mentioned in Section 1, recently conducted studies [3] for the frequently occurring late graduations at Phases III and IV have shown that resources have not been the primary reason. Hence, in order to remove these factors for the current study, it was assumed that resources are available as needed. This assumption allowed the author to concentrate solely on how the duration of a course is affected by weather and aircraft limitation factors.

As a result of various discussions with Subject Matter Experts (SMEs), including A1 Training staff officers, 4 Wing and 15 Wing officers, and the A3 Meteorology (A3 Met) representative at 1 Canadian Air Division, the following factors were considered in the new approach:

- Meteorological Factors
  - *Temperature*: The temperature of the air is a major factor in flying operations. Due to aircraft limitation and crew safety, flying will be suspended if the air temperature is extremely low or high;
  - *Cloud Ceiling*: The cloud opacities are described by a fraction of how much of the sky is covered in cloud. This fraction is always taken by breaking the sky into eight equal parts and deciding how many of these equal parts are covered by cloud. Terms such as: overcast (fraction of 8/8 covered in cloud), broken (5/8 to 7/8), scattered (3/8 to 4/8), few (1/8 to 2/8), and clear (0/8) are meteorological terms used to describe in words how much of the sky is covered by cloud. The cloud ceiling (or cloud deck) is the lowest altitude, measured in hundreds of feet above ground, at which the sky is either overcast or broken;
  - *Visibility*: Visibility, in kilometers, is the distance at which objects of suitable size can be seen and identified. Atmospheric visibility, which can be reduced by precipitation, fog, haze or other obstructions to visibility such as blowing snow or dust, is a very important factor;
  - *Wind Speed*: The speed of motion of air, in kilometers per hour (km/hr), is usually observed at 10 meters above the ground. Flying operations can be canceled if the wind speed exceeds a certain speed. Cancellation criteria depends on crew safety concerns and on aircraft operating capabilities;
  - *Wind Chill*: This is the chilling effect of the wind in combination with low temperature. This has an impact on flying operations, since if the Wind Chill Index is extremely low, instructors and maintainers are not allowed to work outside for safety (frostbite, hypothermia, etc.); and

- *James Brake Index (JBI)*: The JBI is a runway condition reporting program which includes the measurement of runway friction, and has been in place at Canadian airports for approximately 30 years. It is only a factor during the winter months due to icing. If the index is too low, the distance required for the aircraft to land increases, and can consequently exceed the runway length available.

- Aircraft Limitation
  - *Cloud Break*: An important aspect that has to be taken into consideration is the fact that there is no cloud break procedure for the Hawk aircraft during the winter months. This is due to the risk of icing since the aircraft is not certified to fly through/in icing conditions.

2.2.2 Weather Conditions

A *weather condition* is defined as a specific set of meteorological factors that must be satisfied in order to successfully complete a mission. In other words, a weather condition is characterized by six values: minimum and maximum temperatures (in degrees Celcius (˚C)) minimum cloud ceiling (in hundreds of feet), minimum visibility (in km), maximum wind speed (in km/h) and minimum wind chill index. It is explained later in the report how JBI and the cloud break procedure were taken into consideration.

For each phase, a set of weather conditions was built to cover all the mission types that have to be completed by the students. Several discussions with NFTC SMEs at Moose Jaw and Cold Lake led to the weather conditions described in Tables 3 (Phase III) and 4 (Phase IV). Note that mission code definitions for these two tables can be found in Annex A.

Column 7 of both Tables 3 and 4 corresponds to the mission numbers or mission types requiring weather conditions. The last column of Tables A.1 and A.2 of Annex A, which contain the course syllabus for NFTC Phases III and IV, depicts the specific weather condition associated with each mission. Note that the column labeled *WC* in Tables A.1 and A.2 is associated with Column 1 of Tables 3 and 4, respectively.

Conditions 18, 19 and 20 of Table 3 and Conditions 11 and 12 of Table 4 are virtual conditions that were created in order to provide the ability to take into consideration the fact that there is no cloud break procedure for the Hawk aircraft. These conditions are determined based on a combination of other conditions, for instance, Phase III Condition 18 is obtained from Conditions 15, 16 and 17. It is explained later in the report why and how these conditions were populated and used. An additional condition was added in each phase for the FTD missions: Condition 21 for Phase III and Condition 13 for Phase IV.

2.2.3 Historical Weather Data

Thirty years of weather data (1973-2002) for each location was considered in this project. The data, provided by an employe of A3 Met, contained all the weather factor values of each hour of

Table 3: *Phase III – Weather Conditions*

WC	Ceiling ($\times 10^2$ feet)	Vis (km)	Wind (km/h)	Temp (˚C)	Wind Chill	Missions
1	240	8.05	55.56	-30 to 30	-35	CH3
2	160	8.05	37.04	-30 to 30	-35	CH6A, CH7A, CH8A, CH9A, CH10A
3	55	4.83	55.56	-30 to 30	-35	AST (NAV7)
4	120	8.05	55.56	-30 to 30	-35	CH1, CH2, CH4, CH5, CH6, CH7, CH8
5	160	8.05	55.56	-30 to 30	-35	CH9, CH10, CH11, CH12, CH13
6	30	8.05	55.56	-30 to 30	-35	Used for Condition 19
7	60	8.05	55.56	-30 to 30	-35	Used for Condition 19
8	110	8.05	55.56	-30 to 30	-35	Used for Condition 19
9	100	0.80	55.56	-30 to 30	-35	IF1, IF2, IF3, IF4, IF5, IF6
10	4	0.80	55.56	-30 to 30	-35	Used for Condition 20
11	190	0.80	55.56	-30 to 30	-35	Used for Condition 20
12	23	8.05	55.56	-30 to 30	-35	Navigation
13	30	8.05	55.56	-30 to 30	-35	Night
14	20	4.83	55.56	-30 to 30	-35	AST (NAV8, NAV9, NAV10)
15	2	0.80	55.56	-30 to 30	-35	Used for Condition 18
16	110	0.80	55.56	-30 to 30	-35	Used for Condition 18
17	130	0.80	55.56	-30 to 30	-35	Used for Condition 18
18	-	0.80	55.56	-30 to 30	-35	BFM
19	-	8.05	55.56	-30 to 30	-35	FM
20	-	0.80	55.56	-30 to 30	-35	IF7A, IF7B, IF8, IF9
21	-	-	-	-	-	FTD Missions

the period of interest, except the wind chill indexes. Although the values of the wind chill indexes were not directly available, the data provided contained all the information necessary to calculate them. The following equation, found in [8], was used to determine the wind chill index:

$$W(v,t) = 12 + 0.6215t - 11.37v^{0.16} + 0.3965tv^{0.16}$$

where, W is the wind chill index based on the Celsius temperature scale, t is the air temperature in ˚C, and v is the wind speed in km/h.

The same technique proposed in [7] was employed to analyze the weather information. The data

Table 4: *Phase IV – Weather Conditions*

WC	Ceiling ($\times 10^2$ feet)	Vis (km)	Wind (km/h)	Temp (˚C)	Wind Chill	Missions
1	90	4.83	55.56	-30 to 30	-35	CH
2	20	8.05	55.56	-30 to 30	-35	Used for Conditions 11 and 12
3	80	8.05	55.56	-30 to 30	-35	Used for Conditions 11 and 12
4	190	8.05	55.56	-30 to 30	-35	Used for Conditions 11 and 12
5	55	4.83	55.56	-30 to 30	-35	LLAT
6	25	4.83	55.56	-30 to 30	-35	Acad. Weapons (LAD)
7	67	4.83	55.56	-30 to 30	-35	Acad. Weapons (HAD)
8	15	4.83	55.56	-30 to 30	-35	AST1, AST2, AST4
9	90	4.83	55.56	-30 to 30	-35	AST3
10	30	4.83	55.56	-30 to 30	-35	AST5, AST6, ..., AST11
11	-	8.05	55.56	-30 to 30	-35	BFM and ACM
12	-	8.05	55.56	-30 to 30	-35	AI
13	-	-	-	-	-	FTD Missions

received was summarized as the number of times the weather requirements for each weather condition were met for each hour of the day for each month. Take the month of June as an example, since June has 30 days, there were 30 years $\times$ 30 days $=$ 900 observations for each hour of the day in the month. If, for instance, at 1200 hours, all factors of Condition 1 were met 520 times, then a mission requiring Condition 1 in order to be executed, would proceed, on average, 58 per cent of the time at 1200 hours.

The number of times that Condition 1 was satisfied for all the daytime hours in January was averaged to estimate the average percentage of times in January that missions requiring Condition 1 could proceed. The same procedure was repeated for all the conditions for all the months. Note that the sunrise and sunset times used for the daytime period are presented in Table 5. For the night mission in Phase III (missions that require Condition 13), the nighttime hours were used.

Based on the calculated averages, tables containing the likelihood that weather conditions would be met for each month of the year were built. The two populated tables are represented graphically in Figures 2 and 3 (for Phase III) and in Figure 4 (for Phase IV). From the figures, it is clear that the likelihood that the weather conditions would be met changes significantly from month to month. Most missions would take fewer days to complete in the summer than in the winter months.

In order to take JBI into consideration, five per cent was subtracted from the probabilities obtained in the months of December, January and February. This corresponds to approximately three work-

***Table 5:** Moose Jaw and Cold Lake – Sunrise/Sunset Times*

Month	Moose Jaw		Cold Lake	
Jan	0900	1700	0900	1600
Feb	0900	1800	0800	1700
Mar	0800	1900	0700	1800
Apr	0700	1900	0600	1900
May	0600	2000	0500	2000
Jun	0500	2100	0400	2000
Jul	0600	2100	0500	2000
Aug	0600	2000	0500	1900
Sep	0700	1900	0600	1800
Oct	0800	1800	0700	1700
Nov	0900	1700	0800	1600
Dec	0900	1700	0900	1600

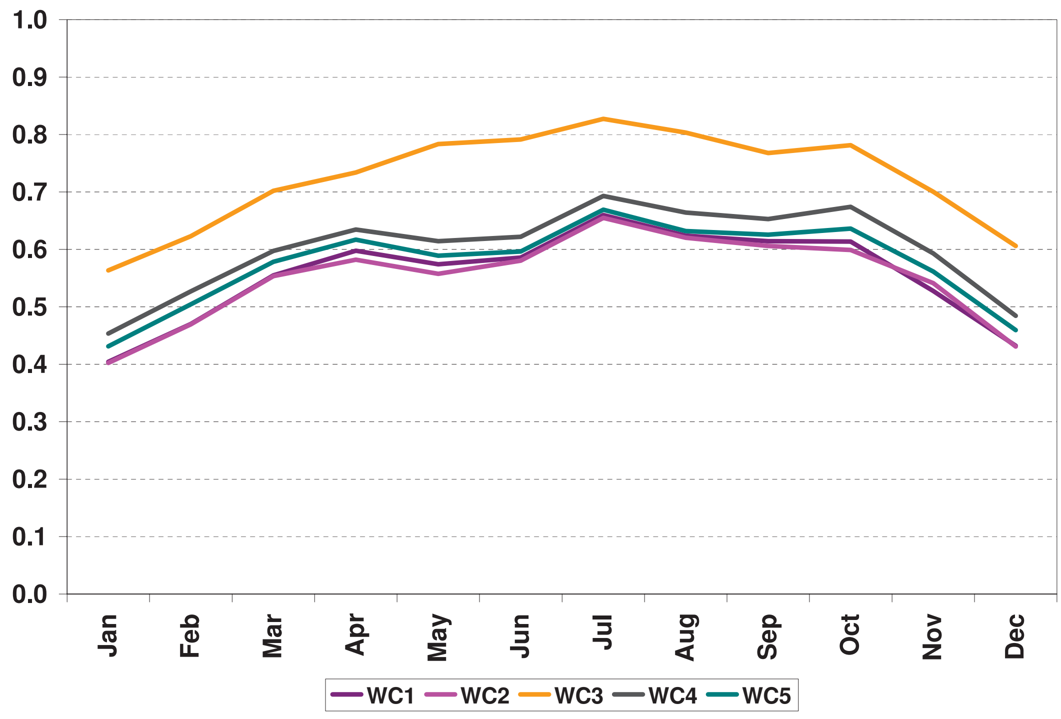

***Figure 2:** Phase III – Likelihood of Meeting Weather Conditions (Part I)*

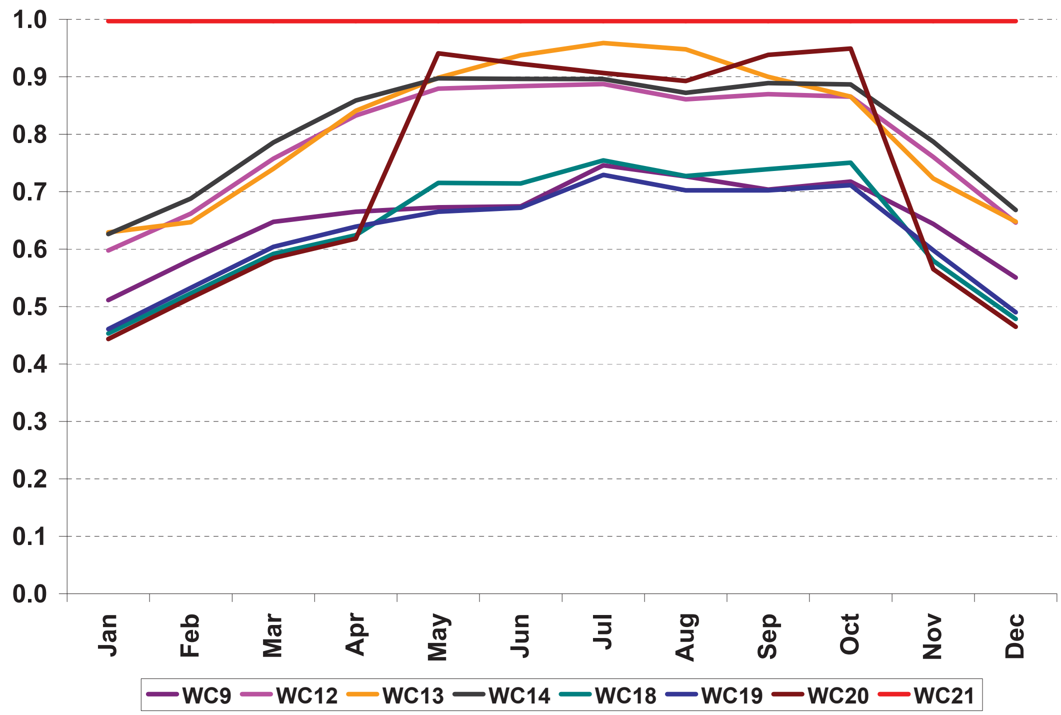

Figure 3: *Phase III – Likelihood of Meeting Weather Conditions (Part II)*

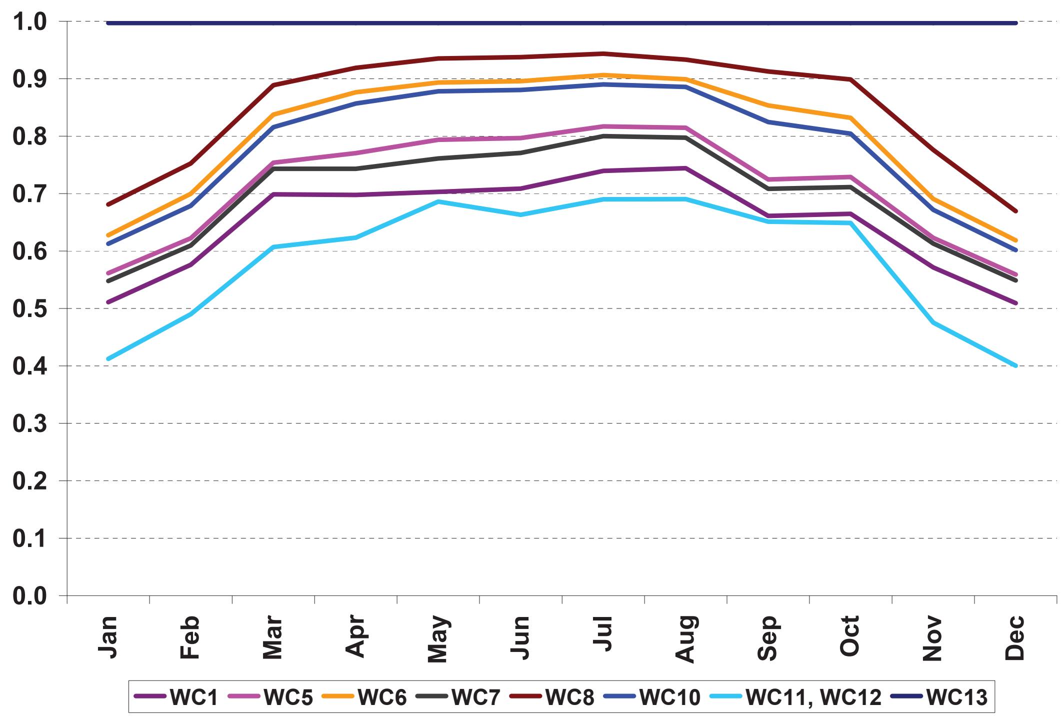

Figure 4: *Phase IV – Likelihood of Meeting Weather Conditions*

ing days total (one per month if one considers about 20 working days per month) lost in the winter, strictly due to JBI. This number was taken from the weather study done at Cold Lake [4].

The monthly probabilities for the FTD conditions (Condition 21 in Table 3 and Condition 13 in Table 4) were set to 1.00. This was based on the assumption that a FTD mission can occur on any working day, as it is not affected by the weather.

It was mentioned previously that there were conditions added due to the inability to conduct cloud break procedure during the winter period. Annex B shows how the probabilities for Conditions 18, 19 and 20 of Table 3 and Conditions 11 and 12 of Table 4 were calculated.

2.2.4 Algorithm

The proposed approach assumes that all missions in the syllabus will follow ITP course flow. In other words, the missions are followed sequentially, meaning that mission k can only be accomplished once mission $k-1$ is completed. Tables A.1 and A.2 of Annex A contain, respectively, the course syllabus for NFTC Phases III and IV. For example, a student following the Phase IV course flow, would have to complete Mission 18 (BFM11) before completing Mission 19 (ACM01S). This is how the new method differs from the one presented at [7], which considered the missions in blocks rather than individually, allowing a student to accomplish the missions within a block in any sequence.

Another assumption made was that the ground school days required at the beginning of a course, along with all the FTD missions, could be scheduled on any working day.

It was also assumed that a student could only accomplish one mission per day. According to the NFTC SMEs, there are some cases, especially in Phase III, where two flying missions could be completed in the same day; mostly a dual mission in the morning followed by a solo mission in the afternoon. However, it is a rare situation that cannot be planned on, and is used as a means to surge when courses get behind. For NFTC Phase IV, because of the duration of the flying missions (briefing, air time, debriefing, etc.), it is almost impossible to perform two flying missions in the same day. Note that, when possible, a FTD mission could be done in the morning and a flying mission in the afternoon. Again, because it is not a common situation, it was suggested by the SMEs not to plan on scheduling two missions in a day.

Assuming that the course flow is sequential and prerequisites driven, and allowing for only one mission per day, provides a conservative schedule which increases the likelihood that the expected end dates will be met more frequently.

The algorithm developed to determine the course duration of a serial is given in Figure 5. The idea behind the new approach is, given a starting date, to return the number of working days expected to complete all the missions in the syllabus. The list of working days was predetermined, and included all the days in the year that are not weekends, statutory holidays or Christmas leave days.

The function $P(wc, curMonth)$ corresponds to the values presented in Figures 2 and 3 for Phase III, and Figure 4 for Phase IV. As an example, for Phase III, the value returned by $P(3, Jan)$ would be 0.563.

Function CourseDuration (sd, n_{gs}, n, d)

Inputs:
sd: The start date of the serial of interest
n_{gs}: Number of ground days at the beginning of the course
n: Number of missions in the syllabus

Outputs:
d: Expected duration, expressed in working days, of a serial starting on sd

```
Begin
    d = n_gs
    For curMsn = 1 to n
        wc = Weather condition of curMsn
        curMonth = Month of the d_th working day after sd
        d = d + 1/P(wc,curMonth)
    End For
    Return d
End
```

Figure 5: *New Method to Estimate End Date*

The value for wc can be found in Column 4 of Tables A.2 and A.1. In the algorithm, $1/P(wc, curMonth)$ corresponds to the expected number of days to accomplish a mission of type $msnType$, during the month of $curMonth$. In other words, $\mu = 1/P(wc, curMonth)$ is the mean of a random variable x following a geometric distribution $g(x; P(wc, curMonth))$. The estimated duration is basically the sum of the means obtained from n geometric distributions.

2.3 Validation of the New Method

2.3.1 Comparing with CY 2003 and CY 2004

In order to validate the weather conditions and the new methodology, the algorithm was applied to the schedules used for Phases III and IV in CYs 2003 and 2004. During these two years, there were nine serials loaded every year at each location. Table 6 shows the average difference, expressed in calendar days, between the real schedule used and the expected duration calculated from the algorithm. For Phase III, the new model predicted that the serials were on average, approximately one week too short (seven and nine days). Similar results were obtained for Phase IV, except for CY 2004 where the difference was about four days.

Table 6: *Average Difference (in Calendar Days) between Reality and Model Predictions*

Phase	2003	2004
III	-9 days	-7 days
IV	-7 days	-4 days

Figures 6 and 7 respectively, graph the duration, expressed in terms of calendar days, calculated for each individual serial for Phase III and Phase IV. The *x*-axis corresponds to the start date of the serials and the *y*-axis, the number of calendar days. Note that the predicted end dates by the model were rounded up to the following Friday, as it was done in the real schedules. There is one point in the graphs for each serial loaded in 2003 and 2004. The green line corresponds to the dates used by the schools and the blue line represents the expected duration calculated by the model.

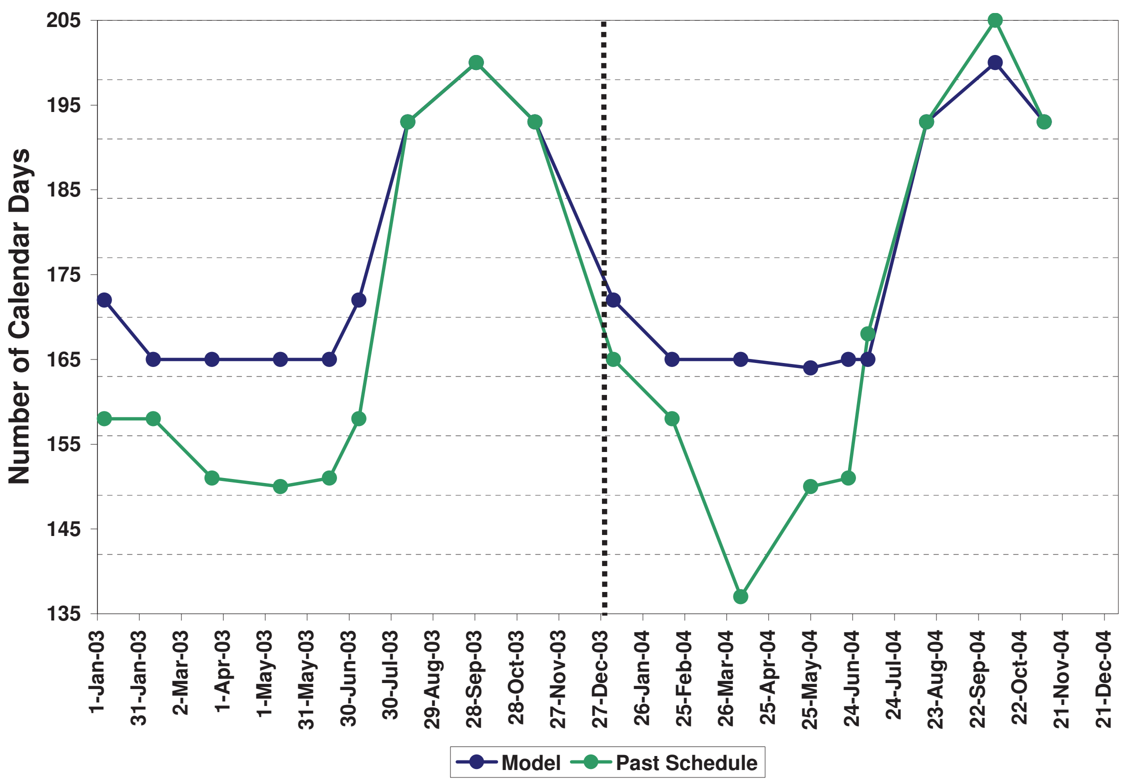

Figure 6: *Phase III – Comparing New and Old Methods in 2003-2004*

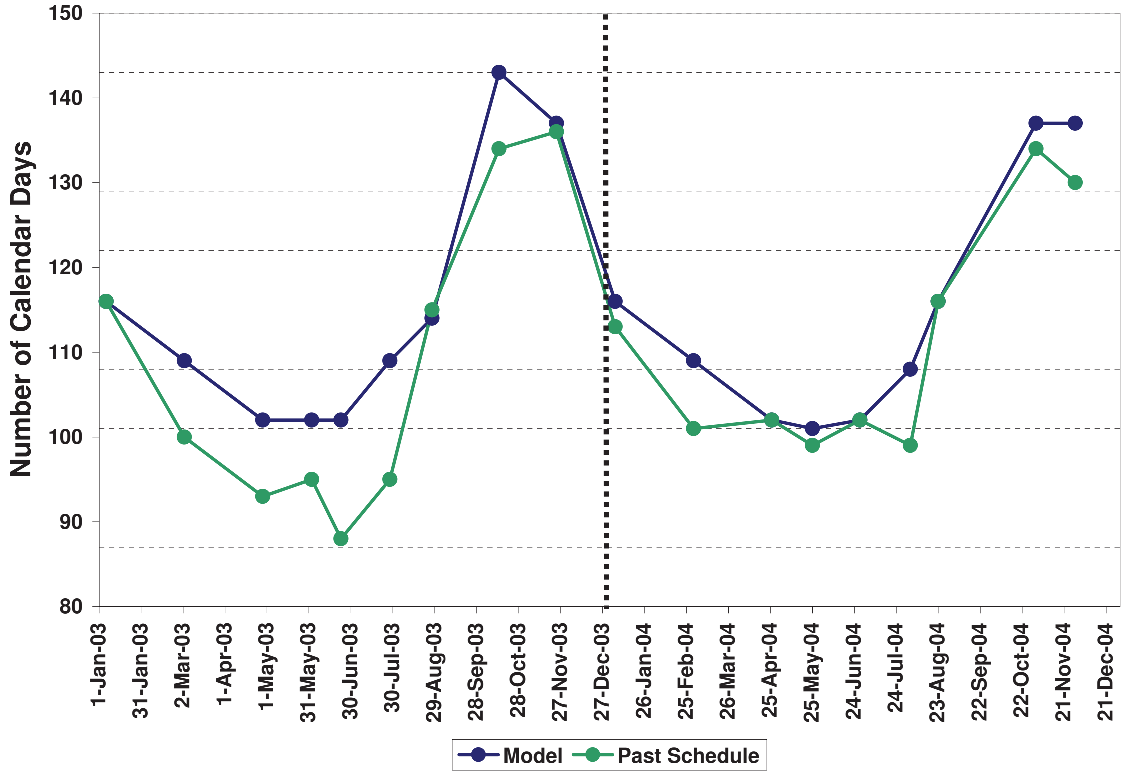

Figure 7: *Phase IV – Comparing New and Old Methods in 2003-2004*

For Phase III, the new method showed that the dates used for the last three serials of the year were good estimates. However, the differences for the first six serials' end date estimations were significant: all were too short by one or two weeks. These results were presented to NFTC SMEs. They noted that the same behaviour was experienced at Phase III during CYs 2003 and 2004, i.e. difficulty to graduate the serials starting during the first half of the year, due to an insufficient number of non-flying days allocated in the 192-FTrgD Cal during late spring and the summer months.

In 2003, the model showed that Phase IV dates used for the first, seventh, eighth and ninth serials of a year were a good approximation. One point brought up by Phase IV SMEs is that, in 2003, the third, fourth, fifth and sixth serials did not graduate on time. This was confirmed by the model, which indicated that respectively, one, one, two and two additional weeks should have been allocated to these four serials.

In 2004, the differences between the real schedule and the model were not as noticeable (only approximately four days too short on average). The reason is, following the problems experienced during 2003, changes were made to the 2004 192-FTrgD Cal used at Phase IV. Non-flying days were moved from the winter months to the summer months to better reflect the weather in the summer months, and therefore, better predict the end date of the serials. This is why the blue and the green lines are closer together in the 2004 Phase IV graph.

Based on the results presented in this section, Phases III and IV NFTC SMEs are convinced that the new method for predicting the course duration introduced in this section is by far better than the one employed for Phases III and IV since the establishment of NFTC.

2.3.2 A Complete Year – 245 Working Days

The new method was used to estimate the course duration of all possible starting dates in a year. A normal year for NFTC, when all the weekends, statutory holidays and Christmas break leave days are taken out, is comprised of 245 working days. For instance, in 2005:

Working Day #1	is	05-Jan
Working Day #2	is	06-Jan
Working Day #3	is	07-Jan
Working Day #4	is	10-Jan
⋮	⋮	⋮
Working Day #244	is	22-Dec
Working Day #245	is	23-Dec

Figure 8 illustrates the result of the model run with the 245 possible start dates. It corresponds to the expected course duration as a function of the start, expressed in terms of working days. The blue line represents the results for Phase III and the magenta line, the results obtained for Phase IV. Note that the start working days are based on CY 2005, however, the use of any subsequent year would have generated very similar lines. Minor variations from one year to another can occur due to the fact that statutory holidays might vary from year to year, e.g. some years Easter falls in March and others in April.

The figure shows that for each phase, the longest course would be for a serial starting approximately in mid-October. For Phase III, a maximum duration of 130.96 working days is obtained if a serial starts on working day #195. For Phase IV, the maximum duration is 91.83 working days for a serial commencing training on working day #198.

This seems right considering the fact that a course starting around mid-October would go through its flying missions during the worst months of the year as far as weather conditions are concerned (November, December, January and February).

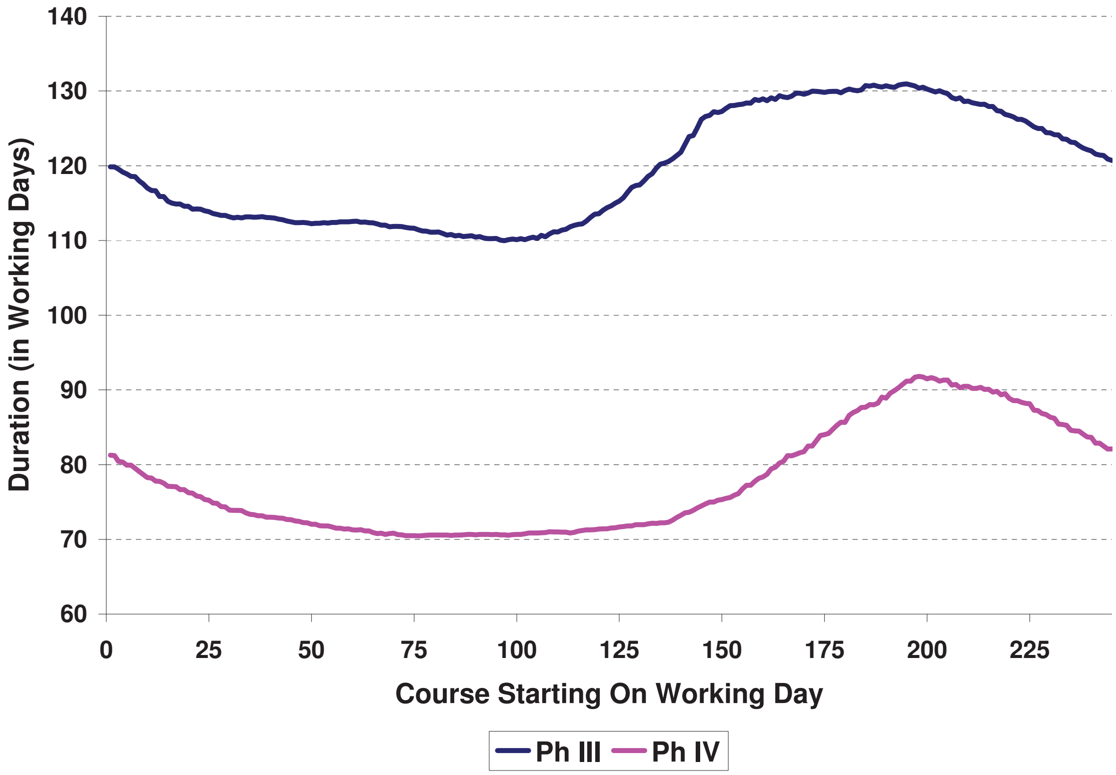

Figure 8: *Expected Number of Working Days as a Function of Start*

3 Resulting Schedule

This section presents how the new course schedules for all phases were produced from the method presented in Section 2 for Phases III and IV, along with an improved Phases IIA and IIB method for estimating course duration.

Although the NFTC contract ends in 2020, the new schedules were only built to calculate until 2011. The reason for this was that the agreement with the UK, which has students in a Phase III conversion and in Phase IV, will terminate at the end of 2010. This implies that the schedule will probably have to be revised at that time. Additionally, based on weather patterns and potential climate change, it is advisable to update the weather condition tables every five years in any case. This section presents the method used to determine the new schedules until 2011.

3.1 Phase II – Redistribution of the 175-FTrgD Cal

As mentioned in Section 2.1, NFTC Phases IIA and IIB use a different FTrgD Cal than Phases III and IV. The calendar used to estimate the duration of a Phase II course includes 175 flying days. According to Phases IIA and IIB SMEs, the total number of flying days, 175, is very close to reality. However, a problem reported by SMEs is that the distribution of the non-flying days is incorrect. The last four years of experience have proven that the 175-FTrg Cal does not provide enough non-flying days in the summer period, and on the other hand, there are too many non-flying days in the winter.

For those reasons, 2 CFFTS requested the continued use of a 175-FTrgD Cal for Phase II with a redistribution of the non-flying days. Their suggestion was to change, in CYs 2005 to 2013[6], eight flying days per year during the summer months to non-flying days, and eight non-flying days in the winter months to flying days. The recommendation was to include the number of non-flying days per month as per Table 7.

The numbers in Table 7 correspond to a more realistic number of non-flying days expected during the summer months. For instance, the original 175-FTrgD Cal for CY 2009 does not have non-flying days in the months of May and August and SMEs claim that these two months should contain three, four or five non-flying days. Table 8 presents the changes that were made in the 175-FTrgD Cal. Column 2 contains the days that were changed from flying to non-flying, and Column 3, the changes from non-flying to flying. Note that the selection of the days was not very important, the important aspect was the total number of non-flying days per month, and especially during the summer months (approximately 12 non-flying days in May, June, July and August). For instance, in 2005, changing 10 May from flying to non-flying rather than 11 May would not represent a significant impact.

[6]CYs 2005 to 2013 are the years necessary to build the schedule until 2011 since a course starting in 2011 may end in 2013. For example, if a student is enrolled in a Phase IIA serial starting in 2011, and continues past Phase IIA, he may graduate from Phases III and IV in 2012 or 2013.

Table 7: *Phase II – Recommended Number of Non-Flying Days per Month*

Month	Number of Non-Flying Days
Jan	9 ± 2
Feb	8 ± 2
Mar	7 ± 2
Apr	4 ± 1
May	3 ± 1
Jun	3 ± 1
Jul	3 ± 1
Aug	3 ± 1
Sep	5 ± 1
Oct	7 ± 1
Nov	9 ± 2
Dec	9 ± 2

The impact of a redistribution of the non-flying days is that some Phase II courses will be lengthened and others shortened but the average Phase II course duration will remain the same. This will be demonstrated in Section IV.

The author acknowledges that, ideally, a thorough weather analysis, similar to the one presented in Section II, should have been done for Phases IIA and IIB as well. However, there are several reasons why a redistribution was accepted rather than a detailed study:

- The primary issue was time constraint. The new schedule had to be completed and presented at the end of February 2005 to the NFTC participating nations at the OpsWG meeting held in Singapore [9]. At the time the project was initiated, there was not enough time to perform a complete weather analysis of all three phases;

- As mentioned in Section 1, there have been no recent graduation problems for Phase II due to reduced CA student loadings (about 105 starts per year versus the contracted 131). Student loads are expected to remain low for the next few years. It was therefore deemed more important to spend the majority of the time on Phases III and IV, which have both recently experienced problems graduating students on time; and

- Finally, there were a few concerns about the number of non-flying days in the summer period in the 175-FTrgD Cal. These were addressed, based on SME recommendations, by moving non-flying days from the winter to the summer months as shown in Tables 7 and 8.

Table 8: *Changes to the 175-FTrgD Cal*

Year	Changed to Non-Flying Day			Changed to Flying Day		
2005	11-May	19-May	02-Jun	05-Jan	19-Jan	10-Feb
	28-Jun	07-Jul	27-Jul	23-Mar	06-Apr	24-Oct
	03-Aug	31-Aug		16-Nov	08-Dec	
2006	02-May	16-May	06-Jun	11-Jan	25-Jan	22-Feb
	29-Jun	06-Jul	18-Jul	13-Mar	29-Mar	18-Oct
	15-Aug	30-Aug		16-Nov	07-Dec	
2007	09-May	30-May	06-Jun	17-Jan	31-Jan	20-Feb
	27-Jun	17-Jul	26-Jul	07-Mar	20-Mar	17-Oct
	08-Aug	29-Aug		21-Nov	18-Dec	
2008	07-May	16-May	06-Jun	31-Jan	20-Feb	17-Mar
	27-Jun	23-Jul	08-Aug	10-Apr	05-Sep	24-Oct
	19-Aug	29-Aug		14-Nov	16-Dec	
2009	06-May	21-May	25-May	06-Jan	27-Jan	06-Feb
	05-Jun	24-Jul	05-Aug	13-Mar	11-Sep	14-Oct
	14-Aug	18-Aug		16-Nov	16-Dec	
2010	04-May	17-May	21-May	05-Jan	25-Jan	24-Feb
	30-Jun	16-Jul	21-Jul	11-Mar	21-Sep	13-Oct
	16-Aug	27-Aug		17-Nov	16-Dec	
2011	11-May	19-May	02-Jun	05-Jan	19-Jan	10-Feb
	28-Jun	07-Jul	27-Jul	09-Mar	23-Mar	24-Oct
	03-Aug	31-Aug		16-Nov	15-Dec	
2012	11-May	30-May	06-Jun	04-Jan	25-Jan	10-Feb
	27-Jun	17-Jul	26-Jul	23-Mar	10-Oct	17-Oct
	03-Aug	30-Aug		16-Nov	18-Dec	
2013	08-May	05-Jun	18-Jun	09-Jan	23-Jan	20-Feb
	27-Jun	23-Jul	01-Aug	13-Mar	09-Apr	17-Oct
	21-Aug	26-Aug		27-Nov	10-Dec	

3.2 Assumptions and Constraints

The following assumptions and constraints were taken into consideration:

1. Phases IIA and IIB use the method presented in Section 2.1 along with the updated 175-FTrgD Cal to determine the course duration;

2. Phases III and IV use the new method for course duration introduced in Section 2.2;

3. The number of Phase IIA serials per year remain at nine;

4. Serials are scheduled to start only on the first working day of the week. If a serial was allowed to start on any working day in a year, there would be 245 possible start dates. However, this constraint restricts the number of possible starts for a serial to 52, therefore a serial could start on the first working day of Week #1, Week #2, . . . , Week #52;

5. The last two weeks of the year, Weeks #51 and #52, are not considered as eligible start dates for a serial because the schools interrupt their operations during that period for Christmas leave;

6. All Phase IIA serials must complete ground school before Christmas break. This means that the last three weeks before the break are eliminated as possible start days because any course starting during Weeks #48, #49 or #50 would not have enough time to complete the three weeks of ground school required at the beginning of Phase IIA. This leaves 47 possible start dates for a Phase IIA serial;

7. The first serial of each year, noted xx01[7], starts on Week #1 every year. Table 9 shows Week #1 for 2005 to 2013 as identified by NFTC SMEs;

Table 9: *Week #1 for 2005 to 2013*

Year	Week #1 on
2005	10-Jan
2006	09-Jan
2007	15-Jan
2008	14-Jan
2009	12-Jan
2010	11-Jan
2011	10-Jan
2012	09-Jan
2013	14-Jan

8. Two consecutive Phase IIA starts must be separated by at least three weeks. This constraint exists so there is never more than one Phase IIA serial at the same time in the ground school period, which reduces the need for additional classrooms;

9. Is is assumed that NFTC has enough resources to support a maximum of:

   (a) Five Phase IIA serials on the flightline[8];

   (b) Four Phase III serials on the flightline; and

   (c) Three Phase IV serials on the flightline.

10. Conflicts will be managed by the course scheduling authority. If Assumption 9 is violated for very short durations, the number of students per serial may be adjusted accordingly;

[7] Serial xx01 refers to serial 01 of year 20xx.

[8] A serial is considered to be on the flightline once its ground school portion is completed.

11. Phase IIA start dates will be based on the same pattern every year;

12. One week is allotted in between Phases II, III and IV;

13. Phase IIB course will start the next working day following the end of Phase IIA; and

14. Course end dates always fall on Fridays.

3.3 Initial Schedule

Define $\vec{s} = (s_1, s_2, \ldots, s_9)$ as a vector containing the start dates of the nine Phase IIA serials, where, s_1 = start date of all serials xx01, s_2 = start date of all serials xx02, ..., s_9 = start date of all serials xx09. For instance, Serial 0704 refers to the fourth Phase IIA serial of CY 2007. The start dates are defined in terms of a week number, meaning that for instance, if $s_1 = 1$, serials 0501, 0601, 0701, ..., 1101, will all start Phase IIA on Week #1. Additionally, define **S** as the search space containing all the possible vectors $\vec{s}$. Based on the set of rules, assumptions, and constraints, the search space **S** containing all possible schedules was constructed using the methodology presented in Annex C. As shown in the annex, the size of **S** was 5,852,925 possible schedules.

The objective was to find the best possible combination of nine Phase IIA starts, such as that the number of conflicts is minimal. A conflict was defined as any time the total number of courses on the flightline is greater than five for Phase IIA, four for Phase III, or three for Phase IV. These limits were provided by NFTC SMEs. They correspond to the maximum number of serials on the flightline that each phase can support at the same time based on the resources available to the Program.

In order to generate the initial schedule, an exhaustive search of all the schedules in **S** was executed. The algorithm and the methodology is presented in Annex C. The optimal combination found by the model was the following:

$$s_1 = 1, s_2 = 8, s_3 = 12, s_4 = 15, s_5 = 20, s_6 = 26, s_7 = 32, s_8 = 36 \text{ and } s_9 = 43.$$

The number of conflicts obtained from the optimal solution was 235, with the following results for Phases IIA, III and IV respectively: 30 days with six serials in-house, 200 days with five serials in-house, and 4 days with four serials in-house. Note that the number of conflicts was computed in a six year period, from CY 2005 until 2010. It means that, on average, the initial schedule generated from the exhaustive search contains 5.00 days per year with conflicts for Phase IIA, 33.33 days per year for Phase III, and 0.67 day per year for Phase IV.

The schedules were built for serials from 2005 (Serials 0501, 0502, ..., 0509) until 2013 (Serials 1301, 1302, ..., 1309). In the initial schedule obtained from the exhaustive search, Serials 1205, 1206, 1207, 1208, 1209, and all the serials in 2013 (Serials 1301, ..., 1309) all ended their respective Phase IV training after 2013, which was the last year taken into consideration. The model assumed steady state, meaning that when a serial ended after 2013, what was left of its training was wrapped-up at the beginning of 2005. For instance, if a serial was scheduled to complete Phase IV at the twelfth working day of January 2014, the model dealt with it as if the serial was doing Phase IV from the first until the twelfth working days of January 2005. This was done because potential conflicts may exist with the first serials (0501, 0502, etc.), otherwise, the first serials would not have been in competition with any other serials.

3.4 Transition

In order to remove the artificiality and to take transition into consideration, the serials that were currently in-house (Serials 0306 to 0409) at the time the study was done (beginning of 2005), were added in the schedule to replace the wrap-up period from Serials 1205, 1206, . . . , 1309. This was done to evaluate the impacts of the transition in terms of conflicts. The phases at which Serials 0306 to 0409 were at the beginning of CY 2005 are shown in Table 10. All the start dates were set to 5-Jan-05 but in reality, all were started in 2004.

Table 10: *Start and End Dates of Transition Period*

	Phase IIA		**Phase IIB**		**Phase III**		**Phase IV**	
Serial	Start	End	Start	End	Start	End	Start	End
s0306	–	–	–	–	–	–	5-Jan-05	15-Mar-05
s0307	–	–	–	–	–	–	5-Jan-05	8-Apr-05
s0308	–	–	–	–	–	–	5-Jan-05	22-Apr-05
s0309	–	–	–	–	5-Jan-05	25-Feb-05	7-Mar-05	17-Jun-05
s0401	–	–	–	–	5-Jan-05	27-Apr-05	2-May-05	5-Aug-05
s0402	–	–	–	–	5-Jan-05	20-May-05	6-Jun-05	2-Sep-05
s0403	–	–	–	–	17-Jan-05	24-Jun-05	4-Jul-05	30-Sep-05
s0404	–	–	5-Jan-05	11-Feb-05	21-Feb-05	26-Jul-05	2-Aug-05	4-Nov-05
s0405	–	–	5-Jan-05	24-Mar-05	4-Apr-05	26-Aug-05	6-Sep-05	22-Dec-05
s0406	5-Jan-05	18-Mar-05	21-Mar-05	13-May-05	24-May-05	14-Oct-05	24-Oct-05	17-Mar-06
s0407	5-Jan-05	29-Apr-05	2-May-05	17-Jun-05	27-Jun-05	18-Nov-05	28-Nov-05	13-Apr-06
s0408	5-Jan-05	18-May-05	19-May-05	8-Jul-05	11-Jul-05	20-Dec-05	9-Jan-06	2-May-06
s0409	5-Jan-05	17-Jun-05	20-Jun-05	5-Aug-05	15-Aug-05	28-Feb-06	6-Mar-06	13-Jun-06

Once the transition period was added to the schedule, the total number of conflicts was reduced from 235 to 216. The new schedule had 36 conflicts for Phase IIA, 179 for Phase III and 11 for Phase IV. Once the new schedule is implemented, the transition is expected to last until 13-Jun-06, which corresponds to the date when Serial 0409 will complete Phase IV. At that time, all dates will be taken from the new schedule.

3.5 Final Schedule Review

A final review of the schedule was conducted by A1 Training officers to determine if any adjustments or improvements were necessary, or if the new schedule contained any anomalies.

A1 Training decided to modify Phases III and IV end dates of the serials that were already in-house in January 2005 because their duration was calculated with the old method (192-FTrgD Cal). It was impossible to lengthen any Phase III serial because Phase IV starts the week after the end of Phase III. NFTC will have to use the old dates and realize that it will be difficult to meet the Phase III end dates of the serials that are already in-house. However, it was possible to make adjustments to some Phase IV end dates. The following modifications were proposed:

1. Serial 0307: Phase IV end date from 8-Apr-05 to 15-Apr-05;
2. Serial 0308: Phase IV end date from 22-Apr-05 to 29-Apr-05;
3. Serial 0402: Phase IV end date from 2-Sep-05 to 9-Sep-05;
4. Serial 0403: Phase IV end date from 30-Sep-05 to 7-Oct-05; and
5. Serial 0404: Phase IV end date from 4-Nov-05 to 18-Nov-05.

Only one change was made to the schedule for the new dates that were generated by the model: Serial 0707 Phase IV's start date was moved from 22-Dec-08 to 5-Jan-09. This was done because if the course started on 22-Dec-08, it would only have the time to do three days of ground school before leaving for the 25-Dec-08 Christmas break. The students would therefore have to come back after the Christmas break for the remaining two days of ground school before starting their missions. It was therefore deemed more reasonable to start in the new year.

Note that all the changes were done making sure not to create any additional conflicts in the schedules. Figures 9, 10 and 11 present the final schedule from CY 2005 to CY 2011. The yellow cells represent the manual changes made as a result of the final review by A1 Training.

Serial	Phase IIA		Phase IIB		Phase III		Phase IV	
	Start	End	Start	End	Start	End	Start	End
s0306	30-Jun-03	2-Apr-04	5-Apr-04	18-May-04	25-May-04	22-Oct-04	1-Nov-04	15-Mar-05
s0307	28-Jul-03	12-May-04	13-May-04	11-Jun-04	21-Jun-04	19-Nov-04	29-Nov-04	15-Apr-05
s0308	18-Aug-03	25-May-04	26-May-04	30-Jun-04	5-Jul-04	20-Dec-04	5-Jan-05	29-Apr-05
s0309	6-Oct-03	25-Jun-04	28-Jun-04	6-Aug-04	16-Aug-04	25-Feb-05	7-Mar-05	17-Jun-05
s0401	12-Jan-04	13-Aug-04	16-Aug-04	24-Sep-04	4-Oct-04	27-Apr-05	2-May-05	5-Aug-05
s0402	16-Feb-04	10-Sep-04	13-Sep-04	29-Oct-04	8-Nov-04	20-May-05	6-Jun-05	9-Sep-05
s0403	22-Mar-04	8-Oct-04	11-Oct-04	20-Dec-04	17-Jan-05	24-Jun-05	4-Jul-05	7-Oct-05
s0404	13-Apr-04	12-Nov-04	15-Nov-04	11-Feb-05	21-Feb-05	26-Jul-05	2-Aug-05	18-Nov-05
s0405	10-May-04	22-Dec-04	5-Jan-05	24-Mar-05	4-Apr-05	26-Aug-05	6-Sep-05	22-Dec-05
s0406	28-Jun-04	18-Mar-05	21-Mar-05	13-May-05	24-May-05	14-Oct-05	24-Oct-05	17-Mar-06
s0407	26-Jul-04	29-Apr-05	2-May-05	17-Jun-05	27-Jun-05	18-Nov-05	28-Nov-05	13-Apr-06
s0408	30-Aug-04	18-May-05	19-May-05	8-Jul-05	11-Jul-05	20-Dec-05	9-Jan-06	2-May-06
s0409	4-Oct-04	17-Jun-05	20-Jun-05	5-Aug-05	15-Aug-05	28-Feb-06	6-Mar-06	13-Jun-06
s0501	10-Jan-05	29-Jul-05	2-Aug-05	30-Sep-05	11-Oct-05	28-Apr-06	8-May-06	18-Aug-06
s0502	28-Feb-05	13-Sep-05	14-Sep-05	25-Nov-05	5-Dec-05	9-Jun-06	19-Jun-06	29-Sep-06
s0503	29-Mar-05	7-Oct-05	11-Oct-05	13-Jan-06	23-Jan-06	7-Jul-06	17-Jul-06	27-Oct-06
s0504	18-Apr-05	4-Nov-05	7-Nov-05	17-Feb-06	27-Feb-06	11-Aug-06	21-Aug-06	15-Dec-06
s0505	24-May-05	11-Jan-06	12-Jan-06	24-Mar-06	3-Apr-06	15-Sep-06	25-Sep-06	9-Feb-07
s0506	4-Jul-05	6-Mar-06	7-Mar-06	12-May-06	23-May-06	27-Oct-06	6-Nov-06	23-Mar-07
s0507	15-Aug-05	20-Apr-06	21-Apr-06	16-Jun-06	26-Jun-06	8-Dec-06	18-Dec-06	27-Apr-07
s0508	12-Sep-05	15-May-06	16-May-06	14-Jul-06	24-Jul-06	26-Jan-07	5-Feb-07	25-May-07
s0509	31-Oct-05	21-Jun-06	22-Jun-06	18-Aug-06	28-Aug-06	9-Mar-07	19-Mar-07	29-Jun-07
s0601	9-Jan-06	28-Jul-06	31-Jul-06	29-Sep-06	10-Oct-06	27-Apr-07	7-May-07	17-Aug-07
s0602	27-Feb-06	12-Sep-06	13-Sep-06	24-Nov-06	4-Dec-06	8-Jun-07	18-Jun-07	28-Sep-07
s0603	27-Mar-06	11-Oct-06	12-Oct-06	19-Jan-07	29-Jan-07	13-Jul-07	23-Jul-07	9-Nov-07

Figure 9: *Final Schedule – Part I*

Serial	Phase IIA		Phase IIB		Phase III		Phase IV	
	Start	End	Start	End	Start	End	Start	End
s0604	18-Apr-06	6-Nov-06	7-Nov-06	16-Feb-07	26-Feb-07	10-Aug-07	20-Aug-07	14-Dec-07
s0605	23-May-06	10-Jan-07	11-Jan-07	23-Mar-07	2-Apr-07	14-Sep-07	24-Sep-07	8-Feb-08
s0606	4-Jul-06	6-Mar-07	7-Mar-07	11-May-07	22-May-07	26-Oct-07	5-Nov-07	20-Mar-08
s0607	14-Aug-06	19-Apr-07	20-Apr-07	15-Jun-07	25-Jun-07	7-Dec-07	17-Dec-07	25-Apr-08
s0608	11-Sep-06	15-May-07	16-May-07	13-Jul-07	23-Jul-07	25-Jan-08	4-Feb-08	23-May-08
s0609	30-Oct-06	18-Jun-07	19-Jun-07	17-Aug-07	27-Aug-07	7-Mar-08	17-Mar-08	27-Jun-08
s0701	15-Jan-07	1-Aug-07	2-Aug-07	5-Oct-07	15-Oct-07	2-May-08	12-May-08	22-Aug-08
s0702	5-Mar-07	17-Sep-07	18-Sep-07	30-Nov-07	10-Dec-07	13-Jun-08	23-Jun-08	3-Oct-08
s0703	2-Apr-07	22-Oct-07	23-Oct-07	1-Feb-08	11-Feb-08	25-Jul-08	5-Aug-08	21-Nov-08
s0704	23-Apr-07	15-Nov-07	16-Nov-07	22-Feb-08	3-Mar-08	15-Aug-08	25-Aug-08	19-Dec-08
s0705	28-May-07	22-Jan-08	23-Jan-08	4-Apr-08	14-Apr-08	26-Sep-08	6-Oct-08	20-Feb-09
s0706	9-Jul-07	13-Mar-08	14-Mar-08	16-May-08	26-May-08	31-Oct-08	10-Nov-08	27-Mar-09
s0707	20-Aug-07	28-Apr-08	29-Apr-08	20-Jun-08	30-Jun-08	12-Dec-08	5-Jan-09	1-May-09
s0708	17-Sep-07	21-May-08	22-May-08	18-Jul-08	28-Jul-08	6-Feb-09	16-Feb-09	5-Jun-09
s0709	5-Nov-07	23-Jun-08	24-Jun-08	22-Aug-08	2-Sep-08	13-Mar-09	23-Mar-09	10-Jul-09
s0801	14-Jan-08	30-Jul-08	31-Jul-08	26-Sep-08	6-Oct-08	24-Apr-09	4-May-09	14-Aug-09
s0802	3-Mar-08	12-Sep-08	15-Sep-08	28-Nov-08	8-Dec-08	12-Jun-09	22-Jun-09	2-Oct-09
s0803	31-Mar-08	7-Oct-08	8-Oct-08	16-Jan-09	26-Jan-09	10-Jul-09	20-Jul-09	30-Oct-09
s0804	21-Apr-08	6-Nov-08	7-Nov-08	13-Feb-09	23-Feb-09	7-Aug-09	17-Aug-09	4-Dec-09
s0805	26-May-08	14-Jan-09	15-Jan-09	27-Mar-09	6-Apr-09	18-Sep-09	28-Sep-09	12-Feb-10
s0806	7-Jul-08	6-Mar-09	9-Mar-09	15-May-09	25-May-09	30-Oct-09	9-Nov-09	26-Mar-10
s0807	18-Aug-08	28-Apr-09	29-Apr-09	26-Jun-09	6-Jul-09	18-Dec-09	4-Jan-10	30-Apr-10
s0808	15-Sep-08	20-May-09	21-May-09	17-Jul-09	27-Jul-09	29-Jan-10	8-Feb-10	28-May-10
s0809	3-Nov-08	24-Jun-09	25-Jun-09	21-Aug-09	31-Aug-09	12-Mar-10	22-Mar-10	9-Jul-10
s0901	12-Jan-09	4-Aug-09	5-Aug-09	2-Oct-09	13-Oct-09	30-Apr-10	10-May-10	20-Aug-10

Figure 10: *Final Schedule – Part II*

Serial	Phase IIA		Phase IIB		Phase III		Phase IV	
	Start	End	Start	End	Start	End	Start	End
s0902	2-Mar-09	11-Sep-09	14-Sep-09	20-Nov-09	30-Nov-09	4-Jun-10	14-Jun-10	24-Sep-10
s0903	30-Mar-09	9-Oct-09	13-Oct-09	15-Jan-10	25-Jan-10	9-Jul-10	19-Jul-10	29-Oct-10
s0904	20-Apr-09	6-Nov-09	9-Nov-09	12-Feb-10	22-Feb-10	6-Aug-10	16-Aug-10	3-Dec-10
s0905	25-May-09	7-Jan-10	8-Jan-10	19-Mar-10	29-Mar-10	10-Sep-10	20-Sep-10	4-Feb-11
s0906	6-Jul-09	4-Mar-10	5-Mar-10	14-May-10	25-May-10	29-Oct-10	8-Nov-10	25-Mar-11
s0907	17-Aug-09	27-Apr-10	28-Apr-10	25-Jun-10	5-Jul-10	17-Dec-10	5-Jan-11	29-Apr-11
s0908	14-Sep-09	19-May-10	20-May-10	16-Jul-10	26-Jul-10	4-Feb-11	14-Feb-11	3-Jun-11
s0909	2-Nov-09	23-Jun-10	24-Jun-10	20-Aug-10	30-Aug-10	11-Mar-11	21-Mar-11	8-Jul-11
s1001	11-Jan-10	4-Aug-10	5-Aug-10	1-Oct-10	12-Oct-10	29-Apr-11	9-May-11	19-Aug-11
s1002	1-Mar-10	14-Sep-10	15-Sep-10	26-Nov-10	6-Dec-10	10-Jun-11	20-Jun-11	30-Sep-11
s1003	29-Mar-10	8-Oct-10	12-Oct-10	14-Jan-11	24-Jan-11	8-Jul-11	18-Jul-11	28-Oct-11
s1004	19-Apr-10	4-Nov-10	5-Nov-10	11-Feb-11	21-Feb-11	5-Aug-11	15-Aug-11	2-Dec-11
s1005	25-May-10	10-Jan-11	11-Jan-11	25-Mar-11	4-Apr-11	16-Sep-11	26-Sep-11	10-Feb-12
s1006	5-Jul-10	2-Mar-11	3-Mar-11	6-May-11	16-May-11	21-Oct-11	31-Oct-11	16-Mar-12
s1007	16-Aug-10	19-Apr-11	20-Apr-11	17-Jun-11	27-Jun-11	9-Dec-11	19-Dec-11	27-Apr-12
s1008	13-Sep-10	13-May-11	16-May-11	15-Jul-11	25-Jul-11	27-Jan-12	6-Feb-12	25-May-12
s1009	1-Nov-10	21-Jun-11	22-Jun-11	19-Aug-11	29-Aug-11	9-Mar-12	19-Mar-12	29-Jun-12
s1101	10-Jan-11	29-Jul-11	2-Aug-11	30-Sep-11	11-Oct-11	27-Apr-12	7-May-12	17-Aug-12
s1102	28-Feb-11	13-Sep-11	14-Sep-11	25-Nov-11	5-Dec-11	8-Jun-12	18-Jun-12	28-Sep-12
s1103	28-Mar-11	11-Oct-11	12-Oct-11	13-Jan-12	23-Jan-12	6-Jul-12	16-Jul-12	26-Oct-12
s1104	18-Apr-11	10-Nov-11	14-Nov-11	17-Feb-12	27-Feb-12	10-Aug-12	20-Aug-12	14-Dec-12
s1105	24-May-11	10-Jan-12	11-Jan-12	30-Mar-12	10-Apr-12	21-Sep-12	1-Oct-12	15-Feb-13
s1106	4-Jul-11	6-Mar-12	7-Mar-12	11-May-12	22-May-12	26-Oct-12	5-Nov-12	22-Mar-13
s1107	15-Aug-11	23-Apr-12	24-Apr-12	15-Jun-12	25-Jun-12	7-Dec-12	17-Dec-12	26-Apr-13
s1108	12-Sep-11	16-May-12	17-May-12	13-Jul-12	23-Jul-12	25-Jan-13	4-Feb-13	24-May-13

Figure 11: *Final Schedule – Part III*

4 Impact

This section demonstrates the impact of the new schedule on NFTC's participating nations. Before any modifications are made to the method for estimating the end dates (as presented in Section 2), or before the implementation of a new schedule, all the countries participating in NFTC have to agree. This is normally done by way of a presentation from the NFTC OpsWG to the NFTC Steering Committee, followed by a vote.

4.1 Time in Canada

At the time the study was completed, there were six participating nations in the Program. Participating nations include the countries that send students through at least one of the NFTC phases. Other countries, such as Germany, Sweden, Finland, and France, who are only sending instructors to NFTC, are considered contributing nations, and do not have a vote at the Steering Committee level. For the purpose of this report, only countries sending students were considered. Table 11 shows the participating NFTC nations: the top part of the table indicates the serials in which they are involved and the bottom part, in what phases. For example, Singapore has students loaded in Serials xx02, xx05 and xx09, but only in Phases III and IV. Note that the Phase III conversion training done by the UK before moving on to Phase IV has not been considered since it only lasts about four weeks.

Table 11: *Participating Nations in NFTC*

	Canada	Denmark	Hungary	Italy	Singapore	UK
xx01	√					√
xx02	√				√	√
xx03	√			√		√
xx04	√					√
xx05	√				√	√
xx06	√					√
xx07	√		√			√
xx08	√	√				
xx09	√		√		√	√
Phase IIA	√	√	√	√		
Phase IIB	√	√	√	√		
Phase III	√	√	√	√	√	
Phase IV	√	√	√	√	√	√

The metric used to determine the impact of the new schedule on all the nations was the *time in Canada*, expressed in terms of calendar days. For each nation, the time the students spent in

Canada during 2002, 2003 and 2004 was compared with how long the students were expected to stay in Canada for future courses. This assumes that, when the new schedule is implemented, the nations will send their students through the same phase(s) and in the same serial(s). Table 12 presents the impact on each nation involved in NFTC.

Table 12: *Impact on the Nations*

	Canada	Denmark	Hungary	Italy	Singapore	UK
New Schedule	606	622	615	587	306	116
2002-2004	594	616	621	559	288	108
Difference (in Calendar Days)	13	6	-7	27	18	8

The impact, in terms of calendar days spent in Canada, is relatively minor. The incremental cost incurred by keeping a student longer in Canada by one week, two weeks, or even a month, are marginal compared to the money it costs to send students through NFTC[9]. The most affected nation is Italy, which will now be asked to spend 27 more days in Canada.

Rather than the time spent in Canada, as raised at [9], a more significant impact on the nations seemed to be related to the new start and end dates. The reason for this is that the dates may no longer be synchronized with their respective in-country training that occurs immediately before or after NFTC. After the completion of Phase IV, the students normally move on to their Operational Training Unit (OTU) or Operational Conversion Unit (OCU). The Phase IV portion of Serial xx05 used to end at the last week of December; however, the new schedule requires that it now ends during the first week of February. So, an OTU (or OCU) start date sometime in January was satisfactory for a past student in xx05, but now, the same student would miss an OTU start in January. This could potentially create exceedingly long Pilot Awaiting Training (PAT) pools, which is undesirable in any pilot training system. The impact regarding PAT pools will have to be determined separately by each nation.

4.2 Individual Course Duration

In order to reduce the time in Canada or to synchronize NFTC with their respective internal country training, certain nations may be tempted to move to different serials. Table 13 corresponds to the average time in Canada by serial by phase. With the new schedule, the shortest Phase II serial is xx01, shortest Phase III serial is xx06, and shortest Phase IV serials are xx01 and xx02. Serial xx02 is the shortest serial for students going through all NFTC Phases. This table would be used by the nations as a tool to help determine the impact of moving to a different serial. For instance,

[9]In 2005, the approximate costs for sending one student through Phases II, III and IV, were respectively: Can$250,000, Can$950,000 and Can$900,000.

if Italy moved to the Serial xx02 rather than staying on the xx03, they would be required to stay in Canada an additional 18 days instead of 27 days. Bilateral discussions will happen between each participating NFTC nation and DND (A1 Training and the Directorate of Air Contracted Force Generation) to try to accommodate the individual needs of each nation.

Table 13: *Course Duration (in days) by Phase and Serial*

Serial	Phase II (A and B)	Phase III	Phase IV	All Phases
xx01	259	200	102	583
xx02	269	186	102	578
xx03	294	165	105	587
xx04	302	165	114	602
xx05	305	165	137	628
xx06	310	158	137	627
xx07	306	165	123	620
xx08	304	188	109	622
xx09	290	193	106	610

4.3 Impact of Redistribution of the 175-FTrgD Cal

It was mentioned in Section 3.1 that the impact of the redistribution of the non-flying days in the 175-FTrgD Cal is that some Phase II courses will be lengthened and others shortened, but that the average Phase II course duration will remain the same. The average duration of the Phase II serials in 2002, 2003 and 2004, including both Phases IIA and IIB, are shown in Table 14. The last column shows the difference, in calendar days, between the old and the new schedules.

As a result of the non-flying days redistribution, the first three serials were lengthened by at least one week, the fourth serial had a variation of only one day, and the last five were all shortened by at least one week. Overall, the difference of the sum of all the variations is only one day shorter for all the serials, for an average of -0.11 day per serial, which is negligible.

4.4 Other Impacts and Comments

Minor contractual issues between the Government of Canada and BA MAT may arise from the implementation of the new schedule. The contract was built such that nine serials of each phase are loaded every year. This is how BA MAT is being remunerated: nine starts per year. However, in the new schedule, there are some years where there are only eight Phase IIA starts. On the other hand, there are years where ten serials are loaded, which equates to an average of exactly nine per year. Some deliberations will have to take place in order to accommodate this issue.

Table 14: *Phase II Course Duration – 2002, 2003 and 2004*

Serial	Old Phase II Duration (A and B)	New Phase II Duration (A and B)	Difference (New - Old)
xx01	255	259	+4
xx02	253	269	+16
xx03	266	294	+28
xx04	301	302	+1
xx05	310	305	-5
xx06	319	310	-9
xx07	318	306	-12
xx08	315	304	-11
xx09	303	290	-13
Total Difference:			-1

Before the start of the project, some individuals were worried that if the courses were to be lengthened, like the case for the Phases III and IV, the program might not be capable of graduating the contracted number of students at the end of 2020. However, this should not be a concern since there would be on average, nine Phase IIA serials loaded every year, and therefore, the required number of students would be trained.

Culture shock may be incurred from the new method for calculating course duration introduced for Phases III and IV. Thus far, the Program has been using flying days as a reference, but the new approach does not consider flying days. Now, the idea is no longer to separate working and flying days (245 working days with 192 of them being flying days) in a year but rather, consider all 245 working days as possible flying days. The difference is that the likelihood of accomplishing a mission on any given day is now determined based on the weather condition associated with the mission to be flown and the time of the year. This is an important philosophical change since the Program is built with an average number of sorties per day, obtained considering 192 flying days.

5 Conclusion

This technical report was intended to serve multiple purposes. A new method for estimating the duration of Phase III and Phase IV serials was presented. It addressed the disadvantages that the old method presented, which were: not enough non-flying days in the summer months, no consideration that a mission has different probabilities of being completed depending on the time of the year, and no history of how non-flying days in the 192-FTrgD Cal were determined. The new method concentrates solely on the effect of weather in determining the length of the course. It is important to mention that it was assumed that the Program has sufficient resources to support the student loads, meaning that resources are available as needed. The new course duration approach was validated when applied to past NFTC schedules as the serials that had problems graduating on time in 2003 and 2004 were identified with the new approach. It showed that on average, Phases III and IV end dates should have been made approximately one week longer.

The report also showed how the new approach for determining the course duration was incorporated into a more complex model used to develop the new NFTC schedule. Due to assumptions made and constraints faced by the Program, the search space of the problem was reduced enough to perform an exhaustive search of all the possible schedules. The criterion used to evaluate the quality of a schedule was the total number of conflicts, which was based on the fact that a maximum of five Phase IIA, four Phase III and three Phase IV serials could be on the flightline simultaneously. The optimal solution showed that, every year, Phase IIA starts should happen on weeks: #1, #8, #12, #15, #20, #26, #32, #36 and #43. The final schedule was obtained after the transition period was added into the schedule and once a final review from A1 Training, proposing minor changes, was completed. The total number of conflicts associated with the final schedule was 216, which equated to 36 conflicts for Phase IIA, 179 for Phase III and 11 for Phase IV.

Before the new schedules were generated, a redistribution of the 175-FTrgD Cal, which is used to estimate the start and end dates of Phases IIA and IIB, was done in order to better allocate the non-flying days during the year. Following a recommendation of 2 CFFTS, eight non-flying days in the winter months were changed to flying days, and eight flying days in the summer months were made non-flying days. This kept the total number of flying days throughout the year constant at 175. It was shown in the report that the redistribution had no impact on the duration of Phase II courses, as it only shortened the serials by an average of 0.11 day per year.

The most important aspect presented in this document was the impact on the participating nations. In order for the new schedules to be implemented by the Program, it had to be demonstrated that there would be very little impact on the nations. It was shown that the impact, in terms of calendar days spent in Canada, is relatively minor. The time in Canada varies from staying 7 days less in Canada (for Hungary) to extending the stay in Canada by 27 days for Italy. The incremental cost incurred by keeping a student in the country longer by one week, two weeks, or even a month, is marginal compared to the money it costs to send students through NFTC. However, a more significant impact on the nations may be in regard to the new start and end dates as the dates may no longer be synchronized with their respective in-country training that occurs immediately before or after NFTC. This could potentially create exceedingly long PAT pools for some nations, which is undesirable in any pilot training system. The impact regarding PAT pools will have to be determined separately by each nation.

A point that is worth mentioning is that before the full implementation of the schedule, the Program will have to go through a year and a half transition period (until June 2006). This may cause some problems as the Program will have to face some important cultural changes, such as the fact that Phases III and IV are no longer based on a fixed FTrgD Cal.

It is assumed that, with the new schedule, as some courses were lengthened, NFTC will increase its chances of meeting the graduation dates because the method for the duration of the course is based on rigorous weather analysis. Obviously, a monitoring period is recommended in order to validate this assumption, and minor modifications may be required as the Program evolves.

5.1 Future Work

When it is time to generate schedules for the remainder of the contract (until 2020), it is recommended that thorough weather analysis be done, similar to the one for Phases III and IV, for Phases IIA and IIB as well, to determine course duration. It was not done for the purpose of this report, mainly due to time constraints. Related to this is a recommendation to update the Phases III and IV weather condition probabilities periodically, every five years, until the end of the contract.

The model introduced for determining the course duration for Phases III and IV is deterministic, meaning that it provides the expected duration of a course as an average. If the level of risk associated with allocating a given number of days to a course is desired, the model would have to be converted into a stochastic process.

The author believes that, because the number of serials on the flightline at the same time is now known, linear programming techniques could be used to determine the optimal course loadings for each phase and for each year. This could be the subject of a later study or project.

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Annex A
NFTC Phases III and IV Syllabus

This annex presents the course syllabus of NFTC Phases III and IV. Column 4 contains the weather conditions that were assigned to each mission. Consider the following notations: ACM=Air Combat Maneuver, AI=Airborne Intercept, AST=Air-to-Surface Tactics, AW=Academic Weapon, BFM=Basic Fighter Maneuver, CH=Clearhood, CM=Composite, FM=Formation, IF=Instrument Flight, LLAT=Low Level Awareness Training, NA=Navigation, and NT=Night.

Table A.1: *Phase III – Course Syllabus*

Msn Nbr	Type	Name	WC	Msn Nbr	Type	Name	WC
1	FTD	CPT01	21	42	FTD	FTD IF09	21
2	FTD	CPT02	21	43	FLY	IF07A	20
3	FTD	CPT03	21	44	FLY	IF07B	20
4	FTD	FTD CH01	21	45	FTD	FTD IF10	21
5	FTD	FTD CH02	21	46	FLY	IF08	20
6	FTD	FTD CH03	21	47	FLY	IF09	20
7	FLY	CH01	4	48	FTD	FTD NT01	21
8	FLY	CH02	4	49	FLY	NT01	13
9	FTD	FTD CH04	21	50	FLY	NT01A	13
10	FLY	CH03	1	51	FTD	FTD FM01	21
11	FLY	CH04	4	52	FLY	FM01	19
12	FTD	FTD IF01	21	53	FLY	FM02	19
13	FLY	IF01	9	54	FTD	FTD NA01	21
14	FTD	FTD IF02	21	55	FLY	FM03	19
15	FLY	CH05	4	56	FTD	FTD NA02	21
16	FTD	EFTD	21	57	FLY	FM04	19
17	FLY	CH06	4	58	FLY	FM04A	19
18	FLY	CH06A	2	59	FLY	FM05	19
19	FTD	FTD IF03	21	60	FLY	FM06	19
20	FLY	IF02	9	61	FTD	FTD NA03	21
21	FLY	CH07	4	62	FLY	NA01	12
22	FLY	CH7A	2	63	FLY	NA02	12
23	FTD	FTD IF04	21	64	FLY	NA03	12
24	FLY	IF03	9	65	FTD	FTD TAC FM	21

Table A.1: Phase III – Course Syllabus (Continued)

Msn Nbr	Type	Name	WC
25	FTD	FTD IF05	21
26	FLY	IF04	9
27	FLY	CH08	4
28	FLY	CH08A	2
29	FTD	FTD IF06	21
30	FLY	IF05	9
31	FLY	CH09	5
32	FLY	CH9A	2
33	FTD	FTD IF07	21
34	FLY	IF06	9
35	FLY	CM01	3
36	FTD	FTD IF08	21
37	FLY	CH10	5
38	FLY	CH10A	2
39	FLY	CH11	5
40	FLY	CH12	5
41	FLY	CH13	5

Msn Nbr	Type	Name	WC
66	FLY	NA04	12
67	FLY	NA04A	12
68	FLY	FM07	19
69	FLY	NA05	12
70	FLY	NA06	12
71	FLY	FM08	19
72	FTD	FTD BFM	21
73	FLY	FM09	18
74	FLY	FM10	18
75	FLY	FM11	18
76	FLY	FM12	18
77	FTD	FTD NA04	21
78	FLY	NA07	3
79	FLY	NA08	14
80	FLY	NA09	14
81	FLY	NA10	14

Table A.2: *Phase IV – Course Syllabus*

Msn Nbr	Type	Name	WC
1	FTD	CH01S	13
2	FTD	IF01S	13
3	FLY	CH01	1
4	FTD	BFM01S	13
5	FTD	BFM02S	13
6	FLY	BFM01	11
7	FLY	BFM02	11
8	FLY	BFM03	4
9	FLY	BFM04	11
10	FLY	BFM05	11
11	FLY	BFM06	11
12	FLY	BFM07	11
13	FTD	BFM03S	13
14	FLY	BFM08	11
15	FTD	IF02S	13
16	FLY	BFM09	11
17	FLY	BFM10	11
18	FLY	BFM11	11
19	FTD	ACM01S	13
20	FLY	ACM01	11
21	FLY	ACM02	11
22	FTD	IF03S	13
23	FLY	ACM03	11
24	FLY	ACM04	11
25	FLY	ACM05	11
26	FTD	LLAT01S	13
27	FLY	LLAT01	5
28	FTD	AI01S	13
29	FLY	AI01	12

Msn Nbr	Type	Name	WC
30	FTD	AI02S	13
31	FLY	AI02	12
32	FLY	AI03	12
33	FTD	AW01S	13
34	FTD	AW02S	13
35	FLY	AW01	6
36	FLY	AW02	6
37	FLY	AW03	6
38	FLY	AW04	7
39	FLY	AW05	7
40	FLY	AW06	7
41	FTD	AST01S	13
42	FLY	AST01	8
43	FTD	AST02S	13
44	FLY	AST02	8
45	FLY	AST03	9
46	FLY	AST04	8
47	FLY	AST05	10
48	FLY	AST06	10
49	FLY	AST07	10
50	FLY	AST08	10
51	FLY	AST09	10
52	FLY	AST10	10
53	FLY	AST11	10
54	FLY	AI04	12
55	FLY	AI05	12
56	FLY	AI06	12
57	FLY	AI07	12
58	FLY	AI08	12

Annex B
Cloud Break Procedure

This annex explains how the probabilities for Conditions 18, 19 and 20 of Table 3 and Conditions 11 and 12 of Table 4 were calculated. These conditions are virtual conditions that were added due to the inability to conduct cloud break procedure during the winter period and because of the level of detail available in the weather data. These conditions are determined based on a combination of other conditions, for instance, Phase III Condition 18 is obtained from Conditions 15, 16 and 17.

Phase IV – Condition 11

In order to explain how the probabilities for the aforementioned conditions were obtained, Phase IV Condition 11 (BFM mission) was used as an example. Condition 11 was derived from Conditions 2, 3 and 4 of Table 4. A typical Phase IV BFM mission requires the weather factors presented in Table B.1:

Table B.1: *Condition 11 (Phase IV BFM) – Weather Factors*

Visibility	$\geq$ 8.05 km
Wind	$\leq$ 55.56 km/hr
Temperature	$\in [-30^o, 30^o]$
Wind Chill Index	$\leq$ -35

As illustrated in Figure B.1, BFM missions are flown at an altitude of 13,000 feet[10]. Additional to the four factors presented in Table B.1, a BFM mission needs a clearly discernible horizon, and a minimum of 10,000 feet clear of cloud (5,000 feet above and below the 13,000 foot line). Due to additional flying regulations, an extra 1,000 feet above the 18,000 foot line is required as a buffer between aircraft and cloud. A problem with the weather data was that it did not contain any information concerning cloud layers. The ceiling factor was therefore used to take the cloud layers into consideration. The air space was divided into four areas as shown in Figure B.1: A, B, C and D. In order to determine if a BFM mission could proceed or not, the following rules were developed:

During the Summer Months
Area A – If all weather factors in Table B.1 are met and the ceiling is at least 19,000 feet, the mission proceeds every time;
Area B – If the ceiling is between 8,000 and 19,000 feet, regardless of the factors in Table B.1, no flying occurs;
Area C – If all weather factors in Table B.1 are met and the ceiling is between 2,000 and 8,000

[10]The altitudes in this annex are given in height Above Ground Level (AGL).

feet, the mission proceeds a proportion (ρ) of the time; and
Area D – If the ceiling is less than 2,000 feet, regardless of the factors in Table B.1, no flying occurs.

During the Winter Months
Area A – If all weather factors in Table B.1 are met and the ceiling is at least 19,000 feet, the mission proceeds every time; and
Areas B, C and D – Regardless of the factors in Table B.1, no flying occurs.

The winter months are November, December, January, February, March and April. They correspond to the time of the year where no cloud break procedures are permitted because, during that time, the air temperature from the ground up is below zero Celcius and any flight through cloud could result in aircraft icing. This explains why a ceiling of 19,000 feet is necessary during the winter months.

The proportion ρ was set to 0.50 as a recommendation from Phase IV SMEs. It corresponds to the proportion of the time when there is a clear, workable, 10,000-foot space above the cloud deck. During the summer, when the ceiling is below 2,000 feet, the mission cannot proceed due to the requirement for an alternate airport and insufficient gas to complete the mission.

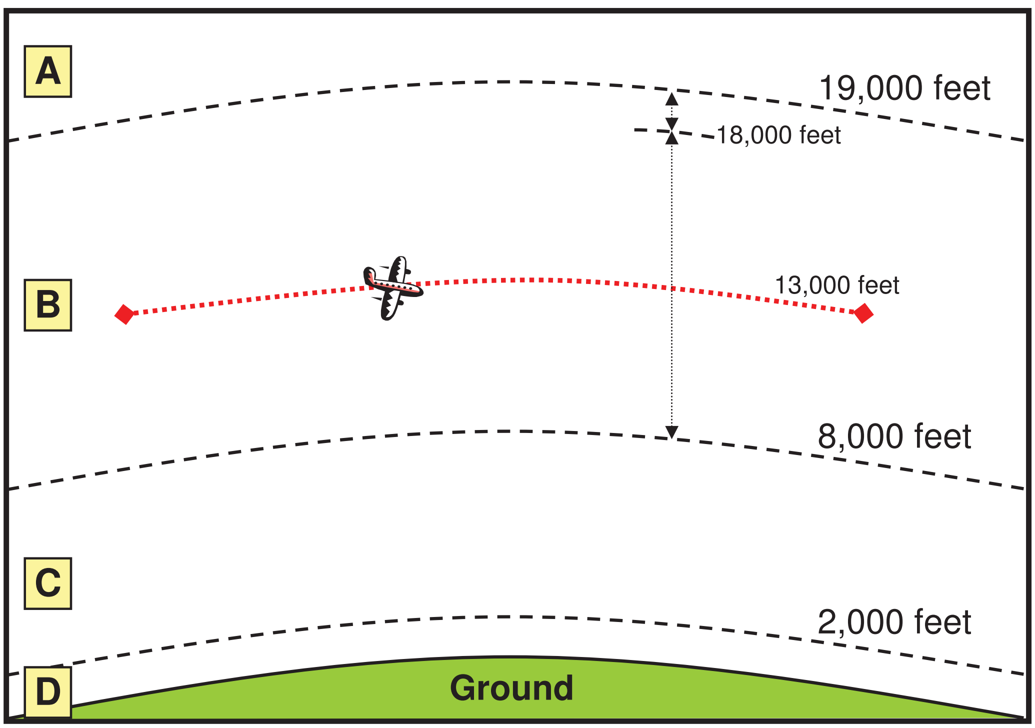

Figure B.1: *Illustration of a Phase IV BFM Mission*

Consider $P(wc, month)$ as a function returning the values of Figures 2 and 3 for Phase III, and Figure 4 for Phase IV. Based on the aforementioned rules, the probabilities associated with Condition 11, noted $P(11, month)$, can be calculated as follows:

$$\begin{array}{l} P(11, month) \\ \rho = 0.50 \end{array} = \begin{cases} P(4, month) + \rho \times (P(2, month) - P(3, month)), \text{ if } month \text{ is May, Jun, Jul, Aug, Sep or Oct} \\ P(4, month) - 0.05, \text{ if } month \text{ is Dec, Jan or Feb} \\ P(4, month), \text{ Otherwise} \end{cases}$$

For the months of December, January and February, 0.05 was subtracted from the probabilities in order to consider the JBI effects (see Section 2.2 for details).

Other Conditions

The same method, using a different combination of conditions, was employed to determine the probabilities for Conditions 18, 19 and 20 of Phase III and for Condition 12 of Phase IV. The equations used were the following:

Phase III

$$\begin{array}{l} P(18, month) \\ \rho = 0.67 \end{array} = \begin{cases} P(17, month) + \rho \times (P(15, month) - P(16, month)), \text{ if } month \text{ is May, Jun, Jul, Aug, Sep or Oct} \\ P(17, month) - 0.05, \text{ if } month \text{ is Dec, Jan or Feb} \\ P(17, month), \text{ Otherwise} \end{cases}$$

$$\begin{array}{l} P(19, month) \\ \rho = 0.50 \end{array} = \begin{cases} P(8, month) + \rho \times (P(6, month) - P(7, month)), \text{ if } month \text{ is May, Jun, Jul, Aug, Sep or Oct} \\ P(8, month) - 0.05, \text{ if } month \text{ is Dec, Jan or Feb} \\ P(8, month), \text{ Otherwise} \end{cases}$$

$$
\begin{array}{l} P(20, month) \\ \rho = 0.10 \end{array} = \begin{cases} P(10, month) + \rho \times (P(11, month) - P(10, month)), \text{ if } month \text{ is May,} \\ \text{Jun, Jul, Aug, Sep or Oct} \\ \\ P(10, month) - 0.05, \text{ if } month \text{ is Dec, Jan or Feb} \\ \\ P(10, month), \text{ Otherwise} \end{cases}
$$

Phase IV

$$
\begin{array}{l} P(12, month) \\ \rho = 0.50 \end{array} = \begin{cases} P(4, month) + \rho \times (P(2, month) - P(3, month)), \text{ if } month \text{ is May,} \\ \text{Jun, Jul, Aug, Sep or Oct} \\ \\ P(4, month) - 0.05, \text{ if } month \text{ is Dec, Jan or Feb} \\ \\ P(4, month), \text{ Otherwise} \end{cases}
$$

Note that the values of ρ differ for the different conditions depending on the location (Moose Jaw versus Cold Lake) and on the type of mission to be flown (BFM versus IF, etc.).

Annex C
Search Space and Initial Schedule

This annex presents how the search space was constructed and the algorithm used to perform the exhaustive search necessary to create the initial schedule.

Start and End Dates of All Phases

Consider the following notations:

xx0y	:	The y*th* Phase IIA Serial of year 20xx[11], $y \in 1, 2, \ldots, 9$, since there are nine IIA serials per year
S_{IIA}(xx0y)	:	Phase IIA start date of Serial xx0y
E_{IIA}(xx0y)	:	Phase IIA end date of Serial xx0y
S_{IIB}(xx0y)	:	Phase IIB start date of Serial xx0y
E_{IIB}(xx0y)	:	Phase IIB end date of Serial xx0y
S_{III}(xx0y)	:	Phase III start date of Serial xx0y
E_{III}(xx0y)	:	Phase III end date of Serial xx0y
S_{IV}(xx0y)	:	Phase IV start date of Serial xx0y
E_{IV}(xx0y)	:	Phase IV end date of Serial xx0y

All phase end dates (IIA, IIB, III and IV), given any Phase IIA start date, can be determined using the steps presented in Figure C.1.

Search Space

Based on Assumption 11 of Section 3.2,

$$\begin{array}{ccccccc} S_{IIA}(0501) & = & S_{IIA}(0601) & = & \ldots & = & S_{IIA}(1101) \\ S_{IIA}(0502) & = & S_{IIA}(0602) & = & \ldots & = & S_{IIA}(1102) \\ \vdots & = & \vdots & = & \vdots & = & \vdots \\ S_{IIA}(0509) & = & S_{IIA}(0609) & = & \ldots & = & S_{IIA}(1109) \end{array}$$

Define $\vec{s} = (s_1, s_2, \ldots, s_9)$ as a vector containing the start dates of the nine Phase IIA serials, i.e. $s_1 = S_{IIA}(0501) = \ldots = S_{IIA}(1101), s_2 = S_{IIA}(0502) = \ldots = S_{IIA}(1102)$, etc. Additionally, define **S**, as the search space containing all the possible vectors $\vec{s}$.

[11] For instance, Serial 0704 refers to the fourth Phase IIA serial of CY 2007.

Step 1	Calculate $E_{IIA}(\text{xx0y})$ using updated 175-FTrgD Cal and method presented in Section 2.1
Step 2	$S_{IIB}(\text{xx0y})$ becomes the next working day following $E_{IIA}(\text{xx0y})$
Step 3	Determine $E_{IIB}(\text{xx0y})$, from $S_{IIB}(\text{xx0y})$, using updated 175-FTrgD Cal and method presented in Section 2.1
Step 4	$S_{III}(\text{xx0y})$ becomes the second working Monday following $E_{IIA}(\text{xx0y})$
Step 5	Evaluate $E_{III}(\text{xx0y})$, from $S_{III}(\text{xx0y})$, using the new approach presented in Figure 5
Step 6	$S_{IV}(\text{xx0y})$ becomes the second working Monday following $E_{III}(\text{xx0y})$
Step 7	Evaluate $E_{IV}(\text{xx0y})$, from $S_{IV}(\text{xx0y})$, using the new approach presented in Figure 5
Step 8	Return the dates

Figure C.1: *End-to-End Course Dates*

Based on Assumptions 6 and 7 of Section 3.2,

$$s_1 = 1 \tag{C.1}$$

and

$$s_i \in \{2, \ldots, 47\}, \forall i \in \{2, 3, \ldots, 9\}. \tag{C.2}$$

Additionally, it can be derived from Assumption 8 of Section 3.2 that:

$$s_{i-1} + 3 \leq s_i \leq 47 - 3 \times (9 - i), \forall i \in \{2, 3, \ldots, 9\}. \tag{C.3}$$

Finally, from (C.1), (C.2) and (C.3), the following nested *For* loops may be used to determine the search space **S** .

$$
\begin{array}{l}
\text{For } (s_1 = 1;\ s_1 \leq 1;\ s_1\text{++}) \\
\quad \text{For } (s_2 = s_1 + 3;\ s_2 \leq (47 - 3 \times 7);\ s_2\text{++}) \\
\quad\quad \text{For } (s_3 = s_2 + 3;\ s_3 \leq (47 - 3 \times 6);\ s_3\text{++}) \\
\quad\quad\quad \text{For } (s_4 = s_3 + 3;\ s_4 \leq (47 - 3 \times 5);\ s_4\text{++}) \\
\quad\quad\quad\quad \text{For } (s_5 = s_4 + 3;\ s_5 \leq (47 - 3 \times 4);\ s_5\text{++}) \\
\quad\quad\quad\quad\quad \text{For } (s_6 = s_5 + 3;\ s_6 \leq (47 - 3 \times 3);\ s_6\text{++}) \\
\quad\quad\quad\quad\quad\quad \text{For } (s_7 = s_6 + 3;\ s_7 \leq (47 - 3 \times 2);\ s_7\text{++}) \\
\quad\quad\quad\quad\quad\quad\quad \text{For } (s_8 = s_7 + 3;\ s_8 \leq (47 - 3 \times 1);\ s_8\text{++}) \\
\quad\quad\quad\quad\quad\quad\quad\quad \text{For } (s_9 = s_8 + 3;\ s_9 \leq (47 - 3 \times 0);\ s_9\text{++}) \\
\quad\quad\quad\quad\quad\quad\quad\quad\quad \text{Add } (s_1, s_2, \ldots, s_9) \text{ to } \mathbf{S}
\end{array}
$$

In this case, **S** corresponds to the list of all possible schedules that exist with the set of rules, assumptions, and constraints that were considered. The nested loops were coded in Microsoft Visual C++ and the size of **S** is 5,852,925 schedules.

Exhaustive Search

A Microsoft C++ module was written to perform an exhaustive search of **S** . The algorithm is presented in Figure C.2. The objective of the search was to find the best possible combination of nine Phase IIA starts, such that the number of conflicts is minimal. A conflict was defined as any time the total number of courses on the flightline[12] is greater than five for Phase IIA, four for Phase III, or three for Phase IV. These limits were provided by NFTC SMEs. They correspond to the theoretical maximum number of serials on the flightline that each phase can support at the same time.

It took approximately 5.5 hours[13] to analyze all the possible solutions and to return the initial schedule. The optimal combination found by the model was the following:

$$s_1 = 1, s_2 = 8, s_3 = 12, s_4 = 15, s_5 = 20, s_6 = 26, s_7 = 32, s_8 = 36 \text{ and } s_9 = 43.$$

The number of conflicts obtained from the optimal solution was 235, with the following results for Phases IIA, III and IV respectively: 30 days with six serials in-house, 200 days with five serials in-house, and 4 days with four serials in-house. Note that the number conflicts were computed in a six year period, from CY 2005 until 2010. It means that, on average, the initial schedule generated from the exhaustive search contains 5.00 days per year with conflicts for Phase IIA, 33.33 days per year for Phase III, and 0.67 day per year Phase IV.

The schedules were built for serials from 2005 (Serials 0501, 0502, ..., 0509) until 2013 (Serials 1301, 1302, ..., 1309). In the initial schedule obtained from the exhaustive search, Serials 1205,

[12] A serial is considered to be on the flightline once its ground school portion is completed.
[13] The C++ program was executed on a personal computer with a 2.4 GHz Pentium IV processor.

Function ExhaustiveSearch (**S** , $\vec{s^*}$, $nConf$)

$\vec{s^*}$ contains the optimal schedule
$nConf = \infty$, where $nConf$ contains the number of conflicts in $\vec{s^*}$

For each possible solution $\vec{s}$ in S
    For each s_i in $\vec{s}$
        Build the full course schedule (Phases IIA, IIB, III and IV)
    End For each s_i
    Based on the generated schedules, compute the number of conflicts in all phases
    Sum the conflicts of all phases
    If the number of conflicts in s_i less than $nConf$
        keep $\vec{s^*} = \vec{s}$
        $nConf$ = number of conflicts in s_i
    End If
End For

Figure C.2: *Exhaustive Search*

1206, 1207, 1208, 1209, and all the serials in 2013 (Serials 1301, ..., 1309) all ended their respective Phase IV training after 2013, which was the last year taken into consideration. The model assumed steady state, meaning that when a serial ended after 2013, what was left of its training was wrapped-up at the beginning of 2005. For instance, if a serial was scheduled to complete Phase IV at the twelfth working day of January 2014, the model dealt with it as if the serial was doing Phase IV from the first until the twelfth working day of January 2005. This was done because potential conflicts may exist with the first serials (0501, 0502, etc.), otherwise, the first serials would not have been in competition with any other serials.

List of Symbols/Abbreviations/Acronyms/Initialisms

ACM	Air Combat Maneuver
AFT-RW	Advanced Flying Training - Rotary Wing
AGL	Above Ground Level
AI	Airborne Intercept
AST	Air-to-Surface Tactics
AW	Academic Weapon
BA MAT	Bombardier Aerospace Military Aviation Training
BFT	Basic Flying Training
BFM	Basic Fighter Maneuver
CFFTS	Canadian Forces Flying Training School
CA	Canadian
CY	Calendar Year
CF	Canadian Forces
CH	Clearhood
CM	Composite
CORA	Centre for Operational Research and Analysis
CPT	Cockpit Procedures Training
DND	Department of National Defence
DRDC	Defence Research and Development Canada
EVOC	Entraînement de Vol de l'OTAN au Canada
FLIT	Fighter Lead-In Training
FTrgD Cal	Flying Training Day Calendar
FTD	Flight Training Device
FM	Formation
IF	Instrument Flight
ITP	Integrated Training Plan
JBI	James Brake Index
LLAT	Low Level Awareness Training
Met	Meteorology
NA	Navigation
NFTC	NATO Flying Training in Canada
NT	Night
OpsWG	Operations Working Group
OCU	Operational Conversion Unit
ORAD	Operational Research and Analysis Directorate
OTU	Operational Training Unit
PAT	Pilot Awaiting Training
RAM	Resource Allocation Model
SOW	Statement of Work

SME	Subject Matter Expert
TT	Tiger Team
UK	United Kingdom
WC	Weather Condition

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Originally, the NATO Flying Training in Canada (NFTC) schedules were developed for all flight training phases until Calendar Year (CY) 2005. A1 Training officers are responsible for the creation and management of the NFTC schedules. They requested the assistance of the Operational Research and Analysis Directorate to build a new and more optimized schedule. During the first years of operation (2001-2004), NFTC has had problems graduating their students on time, especially in Phases III and IV. This was primarily caused by the inefficiencies of the method used to determine the course duration. In order to overcome these frequently occurring graduation problems, a more realistic approach was developed to determine the course duration of the serials in Phases III and IV. The new scheduling method is based on a thorough analysis of weather requirements necessary to fly each mission. This report presents the new approach and how it was integrated into a more complex model used to create all NFTC phases start/end dates until CY 2011. All the assumptions made and the different constraints faced are enumerated in the document. Finally, the report demonstrates the impacts of the new schedule on all NFTC participating nations. The impacts are expressed in terms of number of calendar days spent in Canada.

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Pilot Training
Course Duration
Weather Condition
Scheduling
Exhaustive Search
Flying Training Day Calendar
Phase IIA
Phase IIB
Phase III
Phase IV

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