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PROFILE OF THE COMPUTER AIDED DESIGN AND MANUFACTURING MARKET AS A PART OF THE INFORMATION PROCESSING SEGMENT STUDY

DELIVERABLE 3

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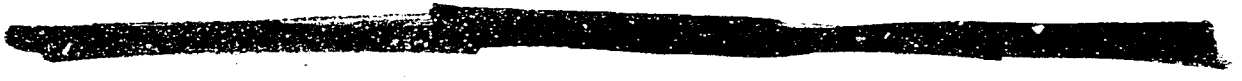
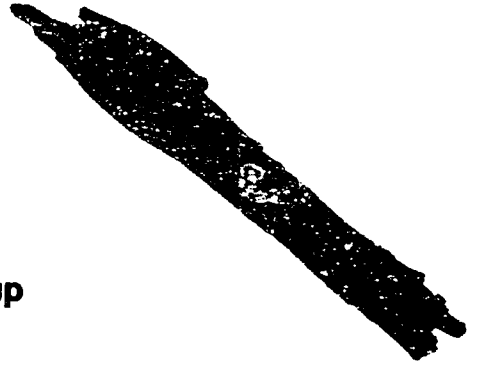




CAD/CAM Overview . . .

COMPUTER-AIDED DESIGN (CAD) AND COMPUTER-AIDED MANUFACTURING (CAM) TECHNOLOGY WAS DEVELOPED BY ENGINEERS AND SCIENTISTS WITHIN THE AEROSPACE AND AUTOMOBILE INDUSTRIES TO IMPROVE COST AND PERFORMANCE EFFICIENCY. THE TECHNOLOGY ENCOMPASSES TWO BASIC FUNCTIONS DESIGN AND MANUFACTURING:

- **DESIGN FUNCTION (CAD)** : Computer-aided design is an electronic aid for draftsman and design engineers which facilitates the construction of highly detailed drawings.
  - CAD systems have a library of stored shapes and commands to facilitate input of designs.
  - Complexity of CAD design software ranges from two dimensional to three dimensional (3-D) applications.
    - -- Two dimensional software is sufficient for drafting a design.
    - -- 3-D software allows designer to construct an "as-is" model to maximize product performance.

- **MANUFACTURING (CAM)** : Computer-aided Manufacturing is a computer assisted manufacturing tool. CAM allows users to control the entire manufacturing process including quality control and inventory management.
  - Facilitates the communications of errors/shortages on the manufacturing line.
  - Connects the manufacturing to design function and allows design engineers direct input the manufacturing process.

THE CAD/CAM SYSTEM MARKET CONSIST OF THREE MAJOR APPLICATION AREAS THAT VARY BY ENGINEERING SPECIALTY: MECHANICAL, ELECTRICAL/ELECTRONIC AND ARCHITECTURAL/CONSTRUCTION.

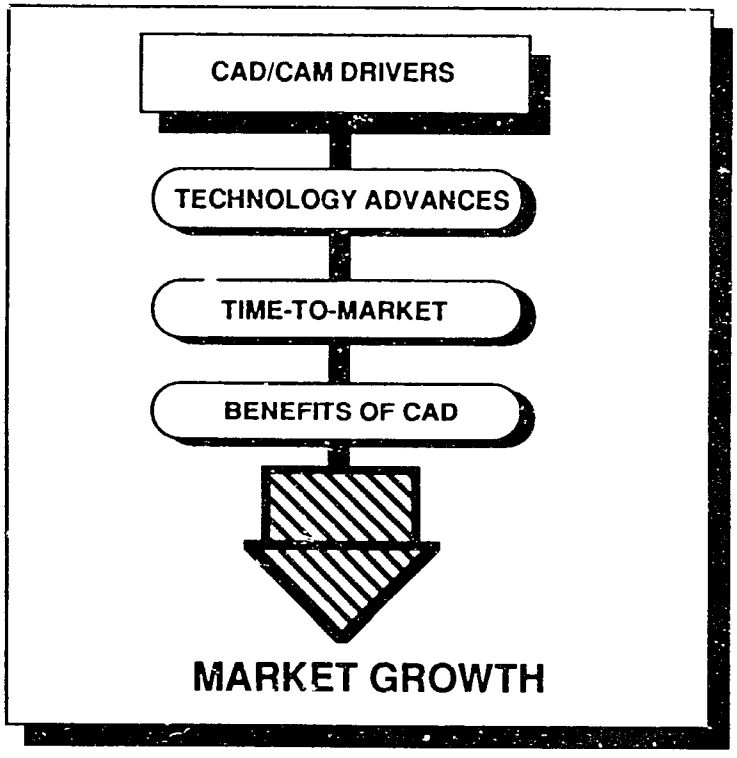
- **MECHANICAL** : CAD/CAM systems are used to design mechanical parts or structures in three dimensions. Benefits to users include:
  - Design analysis tools.
  - Pre-stored designs of components.

- **ELECTRICAL/ELECTRONIC** : CAD/CAM system applications are used for more complex and detail orientated electrical/electronic design. Application of the technology include integrated circuit (IC) and printed circuit board (PCB) layouts.

- **ARCHITECTURAL, ENGINEERING AND CONSTRUCTION (AEC)** : CAD/CAM systems are used to design building structures.
  - Plans for the structural design
  - Electrical, plumbing and layouts of new facilities.

CAD/CAM Drivers . . .

MAJOR DRIVERS FOR GROWTH IN THE CAD/CAM MARKET INCLUDE TECHNOLOGY ADVANCES, AND THE INCREASE IN THE IMPORTANCE OF TIME-TO-MARKET FOR DESIGN AND MANUFACTURING FUNCTIONS.



CAD/CAM Drivers . . .

TECHNOLOGY ADVANCES AND THE SUBSEQUENT REDUCTION IN THE COST OF USING CAD/CAM SYSTEMS HAVE FUELED GROWTH OF THIS MARKET:

- **MENU-DRIVEN COMMANDS** : have improved user friendliness and reduced training cost.
- **DECREASE IN COST** : a significant drop in workstation/PC hardware have lowered overall system costs.
- **GROWTH OF PC-BASED SOLUTIONS** : have also reduced cost of systems and broadened the lower end market (i.e., Small and Mid-sized Firms).
- **OPTICAL DISK TECHNOLOGY** : the introduction of optical disk has facilitated the storage, retrieval, and management of engineering document images:
  - Storage space for a library of drawings into a electronic database for immediate productivity.
  - Easy retrieval of document design to use with current design.
  - Quick distribution of designs for inputs via network.
- **IMPROVED DESIGN TOOLS** : such as 3-D software is increasing demand for CAD systems because of its enhanced features, which allow more sophisticated design capabilities.

CAD/CAM Drivers . . .

THE BENEFITS OF CAD/CAM TO THE MANUFACTURING SECTOR HAS FUELED RAPID GROWTH IN THE CAD/CAM MARKET:

- **IMPROVED EFFICIENCY**:
  - Productivity/accuracy of engineering staff increases with use of computer-assisted design tools.
  - CAD's ability to track supplies needed for manufacturing results in more efficient inventory management.

- **REDUCED COST**:
  - Productivity increases result in reduced labor cost.
  - Better inventory management reduces inventory cost.
  - More accurate designs reduces defects and costs of production.

- **INFORMATION MANAGEMENT**:
  - CAD/CAM provides management with access to meaningful, timely information for the planning, execution, and control of the manufacturing process.

- **FLEXIBILITY**:
  - CAD/CAM technology provides achieve rapid response to market influences by allowing managers to make quick change in product/design features as well changes in the manufacturing process.

THE PRESSURE IN MANUFACTURING TO MINIMIZE "TIME-TO-MARKET" ENCOURAGES THE USE OF CAD/CAM:

- **TIME-TO-MARKET DEFINITION:**
  - The time it takes to develop a product from a concept to an actual design and then to manufacture that design.

- **IMPORTANCE OF TIME-TO-MARKET**:
  - Quick time to market gives a company a competitive advantage in establishing technology leadership.
  - Importance of quick time-to-market has been exemplified by Japanese companies successful capture of market share in various high-technology markets such as semiconductors.

- **HOW CAD REDUCES TIME-TO-MARKET:**:
  - CAD makes a significant contribution to shortening design and development time by allowing design engineers to:
    - -- Quickly edit drawings.
    - -- Retrieve previously drawn components from stored libraries.
    - -- Test designs without having to construct a physical model.

Current CAD/CAM Customers . . . Overall . . .

THE FOLLOWING ORGANIZATIONS ARE MAJOR USERS OF CAD/CAM TECHNOLOGY. THE COMMERCIAL SECTOR IS THE LARGEST CUSTOMER GROUP FOLLOWED BY GOVERNMENT, AND THEN NON-PROFIT ORGANIZATIONS:

- **COMMERCIAL ORGANIZATIONS**:
  - Architectural Firms - use CAD to draft building designs.
  - Construction Firms - use AEC CAD to model pluming and electricity design.
  - Industrial Companies (i.e., Aerospace and Automobile)- use CAD/CAM for research and development, designs, and manufacturing control.
  - Electronic Firms - use CAD to design circuit boards.
  - Manufacturing Firms - use CAD to integrate design and manufacturing departments.

- **GOVERNMENT** :
  - NASA- using CAD to design Space aircraft and stations.
  - Department of Defense- driving the use of CAD by contractors and also initiating standardization of CAD software for contractors.

- **NON-PROFIT ORGANIZATIONS**:
  - Universities- use CAD/CAM to conduct research or as an educational tool for engineering departments.
  - Research Institutes - use CAD for scientific research (i.e., model molecules).

CAD/CAM Customers . . . U.S. Government/Non-Profit Organizations

THE U.S. GOVERNMENT USE OF CAD/CAM TECHNOLOGY IS LIMITED TO THE DEPARTMENT OF DEFENSE AND NASA. OTHER AGENCIES HAVE NOT FOUND RELEVANT APPLICATIONS OF CAD/CAM TECHNOLOGY.

- **NASA**:
  - NASA- using CAD to design Space Station Freedom project. The entire design, analysis, and refinement of the spacecraft will be computer-generated, and the only integrated, pre-launch testing will be in the form of computer simulations.

- **DEPARTMENT OF DEFENSE**:
  - The Computer Aided Logistic System (CALS) Initiative is focused on automating weapon support functions.
    - -- The CALS program requires that designs be in computer format.
    - -- The CALS program is also initiating standardization of CAD system formats.

    Wright Paterson Air Force Base- uses CAD systems to model flight patterns.

COMPUTER/ELECTRONIC AND MANUFACTURING COMPANIES ARE THE LARGEST USERS OF CAD/CAM TECHNOLOGY WITHIN THE COMMERCIAL SECTOR.

- **COMPUTER/ELECTRONIC COMPANIES**: are the largest users of CAD/CAM technology. They are also the largest out sources of services because of their relatively small engineering departments compared to aerospace and manufacturing companies. Examples of their Outsourcing include:

  - GE and Siemens out sourcing the lay-out of PC board designs to a CAD design company.
  - DEC- out sources 35mm filming of engineering drawings to a service bureau in order to input them in to CAD systems.
  - IBM- out sources manufacturing, drafting and conversion to its strategic partner companies.

- **MANUFACTURING COMPANIES**: have made significant investments in CAD/CAM technology and will continue to find ways to use technology to improve cost/profit performance.
  - -- Minardi- is working on a Formula 1 car for the 1991 season using a CAD/CAM system from Computervision. The system will be used to build 3-D geometry, creating and analyzing complex sculptured surfaces, finite element modeling, producing engineering drawings, creating 3-axis surface machining programs and driving automated NC machinery.

CAD/CAM Customers... (Cont.)

- **AEROSPACE COMPANIES**: Aerospace companies include defense contractors and commercial aircraft manufactures. Both are traditional users of CAD/CAM technology and will continue to invest in the technology.

  - Commercial Companies: For the most part Commercial Aerospace firms maintain significant in-house computer-aided engineering departments.
    -- Conair Aviation- drafts designs using CAD systems.
    -- Boeing- has an CAD/CAM integrated manufacturing system.

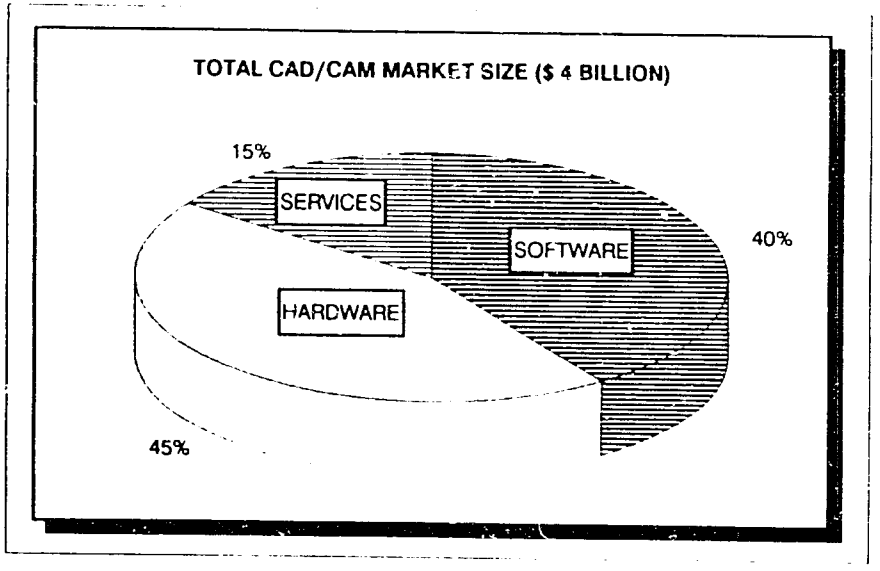
  - Defense Contractors: The use of CAD/CAM technology by defense contractors will continue to grow as the government begins to require weapon designs deliverables to be in CAD format.

    -- General Dynamics- using CAD to design tanks.
    -- McDonell Douglas- design and manufacture helicopters using CAD/CAM technology.

CAD/CAM Products . . .

THE TOTAL CAD/CAM MARKET IS ESTIMATED AT $17.8 BILLION A YEAR WITH AN ANNUAL GROWTH RATE OF 22%. A BREAKDOWN OF THE MARKET BY HARDWARE, SOFTWARE, AND SERVICES IS AS FOLLOWS:

- **SYSTEM HARDWARE**:
  - Unix
  - PC-Based Systems
  - CD-ROMS
- **SYSTEM SOFTWARE**:
  - PC-Based Software
  - Workstation Software
  - Specific Application Software
- **SUPPORT SERVICES**:
  - System Integration
  - Data Conversion
  - Drafting/layout Designs
  - Custom Software



BASED ON THE SCOPE OF THE STUDY, WE FOCUS ON SUPPORT SERVICE AS AN AREA SUITABLE FOR JAMAICA.

CAD/CAM Market- Potential for Jamaica...Analysis of First Level Critical Factors

FIRST LEVEL CRITICAL MARKET FACTORS ARE THOSE FACTORS THAT DETERMINE WHETHER A PARTICULAR SERVICE CAN BE EXPORTED IN AN OFF-SHORE MANNER. THOSE SERVICES WHICH MEET THE FIRST-LEVEL CRITICAL FACTORS WILL BE EXAMINED IN MORE DETAIL AS A TARGET MARKET FOR JAMAICA.

IN THE CASE OF THE CAD/CAM MARKET, FIRST LEVEL FACTORS ARE:

- **PORTABILITY**: Services which can be can be cc npleted remotely from the user site.

- **EASE OF DISTRIBUTION**: Services which can be divided into independent work segments, completed in Jamaica, and later integrated with the rest of the system, without causing disruptions to the customer activities and the operation of the CAD/CAM system in use.

PORTABILITY AND EASE OF DISTRIBUTION DETERMINE WHETHER A MARKET SEGMENT CAN BE SERVICED FROM AN OFF-SHORE FACILITY.

CAD/CAM SERVICE MARKET SECTORS	PORTABILITY	EASE OF DISTRIBUTION	OFF-SHORE POTENTIAL
SYSTEM INTEGRATION	−	−	NO
LAYOUT/DESIGN	+	+	YES
DATA CONVERSION	+	+	YES

LEGEND :

+ Passes first level critical factor test

− Fails first level critical factor test

□ Potential Market For Jamaica

OUR FIRST LEVEL CRITERIA INDICATE THAT DATA CONVERSION AND DRAFTING/LAYOUT ARE THE MOST SUITABLE MARKETS FOR JAMAICA. OUR ANALYSIS ALSO INDICATES THAT MODELING/DRAFTING AND SYSTEM INTEGRATION ARE NOT SUITABLE FOR OFF-SHORE CONTRACTING.

- **PORTABILITY TEST**:

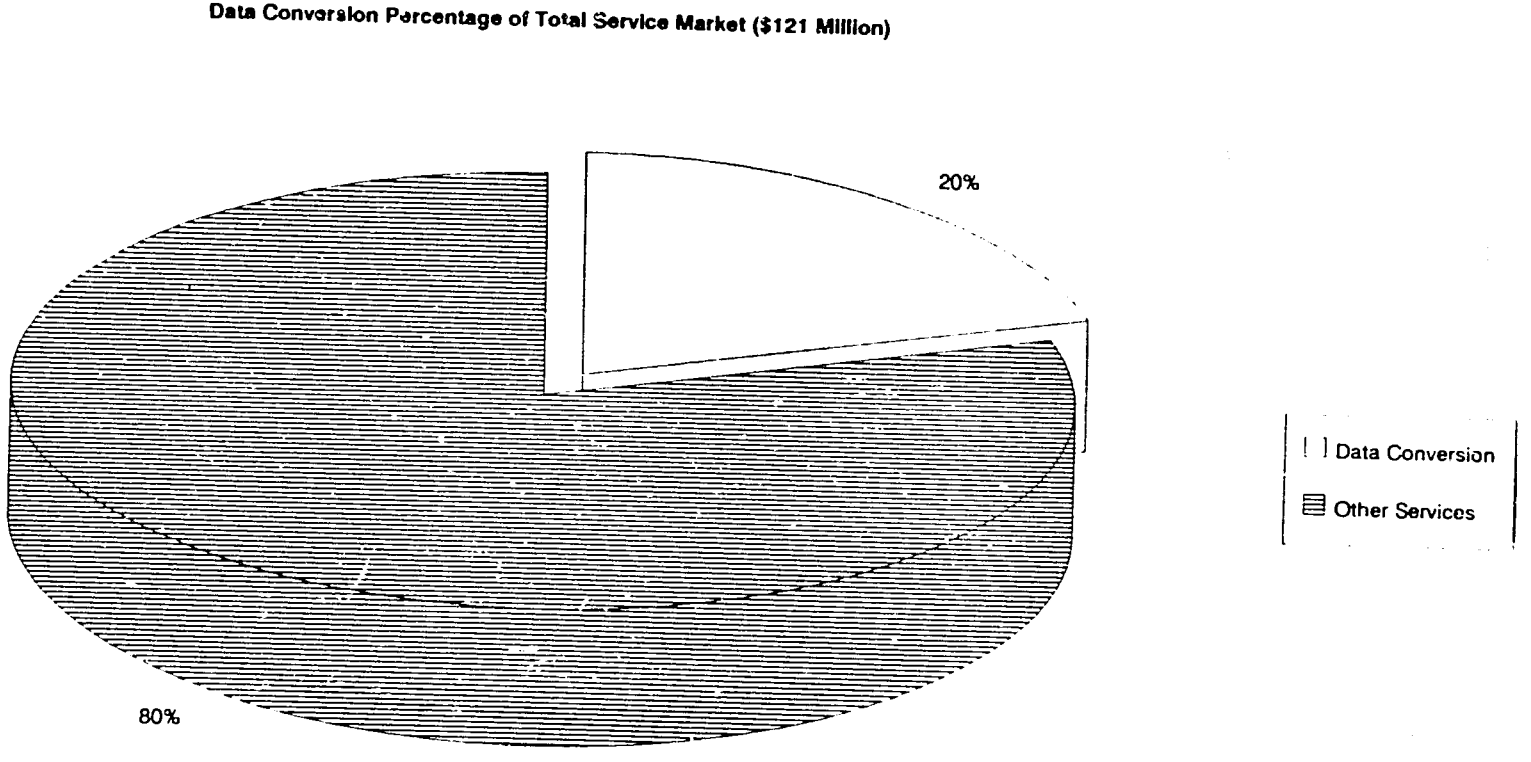
  - Data conversion and drafting/layout can be completed remotely from the user site and later integrated into the system at the client's site in the U.S.
  - Both System integration and drafting/layout require on-site presence. Hence, they are not portable.

- **EASE OF DISTRIBUTION TEST**:

  - Data conversion and drafting/layout design can be divided into independent work segments and easily integrated at a later time.
  - System Integration and modeling/drafting require a closely coordinated effort and can not be easily broken down into distinct functions. Hence, they can not be treated as distributed tasks.

CAD/CAM Conversion/Translation...Overview

THE U.S. CAD/CAM CONVERSION/TRANSLATION MARKET IS CURRENTLY ESTIMATED TO BE $ 121 MILLION WHICH IS 20% OF THE TOTAL CAD/CAM SERVICE MARKET.



WE IDENTIFIED THREE MAJOR MARKET SEGMENTS IN CAD/CAM CONVERSION. THE FOLLOWING SEGMENTS CAN BE DIFFERENTIATED AS EITHER PERFORMING A TRANSLATION, OR CONVERSION FUNCTION:

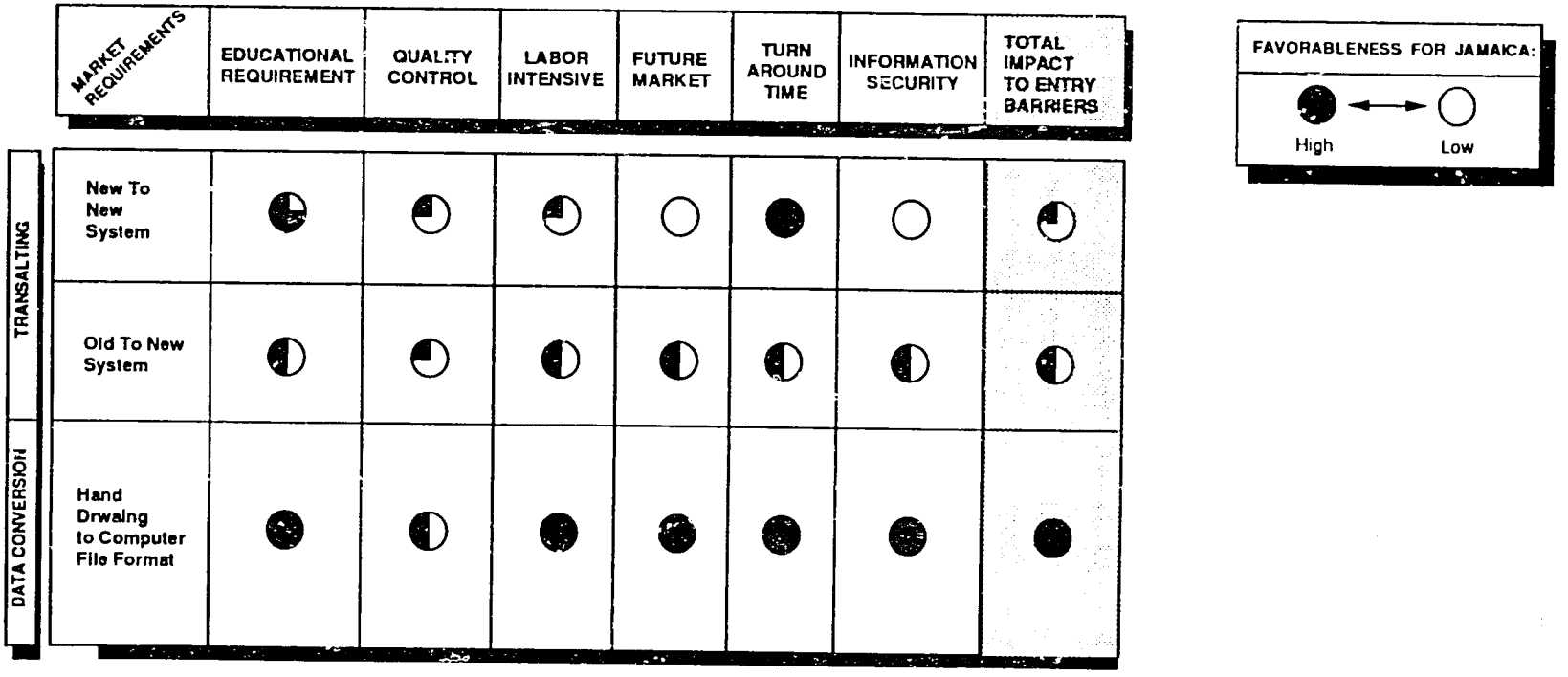
- **TRANSLATING ONE GRAPHIC SYSTEM TO ANOTHER**: includes translating engineering designs from one system format to another and consist of:
  - **New to New System Conversion** - translating designs from one current off-the-shelve software to another.(e.g. Mentor graphic 3-D to Cadence 3-D software).
    - -- This type of conversion is the simplest form of conversion and requires limited "decision-making".
    - -- This segment is limited because of the recent standardization and development of translation software in the CAD/CAM industry.
  - **Old to New System Conversion** - includes the translating designs from out-dated software to advance software.
    - -- This type of conversion is more complex and does require more "decision-making"
    - -- This segment remains a viable segment as organization translates old graphical system to new.

- **CONVERSION OF HAND DRAWINGS TO COMPUTER FORMAT**: consists of converting paper to computer file format.

  This is a major segment in CAD/CAM conversion market that will continue to grow for the next five years as major corporations see the utility and benefits to productivity of using CAD/CAM systems (i.e., GM's need to convert old drawing into computer format to implement CAD/CAM system).

CAD/CAM Data Conversion/Translation Market . . Second Level Critical Factor Screen

AS A NEXT STEP, WE RANKED THESE POTENTIAL SERVICES AGAINST SECOND LEVEL CRITICAL FACTORS THAT DETERMINE WHETHER MARKET REQUIREMENTS ARE FAVORABLE FOR JAMAICA. THE HAND DRAWING TO COMPUTER FILE FORMAT (e.i., DISK, APERTURE CARDS) SCORED HIGHEST FOR OFF-SHORE POTENTIAL IN JAMAICA.



CAD Data Conversion Market . . .

CAD CONVERSION (ENGINEERING DRAWINGS) IS LABOR INTENSIVE BECAUSE A SCANNED IMAGE OF CAD DESIGN REQUIRES EXTENSIVE EDITING TO ACHIEVE APPROPRIATE LEVELS OF ACCURACY.

- The scanned image of the engineering drawing is not totally accurate; it contains many approximation of the original raster image.
- Therefore, the real value-added of a service bureau is the process of correcting and editing the reconstructed vector image by comparing it with the raster image.
- Additional services provided include altering and enhancing the images.

CAD/CAM DATA CONVERSION SERVICES INCLUDE:

BASIC SERVICES IN THE CAD CONVERSION MARKET INCLUDE THE FOLLOWING:

- **Data entry**: The keying of data into a computer system.

- **Scanning**: The scanning operation digitizes the information into computer readable files.

- **Raster to vector conversion** - The process of identifying pixels which represent line work or graphics, separating these pixels from the background and converting them to a vector representation. This vector representation allows graphic information to be easily manipulated, edited, attributed, and stored. Vector representation is a basic component of CAD/CAM.
  - Automated - Requires no human interaction
  - Interactive - Operator points to lines to be vectorized

- **Interactive Editing** - This is the use of a high resolution color graphics workstation to allow an operator to easily view vector graphics as an overlay on top of an original grey scale image of the source document. This interactive editing station is a key ingredient in the automation of conversion, including:
  - Image Editing
  - Raster Drafting

A SUMMARY OF CAD/CAM CONVERSION MARKET IS AS FOLLOWS:

- **Current Market Size:**
  - Total CAD/CAM market: $4 B
  - The Service Market: $606 M (15%)
  - The Conversion Market: $121 M (20%)
  - The Conversion Out-sourced Market: $ 48M (40%)
  - The Off-shore Conversion Market: $ 7M (15%)

- **Market Growth:**
  - Market growth is projected at an annual rate of 22%. CAD/CAM experts estimate over 1 Billion hand-drafted drawings laying in flat files in Industry, academic institutions and government.

- **Training Requirements:**
  - Minimal training requirement for an average CAD/CAM conversion project includes a high school degree with additional computer training.

- **Labor Intensity:**
  - The average ratio of labor to system costs in the CAD/CAM market is 60% to 40%.

- **Information Sensitivity:**
  - Information sensitivity is relatively high in the CAD/CAM market because of the strategic importance of designs.

- **Basic costs of a base system** :
  - System and software cost range dramatically from $10,000-$16,000 for a PC-based system to $20,0000-$40,000 for a workstation system.

- **Geographic Proximity** :
  - Geographic proximity is not of major importance if a firm can provide accurate control.

- **Average Turnaround time:**
  - Turnaround time averages at 10 weeks or more.

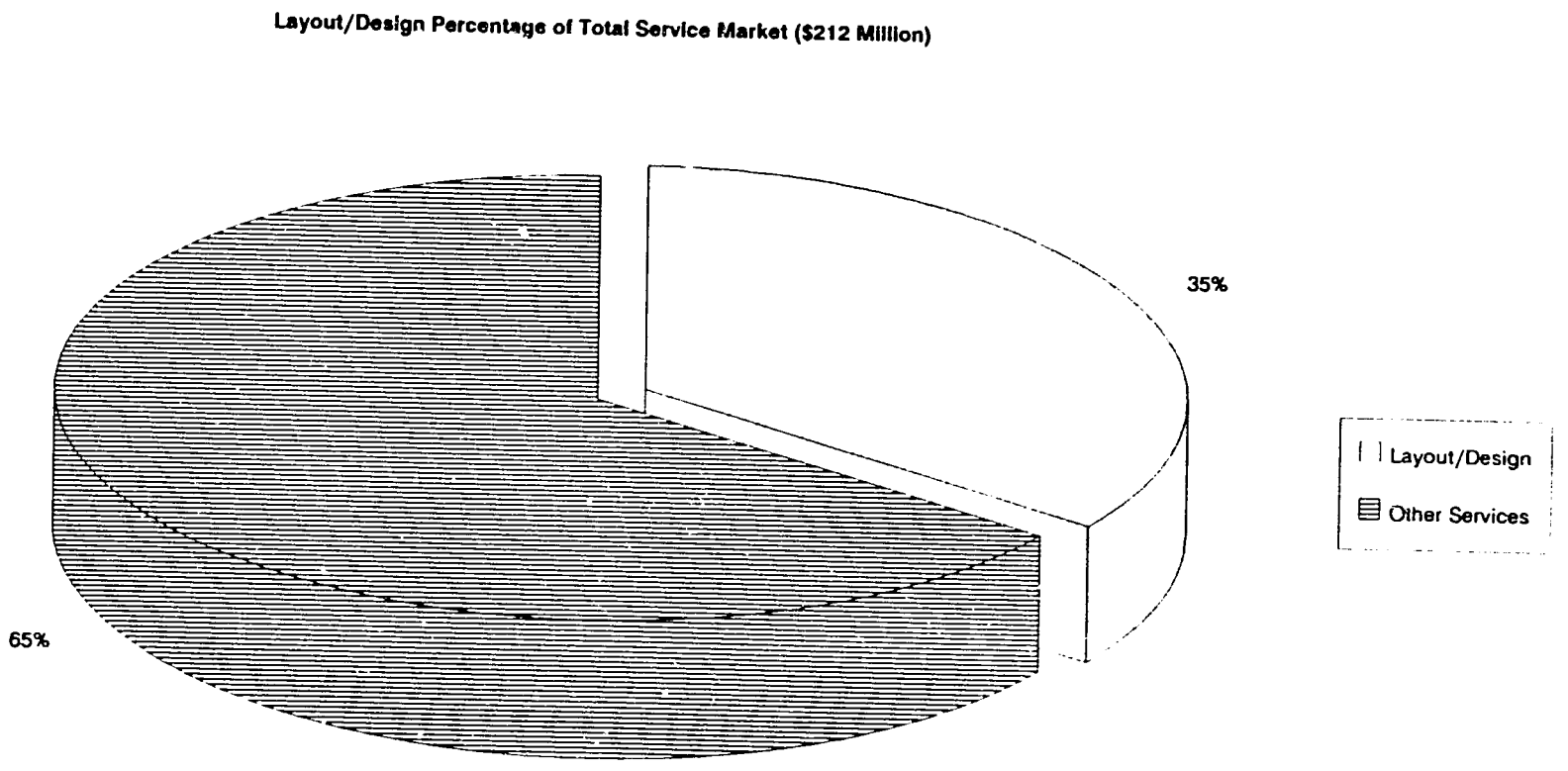
- **Major Customers:**
  - The U.S. industrial/electronic sector is currently the largest user of CAD/CAM.
  - Other major customers include architectural, engineering, and construction companies.

- **Quality Control Importance:**
  - CAD/CAM conversion requires a high level of quality control to maintain accuracy.

- **Technology Obsolescence:**
  - The CAD/CAM market is expected to grow at a steady rate as most companies automate design and manufacturing functions.

CAD/CAM Drafting/Layout Market . . . Overview

THE U.S. CAD/CAM DRAFTING/LAYOUT DESIGN IS ESTIMATED AT A $ 212 MILLION WHICH IS 35% OF THE TOTAL CAD/CAM SERVICE MARKET.



THE FOLLOWING SEGMENTS WERE IDENTIFIED AS POTENTIAL SERVICES SEGMENT WITHIN THE DRAFTING/LAYOUT MARKETS:

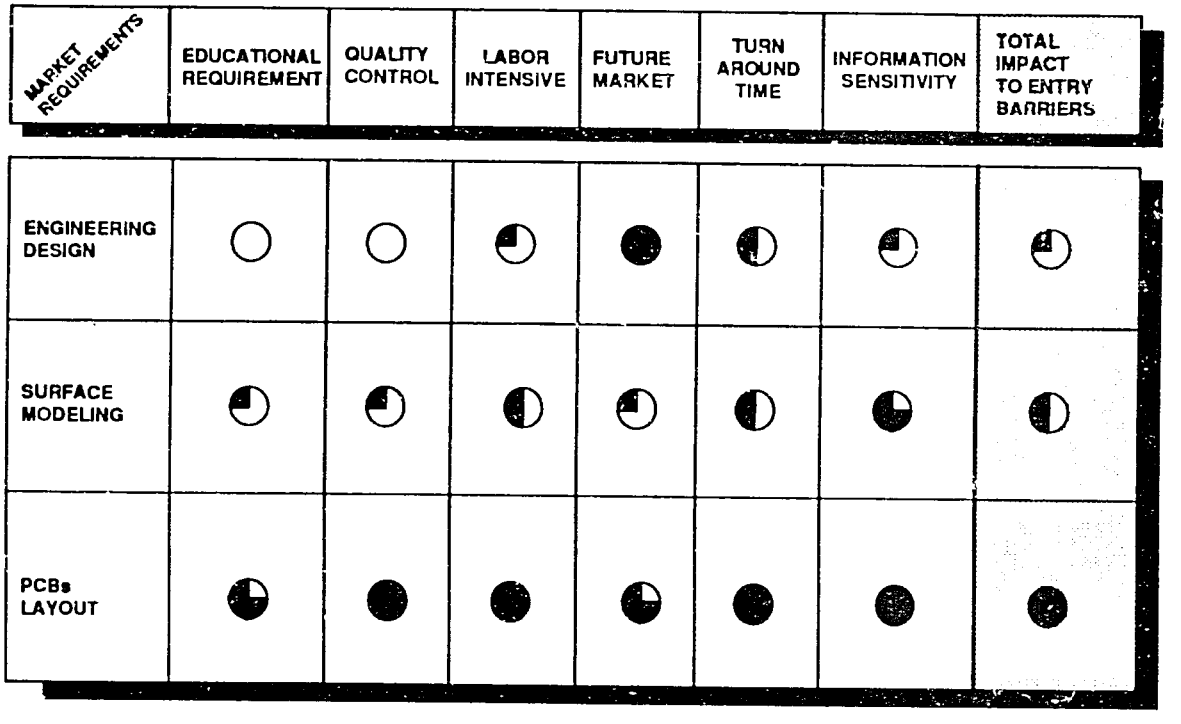
- **ENGINEERING DESIGN**: The actual design of the product (Product specification and features are defined).

- **SOLID MODELING**: The process of adding surface to wiring drawing of engineering designs.
  - A computer drawing that has been done in a 2-Dimensional software package most be given surfaces to take advantage of "as-is" product features that new 3-D software has.

- **PRINT CIRCUIT BOARD LAYOUT**: The process of layout circuit designs on a board.
  - An electric engineer designs circuity on paper and hands the resulting schematic to the PCB designer, who would uses a CAD system to lay out the circuitry on a board. The PCB also receives specifications on positioning of key interface components and other details.

CAD/CAM Drafting/Layout Market . . .

AS THE NEXT STEP WE RANK THESE POTENTIAL SERVICES AGAINST SECOND LEVEL CRITICAL FACTORS TO IDENTIFY THE POTENTIAL OUTSOURCING MARKET.



THE PC BOARD LAYOUT HAS THE GREATEST POTENTIAL FOR OFF SHORE CONTRACTING WHEN COMPARING TURN AROUND TIME, TECHNOLOGICAL COMPLEXITY/EDUCATIONAL REQUIREMENTS, AND INFORMATION SECURITY OF POTENTIAL SECTORS. THE MAJOR BARRIERS FOR JAMAICA ON THE OTHER TWO POTENTIAL SERVICES ARE :

- **ENGINEERING DESIGN**:
  - Educational/training requirement entry barrier is extremely high, because of technical complexity of IC circut design process.
  - Size of market is limited while the capitol expenditure needed to purchase equipment in fairly low.

- **SOLID MODELING**:
  - The market is declining.
    - New CAD design tools have automatic surface features which eliminate for need for solid modeling.
    - Small firms are also investing in software tools and do not require a service bureau to perform modeling.

THE PRINTED CIRCUIT BOARD (PCBs) LAYOUT DESIGN OUT SOURCING MARKET IS ESTIMATED AT A $340-400 MILLION DOLLAR. THE MARKET HAS GROWN RAPIDLY DUE TO THE WIDE USE OF ELECTRONIC PRODUCTS AND THE SHIFT OF TECHNOLOGY GOODS TO A "COMMODITY".

- **WIDE USE OF PCBs IN ELECTRONIC PRODUCTS**:
  - Not only do PCBs control electronic functions in computers, airplanes, cars, and telephone switching systems, they also form the backbone of electrical systems that automate huge factories and processing plants.
    - An average car has about 21 PCBs, these boards control the entire electronic system.
    - PCB production is extremely price sensitive - many producers at high quality. cost

- **SHIFT OF TECHNOLOGY FROM HI-TECH TO A COMMODITY**:
  - PCB production is extremely price sensitive - many producers of high quality. Cost is the determining factor.
    - Mass produced.

A SUMMARY OF CAD/CAM PCB LAYOUT MARKET IS AS FOLLOWS:

- **Current Market Size:**
  - Total CAD/CAM market: $4 B
  - The Service Market: $606 B (15%)
  - The Layout/Design Market: $212 M (35%)
  - The Layout/Design Outsource Market: $169 M (60%)
  - The Off-shore Conversion Market: $17 M (10%)

- **Market Growth:**
  - Market growth is projected to grow at an annual rate of 22%.

- **Training Requirements:**
  - Minimal training requirement for an average CAD/CAM Drafting/Layout project includes a two year design degree plus substantial experience.

- **Information Sensitivity:**
  - Information sensitivity is relatively high in the CAD/CAM market because of the strategic importance of designs.
  - The drafting/layout especially requires information security because product enhancements are often implemented by PCBs board.

CAD/CAM Drafting/Layout Market . . . Summary (Cont.)

- **Basic costs of a base system** :
  - System and software cost range dramatically from $10,000-$16,0000 for a PC-based system to $20,0000-$40,000 for a workstation system.

- **Geographic Proximity** :
  - Geographic proximity is not of major importance if a firm can prove accurate control.
  - Most service bureaus tend to be in high tech centers such as Massachusetts, California and Texas which parallel concentration of computer firms.

- **Average Turnaround time:**
  - Turnaround time averages at 1 week or less. Customers are willing to pay a premium for shorter turn-around time.

- **Major Customers:**
  - The U.S. computer sector is currently the largest user of CAD/CAM drafting layout services.
  - Other major customers include electronic and manufacturing companies.

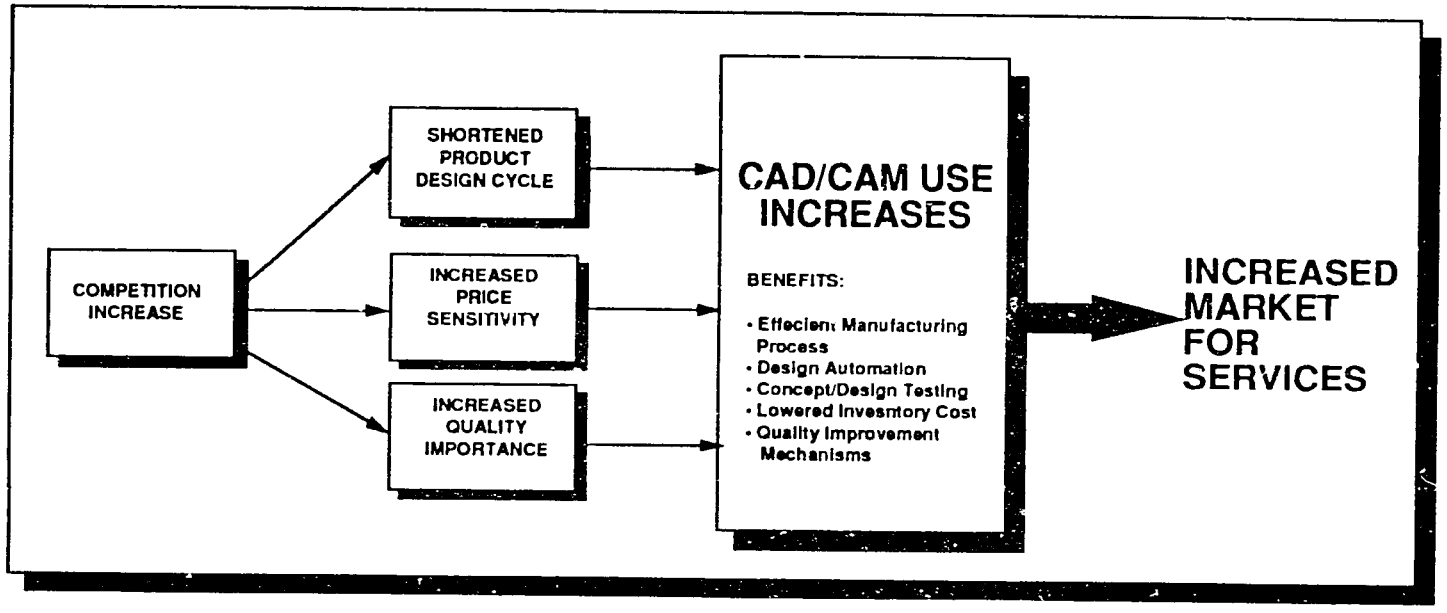
- **Quality Control Importance:**
  - Quality is of utmost importance because layout design drives the manufacturing of component. Hence, drafting errors could result in a batch of faulty components (e.g. computer boards design mistake could resulting millions of dollars in manufacturing loss).

CAD/CAM Drafting/Layout Market - Summary (Cont.)

- **Technology Obsolescence:**
  - The CAD/CAM market is expected to grow at a steady rate as most companies automate design and manufacturing functions.
  - Lay-out design is not technically driven but is more of an "art" so it will not be easily be replaced by software.
- **Distribution/Marketing Channels:**
  - PCB layout service bureaus tend to maintain long-term relationships with clients.
  - Major clients require assurance that their work will be completed in time and require a higher priority for their work.

CAD/CAM Market Trends . . . Future Growth

MARKET INDICATORS SHOW THAT THE U.S. MARKET WILL CONTINUE TO BECOME MORE COMPETITIVE. SUBSEQUENTLY, THE CAD/CAM MARKET SHOULD CONTINUE TO GROW. THIS SHOULD FAVORABLY IMPACT BOTH CONVERSION/LAYOUT SERVICES:



COMPETITION WILL ARISE FROM COUNTRIES WITH A STRONG MANUFACTURING BASE AND TECHNICALLY TRAINED WORK FORCE.

- **STRONG MANUFACTURING BASE**:

  - Brazil, India and Mexico would provide strong competition in the CAD/CAM off-shore service market place:
    - American manufacturing/HI-tech firms have already out sourced manufacturing to firms in these countries.
    - These Off-shore manufacturing firms would be in an advantageous position in capturing off-shore data conversion.
    - Off-shore manufacturing firms can act as a channel for off-shore conversion services.
    - Established manufacturing base generates a trained work-force.

- **TECHNICALLY TRAINED WORKFORCE**:

  - Brazil, India, and Mexico have a large technically trained population compared to Jamaica. In these countries,off-shore manufacturing firms:
    - Provide management for conversion jobs- establish a competitive manager to worker ratio.
    - Achieve a quality image - hard to achieve a quality image without a trained workforce.