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COMPUTER SIMULATION OF U.S. ARMY OFFICER PROFESSIONAL DEVELOPMENT

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ABSTRACT

On January 1, 1992 the grandfather period ended for waiving the legal prerequisites for promoting Army officers to the rank of brigadier general that were imposed by Title IV of the Defense Reorganization Act of 1986. Title IV requires, among other things, that military officers in the armed services serve a minimum of three years in a "joint" duty assignment prior to promotion to general officer. We present a computer simulation for analyzing (1) the impact of Title IV on officer professional development and (2) the impact of the law on officer inventory needed to meet Army personnel requirements. The simulation model permits Army personnel managers to evaluate potential changes to law, policy, and force structure affecting officer professional development.

1 THE ARMY OFFICER SYSTEM

There are over seventy thousand officers in the United States Army assigned around the world to meet needs of the Army in defense of the nation. Effective management of this critical manpower resource is vital to sustaining the vitality of the Army officer corps and to maintaining a high state of readiness in Army units. Unit readiness demands that officers with the proper ranks and specialties be assigned at required levels. Officer professional development (OPD) requires officers to progress through a series of related education, training, and duty assignments as they grow and mature toward increasing levels of responsibility.

At the Army's highest level of management, Department of the Army, personnel managers attempt to satisfy manpower requirements by both grade and job description through the Officer Personnel Management System (OPMS). The objectives of Army personnel management through OPMS are to: (1) develop the professional qualifications of each officer; and (2) properly distribute inventory of Army officers by grade (*rank*), basic Army branch (*primary specialty*), and functional area (*secondary specialty*) to fill Army manpower requirements. In practice, management of these policies is complicated by several factors: (1) the professional qualifications of officers include thousands of combinations of grades, basic Army branches, and functional areas; (2) the constant flux of officer inventory as officers enter the service, change qualifications, and leave the service; and (3) the impact on officer inventory of the defense budget, Congressional law, Army personnel policy, and the nation's economy (e.g., officers are less likely to voluntarily leave the service in a poor job market).

Officer ranks range from 2d lieutenant (grade O1) to general (grade O10). *Company grades* include 2d lieutenant (O1), 1st lieutenant (O2) and captain (O3), while major (O4), lieutenant colonel (O5), and colonel (O6) make up the *field grades*. Normally, officers may be considered (at most) three times for promotion to the next grade. The selection opportunities are: *below the zone* (BZ), *primary zone* (PZ), and *above the zone* (AZ). The one exception, promotion to colonel, allows five opportunities: two BZ, one PZ and two AZ. By Army policy, officers not selected for promotion to the next grade by their (last) AZ promotion opportunity are terminated from service.

For each branch of military service (Army, Navy, Air Force, Marines), certain assignments, called *critical assignments*, are recognized as being more important and professionally challenging than others. Quality performance in all assignments, but especially in critical assignments, translates into timely selection for promotion, military schooling, and positions of increasing responsibility. Selection for critical assignments is competitive with only top performers moving up to the next level of responsibility. Table 1 lists, in sequence, critical Army assignments that define the *critical path* for this study (see Sections 1.1 and 1.2 for an explanation of the acronyms of Table 1).

Table 1. Critical Army Officer Assignments

Grade	Assignment	Duration (yr)
O1	OBC	0.5
O3	OAC	0.5
"	CO CMD	1-2
"	CAS^3	0.2
O4	CGSC	1
"	BN S3 or XO	1-2
O5	BN CMD	1-2
O6	SSC	1
"	BDE CMD	1-2

The variability in time of critical assignments (specifically, those ranging between one and two years) is primarily due to: (1) assignment location (e.g., only one year is available to complete an unaccompanied overseas tour); and (2) assignment policy (e.g., either Department of the Army, or local commanders, may establish policies restricting assignment lengths). For most officers, critical assignments last a full two years.

From each cohort of officers who begin their careers as 2d lieutenants, only a few make it to colonel. Fewer still are promoted to general officer. Officers who serve with distinction may retire after twenty years, and by law, cannot serve beyond 30 years. General officers may not serve beyond 35 years, except at the request of Congress.

1.1 Company Grade Officer Professional Development

Upon commissioning in a basic Army branch, 2d lieutenants attend their branch's officer basic course (OBC) and, following graduation, are almost exclusively assigned to active Army divisions (*troop assignments*) located either in the continental United States (CONUS) or outside it (OCONUS). There are two types of OCONUS tours: (1) *accompanied* (ACC) *tours* (with families) that last between two and four years; and (2) *unaccompanied* (UNACC) *tours* (without families) lasting one year. Normally, officers change geographical locations every three or four years, but may change duty assignments several times while at the same location.

During the 4th or 5th year of service, most officers attend their branch's officer advanced course (OAC) preparing them for company command (CO CMD). Also around the 5th year, officers are assigned a secondary specialty in a functional area that meets special needs of the Army in areas besides primary specialties. In assigning officers to basic branches and functional areas, Army personnel managers strive to match Army needs with the preferences, skills, and educational background of each officer.

Usually, a *nominative tour* follows company command where officers serve as ROTC instructors, Army recruiters, or advisors to national guard and reserve forces. Other officers may pursue a masters degree as a full-time university student followed by a *utilization tour* in their secondary specialty.

Between the 5th and 8th year, all officers spend eight weeks at the Combined Arms Service and Staff School (CAS^3), Fort Leavenworth, Kansas, preparing them to serve on battalion or brigade staffs. The company grade phase ends when captains are selected for promotion to major, normally around their 10th year. At that point, "promotable" captains are managed as field grades. Figure 1 illustrates typical career patterns for most company grade officers matriculating through the Officer Professional Management System (OPMS).

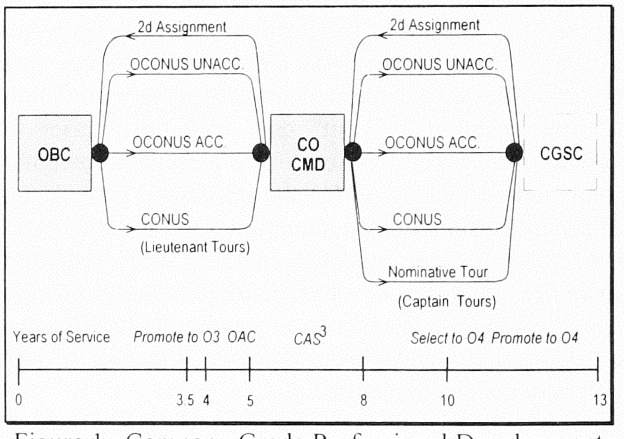

Figure 1. Company Grade Professional Development

1.2 Field Grade Officer Professional Development

Field grade assignments follow a pattern similar to the company grade assignments of Figure 1. However, there are more critical assignments for field grades requiring more time to complete. This confronts Army personnel managers with numerous complex, practical scheduling problems related to field grade officer professional development. Once selected for promotion to major, officers become eligible to attend the Command and General Staff College (CGSC) also located at Fort Leavenworth. The sequence of critical assignments following CGSC are: battalion command (BN CMD), Senior Staff College (SSC), and brigade command (BDE CMD). Once colonels successfully complete their first year of brigade command, they become eligible for selection to brigadier general (henceforth, called a *qualified colonel*). Typical field grade assignment patterns are given in Figure 2.

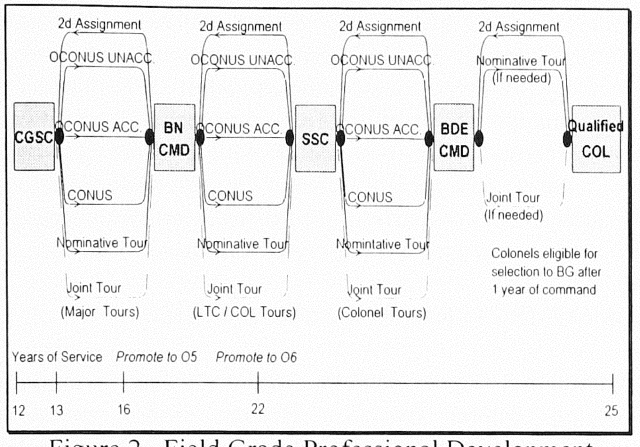

Figure 2. Field Grade Professional Development

The remainder of the paper is organized as follows. Section 2 presents the officer professional development problem. Section 3 addresses alternate methods for modeling the OPD problem. Section 4 discusses the design, development and implementation of a computer simulation model for analyzing changes to officer personnel management. Section 5 concludes the paper.

2 THE OPD PROBLEM

Company grade officers have nine to ten years in which to complete approximately three years of critical assignments (see Table 1). Until recently, most officers graduated from CGSC during their 13th year. Following normal assignment practices, most field grade officers on the *critical path* completed the sequence of critical assignments in (approximately) ten years, on average, so that they entered the pool of qualified colonels around their 23d year of service. This ensured sufficient time was available for brigadier generals (O7) and major generals (O8) to complete critical general officer assignments preparing them for future service at the highest levels of the Army.

In 1986, the United States Congress passed into law the Department of Defense Reorganization Act written by Goldwater and Nichols (1986). Title IV of this law mandates that:

> *[a]n officer may not be appointed to the grade of brigadier general or rear admiral (lower half) unless the officer has completed a full tour in a joint duty assignment.*

A *joint duty assignment* (JDA) is one where an officer serves in a multi-service or multi-national command and participates in exercises involving forces from at least two of the four Armed Services. The purpose of joint duty assignments is to improve the overall quality, education, and experience of military leaders in planning and executing joint operations. The law also stipulates that only field grade officers may be assigned to joint duty billets, according to a joint duty assignment list established and maintained by the Department of Defense. Joint duty assignments typically last two years for a limited number of combat arms officers and 3.5 years for all others.

Adding joint duty to the list of critical assignments extended the time to professionally develop a qualified colonel from 23 to between 25 and 27 years; an outcome that was unacceptable to senior Army leaders. In 1987, the Army's Chief of Staff directed that Army personnel managers from the U.S. Army Personnel Command (PERSCOM), headquartered in Alexandria, Virginia, study the problem and recommend changes to OPMS that would (again) enable colonels to qualify for promotion to brigadier general by their 23d year of service.

3 THE MODELING APPROACH

In 1988, PERSCOM's Force Plans Branch completed the study for the Chief of Staff on the impact of Title IV, and other (potential) changes to officer professional development, to the Officer Personnel Management System (OPMS). Although PERSCOM's study was both thorough and insightful, there were several shortcomings with the analysis.

First, the scope of the study was limited to officer cohorts graduating from CGSC and continuing through qualified colonel; thus neglecting company grade professional development. Second, officer cohorts were aged using a capacitated, deterministic network model [12]; an approach unsuitable for modeling the stochastic aspects of officer professional development (e.g., officer inventory, officer continuation rates, and varying the timing and duration of assignments), or the variability, over time, of promotion, command, and military school selection rates. Finally, aging an officer cohort was done manually making it a tedious, time-consuming task that did not support quick-turn-around analyses of OPMS issues.

In 1989, the Operations Research Center of the United States Military Academy at West Point, New York, and PERSCOM began a collaborative effort to correct the shortcomings described above by developing a robust model capable of supporting repetitive analyses of dynamic Army personnel issues in a timely manner. The initial effort focused on evaluating the impact of Title IV on the Officer Personnel Management System as measured by: (1) officer inventory; (2) the time necessary to develop a qualified colonel; and (3) the

impact of (potential) changes to Army personnel policies aimed at correcting the personnel management problems created by Title IV.

Capabilities that PERSCOM desired in the modeling paradigm included: (1) sensitivity and trade-off analysis; (2) analysis of varying planning horizons; (3) on-line capability to analyze different professional development parameters, such as, personnel policies, law, and force structure (i.e., availability of critical assignment billets (spaces) for battalion and brigade commands); (4) numerical and graphical output consistent with that used at the time to support decision processes; and (5) high-speed report generation.

The literature provides numerous examples of models for studying manpower personnel problems over varying planning horizons, including military applications. Notable approaches include mathematical programming (see Gass et al. (1988), Price (1978) and Wijngaard (1983)), Markovian models (see Davies (1976), Grinold (1976) and Ritzman et al. (1976)) and computer simulation (see Dale (1984), Feng et al. (1976) and Law (1982)). Unfortunately, the first two approaches do not lend themselves to modeling stochastic and time-varying problems; as is the case with officer professional development.

Another obstacle to these (first two) approaches is the size of the officer professional development problem. For example, an integer programming formulation for one year of officer professional development requires indexing six officer grades, thirty years of service, thirty continuation rates (*continuation rates* are the rates at which officers continue to serve, alternatively, the continuation rate is one minus the attrition rate), twenty promotion rates for BZ, PZ, and AZ promotions, six command selection rates, and six military school selection rates. A single-period problem generates $6x30x30x20x6x6$, or approximately, 3.9 million integer variables. A thirty year planning horizon would require approximately 117 million integer variables. A Markov model of the officer professional development problem would require, at least, twenty $30x7$ matrices (by year of service and by grade) for each of the following: (1) officer inventory, (2) continuation rates, (3) officer promotion rates, (4) school selection rates, and (5) command selection rates. Manpower, time and funding constraints made it prohibitive to use these methods to build and maintain a model of the OPD problem.

Computer simulation, on the other hand, is well suited for realistically modeling the stochastic aspects of officer professional development making it a practical alternative to the approaches discussed above. After evaluating several commercial software packages, it was decided to use *Simulation Language for Alternative Modeling* (SLAM) *II* by Pritsker (1986). The user-friendliness of SLAM software supported the need to rapidly prototype a simulation model of OPD in order to demonstrate the benefits of the approach. The software also featured built-in statistical functions for analyzing simulation output in support of decision analyses. Finally, SLAM accommodated non-standard modeling situations via user-written FORTRAN subroutines.

4 COMPUTER SIMULATION MODEL

Simulation model development followed a modular design centered around a dynamic system model of officer professional development. Development of the dynamic system model was motivated by Parlier's (1988) efforts to model OPD for PERSCOM's previous study of Title IV. The initial modeling effort incorporated the most important features of officer professional development, but only distinguished officer inventory by grade and by year of service, for simplicity. A modular design of the simulation model was adopted so the system could be easily extended to support (future) studies, such as, disaggregating officer inventory by primary and secondary specialties. The modules developed for the simulation included: *Company Grade Module*, *Field Grade Module*, *OPD Policy Module*, *Numerical Analysis Module*, *Graphical Analysis Module*, and *Report Generation Module*. Simulation architecture and system modules are shown in Figure 3.

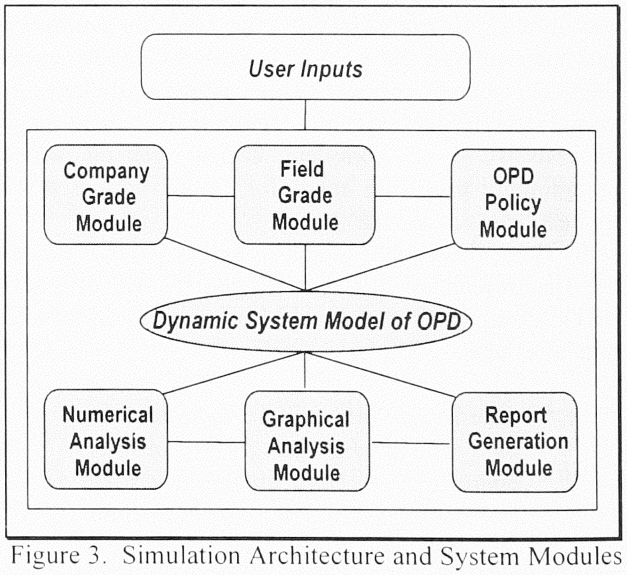

Figure 3. Simulation Architecture and System Modules

The *Company Grade Module* and *Field Grade Module* are analogs of the real-world professional development process. The *OPD Policy Module* enables analysts to input and change officer professional

development parameters studied using the simulation model. Statistics by observation and statistics on time-persistent variables are obtained directly from SLAM. Other statistics are computed from the simulation output that is exported to a *LOTUS 1-2-3* spreadsheet for additional post-simulation processing and analysis. The *Graphical Analysis Module* graphs numerical results and statistics in the spreadsheet environment. The *Report Generation Module* prints numerical and graphical output in formats tailored to support decision analysis based on decision criteria used in practice (at that time) such as: (1) the number, grades, and years of service of officers completing each critical assignment; and (2) the number and years of service of officers who become "qualified colonels" each year.

4.1 Building the Simulation Model

Developing the computer simulation of officer professional development required several simplifying assumptions. First, the simulation only accounts for officers who remain on the critical path to qualified colonel. At each decision point (in the model), entities (officers) not selected for the next critical assignment are culled from the simulation model. In reality, however, many officers "passed over" for critical assignments, such as, commands or military schools, continue to serve in other assignments that are vitally important to the Army. Second, the model accounts for the most common, but not all, officer assignment patterns. Additional assignment possibilities can be added to the model as necessary. Figures 1 and 2 show the officer professional development assignments modeled for this study.

A network flow diagram similar to Figures 1 and 2 was developed to represent the longitudinal flow of officers through the professional development process. Entities are made to flow through the simulation model in a way that mimics how cohorts of officers progress sequentially through the company and field grade phases of OPMS toward qualified colonel. Selection boards for promotions, commands and military schools are represented as decision nodes in the network model. Decision outcomes from officer selection boards are modeled in the simulation via probabilistic or conditional branches emanating from the decision nodes. Officer assignments are simulated by specification of point estimates and probability distributions for (1) the duration of assignments and (2) the rates officers continue to the next assignment (event).

In the simulation, officer "entities" are "tagged" with attributes that describe outcomes of both decision nodes and assignment activities that are then used to create a history of events for realistically simulating officer selection boards. Attributes assigned to officer entities include: (1) creation time (year commissioned), (2) past assignments, (3) current grade, (4) current year of service, and (5) the time (year of service) when critical events or decisions occurred.

4.2 Model Verification

The simulation was built and verified in four sequential, overlapping phases. The system development phases were:

Phase 1. Functional Description of the System;
Phase 2. Preliminary Design of the Simulation Architecture and System Modules;
Phase 3. Company and Field Grade Prototype Development;
Phase 4. Full Simulation Model Development.

Prototypes were developed (separately) for the company grade and field grade phases of OPD to test officer assignment and selection board rules. The field grade prototype was initialized using output from the company grade prototype. Structured walk-throughs of each prototype were regularly conducted with personnel management experts during each phase of model development to verify the logic and correctness of rules used in modeling the OPD process. The prototypes were also verified using different input parameter values to test the reasonableness of simulation output. Tests were conducted on the following model parameters: (1) continuation rates, (2) promotion rates, (3) command selection rates, (4) military school selection rates, (5) duration of assignments and (6) system delays for promotions, assumption of command, and military schooling. Historical data used to compute point estimates and probability distributions for (1) officer selection boards, (2) duration of assignments and (3) system delays was provided by PERSCOM, while historical officer continuation rate data came from the Defense Management Data Center, Monterey, California.

Once the company and field grade prototypes were performing as expected, they were linked to form a complete model of the officer professional development process. The full simulation model was verified using the methods described above.

4.3 Model Validation

The simulation model was validated by comparing simulation output with analytical results obtained from PERSCOM's initial study of Title IV. The work by [12] on the Title IV issue was both well-known and well-

accepted by both Army and Congressional leadership. Therefore, the results were not only very useful in validating the simulation, but incorporating them into the model validation process also helped to establish the credibility of computer simulation as a means of studying complex, dynamic Army personnel management issues. Two "base-case" simulations were developed for validation purposes. The first modeled officer professional development prior to Title IV, while the second simulation incorporated Title IV requirements.

The use of OPD parameters (again, specified by point estimates and probability distributions) characterizing OPD decision outcomes in the simulation model was consistent with [12]'s approach, where historically based OPD parameters were used to forecast future states of officer inventory. The parameters for validating the simulation were empirically derived using a large set of historical data from the previous twenty to thirty years of officer professional development. The simulation parameters were compared with the parameters estimated previously by [12] using appropriate statistical tests. The results showed that the two sets of parameters were very highly correlated. It is believed that these parameter values can be safely used to forecast future states of officer inventory, as long as, future OPD decision outcomes do not substantially differ from the historically based values used in the simulation. Figure 4 shows the type of information obtained from [12] used in validating the simulation of officer professional development.

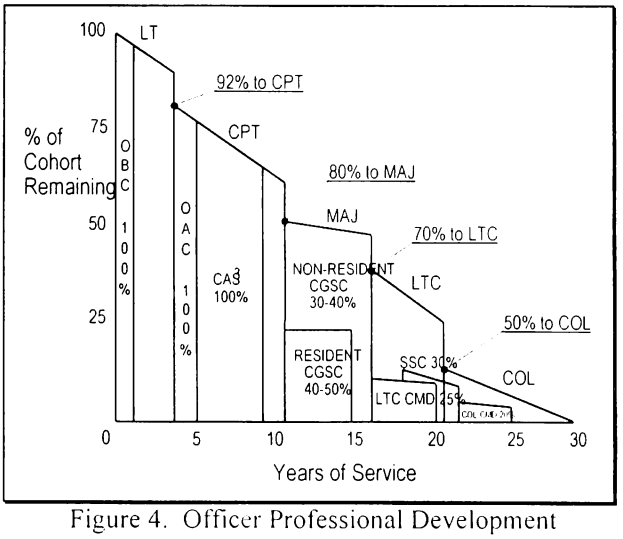

Figure 4. Officer Professional Development Opportunity [18].

4.4 Simulation Output

Model validation required comparing simulation results with analytical results from [12]. The basis for this comparison was decision criteria used in practice to support the decision analysis process. Simulation output summarizes: (1) the number of officer entities that remain on the critical path to qualified colonel following each critical assignment; and (2) the years of service (mean service time) for completing each critical assignment. However, the information from [12], such as that shown above in Figure 4, is expressed as percentages. Therefore, it was necessary to further refine simulation output in order to properly compare it with analytical results from [12].

Confidence intervals were constructed for each modeling parameter based on thirty replications of the two base-case simulation models. The results, in every case, showed that sample means (for decision criteria) from the computer simulation were within one to five percent of the values from [12]. Table 2 gives simulation output for the two base-case models by percentage of cohort remaining after each critical assignment and by *year of service* (YOS).

Table 2. Numerical Simulation Output

Officer Assignment or Event	Mean YOS w/out JDA	% Cohort Left	Mean YOS with JDA	% Cohort Left
Commissioning		100		100
Graduate - OBC	0.4	98.0	.45	98.3
End LT Tours	4.25	90.5	4.26	90.7
Promote to CPT	4.25	83.5	4.26	83.6
Graduate - OAC	4.84	76.0	4.85	76.1
CPT Tours	9.34	61.5	9.37	62.3
Promote to MAJ	9.34	48.2	9.37	49.2
Select - CGSC	10.7	22.2	10.8	22.5
Graduate - CGSC	12.9	21.5	12.9	21.8
MAJ Tours	**15.3**	**19.9**	**16.8**	**14.3**
Promote to LTC	15.3	18.5	16.8	13.2
Select - LTC Cmd	16.3	15.2	17.8	10.6
End LTC Cmd	19.5	14.7	21.8	9.4
Select - SSC	19.5	11.6	21.8	7.9
Graduate - SSC	21.1	11.3	23.4	7.8
Promote to COL	21.1	10.8	23.4	7.2
Select - COL Cmd	21.1	8.8	23.4	7.2
End COL Cmd	22.1	7.6	24.4	6.5
Qualified Colonel	23.1	6.8	25.5	5.9

The results show the impact of Title IV beginning with the field grade assignment following CGSC (shown in bold). Title IV (potentially) adds approximately 2.5 years, on average, to the time required for officers to reach the pool of qualified colonels; a 10.6 percent

increase in time. Simultaneously, the number of officers entering the pool of qualified colonels is reduced by 13.4 percent; a (potential) outcome with serious implications regarding the (future) selection of senior Army leaders. One possible interpretation of this result is as follows. Some officers must be assigned to joint duty billets following CGSC graduation (per Title IV). In most cases, these officers will not have enough time to complete a full tour as a battalion operations or executive officer; a critical assignment for promotion from major to lieutenant colonel. This assignment sequence may delay future assignments, including battalion and brigade commands, and may possibly delay promotion for some officers as well. At worst, delays due to joint duty assignments may result in (those) officers being "passed over" for commands as lieutenant colonels or colonels. Thus, the number of officers entering the pool of qualified colonels and competing for promotion to brigadier general is decreased. Figure 5 graphs the results from Table 2 showing the potential impact of Title IV on officer professional development.

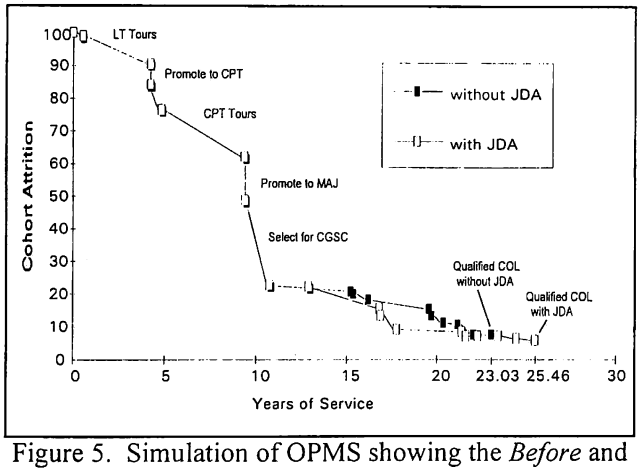

Figure 5. Simulation of OPMS showing the *Before* and *After* Impact of Title IV

The gap between the two base-case models beginning around the 14th year represents the drop in the percentage of officers remaining on the critical path to qualified colonel due to Title IV. The differential (between the two base-case scenarios) indicates the potential shortfall in the number of officers available at each grade to serve in other critical assignments, assuming joint duty requirements are filled first. For example, filling lieutenant colonel Title IV joint duty requirements first reduces the inventory of lieutenant colonels available to compete for battalion command by 36 percent. Therefore, unless officer assignments are carefully synchronized, Title IV may have long lasting and serious consequences for Army personnel management.

One alternative for offsetting the negative effect of Title IV on officer professional development is shortening the time required for officers to enter the pool of qualified colonels; namely, graduate officers earlier from CGSC (see Figure 6).

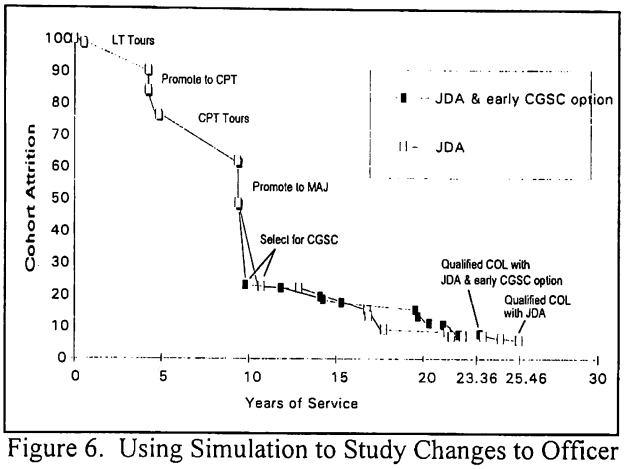

Figure 6. Using Simulation to Study Changes to Officer Professional Development

This alternative is analyzed by making two modifications to the simulation model. First, officer entities are selected one year earlier for CGSC. Second, the delay between the time officers are selected for CGSC and when they arrive for school is reduced by one year. From the results in Figure 6 we see that scheduling officers to graduate from CGSC during their 11th instead of 13th year will ensure sufficient time is available for majors to complete important battalion-level assignments prior to being considered for promotion to lieutenant colonel. Also note that the time to qualified colonel (with joint duty) is reduced from the 25th to the 23d year of service.

Other options evaluated for mitigating the impact of Title IV on OPD included: reducing (other) system delays, increasing class sizes for military schools (CGSC and SSC), and reducing the length of military schools and other assignments. Simulation results from testing these scenarios compared very favorably with PERSCOM's analysis of Title IV, and with the expectations of Army personnel experts. The simulation model was accepted for use in 1989 by PERSCOM's Force Plans Branch.

5 CONCLUSIONS

Army personnel managers are faced with the formidable challenge of properly managing officer inventory to satisfy Army requirements for officers, while simultaneously attempting to meet the

requirements of officer professional development. The computer simulation model presented here was developed (1) to support analysis of a range of professional development issues and (2) to provide a framework for carefully modeling and methodically studying Army personnel management problems where the best alternatives are not obvious. In the computer simulation model, parameters are easily adjusted to reflect potential changes to officer professional development. However, the model neither matches officer inventory against Army requirements, nor identifies OPD alternatives for off-setting the negative effects of Title IV. Nevertheless, the computer simulation of OPD can be used to support properly designed and carefully conducted experiments to help Army personnel managers evaluate the feasibility of OPD alternatives, and to provide insights into the complex dynamics of Army personnel management.

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