

Improving Cadastre: Development of a Workflow Prototype Using ESRI's Parcel Fabric

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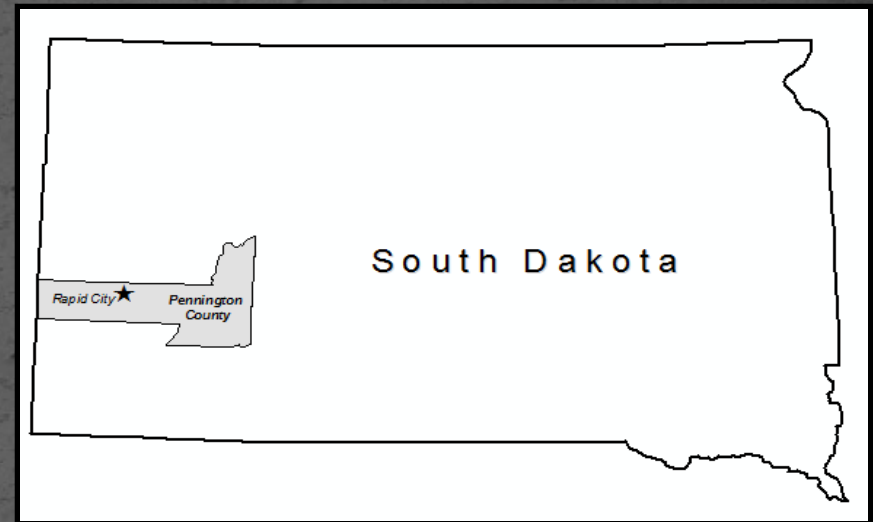


Land Records History / Importance

- property cadastres / land registration systems date back to 14th century BC in Egypt
- a digital cadastre system allows for the
 - management of public infrastructure
 - response to natural disasters
 - homeland security
 - economics – (e.g. tax collection and other revenues) currently high property transaction fees & mortgage crisis
- in the U.S. land records administered by local governments

How Rapid City Uses Land Records

- maintain ownership and tax information
- record zoning and planning designations
- future land use plans
- track annexations
- maintain corporate boundaries
- plan future transportation routes



Infrastructure Management:

- sanitary sewer system
- water system
- other asset management

Why is Improvement Needed?

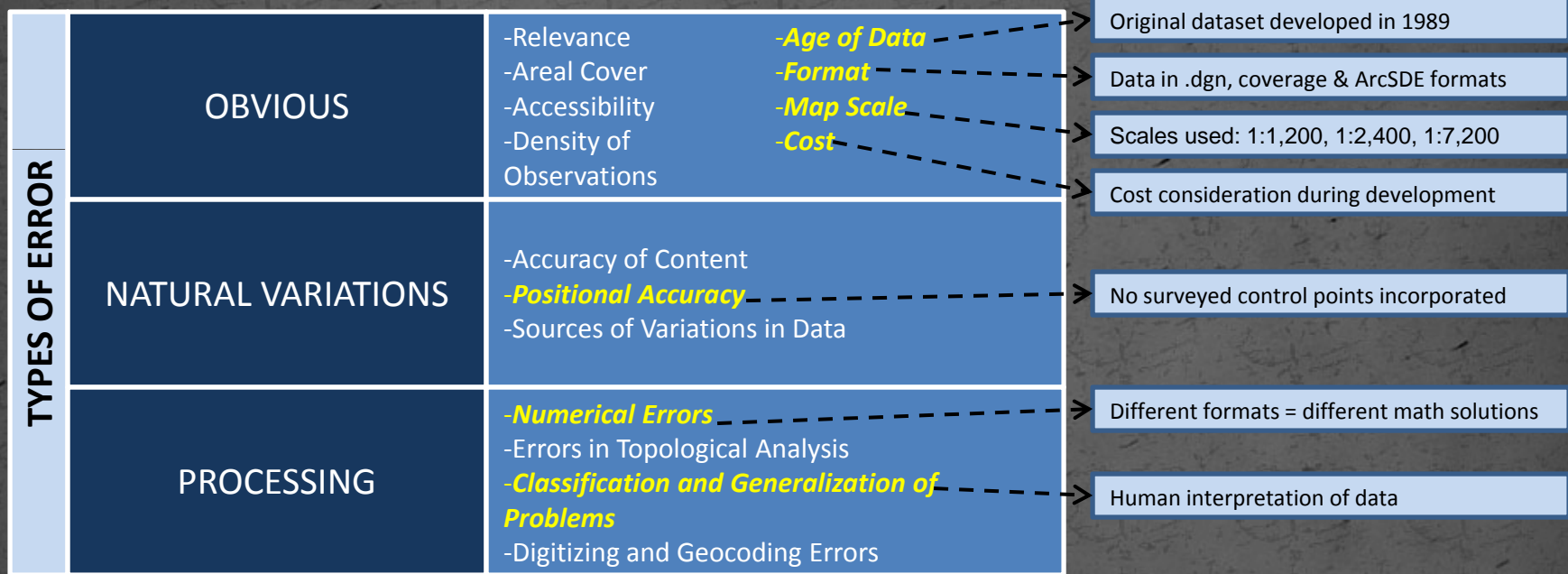
- because Rapid City's parcels dataset accuracy hasn't kept pace with the accuracy of other basemap layers (i.e. aerial imagery)



Rapid City Parcels Dataset History

<p>Parcels digitized from plats Scales: 1:7,200, 1:2,400, 1:1,200</p> <p>Control: USGS quadrangle section corners (7.5 minute)</p> <p>Lines aligned to rectified but not ortho-corrected aerial photos</p> <p>Microstation CAD</p>	<p>Parcels converted to ESRI ArcInfo Coverage</p> <p>Control: USGS DLG & DRG (1:24,000)</p> <p>Lines aligned to USGS DOQQ & Rapid City ortho-photography photos</p> <p>ESRI GIS Software</p>	<p>Parcels converted to single county-wide SDE feature class</p> <p>Maintenance of parcels by COGO input and other editing techniques</p> <p>ESRI GIS Software</p>	<p>Migrate parcels to parcel fabric</p> <p>Maintain cadastre and improve accuracy</p> <p>ESRI GIS Software</p>
1989	2000	2003	2011
Errors: aligning property to aerial photo	Errors: alignment was better in east than in west of county; removal of tax parcel lines to match DLG section lines	Errors: remain uncorrected	Errors: to reduce errors
Data exist as a representation			Need improved accuracy

Sources of Error



Source: Foote and Huebner (1995)

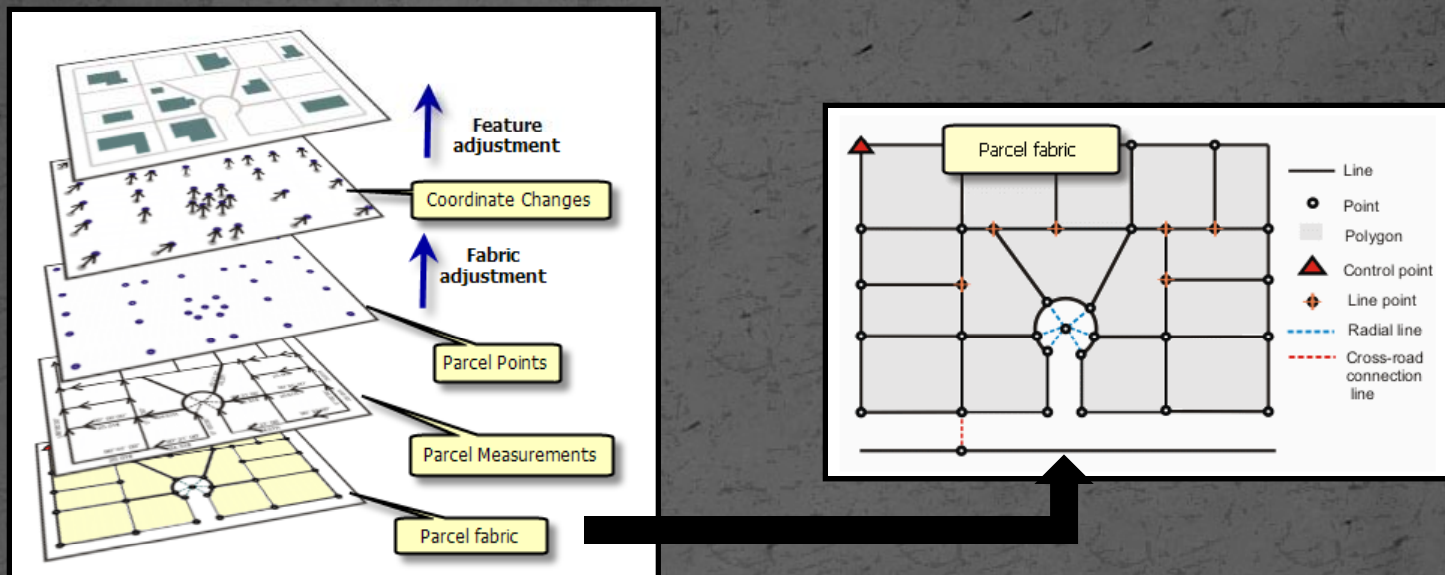
Problems with Error

- current dataset is a representation
- public and city staff use data daily
- problems visually or spatially analyzing features as they relate to property boundaries
- challenges in improving accuracy
 - cost prohibitive to hire a consultant to reconstruct
 - not enough manpower in the GIS Division to re-build
 - need to leave some version of parcels in service at all times
 - up until now, no suitable alternative

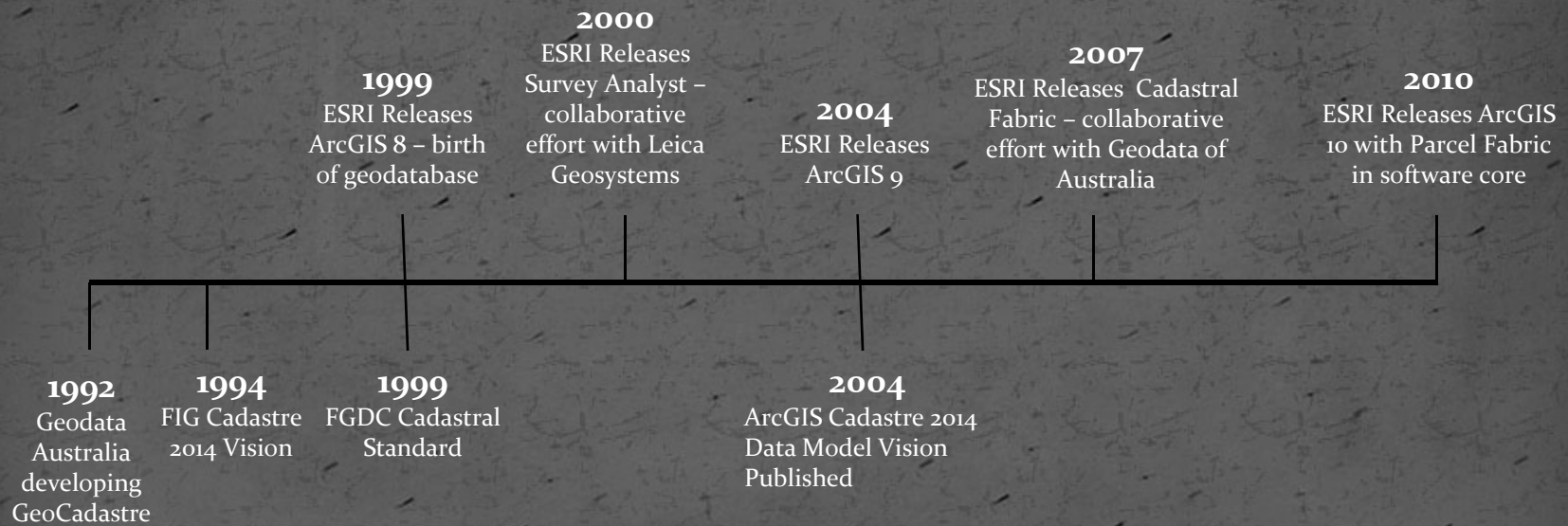
Key Considerations for Building and Managing Cadastre Data

- develop layers with higher spatial accuracy
- update and modify cadastral layers continuously, so as to increase accuracy of cadastre with time
- store legacy data while constructing the maps from oldest to newest surveys
- retrieve easily

How to Accomplish? use ESRI's Parcel Fabric



About the Parcel Fabric

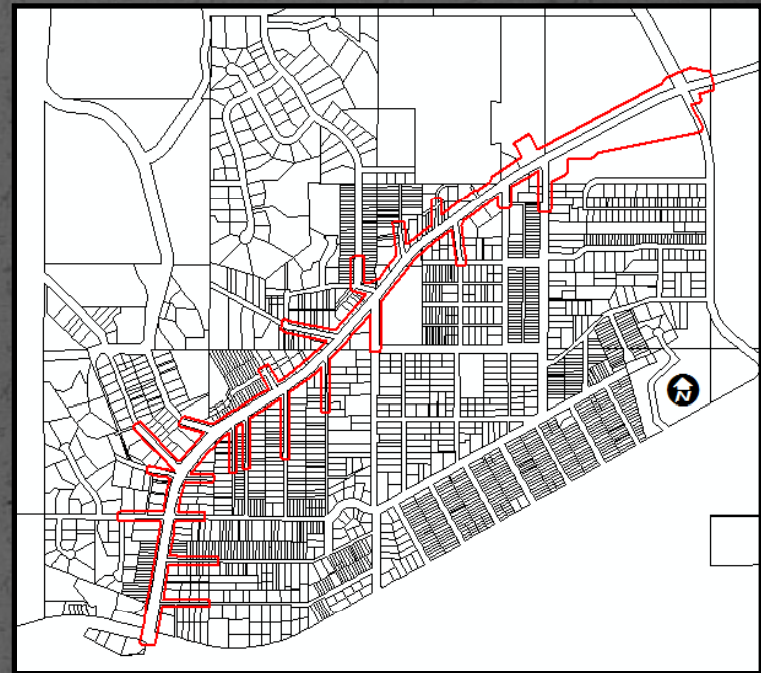
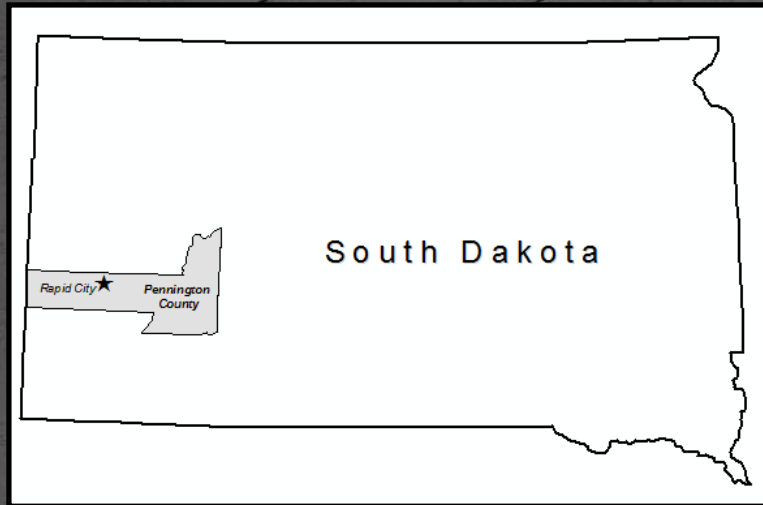


Project Objectives

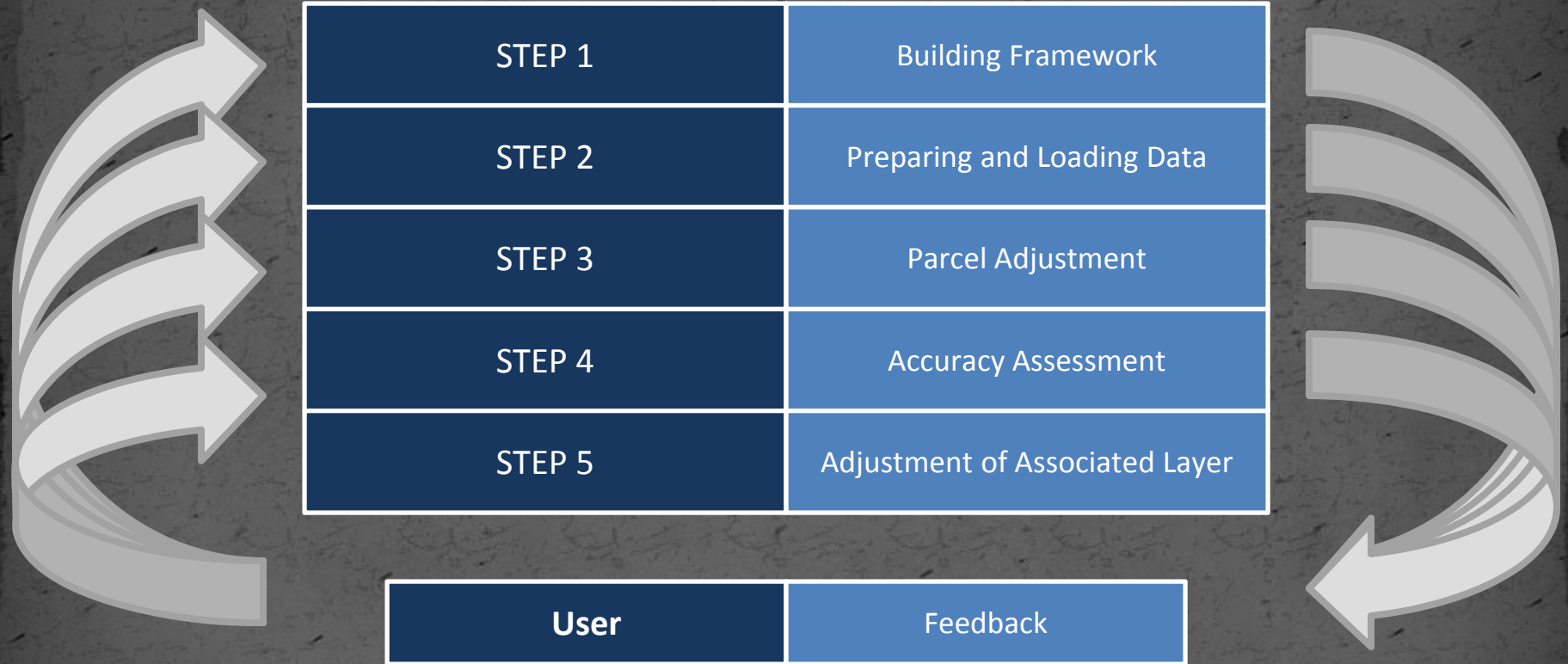
Develop and Evaluate a Workflow to:

- prepare and import existing data into the parcel fabric
- improve the quality of the cadastre over time by adjusting the parcels to control points
- apply the adjustments to associated layers to improve related data

Study Area – Test Data Sample Used



Workflow Development



STEP 1

Building Framework

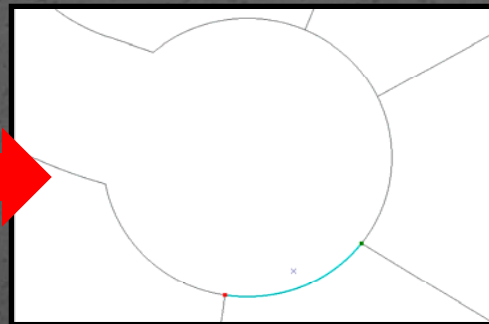
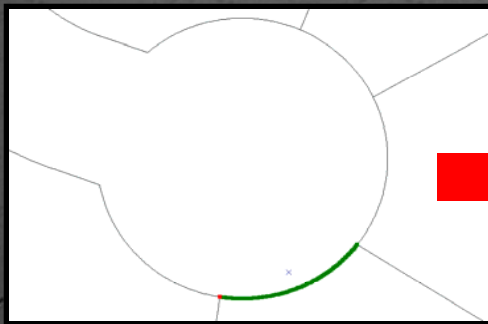
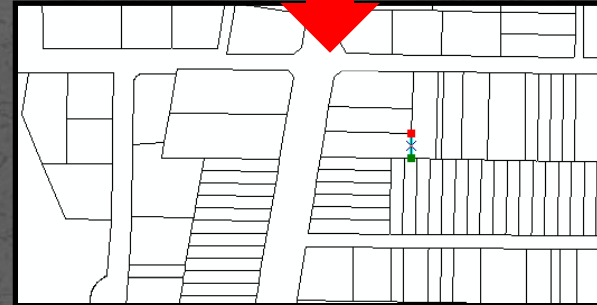
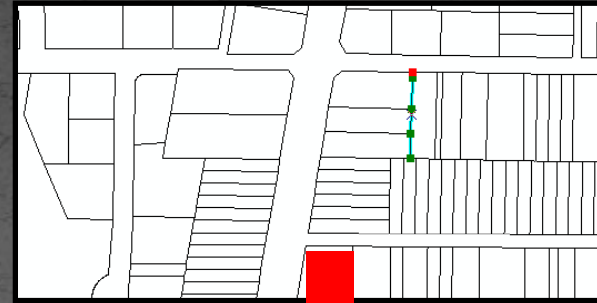
- review
 - ESRI technical documentation
 - other literature
- identify steps necessary to use parcel fabric
- gather feedback from client



STEP 2

Preparing and Loading Data

- prepare data
 - planarize lines and curves
 - verify topology
- load data
 - points, lines & polygons
 - match control points
- capture workflow for client to repeat



STEP 2

Preparing and Loading Data (Cont.)

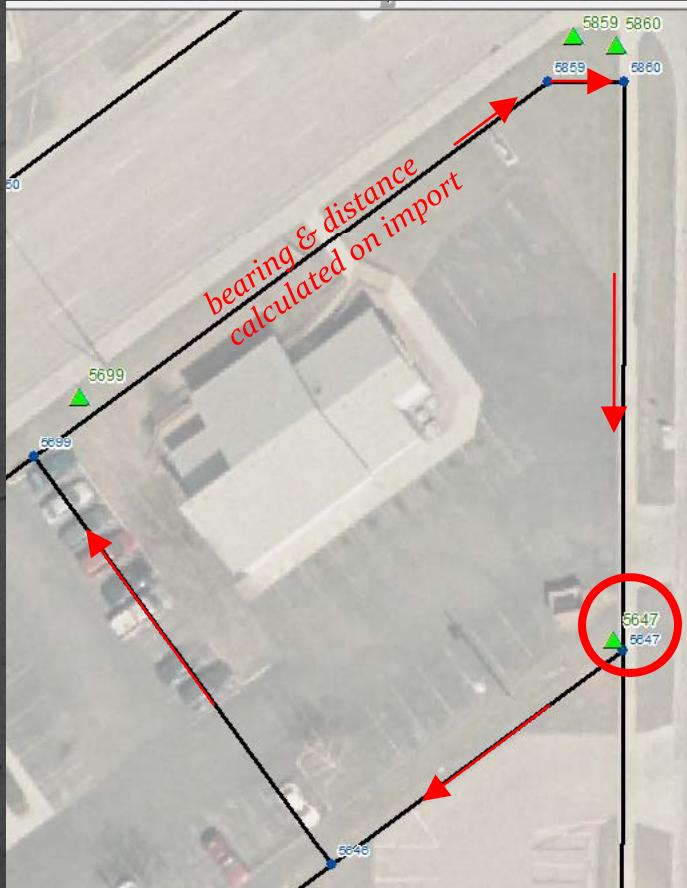
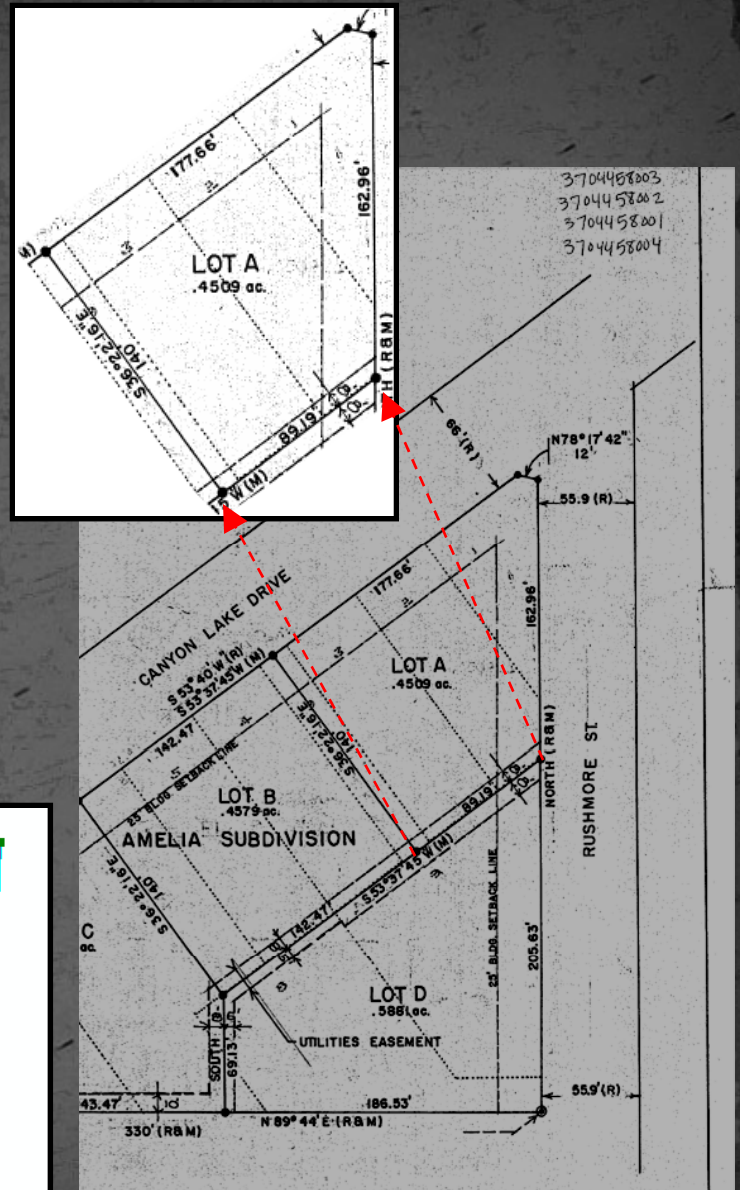
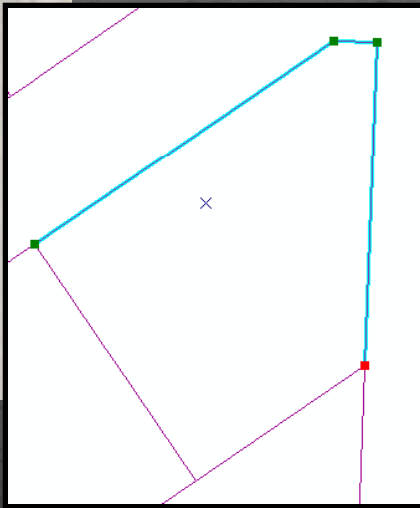


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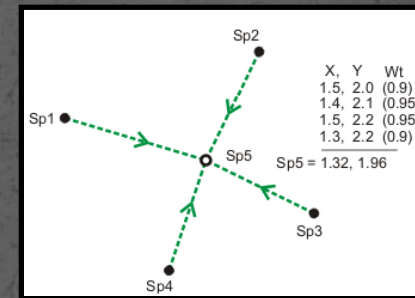
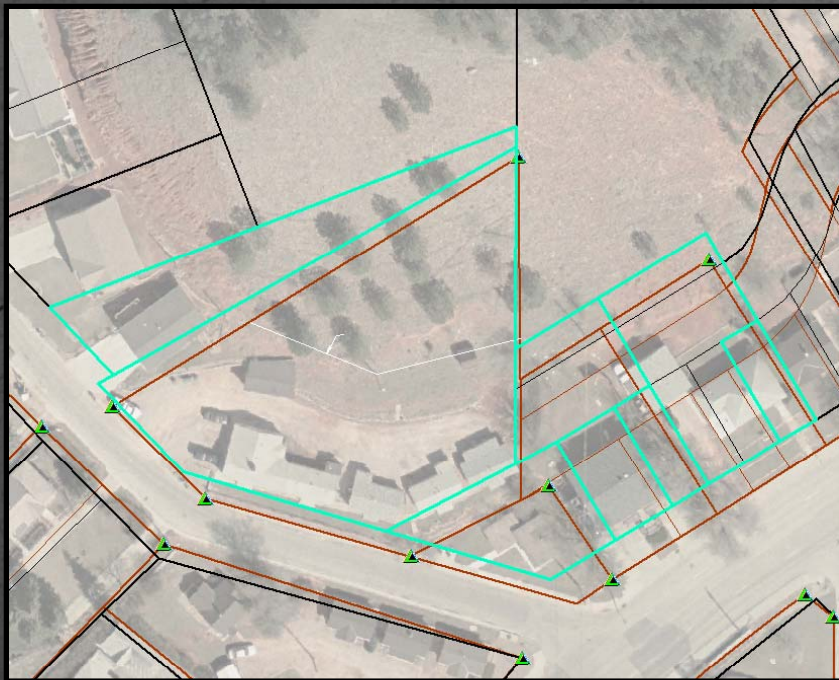
- ParcelFabric
 - Control
 - Others
 - Active
 - LinePoints
 - Points
 - Lines
 - Boundary Line
 - Dependent Line
 - Precise Connection
 - Connection
 - Radial
 - Road Frontage
 - Origin Connection
 - Part Connector
 - Parcels
 - <all other values>
 - Type



STEP 3

Parcel Adjustment

- adjust parcels to surveyed control points
- use least-squares adjustment built into parcel fabric



Source: ESRI 2011

Accuracy categories in the parcel fabric

Accuracy level	Std. deviation bearing (secs)	Std. deviation distance (m/ft)	PPM (m) (parts per million)	Description
1	5	0.001/0.00328	5	Highest
2	30	0.01/0.0328	25	After 1980
3	60	0.02/0.0656	50	1908-1980
4	120	0.05/0.164	125	1881-1907
5	300	0.2/0.656	125	Before 1881
6	3,600	1/3.28	1,000	1800
7	6,000	10/32.8	5,000	Lowest—excluded from adjustment

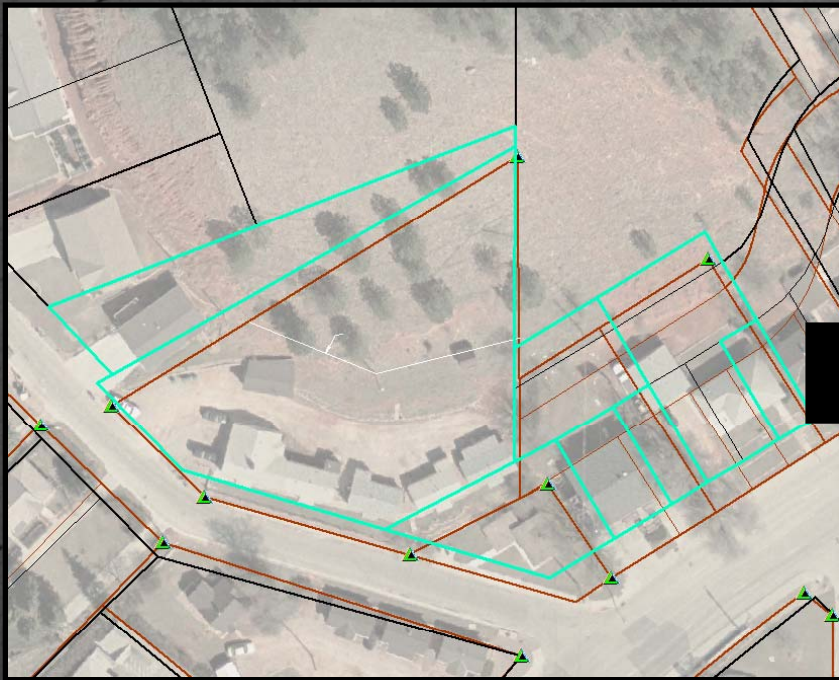
Table of accuracy categories in the parcel fabric

Source: ESRI 2011

STEP 4

Accuracy Assessment

- error evaluation
 - compare adjusted fabric parcels to independently developed AutoCAD parcels – qualitative assessment



STEP 4Accuracy Assessment
(Cont.)

- quantitative assessment
 - 12 samples of parcels adjusted
 - ranged in size from 7 parcels to 44 parcels
 - system established for ranking each adjustment

Rank	Percentage of Parcel Lines +/- 2.0 feet From Control Layer
1	100 – 90%
2	89 – 75%
3	74 – 50%
4	49 – 0%

STEP 4Accuracy Assessment
(Cont.)

- parcel accuracy before any adjustment – 8.33%
- parcel accuracy after first adjustment – 25%

Sample	% Match pre-adjust	Rank	% Match after 1st adjust	Rank
1	11.76	4	64.71	3
2	15.79	4	60.53	3
3	5.00	4	21.67	4
4	25.00	4	83.33	2
5	10.53	4	63.16	3
6	9.52	4	47.62	4
7	73.17	3	82.93	2
8	0.00	4	70.59	3
9	95.35	1	93.02	1
10	10.26	4	61.54	3
11	26.83	4	80.49	2
12	14.81	4	55.56	3

STEP 4

Accuracy Assessment (Cont.)

- why improvement only from 8.33% to 25% after 1st adjustment?
 - result of a number of problems that include:
 - incorrect shape of the parcel boundaries
 - inaccurate control points
 - inadequate control points
 - disproportionately distributed control points (i.e. larger number of control points on the perimeter of the sample and/or clustering of control points with large gaps between control points)

STEP 4Accuracy Assessment
(Cont.)

- summary of adjustment issues

Sample	Problem of Accuracy	Fix
1	inadequate control (c)	points added: 4
2	disproportionate control (d), inadequate control (c)	points added: 3
3	bad parcel shapes (a)	needs to be redigitized from plat.
4	disproportionate control (d), inadequate control (c)	points added: 6
5	disproportionate control (d), inadequate control (c)	points added: 3
6	disproportionate control (d), inadequate control (c)	points added: 5
7	disproportionate control (d), inadequate control (c)	points added: 1
8	disproportionate control (d), inadequate control (c), bad control (b)	points deactivated: 1 points added: 2
9	no problem	
10	disproportionate control (d), inadequate control (c)	points added: 6
11	disproportionate control (d), inadequate control (c)	points added: 6
12	disproportionate control (d), inadequate control (c)	points added: 5

STEP 4Accuracy Assessment
(Cont.)

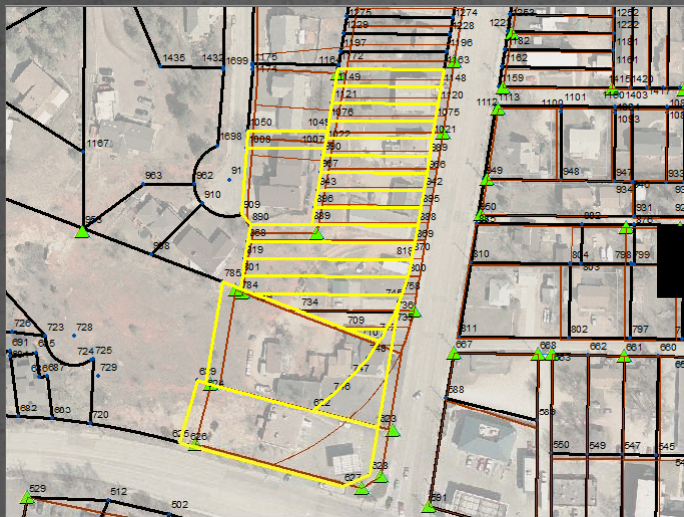
- summary of adjustment results – after 2nd adjustment, 75% match

Sample	% Match pre-adjust	Rank	% Match after 1st adjust	Rank	% Match after 2nd adjust	Rank
1	11.76	4	64.71	3	94.11	1
2	15.79	4	60.53	3	81.58	2
3	5.00	4	21.67	4	23.33	4
4	25.00	4	83.33	2	97.22	1
5	10.53	4	63.16	3	94.73	1
6	9.52	4	47.62	4	68.25	3
7	73.17	3	82.93	2	82.93	2
8	0.00	4	70.59	3	94.11	1
9	95.35	1	93.02	1	93.02	1
10	10.26	4	61.54	3	66.67	3
11	26.83	4	80.49	2	82.93	2
12	14.81	4	55.56	3	85.19	2

STEP 4

Accuracy Assessment (Cont.)

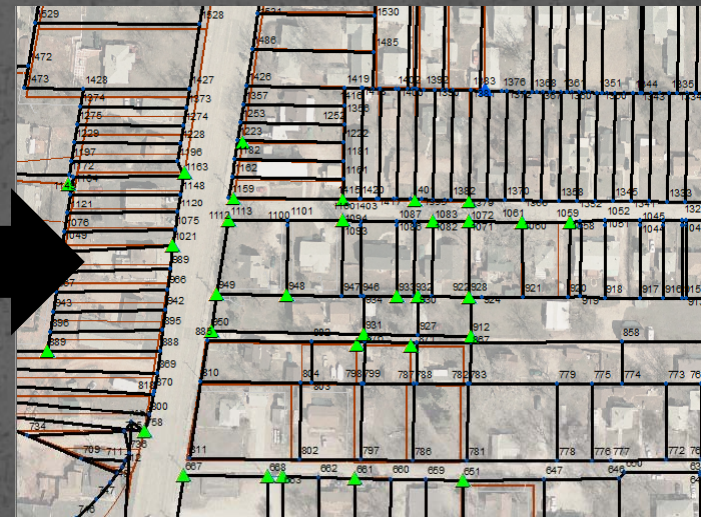
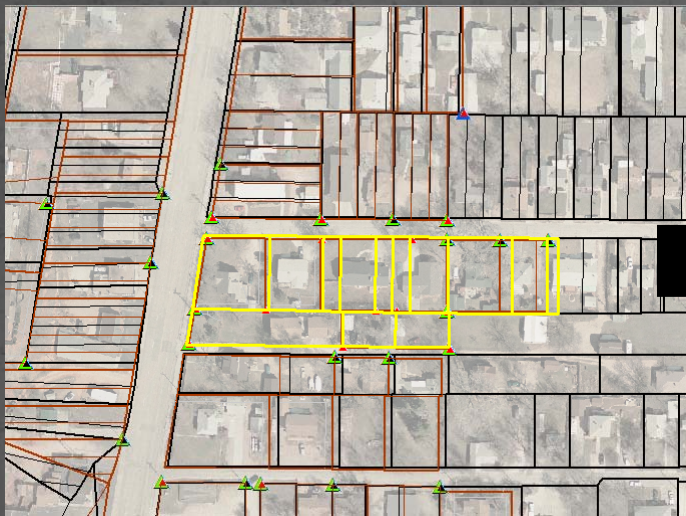
- poorest adjustment – sample 3
- problem: incorrect parcel shape



STEP 4

Accuracy Assessment (Cont.)

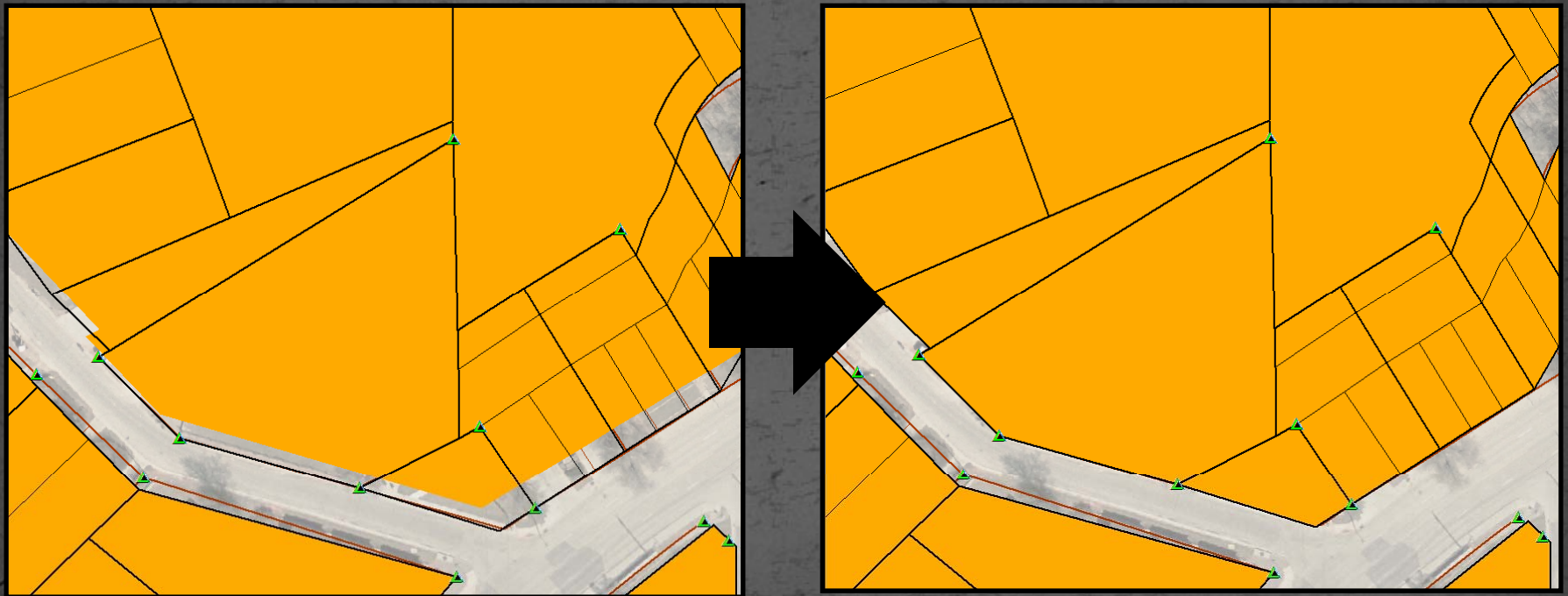
- best adjustment – sample 4
- problem: disproportionate / inadequate control



STEP 5

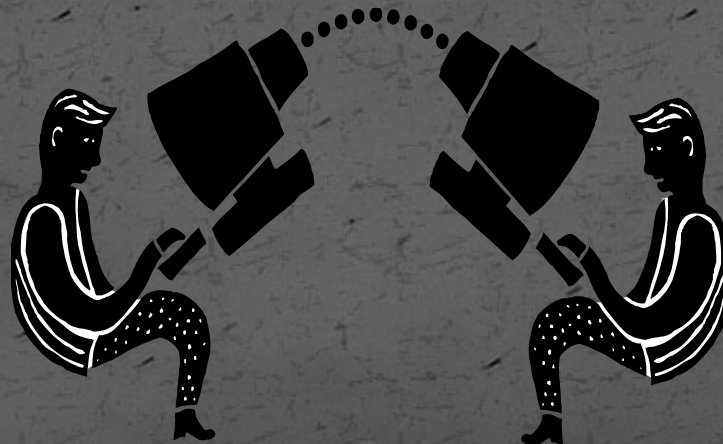
Adjusting an Associated Layer

- apply adjustment to associated layer – zoning



Workflow Evaluation

- worked with City GIS Division staff to test usability of the workflow
- incorporated their feedback into the workflow
- provided a survey to formally document the usability of the workflow



In Summary

- the workflow that was developed as a result of this study has successfully met the objectives set forth:
 - (i) developing a feasible workflow for converting existing data
 - (ii) maintaining and improving cadastre over time
 - (iii) ability to integrate these data with related layers

Acknowledgements

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- Rapid City/Pennington County GIS Division – Don Jarvinen
- ESRI Land Records Division – Chris Buscaglia

References

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Thank You!
Questions?