



ELF EUROPEAN
LOCATION
FRAMEWORK

Consistency and Quality of INSPIRE & ELF Data, using GIS Tools

Presentation to: Workshop on Spatial Data and Map Quality

Author: Paul Hardy ([phardy@esri.com](mailto:p Hardy@esri.com)), Jay Cary, Roberto Lucchi, Rene Hinojosa

Date: 20 Jan 2015, Malta

ESRI Quality Solution

★ Geodatabase Integrity

- ★ Schema constraints (Attribute Domains etc)
- ★ Rich data types (networks, etc)
- ★ Geoprocessing tools (Check Feature etc)
- ★ Data Load Checks (SDE)
- ★ Versioning to protect integrity of long transactions

★ Topology

- ★ Topology Rules and error handling

★ ArcGIS Data Reviewer

- ★ Primary Quality Assessment tool

★ ArcGIS for INSPIRE

- ★ Pre-prepared INSPIRE/ELF geodatabase data models
- ★ Quality rule batch jobs

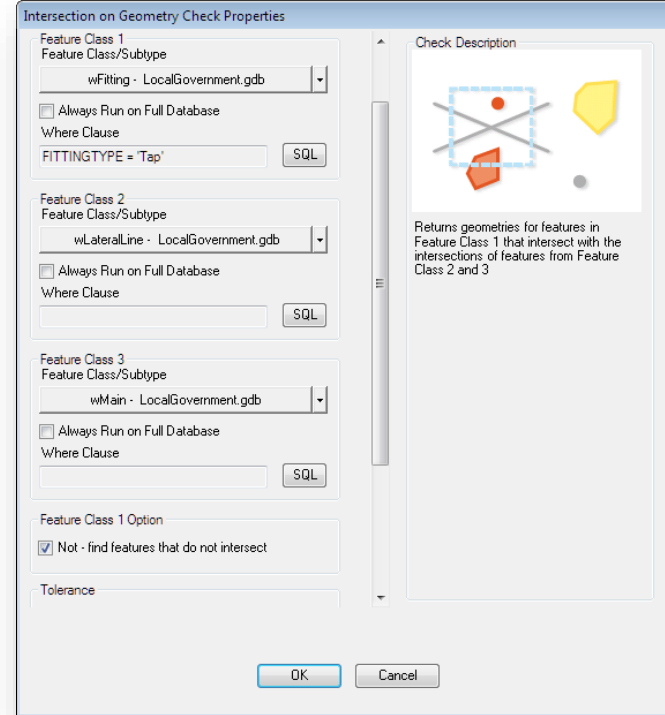
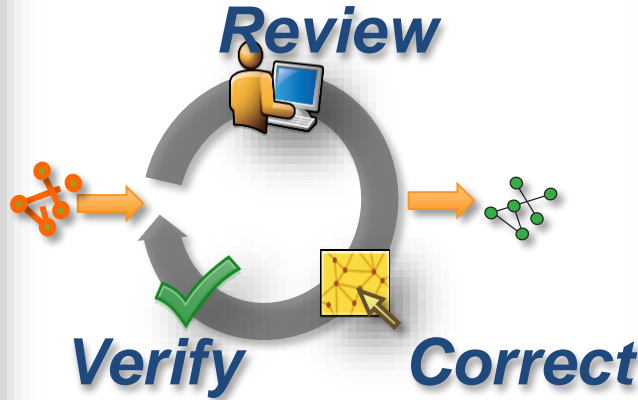
Data Loading and Checking

- ★ ArcGIS reading of shapefiles etc is tolerant of errors
 - ★ Null geometry, Self intersections, Invalid holes
- ★ So two geoprocessing tools to detect and repair
 - ★ Check_Features, Repair_Features
- ★ When data stored in SDE geodatabase – less tolerant
 - ★ SDE will clean geometry on load, to canonical forms
- ★ Geoprocessing framework and model builder
 - ★ 1000+ geoprocessing tools, including ones for data loading and restructuring
- ★ Data Interoperability Extension
 - ★ 70+ formats read
 - ★ Safe Software FME and workbench

ArcGIS Data Reviewer

Checks configurable

Many Automated checks

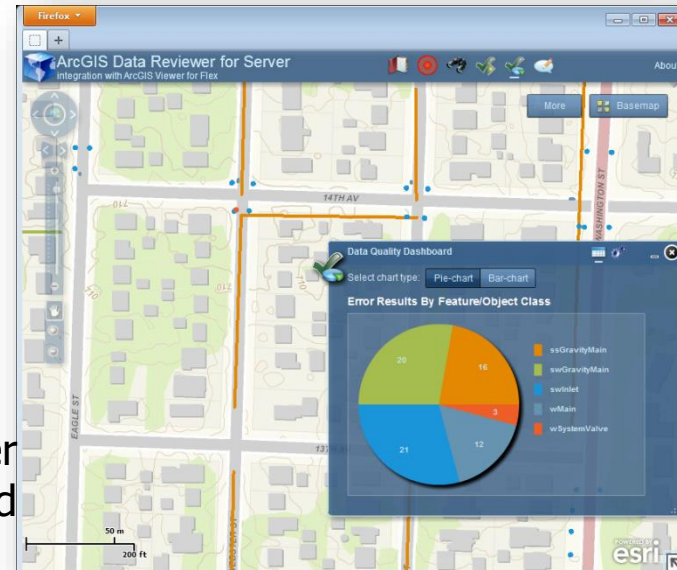


Reviewer Table

RECORDID	OBJECTID	SESSIONID	CHECKTITLE	ORIGINTABLE	ORIGINCHECK
27626	45622	2	Unique FacilityID Check	swGravityMain	Unique ID Check
27627	45623	2	Unique FacilityID Check	swGravityMain	Unique ID Check
27628	26532	2	Unique FacilityID Check	swGravityMain	Unique ID Check
27629	37445	2	Unique FacilityID Check	swGravityMain	Unique ID Check
27630	45707	2	Unique FacilityID Check	swGravityMain	Unique ID Check
27631	45708	2	Unique FacilityID Check	swGravityMain	Unique ID Check
27632	45709	2	Unique FacilityID Check	swGravityMain	Unique ID Check
27633	45721	2	Unique FacilityID Check	swGravityMain	Unique ID Check
27634	45722	2	Unique FacilityID Check	swGravityMain	Unique ID Check
27635	23491	2	Unique FacilityID Check	swGravityMain	Unique ID Check
27636	37439	2	Unique FacilityID Check	swGravityMain	Unique ID Check
27637	45657	2	Unique FacilityID Check	swGravityMain	Unique ID Check
27638	45658	2	Unique FacilityID Check	swGravityMain	Unique ID Check

Errors table Integrated

Server Dashboard

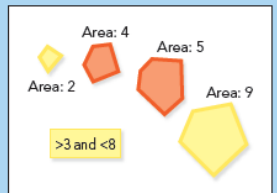


ArcGIS Data Reviewer Checks

Polygon Checks

Evaluate Polygon Perimeter and Area

Searches for polygon, part, ring, or segment features whose area or perimeter is within a specified range



Invalid Hole Feature

Finds features that intersect polygon feature holes



Polygon Sliver

Finds polygons below a specified thinness ratio (t) and optionally whose area is within a specified threshold

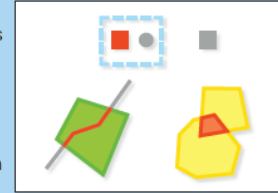


Feature on Feature Checks

Geometry on Geometry

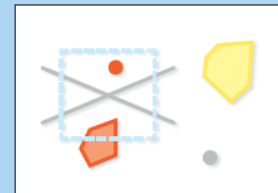
Searches for features from two different feature classes or within the same feature class that spatially interact (e.g., intersect) or are within a tolerance of each other

Comparison to Topology:
Line—Must not overlap, intersect, or overlap with
Polygon—Must not overlap, contain point, or overlap with



Intersection on Geometry

Returns geometries for features in Feature Class 1 that intersect with the intersections from features from Feature Class 2 and 3



Polygon Overlap/Gap Is Sliver

Returns overlap/gap geometries between polygon features from two feature classes that have a thinness ratio beneath a user-specified threshold; optionally requires that the overlap/gap polygons be beneath a maximum area threshold

Comparison to Topology:
Polygon must not have gaps

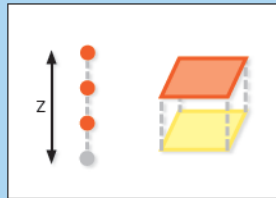


ArcGIS Data Reviewer Checks

Duplicate Geometry Checks

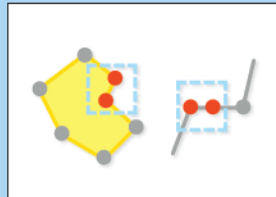
Duplicate Geometry

Finds features of the same geometry type that are collocated



Duplicate Vertex

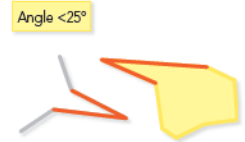
Searches for vertices in selected polyline or polygon feature classes that are within a specified tolerance of each other



Polyline Checks

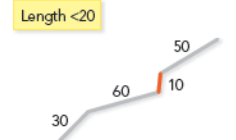
Cutbacks

Identifies segments where the angle between segments in a polygon or polyline is below a specified minimum value



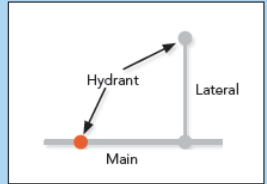
Evaluate Polyline Length

Searches for segment, part/path, and polyline features whose length is within a specified range




Database Validation Checks

Connectivity Rules Returns geometries for features that violate the geometric network connectivity rules

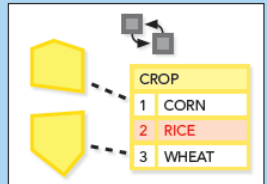


Domain Validates coded value and range domains to ensure that all values meet domain constraints

LAND USE	DESCRIPTION
000	UNCLASSIFIED
AGR	AGRICULTURE PLAN
SDP	INDUSTRIAL
IND	



Relationships Searches for records that are orphans or have improper cardinality in a relationship class



Subtype Searches for feature classes with improper or null subtypes

SUBTYPES	Subtype=0
1 HIGHWAYS	
2 MAJOR ROAD	
3 LOCAL STREETS	
4 ALLEY	


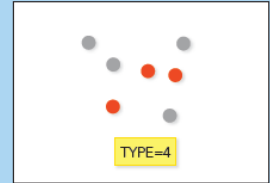


Table Checks

Execute SQL Finds features based on a SQL query WHERE clause



Regular Expression Finds features with attribute values that violate the regular expression

FIELD	REGULAR EXPRESSION	YEAR
YEAR	(19/20)D\D	1805
		1972
		2005
		200A

Table to Table Attribute Returns rows whose attributes match those of a feature class or table and/or comply with a user-defined WHERE clause comparing the attributes between feature classes and/or tables

FEATURE CLASS	OID	SCALE	SCALE
	1	10,000	20,000
	2	20,000	30,000
	3	10,000	
	4	30,000	

Unique ID Checks the values of a set of fields across a set of tables and feature classes for uniqueness within a given workspace

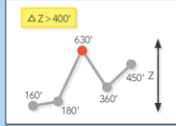
FEATURE CLASS 1	FEATURE CLASS 2
7 25	
8 18	1 36
9 18	2 21
	3 18

ArcGIS Data Reviewer Checks

Z-Value Checks

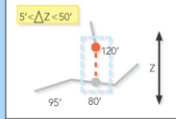
Adjacent Vertex Elevation Change

Finds vertices for polyline or polygon features with elevation (z-value) changes greater than the specified tolerance



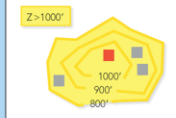
Different Z at Intersection

Finds two intersecting line features whose z-value difference is within the minimum/maximum specified tolerance values at the point where they intersect



Evaluate Z-Values

Searches for features whose z-values are within a specified range



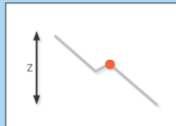
Polygon/Ring Closed

Searches for unclosed rings in polygons based on the x-value, y-value, and z-value



Slope Direction Change (Monotonicity)

Searches for polylines with vertices that change slope direction according to specified conditions



Topology Checks

Find Dangles

Finds polyline features with nodes that are within a user-defined tolerance but not connected to other polyline or polygon features



Orphan

Finds single polyline features that are not connected in the database topology



Unnecessary Nodes

Finds features that share a node and have identical attributes in editable fields
Comparison to Topology:
Line must not have pseudo nodes



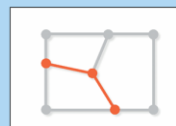
Unnecessary Polygon Boundaries

Finds adjacent polygon features that share a boundary and have identical attributes in editable fields



Topology Rules

Returns the geometry of features that violate the topology rules that have been defined for a feature dataset in the geodatabase



Default Checks

Invalid Geometry

Finds features whose geometry is empty, nothing, or not simple, as well as features with empty envelopes

OBJECTID	SHAPE	FCSUBTYPE
1	POLYLINE	AQ040-BRIDGE LINE
2	POLYLINE	AQ040-BRIDGE LINE
3	NULL	AQ040-BRIDGE LINE

Multipart Line

Searches for polyline features with more than one part
Comparison to Topology:
Line must be single part



Multipart Polygon

Finds polygon features with more than one part and polygon features with holes



Nonlinear Segment

Searches for nonlinear segments, such as arcs and curves, in line and polygon features



Polyline or Path Closes on Self

Finds paths and lines in polylines that touch or cross themselves
Comparison to Topology:
Line must not self intersect or self-overlap



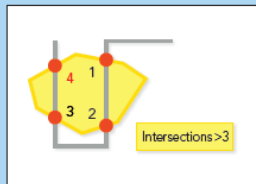
ArcGIS Data Reviewer Checks

Spatial Parameter Evaluation Checks

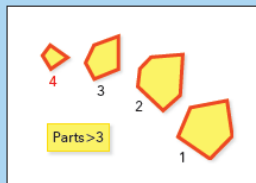
Evaluate Extent Returns features where the extent properties (x and y) are within specified parameters



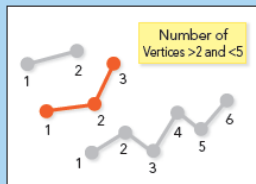
Evaluate Intersection Count Finds vertices for polyline features in one feature class that intersect polyline or polygon features in a second feature class a specified number of times



Evaluate Part Count Finds features with a part count that is within a specified range

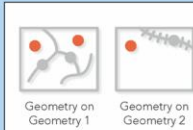


Evaluate Vertex Count Searches for features with a vertex count that is within a specified range

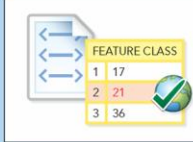


Advanced Checks

Composite Searches for features that satisfy combined Geometry on Geometry and/or Table to Table Attribute checks by feeding the results of one check into the next check



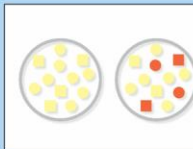
Custom Returns records that meet the validation conditions of a custom check you developed to meet your specific requirements



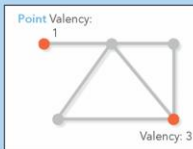
Metadata Validates that the specified GIS item descriptions have been populated to comply with either a standards-based metadata schema or user-specified content requirements

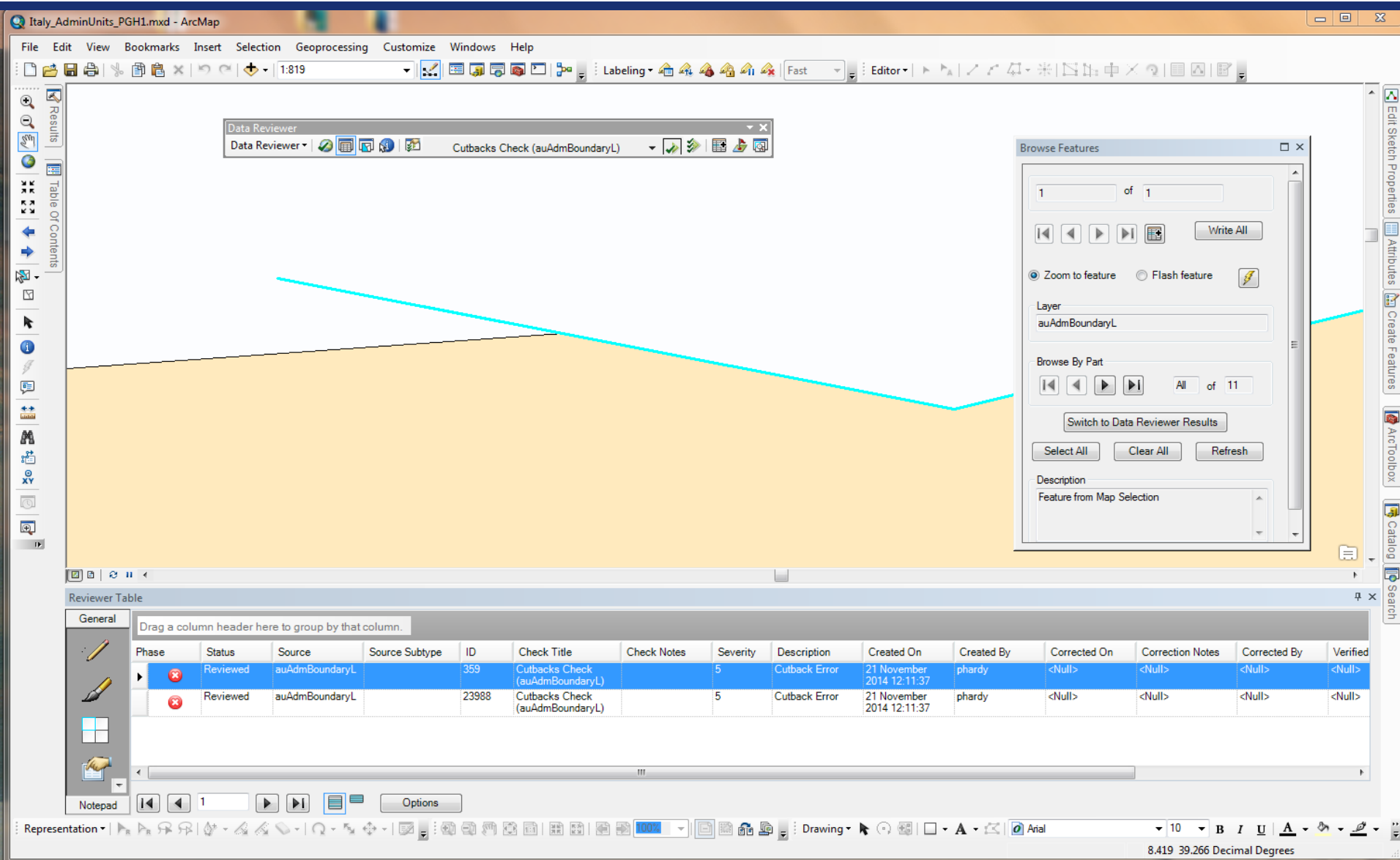


Sampling Generates a statistical sampling of features or records from one or more layers or tables



Valency Searches for points or nodes of linear features that intersect with a specified number of linear features





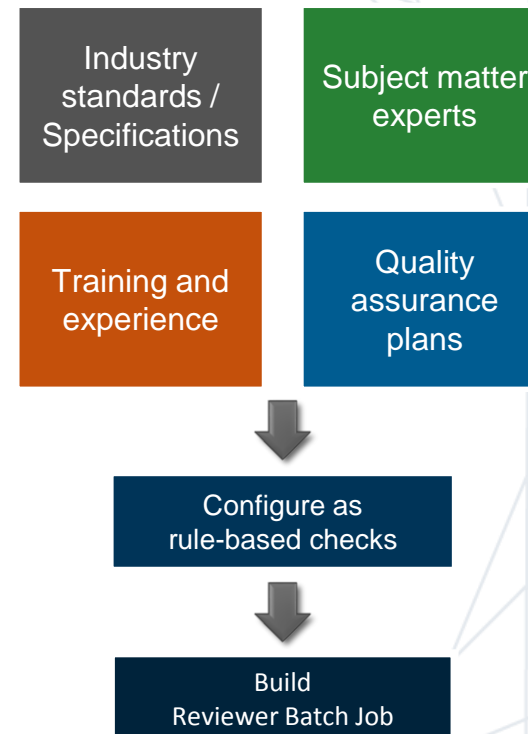
The screenshot shows the ArcMap interface with the Data Reviewer tool active. The main map area displays a yellow polygon and a cyan line. The Data Reviewer toolbar is visible, showing the 'Cutbacks Check (auAdmBoundaryL)' tool. The 'Browse Features' dialog is open, showing the layer 'auAdmBoundaryL' and 'Feature from Map Selection' in the description. The Reviewer Table at the bottom displays the following data:

Phase	Status	Source	Source Subtype	ID	Check Title	Check Notes	Severity	Description	Created On	Created By	Corrected On	Correction Notes	Corrected By	Verified
	Reviewed	auAdmBoundaryL		359	Cutbacks Check (auAdmBoundaryL)		5	Cutback Error	21 November 2014 12:11:37	phardy	<Null>	<Null>	<Null>	<Null>
	Reviewed	auAdmBoundaryL		23988	Cutbacks Check (auAdmBoundaryL)		5	Cutback Error	21 November 2014 12:11:37	phardy	<Null>	<Null>	<Null>	<Null>

Combine Multiple Rules for Batch Check

★ Implementing cumulative review

- ★ Encapsulate QC model
- ★ Designed once and executed many times
- ★ Complete specification check



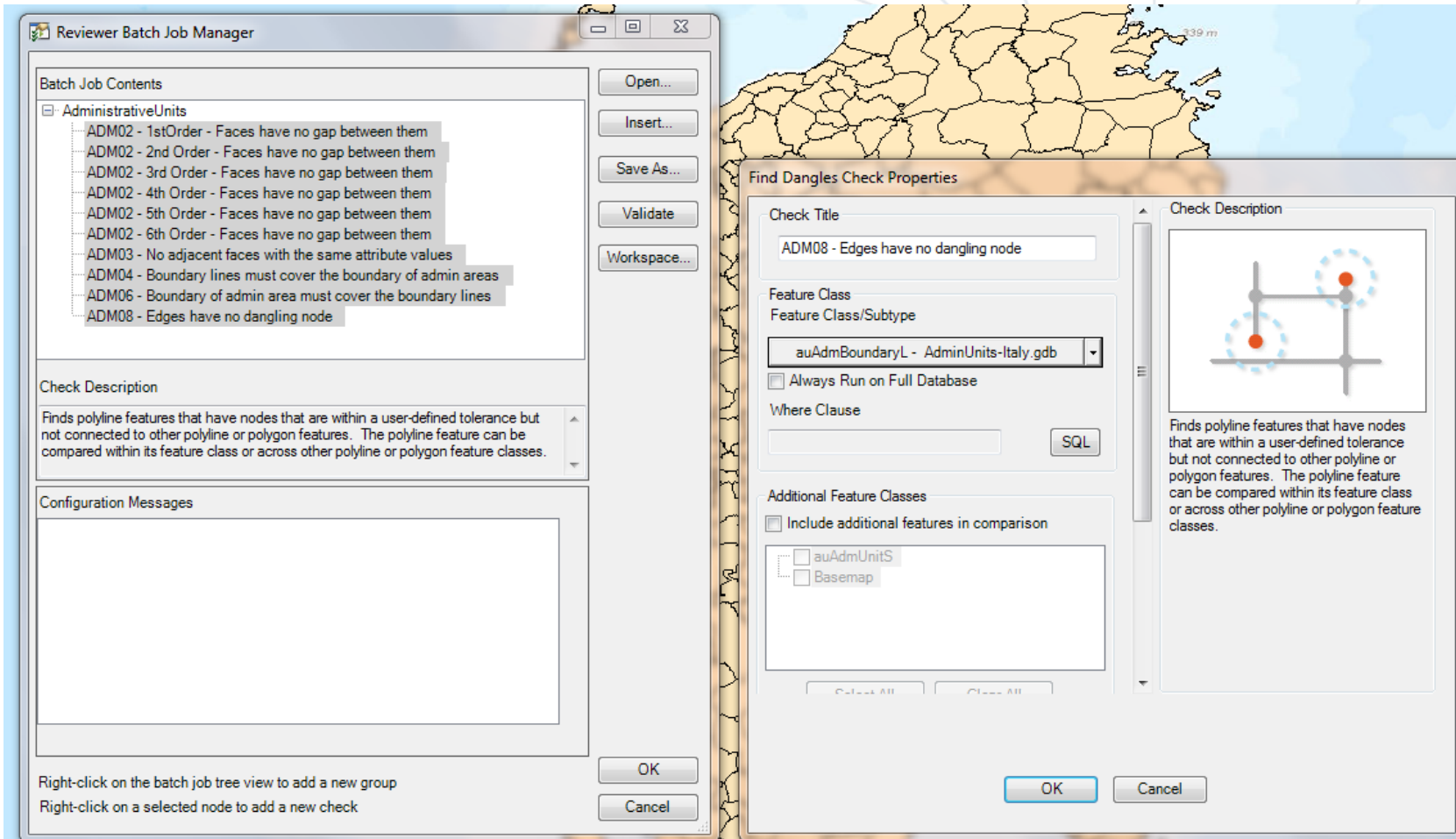
ELF Quality Rules

- ★ Being created in RuleSpeak by WP2
 - ★ For Regional/Global scale initially, then master levels
- ★ Esri has gone through spreadsheet
 - ★ Added column with ADR check for each rule
 - ★ Now implementing rules as an ADR batch job
 - ★ Has been lack of test data
- ★ Spain NMA and Cadastre offered help

RuleSpeak to Reviewer Check

	A	B	C	D	E	F	G
1	RuleID	Quality Element	Feature type	RuleSpeak rule	DR Check/ ArcToolbox	Regional	Global
2	HYD01	completeness commission	Island	The area of a surface feature must be equal or greater than the target area size .	Evaluate Polygon Perimeter and Area	target area size = 0,4km ²	Target area size = 3km ²
3	HYD02	completeness commission	Wetland	The area of a surface feature must be equal or greater than the target area size .	Evaluate Polygon Perimeter and Area	target area size = 0,4km ²	(not included in global)
4	HYD03	completeness commission	StandingWater	The area of a surface feature must be equal or greater than the target area size .	Evaluate Polygon Perimeter and Area	target area size = 0,4km ²	Target area size = 0,5km ²
5	HYD04	Completeness Omission	SeaArea, Shore, StandingWater LandWaterBoundary, DamOrWeir, Watercourse, Wetland, Island, WatercourseLink, HydroNode WatercourseLinkSequence	A feature type that is not voidable must be included in the data set.	Schema Compare Tool		(Feature type Wetland not included)
6	HYD05	Logical consistency topological consistency	HydrogeologicalObjectNatural (voidable), DamOrWeir, PumpingStation (voidable), Lock (voidable), Watercourse, WatercourseLink	A point feature must be connected to a Watercourse line feature or WatercourseLink	Geometry on Geometry		(Feature type Pumpingstation not included)
7	HYD06	Logical consistency conceptual consistency?	Watercourse	A surface feature must have an average width equal or larger than the minimum width	Execute SQL: [Width] ≥ 125m	the minimum width= 125m	the minimum width= 500m
8	HYD07	Logical consistency topological consistency	Lock, DamOrWeir Watercourse StandingWater	A line feature of Lock and DamOrWeir must lie on the boundary of a Watercourse surface feature or of StandingWater surface feature	Geometry on Geometry		(Feature type Lock not included)
9	HYD08	Logical consistency topological consistency	Lock, DamOrWeir Watercourse	A point feature of Lock and DamOrWeir must lie on the endpoint of a Watercourse line feature	Geometry on Geometry		(Feature type Lock not included)
10	HYD09	Logical consistency topological consistency	Watercourse WatercourseLink	A Watercourse surface feature must contain at least one WatercourseLink if all of the following are true: it has at least one ingoing watercourse it has at least one outgoing watercourse	Geometry on Geometry/Composite		
11	HYD10	Logical consistency topological consistency	StandingWater WatercourseLink	A StandingWater surface feature must contain at least one WatercourseLink if all of the following are true: it has at least one ingoing watercourse it has at least one outgoing watercourse	Geometry on Geometry/Composite		
12	HYD11	Logical consistency topological consistency	Wetland WatercourseLink	A Wetland surface feature must contain at least one WatercourseLink if all of the following are true: it has at least one ingoing watercourse it has at least one outgoing watercourse	Geometry on Geometry/Composite	(applies only to regional LoD)	(Feature type wetland not included)
13	HYD12	Logical consistency topological consistency	ShorelineConstruction (voidable), StandingWater, LandWaterBoundary, Falls (voidable), Embankment (voidable), DamOrWeir, PumpingStation (voidable), Watercourse, WatercourseLink, Crossing (voidable) WatercourseLinkSequence, WatercourseSeparateCrossing (voidable), Lock (voidable)	If two or more line features intersect or touch there must be a node	Topology Rules: Must Not Have Pseudo Nodes		(Feature type Falls, Embankment, PumpingStation, Crossing, Lock not included)
			HydrogeologicalObjectNatural (voidable), Falls (voidable), Embankment (voidable), DamOrWeir, Watercourse, WatercourseLink, Crossing (voidable)	A point feature must not be inside one of the following: StandingWater			(Feature type Falls, Embankment, PumpingStation, Crossing, Lock not included)

- ★ Design Batch Jobs in Batch Job Manager
- ★ Run job manually or automatically



The screenshot displays the 'Reviewer Batch Job Manager' application window. On the left, a tree view under 'Batch Job Contents' shows a hierarchy of 'AdministrativeUnits' with various checks listed, such as 'ADM02 - 1st Order - Faces have no gap between them' and 'ADM08 - Edges have no dangling node'. The 'ADM08' check is selected. Below the tree view are sections for 'Check Description' and 'Configuration Messages'. The 'Check Description' for ADM08 reads: 'Finds polyline features that have nodes that are within a user-defined tolerance but not connected to other polyline or polygon features. The polyline feature can be compared within its feature class or across other polyline or polygon feature classes.'

Overlaid on the right is the 'Find Dangles Check Properties' dialog box. It contains the following fields and options:

- Check Title:** ADM08 - Edges have no dangling node
- Feature Class:** auAdmBoundaryL - AdminUnits-Italy.gdb
- Always Run on Full Database
- Where Clause:** (empty field with an SQL button)
- Additional Feature Classes:**
 - Include additional features in comparison
 - auAdmUnitS
 - Basemap

At the bottom of the dialog, there are 'OK' and 'Cancel' buttons. A diagram in the 'Check Description' field of the dialog shows a network of lines with a red dot representing a 'dangling node' that is not connected to the rest of the network.

ArcGIS Data Reviewer – more complex check example – water utilities

WaterUtilityNetworkEditing.mxd - ArcMap

File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help

1:3,000 Data Reviewer Select Data Check

Reviewer Batch Job Manager

Batch Job Contents

- Diameter of System Valve is Null
- Valve Type of System Valve is Null
- Currently Open Status of System Valve is Null
- Install Date of System Valve is Null
- Geometry on Geometry Checks
 - Commercial Service Points not connected to Commercial Laterals
 - Domestic Service Points not connected to Domestic Laterals
 - Hydrants not connected to Hydrant Laterals
 - Diameter mismatch between System
 - Diameter mismatch between System
 - Overlapping Water Mains
 - Overlapping Water Laterals
- Valency Checks
 - Reducers not connected to exactly 2

Check Description

Returns relationship specific geometries for features in Feature Class 1 that have a user-defined relationship to features in Feature Class 2. Relationships include: crosses, intersects, touches, and others. Any 9-Intersection string containing "t", "f", or "*" An optional tolerance can be applied to the relationship for features in both feature classes.

Configuration Messages

Right-click on the batch job tree view to add a new job. Right-click on a selected node to add a new check.

Geometry on Geometry Check Properties

Check Title: Hydrants not connected to Hydrant Late

Feature Class 1: wHydrant - LocalGovernment.gdb

Feature Class 2: wLateralLine - LocalGovernment.gdb

Spatial Relation Check Type: Intersects

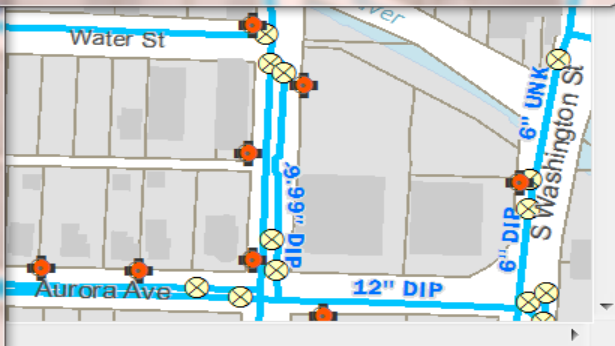
Check Description: Returns relationship specific geometries for features in Feature Class 1 that have a user-defined relationship to features in Feature Class 2. Relationships include: crosses, intersects, touches, and others. Any 9-Intersection string containing "t", "f", or "*" An optional tolerance can be applied to the relationship for features in both feature classes.

Select Features Using a Query

Fields: ACTIVEFLAG, DIAMETER, ENABLED, FACILITYID

Operators: =, <>, >, >=, <, <=, %, (,), Is, Lik, An, Or, Not

Where Clause: LINETYPE = 'Hydrant'



1033046.774 1860391.804 Feet

Reporting

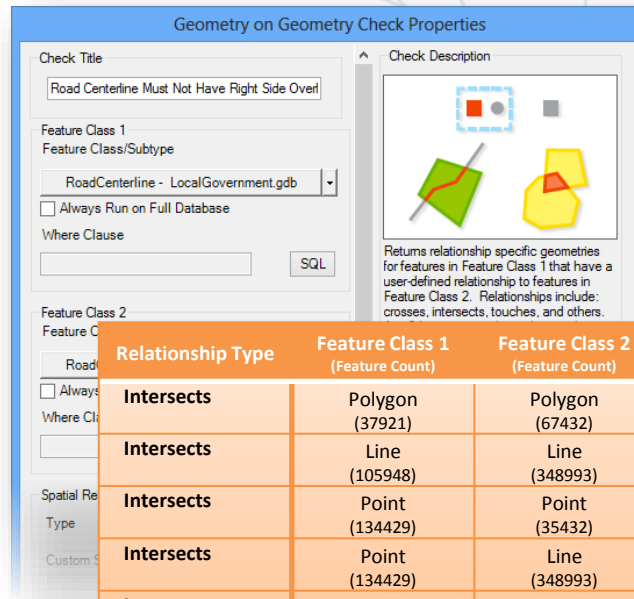
- ★ Automated reporting of quality control results
- ★ Available Reports
 - ★ Automated Check (Origin Table, Subtype, Check Group)
 - ★ Total Record Count
 - ★ Sampling

Date/Time	Origin Table	Subtype	Total Records	Confidence Level	Margin of Error	Sampling Number	Acceptable Error Percentage	Acceptable Error	Number of Errors	Pass/Fail	QC Complete
7/4/2010 11:05:59 AM											
	AtlasMap		153	98%	3%	0	2%	0	0	Pass	Yes
	wControlValve		302	98%	3%	9	2%	1	1	Pass	Yes
		AirRelease				2			0		
		BackflowControl				4			0		
		BlowOff				3			1		
	wFitting		297	98%	3%	9	2%	1	2	Fail	Yes
		Reducer				7			0		
		Tap				2			2		
	wLateralLine		18690	98%	3%	544	2%	17	9	Pass	Yes
		Hydrant Lateral				50			0		
		Service Lateral				493			8		
		Service Lateral To Meter				1			1		

ArcGIS 10.3 - Improved Check Performance

Goals

- ★ Improve stability
- ★ Reduce validation time in commonly-used checks
- ★ Maintain equivalency with prior releases

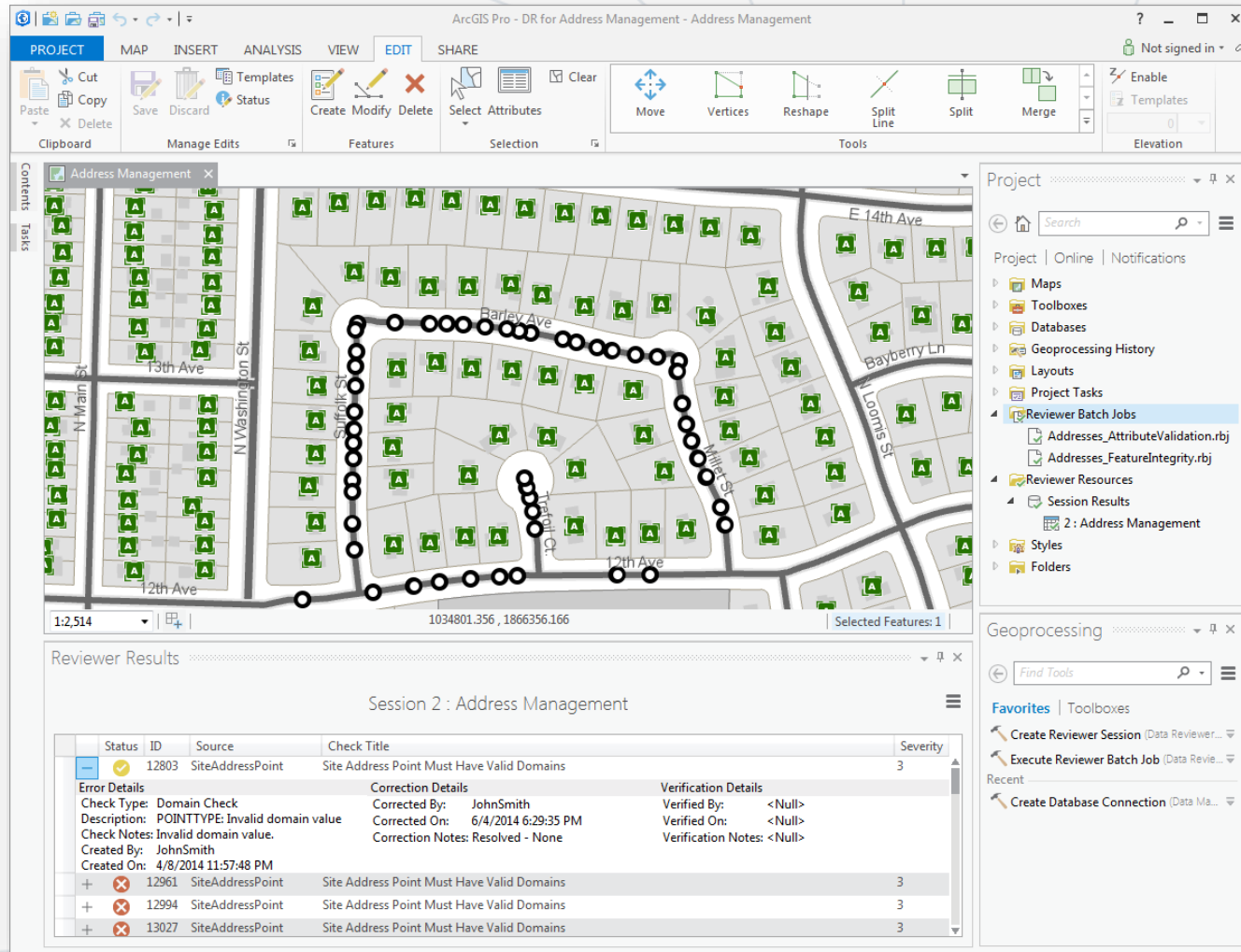


Relationship Type	Feature Class 1 (Feature Count)	Feature Class 2 (Feature Count)	Times Faster
Intersects	Polygon (37921)	Polygon (67432)	4.1
Intersects	Line (105948)	Line (348993)	88.2
Intersects	Point (134429)	Point (35432)	117.6
Intersects	Point (134429)	Line (348993)	102.5
Intersects	Point (134429)	Polygon (67432)	59.2
Intersects	Line (348993)	Polygon (67432)	82.7

* File Geodatabase

ArcGIS Pro

- ★ New UI, 64-bit, multi-threaded, fast graphics
- ★ Integrated Data Quality management



The screenshot displays the ArcGIS Pro interface for 'Address Management'. The main map shows a residential area with green 'A' markers representing address points. A 'Reviewer Results' panel is open at the bottom, showing a table of errors and their details.

Status	ID	Source	Check Title	Severity
✓	12803	SiteAddressPoint	Site Address Point Must Have Valid Domains	3
Error Details				
Check Type: Domain Check		Correction Details		Verification Details
Description: POINTTYPE: Invalid domain value		Corrected By: JohnSmith	Verified By: <Null>	
Check Notes: Invalid domain value.		Corrected On: 6/4/2014 6:29:35 PM	Verified On: <Null>	
Created By: JohnSmith		Correction Notes: Resolved - None		Verification Notes: <Null>
Created On: 4/8/2014 11:57:48 PM				
✗	12961	SiteAddressPoint	Site Address Point Must Have Valid Domains	3
✗	12994	SiteAddressPoint	Site Address Point Must Have Valid Domains	3
✗	13027	SiteAddressPoint	Site Address Point Must Have Valid Domains	3

Questions?

phardy@esri.com