Implementing the ArcGIS Pipeline Data Model (APDM)

Peter Veenstra
M.J. Harden Associates, Inc.
APDM Technical Committee Chairperson
Introduction (Who)

- Peter Veenstra
  - M.J. Harden Associates, Inc.
  - Chairperson of APDM Technical Committee

- Who, What, Where, When, Why of the ArcGIS Pipeline Data Model
APDM (Who)

- ESRI Petroleum and Pipeline Special Interest Groups
- Steering Committee/Technical Committee
APDM (Who)

- Members of the Technical and Steering Committees
- Steering Committee
  - Greg McCool (El Paso Corporation), Chairperson
  - Pamela West (ChevronTexaco), Cochairperson
  - Maggie Mabrey (M. J. Harden Associates, Inc.), Secretary
  - Andrew Zolnai (ESRI), Membership
  - Ron Brush (New Century Software)
  - Ed Wiegele (M. J. Harden Associates, Inc.)
  - Mary Muse (PG&E—California Gas Transmission)
  - Ken Greer (CenterPoint Energy)
  - Danika Yeager (Colonial)
APDM (Who)

- Technical Committee
  - Peter Veenstra (M.J. Harden Associates, Inc.), Chairperson
  - Jay Smith (M.J. Harden Associates, Inc.), Secretary
  - Buddy Nagel (El Paso Energy)
  - Theo Lawrence (Great Lakes Gas Transmission)
  - Tracy Thorleifson (Eagle Information Mapping)
  - Scott Hills (ChevronTexaco)
  - David Nemith (Southern Union Panhandle)
  - Tom Marcotte (James Sewall Co.)
  - Lane Powell (ESRI)
History of the APDM

- **March 2002**—M.J. Harden Associates, Inc., starts initial work on the model.
- **July 2002**—The model is presented at the ESRI User Conference in San Diego, California. An open invitation to participate in the design of the model is extended to the pipeline community.
- **August 2002**—The initial meeting of interested member groups occurs at ESRI in Redlands, California.
- **October 2002**—The Steering and Technical Committees are officially formed at the ESRI Electric/Gas Utility User Group Conference, Coeur d’Alene, Idaho.
- **December 2002–June 2003**—Monthly Technical and Steering Committee meetings at various member organizations take place. Intellectual property agreement, Steering Committee charter, Technical Committee mandate, operational procedures, and APDM content and structure are developed.
- **March 2003**—The APDM is released for public comment at the ESRI PUG meeting, Houston, Texas.
- **July 2003**—Version 1 of the APDM is officially released at the ESRI User Conference, San Diego, California.
- **October 2003**—First revision modeling session – EGUG – Galveston, TX
What is the APDM?

- Data Model Designed for Geodatabase
- Built From Published Data Models
- Starting Point
  - Not Comprehensive, Rather Suggestive
    - "Sophisticated, Yet Relaxed"
  - 80 Percent Pipeline Company Rule
  - Hot Topics: HCA, In-Line Inspections, Risk, Integrity, Operations, Right-of-way
- Core Elements
What is the APDM?

- Standard Versus Template
- PODS—Pipeline Open Data System
- ISAT—Integrated Spatial Analysis Technology
- ISPDM—Industry Standard Pipeline Data Management
- Relational Database Management Systems
- Object-Relational Systems: Geodatabase
Linear Referencing (What !?!)

- Station Series
  - Connected linear features
  - Contain stationing information
  - Station Series = Route
  - Station Equations
  - All referenced features relate to one and only one Station Series (Route)
Station Series 1 (Route)

Station Series

(GeometryType = esriGeometryPolyline, HasM = True, HasZ = False)

- BeginStation : esriFieldTypeDouble = 0.00
- EndStation : esriFieldTypeDouble = 0.00
- EventID : esriFieldTypeString
- LineLoopEventID : esriFieldTypeString
- ReferenceUnits : clmReferenceUnits = 1
- SubtypeField -SubTypeCD : esriFieldTypeInteger = 7
- SourceSeriesEventID : esriFieldTypeString
- SinkSeriesEventID : esriFieldTypeString
- SeriesOrder : esriFieldTypeInteger

Station Equation

Centerline_Subtypes::Continuous
- SubTypeCD : esriFieldTypeInteger = 1

Centerline_Subtypes::Engineering
- SubTypeCD : esriFieldTypeInteger = 2

Centerline_Subtypes::Horizontal
- SubTypeCD : esriFieldTypeInteger = 3

Centerline_Subtypes::Milepost
- SubTypeCD : esriFieldTypeInteger = 4

Centerline_Subtypes::Slack Chain
- SubTypeCD : esriFieldTypeInteger = 5

Centerline_Subtypes::Valve Section
- SubTypeCD : esriFieldTypeInteger = 6

Centerline_Subtypes::Unspecified
- SubTypeCD : esriFieldTypeInteger = 7
Linear Referencing

• Control Points
  • Point feature representing:
    • Known XY location (GPS, Monument, Line Crossing)
    • Known stationed position (Historic Stationing)
    • Point of Inflection (Horizontal/Vertical bend)
  • Control Points are vertices and end points of station series
  • Same subtypes as Station Series
  • Each control point has one station values associated with it.
Centerline_Subtypes::Continuous
-SubTypeCD : esriFieldTypeInteger = 1

Centerline_Subtypes::Engineering
-SubTypeCD : esriFieldTypeInteger = 2

Centerline_Subtypes::Horizontal
-SubTypeCD : esriFieldTypeInteger = 3

Centerline_Subtypes::Milepost
-SubTypeCD : esriFieldTypeInteger = 4

Centerline_Subtypes::Slack Chain
-SubTypeCD : esriFieldTypeInteger = 5

Centerline_Subtypes::Valve Section
-SubTypeCD : esriFieldTypeInteger = 6

Centerline_Subtypes::Unspecified
-SubTypeCD : esriFieldTypeInteger = 7

ControlPoint
(GeometryType = esriGeometryPoint,
 HasM = True,
 HasZ = False)
-ControlPointAngle : esriFieldTypeString
-ControlPointType : clControlPointType = 1
-EventID : esriFieldTypeString
-PIDirection : clControlPointDirection = 1
-ReferenceUnits : clReferenceUnits = 1
-StationingValue : esriFieldTypeDouble = 0.00
-StationSeriesEventID : esriFieldTypeString
«SubTypeField» -SubTypeCD : esriFieldTypeInteger = 7
-SymbolRotation : gnAngle = 0.00
Core Model

- All features in APDM are one of six defined types: online point, online polyline, offline point, offline polyline, offline polygon, core element
- Features are ‘referenced’ by the centerline or they are not referenced
- Features have inherent absolute position
- Events are generated solely on relative position
- All ‘events’ or ‘features’ must have globally unique identifier: EventID
- EventID is used for all relates.
Online Point/Polyline

- Point or Linear Feature
- Geometrically constrained to centerline
- Begin/End position located by stationing
- Participates in Topology
Offline Point/Polyline/Polygon

- Point, Linear or Polygonal Feature
- Usually exists off the centerline
- Does not participate in Topology

Station Series

Measure 0
- HCA Area
- BeginStationSeriesEventID 235, BeginStation 15+00
- Offset Angle 75’, Offset Distance 200ft, Offset Side: Right
- EndStationSeriesEventID 235, EndStation 65+00
- Offset Angle 90’, Offset Distance 175ft, Offset Side: Right

Measure 100
- Structure StationSeriesEventID 235, Station 95+00,
- Offset Angle 90’, Offset Distance 125ft, Offset Side: Left

Measure 225
- Structure StationSeriesEventID 235, Station 135+00,
- Offset Angle 135’, Offset Distance 85 ft, Offset Side: Right

Structure
- StationSeriesEventID 235, Station 95+00,
- Offset Angle 90’, Offset Distance 200ft, Offset Side: Right
Offline Point/Line/Polygon

- Pass-through Polygons, Transportation Networks, Hydrology, Environmental, Operational, and Cultural features
- Object Classes
  - Activities, External Documents, GeoMetadata, Contacts, Companies etc.
Model Tour: Centerline

- Objects that form the centerline
- Linear Referencing Mechanism
  - **StationSeries** – routes of stationing, contains hierarchy information
  - **ControlPoint** – points of known station position, PI’s
  - LineLoop – a collection of station series that comprise a single ‘line’
  - GeoMetaData – source information for control points
  - OwnerOperatorship – Line Loop owner/operator percentages
Model Tour: Facility

- Physical elements that comprise Pipeline
  - Coating (PLFc), Sleeve (PLFc), Casing (PLFc), Appertenance (PtFc), Vessel (PtFc)
  - NonStationedPipe (PLFc), PiggingStructure (PLFc)
  - Pipe Segment (PLFc), Valve (PtFc), Fittings (Meter, Elbow, Tee, Reducer, Closure) (PtFc), PipeJoinMethod (PtFc), Tap (PtFc)
Model Tour: Inspection

- Inspection and Integrity
- Generic classes
- Huge variance in applications and data
  - Anomaly (PtFc) – anomaly or deformity in pipe
  - AnomalyCluster (mPtFc) – cluster of anomalies
  - InspectionRange (PLFc) – linear inspection – eg. Leak Survey, Inline PIG Run, Aerial Survey, Close Interval Survey
Model Tour: Operations

- Regulatory and Operations
  - On or Offline Referenced
    - FieldNote (PtFc) – Field Data Collection
    - ElevationPoint (PtFc) – ground, pipe water elevations
    - Marker (PtFc) – monuments, Mile Posts, PIG Signals
    - SiteBoundary (POFc) – Meter Stations, Compressor Stations, Easements etc.
    - HCAClass (PLFc), PressureTest (PLFc), RiskAnalysis (PLFc), OperatingPressure (PLFc), RightOfWay (PLFc)
Model Tour: Cathodic

- Corrosion Management
- Kept generic
- Based on Distribution Model
  - On or OffLine Referenced
    - CPRectifier (PtFc)
    - GPGroundBed (PtFc)
    - CPAnode (PtFc)
    - CPBond (PtFc)
    - CPTestStation (PtFc)
    - CPCable (PLFc)
Model Tour: Encroachments

• Encroachments on the pipeline
• Encroachments within the Class Corridor
  • HighConsequenceAreas (POFc), StructureOutlines (POFc)
  • LineCrossing (PtFc)
  • LinearEncroachment (PLFc), Structure (PtFc)
Model Tour: Event Support

- **Object Classes to support:**
  - **History, Mapping, Documentation**
    - **Activity (OC)** – any activity that occurs
    - **ActivityEvents (OC)** – events that are part of an activity
    - **AlignmentSheet (POFc)** – sheet boundary and info
    - **Company (OC)** – companies, contractors, divisions
    - **Contact (OC)** – any person in the system
    - **DataSet (OC)** – FeatureDataSet MetaData
    - **DocumentPoint (OC)** – multi-hyperlinked feature
    - **ExternalDocument (OC)** – source document links
    - **GeoMetaData (OC)** – point source meta data
    - **RemovedLine/Point (PL/PTFc)** – removed features
    - **LastEventID (OC)** – holds the last EventID
Top Ten Reasons to use APDM

From the home office in Waverly, Iowa

……

The top ten reasons for using the ArcGIS Pipeline Data Model to implement your Gas/Liquids Transmission Pipeline Geographic Information System

(What, and Why)
Top Ten Reasons to use APDM

- APDM is built on ESRI Geodatabase
  - Leader in GIS Software
  - Highly functional, easy-to-use off-the-shelf GIS software
  - Powered for the enterprise by ArcSDE ...
  - Flexible Object-Relational Data Model that provides ...
    - Both referential and spatial integrity
    - Enforced link between features and attributes
    - Complex relationships, multiuser long transactions, security, scalability, topology, extended object behavior, geoprocessing, raster-based analysis, state-of-the-art map display and cartographic production, web integration, disconnected editing
- “ESRI is the 'epicenter' of what is happening in GIS now and in the future.”  David McGuire, ESRI

ArcGIS Pipeline Data Model (APDM)  EGUG 2003
Top Ten Reasons to use APDM

- APDM is a model with a simple core ...
  - Station Series, Control Points, Line Loops, Pipe Segments, Online Points, Online Polylines, Offline Points
- APDM is a data model that can be readily expanded with object behavior ... complex potential and possibilities ... you define behavior!
Top Ten Reasons to use APDM

• APDM can store both features and events
  
  • Features are static geometry contained in the row that describes the feature
  • Events are ‘dynamic’ geometry that are generated from a specified route and measured position along the route
  • Features are excellent for modeling facilities and permanent features on or along a pipeline
  • Events are excellent for modeling dynamically segmented features, the results of analysis, and ephemeral features such as inspections, anomalies, risk analysis, pressure tests
Top Ten Reasons to use APDM

- APDM translates to-from existing pipeline RDBMS data models...
  - PODS—Pipeline Open Data System
  - ISAT—Integrated Spatial Analysis Technology
  - ISPDM—Industry Standard Pipeline Data Management
- Similar core features:
  - Centerline (Control Points, Station Series, Routes)
  - Online/Offline Referenced Features (Pipes, Valves etc.)
  - Hierarchy (Station Series, Line Loop etc.)
- All Pipeline models incorporate stationing (Route/Measure & Centerline) as mechanism for linear referencing
Top Ten Reasons to use APDM

• APDM is a true GIS model …
• Geometry stored as features in relative and absolute spatial position to other features
• Out-of-the-box data maintenance
• Out-of-the-box data analysis
• If a picture is worth a 1000 words then a map is worth a 1000000 words …
Top Ten Reasons to use APDM

• A Template not a Standard
• Open Model – Extendable
• Works w/ ArcGIS/ArcSDE 8.3 (OOB)

• Designed for the GeoDatabase
• Built from published data models
• Starting Place to build Enterprise GIS
  • Not comprehensive, rather suggestive
  • “Relaxed yet sophisticated”
  • 80% Pipeline Companies Implement RULE
  • Hot Topics: HCA, Inline Inspection, Integrity, RISK
Top Ten Reasons to use APDM

- Integrated Enterprise Solution
- Geodatabase – Versioning – Work Flow
- RDBMS Core – relates to external systems
- GIS Core – features to attributes
- Applications
Top Ten Reasons to use APDM

• Data Maintenance
  • Topology, Snapping, Relationship Classes, Subtypes, Domains
• Spatial Analysis
  • Buffer, Overlay, Intersection, Proximity, Distance, Visualization (2D, 3D, Animated), Business, Routing
• Mapping and Reporting
  • RDBMS server
  • Views
  • Stored Procedures
Top Ten Reasons to use APDM

- Part of ESRI Model Family

- Petroleum
- Gas Distribution
- Geology
- Transportation
- Cadastral
- Street Centerline
- Right of Way
- Census
- Environmental
Top Ten Reasons to use APDM

• **COOL**
  • Cost effective
  • Object Oriented
  • Linear Referenced Data Model

• GIS Driven
• Feature Driven
• Enterprise Driven
The Future of APDM

• Regular meetings
  • ESRI Electric and Gas Utility User Group Meeting (September/October)
  • ESRI Petroleum User Group Meeting (March)
  • APDM User Group Meeting at the ESRI User Conference (July/August)

• Elected positions on the Steering and Technical Committees

• More information?
  • M.J. Harden and ESRI Booths
More Information

- ESRI Web Site: www.esri.com\petroleum
  - UML Model—APDM_V1.vsd (Visio 2002 format) **AVAILABLE (PUG Members)**
  - XMI Repository—APDM_V1xmi.xml (requires uml.dtd) **AVAILABLE (PUG Members)**
  - Logical Model (Visio 2002 format, PowerPoint) **AVAILABLE (Open)**

- Security and Privacy Issues With Sample Data
Disclaimer

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Thank you!