An Electronic Information Model for the Pipeline Industry

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An Electronic Information Model for a Pipeline

Over the life cycle of any facility, vast amounts of information are acquired from various sources, in various formats. This data has signficant value. The objective of the Information Model, is the organization and management of the data, acquisition processes and utilization to improve the return on investment in resources expended on that data.

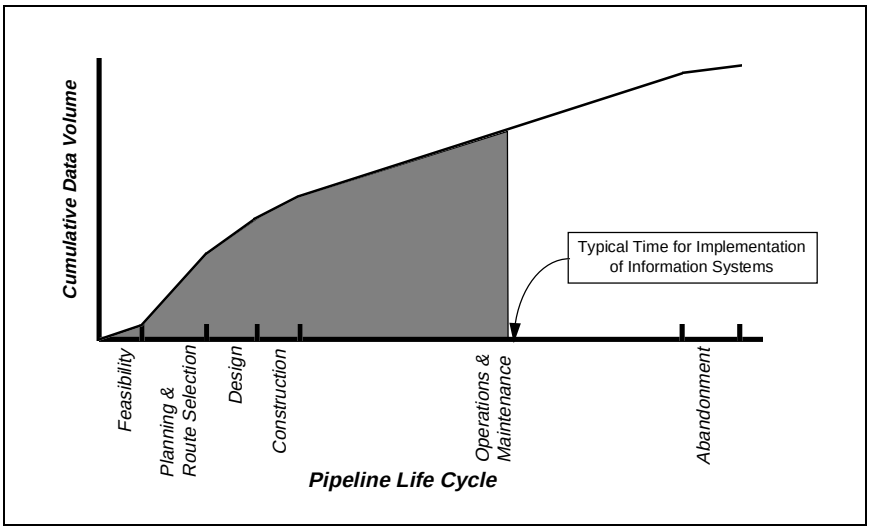

Figure 1: Information Aquisition and Utilization over the Lifecycle of a Pipeline

A pipeline operating company can ***manage the value of the data*** which inherently accumulates throughout the life cycle of the pipeline. The "Information Model" of the pipeline is a coherent, well managed, easily accessible collection of all information regarding the pipeline, the operating environment and operational history.

Pipe Line Information Model (Example)

Relational	*Spatial*	*Drawing*	*Image*	*Survey*	*Documents*	*SCADA*	*Event*
• Land Ownership • Pipeline Attributes • Environmental Attributes	• Pipe Centerline • Soils • Vegetation • Taxation Zones • Building locations • Elevation • Hydrography	• Hardcopy • Electronic	• Air Photo • Satellite • Photograph • Radiograph	• Video • Audio • Pigging • Visual	• Training • Operations • Maintenance • Regulations • Correspondence		• Maintenance • Safety • Environmental • Near miss

Figure 2: Typical information which contributes to the Pipeline Information Model

Application independence is a critical to the information model providing the greatest flexibility and data re-usability. Data structures should not be designed to support specific applications. It must be remembered that of a total investment in information technology, eighty percent or more will be expended on data. Finding an inexpensive applications solution which imposes structures on data or business process, will result in a greatly reduced return on the investment in data.

Why commit to the objective of the Pipeline Information Model?

Competitive pressure and regulatory constraints are placing increasing demands on companies to operate in an efficient and responsible manner. Responding to these demands requires accessibility to information regarding assets and operations ... the information which makes up the pipeline information model.

The information model is a long term objective. It is an objective which must be supported throughout the company, to the executive level. It is also evolutionary and can be initiated with tactical goals to satisfy specific applications requirements, with a policy which states that all survey be delivered in electronic format or with standards on CAD drawings which facilitate their integration with broader corporate data.

Benefits of establishing the "Information Model" as a strategic objective:

1. The information model will provide improved access and utilization of data - resulting in improved return on resources invested to acquire data.

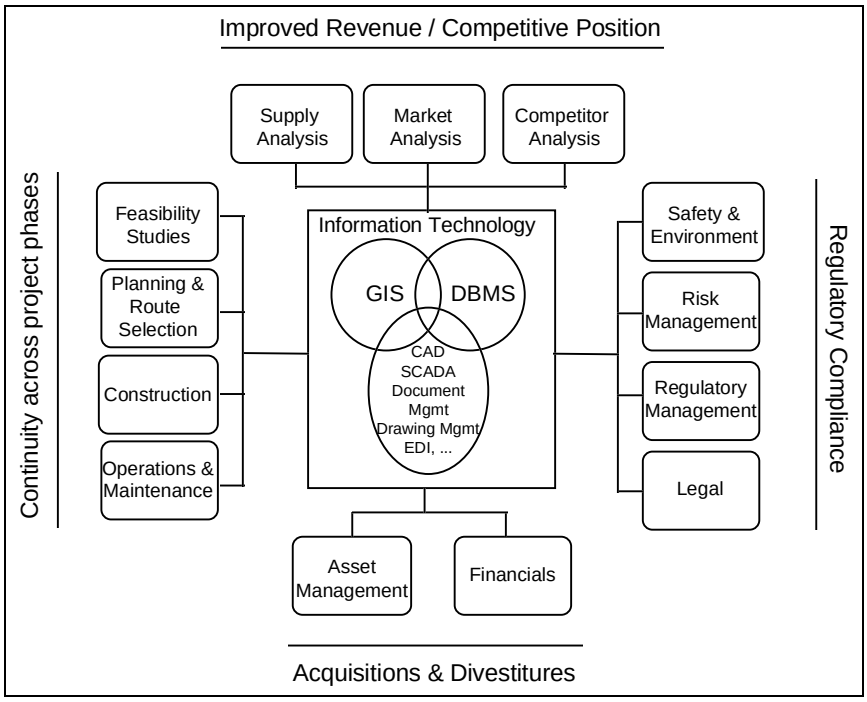

Figure 3: Information Model
Facilitating Enterprise-Wide Information Access

Benefits include:

- Redundant data acquisition is reduced
- Data is re-usable. The same data can support decisions for activities such as planning, construction, maintenance and emergency response. Acquired data has commercial value and can potentially be shared, traded or sold.
- Data provides continuity across phases of construction projects
- Information provides a framework for improved inter-departmental communication.

2. The information model will facilitate more effective decision making through:

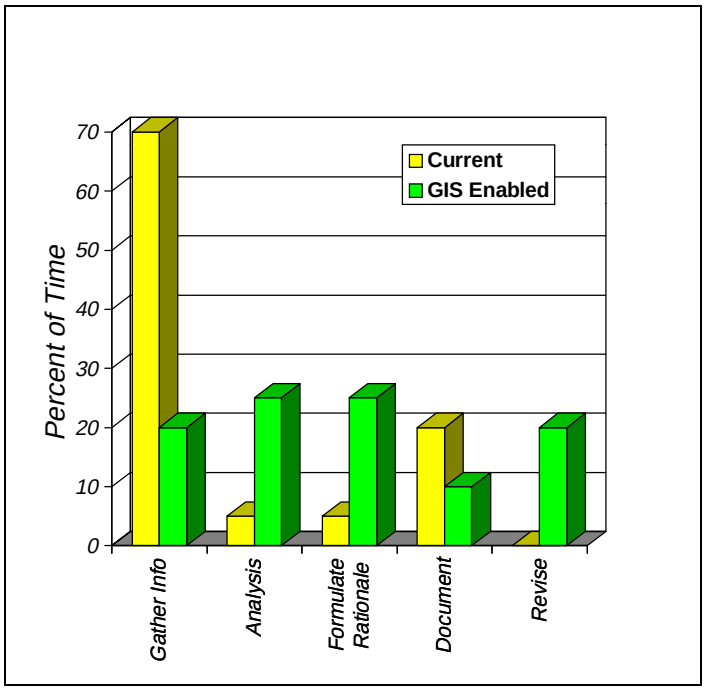

Figure 4: Information Model
Impact on Decision Making Process

- Stepwise reduction in effort to gather and format data
- Extended analytical environment
- Improved formulation of decision rational, scenario building and testing
- Improved documentation tools
- Ability to incorporate revision into the decision making environment.

3. The information model will support applications to improve operating efficiency

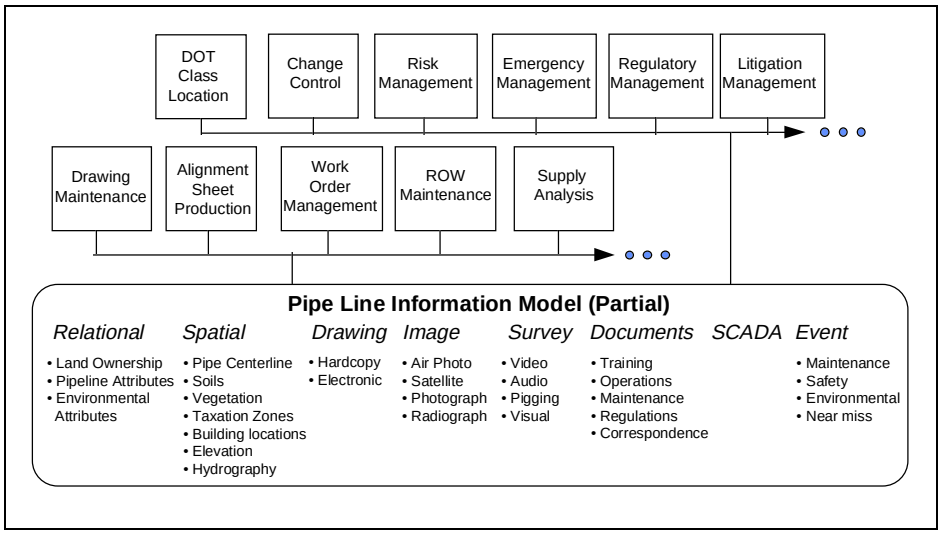

Figure 5: Typcial Applications supported by the Information Model

- support for reporting and permitting (DOT, FERC, EPA)
- One-call dig locating to reduce the number of unnecessary inspections
- support for calculations involving tax districts, land owners, etc.
- Automated mapping - Generation of alignment and strip maps directly from the database - Automated emergency response mapping
- Scheduling and routing for service and maintenance calls
- Generation of location maps providing information such as landmarks to facilitate locating underground facilties
- Integration with facility documentation (e.g. on-line valve maintenance) to ensure access to up-to-date maintenance and operating documents and procedures.

4. The information model will enable the application of risk assessment as a method to improved operational integrity

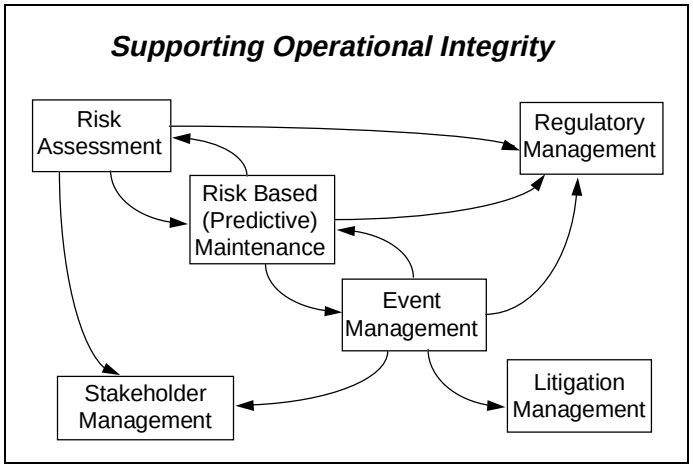

Figure 6: GIS Utilized in Assessment, Prevention, Mitigation and Communication

Disciplined application of objective risk assessment will foster:

- reduction of lost revenues
- reduction in costs associated with remediation
- regulatory compliance
- processes to ensure due diligence
- reduction of uncertainty and liability associated with energy production and transportation in the face of changeable legal and social environments
- management of risks associated with the activities undertaken in the field
- maintenance of a broad perspective regarding the emergence and mitigation of risks

5. Improved competetive positioning
    - Improved reliablity and customer service - Technologies such as GIS and document management can shorten the time to identify equipment failure, locate and dispatch maintenance crews and provide the maintenance crew with the correct information, parts and tools to return equipment to operation quickly and safely.
    - Supply analysis - Identification of areas of new production and cost analysis for tie in to existing system.
    - Interconnect analysis - Identification of "close proximity lines" and factors which may impact the feasibility of interconnection.
    - Product routing - GIS can be utilized to determine least cost paths for product routing. Attributes such as available capacity, tarifs, interconnects, etc. can be modeled.

The role of technology (GIS, Document management, CAD)

If we look at the diverse sources and types of data which will contribute to the information model, it must be recognized that no single technology will suffice as a management, analysis and display technology. Implementation of the information model requires a "cooperative technology" approach. This approach utiililzes appropriate technology to manage appropriate data but the technology and data architectures are designed to facilitate the integration of data across the information model. This provides maximum return on investment in acquired data through "enterprise-wide" utilization of the data in many areas of the company.

Relational Database Management Systems(RDBMS)

The corporate relational database and potentially LAN based departmental relational databases provide the primary repository for the data contributing to the information model. These database tables must have a "key" which associates (relates) the data to a particular entity. This key may be a unique facility identifier or equipment identifier, or the key may be positional such as a line identifier and station location on that line. This positional identification will often be utilized for data such as pipe specification (wall thickness, coating type, etc) or right-of-way data. Techniques for defining the tables to hold this data are well established.

Geographic Information Systems (GIS)

GIS plays a critical role in the information model as a integration technology because of the unique capability of GIS technology to integrate data based solely on geographic position. As illustrated in Figure 7, the GIS functions as a data manager, the GIS provides an applications environment, capable of supporting automated mapping or performing sophisticated spatial modeling and the GIS provides a "Geographic User Interface" which gives the end user an intuitive "map oriented" interface to the information model and the applications which the information model is supporting.

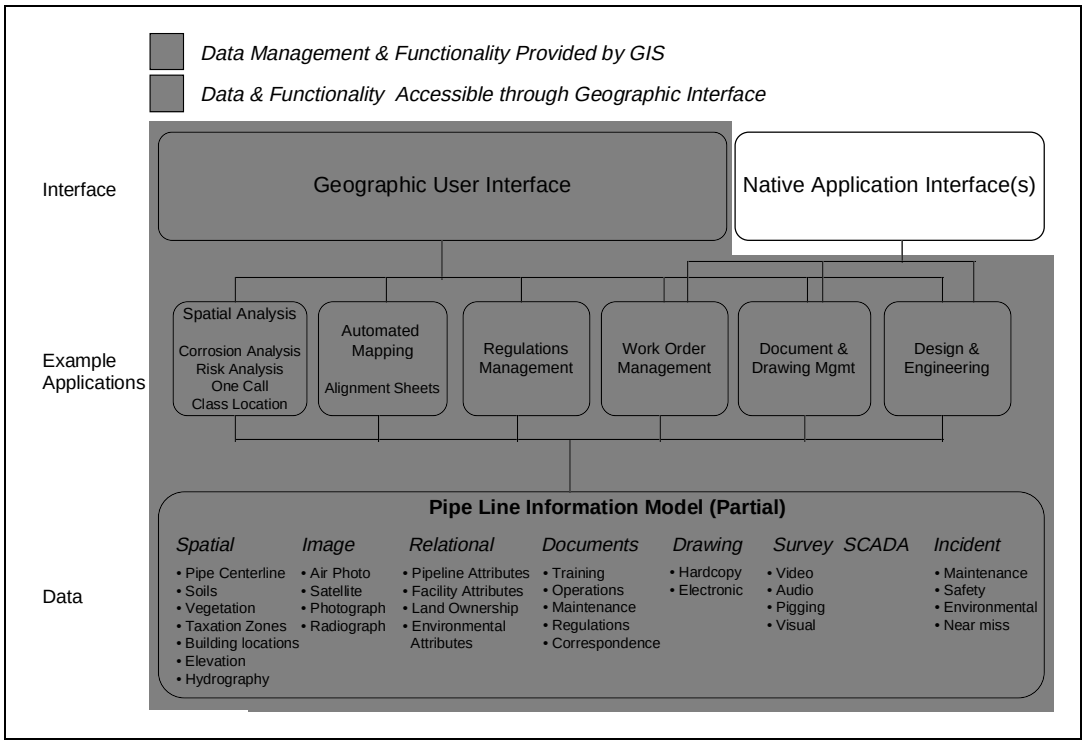

Figure 7: Role of GIS in the Pipeline Information Model

GIS - Data Management and Integration

GIS directly provides the data management capability for such geographically referenced data as the pipe centerline, the surrounding environment such as population density, transportation networks, rivers and flood zones, soil and vegetation types and environmentally sensitive areas. Geographically referenced image data such as satellite imagery and air photo is also managed directly by the GIS. The GIS provides a location mechanism for much of the data stored in the relational database. For example, data which uses the unique facility or equipment id can be associated with a geographic position through the GIS. Data which utilizes line-id and station as an identifier can be directly positioned on the geographically positioned pipe centerline as an "event" using station as the locating mechanism. Documents, drawings, survey (video, pigging), SCADA and other data can also be tied to a geographic location for ease of access.

GIS - Applications

Certain applications are inherently facilitated using a GIS. Such applications involve management of geographical data, spatial modeling and analysis techniques and "map-oriented" manipulation and display of information. A sample of pipeline applications which are suited to GIS include:

- Planning and Route Selection
- Regulatory Reporting and Permitting
- Construction and As-builting
- ROW and Taxation
- Automated Mapping
  - Alignment Sheets
  - Emergency Response Maps
  - Location Maps
- Risk Assessment
  - Impact analysis
  - Corrosion analysis
  - Third party activity
- One-call
- Asset Profitability Analysis
- Supply and Market Analysis

GIS - Geographic User Interface

GIS provides a very natural interface to the information model. Operators and decision makers are familiar with planimetric views of the facility. GIS enables these users to view the facility in this manner and "drill down" into the data (tabular, documents, drawings, etc) for a particular facility. This "drill down" process may also result in the launch of other programs which utilize the data identified by the GIS. Such applications might include gas modeling programs, automated mapping applications (alignment sheet generation) or work order management

Document Management / Engineering Drawing Management Systems

Document management is a key cooperative technology for facility management. Rapid access to documents and drawings can both facilitate decision making and improve operational efficiency and safety. Examples of documents which might be "imaged" or scanned or might be maintained in electronic format could include:

- Right-of-Way documents
- Facility / Equipment specifications, schematics and drawings
- Procedure documents
- Training documents
- Maintenance histories
- Inspection documents

Low volumes of documents (less than 1000) may be managed within the computers file system. However, with a large number of documents (greater than 1000), this becomes unmanagable and specialized software is recommended to facilitate both the entry of the documents, their management and retrieval. These technologies also allow the management of multiple document formats (scanned image, word processing files, drawing files, etc) to be managed transparently.

CAD

CAD has been a critical technology for facility design for many years. Large investments exist in both data (drawings) and CAD expertise. Integration of CAD drawings into the information model can enhance and extend the value of this investment. Drawing files can be integrated into the information model in several ways. Drawings can be classified as follows:

1. Layouts and maps (yard layouts, building layouts, alignment sheets)
   Layouts and maps contain locational (geographic) information. This locational information can be utilized by the GIS to integrated the CAD data with other data within the information model. This data may be additional geographic data, tabular data, images or other drawings, documents, etc. To accomplish this integration, certain standards have to observed in generation of the CAD drawings.
- Utilization of a real world coordinate system is essential.
- Layering of the drawings in an appropriate "thematic" manner (associating common data by layer)
- Avoiding addition of ad-hoc data to layers
- Adding unique identifiers (building-id, equipment-id, facility-id, etc) to drawing entities where possible
- Using additional entity attributes for descriptive information rather than utilizing color or annotation layers
- Using polygons to describe closed features (building or equipment footprints) rather than polylines

2. Engineering drawings (electrical, mechanical, structural, piping, etc.)
   These drawings can be managed as documents and referenced through the CAD system, the document management system or via the geographic user interface, utilizing the pipeline or facility map as a reference environment.

Implementation strategies

The Information Model and Business Process Re-engineering

Business process re-engineering, with subsequent design and implementation of a technology infrastructure, is a lengthy and costly process with many unknowns and risks. It will be many months before tangible results are visible in the form of technology support for improved business practices. In this period, the business climate may change and corporate objectives may be re-focussed. A phased technology implementation will help to *drive* business process change as well as supporting more formally re-engineered business

process. An iterative or evolutionary (business process - technology support) approach can signficantly reduce the risks associated with a formally structured (study - implementation) approach.

Prototyping and Phased Implementation
Tactical (Applications) Focus within the Strategic Framework of the Information Model

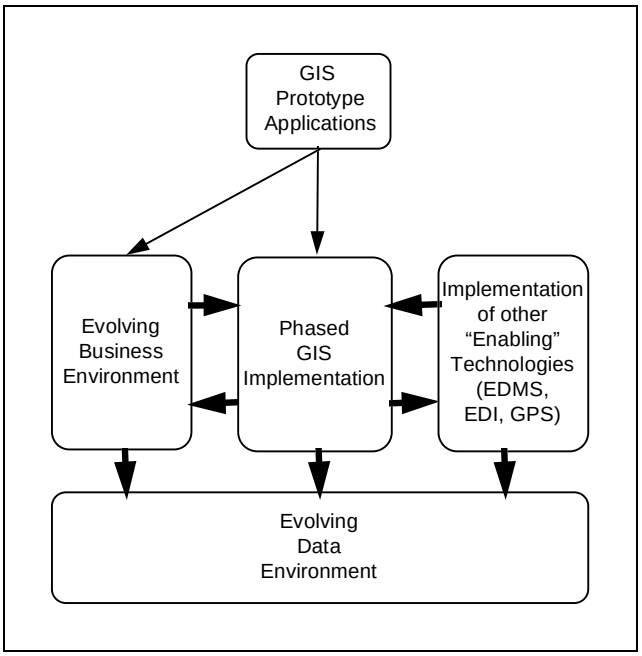

Figure 8: Phased implementation of GIS

GIS prototype applications serve to:

- Introduce GIS across the corporation
- Perform "proof of concept" for business and technical issues
- Define "high leverage" applications for phased GIS implementation

Phased GIS implementation provides the flexibility to:

- Adjust the focus of effort as business and/or regulatory climate dictates
- Integrate with other "enabling technologies" providing comprehensive business support
- Take advantage of continuously advancing technologies
- Initiate the process of building and maintaining a comprehensive information model

Enabling technologies such as GIS and Document management can be implemented in a manner which, while delivering short term objectives such as operations and maintenance support, prepare a data and applications environment which will support strategic applications such as risk management, emergency management and change control. The implementation strategy must be closely coupled to the business strategy and strive to demonstrate payback over the short term. High Leverage applications, driven by business or regulatory necessity, are identified which will have a tangible benefit to the corporation. Implementation of these applications should proceed in a phased manner

such that benefit can be demonstrated in a suitable time frame suitable (3 to 6 months for example). Benefit from the implementation of these high leverage applications will sustain further development of the information model and associated applications.

Data Sources - Contributing to the Information Model

Population of the database is driven by necessity, capability and availability. Acquisition should be coordinated to avoid redundancy (i.e. Environmental and engineering contractors doing separate surveys for the same data or because one has acquired data at a scale which is unusable by the other) Acquired data may not be incorporated into the "master" database immediately due to volume of data being acquired, incomplete data modeling or technology considerations. This does not lessen the necessity to have that data in a format which can be incorporated at a later date.

Basemaps

The first step to building a GIS environment is the development of one or more basemaps. The scale and content of base maps will be determined by their planned usage. Many companies have groups which, unknown to the corporation in general are utilizing GIS. These internal groups may have developed base maps of sufficient accuracy and quality that they may suffice for the corporation in general. Many large oil companies are making extensive use of GIS in their exploration and production departments and have extensive databases which can be transferred to other departments.

"Off-the-Shelf" Data

There is a growing amount of data which is available "off-the-shelf" from various commercial sources and government agencies. Much of the commercial data is "enhanced" government data. This is especially true of the Census data which is re-sold through vendors such as Geographic Data Technologies (GDT). Federal agencies (USGS, USDA, etc), state agencies and local governments are building GIS databases and providing this data to the public, generally at the cost of production.

Cooperative Database Development

Local governments are looking for innovative ways to finance building of planning and engineering databases. The opportunity exists for a cooperative effort in development of GIS databases for right-of-way management, DOT class location and emergency response planning.

Pipeline Databases

Large scale digital maps of pipeline for the US and southern Canada are commercially available. Several pipeline operators are performing extensive digitization of gathering networks and transmission lines with accuracy sufficient for operational purposes. There is some suggestion of cooperation in this effort with digitized pipeline data being treated as a commodity for trade between companies.

Contractors and Suppliers

Most local governments now demand that all contractors for survey services deliver survey results in digital, GIS ready format. The pipeline operator, as the party responsible for the safe and efficient operation of the pipeline, should adopt this practice and mandate

that the suppliers of equipment and services provide all technical documentation, acquired data, surveys, etc. in a form which can be readily integrated into the digital information model of the pipeline.

Internally Generated Information

Data and information are generated by internal sources on a day by day basis. The data comes from all aspects of the pipeline operator's business. A comprehensive pipeline information model is required to allow management and integration of this data for the purpose of supporting the applications model.