Computer Assisted Terminal Operations Management Systems

T.W. Engelhart and B.A. Radomske, Canada

Summary

"A computer-based approach to on-line supervisory control and operations management of bulk materials handling terminals".

This paper describes an integrated computer facility supporting the functions and responsibilities of shift operations, scheduling, maintenance and management using real-time interactive techniques. The functions and responsibilities as related to coal export terminals are specifically addressed, although these functions would be equally applicable to other terminal configurations and other commodities. A discussion of the resulting benefits is presented:

- — throughput efficiency
- — long-term planning and scheduling, using simulation
- — operations monitoring and protection
- — demurrage/despatch optimization
- — preventative maintenance
- — operational productivity

1. Introduction

Recently there have been two significant changes in our continuously evolving industrial world: the decline of oil as a cheap and abundant energy source, and the advent of computers and electronics as tools available for almost every conceivable computation and data handling need.

These two factors, although unrelated, will change the activity of coal handling terminals dramatically in the future. Because of the decline in oil production, coal will increasingly be used as an energy source, at least until alternative energy sources are developed and matured. This increase in coal utilization is causing a flurry of activity in the development of import and export terminals, which form a vital link in the transportation chain. Because of the continually escalating capital costs of these terminals, the equally inflationary operating and labour costs, and the competitive markets which the terminals serve, an efficient, well operated terminal is a necessity. A typical import or export terminal can be operated at a more profitable level by designing and installing a computer system which assists in the control of the terminal, provides a comprehensive management reporting system and also enhances operations through on-line modelling of terminal activities.

This article discusses the nature of such a computer system and points out the advantages and potential financial benefits associated with the system. The facilities described have been developed by two related companies combining their respective expertise. Swan Wooster Engineering Co. Ltd. has been involved in the design and development of ports, harbours and terminals around the world for many years. Datap Systems, a division of Williams Brothers Canada Limited, which is majority-owned by Swan Wooster, has specialized in the design and development of computer-based industrial automation systems since the minicomputer was introduced in 1969. The concepts described in this paper were developed by Swan Wooster and Datap who are in the process of investigating and developing such systems for:

- — Richards Bay Coal Terminal, South Africa
- — Consolidation Coal Sales Co., Baltimore, USA
- — Massey Coal Ltd., Newport News, USA
- — Westshore Terminals, Roberts Bank, Canada
- — Ridley Island Terminals, Prince Rupert, Canada

The concepts and ideas presented herein are equally applicable to bulk terminals handling commodities such as iron ore, sulphur, potash, and grain.

2. Industrial Technology

Recent advances in electronics technology have brought a proliferation of new devices for use by progressive industrial systems designers.

Since its origins in the late 1960s, the minicomputer has been commonly used in process automation and in supervisory control in industries such as petrochemical, steel

T.W. Engelhart, P. Eng., Manager Special Projects, Datap Systems, 1525 Robson Street, Vancouver, B.C., V6G 1C3, Canada, and B.A. Radomske, P. Eng., Manager of Operations Research Department, Swan Wooster Engineering Co. Ltd., 1525 Robson Street, Vancouver, B.C. V6G 1C5, Canada

making, pipeline, electric utility and telecommunications. Although initially used because of its capability to gather important "real time" data at high speeds and thus effect a rapid reaction to given inputs, its ultimate uses have been expanded many times to eliminate inefficient manual data entries, calculations and reports. In addition to potential labour savings, operator efficiency is also improved when the routine tasks of manual reporting are eliminated. This allows more time for planning, organizing and scheduling the terminal operations activities.

Programmable logic controllers, initially introduced in the early 1970s as relay replacement devices, have been so significantly improved that today they can be configured into distributed control systems. They offer rapid sequence and process control to specific devices and machinery while they also provide extensive communications capability for use between themselves and other intelligent devices. As a result, these devices are frequently used in industrial situations to monitor and control individual components, and to act as a unified gathering system for input to a larger computer system.

Using such concepts, data required from belt scales, samplers, position transducers, and other sensing devices are integrated into the controller system to present a continuous upward flow of terminal operating information.

Advances in the use of microcomputers, inexpensive memory and associated electronics have led to the availability of inexpensive auxiliary devices such as colour video display systems, control keyboards and data entry/output terminals. In many cases, these devices can replace the large-scale "mimic" or schematic diagrams used to depict terminal operations. These devices also provide compact, efficient forms of execution of commands/control and display and updates of operating data.

With the minicomputer, programmable controller networks and intelligent video display systems, the industrial control and information systems designer has a limitless range of possibilities for developing cost-effective, efficient, state-of-the-art systems. This technology has been applied, for example, in the following typical systems:

- Pipeline companies have solved the problem of supervising and controlling a facility spread over great distances by using these tools to centralize operations.
- Electric utility and telecommunications companies also monitor and control their physical plant equipment with centralized computer-based systems.
- Process industries such as steel-making, cement manufacturing, petrochemical refining and pulp and paper manufacturing have introduced significant optimization into their processes since the introduction of computer-based control and management information systems.

Now, these techniques can also be applied to bulk handling terminals.

3. Justification of Computers for Bulk Handling Terminals

The concepts used by other industries, and discussed in this paper for use by bulk terminals, developed as a result of a number of factors, are applicable, in varying degrees, to any transshipment terminal, whether handling coal, iron ore, sulphur, potash, grain or other commodities.

- Multiple grades at a terminal require grade segregation, inventory controls, and periodic loading and unloading stop/starts. Contamination of grades results in high financial losses. Multiple grades usually require an increase in stockyard area and handling machinery, requir ing that the higher capital costs be offset by lower operating costs, in order to remain competitive.
- Multiple owners of a terminal result in not only multiple grades (usually), but a variety of different financial reports, production schedules and information consolidation.
- Multiple users or customers of a terminal also create many reporting requirements, contractual commitments, priorities of use and competition with other terminals.
- Increased activity in the blending of various coals causes operating and financial complexities.
- Efficiency improvements by coordinating more bypass operations (dumper direct-to-ship) as a result of improved scheduling information, by eliminating interim (or possibly final) draft surveys and by optimizing stockyard equipment deployment will result in overall lower cost of operation or higher throughputs.
- Increasing costs of manpower, decreasing productivity and organized labour unions cause operating and financial inefficiencies which can be offset by reducing the manpower required to operate the terminal.

These are typical of the complexities, often seen at a terminal, which justify the use of computer-aided operations and decision making. A reduction in labour force, and enhanced maintenance reporting systems are further justifications. Cost/benefits are analyzed in greater detail in a following section.

4. Information and Control Hierarchy

The Terminal Operations Management System (TOMS) described in this paper is a vital component in a hierarchy of systems and subsystems required to fulfil the information and plant control requirements of a modern coal exporting terminal. Fig. 1 shows the various functional levels of such a hierarchy. Each level is structured to support the functional requirements of management, operations, and equipment. A brief summary of the functions and facilities normally provided at each level is given in Fig. 2.

The administrative data processing level and the equipment control level are well known technologies in use at most existing terminals, whereas the terminal management and supervisory control level has been largely overlooked in the past and was only supported by hardwired control boards and manual reporting schemes. The remainder of this discussion will address advances in computer-aided systems to support this level with a facility entitled "Terminal Operations Management System".

The efficiency, profitability and security of terminal operations can be greatly enhanced by the use of an integrated computer system to support the real-time requirements of shift operations, maintenance, scheduling and management. The Terminal Operations Management System provides operational assistance to this end by incorporating the following major design features:

- real-time supervisory control, monitoring and recording of physical plant activities, material receipts and material deliveries;

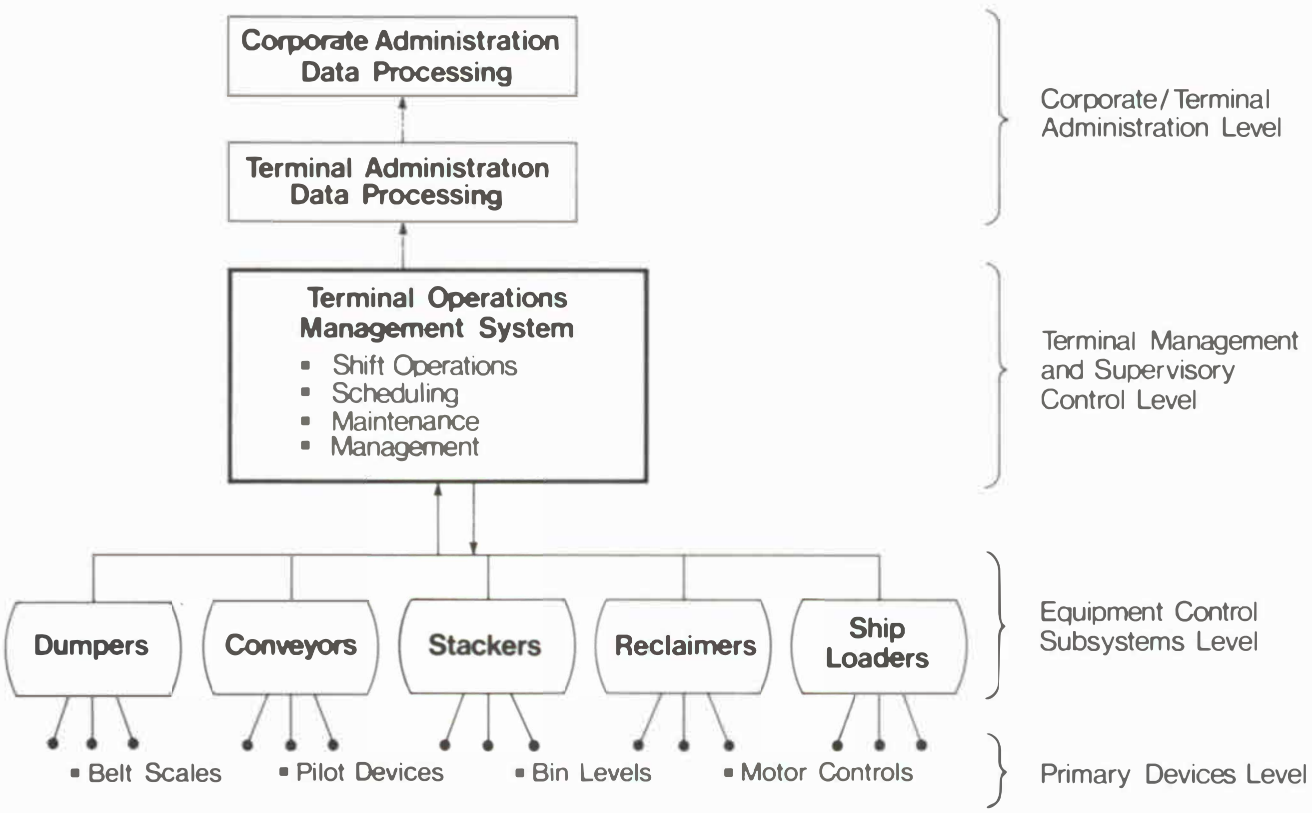

Fig. 1: Information and control functional hierarchy

PRIMARY DEVICES LEVEL	. SCALES, LEVEL, MOTOR AMPS, INSTRUMENTATION . SENSORS, SWITCHES, PILOT DEVICES . LINE-SAFETY DEVICES . SOME INTERLOCKING BETWEEN DEVICES . USUALLY DIRECT WIRED . CLOSE PROXIMITY TO EQUIPMENT
EQUIPMENT CONTROL SUBSYSTEM LEVEL	. INTERLOCKING WITHIN AND BETWEEN SUBSYSTEMS . DATA REDUCTION . CLOSED LOOP CONTROL . DIRECT WIRED OR MULTIPLEXED . IMPLEMENT/MONITOR CONTROL STRATEGY . PROVIDE LOCAL MAN/MACHINE INTERFACE . PROVIDE LOCAL AREA OPERATING INFORMATION . CENTRALLY LOCATED WITHIN AN AREA OR ON A UNIT
TERMINAL MANAGEMENT AND SUPERVISORY CONTROL LEVEL	. PLANT WIDE OPERATIONS MONITORING/REPORTING . EQUIPMENT DEPLOYMENT, SCHEDULING, PLANNING . CENTRAL OPERATOR MAN/MACHINE INTERFACE . MAINTENANCE SCHEDULING/CONTROL . MANAGEMENT DECISION SUPPORT . CENTRALLY LOCATED FOR OVERALL PLANT
CORPORATE/TERMINAL ADMINISTRATION LEVEL	. CORPORATE/TERMINAL LEVEL ACCOUNTING, MANAGEMENT . PLANT LEVEL ACCOUNTING, BUSINESS MANAGEMENT . INDIRECT LINK TO ON-LINE PLANT SYSTEMS

Fig. 2: Functions at each level of the hierarchy

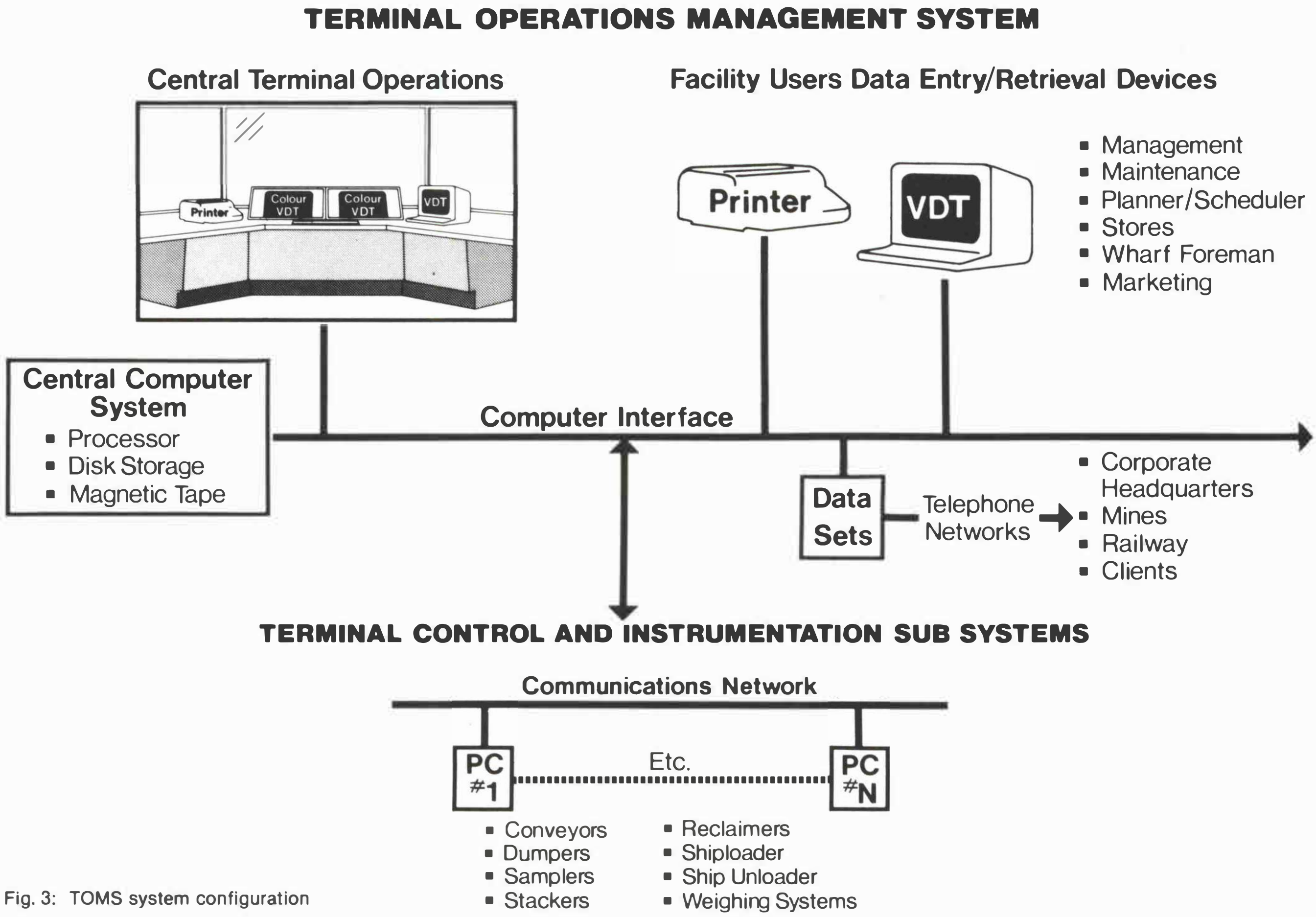

Fig. 3: TOMS system configuration

— on-line management access to operations, maintenance and scheduling data such as receipts and deliveries, current inventory, equipment utilization, and historical operating statistics;
— on-line operations simulation to assist schedulers and planners in establishing optimum import, export, and maintenance schedules by presenting data predicting the effect on terminal operations of various operational maintenance plans.

5. Computer System Configuration

Various configurations of computer system hardware and software can be considered for such an application, depending on the complexity and needs of the terminal. Fig. 3 shows the typical arrangement of such a system.

The TOMS facility is constructed around the Central Computer System which consists of a high-speed, super minicomputer, appropriate disk and tape storage media interfaces to the TOMS devices, and software for execution and applications functions. User access to the system is provided at two levels. Central Terminal Operations is used for the continuous monitoring and control of terminal activities, and is located in the main operations centre. Other Facility Users such as management, maintenance, planners, stores, wharf foreman and marketing are provided with computer terminals for information access and data update. Remote links to other facilities such as corporate headquarters, mines, railways and clients are provided as needed. Interface to the actual terminal equipment is achieved through the Control and Instrument Subsystem.

The following are some of the major features incorporated in the design of each of the subsystems:

5.1 Central Computer System

— a medium sized "Super Mini" computer selected for high speed and real-time input/output handling capability; 32 bit word length with internal memory in excess of one million characters;
— a large, high-speed, hard disk system as the main system bulk storage device, with 20 to 50 million characters of installed capacity;
— a standard magnetic tape system to store source software and media for archiving historical data;
— controlled power failure and automatic restart facilities;
— a virtual memory, multi-programming operating system;
— data base management and forms management support software.

5.2 Central Terminal Operations Interface

— The operator consoles (which typically consist of two or more colour video displays and a special function keyboard) are the heart of this type of system and are custom-designed to terminal functional requirements. Fig. 4 shows a typical arrangement of such a facility.
— Colour video displays are typically semi-graphic types designed to functionally replace the "mimic" diagram commonly used for hardwired systems. The colour video displays will display flow diagrams, both at an overview and at a detailed level. Dynamic field data and status are continuously displayed on both flow schematic and tabular display formats. Colour coding, symbol shapes and

flashing are all used to convey information, depending upon the critical level of the information. Figs. 5, 6 and 7 are black and white renditions of typical, colour-coded displays. Fig. 5 shows one of many material flow schematics. These schematics are continuously updated with current data and status from the plant facilities. Other displays similar to Fig. 5 would depict other areas of the terminal, or more detailed information on specific facilities. Fig. 6 depicts a typical Stockyard Plan Display, indicating stockpile location, grade, tonnage and accessibility to stockyard equipment. Fig. 7 represents a Shiploading Plan Display and is used to illustrate the total pattern of a ship, the respective grades, tonnages, capacities and berth time of the ship.

- Special function keyboards are designed to provide data entry, selection of displays, and to support commonly performed functions such as selection of equipment and alarm acknowledgement. Fig. 8 shows a typical arrangement of such a keyboard.
- Typically, two or more printers are provided to log alarms and events and to provide hard copy of shift logs and reports.

5.3 Data Entry/Retrieval Devices

- Standard monochromatic (i.e., black and white) video display terminals (VDTs) are used for data entry and retrieval for all system users other than the central terminal operator(s). (For security reasons, these devices assign access privileges to limit data access and entry depending on the responsibilities of the user.)
- Standard character printers are also employed in cases where hard copy is required by system users.

5.4 Remote Communications Facilities

- Various facilities for remote data entry and retrieval can be considered. These typically take two forms, remote computer links and remote dial-up VDT/printer terminals.
- Data sets to support the data links are typically accessed via timeshare dial-up facilities or, in the case of computer links, via dedicated leased lines.

5.5 Terminal Control and Instrumentation Subsystem

- General purpose programmable controllers (PCs) are used in the various terminal control subsystems and individual pieces of major equipment such as dumpers, shiploaders and stacker/reclaimers to provide local logic control and a means of remote telemetry of equipment data and status to the central computer system.
- Methods of interface of the PC to the computer system vary depending on the PC vendor but a high speed, local area, data communication highway is the preferred approach.
- Hardwired control panels can be considered to provide direct plant control via the unit and conveyor subsystem PCs, as a backup and local area operator interface.

6. Functional Overview

The following is a summary of a number of typical functional features of terminal computer systems which are incorporated in varying degrees to satisfy owner requirements. An actual system is implemented after a comprehensive definition of requirements, with due regard for systems and meth-

Fig. 4: Typical central terminal operations room

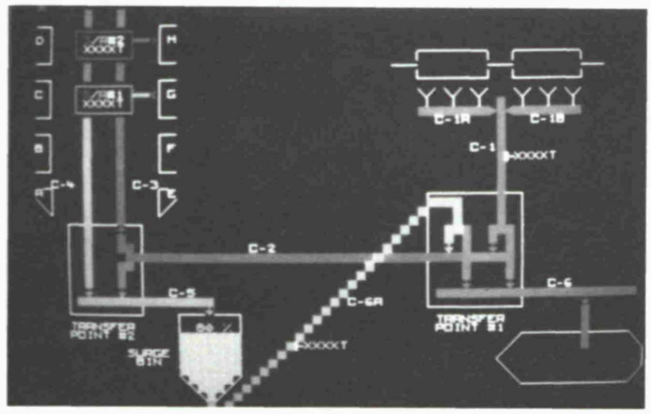

Fig. 7: Shiploading plan display

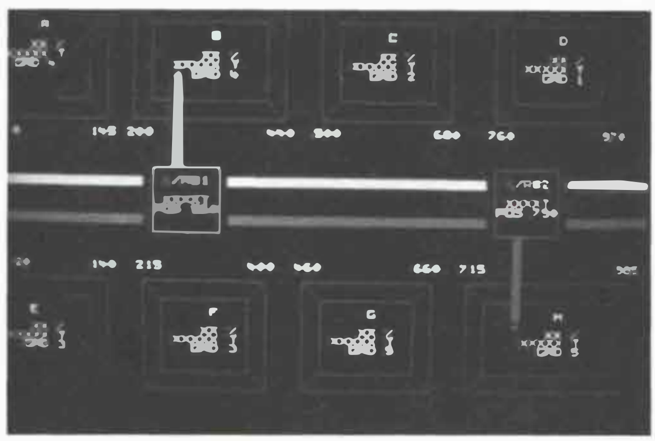

Fig. 5: Terminal overview display

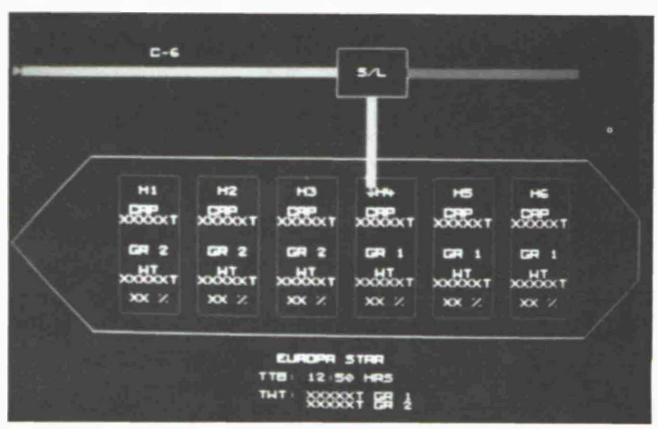

Fig. 6: Terminal stockpile plan display

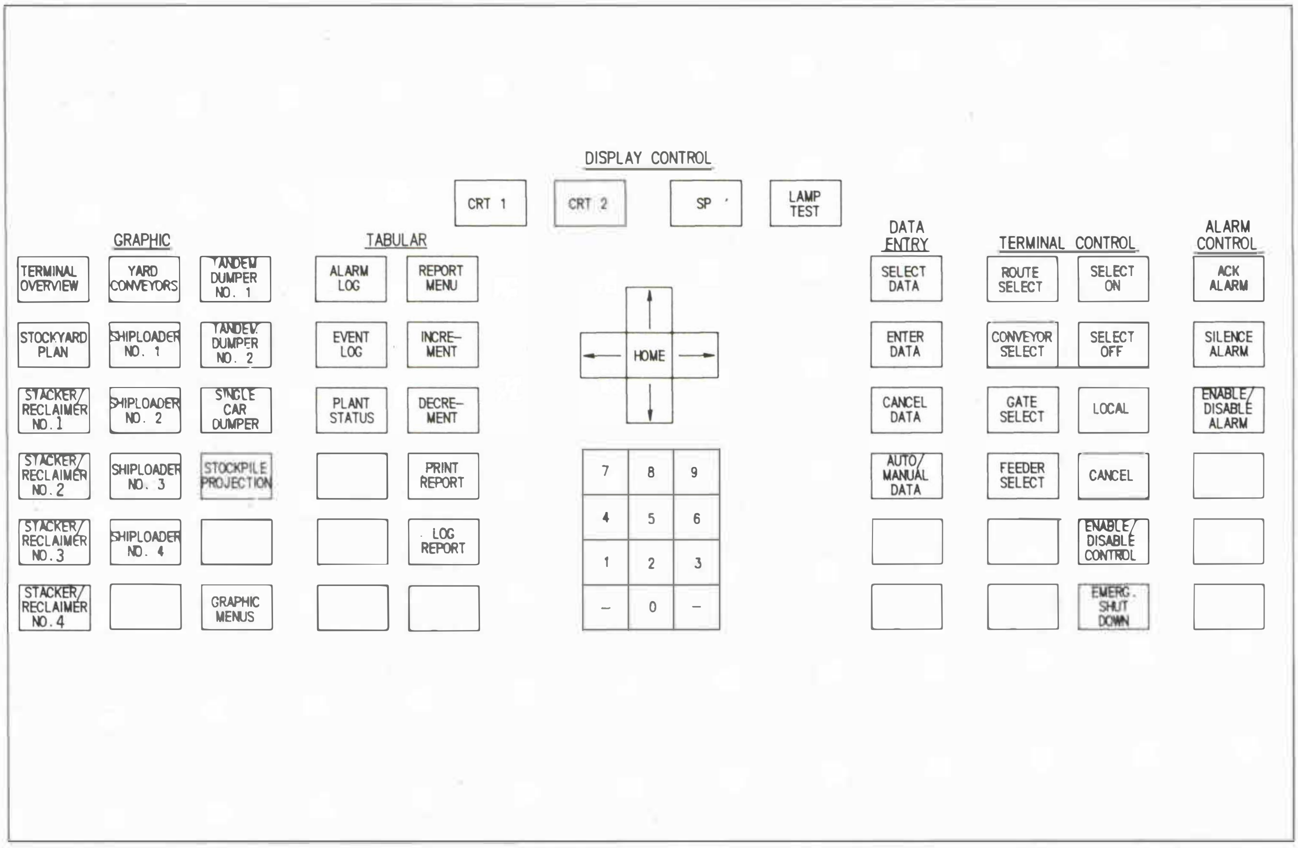

Fig. 8: Typical functional keyboard layout

ods which may be currently in place. The goal is to develop a system or systems to fully serve the needs of operations, management, maintenance and scheduling in a cost effective, integrated manner:

Operations:

- Real-time monitoring/supervision/control of dumping, conveying, stacking/reclaiming, and shiploading equipment
- Operations planning
- Import information and supervision
- Stockpile management
- Export information and supervision
- Shift reporting

Maintenance:

- Equipment management/running hours
- Maintenance scheduling
- Maintenance control (work orders)
- Parts inventory control

Scheduling:

- Scheduling and planning
- Terminal simulation
- Distribution reporting

Management:

- Management reporting/decision support
- Management/accounting interface

A functional overview of software to support these functions is shown in Fig. 9.

The resulting system would provide benefits in the areas of:

— throughput efficiency;
— long-term planning and scheduling, using simulation;
— operations monitoring and protection;
— demurrage/despatch optimization;
— preventative maintenance;
— operational productivity.

6.1 Plant and Inventory Control

Following are some of the basic operational objectives which should be considered, with regard to coal storage and coal flow through the terminal:

— To provide shift operators with data acquisition and supervisory control of all conveying, stacking, reclaiming and shiploading equipment.
— To supervise equipment deployment so as to prevent cross-contamination.
— To provide control and supervision of shift operating procedures, and also checking and prompting of shift log data.
— Logging of shift operations for post mortem review.
— To provide continuous inventory control and monitoring of coal stockpiles for shift operations and marketing.
— To assist marketing in the coordination of import/export demands with immediate and projected stockpile grades and quantities.
— To provide recommendations as to equipment deployment, so as to improve terminal throughput.
— To provide grade and stockpile recommendations for cost effective blending and to provide monitoring of the blending operations.

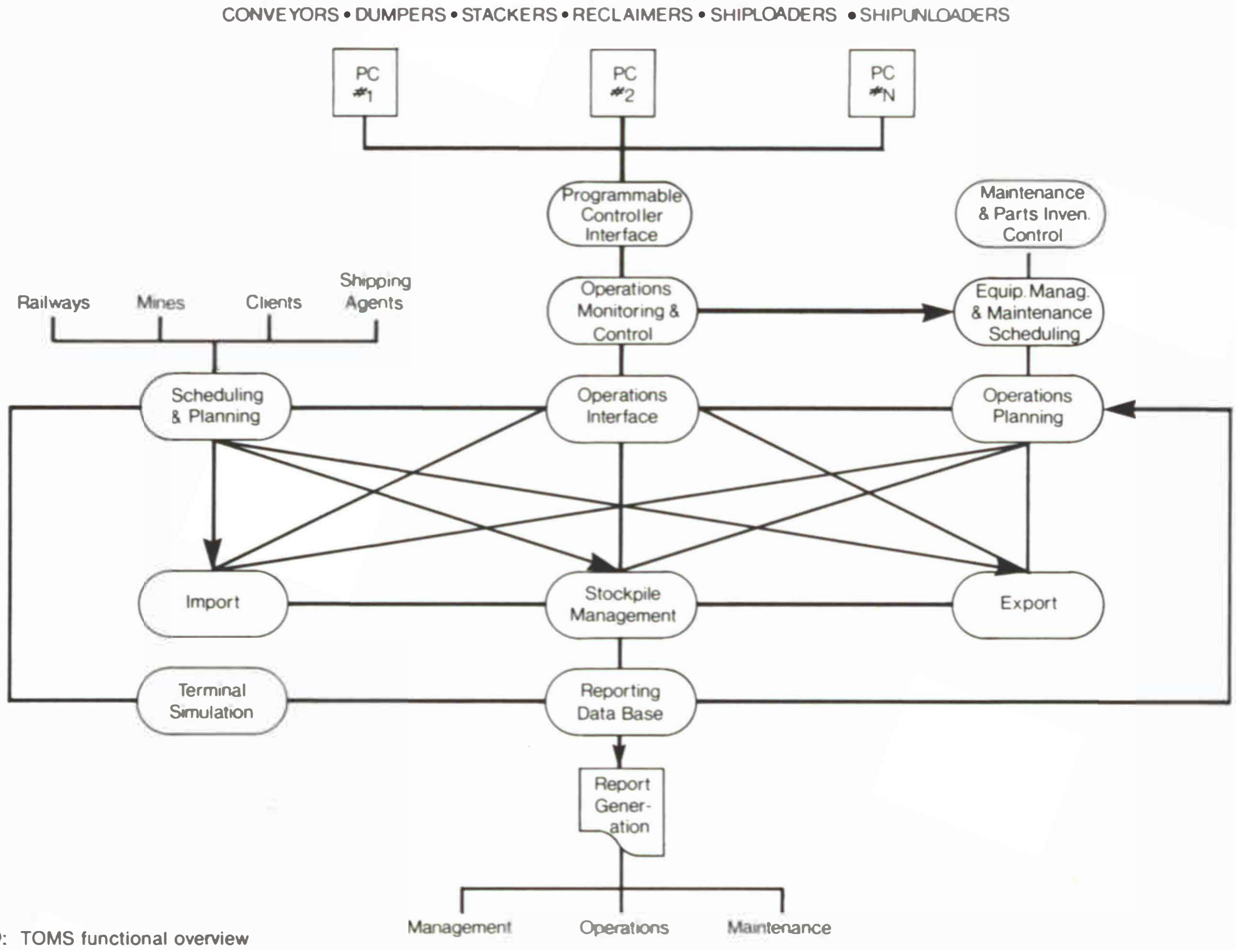

Fig. 9: TOMS functional overview

— To provide plant monitoring and statistical reports to facilitate repair, preventative maintenance and maintenance scheduling.
— To provide statistical management reports on product handling and performance.

Data directly related to these functions, entered manually or automatically derived, are:

— mine dispatch consist data;
— train (and car) identification, content and ETAs;
— plant status;
— equipment deployment;
— stockpile data;
— belt scale weights;
— shiploading schedule;
— product analysis;
— plant maintenance schedules.

In order to properly support the supervisory functions outlined above, and to provide comprehensive control and supervision of shift operations, consideration should be given to the use of semi-graphic colour video systems, as opposed to hardwired control panels, as the normal media for operations. Such facilities can provide the following features:

— terminal flow overview and area details;
— stockpile plan view details;
— colour-coded symbols and data to illustrate changing operational states;
— colour variations to highlight important data and terminal conditions;
— interactive route and equipment selection procedures.

Typical reports available on VDTs or printers directly related to these functions are:

— alarm log;
— event log;
— plant log;
— monthly plant utilization reports;
— shift inventory reports;
— coal analysis reports.

6.2 Import Monitoring and Control

Basic operational objectives to be considered with regard to coal importing are:

— To keep track of train schedules and contents from the mines to the terminal.
— To provide current import information to enable the marketing group to prepare daily terminal operating schedules and to enable the shift operations supervisor to adjust operations efficiently during the shift.
— To account for demurrage liabilities and assist operating staff and management in minimizing such liabilities.
— To utilize terminal modelling techniques to project short-term import schedules, assess demurrage risks and recommend schedule adjustments so as to reduce such risks and to facilitate shiploading.

— To provide statistical management reports on train handling performance.
— To provide reports and information required by the various company departments and client organizations.

Input data directly related to these functions will be entered interactively by marketing and shift operators, as it becomes available, by means of menu driven VDTs. Typical data will include the following:

— short-term marketing (mine) schedules;
— railway train manifest information;
— rail schedules;
— mine coal analysis data.

Typical reports on VDTs or printers directly related to these functions are:

— daily and monthly train handling reports;
— coal analysis reports;
— import schedules and projections;
— dispatched train report;
— train receiving report.

6.3 Export Monitoring and Control

Basic operational objectives to be considered with regard to coal exporting are:

— To keep track of ship schedules and status from the time each ship is taken on charter until it is loaded and the draft survey is complete.
— To account for demurrage liabilities and assist operation staff and management in minimizing such liabilities.
— To prepare, interactively, the ships' "statements-of-facts".
— To provide supervisory control and interlocking to prevent cross-contamination of coal during loading.
— To utilize terminal modelling techniques to project export schedules and terminal capacity so as to predict shortfalls and to recommend cost-effective berthing schedules consistent with expected capabilities and predicted demurrage risks.
— To provide reports and information required by corporate departments and clients.
— To provide statistical management reports on shiploading performance.

Data directly related to these functions would be entered interactively by marketing and shift operators, and would include:

— long-term (e.g., 90 day) ship schedule;
— present coal inventories;
— import schedules;
— shiploading data (e.g., draft surveys, berthing times, demurrage data);
— coal analysis.

Typical data in the form of reports on VDTs or printers directly related to these functions are:

— monthly export summaries;
— shipping schedules;
— shiploading record (i.e., statement-of-facts);
— monthly ship handling summaries;
— shift ship handling log.

6.4 Terminal Maintenance

Basic functional objectives to be considered for a computer system to support terminal maintenance are:

— To identify, log and annunciate equipment failures.
— To log all emergency and scheduled maintenance.
— To accumulate and log major equipment running hours.
— To schedule preventative maintenance consistent with terminal import and export schedules.
— To maintain parts inventory control and procurement.
— To provide statistical reports on maintenance performance.
— To provide reports and information required by various corporate departments (e.g., accounting, procurement).

Data will be entered and retrieved interactively by maintenance personnel using VDTs and printers. Typical reports and displays to be considered are:

— maintenance schedules;
— maintenance logs and work orders;
— monthly repair and maintenance statistics;
— plant status and alarm logs;
— parts inventory reports;
— parts procurement reports.

7. Terminal Operations Simulation

Many terminals are now considering terminal operations simulation to support their long-term planning and scheduling. The operational objectives in this regard are:

— To provide a scheduling planning facility to assist in the long-term coordination of import/export demands, stockpile strategies and maintenance scheduling, so as to improve terminal throughput.
— To simulate terminal operations based on import/export "base case" schedules and historical terminal performance records.
— To derive overall operating costs from manually entered unit cost parameters to guide management in negotiations with clients, and mine and rail officials.
— To assist the operations manager in assessing the long-term effects of various stockpile strategies, grades and capacities, and also in assessing standing operating procedures.

To accommodate these objectives, the system would include an interactive terminal operations simulator. The simulator would model terminal operations over 90 to 120 day periods using present inventory and operations as the starting point and accumulated operating performance factors as modelling parameters. This type of simulator is a modified and constrained version of the type of simulator used by Swan Wooster and other engineering firms to assess terminals from a design point of view.

Simulation modelling is a numerical technique involving mathematical and logical models which describes system behaviour over time. It allows the engineer to answer the "what if" question because the simulation model acts as a controlled laboratory experiment. The model tests the effects of proposed modifications before alterations to the real system are made.

Simulation models include all of the interdependencies of the materials handling system to ensure that all parts of the system are in harmony. These models produce statistics on vessel queuing, equipment utilizations, vessel services times and economic waiting costs which can be used to assess system bottlenecks, storage requirements and equipment capabilities. Various operating conditions are introduced into the model to test their effect on terminal operation.

In addition to the basic analysis provided, such as:

- — equipment utilizations
- — berth occupancies
- — vessel waiting times
- — vessel penalty/bonus
- — stockpile level graphs,

a design simulation model would examine:

- — the effects of annual throughput levels on the terminal operations;
- — the number of grades and their effect on terminal efficiency;
- — blending operations and their effect on terminal efficiency;
- — the effects of train and ship scheduling, penalty/bonus contracts, arrival patterns and acceptance priorities;
- — bulldozing requirements, including an assessment of number of bulldozers and their operating costs;
- — rail system variations such as train sizes and multigrade trains;
- — operational practices such as working holidays, priorities of operations, maximizing despatch and the addition of a bypass conveyor or feedback system;
- — the effect of stockyard storage operations and storage volumes.

The objective of simulation analysis is to minimize operating and capital costs and to maximize the profits produced from an efficiently run terminal. Profits such as vessel despatch, coal tariff rates, blending operation tariffs and cross inventory charges must be balanced against extra costs such as vessel demurrage, additional crew costs, bulldozing requirements and extra maintenance costs.

The operations simulator is a constrained version of the design simulation analysis described above with the following main differences.

- — The input for alternatives to be evaluated would be "interactive" and "menu" driven.
- — The scope and nature of variables and alternatives would be limited and fixed to those developed during the detailed design phase of the project.
- — The structure of the model would be fixed and fitted to the actual terminal design, which will improve processing efficiency and response time.
- — Terminal historical data would be accumulated to reflect the actual terminal behaviour and hence improve the reliability of the predicted results from the model.
- — The output results would be preserved in a pre-defined display format, (i.e., menus), to eliminate the need for the user to learn any special language.

Run time parameters are obtained from the computer real-time data base. Typically these would include such things as:

- — number of mines;
- — number of grades of coal from each mine;
- — train arrival history and known schedules by mine for coming period;
- — equipment availability;
- — history of major equipment breakdowns and number of operating hours since the last equipment breakdown;
- — maintenance schedules;
- — major equipment operating rates based upon historical data;
- — coal pile configuration and arrangement and actual inventories by pile;
- — scheduled and known ship arrival times, expected sizes and requirements;
- — cost related data for above.

Results are made available on VDTs or printers in the form of graphs, bar charts or reports to properly convey data to system users. Typical reports and displays to be used for this purpose could include:

- — Stockpile projection schedules in tabular and bar graph and graphical trend form
- — Equipment utilization in tabular and/or bar graph form
- — Demurrage/despatch projection schedules in tabular bar graph and graphical trend form.

The ongoing use of this technique will enable the operations managers to predict the overall behaviour of the terminal and maximize the throughput by taking calculated risk-related decisions.

8. Cost Benefit Analysis

Potential cost benefits of a TOMS facility are very subjective. They are best assessed for each individual terminal, and often can only be significantly measured after the installation. However, the potential cost savings resulting from small improvements in efficiency are so large, due to the scale of terminal operating costs, that justification in economic terms is quite clear.

An economic sensitivity analysis of a typical terminal is useful in understanding the relative importance of key operating elements and probable economic paybacks. The following illustrate some of the potential benefits in this regard:

8.1 Throughput

For a given terminal, the major source of revenue is from handling charges on volume handled in a given time period. The actual throughput is dependent upon the interaction of numerous variables, some controllable and others not. The following partial list illustrates some of the controllable variables:

- — scheduling of downtime (for maintenance) of major equipment given ship/train schedules and stockpile inventories, to fit into slack periods;
- — scheduling of loading/unloading operations of specific ships and trains;
- — reduction in maintenance downtime duration by planning ahead for required parts, labour etc., hence increasing equipment uptime;
- — improved uptime in equipment as a result of preventative maintenance on equipment and by monitoring actual operating hours;
- — long- and short-term planning and scheduling of trains and ships and the coordination of these to suit terminal resources capabilities.

If the terminal throughput is increased by one percent as a result of the on-going use of a computer system, this increase could be as much as $ 350,000 per year for a 10 million tonnes per year (Mt/y) terminal.

8.2 Labour

The computer provides a series of management and operational reports pertaining to all aspects of terminal operations which should reduce the staffing requirements over those for a similar system. Assuming a cost of $ 30,000 per year per employee (including overhead), the capital value of an equivalent cash-flow for funds at today's interest rate over a ten year period would be approximately $ 150,000.

8.3 Security

The two major grades of coal, metallurgical and terminal, have subgrades dependent on such factors as sulphur, ash and moisture content, and caloric values. Contamination in loading shipholds, for example, could result in a reduction in the value of coal and possible penalties to the terminal.

Assuming a value of $ 65 per tonne for metallurgical coal and $ 50 per tonne for the thermal coal, if one ship's hold (say 10,000 tonnes) is contaminated by a lower grade, the loss in value could be as much as $ 150,000. Implementation of a TOMS could virtually eliminate this hazard.

8.4 Demurrage Penalties

Through short-term scheduling and long-term planning, it should be possible to minimize demurrage payments. For example, if one day of demurrage charges are avoided for one ship, this represents a saving of $ 6,000. Typical terminals in the 10 Mt/y size allocate as much as $ 500,000 per year to demurrage.

8.5 Maintenance Costs

An annual budget of $ 5 million for maintenance is typical for an average size terminal (i.e. 10 Mt/y). By planning maintenance in advance, on a preventative basis, and having a control on part inventory, etc., it should be possible to reduce these costs. Every one percent reduction in these costs represents a saving of $ 50,000 per year.

The extent of benefits derived by a terminal using the TOMS would depend entirely on the user and his specific situation. However, the above analyses illustrate the value of "small" improvements in performance in various areas under the control of terminal management and hence represent potential paybacks if this decision evaluating tool is implemented.

For comparison, the computer management systems described in this paper range in cost from three quarters to one and one-half million dollars depending on complexity. It is, therefore, evident that the potential benefits suggest that the system could result in a full payback in the first two years of operation.

9. Conclusion

This paper has outlined facilities and features of a computer-assisted Terminal Operations Management System and identified potential benefits of such a system applied to coal export terminals. The extent of the future of systems of this type is just becoming apparent in the bulk handling industry. The next five years should see a large number of installations either in operation or under development.

A Terminal Operations Management System application will yield significant economic benefits by optimizing operations efficiency, increasing terminal revenue and decreasing terminal costs. In addition to the more traditional data processing and financial functions, terminal owners and managers should carefully consider computer systems to support overall terminal operations.