# DESCRIPTIVE SURVEY FOR A REFINERY INFORMATION SYSTEM: HYDROCARBON DATA SUPERVISION (HDS)

by

Mr. Thanthach Ritthinam

A Final Report of the Three - Credit Course
CE 6998 Project

Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Science
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| Project Title | Descriptive Survey for a Refinery Information System: Hydrocarbon Data Supervision (HDS) |
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The Graduate School of Assumption University has approved this final report of the three-credit course, CE 6998 PROJECT, submitted in partial fulfillment of the of the requirements for the degree of Master of Science in Computer and Engineering Management.

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# ABSTRACT

Once again today's information age influences the way an organization manages their large amount of information. In particular, the petrochemical and petroleum refining company have varieties of information flowing around the organization. Not only different sources of data generated which results in a different nature of information, but also different end user's requirements depending on their position and their usage of the available information, for example, a need for technical study, performance monitoring, equipment and process monitoring, and business decision making, etc. The organization definitely needs tools in management information system which enables it to manage different sources of data and provide suitable information for each user to fulfill one's requirement. This project provides a guideline as a model description, so called Hydrocarbon Data Supervisory system or HDS. The HDS system conceptually integrates and manages (supervises) refinery information, which mainly consists of information from a plant control domain (shorter cycle time) and from a business control domain (longer cycle time).

The descriptive model of the HDS was developed from gathering practical problems seen in the organization, understanding users' and business' requirements, defining the description of the model and eventually determining the implementation requirements. The descriptive model development adapts the approach of the System Development Life Cycle. The benefits of having the HDS system can be quantified depending on size of the refinery business. Some commercial packages were studied as examples and discussed the features in the project as references for future development and implementation.

**ACKNOWLEDGEMENTS**

I desire to express my sincere gratitude to my advisor, Dr. Tatchapol Poshyanonda for his encouragement and advice through the course of this project.

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# I. INTRODUCTION

## 1.1 Background of the Project

Nowadays, all industries are modifying their production methods in order to take up the new challenges created by an evolution of the market and of the competition. The new methods aim at improving the productivity and also the quality of provided products and services. In this context, the uses of information techniques as well as their application field are increasing.

The devices that automatically control industrial installations are generating an increasingly large amount of data to be managed in real time. The easy unit management implies constant interactions between "business management devices" and the company "real-time information system". This synergy is required to take into account (in a coherent way) constraints set by production, organization, creating recipes or maintenance management. Between industrial automation and traditional data processing, one will find numerous needs in the field of "data supervision and process control". Today, many applications have to make a constant use of information on-line. New domains are so created from the integration of all these applications to the control of installations and plant management. This allows the creation of systems more adapted to the concrete concerns related to the exploitations.

The Management Information System (MIS) is a tool used to progressively constitute and to assure a selective of synthetic information, to allow an efficient communication between the different elements of the production.

The project, "Descriptive Survey for a Refinery Information System: Hydrocarbon Data Supervision (HDS)" generally discusses the typical petroleum refining business process to see where the information system "fits-to-business purpose". This to enable a continuous improvement of the business process and enhance the best possible decision making to be taken. Main purpose of this project is to provide general guidelines and general requirements of implementation of a data supervision, so-called, "Hydrocarbon Data Supervision" particularly in a petroleum refining business. The methodology used in surveying the description of the data supervision model and its requirements is the modified "system development life cycle" concept. Theoretical as well as practical aspects are studied and applied to "derive" the descriptive model. In addition, some of the available commercial package modules are included as an example in the project to compare their strategy of the model and its capability.

It should be noticed that the project provides general information of the model. To implement a system in one petroleum refinery business, fit-to-purpose model needs to be considered based upon size of that business and organizational requirements.

The following sections discuss the entire project study.

## 1.2 Project Objectives

The objectives of the project are described as follows:

(1) To study and provide a general model description of the "Hydrocarbon Data Supervision (HDS)" system used in a Refinery Information System.

(2) To modify and apply a concept of the System Development Life Cycle (SDLC) to develop the descriptive model for the HDS based on business requirement of activities.

(3) To compare and evaluate commercial applications taking into account performance and cost to minimize possible regret investment in a certain refinery.

## 1.3 Project Scope

The project studies the general requirements including users' and functional (technical) requirements to develop a descriptive model for the HDS. The descriptive survey modifies concept of the SDLC which are listed below:

(1) Preliminary investigation: The project starts with problems which is noted by users concerning the interface of the refinery business systems domain and the plant control systems domain in the hydrocarbon processing system.

(2) Requirement analysis: Following the preliminary investigation the project performs a study on the system requirements that must be met to satisfy the business activities supported by the HDS.

(3) System description: After analyzing the requirements, the system description and the application environment are incorporated into a so-called "descriptive model."

(4) System evaluation: Comparing the descriptive model to commercial applications and evaluate among applications in terms of performance and investment cost.

The HDS descriptive model got from this project can be used as a guideline for the refinery to implement the RIS to fit the current business objectives.

The flow chart of the project scope is shown in Figure 1.1.

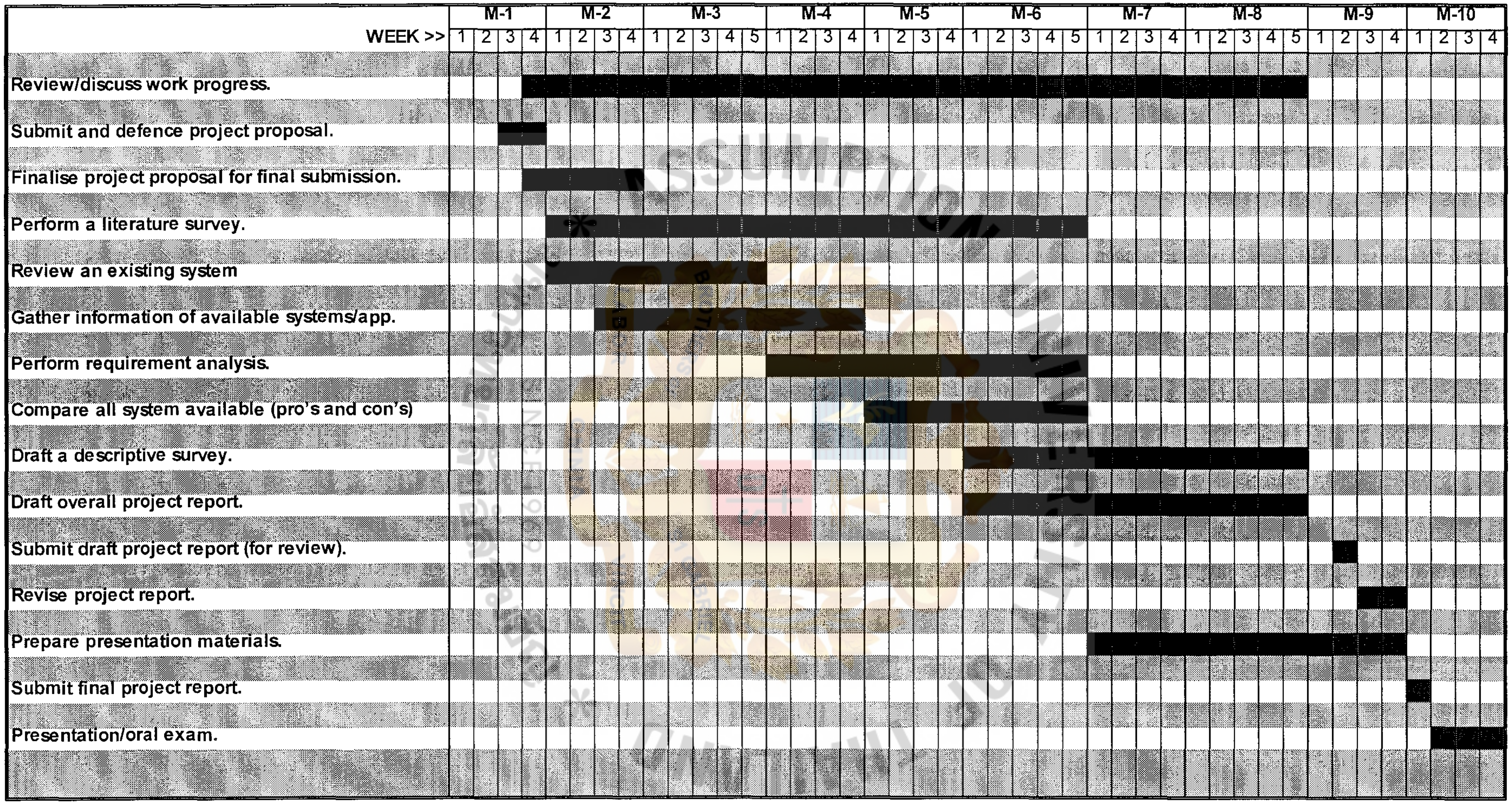


Figure 1.1. Project Schedule.

## II. REFINERY INFORMATION SYSTEM

### 2.1 Typical Petroleum Refining Business Process

Like normal manufacturing enterprises, a petroleum refining business requires four main factors:

(1) Man

(2) Material

(3) Money

(4) Management

The four factors are incorporate in each business function. Mores specifically, the refinery business function can be divided into Supply chain function, Manufacturing function, and Support function.

Supply chain function, this function includes crude and feedstock supply, planning and scheduling, product supply and distributions, also economic function to ensure that the business is planned to operate in the economically competitive environment, i.e. maximize gross refining margin.

Manufacturing function, a petroleum refining process composes of three major sections, (1) Main refinery process section, (2) Utility section, and (3) Oil movement section.

Main refinery process includes operating units to perform physical and chemical process to turn crude oil and other feedstock to be useful products such as Liquefied Petroleum Gas (LPG), chemical feed Naphtha, Gasoline, Diesel Fuel oil, Sulphur, etc. Typically, refining process units in the refinery are Atmospheric crude distiller, High Vacuum distiller, Hydrotreating unit (Naphtha Hydrotreater, Kerosene/Diesel

Hydrotreater), Catalytic Conversion and Reforming units, and Thermocracking unit. This however, depends on the design configuration of the designer/technology licenser. Utility sections include equipment and processes to produce all utilities that support the main unit production, e.g. industrial air, treated water (demineralized water), steam, electricity, etc.

Oil movement section is the area where crude, feedstock, products, and other blending components are handled and stored. In addition, finished product blending and distributing are also included in this section.

Support function, although this is not extensively covered in the study, the support function includes Finance and Administration, Human resources, and also Technical services, e.g. maintenance, process engineering, inspections, etc.

Today's refinery business has faced the economical difficulties in terms of supply demand imbalance, and economics crisis of all regions around the world. Limitation of investment moves in the different direction with the environmental limitation (in terms of product specifications and substituted fuels). To stay in the business, the refiners have to maximize use of the assets in a professional way. As written in the article: In the long term, refiners need to keep two things in mind. First, a refinery won't just produce fuels; it will produce energy and chemicals. Second, the interaction of economic and environmental concerns will significantly affect how the refining industry does business.

As every single part of business process, supply chain and productions contain a lot of useful data and information and most of the information are critical for the business. Improving management information system in the organization can help refiners to improve their productivity and therefore profitability.

## 2.2 Refinery Information System Structure

As Management Information Systems (MIS) became commonplace in industry during the 1960s, many overzealous MIS professionals began pushing the concept of a total information system. The total information system is considered as a site-wide and even an enterprise-wide information system that could meet all of the organization's decision making and transaction processing requirements. As similar to the other organizations in the information age, the refinery business requires an extensive MIS, so called "Refinery Information System (RIS)".

There are many RIS structures have been developed over the last number of years however, the simple business model developed by Solomon is used as a guideline of the RIS model for this project. The Solomon's Refinery Information System Model Architecture (Figure 2.1) describes the functional areas of hydrocarbon processing and management. The model has two dimensions: one covers the activity areas which are planning and scheduling, process, oil movement, quality, maintenance, engineering documents management, finance, and administration and regulatory. The other separates the activities within each activity area on a control time basis, i.e. higher level activities have longer control times.

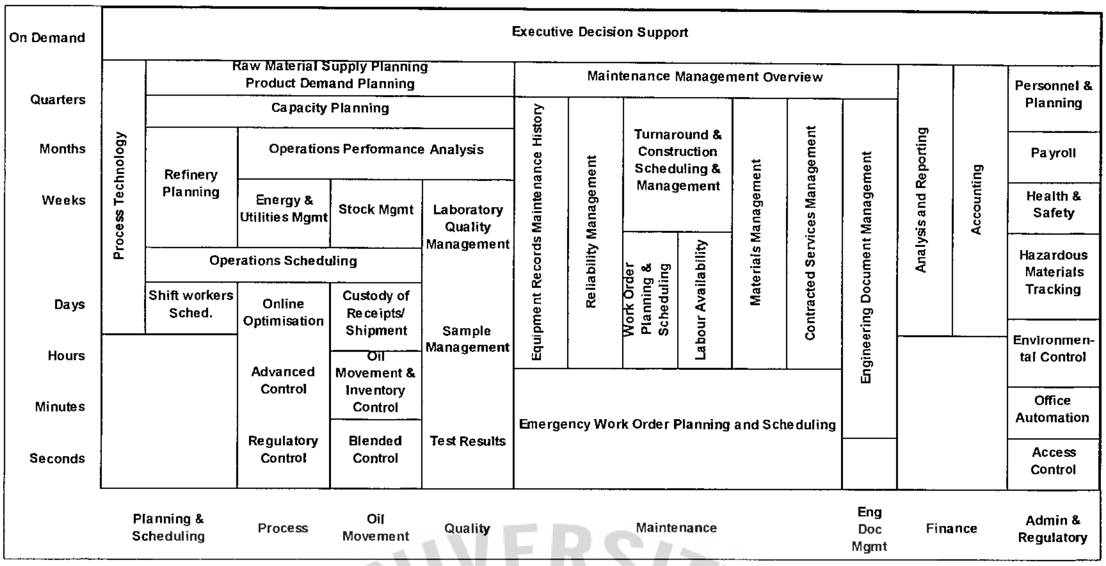


Figure 2.1. Solomon's Refinery Information System Model Architecture.

## 2.3 Hydrocarbon Data Area and Its Significance

Considering this project, the hydrocarbon processing area covers all functions, which concern the operation of the process plant. The activities appearing in the hydrocarbon processing area are listed below:

(1) Raw material supply planning

(2) Product demand planning

(3) Capacity planning

(4) Refinery planing

(5) Operations performance analysis

(6) Utilities and energy management

(7) Stock management

(8) Laboratory quality management

(9) Sample management

(10) Laboratory test results

(11) Operation scheduling

(12) Shift worker scheduled

(13) Online optimization

(14) Advanced process control

(15) Regulatory process control (based layer control)

(16) Custody of receipts and shipment

(17) Oil movement and inventory control

(18) Blend control

Based upon the functional hierarchy model, i.e. activities versus control times, the simple hydrocarbon processing system can be structured by grouping the common activities and the common control times. The hydrocarbon processing system structure consists of two basic system domains having common activities inside each domain. The two domains are:

(1) The refinery business systems domain that performs those functions for which the control has a long cycle times. For instance, raw material supply planning, product demand planning, capacity planning, performance analysis, utilities and energy management, stock management, and laboratory information system.

(2) The plant control systems domain, which performs and supports basic control, enhanced and advanced process control and monitoring, oil movement management and control, product blend control, and plant optimization. This domain obviously has a shorter control time.

The structure of the hydrocarbon processing system is shown in Figure 2.2.

Since the difference in level of control time, the nature or the characteristic of applications in each domain will be different. In order to make a proper access of both system domains enabling people who support, monitor or give advice plant operations, the supervisory as an information-bridge system is required for the hydrocarbon processing system.

Descriptive survey was done in this project to provide the requirements and descriptions of the information-bridge or the supervisory system in the hydrocarbon processing system, which will be referred as a "Hydrocarbon Data Supervision-HDS."

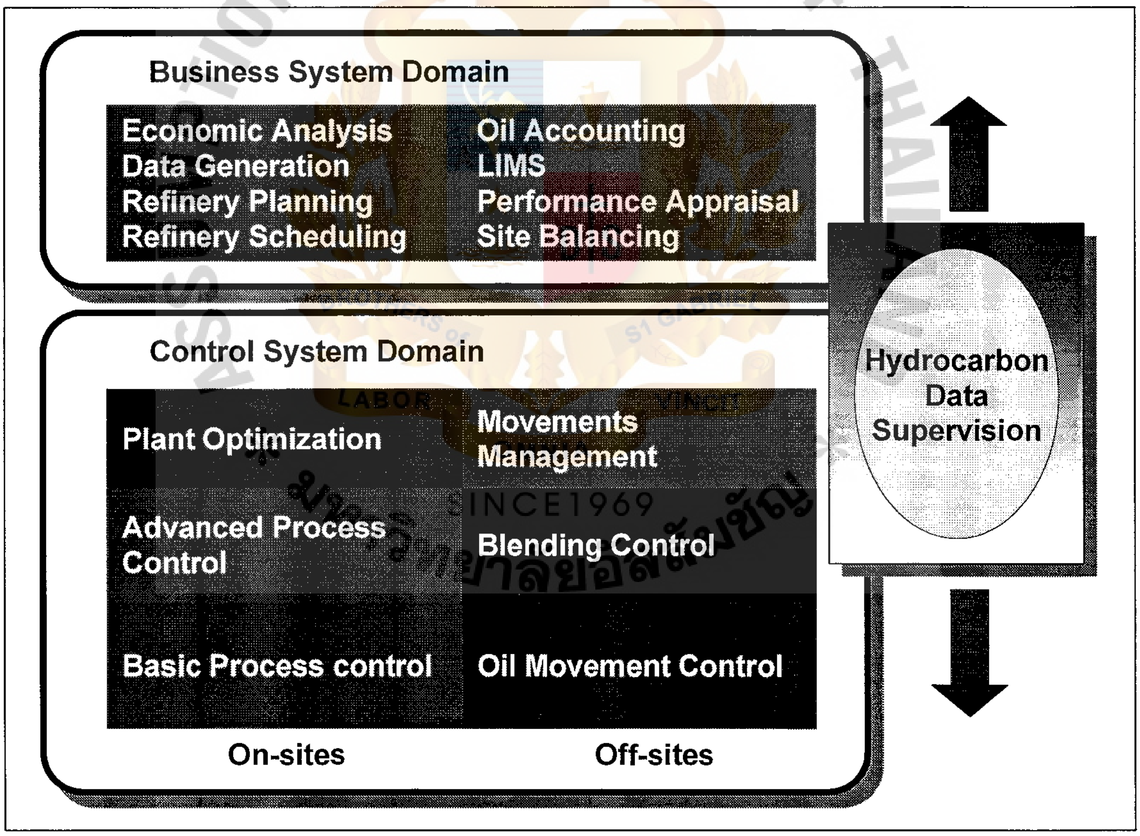


Figure 2.2. Hydrocarbon Data System Structure.

# III. PROJECT METHODOLOGY

## 3.1 System Development Life Cycle Concept

Systems development consists of five activities, all or any of which may pertain to the development of a given system. These activities, which form a cycle, are described as follows:

(1) Preliminary investigation: A preliminary investigation is undertaken when users note a problem or opportunity and submit a formal request for a new system to the MIS department. The investigation is brief, and numerous options concerning how to solve or take advantage of the situation are proposed to management so that it can decide how to proceed.

(2) Requirement analysis: If, after studying the results of the preliminary investigation, management decides to continue the development process, user needs are studied. Then, systems requirements that must be met to satisfy the new or changed user applications environment are produced. This step is called requirements analysis (sometimes it is referred to as systems analysis).

(3) System design: During system design, the user requirements that arose from analyzing the user applications environment ate incorporated into a new system's design.

(4) System acquisition: After the system design details ate resolved, such resource needs as specific types of hardware and services are determined. Subsequently, choices are made regarding which products to buy or lease from which vendors. These activities are part of system acquisition.

(5) System implementation and maintenance: During system implementation, the system is set up and run, and any necessary adjustments are continually made. Users are then trained in the new system and eventually work in it alone. After the system is in place, the system is maintained; it is modified to adapt to changing user and business needs so that the system can be useful to the organization for as long as possible.

The systems development life cycle (SDLC) is so named because, for many applications, systems development is a process that never ends. Thus, even when a system is completely specified, designed, purchased, and running, it is continually being enhanced or maintained.

Enhancement and maintenance any require returning to one of the earlier stages of the systems development process. For instance, consider the evolution of order-entry systems. In the 1960s, when some firms first used computers for their order-entry operations, many of them went through the five stages of systems development to justify batch-oriented systems to management. These systems used mostly punched cards and magnetic tape. Subsequently, each time a new technology or business condition made it economically worthwhile to reconsider these systems, computer professionals had to undergo the systems development process again. For example, when disk technology made direct access possible, many order-entry systems were re-developed to take advantage of this. Such technology products as on-line terminals, sophisticated communications systems, and database processing often initiated further redevelopment. Thus, the evolution of the order-entry application conforms to a cyclical pattern in which each period of the cycle represents a new or modified order-entry system that was created by re-applying systems development practices.

Changing business conditions can play just as great a role as changing technologies in creating the need for systems to be maintained or enhanced. For example, a lot of companies look at their order-entry systems as competitive weapons, which means that many of these systems are being re-developed to accommodate on-line terminals at customer sites. On Wall Street, several investment firms built new on-line trading systems in the early 1980s that were then re-development to handle such new business-related complexities as global markets and options trading. In 1992, pen-based computers were first introduced in some parts of the Chicago stock market, enabling traders to make complete transactions in the trading pits themselves. Similarly, airline deregulation caused the airline industry to have additional information needs, and many reservations systems were expanded to add new, strategic-oriented applications.

### 3.2 HDS Model Development Method

In this project, the above SDLC concept is used as a reference to derive the descriptive model of Hydrocarbon Data Supervision system. Stating from:

(1) defining the problem as a preliminary investigation,

(2) surveying and analyzing the requirements both of business and technical requirements, and

(3) describing the system design and acquisition as part of the descriptive specifications for future implementation.

Preliminary Investigation (Defining the problem): this includes survey of literatures interview existing organization, and list number of common business problems with regards to uses of Refinery Information.

# IV. ANALYZING SYSTEM REQUIREMENTS

## 4.1 Objectives of the HDS

It is obvious that the HDS is the system application that provides operational data in the hydrocarbon processing system to the person who supports, monitors, and gives advice regarding plant performances. The HDS enables the users to access information in order to make reliable decisions in a refinery. It consists of a large real time database for storage of tag data, reporting facilities, set of applications, and an associated related database. The objectives of the HDS can be summarized below:

(1) To provide historical data and real-time-high-resolution (RTHR) data across a refinery.

(2) To retain, retrieve, and increase knowledge of the plant.

## 4.2 Problem as Preliminary Investigation

As mentioned before the different characteristic of the two system domains has made difficulties for the users. The plant control systems domain has a short control time. The problems of integrating the two domains are:

(1) Too much detail, not enough information

(2) Too many different data sources

(3) Same data from different sources are inconsistent

(4) Too much manual and clerical effort

(5) Inconsistent timing / line-up of data

(6) Data integrity can be questionable

(7) Data not available when needed

A good supervisory system (in this case the HDS) requires to oversee the information from both system domains should have flexibility in real time mode with high availability for data collection.

### 4.3 Business Activities' Requirements

The bottom up approach is used to perform the requirement analysis of the HDS system in the project. The requirement analysis starts from the business activities, which are supported by the HDS and then investigate the requirement of the different group of users. The HDS supported activities including objective and users are listed below:

(1) Plant data, business data, applications, procedures - all are unified by a common database structure.

(2) Global system data management eliminates duplication of databases and multiple data entry.

(3) All applications use consistent data.

(4) Information is pervasive, reliable, ease to get at.

(5) Information access is intuitive.

(6) Operating problems become obvious.

(7) Engineers are able to spend their time on improving functional performance instead of integration.

### 4.4 Business Activities and Conceptual Architecture

4.4.1 Plant Performance Monitoring

Objective: To monitor and interpret process performance to ensure optimal performance of the plant, identify non-conformance and trigger corrective actions. Measuring and interpreting performance indicators is done regularly, using measured variables, data derived from measurements, and data reconciled around the process unit. Data includes, quality give away margins, utility consumption, efficiencies of processes or equipment, fouling trends.

Deviation from target and attainment of physical or technical constrains are signaled for corrective human action.

Data reconciliation, which compensates for measurement error can be performed on actual plant data to ensure that comparing with plan are accurate.

Unit mass balance must be performed.

Users: process operators, maintenance staff, process engineer, plant management, scheduling, site remote experts.

4.4.2 Equipment Performance Monitoring

Objective: To monitor the operational performance of equipment, for instance, compressors, heat exchangers, instrumentation, to ensure performance, early detection of degradation or non conformance and initiate the onset corrective action.

Attainment of physical and/or technical constrains trigger corrective action.

Users: process operators, maintenance staff, inspection, process engineers.

4.4.3 Plant and Equipment Performance Analysis

Objective: To analyze plant and equipment performance and provide the means to structural improvement of process performance with improved understanding of process behavior.

This trouble shooting activity includes analyzing production performance, loss product qualities and give away for the assessment of utilization and deviation report. Process engineers and operation personnel require process variable trends to understand and improve plant performance. The hundreds of thousands of data collected from a multitude of sensors are a wealth of information that can be used by technologists and operation management.

These activities finally result in guiding and recommending technical setting for the production process or recommendations of plant changes.

Users: operators, maintenance staff, process engineers, plant management, site remote advisors.

4.4.4 Target Setting

Objective: To fix and set targets for production process. Different techniques can be applied to calculate the targets: on line optimization, based on rigorous models, modes and targets, based on retaining and applying best practice and expert systems that capture rules based on experience and knowledge. The targets are then sent to the control level for open or closed loop execution.

On line plant optimizers automatically generate production targets which are downloaded to the DCS. On line optimization is not in the scope of HDS, but HDS can provide an environment for on-line optimization.

Modes and Targets application supports the process of getting plants running efficiently by providing targets for the various/typical cases of normal operation. The Modes and Targets application is in the scope of HDS. Modes and Targets can be used in combination with on-line optimization, i.e. for initial target setting.

Expert Systems are rule-based models to retain and apply the knowledge. Expert systems are promising tools that can be used to warn the operator at an early stage of a deviation in a reliable way, to avoid the disturbance to be more serious. Expert systems are now available but we have little practical experience.

Models (off-line and on-line) tuned to actual plant performance also retains and increases knowledge of plant behavior. Model results (e.g. monitoring of catalyst activity, heat transfer coefficients, etc.) could be made available via the HDS but process simulation is not part of HDS functionality.

Users: process operators, plant management, process engineers, scheduling.

4.4.5 Storage and Retrieval of Data

Objectives: To store, receive, and provide data from/to other activities. Duplication of data should be avoided and consistent data management is ensured. Generic data access requirements (either one-way or two-way) should be considered between the HDS environment and other systems or application, requiring operational data or where the data residing in other systems would enhance the activity supported by HDS.

(1) Basic data generation and the process modeling environment

(2) Refinery Planning (including crude valuation and selection)

(3) Refinery Scheduling (crude, process and blend scheduling)

(4) Supply and Marketing (arrival/lifting nominations, prices, etc.)

(5) Site Balancing (yield accounting)

(6) Oil Accounting

(7) Laboratory Information Management System (LIMS)

(8) Performance Monitoring and Analysis, with a time resolution of a production run (feed/mode), day, or longer.

(9) Process Simulation and Optimization

(10) Process Control and Measurement

(11) Maintenance/Engineering systems

All of these systems or activities use data from the HDS or provide data to the HDS. The way in which the data is physically transferred between the different systems will differ between locations based on existing systems and infrastructure and also for historical reasons.

The activity or application areas, which may require a data flow in or out of the HDS is shown in Figure 4.1.

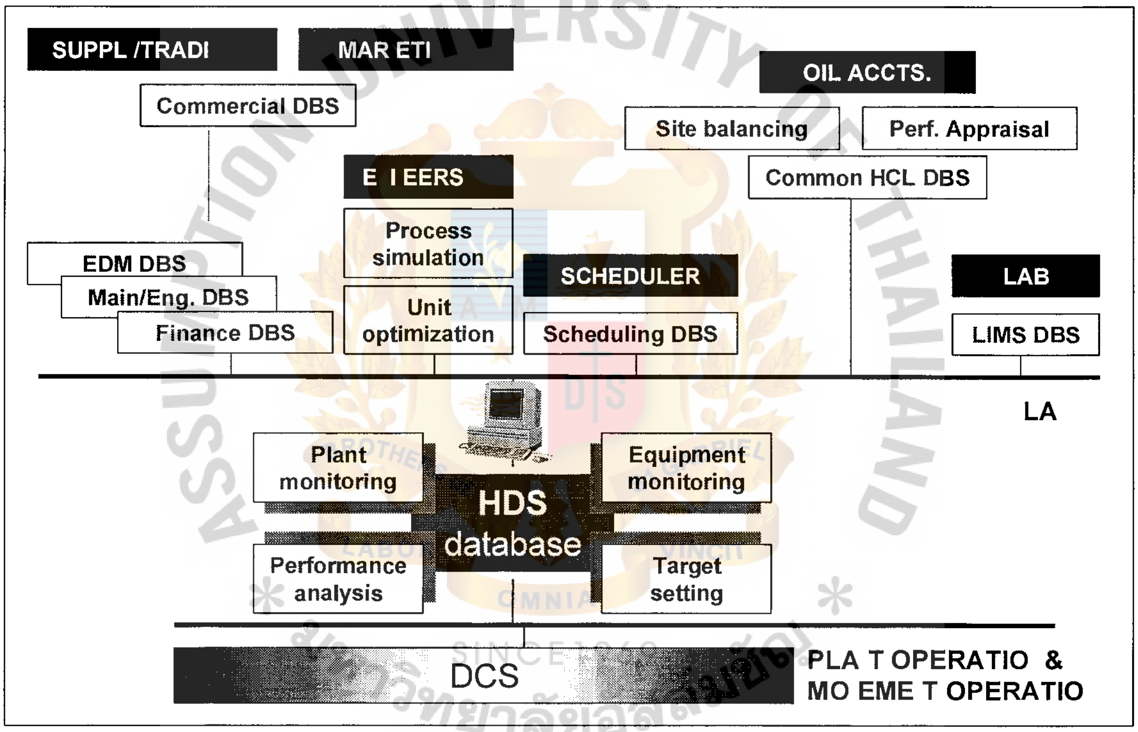


Figure 4.1. HDS Integration Architecture – Conceptual View.

## V. FUNCTIONAL DESCRIPTION AND REQUIREMENTS

The HDS system has four main functions as follows. Each functional requirements is described hereafter.

(1) Collect, store and historize by means of the database.

(2) User interface and reporting by means of the access to the data.

(3) Applications by means of the manipulation of data.

(4) Interface with other systems by means of the communication with business and control systems.

### 5.1 Data Management Requirement

Function: Collect, Store and Historize process data site wide

Objectives:

(1) All process values from the Distributed Control System (DCS) or other measuring systems (process measurements, equipment measurements, analogue or digital, are collected and retained for a period of typically a year.

(2) Register all events, which are relevant for operating and managing the plant (support the activities monitoring, analyzing, etc.).

5.1.1 Types of Data

The data to be handled can be distinguished in four different categories:

Spot data: All spot data, often called snapshot data are tag based and time stamped. Spot data can be related to equipment and/or a location.

(1) Measurement tag data collected from the DCS systems and other measuring systems; analog process and equipment data (including simple calculation results as e.g., temperature or pressure compensation, done in the DCS,

rotating equipment data, etc.); controller data; and; data calculated within the DCS.

(2) Calculated tag data created in the DCS, sub-system or HDS and derived from measurement tag data.

(3) Sample analysis results- although HDS is not a lab system, some laboratory data should be collected for calculation purposes. Lab data are time stamped at the time the sample has been taken. Lab data often resides in Laboratory information systems (LIMS).

(4) Status- (valve status (open/close), running equipment status (on/off), active constraints. These are generally within the DCS.

(5) Process, equipment and all other alarms. Time stamping is important so that at the HDS level all events have the right time when they occurred are also stored).

Events: Two types of events can be distinguished:

(1) Events useful for reporting and later for analyzing purposes only

(2) Events that can be used to determine the start or the end of a period

Operators may register events when they occur; this needs a user friendly entry screen either in the DCS or the HDS. Events can be generated from process data (e.g., opening of a value, quality off-spec, trip, etc.). Typical events are alarms, mode switch, feed switch, and important changes in operating conditions.

Events are time stamped. A link with equipment, unit or plant is useful to enable retrieval and e.g. statistics on events. An event can be linked to a category and other related data, i.e. a set of scheduling targets.

Aggregated data: Spot values are converted into data aggregated within a period. The aggregation is done either on a regular basis (i.e. hourly averages, daily averages) or can be defined by an event, i.e., average of the spot reading values during a period bounded by events. Other values that are valid during a period are considered as aggregated values (operating targets, economic data).

Reference data: These can be standard data (e.g., material names, properties) or configuration data (tag description, scales, and limits).

### 5.1.2 Data Acquisition

The system collects spot data at a rate of typically once per minute, spread over the minute. All analogue values shall be collected in engineering units, as this is the simplest thing to do. Data quality indicating the degree of confidence shall be attached to the data. Standard tag-names, with the same naming conventions as the DCS, shall be used to reference process variables.

For calculated (non-measured) variables more freedom in assigning variable (tag) names is required. For alarm analysis, it is required to know the exact sequence of event and one-minute time stamp is not accurate enough. The alarm status shall be linked with the time stamp from the DCS for pre alarms.

### 5.1.3 Data Preconditioning and Data Validation

All measurement data shall be automatically checked as being a reasonable process measurement. This is because the calculations require the use of inputs from various parts of the plant and from potentially sensitive analyzers, and thus errors or discrepancies that may appear frequently should be highlighted and resultant errors in the calculations should be traceable.

It is therefore required that "quality indicators" be attached to all database points. A quality indicator for a point scanned from the DCS system will indicate whether it is a good value. Facilities exist in all DCS to check measurements and a flag is set to indicate the data quality. The DCS usually links this quality indicator to the associated value and this too can be scanned into the HDS. For a DCS calculated point an identical approach can exist and this can indicate whether or not any of the components of the calculation are not good values.

Within the HDS, calculated variables should have identical quality data flags that operate and function as do those coming from the DCS. A mechanism is required to propagate the quality indicators in calculations. The mechanism of propagation should be selected, on-line, by the user.

Preference is given to definitions associated with the DCS. Different DCSs have different definitions. The following definitions are DCS independent but are indicative. For example:

(1) GOOD: If a scanned point, then a good value; if a calculated value, then involving only GOOD components.

(2) INSERTED: Entered by the operator. Stops the point being scanned or recalculated.

(3) SUSPECT: For a calculated value, involving one or more INSERTED or SUSPECT values. For a scanned point this means out of target range.

(4) BAD: For a scanned variable, out of instrument range, instrument broken, etc. For a calculated variable, involving one or more BAD values.

(5) NO DATA: Data not received from the DCS.

5.1.4 Historizing

The data base configuration (Real-time Database: RTDB) must have an efficient data compression function that minimizes the mass storage requirements. Data compression may have negative consequence on data analysis by advanced statistical methods. Hence, it must be possible to disable the data compression for a defined set of data selected over a particular time scan. The history system, to be accommodated in the RTDB, shall provide sufficient memory for:

(1) Spot values and events to be retained typically six months to one year.

(2) Aggregated data to be held for one year (typically twelve minutes, hourly, daily, monthly averages and event driven aggregated data).

(3) The RTDB shall store all types of data defined above. This includes lab data that are necessary in the HDS.

5.1.5 Archiving

The RTDB shall be kept in computer archive files for at least two stop-to-stop periods (6 years) or turn around. If the HDS is upgraded over this time then upward compatibility must be catered for so that archived data can be replayed by the newer system. Archiving should be done on-line and be automatic. It should be possible to reply archived data in an easy and fast way without stopping the system.

**5.2 User Interface Requirements**

Function: User Interface and Reporting

5.2.1 Standard User Interface

Objective: User friendly displays, commands and controls that allow users to retrieve data, trends calculate, report and otherwise use the HDS.

The capability of an HDS resides in its ability to retrieve and present data coming from different databases to the users. The HDS human/machine interface, HMI shall be such that data from the HDS RTDB or relational database and from other systems (e.g., LIMS) are collected, retrieved and displayed comfortably for the user.

The standard desktop environment Microsoft Windows is the preferred HMI for users of the HDS. HDS data can be called in and further manipulated with applications such as Excel; data access from the PC to HDS data shall be via clicking on HDS icons in the various PC applications. Data and tag search facilities, attribute selection, must all be available. The HMI must include a trending package, allowing users to plot process data, events, laboratory data on one picture.

It is important to distinguish two environments. Some reports have to be controlled (e.g. unit performance, emission reports, shift reports); they have to be auditable, documented, protected and could be modified only by authorized personnel. This environment is the managed environment. On the other hand, a maximum flexibility is required by users for ad-hoc calculations and reports. No protection is required in this case.

The HMI shall be uniform for all functions within the HDS (i.e., consistency in keys/functions behind the keys/icons/mouse and window set-ups etc.). The HMI shall have easy to use mechanisms that allow users to navigate through the different applications and functions within the HDS. It shall have help screens for all standard functions and applications.

The HDS HMI must support standard query language SQL, thus allowing to access data stored in relational data bases (RDBs) of other systems such as LIMS. The user must be able to display/trend data coming e.g. from the RTDB and from a RDB, such as LIMS on one display.

5.2.2 Generic Report Types

A report can be a combination of data in any form (e.g., texts, trends, graphics) which may appear either on a VDU screen or on a printer.

Typical reports are listed below:

(1) Overview of key variables with targets

(2) Shift summaries

(3) Process unit economic summaries

(4) Technological reporting (user defined)

(5) Unit-wide material balancing

(6) Scheduling targets

(7) Controller performance summaries

Each report shall have the possibility to include any combination of data types. In addition to having standard predefined reports, it must be possible to define ad-hoc reports using all types of data in the Excel environment.

Typically, shift summaries are used in electronic shift logbook, that summarizes the plant key parameters, and stream quality targets and results. The event registration is the basis of the shift summary report. At the end of the shift, the shift supervisor modifies and approves the events registered by the operator. Space must be included for shift personnel details and notes to be entered for the explanation of production deviations.

Daily process unit economic summaries are the main daily management interface to the plants via the instrumentation system. Each provides a one-page summary, for each plant, oil movements and the utilities area, of measured plant performance (the daily aggregated value) versus plan. Information includes direct measures values as well as simple calculation results, such as:

(1) Key operating variables

(2) Plant intake and scheduling target

(3) Product yields (and targets, if any)

(4) Product qualities versus scheduling targets

(5) Summary of the plant give-away versus the two or three process constraints on intake or severity, such as (if applicable) e.g., degrees below maximum skin temperature, hydraulic limits, as evidenced by average valve positions

(6) A summation of gas flared or letdown to fuel or vented

(7) Constraint violations

Trending is an important feature of the HMI. It must be possible to freely define any combination of tag-data in trends. It shall be possible to trend laboratory data together with their target values.

## 5.3 Application Requirements

Below follows a list of applications, which HDS system should be able to support. Refinery might choose to implement some applications only or in a phased manner.

### 5.3.1 Calculation

Objectives: Easy to use means to manipulate data. Calculations can be performed in the DCS and in the standard desktop (e.g., using Excel). Instead of locating all calculations in the HDS computer, it is the best to use the following distribution:

(a) Calculations required for closed loop control and automaton should be housed in the DCS. Flow compensations should reside in the DCS.

(b) Scheduled calculations for monitoring and process analysis should preferably be performed in the HDS. Mass balances, unit data reconciliation, efficiency calculations are some examples.

(c) Ad-hoc calculations could be performed using standard tools such as Excel spreadsheet and routine complex calculations requiring input of values and analysis before reporting (e.g. operating test runs).

(d) It is possible to use process simulation tools (e.g. PROVISION, ASPEN, HYSIM) to perform calculations. Data can be sent to the process simulator and the calculation results stored back in the HDS.

General Requirements for the HDS Calculations

(a) Presentation of actual implemented calculations should be transparent, so that engineering and technical content of calculations can be easily checked by users.

(b) Any code required for communication of data with the database shall be made effectively invisible to the user by using standard database access subroutines.

(c) A full range of standard mathematical operators shall be provided.

(d) Logic and sequencing can be applied in calculations.

(e) Calculations should be segmented operation of most of the calculation subsystem during maintenance of part of it. A suitable basis of segmentation would be by process unit. Further, use of subroutines is desirable for often-used code to allow centralized adjustments to the code if required.

(f) All calculations and results shall be in engineering units as defined in the DCS.

(g) A facility is required to cross-reference usage of tag-names, to enable tracing where a tag has been used and avoid duplication of calculation.

(h) Version management facilities shall be provided

Typical Calculation in the HDS

The following lists typical calculations useful to fulfill the HDS activities.

(a) Gas property calculations from composition data

(b) Liquid stream property calculations from average data

(c) Steam property calculations.

(d) Distillation Tray/Packing Loading

(e) Compressor calculations

(f) Turbine and expander calculations

(g) Heat exchanger and air-cooler performance calculations

(h) Furnace and boiler efficiency calculations

(i) Reactors-Calculations of catalyst activity/selectivity

(j) Networks-mass and energy balances of main networks (e.g. steam, hydrogen)

5.3.2 Data Aggregation

Objective: Aggregate the data to allow effective comparison of actual performance with plans and process targets. Aggregation of data can be done on regular basis or can be event driven.

On a regular basis, hourly, shift and daily averages should be calculated and stored. The requirement for event driven aggregation is to allow the comparison of plans and schedules against the actual performance; daily averages are not sufficient for such comparison. The actual performance must be structured in the format of the schedule, i.e. unit production runs, blends, movements, etc., and shall be expressed in terms of quantities, qualities, yields. The start and end of a period are given by the events. Some examples are the start/end of a crude run, change of a mode, unit trip or upset (recycle mode), start/end of a blend.

The data structure should support the linking of process data to events. This allows the data to be referenced to the different periods (production runs, blends, etc.). The aggregation of data can be made on the period, i.e. total, averages, max, or min within the period, etc.

5.3.3 Data Validation and Reconciliation

Objective: Improve the accuracy and consistency of data for performance monitoring and appraisal.

The application should identify instrumentation measurement errors and should provide the reconciled data for other applications, in particular, plant mass balance, optimization models, and performance analysis. Detection of drifts can initiate maintenance work orders. Technologists may apply data reconciliation on an ad-hoc basis in order to appraise plant performance with reconciled data. The data reconciliation at the unit level included heat and material balances. It should be possible to run data reconciliation with aggregated data. Reconciliation is performed on a refinery wide basis, not on a multi-plant or site wide level. The site wide level reconciliation is performed in the business system.

5.3.4 Event Registration

Objective: Register all events that are relevant for operating and managing the plant in order to enable analysis of problems occurring in the plant and automatic shift reporting.

A user friendly entry screen is required for operators to record events when they occurred. Events will always be time stamped and categorized. An event shall be linked with equipment or area. Textual comments are added to an event. These events can be automatically generated (e.g. by the mode system); in that area, the operator may have the possibility to add comments and make modifications.

Event registration is used at the end of the shift to make the shift report. Events registration is a basic requirement for data aggregation based on production runs and the link between the actual run and the planned run should be captured with the event.

5.3.5 Statistical Process Control

Objective: Improve refinery performance by mapping the actual performance of the plant compared with targets and constraints and provide advice on corrective actions; and improve knowledge of the plant.

Statistical process control (SPC) is used for the isolation of significant trends from noisy and random process data, in real time or from historical data. Thus it is useful in locating changes in performance of plants before the sustained change becomes costly, without generating spurious alarms due to short-term process or spikes.

Many of the technological parameters calculated are monitored with SPC. The values should typically be normalized, or performance index (so not affected by mode switches or ambient variations, etc.). Thus significant trends in items such as fouling or catalyst activity will be located early, and remedial action taken. This also saves technological effort in the scanning of normally satisfactory data. The package shall at least provide the following statistical functions (Univariate-SPC):

(1) X-Y plots

(2) Graphics (e.g. bar chart , pie chart)

(3) Control charts (e.g. cusum, zone control)

(4) Curve fitting

(5) Regression analysis

It shall be possible to use data from all databases freely in the statistical analysis package.

Multivariate Statistical Process Control (MSPC) addresses the problem of understanding and interpreting large amounts of complex, highly correlated noisy data. In a refinery, thousands of data are collected by a multitude of sensors. The process can be redefined in terms of a much smaller set of variables, which reflects the true dimension of the system. Typically, three to four latent variables are sufficient to describe and monitor the process adequately. The MSPC analysis is done in an package (e.g. PCTP), collecting historical data from the HDS. After the analysis, the reduced set of variables can be calculated on-line in the HDS in order to monitor on-line plant performance.

5.3.6 Modes and Targets

Objectives: Support the process of getting process units running efficiently by providing targets for the various typical cases of operation; and share best practice between shifts, gaining from experience and capturing best practices.

Knowledge of key variables is updated in a library of modes. A mode selected by scheduler and technologists gives targets which gives guidance so that the plant is operated in a desirable and consistent way across all shifts, incorporating the accumulated knowledge of what the key variables are and at what level they should be kept. The targets can be automatically downloaded to the DCS where operators can acknowledge the targets as new set points in an open loop fashion:

The panel operator selected the required mode (from a library); the corresponding targets and limits are downloaded to the DCS. An engineer defines and maintains the library of modes. The mode defines the feeds, yields, key properties and the targets for the corresponding optimal operating conditions.

5.3.7 Batch Production Management

Batch processes are common in chemical industry, but not in refineries. This functionality is very powerful and can be very useful in a refinery to monitor production runs, blending, start-up period, etc., and for units operating in a batch mode such as lube oil units. The modes and targets and the data aggregation can make use of batch structure.

Production management of batches is made up of three activities: (1) Recipe management, (2) Production Scheduling, and (3) Batch history management.

(1) Recipe management: A recipe management should maintain a database of master recipes for various products, formulas and procedures that are used for various products, and specific information on the equipment that can run each operation within the procedure. A control recipe can be built from a master recipe. Control recipes can be downloaded to the control level.

(2) Production scheduling management: Develop a detailed schedule for a given time frame to achieve the production targets set by the production plan. It should specify the start and completion times for individual operations of the recipe. This activity is not in the scope of HDS and is part of business systems.

(3) Batch history management: Receive and store information from batch control on the individual batches, produce batch reports and maintain a batch history.

Batch history entries may also come from outside the process control domain and may include sample results, raw material data, etc. Batch end reports include the recipe that was used to make the batch, identification of the batch, utilities consumption, equipment run times, temperatures, etc., for the entire batch. A batch log produced at the end of a batch containing the complete process history of a batch.

A good batch historian must collect and maintain identifiable sets of dissimilar data to provide an easily usable batch history. This event-triggered data set will typically contain the following related data associated with a batch or product:

(1) Continuous process data (flows, pressures, temperature)

(2) Event data (operator actions, alarms, notes)

(3) Quality data (lab analysis, inspection data)

(4) Recipe data (set points)

(5) Calculated data (totals, material usage)

(6) Manual entries

(7) Batch lot identification

(8) Time/date of collection

SQL query capabilities / statistical key points in batch control.

5.3.8 Expert Systems

Diagnosis and Decision Support Tools based on process analysis and operator experiences should warn the operator at an early stage in a reliable way, to avoid the disturbances that are more serious. Expert systems are promising tools in this domain.

(1) Alarm Analysis: Analyze frequency and characteristics of alarms to avoid operation to be overwhelmed by alarms. Alarms should be historized (with a DCS time stamp) and statistics on alarm history can be made in order to improve alarm settings (limits, hysteresis, etc.).

(2) Alarm management: Reduce down time and numbers of trips by helping the operator to identify the root cause of alarms and prioritize/masking depending on plant conditions. The operator will react correctly in a timely manner if he is assisted by an alarm management package. During large disturbances, the number of process alarms generated by the DCS may grow considerably; the operator has to determine quickly what is the root cause, which alarms are significant, and decide which actions he has to take to avoid further degradation of the process. Operators can come in a stress situation and interpretation of this large volume of information is difficult which may lead to a wrong diagnostic and wrong actions.

(3) Environment monitoring system: Provide an emission monitoring system that enables coordination of emissions on a site basis; fulfill government reporting requirements on emission levels. All emissions on a site basis should be monitored during all process states; targets and limits can be defined for individual plants. Pre defined reports shall be prepared for technologists and compliance with authorities' requirements.

### 5.4 Interface with Other System Requirement

This section covers the interface between HDS and external business system, typically running on an off-line mainframe or a business system computer. The HDS shall have capabilities to communicate the information with the external systems.

Flowing of data in and out the HDS can be categorized into two manners: (1) Feed-forward data flow, and (2) Feed-backward data flow. Typical interface data flows between the HDS and other system is discussed in this section.

5.4.1 Feed-Forward Data Flows

The feed-forward data flows are usually flows of data incoming to the HDS or used by the HDS from the external systems for examples the data created by:

(a) Scheduling system- Planning/scheduling target:

(1) Expected arrivals/lifting and tank allocations

(2) Crude and feed sequences

(3) Intake and mode targets

(4) Expected yields and properties per feed or mode

(5) Blend sequence, recipes, and bound

(6) Required tank transfers

(7) Projected tank inventory and quality

(8) Expected constraints

(b) Planning and scheduling system:

(1) Economic steering values-Product, intermediate, and component prices

(2) Blend specifications

(c) Laboratory Information System (LIMS):

(1) Laboratory process and utility results – transferred on a batch or when released basis

(2) Laboratory quality measuring instruments or analyzers calibration results – transferred on when released basis

(d) Oil Movement Information System (OMIS):

(1) Laboratory oil movement results (tank, shipping) – transferred on a batch or when released basis

(2) Data from a road and rail loading system

5.4.2 Feed-Backward Data Flows

In contrast, the feed-backward data flows are flows of data created by the HDS and received/used by the other external system such as:

(1) Process data created by HDS: A subset of the process data (average flows, temperatures, pressures, analyzer measurements, derived variables, etc.). Hourly averages and daily averages are normally used and potentially include any of several attributes of a tag (raw value, set point, controller output, status of the measurements, e.g. bad, out of range, etc.). Available reconciled data from the unit optimizer or an on-line reconciliation system will be transferred in addition to the raw data. These data are normally received/used by site balancing, scheduling, oils accounting system (OAS), performance monitoring, and process engineering systems.

(2) Tank data, Oil Movement, and Blend Data: Tank data (level, temperature, pressure, volume, weight, density, composition, etc.) at a daily reference time, at a specified frequency, or upon request will be generated. Oil movement data such as quantity, source, destination, material, start and end conditions of source and destination tanks, etc. will be created by the HDS. These data are normally received/used by site balancing, scheduling, oils accounting system (OAS), and performance monitoring systems.

(3) Model Calculations: The calculation such as heat exchanger efficiencies, furnace efficiencies, flooding of the column, gas and liquid properties can be created by the HDS and used in Process simulation model, optimization models.

(4) Event Data: Information that fully describes an event which delimits a production run, i.e. feed or mode change (production run ID, start/end time, run type, feed, etc.). This data will be linked to the appropriate aggregated actual data. These data are normally received/used by site balancing, scheduling, process engineering, and performance monitoring systems.

(5) Equipment Data: Information likes process events or conditions that trigger a maintenance or inspection action, meter error, and equipment availability are created and used by maintenance management system.

(6) Material Requirements: For examples chemicals, catalysts, consumables, etc. will be created and trigger the action materials system, financial system.

# VI. TECHNICAL REQUIREMENTS

## 6.1 General System Requirements

6.1.1 System Availability

The HDS system availability has to be in excess of 99.5% including both planned (regular system maintenance and management) and unplanned system down time. The unplanned down time software support shall be available on a 24 hours, 365 days cover to limit the maximum duration of a failure to 8 hours. The mean time between failures shall be at a minimum of 3 to 4 months (on annual basis).

6.1.2 Performance

The following display evocation times must be met in 95% of all responses at any user station on the LAN:

(1) Simple enquiry (e.g. present a display with 20 values) < 2 seconds

(2) Complex enquiry (e.g. present a display with 24 hour trends) 5 seconds

(3) Browse (to next/previous page of report) 1 second

(4) Data transfer to PC application (100 points/100 daily values) 30 seconds

The network and any required upgrade/modification will be managed by the organization's IT department.

6.1.3 Spare Capacity

The hardware capacity shall be specified such that the average load on the CPU may not exceed 50% of the capacity, while the peak load may not exceed 80% for more than 5% of the time. The database and history system shall have a spare capacity of 20% at delivery (data). The mass storage shall have a spare capacity of 50% at delivery.

The spare capacity in the hardware extension slots (for extra memory and communication cards) shall be at least 30%.

6.1.4 Security

Process control system, i.e. computer equipped with hardware and software capable of influencing plant actuators without human intervention, need extra protection against intruders who could endanger plant safety via these systems. Intruders could, via network connections, through exploiting faults or imperfections in the security software and errors in the security settings a system, and/or by finding out user secrecy which are part of the protection, get access to a system, misuse system functions and introduce malicious programs.

The security of systems in the network depends on the security of each individual system. Implementing security system in each system is difficult and time consuming. Different types of systems have different security features of different qualities. Ensuring that the correct setting are in place at all times is difficult to achieve, especially in systems with many different users, many applications and different network connections.

It is typically recommended to place safety-critical systems within a security perimeter in a so called, secure domain. All communications from the outside with systems in the secure domain must be routed via special gateway systems called firewalls, in the security perimeter. Such a gateway system is designed for access control and shall allow only communication types which cannot be exploited to intrude systems and shall restrict the systems and terminals which can communicate with systems inside the secure domain to the terminals which can communicate with systems inside the secure domain to the minimum required to reduce exposure. All data communication from outside the secure domain to systems in it must be relayed by trusted (and audited) applications in the gateway system to trusted (and audited) applications in the destination systems. Communication types which currently are considered to pose a security risk are for example: X-windows, SQL*NET, and log-ins. In case the HDS system is placed in a PCS secure domain, user access via systems and desktop computers outside this domain needs to take place via a gateway system. Special client/server software, including an application in the gateway, sometimes called a proxy application will be necessary.

In case the HDS is placed outside the secure domain a special data transfer mechanism must be developed, which, via an application in the gateway system, will keep the database in the HDS system up to date. User access from the desktop computers connected to the network in the secure domain would need to go via the gateway system by means of software as described in the previous case. However, depending on local circumstances, a site could form one secure domain and the gateway system could be placed at the "refinery fence". Local circumstances to be considered are the network configuration, the requirements for communication with the outside world, and the trust that there are no security threats from with in the secure domain.

Temporary supervised connections with full functionality can be done securely for remote experts. Some sites used the so-called defender system.

More specifically, LAN file services will be provided to store and manage standard desktop output files with appropriate directory and protection capability, which allows the followings:

(1) Read only for development of information reports which allow limited user update, but full user read only access.

(2) Secure read-write (individual) for secure documents, which can only be read or updated by individual.

(3) Secure read-write (group) for secure documents, which can only be read or updated by a member of an approved group.

(4) Full read-write for documents which can be read or updated by anyone.

## 6.2 Network and Computer System Requirement

The real time inputs as HDS Real-time Database input data will be directed from the process control domain, DCS system. The network requirements are discussed as follows:

### 6.2.1 Network Security Gateway System

All process control data shall be placed in a safe location called a "secure domain" with a special safety barrier at its entrance. The router used is the sole communication link between computer inside and computer outside the secure domain. The router is a computer system, dedicated for this purpose which contains all critical access controls. The main functional specifications for the router are as follows:

(a) For computer to computer communications:

(1) The router should not allow direct computer to computer network connections to be established. A filtered store and forward mechanism has to be used for data transfers.

(2) The router should accept data only from authenticated sending computers from outside the secure domain to which it belongs. The router only forward data to specific trustworthy programs in authenticated receiving computer in the secure domain.

(3) The router must prohibit all types of data transfers in both directions except via a special data transfer mechanism.

(4) The data transfer mechanism only allow "push file" functionality and prohibit "pull file" functionality.

(5) The data transfer mechanism can only "push" to pre-defined-trustworthy-target destination.

(6) The data transfer mechanism can only activate pre-defined-trustworthy program files (executables).

(b) For interactive terminal access

(1) access from outside the secure domain. The router must uniquely identify these persons by way of a "challenge response system".

(2) Interactive terminal access must be terminated automatically after more than one hour without any activity.

For the project, it is proposed to implement two levels of network security on site. One is being a highly secure process control domain, which fully adheres to the requirement stated above. Another is being a business domain, which will permit some of these functions but still provides a relatively secure environment.

6.2.2 System Security

The HDS system shall be part of the business domain of the refinery network infrastructure. Its access from outside is controlled by an overall refinery network firewall. The HDS system must meet the following security list:

(1) Access to the system is user password protected

(2) Password aging

(3) Password must be difficult to guess. This shall be enforced by the system

(4) Logging facility to monitor all login and logout actions (both successful and unsuccessful attempts)

(5) Session time-out (automatic log off procedure after a pre-defined period during which no user actin has taken place)

It must be possible to define users' authority profiles for access (create/update/delete) to each individual application, function, report, and data-item.

### 6.3 Hardware Requirements

6.3.1 HDS Server Hardware Platform

(a) Processor: The processor must allow sufficient processing capability for the basic database update and user access load. The data acquisition, historizing, reporting, and calculation requirements must be handled effectively and efficiently by the processor. Dual processor technology is preferred.

(b) Disc Storage: The system shall be equipped with sufficient hard disc space to store all software required for:

(1) Operating system

(2) Process Supervisory System software

(3) Application software

(4) Data files for historizing and archiving

The system shall be equipped with disk mirroring at disk controller level to preserve system availability in the event of disk failure.

(c) Tape Storage or Optical Drive: An appropriate tape device shall be specified for the loading of software and to allow disk back up activities to be performed.

6.3.2 HDS Client Hardware Platform

The user interfaces can be implemented on any workstations e.g. Intel based workstations having the ability to run on at least Pentium P400 with 128 MB memory. The applications shall be window based, for example, Window 98 with MS-Office 97.

The user interface shall be uniform for all functions within HDS (i.e., consistency in keys/functions behind the keys/icons/mouse and window set up, etc.). The user interface shall have a user-friendly mechanism to navigate through the different applications/functions with in the HDS.

6.3.3 Users' Stations

All PC client hardware, standard desktop software (e.g., MS-Office) and network connectivity hardware and software will be provided.

6.3.4 Disk Resilience

To prevent loss of data, all data held on the hard disks shall be redundant to allow the system to continue to function in the event of failure of a disc or disk controller. In such an event, after a disc or a controller is repaired, the newly repaired part shall be automatically brought up to date with the data on the still functioning part with out the system being taken off line. To achieve this, disk mirroring on controller level should be implemented.

## 6.4 Software Requirements

6.4.1 Supervisory System Software

It is envisaged that the supervisory system consists of Database(s) and standard user interface packages.

(1) Real time database (RTDB)

(2) Relational database (RDB) – prefer ORACLE database V7.3 or higher

(3) Fixed graphic and report writer package

(4) Simple user interface to PC environment

(5) Optional software package, SPC

The HDS software shall provide all process monitoring and reporting facilities. User licenses shall be procured and managed along with all application software source code.

Fixed Graphic and Report Writer Package: A facility is required to define standard graphics and reports to be displayed within the standard desktop environment (i.e., MS-Window 95). This package shall not require special programming skills and shall not be accessible for all users. The package shall provide a library of all components used in the graphics.

Simple User Interface to PC Environment: A facility is required to download real-time, historian, trend, and archived data to standard desktop packages. The facility shall operate without the need of manual data transfer or conversion. It shall be possible to retrieve process data based on tag-name entry, with "browser" option. This facility will make use of refinery standard tools.

6.4.2 End Users' General Software Requirements

It is imperative that the software environment that supports the reporting and monitoring is user-friendly for all level of users as well as for system and application system maintenance purposes. Certain demands are put on the computing environment by the need to perform calculations of reasonable complexity, and yet to be able to respond in a timely way to user requests for modifications of that reporting. The following specification defines the features of the programming environment.

(1) It shall be possible to test programs using real time or historized data. The location of errors shall be reported.

(2) The editing and testing of new or existing programs shall not affect the real time executing programs.

(3) A fault in the logic of a program, causing a crash, should effect only a faulty program, i.e. the execution of other programs shall not be affected. Such faults shall cause a report of the fault to be made to a fault log, which will appear on the system console.

(4) Programs and reports generation shall be able to sequence and schedule for execution at user defined frequencies, on manual request, at certain pre-defined times, or when new information becomes available.

(5) The compilation, linking and installation of the programs, if any, shall be automated.

(6) It is intended that the HDS will write some data back to the process control system for display.

Generally, as the reporting system is to be utilized, extended and adapted by personnel with a process engineering background, the level of systems and software understanding that is required form the users shall be limited to that available from typical PC application users.

### 6.5 System Management Procedure Requirements

Effective management of the environment is necessary without the need for continuous presence of day-to-day local or vendors support staff, i.e. tools shall be provided to enable this.

6.5.1 Back Ups

The newly installed system will be included as part of the existing organization's back up procedure. The system must be capable of Network back up (i.e. the back up will be performed by/to a central back up server on the Ethernet/FDDI network) and a procedure for full or partial restoration should be available.

6.5.2 Archive

All real-time, calculated, history and trend data stored in the HDS database will be archived and kept indefinitely. The restore function will ensure that the database is consistent and available to users via the standard data access tools on their desktop (i.e. accessible using the same tools using the same tools used in access online data).

6.5.3 System Start up and Shutdown

Procedures will be developed to start up and close down the system securely. A system specific start up command procedure will be required on the HDS system, which will load and run all software required by the system. The procedure will, by default, run completely automatically and will require no system operator intervention. However, it must also be possible to manually intervene during this otherwise automatic process, particularly at the following stages:

After all standard operating system software has been started but before any HDS or application software.

After the standard HDS system has been started but before any LAN connection process, i.e. before anybody can access the system via the LAN.

At each stage the system manager/operator may run diagnostic and/or maintenance software and may then resume the start up procedure from the point at which it was interrupted. To perform orderly shut down of the system, a shutdown command procedure will be provided. This must be run by the system manager and the operator.

When HDS system shutdown (or fail), any LAN console connected to the system will recognize this as a communication failure, i.e. LAN consoles cannot distinguish between supervisory shutdown, supervisory failure and communications link failure, next time they attempt to transmit to the supervisory system. In this case, an appropriate message shall be displayed on each console, which recognizes the failure.

### 6.6 Documentation Requirements

The following documentation will be prepared:

(1) Detailed Functional Specification by Refinery' IT

(2) Hardware Specification, by Vendor (with site's approval)

(3) Technical Design Document, by Vendor/Refinery joint

(4) Acceptance Test Specifications, by Vendor (with Refinery input)

(5) Supervisory System Documentation, by Vendor

Copies of such documentation shall be provided, except when an electronic form is available, In that case two copies an electronic copy is sufficient. Any document written to support the HDS system on an ongoing basis must be delivered in electronic form in MS-Word-for-Windows format. This holds especially for the System and Implementation specific documents. All documentation shall be in the English language.

During all phases of the project a copy of the documentation will be staged at site at Refinery. The Refinery copy will be frequently updated and modified and will therefore be the one and only master copy until delivery of the final.

6.6.1 Detailed Functional Specification

The Detailed Functional Specification will define in detail how the requirements laid down in the design specification will be met by the system to be supplied by the vendor. This document will be produced by the vendor, and shall clearly state those area's where the detailed functionality deviates from the design specification. Approval on these points shall be requested from Refinery. After approval this document it will become, in conjunction with the Hardware Specification, a contractual document for the project.

6.6.2 Hardware Specification

The Hardware Specification will contain descriptions of all equipment to be supplied, with cabling details, room lay-outs, and maintenance procedures. This document shall be produced by the vendor and approved by Refinery it will then become, in conjunction with the Functional Specification, a contractual document for the project.

6.6.3 Technical Design Document

The Technical Design Document will describe the overall final design of all application specific software, the interfaces between different software modules, shared data structures and the common procedures required to access these data structures.

6.6.4 Acceptance Test Specification

The Acceptance Test Specifications will be logically divided into two, although they may be physically combined into one volume. The Acceptance Test Specification will be prepared by the vendor, and approved by Refinery, before Acceptance Tests commence. The two parts will be Hardware Test Specification, and System Test Specification.

(1) Hardware Test Specification: The Hardware Test Specification will describe all the stand-alone tests to be performed on each hardware module supplied by the Vendor and his sub-Vendors, to demonstrate its correct functioning.

(2) System Test Specification: The System Test Specification will describe the tests to be performed during the Acceptance Tests (beyond those in the Hardware Test Specification), to demonstrate that the system as a whole meets the requirements of the Functional Specification.

6.6.5 Supervisory System Documentation

The following system documentation shall be provided:

(1) Operators Manual

(2) Database Use's Manual

(3) Applications Managers Manual

(4) Installation Manual

Operators' Manual

This will provide all the details required by an operator to run the HDS. It will include the following:

(1) How to use the keyboard

(2) How to use the security levels

(3) How to call up a report, graphic or trend

(4) How to navigate between reports, graphics or trends

(5) How to use the keys for data entry

On-line help is allowed as an acceptable alternative for user documentation.

Database User's Manual

The database user's manual will contain additional information for technology and other users of the HDS. It will, together with the spreadsheet manual, enable those users to create ad-hoc reports with calculations using the spreadsheet user interface.

System Manager Manual

The system manager manual will contain additional information which must enable the system manager to:

(1) Create, modify and delete point definitions.

(2) Create, modify and delete standard calculation routines.

(3) Create, modify and delete standard graphics.

It will be a guide for first-line maintenance of the system.

Installation Manual

The installation manual will contain additional information in a step by step approach to enable the system manager to:

(1) Install the client software on the PC of a new user.

(2) Uninstall the client software on the PC of a user

(3) Install new software modules on the server.

## 6.7 Training Requirements

Three levels of training will be required:

(1) Level 1. Basic training in system operation for all users groups.

(2) Level 2. Advanced training with for EXCEL/SQL technical users.

(3) Level 3. Training of system manager and application engineer.

Refinery will provide up to 12 PC's in a class room environment for training.

6.7.1 Operator/Senior Management Training

Training of basic users will be carried out on-site at Refinery to teach them how to use the supervisory system. It is expected that a (maximum) 4 hours classroom session will be given at least 6 times over a 2 weeks period. In addition, informal hands-on training will be required.

6.7.2 Advanced User Training

Training of technologists, etc. will be carried out at Refinery. This will include details of how to use the EXCEL adding, simple SQL commands and any other advanced applications. This is expected to be one-day course and will be held 3 times over a two weeks period. The option of combing it with the basic course as a single entity could be considered.

6.7.3 System Manager

It is envisaged that two types of training will be required for the system manager.

(1) Training on manufacturer's standard courses.

(2) Project specific training at Refinery.

The system manager training shall include instruction in the running of the supervisory system. The system manager should be trained before building of the system, and be actively involved in building the application and test the system.

# VII. EVALUATION

## 7.1 Benefits of HDS

Benefits of HDS are based on the assumption that to improve a performance, data about the current and historic performance is required. It is however difficult to assess the benefits in quantitative terms until records of implementations show what has been achieved. Closed loop control is basically comparing the measurement with the set point and based on the deviation, calculating an action to reach the objective. The same applies for open loop decisions, a decision and an action are valid if the objective is known and realistic and if the actual performance is known.

Monitoring of the process by operators, technologists, production coordinators improves the performance of the plant, leading to less give away, better efficiency, and steadier performance of the plant.

Equipment monitoring is essential to prevent unscheduled shutdowns and reduction of production due to constraints in equipment (e.g. fouling of heat exchanger may limit the production capacity, monitoring heat exchanger fouling could be used by maintenance schedulers).

Analysis of plant performance can be greatly improved and technologists can be much more efficient with easy access to data and tools to exploit the data. In particular, the aggregation of data with event registration allows an accurate comparison of plans or plant design versus the actual performance.

Real time process data is needed to perform process trouble shooting, analysis of performance and for predictive analysis. Transition analysis during feedstock changes, efficiencies and fouling trends consistent with analyzer and lab results are a few examples.

The purpose is to serve a continuous improvement of the process. Without an HDS, this monitoring / analysis is very time consuming as it requires to extract data from DCS, copy, manually load the data into personal computers for analysis. As a result the frequency of process analysis (and also equipment monitoring (compressors, turbines, etc.) is not performed at a desirable level.

Retention of knowledge and capturing best practice is obviously essential for continuous improvement of the plant.

The potential benefits of enterprise wide access are certainly very high. Experts from an outside technical service could advise based on actual data in a much faster and efficient way compared with the present situation. At present a lot of communication by faxes, telephone calls is required and even then accuracy and completeness of information is not perfect. With remote access to actual plant data, the analysis will be done faster and better, because it will be based on complete and accurate information. In refineries with very limited expertise, it is possible to imagine extensive use of remote expertise of technical services or even in another location. Comparison of performance of similar processes in different locations may help to identify cause of performance degradation and help to restore the situation This remote access can be envisaged for all technology departments (e.g. conversion processes) and many engineering departments (e.g. rotating equipment) that can assist refineries remotely. Research and development may benefit as well by better monitoring of development implementation.

Ultimately, not having HDS functions has a negative impact on the reliability and the effectiveness of operation. The HDS can be considered as a key element to "sweating the assets".

To guide in assessing the benefits, Tables 7.1, 7.2 and 7.3 categorize the benefits by key performance indicators where relationship with activities and applications is defined. For each activity and application, the impact on key performance indicator is ranked in four categories:

(1) B = basic requirement (e.g. required to run other activities or applications)

(2) H, M, L = high, medium, low positive impact on the performance indicators.

No $ value is estimated, H for example means that the related activity has potentially a high contribution to the related performance indicator. The quantification in money terms requires an analysis on the particular process/site considered.

Performance indicators:

(1) Yields: Process performance as compared with theoretical performance.

(2) Availability: mechanical availability of processing units. Impact is on turnaround and duration of schedule shutdowns. Unscheduled shutdown is caused by e.g. trips or equipment failure.

(3) Utilization: utilization of the available capacity.

(4) Variable costs: consumption of energy, catalysts and chemicals.

(5) Fixed costs: mainly maintenance costs.

Table 7.1. Benefit of the HDS in the Activity of the Activities and Contribution to Performance Indicators.

| Activities | Yields | Availability | | Utilization | Costs | |
|---|---|---|---|---|---|---|
| | | Planned s/d | Unplanned s/d | | Var. cost | Fixed cost |
| Performance monitoring | H | L | M | H | H | M |
| Equipment monitoring | M | M | H | M | M | H |
| Performance analysis | H | M | H | H | H | H |
| Target setting | H | L | L | H | H | H |
| Storage/retrieval data | B | B | B | B | B | B |

Table 7.2. Benefit of the HDS in the Activity of the Applications and Contribution to Performance Indicators.

| Applications | Yields | Availability | | Utilization | Costs | |
|---|---|---|---|---|---|---|
| | | Planned s/d | Unplanned s/d | | Var. cost | Fixed cost |
| Calculations | B | B | B | B | B | B |
| Data aggregation | H | L | L | H | M | L |
| Data validation/reconcil. | M | L | M | M | M | L |
| Event registration | H | L | L | L | L | L |
| SPC | L | L | M | M | L | L |
| Modes/Target | H | L | M | H | H | M |
| Batch management | H | L | L | H | H | L |
| Expert systems | M | L | H | M | H | M |
| Alarm analysis | L | L | L | M | L | L |
| Alarm diagnostic | L | L | H | M | L | L |

Table 7.3. Benefit of the HDS in the Activity of Typical Users and Contribution to Performance Indicators.

| | Yields | Availability | | Utilization | Costs | |
|---|---|---|---|---|---|---|
| **Users** | | **Planned s/d** | **Unplanned s/d** | | **Var. cost** | **Fixed cost** |
| **Operators** | **H** | **L** | **H** | **M** | **M** | **M** |
| **Engineers** | **H** | **M** | **L** | **H** | **H** | **M** |
| **Supply and planning** | **M** | **L** | **L** | **H** | **L** | **L** |
| **Maintenance** | **L** | **M** | **L** | **L** | **L** | **M** |
| **Operation management** | **H** | **M** | **M** | **H** | **H** | **H** |
| **Remote expert** | **M** | **L** | **L** | **L** | **M** | **L** |

## 7.2 Case Study

NORCO asked IBM to study how Shell NORCO can further improve performance and profitability in the areas of Operations, Maintenance and Engineering Management using Information Technology (IT). The study applies IBM's assessment methodology called MITE (Measurement of Information Technology Effectiveness). This method is a structured technique used to measure a present situation and to compare it with the industry best practices. Although NORCO is already equipped with process computers (for advanced process control applications), application of IT on Process Operation came first in the list of potential benefits.

Potential benefits in NORCO of HDS functionality have been estimated at 2.5 M$/annum for a complex refinery (215 kBBL/day) including an olefins plant which represents around 3 cent/bbl.

# VIII. EXAMPLE OF COMMERCIAL APPLICATIONS

## 8.1 InterPlant

Application: InterPlant is a total plant "operations information solution" supported by an experienced team of experts in the hydrocarbon processing industry. InterPlant includes a fully integrated Plant Information Management environment, a comprehensive suite of applications to support quality, operations, production and environment management functions, and a tool set to effectively use the information and applications.

InterPlant Plant Information Management provides a common integrated base of plant process, operations and business data. A combination of real-time and relational database capabilities support continuous and transaction data.

InterPlant Applications provide a comprehensive, integrated suite of applications that is unique within the hydrocarbon processing industry. The applications are organized into five categories – production planning, quality management, operations management, production management and environment management.

InterPlant Toolset incorporates industry standard tools that provide flexible and powerful integration, data analysis and user interface functions. The tool set is designed to be application independent.

Strategy: InterPlant is a comprehensive, integrated suite of applications that support improved management of plant operations, product production, product quality, environment emissions and new product development. InterPlant's open architecture employs industry standard, proven technology for effective integration and data exchange with existing plants systems (DCS, PLC, SCADA, process modeling, planning & scheduling, lab and business systems). InterPlant supports five important plant goals: (1) integrated people knowledge, operating data, applications and procedures; (2) leveraged utilization of personnel, equipment, resources and point solutions; (3) timely problem identification; (4) continuous improvement; and (5) effective opportunity evaluation and assessment.

Economics: Benefits are realized from effective use of information in decision making, operations planning problem identification and solution development. Benefit level is a function of plant processing complexity and supply/demand environment. Typical pay back periods are 6 months to 1 year. Major benefit areas are improved: personnel productivity, operational effectiveness, market responsiveness, quality control, customer satisfaction, conformance to environment controls and control, customer satisfaction, conformance to environment controls and reduced: working capital requirements, operating costs, raw material utilization, utility consumption, product returns and inventory level.

Commercial installations: InterPlant is implemented in over 20 sites including refineries, gas plants, chemical plants, petrochemical complexes and waste management facilities. Installation sites are in North America, Australia, Pacific Rim and Southeast Asia. The IntePlant suite of applications is currently installed under open VMS and Windows NT server operating systems with Oracle, Sybase, and SQL server RDBMS alternatives.

Licensor: InterPlant Consulting Inc., Calgary, Alberta, Canada.

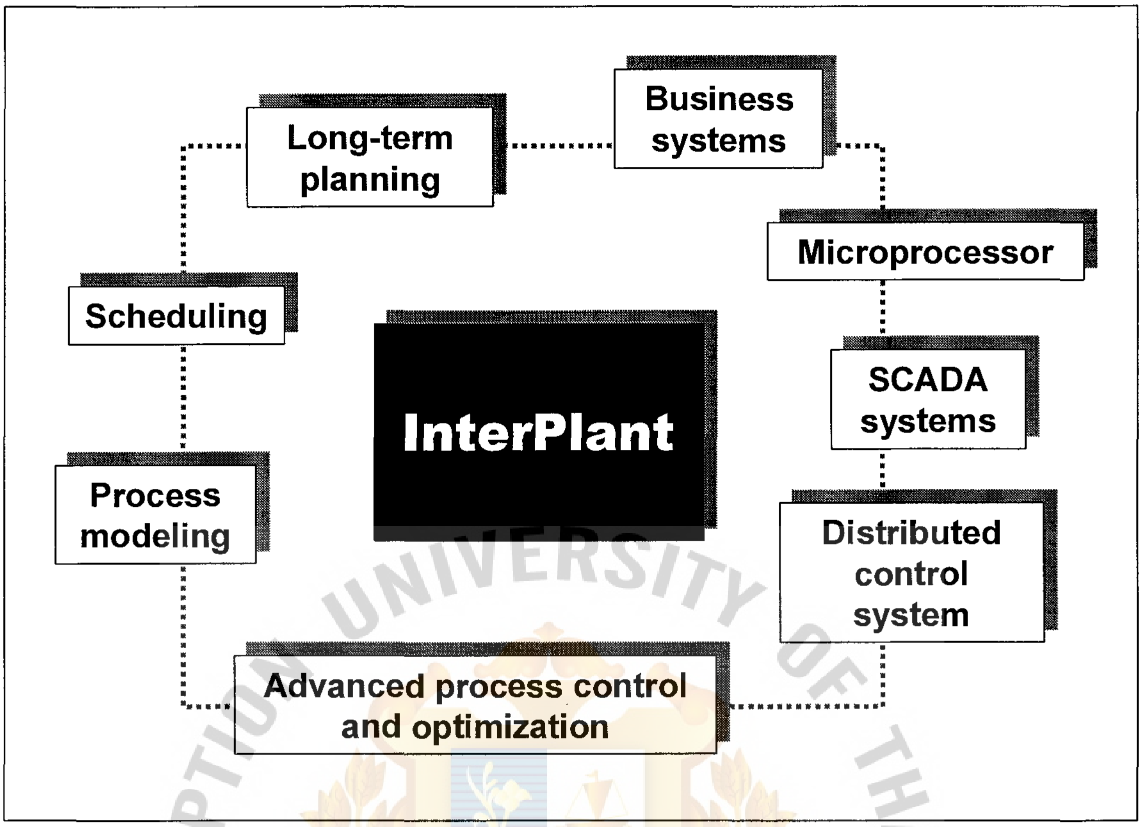


Figure 8.1. InterPlant System Architecture.

## 8.2 PI

Application: The PI System is a set of server and client-based software programs designed to fully automate the collection, storage and presentation of plant data. PI Systems range in size from 2 to over 250 users, and from archives with less than 1,000 points to systems with over 100,000.

Development strategy: The computing industry is in a position unknown since the days of "Big Blue." Microsoft's dominance in the market is enabling one company to successfully create standards and trends. For the first time in well over a decade, MIS departments have "low risk" options. In the next few years, many refinery operations and business applications will integrate through OLE controls and other Microsoft automation technologies.

Description: PI is based on a client/server network architecture. The PI Server provides centralized data collection from multiple data sources, and the client software packages put the maximum amount of information processing power possible in the hands of the user. Primary components of the PI System include:

(1) Data server. Process data are stored in a time-series database designed especially to store large quantities of refinery data efficiently. Years of history may be kept online for all process control, laboratory, manually collected, tank farm and other data points.

(2) Client applications. PC packages work in the Microsoft Windows environment. Applications permit users to create their own graphical displays, spreadsheet analyses and reports, or to share applications over a network. Current releases support ODBC and OLE2; the next release will support OLE controls and scripting.

(3) Integration tools. PI data are accessible to other applications via a set of APIs, through ODBC and OLE automation.

(4) Interfaces. Over 65 interfaces to common systems are available to transfer data to/from the PI System. A single system can include many interfaces, permitting data from several control systems or process areas to be accessible throughout the facility.

Economics: PI System users report that higher profits or savings have resulted from increased production, improved product quality, simplified environmental and production reporting and reduced waste/improved use of raw materials. Most PI System users find that the software meets unanticipated needs and provides many unexpected benefits.

Commercial installations: The PI System has been installed inn 750 operating plant sites, including refineries, petrochemical plants and numerous other process facilities. Over 10,000 copies of the client software packages have been shipped.

Licensor: Oil Systems, Inc., San Leandro, California; Oil Systems GmbH, Altenstadt, Germany.

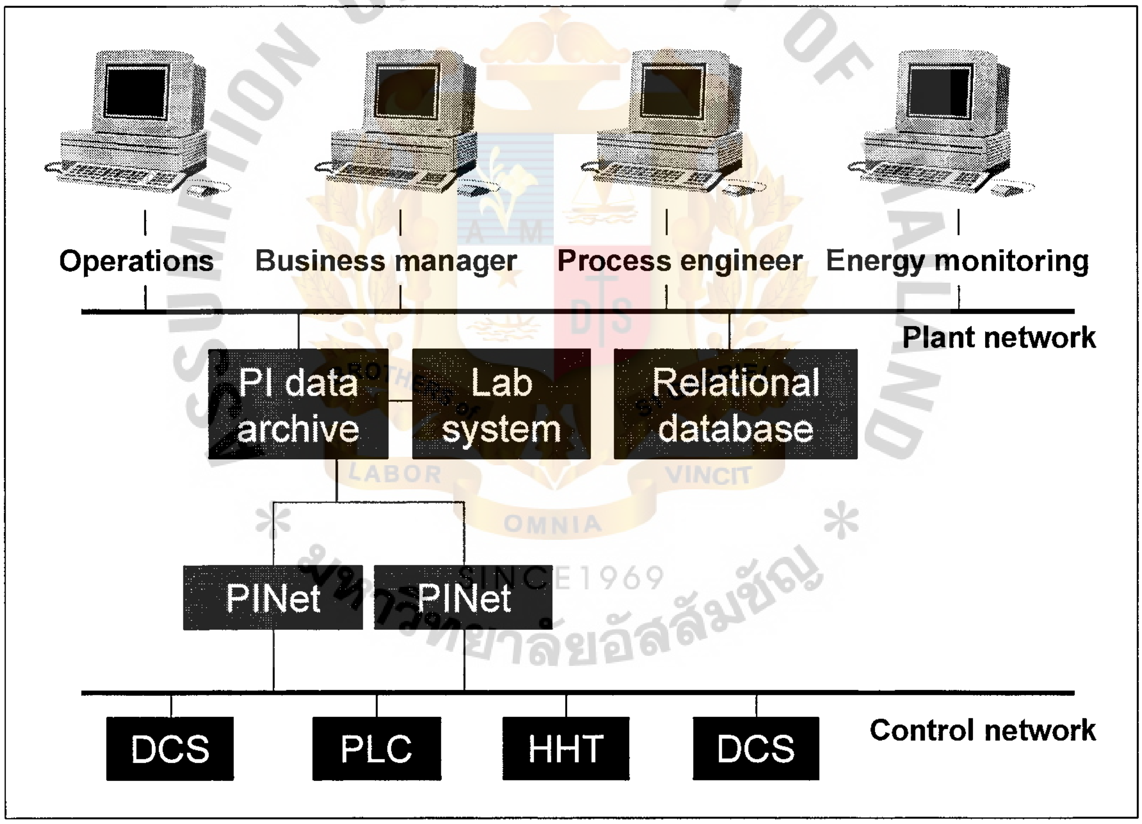


Figure 8.2. Plant Information (PI) System Architecture.

## 8.3 APMS

Application: The Advanced Plant Management System (APMS) is both an online and offline advisory system. In an overall plant automation scheme it is located between the regulatory/advanced plant control and the economic departments like accounting and planning. It is designed to assist the operations staff in the optimal operation of the total plant and in the evaluation/improvement of plant performance.

Strategy: APMS is a modular system allowing maximum flexibility in configuration and a step-wise introduction of the various technologies it contains. Modules in AMPS include:

(1) Plant simulator. A key element in an APMS system is the global (nonlinear) equation-based plant model tailored to the key requirements of the client. This central model is used as a key information source for simulation, data reconciliation, optimization and scheduling.

(2) Scheduling assistant. In this real-time expert system shell the process and operational expertise of key staff members is embedded in rule sets. These rules, together with target planning, tank inventories and calculation results of the plant simulator yield feasible and optimal production schedules.

(3) Data diagnoser. The combination of statistical process analysis together with diagnostic rule sets embedded in the expert system shell is used to perform detailed (long-term) analysis of those units that are most critical for a plant.

(4) Data archiving. All APMS- related data are stored in a proprietary database system, which can communicate directly with the DCS or a real-time

database system. Data transfer to any other information system is possible through import/export drivers.

(5) User interfacing. The user interface has been designed according to the OSF-Motif "look and feel" standard and its open design allows free configuration of displays, reports and graphs. It gives easy access to raw plant data and calculation results of the simulator and the scheduling assistant.

The APMS philosophy is one of conforming to open standards. This assures implementation on a wide range of hardware platforms. Its client – server – based architecture allows maximum integration in already existing systems.

Economics: An APMS system typically improves operating profit by 3% or more, depending on the level of sophistication already present in the information networks. Payback times of 6 to 12 months are typical.

Commercial installations: APMS has been successfully installed at several olefins plants, one petrochemical complex and a mini-refinery, with two additional projects in progress.

Licensor: Pyrotec, a division of KTI.BV, Zoetermeer, The Netherlands.

Control strategy: The "management control cycle" concept is a key design element of all Procise applications. This concept covers the full life cycle of operations data through planning, scheduling, execution and evaluation. The concept is applied to both offsite and onsite applications. Offsite applications manage oil receipts, movements, blending and shipping while onsite applications set operating and quality targets and perform multiunit optimization for processing units.

Procise applications are organized into a number of modules that can be selected as needed to meet specific business requirements. All Procise applications are driven from a configurable plant model stored in the relational database. The plant model defines such things as products, equipment, connections and measurements so that the system can be maintained as the plant changes through use of appropriate data tables. Furthermore, operations data are collected and stored in the database according to the plant model. Generic reference by users and integrated applications reduce dependency on tag names.

Procise applications available include:

(1) Process operations management provides process operating instructions, parameter tracking, monitoring of utility and catalyst consumption and unit/multiunit optimization.

(2) Performance monitoring provides plant balancing and reconciliation, production accounting, actual vs. plan reporting, production costing, product and batch tracking.

(3) Operations scheduling use planning targets and marketing projections to determine an optimum schedule. Outputs are operating instructions and movement orders, including blending.

(4) Off sites management provides movement validation, equipment and path selection, blend optimization/control, movement monitoring, tank quality tracking and inventory management.

Economics: Economics for Procise typically range from 10 to 80 c/bbl of crude depending on the applications selected.

Commercial installations: Procise integration technology, with various built-in applications, has been implemented in twelve refineries and petrochemical plants in North America, South America, Europe, Africa and Southeast Asia.

Licensor: Setpoint Inc., Houston, Texas.

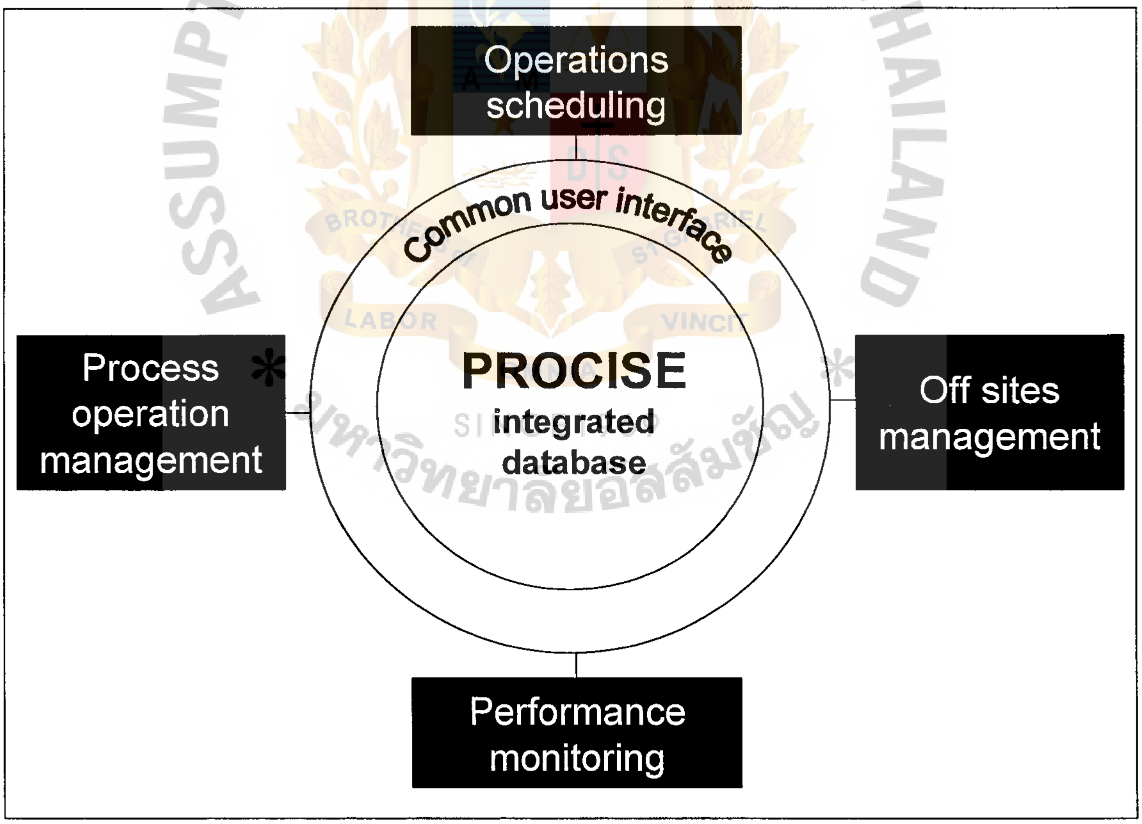


Figure 8.4. PROCISE System Interface.

# IX. CONCLUSIONS

## 9.1 Project Summary and Achievement

The project studies and defines basic requirements of the "Hydrocarbon Data Supervisory (HDS)" in the Refinery Information System (RIS). The HDS, as a tool, is the conceptual management framework to manage varieties of information flowing around the organization which has a different nature, such as types of data, time span. The HDS gathers data from different sources and produces different information for different end-users' requirements. The study started from identifying the problems exist in one's organization, surveying the needs or requirements of information usage, describing the ideal tools to handle the users' requirements, defining other technical requirements including computing security requirements and finally seeking for application available in the market. Numbers of case studies are also given and an example of implementation of the HDS system in the refinery. The summary of key points of achievement from the study is as follows:

(1) Main objective of the Refinery Information system is to enable usage and managing of information efficiently.

(2) Main objective of the HDS system is to provide historical data and real-time data across the refinery.

(3) Major problem in managing information in the refinery is the difficulties of compiling and providing the information which has a different time cycle, i.e. a short cycle of "plant control system domains" and long cycle of "business system domain."

(4) End-users in the refinery vary from technicians, process engineers, maintenance engineers, middle management, to top management.

(5) The system requirement and general description of the system are provided.

Eventually, the outputs from this study will be used as a reference and guideline for any refining organizations to evaluate need of the Hydrocarbon Data Supervisory system in the future.

# BIBLIOGRAPHY


1. "Advanced Control and Information Systems' 95-Plant Information," Hydrocarbon Processing, September 1995: 154-159.

2. CIMVIEW Marketing Tools 1997, Information on Commercial CD – ROM, 1997.

3. Dormer, A. and S. Raynor. "Real-time Optimization: An "Alternative" Approach," Hydrocarbon Processing, September 1998: 81-89.

4. Harkins, B. L., E. S. Middleton, and D. A. Mushin. "Linking the Plant Floor to the Enterprise: Benefits and Pitfalls," Hydrocarbon Processing, June 1999: 49-54.

5. Honeywell, TOTAL PLANT SOLUTIONS – TPS, Information on Commercial CD – ROM, 1997.

6. IBM Process and Petroleum Industry Down Stream Solutions, Information on Commercial CD-ROM, 1997.

7. Lowell, B. K. "Process Control & Information Systems-Quantity Information System Benefits," Hydrocarbon Processing, June 1995: 41-56.

8. Parker, C. and T. Case. Management Information Systems, Strategy and Action, 2nd Edition. New York: Mitchell McGRAW-HILL, Inc., 1993: 3-24, 597-640.

9. Pfleeger, P. Charles. Security in Computing, 2nd Edition. New York: Prentice-Hall, Inc., 1997: 405-402.

10. Williams, A. K. and M. Rameshni. "Real-time Economic Control," Hydrocarbon Processing, September 1998: 99-110.