MIMOSA – Four Years Later

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Great progress is being made in MIMOSA, the Machinery Information Management Open Systems Alliance. Since MIMOSA's formal introduction in the September 1995 issue of *Sound and Vibration*, an open method for transferring vibration and other crucial predictive data has been developed and demonstrated among a group of progressive suppliers. The MIMOSA Common Relational Information Schema (CRIS), originally developed for vibration data, has been expanded to include virtually all predictive technology and equipment information required by control, condition and maintenance management systems. MIMOSA now includes most suppliers of predictive systems and many progressive users. MIMOSA is moving forward on three parallel paths to refine and extend the CRIS table structure, develop a work integrator specification and formulate an object model based upon Microsoft's Component Object Model (COM) and Distributed COM (DCOM). If you are a user or supplier of equipment information, MIMOSA offers a consensus path to open data exchange that will be highly beneficial to you.

Over two hundred people representing more than sixty companies in the US, Canada, Europe, Russia, Japan and Australia have contributed to MIMOSA's progress toward open exchange of equipment information. Companies include the premier suppliers of condition monitoring products and systems, representing nearly 80% of total worldwide product and service sales. Led by Ken Bever, originally with The Hartford Steam Boiler Inspection and Insurance Company and now with Entek IRD International, MIMOSA has developed the Common Relational Information Schema (CRIS) and the model for information exchange between condition assessment, control, maintenance management and enterprise information systems.

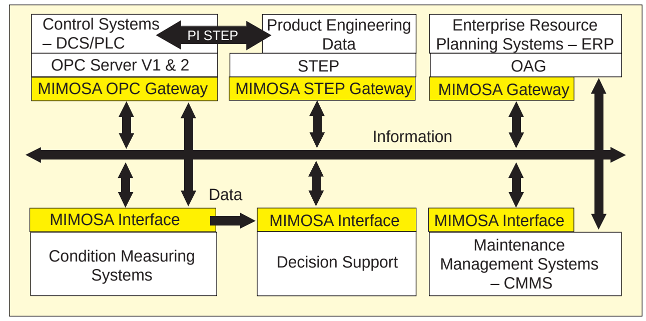

Figure 1. MIMOSA information diagram.

The MIMOSA Information Model

The MIMOSA information model, Figure 1, is an essential beginning. The model illustrates six functions that may be linked effectively with MIMOSA conventions to both transmit and receive equipment information. All will be accessible through open MIMOSA interface gateways employing standard CRIS based exchange protocols. This eliminates the costly requirements for custom mapping between every combination of functional systems from multiple suppliers.

The center, horizontal arrow in the information model represents the open MIMOSA link between various system functions. It can also provide links to functions and access for display elsewhere in the facility and enterprise as shown by the

Table 1. Detailed functions that can be accommodated by the MIMOSA information model.

System Technology and Functions – Condition Measurement Systems ♦ Vibration: on-line protective; off-line, periodic predictive ♦ Fluid (lubricating and hydraulic oil) condition ♦ Thermography ♦ Electric motor characteristics: on-line current spectrum; circuit tests ♦ Performance from control system and logs ♦ Cathodic and anodic protection voltages ♦ Ultrasonic: leak detection; corrosion thickness ♦ Water chemistry	**Information to Decision Support** ♦ Events ♦ Numerical (scalar) values ♦ Vibration characteristics: numerical values; vectors; time waveforms; order and frequency FFT and CPB spectra ♦ Fluid chemistry and particle distribution
Maintenance Management Systems ♦ Functional location and asset hierarchy ♦ Asset management ♦ Workforce management ♦ Scheduled (preventive) maintenance ♦ Maintenance (MRO) work management ♦ Spares inventory management ♦ Tool and rental equipment management ♦ Maintenance cost accounting	♦ Nameplate data ♦ Manufacturer's specifications ♦ Maintenance history: work accomplished – action taken; cost; process downtime ♦ Spare parts availability ♦ Work order: issued, number; requirements, parts, resources, safety precautions; schedule ♦ Conditions found
Product Engineering ♦ Engineering design ♦ Plant configuration	♦ Design specifications and drawings ♦ Plant configuration
Decision Support ♦ Mechanical diagnostics life assessment ♦ Life assessment – prognosis ♦ Performance/efficiency calculations ♦ Operating deflection shape (ODS) analysis ♦ Root cause failure analysis (RCFA) ♦ Reciprocating machine analysis	**Information from Decision Support** ♦ Status of health ♦ Event – abnormal change occurred ♦ Rate of change of health ♦ Time to action ♦ Problem identification – description ♦ Components affected ♦ Recommendations – operating and maintenance ♦ Remarks/comments – *explanatory information* ♦ Work requested

Acronyms

BLOB	Binary Large Object
CMS	Condition Measuring Systems
CMMS	Computerized Maintenance Management Systems
COM	Component Object Model
CORBA	Common Object Request Broker Architecture
CRIS	Common Relational Information Schema
DCOM	Distributed Component Object Module
DCS	Distributed Control System
ERP	Enterprise Resource Planning Systems
FFT	Fast Fourier Transform
GMT	Greenwich Mean Time
HDA	Historical Data Sources
HTML	HyperText Markup Language
IT	Information Technology
MBO	MIMOSA Business Object Model
MED	MIMOSA Export Data
MIMOSA	Machinery Info. Management Open Systems Alliance
OAG	Open Applications Group
ODBC	Open DataBase Connectivity
OPC	OLE for Process Control
OLE	Object Linking and Embedding
OSI	Open Systems Interconnection
PI STEP	STEP for Process Control
PLC	Programmable Logic Controller
SQL	Structured Query Language
STEP	Standard for Exchange of Product Model Data

ending arrows.

STEP, discussed later, is a growing international standard for exchanging manufacturing specifications and drawings. PISTEP, being developed by the control industry, is an adaptation to directly import component drawings and specifications. The Open Applications Group (OAG) is establishing standards for exchanging enterprise business, financial and administrative information. Several suppliers of maintenance management systems (CMMS) have created proprietary links to enterprise systems as shown by the upward arrow directly linking the two functions. MIMOSA will provide a vital open link between equipment predictive and information systems and enterprise, manufacturing and control system standards that maintains the rich characteristics necessary for optimizing operations and production planning.

Within the Condition Measuring Systems function block, MIMOSA CRIS conventions provide a standardized, open means to exchange information between a variety of systems. These include on- and off-line vibration, fluid (lubrication and hydraulic oil) analysis, motor electrical analysis, ultrasonic, thermographic temperature imaging and operating logs. Details and status of MIMOSA exchange conventions for these technologies are described in a later section.

In addition to illustrating links for information exchange, the model defines requirements for optimized equipment management information at logical functional boundaries. Information requirements are amplified in Table 1. The model and information requirements also provide the basis for the vital decision support function that converts equipment operating and condition measurements into actionable predictive information, operating and maintenance recommendations. The decision support process must include the means for collective evaluation of operating and complex static and dynamic data from sources listed in the previous paragraph – this to arrive at the comprehensive picture of current condition and predicted lifetime necessary for effective product, operations and maintenance planning.

Today, decision support is largely accomplished manually by experts. With open MIMOSA links providing greater access to more data at less cost, increased resources can be applied to extending and improving the vital decision support process. This will allow scarce human expertise to be concentrated on tasks with high economic value – analyzing root cause and developing corrective action for complex deficiencies.

The Common Relational Information Schema (CRIS)

Dynamic data such as FFT spectra and time waveforms must be accompanied by descriptive measurement parameters such as Window Type, Lower and Upper Frequency, Method of Averaging, Resolution and Measurement Units. Predictive software programs have traditionally maintained the data and measurement parameters in a relational type database. The Structured Query Language (SQL) has become a universal, generic way to *query* or access a data source about its contents. In use, SQL must be accompanied by a map that directs information from one program into the proper location in another program. A unique map is typically required for each program. The map must be altered any time the source or receiving database structure is modified. When multiple programs and multiple database formats are involved, the task of developing, supporting and maintaining current all possible combinations is extremely expensive and complicated. To eliminate this problem, MIMOSA has added CRIS, a specific format for equipment data, on top of SQL. CRIS provides a standard method for exchanging measurements such as FFT data and the associated measurement parameters in specified data fields. With the MIMOSA CRIS standard implemented, systems are able to exchange data including FFT, Time Waveforms, etc., in a standard format that eliminates requirements for custom mapping.

HTML is another often used method of communications that is excellent for publishing text documents (unformatted materials). Virtually anything can be typed into HTML – it doesn't force a structure to the data. MIMOSA has an area in CRIS for this type of information (called a BLOB – Binary Large OBject) which can store HTML, Word documents, Images, etc.

The MIMOSA Architecture

The MIMOSA architecture is designed to provide a neutral, dynamic and flexible framework upon which to build interoperable applications capable of sharing data. Figure 2, "MIMOSA-On-A-Page" shows the four MIMOSA Support Levels (File, Data, SQL and Object), the various information technologies supported (Vibration, Reliability, Asset Register Management, etc.), and the data category divisions (Service Segments or Physical Locations, Assets, etc.). *Think of segments as physical locations in a process that are filled by assets. A motor (asset) could move between various locations (segments) within a facility or even between multiple facilities (also segments).* This important feature allows tracking the history of both individual assets and the locations they occupy in a process. This dual tracking capability is essential for the purposes of finding and understanding the root cause of problems. Is a given problem due to a spread defect such as inadequate alignment procedures, a localized problem in the process (continuing failures at a specific location) or a 'lemon' asset (fails wherever installed)?

Note that CRIS, the MIMOSA Common Relational Information Schema, is the foundation on which the framework illustrated in Figure 2 rests. Table 2 lists the current status of the 118 MIMOSA exchange specifications and their release. A more detailed breakdown will be available on the MIMOSA web site, **http://www.mimosa.org**.

MIMOSA Common Relational Information Schema (CRIS). As stated earlier, a relational format is currently the most widely-used method of specifying an information schema. The relational method is analogous to a blueprint drawing which defines the various *room names* where data will be stored, the data *contents* of the rooms and each data element's unique identifying *key*. MIMOSA CRIS is a comprehensive information schema consisting of a standardized map that is embedded in supplier's software. By converting to the common schema, proprietary machinery databases or file specifications can be linked for data exchange without any custom mapping.

CRIS is a supplier-independent composite, allows integrating many sources of machinery information, supports peer-to-peer databases, permits user-defined lookup entries and utilizes a standardized timestamp dating method. Supplier independence is vital to MIMOSA's success. Many suppliers and users have implemented various relational databases and modeled machinery data in different ways. MIMOSA did not

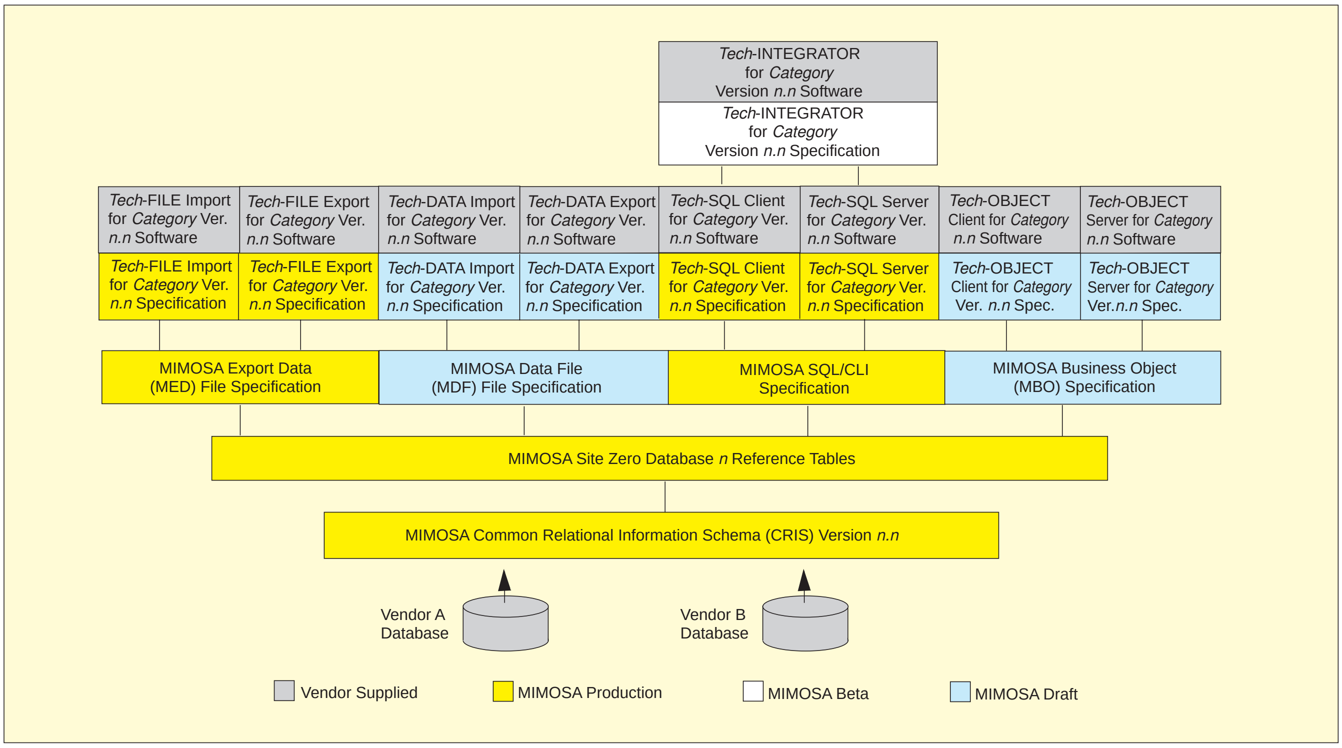

Figure 2. MIMOSA schematic.

rely on any existing system, but selected a best composite from participating companies to construct and refine the MIMOSA relational database schema.

Allowing the integration of many sources of machinery data is a key element toward the long-term success of the MIMOSA CRIS conventions. Figure 3 is a top-to-bottom summarized overview of CRIS. It begins at the site level, provides the basic elements necessary to define a database, segments (*physical location*) and assets (*tag numbered components*) and the map between segments and assets (*utilization*). The overview continues with measurement location, time (*event*) and a full description of measurements, one path for measurements requiring signal processing and a second for static (*scalar*) values. Finally, CRIS provides a method for transferring alarm information.

Table 2. Status of MIMOSA specifications (November 1998).

Technologies	File Ver	Data Ver	SQL Ver	Integrator Ver	Object Ver
Data category – Service Segments (physical locations) and assets (serialized equipment):					
TREND (static value, alarms)	1.1 Prod	1.1 Draft	1.1 Prod	N/A	1.1 Draft
VIB (dynamic vibration, sound, electric current)	1.1 Prod	1.1 Draft	1.1 Prod	N/A	1.1 Draft
SAMPLE (oil, fluid, gas tests)	2.0 Beta	2.0 Draft	2.0 Beta	N/A	2.0 Design
THERM (thermography, infrared imaging)	2.0 Beta	2.0 Draft	2.0 Beta	N/A	2.0 Design
REG (asset management registry)	2.0 Beta	N/A	2.0 Beta	N/A	2.0 Design
DIAG (diagnostics, recommendations)	2.0 Beta	2.0 Draft	2.0 Beta	N/A	2.0 Design
REL (reliability data, failure modes)	2.0 Beta	N/A	2.0 Beta	N/A	2.0 Design
WORK (work management)	2.0 Beta	N/A	2.0 Beta	2.0 Beta	2.0 Design
Data Category – Ordered Lists (routes, etc.):					
REG (asset management registry)	2.0 Beta	N/A	2.0 Beta	N/A	2.0 Draft
WORK (work management)	2.0 Beta	N/A	2.0 Beta	2.0 Beta	2.0 Draft
Data Category – Solution Packs (pre-planned work):					
WORK (work management)	2.0 Beta	N/A	2.0 Beta	2.0 Beta	2.0 Draft

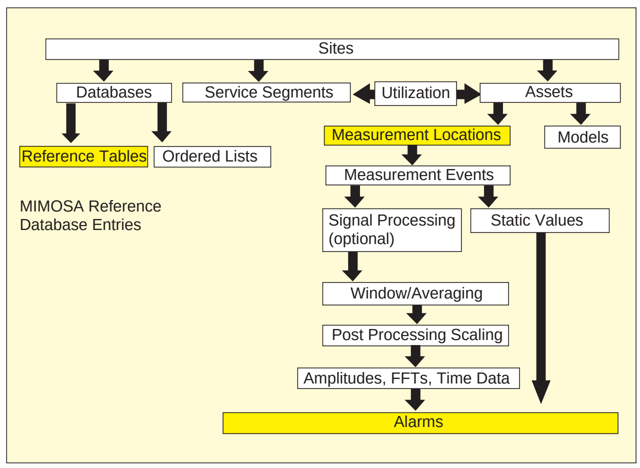

Figure 3. MIMOSA CRIS schematic.

The table structure for storing global database definitions, site, site specific database definitions, ordered lists, plant service segments, assets, the map between assets and model/part information is expanded in Figure 4. The two arrows at the bottom of the illustration connect to the measurement locations illustrated in Figure 5.

Figure 5 schematically illustrates the relationship of a portion of the measurement tables specified in the CRIS Version 1.1 schema. CRIS tables describe measurement locations, events, data measurement sources, transducers, method of storing single-valued numeric data, data and measurement parameters for Fast-Fourier Transform and time waveforms and alarms. Refer back to Figure 2 for a summary of the current status of CRIS completion.

The Version 2.0 CRIS extends the schema to additional information related to sample test information (from fluid, gas

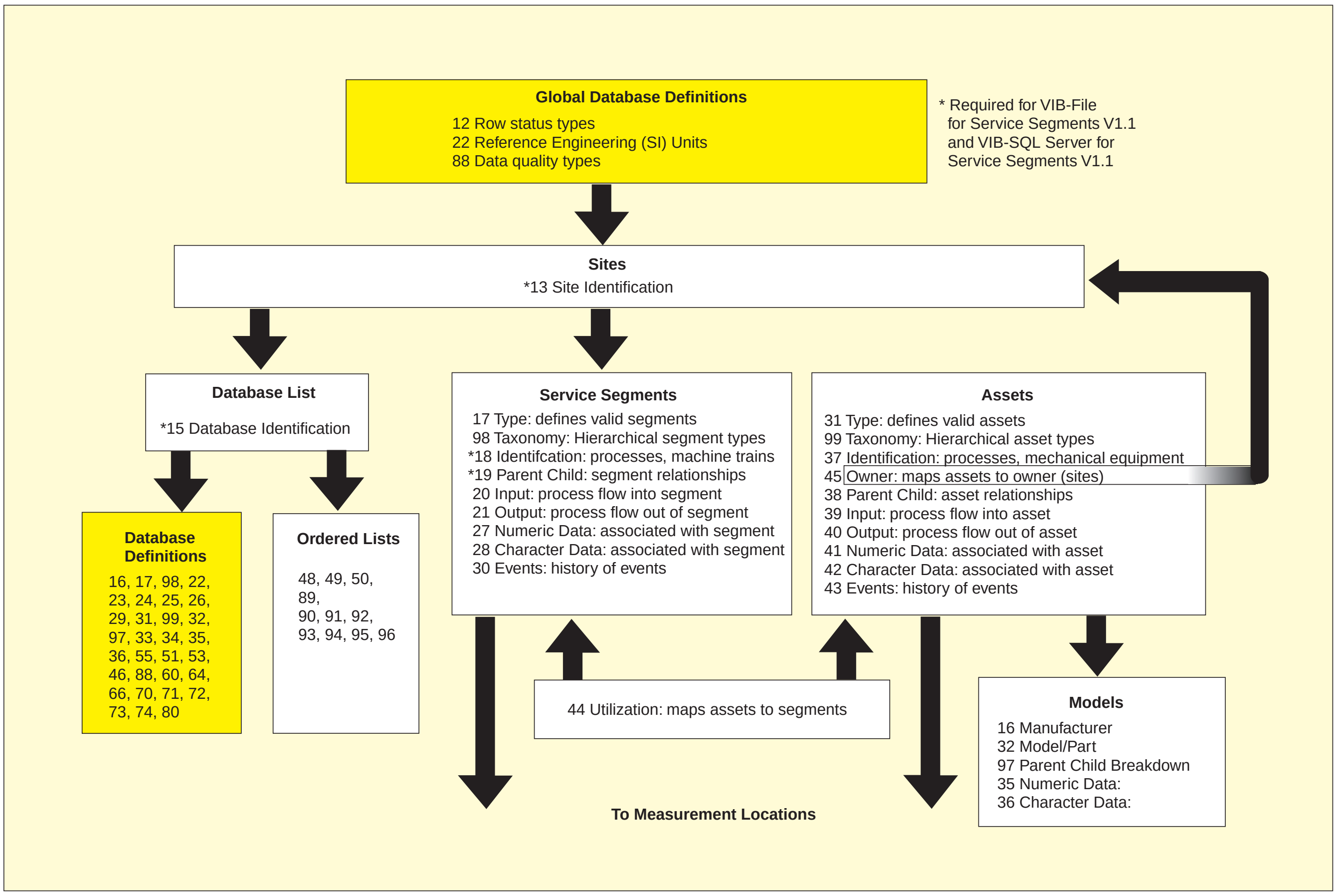

Figure 4. MIMOSA CRIS Measurement and Alarm Tables.

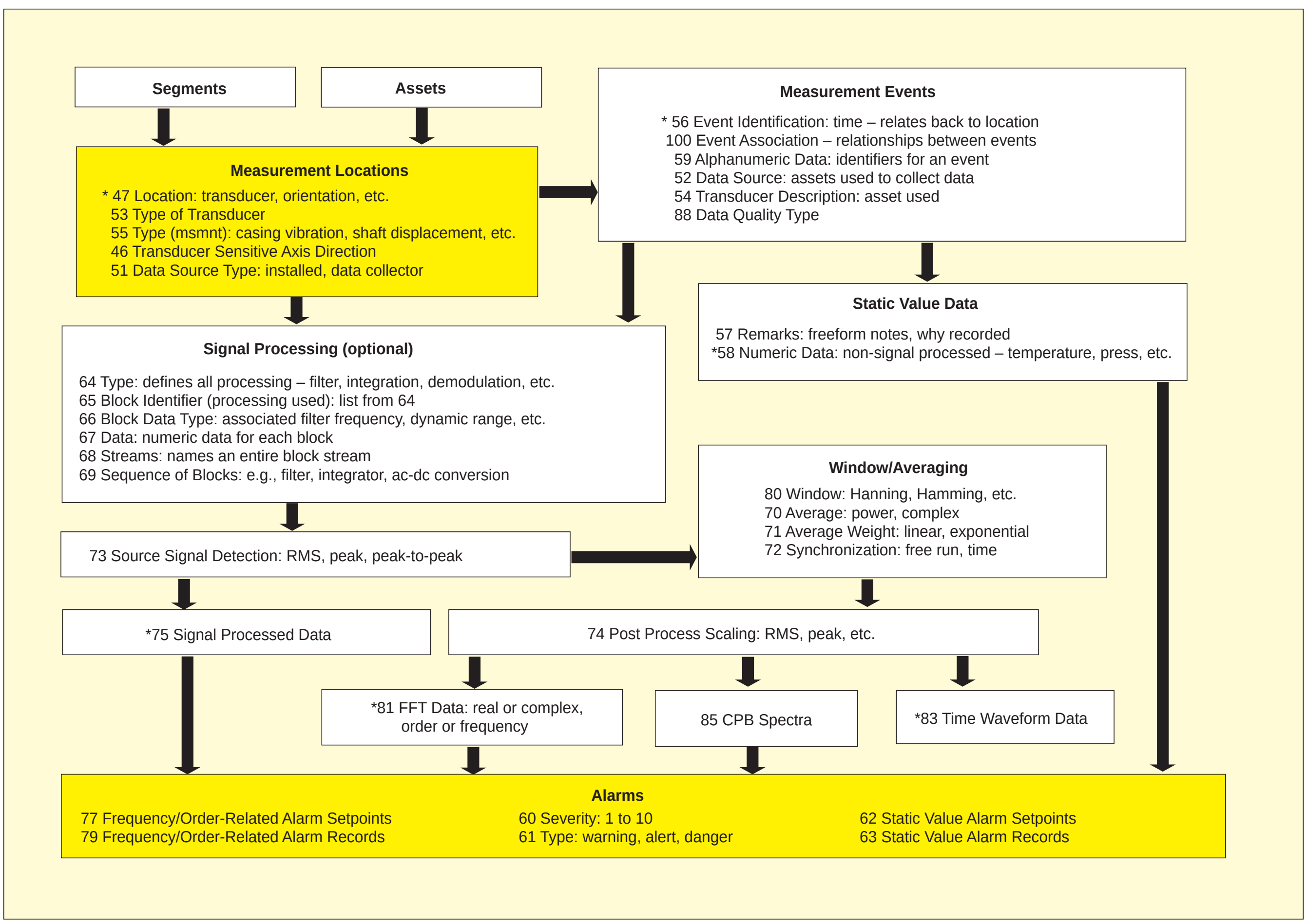

Figure 5. MIMOSA CRIS Database, Site, Model and Segment Tables.

or solid sampling systems), binary large object information (such as thermographic images, digitized video or documents), diagnostic analysis information, reliability data, asset and work management information.

MIMOSA is constructed on a peer-to-peer database architecture. This is a *network* view of databases that may be scattered throughout a corporation or the world. The network view means that each MIMOSA database is a peer with every other database. No centralized *server database* is required. Updates can flow from one database to another without going through a centralized database. In order to maintain database consistency in this architecture, the date of the last update on every row of data, along with the status of the row, are maintained.

Greenwich Mean Time (GMT) used throughout the system is required for the peer-to-peer database architecture accommodating the likelihood that data to be compared may reside in multiple time zones and for merging data between MIMOSA-complaint databases. A local reference time stamp is also supported on measurements to display the local time that a measurement was recorded for an operator.

MIMOSA Site Zero Database Reference Entries. In order to communicate common functional service segment types, asset types, etc., MIMOSA provides and updates MIMOSA Site Zero Database Reference Table entries shown in Figure 2. These are used between systems from different suppliers to align equipment types, measurement units, etc. The CRIS schema allows for individual databases to create and maintain additional reference table entries to provide maximum flexibility.

CRIS and other MIMOSA information are available on the internet at **http://www.mimosa.org**.

MIMOSA Transfer Options

As stated earlier, MIMOSA is building toward four basic methods of data transfer to meet all requirements. These are: File, Bulk, SQL and Object.

MIMOSA Export Data (MED) Import/Export File. A MIMOSA Export Data (MED) file contains data from one relational MIMOSA table. MIMOSA has defined the format of these general-purpose ASCII files which are used to transfer data from one database or device and move it to another.

MIMOSA *Tech*-File Export & Import Specifications. The MIMOSA *Tech*-File Export specifications relate to which subset of CRIS tables and columns a server application must export to MED files and the user interface required to set up this action. For example, "TREND-File Export for Service Segments V1.1" specifies that 7 CRIS tables must be supported.

The MIMOSA *Tech*-File Import specifications relate to which MED files a client application can utilize during an import, how a client application or a client database loading program should import from these MED files, and the user interface required to set up this action.

Components of the *Tech*-File architecture are shown schematically in Figure 6.

MIMOSA *Tech*-Data Bulk Transfer Export & Import Specifications. The MIMOSA *Tech*-Data Export and Import specifications, Figure 7, enables moving bulk measurements between databases in one large, compressed data file. This MIMOSA support method was requested by the MIMOSA user committee to meet the need of periodically transferring large volumes of measurement data between systems such as might occur as the result of oil analysis, etc. The *Tech*-Data method compresses the measurement events and associated data for process trend data, vibration data, oil sample data and thermographic data into single MIMOSA Bulk Data (MBD) ASCII files.

MIMOSA SQL/Call Level Interface Export Definition. As stated earlier, most condition monitoring and reliability systems store data in a relational database. The Structured Query Language (SQL) has become a universal way to query a data source about its contents. However, SQL is a generic standard which only provides access. MIMOSA has adopted the SQL format and added a requirement that only CRIS tables and columns can be queried. This guarantees that dynamic data

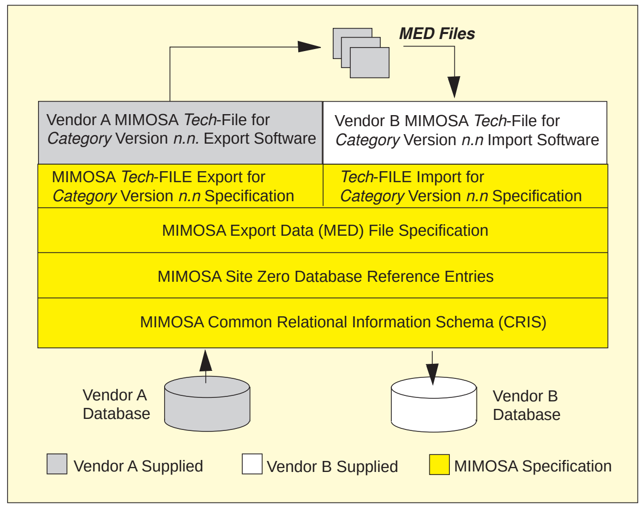

Figure 6. MIMOSA CRIS Tech-File transfer schematic.

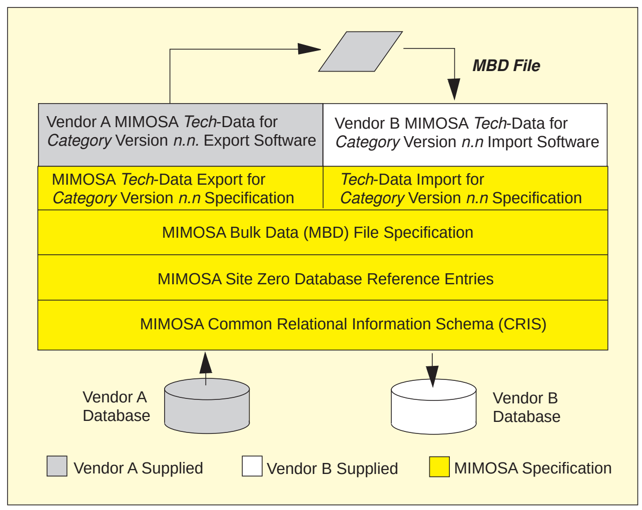

Figure 7. MIMOSA CRIS Tech-Data bulk transfer schematic.

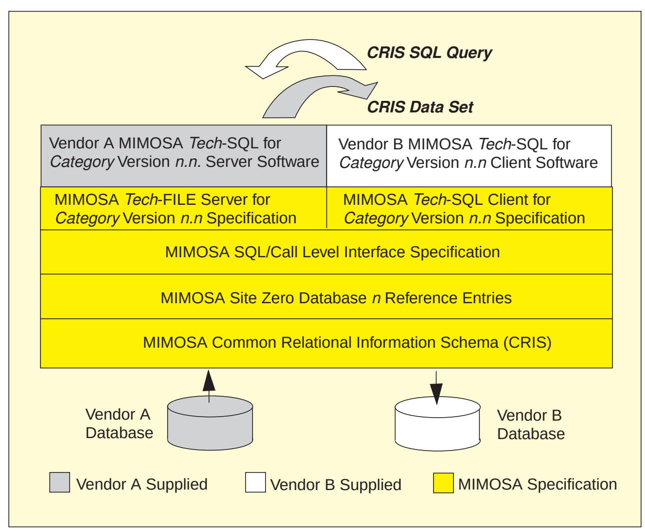

Figure 8. MIMOSA CRIS Tech-SQL transfer schematic.

such as FFT spectra as well as common equipment data are queried in a standardized way. Thus, MIMOSA CRIS applied to SQL provides standard access while eliminating the necessity for custom mapping between every possible combination of equipment information databases.

The MIMOSA SQL support level is a higher level of application access that is a programmatic interface level of interoperability. A very common method for report writers and other general purpose applications to gain access to databases is through Microsoft's Open DataBase Connectivity (ODBC) specification. MIMOSA has defined a read-only SQL Call Level Interface utilizing industry standards to allow a server to *post* its data in a set of ODBC-accessible tables and allow a client to access a data source using ODBC.

MIMOSA *Tech*-SQL Server & Client Specifications. The MIMOSA *Tech*-SQL Server specifications, illustrated in Figure 8, relate to which subsets of CRIS tables and columns an ODBC server application must support when queried for information and the user interface required to set up the server. There are two methods for a server to implement SQL support.

The first method is known as the *Snapshot* method. Using this method, the server supports periodic exports of data from a proprietary database into a MIMOSA CRIS standard set of tables or views which is then accessible to an application by issuing a minimum SQL *Select* grammar statement. For example, "VIB-SQL Server for Service Segments Version 1.1" mandates supporting a set of 10 CRIS tables. Through a user interface, a compliant application will allow a user to specify export options which are similar to the VIB-File specification. However, instead of writing the data to a file format, the application will create a subset of CRIS views or tables which are accessible to other applications through an ODBC driver or a ISO/IEC 9075 Call Level Interface driver.

The second method for a server to implement SQL support is through a live *Dynaset* connection to their database. Some databases may choose to implement the MIMOSA CRIS schema as their physical data model in a standard relational database with an ODBC driver provided to the database. When the database is queried through ODBC, up-to-date data will be returned to a SQL client. Another method of supporting the Dynaset method is by writing a MIMOSA SQL compliant ODBC driver to respond to requests for MIMOSA table data and translate these requests into proprietary data access requests and then returning the data to the client application through standard ODBC interfaces.

The MIMOSA *Tech*-SQL Client specifications relate to which CRIS tables and columns an ODBC client application can query from a MIMOSA *Tech*-SQL Server.

The universal support for ODBC throughout Microsoft's products provides a straightforward method to create a database query in Excel using the MIMOSA CRIS schema table and column names. This greatly facilitates retrieving information from any MIMOSA SQL Server into Excel for further manipulation and graphing. Figure 9 illustrates this process.

MIMOSA Tech-Integrator Specification

Providing database-to-database communication between MIMOSA systems is currently addressed by the Tech-Integrator specifications, that builds on the Tech-SQL Client and Server framework. The MIMOSA Work-Integrator specification allows generating work requests and work tracking between two MIMOSA Compliant systems. This is accomplished by the use of additional standard notification tables and by each supplier's support of the MIMOSA Work-SQL standards. The Integrator specification provides a standardized method for Computerized Maintenance Management Systems (CMMS) and condition assessment systems supporting this functionality to send work requests to each other and receive updates on the requests. In the near future, MIMOSA Tech-OBJECT Clients and Servers will provide a more elegant solution by bypassing database-to-database communication and providing true interoperability.

Success to Date

A core group of CRIS tables, defined for vibration monitoring (VIB-File), was demonstrated successfully with a multi-supplier data exchange to a generic MIMOSA CRIS Interpreter. The demonstration took place during the Predictive Maintenance Technology National Conference sponsored by *P/PM Technology* in early December 1996 and was repeated at the same conference in December 1997. A networked demonstra-

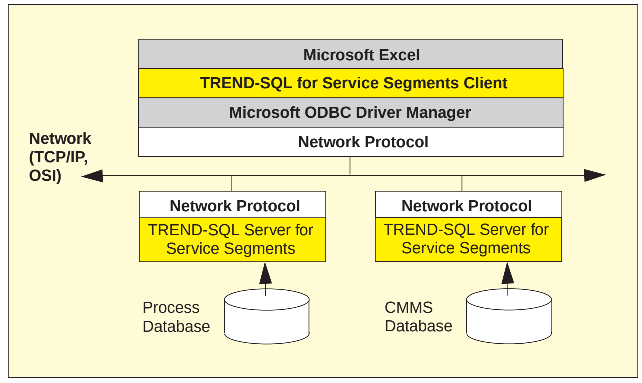

Figure 9. MIMOSA CRIS transfer to Microsoft Excel.

tion was conducted at the P/PM National Conference in November 1998.

Is MIMOSA successful? A participant at a recent developer's meeting commented that only a few short years ago, who would have ever dreamed that representatives from the major predictive system suppliers would gather at one competing supplier's facilities to work on cooperative conventions for information exchange. But, that is exactly what took place in August 1998. The fact is that open exchange conventions are a necessity and foundation for success of user and supplier alike. If there is any doubt about the truth in that statement, just compare the success and wealth created by the IBM/Wintel open platform to Apple, a closed platform. IBM Wintel has, and continues to drive what may be the largest creation of wealth and expansion of technology in the twentieth century, perhaps ever!

In the product arena, the network version of CSI's 32-bit RBMWare, scheduled for release in 1st quarter 1999, will be MIMOSA VIB-File and VIB-SQL compliant and support Work Integrator. Entek IRD International's Odyssey software is currently shipping with MIMOSA VIB-File and VIB-SQL technology built-in. Compliance testing is underway. SKF Condition Monitoring supports CRIS export in the latest release of PRISM 4. Import functionality will be included in an upcoming release. Vibration Specialty's WinProtect, scheduled for release in 4th quarter 1998, will be MIMOSA Compliant. With MIMOSA Compliant products either available or scheduled from virtually every predictive supplier there can be no doubt that MIMOSA has successfully achieved the first objective – creating an accepted, standardized, fully open method of exchanging equipment predictive information. Now the concept of open exchange that preserves all the rich detail necessary for accurate condition assessment and long term lifetime prediction must be extended to control, maintenance management and enterprise information systems.

To drive home the necessity for preserving predictive information and technology, consider a symphony orchestra. Quality is determined by a complex mix of tones produced by individual instruments and dependent on the musicians and conductor's technique. An experienced critic can immediately spot an instrument out-of-tune, poor technique or a departure from the intended score. The predictive community has developed a body of knowledge that accomplishes the same condition assessment for complex equipment by, among other things, recognizing abnormal patterns within a complex signal long before they would be noted as a change in overall level. This is the heart of vital advanced warning! Some, lacking a complete understanding of requirements for accurate condition assessment and lifetime prediction, believe condition assessment and lifetime prediction are nothing more than trending overall levels and issuing a warning when a value or trend exceeds a setpoint. Trending an overall level to determine condition is analogous to judging the quality of an orchestra by how loud they are playing. A valid indicator? Definitely not if the objective is earliest warning of a defect that may restrict or halt production!

Migration to a Business Object Model

In the world of enterprise information systems and client/server distributed computing, business objects are rapidly becoming a preferred method for interfacing systems and data. Business objects expose the properties, methods and events associated with entities such as a **Customer**, an **Invoice**, a **Turbine** or a **Pump** while encapsulating and hiding the implementation details such as how the data are stored or even where it is stored. By specifying a standard business object model for machinery information, suppliers can implement these interfaces and write their applications to use these objects without regard for the underlying structure or storage of the object source.

Led by Nathan Manning of CSI (Computational Systems Incorporated), significant work has been accomplished in 1998 to specify the MIMOSA Business Object Model (MBO). This next stage will facilitate high level programmatic access to information within systems by MBO compliant suppliers. The Business Object Model supports the three-tiered client/server development model. It is based upon Microsoft's Component Object Model (COM) and Distributed COM (DCOM) specification and can be implemented in the CORBA or STEP model. Indeed, business objects offer the most effective and practical interaction between compliant systems!

Microsoft COM and DCOM are the foundation technology for OLE for Process Control (OPC) described in more detail in a following section. The MIMOSA object model is being optimized for equipment management and decision support. Both require features such as hierarchies that are not yet included in the OPC model. The MIMOSA object model may refer to OPC data sources at the Measurement Location Level for both current and Historical Data Sources (HDA) in the OPC model. This adds the contextual dimension that is missing from the current OPC model. The MIMOSA object model is being designed to integrate into OPC. MIMOSA considers this plan optimum to assure that all facilities required for accurate condition assessment are included. Hopefully, OPC members who see value in an integrated convention will participate in the development of the MIMOSA model to assure full compatibility. When a first version of the MIMOSA object model is complete, it will be submitted to OPC as a solution that provides OPC compliant systems with access to a full range of rich, equipment condition assessment information.

The Component Object Model provides a mechanism whereby business objects can be accessed and utilized across multiple programs and even multiple computers in a way that the client program does not have to be concerned about where the objects reside. A notable example of how this can be exploited is found in the tight interoperability between the various members of the Microsoft Office Suite and other COM-enabled applications such as Visio, Visual Basic, PowerBuilder and others. Numerous industry groups and vendors are working to define standard business objects for various types of information common to vertical applications.

The MIMOSA Business Object Model is derived from the Common Relational Information Schema (CRIS). The MBO architecture model's plan asset and process segment hierarchies, measurement locations, events and associated data objects that can be provided by a plant operations and maintenance systems. These objects are accessed by requests to an Active*X* Server usually named MBOSRVR.EXE, which can be running on the client machine or as a service anywhere on the network. The object model consists of a hierarchy of collections of objects as shown in Figure 10.

Applications utilizing the MBO Server can request access to collections of **Sites**, **SiteDatabases**, **Segments**, **MeasLocations** and **MeasEvents**, as well as waveform, spectral and single value datasets. Each **Site** object in the **Sites** collection exposes properties that describe the site, as well as a collection of **SiteDatabases** that belong to that site. Each **SiteDatabase** object in the **SiteDatabases** collection exposes properties that describe the database as well as a collection of top level **Segments** within the **SiteDatabase**. Each **Segment** within the **Segments** collection exposes properties that describe that segment as well as a **ChildSegments** collection, a **MeasLocations** collection and **Input** and **Output Segments** collections. Figure 10 illustrates how the entire object model is nested.

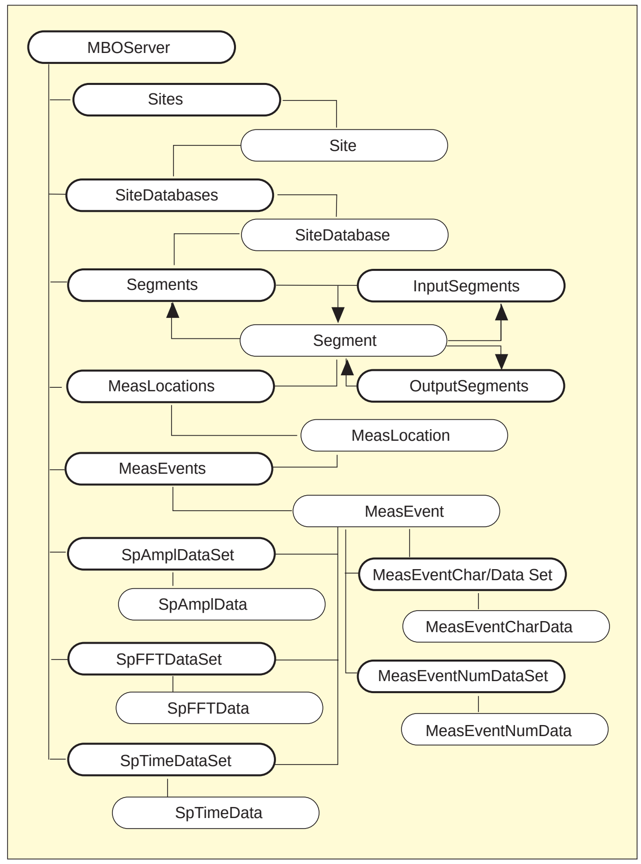

Figure 10. MBO vibration object hierarchy (MIMOSA Business Object Model, Draft ver. 1.0).

Each collection shares a set of methods for supporting navigation and scoping of the collection. These methods are: **IsBOF**, **IsEOF**, **MoveFirst**, **MoveNext**, **MovePrev**, **MoveLast**, **Move**, **Add**, **Remove** and **Refresh**. Additionally, the collections expose a Filter property that can be set with the equivalent of an SQL WHERE clause for restricting the scope of the member elements of the collection. By default, this filter is set to an expression that restrains the members to only those that belong to the parent object, e.g., Site = MySite. Each non-collection object shares a set of methods also. These methods are: **Edit**, **Update** and **CancelEdit**. All of these methods together make up the Persistence Interface for the MBO model.

The remaining properties of each of the objects reflect the attributes that describe the individual instance of the object - corresponding directly to the columns defined for the tables found in the CRIS specification.

MIMOSA Compliant

MIMOSA Compliant is a trademark informing the purchaser that a product displaying the mark can exchange specified information with equivalently certified systems from other suppliers without any special software or links. MIMOSA Compliant has several levels and variations to meet specific requirements. For example, some systems may only export information, others may both export and import. Some may support a certain type of transfer, others may support multiple methods.

MIMOSA Compliant will be self-certified by the supplier based on verification specifications supplied by MIMOSA. MIMOSA encourages use of the trademark and will compile and publish a list of certified products.

Interoperability with Other Industry Conventions

MIMOSA considers interoperability with current and proposed conventions for exchanging control and enterprise information imperative for all. Thus far there aren't any emerging standards that satisfy the rigorous requirements for exchanging complex machinery condition, predictive, reliability and asset optimization information. As mentioned earlier, use of general standards such as SQL require custom mapping between applications which must be kept current and supported. Industry specific standards such as OPC and STEP described later may not be capable of addressing issues such as transferring the rich detail and measurement parameters required by FFT, time waveforms and lube oil particle size and distribution to a decision support system for collective analysis. Full integration with other communities and standards poses a number of challenges including:

1. *Major differences in terminology*. It has been proven that effective equipment diagnostics directed to gaining earliest indication of a change in condition and predicting lifetime requires sophisticated signal processing and comparison to detailed historical records. Abnormal changes must be extracted and detected from complex dynamic signals that may extend to 20 kHz or more. Many who believe their systems should receive this type of information don't recognize the necessity for descriptive measurement parameters to assure comparing equivalent data or even requirements for comparison.
2. *Differences in diagnostic concepts and methodology*. Diagnostics to determine equipment condition and predicted lifetime are quite different in both concept and implementation compared to diagnostics performed within other information and control systems. The differences are readily apparent when comparing equipment diagnostics to control system and component diagnostics implemented within open control system standards such as Fieldbus.
3. *Cultural differences*. For the most part, culture within the control community is heavily oriented toward real time action based on numeric scalar values. MIMOSA experience has been that it is difficult to convey the necessity for highly detailed current and historical data such as single and multiple FFTs and time waveforms as a basis for effective equipment condition assessment. Equipment condition assessment has evolved from overall scalar amplitude to a stage where earliest warning and identification of a defect requires careful evaluation of low level contributors within a very complex signal. This is a foreign concept to most people outside the predictive community.
4. *Ownership*. Many technical specialties outside the predictive community, e.g., Information technology (IT), control and maintenance management appear to believe that managing the condition of equipment including complex machinery and providing vital decision support, should be controlled and performed within their specialty. During discussions, suppliers within these communities have been asked whether their system can automatically initiate a work request for mechanical equipment that includes specific, detailed operating and maintenance recommendations for an operator, reliability engineer or maintenance person based on a comprehensive analysis of actual conditions. As mentioned earlier, few outside the predictive community understand the question and the magnitude of signal processing and comparison of complex data necessary to arrive at an accurate answer.

In addition to OPC discussed in detail in a following section, MIMOSA is often questioned about applicability to Fieldbus. The generic name Fieldbus has several implementations and is primarily a control industry standard for communicating process measurements. MIMOSA hopes that Fieldbus suppliers will select MIMOSA conventions as the most effective method for communicating equipment information.

The net result is that MIMOSA believes it is imperative to preserve, build-on and extend capabilities that have proven highly effective as indicators of equipment condition and lifetime predictors as functions move into a fully integrated enterprise information structure. It would be truly tragic if current machinery predictive and diagnostic capabilities were lost because they couldn't conveniently fit into a system architecture designed for a totally different purpose.

The preceding defines the need for the comprehensive decision support system described in an earlier section. The ideal decision support system will be linked to and communicate with a broad range of sources. It must be fully capable of utilizing complex dynamic and image data. The decision support system must be able to consider diverse factors such as risk, the financial impact of reduced or interrupted production, spares availability and priority among equipment that might share common parts. The most effective decision support system may well have a virtual architecture similar to the Internet, drawing needed information directly from diverse sources, rather than requiring a centralized database that imposes the challenge of synchronization. A tall order on which MIMOSA seems to have the best conceptual solution.

STEP. STEP (Standard for Exchange of Product Model Data, ISO 10303) is a growing standard for data exchange that originated in the design community. STEP provides a standard method to exchange product drawings, documentation and other information independently of the originating organization. STEP is being extended to other areas including process control (PISTEP) and the STEP consortium has indicated an intent for a further extension to include maintenance information.

In early 1998, Hans Klemme-Wolff of Siemens, a valued MIMOSA sponsor, hosted a meeting to discuss the feasibility and time required to map MIMOSA CRIS into STEP using EXPRESS, the STEP language. The meeting concluded that the effort was a bit premature and other, higher priority initiatives, such as extending CRIS and the Business Object Model optimized for equipment management, described earlier, should be addressed first. Details of the discussion and the conclusion were presented at the 1998 MIMOSA Annual Meeting, accepted by MIMOSA membership, and are available in the meeting minutes on the MIMOSA web site.

OPC. OPC (OLE for Process Control) is a rapidly growing interoperability convention being constructed on the Microsoft Component Object Model (COM) and Distributed COM (DCOM). OPC originated in the control automation area as a favored, high level means to exchange information. Many consider conformance with OPC as a necessity for fully integrating equipment predictive information with control and automation systems. MIMOSA has studied OPC from the perspectives of full conformance and integration. Apart from the obvious difference between object (OPC) and relational (CRIS) structures that is being addressed by the MIMOSA Business Object Model described earlier, there are other significant differences between OPC and CRIS. As one example, OPC is constructed in a flat form based on process tag numbers. OPC, including the OPC Historian, doesn't currently include provisions for a hierarchy.

MIMOSA considers a hierarchy imperative for optimized condition assessment and equipment management. The hierarchical structure facilitates access, makes it easier to identify repetitive, common source problems and, as mentioned earlier, determines whether a procedure (e.g., alignment, balancing), local conditions or a 'lemon' machine is the root cause. As illustrated in the overall schematic, Figure 3, CRIS contains two hierarchies plus a map to connect one with the other. The two CRIS hierarchies permit tracking crucial maintenance and reliability information by both process location and specific equipment (assets).

It has also become apparent that OPC addresses only a small portion of the information requirements for effective equipment predictive monitoring and decision support. For example, MIMOSA CRIS versions 1.1 and 2.0 require approximately 240 tables to describe all the condition, maintenance and operating information considered necessary by the experts participating in the MIMOSA process. The MIMOSA vibration object model, VIB-Object, is already up to about 60 objects. MIMOSA has concluded that adding full resources for equipment condition assessment to OPC will require substantial additions in areas that may not be considered particularly important or valuable by the control community.

As stated earlier MIMOSA believes in the necessity of an object model and is committed to developing a model that will assure the availability of full value and benefits from equipment condition and predictive information. During discussions regarding immediate conformance to OPC, MIMOSA participants concluded that the absence of details within OPC that are not particularly relevant or important for control applications could limit its effectiveness for equipment management. As a result, it was decided that MIMOSA should move ahead independently and assemble an object convention constructed on COM and DCOM, which is the technology of OPC. The MIMOSA Business Object Model described earlier will retain CRIS features such as hierarchies that are necessary for optimized equipment management and decision support.

Developing an optimized object structure for equipment management and then back integrating to OPC assures that hierarchy and other details needed for equipment management are preserved. Constructed in this way, the MIMOSA object model will map into an OPC system, albeit with some loss of functionality if areas considered necessary for effective equipment management and decision support in the MIMOSA Business Object Model are not supported by OPC.

Conclusions

MIMOSA, "You've come a long way baby!" From a casual conversation in 1994, MIMOSA exchange is now, or shortly will be, a standard method between equipment information systems offered by nearly every predictive supplier. As stated earlier, MIMOSA exchange is thus a reality within the condition and predictive communities. But, challenges are still ahead.

MIMOSA conventions that assure the ability to preserve the rich detail and measurement description of complex dynamic condition data must gain full acceptance as the most effective method of exchange with control, maintenance management and enterprise information systems. With this accomplished, predictive technology will gain new life driven by the necessity and business value of forecasting future production capacity within the enterprise information structure.

MIMOSA is the pioneer. The vision and method are in place and accepted – now it is up to you. Demand compliance and equipment predictive technology will grow and prosper as the only method capable of assuring production commitments can be met on schedule and cost. Do nothing and equipment predictive technology is likely to become increasingly marginalized and pushed aside by larger, stronger communities with greater influence within the enterprise and little or no comprehension of the requirements and potential value of equipment condition and predictive information. The opportunity and time are now, success requires your participation and support! S/V