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**RE-ENGINEERING NASCOM 'S NETWORK MANAGEMENT
ARCHITECTURE**

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ABSTRACT

The development of Nascom systems for ground communications began in 1958 with Project Vanguard. The low-speed systems (rates less than 9.6 Kbs) were developed following existing standards; but, there were no comparable standards for high-speed systems. As a result, these systems were developed using custom protocols and custom hardware.

Technology has made enormous strides since the ground support systems were implemented. Standards for computer equipment, software, and high-speed communications exist and the performance of current workstations exceeds that of the mainframes used in the development of the ground systems.

Nascom is in the process of upgrading its ground support systems and providing additional services. The Message Switching System (MSS), Communications Address Processor (CAP), and Multiplexer/Demultiplexer (MDM) Automated Control System (MACS) are all examples of Nascom systems developed using standards such as, X-windows, Motif, and Simple Network Management Protocol (SNMP). Also, the Earth Observing System (EOS) Communications (Ecom) project is stressing standards as an integral part

of its network. The move towards standards has produced a reduction in development, maintenance, and interoperability costs, while providing operational quality improvement.

The Facility and Resource Manager (FARM) project has been established to integrate the Nascom networks and systems into a common network management architecture. The maximization of standards and implementation of computer automation in the architecture will lead to continued cost reductions and increased operational efficiency. The first step has been to derive overall Nascom requirements and identify the functionality common to all the current management systems. The identification of these common functions will enable the reuse of processes in the management architecture and promote increased use of automation throughout the Nascom network.

The MSS, CAP, MACS, and Ecom projects have indicated the potential value of commercial-off-the-shelf (COTS) and standards through reduced cost and high quality. The FARM will allow the application of the lessons learned from these projects to all future Nascom systems.

INTRODUCTION

The development of NASA Communication (Nascom) systems for ground communications began in 1958 with Project Vanguard. The low-speed systems (less than 9600 bps) were developed following existing standards. However, the existing communication standards could not be used to meet the higher data rates and transmission reliability requirements demanded by next generation of NASA projects. As a result, custom protocols and associated hardware had to be developed to meet the needs of the growing space agency.

The Nascom protocol that was developed in 1968 consisted of a 1200-bit block with header information, data field, and polynomial error control field at the end. Over time, user communication requirements increased and the Nascom block size was increased to 4800 bits. The basic structure remained the same, but provided an expanded user data field.

In the 1970's, development began on a system of geosynchronous satellites to relay data around the world instead of many earth stations. As the Tracking and Data Relay Satellite System (TDRSS) grew, it became evident the manual network control and monitoring would be impossible. Nascom began to automate its portion of the network.

Once again, network management standards did not exist to meet NASA's requirements. Nascom began custom development for automated network management, using the existing Nascom protocol with 1200-bit blocks as the management protocol.

With today's reality of budget reductions and the high cost of custom development, the use of standards has become as important as high-speed and data

integrity. Fortunately, communication standards for both transmission and management had been developing over the last few years to keep up with user demands.

Nascom began its move towards standards with development of an X.25 network for the Pacor/Gamma Ray Observatory (GRO) project and the Mission Operations and Data Systems Directorate (MO&DSD) Operational/Development Network (MODNET)/Nascom Operational Local Area Network (NOLAN) for high-speed local data distribution. Now, Nascom is developing a high-speed Asynchronous Transfer Mode (ATM) network for the EOS project and re-engineering its automated network management architecture to integrate these standards-based networks and the existing customized network into a centralized operations area.

EXISTING ARCHITECTURE

Nascom currently has three distinct networks with separate management systems: the Data Distribution and Command System (DDCS), MODNET, and the 4800-bit block network.

The DDCS X.25 network has two nodes located at GSFC, a node at Marshall Space Flight Center (MSFC) and a node at the University of California at Berkeley (UCB) (figure 1), distributing X.25 packets at data rates up to 224 Kbps. Each node has a redundant backup for automatic fail over. It is composed of COTS hardware and software with integrated network management software. The controlling node is located in the Nascom computer facility at GSFC.

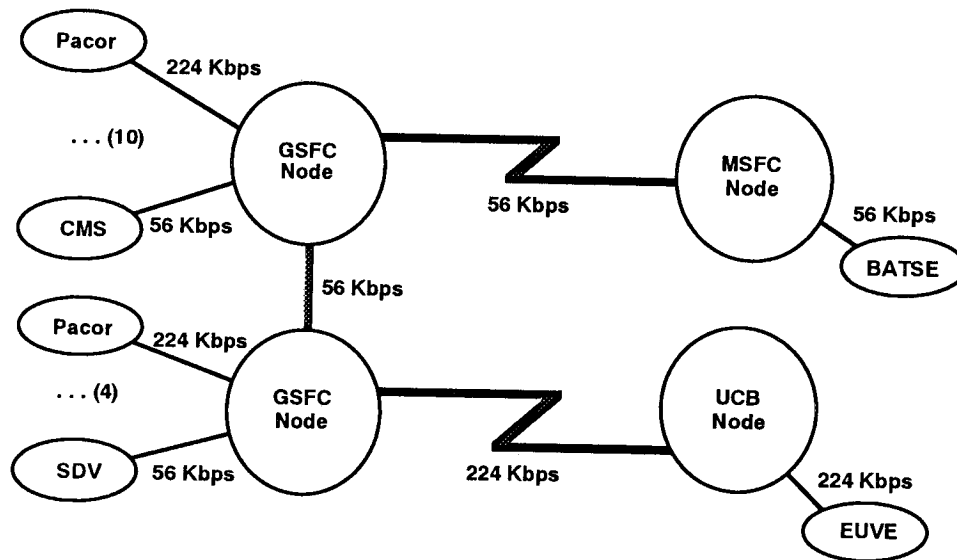


Figure 1. The DDCS

The second network is the Mission Operations and Data Systems Directorate (MO&DSD) Operational/ Development Network (MODNET). MODNET was formed in May 1986 through the integration of three division-level networks: the MOD&DSD Network (MNET), Mission Operations Division (MOD) Local Area Network

(MODLAN), and the Information Processing Division LAN (InfoLAN). This network provides high-speed, 50 Mbps, interconnectivity between operational LANs and computer systems at GSFC (figure 2).

The LAN technology used by MODNET is HYPERchannel.

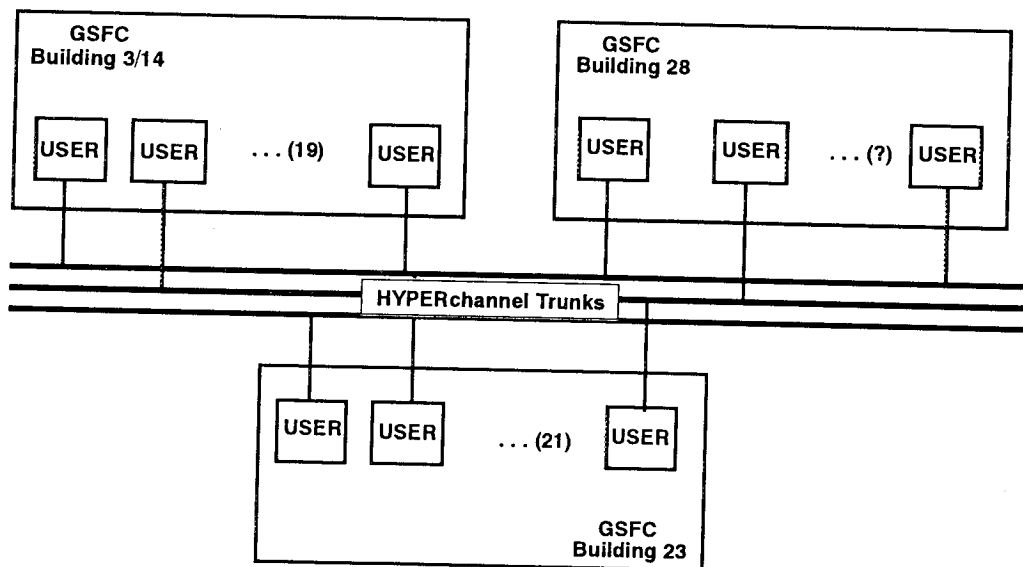


Figure 2. MODNET

HYPERchannel, a registered trademark, is a generic name for the various network components and protocols developed by Network Systems Corporation (NSC) to provide networking capabilities between

entities within Nascom to handle the data requirements each with their own control capabilities. The MSS is the original Nascom block star network hub (figure 3). The MSS provides packet switching

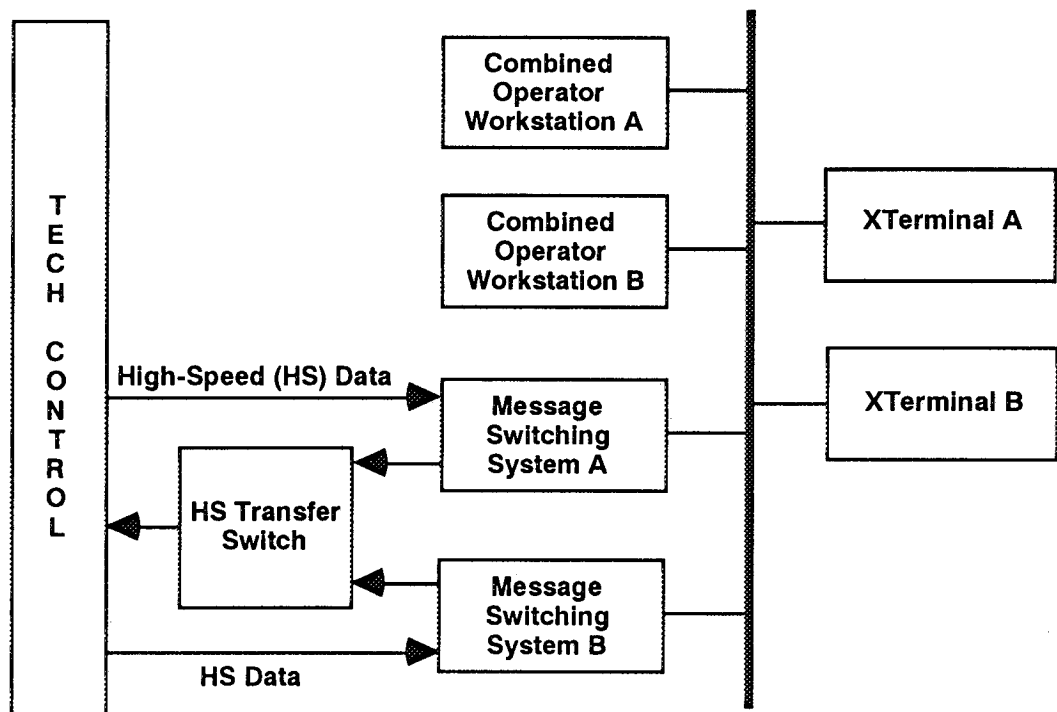


Figure 3. The MSS

networked computers. The fastest alternative protocol at the time MODNET was formed was the 10 Mbps Ethernet.

The NOLAN will expand upon MODNET's capabilities using a Fiber Distributed Data Interface (FDDI) backbone with a larger distribution area. MODNET/NOLAN will be managed by Nascom operations using Hewlett-Packard's HP Openview network management system with ISICAD for automated trouble ticketing.

The final network is the 4800-bit block network that distributes data throughout the world with data rates ranging from 50 baud to 2 Mbps. There are two network

capabilities for hundreds of 4800-bit block users with data requirements ranging from 9600 bps to 1.544 Mbps. The management control consists of custom developed software operating on a Sun workstation.

The TDRSS network portion of Nascom consists of custom built Multiplexer/Demultiplexers (MDMs) and controllers located at the Johnson Space Center (JSC), NASA Ground Terminal (NGT), MSFC, and GSFC, a custom Digital Matrix Switch (DMS) and controller at GSFC, and custom Data Link Monitoring Systems (DLMS) located at GSFC, JSC, and NGT. This network equipment is being constantly

reconfigured according to the network schedule supplied by the Network Control Center at GSFC. In order to meet the reconfiguration requirements of the network, the Control and Status System (CSS) was a custom development to provide automated network management (figure 4). The CSS uses the Nascom 1200-bit block to send commands and receive status from the network equipment.

and engineer an efficient network management architecture using new technology and standards. Computer workstations today can process the same data that required mainframes ten years ago. Standard protocols can send data at higher rates and provide interconnectivity between different hardware platforms. COTS software packages can be found to meet almost every need. Custom systems are not an effective application of limited resources any more.

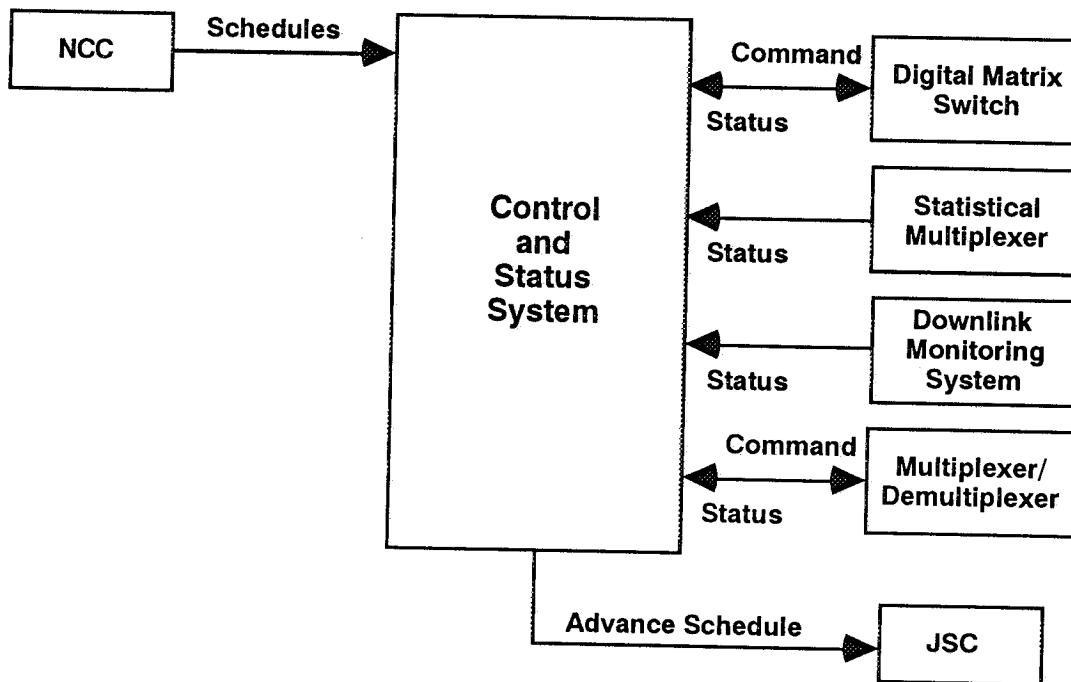


Figure 4. The CSS

MORE WITH LESS

Do more with less is the motto of the world today. Every year, the demand increases and the budget decreases. In order to maintain communication services for the Agency, Nascom has begun a project to re-engineer its network management architecture.

The Facility and Resource Manager (FARM) is an attempt to step back, analyze Nascom's management requirements, with an eye to the future,

The basic goal of the FARM is to meet today's motto, more with less. More network operational demands with less budget cause additional capabilities and requirements to be engineered into the systems with less engineering budget. Standards, COTS, reuse, and new technology are the FARM's tools.

Operational Costs

The biggest cost to Nascom operations is the large number of personnel required to run the networks. The 4800-bit block

network is very manually intensive and operates in a reactive mode for troubleshooting. MODNET, NOLAN, and the X.25 networks are a little more automated, less personnel dependent; but being separate networks, they still require additional operations personnel. In the near future, Nascom will implement and operate the Federal Telecommunications System (FTS)-2000 network and the EOS Communications (Ecom) ATM network. Although these are both highly automated networks, they also have their own network management systems that have to be operated, requiring additional personnel.

from text menus to windowed graphical interfaces. Comprehensive operator training for each system has to be developed, which is time consuming and expensive.

THE FARM ARCHITECTURE

The FARM is developing the functional requirements of all the management systems and designing a workstation-based distributed network management architecture using SNMP between the systems. By down-sizing from mainframes, using COTS products, and Object Oriented (OO) development methodologies for software reuse, the

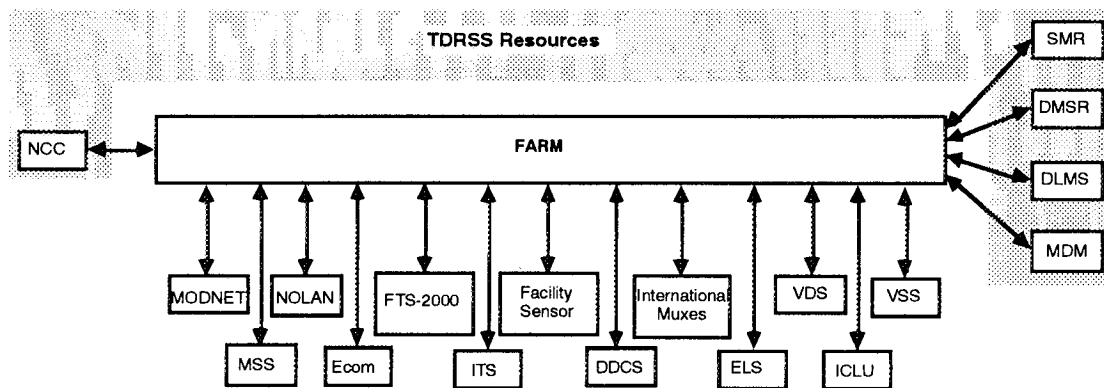


Figure 5. The FARM

Engineering Costs

Nascom engineering costs largely come from developing and maintaining specialized hardware and software. Until recently, to perform real-time processing of large amounts of data required the use of mainframes in conjunction with mini-computers and large amounts of assembly code. Add to that a unique protocol, requiring specialized hardware, and you have a recipe for a marching army of software and hardware engineers to keep Nascom operational.

Another cost is training personnel on every new system or network. Every one of the management systems operated by Nascom has a different user interface,

FARM will reduce engineering costs and development time. By consolidating multiple network management systems into a consolidated environment, the FARM will provide a consistent operator interface into the different networks, reducing training time and the need for separate operators for each system (figure 5).

The FARM has five functions: operator interface, data management, resource scheduling, system automation, and a non-SNMP gateway (figure 6). The operator interface will be designed using X-window and Motif standards to provide a comprehensive graphical user interface. COTS development tools, such as TAE+, will be used to provide rapid

screen prototyping. This will allow the FARM the capability to provide the most efficient user interface in the shortest amount of time.

The data management function will provide storage and retrieval of network configuration, management, and

project is evaluating several vendor packages for most comprehensive adherence to requirements.

System automation will be provided by using expert systems. Several of the COTS management systems also provide expert system development tools. The

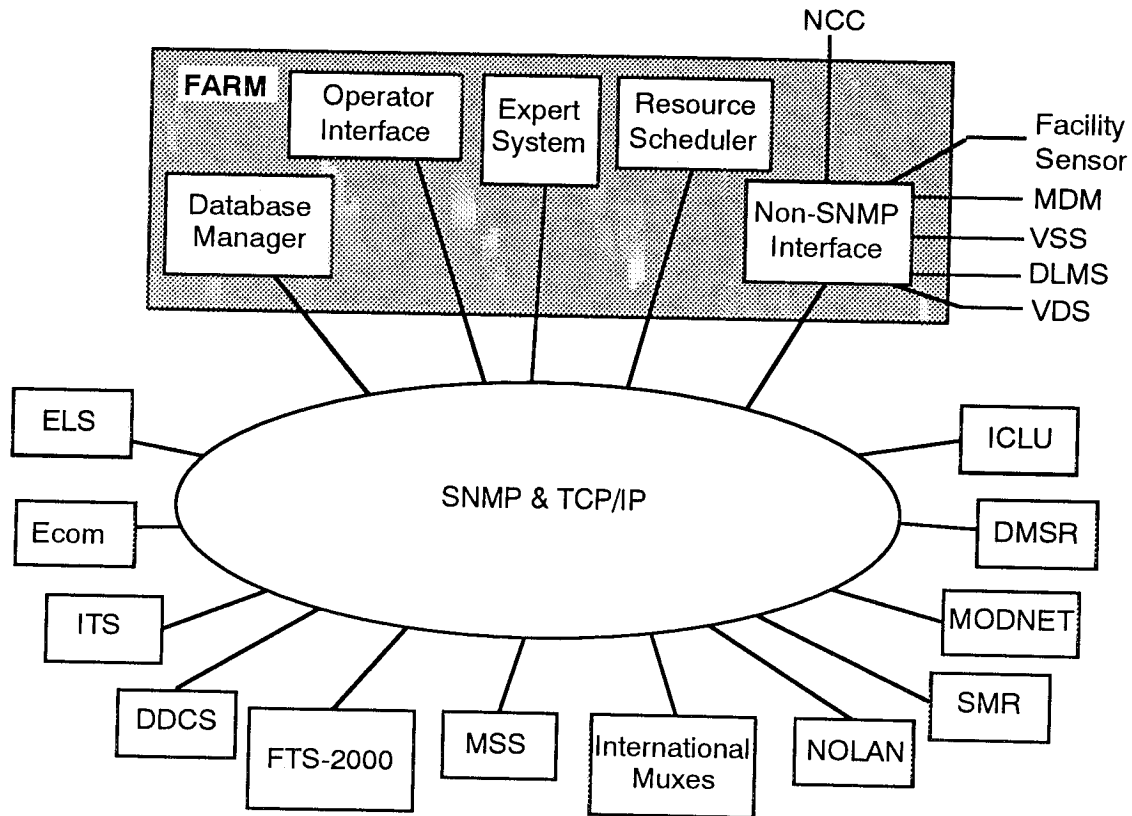


Figure 6. The FARM Functions

statistical information for the FARM. This functional will be performed using a Structured Query Language (SQL)-based database management system, such as Oracle or Sybase.

The resource scheduling function provides the FARM with the ability to configure TDRSS network equipment according to the network event schedule supplied by the Network Control Center. A large portion of this function can be performed by COTS network management software. The FARM

expert systems will analyze alarms and passive circuit monitoring equipment to perform pro-active troubleshooting for the network.

The Nascom networks have equipment and interfaces with specialized protocols. These non-SNMP interfaces will require gateways to convert between protocols. Again, several of the COTS management systems provide the capability to define unique interfaces.

DEVELOPMENT METHODOLOGY

Development costs will also be reduced by applying some of the ideas from Object-Oriented (OO) methodologies to enhance reuse of already developed components and COTS products.

The FARM will not use an OO implementation language, as the project's short schedule, the long learning curve for OO methodologies, and the questionable success of OO projects are incompatible. Instead, the ideas within OO development that have been designed to enhance reuse are being employed.

The first of these OO development ideas is to perform a problem domain analysis. A domain is a problem area defined by the user interface, external interfaces and interaction of a proposed system. Its extent depends, in large, on the definition of what a user is. In the case of the FARM, users are operations personnel and developers. However, the developer is a user only to the extent necessary to safeguard reuse.

The problem domain analysis concludes with the specification of a development framework. The framework consists of the components identified in the problem domain analysis that appear to be candidates for reuse or COTS products in the system.

TESTING METHODOLOGY

COTS and reusable components are integrated into system development following System Engineering and Analysis Support (SEAS) System Development Methodology (SSDM). There are different levels of development testing required for COTS and reusable components depending on their level of reusability. The basic idea is that the

supplied component is assumed to be fully tested and working. The task of development testing is to ensure it works within the system, that the interfaces are functioning as stated. System testing remains the same: the system is still tested to ensure requirements are met.

The level of testing, and when testing begins, depends on the component's position in the hierarchy of system components. When an entire function is reusable or COTS, the lowest level of testing required is module testing to ensure that the interface matches expectations. If the supplied function is more-or-less a client/server function, then integration testing is required to ensure that the client/server interface is correct.

Using the definition of a process as the smallest stand-alone system entity; testing should start at the level of testing in the following table:

Table 1. Testing Requirements

Level of Reuse/COTS	Testing Required
One or more processes	Integration testing
Complete function	Integration testing or Module testing
One or more units	Module testing
Modified unit	Unit testing

IMPLEMENTATION PLAN

The integration of management systems will be done in a phased approach, attacking the manually intensive legacy systems first, then moving to the more automated standards-based networks in later phases. This will allow Nascom to replace the expensive custom control systems, reducing the software maintenance costs.

The CSS and its associated control systems in the TDRSS network will be re-engineered to provide the framework for the consolidated network operations center. These systems are the most manually intensive, least automated systems. By consolidating these systems and implementing expert systems technology, operational costs will be greatly reduced.

Future phases of the FARM will integrate the remaining COTS management systems through SNMP interfaces and increasing operational automation.

A FARM lab is being developed which will be used to evaluate and test different hardware platforms and software packages, perform network performance analysis, and prototype new technologies and configurations for use in the FARM. By performing rapid prototyping and evaluation on every aspect of the FARM development, road blocks and design flaws will be identified early in the project life cycle.

CONCLUSION

The Nascom networks have evolved over the last thirty years into what they are today. Each system and network were developed to meet a specific set of requirements to support NASA's communications needs. Today, technology and standards have matured to the point that it makes engineering sense, as well as budgetary sense to start over from the beginning and re-engineer Nascom's network management architecture.