IPC Quick Start Guide

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X-Tek X-ray and CT Inspection

IPC Quick Start Guide

IPC programming for Inspect-X XTM0499-A1

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Contents

1	Introduction	1
1.1	About this guide	1
1.2	Prerequisites	2
1.3	Getting started with C#	2
1.4	Acknowledging this work	2
1.5	Disclaimer	2
1.6	Important information	2
2	Setting Up	3
3	Tutorial 1: Writing your first IPC program - Switching X-rays on and off	5
3.1	Creating and setting up the Visual Studio project	5
3.2	The front-end user form and back-end code	10
3.3	An overview of the code	14
3.4	Channel connections	17
3.4.1	Specifying the channels to switch on	17
3.4.2	Opening the channels and attaching event handlers	17
3.4.3	Detaching event handlers	18
3.4.4	Linking channel connections to the user form	18
3.5	Defining callback functions	20
3.5.1	Heartbeat callback functions	20
3.5.2	All other callback functions	21
3.6	X-ray routine	21
3.7	Initialising a new thread	22
3.8	Finalising the user interface	22
3.9	Running the application	24
3.10	Troubleshooting tutorial 1	24
3.10.1	General troubleshooting	24
3.10.2	Debugging	24
3.10.3	A known bug in Inspect-X 5.1 with the X-ray Entire Status event	25
3.10.4	Further errors	26
3.10.5	Sample answer for tutorial 1	26
4	Tutorial 2: Moving the manipulator	27
4.1	Set up folders, solution and project	27
4.2	Establish channel connections and callback functions	27
4.3	Understanding manipulator move events	27
4.4	Manipulator rotate application	28
4.5	Sample answer	29
4.6	Extensions	29
5	Tutorial 3: Acquiring an image	31
5.1	Set up folders, solution and project	31
5.2	Establish channel connections and identify appropriate events	31
5.3	Image-processing routine	31
5.4	Sample answer	32
5.5	Extensions	32
6	IPC - Expanding the potential of Nikon X-ray CT systems	33
6.1	Time-lapse imaging	33

6.2	Batch 3D scans.....	33
6.3	Integration with 3rd party software	34
6.4	Integration with 3rd party hardware	34
6.5	Limitless potential...!	34
7	Appendix: Sample code	35
7.1	Tutorial 1: UserForm.cs	35
7.2	Tutorial 2: UserForm.cs	42
7.3	Tutorial 3: UserForm.cs	48

1 Introduction

1.1 About this guide

The Nikon Inspect-X software used for controlling Nikon X-ray Computed Tomography (CT) systems allows users to perform a wide variety of tasks, including inspections, 2D and 3D CT scans and batch scheduling. Whilst the Inspect-X software fulfils the requirements of the majority of users, there may, however, be cases where users want to use their X-ray CT system to do something that cannot (easily) be done with Inspect-X. For example, users may wish to sequentially acquire and manipulate radiographs, perform CT scans at certain predetermined times or allow communication between the X-ray CT system and an external module or experimental rig.

One of the lesser known features within the Nikon Inspect-X software is that it allows users to control and manipulate their Nikon X-ray CT system from a custom-built application through Inter Process Communication (IPC). Inspect-X exposes a number of interfaces which we can access by programming using the Microsoft .NET platform. Basic operations can be accessed, for example switching X-rays on, moving the manipulator and acquiring images from the detector, as well as higher level operations such as performing a CT scan and allowing users to develop highly complex and customised applications.

The IPC interface replaces the Visual Basic for Applications (VBA) programming that was available in older versions of Inspect-X (Versions 2.2 and older). All versions of Inspect-X from version 3 onwards use the IPC interface. The new IPC interface provides a much greater potential for creating custom applications for both industrial and academic environments; however, initially getting started with IPC can be confusing and overwhelming.

The aim of this Quick Start Guide is to help you set up and start programming using IPC by writing simple applications:

- A walk-through tutorial is provided in ***Tutorial 1: Writing your first IPC program - Switching X-rays on and off*** (on page 5) for a simple program to switch X-rays on and off. This also explains some basics of the IPC communications.
- Two further tutorial tasks can be found in ***Tutorial 2: Moving the manipulator*** (on page 27) and ***Tutorial 3: Acquiring an image*** (on page 31), which will help bring familiarity with controlling the manipulator and image-processing channels.
- Sample code is provided in ***Appendix: Sample code*** (on page 35).

This Quick Start Guide is not exhaustive, and there is a lot which is not covered. For instance, we might want to develop complex applications with complex user interfaces, created through the Designer. There are many online tutorials and books for this, and the Quick Start Guide only uses basic features of form design. The Quick Start Guide concentrates more on explaining the basics of IPC communication with Inspect-X, and it is hoped that these sections will provide sufficient experience of the IPC interface to allow you to develop your own custom applications.

Note: This Quick Start Guide was written using Inspect-X version 5.1.4 and Visual Studio 2012 Professional. Other versions may look slightly different.

1.2 Prerequisites

1. A working Nikon X-ray CT system with Inspect-X software (version 4 or later) installed.
2. Microsoft Visual Studio 2010 (or later) with Microsoft Visual C# compilers.
3. Basic previous programming experience.

1.3 Getting started with C#

If you have some prior experience in programming, then you should be able to successfully follow the tutorials in this guide to build some simple IPC applications in C# that perform basic operations with the X-ray CT system. If you wish to learn more about C#, then an online tutorial can be found at <https://www.tutorialspoint.com/csharp/index.htm>.

1.4 Acknowledging this work

I hope this Guide helps you get to grips with the basics of IPC programming, helping you create custom research and industrial applications. If you can, I would be grateful if you can cite this work as:

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1.5 Disclaimer

The use of the IPC Programming Interface is taken solely at the discretion of you and your company together with your Nikon point of contact.

The author of this Quick Start Guide takes no responsibility for any business losses, including without limitation loss of or damage to profits, income, revenue, use, production, anticipated savings, business, contracts, commercial opportunities or goodwill that arises from using IPC Programming or following the material in this Guide.

1.6 Important information

It is illegal (against the Ionising Radiations Regulations, 1999) to write code which automatically switches X-rays on without any user interaction. Your application must include an 'OK/Cancel' button to control the generation of X-rays. This means that if the X-rays switch off because an interlock has been broken, they cannot be restarted automatically by the IPC code. If an interlock has not been broken, then a user may switch the X-rays back on again using an 'OK' button.

2 Setting Up

Microsoft Visual Studio should be installed on the acquisition computer. The .NET programming in this Quick Start Guide will be done in Visual C#, so ensure that these options are selected on installation and first start up.

Figure 2-1: Visual Studio start-up screen

It is possible to check whether Visual C# is installed by navigating to **Help > About Microsoft Visual Studio** and checking the list of installed products.

Figure 2-2: Checking whether Visual C# is installed in Visual Studio

The next step is to copy the sample IPC programs to our documents directory (or another folder of our choice). This leaves the originals intact, in case the client-contract interfaces are erroneously damaged when programming.

- Navigate to <OS Drive>\ProgramData\Nikon Metrology

Note: It may be necessary to show hidden files and folders to locate the ProgramData folder.

Setting Up

Figure 2-3: Locating the IPC Examples folder

- Copy the entire “IPC Examples” folder to a destination folder of your choice (for example My Documents, namely Libraries\Documents).
- Navigate to the new “IPC Examples” just created (C:\User\User1\Documents\IPC Examples), and open the “Programs” folder.

This should contain five folders named “IpcContract”, “IpcContractClientInterface”, “IpcDemo”, “IPCTemplate” and “IpcUtil”.

Figure 2-4: The contents of the IPC Examples folder

The first three folders contain code that governs the communication between Inspect-X and the custom application.

The “IpcDemo” folder contains a sample working IPC application that performs a simple circular CT scan. Whilst this sample application may initially appear quite daunting, it should hopefully be more understandable after working through this Quick Start Guide.

Finally, the “IPCTemplate” folder contains a template for developing new applications. We will base our new applications on this template by copying the template folder for each new application.

3 Tutorial 1: Writing your first IPC program - Switching X-rays on and off

This tutorial is the IPC equivalent of a “Hello World” program in basic programming courses, which will give familiarity with different function calls in IPC, and yields a program that switches X-rays on, waits for five seconds after X-rays have stabilised, then switches X-rays off again.

Creating and setting up the Visual Studio project (on page 5) and **The front-end user form and back-end code** (on page 10) set up the Visual Studio project. The renaming allows each new application to contain appropriate titles, and although it may take a short amount of time in the first few instances, experience will allow you to rename everything very quickly.

An overview of the code (on page 14) provides an overview of the code and explains how the IPC interfaces work.

Channel connections (on page 17) through to **Running the application** (on page 24) constructs our first application in small segments.

If you have problems, refer to **Troubleshooting** (on page 24).

3.1 Creating and setting up the Visual Studio project

The simplest way to create new IPC applications is to use the “IPCTemplate” as a starting point, since a large amount of the complex code dealing with the communication with Inspect-X is already included.

- Create a copy of the “IPCTemplate” folder and rename it to “Tutorial1_XraysOnOff”.

Figure 3-1: Creating the “Tutorial1_XraysOnOff” folder

- Open the folder, which will contain a folder named “IPCTemplate” and a Microsoft Visual Studio Solution. Rename the folder again to “Tutorial1_XraysOnOff”, but do not rename the Microsoft Visual Studio Solution.

Documents library
Tutorial_XraysOnOff

Name	Date modified	Type	Size
Tutorial_XraysOnOff	16/01/2017 09:51	File folder	
IPCtemplate	30/03/2016 15:11	Microsoft Visual S...	5 KB

At the bottom of the window, the status bar shows:
 IPCtemplate Date modified: 30/03/2016 15:11 Date created: 16/01/2017 09:51
 Microsoft Visual Studio Solution Size: 4.85 KB

- Double-click the Microsoft Visual Studio Solution to open it in Visual Studio, ignoring the following warning:

The screenshot displays the Microsoft Visual Studio IDE. The top menu bar includes FILE, EDIT, VIEW, PROJECT, BUILD, DEBUG, TEAM, SQL, TOOLS, TEST, ANALYZE, WINDOW, and HELP. The toolbar shows icons for opening files, saving, building, and debugging. The left sidebar contains the 'Toolbox' and 'Data Sources' tabs. The main workspace is empty.

The **Output** window at the bottom shows the following error message:

```
Show output from: Solution
C:\Users\Parmesh\Documents\IPC Examples\Programs\Tutorial1\XrayOnOff\IPCTemplate\IPCTemplate.csproj : error : The project file could not be loaded. Could not find a part of the path 'C:\Users\Parmesh\Documents\IPC Exa...
```

The **Solution Explorer** on the right shows a solution named 'IPCTemplate' containing 4 projects. The 'References' section for the selected project lists the following assemblies:

- CTResponse.cs
- CTStatus.cs
- Inspection2DError.cs
- Inspection2DStatus.cs
- InspectAlarms.cs
- InspectStatus.cs
- MetaDataSchema.cs
- NotifyOperatorOption.cs
- ReconstructionPCStatus.cs
- SamplingInformation.cs
- ShadingCorrectionError.cs
- ShadingCorrectionResponse.cs
- ShadingCorrectionStatus.cs
- StringResourceAttribute.cs
- VolumeOfInterest.cs
- WorkflowId.cs

The **Properties** window shows the 'IPCTemplate' project properties, including the file path: 'C:\Users\Parmesh\Documents\IPCTemplate\IPCTemplate.csproj'.

6 XTM0499-A1 IPC Quick Start Guide

There are a few small ‘fiddly’ things that we will set up and rename from with Visual Studio:

- Firstly, find “Solution ‘IPCTemplate (4 Projects)” at the top of the Solution Explorer (usually on the right-hand edge of the screen).
- Right click on this (or press **F2**), and rename it to “Tutorial1_XraysOnOff”.

Figure 3-5: Rename the entire Project Solution

- To correct the error when loading the solution, find the “IPCTemplate” project (next to a blue rectangular box containing an exclamation mark) and select it. It will have “unavailable” written next to it.

In the **Properties** pane (usually below the Solution Explorer), find “File path”.

Figure 3-6: Find the File path property for the IPCTemplate in the Properties pane

Tutorial 1: Writing your first IPC program - Switching X-rays on and off

Click the “File path” and then click the ellipsis (...) on the right-hand side.

Figure 3-7: Clicking on the file path shows the ellipsis to locate the project file

This will bring up a dialog box in which there is one folder showing, namely “Tutorial1_XraysOnOff”.

Figure 3-8: The first dialog should contain one folder called “Tutorial1_XraysOnOff”

Enter this folder, and select the Visual C# Project File called “IPCTemplate”.

Figure 3-9: Select the Visual C# Project File called “IPCTemplate”

Then right-click on the IPCTemplate project in the Solution Explorer (saying unavailable next to it), and click **Reload Project**.

The unavailable should now disappear, and the blue box should be replaced by a C#.

Tutorial 1: Writing your first IPC program - Switching X-rays on and off

- Rename this IPCTemplate project (by right-clicking or pressing F2) to “Tutorial1_XraysOnOff”.

Figure 3-10: Rename the IPCTemplate project to “Tutorial1_XraysOnOff”

- Open more contents of the “Tutorial1_XraysOnOff” project by double-clicking on it in the Solution Explorer, and then double-click on **Properties**.

Figure 3-11: The properties of the “Tutorial1_XraysOnOff” project

Tutorial 1: Writing your first IPC program - Switching X-rays on and off

Change both the **Assembly name** and **Default namespace** to “Tutorial1_XraysOnOff”. Click the **Assembly Information** button, and change the title to “XT IPC Tutorial 1: Switching X-rays on and off”.

Figure 3-12: Changing the Assembly Information

Click **OK** on the dialog box, then CTRL-S on the keyboard to save, and close the tab.

Finally, the default startup project for the entire solution must be chosen to be our Tutorial1_XraysOnOff project.

- Select the “Solution ‘IPCTemplate (5 Projects)’” at the top of the Solution Explorer, right-click and select **Properties**.
- In the list, next to **Single startup project**, select Tutorial1_XraysOnOff.

Figure 3-13: Changing the Startup project

- Click **OK** to finish.

3.2 The front-end user form and back-end code

The application consists of the front-end User Form, which is the Graphical User Interface (GUI) that the final user interacts with. Behind all of this is the back-end C# code where we specify what we want the application to do. We will change the names of the form and change the namespaces in the code in preparation for creating our application.

- Navigate to the “Tutorial1_XraysOnOff” project in the Solution Explorer, and click the horizontal arrow to reveal its components. At the bottom will be “TemplateForm.cs”.

Figure 3-14: Locating TemplateForm.cs

To begin with, rename this to “UserForm.cs”. Upon renaming the form, the Solution Explorer will reveal three further components nested within “UserForm.cs”. The bottom component will still carry the name “TemplateForm”; this cannot be renamed in the usual manner, and we will rename it shortly.

- Double-clicking the UserForm.cs will bring up the Designer for the form.

Figure 3-15: The UserForm Designer

Tutorial 1: Writing your first IPC program - Switching X-rays on and off

This is where we will create buttons, trackbars, menus, and so on, that the user can interact with. The properties for each of the items on the form can be modified in the **Properties** pane. For example, when the entire form is selected, the **Name** can be changed from “TemplateForm” to “UserForm”.

Figure 3-16: Changing the Form name to UserForm

Similarly, the **Text** property can be changed to “Tutorial 1- X-rays on and off”. Note that this changes the title at the top of the form.

- Click the **Start** button on the top menu to build the form, and launch a debug version of the application.

At this stage, the form should compile successfully, and a blank form should appear on the screen.

Figure 3-17: The debug application

Tutorial 1: Writing your first IPC program - Switching X-rays on and off

- After closing the debug application, the back-end code can be revealed by pressing **F7**, and you can return to the Designer by pressing **SHIFT+F7**.

Figure 3-18: The back-end code behind the UserForm

- One final renaming task remains. At the top of the code, below the references is a line marked namespace IPCTemplate. Change “IPCTemplate” to “Tutorial1_XraysOnOff”. Upon doing so, a small red box appears at the end of the new name. Hovering over this brings up the option of a menu for auto-renaming of all instances of the IPCTemplate. Click to access the menu, and choose the first option, **Rename ‘IPCTemplate’ to ‘Tutorial1_XraysOnOff’**.

Figure 3-19: Changing the Namespace

All instances within the entire solution automatically update - we can see this by the red lines under `InitializeComponent()`; disappearing.

We have now completed setting up our project, and are now ready to understand more about mechanics of the IPC code.

3.3 An overview of the code

Before we change the mechanics of the code to construct our application, it will be useful to overview the existing template code to understand the mechanics of the IPC interface.

The Nikon X-ray CT machine is controlled directly by the Inspect-X software on the acquisition computer. Inspect-X then communicates with our custom application through eight different communication channels, with each channel corresponding to a different aspect of the CT machine. This is illustrated in the following diagram:

Figure 3-20: A sketch showing how communication occurs between the X-ray CT machine and the software running acquisition computer, with the client application communicating with Inspect-X, which communicates with the X-ray CT system

Communication along each channel is specific to that part of the X-ray CT system. For example, the X-rays channel allows communication with the X-ray subsystem and the Image-Processing channel allows communication with the Image Processing subsystem. As can be seen in the diagram, the Inspect-X software acts as the intermediary between the custom application and the X-ray CT system, and so Inspect-X is required to be running for our custom application to work.

Let us take a closer look at the X-ray channel to understand more about the communication:

Figure 3-21: A sketch showing how communication occurs along the X-ray channel

Once the channel is open, the custom application can send commands to Inspect-X, for example instructing X-rays to be switched on, or instructing the demand voltage to be set to a certain level. The custom application can also demand statuses from Inspect-X, for example it could request the actual current voltage on the X-ray system, and Inspect-X would immediately provide this information.

In general, communication is asynchronous: once a command is sent to Inspect-X, say to switch X-rays on, Inspect-X does not provide any feedback and our code will move onto the next line without knowing whether the command has been implemented or not. This is a significant difference to anyone familiar with the former VBA programming module, where if X-rays were switched on, then Inspect-X would feedback with the generation status and our code would wait for this status to be received before moving on. The asynchronous nature provides far greater flexibility to create complex multi-threaded application that perform many tasks simultaneously.

Although instantaneous feedback is not provided, Inspect-X is able to provide notifications of important events using the C# event handling mechanism. For example, when the entire X-ray status changes, the `mEventSubscriptionInspectXStatus` event is raised, and a function named `EventHandlerXRayEntireStatus` is called. These events with associated event-handlers and callback functions allow the user to create their own feedback loops. The events for a selected number communication channels are listed the following table:

Table 3-1: List of events for the application, X-rays, manipulator and image-processing channels

Channel	Event	Description
Application	<code>mEventSubscriptionHeartbeat</code>	Heartbeat status from Application channel
	<code>mEventSubscriptionInspectXStatus</code>	Status of Inspect-X
	<code>mEventSubscriptionInspectXAlarms</code>	Alarms raised by Inspect-X
X-rays	<code>mEventSubscriptionHeartbeat</code>	Heartbeat status from X-rays
	<code>mEventSubscriptionEntireStatus</code>	Status of X-rays
	<code>mEventSubscriptionAutoConditionUpdate</code>	Progress update on auto-condition
Manipulator	<code>mEventSubscriptionHeartbeat</code>	Heartbeat status from Manipulator
	<code>mEventSubscriptionManipulatorMove</code>	Manipulator move events
	<code>mEventSubscriptionDoorStateChanged</code>	Change in door status
	<code>mEventSubscriptionAxisPositionChanged</code>	Change in subscription axis position
Image-Processing	<code>mEventSubscriptionHeartbeat</code>	Heartbeat status from Image-Processing
	<code>mEventSubscriptionImageProcessing</code>	Image-Processing events

Further details and a complete list of events and event handlers for all of the channels can be found in the Inspect-X IPC Programming Manual.

Tutorial 1: Writing your first IPC program - Switching X-rays on and off

We can identify different parts of the code with each part of this communication process. Scrolling down, the remaining code should appear like the figure below. If it appears that there is more code showing, then any regions encased with `#region` and `#endregion` commands can be collapsed. Conversely, any region (shown with a grey box around it) can be expanded to reveal the code within it.

Figure 3-22: An overview of the remaining template form code

We can see that the `namespace Tutorial1_XraysOnOff`, contains a `public class UserForm`. At the top, there is a region called “Standard IPC Variables”, followed by a function called `public UserForm()`. This is followed by three further regions called “Channel connections”, “Heartbeat from host” and “STATUS FROM HOST”. Each region contains skeleton code which we will modify and supplement to create our application.

The `public UserForm()` contains eight lines of code, which decide which communication channels are switched on:

```
mChannels.AccessApplication = true;
mChannels.AccessXray = true;
mChannels.AccessManipulator = true;
mChannels.AccessImageProcessing = true;
mChannels.AccessInspection = true;
mChannels.AccessInspection2D = true;
mChannels.AccessCT3DScan = true;
mChannels.AccessCT2DScan = true;
```

To switch a communication channel off, we can simply change `true` to `false`. The “Channel connections” region contains functions which open and close communication along the specified channels. We can also decide on which event notifications we add to each channel. Whenever an event notification is raised, we can decide how we wish to react and process them. The functions called every time a “Heartbeat” event notification is received are defined in the “Heartbeat from host” region, and code for all of the other event notifications can be found in the “STATUS FROM HOST” region.

Let us examine each of these in further detail as we develop our application to turn X-rays on and off.

3.4 Channel connections

3.4.1 Specifying the channels to switch on

In the template form, the eight lines within the UserForm function shows that all the channels are switched on. For this tutorial, we will use only the Application channel and the X-rays channel. The Application channel is needed to open all communication with Inspect-X, that is, for signals on the X-ray, Manipulator and Imaging Processing channels, and so on, to occur. This application will also be using X-rays, so we need the X-ray channel.

- Leave the flags for the Application and X-ray channels as true, and set the flags for the other six channels to false.

3.4.2 Opening the channels and attaching event handlers

The Channel connections region defines opening and closing of the communication channels. If the region has been collapsed, it will say Channel connections with a grey box around it. Double-clicking this will expand the region, revealing two functions called:

```
private Channels.EConnectionState ChannelsAttach()
private bool ChannelsDetach()
```

Firstly, the ChannelsAttach function opens the channels specified earlier opened with the line:

```
Channels.EConnectionState State = mChannels.Connect();
```

The two functions also let us attach/detach event handlers to the appropriate channels for the events that we wish to monitor. The template displays all of the events for each of the channels, with the events grouped in 'if' clauses for the communication channel they correspond to. The code will only be activated, however, for the channels set to **true** in **Specifying the channels to switch on** (on page 17), and so it is perfectly safe to delete code for any channel that is switched off.

Examine the ChannelsAttach function, and consider the 'if' clause for the Application channel:

```
if (mChannels.Application != null)
{
    mChannels.Application.mEventSubscriptionHeartbeat.Event
    += new EventHandler
    <CommunicationsChannel_Application.EventArgsHeartbeat>
    (EventHandlerHeartbeatApp);
    mChannels.Application.mEventSubscriptionInspectXStatus.Event
    += new EventHandler
    <CommunicationsChannel_Application.EventArgsInspectXStatus>
    (EventHandlerInspectXStatus);
    mChannels.Application.mEventSubscriptionInspectXAlarms.Event
    += new EventHandler
    <CommunicationsChannel_Application.EventArgsInspectXAlarms>
    (EventHandlerInspectXAlarms);
}
```


The code begins by querying whether `mChannels.Application` is set to true. If it is, then event handlers are attached (through the `+=`) for the all three events within the Application channel (see **An overview of the code** (on page 14)), namely for the Application Heartbeat, for the Inspect-X status and for Inspect-X alarms. For example, the `mEventSubscriptionInspectXAlarms` event has an event-handler called `EventArgsInspectXAlarms`. When Inspect-X notifies our application of one of these events, the event handler will call the functions in parentheses, which are appropriately known as callback functions. For example, the `EventHandlerInspectXAlarms` callback function will be executed by the `EventArgsInspectXAlarms` event handler whenever Inspect-X raises an Inspect-X Alarm in the Application communication channel.

- For this simple first program that switches X-rays on and off, we will only be interested in the following events:

```
mChannels.Application.mEventSubscriptionHeartbeat.Event
mChannels.Xray.mEventSubscriptionHeartbeat.Event
mChannels.Xray.mEventSubscriptionEntireStatus.Event
```

Code for all of the other events can be deleted from the `ChannelsAttach` functions. In particular, all of the `'if'` clauses for the channels apart from `mChannels.Application` and `mChannels.Xray` can be deleted, and the any event within these two channels that is not in the list above can be deleted.

For more information or simple tutorials on events and event handlers in C#, please see the further resources in **Getting started with C#** (on page 2).

3.4.3 Detaching event handlers

Similarly, the `ChannelsDetach` function removes event handlers from the communication channels when we have finished. Only those event handlers which have been attached in **Opening the channels and attaching event handlers** (on page 17) need to be removed.

- The code for the `ChannelsDetach` function can be simplified by deleting those event handlers we are not interested in, leaving only code for `mEventSubscriptionHeartbeat`, `mEventSubscriptionHeartbeat` and `mEventSubscriptionEntireStatus`.

Notice that in this `ChannelsDetach` function, the event handlers are detached using the `-=` command, rather than the `+=` used to attach the event handlers in **Opening the channels and attaching event handlers** (on page 17).

The code can be checked against the sample code for **tutorial 1** (on page 35).

3.4.4 Linking channel connections to the user form

The final part of establishing the channel connections is to invoke the `ChannelsAttach` function when the form is loaded and the `ChannelsDetach` function when the form is closed.

1. Firstly, find the region at the top of the code called "Standard IPC Variables". Immediately after this region (that is, after `#endregion Standard IPC Variables`), create a new region called Application Variables through the following code:

```
#region Application Variables

#endregion Application Variables
```

We will add variables to this section as we develop our application. To begin with, we will initialise a variable that will keep track of the connection status of our application.

2. Type the following code within the new region:

```
/// <summary> Status of the application </summary>
private Channels.EConnectionState mApplicationState;
```

This creates a new variable that will hold the application status.

Tutorial 1: Writing your first IPC program - Switching X-rays on and off

- Next, open the Designer for the form by pressing SHIFT+F7. Select the entire form, and navigate to the **Properties** pane. The Events associated with the form can be selected by pressing the button with a lightning strike in it.

Figure 3-23: Events associated with Form

Find “Load” and double click on it to create a new form event associated with loading the form. This code will be executed every time the form is loaded. This will take us back to the code-editor, where a new function will have been created:

```
private void UserForm_Load(object sender, EventArgs e)
{
}
}
```

Within this function, place the following code to attach the channels, whilst catching any exceptions that may be raised:

```
try
{
    // Attach channels
    mApplicationState = ChannelsAttach();
}
catch (Exception ex) { AppLog.LogException(ex); }
```

- Similarly, create a new event for “FormClosing”, and place within it the following code:

```
try
{
    // Detach channels
    ChannelsDetach();
}
catch (Exception ex) { AppLog.LogException(ex); }
```

- To keep the entire code tidy, place these form functions within a new region called “Form Functions”.

3.5 Defining callback functions

Now that we have initialised the channel connections, we must define how we want our application to process signals that it receives from Inspect-X about the X-ray CT system. This is done by defining the callback functions, which we invoked in the circular parentheses when attaching and detaching our channels above. The asynchronous nature means that we have the flexibility to react immediately within our program when an event is raised or simply store the state in a variable, which we can look up later. For example, if an Alarm event is raised, then we may want to immediately close our application, but if the X-rays status event is raised, then we may store the state in a variable which we can look up later.

After simplifying our code in **Specifying the channels to switch on** (on page 17) to remove the code for events we are not interested in, we should be left with code that handles the following three events:

```
mChannels.Application.mEventSubscriptionHeartbeat.Event
mChannels.Xray.mEventSubscriptionHeartbeat.Event
mChannels.Xray.mEventSubscriptionEntireStatus.Event
```

which have the associated callback functions given in parentheses:

```
EventHandlerHeartbeatApp
EventHandlerHeartbeatXRay
EventHandlerXRayEntireStatus
```

3.5.1 Heartbeat callback functions

The first two of these callback functions respond to the 'heartbeat' that each of the channels produces to indicate the status of the communication channels. The "Heartbeat from Host" region contains callback functions for each of the eight communication channels.

- At this stage, the heartbeat callback functions for the six channels we are not using can be discarded.

We are left with the EventHandlerHeartbeatApp and EventHandlerHeartbeatXRay functions. The code for the former is shown below:

```
void EventHandlerHeartbeatApp(object aSender, CommunicationsChannel_Application.EventArgsHeartbeat e)
{
    try
    {
        if (mChannels == null || mChannels.Application == null)
            return;
        if (this.InvokeRequired)
            this.BeginInvoke((MethodInvoker)delegate
            { EventHandlerHeartbeatApp(aSender, e); });
        else
        {
            //your code goes here....
        }
    }

    catch (ObjectDisposedException) { } // ignore
    catch (Exception ex) { AppLog.LogException(ex); }
}
```

The code which we want to be executed when a heartbeat signal is received is placed where it says *// your code goes here*. For example, we may have a heartbeat animation on the User Interface form or a text box containing the number of seconds that the client has been connected. We will not place any code here in this tutorial, but the IPCDemo contains an example of a heartbeat animation.

3.5.2 All other callback functions

All the other callback functions are handled in the “STATUS from host” region. Opening the region will show 8 further regions for each communication channel. Each region contains skeleton code for each of the possible non-heartbeat event callback functions on that channel.

- Our sample tutorial program only has one callback function left, namely

```
EventHandlerXRayEntireStatus
```

which corresponds to the event:

```
mChannels.Xray.mEventSubscriptionEntireStatus.Event
```

To keep the code succinct, all the other callback functions can be deleted.

Examining the one remaining callback function, we can see from the name that this event is fired every time Inspect-X sends a new signal with an update on the Entire Status of the X-ray system. Each of the different status messages that could be received are listed as different cases in the switch clause; for each case, we have space to insert our own code when that particular status is received.

Let us create a new variable called `XRaysStable`, that will act as a flag that turns to true when a success status is received. Later on, we can check whether X-rays have stabilised by checking the value of this variable.

- Firstly, create a `private` Boolean variable in the Application Variables region called `mXraysStable` and initialise it to `false`.

```
/// <summary> Flag for X-ray stability </summary>
private Boolean mXraysStable = false;
```

- Next, within the status callback function, find the case for “Success”. Under this, set the `mXraysStable` flag to be true. The flag will remain false until the X-rays are both on and stable, when it will be set to true.
- Within the status callback function, set the `mXraysStable` flag to be false under the “SwitchedOff” case. This will reset the flag when X-rays are turned off.

A good debugging tip is to `Debug.Print` the statuses received in the callback functions to see what signals are actually coming from Inspect-X, and when. See **Debugging** (on page 24) for more details.

Now we are ready to write our custom routine for switching X-rays on, wait for stability and then wait five seconds before turning off.

3.6 X-ray routine

Let us construct a short routine to switch the X-rays on, wait for stability and then wait a further five seconds before turning the X-rays off again.

Rather than copying and pasting code, it is recommended to type the code and use IntelliSense to understand how different variables in IPC are nested.

- After the last region in the code (which should now be the Form Functions region), create a new region called X-ray functions. Within this, create a new `private void` function called `XrayRoutine` that has no arguments.

```
private void XrayRoutine()
{
}
}
```

Tutorial 1: Writing your first IPC program - Switching X-rays on and off

- The first thing we will do is check that the channels we attached correctly; else none of the subsequent operations will work.

```
// If ApplicationState is not connected then immediately exit the routine
if (mApplicationState != Channels.EConnectionState.Connected)
    return;
```

- Next we set the mXraysStable flag to `false`. This is so that the flag is correctly set to true only after the X-rays have been turned on in this execution.

```
// Set mXraysStable flag to false
mXraysStable = false;
```

- It is then time to turn the X-rays on:

```
// Turn the X-rays on.
mChannels.Xray.XRays.GenerationDemand(true);
```

- We will then wait in a loop until we receive a signal that the X-rays have stabilised. We check whether the X-rays flag is `false`, and if so we wait for 5 milliseconds and reassess. Once the X-rays flag turns to `true`, this would loop would end.

```
// Wait until X-rays have stabilised
while (!mXraysStable)
    Thread.Sleep(5);
```

- Once the X-rays have stabilised, we then wait for five seconds (5000 milliseconds).

```
// Once stable, wait for a further 5 seconds
Thread.Sleep(5000);
```

- Finally, we turn the X-rays off, and wait until they have turned off by checking that the mXraysStable returns to `false`.

```
// Turn the X-rays off
mChannels.Xray.XRays.GenerationDemand(false);

// Wait until X-rays have turned off
while (mXraysStable)
    Thread.Sleep(5);
```

3.7 Initialising a new thread

In order for the communication from Inspect-X to be handled in a parallel manner, at the same time as our own routine is running, we must execute our routine on a new thread.

- To set up for this, create a new `private Thread` variable in the Application Variables region and initialise it to null:

```
/// <summary> Thread for X-ray Routine </summary>
private Thread mXrayRoutineThread = null;
```

3.8 Finalising the user interface

In order for our user to execute our X-ray routine, we need a button on the User Interface for them to click Start.

Tutorial 1: Writing your first IPC program - Switching X-rays on and off

- Go to the Form Designer (SHIFT+F7) and create a button from the toolbox on the left.

Figure 3-24: Creating a button on the UserForm

After resizing it to an appropriate size, go to the **Properties** pane. Change the **Name** to “btn_Start” and the **Text** to “Start”.

- Double-clicking on the button will generate a stub function btn_Start_Click for code that is executed when the button is clicked.

```
private void btn_Start_Click(object sender, EventArgs e)
{
}
}
```

- We wish to run our X-ray routine, so within the btn_Start_Click function, we assign our function to the thread we created, and then start it.

```
// Assign the XrayRoutine to the mXrayRoutineThread
mXrayRoutineThread = new Thread(XrayRoutine);
// Start the thread
mXrayRoutineThread.Start();
```

- The btn_Start_Click routine can be moved to the “Form Functions” region to keep similar functions together.

One final safety measure remains. Whilst our XrayRoutine is running, we do not want the user to be able to press the **Start** button again (and thus initialise another thread which runs the XrayRoutine). To prevent this, we disable the **Start** button immediately when the XrayRoutine is started, and enable it again when the Routine finishes.

As we have initialised a new thread for XrayRoutine, we are on a different thread to the User Form functions, and so the Invoke property is needed to change Form properties from within the XrayRoutine function.

- Go to the XrayRoutine function, and at the top of the function will be three lines that check whether the channels have been attached correctly.
After this, place the following code that disables the **Start** button:

```
// For safety, disable the Start button
this.Invoke((MethodInvoker)delegate { btn_Start.Enabled = false; });
```

- To re-enable the **Start** button at the end, insert the following code immediately before the end of the XrayRoutine:

```
// Re-enable the Start button
this.Invoke((MethodInvoker)delegate { btn_Start.Enabled = true; });
```

We are now ready to test our simple application.

3.9 Running the application

Before testing our application, remember that Inspect-X is needed for any communication with the X-ray system to occur (see **An overview of the code** (on page 14)).

First, ensure that the Inspect-X is running and that there are no X-ray alarms. Then, clicking **Run** below the menu bar in Visual Studio should successfully build the application.

Clicking the **Start** button in our application will switch the X-rays on, stay on for five seconds after stability, and then automatically switch the X-rays off again.

3.10 Troubleshooting tutorial 1

3.10.1 General troubleshooting

If the program fails to build then check that each of the steps in the tutorial have been followed correctly.

If the program builds and runs successfully, but the X-rays do not come on, then ensure try manually switching X-rays on and off from Inspect-X. If this does not work, then it is likely there are alarms on the X-ray CT system which can be corrected. If it still does not work despite there being no alarms, then the problem is between Inspect-X and our application, and we need to check the code as below.

3.10.2 Debugging

A useful way to find run-time problems in our code is to use `Debug.Print` statements at important parts of the code. We will place debug statements at key points in our Tutorial 1 application.

- To check whether channels are attached correctly, find the `UserForm_Load` function. With the `try` loop, place the following code at the end:

```
if (mApplicationState == Channels.EConnectionState.Connected)
    Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " : Connected to Inspect-X");
else
    Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " : Problem in connecting to Inspect-X");
```

- Similarly, to check whether channels detach correctly, place the following code at the end of the `try` loop in the `TestForm_FormClosing`:

```
Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " : Disconnected from Inspect-X");
```

- To see what X-ray Entire Status events are being raised by Inspect-X, go to the `EventHandlerXRayEntireStatus` function (which is found in the 'STATUS FROM HOST' region, nested under 'XRay'). Immediately above the `switch` loop, where it says `// Your code goes here...`, place the following line:

```
Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " :
    e.EntireStatus.XRaysStatus.GenerationStatus.State=" +
    e.EntireStatus.XRaysStatus.GenerationStatus.State.ToString());
```


- To check the value of `mXraysStable`, place the following code after the end of the `switch` loop:

```
Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " : mXraysStable=" +
mXraysStable.ToString());
```

The results from these debug statements will be printed to the Output window (or Immediate window depending on Visual Studio settings), which can be displayed whilst the Debug application is running by going to **Debug > Windows > Output (or Immediate)**.

Figure 3-25: Debug output in the Output window

3.10.3 A known bug in Inspect-X 5.1 with the X-ray Entire Status event

A known bug in the current version of Inspect-X (5.1) is that the “Success” X-ray Entire Status event is sometimes not raised. Instead, a second “WaitingForStability” event is raised. The `mXraysStable` is thus never set to true, and so our tutorial program hangs within the `XrayRoutine` waiting for stability. In this case, the Output log may look similar to the following:

```
18/01/2017 17:24:51.613 : Connected to Inspect-X
18/01/2017 17:25:33.905 : e.EntireStatus.XRaysStatus.GenerationStatus.State=SwitchedOff
18/01/2017 17:25:33.906 : mXraysStable=False
18/01/2017 17:25:36.940 : e.EntireStatus.XRaysStatus.GenerationStatus.State=WaitingForStability
18/01/2017 17:25:36.941 : mXraysStable=False
18/01/2017 17:25:38.763 : e.EntireStatus.XRaysStatus.GenerationStatus.State=WaitingForStability
18/01/2017 17:25:38.764 : mXraysStable=False
```

Shortly following the erroneous second “WaitingForStability” event, Inspect-X does in fact set the X-ray Entire Status to “Success”, but does not raise an event for it.

The simply way to rectify this bug is by manually updating the X-ray Entire Status if the “WaitingForStability” event is raised twice.

- Close the debug application, and stop the debugger.
- Add the following code to Application Variables section to declare the variables that will be used for the manual status update:

```
/// <summary> Entire Xray Status (for bug correction) summary>
private IpcContract.XRay.EntireStatus mXrayEntireStatus;

/// <summary> Generation status summary>
private IpcContract.XRay.GenerationStatus.EXRayGenerationState mXrayGenerationStatus;

/// <summary> Stability event counter summary>
private int mXraysStabilityCounter = 0;
```

- Go to the `EventHandlerXRayEntireStatus` function, and find the `switch` loop. After the `WaitingForStability` case, where it says `// Your code goes here...`, place the following code to manually update the X-ray Entire Status:

Tutorial 1: Writing your first IPC program - Switching X-rays on and off

```
// Increment stability counter;
mXraysStabilityCounter++;

// If stability counter is greater than 1 then must manually check update X-ray Entire status
if (mXraysStabilityCounter > 1)
{
    // Manual loop to update X-ray Entire Status until "Success"

    Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " : Manually checking for
        stability");

    do
    {
        // First sleep for a small amount of time to allow status updates
        Thread.Sleep(100);
        // Then get a updated X-ray Entire Status
        mXrayEntireStatus = mChannels.Xray.GetXRayEntireStatus();
        // Find generation part of Entire Status
        mXrayGenerationStatus = mXrayEntireStatus.XRaysStatus.GenerationStatus.State;

        Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " :
            mXrayGenerationStatus=" + mXrayGenerationStatus.ToString());
    }
    while (mXrayGenerationStatus != IpcContract.XRay.
        GenerationStatus.EXRayGenerationState.Success);

    Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " : Manually found stable X-
        rays- Proceed");

    // Once "Success" obtained then set mXraysStable flag to true
    mXraysStable = true;

    // Reset stability counter
    mXraysStabilityCounter = 0;
}
```

3.10.4 Further errors

If you still have trouble compiling, building and running this first tutorial program, then you are advised to liaise with your Nikon point of contact.

3.10.5 Sample answer for tutorial 1

A sample answer for the tutorial 1, including debugging and a fix for the known bug above, can be found in **Sample code - tutorial 1** (on page 35) at the end of this Quick Start Guide.

4 Tutorial 2: Moving the manipulator

In this second tutorial, we will extend our knowledge and experience of the IPC system by writing a program to control the manipulator.

4.1 Set up folders, solution and project

- Following **Creating and setting up the Visual Studio project** (on page 5) and **The front-end user form and back-end code** (on page 10), create a new copy of the IPCTemplate and rename it.
- Rename the entire solution and IPCTemplate Project, changing the Project and Solution properties as necessary. Ensure that the entire solution builds successfully.
- Rename the TemplateForm.cs file, and appropriately set the form properties. Within the form code, change the Namespace.
- Test to ensure that the debug application compiles and builds successfully.

4.2 Establish channel connections and callback functions

This section is based on **Channel connections** (on page 17) and **Defining callback functions** (on page 20) in the previous **tutorial** (on page 5).

- As in **Specifying the channels to switch on** (on page 17), set the initial flags to allow access to the Application and Manipulator channels only.
- The only events we are interested in are the following:

```
mChannels.Application.mEventSubscriptionHeartbeat.Event  
mChannels.Manipulator.mEventSubscriptionHeartbeat.Event  
mChannels.Manipulator.mEventSubscriptionManipulatorMove.Event
```

All other events can be removed from the ChannelsAttach and ChannelsDetach functions.

- Finally, we need to link our channels to our user form. Following **Linking channel connections to the user form** (on page 18), create an mApplicationState variable, and then assign the ChannelsAttach and ChannelsDetach functions to the “Load” and “FormClosing” events of the main user form.
- Remove any code for callback functions associated with events that we are not interested in.

4.3 Understanding manipulator move events

Before we construct our application to move the manipulator, it is worthwhile to understand how different Manipulator Move Events are raised. We can do this using `Debug.Print` of **Debugging** (on page 24).

- Go to the EventHandlerManipulatorMoveEvent callback function that is called whenever a Manipulator Move Event is raised. This can be found in the “STATUS FROM HOST” region, nested under “Manipulator”. Immediately above `switch (e.MoveEvent)`, insert the following debugging statement:

```
Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " : e.MoveEvent=" +  
e.MoveEvent.ToString());
```

- Compile and build the debug application. Ensure Inspect-X is running and run the debug application. Open the Output/Intermediate window in Visual Studio to monitor the debug output.
- Move the manipulator in different ways from Inspect-X (for example, homing, joystick control, position go), and monitor the debug output. Try to understand which events are raised, and when.

- Consider what happens when the demanded position of the manipulator is the same as its current position. What events are raised?
For systems with a rotate axis, what happens if the axis is asked to move to a position that is factor of 360 degrees away?

4.4 Manipulator rotate application

We will now use this knowledge of Manipulator Move events to develop a simple useful application. We want a button on the user interface that causes the manipulator to rotate from its current position by a set amount. The user can specify the amount through a numeric up-down box that is also present on the user interface.

- Create a variable in the 'Application Variables' section that represents the Rotate axis of the manipulator.

```
/// <summary> Define the rotate axis (constant) summary>
const IpcContract.Manipulator.EAxisName mRotateAxis = IpcContract.Manipulator.EAxisName.Rotate;
```

- Decide on the appropriate event(s) that will signal when the manipulator has started and stopped moving. Create appropriately named Boolean flags for these in the 'Application Variables' section. Set the flag(s) to be true at appropriate place(s) in the EventHandlerManipulatorMoveEvent callback function when the relevant event(s) are raised.
- Create an appropriately named `private decimal` variable in the 'Application Variables' section to store the rotate amount, with an initial value of 10.
- On the Designer for the UserForm, add a numeric up-down box from the Toolbox. Resize it, give it an appropriate name and set its initial value to also be 10. Add a label beside the box to tell the user what variable it is for.
- Double-clicking the numeric up-down box creates a function that is called every time the user updates the value in the box. Within this function, set the value of our global rotate amount to the value of the numeric up-down box. The line of code will be similar to below, but differing due to whichever names we choose.

```
mRotateAmount = NumericUpDown_RotateAmount.Value;
```

- Create a button on the Designer for the user interface, and change its properties as appropriate. Pressing this button will initiate our move routine.
- Construct a `private void ManipulatorMove()` function that will run when the button on the user interface is pressed. The routine should first check to see whether the application has connected to Inspect-X. In addition to initialising any necessary variables, the routine should then look up the current manipulator position of the rotate axis, set a new target position for the rotate axis, instruct the rotate axis to move and wait until the manipulator has finished moving.

The functions that are available in each channels can be found by going to `mChannels.<ChannelName>`, and looking at its member functions. For example, in the manipulator channel under the Axis member, we can find the Position function to look up the position of a particular axis:

```
mChannels.Manipulator.Axis.Position(mRotateAxis);
```

- Create a new thread variable. Add code to run the ManipulatorMove function on a new thread when the button is clicked.
- Add appropriate lines to the ManipulatorMove function that disables everything on the user interface after it has been clicked, and re-enables it once the our Manipulator Move routine has finished.
- Compile, build and test the debug application to ensure that it works correctly.

4.5 Sample answer

A sample answer for this tutorial can be found at the end of this Guide in **Sample code - tutorial 2** (on page 42).

4.6 Extensions

1. Modify the program to move the X axis by a specified amount instead the rotate axis. What other precautions need to be taken with the X or Y axis?
2. Add an extra numeric up-down button to the user interface so that travel distances for two separate axes can be set. Modify the ManipulatorMove routine so that both axes move together.
3. Add an extra button to the user interface that will home all of the axes.

Tutorial 2: Moving the manipulator

5 Tutorial 3: Acquiring an image

Continuing our exploration of the IPC interfaces, we will write a simple application that will acquire an image from the detector using Inspect-X.

5.1 Set up folders, solution and project

- Following *Creating and setting up the Visual Studio project* (on page 5), *The front-end user form and back-end code* (on page 10) and *Set up folders, solution and project* (on page 27) , create a new solution from a copy of the IPCTemplate. Rename properties as appropriate.
- Test to ensure that the debug application compiles and builds successfully.

5.2 Establish channel connections and identify appropriate events

- Set the initial flags to allow access to the Application and Image Processing channels only.
- Remove all of the events associated with the other channels from the ChannelsAttach and ChannelsDetach functions.
- Create an mApplicationState variable, and then assign the ChannelsAttach and ChannelsDetach functions to the “Load” and “FormClosing” events of the main user form.
- Place `Debug.Print` statements within the one non-heartbeat callback function. Build, compile and run the debug application.
- From within Inspect-X, perform a variety of Image Processing tasks and use the debug output to observe which events are raised.
- Decide whether there are any unnecessary event-handlers and remove these from the ChannelsAttach and ChannelsDetach functions.

5.3 Image-processing routine

Let us now create a routine that will average a user-defined number of images, and save the averaged image to disk. The user should be able to specify the number of images to average along with the file name.

- Create Boolean flags for the important events, and set them to be true when the appropriate events are raised.
- Create an integer variable with an initial value of 1 for the number of images to average. Add a numeric up-down box to the user form in the designer, and update the value of the integer variable when the numeric up-down box is changed.
- Create a string constant (`const string`) that stores the directory in which the final images will be saved. Ensure that the literal string value that this constant is given represents the path of a directory that exists.
- Create a `private string` variable that will store the filename, and give it an initial value. Add a text box to the user form, and update the value of the filename variable when the text box text is changed.
- Construct a `private void ImageAverageSave()` function for averaging and saving the image. The function should first check that the appropriate channels are connected. Next, it should create a variable for the actual image file path, concatenating the directory, filename and image extension. The routine should then average the user-defined number of images and wait until averaging has completed. The image should be saved, waiting until the save has completed successfully.
- Create a new thread variable. On the Designer for the user interface, insert a button that will run the ImageAverageSave routine on a new thread when it is clicked.

- Add code to the ImageAverageSave routine to disable and enable the button where appropriate.

5.4 Sample answer

A sample answer for this tutorial can be found at the end of this Guide in **Sample code - tutorial 3** (on page 48).

5.5 Extensions

1. Modify the program to switch into the live imaging mode and capture the live image rather than take an average of images.
2. Correct the image before saving. For example, one method of correcting the raw image would be to subtract the background black field, divide by the background white field before finally multiplying by a target value, say 60,000.

6 IPC - Expanding the potential of Nikon X-ray CT systems

This Quick Start Guide has introduced you to the basics of IPC programming provided in Inspect-X, and has shown how to write very simple applications on the X-ray, manipulator and image processing sub-systems. These can be combined to build up more complex applications, that could do almost anything that you could envisage. Let us briefly discuss a few more examples, out of the unlimited scope that is possible.

6.1 Time-lapse imaging

The imaging acquisition and save routines studied in ***Tutorial 3: Acquiring an image*** (on page 31) could be combined in a loop with `Thread.Sleep()` command to create a routine that acquires radiographs in a time-lapsed manner.

6.2 Batch 3D scans

This Guide has utilised the application, X-ray, manipulator and image processing communication channels, but there are a number of other channels, which provide other useful functionality. For instance, the CT 3D Scan communication channel allows us to start a 3D CT scan from a saved profile.

```
// Get profile list
List<string> profiles = mChannels.CT3DScan.ProfileList();

if (profiles.Count > 0)
{
    // Sample Info
    System.Collections.Generic.Dictionary<string, Object> sampleInfo =
        new System.Collections.Generic.Dictionary<string, Object>();

    sampleInfo.Add("Dataset name", "Test");

    // Response variable
    Inspect_X_Definitions.CTResponse response;
    Debug.Print("profiles[0]=" + profiles[0].ToString());
    // Start run
    response = mChannels.CT3DScan.Run(profiles[0], sampleInfo);
}
```

Several different profiles could be predefined, for example high and low resolutions scans of the same sample, with the above code adapted to perform a batch scan of each profile in turn. The scans can also be automatically reconstructed, with Inspect-X returning status updates on the progress of the reconstruction.

6.3 Integration with 3rd party software

One of the advantages of developing programs through IPC is the ability to integrate and interact with other software separate to Inspect-X, for example VG-Studio or Microsoft Word. After acquiring and reconstructing the data, VG-Studio could be used to analyse whether measurements are within certain tolerances: Are there an acceptable number of defects? Are the walls of the sample within a given tolerated thickness? These results could then be neatly presented in a report using Microsoft Word. In this way, a completely automated acquisition, reconstruction, analysis and reporting pipeline could be created.

6.4 Integration with 3rd party hardware

Similarly, IPC can be used to integrate with hardware that is separate from the Nikon X-ray CT system. For example, the alarm callback functions could be linked to control room software, or the results reported from automated reconstruction and analysis could be linked directly to the production line, with production paused if tolerances fall below a given value.

6.5 Limitless potential...!

The IPC interface thus expands and extends the potential functionality of the Nikon X-ray CT system, allowing us to perform and automate many complicated tasks that are not possible simply through the Inspect-X software. The full range of IPC commands can be found in the IPC Programming Manual which accompanies the Inspect-X installation.

This Guide has simply scratched the surface of what is possible, but the possibilities and scope for using IPC are endless. In short, it allows the Nikon X-ray CT system to be used in an unlimited manner!

7 Appendix: Sample code

7.1 Tutorial 1: UserForm.cs

```
1  using System;
   using System.Collections.Generic;
3  using System.ComponentModel;
   using System.Data;
5  using System.Drawing;
   //using System.Linq;
7  using System.Text;
   using System.Windows.Forms;
9
11 using IpcContractClientInterface;
   using AppLog = IpcUtil.Logging;
13 using System.Globalization;
   using System.Threading;
15 using System.Diagnostics;
   using System.IO;
17
   namespace Tutorial1_XraysOnOff
19 {
   public partial class UserForm : Form
21     {
       /// <summary>Are we in design modesummary>
23         protected bool mDesignMode { get; private set; }
25
       #region Standard IPC Variables
27
       /// <summary>This ensures consistent read and write culturesummary>
       private NumberFormatInfo mNFI = new CultureInfo("en-GB", true).NumberFormat; // Force UN English culture
29
       /// <summary>Collection of all IPC channels, this object always exists.summary>
31         private Channels mChannels = new Channels();
33
       #endregion Standard IPC Variables
35
       #region Application Variables
37
       /// <summary> Status of the application summary>
       private Channels.EConnectionState mApplicationState;
39
       /// <summary> Flag for X-ray stability summary>
41         private Boolean mXraysStable = false;
43
       /// <summary> Thread for X-ray Routine summary>
       private Thread mXrayRoutineThread = null;
45
       /// <summary> Entire Xray Status (for bug correction) summary>
47         private IpcContract.XRay.EntireStatus mXrayEntireStatus;
49
       /// <summary> Generation status summary>
       private IpcContract.XRay.GenerationStatus.EXRayGenerationState mXrayGenerationStatus;
51
       /// <summary> Stability event counter summary>
53         private int mXraysStabilityCounter = 0;
55
       #endregion Application Variables
57
       public UserForm()
       {
```

Appendix: Sample code

```
59         try
60         {
61             mDesignMode = (LicenseManager.CurrentContext.UsageMode == LicenseUsageMode.DesignTime);
62             InitializeComponent();
63             if (!mDesignMode)
64             {
65                 // Tell normal logging who the parent window is.
66                 AppLog.SetParentWindow = this;
67                 AppLog.TraceInfo = true;
68                 AppLog.TraceDebug = true;
69
70                 mChannels = new Channels();
71                 // Enable the channels that will be controlled by this application.
72                 // For the generic IPC client this is all of them!
73                 // This just sets flags, it does not actually open the channels.
74                 mChannels.AccessApplication = true;
75                 mChannels.AccessXray = true;
76                 mChannels.AccessManipulator = false;
77                 mChannels.AccessImageProcessing = false;
78                 mChannels.AccessInspection = false;
79                 mChannels.AccessInspection2D = false;
80                 mChannels.AccessCT3DScan = false;
81                 mChannels.AccessCT2DScan = false;
82             }
83         }
84         catch (Exception ex) { AppLog.LogException(ex); }
85     }
86
87     #region Channel connections
88
89     /// <summary>Attach to channel and connect any event handlers</summary>
90     /// <returns>Connection status</returns>
91     private Channels.EConnectionState ChannelsAttach()
92     {
93         try
94         {
95             if (mChannels != null)
96             {
97                 Channels.EConnectionState State = mChannels.Connect();
98                 if (State == Channels.EConnectionState.Connected) // Open channels
99                 {
100                     // Attach event handlers (as required)
101
102                     if (mChannels.Application != null)
103                     {
104                         mChannels.Application.mEventSubscriptionHeartbeat.Event +=
105                             new EventHandler<CommunicationsChannel_Application.EventArgsHeartbeat>(EventHandlerHeartbeatApp);
106                     }
107
108                     if (mChannels.Xray != null)
109                     {
110                         mChannels.Xray.mEventSubscriptionHeartbeat.Event +=
111                             new EventHandler<CommunicationsChannel_XRay.EventArgsHeartbeat>(EventHandlerHeartbeatXRay);
112                         mChannels.Xray.mEventSubscriptionEntireStatus.Event +=
113                             new EventHandler<CommunicationsChannel_XRay.EventArgsXRayEntireStatus>(EventHandlerXRayEntireStatus);
114                     }
115                 }
116             }
117             return State;
118         }
119         catch (Exception ex) { AppLog.LogException(ex); }
120     }
```

```

121         return Channels.EConnectionState.Error;
122     }
123
124     /// <summary>Detach channel and disconnect any event handlers</summary>
125     /// <returns>true if OK</returns>
126     private bool ChannelsDetach()
127     {
128         try
129         {
130             if (mChannels != null)
131             {
132                 // Detach event handlers
133
134                 if (mChannels.Application != null)
135                 {
136                     mChannels.Application.mEventSubscriptionHeartbeat.Event -=
137                         new EventHandler<CommunicationsChannel_Application.EventArgsHeartbeat>
138                             (EventHandlerHeartbeatApp);
139                 }
140
141                 if (mChannels.Xray != null)
142                 {
143                     mChannels.Xray.mEventSubscriptionHeartbeat.Event -=
144                         new EventHandler<CommunicationsChannel_XRay.EventArgsHeartbeat>
145                             (EventHandlerHeartbeatXRay);
146                     mChannels.Xray.mEventSubscriptionEntireStatus.Event -=
147                         new EventHandler<CommunicationsChannel_XRay.EventArgsXRayEntireStatus>
148                             (EventHandlerXRayEntireStatus);
149                 }
150
151                 Thread.Sleep(100); // A breather for events to finish!
152                 return mChannels.Disconnect(); // Close channels
153             }
154         }
155         catch (Exception ex) { AppLog.LogException(ex); }
156         return false;
157     }
158
159     #endregion Channel connections
160
161     #region Heartbeat from host
162
163     void EventHandlerHeartbeatApp(object aSender, CommunicationsChannel_Application.EventArgsHeartbeat e)
164     {
165         try
166         {
167             if (mChannels == null || mChannels.Application == null)
168                 return;
169             if (this.InvokeRequired)
170                 this.BeginInvoke((MethodInvoker)delegate { EventHandlerHeartbeatApp(aSender, e); });
171             else
172             {
173                 //your code goes here....
174             }
175         }
176         catch (ObjectDisposedException) { } // ignore
177         catch (Exception ex) { AppLog.LogException(ex); }
178     }
179
180     void EventHandlerHeartbeatXRay(object aSender, CommunicationsChannel_XRay.EventArgsHeartbeat e)
181     {
182         try
183         {
184             if (mChannels == null || mChannels.Xray == null)
185                 return;
186             if (this.InvokeRequired)

```

Appendix: Sample code

```

        this.BeginInvoke((MethodInvoker)delegate { EventHandlerHeartbeatXRay(aSender, e); });
185     else
186     {
187         //your code goes here....
188     }
189 }
190 catch (ObjectDisposedException) { } // ignore
191 catch (Exception ex) { AppLog.LogException(ex); }
192 }
193
194 void EventHandlerHeartbeatMan(object aSender, CommunicationsChannel_Manipulator.EventArgsHeartbeat e)
195 {
196     try
197     {
198         if (mChannels == null || mChannels.Manipulator == null)
199             return;
200         if (this.InvokeRequired)
201             this.BeginInvoke((MethodInvoker)delegate { EventHandlerHeartbeatMan(aSender, e); });
202         else
203         {
204             //your code goes here....
205         }
206     }
207     catch (ObjectDisposedException) { } // ignore
208     catch (Exception ex) { AppLog.LogException(ex); }
209 }
210
211 void EventHandlerHeartbeatIP(object aSender, CommunicationsChannel_ImageProcessing.EventArgsHeartbeat e)
212 {
213     try
214     {
215         if (mChannels == null || mChannels.ImageProcessing == null)
216             return;
217         if (this.InvokeRequired)
218             this.BeginInvoke((MethodInvoker)delegate { EventHandlerHeartbeatIP(aSender, e); });
219         else
220         {
221             //your code goes here...
222         }
223     }
224     catch (ObjectDisposedException) { } // ignore
225     catch (Exception ex) { AppLog.LogException(ex); }
226 }
227
228 void EventHandlerHeartbeatInspection(object aSender, CommunicationsChannel_Inspection.EventArgsHeartbeat
e)
229 {
230     try
231     {
232         if (mChannels == null || mChannels.Inspection == null)
233             return;
234         if (this.InvokeRequired)
235             this.BeginInvoke((MethodInvoker)delegate { EventHandlerHeartbeatInspection(aSender, e); });
236         else
237         {
238             //your code goes here....
239         }
240     }
241     catch (ObjectDisposedException) { } // ignore
242     catch (Exception ex) { AppLog.LogException(ex); }
243 }
244
245 void EventHandlerHeartbeatInspection2D(object aSender,
CommunicationsChannel_Inspection2D.EventArgsHeartbeat e)
246 {
247     try
```

```

249     {
250         if (mChannels == null || mChannels.Inspection2D == null)
251             return;
252         if (this.InvokeRequired)
253             this.BeginInvoke((MethodInvoker)delegate { EventHandlerHeartbeatInspection2D(aSender, e); });
254         else
255         {
256             //your code goes here....
257         }
258     }
259     catch (ObjectDisposedException) { } // ignore
260     catch (Exception ex) { AppLog.LogException(ex); }
261 }
262
263 void EventHandlerHeartbeatCT3DScan(object aSender, CommunicationsChannel_CT3DScan.EventArgsHeartbeat e)
264 {
265     try
266     {
267         if (mChannels == null || mChannels.CT3DScan == null)
268             return;
269         if (this.InvokeRequired)
270             this.BeginInvoke((MethodInvoker)delegate { EventHandlerHeartbeatCT3DScan(aSender, e); });
271         else
272         {
273             //your code goes here....
274         }
275     }
276     catch (ObjectDisposedException) { } // ignore
277     catch (Exception ex) { AppLog.LogException(ex); }
278 }
279
280 void EventHandlerHeartbeatCT2DScan(object aSender, CommunicationsChannel_CT2DScan.EventArgsHeartbeat e)
281 {
282     try
283     {
284         if (mChannels == null || mChannels.CT2DScan == null)
285             return;
286         if (this.InvokeRequired)
287             this.BeginInvoke((MethodInvoker)delegate { EventHandlerHeartbeatCT2DScan(aSender, e); });
288         else
289         {
290             //your code goes here....
291         }
292     }
293     catch (ObjectDisposedException) { } // ignore
294     catch (Exception ex) { AppLog.LogException(ex); }
295 }
296
297 #endregion Heartbeat from host
298
299 #region STATUS FROM HOST
300
301 #region XRay
302
303 void EventHandlerXRayEntireStatus(object aSender, CommunicationsChannel_XRay.EventArgsXRayEntireStatus e)
304 {
305     try
306     {
307         if (mChannels == null || mChannels.Xray == null)
308             return;
309         if (this.InvokeRequired)
310             this.BeginInvoke((MethodInvoker)delegate { EventHandlerXRayEntireStatus(aSender, e); }); //
311             Make it non blocking if called form this UI thread
312         else
313         {
314             if (e.EntireStatus != null)

```

Appendix: Sample code

```
313         {
315             Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " :
e.EntireStatus.XRaysStatus.GenerationStatus.State=" +
e.EntireStatus.XRaysStatus.GenerationStatus.State.ToString());

317             switch (e.EntireStatus.XRaysStatus.GenerationStatus.State)
318             {
319                 case IpcContract.XRay.GenerationStatus.EXRayGenerationState.Success:
320                     // Set mXraysStable Flag to true indicating stability has been reached
321                     mXraysStable = true;
322                     break;
323                 case IpcContract.XRay.GenerationStatus.EXRayGenerationState.WaitingForStability:
324                     // Increment stability counter;
325                     mXraysStabilityCounter++;

327                     // If stability counter is greater than 1 then must manually check update X-ray
Entire status
329                     if (mXraysStabilityCounter > 1)
330                     {
331                         // Manual loop to update X-ray Entire Status until "Success"

333                         Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " : Manually
checking for stability");

335                         do
336                         {
337                             // First sleep for a small amount of time to allow status updates
Thread.Sleep(100);
339                             // Then get a updated X-ray Entire Status
mXrayEntireStatus = mChannels.Xray.GetXRayEntireStatus();
341                             // Find generation part of Entire Status
mXrayGenerationStatus =
mXrayEntireStatus.XRaysStatus.GenerationStatus.State;

343                             Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " :
mXrayGenerationStatus=" + mXrayGenerationStatus.ToString());
345                         }
while (mXrayGenerationStatus !=
IpcContract.XRay.GenerationStatus.EXRayGenerationState.Success);

347                         Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " : Manually
found stable X-rays- Proceed");

349                         // Once "Success" obtained then set mXraysStable flag to true
mXraysStable = true;

351                         // Reset stability counter
353                         mXraysStabilityCounter = 0;
354                     }
355                     break;
356                 case IpcContract.XRay.GenerationStatus.EXRayGenerationState.NoXRayController:
357                     // Your code goes here...
358                     break;
359                 case IpcContract.XRay.GenerationStatus.EXRayGenerationState.StabilityTimeout:
360                     // Your code goes here...
361                     break;
362                 case IpcContract.XRay.GenerationStatus.EXRayGenerationState.StabilityXRays:
363                     // Your code goes here...
364                     break;
365                 case IpcContract.XRay.GenerationStatus.EXRayGenerationState.SwitchedOff:
366                     // Set reset flag when X-rays are turned off
367                     mXraysStable = false;
368                     break;
369             }
```

```

371         Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " : mXraysStable=" +
           mXraysStable.ToString());
           }
373     }
    }
375     catch (Exception ex) { AppLog.LogException(ex); }
    }
377
379 #endregion
381 #endregion Status from host
383
385 #region Form Functions
386
387 private void UserForm_Load(object sender, EventArgs e)
388 {
389     try
390     {
391         // Attach channels
392         mApplicationState = ChannelsAttach();
393
394         if (mApplicationState == Channels.EConnectionState.Connected)
395             Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " : Connected to Inspect-X");
396         else
397             Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " : Problem in connecting to
398                 Inspect-X");
399     }
400     catch (Exception ex) { AppLog.LogException(ex); }
401
402
403 private void UserForm_FormClosing(object sender, FormClosingEventArgs e)
404 {
405     try
406     {
407         // Detach channels
408         ChannelsDetach();
409
410         Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " : Disconnected from Inspect-X");
411     }
412     catch (Exception ex) { AppLog.LogException(ex); }
413
414
415 private void btn_Start_Click(object sender, EventArgs e)
416 {
417     // Assign the XrayRoutine to the mXrayRoutineThread
418     mXrayRoutineThread = new Thread(XrayRoutine);
419
420     // Start the thread
421     mXrayRoutineThread.Start();
422 }
423 #endregion Form Functions
424
425 #region X-ray functions
426
427 private void XrayRoutine()
428 {
429     // If ApplicationState is not connected then immediately exit the routine
430     if (mApplicationState != Channels.EConnectionState.Connected)
431         return;
432
433     // For safety, disable the Start button

```


Appendix: Sample code

```
435         this.Invoke((MethodInvoker)delegate { btn_Start.Enabled = false; });

437         // Set mXraysStable flag to false
        mXraysStable = false;

439         // Turn the X-rays on.
        mChannels.Xray.XRays.GenerationDemand(true);

443         // Wait until X-rays have stabilised
        while (!mXraysStable)
445             Thread.Sleep(5);

447         // Once stable, wait for a further 5 seconds
        Thread.Sleep(5000);

449         // Turn the X-rays off
        mChannels.Xray.XRays.GenerationDemand(false);

451         // Wait until X-rays have turned off
        while (mXraysStable)
455             Thread.Sleep(5);

457         // Re-enable the Start button
        this.Invoke((MethodInvoker)delegate { btn_Start.Enabled = true; });
459     }

461     #endregion X-ray functions

463

465 }
}
```

7.2 Tutorial 2: UserForm.cs

```
using System;
2 using System.Collections.Generic;
using System.ComponentModel;
4 using System.Data;
using System.Drawing;
6 //using System.Linq;
using System.Text;
8 using System.Windows.Forms;

10
using IpcContractClientInterface;
12 using AppLog = IpcUtil.Logging;
using System.Globalization;
14 using System.Threading;
using System.Diagnostics;
16 using System.IO;

18 namespace Tutorial2_MovingManipulator
{
20     public partial class UserForm : Form
    {
22         /// <summary>Are we in design modesummary>
        protected bool mDesignMode { get; private set; }

24         #region Standard IPC Variables

26         /// <summary>This ensures consistent read and write culturesummary>
        private NumberFormatInfo mNFI = new CultureInfo("en-GB", true).NumberFormat; // Force UN English culture
28
```

```

30    /// <summary>Collection of all IPC channels, this object always exists.summary>
    private Channels mChannels = new Channels();
32
33    #endregion Standard IPC Variables
34
35    #region Application Variables
36
37    /// <summary> Status of the application summary>
38    private Channels.EConnectionState mApplicationState;
39
40    /// <summary> Define the rotate axis (constant) summary>
41    const IpcContract.Manipulator.EAxisName mRotateAxis = IpcContract.Manipulator.EAxisName.Rotate;
42
43    /// <summary> Go signal sent flag summary>
44    private bool mManipulatorGoSignalSent = false;
45    /// <summary> Go complete flag summary>
46    private bool mManipulatorGoComplete = false;
47
48    /// <summary> Rotate amount summary>
49    private decimal mRotateAmount = 10;
50
51    /// <summary> Manipulator thread variable summary>
52    private Thread mManipulatorThread = null;
53
54    #endregion Application Variables
55
56    public UserForm()
57    {
58        try
59        {
60            mDesignMode = (LicenseManager.CurrentContext.UsageMode == LicenseUsageMode.Designtime);
61            InitializeComponent();
62            if (!mDesignMode)
63            {
64                // Tell normal logging who the parent window is.
65                AppLog.SetParentWindow = this;
66                AppLog.TraceInfo = true;
67                AppLog.TraceDebug = true;
68
69                mChannels = new Channels();
70                // Enable the channels that will be controlled by this application.
71                // For the generic IPC client this is all of them!
72                // This just sets flags, it does not actually open the channels.
73                mChannels.AccessApplication = true;
74                mChannels.AccessXray = false;
75                mChannels.AccessManipulator = true;
76                mChannels.AccessImageProcessing = false;
77                mChannels.AccessInspection = false;
78                mChannels.AccessInspection2D = false;
79                mChannels.AccessCT3DScan = false;
80                mChannels.AccessCT2DScan = false;
81            }
82        }
83        catch (Exception ex) { AppLog.LogException(ex); }
84    }
85
86    #region Channel connections
87
88    /// <summary>Attach to channel and connect any event handlerssummary>
89    /// <returns>Connection statusreturns>
90    private Channels.EConnectionState ChannelsAttach()
91    {
92        try
93        {
94            if (mChannels != null)
95            {

```

Appendix: Sample code

```
96         Channels.EConnectionState State = mChannels.Connect();
97         if (State == Channels.EConnectionState.Connected) // Open channels
98         {
99             // Attach event handlers (as required)
100
101             if (mChannels.Application != null)
102             {
103                 mChannels.Application.mEventSubscriptionHeartbeat.Event +=
104                     new EventHandler <CommunicationsChannel_Application.EventArgsHeartbeat>
105                         (EventHandlerHeartbeatApp);
106             }
107
108             if (mChannels.Manipulator != null)
109             {
110                 mChannels.Manipulator.mEventSubscriptionHeartbeat.Event +=
111                     new EventHandler <CommunicationsChannel_Manipulator.EventArgsHeartbeat>
112                         (EventHandlerHeartbeatMan);
113                 mChannels.Manipulator.mEventSubscriptionManipulatorMove.Event +=
114                     new EventHandler <CommunicationsChannel_Manipulator.EventArgsManipulatorMoveEvent>
115                         (EventHandlerManipulatorMoveEvent);
116             }
117         }
118         return State;
119     }
120     catch (Exception ex) { AppLog.LogException(ex); }
121     return Channels.EConnectionState.Error;
122 }
123
124 /// <summary>Detach channel and disconnect any event handlers</summary>
125 /// <returns>true if OK</returns>
126 private bool ChannelsDetach()
127 {
128     try
129     {
130         if (mChannels != null)
131         {
132             // Detach event handlers
133
134             if (mChannels.Application != null)
135             {
136                 mChannels.Application.mEventSubscriptionHeartbeat.Event -=
137                     new EventHandler <CommunicationsChannel_Application.EventArgsHeartbeat>
138                         (EventHandlerHeartbeatApp);
139             }
140
141             if (mChannels.Manipulator != null)
142             {
143                 mChannels.Manipulator.mEventSubscriptionHeartbeat.Event -=
144                     new EventHandler <CommunicationsChannel_Manipulator.EventArgsHeartbeat>
145                         (EventHandlerHeartbeatMan);
146                 mChannels.Manipulator.mEventSubscriptionManipulatorMove.Event -=
147                     new EventHandler <CommunicationsChannel_Manipulator.EventArgsManipulatorMoveEvent>
148                         (EventHandlerManipulatorMoveEvent);
149             }
150
151             Thread.Sleep(100); // A breather for events to finish!
152             return mChannels.Disconnect(); // Close channels
153         }
154     }
155     catch (Exception ex) { AppLog.LogException(ex); }
156     return false;
157 }
```

```

#endregion Channel connections
158
#region Heartbeat from host
160
void EventHandlerHeartbeatApp(object aSender, CommunicationsChannel_Application.EventArgsHeartbeat e)
162
{
    try
164
    {
        if (mChannels == null || mChannels.Application == null)
166
            return;
        if (this.InvokeRequired)
168
            this.BeginInvoke((MethodInvoker)delegate { EventHandlerHeartbeatApp(aSender, e); });
        else
170
        {
            //your code goes here....
172
        }
    }
174
    catch (ObjectDisposedException) { } // ignore
    catch (Exception ex) { AppLog.LogException(ex); }
176
}

178
void EventHandlerHeartbeatMan(object aSender, CommunicationsChannel_Manipulator.EventArgsHeartbeat e)
{
180
    try
    {
182
        if (mChannels == null || mChannels.Manipulator == null)
            return;
        if (this.InvokeRequired)
184
            this.BeginInvoke((MethodInvoker)delegate { EventHandlerHeartbeatMan(aSender, e); });
        else
186
        {
            //your code goes here....
188
        }
190
    }
    catch (ObjectDisposedException) { } // ignore
192
    catch (Exception ex) { AppLog.LogException(ex); }
194
}

#endregion Heartbeat from host
196
#region STATUS FROM HOST
198
#region Manipulator
200
void EventHandlerManipulatorMoveEvent(object aSender,
    CommunicationsChannel_Manipulator.EventArgsManipulatorMoveEvent e)
202
{
    try
204
    {
        if (mChannels == null || mChannels.Manipulator == null)
206
            return;
        if (this.InvokeRequired)
208
            this.BeginInvoke((MethodInvoker)delegate { EventHandlerManipulatorMoveEvent(aSender, e); }); //
            Make it non blocking if called form this UI thread
        else
210
        {
            Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " : e.MoveEvent=" +
                e.MoveEvent.ToString());
212
            switch (e.MoveEvent)
214
            {
                case IpcContract.Manipulator.EMoveEvent.HomingStarted:
216
                    // Your code goes here...
                    break;
218
                case IpcContract.Manipulator.EMoveEvent.HomingCompleted:
                    // Your code goes here...

```

Appendix: Sample code

```
220         break;
221     case IpcContract.Manipulator.EMoveEvent.ManipulatorStartedMoving:
222         // Your code goes here...
223         break;
224     case IpcContract.Manipulator.EMoveEvent.ManipulatorStoppedMoving:
225         // Your code goes here...
226         break;
227     case IpcContract.Manipulator.EMoveEvent.FilamentChangePositionGoStarted:
228         // Your code goes here...
229         break;
230     case IpcContract.Manipulator.EMoveEvent.GoCompleted:
231         // Set mManipulatorGoComplete flag to be true
232         mManipulatorGoComplete = true;
233         break;
234     case IpcContract.Manipulator.EMoveEvent.GoStarted:
235         // Set mManipulatorGoSignalSent flag to be true
236         mManipulatorGoSignalSent = true;
237         break;
238     case IpcContract.Manipulator.EMoveEvent.LoadPositionGoCompleted:
239         // Your code goes here...
240         break;
241     case IpcContract.Manipulator.EMoveEvent.LoadPositionGoStarted:
242         // Your code goes here...
243         break;
244     case IpcContract.Manipulator.EMoveEvent.Error:
245         // Your code goes here...
246         break;
247     default:
248         break;
249     }
250 }
251 }
252 catch (Exception ex) { AppLog.LogException(ex); }
253 }
254
255 #endregion
256
257
258
259 #endregion Status from host
260
261 #region User functions
262
263 private void UserForm_Load(object sender, EventArgs e)
264 {
265     try
266     {
267         // Attach channels
268         mApplicationState = ChannelsAttach();
269
270         if (mApplicationState == Channels.EConnectionState.Connected)
271             Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " : Connected to Inspect-X");
272         else
273             Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " : Problem in connecting to
274                 Inspect-X");
275     }
276     catch (Exception ex) { AppLog.LogException(ex); }
277 }
278
279
280 private void UserForm_FormClosing(object sender, FormClosingEventArgs e)
281 {
282     try
283     {
284         {
```

```

286         // Detach channels
        ChannelsDetach();

288         Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " : Disconnected from Inspect-X");
    }
290     catch (Exception ex) { AppLog.LogException(ex); }
    }

292

294     private void numericUpDown_RotateAmount_ValueChanged(object sender, EventArgs e)
    {
296         mRotateAmount = numericUpDown_RotateAmount.Value;
    }

298

300     private void btn_Start_Click(object sender, EventArgs e)
    {
302         // Initialise a new thread for Manipulator move to run on
        mManipulatorThread = new Thread(ManipulatorMove);
304         // Start the thread
        mManipulatorThread.Start();
306     }

308

310     #endregion User functions

312     #region Manipulator routines

314     private void ManipulatorMove()
    {
316         // If ApplicationState is not connected then immediately exit the routine
        if (mApplicationState != Channels.EConnectionState.Connected)
318             return;

320         // For safety, disable the Start button
        this.Invoke((MethodInvoker)delegate
322         {
            btn_Start.Enabled = false;
324             lbl_RotateAmount.Enabled = false;
            numericUpDown_RotateAmount.Enabled = false;
326         });

328         // Variable for current manipulator position
        float aManipulatorCurrentPosition;

330

332         // Variable for demanded manipulator position
        float aManipulatorDemandedPosition;

334         // Set Movement flags to be false
        mManipulatorGoSignalSent = false;
336         mManipulatorGoComplete = false;

338         // Look up current position
        aManipulatorCurrentPosition = mChannels.Manipulator.Axis.Position(mRotateAxis);

340

342         // Calculate new demanded position
        aManipulatorDemandedPosition = aManipulatorCurrentPosition + (float)mRotateAmount;

344         // Set target position of rotate axis to be demanded position
        mChannels.Manipulator.Axis.Target(mRotateAxis, aManipulatorDemandedPosition);

346

348         // Tell manipulator to move
        mChannels.Manipulator.Axis.Go(mRotateAxis);

350         // while both movement flags are still not positive, then wait

```

Appendix: Sample code

```
352         while (!mManipulatorGoSignalSent || !mManipulatorGoComplete)
            Thread.Sleep(10);

354         // Re-enable the Start button
        this.Invoke((MethodInvoker)delegate
356         {
            btn_Start.Enabled = true;
358            lbl_RotateAmount.Enabled = true;
            numericUpDown_RotateAmount.Enabled = true;
360        });

362    }

364    #endregion Manipulator routines

366

368    }
370 }
```

7.3 Tutorial 3: UserForm.cs

```
using System;
2 using System.Collections.Generic;
using System.ComponentModel;
4 using System.Data;
using System.Drawing;
6 //using System.Linq;
using System.Text;
8 using System.Windows.Forms;

10
using IpcContractClientInterface;
12 using AppLog = IpcUtil.Logging;
using System.Globalization;
14 using System.Threading;
using System.Diagnostics;
16 using System.IO;

18 namespace Tutorial3_AcquiringAnImage
{
20     public partial class UserForm : Form
    {
22         /// <summary>Are we in design modesummary>
        protected bool mDesignMode { get; private set; }

24
        #region Standard IPC Variables

26
        /// <summary>This ensures consistent read and write culturesummary>
28         private NumberFormatInfo mNFI = new CultureInfo("en-GB", true).NumberFormat; // Force UN English culture

30
        /// <summary>Collection of all IPC channels, this object always exists.summary>
        private Channels mChannels = new Channels();

32
        #endregion Standard IPC Variables

34
        #region Application Variables

36
        // Application connection status
38         private Channels.EConnectionState mApplicationState;

40
        // Flag for Average Complete
        private Boolean mImageAverageComplete = false;
```

```

42
43     // Flag for Image Save complete
44     private Boolean mImageSaveComplete = false;

45
46     // Number of images to average
47     private int mNumberImagesToAverage = 1;
48
49     // String constant for Directory
50     const string mDirectory = @"C:\Users\User\Pictures";

51
52     // String for filename
53     private string mFilename = "untitled";
54
55     // Thread for image average save routine
56     private Thread mThreadImageAverageSave = null;

57
58     #endregion Application Variables

59
60     public UserForm()
61     {
62         try
63         {
64             mDesignMode = (LicenseManager.CurrentContext.UsageMode == LicenseUsageMode.DesignTime);
65             InitializeComponent();
66             if (!mDesignMode)
67             {
68                 // Tell normal logging who the parent window is.
69                 AppLog.SetParentWindow = this;
70                 AppLog.TraceInfo = true;
71                 AppLog.TraceDebug = true;

72
73                 mChannels = new Channels();
74                 // Enable the channels that will be controlled by this application.
75                 // For the generic IPC client this is all of them!
76                 // This just sets flags, it does not actually open the channels.
77                 mChannels.AccessApplication = true;
78                 mChannels.AccessXray = false;
79                 mChannels.AccessManipulator = false;
80                 mChannels.AccessImageProcessing = true;
81                 mChannels.AccessInspection = false;
82                 mChannels.AccessInspection2D = false;
83                 mChannels.AccessCT3DScan = false;
84                 mChannels.AccessCT2DScan = false;
85             }
86         }
87         catch (Exception ex) { AppLog.LogException(ex); }
88     }

89
90     #region Channel connections

91
92     /// <summary>Attach to channel and connect any event handlers</summary>
93     /// <returns>Connection status</returns>
94     private Channels.EConnectionState ChannelsAttach()
95     {
96         try
97         {
98             if (mChannels != null)
99             {
100                 Channels.EConnectionState State = mChannels.Connect();
101                 if (State == Channels.EConnectionState.Connected) // Open channels
102                 {
103                     // Attach event handlers (as required)

104
105                     if (mChannels.Application != null)
106                     {
107                         mChannels.Application.mEventSubscriptionHeartbeat.Event +=

```


Appendix: Sample code

```
108         new EventHandler <CommunicationsChannel_Application.EventArgsHeartbeat>
            (EventHandlerHeartbeatApp);
110     }
112     if (mChannels.ImageProcessing != null)
113     {
114         mChannels.ImageProcessing.mEventSubscriptionHeartbeat.Event +=
            new EventHandler <CommunicationsChannel_ImageProcessing.EventArgsHeartbeat>
            (EventHandlerHeartbeatIP);
116         mChannels.ImageProcessing.mEventSubscriptionImageProcessing.Event +=
            new EventHandler <CommunicationsChannel_ImageProcessing.EventArgsIPEvent>
            (EventHandlerIPEvent);
118     }
120
121     }
122     return State;
123 }
124 }
125 catch (Exception ex) { AppLog.LogException(ex); }
126 return Channels.EConnectionState.Error;
127 }
128
129 /// <summary>Detach channel and disconnect any event handlers</summary>
130 /// <returns>true if OK</returns>
131 private bool ChannelsDetach()
132 {
133     try
134     {
135         if (mChannels != null)
136         {
137             // Detach event handlers
138
139             if (mChannels.Application != null)
140             {
141                 mChannels.Application.mEventSubscriptionHeartbeat.Event -=
142                     new EventHandler <CommunicationsChannel_Application.EventArgsHeartbeat>
143                     (EventHandlerHeartbeatApp);
144             }
145
146             if (mChannels.ImageProcessing != null)
147             {
148                 mChannels.ImageProcessing.mEventSubscriptionHeartbeat.Event -=
149                     new EventHandler <CommunicationsChannel_ImageProcessing.EventArgsHeartbeat>
150                     (EventHandlerHeartbeatIP);
151                 mChannels.ImageProcessing.mEventSubscriptionImageProcessing.Event -=
152                     new EventHandler <CommunicationsChannel_ImageProcessing.EventArgsIPEvent>
153                     (EventHandlerIPEvent);
154             }
155
156             Thread.Sleep(100); // A breather for events to finish!
157             return mChannels.Disconnect(); // Close channels
158         }
159     }
160     catch (Exception ex) { AppLog.LogException(ex); }
161     return false;
162 }
163
164 #endregion Channel connections
165
166 #region Heartbeat from host
167
168 void EventHandlerHeartbeatApp(object aSender, CommunicationsChannel_Application.EventArgsHeartbeat e)
```

```

170         {
171             if (mChannels == null || mChannels.Application == null)
172                 return;
173             if (this.InvokeRequired)
174                 this.BeginInvoke((MethodInvoker)delegate { EventHandlerHeartbeatApp(aSender, e); });
175             else
176             {
177                 //your code goes here....
178             }
179         }
180         catch (ObjectDisposedException) { } // ignore
181         catch (Exception ex) { AppLog.LogException(ex); }
182     }
183
184     void EventHandlerHeartbeatIP(object aSender, CommunicationsChannel_ImageProcessing.EventArgsHeartbeat e)
185     {
186         try
187         {
188             if (mChannels == null || mChannels.ImageProcessing == null)
189                 return;
190             if (this.InvokeRequired)
191                 this.BeginInvoke((MethodInvoker)delegate { EventHandlerHeartbeatIP(aSender, e); });
192             else
193             {
194                 //your code goes here...
195             }
196         }
197         catch (ObjectDisposedException) { } // ignore
198         catch (Exception ex) { AppLog.LogException(ex); }
199     }
200
201     #endregion Heartbeat from host
202
203     #region STATUS FROM HOST
204
205     #region ImageProcessing
206
207     void EventHandlerIPEvent(object aSender, CommunicationsChannel_ImageProcessing.EventArgsIPEvent e)
208     {
209         try
210         {
211             if (mChannels == null || mChannels.ImageProcessing == null)
212                 return;
213             if (this.InvokeRequired)
214                 this.BeginInvoke((MethodInvoker)delegate { EventHandlerIPEvent(aSender, e); }); // Make it non
215                 blocking if called form this UI thread
216             else
217             {
218                 Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " : e.IPEvent.EventType=" +
219                     e.IPEvent.EventType.ToString());
220
221                 switch (e.IPEvent.EventType)
222                 {
223                     case IpcContract.ImageProcessing.IPEvent.EEventType.Live:
224                         // Your code goes here...
225                         break;
226                     case IpcContract.ImageProcessing.IPEvent.EEventType.Capture:
227                         // Your code goes here...
228                         break;
229                     case IpcContract.ImageProcessing.IPEvent.EEventType.Average:
230                         // Your code goes here...
231                         break;
232                     case IpcContract.ImageProcessing.IPEvent.EEventType.AverageComplete:
233                         // flag set to true when image averaging complete
234                         mImageAverageComplete = true;

```

Appendix: Sample code

```
                break;
234         case IpcContract.ImageProcessing.IPEvent.EEventType.LoadImageComplete:
                // Your code goes here...
                break;
236         case IpcContract.ImageProcessing.IPEvent.EEventType.SaveImageComplete:
                // flag set to true when image saved
                mImageSaveComplete = true;
238         break;
240         default:
                // Your code goes here...
                break;
242     }
244 }
246 }
    catch (Exception ex) { AppLog.LogException(ex); }
248 }

250 #endregion

252 #endregion Status from host

254 #region User functions

256 private void UserForm_Load(object sender, EventArgs e)
257 {
258     try
259     {
260         // Attach channels
261         mApplicationState = ChannelsAttach();
262
263         if (mApplicationState == Channels.EConnectionState.Connected)
264             Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " : Connected to Inspect-X");
265         else
266             Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " : Problem in connecting to
                Inspect-X");
267     }
268     catch (Exception ex) { AppLog.LogException(ex); }
269 }
270
271 private void UserForm_FormClosing(object sender, FormClosingEventArgs e)
272 {
273     try
274     {
275         // Detach channels
276         ChannelsDetach();
277
278         Debug.Print(DateTime.Now.ToString("dd/MM/yyyy H:mm:ss.fff") + " : Disconnected from Inspect-X");
279     }
280     catch (Exception ex) { AppLog.LogException(ex); }
281 }
282
283 private void numericUpDown_NumberImagesToAverage_ValueChanged(object sender, EventArgs e)
284 {
285     mNumberImagesToAverage = (int) numericUpDown_NumberImagesToAverage.Value;
286 }
287
288 private void textBox1_TextChanged(object sender, EventArgs e)
289 {
290     mFilename = textBox_Filename.Text.ToString();
291 }
292
293 private void btn_Start_Click(object sender, EventArgs e)
294 {
295     // Initialise the thread with the ImageAverageSave routine
296     mThreadImageAverageSave = new Thread(ImageAverageSave);
297     // Start the thread
298 }
```

```

298         mThreadImageAverageSave.Start();
299     }
300
301     #endregion User functions
302
303     #region Image Processing Routines
304
305     private void ImageAverageSave()
306     {
307
308         // If ApplicationState is not connected then immediately exit the routine
309         if (mApplicationState != Channels.EConnectionState.Connected)
310             return;
311
312         // For safety, disable the Start button
313         this.Invoke((MethodInvoker)delegate { btn_Start.Enabled = false; });
314
315         // Set filepath
316         string aFilepath = mDirectory + "\ " + mFilename + @".tif";
317
318         // Set flags to false
319         mImageAverageComplete = false;
320         mImageSaveComplete = false;
321
322         // Average set number of images
323         mChannels.ImageProcessing.Image.Average(mNumberImagesToAverage, false);
324
325         // Wait until average is complete
326         while (!mImageAverageComplete)
327             Thread.Sleep(10);
328
329         // Save image
330         mChannels.ImageProcessing.Image.SaveAsTiff(aFilepath, false, false, false);
331
332         // Wait until save has completed
333         while (!mImageSaveComplete)
334             Thread.Sleep(10);
335
336         // Re-enable the Start button
337         this.Invoke((MethodInvoker)delegate { btn_Start.Enabled = true; });
338     }
339
340     #endregion Image Processing Routines
341
342 }
343
344 }

```

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