

ARIES-II IMAGE ANALYSIS SYSTEM AND THE NEW ADVANCED
IMAGE PROCESSING ARCHITECTURE FOR THEMATIC MAPPER
AND SPOT DATA

Vijay Dubé, P.Eng.
Marc A. Schindler, B.Sc.
DIPIX Systems Limited
Canada
Commission II

A B S T R A C T

ARIES-II is a proven image analysis system used extensively for remote sensing. The ARIES product line consists of a user-friendly workstations ranging from peripheral workstations which operate on a user's host computer, to stand-alone workstations with integral computer, and network workstations to add extra processing power. Extensive application software and a well structured programming environment make ARIES an extremely operational and flexible system. Development of a new high speed bus and advanced display architecture augment the DIPIX image processing system to provide high speed processing of larger images.

INTRODUCTION

DIPIX Systems Limited manufactures and markets the internationally recognized and proven ARIES-II Image Analysis System with a comprehensive configuration of equipment and computer software programs for resource data handling, thematic land use plotting meteorological monitoring and interactive image analysis using remote sensing techniques. As well, the higher resolution of the LANDSAT 4 Thematic Mapper and the SPOT Satellite due to be launched in the near future present new opportunities for the remote sensing scientist and the operational user.

A user can choose from an entire family of ARIES systems, ranging from stand-alone image analysis systems with integral processors to a network of distributed multi-processor workstations on a host computer. Both stand-alone systems and workstations are available in entry-level configurations for turnkey image analysis operation or with integral processing power ranging from the LSI-11/23 upwards through the PDP-11 series to the VAX-11/780 "super-mini" computer. Workstations are also available which run on customer-supplied PDP-11 or VAX-11 computers.

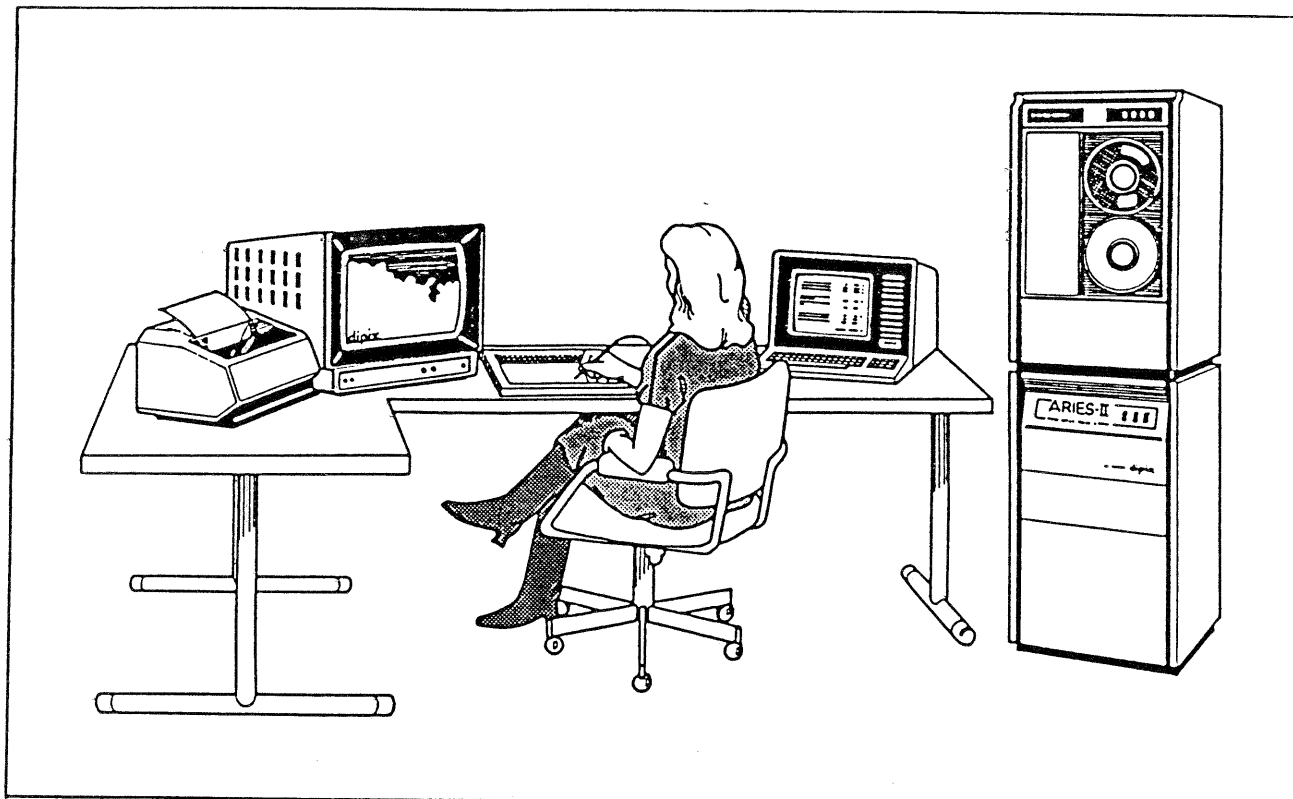


FIGURE 1. THE ARIES-II DIGITAL IMAGE ANALYSIS SYSTEM

Features and benefits of the ARIES-II:

- . more than 100 man-years of software developed in-house under uniform and strict guidelines have resulted in proven, comprehensive software packages that truly satisfies a user's needs and which install quickly and easily for turnkey operation;
- . user-friendly interaction, both through menu-oriented software and interactive peripherals; software is easy to learn and use;
- . hardware which is based on DIPIX's unique Image Display Subsystem, computers accepted world-wide from Digital Equipment Corporation (DEC), and advanced, image, mapping and input/output peripheral equipment, all integrated in DIPIX's factory;
- . total maintenance and training support world-wide;
- . unique system architecture which provides superior speed and data handling capabilities and efficient processing of large images.

ARIES-II CONFIGURATION OVERVIEW

The single-workstation ARIES-II system is a stand-alone image analysis system, and forms a building block to larger multi-station configurations. All ARIES-II systems encompass the following design philosophy:

- The proposed solution must fit the end-user's requirement;
- Overall design must be essentially conservative without compromising performance or cost;
- The system must be reliable and easy to maintain;
- System operation need not require expertise in computers and electronic engineering;
- System must be planned for expansion;
- Compatibility between image analysis systems must be maintained as far as possible.

SYSTEM CONFIGURATIONS

ARIES-II systems are composed of a versatile range of configurations of four basic subsystems, augmented by optional peripherals. These basic subsystems are:

ARIES-II Image Display Subsystem (IDS) The Image Display Subsystem consists of video display electronics, dynamically allocatable video memory, a dedicated display control processor, a high resolution colour monitor (TV-H) and a graphics control tablet. The video display subsystem is the core of the ARIES-II system, providing manipulation and display of images.

The video display subsystem is a self-sufficient entity. Once an image has been downloaded into the display subsystem, via the host bus, the display subsystem places no further demands on the host CPU. Image display functions, such as smooth continuous zoom, roam, scaling, overlay and lookup table operations are performed locally within the video display subsystem, under the control of the digitizing tablet. The control tablet is an 11" x 11" (28 cm x 28 cm) digitizing tablet which provides the full range of control functions normally associated with trackballs, joysticks and function pads.

The colour monitor can be any RS170 525 line 60 Hz standard monitor accepting red, green, blue and sync inputs. A range of monitors is supported, from small size low cost 13" monitors to 19" studio monitors.

Computer Subsystem (CSS) The Computer Subsystem consists of a general purpose computer, with its associated multi-user operating system memory, floating point unit and serial interface ports, as well as a VGT-100 operator's video graphics terminal, a PRISM

operator's console printer and, optionally, an array processor. The terminal and printer are also referred to collectively as OT-1.

The general purpose multi-user computer is one of the Digital Equipment Corporation (DEC) series, ranging from the LSI 11/23 through PDP 11/24, PDP 11/44, to the "super minis": VAX 11/750 and VAX 11/780.

The standard operator's station consists of a black and white graphics terminal and a hard copy workstation log device. The graphics terminal is used by the ARIES software package (A2ASP) for operator dialogue and for graphics output. The workstation log is used by A2ASP for hardcopy output, such as tables, and for recording all system events, such as error message, task entry and exit and file creation and deletion. In addition, a screen copy facility is provided, allowing both alphanumeric and graphic output to be copied from the terminal to the hardcopy log.

Image Storage Node Subsystem (ISN) The Image Storage Node consists of a disk controller plus a disk drive. This disk drive is segmented, under a combination of software and hardware control, to appear to the operating system as two separate devices, referred to as logical disks. The first of these logical disks serves as the boot device for the CSS, and also holds the A2ASP system tasks. The second logical disk is used as a bulk foreign image storage disk. An ISN may incorporate more than one disk drive.

ARIES-II Applications Software Package (A2ASP) Three software packages are available with ARIES-II. The basic software package (A2ASP/B) contains all the routines necessary to support a turnkey image analysis system. This package is included in the basic price of the Image Display Subsystem. An additional set of software, the extended software package, (A2ASP/X), contains additional tasks that add considerable scope to the power of the system. For users who intend to develop their own specific application-oriented software, the extended software package comes in two additional formats besides run-time object code: the Library Package (A2ASP/LS) is available. This package provides the user with over 120 FORTRAN - callable subroutines in a library, with capabilities to interact with image film, the Image Display Subsystem, and other parts of the ARIES-II system; additionally, the actual application task source code is also available (A2ASP/S). Additional libraries of specialized tasks intended for unique applications is also available.

Various combinations of these modules, together with optional peripherals constitute a complete ARIES-II system configuration. The actual ARIES-II configuration selected is dependent on the user's functional requirements such as system throughput, functionality, maintainability, and of course, budget. As well, an array processor can be configured as an additional part of the computer subsystem. This could be useful in certain situations where considerably more calculations are required than normal in an image analysis environment.

WORKSTATION CONFIGURATION

ARIES-II systems fall into three classes, "Single Processor" systems, "Peripheral Workstation" systems, and "Network Workstation" systems. Within each class a wide variety of options is available and moreover a Single Processor system is generally upwards compatible to a workstation system, and a Peripheral Workstation system is upwards compatible to a Network Workstation system.

Single Processor System A functional block diagram of a Single Processor system is shown in Figure 2. Here the single Computer Subsystem is responsible for all processing activity. It controls movement of image files between the Image Storage Node and any of the optional peripherals or the Image Display. It performs image processing on a disk-to-disk basis by transforming source image files on the Image Storage Node to destination image files also on the Image Storage Node. It fields all operator interaction with the system.

The Single Processor systems can have one of several Computer Subsystems (CSS, from DEC LSI 11/23 to VAX 11/780). Along with supporting the Image Display Subsystem, the single processor systems also support a variety of peripherals.

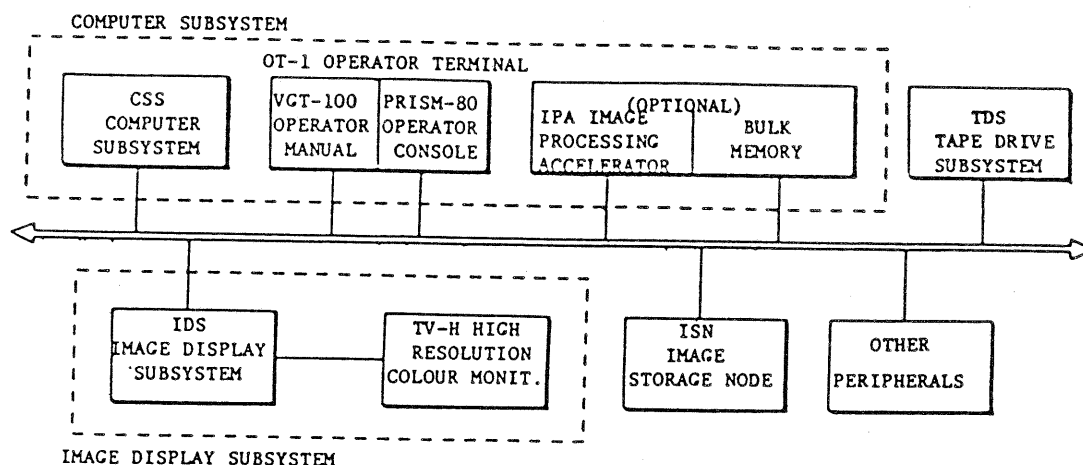


FIGURE 2. ARIES-II CONFIGURATION: SINGLE (STAND-ALONE) PROCESSOR SYSTEM

Peripheral Workstation Configuration A functional block diagram of a typical Peripheral Workstation ARIES-II configuration is shown in Figure 3. The diagram shows an Image Analysis Workstation comprised of an optional Image Storage Node, Peripherals and an Image Display Subsystem, linked via an interface to a Host Computer bus. Each Image Analysis Workstation (and there can be more than one) is a dependent ARIES-II configuration. The host computer in this configuration is usually a larger computer, such as a PDP 11/44 or one of the VAX series.

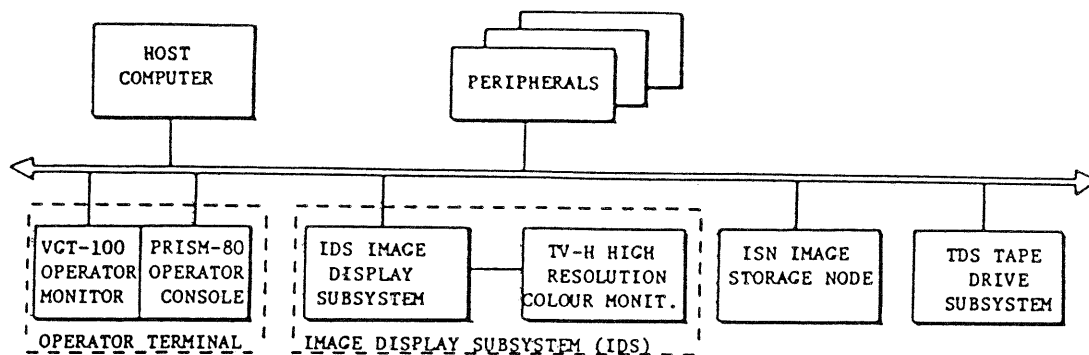


FIGURE 3. ARIES-II CONFIGURATION: MULTI-PROCESSOR SYSTEM (PERIPHERAL WORKSTATION)

Optional peripherals can also be attached to the Host Computer bus. Any Image Analysis Workstation may use these peripherals as required, by raising a request to the Host Computer to move data between the chosen peripheral and the Image Storage Node associated with that Image Analysis Workstation.

Network Workstation Configuration A functional block diagram of a typical Network Workstation ARIES-II Configuration is shown in Figure 4. The diagram shows an Image Analysis Workstation consisting of a Computer Subsystem, Image Storage Node, Peripherals, and an Image Display Subsystem. The workstation is linked via the second port of the Image Storage Node to an interface which connects to a network node. Each Image Analysis Workstation (and there can be more than one) is equivalent to a single-processor ARIES-II configuration, capable of stand-alone operation in its own right. The host computer in this configuration is usually a larger computer, such as a VAX.

Optional peripherals can also be attached to the Host Computer bus. Any Image Analysis Workstation may use these peripherals as required, by raising a request to the Host Computer to move data between the chosen peripheral and the Image Storage Node associated with that Image Analysis Workstation.

Multi-processor systems, both Peripheral Workstation and Network Workstation configurations, are truly multi-user. They can support up to 16 Image Analysis Workstations, each dedicated to an independent user. Each user is fully protected from the others or, for that matter in the case of the Network Workstation Configuration, from failures of the Host Computer itself.

Network vs. Peripheral Workstations Network and peripheral workstations are designed to be used in different circumstances. A few examples provide some illumination.

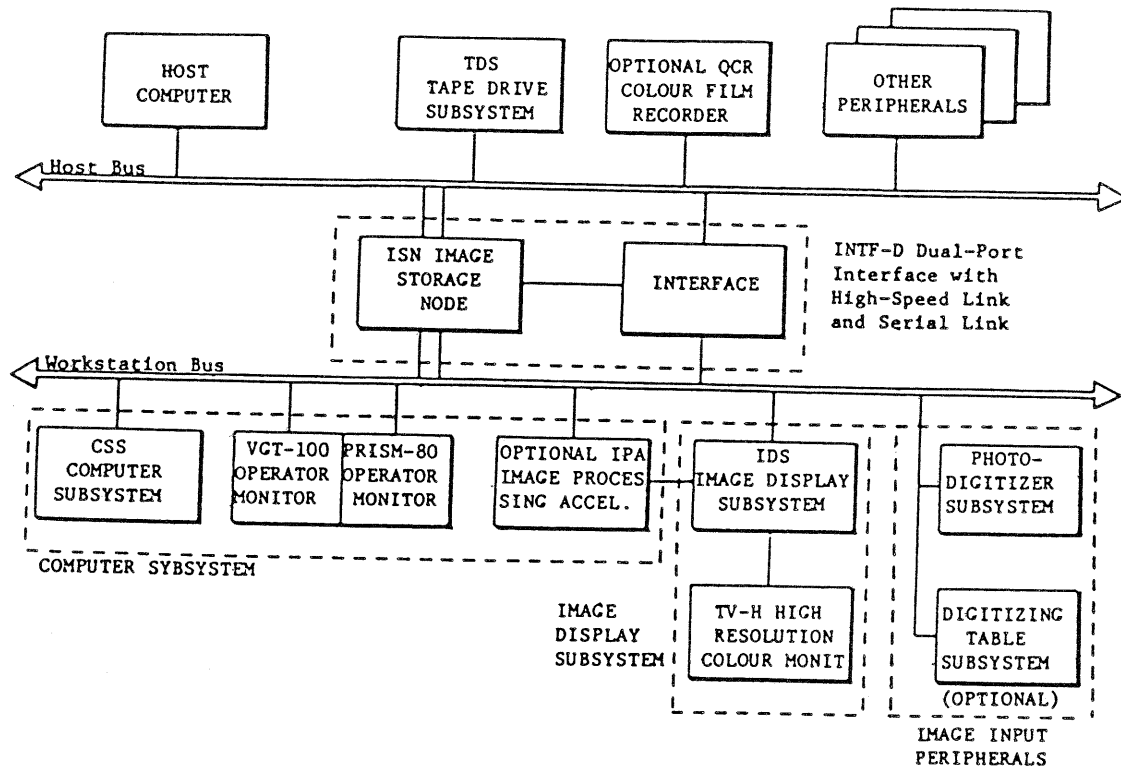


FIGURE 4. ARIES-II CONFIGURATION: MULTI-PROCESSOR SYSTEM (NETWORK WORKSTATION)

If a customer has a host which is heavily loaded during the day, but available at night, a network workstation would be the best choice. Processing jobs generated during the day can be either processed locally on the network workstation CPU, or queued for processing at night on the host. In addition, the network workstation need not have its own tape drive, as the A2ASP software will allow the workstation user to access the host tape drive.

Since the network workstation is interfaced to the host via a dual ported disk, little overhead is introduced by submitting a job to the host, as the data to be processed are visible to both systems.

If a customer has a powerful host which is either dedicated to image analysis, or not heavily used, then a peripheral workstation may be indicated. A peripheral workstation on a powerful CPU will function faster than a network workstation on a less powerful CPU, and will tend to cost less as well.

Peripheral and network workstations may be mixed in a single system. In larger configurations, it is highly recommended and in some configurations mandatory, that at least one peripheral workstation be included on the host. This workstation would be used primarily to control batch processing and common peripherals. As an absolute minimum, a host system must have an operator's station from which batch processing is controlled.

ARIES-II SYSTEM SOFTWARE

This section provides a detailed description of the ARIES-II Application Software Package (A2ASP), highlighting its unique design features and its comprehensive set of image manipulation, enhancement, and classification tasks.

SOFTWARE POLICY "The worth of any computer based system is largely a function of the quality of its software". DIPIX Systems Limited takes great pride in the quality and integrity of its software and traditionally has put a major effort into software design and configuration control. The entire A2ASP represents over 100 man-years of software development effort.

PERFORMANCE System performance is determined by the capability of the hardware and by the quality of the software. Generally, for Image Analysis Systems, speed is of essence and software must be optimized to return the best speed performance consistent with availability of system resources, ease of use, flexibility and maintainability. ARIES-II software has been optimized for speed wherever applicable without adversely affecting the two remaining objectives listed below. Software design which is hardware-resource hungry is poor design. ARIES-II software utilizes hardware resource in a manner which is both efficient and cost-effective.

Software which is prone to failure is hardly suited to an operational environment. The production of error free software is aided through adequate attention being given to quality control during software testing and debugging. Nevertheless, only well designed software which has been extensively used in the field will attain an error-free status consistent with an operational environment. ARIES-II software has a release history going back over many years with continual feedback to the designers from application oriented users. Over the period, ARIES-II software has developed into an extremely relevant and mature software package.

EASE OF USE Software must be designed to be easily used by personnel without computer expertise. This is ensured by insisting that all operator interaction be in the form of clearly prompted plain language instructions, by careful checking of operator responses for error, and by the provision of a comprehensive, easy to follow operator's manual.

MAINTAINABILITY System software must be easy to maintain particularly with a view to expanding the software package to include new functions. ARIES-II software maintainability is enhanced through:

- a) Provision of excellent software documentation, mainly in the form of self-documenting source code.
- b) Use of a highly structured approach to software generation using standards refined over many years and proven in many different projects.

- c) Use of ANSI FORTRAN wherever possible, the only exceptions being microcode in the Array Processor and some assembly code in time critical areas of other processors constituting ARIES-II.
- d) The provision of a large library of FORTRAN callable common software routines. Most of these routines have been especially developed for image processing requirements.
- e) Use of a sophisticated operating system. ARIES-II runs under the DEC operating systems recognized throughout the industry for its superior performance particularly in a multi-tasking, resource limited environment.
- f) Careful attention to error reporting. All ARIES-II errors are logged in hard copy format listing all details of the error together with the precise time of occurrence.
- g) The provision of making the source code available to the user at a very reasonable price. This allows the user to add his own specific application oriented tasks to the existing software package.

It is through dedicated adherence to this software policy that DIPIX Systems Limited is confident that ARIES-II software meets the highest possible standards.

OPERATOR INTERACTION All operator interaction with an ARIES-II system is exercised from the Operator's Terminal. Operator communication is implemented via a software package called "Operator Interaction System (OIS)". This package provides virtually all of the services usually required for operator input and output, including error checking and message sequencing, thus relieving the application software of many of these housekeeping functions. Most important, all operator's messages are held in a common disk file. This has two major advantages over the traditional manner of embedding operator's messages into the executable code:

1. The size of the task image is much reduced.
2. Messages may be easily modified without changing the program itself. In fact, the message file can be translated into a language other than English, if required.

Another feature included in the OIS structure is the simultaneous multi-tasking support from a single operator's terminal. Up to 6 tasks at a time may be run from the terminal with OIS sequencing the messages being sent and received from each task. The operator may suspend any task while he communicates with another task. This feature has proven extremely useful when an operator finds himself well into the operator dialogue with a task and suddenly realizes that he has overlooked performing another task first. Rather

than abort the task (or go to another terminal) he may suspend it and run the overlooked task in its place. When all the required results are available the suspended task may be restarted.

BATCH VS. INTERACTIVE SOFTWARE Many image processing algorithms require substantial processing time, ranging from minutes to hours, depending on the size of images and complexity of the algorithms. In order to make most efficient use of the user's time, such a task is divided into an operator interaction section and a processing section. The operator interaction task guides the operator through the selection of processing parameters, and when complete, creates a batch control file containing the selected parameters. The processing task reads this batch control file and performs the actual processing. An ARIES batch scheduler task (available only with A2ASP/X software) controls the scheduling of the processing tasks.

There are several benefits to this approach. For one thing, the actual processing of a job does not have to take place immediately after the operator interaction. It can be delayed until a more suitable time, such as at night, when the system is less heavily loaded. In addition, the processing does not have to take place on the same system as the interaction. Thus a network workstation can perform the operator interaction portion of a job, and then submit the actual processing to the host, which may be a more powerful processor, or may possess a required peripheral.

The use of the batch concept allows expensive peripherals, such as image recorders and tape drives, to be interfaced to the host, but to be accessed via user interaction on a network workstation. The A2ASP software package makes all peripherals in the network accessible from the user's system.