MOBILE AUTOMATED FIELD INSTRUMENTATION SYSTEM
TRADOC COMBINED ARMS TEST ACTIVITY (TCATA)

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INTRODUCTION

In early 1978, as part of on-going organizational and resource assessments at Headquarters, U.S. Army Training and Doctrine Command (TRADOC), one important factor evaluated was the most efficient and effective way to support current and future TRADOC sponsored user tests and how to maximize TRADOC support to the Operational Test and Evaluation Agency (OTEA) and joint testers within existing and anticipated resource limitations. It was concluded that existing test and evaluation instrumentation was:

a. Not mobile which caused test scheduling conflicts at fixed test sites.

b. Not adequate to support current and future Army user and joint test requirements for large scale realistic scenarios and

c. Obsolete and becoming uneconomical to operate and maintain; particularly at the TRADOC Combined Arms Test Activity (TCATA).

In May 1978, TCATA, in conjunction with the Combat Developments Experimentation Center (CDEC), was directed to develop TRADOC requirements and a concept for an instrumentation system that would meet the goals indicated in Figure 1. Some of the key goals indicated in this tasking are commonality and interoperability of test and training range instrumentation and the capability of instrumenting field exercises. The concept developed as a result of this directive is the Mobile Automated Field Instrumentation System (MAFIS) development program. The purpose of this presentation is to provide a MAFIS system overview and discuss the implementation of the various MAFIS subsystems and how the chosen implementation supports the goals identified by the TRADOC Commander.

SYSTEM DESCRIPTION

MAFIS will be a transportable, self-contained, software driven, realtime casualty assessment (RTCA) system. It will be capable of following multiple scenarios involving a variety of activities while simulating battlefield events for the collection, documentation, and objective analysis of tactics, doctrine, weapon systems, and training. Figure 2 provides the system requirements to be satisfied by MAFIS.

It is obvious that one program, such as MAFIS (see Figure 3), cannot satisfy all of the test instrumentation requirements of the TRADOC test and evaluation community. Therefore, it is important to establish which functions the development is to satisfy. Normally there are at least five basic functional areas that instrumentation systems supporting test and training ranges possess. They are (1) a position location function to determine player location; (2) player instrumentation devices (lasers, detectors, simulators) to measure, detect or provide interaction with other players; (3) a data communications link to transmit test generated data and control commands between system components; (4) a logical interface device to interface the position location, instrumentation devices and communications functions; and (5) a central control function to record event and test data and control the actions of the players in the field. The MAFIS development is intended to satisfy four of these five functions; the exception being the area of instrumentation/ engagement devices. This is a logical partition in that the instrumentation device requirements are changeable from test to test and each test/training activity must determine the data collection needs and the best approach to obtain this data. The point of interface to the remainder of the system is, however, part of the MAFIS development and MAFIS will use existing or newly developed instrumentation/engagement devices as required by the particular test being conducted.

MAFIS is composed of three subsystems: the Field Instrumentation Subsystem (FIS), the Command & Control (C&C) Subsystem, and the Operational Support Subsystem (OSS). Although the subsystem is independent in operation, all of the various subsystem functions are required for the complete data collecting capacity of MAFIS.

The C&C subsystem will consist of two vans and will contain the major components shown in Figure 4. The first van will house the Central Instrumentation Facility (CIF). The Communications Interface Controller (CIC) is a minicomputer (Data General MV8000) which will be dedicated to accomplishing the real-time system control and data logging tasks. The CIC will receive event/status data from the field and ensure that it is time tagged and logged in the van database file. It will then reformat the data and transmit the event/status data to the other C&C components by way of the delta event bus. The CIC will also input messages/queries from the Applications Processor and transmit them to players when required. A major task of the CIC will be to manage the data communications network. The network organization software will be located in the CIC and, on a real-time basis, will control all other data communications devices in the system. This control includes assignment of time slots and repeater assignments. Players moving from one repeater operational area into another will be automatically reassigned.

The Applications Processor, also a Data General MV8000, will run applications programs tailored for each specific test. Normal functions will include construction of a historical database with events logged in chronological order, preplanned test activities such as minefields, simulation of artillery fire, etc.; and control the interaction of the Test Control Center/MAFIS Operations Center (TCC/MOC) with the CIF. The CIF will have two operator positions for equipment control. The two processors are identical and if one should fail, the other can assume its functions but an overall decrease in functionality will result.

The Data Communications Interface, a Universal Field Element (UFE) with special network software, will be used in the CIF to provide the interface of the data network to the CIC.

The TCC/MOC will be co-located within the second van. Test officers will be able to monitor test activities, key players, and incoming data in near realtime within the TSC. The test officers will also be able to query the CIC historical database for replay purposes, invoke preplanned activities, and design, change, and input preplanned activities as desired.

Personnel responsible for the proper operation of MAFIS equipment will be able to monitor instrumentation performance and communicate with support personnel in the field with MOC equipment. Both test officers and support personnel will be able to interrogate field instrumentation during an exercise and, if required, modify the operation, configuration, or performance of various platforms or other subsystems.

The FIS consists of the Universal Field Element, a Position Location (PL) Group, a Communications Group, and Engagement Peripherals which are briefly described below and in more detail later.

a. The UFE will be the MAFIS instrumentation package mounted on individual tactical platforms and will consist of a UHF communication transceiver, a Global Positioning System (GPS) receiver, a logic module (LM), and power supply.

b. The PL Group will use the NAVSTAR GPS being developed by DOD. GPS satellites will transmit signals which will be interpreted and utilized by the receivers within the UFE to determine player position. This information will be passed to the LM for use in RTCA and for transmission to the C&C subsystem.

c. The Communication Group consists of UFE communication transceivers, repeaters, and a network controller located at the C&C. Spread spectrum radio technology will be used to improve jamming resistance of the subsystem. The system transmits “line-of-sight.” A large, nonvolatile memory will be located within the UFE LM to store messages and data when outages caused by terrain masking or jamming occur.

d. The engagement subsystem includes peripheral engagement devices (PED) and computer processing within the UFE LM. The PED’s will consist of existing and newly developed TRADOC signature and queing devices, lasers, and detectors. The UFE LM will perform the required RTCA calculations. Using the lasers to provide pairings and to transfer information from a firer to target, the target UFE will perform the RTCA.

The OSS includes equipment to store, test, maintain, and install the MAFIS. Automatic test equipment, power supplies, field service vehicles, a central maintenance facility, and containers for shipping are the major components of the OSS.

A brief description of the normal operations of MAFIS is supported by Figure 5. The center and top-left UFE’s represent the players in a test situation. The bottom-right Field Service Module (FSM), a UFE with a special software configuration, would initialize all players/participants as tank, crew-served weapons, etc., players configuring them with respect to all armaments each has and also the appropriate types and quantity of munitions. During the play of the test, a player will engage another with a laser beam which carries the identity code of the firing player and an ammunition/weapon type code. A player who has been engaged would detect the laser signal through a surface mounted detector and the detector would decode the laser message and pass it to the logic module of the UFE. The logic module would recognize the opposing player identity code and listen to the communication link for that player to transmit his firing report of this information. The attacked player’s logic module will use the ammo/weapon type, relative distance between firer and target, and an RTCA algorithm stored in software to evaluate the outcome of the engagement. All events and results of engagements are transmitted back to the C&C; often through network repeaters. The functions of the C&C have been previously addressed. The bottom-left Umpire/Controller Element (U/CE) operates normally in the field and, through the use of an input/output (I/O) display device and a laser, can interact with players which can be administratively “killed,” resurrected, disarmed, reloaded, etc.

The MAFIS is not limited to RTCA instrumentation as might be implied by the foregoing description. The system or components of the system can be configured to suit the needs of the test designer. The UFE can be operated in an RF silence mode when immediate two-way data/control linkage is not required or is not desired. The four general purpose ports support a wide range of data collection devices and the programmability of the UFE provides a means of data processing and test control for tests that are as yet undreamed of. Figure 6 is an example of how low cost, test unique signal conditioning can be interfaced with the UFE to gather non-RTCA data coincidental with RTCA tests. The UFE programmability, the on-board memory, the ability to function without a data link to the C&C facility and the general purpose ports combine to make the UFE a versatile, general purpose piece of test equipment for the test designer.

MAFIS SOFTWARE DEVELOPMENT

To provide the user community with the appropriate flexibility from a general purpose RTCA system requires test-by-test tailoring. For MAFIS, this flexibility is provided by the use of microprocessors in all components of the system to support software programmability, and adequate hardware resources to accommodate the test-by-test enhancement of the system. To insure that MAFIS can support the goals of system flexibility, the software is being developed in accordance with a very detailed, comprehensive software management plan. Additionally, the Ada programming language has been chosen as the MAFIS Higher Order Language (HOL) for the implementation of the C&C software and the majority of the FIS software. This decision was made to promote machine independence, increase the efficiency of future software development, and support an effective software configuration management program.

Having established the overall system design and proposed mode of operation, a discussion of each of the components of the FIS will add more clarity and better understanding of the system design and the variety of means of employing the product of the MAFIS development. The discussion below looks at the Universal Field Element concept initially and then the key components – the Logic Module, Communications Module, and Position Location Module – in more detail.

UFE CONCEPT

The Universal Field Element is designed to provide the common baseline element for weapons platform instrumentation. Figure 7 depicts the UFE concept. It provides four basic functions for data collection.

a. Controls what is collected. The logic module.

b. Identifies where the data was collected. The position location module.

c. Identifies when the data was collected. Network synchronized time.

d. Stores the data as it's collected. On board storage, and commo module.

The position location module is a GPS receiver interfaced to the LM by a 19.6 kbaud serial port. The commo module is a spread spectrum receiver/transmitter interfaced to the LM by a 400 kbaud serial port. Both of these modules receive power and control signals thru the Logic Module (LM).

The LM is the platform instrument controller and provides the processing power to readily adapt to a variety of sensors. This modularized microcomputer is highly versatile with adequate memory and throughput to address all identified MAFIS requirements. Its four general purpose I/O ports are software configurable over a range of from 1200 baud asynchronous TTL signals to 400,000 baud synchronous serial multidrop differential bus. This allows a reliable interface to instruments that range from a simple UART and a switch closure to a collection of highspeed devices connected to the data bus operating in a high electrical noise environment.

The Peripheral Engagement Devices are the engagement instrumentation and include a Laser Weapon System (LWS), a Detector Array Subsystem (DAS), a Fire Simulator (FS), a Kill Simulator (KS), and a Test Control Panel (TCP).

LOGIC MODULE HARDWARE PARTITIONING

The Logic Module consists of four main cards, partitioned according to function as depicted in Figure 8.

The central processing unit (CPU) card contains a 16-bit microprocessing unit (MPU) (MC68000 family) and functions as a stand-alone monoboard microcomputer. In addition to the MPU, it has local memory resources, including 32k bytes of CMOS SRAM and 16 to 32k bytes of EPROM.

The 68000 MPU has a linear address space of 16M bytes; the logic module of the UFE needs far less memory, so its address space is apportioned with all local resources at the lowest locations. The CPU card provides itself with a hardware access-protection mechanism for the lowest 2048 byte segment. Thus, all memory used by the LM in a UFE configuration normally resides in this lowest segment, particularly if software-programmable access-security is required. The Protection RAM, a 16k-bit SRAM on the CPU card, grants or withholds permission on every memory access along the lines of supervisor/user, program/data and read/write. The protection RAM itself lies in the address space which is protected by the hardware on the CPU card.

The DRAM card contains 256k bytes of DRAM with bytewise parity. This card can be fully populated to 512k bytes and with the use of 256 k x 1 chips can be expanded to 2M bytes.

The SRAM card contains 192k bytes of CMOS SRAM, with bytewise parity and provisions for battery-backup, jumper-selectable for each 64k byte SRAM-block. An SRAM card can replace the DRAM card for a total of 384k bytes of SRAM.

The I/O card has five full duplex serial ports controlled by an 8-bit processor (NSC800). The processor makes use of DMA device and dual-port SRAM for communication between the VMEbus and the I/O channels. This card is capable of stand-alone operation as a monoboard microcomputer.

The four cards communicate with each other by means of a bus which satisfies the specifications of the “VMEbus” promulgated by Motorola, Mostek, and Signetics. The VMEbus supports 16/32-bit word length data – transfers and supports multiprocessing. The Eurocard standard is becoming widely accepted in the United States as its pin-and-socket connectors are more reliable than the card-edge connector and its compact board size provides high density packaging when high-density VLSI chips are used.

MAFIS COMMUNICATIONS MODULE

The Communications Module (CM) is the heart of the Communications Network (see Figure 9). It is a component of the Universal Field Element and is a key element in the transmission of test and player data and information to the Command and Control facility. The CM is also a key element in the C&C facility. The UFE transmitted data is received at the C&C facility via a CM termed the Communications Interface Controller which is housed in a UFE also. The same CM is also used as a component part of the Repeater Network, which provides communications beyond the line-of-sight. In a hilly environment or where long distances must be dealt with, repeaters are necessary to meet a 50 km by 50 km minimum test area communications requirement. A fourth use of the CM, as part of a UFE, is in support of an application termed a field support maintenance unit. This unit is used as an initialization device, for field maintenance diagnostic support, and to off-load test data stored in the UFE. Finally, this same CM equipment, still housed in a UFE, is to be used by test controllers and umpires. Although designed to operate as part of the UFE, the CM can be operated with other digital controllers.

The implementation of the-CM consists primarily of a transceiver plus a digital section (Figure 10). The components of the CM consist of a transceiver with a modulator and demodulator (modem), RAM and ROM storage, an I/O Controller (IOC), a Control Processor (CP), a Real-Time Clock (RTC), a Data and Control Interface (D/CI); all tied together by a Data, Address and Control Bus. The D/CI provides an interface to a component of the UFE called the Logic Module. The ROM unit provides software and firmware storage. The RAM provides software storage, message buffering and working space for the processors. The CP provides control and data-flow operations plus interface-protocol and RTC control.

The I/O Controller also provides some interface-protocol control as well as direct control of CM interfaces. The RTC (with a timer) provides timing and scheduling of time-critical protocol operations. As noted on the first figure, the D/CI has numerous lines to the LM including serial data lines. By means of these interfaces, the LM exerts considerable controls over the CM through its software. The CM also contains its own software for internal operation. Through its interfaces to the LM, other UFE's, and the CIC via the Communications Network, the CM is also responsive to external software controls.

Figure 11 depicts the general features of the CM. The transceiver makes use of a pseudo-noise (PN), direct sequence, spread spectrum technology which is based on the AN/ARC-164. By use of transmitter, receiver and frequency synthesizer slices of the ARC-164 transceiver, a high degree of reliability is inherent to this design which has a requirement for a 4000 hour MTBF. Figure 12 provides specific features of the CM. The MAFIS transceiver has an operating range of 340-390 MHz with a carrier frequency range of 350-380 MHz, a signal spread of 20 MHz, software tuneable from 350-380 MHz with 31 discrete frequencies spaced 1 MHz apart, and a data rate of 400k bits/sec. It uses an MSK modulation with a receiver dynamic range of at least 80 dB. It has a Bit Error Rate (BER) of better than 10**-6 over the receiver dynamic range. The VSWR is 1.5 to 1 or better across the band.

The important physical characteristics are weight and volume. The maximum weight allocated for the CM components installed in the CM box (a portion of the UFE) is 6.5 lbs. With the antenna vehicle and man-pack antenna installed, a maximum of 2 lbs, the CM and antenna assembly has a maximum weight of no more than 8.5 lbs. Current prototype modules with antennas weigh approximately 11 lbs and the production modules will be closer to this weight than the 8.5 lbs design goal. The maximum volume is limited to 220 cubic inches. There is a separate antenna for the repeater application whose maximum weight is 24 lbs.

In summary, the UFE houses the CM and due to its weight and size gives the CM a man-portable capability. In this configuration, position information and other data will be available to the CM for processing and/or transmission to other players or the C&C facility via the Communications Network. The initial network is designed to support up to 200 players and is to be upgradable to 2000 players without discarding components but purely by adding more equipment. The CM, when operating at a high level of throughput processing, is expected to be busy on the average of no more than 40 percent of the time, thus providing a large reserve of processing space for use in extraordinarily dense environments. The spread spectrum transceiver will aid in noise and interference reduction. The repeater or relay application of the CM will provide beyond the line-of-sight operations over a 50 km-by-50 km operational area.

MAFIS POSITION LOCATION MODULE

The MAFIS Position Location System uses the Global Positioning System to provide the individual player position information. Position information is test data to provide location and movements of players and to provide the relative positioning information for real time casualty assessments. Figure 13 shows the MAFIS concept of GPS utilization.

The use of GPS offers advantages for transportability. The primary position location module is a passive receiver that can receive navigation signals from the NAVSTAR satellites anywhere in the world. No special transmitters and the associated problems of frequency authorization and transmitter installation are required for the position location function.

Each Universal Field Element on the MAFIS will have a Position Location Module (PLM). The PLM receives navigation signals from at least four NAVSTAR satellites. The receiver uses the measurements from the four signals and data encoded on the signals to solve for three dimensional position and time. Player velocity is also available from the GPS receiver. The computed navigation solution for each player is accomplished in the PLM consistent with the MAFIS distributed processing architecture. Positions are used by the Logic Module and periodically reported to the MAFIS Command & Control System over the MAFIS Communications network.

Time output from the PLM is a by-product of using GPS. The navigation solution provides an accurate common time reference for all users without interconnecting wires or communications overhead. The PLM will output two time periodics at 1.023 MHz and 1 PPS. A time word output is available at the 1 PPS time mark accurate to less than 1 microsecond relative to Universal Time Coordinated.

The performance of the GPS can be improved by implementing a differential correction system. For MAFIS the advantages of the differential corrections are being used to obtain local area accuracy from lower cost and less complex GPS receivers on each player.

Differential operation can substantially reduce bias and common mode errors in the GPS navigation system. Since these errors tend to be slower changing than random errors, the differential corrections are updated only every 10 seconds. The correction terms are related to each satellite visible in the local area. The correction terms for each visible satellite are broadcast to all players using the MAFIS communication network. The individual PLM selects the correction terms to use based on which satellites it is tracking. The PLM can then compute the corrected navigation solution on-board. This approach to differential correction fits well into the overall MAFIS architecture.

The positioning accuracy available with GPS is complex and dependent on many things. Under typical static conditions (no acceleration) and with reasonable signal carrier-to-nose ratio, the differentially corrected PLM can be expected to provide position accuracies less than 10 meters RMS and velocity accuracies of 1 meter/sec RMS. The position data will be output in the Universal Transverse Mercator (UTM) coordinate system at rates up to once per second.

The PLM will accommodate dynamics with velocities up to 120 feet per second and accelerations to 1 g. Other GPS receivers will be available which can be interfaced to accommodate vehicle dynamics beyond these limits.

Although performance is best with differential corrections, the PLM can also perform navigation solutions without the differential operation. The system accuracy will degrade however. The position accuracy for autonomous operation of the PLM is expected to be approximately 100 meters RMS.

A major concern for application of GPS on a system like MAFIS is the effect of satellite visibility masking on performance. Masking is caused by obstructions in the line of sight such as terrain, buildings, vegetation, or aircraft fuselage. The PLM will include operational features to minimize the effects of masking on overall performance.

The PLM will be packaged to interface with the MAFIS UFE. The unit will be 250 cubic inches, weigh less than 8 pounds, and use 8 to 12 watts of power. The antennas and preamplifier will be capable of being installed remotely from the UFE for vehicle installation.

The Position Location Module for the MAFIS is being developed in conjunction with a Tri-Service Joint Program called the Range Applications Joint Program Office (RAJPO). The Air Force is the lead service in the joint program to develop GPS instrumentation equipment to support DOD test and training ranges. The RAJPO awarded a development contract to Interstate Electronics Corporation in May 1985. The development includes the low cost position location module which specifically meets the requirements of MAFIS.

An accelerated development and production is also a part of the acquisition plan. This position location module (PLM) for MAFIS is projected to cost approximately $8K each and projected delivery could start as early as February 1987. The RAND development also includes a GPS reference receiver and high dynamic instrumentation set (HDIS) for application with MAFIS. These items are not accelerated and delivery of these components is not projected until FY90/91. It is anticipated that the HDIS will provide the PL instrumentation for fast moving players and integrated system testing with prototype HDIS equipment is planned to ensure compatibility with production sets. Also projected is a MAFIS-RAJPO data communications link interface which would permit a high-performance aircraft equipped with the standard HDIS instrumentation pod to interoperate with MAFIS instrumented test platforms.

SUMMARY

The major design goal of the MAFIS development is to implement a system that meets all stated requirements, but in such a way as to promote maximum flexibility of configuration to permit many different modes of operation, addition of new functions with a minimum of resource expenditure and permit use of subsystems or components of the development in existing or new systems. The MAFIS program is moving forward swiftly and the current development schedule projects Limited Operational Capability (LOC) attained by 4th Quarter FY86.

TRADOC COMMANDER'S GUIDANCE — 1 MAY 1978

WHERE THE FUTURE IS NOW

TASKING:

- DEVELOP INSTRUMENTATION PACKAGES TO SUPPORT EXPORTED TESTING AND INSTRUMENTING OF FIELD EXERCISES.
- ENSURE MAXIMUM INTEROPERABILITY AMONG TEST ACTIVITIES.
- DEVELOP MAXIMUM COMMONALITY AMONG TEST EQUIPMENTS AND SYSTEMS WHEREVER POSSIBLE.
- INVESTIGATE ADVANCED TECHNOLOGY OPPORTUNITIES THAT PROMISE TO SATISFY TRADOC'S REQUIREMENTS.

Figure 1

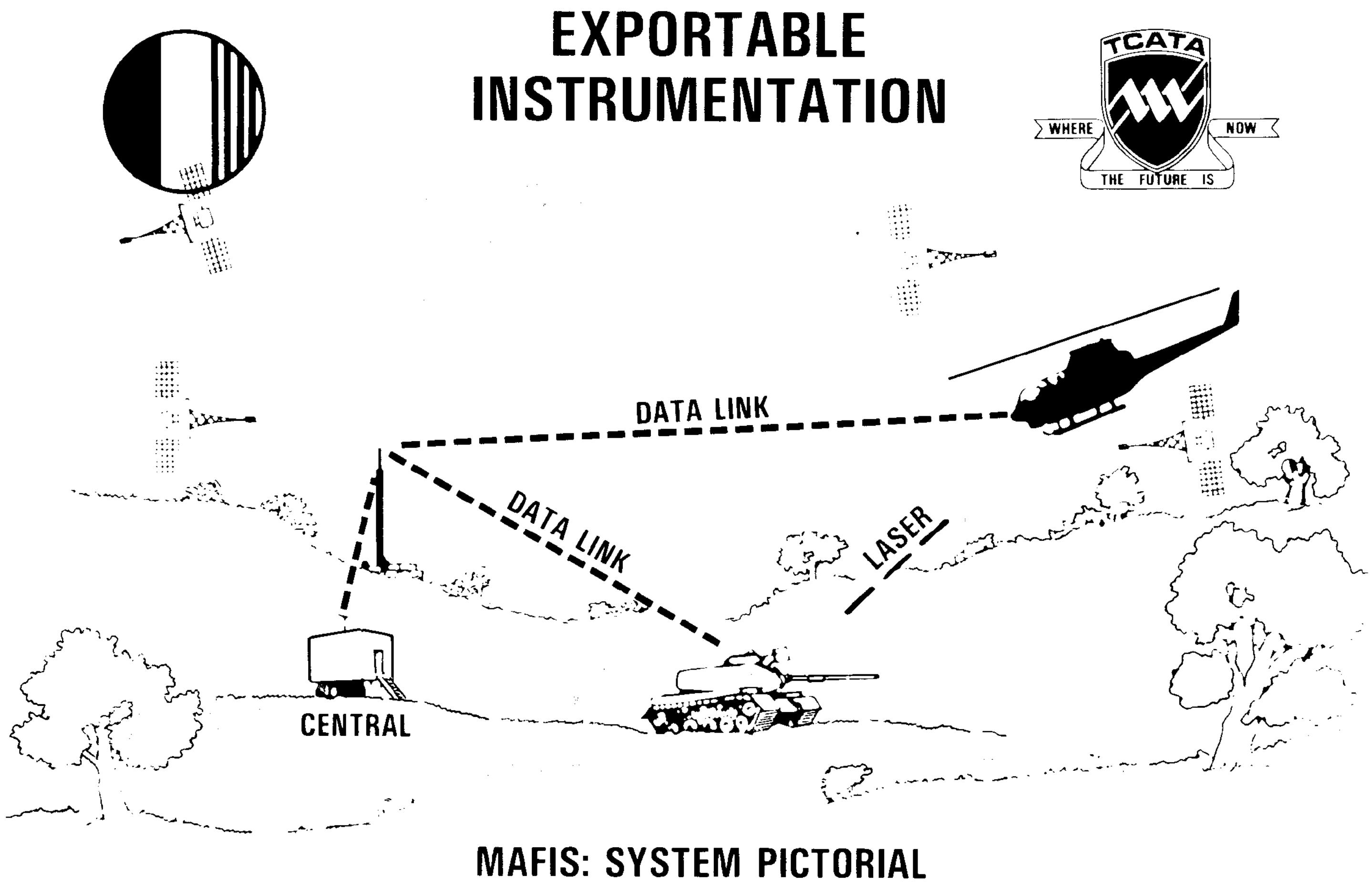

EXPORTABLE
INSTRUMENTATION
TCATA
WHERE
NOW
THE FUTURE IS
DATA LINK
DATA LINK
LASER
CENTRAL
MAFIS: SYSTEM PICTORIAL

Figure 2

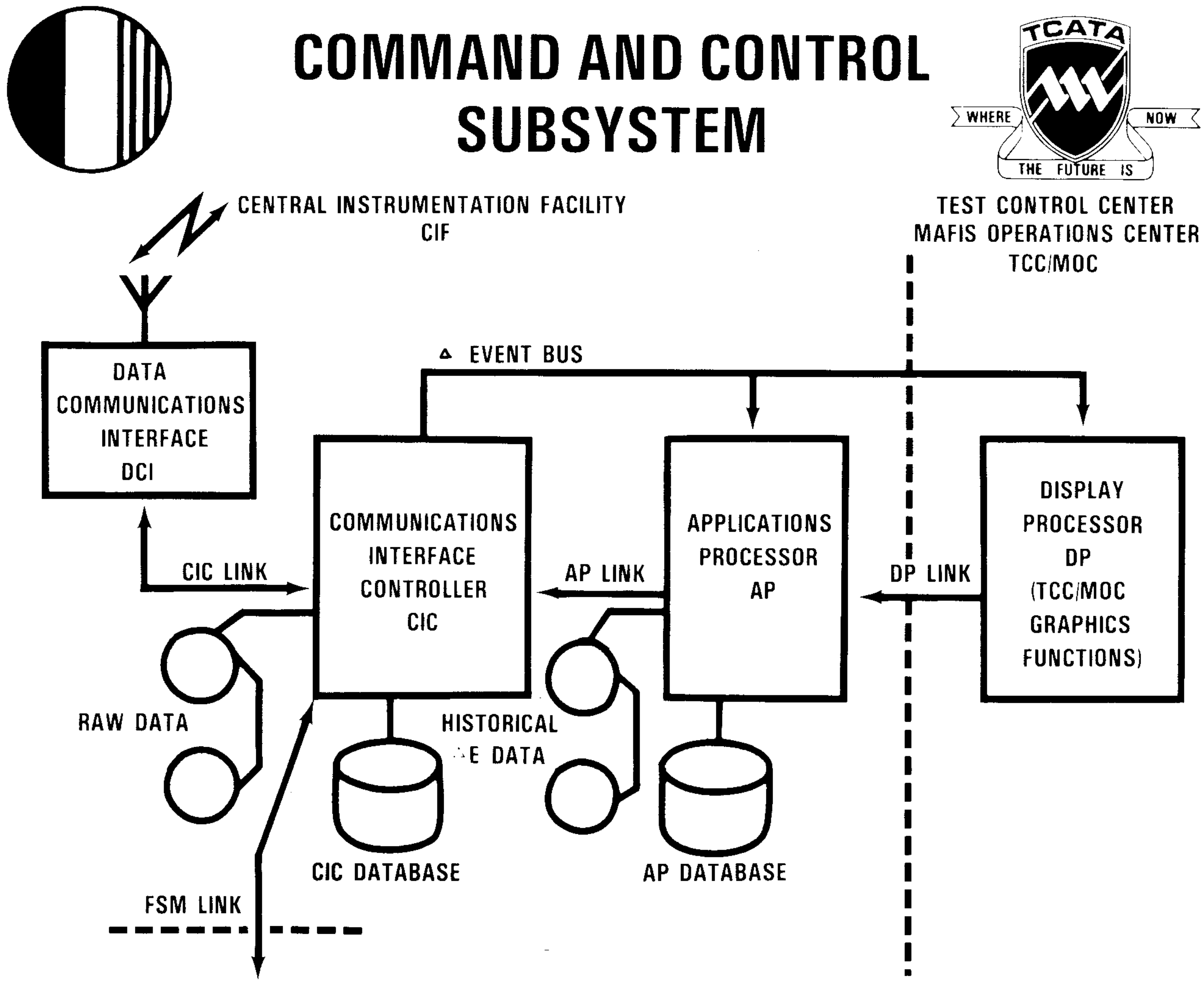
SYSTEM REQUIREMENTS

TCATA

WHERE THE FUTURE IS NOW

- TOTALLY TRANSPORTABLE.
- 200 + PLAYER ELEMENTS.
- APPLICATION TO: SOLDIERS, COMBAT VEHICLES AND AIRCRAFT.
- ALL WEATHER, DAY, NIGHT.
- IMPROVED REALISM/TRANSPARENT TO PLAYERS.
- IMPROVED DATA COLLECTION CAPABILITY.
- MINIMIZE CONSTRAINTS ON TEST DESIGN.
- CAPABLE OF GROWTH/EXPANSION.

Figure 3



COMMAND AND CONTROL SUBSYSTEM
TCATA
WHERE THE FUTURE IS NOW
CENTRAL INSTRUMENTATION FACILITY
CIF
TEST CONTROL CENTER
MAFIS OPERATIONS CENTER
TCC/MOC
EVENT BUS
DATA COMMUNICATIONS INTERFACE DCI
COMMUNICATIONS INTERFACE CONTROLLER CIC
APPLICATIONS PROCESSOR AP
DISPLAY PROCESSOR DP (TCC/MOC GRAPHICS FUNCTIONS)
CIC LINK
AP LINK
DP LINK
RAW DATA
HISTORICAL
DATA
CIC DATABASE
AP DATABASE
FSM LINK

Figure 4

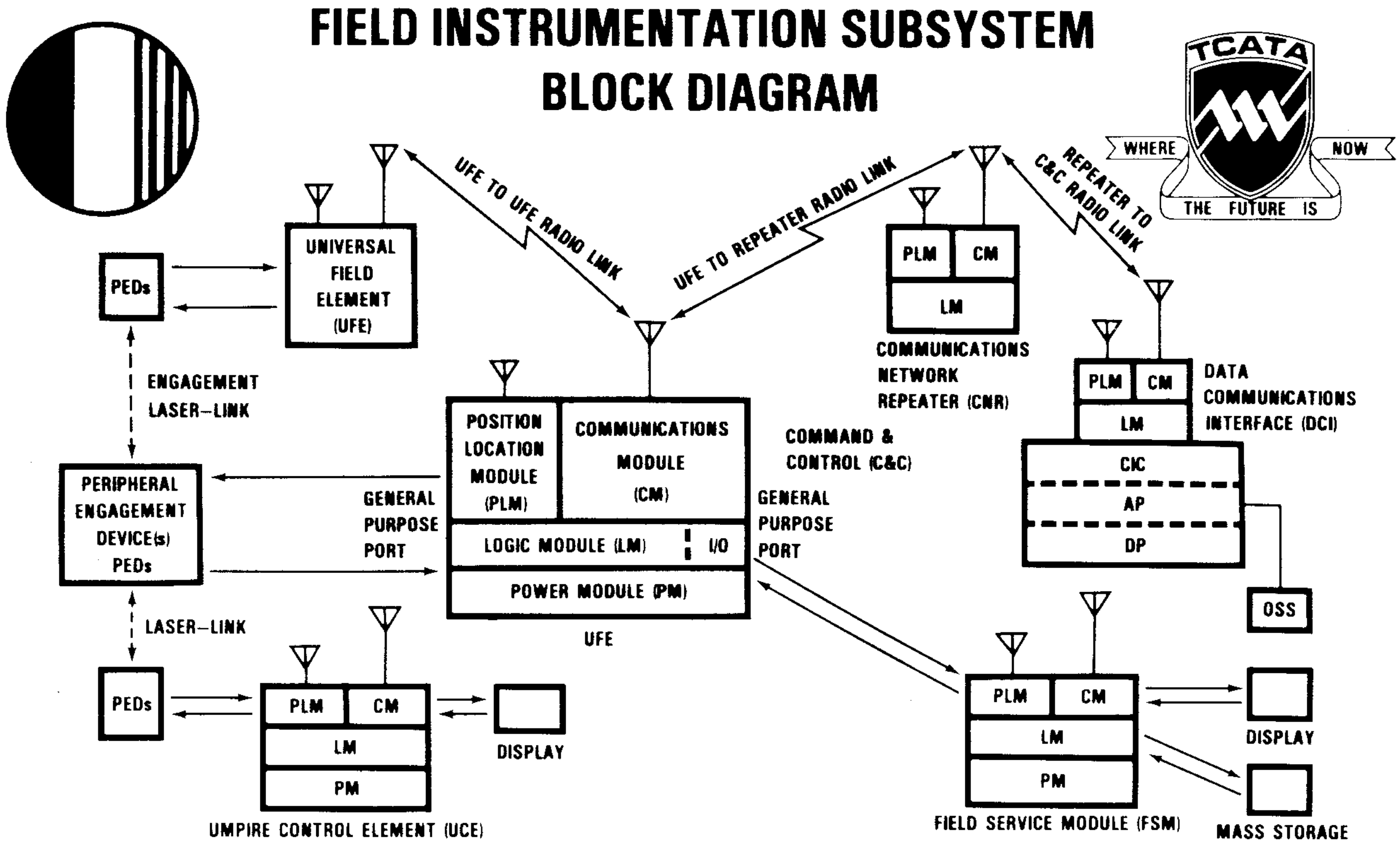
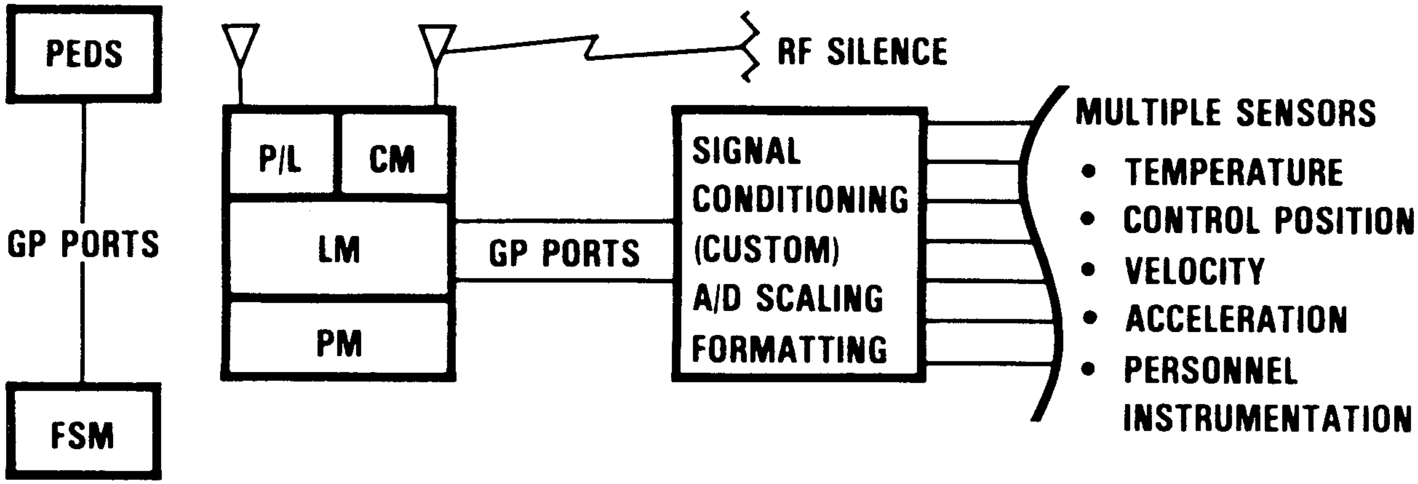

FIELD INSTRUMENTATION SUBSYSTEM
BLOCK DIAGRAM
TCATA
WHERE
NOW
THE FUTURE IS
UFE TO UFE RADIO LINK
UFE TO REPEATER RADIO LINK
REPEATER TO C&C RADIO LINK
PEDs
UNIVERSAL FIELD ELEMENT (UFE)
ENGAGEMENT LASER–LINK
PLM
CM
LM
COMMUNICATIONS NETWORK REPEATER (CNR)
DATA COMMUNICATIONS INTERFACE (DCI)
CIC
AP
DP
OSS
COMMAND & CONTROL (C&C)
PERIPHERAL ENGAGEMENT DEVICE(s) PEDs
GENERAL PURPOSE PORT
POSITION LOCATION MODULE (PLM)
COMMUNICATIONS MODULE (CM)
LOGIC MODULE (LM)
I/O
POWER MODULE (PM)
UFE
GENERAL PURPOSE PORT
LASER–LINK
PEDs
PM
DISPLAY
UMPIRE CONTROL ELEMENT (UCE)
FIELD SERVICE MODULE (FSM)
MASS STORAGE

Figure 5

NON-RTCA TESTS



- PROGRAMMABLE
- ON-BOARD DATA STORAGE
- RF SILENCE
- 4 GP PORTS

Figure 6

UFE CONCEPT

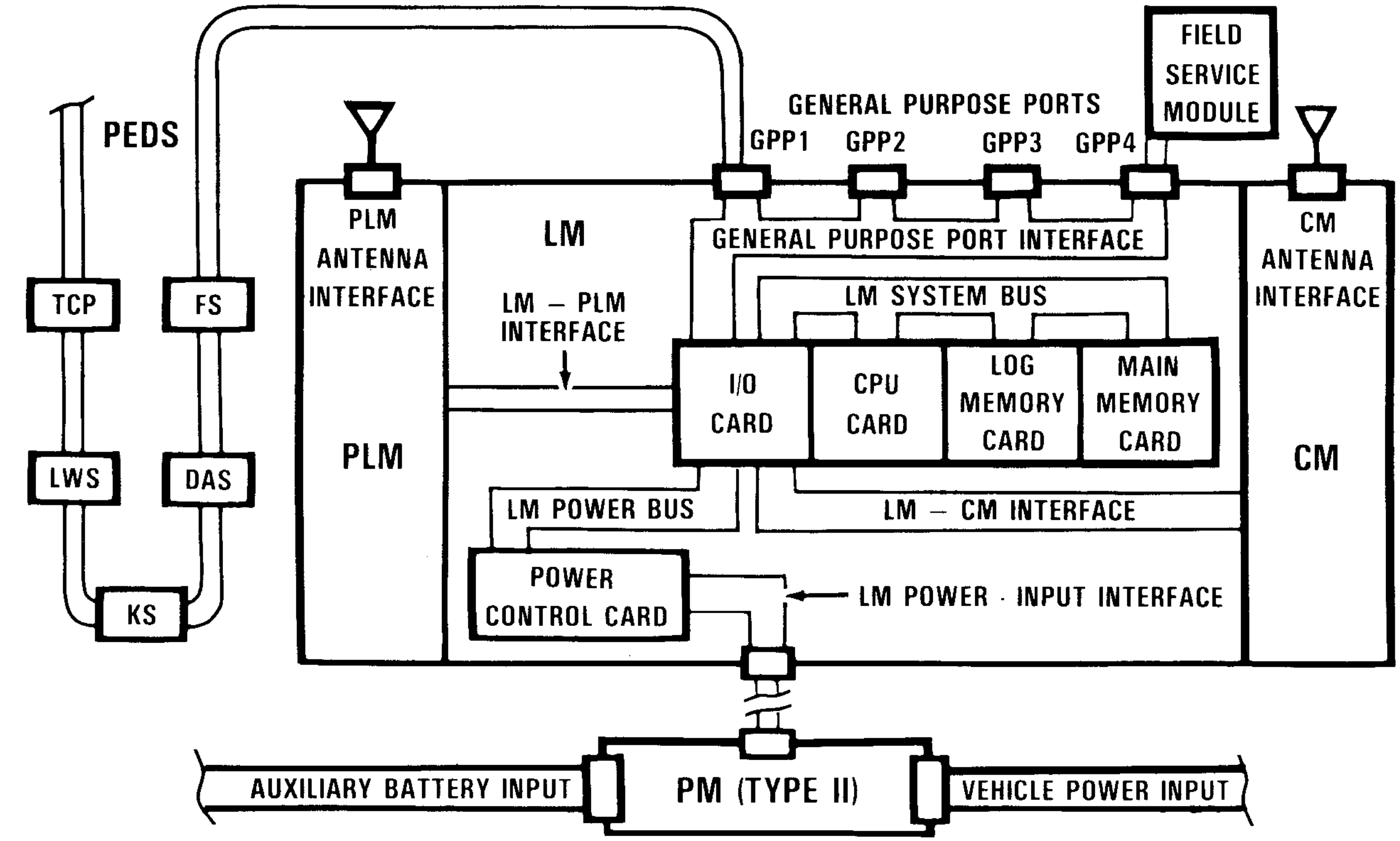


Figure 7

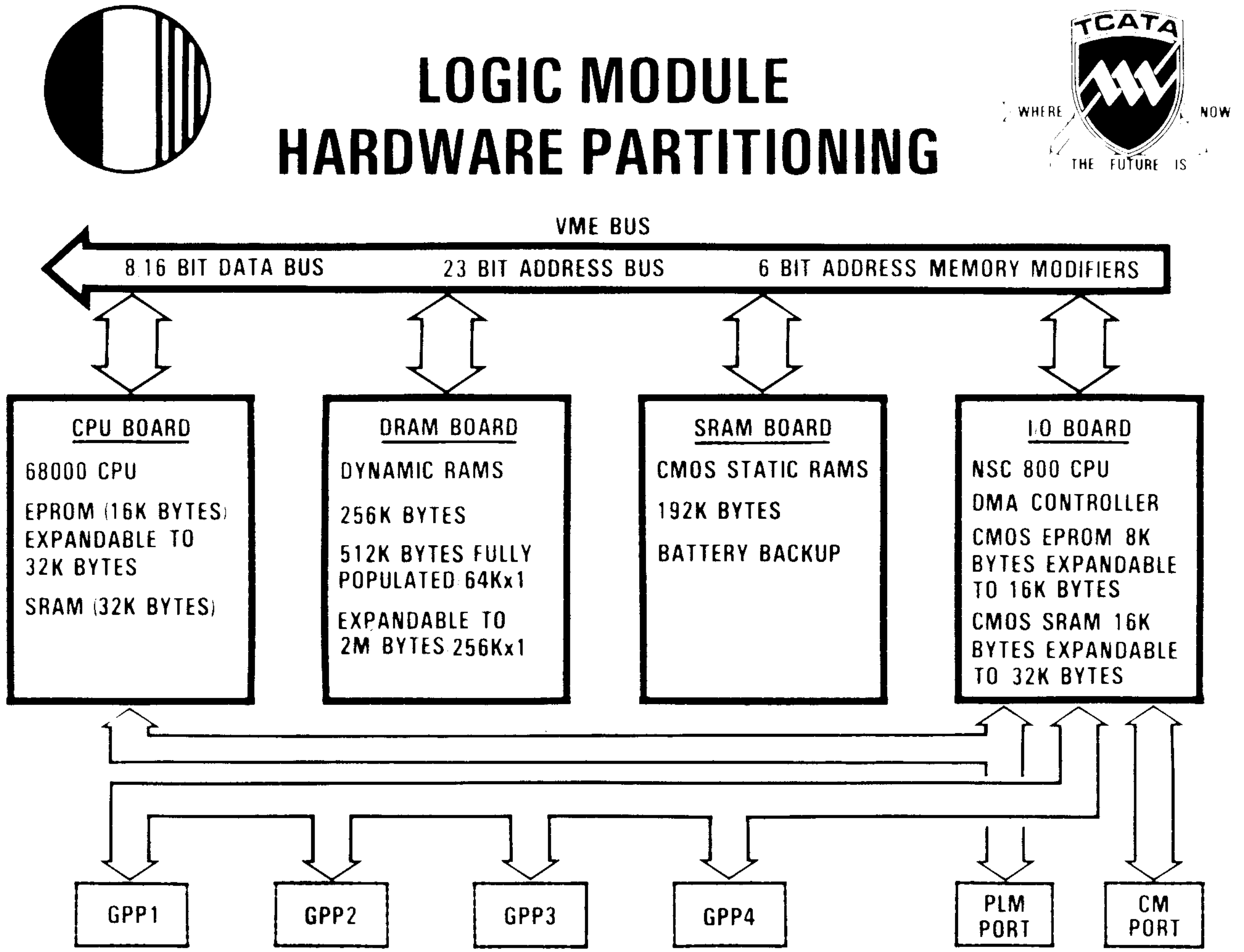

LOGIC MODULE
HARDWARE PARTITIONING
TCATA
WHERE THE FUTURE IS NOW
VME BUS
8/16 BIT DATA BUS
23 BIT ADDRESS BUS
6 BIT ADDRESS MEMORY MODIFIERS
CPU BOARD
68000 CPU
EPROM (16K BYTES) EXPANDABLE TO 32K BYTES
SRAM (32K BYTES)
DRAM BOARD
DYNAMIC RAMS
256K BYTES
512K BYTES FULLY POPULATED 64Kx1
EXPANDABLE TO 2M BYTES 256Kx1
SRAM BOARD
CMOS STATIC RAMS
192K BYTES
BATTERY BACKUP
I/O BOARD
NSC 800 CPU
DMA CONTROLLER
CMOS EPROM 8K BYTES EXPANDABLE TO 16K BYTES
CMOS SRAM 16K BYTES EXPANDABLE TO 32K BYTES
GPP1
GPP2
GPP3
GPP4
PLM PORT
CM PORT

Figure 8

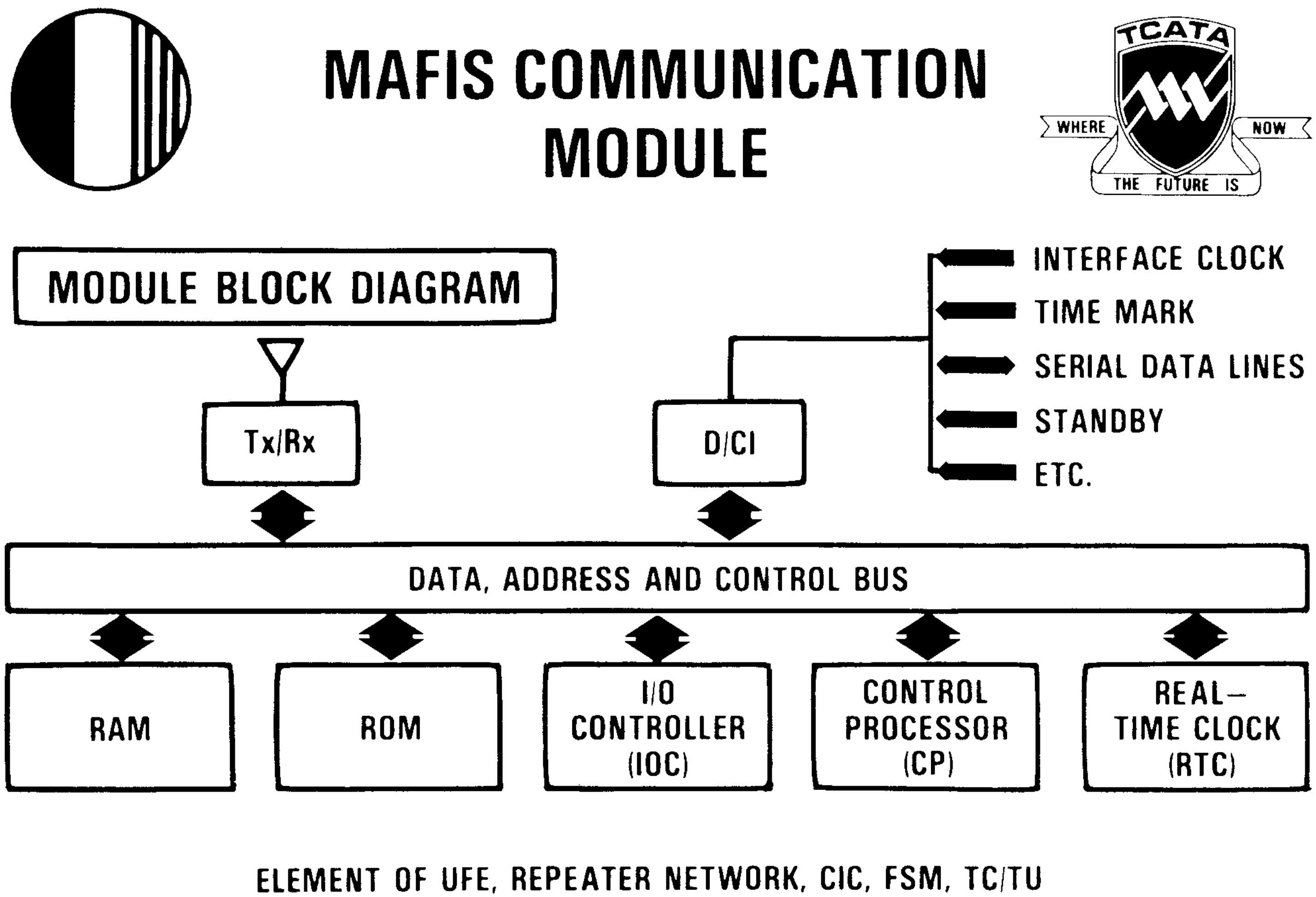
MAFIS COMMUNICATION MODULE

THE CM IS THE HEART OF THE COMMUNICATIONS NETWORK

NETWORK FUNCTIONS

- DISTRIBUTES C^2 INFORMATION TO TEST PLAYERS
- TRANSMITS TEST/PLAYER INFORMATION TO C^2 FACILITIES
- SUPPORTS FIELD MAINTENANCE AND TEST CONTROLLERS/UMPIRES

Figure 9



MAFIS COMMUNICATION MODULE
WHERE THE FUTURE IS NOW
TCATA
MODULE BLOCK DIAGRAM
Tx/Rx
D/CI
INTERFACE CLOCK
TIME MARK
SERIAL DATA LINES
STANDBY
ETC.
DATA, ADDRESS AND CONTROL BUS
RAM
ROM
I/O CONTROLLER (IOC)
CONTROL PROCESSOR (CP)
REAL-TIME CLOCK (RTC)
ELEMENT OF UFE, REPEATER NETWORK, CIC, FSM, TC/TU

Figure 10

MAFIS COMMUNICATIONS MODULE

GENERAL FEATURES

- INITIAL CONFIGURATION SUPPORTS UP TO 200 PLAYERS
- HIGH THROUGHPUT, HIGHLY RELIABLE, ERROR FREE COMMUNICATIONS PROVIDED
- NOISE/INTERFERENCE PROBLEM-REDUCTION PROVIDED BY SS MODULATION
- NETWORK REPEATERS USED TO COVER AREAS BEYOND LINE-OF-SIGHT
- FOUR TRANSMIT MODES PROVIDED
  - ON DEMAND
  - AT ASSIGNED TIME
  - TDMA
  - CARRIER SENSE
- D/CI PROVIDES
  - BIDIRECTIONAL
  - FULL DUPLEX
  - SERIAL
  - SYNCHRONOUS INTERFACE

Figure 11

MAFIS COMMUNICATIONS MODULE

TCATA
WHERE THE FUTURE IS NOW

SPECIFIC FEATURES

- TRANSCEIVER
  - PSEUDO–NOISE, DIRECT SEQUENCE, SPREAD SPECTRUM TYPE
  - 340-390 MHZ FREQUENCY RANGE
  - 20 WATT POWER OUTPUT
  - MSK MODULATOR
  - SOFTWARE TUNED
  - 400K BITS/SEC DATA RATE
  - 20 MHZ SIGNAL SPREAD

  USES AN/ARC-164 FOR DESIGN BASELINE
- PHYSICAL CHARACTERISTICS
  - 220 CU IN MAXIMUM VOLUME
  - 6.5 LBS MAXIMUM WEIGHT
  - 2 LBS MAXIMUM ANTENNA WEIGHT

Figure 12

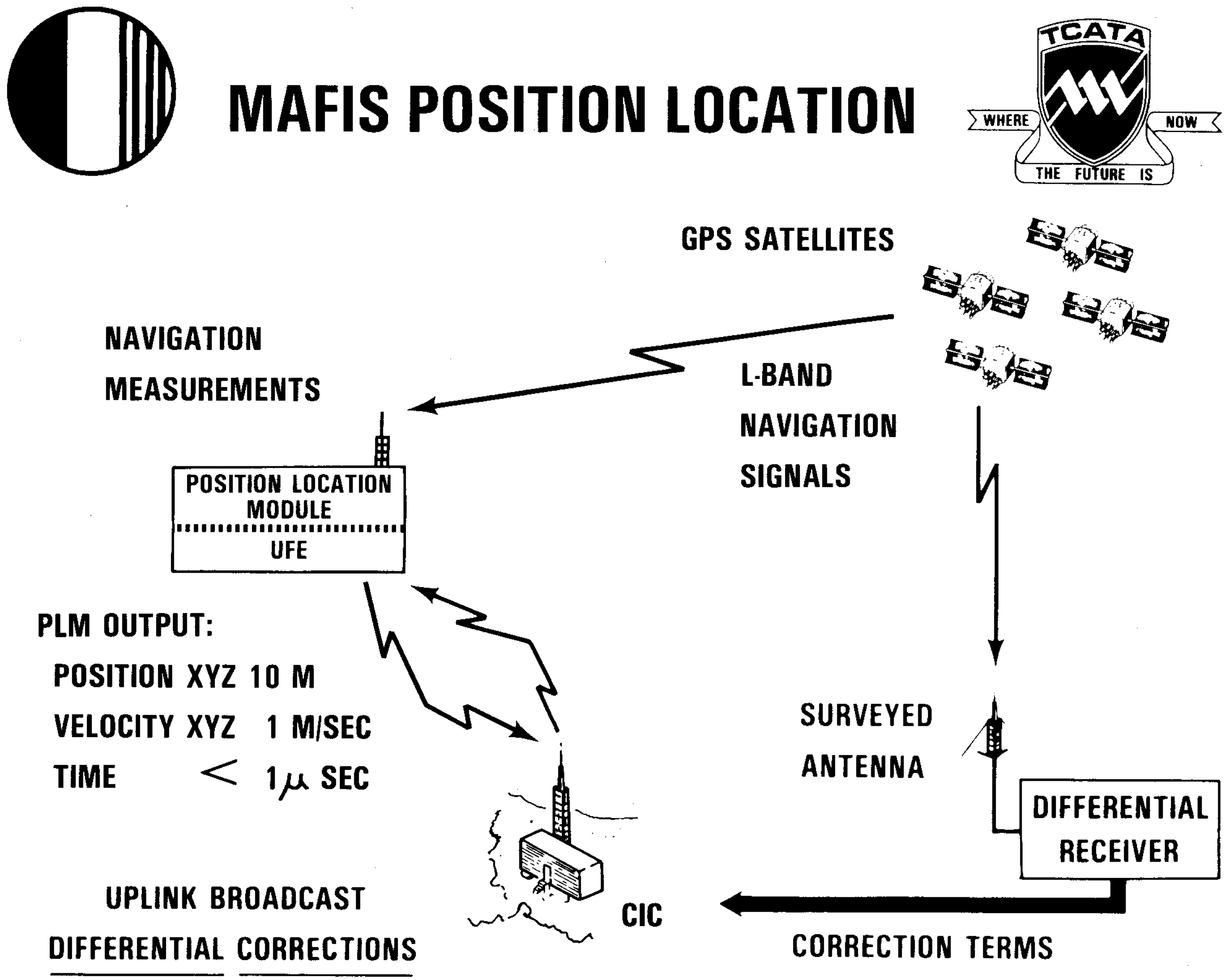

MAFIS POSITION LOCATION
TCATA
WHERE THE FUTURE IS NOW
GPS SATELLITES
NAVIGATION MEASUREMENTS
L-BAND NAVIGATION SIGNALS
POSITION LOCATION MODULE
UFE
PLM OUTPUT:
POSITION XYZ 10 M
VELOCITY XYZ 1 M/SEC
TIME < 1μ SEC
SURVEYED ANTENNA
DIFFERENTIAL RECEIVER
UPLINK BROADCAST
DIFFERENTIAL CORRECTIONS
CIC
CORRECTION TERMS

Figure 13