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ON-LINE VEHICLE MAINTENANCE DATA MANAGEMENT: PROTOTYPE DEVELOPMENT PLANNING

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This technical report has been reviewed and is approved for publication.

ALPHONSO J. OBUCHOWSKI, JR., CAPT
Project Engineer

PETER R. VECKERY, GS-14
Project Officer

FRANK J. EMMA, Colonel, USAF
Director, Information Systems
Technology Applications Office
Deputy for Command and Management Systems

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Air Force vehicle maintenance data management is supported by the Vehicle Integrated Management System (VIMS), a standard base-level batch data system. Functions which could profit from on-line access to VIMS were identified and incorporated into an on-line system model in the Data Handling Applications Center. Teams of vehicle maintenance specialists were brought to the Center to evaluate the model. Their comments,

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together with the model specification, form a requirements and design base for an operational prototype system.

Volume II presents the model specification and test results, Volume III documents model software and data base, Volume IV presents prototype development guidelines, and Volume I summarizes these same topics.

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GLOSSARY

AFDSDC	- Air Force Data System Design Center, Gunter AFS AL 36114
AFOLDS	- Air Force On-line Data System, a generalized data management system operating on the Burroughs B3500
BASE-TOP	- Base Automated Systems for Total Operations
BLADPE	- Base-Level Automatic Data Processing Equipment (ADPE)
CAPS	- Configuration Analysis and Projection System (CAPS), used to prepare configuration management reports (future hardware and software impacts) for each base-level data processing installation, prepared by AFDSDC's Operations Research Division.
COPARS	- Contractor operated parts store supporting the vehicle maintenance function at base-level
DAR-DPD-DPP	- Composite document which performs the functions of the data automation requirement, data project directive, and data project plan
DMS	- Data Management System: a series of file management software modules
DPI	- Data Processing Installation
DTH	- Direct Time Hours: that fraction of B3500 operating time directly chargeable to functional data systems based on execution time of functional software and time expended by the B3500 operating system in direct support of functional data systems.
FEP	- Front-end Processor: a small communications processor associated with a host computer
MACARMS	- Military Airlift Command Aircrew Resource Management System
MB	- Megabytes, or millions of bytes of data storage capacity
MMICS	- Maintenance Management Information and Control System

GLOSSARY (Concluded)

OLV3500 - Proposed implementation of on-line VIMS to operate solely on the B3500

OLVDED - Proposed implementation of on-line VIMS to operate solely on a dedicated minicomputer

OLVHYB - Proposed implementation of on-line VIMS to operate on a hybrid configuration including the B3500 and an FEP minicomputer

OLVP - On-line VIMS Prototype System

OUH - Operational Use Hour: for any given B3500 operating hour, the sum of direct (DTH) and prorated time (PTH) accumulated during the hour

PTH - Prorated Time Hour: that fraction of B3500 operating time (charged on a prorata basis to functional systems) during which the B3500 operating system is essentially idle, providing no direct processing support to functional systems

R&A - Reports and Analysis: a work center supporting the base-level vehicle maintenance function

SADPR-85 - Support of Air Force Automatic Data Processing Requirements through the 1980's (Technical Report, Electronics Systems Division, AF Systems Command, L. G. Hanscom Field, June 1974)

STALOG - System to Automate Logistics at the Base Level

WAM - Workload Analysis Model: a regression analysis model for prediction and measurement of computer utilization employed by AFDSDC's Operations Research Division

SECTION I

INTRODUCTION

This volume of ESD-TR-75-301 describes the findings of an on-line VIMS prototype (OLVP) development study. As discussed here, the "prototype" system is assumed to be the first operational version installed in the field, the forerunner of more than 100 similar installations (same equipment, similar software). The material presented identifies and clarifies some development issues and should, therefore, provide help to VIMS planners in their decision whether or not to move ahead with a prototype, and how to proceed if prototype development is undertaken.

Fortunately, VIMS functions today as a working data system operating on the Burroughs B3500 in batch mode. This circumstance, combined with others, provides a set of practical constraints which permit escape from a universe of unlimited development choices. Major factors are:

- The strong risks incurred in totally abandoning the B3500 as the currently successful processor of VIMS master files.
- The necessity of preserving the stability of batch VIMS software and data products during, and possibly after, transition to an on-line mode of operation. Periodic batch reports will still be needed not only for vehicle maintenance management but as backup documentation for the on-line system.
- AFDSDC/LGTV´s desire for an early on-line capability as reflected in its planning for an OLVP implementation by October, 1977.
- The imminence of a major base-level ADPE (BLADPE) upgrade under auspices of the BASE-TOP and STALOG programs. Current expectations call for program planning to be essentially completed by 1977-78. Such an upgrade might involve replacement or significant enhancement of the B3500.

The findings of the study, based on these factors, are presented in succeeding sections which deal with prototype development options, design concepts, preliminary projections of the prototype´s B3500 processing and storage requirements and on-line activity, and prototype development planning. It should be noted that these aspects of the prototype system are discussed with particular emphasis on daily operations, as opposed to weekly/monthly/quarterly processing. It should be noted as well that although no specific system design recommendations are made, some extremely general design concepts are defined in order to examine their feasibility. Finally, preliminary projections related to prototype performance are based on the best data available during this study. As better data becomes available, the analysis techniques used here can be applied to refine projections.

SECTION II

DEVELOPMENT OPTIONS

The method used to derive development recommendations involves definition of four basic alternatives which must be evaluated in light of several criteria of corresponding generality.

BASIC ALTERNATIVES

Figure 1 defines four alternatives for development of the on-line VIMS prototype and indicates some relationships among them. Note that each alternative must ultimately deal with the advent of new base-level ADPE. New BLADPE may take the form of a single base computer, a central base computer augmented by functionally-oriented minicomputers, or complete dispersal of base processing to functional minis. There have also been recent proposals calling for consolidation of base-level data processing in a small number of massive regional computing centers. (SADPR-85: Support of Air Force Automatic Data Processing Requirements through the 1980´s, Electronic Systems Division, Air Force Systems Command, L.G. Hanscom Field, June 1974.)

The first alternative calls for no action on prototype development until new BLADPE has been specified in some detail. This is essentially a non-option in view of the constraint to provide an on-line capability as soon as practically possible. However, due to unforeseen changes in funding, technical, or institutional circumstances, inaction cannot be dismissed as a possibility.

The second alternative (OLV3500) calls for an on-line prototype supported solely by the B3500. The third alternative (OLVHYB) is a hybrid VIMS prototype with real-time file processing assumed by a front-end processor (FEP) minicomputer, and the fourth (OLVDED) calls for development of the prototype on a dedicated minicomputer after a transitional implementation of OLVHYB.

NOTE: The term "dedicated" refers to the equipment´s relationship to on-line VIMS, not to its relationship with other base-level processors. It is presumed that any minicomputer supporting VIMS would be linked via communications to other computers to the extent that data exchange or mutual back-up requirements would dictate, and that any residual processing capacity could be used to support other elements of the logistics community.

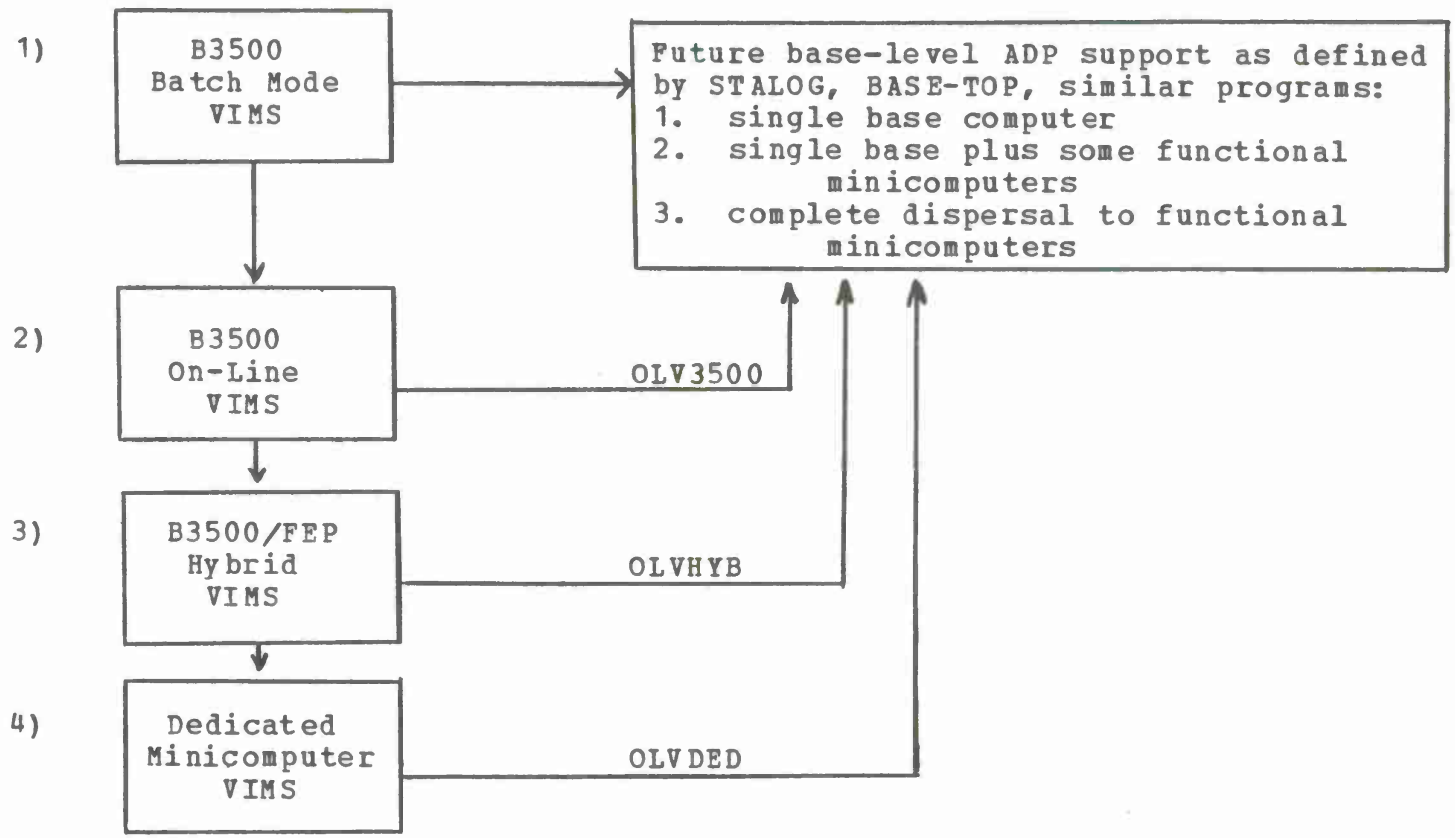

Figure 1. Development Alternatives

Although OLVDED presumes an eventual transition from OLVHYB to FEP-only operation, such a transition would not take place until after adequate experience has been gained with FEP equipment, a new operating system, and with use of on-line VIMS in general.

Note that the specified development sequence begins with an analysis of the B3500 as the prototype host computer, and that the succeeding alternative calls for retention of some file processing on the B3500. This is an essentially conservative position based on the hope that much of today's batch VIMS software can be used to support the on-line version of the system. Use of current software is highly desirable because it would

- Lessen the expense and technical risk incurred in the on-line system implementation effort,
- Reduce the possibility of damage to VIMS data bases,
- Preserve the continuity of proven batch data products, and
- Assure availability of updated VIMS master files for use in batch mode as back-up in event of on-line system failure.

("Design Concepts", Section III, describes a hybrid file configuration which could permit retention of some current VIMS software).

The arrows leading from alternative to alternative in Figure 1 indicate a <u>progression</u> of analysis and preliminary system design, with arrival at any one choice dependent upon evaluation of each of the preceding alternatives. Such analyses require use of evaluation criteria:

- Performance
- Cost
- Technical Risk

Whatever prototype development strategy is selected, the decision must be based on an acceptable balance of cost, performance, and technical risk, including the probable compatibility of the prototype implementation with future BLADPE.

EVALUATION CRITERIA

<u>Performance</u> - The performance criterion is concerned with the timeliness with which the on-line system responds to user commands.

Because of the data management (as opposed to computational) orientation of on-line VIMS, system performance will equate to file access performance. Some of the time expended in file processing is keyed to storage device performance (disk latency, transfer rate). By far the greatest access delays are encountered, however, during the time an individual read/write request must wait enqueued until prior requests have been serviced. This means that, equipment performance factors being equal, the less software contention for storage access the faster the rate of access for any particular software system.

Cost - "Prototype Development Planning", Section V, presents the method used to estimate costs of the three development options. As one might suspect, development program costs vary directly with the amount and complexity of new prototype software which must be written.

Technical Risk - The degree of technical risk presented by each alternative equals the extent to which its successful implementation is threatened by technical complexities and unknowns. There seem to be two separate sources of risk: difficulty of transition to new BLADPE, and the relative magnitude of new equipment and software to be incorporated in the protoyope configuration.

CRITERIA APPLIED

Table I summarizes the evaluation of development options in light of the criteria defined above.

Performance

OLV3500 performance, although potentially acceptable (and currently unknown) would be poorer than that provided by the other alternatives since VIMS software would have to compete with other B3500 users for file access facilities. (This would be the case unless VIMS were provided with a dedicated on-line storage device and data channel.) Given an FEP to process "on-line" files, performance of OLVHYB would be superior to that of OLV3500 since contention with other systems for storage access would occur only in the B3500. Use of a dedicated minicomputer would further reduce contention by non-VIMS software.

In the absence of a system design, the performance baseline represented by OLV3500 is currently inestimable. Once a rough design is postulated, however, the number of random access

Table I

Evaluation of Development Options

CRITERIA / OPTIONS	ESTIMATED PERFORMANCE	TECHNICAL RISK		ESTIMATED DEVELOPMENT COST
		SYSTEM DEVELOPMENT	TRANSITION TO NEW BLADPE	
BATCH MODE VIMS	-	-	?	-
OLV3500	? (until Prelim-inary design)	LEAST	?	$ .5M
OLVHYB	BETTER	MORE	?	$1.0M
OLVDED	BEST	MOST	?	$1.5M

read/write operations per transaction type will be established, and these, multiplied by projected transaction volumes, can then yield total storage accesses per some unit time. Matched against current B3500 response time/storage access baselines for other on-line systems, these figures will provide some clue to probable OLV3500 performance. Related preliminary projections are included in Section IV.

Technical Risk

Development risk increases with use of unfamiliar equipment and system software, the requirement to write and test new application software, and the decision to abandon use of proven software. Hopefully, risk associated with an OLVDED implementation would be minimized through the familiarity with new equipment and software gained during the OLVHYB experience.

The characteristics of new BLADPE are currently unknown. However, the closer the similarity of system architectures (OLVP-BLADPE), the easier the transition. On-line VIMS designers should have some hints as to the new BLADPE configuration prior to specifying the prototype´s final architectural details.

Beyond architecture, ease of transition depends heavily on the language facilities to be employed with new equipment. For example, should OLVHYB be implemented in COBOL on both the B3500 and FEP, transition to a base computer plus functional mini (if a mini transition were needed) would be greatly aided if COBOL were available on the new machine(s). (Plans are currently being advanced within DOD to develop a universal minicomputer COBOL compiler compiler.)

Cost

"Prototype Development Planning", Section V, contains a detailed breakdown of costs by development option by program year.

Summarized, these are:

	Manpower Costs	Equipment Costs	Total Costs
OLV3500	$ 395,200	$ 12,000	$ 407,200
OLVHYB	$ 904,800	$112,000	$1,016,800
OLVDED	$1,320,800	$112,000	$1,432,800

CONCLUSIONS

An OLV3500 prototype appears cheapest and least risky to develop, but its performance will be unknown until a preliminary system design is completed, as indicated above. If OLV3500 performance is eventually projected as marginal or unacceptable, then OLVHYB should be considered as a means to relieve the B3500 of most real-time file processing. This would then leave the option open to progress to OLVDED for ease of transition to new BLADPE, or for other reasons.

Presuming OLV3500 performance is judged adequate, cost and technical risk factors must be inspected. If either of these is unacceptable, (with OLVHYB and OLVDED offering progressively higher cost and technical risk), then there seems to be no choice but to await specification of new BLADPE while operating VIMS in standard batch fashion. If cost and technical risk are acceptable, then OLV3500 has qualified as an alternative and the decision must be made to either move ahead with an OLV3500 implementation or to qualify OLVHYB as another candidate through analysis and preliminary design.

SECTION III

DESIGN CONCEPTS

The following subsections provide general descriptions of data file configurations, equipment, and software which might be incorporated in each of the three prototype implementations.

HYBRID FILE CONFIGURATION

Both OLV3500 and OLVHYB would incorporate B3500-based master file processing and retention of the current end-of-day batch run for the following reasons:

- An implementation effort utilizing existing, checked-out software appears faster, cheaper, and less technically risky than a complete redesign and implementation.

- Utilization of current batch software to the extent possible would reduce risk of damage to VIMS data bases and would therefore preserve the continuity of proven batch products, many of which would still be required by VIMS users after on-line services were available, independent of the implementation strategy selected.

- Retention of the B3500 batch run would assure availability of updated master files for use in a batch-only mode as a back-up measure in event of major on-line equipment or software failure.

Given retention of as much of the current VIMS batch software as possible, a functional distinction must be made between the batch run master files, to be accessed in "read-only" mode during on-line operations, and a second set of on-line files: master file subsets and update transaction files. These latter would be processed in normal read/write mode during the on-line day and would be post-processed to create update input tailored for the batch run. With OLV3500, the functional distinction between master and on-line files would be maintained, although both sets would be processed by the single computer. Under OLVHYB, the FEP minicomputer would process the on-line files, with master file processing retained on the B3500. Both sets of files would be processed by the former FEP under OLVDED.

Separation of master and on-line files would provide well-defined interfaces to the system designers who must specify the on-line VIMS monitor, command language processor, transaction manager, and file manager. (These pieces of software would have to be developed in any case regardless of data base locations.) As well, separation of files would simplify the analysis needed to support the decision for or against use of a generalized data management system. It also makes sense to leave VIMS master file processing functions in COBOL-based software for ease of hardware transition to new BLADPE.

Figure 2 indicates some suggested major relationships among "master" files and their pre-processed input files, and "on-line" files which would be directly accessible to the prototype on-line VIMS system during normal working hours. (Obviously, a category of supporting files has been omitted here: file indices, executable software elements, file management catalogs, message logging/accounting files, I/O spooling files, scratch files, and others.)

Under an OLVHYB development plan, the files designated "end-of-day batch" would be processed initially by the B3500, to be transferred in a subsequent OLVDED implementation to the FEP which would initially process only the on-line files. Under OLV3500 all files would be processed by the B3500.

Regardless of how the various on-line files might be associated with processors, the decision to retain a VIMS end-of-day batch run would require that several kinds of modifications be made:

1. Addition of batch pre-processing. In order to use existing batch file update software to the maximum extent possible, the content of the on-line "transaction" files must be reformatted prior to processing during the batch run. These include the Vehicle Update, Work Order, Deferred Maintenance, and Employee Transaction files.

2. Changes to batch run input routines such that pre-processor output can be accepted in addition to the current classes of input files.

3. Addition of batch post-processing to regenerate on-line files for the next day's operation. These files include the Vehicle, Work Order, and Employee subsets, and the Deferred Maintenance, and High Cost Bench Stock files.

4. Addition of update processing to the current batch run required by new on-line prototype files. These are the Vehicle Historical Repair, Back-Ordered Parts, and Parts

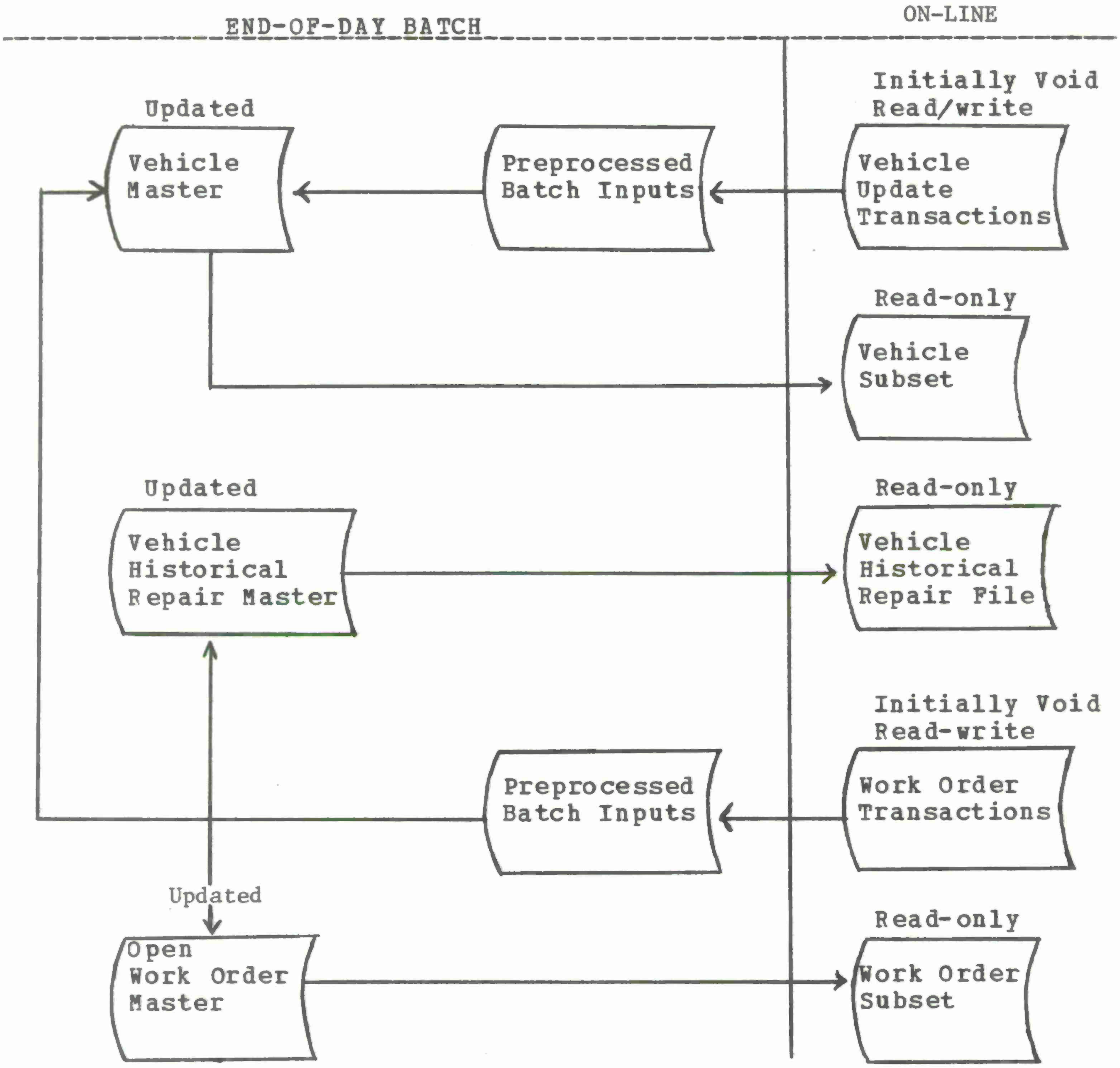

Figure 2. Hybrid File Configuration

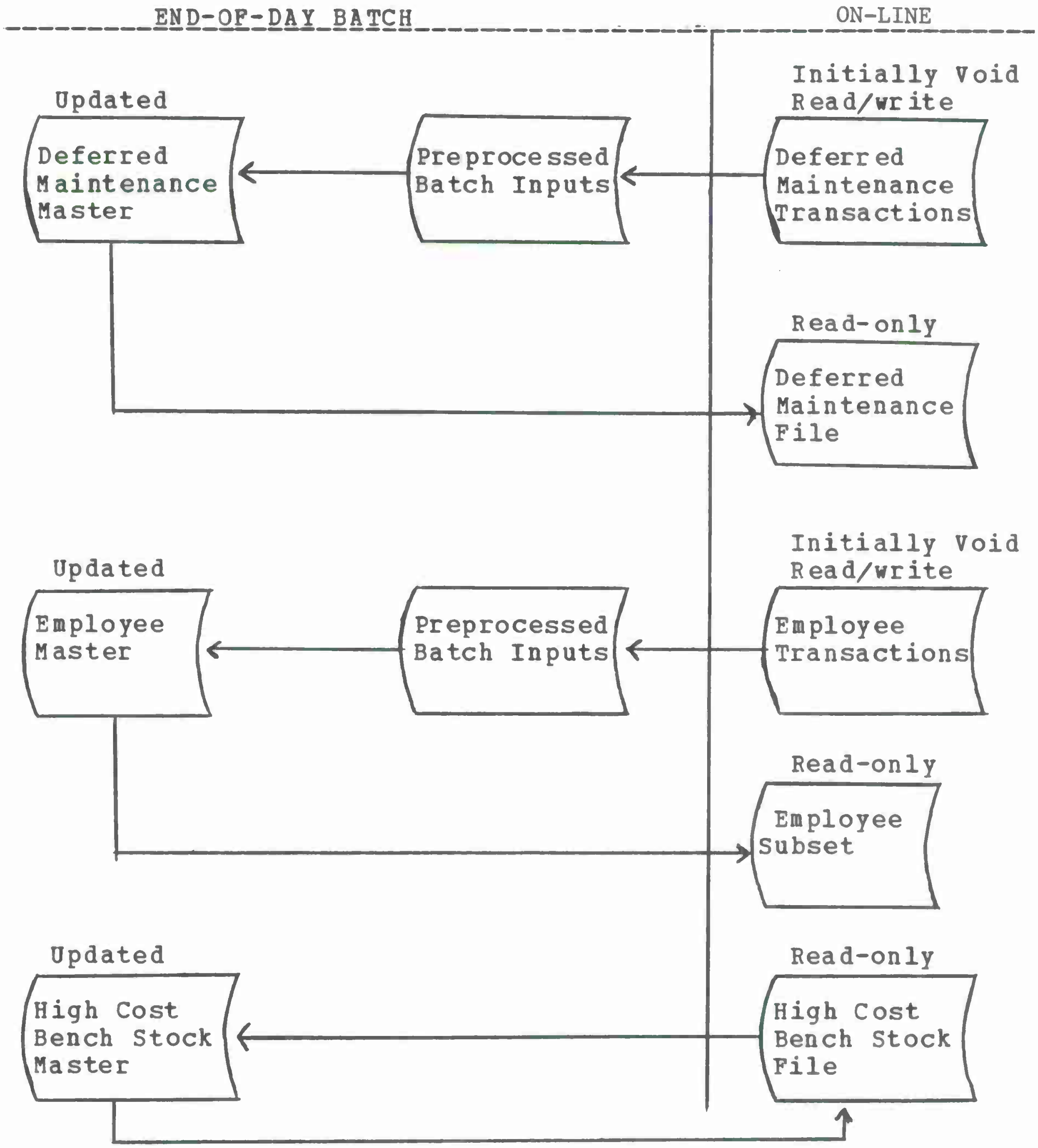

Figure 2. Hybrid File Configuration (Continued)

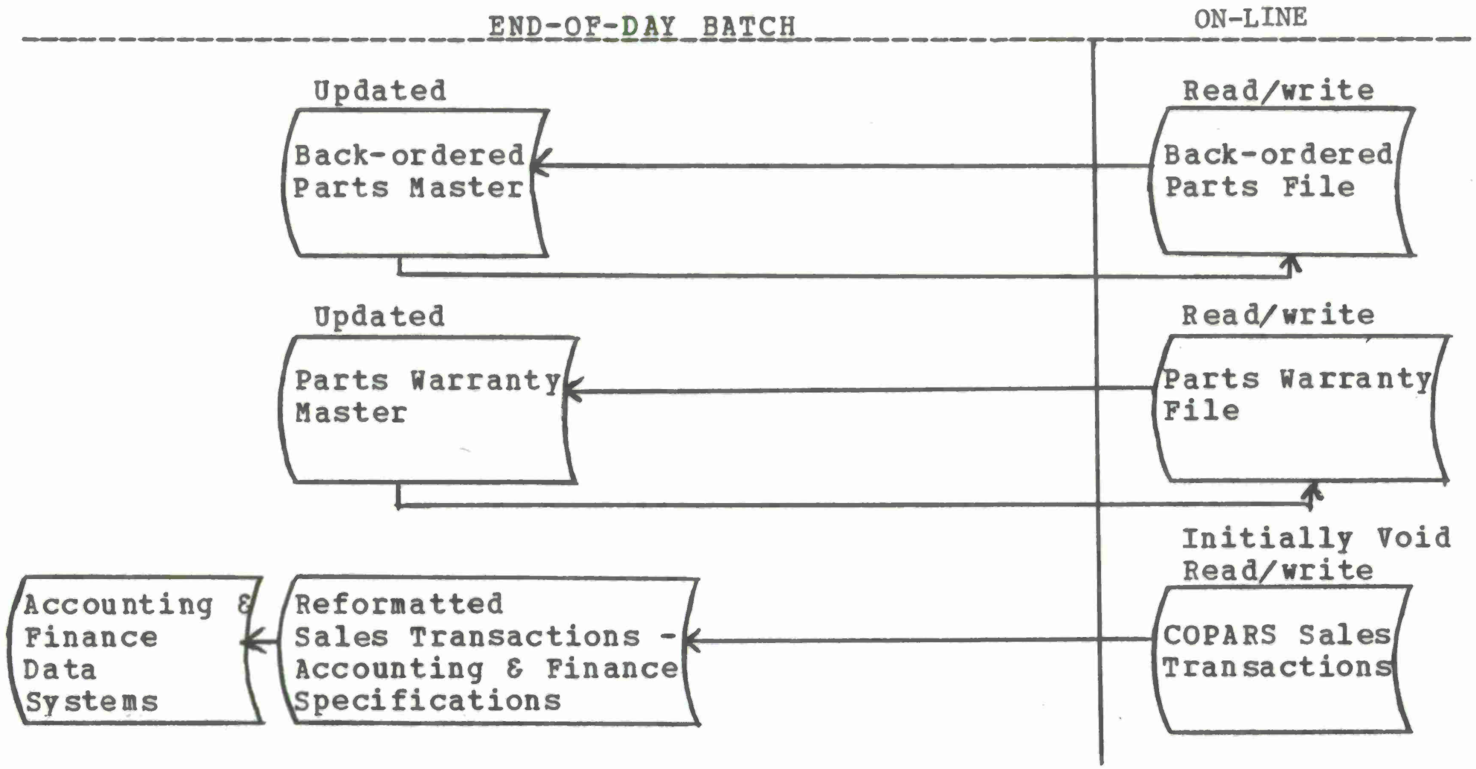

Figure 2. Hybrid File Configuration (Concluded)

Warranty files plus COPARS sales transactions (for Accounting and Finance).

5. Changes to existing batch file update routine required by expanded file content (such as the addition of job-specific data items to the Work Order and Deferred Maintenance files).

EQUIPMENT COMPONENTS, CONFIGURATIONS

The intent to proceed with prototype development from a base of proven technology (VIMS batch software operating on the B3500) limits equipment configuration options to combinations of the following components:

- B3500 processor and associated auxiliary storage (disk)
- Basic terminal: CRT/keyboard with hardcopy printer
- Enhanced terminal: Basic terminal enhanced by addition of a programmable processor and auxiliary storage.
- Front-end Processor (FEP) communicating with the B3500 either dedicated to transportation or shared by multiple on-line systems.
- Disk file controller modified to permit sharing of B3500 auxiliary storage with an FEP. (The disk sharing feature is available from Burroughs at extra cost.)

For a number of reasons (explored below), best combinations of components for each prototype implementation seem to be:

(OLV3500)
B3500, associated disk storage, basic terminals

(OLVHYB)
B3500 and FEP, each with associated disk storage, basic terminals

(OLVDED)
Minicomputer, disk storage, basic terminals

Further, OLVDED's minicomputer would be the same as OLVHYB's FEP, possibly enhanced by a larger memory and more disk storage, since the OLVDED alternative would probably be developed via a transitional implementation of OLVHYB.

Note that these configurations are the simplest possible of many potential conbinations of components. These were selected because of ease of relative comparison and because they seem capable of performing the prototype mission. This is not to say that there are no potential advantages in the use of shared disk storage or enhanced terminals.

Like the FEP, an enhanced terminal could provide useful pre-processing services to the on-line VIMS system:

- Real-time edit checks and on-line error correction of input transactions.

- Local storage and transfer of screen formats used with the CRT terminals.

In addition to its on-line pre-processing role, the enhanced terminal could perform as a transaction concentrator during periods of B3500 outage or saturation. If the terminal is to perform extensive editing of input transactions it must have available to it some subset of the VIMS master files, and this subset must be strictly synchronized in content with the files processed by the other computer(s). This would incur some measure of overhead processing and would introduce another element of risk. As well, location of large on-line files at the terminal might require use of disk drives needing more controlled environmental conditions (air conditioning/cleaning, vibration suppression) than could be provided by many vehicle maintenance offices. Enhanced terminals could offer more rapid, seemingly instantaneous response to an operator, than basic terminals remote from a minicomputer. The two become functionally equivalent, however, with "adequate" communications bandwidth between the basic terminal and the minicomputer; adequate bandwidth is a function of the particular application, and is probably 2400 bps for OLVP. If advanced interactive techniques involving light-pen selection from rapidly changing display formats were to be used for VIMS, required bandwidth would probably have to be much greater. Such techniques might be explored for future enhancements to on-line VIMS.

Sharing B3500 disk storage with an FEP would provide the following advantages: on-line VIMS software could access all files directly (both master and update transaction files) without incurring idle time waiting for requests to clear B3500 I/O queues, although some waiting would take place when access conflicts arose (disk busy with B3500 I/O operation); B3500-resident VIMS software might be reduced by that amount needed to perform file processing (during the on-line period); the FEP could lend some pre/post processing support to the B3500 batch run; VIMS could remain on-line during some classes of B3500 failure, maintaining access to data; shared disk would provide an alternate communication path with the B3500 which could be used should the primary path (communication line, I/O channel, etc.) fail.

It appears that these advantages are heavily outweighed by the following penalties: one of the processors, B3500 or FEP, would remain roadblocked and idle until the other released the shared disk (presuming a software-controlled request/release feature at the disk controller level); I/O control software operating in the B3500 would have to be rewritten to incorporate request/release statements; disk control hardware would have to be acquired (an extra cost feature*); choice of an FEP would be restricted to a processor which could support the signalling protocols used with the shared disk controller; use of shared disk would heighten the complexity of the overall configuration, software interfaces, and check-out procedures, and would increase the total technical risk incurred during development.

SOFTWARE

Ignoring some duplication, roughly the same classes of software elements will be required by each of the three prototype development alternatives. Listed below are software elements as they would be allocated to processors in the OLVHYB configuration. Note that OLV3500 calls for all software to operate on the B3500, and that the transition from OLVHYB to OLVDED requires a rewrite of B3500-resident software as its functions are assimilated by the FEP. A decision would have to be made at this point whether to retain

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* Note: Equipment rental costs would exceed $1,000 per installation per month using a one year lease pricing schedule.

current data structures and master file processing logic or whether to redesign these for optimized efficiency with the FEP (presuming optimization appears possible).

OLVHYB SOFTWARE ELEMENTS

(presuming operating system support of job scheduling, interrupt servicing, and program language processing functions.)

B3500-RESIDENT

- On-line VIMS file manager, to accept and process master file access requests transmitted from the FEP
- Current batch file processors, modified as indicated below
- Batch run pre-processor
- Batch run post-processor

FEP-RESIDENT

- VIMS executive, to perform status posting, task scheduling, communications logging, recovery checkpointing and similar functions
- Command analyzer and command processors, to respond to user input commands
- Terminal device drivers
- Transaction manager and edit routines (with some edit logic borrowed from the current batch run)
- File manager, to perform logical file I/O to the extent this function is not provided by the operating system
- File loader/structurer for daily file up-loads
- System and file recovery modules
- Report generators, to produce on-line traffic analyses, file activity reports, etc.

With individual software tasks defined, it is appropriate to question whether or not a generalized/centralized data management system could assume the functions of multiple software elements with some savings in implementation costs and manpower. Typical commercially available DMS's provide some or all of the following facilities:

- Self-contained data access and update languages.
- Data access and update services which may be invoked through a "host" programming language such as COBOL.
- A file structuring capability which provides some measure of software independence from data structure detail.
- An on-line transaction routing and filing capacity.
- A generalized input data edit and file conversion capability.
- A data base checkpoint and recovery capability.
- Facility for collection of operational usage and performance statistics.

Availability of a commercially-proven, seasoned DMS could be a strong point in favor of candidate FEP equipment when planning for a hybrid implementation of the on-line VIMS prototype. (Less elaborate data management aids such as file access methods and higher level languages are readily available for use on minicomputers. For example, a COBOL subset compiler for a mini can be purchased today for less than $3,000.) Because of the potential complexity of DMS software, it cannot be stressed too strongly that any such system procured should have been exercised over a period of time on a wide variety of applications to ensure identification and repair of residual program errors. A commercial DMS is preferable to "free" government-owned systems since the latter typically suffer from a lack of adequate documentation, and because their performance and maintenance are not ensured by any sort of enforceable contract leverage.

Beyond software stability, the following criteria should be applied to a DMS in evaluating it for a possible role in a VIMS prototype:

- Basic DMS costs, which might range from zero to hundreds of dollars per month per installation (presuming an on-going software maintenance and enhancement service)

- DMS capabilities directly useful to on-line VIMS prototype processing and cost of acquiring capabilities not provided by the DMS

- Extent and costs of modifications to VIMS or the DMS required to achieve satisfactory interfacing.

In considering the role of a DMS in an OLV3500 implementation it is necessary to analyze the potential capabilities and liabilities of the Air Force On-Line Data System (AFOLDS) as developed by AFDSDC since it is apparently the only generalized/centralized DMS currently operating on the B3500. Those responsible for the design of the on-line VIMS prototype should, before making any decision as to AFOLDS' role in their planning, attempt to answer the following questions:

- Is AFOLDS software stable to the point where it will not compound the recognized danger of VIMS software modification?

- Does use of AFOLDS' data management services require additional changes to VIMS software in any major way? What are the risks and costs of modification? The OLVP user interface as presently specified (and as verified during model test) relies heavily on use of source documents and video presentations of source documents currently utilized by transportation maintenance personnel. The on-line VIMS "language" is therefore not generalized in the fashion of the AFOLDS languages used for data retrieval and update. OLVP use of AFOLDS facilities would require implementation of translator software.

- Should the VIMS on-line prototype design and implementation be keyed to AFOLDS data management services, how transferable is the AFOLDS software to the non-B3500 processors to be used following transition to new base-level ADPE?

In sum, data management systems can provide an assortment of highly useful data manipulation services and can potentially reduce system implementation schedules. In fact, in the case of an OLVHYB or OLVDED implementation, availability of a proven DMS on a particular equipment model could weigh heavily in its favor in the equipment selection process. Use of an unproven DMS, however, would invite serious system development problems.

SECTION IV

PRELIMINARY PROJECTIONS

The following subsections present brief analyses projecting the prototype´s requirements for B3500 processing support and data storage, and the on-line transaction activity that might be anticipated. These analyses were prepared using the best data available, essentially no more exact than best estimates from a range of sources. As the quality of projected data improves (B3500 workload baseline, OLVP data structures, etc.) the same methods may be used to develop more exact results.

B3500 WORKLOAD

Presuming the possibility of a B3500-based on-line VIMS prototype, it becomes important to project system workloads in order to assess impact on computer resource demand. The issue is straightforward: will addition of on-line VIMS processing saturate the capacity of any B3500 DPI´s during the daily on-line period?

Ideally, one would make a judgement after comparing projected VIMS resource demands against residual resources remaining above a demand baseline computed for the on-line shift. This is a simplistic process and potentially a misleading one since, in the absence of an instantaneous resource baseline, resource demands must be arbitrarily smoothed across the daily on-line shift. The actual, and largely randomly-occurring, demand peaks and valleys are thereby lost. Confidence in the results of the workload projection task must be tempered with the knowledge that where there is a coincidence of demand by VIMS and by competing on-line systems, response time of all systems must degrade.

Using the methods described below, it was found that on a <u>monthly</u> basis, addition of on-line VIMS processing would increase the B3500 operational use hours (OUH) expended at 20 sample bases by an average of six percent. On a <u>daily</u> basis (on-line shift), VIMS would increase the OUH processing load by six to 31 precent at 24 sample bases. The significance of these estimates will become evident as the methods of estimation are described. The following list provides an overview of the estimation process and a guide to the following text. (Source calculations appear in Appendix I).

1) Relationships between fleet size and monthly transaction volumes, and between B3500 direct time hours (DTH) and disk I/O volumes were confirmed.

2) Numbers of disk I/O´s were assigned to on-line VIMS transaction types.

3) Total monthly disk I/O´s for nine sample bases were calculated using volumes of batch transactions corresponding to on-line VIMS transactions.

4) Monthly I/O´s were converted to monthly DTH.

5) Fleet size was related to monthly direct time hours, and monthly and daily DTH were projected for 20 and 24 sample bases.

6) Monthly and daily DTH were converted to OUH and impact on current workloads was analyzed.

The objective of the workload projection effort was to construct a method by which on-line VIMS prototype demands for B3500 computer time, a dependent variable, could be estimated for any DPI using an independent variable. Vehicle fleet size was the independent variable chosen because of its easy availability as a data item and because of its assumed high correlation with monthly/daily VIMS transaction volumes. It was assumed in turn that computer time requirements would vary directly with transaction volumes.

By convention, B3500 computer time, expressed in operational use hours, is made up of two components: direct time hours (DTH), that fraction of time during which work is being done by or for specific data systems, and prorated time hours (PTH), that remaining fraction which is overhead time not chargeable to specific systems yet assigned to all on a prorated basis as a function of the job mix. Of these categories of processing time, DTH most closely reflects the "real" computer time requirements of data systems, since both PTH and OUH are tied to transient conditions of the job mix. What is needed, then, is a reliable predictor of DTH which could also be tied to vehicle fleet size.

As it turns out, DTH varies closely and directly with numbers of physical disk reads and writes on the B3500. Given these relationships, a method was developed whereby numbers of physical disk I/O´s were arbitrarily assigned to the various on-line VIMS transaction types, numbers of on-line transactions were predicted using today´s volumes of batch transactions (tied to fleet sizes at nine bases), and the disk I/O´s thus projected on a monthly basis were converted to monthly DTH. Regression equations were then developed expressing the relationship of fleet sizes to monthly DTH workloads at the sample bases.

By convention, however, DPI saturation occurs when OUH required exceeds OUH available, so some means of DTH-to-OUH conversion was needed. Since B3500 accounting software monitors both DTH and PTH, the "percent direct" component may be computed for an OUH total. The conversion factor (developed from a month's worth of observations at 24 sample DPI's) was then used to inflate monthly DTH values to monthly OUH.

Several regression equations were developed based on data collected from separate sources. There were five equations in all, derived from:

(1) Observed VIMS batch processing, 24 sample bases, June, 1974 (provided by AFDSDC/SYO)

(2) As above, incorporating July, 1974 data

(3) A disk I/O-DTH conversion factor borrowed from AFDSDC's Workload Analysis Model (WAM)

(4) A disk I/O-DTH conversion factor developed from batch VIMS processing data

(5) A disk I/O-DTH conversion factor developed from current on-line system observations.

All five equations relate monthly DTH to fleet size: the first two were developed directly from fleet and DTH data, the last three were prepared using the intermediate conversion of projected transactions-to-disk I/O's-to-DTH.

Despite the diverse origins of the equations, their corresponding regression lines are not wildly dispersed. (See Appendix I). A maximum and minimum monthly DTH (against fleet size) envelope was drawn outside the group of regression lines and the extreme values, lying along the envelope's boundaries, were used to construct monthly and daily analyses. The results of these were as reported above: a projected six percent rise in monthly OUH workload at 20 sample bases, and a daily OUH increase of from six to 31 percent projected for 24 sample bases. Given the extreme values used in the analyses, the following conclusion appears reasonable:

To the extent that the monthly and daily resource demand baselines can be trusted as reasonably accurate, and in the absence of additional high activity on-line systems in the future, it appears that the operation of an on-line VIMS prototype will not dangerously threaten saturation of

B3500 resources during the on-line shift except at those DPI´s requiring upgrade which operate today in a condition of marginal saturation.

B3500 DISK STORAGE

Presuming a functional split between VIMS "master" files and the "on-line" files, we are concerned about the storage capacities (expressed in megabytes) required for each class. The following tables summarize the results of a brief on-line VIMS disk storage analysis.

Table II shows OLVP disk storage requirements in megabytes for each of three arbitrary fleet size categories as established for a sample of 24 bases. Note that segregation of master and on-line files by processor would occur only with OLVHYB. For the other alternatives the storage total would apply to a single processor (B3500 or minicomputer).

Table II

On-Line VIMS Prototype Disk Storage Requirements

Fleet Size	No. Bases	Master Files MB Disk B3500	On-Line Files MB Disk FEP	Total
1191-752	6	10.4	2.6	13.0
744-466	11	7.1	1.8	8.9
447-235	7	3.8	1.0	4.8

Using fleet size as an entering argument, B3500 requirements were taken directly from the DAR-DPD-DPP for on-line VIMS (AFDSDC/LG, 16 December 1974). FEP figures for each base were calculated by multiplying the B3500 master file allocations by .25 to account for subset and transaction files. These results seem reasonable in view of the correspondingly larger storage requirements of higher activity on-line systems. (MMICS operation requires from 14.4 MB to 69.6 MB of disk storage depending upon forecasted base activity.)

Using CAPS Report Number Nine, a disk storage projection current to June, 1976 was constructed for each sample base and the calculated OLVP requirements were added to this baseline in each case. The results are summarized in Table III.

Table III

DISK STORAGE REQUIRMENT SUMMARY

24 SAMPLE BASES

Disk Saturation Projected (June, 1976) Without On-Line VIMS	25% (6 DPI's)
Max Disk Deficit	7.7 MB
Avg Disk Deficit	4.9 MB
Total Saturated After Addition Of On-line VIMS	54% (13 DPI's)
Saturated Due Only To On-line VIMS	29% (7 DPI's)
Max Disk Deficit (Incl On-line VIMS)	16.6 MB
Avg Disk Deficit (Incl On-line VIMS)	8.2 MB
Max On-line VIMS Disk Requirement	13.0 MB
Avg On-line VIMS Disk Requirement	8.8 MB
Active AF Bases (June, 1974)	103
DPI's Potentially Saturated Due To OLVP	30

The picture presented in Table III could be somewhat misleading because:

- Planned upgrades to disk capacities (based on CAPS projections) will no doubt have been made prior to June, 1976.

- Addition and deletion of standard B3500 systems, and the corresponding rise and fall in storage requirements, may not occur in accordance with the schedule presented in the

CAPS report. As well, the storage requirements of many new systems are reflected in CAPS as "UNK."

- The projected storage requirement baselines and computed VIMS storage requirements of the sample bases may misrepresent the requirements of the entire population of bases.

ON-LINE ACTIVITY PROJECTION

Summary

The simple method of transaction volume projection described below involves -

1) Identification of transaction types employed today in VIMS batch processing which will make up the bulk of on-line VIMS transaction volumes.

2) Identification of relationships between vehicle fleet sizes and daily volumes of on-line transaction types.

3) Validation of these relationships against observed batch transaction volume data.

4) Collection and analysis of sample data which indicate the work order processing time distributions to be encountered at Workload Control. (The transaction processing workload at Reports and Analysis can be controlled arbitrarily through procedure, since it is not closely synchronized with events external to the processing system such as arrival of vehicles to be serviced, completion of work orders, amendment of work orders, etc.)

5) Projection of daily transaction processing at Workload Control distributed across a working shift at several sample bases with differing fleet sizes.

High Volume Transaction Types

Inspection of the monthly batch transaction totals at 17 bases (data supplied under LGT cover letter of 11 February 1975) reveals that only four transaction types comprise the bulk of the workload reported for the period. Mean relative volumes are found to be -

MZ 46% (Fuel/Oil Slips)

GZ	21%	(Labor Time Cards)
WZ	15%	(Work Order Closes with Job Detail)
FZ	9%	(Work Order Open without Job Detail)
	91%	

It is assumed that current FZ and WZ transaction volumes may be used as valid indices to the future numbers of on-line, work order-based transactions (OPEN, CLOSE, AMEND, etc.) that will be encountered at Workload Control. Similarly, MZ and GZ volumes (fuel/oil issues, labor time cards) are taken as valid predictors of their on-line counterparts to be processed at Reports and Analysis.

Relationship Between Fleet Size and High Volume Transaction Types

For ten sample bases, monthly totals of high volume transaction types are first divided by 21 to produce daily totals and are then divided by vehicle fleet size to generate a daily per-vehicle index. For each transaction type, the maximum and minimum values are discarded and the mean value calculated for the remaining bases. The per-vehicle daily transaction coefficients thus yielded are -

MZ	.248
GZ	.139
WZ	.105
FZ	.051
	.543

As an example, the daily volume of fuel/oil issue transactions for any particular base is projected as roughly equal in number to one-quarter of the base's vehicle fleet size. Since these factors were derived in arbitrary fashion they had to be verified against observed data.

Coefficient Validation

A sample of nine bases was used to check the transaction projection coefficients using the following method -

(21)(fleet x .543) - (observed monthly total of MZ+GZ+WZ+FZ) = difference between predicted and actual monthly totals.

On a percentage basis, the coefficients yielded predictions that varied from five percent low to 52 percent high, with a mean error of 20 percent on the high side. This appears to be acceptable accuracy. Figure 3 presents a plot of predicted daily transaction

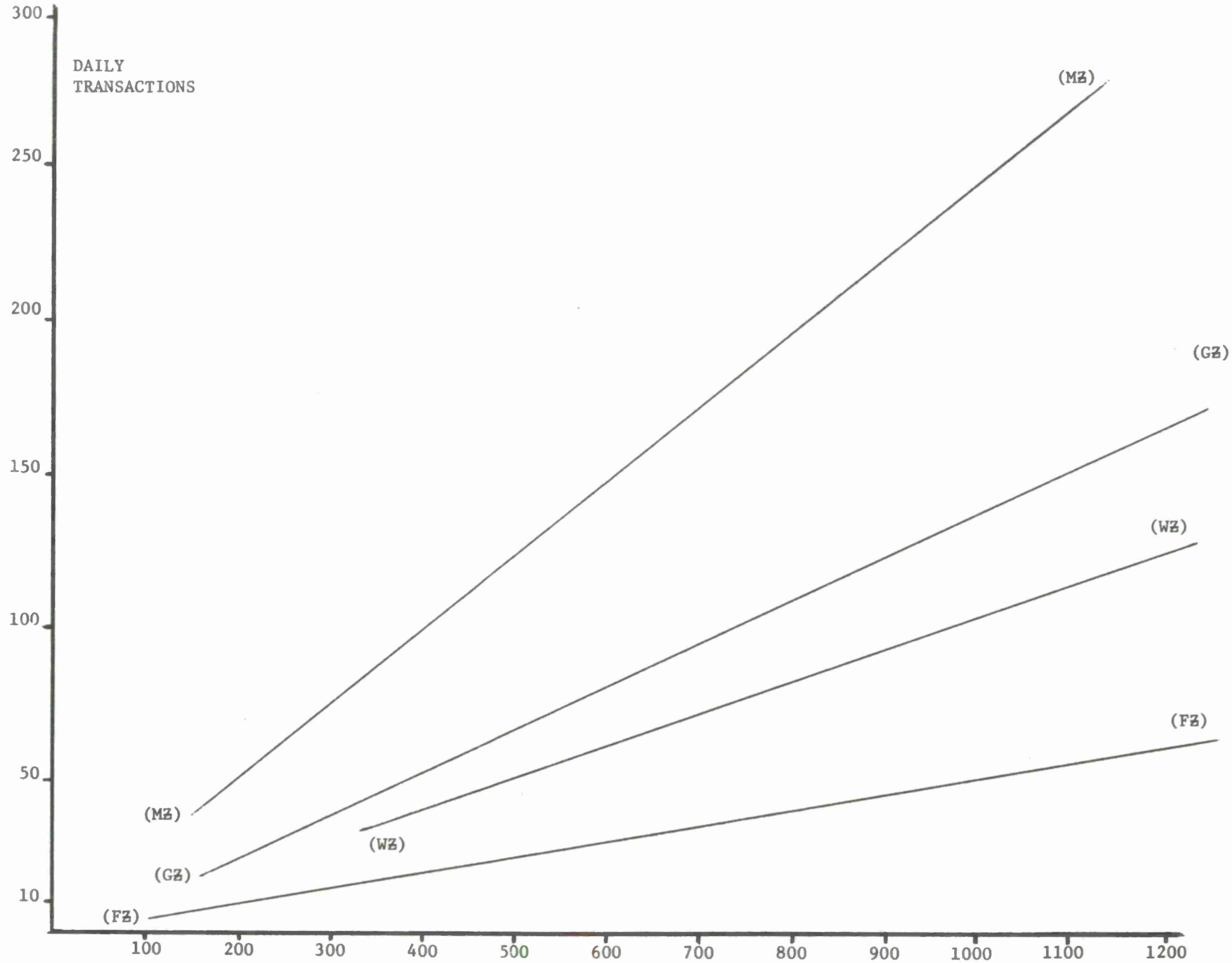


Figure 3 . Daily Plot of High Volume Transaction Types

volumes against vehicle fleet size as developed from the coefficients calculated above.

Time Distribution of Predicted Transaction Volumes at Workload Control

Unlike that of R&A, much of the transaction processing load at Workload Control is keyed to external factors which personnel operating on-line VIMS cannot easily regulate. In order to identify a typical pattern of workload generation over time, a sample of 100 work orders from Hanscom AFB's files was analyzed in terms of time of day of work order OPEN and CLOSE. Separate tallies by shift hour for both OPEN and CLOSE were accumulated while ignoring individual job continuity across shift boundaries. Figures 4 and 5 show for each shift hour the precentage of total OPEN's and CLOSE's processed. Figure 6 shows combined totals of work order operations spread across the shift.

Sample Projection

Using fleet size as the entering argument, daily FZ and WZ volumes were developed for the five bases in Table IV. For each base, the FZ and WZ volumes were combined and spread across the daily shift in accordance with the Hanscom workload profile. Note that the peak hour begins at 0900, and that for any base the number of peak hour transactions equals fleet size x .022, where the latter is FZ + WZ coefficients (.156) x peak hour distribution (.14). Note also that no time-flow projections have been made for R&A since the workload there can probably be managed via arbitrary procedure. In any case, MZ and GZ volumes do not seem to threaten terminal saturation. (Combined total for a 1200 vehicle base would require processing at a rate of roughly 60 per hour.)

Caveats

The foregoing analysis and conclusions are vulnerable to the usual kinds of questions, some of which, hopefully, have been anticipated below.

- Only a portion of the total number of on-line transaction types have been considered: those specifically related to the FZ, GZ, MZ, WZ transactions of today's batch system. Transaction volumes projected for Workload Control, for example, could be potentially lower than the actual volumes (which might include Materiel Control transactions and other types).

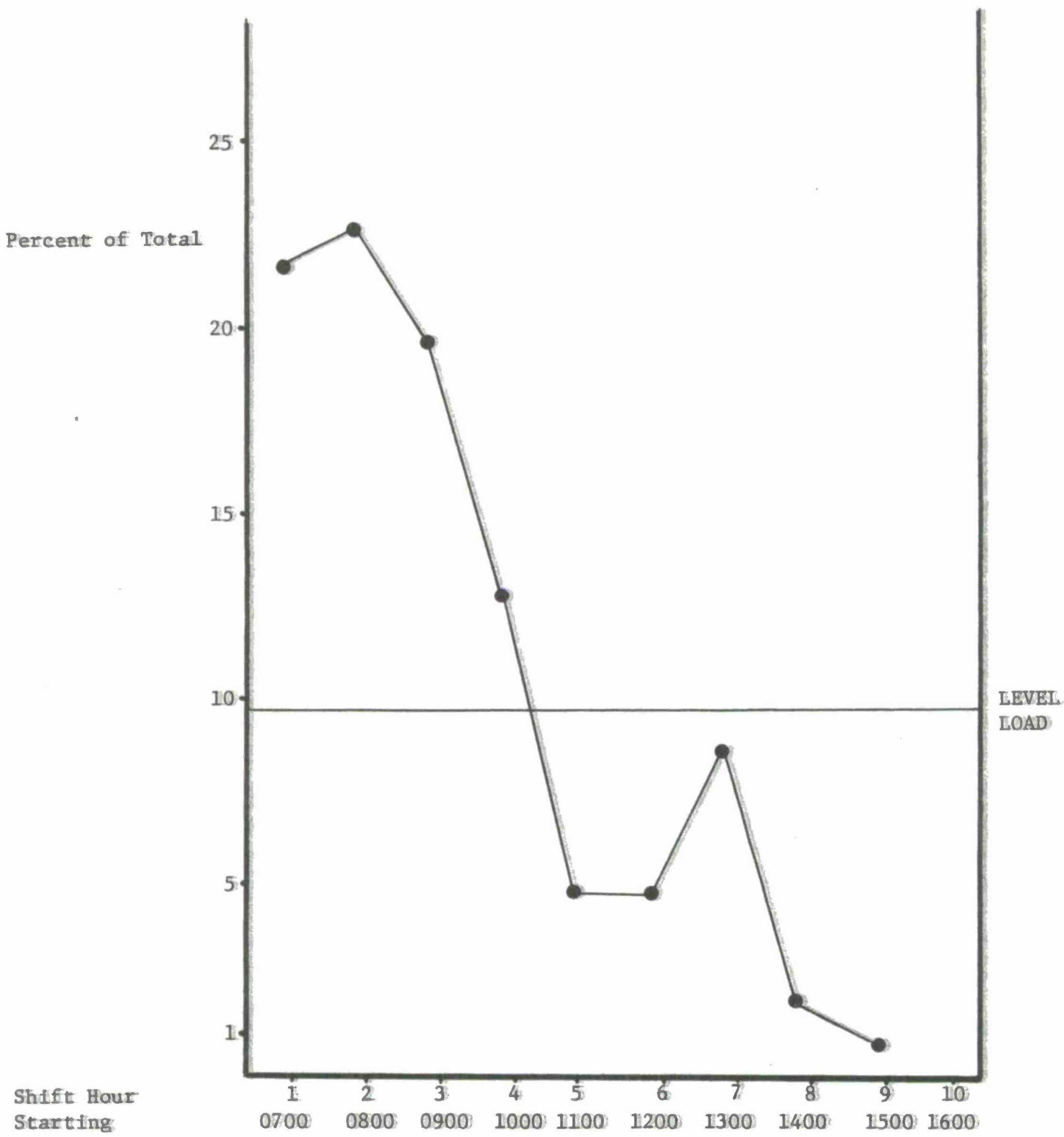


Figure 4. Percentage/Time Distribution of Work Order OPEN Operations — Sample of 100, Hanscom AFB

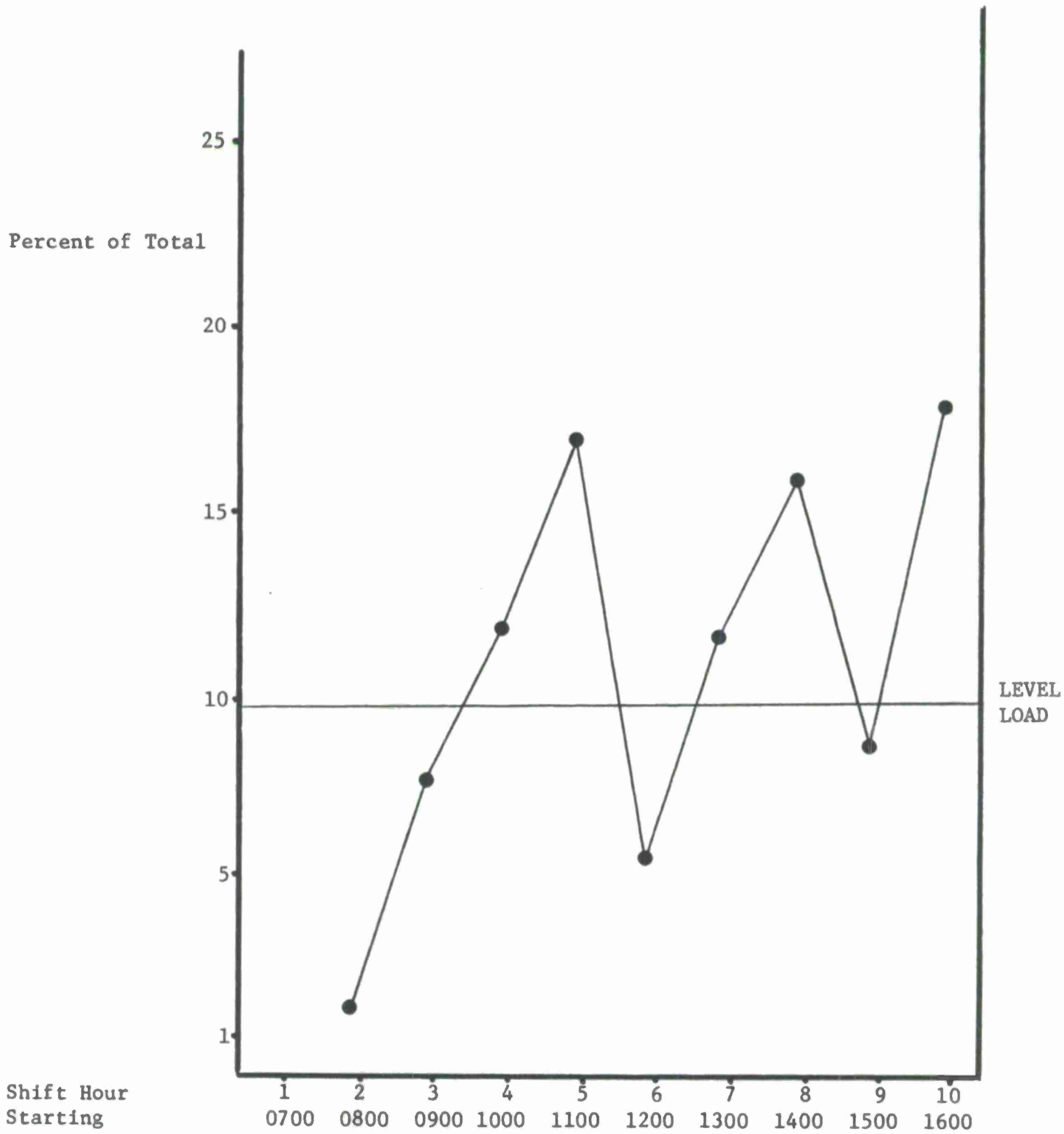


Figure 5. Percentage/Time Distribution of Work Order CLOSE Operations - Sample of 100, Hanscom AFB

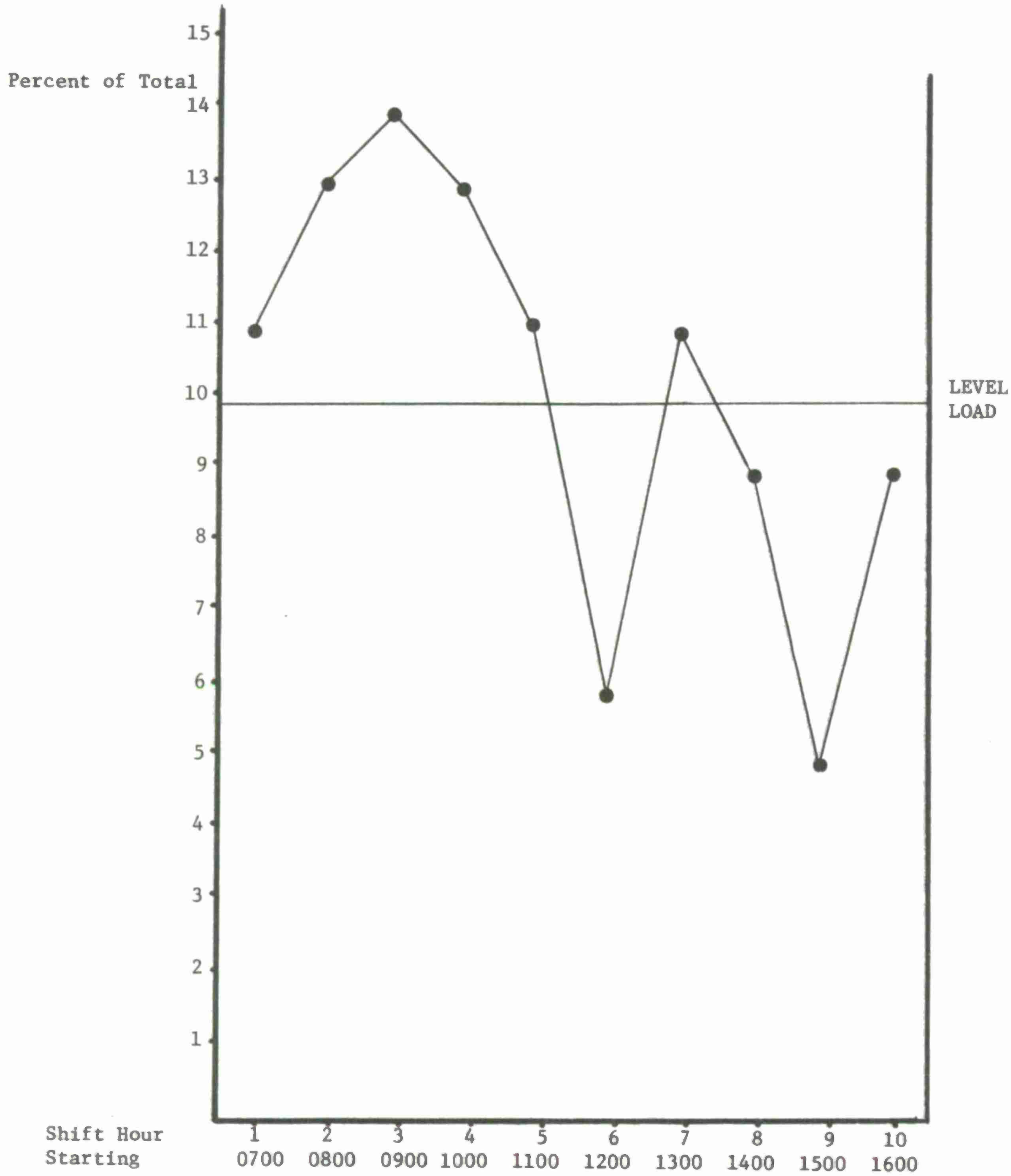


Figure 6. Combined Percentage/Time Distribution of Work Order OPEN and CLOSE Operations - Sample of 100

Table IV

Daily Workload Control Transaction Flows
Projected for Five Sample Bases

VEHICLES	BASES	1 0700	2 0800	3 0900	4 1000	5 1100	6 1200	7 1300	8 1400	9 1500	10 1600
1037	Davis-Monthan	18	21	23	21	18	10	18	15	8	15
1150	McGuire	20	23	25	23	20	11	20	16	9	16
1197	Shaw	21	24	26	24	21	11	21	17	9	17
614	Whiteman	10	12	14	12	10	6	10	9	5	9
387	Lowry	7	8	9	8	7	4	7	5	3	5

Combined work order OPEN's/CLOSE's distributed across shift hours in accordance with percentage distributions established by Hanscom sample.

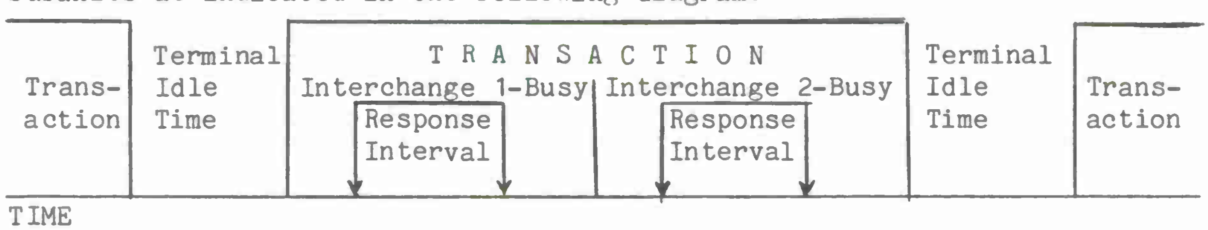
- The Hanscom workload profile may not be a valid predicting tool because a) Hanscom operating procedures are not representative of those at other bases, or b) the Hanscom work order sample reflects some temporary, unusual condition. As with any workload projection method, best practice calls for use of workload histories from the entire population of potential users, covering a year's time period to permit detection of seasonal variations.

- In calculating daily workloads, observed monthly totals were assigned uniformly across daily boundaries over 21 work days, when in fact peaks and valleys in the workload are probably more typical.

Having developed a method to project transaction workload, it remains to construct the rough prototype performance estimators needed to test for terminal input saturation given the workloads projected.

Prototype Performance

A simplistic performance model has been constructed by arbitrarily segmenting the on-line system's operating time into subunits as indicated in the following diagram:



That is, during any particular operating hour there may be both idle and transaction time. A transaction is composed of one or more interchanges, the basic performance accounting unit which represents "busy" time at an input terminal. The "response" interval lies within a busy period as shown in Figure 7 which presents the segments of activity included in a single interchange.

The intent is to develop a method whereby some quantity of elapsed time can be assigned to each activity based on a set of variables describing system communication and processing characteristics. These variables are number of terminals per communication line, line data rate, printer speed, average message length, disk access time, coincident disk demand (multi-programming factor), processing priority assigned to on-line VIMS, and a human

ACTIVITY TYPE

(1) User (external) Action
*
(2) Line Acquisition (IN)
(3) Transmission (IN)
(4) Process IN/OUT
(2) Line Acquisition (OUT)
**
(3) Transmission (OUT)
(1) User (external) Action

Terminal Awaiting Response (from * to **)

Terminal BUSY (from (1) User (external) Action to (1) User (external) Action)

* - User roadblocked, awaiting response
** - First character of response arrives at terminal

Figure 7. Interchange Activities

activity factor. Each activity is described below keyed to its associated number in the figure.

(1) An external activity might be human in character (document analysis, a keying operation, conversation, or simple inattention), or it might be a printing operation. Print rate is a performance variable and print duration can be calculated as a function of output length in characters. For timing purposes, it is assumed that the terminal's memory is used to drive the printer, and that terminal operation is roadblocked during the print process. Timing of human operations is based on observations of the model on-line VIMS system in action.

(2) Presuming the possibility of a multi-drop communications configuration, some time would be expended in waiting to use a busy line (waiting for a poll message from the processor). This quantity is calculated as the product of average line time in or out (see below) and half the number of terminals on the line, excluding the "object" terminal (the terminal for which performance calulations are to be made).

(3) Transmission (line) time is the product of average message length in or out (in characters) and transmission code length in bits divided by the line data rate in bits per second. Code length is assumed to be 10 bits per character, eight data bits and start/stop bits.

(4) The process in/out activity incurs a cost in time as the object terminal's input message waits in an incoming line queue of a length equal to half the terminals on the line less the object terminal. Input messages are cleared from the queue at a rate of one per 23 disk I/O access times (in milliseconds). The figure of 23 disk I/O's per interchange is considered conservatively high: according to SADPR-85, several current B3500 on-line systems require a mean of 23 I/O's per <u>transaction</u>. Added to the input queue time is the product of on-line VIMS's processing priority, the number of systems concurrently contending for I/O resources, and the time incurred by 23 I/O's per transaction in the queue. This quantity is disk I/O queue wait time. Added to the total is time required for the 23 I/O's for the object terminal's interchange. It is assumed that all systems contend for use of a <u>single</u> disk channel/controller.

The following notation is used to identify the variables introduced earlier:

U_1 - user activity, pre-response (sec's)

U_2 - user activity, post-response (sec's)

T - terminals per multi-drop line

L - line data rate (bits per second)

P - print speed (characters per second)

A_1 - avg. input (to processor) message length (characters)

A_2 - avg. output message length

A_3 - avg. printer output length

D - disk access time (milliseconds)

C - coincident disk demand (jobs active)

V - VIMS's processing priority (1 = equal other jobs)

Where B = terminal busy time in seconds and R = response interval in seconds, the following relationships are established: (The number prefixing each term of the equation refers to the textual explanation presented above.)

B =

(1) U_1 +

(2) $\frac{(10A_1)}{L}\frac{(T-1)}{2}$ +

(3) $\frac{10A_1}{L}$ +

(4) $\frac{\frac{(T-1)}{2}(23D) + 23VCD + 23D}{1000}$ +

(2) $\frac{(10A_2)}{L}\frac{(T-1)}{2}$ +

(3) $\frac{10A_2}{L}$ +

(1) U_2 and, if printing, $\frac{A_3}{p}$.

$$R = B - (U_1 + \frac{10A_2}{L} + U_2 + \frac{A_3}{P})$$ for any particular interchange.

The effect of changes in the processing environment on busy and response times can be assessed by introducing changes in the variables used in the above calculation. The test for terminal saturation during a peak transaction hour is found by the following calculation: 3600 seconds -

[(interchanges per transaction) x (interchange cost in seconds) x (transactions per peak hour)]

If the result is zero or negative, then terminal saturation is projected. Once again, it is the Workload Control terminal that is of interest here, since the arrival timing of its transaction volumes is only minimally controllable by the system user.

Tables V and VI show the results of some calculations made at the transaction level. Assumptions implicit in these calculations are

- Workload Control will primarily process work order OPENs, CLOSEs and AMENDs. This presumes use of a terminal at Materiel Control to service parts and COPARS transactions at larger bases, and a terminal at R&A for oil/gas transactions, time cards, and analytical work.

- The most costly Workload Control transaction, the work order OPEN, requires 13 interchanges and involves two work order print operations. This estimate is made based on current workings of on-line VIMS model software, and implies error-free transactions involving only single page presentations of potentially multi-page formats.

Table V shows the values of the variables used to reflect characteristics of the on-line VIMS model's processing environment together with projected minutes per transaction (verified against actual model performance), and projected throughput in transactions per hour. These results are generated by a kind of "best case" processing environment: dedicated minicomputer, reasonably high line speed, single-drop communications, etc. Table VI shows how

Table V

<u>Variables for On-Line VIMS Model</u>

In	Quantity - Units	Origin	Value
$U_{1,2}$	Human Action - Seconds	Observations	6/6
T	Terminals Per Line	Model's Equipment Configuration	1
L	Linespeed - BPS	"	2400
P	Print rate - CPS	"	475
D	Disk Access Time - MILS	"	24
A_1	Avg. Input Message - Chars.	Model's Current Software Configuration	60
A_2	Avg. Output Message - Chars.	"	250
A_3	Avg. Printer Output - Chars.	"	2000
C	Coincident Disk Demand (Beyond VIMS)	"	0
V	VIMS Priority	"	1

Calculation yields 13.84 secs/interchange + 4.21 secs/print = 3.14 minutes/transaction = 19 transactions/hour (Results validated by observation).

Table VI

Selected Variable Combinations

Case	Key Variable	Elapsed Time Per Transaction (Min's)	Throughput: Projected Transactions Per Hour	Response Time Per Interchange (sec's)
1	T=3, L=1200, P=113, C=2, V=1, D=23	4.77	12	5
2	C=4 V=1	5.00	12	6
3	C=4 V=2	5.45	11	8
4	C=4 V=4	6.37	9	13
5	D=40 + case 1	5.11	11	7
6	D=40 + case 2	5.50	10	9
7	D=40 + case 3	6.30	9	12
8	D=40 + case 4	7.90	7	20

projected on-line VIMS performance varies with some changes in its operating environment.

For cases 1-8, the variables were established to simulate a multi-programming environment (as opposed to a dedicated computer), with differing numbers of systems contending for disk access and with VIMS given a progressively lower priority. Communications variables were configured to simulate a 1200 bps line shared by three terminals. (AFDSDC/SYO's "Terminal Configuration Guide" urges that 1200bps lines be used initially with all CRT's installed at base level, and presents several configuration options incorporating shared lines.) As well, a print speed variable of 113 cps was used to simulate the 85 lpm performance of the Burroughs B9249-1 printer projected for use with the TD822 terminal. (The TD822 will be installed with MMICS increment 2 and MACARMS).

In cases 1-4, disk access time was set to 23 milliseconds, and for cases 5-8 it was set to 40 milliseconds. CAPS Report Number Nine indicates that a base DPI may be equipped with either or both of these classes of disk storage.

The last column of Table VI presents response time per interchange in seconds computed for each of the processing environments outlined above. Response time yielded by the calculation when variables are set to simulate the on-line VIMS model is 0.8 seconds which corresponds closely with the model's observed performance.

Figure 8 is a terminal sizing graph which, when used with output from the performance model, yields an estimate of the number of terminals required to OPEN, CLOSE, and AMEND work orders at bases with various fleet sizes. For example, a 500 vehicle base must be able to complete a transaction in something under five and a half minutes if a single Workload Control terminal is to suffice. Some words of caution:

- The graph assumes that all peak hour transaction loads must be processed during that hour, although some small residual loads from the peak hour could be absorbed during succeeding hours. Note: The Hanscom AFB workload profile was used in developing the graph. This profile should be validated against those of several other installations before any serious sizing decisions are made.

- The number of interchanges used to develop transaction timing is keyed to the current software configuration of the on-line VIMS model. The actual number of interchanges

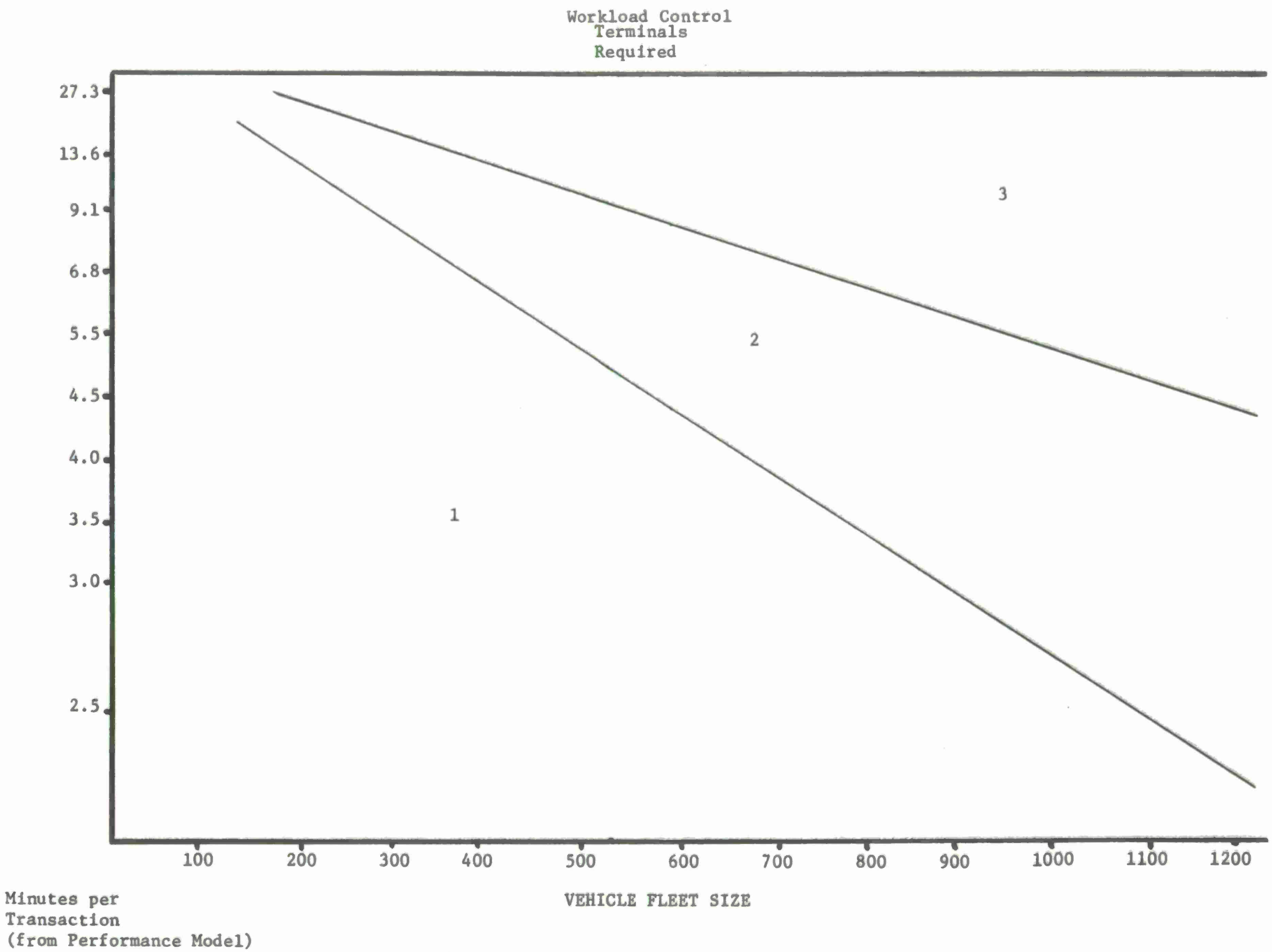


Figure 8. Terminal Sizing Graph

per work order transaction will remain unknown until design of the prototype is complete and, in fact, the design may be keyed to the minimization of interchanges if system performance estimates appear marginal.

- It's possible that local conditions may dictate use of more Workload Control terminals than the numbers suggested by the sizing graph. This would be the case, for example, at those bases operating multiple Workload Control processes in parallel at widely separated locations. These same kinds of conditions could require use of multiple terminals to perform the Materiel Control or Reports and Analysis functions at high activity bases.

SECTION V

PROTOTYPE DEVELOPMENT PLANNING

This section identifies development tasks, schedules, and costs associated with the development alternatives.

TASKS AND SCHEDULES

Identified below are the significant prototype development tasks associated with each implementation option. Tasks have been assigned to development program years without special knowledge of AFDSDC's capabilities in various technical areas or the planned interactions with other development programs (STALOG, BASE-TOP, etc.). Obviously, each task identified below may be fragmented into any number of subtasks. The projected schedules are considered tight, and can be met only through very careful planning, availability of competent and productive software personnel, and availability of adequate computer time for system development. For scheduling purposes, OLVDED is considered as a planned extension of OLVHYB for program years 4 and 5.

OLV3500: B3500-Only Implementation

Year 1 Tasks

1) Plan project (equipment acquisition, software development, file conversion, etc.), assign and brief personnel.

2) Document the current batch VIMS system to a degree permitting identification of individual functional modules and their processing characteristics. Much of this task must be completed prior to completion of 1) above.

3) Write an external functional description of OLVP (including operator procedures) and a preliminary test plan.

4) Analyze AFOLDS in its current and projected forms to determine its possible assistance in a data management role.

5) Perform communications systems analysis and prepare terminal and line specifications. (See AFDSDC/SYO's "Terminal Configuration Guide," January 1975).

6) Procure and accept terminals.

7) Based on Tasks 1) - 5), design new on-line software, and changes to the batch run. Review and document in accordance with established procedures.

Year 2 Tasks

1) Write, check out, and document software:

Modified batch run
On-line support
File conversion/installation utilities.

2) Conduct integration and first level test of OLVP equipment and software.

3) Write prototype installation and conversion Plan.

4) Design and implement user training course, and conduct user training.

5) Conduct second level (field) testing and system cutover.

6) Write transition plan in preparation for system conversion to new base-level ADPE environment.

OLVHYB: Hybrid FEP-B3500 Implementation

Year 1 Tasks

Same as OLV3500

Less:

- AFOLDS Analysis

Plus:

- FEP Procurement and Acceptance Testing
- Programmer Training (equipment, operating system, etc.)

Year 2 Tasks

1) Continue design effort begun during year 1.

2) Write, check out, and document software:

Modified batch run

On-line Support (B3500)
On-line Support (FEP)
File conversion/installation utilities.

3) Conduct integration and first level test of OLVP equipment and software.

Year 3 Tasks

1) Write prototype installation and conversion Plan.

2) Design and implement user training course, and conduct user training.

3) Conduct second level (field) testing and system cutover (hybrid implementation).

4) Plan transition to OLVDED based on observation of hybrid system.

OLVDED: Dedicated VIMS Minicomputer Implementation (Scheduled as OLVHYB Extension)

Year 4 Tasks

1) Design and implement FEP-only master file processing and file conversion software.

2) Conduct integration and first level test of FEP-only configuration.

3) Write installation and conversion plan.

Year 5 Tasks

1) Conduct second level (field) testing and system cutover

Summary

To summarize the schedules defined above:

- OLV3500 development appears to fit within a two year time frame.

- OLVHYB implementation spills into a third year because of the potentially more complex procurement problem associated with FEP acquisition, and the need to train and familiarize personnel with a new computer. An additional year is required for observation of the system in its hybrid implementation, and for design and implementation of additional FEP software.

The OLVHYB schedule could be compressed should the FEP acquisition process be shortened, or if FEP operating system software can provide extensive transaction routing/queuing services, or if the FEP can be provided with a proven centralized/generalized data management system.

Keyed to calendar years, the schedules implied above are equivalent to:

OLV3500

Start development: July, 1975
On-line: July, 1977

OLVHYB/DED

Start development: July, 1975
OLVHYB on-line: January, 1978
OLVDED on-line: July, 1979

MANPOWER REQUIREMENTS

The tasks and schedules specified above imply the use of various numbers of personnel within several labor categories. For convenience, these categories have been grouped into teams to deal with project management, software development, equipment and services procurement, system test, training and installation, and computing facilities. It is recognized that AFDSDC's organizational conventions probably do not coincide with the project organization proposed here. Whatever formal structures are employed, however, the tasks to be accomplished remain the same.

Table VII defines the man-loading and labor categories associated with each of the development options.

Table VIII indicates team phasing and man-loading totals across development program years.

Table VII

Development Manpower

SYSTEM DEVELOPMENT TEAMS	OLV3500	OLVHYB/DED
Project Management		
Managers	2	2
Clerical	1	1
Software Development		
Software Supervisors	2	3
Functional Consultants/Liaison	2	2
Programmers	5	8
Clerical	2	3
Equipment/Services Procurement		
Technicians	2	4
Clerical	1	2
System Test, Training, and Installation		
Supervisors	1	1
Training Specialists	2	2
Programmers	2	3
Clerical	2	2
Computing Facilities		
Supervisors	-	1
Computer Operators	-	2
Equipment Maintenance	-	2
TOTAL	24	38

NOTE: Actual numbers of individuals required should be smaller than indicated totals since multiple roles may be assumed by a single individual during succeeding phases of the project.

NOTE: More STT&I teams would be needed should plans call for parallel installation of the prototype at multiple bases.

Table VIII

Manpower by Development Year

DEVELOPMENT YEAR	1	2	3	4	5
Project Management	3	3			
Software Development	11	11			
Equipment/Services Procurement	3				
System Test, Training, and Installation		7			
Computing Facilities					
TOTALS OLV3500	17	21			
Project Management	3	3	3	3	3
Software Development	16	16	16	16	
Equipment/Services Procurement	6	6			
System Test, Training, and Installation			8		8
Computing Facilities		5	5	5	5
TOTALS OLVHYB	25	30	32	24	16

OLVDED

EQUIPMENT REQUIREMENTS

In addition to the B3500, an OLV3500 implementation would require two basic terminals, while the OLVHYB and OLVDED configurations would require addition of an FEP minicomputer:

Basic Terminal (CRT Keyboard and Printer)

Data Rate: 1200-2400 bps

Screen Capacity: 2000 chars (with full screen buffer and protected fields feature)

Print Rate: 165-200 chars/sec

FEP Minicomputer

Main Memory: 32-64K bytes

Secondary Memory: 20 megabytes, removable disk storage

Standard Peripherals: Console, Tape and Card I/O, Line Printer

COSTS

Equipment cost estimates were derived from the Auerbach Reports, vendor literature, and the SADPR-85 final report (Support of Air Force Automatic Data Processing Requirements through the 1980's, Vol. 3, Technology: Electronics Systems Division, Air Force Systems Command, June 1974).

The costs shown below reflect a predicted decline: those quoted in the total program cost summary (Table IX) are the maximum estimates for 1975.

	Purchase Cost 1975	Purchase Cost 1977
Basic Terminal	\$3,000 - \$6,000	\$2,000 - \$5,000
FEP Minicomputer	\$65,000 - \$100,000	\$50,000 - \$75,000

Table IX summarizes total program costs by option by development year. Personnel costs are developed from the man-loading totals presented in Table VIII and a man-year cost factor of \$10,400 (STALOG precedent). Costs of a conditional B3500 disk storage upgrade described earlier are not included in these totals.

Table IX

Total Prototype Development Program Costs

Development Year	OLV3500			OLVHYB			OLVDED*		
	Equip.	Pers.	Tot.	Equip.	Pers.	Tot.	Equip.	Pers.	Tot.
1	$12,000	$176,800	$188,800	$112,000	$260,000	$372,000	-	-	-
2	-	218,400	218,400	-	312,000	312,000	-	-	-
3	-	-	-	-	332,800	332,800	-	-	-
4	-	-	-	-	-	-	-	$249,600	$249,600
5	-	-	-	-	-	-	-	$166,400	$166,400
TOTAL	$12,000	$395,200	$407,200	$112,000	$904,800	$1,016,800	*-	$416,000	$416,000

* OLVDED would utilize equipment procured for OLVHYB. Personnel costs are in addition to those for OLVHYB.

APPENDIX I

ON-LINE VIMS WORKLOAD PROJECTION

This Appendix describes in detail the methods used to forecast on-line VIMS prototype workloads to be processed by the B3500 computer. Projections made here should also be valid for computers incorporating processors and disk I/O configurations similar to those of the B3500.

Figure 9 provides a guide to the workload estimation process. Of the variety of possible measures, direct time hours (DTH) was selected as most convenient for use in VIMS workload projection. A B3500 operational use hour (OUH) is composed of DTH, that fraction of time during which work is being done by or for specific data systems, and prorated time hours (PTH), that remaining fraction which is overhead time not chargeable to specific systems, yet assigned to all on a prorated basis as a function of the job mix. A data system's OUH demand per some unit time at a specific DPI can be calculated by estimating DTH, as is shown below, and inflating this value by some measure of PTH based on the DPI's history of "percent direct," a statistic available through B3500 accounting routines. It is necessary to convert DTH to OUH in this fashion since DPI saturation is calculated on an OUH basis.

The objective, then, was to develop a method to calculate projected on-line VIMS DTH using some independent variable, add PTH, and test for OUH saturation. Vehicle fleet size seemed to be a sensible independent variable since on-line VIMS will process many transactions corresponding on a one-to-one basis with specific vehicles, each transaction incurring a cost in DTH. As requested, AFDSDC/SY provided several regression analyses (LGT cover letter 18 October 1974) indicating the relationships between vehicle fleet sizes and DTH, PTH, cards read/punched, disk I/O's and other potential workload measures. The analyses were made using B3500 accounting data gathered at 24 bases during the months of June and July, 1974. These provided two linear equations showing the relationship between <u>fleet size</u> and <u>monthly DTH</u> for the current <u>batch mode VIMS.</u> The equations are of the form

$$Y = a + bX$$

where

Y is the dependent variable, monthly DTH,

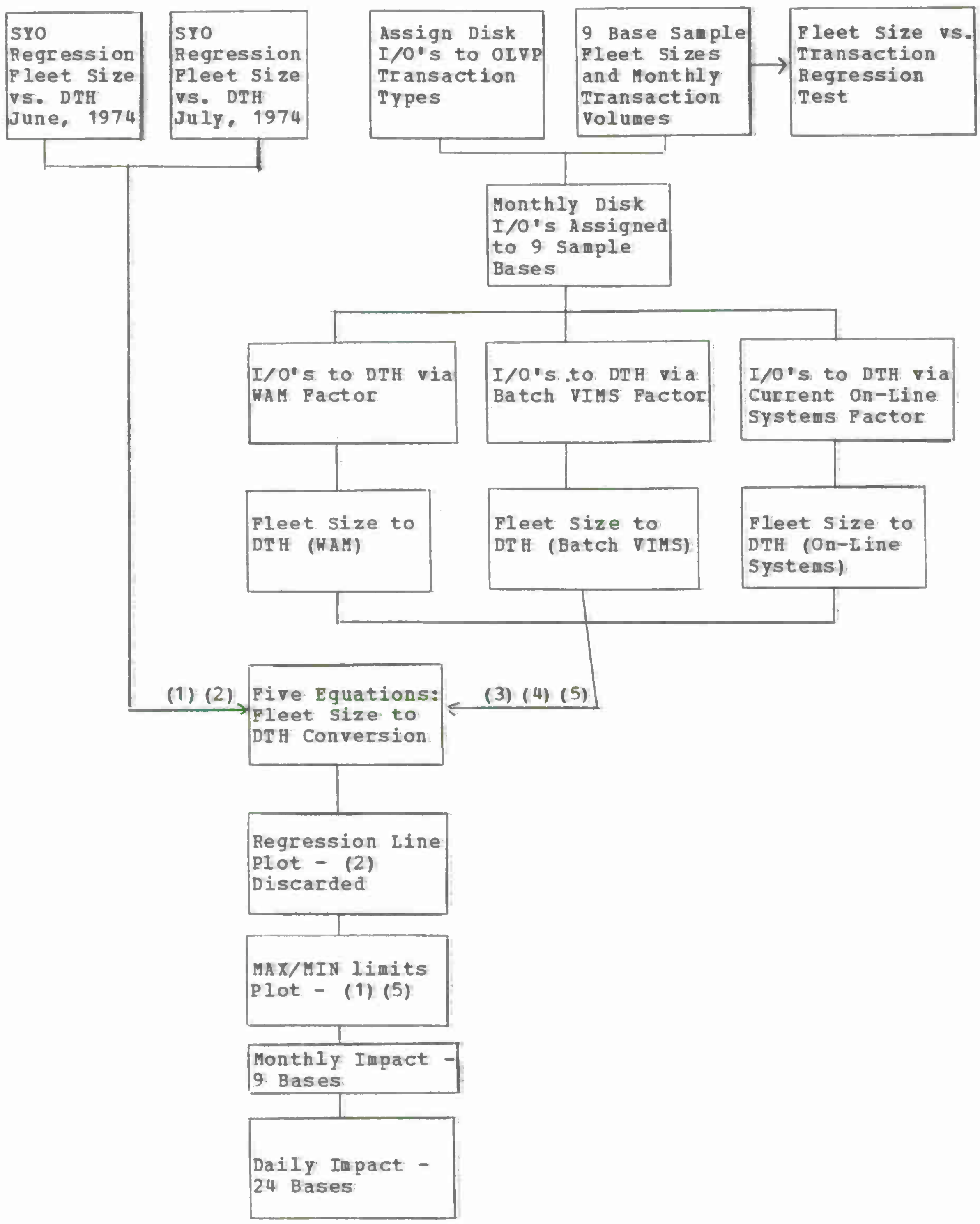


Figure 9. Overview: OLVP Workload Analysis

X is the independent variable, vehicle fleet size,

a is the Y value at the point where the regression line described by the equation intercepts the Y axis, and

b is slope of the regression line, the value by which Y increases per unit increase in X.

Figure 9 indicates that the two equations (one based on June, 1974 data, the other based on July data) were incorporated directly into a list which later grew in size to five entries. Because these two equations were derived from observations of batch processing rather than on-line processing, and because the July data was suspect (for reasons given below), it was determined that a second set of equations was needed incorporating an on-line, transaction processing orientation.

The scheme chosen to develop the second set was based on the apparent close relationship between DTH and physical disk I/O's performed per unit time as demonstrated by current VIMS batch processing on the B3500. (A regression analysis yielded a correlation coefficient of .95 using monthly DTH and disk I/O data from 23 sample bases.) In brief, the objective was to assign a number of disk I/O's required by each on-line VIMS transaction type, convert these to a corresponding DTH value using several different methods, and by means of subsequent regression analyses relate vehicle fleet size to the DTH values thus developed. These could then be used as a basis from which to project monthly and daily workloads generated by fleets of various sizes.

The point of departure was a tabulation of monthly batch VIMS transaction volumes gathered from nine sample bases whose fleet sizes ranged from 387 to 1197 vehicles (both registered and non-registered). See Table X. The suspected correspondence between fleet sizes and total batch transaction volumes was confirmed through a regression analysis which yielded a correlation coefficient of .95. (Transaction totals per base included only those applicable to on-line VIMS: FZ, WZ, SZ, NZ, PZ, EZ, QZ, MZ, and GZ)

It was then necessary to assign numbers of disk I/O's to each on-line transaction type. This was done in an arbitrary fashion using a single set of assignment ground rules. Each transaction type was analyzed to identify the data file read/write operations it required; it was assumed that access to each file would require use of three-level indices (two of these disk-resident); it was assumed that each message generated by a transaction (number arbitrarily assigned) would be logged on disk and subsequently logged off to magnetic tape. The I/O's per the 20 odd on-line transaction types (the sum of data file reads/writes, index fetches, and message logging) ranged from 11 to 27 with a mean of 19. (The mean I/O per transaction estimate of 19 seems reasonable when one considers that 23 is the mean number of I/O's per transaction associated with the current B3500 on-line systems serving the personnel, accounting and finance, and civil engineering functional areas.) The following procedure was used to derive total monthly I/O tallies for each of the nine sample bases.

For each base, the 10 most frequently occurring on-line transaction types, accounting for 90 percent of total volume, were summed and augmented by 10 percent of the sum to account for infrequently occurring types. This sum was multiplied by 19 (mean number of I/O's per transaction) and this I/O total was arbitrarily inflated by 50% to allow for growth and contingencies (disk activity of the B3500 operating system in support of VIMS, periodic checkpointing operations in support of a system restart capability, etc.). See Table X.

These monthly I/O volumes for the nine sample bases were the common departure point for three separate I/O-to-DTH conversion procedures proceeding from three different data sources: a disk I/O conversion coefficient incorporated in the Workload Analysis Model (WAM-Operations Research Division, Directorate of Systems Technology, AFDSDC), a coefficient derived from observation of batch VIMS operations, and a coefficient derived from observation of current on-line systems.

Section III of WAM Report #2 (OR Project All-72, November 1972, AFDSDC/SYO) presents several equations used by the model to forecast direct time from a number of combinations of I/O operations (lines printed, cards punched, etc.). One of these equates one hour of direct time to 71,200 physical disk I/O's, based on one month's worth of DTH and I/O's observed at 25 B-level DPI's.

The batch VIMS conversion factor was derived from a regression analysis incorporating data from 23 bases gathered during June of 1974. The on-line system conversion factor was produced via regression analysis using on-line activity data gathered during September of 1974 at the same bases.

The conversion algorithms developed from the sources identified above are:

- (WAM Constant)

Table X
Fleet Sizes and Monthly Transaction Volumes

For Nine Sample Bases (From STALOG's Source Data

"Base Collection Files" Processes
B34-35)

Base	Fleet Size*	Monthly Transactions**	Projected Monthly Disk I/O's***
Davis-Monthan	1037	13,230	414.7
McGuire	1150	13,350	418.5
Shaw	1197	11,000	344.8
Whiteman	614	6,800	213.2
Grissom	564	5,200	163.0
Randolph	645	6,475	202.9
Castle	434	4,000	125.4
Lowry	387	4,300	134.8
Hanscom	475	3,600	112.8

*NOTE: Includes both registered/non-registered vehicles.

**NOTE: Transaction volumes reflect only those types applicable to on-line VIMS: FØ, WØ, SØ, NØ, PØ, EØ QØ, MØ, GØ.

***NOTE: Expressed in thousands, where

Total I/O's =
(110% transactions)(28.5 I/O's)

$Y = 0 + .014045X$

- (Batch VIMS)
  $Y = -.02709 + .0065X$

- (Current On-line Systems)
  $Y = -.88219 + .01137X$

(Where Y is monthly DTH, and X is monthly disk I/O's expressed in thousands.)

Each of the three sets of nine DTH data points was associated with fleet size data points for each of the nine bases to produce regression equations (3), (4), and (5) of the following list. As mentioned above, equations (1) and (2) were produced by AFDSDC/SYO's regression analyses based on June and July 1974 observations.

(1) $Y = .63327 + .00338X$
$r_2 = .45$ $2S_{yx} = 2.09614$
VIMS Batch, 24 Bases, June 1974

(2) $Y = .00574 + .00720X$
$r_2 = .72$ $2S_{yx} = 2.55468$
VIMS Batch, 24 Bases, July 1975

(3) $Y = -.43691 + .00512X$
$r_2 = .91$ $2S_{yx} = 1.10790$
Projected on-line workload, I/O-to-direct time conversion via WAM constant

(4) $Y = -.22554 + .00241X$
$r_2 = .91$ $2S_{yx} = .51402$
Projected on-line workload, I/O-to-direct time conversion via batch VIMS coefficient

(5) $Y = -1.05125 + .00409X$
$r_2 = .85$ $2S_{yx} = 1.17722$
I/O-to-direct time conversion via on-line systems coefficient

Figure 10 shows a plot of the regression lines represented by the five equations. The lines appear to cluster together in an encouraging way. For a fleet of 600 vehicles, for example, the maximum and minimum DTH values as projected by equations (2) and (4) are 4.25 and 1.25 hours respectively. Given a mean processing load (24 base sample) of 171.47 DTH per month, the difference between these values becomes insignificant.

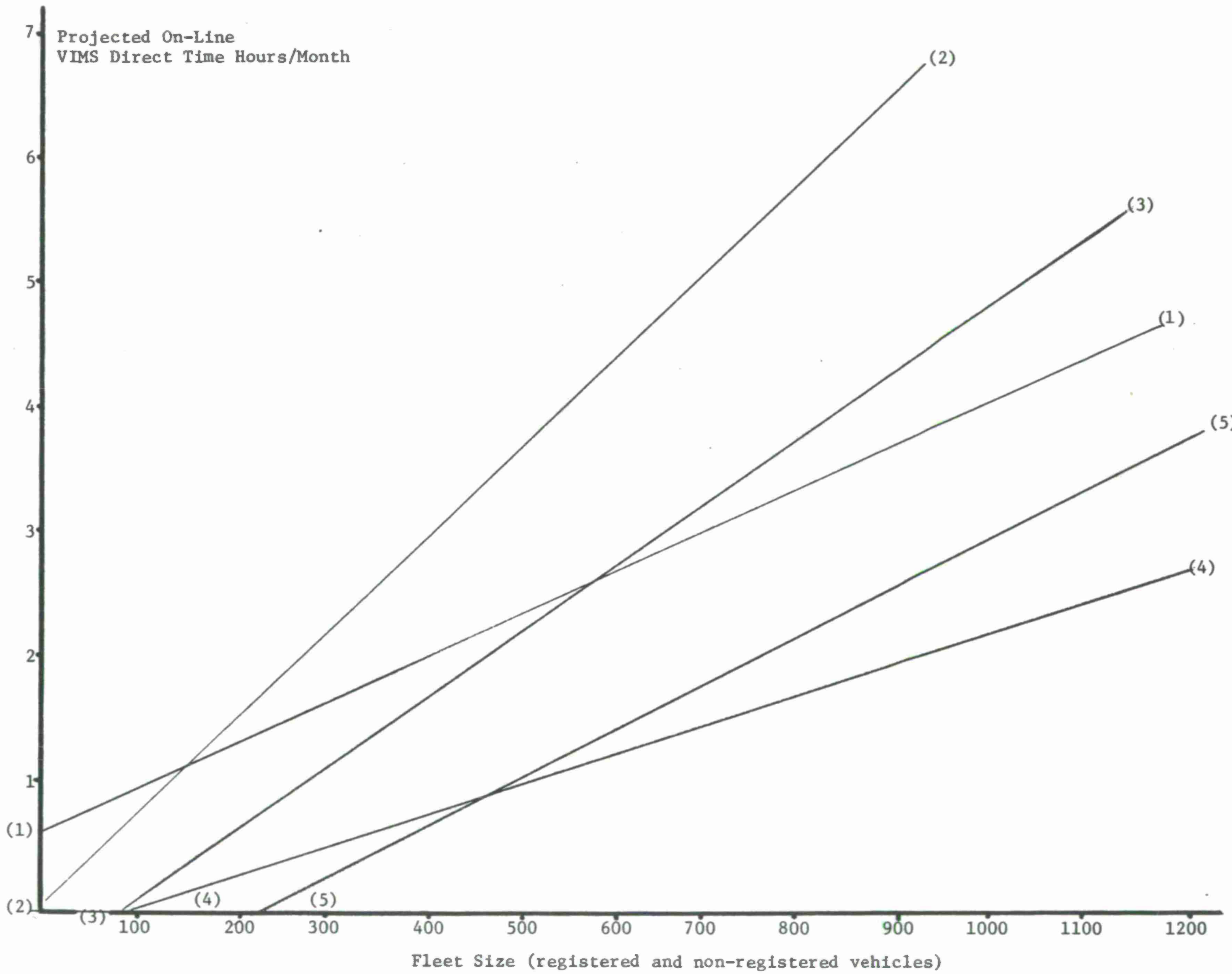


Figure 10. Projected On-Line VIMS Direct Time Hours Per Month

There are grounds for disqualification of equation (2), based on irregularities in the July 1974 data from which it was derived: the July data includes processing for the April - June quarter, a one-time effort to convert management codes for all vehicles, and a one-time upload of the CAFVIMS data base. (See AFDSDC/LGT letter of 18 October 1974.) Discarding equation (2), the picture improves nicely, given the small dispersion of the remaining regression lines, particularly in light of their diverse origins.

Figure 11 shows the maximum and minimum value envelope where the dashed lines represent two times the standard error of estimate for equation (1) on the high side and for equation (5) on the low side. (Given a normal distribution of points, the : 2Syx bands on either side of a regression line designate an area within which 95 percent of all points should fall.) The extent of the envelope is obviously exaggerated since scope is permitted for negative DTH for fleet sizes of less than 600.

Table XI summarizes the impact of on-line VIMS processing on the workloads of 20 sample bases projected, via the CAPS Report, for June of 1976. The CAPS baseline data is presented first, followed by projected on-line VIMS OUH. A worst case monthly DTH value was selected for each fleet size from along equation (1)'s 2Syx parallel and converted to monthly OUH by use of a "percent direct" value of 18.8. This figure represents the mean direct time component of the OUH totals for on-line systems observed at 24 bases during the month of September 1974. For the 20 base sample, a mean increase in workload of six percent was projected.

The negligible workload increase attributable to VIMS as shown by the monthly analysis may be misleading since competition for on-line computer resources is not spread uniformly and cooperatively across a month but takes place instantaneously and randomly. Coincidence of demand can create a momentary saturation whose externally perceptible symptom would be an increase in response time of on-line systems. There is no instantaneous resource demand baseline available for the on-line systems operating today with which on-line VIMS will have to compete. The next best measure appears to be a daily, on-line shift baseline, but even this can be misleading since workloads must be distributed uniformly across daily boundaries.

Table XII presents daily analyses derived from extreme DTH values (corresponding to fleet sizes) which lie along the 2Syx parallels of equations (1) and (5). Projected daily on-line VIMS OUH were calculated by inflating monthly DTH by the 18.8 "percent direct" factor and dividing by the number of on-line days in the

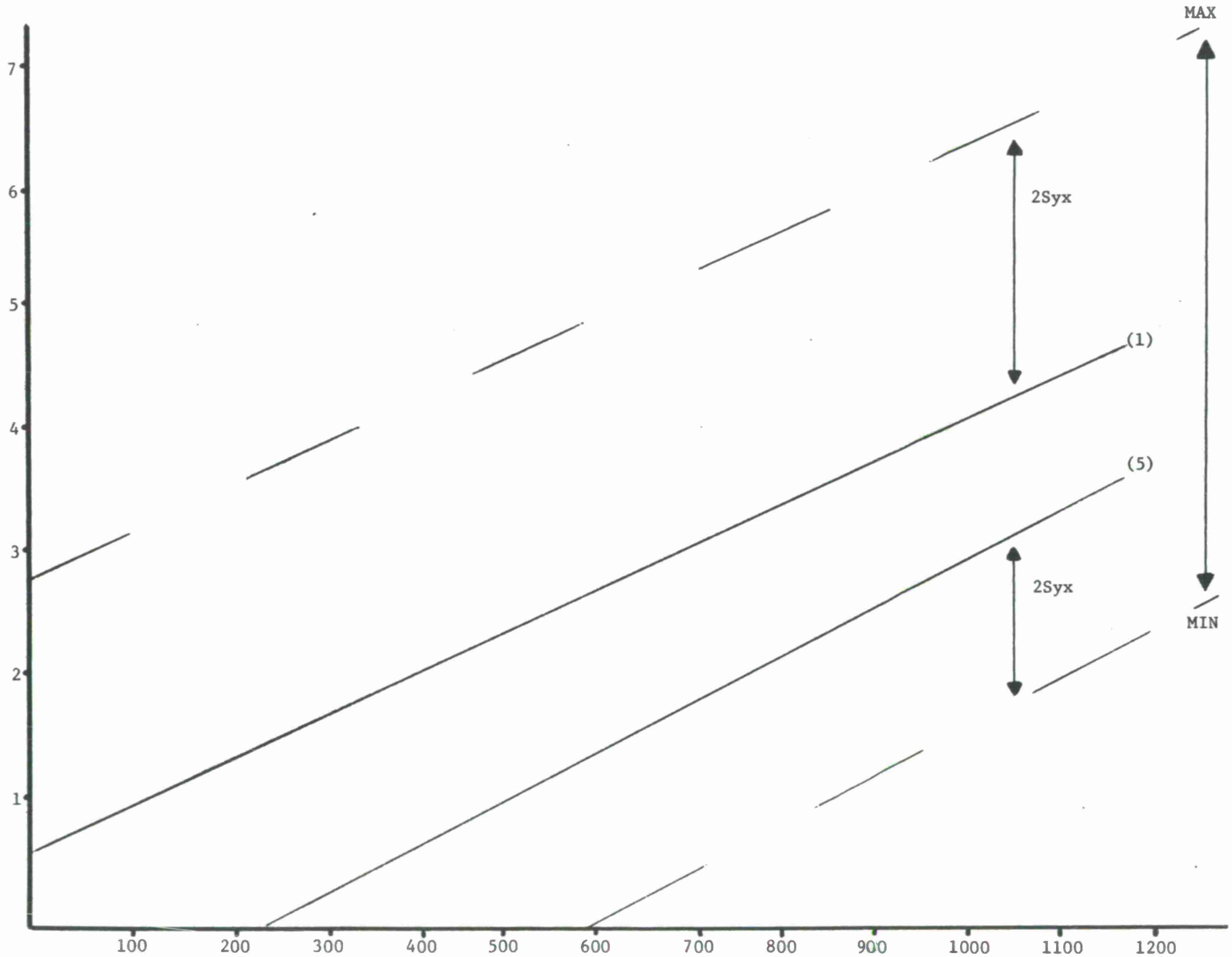


Figure 11. Projected DTH: Max/Min Envelope

Table XI

Monthly Impact of On-Line VIMS

Summary: 20 Sample Bases

	Fleet Size	June 1976 Baseline (CAPS Nine)			VIMS OUH Workload	Percent Increase	Percent Utilized with VIMS
		Max OUH Workload	Projected Workload	Percent Utilized			
Max	1197	663	612	95	39	7	99
Min	235	601	421	65	19	4	69
Mean	724	641	496	77	28	6	82

Table XII

Daily Impact of On-Line VIMS

Summary: 24 Sample Bases

	Sampled On-Line Days	Fleet Size	Mean Daily On-Line OUH	Projected Daily VIMS OUH	Total	Percent Increase
Equation (1) - Maximum VIMS OUH Values						
Max	27	1191	4.87	1.88	6.07	52
Min	15	235	2.76	.78	4.03	17
Mean	20	600	3.94	1.21	5.15	31
Equation (5) - Minimum VIMS OUH Values						
Max	27	1191	4.87	.59	4.92	14
Min	15	235	2.76	-	-	-
Mean	20	600	3.94	.22	3.94	6

NOTE: Max/Min/Mean values are summarized from the 24 base tabulation on a Column basis. The figures shown above have no particular relationship on a row basis.

reporting period for each base. Results indicate a mean OUH demand increase during the on-line shift of from 15 minutes to an hour and 15 minutes. The mean percentages of increase of six and 31 should not be interpreted as increases in on-line system response time since resource demands, and therefore instantaneous saturation conditions, could occur randomly.

CONCLUSIONS

To the extent that the monthly and daily resource demand baselines can be trusted as reasonably accurate, and in the absence of additional high activity on-line systems in the future, it appears as if the operation of an on-line VIMS prototype will not dangerously threaten saturation of B3500 resources during the on-line shift except at those DPI's needing upgrade which operate today in a condition of marginal saturation.

When interpreting the results of the prototype on-line VIMS workload analysis, one must recall certain features in the method used:

1. As with any correlation-based forecast, the equations derived represent an idealized best fit of a line to what may actually be widely dispersed data points. In any case, valid estimates of the dependent variable (workload expressed as monthly DTH) can be made only when employing values of the independent variable (vehicle fleet size) which lie between the extremes observed when constructing the regression line. That is, the equations presented above can yield valid workload estimates only for the cases where fleet size lies between 400 and 1200.

2. Although a generous sample of bases (24) was available for calculation of DTH and physical disk I/O quantities, only a limited sample (9) could be used to calculate transaction oriented data. However, the sample did contain a representative spread of fleet sizes and demonstrated excellent correlation between fleet sizes and transaction volumes, confirming what had been an intuitive assumption.

3. The assignment of disk I/O's to on-line transactions was arbitrary and represents a best guess only in the absence of a preliminary system design. By the same token, arbitrary assignment is consistent. Note also that a 50 percent expansion factor was added to the I/O total of each sample base.

4. Use of a "percent direct" value of 18.8 percent for conversion of DTH to OUH is not entirely realistic since the value actually varies from base to base and, for any one base, can vary over time. In its favor, the figure describes observed performance of on-line systems at 24 bases during the month of September, 1974.

5. The monthly and daily workload baselines and VIMS projections are likewise not entirely realistic since they were of necessity spread uniformly across units of time. Hopefully, however, any errors introduced were made on the high side since care was taken to add a 50 percent I/O expansion factor and to develop the monthly and daily analyses from data lying along the extreme boundary of the workload envelope.

6. Installation of high activity on-line systems in the future will invalidate the workload baseline assumptions used above and thereby invalidate judgements made as to on-line VIMS' potential for B3500 saturation. (The daily analysis utilizes a baseline corresponding to current on-line workloads at 24 bases. The monthly analysis uses baseline data projected by CAPS Report Number Nine for June, 1976, which presumably accounts for the incorporation of anticipated new systems prior to that time.)