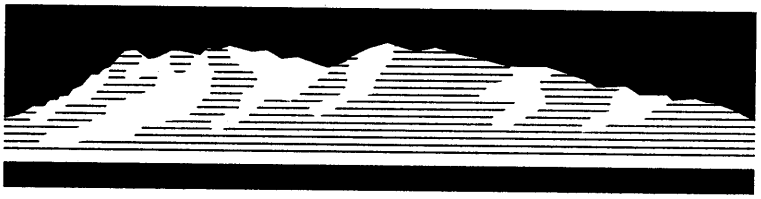

Cheyenne

EXECUTIVE SUMMARY

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John C. Gyllenhaal 9 Nov 87

Responsible Engineer/Manager *Date*

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PRISM Systems
Cheyenne Executive Summary

At Exit from Phase 0

Revision number: 1.0

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Preface

Scope of this document

This document is an overview of the Cheyenne database server program, giving the reader a basic understanding of the program at Phase 0 exit. This document primarily describes the Cheyenne target market, the requirements of that market and the financial analysis of the program at Phase 0.

Associated Documents

- Cheyenne Master Documentation Plan
- Cheyenne Market and Product Requirements Document
- Cheyenne Business Plan
- Cheyenne and Glacier Sales Impact Statement
- Cheyenne Alternatives and Feasibility Statement
- Cheyenne and Glacier Manufacturing Impact Statement
- Cheyenne Customer Services Impact and Requirements Document

Change History

Date	Issue #	Description
Nov. 5, 1987	0.5	Cheyenne Preliminary Executive Summary
Nov. 18, 1987	0.6	Incorporated Review Comments
Nov. 20, 1987	1.0	Phase 0 Version

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1 Introduction

Cheyenne is DIGITAL's response to the major challenge of meeting the needs of the OLTP marketplace. DIGITAL's success in hardware, software and networks has gained DIGITAL customers in all of the major enterprises; each of the Fortune 100 companies, all of the major government agencies, and every major educational institution.

With each of those customers a major application area has, for the most part, eluded us. That area is high-performance, production, on-line transaction processing (OLTP). Success in the OLTP area has the potential for major rewards. Market size estimates show OLTP is a $30 billion market in 1987 alone, and growing faster than the computer industry as a whole. Managing OLTP-class applications provides a computer vendor the rewards of being a strategic partner with OLTP customers and of opening many other application areas.

These rewards, however, do not come without an entry price and a good deal of risk. The nature of OLTP applications for most customers is "you bet your business" and as such have stringent requirements. The competitive environment is also stringent and demanding. IBM has made OLTP one of the main-stays of its business from product, account management and revenue stand-points. Estimates are that IBM owns 75% of the OLTP business today.

The requirements for OLTP products — availability, data integrity, performance, capacity and price /performance — demand that a vendor produce a highly integrated hardware/software solution to be competitive. Cheyenne gives DIGITAL the opportunity to build a product that meets the OLTP requirements, a product with capabilities that do not currently exist in any other DIGITAL product today.

Presented in this and related documents, is the full range of information about Cheyenne at Phase 0 exit. Cheyenne is built on the PRISM architecture, and integrates advanced database management and operating system software with hardware. The requirements of the OLTP market are driving the Cheyenne design; the opportunity to make optimal hardware/software and database/operating system trade-offs is being fully exploited.

Cheyenne represents not only a strategic opportunity for DIGITAL, but a sound financial investment as well. This document summarizes a revenue plan of $8 billion for the 1990s, generating 23% profit before taxes and 31% internal rate of return. Yet this represents only a conservative 5% of the OLTP market, with 1200 systems installed during the 1990s time frame. Cheyenne does not represent all OLTP revenue for DIGITAL, but it is a critical element of DIGITAL's OLTP strategy and solution; other elements of the OLTP solution are VAX hardware, storage, and software for relational databases, OLTP, and applications.

As DIGITAL moves into the 1990s, the PRISM architecture provides the foundation to meet the increasing demands of the computing market and the increasing capabilities of the competition. Cheyenne builds on the PRISM foundation, combining the Rock hardware, Mica operating system, and Quartz database software to give DIGITAL a product that can evolve from special to general purpose to meet the requirements of the OLTP and end-user information management (EUIM) market of the 1990s.

1.1 Cheyenne System Definition

A Cheyenne database server consists of:

- Rock hardware
- Mica operating system
- Quartz database software
- Software distribution device
- Disks and controllers

A Cheyenne database server may include multiple interconnected Rock systems and optional I/O subsystems to provide high availability and greater capacity.

1.2 Cheyenne Program Goals

There are many goals, detailed throughout the plans, that define success for Cheyenne. A summary of the major goals at Phase 0 are:

- Market - Provide access to, and achieve significant penetration in, the lower 75% of the OLTP Market.
- Competitive - Provide a leadership product versus IBM and Tandem in terms of reliability, availability, service, price/performance and database functionality.
- Product - provide 100% Data Integrity - configurable for 100% availability - provide scaled performance from 100 to 600 TPS - provide a fully DSRI compliant database server family
- Schedule - FRS in Q2 FY91
- Financial - Internal Rate of Return 30% - Profit Before Tax 17%

2 Database/OLTP Strategy

DIGITAL's Database/OLTP strategy is to achieve leadership by continued improvement in meeting the needs of the end-user information management (EUIM) market, and by providing products that will enable DIGITAL to make a successful entry into the high performance OLTP marketplace.

DIGITAL has developed and sold database products for a significant number of years. DIGITAL products are used for OLTP today. VAX systems running Rdb/VMS, DBMS and ACMS have met the needs of some number of applications. Customized solutions have also been built to provide OLTP for an additional number of customers. Use of third-party software products, like INTACT (soon to be a DEC product) have solved still another number of customers' TP problems. The majority of these installations have been in the lower performance and database size range, and have been in environments that do not require extremely high integrity, availability and reliability.

The current set of database products, VAX Rdb/VMS and VAX DBMS, will continue to be the basis for DIGITAL's database offering for the VAX/VMS environment. VAX Rdb/VMS will be enhanced to meet the needs of applications in the lower to mid-range of database and OLTP applications. Enhanced distributed capabilities, enhanced performance and support for larger databases, as well as enhanced tools and languages will be the focus of continued development activities. VAX-based tools and applications, including transaction processing monitors (TPM), will be the "front-end" to Cheyenne servers at first release.

Cheyenne will provide DIGITAL access to a greater share of the OLTP market by providing high availability, reliability, data integrity, high performance, and accommodation of databases of up to 250 gigabytes. PRISM has been selected as the architecture for Cheyenne based on its ability to support these requirements, and the price/performance requirements of the high-end OLTP and EUIM markets.

Database support for OLTP will be provided by both VAX Rdb/VMS and Cheyenne. OLTP and decision support applications range from very low transaction per second (TPS) and database size requirements to hundreds of TPS and gigabytes of storage capability. The positioning for VAX Rdb /VMS and Cheyenne will be based on these two factors, database size and TPS. VAX Rdb/VMS will cover the low-end up to ~150 TPS and 100 GBs, and Cheyenne will start at ~100 TPS and cover the applications up to 600+ TPS. VAX Rdb/VMS and Cheyenne will be used together in a DIGITAL network.

3 Market

DIGITAL has made a commitment to succeed in the OLTP market. This market represents a huge opportunity, virtually untapped by DIGITAL. Estimates vary, but our somewhat conservative projections show the OLTP market to be almost $40 billion in 1990, of a total EDP market of $225 billion. The OLTP market is assumed to continue growing at a CAGR of 9% a year.

The OLTP market has stringent requirements which will become more stringent over time. The requirements of these customers and applications may be characterized by the following categories:

- Data Integrity, Availability and Reliability
- Performance
- Database Size
- Price/Performance
- Tools
- Support
- Vendor Reputation

The first three categories define the basic characteristics that determine what vendors and products can even be considered for various OLTP applications. The later categories work together with the first three to provide a competitive differentiation.

The challenge ahead, for Cheyenne and related OLTP products, is to meet the basic needs that allow us access to 75% of the OLTP market (as a % of revenue). 75% has been targeted as a corporate goal. The top 25% of the market represents an extremely small number of installations, with extremely rigorous product and support requirements. Success in the very top end of the market would be high-risk and involve a great deal of highly specialized engineering, sales and support investment, and has not been targeted.

In the FY91 time-frame access to 75% of the OLTP market this has been defined to be:

- Performance 600 Transactions per Second
- Maximum Database Size 250 GB (net user data)
- Integrity 100%
- Availability 99.95-100%

(See the supporting documents for a precise definition of terms) To win the business, our competitive edge will be provided by the high quality of our products, a price/performance advantage, the richness and range of tools (for application development, end-users and systems management), the general ease-of-use and productivity of our products, and the competitive advantages of DIGITAL's "total enterprise" networked solutions. The price/performance target we have set positions us versus the major competitors, IBM and Tandem. Our goal is to be at Tandem's price/performance and significantly below (> 20%) IBM's price. (Price/performance is expressed in $K/TPS.)

3.1 Market Size and Forecast

The OLTP market is extremely large and growing. Current market sizing estimates the market to be $30 billion in 1987 and growing at a rate to support the following projections for the 1990s. The Cheyenne forecasted share of the OLTP market, and resulting revenues, are quite conservative at this stage of the project. The underlying assumptions will be re-evaluated on an on-going basis.

3.1.1 OLTP Market Size

DIGITAL's "1987 Engineering PBU Market Model - Extended Forecast" provides the projection shown in Table 1 of the total EDP revenue for worldwide manufacturers' sales. This model is being used due to its wide acceptance throughout DIGITAL and is included here to provide a context for the OLTP revenue forecast that follows.

Table 1: Total Worldwide EDP Revenue, 1990-1996

	Total Worldwide EDP Revenues ($Billions)							
	1990	1991	1992	1993	1994	1995	1996	CAGR
Grand Total	225.2	249.3	271.9	292.0	309.6	324.9	337.9	7.0%

There are several sources of OLTP market size estimates. From these, Dataquest's was chosen because it is in agreement with the "1987 Engineering PBU Market Model" and is more conservative than all of the other sources.

Table 2 shows Dataquest's worldwide OLTP market estimate.

Table 2: Total Worldwide OLTP Revenue, 1990-1996

	Total Worldwide OLTP Revenues ($Billions) (Source: Dataquest)							
	1990	1991	1992	1993	1994	1995	1996	CAGR
OLTP Revenues	38.5	42.9	47.3	51.7	56.1	60.5	64.9	9.1%

3.1.2 Cheyenne Target Industries

According to Dataquest, banking, finance, and manufacturing are the three largest industries in the OLTP market and represent over 50% of the OLTP market. We have targeted these industries, and will optimize our OLTP solutions to meet their requirements. However, we will take every opportunity to insure our solutions are competitive in other industries as well.

3.1.3 Cheyenne Forecast

The Cheyenne Revenue and Unit forecasts, shown in the following tables, are based on projected market sizings for the EUIM (Ad Hoc) and OLTP markets.

The World-wide OLTP Revenue Table 2 is used as a starting point, and defined or discounted by the following assumptions:

- Performance range of 100 to 600 TPS defines the market segment addressed
- Gartner Group discounting factor for entrance to a new market
- Target Industry % of Market
- DIGITAL's experience in penetrating new market (discounting factor)

Similar factors have been applied to the EUIM market. These assumptions have resulted in the following revenue/market share forecast.

Table 3: Market Sizing

Description	FY91	FY92	FY93	FY94	FY95	FY96	FY97
Addressable Market Size ($ Millions)							
EUIM	1081	1193	1303	1412	1517	1621	1718
OLTP	3735	4546	5308	5998	6576	7225	7766
Forecasted DIGITAL Market Revenue ($ Millions)							
EUIM	11	36	182	325	228	130	69
OLTP	37	136	743	1379	986	578	311

The ASV is the weighted average, based on projected sales distributions, of the MLPs for small, medium, and large configurations.

Table 4 shows ASVs and unit ship forecasts for Cheyenne.

Table 4: Cheyenne Average System Values and Unit Forecast

Description	FY91	FY92	FY93	FY94	FY95	FY96	FY97
Average System Value ($K) Without Front End	4413	5230	4929	4427	3996	3607	3258
Unit Forecast							
EUIM	2	6	35	69	54	34	20
OLTP	7	25	142	292	232	151	90
Total	9	31	177	361	286	185	110

Also making a major contribution to Revenue is upgrades to the initial system configurations. The Cheyenne System is configured such that processor and memory boards, and storage devices may be easily added to upgrade using the base system cabinetry.

3.2 Market Requirements

There are numerous requirements in this market, ranging from product to service and support. The requirements fall into two major categories, those that allow entry to a particular segment of the market, and those that allow for competitive differentiation within market segments. This section discusses the key requirements for our target customers.

3.2.1 Data Integrity, Availability and Reliability

These categories are closely interwoven. It is not possible to derive the maximum benefit from any of these categories without support from the other three. For many customers, this category dictates their purchase decision. They must be assured (reality or perception) that their data is "safe", and that their systems will be available for use.

Data integrity is freedom from any change in data that is not requested by the user and is not detected by the system, or when detected, is not recoverable through some corrective action of the hardware, software or operations staff.

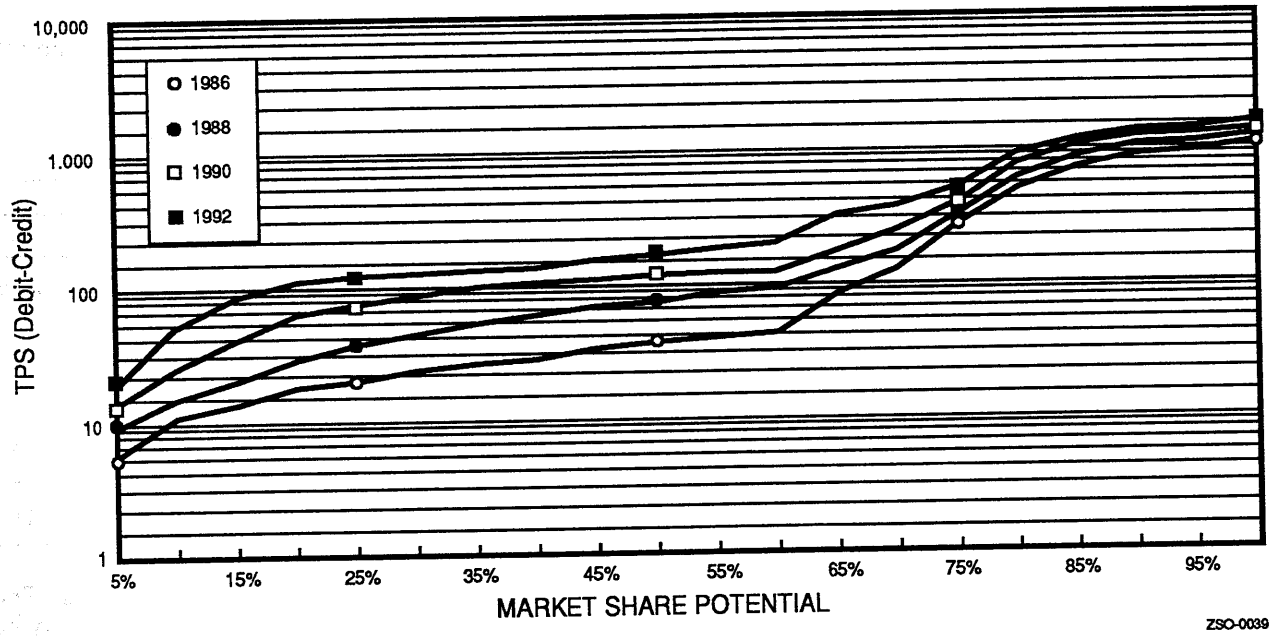
Availability, to a customer, means that the system is ready and capable of being used. The factors that effect availability are (1) the rate of failure and (2) the time needed to recover from the failure.

Reliability is an element of availability. Poor reliability (failure of a component), causes costs of service to be higher and adds risk that availability or data integrity goals will not be met.Serviceability is the ease with which failures can be removed from the system and upgrades and enhancements can be made to the system. It influences the cost of service and the system availability.

3.2.2 Performance

Through several meetings with Arthur Andersen and the Gartner Group, each individually forecasted the percent of the OLTP market accessible in terms of performance over years. Performance is expressed in terms of Debit-Credit transactions that are described in the *Cheyenne Business Plan.* These two sets of inputs were then averaged, resulting in the information shown in Figure 1.

Figure 1: Performance Requirements by Market Revenue Access



The performance levels shown are for a single, tightly coupled computer system, including clusters. The performance level is the aggregate requirement of one or more applications making requests against one or more databases that exist on one logical database system. A logical database system is one or more physical database systems that appear as one. The solution may be one or more products to cover the TPS range as long as it is cost effective across the range.

Low variability of response time is also important. This specifies the percentage of transactions that must complete within the response-time requirement. Arthur Andersen claims that 95% of OLTP transactions must complete within the required response time, e.g., 1 second.

3.3 Database Size

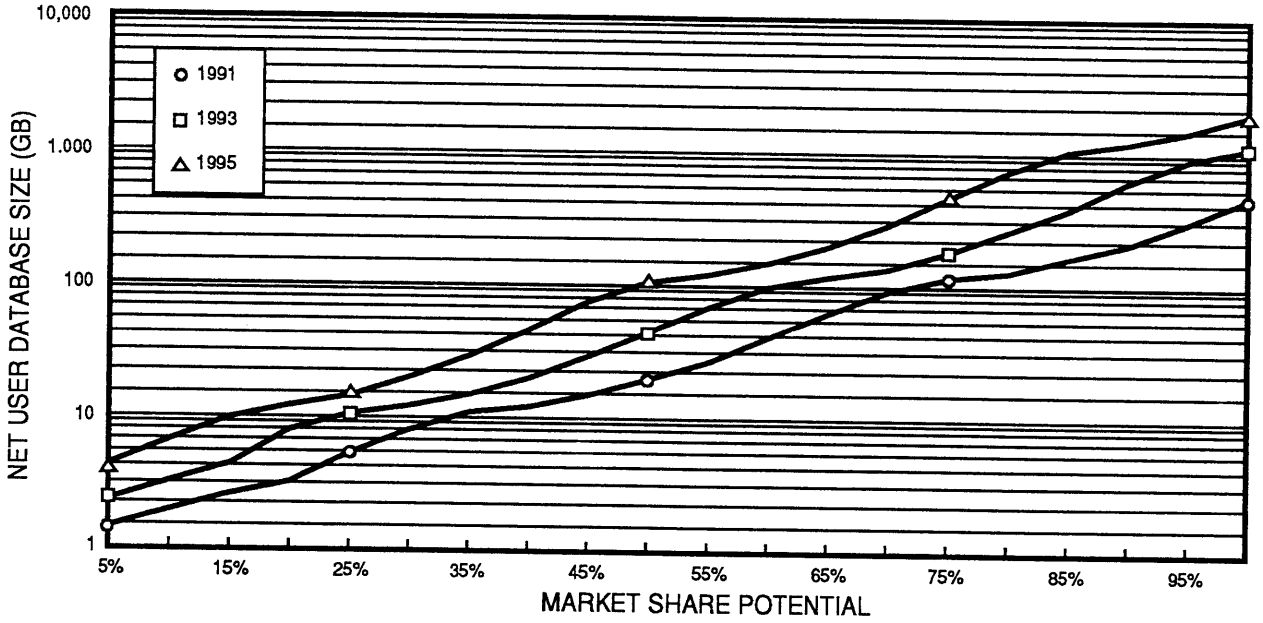
Figure 2 shows market requirements for database size. The values given are in terms of percentage market access by revenue; i.e., the corresponding database size must be supported to have access to a given percent of the total database market revenue.

The market requirement for database size is expressed as the *net size of the user data* for a single, integrated database environment. "Net user data" is the size of the data as stored in a flat file with no overhead space for metadata, index structures, or wasted disk capacity due to the granularity of disk allocation. The single, integrated database environment consists of one or more Cheyenne database servers that appear to users as one database system. In this environment, one or more databases may exist.

The gross database size which includes metadata, overhead data structures such as indexes, and empty space to accommodate new data is about two times the net database size. The shadowed storage capacity requirement is two times the gross database plus any required storage for system software. For example, to permit access to 75% of the market in 1991 a total connectivity of 500 gigabytes ((121 * 2 * 2) + system code) is required.

The database sizes in Figure 2 do not include headroom; therefore, the mid-life FY93 number of 250 GB net user data is used for the FRS requirement.

Figure 2: Database Size Requirements by Market Revenue Access



3.4 Price/Performance

Price/performance is the MLP price of a database solution configured for the Debit-Credit benchmark divided by the Debit-Credit TPS rate it provides. Price/performance can be expressed in two ways:

- Initial sale price/performance

  Included are the processor(s), software, and storage. The Debit-Credit Benchmark specification requires the amount of storage to be a function of TPS; i.e., a 500 TPS system requires proportionately more storage than a 50 TPS system.

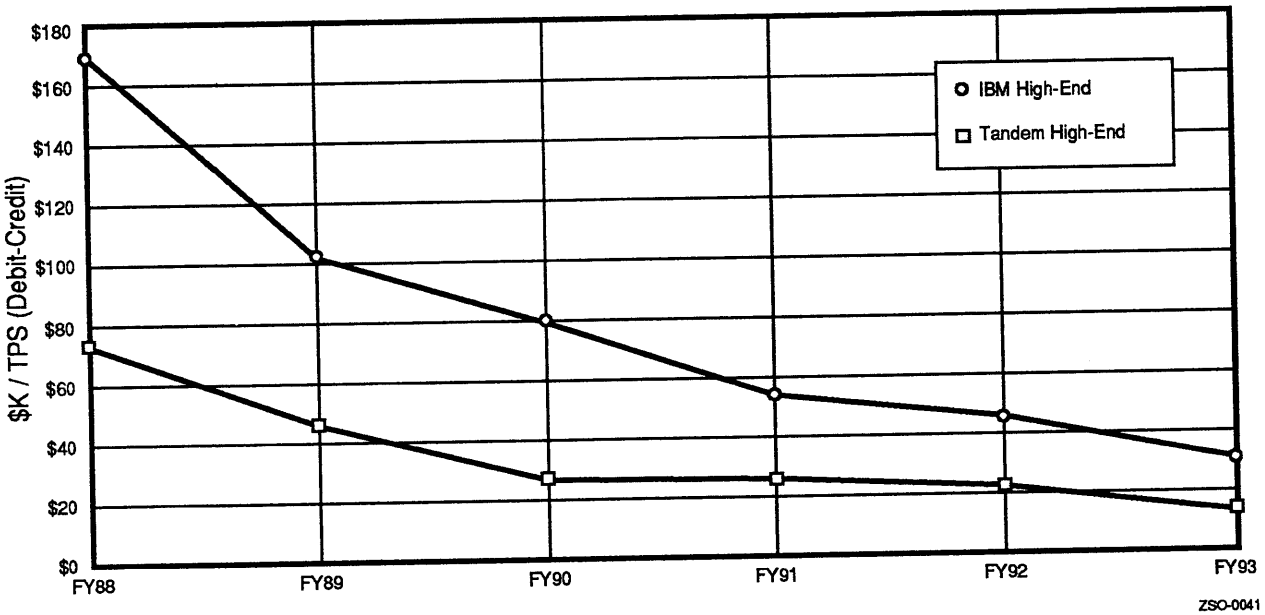
- Cost of ownership (COO) price/performance

  Included are the items listed in Initial Sale Price/Performance plus the cost of maintenance and service over a five year period. COO price/performance calculations in this document are the present value of all described costs over a five year period assuming a tax rate of 38% and an interest rate of 12%.

Figure 3 shows the predicted price/performance in terms of initial systems sale for the high end of IBM's and Tandem's offerings over time. As shown, it is expected that IBM's ISS price/performance in FY91 will be $54K/TPS for DB2 and that Tandem's will be $25K/TPS for NonStop SQL.

The market requirement is to match Tandem's FY91 ISS price/performance at $25K/TPS or to be 20% less than IBM's, whichever is less.

Figure 3: Competitive Price/Performance Trends



3.5 Competition

A major determinant of the markets expectations is the competitive offerings available. The major competitors today, and forecasted for the 1990s, are IBM and Tandem. Cheyenne's primary competition is IBM's high-end systems (3090, Summit series) running DB2 and Tandem's NonStop systems (VLX, future series) running NonStop SQL. IBM and Tandem have been successful in addressing many of the requirements of OLTP customers. They have the image of providing very close to 100% Data Integrity. Tandem offers high-availability, fault tolerant systems which achieve this through hardware (and and software supported) redundancy. Service programs including early detection and replacement of potentially faulty hardware devices.

Table 5 summarizes the 1987 features of DB2 and NonStop SQL.

Table 5: IBM and Tandem Competitive Summary

	DB2	NonStop SQL
Performance:		
TPS (95%, 1 sec)	60	120
CPU	3090-400E	4*8 VLXs
OS	MVS/XA	GUARDIAN90
Price/Performance:		
ISS Price	$10.1M	$9.1M
$K/TPS (ISS)	$168K	$76K

Both DB2 and NonStop SQL support the SQL data manipulation language.

3.5.1 IBM

For the majority of the OLTP market, IBM has a dual database strategy. IMS/VS DB (DL1) is suggested for high-volume production environments and DB2 is intended for the EUIM and low-volume production environments. IMS and IMS Fast Path support up to 400 TPS in 1987 according to an IBM report from their Santa Teresa lab entitled "IMS/VS V2 Release 2 Fast Path Benchmark" by Dave Viguers, dated August 1987 (and presented at the SHARE 69 conference in Chicago, Illinois). The performance gap between DB2 and IMS will continue to narrow. According to published accounts, IBM will follow this dual database strategy until 1990. After that, however, things could change. IBM has said that, "Over time, you'll see IBM developing into a relational database provider". For today's applications requiring from 150 TPS to 1000 TPS, IBM provides TPF2. TPF2 is expected to continue to be offered by IBM through 1990, at least, to handle high performance requirements. Differing views predict TPF2's future performance. The most common view predicts that TPF2 will reach 1100 TPS by 1990.

In terms of sales, relational database technology has emerged as the dominant database access method of the 1980s and is expected to remain so through the 1990s. As IBM's high-end relational offering, DB2 is IBM's strategic database product. IBM will put most of its database development money into DB2.

IBM's high-end systems, 3090s, range in performance from 7.5 MIPs (120E) to 76 MIPs (600E). The 3090-600E has an average of a quarter of a Terabyte of connected DASD. 3090s have up to 96 I/O channels. The 3090/600E supports 1.25 Gbytes of memory (256 Mbytes main storage plus 1 Gbyte Extended Storage) and it is expected that the future Summit systems will have 40-50 Mbytes per MIP on a 150 MIP processor.

3.5.2 Tandem

Tandem's business is fault tolerant OLTP. Tandem's key markets are commercial OLTP and manufacturing OLTP. Tandem claims:

- 60% share of the ATM and EFT markets.
- Fifteen major stock exchanges, including the Big Board, use Tandem systems.
- Every oil company uses Tandem for credit card transactions.

Tandem tried to compete head-to-head with IBM, replacing IBM's TPF systems (high-end OLTP). Conversion costs, up to $75M, caused Tandem to switch to an "IBM coexistence" strategy, acting as front-ends to offload TPF systems. A 32 (4 nodes of 8 processor each) processor NonStop SQL system can handle 120 qualified TPS (Debit-Credit), and additional interconnected systems can approach TPF speeds.

Tandem's key selling features are:

- Fault tolerance
- Expandability and modularity with demonstrated linear performance improvement
- Integrated networking
- Distributed databases
- Performance

The NonStop VLX announced in March 1986 for June 1986 FRS, is Tandem's high-end fault-tolerant system (starts at $1M). Compared to the previous high-end system, NonStop TXP, the VLX is software compatible, provides twice the throughput, and triple the hardware reliability.

- The VLX has a 3 MIP engine with 4 to 16 processors per node with a maximum of 240 VLXs per LAN that appear as one logical system.
- Each processor has 8 to 16 MB of memory and a 64 KB cache.
- NonStop SQL's Debit-Credit benchmark results are 208 TPS on a 4 node by 8 VLXs per node system with 90% of the transactions completing within 2 seconds. Adjusting the TPS to comply with the Debit-Credit benchmark requirement of 95% within 1 second yields 120 TPS.
- A series of tests run on increasingly larger systems demonstrated linear performance increases, suggesting higher than 120 TPS performance on larger systems is possible.
- GUARDIAN90 is the VLX operating system. GUARDIAN90 is a multiprocessing, multiprogramming, and fault-tolerant operating system. Mirrored copies of the operating system, system programs, some application programs, and data are maintained on separate disks.

4 Product Requirements

Based on market, competitive, and business analysis, Table 6 summarizes Cheyenne product requirements at first revenue shipment (FRS). To the extent that these requirements are not achieved, the number of customer applications, and as a result the segment of the overall market, that can be addressed becomes smaller. For example, if the TPS rates are not achieved, that moves us to a different point on the market access chart.

Cheyenne represents an integral part of the DIGITAL OLTP solution. In addition to Cheyenne, terminals and workstations, networks, front-end VAX systems and front-end software (including TP monitors, databases, tools and utilities) are part of the entire OLTP system as installed. The Cheyenne product requirements have taken into account the over-all OLTP system requirements. Table 6 contains both system level and Cheyenne-specific requirements.

Table 6: Configuration Dependent Product Requirements

	Standard Configuration			High Availability Configuration	
	System (Debit-Credit)	Single Box	Multiple Box	System (Debit-Credit)	Multiple Box
Data Integrity:	100%	100%	100%	100%	100%
Availability:	~99.9%	99.95%	99.95%	100%	100%
Maximum Throughput:	600 TPS	100 TPS	600 TPS	600 TPS	600 TPS
Response Time: 95%	1 sec	0.5 sec	0.5 sec	1 sec	0.5 sec
Maximum Database Size:	-	125 GB	250 GB	-	250 GB
Price/Performance: (Debit-Credit)	$25K/TPS ISS $21K/TPS 5yr COO PV	N/A	N/A	?	N/A

TPS numbers are based on standard Debit-Credit transactions.
Database size is net user data. It does not include overhead for data structures (metadata) or shadowing.
?— No analysis yet on High Availability $K/TPS

5 Cheyenne System Description

The following sections describe current plans and initial designs to meet the product requirements. The designs and functional specifications will be completed during Phase 1.

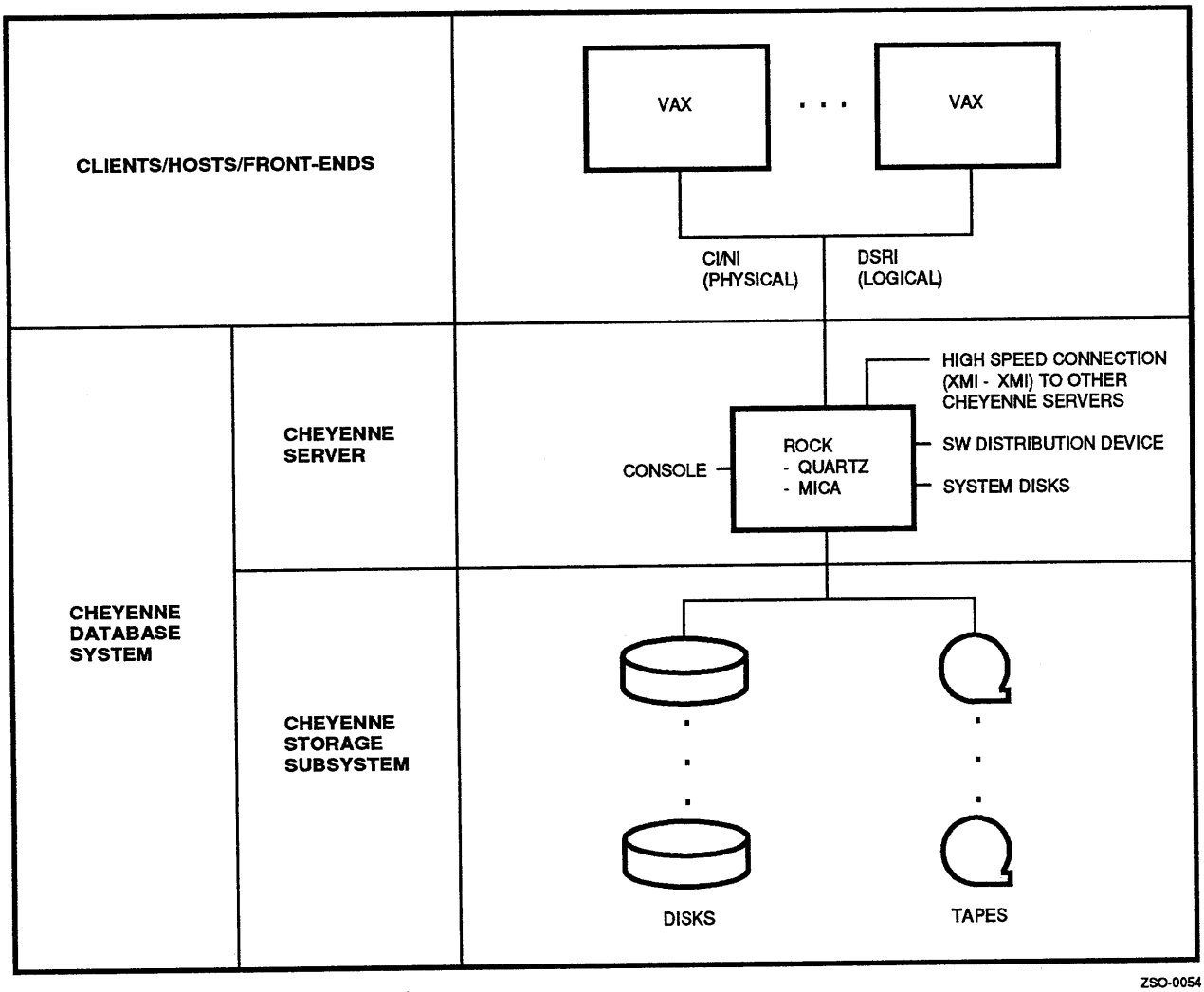
5.1 Cheyenne System

A Cheyenne database server consists of:

- Rock hardware
- Mica operating system
- Quartz database software
- Software distribution device
- Disks and controllers

A Cheyenne database server may include multiple interconnected Rock systems and optional I/O subsystems to provide high availability and greater capacity. Figure 4 illustrates the parts that make up a Cheyenne system and a Cheyenne database server. The figure also illustrates how front-end hosts, called *clients*, are connected to a Cheyenne server with computer interconnects (CI) and network interconnects (NI).

Figure 4: Cheyenne Terminology



5.2 Quartz Database Software Description

Quartz is the Cheyenne component that does the actual preparation and processing of transactions. As the database software for the family of Cheyenne servers, the goals for Quartz are to:

- Provide a *full-function, relational database system.*
- Maintain 100% *data integrity* in the face of hardware and software failures.
- Provide *high availability* in multi-box environments.
- Have *high performance.*
- Support *database sizes* up to 1000 Gigabytes.
- Provide for *incremental growth* without impacting performance.

  Quartz is flexible: as new techniques are invented for query optimization or transaction management, they can be incorporated in Quartz products.

  Quartz is scalable: it can grow in the number of processors, the size of memory and the number of disks.

5.3 Mica Operating System Software

The Mica operating system is being designed and developed at DECwest with the Rock hardware. Quartz requires an operating system that can take advantage of PRISM's emphasis on symmetric multiprocessing, large physical and virtual address spaces, and large register set. Mica, the operating system software for Cheyenne, provides such capabilities.

Mica is a state-of-the-art operating system using contemporary design features and capabilities. It is a reliable, modular, high-performance operating system designed to be easy to extend and enhance for many years to come. Mica has been designed to provide Quartz with the features and performance needed to meet the stringent requirements for Cheyenne. Some of these capabilities include:

- Fault Management
- Symmetric Multiprocessing
- Memory Management Features
- Mass Storage I/O
- Network Communications

  The client/server database and management communications take place over the CI bus and the Ethernet. Client/server communications uses DECnet. Intra-Cheyenne communications uses SCA on the CI.
- System Management

5.4 Rock Hardware

Rock is the hardware for the Cheyenne database server. Rock is designed to directly support the requirements of the Cheyenne program.

5.4.0.1 Data Integrity

Each scalar processor in the Rock system is actually two shadowed processor chips. These two chips compare results: if the results differ, both are taken off-line before user data is corrupted.

Error correction logic is used on internal interfaces, processor caches, and memory arrays to prevent propagation of errors.

5.4.0.2 Availability, Reliability, and Serviceability

Rock contains hot-swappable and redundant CEAG power supplies and an integral motor generator set to isolate the system from power surges and individual power supply failures.

Instruction retry is supported for certain classes of instructions.

Users may configure two Rock systems together with software failover where very high availability is required.

5.4.0.3 Technology and Schedule

Performance competitiveness in the OLTP and database markets requires an aggressive hardware development effort, with trade-offs between advanced and proven components.

Rock is implemented using 1.0 micron etch CMOS-III custom chips and standard-cell gate arrays. Surface mount technology and high-performance tape packages (HPTP) allow high component density. The PRISM architecture allows Rock to achieve at least two times the scalar performance of the Mariah Rigel-enhancement, which also uses these technologies and components.

14-layer printed circuit boards and CEAG power supplies help reduce schedule risk.

5.4.0.4 Scalar Processors and Multiprocessing

Each CMOS-III PRISM chip, running at a TBD nanosecond cycle time, provides at least 20 times the scalar performance of the VAX–11/780.

Each Rock processor board contains two of these 20 VUP processors. Rock can contain up to eight of these modules, for a total system peak performance of 320 VUPs. Sustainable performance may be lower, however, due to multiprocessor hardware and software resource contention.

5.4.0.5 Memory and I/O Subsystems

Rock supports up to eight memory modules, each of which contains 256 MBytes of memory with 4 MBit RAM chips, for a system total of 2048 MBytes. Each memory module contains its own memory controller to reduce access conflicts, which limit performance.

Memory bandwidth limitations are another factor restricting sustainable performance. The Rock crossbar provides an 160 MByte per second dedicated path between each processor and memory, augmented by a 512-KByte scalar cache for each processor.

The scalar caches on Rock use a write-back strategy for improved performance and to maximize the number of scalar processor pairs.

Rock is based on a eighteen-way crossbar, with individual ports for up to eight scalar/vector processor pairs, one to eight memory modules, and two I/O ports with two XMI I/O card cages each. Implementation of the crossbar avoids a system bus as a single point of contention and increases available per-processor bandwidth.

Rock supports up to four XMI busses. The XMI bus provides the high I/O data rates required by Cheyenne, and allows device compatibility with Argonaut and Aquarius.

Adaptors supported on the XMI bus include:

- XCA — HI to cluster adaptor
- XNA — HI to Ethernet adaptor
- Wildcat (HSX) — HI to disk and tape adaptor

6 Financial Analysis

6.1 Summary

The financial analysis is based on the Cheyenne system which includes Quartz, Mica, Rock, disks, controllers, and I/O projected to be sold as part of the initial system along with add-on, upgrade, and service business. The front-end VAX is excluded from this analysis. The financial calculations for Cheyenne assume that other DIGITAL database products will replace it beginning about five years after FRS. The analysis considers the entire expected life of Cheyenne (FY91 — FY97) and is based on goals for engineering, manufacturing, marketing, selling, and servicing Cheyenne.

There are three significant areas that will be continually analyzed, and appropriate action taken, based on their significance to the Cheyenne financial position:

1. *Pricing* is driven by our estimate of IBM and Tandem's pricing. We will continue to fine-tune these projections, and we will begin elasticity analysis to understand our pricing flexibility in this market.
2. Cheyenne *total revenue*, is derived from % of Market Revenue penetration. More detailed analysis and targeting of specific industries and customers, with supporting sales programs will allow for more precision in our volume forecast. There appears to be significant up-side potential, based on the conservative forecasting/market share approach we have taken at this point in the program.
3. *Field expense* has been estimated to be a sizable 40% of Net Operating Revenue. Given the specialized nature of the Cheyenne target customer, there are more cost effective distribution and sales models we will pursue in refining our sales and support plans.

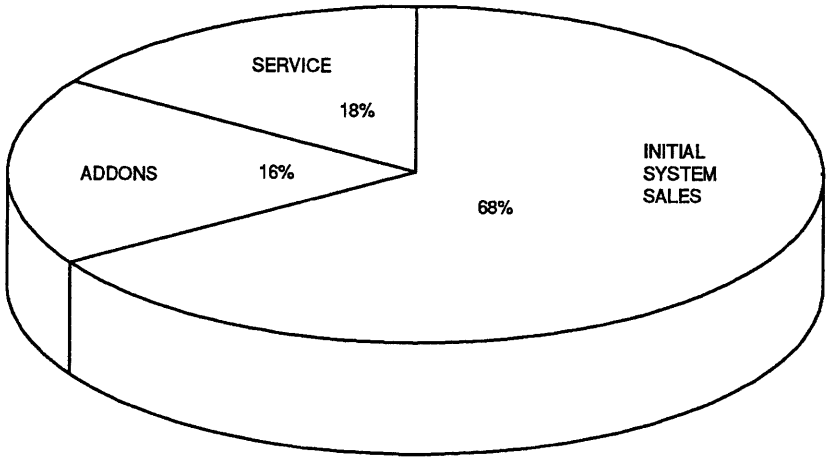
The key financial metrics for Cheyenne Table 7.

Table 7: Cheyenne Executive Financial Summary–Lifetime ($ Millions)

Metric	Fully-Loaded	% of NOR	Incremental	% NOR
Number of units	1159		1231	
Net operating revenue (equipment & service)	$8452	100.0%	$8826	100.0%
Gross margin	$5554	65.7%	$5859	66.4%
Profit before taxes	$2007	23.7%	$2168	24.5%
Profit after taxes (tax rate = 35%)	$1405	16.6%	$1518	17.2%
Internal rate of return	31.0%		32.9%	
First Revenue Ship	Q2 FY91		Q2 FY91	
Lifetime markup	7.43 times		7.82 times	
Quarters to breakeven	13		13	

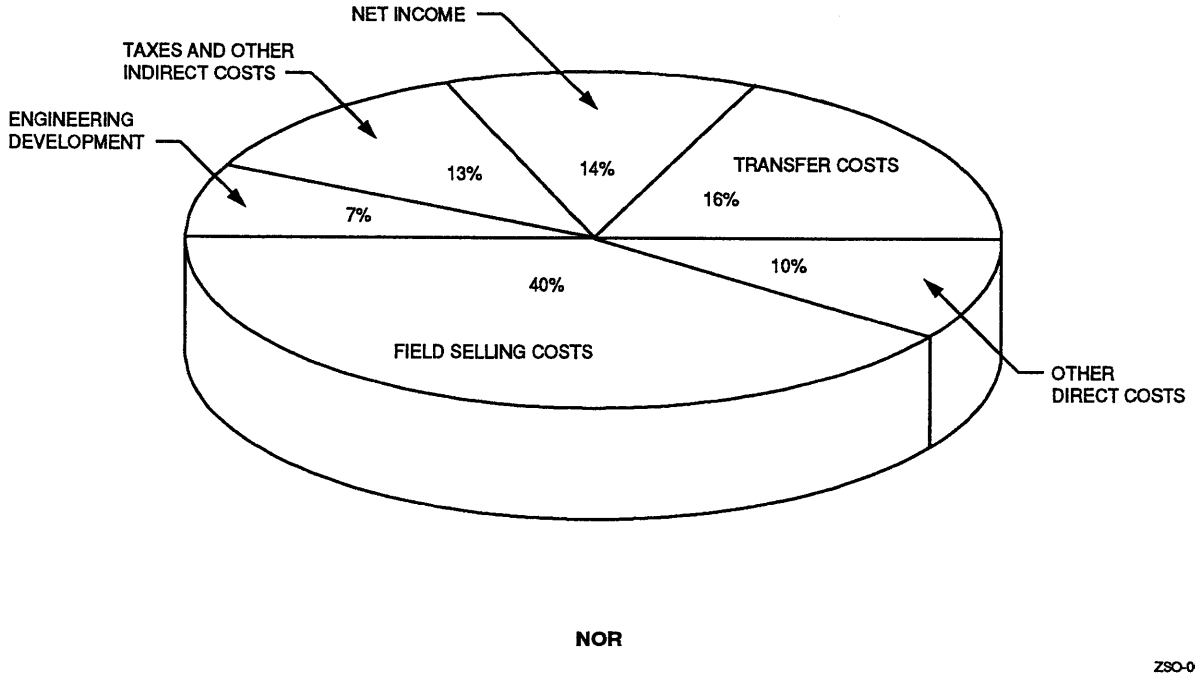
The purpose of Figure 5 is to clearly identify the specific sources of revenue from Cheyenne. ISS accounts for 66% of NOR, service generates 18% of NOR; the remaining 16% of NOR is generated from add-on sales.

Figure 5: Revenue Components of NOR



The cost structure of Cheyenne is illustrated in figure Figure 6.

Figure 6: Cost Components of NOR



6.1.1 Fully-Loaded Analysis: One Page Business Plan

Figure 7 is a summary of the fully-loaded business plan, showing initial system sales (ISS), add-ons, and service.

Figure 7: Fully-Loaded Business Plan Summary

	($ MILLIONS)	INITIAL SYSTEM SALES (ISS)								LIFETIME TOTALS			
		ALL PRIOR YEARS	FY 91	FY 92	FY 93	FY 94	FY 95	FY 96	ALL FUTURE YEARS	ISS	ADD-ONS	SVC	GRAND TOTAL
VOLUME & PROFITABILITY:	UNITS SHIPPED (#)	-	9	31	177	361	286	185	110	1159			
	MLP $	-	48.6	198.3	1078.0	1999.8	1662.9	1307.9	786.6	7082.1	1541.3	-	8623.4
	NOR $	-	39.7	162.2	881.8	1635.8	1360.2	1069.9	643.4	5793.1	1331.9	1327.4	8452.5
	GROSS MARGIN % NOR	-	47.1%	71.7%	72.9%	72.8%	74.3%	77.1%	77.4%	73.9%	59.5%	36.3%	65.7%
	OPERATING PROFIT: ($)	<227.8>	<57.1>	9.4	212.3	420.0	365.7	311.2	177.7	1217.5	409.4	380.1	2007.0
	OPERATING PROFIT: (% NOR)	-	<128.7 %>	5.8%	24.1%	25.7%	26.9%	29.1%	27.6%	21.0%	30.7%	28.6%	23.7%
	AFTER TAX ROA %		<108.2 %>	7.5%	53.3%	52.0%	40.4%	43.1%					
	IRR %									24.3%			31.0%

		TOTAL
ENGINEERING EXPENSE:	SYSTEMS DIRECT SPENDING	178.1
	SYSTEMS INDIRECT SPENDING	55.8
	TOTAL SYSTEMS SPENDING	233.9
	COMPONENT/ ALLOCATED SPENDING	306.6
	TOTAL ENGINEERING SPENDING	540.5
	MANUFACTURING EXPENSE (NPSU)	29.2
	CAPITAL EXPENDITURES	32.5

		ALL PRIOR YEARS	FY 91	FY 92	FY 93	FY 94	FY 95	FY 96	ALL FUTURE YEARS
ENGINEERING EXPENSE:	SYSTEMS DIRECT SPENDING	75.5	23.0	14.3	13.1	12.6	12.5	13.1	14.0
	SYSTEMS INDIRECT SPENDING	26.4	7.2	4.0	3.6	3.5	3.5	3.7	3.9
	TOTAL SYSTEMS SPENDING	101.9	30.2	18.3	16.7	16.1	16.0	16.8	17.9
	COMPONENT/ ALLOCATED SPENDING	102.0	21.6	14.8	13.2	14.3	35.9	59.7	45.1
	TOTAL ENGINEERING SPENDING	203.9	51.8	33.1	29.9	30.4	51.9	76.5	63.0
	MANUFACTURING EXPENSE (NPSU)	22.6	6.6	-	-	-	-	-	-
	CAPITAL EXPENDITURES	27.2	5.3	-	-	-	-	-	-
NET ASSET INVEST:	INVENTORY	-	5.8	38.7	79.7	78.4	82.0	54.8	-
	RECEIVABLES	-	6.3	35.2	193.9	372.2	373.3	366.7	253.7
	OTHER (NET)	29.1	38.8	52.7	180.2	319.3	307.3	293.2	192.4
	TOTAL	29.1	50.9	126.6	451.8	769.9	762.6	714.7	446.1

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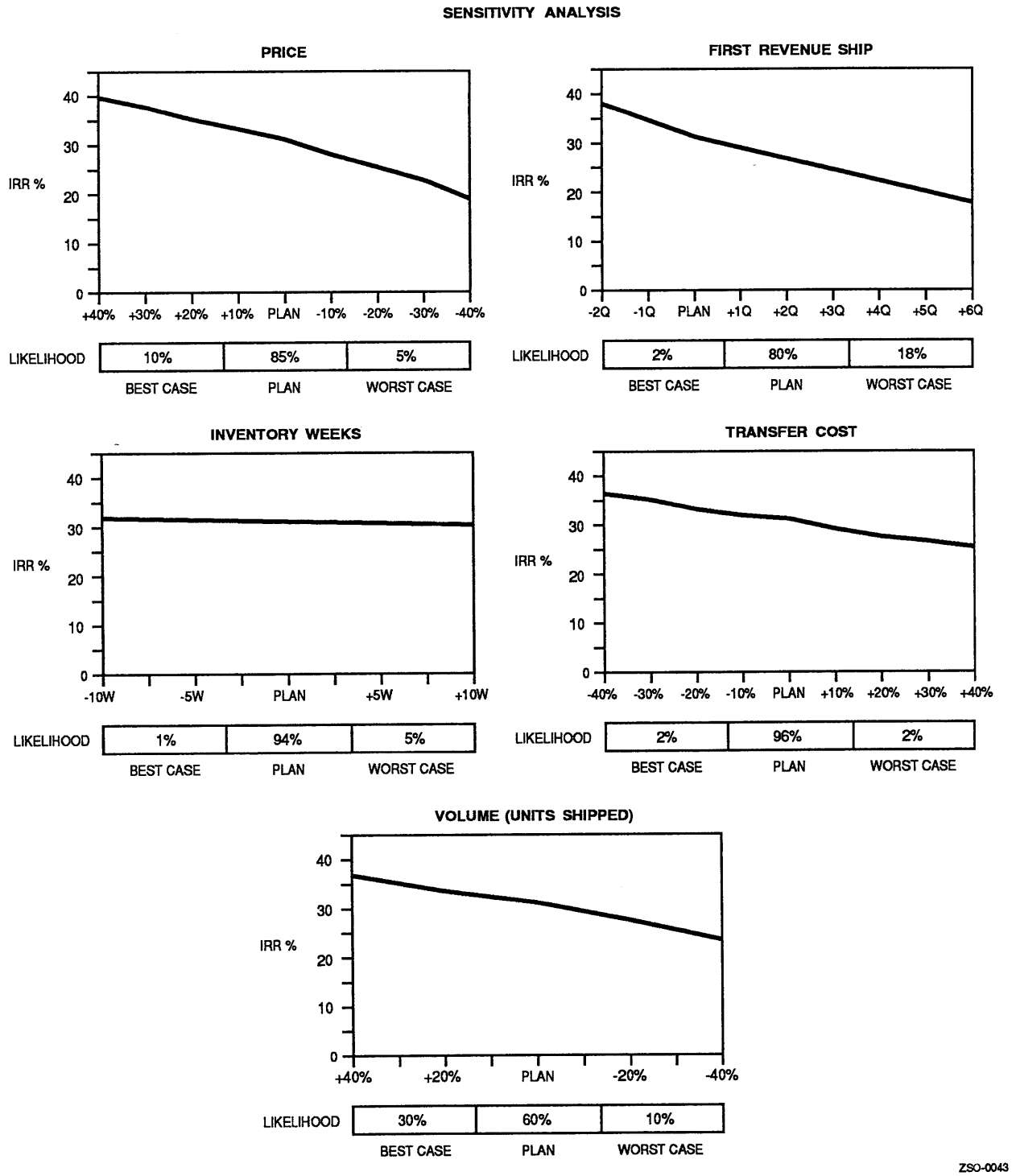
6.1.2 Fully-Loaded Sensitivity Analysis

This analysis measures the sensitivity of the IRR to the variability of key factors. It is also an indicator of business risk. A description of the sensitivity of each element is shown in Figure 8.

Figure 8: Fully-Loaded Sensitivity Analysis



6.2 Major Assumptions: Supporting Financial Data

The following sections provide major assumption details on what Cheyenne assumptions are based.

6.2.1 Cheyenne Revenue

Cheyenne MLP includes Rock, Mica, Quartz, disks, and controllers. This does not include front-end VAX systems.

6.2.1.1 Configuration mix assumption

Table 8: Cheyenne MLP by Year ($ Thousands)

Configuration	FY91	FY92	FY93	FY94	FY95	FY96	FY97
Small	4606	4145	3731	3358	3022	2720	2448
Medium	11710	10539	9485	8537	7683	6915	6223
Large	18477	16629	14966	13470	12123	10910	9819

6.2.1.2 Discount, Allowance, Uplift Assumption

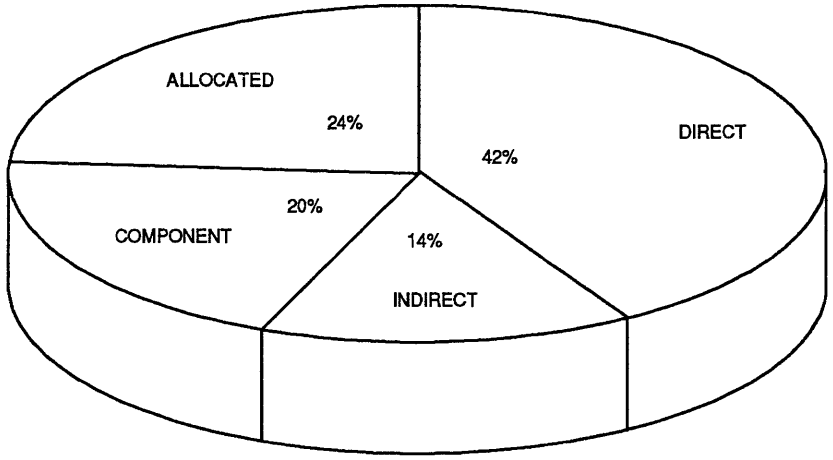
Uplift, discounts, and allowances are derived from estimated selling channel and geography distributions for Cheyenne. Although this analysis assumes the following percentages for the life of the product, issues regarding allowance structure for maturing products and uplift accounting in the future, which may vary over time, will be addressed in Phase 1.

- Uplift: 10.4%,
- Discounts: 18.6%,
- Allowances: 10.0%.

6.2.2 Development Costs

The base hardware and operating system developed at DECwest will be utilized by both Cheyenne and Glacier. These jointly-incurred direct costs were allocated to the individual programs based on total kernal NOR including memory but excluding I/O devices. This method of allocation is based upon the benefits expected from each project and is in concurrence with past mid-range systems (MSB) allocation methods.

Figure 9: Components of Engineering Development Costs



ENGINEERING DEVELOPMENT COSTS

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6.2.3 Service Revenue, Expense, and Warranty

Field Service revenue, expense, and warranty as shown in Table 9 are based on the Cheyenne Unit and Revenue Forecast V8.3 and provided by Cheyenne CSSE. The service forecast includes service revenue and expense projections for hardware, software, and support services; warranty expense assumes a one-year remedial service and installation. The pricing is based on an annual service price goal as a percent of Cheyenne's average system value. The service expenses are based on standard margin goals which are applied to service revenue. Warranty expenses are derived from the calculated cost of service, are based on a one year warranty, and are 4.3% of equipment NOR.

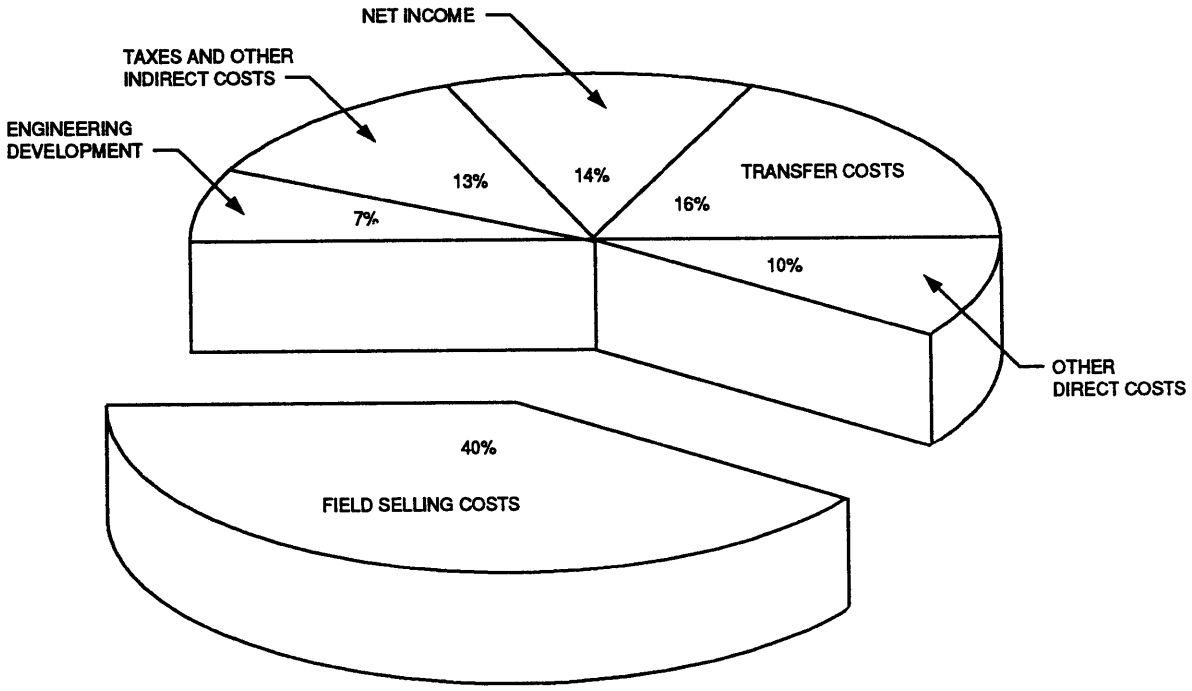
Table 9: Cheyenne Service Revenue, Expense, and Warranty

($ Millions)	FY91	FY92	FY93	FY94	FY95	FY96	FY97	Total
Service revenue	2.1	11.5	60.8	176.1	298.6	373.3	406.1	1328.5
Service expense	2.8	8.7	45.3	123.5	201.1	230.7	232.9	845.1
Warranty expense	6.5	11.8	44.3	72.5	53.2	33.0	18.9	240.3
Service margin (% of revenue)	-37.0%	23.7%	25.5%	29.9%	32.6%	38.2%	42.7%	36.4%

6.2.4 Field Selling and Marketing Costs

Field expense has been estimated to be a sizable portion of Cheyenne NOR as illustrated in Figure 10. Field selling costs are projected to be 40% of NOR.

Figure 10: Significance of Field Selling Costs



NOR

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7 Schedule

Cheyenne System Phase	Date of Exit from Phase (C/YR)
0 (Strategy & Requirements)	Dec 1987
1 (Planning)	Jul 1988
2 (Implementation)	Jun 1990
3 (Qualification)	Dec 1990
4 (Production and Support)	TBD
5 (Retirement)	TBD

8 Functional Plans

The following sections summarize the functional plans submitted by engineering, manufacturing, sales, CSSE, and documentation.

8.1 Alternatives and Feasibility

Alternatives for a DIGITAL database server have been researched since 1982. The alternatives include external buyouts (Britton-Lee, Teradata, Sequoia), use of internal projects that were already underway (PPA, Aquarius, or Cirrus hardware; VMS or ULTRIX operating system; VAX Rdb/VMS or VAX Rdb/ELN database software), and development of a new product. Research indicates that building a new product is DIGITAL's best alternative. In early 1987, the STF recommended developing a database server using the PRISM hardware architecture. The result of that recommendation is Cheyenne.

Cheyenne is feasible because much of the hardware and software uses well-understood technology. Further, simulations of the hardware and software indicate that the performance goals are achievable. The developers understand the areas where they are pushing the technology, and they are monitoring these areas carefully.

The risks for Cheyenne fall into three areas:

- Aggressive product goals for performance, high availability and reliability, data integrity, and time-to-market
- A development environment that relies on a high level of integration with other DIGITAL groups
- Geographically distributed project teams, members of which reside in five sites in three areas: Colorado Springs, Seattle, and New England

To manage these risks, the management team is producing development and test plans that will ensure Cheyenne's functionality and performance. Software is being developed in stages to reduce risk and to identify and correct performance bottlenecks before the product is shipped. The intergroup dependencies are being carefully monitored, and regular meetings among the geographically dispersed groups are being held.

Cheyenne is the best alternative for meeting the database needs of the OLTP computing market. The development teams consist of capable people who are highly motivated to ship the Cheyenne database server, and who are dedicated to producing an increased DIGITAL presence in the OLTP marketplace.

8.2 Manufacturing

The following summary outlines the manufacturing goals for Rock, as well as the current risks and issues for manufacturing.

8.2.1 Manufacturing Goals

The following are the Rock manufacturing goals:

- Build a quality product — Develop and implement manufacturing processes that produce a product which meets the program goals for performance reliability, and availability. Build it right the first time.
- Maintain schedule — Make sure that manufacturing is not on the critical-path.
- Manufacturing process development — Optimize to meet or beat the lowest cost in the industry.
- Total system responsibility — Ensure that all of the system components are of the highest quality possible, are delivered on time, and are installed at the customers site in a timely and professional manner.

- Customer satisfaction — Develop and implement a program to investigate and improve customer installations (99% PFI by the 150th Rock ship).

8.2.2 Risks/Issues

The following risks and issues have been identified:

- Managing external program dependencies
- Module Process — First product using high-density, double-sided SMT, on extended-hex modules
- CMOS-III Technology — It is a leading-edge technology and the program schedule is critically dependent on the HLO CMOS-III development
- HPTP/324-pin TAB — HPTP technology is new (hopefully it will be debugged by Rigel, but it is still a major manufacturing risk)
- System Diagnostics — Success in developing the diagnostic tools that are required is paramount to the program's success

8.2.2.1 Phoenix

- There is an infinite number of product configuration possibilities
- The following verification processes are not determined:
  - Availability specifications
  - Total system reliability
  - Redundancy and fault tolerance

8.2.2.2 Greenville

- Not much manufacturing data exists for testing blind/buried vias. GSO requires insight into the testing process, and needs test access designed/ included in the data.
- Volume test capability of true 50 mil grid 12.5 pitch products do not exist operationally today.

8.2.2.3 Marlboro

- Dynamic functionality testing at high speed (20ns clock speed) represents risk because it's currently beyond our test capability. Significant tester development will be required, as will related capital investment.
- Gate arrays in the memory design have 324 pins, tab bonding and 12.5 mil lead spacing. These characteristics create the need for new assembly repair and cleaning processes and tools, as well as significant changes to the GR test process.
- Current design calls for .33 uf bypass capacitors for the DRAMs. The dimensions of .33 uf capacitors exceed the clearance of commodity DRAMs.
- DRAM availability and cost represent the most significant risks. The availability and cost of the 4 Mbit DRAMs can only be speculated at this time. This is because of the unclear future of the trade relations between Japan and the U.S., and because of current development efforts by the DRAM vendors.

8.2.2.4 Kanata

- Limited vendor base and lead times for advanced-technology backplane PWB sourcing
- Current lack of a QTA supplier.
- Process development efforts for the Moraine crossbar with respect to assembly and test, are currently somewhat defined, but will be critical in meeting the aggressive schedule requirements.
- Managing manufacturing links into the joint Engineering development effort, and potentially two different manufacturing program teams.
- All financial projections are based upon preliminary designs, and assume a specific design configuration. The configuration is only one of many possible interpretations of the design that the final backplane/ cardcage will take.
- The process implications of using the crossbar components mounted to the backplane on the Moraine backplane is not fully understood and needs to be further evaluated before the validity of the cost projections are substantiated.

8.3 Sales

Sales is a key area for the success of Cheyenne. This is a new market and a new type of sale for the DIGITAL Sales force. System size will be larger than previously experienced ($3-10 M/system), the high level of expected support and "hand-holding" on the part of the customer will be unfamiliar. The sales cycle may be much longer than the current average commercial sale. There are, however, a number of advantages we will have in this area. The target customers are already DIGITAL customers. We will be selling into different departments, for different applications, but the target companies will already be familiar with DIGITAL and will be users of our products. The number of installations is small enough so that only a small percentage of the Sales force will need to be trained and will actually be selling Cheyenne Systems.

The sales impact statement stresses the need to properly position Cheyenne in relation to the VAX family in general and Rigel, Aquarius, Aridus, and Argonaut in particular. PRISM systems should complement and enhance VAX systems, providing incremental revenue to the existing VAX revenue stream. PRISM systems should be portrayed as evolving from the VAX architecture.

Sales education in vector processing, symmetric multiprocessing, and database and compute server technology is required six months prior to announcement.

Benchmark data characterizing Glacier and Cheyenne performance is needed four months before announcement.

Multiyear sales goals for PRISM systems may required as incentives to the sales force.

8.4 Customer Services

Service is indeed a critical component in the total OLTP offering. The service delivery of Cheyenne will require that the service engineer be very knowledgeable on the total system including hardware, applications, operating system software and software/firmware running in various parts of the system.

To handle the maintenance of Cheyenne will require new troubleshooting and maintenance techniques, some of which are implemented today for the cluster service delivery. For Cheyenne we will have to go several steps further to offer a more complete service package (or packages) to fulfill the customer needs in the commercial, and other very demanding markets.

The service strategy will be to train first level engineers in troubleshooting techniques that include hardware tools, diagnostics, error logs, and system software to a level that will enable them to perform basic diagnosis of the failure and then effect the remedial action required without interrupting the operation of the database, should non-interrupted operation be feasible and practical. Second level engineers will be trained to achieve a fuller understanding of how the hardware works, how the software works, and how to use the software to diagnose any failures, and then perform repair without interruption of the database operation. The second level service engineers would also perform remedial software activities for the total system and applications.

The priority design goals for Cheyenne are data integrity and high availability. The high availability goal will be achieved through fault tolerance. The repair strategy based on these goals will be "periodic" on-site field replaceable unit (FRU) replacement. The fault tolerance will enable the application to continue running (possibly degraded) and corrective maintenance to be scheduled to the convenience of the customer and the service engineer, possibly as a periodic event, similar to the way preventive maintenance is performed today.

Since there are no existing products that DEC ships in the Cheyenne target market, the service pricing will be determined mainly by the competitive environment. At present the majority of competitive products have their yearly service charge set at 12% of MLP, and the service includes maintenance of the hardware, software and documentation, although in some cases all of these offerings are quoted separately.

The key issues and requirements to service Cheyenne are:

- Hardware/software fault tolerance, so that the application can continue operation under fault conditions.
- Hardware and software training effectiveness has to be very good so that the service engineer is capable of full service delivery.
- Combined hardware/software service plans.

8.5 Documentation

Traditionally, DIGITAL products clearly separate documentation into hardware manuals and software manuals; a separation useful for products that are used or serviced by only hardware or only software people. Cheyenne is a product that provides customers with such high reliability, availability, and maintainability features that in many cases the boundary between use or support of hardware and software is blurred. Users and support people both require a combination of hardware and software information to learn everything they need to know about Cheyenne.

The Cheyenne customer documentation contains information for database administrators, programmers, and system managers. The customer documentation is designed to appear as an integrated component of DIGITAL's VAX Information Architecture (VIA)/DSRI and OLTP product offerings.

The Cheyenne service (support) documentation includes a set of manuals that is common to all Rock/Mica-based products. Because it is written and organized in a modular fashion, the service documentation easily shows where Cheyenne and other Rock/Mica-based products differ. A single set of manuals for all Rock/Mica-based products:

- Keeps to a minimum the number of service manuals that support people must keep track of and use.
- Minimizes DIGITAL's cost of producing the service documentation.
- Minimizes DIGITAL's cost of providing support people with the service documentation.

9 Summary at Phase 0 Exit

9.1 Risks and Dependencies

Following is a chart highlighting the risks associated with the Cheyenne Program.

Figure 11: Risk Assessment

	TECHNOLOGY	MANUFACTURING	SERVICE	MARKET	PRODUCT	SALES
RISK ASSESSMENT	4	3	3	5	4	4
MAJOR DEPENDENCY	CMOS TAB PACKAGING (HPTP)	UNIPROCESSOR TRANSFER COST AND STAGE I PROCESS	COURSE DEVELOPMENT	NEW MARKET TO DIGITAL, LITTLE MARKET PRESENCE HEAD-TO-HEAD WITH IBM	SMP PERFORMANCE I/O BANDWIDTH AMOUNT OF MEMORY SUPPORTED	NEW, UNFAMILIAR PRODUCT, NEW TRAINING PROGRAM NEW MARKET

	CUSTOMER SERVICES	ENGINEERING	SUPPORT	BUSINESS	OTHER
RISK ASSESSMENT	3	4	4	4	5
MAJOR DEPENDENCY	FIELD EXPERTISE AT FRS	ADVANCED DATABASE SYSTEM TECHNOLOGY	SOFTWARE SERVICES, SALES, AND BENCHMARKING	LARGE INVESTMENT, CONTROL VARIABLES TO ACHIEVE IRR	OLTP-LEVEL SYSTEM INTEGRATION AND TEST PROCESS AND IMPLEMENTATION

RANK: 1=LOW, 5=HIGH

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9.2 Conclusions

Cheyenne is the product that lets DIGITAL enter into the high-performance OLTP market. By providing systems scaled from 100-600 TPS with high integrity, availability and reliability, Cheyenne provides DIGITAL a product offering that competes for OLTP applications against IBM and Tandem. Because OLTP is a competitive and new market for DIGITAL, there are risks. However, the potential rewards — shown by the market and financial analysis, and actions to minimize risk — move the balance heavily in favor of continuing development of Cheyenne and related programs.

APPENDIX A

CHEYENNE MANAGEMENT TEAM

Group Managers:

David Cutler, *DECwest Group Manager*
Hans Gyllstrom, *Database Systems Group Manager*

Database Engineering:

Dave Schrader, *Quartz Engineering Manager*
Kevin Smith, *Database Systems Engineering Manager*

DECwest Engineering:

John Balciunas, *DECwest Hardware Program Manager*
John Gilbert, *DECwest Software Engineering Manager*
Don MacLaren, *Pillar and C Engineering Manager*
Robert Short, *Rock Hardware Engineering Manager*

Product Management:

Reid Brown, *DECwest Manager Product Management*
John Coombs, *DECwest Hardware Product Manager*
Bill Hodgson, *Database Systems Planning Manager*
Rockie Morgan, *DECwest Technical Product Manager*
Terry Morris, *DECwest Technical Product Manager*
Garth Reid, *Cheyenne Product Manager*
Cathie Richardson, *DECwest Business Product Manager*
Chuck Rozwat, *Database Systems Manager Product Management*

Finance:

Salley Anderson, *DECwest Financial Analyst*
Rich Butler, *Mid-Range Systems Finance Manager*
Donna Eastep, *Database Systems Financial Manager*
David Lash, *Database Systems Group Finance Manager*
Lon Willoughby, *DECwest Financial Manager*

Documentation:

Dick Stone, *ESDP Documentation Manager*
Ken Western, *DECwest Documentation Manager*

Manufacturing:

Jim Byrne, *Software Manufacturing Product Manager*
Al Morrow, *Mid-Range Systems MBU - West Finance Manager*
Jerry Quick, *Mid-Range Systems MBU - West Manager*
Bud Sawisch, *Rock 32-bit Manufacturing System Program Manager*

Customer Services:

Rick Ellison, *Database Systems Customer Services Program Manager*
Bill Hilton, *PRISM DECwest Customer Services Program Manager*