Standard Operating Procedures for GIS Digitization and Renovation to a New Base Map in ArcMap 10.3

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PURPOSE

GIS is the current standard for geologic mapping; however, many maps published as print only or scanned to PDF contain essential information that can inform current studies of planetary bodies. To make these maps useful as geographic data they must be digitized in GIS form. Additionally, many of these maps were created using basemaps derived from legacy control networks and lower resolution imagery. As part of the digitization process this SOP will also describe the renovation of data to a more current base – this does not include interpretations of any mapped features, but rather a way to represent maps from different eras in the same spatial context. For an example of this process applied to the Mariner 9 1:5,000,000-scale geological maps of Mars refer to this LPSC abstract or download this finished product.

Required systems/software

ArcGIS Desktop 10.1 or higher Advanced License

Basic ArcGIS features used in this SOP

Editing

Layer Properties

Spatial Reference

Georeferencing

Create GIS Project

1) Create a project directory where all files will be saved, and other subdirectories as needed to organize data, such as rasters, coordinate systems or map symbols. Then, create a new map document and import the new basemap to which the map will be georeferenced. This will set the spatial reference of the data frame to that of the new basemap, to be changed in the next step. Within the project directory create a file geodatabase (GDB, preferred to shapefiles). This is most easily accomplished through the ArcCatalog tab by right-clicking the directory and selecting New > File Geodatabase.

Define Spatial Reference

2) If a file containing the map coordinate system already exists then it may be used directly in the data frame (via Import); otherwise a custom one must be created by modifying an existing version of the projection. Mercator and equirectangular projections are simple to modify since they just require a center longitude, but mid-latitude projections such as Lambert conformal have standard parallels that are typically, but not always, noted in the map text. If these parameters are not included with the map the same projection may be adopted from another body by changing the geographic coordinate system (GCS). Once the projection parameters have been modified rename and save it out as a (*.prj) file for later use.
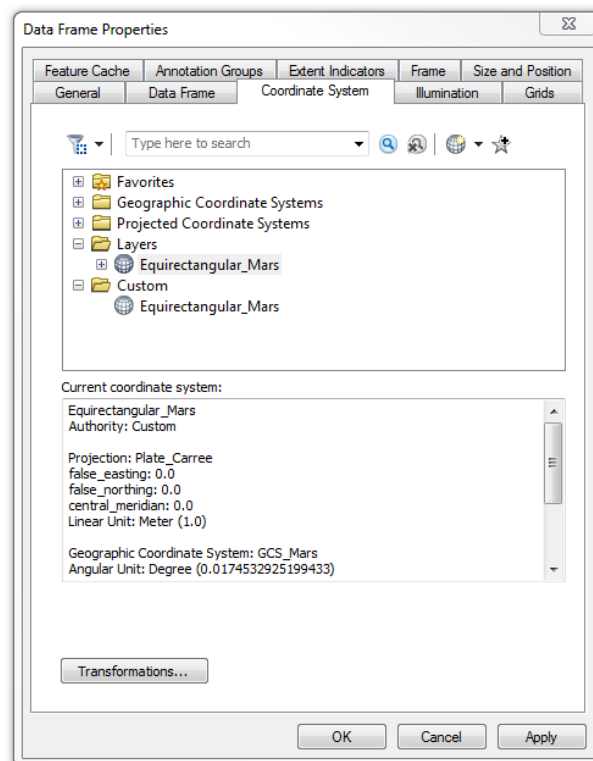
Data Frame Properties > Coordinate Systems can search saved files or import from other geographic datasets.
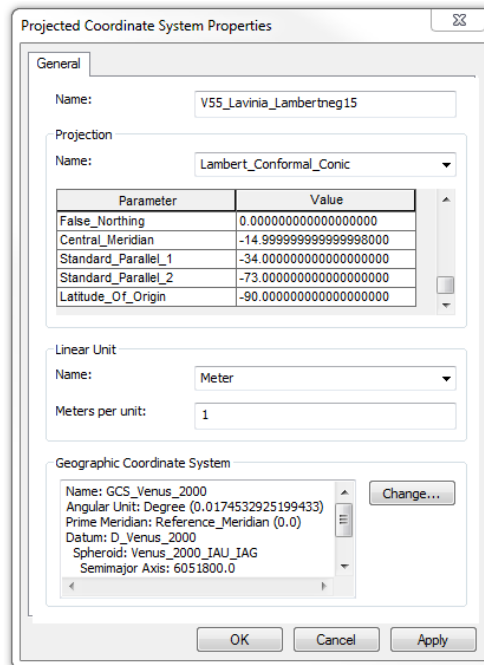
Coordinate system Properties may be modified using existing projections and GCS's.
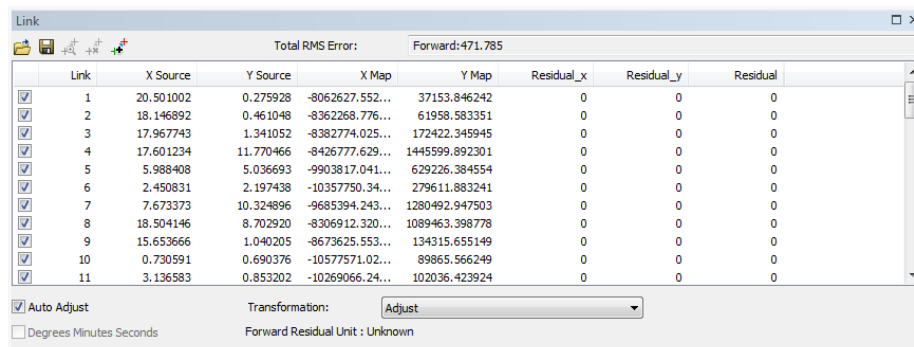
Next, create a new feature dataset in the project file geodatabase (right-click GDB > New > Feature Dataset). A feature dataset is like a sub-directory in a geodatabase that houses like datasets with a common spatial reference and scale (tolerance). The setup wizard will prompt the user to provide the spatial reference to be used for all datasets contained in it, and this can be imported from the *.prj file created earlier. Now any feature classes created in, or imported into, will use this coordinate system.

Georeference Digital Map

3) Now import the scanned source map into ArcMap, and open the **Georeferencing Toolbar**. A standard digitization would simply entail georeferencing the map to a boundary defined by the map extent, but renovation to a new base requires many tie points throughout the map, and the resulting boundary may not coincide with the original coordinates.

To begin adding tie points select the Add Control Points button, and select Zoom To Layer for the source map. Ideal tie points are peaks, distinct crater centers, or points where features converge; the point must be identifiable in both the source and base maps. There is no maximum, but the recommended minimum is 30-40 tie points, provided there is coverage throughout the map. In areas of most significant offset ensure that tie points are used along the map boundary.

Lastly, select the Open Links Table button to review tie points and identify any potential root square mean error (RSME) outliers, as they will adversely impact georeferencing results. Use the Update Display button under the Georeferencing toolbar to view the warp before saving it out to a new dataset via the Rectify button (use Update Georeferencing to save the warp to the current map rather than saving a new one). The tie points may also be saved for reference through the Link window.


Link	X Source	Y Source	X Map	Y Map	Residual_x	Residual_y	Residual
1	20.501002	0.275928	-8062627.552...	37153.846242	0	0	0
2	18.146892	0.461048	-8362268.776...	61958.583351	0	0	0
3	17.967743	1.341052	-8382774.025...	172422.345945	0	0	0
4	17.601234	11.770466	-8426777.629...	1445599.892301	0	0	0
5	5.988408	5.036693	-9903817.041...	629226.384554	0	0	0
6	2.450831	2.197438	-10357750.34...	279611.883241	0	0	0
7	7.673373	10.324896	-9685394.243...	1280492.947503	0	0	0
8	18.504146	8.702920	-8306912.320...	1089463.398778	0	0	0
9	15.653666	1.040205	-8673625.553...	134315.655149	0	0	0
10	0.730591	0.690376	-10577571.02...	89865.566249	0	0	0
11	3.136583	0.853202	-10269066.24...	102036.423924	0	0	0

Total RMS Error: Forward:471.785

☑ Auto Adjust   Transformation: Adjust
☐ Degrees Minutes Seconds   Forward Residual Unit : Unknown

The Link window allows users to manage, delete and save tie points, and preview different transformation methods.

Digitize Contacts

4) If the georeferenced source map is high resolution (little visible impact from the scanning process) and the underlying base map does not bleed through heavily it may be a good candidate for ArcScan automatic vectorization extension, which can greatly reduce digitization time. Refer to the ArcScan Conversion SOP for instructions on this method; this document will address manual digitization.

Before any digitization can take place a contacts feature class must be created in the project GDB, and the editing environment must be set. Within the project GDB right-click on the feature dataset and select New Feature Class (additional fields such as "TYPE" may be created at this time, but may also added later). Then, begin editing the contacts layer and, under the **Editor toolbar**, open Options. Under the General tab, enter an initial stream tolerance of 10,000x less than the printed map scale, which may be adjusted after testing. Also, open the Snapping toolbar, and enable snapping for vertices and endpoints.
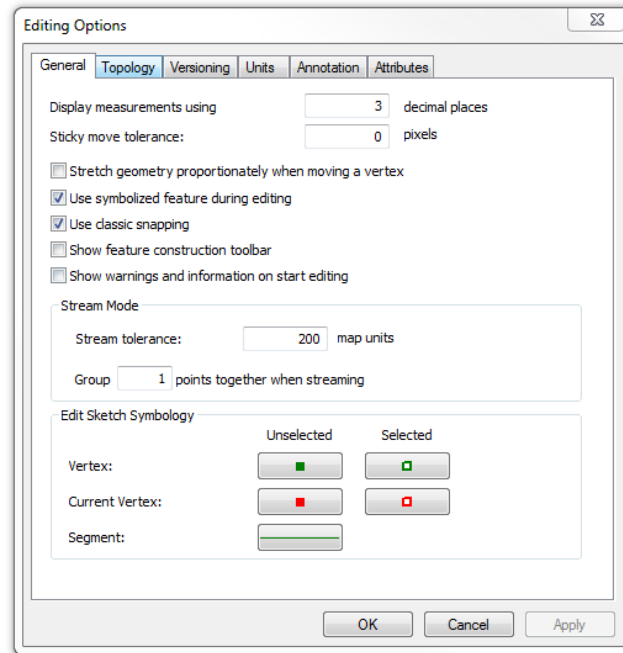
Editing Options may only be modified while editing a map layer.

There are a number of tools such as interactive tablets and smart pens for increasing the ease and efficiency of digitization, but users can still achieve quality results by using the streaming method with a traditional mouse. To begin streaming (after selecting Create Feature), right-click anywhere on the map and select Streaming or use the F8 shortcut key. The first click will begin streaming, a second click will pause it, and a double-click will complete the feature. This may be used in conjunction with Ctrl + C to pan around the map document to digitize large features at once.

NOTE: Mouse speed may be adjusted through the computers Control Panel to make the cursor more or less responsive to hand movements.

Check Topology

5) In GIS a topology is s set of rules that define how features share coincident geometries, and can help to identify errors in data. To assist with this task the PGM Toolbox has a Check Topology tool which creates a topology class, adds commonly used rules, and validates the input feature class. This will identify errors that will cause problems when converting contacts to geologic units. Once errors are corrected, save edits, right-click on the topology class in ArcCatalog and select Validate to test the topology again.
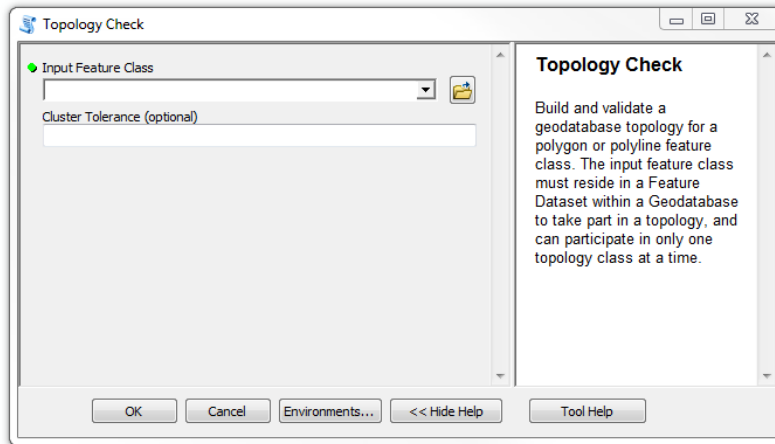
The Topology Check tool in the PGM Toolbox is available at on the MRCTR GIS Lab website.

Smooth, Densify

6) The topologically intact polyline feature class will be accurate, but may lack the smoothness of the original. To correct this effect run the Smooth Line tool, using the PAEK smoothing algorithm with a tolerance equal to the maximum offset found during sampling. Then use the Densify tool on the smoothed feature class; this will ensure polygons derived from these lines will retain their smooth shape.
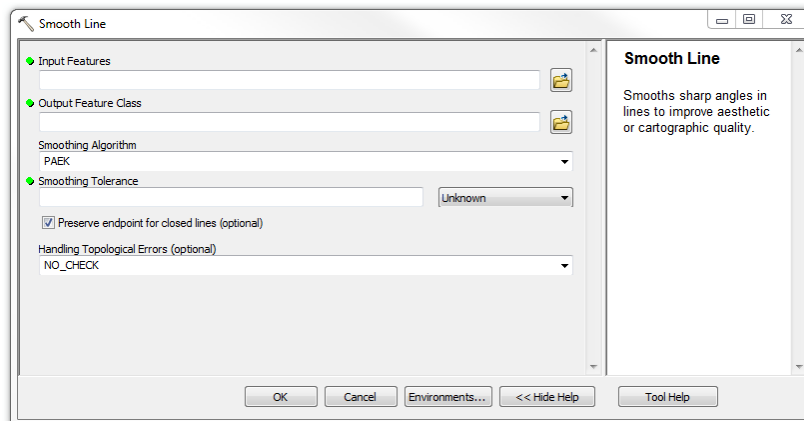
The Smooth Line tool removes much of the jaggedness introduced during digitization.
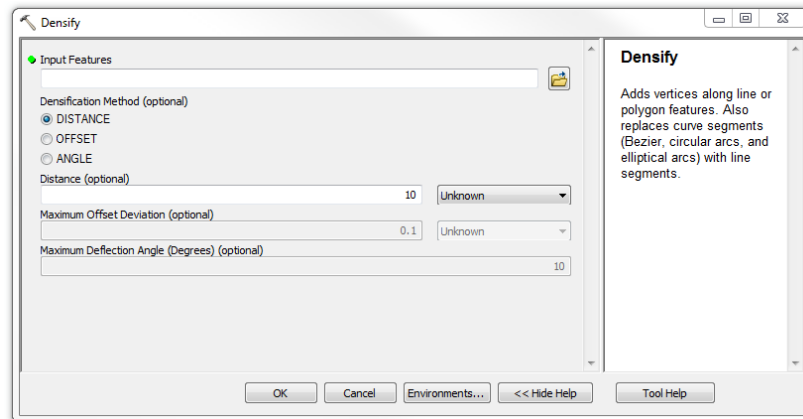
Densifying the smoothed lines ensures derived polygons retain their shape when projected.

Attribute, Symbolize

7) With the line work completed, attribute by contact type, symbolize and save out the layer file. An optional step at this point is to use the **Dissolve tool** to merge contacts by type, which does not have visible effect on the data, but does clean and simplify lines. Also, for most purposes the "Geology 24K" contact symbols are equivalent to FGDC Chapter 25 Planetary Mapping Symbols.

Lines to Polygons

8) To convert the contacts feature class to geologic units run the Feature to Polygon tool from the PGM Toolbox, then attribute the polygons based on the original map (this is when coded domains are very useful). This polygon feature class can also be tested with the Topology toolbar; if errors are found, convert the polygon feature class to points (preserve attributes), correct the contacts, and build polygons again using the points to carry forward the unit attributes. As with the contacts, symbolize the polygons (sampling RGB values of the scanned map in Adobe Illustrator provides accurate recreation of unit symbols), and save out as a layer file.
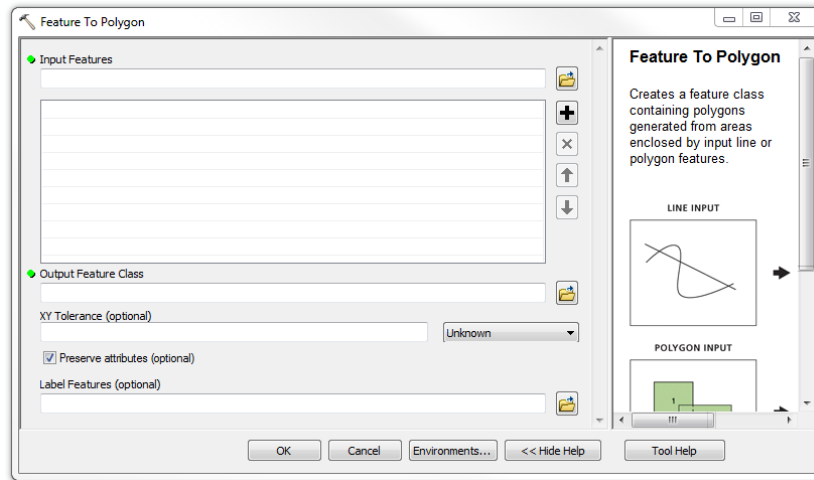
Creating polygons from polylines can be an iterative process as errors are identified and corrected.

Document

9) All geologic maps converted to GIS should include documentation, including FGDC-standard metadata and a ReadMe file detailing all elements and processing steps of the packaged project. ArcGIS supports the creation, transference and exporting of many metadata styles. Metadata is best created at the feature dataset level and then imported into each feature class.
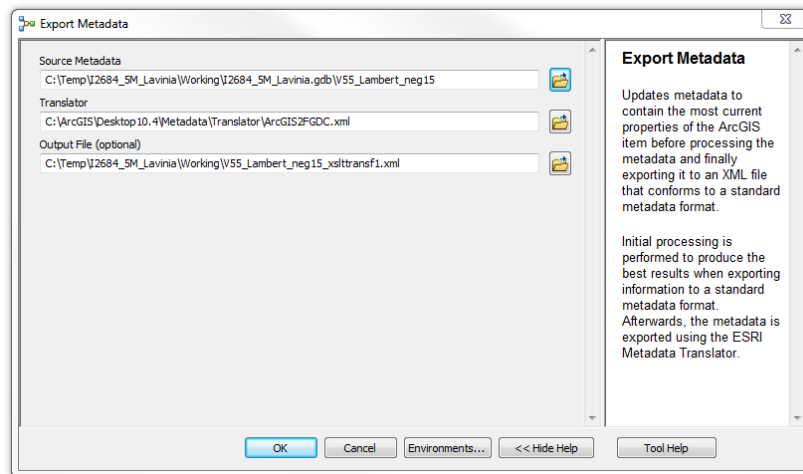
Metadata can be edited, exported and imported in ArcCatalog using most format standards.

Package, Review

10) The final step is to remove all intermediate and redundant datasets in the project directory, rename files to match organizational standards, and prepare for distribution. It is good practice to test GIS projects on other machines, preferably with other versions of ArcMap as well.

Please direct any questions, comments or improvements to:

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