

ENVIRONMENT

THE CYBER-80 PROGRAM HAS AS IT'S MAJOR OBJECTIVE, THE DESIGN AND PRODUCTIZATION OF A NEW CDC SYSTEM OFFERING WHICH IS TO BE COMPETITIVE AND PROFITABLE IN THE MARKETPLACE FROM 1976 THROUGH 1986-1990. AS AN INITIAL STEP TOWARDS ACHIEVING THIS OBJECTIVE, THE ADVANCED SYSTEMS LABORATORY DESIGN TEAM HAS PROJECTED WHAT IT BELIEVES WILL BE THE STATE OF THE COMPUTER INDUSTRY THROUGHOUT THAT TIME FRAME. RATHER THAN ATTEMPTING TO PREDICT POSSIBLE STATE-OF-THE-ART BREAKTHROUGHS AND ADVANCES IN COMPUTING TECHNOLOGY, THE DESIGN TEAM HAS ESSENTIALLY EXTRAPOLATED PAST AND CURRENT TRENDS IN THE INDUSTRY. AS A PART OF THIS PROCESS, SOME INDICATIONS OF AREAS OF BREAKTHROUGH WILL BE PRESENTED.

THE MOST UNIVERSAL TREND THAT HAS BEEN ESTABLISHED IN THE COMPUTING INDUSTRY IS THAT OF 'INFORMATION SHARING'. IN THE CONTEXT OF THIS DOCUMENT, INFORMATION IS A GENERALIZED TERM ENCOMPASSING DATA {TRADITIONAL DEFINITION}, PROGRAMS, FACILITIES, PROCESSING CHARACTERISTICS, AND RESOURCES, HARD AND SOFT. AN ANALOGY TO THIS SITUATION CAN BE FOUND IN A LIBRARY SYSTEM. THE OBVIOUS INFORMATION SHARING TAKES PLACE WITH THE VARIOUS TEXT MATERIALS BUT, IN FACT, THE PHYSICAL FACILITIES, LIBRARY PERSONNEL, INTER AND INTRA LIBRARY COMMUNICATION SYSTEMS AND PROCEDURES ARE ALL INVOLVED IN AND SUPPORTIVE TO THE SHARING OF THE VARIOUS TEXT DATA. SO IT IS WITH INFORMATION SHARING INVOLVING COMPUTERS AND COMPUTING RESOURCES. THE BALANCE OF THIS DOCUMENT WILL ESTABLISH THIS TREND FROM PAST THROUGH TODAY AND WILL ADDRESS THE FUTURE IMPLICATIONS OF THIS TREND.

## ENVIRONMENT

INITIAL COMPUTING SYSTEMS WERE GENERALLY JUSTIFIED ON AND APPLIED TO HIGHLY SPECIALIZED DEDICATED APPLICATIONS; I.E., TRAJECTORY ANALYSIS, CENSUS DATA REDUCTION. AS SUCH THE SPHERE OF INFLUENCE OF EACH SYSTEM WAS EXTREMELY SMALL AND THE PEOPLE DEALING WITH THESE EARLY MACHINES WERE HIGHLY SPECIALIZED TECHNOLOGISTS. THE AMOUNT OF ON-LINE DATA UNDER DIRECT CONTROL OF THE SYSTEM WAS QUITE SMALL, IN FACT NON-EXISTANT IN MANY SITUATIONS. THE MAIN EMPHASIS WAS ON THE 'COMPUTING ENGINE' PROCESSING DATA FED TO IT FROM OUTSIDE SOURCES. SYSTEM FAILURES WERE TOLERATED AND NECESSITATED ONLY RESTARTING THE THEN CURRENT JOB AT THE BEGINNING {WASTEFUL BUT NOT DISASTEROUS}.

TODAY'S SYSTEM USAGE REPRESENTS THE NEXT POINT ON THE LINE OF EXTRAPOLATION. WHILE THE SPECIALIZED DEDICATED SYSTEM CUSTOMERS STILL EXIST, THEIR RELATIVE PERCENTAGE OF ALL CUSTOMERS HAS SIGNIFICANTLY DECREASED. THE ADVENT OF NEW PACKAGING AND CIRCUIT TECHNOLOGIES HAS BROADENED THE BASE OF COMPUTER USERS SUCH THAT IT ENCOMPASSES A SIGNIFICANT PERCENTAGE OF THE SCIENTIFIC AND TECHNOLOGICAL COMMUNITY. THE MAJOR PORTION OF TODAY'S COMPUTER SYSTEMS ARE USED FOR BUSINESS APPLICATIONS WHICH DEMAND AN EVER INCREASING DIVERSITY IN SYSTEM CAPABILITY. INDEED, MOST SCIENTIFIC AND ENGINEERING APPLICATIONS ARE DEMANDING SIMILAR CAPABILITY IMPROVEMENT.

CONCEPTS SUCH AS FILE SHARING, MULTI-PROGRAMMING, TIME SHARING {RESOURCE SHARING} AND COUPLED SYSTEMS HAVE BEEN DEVELOPED TO

## ENVIRONMENT

VARIOUS DEGREES TO ATTEMPT TO MEET THE EVER INCREASING CAPABILITY DEMANDS BY AN EVER INCREASING USER POPULATION. THE CONCEPTS OF OPERATING SYSTEMS, JOB CONTROL LANGUAGES, COMPILER LANGUAGES AND EXTENSIVE APPLICATION AND UTILITY LIBRARIES HAVE PARTIALLY REDUCED THE LEVEL OF EXPERTISE NECESSARY TO REALIZE GAINFUL WORK FROM MODERN COMPUTERS. A DIRECT RESULT OF THESE CONCEPT IMPLEMENTATIONS HAS BEEN A GRADUAL BLENDING OF THE USER COMMUNITIES {SCIENTIFIC AND BUSINESS} INTO A COMMON GROUP, SHARING A SINGLE SYSTEM CONFIGURATION AND UTILIZING WHATEVER CAPABILITIES ARE MADE AVAILABLE.

A RECENT CONCEPT ACHIEVING LIMITED IMPLEMENTATION STATUS IS THAT OF INTERCONNECTED SYSTEMS WHICH ARE GEOGRAPHICALLY SEPARATED. TO DATE, THE MAIN APPLICATION FOR SUCH SYSTEMS IS TO PROVIDE MESSAGE AND JOB SWITCHING OR ROUTING FACILITIES FOR RELATIVELY SPECIALIZED APPLICATIONS. DATA SHARING THROUGHOUT THESE NETWORKS IS PRACTICALLY NON-EXISTANT, AND AT MOST COMMON DATA CAN BE COPIED TO MULTIPLE SITES BUT NO DYNAMIC DATA SHARING IS PERMITTED.

EVEN THIS LIMITED SHARING CAPABILITY OF PROCESSORS AND/ OR DATA HAS PLACED INCREASING DEMANDS ON SYSTEM SUPPLIERS FOR CORRECT, CONSISTANT EFFICIENT AND EFFECTIVE SYSTEMS WHICH CAN BE UTILIZED BY AN EVER INCREASING USER POPULATION. RECENT DISCOVERY AND PUBLICATION OF SECURITY BREACHES AND CONSUMER DISSATISFACTION ATTEST TO THE MINIMAL SUCCESS THE SUPPLIERS HAVE HAD TO DATE.

## ENVIRONMENT

ANOTHER MAJOR FACET OF TODAY'S SYSTEMS IS THE DRAMATIC INCREASE IN THE AMOUNT OF DATA THAT IS MAINTAINED IN AN ON LINE ENVIRONMENT AND PERHAPS MORE ASTOUNDING IS THAT THE VERY EXISTENCE OF MANY CORPORATIONS DEPENDS ON THE CONTINUED INTEGRITY OF THIS THIS DATA.

BASED ON THE TREND EXAMPLES OF THE PAST AND TODAY, WE CAN ENDEAVOR TO PROJECT THE STATE OF THE INDUSTRY DURING 1977 THROUGH 1986.

THE DRAMATIC GROWTH OF THE MINI-COMPUTER AND TERMINAL BUSINESS, COMBINED WITH THE INCREASING DEMAND FOR VERY LARGE DATA STORAGE DEVICES {DISKS, LASER MEMORIES, BUBBLE MEMORIES, ELECTRON BEAM, ...} SYSTEMS INDICATE A CONTINUATION OF THE DISPERSAL OF COMPUTING CAPABILITIES TO A LARGER USER COMMUNITY WHO IN TURN WILL BE REQUIRING LARGER AMOUNTS OF INFORMATION TO BE AVAILABLE FOR IMMEDIATE ACCESS. THE ROLE OF THE LARGE COMPUTER SYSTEM IN SUCH AN ENVIRONMENT WILL BE THAT OF AN 'INFORMATION ENGINE'; THAT IS MAINTAINING ADMINISTRATIVE CONTROL OVER THE DIVERSE DEMANDS FOR DATA AND PROCESSING POWER OF ALL TYPES AS WELL AS PROVIDING A PORTION OF THE SYSTEM OF NETWORK POWER. THE OPERATIONAL INTEGRITY OF SUCH INFORMATION ENGINES WILL BECOME OF PARAMOUNT IMPORTANCE TO A VARIETY OF USERS FROM LARGE CORPORATIONS TO SMALL PRIVATE BUSINESSES.

TO MORE CONCISELY DESCRIBE SUCH A SITUATION IN GENERAL AND FOR CYBER-80 IN PARTICULAR, A LIST OF SOME DIRECT IMPLICATIONS OF

## ENVIRONMENT

THAT SITUATION IS GIVEN.

DATA SHARING WILL BE REQUIRED AT A SMALLER UNIT OF ACCESS CONTROL THAN IS GENERALLY IMPLEMENTED TODAY TO MEET THE RESPONSE REQUIREMENTS OF THE LARGER USER COMMUNITY ACCESSING LARGER DATA BASES.

EX. DATA ELEMENTS WILL BE SHARED.

IMMEDIACY OF INFORMATION WILL BE A MANDATORY REQUIREMENT FOR THE VERY EXISTENCE OF AN INCREASING PERCENTAGE OF THE CUSTOMER COMMUNITY.

THE CENTRALIZATION AT CRITICAL DATA BASES WILL REDUCE OR ELIMINATE THE NATURAL REDUNDANCY THAT EXISTS IN TODAY'S DECENTRALIZED DATA WORLD, THEREBY LEADING TO DRAMATICALLY INCREASED DEMANDS FOR SYSTEM INTEGRITY AND SECURITY.

THE IMPACT OF ANY USER VISIBLE FAILURE OF ANY CRITICAL RESOURCE WILL BECOME INCREASINGLY PERVASIVE IN ITS EFFECT.

THE POTENTIAL FOR ANY SINGLE MAIN FRAME SYSTEM TO PROVIDE THE CAPABILITIES OF THE INFORMATION ENGINE WILL DIMINISH THROUGH TIME AND COMBINATIONS OF SYSTEMS WILL BECOME THE ONLY ECONOMICAL ALTERNATIVE. IN PARTICULAR, THE ENVISIONED COMPUTER UTILITY WILL CONTINUE TO EVOLVE THROUGH SYSTEM NETWORKING.

AS USERS BECOME MORE DISTANT FROM DISCRETE SYSTEMS VISIBILITY, THE EVOLUTION OF USER ORIENTATION WILL

## ENVIRONMENT

CONTINUE FROM MACHINE {PAST} THROUGH PRODUCT {TODAY} TOWARD PROBLEM/SOLUTION {TOMORROW}. IN PARTICULAR SYSTEM VALUE WILL BE DETERMINED IN TERMS OF SOLUTIONS PER USER MONTH RATHER THAN JOBS PER HOUR.

AS THE RELATIVE DENSITY OF COMPUTER EXPERTISE WITHIN THE USER COMMUNITY DIMINISHES, THE INFORMATION ENGINE WILL HAVE TO ASSUME MORE AND MORE TASKS THAT ARE TODAY RELEGATED TO COMPUTER SPECIALISTS. A SMALL EXAMPLE, DATA STRUCTURE WILL BE DETERMINED BY THE SYSTEM RATHER THAN THE USER.

AS MORE USERS ARE ABLE TO PURCHASE MINI AND MIDI PROCESSORS {WHOSE CAPABILITY ALREADY APPROACHES THAT OF A CYBER-73}, THE DEMAND FOR ARBITRARY SYSTEM INTERCONNECTABILITY AND PROCESSING DECENTRALIZATION WHILE STILL ACCESSING PUBLIC DATA BASES WILL INCREASE.

ENOUGH. {THERE ARE MORE...}

### SOME DIRECT IMPLICATIONS SEEN FOR CYBER-80:

THE REQUIREMENT FOR SYSTEM INTEGRITY {H/W AND S/W} WILL BECOME PARAMOUNT.

RAW PERFORMANCE WILL CONTINUE AS A MAJOR FACTOR IN OVERALL SYSTEM EFFECTIVENESS.

CONFIGURATION {H/W AND S/W} FLEXIBILITY AND ADAPTABILITY WILL BE A MAJOR FACTOR IN THE CONTINUED MARKETABILITY OF

ENVIRONMENT

THE PRODUCT LINE.

THE MARRIAGE OF SYSTEMS AND SERVICES MUST SUCCEED.

AT ANNOUNCEMENT TIME FOR CYBER-80, IT MUST POSSESS AT LEAST AS MUCH CAPABILITY AS THE THEN CURRENT INFORMATION ENGINES. {CYBER-70, 170 AND OTHERS}.

## ENVIRONMENT

### APPENDIX

TO SUBSTANTIATE THE TREND PREDICTIONS, AT LEAST AS PER CDC, A SAMPLE OF THE CURRENT CUSTOMER BASE REVEALS THAT:

LIVERMORE LABS, A TRADITIONAL NUMBER CRUNCHER, HAS INVESTED HEAVILY IN THE GENERATION OF A LOCAL COMPUTER UTILITY INCLUDING A DATA ENGINE, A PROCESSING ENGINE, AND A COMMUNICATION ENGINE WHICH TOTALS TO A LOCAL INFORMATION ENGINE.

BETTIS AND KNOWLS ATOMIC POWER LABS HAVE DEVELOPED LOCAL INFORMATION ENGINES FOR THE GENERATION OF SOLUTIONS TO VARIOUS NUCLEAR POWER PROBLEMS.

FLOUR CORPORATION HAS DEVELOPED A WORLD WIDE INFORMATION ENGINE FOR THE SOLUTION OF LARGE SCALE CONSTRUCTION PROBLEMS.

CDC CYBERNET SERVICES IS DEVELOPING A WORLD WIDE INFORMATION ENGINE TO PROVIDE SOLUTIONS TO AN EVER BROADENING DIVERSITY OF USER PROBLEMS.

PURDUE UNIVERSITY IS DEVELOPING AN INFORMATION ENGINE TO PROVIDE SOLUTIONS TO THE PROBLEM OF RESEARCH, EDUCATION AND ADMINISTRATION AT A LARGE UNIVERSITY.

UNION BANK OF SWITZERLAND HAS PURCHASED A SOLUTION TO A LARGE SCALE BANKING PROBLEM.



IMPLICATIONS OF THE INFORMATION ENGINE

THE MOST FUNDAMENTAL UNDERLYING IMPLICATION DERIVED FROM THE 1980 ENVIRONMENT PAPER IS THAT THE NCR/CDC INTEGRATED PRODUCT LINE (IPL) CANNOT BE DESIGNED, DEVELOPED OR RELEASED WHILE CONSIDERING ONLY THE NEEDS OF A SMALL (OR HISTORICAL) MARKET SEGMENT. CDC MUST CONTINUE TO MOVE FROM THE POSITION OF SUPPLYING ONLY FORTRAN HORSEPOWER, AND NCR MUST CONTINUE TO MOVE INTO THE AREA OF TOTAL APPLICATION PROCESSING. THIS IS TRUE FOR THE TECHNICAL, MARKETING AND BUSINESS ASPECTS OF IPL.

THE DEVELOPMENT AND SUPPORT OF 1980-1990 INFORMATION ENGINES WILL BE CONSIDERABLY MORE COMPLEX AND DIFFICULT THAN SIMILAR EFFORTS TODAY. IN FACT, THE ACTUAL ACHIEVING OF SUCH SYSTEMS MAY WELL BE PREDICATED ON STATE-OF-THE-ART BREAKTHROUGHS, PARTICULARLY IN THE AREAS OF SOFTWARE DEVELOPMENT, HARDWARE RELIABILITY, COMMUNICATIONS FACILITIES AND MAINTENANCE FACILITIES. A SUCCESSFUL VENDOR OF THESE SYSTEMS WILL HAVE ACHIEVED SIGNIFICANT ADVANCEMENTS IN EACH OF THESE AREAS, AS WELL AS OTHERS.

A SIGNIFICANT OPERATIONAL AND ADMINISTRATIVE DIFFERENCE BETWEEN TODAY'S SYSTEMS AND THE INFORMATION ENGINE SYSTEMS LIES IN THE AREAS OF INFLUENCE AND CONTROL. TODAY'S SYSTEM USERS ARE

## IMPLICATIONS OF THE INFORMATION ENGINE

GENERALLY ORGANIZATIONALLY LOCATED RATHER CLOSE TO THE COMPUTER ADMINISTRATION FUNCTION, AT LEAST THE USERS AND THEIR CORPORATE RESPONSIBILITIES ARE KNOWN OR KNOWABLE. FROM THIS SITUATION SUCH TASKS AS SYSTEM CONVERSION ARE AT LEAST PRACTICAL, ALTHOUGH NOT DESIRABLE, AND THE TOTAL IMPACT OF SUCH CHANGES IS SOMEWHAT PREDICTABLE. THE USER COMMUNITY OF THE INFORMATION ENGINE WILL BECOME MORE LOOSELY COUPLED TO THE SYSTEM THROUGH TIME, EVENTUALLY LEADING TO A SITUATION IN WHICH THE EFFECTS OF A MAJOR, OR MINOR, SYSTEM CHANGE WILL BECOME TOTALLY UNPREDICTABLE. A FORMALISM IS THAT THE SPHERE OF INFLUENCE OF THE SYSTEM WILL EXTEND BEYOND THE SPHERE OF CONTROL OF THE SYSTEM ADMINISTRATORS.

GIVEN THESE GENERAL IMPLICATIONS, SOME SPECIFIC EFFECTS ON IPL CAN BE DETERMINED.

SYSTEM AND SERVICE AVAILABILITY IS AN ABSOLUTE REQUIREMENT THAT CANNOT BE COMPROMISED (OBSERVE THE SOCIOLOGICAL IMPACT OF INTERMITTANT POWER AND FUEL ABBERATIONS).

RAW PROCESSING POWER WILL CONTINUE AS A MAJOR DESIGN REQUIREMENT. THE MAJOR CHANGE BEING THE CHOICE OF APPLICATION OF THE POWER TO AREAS OTHER THAN #NUMBER CRUNCHING#.

## IMPLICATIONS OF THE INFORMATION ENGINE

THE ABSOLUTE MAGNITUDE OF COMPUTER CONTROLLED ON-LINE DATA STORAGE WILL INCREASE TO SIZES IN THE RANGE OF  $10^9$  TO THE  $10^{10}$  TO  $10^{12}$  CHARACTERS OF INFORMATION. SUPPORT OF DATA BASES OF SUCH SIZES WILL PLACE GREAT STRESS ON THE PERFORMANCE AND PROTECTION CHARACTERISTICS OF ALL SYSTEM COMPONENTS, HARDWARE, SOFTWARE AND OPERATIONAL.

THE INCREASING DIVERSITY OF THE SYSTEM USER COMMUNITY COUPLED WITH THE REDUCED #COMPUTER EXPERTISE# OF THESE USERS WILL PLACE GREATER DEMANDS ON THE HUMAN SUPPORT ASPECTS OF THE SYSTEM. THAT IS, THE SYSTEM MUST BE ABLE TO PERFORM ALL #PROGRAMMING TASKS# AUTOMATICALLY AND CONCEAL FROM THE USER ALL OF THE IDIOSYNCRACIES OF THE HARDWARE COMPLEX. SOME EXAMPLES:

DATA FORMATS AND STRUCTURAL ORGANIZATION WILL NOT BE A USER CONCERN, ONLY THE CONTENT OF DATA STRUCTURES WILL BE USER SPECIFIED. PERFORMANCE REQUIREMENTS MAY BE FED TO THE SYSTEM WHICH THEN STRUCTURES THE DATA ACCORDINGLY (AND AUTOMATICALLY). EVIDENCE OF THIS TREND CAN BE FOUND IN THE DATA BASE TASK GROUP, OF CODASYL, REPORT OF APRIL, 1971.

USERS WILL INCREASINGLY INTERFACE TO APPLICATION AND

## IMPLICATIONS OF THE INFORMATION ENGINE

SUPPORT PACKAGES RATHER THAN ASSEMBLERS AND COMPILERS AS IS TODAY'S SITUATION.

THE GROWTH OF #NETWORK SYSTEMS# WILL PLACE GREATER DEMAND UPON THE CAPACITY OF A SYSTEM TO EFFICIENTLY INTERFACE TO OTHER SYSTEMS, OF LIKE AND UNLIKE ARCHITECTURE. THIS INTERFACE PROBLEM WILL BE PARTIALLY ALLEVIATED BY VARIOUS STANDARDS GROUPS, BUT WILL CONTINUE TO INFLUENCE SYSTEM DESIGN.

A RESULT OF SEVERAL PRECEDING IMPLICATIONS IS THE NEED FOR EXTENSIBLE SYSTEM TRAITS. THAT IS, AN INFORMATION ENGINE MUST CONTINUE TO GROW AND INCREASE IN CAPABILITY AND FEATURES, BUT IT IS IMPERATIVE THAT THIS BE DONE WITHOUT NOTICE TO ANY CURRENT SYSTEM USERS. THIS IS CERTAINLY NOT THE CASE TODAY.

THE CAPABILITY TO SUPPORT LARGE NUMBERS OF USERS SHARING VARIOUS UNITS OF INFORMATION WITH VARIOUS PERFORMANCE REQUIREMENTS WILL NECESSITATE RIGOROUS AND IMPREGNABLE PROTECTION SYSTEMS WITHIN THE HARDWARE/SOFTWARE SYSTEM. SINCE THE UNIT OF INFORMATION THAT IS LIKELY TO BE SHARED WILL BE PART OF LARGE (AND VERY LARGE) DATA FILES, AND BECAUSE THE RESPONSE TIME REQUIREMENTS WILL BECOME MORE

## IMPLICATIONS OF THE INFORMATION ENGINE

STRINGENT, A MECHANISM WILL BE REQUIRED TO ALLOW INFORMATION SHARING FOR VERY SMALL UNIT SIZES. (ELEMENT AND RECORD-LEVEL SHARING AS COMPARED WITH TODAY'S FILE AND PACK SHARING SCHEMES.) THIS SITUATION WILL PLACE ADDED BURDEN UPON THE PROTECTION AND INTELOCK MECHANISMS OF THE HARDWARE/SOFTWARE SYSTEM.

AS THE SOFTWARE PRODUCT INDUSTRY FLOURISHES AND GAINS GENERAL RECOGNITION AMONG THE GENERAL USER COMMUNITY, THE SYSTEM SUPPLIER MUST BE ABLE TO PROVIDE MECHANISMS FOR REGULATING USAGE OF DISCRETE SOFTWARE PRODUCTS, PROBABLY AT A USER LEVEL, AND MUST PROVIDE BILLING STRUCTURES THAT ALLOW CHARGING ON A PER ANSWER BASIS RATHER THAN ON A RAW TIME OR EQUIPMENT BASIS (OBSERVE THE CURRENT TREND WITH DATA SERVICES IN THIS AREA). ADDITIONALLY, EACH SOFTWARE PRODUCT SUPPLIER MUST BE ABLE TO INSTALL, ALTER, TEST AND ENHANCE THEIR PRODUCTS WITHOUT AFFECTING THE INTEGRITY OF THE SYSTEM OR OTHER SOFTWARE PRODUCTS. SUCH PRODUCT MANIPULATION MAY BE DONE THRU NETWORK COUPLINGS OR TERMINALS, AND THE SYSTEM OWNER MAY NOT BE AWARE OF SUCH ACTIVITY.

AS IS BY NOW OBVIOUS, THE IMPLICATIONS OF THE INFORMATION ENGINE CONCEPTS ARE MANY AND ARE GOING TO HAVE CONSIDERABLE IMPACT ON THE IMPLEMENTATION OF THE NCR/CDC INTEGRATED PRODUCT

## IMPLICATIONS OF THE INFORMATION ENGINE

LINE. THE LIKELY EFFECTS OF THE SECURITY, PROTECTION AND RELIABILITY DEMANDS ON THE SYSTEM WILL BE PLACING MUCH OF THIS BURDEN ON THE HARDWARE PRODUCT. THIS WILL CERTAINLY BE TRUE FOR THE HIGHER PERFORMANCE MODELS OF THE LINE, AND MUST BE DESIGNED SUCH THAT SOME OF THE FUNCTIONS MAY BE PERFORMED VIA SOFTWARE IN THE LOWER PERFORMANCE MODELS (ALTHOUGH IT MAY WELL COST MORE INITIALLY TO PROVIDE SUCH TYPES OF CAPABILITY VIA SOFTWARE).

THE NEXT STEP IN THIS SERIES OF DOCUMENTS WILL DESCRIBE A FIRST CUT OF IMPLEMENTATION STRATEGIES TO PRODUCE AN INFORMATION ENGINE.