Workflow:
Faults in ArcGIS ⇨ FSP Software ⇨ ArcGIS

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Faults ArcGIS to FSP Software and back to ArcGIS

ArcGIS

Step 1. Establish Faults

Step 2. Segment Faults

Step 3. Add Fault Attributes

Step 4. Prepare Table for FSP Fault Inputs

Step 5. Tailor “FSPStartupSpecifications” text file

ArcGIS and FSP Software(v.2.0)

Step 6. Run FSP like normal

- 6a DFSP: Load stress data, fault data, well or hydrology model
- 6b PFSP: Load Default Dataset, hit “run” through each window to allow PFSP to run properly. Then, load stress data, fault data, well of hydrology model

Step 6. Add Field in ArcGIS Attribute Table

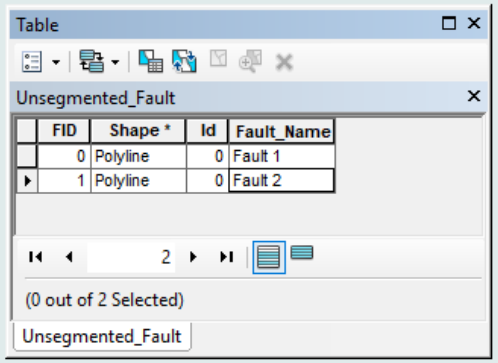
Step 7a Manually Type FSP results into Table

Step 7b (alternative - almost automatic!)

Step 8. Apply Symbology to FSP Results

Step 1: Establish Faults

- For this workflow, I will be using 2 faults.
- Faults should be pointing in the correct direction (RHR)
  - You can use the “Flip Line” tool to get the lines pointing the correct direction
- Make sure everything is in the same coordinate system as you go through the workflow



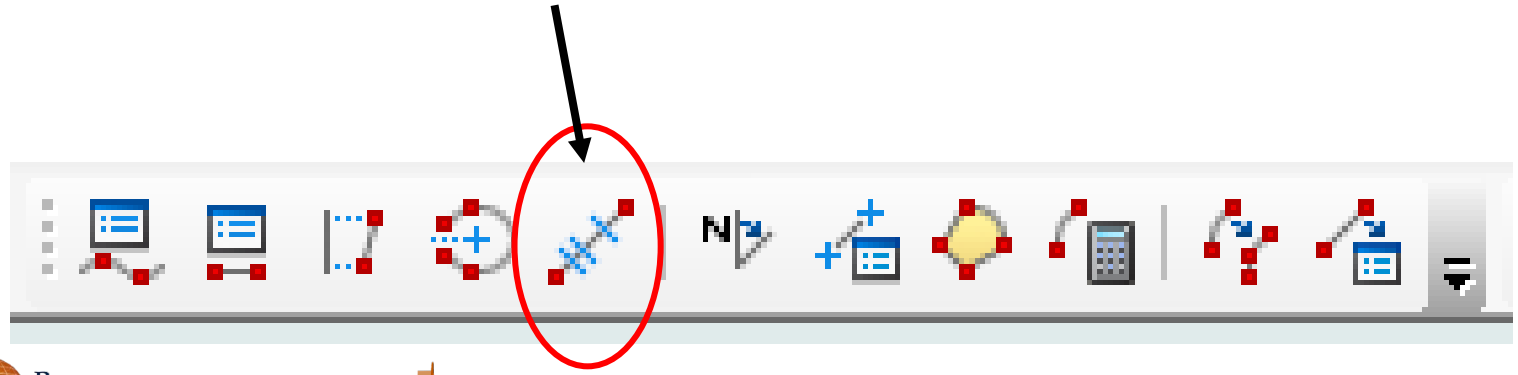
Screenshot from ArcGIS

Step 2: Segment faults

- In order to get accurate results for a fault that changes strike, the faults must be segmented into smaller values. For this, I chose 1000m segments. This is up to the user.

- How to Segment Faults

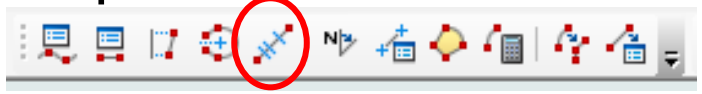
1. Install the COGO toolbar
    1. Customize/Toolbars/COGO
    2. The tool is called “Proportion”
    3. You will be using this tool

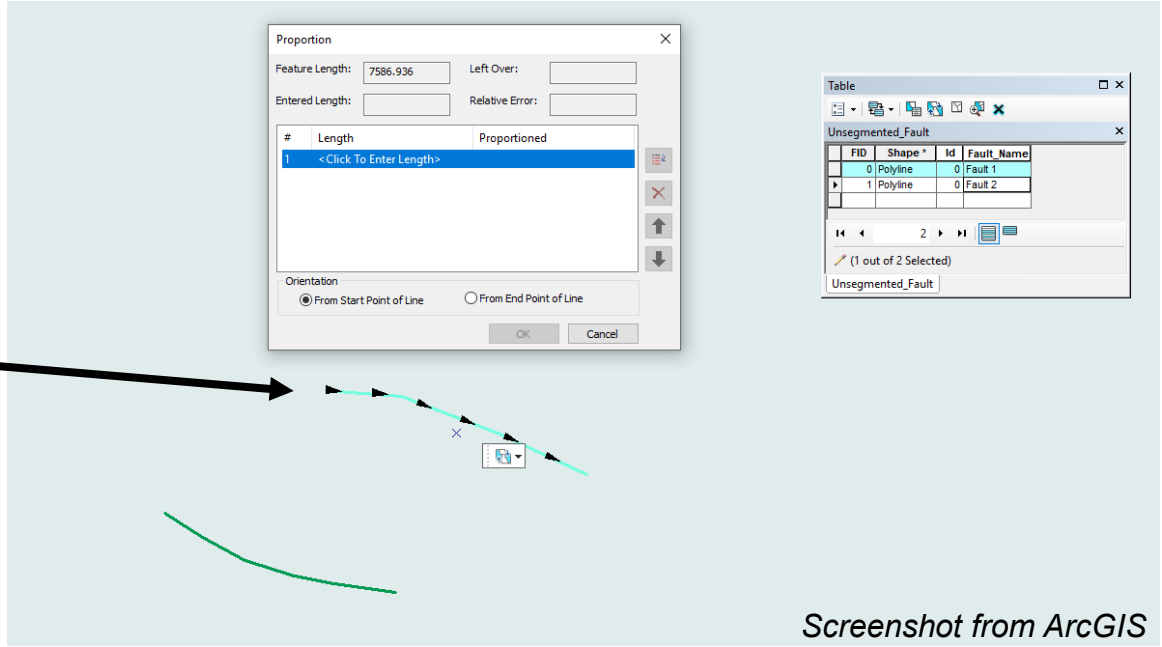


Step 2: Segment faults

- Using Proportion tool to segment the fault

1. Start editing faults
2. Select a fault
   - Here I selected Fault 1
3. Now start using the Proportion tool





Screenshot from ArcGIS

Step 2: Segment faults

- Using Proportion tool to segment the fault

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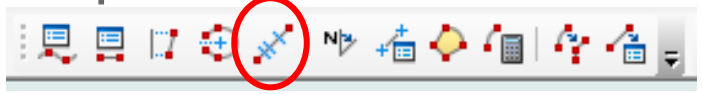
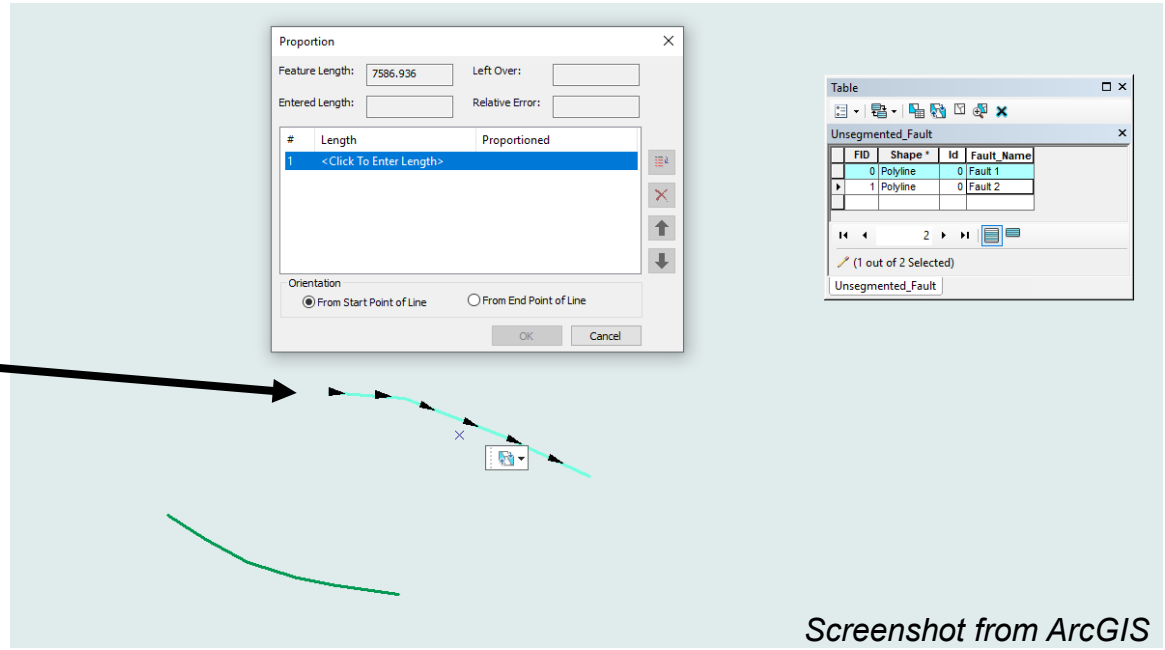
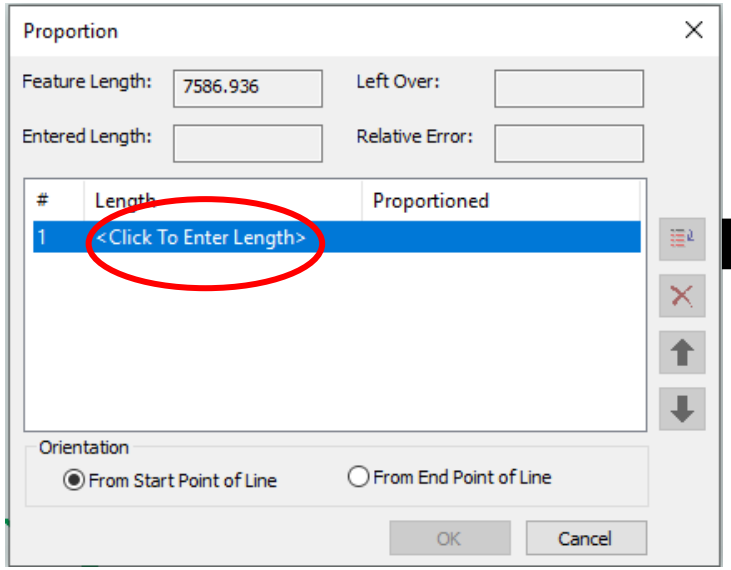
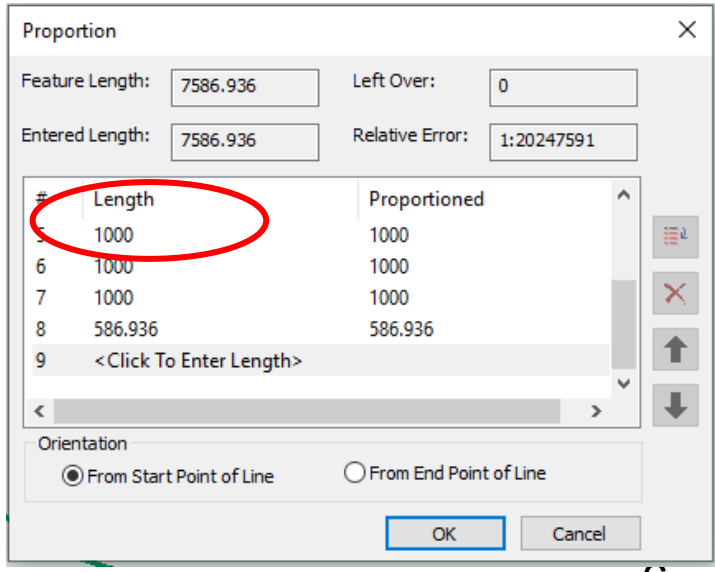


4. Enter length of segments desired into the circled box
   - I chose 1000m segments
   - The featured length is the total length of your fault segment (mine is in meters)



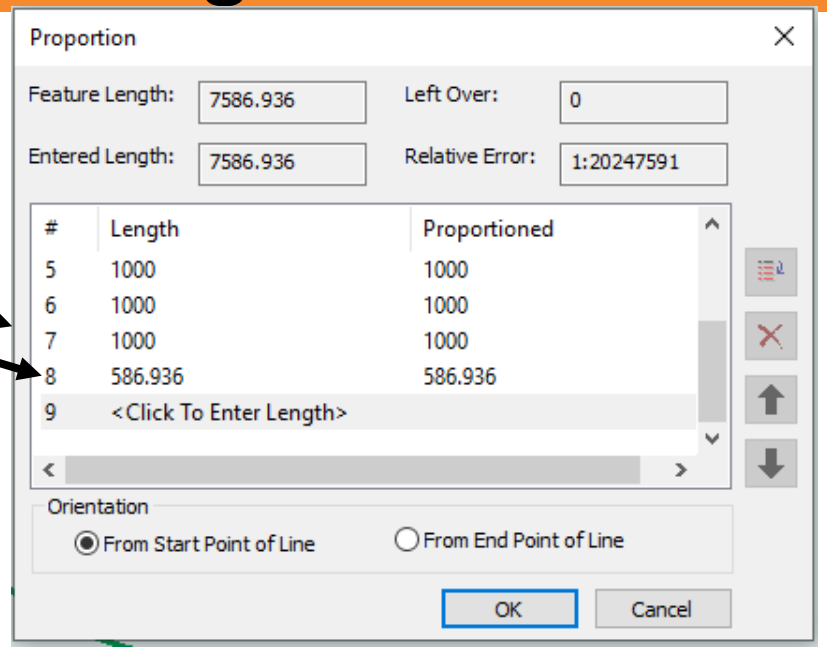
Screenshot from ArcGIS

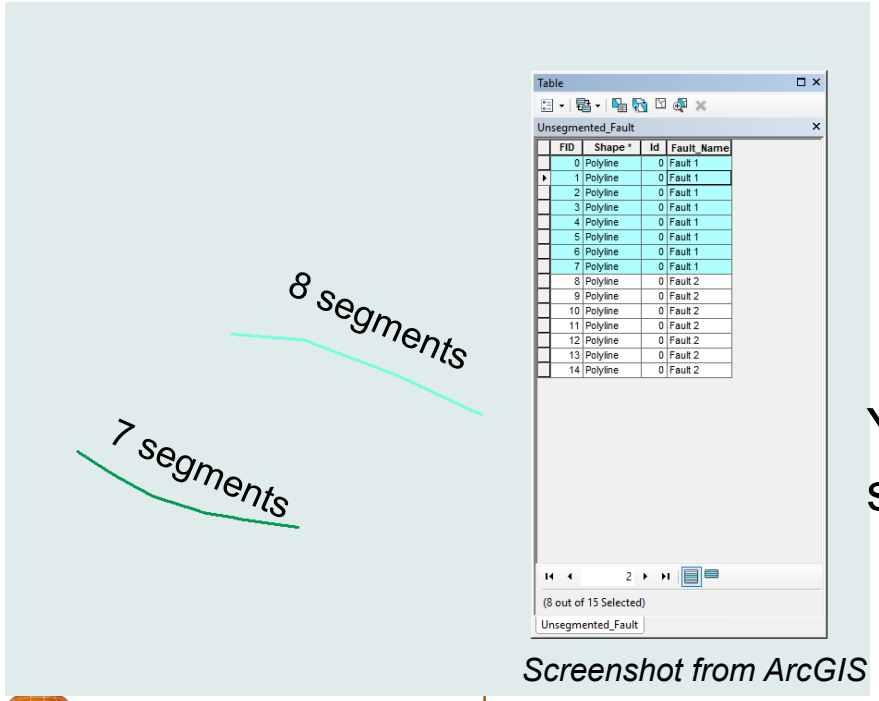




Step 2: Segment faults

- I ended up with 8 segments for 1 fault
  - 7 x 1000m
  - 1 x 586.936m
- Repeat for all faults!





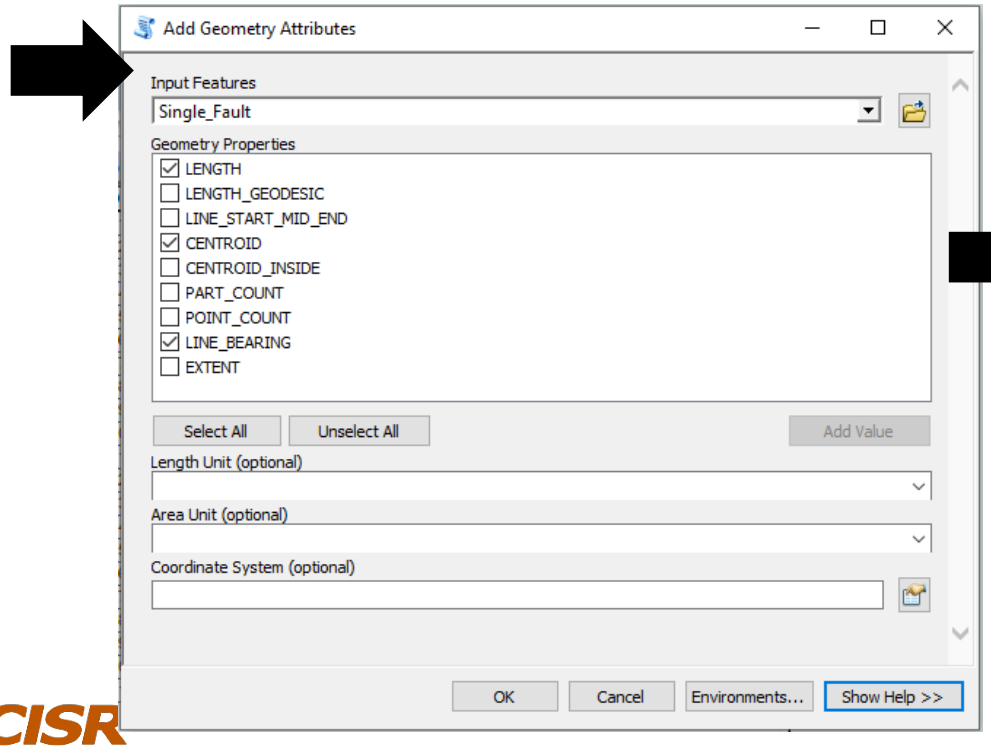
Screenshot from ArcGIS

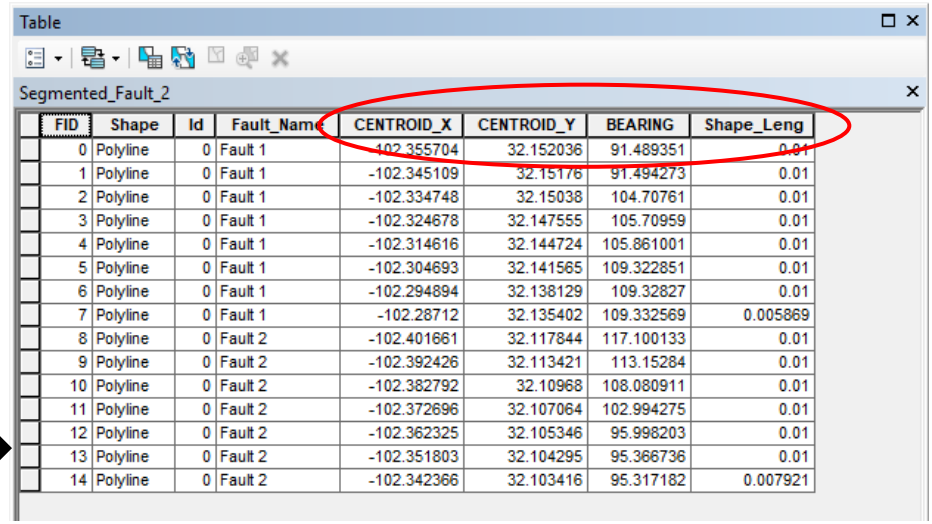
Your attribute table should now reflect the segmented faults

Step 3: Add Fault Attributes

The next step is to add length, centroid and line bearing to the fault segment.

1. Search for the “Add Geometry Attributes” (Data Management) Tool
2. Select the following geometry features
    1. Length
    2. Centroid
    3. Line_Bearing

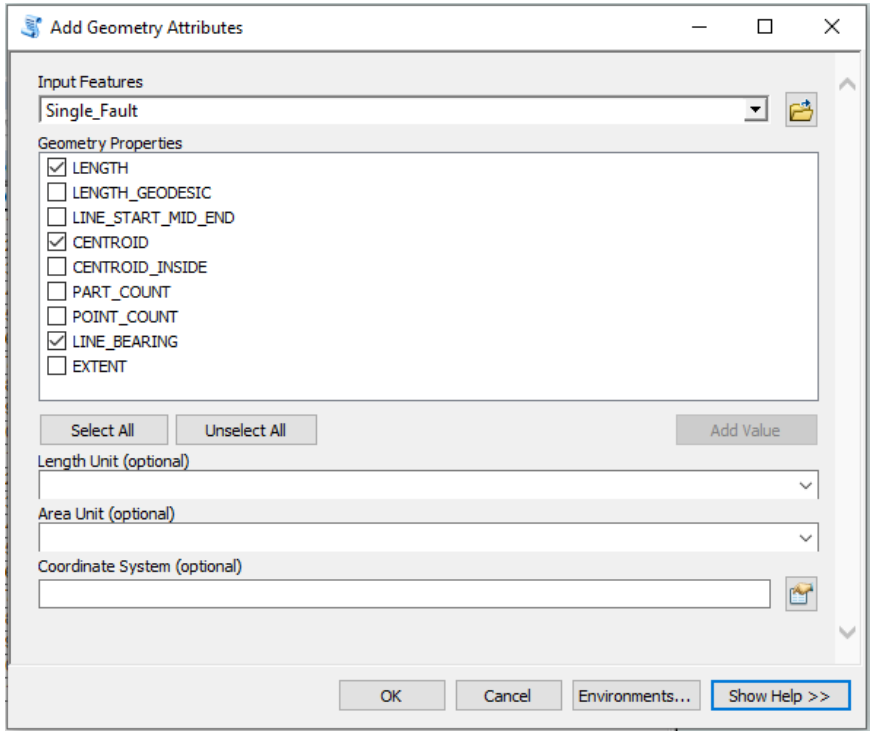




FID	Shape	Id	Fault_Nam	CENTROID_X	CENTROID_Y	BEARING	Shape_Leng
0	Polyline	0	Fault 1	-102.355704	32.152036	91.489351	0.01
1	Polyline	0	Fault 1	-102.345109	32.15176	91.494273	0.01
2	Polyline	0	Fault 1	-102.334748	32.15038	104.70761	0.01
3	Polyline	0	Fault 1	-102.324678	32.147555	105.70959	0.01
4	Polyline	0	Fault 1	-102.314616	32.144724	105.861001	0.01
5	Polyline	0	Fault 1	-102.304693	32.141565	109.322851	0.01
6	Polyline	0	Fault 1	-102.294894	32.138129	109.32827	0.01
7	Polyline	0	Fault 1	-102.28712	32.135402	109.332569	0.005869
8	Polyline	0	Fault 2	-102.401661	32.117844	117.100133	0.01
9	Polyline	0	Fault 2	-102.392426	32.113421	113.15284	0.01
10	Polyline	0	Fault 2	-102.382792	32.10968	108.080911	0.01
11	Polyline	0	Fault 2	-102.372696	32.107064	102.994275	0.01
12	Polyline	0	Fault 2	-102.362325	32.105346	95.998203	0.01
13	Polyline	0	Fault 2	-102.351803	32.104295	95.366736	0.01
14	Polyline	0	Fault 2	-102.342366	32.103416	95.317182	0.007921

Step 3: Add Fault Attributes

1. This tool is tricky sometimes. I've found it works best (with no problems) if you keep the attribute table open.
2. If the new columns don't show up right away..
    1. Save the project
    2. Remove and re-add the shapefile
    3. The columns should appear after this step



Step 4: Prepare Table for FSP Fault Inputs

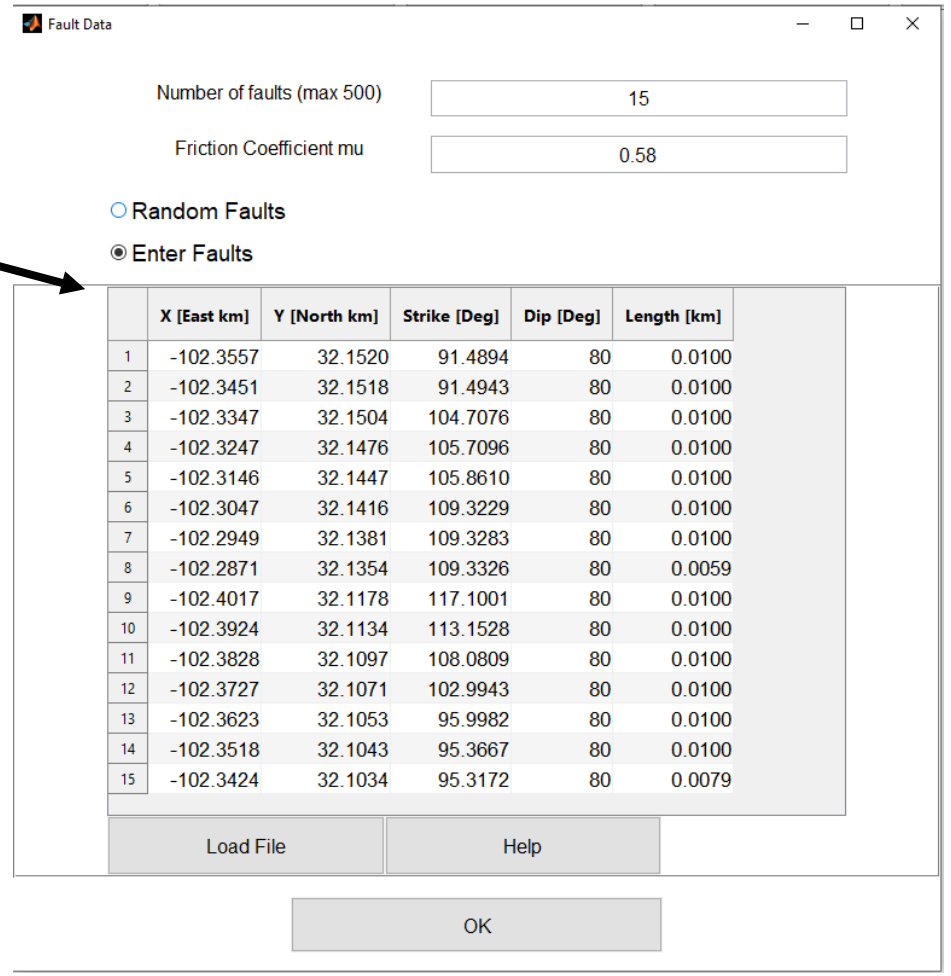
1. FSP Software Requirements for Fault Data: X (km), Y (km), Strike (degrees) Dip (degrees), length (km)

   note your units

   might need to convert

2. Reorganize columns for appropriate FSP inputs (remove all headers)

	A	B	C	D	E	F
1	-102.3557039	32.15204	91.48935	80	0.009999837	
2	-102.3451088	32.15176	91.49427	80	0.009999836	
3	-102.3347477	32.15038	104.7076	80	0.009999881	
4	-102.3246776	32.14755	105.7096	80	0.009999877	
5	-102.3146155	32.14472	105.861	80	0.009999871	
6	-102.3046934	32.14157	109.3229	80	0.009999886	
7	-102.2948944	32.13813	109.3283	80	0.009999877	
8	-102.2871196	32.1354	109.3326	80	0.005869283	
9	-102.401661	32.11784	117.1001	80	0.009999886	
10	-102.3924259	32.11342	113.1528	80	0.00999984	
11	-102.3827924	32.10968	108.0809	80	0.009999792	
12	-102.3726963	32.10706	102.9943	80	0.00999975	
13	-102.3623248	32.10535	95.9982	80	0.009999716	
14	-102.3518027	32.10429	95.36674	80	0.009999712	
15	-102.3423658	32.10342	95.31718	80	0.007921059	
16						
17						



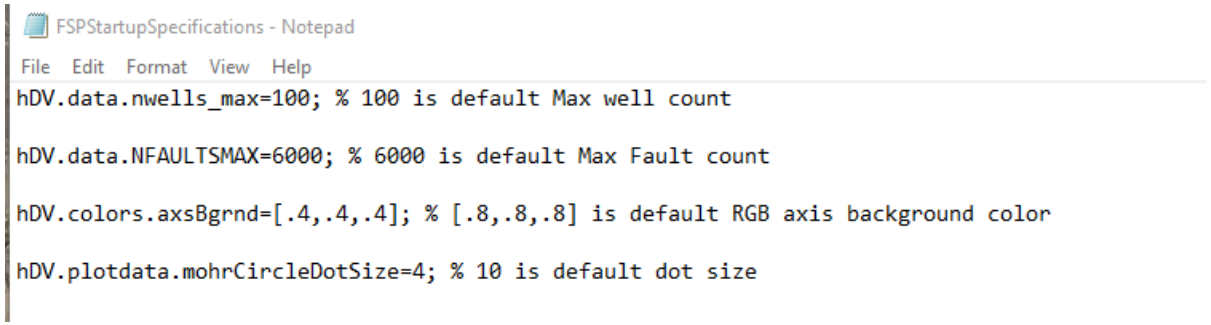
	X [East km]	Y [North km]	Strike [Deg]	Dip [Deg]	Length [km]
1	-102.3557	32.1520	91.4894	80	0.0100
2	-102.3451	32.1518	91.4943	80	0.0100
3	-102.3347	32.1504	104.7076	80	0.0100
4	-102.3247	32.1476	105.7096	80	0.0100
5	-102.3146	32.1447	105.8610	80	0.0100
6	-102.3047	32.1416	109.3229	80	0.0100
7	-102.2949	32.1381	109.3283	80	0.0100
8	-102.2871	32.1354	109.3326	80	0.0059
9	-102.4017	32.1178	117.1001	80	0.0100
10	-102.3924	32.1134	113.1528	80	0.0100
11	-102.3828	32.1097	108.0809	80	0.0100
12	-102.3727	32.1071	102.9943	80	0.0100
13	-102.3623	32.1053	95.9982	80	0.0100
14	-102.3518	32.1043	95.3667	80	0.0100
15	-102.3424	32.1034	95.3172	80	0.0079

Step 5: Tailor “FSPStartupSpecifications” text file

- The FSPStartupSpecifications text file (open in Notepad) allows you to modify the maximum number of wells an faults to run in Fault Slip Potential
- Default:
  - 10 wells

    (hDV.data.nwells_max=10; % 10 is default Max well count)
  - 500 faults

    hDV.data.NFAULTSMAX=500; % 500 is default Max Fault count
- Modified:
- 100 wells
  - (hDV.data.nwells_max=100; % 100 is default Max well count)
- 6000 faults
  - hDV.data.NFAULTSMAX=6000; % 6000 is default Max Fault count



You can change these values by modifying the numbers in the script, as shown above

Note, once you modify the startup specifications, it will take longer for the FSP window to open!!!

Step 6a: Run FSP like normal (DFSP)

Deterministic fault slip potential needs to be calculated before any of the probabilistic uncertainty values are added.

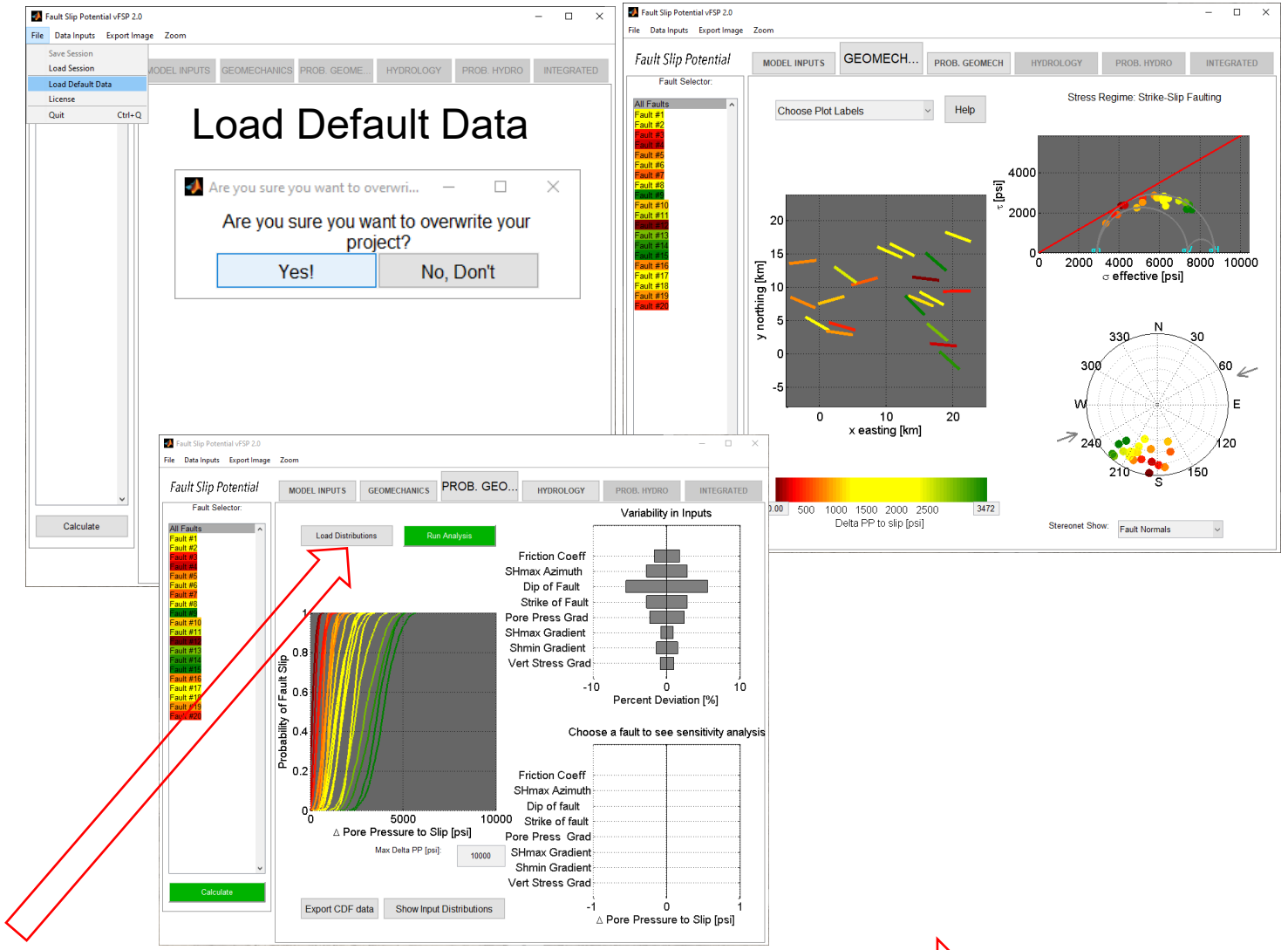
Therefore, it is best to:

1. Open FSP (may take ~30 min to load, if you modified the FSPStartupSpecifications!)
2. Load Data “Data Inputs”
3. Hit calculate in:
    1. “Model Inputs”
    2. “Geomechanics” (Step 8a)
        - You can read the DFSP results off of the Geomechanics window, by hand, or in…
    3. “Probabilistic Geomechanics” (Step 8b)
        - This window allows you to export a spreadsheet with DFSP results, by selecting “**Export CDF data**”
    4. **<u>There is no need to go any further, as the “ Export CDF data will result in the DFSP values for each fault</u>**

Step 6b: Run FSP like normal (PFSP)

- Deterministic fault slip potential needs to be calculated before any of the probabilistic uncertainty values are added. Therefore, it is best to:

1. Open FSP (may take ~30 min to load, if you modified the FSPStartupSpecifications!)
2. Load Default Data “File”
   - Always hit that you want to overwrite your existing project
3. Hit **calculate** on every single window before you attempt to add your own data inputs
   - The next analyis window will be greyed out unless calculate is hit in each earlier window
   - This primes the final “integrated” window
4. Once run, you must scroll back to
   - “Model Inputs” and then load your desired stress data, fault data, and well or hydrology model
5. Now, you can run FSP like “normal”
   - Remember to add uncertainty ranges by selecting “**Load Distributions**” in the “Probabilistic Geomechanics” window



Examples on Next Slide

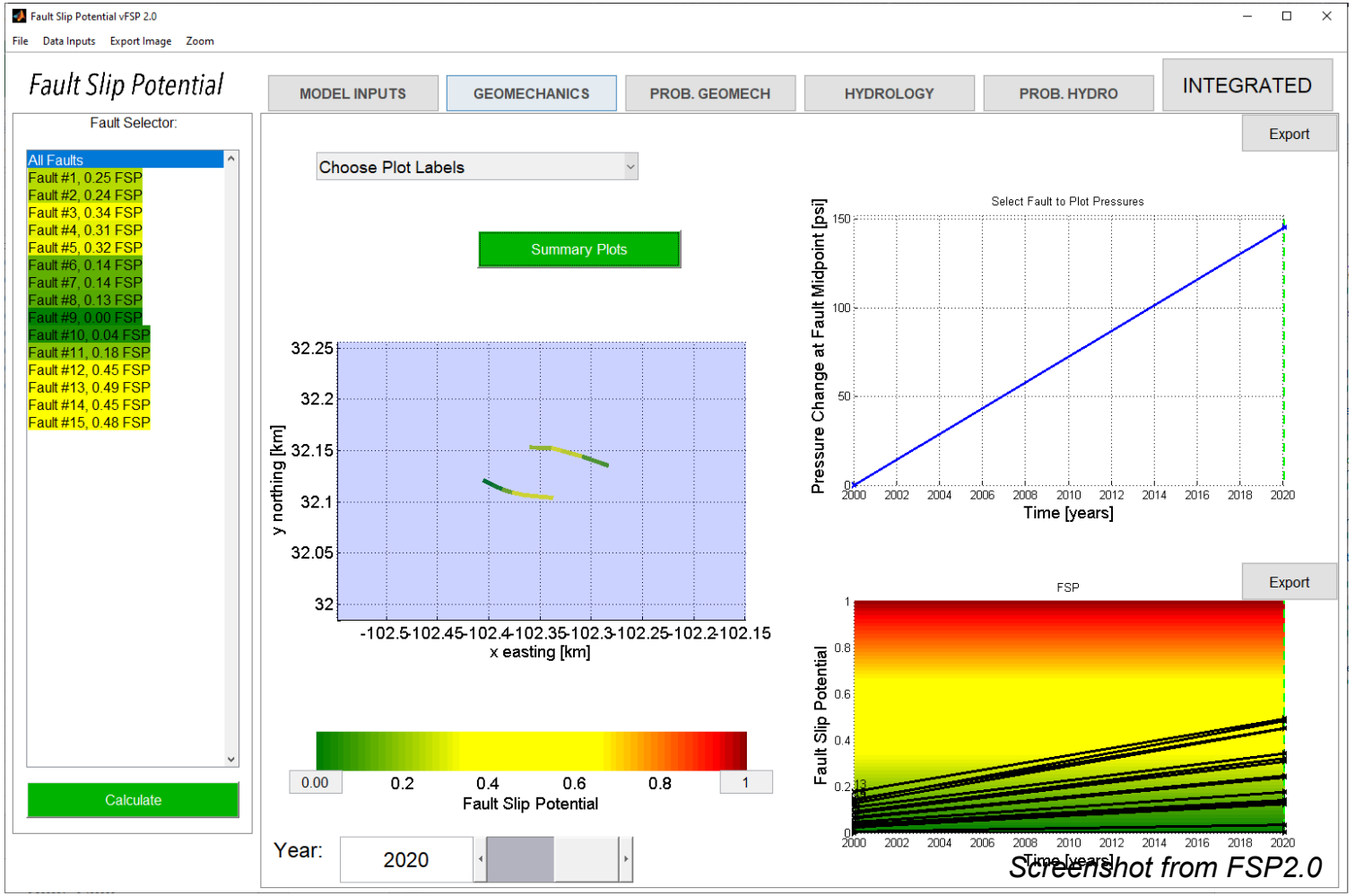
Screenshots from

Step 6: Run FSP like normal

- Final FSP results displayed in the Integrated Tab

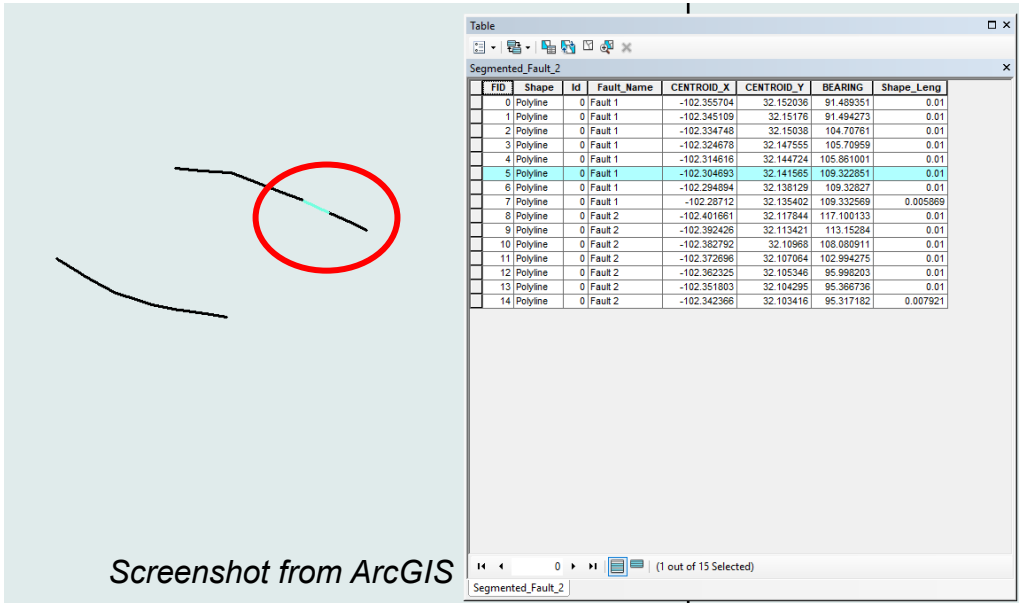
- The Fault segments loaded into FSP are in the same order as the faults in ArcGIS
  - If you click through each segment in FSP software, the same order will appear in the attribute table in ArcGIS

Examples on Next Slide



Screenshot from FSP2.0

Example of Attribute Table and FSP Faults



Screenshot from ArcGIS

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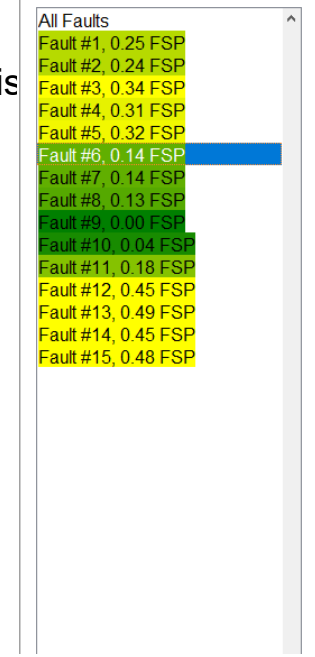
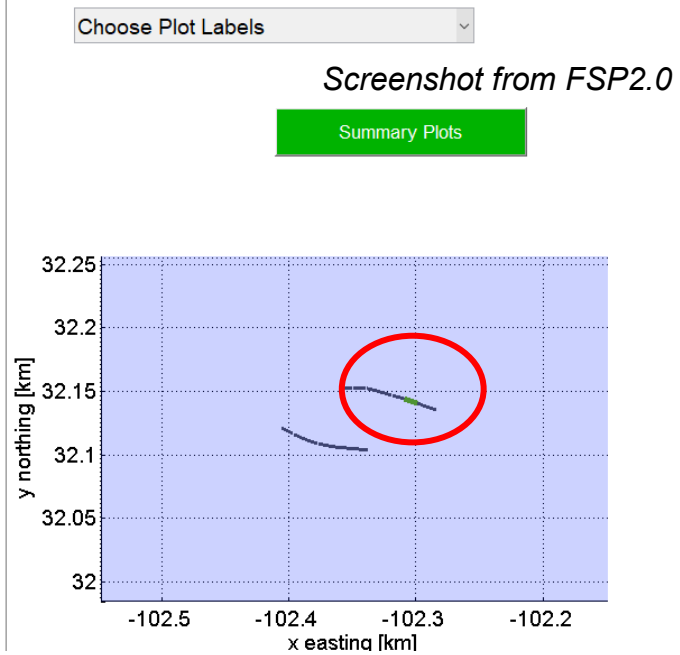
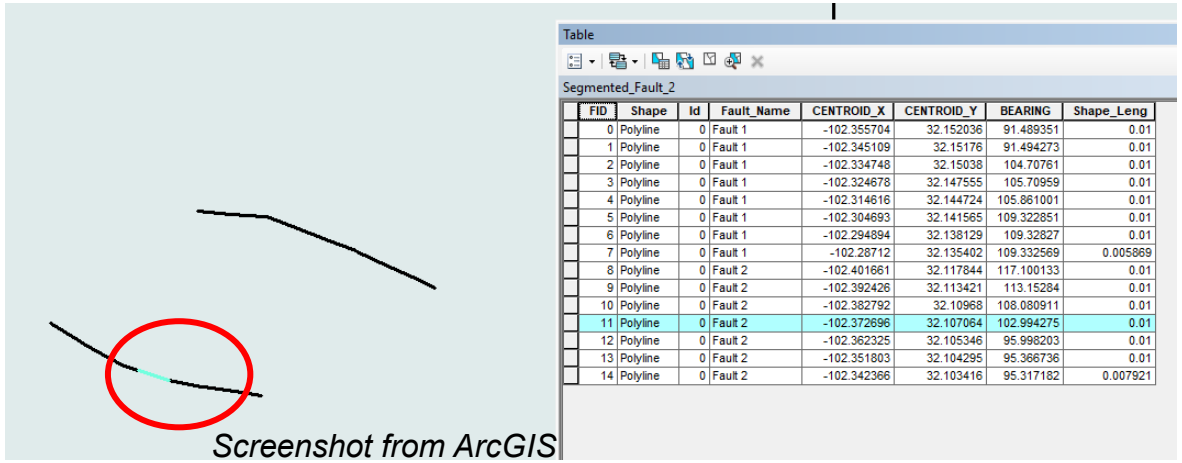
14	Polyline	0	Fault 2	-102.342366	32.103416	95.317182	0.007921

Example #1: The 6th fault segment in Arc is the 6th fault in FSP software





Screenshot from FSP2.0



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2	Polyline	0	Fault 1	-102.334748	32.15038	104.70761	0.01
3	Polyline	0	Fault 1	-102.324678	32.147555	105.70959	0.01
4	Polyline	0	Fault 1	-102.314616	32.144724	105.861001	0.01
5	Polyline	0	Fault 1	-102.304693	32.141565	109.322851	0.01
6	Polyline	0	Fault 1	-102.294894	32.138129	109.32827	0.01
7	Polyline	0	Fault 1	-102.28712	32.135402	109.332569	0.005869
8	Polyline	0	Fault 2	-102.401661	32.117844	117.100133	0.01
9	Polyline	0	Fault 2	-102.392426	32.113421	113.15284	0.01
10	Polyline	0	Fault 2	-102.382792	32.10968	108.080911	0.01
11	Polyline	0	Fault 2	-102.372696	32.107064	102.994275	0.01
12	Polyline	0	Fault 2	-102.362325	32.105346	95.998203	0.01
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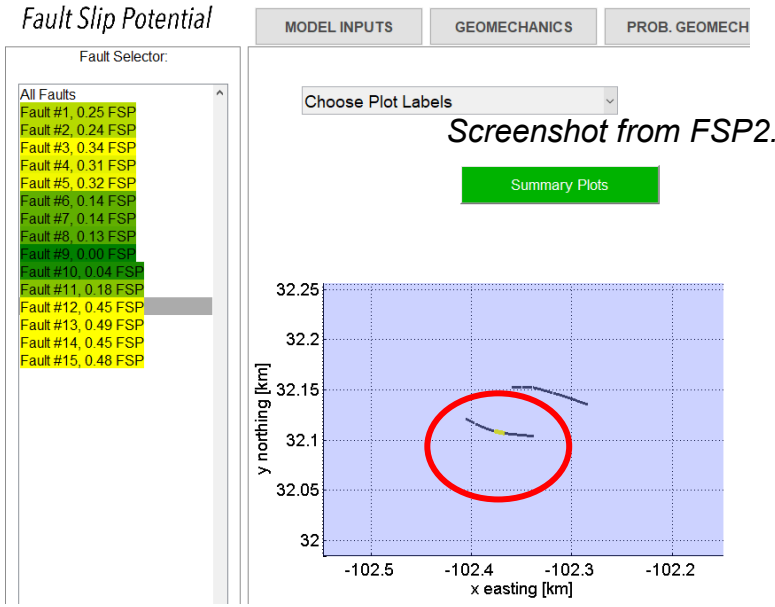
14	Polyline	0	Fault 2	-102.342366	32.103416	95.317182	0.007921

Example #2: The 12th fault segment in Arc is the 12th fault in FSP software



Screenshot from FSP2.0

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Step 7: Add Field in ArcGIS attribute table

- Add a column by using “Add Field” in Fault Attribute Table that will hold your FSP results
  - Use floating point for decimal values

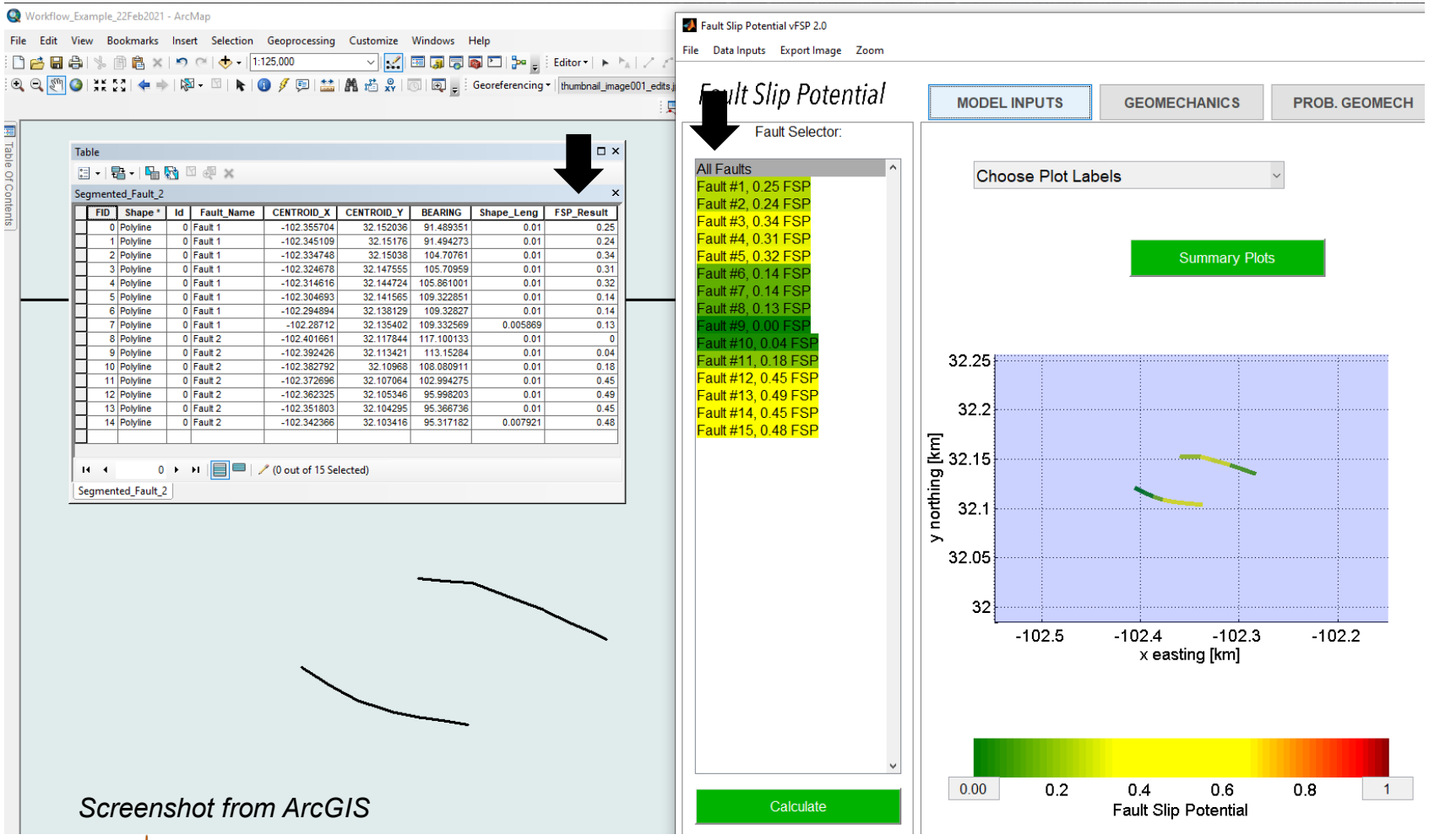
Table

Segmented_Fault_2

FID	Shape *	Id	Fault_Name	CENTROID_X	CENTROID_Y	BEARING	Shape_Leng	FSP_Result
0	Polyline	0	Fault 1	-102.355704	32.152036	91.489351	0.01	0
1	Polyline	0	Fault 1	-102.345109	32.15176	91.494273	0.01	0
2	Polyline	0	Fault 1	-102.334748	32.15038	104.70761	0.01	0
3	Polyline	0	Fault 1	-102.324678	32.147555	105.70959	0.01	0
4	Polyline	0	Fault 1	-102.314616	32.144724	105.861001	0.01	0
5	Polyline	0	Fault 1	-102.304693	32.141565	109.322851	0.01	0
6	Polyline	0	Fault 1	-102.294894	32.138129	109.32827	0.01	0
7	Polyline	0	Fault 1	-102.28712	32.135402	109.332569	0.005869	0
8	Polyline	0	Fault 2	-102.401661	32.117844	117.100133	0.01	0
9	Polyline	0	Fault 2	-102.392426	32.113421	113.15284	0.01	0
10	Polyline	0	Fault 2	-102.382792	32.10968	108.080911	0.01	0
11	Polyline	0	Fault 2	-102.372696	32.107064	102.994275	0.01	0
12	Polyline	0	Fault 2	-102.362325	32.105346	95.998203	0.01	0
13	Polyline	0	Fault 2	-102.351803	32.104295	95.366736	0.01	0
14	Polyline	0	Fault 2	-102.342366	32.103416	95.317182	0.007921	0

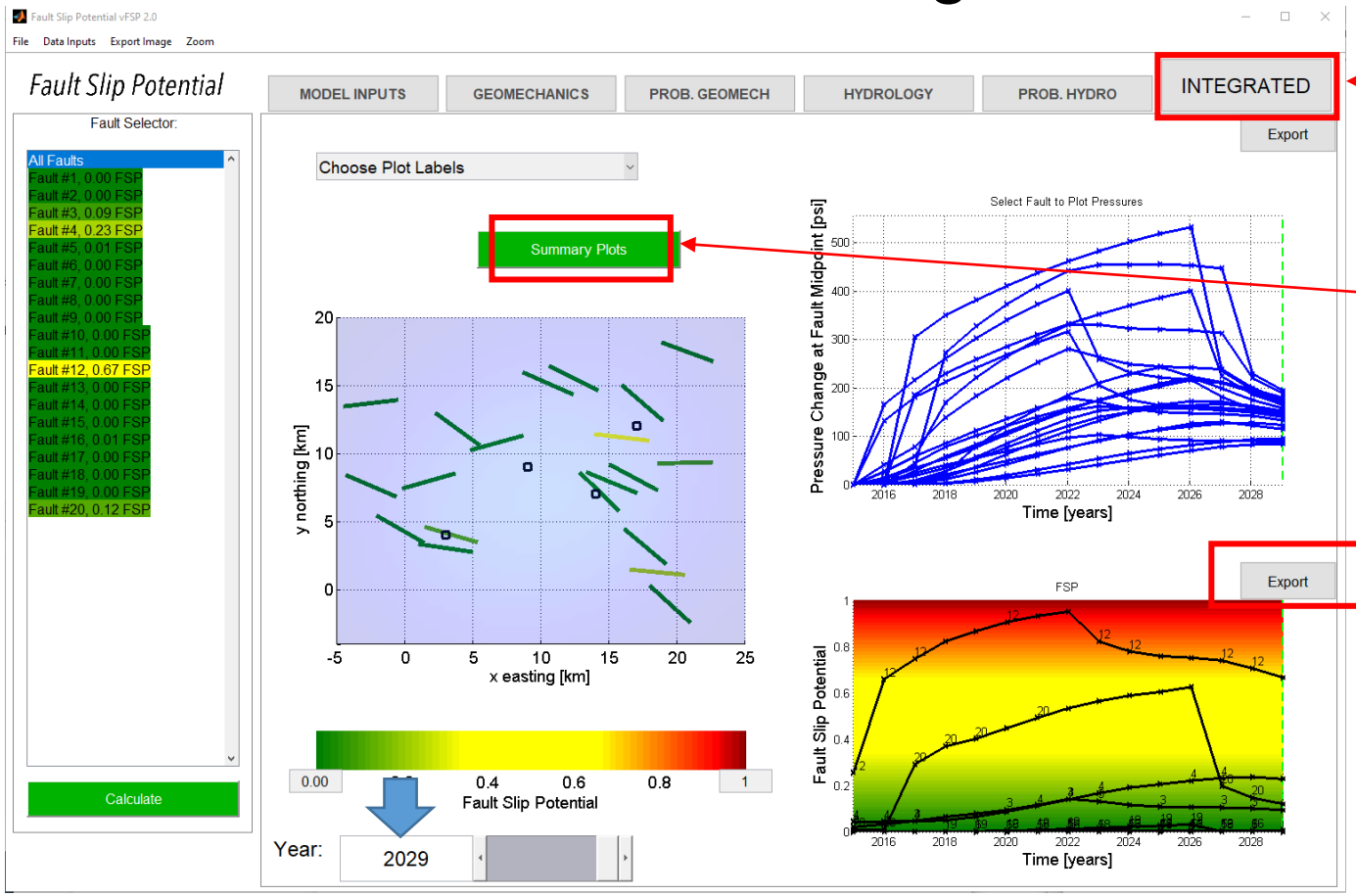
Step 8a: Manually type FSP results into table

- Manually add (type) the FSP results into the Attribute table
  - The order of the segments are the same



Step 8b: (alternative - almost automatic!)

- Although you can manually add FSP results (as shown in slide 15) there is an option to export the results as a full spreadsheet.
- This will be under the “Integrated” window in FSP.



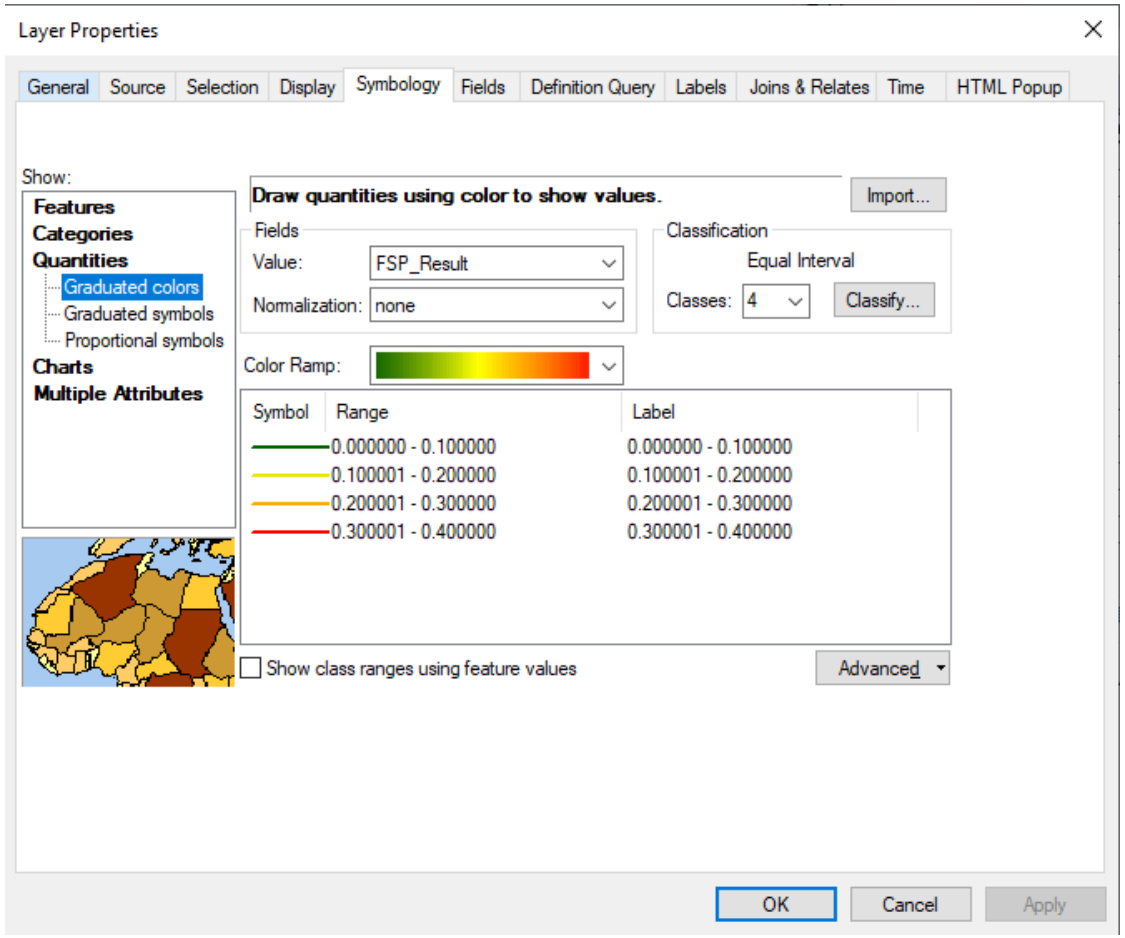
Step 1 (get to this point in FSP)

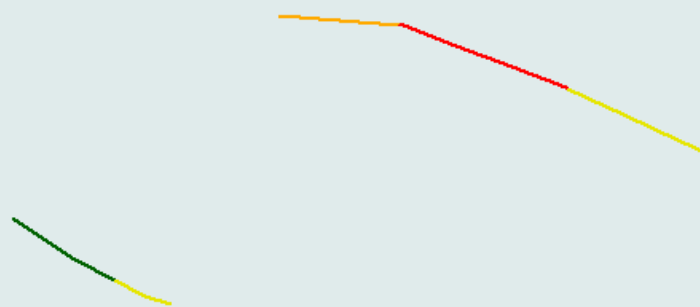
Step 2, you want to calculate & click the summary plots. Depending on your project it will go through all years, the bar at the bottom (blue arrow) shows that it made it through to 2029 (default session)

Step 3 – once step 2 is complete, you can hit export. This will allow you to save a CSV containing FSP calculated for each node on each year. From this CSV, you can copy and paste into your ArcGIS shapefiles attribute table (make sure you are in edit mode!)

Step 9: Apply Symbology to FSP Results

In Layer Properties, create a scale of colors that you want to display the FSP results as.





Screenshot from ArcGIS