AUTOMATING GAS MEASUREMENT

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Introduction

Since the discovery of oil and gas and the advent of commercial conveniences, which use oil and gas, companies have been confronted with the need to accurately measure the oil and gas bought and sold in the marketplace. And, as usual, the technology available at the time was brought to bear on the measurement process.

All gas companies must, of course, deal with gas measurement and are positioned somewhere on the automation curve. As time moves forward, so does the technology. New products and measurement techniques are constantly being offered to improve the gas measurement process. Unfortunately, adopting the new technology always brings with it a price. And the price is not only measured in dollars, but in ever increasing difficulty in making intelligent decisions and choices.

So how does a company, with the need to progress on the automation curve, sort through the many options available today? The effort requires a continuing education process. The decision maker must understand not only what the available technology can do for his company today but must understand its future impact on the company.

The Race toward Automation

The Gas Company cannot stand still, but must continue to push toward increased automation utilizing the continually changing technology. The question "Should I automate or not?" is no longer a valid question. The answer has to be "Yes" as competition and government regulation requires it. The new computer technology offers us ways to improve measurement accuracy and to reduce the amount of human resource required to manage and complete the measurement process. By incorporating the new technology, our cost is reduced.

So, faced with the need to automate, the more relevant question is "How do I design my system and choose the proper system components to meet my corporate objectives?"

Problems Faced with Automation

During the course of an automation project a number of questions, issues, and problems will surface and have to be addressed. How they are resolved will dictate the ultimate success of the project. Some of the more critical questions are:

- What are the short term and long term corporate objectives? Is the proposed automation step consistent with these objectives?

- What are the shortcomings and inefficiencies in the company's current measurement process?

- Is the proposed new technology well understood? How closely does it match the desired solution? How much of it is enticing chrome or dazzle which is generally of short-term value. What kind of functionality is "under the hood" that will really help the business over the long haul? Does the technology offer real benefits and meaningful features to the current measurement process?

- Will the technology eliminate or reduce current inefficiencies and costs? If so, how and at what price?

- Is the technology both a good short-term and long-term solution?

Most technological advances are geared toward particular markets and may not provide the best solution for a particular application. This can be particularly true with software.

No solution comes without a price. This phrase applies heavily to the gas measurement system solution and it is imperative that the decision-maker who is responsible for selecting the right system components evaluate all aspects of a particular solution.

A pertinent example is the continuing rush to adapt the latest graphical user interface (GUI) advances to SCADA or communications intensive functions at the expense of operational functionality. Standardized point-and-click interface benefits are recognized and are essential in operating today's systems. Operators not familiar with computers can quickly become computer literate and learn to operate new programs. But what about the on-going long-term price to be paid after the operator has achieved computer literacy and familiarity and is now looking for functionality related to his or her day-to-day tasks? Experience may indicate that added graphic "flash" in an already user-friendly system may just create more layers between the operator and important data and may steal valuable "horsepower" from the communications-intensive system environment.

So an objective of the successful project must therefore be to keep operational functionality at the top of the priority list.

The project's scope must be defined. Is the focus on procuring a "system" solution to meet "system requirements or is the decision-maker focusing only on individual components without thought toward how they will be integrated and work together?

A system solution requires the right mix of components and, more importantly, an appropriate amount of system engineering to ensure that the various components play together properly. Is the Company going to do the system engineering? If not, then the level of required outside engineering and integration services needed must be factored into the process. The required level and cost of outside engineering will be greatly impacted by the selection of software and hardware components and vendors.

The Challenge

Why is the planned automation path such a risky endeavor? Because the right answers to the questions and issues encountered during the project are not easy to come by. Several major reasons can be identified.

- The technology is changing so fast that even vendors in the business find it hard to keep up.
- Vendors bombard the decision-maker with a wealth of confusing information and complex products, all seemingly designed to solve every current and even future problem.
- Most vendors prefer to sell components and tend to avoid the responsibility of offering a total system solution as this requires a diversity of expertise and technologies which typically goes beyond the vendor's product line.

The following approach or process, if followed, will help the decision-maker wade through the confusion in a constructive manner. This process leads to intelligent decisions based on real data. Key steps in the process are:

- Remain focused on the basics, the Company's objectives and the desired functional solution.
- Assess and evaluate all available system components in terms of the basics and how they contribute to the overall system solution.
- Ask vendors the right questions.
- Let the accumulated data lead you to the best solution.

Gas System Components

A technical evaluation of the components in the gas measurement system requires that the decision-maker understand fundamentally how they work and what they contribute to the process. The following discussion not only provides this overview, but more importantly, identifies some pertinent system related questions which should be asked as part of the evaluation. Assessing the answers to these questions will lead to the best choices in selecting the system components.

Sensors and Transmitters

The computation of gas flow, i.e. flow rate, through a pipeline by an electronic flow meter (EFM) or a smart transmitter requires various measurement inputs such as gas temperature and static pressure.

Several standard technologies have been around for a number of years. Orifice measurement, the most common, uses the principle that the gas pressure measured via a differential sensor behind a restriction in the pipeline (the orifice plate), is inversely proportional to the velocity of the gas through the orifice. This measurement when compared to the static pressure in front of the orifice is used to compute the flow rate. A second common technique uses the number of revolutions of a rotary or turbine meter sensor in the pipeline to compute the flow rate.

The technology associated with pressure and temperature sensors is, today, quite well understood. However, advances are continually surfacing in regard to design, accuracy, and cost. Traditional sensors output a current or voltage which is proportional to the measured item and is used by the EFM to obtain the measurement. A new trend today involves "smart" sensors or transmitters with a digital interface. This type of sensor can be useful for applications where the measurements obtained from the sensor or transmitter are the only measurements required from the field. The host communications system can interface directly to the sensor without requiring intermediate RTU or EFM equipment.

Another new class of smart transmitter is available and can be useful in applications such as plant automation. These transmitters actually perform the American Gas Association Report No. 3 (AGA-3) flow rate calculation and maintain a history of hourly and daily flow. These sensors, however, cannot be considered functionally redundant to EFMs until they fully implement all required calculations, e.g. the AGA-8 compressibility calculation. Use of this transmitter is generally limited to applications where the gas composition is relatively constant or where the host system can automatically download new composition and compressibility information. Future benefits to gas measurement from smart transmitters will be the improved accuracy and lower cost as they evolve into functional replacements for the traditional EFM.

A relatively new technology is available today and can offer cost effective benefits in certain applications. The ultrasonic flow meter, although costly compared to the above more common technologies, offers substantial indirect cost savings as this technology uses sound waves to measure flow rate and therefore does not restrict the gas flow. This can mean real savings in the cost of compressor stations on long transmission pipelines.

System issues related to sensor technology are as follows:

- Typical interface between the standard sensor and the EFM is a wiring interface adhering to a standard current of 4 to 20 milliamps or a voltage of 1 to 5 volts.

- As the sensor must be installed in hazardous areas, equipment must be selected which adheres to applicable ANSI and NFPA standards for those areas.

Electronic Flow Meter (EFM)

An essential component of the measurement system, this computer-based device computes the flow rate based on sensor inputs. AGA has defined the computations to be used for flow calculation for custody transfer. The AGA-3 standard relates to orifice measurement calculations and AGA-7 to turbine meter calculations. A relatively new standard, AGA-8, more accurately computes the compressability factor to yield a more accurate flow rate calculation.

EFM technology is as well understood as sensor technology and does not pose much mystery to the decision-maker. There are, however, major system-related issues which must be addressed when selecting EFM equipment:

I/O Capacity

The move today is toward integration of technologies to reduce costs. Flow-related data represent only a part of the information desired from the some field sites. Interfaces for compressor alarms, valve controllers, tank level sensors, and fugitive emission sensors, e.g. H_2S "sniffers", are being integrated for transmission over a common comm link to the field office or central host system.

In the past, both EFM equipment and RTUs or PLCs had to be installed at the same site to gather the required data. This approach also required a duplication of comm media. In the future, the need to consolidate all measurement into the same box will be a priority to reduce hardware and communications costs.

Physical Comm Link Support

The system solution requires that EFM data be transmitted to the user's office. This requires a comm media link between the office and the field site. In general, an RS-232 asynchronous interface on the EFM will be acceptable for the communications interface; however, should the site be such that multiple "clustered" devices need to be interfaced in the future, then an RS-485 multi-drop interface in the EFM will be useful. A single communications link could, via a data concentrator, be used to link the clustered devices to the remote office.

Programmability

The selected EFM unit should offer the end-user the ability to easily configure the unit.

Archival Storage

The host communications software periodically accesses the EFM to upload the archived hourly and daily information. The EFM must retain ample hourly and daily information to compensate for a worst-case scenario where the host cannot access the data for a period of time. Most units today archive at least a month of hourly and daily data.

Supported Communications Protocol

Communications to the host communications software is via a language or protocol. This issue is important enough to be discussed later as a key system component.

Hazardous Rating

As the equipment may need to be installed in hazardous areas, equipment must be selected which adheres to applicable ANSI and NFPA standards for those areas.

Data Concentration Devices

Technology is available today to allow multiple site devices to be polled locally by a data concentrator in the field. This device can offer a number of advantages in certain applications:

- Reduced communications costs. Interface to the host system communications software is via a single communications media link.

- Report-by-exception, whereby alarms are reported to the host when they are detected, can be supported by the concentrator.

- Native protocols for the field devices and for the host can be supported. The concentrator can gather data from the field devices using the native protocols of the devices and report the data to the host using the native protocol of the host thus allowing an already in-place host system to gather data from multi-vendor field devices.

The Communication Protocol

The communication protocol is the language used to communicate with the host communications software. Supported communication protocols are an extremely important issue for consideration when choosing EFMs. Unfortunately, the required system solution often involves multi-vendor equipment in the field with different protocols. The consequences of this and suggested solutions are discussed later while looking at the host communications software component. Here are general guidelines for the decision-maker:

- Avoid proprietary protocols. Arguments that a proprietary protocol is desirable or necessary to provide data security are not significant enough to offset the ultimate cost of this decision. A closed protocol is not necessary to provide a secure interface to EFM data. Many EFMs require a security password to allow login and will reject any attempt to login without the appropriate password. The consequence of a closed protocol is to leave the end-user with fewer options for integrating equipment from multiple vendors.

- Acquisition of data from multi-vendor equipment is greatly simplified if a common protocol can be used for interface to the equipment.

- Select, when possible, equipment which supports a well-behaved, open protocol, e.g. MODBUS. A well-behaved protocol would be one which supports relatively small message packets rather than large data dumps. Reliable transmission of data dumps over potentially unreliable comm links such as cellular can be very difficult. An open protocol would be one which is non-proprietary, well documented, and supported by a large number of vendors.

- Use fully implemented robust protocols rather that partial implementations. An EFM vendor may support a particular protocol but in reality cannot provide a robust interface to the host software using that protocol. For example, the support may only provide access to instantaneous data and not archived historical data. Access to the historical may require the vendor's proprietary protocol.

The industry familiar MODBUS protocol can provide an example of these criteria. Access to EFMs is often by dialup telephone requiring a long distance phone call. The original standard MODBUS protocol, as defined by the Gould Modicon specification, only supports the acquisition of integer data from registers. That is, one can only ask for "single layer" data from the device. Some time ago it was recognized that this specification needed to be expanded to accommodate the need for floating point measurement data and for “multi-layer” historical data. An example of an extended MODBUS definition, which is widely used today, is the non-proprietary Daniel Extended MODBUS protocol. An EFM supporting MODBUS without extensions may need to be called every hour if hourly data is needed, whereas, an EFM supporting the Daniel Extended MODBUS protocol can be accessed infrequently, e.g. daily or weekly, to acquire multiple hours of historical data. This type of access is essential where hundreds of EFMs must be contacted via long distance phone calls.

The Communications Media

Host-to-EFM links can use phone lines, cellular, radio, and satellite interfaces. Selecting the proper communications media for the office to EFM link must first be based on the type of interface required to satisfy company objectives. Do the planned system functions require that the interface be a dedicated real-time two-way interface such as for the gas control function; or, can the system needs be met by a once-a-day or once-an-hour data acquisition approach. Once the candidate media are defined, the decision is usually based on a consideration of initial installation cost and on-going operational cost.

Some other system related issues should be considered.

Site limitations.

Does the site have cellular coverage, satellite coverage, power, available and line?

Data reliability.

How reliable is the media for data? This is primarily as issue with media such as landline telephone and cellular telephone, which were initially designed for voice communications. Landline modems used in the system should, where possible, support error correction algorithms. Cellular links can suffer special problems such as signal fade and cell switching requiring the use of special cellular modem protocols such as MNP-10 to handle these problems effectively.

Host limitations and issues.

How many communication ports are available in the host? Each type of media to be used will typically require at least one dedicated port on the host.

Can the host software handle different protocols over the same comm port?

Can the host support different poll frequencies over the same comm port? Can the user relax the timeouts in the host if needed to accommodate retry delays in error correcting modems?

Governmental restrictions.

Is FCC licensing required for the media as is the case for 900 MHz standard radios? Can the license be obtained and how long does it take?

Host System Software

Selecting the best host system software to support the company objectives is perhaps the most difficult task in configuring the gas measurement system. This technology, involving both hardware and software, is changing daily. The decision-maker is constantly being enticed to accept new "state-of-the-art" capabilities.

In this environment, some practical advice is to not forget the company's fundamental objectives and requirements for the system. These basics are the major functions which should be provided by the host software:

- Field Communications
- Data Archival
- Data Presentation
- Data Editing
- Data Distribution
- Custom Reporting
- Applications Platform

These functions are applicable to all gas measurement systems encompassing the smallest single PC system with few EFMs to those running on networks with hundreds of EFMs.

No single host software package can provide the best in each area. Choosing the perceived best in one area may impose constraints in another. For example, assigning the communications function to the GUI presentation software with the most "flash" may not provide the desired system solution to support future growth in the communications and applications arena.

So how does the decision-maker deal with this dilemma? A good starting point is to define explicitly the current and future requirements in each basic area and then to use this as a yardstick in evaluating each software package. Do not hesitate to press for benchmark information documenting the expected communications performance once the system expands to its largest planned size. From this evaluation, the decision-maker will understand whether a single system package is adequate or whether an integrated system concept is required.

The integrated system concept is one where the selected host system is really an integration of several different software packages, each dedicated to a particular system function. For example, communications processors, a master station server, and console stations for the operators can together comprise the host system. The communications processors handle communications efficiently, the master station has responsibility for data applications, data archiving, data reporting and data distribution functions, and the consoles provide the user-friendly GUI interface for the operator.

Selecting the best host components should be based on an evaluation of available functionality, design, and performance for each of these areas. For example, the master station server should offer a large number and variety of available vendor applications to do the needed data manipulation. Selecting an integrated system from a single vendor offers the advantage of proven component interfaces but a possible disadvantage of limiting functionality. Choosing to integrate components from multiple vendors allows more freedom in selecting the best functionality but will require considerable system engineering to integrate the system.

Seeking to answer key design-related questions in each functional area will help the decision-maker identify potential constraints and pitfalls in selecting the host system.

Communications

The design of this function in the gas measurement system is crucial and the capabilities of the selected host software in this area should be closely scrutinized.

The vendor’s operating system platform for this host component should also be closely scrutinized. A continuously operating, reliable and field-proven environment is required. Avoid initial releases of the latest and greatest versions of any operating system until bug-fixing revisions are available. A nuisance bug in the operating system can bring down your communications and the only fix may be a work-around by the host software vendor.

The communications software component should, if at all possible, be assigned to a dedicated platform with unneeded options de-activated in the operating system. No potentially interfering software should be installed on the platform. Pertinent communications-related questions are:

- What is the priority of the communication function relative to operator keyboard activity? Can operator or network-related activity impact the system's ability to efficiently acquire necessary data from the field?

- Does the system provide online communications analysis tools to support troubleshooting? Does it allow the system administrator to capture and review bi-directional asynchronous communications at the port level?

- What is the practical limit on the number of EFMs with which the system can communicate? Can the vendor provide benchmark test data quantifying performance when communicating with the planned number of EFM devices?

- How does one add a new EFM device to the system? Is this task simple or complicated?

- Are operator-initiated communications requests handled at higher priority than scheduled communications tasks?

- Can the system support multiple communication ports with the same field device protocol? With different protocols? How many ports can be used for concurrent communications?

- Can the system support concurrent interface to multiple types of communications media?

- Can the system support different protocols to different types of equipment on the same communication port?

- Can the user fine-tune communications by configuring command timeouts, retries and polling frequencies at the command and device level, or only at the port level?

- Can the system support unsolicited communications or just solicited master/slave communications? For example, can it listen for and respond to a field device calling in with a report-by-exception alarm?

- Does the system support download of date/time and configuration data to the EFM?

- After a communications failure period, does the system automatically access historical data archives in the EFM to acquire uncollected hourly and daily data?

- Is information from different types of field devices integrated and archived into a single non-vendor specific format?

Figure II shows a multi-component project where master station software is responsible for collecting data from a number of different field devices.

Data Archival

The system must archive all received historical EFM hourly and daily data. Here are important questions for the decision-maker:

- Is received hourly and daily data archived in such a way as to eliminate duplicate data should the same data be received more than once?

- Is the data archived and reported with the date/time stamp from the EFM rather than the host system time stamp?

- Can the system be configured to archive the collected data directly to folders on a network server? If so, are the files treated by the system in a network-aware fashion to allow multiple network users to access the archive files concurrently?

Data Presentation

Some data presentation requirements will be a function of the available system environment. Whether this environment is Windows, Unix, DOS or LAN-based, the selected MMI interface software for the gas controller or measurement operator should provide a meaningful and user-friendly access to current and archived EFM data. Decision-maker questions are:

- Is the operator’s access to the information intuitive? How long is the vendor’s suggested operator training program? Is it reasonable considering program content? An unusally long program can indicate lack of intuitive design.

- Is the data presentation and arrangement logical and pertinent to the operator’s day-to-day function?

- How many layers, or clicks, does the operator have to pass through to review correlated data?

- Does the system provide a mechanism for reviewing and analyzing historical data trends, i.e. changes in measurements over time?

- How are detected alarms annunciated to the operator? Can alarms and their annunciation be prioritized from non-critical to critical?

- Can the presentation be customized? Are tools provided with the system to allow the user to implement a hierarchy of overview displays?

The user friendliness of the interface and the functional design features available for interfacing with the archived data are areas of major importance as they define the ease with which daily measurement tasks will be accomplished.

For users of Windows presentation software who wish to access EFM data via the Microsoft DDE interface, the selected host server software must be able to act as a DDE server or to pass the data to a separate DDE server program.

Data Editing

The selected host software must provide a mechanism for copying the acquired EFM hourly and daily data into an area for editing and for AGA-3, AGA-7 re-calculation. There will be times when the EFM field data is found to be erroneous and flow rates and volumes must be re-computed in the host system. An example would be a change to a different size orifice plate and the new size is accidentally not updated in the EFM. Decision-maker questions are:

- Does the editing interface prevent the user from modifying raw field data? This is essential as the field data must be preserved in its unaltered form.

- Is the operator interface to the archive data for copying, editing, and re-calculation user-friendly? Although this is a subjective measure, the interface which the measurement operator uses day-after-day should be logical and easy to use.

- Does the system in a LAN environment allow multiple measurement personnel to work concurrently on pre-defined subsets of the archive data?

- Does the system provide an audit function to check received field archive data for consistency and to flag data deemed incomplete or questionable? This function is highly desirable in a system with many EFMs.

Data Distribution

After the measurement data has been reconciled (checked, edited, and saved), others in the organization, particularly the accounting group, need to have access to the information. The mechanisms available in the host system for distribution of this data should be evaluated. Some pertinent decision-maker questions are:

- Can the reconciled measurement data be stored on a LAN server for access by any and all authorized persons on the network?

- Can the data be automatically transferred to the accounting mainframe in a usable format?

- Can the data be automatically stored in a corporate database?

- Can the data be directed automatically to a web site for internet access by gas brokers, marketers, and producers?

- What network interfaces are possible with the system? Can the system function as a TCP/IP server to deliver archived data to other users? Can the system function as a TCP/IP client to deliver data to a server?

Custom Reporting

The host system should provide features for installing custom reports to be printed automatically and on operator demand. Pertinent decision-maker questions are:

- Can the system support multiple printers, such as one for reports and one for alarms and audit events?
- Can the system automatically direct reports to a TCP print server on the network?

Applications Platform

The selected host system platform design should support ongoing installation of add-on applications. Ideally, the user should be able to install both new applications available from the host vendor and custom applications developed in-house. Some systems today offer the user a large selection of applications from the vendor's application library, e.g. accounting applications to manipulate and analyze EFM data and energy de-regulation related applications for handling gas nominations and gas marketing. These features allow the user to enhance the system as needs change without vendor support.

Selecting the right host software is a difficult task. The variety of host system capabilities and options make the task even more difficult.

An additional important issue relating to the overall host system is that of vendor support. Decision-maker questions are:

- How many software vendors are represented by the proposed components of the host system? If multiple vendors are represented, then the interfaces between the software products must be well defined to minimize finger pointing when a need for vendor support arises.
- What kind of support will be available after-the-sale to fix problems or implement enhancements?

In general, obtaining timely and relevant support from vendors of commercial "off-the-shelf" software may be difficult. If the decision-maker intends to utilize this type of software in the measurement process, he should make sure that the software contains the necessary functions and features to meet his current and future expectations.

On the other hand, one should expect and demand quality support from a vendor offering software specifically designed for the gas measurement system. The decision-maker should ask for and check references regarding software performance and the quality of after-sale vendor support.

Vendors whose primary product is field hardware may be reluctant to provide software enhancement support. Although some software packages from EFM vendors are highly functional for their equipment, the decision-maker cannot generally count on the vendor to develop driver interfaces to competitors' EFM equipment. Also, as this software is generally offered free or at low price, the adage "you get what you pay for" may apply. These vendors will typically not be eager to implement enhancements. The decision-maker should investigate software sources for the host software whose specialty and primary product is the software itself.

Host System Architecture

Figure 1 shows an integrated concept gas measurement system configured for a LAN network platform. Component functions are as follows:

- Host Communications master stations or servers are responsible for collecting and archiving all field EFM data. These stations can also serve as front-end communications processors responsible for the interface to gas control RTUs and PLCs in the field. As the network grows in size, additional master stations can be added easily. Measurement data is archived on the LAN Network Server.

- Console stations are used by measurement personnel to reconcile the data. The reconciled data is again stored on the LAN Server.

- SCADA gas control stations provide for gas control functions with communications via the communications servers.

Important advantages of the integrated concept architecture are:

- No duplicate hardware function or communications media links are needed.

- Architecture is applicable to small or large networks.

- Architecture can combine the benefits of a high-performance master station server and communications platform with GUI based platforms for operator stations.

Conclusion

The task of designing, procuring, and commissioning a gas measurement system is complex and tedious. Asking vendors the right questions and seeking information from others with experience will lead to the right system for the decision-maker. The key components and basic features required in a gas measurement system are the same whether the system is small with a single PC platform or is large with a LAN network. Keep the focus on the required basic system functions to be provided and evaluate the system in regard to them. This is far more important than being influenced by the day-to-day bells and whistles offered by vendors to hock their wares. Don't be afraid to ask to see “under the hood”.

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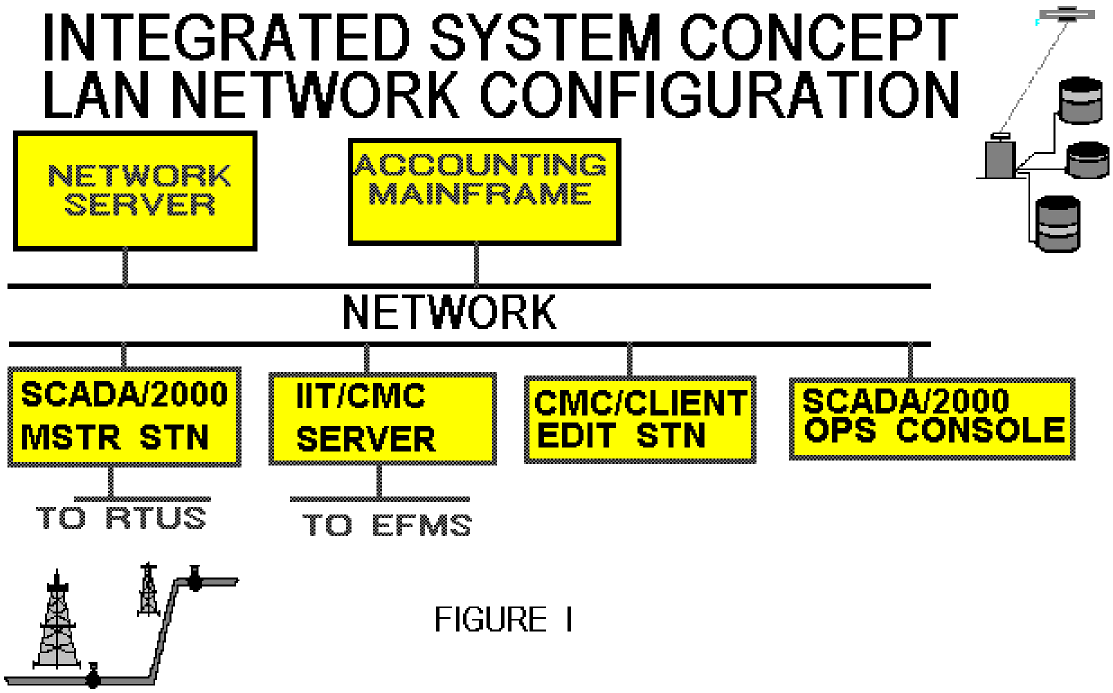
INTEGRATED SYSTEM CONCEPT
LAN NETWORK CONFIGURATION
NETWORK SERVER
ACCOUNTING MAINFRAME
NETWORK
SCADA/2000 MSTR STN
IIT/CMC SERVER
CMC/CLIENT EDIT STN
SCADA/2000 OPS CONSOLE
TO RTUS
TO EFMS

FIGURE I