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TR-06-94
Mobile Computer Workstation Future Trends and Technology Development

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TECHNICAL REPORT

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NOTE: Further information about this report can be obtained by calling the CPRC information number (613) 998-6342

SUMMARY

The company of Fraser, Popovski & Associates Inc. was contracted to develop a common set of requirements for public safety agencies, in combination with a thorough industry review of current and emerging technologies. In order to accomplish this task, a survey of a large segment of the police and security community was conducted. The ensuing Standard(TR-03-94) is intended to define the elements and performance of the equipment in order to facilitate compatibility and standardization without limiting the design approach of individual suppliers.

This Standard defines the requirements for a mobile workstation from a hardware perspective. The requirements for application software, wireless communication and connectivity through radio systems are considered to a limited extend.

This Standard defines a mobile workstation device as an MS-DOS compatible computer, for installation in a vehicle, with a primary function of being a mobile data communications device. Even though the main function of the workstation is to serve as an integral part of the vehicle's radio communications system, it must be removable as well as capable for use as a personal computer.

In addition to this Technical Report are three others resulting from the contract work:

- Common Requirements for a Police Specific Enhanced Mobile Workstation(TR-04-94)

- Technology Developments and Industry Product Reviews for a Police Specific Enhanced Mobile Workstation(TR-05-94)

- Future Trends and Technology Developments for Police Mobile Workstations(TR-06-94)

The Canadian Police Research Centre would like to thank Mr. Robert Fraser, Mr. George Popovski, and Mr. David Burns of Fraser, Popovski & Associates Inc., the Committee members, Ms. Francine Boucher of the Royal Canadian Mounted Police, Mr. Peter Ungar of Peel Regional Police, and Constable Graydon Patterson of Ottawa Police, and finally, all those police and security agencies that participated in this very worthwhile project.

SOMMAIRE

Une entente a été conclue avec la compagnie Fraser, Popovski & Associates Inc. en vue de l'elaboration d'une série commune d'exigences pour les organismes de securite publique, en plus d'un examen approfondi des technologies actuelles et naissantes offertes par l'industrie. Afin de réaliser ce projet, on a fait un sondage auprès d'une grande partie de la communaute policière et des organismes charges de la securite. La norme qui suit(TR-03-94 vise à définir les elements et les caracteristiques du materiel afin de faciliter la compatibilité et la normalisation sans imposer de limites aux conceptions des fournisseurs individuels.

La présente norme definit les exigences d'un poste de travail mobile du point de vue du materiel. On y traite dans une certain mesure des exigences reliées aux logiciels d'application, à la communication sans fil et à la connectivité par des liaisons radioelectriques.

La norme definit un poste de travail mobile comme étant un ordinateur compatible avec le MS-DOS pouvant être installé dans un véhicule et servant avant tout de dispositif mobile pour la transmission des données. Même si la premiere fonction du poste de travail est de servir de pat-tie integrante du système de radiocommunications du véhicule, il doit être amovible et utilisable comme ordinateur personnel.

A cause des travaux de ce contrat trois autres rapports en résulte en plus du Rapport technique:

- Exigences communes reliées à un poste de travail mobile amélioré destine à la police(TR-04-94)

- Mises au point et examens des produits de l'industrie pour un poste de travail amélioré destine à la police(TR-05-94

- Tendances futures et developpements technologigues pour des postes de travail mobile destines à la police(TR-06-94)

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REPORT ON
FUTURE TRENDS AND
TECHNOLOGY DEVELOPMENTS
FOR
POLICE MOBILE WORKSTATIONS

February, 1994

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2. INTRODUCTION

This report is the final and concluding report in a series of investigative studies identifying the technical and operational parameters for an enhanced police mobile workstation. The Development Of Standards For Mobile Workstation Devices project was commissioned by the Canadian Police Research Centre and executed by an appointed Technical Steering Committee comprised of police community specialists and the consulting firm Fraser, Popovski & Associates Inc.

The objectives of this report are to provide insight on future directions for mobile workstation technology considering previous research of user requirements and industry developments conducted in earlier project phases. Furthermore, to provide recommendations for future studies and strategic planning to be conducted by the Canadian police community.

Previous reports include:

1. A report on common requirements for a police specific enhanced mobile workstation which reported the findings of a survey of over 50 police agencies across Canada.

2. A report on the Technology Developments and Industry Product Reviews of a Police Specific Enhanced Mobile Workstation which reported the current product offerings of the industry.

3. A Minimum Standard for a Police Mobile Computer Workstation which, based upon the findings of the police survey and industry study, presented a minimum specifications for a workstation.

2.1 User Requirements

Throughout the course of this investigation a general description of the requirements for an Enhanced Mobile Workstation has been obtained. Although specific requirements may differ from agency to agency, the majority of requirements are common and have been reported.

The Standard for a Police Mobile Workstation was created by combining the common requirements of police agencies with the current product offerings of the industry.

The police agency questionnaire addressed such issues as:

1) the ergonomic parameters of the keyboard, display, and sub-system components of the MWS

2) environmental considerations of temperature, vibration and shock

3) general information regarding the size and level of computer automation of each agency

4) investigation of current data communication applications and uses

5) deriving general opinions of future application and uses for a MWS

The above items were re-addressed and quantified in the Minimum Standard for a Police Mobile Computer Workstation document.

Many of the envisioned future applications of a MWS involve wireless data communication. The technical feasibility of these potential applications is in a large part dependent upon the sophistication of the supporting radio communication infrastructure and not directly related to MWS parameters. As a result it has been difficult to postulate the workability of some potential applications not knowing the future means by which wireless connectivity will be achieved.

We will examine both radio data communication and connectivity to centralized databases, as well as an alternative vehicular database mass storage system in the following.

3. MAJOR TECHNOLOGY DEVELOPMENTS

3.1 CPU Architecturerrs

Recent advancements in microcomputer CPU architectures are probably the most significant technological advancement of the mid 1990's. They are directly responsible for the much anticipated multimedia revolution in personal computing.

The end of 1993 saw the emergence of commercial portable computers equipped with 486-DX 33 MHz processors representing approximately 10 MIPS of processing power - a 10 fold increase over the previous year. By the end of 1994 we estimate the availability of RISC or Pentium based portable computers with over 100 MIPS of processing power. All of these machines are being designed to interface with industry standard components, such as video systems, disk drives, and PCMCIA cards, and as a result they are remaining competitively priced even as they increase in complexity.

Such growth in readily available cost effective computing power, close to an order of magnitude per year is unprecedented. Not only is raw CPU power increasing - new fabrication techniques such as 0.6 micron 3.3 volt geometry's will provide this class of CPU low power consumption for portability.

Some of the major players are IBM, Motorola and Apple with their Reduced Instruction-Set Computer (RISC) PowerPC microprocessor and Intel's Pentium, which is currently being made at 0.8-microns. The PowerPC is presently being manufactured at the 0.6-micron geometry with a die size and power consumption of far less than the Pentium. Intel plans a redesign of the Pentium at 0.6 microns, the P54C, before the 3rd quarter of 1994. Both microprocessors in their current configuration exceed 100 MIPS with newer versions promising more.

Another player, AT&T, was first out of the gate with a chip called Hobbit, a RISC processor optimally designed for low-power personal communicators. Eo Inc., a startup partially funded by AT&T, soon followed with a Hobbit-based Personal Digital Assistant (PDA). And now both NEC and Toshiba are planning similar devices built around AT&T's CPU. While AT&T clearly has the jump on other chip companies, Intel and MIPS Technologies are moving quickly to challenge AT&T's momentum. Intel is reportedly co-developing a low-power, high-speed processor with VLSI Technology, a Tempe,

Ariz. based firm that specializes in power-managed chip sets for notebook PCs. The new chip will most likely use some of the Pentium structures.

The Hobbit was originally built for Apple to incorporate in an early version of Newton, but after a falling out with AT&T, Apple passed it over in favor of the ARM processor manufactured by the British firm Advanced RISC Machines Ltd. (ARM). There is still speculation that future Newtons may be based on the Hobbit because the AT&T chip is faster and better-suited to communications tasks than the ARM RISC chip used in the first Newtons

The Hobbit and ARM CPUs were specifically developed for the growing PDA market, do not run the DOS operating system, and do not approach the power of the Pentium or the PowerPC chips. It is the introduction of these former CPUs into portable computing devices that will significantly alter the man-machine interface with computers. Visionaries and marketers refer to this as a "new paradigm" in personal computing.

3.2 CD-ROM Technologies

In 1990 there was less than 500 published CD-ROM titles and a CD-ROM player cost more than $1000. Today there are more than 5000 titles and a high speed reader cost less than $200.

Most PC manufacturers are now including CD-ROM drives in their standard product PC configurations. This month the standard is double-spin speeds for higher reading throughput to the computer. Within six months the standard will be triple-spin or quad speed drives.

Pioneer New Technologies Inc. has recently introduced what it calls the world's first four-speed drive, the DRM-604X. The $1,845 US jukebox-style device holds up to six CD-ROMs totaling 3 Gbytes of on-line storage.

A complete CD-ROM publishing system cost less than $5,000, down from $50,000 three years ago. Production disks cost less than $1 to publish. CD-ROM has been called "the new papyrus".

One of the reasons for such growth has been from software manufacturers. It is far cheaper to publish a CD-ROM containing

all installation software and documentation for a product than it is to provide hard copy manuals and many high density floppy disks. As a result more and more software application programs are being distributed via CD-ROM.

In fact some software distributors are packaging many different programs on one disk and allowing customers to "try out" programs before purchase. When a purchase is made a unique key is obtained by the purchaser allowing the program to operate in full feature mode.

The most prevalent application of CD-ROM is database publication. Almost anything can now be obtained from full encyclopedias to celestial star charts, world atlases, and magazine racks, to the complete works of William Shakespeare.

The low production and publication costs of CD-ROM databases may be of interest to public safety agencies. We will examine this thought further in the next section of this document.

3.3 Hard Drives

Even though the dominant mass storage devices of the distant future will most likely be based totally on solid-state technology with no moving parts, advances in the development of miniature mechanical hard disk drives for mobile workstations continues at a very rapid pace. In 1992 Hewlett-Packard Co. pioneered the technology for **1.3** inch platter miniature high performance drives by introducing a 21.4 M bytes model measuring 2 inches by 1.44 inches by .4 inches and weight of only 1 ounce.

Only one year later, uniform industry standards for the technology were in place and several manufacturers (IBM, Maxtor and Seagate Technologies) have recently announced 1.3 inch drive models, scheduled for delivery in the first quarter of 1994.

In September of 1993 HP announced a second generation 1.3 inch hard disk drive with a capacity of 42.8 M bytes, a remarkable operating shock resistance of 150 G and identical size and weight as the earlier model. It is expected that the advances of the 1.3 inch hard disk drive technology will continue with increase of capacity and lower prices. The current price of U.S. $ 10 per megabyte is expected to drop to U.S $3 per megabyte by 1995.

The more conventional 2.5 inch compact hard disk drives currently used in most of the portable computer workstations are undergoing constant improvement leading to ever increasing capacity and performance. The common magnetic recording media on aluminum platter is being replaced with the new rugged glass substrate disks, allowing greater shock stability and overall reliability required for the demanding mobile workstation environment. The present state-of-the-art 2.5 inch hard drives have capacity of up to 260 M bytes. It is expected that 380 M bytes 2.5 inch drives for portable computers will be available by 1995.

Recognizing the demanding operating environment of the modern mobile computer workstations, the manufacturers are developing various technologies for increasing the capacity and the ruggedness of the miniature hard disk drives. In addition to utilizing glass magnetic media substrates and different methods for temperature compensation for extending the operating temperature range of the drives, some manufacturers are experimenting with thermostatically controlled heating elements and active shock sensing to achieve even more impressive levels of performance.

Of particular interest is the active shock sensing technology considered for implementation by several leading drive manufacturers. The active shock sensing technique, involves accelerometers to detect the incoming shock and to activate a mechanism which temporarily interrupts the drive operation and mechanically restrains the read/write heads to prevent damage and protect data integrity. It is reported that prototype drives employing the technology have achieved operating shock stability of over 200 G. 3.5-inch ruggedized drives with active shock sensing are already on the market. It is only a matter of time for the technology to be adapted for smaller drives unless high capacity solid-state read/write technologies appear sooner than anticipated.

All solid-state mass data storage devices are currently available on the market packaged as PCMCIA cards. The storage modules employ several different technologies, including flash memory, battery backed RAM and Static RAM (SRAM). At the present only small data capacity (2-3M byte) PCMCIA memory cards are available at reasonable cost. Larger devices with capacity of 10 -40 M bytes are available, but are expensive. It is expected that 70M bytes flash memory cards will be on the market in the very near future. Even larger capacity solid-state storage devices will quickly

become available as a result of the expected advancement of the present semiconductor technology.

The all solid-state data storage devices are faster, use less power and are more rugged than the conventional mechanical hard drives. It is expected that with improved manufacturing efficiency and increased volumes of production the prices of the memory cards will proceed to drop and eventually will become equal to those of the best mechanical hard drives with similar capacity and performance.

4. FUTURE TRENDS

This year will represent a redefinition of the basic architecture of the PC. By 1995 and into the second half of the decade, PC is destined to mean machines based on incredibly fast RISC-influenced, superscalar CPUs running portable 32-bit, multitasking operating systems.

The implications of such a change will no doubt result in an overall improvement to existing software applications, graphical user interfaces and multi-media computing. We believe the most significant result of this increase in computing power to the police community will be in the application of computer pattern recognition.

4.1 Pattern Recognition

For the purposes of this report we loosely define pattern recognition as a process where a digital representation of an analog source is assembled for analysis and comparison by a computer. This includes computer voice and image recognition, optical character recognition (OCR) and pen based computer handwriting recognition.

For well over a decade algorithms for pattern recognition have improved with advancements in such areas as Fractial imaging and Neural Networks. Unfortunately, these algorithms remain mathematically intensive routines, and as such, the computing power to execute these routines for real time human interaction has not been available in the standard PC architecture.

Although the Intel 486 architecture and the specialized RISC based processors mentioned above allow for limited voice, character and handwriting recognition routines to run sucessfuly on PCs and PDA's (Personal Digital Assistant), they are limited in “vocabulary”, prone to error, and not suited for public safety application.

Currently, successful implementations of pattern recognition execute on specialized digital signal processors offering on average 40 MIPS of processing power. These implementations will be transported to the new generation of 100+ MIPS PC microprocessors allowing for a complete redefinition of human interaction with PC based computers.

For example, the following PC subsystems are completely technically feasible and now cost effective.

A background task for a Pentium based police mobile workstation could be to scan the video frames from a standard video camera mounted on the dash of the police vehicle. The camera, pointing forward, would capture frames containing the license plate of either the oncoming traffic or any vehicle being followed. The character recognition task would extract the license plate number and query a database. If any information regarding the vehicle should be presented to the officer the workstation would present the alert and information.

Another now possible task could be a voice interaction sub-system where the officer has been trained to communicate with the computer in a similar fashion to radio communication procedures (i.e. 10-4). This would allow for hands-free operation of potentially all vehicle systems including lights, siren, and voice radio. Database queries could be managed through an interactive voice script, with the computer confirming all voice inputs before initiating the query or action. The recognition algorithm can be designed to be either speaker dependent or independent.

The new level of processing power will allow pen-based computers to recognize continuous script writing with little training. Although, the long awaited pen-based computer revolution may be overstepped by a combined touch screen · voice recognition interface.

4.2 Mass Storage

As outlined in the previous section, CD-ROM publishing and production technologies are now extremely cost efficient. Research organizations who previously leased access time on large information databases are finding the purchase of CD-ROM infobases for in-house use more cost effective. As further penetration into consumer markets occur the costs of this technology will decrease even more.

The low cost of publication and distribution of CD-ROM poses an interesting question for public safety organizations. Can the cost of radio system infrastructure expansion to accommodate future requirements for text and graphical information transmission to the patrol vehicle be justified in light of potential alternatives of CD-ROM distribution?

Our research indicates the approximate cost for a trunk mount CD-ROM storage system of 3,000 Mega Bytes is about $3,000 +/- $1,000. The cost of publication is about $1 per CD-ROM. Many unbreakable encryption algorithms exist, each of which can provide information security and render the CD-ROM unusable unless the appropriate security keys are known.

Furthermore, what are the future applications for police radio data communications - is the transmission of graphical information a requirement, and if so, what amount of data, what channel bandwidths will be required, and is there sufficient spectrum available? In addition, can or will the proprietors of the existing or future databases used by police agencies allow for weekly or daily publication via CD-ROM?

Clearly the advent of this new medium may be of significant benefit to police field operations but many non-technical obstacles exist.

4.3 Spectrum Utilization for Public Safety

Presently, Industry Canada's (IC) spectrum bandwidths for mobile radio in the VHF band is **30 KHz.** and **25 KHz** in the UHF band. These bandwidths will be reduced in the near future. Manufacturers currently supply data modems which operate at these bandwidths with data rates of 4.8 Kbps to **12** Kbps.

APCO project **25** has selected, in all bands, 12.5 KHz channel bandwidths to be reduced later (i.e. 10 years) to 6.25 KHz. for integrated voice and data transmission. With error correction and control the effective data rate for these channels will be in the range from 2.4 Kbps to 7.2 Kbps.

In the distant future (10 years+) FDMA is not likely to remain a method for increasing spectrum efficiencies. Initially the dominant channel access method will be Time Division Multiple Access, TDMA. A 25 KHz channel can be simultaneously shared by five **or** more users. At present TDMA allows circuit switched data transmission at 4.8 Kbps effective rate with error correction. Packet switched data can be transmitted on a TDMA 25 KHz channel for 4 to 6 users simultaneously at effective rates of 20 Kbps.

It is most likely that TDMA will be replaced by CDMA **(Code** Division Multiple Access) as the dominant method for spectrum

sharing. CDMA or spread spectrum promises the highest spectrum efficiency and data transmission rates.

The future expansion of radio spectrum for public safety will be in the frequency bands above 1000 MHz. Beginning in the next decade there is a strong indication that for urban communications the frequencies above 10 to 20 GHz will be extensively used. This is the only area where the bandwidth requirements for 100's of Kbps transmission rates are feasible. The limited propagation characteristics of these frequencies will require extensive infrastructure consisting of many micro-cells.

These future directions of regulatory policy will impact the potential for innovation of field information delivery technologies.

5. RECOMMENDATIONS AND CONCLUSIONS

Technology changes in microprocessor and portable computing devices seem to be ever-advancing. At first glance, and generally speaking, this is true. If so, it is then difficult to justify purchase of this technology knowing very well it will be obsolete before it is commissioned.

Alternatively, if one obtains a historical view of revision combined with the present day synergy's of corporate joint ventures, technology sharing agreements, and market demands, it is possible to uncover trends and gain sufficient knowledge to optimize the timing when one "gets aboard'.

Additionally, evaluation of the state-of-the-art is only a small portion of the overall process. User requirements and needs are, of course, the primary focus.

The forces behind these changes are not so much due to the demands of existing users of mobile data terminal technology, as they are due to the general commercial market forces of combined communication, computation, and mobility, driven by stakeholders who pledge productivity enhancement.

During the course of our research we believe we have uncovered a scenario where significant advancements to many of the sub-systems within the architecture of a Mobile Workstation Computer will create dramatic changes to the traditional concept of what a mobile computing device is and how a user interacts with it.

We perceive many new products being introduced in 1995 combined with the cohesion of supporting standards. By 1996 the new standards and successful products will define the de facto by which all industry will aspire. The basic building blocks used to develop these new devices will be similar, but the form factor and application software will enable a wide array of application specific devices.

In practical terms, we recommend that agencies who have defined their needs and are in the process of acquiring new mobile computing technologies in 1994 should continue to do so, and use portions of the Minimum Standard for a Police Mobile Computer Workstation specification for definition. Those who are planning purchases in late 1995 should postpone their purchase and wait,

perhaps a year, for the new generation of computing devices to stabilize.

Police field workers have sufficient market proportions to gain the attention of some of these "application specific manufacturers". As a result, the police community should continue with internal definition of requirements in light of new innovations such as voice recognition.

A better definition of graphical data usage and field delivery methods is also required. This includes radio spectrum requirements, radio system infrastructure requirements, and options such as CD-ROM.

As the commercial/consumer momentum behind the convergence of wireless communication and mobile computing increases even further, public safety organizations - perhaps the first users of mobile radio communication - will be one of the many benefactors.