CadetSIM: A System Dynamic Simulation of Cadet Life at the United States Air Force Academy

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Abstract:
Cadets at the U.S. Air Force Academy face one of the most challenging academic experiences available. In addition to taking a heavy load of courses, they are required to participate in athletic and military training activities. Additionally, many choose to pursue significant involvement in military leadership, airmanship programs, or intercollegiate athletics. Time pressure for these cadets is intense, leading in many cases to lower academic performance than cadets are capable of demonstrating. Many struggle to learn effective time management in this environment. Leaders at the Academy have been evaluating how to potentially reduce the time pressure to improve the end result for graduates. This paper presents the development of a dynamic system simulation, called CadetSIM, that can assist cadets with time management decisions and that can provide insight to institutional decision-makers.

The environment at the U.S. Air Force Academy was analyzed at the system level in terms of time requirements. System design and analysis tools were used to structure a model of the cadet time environment. Tools included brainstorming, system architecting, and the construction of a System Dynamic Matrix. Causal relationships stemming from procrastination were incorporated. Due to transient time requirements and system feedback from procrastination, a dynamic system simulation was chosen as the preferred method to analyze system behavior. A commercial software package, STELLA®, was used to create the final product.

The results of this work produced CadetSIM, a continuous-time dynamic system simulation of cadet time requirements over the course of a semester. CadetSIM’s tailored input interface allows the user to create a particular cadet profile to simulate. Output from the simulation shows the user how time expenditure for academics, athletics, military training, sleep, maintenance functions, and discretionary activities will dynamically interact through the semester.

A profile for a typical cadet majoring in engineering is analyzed and presented in this paper. Results show that this cadet has very little discretionary time and experiences periodic sleep deprivation. Most interestingly, we find that with increased procrastination discretionary time and possibly sleep will decrease to maintain a desired level of performance.

CadetSIM will allow a cadet to evaluate the future impact of decisions about activities and study behavior. CadetSIM can help institutional decision makers better understand the dynamic
interaction of time requirements placed on cadets. The development team is currently leading a multidisciplinary effort to enhance CadetSIM to make it broadly available to users across the U.S. Air Force Academy.

Introduction:
At the US Air Force Academy, cadet time is segmented into four distinct baskets: personal time, athletic time, military time, and academic time. Personal time includes time to sleep, perform personal maintenance (hygiene, laundry, eating, etc), and discretionary time. Athletic time includes all activities associated with fitness. Approximately 33% of the student body participates in an intercollegiate sport and all cadets participate in mandatory physical education, physical training and intramurals. Military time represents all of the activities cadets spend on mandatory weekly military activities. Military activities include formations, parades, attendance at sporting events to name a few. Academic time includes all weekly classroom and study requirements.

Information Gathering:
The first step in developing a model to analyze how cadets spend time was to interview the staff responsible for the previously defined time areas, as well as to interview the cadets. During the interview, individuals were asked to define the minimum time requirements for each time area.

For military time area, the military leadership and cadets provided a spreadsheet of all the activities for the school year. The time requirements were allocated to each activity and are illustrated in Figure 2.
To determine the time requirements for the athletic time area, the athletic staff and cadets provided NCAA time restrictions and Academy policy as inputs. Figure 3 illustrates the weekly time requirements for an in-season intercollegiate athlete.

In the academic time area, the Dean’s time requirement is an average two hours of study time per hour of classroom contact. The 2 to 1 ratio is designed to ensure cadets are able to meet their academic potential. When interviewing the cadets and faculty it was discovered that the minimum time required for an average cadet to receive a C average is 30 minutes of study per hour of classroom contact. The assumption is that if cadets execute their schoolwork as it is assigned, the academic time requirements do not fluctuate greatly during the semester.
Personal time was broken into three distinct areas: Sleep, maintenance, and discretionary time. Cadets are expected to average 7 hours of sleep per night. Cadets were interviewed for personal maintenance time requirements for hygiene, eating, and laundry was collected. Discretionary time is the remaining time available after all of the time requirements were satisfied. Cadets and staff agreed that a minimum of 20 hours per week of discretionary time was desired.

Model Development:
Once the information had been gathered, the team was ready to begin the modeling process. A commercially available software tool Stella®, was used to create a baseline model which capture the weekly time requirements throughout the semester.

![Welcome to CadetSIM](image)

The baseline model served as a dynamic spreadsheet with a GUI user interface and graphical output. Figure 5 illustrates a typical output of the model.

![Figure 5. Output from model](image)
To gain deeper insight, a systems dynamics approach was utilized to understand the effects of human behavior on the system. Researchers at MIT Sloan School of Management performed a study which investigated the academic performance of MIT undergraduates using a similar approach. (1) MIT researchers found student performance resulted from procrastination behaviors. The students with high procrastination were consistently outperformed by students with low procrastination tendencies. The MIT team developed causal structure to illustrate student procrastination behaviors, see Figure 6.

![Procrastination Routine](image)

Figure 6  Procrastination Feedback Routine

The causal structure reveals the following: The greater a student’s propensity to procrastinate the larger the academic backlog. The greater the academic backlog the more study time required. The more study time required the student has less personal time available. If the student does not maintain enough personal time to recharge, burn-out sets in and productivity decreases. As productivity decreases, the time required to study increases due to inefficiency.

The team tailored MIT’s model structure to the unique academy environment and mechanized it by determining mathematical nature of the causal relationships and translating these relationships into a system dynamics model.

*Simulation Results:*  
The results of the model were interesting. Figure 7 illustrates the minimum requirements without procrastination behaviors.
The results of the minimum cadet requirements charts revealed that unengaged cadets had an extraordinary amount of free time (over 55 hours/week). As one might expect, very few cadets fall into this extreme category. The results revealed the minimum requirements imposed on cadets are not too stringent and academy officials were pleased to see that cadets had sufficient time to pursue excellence.

The next scenario illustrates the time requirements for a typical engineering cadet. An engineering cadet who is striving in the classroom and minimally engaged in other activities enjoys adequate personal time and sleep. See Figure 8.

When using the same scenario with the procrastination factor, the team observed that the cadet has significantly less personal time due to fluctuations in academic work. Despite a high procrastination factor, the cadet is able to maintain balance of time.
Unlike the engineering student focusing exclusively on academics, the engineering student who is an athlete enjoys significantly less personal time during the semester. The model reveals that the athlete/scholar may lose sleep if they are striving to meet the Dean’s and NCAA time requirements.

If the student/athlete procrastinates, matters are far worse. Figure 11 reveals that a procrastinating scholar/athlete are likely to burnout before the end of the semester.

**Validation/Verification:**
CadetSIM simulation results were compared with student time-survey data collected by Academy institutional research (USAFA/XPR). Although more historical data exists, this paper uses cadet time survey results based on formal data collection conducted by USAFA/XPR from 1998 – 2001. This data is compared to CadetSIM results based on data collected from extensive discussions with cadets, AOCs, faculty, and athletic staff.

The table below compares CadetSIM results for semester percentage of cadet time use with results of the USAFA/XPR time survey. Results for in-season athletes and non-athletes are compared separately.
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<thead>
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</thead>
<tbody>
<tr>
<td>Academics</td>
<td>26 %*</td>
<td>27 %</td>
<td>24 %</td>
<td>22 %</td>
</tr>
<tr>
<td>Athletics</td>
<td>4 %</td>
<td>5 %</td>
<td>11 %</td>
<td>14 % (18 %)*</td>
</tr>
<tr>
<td>Military</td>
<td>9 %</td>
<td>10 %</td>
<td>7 %</td>
<td>7%</td>
</tr>
<tr>
<td>Sleep</td>
<td>30 %</td>
<td>29 %</td>
<td>31 %</td>
<td>29 %</td>
</tr>
<tr>
<td>Eating/Misc</td>
<td>11 %</td>
<td>11 %</td>
<td>10 %</td>
<td>11 %</td>
</tr>
<tr>
<td>Personal</td>
<td>20 %</td>
<td>18 %</td>
<td>17 %</td>
<td>17 % (13 %)**</td>
</tr>
</tbody>
</table>

* All percentages are based on 168 hour week (24 hours * 7 days) and represent a weekly average.
** The parentheses indicate the semester percentages when one considers time spent away from USAFA for contests as athletic time rather than personal time.

**Interpreting results:**
- Academics: Dean’s policy is 2 hours of study per 1 hour of class, which translates into an average of 45.36 hours per week or 27% of cadet time. On average, athletes do not meet Dean’s policy.
- Athletics: 5% represents an average of 8.4 hours per week. Number includes intramurals, PE, and discretionary physical conditioning.
- Military: 10% represents an average of 16.8 hours per week. Activities include formations, year specific duties, MCQ, etc.
- Sleep: 29% represents 49 hours of sleep or 7 hour nightly average.
- Eating/Misc: 11% represents the 18.5 hours cadets spend on basic human requirements including: meals, laundry, hygiene, etc.
- Personal: 18% represents the 30 hours cadets have available for discretionary time. In season athletes have less personal time than non-athletes.

**Conclusion:**
CadetSIM can improve institutional decision makers understanding of the dynamic interaction of time requirements placed on cadets. In addition, CadetSIM can enable cadets to evaluate the future impact of decisions about activities and study behavior. CadetSIM is available for use.

**Bibliography:**
1. STELLA is a commercially available software application, isee systems, 46 Centerra Parkway, Suite 200, Lebanon, NH 03766