

Customization of ArcGIS Pro: WSDOT's GIS Workbench Data Access Add-In

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Over the past decades, many organizations have invested significant time and money in developing custom extensions, toolboxes, styles, map templates, and Add-Ins for use in ESRI's 32-bit ArcGIS Desktop application. ESRI's introduction of ArcGIS Pro, a 64-bit multi-threaded desktop application in 2015, was the first indication that the current generation of 32-bit desktop applications were nearing end of life. The large investments made in the 32-bit ArcGIS Desktop family and the inability to deploy ArcGIS Pro in a concurrent use enterprise environment prevented its wide spread adoption. ESRI's decision in 2016 to begin supporting a concurrent use license model for ArcGIS Pro finally made it a viable replacement for ArcMap in our enterprise environment. Described here is the process used by the Washington State Department of Transportation to configure ArcGIS Pro for concurrent use, deploy the application, and customize its installation to include WSDOT specific project templates and the WSDOT GIS Workbench Data Access Add-In.

Background

The original Environmental GIS Workbench was developed between 1995 and 1997 in ArcView and was designed to provide simplified access to GIS data and tools needed to perform Environmental Review and Permitting at the Washington State Department of Transportation (WSDOT). The user base of the Environmental GIS Workbench rapidly grew beyond the original environmental staff to include all business groups that had a need to visualize the geographic location of the agencies data. As other business areas came to recognize the value of the workbench concept, it became apparent that a more flexible approach for the Workbench was needed to avoid duplication of effort.

To meet this need an ArcMap based extension known as the GIS Workbench was developed in 2003 that supported multiple business functions by employing an "application definition" database to contain business rules for each business area. The GIS Workbench tailored the datasets and tools that were displayed in the interface on-the-fly based on the business rules stored for each business area in the application database. Implementation of this conceptual model ensured that the department's enterprise GIS data was readily accessible for analysis and mapping while avoiding costly software development (i.e., one GIS Workbench to meet the needs of many). This allows the same data to be represented in multiple forms for various business areas. The GIS Workbench has been enhanced over the years and is now at its tenth major upgrade and is currently supported in ArcGIS Desktop 10.4.1.

The success of the GIS Workbench can be attributed to the initial vision of its design team (Figure 1). Their vision emphasized the need to provide access to the analytical tools available in GIS to our employees while removing one of the greatest barriers to its use –knowing where the data are located. The GIS Workbench allows users to simply search for data by subject, without needing to know the network path to where the data is stored. The value of the GIS Workbench concept has been recognized agency wide. Currently 8% of our employees directly 'touch' this extension monthly. It is used for Project Scoping and Cost Estimation of every construction project undertaken by the Washington State Department of Transportation, for facilities management, and by our emergency operations center.

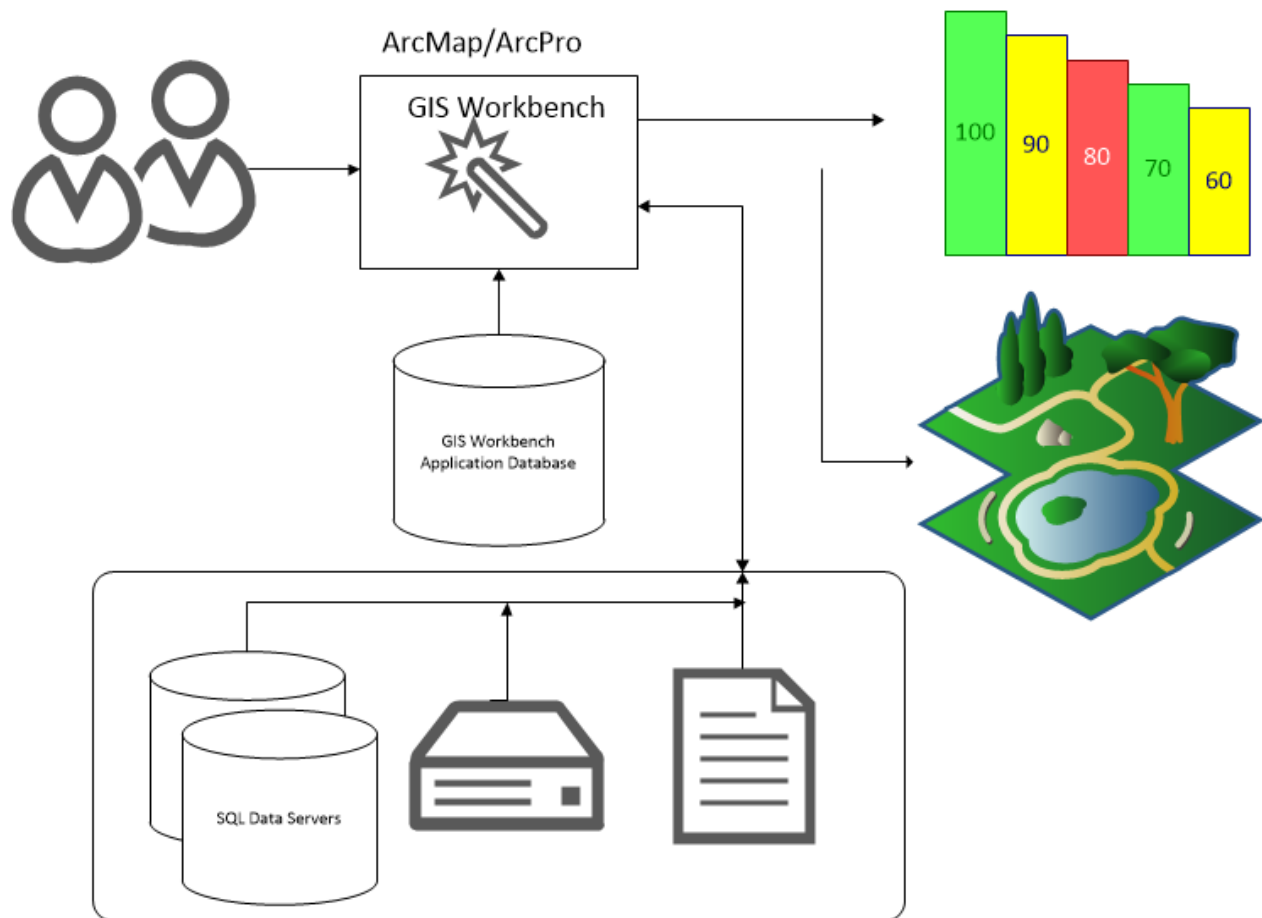


Figure 1. Conceptual diagram showing how the GIS Workbench extension removes the need to know “where” data are stored when using the analytical tools provided by ArcGIS.

ArcGIS Pro – The Next Generation of Desktop Mapping

ESRI’s decision in 2016 to begin supporting a concurrent-use license model for ArcGIS Pro made it a viable replacement for ArcMap in enterprise environments. ArcGIS Pro 1.4.1 is a stable platform that is suitable for software development and production use. Prior to deploying ArcGIS Pro to the enterprise, we needed to determine how to customize and deploy the next generation of the GIS Workbench in the ArcGIS Pro environment. This project had three major components:

- Identifying an enterprise deployment methodology for ArcGIS Pro
- Development of custom WSDOT Project Templates & Styles
- Development of a GIS Workbench Pro Add-In and WSDOT Ribbon

These three activities have been completed and the GIS Workbench Add-in was released for initial user evaluation in March 2017. We will update our *Introduction to GIS* training class to include ArcGIS Pro in the fall of 2017. We expect the migration from ArcMap to ArcGIS Pro to begin in earnest in 2018 with ArcMap targeted to becoming “legacy” software in the fall of 2020.

Deployment methodology

At WSDOT we use Microsoft Software Center and other automated deployment technologies to install GIS software on the end users machine. We install ArcGIS Desktop and the GIS Workbench to

approximately 2,100 machines each time a new version of ArcGIS Desktop is released. Along with these two packages, we install several supporting custom packages. These include our ArcInfo Shortcuts and WSDOT ArcGIS Desktop Customizations package. The need to update custom packages such as these has caused large organizations like WSDOT to lag behind the ArcGIS Desktop release cycle (e.g., at this writing WSDOT is just beginning the migration to ArcGIS Desktop 10.4.1 and ESRI™ has already released ArcGIS 10.5).

The Add-In methodology supported by ArcGIS Pro fits well with our existing GIS Workbench design and is amendable to the Agile software development approach. It removed the need for creating an install package and scheduling an agency wide deployment at each software release, as is required for a traditional ArcObjects™ extension. This change, from an extension to an Add-In, has allowed us to focus on the programming and reengineering aspects of the project. We refactored the GIS Workbench into smaller functional components that could be developed quickly, easily maintained, and incrementally released; thus, allowing for iterative software development.

In ArcGIS Pro, Add-Ins can be added into the Pro interface without deploying the code to the end-users computer. Rather we add a registry setting into the ArcGIS Pro hive that points to a 'well known location' (this registry setting is installed by our WSDOT ArcGIS Pro Customization install package, described below). Any Add-Ins located at the well-known location are read by ArcGIS Pro on start-up and automatically downloaded and cached locally. ArcGIS Pro checks for updates each time it starts; if the source code at the well-known location is updated the new version it is automatically downloaded and the cache updated.

WSDOT Project Templates and Styles

The out of the box interface for ArcGIS Pro is suitable for skilled GIS practitioners or those working independently. However, in organizations with fixed geographic boundaries or large number of users the time lost to 'recreate or load' a base map becomes an issue. Using a consistent base map within an organization contributes to developing a common operational picture. This speeds map production and simplifies map interpretation and sharing within your organization.

As mentioned previously, WSDOT currently deploys a Microsoft install package containing WSDOT specific customizations to all users who have ArcGIS Desktop installed. To support ArcGIS Pro a similar customization package was created. This package contains the following three components:

Two custom Project Templates, made available in the Pro Interface by installing the APTX files to:

C:\Program Files\ArcGIS\Pro\Resources\ProjectTemplates

One custom Style file, made available in the Pro Interface by installing the STYLX file to:

C:\Program Files\ArcGIS\Pro\Resources\Styles

The path to our custom Add-Ins (in our case located on a network share) are made searchable by Pro by adding their path to the registry. The PATH data is added to the registry at the following location:

HKLM\Software\ESRI\ArcGISPro\Settings\Add-in Folders

After installation of the WSDOT ArcGIS Pro Customizations, the templates and styles are directly available within the ArcGIS Pro interface and any Add-Ins located at the well-known locations defined in the registry are automatically loaded as Shared Add-Ins and made available within the ArcGIS Pro interface (Figure 2).

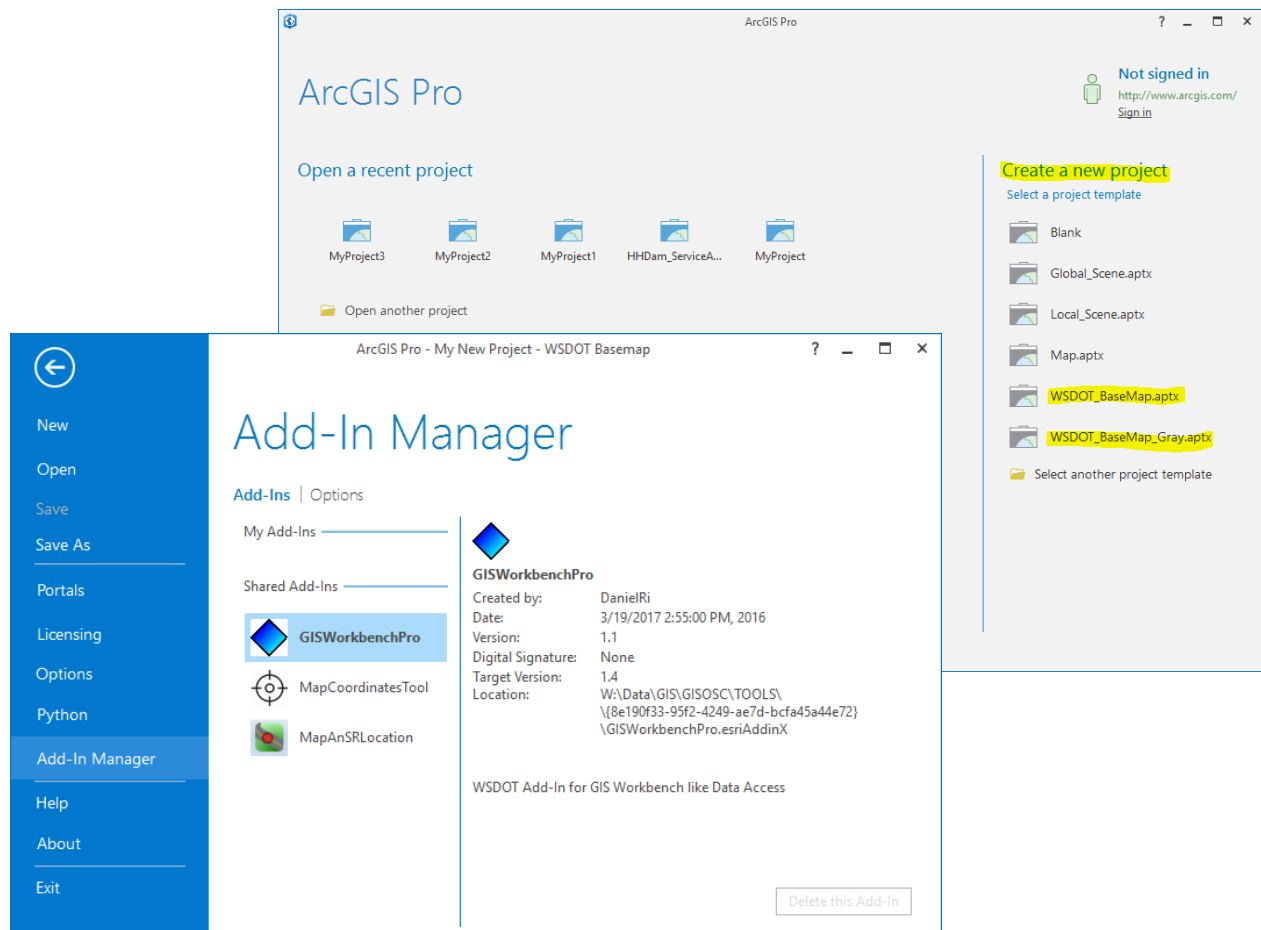


Figure 2. Display of the startup screen in ArcGIS Pro and the Add-In Manager screen. Note the two custom WSDOT project templates listed on the middle right of the start-up screen window and the three Add-Ins listed under ‘Shared Add-Ins’ in the Add-In Manager.

When preparing to deploy ArcGIS Pro for enterprise use we make the following updates to the Properties Table contained within ESRI’s Microsoft install package for ArcGIS Pro (Table 1). Making these changes ensures that the end-user does not have to deal with licensing and setup issues on first use of the application. These edits may be done in one of several MSI editing tools; I recommend the Orca Editor provided by Microsoft since it is free, simple to use, and intuitive.

Table 1. Values contained in the ArcGIS Pro MSI Properties or Registry Tables that should be updated prior to enterprise deployment

NAME of Property or Registry setting to Update:	ArcGIS Pro 1.4.1	ArcGIS Pro 2.0
ARCPRO_AUTH_TYPE	BASIC (Property)	BASIC (Registry)
AUTHORIZATION_TYPE	CONCURRENT_USE (Property)	CONCURRENT_USE (Registry)
AgreeToLicense	Yes (Property)	Yes (Property)

ApplicationUsers	AllUsers (Property)	AllUsers (Property)
SEAT_PREFERENCE	Float (Property)	Float (Registry)
ESRI_LICENSE_HOST	<License Server Name> (Property)	<License Server Name> (Property)

Note - The license server name is the name of the server hosting the licensing for ArcGIS Pro (e.g., LIC_SERVER_001); this may be the same license manager currently utilized for ArcGIS Desktop. If you make these changes to the ArcGIS Pro package, when your end user starts the software for the first time they will be taken directly to the 'Open a recent project' screen shown in **Figure 2** rather than a sign-in screen for ArcGIS Online or a 'select license level' screen -both of which are confusing to a novice user.

GIS Workbench Pro Add-In and WSDOT Ribbon

Add-Ins for ArcGIS Pro are developed based on the add-in and configurations extensibility pattern and leverage modern .NET features and patterns such as Task Asynchronous Programming (TAP), LINQ, WPF Binding, and MVVM to write integrated 2D/3D add-ins using Pro's new APIs. If you have access to Visual Studio 2013 or 2015 (Professional, Enterprise, and Community Editions) you can start building your own Add-Ins using Project Templates loaded by the Pro SDK for Visual Studio¹ or code snippets available at GitHub².

This paper is too short to cover the ins and outs of building an Add-In using the ArcGIS Pro SDK in Visual Studio; but let us take a look at the Add-In configuration file created for each Add-In. The configuration file follows common XML formatting rules and defines how the Add-In is displayed in the ArcGIS Pro interface.

When you create an Add-In in Visual Studio it is assigned a Global Unique Identifier (GUID) that is saved in the configuration file. Unless you manually change it the GUID it will stay the same throughout the life of the project. This ID can be thought of as a unique name for the Add-In. When Add-Ins are loaded by ArcGIS Pro they are added to the interface in sequence based on their GUID. Thus, an Add-In with a GUID of {AA3e4567-e89b-12d3-a456-426655440000} is read before an Add-In with GUID of {BB3f4567-e89b-12d3-a456-426655440000}.

ArcGIS Pro uses the Last Edited or Creation date contained in your configuration file (i.e., the Config.daml file) to determine if it needs to update the locally stored version of the Add-In. It will look at any 'Well Known Location' defined in the registry to see if the Add-In Source located there is newer than the one stored in the local Add-In cache; if true, the new code will be downloaded.

Both the GUID and Date are stored in the configuration file associated with your project. The Config.daml file also contains the definitions for your custom Tabs (a.k.a., Ribbons), Groups, and Controls (i.e., buttons and tools). The basic anatomy of the configuration file is shown in Table 2.

¹ArcGIS Pro 1.4 SDK for .NET can be found at <https://github.com/Esri/arcgis-pro-sdk/wiki#arcgis-pro-sdk-for-net-templates>.

²Code samples can be found at <https://github.com/Esri/arcgis-pro-sdk>

Table 2. Anatomy of a Config.daml XML configuration file. The GUID and last edited date are contained within the <AddInInfo> tag and that <modules> tag contains the controls, groups and Tabs tags.

```

<ArcGIS defaultAssembly="ProAppModule1.dll" ...>
  <AddInInfo id="{6f55c658-9e44-463d-8f1e-72380bd8c773}" version="1.0 ...>
    <Name>ProAppModule1</Name>
  ...
  <Date>4/27/2017 5:00:01 PM, 2017</Date>
</AddInInfo>
<modules>
  <insertModule id="ProAppModule1_Module" className="Module1" ...>
    <tabs>
      <!-- add groups to Ribbon/Tab, Step 3-->
    </tabs>
    <groups>
      <group> <!-- add controls to groups, Step 2 --> </group>
    </groups>
    <controls>
      <!--add/DEFINE your controls here, Step 1 -->
    </controls>
  </insertModule>
</modules>
</ArcGIS>

```

In the case of the GIS Workbench Pro Add-In, we defined three controls: Data, Tools, and StreetView™ (Step 1). These three controls were then placed into a group (Step 2). The group was then added to a custom tab named WSDOT (Step 3). Figure 3 shows how the GIS Workbench Pro Add-In would appear in ArcGIS Pro.

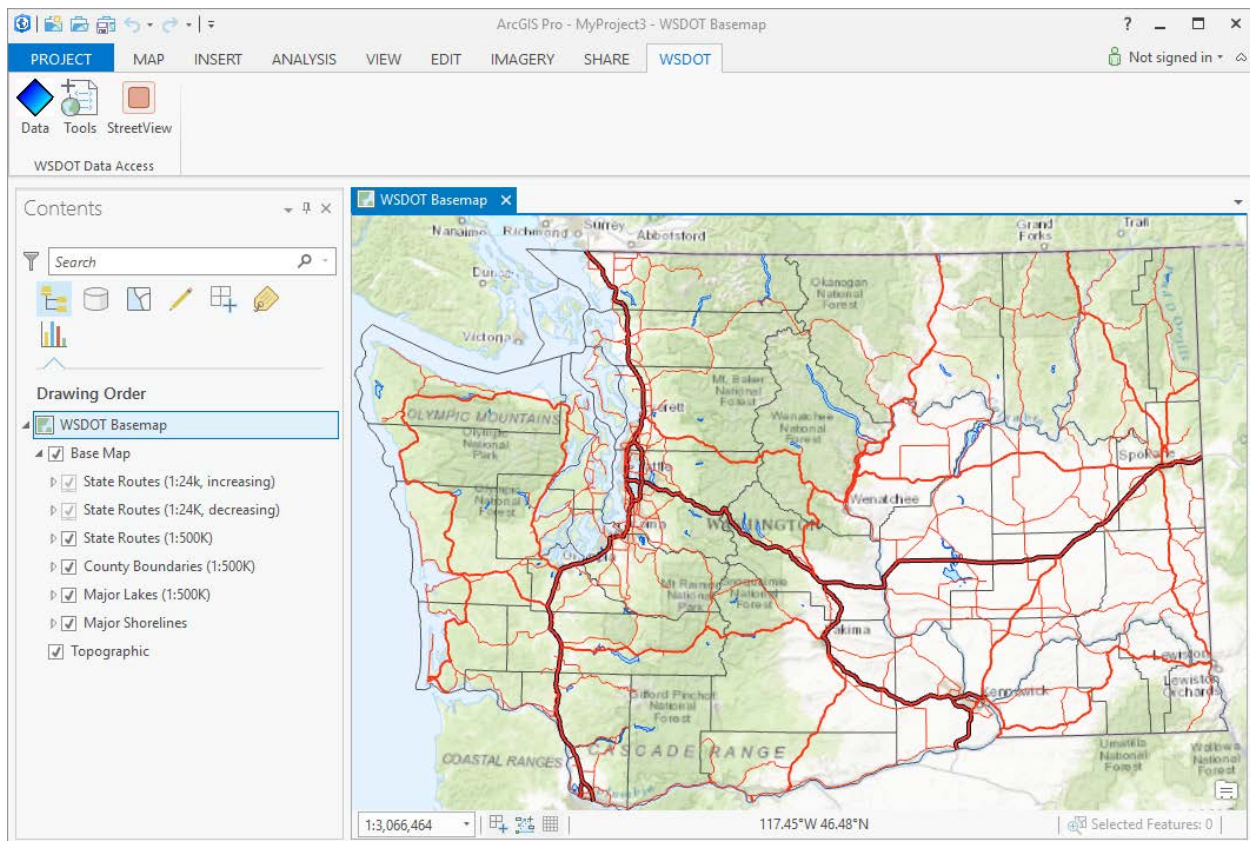


Figure 3. GIS Workbench Pro Add-In loaded into the ArcGIS Pro interface. There are three controls in one group located on the WSDOT custom Tab (groups are indicated by the vertical bars, in this case to the right of the StreetView™ control).

To add additional controls to the WSDOT custom tab, the config.daml file of the second, third, etc. Add-In would be edited to ADD the control to the existing WSDOT tab. For this to work the GUID of the second, third, etc. Add-Ins have to be higher, alphabetically, than that of the first. This is because Add-Ins are loaded in sequence based on their GUID and the WSDOT tab would not be defined in ArcGIS Pro if the 'second' Add-In were loaded before the GIS Workbench Pro Add-In.

In the following example, we add the Show Coordinates control to the WSDOT tab. To do this we build the new Add-In as usual but when complete we edited the config.daml to comment out the <tab> element and added a new <updateModule> element. The updateModule element is used in a DAML file to ADD a group to an existing tab in the ArcGIS Pro interface. In Figure 4 we demonstrate how to add a control, in this case Show Coordinates, to the WSDOT tab. Note - this same pattern could be used to add a custom control to an existing ArcGIS Pro tab.

```

1 <ArcGIS defaultAssembly="BasicMapTool.dll" defaultNamespace="BasicMapTool" xmlns="http://schemas.esri.com/DADF/Regis
2 <AddInInfo id="{aa226987-8efd-4d34-b606-3e731c8cd2ad}" version="1.0" desktopVersion="1.4.7198">
3   <Name>MapCoordinatesTool</Name>
4   <Description>Provides a basic map tool that can be used as a starting point for more
5   sophisticated tool development. It has all the basic features such as key handling, simple mouse click
6   implementation, and an associated embeddable control that can be moved around the Map View.</Description>
7   <Image>Images\crosshair32.png</Image>
8   <Author>Esri; Modified by DanielRi</Author>
9   <Company>WSDOT</Company>
10  <Date>3/26/2017 3:55:00 PM, 2016</Date>
11  <Subject>Map Exploration</Subject>
12  <!-- Note subject can be one or more of these topics:
13       Content, Framework, Editing, Geodatabase, Geometry, Geoprocessing, Layouts, Map Authoring, Map E
14 </AddInInfo>
15 <modules>
16   <insertModule id="BasicMapTool_Module" className="MapCoordinatesTool" autoLoad="false" caption="MapCoordinatesTo
17   <!-- uncomment to have the control hosted on a separate tab-->
18   <tabs>
19     <!--<tab id="BasicMapTool_Tab1" caption="New Tab">
20       <group refID="BasicMapTool_Group1"/>
21     </tab-->
22   </tabs>
23   <groups>
24     <!-- comment this out if you have no controls on the Addin tab to avoid
25     an empty group-->
26     <group id="GISWorkbenchPro_Group2" caption="Add-In Tools" appearsOnAddInTab="false" keytip="Tool">
27       <!-- host controls within groups -->
28       <tool refID="GetCoordinatesTool_BasicMapTool" size="large" />
29     </group>
30   </groups>
31   <controls>
32     <!-- add your controls here -->
33     <tool id="GetCoordinatesTool_BasicMapTool" caption="Show Coordinates" keytip="T1" className="BasicMapTool" 1
34     <tooltip heading="Show Coordinates">Show Coordinates of last left mouse click.<disabledText /></tooltip>
35   </tool>
36   </controls>
37 </insertModule>
38 <!-- This adds the custom tool to an existing Tab and places it 'after' the tools already on the tab -->
39 <updateModule refID="GISWorkbenchPro_Module">
40   <tabs>
41     <updateTab refID="GISWorkbenchPro_WSDOT_Tab">
42       <insertGroup refID="GISWorkbenchPro_Group2" insert="after"></insertGroup>
43     </updateTab>
44   </tabs>
45 </updateModule>
46 </modules>
47 </ArcGIS>

```

Figure 4. XML configuration file for the Show Coordinates Add-In. Note that the <tab> element is commented out and the presence of the <updateModule> element, which is used to update an existing tab (i.e., WSDOT_Tab) by adding a new group (GISWorkbenchPro_Group2) which contains one control.

After making the changes shown in Figure 4 and updating the last edited date, the Show Coordinates Add-In would then be recompiled and posted to our well-known Add-In location. The next time ArcGIS Pro is started the updated Add-In would be downloaded and the **GetCoordinatesTool** control, located on the GISWorkbench_Group2 group, would be added to the WSDOT tab after any groups currently on the ribbon. The updated ArcGIS Pro interface would then appear as shown in Figure 5.

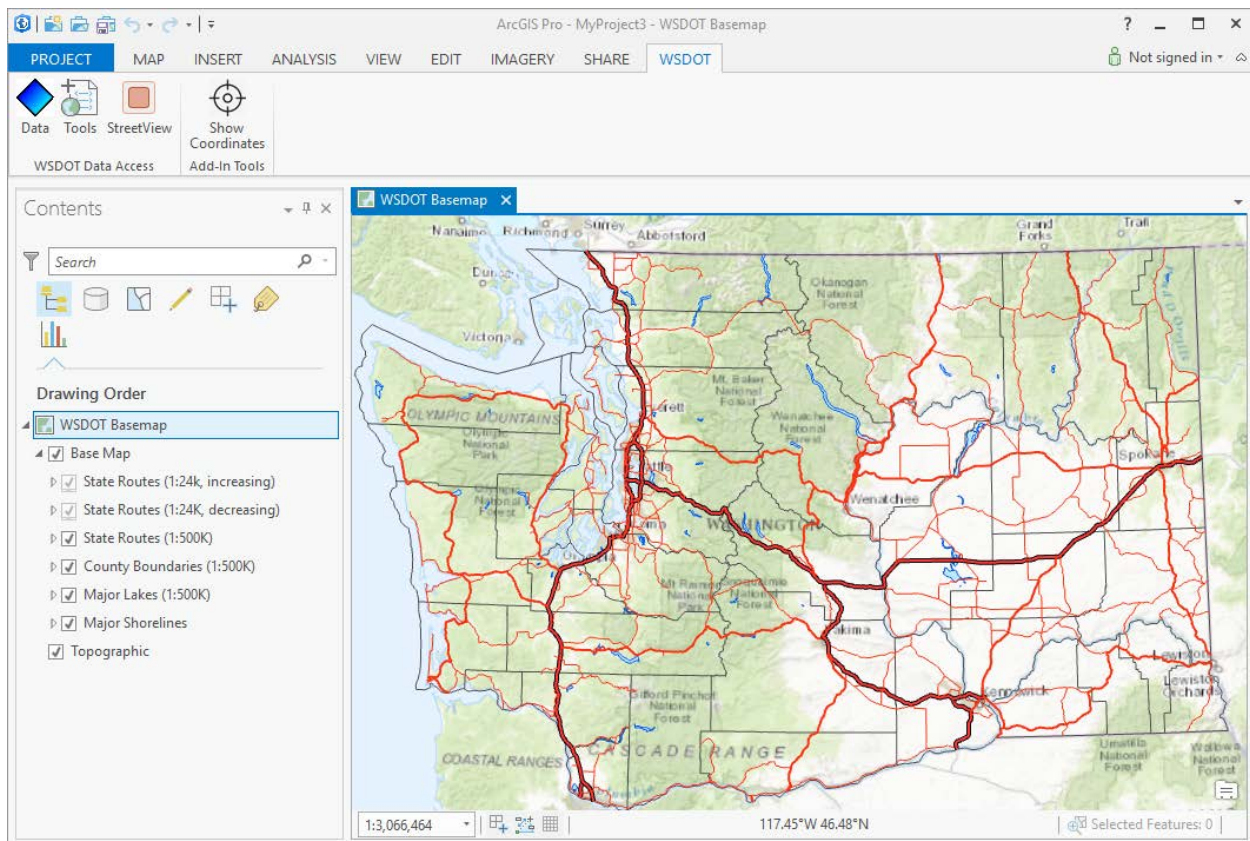


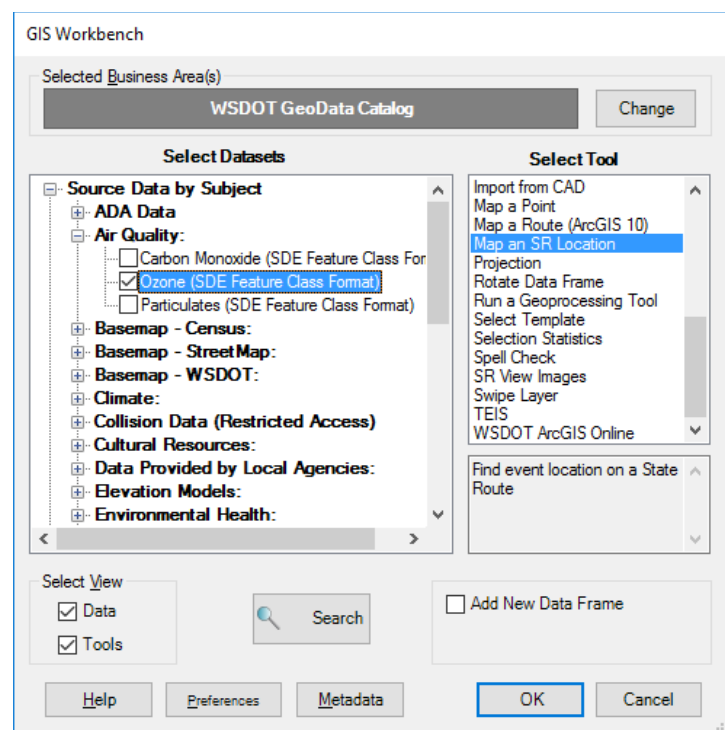
Figure 5. ArcGIS Pro interface showing the custom WSDOT tab containing both the GIS Workbench Pro Add-In and Show Coordinates Add-In (a.k.a., Get Coordinates).

GIS Workbench Pro Demonstration

The WSDOT tab was created to host our agencies custom Add-Ins; currently this tab hosts three Add-Ins:

1. GIS Workbench Pro, which contains three buttons (Data, Tools, and StreetView™),
2. Show Coordinates, which contains one map tool, and
3. Map an SR Location, which contains one button.

The GIS Workbench Pro add-in replicates most of the capabilities contained within the original GIS Workbench for ArcMap extension (shown at right) but takes advantage of the new Add-in paradigm by splitting Data and Tools into their own command window. Controls that require significant programming, such as Map an SR Location, have been further divided out



and compiled into their own Add-In. The use of Add-Ins will allow us to develop and incrementally release new functionality to the agency as time and programming resources permit and will not require an agency wide redeployment.

The GIS Workbench Pro Add-In shown in Figure 5 contains three controls: Data, Tools, and StreetView™. We will focus here on the first two controls since they replicate the functionality provided in the ArcGIS Desktop version of the GIS Workbench extension.

To use the GIS Workbench for Pro click on the Data control () or Tools control () in the WSDOT tab (Figure 5). Clicking the Data control will show the screen shown in Figure 6a. A fundamental part of the GIS Workbench concept is the ability to define custom views of the data and tools presented based on the currently selected Business Area. The current business area displayed in this example is the *WSDOT GeoData Catalog* business area. The selected Business Area determines the tools available in the Tools window when it is opened (Figure 6b).

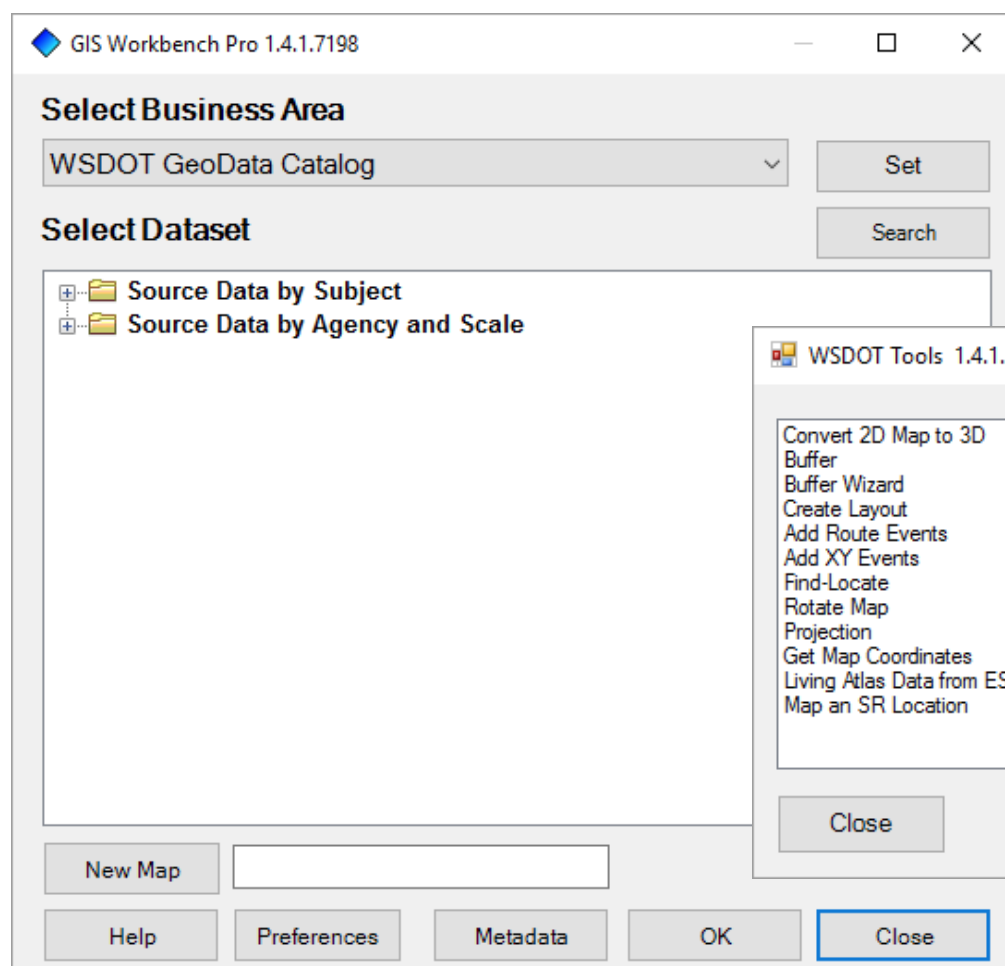


Figure 6a

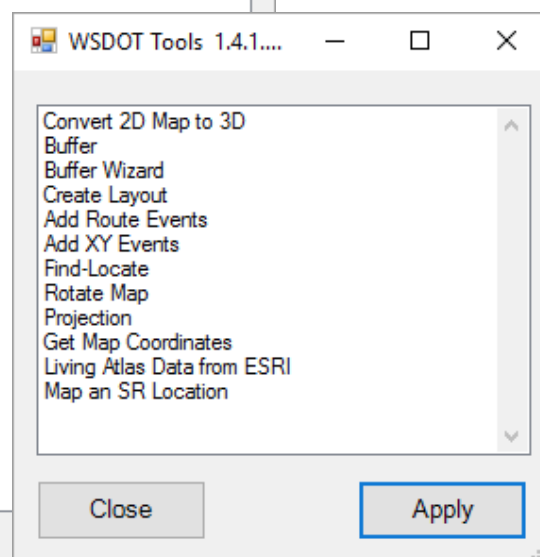


Figure 6b

Figure 6. GIS Workbench Pro Data and Tools windows. These windows are launched by clicking on the Data or Tools control, respectively, in the WSDOT tab.

To change the current business area, on the Data window click on the business area pulldown and select a Business Area name from the list (e.g., EOC, Environmental, Facilities, Systems Analysis, etc.). Once a

name is selected, the user would click the Set button. This will save the change, update the dataset list, and refresh the list of tools available in the Tools window.

In Figure 6b the tools associated with the WSDOT GeoData Catalog business area are shown. In general, the tools available in ArcGIS Pro for the GIS Workbench fall into three types:

1. Custom code built within the GIS Workbench Add-In itself (e.g., Rotate Map),
2. Connections to another Add-In (e.g., Get Map Coordinates and Map an SR Location), and
3. Commands that execute existing built-in ArcGIS Pro geoprocessing scripts (e.g., Buffer) with predefined parameters obtained from the GIS Workbench application database.

Figure 7 and 8 demonstrate how the Data window is used to obtain Metadata about a dataset and add data to the active map. Functionality available in the Data screen includes changing business areas, searching for a key word in the dataset list, adding a new map to a ArcGIS Pro project, setting user preferences (i.e., set a default business area), obtain metadata for a dataset, and add data to the map.

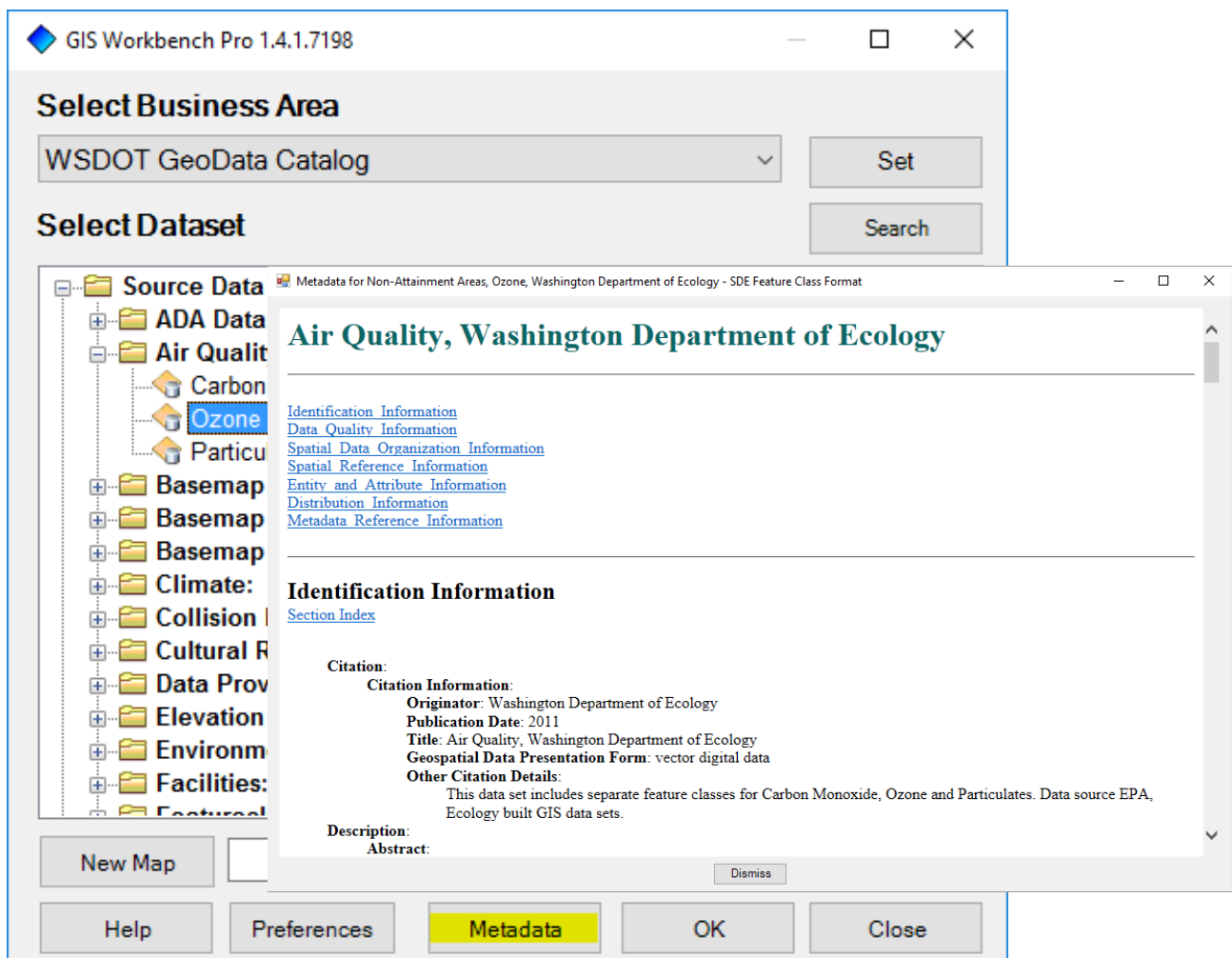


Figure 7. In the GIS Workbench Pro Data window the Ozone dataset is selected in the data tree and the user clicked on the Metadata button. The FGDC Metadata for the Ozone dataset was then displayed.

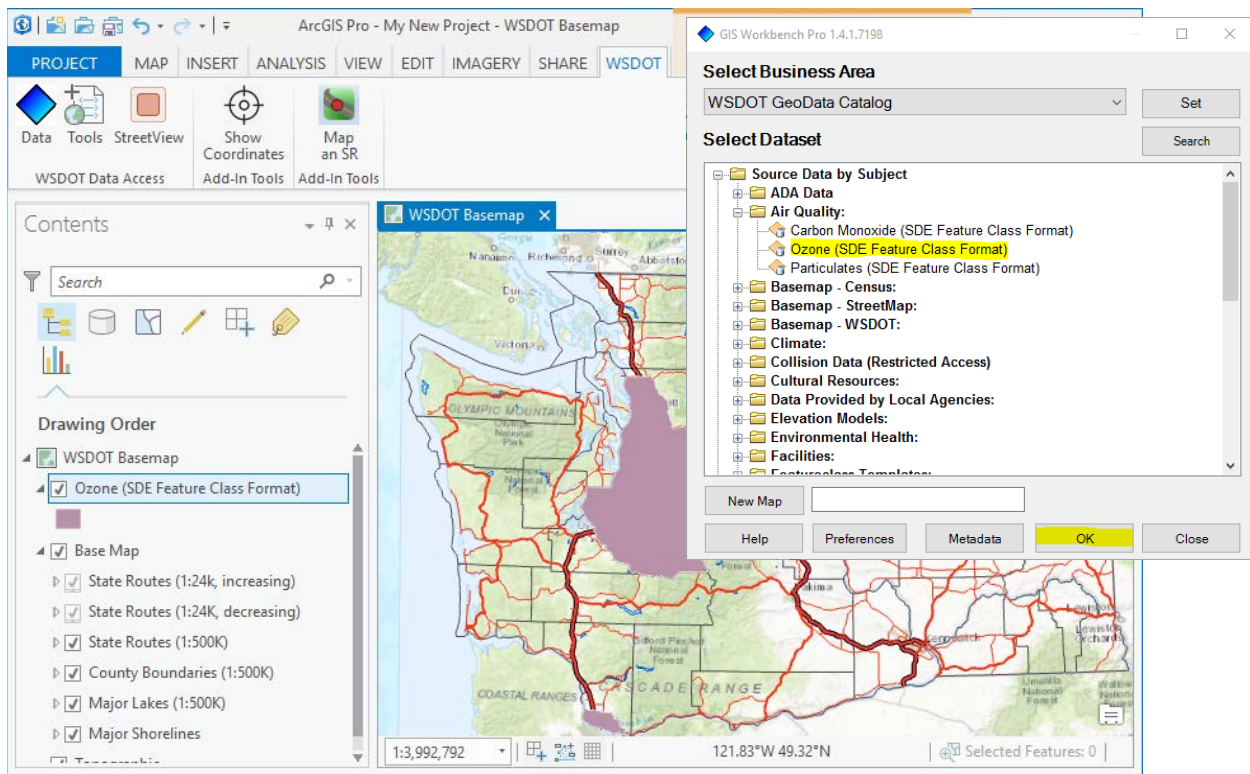


Figure 8. To add the selected data set, Ozone, to the current active map the user clicked on the OK button in the GIS Workbench Pro Data window.

Summary

ESRI has positioned ArcGIS Pro as the next generation of desktop mapping technology for professional GIS analysts. Before ArcGIS Pro can replace ArcMap in the WSDOT corporate environment, several key internal supporting applications need to be reengineered and recompiled to function within a 64-bit operating system. At WSDOT, one of the key supporting applications is a 32-bit DLL known as the Accumulated Route Mile (ARM) to State Route Mile Post (SRMP) calculation library (ARMCALC). This library supports the conversion to/from mileage measurements taken on the ground along our State Routes to an actual roadway 'length' (i.e., ARM's). SRMP's are critical to our organization because they are used to locate facilities and objects along our roadways. The derived ARM's are used to map these features on our linear referencing system within ArcGIS Desktop and ArcGIS Pro.

Updating the ARM to SRMP 32-bit library to 64-bit was a fundamental first step in making the transition to ArcGIS Pro. Once the 64-bit version of this library was available, the stage was set for creating the Map an SR Location Add-In. The ARM to SRMP library and the other Add-Ins described in this paper were required precursors to scheduling the agency-wide implementation of ArcGIS Pro. Now that these items are in place, the stage is set for the deployment of ArcGIS Pro to the agency. Our current timeline is to begin the transition to ArcGIS Pro in 2018 with the goal of making ArcMap "legacy" software in 2019.