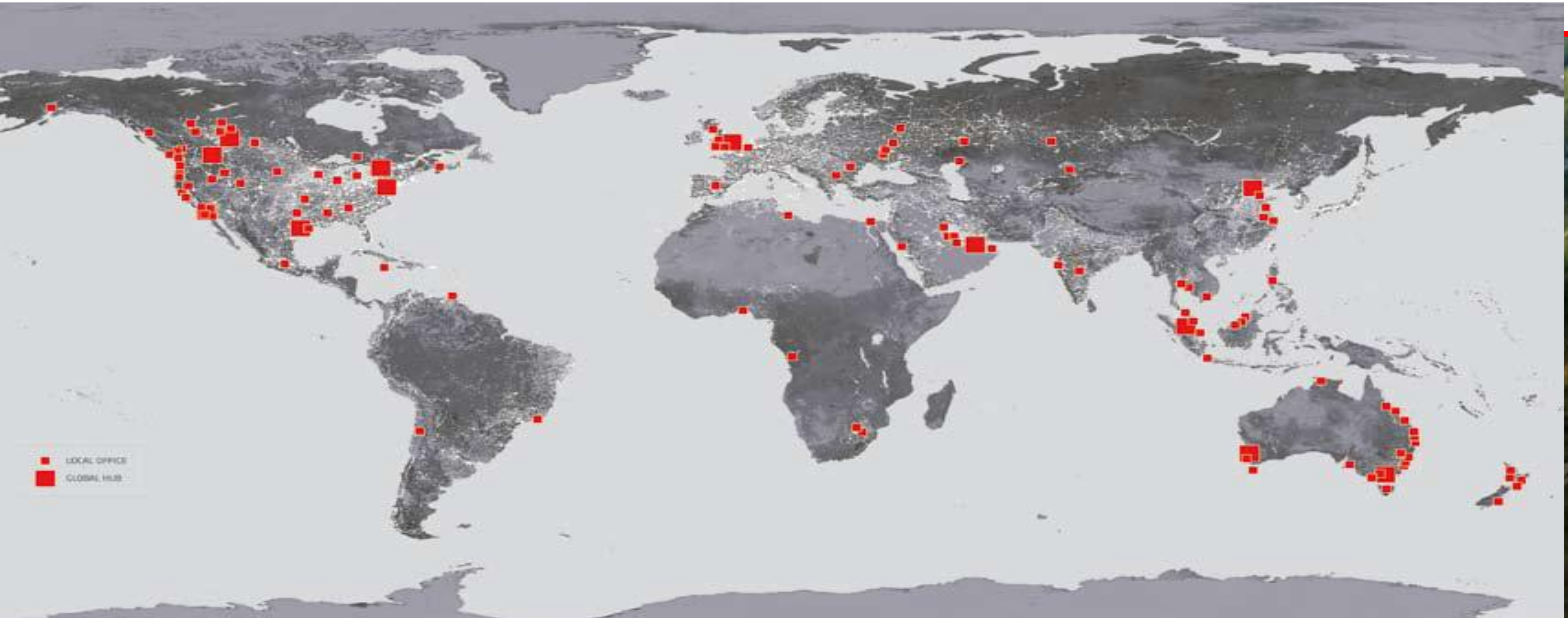
WorleyParsons

resources & energy

EcoNomics™

Geomatics

Geomatics - Part of the WorleyParsons Service Offering



Agenda

▶ Geomatics Fundamental

- What is Geomatics ?
- Geomatics Workflow for Engineering projects
- Why Geomatics ?
- Software and Tools
- Projects

What is Geomatics?

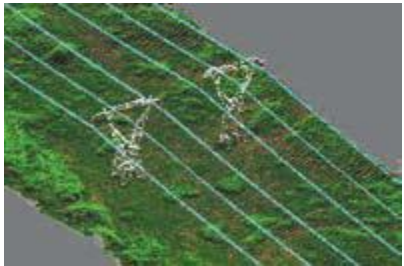
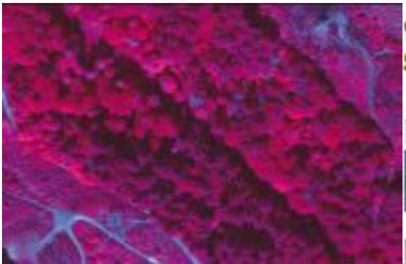
- **Geomatics** is the discipline of:
  - gathering,
  - storing,
  - processing, and
  - delivering of geographic information, or spatially referenced information

- **Geomatics Engineering** is a modern discipline, which integrates :
  - acquisition,
  - modeling,
  - analysis, and
  - management of spatially referenced data, i.e. data identified according to their locations.

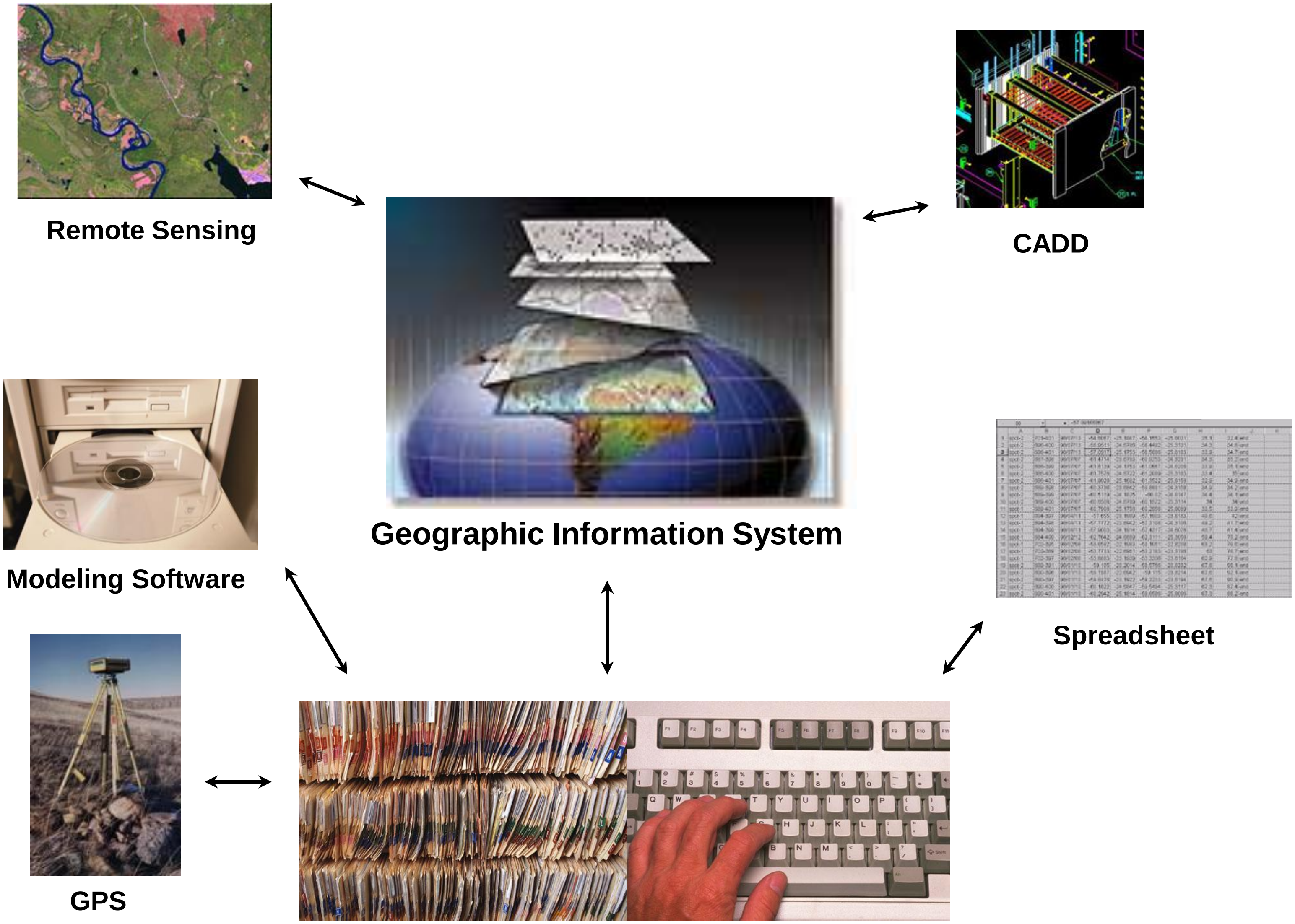
What is Geomatics?

- **Geomatics** encompasses the fields of
  - Surveying & Geodesy
  - Geospatial Data acquisition
    - Remote Sensing
    - Photogrammetry
    - Lidar and 3D Laser scanning
    - Cartographic Mapping
  - Geographical Information System (GIS)
    - Spatial data
      - Integration
      - Management
      - Analysis
      - Publishing

- **Geomatics** are the managers of the information supply chain on a project:
  - GIS Analyst
  - Remote Sensing Analyst
  - Spatial Database Managers
  - Geomatic Engineers / Survey
  - Engineering Designers

What is Geomatics?



Remote Sensing

CADD

Geographic Information System

Modeling Software

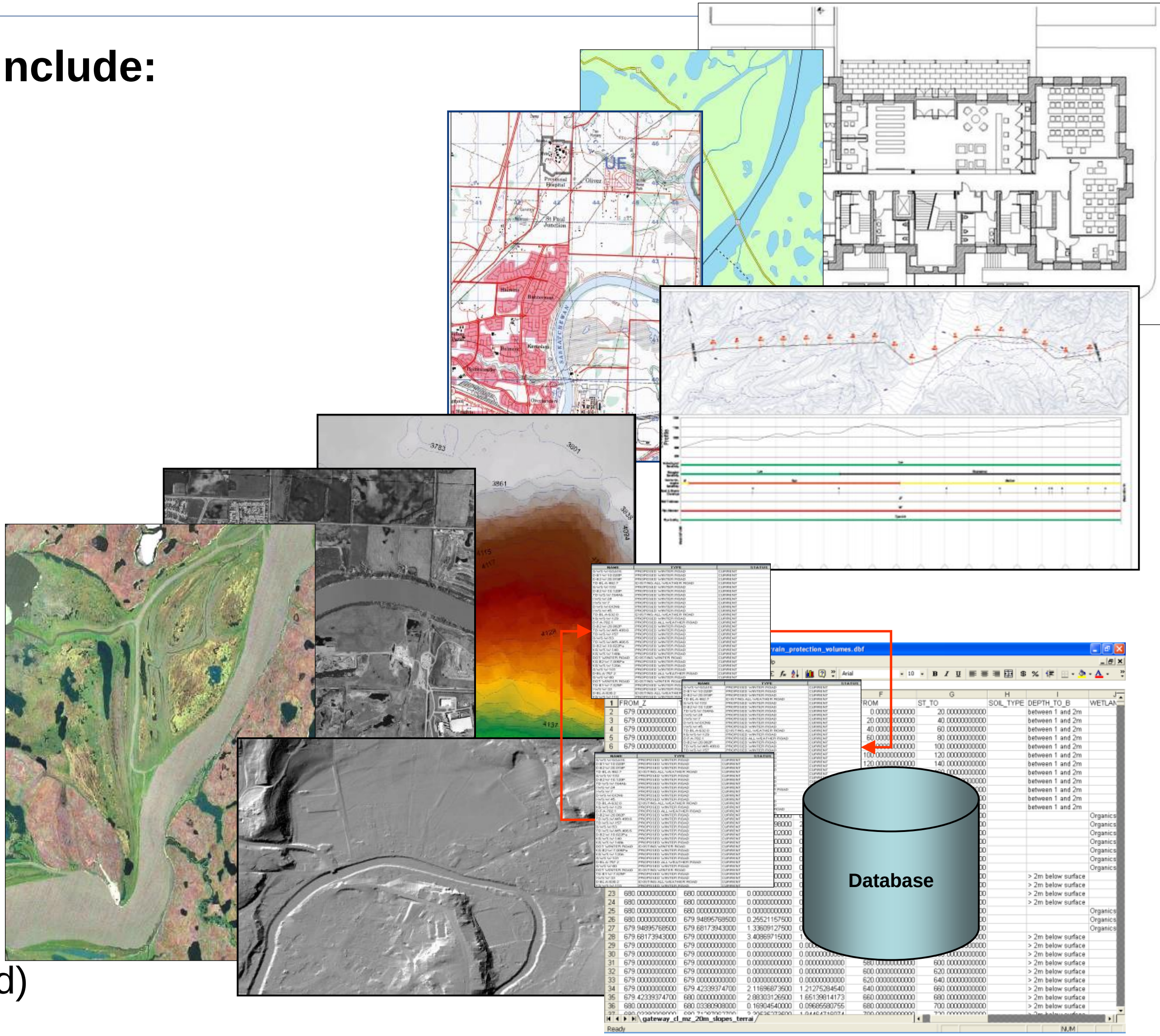
Spreadsheet

GPS

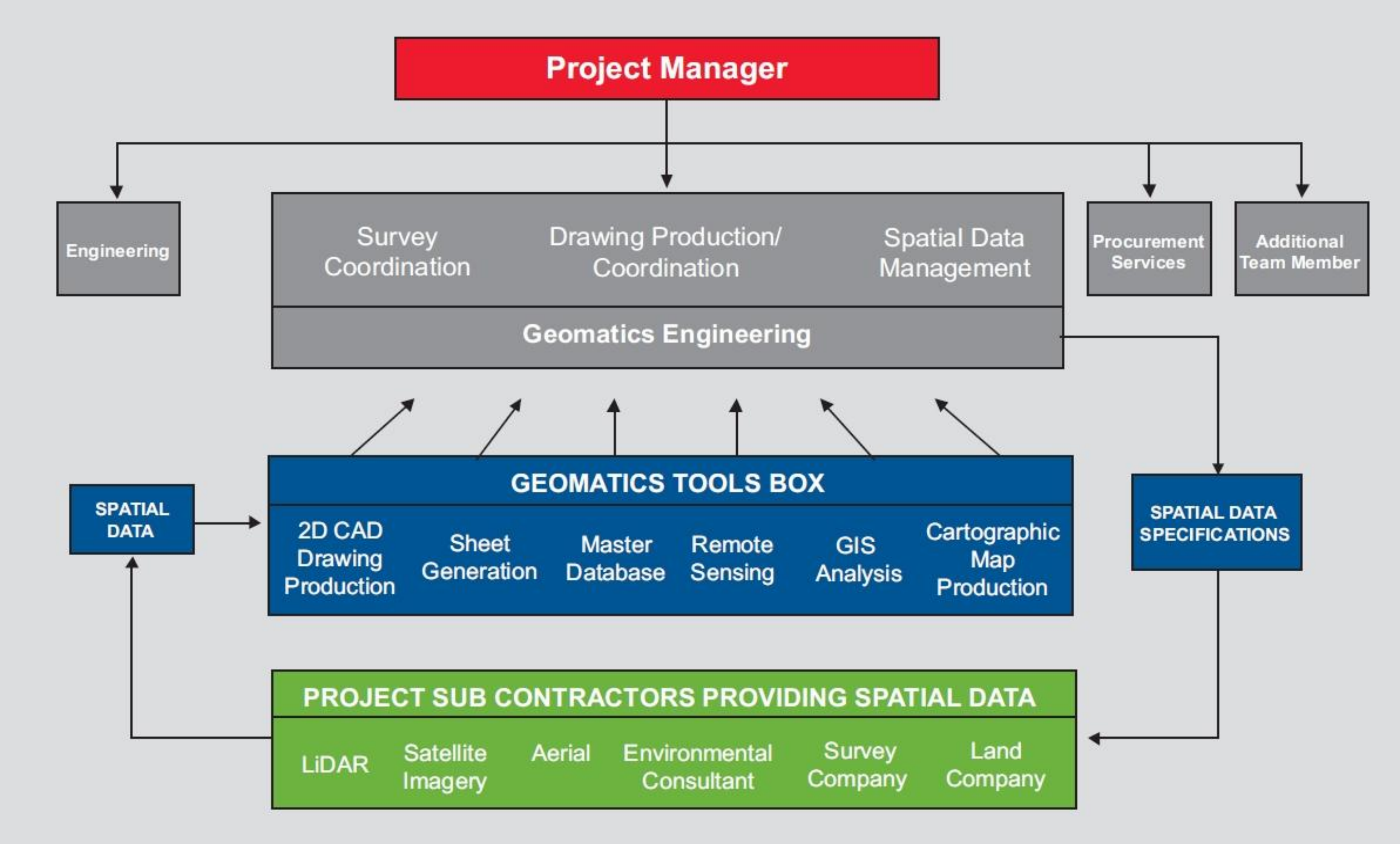
Database

Examples of spatial data include:

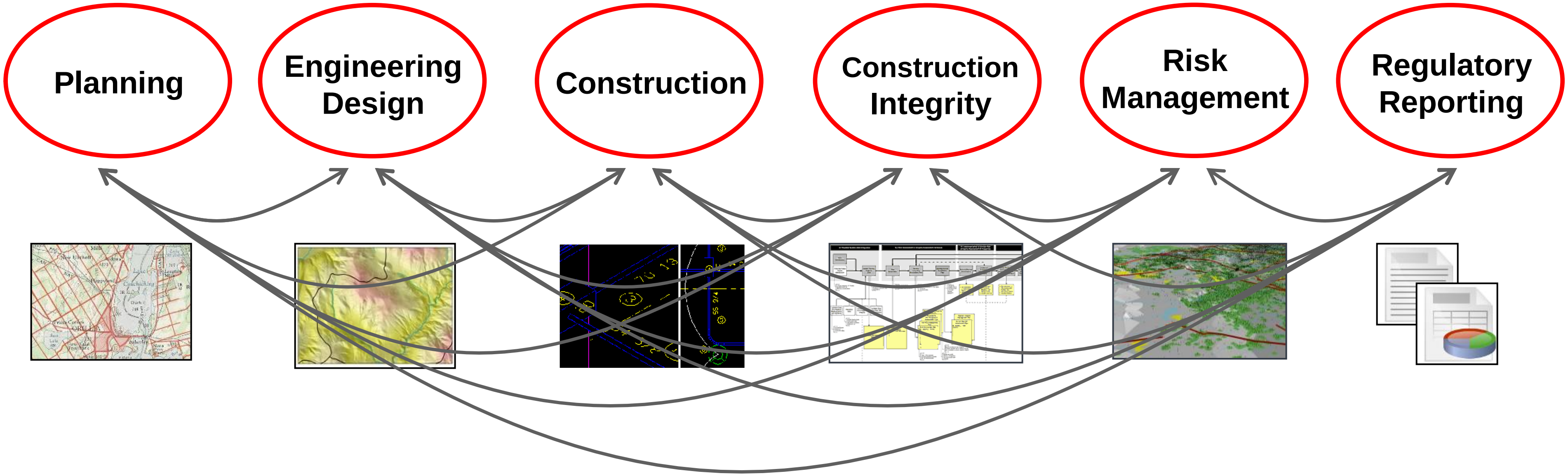
- Hardcopy Maps
- Digital Maps & Data (GIS)
- AutoCAD Drawings
- Alignment Sheets
- Inspection reports
- Emergency Planning Zones
- As-built surveys
- Elevation Data
- LiDAR
- Satellite/Aerial Imagery
- Data Management
- 3D Laser Scanning (brownfield)



Geomatics Workflow for Engineering projects



Data Silos



Planning

Engineering Design

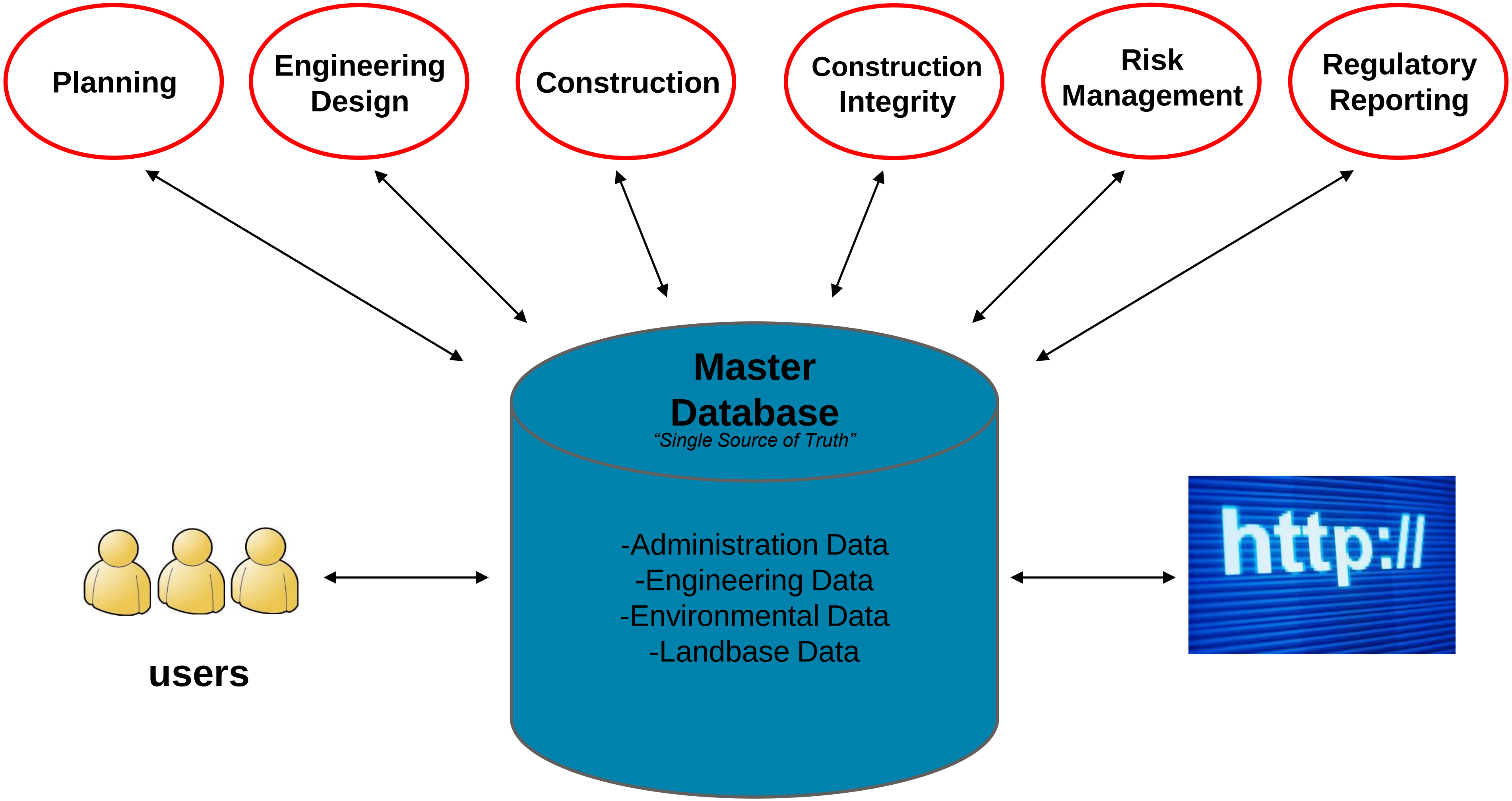
Construction

Construction Integrity

Risk Management

Regulatory Reporting

Centralized Data



Planning

Engineering Design

Construction

Construction Integrity

Risk Management

Regulatory Reporting

Master Database

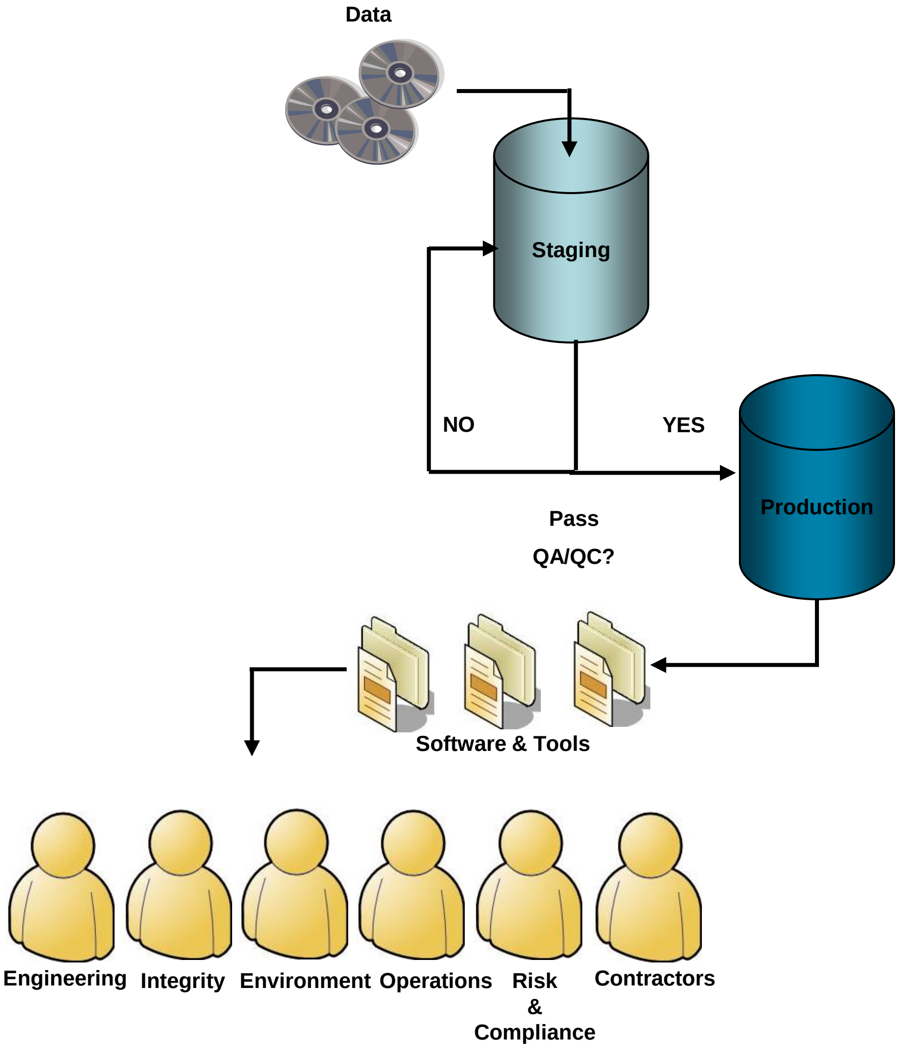
"Single Source of Truth"

-Administration Data
-Engineering Data
-Environmental Data
-Landbase Data

users

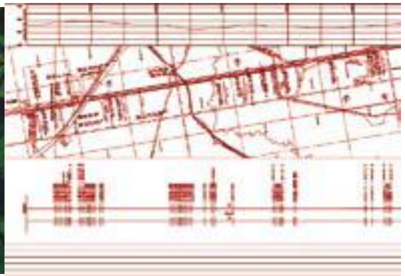
Master Database

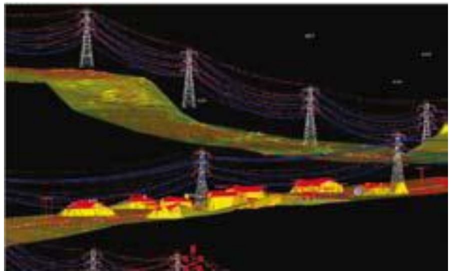
- Manage data
  - Data storage
  - Data retrieval
  - Data change
- Standards
  - Metadata
  - Geodetic
  - Database
- All data in one location - single source of truth
- MDB can be used by all disciplines on project
- Security



Why Geomatics?

- Geomatics bring to a project:
  - Increased operational efficiencies through rapid and consistent access to data.
  - Improved quality and integrity of data.
  - Reduced effort to comply with information requests.
  - Automated tasks (i.e. Alignment sheets, route maps).
  - Engineering Analysis



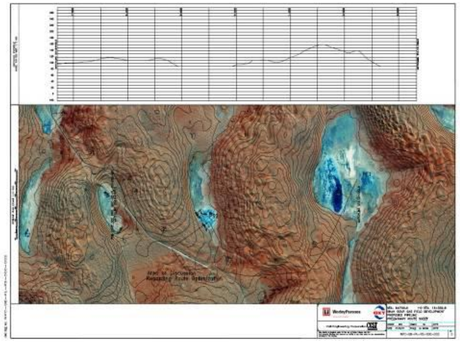


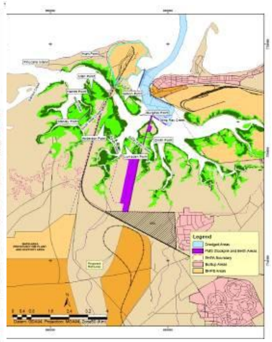
Geomatics on Engineering Project

- Select
  - Help in basic visualization of the project space, potential issues / challenges
  - We have good data available from day one
  - A geomatics person can help answer a lot of question
- Geomatics support ramps up with project progress
  - Dependent on size and *complexity* of project
  - As most work is desktop, therefore work distribution just needs to be managed.
- Commissioning
  - During the project we interact with the client to ensure the data we hand over is in the optimal format for their use after commissioning.

Deliverables on Engineering Projects

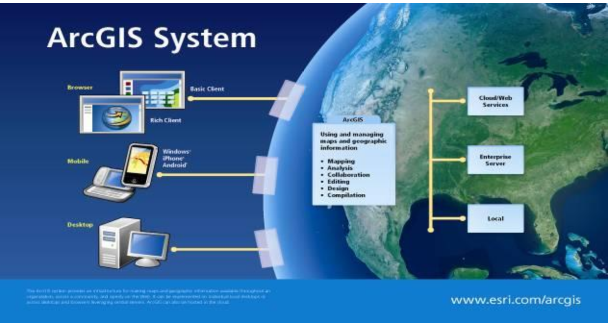
- •Thematic Maps and drawings
- •GIS Database (e.g. Environmental, historical sites, spread contractors)
- •Digital Elevation Model, Hydrological network
- •Visualization
- •Decision Support System
- •Logistics support (mapping, planning etc.)
- •Engineering Calculations (In a Spatial Context)

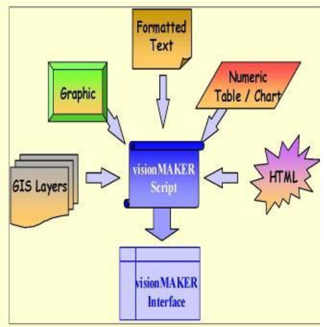


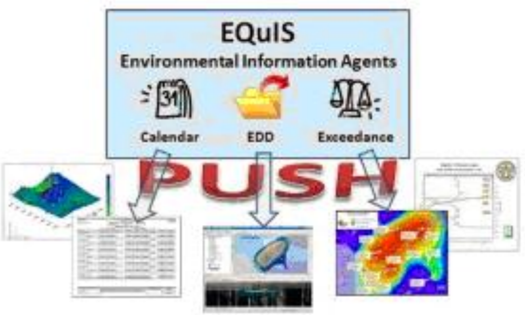


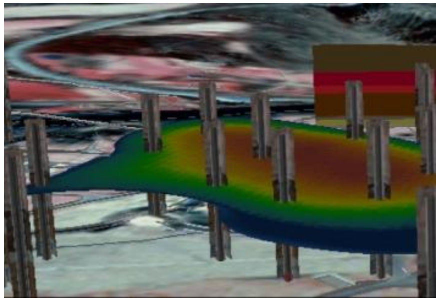
GIS Software & Tools

- ArcGIS 10.1 and Extensions(Spatial,3D,Geostatistical, Sheet cutter, Template designer..etc)
- Vision MAKER(In house GIS data presentation software)
- CIVIL 3D, AutoCAD Map,
- Map Source, Quantum GIS 1.8
- EQuIS







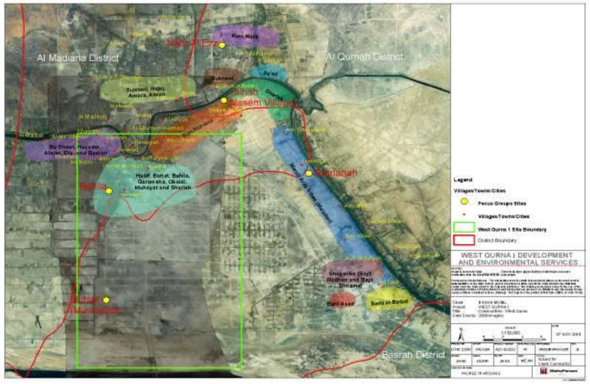


Project Examples

Geomatics – Example

- Project: West Qurna Field Development
- Client: Exxon Mobil
- Scope: Support Environmental team with GIS, Remote Sensing and database management services. Integrate Client's GeoDatabase with WP Environmental data.
- Innovation: By using the high resolution Imagery, we were able to do the preliminary study of the Contamination on the desktop. We built a user friendly database in VisionMaker which could easily be used by the field staff without any training. The field study and the laboratory test data has been incorporated in the GIS database for efficient analysis and graphical representation of the data.

Al Amarah
Maysan
Al-Qadisiyah
Ahvaz
Dhi-Qar
An-Nasiriyah
Basra
Basra
Al-Muthannia
Kuwait
Al-Jahrah
Hawalli


Al Madiana District
Al Qurnah District
Bani Malik
Buwaeed
Sa'ed
Buwaeed, Hajaj, Amara, Alwan
Sharish
Nasem Village
Bu Shawi, Hayader, Alwan, Elly and Badran
Halaf, Battat, Bahila, Garamsha, Obaidi, Muhayat and Sharish
Shaganba (Bayt Radhan and Bayt Shnane)
Bani Asad
Sada al-Battat
Basrah District
Legend
Villages/Towns/Cities
Focus Groups Sites
Villages/Towns/Cities
West Qurna 1 Site Boundary
District Boundary
WEST QURNA I DEVELOPMENT AND ENVIRONMENTAL SERVICES
Client: EXXON MOBIL
Project: WEST QURNA I
Title: Communities - West Qurna
Date Source: 2009 Imagery
1:150,000
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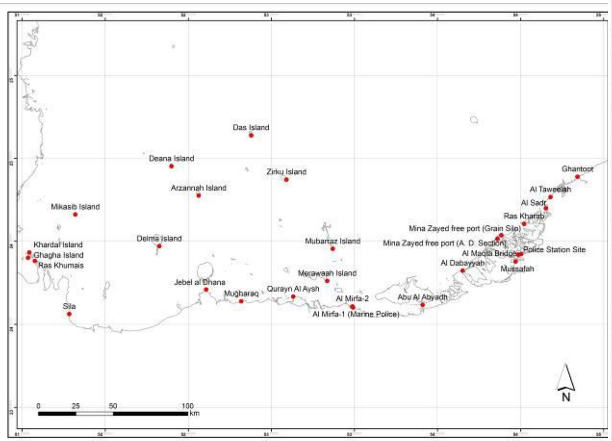
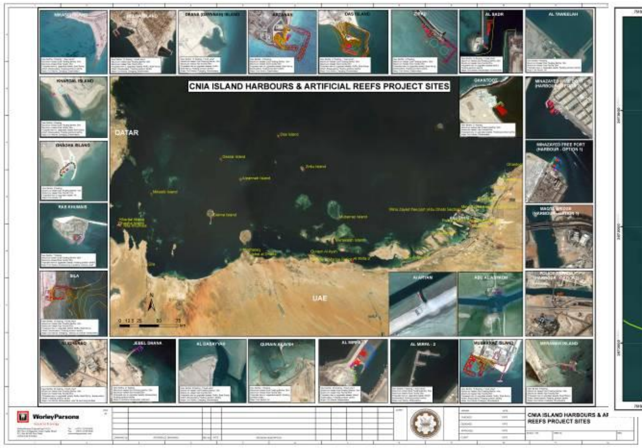
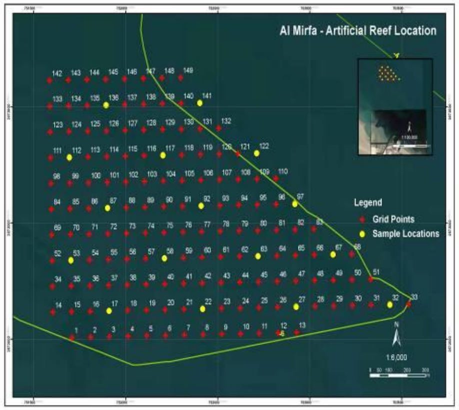
Geomatics – Example

Project:	Harbor and Habitat Enhancement
Client:	Critical National Infrastructure Agency
Scope:	Support Engineering and Environmental team with GIS,RemoteSensing and database management services. Providing user friendly GIS database system to the client.
Innovation:	By using the high resolution Imagery and the marine chart, we were able to do the preliminary study of the 25 sites on the desktop. We built a user friendly database in VisionMaker which worked as communication tool among project team and stakeholder. Data migration were done between GIS and CAD system.




CNIA ISLAND HARBOURS & ARTIFICIAL REEFS PROJECT SITES
QATAR
UAE
WorleyParsons
CNIA ISLAND HARBOURS & ARTIFICIAL REEFS PROJECT SITES



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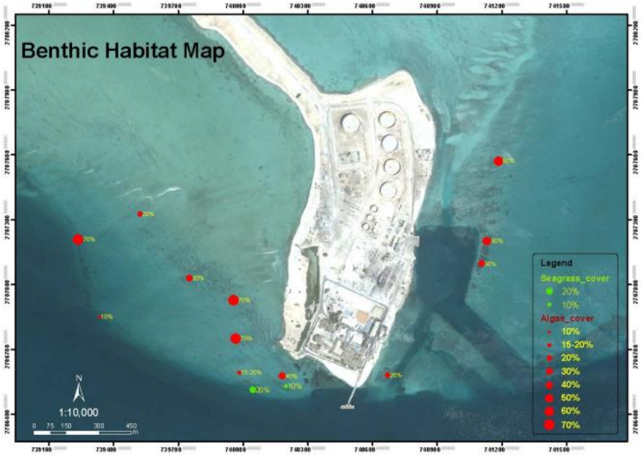
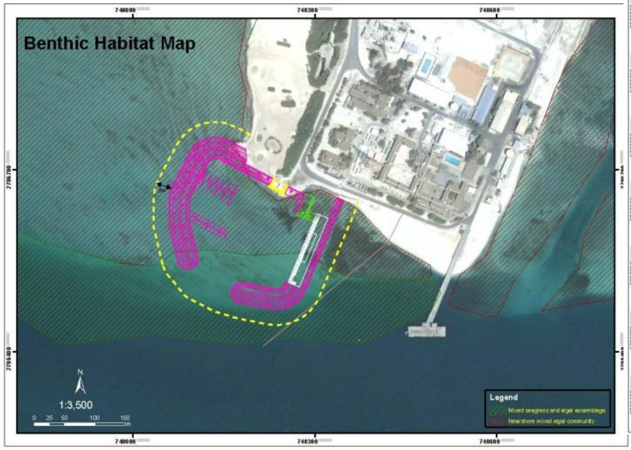
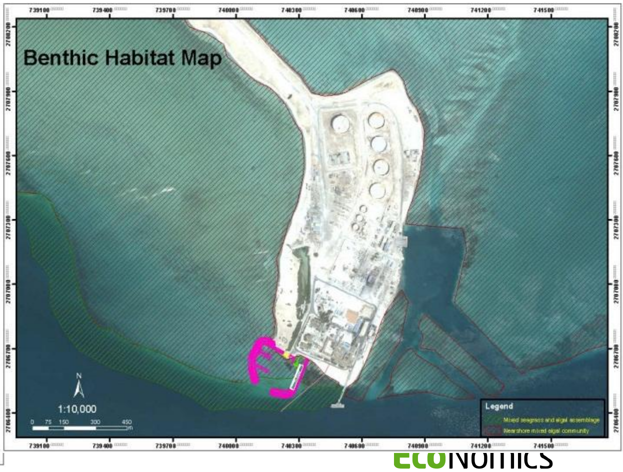
Geomatics – Example

- Project: Metocean Survey Abu Dhabi
- Client: Critical National Infrastructure Agency
- Scope: Support Engineering and Environmental team with GIS, Remote Sensing. Providing GIS Analysis and mapping.

- Innovation: By using the high resolution Imagery , water and sediment sample survey, we were able to provide the Water and sediment sample location map and Benthic Habitat map etc. Results of the image Classification was compared with survey points.

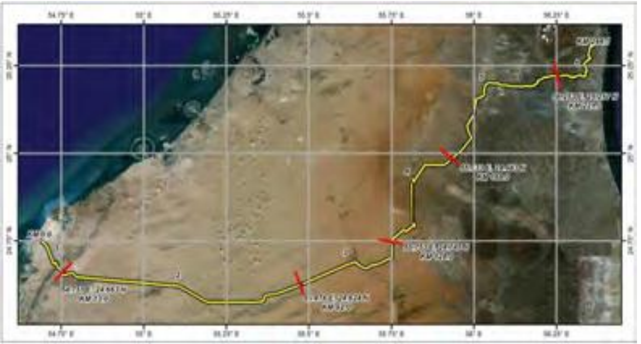


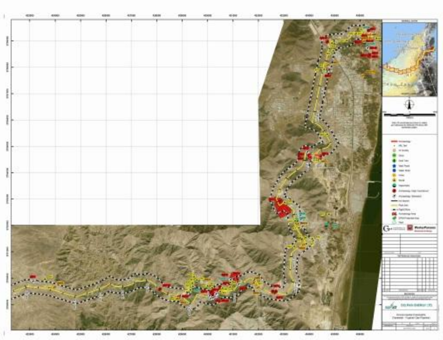

Benthic Habitat Map
1:3,500
Legend
Mixed seagrass and algal assemblage
Nearshore mixed algal community

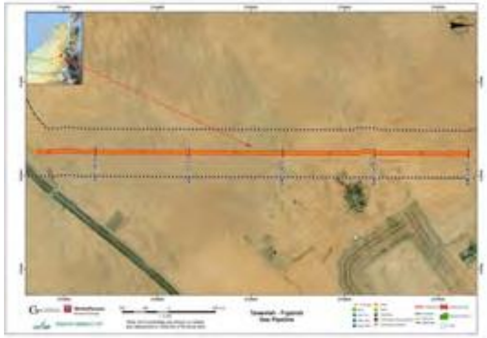

Benthic Habitat Map
1:10,000
Legend
Mixed seagrass and algal assemblage
Nearshore mixed algal community

Geomatics – Example

▶ Project:	Taweelah Fujairah Gas Pipeline
▶ Client:	Dolphin Energy
▶ Scope:	Support Engineering design and Environmental approvals for Pipeline Route Selection and Block Valve Station Study; acquire high resolution imagery and Digital Elevation Model data; manage project spatial database.
▶ Innovation:	Integrating new pipeline with existing infrastructure using a sophisticated spatial data management service. Alignment Sheet generation with profiling.

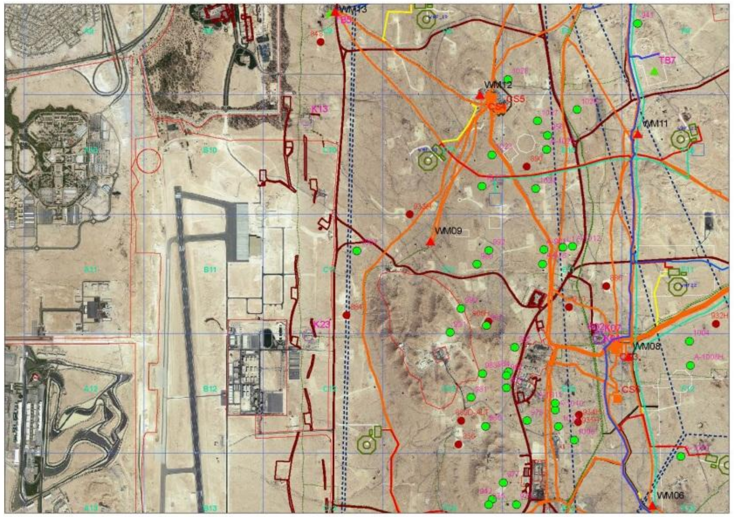


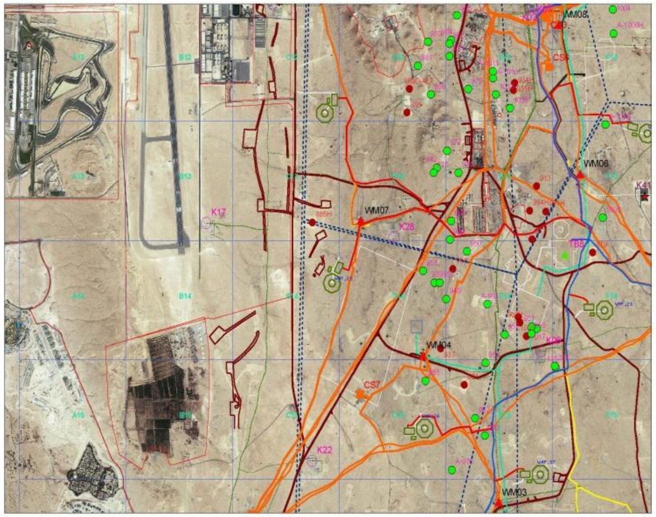




Geomatics – Example

- Project: BAHRAIN FIELD DEVELOPMENT ASSOCIATED GAS EXPANSION PROJECT
- Client: Tatweer Petroleum
- Scope: Support Engineering design team for Pipeline Route Plan and other components design (like Well manifolds,CS etc) through high resolution imagery and Digital Elevation Model data. Manage project spatial database mainly conversion of CAD to GIS & GIS to CAD for deliveries from Design team to Client and from Client to Design team.





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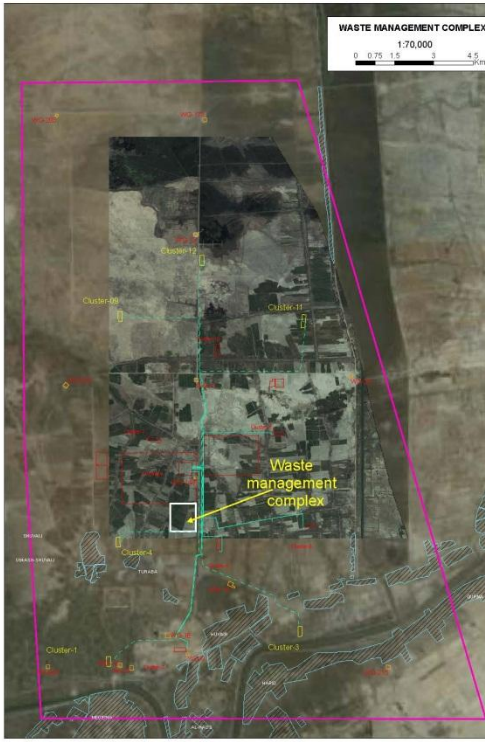
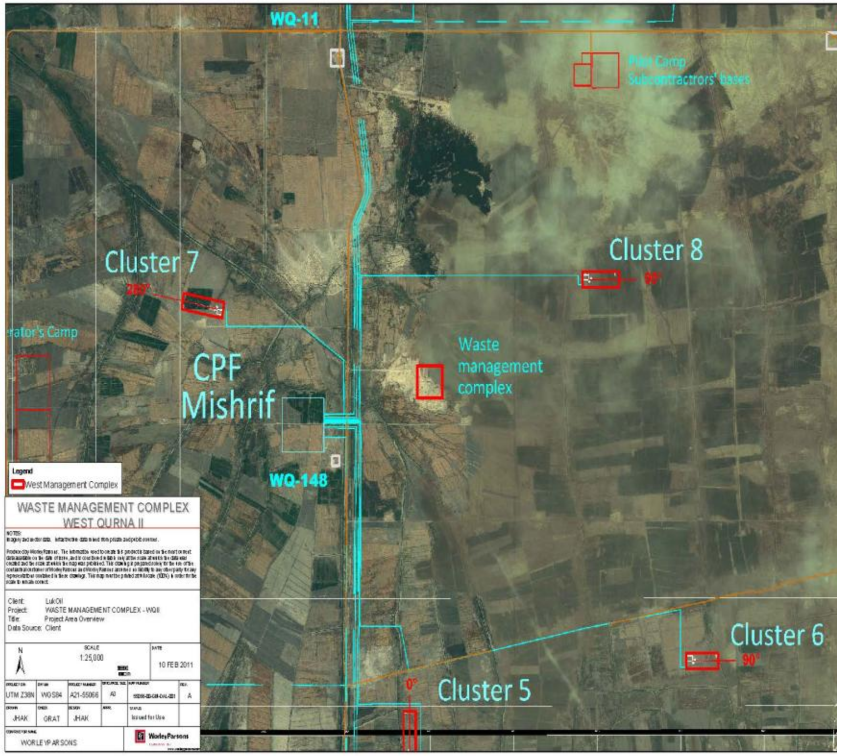
Geomatics – Example

- Project: Waste Management complex
- Client: Lukoil
- Scope: Support Engineering design for waste management complex site selection and development. Acquire high resolution imagery, manage project spatial database and mapping of various themes.





WASTE MANAGEMENT COMPLEX
WEST QURNA II

Client: LukOil
Project: WASTE MANAGEMENT COMPLEX - WQII
Title: Project Area Overview
Data Source: Client

N
SCALE 1:25,000
DATE 10 FEB 2011

UTM Z38N	WGS84	A21-55066	A3	[illegible]	A
JHAK	GRAT	JHAK		Issued for Use	

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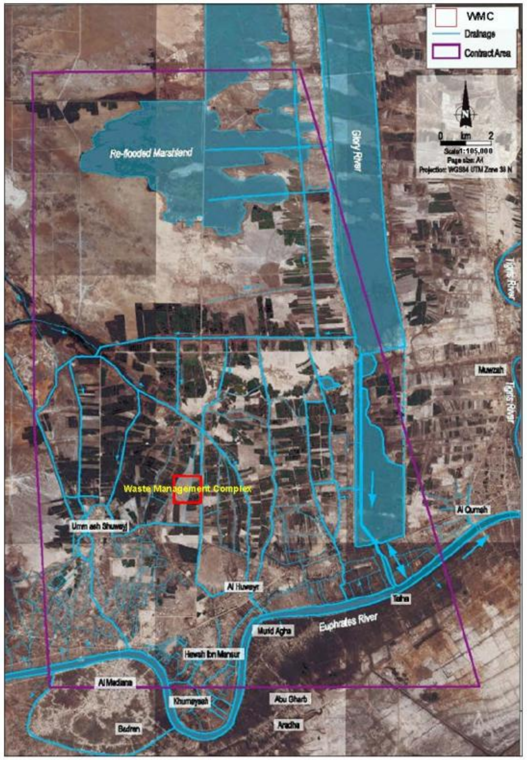
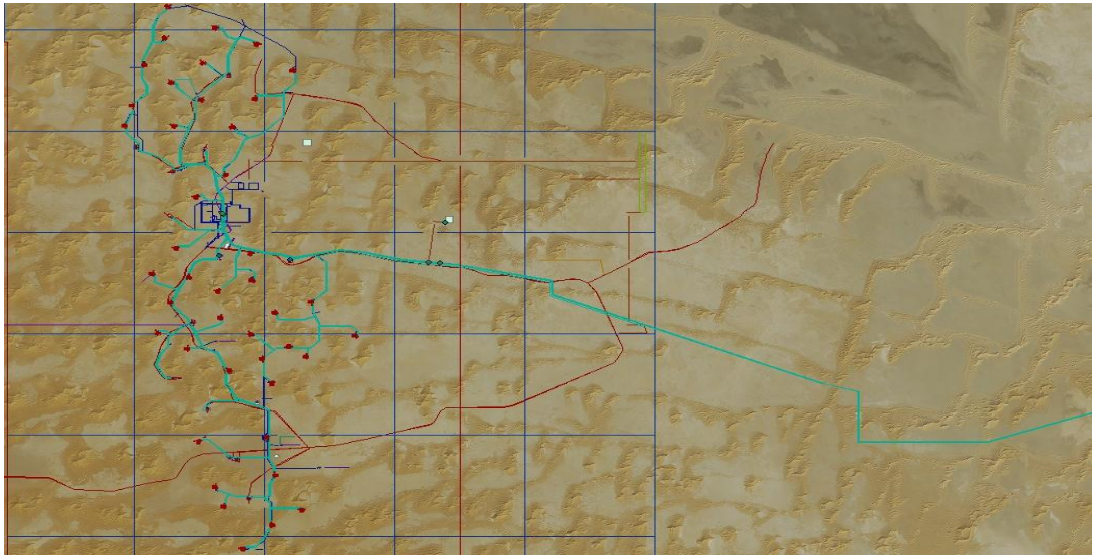


- Project: GIS Implementation in Gathering & Transmission of pipeline

- Client: OOCEP (Oman Oil Company Exploration & Production)

- Scope: Spatial database design, processing of high resolution imagery and Lidar data. Manage project spatial database and mapping of various themes.



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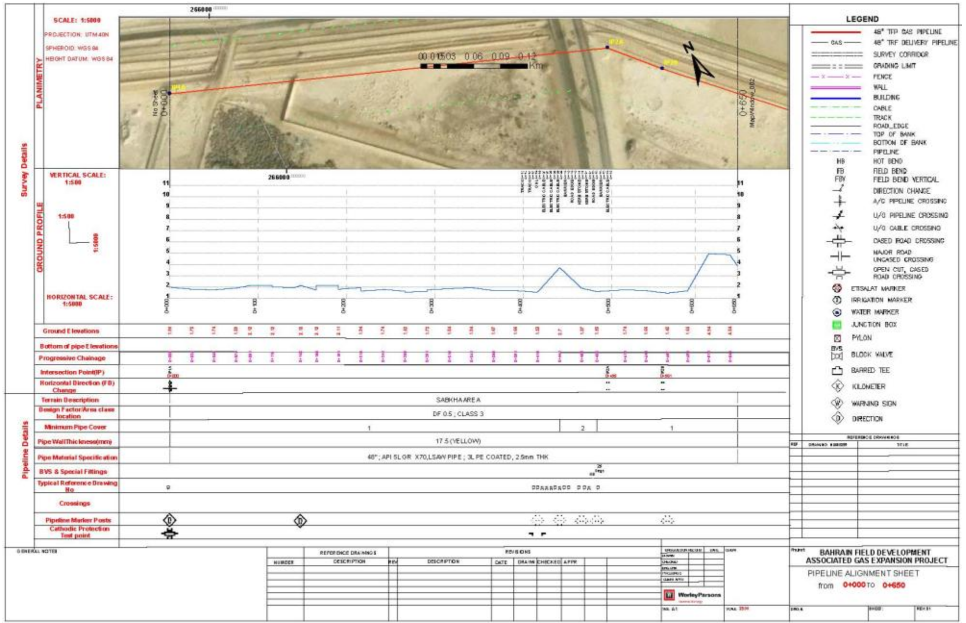
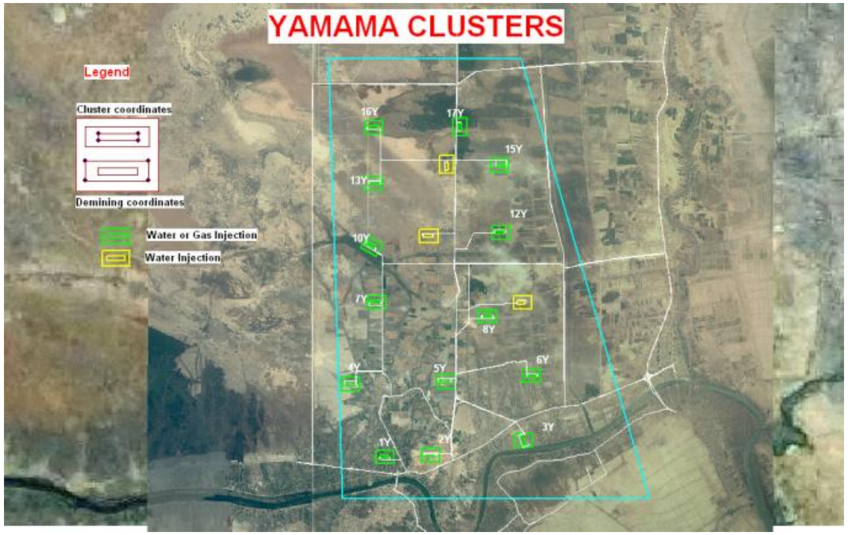
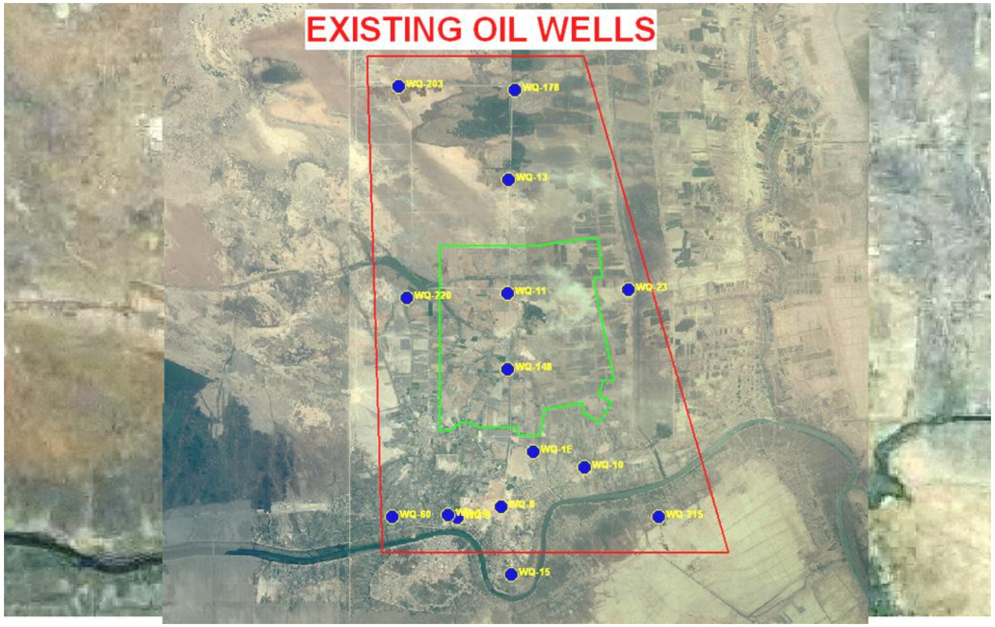
- **Pilot Project:** GIS Implementation using APDM in Gathering & Transmission of pipeline and generation of automatic alignment sheets using New Century Software.

- **Scope:** Spatial database design, processing of Lidar data. Manage project spatial database for automatic alignment sheet generation using NCS plug-in for Arcgis.



- **Project:** GIS Implementation and support engineering design team for Early Production facilities West Qurna 2(iraq).
- Client: LUKOIL, Dubai.
- Scope: Cad to GIS conversion, GIS Database creation using ARC SDE and Vision Maker, Mapping and Analysis.



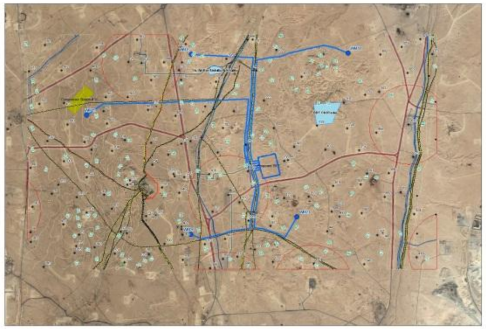


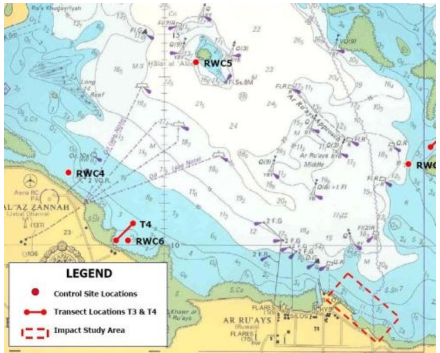
- **Project:** GIS Implementation and support engineering team for Khazzan Early Infrastructure Works & Export System.
- Client: BP, Oman.
- Scope: Cad to GIS conversion, Central GIS Database updating, raster and vector processing, Alignment sheets(Plan & Profiles) creation using Civil 3d & Arc GIS, Tag information creation and updating using SPF for pipeline equipment, Converting pipeline data(GIS & CAD) to the PODS suitable format.

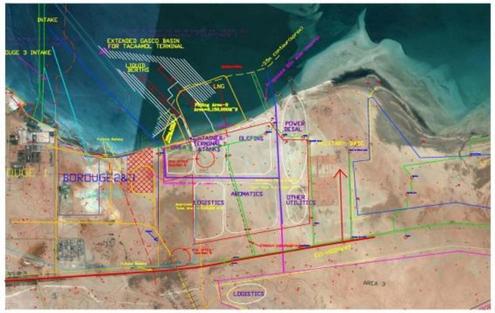
Geomatics – Example

Other projects used GIS support :

- Rabdan Academy - Environmental and Social Impact Assessment – CNIA
- Akwa Ibom Industrial City – Delta Afrik
- Awali Field Development – Tatweer Petroleum
- GASCO and CNIA – CAD to GIS data conversion
- KAP(King Abdulla Port, KSA)
- NABUCCO (Natural gas pipeline from Middle east to central Europe)
- Qatar Rail (Qatar)







THANK YOU…….

GIS Databases and Pipelines

Why Organize Your Data?

•Profitability(efficiency and effectiveness) :

•Operational complexity: As technology and business management practices evolve, pipeline companies are increasingly complex in nature. Needs coordination b/n different business units (ex: control centres interact with engineering team to design and monitor linepressure)

•Aging Infrastructure(for successful management of aged pipelines needs extraordinary attention. Modern inline inspection Direct assessment, close interval survey are all critical elements of BAP and ongoing mitigation plans. These tools and processes produce large volumes of informatin.

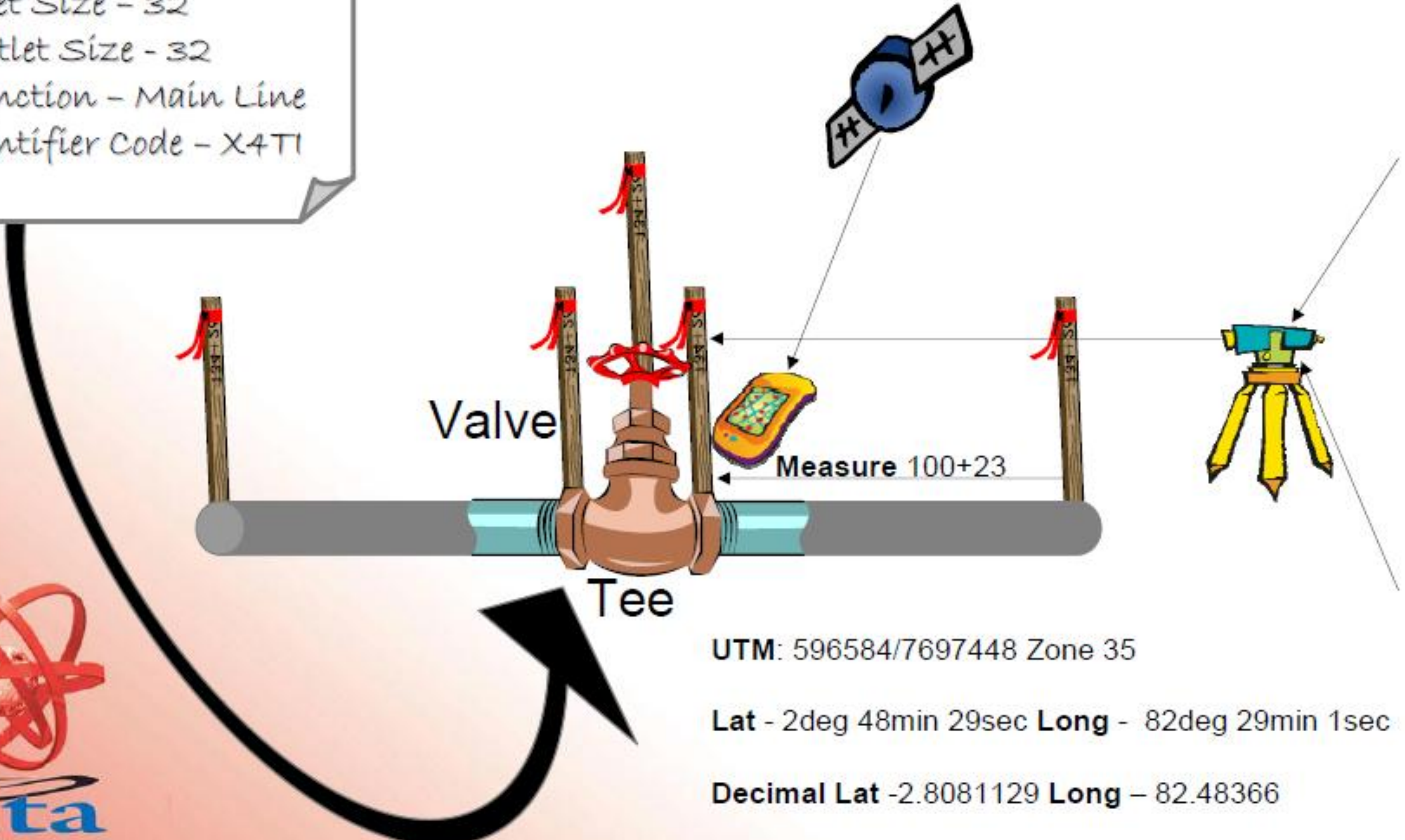
•Suburban expansion(due to that Row is encroaching suburban, this trend increasing public notification burden, third party damage, risk analysis, effective strategies required dealing with suburban encroaches.

•Mergers, acquisitions and restructuring(pipeline systems change hands, many companies find themselves faced with tasks of integrating staff, business process and work flows, and data management systems

•Aging work force (For many pipeline companies, much of the corporate knowledge base is stored in the brains in the minds of senior staff. In case they retire or move to other place. Such knowledge is not retrievable or it needs unnecessary cost to reproduce it.

Where it begins

Type – Ball
Line - Chinook
Inlet Size – 32
Outlet Size - 32
Function – Main Line
Identifier Code – X4T1



UTM: 596584/7697448 Zone 35

Lat - 2deg 48min 29sec **Long** - 82deg 29min 1sec

Decimal Lat -2.8081129 **Long** – 82.48366

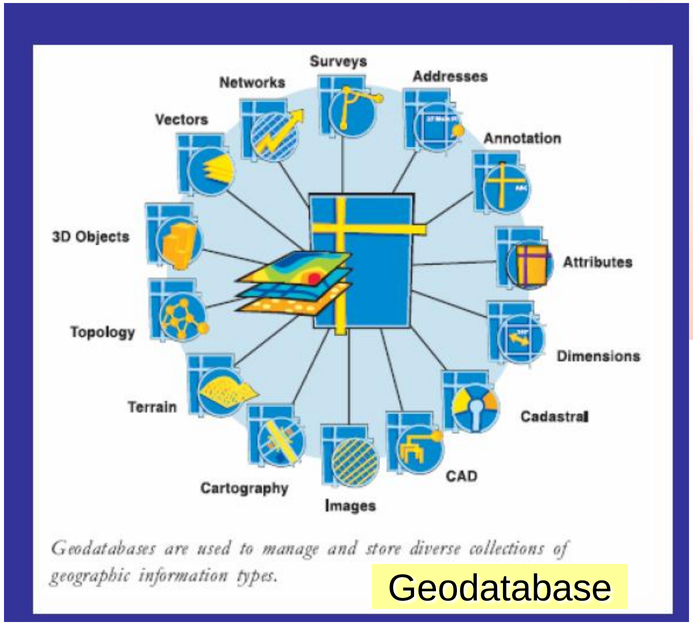
Linear Referencing (Data model method)

Location is given in terms of known feature and a position or measure on it.

Ex: Route I-10,Kilometer 23.

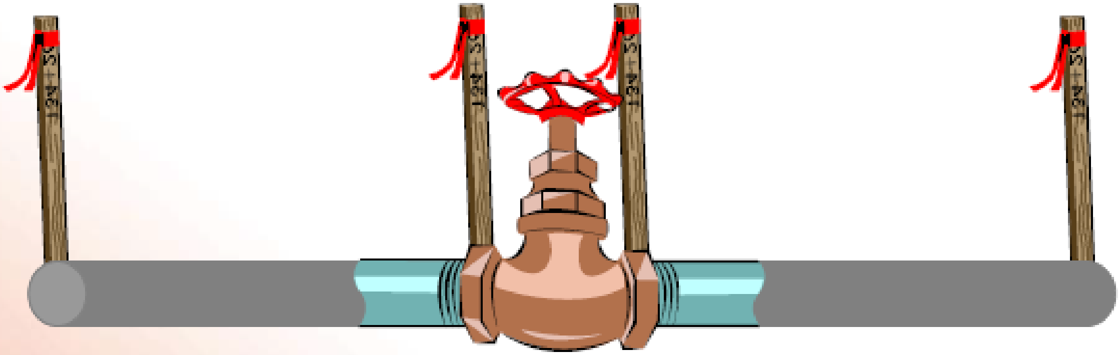
It is uniquely identified without the need of x,y coords or long-lots. Ex : Roads, pipelines etc.

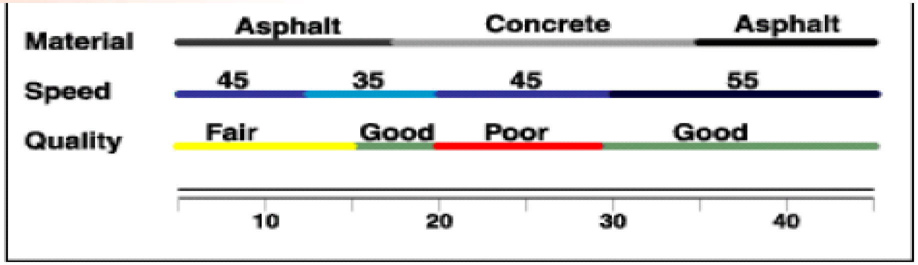
A Geodatabase is an object-relational construct for storing and managing geographic data as features within RDBMS



Geodatabases are used to manage and store diverse collections of geographic information types.

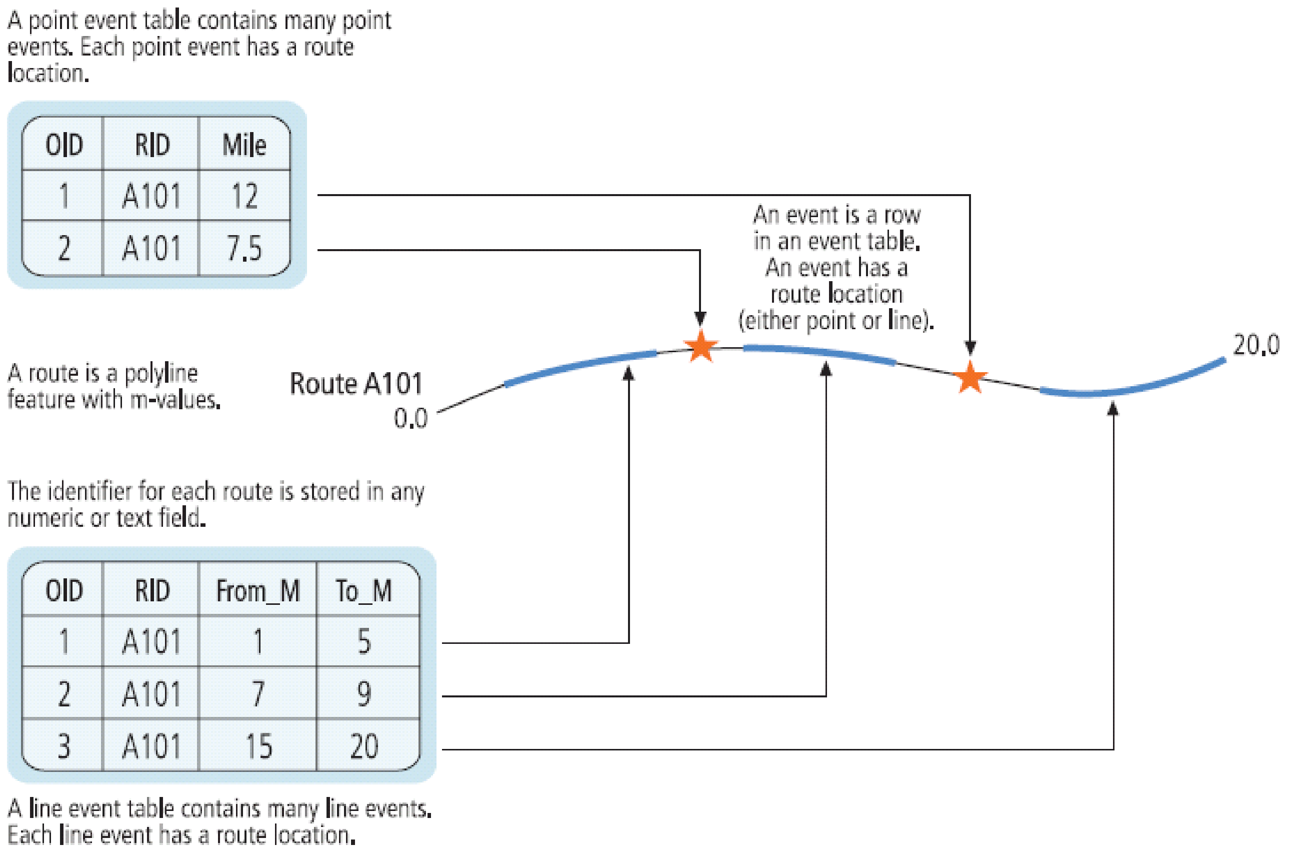
Geodatabase





Dynamic Segmentation

Dynamic segmentation is the process of transforming linearly referenced data that have been stored in a tables into features and that can be displayed and analyze a map. It needs unique identifier and position along the feature for each event in the event table. Allows multiple set of attributes to be associated with any portion of linear feature.



A point event table contains many point events. Each point event has a route location.

OID	RID	Mile
1	A101	12
2	A101	7.5

An event is a row in an event table. An event has a route location (either point or line).

A route is a polyline feature with m-values.

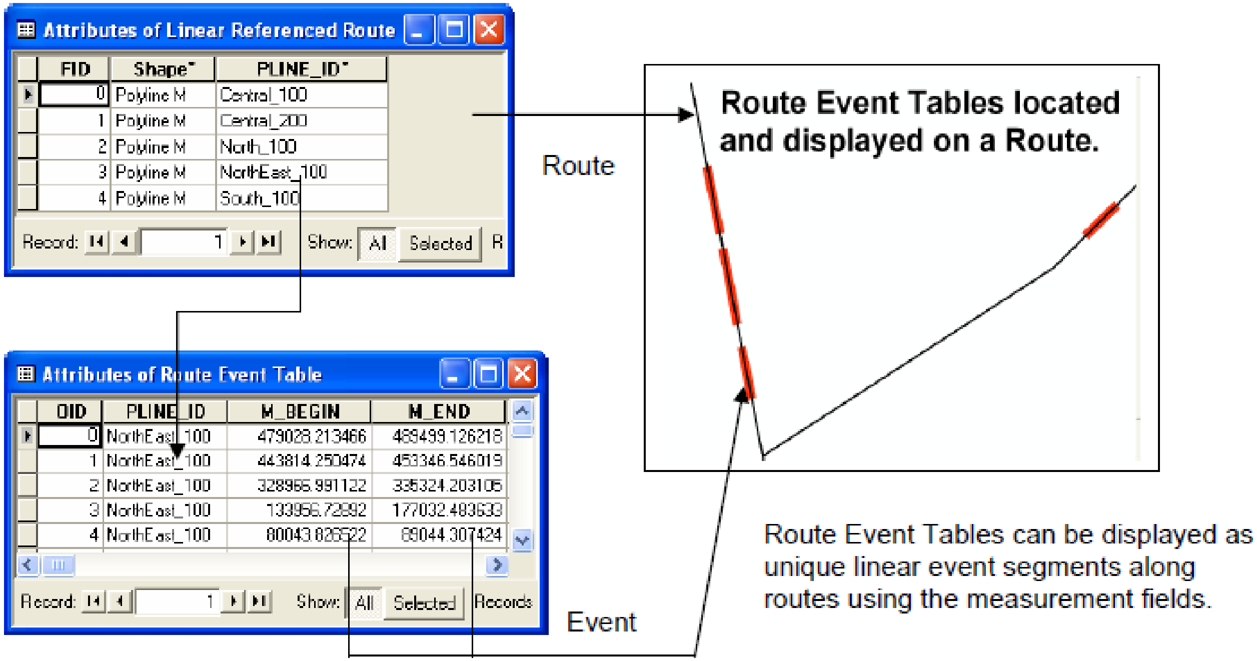
The identifier for each route is stored in any numeric or text field.

OID	RID	From_M	To_M
1	A101	1	5
2	A101	7	9
3	A101	15	20

A line event table contains many line events. Each line event has a route location.

Routes and Measures

- To handle dynamic linear characteristics ESRI brought a linear referencing data model in ArcGIS. Hence Route is a linear referenced pipeline.
- Route is simply a linear feature on which attributes can be defined because each route has an identifier stored in a field and has an associated measurement svstem.



Attributes of Linear Referenced Route

FID	Shape*	PLINE_ID*
0	Polyline M	Central_100
1	Polyline M	Central_200
2	Polyline M	North_100
3	Polyline M	NorthEast_100
4	Polyline M	South_100

Attributes of Route Event Table

OID	PLINE_ID	M_BEGIN	M_END
0	NorthEast_100	479028.213466	489499.126218
1	NorthEast_100	443814.250474	453346.546019
2	NorthEast_100	328966.991122	335324.203105
3	NorthEast_100	133956.72892	177032.483633
4	NorthEast_100	80043.826522	89044.307424

Route Event Tables located and displayed on a Route.

Route Event Tables can be displayed as unique linear event segments along routes using the measurement fields.

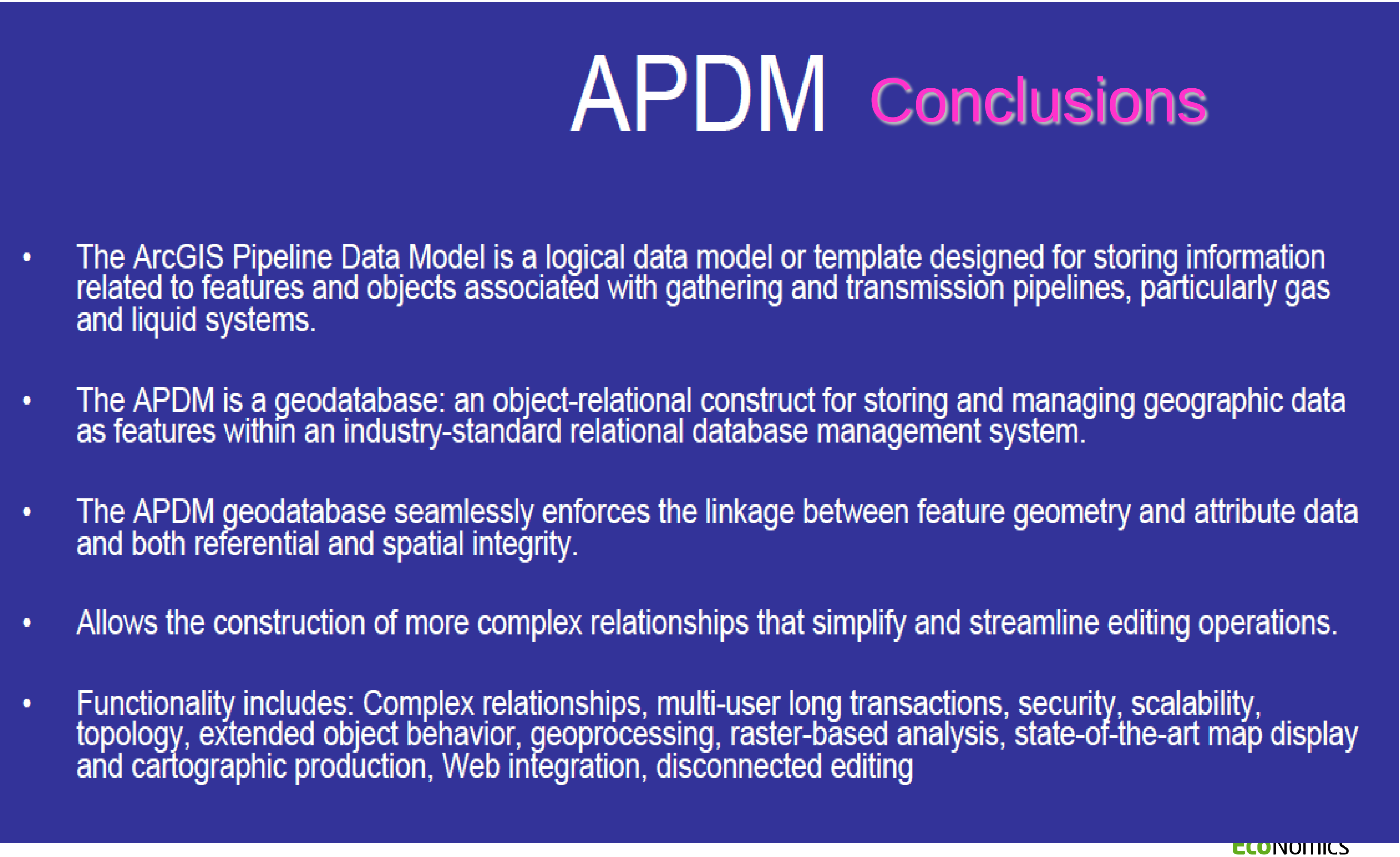
Linear Reference Options Available

- Pipeline Open Data Standard (PODS)
- Industry Standard Pipeline Data Management (ISPDM)
- Integrated Spatial Analysis Techniques (ISAT)
- ArcGIS Pipeline Data Model (APDM) :
- Reduce the entry cost - build a model that can be extended as needed
- Decrease need for software development
- Focused on pipelines that use stationed position AND XY coordinates to locate positions of features on or along the pipeline
- A comprehensive pipeline data template managed by APDM/PIG
- No specific organizational targets but used mostly in integrity management and operations
- Designed for gas or liquid systems
- Designed for gathering, distribution, and transmission lines
- An open template
- The intellectual property of “ESRI”

- APDM is an ESRI Geodatabase object model, and therefore it explicitly uses ESRI's linear referencing, route and measure technology, hierarchical/geographical organization of pipeline features and topology data structures and technology, and has GIS "built into" the model.
- APDM links to external systems-ERP, Document Management, Work order Ms
- APDM follows the service oriented architecture (SOA) model for enterprise integration as outlined by ESRI.
- The SOA provides a modularity of pipeline business logic, which can be presented as service for other enterprise clients.
- These services are loosely coupled where the interface exists in the enterprise application and remains completely independent of the service layer.
- APDM does not support tight integration because it can be hazardous to the integrity of the geodatabase.

Typical Pipeline Information:

- Wall Thickness,Diameter, Pipe Grade
- Manufacturer,Seam Weld Type, Casings, Valves, Appurtenances, Landowner, Crossing data
- Alignment/Route Sheets, Hydro test records, Existing/Construction Inspections, Joint Coating Type
- Repair Coating, Station Drawings, Year of Construction, GPS Surveys Control/AGM, Pipe Profile/Elevation/Depth of Cover
- As-Built Drawings, Pipe Support, Aerial Photography, Mill Test Pressure, Material Properties, Joining process and Inspections, Pipe Weights



APDM Conclusions

- The ArcGIS Pipeline Data Model is a logical data model or template designed for storing information related to features and objects associated with gathering and transmission pipelines, particularly gas and liquid systems.
- The APDM is a geodatabase: an object-relational construct for storing and managing geographic data as features within an industry-standard relational database management system.
- The APDM geodatabase seamlessly enforces the linkage between feature geometry and attribute data and both referential and spatial integrity.
- Allows the construction of more complex relationships that simplify and streamline editing operations.
- Functionality includes: Complex relationships, multi-user 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

How Implement APDM ?

- APDM Concentrates on defining and documenting CORE features using “80% Typical” rule- these are features and phenomena that 80% or more of all pipeline companies track information on or use as part of their daily operations.
- The APDM is starting point that can be extended and implemented to suit the needs of business
- APDM describes a pipeline by defining CORE elements of 24 tables:
- Pipeline centerline : *route, series, corridor*
- Activities: Work orders, inspections etc
- External documents: document version, reports, design drawings, spreadsheets, photos etc
- Ownership and company hierarchy: upstream, downstream, holding
- Product delivered:
- Sites:
- Reference modes: Measure, Station, KM/Mile Post
- APDM behavior through the use of ABSTRACT classes of pipeline features when they are created in the database, edited as part of the database individually or as part of a change to the pipeline centerline.
- Abstract classes are the templates from which behavior (defined as attributes in the class and relation ships, geometry to the other classes) are passed down to concrete feature/object classes in the APDM Geodatabase using a concept called ‘Inheritance’.
- Ex: Control point inherit behavior from the Centerline Point Abstract class.
- Ex: Elbows, Valves, and Flanges inherit behavior from the Online Point Facility Abstract class.
- Ex: Structures inherit behavior from the Offline Point Abstract Class.
- Abstract classes defines a specific set of behavior for a specific set of features particularly for edit operations. Ex: Control points will act this way when the xy or M(station) value is altered
- Ex: Elbows, valves and Flanges will act this way when the centerline they are located on is edited(a tow point re-route occurs, the route is trimmed back or extended.

- Ex: Structures located within 660 feet of the centerline will act this way when the centerline is edited(the cease to impact the delineation of HCA)
- The abstract classes define the framework of the APDM and are required elements of the model. They never actually appear physically in an implemented APDM geodatabase. Appear only in the logical and physical(UML)models.
- Core classes are those object, feature and relationship classes, together with associated domains, that are required to maintain APDM compliance. These are concrete and physically appear in the implemented apdm geodatabase. they define centerline features, stationing attributes, and supporting model elements.
- Optional classes are distributed with the model as implementation examples. But none of them are required elements of the model.
- Topology feature classes can be used to define editing behaviours for spatially coincident features from different feature classes.
- In the APDM, a template is a pattern that defines an object or class containing known and predictable behaviour. The pattern is defined as a set of attributes, including geometry, and relationships to other classes.
- A concrete class in the APDM geodatabase inherits certain base attributes and relationships result in the creation of an individual, concrete feature or object class within the geodatabase.

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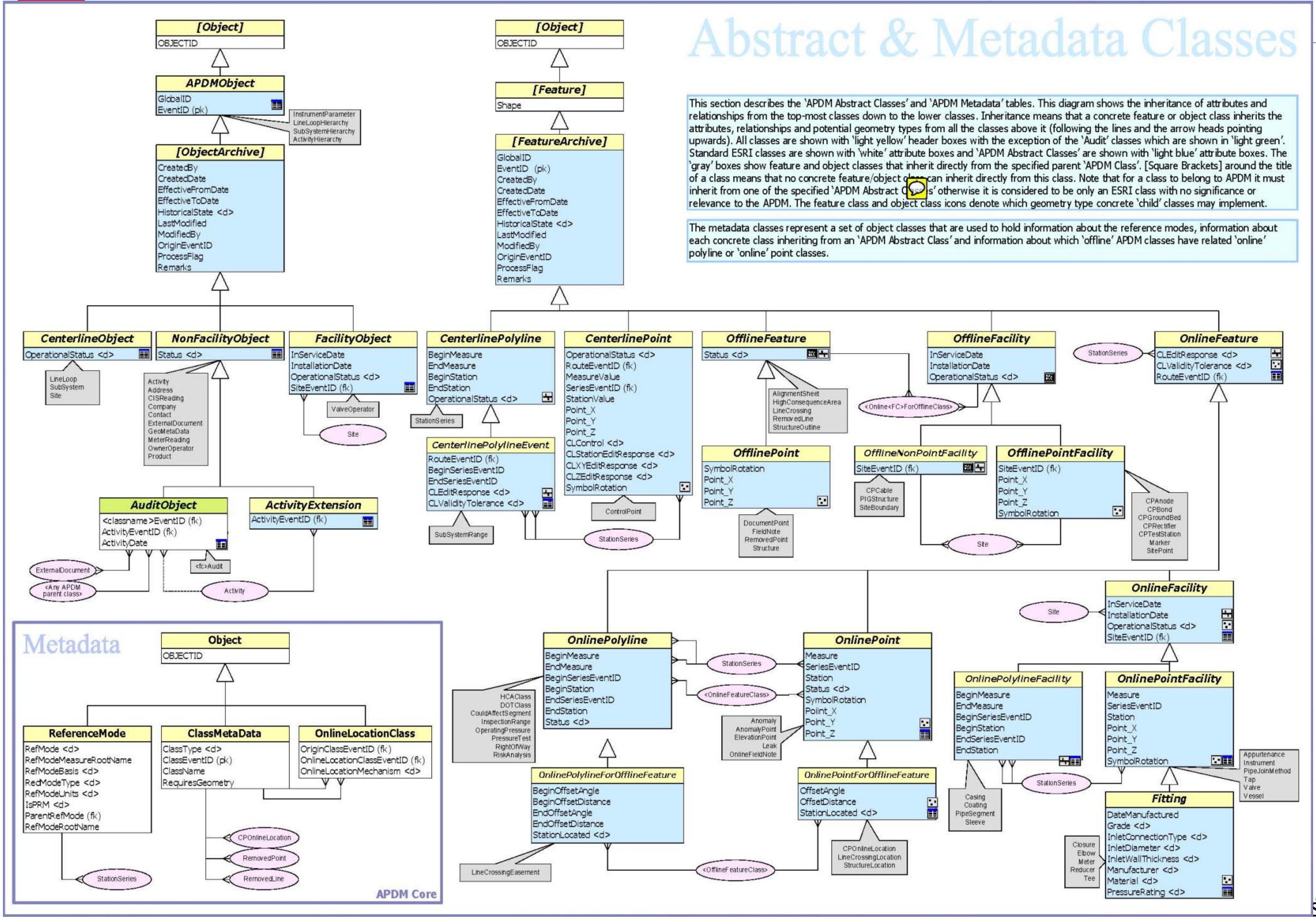
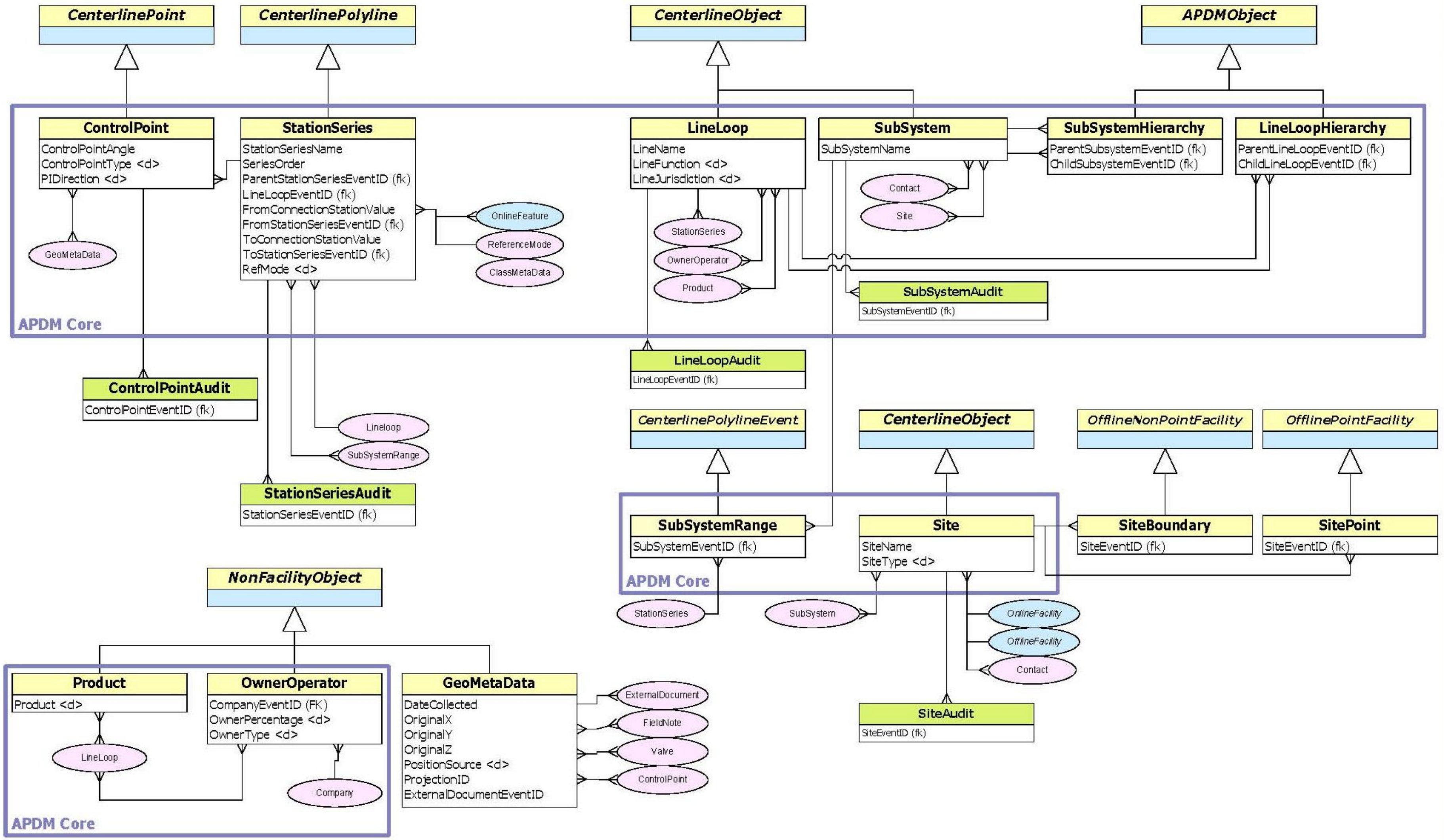
Abstract & Metadata Classes



This section describes the 'APDM Abstract Classes' and 'APDM Metadata' tables. This diagram shows the inheritance of attributes and relationships from the top-most classes down to the lower classes. Inheritance means that a concrete feature or object class inherits the attributes, relationships and potential geometry types from all the classes above it (following the lines and the arrow heads pointing upwards). All classes are shown with 'light yellow' header boxes with the exception of the 'Audit' classes which are shown in 'light green'. Standard ESRI classes are shown with 'white' attribute boxes and 'APDM Abstract Classes' are shown with 'light blue' attribute boxes. The 'gray' boxes show feature and object classes that inherit directly from the specified parent 'APDM Class'. [Square Brackets] around the title of a class means that no concrete feature/object class can inherit directly from this class. Note that for a class to belong to APDM it must inherit from one of the specified 'APDM Abstract Classes' otherwise it is considered to be only an ESRI class with no significance or relevance to the APDM. The feature class and object class icons denote which geometry type concrete 'child' classes may implement.

The metadata classes represent a set of object classes that are used to hold information about the reference modes, information about each concrete class inheriting from an 'APDM Abstract Class' and information about which 'offline' APDM classes have related 'online' polyline or 'online' point classes.

Centerline & Hierarchy



CenterlinePoint

CenterlinePolyline

CenterlineObject

APDMObject

ControlPoint
ControlPointAngle
ControlPointType <d>
PIDirection <d>

StationSeries
StationSeriesName
SeriesOrder
ParentStationSeriesEventID (fk)
LineLoopEventID (fk)
FromConnectionStationValue
FromStationSeriesEventID (fk)
ToConnectionStationValue
ToStationSeriesEventID (fk)
RefMode <d>

LineLoop
LineName
LineFunction <d>
LineJurisdiction <d>

SubSystem
SubSystemName

SubSystemHierarchy
ParentSubsystemEventID (fk)
ChildSubsystemEventID (fk)

LineLoopHierarchy
ParentLineLoopEventID (fk)
ChildLineLoopEventID (fk)

GeoMetaData

OnlineFeature

ReferenceMode

ClassMetaData

StationSeries

OwnerOperator

Product

Contact

Site

SubSystemAudit
SubSystemEventID (fk)

APDM Core

ControlPointAudit
ControlPointEventID (fk)

LineLoopAudit
LineLoopEventID (fk)

Lineloop

SubSystemRange

StationSeriesAudit
StationSeriesEventID (fk)

CenterlinePolylineEvent

CenterlineObject

OfflineNonPointFacility

OfflinePointFacility

SubSystemRange
SubSystemEventID (fk)

Site
SiteName
SiteType <d>

SiteBoundary
SiteEventID (fk)

SitePoint
SiteEventID (fk)

APDM Core

StationSeries

SubSystem

OnlineFacility

OfflineFacility

Contact

SiteAudit
SiteEventID (fk)

NonFacilityObject

Product
Product <d>

OwnerOperator
CompanyEventID (FK)
OwnerPercentage <d>
OwnerType <d>

GeoMetaData
DateCollected
OriginalX
OriginalY
OriginalZ
PositionSource <d>
ProjectionID
ExternalDocumentEventID

ExternalDocument

FieldNote

Valve

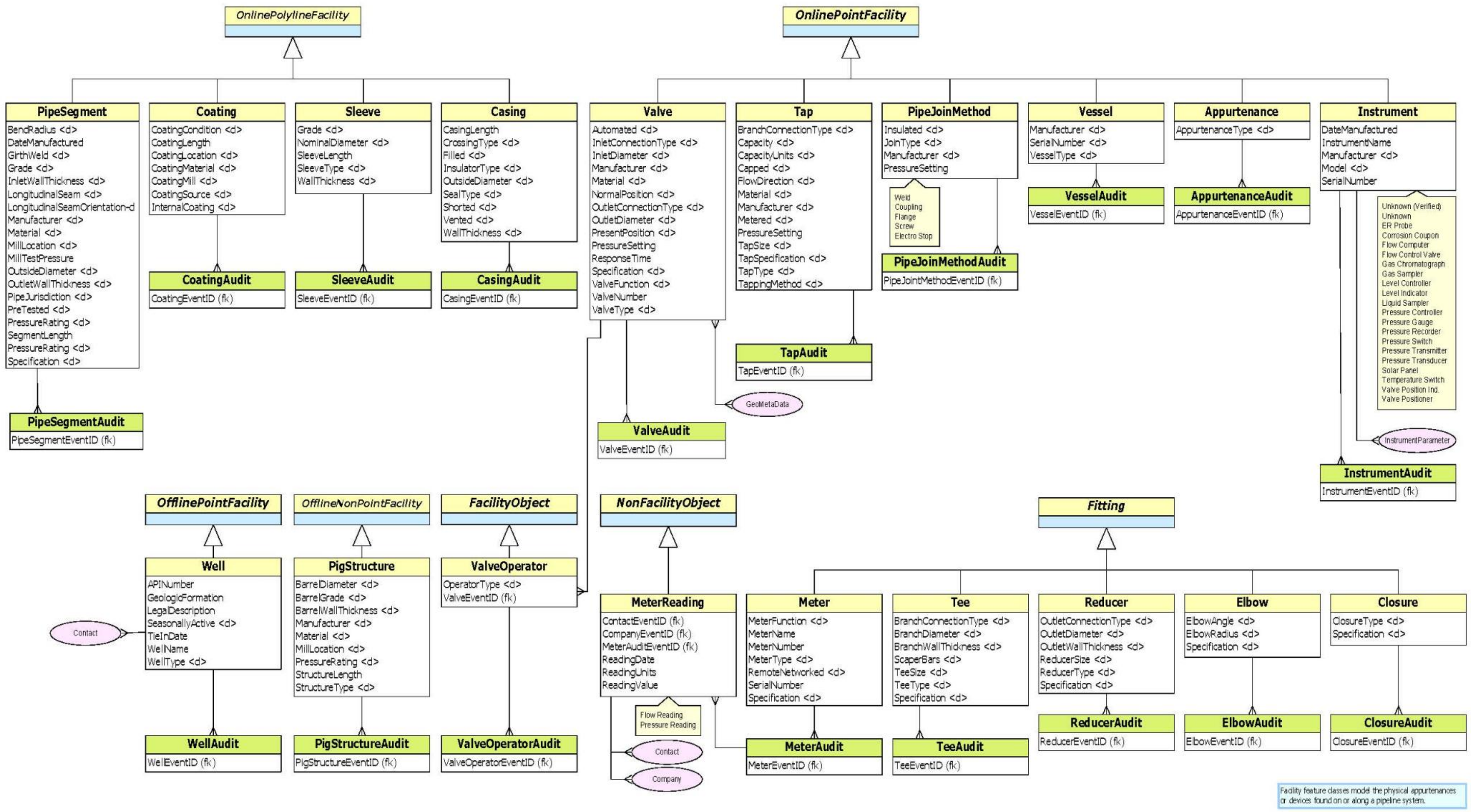
ControlPoint

LineLoop

Company

APDM Core

Facilities



OnlinePolylineFacility

OnlinePointFacility

PipeSegment
BendRadius <d>
DateManufactured
GirthWeld <d>
Grade <d>
InletWallThickness <d>
LongitudinalSeam <d>
LongitudinalSeamOrientation<d
Manufacturer <d>
Material <d>
MillLocation <d>
MillTestPressure
OutsideDiameter <d>
OutletWallThickness <d>
PipeJurisdiction <d>
PreTested <d>
PressureRating <d>
SegmentLength
PressureRating <d>
Specification <d>

PipeSegmentAudit
PipeSegmentEventID (fk)

Coating
CoatingCondition <d>
CoatingLength
CoatingLocation <d>
CoatingMaterial <d>
CoatingMill <d>
CoatingSource <d>
InternalCoating <d>

CoatingAudit
CoatingEventID (fk)

Sleeve
Grade <d>
NominalDiameter <d>
SleeveLength
SleeveType <d>
WallThickness <d>

SleeveAudit
SleeveEventID (fk)

Casing
CasingLength
CrossingType <d>
Filled <d>
InsulatorType <d>
OutsideDiameter <d>
SealType <d>
Shorted <d>
Vented <d>
WallThickness <d>

CasingAudit
CasingEventID (fk)

Valve
Automated <d>
InletConnectionType <d>
InletDiameter <d>
Manufacturer <d>
Material <d>
NormalPosition <d>
OutletConnectionType <d>
OutletDiameter <d>
PresentPosition <d>
PressureSetting
ResponseTime
Specification <d>
ValveFunction <d>
ValveNumber
ValveType <d>

ValveAudit
ValveEventID (fk)

GeoMetaData

Tap
BranchConnectionType <d>
Capacity <d>
CapacityUnits <d>
Capped <d>
FlowDirection <d>
Material <d>
Manufacturer <d>
Metered <d>
PressureSetting
TapSize <d>
TapSpecification <d>
TapType <d>
TappingMethod <d>

TapAudit
TapEventID (fk)

PipeJoinMethod
Insulated <d>
JoinType <d>
Manufacturer <d>
PressureSetting

Weld
Coupling
Flange
Screw
Electro Stop

PipeJoinMethodAudit
PipeJointMethodEventID (fk)

Vessel
Manufacturer <d>
SerialNumber <d>
VesselType <d>

VesselAudit
VesselEventID (fk)

Appurtenance
AppurtenanceType <d>

AppurtenanceAudit
AppurtenanceEventID (fk)

Instrument
DateManufactured
InstrumentName
Manufacturer <d>
Model <d>
SerialNumber

Unknown (Verified)
Unknown
ER Probe
Corrosion Coupon
Flow Computer
Flow Control Valve
Gas Chromatograph
Gas Sampler
Level Controller
Level Indicator
Liquid Sampler
Pressure Controller
Pressure Gauge
Pressure Recorder
Pressure Switch
Pressure Transmitter
Pressure Transducer
Solar Panel
Temperature Switch
Valve Position Ind.
Valve Positioner

InstrumentParameter

InstrumentAudit
InstrumentEventID (fk)

OfflinePointFacility

OfflineNonPointFacility

FacilityObject

NonFacilityObject

Fitting

Well
APINumber
GeologicFormation
LegalDescription
SeasonallyActive <d>
TieInDate
WellName
WellType <d>

Contact

WellAudit
WellEventID (fk)

PigStructure
BarrelDiameter <d>
BarrelGrade <d>
BarrelWallThickness <d>
Manufacturer <d>
Material <d>
MillLocation <d>
PressureRating <d>
StructureLength
StructureType <d>

PigStructureAudit
PigStructureEventID (fk)

ValveOperator
OperatorType <d>
ValveEventID (fk)

ValveOperatorAudit
ValveOperatorEventID (fk)

MeterReading
ContactEventID (fk)
CompanyEventID (fk)
MeterAuditEventID (fk)
ReadingDate
ReadingUnits
ReadingValue

Flow Reading
Pressure Reading

Contact

Company

Meter
MeterFunction <d>
MeterName
MeterNumber
MeterType <d>
RemoteNetworked <d>
SerialNumber
Specification <d>

MeterAudit
MeterEventID (fk)

Tee
BranchConnectionType <d>
BranchDiameter <d>
BranchWallThickness <d>
ScaperBars <d>
TeeSize <d>
TeeType <d>
Specification <d>

TeeAudit
TeeEventID (fk)

Reducer
OutletConnectionType <d>
OutletDiameter <d>
OutletWallThickness <d>
ReducerSize <d>
ReducerType <d>
Specification <d>

ReducerAudit
ReducerEventID (fk)

Elbow
ElbowAngle <d>
ElbowRadius <d>
Specification <d>

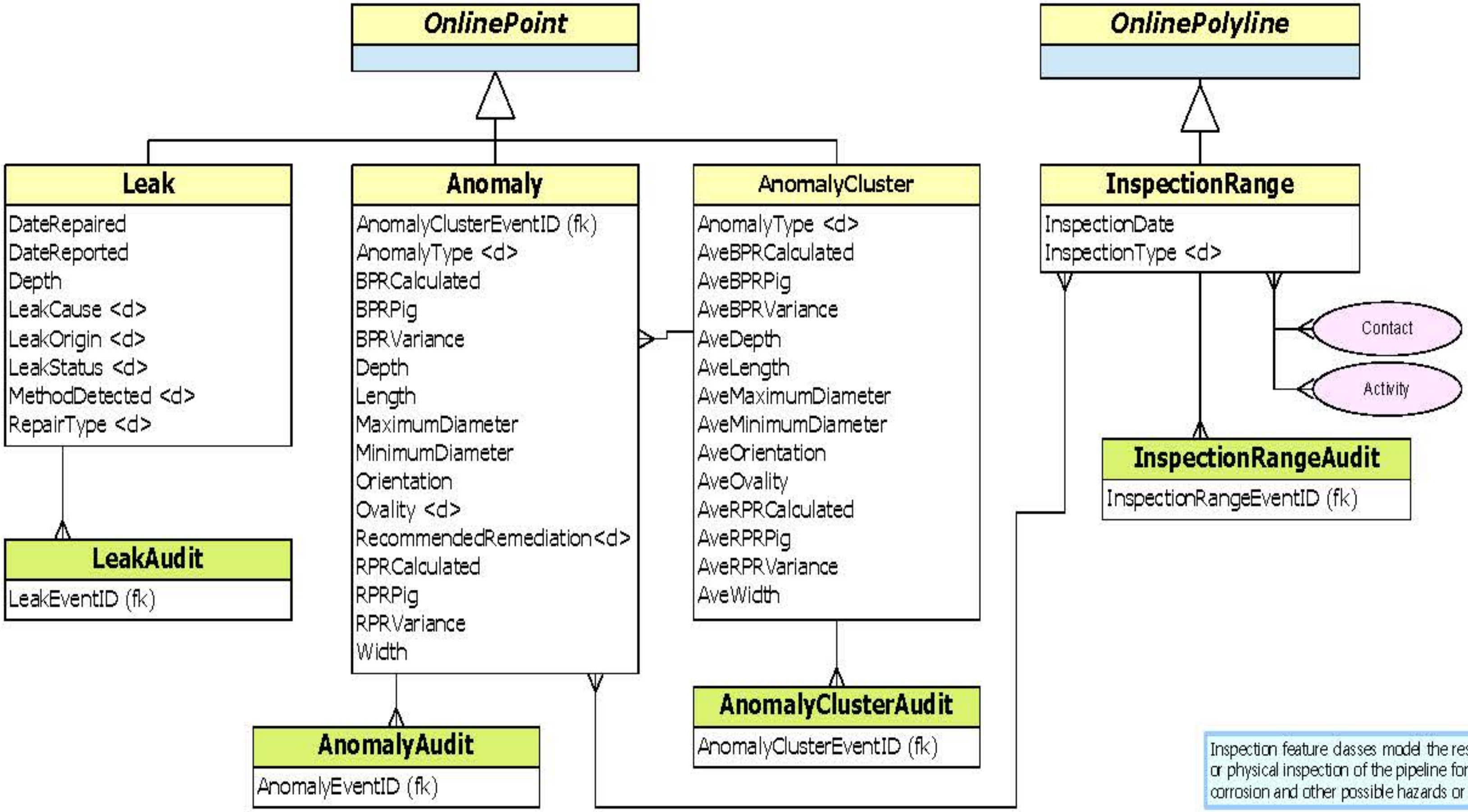
ElbowAudit
ElbowEventID (fk)

Closure
ClosureType <d>
Specification <d>

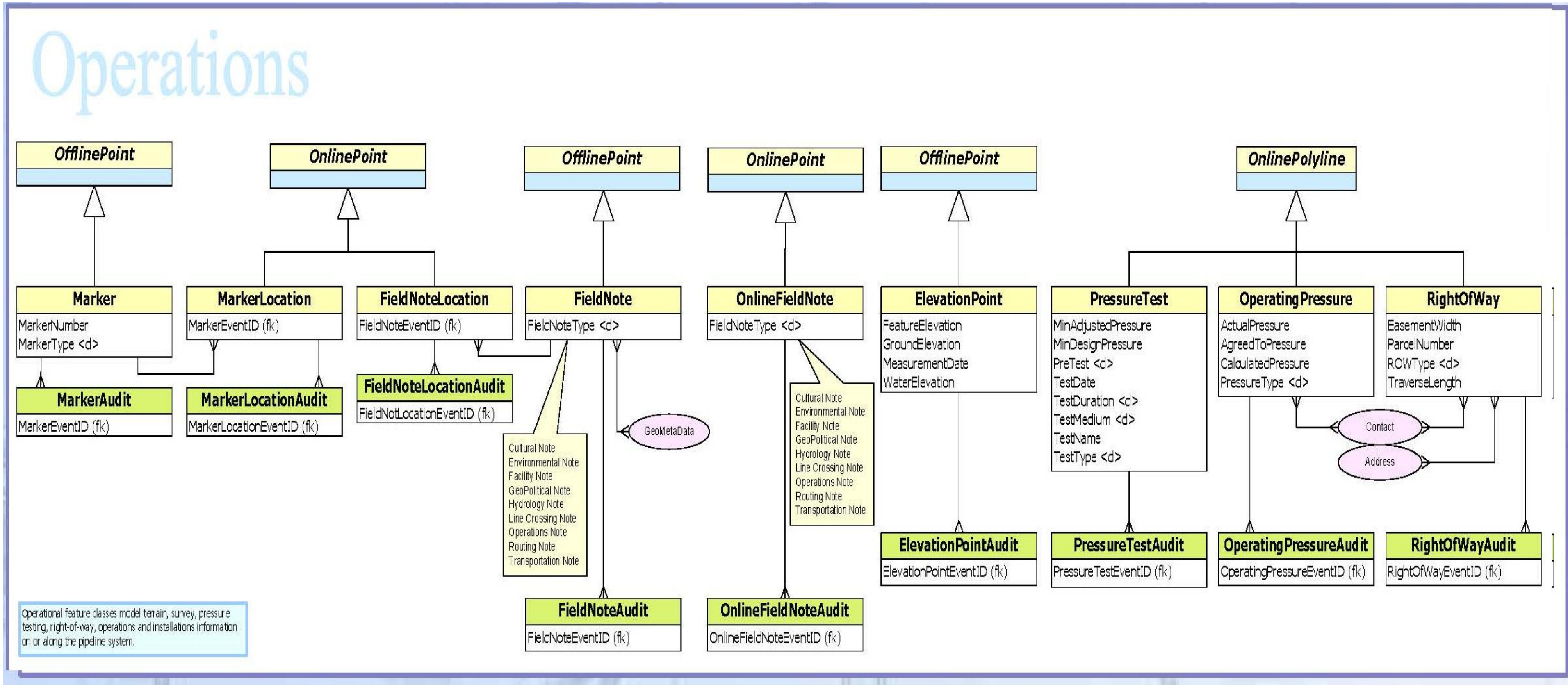
ClosureAudit
ClosureEventID (fk)

Facility feature classes model the physical appurtenances or devices found on or along a pipeline system.

Inspections

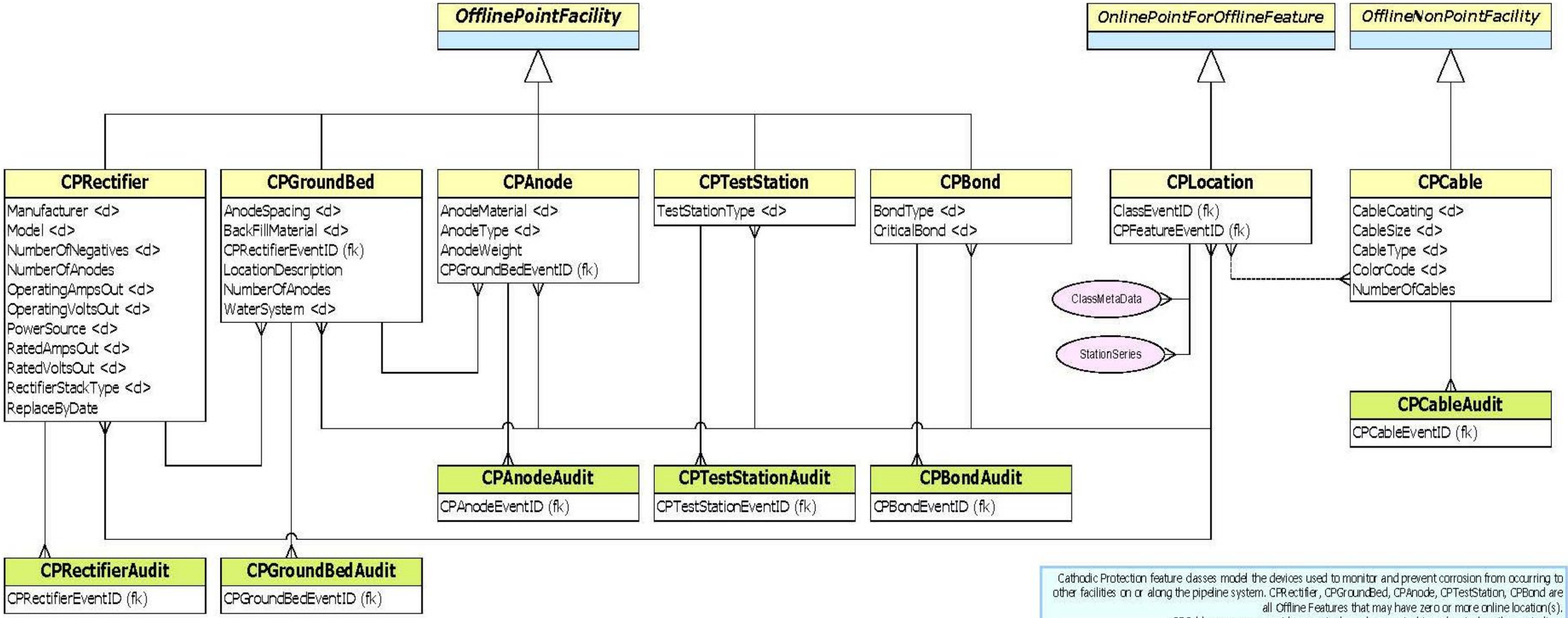


Inspection feature classes model the results of in-line or physical inspection of the pipeline for anomalies, corrosion and other possible hazards or defects.

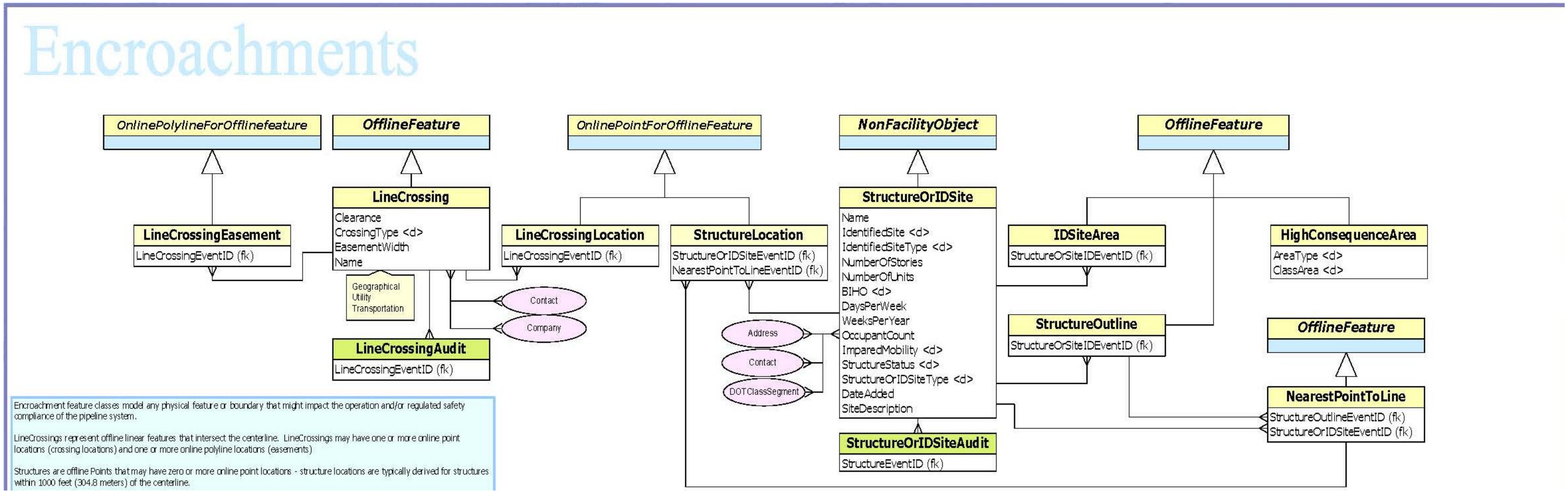


Operational feature classes model terrain, survey, pressure testing, right-of-way, operations and installations information on or along the pipeline system.

Cathodic Protection



Cathodic Protection feature dasses model the devices used to monitor and prevent corrosion from occurring to other facilities on or along the pipeline system. CPRectifier, CPGroundBed, CPAnode, CPTestStation, CPBond are all Offline Features that may have zero or more online location(s).
CPCable may or may not have a single end connected-to or located-on the centerline.

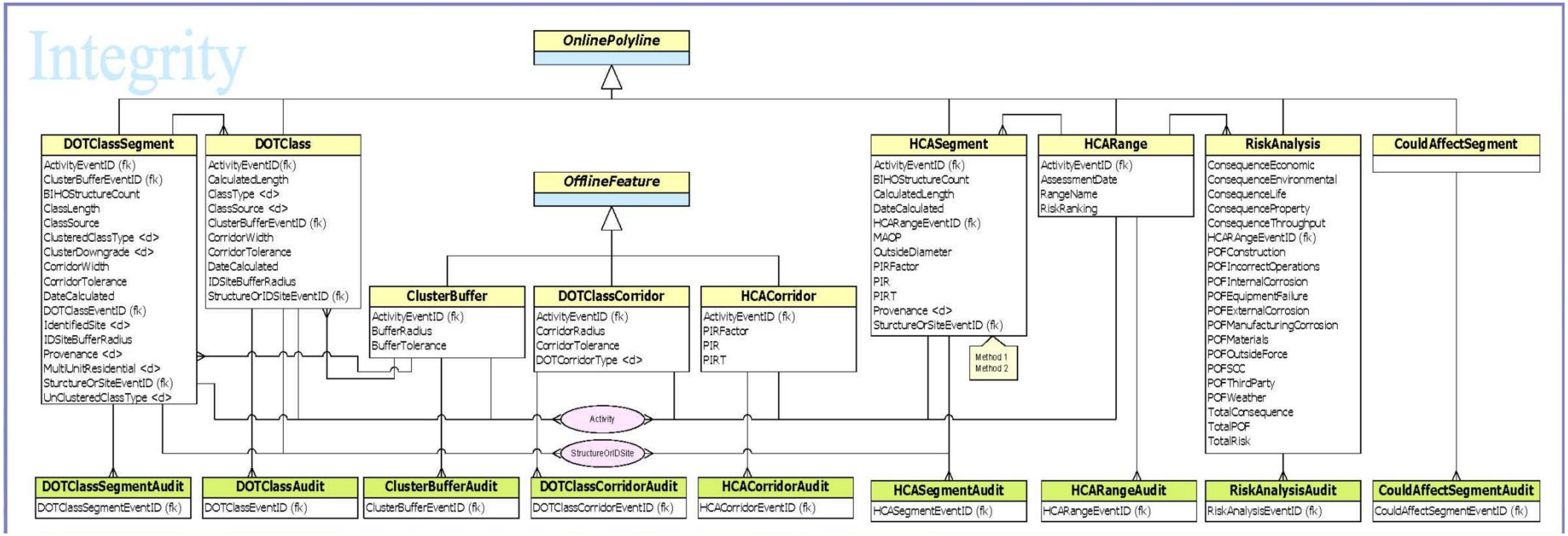


Encroachments

Encroachment feature classes model any physical feature or boundary that might impact the operation and/or regulated safety compliance of the pipeline system.

LineCrossings represent offline linear features that intersect the centerline. LineCrossings may have one or more online point locations (crossing locations) and one or more online polyline locations (easements)

Structures are offline Points that may have zero or more online point locations - structure locations are typically derived for structures within 1000 feet (304.8 meters) of the centerline.



Integrity

OnlinePolyline

OfflineFeature

DOTClassSegment
ActivityEventID (fk)
ClusterBufferEventID (fk)
BIHOStructureCount
ClassLength
ClassSource
ClusteredClassType <d>
ClusterDowngrade <d>
CorridorWidth
CorridorTolerance
DateCalculated
DOTClassEventID (fk)
IdentifiedSite <d>
IDSiteBufferRadius
Provenance <d>
MultiUnitResidential <d>
SturctureOrSiteEventID (fk)
UnClusteredClassType <d>

DOTClass
ActivityEventID(fk)
CalculatedLength
ClassType <d>
ClassSource <d>
ClusterBufferEventID (fk)
CorridorWidth
CorridorTolerance
DateCalculated
IDSiteBufferRadius
StructureOrIDSiteEventID (fk)

ClusterBuffer
ActivityEventID (fk)
BufferRadius
BufferTolerance

DOTClassCorridor
ActivityEventID (fk)
CorridorRadius
CorridorTolerance
DOTCorridorType <d>

HCACorridor
ActivityEventID (fk)
PIRFactor
PIR
PIRT

HCASegment
ActivityEventID (fk)
BIHOStructureCount
CalculatedLength
DateCalculated
HCARangeEventID (fk)
MAOP
OutsideDiameter
PIRFactor
PIR
PIRT
Provenance <d>
StructureOrSiteEventID (fk)

Method 1
Method 2

HCARange
ActivityEventID (fk)
AssessmentDate
RangeName
RiskRanking

RiskAnalysis
ConsequenceEconomic
ConsequenceEnvironmental
ConsequenceLife
ConsequenceProperty
ConsequenceThroughput
HCARAngeEventID (fk)
POFConstruction
POFIncorrectOperations
POFInternalCorrosion
POFEquipmentFailure
POFExternalCorrosion
POFManufacturingCorrosion
POFMaterials
POFOutsideForce
POFSCC
POFThirdParty
POFWeather
TotalConsequence
TotalPOF
TotalRisk

CouldAffectSegment

Activity

StructureOrIDSite

DOTClassSegmentAudit
DOTClassSegmentEventID (fk)

DOTClassAudit
DOTClassEventID (fk)

ClusterBufferAudit
ClusterBufferEventID (fk)

DOTClassCorridorAudit
DOTClassCorridorEventID (fk)

HCACorridorAudit
HCACorridorEventID (fk)

HCASegmentAudit
HCASegmentEventID (fk)

HCARangeAudit
HCARangeEventID (fk)

RiskAnalysisAudit
RiskAnalysisEventID (fk)

CouldAffectSegmentAudit
CouldAffectSegmentEventID (fk)

Automatic alignment sheet generation using ArcGIS & New century software

- Data base creation using APDM (Arcgis pipeline database model)
- Template design in NCS plug-in as per requirements.
- Sheet cutter mdb and pipeline mdb creation using the main database (APDM) as per the automatic alignment sheet bands requirement.
- Marker symbols and line symbols creation in ArcGIS using style manager as per the requirements.

Inputs required for Automatic sheet generation:

- Sheet cutter mdb and pipeline mdb.
- Survey data either in dwg, dbf, .xls …etc
- Route maps (pipeline routes) & design details, feature details.
- DEM/lidar/ contours/ point ht information in any format for profile generation.
- Chainage /Measure /Stationing information for linear referencing
- APDM model for all other features(online/offline)

Sheet cutter & Template Designer
By
NEW CENTURY SOFTWARE

Release Date: 6/27/2011

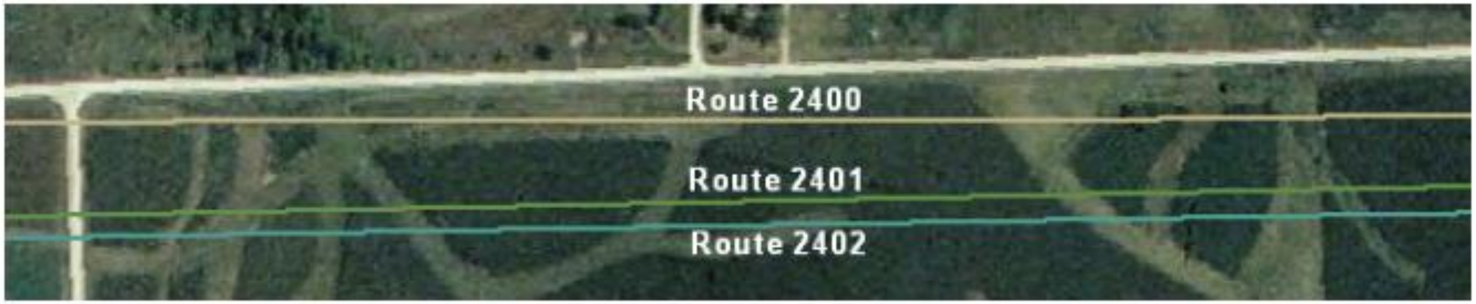
Version: 7.2

NEW CENTURY SOFTWARE

Sheet cutter:

- Sheet cutter is an ArcMap extension that creates customizable map Sheets.
- Each sheet provides a visual representation of data associated with a particular section of the centerline.
- We can produce 1) Alignment sheets 2) Area maps
- Sheet cutter uses Linear referencing to retrieve data about a route or centerline.
- Input data can be from PODS,APDM, ESRI feature datasets.
- Slots can be used, when sheet cutter needs to report data for multiple routes on the same sheet. Ex: each route is assigned to a slot.

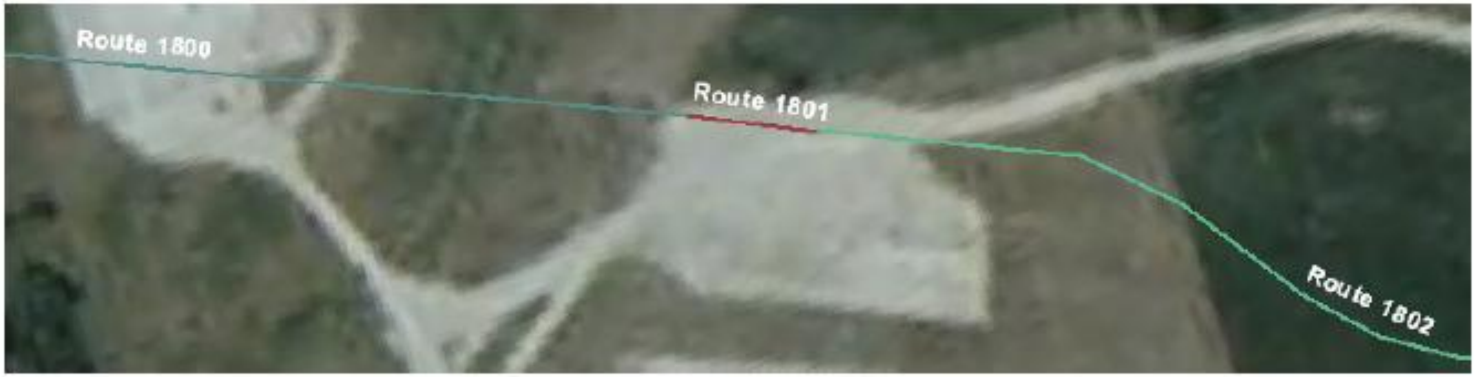
1. **Scenario 1: Parallel Routes.** Routes that run parallel to each other.



Slot Assignment

Slot 1 = Route 2400
Slot 2 = Route 2401
Slot 3 = Route 2402

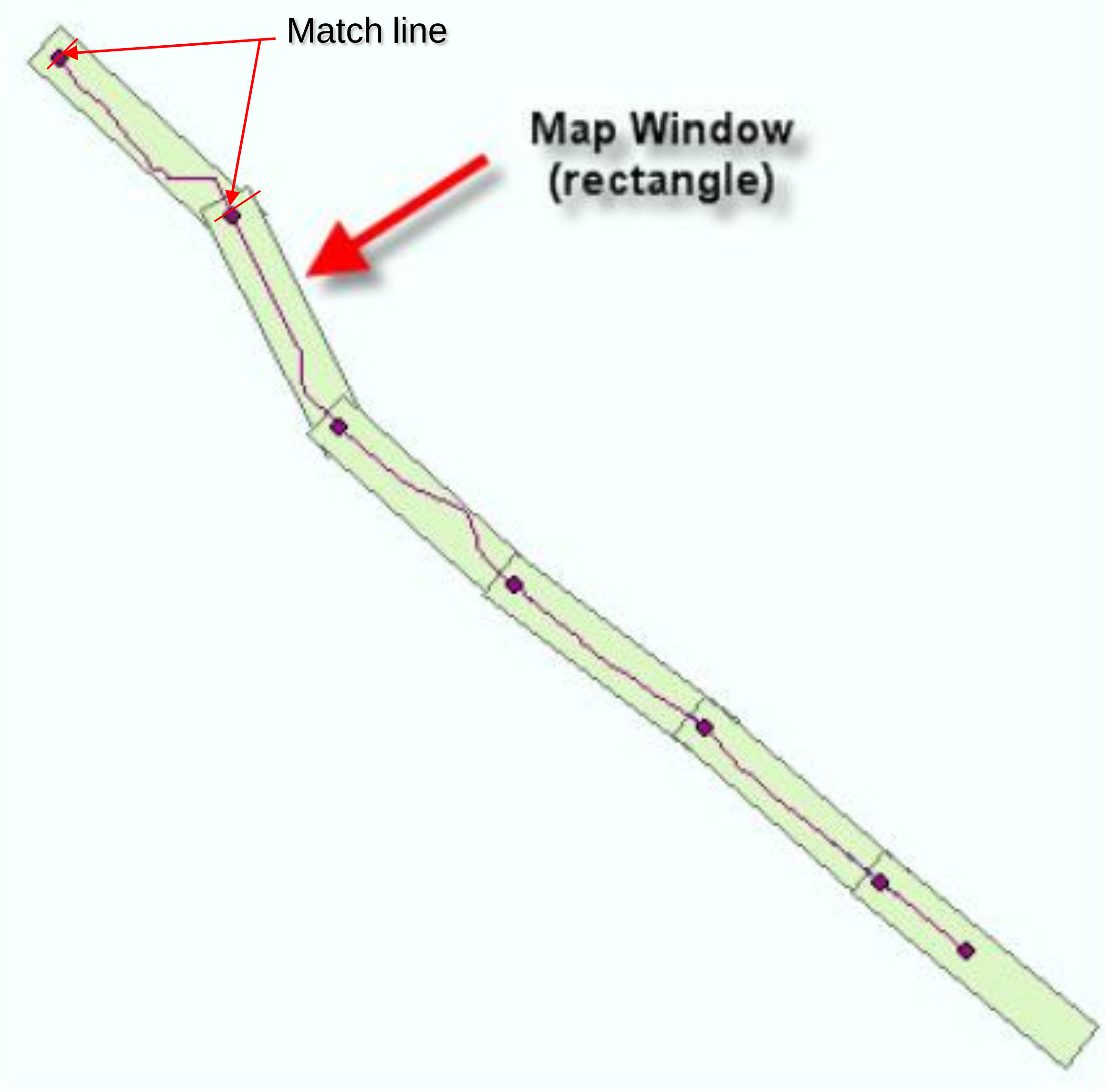
2. **Scenario 2: Adjoining Routes.** Routes that end and start at the same location.



- Template Designer:
- Template Designer is an ArcMap extension that creates and customizes templates.
- Sheet cutter, inturn, uses these templates to generate different kinds of maps.
- Each template consists of a number of “bands” that represent different types of data associated with the map.
- The template determines what information will be used in the band and how it will appear.

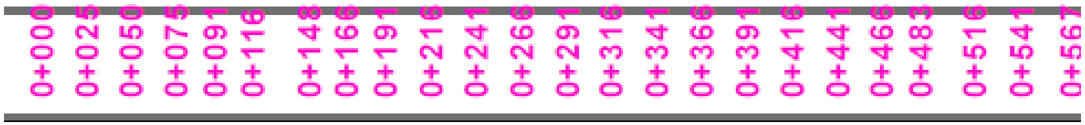
Map Bands:

Matchline Band : To show the portion of centreline of the each alignment sheet.

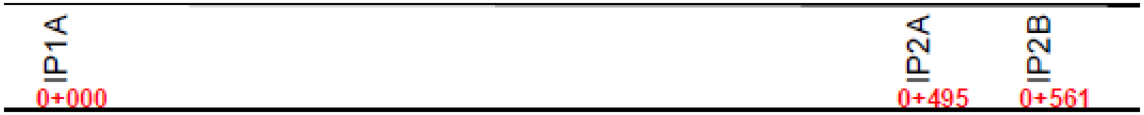

Match line
Map Window
(rectangle)

Field note Band : To show the various information in alignment sheet Like (chainage, elevation, wall thickness ,…etc)

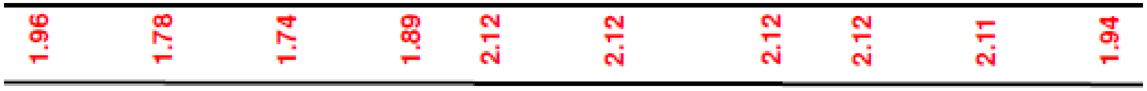
Chainage



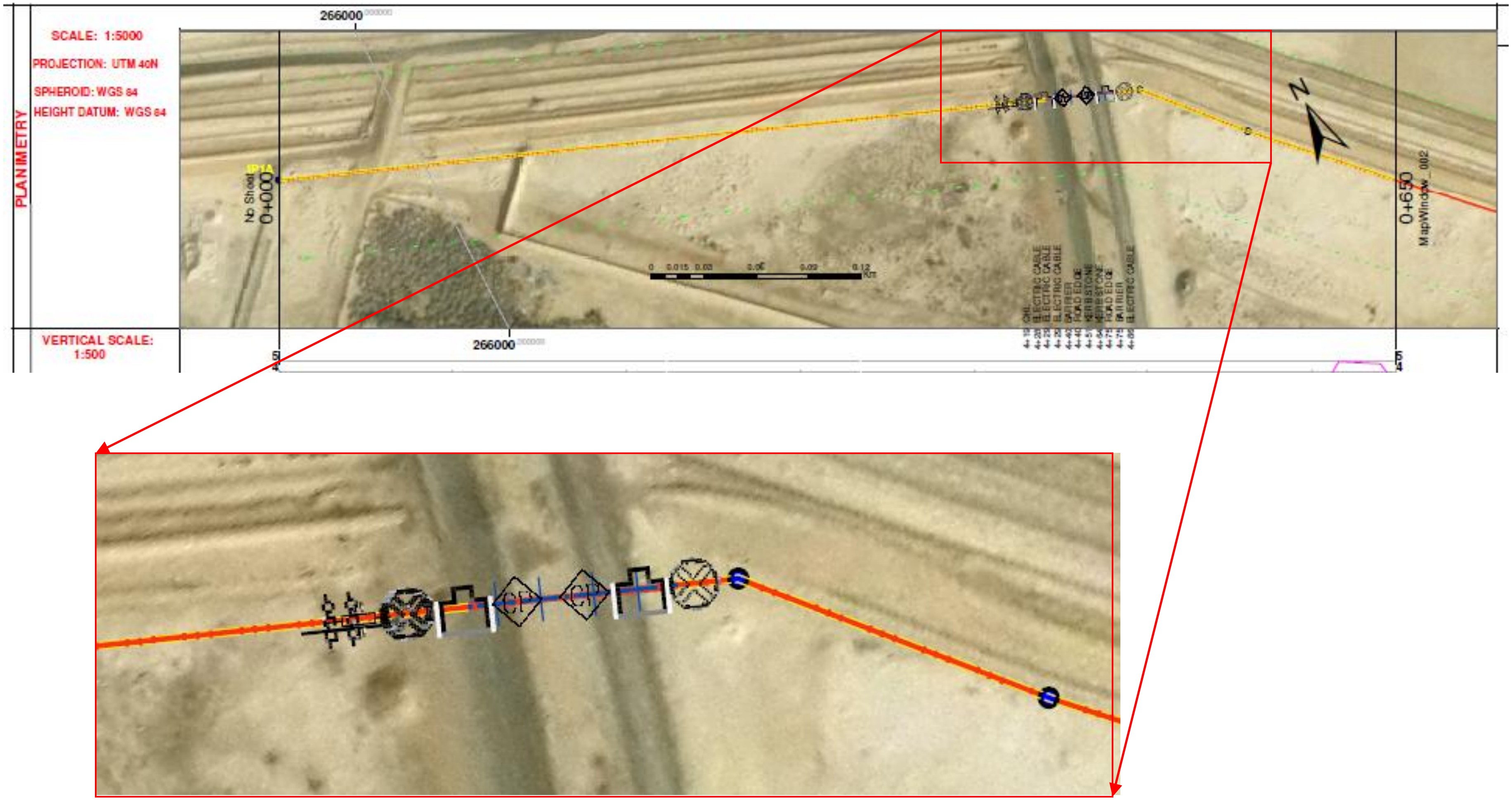
Intersection Point



Ground Elevations

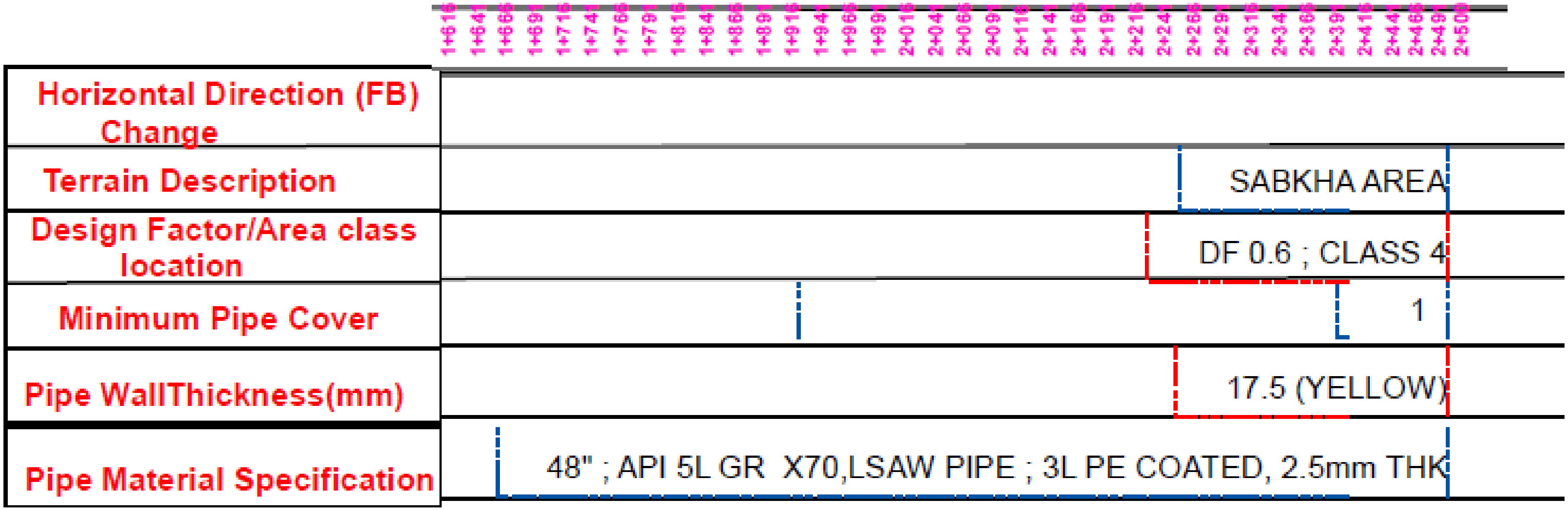


Marker Band: Is used to show description, Measure, symbol information over map band along the centerline.



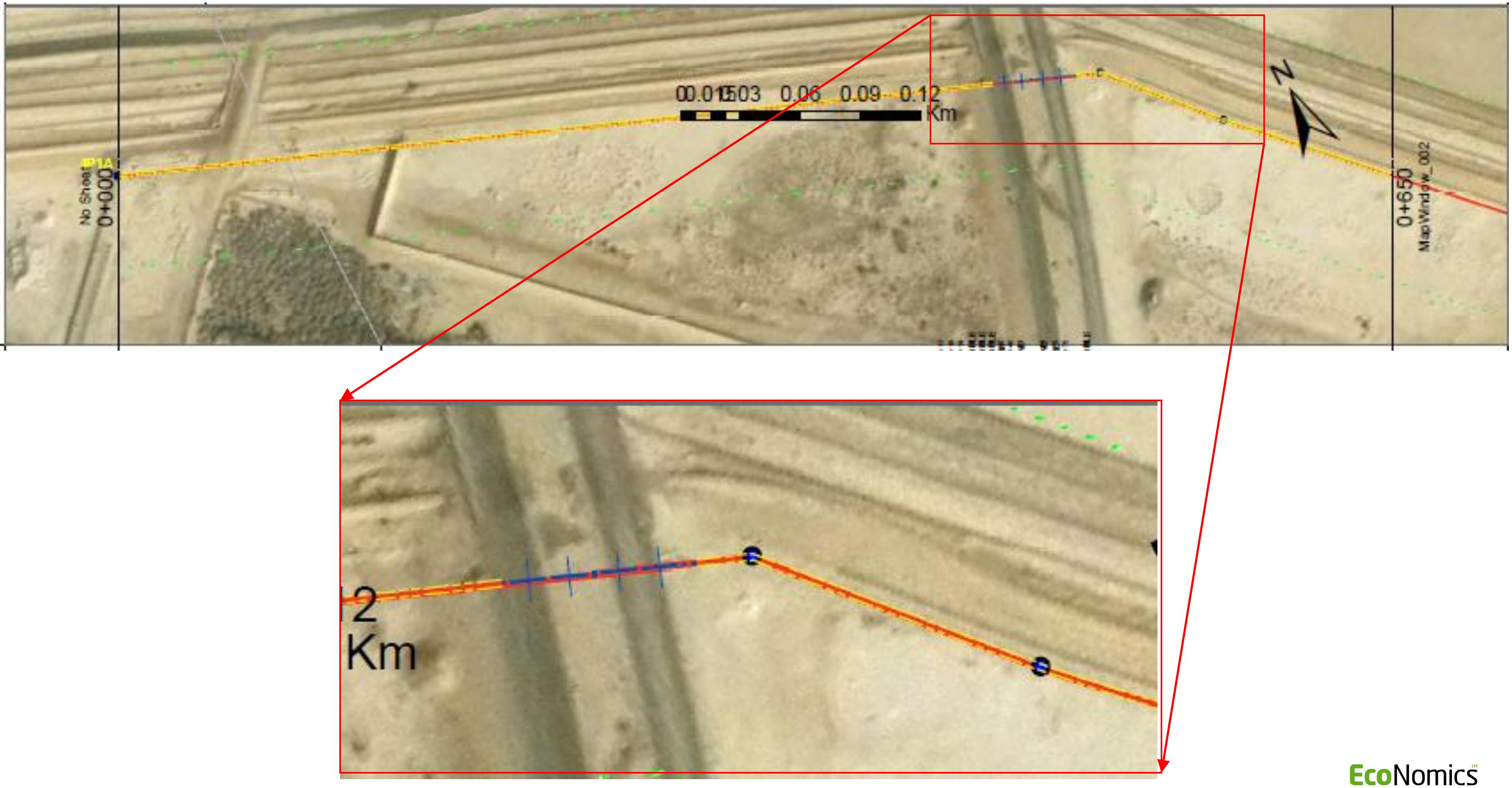
Linear Band:

Linear band can be used to show the line information like pipe segments, cathodic protection, dot class, pipe cover ..etc in alignment sheets nicely.



Horizontal Direction (FB) Change	
Terrain Description	SABKHA AREA
Design Factor/Area class location	DF 0.6 ; CLASS 4
Minimum Pipe Cover	1
Pipe WallThickness(mm)	17.5 (YELLOW)
Pipe Material Specification	48" ; API 5L GR X70,LSAW PIPE ; 3L PE COATED, 2.5mm THK

Line Marker: **Is like marker band to show the line information over map band of centerline.**



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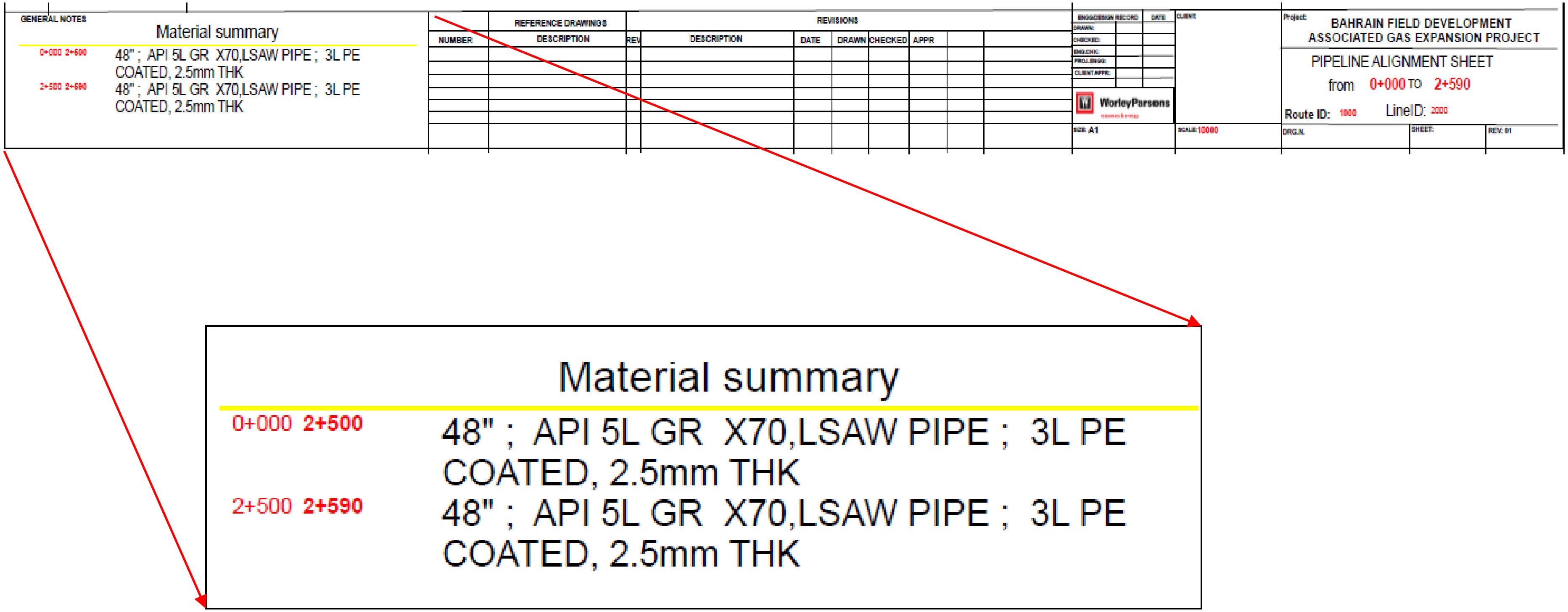
Summary Band: To list some details in the layout from the table or from the feature table. Ex: Design details like pipe material.. Etc.



GENERAL NOTES

Material summary

0+000 2+500 48" ; API 5L GR X70,LSAW PIPE ; 3L PE COATED, 2.5mm THK

2+500 2+590 48" ; API 5L GR X70,LSAW PIPE ; 3L PE COATED, 2.5mm THK

REFERENCE DRAWINGS		REVISIONS					
NUMBER	DESCRIPTION	REV	DESCRIPTION	DATE	DRAWN	CHECKED	APPR

ENGG/DESIGN RECORD		DATE
DRAWN:		
CHECKED:		
ENG.CHK:		
PROJ.ENGG:		
CLIENT APPR:		

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CLIENT:

Project: BAHRAIN FIELD DEVELOPMENT
ASSOCIATED GAS EXPANSION PROJECT

PIPELINE ALIGNMENT SHEET

from 0+000 TO 2+590

Route ID: 1000 LineID: 2000

SIZE: A1

SCALE: 10000

DRG.N.

SHEET:

REV: 01

Material summary

0+000 2+500 48" ; API 5L GR X70,LSAW PIPE ; 3L PE COATED, 2.5mm THK

2+500 2+590 48" ; API 5L GR X70,LSAW PIPE ; 3L PE COATED, 2.5mm THK

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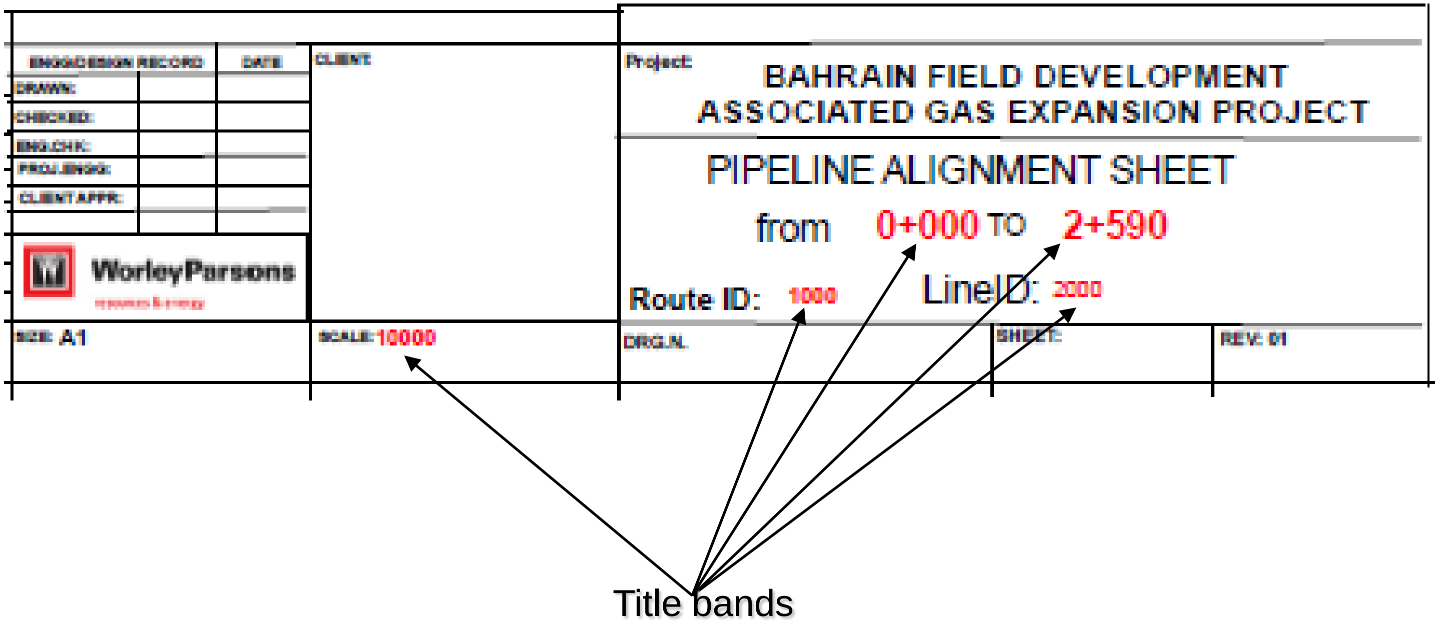
Title band: Title band reads legend and other details form feature field or table field to show any where in the sheet.

Ex: Date, Route id, Line id, Sheet name, Dwg no, Chainage, scale …etc.



ENGG DESIGN RECORD | DATE

DRAWN:

CHECKED:

ENG.CHK:

PROJ.ENGG:

CLIENT APPR:

CLIENT:

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Project:

BAHRAIN FIELD DEVELOPMENT
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Route ID: 1000

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SIZE: A1

SCALE: 10000

DRG.N.

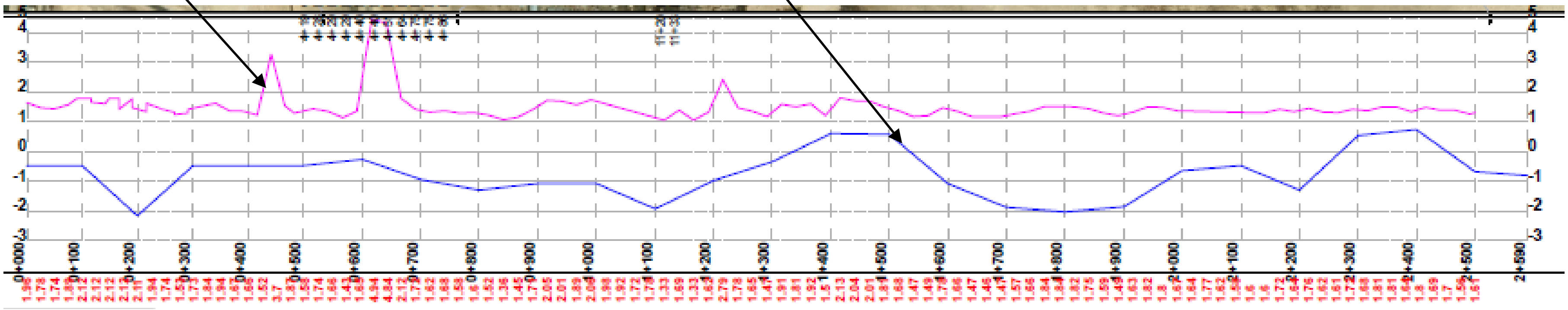
SHEET:

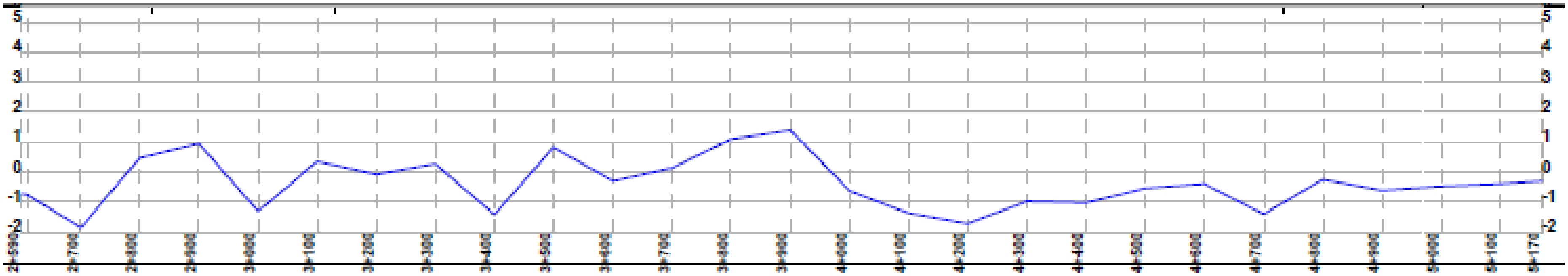
REV: 01

Line Chart : Line chart can be used to create a profile using elevation along the chainage value.

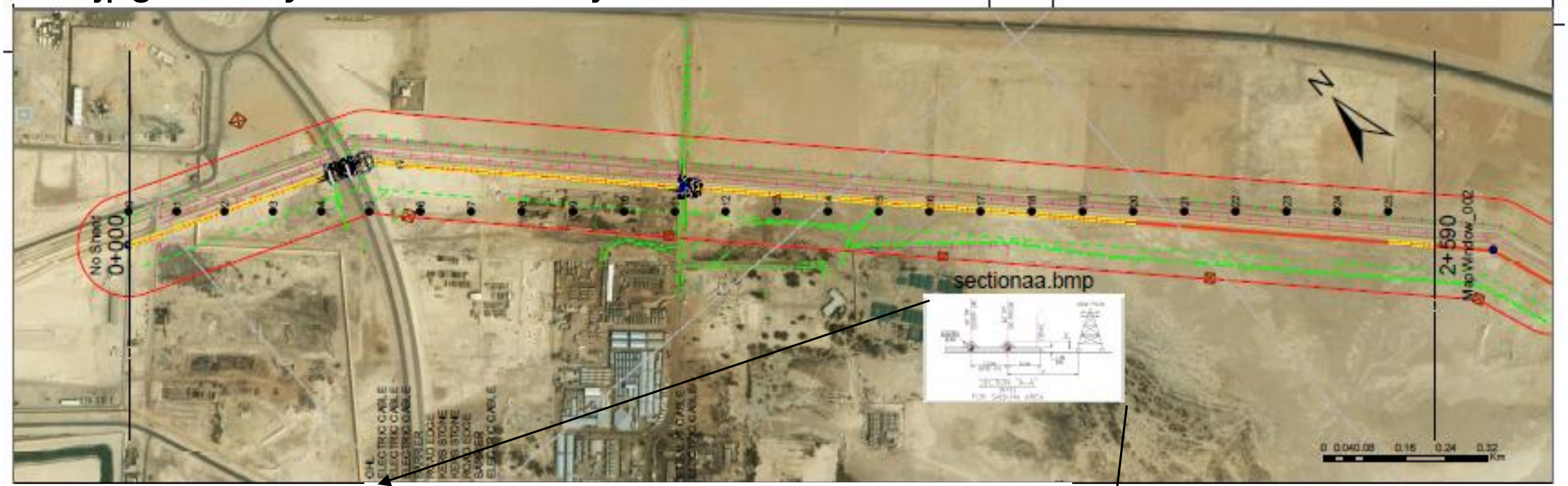
Ground elevation profile

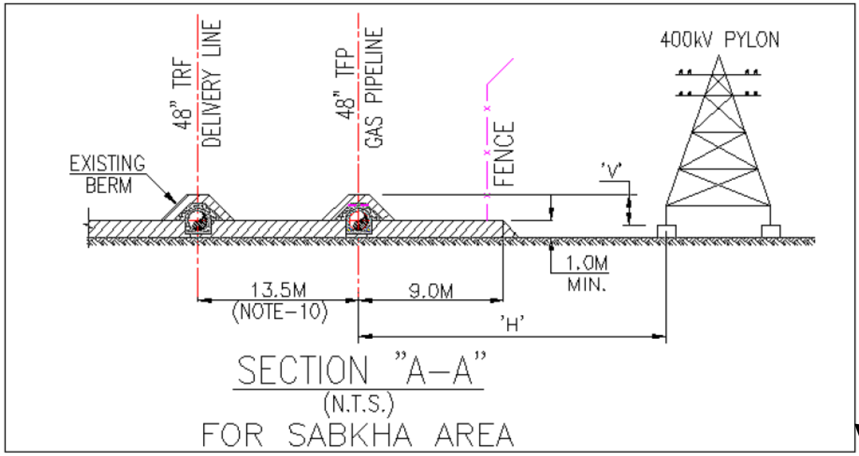
Elevation profile for the bottom of pipe



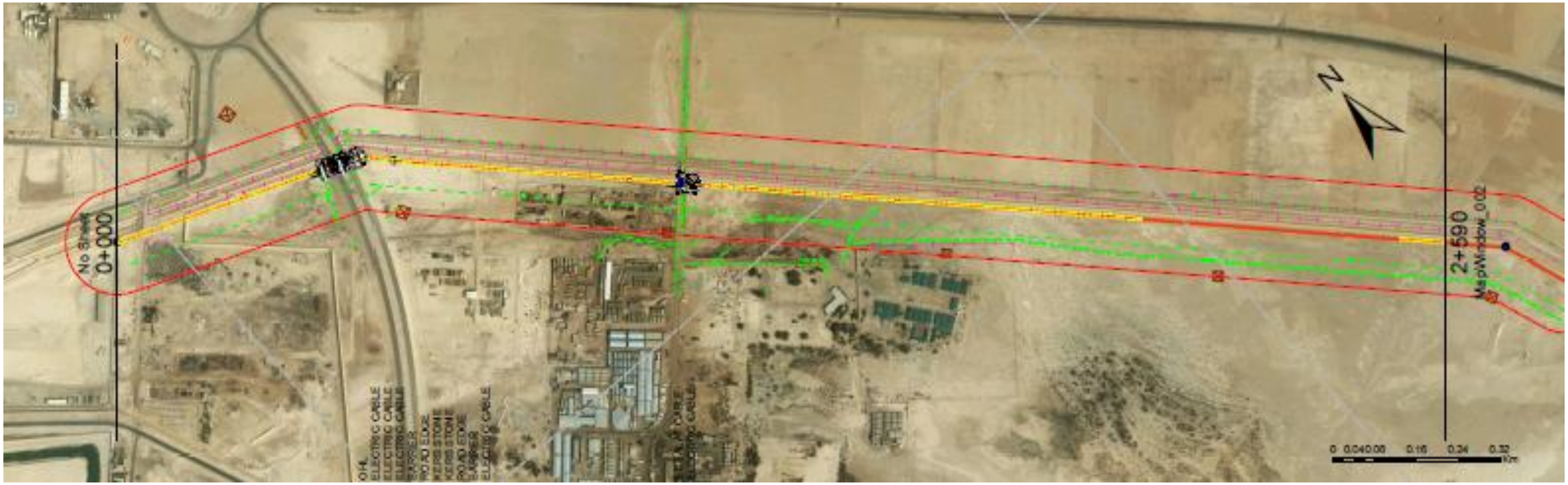


Attachment Band: Attachment band can be used for attaching dwg, jpg, tiff any other ESRI objects in the sheet.





Load layer band: To load the required layer or image into the respective sheet can be loaded dynamically using load layer. It needs a polygon index layer contains information about the feature or image to be loaded dynamically. Index layer should have attributes like name of file with extension and path. **Buffer band:** Displays map feature that demarcates an area within a specified distance of the centerline feature in the map. Ex: 1) Areas to be included in risk analysis 2) A corridor for environmental analysis.



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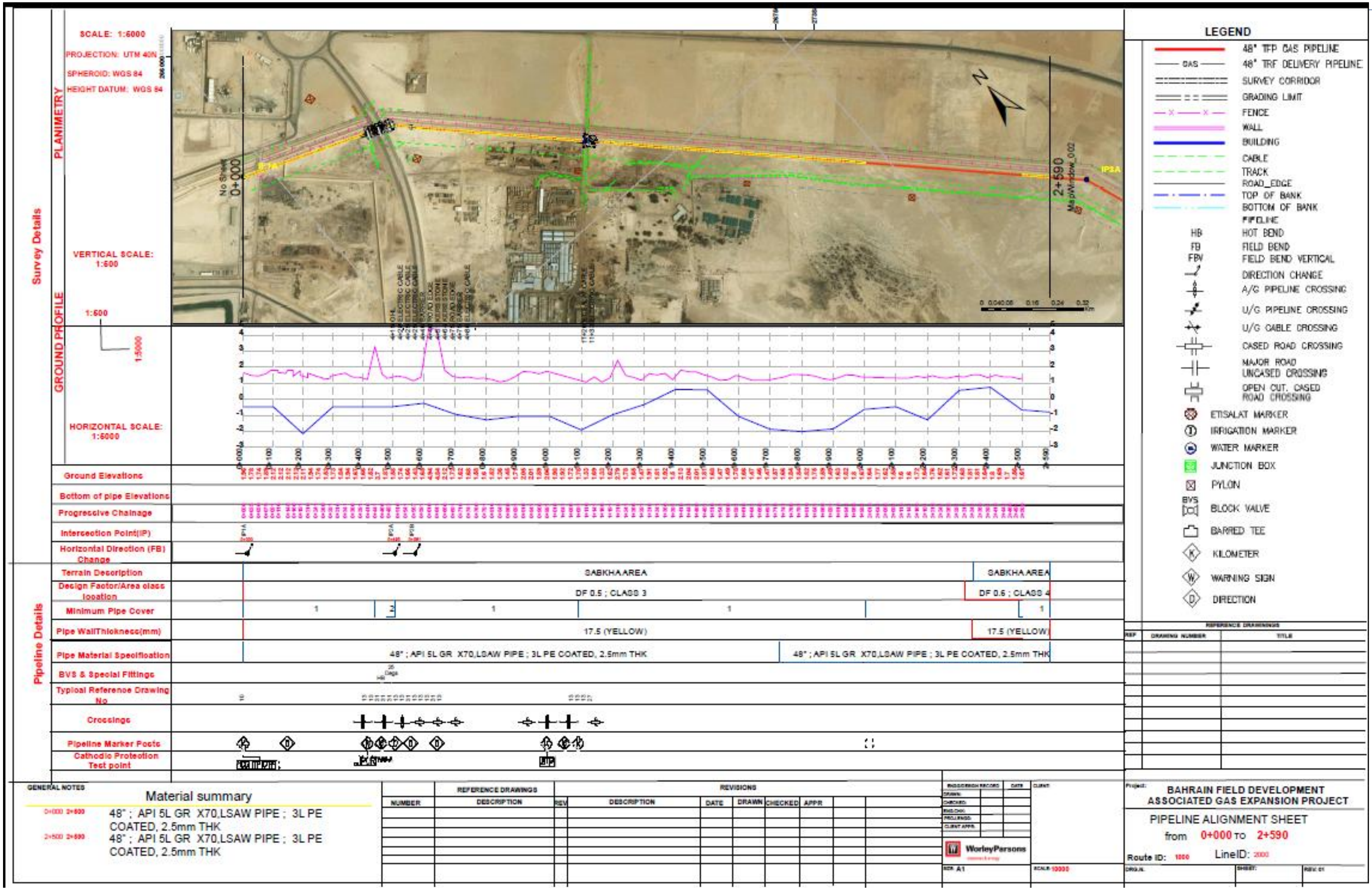

EcoNomics

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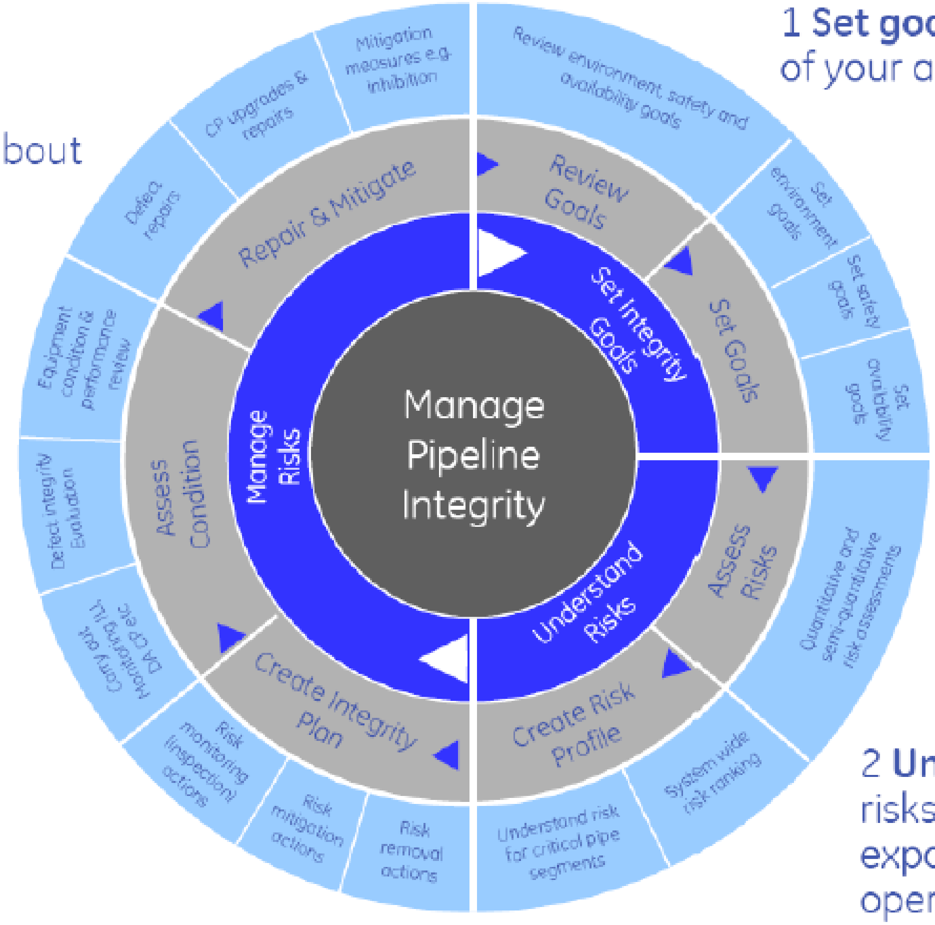
THANK YOU…….

THANK YOU…….

PIPELINE INTEGRITY MANAGEMENT SYSTEM


Manage Pipeline Integrity
Set Integrity Goals
Understand Risks
Manage Risks
Review Goals
Set Goals
Assess Risks
Create Risk Profile
Create Integrity Plan
Assess Condition
Repair & Mitigate
Review environment, safety and availability goals
Set environment goals
Set safety goals
Set availability goals
Quantitative and semi-quantitative risk assessments
System wide risk ranking
Understand risk for critical pipe segments
Risk removal actions
Risk mitigation actions
Risk monitoring (inspection) actions
Carry out Monitoring ILI DA CP etc
Defect integrity Evaluation
Equipment condition & performance review
Defect repairs
CP upgrades & repairs
Mitigation measures e.g. inhibition

1 **Set goals** for the integrity of your asset

2 **Understand** the risks that you are exposed to in operating that asset

3 Do something about those risks –put another way – **manage** the risks

- Station series is a linear path representing a portion of the centerline of the pipeline or the route
- The cumulative measure of stationing values from the start of the station series to the terminus of the Station series is called station position.
- At each point along the station series where the centerline bends horizontally or vertically, a control point is placed. There are known points of stationing and coordinates. (X, Y and Measure).
- When pipeline is first built stationing measurements are uninterrupted and continuous.
- When a pipeline is rerouted, the points of the breaks in stationing are known as station equations.
- Once the equation is introduced into the centerline, the stationing is altered for the portion of the centerline that has been rerouted with the addition of a new station series.
- Stationing is based on traditional field survey and drafting methodology.
- Common forms of Stationing measures:

  1)slack chain: 3d distance b/n two points along the earth surface, also called vertical or Engineering.

  2)Horizontal: 2d distance b/n two points along the earth surface.

  3) Continuous: Stationing starts at a set value and continuously and cumulatively measures either slack or horizontal distance from the start to the end of a centerline along all station series.

  4) Arbitrary (pseudo-distance based):

  a) Mile posting: posts or other markers are placed in or on the ground at arbitrary intervals and used as reference points for locating features.

  b) Offset Based –Measurements are taken as offset values from known points along the centerline (ex: valve section- the feature is located 100 feet downstream from the mainline valve)

- The centerline of a pipeline system is composed of station series features, which in turn are composed of control points.
- It is also possible to have duplicate station values for different line loops in the pipeline.
- Control points(x,y,m) occur at changes in the centerline direction of the pipeline are called point of Inflection.
- centerline ties where a distance and/or angle exists to an offline point event with known geographic coordinates.

- Since control points are used to form the vertices of the station series feature, the measure value in the vertex is also the station value assigned to the control point.
- Events are point or line entities or objects that occur on, along, or beside the centerline have absolute position and relative position
- The relative position of an event is measured by identifying a unique route (station series) and a measure value (station). If the event falls along the station series in between two control point, the position of the event is interpolated along the station series relative to the station values of the bordering control points and the station value of the event.
- Hierarchy: Pipeline companies often organize or group features according to a hierarchy. Line loop is modeled as an object class in the APDM and is considered to be one of core elements. Other hierarchical elements in the model are line loop hierarchy, subsystem, and Subsystem hierarchy.
- Coincident Geometry: Any feature located by relative position (stationing) is coincident or offset from the centerline. Any change in geometry and/or the underlying station(measure) of the centerline route system has ramifications on the geometric location of features or events whose positions are dependent on the applied measures and position of the centerline.

Ex: Coating, pressure tests are chaild features dependent on the presence of parent linear features. such as pipe segments. The relationship between these features dictates that if the parent is removed or altered (partially removed, or vertex position changed) then the child must be similarly altered. Same relationship applies to pipe segment (child) and station series (parent). Relationship classes are used to maintain the station relationships between the centerline and dependent child features. Topology is the recommended solution for handling the geometric relationships between coincident geometries from different feature classes.

- APDM can be implemented with feature stored in feature classes(Geometry is stored in X,Ycoord), event tables (geometry is dynamically generated from Route-Id and measure values), or a combination of both.
- In case of Geometry stored as features: 1) features can be displayed quickly 2)features can be edited directly in arcmap.3) geometries are not automatically updated when routeid and measure values are updated.
- In case of geometry is generated dynamically: 1) Geometry can be quickly refreshed whenever the Route-id measure values are updated.2)In case any error, error message can be appended to the row of feature. 3) Display is poor. In case large volume(>10,000 events).
- Custom application code for gdb: requires to automatically update when the route-id and/or measure values are altered.

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How Implement APDM ?

- APDM Concentrates on defining and documenting CORE features using “80% Typical” rule- these are features and phenomena that 80% or more of all pipeline companies track information on or use as part of their daily operations.
- The APDM is starting point that can be extended and implemented to suit the needs of business
- APDM describes a pipeline by defining CORE elements of 24 tables:
- Pipeline centerline : *route, series, corridor*
- Activities: Work orders, inspections etc
- External documents: document version, reports, design drawings, spreadsheets, photos etc
- Ownership and company hierarchy: upstream, downstream, holding
- Product delivered:
- Sites:
- Reference modes: Measure, Station, KM/Mile Post
- APDM behavior through the use of ABSTRACT classes of pipeline features when they are created in the database, edited as part of the database individually or as part of a change to the pipeline centerline.
- Abstract classes are the templates from which behavior (defined as attributes in the class and relation ships, geometry to the other classes) are passed down to concrete feature/object classes in the APDM Geodatabase using a concept called ‘Inheritance’.
- Ex: Control point inherit behavior from the Centerline Point Abstract class.
- Ex: Elbows, Valves, and Flanges inherit behavior from the Online Point Facility Abstract class.
- Ex: Structures inherit behavior from the Offline Point Abstract Class.
- Abstract classes defines a specific set of behavior for a specific set of features particularly for edit operations. Ex: Control points will act this way when the xy or M(station) value is altered
- Ex: Elbows, valves and Flanges will act this way when the centerline they are located on is edited(a tow point re-route occurs, the route is trimmed back or extended.

- Ex: Structures located within 660 feet of the centerline will act this way when the centerline is edited(the cease to impact the delineation of HCA)
- The abstract classes define the framework of the APDM and are required elements of the model. They never actually appear physically in an implemented APDM geodatabase. Appear only in the logical and physical(UML)models.
- Core classes are those object, feature and relationship classes, together with associated domains, that are required to maintain APDM compliance. These are concrete and physically appear in the implemented apdm geodatabase. they define centerline features, stationing attributes, and supporting model elements.
- Optional classes are distributed with the model as implementation examples. But none of them are required elements of the model.
- Topology feature classes can be used to define editing behaviours for spatially coincident features from different feature classes.
- In the APDM, a template is a pattern that defines an object or class containing known and predictable behaviour. The pattern is defined as a set of attributes, including geometry, and relationships to other classes.
- A concrete class in the APDM geodatabase inherits certain base attributes and relationships result in the creation of an individual, concrete feature or object class within the goedatabase.

- APDM Logical model: an object diagram of the APDM. Which depict the classes, attributes of classes, relationships between classes (optionality and cardinality), and inheritance from classes.
- Optionality: must-have, may-have
- Cardinality (number of instances): one-to-many, zero-to-one, many-to-many

ABSTRACT CLASSES

- Activity object class has one-to-many relationship with each audit object class.
- **APDM object**: Lineloop hierarchy, Activity Hierarchy and subsystem hieracrchy are core classes inherit from APDM object.
- **Object Archive**: centerline object, Facility object, Non Facility object are abstract classes inherit from Object archive. Historical state is domain.
- **Centerlineobject:** Lineloop, Subsystem,site are core classes inherit from the centerline object. Operational status is domain.
- **Nonfacilityobject:** Activity, address, CISreading, company, contact, Externaldocument,Geometadata,Meterreading,Owneroperator,Product are core classes inherit from the nonfacilityobject. Status is domain.
- **Facilityobject:** Valveoperator is a core class inherit from the Facility object. Operational status is domain. Facility object is having Relation ship with Site core class of M:1
- **Feature Archive**: inherited from Esri simple feature. Centerline polyline,
- centerlinepoint, offlinefeature, onlinefeature, offlinefacility are core classes. Historical state is domain.
- **Centerlinepolyline**: Stationseries is inherited from centerlinepolyline. Operationalstatus is
- Domain.
- **CenterlinepolylineEvent**: inherited from the centerlinepolyline. Subsystemrange is core class inherited from centerlinepolylineevent. CLEditresponse, CLvalidity tolerance are domains. Centerlinepolylineevent is having relationship with stationseries core class of M:1
- **Centerlinepoint**: inherited form the featurearchive. controlpoint is a core class inherited from the centerlinepoint. Operationalstatus,CLControl,CLStationEditresponse, CLXYEditresponse, CLZEditresponse are domains. Centerlinepoint is having relationship with stationseries of M:1. centerlinepoint encapsulates and describes the behavior of

ABSTRACT CLASSES

- Points that participate in the construction of the centerline.
- **Offline Feature:** implemented as a non m aware polyline or polygon feature. Inherited from the feature archive.
- Alignmentsheet, Highconsequencearea, linecrossing, Removedline, structureoutline are inherited from offlinefeature.
- Offlienfeatures are comprise any feature that is ancillary to the operations and description of the pipeline system and underlying geography. Each and every offline feature may have 0 or more online locations stored in a class inheriting from the onlinepoint or onlinepolyline for offlineclass APDM abstract classes. These relationships are added to the apdm metadata table of onlinelocationClass.
- **Offline point:** implemented as a non m-aware point feature class**.** inherited from the offline feature**.**

  Document point, Fieldnote, Removed point, Structure are inherited core classes**.** may have 0 or more online locations stored in a class inheriting from the onlinepoint or onlinepolyline for offlineclass APDM abstract classes. These relationships are added to the apdm metadata table of onlinelocationClass.
- **Offline Facility:** implemented as a non m-aware polygon feature. Inherited from feature archive. these features may be related to features in classes inheriting from onlinepolylineforofflinefeature or onlinepointforofflinefeature. Each and every offlinefacility may have 0 or more online locations stored in a class inheriting from onlinepoint or onlinepolylines for offlineclass APDM abstract classes.
- **OfflineNonPointFacility**: implemented as a non m-aware polygon or polyline feature class. Inherited from offlinefacility.
- Cpcable, Pigstructure, Siteboundary are inherited core classes. This is intended for use with offline facilities features that are best represented by polyline or polygon shapes. Offlinenonpointfacility is having relatinship with Site of M:1
- **Offlinepointfacility:** implemented as a non m-aware point feature class. Inherited form the offline facility.
- CPanode, Cpbond, CPGroundbed, CPRectifier, CPTeststation, Marker, Site point are core classes inherited from offlinepointfacility. Offlinepointfacility is having relationship with Site of M:1.
- **OnlineFeature**:implemented as m-aware polyline or point feature class or object class representing an event table. Inherited from feature archive. Onlinefeature is having relationship with Stationseries of M:1. CLEditresponse,CLValiditytolerence are domains. Online point features must be geometrically coincident and share edge.

ABSTRACT CLASSES

- Onlinepolyline features geometrically constrained to the centerlinefeatures. linear features that share not only edge of the centerline but also every intervening vertex between the start and endpoint of linear feature. CLEditresponce and CLValidity tolerence describes what happens to the online feature when the underlying station series feature is edited. These define how and if the feature is re-built on the centerline during a reroute.
- **Onlinepolyline:** implemented as m-aware polyline feature class or object class representing an event table.inherited from the onlinefeature.

  HCA class, DOT class, CouldaffectSegment, InspectionRange, OperatingPressure,PressureTest,Rightofway,Riskanalysis are core classes inherited from onlinepolyline. Each and every onlinepolyline may have 0 or more onlinepolyline or onlinepoint features(M:1)
- **OnlinepolylineforOfflinefeature:** Implemented as an M-aware polyline feature or object class. Inherited from onlinepolyline. LinecrossingEasement is a core class inherited from onlinepolylineforofflinefeature. Each and every onlinepolylineforofflinefeature must be the onlinelocation for one and only one offline feature.(M:1). This encapsulates the attributes and relationships that define the onlinepolyline location for an offline feature. This contains begin and end of offset angle and distance information.
- **Onlinepoint:** Implemented as an M-aware point feature or object class. Inherited from onlineFeature.

  Anomaly, Anomalypoint, Elevation point,Leak, OnlineFieldNote are core classes inherited from Onlinepoint. Each and every onlinepoint may be represented by 0 or more onlinepolyline or onlinepoint alternative geometries(M-1)
- **OnlinePointforofflinefeature:** implemented as an m-aware point feature or object class**.** Inherited form onlinepoint**.** CPonlinelocation, Linecrossing location, structurelocation are core classes inherited from the onlinepointforofflinefeature.

  Each and every onlinepointforofflinefeature must be the online location for one and only one offline feature(m-1)

  onlinepointforofflinefeature encapsulates the attributes and relationship that define the onlinepoint for an offlinefeature.

ABSTRACT CLASSES

- **Onlinefacility:** Implemented as an M-aware polyline or point feature or object class representing and event table. Inherited from the onlinefeature. Onlinefacility is having relationship with site of M:1.

  facility objects are those representing real features in the world such as pipes, coatings, taps, tees, and valves are primarily defined by In-service date, Installation date, and operational status which describes the operational and lifespan properties of the features. Inherited onlinebehaviour such as a relationship with stationseries feature class.
- **OnlinePolylineFacility:** Implemented as an M-aware polyline feature or object class representing and event table. Inherited from the online facility. Casing, coating, pipe segment, Sleeve are core classes inherited from onlinepolylinefacility. Inherits the facility attributes like In-service date, Installation date, and operational status from the onlinefacility.
- **OnlinepointFacility:** Implemented as an M-aware point feature or object class representing and event table.inherited from the onlinefacility. Appurtenance, Instrument, Pipejointmethod, Tap, Valve, vessel are core classes inherited from the

  Onlinepointfacility. Inherits the facility attributes like In-service date, Installation date, and operational status from the onlinefacility.
- **Fitting:** Implemented as an M-aware point feature or object class representing and event table. Inherited from the Onlinepointfacility. Closure, Elbow, Meter, Reducer, Tee are core classes inherited from Fitting.

  Grade, Inletconnection type, Inletdiameter, inletwallthickness, Manufacturer, material, pressurerating are domains.
- **APDM meta data:** metadata imbuces an APDM geodatabase with sufficient intelligence to allow applications to deal consistently with schema and data content variation. 1) class level metadata 2) Feature level metadata.
- Class level metadata stores additional behavioral information for an object or feature class that applies to all objects in the class, or to all objects within a subtype of class. Class level metadata is stored externally to the APDM class itself.
- Feature level metadata applies to individual objects within a class. Feature level metadata is stored internally within an APDM object or feature class in the form of metadata attributes.

Class level Metadata: Reference mode

- Three metadata (class level) tables are implemented in the APDM schema: 1) Reference mode 2)APDM class 3)Onlinelocation class

  Reference mode: stores metadata pertaining to the reference modes common to controlpoint, stationseries, and AltrefMeasure classes.

  Reference modes represent different methods of recording station values and how these values are applied at the lineloop level.

  Attributes:

  clReferenceMode subtype Value: 1) Unknown 2)Continuous 3)Engineering 4)Horizontal 5)Milepost 6)Slackchain 7)Valvesection 8)Unspecified

  gnRefModeUnits: 1)Unknown 2)esriSRunit_Meter 3)esriSRunit_Foot 4)esriSRunit_surveyfoot 5) esriSRunit_surveychain

  6) esriSRunit_surveylink 7) esriSRunit_surveymile 8) esriSRunit_Kilometer

  gnRefModeBasis: describes the basis for determining the oringin of distance measurements for a particular stationing method.1) Unknown 2)Arbitrary 3) 3D projected 4) 3D Slack chain 5) 3D Geoid 6)2D Projected

  Arbitrary : Mile posts or above ground markers.

  3d projected distance: Distance = Square root((X1-X2)2 +(Y1-Y2)2+(Z1-Z2)2)

  3d slack chain: distance calculations by draping a metal chain on the earths surface.

  3d Geoid: distance calculations by standard survey triangulation method using great circle.

  2d projected: Distance = Square root((X1-X2)2 +(Y1-Y2)2)

  gnRefModeType: stores coded values that determine how the stationseries features in each reference mode behave during a

  Uninterrupted: cannot split into multiple station series features during a reroute operation, station equations are not introduced. **Interrupted:** can be split into multiple station series, station equations can be introduced.

  Adjustable: Station values may be recalculated downstream of a reroute.

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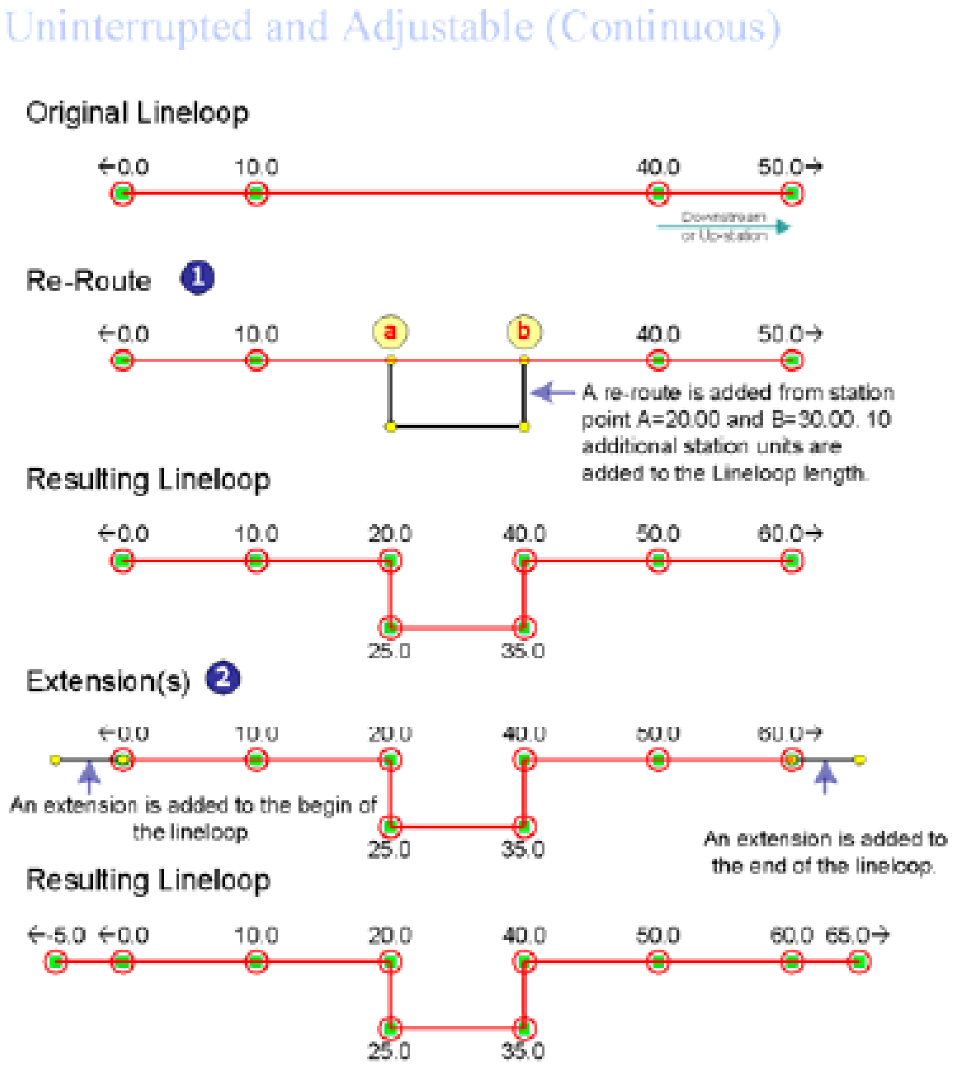
Class level Metadata: Reference mode

Not Adjustable: station values may not be recalculated downstream of reroute.

1) **Uninterrupted and Adjustable (continuous):** any addition, such as a re-route or a extension to the geometry of the station series increases overall stationed length of the lineloop. (PODS continuous measure)


Uninterrupted and Adjustable (Continuous)
Original Lineloop
←0.0
10.0
40.0
50.0→
Downstream or Up-station
Re-Route 1
←0.0
10.0
a
b
40.0
50.0→
A re-route is added from station point A=20.00 and B=30.00. 10 additional station units are added to the Lineloop length.
Resulting Lineloop
←0.0
10.0
20.0
40.0
50.0
60.0→
25.0
35.0
Extension(s) 2
←0.0
10.0
20.0
40.0
50.0
60.0→
An extension is added to the begin of the lineloop
25.0
35.0
An extension is added to the end of the lineloop
Resulting Lineloop
←-5.0
←0.0
10.0
20.0
40.0
50.0
60.0
65.0→
25.0
35.0

The Uninterrupted and Adjustable Reference Mode maintains a single station series feature for the entire lineloop. Any addition, such as a re-route or a extension to the geometry of the station series increases the overall stationed length of the lineloop. Increases in station value are always cascaded down stream with the exception of an extension to the beginning of the lineloop (?).

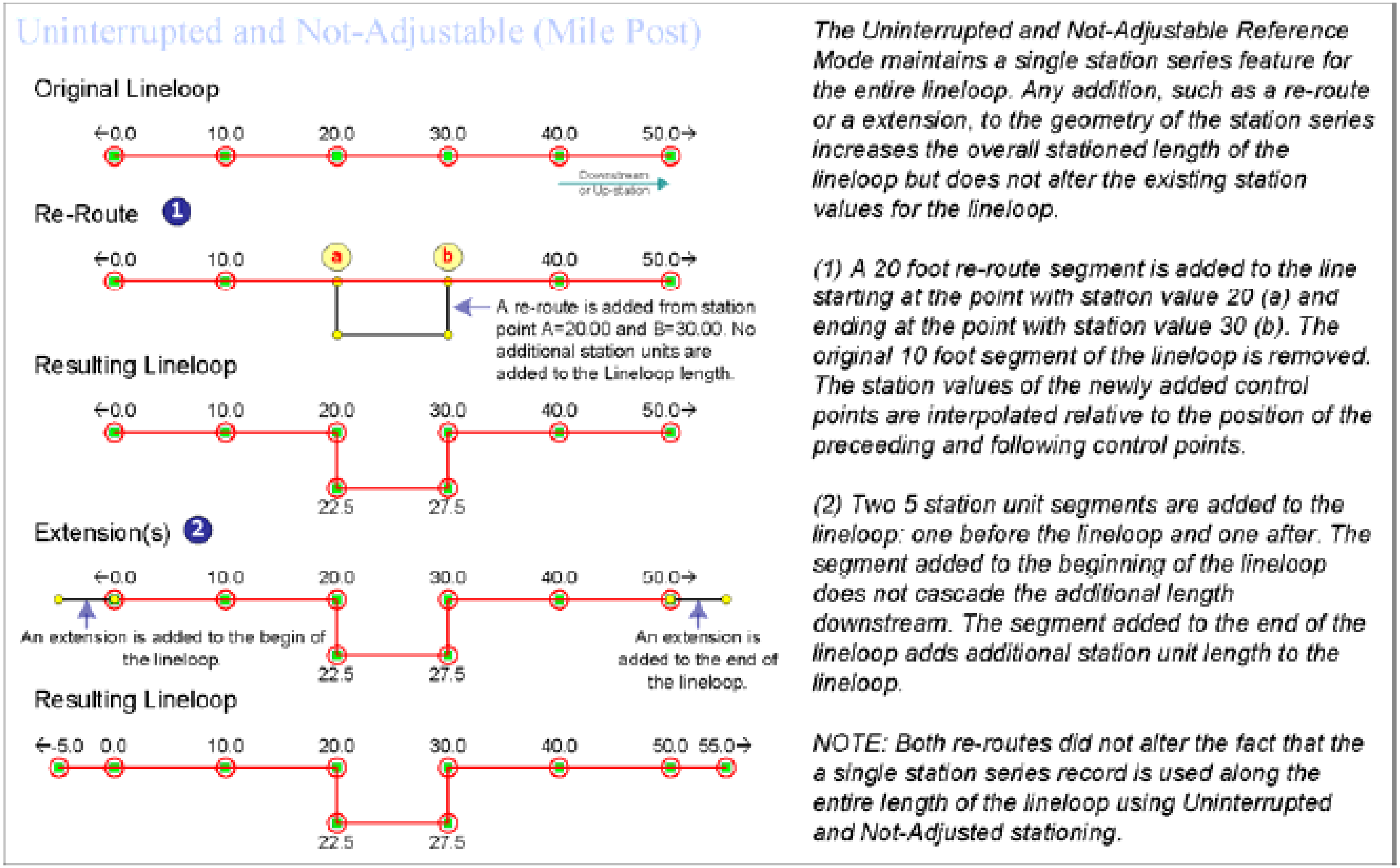
(1) A 20 foot re-route segment is added to the line starting at the point with station value 20 (a) and ending at the point with station value 30 (b). The original 10 foot segment of the lineloop is removed. Since an additional 10 feet were added to the lineloop the overall station value of the downstream (upstation) control points are increased by 10 station units.

(2) Two 5 station unit segments are added to the lineloop: one before the lineloop and one after. The segment added to the beginning of the lineloop does not cascade the additional length downstream. The segment added to the end of the lineloop adds additional station unit length to the lineloop.

NOTE: Both re-routes did not alter the fact that the a single station series record is used along the entire length of the lineloop using Uninterrupted and Adjustable stationing.

Class level Metadata : Reference mode

2)Uninterrupted and Not-adjustable (Mile post)



Uninterrupted and Not-Adjustable (Mile Post)

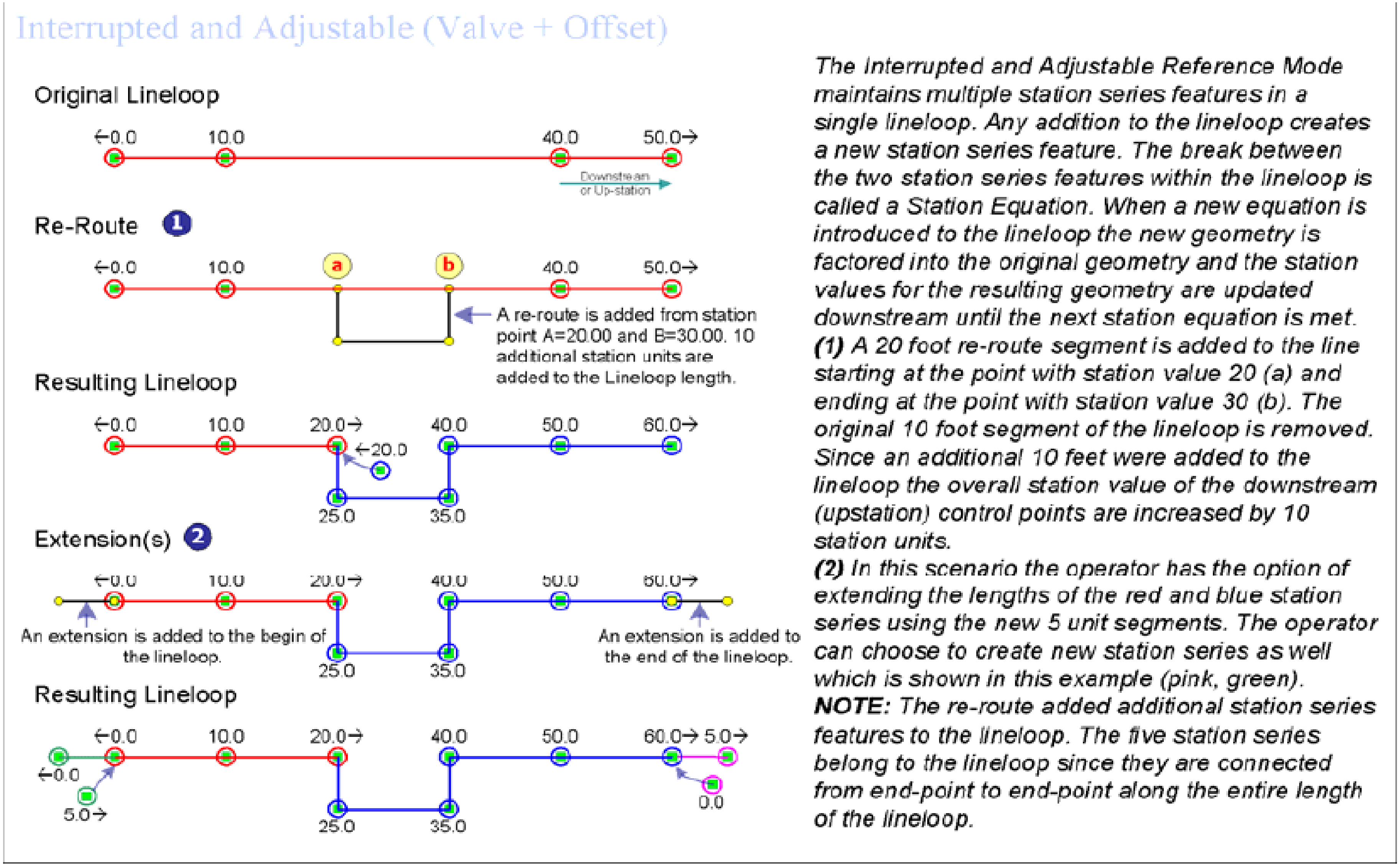
The Uninterrupted and Not-Adjustable Reference Mode maintains a single station series feature for the entire lineloop. Any addition, such as a re-route or a extension, to the geometry of the station series increases the overall stationed length of the lineloop but does not alter the existing station values for the lineloop.

(1) A 20 foot re-route segment is added to the line starting at the point with station value 20 (a) and ending at the point with station value 30 (b). The original 10 foot segment of the lineloop is removed. The station values of the newly added control points are interpolated relative to the position of the preceeding and following control points.

(2) Two 5 station unit segments are added to the lineloop: one before the lineloop and one after. The segment added to the beginning of the lineloop does not cascade the additional length downstream. The segment added to the end of the lineloop adds additional station unit length to the lineloop.

NOTE: Both re-routes did not alter the fact that the a single station series record is used along the entire length of the lineloop using Uninterrupted and Not-Adjusted stationing.

3)interrupted and adjustable (Valve Section (valve + offset)



Interrupted and Adjustable (Valve + Offset)

A re-route is added from station point A=20.00 and B=30.00. 10 additional station units are added to the Lineloop length.

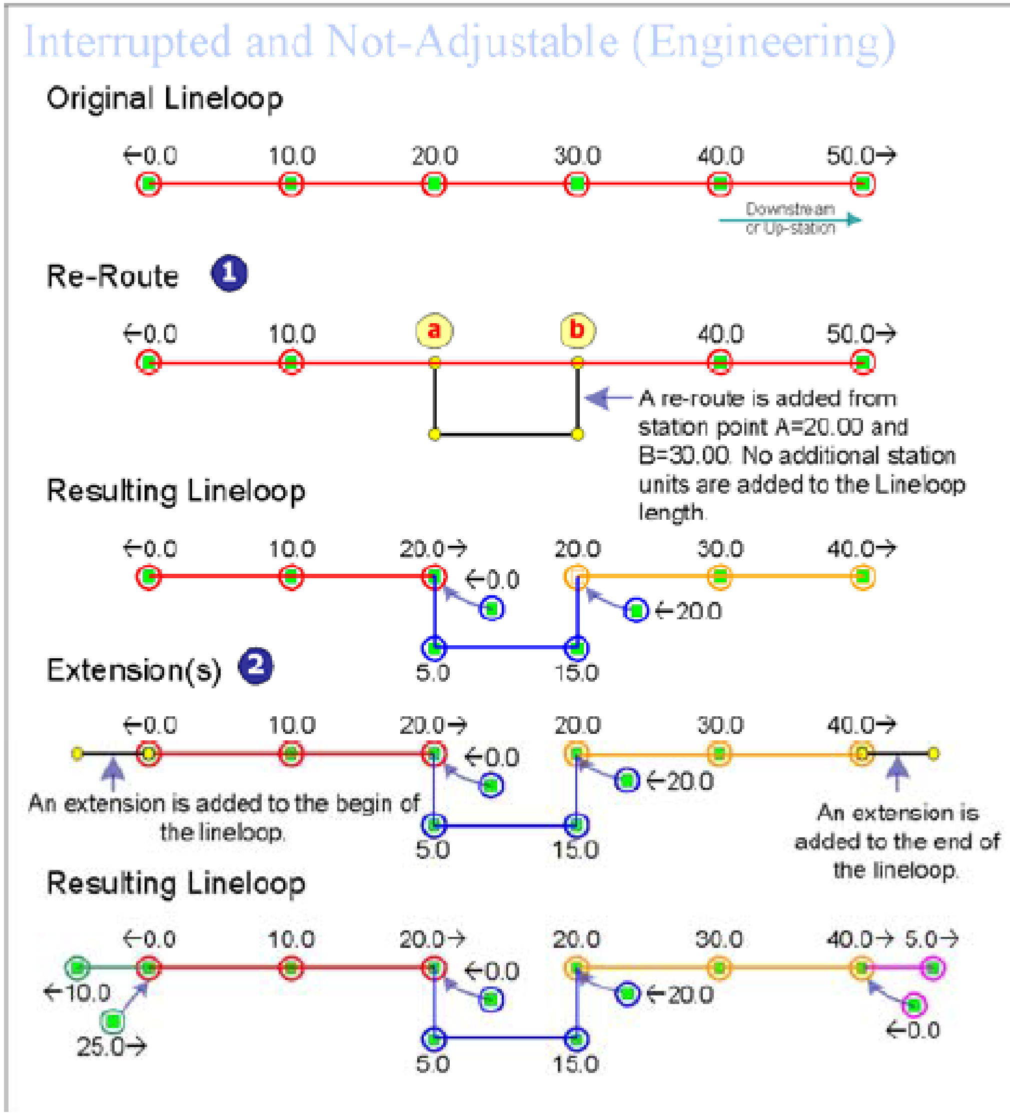
An extension is added to the begin of the lineloop.

An extension is added to the end of the lineloop.

The Interrupted and Adjustable Reference Mode maintains multiple station series features in a single lineloop. Any addition to the lineloop creates a new station series feature. The break between the two station series features within the lineloop is called a Station Equation. When a new equation is introduced to the lineloop the new geometry is factored into the original geometry and the station values for the resulting geometry are updated downstream until the next station equation is met. ***(1)*** *A 20 foot re-route segment is added to the line starting at the point with station value 20 (a) and ending at the point with station value 30 (b). The original 10 foot segment of the lineloop is removed. Since an additional 10 feet were added to the lineloop the overall station value of the downstream (upstation) control points are increased by 10 station units.*

(2) *In this scenario the operator has the option of extending the lengths of the red and blue station series using the new 5 unit segments. The operator can choose to create new station series as well which is shown in this example (pink, green).* ***NOTE:*** *The re-route added additional station series features to the lineloop. The five station series belong to the lineloop since they are connected from end-point to end-point along the entire length of the lineloop.*

4)Interrupted and Not adjustable (Engineering)



A re-route is added from station point A=20.00 and B=30.00. No additional station units are added to the Lineloop length.

An extension is added to the begin of the lineloop.

An extension is added to the end of the lineloop.

The interrupted and Not-Adjustable Reference Mode maintains multiple station series features for a single lineloop. Any addition, such as a re-route or a extension to lineloop creates a new station series feature. The break between the two station series features within the lineloop is called a Station Equation. When a new equation is introduced to the lineloop the new re-route or extension geometry creates a new station series feature.

***(1)** A 20 foot re-route segment is added to the line starting at the point with station value 20 (a) and ending at the point with station value 30 (b). The original 10 foot segment of the lineloop is removed. The station values of the newly added control points are interpolated relative to the position of the preceeding and following control points.*

***(2)** Two 5 station unit segments are added to the lineloop: one before the lineloop and one after. The segment added to the beginning of the lineloop does not cascade the additional length downstream. The segment added to the end of the lineloop adds additional station unit length to the lineloop.*

***NOTE:** The re-route added additional station series features to the lineloop. The five station series belong to the lineloop since they are connected from end-point to end-point along the entire length of the lineloop.*

Class level Metadata : APDM class

- APDM Class: this class stores metadata describing the abstract class type of each object and feature class in the APDM schema. This table will provide a permanent repository for this information.
- APDM class is having relationship with CPonlinelocation, Removedpoint, Removedline of 1:M
- APDM offline class can have multiple online location classes associated with it, an online location class can only be associated with one parent APDM offline class.
- APDM class types: 1)APDM object 2)Centerlineobject 3)NonFacilityObject 4)Centerlinepolyline 5)CenterlinePolylineEvent 6)CenterlinePoint 7)OfflineFeature 8)Offlienepoint 9)OfflineFacility 10) OfflinePointFacility 11)OfflineNonPointFacility 12)OnlineFeature 13)OnlinePolyline 14)OnlinePolylineForOfflieneFeature 15)Onlinepoint 16)OnlinepointforOfflinefeature 17)OnlineFacility 18)OnlinePolylineFacility 19)OnlinepointFacility 20)Fitting 21)Audit

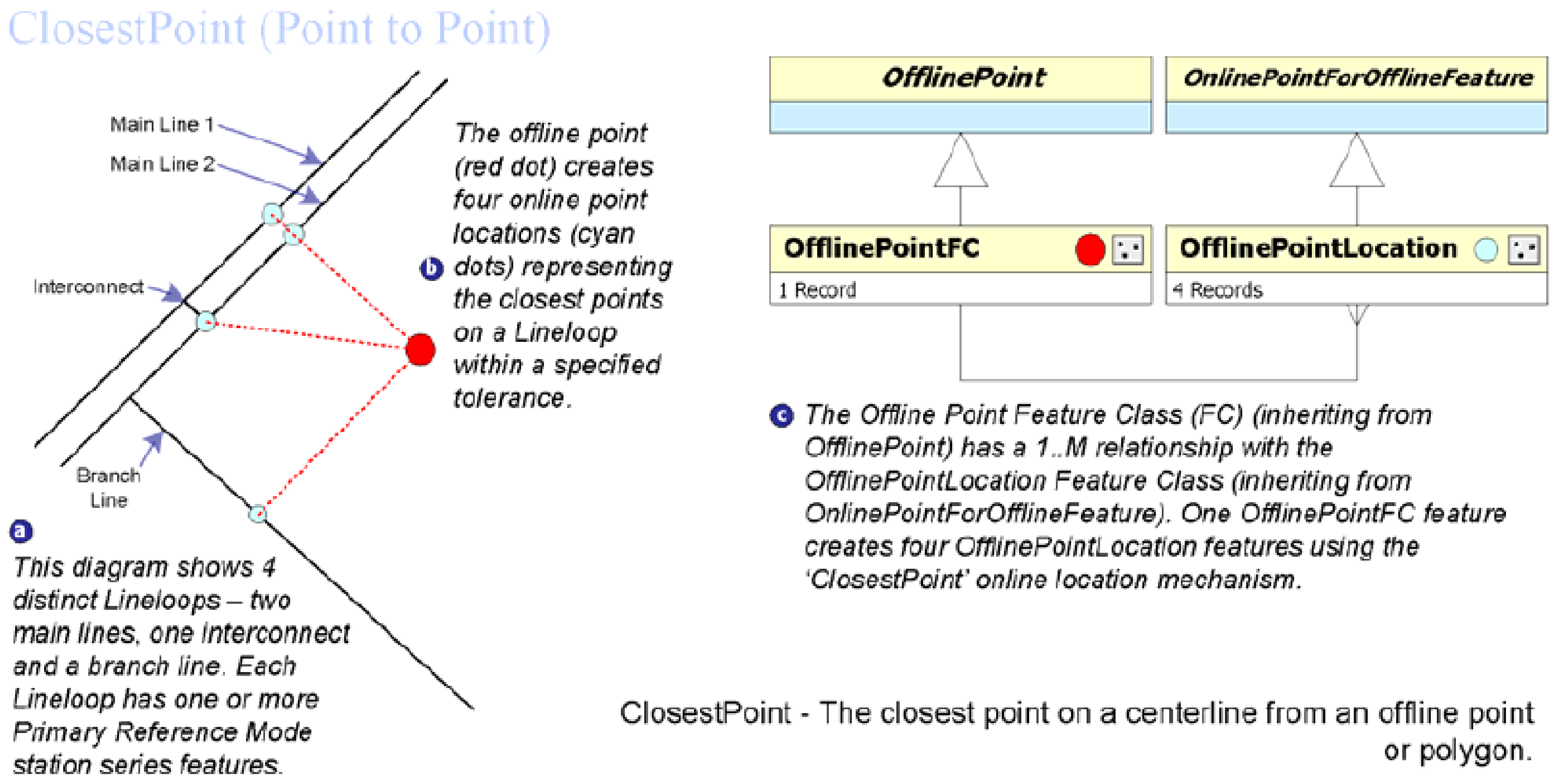
Metadata: OnlinelocationClass

Onlinelocation class stores the class eventid for the offline and online classes involved in an offline and online location relationship. Onlinelocationclass is having relationship with APDMA class origin class. APDM offline class can have multiple online location classes associated with it, an online location classes can only be associated with one parent APDM offline class. The offline class must inherit from the offline feature or offlinefacility or their descendants. The online class must inherit from either the onlinepolylineforofflinefeature or onlinepointforofflinefeature APDM abstract classes. Gnonlinelocationmechanism attribute indicates how the location of the 'online location' feature is derived from the offline feature.

ClosestPoint: the closest point on a centerline from an offline point or polygon

Class level Metadata : onlinelocationmechanism

ClosestPoint: (Point to Point)



ClosestPoint (Point to Point)

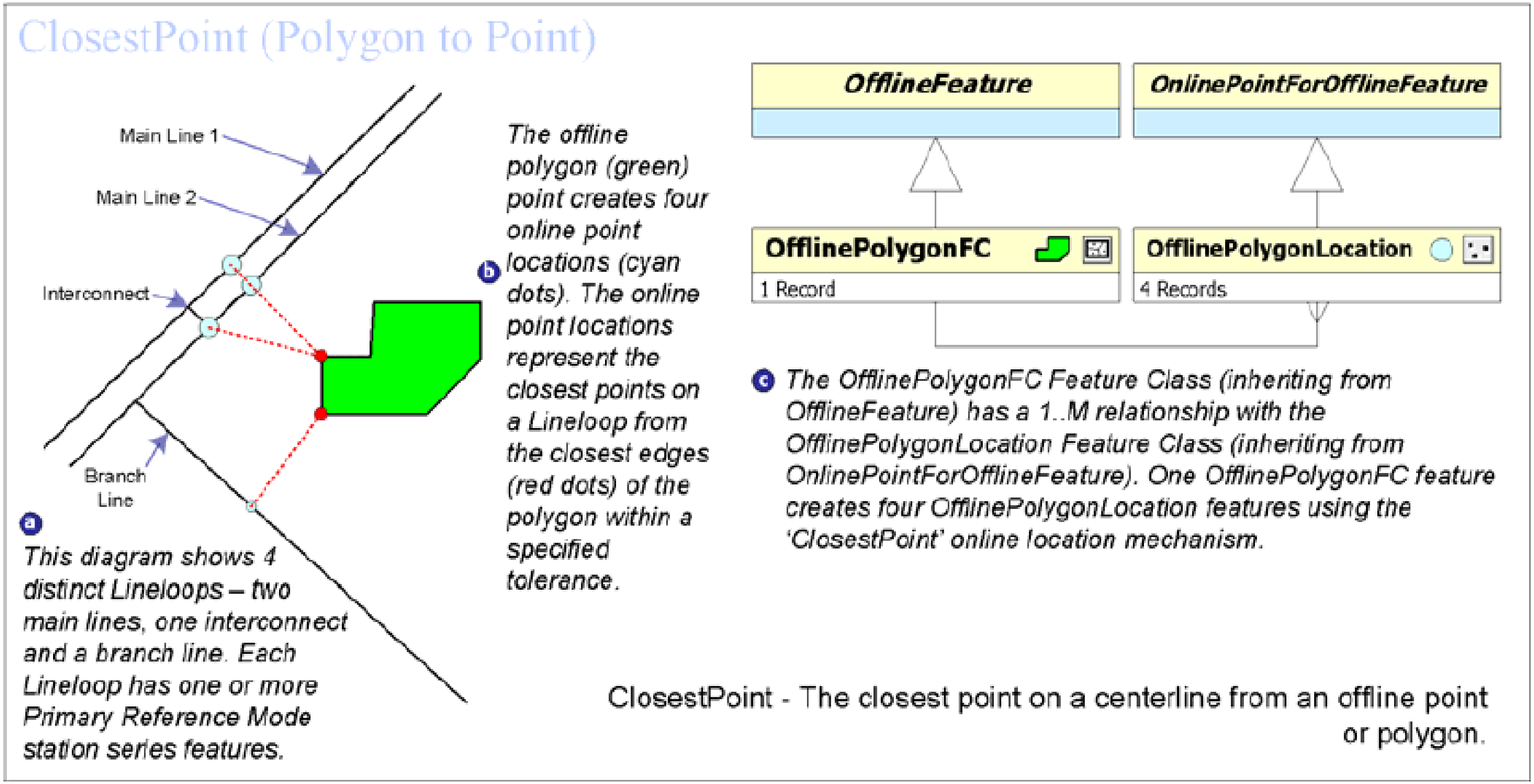
b The offline point (red dot) creates four online point locations (cyan dots) representing the closest points on a Lineloop within a specified tolerance.

a This diagram shows 4 distinct Lineloops – two main lines, one interconnect and a branch line. Each Lineloop has one or more Primary Reference Mode station series features.

c The Offline Point Feature Class (FC) (inheriting from OfflinePoint) has a 1..M relationship with the OfflinePointLocation Feature Class (inheriting from OnlinePointForOfflineFeature). One OfflinePointFC feature creates four OfflinePointLocation features using the 'ClosestPoint' online location mechanism.

ClosestPoint - The closest point on a centerline from an offline point or polygon.

ClosestPoint: (Polygon to Point)



ClosestPoint (Polygon to Point)

a This diagram shows 4 distinct Lineloops – two main lines, one interconnect and a branch line. Each Lineloop has one or more Primary Reference Mode station series features.

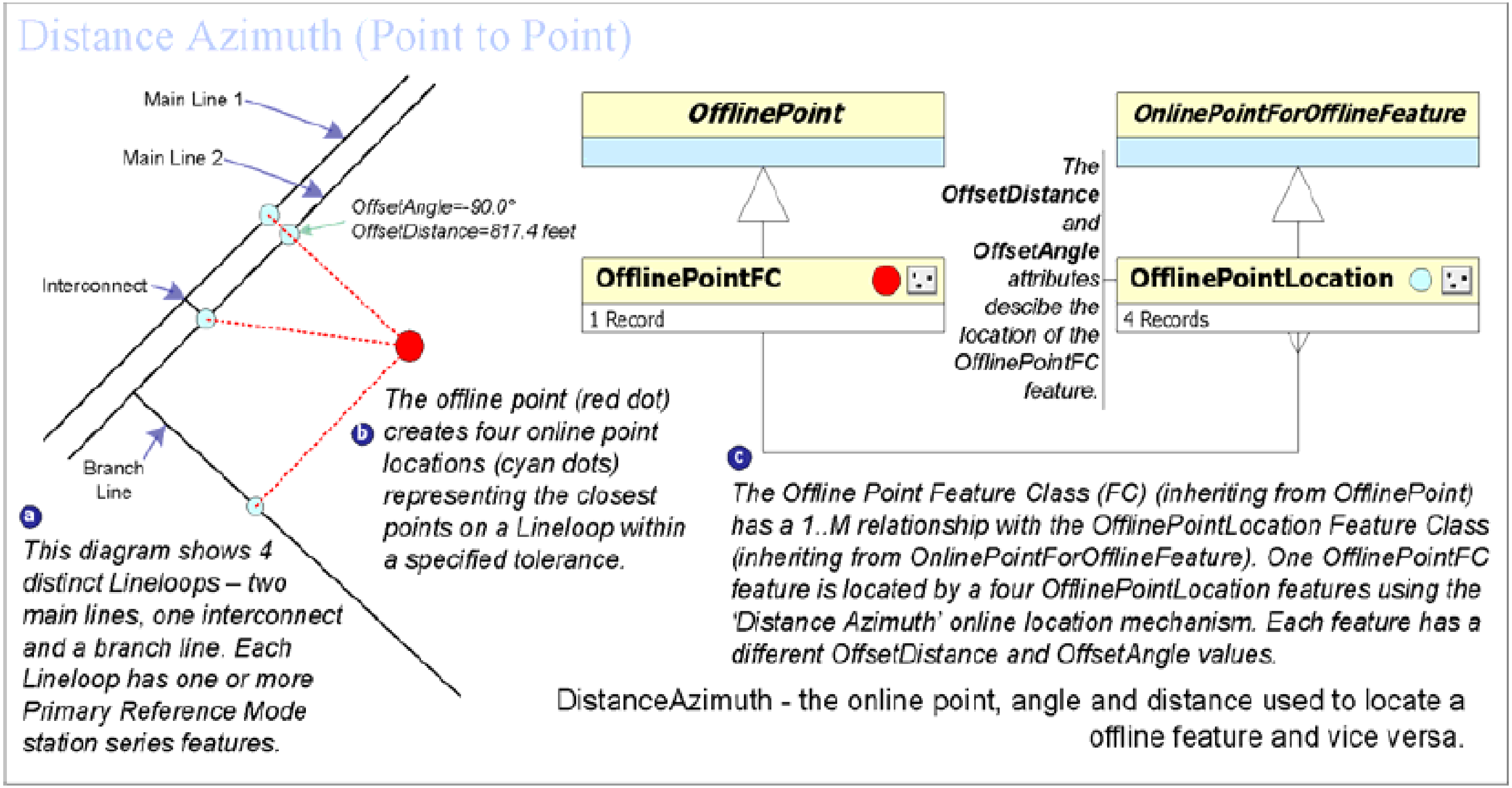
b The offline polygon (green) point creates four online point locations (cyan dots). The online point locations represent the closest points on a Lineloop from the closest edges (red dots) of the polygon within a specified tolerance.

c The OfflinePolygonFC Feature Class (inheriting from OfflineFeature) has a 1..M relationship with the OfflinePolygonLocation Feature Class (inheriting from OnlinePointForOfflineFeature). One OfflinePolygonFC feature creates four OfflinePolygonLocation features using the 'ClosestPoint' online location mechanism.

ClosestPoint - The closest point on a centerline from an offline point or polygon.

Class level Metadata : onlinelocationmechanism

Distance Azimuth: (Point to Point)



Distance Azimuth (Point to Point)

The OffsetDistance and OffsetAngle attributes descibe the location of the OfflinePointFC feature.

a This diagram shows 4 distinct Lineloops – two main lines, one interconnect and a branch line. Each Lineloop has one or more Primary Reference Mode station series features.

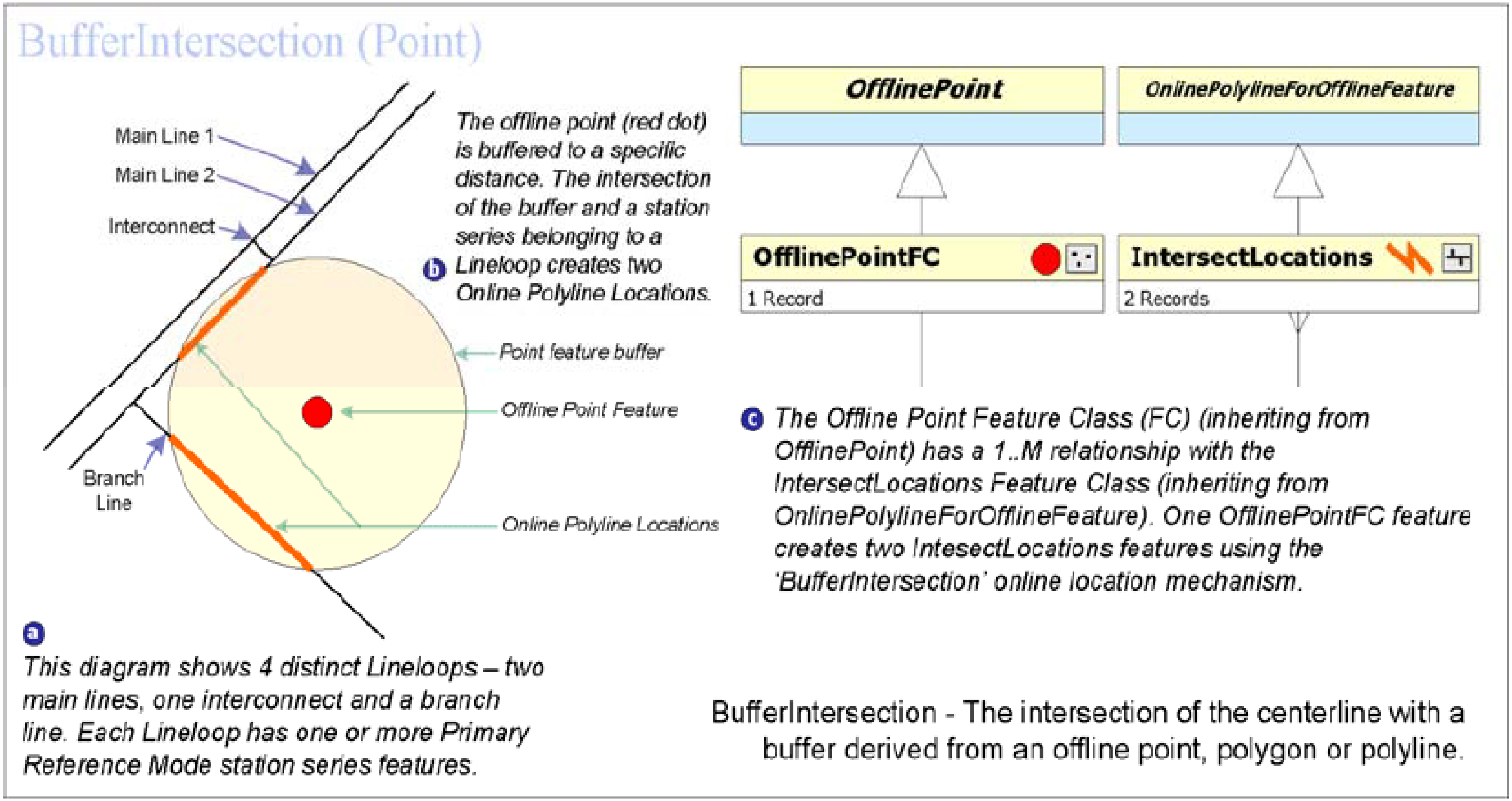
b The offline point (red dot) creates four online point locations (cyan dots) representing the closest points on a Lineloop within a specified tolerance.

c The Offline Point Feature Class (FC) (inheriting from OfflinePoint) has a 1..M relationship with the OfflinePointLocation Feature Class (inheriting from OnlinePointForOfflineFeature). One OfflinePointFC feature is located by a four OfflinePointLocation features using the 'Distance Azimuth' online location mechanism. Each feature has a different OffsetDistance and OffsetAngle values.

DistanceAzimuth - the online point, angle and distance used to locate a offline feature and vice versa.

Class level Metadata : onlinelocationmechanism

Buffer Intersection: (Point)



BufferIntersection (Point)

ⓑ The offline point (red dot) is buffered to a specific distance. The intersection of the buffer and a station series belonging to a Lineloop creates two Online Polyline Locations.

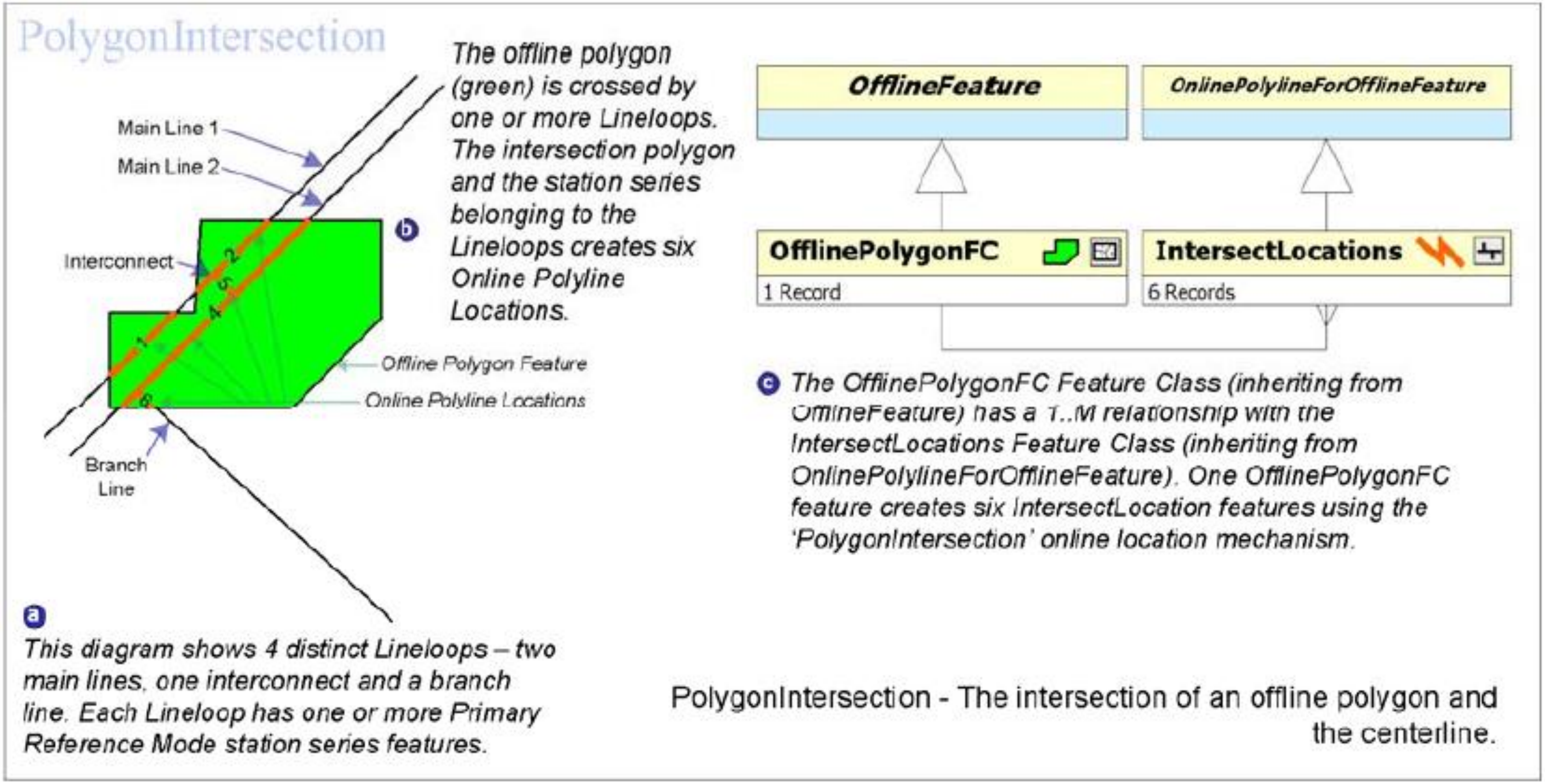
ⓒ The Offline Point Feature Class (FC) (inheriting from OfflinePoint) has a 1..M relationship with the IntersectLocations Feature Class (inheriting from OnlinePolylineForOfflineFeature). One OfflinePointFC feature creates two IntesectLocations features using the 'BufferIntersection' online location mechanism.

ⓐ This diagram shows 4 distinct Lineloops – two main lines, one interconnect and a branch line. Each Lineloop has one or more Primary Reference Mode station series features.

BufferIntersection - The intersection of the centerline with a buffer derived from an offline point, polygon or polyline.

Class level Metadata : onlinelocationmechanism

Polygon Intersection



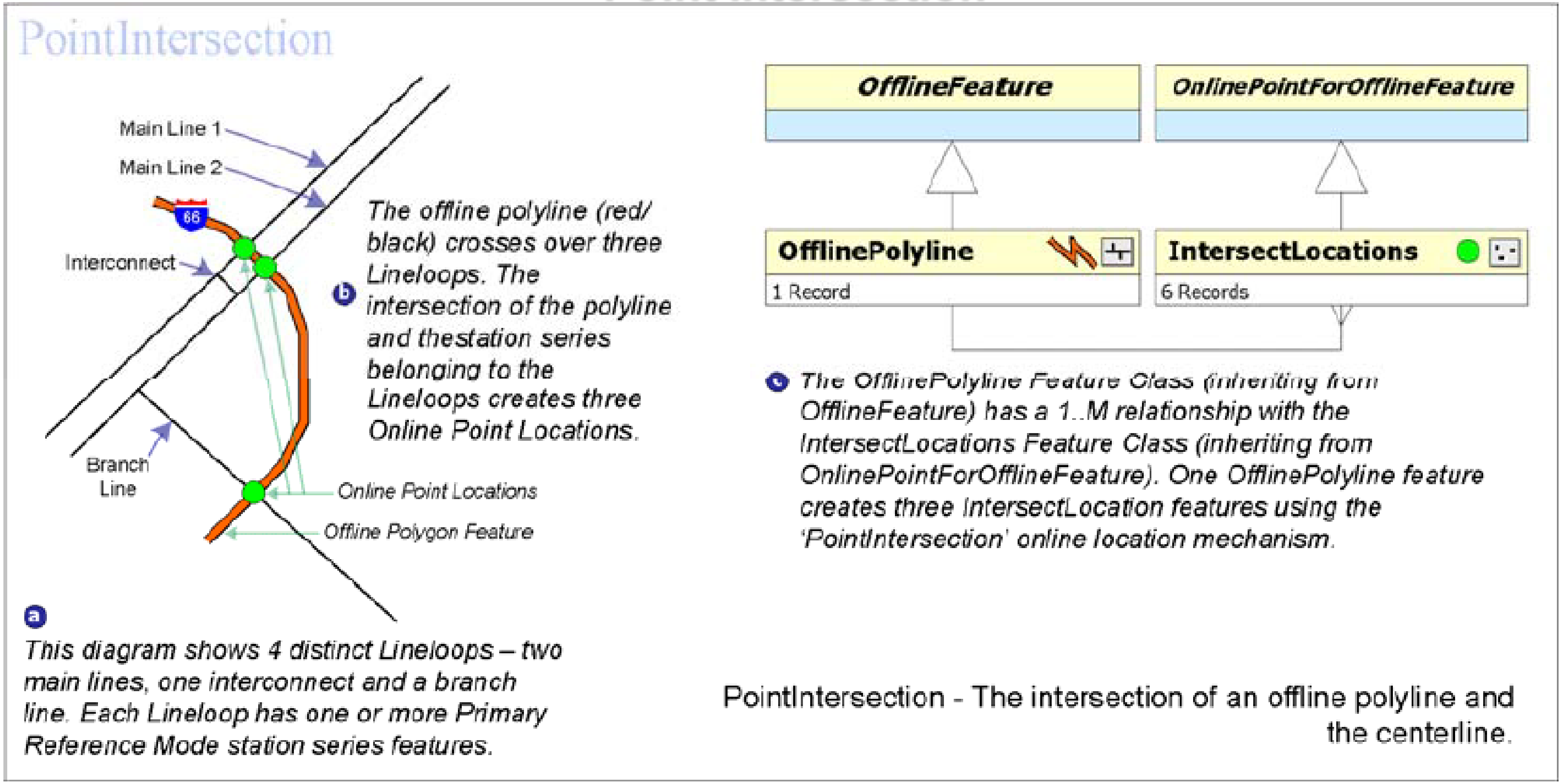
The offline polygon (green) is crossed by one or more Lineloops. The intersection polygon and the station series belonging to the Lineloops creates six Online Polyline Locations.

The OfflinePolygonFC Feature Class (inheriting from OfflineFeature) has a 1..M relationship with the IntersectLocations Feature Class (inheriting from OnlinePolylineForOfflineFeature). One OfflinePolygonFC feature creates six IntersectLocation features using the 'PolygonIntersection' online location mechanism.

This diagram shows 4 distinct Lineloops – two main lines, one interconnect and a branch line. Each Lineloop has one or more Primary Reference Mode station series features.

PolygonIntersection - The intersection of an offline polygon and the centerline.

Point Intersection



PointIntersection

b *The offline polyline (red/ black) crosses over three Lineloops. The intersection of the polyline and thestation series belonging to the Lineloops creates three Online Point Locations.*

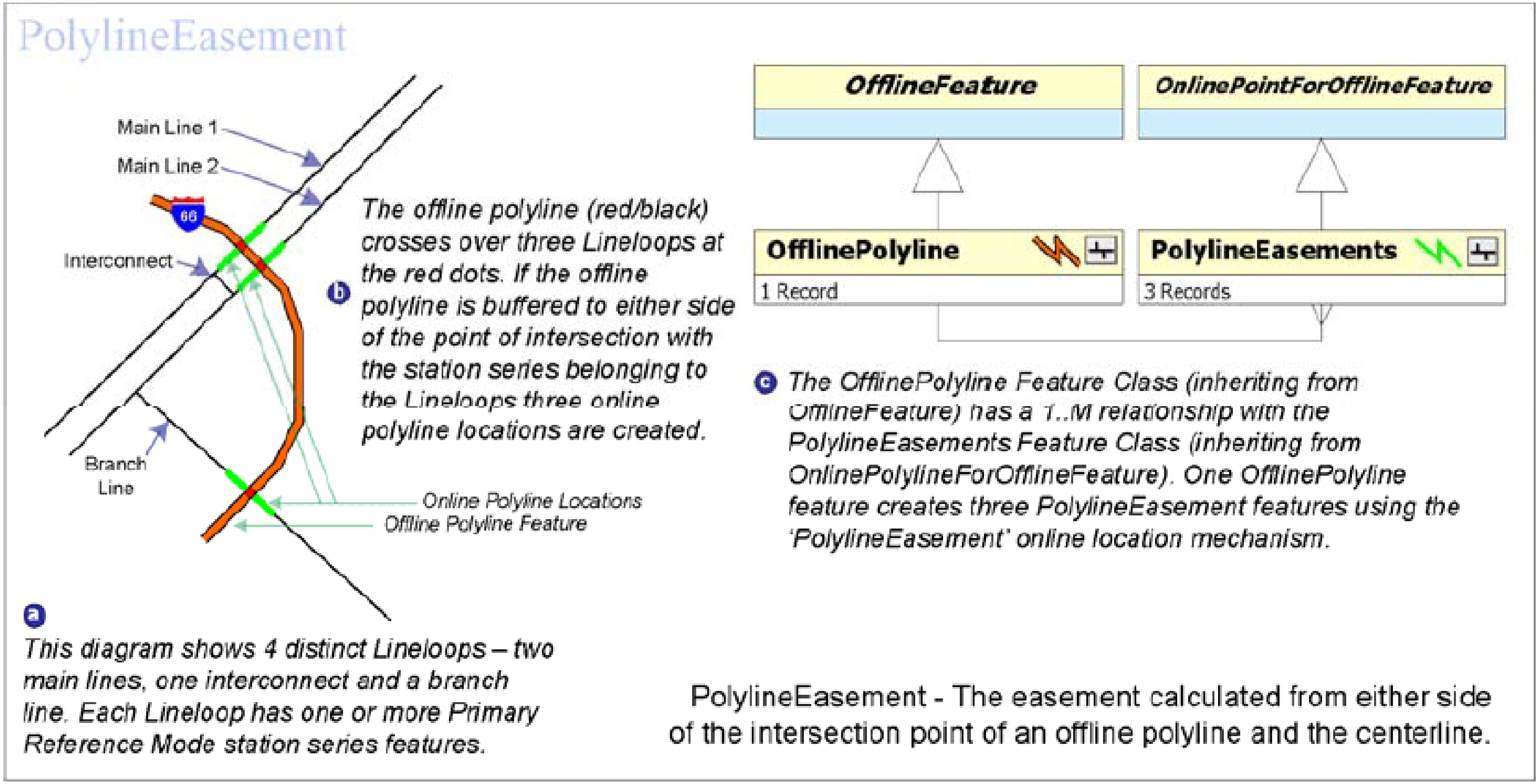
c *The OfflinePolyline Feature Class (inheriting from OfflineFeature) has a 1..M relationship with the IntersectLocations Feature Class (inheriting from OnlinePointForOfflineFeature). One OfflinePolyline feature creates three IntersectLocation features using the 'PointIntersection' online location mechanism.*

a *This diagram shows 4 distinct Lineloops – two main lines, one interconnect and a branch line. Each Lineloop has one or more Primary Reference Mode station series features.*

PointIntersection - The intersection of an offline polyline and the centerline.

Class level Metadata : onlinelocationmechanism

Polyline Easement



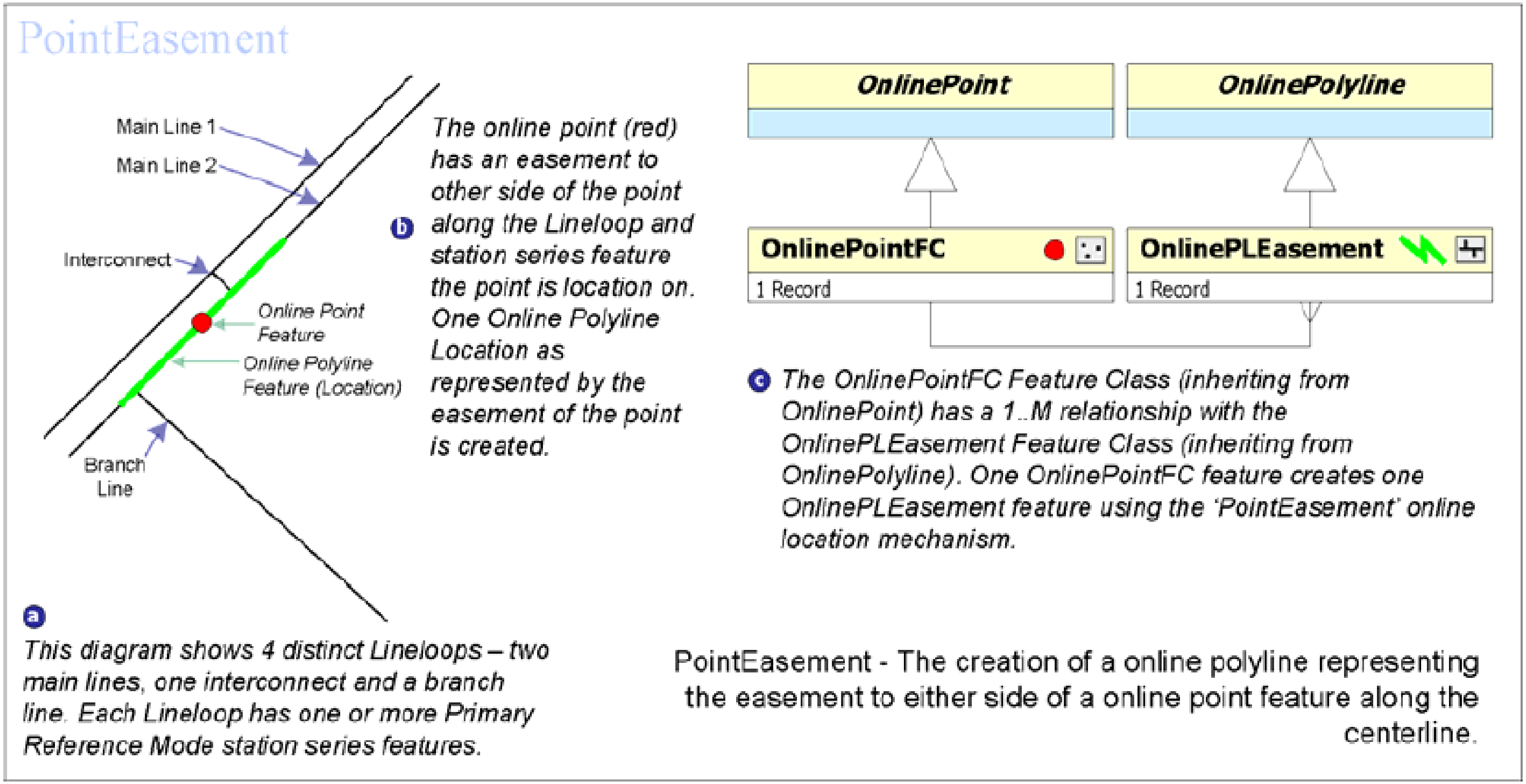
b The offline polyline (red/black) crosses over three Lineloops at the red dots. If the offline polyline is buffered to either side of the point of intersection with the station series belonging to the Lineloops three online polyline locations are created.

c The OfflinePolyline Feature Class (inheriting from OfflineFeature) has a 1..M relationship with the PolylineEasements Feature Class (inheriting from OnlinePolylineForOfflineFeature). One OfflinePolyline feature creates three PolylineEasement features using the 'PolylineEasement' online location mechanism.

a This diagram shows 4 distinct Lineloops – two main lines, one interconnect and a branch line. Each Lineloop has one or more Primary Reference Mode station series features.

PolylineEasement - The easement calculated from either side of the intersection point of an offline polyline and the centerline.

Point Easement



PointEasement

ⓑ The online point (red) has an easement to other side of the point along the Lineloop and station series feature the point is location on. One Online Polyline Location as represented by the easement of the point is created.

ⓒ The OnlinePointFC Feature Class (inheriting from OnlinePoint) has a 1..M relationship with the OnlinePLEasement Feature Class (inheriting from OnlinePolyline). One OnlinePointFC feature creates one OnlinePLEasement feature using the 'PointEasement' online location mechanism.

ⓐ This diagram shows 4 distinct Lineloops – two main lines, one interconnect and a branch line. Each Lineloop has one or more Primary Reference Mode station series features.

PointEasement - The creation of a online polyline representing the easement to either side of a online point feature along the centerline.

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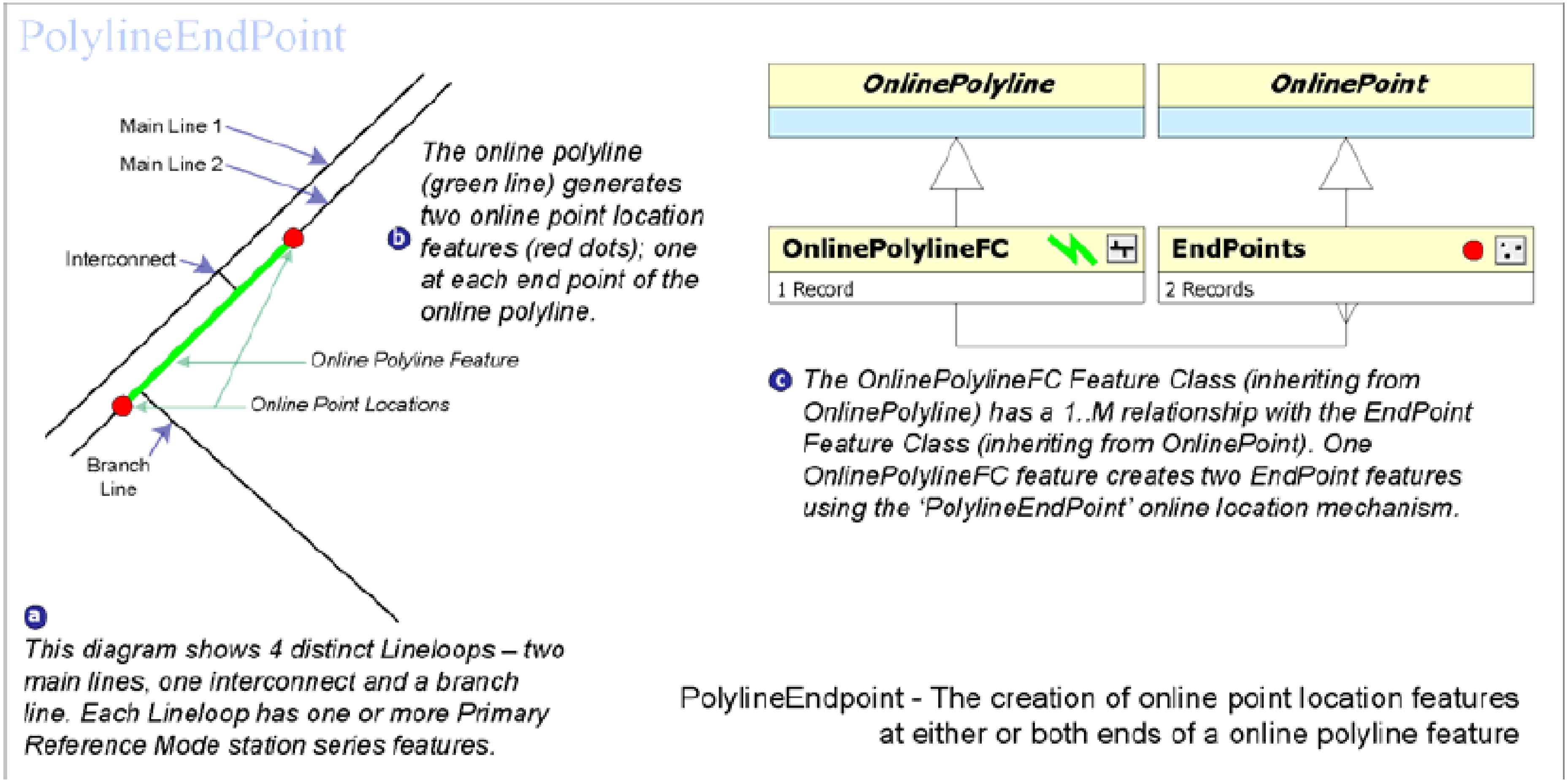
Class level Metadata : onlinelocationmechanism

Polyline End point



PolylineEndPoint

b The online polyline (green line) generates two online point location features (red dots); one at each end point of the online polyline.

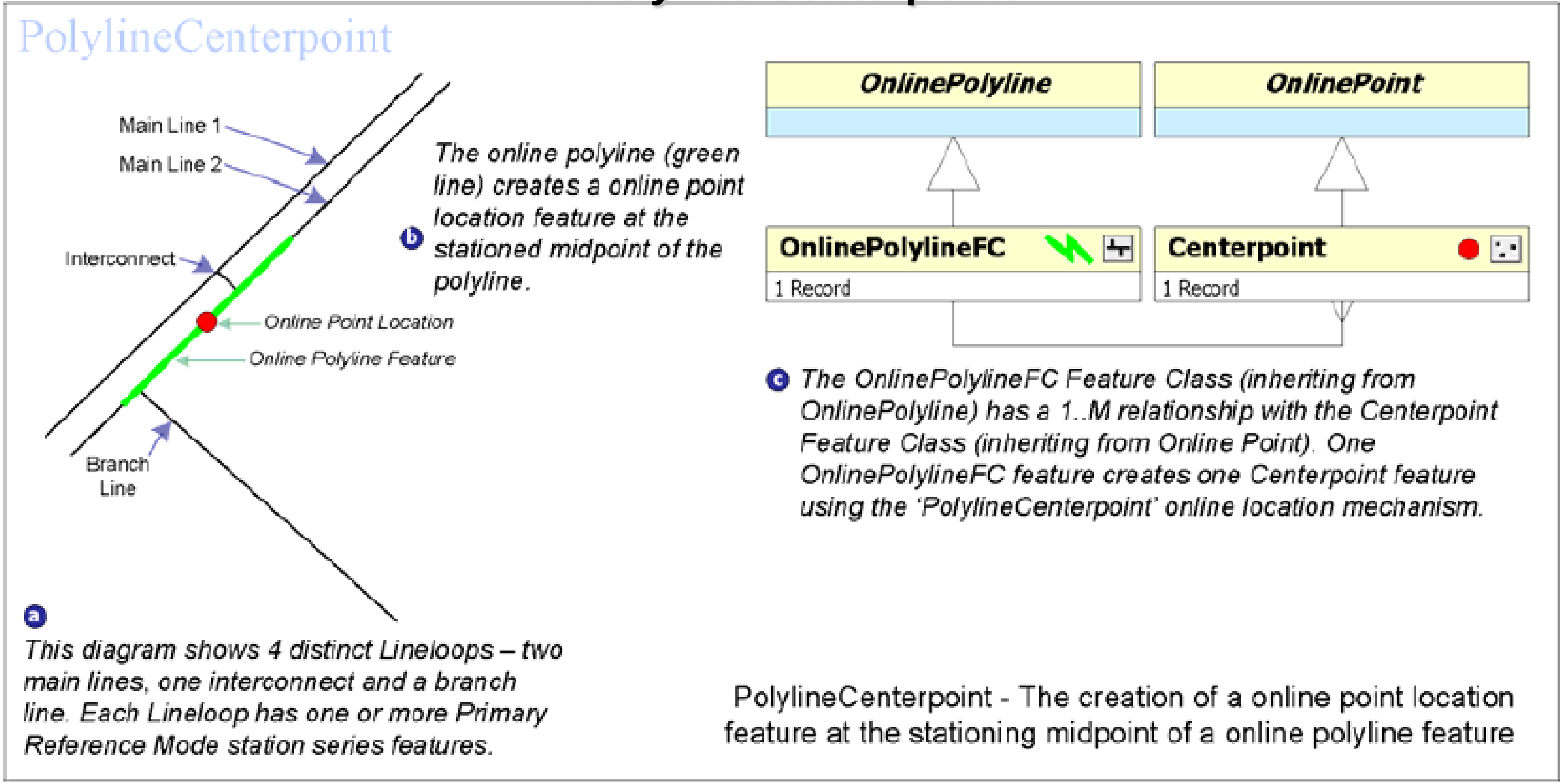
c The OnlinePolylineFC Feature Class (inheriting from OnlinePolyline) has a 1..M relationship with the EndPoint Feature Class (inheriting from OnlinePoint). One OnlinePolylineFC feature creates two EndPoint features using the 'PolylineEndPoint' online location mechanism.

a This diagram shows 4 distinct Lineloops – two main lines, one interconnect and a branch line. Each Lineloop has one or more Primary Reference Mode station series features.

PolylineEndpoint - The creation of online point location features at either or both ends of a online polyline feature

Class level Metadata : onlinelocationmechanism

Polyline Centerpoint



PolylineCenterpoint

b The online polyline (green line) creates a online point location feature at the stationed midpoint of the polyline.

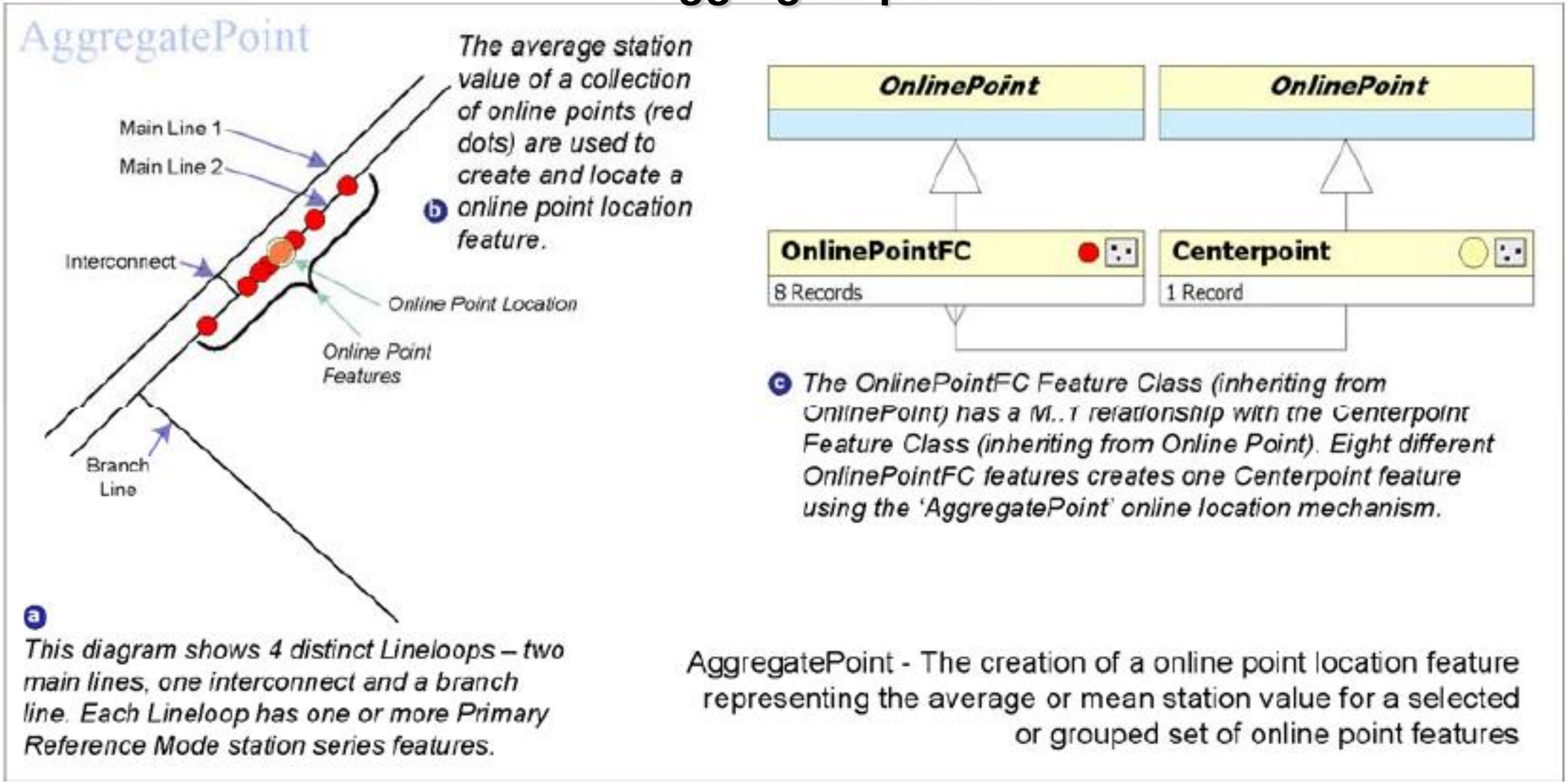
c The OnlinePolylineFC Feature Class (inheriting from OnlinePolyline) has a 1..M relationship with the Centerpoint Feature Class (inheriting from Online Point). One OnlinePolylineFC feature creates one Centerpoint feature using the 'PolylineCenterpoint' online location mechanism.

a This diagram shows 4 distinct Lineloops – two main lines, one interconnect and a branch line. Each Lineloop has one or more Primary Reference Mode station series features.

PolylineCenterpoint - The creation of a online point location feature at the stationing midpoint of a online polyline feature

Class level Metadata : onlinelocationmechanism

Aggregate point



b The average station value of a collection of online points (red dots) are used to create and locate a online point location feature.

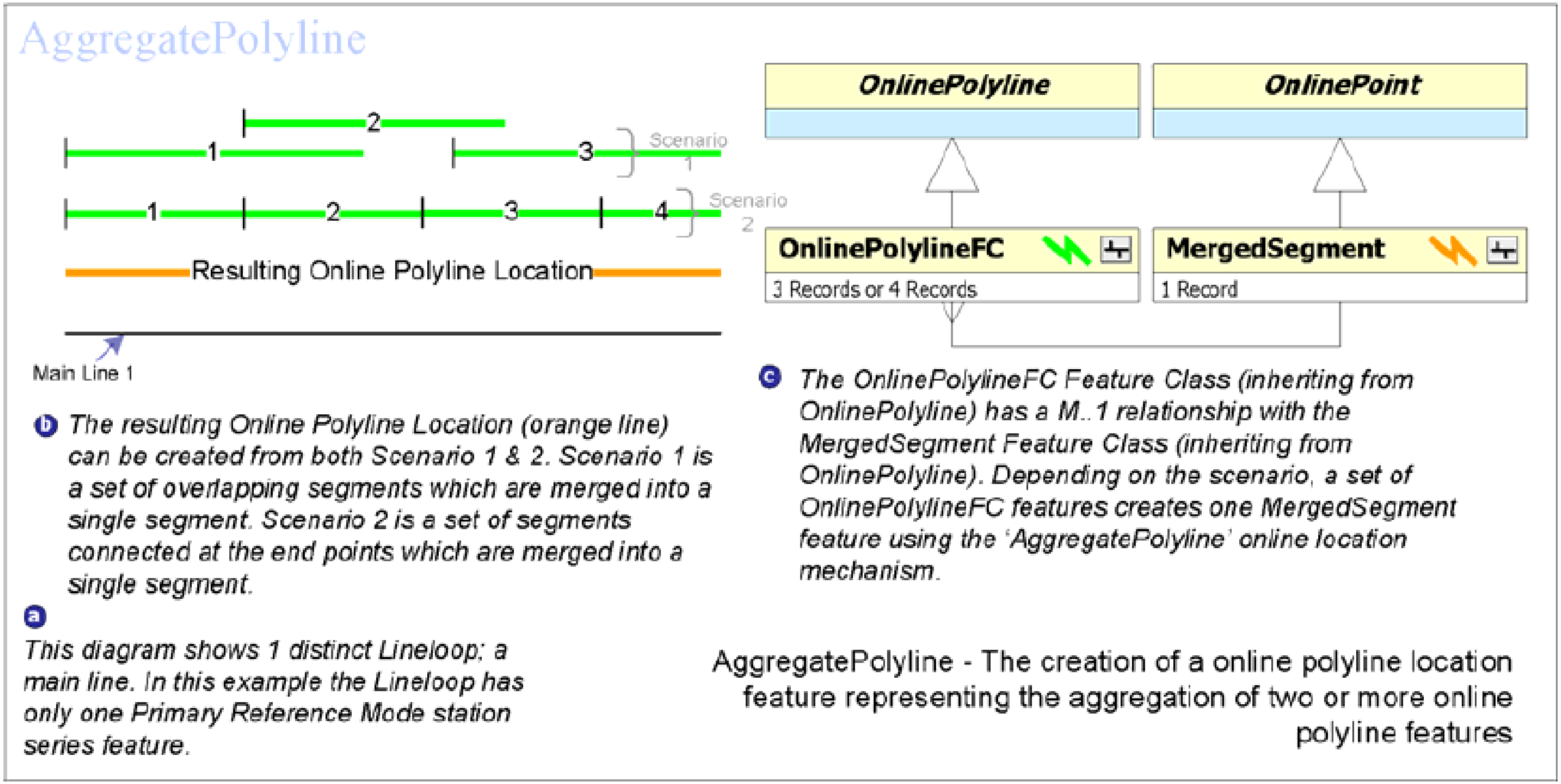
c The OnlinePointFC Feature Class (inheriting from OnlinePoint) has a M..1 relationship with the Centerpoint Feature Class (inheriting from Online Point). Eight different OnlinePointFC features creates one Centerpoint feature using the 'AggregatePoint' online location mechanism.

a This diagram shows 4 distinct Lineloops – two main lines, one interconnect and a branch line. Each Lineloop has one or more Primary Reference Mode station series features.

AggregatePoint - The creation of a online point location feature representing the average or mean station value for a selected or grouped set of online point features

Class level Metadata: onlinelocationmechanism

Aggregate polyline



AggregatePolyline

b *The resulting Online Polyline Location (orange line) can be created from both Scenario 1 & 2. Scenario 1 is a set of overlapping segments which are merged into a single segment. Scenario 2 is a set of segments connected at the end points which are merged into a single segment.*

a *This diagram shows 1 distinct Lineloop; a main line. In this example the Lineloop has only one Primary Reference Mode station series feature.*

c *The OnlinePolylineFC Feature Class (inheriting from OnlinePolyline) has a M..1 relationship with the MergedSegment Feature Class (inheriting from OnlinePolyline). Depending on the scenario, a set of OnlinePolylineFC features creates one MergedSegment feature using the 'AggregatePolyline' online location mechanism.*

AggregatePolyline - The creation of a online polyline location feature representing the aggregation of two or more online polyline features

Feature level Metadata attributes: Online events

Featurelevel-Metadata: stores information that defines the behaviour of individual features within a feature class. Because feature-level metadata affects individual features, these metadata elements can be stored with the features themselves.

1)Online event feature-level metadata attributes 2)Controlpoint feature-level metadata attributes

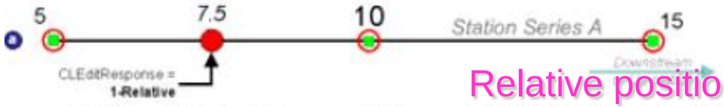
1) **Online Events:** two feature-level metadata attributes define the behaviour of online event features during the centerline edits: a)CLEditResponse b)CLValidityTolerence

1.a) CLEditResponse: describes how the location of a stationed feature responds to a centerline edit. It contains coded values that determine how the position of an online feature is calculated in response to a centerline edit that changes the shape of centerline or alters the station values of Controlpoint features in the vicinity of the affected feature.

1.a.1) Relative:

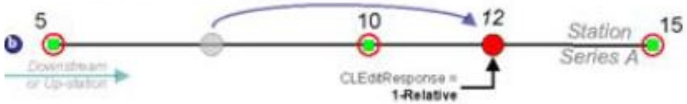
Feature level Metadata attributes: Online events

The location of a OnlineFeature is determined solely by station value (point) and station values (polyline). If the centerline moves (one or more control points comprising the underlying PRM station series coordinate position is altered), the event moves with it. If station values on the nearest surrounding ControlPoint feature(s) are altered, the position of the event slides up or down the centerline relative to the start of the station series and surrounding control points accordingly. OnlineFeatures are essentially events where the only source data for positioning is stationing. This kind of positional behavior is the default for OnlineFeatures.

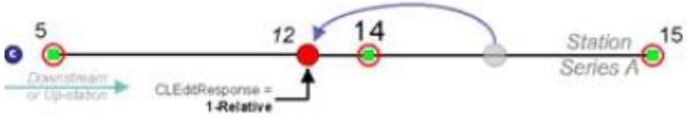


Relative position

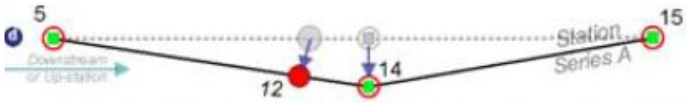
a – Three control points are located on a single PRM station series (A). A single point OnlineFeature with a CLEditResponse = 1 is located at station value 7.5 which places it ½ way between the control points with station value 5 and 10 respectively.



b – Changing the station value of the OnlineFeature point from 7.5 to 12 moves the point down the centerline. The new position of the OnlineFeature point will be interpolated in between the middle and right-most control points.



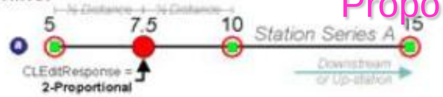
c – Changing the station value of the middle ControlPoint from 10 to 14 will cause the OnlineFeature point to move back up the centerline. The new position of the OnlineFeature point will be interpolated in between the left-most and middle control points.



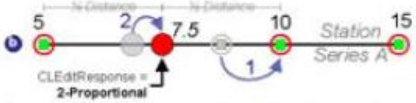
d – Changing the coordinates of the middle control point will change the coordinate location of all OnlineFeatures located in between the control points to either side although they will retain their relative position.

The location of an OnlineFeature must fall on the centerline, but its position is determined by its proportional distances from the nearest surrounding ControlPoint features. If the position of either ControlPoint changes the centerline then the OnlineFeature moves with it. The OnlineFeature's proportional distances from the nearest surrounding ControlPoint features remain constant. If the station value(s) of the nearest surrounding ControlPoint features change, the station value(s) of the OnlineFeature changes accordingly, but its proportional distances from the nearest surrounding ControlPoint features remain constant. One use for 'Proportional' OnlineFeatures is when data is captured from originally non-stationed systems, or from systems where stationing was unclear or missing on source documents. Properly setting ControlPoint station values may require extensive adjustment. Setting OnlineFeatures to 'Proportional' will keep them in position without sliding up and down the centerline as ControlPoint station values are altered. If the ControlPoint coordinate positions change then the 'Proportional' features will move in unison with the centerline.

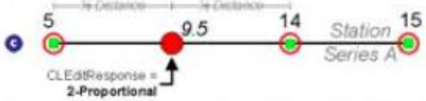
Proportional position



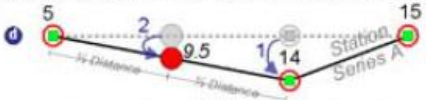
a – Three control points are located on a single PRM station series (A). A single point OnlineFeature with a CLEditResponse = 2 is located at station value 7.5 which places it ½ way between the control points with station value 5 and 10 respectively.



b – The position of the middle control point is shifted downstream (1). The position of the OnlineFeature point is shifted (2) so that it maintains it's geometric distance of ½ between control point 5 and 10.



c – The station value of the middle control point is updated from 10 to 14. The coordinate position of the OnlineFeature point is maintained but the station value of the point is re-calculated to ½ of the station value between that of control point 5 and 14 = 9.5

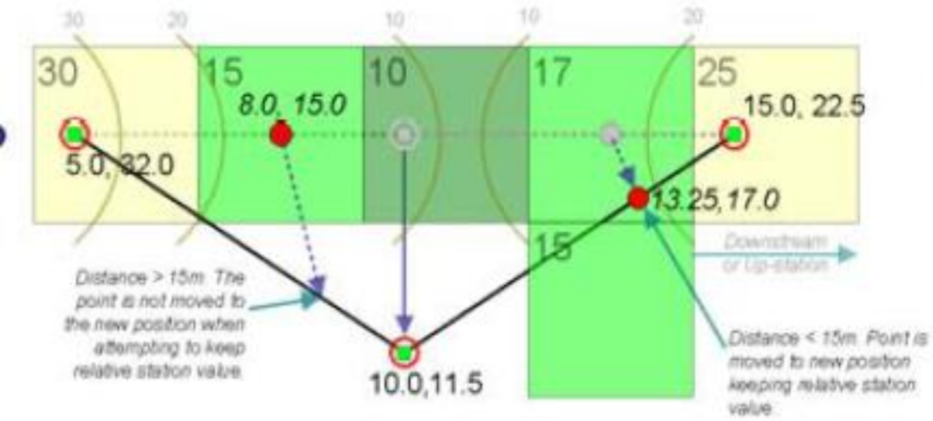


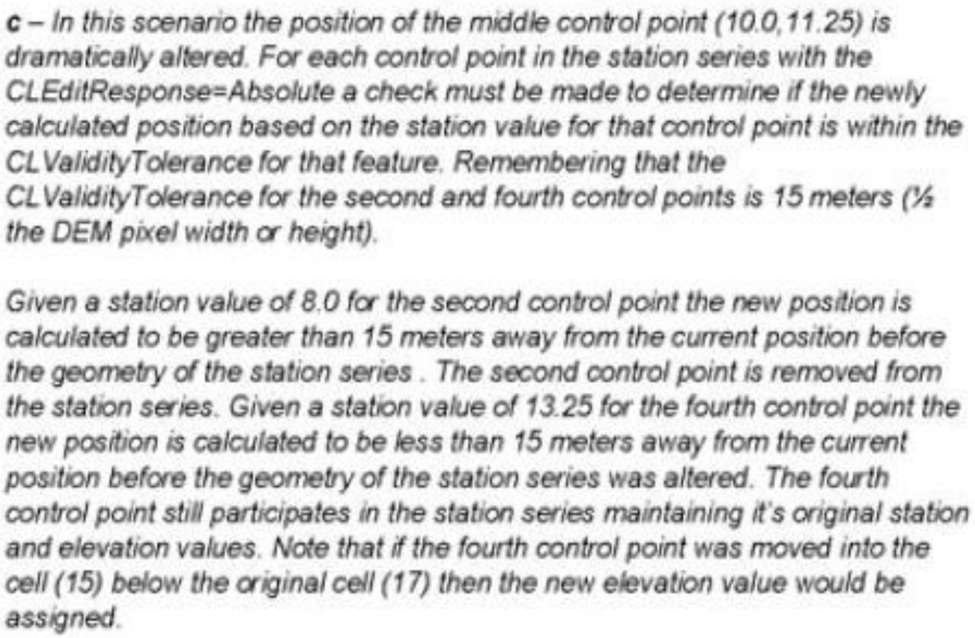
d – Changing the coordinates of the middle control point will change the coordinate location of all 'Proportional' OnlineFeatures located in between the control points to either side although they will retain their proportional position.

Feature level Metadata attributes: Online events

Absolute: The location of an event is determined solely by its X/Y position. If the centerline moves, the event location remains unchanged, even if that means the event no longer falls on the centerline.

CLValidityTolerance


30
20
10
10
20
30
15
10
17
25
15
8.0, 15.0
15.0, 22.5
5.0, 32.0
13.25,17.0
10.0,11.5
Downstream or Up-station
Distance > 15m. The point is not moved to the new position when attempting to keep relative station value.
Distance < 15m. Point is moved to new position keeping relative station value.



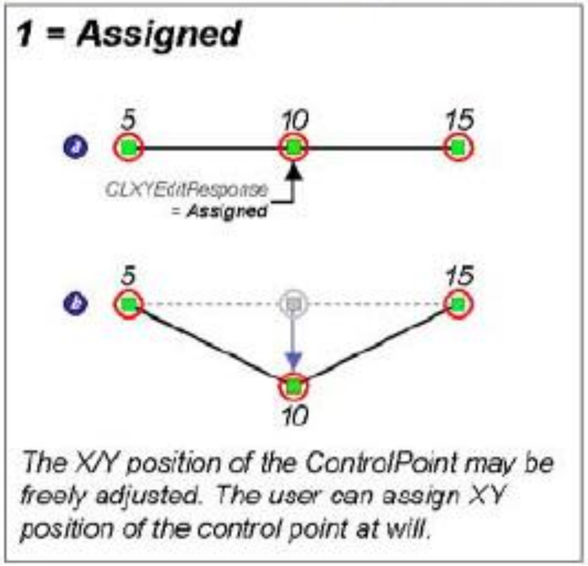
c – *In this scenario the position of the middle control point (10.0,11.25) is dramatically altered. For each control point in the station series with the CLEditResponse=Absolute a check must be made to determine if the newly calculated position based on the station value for that control point is within the CLValidityTolerance for that feature. Remembering that the CLValidityTolerance for the second and fourth control points is 15 meters (½ the DEM pixel width or height).*

Given a station value of 8.0 for the second control point the new position is calculated to be greater than 15 meters away from the current position before the geometry of the station series . The second control point is removed from the station series. Given a station value of 13.25 for the fourth control point the new position is calculated to be less than 15 meters away from the current position before the geometry of the station series was altered. The fourth control point still participates in the station series maintaining it's original station and elevation values. Note that if the fourth control point was moved into the cell (15) below the original cell (17) then the new elevation value would be assigned.

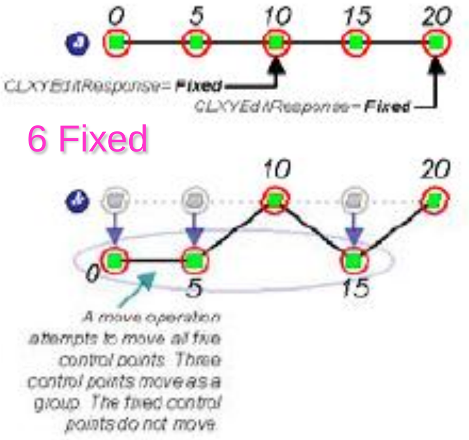
CLXYEditResponse

ControlPoint :Feature level Metadata attributes

- ➢There are four attributes: 1)CLXYEditResponse 2)CLStationEditResponse 3)CLZEditResponse 4)CLControl. These attributes are defined in the CenterlinePoint APDM Abstract class.
- ➢The controlPoint metadata attributes come into play during centerline edit operations that change the locations or station values of ControlPoint features.
- ➢Reroute behavior is governed by class-level reference mode.
- ➢The behaviour of online features during centerline edit operations is governed according to their CLEditResponse codes and CLValidity Tolerance values.
- ➢Fixed distance and fixed deflection may be thought of as less restrictive subsets of fixed geometry. These may both be applied to individual control points.
- ➢Fixed geometry must be applied to two or more contiguous control points.
- ➢The above two properties are useful for adjusting as-built survey traverse.
- ➢Ex: a user can stretch a traverse in such a way that all deflection angles are preserved, but the distances between control points are increased and wise versa.



The X/Y position of the ControlPoint may be freely adjusted. The user can assign XY position of the control point at will.



6 Fixed

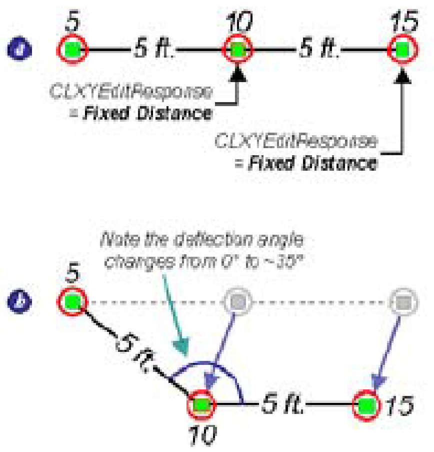
A move operation attempts to move all five control points. Three control points move as a group. The fixed control points do not move.

The X/Y position of the control point is fixed and cannot be altered. "Fixed" can be applied to a single control point if desired.

CLXYEditResponse

ControlPoint :Feature level Metadata attributes

2 = Fixed Distance

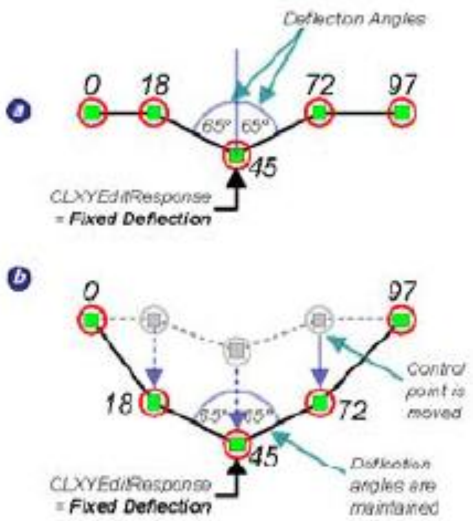


For Fixed Distance, a control point can be moved, but the distances to the surrounding control points must held constant. The deflection angle at the control point in question can vary, though. Fixed Distance can be applied to a single control point or a group of two or more adjacent control points.

a - The two right-most control points have 'fixed distances' to their neighbors.

b - Moving the middle control point forces the move of the right control point.

3 Fixed Deflection

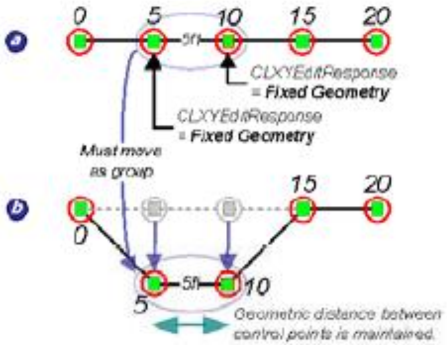


With Fixed Deflection, a control point can be moved, but the deflection angle at the control point relative to surrounding control points must remain constant. Fixed deflection allows the preceding and following control points to be translated in or out (in terms of distance from the Fixed Deflection control point). Fixed Deflection can be applied to a single ControlPoint or a group of two or more adjacent ControlPoints.

a – The middle control point (45) is fixed at a 65 angle to the proceeding (18) and following (72) control points.

b – The following control point (72) is moved causing the middle (45) and proceeding (18) control points to likewise shift position in order to maintain the 65 degree angle between control points 18-45 and 45-72.

4 = Fixed Geometry



'Fixed Geometry' allows a group of adjacent control points to be treated as a single unit for X/Y translations. The 'Fixed Geometry' control point can be moved, but only as a unit with the surrounding control point features.

a - The control point belongs to a segment of the centerline with a fixed shape; the segment can be moved, but the segment's shape is constant. "Fixed Geometry" must be applied to two or more adjacent control point features to be meaningful.

b – When either control point 5 or 10 are moved the other 'Fixed Geometry' control point must likewise translate. The geometric distance between the control points remains equidistant before and after the move.

Note: Fixed geometry is used for data retrieved from old as-built drawings where the position of control points relative to each other is well known, although the absolute location may not be.

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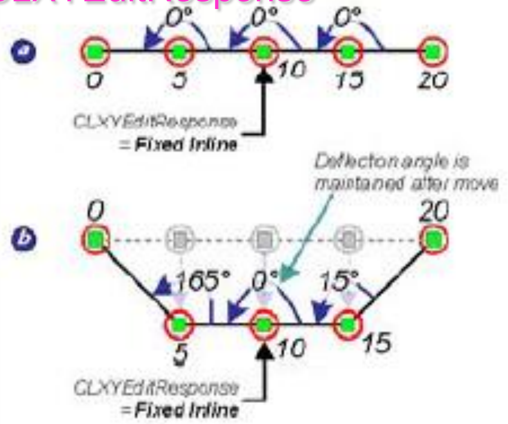
CLStationEditResponse

ControlPoint :Feature level Metadata attributes

5 = Fixed Inline

CLXYEditResponse



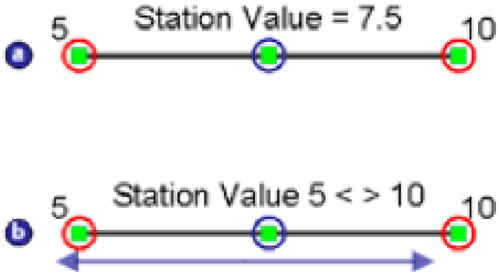
The 'Fixed Inline' control point can be moved, but it must always be inline with surrounding control points.

a - The deflection angle between control points 5-10-15 must remain 0° to either side of the fixed inline control point (10) since the veracity of it's coordinate position has been determined by GPS. "Fixed Inline" is a special case of "Fixed Deflection" where the deflection angle must be 0°.

b – Moving the middle control point (10) forces the move of the preceding (5) and following (15) control points.

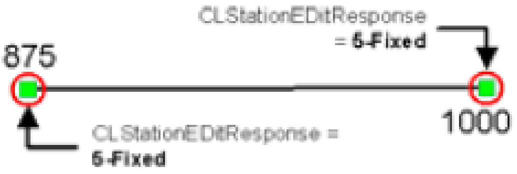
Note: Fixed Inline addresses the concern regarding maintaining a control point at a spot that has been located precisely by a GPS and is surrounded by control points representing P.I.s (Points of Inflection).

1 = Assigned



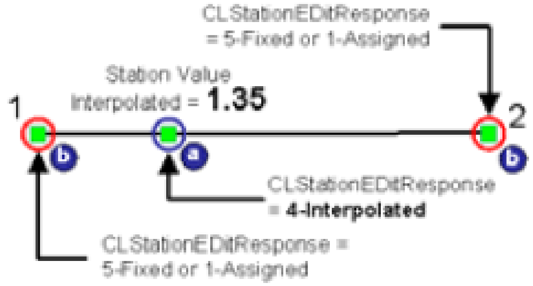
a – The station value for the control point may be freely adjusted within the station range of the surrounding control points. The station value of the control point in example (**a**) located at 7.5 can be altered to any value greater than 5 and less than 10 (the station value of the proceeding and following control points)

5 = Fixed



The station value for the control point is fixed and may not be altered. This is the most common and default value for the control point CLStationEditResponse attribute.

4 = Interpolated



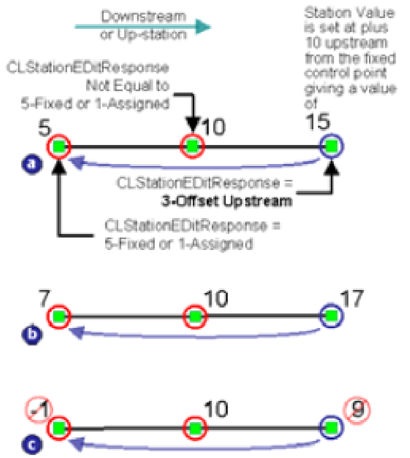
The station value for the control point (**a**) is interpolated linearly between surrounding control points that have CLStationEditResponse set to 'Fixed' or 'Assigned'. For example, in a milepost style of reference mode, the value of "Interpolated" would be applied to an intermediate (**a**) control point situated between control points associated with actual mileposts (**b**).

EcoNomics

CLStationEditResponse

ControlPoint :Feature level Metadata attributes

3 = Offset Upstream


Downstream or Up-station
Station Value is set at plus 10 upstream from the fixed control point giving a value of
CLStationEDitResponse Not Equal to 5-Fixed or 1-Assigned
5
10
15
a
CLStationEDitResponse = 3-Offset Upstream
CLStationEDitResponse = 5-Fixed or 1-Assigned
7
10
17
b
1
10
9
c

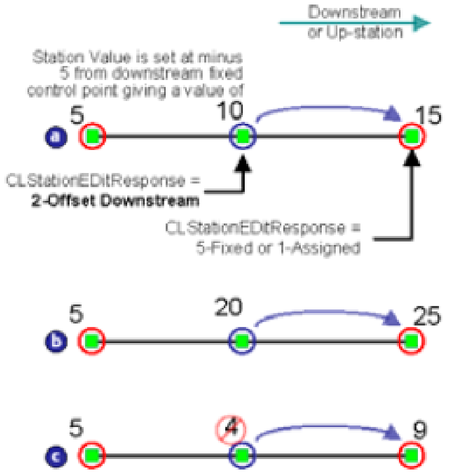
Offset upstream is exactly the same as Offset downstream except the direction of the offset is different. The following example shows the offset skipping an intermediate control point.

***a** - The station value of the right-most control point is set relative and constant to the closest upstream (down station) control point that has has a CLStationEditResponse of either 'Fixed' or 'Assigned' (in this case the left-most control point).*

***b** - If the station value of the fixed (left-most) control point is updated from 5 to 7 then the station value of the relative control point is likewise updated from 15→17.*

***c** – Similarly the station value of the relative control point (right-most) cannot be less than than that of a proceeding (upstream, down-station or middle) control point. Since the right-most control point station value is dependant on the left-most control point station value then the left-most control point station value (the fixed control point) cannot be reduced below 10.1 without violating the basic rule of stationing monotonicity.*

2 = Offset Downstream


Downstream or Up-station
Station Value is set at minus 5 from downstream fixed control point giving a value of
5
10
15
a
CLStationEDitResponse = 2-Offset Downstream
CLStationEDitResponse = 5-Fixed or 1-Assigned
5
20
25
b
5
4
9
c

***a** – The station value of the middle control point is set relative and constant to the first control point that has has a CLStationEditResponse of either 'Fixed' or 'Assigned' downstream (up station)*

***b** - If the station value of the fixed control point is updated (15→25) then the station value of the relative control point is likewise updated.*

***c** - The station value of the control point whose station value is relative (middle control point) cannot be less than that of a proceeding (upstream, down-station) control point (5) to maintain station values monotonicity. Thus, an invalid situation would occur if the fixed control point (right-most) was changed from from 15 to 9. A -6 reduction in station offset applied to the middle control point would give it a value (4) which is less than the left most control point (5).*

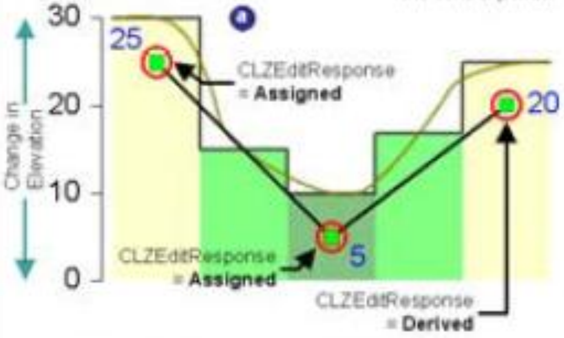
CLZEditResponse

ControlPoint :Feature level Metadata attributes

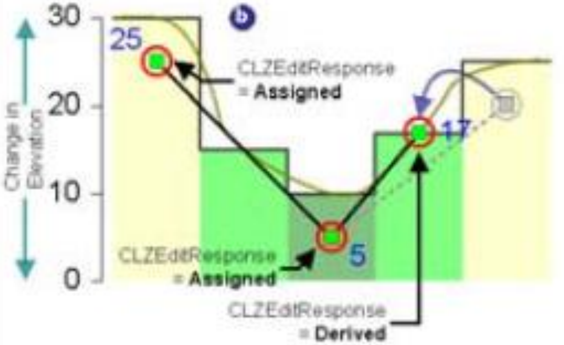
3 = Derived

The elevation of the control point is derived from a topographic surface, in this case, a Digital Elevation Model (DEM).

The numbers in blue represent the elevation of the control points.


a
30
20
10
0
Change in Elevation
25
CLZEditResponse = Assigned
20
5
CLZEditResponse = Assigned
CLZEditResponse = Derived

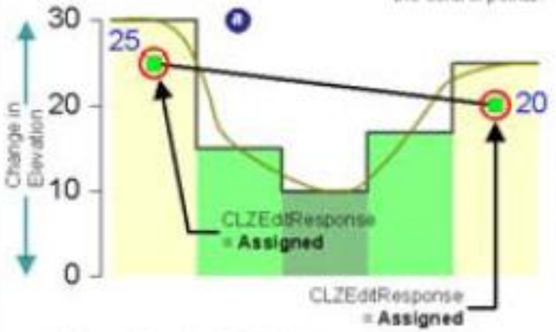
*a – If the right-most control point is moved (**b**), then the elevation (or Z value) must be recalculated against the topographic surface (20 to 17).*


b
30
20
10
0
Change in Elevation
25
CLZEditResponse = Assigned
17
5
CLZEditResponse = Assigned
CLZEditResponse = Derived

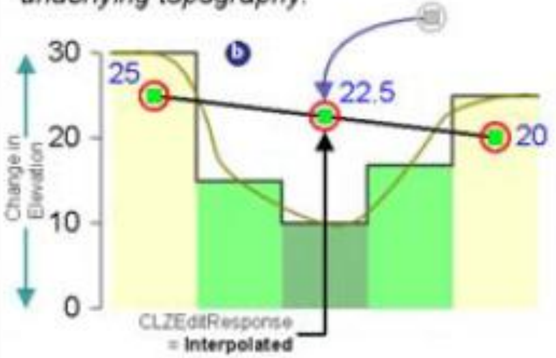
4 = Interpolated

The elevation of the control point is interpolated linearly between surrounding control points.

The numbers in blue represent the elevation of the control points.



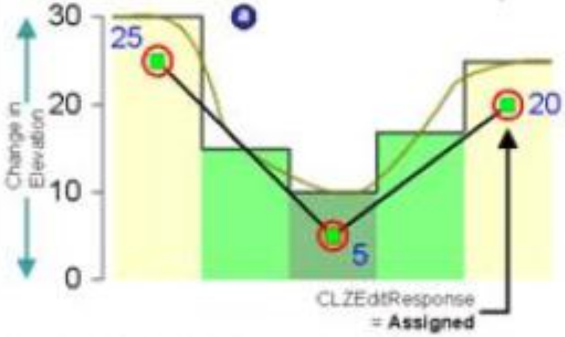
*a – Two ControlPoints are assigned elevation values. A third control point is added ½ in-between the two control points and the elevation (or Z) value for the new control point is interpolated (**b**) to be ½ the elevation of the surrounding ControlPoints = 22.5 regardless of the underlying topography.*



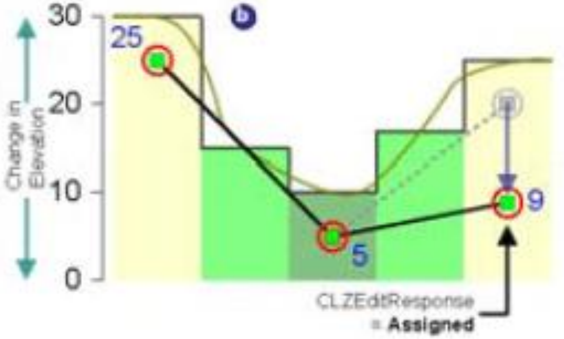
2 = Assigned

The elevation of the ControlPoint may be freely adjusted.

The numbers in blue represent the elevation of the control points.



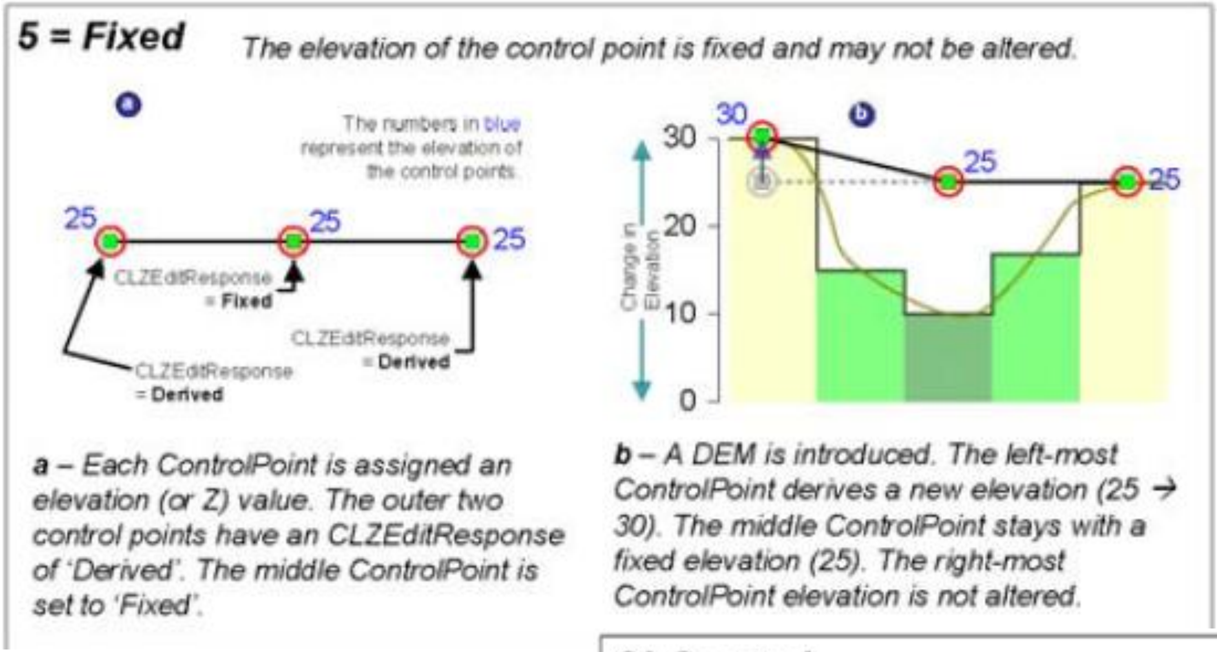
a – Each control point is assigned an elevation (or Z) value.



b – The user opts to change the Z value of the right-most control point from 20 to 9 and the control point is moved on the Z plane.

CLZEditResponse

ControlPoint :Feature level Metadata attributes



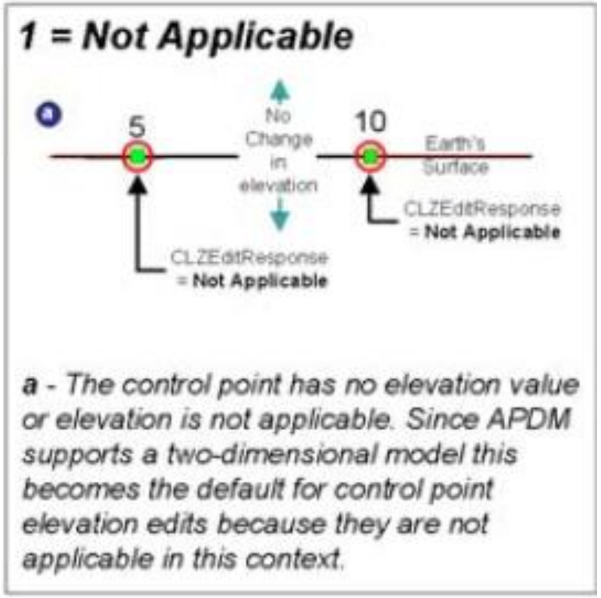
5 = Fixed

The elevation of the control point is fixed and may not be altered.

a
The numbers in blue represent the elevation of the control points
25
25
25
CLZEditResponse = Fixed
CLZEditResponse = Derived
CLZEditResponse = Derived
b
30
30
25
25
20
10
0
Change in Elevation

a – Each ControlPoint is assigned an elevation (or Z) value. The outer two control points have an CLZEditResponse of 'Derived'. The middle ControlPoint is set to 'Fixed'.

b – A DEM is introduced. The left-most ControlPoint derives a new elevation (25 → 30). The middle ControlPoint stays with a fixed elevation (25). The right-most ControlPoint elevation is not altered.

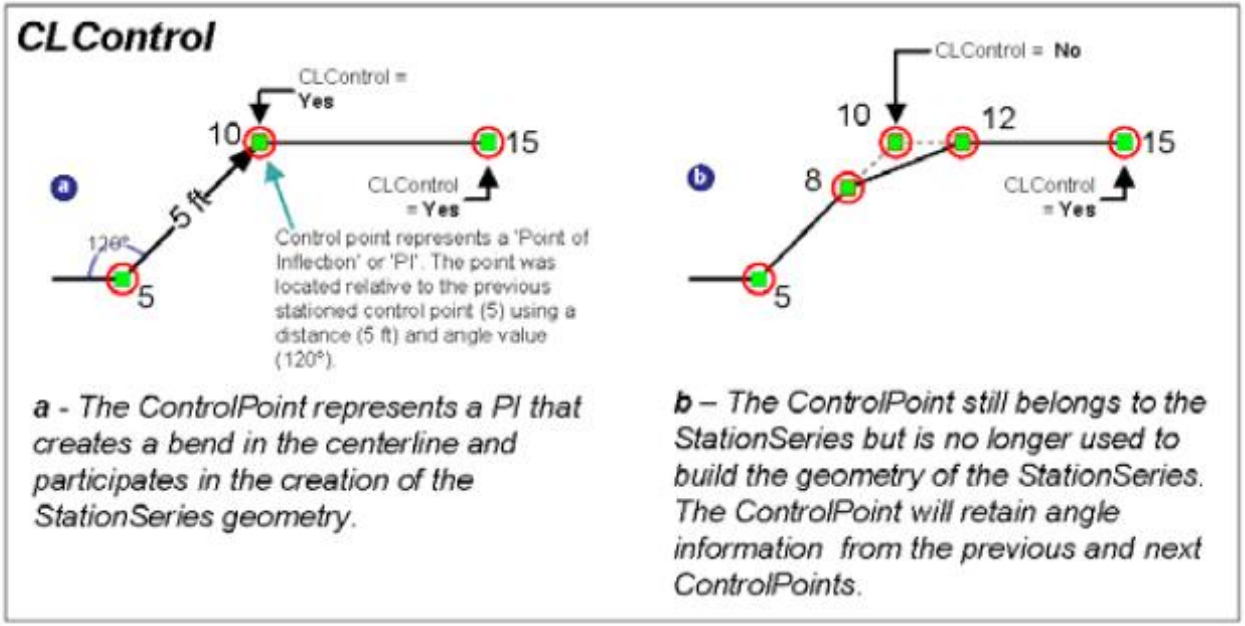


1 = Not Applicable

a
5
10
No Change in elevation
Earth's Surface
CLZEditResponse = Not Applicable
CLZEditResponse = Not Applicable

a - The control point has no elevation value or elevation is not applicable. Since APDM supports a two-dimensional model this becomes the default for control point elevation edits because they are not applicable in this context.

The principal reason for implementing **CLControl** is to handle the transition from traditional surveying methods to modern differential GPS control in defining the centerline. Traditionally, the centerline is represented as a traverse defined by a serie of Points of Inflection (P.I.'s). P.I.'s are actually survey artifacts with respect to the true location of the centerline; the centerline does not actually pass through P.I.'s. As tim goes by you can expect to replace P.I. contr point features with differential GPS control point features. By setting **CLControl** to 'No' you can maintain a P.I. control point for historical value, but not allow it to participate in the construction of station series features.



CLControl

a
CLControl = Yes
10
15
5 ft
120°
5
CLControl = Yes
Control point represents a 'Point of Inflection' or 'PI'. The point was located relative to the previous stationed control point (5) using a distance (5 ft) and angle value (120°).
b
CLControl = No
10
12
15
8
5
CLControl = Yes

a - The ControlPoint represents a PI that creates a bend in the centerline and participates in the creation of the StationSeries geometry.

b – The ControlPoint still belongs to the StationSeries but is no longer used to build the geometry of the StationSeries. The ControlPoint will retain angle information from the previous and next ControlPoints.

CORE Classes

- These core elements are required to maintain the semantic framework and behavior of the model, particularly with respect to the centerline and the methodology for applying and using linear referencing along the centerline.
- For a particular APDM implementation to be considered complaint, the APDM core classes must be implemented with the same names, attributes and relationships.
- The core class station series implements a one-to-many relationship with all online feature classes.
- Beyond the core elements there are no required or mandated elements in the model. End users are free to remove, add, or modify any of the suggested feature classes and attributes except the core elements to build a model that meets their business needs.
- **1)EventID(FeatureID or GeoEntityID):** All feature and object classes must have an attribute named EventID(GUID).this is a global id for any event that occurred on or along a pipeline system. Be it an online or offline feature. String(38) or GUID type

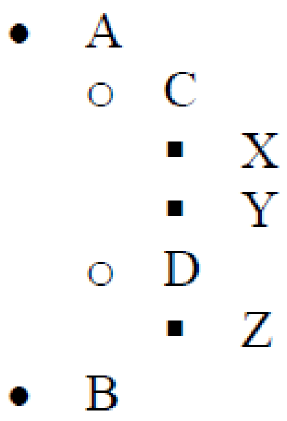
  Core Object Classes:

- **2)Activity:** Inherited from the object archive->non facilityobject, is object class is used to track regular pipeline activities and the events that are affected by those activities. Activities conducted on the pipeline that affect one or more events or features on or along the pipeline. Ex: work orders, inspections, excavations and tests..
- Gnactivitytype are: 1) unknown 2) Abandon 3) Approval For Expenditure (AFE) 4) Cathodic Protection Investigation Report 5) Class Location Verification 6) Close Interval Survey 7)Excavation 8) Hydrostatic Test 9) Inline Pig Run 10) Job Number 11) Leak Report 12) One-call Locate Ticket 13) Pipe Exposure Inspection 14) Pressure Test 15) Rectifier Reading 16) Shorted Casing Inspection 17) Work Order 18) Work Report
- Relationship: 1) Chaild Activity is 1:M with activity hierarchy 2) Parent activity is 1:M with activity hierarchy 3)InspectionRange is M:N with Activity 4)Activity is M:N with External document. 5) Activity is 1:M with Audit.

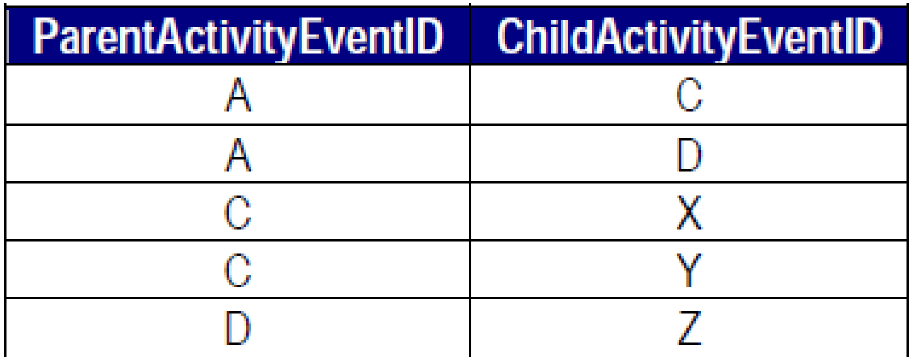
3)Activity Hierarchy: is object class**,** Inherited from the APDM object,,

Attributes: ParentActivityEventid, ChildactivityEventid,

Relationship: 1) chaild Activity is 1:M with ActivityHierarchy 2) parent Activity is 1:M with ActivityHierarchy



- A
  - C
    - X
    - Y
  - D
    - Z
- B



ParentActivityEventID	ChildActivityEventID
A	C
A	D
C	X
C	Y
D	Z

4) Audit class： Inherited from the Object archive->non facilityobject
Attributes: 1)Activity Date 2)Activity EventID 3)classEventid
Relationship: 1) Activity is 1:M Audit 2) classname audit is 1:M with Audit 3) <classname> audit is M:N with Externaldocument.

➢ description: a 1-M relationship class must exist b/n activity class and audit class. The value of the ActivityEventID is not required to be populated for each record, The purpose of this mechanism is to relate many features to a single activity via feature audit class. Ex: a pipe inspection exposes a pipe segment and two valve features. Each of the three features has an audit record created to signify the inspection and each audit record has the EventID value of the activity. These related audit records would then relate to the parent features in the valve and pipe segment tables respectively.

➢Technically the <classname> audit object class provides the mechanism that relates features to activities. The <classname> audit object class mediates what is actually a many to many relationship b/n the the <classname> object/feature class and activity. a <classname> audit object class must be created for any feature class or object class within the APDM geodatabase that needs to be associated with activities or external documents.

5)Company : Inherited from the object archive-> **non facilityobject**
Attributes: 1)Company name 2)Company label 3)Company type 4)Company Owner operator
Relationship: 1) Linecrossing is M:N with Company 2)Company is M:N contact 3)Company is M:N with Address 4)Company is 1:M with meter reading 5) Company is 1:M with CIS Reading
Description: this object class is designed to store information about any company that owns,operates,services,supplies,repairs, and/or maintains Any features or events that occur on or along the pipeline system. It has many-to-many relation ship with address and contact.

gncompanytype: 1)unknown 2) City Government 3) County Government 4) Electric Utility 5) Federal Government 6) Gas Utility 7) Individual 8) Oil and Gas 9) Pipeline Contractor 10) Pipeline Pigging Company 11) Cathodic Protection Inspection 12) Land Owner 13) Tenant 14) Pipeline Company Owner 15) State Government 16) Telephone/Communication Utility 17) Water Utility

6)External document: inherited from Nonfacilityobject

Attributes: 1)document description 2)documentype 3)File path 4)Filename(with ext) 5)Hyperlink

Relationship: 1) Externaldocument is 1:M with Geometadata 2) <class name> Audit is M:N with external document. 3)Activity is M:N with Externaldocument 4)DocumentPoint is M:N with Externaldocument

gnexternaldocumenttype domain: 1) Unknown 2) Adobe Acrobat (*.pdf) 3) ArcMap Document (*.mxd) 4) AutoCad Drawing (*.dwg) 5) Bitmap (*.bmp) 6) GIF (*.gif) 7) HTML (*.htm) 8) JPEG (*.JPG) 9) Microsoft Word (*.doc) 10) Microstation Design (*.dgn) 11) Text (*.txt) 12) TIFF (*.tif) 13) URL

Description: this object class stores information describing the location and content of an external file object stored on a disk drive, web folder or document management system. Purpose is to link features and events with external documentation. Externaldocument object class has many to many relationship with the documentpoint feature. Externaldocument has a many-to-many relationship with activity. Such that a single document can provide information about many activities. And a single activity can be associated with many documents.\

7)Lineloop: inherited from centerlineobject.

Attributes: 1) Line name 2) Line function 3)LineJurisdiction

Relationship:1) Lineloop is 1:M with stationseries 2)chaild Lineloop is 1:M with lineloop hierarchy 3) Parent Lineloop is 1:M with lineloop hierarchy 4) Line loop is M:N with ownerOperator 5)Lineloop is M:N with product 6)Lineloop is 1:M with LineloopAudit.

Linefunction domains : 1) Unknown 2)Blowoff 3)Bypass 4)Crossover 5) Design Phase - No Pipe 6) Header (Trunk) 7) Interconnect 8) Lateral 9) Launcher 10) Kicker 11) Mainline 12) Receiver 13) Storage Line 14) Tap Line 15) Well Line

LineJurisdiction domains: 1)unknown 2) offshore 3)onshore

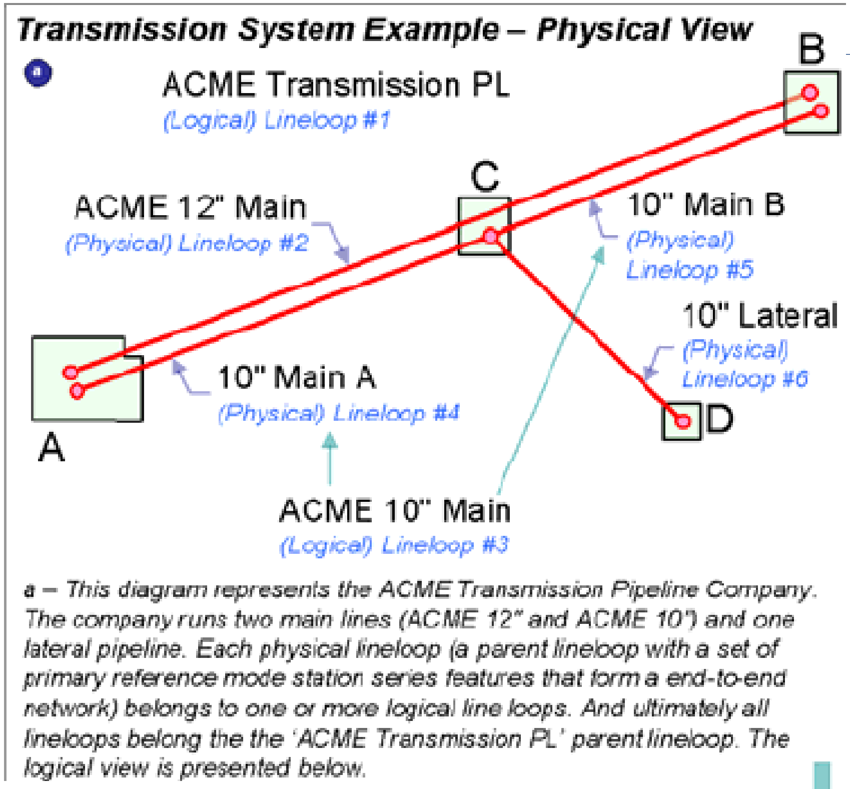
Description: Lineloop class is designed to store information describing both physical segments of pipe and also their logical groupings.

Most pipeline companies logically group a collection of connected physical line loops(usually with common diameter and other attributes) under a single line name or line number as a pipeline. In the APDM such a grouping corresponds to a logical line loop.

7)Lineloop Hierarchy: inherited from the APDM object,

Attributes: 1)ParentLineloopEventID 2)ChildLineloopEventID

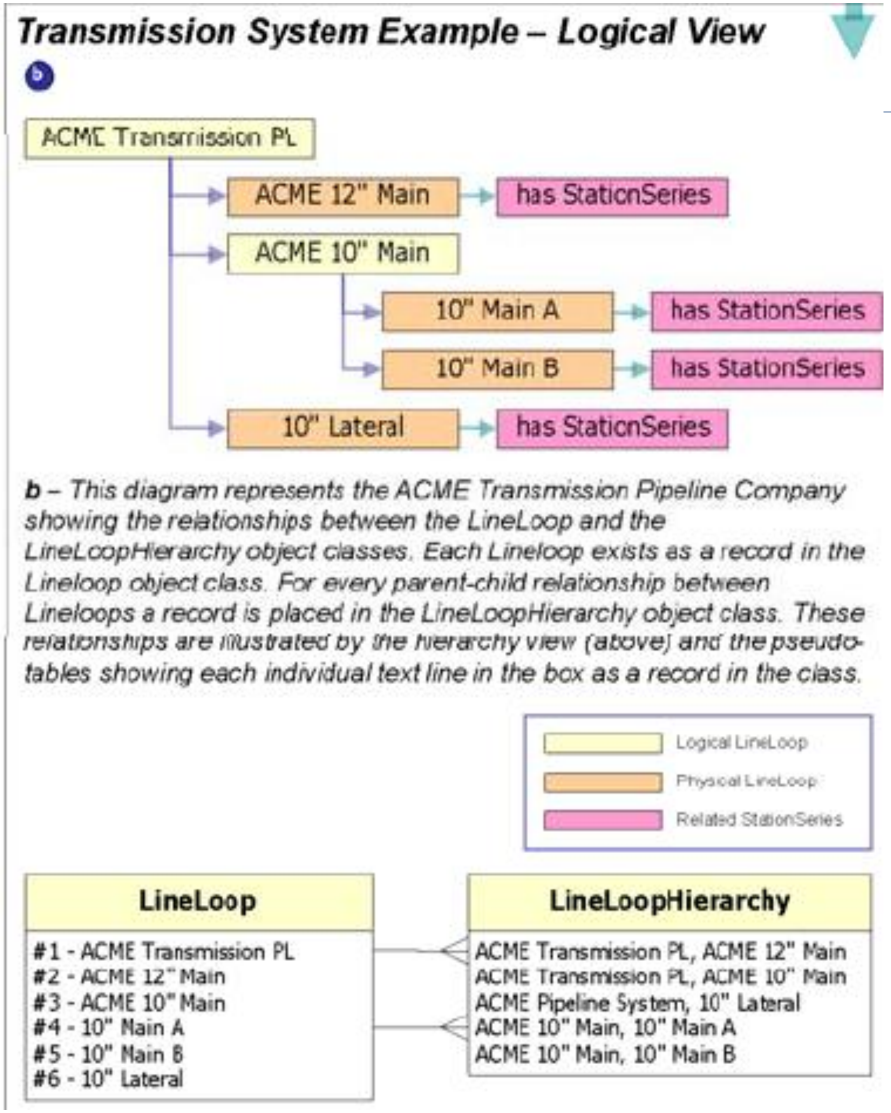
Relationship: 1)ChildLineLoop is 1:M with LineloopHierarchy 2)ParentLineLoopHierarchy is 1:M with LineloopHierarchy



Transmission System Example – Physical View

a – This diagram represents the ACME Transmission Pipeline Company. The company runs two main lines (ACME 12" and ACME 10") and one lateral pipeline. Each physical lineloop (a parent lineloop with a set of primary reference mode station series features that form a end-to-end network) belongs to one or more logical line loops. And ultimately all lineloops belong the the 'ACME Transmission PL' parent lineloop. The logical view is presented below.

EventID	LineName	LineType
1	ACME System	Transmission
2	ACME 12"	Transmission
3	ACME 10"	Transmission
4	10" Lateral	Transmission
5	ACME Gathering System	Gathering
6	6" Trunk Line	Gathering
7	4" Gathering Line	Gathering
8	Well #1	Gathering
9	Well #2	Gathering
10	Well #3	Gathering



Transmission System Example – Logical View

b – This diagram represents the ACME Transmission Pipeline Company showing the relationships between the LineLoop and the LineLoopHierarchy object classes. Each Lineloop exists as a record in the Lineloop object class. For every parent-child relationship between Lineloops a record is placed in the LineLoopHierarchy object class. These relationships are illustrated by the hierarchy view (above) and the pseudo-tables showing each individual text line in the box as a record in the class.

🟨	Logical LineLoop
🟧	Physical LineLoop
🟪	Related StationSeries

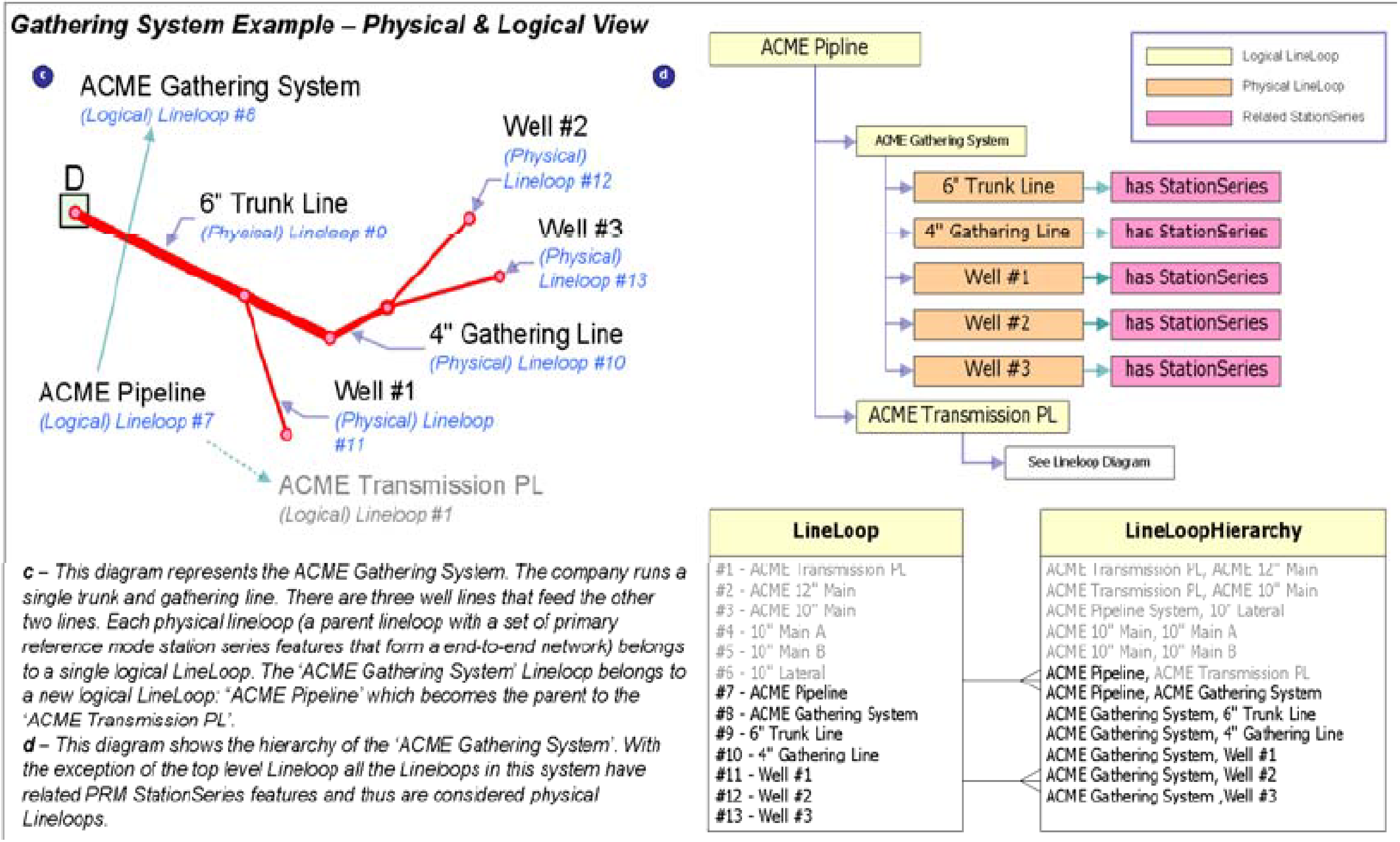
LineLoop
#1 - ACME Transmission PL
#2 - ACME 12" Main
#3 - ACME 10" Main
#4 - 10" Main A
#5 - 10" Main B
#6 - 10" Lateral

LineLoopHierarchy
ACME Transmission PL, ACME 12" Main
ACME Transmission PL, ACME 10" Main
ACME Pipeline System, 10" Lateral
ACME 10" Main, 10" Main A
ACME 10" Main, 10" Main B

Logical line loops of ACME Transmission PL:

1) ACME 12' main

2) ACME 10" Main



Gathering System Example – Physical & Logical View

c – This diagram represents the ACME Gathering System. The company runs a single trunk and gathering line. There are three well lines that feed the other two lines. Each physical lineloop (a parent lineloop with a set of primary reference mode station series features that form a end-to-end network) belongs to a single logical LineLoop. The 'ACME Gathering System' Lineloop belongs to a new logical LineLoop: "ACME Pipeline' which becomes the parent to the 'ACME Transmission PL'.

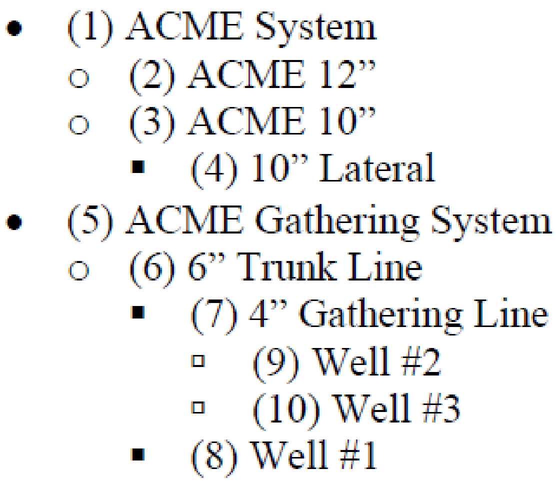
d – This diagram shows the hierarchy of the 'ACME Gathering System'. With the exception of the top level Lineloop all the Lineloops in this system have related PRM StationSeries features and thus are considered physical Lineloops.

LineLoop
#1 - ACME Transmission PL
#2 - ACME 12" Main
#3 - ACME 10" Main
#4 - 10" Main A
#5 - 10" Main B
#6 - 10" Lateral
#7 - ACME Pipeline
#8 - ACME Gathering System
#9 - 6" Trunk Line
#10 - 4" Gathering Line
#11 - Well #1
#12 - Well #2
#13 - Well #3

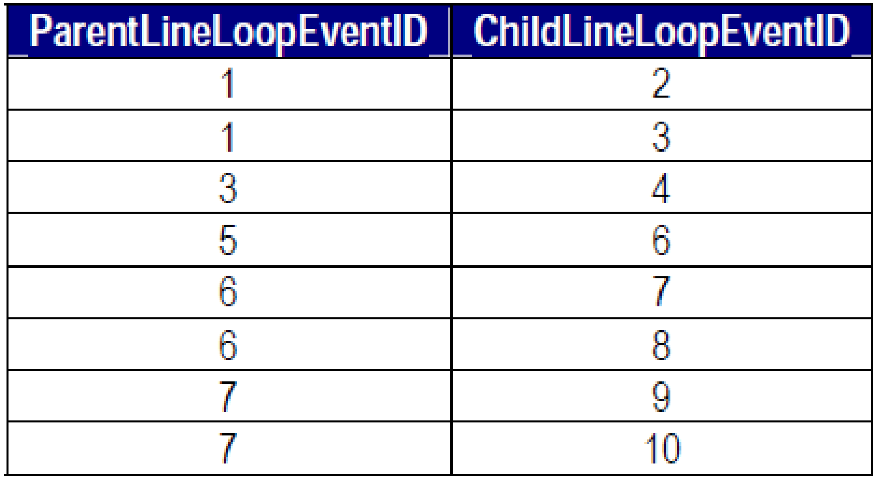
LineLoopHierarchy
ACME Transmission PL, ACME 12" Main
ACME Transmission PL, ACME 10" Main
ACME Pipeline System, 10" Lateral
ACME 10" Main, 10" Main A
ACME 10" Main, 10" Main B
ACME Pipeline, ACME Transmission PL
ACME Pipeline, ACME Gathering System
ACME Gathering System, 6" Trunk Line
ACME Gathering System, 4" Gathering Line
ACME Gathering System, Well #1
ACME Gathering System, Well #2
ACME Gathering System ,Well #3

The above Gathering system is having a single logical line loop of ACME gathering system.

Description: LineloopHierarchy objectclass models relationships between parent and child lineloops and is used to establish a hierarchy of lineloops. The lineloop hierarchy groups lineloops as sets of lineloops belonging to higher sets of lineloops. Each record in lineloophierarchy stores a parent and child line loop in the line loop hierarchy.



- (1) ACME System
    - (2) ACME 12”
    - (3) ACME 10”
        - (4) 10” Lateral
- (5) ACME Gathering System
    - (6) 6” Trunk Line
        - (7) 4” Gathering Line
            - (9) Well #2
            - (10) Well #3
        - (8) Well #1



ParentLineLoopEventID	ChildLineLoopEventID
1	2
1	3
3	4
5	6
6	7
6	8
7	9
7	10

8)OwnerOperator: Inherited from Non facility object

Attributes: 1)OwnerPercentage 2)Owner type 3)
Relationship:1) LineLoop is M:N with OwnerOperator 2)Company is 1:M with OwnerOperator.
Description: Owner operator object class is used to define the percentage ownership and/or operatorship for a Lineloop.
Domains: 1)Unknown 2)OwnerShip 3)Operator 4)Leasee

9)Product: Inherited from Non facility object.

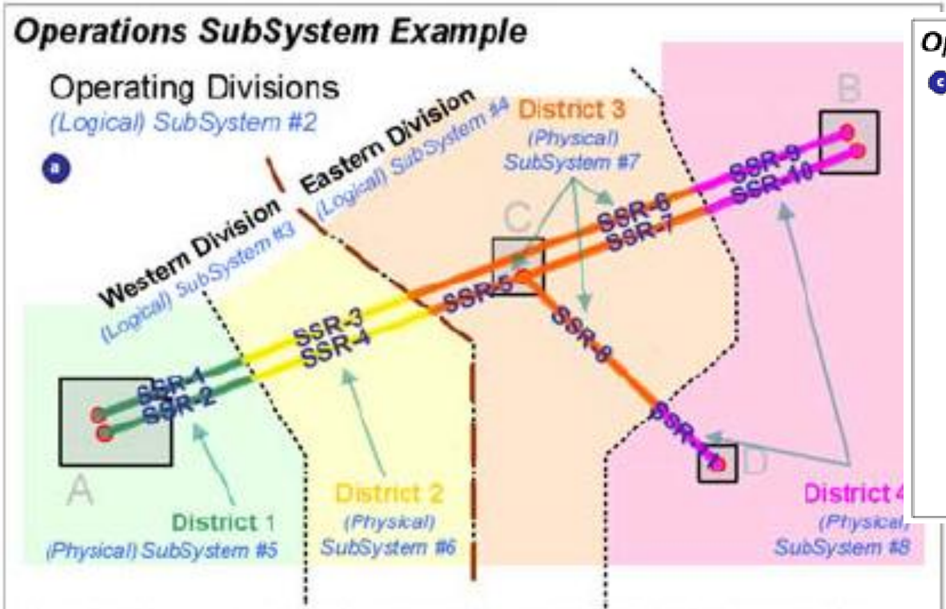
Attributes:1)Product 2)Producttype
Relationship: 1)Lineloop is M:N with Product.
Description: The product object class is used to store information about the types of products carried in the pipeline.
Domains: 1)Unknown 2)Air 3) Crude oil 4) Diesel 5)Gasoline 6) Liquid Natural Gas 7) Liquid Petroleum Gas 8) Natural Gas 9) Nitrogen 10) None 11) Water 12) Multi-Phase (Bulk)

10) Subsystem: Inherited form the centerline object.

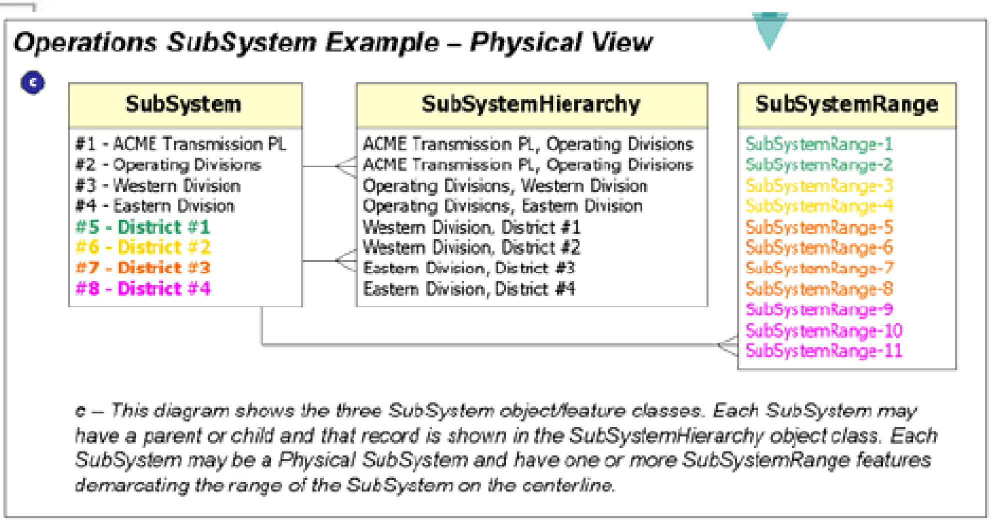
Relationship: 1) child subsystem is 1:M with SubsystemHierarchy 2)Parent Subsystem is 1:M with SubsystemHierarchy 3)Subsystem is 1:M with Subsystem range 4)Subsystem is M:N with Site 5) Subsystem is 1:M with subsystem Audit. 6)Subsystem is M:N with contact.

Description: The subsystem object class is used to categorize, organize, and group pipeline segments into logical groupings that may cut across line loops and station series. Uses: 1)to define organizational boundaries ex: divisions, districts, and operating areas.2) record administrative boundaries such as taxing districts.3)organize subsystems into hierarchy

A logical subsystem is a grouping of physical subsystems and/or lower level logical subsystems.



a – This diagram represents the ACME Transmission Pipeline Company and the Operating Divisions and Districts that are used to organize the pipeline into manageable units. The pipeline is divided into two divisions (Western and Eastern). Each division is divided into two districts (District 1, 2 and District 3, 4 respectively. The portion of the centerline that intersects the district boundaries is used to create SubSystemrange (SSR) CenterlinePolylineEvent features. The logical view is presented below.



Operations SubSystem Example – Physical View

c

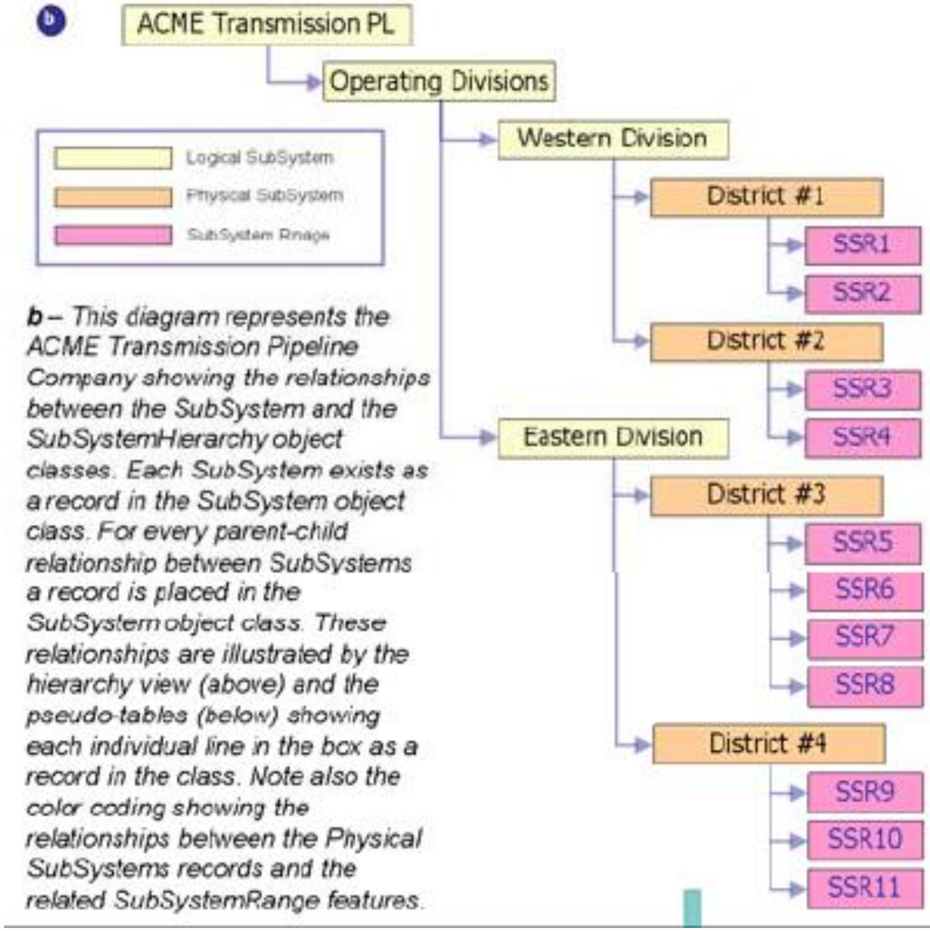
SubSystem
#1 - ACME Transmission PL
#2 - Operating Divisions
#3 - Western Division
#4 - Eastern Division
#5 - District #1
#6 - District #2
#7 - District #3
#8 - District #4

SubSystemHierarchy
ACME Transmission PL, Operating Divisions
ACME Transmission PL, Operating Divisions
Operatng Divisions, Western Division
Operatng Divisions, Eastern Division
Western Division, District #1
Western Division, District #2
Eastern Division, District #3
Eastern Division, District #4

SubSystemRange
SubSystemRange-1
SubSystemRange-2
SubSystemRange-3
SubSystemRange-4
SubSystemRange-5
SubSystemRange-6
SubSystemRange-7
SubSystemRange-8
SubSystemRange-9
SubSystemRange-10
SubSystemRange-11

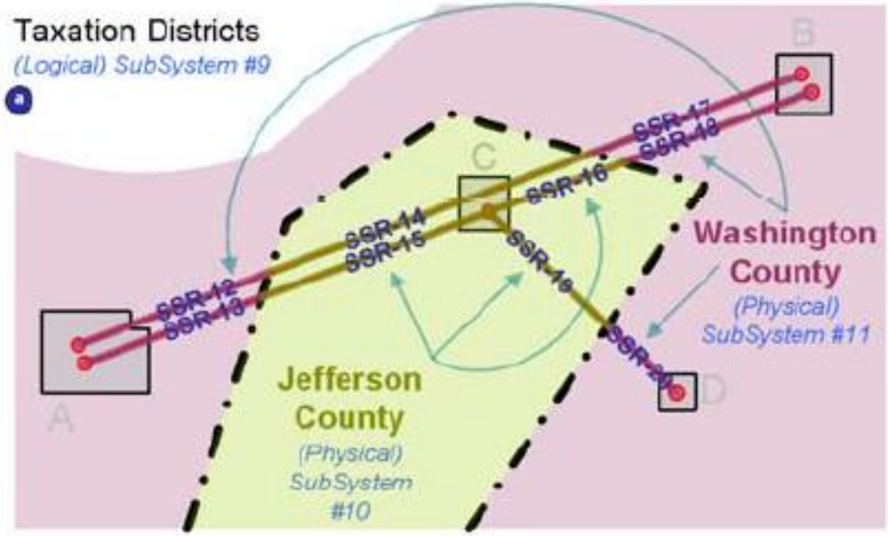
c – This diagram shows the three SubSystem object/feature classes. Each SubSystem may have a parent or child and that record is shown in the SubSystemHierarchy object class. Each SubSystem may be a Physical SubSystem and have one or more SubSystemRange features demarcating the range of the SubSystem on the centerline.

Operations SubSystem Example – Logical View

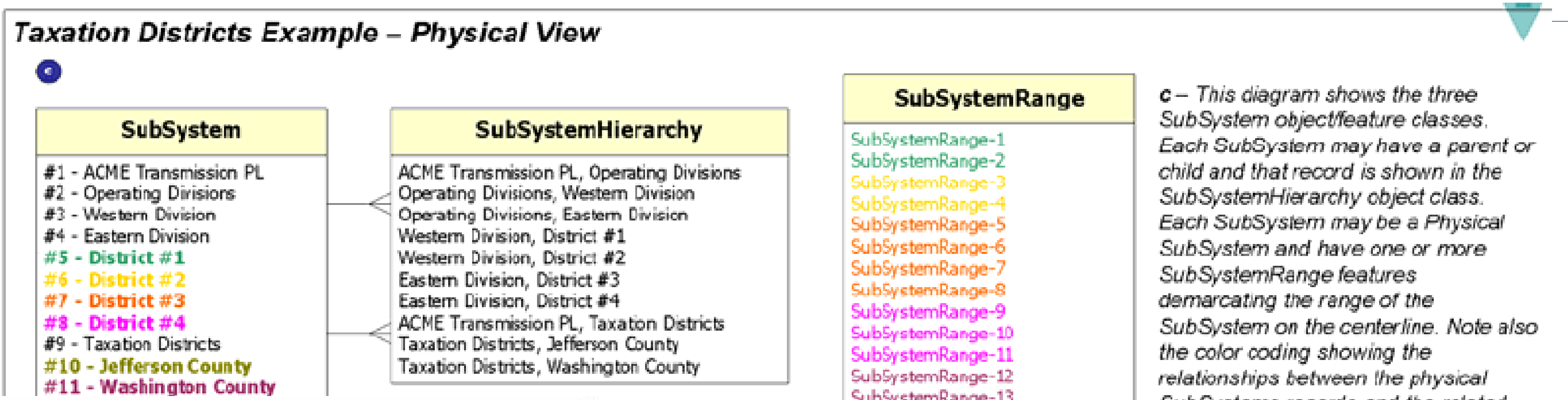


b – This diagram represents the ACME Transmission Pipeline Company showing the relationships between the SubSystem and the SubSystemHierarchy object classes. Each SubSystem exists as a record in the SubSystem object class. For every parent-child relationship between SubSystems a record is placed in the SubSystem object class. These relationships are illustrated by the hierarchy view (above) and the pseudo-tables (below) showing each individual line in the box as a record in the class. Note also the color coding showing the relationships between the Physical SubSystems records and the related SubSystemRange features.

Taxation Districts SubSystems



a – This diagram represents the ACME Transmission Pipeline Company and the Taxation Districts (Country Boundaries) used to manage tax burden on assets. The pipeline is divided into two counties or taxation districts (Jefferson and Washington). Each district is a child of a logical SubSystem named Taxation District which in turn is a child of the ACME Transmission PL Subsystem. The portion of the centerline that intersects the county boundaries is used to create SubSystem range (SSR) CenterlinePolylineEvent features.



Taxation Districts Example – Physical View

SubSystem

#1 - ACME Transmission PL
#2 - Operating Divisions
#3 - Western Division
#4 - Eastern Division
#5 - District #1
#6 - District #2
#7 - District #3
#8 - District #4
#9 - Taxation Districts
#10 - Jefferson County
#11 - Washington County

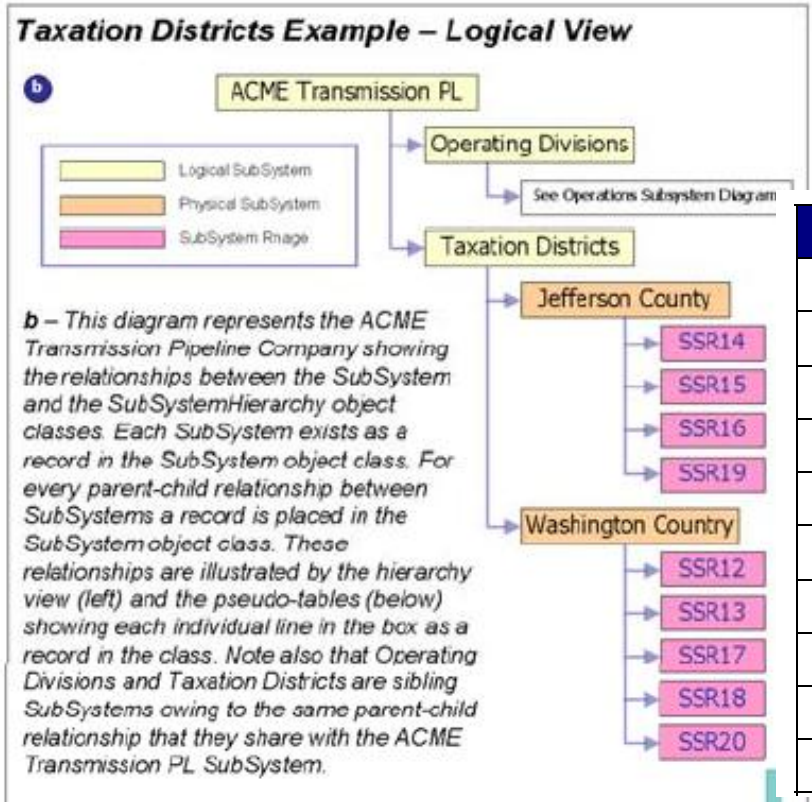
SubSystemHierarchy

ACME Transmission PL, Operating Divisions
Operating Divisions, Western Division
Operating Divisions, Eastern Division
Western Division, District #1
Western Division, District #2
Eastern Division, District #3
Eastern Division, District #4
ACME Transmission PL, Taxaton Districts
Taxation Districts, Jefferson County
Taxation Districts, Washington County

SubSystemRange

SubSystemRange-1
SubSystemRange-2
SubSystemRange-3
SubSystemRange-4
SubSystemRange-5
SubSystemRange-6
SubSystemRange-7
SubSystemRange-8
SubSystemRange-9
SubSystemRange-10
SubSystemRange-11
SubSystemRange-12
SubSystemRange-13
SubSystemRange-14
SubSystemRange-15
SubSystemRange-16
SubSystemRange-17
SubSystemRange-18
SubSystemRange-19
SubSystemRange-20

c – This diagram shows the three SubSystem object/feature classes. Each SubSystem may have a parent or child and that record is shown in the SubSystemHierarchy object class. Each SubSystem may be a Physical SubSystem and have one or more SubSystemRange features demarcating the range of the SubSystem on the centerline. Note also the color coding showing the relationships between the physical SubSystems records and the related SubSystemRange features.



Taxation Districts Example – Logical View

b – This diagram represents the ACME Transmission Pipeline Company showing the relationships between the SubSystem and the SubSystemHierarchy object classes. Each SubSystem exists as a record in the SubSystem object class. For every parent-child relationship between SubSystems a record is placed in the SubSystem object class. These relationships are illustrated by the hierarchy view (left) and the pseudo-tables (below) showing each individual line in the box as a record in the class. Note also that Operating Divisions and Taxation Districts are sibling SubSystems owing to the same parent-child relationship that they share with the ACME Transmission PL SubSystem.

EventID	SubSystemName
1	Operating Divisions
2	Western Division
3	Eastern Division
4	District 1
5	District 2
6	District 3
7	District 4
8	Tax Authorities
9	Washington County
10	Jefferson County

- Operating Divisions
  - ○ (2) Western Division
    - ▪ (4) District 1
    - ▪ (5) District 2
- (3) Eastern Division
    - ▪ (6) District 3
    - ▪ (7) District 4
- (8) Tax Authorities
  - ○ (9) Washington County
  - ○ (10) Jefferson County

Core Feature Classes

11) Subsystem Hierarchy: inherited as APDM object.

Attributes: 1)Parent subsystem EventID 2)Child subsystem EventID

Relationship:1) Child subsystem is 1:M with Subsystem Hierarchy 2) Parent subsystem is 1:M with Subsystem Hierarchy.

Core Feature classes:

1)ControlPoint: Inherited from centerlinePoint, M-aware point feature.

Attributes: 1)ControlPointAngle 2) Control point Type 3)PIdirection

Relationship: 1) Station series is 1:M with Control point. 2) ControlPoint is 1:M with Control point Audit.

Domains:

Control point type : 1) Unknown 2) PI 3) Known point 4) GPS Point 5) Monument 6) Crossing Location

Control Point direction: 1)Unknown 2)None 3)LT 4)RT

Description: Control points are known X,Y and station value along the pipeline centerline. Control point feature define the pipeline centerline.

1)APDM requires that one subtype be defined as the primary reference mode(default measurement system) for the pipeline centerline. Other control point subtypes, or measurement systems, present in the model are considered secondary measurement systems. All secondary measurement systems must be geometrically conicident and geometrically constrained to the primary measurement system control points and station series features. Representations for all control point features must be present in all reference modes. The default measurement system becomes the stationing method applied to all online features. Online features are stored only in the primary reference mode.

2)Control point implements a one-to-many relationship with control point audit; this relationship ties ControlPoint to both Activity and External Document. Through ControlPointAudit records a control point may be associated with multiple activities and/or documents, and vice versa.

2)Site: Inherited from the Offline facility.

Attributes: 1)Site Name 2)Site type

Relationship: 1) Site is 1:M with Site Audit 2)Subsystem is M:N with Site 3)Site is M:N with Contact 4) Site is 1:0..M with <Online or Offline Facility classname>

Domains: 1) Unknown 2) Check Meter Station 3) Compressor Station 4) Corrosion Station 5) Custody Transfer Station 6) Drip Site 7) Junction 8) Mercury Site 9) Meter Station 10) Odorant Station 11) Office 12) PCB Site 13) Permanent Easement 14) Plant 15) Regulator Station 16) Storage Area 17) Temporary Easement 18) Town Border Station 19) Valve Station 20) Warehouse

Description: 1) The site feature class is designed to store the polygonal boundaries of the various stations and other properties housing facilities owned by a pipeline company. Site features might be used to define the boundaries of properties, easements, temporary work areas, and large pipeline complexes such as meter stations, compressor stations, refineries, custody transfer stations, and valve stations. Site features may also be used to demarcate the limit of stationed pipes and non-stationed pipes.2) Site implements an optional one-to-many relationship with all online and offline facility feature classes.2)Site implements a one-to-many relationship with site audit; this relationship ties site to both Activity and External Document. Though site audit records, a site may be associated with multiple activities and/or documents and vice versa.

3)Station Series: Inherited from the Centerlinepoint. M-aware polyline feature

Attributes:1) Series Name 2)Series order 3)Begin station 4)End Station 5)RefMode 6)FromSeriesEventID 7)FromConnectionStationValue 8)ToSeriesEventID 9)Toconnectionstationvalue 10)LineloopEventID

Core & Optional Feature Classes

Domains : RefMode :1) Unknown 2)Continuous 3)Engineering 4)Horizontal 5)Milepost 6)Slack Chain 7)Valve Section 8)Unspecified

Relationship: 1) Line loop is 1:M with Stationseries 2)Station series is 1:M with <Online feature class name> 3)Station series is 1:M with Alt RefMeasure

4) ReferenceMode is 1:M with Station Series. 5) Station Series is 1:M with StationSeriesAudit.

Description:1) Stationseries feature class stores the routes that comprise the pipelinecenteline. 2)All online features in the APDM are referenced against primary reference mode stations series features.3)Each station series feature is an ESRI Route with an assigned begin and end measure value assigned to it. 4)Each vertex in the station series feature has a measure value assigned to it.

4)SubsystemRange: Inherited from the CenterlinePolylineEvent. Implemented as M-aware polyline feature.

Relationship:1) Subsystem is 1:M with SubsystemRange 2) Station series is 1:M with SubsystemRange 3) SubsystemRange is M:N withAltRefMeasure.

Description: SubsystemRange stores the actual physical extent of a subsystem as one or more online polyline event features. 2)Each station series segment in a subsystem corresponds to a subsystem range feature.

Optional classes

- The optional classes are included as starting template and also as an implementation examples.
- Domains provided with the model are designed to contain common values found in most of the pipeline systems.
- Two letter designation of domains: gn – Generic: domains that are applied to object classes and features in the model.
- Cp- cathodic protection domains
- Op- pipeline operations
- ep – encroachments
- fc –facility feature classes
- cl –centerline feature and object classes and inspection features

1)Site point : Implemented as a point feature class .Inherited from offline pint.

Relationship: Sitepoint is 1..1 with site

2)Appurtenance: Implemented as M-aware point feature class. Inherited from OnlinePointfacility.

Attributes: AppurtenanceType(fcAppurtenanceType)

Relationship: Appurtenance is 1:M with Appurtenance Audit

Description: this feature class is used to store adhoc, non-pressurized point features that are found on and along a pipeline system. This can be used as a catchall for referenced online point features that do not fit into any other APDM feature class. Ex: anchor rods, hold-down blocks, river weights, and thrust blocks.

3)Casing: implemented as an M-aware polyline feature class.inherited from the

Optional Classes

THANK YOU…….

THANK YOU…….

THANK YOU…….

Abstract classes -> Concrete classes

- Object->APDM Object-> 1)Instrument parameter 2)LineLoopHierarchy3)SubsystemHierarchy4)Activity Hierarchy.
- Object->APDM Object->Object Archive-> Centerlineobject-> 1)LineLoop2)SubSystem3)Site
- Object->APDM Object->Object Archive->NonFacilityobject-> 1)Activity 2)Address 3)CISReading 4)Company 5)Contact 6)ExternalDocument 6)Geometadata 7)MeterReading 8)Owneroperator 9)Product
- Object->APDM Object->Object Archive->FacilityObject-> 1)Valve Operator
- Object->APDM Object->Object Archive->NonFacilityobject->AuditObject->1)Audit
- Object->Feature->Feature Archive-> CenterlinePolyline-> 1)StationSeris
- Object->Feature->Feature Archive-> CenterlinePolyline->CenterlinePolylineEvent->1)SubSystemRange
- Object->Feature->Feature Archive-> CenterlinePoint->1)ControlPoint
- Object->Feature->Feature Archive->OfflineFeature->1)Alignment Sheet 2)HighConsequenceArea 3)Linecrossing 4)RemovedLine 5)StructureOutline

- Object->Feature->Feature Archive->OfflineFeature->OfflinePoint->1)DocumentPoint 2)FieldNote 3)RemovedPoint 4)Structure
- Object->Feature->Feature Archive-> OfflineFacility->OfflineNonPointFacility->1)CPCable 2)PIGStructure 3)SiteBoundary
- Object->Feature->Feature Archive-> OfflineFacility-> OfflinePointFacility->1)CPAnode 2)CPBond 3)CPGroundBed 4)CPRectifier 5)CPTestStation 6)Marker 7)SitePoint

APDM Design Rationale

- Core Features and Abstract classes allow for customized and individualized implementations with a standard ‘core’ for flexibility and interoperability
- APDM was designed to be implemented and maintained in ESRI Geodatabase without the need for custom application code
- It is relatively simple to represent other data models within the APDM using the CORE classes
- Features can be located on or along a pipeline by either/or both absolute positioning (coordinates) and/or linear referencing (Route/Measure, Mile/KMPost)
- A combination of feature classes and event tables is allowed within a single APDM Geodatabase.
- By implementing a CORE set of classes and by ensuring that all NEW classes added to the model implement the attributes and relationships of the ABSTRACT class that describes the newly created Feature/Object class = Valid APDM
- Data can be exchanged via all APDM models who implement the CORE and adhere to the ABSTRACT class definitions

- Anything as long as the core classes, relationships between then and the ABSTRACT classes are used to define any new feature or object classes you add to the model.
- Add attributes to the core classes
- Add new feature/object classes to the model using the ABSTRACT classes as templates
    - You can use the example classes
    - You can add attributes to the existing classes
    - You can add new classes
    - You can remove example classes
    - Any class that you add or remove to/from the model must be registered in the APDM class metadata table
- The APDM metadata classes represent a set of object classes that are used to hold information about the reference modes, information about each concrete classes inheriting from an ‘APDM abstract class and information about which offline APDM classes have related ‘online’ polyline or ‘online’ point classes.

- APDM implementations:
- Examples: 1) Non-stationed using Absolute coordinates
- 2)Stationed Core w/ Example classes as Feature classes
- 3)Stationed core w/Example classes as event object classes or tables
- 4)Stationed core w/one object class/event-table and many related object classes/tables
- 5)

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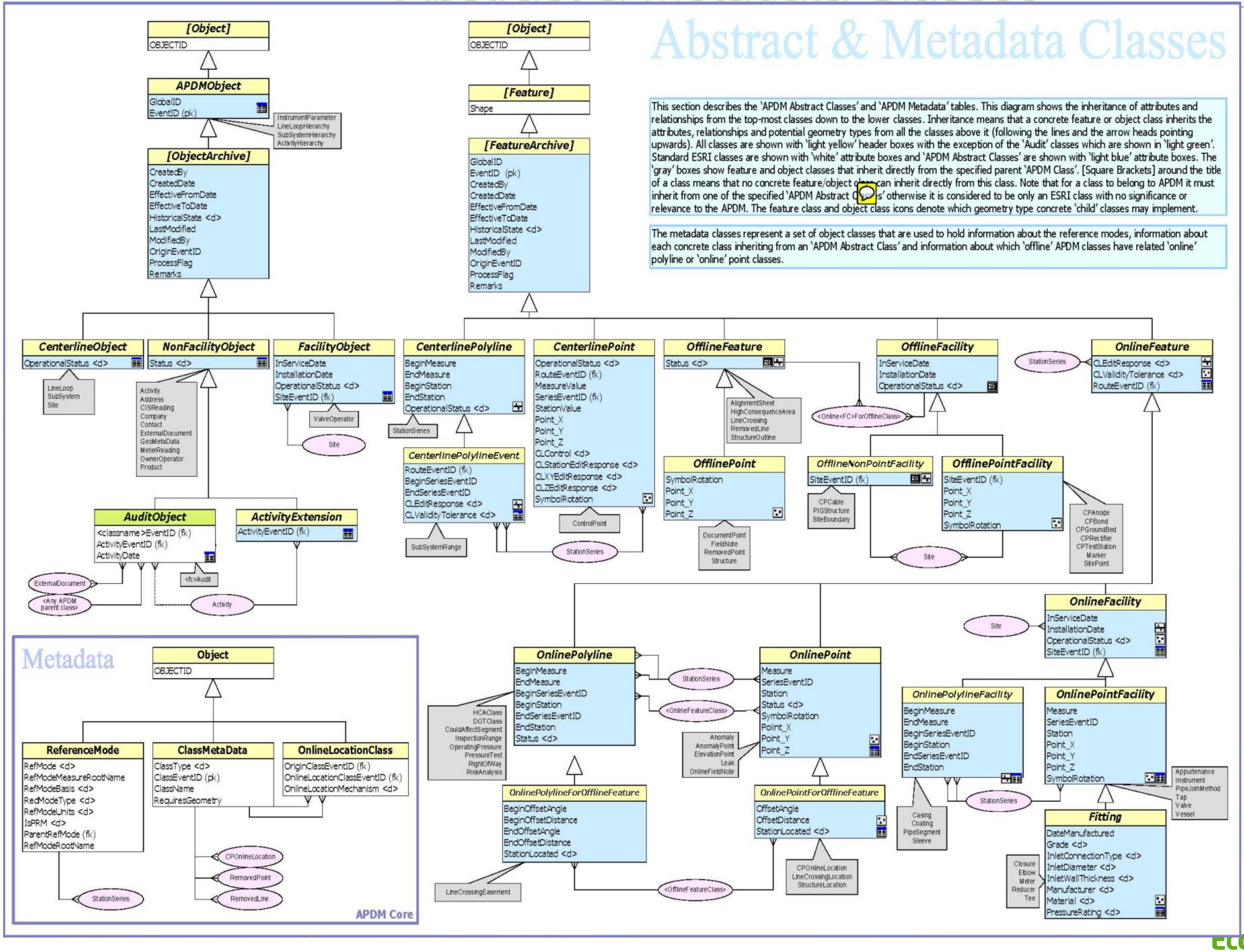
Abstract & Metadata Classes



Abstract & Metadata Classes

This section describes the 'APDM Abstract Classes' and 'APDM Metadata' tables. This diagram shows the inheritance of attributes and relationships from the top-most classes down to the lower classes. Inheritance means that a concrete feature or object class inherits the attributes, relationships and potential geometry types from all the classes above it (following the lines and the arrow heads pointing upwards). All classes are shown with 'light yellow' header boxes with the exception of the 'Audit' classes which are shown in 'light green'. Standard ESRI classes are shown with 'white' attribute boxes and 'APDM Abstract Classes' are shown with 'light blue' attribute boxes. The 'gray' boxes show feature and object classes that inherit directly from the specified parent 'APDM Class'. [Square Brackets] around the title of a class means that no concrete feature/object class can inherit directly from this class. Note that for a class to belong to APDM it must inherit from one of the specified 'APDM Abstract Classes' otherwise it is considered to be only an ESRI class with no significance or relevance to the APDM. The feature class and object class icons denote which geometry type concrete 'child' classes may implement.

The metadata classes represent a set of object classes that are used to hold information about the reference modes, information about each concrete class inheriting from an 'APDM Abstract Class' and information about which 'offline' APDM classes have related 'online' polyline or 'online' point classes.

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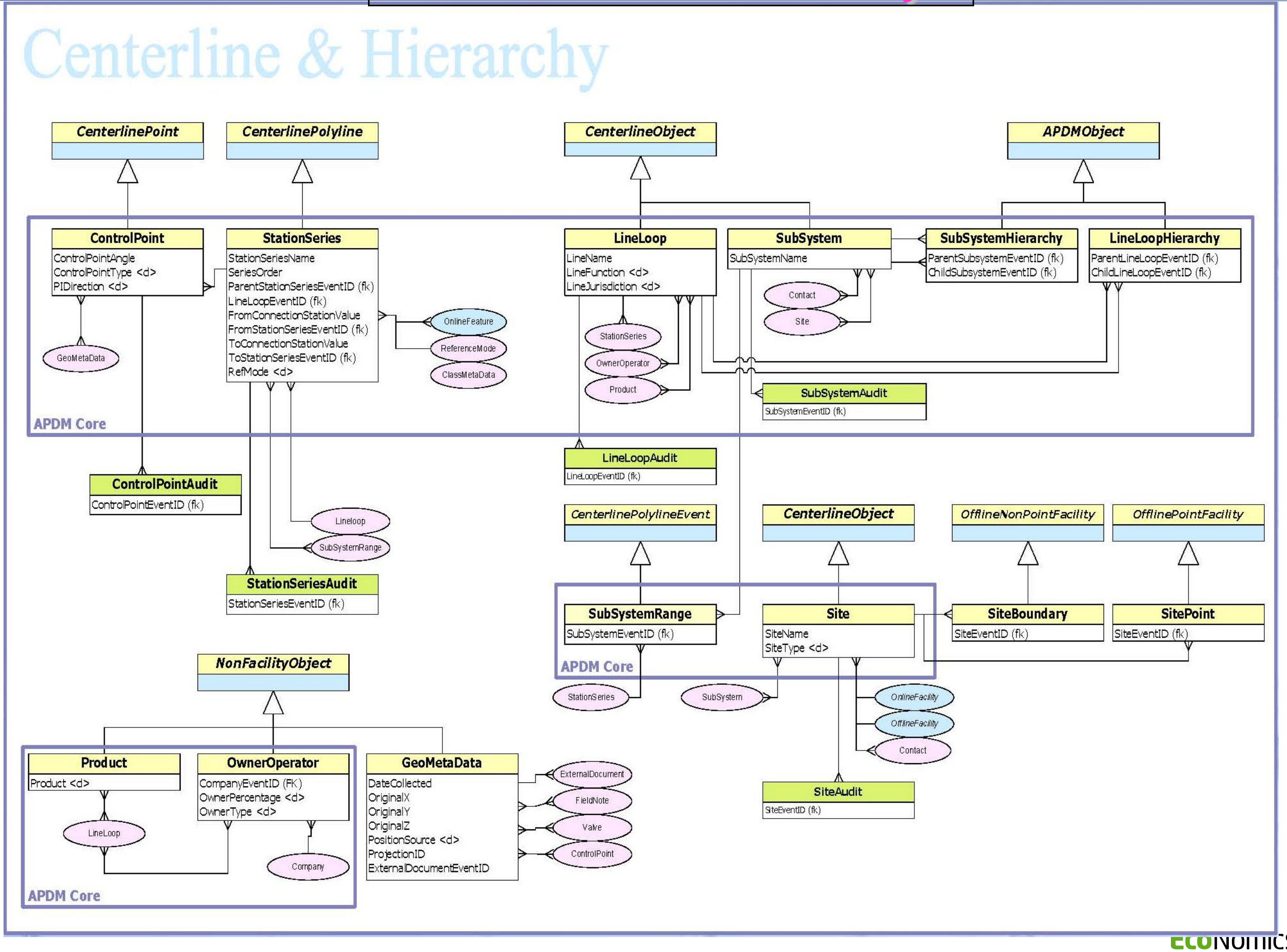
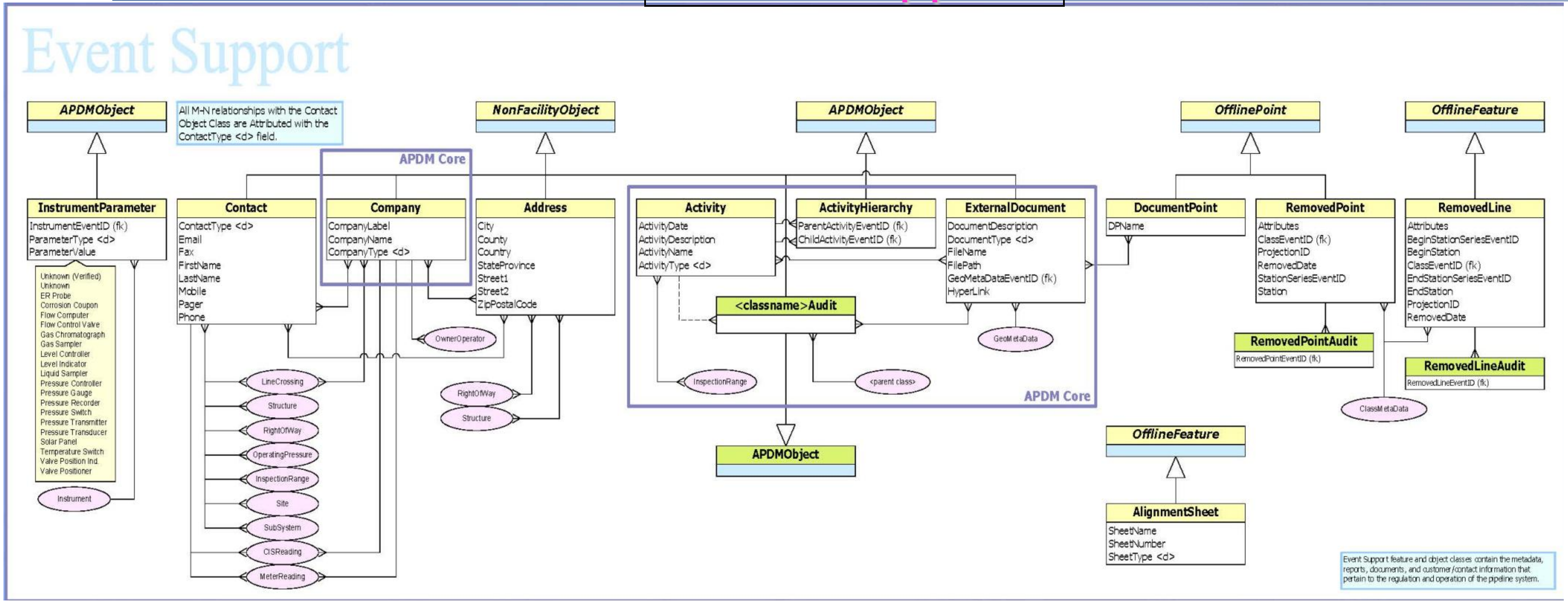
Centerline & Hierarchy



Event Support



Event Support

All M-N relationships with the Contact Object Class are Attributed with the ContactType <d> field.

APDMObject

InstrumentParameter
InstrumentEventID (fk)
ParameterType <d>
ParameterValue

Unknown (Verified)
Unknown
ER Probe
Corrosion Coupon
Flow Computer
Flow Control Valve
Gas Chromatograph
Gas Sampler
Level Controller
Level Indicator
Liquid Sampler
Pressure Controller
Pressure Gauge
Pressure Recorder
Pressure Switch
Pressure Transmitter
Pressure Transducer
Solar Panel
Temperature Switch
Valve Position Ind.
Valve Positioner

Instrument

Contact
ContactType <d>
Email
Fax
FirstName
LastName
Mobile
Pager
Phone

APDM Core

Company
CompanyLabel
CompanyName
CompanyType <d>

NonFacilityObject

Address
City
County
Country
StateProvince
Street1
Street2
ZipPostalCode

OwnerOperator

LineCrossing
Structure
RightOfWay
OperatingPressure
InspectionRange
Site
SubSystem
CISReading
MeterReading

RightOfWay
Structure

APDMObject

Activity
ActivityDate
ActivityDescription
ActivityName
ActivityType <d>

ActivityHierarchy
ParentActivityEventID (fk)
ChildActivityEventID (fk)

ExternalDocument
DocumentDescription
DocumentType <d>
FileName
FilePath
GeoMetaDataEventID (fk)
HyperLink

<classname>Audit

GeoMetaData

InspectionRange

<parent class>

APDM Core

APDMObject

OfflinePoint

DocumentPoint
DPName

RemovedPoint
Attributes
ClassEventID (fk)
ProjectionID
RemovedDate
StationSeriesEventID
Station

RemovedPointAudit
RemovedPointEventID (fk)

OfflineFeature

RemovedLine
Attributes
BeginStationSeriesEventID
BeginStation
ClassEventID (fk)
EndStationSeriesEventID
EndStation
ProjectionID
RemovedDate

RemovedLineAudit
RemovedLineEventID (fk)

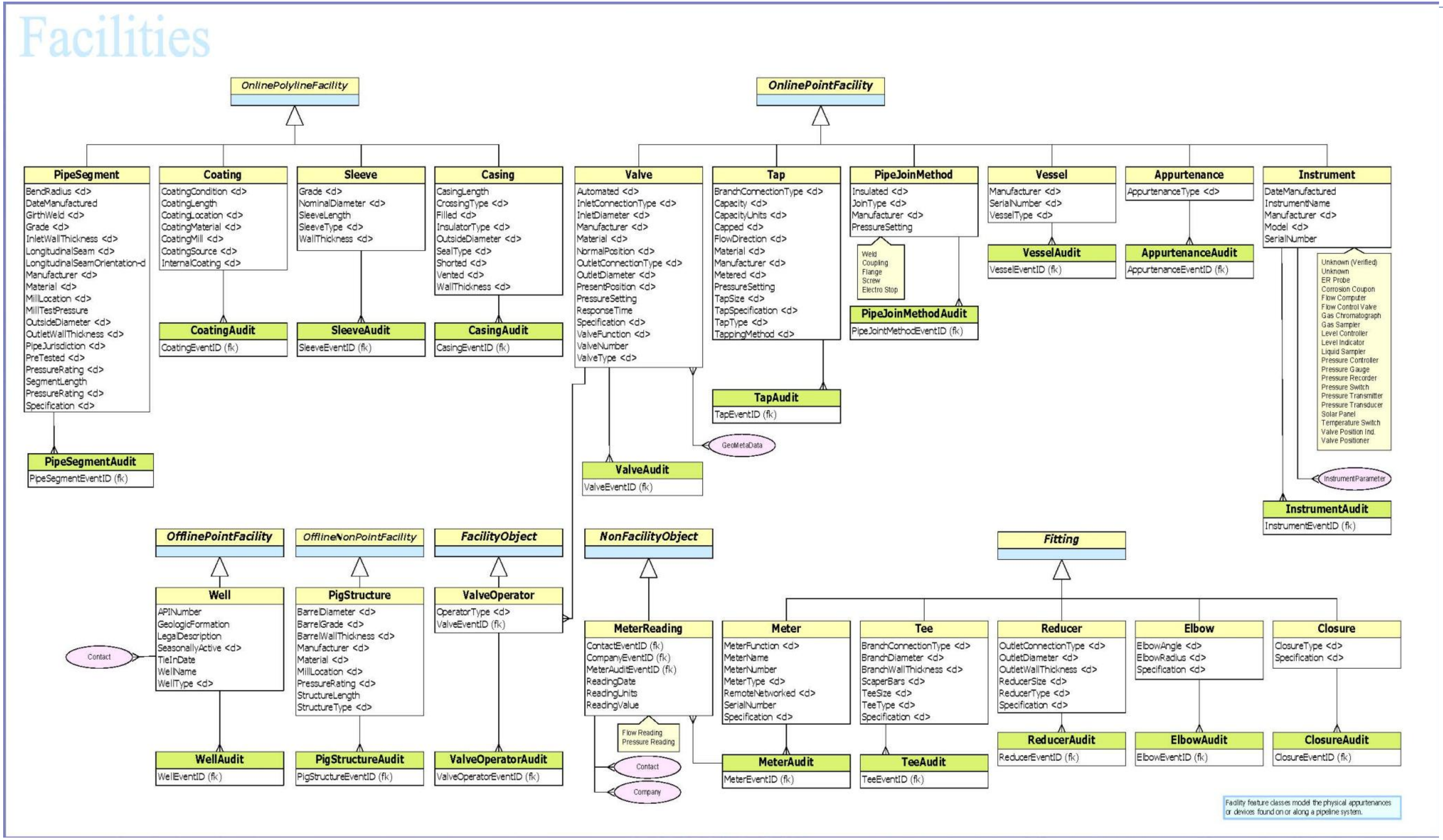
ClassMetaData

OfflineFeature

AlignmentSheet
SheetName
SheetNumber
SheetType <d>

Event Support feature and object classes contain the metadata, reports, documents, and customer/contact information that pertain to the regulation and operation of the pipeline system.

Facilities



Facilities

OnlinePolylineFacility

PipeSegment
BendRadius <d>
DateManufactured
GirthWeld <d>
Grade <d>
InletWallThickness <d>
LongitudinalSeam <d>
LongitudinalSeamOrientation-d
Manufacturer <d>
Material <d>
MillLocation <d>
MillTestPressure
OutsideDiameter <d>
OutletWallThickness <d>
PipeJurisdiction <d>
PreTested <d>
PressureRating <d>
SegmentLength
PressureRating <d>
Specification <d>

PipeSegmentAudit
PipeSegmentEventID (fk)

Coating
CoatingCondition <d>
CoatingLength
CoatingLocation <d>
CoatingMaterial <d>
CoatingMill <d>
CoatingSource <d>
InternalCoating <d>

CoatingAudit
CoatingEventID (fk)

Sleeve
Grade <d>
NominalDiameter <d>
SleeveLength
SleeveType <d>
WallThickness <d>

SleeveAudit
SleeveEventID (fk)

Casing
CasingLength
CrossingType <d>
Filled <d>
InsulatorType <d>
OutsideDiameter <d>
SealType <d>
Shorted <d>
Vented <d>
WallThickness <d>

CasingAudit
CasingEventID (fk)

OnlinePointFacility

Valve
Automated <d>
InletConnectionType <d>
InletDiameter <d>
Manufacturer <d>
Material <d>
NormalPosition <d>
OutletConnectionType <d>
OutletDiameter <d>
PresentPosition <d>
PressureSetting
ResponseTime
Specification <d>
ValveFunction <d>
ValveNumber
ValveType <d>

ValveAudit
ValveEventID (fk)

Tap
BranchConnectionType <d>
Capacity <d>
CapacityUnits <d>
Capped <d>
FlowDirection <d>
Material <d>
Manufacturer <d>
Metered <d>
PressureSetting
TapSize <d>
TapSpecification <d>
TapType <d>
TappingMethod <d>

TapAudit
TapEventID (fk)

PipeJoinMethod
Insulated <d>
JoinType <d>
Manufacturer <d>
PressureSetting

Weld
Coupling
Flange
Screw
Electro Stop

PipeJoinMethodAudit
PipeJointMethodEventID (fk)

Vessel
Manufacturer <d>
SerialNumber <d>
VesselType <d>

VesselAudit
VesselEventID (fk)

Appurtenance
AppurtenanceType <d>

AppurtenanceAudit
AppurtenanceEventID (fk)

Instrument
DateManufactured
InstrumentName
Manufacturer <d>
Model <d>
SerialNumber

Unknown (Verified)
Unknown
ER Probe
Corrosion Coupon
Flow Computer
Flow Control Valve
Gas Chromatograph
Gas Sampler
Level Controller
Level Indicator
Liquid Sampler
Pressure Controller
Pressure Gauge
Pressure Recorder
Pressure Switch
Pressure Transmitter
Pressure Transducer
Solar Panel
Temperature Switch
Valve Position Ind.
Valve Positioner

InstrumentAudit
InstrumentEventID (fk)

OfflinePointFacility

Well
APINumber
GeologicFormation
LegalDescription
SeasonallyActive <d>
TieInDate
WellName
WellType <d>

WellAudit
WellEventID (fk)

OfflineNonPointFacility

PigStructure
BarrelDiameter <d>
BarrelGrade <d>
BarrelWallThickness <d>
Manufacturer <d>
Material <d>
MillLocation <d>
PressureRating <d>
StructureLength
StructureType <d>

PigStructureAudit
PigStructureEventID (fk)

FacilityObject

ValveOperator
OperatorType <d>
ValveEventID (fk)

ValveOperatorAudit
ValveOperatorEventID (fk)

NonFacilityObject

MeterReading
ContactEventID (fk)
CompanyEventID (fk)
MeterAuditEventID (fk)
ReadingDate
ReadingUnits
ReadingValue

Flow Reading
Pressure Reading

Fitting

Meter
MeterFunction <d>
MeterName
MeterNumber
MeterType <d>
RemoteNetworked <d>
SerialNumber
Specification <d>

MeterAudit
MeterEventID (fk)

Tee
BranchConnectionType <d>
BranchDiameter <d>
BranchWallThickness <d>
ScaperBars <d>
TeeSize <d>
TeeType <d>
Specification <d>

TeeAudit
TeeEventID (fk)

Reducer
OutletConnectionType <d>
OutletDiameter <d>
OutletWallThickness <d>
ReducerSize <d>
ReducerType <d>
Specification <d>

ReducerAudit
ReducerEventID (fk)

Elbow
ElbowAngle <d>
ElbowRadius <d>
Specification <d>

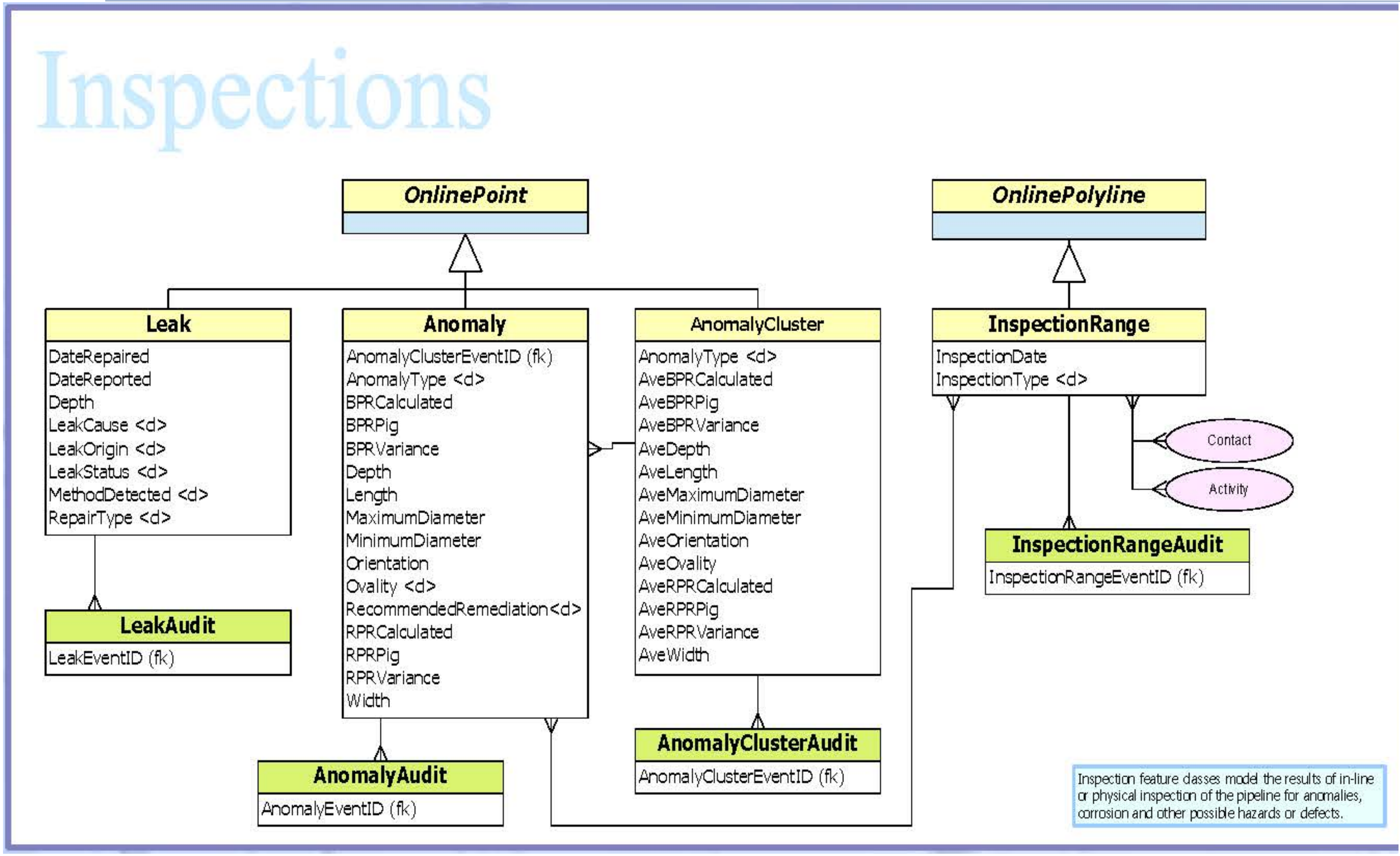
ElbowAudit
ElbowEventID (fk)

Closure
ClosureType <d>
Specification <d>

ClosureAudit
ClosureEventID (fk)

Facility feature classes model the physical appurtenances or devices found on or along a pipeline system.

Inspections



Inspections

OnlinePoint

OnlinePolyline

Leak
DateRepaired
DateReported
Depth
LeakCause <d>
LeakOrigin <d>
LeakStatus <d>
MethodDetected <d>
RepairType <d>

LeakAudit
LeakEventID (fk)

Anomaly
AnomalyClusterEventID (fk)
AnomalyType <d>
BPRCalculated
BPRPig
BPRVariance
Depth
Length
MaximumDiameter
MinimumDiameter
Orientation
Ovality <d>
RecommendedRemediation<d>
RPRCalculated
RPRPig
RPRVariance
Width

AnomalyAudit
AnomalyEventID (fk)

AnomalyCluster
AnomalyType <d>
AveBPRCalculated
AveBPRPig
AveBPRVariance
AveDepth
AveLength
AveMaximumDiameter
AveMinimumDiameter
AveOrientation
AveOvality
AveRPRCalculated
AveRPRPig
AveRPRVariance
AveWidth

AnomalyClusterAudit
AnomalyClusterEventID (fk)

InspectionRange
InspectionDate
InspectionType <d>

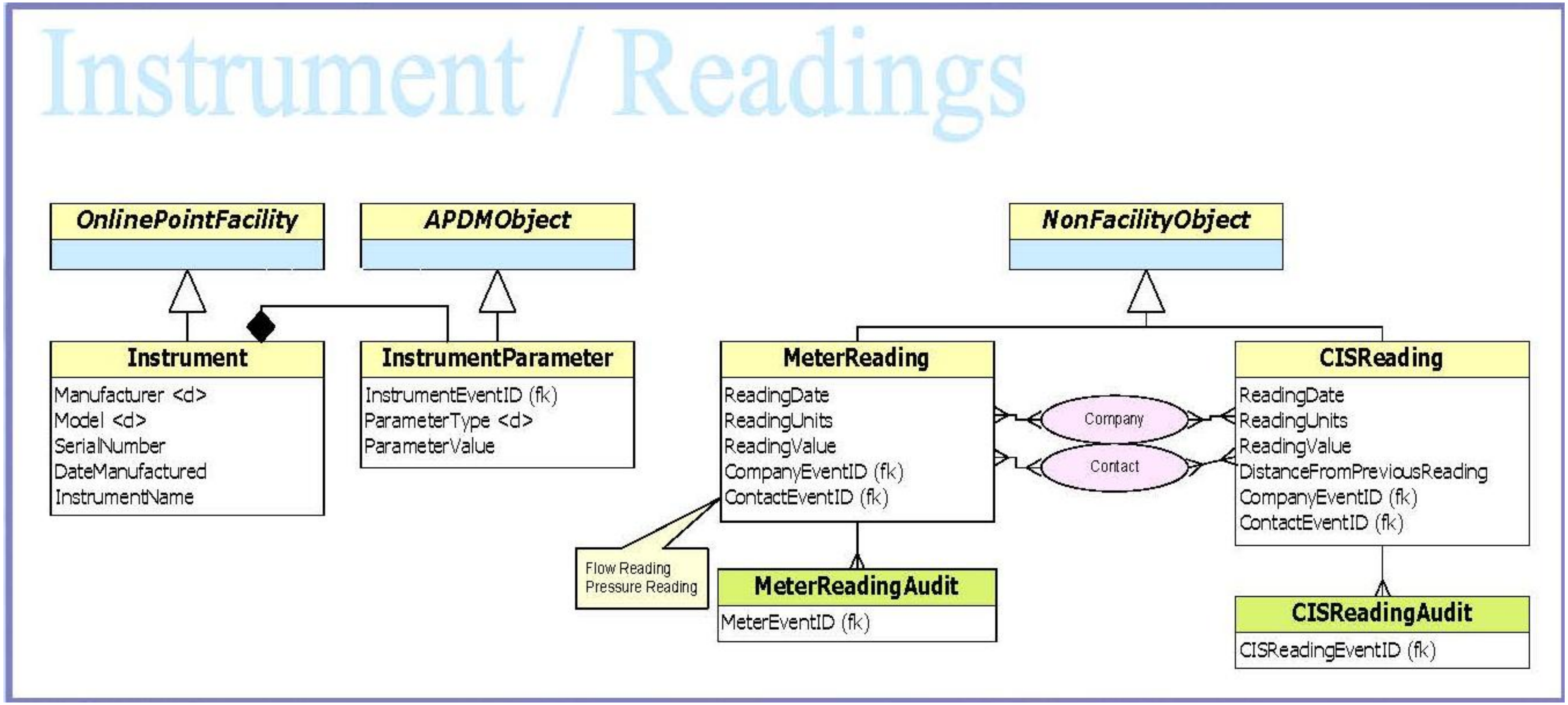
Contact

Activity

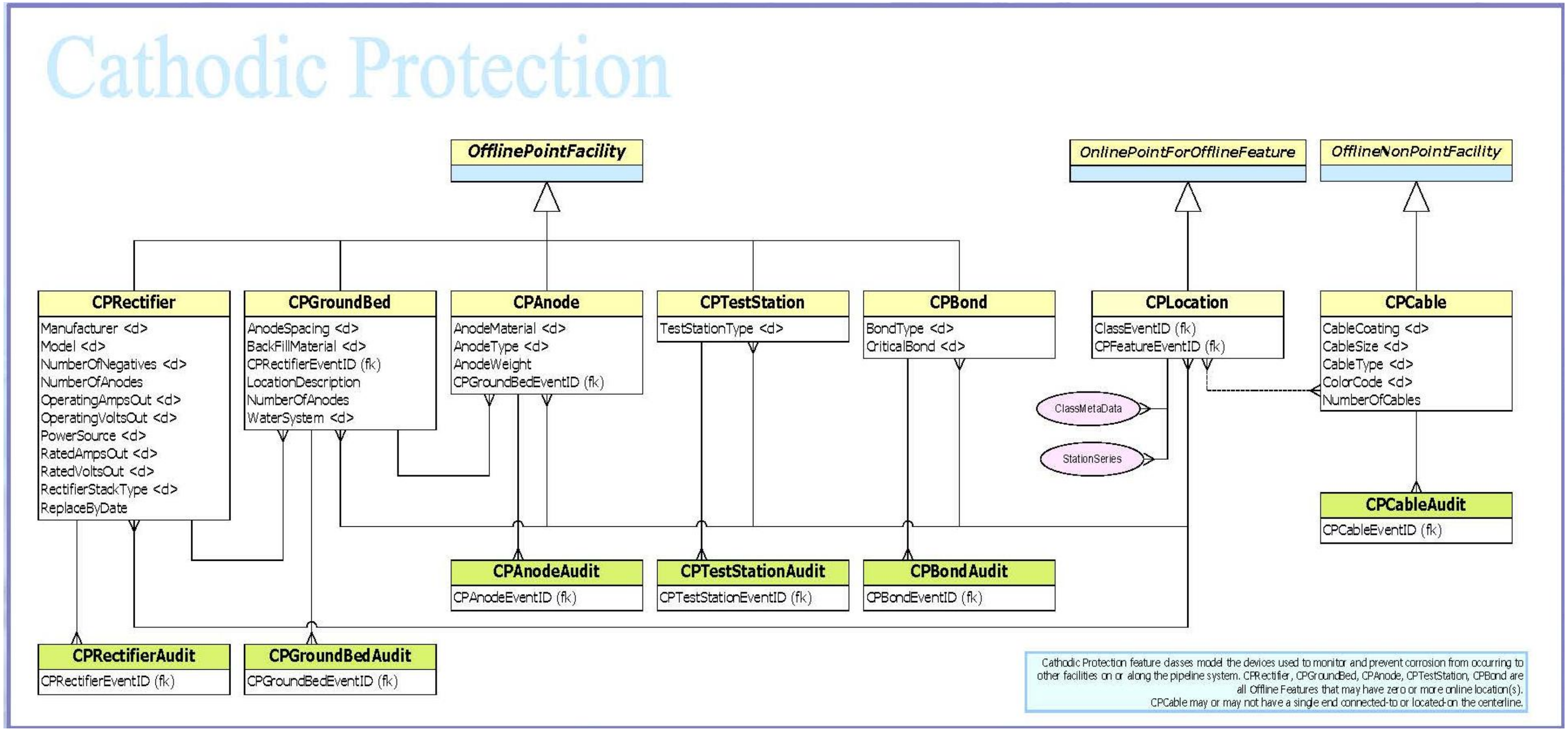
InspectionRangeAudit
InspectionRangeEventID (fk)

Inspection feature classes model the results of in-line or physical inspection of the pipeline for anomalies, corrosion and other possible hazards or defects.

Instrument / Readings



Cathodic Protection



Cathodic Protection

OfflinePointFacility

OnlinePointForOfflineFeature

OfflineNonPointFacility

CPRectifier
Manufacturer <d>
Model <d>
NumberOfNegatives <d>
NumberOfAnodes
OperatingAmpsOut <d>
OperatingVoltsOut <d>
PowerSource <d>
RatedAmpsOut <d>
RatedVoltsOut <d>
RectifierStackType <d>
ReplaceByDate

CPGroundBed
AnodeSpacing <d>
BackFillMaterial <d>
CPRectifierEventID (fk)
LocationDescription
NumberOfAnodes
WaterSystem <d>

CPAnode
AnodeMaterial <d>
AnodeType <d>
AnodeWeight
CPGroundBedEventID (fk)

CPTestStation
TestStationType <d>

CPBond
BondType <d>
CriticalBond <d>

CPLocation
ClassEventID (fk)
CPFeatureEventID (fk)

CPCable
CableCoating <d>
CableSize <d>
CableType <d>
ColorCode <d>
NumberOfCables

CPCableAudit
CPCableEventID (fk)

CPAnodeAudit
CPAnodeEventID (fk)

CPTestStationAudit
CPTestStationEventID (fk)

CPBondAudit
CPBondEventID (fk)

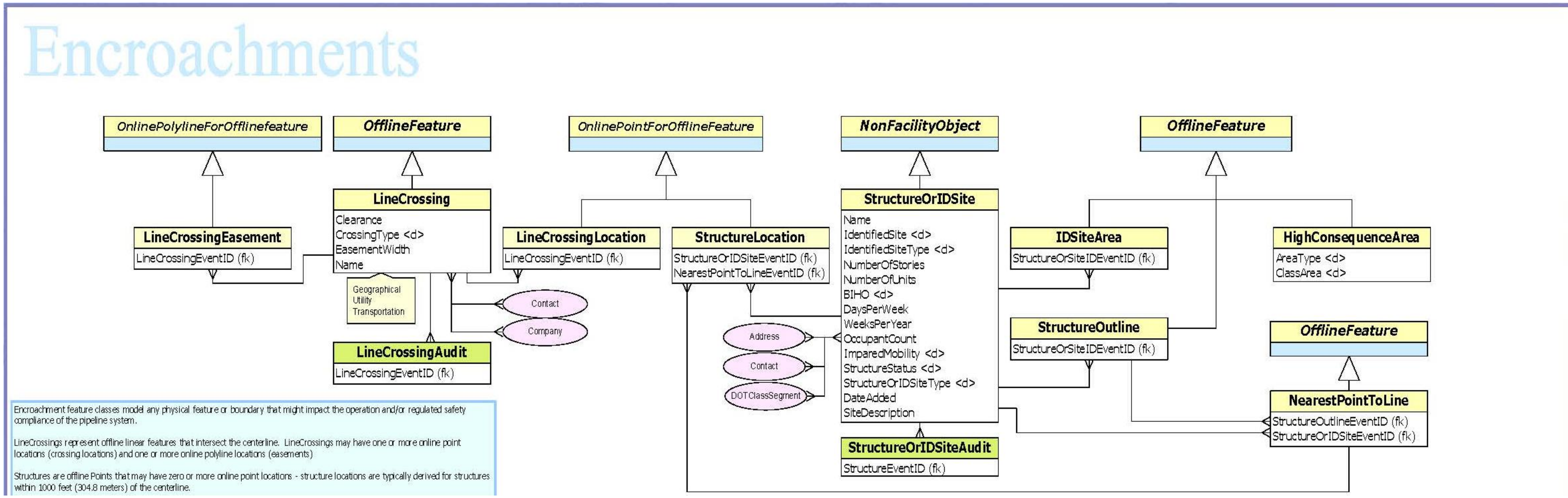
CPRectifierAudit
CPRectifierEventID (fk)

CPGroundBedAudit
CPGroundBedEventID (fk)

Cathodic Protection feature classes model the devices used to monitor and prevent corrosion from occurring to other facilities on or along the pipeline system. CPRectifier, CPGroundBed, CPAnode, CPTestStation, CPBond are all Offline Features that may have zero or more online location(s).
CPCable may or may not have a single end connected-to or located-on the centerline.

WorleyParsons
resources & energy

Encroachments



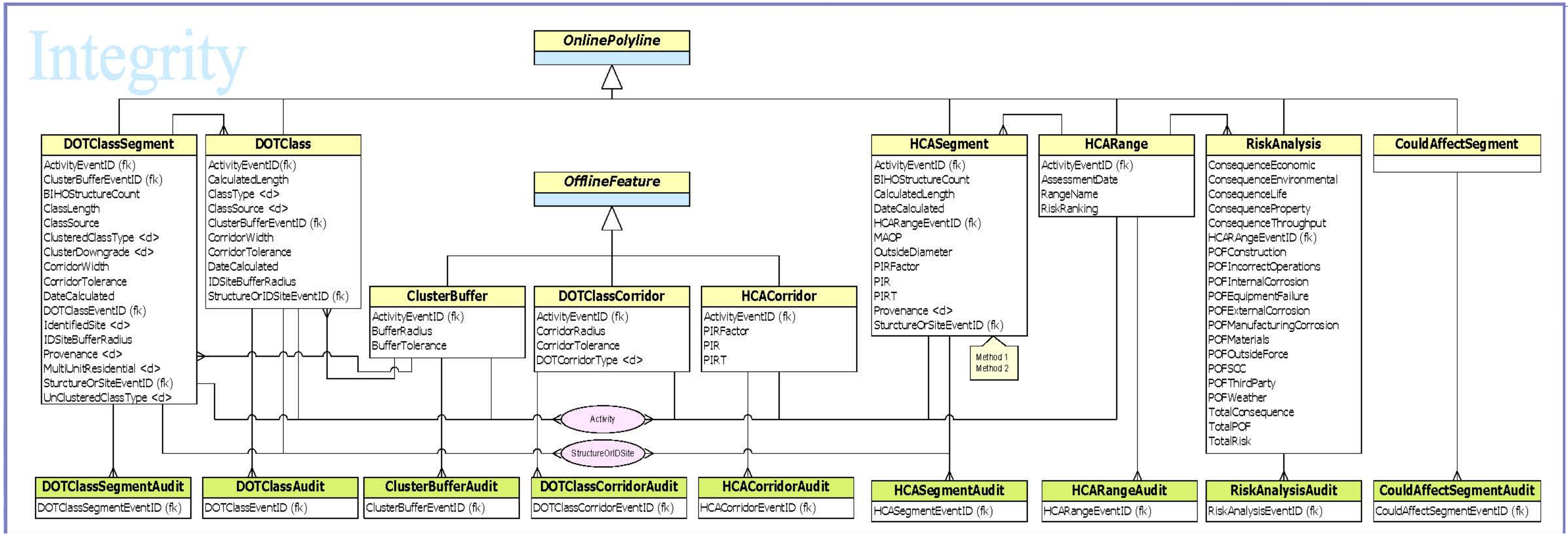
Encroachments

Encroachment feature classes model any physical feature or boundary that might impact the operation and/or regulated safety compliance of the pipeline system.

LineCrossings represent offline linear features that intersect the centerline. LineCrossings may have one or more online point locations (crossing locations) and one or more online polyline locations (easements)

Structures are offline Points that may have zero or more online point locations - structure locations are typically derived for structures within 1000 feet (304.8 meters) of the centerline.

Integrity



Integrity

OnlinePolyline

OfflineFeature

DOTClassSegment
ActivityEventID (fk)
ClusterBufferEventID (fk)
BIHOStructureCount
ClassLength
ClassSource
ClusteredClassType <d>
ClusterDowngrade <d>
CorridorWidth
CorridorTolerance
DateCalculated
DOTClassEventID (fk)
IdentifiedSite <d>
IDSiteBufferRadius
Provenance <d>
MultiUnitResidential <d>
SturctureOrSiteEventID (fk)
UnClusteredClassType <d>

DOTClass
ActivityEventID(fk)
CalculatedLength
ClassType <d>
ClassSource <d>
ClusterBufferEventID (fk)
CorridorWidth
CorridorTolerance
DateCalculated
IDSiteBufferRadius
StructureOrIDSiteEventID (fk)

ClusterBuffer
ActivityEventID (fk)
BufferRadius
BufferTolerance

DOTClassCorridor
ActivityEventID (fk)
CorridorRadius
CorridorTolerance
DOTCorridorType <d>

HCACorridor
ActivityEventID (fk)
PIRFactor
PIR
PIRT

HCASegment
ActivityEventID (fk)
BIHOStructureCount
CalculatedLength
DateCalculated
HCARangeEventID (fk)
MAOP
OutsideDiameter
PIRFactor
PIR
PIRT
Provenance <d>
SturctureOrSiteEventID (fk)

Method 1
Method 2

HCARange
ActivityEventID (fk)
AssessmentDate
RangeName
RiskRanking

RiskAnalysis
ConsequenceEconomic
ConsequenceEnvironmental
ConsequenceLife
ConsequenceProperty
ConsequenceThroughput
HCARAngeEventID (fk)
POFConstruction
POFIncorrectOperations
POFInternalCorrosion
POFEquipmentFailure
POFExternalCorrosion
POFManufacturingCorrosion
POFMaterials
POFOutsideForce
POFSCC
POFThirdParty
POFWeather
TotalConsequence
TotalPOF
TotalRisk

CouldAffectSegment

Activity

StructureOrIDSite

DOTClassSegmentAudit
DOTClassSegmentEventID (fk)

DOTClassAudit
DOTClassEventID (fk)

ClusterBufferAudit
ClusterBufferEventID (fk)

DOTClassCorridorAudit
DOTClassCorridorEventID (fk)

HCACorridorAudit
HCACorridorEventID (fk)

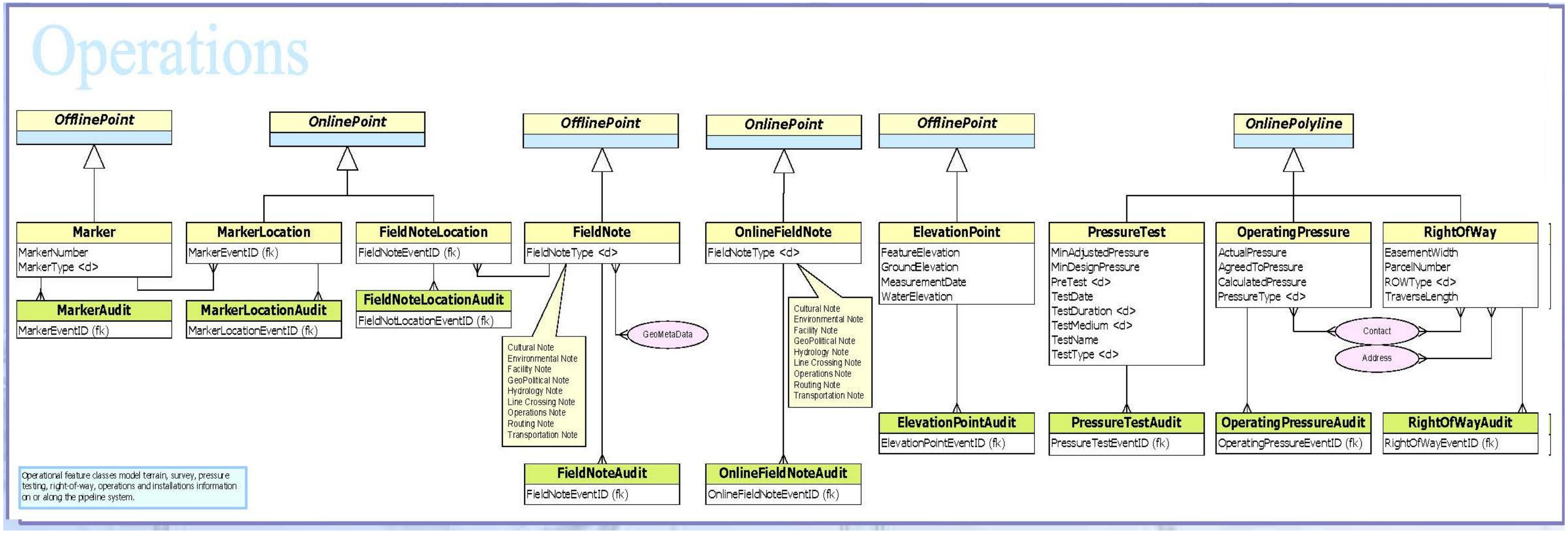
HCASegmentAudit
HCASegmentEventID (fk)

HCARangeAudit
HCARangeEventID (fk)

RiskAnalysisAudit
RiskAnalysisEventID (fk)

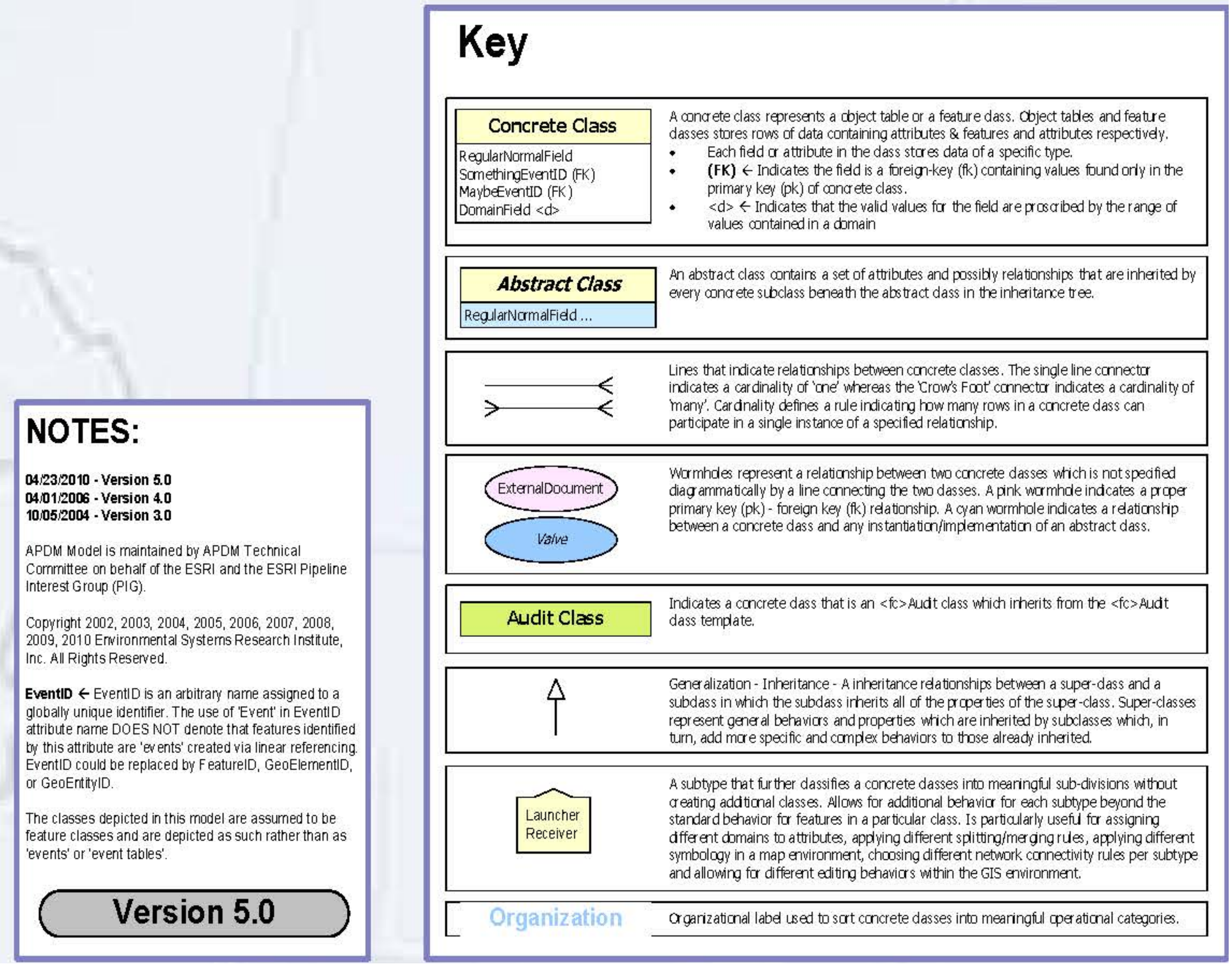
CouldAffectSegmentAudit
CouldAffectSegmentEventID (fk)

Operations



Operational feature classes model terrain, survey, pressure testing, right-of-way, operations and installations information on or along the pipeline system.

Key Info



Key

Concrete Class
RegularNormalField
SomethingEventID (FK)
MaybeEventID (FK)
DomainField <d>

A concrete class represents a object table or a feature class. Object tables and feature classes stores rows of data containing attributes & features and attributes respectively.

- Each field or attribute in the class stores data of a specific type.
- **(FK)** ← Indicates the field is a foreign-key (fk) containing values found only in the primary key (pk) of concrete class.
- <d> ← Indicates that the valid values for the field are proscribed by the range of values contained in a domain

Abstract Class
RegularNormalField ...

An abstract class contains a set of attributes and possibly relationships that are inherited by every concrete subclass beneath the abstract class in the inheritance tree.

Lines that indicate relationships between concrete classes. The single line connector indicates a cardinality of 'one' whereas the 'Crow's Foot' connector indicates a cardinality of 'many'. Cardinality defines a rule indicating how many rows in a concrete class can participate in a single instance of a specified relationship.

ExternalDocument

Valve

Wormholes represent a relationship between two concrete classes which is not specified diagrammatically by a line connecting the two classes. A pink wormhole indicates a proper primary key (pk) - foreign key (fk) relationship. A cyan wormhole indicates a relationship between a concrete class and any instantiation/implementation of an abstract class.

Audit Class

Indicates a concrete class that is an <fc>Audit class which inherits from the <fc>Audit class template.

Generalization - Inheritance - A inheritance relationships between a super-class and a subclass in which the subclass inherits all of the properties of the super-class. Super-classes represent general behaviors and properties which are inherited by subclasses which, in turn, add more specific and complex behaviors to those already inherited.

Launcher
Receiver

A subtype that further classifies a concrete classes into meaningful sub-divisions without creating additional classes. Allows for additional behavior for each subtype beyond the standard behavior for features in a particular class. Is particularly useful for assigning different domains to attributes, applying different splitting/merging rules, applying different symbology in a map environment, choosing different network connectivity rules per subtype and allowing for different editing behaviors within the GIS environment.

Organization

Organizational label used to sort concrete classes into meaningful operational categories.

NOTES:

04/23/2010 - Version 5.0
04/01/2006 - Version 4.0
10/05/2004 - Version 3.0

APDM Model is maintained by APDM Technical Committee on behalf of the ESRI and the ESRI Pipeline Interest Group (PIG).

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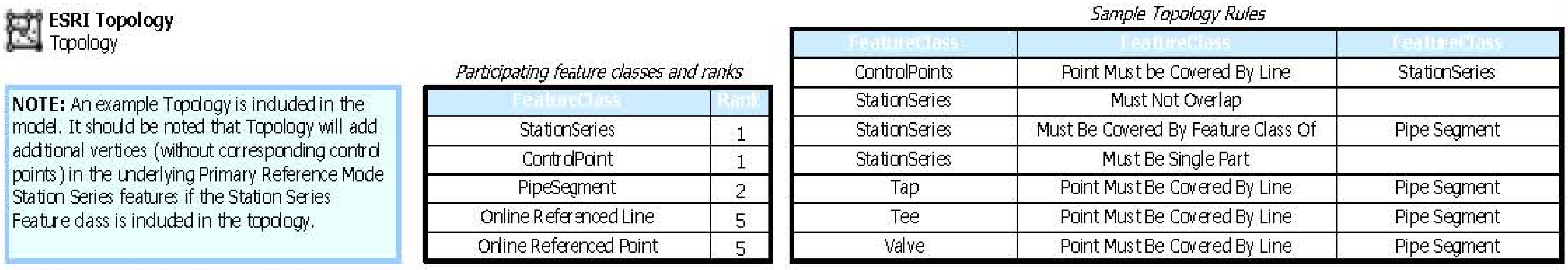
EventID ← EventID is an arbitrary name assigned to a globally unique identifier. The use of 'Event' in EventID attribute name DOES NOT denote that features identified by this attribute are 'events' created via linear referencing. EventID could be replaced by FeatureID, GeoElementID, or GeoEntityID.

The classes depicted in this model are assumed to be feature classes and are depicted as such rather than as 'events' or 'event tables'.

Version 5.0

Topology



ESRI Topology
Topology

NOTE: An example Topology is included in the model. It should be noted that Topology will add additional vertices (without corresponding control points) in the underlying Primary Reference Mode Station Series features if the Station Series Feature class is included in the topology.

Participating feature classes and ranks

FeatureClass	Rank
StationSeries	1
ControlPoint	1
PipeSegment	2
Online Referenced Line	5
Online Referenced Point	5

Sample Topology Rules

FeatureClass	FeatureClass	FeatureClass
ControlPoints	Point Must be Covered By Line	StationSeries
StationSeries	Must Not Overlap	
StationSeries	Must Be Covered By Feature Class Of	Pipe Segment
StationSeries	Must Be Single Part	
Tap	Point Must Be Covered By Line	Pipe Segment
Tee	Point Must Be Covered By Line	Pipe Segment
Valve	Point Must Be Covered By Line	Pipe Segment