SAIC-90/1223

MARKET INVESTIGATION

FOR

AUTOMATED WAREHOUSING

FINAL TECHNICAL REPORT

BY

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PREPARED FOR THE

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19 ABSTRACT (Continue on reverse if necessary and identify by block number)

This market investigation was conducted by the US Army Belvoir Research, Development and Engineering Center. The objective was to conduct a comprehensive market analysis of the current and developing automated material handling technologies that may be suitable for adaptation to an automated field warehousing system or individual components that may be integrated into such a system.

The Army moves large tonnages of supplies on a daily basis. This operation, as it is currently done, is extremely labor intensive. Perhaps automated material handling technology can ease this labor intensive operation and improve the productivity of receiving, storing and issuing supplies.

The purpose of this technical report is to document the study effort which included a literature search, development of a questionnaire, distribution and collection of data from the questionnaire, analysis of the responses to the questionnaire, and selected site visits.

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STUDY GIST - MARKET INVESTIGATION FOR AUTOMATED WAREHOUSING

PRINCIPAL FINDINGS

1. No company manufactures a complete system application that can be used to fully automate a field warehouse.

2. There are fifteen companies that manufacture promising automated hardware components or subsystems that may be adaptable for use in certain aspects of a field warehouse.

3. There are three companies that can develop software automation programs to control and manage systems in support of a field warehouse.

4. There is no emerging technology that can be applied to automate a field warehouse.

5. Supply work at the general support unit and direct support unit levels is labor intensive.

6. Vans used by units to transport small repair parts on the authorized stockage list (ASL) do not contain standard shelving to store and secure the parts, thus increasing the chance for damage during transit.

MAIN ASSUMPTION

There is Army interest in an automated warehouse that can operate in a field environment.

PRINCIPAL LIMITATIONS

There were no limitations to the conduct of this market investigation.

SCOPE OF EFFORT

The scope of this effort was to investigate the commercial marketplace to identify current technology and any developing technology that could be applied to automating a field warehouse.

OBJECTIVE

The objective was to perform a comprehensive market investigation of the current and developing technologies that may be suitable for adaption to an automated field warehousing system or individual components that may be integrated into such a system.

BASIC APPROACH

The basic approach used in this effort consisted of applying management science and system/hardware integration techniques to the development of the market investigation. Key elements in the basic approach were conducting a literature search; developing a market investigation questionnaire; distributing and collecting data from the questionnaire; analyzing the results of the questionnaire; visiting selected commercial and Government facilities; and, documenting the study effort in a Technical Report and Study Gist.

REASONS FOR PERFORMING THE STUDY

The reasons for performing the market investigation were to determine if the commercial marketplace can support automating a field warehouse and to document the effort for future use.

IMPACT OF THE STUDY

The market investigation indicates that the commercial marketplace cannot provide a single system that can completely automate a field warehouse. However, there are several companies that manufacture promising hardware components and software products that may be adaptable for use in automating segments of a field warehouse.

The Materiel Developer can use the market investigation to continue the study of automating a field warehouse, possibly at the subsystem level. Additionally, future study should consider automating a field warehouse at the theater level.

SPONSOR

US Army Belvoir Research, Development and Engineering Center

PRINCIPAL INVESTIGATOR

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INTRODUCTION

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INTRODUCTION

1.1 BACKGROUND

The Logistics Equipment Directorate at the US Army Belvoir Research, Development, and Engineering Center (BELVOIR) is responsible for the research and development of various Army materiel projects. One of these projects is the Army Field Warehousing System (AFWS). The AFWS project will attempt to identify automated equipment and vehicles, guidance sensor systems, inventory control systems, and computer control systems to automate inventory control and materiel handling from first stage storage through Corps forward supply points. Unlike most commercial fixed warehousing systems, the AFWS must have flexibility for frequent change of the ground layout configuration and the types of materiel handled. This system must also be able to interface with the existing Army inventory control system to provide real time inventory control from first stage storage through to the Corps forward supply points. Currently, supply operations and warehousing are labor intensive and basically a manual process. The AFWS project will explore the possibilities to field a system that allows the soldier to receive, store, and issue supply items with greater efficiency. This initial effort is needed to identify the current commercial automated warehousing technologies or any developing technologies that could improve the warehousing operations through all stages.

1.2 OBJECTIVE

The objective of this task was to conduct a comprehensive market investigation of the current and developing technologies in automated material handling equipment that may be suitable for adaption into a US Army field warehousing system. It should be noted that,

although the task's title was market investigation, it should have been titled a market surveillance according to AR-70-1, Systems Acquisition Policy and Procedures, due to the lack of any requirements documentation, such as an Operational and Organizational (O&O) Plan or a Required Operational Capability (ROC). Upon completion of the investigation of systems and technologies, an analysis was performed to provide BELVOIR with an evaluation of possible candidate systems and possible alternative methods of adapting current or developing technologies to automated field warehousing. The ultimate goal was to determine if automated material handling technology can improve the Army's ability to receive, inventory, maintain, and transfer materiel in the most expeditious and efficient manner, while on the battlefield.

1.3 STUDY APPROACH

The contractor's expertise in system/hardware integration was used to conduct a market investigation of automated warehousing systems that can function in a field environment. The contractor identified and reviewed systems that are currently available or being developed throughout industry and in the military. The contractor developed a questionnaire based upon Government input to assess the potential of candidate systems or products for use in automated field warehousing. The survey was conducted and the required information collected, organized, and categorized. The contractor reviewed the information received in response to the market investigation and from other relevant sources. This process has the following main tasks.

Task 1: Literature Search and Development of a Market Analysis Questionnaire.

The contractor will conduct a literature search of relevant Army documents pertaining to field warehousing procedures. A description of the current Army system will be developed from these documents to serve as a baseline for the market investigation. This baseline will be updated as new information becomes available. A market analysis questionnaire will be

developed in conjunction with BELVOIR.

Task 2: Distribution and Collection of Data from the Market Analysis Questionnaire.

The contractor will develop a distribution list for the market analysis questionnaire in conjunction with BELVOIR. This distribution list will be based on the results of the literature search into the commercial area of automated warehousing. The contractor will collect, organize, and categorize the available data received from the questionnaire.

Task 3: Analysis of Results of Questionnaire.

The contractor will review the responses to the survey, and contact the necessary responders for follow-up information. The data will be reviewed based on the objectives of the task order, and the potential requirements from the Army's logistical support needs.

Task 4: Site Visits.

The contractor will identify several promising commercial sites and facilities and Government installations that are relevant to the objective of this task order. After receiving approval from BELVOIR the contractor will visit these sites to investigate currently available systems and the potential for application to field warehousing.

Task 5: Technical Report.

The above tasks will be documented in a final report. The results of the investigation and the review of the candidate systems will be documented in a technical report and study gist.

SECTION 2

LITERATURE SEARCH

SECTION 2
LITERATURE SEARCH

2.1 IDENTIFICATION OF MANUFACTURERS

To identify firms that may be involved in automated field warehousing, a literature search was performed. Research was conducted at the George Mason University and George Washington University libraries, the American Production and Inventory Control Society, the Library of Congress, and the Regional Public Libraries in Virginia. Materials, such as trade periodicals, industry registers, casebook directories, reference publications, and automated material handling association publications provided an excellent cross reference of information. Using these reference materials, the study team was able to narrow the broad field of automated equipment to specific fields, such as automated storage and retrieval systems (AS/RS), automatic guided vehicles (AGV), automation equipment, conveyors, cranes and stackers, robotic palletizers, pickers, robotic positioners, robotic system integrators, robotic tracking systems, and robots (material handling). This effort yielded a list of 121 companies involved in automated material handling. These firms were selected and grouped into three categories: material handling, robotics, and automation software. This group represented a reasonable cross section of private industry's manufacturing capability in the specific fields of automated equipment and would serve as the sample base for the market investigation.

2.2 DESCRIPTION OF THE ARMY'S CURRENT CORPS SUPPLY AND DISTRIBUTION SYSTEM

2.2.1 Introduction.

Successful combat operations are dependent on responsive combat service support (CSS) provided by a command headquarters to its military forces. Since the corps represents the largest tactical headquarters in the Army, this section will describe the supply and distribution system used by the corps to support a military force, which can consist of two to five divisions. Supply is part of the logistic support process that provides the items required to equip, maintain, and operate corps units. Supply functions include procurement, receipt, storage, and disposition of these items within the corps. Although the focus will be at the corps level, the CSS relationships between the corps and the theater army will be included to round out the description.

2.2.2 Supply Management and Requirements Determination.

Supply management consists of the functions and actions taken by the corps' Materiel Management Center (MMC) to support weapons systems on the corps battlefield. Supply management involves coordination between the user, direct and general support supply units, and MMC's at the theater army, corps, and division levels. It includes functions pertaining to planning, stock control, flow of requisitions and distribution, and storage.

Supply requirements are statements of need for specific quantities of supplies and equipment for a specified period of time. The requirements are based on tactical plans, demand data, previous experience, troop strength, equipment density, and other data available at the various levels of command. With this information and data, the MMCs at the various levels

develop quantities of each supply item for their respective commands. Such requirements are for the initial issue or to fill shortages in the initial issue rather than replacement and consumption requirements during the initial phase of an operation.

Replacement and consumption requirements keep initial equipment at authorized quantities and replenish supplies consumed, expended, lost, or destroyed. Successful combat operations demand that supplies be available when needed. If supplies are received daily, then needs can be met with a minimum operating level of supply. When supplies are received less frequently, it is usually necessary to increase levels of supply. The computation of replacement and consumption requirements is based on authorized days of supply, projected troop strength, seasonal requirements, major changes in the supported force, special requirements of an operation, and replacement factors and replacement rates.

Supply planning includes the capability for making quantitative supply estimates, especially when planning and conducting corps combat operations. Supply estimates are prepared by the corps staff primarily to assist in determining the tonnages to be received, stored, and distributed to the various locations and units in the corps area. When estimating supply tonnages, the corps staff uses three basic items of information: troop strength, consumption rates, and number of days supplies are required. For materiel supply estimates, an additional item of information pertaining to equipment allowances is required. After the total tonnages are estimated, staff planners then estimate the tonnages to be moved into each corps area and the combat zone each day. These tonnages become distribution and storage requirements. Distribution requirements will impact on corps transportation capabilities and, if required, identify requirements for theater army transportation assistance. Storage requirements will impact on what and how much stock will be stored at corps sites and at general support unit and direct support unit locations.

To facilitate supply management and planning, supplies have been divided into 10 classes. The classes of supplies provide categories so that items can be identified to each class, establish a common terminology, and enhance communications between supply personnel at all levels. The 10 classes of supplies are:

Class I - Subsistence;

Class II - Items of equipment, other than principal items, which are prescribed in authorization and allowance tables: clothing, individual equipment, tentage, tool sets and tool kits, hand tools, and housekeeping supplies and equipment;

Class III - Petroleum, oils, and lubricants;

Class IV - Construction and barrier materials;

Class V - Ammunition;

Class VI - Personal demand items;

Class VII - Major end items;

Class VIII - Medical material;

Class IX - Repair parts and components, including kits and assemblies; and,

Class X - Material required to support nonmilitary programs, such as agriculture and economic development projects.

2.2.3 The Corps MMC.

The MMC at the corps level is a subordinate element of the Corps Support Command (COSCOM) which is a major command that supports the corps. It is organized along functional lines with the following services and materiel management elements:

Service Support Division;

Logistics Automation System Support Office;

Aviation Division;

Electronic Division;

Armament and Combat Vehicle Division;
Missile and Munitions Division;
Automotive Division;
Troop Support Division; and,
Petroleum and Water Division.

The MMC is the focal point of the corps level supply management system. It is normally centrally located in the corps area. This organization exercises integrated materiel management of all classes of supply, less communications security, medical, and classified maps, which are controlled and managed by other Army agencies. The MMC is involved with requirements computation, establishment of stockage levels, supply distribution, procurement direction, disposal, and maintenance priorities. From an operational viewpoint, the supply system in the corps is based on decentralized stock locations with centralized management at the MMC.

The MMC also performs stock control functions of general support supply within the corps. Such centralized stock control improves the responsiveness to the demands of the supported units while providing control over assets as well as the CSS units. The stock control system is a combination of manual or automated operations at the direct support supply level and automated operations at the corps general support level. Formal stock control at the MMC is maintained for supplies at the general support level. Stock control for supplies at the direct support supply level is maintained by the nondivision direct support unit and by the division's MMC for the division direct support unit.

The theater army is responsible for resupplying the corps' general support units in an overseas area. This responsibility is executed through the MMCs at the theater and corps levels. Because the theater army MMC serves as the primary interface between the theater and the wholesale support base in the United States, supply requisitions from this MMC are transmitted

directly to the National Inventory Control Points for fill and shipment.

2.2.4 Supply Stockage Levels.

Corps units at different combat organizational levels stock and carry all classes of supplies, except repair parts and medical material. The amount of stockage is prescribed in terms of days of supplies. For example, in the brigade area, one to three days at the forward direct support unit; in the division area, three to five days at the direct support unit; and, in the corps area, three to five days at the direct support unit and 30 days at the general support unit. Repair parts are stocked in varying amounts up to 30 days of supply plus order ship time to the United States at each supply level in the COSCOM. Medical materials are stocked up to 10 days of supplies by the medical CSS units in the COSCOM.

2.2.5 Storage Operations.

Storage operations within the corps can be characterized by direct distribution of supplies, minimum administration, maximum use of material handling equipment, and skilled and specialized personnel. Direct distribution of supplies can best be described as bypassing the general support level whenever possible, with delivery to the direct support or user level. When this is done, the supply system becomes more responsive and inventory and storage requirements are reduced. Since the stock control functions of the general support units are in the MMC, these units perform only those administrative functions that pertain to storage operations. General support units maintain a locator system, report receipts, process shipments, conduct physical inventories, and perform care and preservation of supplies in storage.

General support supply is basically a warehouse operation. To facilitate storage and warehousing, supply shipments to the corps are palletized and containerized so that general

support supply units can take full advantage of available space and material handling equipment (MHE). These supplies are grouped for warehousing according to similar material handling requirements. Accordingly, general support supply units are organized to handle general supplies, repair parts, ammunition, heavy materiel, and fuel.

2.2.6 Requisition Flow and Supply Distribution.

General support and direct support supply units and direct support maintenance units are normally supplied from the United States through the Direct Support System (DSS). On an exception basis, high priority supply requisitions are filled from in-theater operational, war reserve, and contingency stocks maintained by the corps, or theater army.

The COSCOM MMCs receive supply requisitions from the division MMCs and from nondivision direct support supply units and intermediate direct support maintenance units. Requisitions are filled and when the item is not available for issue, the requisition is passed to the wholesale support base in the United States. The materiel will then be shipped directly to the general support and direct support units designated DSS or air line of communications (ALOC). Selected line items and classes of supply may be managed by the theater army MMC. Requisitions for these items flow from the COSCOM MMC through the theater army MMC to the wholesale support base where they are filled and in turn, shipped to the theater or corps. Figure 1 depicts the data flow (includes requisitions) and the distribution of supplies.

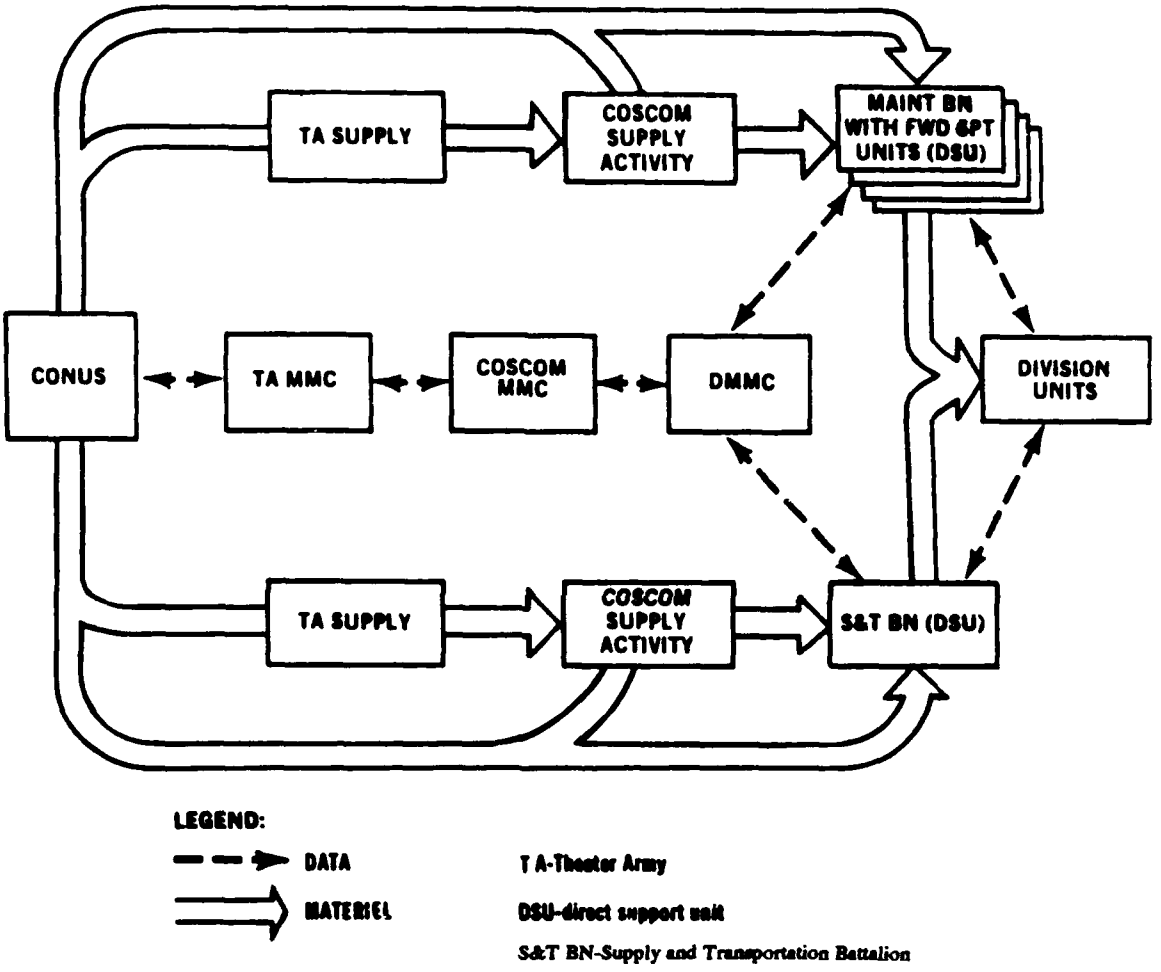


FIGURE 2-1. Data Flow and Distribution of Supplies

The DSS is the Army's standard distribution system for classes II, III (packaged), IV, V (missile components only), VII, and IX. When the COSCOM MMC receives requisitions from supported units for items in these classes of supply, the requisitions are filled or passed to the wholesale support base in the United States. DSS expedites the movement of these supplies from the United States directly to the requisitioner, bypassing intermediate supply activities. DSS uses surface transportation, which includes sea lines of communications (SEALOC) or ALOC for overseas shipments. Materiel in classes II (nonair eligible), III (packaged), IV, V (missile components), VII, and IX (nonair eligible) are shipped via SEALOC. ALOC is used for priority shipments of air eligible class IX repair parts and maintenance related class II items to designated ALOC units overseas. The ALOC segment of the system increases repair parts availability by reducing order-ship time from the United States, which in turn improves unit readiness.

SECTION 3

DESIGN, DISTRIBUTION, AND COLLECTION OF DATA FROM QUESTIONNAIRE

SECTION 3
DESIGN, DISTRIBUTION, AND COLLECTION OF DATA FROM QUESTIONNAIRE

3.1 COMPILATION OF QUESTIONNAIRE DISTRIBUTION LIST

Once the identification of manufacturers involved in automated material handling, mentioned in Section 2.1, was completed, a distribution list for the questionnaire was developed. The list contained 121 companies. These firms were selected and grouped into three categories: material handling, robotics, and automation software. The distribution list was submitted to the Project Engineer and approved as an acceptable representation of the commercial marketplace for automated warehousing. The distribution list can be found in Appendix B.

3.2 DESIGN, APPROVAL, AND DISSEMINATION OF THE QUESTIONNAIRE

A questionnaire was designed that would solicit a company's product applicability toward fulfilling the automated field warehousing requirements and gain information on any emerging technologies they may be developing. A short questionnaire with a few vital questions to facilitate an initial response was desired over a lengthy one. It has been Science Applications International Corporation's (SAIC's) experience that on a study of this nature, where the object is to retrieve initial information on a topic where there is no set requirement(e.g., no O&O or ROC) and therefore no specific technical questions to ask(e.g., no design specifications); a lengthy questionnaire only discourages companies to respond. The more simplified and easy to fill out a questionnaire is, the greater the chances are of making the initial contact through a response. Then, if more information became necessary, a follow-up would usually be all that is needed once a point of contact had been established.

A cover letter was designed that would accompany the questionnaire to familiarize the recipient companies with the project, the field environment, and solicit completion of the questionnaire. The questionnaire and cover letter were completed and given to the Project Engineer for approval. The cover letter and questionnaire can be found in Appendix C. The questionnaire was mailed out on January 5, 1990. The companies were asked to return the questionnaire within 30 days from the day they received the package.

3.3 DATA OBTAINED FROM THE QUESTIONNAIRE

Out of the 121 questionnaires sent out, 30 companies responded initially. This corresponded to a 25% response rate. The firms that responded offered a wide variety of automation applications in the form of both products and services. The next section describes the follow-up conducted of the companies that did not initially respond. It also has a more careful examination of the firms that initially responded, and the potential for adapting their current technology or use of an emerging technology to automate the Army's field warehousing operations.

SECTION 4

ANALYSIS OF QUESTIONNAIRE RESPONSES

SECTION 4
ANALYSIS OF QUESTIONNAIRE RESPONSES

4.1 CURRENT SYSTEMS AND COMPONENTS

The responses to the questionnaire yielded information on a wide variety of automation products. Although varied they can be categorized into the following general groups: AGVs, AS/RSs, and Computer Control Systems. Each has a different area of application in automated warehousing. A brief description of each group follows.

AGVs are autonomous self-propelled vehicles used in the transportation of material in an inventory system. AGVs can be equipped with a pallet load carrier, or be used as a tug for pulling various other loads. These units can carry large amounts of material, with some units carrying as much as 200,000 pounds. The unit is usually guided by a guide wire embedded in the warehouse floor. It is through this wire that the unit communicates with the master computer. Some AGVs can operate on a pre-programmed path or by remote operator guidance. Other methods of guidance are optical sensors and radio frequency (RF). Most units can be programmed to be taken out of service when they need recharging and plug themselves in automatically to the recharging station.

AS/RS units usually run on a monorail. When operating these systems, the operator inputs the type of product or the location of that product on the shelves. The unit will automatically move to that location retrieve the item off the shelf and deliver it to the operator or an AGV. If the units being inventoried are larger in size, an AS/RS can be equipped with cabs where an operator can ride with the unit itself and assist the machine in

retrieving the inventory item or retrieve it themselves. AS/RS's vary greatly in size from eight to over 100 feet tall. An offshoot of this technology is the carousel system which is used to store much smaller types of inventory. The machine rotates the shelf or tray itself to the operator's work station as they request specific items for retrieval.

Computer Control Systems are designed to audit, report, and control inventory systems. Bar coding is the most popular and efficient way of imputing data into the system. Once in the system, a "real-time" environment is created in which, as inventory leaves the warehouse, it is simultaneously logged out in the inventory computer system. Also, a whole range of hardware has been developed to facilitate the use of such control systems.

4.2 EMERGING TECHNOLOGIES

The term emerging technology means any technology that is beyond the current bounds of, or is a radically different way of approaching automated warehousing problems. It is not merely an improvement on an old or current method, product, or technology. The responses from the questionnaire indicated no emerging technology that is applicable to automated field warehousing.

4.3 FOLLOW-UP PROCEDURES

A follow-up was conducted to contact the firms that did not initially respond in order to verify that they either received the questionnaire and felt they could not assist, or that they never received the questionnaire, in which case one would be mailed to them. Out of the 121 questionnaires sent out, 53 additional responses were received through the follow-up. This corresponds to a 69% response rate. Of the 83 total responses, 48 were not applicable or

were not interested, and 35 sent responses to the questionnaire, most with promotional and/or technical information.

4.4 MILITARY APPLICATIONS OF CURRENT TECHNOLOGIES

An assessment was made of the potential applicability of the 35 completed written responses to the questionnaire. Out of the 35, 18 are seen as having potential for application. Some of the evaluation criteria for this assessment included product adaptability to the field environment, human factors engineering criteria as described in MIL-STD-1472 and DOD-HDBK-761, and product ability to accommodate various types of inventory. This potential for application varies in degree for each company and product. Therefore, some are considered to have more potential for use in the field environment than others. The following text contains summaries of these 18 companies with a description of their applicability including a graphical representation where available and reasons why the other 17 firms were not applicable.

COMPANY	CURRENT PRODUCT	IMPROVED PRODUCT
LXE 303 Research Dr. PO Box 926000 Norcross, GA 30092-9200	RF remote terminals.	None

DESCRIPTION OF PRODUCT

The LXE remote terminals enable remote communication between a user and the main computer control system, through the use of RF. These units provide the tools for real time data collection. The RF data terminals are centrally driven on a transaction by transaction

basis or programs are downloaded via the RF channel or RS232 port. Data is either key-stroked or entered via bar code reading devices. Typical warehouse applications include picking, putaway, receiving, and shipping. The data is transmitted to the base station receiver or remote receiver and then passed to the network controller. The latter device is interfaced into the host (mainframe or PC). Users are given the ability to communicate from where the work is being done, to include remote locations, with full RF coverage. Information about stock level changes are posted as they occur and not at the end of the shift, day, or week.

IMPROVEMENTS

LXE will announce a 1.4GHz terminal by June 1990. This is a significant advance in that the typical spectrum used in continental United States (CONUS) is 406-420MHz. This new terminal will have a synthesized RF module capable of providing 400 frequency selections for both the United States and overseas.

ASSESSMENT FOR ADAPTATION AND APPLICATION

These remote terminals could have application to the field environment with modifications in structural design to meet the standards of the field environment. But the ability to communicate with a main system controller to gain "real-time" inventory management is essential to automating any warehousing operation.

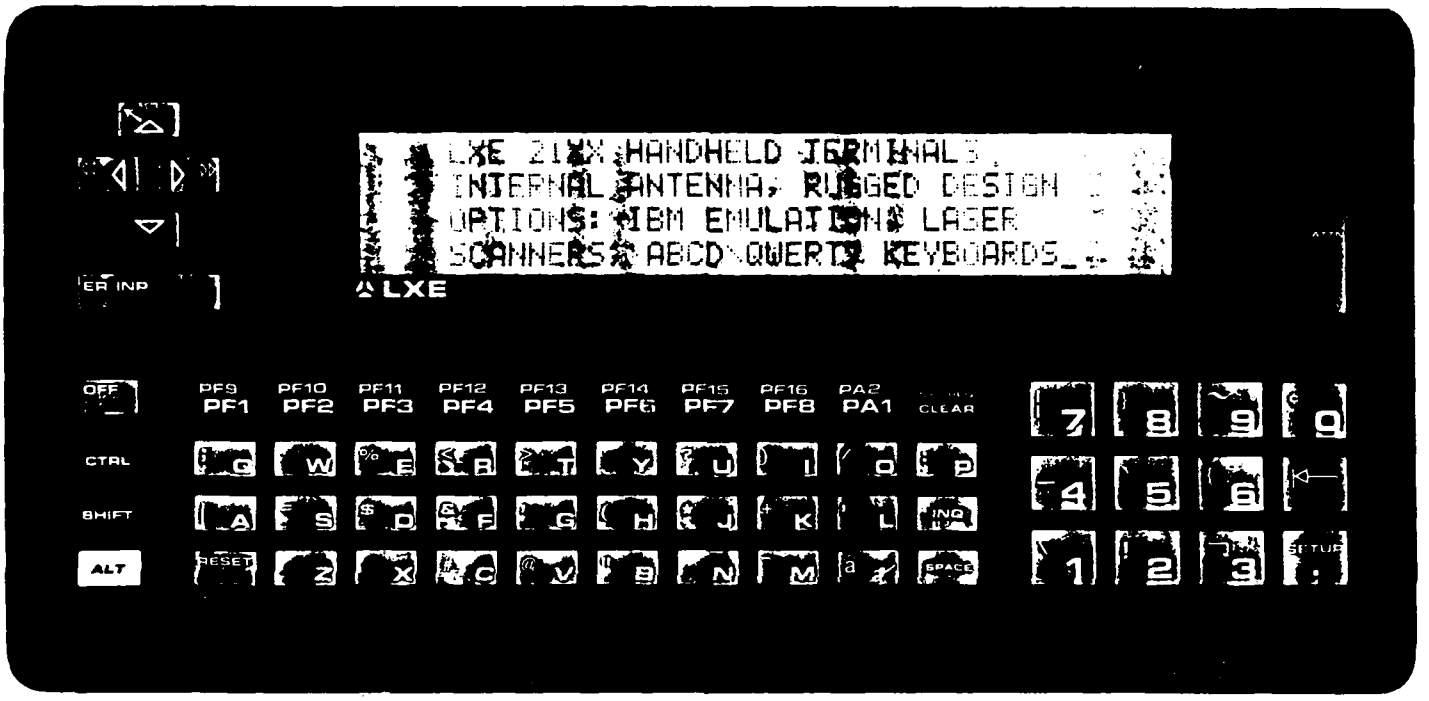


Figure 4-1. LXE Handheld Terminal

COMPANY	CURRENT PRODUCT	IMPROVED PRODUCT
BSP 1837 South 3230 West Salt Lake City, Utah 84104	PROPRIETARY	PROPRIETARY

DESCRIPTION OF PRODUCT

Information on this product was withheld from publication here, because of the proprietary nature of the data. This information was provided to the Government under separate cover.

COMPANY	CURRENT PRODUCT	IMPROVED PRODUCT
Cybermotion 5457 Aerospace Rd. Roanoke, VA 24014	Navmaster	Autonomous vehicle navigation Wide area sonar Vehicle routing and dispatching

DESCRIPTION OF PRODUCT

The Navmaster is an autonomous navigational vehicle which operates independent of wires, beacons, or tracks. When equipped with a paraflex (company name for mechanical arm assembly) lift turret and/or transport conveyor turret the Navmaster can lift and transport materials through predetermined routes programmed by the dispatcher software. Multiple

paths can be pre-programmed whereby the robot carries out several tasks independently or the robot can be manually controlled by a monitoring control operator using a joystick.

The Navmaster remains in constant communication with the host base station using full duplex RF modems. If RF modem communication presents a security concern, optical communication systems can be used. Navmaster can be preprogrammed for an extended period, like a day, week, month, or the programmed path can be interrupted, controlled manually, changed permanently, or returned to its original programmed path and continue automatically.

The Navmaster has permanent on board batteries which can be automatically recharged using an autocharging station. In addition, a docking beacon system is incorporated into the autocharging station which can reprogram the path and/or tasks of the robot, and as necessary download system informational data.

IMPROVEMENTS

None

ASSESSMENT FOR ADAPTATION AND APPLICATION

Although not an AGV in the strict sense, the Navmaster offers great flexibility over standard models. Attributes such as no wires needed for guidance, goes over 4 inch curbs, climbs up to 40 percent grade, make this unit a candidate to perform the tasks required in a field environment. The only drawback would be that it can only lift 50 pounds. This shortcoming needs to be overcome to operate fully in the field.

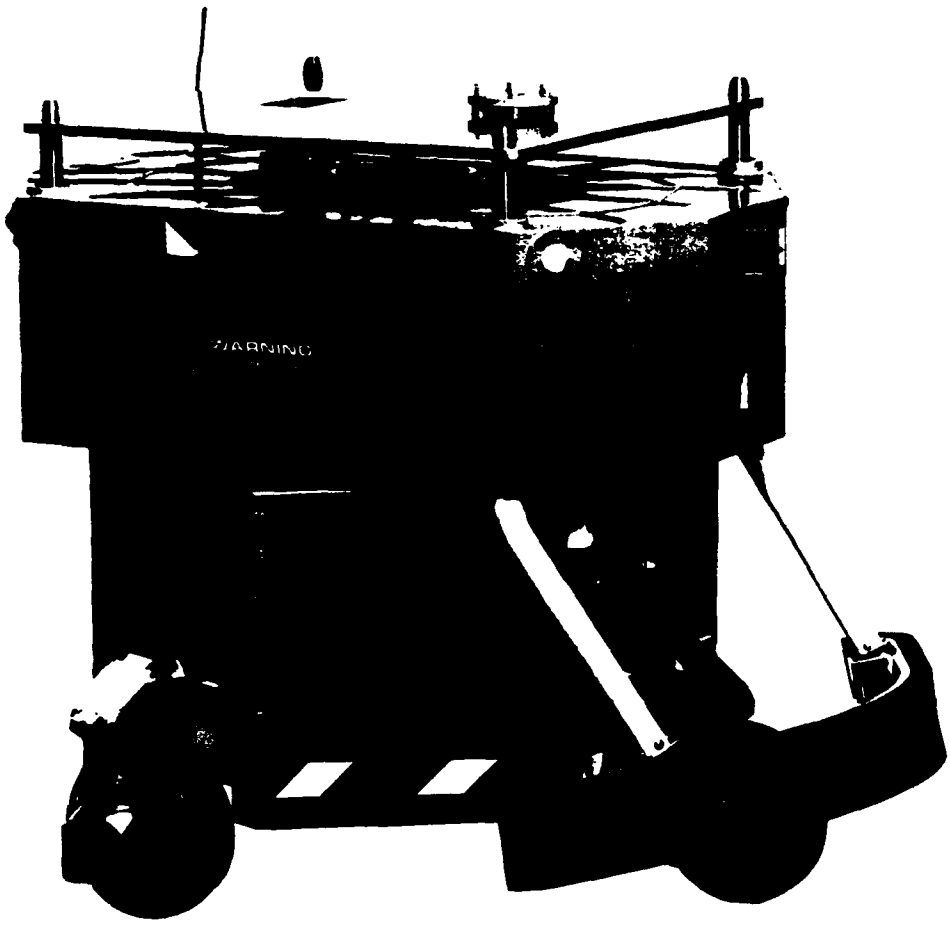


Figure 4-2. Navmaster

COMPANY	CURRENT PRODUCT	IMPROVED PRODUCT
Symbol Technologies Inc. 2010 Corporate Ridge Suite 520 Mclean, VA 22102	Bar code scanners	Radio Frequency Transponders

DESCRIPTION OF PRODUCT

Designed as a compact, versatile terminal that can resist water, wind, and dust and allow both keying data and bar code reading in harsh environments, this unit is suited for utility meter reading, pipeline flow monitoring, and Government and agricultural applications.

Although lightweight, this unit features a powerful, built-in decoder to read all popular bar codes. Ten AA size alkaline batteries provide for approximately 22,000 bar code decodes and a lithium power cell ensures against memory loss during replacement. It has 55 alphanumeric extra large keys for faster, more precise manual data entry. The liquid crystal display, with electroluminescent panel and adjustable viewing angle, is easy to read indoors and out.

IMPROVEMENTS

None

ASSESSMENT FOR ADAPTATION AND APPLICATION

The Army is already using a Symbol Tech. unit. Since the Army is moving towards

bar coding everything, these units will be necessary in maintaining proper inventory control and therefore have application in the field environment.

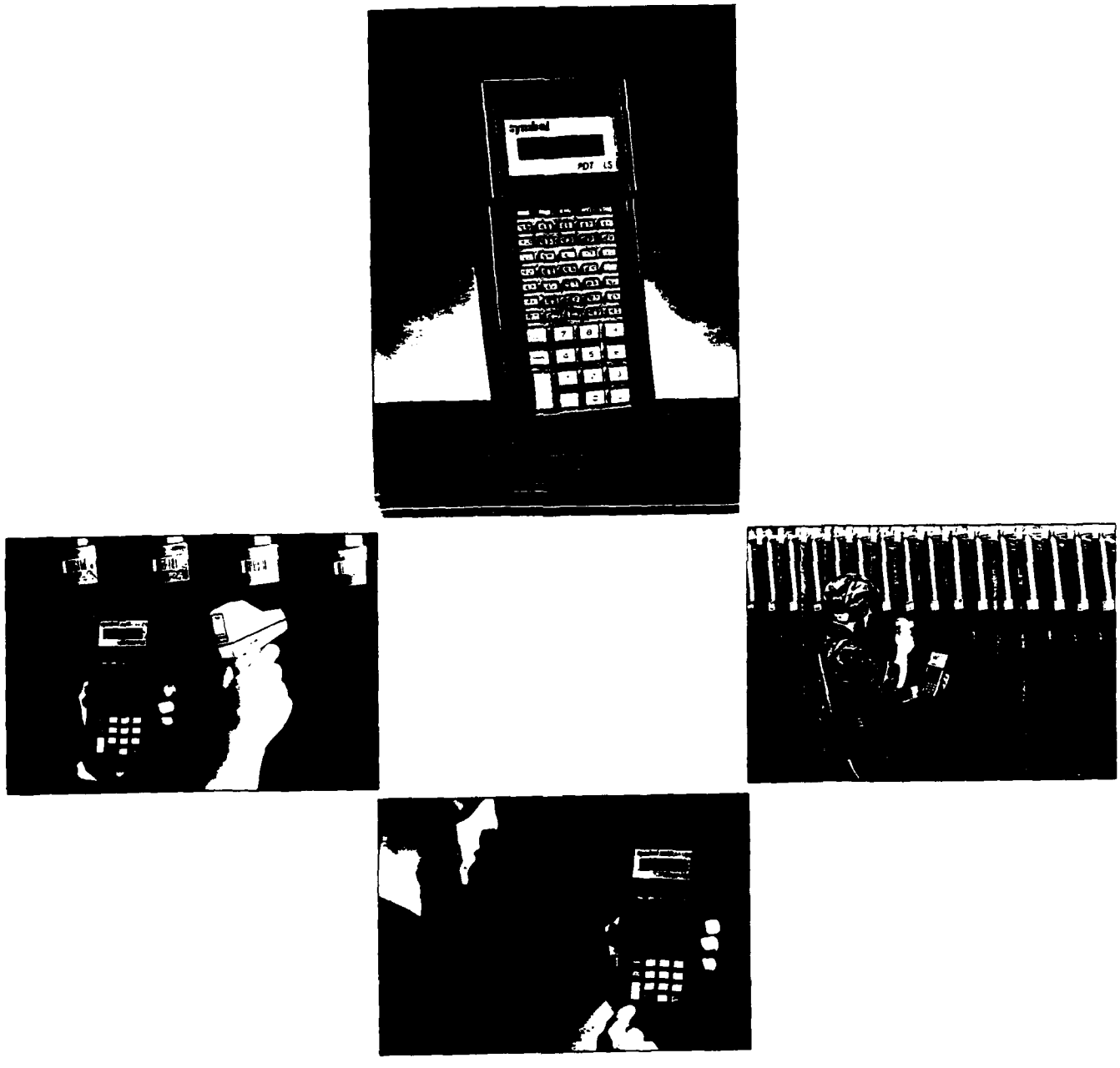


Figure 4-3. Symbol Scanners

COMPANY	CURRENT PRODUCT	IMPROVED PRODUCT
Logan Co. 200 Cabel Street PO Box 6107 Louisville, KT 40206	Mini-Load AMS 200 AS/RS	Multi-belt accumulating conveyor

DESCRIPTION OF PRODUCT

AMS 200 is a modularized AS/RS. It stores and distributes units weighing up to 440 pounds. It provides maximum product accessibility with minimum floor space use. On-board machine controls interface with the PC end-of-aisle controllers for complete automation. Its modular design allows system configuration to specific applications.

IMPROVEMENTS

None

ASSESSMENT FOR ADAPTION AND APPLICATION

The AMS 200 has promising application due to its ability to be modularized. This unit could be adapted to fit on a flatbed or another similar vehicle, thus providing a mobile AS/RS for small repair parts.

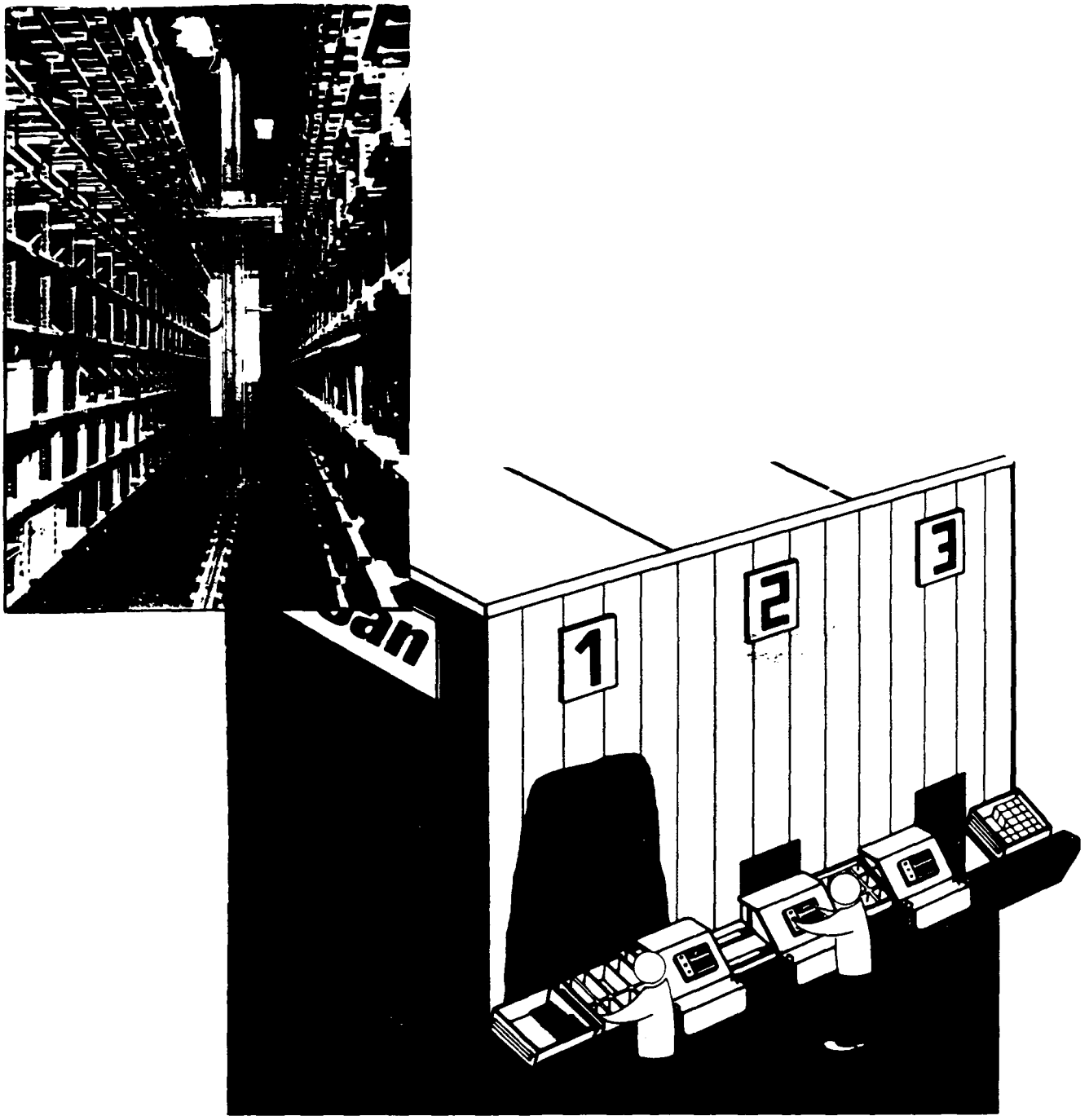


Figure 4-4. Logan Mini-Load

COMPANY	CURRENT PRODUCT	IMPROVED PRODUCT
American Turnkey 15 Chris Terrace Ringwood, NJ 07456	System Integration	None
Eaton-Kenway, Inc. 515 East 100 South Salt Lake City, UT 84102	System Integration	None
Munck Automation Technology PO Box 6677 Newport News, VA 23606	System Integration	None

DESCRIPTION OF PRODUCT

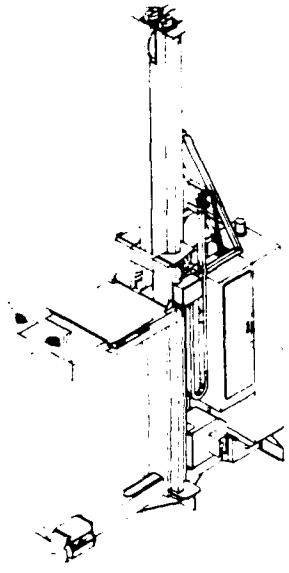
System integration companies have the ability to pull from a wide range of technological disciplines to solve problems using automation. All three of these companies would be able to approach this problem. The following comments concerning American Turnkey apply to the other two companies as well. American Turnkey is a systems design/integrator for automated manufacturing, distribution, and material handling. They offer a proven approach that utilizes their expertise in system solutions in conjunction with strategic alliances and advanced products to meet the needs of their customer. Their experience ranges throughout all types of industries from automotive to electronics manufacturing. They offer the ability to manufacture or find the best equipment and software to solve the problem. They approach the problem from a systems standpoint to ensure all facets of the problem are being addressed.

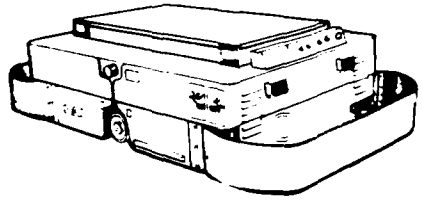
IMPROVEMENTS

None

ASSESSMENT FOR ADAPTATION AND APPLICATION

Although this company has no direct application it is perhaps large enough and has enough experience to be able to adapt and modify technology to suit the needs of the field warehouse environment.





System Integrators
Tie All Facets of
Automation Together

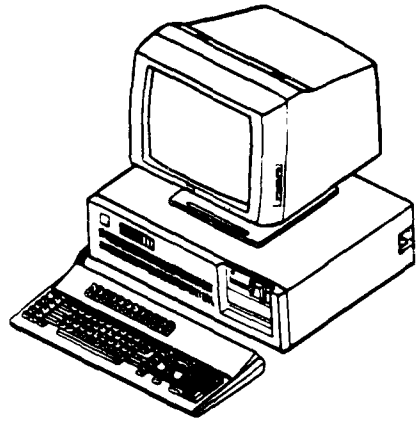


Figure 4-5. Systems Integration

COMPANY	CURRENT PRODUCT	IMPROVED PRODUCT
Control Engineering 8212 Harbor Springs Road Harbor Springs, MI 49740	AGV	None
Mentor 8500 Station Street PO Box 898 Mentor, OH 44061	AGV	None
Modular Automation Corp. Route 12 South Greene, New York 13778	AGV	None
Warehouse Handling Systems 5108 Buchanan Street Hyattsville, MD 20781	AGV	None
Appogee Robotics 2643 Midpoint Drive Fort Collins, CO 80525	AGV	None
Mannesmann Demag 2660 28th, S.E. Grand Rapids, MI 49508	AGV	None
Translogic 10825 East 47th Ave. Denver, CO 80239-2913	AGV	None

DESCRIPTION OF PRODUCT

Control Engineering represents one of the seven company responses for AGVs. It is believed that any of these companies is large enough to explore the adaptation of AGV

technology to the field environment. Control Engineering has been chosen as an example. Control Engineering's family of AGV's includes "prontow" (company name) towing vehicles, a variety of "auto-trans" (company name), low profile vehicles "LPV", unit load vehicles, several types of fork vehicles, and custom load vehicles. Maximum load capacities range from 500 pounds to 100,000 pounds for unit load vehicles and up to 50,000 pounds for standard towing vehicles. These machines are microprocessor controlled, have a modular design and have extensive on-board diagnostics with "plain english" readouts. They come with patented emergency bumpers, full manual controls, and visual/audible warning devices.

IMPROVEMENTS

None

ASSESSMENT FOR ADAPTION AND APPLICATION

AGVs are one of the key components in any automated warehousing operation. However, their use in the field environment is questionable due to the terrain and other conditions which exist there. If adaptation for the field environment could be engineered, AGVs could be as useful in the field, as they are in a fixed environment.

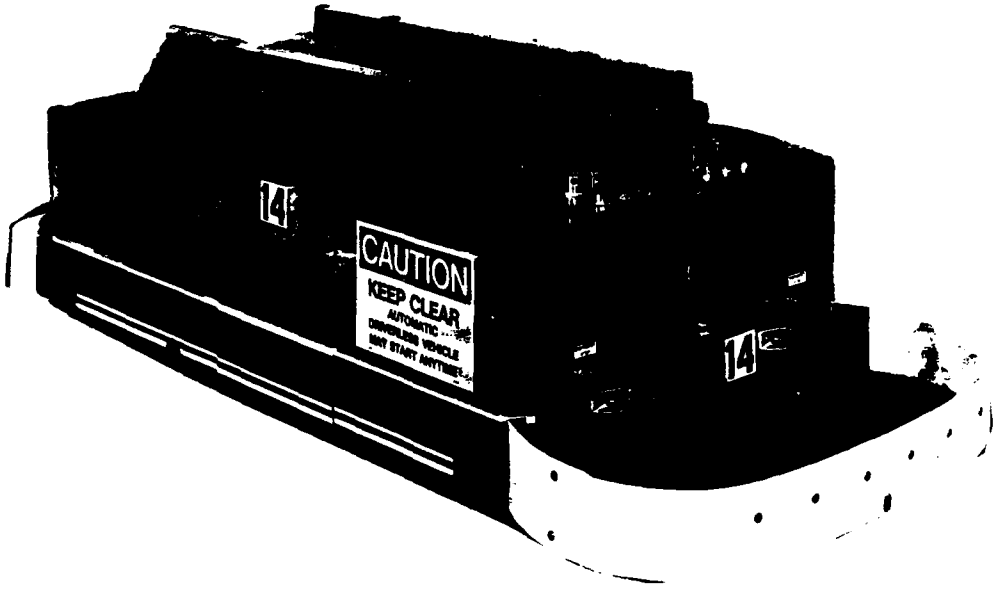


Figure 4-6. AGV

COMPANY	CURRENT PRODUCT	IMPROVED PRODUCT
Logisticon 4001 Burton Drive Santa Clara, CA 95054	Control software	None
Cambar Software 80 Orville Drive Bohemia, NY 11716	Control software	None
ICIS 4516 South 700 East #230 Salt Lake City, Utah 84107	Control Software	None

DESCRIPTION OF PRODUCT

Logisticon is one of three computer control system responses received. It is believed that any one of these three companies could design a system to automate a field warehouse. Logisticon and its package Dispatcher was chosen as an example. Dispatcher is an integrated material management system which is used to regulate warehouse operations and controls. Dispatcher is a "turnkey" system which includes all the hardware, software and client services necessary to implement a warehouse management system. It has the ability to adapt to many major computer hardware platforms. Dispatcher will handle all warehouse control and material movement operations including receiving, bar code labelling of receipts, putaway, picking, replenishment, shipping, relocation, consolidation and cycle counting. It is designed to easily interface with automated material handling devices, such as AGVs, AS/RS, carrousels, pallet and case conveyors, tote systems, automatic palletizers, paperless picking systems, and sortation systems.

IMPROVEMENTS

None

ASSESSMENT FOR ADAPTATION AND APPLICATION

Computer control software is the vital element which links all the facets of any automated system together. All three companies have the ability and technique to integrate an automated system to fit the Army's field environment need.

OTHER MANUFACTURER RESPONSES

The 17 companies which responded and were considered not applicable are listed below. They were considered not applicable for a variety of reasons. Some firms didn't make automation equipment useful in a field warehouse, while other products were dedicated to a fixed warehouse environment. For example, there are companies listed here which manufacture AS/RSs, but these particular units were so large and so dedicated to the fixed environment that modification was judged inefficient. There are also computer software firms listed here which were judged as being too specific to a certain type of automation, usually dealing with manufacturing.

A.E. Gray and Assoc. - Scanners
ABB Robotics - Robots
Advanced Manufacturing Systems - Gantry+Monorail MOBOTS
AMTECH - RF Tags
Ariel Software - Automation Software

Automated Equipment - AS/RS

Blue Giant - Lifttrucks

C+D Machine and Engineering - Gantry Robots

Cimtechnologies Corp. - Manufacturing Software

Custom Tech. Inc. - System Consultants

Cybernated Automation Corp. - AS/RS

General Machine Design - Low-Bot Robot Palletizer

GMF Robotics - Robotics

Process Data Corp. - Automated Software

Stanley-Vidmar - AS/RS

White Storage and Retrieval - AS/RS

Yale Materials Handling Corp. - Forklifts

SECTION 5

SITE VISITS

SECTION 5
SITE VISITS

5.1 PURPOSE OF SITE VISITS

After identifying manufacturers that may be involved in automated field warehousing and soliciting information and data pertaining to their product line, there was a need to visit some of the more promising companies. The visits were conducted to: discuss the potential application of their current technology and product line to the automated field warehousing project; determine if any new directions were being pursued; and identify any emerging technologies being developed which would have application to the project.

In addition to visits to the private sector, there was also a need to visit selected military organizations involved in the Army's supply business. These visits were conducted to: discuss the project with supply personnel; observe the methods and techniques currently being used to receive, store, and issue supplies; and identify potential applications for automated field warehousing.

5.2 COMMERCIAL SITE VISITS

Visits were made by Government representatives and study members to BSP Development Corporation and Eaton-Kenway Corporation located in Salt Lake City, Utah, and Munck Automation Technology Corporation located in Hampton, Virginia. BSP Development Corporation is a manufacturer, whereas Eaton-Kenway and Munck Automation Technology Corporations are system integrators for automated material handling equipment used in warehousing and distribution centers. Specific comments and observations from the

visits were provided to the Government under separate correspondence. The following information summarizes the visits.

BSP Development Corporation

BSP Development Corporation has a proprietary product that may have a specific component application to handle selected supply items. Because of the obligation to protect proprietary information, further discussion about the visit and the product will not be made.

Eaton-Kenway

At Eaton-Kenway, corporate personnel briefed one of their latest projects which involved construction of an automated distribution center to move large volumes of produce. Major equipment installed included AS/RS, AGVs, conveyors, sorters, and a control system to drive the automated equipment. After briefing the automated field warehousing project to Eaton-Kenway, the discussion that followed centered on what they thought could be done to assist in the project. Eaton-Kenway was positive and eager to assist; however, they did not offer any specific suggestions or ideas. Eaton-Kenway recognized the challenge of making the automated field warehousing system flexible for frequent configuration changes and movement in a field environment. In discussing possible new directions and emerging technology from Eaton-Kenway, they stated that there is no new technology for automated MHE. They were of the opinion that the current technology could be modified for field operations. For example, exploring current AGV technology to modify components so that the vehicle could operate under field conditions.

Munck Automation Technology

At Munck Automation Technology, discussions were held with corporate personnel concerning the automated field warehousing project. They were of the opinion that the most important area to automate first was the inventory management aspect of warehousing. By

using some type of computer control system to monitor inventory operations a "real-time" environment would be created in the process. They considered AS/RSs to be the most promising hardware application. They envisioned a mini-load AS/RS constructed in an International Standard Organization (ISO) container to handle small items, such as repair parts. Munck Automation Technology saw no problems in engineering existing ISO containers to make this idea work. They put a similar idea to work for Dupont where the container with the mini-load AS/RS in it was placed on wheels when it was transported around the plant.

5.3 MILITARY SITE VISITS

Visits were made by Government representatives and study members to New Cumberland Army Depot (NCAD) located in New Cumberland, Pennsylvania, the 13th COSCOM MMC located at Fort Hood, Texas, and the 1st COSCOM MMC located at Fort Bragg, North Carolina. Specific comments and observations from the visits were provided to the Government under separate correspondence. The following information summarizes the visits.

5.3.1 NCAD.

For the past few years, a new supply distribution center has been under construction at NCAD. When operational, the depot will be the largest supply distribution center in the Army and will operate from a single, modern, state-of-the-art (within approved budget limitations) facility. Because of the modernization effort and the depot's major supply distribution mission, NCAD was a candidate for a site visit to see if any of the installed equipment might have some application to the Automated Field Warehousing Project.

The depot receives repair parts from Army procurements initiated at the National Inventory Control Points (NICPs) by respective Item Managers stores the items in warehouses and issues these repair parts to Army customers (units) world-wide. To increase efficiency, reduce costs, and provide better response to its customers, the depot is oriented toward designated geographical areas in the United States and overseas areas. For example, NCAD services customers stationed along the east coast, in Europe, and the Caribbean. Other Army distribution centers service customers stationed in the rest of the United States, in Alaska, and the Pacific.

The new distribution center will be capable of handling 50,000 Materiel Release Orders (MROs) on a daily basis. The installed equipment includes automated tote carts, automated conveyor system, medium and large size racks, small and medium size bins, automated sweeper arms to divert supplies, a single robotic arm for diverting cargo for shipment, scanners to read bar codes, man-aboard and computer-assisted hybrid stackers with a 60 foot reach for picking items from vertical bin areas, a management and control system for the supply process and determining workload, and a computer system to control the installed equipment. In addition to the installed equipment, there will be 4,000 and 6,000 pound commercial forklifts to assist in handling bulk items and pallet loads. The following information provides a perspective about the facility:

- Over 1.6 million square feet;
- Over 5 miles of towline;
- Over 4 miles of conveyors;
- 54 receiving doors;
- 68 outloading doors;
- Over 44,000 rack storage locations;
- Almost 250,000 bin storage locations;
- 368 sortation chutes; and

An indoor railcar staging area of 240 feet.

The distribution center was not fully operational at the time of the visit; however, since most of the equipment was installed and running, it was easy to visualize the handling, storage, and movement of supplies throughout the facility. The equipment is representative of what is available in the marketplace to handle and move large volumes of supplies. Because the distribution center is a fixed facility, and the volume of supply business is far greater than what can be expected for units operating in the field, it was difficult to determine potential applications of the installed equipment in a field environment. New product developments and emerging technologies sought by the Automated Field Warehousing Project may provide some answers and directions for future applications. However, based on the visit to NCAD, the use of scanners to help automate the receipt and inventory control of supply items at the user level appears to have some potential application.

5.3.2 13th COSCOM MMC.

While visiting the 13th COSCOM MMC, discussions were held with personnel in the following type organizations: a Supply and Services (S&S) Company (General Support [GS]); Centralized Ammunition Management Office (CAMO); Fort Hood Ammunition Supply Point (ASP); Transportation Aircraft Maintenance Company (Aviation Intermediate Maintenance [AVIM]); and an Automotive Maintenance Company (Direct Support [DS]).

The MMC is the organization responsible for supply management within III Corps located at Fort Hood. The MMC is involved with the requisition process, computation of replacement and consumption requirements, and direction of supply storage and distribution. The overall objective of the MMC is to support the weapon systems normally used by the corps. The use of automated data processing equipment (ADPE) and associated computer

programs assists the MMC in accomplishing this objective. Currently, the Standard Army Intermediate Level Supply (SAILS) system is used by the MMC to process supply and maintenance management data and information. However, in an effort to centralize supply and maintenance management with a common-user computer system, Decentralized Automated Service Support System (DAS3) computers and Tactical Army Combat Service Support Computer System (TACCS) computers will be assigned to the MMC to assist in processing supply and maintenance data. These new computers and related programs will provide the capability to transmit and process supply and maintenance data throughout the MMC using magnetic tape instead of a combination of cards (a manual process) and magnetic tape.

Within the COSCOM, the S&S Company provides GS to the corps. The MMC coordinates and directs the company's workload through automated output products; however, supply operations are basically a manual process. The receipt, storage, and issue of individual supply items, bulk items, and repair parts are done by soldiers using commercial and rough terrain MHE. These supply operations take place in temporary buildings approximately 50x500 feet. The warehouse section of the building consists of bin locations for small items and rack locations for medium items and pallet loads. The outdoor storage yard contains supplies that can be stored outside and consists of bulk or containerized items. The company controls and stocks an authorized stockage list (ASL) consisting of 3200 lines of repair parts.

The CAMO provides staff supervision over ammunition supply for the corps and Fort Hood. The CAMO coordinates the allocation and distribution of ammunition and manages the ASP through the reconciliation of all receipts and issues. This and other ammunition data is provided by the ASP to the CAMO via TACCS.

The ASP is a fixed facility consisting of open storage sites and bunkers. Most, if not all of the ammunition is received on pallets. The pallet configuration facilitates handling, storage, inventory, and issue functions. However, the pallets are not bar coded and at this time, scanners are not planned to facilitate more efficient handling of ammunition. The ASP uses 4,000 and 6,000 pound electric forklifts and 4,000 and 6,000 pound rough terrain forklifts to move and handle ammunition. Other MHE available for use in the ASP includes pallet jacks and hand carts. Aside from the MHE, ammunition supply operations are basically a manual process. For example, when less than pallet loads of ammunition are issued, the requesting unit must provide the manpower to break the pallets down and load the ammunition for transport.

The ASP provides ammunition supply support to the ammunition transfer points (ATPs) established in the division areas by the Division Ammunition Officer (DAO). The ATPs store their ammunition on dunnage in open storage or in CONEX containers. MHE available for use in the ATPs consist of rough terrain forklifts and the cranes on the Heavy Expanded Mobility Tactical Truck (HEMTT), which are normally used for transporting ammunition. Again, like the ASP, ammunition supply operations are basically a manual process.

AVIM supply support to aviation maintenance centered on an ASL consisting of stocking 50 of 500 lines of repair parts. The difference of 450 lines represents shortages and the scarcity of the repair parts normally stocked by this unit. Other than the volume and type of repair parts, AVIM supply operations were similar to that found at the GS level. The receipt, storage, and issue of repair parts are done by soldiers using commercial and rough terrain MHE in and around a temporary building approximately 75x75 feet. The warehouse section of the building consists of bin locations for small items and rack locations for medium items, containers, and some pallet loads. The outdoor storage yard contains bulk items and

containerized major aircraft assemblies.

The Maintenance Company provides intermediate DS maintenance and DS repair parts supply support to selected nondivision units in III Corps. The company maintains shop stock for its maintenance operations and provides repair parts to supported units from its ASL. The company currently controls and stocks an ASL consisting of approximately 2000 lines of repair parts. Requisitions from supported units are filled from the company's ASL. When requisitions cannot be filled from the ASL or when the ASL requires stock, the company submits their requisitions to the MMC for replenishment from the GS supply level. The company uses TACCS and DAS3 computer systems to assist in managing the supply and maintenance process. When in the field, the company uses tents to set up its receiving, issuing, warehousing, and turn-in operations. The company uses three M750 military vans to carry approximately 500 lines of mission essential repair parts to the field. Each van is capable of dropping both sides to retrieve parts, and consists of four sections of bin locations for small items. In addition, the company is authorized seven trailers to move larger items on the ASL to the field. Once in a field location, storage and warehousing is rather simple and austere. Major assemblies are stored on dunnage on the ground, and pallet loads are stored on the trailer beds. Essentially, supply operations are run from tents, M750 military vans, and open storage.

Observed supply operations and warehousing within the MMC and COSCOM are labor intensive and basically a manual process. On the surface, it would appear that the Automated Field Warehousing Project would have an immediate impact on making the tasks of receiving, storing, inventorying, and issuing supply items easier for the soldier. However, automation applications for warehousing in a fixed location are not the same as a similar operation in a field location. Because of the fluidity and temporary environment of an Army unit operating in the field, it will be a bigger challenge to automate field warehousing

activities. Despite the foregoing, some preliminary thoughts for automating aspects of the supply operations observed within the COSCOM include the use of scanners at the GS level for reading and storing bar code label information on repair parts (DS units have the scanners), the use of scanners and bar code labels for ammunition, and the use of an automated device for storing and issuing mission essential repair parts from the M750 military van used by the DS unit.

5.3.3 1st COSCOM MMC.

During the visit to the 1st COSCOM MMC, discussions were held with personnel in the following type organizations: two S&S Companies (GS); a Missile Maintenance Company (GS/DS); a Communications and Electronic Maintenance Company (DS); the CAMO; and the Fort Bragg ASP.

The supply operations and warehousing within the 1st COSCOM are also labor intensive and basically a manual process. From a logistic operational viewpoint, this COSCOM is similar to the 13th COSCOM at Fort Hood. The only difference between the two COSCOMs is what they stock and the quantity. Because the units at Fort Hood are armor and mechanized infantry, supply items and repair parts are larger and heavier. Since units at Fort Bragg are airborne, without armor and mechanized infantry, supply items and repair parts are smaller and lighter. On the surface, it would appear that the Automated Field Warehousing Project would have an immediate impact on making the tasks of receiving, storing, inventorying, and issuing supply items easier for the soldier. The problem is compounded when you factor in the mobility requirements of airborne units. There is probably no requirement for an AFWS in an airborne corps. Component or subsystem applications may be the only practical solutions for this type unit. Despite the foregoing, some preliminary thoughts for automating aspects of the supply operations observed within

the COSCOM include the use of scanners at the GS and DS level for reading and storing bar code label information on repair parts, the use of scanners and bar code labels for ammunition, and the use of an automated device for storing and issuing mission essential repair parts from the vans used by the maintenance units.

SECTION 6

CONCLUSIONS AND RECOMMENDATIONS

SECTION 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

Study conclusions are as follows:

- o No company manufactures a complete system application that can be used to fully automate a field warehouse;
- o Fifteen companies manufacture promising automated hardware components or subsystems that can be modified for use in certain aspects of a field warehouse;
- o There are three companies that can develop software automation programs to control and manage systems in support of a field warehouse;
- o There is no emerging technology that can be applied to automate a field warehouse;
- o The capability to change configuration and move an automated field warehouse is a difficult challenge;
- o All military units visited have difficulty moving their entire ASL to the field;
- o Those vans used by units to transport small, binable repair parts on the ASL do not contain standard shelving to store and secure the parts, thus increasing the chance for damage during transit; and,
- o Bar code technology has not been extended to include class V, ammunition.

6.2 RECOMMENDATIONS

Recommend that Belvoir:

- Delete from future considerations the search for a complete system application to fully automate a field warehouse;
- Continue to investigate the use of automated hardware components and software products to support automating segments of a field warehouse;
- Not expect the commercial marketplace to develop any new technology to automate a field warehouse in the near future;
- Consider reducing the requirements for having an automated field warehouse that has the flexibility to change its ground layout configuration and the implied capability to move frequently in the field;
- Pursue the application of automating the vans used to store and transport small repair parts on a unit's ASL; and,
- Pursue the application of bar code technology to class V, ammunition.

REFERENCES

REFERENCES FOR AUTOMATED WAREHOUSING

1. FM 10-60: Subsistence Supply and Management in Theater of Operations, August 1981

2. FM 29-51: Division Supply and Field Service Operations, November 1984

3. FM 29-147: S&S Company, Direct Support (DS), April 1981

4. FM 38-741: Direct Support Unit Storage Operations, June 1984

5. FM 54-11: Container Movement and Handling in Theater of Operations, January 1981

6. FM 54-23: Material Management Center, Corps Support Command, December 1984

7. FM 54-40: Area Support Groups, July 1987

8. AR 740-1: Storage and Supply Activity Operations, April 1971

9. TM 743-200: Storage and Materials Handling, January 1958

10. TM 743-200-1: Storage and Materials Handling, January 1958

11. TM 743-200-2: Storage Modernization, November 1967

12. TM 743-200-3: Storage and Materials Handling, July 1971

13. FM 63-2: Combat Service Support Operations - Division, November 1983

14. FM 63-3J: Combat Service Support Operations - Corps, August 1985

15. FM 63-5: Combat Service Support Operations - Theater Army, February 1985.

16. Material Handling Product Directory. - Material Handling Institute - 1989.

17. Modern Materials Handling Casebook Directory. - Modern Materials Handling - 1990.

18. Thomas Register of American Manufacturers. 1988.

GLOSSARY

GLOSSARY

ADPE	-	Automated Data Processing Equipment
AGV	-	Automated Guided Vehicle
ALOC	-	Air Line of Communication
ASP	-	Ammunition Supply Point
AS/SR	-	Automated Storage and Retrieval System
ATP	-	Ammunition Transfer Point
AVIM	-	Aviation Intermediate Maintenance
CAMO	-	Centralized Ammunition Management Office
CONUS	-	Continental United States
COSCOM	-	Corps Support Command
CSS	-	Combat Service Support
DAO	-	Division Ammunition Officer
DAS3	-	Decentralized Automated Service Support System
DS	-	Direct Support
DSS	-	Direct Support System
GS	-	General Support
HEMTT	-	Heavy Expanded Mobility Tactical Truck
OCONUS	-	Outside Continental United States
MMC	-	Materiel Management Center
MRO	-	Materiel Release Orders
NCAD	-	New Cumberland Army Depot
NICP	-	National Inventory Control Points
RF	-	Radio Frequency
S&S	-	Supply and Services
SAILS	-	Standard Army Intermediate Level Supply
TACCS	-	Tactical Army Combat Service Support Computer System

APPENDIX A

STATEMENT OF WORK

STATEMENT OF WORK AND SERVICES

1. TASK ORDER TITLE: Market Investigation for Automated Warehousing

2. TASK LOCATION: This task order will be accomplished primarily at the contractor's facilities, through visits to the US Army Belvoir Research, Development and Engineering Center, and visits to hardware developers/ manufacturers and users as required.

3. CONTRACT LINE ITEMS: Sections B.1, CLINS 0003, 0003AA, 0003AB, 0004; and C.4.1.a and b; C.4.1.c; and C.5.

4. CONTRACT END ITEMS: The primary deliverable end item will be a Technical Report (A007) and a Study Gist (A008) which details the findings and results of the tasks outlined below. A draft of the Final Report (A007) and the Study Gist (A008) will be delivered no later than 45 days prior to the task order completion date for Government review and approval. The Final Report and Study Gist, incorporating Government comments, will be delivered no later than six (6) months after task order award. Short monthly letter progress reports (A009) will be prepared and delivered NLT five (5) working days after the end of each month following the date of award. In-progress briefings conducted every two (2) months will be documented by Progress/Status Meeting Reports (A001) and delivered to the Government within seven days after each briefing. Cost and Performance Reports (A002) will be submitted no later than the tenth working day after the last billing date of the month. Distribution of above reports is:

a. Progress/Status Meeting Reports (A001) - one (1) copy each to STRBE-HP, STRBE-FMR and AMSTR-PBCA.

b. Cost and Performance Reports (A002) - one (1) copy each to STRBE-HP and AMSTR-PBCA.

c. Monthly Letter Progress Reports (A009) - one (1) copy each to STRBE-HP, STRBE-FMR, and AMSTR-PBCA.

d. Draft Market Analysis Questionnaire (Task I) - one (1) copy to STRBE-HP, STRBE-FMR and AMSTR-LAL.

e. Draft Technical Report (A007) and Study Gist (A008) - one (1) copy to STRBE-HP and five (5) copies to STRBE-FMR.

f. Technical Report (A007) -

-one (1) copy to Technical Library (STRBE-BT)
-two (2) copies to STRBE-HP accompanied by DD 250
-one (1) copy to STRBE-TQL
-five (5) copies to STRBE-FMR
-two (2) copies mailed to:

Defense Technical Information Center
Cameron Station
ATTN: DTIC
Alexandria, Virginia 22314

g. Study Gist (A008) - one (1) copy to:

Commander TROSCOM
ATTN: AMSTR-CS
4300 Goodfellow Boulevard
St. Louis, Missouri 63120-1798

5. DESCRIPTION OF WORK:

Background: The Logistics Equipment Directorate is responsible for development of Army Materiel systems. Two of these systems are the Automated Field Warehouse System (AFWS) and the Universal Self-Deployable Cargo Handler (USDCH). The primary goal of the USDCH program is to field an autonomous forklift truck that can replace the currently fielded 4,000, 6,000, and 10,000 lb. forklift trucks in any environment, including Nuclear, Biological, and Chemical. The objective of the Automated Warehousing System is to identify new technology which can improve Army field warehousing productivity and capabilities. More specifically, the objective of the Automated Field Warehousing System program is to identify automated equipment and vehicles, guidance sensor systems, inventory control systems, and computer command control systems for use with the USDCH to fully automate from the first stage storage through to Corps forward supply points and interface with the Army Inventory Control System. This effort will enhance the Army's ability to rapidly receive, conduct inventories, and transfer material to the battlefield. It is essential that a market analysis identify the current commercial automated warehousing technology or any developing technology that could be applied to the automation from the first stage storage through to Corps forward supply points. These field storage areas, unlike most commercial fixed warehousing facilities, must allow flexibility in the ground layout and materials handled.

Objective: The objective of this task is to conduct a comprehensive market analysis of the current and developing technologies that may be suitable for adaption to an automated field warehousing system or individual components that may be integrated into such a system.

Program Approach: The contractor's expertise in system/hardware integration will be used to conduct a market analysis of automated warehousing systems or subsystems that could be adapted to function in field storage areas. The contractor shall look at those systems/subsystems that are currently available or being developed throughout industry and in the military. The contractor will conduct a preliminary analysis within a two month time frame. The contractor will develop a questionnaire based upon Government input to assess the potential of candidate system for adaptation from first state storage through to Corps forward supply points. The contractor will provide an analysis of the results of this market analysis and other relevant information.

Task I. Literature Search and Development of a Market Analysis Questionnaire. The contractor will conduct a literature search and a review of applicable documents. These documents will provide a basis for the development of a description of the current Army system, which will serve as a baseline for this market investigation. This baseline description is to be updated as new information becomes available. The contractor will develop a market analysis questionnaire in conjunction with the Government. The market survey questionnaire shall be completed within 60 days following the contract award date. (C.4.1. a and b)

Task II. Distribution and Collection of Data from the Market Analysis Questionnaire. The contractor will develop a distribution list for the market analysis questionnaire in conjunction with the Government. This distribution list will be based upon the results of the literature search and the vendors/users provided by the Technical Point of Contact. This Government approved list will be used to distribute the questionnaire. The contractor will conduct a market analysis of commercially available automated warehousing system technology or developing technology that may be adapted for use in first stage storage through to Corps forward supply points. Unlike most commercial fixed warehousing systems, the system required for the first stage storage through to Corps forward supply points must have flexibility for frequent change of the ground layout configuration and the types of materials handled. This system must also be able to interface with the Army Inventory Control System to provide real time inventory control from first stage storage through to the Corps forward supply points. The contractor will collect the data received in response to the questionnaire. (C.4.1.b)

Task III. Analysis of Results of Questionnaire. The contractor will analyze the responses to the questionnaire and, when necessary, will contact the responders for follow-up information to complete their responses. (C.4.1.c)

Task IV. Site Visits. The contractor should identify several CONUS Government and non-Government sites, appropriate to be visited for meeting the objective of this task order, and should visit these sites after receiving Government approval. In looking at currently available systems, that is users, it is important to investigate both commercial and military functioning installations. (C.4.1.b)

Task V. Technical Report. The contractor will document results of the above tasks in a Final Technical Report (A007). (C.5)

6. CLASSIFICATION: Work on this task order may be classified up to and including SECRET. If classified information is included in the final report, it will be placed in a separate annex.

7. The contractor shall address accepted Human Factors Engineering Criteria as described in MIL-STD-1472 and DOD-HDBK-761 when evaluating possible candidates for recommendations.

8. PERFORMANCE PERIOD: From date of award through 28 March 1990.

APPENDIX B

QUESTIONNAIRE

DISTRIBUTION LIST

Automated Warehousing

Control Enginnering Co.
8212 Harbor Springs Rd.
Harbor Springs, MI 49740

Interlake
Materials Handling Div.
550 Warrenville Rd.
Lisle, IL 60532

Jervis B. Webb
34375 West 12 Mile Rd.
Farmington Hills MI 48331

Muller Packaging Syst. Inc.
P.O. Box 4759
Wilmington, NC 28406

Litton Idustrial Automation
7300 Turfway
Suite 410
Florence, KY 41042

Yale Materials Handling Corp.
Route 523+31
Flemington, NJ 08822

LXE
303 Research Dr.
Suite 225
Norcross(Atlanta), GA 30092

Raymond Corp.
South Canal St.
Greene, NY 13778

Kardex
P.O. Box 171
Marietta, OH 45750

Panasonic
Factory Automation Co.
9501 W. Grand Ave.
Franklin Park, IL 60131

Eaton Corp.
Cutler-Hammer Products
4201 N 27th St.
Milwaukee, WI 53216

Symbol Technologies
116 Wilbur Place
Bohemia, NY 11716

Automatic Systems Inc.
4407 Empire Way
Suite 9EI
Lansing, MI 48917

Southern Systems Inc.
4101 Viscount
Memphis, TN 38118

Automated Equipment
Route 1
P.O. Box 70A
Paris, TN 38242

LISTA International Corp.
106 Lowland St.
Holliston, MA 01746

ERIE Press Systems
1253 West 12th St
Erie, PA 16512

FMC
Material Handling Div.
400 Highpoint Dr.
Chalfort, PA 18914

BT Systems Inc.
7000 Nineteen Mile Road
Sterling Heights, MI 48078

Big Joe Manufacturing Co.
7225 North Kostner Ave.
Lincolnwood, IL 60646

Barret Vehicle Systems
2660 28th St. SE
Grand Rapids, MI 49508

White Storage and Retrival
30 Boright Ave.
Kenilworth, NJ 07033

Hercules Insustries
2933 Armory Dr.
Nashville, TN 37204

Mannesmann Demay Corp.
Materials Handling Div.
2600 28th St. SE
Grand Rapids, MI 49512

CLARK Material Systems
333 West Vine St.
Lexington, KY 40507-1640

Blue Giant Equipment
One Industrial Park Drive
Pell City, AL 35125

Interroll
3000 Corporate Dr.
Wilmington, NC 28405

Mentor AGVS Inc.
8500 Station St.
P.O. Box 898
Mentor, OH 44061-0898

ACCO System Div.
Babcock Inc.
12755 East Nine Mile Road
Warren, MI 48089

FATA Automation
37050 Industrial Rd.
Livonia, MI 48150

AGV Products Inc.
2101 Sardis Rd. North
Charlotte, NC 28212

Eaton-Kenway
515 East 100 South
Salt Lake City, UT 84102

Meridian Corp.
P.O. Box 10
Winneconne, WI 54986

Modular Automation Corp.
Box 36
Greene, NY 13778

Logan Company
200 Cabel St.
Louisville, KY 40206

Design Technology Corp.
5 Surburban Park Dr.
Billerica, MA 01821

Elwell-Parker Electric
4205 St. Clair Ave.
Cleveland, OH 44103

Hovair Systems Inc.
1210 Andover Park E.
Seattle, WA 98188

IDAB Inc.
5301 N.W. 35th Terrace
Ft. Lauderdale, FL 33309

Industrial Kinetics
825 Blackhawk Dr.
Wastmont, IL 60559

Protec Inc.
4500 Western Ave.
Lisle, IL 60532

Professional Materials
Handling
4203 Landmark Dr.
Orlando, FL 32817

Air Technical Indust.
7501 Clover Ave.
Mentor, OH 44060

Applied Systems Corp.
26401 Harper Ave.
St. Clair Shores, MI 48081

Reis Machines
1340 Holmes Rd.
Elgin, IL 60123

GMF Robotics Corp.
2000 S. Adams Rd.
Aubrun Hills, MI 48057-2090

ASC Industries, cin.
8967 Pleasantwood Ave. NW
P.O. Box 2523
North Canton, OH 44720

Munck
P.O. Box 6677
Newport News, VA 23606

Intemation Inc.
Suite 20
3322 S. Memorial Pkwy.
Hunstville, AL 35801

US Controls
22427 Norwalk Blvd.
Hawaiian Gardens, CA 90716

Hyster Co.
2020 Hytrol St.
Jonesboro, AR 72401

Beumer Corp.
P.O. Box 1192
Plainfield, NJ 07061

TEI Engineering
106 Boss Rd.
Syracuse, NY 13211

Kohol Systems Inc.
980 Senate Dr.
Centerville, OH

Cybermation
5457 Jae Valley Rd.
Raonoke, VA 24014

Apogee Robotics Inc.
2643 Midpoint Dr.
Fort Collins, CO 80525

X-Celsior Machine Corp.
2305 X-Celsior Dr.
Oxford, MI

Allen Automated Systems Co.
400 Florence
Box 2049
Saginaw, MI 48603

Custom Tech. Inc.
P.O. Drawer 3245
Alliance, OH 44601

Bear Industrial Equipment Co.
7522 Reindeer Trail
San Antonio, TX 78238

TMH Systems
Route 20
Box 180
San Antonio, TX 78297

Mayser Co.
P.O. Box 419
Depdt P
Merrifield VA 22116

RAFS Inc.
309F Mclaws Cir.
Williamsburg, VA 23185

Acro-Go
1170 Andover Park West
Seattle, WA 98188

FARED System Inc.
7410 Pebble Dr.
P.O. Box 185579
Fort Worth, TX 76181-5579

General Machine Design
441 Market St.
Saddle Brook, NJ 07662

Heco-Pacific Manufacruing 1510
Pacific St.
Union City, CA 94587

Hitachi America
50 Procpect Ave.
Tarrytown, NY 17591

Hudson Robotics
44 Commerce St.
Springfield, NJ 07081

Intelledex
4575 SW Research Way
Corvallis, OR 97333

Westinghouse Electric Corp.
Automation Div./Unimatic
Inc.
P.O. Box 160
Pittsburgh, PA 15230

Cross + Trecker Corp.
505 N Woodward Ave.
Bloomfield Hills, MI 48013

Engineered Sys.+ Dev. Corp.
600 Meridian Ave.
San Jose, CA 95126

American Turnkey
3505-T Cadillac Ave.
Bldg L-3
Costa Mesa, CA 92626-28

DEXON
3842 Washington Ave.
Minneapolis, MN 40507-1640

Conveyor Warehouse, Inc.
Dept. A
1734 MacArthur Blvd.
Atlanta, GA 30318

AMTECH
4514 Cole Ave.
Suite 1200, LB 28
Dallas, TX 75205

Proxim
295 N. Bernardo Ave.
Mountian View, CA 94943

Robotics Companies

Adept Technology Inc.
150 Rose Orchard Way
San Jose, CA 95134

Translogic Corp.
10825 E. 47th Ave.
Denver, CO 80239

WHS Robotics
2 Gosset Dr.
P.O. Box 415
Kirkwood, NY 13795

System Product Corp.
2323 W. 18th St.
Chicago, IL 60608

Wesley International Corp.
P.O. Box 934
Scottdale, GA 30079

ABB Robotics Inc.
P.O. Box 1560
Milwaukee, WI 53201

Advanced Manufacturing Systems
1880 Dairy Ashford
Houston, TX 77077

Anorad Corp.
110 Oser Ave.
Hauppauge, NY 11788

Automaker Inc.
12705 S. Kirkwood Suite 210
Stafford, TX 77477

Automatix Inc.
755 Middlesex Turnpike
Billerica, MA 01821

Graco Robotics
12898 Westmore Ave.
Livonia, MI 48150

C+D Machine and Engineering
690 Hazel Street
Beaumont, TX 77701-2069

CIMCORP
899 W. Highway 96
Shoreview, MN 55126

CMW
P.O. Box 160
Highway 63 E.
Clarksville, AR 72830

Cincinnati Milicron Inc.
Industrial Robots Div.
P.O. Box 1327
Greenwood, SC 29646

Cybernated Automation Corp.
3561 N.W. 126th Ave.
Coral Springs, FL 33065

E+H Systems Inc.
1907 Collegewood
Ypsilanti, MI 48197

Software Firms

TCM
P.O. Box 429
Bridgeport, NJ 08014

Telxon
3330 West Market St.
Akron, OH 44313-3352

TanData Corp.
Dept. 211
700 TanData Plaza
1400 S. Boston
Tulsa, OK 74119-3612

American Software
470 E. Paces Ferry Rd.
Atlanta, GA 30305

Ariel Consultants
7446 N. Hoyne
Chicago, IL 60645

Arthur Anderson & Co.
69 W. Washington St.
Chicago, IL 60602

Eric C. Baum and Assoc.
205 W. Wacker Dr.
Chicago, IL 60606

CIF
PO Box 266955
Houston, TX 77207

Camber Software
PO Box 10266
Charleston, SC 29411

Catalyst USA
1971 Washington ST.
Grafton, WI 53024

Chase Trans-Info
560 Mission St.
San Francisco, CA 94105

Computive Transportation Sys.
16535 W. Bluemound Rd.
Brookfield, WI 53590

Control Software
998 Old EAgles School Rd.
Wayne, PA 19087

Cullinet Software
400 Blue Hill Dr.
Westwood, MA 02090

Friedman+Associates
108 Wilmont Rd.
Deerfield, IL 60015

GSI Transcomm
1380 Old Freeport Rd.
Pittsburgh, PA 15238

ICIS Inc.
4516 South 700 East
#230
Salt Lake City, UT 84107

Logisticom
4001 Burton Dr.
Santa Clara, CA 95054

Process Data Corp.
PO Box 795666
Dallas, TX 75023

Rinehart Engineering
2115 Rutledge Rd.
New Freedom, PA 17349

STSC Inc.
2115 E. Jefferson
Rockville, MD 20852

System Software Assoc.
500 W. Madison
32nd Floor
Chicago, IL 60606

Vacam Systems
10800 Lyndale Ave. S.
Bloomington, MN 55420

IBM Manufacturing Systems
1000-T NW 51st Street
Boca Raton, FL 33429

BALOGH
912 N. Main Street
Ann Arbor, MI 48104

APPENDIX C

QUESTIONNAIRE AND COVER LETTER

DEPARTMENT OF THE ARMY
US ARMY BELVOIR RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
FORT BELVOIR, VIRGINIA 22060-5606

REPLY TO
ATTENTION OF

DEC 29

MHE Team

SUBJECT: U.S. Army Market Surveillance of Automated Warehousing

TO: Select Manufacturers and Distributors of Automated Warehousing Systems

Dear Sirs/Madames:

The Marine and Mechanical Equipment Division at the U.S. Army Belvoir Research, Development and Engineering Center (BELVOIR) is conducting a market surveillance to gather information on automated field warehousing systems for the purpose of developing and maintaining an awareness of marketplace technologies and related system by-products. Field warehousing can occur under any environment in terms of terrain and climate and varies in terms of size and types of items stored. We are interested in obtaining data pertaining to current and developing (emerging) technologies to determine potential applications for enhancing the Army's capability to automate supply and warehousing functions in a field environment.

Our initial goals are to identify state-of-the-art technologies and those systems that can improve the Army's capability to rapidly receive, store, issue, transfer, and inventory supply items; and look to the future for developing technologies that may provide better, faster, lighter, and stronger systems to perform the same supply functions by adapting automation to the field environment. We are requesting and would welcome data in areas such as, automated equipment and vehicles, guidance sensor systems, inventory control systems, and computer command control systems, including computer programs and/or software packages. BELVOIR realizes that some of the information requested could be proprietary and therefore will take the necessary precautions to protect any such information that is so identified.

Your company has been identified by BELVOIR as a manufacturer or distributor of automated systems. We invite you to furnish the information about your product(s) and technological advances by completing the enclosed survey. Please return it along with any

commercial literature to the following address of BELVOIR or the contractor who is assisting BELVOIR with the survey.

Commander
U.S. Army Belvoir RD&E Center
ATTN: STRBE-FMR (Stephen Sousk)
Fort Belvoir, VA 22060-5606

Science Applications International Corporation
ATTN: Mr. Tom Wing (T1-7-2)
McLean, VA 22102

Questions or comments may be directed to Mr. Tom Wing at (703) 749-8676 or Mr. Christopher Hedden at (703) 749-8649. We appreciate your response and help in this effort and expect that the information collected will provide us with a better understanding of what is happening in the marketplace and the directions of the technologies being pursued to improve automated systems.

Sincerely,

Lynwood C. Root
Chief, Marine and Mechanical
Equipment Division

Enclosure

AUTOMATED WAREHOUSING QUESTIONNAIRE

INTRODUCTION

The Marine and Mechanical Equipment Division at the U.S. Army Belvoir Research, Development and Engineering Center (BELVOIR) is conducting a market surveillance to gather information on automated field warehousing systems for the purpose of developing and maintaining an awareness of marketplace technologies and related system by-products. Field warehousing can occur under any environment in terms of terrain and climate and varies in terms of size and types of items stored. We are interested in obtaining data pertaining to current and developing (emerging) technologies to determine potential applications for enhancing the Army's capability to automate supply and warehousing functions in a field environment.

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Please complete and return this questionnaire within 30 days of receipt to BELVOIR or the contractor who is assisting BELVOIR with this survey:

Commander
U.S. Army Belvoir RD&E Center
ATTN: STRBE-FMR (Stephen Sousk)
Fort Belvoir, VA 22060-5606

Science Applications International Corporation
ATTN: Mr. Tom Wing (T1-7-2)
McLean, VA 22102

Please feel free to provide additional promotional data or technical information about your systems or subsystems which have not been addressed in the following pages. If your company has brochures, or similar literature that provides sufficient technical information, please feel free to send them in light of filling out the questionnaire.

SURVEY QUESTIONS

1. Please list the product name(s) and model number(s) that may have application to the automation needs discussed.

2. Please provide a brief description of your product's applicability to automated warehousing and its capabilities or attach an information sheet.

3. Please identify any manufacturer proprietary components of your product.

4. If there is an improved product in development, please list its projected new capabilities and date of availability.

5. If there is an emerging technology that your company is pursuing for potential application to automated warehousing, please provide a general description of the effort or attach an information sheet.

6. Has your product ever been sold to any Government Agency? If so, to whom and how many?

7. Does your company have any available commercial literature discussing any components that might be of use to an automated field warehousing system? (If so, please furnish a copy.)

DISTRIBUTION

1. US Army Belvoir Research, Development and Engineering Center
   Fort Belvoir, Virginia 22060-5606

   STRBE-FMR 5

   STRBE-HP 2

   STRBE-TQL 1

   STRBE-BT 1

2. Defense Technical Information Center 2
   Cameron Station
   ATTN: DTIC
   Alexandria, Virginia 22314

3. Commander .....(Study Gist Only) 1
   TROSCOM
   ATTN: AMSTR-CS
   4300 Goodfellow Boulevard
   St. Louis, Missouri 63120-1798