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# Optimizing Undergraduate Pilot Training 2.5 at Vance Air Force Base

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**Abstract:** With a continued increase in demand for qualified pilots, in an environment of continual budget constraints, the Air Education Training Command has been searching for ways to streamline Undergraduate Pilot Training (UPT). Leadership has recently implemented UPT 2.5 to train pilots more effectively. However, the 8th and 33rd Flight Training Squadrons at Vance Air Force Base have had issues efficiently cycling students through. Although UPT 2.5 specifies that it takes no more than 90 days for students to complete the post-preflight portion of the syllabus, it currently takes 126 days on average. We developed a discrete event simulation model of pilot training to identify bottlenecks in the current system, find an optimal class size given current resources, and optimize resources to graduate 32 students per class, the number required by AETC. The results will inform recommendations to increase efficiency within UPT and reduce the pilot shortage.

*Keywords:* Pilot Training, Simulation, Process Improvement

## 1. Introduction

Our project is based out of the 33rd and 8th Flying Training Squadrons (FTS) at Vance Air Force Base (AFB). They are one of four flight training programs in the country where Air Force pilots learn basic flying skills. Our client, Major Jared Ostroski, is the Chief Flight Instructor at the 33rd, one of two UPT squadrons. The 8th and 33rd have recently transitioned from the UPT 2.0 syllabus to the UPT 2.5 syllabus. This change has created challenges for the squadrons in effectively training students on time. Currently, the Air Education and Training Command (AETC) is pushing the 8th and 33rd FTS to output at least 32 pilots per class, but they are consistently unable to train classes larger than 27 in the 90 days allotted by the new syllabus. With the current operations tempo, 32 student classes take 126 days to graduate. This creates training backlogs that cost time, money, and ultimately affect Air Force readiness.

### 1.1 Problem Statement

The 33rd FTS is taking 36 extra days to graduate students, which results in failure to output enough trained pilots annually as specified by the UPT 2.5 syllabus and required by AETC.

### 1.2 Related Work

While our problem is new and unique, there have been similar studies in the past to attempt to improve pilot training pipelines. One of the most relevant studies from 2008 examined an F-16 squadron's training program. Okal (2008) used simulation modeling to effectively train students in the 143rd F-16 Squadron. He found that there was a projected increase in the number of students who would soon be receiving training at the squadron. For this reason, he needed to identify bottlenecks in the syllabus to lower the total training time for each student. Okal simulated the training process using a program called Arena and performed further analysis using design of experiments, regression analysis, and metamodeling. Erickson (2014) integrated the flow of student pilots through training integrated with aircraft availability. The problem highlighted in these two studies is like the problem that Vance is currently facing. We referenced how daily weather and annual leave periods were



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incorporated into the model, as well as how basic and dual sorties were modeled. We used a similar simulation process to model UPT 2.5 requirements and resources and referenced this study to better understand how to simulate it.

Similarly, an article written by Major Colby Shufeldt (2020) applied several manufacturing principles to pilot training to improve efficiency. In particular, she found that identifying and exploiting bottlenecks, eliminating artificial dependency, and cutting losses early could help streamline training. This article was particularly helpful as we started our model. We used the techniques that Maj Shufeldt discussed to identify bottlenecks at Vance. Additionally, we applied other techniques when we determined the optimal number of resources and students per class to meet various requests of our client.

### 1.3 Organization

In this paper, Section 2 describes the methodology that we will use to solve our problem and effectively simulate UPT 2.5. Section 3 outlines the results that we obtained from our model as well as our analysis of potential bottlenecks in the system and strategies to improve scheduling. Section 4 includes our conclusions, recommendations, and opportunities for future research. Lastly, section 5 lists the references and resources that we used to effectively model the syllabus.

## 2. Methodology

We focused on improving UPT 2.5 for the 8th and 33rd FTS at Vance AFB. The two squadrons were modeled as one large squadron that shared the following resources: aircraft, military instructor pilots (IPs), Civilian Simulator Instructors (CSIs), and simulators (ITDs, IFTs, & OFTs). The factors considered include flying windows throughout the year, flying down days, syllabus requirements, re-fly rates, AETC regulations, and the maximum number of daily sorties.

We did not directly model the duration of sorties, aircraft maintenance/relocation, trainee/IP attrition, weather delays, or any process that occurs before or after the UPT syllabus. However, we made broad and informed assumptions to take these factors into account. We did not change any of the syllabus training requirements. Our goal was not to modify pilot training in terms of changing what students need to do to become qualified pilots. Our goal was to utilize the current resources available and provide evidence of what an increase in resources could do to improve graduate numbers or training time. Additionally, we manipulated the timing of training within the syllabus (i.e., interchanging simulators and flights depending on availability) to make the overall process more efficient. We did not model each FTS individually since they share resources.

We will develop two models using SIMIO, a discrete event-based simulation program. The first model simulated the flow of classes of students through the UPT 2.5 syllabus with the current number of resources at Vance AFB. We used this model to determine a reasonable class size given the current operations at Vance. We created a second model to simulate the flow through UPT 2.5 to determine how many resources are required to output 32 pilots per class, as required by AETC.

As we continued to develop the SIMIO models, we referenced the current UPT 2.5 syllabus to determine the number of sorties that are required in each of the four phases of training, the total number of hours required for academics, simulator time, and flight time, and certain prerequisites and AETC regulations that must be followed. Throughout the modeling process, we verified our assumptions with Maj Ostroski and validated our current operation model with the given data.

### 2.1 Data

We visited Vance AFB to collect data from personal interviews with instructors and gathered metrics about the processes in pilot training. We clarified the flow of UPT 2.5 as well as the resources required to pass students through the syllabus. One of the most critical data points for our project was the average attrition for each flight. Not every scheduled sortie contributed to progressing a student through the syllabus. Weather, maintenance, and scheduling conflicts all caused a sortie to get canceled or delayed. Furthermore, some sorties did not directly contribute to the syllabus but are still required for training. For example, if there are an odd number of students in a class going through formation training, one instructor will have to fly a T-6 without a student. Additionally, instructor pilots must fly continuation training sorties to maintain proficiency and currency. Lastly, when students fail a flight, they can have up to two additional flights with specific instructors to pass the event they were deficient in. These flights do not progress the student through the syllabus but are still required for them to continue through UPT. According to our client, the 19th Air Force accounts for a 22% attrition rate in UPT 2.5, meaning that only 78% of all scheduled sorties will advance a student in UPT 2.5. Leadership within the 33rd FTS believes that this attrition rate may be overly optimistic; therefore, we calculated it to be 25%. We obtained historical data from the Wing Programming Officer, which highlights sortie cancellations due to weather, maintenance, and operations.


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In addition to obtaining attrition data, we also gathered data about the resources at Vance AFB. Although we are only working directly with the 33rd FTS, there is another T-6 squadron there that shares the same aircraft, simulators, and instructors. We obtained data from Wing Programming about the total and average number of available and spare aircraft. They currently share 96 planes; however, they can only use up to 60 of them daily per the maintenance contract. This is caused by delays due to part shortages and limited maintenance staff. Furthermore, there is an operations cap in the contract, which typically limits them to 35-50 aircraft per day. Five of the 35-50 aircraft available are reserved as spares.

From the Simulator Instructor Lead, we recorded the available number of each type of simulator as well as the number of civilian contractors who instruct simulators and academic classes. Vance currently has access to 5 OFT, 7 IFT, and 5 ITD simulators. We also recorded that there are currently 123 instructor pilots working in the squadron, 15 classes going through UPT at the same time, and 150 sorties are scheduled per day on average. Although they are contracted to employ 51 civilian instructors to teach academic classes and instruct simulator events, they currently only employ 35, of which only 18 are qualified to teach academics. Every day, a maximum of 60 simulator events can be scheduled; however, of these 60, typically only 10-15 sim lines are available for students in the flying portion of the syllabus, which is the portion that our model is focused on. Our model does not explicitly schedule academic classes. However, it leaves sufficient unutilized time each day for students to complete requirements such as classes and exams. This results in the same outcome while simplifying the model.

## 2.2 Data Processing

To process the attrition data, we calculated the total flights canceled over the last 5 years and divided that number by the total number of sorties scheduled. We found that the average attrition due to weather is 16%, the average attrition due to maintenance is 1%, and the average attrition due to operations and other reasons is 7.3% and 3.15%, respectively. We then calculated the total attrition by finding the probability of a flight being canceled due to weather, maintenance, operations or other reasons. We estimated total attrition to be 25%. This value was 3% higher than the value that AETC recognizes. However, it more closely aligns with the anecdotal attrition values we were given by leadership at the 33rd FTS.

All other data regarding the total number of resources available at Vance was inputted directly into the model. We used the total number of IPs, and the average number of times they fly per day to calculate the number of IPs available for each window of flying. Some data was given to us anecdotally. A range between 2 numbers was modeled as an average. A range with a mode was modeled as a triangular distribution with the minimum, maximum, and most likely values.

## 2.3 SIMIO Modeling

We built a model in SIMIO based on a broad flow of the UPT 2.5 syllabus, after the preflight phase. We have created a more general model focused on tracking the progress of one class throughout the transition, navigation, formation, and mission phases. Our model has six phases that are divided by each training block of UPT. Each phase contains prerequisites that are required to progress to the subsequent phases. The sixth phase is the shortest with only a ground training test and the final check flight. The model is designed so that each student entity cycles through a phase until they reach the required number of events for that phase, at which point they can progress. Each phase shares all resources, including instructor pilots, civilian simulator instructors, simulators, and aircraft. All UPT events have been modeled so that students only complete an average of two events a day, which mimics the current operations tempo at Vance AFB.


Figure 1. Model Design Flow

Calculating the number of resources required per class for each phase in the syllabus allowed us to see how long it took a class to get through the syllabus once resources were split up among 15 classes at one time. This allowed us to see what the maximum class size was in order to complete timely training with few constraints. This was helpful for our initial analysis regarding the feasibility of completing the UPT 2.5 syllabus in the timeline set by the 19th Air Force. Once more constraints were added, we found the maximum class size to decrease and training time to increase.


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We made multiple assumptions for simplicity in both models. The first was that the scheduling of events in the syllabus was completely efficient. We also assumed the work week was Monday through Friday with everyone working 12-hour days. Given these assumptions of efficiency, we assessed how long it currently took a student to get through UPT. Our next step was assessing how many resources a class required on average to complete all academics, simulator flights, and actual flights in the specified syllabus time.

Another set of assumptions involved the IP resource. We assumed that checkride-capable IPs are the same resource as all other IPs. In actuality, there are only about 30 officers who are certified to grade checkrides. We assume that IPs will optimize themselves within the schedule to ensure this is done correctly. Regarding the final checkride in Phase 6, we assumed that it would take the entire day. This resulted in the last ground training event taking an entire day as well, which may not occur in normal operations. A final assumption was that IPs are not used for simulation events. In actuality, IPs are qualified to instruct those events and often do get utilized in that capacity.

## 3. Results and Analysis

Our initial model confirmed our calculations regarding the number of student pilots that can complete UPT 2.5 in one year. We modeled current operations with a 27-student class entering every 3.46 weeks. They had 45 aircraft, 84 IPs available for flying windows (three windows occur each day), 4 simulation events per window, 7 IFTs, 20 ITDs, and 5 OFTs. Our model produced 339 graduates and 62 washouts in one year, with each class taking 103 Operational and Maintenance (O&M) days on average to complete the flying portion. These results were verified by our client's data, which indicated an average of 105.6 days to complete flying training. Our client requested data for a 32-student class. Utilizing current resources, our model determined they could graduate about 397 students in one year. However, it would take the students over 125 days to complete the flying portion, which far exceeds the 90-day requirement established in the syllabus. We ran multiple simulations of our model with adjusted resource values to determine how many of each type of resource would be required to graduate 32-student classes in 90 days.

We calculated the marginal benefit of adding one additional unit of each resource in terms of resource cost versus the total decrease in O&M days for syllabus completion. The results of our analysis are pictured in Figure 2 below. Ultimately, we found that the number of sim lines available each day was the most binding resource and the most cost-effective resource to increase. Being able to complete one more sim event each day would result in students graduating approximately five days sooner. After sim lines, IFTs and IPs were the next most binding resources and would decrease the O&M days required by approximately 2.1 days and 2 days respectively. Aircraft are currently the least binding resource, and one additional unit would only save graduates 1.43 O&M days on average. Figure 3 shows the marginal cost that is required to reduce the total number of O&M days by one. For example, Vance would have to spend $38,374 on acquiring enough extra sim lines to decrease the required O&M days by one.

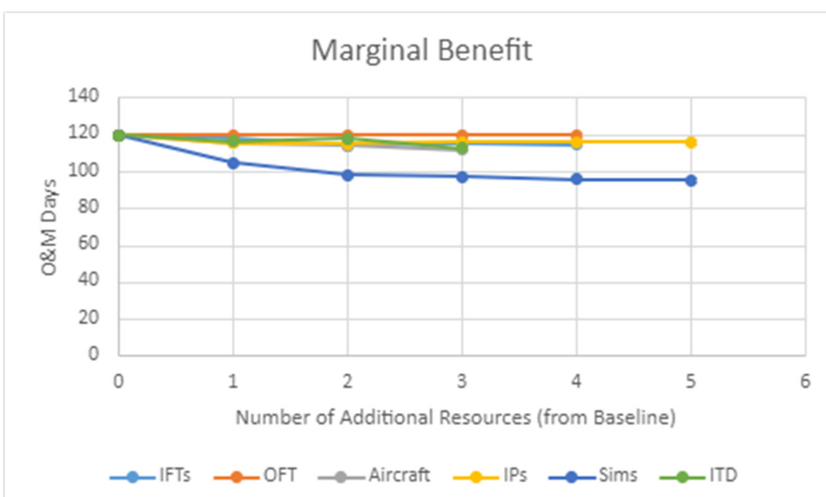


Figure 2. Marginal Benefit of Changing Resource Quantities



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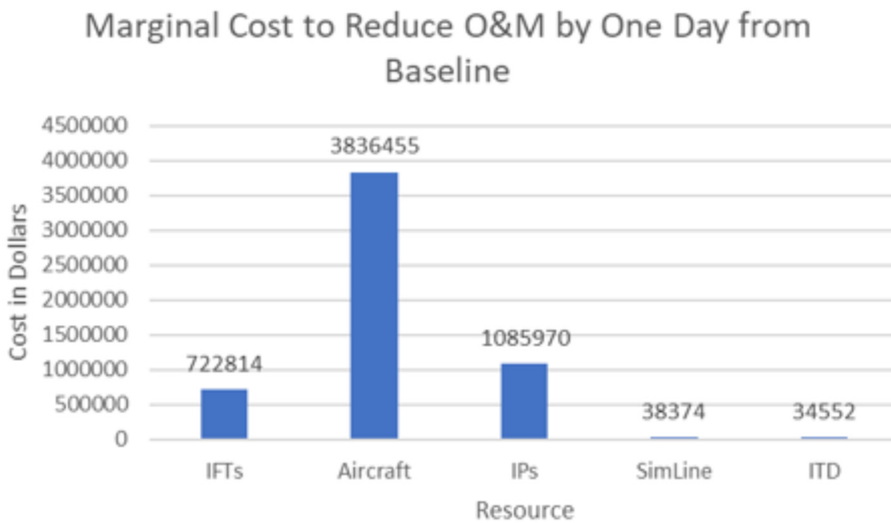


Figure 3. Marginal Cost to Reduce O&M Days

We used an iterative approach to increase the most binding resource at the end of every six replications of our simulation. We kept running iterations until there were enough resources to graduate a 32-student class in 90 days or less. Ultimately, we found that the 33rd FTS and 8th FTS would need to provide 24 sim lines per day, 84 IPs available for each window of flying, 51 aircraft, 22 ITDs, 9 IFTs, and 5 OFTs. Table 1 walks through our iterative process. The resource boxes highlighted in yellow indicate whichever resource was increased at the beginning of an iteration. The row with enough resources to meet the goal is highlighted in green. The total extra cost highlighted at the bottom of the table indicates the total cost of increasing resources to graduate students on time.

Table 1. Resources to Graduate 32-Student Classes in 90 O&M Days

| Resources | | | | | | | Time in System (Days) | | Throughput | | | Total Extra Cost | Marginal Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trial | Sim Lines | IFTs | IPs | ITDs | Aircraft | OFTs | O&M | Std Deviation | Graduates | Washouts | Throughput | $ | $/day |
| 1 | 18 | 7 | 84 | 20 | 45 | 5 | 97.8 | 5.61 | 393.33 | 83.67 | 477 | $1,161,000.00 | $53,100.99 |
| 2 | 18 | 9 | 84 | 20 | 45 | 5 | 96.87 | 3.84 | 390 | 78 | 468 | $4,161,000.00 | $182,548.04 |
| 3 | 18 | 9 | 86 | 20 | 45 | 5 | 98.82 | 2.10 | 398 | 72 | 470 | N/A | N/A |
| 4 | 18 | 9 | 84 | 22 | 45 | 5 | 96.18 | 4.48 | 394.67 | 77.33 | 472 | $4,275,000.00 | $182,038.83 |
| 5 | 18 | 9 | 84 | 22 | 48 | 5 | 94.09 | 5.05 | 390 | 82 | 472 | $20,775,000.00 | $812,348.48 |
| 6 | 21 | 9 | 84 | 22 | 48 | 5 | 93.51 | 3.23 | 397.33 | 71.67 | 469 | $21,355,500.00 | $816,529.02 |
| 7 | 21 | 9 | 84 | 22 | 51 | 5 | 91.75 | 1.28 | 398 | 78 | 476 | $37,855,500.00 | $1,356,147.45 |
| 8 | 24 | 9 | 84 | 22 | 51 | 5 | 89.33 | 3.23 | 387.67 | 86.33 | 474 | $38,436,000.00 | $1,267,093.03 |

In addition to determining necessary resource values, our client also requested that we provide the best class size to graduate students in 90 days, given the current squadron resources. To find the optimal class size, we ran 24 different scenarios of our model and varied the class size from 18 students to 40 students per class. We found that in order to maximize the number of graduates per year, classes should consist of 35 students. However, if class sizes are this large, it will take students approximately 142 O&M days to complete the flying portion of the syllabus. To graduate students within 90 days, class sizes should be no larger than 23 students. Ultimately, this would result in approximately 291 graduates per year. The results of our analysis are depicted in the table below with relevant rows highlighted. Rows highlighted in green indicate ideal scenarios and rows highlighted in yellow indicate the current conditions: class sizes are currently made up of 27 students on average; however, AETC is pushing for 32 students per class.

Table 2. Ideal Class Size to Graduate Students in 90 O&M Days

| | Throughput | | | | | Time in System (Days) | |
|---|---|---|---|---|---|---|---|
| Class Size | # Entered | Throughput | Throughput % | Graduates | St. Deviation | O&M | St. Deviation |
| 21 | 315 | 316.33 | 1.00 | 267.00 | 5.52 | 84.81 | 2.35 |
| 22 | 330 | 330.00 | 1.00 | 280.00 | 10.83 | 87.62 | 3.84 |
| 23 | 345 | 342.00 | 0.99 | 291.33 | 1.94 | 90.62 | 1.34 |
| 26 | 390 | 389.33 | 1.00 | 330.00 | 5.52 | 100.77 | 4.50 |
| 27 | 405 | 401.00 | 0.99 | 339.00 | 4.39 | 102.96 | 2.07 |
| 31 | 465 | 447.67 | 0.96 | 379.00 | 15.37 | 119.92 | 7.23 |
| 32 | 480 | 471.00 | 0.98 | 396.67 | 4.07 | 125.64 | 1.45 |
| 33 | 495 | 473.33 | 0.96 | 403.00 | 6.59 | 131.83 | 4.13 |
| 34 | 510 | 476.67 | 0.93 | 394.33 | 7.64 | 134.25 | 4.37 |
| 35 | 525 | 489.00 | 0.93 | 411.67 | 3.19 | 141.71 | 4.20 |
| 36 | 540 | 490.67 | 0.91 | 406.33 | 12.05 | 145.22 | 1.44 |

## 4. Conclusions, Recommendations, and Future Research

Our client's goal was to reduce the backlog in UPT by training student pilots more efficiently. Based on our analysis, we recommend hiring more CSIs or IPs purely for the purpose of instructing more simulator events each day. Additionally, we recommend purchasing additional IFTs and ITDs and working with maintenance to provide more mission-capable aircraft each day. Currently, the 8th FTS and 33rd FTS have approximately 45 aircraft, 84 IPs available for each flying window, 12 sim lines per day, 7 IFTs, 5 OFTs, and 20 ITDs. We found that to graduate class sizes of 32 students in 90 O&M days, they would need 51 aircraft, 86 IPs per flying window, 24 sim lines per day, 9 IFTs, 5 OFTs, and 22 ITDs.

Additionally, we recommend that class sizes should not exceed 23 students in order to graduate on time. Although the results from our model indicate that Vance AFB could maximize the number of graduates by increasing class sizes to 35, this would put a severe strain on every resource at the 8th FTS and 33rd FTS and would require students to spend approximately 142 O&M days to complete just the flying portion of the syllabus. Furthermore, it is possible that by straining the resources so much, attrition would increase. If aircraft and simulators are constantly in use, they may have more maintenance issues. Likewise, if students, IPs, and CSIs are constantly overworked with large class sizes, fewer IPs may be available to assist struggling students, resulting in higher student attrition. Furthermore, CSIs and IPs may experience more health problems, which would affect their ability to instruct. Although the results from our model indicate that class sizes of 35 may result in the highest number of graduates, we recommend that AETC not exceed 23 students without increasing resources to limit strain, attrition, and required O&M days to complete UPT 2.5.

In the future, an additional analysis could be conducted in order to determine how attrition changes depending on the season. Leadership has noticed that the weather is more challenging in the winter, and there is not as much daylight for flying. It is possible that class sizes should be reduced from October to March and increased from March to October to account for the changes in attrition. Additionally, the client mentioned the use of optimal scheduling practices. It may be important to provide the client with good scheduling practices, which are tailored to their needs, in future research. Lastly, further research could investigate options, other than adjusting resources and class sizes, to more efficiently facilitate UPT 2.5 at Vance AFB.

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