STMicroelectronics SensorTile Tutorial: Introduction to STMicroelectronics Development Environment and DataLog Project Example for Windows Platforms

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1. Introduction

The SensorTile is a new Internet of Things (IoT) system provided by STMicroelectronics integrating state-of-the-art processor, wireless interfaces, and sensor systems. The SensorTile can form the foundation for wearable consumer devices, wearable medical devices, residential IoT systems and vehicle IoT systems.

The SensorTile system provides an exceptionally powerful and well-supported platform for introduction to IoT technology. The SensorTile is remarkably compact as shown in Figure 1.

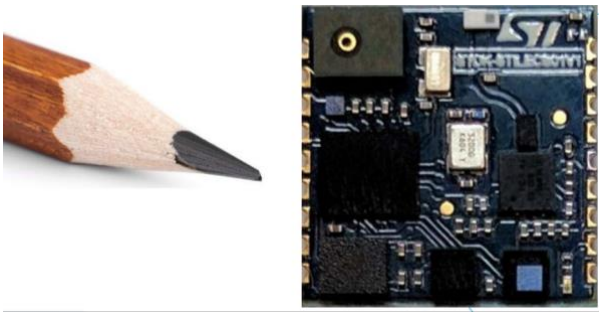

Figure 1. The STMicroelectonics SensorTile Platform with a pencil reference indicating its compact geometry.

The SensorTile includes these components:

1) The SensorTile Processor System is an STM32L4 microprocessor based on the ARM Cortex M4 system. This provides introduction to the ARM processor architecture that is deployed on nearly every smartphone on earth.
2) The SensorTile Sensors includes:
   a) The LSM6DSM combining microaccelerometer and microgyroscope.
   b) The LSM303AGR combining microaccelerometer and magnetometer for compass heading
   c) The LPS22HB barometric pressure sensor for determination of altitude and atmospheric pressure.
   d) The MP34DT04 microphone
3) The SensorTile also includes a Bluetooth Low Energy (Bluetooth Smart) wireless interface the BlueNRG-MS system.
4) The SensorTile also includes non-volatile flash storage that stores the executable code that enables IoT system operation.
5) The SensorTile also includes a cradle accessory with additional features including:
   a) SD Card Flash Storage System
   b) STC3115 Battery Monitor providing detailed energy monitoring for the SensorTile
   c) HTS221 Humidity and Temperature environmental sensors

2. Introduction to This Tutorial

This Tutorial introduces the development environment for the SensorTile system.

Development environments are essential to development of software for IoT systems and other products. These provide support to developers for both creation of systems, testing, debugging, and installation of software systems on platforms.

This development environment is referred to as an Integrated Development Environment (IDE). This includes all software tools required to create a software distribution for the SensorTile, compile this software system into the processor instruction set using a Build capability, execute this system using a Debug capability, and create an "image" file that can be installed in the SensorTile non-volatile storage.

This tutorial is intended for users that have Windows platforms, and will guide users through the tasks listed below. *Please note that there is a companion Tutorial for users that have Apple Mac Platforms.*

The Tutorial steps include:

1. Installing an Integrated Development Environment (IDE) on Window.
2. Obtaining reference design example project software. This will specifically include a sensor Data Logging system.
3. Usage of the IDE to Import, Build, Run, Debug and Flash the SensorTile board to run the example Data Logging project.

For more information regarding the SensorTile board, please open the following link on a web-browser on your PC.

www.st.com/sensortile

2.1. List of Required Equipment and Materials

1) 1x STMicroelectronics SensorTile kit.
2) 1x STMicroelectronics Nucleo Board.
3) 1x Windows with two USB type-A inputs OR you must have a powered USB hub.
4) 1x USB 2.0 A-Male to Micro-B Cable (micro USB cable).
5) 1x USB 2.0 A-Male to Mini-B Cable (mini USB cable).
6) Network access to the Internet.

3. Integrated Development Environment Installation

This portion of the document will guide users through the System WorkBench Integrated Development Environment (IDE) installation process.

3.1. Prerequisite Steps

1. Open the following link to register an account with the OpenSTM32 community.

   http://www.openstm32.org/tiki-register.php

2. Update your Windows operating system (OS) to the latest version (Windows 10 or newer). Open the following link on a web-browser on your Windows for more details.

   https://support.microsoft.com/en-us/help/12373/windows-update-faq

3.2. Install System WorkBench (IDE)

1. Open the following link on a web-browser on your PC to download the System Workbench Installer.

   https://drive.google.com/open?id=1SXOPiF9RF3OSRB8lELfcFkH3tLJbgo5E

2. Move the installer (*install_sw4stm32_win_64bits-v2.2*) to Desktop.

3. Install System WorkBench by double-clicking the installer. Then, you should see the installation information like Figure 2.

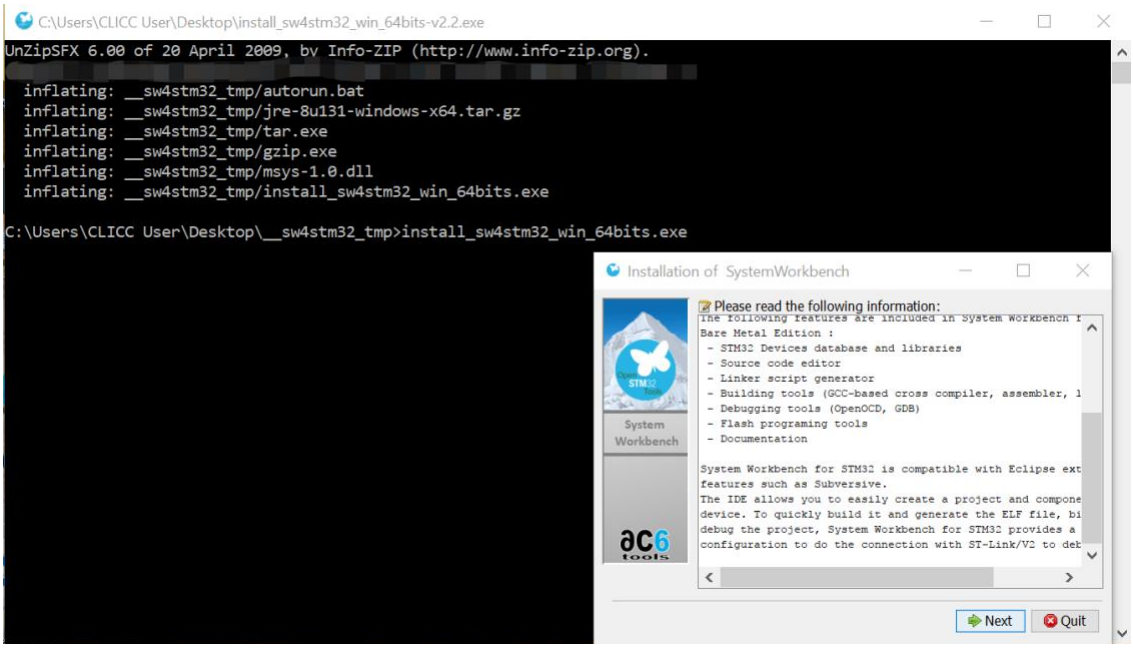

Figure 2: System WorkBench Installation information

4. Wait for a few seconds, you will see a GUI installation interface popup as Figure 3.

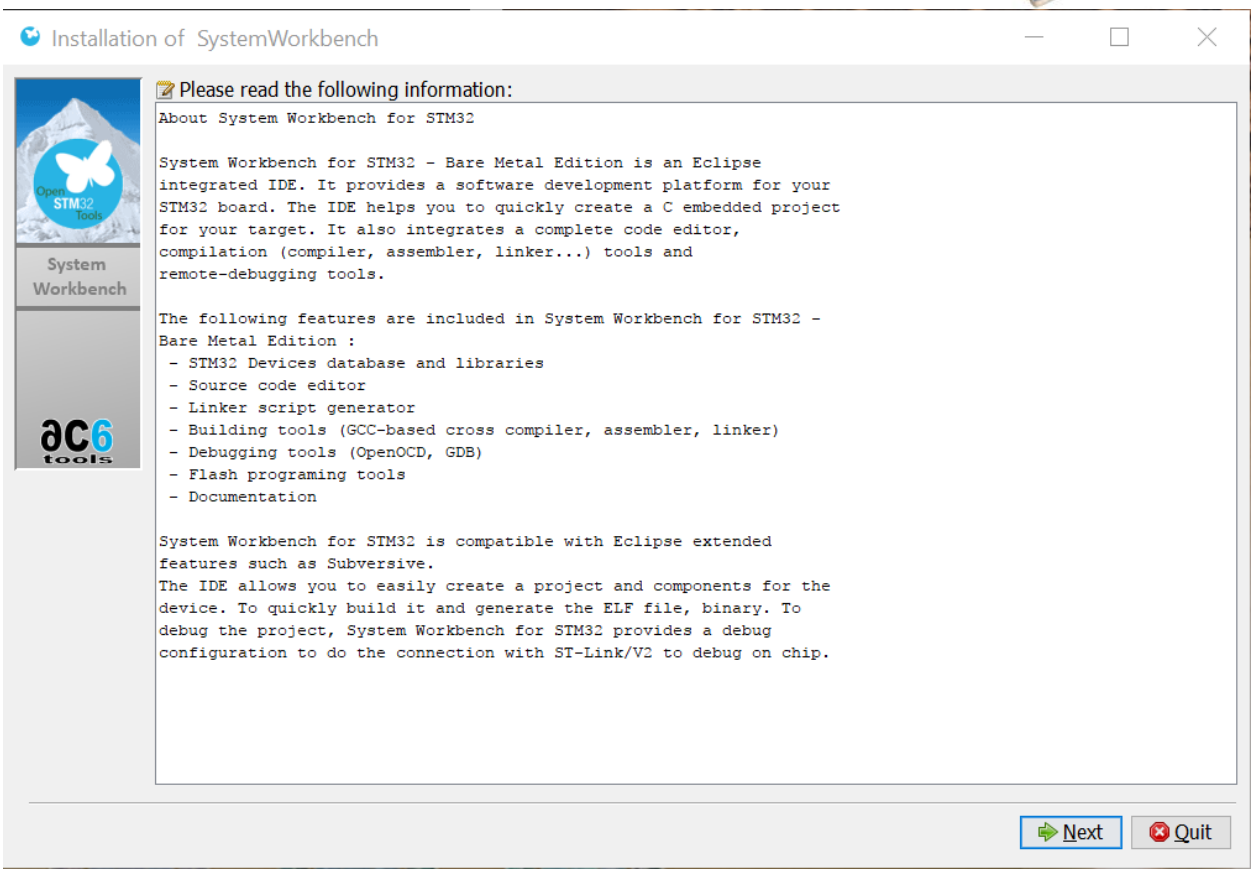

Figure 3: GUI installation interface of System WorkBench

5. Click on Next to continue. Accept all the license agreement and click next to continue as Figure 4.

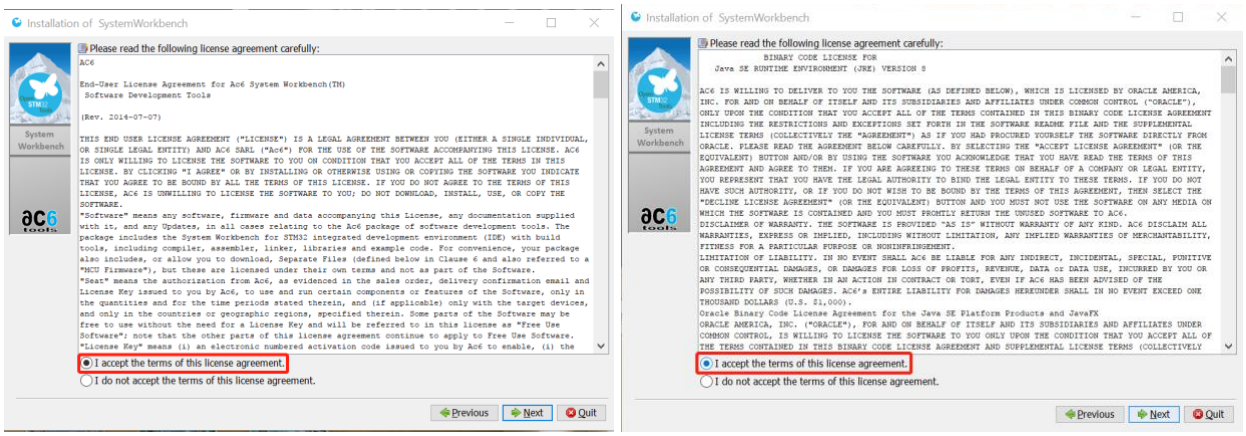

Figure 4: Agree the license agreement for System WorkBench.

6. Use its **default** installation directory and click next to continue. See Figure 5.

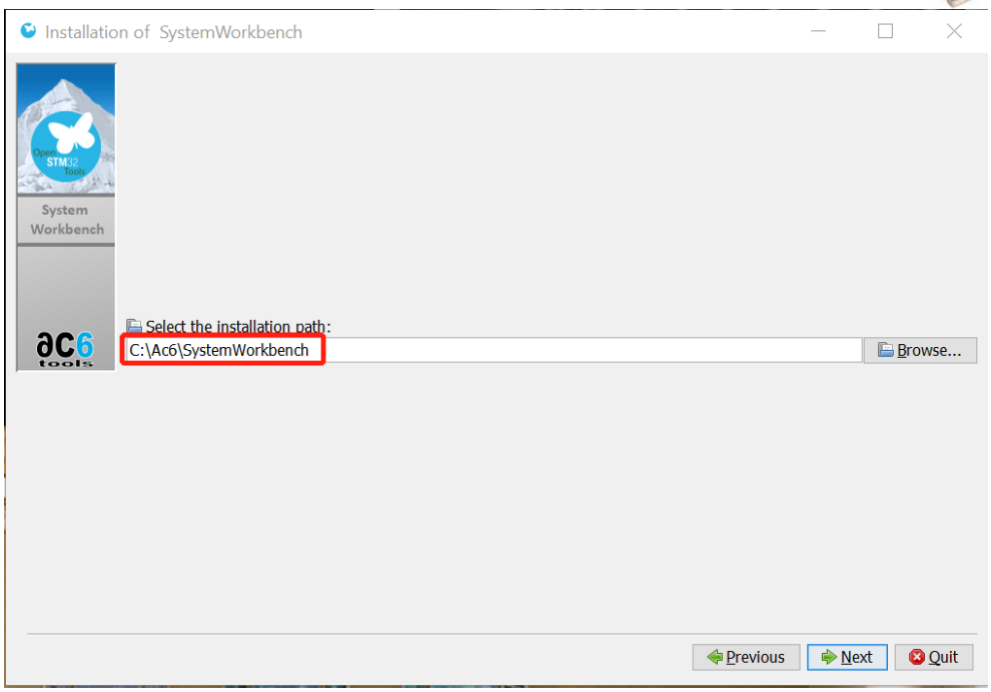

Figure 5: Use default installation directory

7. Click OK in the pop-up window. See Figure 6.

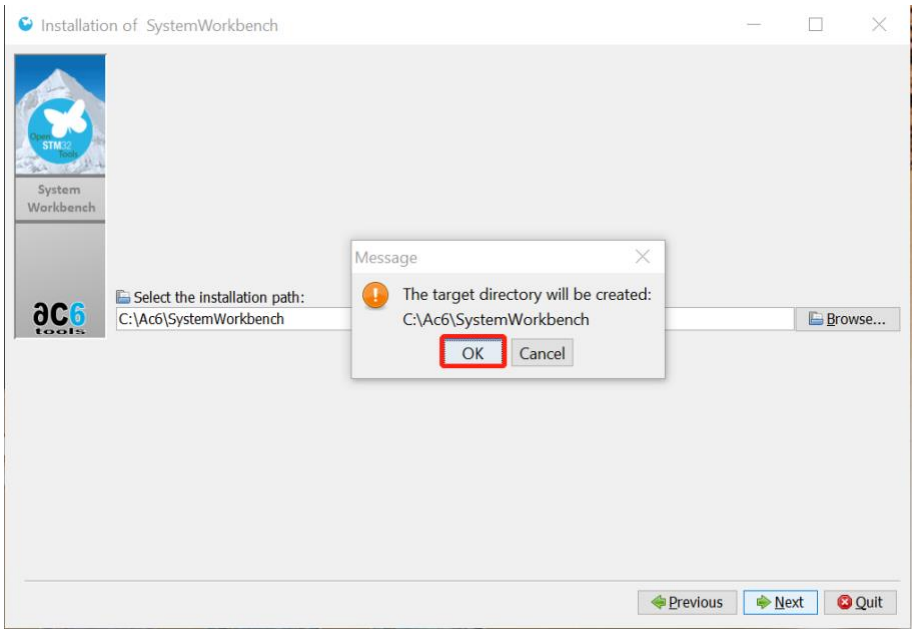

Figure 6: Create the installation directory

8. Make sure that all installation options have been checked and click next to continue. See Figure 7.

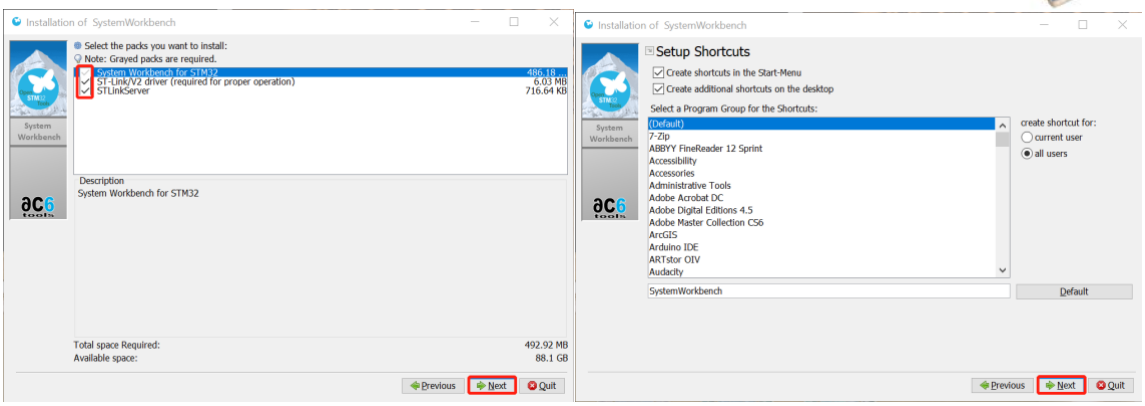

Figure 7: Install everything in the package

9. Wait until the installation has been finished. See Figure 8.

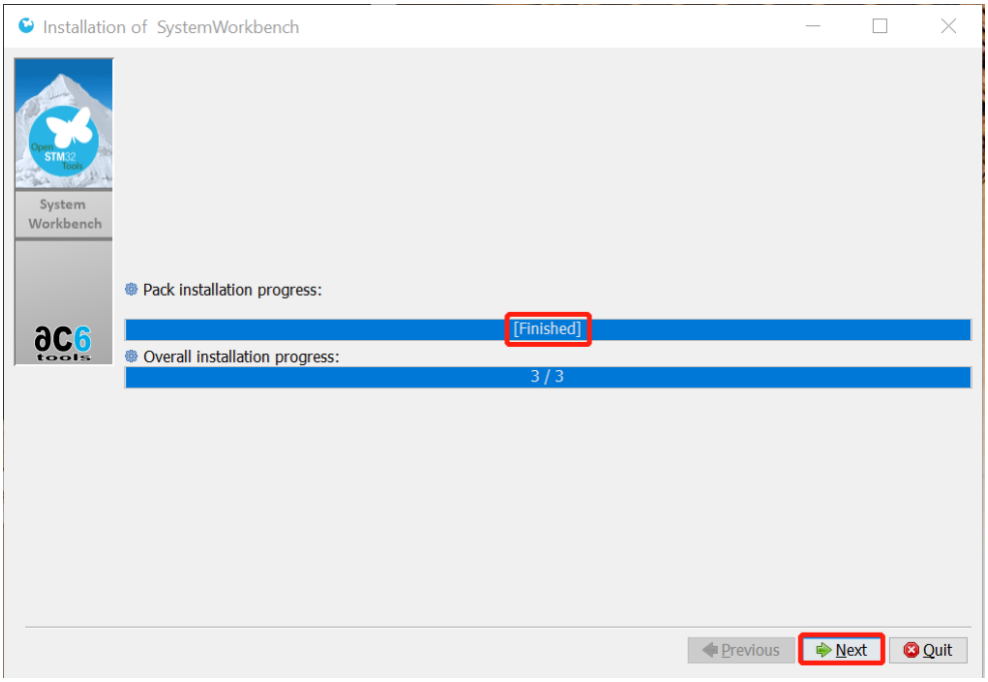

Figure 8: Installation has been finished

10. Install the driver according to the installer interface.

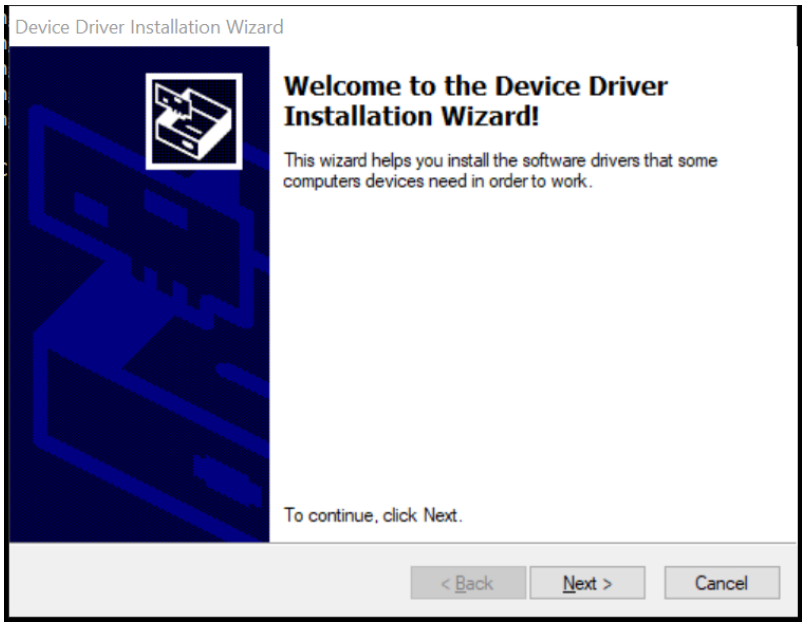

Figure 9: Driver installation

11. Make sure your computer is connected to the Internet and double-click SystemWorkbench shortcut on your desktop. Use the default workspace directory and wait for the final step of installation as Figure 10.

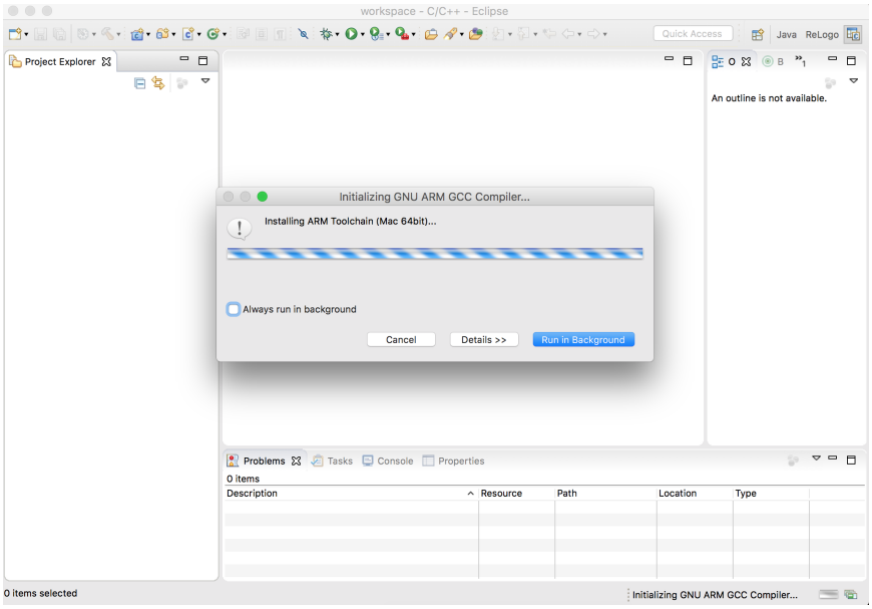

Figure 10: Last step of System Workbench (IDE) installation

12. After step 11, you System Workbench (IDE) is ready to go. System Workbench is an Eclipse with proper configuration and compiler tools.

3.3.ST-Link Utilities for STM32

This section will guide users through the process of downloading and installing a flash tool.

1. Restart your PC.

2. Ensure that you have administrative privileges on your PC before proceeding.

3. Download the STM32 ST-LINK utilities from the following weblink. Follow a similar process to section “5.1 Download”, but look for the file labelled **STSW-LINK004** instead of **STSW-STLKT01**.

   http://www.st.com/en/embedded-software/stsw-link004.html

4. Extract the contents of the archive labelled “en.stsw-link004.zip”.

5. Double click file that was extracted to begin installation.

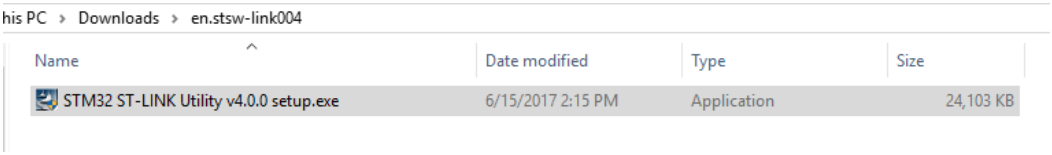

Figure 12: The file used to start the install process for the ST-LINK utilities.

6. Download the STM ST-LINK USB Driver from the following weblink. Follow a similar process to section “5.1 Download”, but look for the file labelled **STSW-LINK009** instead of **STSW-STLKT01**.

   Copy and paste this link into your browser if it does not function as intended.

   http://www.st.com/content/st_com/en/products/embedded-software/development-tool-software/stsw-link009.html

7. Extract the contents of the archive labelled “en.stsw-link009.zip”.

8. If you are using a 64-bit operating system, double click the file labelled “dpinst_amd64.exe” to begin installation. Otherwise, double click the file labelled “dpinst_x86.exe”. See Figure .

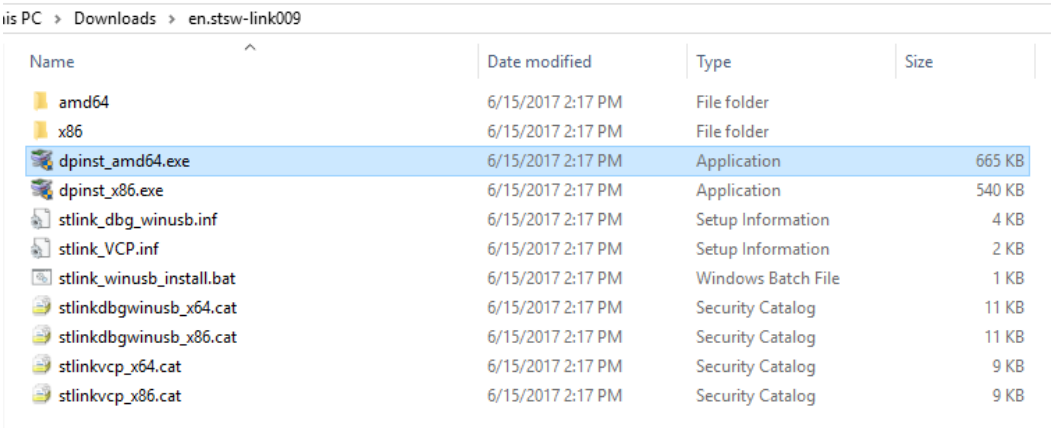

Figure 13: The file highlighted in blue is the installer used to install ST-LINK USB drivers.

9. Download the STM32 Virtual COM Port Driver from the following weblink. Follow a similar process to section “5.1 Download”, but look for the file labelled **STSW-STM32102** instead of **STSW-STLKT01**.

   http://www.st.com/en/development-tools/stsw-stm32102.html

   From the extracted files, select the one whose filename contains “W8” if your system is Windows 8 or newer. Otherwise, select the one whose filename contains “W7”.

   If you are using a 64-bit operating system, select the file ended with “64bits”. Otherwise, select the one ended with “32bits”.

   Launch the installer by double clicking the selected file.

   Use the default install location for consistency with the rest of this tutorial.

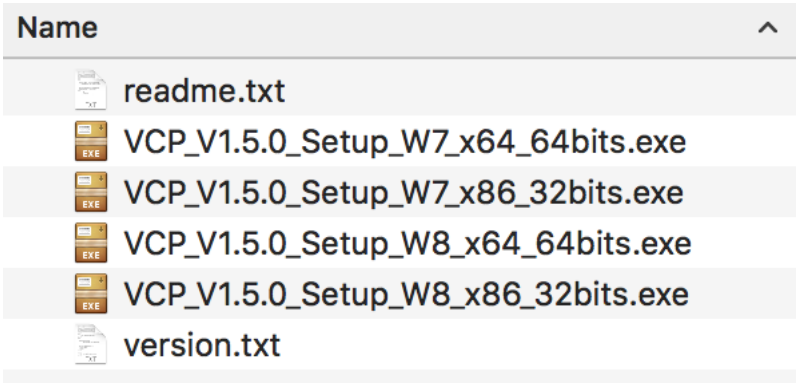

Figure 14: The ST32 Virtual COM Port Driver installers.

4. PuTTy

PuTTY is an SSH and telnet client, developed originally by Simon Tatham for the Windows platform. PuTTY is open source software that is available with source code and is developed and supported by a group of volunteers.

PuTTy is the program that will enable us to see the data transmitted by the SensorTile board over serial USB connection to your personal computer.

1. Open the following web-link on your personal computer.

   https://www.chiark.greenend.org.uk/~sgtatham/putty/latest.html

2. Download the correct executable binary file for your operating system as highlighted in Figure .

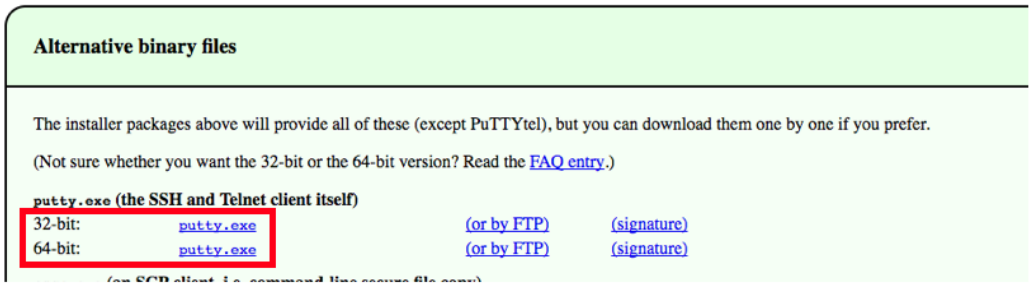

Figure 15: Downloading the correct PuTTy binary file.

3. Double click the file to launch it. Note: This file is an **EXECUTABLE BINARY FILE**, this file is NOT an installer. As such, make sure you do not delete this file after you execute it once. You may also want to create a shortcut to this application on your desktop for ease of access.

5. Example Data Logging Project

5.1. Download

Follow the instructions below to download an existing data-logging project for the SensorTile.

First, please note that this Tutorial supported Version 1.2.0 of the SensorTile Firmware, STSW-STLKT01

Instructions to download firmware from STMicroelectronics websites.

1. Open the following link on a web-browser on your PC.

   http://www.st.com/content/st_com/en/premium-content/sensortile-curriculum-stsw-stlkt01_zip.html

2. Scroll to the bottom of the page, and click “Get Software” for the entry **STSW-STLKT01**.

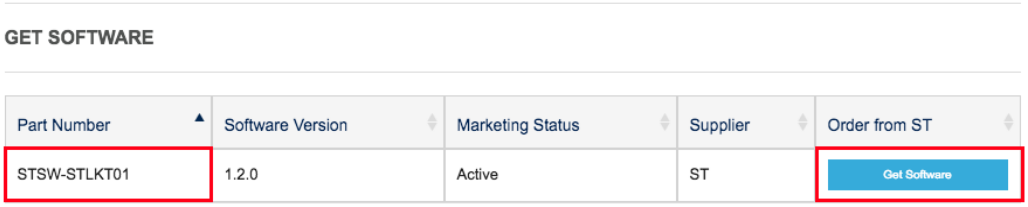

Figure 16: This figure depicts what to click to acquire the example project files.

3. When the license agreement appears (Figure), read through it.

After reading the agreement, click “Accept” at the top of the page.

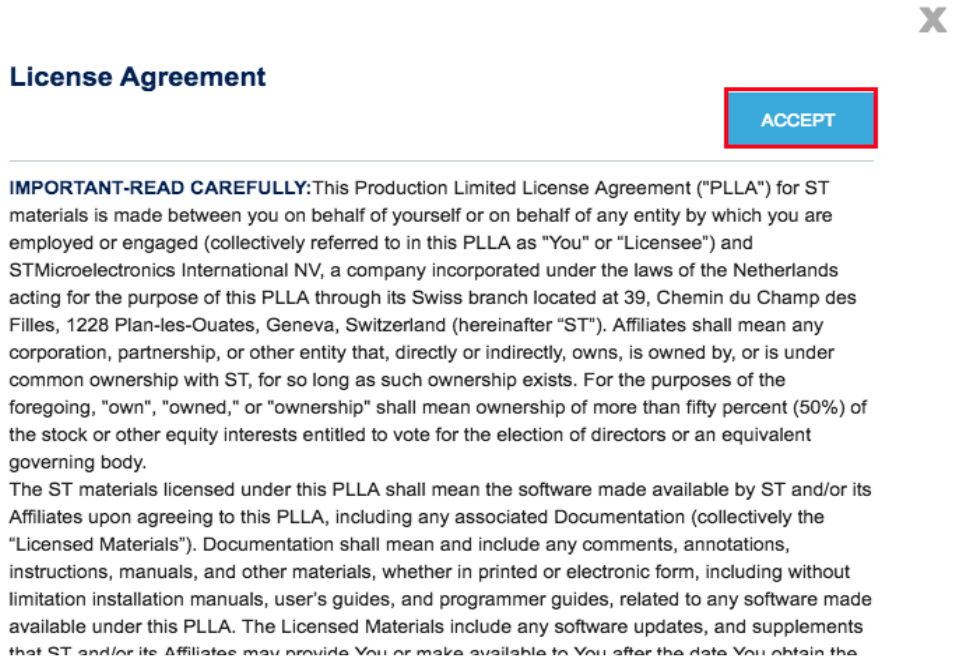

Figure 17: License agreement that appears once you click "Get Software".

4. Either register an account, or enter your name and email address when prompted by the popup depicted in Figure .

Then, click “Download” at the bottom of the popup screen.

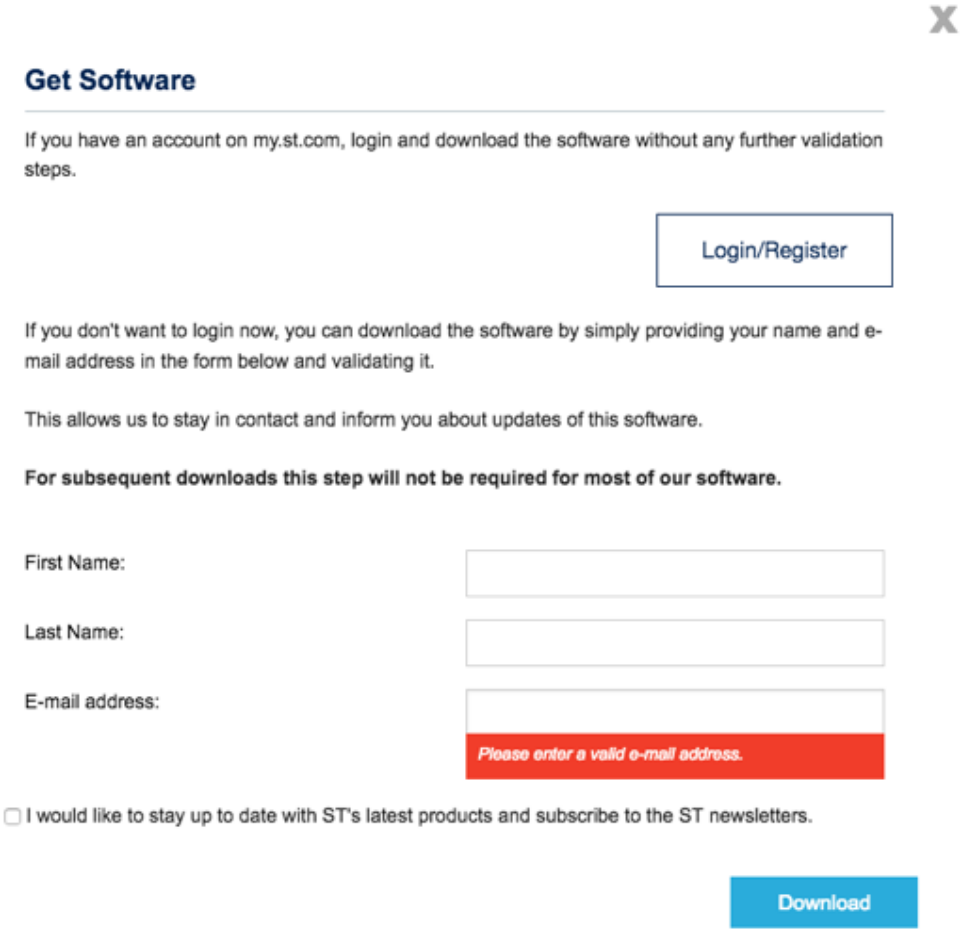

Figure 18: Dialog box that collects developer information prior to enabling acquisition of example project files.

5. The popup box should resemble Figure if all steps have proceeded successfully.

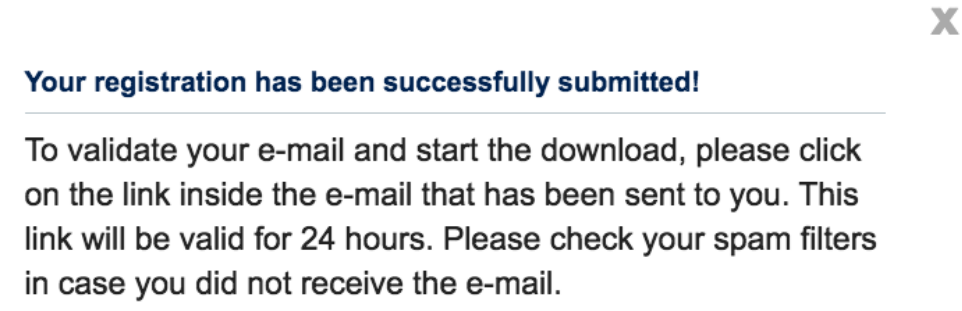

Figure 19: This is a successful registration notification box.

6. Check your email **inbox** and **spam** folders for the email. Follow the link that you were sent to download the example code. The email should resemble Figure .

   Note: this link will not function if your web-browser is in “Incognito” or “Private” mode.

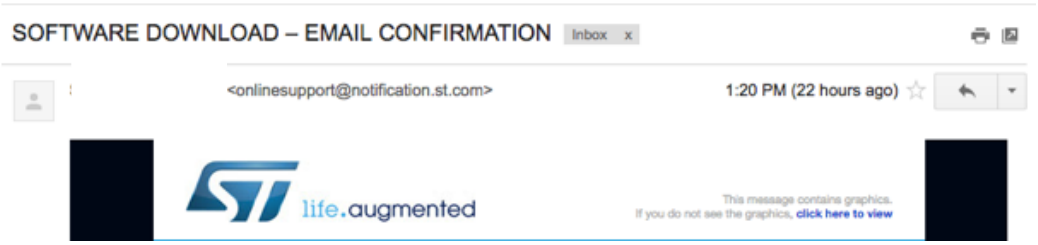

Figure 20: Email from STMicroelectronics containing weblink to enable access to download example project.

7. Extract the contents of the archive. The default output folder name should be **v1.2.0**. For consistency with this tutorial, please extract the archive into the Downloads directory.

   The full path of the directory should resemble the following.

   “C:\Users\<USERNAME>\Downloads\en.stsw-stlkt01\v1.2.0”.

   Note: if the path to the folder labelled **v1.2.0** has a space in it, move it to a location where the path does not contain any spaces.

   The IDE will not be able to compile projects that have spaces in their paths.

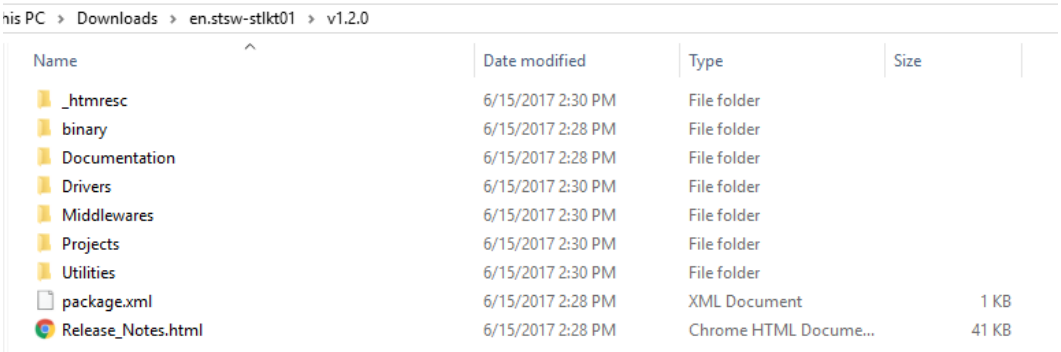

Figure 21: Contents of folder "v1.2.0".

5.2. Import

Follow the instructions below to import the example project into the System WorkBench IDE. Note: while we call this System WorkBench, it will be listed as "Eclipse" on your desktop.

1. Open the System WorkBench application.

2. Use the default workspace directory, and click "Ok". See Figure .

   Note: Ensure that the workspace you select does not contain any spaces. If the path to the workspace contains spaces, the IDE will not be able to compile the projects.

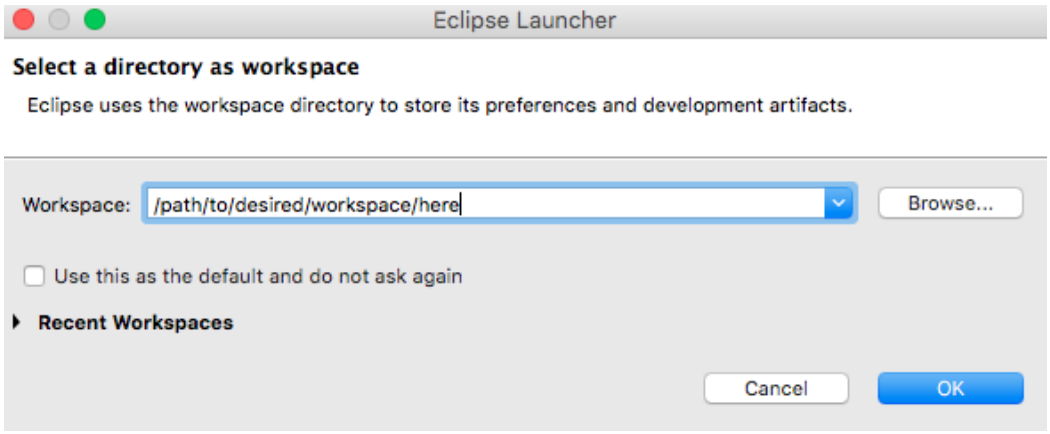

Figure 22: Selecting your workspace directory. It is recommended that you use the default location. It will resemble the form "C:\Users\<USERNAME>\workspace".

3. If you see a welcome screen, close it by clicking the "x" in the top left corner. See Figure .

Figure 23: Closing the welcome splash page.

4. Once you are on the main screen of System WorkBench, click "File > Import …" to begin importing the project. See Figure .

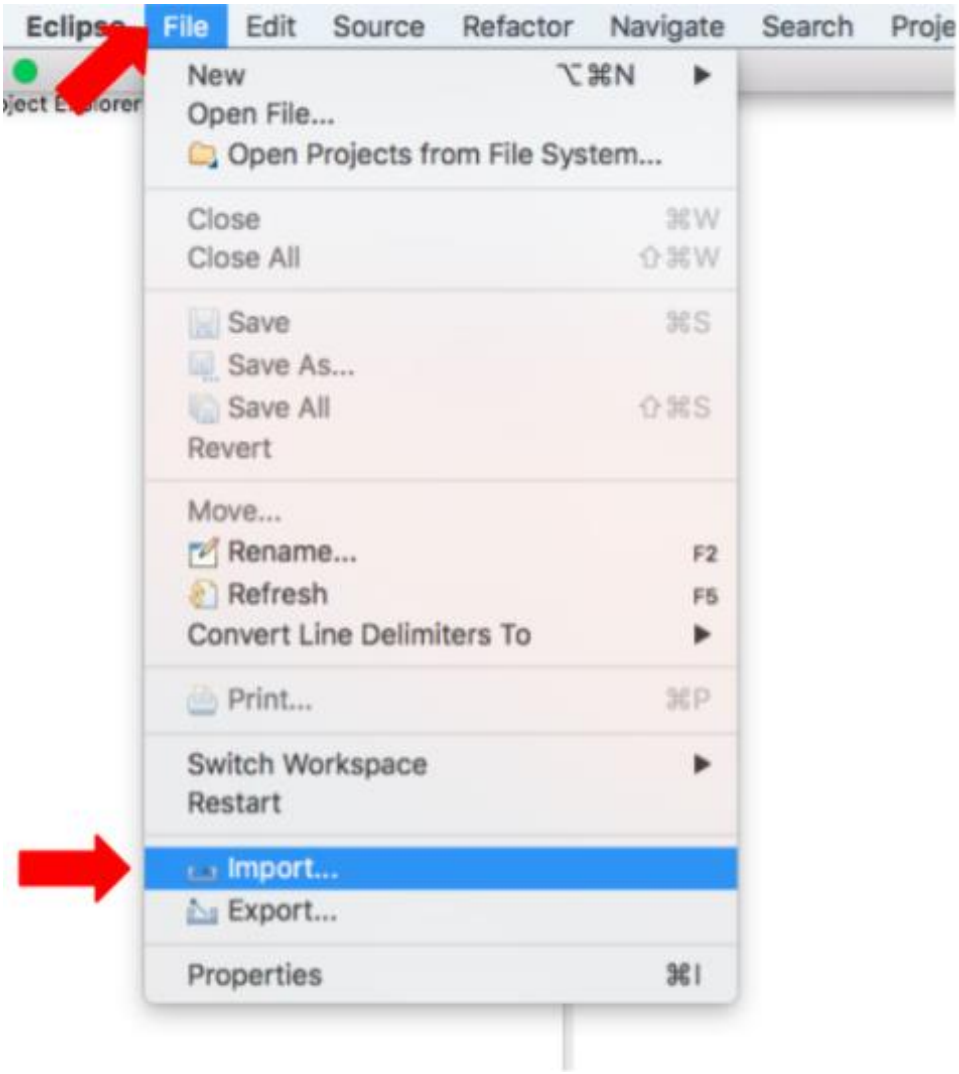

Figure 24: Importing an existing project into the workspace.

5. When the new window popup appears, click double click the entry “General”. See Figure .

6. Double click the “Existing Projects into Workspace” option that appears under “General”. See Figure .

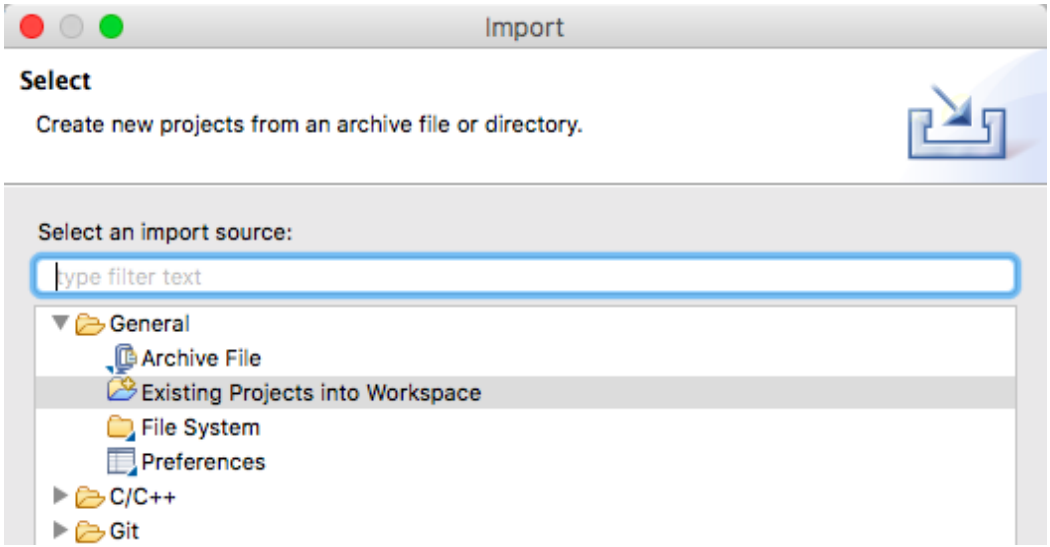

Figure 25: Instructions on the "Select" dialog box.

7. **<u>DO NOT CLICK FINISH UNTIL YOU COMPLETELY READ THROUGH STEP 8</u>**.

   There are three projects in the v1.2.0 folder. If you import more than one project at a time, compilation will fail. This is because the three projects are dependent on other files in the folder.

   On the new popup window, enter the path to the folder **v1.2.0** in the text field "Select root directory". **<u>DO NOT CLICK FINISH</u>**.

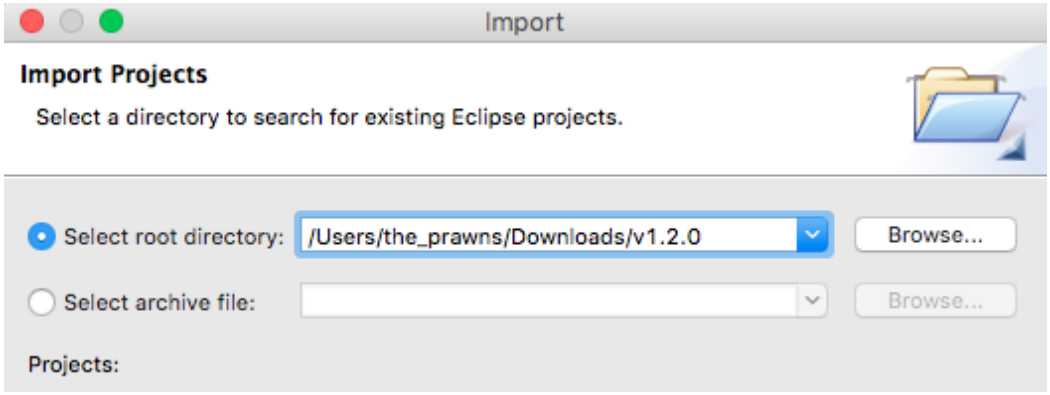

Figure 26: Selecting the folder where the existing project was extracted.

8. The projects box should be populated with 3 projects.
   8.1. AudioLoop (DE-SELECT THIS).
   8.2. BLE_SampleApp (DE-SELECT THIS).
   8.3. DataLog (Keep this selected).

Uncheck the boxes next to AudioLoop and BLE_SampleApp.

Figure 27: Only selecting one project from the existing files to import into the workspace.

If you have selected more than one project and clicked "Finish", you will need to open your workspace directory on the Finder application on your Windows and manually delete all of the files.

```
/SensorTile/Applications/AudioLoop/SW4STM32/STM32L4xx-SensorTile)
/SensorTile/Applications/BLE_SampleApp/SW4STM32/STM32L4xx-SensorTile)
/SensorTile/Applications/DataLog/SW4STM32/STM32L4xx-SensorTile)
```

Figure 28: Close-up image of text from Figure .

Click "Finish" with **only one project** selected.

9. Your screen should resemble the screenshot depicted below.

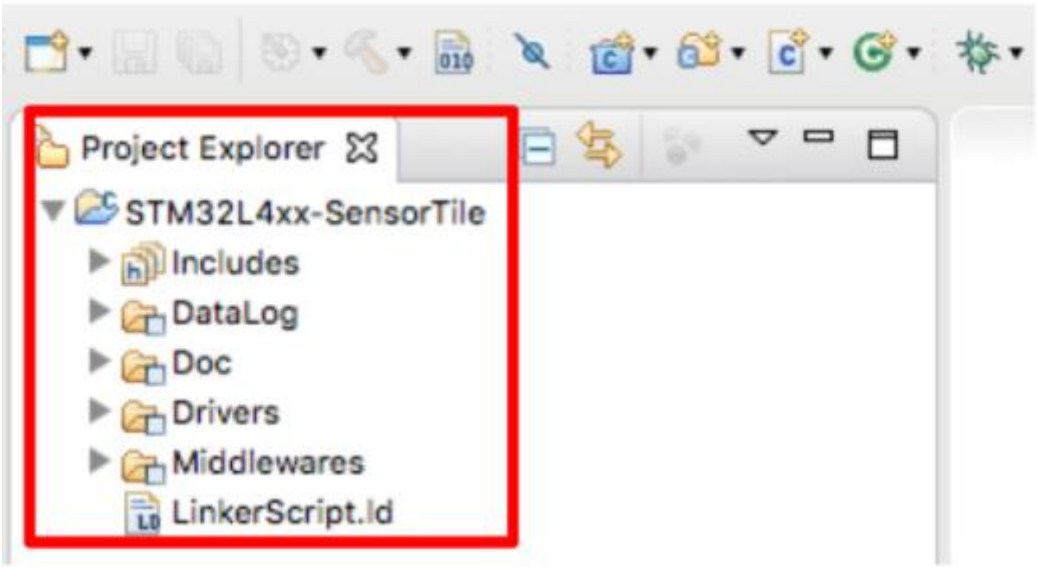

Figure 29: Contents of "Project Explorer" after successfully importing the example project files.

5.3. Build

This portion of the document will guide users through the process of compiling the C-source code into a binary file that can be loaded onto the SensorTile board.

1. Select STM32L4xx-SensorTile -> DataLog in Project Explorer. Then, click Project -> Build Project (see Figure).

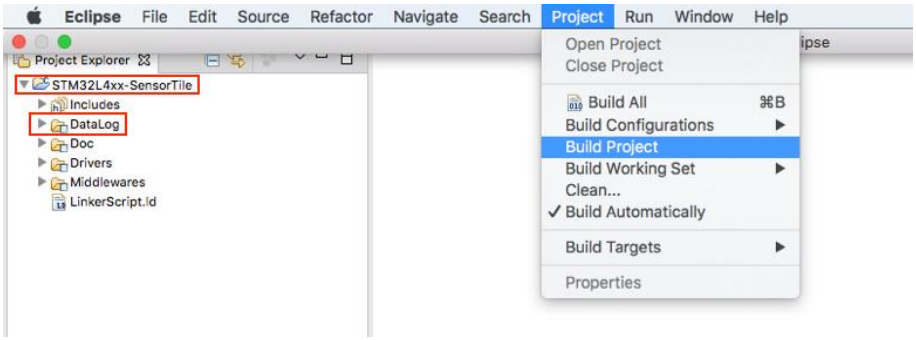

Figure 30: Compiling the source code for the example project.

2. If step 1 completed successfully, a folder named “Release” should appear and contain a **.bin** file. See Figure . Skip to section 5.4 SensorTile Hardware Platform if this file appears.

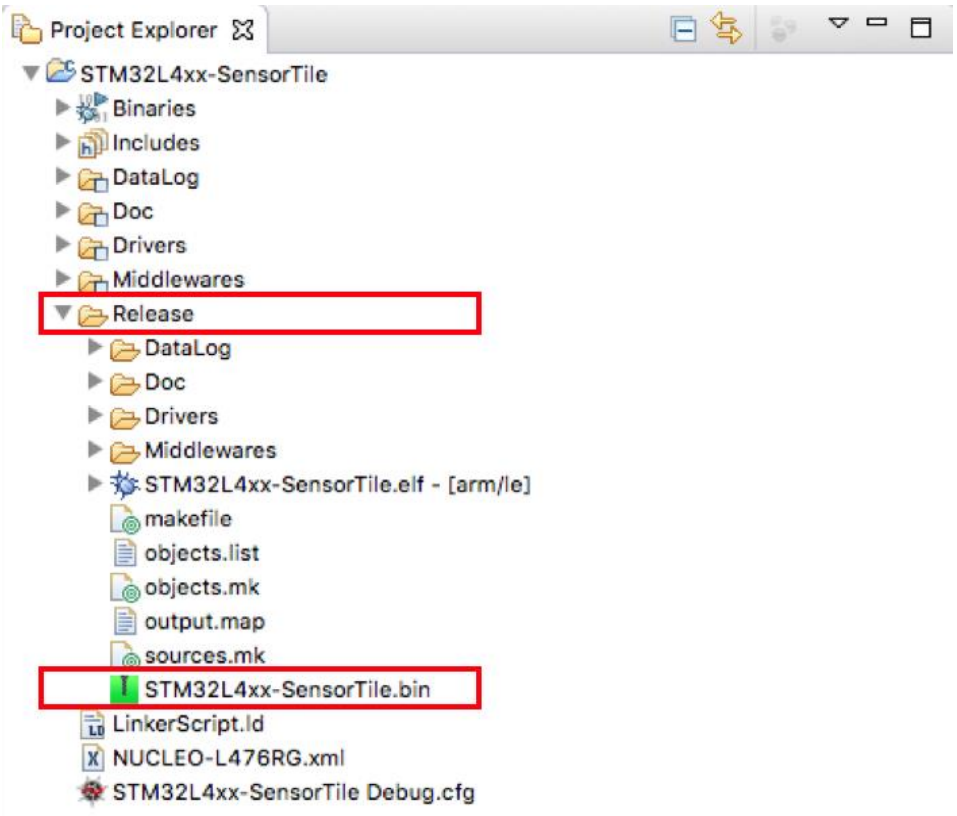

Figure 31: Project directory contents after successful compilation of project source code.

3. If this file did not appear, ensure that none of the paths have a space in their names. If any path has a space, it will cause the make command to fail.

   If any path has a space in it, repeat all installation steps ensuring that the path no longer has a space in it. Then, repeat step 1. If the binary file appears, skip to section 5.4 SensorTile Hardware Platform.

4. Attempt to build the project using Eclipse's internal builder. First, right-click the project, then click "Properties". Navigate to the subheading "C/C++ Build", and change the value of the field "Builder type" to be "Internal builder". See Figure for more details.

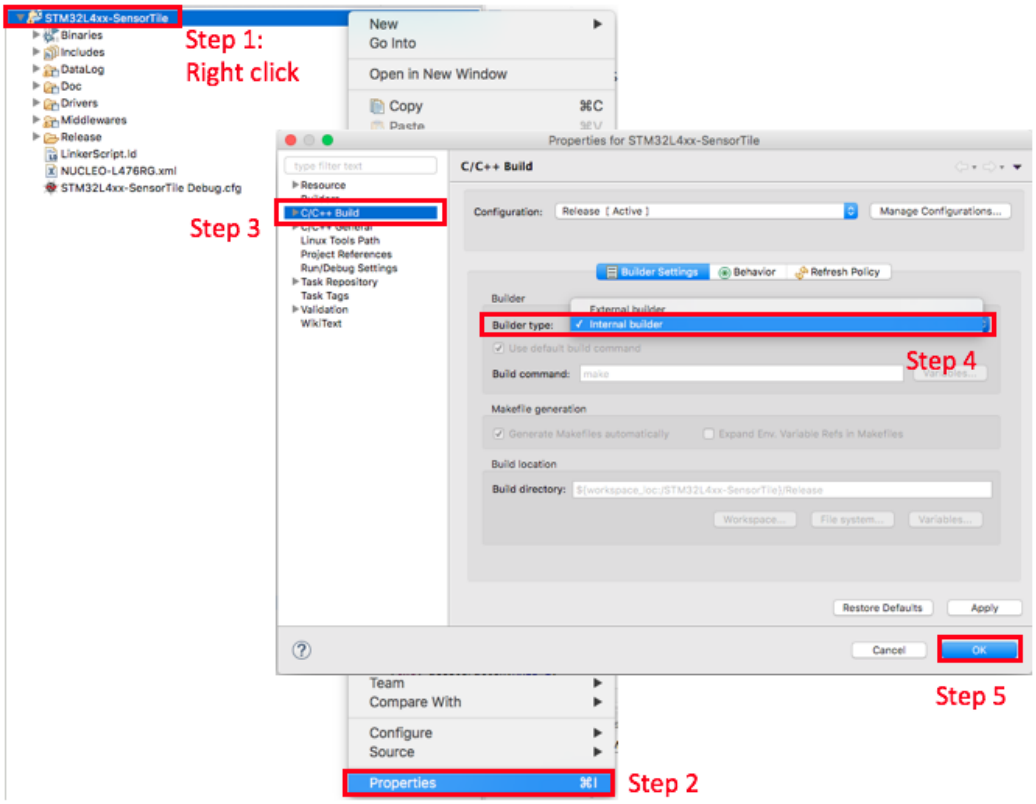

Figure 32: Using the Internal Builder to compile the project.

5.4. SensorTile Hardware Platform

This section describes how to configure the hardware. Be very careful in this section, if the wire connections are not configured correctly, the boards could be permanently damaged. Do not proceed with the tutorial until an instructor has verified that your board is correctly configured.

1. Remove the Nucleo - L476RG board from its packaging.

2. Remove the CN2 Jumpers. (Remove both of them). See Figure 5.

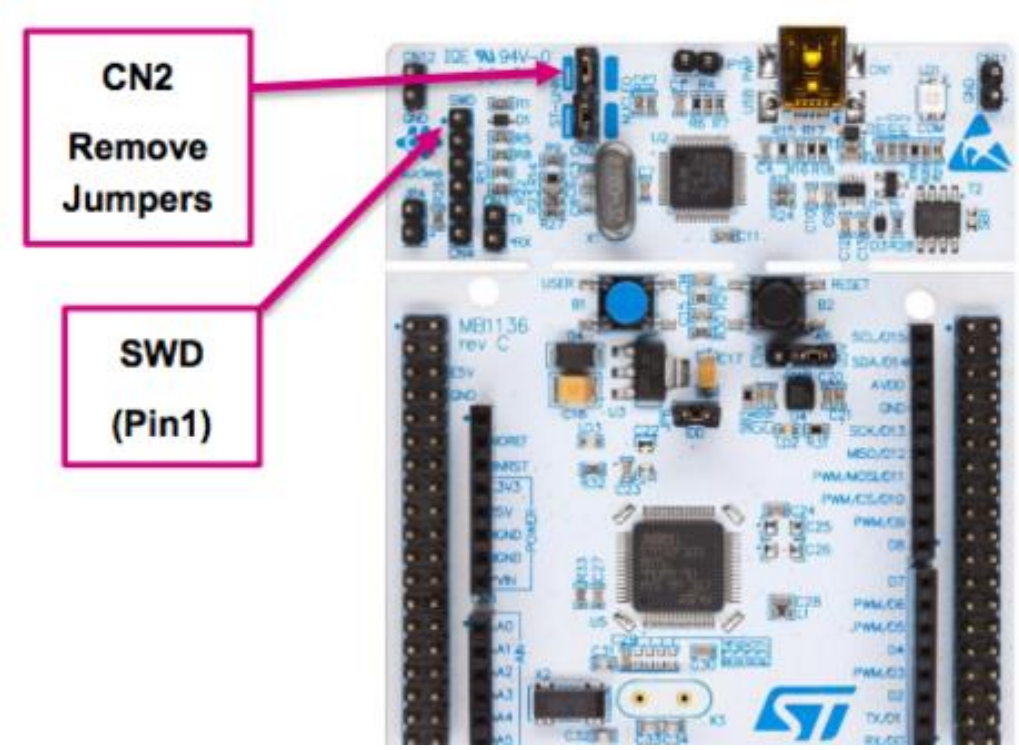

Figure 5: Removing the CN2 Jumpers from the Nucleo-L47RG board.

3. Place the SensorTile on the larger evaluation board. Ensure the orientation of the SensorTile matches Figure 6.

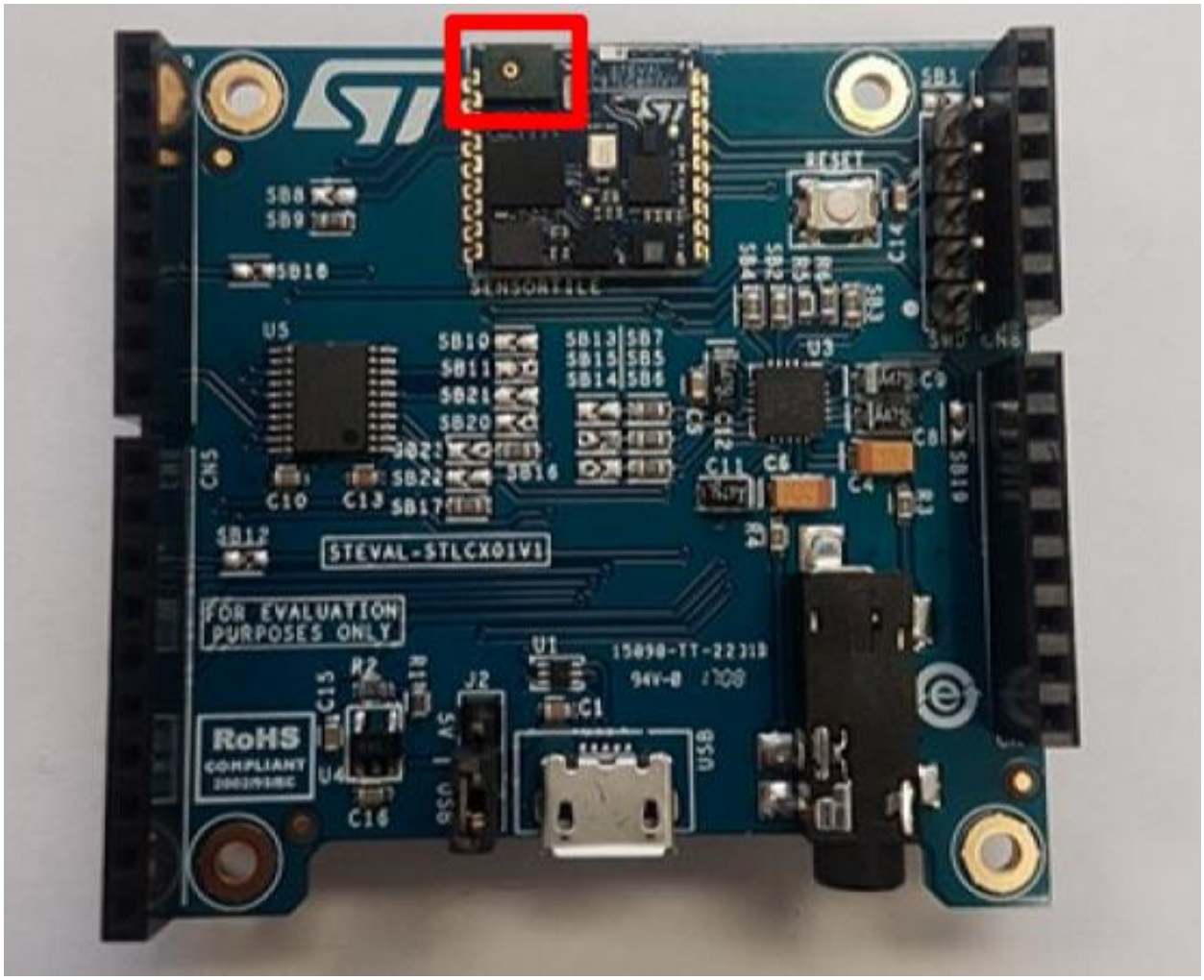

Figure 6: Ensure the orientation of the SensorTile on the larger evaluation board matches this figure. There should be a green protrusion with a little metalic hole right next to the ST logo.

4. Connect the boards by attaching an SWD connector from the Nucleo board to the SensorTile board. Be **very** careful in this step. Please examine the figures Figure 7 - Figure 8. Do not proceed with this tutorial until you have verified with an instructor that the hardware is correctly configured.

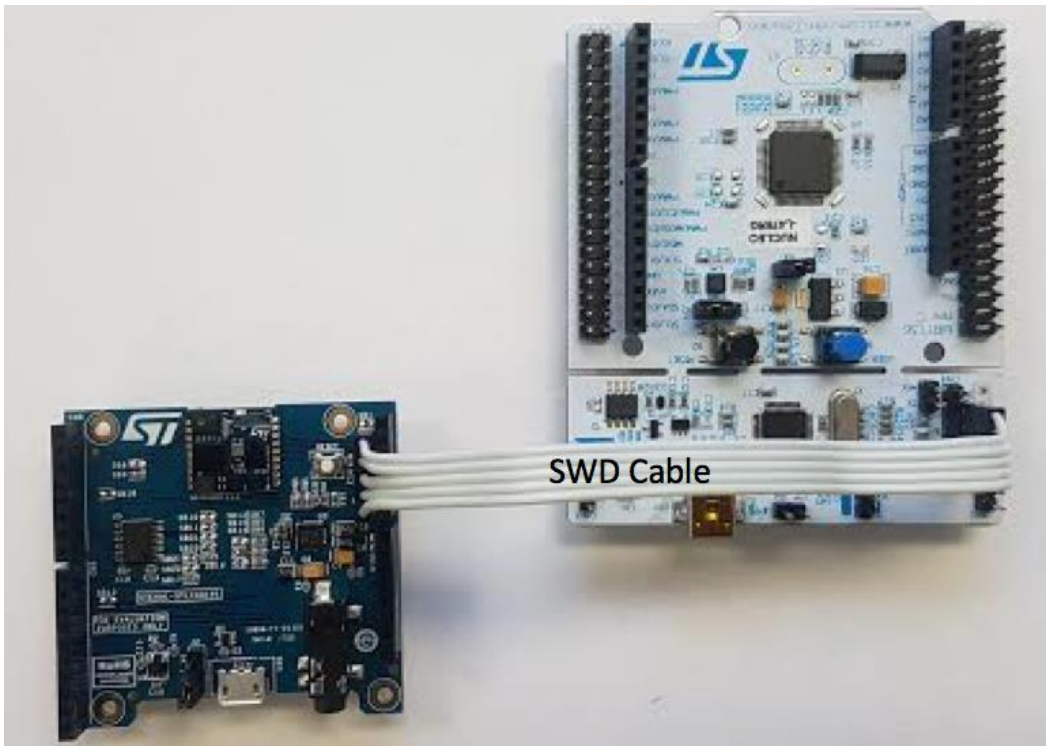

Figure 7: First figure depicting correct hardware configuration. Ensure that the SWD cable is oriented such that the pins marked "SWD" are connected via the same wire.

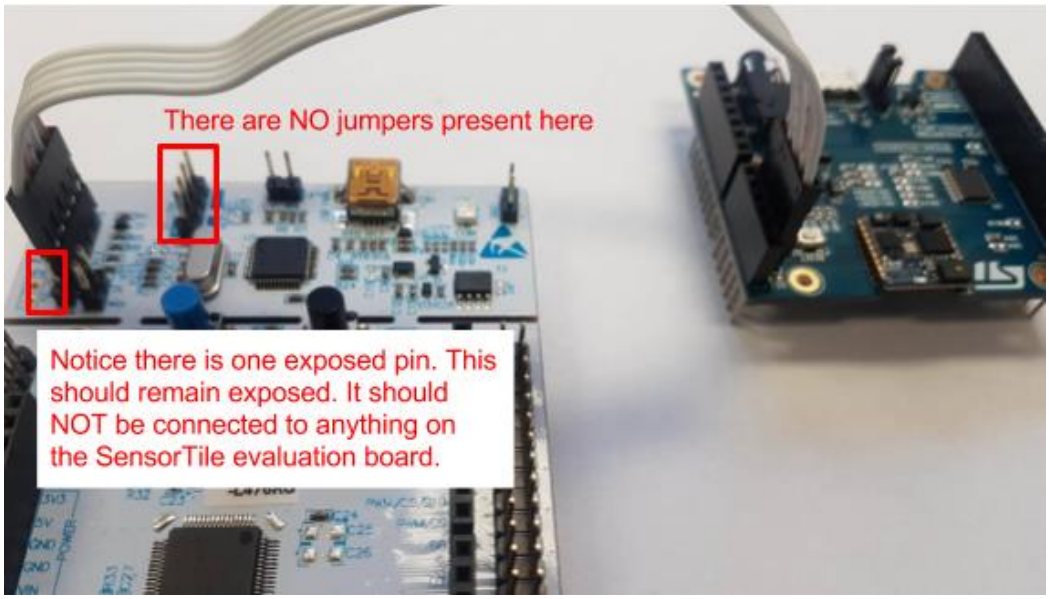

Figure 8: Second figure depicting correct hardware configuration.

5.5. Debug

This section will guide users through the process of running the **DataLog** application in debug mode on the SensorTile board.

1. Attach a mini-USB cable from the **Nucleo** to your PC. Attach a micro-USB cable from the **SensorTile** to your PC. See *Figure* .

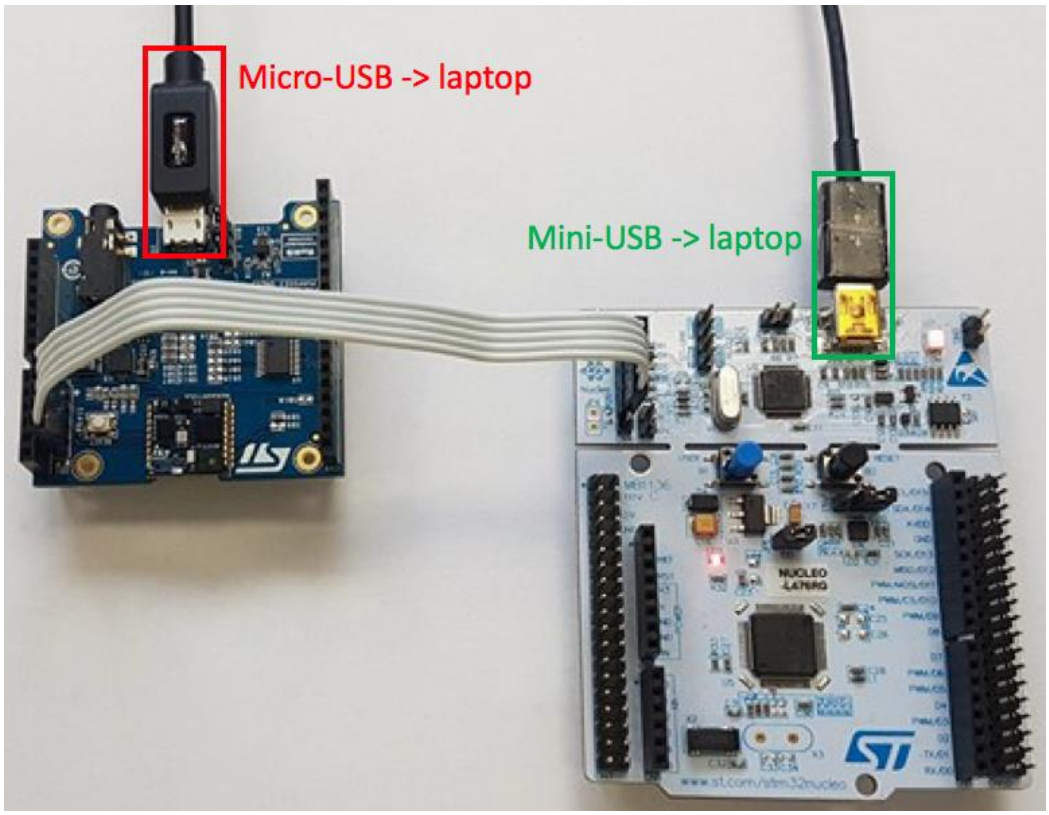

Figure 37: Establish a USB-wireline connection between each board and your PC.

2. Select the project folder, “STM32L4xx-SensorTile”, in Project Explorer. Then, click “Run -> Debug As -> AC6 STM32 C/C++ Application”. See *Figure* in the next page.

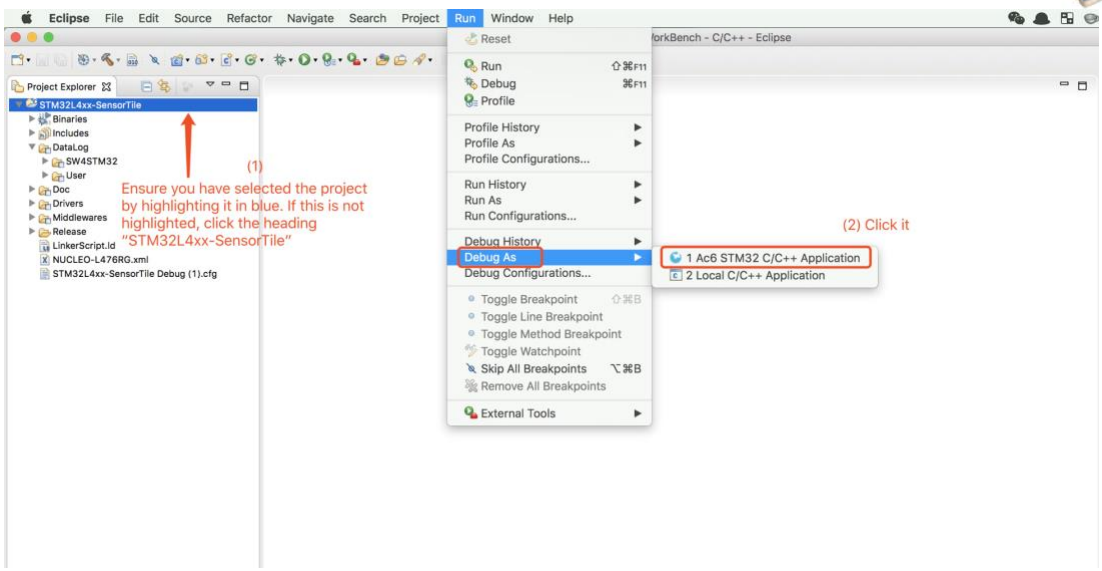

Figure 38: Launching the DataLog program in debug mode.

3. A dialog box may appear. Click “Yes” on this dialog box.

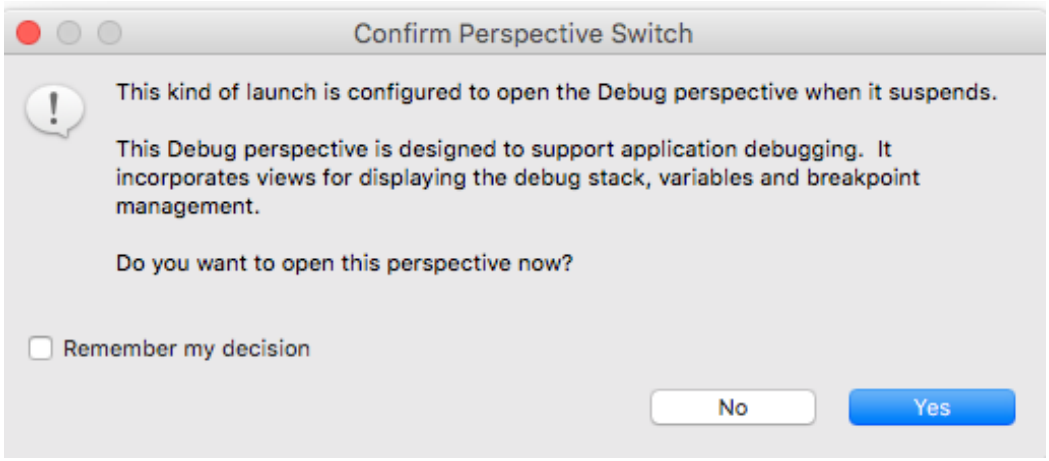

Figure 39: Click "Yes" on this dialog box.

4. A debugging interface should appear *Figure*.

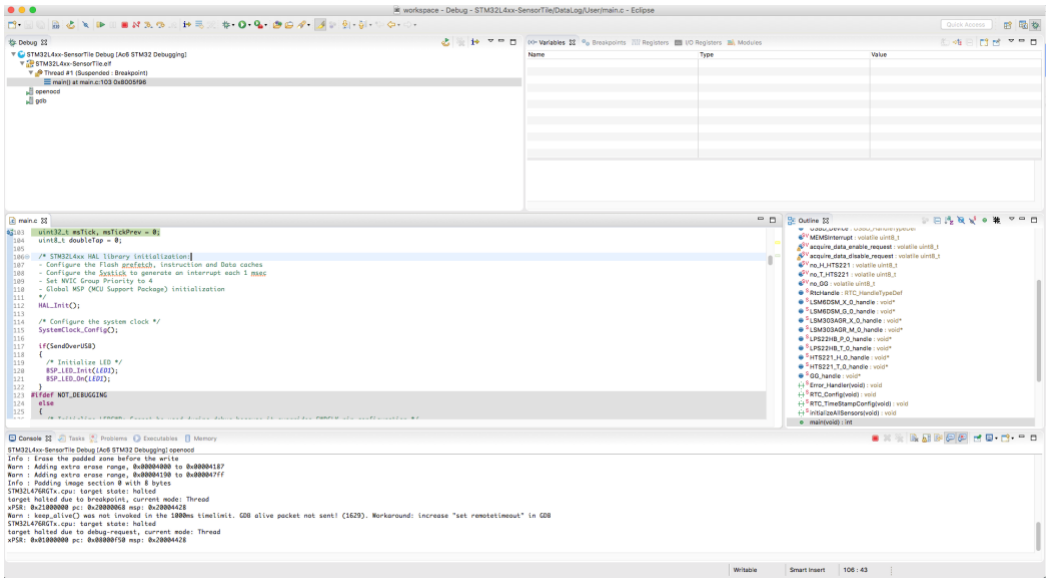

Figure 40: Debugging interface.

If you wish to switch back to the C/C++ view, click the top right corner button labeled “C/C++”. See *Figure* .

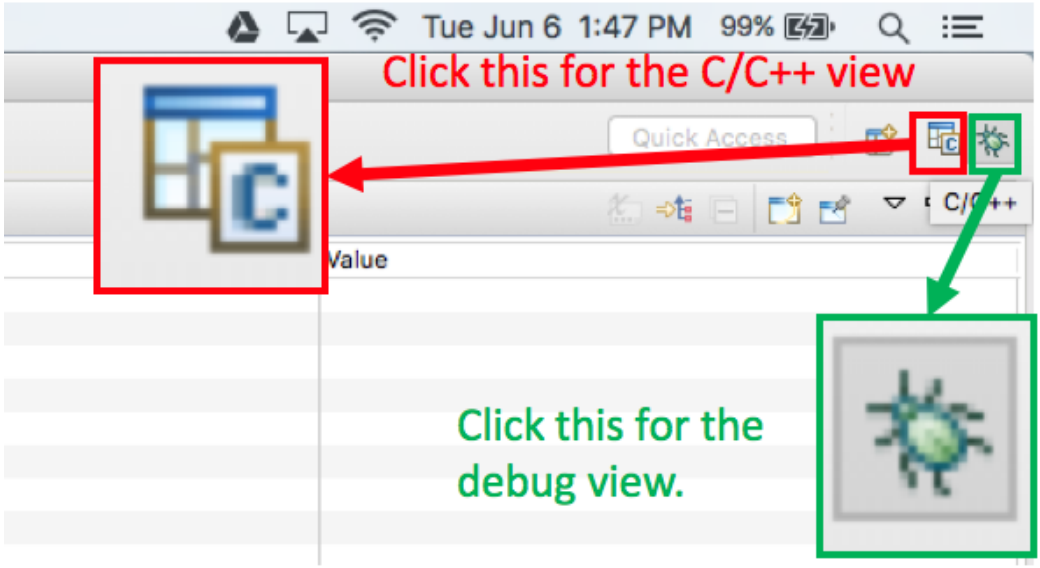

Figure 41: To enter the "C/C++" view, click the button highlighted in the red box. To enter the "debug mode" view, click the button highlighted in the green box.

5. Examine your SensorTile device. Notice how none of the LED’s are activated.

6. Press the “green arrow with the yellow bar on its left” button that indicates “Resume” when you mouse over it. See *Figure* .

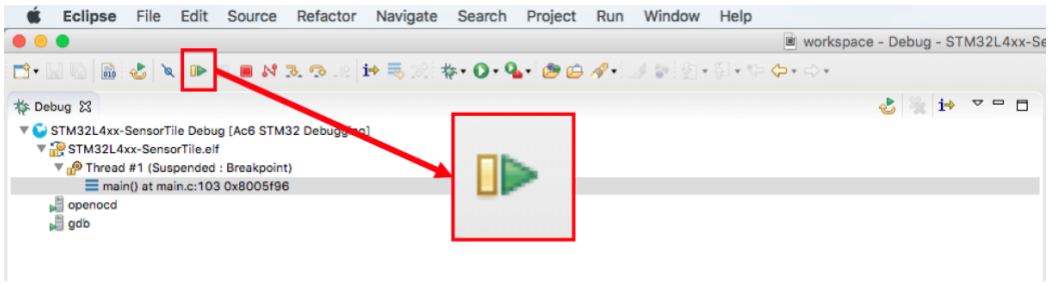

Figure 42: Starting the application in debug mode.

7. Examine your SensorTile device. Notice how the orange LED is rapidly blinking.

8. Find the COM port assigned to the SensorTile board by opening the device manager. For more information on how to open the device manager, please follow the weblink below.

   https://support.microsoft.com/en-us/instantanswers/005a1acb-776e-4320-b9f2-3a2302a320da/open-device-manager

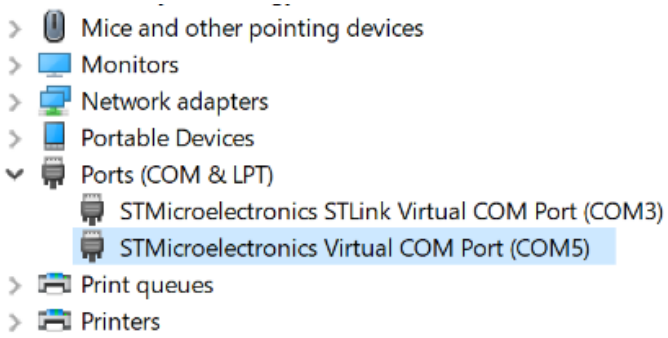

Figure 43: Inspecting the devices connected via USB.

   Notice how there are two devices listed.

   The device listed as “STLink Virtual COM port” is the Nucleo board.

   The device highlighted in blue and listed as “STMicroelectronics Virtual COM Port” is the SensorTile.

   Note: The device will not be detected by the Device Manager until the program is running. So ensure that you have performed step 6 if you do not see your device.

9. Inspect the data the SensorTile is sending over serial wireline USB connection opening PuTTy and entering the information as shown in *Figure* . Make sure this command is edited to suit the COM port of the device as it appears in your device manager. The output should resemble *Figure* .

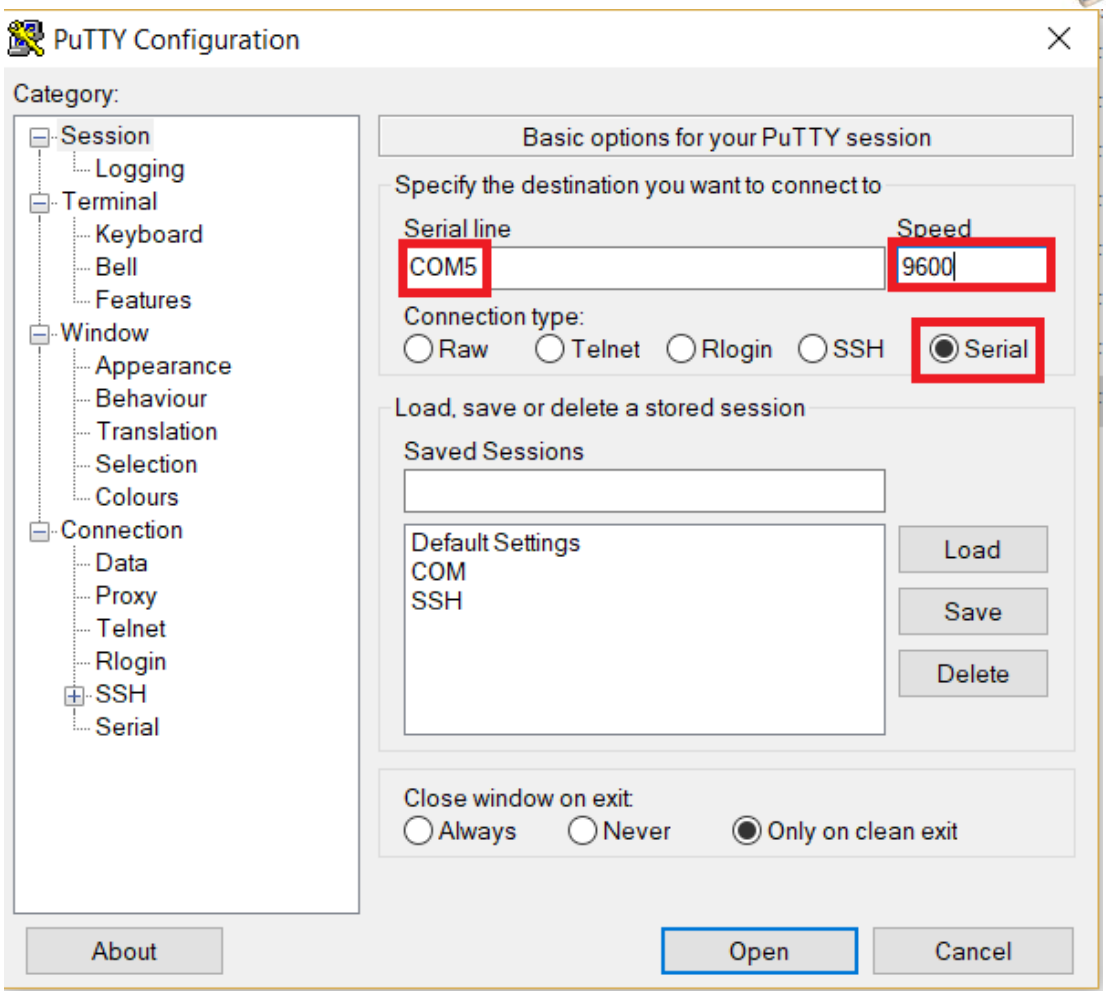

Figure 44: Examining the output from the SensorTile. Ensure that COM5 is replaced with the relevant COM port found from Figure . Ensure that the Speed is set to 9600. If you do not see these two fields in PuTTy, ensure that the Connection Type has been set to Serial.

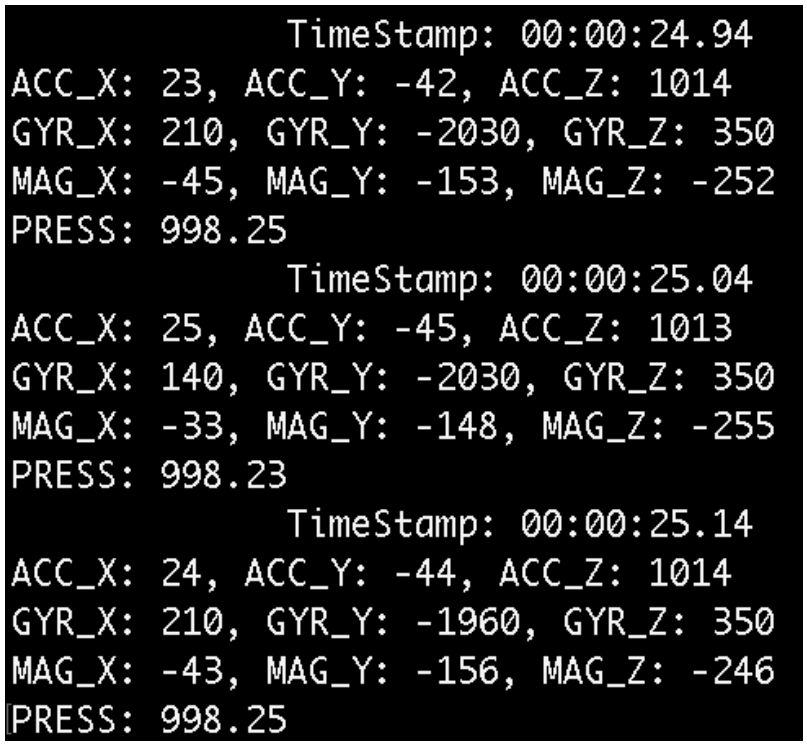

Figure 45: Data being captured by the SensorTile.

5.6. Flash

This section will guide users through the process of uploading a compiled binary file onto the SensorTile for execution. Once the program is uploaded to the board, it will run every time the SensorTile is supplied with power. The SensorTile will no longer need to be connected to the Nucleo board, nor will users have to interface with System WorkBench (the IDE).

1. Terminate and remove all existing applications on the SensorTile board as shown in *Figure* .

   Note: Ensure to remove ALL existing applications. Figure only contains one application. If there are more, delete all of them.

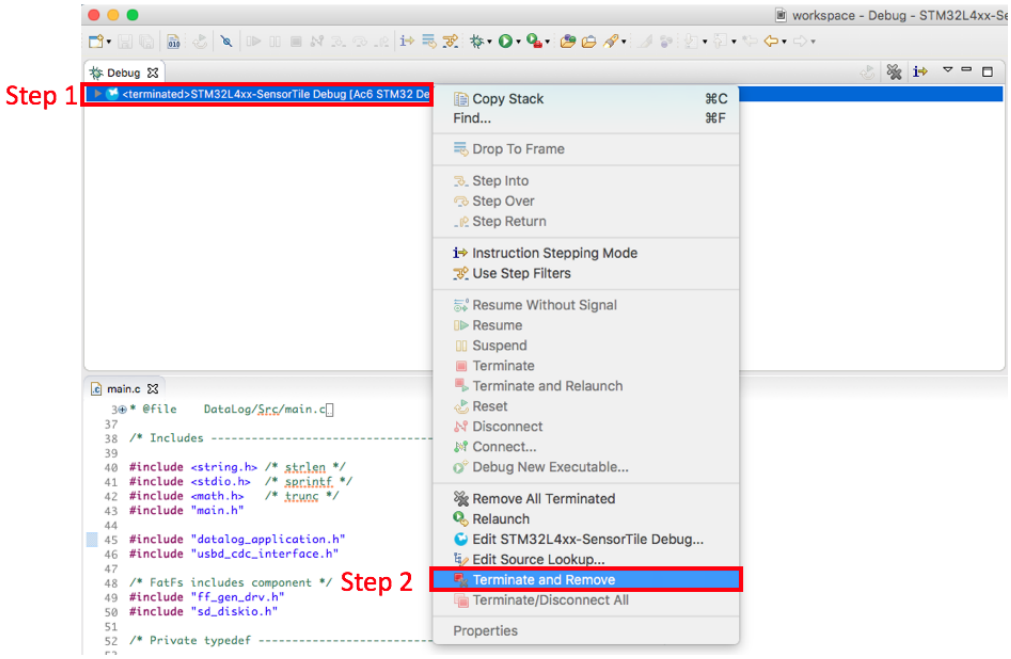

Figure 46: Terminating and removing existing applications on the SensorTile board.

2. Open the ST-LINK utility you downloaded at the start of this tutorial. There should be an icon on your desktop for this.

Figure 47: ST-LINK Utility Desktop Shortcut Icon.

3. A new window should appear.

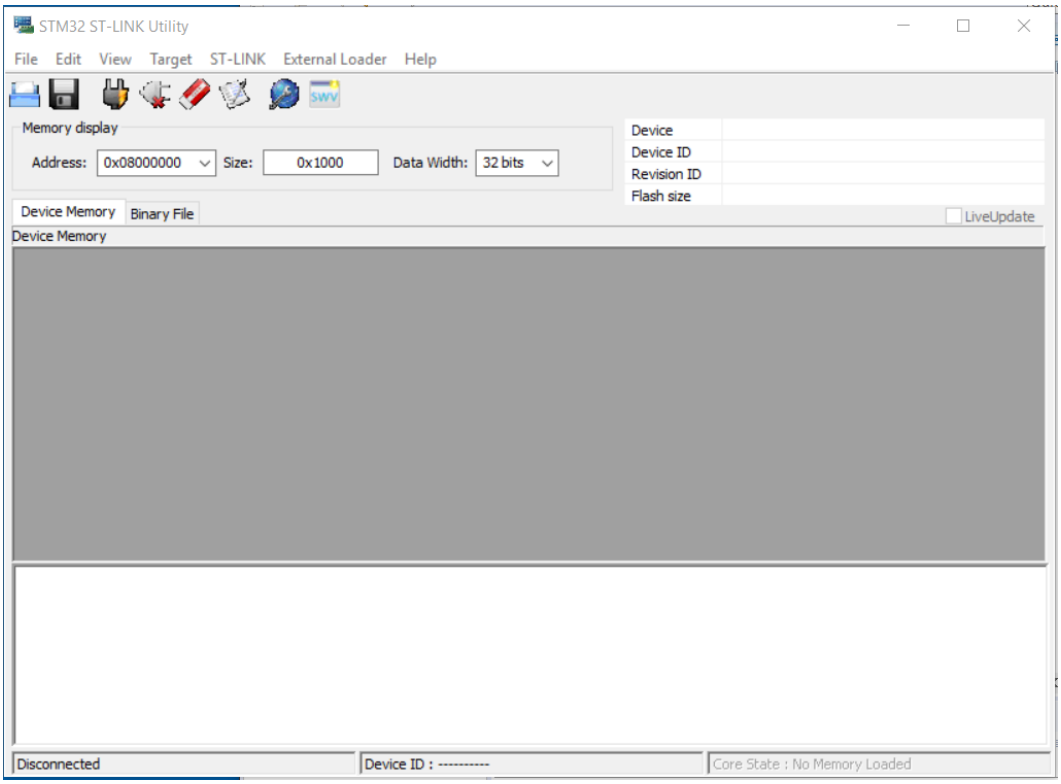

Figure 48: The ST-LINK Utility Window.

4. Click File > Open Files. A file browsing window should appear.

5. Navigate to the folder where you extracted the Example project source code.

6. Navigate to the following directory.

   …\v1.2.0\Projects\SensorTile\Applications\DataLog\SW4STM32\STM32L4xx-SensorTile\Release

7. Click the file labelled **STM32l4xx-SensorTile.bin**. Click the “open” button.

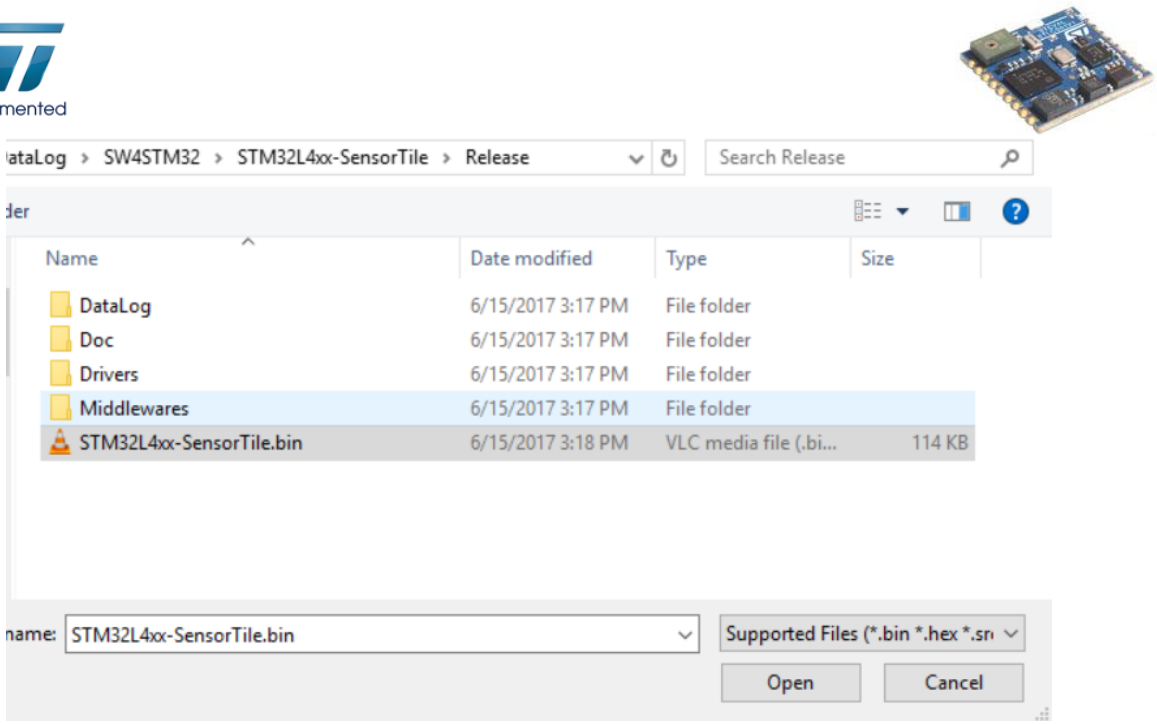

Figure 49: Opening the compiled binary file.

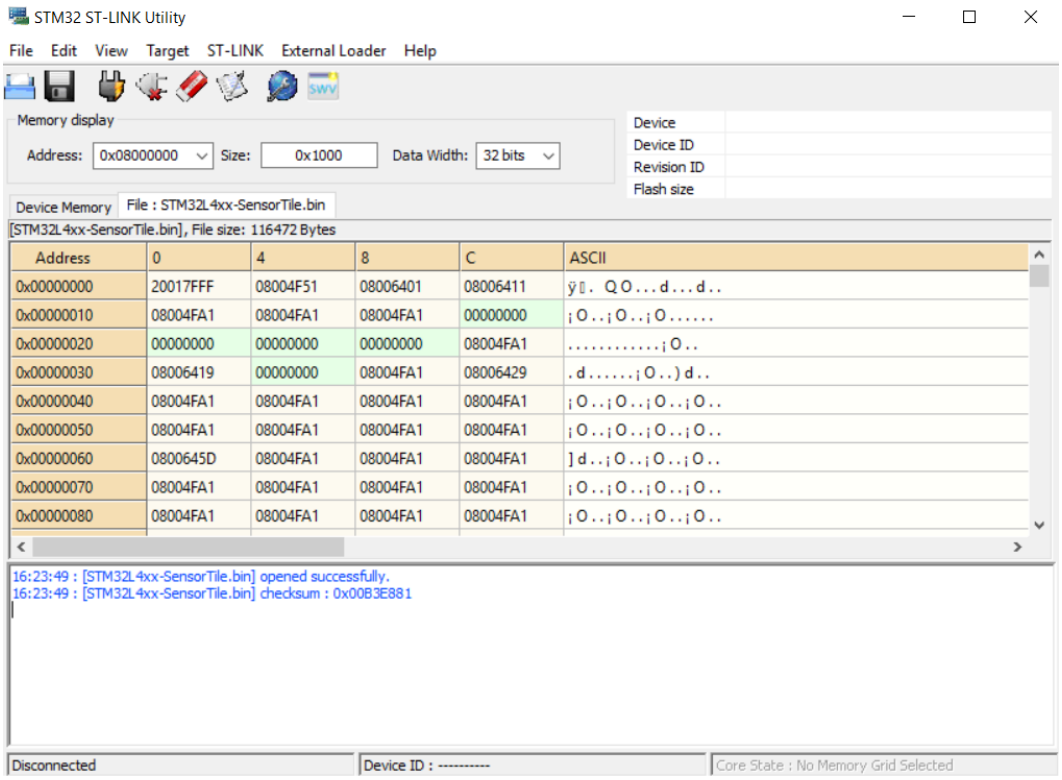

Figure 50: How the ST-LINK window should appear after clicking open.

8. Change the value of the “Address” field to be 0x08004000.

9. Change the value of the “Size” field to be 0x1000.

10. Your window should match

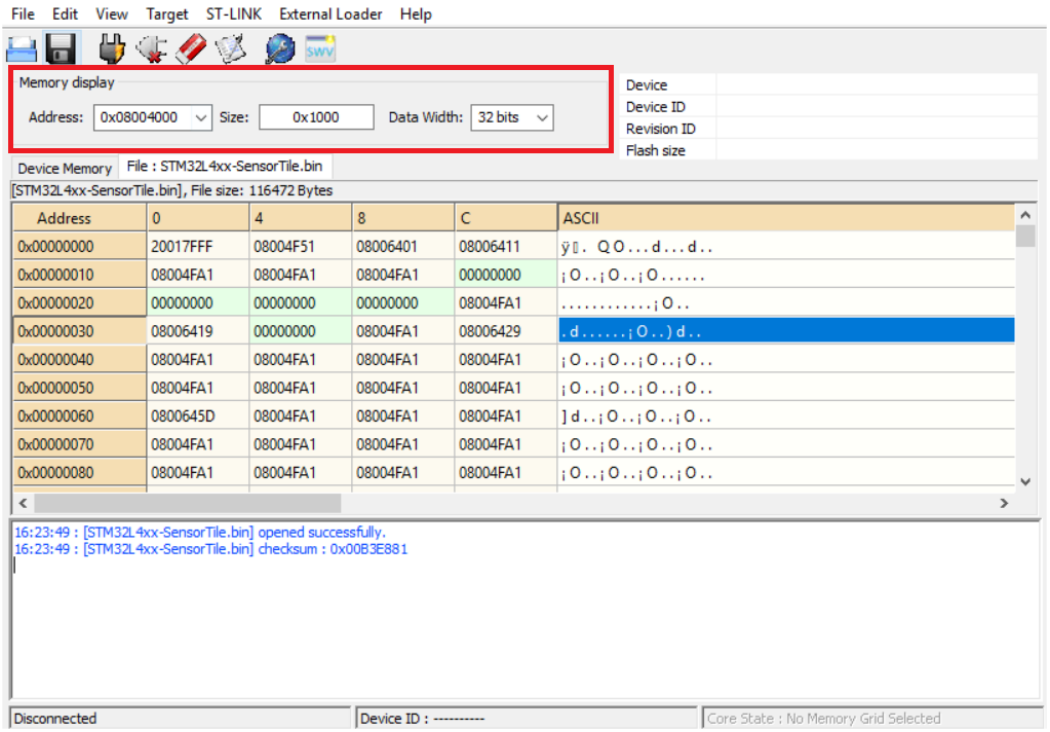

Figure 51: Updated value of Address and Size.

11. Click Target > Connect.

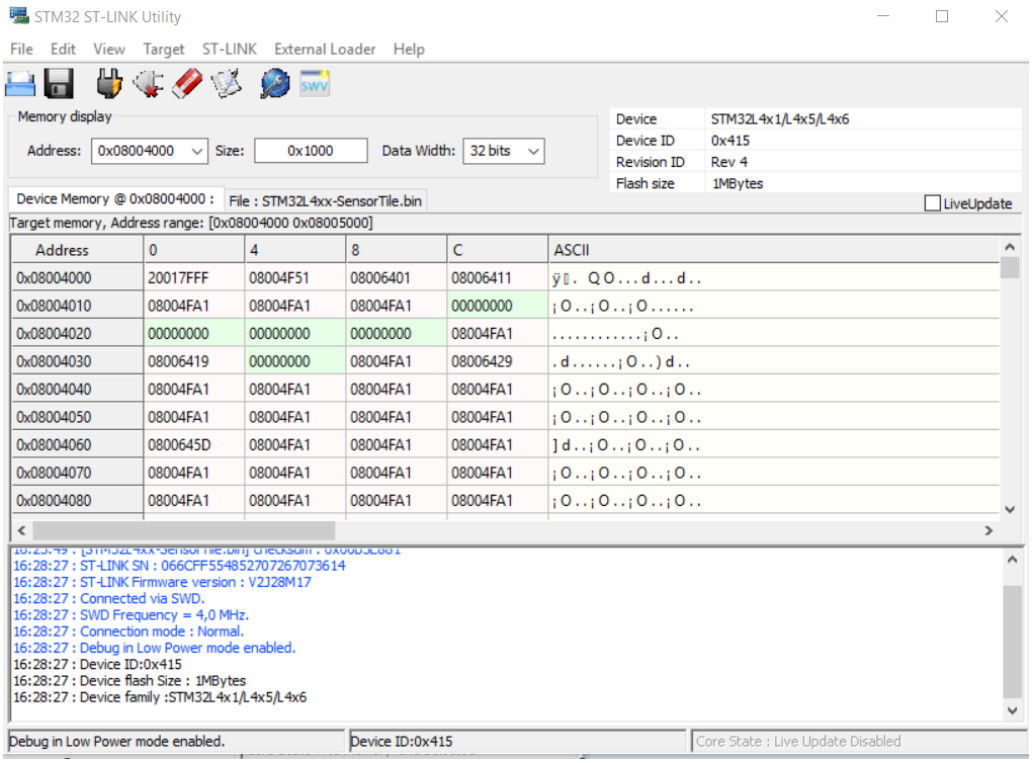

Figure 52: Window after clicking "Target > Connect".

12. Click Target > Program. Modify "Start Address" to be 0x08004000.

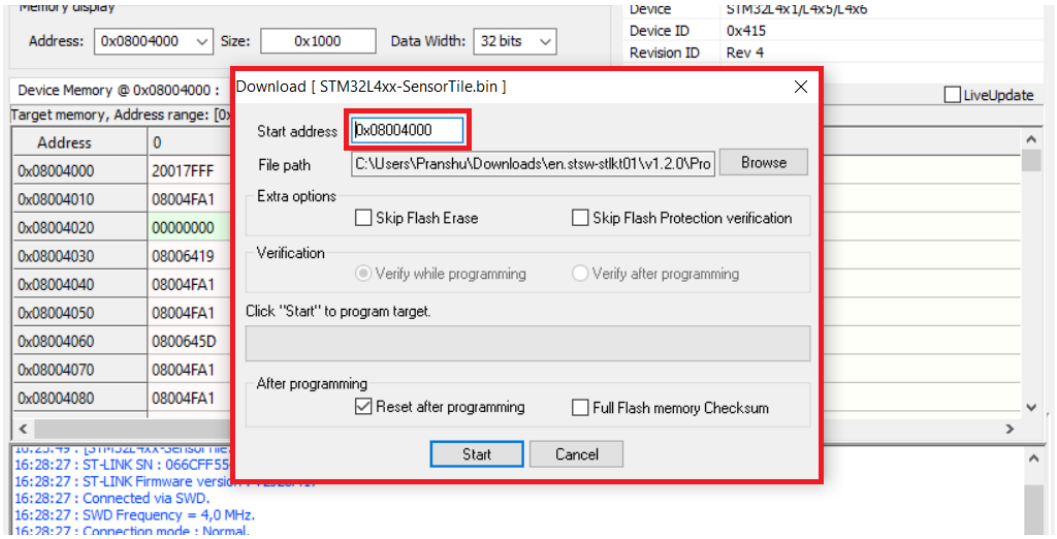

Figure 53: Target > Program window after modifying "Start Address".

13. Click Start.

14. Click File > Close File.

15. Click File > Open File.

16. Navigate to the folder where you extracted the Example project source code.

17. Navigate to the following directory.

    …\v1.2.0\Utilities\BootLoader\STM32L476RG

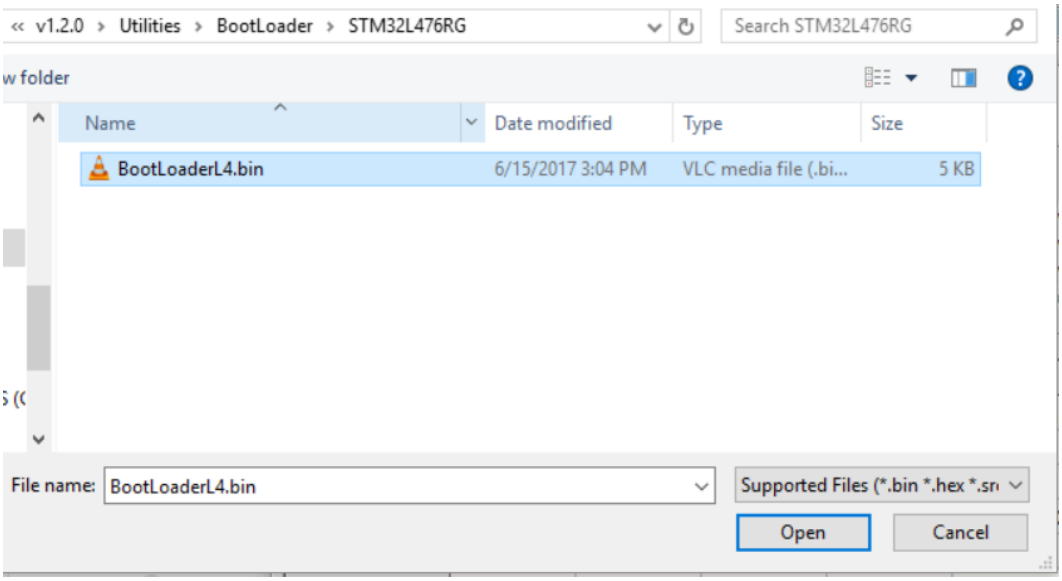

Figure 54: Opening the BootLoader file.

18. Click the file labelled “BootLoaderL4.bin” (also highlighted in *Figure*) and click Open.

19. Change the Address field to be 0x08000000.

20. Click Target > Program.

21. Change the start address to be 0x08000000.

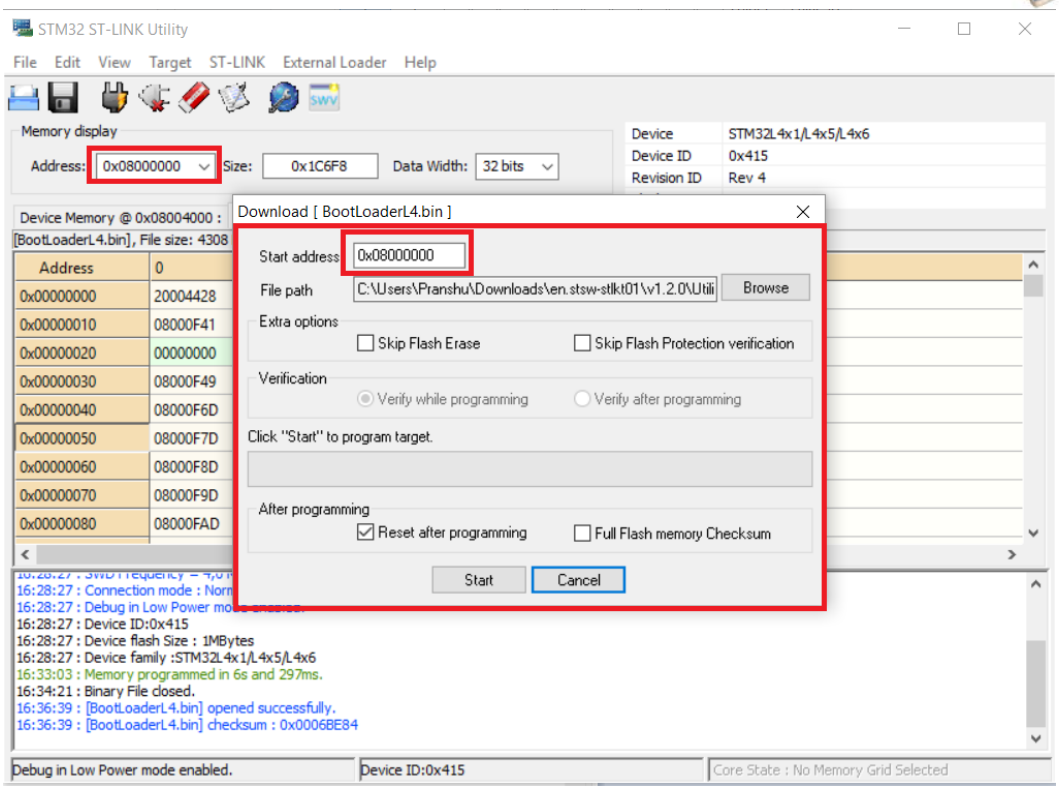

Figure 55: Updating the BootLoader.

22. Click start.

23. Disconnect the USB cables connecting the SensorTile and the Nucleo boards to your PC. This will power down the devices, enabling us to safely disconnect the SWD connection between the SensorTile board and the Nucleo board.

24. Disconnect the SWD cable connecting the SensorTile board to the Nucleo board.

25. Reconnect SensorTile board to your Windows. Do not reconnect the Nucleo board to your PC.

26. Notice that the SensorTile device immediately starts streaming data over serial USB connection to your PC by examining the blinking LED.

27. Examine the data transmitted from the SensorTile by Repeat step 9 from 5.5 Debug.

28. You will now observe complete system operation with a stand-alone, automatically operating SensorTile IoT system.