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A Study Performed Under Office of Navy Research Contract  
N00014-80-C-0200

for the Office of Assistant Secretary of Defense

Report No.: ONR-200-8

AD-A140 914

MANAGEMENT OF THE ARMED SERVICES' DELAYED ENTRY POOLS:

A Comparison of Recruiting Philosophies and Issues

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January, 1983

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ACKNOWLEDGEMENTS

This work was supported under a contract administered by the Office of Naval Research, Contract N00014-80-C-0200, with support from the Assistant Secretary of Defense, Dr. Thomas Sicilia (sponsor) and Dr. Bert King from ONR as the Project Officer. The time, background papers and discussions provided by the following have been very helpful and appreciated:

Commander Ralph McCumber of the Navy Recruiting Command

Lt. Commander David T. Thalman of the Navy Recruiting Command

Mr. J. J. Miller of DMDC and formerly with the Navy Recruiting Command

Admiral Freeman (ret.) of the Navy Recruiting Command

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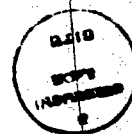
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*letter on file*

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## 1.0 BACKGROUND

### 1.1 The Delayed Entry Mechanism: Its Perceived Advantages and Disadvantages

Each of the Armed Services' Recruiting Commands enables a potential recruit to delay his actual shipping date (called his accession date) for up to a year from the time he signs an obligation (a so-called contract) to enter a given Service. If a recruit chooses to delay his shipping date beyond a month of his time of contract signing, he enters the so-called Delayed Entry Pool (DEP)<sup>1</sup>; those recruits who do not enter the DEP are called "Direct Shipments." The DEP device is very popular with both recruits and with the recruiting managers, with over 80% of all DOD accessions utilizing the mechanism. *The DEP device is the device used by the Armed Services to recruit and accessions on the Direct Entry Mechanism.*

The Delayed Entry mechanism has both its advantages and disadvantages which can be summarized as follows. First consider the advantages:

#### Advantage 1: DEP Aids Production

The size of the DEP pool is known to have a positive impact on recruiting efforts in that it synergistically complements the expenditures of recruiting advertising and of individual recruiter's efforts. These recruits who have made a decision to enlist often encourage their peers to inquire about the Services as a possible option and often become a type of recruiter aide. Indeed the Navy encourages referrals by a recruit in DEP by awarding an advance in his paygrade, if the number of referrals who actually enlist exceeds 2. Several studies bear this out, namely:

- i) a previous study<sup>2</sup> utilized a two stage simultaneous regression equation approach with both the current number of HSG Contracts as well as the size of the Navy's DEP pool as dependent variables. It esti-

<sup>1</sup> The Air Force utilizes more than 15 calendar days as their criterion for a "deper."

<sup>2</sup> The Impacts of Various Types of Advertising Media, Demographics and Recruiters on Quality Enlistments: Results from Simultaneous and Heteroscedastic Models, Richard C. Morey and John M. McCann, a Technical Report from Duke's Center for Applied Business Research, Office of Navy under Research Contract N00014-80-C-0200 July, 1980.

mated the long term elasticity of the size of the Navy's DEP pool on Navy, male, non-prior service, High School Graduate enlistment contracts to be .19; i.e., an increase in the size of the DEP pool of 10% would be accompanied over the long term by an increase in the number of High School Graduate (HSG) contracts of 1.9%. To put this number in perspective, the DEP elasticity is approximately equal to the estimated impact of a change in the unemployment rate. The size of the DEP pool also had a positive effect on the number of the Navy's National (NOIC) Leads. The data base utilized was from 1976-1978, at the monthly-district level.

- ii) An internal Navy study (see, CNRC Production Upgrade Management Program, by Admiral Freeman) estimated, based on empirical analyses, that when the DEP size per recruiter increased from 5 to 15, there was a 33% increase in the production or output of the recruiter.<sup>1</sup> The study further claimed that the increase in production could be as much as 60% if the DEP position per recruiter increased say from 0 to 15.<sup>2</sup>
- iii) The Air Force in an internal study, Delayed Enlistment Program: A Costing Analysis, by Captain Schumacher mentions that the size of the DEP/recruiter (unless it becomes too unwieldy) can be of aid in recruiting. Interestingly, the average DEP per recruiter in the

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<sup>1</sup>Incidentally, this agrees remarkably well with the estimated elasticity of .19 from the previous regression study, of the size of the DEP pool on HSG Contracts. To see this, note that an increase in DEP/recruiter from 5 to 15 represents an increase in DEP of 200% (assuming the number of recruiters are held constant); then an elasticity of .19 for DEP on HSG Contracts implies that a 200% increase in DEP would be accompanied by a 38% increase in HSG Contracts. Given that the estimated elasticity was for HSG Contracts, the agreement with Freeman's estimate of a 33% increase overall is very close.

<sup>2</sup>It should be mentioned that the above result could simply be capturing the fact that successful recruiters obtain more contracts and hence as a result have more DEP; in this case the size of the DEP position is not a causal factor on his production level but merely an accompanying outcome.

Air Force was approaching levels of 45<sup>1</sup> which were considered no longer manageable, the consequences being that the Air Force's DEP position has consciously been lowered recently.

Advantage 2: DEP Facilitates Planning and is a Hedge Against Adverse Recruiting Environment

The existence of the DEP pool, a "pipeline" of recruits, facilitates better long range planning in that it provides:

- i) an "early warning" system of recruiting problems since goals can be set on contracts as well as on accessions;
- ii) provides the information and flexibility needed for the Services to eliminate imbalances by reallocating resources and quotas to be better able to increase overall productivity. We shall see that the various Services differ substantially on their philosophies for management of their DEP pool.
- iii) be able to adjust to modifications in goals;
- iv) be better able to insure the filling of critical training seats as management can "persuade" those in DEP into shipping earlier or later, as is needed.
- v) build a pipeline in case economy upturns or other adverse events occur which impact on recruiting success.

Advantage 3: DEP Lowers Attrition

There are studies<sup>2</sup> that show the recruits who become accessions out of the DEP program attrit less from "boot camp," and from the training schools. The Air Force indeed claims that their boot camp attrition rate is about 8% for "direct ships" and between 5-6% for those coming out of DEP. This may well be due to the fact that those allowed to enter the DEP may have (or will have) a High School Degree Diploma (which is highly correlated with non-attrition). Nevertheless, while the recruit

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<sup>1</sup> This is in contrast to average DEP per recruiter levels in the Navy of 10-12.

<sup>2</sup> For example, the above referenced Air Force study.

is in the DEP, he attends liaison meetings with the recruiter and others so that the recruit gains more of a realistic expectation of boot camp and the Service in general, all of which can contribute to lower attrition rates.

Advantage 4: DEP "Smooths" Sales Efforts

Over and above the "peer grapevine network" advantage cited in (1), the DEP renders the expenditures of recruiting efforts more cost-effective in that their "sales" efforts can be made more uniform over the year. As a consequence certain diseconomies of scale (related to surges in expenditures of advertising and recruiter resources) do not have to occur so frequently, i.e., with a more uniform effort over the year, one is not as high "up the diminishing return curve" as one would be with a more volatile operation.

The major disadvantages of the DEP system can be summarized as:

Disadvantage 1: Increased Pay

Time spent in the DEP counts as longevity for base pay. Under Public Law 96-342 and the Military Manpower Management Act (PL 93-343), the level of base pay is a function not only of the individual's rating (i.e., E-1 through E-9), but also his years of service. As an example an E-5 with 4 years of service earns \$747.00 per month, compared to \$796.50 for an E-5 with 6 years of service. Hence the higher base pay associated with time spent in DEP argues for minimizing the recruit's time spent in the DEP. The Air Force emphasizes this aspect by discouraging anyone from "deping" out for more than 4 months.

Disadvantage 2: DEP Attrition

There is some attrition which occurs while the recruit is in DEP. Indeed the curve is "bathtub shaped" in that some recruits vacillate immediately after enlisting and attrit, whereas those in for very long periods also have a higher tendency to attrit. The attrition percentages are quite low, i.e., of the order of 5-8%. Thomas Savings in "The Supply

of Military Personnel: A Life Cycle Approach" (an Air Force sponsored study) in July, 1980 claimed that the longer the required waiting period in DEP, the lower the enlistment rate.

Disadvantage 3: Adapting to Lower Accession Goals and Maintaining Slots for Direct Ships

If the DEP "pipeline" is flowing, it may be difficult or impossible to turn it off or down if the accession goals are decreased suddenly. For this reason the Marine Corps limits their percent of a district's accession goal coming out of DEP to less than 80% for the next out-month, to 70% for the second outmonth, 60% for the third outmonth, 50% for the fourth outmonth, and 45% thereafter. They feel this provides them the flexibility needed if accession goals are reduced (say due to a higher reenlistment rate), or if prior service or other high quality candidates present themselves and want to enter immediately.

Disadvantage 4: Recruiter's Reliance on DEP Pool

The recruiter may feel he can "live" off his pipeline for meeting his accession quota and may not be as productive as possible. This could especially be a problem when a recruiter's tour of duty is terminating and he feels there is little incentive for him to keep up his DEP position. The Services are dealing with this by not allowing recruiters to "bank" all of their accession quotas and by setting quotas on contracts (rather than accessions).

Disadvantage 5: DEP Takes Some of Recruiter's Time

Some of the recruiter's efforts must be spent in liaison with those in the DEP Pool. Indeed the Navy requires their recruiters to have a face-to-face meeting with depers at least once a month and to be in touch with them by phone on a more frequent basis. This may conceivably dilute some of his other efforts.

Disadvantage 6: Equity Problems in Resource Allocation

New recruiters may have less of a DEP bank than others in the system and feel there are inequities in the resource allocation system. This

is due to the perception that the higher the DEP per recruiter, the easier it may be for the recruiter to be successful. The Navy is dealing with this consideration by varying the accession goals (but not the contract goals) of various districts that are "poor" in DEP per recruiter so that the DEP positions per recruiter can become more equalized. This philosophy views the DEP per recruiter as a valuable, scarce resource that needs to be parcelled out, similar to advertising expenditures or recruiter aids.

Note that the Services' contract prediction equations (used to build the fair contract market share percentages for each region), while they include recruiters, advertising, propensities, etc., do not include the DEP size.<sup>1</sup> It is well recognized that there will be legitimate differences in the number of goaled contracts per recruiter between areas (based on differences in unemployment rates, size of male High School senior population, propensities, etc.). However, since DEP is not included in the contract equations, then one equitable way to parcel it out is so that the DEP per recruiter levels are as equal as possible across recruiting areas. Of course this also is not without its problems since in order to reduce imbalances in the DEP/recruiter levels, districts with relatively strong DEP positions will be penalized by having to carry more of the accession load. Also, the above efforts notwithstanding, it is difficult to insure at the station level or at the individual recruiter level, that imbalances still do not occur.

#### 1.2 Summary of Previous Research in DEP Management

There are only three articles known to this researcher which deal with management of the Delayed Entry Program. The meager offering in this area underscores the need for more research in this important area. The three items, with a brief abstract, are:

- 1) A Goal Setting Procedure for the Navy's Delayed Entry Program, Richard

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<sup>1</sup>This would be inappropriate since the DEP size results from the contract flow, less accessions.

C. Morey, Duke University Report, ONR-200-3, October, 1981). This model was developed as an alternative to a procedure used by the Navy several years ago in their DEP management. At that time the Navy promulgated guidelines that encouraged recruiters to have at least 65% of their next month's accession quota in DEP, planning to be shipped that month. The further outmonth guidelines were 45% for 2 months out, and 35% for three months out. However, it was well recognized that DEP management must deal with the following highly interactive and dynamic interactions surrounding recruiting, e.g.:

- i) HSG enlistments contracts are highly seasonal with peaks in the summer, and January through March;
- ii) accession quotas are highly seasonal, particularly for HSG's, with the peaks in the summer months;
- iii) the average time spent in DEP, from the signing of a contract to shipment is a function of the month when the contract was signed and varies significantly. Given these considerations, a method for calculating DEP targets for an upcoming year, by month by district, was developed and illustrated which included the following factors:

- a) the actual or estimated initial DEP positions by Area (or by District) at the beginning of the fiscal year;
- b) the rate at which the initial DEP position is converted to shipments, i.e., the estimated fraction of the initial DEP position that will ship each month in the future;
- c) the estimated attrition (i.e., fraction of recruits who enter the pool but later drop out) from the initial DEP pool as well as from contracts signed throughout the year;
- d) the delays that occur between contract signing and shipment. These varied by month and were expressed as the percent of those, signing a contract in month  $j$ , who ship  $X$  months later.

e) the "optimal" flow of contracts during the year. This in turn was a function of the yearly or monthly accession goals, the required DEP position at the end of the year and key demographics related to projected unemployment rates, High School senior population, etc. The "optimal" referred to the strategy which minimized the total cost required to meet given yearly or monthly accession goals and a terminal DEP target, taking into account differences in contract yield rates between the various areas and times of year.

The optimization model<sup>1</sup> outputted the optimal contract and accession flow, by district by month. The non-linear programming model could be utilized in either a budget generation mode (to develop the budget, given some goals) or in a budget execution mode (given the budget and some desired goals). It also could be run with pre-set total monthly accession goals, or even with pre-set area, monthly accession goals.

The model could produce the resulting "optimal" DEP positions by month by area, since it produced the "optimal" contract flow (by area by month), and the optimal or prescribed accession flow (by month by area). These factors, together with the initial DEP positions, attrition and the time lagged conversions of contracts into accessions, yielded the DEP positions.

- 2) CNRC Production Upgrade Management Program (PUMP): A Concept Paper, Dewitt L. Freeman, Rear Admiral (retired), 1980. This concept paper focused on the important insight that the DEP position per recruiter was an important recruiting resource much akin to advertising, recruiter aids, etc. Given this perspective, it behooves management to allocate

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<sup>1</sup>"A Multi-Year Budget Generation Program for Use in Navy Recruiting: A User's Manual," Richard C. Morey, Duke University Report ONR-200-2, October, 1981.

accessions to the various geographical areas so as to bring the allocation of this scarce resource (i.e., DEP per recruiter) into balance. This is accomplished by allowing those areas initially weak in DEP per recruiter to "grow" DEP by cutting back on their accession quotas. The correct objectives are unchanged and follow the fair market share logic. This concept has been implemented by the Navy's Recruiting Command and indeed appears to give rise, at the end of the year, to more uniform DEP/recruiter positions across the Navy's six regions. However, as will be shown in Section 4.3, the rather static process used by the Navy to allocate the area accessions mission can be improved and made more dynamic so as to alleviate imbalances in the DEP/recruiter positions throughout the year as well.

- 3) The Delayed Entry Program: A Costing Analysis or 'What is the Optimum Size of the DEP?', Captain Schumacher, Air Force Recruiting Command, 1981. This consists of a series of slides which has its purpose the determination of the most economical size of the DEP pool. It recognizes the tradeoff between increased longevity pay (as the DEP pool grows or as the average time spent in DEP grows) and the benefits of increased DEP size in terms of lower attrition/discharges in boot camp and in the training schools. It also mentions the reduced risk of training seats being unfilled through the use of DEP. However, there is no recognition in this analysis of the significant role of DEP in aiding in the production of contracts. Also the costing analysis is only illustrative in that there is no real rationale for how to estimate the dollar savings from lower attrition or discharge rates. (One half of the variable cost is utilized.)

His conclusions are that if one includes both the tangible and opportunity factors, the total DEP size should be "packed in" at a size

equal to the next 4 months of the accession goal, with an optimal average time spent in DEP of 2 months. Indeed this is the policy currently being used by the Air Force.

## 2.0 A COMPARISON OF THE DEP MANAGEMENT PHILOSOPHIES UTILIZED BY THE THREE SERVICES

### 2.1 The General Environment

The four Services, i.e., Navy, Army, Air Force and Marine Corps approach DEP management quite differently. It is important in viewing this issue to keep in perspective the differences in the recruiting environment for the three Services, i.e., the relative ease of the Air Force vis-a-vis the Army in obtaining quality enlistments, the vast differences in DEP/recruiter across the Services (i.e., 12.5 for the Navy versus 40-45 for the Air Force), the vast differences in advertising expenditures (i.e., \$82M in FY82 for the Army versus \$20.6M for the Navy), the contract and accession goals (e.g., 155,000 contracts and 147,000 accessions for the Army for FY83 versus 104,000 contracts and 100,000 accessions for the Navy in FY83), and the various quality standards in force (e.g., at least 63% category 1-IIIAs for the Navy versus a corresponding 53% for the Army). In addition, there appear to be large differences in the level of sophistication across the Services used in assigning recruiters, or in developing each district's fair market share of the quotas. Hence, some of the Services are still trying to "catch up" on the more basic problems and haven't had the time nor felt the need to be as concerned with DEP management as others have. Finally there are legitimate differences across the Services in how best to deal with "equity" considerations versus increased productivity issues.

Before getting into some of the more detailed considerations, it is also important to appreciate that at the recruiting command headquarter's level, DEP management centers principally on the following issues:

- i) how contract goals are assigned to various regions of the country;
- ii) how accessions are assigned to various regions of the country;
- iii) what constraints on desired DEP policy operate, e.g., the maximum percent that can ship from DEP, the "compactness" of DEP, etc;
- iv) the targets for the size of the DEP pool.

It will be seen that there are substantial differences as to how the three Services approach the above considerations.

## 2.2 Similarity of Processes Used to Assign Contract Objectives

While there are vast differences concerning the DEP management philosophies used across the various Services, there is general agreement between them as to the setting of contract objectives. We also observe, once contract objectives are set (by month, by region), that DEP goals, by month by region, are then only a function of the initial DEP positions, the accession allocation scheme used and to some small degree, DEP attrition. Of course, only the accession allocation scheme is controllable by the management.

Consider first the general procedure used by the three Services to assign contracts, both the annual total by region as well as the timing over the year. We first observe that once the DEP position desired at the end of the year and the total number of accessions required over the year are set, the total number of contracts needed throughout the year is determined from the relationship:<sup>1</sup>

$$D_T = D_0 + C_T - A_T \quad (1)$$

where

- $D_T$  = terminal DEP position desired at end of year (nationwide)
- $D_0$  = initial DEP position at beginning of year (nationwide)
- $C_T$  = total number of contracts required throughout year (nationwide)
- $A_T$  = number of accessions desired throughout year. (nationwide)

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<sup>1</sup>This ignores attrition in the initial DEP pool as well as attrition associated with the contracts signed during the year. These additional parameters can be easily included (see Morey, "A Goal Setting Procedure for the Navy's Delayed Entry Program," October, 1981). However, to facilitate the exposition, these complications are not included.

The remaining question is how to spread this resulting national, yearly contract objective,  $C_T$ , over the various geographical areas and over the months. For each of the services, there is an effort made to assign contracts based on equity, i.e., to recognize there are differences in propensities, local unemployment rates, the numbers of High School seniors, etc. and the numbers of recruiters and advertising resources allocated to given areas. In every case the Services allocate the yearly percentage share of the total contract objective based on a regression model which forecasts the total number of contracts, sometimes by types from a given area, given its key demographics. These numbers are added up and the resulting percentages from each area, subject to some overrides and negotiation, are applied to the national, yearly contract objectives to set the yearly contract objectives for each region of the country. The distribution of that objective across the various months varies by Service. Consider briefly each Service's detailed process:

1) The Navy's Contract Allocation Process

The Navy utilizes a log-log regression model to build a multiplicative equation where the variable being forecasted is total male, non-prior service enlistment contracts.<sup>1</sup> The model is built using pooled cross sectional, time series observations from all of the Navy's 41 districts. The independent variables include: the number of recruiters projected to be in place in each area; the estimated numbers of male High School seniors by area; the forecasted unemploy-

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<sup>1</sup>They now have available and operational at headquarters a computer program developed by this Investigator where the dependent variable is male, non-prior service, HSG Contracts or Upper Mental, HSG Contracts. This model is more detailed in that it incorporates the results of a sophisticated heteroscedastic regression model incorporating lag times, advertising of various types and has undergone extensive validation efforts. The model captures the diminishing return nature of recruiting resources (see, "The Tactical Allocations of Quality Recruiting Goals Across Regions and Districts: Its Use in Identifying 'Exceptional' Producers," Duke University Report ONR-200-5 (Principal Investigator: Richard C. Morey), March, 1982).

ment rates by area; the area's propensity, urban-rural mix, percent black, etc. This determines the overall percentages of the total yearly contract objective for each of the Navy's six regions. The regional commanders then, with the advice of Headquarters, allocate this regional contract objective to the districts in their regions. The timing of the contracts objective over the year by region is determined using the distributions of various types of contracts from the past year. In this way a monthly, contract objective by district is generated for the Navy.

ii) The Army's Contract Allocation Process<sup>1</sup>

The Army utilizes a similar scheme to the Navy but with some important exceptions:

- a) they have separate regression market share equations for various types of recruits;
- b) they utilize quarterly data;
- c) they build separate models for each of their five areas using pooled time series, cross sectional observations from within each area;
- d) they utilize a linear model which cannot capture the diminishing return nature of recruiting resources;
- e) they rely on several overrides which are used when the forecaster produces "unreasonable" results. This override is applied frequently since the forecaster is still in its infancy, and;
- f) Headquarters assigns the quotas at the district level.

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<sup>1</sup>This material is based on, "The Army's Enlisted Production Model: A Critique and Suggested Directions for the Future," Richard C. Morey and John M. McCann, A Report prepared for the Army Recruiting Command under Purchase Order with Battele Institute, August, 1982).

As far as the spreading of the contract objective over time, the total yearly contract objective is split into 12 equal parts (to equalize the workload), but the types of contracts required each month are varied to reflect seasonal patterns observed over the past two years.

iii) The Air Force's Contract Allocation Process

The Air Force utilizes a market share model consisting of the five factors: local unemployment rate, number of High School seniors, civilian wages, total number of military bases in region, and percent of High School seniors that are college bound. A linear regression model is used. Note also that recruiters were not included in the regression analysis used to build the equitable market share. The resulting percentages are used to determine a yearly contract objective by area. These numbers are simply spread evenly over the year by month.

iv) The Marine Corps Contract Allocation Model \*

They utilize an informal market share prediction equation which includes key demographics and propensities. They also build enough excess contracts into each districts goal so that each district will be able to begin the next fiscal year with 45% of their next year's accession goal already in the bank.

2.3 Differences in Accession Allocation Strategies Across the Three Services

While we have seen that the general philosophy used to assign contract objectives across the various regions of the country is approximately the same across the three Services, we shall see their accession allocation policies are quite different and are driven by different considerations. Consider each in turn, starting with the Air Force's and Marine Corps' which is the easiest to describe.

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\* Based on discussion with Lt. Col. C.G. Tyrian of the Marine Corps Recruiting Command in Arlington, VA.

2.3.1 Accession Area Allocation Scheme/DEP Management Process Utilized by Air Force's Recruiting Command and the Marine Corp's Recruiting Command

As mentioned earlier, the Air Force arrives at a contract objective for each of its thirty-five recruiting squadrons based on a fair market share model. The total yearly contract objective is arrived at from the desired yearly accessions level, the initial DEP position, the size of the desired DEP position at the end of the year, and an estimated DEP attrition factor. The annual squadron contract objectives are spread across the months based on a uniform production schedule throughout the year. The accession quotas by squadron by year, are spread in exactly the same manner as the contracts, using the fair market share for contracts. Differences in each squadron's initial DEP positions are not taken into account since it is felt it would not be equitable to penalize squadrons strong in DEP by allocating them a higher proportional share of the accessions. The Air Force and Marine Corp, while well aware of the impact that DEP/recruiter may have on production, prefer to leave the imbalances rather than penalize those who have worked diligently to produce strong DEP positions.

Some other characterizations of the Air Force DEP management philosophy include:

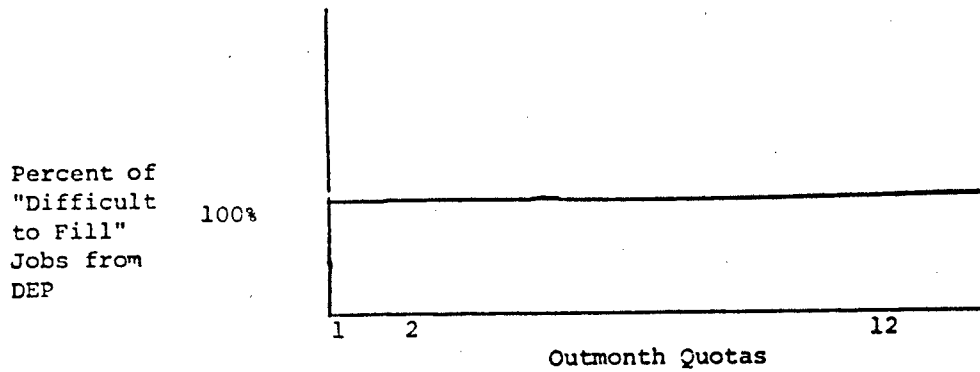
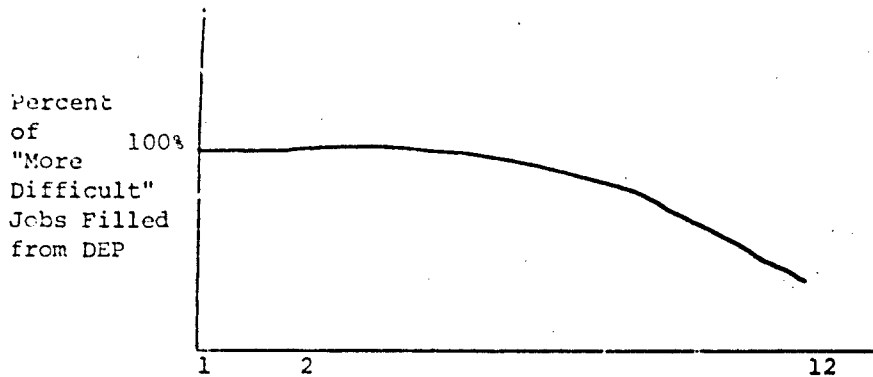
- i) a DEP target of about 36,000 men (on target as of August, 1982);
- ii) actively discouraging recruits from being in DEP for more than 4 months. Hence, their ideal DEP position can be plotted as:

Hence,

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\* Based on personal discussions with Lt. Col. Ben Varn & Bill Bennett of the Air Force Recruiting Command at Randolph Air Force Base, San Antonio, Texas.





- iv) Their present position is not one of growing DEP (as is the case with the other Services) since their DEP/recruiter positions were becoming too large to effectively manage.

In contrast the Marine Corps limits the percentage of each outmonth's accession quotas that can be in DEP to 80%, 70%, 60%, 50% for the next month out, 2 months out, etc. For more than 4 months out, the goal and maximum is 45%. This is done to maintain some slots for direct shippers and to be able to absorb reduction in the accession quotas. The Marine Corps has a FY80 accession goal for enlisted personnel of about 52,000 with a complement of about 2,175 recruiters. We observe the Marine Corps DEP philosophy is not one of "packing" the DEP, and they do allow and encourage recruits to DEP quite far out.

2.3.2 Accession Area Allocation Scheme/DEP Management Philosophy Utilized  
by the Navy's Recruiting Command<sup>1</sup>

The Navy's accession allocation scheme is motivated by a desire to reduce imbalances in the DEP per recruiter position over their six Recruiting Regions. To accomplish this, they lower the number of accessions in regions which are relatively poorer in DEP per recruiter to allow them to grow more DEP. The contract objectives are unaltered and are based strictly on the fair market share percentages from the regression models discussed in 2.1.

To illustrate their scheme, the initial DEP for the Navy at the beginning of FY83 was 39,189 with 3,137 production recruiters, yielding an initial average DEP/recruiter over the entire nation of 12.49. However when one examines<sup>2</sup> the DEP/recruiter for the six areas, one finds one region (NRA 400) at 13.7 and another (Area 700) at 10.8. Now the former Area's fair market share of all male contracts is 19.8%. However, the Navy computes its share of accessions over the year to be 20.2%, to bring down its DEP/recruiter to 13.1. On the other hand, Area 700's fair market share for contracts is 12%, whereas its assigned accession percentage is 11.5%, with the result that its DEP/recruiter at the end of the year should increase from 10.8 to 12.5. The terminal DEP position desired at the end of the year is 43,308 with a projected number of recruiters of 3,382; this yields an average DEP/recruiter at the end of the year of 12.8.

The PUMP procedure calculates the required percent of yearly accessions to be assigned to each Area so that the terminal DEP per projected recruiter for each Area is equalized. Note that this can be accomplished using the following logic:

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<sup>1</sup>Based on discussions at Navy Recruiting Command Headquarters in Arlington, VA with Commander Ralph McCumber, and David Thalman. Discussions with J.J. Miller, now at DMDC were also helpful.

<sup>2</sup>These figures come from the Navy's monthly PUMP reports (dated 9/20/82).

Let  $D_T$  = desired terminal DEP position for country as a whole at end of year

$D_0$  = initial DEP position for country as a whole

$D_{iT}$  = terminal DEP position at end of year for the  $i^{\text{th}}$  area  
( $i = 1, 2, \dots, 6$ )

$R_{i,T}$  = projected production recruiters for Area  $i$  at end of Fiscal year ( $i = 1, 2, \dots, 6$ )

$A_T$  = total number of accessions desired over year (nationwide).

Then for all areas to have equal DEP/recruiter positions at the end of the year, we desire

$$\frac{D_{iT}}{R_{i,T}} = \frac{D_T}{\sum_{j=1}^6 R_{j,T}} \quad \text{for all } i. \quad (2)$$

Hence, the terminal DEP target for area  $i$  is given by

$$D_{iT} = \frac{D_T \times R_{i,T}}{\sum_{j=1}^6 R_{j,T}} \quad (i = 1, 2, \dots, 6) \quad (3)$$

where all of the quantities on the right side are either known or management goals.

Then let  $C_i$  be the annual fair share number of contracts for the  $i^{\text{th}}$  area.<sup>1</sup> Now we claim that  $A_i$ , the total number of annual accessions from the  $i^{\text{th}}$  area is also determined. This follows since:

$$D_{iT} = D_{i0} + C_i - A_i \quad (i = 1, 2, \dots, 6) \quad (4)$$

Hence since  $C_i$  is known,  $D_{iT}$  is known from (3), and  $D_{i0}$  is observable, we can compute  $A_i$ . Hence the PUMP procedure computes the ratio of:

$$\frac{A_i}{\sum_{j=1}^6 A_j} \quad (5)$$

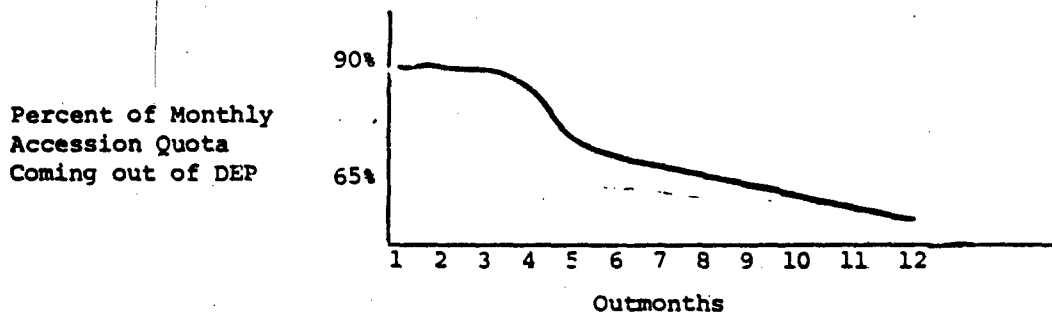
and applies this one percentage to all of the national, monthly accession goals

passed down to them by the Secretary of the Navy. In this way they arrive at monthly, area accession goals which if followed, should bring about a balance in the terminal DEP per recruiter across the six areas. The Navy repeats this exercise monthly, updating the number of recruiters, and adjusting for any observed attrition, the end goal being to bring the DEP/recruiter levels across the Areas in balance at the end of the fiscal year.

Some other important aspects of the Navy's DEP management are:

- i) They now set a max of 90%, 90%, 90%, 65% of the next four month's accession goal that can come out of DEP. This is very different from the Air Force where the goal is 100% for the next four months. The Navy feels these maximums are important to:
  - a) be able to absorb reductions in the monthly accession goals;
  - b) not enable recruiters to live off their "pipeline;"
  - c) be able to provide slots for prior service recruits who usually wish to direct ship.

Hence the Navy's curve of % DEP versus outmonths (to be compared with total of the Air Force in Section 2.3.1) is given by:



Note that it has a somewhat different shape from the Air Force's and enables recruits to DEP much further out.

<sup>1</sup> Recall the  $C_i$ 's are known since the fair market share percentages are known and that  $C_T$ , the total number of contracts over the year from the entire country satisfies (neglecting any attrition in the DEP pool) the relationship:

$$D_T = D_0 + C_T - A_T$$

Hence since  $D_T$ ,  $D_0$ , and  $A_T$  are all known,  $C_T$  is determined, and hence  $C_i$ .

- ii) Their long range DEP target is 45,000, to bring the average DEP/recruiter up to the level of about 15.

2.3.3 The Accession Area Allocation/DEP Management Philosophy Used by Army<sup>1</sup>

We have seen that the Air Force has chosen to ignore differences in the initial DEP positions of their various recruiting squadrons in assigning accession quotas, i.e., they assign the accession goals in the same proportions as the contract goals, so that imbalances in the DEP/recruiter are allowed to continue. The Navy at the other extreme, assigns accessions with an eye towards "growing" DEP in those areas where the DEP/recruiter averages are poor. They accomplish this by assigning more of the accession quotas to the areas relatively richer in DEP per recruiter.

The Army's philosophy can be thought of as a half-way house where the initial DEP positions are used to assign accessions, and where each area is allowed to grow DEP in proportion to its fair market share of contracts. Their strategy thus takes into account, not only the size of the initial DEP position for each area, but also the planned disbursement of that DEP position as to when contracts in the DEP pool will convert to accessions. This is important information which is apparently not presently used by the Navy in assigning its accession goals.

The Army's procedure for accession assignment can be summarized as follows:

Let:  $I$  = number of districts

$D_{i0}$  denote the initial DEP positions for the  $i^{\text{th}}$  area ( $i = 1, 2, \dots, I$ )  
(known constants)

$\alpha_{ij}$  ( $i = 1, 2, \dots, I; j = 1, 2, \dots, 12$ ) denote the percent of the  $i^{\text{th}}$  area's initial DEP pool that is planning to be shipped in out-month  $j$  (known constants)

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<sup>1</sup>Based on discussions at Ft. Sheridan, Illinois with Col. Falke and Major Dickson

where  $\sum_{j=1}^{12} \alpha_{ij} = 1$  for each  $i$ .

$m_i$  = fair market percentage share of contracts (male, non-prior service) for  $i^{\text{th}}$  area (developed from the Army's Enlisted Production Model, a combination of regression analysis and management inputs )

where  $\sum_{i=1}^I m_i = 1$ .

$A_{ij}$  = monthly accession goal for area  $i$ , outmonth  $j$  (decision variables)

$(RA)_j$  = required accessions from nation as a whole for outmonth  $j$  (i.e.,  $j = 1, 2, \dots, 12$  (known constants)

Then consider the accession goal for the 1st outmonth for area  $i$ , where the total monthly accession requirement (passed down by the Secretary of the Army) is  $(RA)_1$ . Then

$$\sum_{i=1}^I \alpha_{i,1} D_{i,0}$$

represents the total number of accessions already in the "bank" for the 1st outmonth, i.e., these are the accessions coming out of the DEP, planning to be shipped in the first month. If

$$\sum_{i=1}^I \alpha_{i,1} D_{i,0} \geq (RA)_1, \quad (7)$$

then no new accessions are required for the first outmonth, and in this case

$$A_{i1} = D_{i,0} \alpha_{i,1}, \text{ i.e.,}$$

the accession quotas for the 1st month for area  $i$  are just the ones coming out of DEP. Suppose however that

$$\sum_{i=1}^I \alpha_{i,1} D_{i,0} < (RA)_1, \quad (7)$$

so that more accessions are required than is in the bank. How does the Army distribute this additional need over the various districts? The Army spreads this deficit in terms of the area's fair market share of contracts, i.e., if

$A_{i1}^E$  denotes the extra accessions required from area  $i$  for the first outmonth (over and above the accessions coming out of its bank), then  $A_{i1}^E$ , as a proportion of the total deficit for the first outmonth (i.e.,

$$(RA)_1 - \sum_{j=1}^I \alpha_{j1} D_{j,0}$$

should be set at the market share percentage of contracts for area  $i$ , i.e.,  $A_{i1}^E$  satisfies the following relationship:

$$\frac{A_{i1}^E}{(RA)_1 - \sum_{j=1}^I \alpha_{j1} D_{j,0}} = m_i \quad (i = 1, 2, \dots, I) \quad (8)$$

and

$$A_{i,1} = \alpha_{i,1} D_{i,0} + A_{i,1}^E \quad (i = 1, 2, \dots, I) \quad (9)$$

i.e., each area is allowed to grow DEP in proportion to its market share of contracts,<sup>1</sup> (i.e., the larger the district's contract market share, the larger its DEP growth allowed). We observe this is quite different from the Navy's system since in the Army system it is quite possible for those areas rich in DEP/recruiter to become even richer and those areas with low DEP/recruiter to become even poorer. This can happen since a district with say a large DEP position initially but with a relatively small percentage of it to be drained off in the 1st outmonth (i.e., a small  $\alpha_{i1}$ ) is assigned additional accession based solely on its market share. This procedure does not take cognizance of the fact that its DEP per recruiter position may be getting even larger.

In comparison with the Navy's system, we observe that the Army's procedure: i) takes into account the time distribution of the initial DEP positions (which is commendable), and ii) that the area accesssion percentages of the required monthly totals vary by month (in contract to both the Air Force and

<sup>1</sup>Note that since  $D_{i,1} = D_{i,0} + C_{i,1} - A_{i,1}$ , we have  $D_{i,1} - D_{i,0}$  (the growth in DEP for  $i^{\text{th}}$  area =  $C_{i,1} - A_{i,1} = C_{i,1} - \alpha_{i,1} D_{i,0} - A_{i,1}^E = C_{i,1} - \alpha_{i,1} D_{i,0} - m_i [(RA)_1 - \sum_{j=1}^I \alpha_{j,1} D_{j,0}]$ . Also,  $C_{i,1}$  is a linear function of the fair market shar for area  $i$  (i.e.,  $m_i$ ) so it is clear that the amount of growth in DEP for area  $i$  is proportional to its fair market share.

Navy's system). It's possible weakness is that imbalances in the DEP/recruiter levels across recruiting areas can persist and in fact become exacerbated.

3.0 NUMERICAL ILLUSTRATIONS OF IMPACT OF SERVICES' ACCESSION AREA ALLOCATION/ DEP MANAGEMENT POLICIES

3.1 The Common Scenario:

Consider the following concrete scenario of a Recruiting Command with only 2 regions, i.e.,  $I = 2$  and 2 time periods (i.e.,  $J = 2$ ), chosen for ease of presentation. Suppose that initially the entire DEP position is 2,300 with 1,300 in Region 1 and 1,000 in Region 2, i.e., in the notation developed earlier  $D_{1,0} = 1,300$  and  $D_{2,0} = 1,000$ . Also suppose that management has chosen a DEP target at the end of the year (i.e., at the end of the second period) of 4,000 (i.e.,  $D_T = 4,000$ ) and that the required period accessions from the entire country is 2,000 for the 1st period, and 2,500 for the second period. i.e.,  $(RA)_1 = 2,000$ , and  $(RA)_2 = 2,500$ . Hence it is clear that a total of 6,200 new contracts (neglecting any DEP attrition) must be obtained since,  $A_T$ , the total number of yearly accessions is  $4,500 = (RA)_1 + (RA)_2$ ;

$$D_T = D_0 + C_T - A_T$$

where  $D_T = 4,000$

$$D_0 = 2,300;$$

hence  $C_T = 6,200$

Also suppose the projected level of production recruiters,  $R_{ij}$ , for each area  $i$  and period  $j$  is as follows:

Projected Level of Recruiters by Region by Period

	Region 1	Region 2
Period 1	100	100
Period 2	60	100

Then we observe that at the beginning of the year there is a severe imbalance in the initial DEP/recruiter, i.e., for Area 1 we have a DEP/recruiter level of

$$\frac{D_{1,0}}{R_{1,1}} = \frac{1,300}{100} = 13; \quad \frac{D_{2,0}}{R_{2,1}} = \frac{1,000}{100} = 10.$$

Also, suppose based on a fair market share analysis of contracts (utilizing recruiters, propensities, population, demographics), it is felt the fair share of all contracts to be obtained from Region 1 is 40% and the fair share of contracts from Region 2 is 60%, i.e.,  $m_1 = .40$ ;  $m_2 = .6$ . Suppose also, to equalize the workload over the year, management in an a priori manner sets the contract objectives  $C_{ij}$ , by period by region, as:

New Contract Objectives by Period by Region ( $C_{ij}$ )

	Region 1	Region 2	Country
Period 1	1240	1860	3100 (50%)
Period 2	1240	1860	3100 (50%)
Entire Year	2480 (40%)	3720 (60%)	6200 (100%)

Finally, suppose that the initial DEP position for Region 1 and Region 2 differ somewhat in terms of their planned disbursement, i.e., the timing as to when the recruits plan to ship. To be specific, of Region 1's initial DEP position of 1,300, 375 plan to ship in period 1 and 925 in period 2; for Region 2 initial DEP position of 1,000, 500 plan to ship in period 1 and 500 in period 2, i.e.,

DEP Flow by Region by Month from Initial DEP Position

	Region 1	Region 2	Country
Period 1	375	500	875
Period 2	925	500	1425
Entire Year	1300	1000	2300

In the notation developed earlier this implies:

$$\alpha_{1,1} = .25, \alpha_{1,2} = .75$$

$$\alpha_{2,1} = .5, \alpha_{2,2} = .5$$

where the first index refers to the area, and the second index to the period. Finally, suppose there are no ceilings as to the maximum amounts that can come out of DEP for the outmonths. (We note that the Navy and Marine Corps do incorporate such ceilings to insure sufficient slots are available for direct shippers).

The key question to be addressed is, "How should the accession quotas be assigned to each Region in each period?" i.e., how should decision variables  $A_{ij}$  = number of accessions required of Region  $i$ , in the  $j^{\text{th}}$  period be set so that:

$$A_{1,1} + A_{2,1} = (RA)_1 = 2,000 \text{ (required accessions for period 1 from country)}$$

$$A_{1,2} + A_{2,2} = (RA)_2 = 2,500 \text{ (required accessions for period 2 from country).}$$

Note that these decisions, together with the initial DEP position, its disposition over time, and the exogeneous contract flow will determine the respective DEP positions by region, by period at the end of the year, and also the DEP/

recruiter levels resulting at various points throughout the year.

3.2 The Results of Air Force and Marine Corps DEP Management Policy for the Common Scenario

Consider first the Air Force's approach to the setting of  $A_{ij}$ 's. They would simply rely on the fair market percentages, i.e.,  $m_1 = 40\%$ ,  $m_2 = 60\%$ , and would goal each Region's accession level based essentially on this only. Hence, in period 1, if 2,000 accessions are needed from the country in total, Region 1 would be assigned an accession goal for the 1st period of  $.40(2,000) = 800$ , i.e.,

$$A_{1,1} = 800$$

$$A_{2,1} = 1,200$$

In the same manner  $A_{1,2} = .4(RA)_2 = .4(2,500) = 1,000$

$$A_{2,2} = .6(RA)_2 = .6(2,500) = 1,500$$

Now consider the consequences on DEP of this accession allocation policy.

Let  $D_{ij}$  = DEP position for Region  $i$ , at the end of period  $j$ , ( $j = 0, 1, 2$ ) so that  $D_{i,0}$  is the DEP position at the beginning of the year (i.e., the beginning of the 1st period) and  $D_{i,2}$  is the DEP position at the end of the year for the  $i^{th}$  region. Then:

$$D_{i,1} = D_{i,0} + C_{i,1} - A_{i,1} \tag{10}$$

i.e., the DEP position for region  $i$ , at the end of the 1st period is the DEP level at beginning of the first period plus any new contracts signed less any shipments in the first period. Note the DEP position at the end of the 1st period in Region  $i$  can also be thought of as the portion of the initial DEP left at the end of the 1st period, plus any new contracts less any extra accession required of region  $i$  in the 1st period (over and above those from the initial DEP). Similarly (neglecting any DEP attrition),

$$D_{i,2} = D_{i,0} + C_{i,1} + C_{i,2} - A_{i,1} - A_{i,2} \tag{11}$$

Therefore the Air Force accession policy of  $A_{11} = 800$ ,  $A_{21} = 1,200$ ,  $A_{1,2} = 1,000$ ,  $A_{22} = 1,500$ , together with the contract flow specified in 3.1, yields:

$$D_{1,1} = D_{i,0} + C_{i,1} - A_{i,1} = 1,300 + 1,240 - 800 = 1,740$$

$$\begin{aligned} \text{Similarly } D_{1,2} &= D_{i,0} + C_{i,1} + C_{i,2} - A_{i,1} - A_{i,2} \\ &= 1,300 + 1,240 + 1,240 - 800 - 1,000 = 1,980 \end{aligned}$$

In a similar manner:

$$D_{2,1} = 1,660; D_{2,2} = 2,020$$

Consider now the wide variation in DEP/recruiter resulting throughout the year, i.e.,

$$\frac{D_{ij}}{R_{i,j}} \quad (j = 0, 1, 2).$$

DEP/Recruiter Levels by Region by Period

	Region 1	Region 2	Country
Initially	13	10	$\frac{2300}{200} = 11.5$
End of Period One	$\frac{1740}{100} = 17.4$	$\frac{1660}{100} = 16.6$	$\frac{3400}{200} = 17$
End of Period Two (End of Year)	$\frac{1980}{60} = 33$	$\frac{2020}{100} = 20.2$	$\frac{4000}{160} = 25$

Note that the end of the year the relative DEP/recruiter levels are even more imbalanced than initially. Also note that, over and above the accessions coming out of the DEP "bank," the extra accessions required each period vary drastically, i.e.,

$$A_{1,1}^E = A_{1,1} - \alpha_{1,1} D_{1,0} = 800 - .25(1,300) = 475$$

$$A_{1,2}^E = A_{1,2} - \alpha_{1,2} D_{1,0} = 1,000 - .75(1,300) = 25$$

$$A_{2,1}^E = A_{2,1} - \alpha_{2,1} D_{2,0} = 1,200 - .5(1,000) = 700$$

$$A_{2,2}^E = A_{2,2} - \alpha_{2,2} D_{2,0} = 1,500 - .5(1,000) = 1,000$$

3.3 The Results of Navy DEP Management Policy for the Common Scenario

Consider next the implications of the Navy's accession allocation policy for the same scenario. The Navy's PUMP philosophy is geared towards equalizing the DEP position per recruiter resulting at the end of the year. Given the scenario's 4,000 target DEP position at the end of the second period for the entire country and the nation's 160 projected recruiters, this yields a target DEP per recruiter in each region of 25. Given the number of recruiters projected for Region 1 and Region 2, this in turn implies a terminal DEP position of 1,500 for Region 1, i.e.,  $D_{1,2} = 1,500$  and 2,500 for Region 2, i.e.,  $D_{2,2} = 2,500$ . Then since

$$1,500 = D_{1,2} = D_{1,0} + C_{1,1} + C_{1,2} - A_{1,1} - A_{1,2} = 1,300 + 1,240 + 1,240 - A_{1,1} - A_{1,2} \quad (12)$$

we have  $A_{1,1} + A_{1,2} = 2,280$ .

Given a total annual requirement of 4,500 accessions for the country, this implies that  $2,280/4,500$  or 50.67% of the total yearly accessions should come from Region 1. Hence, using the PUMP procedure, the percent of period 1's total accessions that should come from Region 1 then would be 50.67%. Hence,

$$A_{1,1} = (.5067)(RA)_1 = .5067(2,000) = 1,013$$

Likewise  $A_{2,1} = (RA)_1 - A_{1,1} = 2,000 - 1,013 = 987;$

$$A_{1,2} = .5067(RA)_2 = .5067(2,500) = 1,267, \text{ and;}$$

$$A_{2,2} = (RA)_2 - A_{1,2} = 2,500 - 1,266 = 1,233.$$

Note that the results of this accession allocation policy is indeed that the terminal DEP positions/recruiter are the same, i.e.,

$$\begin{aligned} D_{1,2} &= D_{1,0} + C_{1,1} + C_{1,2} - A_{1,1} - A_{1,2} \\ &= 1,300 + 1,240 + 1,240 - 1,013 - 1,267 = 1,500, \end{aligned}$$

with  $\frac{D_{1,2}}{R_{1,2}} = \frac{1,500}{60} = 25$ , and

$$\begin{aligned} D_{2,2} &= D_{2,0} + C_{2,1} + C_{2,2} - A_{2,1} - A_{2,2} \\ &= 1,000 + 1,860 + 1,860 - 987 - 1,233 = 2,500, \end{aligned}$$

with  $\frac{D_{2,2}}{R_{2,2}} = \frac{2,500}{100} = 25$ .

Hence the terminal DEP is at 4,000 as advertised and the DEP per recruiter levels at the end of the year are both equal. Hence the imbalance associated with the 13 and 10 initial DEP positions per recruiter for Regions 1 and 2 have been removed by the end of the year. However, we also observe that these imbalances were not removed until the end of the second period, i.e., at the end of the first period, the DEP positions for Region 1 and Region 2 were respectively:

$$\begin{aligned} D_{1,1} &= D_{1,0} + C_{1,1} - A_{1,1} \\ &= 1,300 + 1,240 - 1,013 \\ &= 1,527, \end{aligned}$$

with  $\frac{D_{1,1}}{R_{1,1}} = \frac{1,527}{100} = 15.27$

On the other hand  $D_{2,1} = D_{2,0} + C_{2,1} - A_{2,1}$   
 $= 1,000 + 1,860 - 987$   
 $= 1,873,$

with  $\frac{D_{2,1}}{R_{2,1}} = \frac{1,873}{100} = 18.73$

Hence the imbalance in DEP/recruiter, using the PUMP procedure, was allowed to persist until the end of the year. This is due to the fact that the PUMP mechanism: 1) ignores the planned disbursement of the initial DEP, i.e., the rates at which the contracts in the initial DEP pool will convert to accessions; and

2) the PUMP procedure utilizes the same percentage rate for each month for each region's share of the national monthly accession quota. A more dynamic procedure for assigning accessions which alleviates these weaknesses and attempts to prevent DEP/recruiter imbalances from occurring throughout the year is given in Section 4.

Before leaving the PUMP analysis, we see that the implications of the PUMP regional accession allocation policy is:

$$A_{1,1}^E = A_{1,1} - \alpha_{1,1} D_{1,0} = 1,013 - 325 = 688$$

$$A_{1,2}^E = A_{1,2} - \alpha_{1,2} D_{1,0} = 1,267 - 975 = 292$$

$$A_{2,1}^E = A_{2,1} - \alpha_{2,1} D_{2,0} = 987 - 500 = 487$$

$$A_{2,2}^E = A_{2,2} - \alpha_{2,2} D_{2,0} = 1,233 - 500 = 733$$

where the superscript E presents the extra accessions required from each region for each period, over and above those in the "bank," i.e. those automatically coming from the initial DEP position.

### 3.4 The Results of Using Army Accessions Policy for the Common Scenario

We recall that the Army utilizes the timing distribution of the initial DEP positions, unlike the Air Force and Navy, in assigning accessions. However, in a manner similar to the Air Force, they use the fair market share percentages developed for contracts, to spread the extra accessions needed.

To illustrate, consider the development of  $A_{1,1}$  using the Army's logic:

a) For the first period, there is a total accession goal across the country of  $(RA)_1 = 2,000$ .

b) Of this amount, the amounts coming out of the initial DEP, is

$$\begin{aligned} & \alpha_{1,1} D_{1,0} + \alpha_{2,1} D_{2,0} \\ & = 325 + 500 \\ & = 825 \end{aligned}$$

Hence a total of 1,175 extra accessions must be obtained from Region 1 and Region 2 in the first period.

- c) The allocation method for these additional accessions is to spread then according to the fair market percentages developed for contracts, i.e.,

$$\frac{A_{1,1}^E}{(RA)_1 - \alpha_{1,1}^D D_{1,0} - \alpha_{2,1}^D D_{2,0}} = m_1$$

or 
$$\frac{A_{1,1}^E}{1,175} = .4 \Rightarrow A_{1,1}^E = 470$$

There 
$$A_{1,1} = A_{1,1}^E + \alpha_{1,1}^D D_{1,0} = 470 + 325 = 795$$

Hence we have 
$$A_{2,1} = (RA)_1 - A_{1,1} = 2,000 - 795 = 1,205;$$

$$A_{2,1}^E = A_{2,1} - \alpha_{2,1}^D D_{2,0} = 1,205 - 500 = 705.$$

In a similar fashion, since

$$(RA)_2 = 2,500 \text{ and}$$

$$\alpha_{1,2}^D D_{1,0} + \alpha_{2,2}^D D_{2,0} = 975 + 500 = 1,475,$$

a total of 1,025 additional accessions are required for period 2. Hence

$$\frac{A_{1,2}^E}{1,025} = m_1 = .4 \Rightarrow A_{1,2}^E = 410 \Rightarrow A_{1,2} = A_{1,2}^E + \alpha_{1,2}^D D_{1,0} = 410 + 975 = 1,385$$

Therefore 
$$\begin{aligned} A_{2,2} &= (RA)_2 - A_{1,2} \\ &= 2,500 - 1,385 \\ &= 1,115, \end{aligned}$$

and 
$$\begin{aligned} A_{2,2}^E &= A_{2,2} - \alpha_{2,2}^D D_{2,0} \\ &= 1,115 - 500 \\ &= 615. \end{aligned}$$

Hence we see that the Army policy yields for the various DEP positions:

$$\begin{aligned} D_{1,1} &= D_{1,0} + C_{1,1} - A_{1,1} \\ &= 1,300 + 1,240 - 795 \\ &= 1,745, \end{aligned}$$

with  $\frac{D_{1,1}}{R_{1,1}} = 17.45;$

$$\begin{aligned} D_{1,2} &= D_{1,0} + C_{1,1} + C_{1,2} - A_{1,1} - A_{1,2} \\ &= 1,300 + 1,240 + 1,240 - 795 - 1,385 \\ &= 1,600, \end{aligned}$$

with  $\frac{D_{1,2}}{R_{1,2}} = \frac{1,600}{60} = 26.67;$

$$\begin{aligned} D_{2,1} &= D_{2,0} + C_{2,1} - A_{2,1} \\ &= 1,300 + 1,860 - 1,205 \\ &= 1,655, \end{aligned}$$

with  $\frac{D_{2,1}}{R_{2,1}} = 16.55;$

and 
$$\begin{aligned} D_{2,2} &= D_{2,0} + C_{2,1} + C_{2,2} - A_{2,1} - A_{2,2} \\ &= 2,300 + 1,860 + 1,860 - 1,205 - 1,115 \\ &= 2,400 \end{aligned}$$

with  $\frac{D_{2,2}}{R_{2,2}} = 24.$

Hence we see that the terminal DEP/recruiter positions are somewhat out of balance at the levels of 26.67 and 24.

### 3.5 Overall Comparison of Different Outcomes from Using Different DEP Management Policies

As a summary comparison, we present Table 1. From an inspection of this table, we observe there are large differences in the impacts of the Services' accession allocation policies. As an example, Region 2's accession level ranges from a high of 60% (Air Force) to a low of 49.33% (Navy) with the Army at 51.56% of the national requirement. Note that the Air Force's is based strictly on the fair contract share of 60% for Region 2, whereas the Navy, in attempting to bring up Region 2's DEP/recruiter, lowers the accession percentage the most. If we look at the DEP/recruiter positions by region, at the end of the year, we can see they are the same for the Navy, very different for the Air Force (at 33 and 20.2) and reasonably close for the Army (at 26.67 and 24).

This numerical section then underscores the fact that the Services' various DEP management policies can produce quite different outcomes and impact differently on issues of productivity and equity. The next Section presents a DEP management model which has the same general philosophy as the Navy's PUMP system but which is more dynamic and removes the relatively minor weaknesses of the Navy's innovative system.

## 4.0 AN OPTIMIZATION MODEL TO BETTER ACHIEVE THE NAVY'S "PUMP" PROGRAM OBJECTIVES

### 4.1 Motivation for an Improved Model

We have earlier seen that the Navy's management of their DEP position is geared towards removing imbalances in the DEP/recruiter positions across their six Regions, a very commendable goal. The PUMP program accomplishes this by its allocation of accessions to its various regions, the thrust being to lower a Region's accession share below its fair contract share if it is poor in DEP/recruiter, and to put more of the accession burden on those regions relatively rich in DEP per recruiter. This is done in the spirit that DEP per recruiter

TABLE 1

COMPARISON OF OUTCOMES USING AIR FORCE, NAVY AND ARMY  
DEP MANAGEMENT/ACCESSION ALLOCATION POLICIES ON SAME SCENARIO

	<u>Air Force</u>	<u>Navy</u>	<u>Army</u>
<u>INITIAL CONDITIONS</u>			
Initial DEP Position:			
Region 1	1300	1300	1300
Region 2	1000	1000	1000
Total	2300	2300	2300
Initial DEP/Recruiter:			
Region 1	13	13	13
Region 2	10	10	10
Fair Market Share for Contracts:			
Region 1	.4	.4	.4
Region 2	.6	.6	.6
Contract Flow:			
Region 1	6200	6200	6200
Period 1	1240	1240	1240
Period 2	1240	1240	1240
Region 2	1860	1860	1860
Period 1	1860	1860	1860
Period 2	1860	1860	1860
<u>OUTCOMES</u>			
Accession Flow (Total)			
Region 1 (Total)	1820 (40%)	2280 (50.67%)	2180 (48.44%)
Period 1	800	1013	795
Period 2	1000	1267	1385
Region 2 (Total)	2700 (60%)	2220 (49.33%)	2320 (51.56%)
Period 1	1200	987	1205
Period 2	1500	1233	1115
DEP Positions:			
Region 1	1740	1527	1745
Period 1	1980	1500	1600
Period 2			
Region 2	1660	1873	1655
Period 1	2020	2500	2400
Period 2			
Total DEP Sizes at End of Year (End of Period 2)			
	4000	4000	4000
DEP/Recruiter:			
Region 1	17.4	15.27	17.45
Period 1	33.0	25.00	26.67
Period 2			
Region 2	16.6	18.73	16.55
Period 1	20.2	25.00	24.00
Period 2			
Additional Accessions Required (Over & Above those from Initial DEP)			
Region 1 (Total)	2200	2200	2200
Period 1	500	980	280
Period 2	(22.7%) 475	(44.5%) 688	(40%) 470
Period 2	25	292	410
Region 2	1860	1860	1860
Period 1	1860	1860	1860
Period 2			

is a scarce resource, much akin to advertising dollars, recruiter aids, etc., that needs to be allocated in a more equitable manner to improve the overall productivity of the entire operation.

The PUMP procedure is to compute the required percent of all accessions throughout the year that should come from each region so that at the end of the year the DEP per recruiter positions will be equalized. This key percentage then is used to develop all of the regional, monthly accession quotas. The consequences of the process is that, while the DEP per recruiter positions will be equalized by the end of the year, severe imbalances could persist prior to that time. What is needed is a more dynamic mechanism which can achieve the same goal as the present PUMP program, but which can also equalize the DEP per recruiter levels throughout the year as well.

In order to accomplish the above, not only will the initial DEP positions for each region be utilized, but also the planned disbursement of that initial DEP, i.e., its planned conversions to shipments over time. The model proposed utilizes so-called "goal programming" techniques which can be solved using any linear programming code. Its features are that it can accommodate management's priorities regarding the relative criticalities of equalizing the DEP/recruiter positions over time. For example, the highest priority might be at the end of the year, the second highest priority may be at midyear, the third highest at the 1st quarter of the year, etc. A numerical example comparing the outcomes from exercising of the optimization model with that of the Navy's present PUMP process on the Scenario in Section 3.1 follows. Section 4.3 contains the formal goal programming model.

#### 4.2 Numerical Comparison of Outcomes Using Goal Programming Approach PUMP Process on Same Scenario

Before presenting the formal model, it may be insightful to compare the numerical impacts for the Scenario in 3.1, of utilizing the optimization approach versus that of the PUMP process. These results are shown in Table 2, based

TABLE 2  
COMPARISON OF OUTCOMES FROM OPTIMIZATION MODEL  
WITH THAT OF PUMP PROCEDURE ON SAME SCENARIO

	<u>PUMP</u>	<u>OPTIMAL</u>
<u>ACCESSION FLOW (Total)</u>	4500	4500
Region 1 (Total)	2280 (50.67%)	2000 (44.44%)
Period 1	1013 (50.67%)*	840 (42%)*
Period 2	1267 (50.67%)*	1440 (57.6%)*
Region 2 (Total)	2220 (49.33%)	2500 (55.56%)
Period 1	987 (49.33%)*	1160 (58%)*
Period 2	1233 (49.33%)*	1060 (42.4%)*
 <u>DEP POSITIONS</u>		
Region 1		
Period 1	1527	1700
Period 2	1500	1500
Region 2		
Period 1	1873	1700
Period 2	2500	2500
Total DEP at End of Year	4000	4000
 <u>DEP/RECRUITER LEVEL</u>		
Region 1		
Period 1	15.27	17
Period 2	25.00	25
Region 2		
Period 1	18.73	17
Period 2	25.00	25

\* Percent of period, national requirement.

on the scenario and assumptions utilized in Section 3.1. The Navy's PUMP results have been reproduced to facilitate the comparison.

Upon inspection of Table 2, we recall that the PUMP process yielded a Region 1 accession share of 50.67% (compared to a fair market contract share of 40%) and a 49.33% accession share for Region 2 (with a fair contract market share of 60%.) Note that these percentages are used in all periods in the PUMP logic. This is in contrast to the LP approach where the period percentages vary substantially. Also note that the LP solution equalizes the DEP per recruiter positions in both periods, not only at the end of the year as did the PUMP logic. Note that the PUMP procedure leaves an imbalance of 15.27 versus 18.73 for the DEP/recruiter positions for Region 1 and Region 2 at the end of the first period, whereas LP procedure balances this at 17 for both Regions. It accomplishes this by varying the accession percentages required from each Region over the different periods. This is in contrast to the PUMP procedure that utilizes one fixed percentage for all months, and does not take into account any differences in the rates of flow of the initial DEP position into shipments.

#### 4.3 The Goal Programming Model to Achieve the Objectives of PUMP

The formulation, utilizing what is known as a goal programming model\* (which is in turn a linear program) follows:

##### 4.3.1 Notation

Let  $D_{i,0}$  denote the initial DEP positions for region  $i$  at the beginning of the year ( $i = 1, 2, \dots, 6$ ). (Hence  $\sum_i D_{i,0}$  equals the total initial DEP position at the beginning of the year).

$(RA)_j$  = the required number of national accessions in month  $j$   
( $j = 1, 2, \dots, 12$ ).

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\* See for example Charnes and Cooper, Management Models and Industrial Applications of Linear Programming, John Wiley & Sons, 1961.

$C_{ij}$  = the exogeneously specified contract flow from Region  $i$ , month  $j$  ( $i = 1, \dots, 6; j = 1, 2, \dots, 12$ ). These are based on the fair share percentages for each region, as well as seasonal patterns for contracts.

$D_T$  = the national size of the DEP position required at the end of the year.

$\alpha_{ij}$  = percent of the  $i^{\text{th}}$  region's initial DEP position that will convert to a shipment in outmonth  $j$  where

$$\sum_{j=1}^{12} \alpha_{ij} = 1^1.$$

$R_{ij}$  = projected number of production recruiters in field for Region  $i$ , month  $j$  ( $i = 1, \dots, 6; j = 1, 2, \dots, 12$ ).

We observe that the above are all known quantities or are management inputs into the present regional accession allocation scheme. Consider now the decision variables, i.e.,

$A_{ij}$  = the number of accessions assigned to the  $i^{\text{th}}$  region,  $j^{\text{th}}$  month ( $i = 1, \dots, 6; j = 1, 2, \dots, 12$ ).

$D_{ij}$  = the size of the DEP pool for Region  $i$ , at the end of month  $j$  ( $i = 1, 2, \dots, 6; j = 1, 2, \dots, 12$ ).

#### 4.3.2 Constraints in the Goal Programming Formulation

Hence the above represents a total of 144 decision variables, i.e., 72 accession regional-monthly quotas and 72 regional-monthly DEP positions. Consider the constraints in turn; namely:

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<sup>1</sup>We are ignoring for the moment any attrition in the DEP pool, a factor which can be easily accommodated by simply setting

$$\sum_{j=1}^{12} \alpha_{ij} = 1 - A_i$$

where  $A_i$  is the attrition factor for Region  $i$ . We have chosen  $A_i = 0$  since it is presently ignored in the PUMP calculations.

$$\sum_{i=1}^6 D_{i,12} = D_T \quad (12)$$

(i.e., the national DEP target at the end of the year, i.e., at the end of month 12, must be satisfied).

$$\sum_{i=1}^6 A_{ij} = (RA)_j \quad (j = 1, 2, \dots, 12) \quad (13)$$

(i.e., the monthly, national accession quotas must be met),

$$D_{i,j} = D_{i,0} + \sum_{k < j} C_{i,k} - \sum_{k < j} A_{i,k} \quad (14)$$

(i = 1, 2, ..., 6; j = 1, 2, ..., 12)

monthly district balance equations which state that the DEP position at the end of month j for Region i is equal to the Region's initial DEP position plus the total of any contracts obtained prior to and including the j<sup>th</sup> month, less the total of any accessions up through the j<sup>th</sup> month;

The Navy also has ceilings on the maximum percents of the various out-month's accession quotas that can be banked at any given time. For the Navy these ceilings are 90%, 90%, 90%, and 65% for the next four outmonths, e.g., no more than 90% of next month's accession quotas can now be in the DEP bank, planning to be shipped next month. These constraints can also straightforwardly be included, but one must also estimate the fraction of each month's contracts that will ship in the various outmonths, i.e.,  $B_{i,j,q}$  = percent of contracts signed in month j, from area i, that plan to ship q months later where  $\sum_{q=0}^{12} B_{i,j,q}$  equals 1 (except for attrition). With these  $\{B_{i,j,q}\}$  estimated (based on historical data) consider the constraint which captures the 90% for the first outmonth, e.g., the percent of November's accessions (for a given Area) that can be in the DEP bank at the end of October, waiting to be shipped sometime in November must be no higher than 90%. This is accomplished by noting that the total number of contracts in the DEP pool at the end of October, which plan to ship in November, is given by:

(The number of contracts in the DEP pool at the beginning of year)

X

(fraction of contracts in DEP at beginning of year which plan to ship 2 months later)

+

(fraction of contracts signed in October which plan to ship 1 month later)

Hence the above constraint is satisfied by imposing the constraint that the ratio of the above quantity and the area's accession quota for November is less than or equal to .90, i.e., in the notation developed earlier,

$$\frac{D_{i,0}^{\alpha_{i,2}} + C_{i,1} B_{i,1,1}}{A_{i,2}} \leq .9 \quad (15)$$

where  $A_{i,2}$  is the only decision variable in (15), since  $D_{i,0}$  is known beforehand, and  $C_{i,1}$  is determined from the fair market share consideration.

The ceiling constraint for the second outmonth is similarly represented by:

$$\frac{D_{i,0}^{\alpha_{i,3}} + C_{i,1} B_{i,1,2} + C_{i,2} B_{i,2,1}}{A_{i,3}} \leq .9$$

i.e., the shipments coming the initial DEP plus those coming from contracts signed in October plus those coming from contracts signed in November must be less than .90 x the accession quota in December. If there are no explicit ceilings, the right hand side of constraint (15) will be unity which captures the constraint that we do not wish to overship, at least for the nation as a whole.

#### 4.3.3 The Objective Function

Consider the objective of the optimized DEP management policy, i.e., to eliminate imbalances in the DEP per recruiter positions across the different regions for each time period, that is, we desire to allocate accessions so that, if possible,

$$\frac{D_{ij}}{R_{ij}} = \frac{D_{kj}}{R_{kj}} \text{ for all } i \neq k \text{ for each } j \quad (16)$$

However, it is recognized this may or may not be achievable due to the exogeneously specified contract flow, the initial DEP position, etc. To see if it is indeed possible to eliminate all regional imbalances throughout the year, consider the addition to the LP of decision variables,  $d_{ikj}^-$  and  $d_{ikj}^+$  for  $i \neq k$ , and  $j = 1, 2, \dots, 12$  and the additional constraints:

$$\frac{D_{i,j}}{R_{i,j}} + d_{i,k,j}^- - d_{i,k,j}^+ = \frac{D_{k,j}}{R_{k,j}} \quad (i \neq k; j = 1, 2, \dots, 12) \quad (17)$$

Hence the  $d_{i,k,j}^-$ ,  $d_{i,k,j}^+$  represent so called "deviational" variables used in goal programming formulations where  $d_{i,k,j}^-$  represents the amount by which the DEP per recruiter for Region  $i$ , month  $j$  may be less than that for Region  $k$ , month  $j$ ; similarly  $d_{i,k,j}^+$  represents the amount by which the DEP per recruiter for month  $j$ , Region  $i$  may actually exceed that for Region  $k$ , month  $j$ .

Then imbalances can be addressed by considering the objective function:

$$\text{Minimize } \left\{ \sum_{j=1}^{12} \sum_{i \neq k} (d_{ikj}^- + d_{ijk}^+) \right\}. \quad (18)$$

Only if the optimal value of (18) is zero can all imbalances in the DEP/recruiter levels across the regions be eliminated. If not, then all imbalances cannot be eliminated simultaneously, and those  $d_{ikj}^-$  or  $d_{ijk}^+$  that are positive in the optimal solution will mark those regions and time periods where imbalances will still remain and can not be further eliminated.

It should be remarked that (18) considers each time period and each region equally important in eliminating imbalances. Suppose however that elimination of imbalances may be perceived by management to be most important for the 12<sup>th</sup> month, next most important for the 11<sup>th</sup> month, ..., and least important for the 1st month (or alternatively more important for the 1st month, next most important for the second month, ..., and least important for the 12<sup>th</sup> month).

If this type of so called lexicographic ordering can be specified, then the objective function in (18) can be easily modified by simply weighting the deviational variables in (18) differently so that the most critical time periods receive the most weight. Indeed, e.g., if one makes the weights on the 12<sup>th</sup> time period much larger than those of the other time periods, the model will first insure that all imbalances are eliminated by the end of the year (as PUMP does currently): only then will it strive to eliminate or reduce other imbalances throughout the year.

In the numerical example of 4.2, it is observed that all imbalances could be eliminated simultaneously, i.e., the optimal value of (18) was zero. In practice the PUMP computation are currently rerun every month with updated information, with the accession levels being updated to best insure that the imbalances are eliminated by the end of the year. If the above optimization were run in its place every month, the weights on the deviational variables could be selected, e.g., to give highest priority to the upcoming period, secondary priority to the terminal position and tertiary priority to the other periods. In this way the Recruiting Command would be allocating accessions so as to reduce any imbalances as quickly as possible and thereby increase the overall productivity of the entire operations as soon as possible.

5.0 SUMMARY

SUMMARY OF SERVICES' DEP MANAGEMENT POLICIES

Aspect	Air Force	Navy	Army	Marine Corps
1) Contract Allocation Policy	Market Share model; utilizes linear regression model with only 5 independent variables; unemployment rate, High School seniors, wages, total number of military bases in area and percent of High School senior population that is college bound. The number of recruiters is not used. The monthly allocation is uniform across the year.	Validated market share model which captures diminishing returns. Utilizes level of recruiters and important demographics. Past seasonal patterns used to determine monthly quotas.	Market share model; utilizes separate linear models for each Region and type of recruit with many overrides utilized. Monthly quotas based on seasonal variation.	Market share based on demographics and population.
2) Area Accession Allocation Philosophy	Based solely on area's fair share of contracts. Recognizes that DEP/recruiter levels vary, but feels inequitable to penalize areas who have built up strong DEP levels. Ignores differences in area's initial DEP positions and its deisbursement rates. Level loads accessions over year.	Geared towards reducing imbalances in DEP/recruiter levels. Allocates more of accessions goals to areas relatively well off in DEP/recruiter to allow areas poor in DEP to "grow" DEP. Takes into account differences in an area's initial DEP positions but not differences in its deisbursement rates.	Takes into account differences in initial DEP levels and its disbursement rates. Utilizes fair market share of contracts to spread any additional accession needed. DEP is allowed to grow in proportion to contract market share.	Similar to Air Force philosophy. Not willing to let districts underperforming off the hook by reducing accession quotas. Limits outmonth ceilings for percent of accession quota that can be banked to 80%, 70%, 60%, & 50%. Utilizes terminal DEP targets of 45% for each district. Allows DEP to be at 45% level for up to year out.
3) DEP Constraints and Goals	Discourage any recruit deping more than 4 months out (except for summer). Pack in DEP and aim for 100% in DEP of next 4 months accessions. Highly geared to filling difficult type job seats. Goal is about 36K.	Limits percentage of area's accession goal that can come out of DEP to retain flexibility and motivate recruiters; Navy DEP's recruits throughout entire year. Long range DEP goal of 45K.	Packs in DEP at 4 month level plus builds "hump" for summer months.	

KEY FEATURES

	<u>Air Force</u>	<u>Navy</u>	<u>Army</u>	<u>Marine Corps</u>
<u>Contract Market Share Equation</u>				
1) Captures Diminishing Return		X	In process	
2) Validated		X		
3) Includes Recruiting Resources Allocated to Each Area		X	X	
4) Different Equation for Different Areas		In process	X	
5) Different Equation for Different Categories of Recruits		X	X	X
6) Utilizes Seasonal Pattern in Monthly Goal Setting		X	X	
7) Relies Heavily on Management Override			X	
<u>Regional Accession Allocation Philosophy</u>				
1) Views DEP/Recruiter as a Resource to be Allocated		X		
2) Relies Heavily on Contract Market Share	X		X	X
3) Takes into Account Differences in Initial DEP Levels Across Different Areas		X	X	
4) Takes into Account Differences in Disbursement Rate of Initial DEP			X	
5) Mechanized		X	In process	
<u>DEP Constraints and Goals</u>				
1) "Pack" DEP	X		X	
2) Max Limits on Percentages that Can DEP in Near Outmonths		X		X
3) Geared to Filling Difficult Job Seats	X			

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