PARSim, a Simulation Model of the Royal Canadian Air Force (RCAF) Pilot Occupation

An Assessment of the Pilot Occupation Sustainability under High Student Production and Reduced Flying Rates

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Abstract: Training personnel to operate extremely complex and expensive equipment requires a large monetary investment and takes lengthy periods of time. It goes without saying that careful planning is of the outmost importance. Such is the case for military pilots. The Pilot Production, Absorption, Retention Simulation (PARSim) model that was developed by the Centre for Operational Research and Analysis (CORA) simulates the flow of pilots from recruitment, through training, onto the operational training units and into the various operational fleets, accounting for attrition, instructor pilots and staff requirements. A key feature of the model is that it simulates the acquisition of experience, dynamically adjusting the experience acquisition rate in response to the existing experience level on the squadrons and the availability of resources. The model is a tool that can be used to perform what-if analysis quickly and easily. This paper describes the simulation model and reports on a study where the impact of high production combined with reduced budgets is analysed.

1 INTRODUCTION

Training pilots in the Royal Canadian Air Force (RCAF) as in many other air forces in the world requires a large investment in time and resources. As such the number of each type of pilots trained needs to be carefully planned and managed. Pilots in the RCAF go through several phases of training to acquire their wings. They are then assigned to an operational training unit (OTU) to learn to fly a specific type of military aircraft and then to an operational (ops) squadron to acquire superior skills. This is accomplished by flying with or under the supervision of an experienced pilot or mentor. Once the required skills are obtained the need for supervision is lifted, the pilot upgrades to a superior level and can start mentoring new recruits himself. The mentoring period for each pilot usually lasts several months and for some aircraft types it may take up to two years. The rate at which pilots upgrade depends on the number of mentors and the amount of flying hours available. The process of training and mentoring pilots is part of what is commonly known in military jargon as Force Generation (FG) whereas the term Force Employment (FE) is used for all operations, missions and tasks that military personnel accomplish.

The process of mentoring is often referred to as the absorption of new recruits. The various schools are responsible for the production of new pilots and squadrons are responsible for their absorption for final training. As squadrons have fixed size (known as Preferred Manning Level (PML)), usually established by the RCAF and government policies, each new recruit posted to a squadron pushes another pilot out of the squadron; usually an experienced pilot which will be moving to another posting requiring experience (instructor or staff). The production and the absorption rates are obviously closely linked but another crucial factor also needs to be considered: the attrition of pilots. Attrition mainly occurs for experienced pilots as younger pilots are under contract and restricted from being released. For steady state to be achieved,

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production needs to match attrition and squadrons need to be able to absorb all pilots produced; otherwise, the pilot occupation becomes under or over staffed. If production is not absorbed by squadrons, pilot candidates accumulate in waiting “queues” and gradually lose their skills. If production is too high and pushed onto squadrons anyway, the mentoring process is slowed down as fewer and fewer mentors are available for a constantly increasing number of mentees (as the size of squadrons is fixed). Unless quickly corrected, this process goes into an unstoppable downward spiral. Similarly, but at a slower pace, if production is too low to compensate for attrition, experienced pilots are lost which slows down the mentoring process and thus the rate at which younger pilots upgrade and become mentors themselves. In summary, the pilot occupation can be viewed as a system in a delicate equilibrium and with a large inertia due to the lengthy training and upgrade process.

Figure 1 shows a high level diagram of the flow of pilots through the system. The top half corresponds to the undergraduate portion of pilot training done at the various schools. The bottom half represents all graduate pilots in all positions: operational squadrons (Sqns), instructor pilots (IP) at OTUs and in training (Trg) schools, and staff positions. The diagram only shows a few of the RCAF fleets: fighter (FTR), rotary-wing (RW) tactical helo, maritime helo, search-and-rescue helo, multi-engine (ME) tactical transport and maritime patrol.

The terms in green at the top are the various entry training programs (TPs) into the pilot streams: Regular Officer TP (ROTP), Direct Entry Officer (DEO) TP, Continuing Education Officer TP (CEOTP), and Community College Entry Program (CCEP). ROTP is the usual university education and pilot training program; students usually attend university for the first three years, then continue to Phase I followed by their last year of university before continuing with pilot training. DEO is for officers that change occupation and already have a degree. CEOTP is similar to ROTP with the exception that members obtain their degree from a community college rather than from a Military College; as for ROTP, candidates of CEOTP go to college between Phase I and II but also after Phase III. Finally, CCEP candidates, as DEO candidates, have already completed a college degree but they also already have a pilot license which allows them to bypass Phase I.

The red arrows indicate where attrition from the occupation is possible. The yellow boxes contain the inexperienced pilots (mentees) that need mentoring. The light green boxes contain experienced pilots and the olive green boxes represent operational squadrons. More details will be provided below when the model is discussed.

Numerous “external” factors affect the system

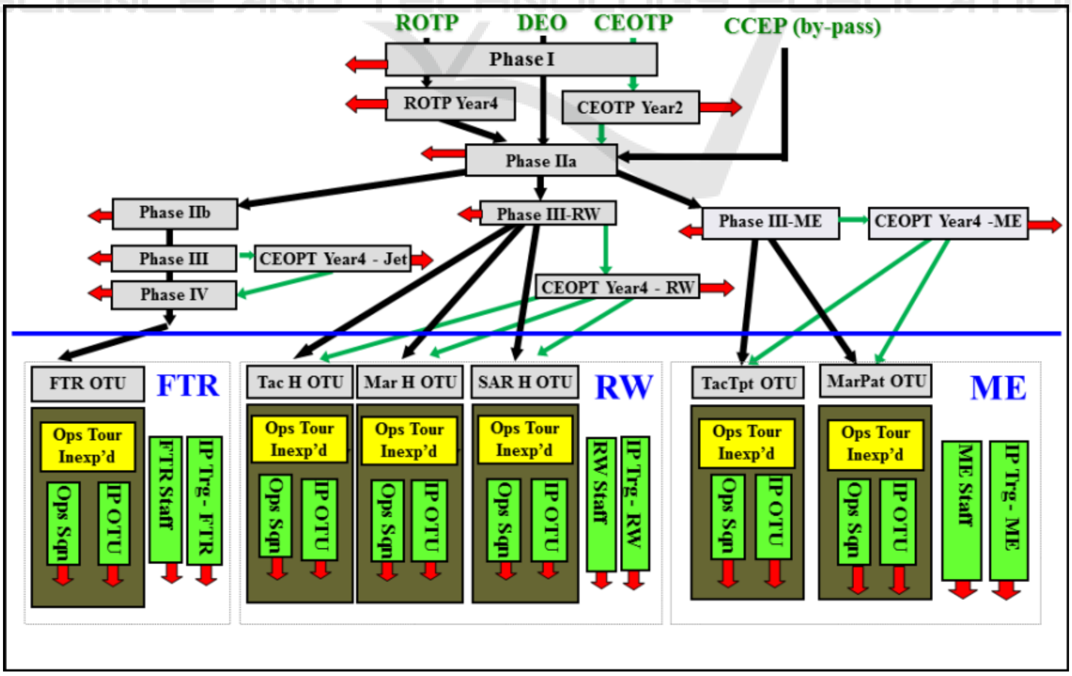

Figure 1: High-level diagram of the pilot occupation.

and can result in significant issues if not carefully managed. For example, attrition may increase significantly if a large group of pilots leave the Air Force to join civilian airlines once their contract is completed. A second example would be if budgets are decreased and pilots see a reduction of their yearly flying rate (YFR). Another example is when the Air Force fleet is modified due to the introduction of a new type of airplane or the transition from a legacy platform to a newer aircraft. All these issues push the system away from steady state and carefully crafted plans with timely actions need to be devised to avoid serious consequences.

Pilot production and absorption issues have been studied for decades (Mooz, 1969) but it seems that increased efforts have started in the early 80's (Moscrip, 1980) with lots of studies in the last 20 years (Taylor, 1992a, 1992b; Graff et al., 1994; Thie et al., 1995). Simulation work on pilot training has started in Canada with the work of Boulet (1993, 1994a, 1994b). Following work done under the RAND Corporation's Project Air Force (Taylor, Moore and Roll, 2000), CORA developed a dynamic simulation model of the mentoring process (Latchman, Corbett and Hunter, 2001) followed by a more complete model of the pilot occupation (Latchman and Hunter, 2002). The RAND Corporation has continued to study pilot absorption issues concentrating on the fighter community (Taylor at el., 2002; Bigelow et al., 2003a; Bigelow et al., 2003b; Marken et al., 2007; Taylor, Bigelow and Ausink, 2009). At the same time, CORA continued to evolve its model to simulate the whole RCAF pilot occupation from recruitment to retirement and to include all fleets employed. A study on the effects of increasing UAV pilot requirements on the fighter community can be found in Garner and Villem (2005).

For several years the RCAF has experienced a period of shortage of seasoned pilots for several staff positions. In the last few years the RCAF has strived to achieve a higher production of pilots at the training schools to bring up the staffing level closer to what it should be. Due to the inertia of the system this is a lengthy process. Unfortunately, this year the RCAF budget has been reduced which may impact the amount of flying hours each fleet will be allocated. Absorbing higher levels of newly winged graduates is already difficult for squadrons, but combined with reduced resources it is a very difficult challenge. After describing the simulation model, this paper reports on a study where the impact of high production combined with reduced budgets is analysed.

2 METHODOLOGY AND MODEL

Even though small individual pieces of the pilot production and absorption system could potentially be analysed analytically, the sheer complexity of the problem with its feedback loops, conflicting objectives, dynamic and stochastic nature, and numerous concurrent events makes simulation the only viable option to study the RCAF pilot occupation in its entirety. At CORA, a System Dynamics (Sternman, 2001) approach has been used since the early stages of development of the pilot system model. Initially, only the undergraduate portion of pilot training was modelled, then a separate OTU model was designed, followed by a fully connected model of the training system and the main fleets of the RCAF (Latchman and Hunter, 2002). Since then, the model has been known as the Pilot Production, Attrition, Retention Simulation (PARSim). Corbett (2013) documented the mathematical foundations of the initial model. In 2006, with the imminent introduction of the new strategic airlift fleet and the transition from the old fleet of tactical airlift aircraft to a new platform, the model was expanded to be able to study modifications to the RCAF fleet. Further refinements were implemented over the following years, the latest being the capability to take into account YFR constraints. Since its inception, 12 years ago, the model has been used numerous times to study various issues such as how to overcome high attrition (Latchman and Hunter, 2002), how to get rid of large queues for courses, what are the optimal fleet intake/absorption levels, how to optimally plan the transition of platforms or the introduction of a new capability.

The model has been implemented using the Powersim Software simulation environment (Powersim, 2014). It is comprised of four major types of modules: 1) training phases modules where pilots gradually learn to fly more complex missions and more specific aircraft, 2) operational fleets modules where pilots acquire experience through the dynamic mentoring process, 3) cross-flow (CF) modules to manage the transfer of experienced pilots from one type of aircraft to another, and 4) intermediary modules to calculate various quantities used to obtain the correct behaviour from the other modules.

The model is complex as it simulates the whole pilot occupation from recruitment to retirement. It is a high-level integrated model that does not track individual pilots but rather groups of similar pilots (for example, ME tactical transport pilots, fighter demonstration team pilots, etc.). Therefore, it does not track data such as years of service and time in rank. It is designed to assess the health of the occupation as a whole and ensure that every fleet is staffed properly and at the right level of experience. The model is used as an options test bed to perform what-if analyses. Depending on the type of analysis required the amount of input required can be substantial. For long-term high-level issues, approximate starting values can be used but for very precise and shorter horizon studies, great care must be taken to seed the model correctly. Since the model is never used from scratch, it has to be seeded with current values. For example, the number of pilots of each type, the number of students in each course, the number of people waiting in queues, etc.

In several studies, transitioning issues had to be analysed. For this, the ability to vary the values of "elements" over time is essential. In Powersim, this is done by cloning constants at the appropriate time. For example, when standing up a new fleet, the number of pilots and thus the number of students required for the OTU will be slowly increased from year to year and the model will slowly start sending newly winged graduates (NWGs) to the new fleet. Obviously, a few more elements need to be cloned to complete the task of standing up a new fleet and they need to be carefully timed but the principle is the same.

2.1 Operational Fleet and Cross-Flow Modules

As an illustration, Figure 2 shows a module for one of the operational fleets; the whole model consists of 33 such modules. Specific details of the figure are not important here, the goal is to provide an appreciation for the model. In this particular module, the main portion is at the top right and flows of pilots come in from and go out to other modules of the model through the cyan coloured flows. The main entry is through the leftmost cyan "cloud" flow, where pilots arrive from the school and are put in a queue (first yellow block) for the next OTU course (second yellow block). Once this course is completed, pilots are qualified on a specific aircraft but need to acquire experience through the mentoring process. While acquiring this experience they are dubbed inexperienced and "stored" in the third yellow box. After upgrading to the experienced status, they move to the fourth yellow box. The flow of pilots between these two stages is a crucial piece of the model and is controlled via the mentoring sub-model at the bottom right where every week the resources (level of YFR and number of mentors (experienced operational pilots)) are assessed to find out how much flying hours can be allocated to each mentee for the upgrade process.

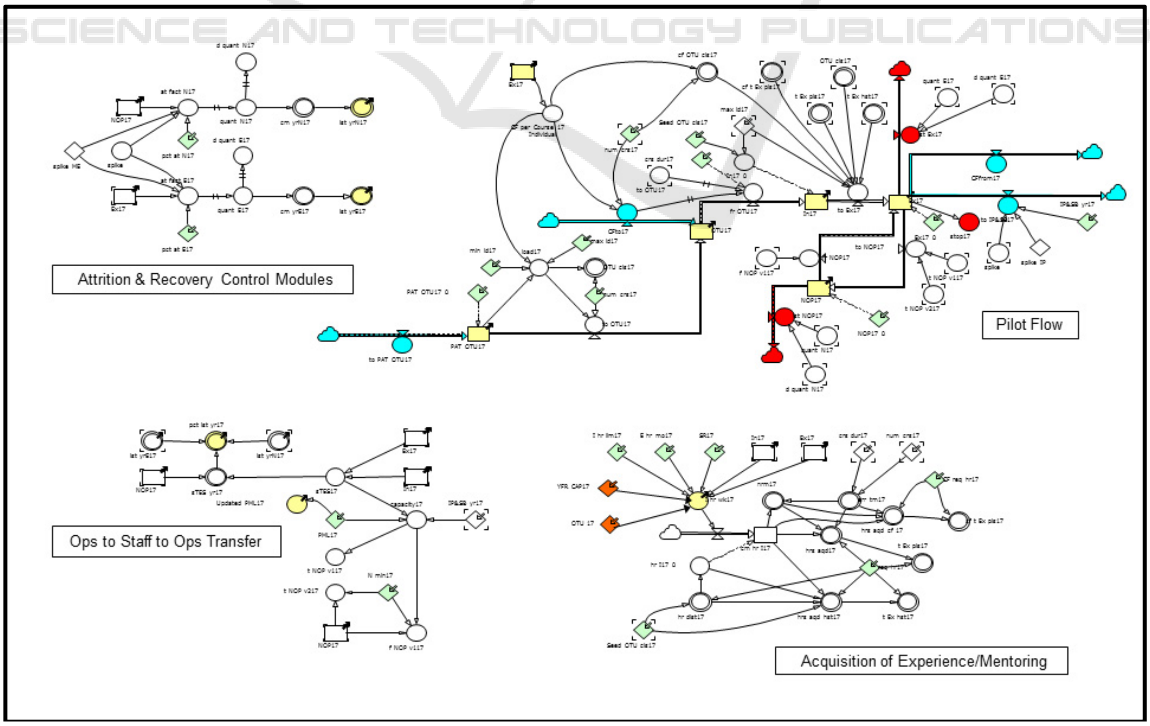

Figure 2: A fleet sub-model.

There is a second cyan inflow of pilots in the diagram which is connected directly to the OTU box; this second flow corresponds to experienced CF pilots arriving from another fleet (transfers). This is a minor input channel for the large majority of fleets but can be used extensively if a fleet has a need for very experienced pilots. This flow is connected directly to the OTU as it is not modelled as a push from the school but rather as a pull from the fleet and as such these pilots have priority over NWGs. The model always verifies the health of the provider fleets before allowing the transfers out to ensure that no fleet is disadvantaged in the process. The health is assessed using the ratio of mentors to mentees (or experience ratio) and the manning ratio of the trained effective strength (TES) (number of ops pilots (mentors plus mentees)) to the PML of the fleet. The experience ratio should always be above 50% and the manning ratio should be close to 100%.

There are two cyan flows out of the Experienced block: one that sends pilots out to the various schools to become IPs to compensate for IP attrition and one for CFs out to satisfy the pull for CFs from other fleets. Note that since CFs are defined as pulled quantities and the health of the various fleets may not allow for all requests to be satisfied, the model has to decide how many and which requests can be satisfied, and from which fleets.

Every time there are requests for CFs from OTUs, the model first evaluates how many pilots can be provided for CF purpose. This is based on a proportion of the number of experienced ops pilots that each healthy fleet can provide. This establishes the proportion of the total CF requests that can be satisfied by these fleets. In a second step the model calculates what proportion of these achievable requests can be filled by each healthy fleet. Then a random process based on these proportions is used to determine which fleet will actually be providing the CFs. In a very healthy situation, the probability of a large fleet to be a provider is greater than that of a small fleets and the use of randomness ensures that small fleets provide some CFs some of the time.

It is worth noting that the model also deals with the following two elements of the CF process: 1) a fleet may simultaneously be a provider of CFs as well as a receiver and, 2) CF requests for fleets are defined annually but the pilots pulled in as CFs must be spread over OTU courses offered throughout the year. Finally, a constraint (that is rarely restrictive) has been used to simplify implementation of the CF process: a provider fleet is allowed to give a maximum of one pilot per course per requesting fleet.

Red flows are for attrition; they are controlled by the top left sub-model and can happen any time over the year. In the main flow there is a loop for experienced pilots to move between the sets of operational and staff positions. Movement of pilots between these two groups is managed with the sub-model on the bottom left. It ensures first that a mandated minimum number of staff positions are always filled. Then, it verifies if there are enough pilots in the ops squadron or too many. If any of the manning levels are incorrect, the model transfers pilots from one group to the other. This adjustment is done once a year to mimic the re-assignment posting cycle of the RCAF.

In the key mentoring sub-model at the bottom right, resources are evaluated each week to find out how many flying hours can be allocated to each individual pilot for the upgrade process. It is also in this sub-model that the verification of the hours acquired is done to grant upgrade to mentees. Even though in practice mentees may upgrade with varying levels of flying hours due to their individual skills, an average value is used in the simulation for all mentees. Note that only flying hours are considered in the model to grant the upgrade. In practice, simulation hours may also be used and required. As flying hours is a much scarcer resource, it is assumed that the simulation hours required can be acquired during the several months it takes to acquire the flying hours.

The number of weekly hours available for the upgrade process depends on the number of experienced pilots (mentors) e available (which varies due to attrition, posting and upgrade of pilots), on the number of inexperienced pilots i to upgrade, on the annual flying budget allocated to the specific fleet y and on flying limits $\bar{e}$ and $\bar{\iota}$ imposed on pilots (both mentors and mentees). For the budget component, only hours that can be used for FG are included which means that pure FE hours (pure FE is taken to mean here that none of these FE hours can be used for training purposes (for example, expeditionary operations)), OTU hours and any other reserved hours (for example, Standardization and Evaluation Team) have to be removed. Some fleets may also allow a mentor to train two mentees at a time on some flights; p is the percentage of flights where this is allowed. Even though pilots may fly at different rates in practice, it is assumed that all mentors fly at the same rate as well as all mentees (however, mentors and mentees may fly at a different rate). The equation for the weekly number of hours for each mentee is:

$$\min\{\bar{\imath}, (1+p) * \bar{e} * \frac{e}{i}, \frac{(1+p) * \frac{y}{52}}{i}\} \qquad (1)$$

Some fleets also have augmentees which are experienced pilots that can help in the upgrade process but at a reduced flying rate compared to normal mentors. For those fleets, equation (1) would be slightly modified. Furthermore, experienced pilots that come in from other fleets also need to upgrade on the new aircraft type but they require less time than NWGs and thus have to be tracked separately. This means a portion of the mentoring sub-model is repeated. Finally, as the model is seeded with the current number of pilots, some of them will be at various stages of the upgrade process. The bottom section of the mentoring sub-model tracks those groups of pilots that have been seeded with a varying number of flying hours already acquired at the start of the simulation.

We will now discuss the section of the main flow where NWGs are moving from the queue (the term PAT, for Personnel Awaiting Training, is commonly used in military settings) to the OTU course. This section is structurally the same for all courses in all phases of training and is illustrated in Figure 3.

As can be seen in the figure, rules are used to govern the flow between the queue and the course. These include such elements as the minimum $\underline{l}$ and the maximum $\bar{l}$ number of students on each course, the frequency of the course and the number of CFs c the OTU was actually successful in obtaining from other fleets for this specific offering of the course. If q is the number of students in the queue, the dynamic equation used for calculating the student loading is the following:

$$\begin{aligned} &if\left(q < \underline{l} - c\right) then\ 0 \\ &else\ \min\{q, \bar{l}\} - c \end{aligned} \qquad (2)$$

Student course failures need to be implemented carefully as the majority of the classes are small and using simply a proportion of students would be inaccurate. A binomial distribution has been implemented using a vector of Bernoulli random variables (Corbett, 2013; Law and Kelton, 2000). It is also worth mentioning that failures at more advanced stages of jet training result in students being moved to another stream rather than being removed from the pilot occupation.

Finally, it is important to mention that in thistraining section (as in numerous other training sections of the model) the flow of students that successfully complete the course and move on to the next block is linked to the load into the course and "controlled" by a delay defined by the length of the course duration. This delayed link (illustrated by the dash lines in Figure 3) plays a similar role as delayed signals in discrete event simulations.

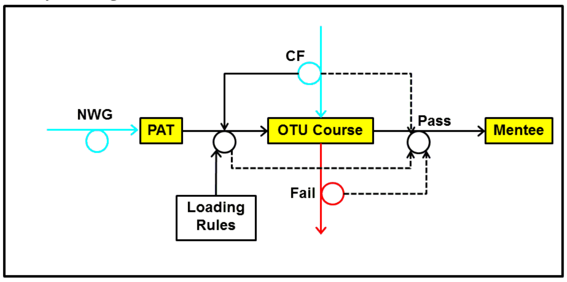

Figure 3: OTU portion of a fleet sub-model.

2.2 Operational Fleet – Special Case Modules

Some fleets have extra elements in their module. For example, the current ME tactical airlift fleet is connected directly to the new tactical airlift fleet to be able to directly and gradually transfer pilots. Usually an initial cadre of experienced pilots and some staff positions are first transferred to establish the new training capability (Standardization and Evaluation Team and IPs) for the fleet. Then, more experienced pilots are transferred to be trained and establish an operational squadron. The initial training for the new aircraft may be accomplished through a shorter conversion course if the new aircraft is not too drastically different. Some NWGs are slowly being sent to the new OTU. Gradually all remaining experienced pilots (ops and staff) are moved to the new fleet. The legacy OTU is closed at some stage and NWGs are then only sent to the new fleet. When the legacy fleet is completely retired, some mentees may not have completed their upgrade process. Unless they are very close to completion, they may have to start over on the new aircraft. This is a waste of time and resource and shows how important it is to precisely plan the transition from the legacy fleet to the new one.

Another important special case is the feeder fleet. Two different variations are possible: pilots are either fed just after the OTU or only after they have acquire experience. The first case is for fleets that use the same aircraft but in different roles. In this situation, once basic training at the OTU is completed, pilots are streamed to squadrons for the upgrade process. In the model, this is reflected by having one fleet with an OTU that feeds other fleets directly at the mentee stage; the modules of these receiving fleets do not have an OTU portion. The second case is for a fleet sending experienced pilots to another fleet in a very similar fashion as was done in the case of the transition from a legacy aircraft to a new model. However, in this case, the feeder fleet is not retired and continues operation. This model can be used to start a new capability that is similar to an existing one or for a specialized capability that requires previous experience in another capability. In the first case, the link between the feeder fleet and the receiving fleet may be severed after some time. In all cases, the receiving fleet has an OTU as it uses a different aircraft. Depending on the situation, the OTU may or may not receive NWGs, but experienced pilots fed in usually have to go through a full OTU course.

2.3 Training and Intermediary Modules

The top portion of Figure 1 provides a high-level view of the training system which will now be discussed in more details. As already mentioned, all courses are modelled on the pattern shown in Figure 3. The various courses are successively linked as presented in Figure 1. There is a split after Phase IIa where students are assigned to one of the three generic types of aircraft: RW, ME or FTR. The proportion sent to each type is based on the relative size of each community and is usually entered as a constant, but can be changed over time in the rare cases where the proportion is expected to change due to a significant modification of the RCAF fleet composition.

There is another split at the junction of the training and fleet sections. This is where pilots are assigned to specific military aircraft types. For example, in Figure 1, students who finish Phase III RW are assigned to one of the three RW fleets. These splits are calculated dynamically by the model in intermediary modules and based on the size of the fleets involved. The dynamic nature of these splits is really useful for fleets transitioning from a legacy aircraft to a new model as the flow going to the old model is gradually stopped while the flow going to the new model is increased (aircraft models are usually retired in a tiered fashion). Various constraints and rules may be added and used in these dynamic calculations to prevent, for example, the assignment of NWGs to fleets that only use experienced pilots.

2.4 Running the Simulation

Inputs and outputs are accomplished through Microsoft Excel workbooks, and Powersim interacts directly with those. Usually around 20 workbooks are used: one for each operational fleet, one for the undergraduate portion of pilot training and a few for specialized output analysis. Further input values are defined as clones and several control variables are defined directly in the model itself.

The simulation step is one week. The model is run for 30 years to ensure that no unwanted behaviour is slowly building. Each run takes only a few seconds on a standard laptop computer. Usually, about ten runs are done but as the pilot occupation is a system in delicate equilibrium, the results of each run are nearly identical: the system collapses, the system is stable or a trend is observable. On rare occasions, one of the runs may display a different behaviour but it is rare and it is always a collapse caused by extreme factors combining with an already undesirable trend visible on all other runs.

Table 1 summarizes the input data required for each fleet and training phase, as well as some miscellaneous inputs.

Table 1: Input table.

FLEET DATA
Initial number of ops pilots
Initial number of staff positions filled
Minimum number of staff positions that have to be filled
Initial number of mentees
Initial size of the OTU PAT queue
Established number of ops positions
Attrition rate for experienced ops pilots
Attrition rate for staff
Maximum number of flying hours allowed for mentors
Maximum number of flying hours allowed for mentees
FG YFR for the fleet
Number of cross flow pilots requested per year
Number of hours required of a NWG to upgrade
Number of hours required of a CF pilot to upgrade
Percentage of times a mentor can train two mentees
OTU course duration
Number of courses per year
Maximum loading
Minimum loading
Minimum experience ratio to be consider healthy
TRAINING PHASE DATA
Course duration
Number of courses per year
Maximum loading
Minimum loading
Failure rate
EXTRA DATA
Yearly recruitment values for each entry program
IP requirement for each school
IP attrition rate
Source of IP as proportion
Breakout percentage after Phase IIa

A large amount of output is produced by the model and several graphs spanning the 30 year horizon are automatically produced by Excel based on the data generated by the simulation. A series of graphs is produced for each fleet and each training phase. The majority of these charts are also provided in an aggregated form on a single graph to help an experienced analyst quickly assess the health of the occupation for the issue under study. Another series of graphs show results where values have been summed for all fleets. Finally, one graph showing the staffing transition can be produced for fleets being converted from a legacy model to a new model of aircraft.

Table 2 summarizes the various graphs available and Figures 4 to 7 illustrate a few of these graphs.

Table 2: Output graphs.

TRAINING GRAPHS
Throughput
PAT pool size
PAT pool size for all training phases on a single graph
Average wait
FLEET GRAPHS
OTU intake
PML vs. TES (PML tracking)
Experience ratio
Number of staff position filled
Flying hours used and remaining
Upgrade time
Attrition
CF provided and received
PAT pool size
Waiting time
AGGREGATED GRAPHS
Number of NWGs
PML vs. TES
Number of staff position filled
Attrition
OTU PAT pool size
TRANSITION FLEETS (sum of the two fleets)
Mentors, Mentees, Staff positon filled, PML vs. TES, OTU throughput

In Figure 4, student wait time to get onto an OTU is shown. The curve illustrates the case where a large pool of students initially had to wait for more than a year. Once an issue was corrected, the situation vastly improved over the next two years.

In Figure 5, the level of staffing for a single fleet is shown for the four categories of pilots tracked by the model. The case illustrated here is for a scenario that is relatively stable. The constant variations noted on every curve are mainly due to pilots moving from one category to another but also due to attrition.

In Figure 6, the attrition for experienced staff and ops pilots is displayed. This scenario is for a case where attrition is constant and where attrition of staff officers is slightly higher than for ops pilots.

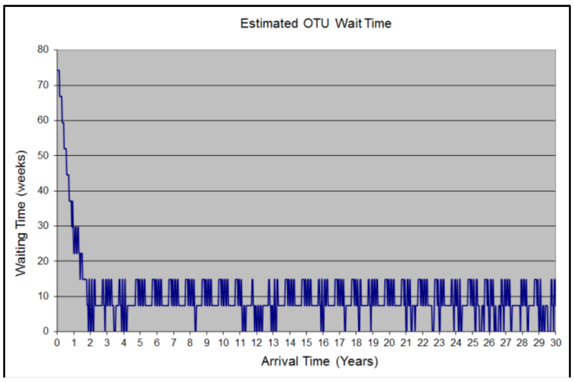

Figure 4: Wait time at a fleet OTU.

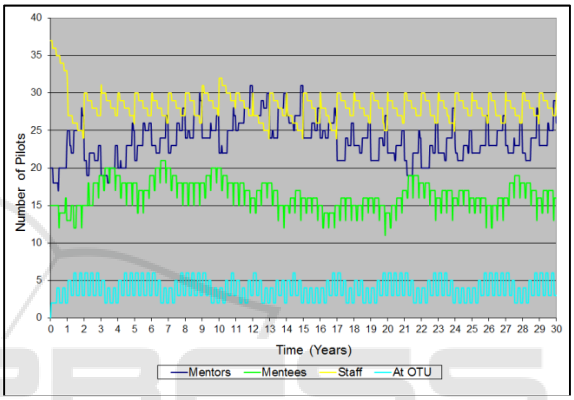

Figure 5: Number of pilots in each type of position for a single fleet.

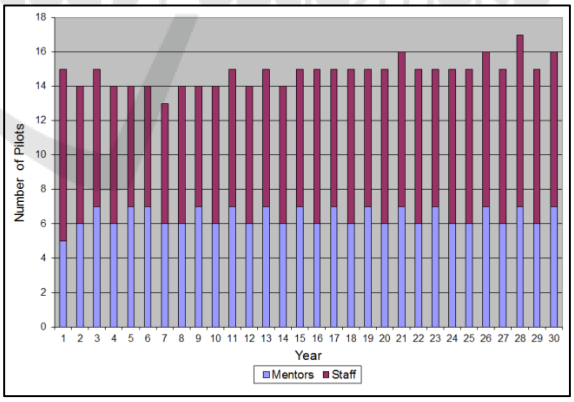

Figure 6: Attrition for experienced pilots of a single fleet.

In Figure 7, flying hours usage is displayed. Hours used at the OTU as well as on squadron for the mentoring process are shown. Using the fleet's YFR allocation, the remaining hours that can be used for pure FE are also displayed. This graph illustrates a situation where around 75% of the YFR allocation is required for FG.

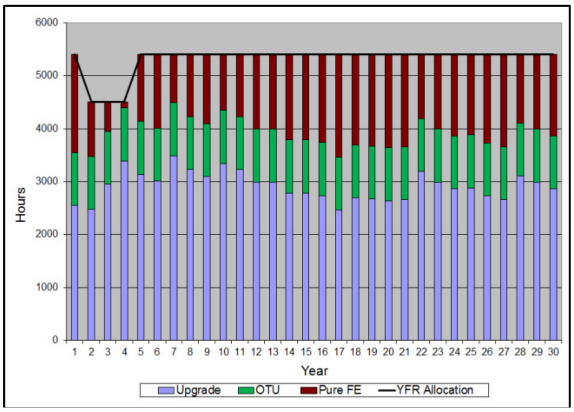

Figure 7: Flying hours usage for various tasks.

3 RESULTS

As stated earlier, the aim of the study was to assess the impact of planned YFR reductions while the RCAF had started the process of increasing the size of the occupation by producing more NWGs at the training schools. The targeted increase in NWG production was planned to gradually reach around 35% in the next five years and the imminent planned reduction in YFR was on average 16% with some fleets seeing as little as 5% reduction but others as much as 39%. As it is anticipated that these two factors would make it very difficult for squadrons to absorb NWGs, the model was allowed to use all YFR for FG and measure how much would be left, if any, for pure FE.

In the first scenario, the production increase and the YFR reductions were permanent. The simulation stopped after five years (See Figure 8) due to the complete collapse (experience ratio down to 0%) of one of the fleets (red curve on the graph). As was explained in the introduction, this is due to too many NWGs being pushed into the squadron in turn pushing too many mentors out and continuously slowing down the upgrade process until there are no mentors left. Two other fleets displayed extremely low experience ratios for extended periods of time which entails significant risks (pale yellow and teal curves).

In view of these results, a second scenario was assessed where the YFR reduction would be in effect for only three years rather than permanently. This easing was not sufficient to help the troubled fleet recover. As the RCAF was already committed to four years of higher production reaching an increase of around 25% but future years were still uncommitted, the next scenario was set with those four years at the higher levels of production followed by a return to a normal level for the rest of the simulation. The YFR reduction was applied for only three years as in Scenario 2 to assess first if this relaxed YFR reduction scenario would be feasible. If so, a permanent YFR reduction scenario could be assessed. To prevent the rapid erosion of experience observed in the previous scenarios for some fleets, OTU intake was greatly reduced during the three years of YFR reduction. For subsequent years, intake of NWGs at the squadrons was set to allow fleets to "survive" with absolute minimal capabilities.

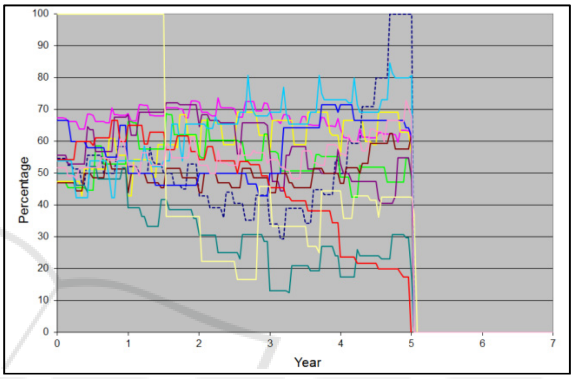

Figure 8: Experience ratios for Scenario 1.

Contrary to the first two scenarios, experience levels were relatively satisfactory with only two fleets experiencing levels below 50% for some periods. However, as shown in Figure 9, two fleets had difficulties maintaining sufficient staffing levels (green and blue curves) and portrayed trends dipping well below 10% under PML. The red curve is also showing low levels in the first few years. This curve is linked to a fleet that is being stood up and is having difficulties meeting its scheduled growth planned before YFR cuts were announced. These difficulties are due to lower NWG intake required to survive with a low YFR. However, the fleet eventually meets its target PML after a few years.

Another issue, that is evident in Figure 10, is the fact that four fleets need to use virtually all their flying hours to be able to absorb NWGs. This is shown by the blue and orange curves never straying far from the 0% mark and the green and yellow curves being generally above the -10% mark. It is also clear that the three years of YFR reduction are strongly affecting several fleets as all curves show an upward trend in the first few years indicating that all the fleets graphed needed virtually all of their YFR allocation just for the upgrade process.

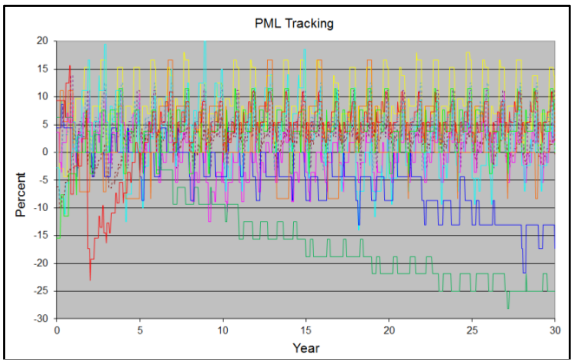

Figure 9: PML tracking for Scenario 3.

Finally, an important outcome of this scenario which is resulting from the intake reduction strategy is that the queues of pilots waiting to start their OTU course are growing as intake is now insufficient to absorb production. In this scenario, the total intake is annually about 10% too low. This implies that queues would quickly build up to levels that are unacceptable as students would have to wait longer and longer before starting they course. If the wait is too long, pilots lose their skills and have to be at least partially retrained at extra cost and further burden to the training resources.

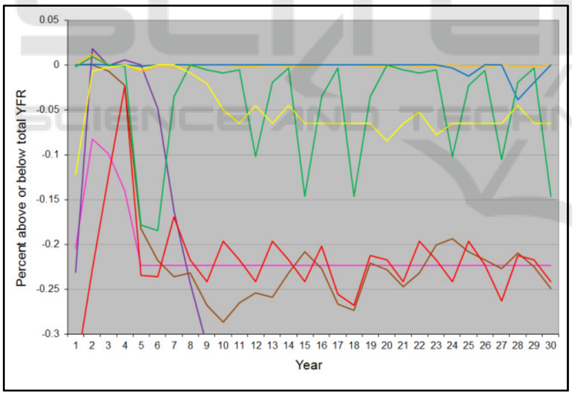

Figure 10: YFR usage in Scenario 3.

In view of the poor performance observed for Scenario 3, a permanent YFR reduction was not examined as alluded to in the description of that scenario. Therefore, for the last scenario that was run, the goal was to generate a plan where: 1) NWGs would all be absorbed, 2) all fleets would have some hours available for pure FE, 3) upgrade would be completed in 30 months or less, 4) all fleets would be staffed at 95% or more and, 5) experience ratios would be at least 50%.

Production of NWGs was similar as in Scenario 3: four years at a higher level and back to normal levels after that. Intake of NWGs was reduced for the three years of YFR reduction but was subsequently increase to at least match production to prevent the growth of large queues at OTUs. However, to achieve the plan some extra measures had to be adopted for certain fleets. The growth of a fleet that was in the process of being stood up was slowed down. For five of the fleets, the YFR reduction had to be applied only for a single year rather than three. Furthermore, for three of these five fleets, the YFR had to be increased to levels higher than before the reduction. Although the percentage of increase was significant for these three fleets with an average of 29%, the total number of flying hours added was modest since these fleets are not the most intense flyers.

On the positive side and despite the reduced production (compared to what was planned), the occupation was still able to grow by about 15% in seven years. However, even though the scenario's objectives were met, the situation was not perfect. As can be seen in Figure 11, some fleets still do not have many hours available for pure FE and several have virtually none during the first few years. As for OTU queues, even though no build-up was observed in the long run, the total number of pilots waiting did increase during the first years due to the YFR reduction and associated lowered OTU intake. The increase was equivalent to about 70% of the total annual intake and it took a very long time to clear up. This implies that some pilots would experience long wait times; a further indication that the scenario is far from completely satisfactory.

All these results are signs that the original YFR allocation was too low to allow the absorption of a high pilot production by the schools and that actions of a more strategic nature are necessary to obtain a sustainable plan for the pilot occupation.

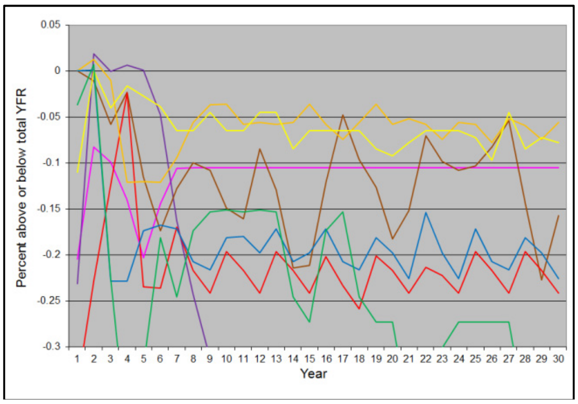

Figure 11: YFR usage in Scenario 4.

4 CONCLUSIONS

Training air force pilots is costly and lengthy. The relationships between school production, OTU absorption, flying rates, experience levels, cross-flows and attrition are complex and volatile. The pilot occupation is a system in a delicate equilibrium and with a large inertia. A single action or decision may have drastic long-term effects. Complex, concerted and multi-faceted efforts are often required to solve problems encountered. In view of all this, simulation is a necessity.

The PARSim simulation model has been presented. It is a realistic high-level representation of the pilot occupation. It is an efficient, powerful and versatile what-if analysis tool. It can help assess what combination of actions may provide the maximum benefit, how quickly can changes be implemented and, what side-effects decisions taken for a portion of the occupation may have on the rest of the system.

The tool has been used for several projects over the years and results were provided here on one of the studies: assessment of the impact of reduced budget and thus flying rates combined with the simultaneous absorption of a high production of students at the training school. A feasible but not completely satisfactory plan was devised. It showed that actions of a more strategic nature are necessary to obtain a sustainable plan for the pilot occupation.

The tool will undoubtedly continue to be improved. Currently the model does not directly take into account hours acquired in simulators and it could be beneficial to include this element in the model to assess directly the impact of their use. It could also be useful to implement the cross-flow feature between the rotary wing fleets and potentially between all fleets.

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