

TrueSTUDIO®

User Guide



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ABOUT THIS DOCUMENT

Welcome to the **Atollic TrueSTUDIO® for STM32** User Guide. The purpose of this document is to provide information on how to use **Atollic TrueSTUDIO®**.

INTENDED READERS

This document is primarily intended for users of **Atollic TrueSTUDIO®**.



Please note that this manual applies to users of STM32 target devices only.

DOCUMENT CONVENTIONS

The text in this document is formatted to ease understanding and provide clear and structured information on the topics covered. The following typographic conventions apply:

Style	Use
Command	Keyboard Command or Source Code Section.
Object Name	Name of a User Interface Object (Menu, Menu Command, Button, Dialog Box, etc.) that appears on the computer screen.
<i>Cross Reference</i>	Cross reference within the document, or to an external document.
Product Name	Name of Atollic product.
	Identifies instructions specific to the Graphical User Interface (GUI).
	Identifies instructions specific to the Command Line Interface (CLI).
	Identifies Help Tips and Hints.
	Identifies a Caution.

Table 1 – Typographic Conventions



Section 1. **GETTING STARTED**

This section provides information on how to begin using **Atollic TrueSTUDIO® for STM32**.

The following topics are covered:

- Introduction
- Preparing for Start
- Starting the Program
- Creating a New Project
- Configuring the Project
- Building the Project
- Debugging

INTRODUCTION

Welcome to **Atollic® TrueSTUDIO® for STM32**. The product is available for free. Advanced functionality which earlier required a license is now fully enabled directly after installation.

TrueSTUDIO has the following key features:

- Built on Open Standards (Eclipse, CDT, GCC, and GDB)
- Edit, Compile & Build (No code size limitation)
- Project Management
 - STM32 MCUs and Board support
 - CMSIS-Pack project support
 - Build/Memory Analyzer
 - Stack Analyzer
 - Bug Tracking
 - Version Control
- Debug
 - Hard Fault Analyzer
 - Live Variable Watch
 - Trace (SWV, ETM, ETB, MTB)
 - Statistical Profiling
 - RTOS-aware Debug
 - Multi Project Debug

PREPARING FOR START

Atollic TrueSTUDIO is built using the ECLIPSE™ framework, and thus inherits some characteristics that may be unfamiliar to new users. The following sections outline important information to users without previous experience of ECLIPSE™.

WORKSPACES & PROJECTS

As **Atollic TrueSTUDIO** is built using the ECLIPSE™ framework, the ECLIPSE™ project and workspace model applies. The basic concept is outlined below:

- A workspace contains projects. Technically, a workspace is a directory containing project directories or references to them.
- A project contains files. Technically, a project is a directory containing files that may be organized in sub-directories.
- A single computer may hold several workspaces at various locations in the file system. Each workspace may contain many projects.
- The user may switch between workspaces, but only one workspace can be active at any one time.
- The user may access any project within the active workspace. Projects located in another workspace cannot be accessed, unless the user switches to that workspace.
- Switching workspace is a quick way of shifting from one set of projects to another set of projects. It will trigger a quick restart of the product.

In practice, the project and workspace model facilitates a well-structured hierarchy of workspaces, containing projects, containing files.

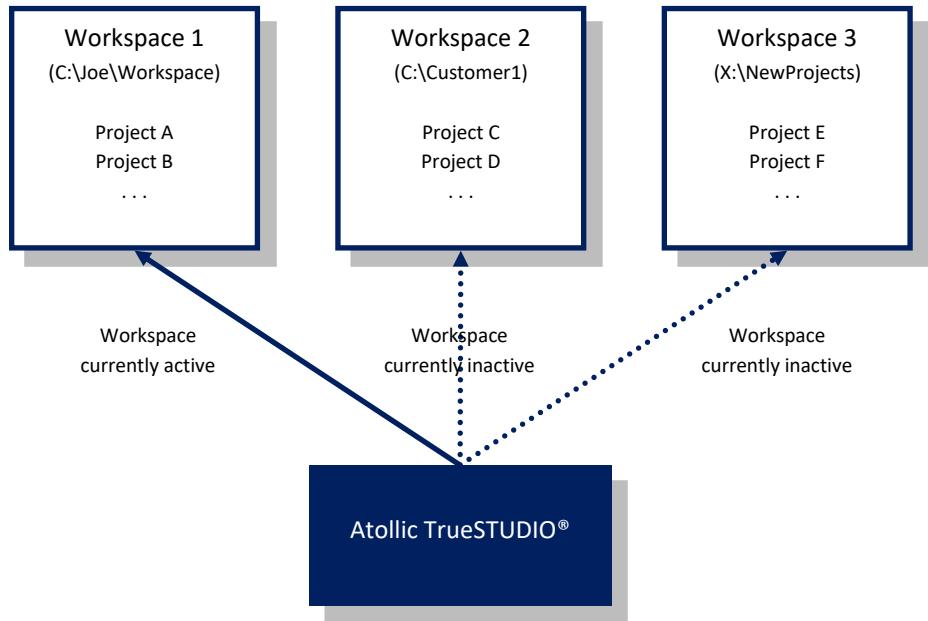


Figure 1 - Workspaces and Projects

PERSPECTIVES & VIEWS

Atollic TrueSTUDIO is a very powerful product with a great many views, loaded with various features. Displaying all views simultaneously would overload the user with information that may not be relevant to the task at hand.

To overcome this problem, views can be organized in perspectives, where a perspective contains a number of predefined views. A perspective typically handles one development task, such as:

- C/C++ Code Editing
- Debugging
- Bug Database Access
- Version Control
- Code Review

As an example, the **C/C++ Editing** perspective displays views that relate to code editing, such as Editor Outline and Class Browser. The **Debug** perspective displays views that relate to Debugging, such as Breakpoints and CPU Registers.

Switching from one perspective to another is a quick way to hide some views and display others.

Atollic TrueSTUDIO comes with a number of pre-configured perspectives. Developers may modify these, or create entirely new, at will. **Atollic TrueSTUDIO** is designed around a philosophy that one perspective shall be used for one task, and that a perspective should not contain a lot of GUI objects from other perspectives.

As the figure below outlines, the idea is that one perspective shall be used for each work task. It is however clear that one perspective, the **C/C++ editing** perspective is the “master” perspective where developers spend most time. Therefor that perspective is the center-point of **Atollic TrueSTUDIO**, and developers temporarily jump to other perspectives to do other tasks, and when completed, jump back to the editing and building perspective again.

The C/C++ Editing perspective is also the perspective that is opened when **Atollic TrueSTUDIO** is started the first time.

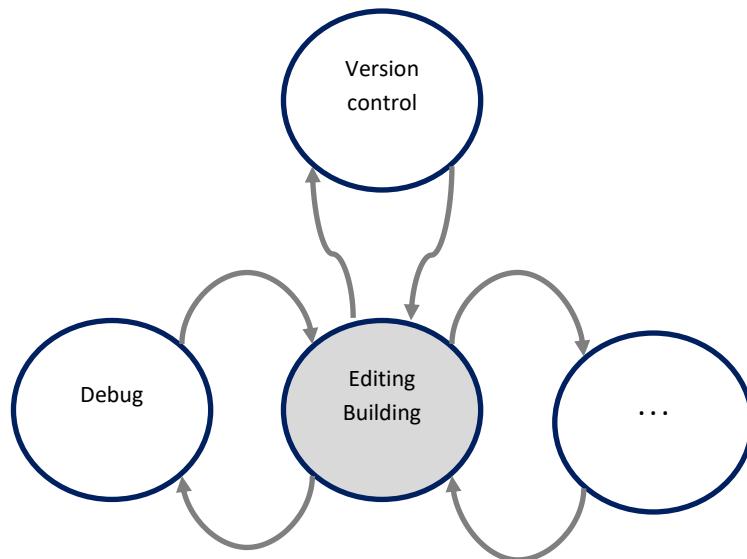


Figure 2 – Editing Perspective

We think it is valuable to use the editing and building perspective as the master perspective, and all other perspectives used temporarily for other work tasks.

To switch perspective, select the **Open Perspective** toolbar button or use the menu command **View, Open Perspective**:

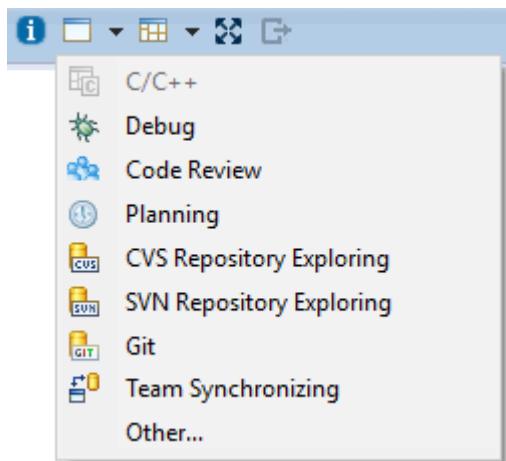


Figure 3 - Switch Perspective

Alternatively, click any of the perspective buttons in the top right corner of the main window (only the last few ones active are displayed here):



Figure 4 - Switch Perspective

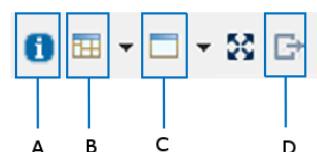


Figure 5 – Toolbar Buttons for Perspectives and Views

One can always return to the default **C/C++ Editing** and **Building** perspective by clicking the **Return to editor and building perspective** toolbar button (D). Editing and Building is the main activity for most C/C++ developers, hence the dedicated button.

VIEWS

When **Atollic TrueSTUDIO** is started for the first time, the **C/C++ Editing** Perspective is activated by default. This perspective does not show all available views by default, to reduce information overload. The same principle applies to all perspectives.

To access additional features built into the product, open additional views. To do this, select the **View** toolbar button (C) or use the menu command **View**:

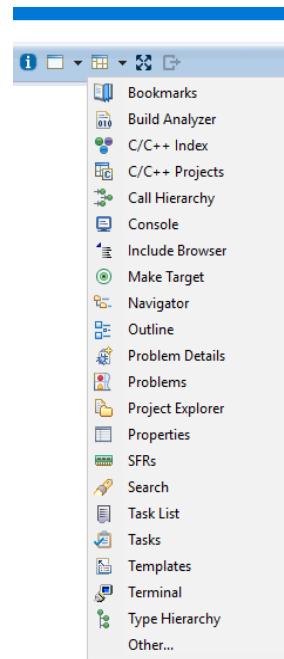


Figure 6 - View Menu toolbar button

The above list of views, while comprehensive, is still not complete. This list only contains the most common views for the work task related to the currently selected Perspective. To access even more views, select **Other...** from the list. This opens the **Show View** dialog box. Double click on any view to open it and access the additional features:

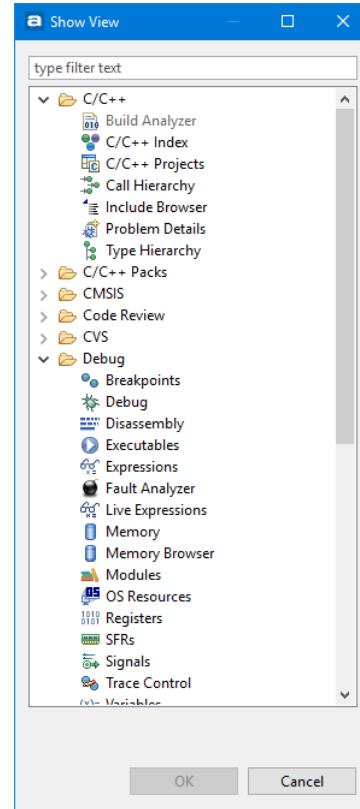


Figure 7 - Show View Dialog Box

The remaining toolbar buttons related to perspectives and views are:

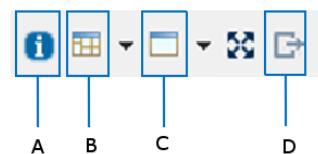


Figure 8 – Toolbar Buttons for Perspectives and Views

Information Center (A) – Displays the initial welcome screen from the first time the product was started, after being installed. More details will follow in “Starting the Program” below.

Perspective (B) – A shortcut that opens a perspective of the user’s choice.

STARTING THE PROGRAM

After installing **Atollic TrueSTUDIO** according to *Atollic TrueSTUDIO Installation Guide*, start the program by performing the following steps (applies to Microsoft® Windows® Vista® and Windows 7®):

1. Open the Microsoft® Windows® **Start Menu**
2. Click on **All Programs**
3. Open the **Atollic** folder
4. Open the **TrueSTUDIO for STM32** folder
5. Click on the **Atollic TrueSTUDIO** item in this folder
6. Wait for the program to start, and the **Workspace Launcher** dialog to be displayed.

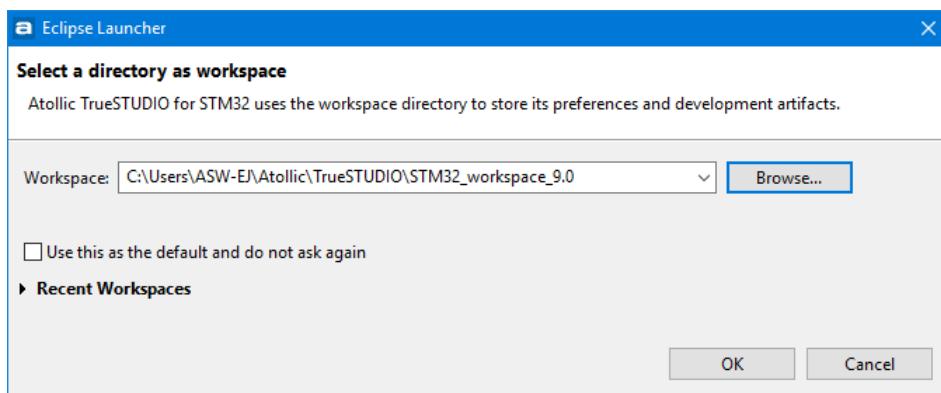


Figure 9 - Workspace Launcher

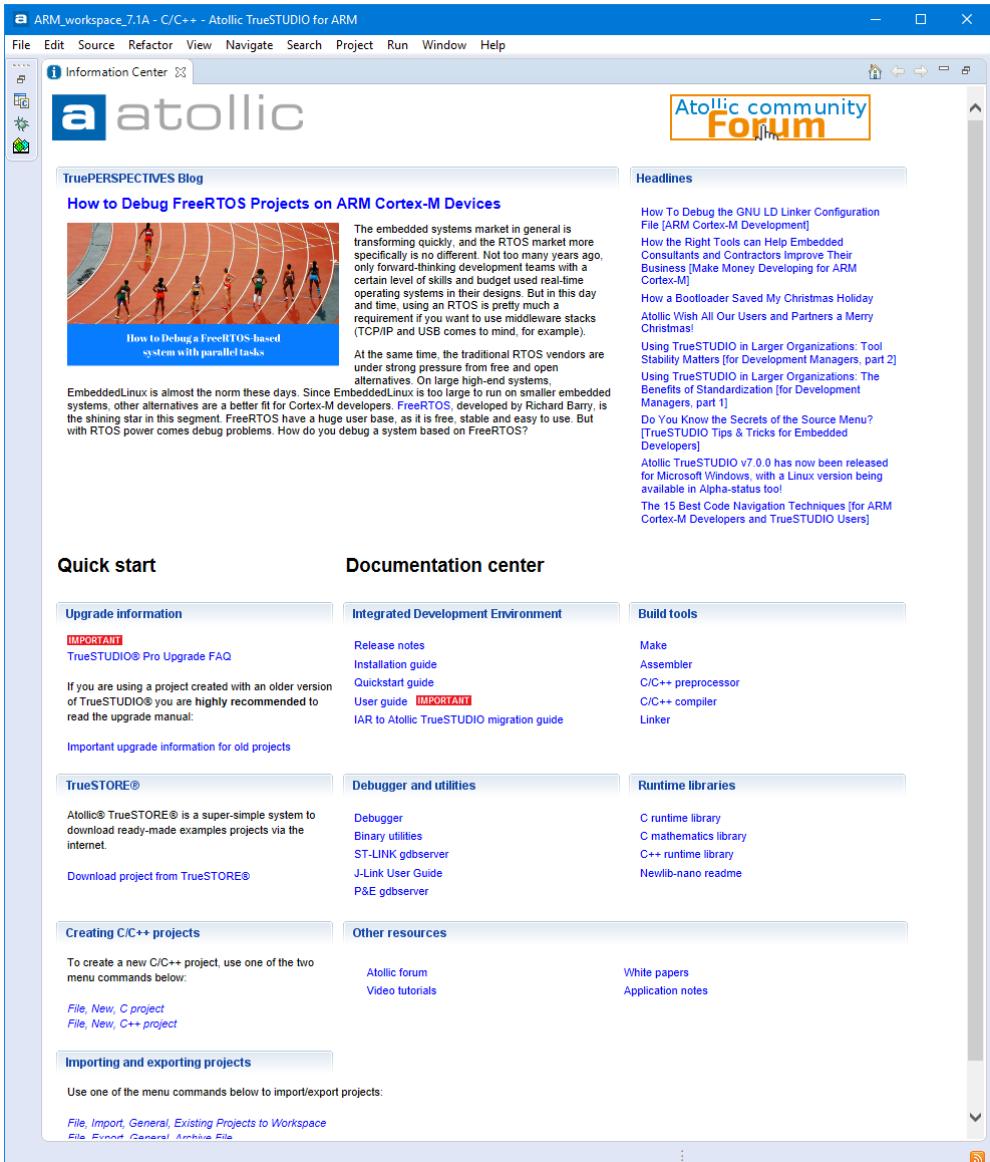
This dialog enables the user to select the name and location of the Active Workspace. The Active Workspace is a folder that will hold all projects currently accessible by the user. The user may open any existing project in the workspace. Any newly created projects will be stored in the workspace.

7. Enter the full name (with path) of the workspace folder to be used for the current session. Alternatively, browse to an existing workspace folder, or use the default workspace folder. This is located within the home directory of the current user, e.g. C:\Users\User\Atollic\TrueSTUDIO
If the appointed workspace folder does not yet exist, it will be created.
8. Click on the **OK** button

 The user must have write-access to the home directory to be able to start **Atollic TrueSTUDIO**.

 Atollic recommends that the Active Workspace folder is located not too many levels below the file system root. This is to avoid exceeding the Windows® path length character limitations. This can cause build errors if the file paths become longer than Windows can handle.

1. Wait for the Information Center window to be displayed.



The screenshot shows the Atollic TrueSTUDIO Information Center window. The window title is "ARM_workspace_7.1A - C/C++ - Atollic TrueSTUDIO for ARM". The main content area includes:

- TruePERSPECTIVES Blog:**
 - How to Debug FreeRTOS Projects on ARM Cortex-M Devices**: Includes an image of people running on a track and a link to "How to Debug a FreeRTOS-based system with parallel tasks".
 - A sidebar with text about the embedded systems market and FreeRTOS.
 - A sidebar with links to "How To Debug the GNU LD Linker Configuration File [ARM Cortex-M Development]", "How the Right Tools can Help Embedded Consultants and Contractors Improve Their Business [Make Money Developing for ARM Cortex-M]", and "How a Bootloader Saved My Christmas Holiday".
- Headlines:**
 - How To Debug the GNU LD Linker Configuration File [ARM Cortex-M Development]
 - How the Right Tools can Help Embedded Consultants and Contractors Improve Their Business [Make Money Developing for ARM Cortex-M]
 - How a Bootloader Saved My Christmas Holiday
 - Atollic Wish All Our Users and Partners a Merry Christmas!
 - Using TrueSTUDIO in Larger Organizations: Tool Stability Matters [for Development Managers, part 2]
 - Using TrueSTUDIO in Larger Organizations: The Benefits of Standardization [for Development Managers, part 1]
 - Do You Know the Secrets of the Source Menu? [TrueSTUDIO Tips & Tricks for Embedded Developers]
 - Atollic TrueSTUDIO v7.0.0 has now been released for Microsoft Windows, with a Linux version being available in Alpha-status too!
 - The 15 Best Code Navigation Techniques [for ARM Cortex-M Developers and TrueSTUDIO Users]
- Quick start:**
 - Upgrade information:** Includes a link to "TrueSTUDIO® Pro Upgrade FAQ".
 - Important upgrade information for old projects:** Includes a link to "IAR to Atollic TrueSTUDIO migration guide".
- Documentation center:**
 - Integrated Development Environment:** Includes links to "Release notes", "Installation guide", "Quickstart guide", "User guide", and "IAR to Atollic TrueSTUDIO migration guide".
 - Build tools:** Includes links to "Make", "Assembler", "C/C++ preprocessor", "C/C++ compiler", and "Linker".
 - TrueSTORE®:** Includes a link to "Download project from TrueSTORE®".
 - Debugger and utilities:** Includes links to "Debugger", "Binary utilities", "ST-LINK gdbserver", "J-Link User Guide", and "P&E gdbserver".
 - Runtime libraries:** Includes links to "C runtime library", "C mathematics library", "C++ runtime library", and "Newlib-nano readme".
 - Creating C/C++ projects:** Includes a link to "File, New, C project" and "File, New, C++ project".
 - Other resources:** Includes links to "Atollic forum", "Video tutorials", "White papers", and "Application notes".
 - Importing and exporting projects:** Includes a link to "File, Import, General, Existing Projects to Workspace" and "File, Export, General, Archive File".

Figure 10 - Information Center



Sometimes when opening an old workspace the **Information Center** does not display valid information, e.g. "This page can't be displayed" is shown or old manuals are opened when accessing documents. In such case reload the page by clicking the **Home** button, , at the top right corner of the **Information Center** window.

This window enables the user to quickly reach information regarding the product, and how to use it, by clicking on the corresponding hypertext links. It is not required to read all material before using the product for the first time. Rather, it is recommended to consider the **Information Center** as a collection of reference information to return to, whenever required during development. When connected to internet also Atollic TruePERSPECTIVES Blog articles can be reached.

The **Information Center** window may be reached at any time via the **Help, Information Center** menu command or via the **Information Center** toolbar button.

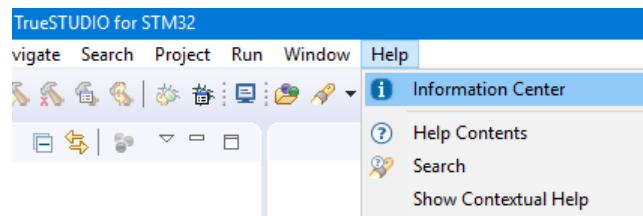


Figure 11 – Information Center Menu Command

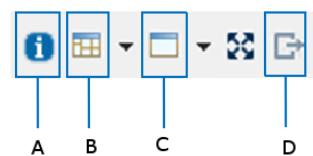


Figure 12 – Information Center Toolbar Button (A)

9. Start using **Atollic TrueSTUDIO** by closing the **Information Center** page (click the "X" in the **Information Center** page tab above its main window area). The **Information Center** window is closed, but may be restored at any time, as described above.

STARTING WITH DIFFERENT LANGUAGE

Start **Atollic TrueSTUDIO** from command line using following options:

English TrueSTUDIO.exe -nl en
Japanese TrueSTUDIO.exe -nl ja
Korean TrueSTUDIO.exe -nl ko
Simplified Chinese TrueSTUDIO.exe -nl zh

CHANGE WHAT IS STARTED

If some parts of **Atollic TrueSTUDIO** is never used, it is a good idea to not start them at all. That reduces the memory used and speeds things up a bit.

In the menu select **Window, Preferences** and in the Preference Dialog select **General, Startup and Shutdown**.

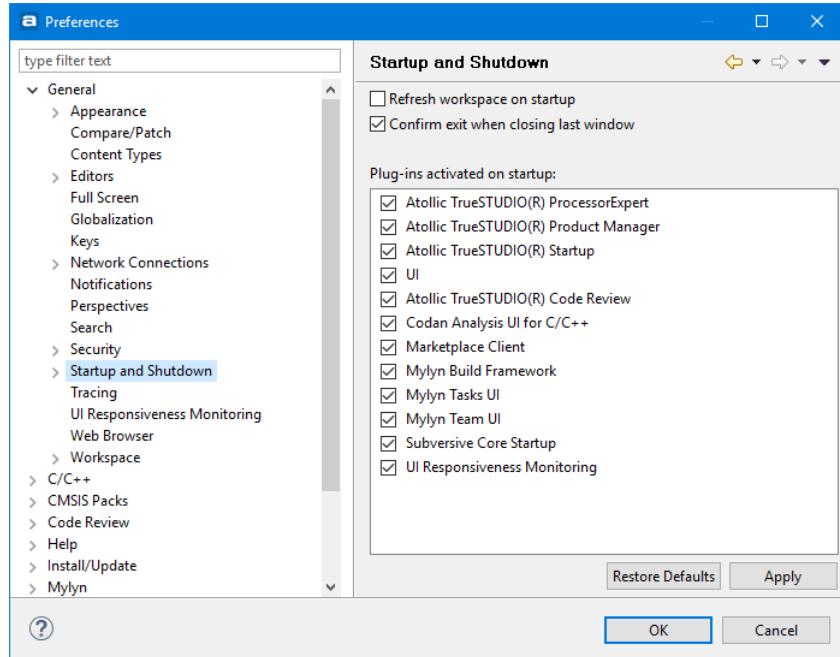


Figure 13 – Startup Preferences

CREATING A NEW PROJECT

Atollic TrueSTUDIO supports both Managed and Unmanaged projects. Managed projects are handled entirely by the IDE and may be configured via GUI settings. Unmanaged projects require the existence of a makefile, which needs to be maintained manually.

The toolbar has three buttons for quick creation of new projects.

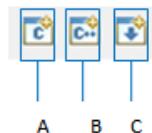


Figure 14 – Project Creation Buttons

To create a new Managed Mode C project, perform the following steps:

1. Click the button A to create a **C Project** (A).

As an alternative, select the **File, New..., C Project** menu command to start the **Atollic TrueSTUDIO** project wizard.

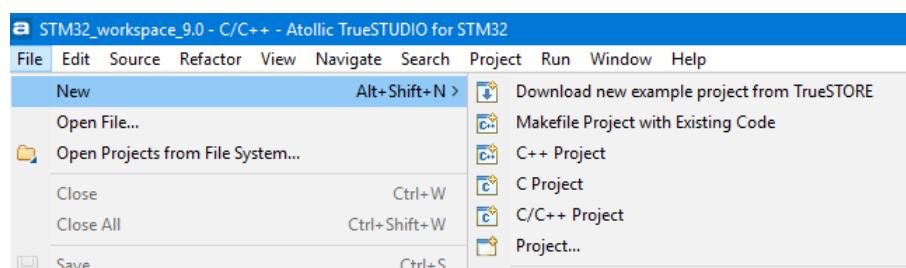


Figure 15 - Starting the Project Wizard

Wait for the **C Project** configuration page to be displayed where different kind of projects can be created. The **Atollic TrueSTUDIO** product contains two kind of toolchains, an **Atollic ARM Tools** and a **Atollic PC Tools**. The **Atollic ARM Tools** toolchain shall be used when building embedded projects. The **Atollic PC Tools** toolchain is usable for testing code on the PC.

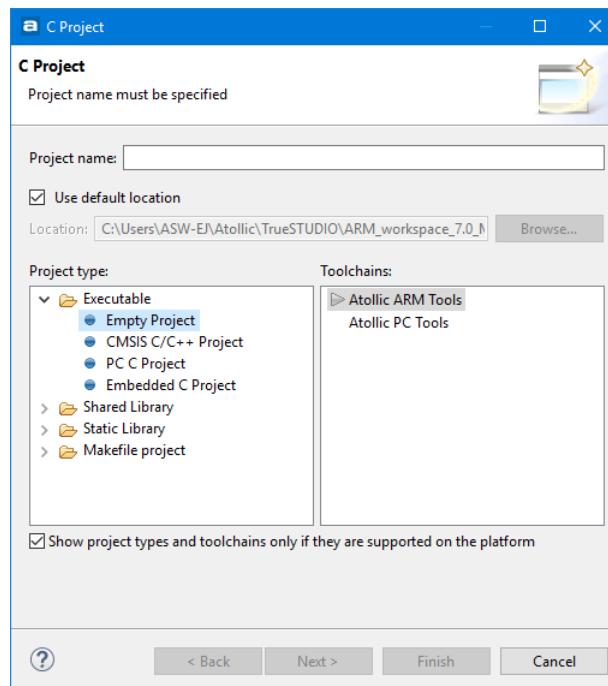


Figure 16 - C Project Configuration

Enter a **Project name** (such as "MyProject"), select **Embedded C Project** as **Project type**. Click the **Next** button.



The project type **CMSIS C/C++ Project** requires some preparations before it can be used. Please read the Using CMSIS-Pack in TrueSTUDIO section at page 166 and Create CMSIS-Pack Based Projects at page 177.

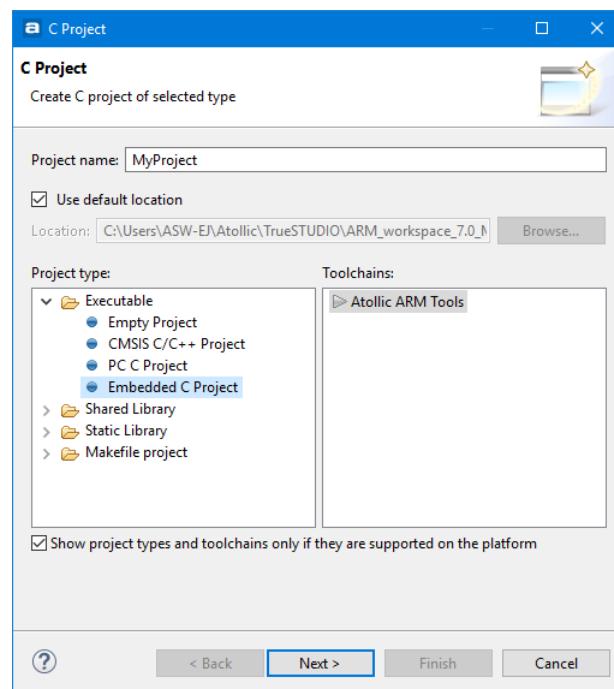


Figure 17 - C Project Configuration

2. Wait for the **TrueSTUDIO Hardware configuration** page to be displayed.

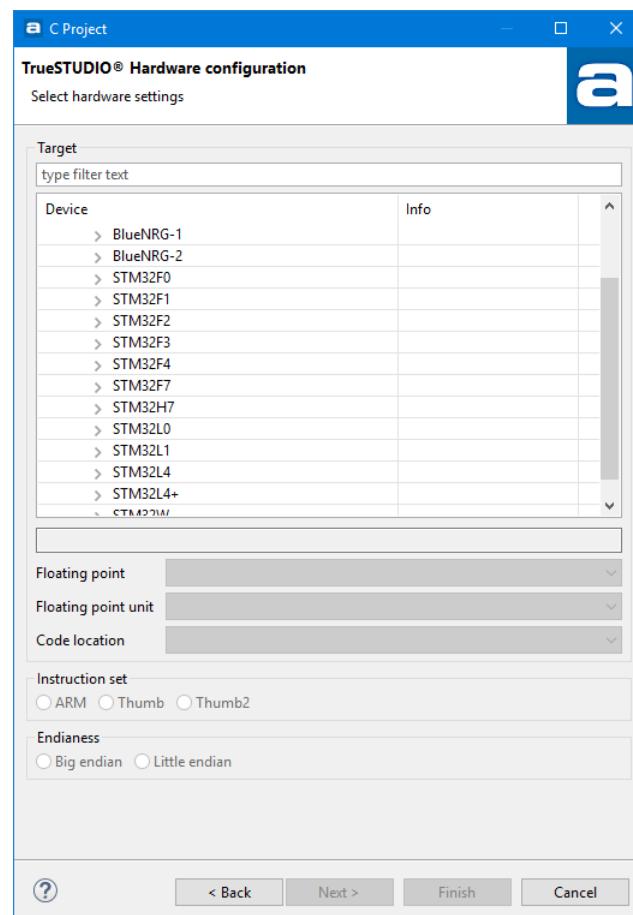


Figure 18 - TrueSTUDIO Hardware Configuration

Configure the hardware settings according to your evaluation board or custom board design. The **Atollic TrueSTUDIO** product contains support for STM32 and BlueNRG microcontrollers and boards.

To make the selection easier to find a specific board or microcontroller the **Select Hardware Settings** dialog includes a **Target Filter** search field. When this field contains some characters only Board/Microcontroller matching the text in the filter field is selectable in the **Board/Microcontroller** fields. Enter some characters in the **Filter** field to reduce the number of selectable boards/microcontrollers.

For instance if you know the name of your Board/MCU contains “F446” then enter **F446** into the search field. This will limit the number of items which can be selected and makes it much more easy to find the Board/MCU.

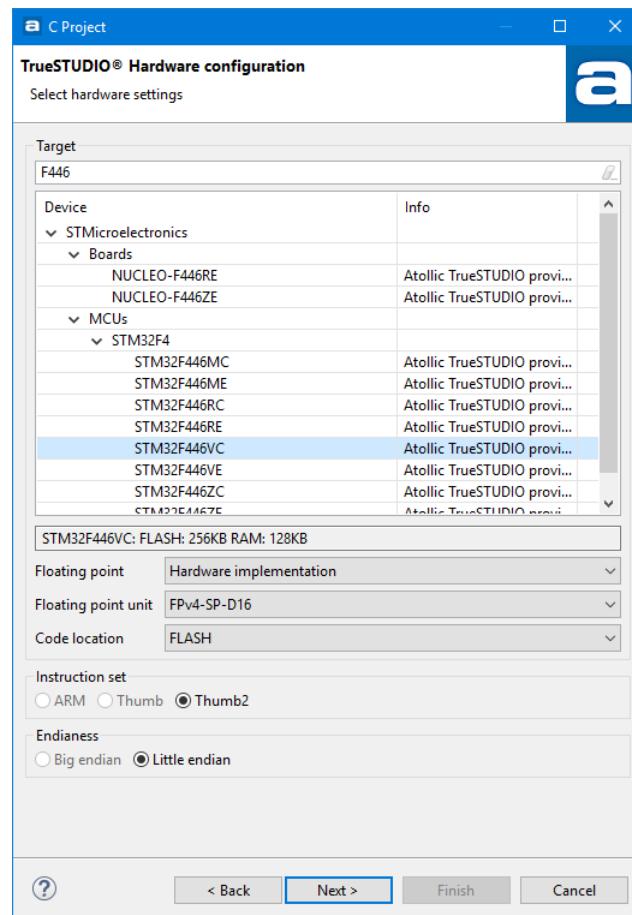


Figure 19 - TrueSTUDIO Project Wizard Using Search Field

If the name of your board starts with “Disc” then just enter **Disc** into the search field and only boards and devices containing Disc in the name will be listed.

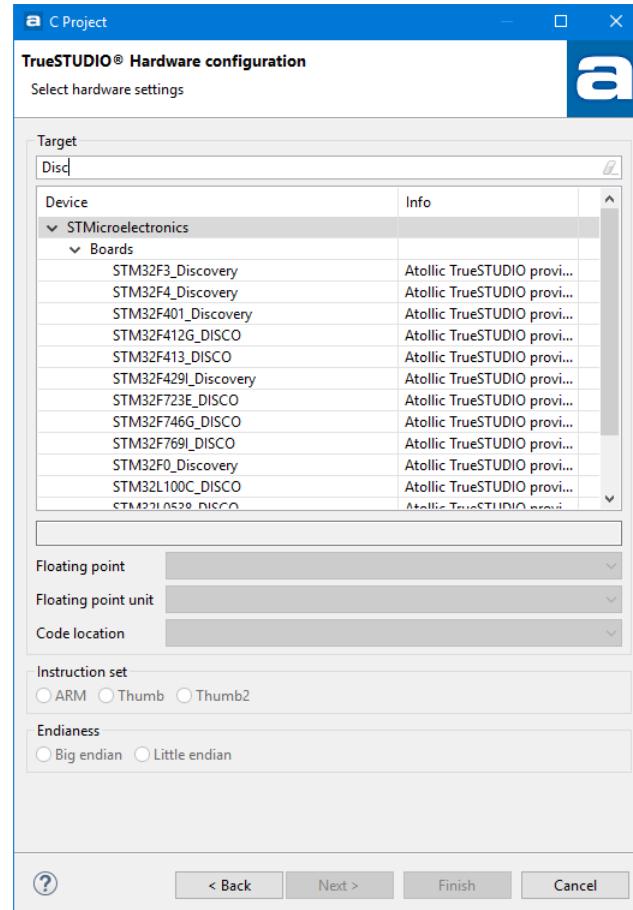


Figure 20 – TrueSTUDIO Filter Board/Microcontroller

Select the board or microcontroller to create a project for.



The **Info** table in the **Project Wizard** displays **Atollic TrueSTUDIO provided this device**, or **CMSIS-Pack provided this device**. The information depends on if the project will be created based upon Atollic TrueSTUDIO Target Supported Device information or if it will be based on installed CMSIS Pack files. See the section **Using CMSIS-Pack in TrueSTUDIO** on page 166 for more information about CMSIS-Pack.

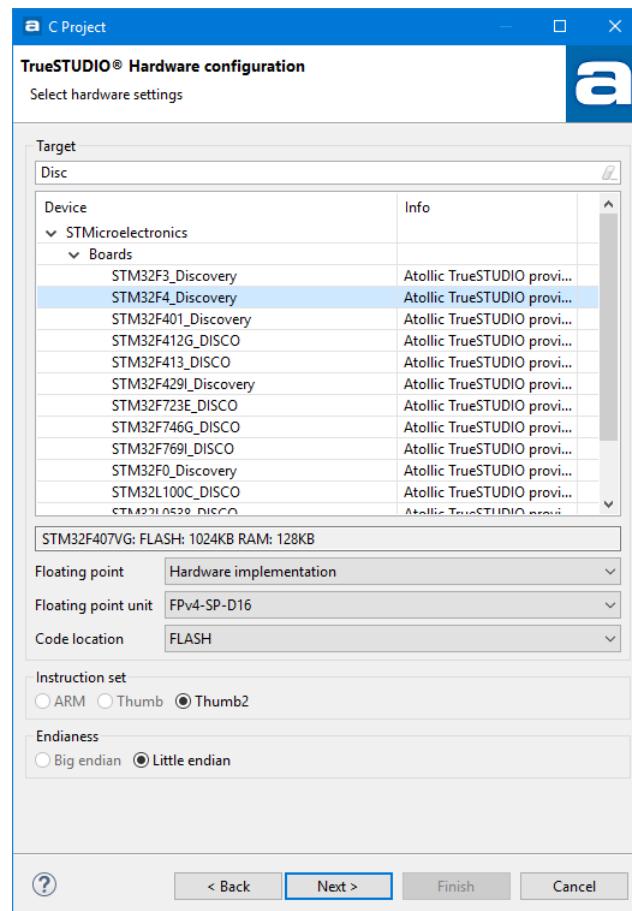


Figure 21 - TrueSTUDIO Hardware Configuration



The text field below the tree displays information about the used device when a **Board** or **MCU** is selected in the tree.

The default selection for floating point operations is either **Software implementation**, **Mix HW/SW implementation** or **Hardware implementation**, depending on the selected microcontroller.

Some microcontrollers have floating point support implemented in hardware. For such microcontrollers, the selection **Hardware implementation** is more efficient, and will thus be default.

However, this setting will not work properly on devices that do not have floating point support in hardware. In such a case, **Software implementation** will be default.

Please note that evaluation boards may have hardware switches for configuration of **Code location** in RAM or FLASH. The setting selected in the project wizard *must* correspond to the settings on the board.

The **Mix HW/SW implementation** is for those projects that have libraries that aren't compiled for hardware floating point. In this implementation the function calls are not using the FPU-registers as in a pure **Hardware implementation**. The FPU will however still be used inside the project functions.

When finished, click the **Next** button.

3. Wait for the **TrueSTUDIO Software configuration** page to be displayed.

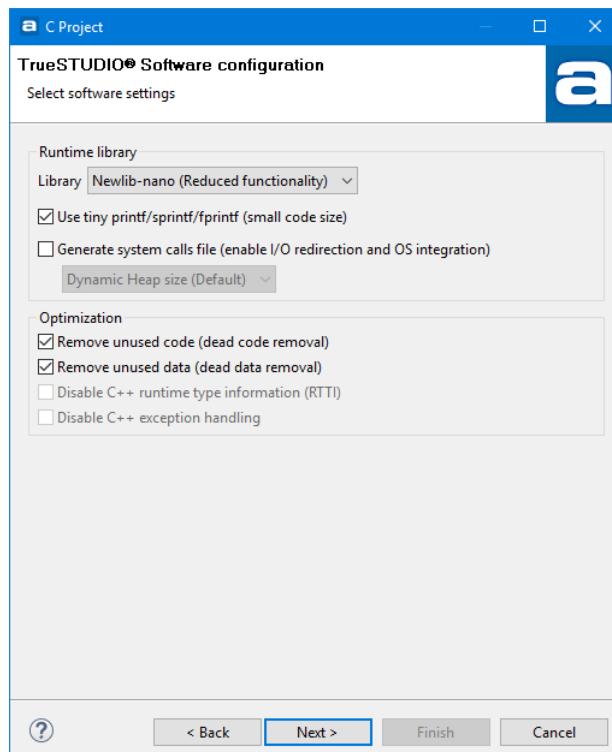


Figure 22 - TrueSTUDIO Software Configuration

Select the desired **Runtime library** to be used. For information about the differences between **Newlib-nano** and the regular **Newlib**, please refer to the **Newlib-nano** readme file, accessible from the **Information Center** (Figure 10).

If the target board has a limited amount of memory, the **Use tiny printf/sprintf/fprintf (small code size)** setting is recommended.

When finished, click the **Next** button.



If **Newlib-nano** is used and float shall be used by scanf/printf add these options to the “C Linker” options field

-u_scnf_float -u_printf_float

E.g. The option field line may now look like

-Wl,-cref,-u,Reset_Handler -u scanf_float -u printf_float



If using an RTOS, it is recommended to generate a **system calls file**, and select the **Fixed Heap size** option. This option requires that the **_Min_Heap_Size** symbol is defined in the linker script **.ld** file. The **.ld** file is stored in the root directory of the currently selected project. The heap size defined by **_Min_Heap_Size** must meet the heap size required by the application.

4. Wait for the **TrueSTUDIO Debugger configuration** page to be displayed.

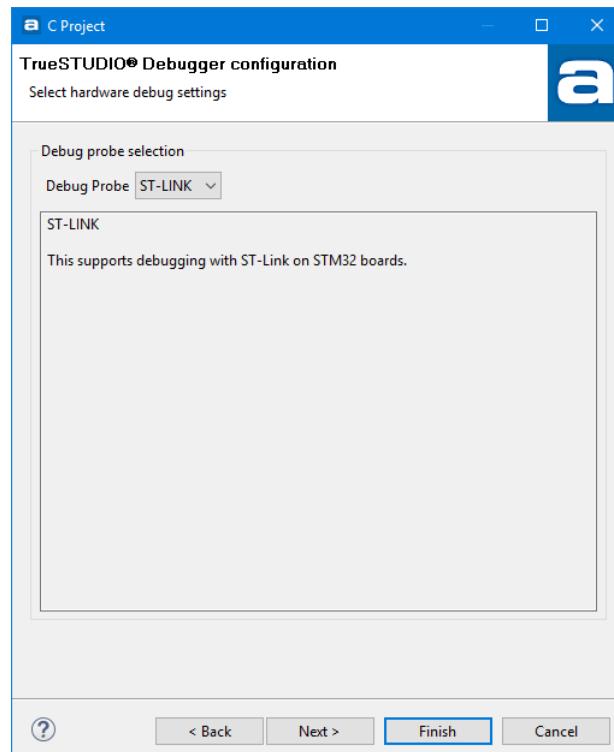


Figure 23 - TrueSTUDIO Debugger Configuration

Atollic TrueSTUDIO supports several different types of JTAG probes. Select the probe to be used during debugging.

When finished, click the **Next** button.

5. Wait for the **TrueSTUDIO Select Configurations** page to be displayed.

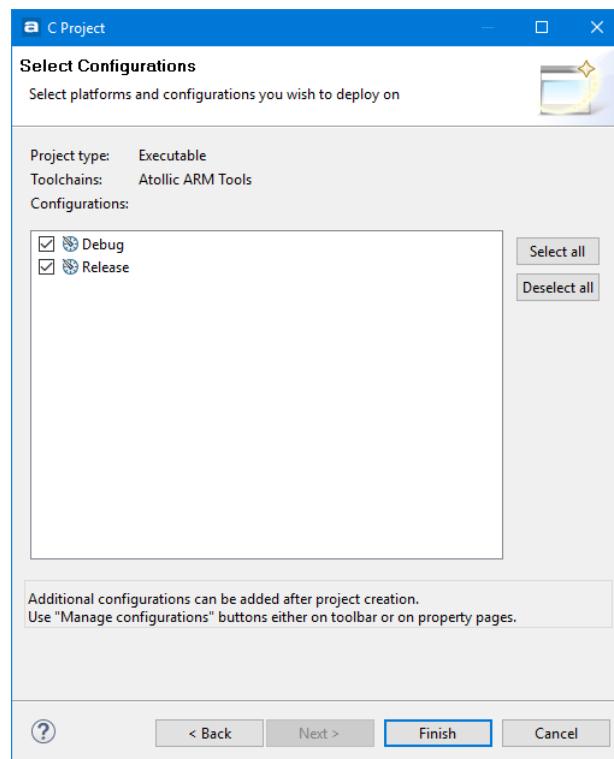


Figure 24 - Select Configurations

Keep the default selections. Click on the **Finish** button.

A new Managed Mode C-project is now created. **Atollic TrueSTUDIO** generates target specific sample files in the project folder to simplify development.

6. Expand the project folder ("MyProject" in this example) and the **src** subfolder in the **Project Explorer** view.

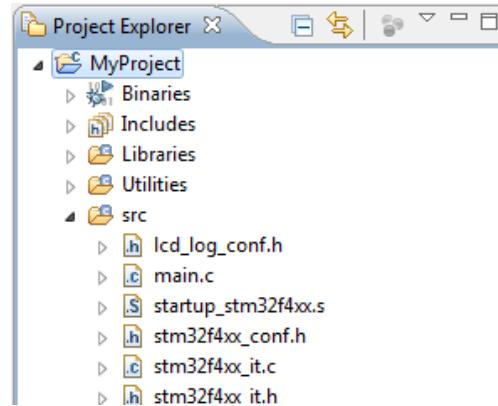


Figure 25 - Project Explorer View

7. Double click on the **main.c** file in the **Project Explorer** tree to open the file in the editor.

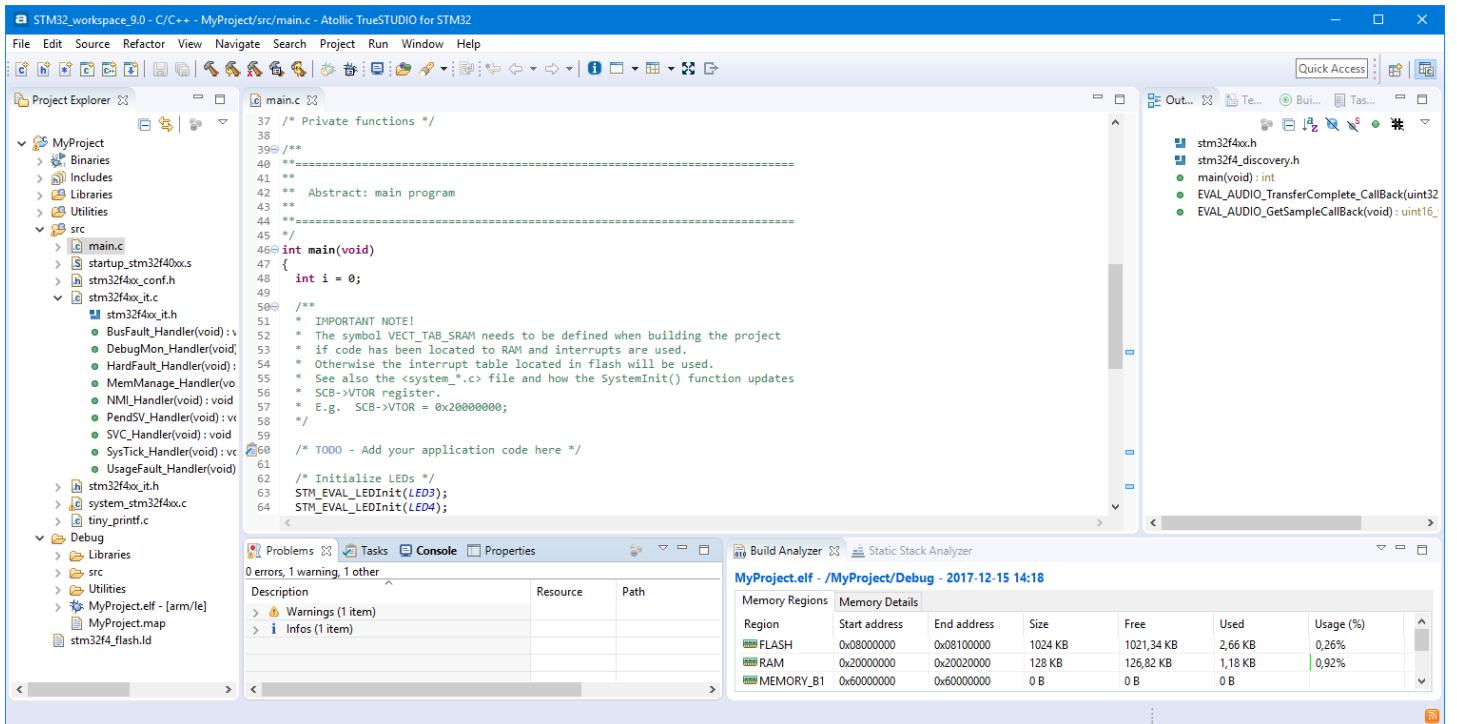


Figure 26 – Editor View

ONE-CLICK EXAMPLE PROJECT INSTALLATION

The **Atollic TrueSTORE** system is a repository with hundreds of free example projects for various evaluation boards. **Atollic TrueSTUDIO** users can easily find the latest available set of example projects on our server, as well as download and install them into the **Atollic TrueSTUDIO** Active Workspace, with a single mouse-click! Any example application of interest is up and running on the target hardware in less than a minute.



The **Atollic TrueSTORE®** requires an internet connection to work, as all example projects are stored on our internet server.

To find the examples relevant to a specific target board, select the **Download** button in the toolbar (C in the image below).

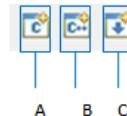


Figure 27 – Project Creation Buttons

Wait for the **Atollic TrueSTORE** Dialog box to open.

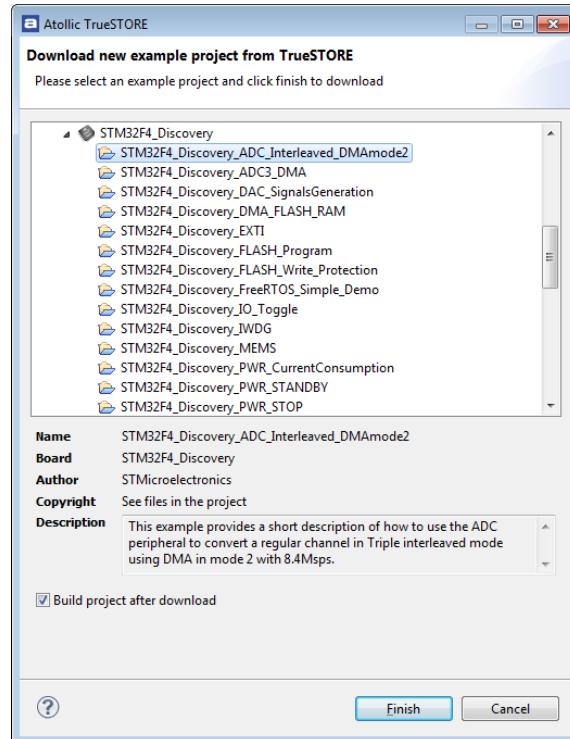


Figure 28 – Atollic TrueSTORE

Select the project(s) of interest and click **Finish**. The project is imported into the Active Workspace and is immediately ready to be built and executed on the target board. The whole process typically takes less than a minute.

USING AN EXISTING PROJECT

To use an existing project in **Atollic TrueSTUDIO**, double-click the **.project** file located within the project folder to open it. This requires that **Atollic TrueSTUDIO** is associated to be used for **.project** files.

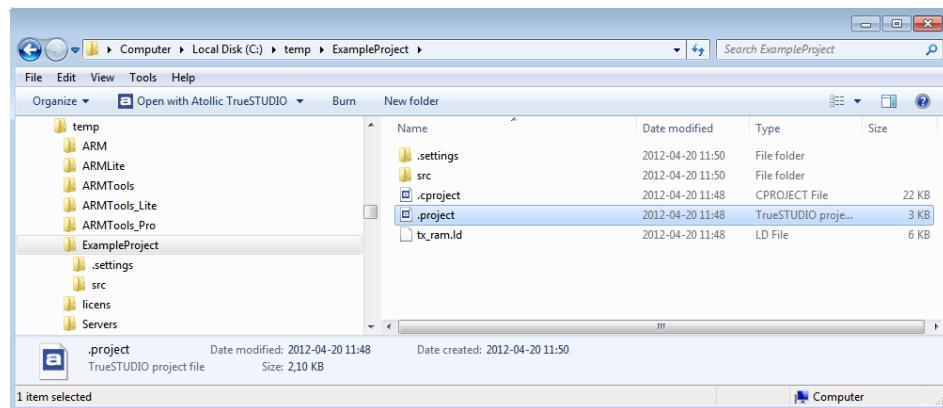


Figure 29 – Selection of Existing Project File

Wait for **Atollic TrueSTUDIO** to start, as a result of double-clicking the **.project** file.

 Please note that if the File Browser is configured not to display file extensions, two nameless icons will appear in the file list, representing the **.project** and the **.cproject** files. The use of files without a filename is an unfortunate heritage from the ECLIPSE™ framework.

 Atollic recommends that example projects downloaded from outside **Atollic TrueSTUDIO®**, e.g. from STMicroelectronics, be located not too many levels below the file system root. This is to avoid exceeding the Windows® path length character limitations.

When clicking on the **.project** file the **Project Import Converter** will investigate the project and if it is made for **Atollic TrueSTUDIO** it is directly imported. But if the project is made from some other tool the **Project Import Converter** tries to identify if it is a known project format and in such case will convert the project to an **Atollic TrueSTUDIO** project. There are two sections which covers conversion of projects in this manual:

- Importing AC6 Projects - conversion of STM32CubeMX (AC6) projects
- Importing EWARM Projects – importing IAR EWARM projects

PREVENT “GCC NOT FOUND IN PATH” ERROR

Some old projects will issue an error in the **Problems** view saying **Program “gcc” not found in PATH**. The error is caused when the project uses a deprecated discovery method setting. The error can be removed by updating **Window Preferences** and **Project Properties** settings.

1. Open **Window, Preferences**. In **Preferences** dialog select **C/C++, Property Pages Settings** and enable checkbox: **Display “Discovery Options” page**.
2. Open **Project , Properties, C/C++ Build, Discovery Options** and disable checkbox: **Automate discovery of paths and symbols**.

CREATING A STATIC LIBRARY

To create a Static Library-project select in the top menu **File, New, C Project** and in the wizard-dialog that pops up select **Static Library**, **Embedded C Library** and **Atollic ARM Tools**.

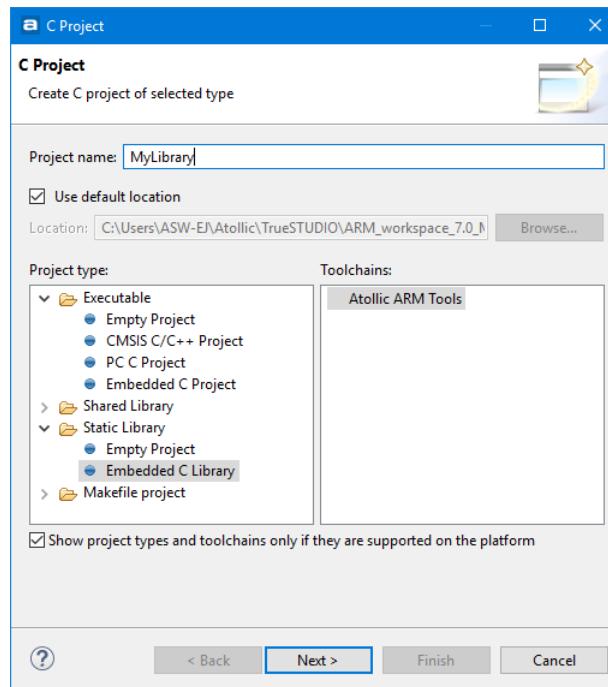


Figure 30 – Selection of Static Library Project

Press **Next** and select the device to be used. This will make the project build settings correct. The project will then be built as an archive file with the name `lib{project-name}.a`, as for an instance `libMyLibrary.a`.



It is recommended to always place a library and the library code in a separate project and never include them in the main-project.



If the library project should be recompiled at the same time as the project that have included it, the library project should be added as a reference to the other project. Select **Project, Properties, C/C++ General, Paths and Symbols** and in **References-tab** select the library project.

For more information about Project referring, see *Referring Project* on page 119

The GNU Binary Utilities command line tools are needed to create an archive file from an object file without first creating a library project.

1. Open a Windows command prompter – cmd.exe
2. Move to the ARMTOOLS\bin folder in TrueSTUDIO installation folder
cd C:\%installdir%\ARMTools\bin
3. Run the archive command
arm-atollic-eabi-ar -r libStaticLibrary.a src\syscalls.o

HIDE INFORMATION IN A STATIC LIBRARY

The GNU Binary Utilities is included in the Atollic Toolchain and contains several programs. The programs `strip` and `objcopy` takes parameters which removes information or change information from the archive file.

For instance `objcopy` can be used if a library shall be exported and used by other people and there is a need to hide information in the library such as function names or variables.

Below is an example on how to remove symbols and redefine some names in a library.

1. Open a Windows command prompter – cmd.exe
2. Move to the ARMTOOLS\bin folder in TrueSTUDIO installation folder
cd C:\%installdir%\ARMTools\bin
3. Run the `objcopy` command to change some information.
arm-atollic-eabi-objcopy --strip-unneeded --redefine-sym myfunc=aaaa libTest.a libRenamed.a

This will open library `libTest`, remove all symbols that are not needed for relocation processing and will also redefine `myfunc` to `aaaa`, and create a new library `libRenamed`.

Option	Information
<code>-g</code> <code>--strip-debug</code>	Do not copy debugging symbols or sections from the source file.

--strip-unneeded	Strip all symbols that are not needed for relocation processing.
--redefine-sym old=new	Change the name of a symbol old, to new. This can be useful when one is trying link two things together for which you have no source, and there are name collisions.

Figure 31 – Examples of options to be used with objcopy

The GNU Binary Utilities Manual contains complete information on how to use the included Binary Utilities software.

CREATING A MAKEFILE PROJECT FROM EXISTING CODE

To import an existing makefile project select **File**, **New** and **Makefile Project with Existing Code**.

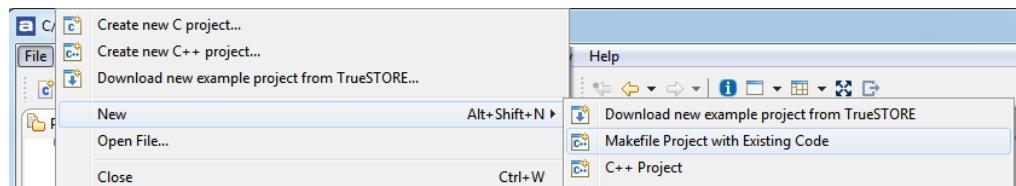


Figure 32 – Create a Makefile Project from existing code

Enter the name of the new project and the location of the existing code.

Make sure to select <none> as the **Toolchain for the Indexer Settings**.

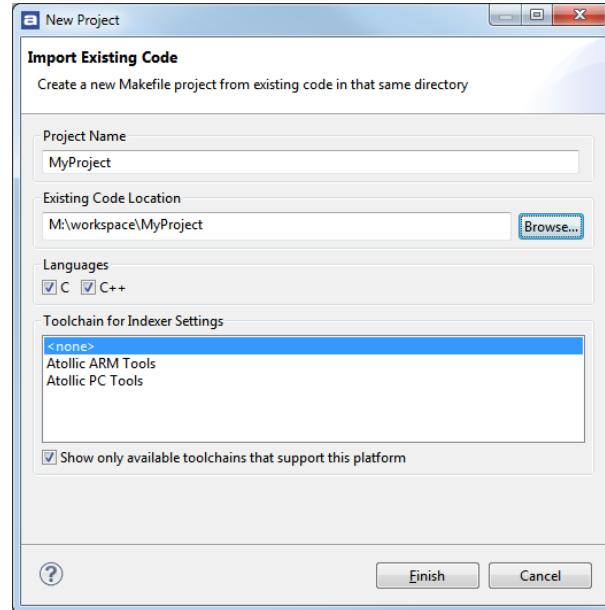


Figure 33 – Locate the code and select <none>

Then add the path to the existing toolchain to the system **PATH** environment variable. That can be done from within **Atollic TrueSTUDIO** by select **Project, Properties** and then **C/C++ Build, Environment**.

Locate the **PATH** variable in the list, select it and click **Edit**. If **PATH** can't be located, click **Add** and write **PATH** in the Name textbox.

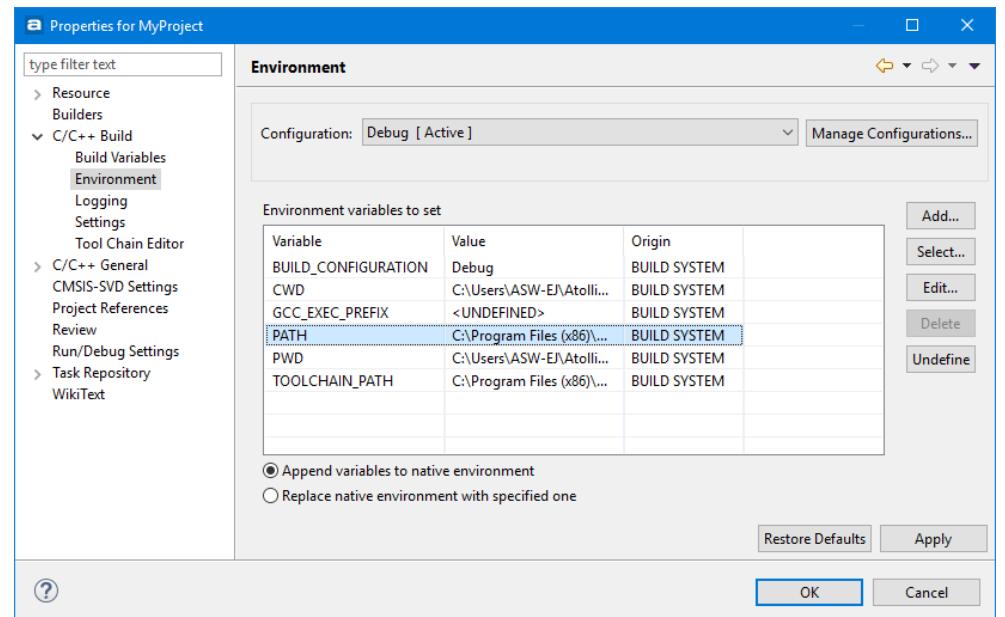


Figure 34 – Edit the PATH variable

In the **Value** textbox, add the full path to the location of the toolchain, and also any other location from where any executables in the makefile are located. Separate the paths with a ";".

IMPORTING EWARM PROJECTS

Atollic TrueSTUDIO v8.0 has a new **Project Import Converter** supporting IAR Embedded Workbench® for ARM® (EWARM) projects. The new **Project Import Converter** automatically updates EWARM projects to **Atollic TrueSTUDIO** format during import. After an import the project will need manual updates in order to build correctly.

The **Project Import Converter** will not modify any source or project files for your original EWARM project. It is however recommended that you backup or make a copy of the original EWARM project since you most likely need to modify some of the source code after the project has been imported to **Atollic TrueSTUDIO**.



It is always recommended to make backups of the project files and source code before converting projects.

A log file is created in the project folder during import. The name of this log file is `ProjectName_converter.log`. This log file is placed into the same folder as the `.project` file and can be investigated to find information about the conversion. The `ProjectName_converter.log` can for instance contain the following info.

Project: STM32F4-Discovery
Converter: IARProjectParser
Date: 20170421

Project needs GCC compatible startup code and linker script

USING THE PROJECT IMPORT CONVERTER

You must use **Import Projects from Folder or Archive** in **Atollic TrueSTUDIO** in order to import EWARM projects into **Atollic TrueSTUDIO**.



Please note! The imported project will not be copied to the workspace. All files in the project will be located at the original place and will be overwritten when manual changes are made.

IMPORT PROJECTS FROM FOLDER OR ARCHIVE

Use the following method to import one or many projects.

To open the **Import** wizard, select **File, Import...**

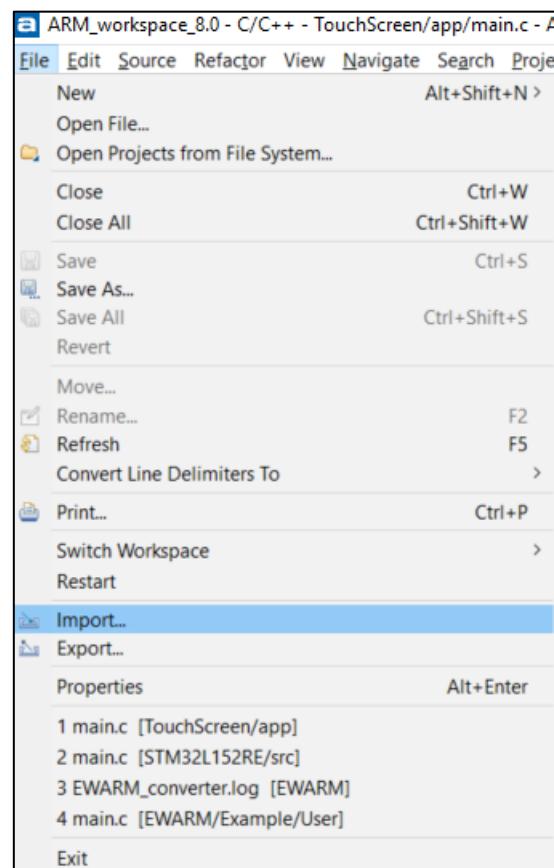


Figure 35 - Import Projects (EWARM)

In the **Import** wizard select **Projects from Folder or Archive** and press **Next**.

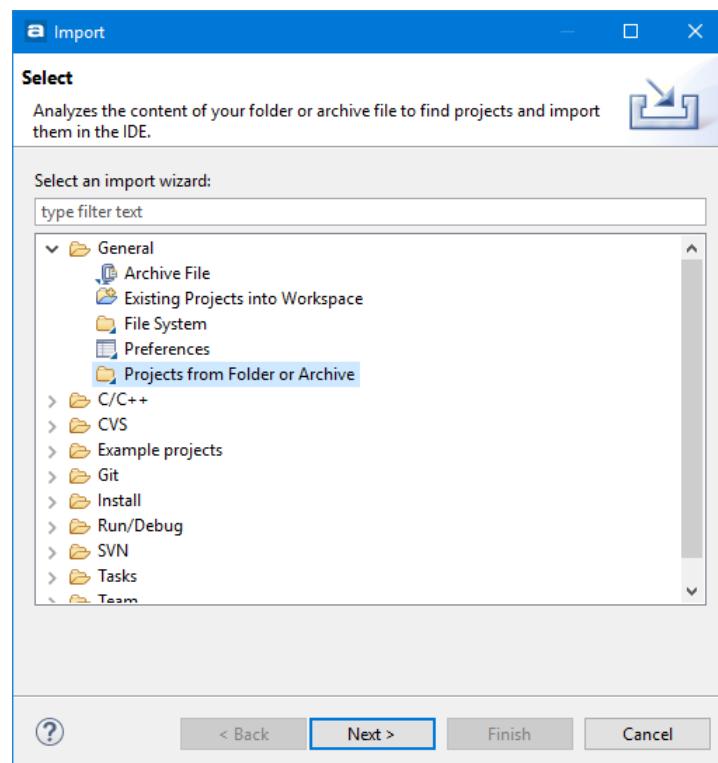


Figure 36 - Import Projects from Folder or Archive (EWARM)

The **Import Projects from File System or Archive** dialog is opened.

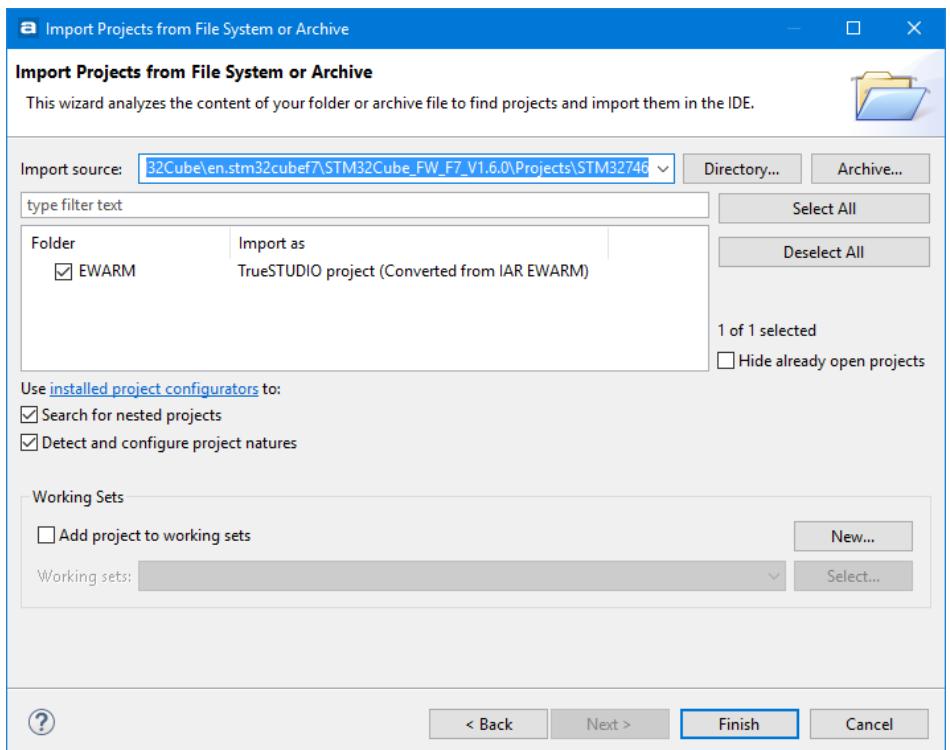


Figure 37 - Import Projects from File System (EWARM)

To see the **Installed project configurators** in the product, press the **installed project configurators** link in the **Import Projects from File System or Archive** dialog.

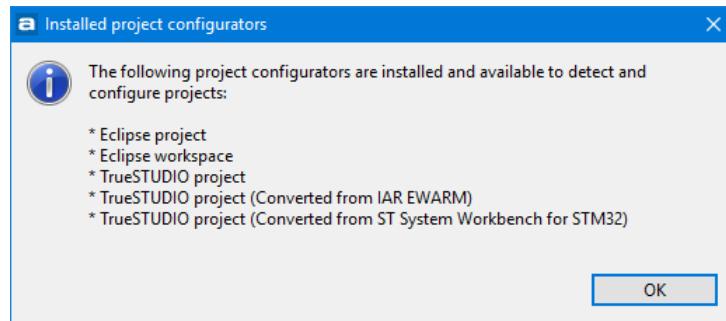


Figure 38 - Display Installed Project Configurators (EWARM)

In the **Import Projects from File System or Archive** dialog browse to the folder containing the project to be imported.



Eclipse cannot handle two projects with the same name in a workspace. Therefore it may only be possible to import one project for a board into the workspace. If an attempt is made to import a second project with the same name, the import will be cancelled silently without any specific message. Remove the first project from the workspace or create a new workspace if another project shall be tested.

Select the project and make sure the checkbox **Detect and configure project natures** is enabled otherwise the **Project Import Converter** will not be used. Press **Finish** to import the project.

The project is now imported into the workspace. Please note that files included in the project are not copied to the workspace, instead all files are linked to the workspace. This means that the actual files will be updated in the original EWARM project. Press **OK** to use the imported project.

If a folder which contains several projects are selected and **Search for nested projects** are selected several projects will be seen in the dialog.

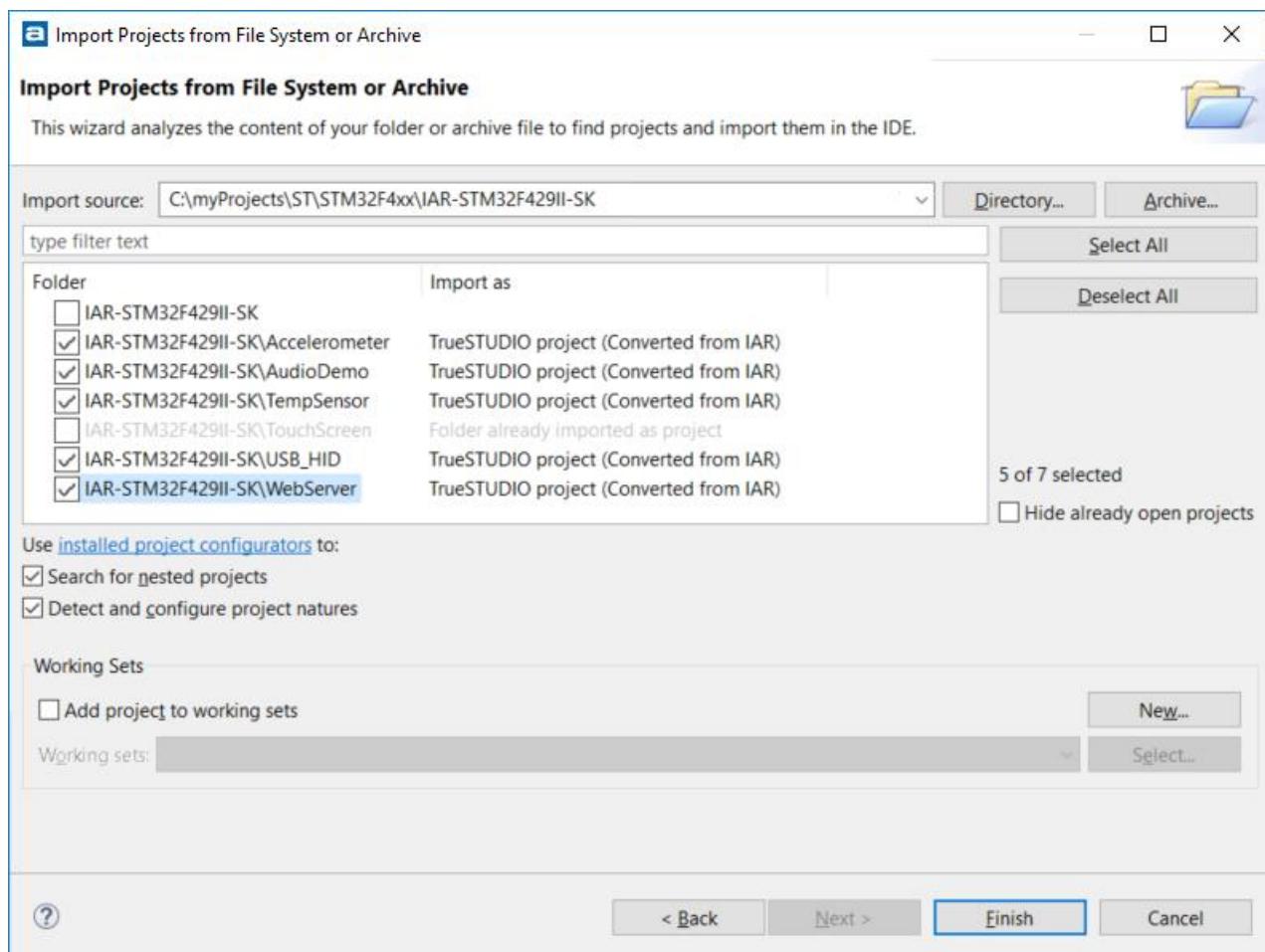


Figure 39 - Import Several Projects from File System (EWARM)

Many projects can then be imported in one step using this method. However, as mentioned earlier, Eclipse requires different names to be used for each selected project. If you run into this problem you can either rename the original EWARM project(s), or import them into different **Atollic TrueSTUDIO** Workspaces.

BEFORE BUILDING IMPORTED PROJECT

Start by having a look in the generated log file that is included in your imported project. This log file contains valuable information about the imported project, for example if there were problems importing certain parts for EWARM.

Before we build we need to make some manual modifications to the source code and make sure that the build options are set correctly. Below is a step-by-step list and we will walk through this list and give examples on what typically needs to be done to get to a project that builds in **Atollic TrueSTUDIO**.



For more detailed information on how to migrate EWARM code and build options, please see the *IAR to Atollic Migration Guide, sections 3 and 4*.

You can access the *IAR to Atollic Migration Guide* from **Atollic TrueSTUDIO Information Center**.

There are essentially four parts of the migration process that you need to manually update. Review and modify build options, modify assembler source code, add a linker script file and watch out for tool specific code. These steps are described below and will in most cases lead to a project that builds and functions correctly.



Linker scripts, startup code and standard C/C++ libraries are tightly released so we must make sure to use either **Atollic TrueSTUDIO** or EWARM versions of this code and scripts. It is strongly recommended to use **Atollic TrueSTUDIO** versions since migrating all this from EWARM to **Atollic TrueSTUDIO** would be very time consuming and prone to errors.



In the process of manually updating our new **Atollic TrueSTUDIO** project we will need startup code and a linker script file. We can easily get this if we create a dummy project in our **Atollic TrueSTUDIO** Workspace. The only thing you have to remember is to make sure that our dummy project is based on the same ARM device as our original project.

STEP-BY-STEP CHECKLIST

The following steps are necessary to double-check in order to obtain a successful build.

1. Update *Atollic TrueSTUDIO* build options.

We should make sure that pre-defined symbols, include paths, FPU selection and C/C++ language settings match the original project.

With one exception, all pre-defined symbols and search paths have already been updated but you should make sure that options like FPU and C/C++ language matches the original project. See table below for information on where to find different build options.

Option	EWARM	TrueSTUDIO
FPU	General Options -> Target -> Floating point settings	[Build tool] -> Taget -> Floating point / FPU Note: [Build tool] is either Assembler, C Compiler, C++ Compiler or C++ Linker. If you change the FPU option then you should make the same change in all four build tools.
C/C++ language	C/C++ Compiler -> Language 1	C Compiler -> General C++ Compiler -> General Note: The <i>Atollic TrueSTUDIO</i> project will by default use the C compiler for C files and C++ compiler for C++ files.
Compiler defines	C/C++ Compiler -> Preprocessor -> Defined Symbols	C Compiler -> Symbols -> Defined symbols
Compiler paths	Assembler -> Preprocessor -> Additional include directories	C Compiler -> Directories -> Include path
Assembler defines	Assembler-> Preprocessor -> Defined Symbols	Assembler -> Symbols -> Defined symbols
Assembler paths	C/C++ Compiler -> Preprocessor -> Additional include directories	Assembler -> Directories -> Include path

Table 2 - EWARM vs TrueSTUDIO build options

The exception mentioned in the paragraph above is the CMSIS include path. In EWARM you can specify to use CMSIS with the Use CMSIS option.

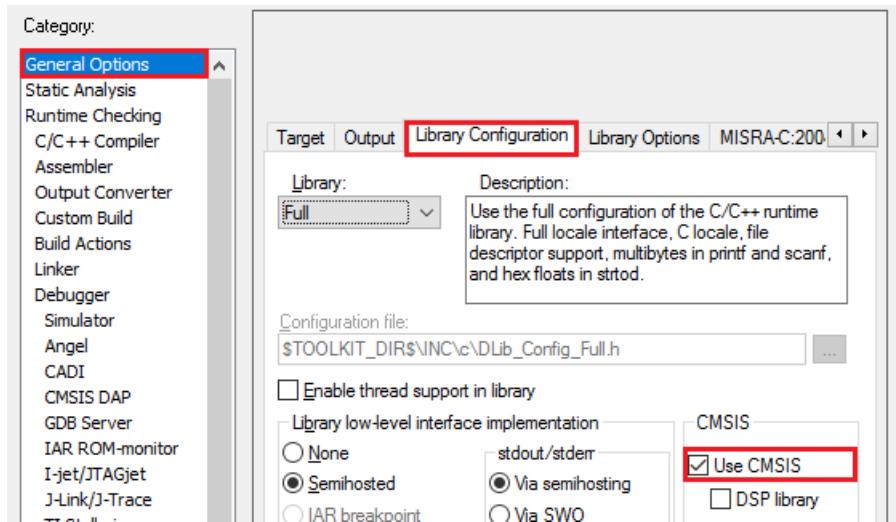


Figure 40 - EWARM CMSIS option

If **Use CMSIS** is checked then you will need to add a path to the CMSIS library to use in your application. You can do this in the Directory part of the C Compiler settings. The path to add is the absolute path the CMSIS/Include located in your EWARM installation, typically something like this:

C:\Program Files (x86)\IAR Systems\Embedded Workbench x.x\arm\CMSIS\Include

In the Directory part of the C Compiler setting (see picture below), click the Add... icon () to add your path.

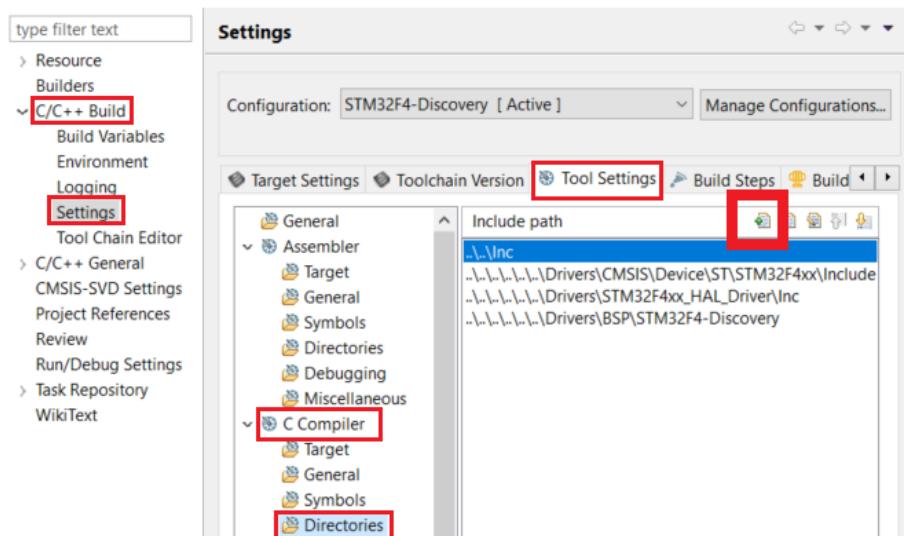


Figure 41 - TrueSTUDIO compiler include paths

2. Modify or replace assembler source files.

The IAR assembler code syntax differs from what is used by **Atollic TrueSTUDIO** so we will need to rewrite all assembler source code.

A special case is the startup file that comes with most projects and usually are written in assembler code. **Atollic TrueSTUDIO** can generate this startup file for you so that you do not have to write this code yourself. A recommended way is to add an. iar extension to the startup file that was added to your imported EWARM project. After this you can add a **Atollic TrueSTUDIO** startup file based on the same ARM device to your imported project. If you created a dummy project as described in the tip above, then you can simply drag-and-drop the startup file from your dummy project to your imported project.

Once we have our new startup file we can compare it against the original startup file. We can ignore the C/C++ initialization code since we will be using **Atollic TrueSTUDIO standard libraries and we are using an Atollic TrueSTUDIO** generated startup file now. What we should pay attention to is for example the content of vector table and exception/interrupt handlers. For example, interrupt handlers that was implemented and used in the original project must also be implemented in our new startup file.

3. Add an **Atollic TrueSTUDIO** linker script file.

No linker script file is included so we need to add one that matches what we had in our original EWARM project. A starting point is to have **Atollic TrueSTUDIO** generate a linker script file that is based on the same ARM device as the original project and add that linker script file to your imported project.

If you have your dummy project as described above, then you can simply, in **Atollic TrueSTUDIO** Project Explorer, drag-and-drop that linker script file into the root of your imported project.

We need to let the linker know which linker script file to use and this is done in the General Settings of the C++ Linker.

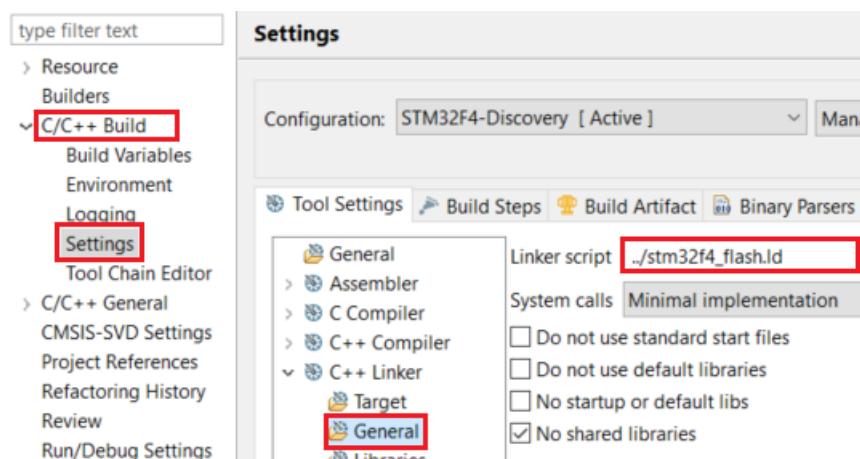


Figure 42 - TrueSTUDIO linker script file option

You can either Browse to the linker script file, or if it is located in the root of your imported project, type in the path.

In our example, we use STM32F4 so that path would be then “`../stm32f4_flash.ld`”.

With the linker script file in place we need to make sure that the memory configuration in the linker script matches the configuration in the IAR .icf-file. Usually most memory segments do not have to be located at a specific address, as long as it is in the correct memory region. There are however applications that require that some memory regions and entry labels are located at an absolute address. In this case you should make sure your new application locate these regions/labels at the same memory location. See the *IAR to Atollic Migration Guide* for more details on how this can be done in **Atollic TrueSTUDIO**.

4. The last step before we try our build is to see if there are tool specific code in our project, other than the startup file mentioned above.

Applications and libraries that comes from silicon vendors or 3'rd party companies can contain source code, or libraries, that are created just for a specific development toolchain. If this is the case in your project, then you should see if you can find that corresponding code for TrueSTUDIO or GCC and replace source code, libraries and include paths with the versions created for TrueSTUDIO or possible GCC.

As an example, FreeRTOS have in their `Source` folder a sub-folder called `portable`. Here you have source code ported to various development tool vendors. An imported EWARM project using FreeRTOS would normally contain files in the `Source/portable/IAR` folder. We should replace that code with the code in `Source/portable/GCC`.

Once we have replaced this code we must also update our build tools include paths so that any reference to `Source/portable/IAR` is changed to `Source/portable/GCC`.

Intrinsic functions are also part of code that can differ from tool vendor to tool vendor. Luckily CMSIS defines a set of intrinsic functions used for Cortex-M and both EWARM and **Atollic TrueSTUDIO** follow CMSIS. In order to make sure that we include declarations of CMSIS we should include CMSIS `cmsis_gcc.h` instead of EWARM `intrinsics.h` in our source code.

For information about none CMSIS intrinsic functions and other ARM language extensions used by, see [ARM® C Language Extensions](#) and [CMSIS Core documentation](#).

You are now ready to build the newly imported project and correct any remaining error and check warnings. Depending on your project there might be more things that you manually would need to modify in order to get to a **Atollic TrueSTUDIO** project that matches the original EWARM project. For this reason, and for those who would not use the EWARM import wizard, there is an *IAR to Atollic Migration Guide* available from **Atollic TrueSTUDIO Information Center** with detailed information on how migrate a project from EWARM to **Atollic TrueSTUDIO**.

COMMON BUILD ERRORS

This section will list and suggest solutions for the most common errors you would see after building a project imported from EWARM to **Atollic TrueSTUDIO**.

fatal error: intrinsics.h: No such file or directory

EWARM `intrinsics.h` mostly contains declarations of various intrinsic functions. Most the once used in a Cortex-M project are available in the CMSIS `core_cmFunc.h` and `cmsis_gcc.h` header files. So, what we can do is to replace all occurrences of `intrinsics.h` with for example `cmsis_gcc.h`.

undefined reference to 'xyz'

Here 'xyz' can be a variable or a function that used in your application but not defined. One way to find where this missing variable/function should be defined is to find the definition in the original EWARM project.

There is a chance that the missing function could be defined as an intrinsic function that is not included in our `core_cmFunc.h` or `cmsis_gcc.h` header files.



Unresolved issues? If still not successful after reading the *IAR to Atollic Migration Guide*, please contact your local distributor or Atollic support for assistance.

CONFIGURING THE DEBUGGER

After the imported project builds without errors we can test and debug the application using any of the **Atollic TrueSTUDIO** supported debuggers. Before we download and debug our application we need to configure the debugger and we do this in the **Debug Configuration** dialog that we can access from the **Run** menu or the toolbar icon. (The

same dialog will open if we attempt to start a debug session before we have created our debug configuration.)

In the **Main** tab, we need to make sure that the Name of the ElfDwarf file is correct as well as the Application and the Project selected.

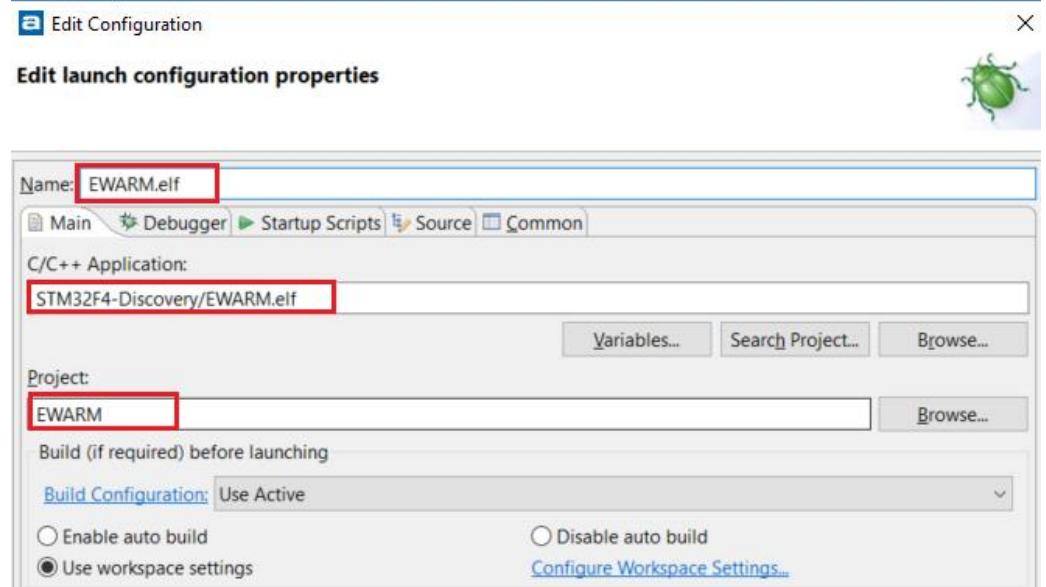


Figure 43 - Edit Debug Configuration

After this is done we select the **Debugger** tab. Here we first of all select which Debug probe we will be using. Once we have selected our debug probe we can modify our GDB Connection, select debug interface, add trace (if we have that available) and more.

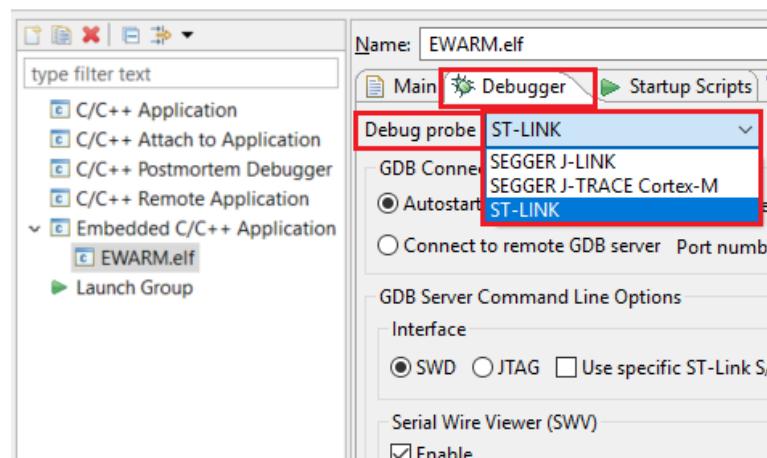
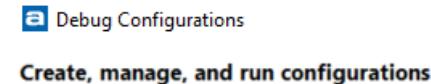


Figure 44 - Selecting Debug Probe



If you are uncertain on how to configure your debugger after selecting the debug probe, then try the default values.

After you select a debug probe, **Atollic TrueSTUDIO** will default to a debug configuration that works for most projects that use that particular debug probe.

In case the default values does not work, check your debug settings in EWARM and apply the same values to your debug configuration in **Atollic TrueSTUDIO**.

If you like to get more control over the download and debug session, then you can do this in the **Startup Scripts** tab. Here you can add commands to for example load additional files or debug information, chose to download without starting a debug session, stop at the application entry point or run to main (or any global label in your application) and much more. For more information see *The Startup Script* chapter at page 227.

Now we are ready to download and test our application and we can do this by clicking on OK or Debug (depending on how you started the Debug Configuration dialog).

For more detailed information on migrating EWARM projects, see the *IAR to Atollic TrueSTUDIO migration guide*.

IMPORTING AC6 PROJECTS

As of **Atollic TrueSTUDIO v7.1**, there is a new **Project Import Converter** supporting System Workbench for STM32 (AC6, SW4STM32) projects. Such projects can be found in STMicroelectronics software such as STM32Cube Firmware Package projects.

The new **Project Import Converter** automatically updates System Workbench for STM32 (AC6, SW4STM32) projects to **Atollic TrueSTUDIO** format during import. After an import the project shall build and it shall be possible to debug the project in **Atollic TrueSTUDIO**. In some cases it may be needed to do some manual target or build setting changes.

The **Project Import Converter** makes it easy to import, build and debug ready-made projects located in the STMicroelectronics STM32Cube Firmware Package projects even if STMicroelectronics only have prepared SW4STM32 projects in the examples package.

Example from STM32CubeF7:

```
G:\ST\STM32Cube\en.stm32cubef7\STM32Cube_FW_F7_V1.5.0\Projects\STM32F  
769I-  
Discovery\Examples\DMA\DMA_FLASHToRAM\SW4STM32\STM32769I_DISCOVERY
```

The **Project Import Converter** will update the imported project but it will make backup copies of the .project and .cproject files before these are changed. See the section *Restoring Converted Projects* at page 82 for information on how to restore the project if it shall be used with AC6 later.



It is always recommended to take manual backups of the project files and source code before converting projects. When using STM32Cube Firmware Package projects it could be possible to reinstall the complete package.

During import a log file is created in the project folder. The name of this log file is ProjectName_converter.log. This log file is placed into the same folder as the .project file and can be investigated to find information about the conversion. The ProjectName_converter.log. can for instance contain the following info. This is normal behavior.

```
Project: STM32F4-Discovery  
Converter: AC6 project converter  
Date: 20170127
```

USING THE PROJECT IMPORT CONVERTER

The **Project Import Converter** can be started in two ways:

1. Use Import Projects from Folder or Archive in *Atollic TrueSTUDIO*.

2. Double-click the .project file in Windows File Explorer.

These two different ways of using the Project Import Converter is described in next sections.



Please note! The imported project will not be copied to the workspace. All files in the project will be located at the original place and will be overwritten when changes are made.

IMPORT PROJECTS FROM FOLDER OR ARCHIVE

Use the following method to import one or many projects.

To open the **Import** wizard select **File, Import...**

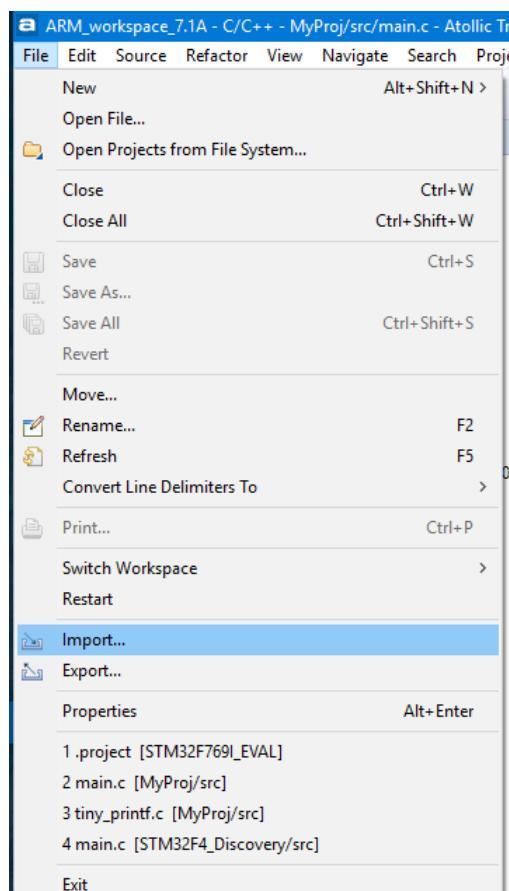


Figure 45 – Import Projects

In the **Import** wizard select **Projects from Folder or Archive** and press **Next**.

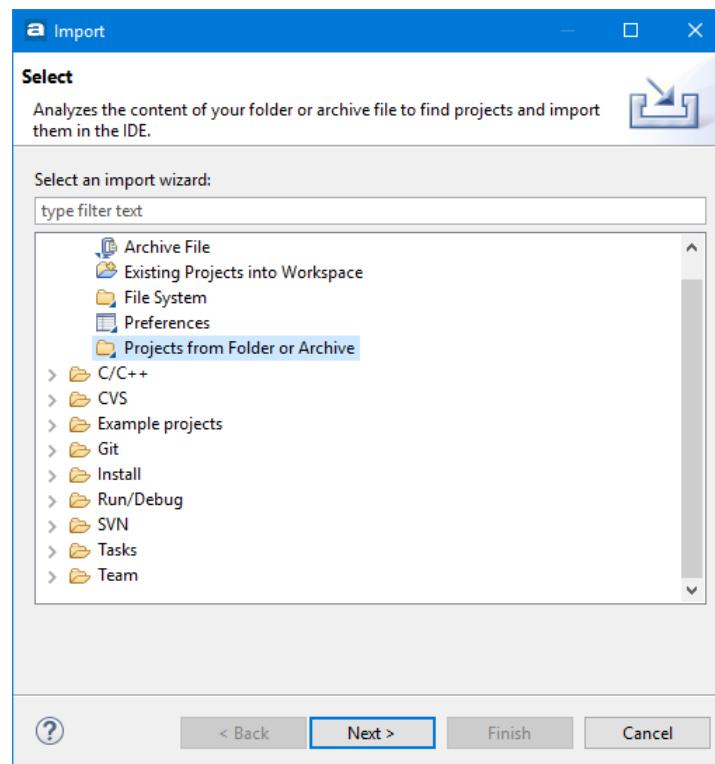


Figure 46 – Import Projects from Folder or Archive

The **Import Projects from File System or Archive** dialog is opened.

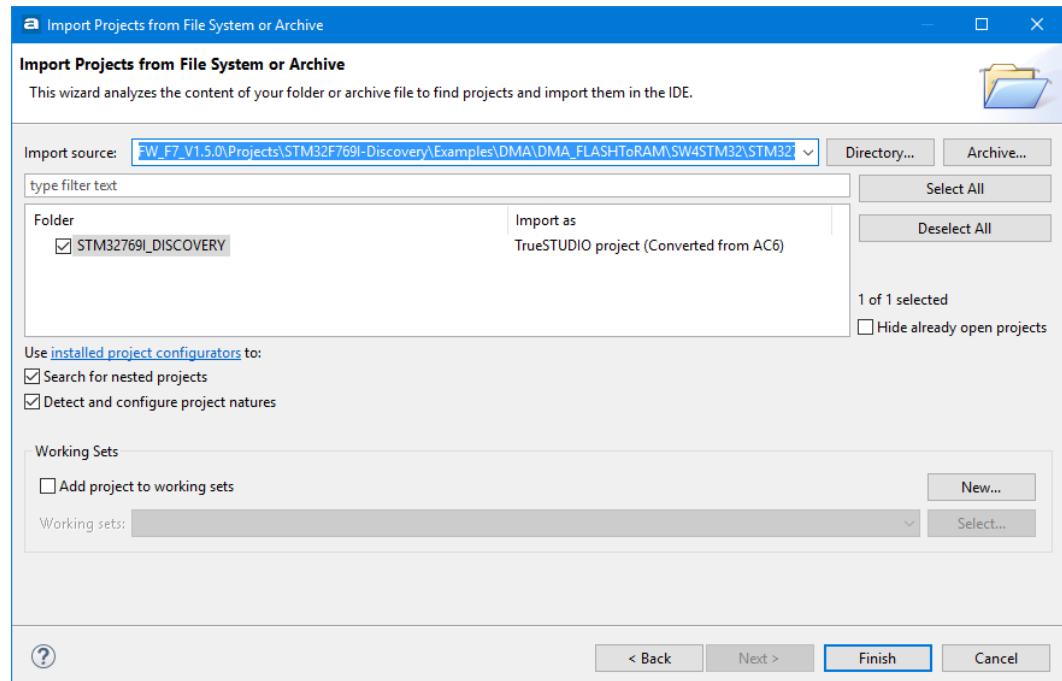


Figure 47 – Import Projects from File System

To see the **Installed project configurators** in the product press the **installed project configurators** link in the **Import Projects from File System or Archive** dialog.

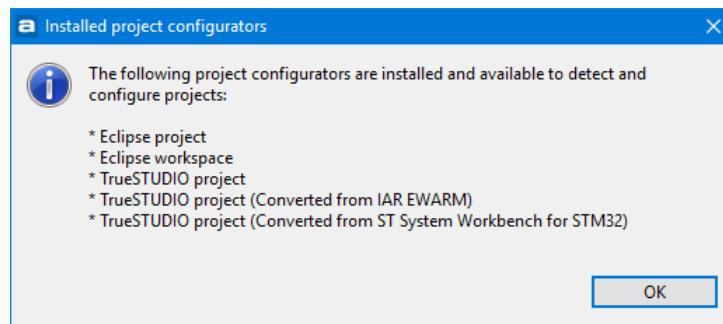


Figure 48 – Display Installed Project Configurators

In the **Import Projects from File System or Archive** dialog browse to the folder containing the project to be imported.



In the **Import as** column in the **Import Projects from File System or Archive** dialog it displays **TrueSTUDIO project** or **TrueSTUDIO project (Converted from AC6)** which informs how the project will be imported.

Do not try to import lines where no information is available in the **Import as** column.

The **Import as** column may also display **Folder already imported as project** and in such cases it will not be possible to import it again into current workspace.



Some examples may use identical project names for projects aimed at different boards. Eclipse cannot handle two or more projects with the same name in a workspace. Therefore, it may only be possible to import one project for a board into the workspace. If an attempt to import a second project with the same name is made, the import will be cancelled silently without any specific message. To import a second project, remove the first project from the workspace or create a new workspace.

Select the project and make sure the checkbox **Detect and configure project natures** is enabled otherwise the **Project Import Converter** will not be used. Press **Finish** to import the project.

The following dialog can be displayed if the **Project Import Converter** prepares to convert the project.

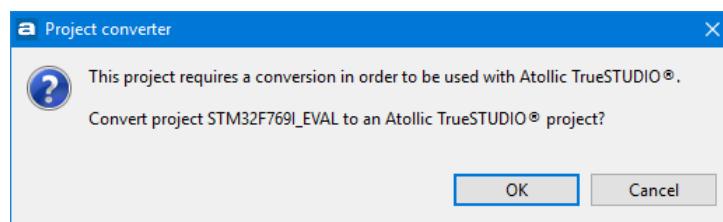


Figure 49 – Project Converter Conversion Information

Press **OK** to import the project with conversion.

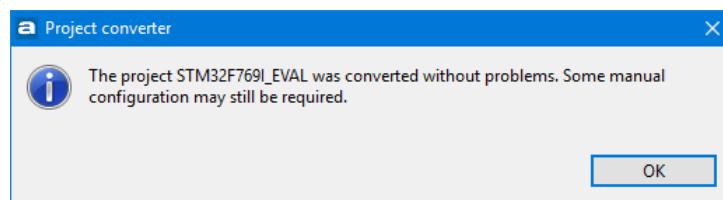


Figure 50 – Project Imported Information

The project is now imported into the workspace. Please note that files included in the project are not copied to the workspace, instead all files are linked to the workspace. This means that the actual files will be updated in the STM32Cube package in this case. Press **OK** to use the imported project.

If a folder which contains several projects are selected and **Search for nested projects** are selected several projects will be seen in the dialog.

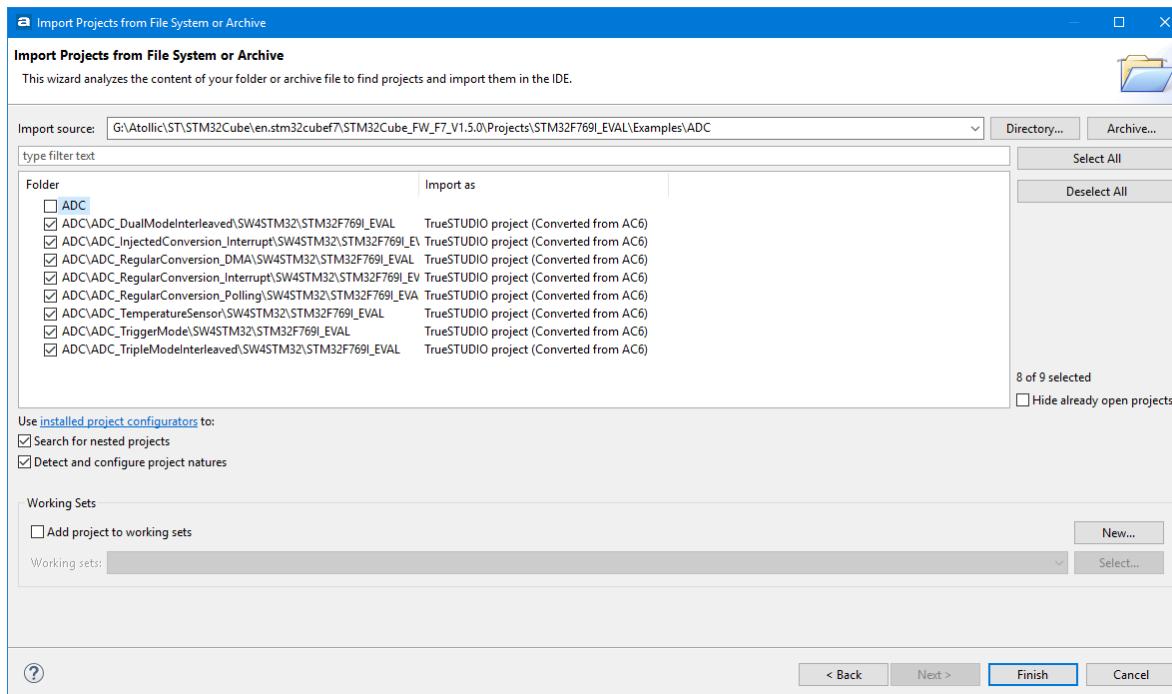


Figure 51 – Import Several Projects from File System

Many projects can then be imported in one step using this method. However, as mentioned earlier the STM32Cube examples uses the same project name for each board and as Eclipse requires different names to be used only one of the selected project in such case will be imported.

IMPORT PROJECTS USING DOUBLE-CLICK

When using double-click on the .project file in Windows File Explorer to import an STM32CubeMX (AC6, SW4STM32) project follow this guide.

After double-click on .project file, **Atollic TrueSTUDIO** will be opened if it is not already started, and the following dialog is displayed.

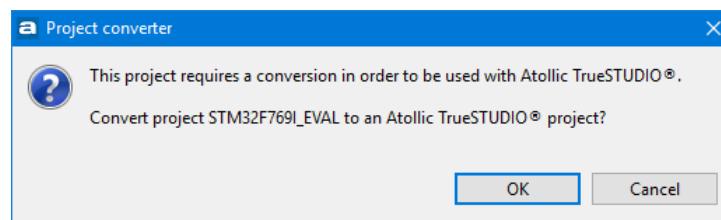


Figure 52 – Project Converter Information

Press **OK** to convert the project and import it into the workspace and a new dialog is opened after a successful conversion.

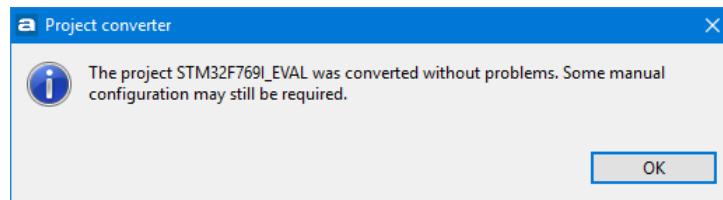


Figure 53 – Project Imported Information

The project is now imported into the workspace. Press **OK** to use the imported project. Please note that files included in the project are not copied to the workspace, instead all files are linked to the workspace. This means that the actual files will be updated in the STM32Cube package in this case.



Some examples may use identical project names for projects aimed at different boards. Eclipse cannot handle two or more projects with the same name in a workspace. Therefore, it may only be possible to import one project for a board into the workspace. If an attempt to import a second project with the same name is made, the import will be cancelled silently without any specific message. To import a second project, remove the first project from the workspace or create a new workspace.

USING IMPORTED PROJECTS

When a STM32CubeMX (AC6, SW4STM32) project has been imported and is converted to **Atollic TrueSTUDIO** project there could be some updates needed. But in most cases it should work to build and debug the project directly.

The first step to use the project in **Atollic TrueSTUDIO** could be to make a build and verify that it builds without errors. After the project has been built a debug session can be started.

First time a debug session is started the **Debug Configurations** dialog will be opened. Make sure to configure to use correct Debug probe, e.g. **ST-LINK** or **SEGGER J-LINK**, and Interface **SWD** or **JTAG** according to hardware requirements. If SWV shall be used then make sure to set the **Core Clock** to the speed of the clock that will be used by the target when debugging the project.

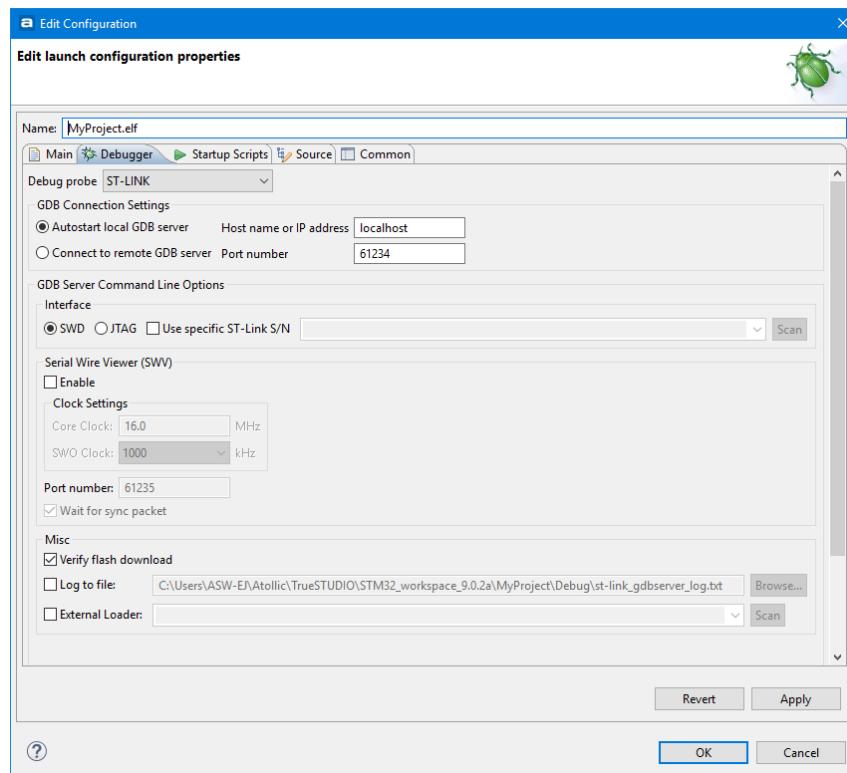


Figure 54 – Edit Debugger Configuration

When correct setting for debugging is set make sure the debugger probe and board is connected and start a debug session by pressing the **OK** button.

RESTORING CONVERTED PROJECTS

As mentioned earlier the **Project Import Converter** made copy of the `.project` and `.cproject` files when the project was converted. The original `.project` file was copied to `.project_org` file. The original `.cproject` file was copied to `.cproject_org` file.

One way to restore the project and use it with AC6 again is to replace these project files with the original files. Open a command prompt and rename the files. (Note! The filename can not be renamed using Windows File Explorer as this program does not allow to rename a file to start with “.”.)

E.g. In a Command Prompt window use the move command to rename the files

1. Rename the converted projet files if you these files shall be kept.

```
move .project .project_ts
move.cproject .cproject_ts
```

2. Replace and use the original files

```
move .project_org .project
move.cproject_org .cproject
```

The project should now be ready to be opened with System Workbench for STM32 (AC6, SW4STM32) again.

CONFIGURING THE PROJECT'S BUILD SETTINGS



How a project is built is saved in a Build Configuration. Each configuration has many Build settings.

Managed Mode projects can be configured using dialog boxes. Unmanaged Mode projects require a manually maintained makefile.

Atollic TrueSTUDIO provides extensive GUI controls for configuration of command line tool options using a simple point-and-click mechanism.

To configure a Managed Mode project, perform the following steps:

1. Select a project in **Project Explorer** view.
2. Click on the **Build settings** toolbar button or select **Project, Build Settings...**



Figure 55 – Build Settings Toolbar Button

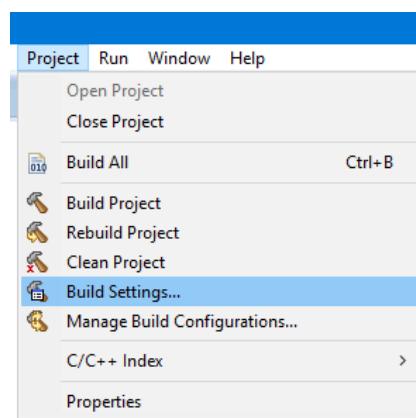


Figure 56 – Build Settings Menu Selection

3. The project **Properties** dialog box is displayed.
4. Expand the **C/C++ Build** item in the tree in the left column. Then select the **Settings** item to display the build **Settings** panel for the active Build Configuration.

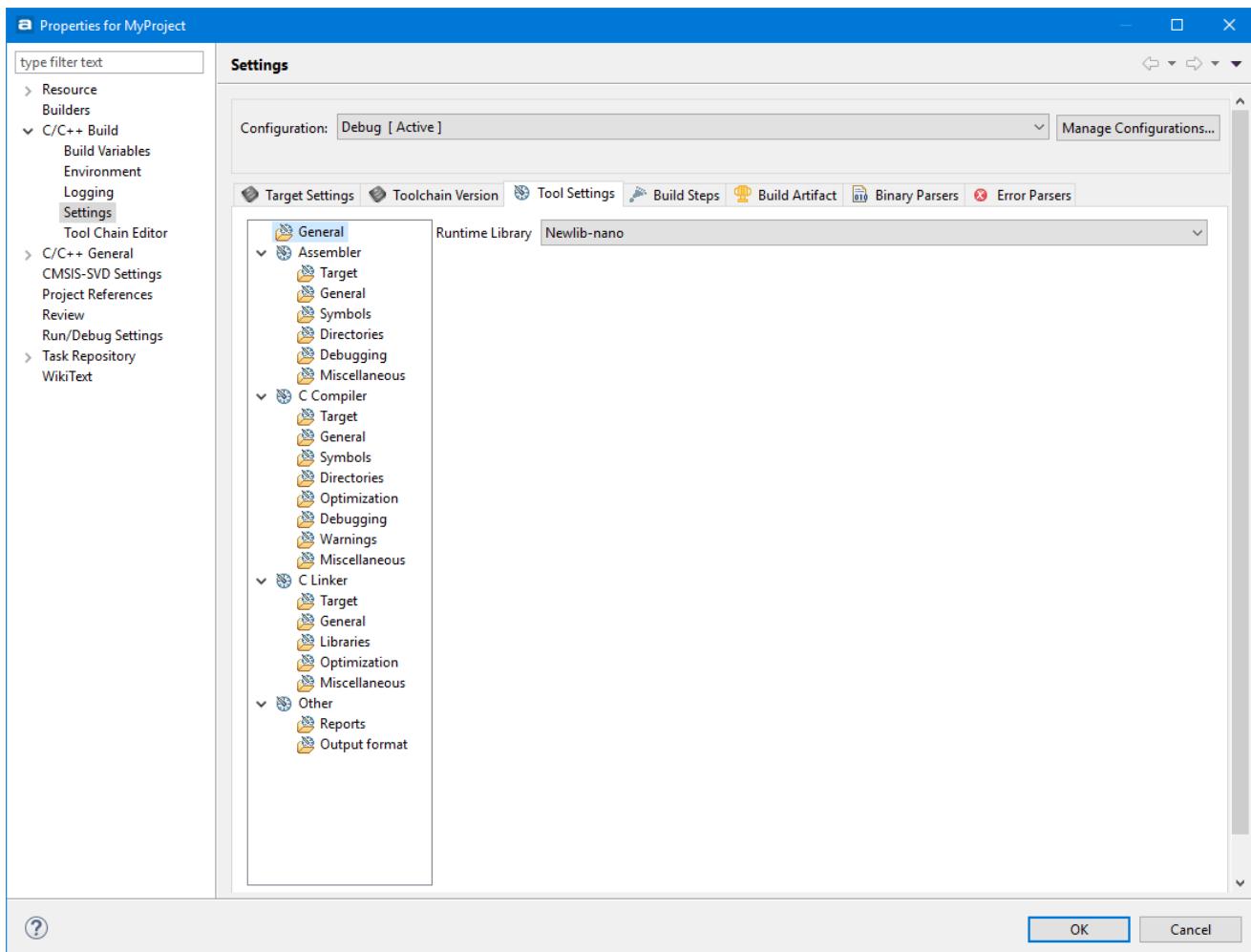


Figure 57 - Project Properties Dialog Box

5. Select panels as desired and configure the command line tool options using the GUI controls.

Advanced users may wish to enter command line options manually. This can be done in the **Miscellaneous** panel for any tool.

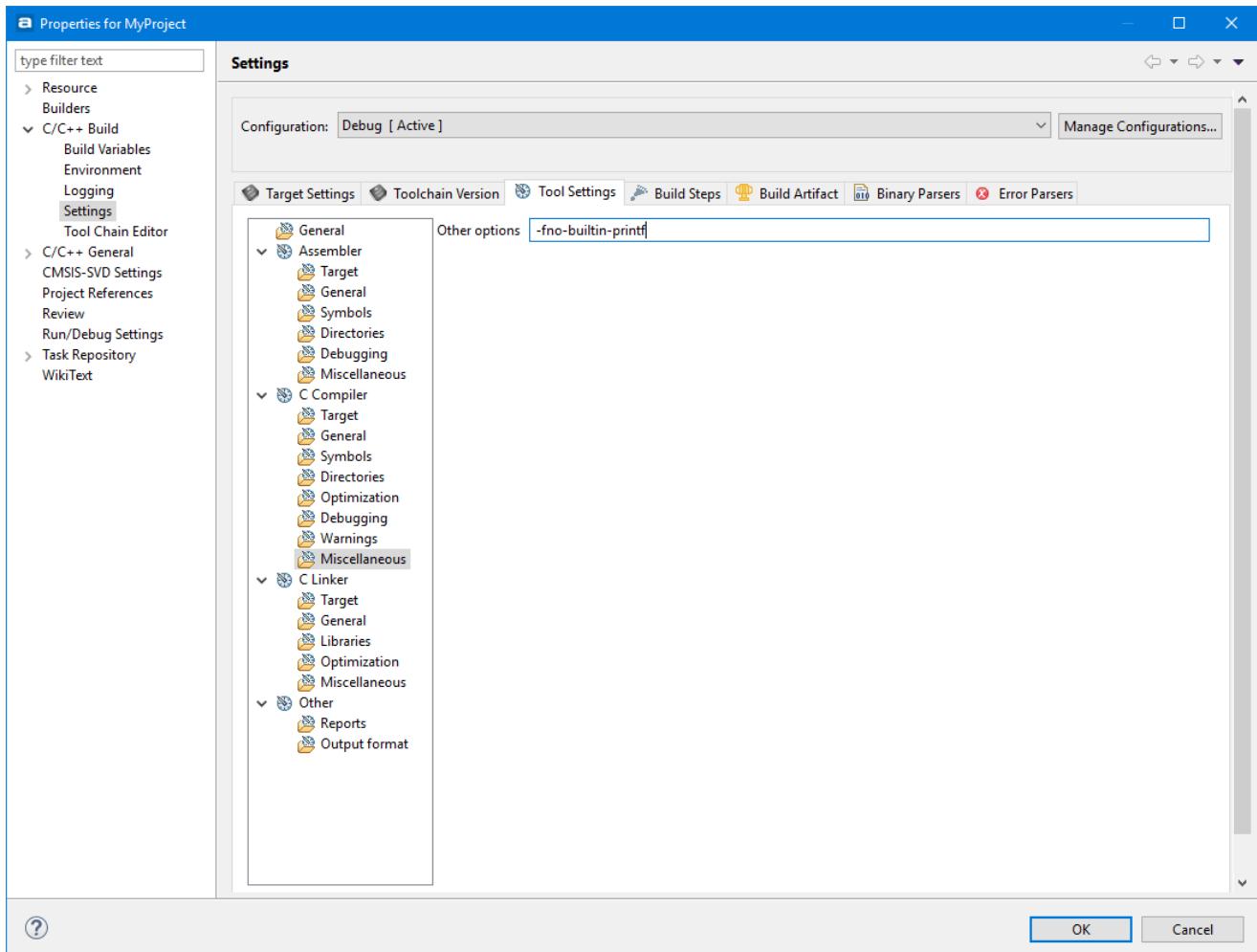


Figure 58 – Tool Settings, Miscellaneous Options

- 6.** Some project build settings are relevant for both Managed Mode projects and Unmanaged Mode projects. For instance the selected microcontroller or evaluation board may affect both the options to the compiler during a Managed Mode build, and also how additional components in **Atollic TrueSTUDIO**, for instance the **SFR** view, and debugger, will behave.

Project build settings relevant for both Managed Mode projects and Unmanaged Mode projects are collected in the **Target Settings** panel.

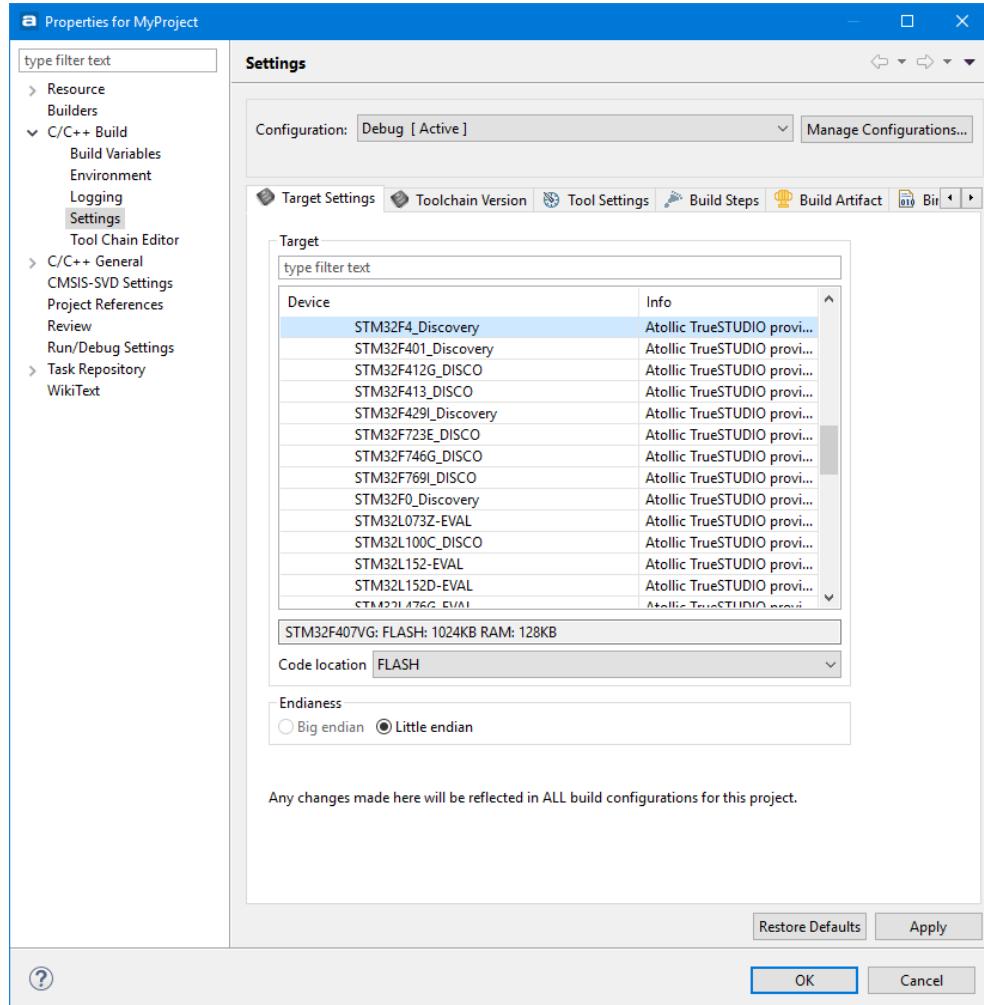


Figure 59 – Target Settings Dialog Box



Any changes made here will be reflected in ALL build configurations for this project.

Changing to a different hardware target, will cause a new linker script file (`.ld`) to be generated, with FLASH and RAM settings adjusted to the memory size of the new target device. See Generate a New Linker Script, page 131 for more information.

However, libraries, header files, etc. will *not* be generated automatically for the new target! These must be added manually to the project.



If the target device needs to be changed, Atollic recommends generating a new project for that target. Copy the source code from the current project to the new project.

7. Click the **OK** button to accept the new settings. This will change the settings for the selected Build Configuration.



The **Build Analyzer** view can be used to analyse the size and location of a program in detail. Please read more about the **Build Analyzer** at page 264

BUILD CONFIGURATIONS

A Build Configuration stores how a project is built. Each Build configuration has several Build Settings. Each Build Setting can be individually set for each Build Configuration.

A Project can have an unlimited number of Build Configurations. This is a very powerful tool to be able to quickly build a project in different ways, such as with different optimization levels, tool chain versions and even different build behavior can be set. It is even possible to have a project be built as both a library and an executable with two different Build Configurations.

A project created in **Atollic TrueSTUDIO** contains by default two Build configurations, the **Debug** and the **Release** configuration. In these configurations there are two build settings that differentiate them. The Debug configuration is built with debugging information and no optimization level. The Release configuration is optimized for small code size and with no debugging information.

Settings done in the project will usually only affect the current configuration. However what Build Configuration that is affected can be selected in the dropdown list located at the top of the panel.

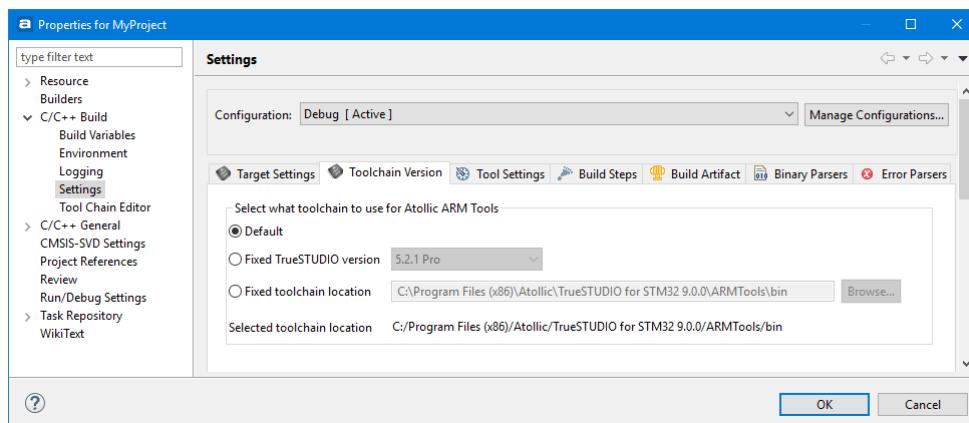


Figure 60 – Select Affected Build Configuration

This does not change what Build Configuration is used when building. To change that the Active Configuration needs to be changed, see [Changing Active Build Configuration](#) on page 90.

When building is done, the build-result such as an .elf-file, is stored in a folder with the same name as the Build Configuration. This makes it easy to locate. For this reason it is also a good idea to not use white space in the name of a Build Configuration.

CREATE A NEW BUILD CONFIGURATION FOR RELEASE

When most of the development is done and it is time to switching to the Release configuration, there might be a lot of settings done under the development process that is missing in the Release configuration.

To make sure that the Release configuration contains all necessary settings, it may be easiest to create a new Release configuration, copy the settings from the Debug configuration, and then just change the debug information level and optimization level.

1. Select the project in the Project Explorer and right click **Project, Manage Build Configurations...**
2. Optional - Delete the old Release configuration or the configuration that does not have all the used settings
3. Click **New...**
4. Name the new configuration. E.g. NewRelease. It is recommended not to use any whitespaces in the name of the Build Configuration.
5. Select to copy settings from the existing Debug configuration.
6. Click **OK**.
7. Select the new NewRelease configuration and click **Set Active**. This determines what Build Configuration is to be used when building the project.
8. Close the dialog by clicking the **OK** button.

Next, open up **Project, Properties**, and navigate to **C/C++ Build, Settings, Tool Settings**. In the **Debugging** node, for the Assembler and C/C++ Compiler, set the debug level to **none**. Then select an optimization level in the **Optimization** node for the C/C++ Compiler.

The build output folder will be named as the active build configuration. So when the project is built, the .elf file will be located in the NewRelease folder for the new Release configuration.

Building all Build Configurations

It is easy to build all Build Configurations at the same time.

For another example see *Create a New Build Configuration For an Old Toolchain Version* on page 101.

CHANGING ACTIVE BUILD CONFIGURATION

To change what Build Configuration is used to build, right click the project and select Build Configuration, Set Active and select the preferred Build Configuration

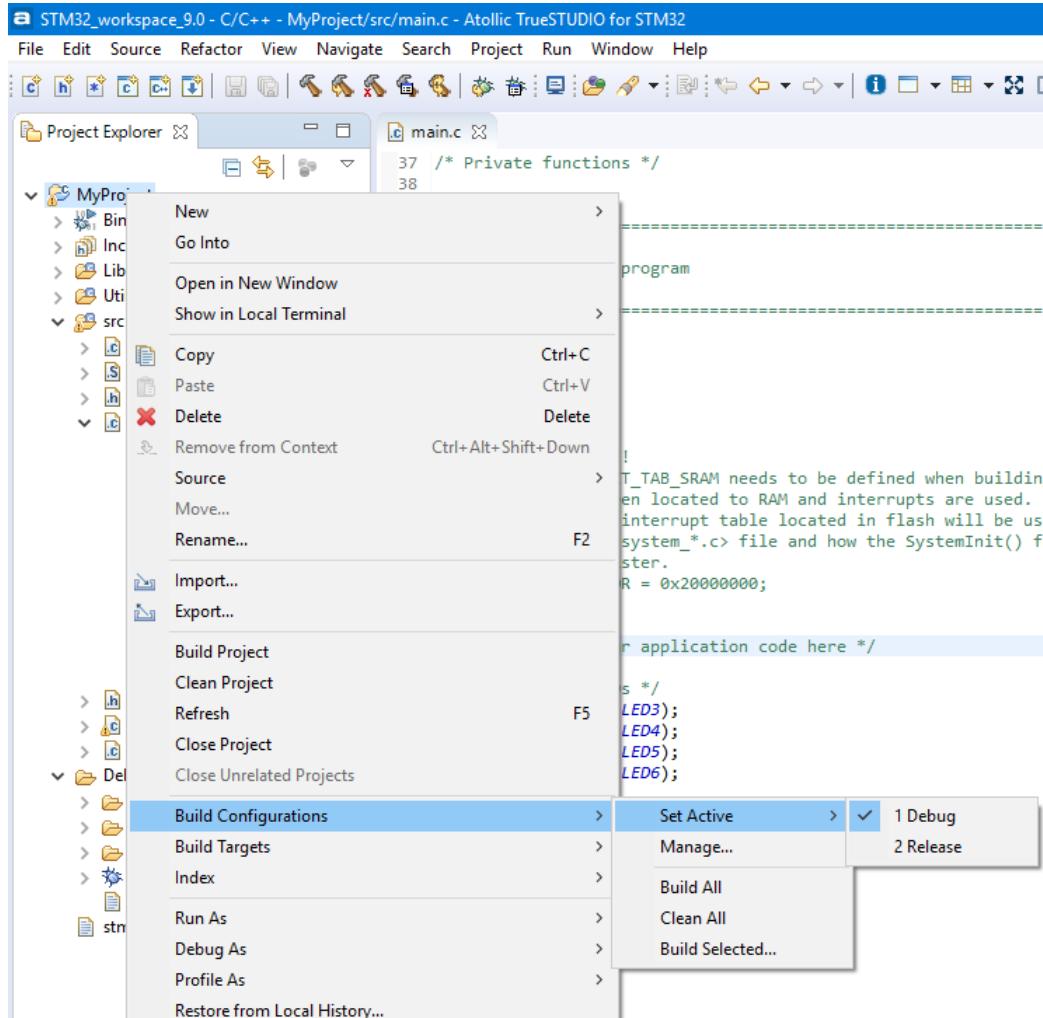


Figure 61 – Change active Build Configuration

SOURCE FOLDERS

A folder within a project can be recognized as a source folder if it is annotated with a small C-icon in the **Project Explorer**.

For **Atollic TrueSTUDIO** to be able to recognize changes in a source file, it needs to be located in a source folder. Either as a resource located within the project or linked from some other location.

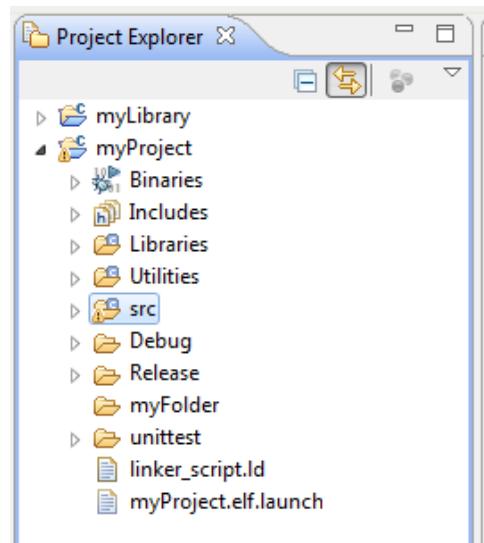


Figure 62 – Source Folders

To make **Atollic TrueSTUDIO** handle an existing folder as a new source folder do the following steps:

1. Select the project and in the top menu select **Project, Properties**.
2. In the **Properties** panel open **C/C++ General, Paths and Symbols** and then the **Source Location** tab.

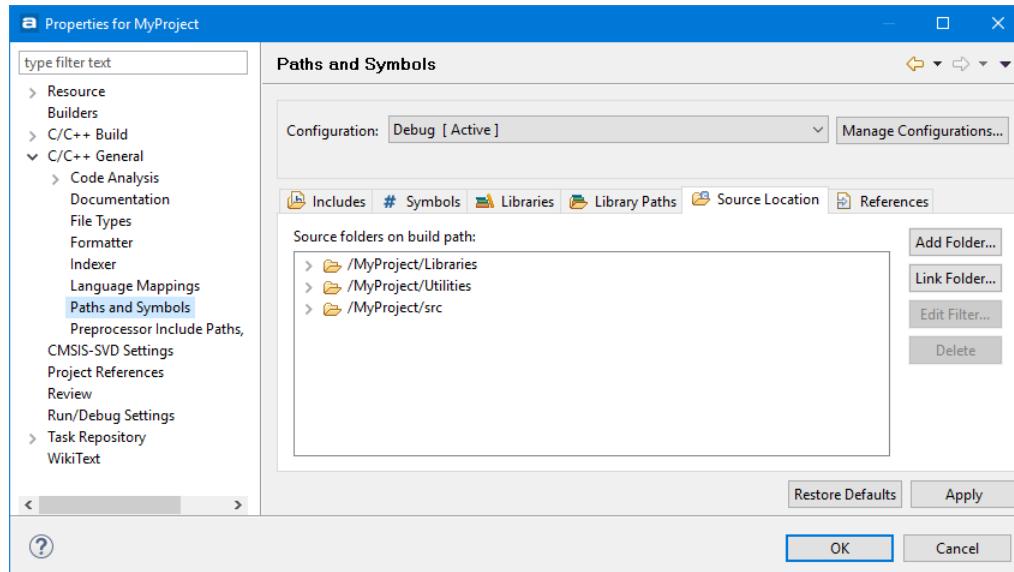


Figure 63 – Source Location Tab

3. Click **Add Folders...** and select the new source location.

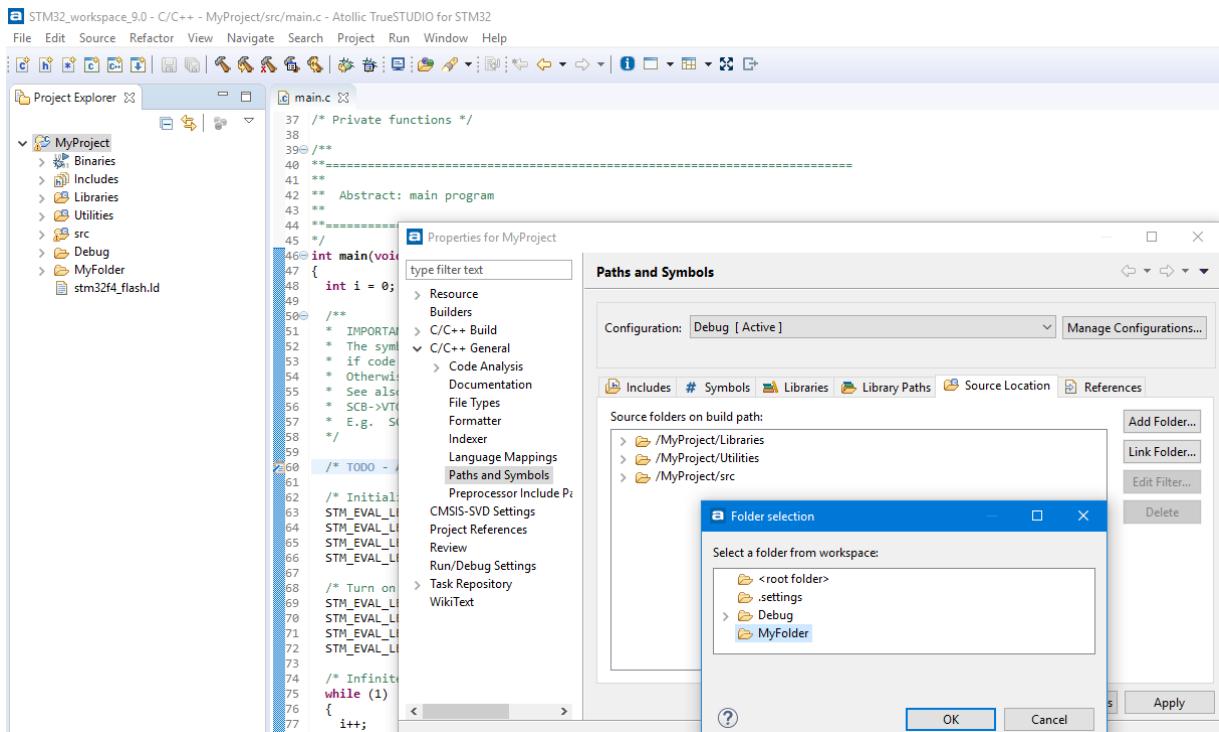


Figure 64 – Folder Selection Tab

There should then be a new Source folder in the project.

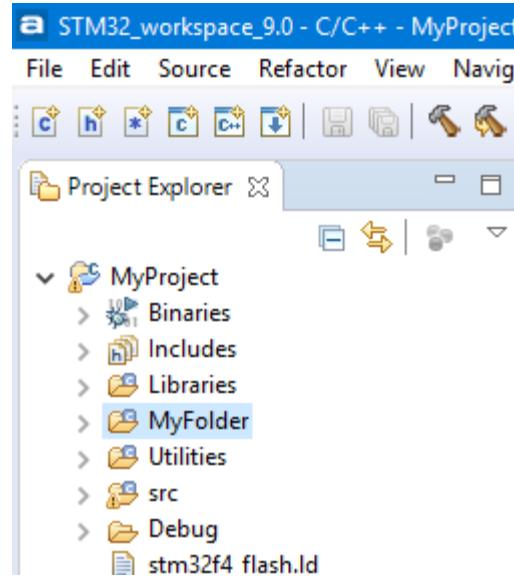


Figure 65 – New Source Folder

INCLUDE LIBRARIES

This guide is for including libraries into **Atollic TrueSTUDIO** projects. For information how to refer to a library created in an existing project, see *Referring Project* on page 119. On page 155 there is a guide for how to Update CMSIS Math library.

In order to include a library into a project right-click on the project where the library will be included; select **Properties**, **C/C++ Build** and **Settings**. Then select the **Tool Settings**-tab, select **C Linker, Libraries**.

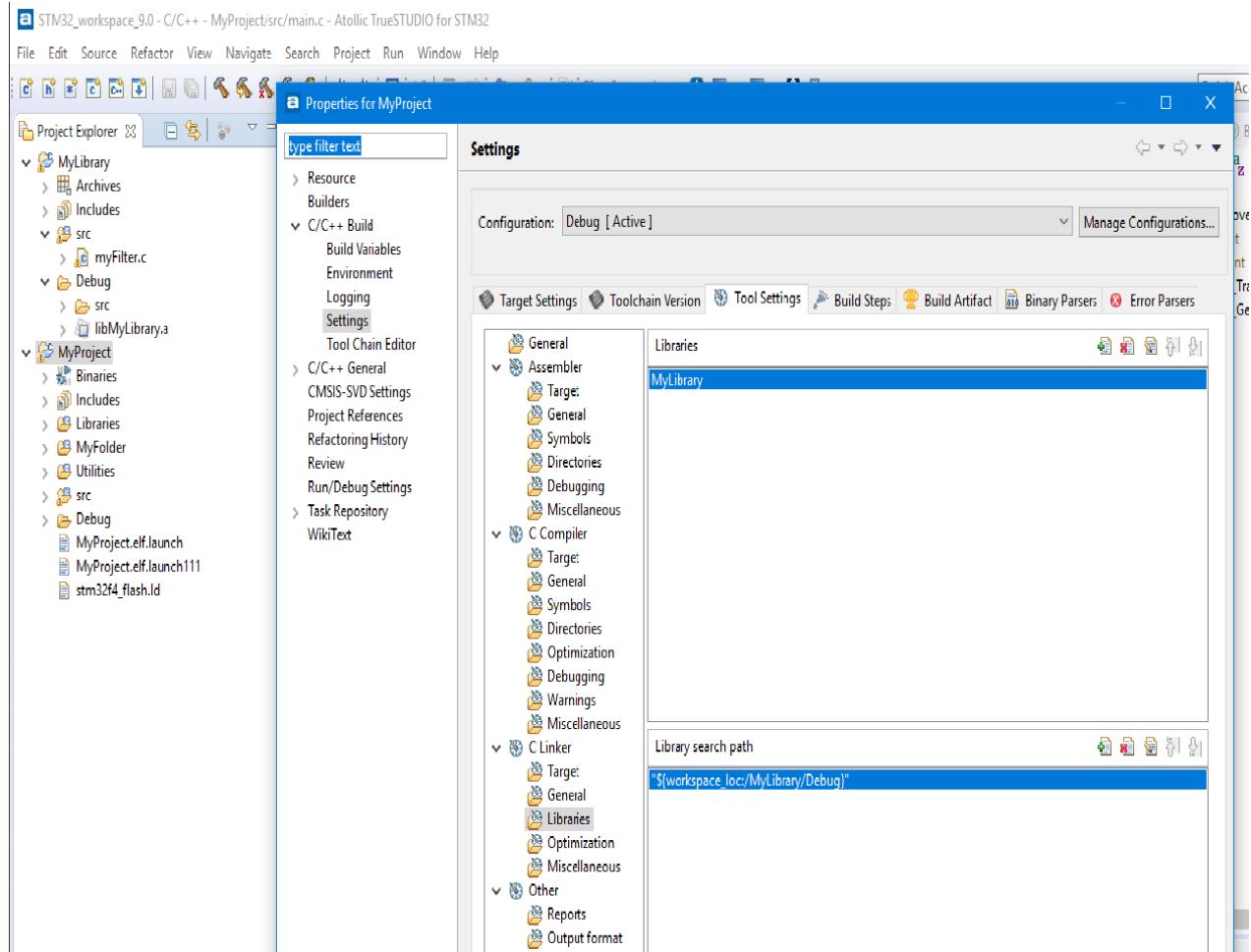


Figure 66 – Include a Library

- 3.** In the **Libraries** list add the name of the library - not the path! The name is the filename without “lib” prefix and without the file extension (.a). It is important not to include those parts of the name. This is a GCC convention.

Example: For a library-file named libMyLibrary.a add the name **MyLibrary**.

If by any chance the library’s name don’t confirm to the GCC convention, the full name to the library can be entered, preceded by a colon “:”.

Example: For a library-file name STemWin524b_CM4_GCC.a add the name **:STemWin524b_CM4_GCC.a**

- 4.** In the **Library Paths** list, set the path to where the library is located. Do not include the name of the library in the path.

Example: `../../MyLibrary/Debug`, this is the path to the archive file of the library project `myLibrary` residing in the same workspace as the application project.

- 5.** The source folder for the header files should also be added to the Include paths. Do that by selecting **Project, Properties, Tool Settings, C Compiler, Directories** and press the **Add...** button. Then add the path to the source folder for the header files in the library.

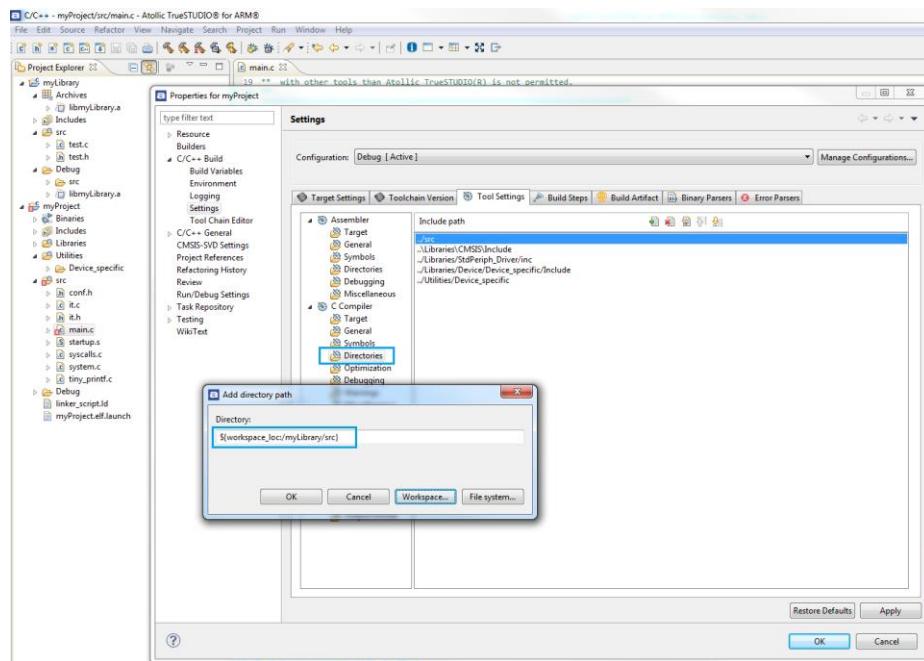


Figure 67 – Add the Library to the Include Paths



Libraries added by include paths are considered static in that way that they are provided by external parties. The .h files are not rescanned as the content should not have changed for external header files.

If external libraries is to be treated as normal source folder, the folders must also be added as source-folders to the project.

This is particularly important when using tools that generates external code, such as STM32CubeMX

The included libraries can also be found by right-clicking the project and select **C/C++ General** and open the **Libraries**-tab and the **Libraries Path**-tab.

See *Referring Project* on page 119 for more information if a project is referring to another project, a library or a normal project.

COMPILER SETTINGS

All the settings for the compiler can be found by open the Build Configuration with the **Build Settings** Toolbar button.

Then select the Build Configuration that should be changed and the **Tool Setting** tab. Select the **C Compiler** tool node.

The compilers command line command and options are then displayed.

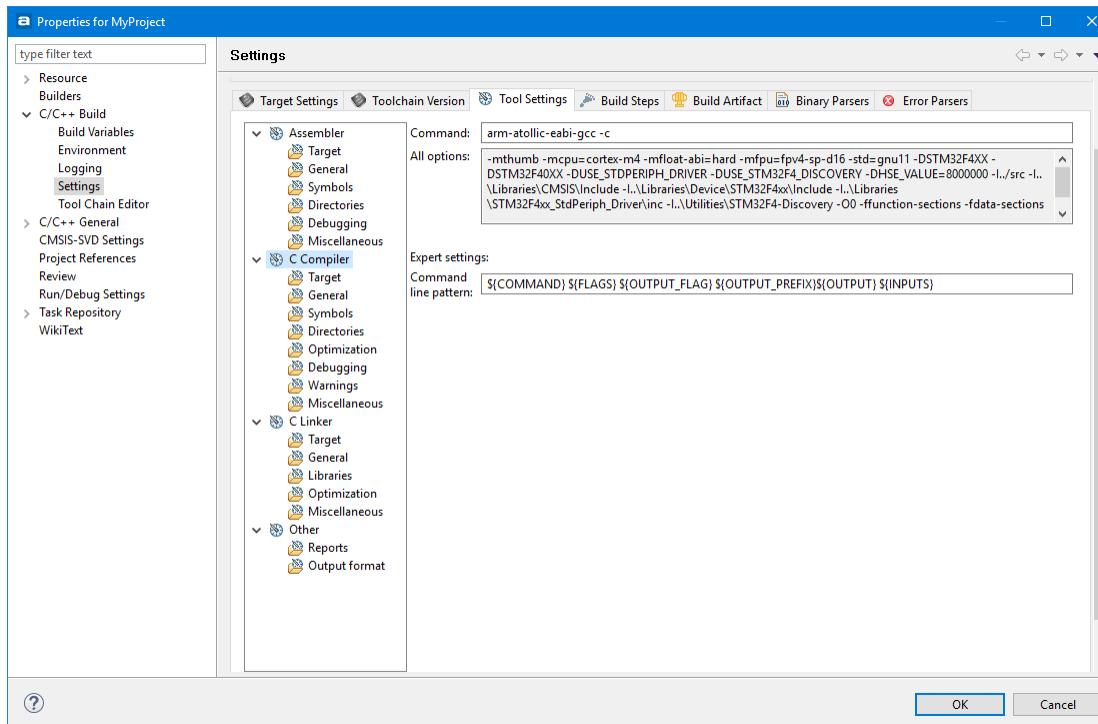


Figure 68 – Compiler Settings

The different nodes below the C Compiler can then be selected to configure how the compiling is done. More about these options are found in the following pages in this chapter.

The options can also be manually changed by editing the **All options** field.

More about all options are found in the *Compiler manual* found in the **Information Center** as the **C/C++ Compiler** link.



See also section *Add or Remove Folder to Include Path* on page 153 for information on an easy way to update the include path.

More information about compiler settings can be found in the Compiler manual. The manual can be found from the **Information Center** view.

Quick start	Documentation center	
Upgrade information	Integrated Development Environment	Build tools
IMPORTANT TrueSTUDIO® Pro Upgrade FAQ If you are using a project created with an older version of TrueSTUDIO® you are highly recommended to read the upgrade manual: Important upgrade information for old projects	Release notes Installation guide Quickstart guide User guide IMPORTANT IAR to Atollic TrueSTUDIO migration guide	Make Assembler C/C++ preprocessor C/C++ compiler Linker
TrueSTORE®	Debugger and utilities	Runtime libraries
Atollic® TrueSTORE® is a super-simple system to download ready-made examples projects via the internet. Download project from TrueSTORE®	Debugger Binary utilities ST-LINK gdbserver J-Link User Guide	C runtime library C mathematics library C++ runtime library Newlib-nano readme
Creating C/C++ projects	Other resources	
To create a new C/C++ project, use one of the two menu commands below: File, New, C project File, New, C++ project	Atollic forum Video tutorials	White papers Application notes

Figure 69 – Finding the C/C++ Manual in Information Center

SET THE COMPILER TO USE THE C99-STANDARD

User can set the compiler to use the C99 standard by adding the '-std=c99' switch to the c compiler tool.

Do this by selecting the General node.

From the dropdown menu select **C99**.

This change will also be reflected in the editor's behavior.

Read more about the status of the C99 implementation here <http://gcc.gnu.org/gcc-4.5/c99status.html>.

Other C standards can also be set with the same drop down menu.

COMPILER OPTIMIZATION

The GNU C/C++ compiler (and hence **Atollic TrueSTUDIO**) have 6 levels of compiler optimization; `-O0` for no optimization up to `-O3` for full optimization. There is one level for size optimization (`-Os`) which is commonly required in embedded projects and another level for speed optimization (`-Ofast`).

Also available is a level for turning on optimizations that won't interfere with the debug experience (`-Og`).

To enable compiler optimization in the commercial versions of **Atollic TrueSTUDIO**, select optimization option from the dropdown list in the **C/C++ Build, Settings, Tool Settings, C compiler, Optimization panel** in the **Project Properties** dialog box. The optimization options can also be set per file in the **File Properties** dialog box, found by right-clicking an individual file.

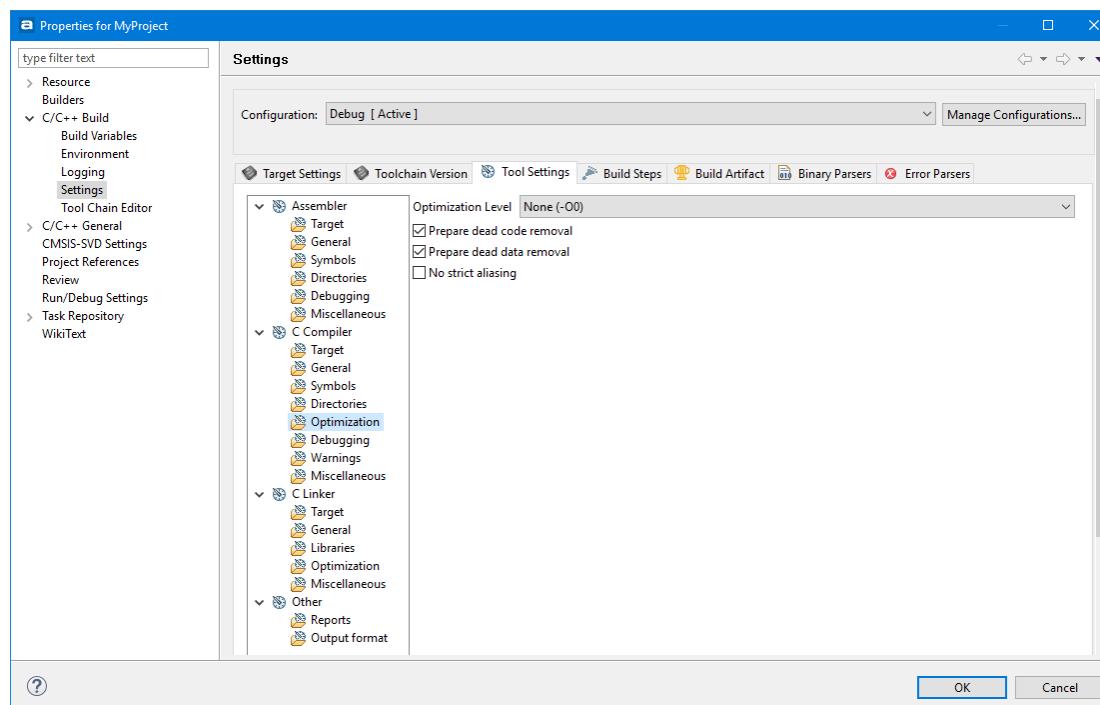


Figure 70 – Compiler Optimization Settings for a Project

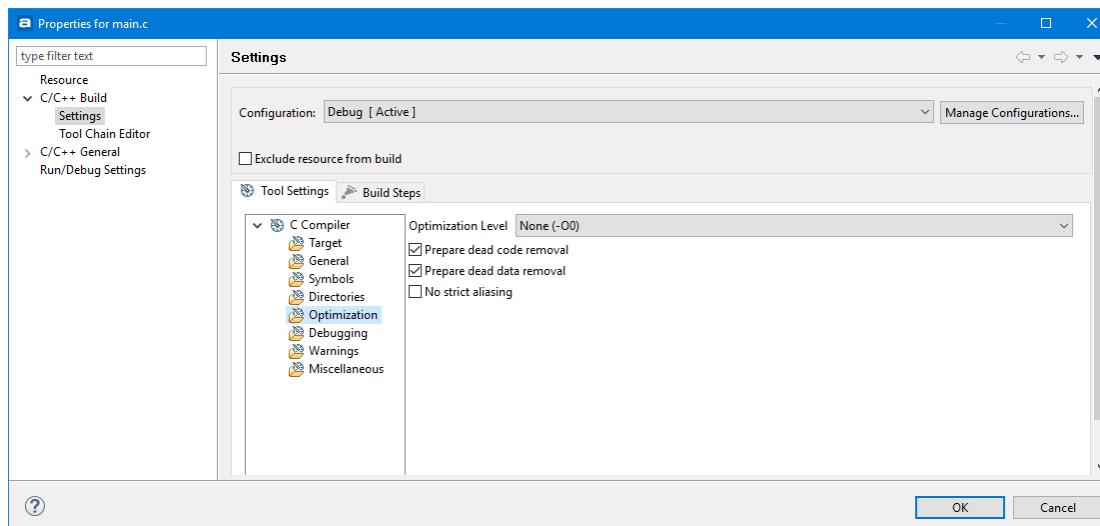


Figure 71 – Compiler Optimization Settings for a File

The optimization setting is per Build Configuration. Per default the Debug configuration is optimized with `-O0` and the Release configuration has `-Os`.

In addition to the simplified optimization settings mentioned above, about 100 optimization settings can be set individually using various command line options and `#pragmas`. Consult the Compiler manual for details. It can be found from the **Information Center** view.

To define a specific optimization level on a block of code, use the `optimize` attribute on the block:

```
void __attribute__((optimize("O1"))) myFunc(unsigned char
data) {
    // The code the needs to have the -O1 optimizing
}
```

LINK TIME OPTIMIZATION (LTO)

Using LTO means that when compiling individual files the output is not object code, but instead an intermediate internal format between the original source code and assembly code. This means that when the linker is doing the final link it has access to more optimizable information about each file and a globally optimized program is generated.

However, because of the way this works also means that in order to use this feature fully it is necessary to provide the linker tool with some extra information that usually has only been supplied to the compiler tool. This extra information can be any optional extra flag that you might have added to the compiler process.

In most cases however it will only be required to add the following flags to the Linker tool **Miscellaneous** field

```
-fno-lto -ffunction-sections -fdata-sections -Os -g
```

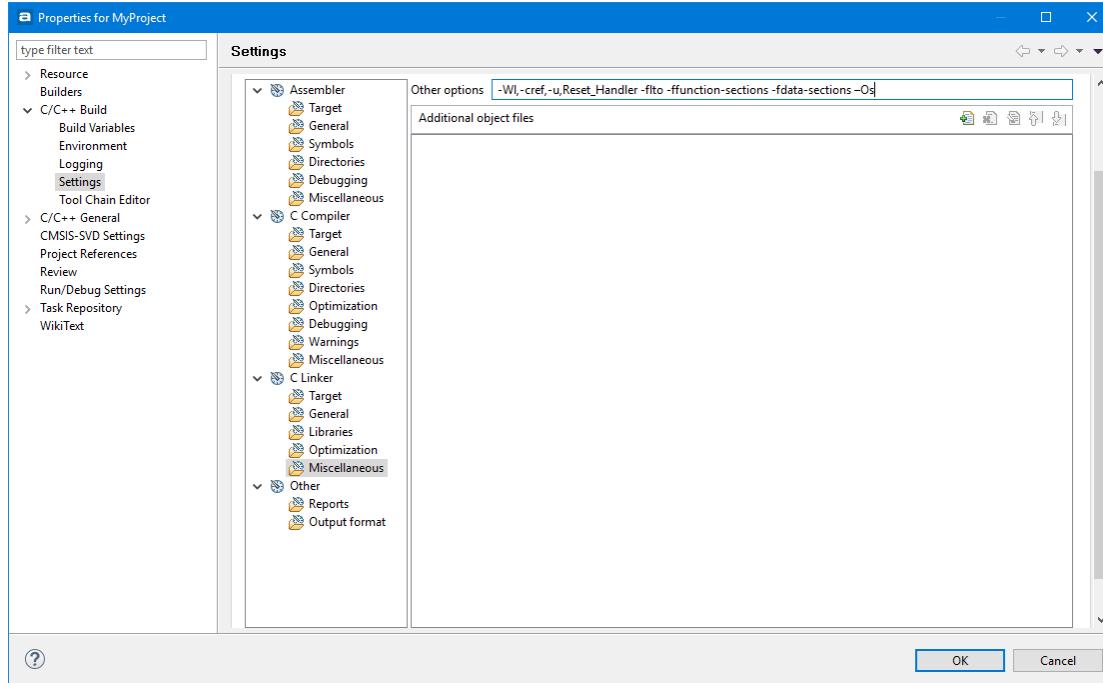


Figure 72 – Linker LTO Settings for a Project

The optimization flag (`-Os`) should have the same value as the optimization flag for the compiler, see page 93 for more information.

Please note! `-g` shall be used to get extra debug information needed when debugging the program.

It is also required to change the Compiler tool settings and there add the `-fno-lto` flag to the miscellaneous field.

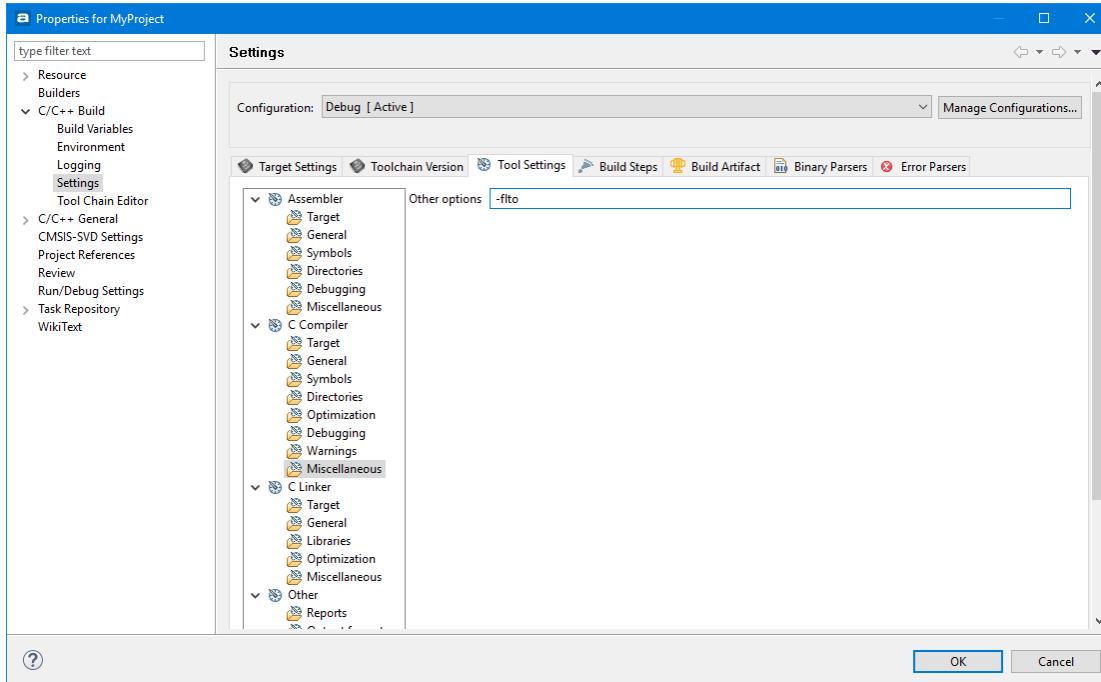


Figure 73 – Linker LTO Settings for a Project

CHANGING TOOLCHAIN VERSION

When upgrading to a new version of **Atollic TrueSTUDIO** it is a good idea to not immediately also switch the tool chain.

To change to an older version of the Atollic ARM Tools toolchain or the PC toolchain click on the **Build Settings** toolbar button.



Figure 74 – Build Settings Toolbar Button

Select the **Toolchain Version** tab.

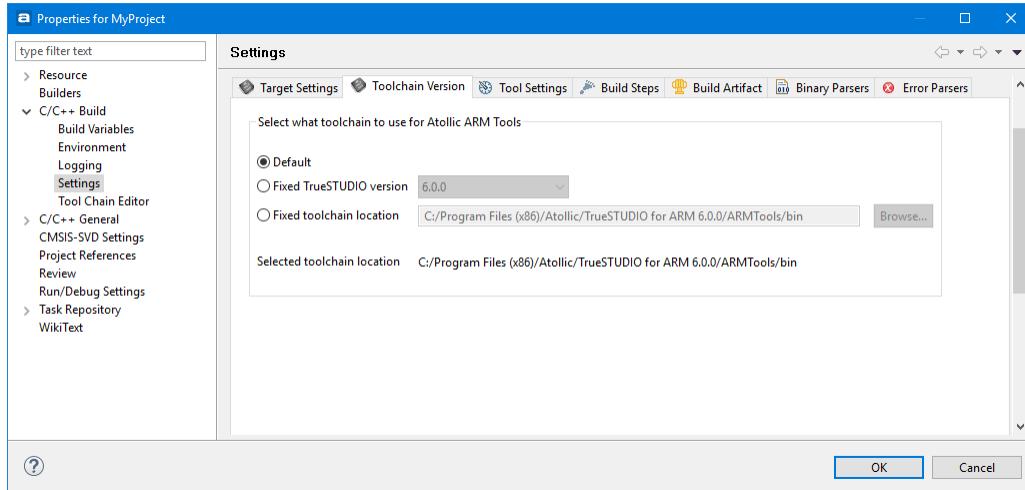


Figure 75 – Tool Chain Version tab

There are three options available here:

- **Default** – This option will use the tool chain in the currently running installation of TrueSTUDIO.
- **Fixed TrueSTUDIO version** – if there are other versions of *Atollic TrueSTUDIO* installed on the computer, this option allows the user to select from what version the tool chain will be selected. It will then select that version even if the installation folder for the selected version is changed.
- **Fixed toolchain location** – Used to point to a specific folder.



When working with a version control system in a team, the second option is strongly recommended for a project. That way all developers will use the same toolchain even if using different versions of *Atollic TrueSTUDIO*.

These setting are saved individually for each Project's Build Configuration. That way it is possible to have different Build Configurations using different toolchain versions. This way a quick regression test can be created.

CREATE A NEW BUILD CONFIGURATION FOR AN OLD TOOLCHAIN VERSION

To create a new Build Configuration for an older version of the toolchain, do the following:

1. Right click the project and select **Build Configurations, Manage...**

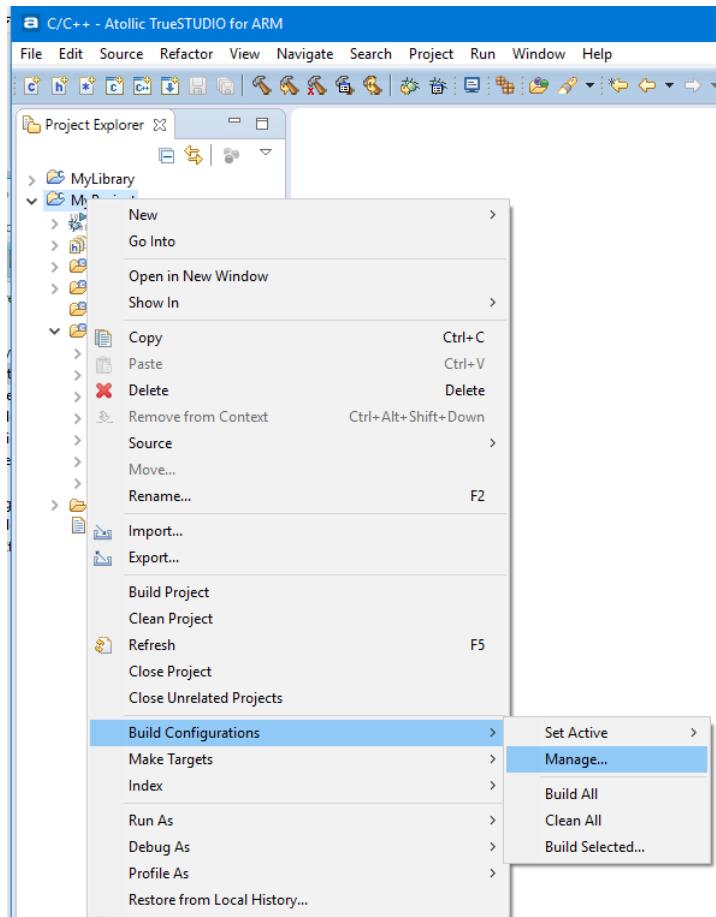


Figure 76 – Manage the Build Configurations

2. In the panel select **New...** to create a new Build Configuration.
3. Enter a good name for the new Build Configuration. Use one word, such as **OldToolChain**, without white space and press **OK** and **OK** again in the **Manage Configuration** panel.

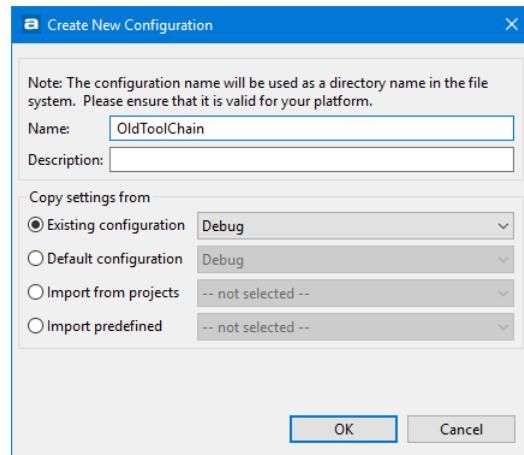


Figure 77 – Create New Configuration

4. In the Toolchain Version tab it is now possible to set the **Default** version of the tool chain for the normal Debug Build Configuration and a **Fixed TrueSTUDIO version** for the OldToolChain **Build Configuration**.

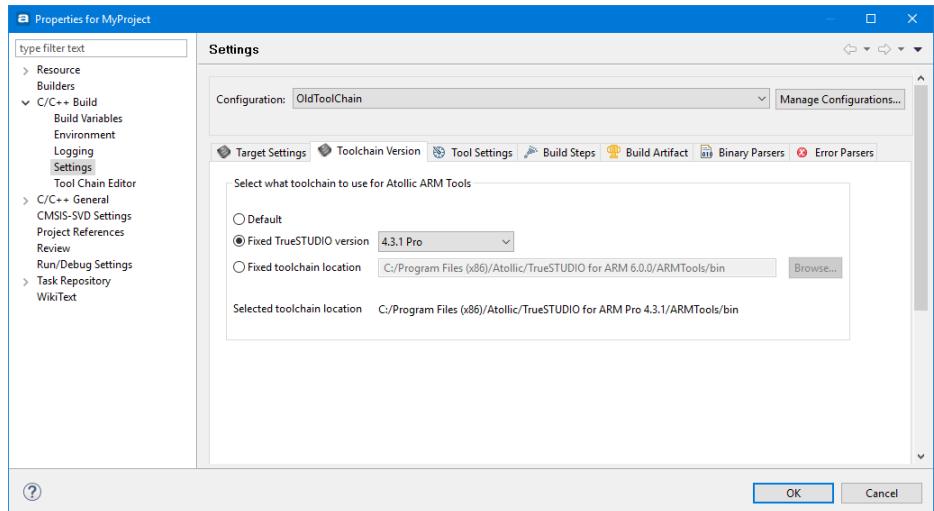


Figure 78 – Old Tool Chain Version for the New Build Configuration

CONVERT .ELF-FILE TO ANOTHER OUTPUT FORMAT

To convert your program to another output format, do the following:

1. Open up **Project, Properties, C/C++ Build, Settings, Tool Settings, Other, Output format**
2. Check the box Convert build output and choose a format in the dropdown menu.

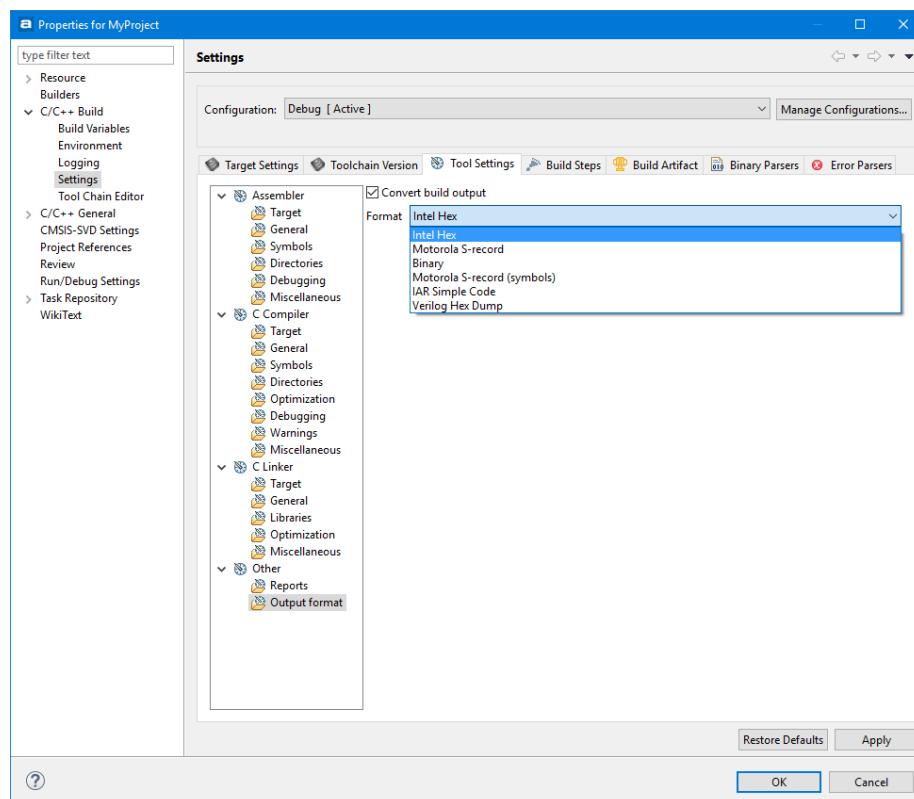


Figure 79 – Output Format Selection

3. Build the project

The converted output will be located in the output directory associated with the currently active Build Configuration, typically Debug/Release directory.

Other supported file formats are: Binary, Motorola S-record, Motorola S-record with symbols, IAR Simple Code and Verilog Hex Dump.

To manually create .hex, .srec and .bin-files, add Post-build steps in the **Build Step** tab:

```
arm-atollic-eabi-objcopy -O binary myfile.elf myfile.bin  
arm-atollic-eabi-objcopy -O ihex myfile.elf myfile.hex  
arm-atollic-eabi-objcopy -O srec myfile.elf myfile.srec
```



Conversion to the IAR Simple Code File Format can only be made using the dropdown menu in **Atollic TrueSTUDIO**. The IAR Simple Code File Format can not be generated with `objcopy`.

TEMPORARY ASSEMBLY FILE

Save the temporary assembly file by adding the -save-tempas flag to the compiler.

In the menu select **Project, Properties, C/C++ build, Settings**.

Open the **Tool Settings** tab.

Then **C Compiler, Miscellaneous**. Add `-save-tempas` and rebuild the project.

The assembler file will be located in the build output directory and will be called:

`FILENAME.s`

There will also be a `FILENAME.i` that is the preprocessed c-code. That is the code as it will look after the preprocessor but before the code is compiled. If there might be a problem with some `#define` then looking into this file is a good idea.

BUILDING THE PROJECT

To start a Build, click on the **Build** toolbar button. Only files that are changed since the last build, or that depends on changed files or settings, will be built.



Figure 80 - Build Toolbar Button

The Build result is displayed in the Console window. At the end are the code size figures. For example:

```
Print size information
text      data     bss     dec      hex           filename
66232    2808    4004   73044  11d54  GSM lib cb1.elf
Print size information done
```

The values are organized according to memory sections and areas. Per default, the linker arranges the memory into the sections `text`, `data`, `bss`. More information is found in the linker script file (`.ld`).

The `dec` and `hex` figures express the size of the `.elf` file. Below the `filename` header is the name of the `.elf` file.



The **Build Analyzer** view can be used to analyse the size and location of a program in detail. Please read more about the [Build Analyzer](#) at page 264

ENABLE PARALLEL BUILD

Parallel Build is when more than one thread is used at the same time to compile and build the code. Most of the times it will reduce the build time significantly. The optimal number of threads to use is usually equal to the number of CPU cores on the computer.

To enable Parallel Build select **Project, Properties** and in the **Properties panel** select **C/C++ Build**. Open the **Behavior** tab and **Enable Parallel Build**.

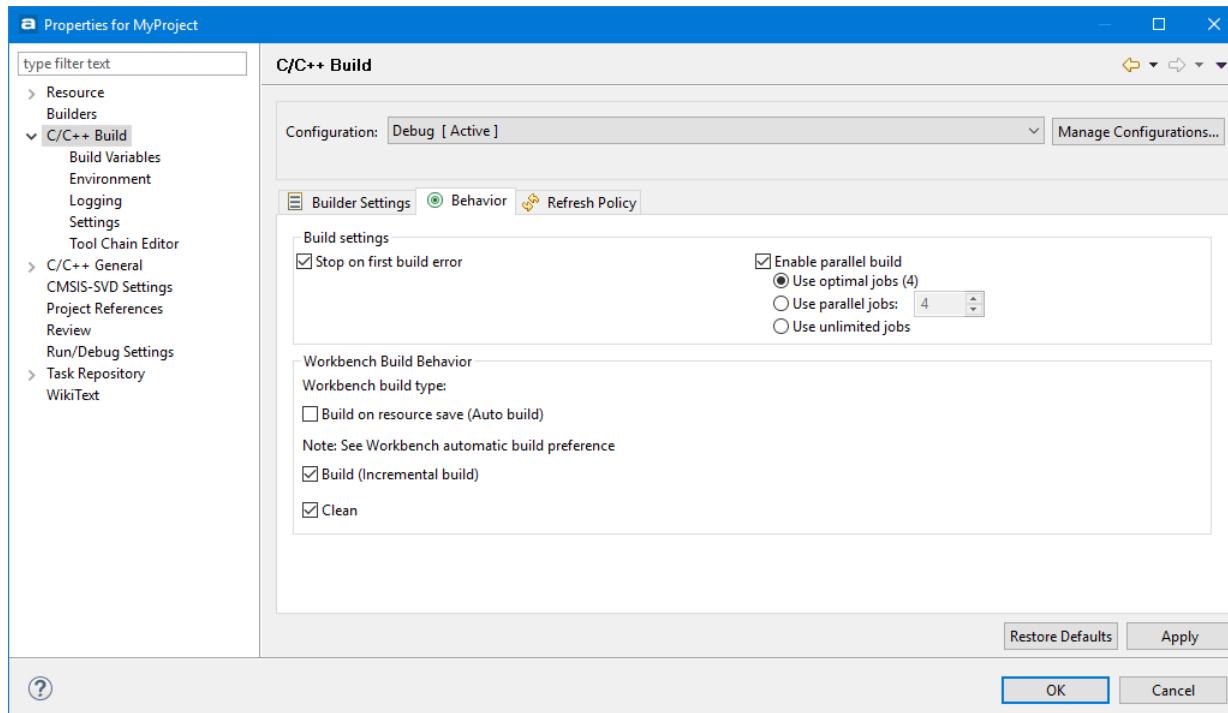


Figure 81 – Parallel Build

ENABLE BUILD ON SAVE

To enable **Atollic TrueSTUDIO** to automatically build a file when it is saved, the **Build Behavior** setting needs to be changed.

In the top menu select **Project, Properties** and in the **Properties panel** select **C/C++ Build**. Open the **Behavior** tab and enable **Build on resource save**.

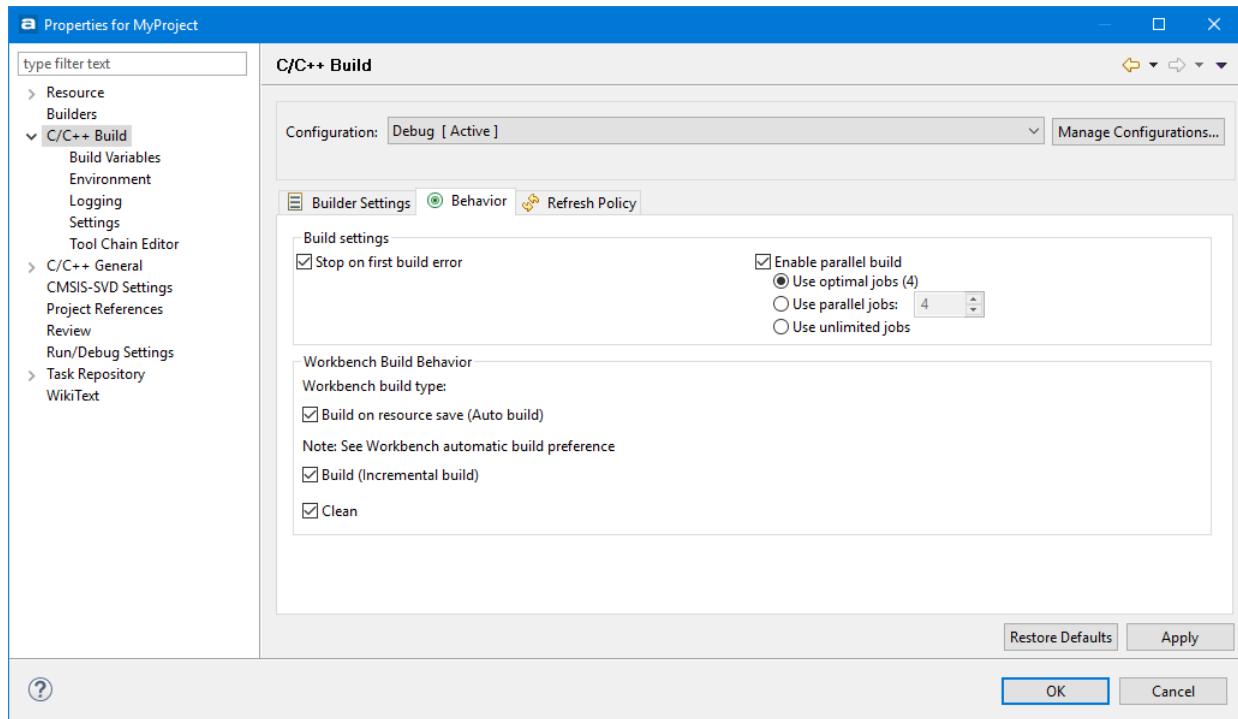


Figure 82 – Build on Save

REBUILD PROJECT

To force a Rebuild of all files included in the project, click on the **Rebuild** toolbar button or select the menu command **Project, Rebuild Project**.



Figure 83 – Rebuild Toolbar Button

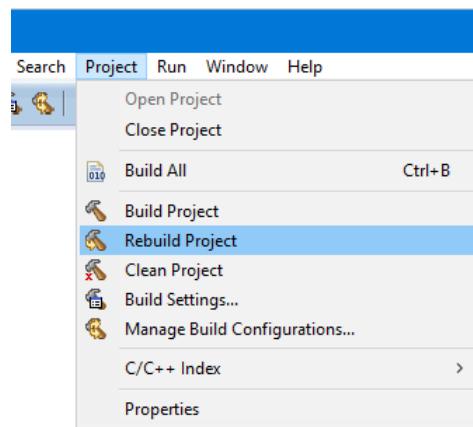


Figure 84 – Rebuild Active Configuration Menu Selection

BUILD ALL PROJECTS

To build all open projects in a workspace, select **Project** in the top menu and then **Build All** or press **Ctrl+B**. This will build the active Build Configuration for each project.

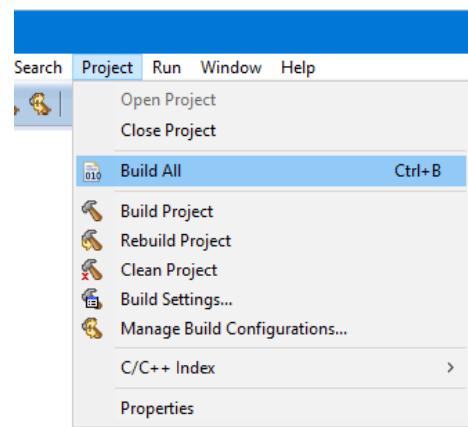


Figure 85 – Build All Projects

BUILD ALL BUILD CONFIGURATIONS

To build all Build Configurations for a project, right-click the project and in the context menu select **Build Configurations** and **Build All**.

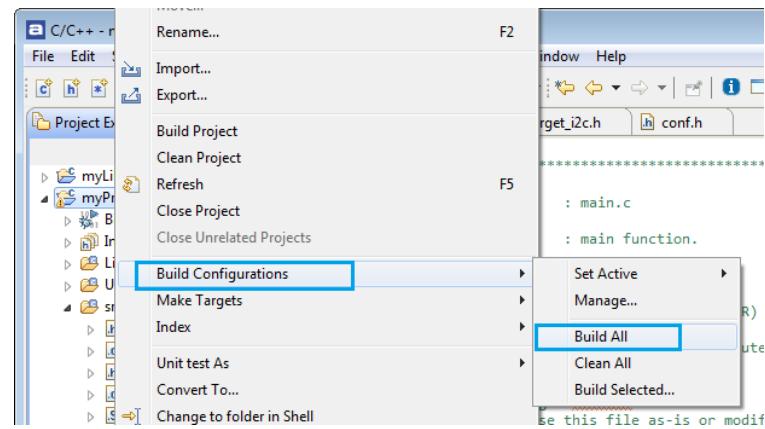


Figure 86 – Build All Build Configurations

HEADLESS BUILD

This is intended for Managed Mode projects that are to be integrated into script-controlled builds, such as nightly builds on build servers for continuous integration process methods, etc. It is possible to start a build process from the operating system command line also for Managed Mode projects. The IDE GUI is never displayed in this case, and the user does not have to interact manually with the IDE at all.

The IDE installation folder, e.g. C:\Program Files (x86)\Atollic\TrueSTUDIO for STM32 9.0.0\ide, contains the file `headless.bat`, which is used for running headless builds.

Option	Description
-data {[uri:/]/path/to/workspace}	This option is always required and selects which workspace to use for the headless build. If the selected workspace folder does not exist, it will be created automatically.
-import {[uri:/]/path/to/project}	Optionally import a project into the workspace before the headless build starts. Please note that importing into a workspace is <i>not</i> the same as copying the files to the workspace. It tells Atollic TrueSTUDIO that there exists new files in a workspace.
-importAll {[uri:/]/path/to/projectTreeURI}	Optionally import several projects into the workspace before the headless build starts.
-build {projname_reg_exp}	Build all build configurations (see page 88 for more information) of the selected project. If the project name contains wildcards (?) and (*), all matching projects will be built.
-build {projname_reg_exp/configname}	Build the selected project using only the selected build configuration. If the project name contains wildcards (?) and (*), all matching projects will be built. This option can be used several times. That way libraries can be built before the project depending on them.
-build all	Build all configurations of all projects in the selected workspace.
-cleanBuild {projname_reg_exp}	Rebuild all build configurations of the selected project. If the project name contains wildcards (?) and (*), all matching projects will be rebuilt.
-cleanBuild {projname_reg_exp/configname}	Rebuild the selected build configuration of the selected project. If the project name contains wildcards (?) and (*), all matching projects will be rebuilt.
-cleanBuild all	Rebuild all build configurations of all projects in the selected workspace.
-I {include_path}	Additional include path to add to tools.
-include {include_file}	Additional include file to pass to tools.
-D {prepoc_define}	Additional preprocessor defines to pass to the tools.
-E {var=value}	Replace/add value to environment variable when running all tools.
-Ea {var=value}	Append value to environment variable when running all tools.
-Ep {var=value}	Append value to environment variable when running all tools.

Option	Description
-Er {var}	Remove/unset the given environment variable.

An option argument is parsed as a string, a comma separated list of strings, or a boolean, depending on the type of option.

Example:

```
headless.bat -data "C:\Users\User\headless\buildWS" -importAll "C:\Users\User\headless\checkOutDir" -cleanBuild all > "C:\Users\User\headless\build.log"
```

This command will create a temporary workspace folder `buildWS` for this build. It will import all projects from the folder `checkOutDir` (not copy, just import to the temporary workspace) and build all build configurations defined in each project. The result will be stored in the folder `checkOutDir`. A log file will be created in the folder `headless`.

Doing an import is vital if either a temporary workspace is used or a batch-script is used and the project to build is checked out from a repository before the build. This is because **Atollic TrueSTUDIO** needs to know about the files before using them to build.

LOGGING

To enable project build logging, right-click on the project and select **Properties**. Then select **C/C++ Build, Loggings**.

The logs can then by default be found in

```
WORKSPACE_PATH\.metadata\.plugins\org.eclipse.cdt.ui\MyProject.build.log
```

A global build log for all projects in a workspace can be enabled by selecting **Window, Preferences** and in the dialog open **C/C++, Build, Logging** and **Enable global build logging**.

THE BUILD SIZE

After building a project, object files and an application binary file (typically in ELF format) exist under the `Debug` or `Release` folder in the **Project Explorer** view file tree.

To study the properties (such as code or data size) of an object file, open the **Properties** view.

To open the Properties view, press the **Show View** toolbar button and select the **Properties** view.

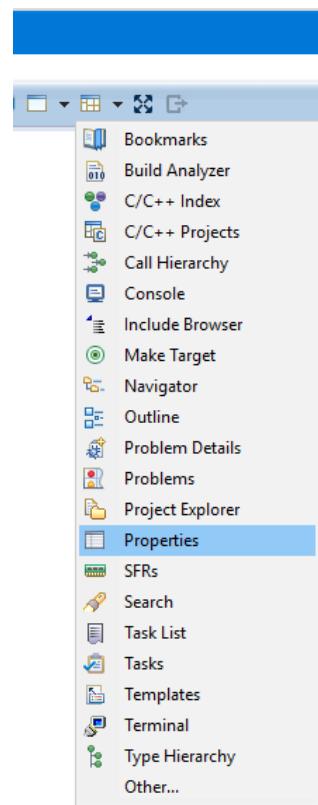


Figure 87 – Open the Properties view

Then select the object file in the **Project Explorer** view. The **Property** view will display a large number of properties, including code and data sizes of the object module.

To study the properties (such as code or data size) of a linked application binary file, open the Properties view and select the ELF file in the **Project Explorer** view.

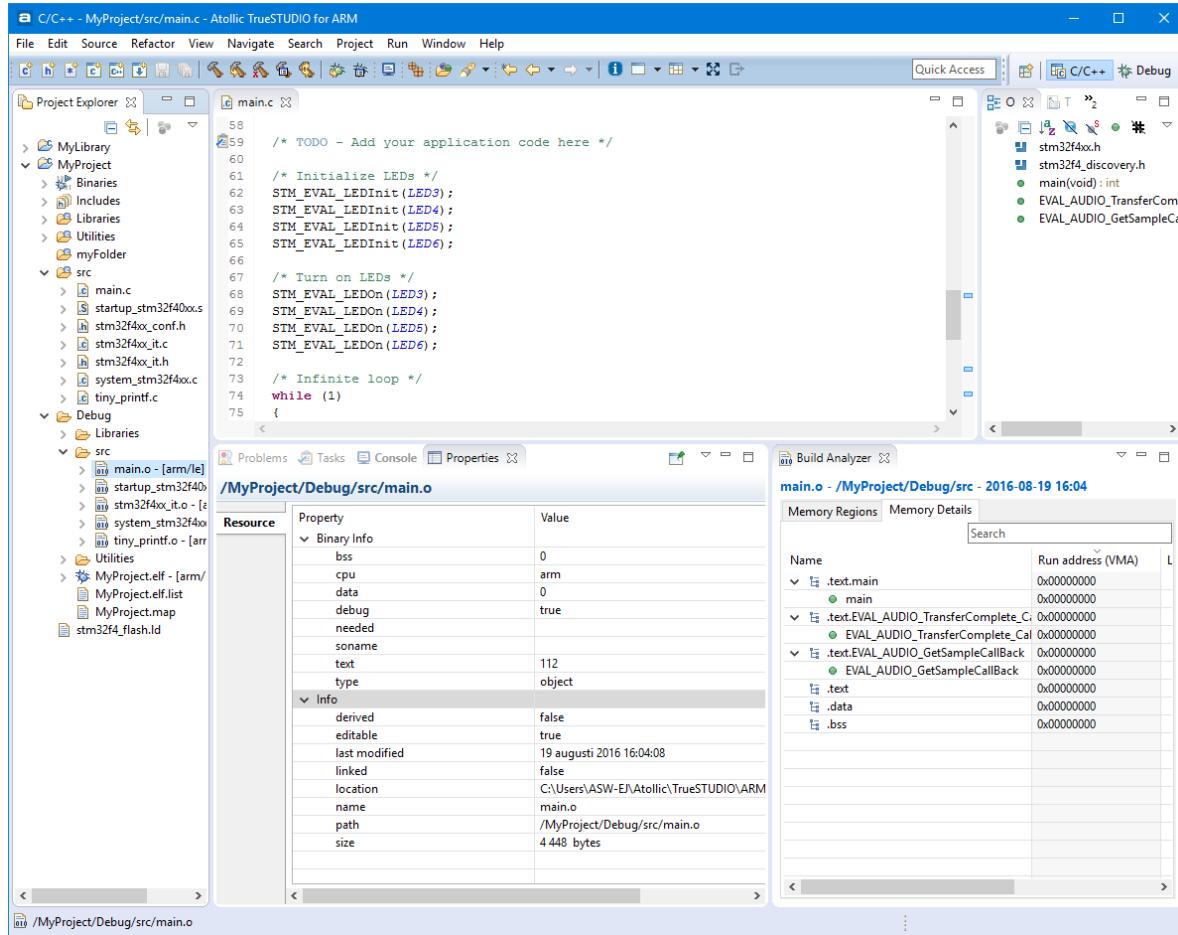


Figure 88 – Open the Properties view

The **Property** view will display a large number of properties, including code and data sizes of the complete application.

Data is normally stored in the "data" segment and code is normally stored in the "text" segment.



The **Build Analyzer** view can be used to analyse the size and location of a program in detail. Please read more about the [Build Analyzer](#) at page 264

COMMAND LINE PATTERNS

The Command Line Pattern is used to assemble parts the builds up the command line that is used to build the project.

To find it, press the **Build Settings** toolbar button.



Figure 89 – Build Settings Toolbar Button

In the **C/C++ Build, Settings** select the **Tool Settings** tab. Each one of the different tools in the toolchain (Assembler, Compiler, Linker and Other) has its own pattern that can be modified.

The pattern consists of the replaceable variables COMMAND, FLAGS, OUTPUT_FLAG, OUTPUT_PREFIX, OUTPUT and INPUTS.

The default command line pattern is \${COMMAND} \${FLAGS} \${OUTPUT_FLAG} \${OUTPUT_PREFIX} \${OUTPUT} \${INPUTS}

White space and other characters are significant and are copied to the created command.

The environment variables can also be used. They are defined in **Project, Properties, C/C++ Build**, and then **Environment**.

CREATE .LIST-FILES

To get list files with assembler information when the files in the projects are compiled the build configurations for the C/C++ compiler needs to be updated.

In the **C/C++ Build, Settings** select the Tool Settings tab and then **C Compiler**. In the **Expert settings** for **Command Line Pattern** add `-Wa,-aln=${OUTPUT}.list` as shown below.

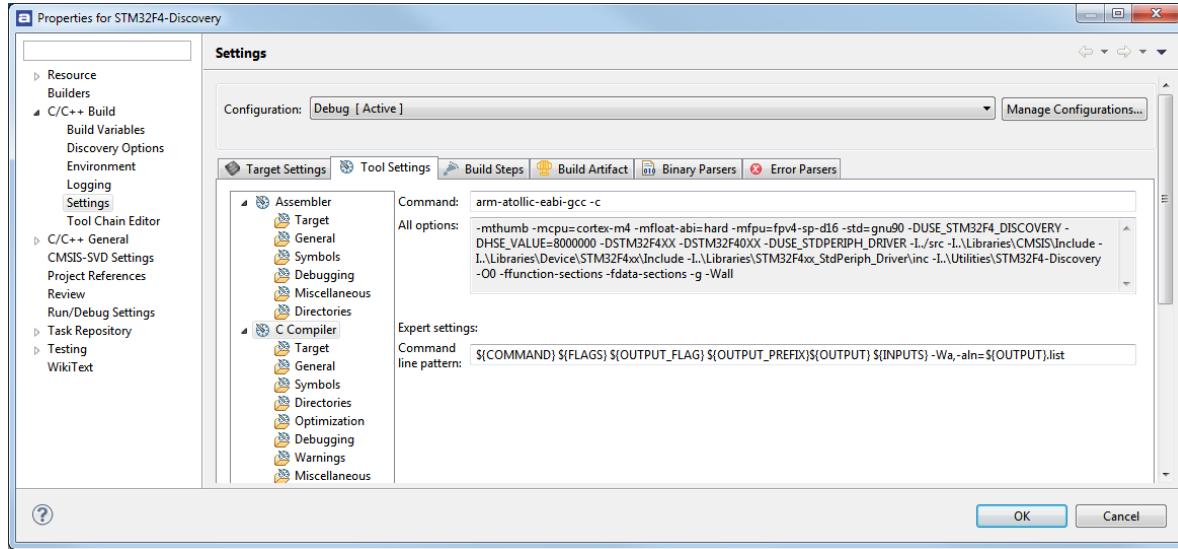


Figure 90 – Generate –list Files

BUILDING ONE FILE

It is a bit complicated to enable the build option to build only one file in a project. It cannot be done while the default setting **Build Automatically** is enabled. This will also disable the **Build on resource save** behavior.

In the top menu select **Window, Customize Perspective** and in the dialog window open the **Menu Visibility** tab.

Expand the **Project** node and enable the **Build Automatically** option.

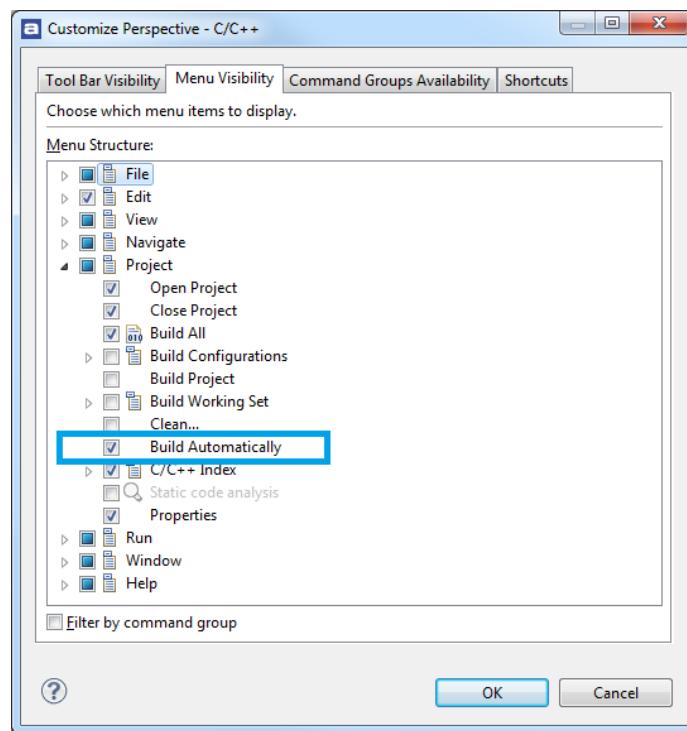


Figure 91 – Enable the Build Automatically Menu Item

Press **OK**, then go to the Project menu and make sure **Build automatically** is unchecked for the project.

The popup menu option **Build Selected File(s)** is now enabled.

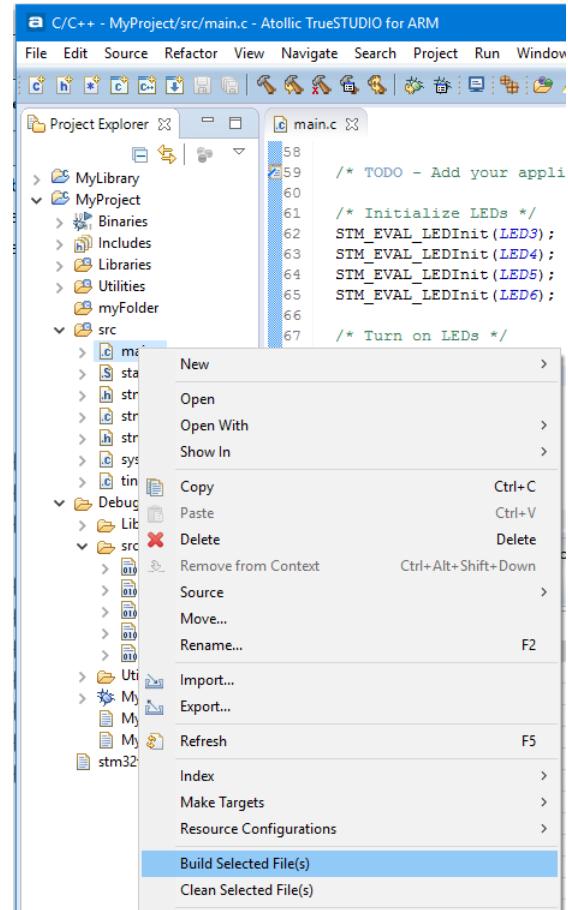


Figure 92 – Build Selected File(s)

LINKING THE PROJECT

For detailed information about the linker, please read The GNU Linker manual. It can be found by selecting the **Information Center** toolbar button and open the **Information Center** view. Locate **Document center**, **Debugger utilities** in the **Information Center** and press the **Linker** link.

Quick start	Documentation center		
Upgrade information	Integrated Development Environment	Build tools	
IMPORTANT TrueSTUDIO® Pro Upgrade FAQ If you are using a project created with an older version of TrueSTUDIO® you are highly recommended to read the upgrade manual: Important upgrade information for old projects	Release notes Installation guide Quickstart guide User guide IMPORTANT IAR to Atollic TrueSTUDIO migration guide	Make Assembler C/C++ preprocessor C/C++ compiler Linker	
TrueSTORE® Atollic® TrueSTORE® is a super-simple system to download ready-made examples projects via the internet. Download project from TrueSTORE®	Debugger and utilities Debugger Binary utilities ST-LINK gdbserver J-Link User Guide	Runtime libraries C runtime library C mathematics library C++ runtime library Newlib-nano readme	
Creating C/C++ projects To create a new C/C++ project, use one of the two menu commands below: File, New, C project File, New, C++ project	Other resources Atollic forum Video tutorials	White papers Application notes	

Figure 93 – GNU Linker manual link

This chapter will explain some of the more common problems encountered during linking.

REFERRING PROJECT

Whenever one project is using code from another project, these should be referring to each other.

If a project needs to refer to a specific build of another project, select instead **Project**, **Properties** and then **C/C++ General, Paths and Symbols** and open the **References** tab and select the **Build Configuration** that the current project is referring to.

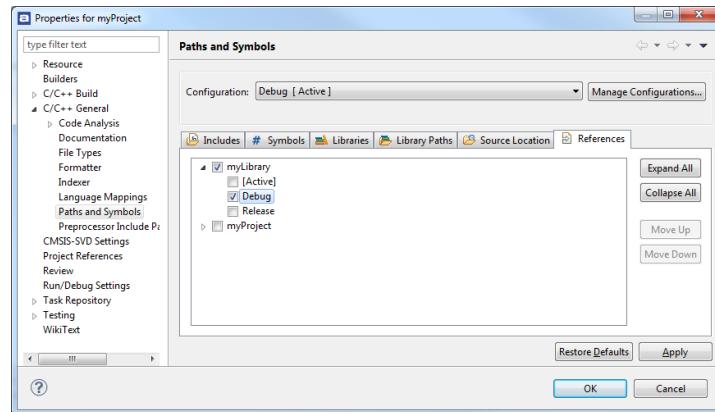


Figure 94 – Set Project References

With this way of referring between different Build Configurations. Note that the references also can have priority among each other.

There are many advantages to having project references correctly set:

- The involved projects will not be rebuilt more than necessary.
- The Indexer will also be able to find functions from the library and open them. To do that press the **Ctrl** key and in the editor, click the library-function where it is used. The source file in the library will then be opened in an editor. For more information about the Indexer, see page 148.
- It is possible to create the Call hierarchy for the functions in the library. To find the Call Hierarchy, mark the function name and press **Ctrl+Alt+H**. The Call Hierarchy will then be displayed in the **Call Hierarchy** view.

If a library project is added as a reference, all the correct setting in **Paths and Symbols** property page for the library will be entered. The tool settings that depends on this Property page will also be adjusted.

This is the recommended method of adding libraries that is developed locally. For more information about adding libraries see page 93.

There is another way to have projects referring to each other. In the top menu select **Project**, **Properties** and select **Project References**. Then select and mark the referred project.

However it is not possible to refer to different Build Configurations from this preference and it will not automatically set up libraries.

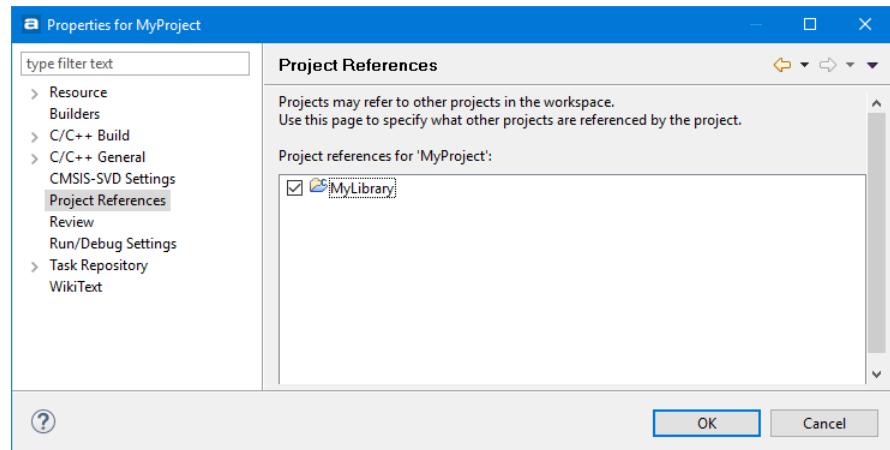


Figure 95 – Set Project References

DEAD CODE REMOVAL

Linker optimization is the process where the linker removes unused code and data sections from the output binary. Runtime- and middleware libraries typically include many functions that are not used by all applications, thus wasting valuable memory unless removed from the output binary.

To enable linker optimization, select the **Remove unused code** and/or the **Remove unused data** checkboxes in the Project wizard as appropriate (at project creation time).

Dead code removal can be selected at any time by opening the Build Configuration in the properties for the project. Right-click the project and select **Properties** and in the dialog select **C/C++ Build, Settings**. In the panel select the **Tool Settings-tab, C Linker, General**. Enable **Dead code removal** and rebuild the project.

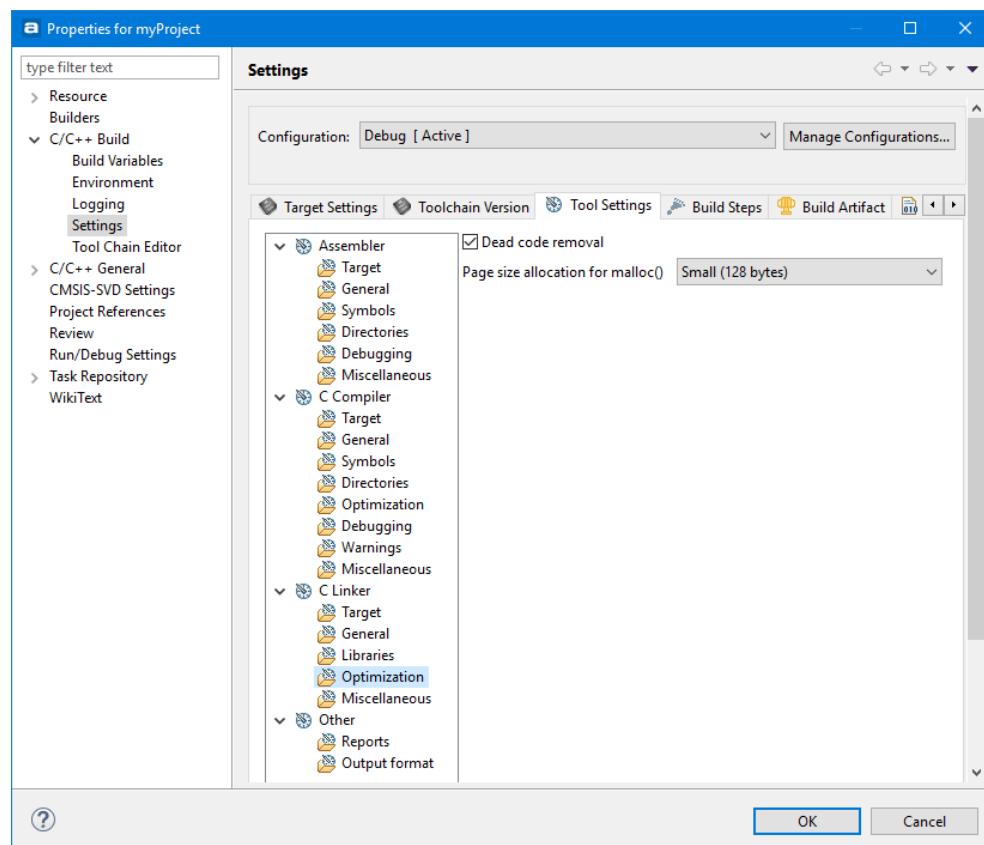


Figure 96 – Enable Dead Code Removal

ADDING CODE TO BE EXECUTED BEFORE MAIN()

The check-box **Do not use standard start files** gives two options to execute user-defined code before entering main, instead of modifying the Reset-handler. Both are triggered by the `libc_init_array` call in the startup code.

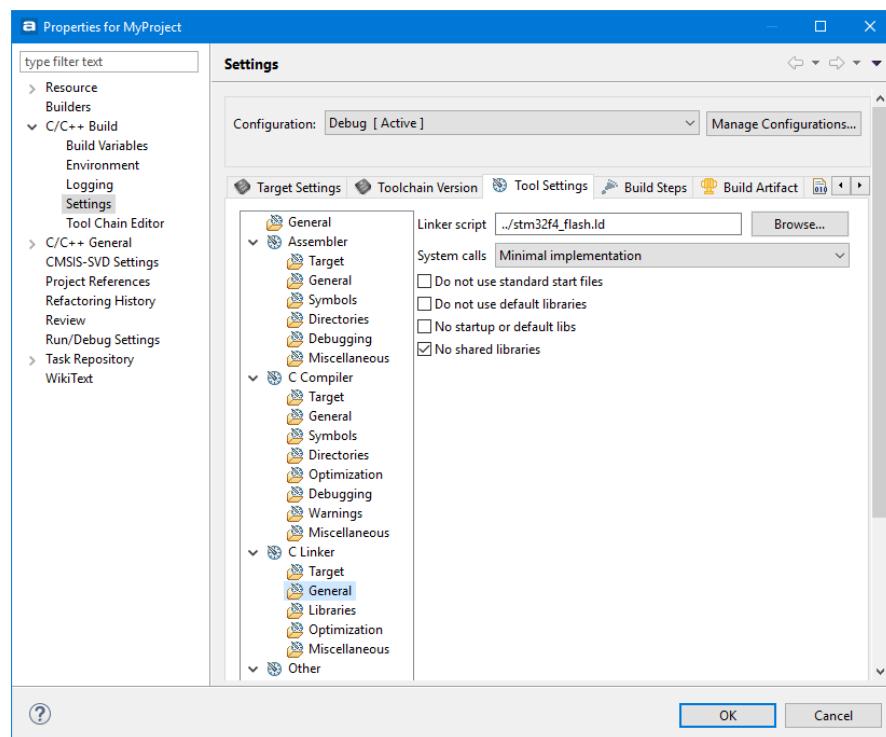


Figure 97 – Do Not Use Standard Start Files

Option1: Constructors for objects or constructor functions are placed in a list called `.init_array`. These functions are then executed one by one by the `libc_init_array`.

Option2: Add code to an `.init` section. `libc_init_array` will run the `_init` function which will execute all instructions added to the `.init` section. The `crti` and `crtn` contains the start and end of the `_init` function.

PAGE SIZE ALLOCATION FOR MALLOC

The page size setting for `malloc` can be changed from 128 bytes to 4096 bytes. The setting for a new project uses 128 as the default value (`malloc_getpagesize_P=0x80` is used when building the project). This means that the heap increases in chunks of 128 bytes. When the page size is set to 4096 the heap will increase in chunks of 4096 bytes. Update the setting if a page size of 4096 is preferred.

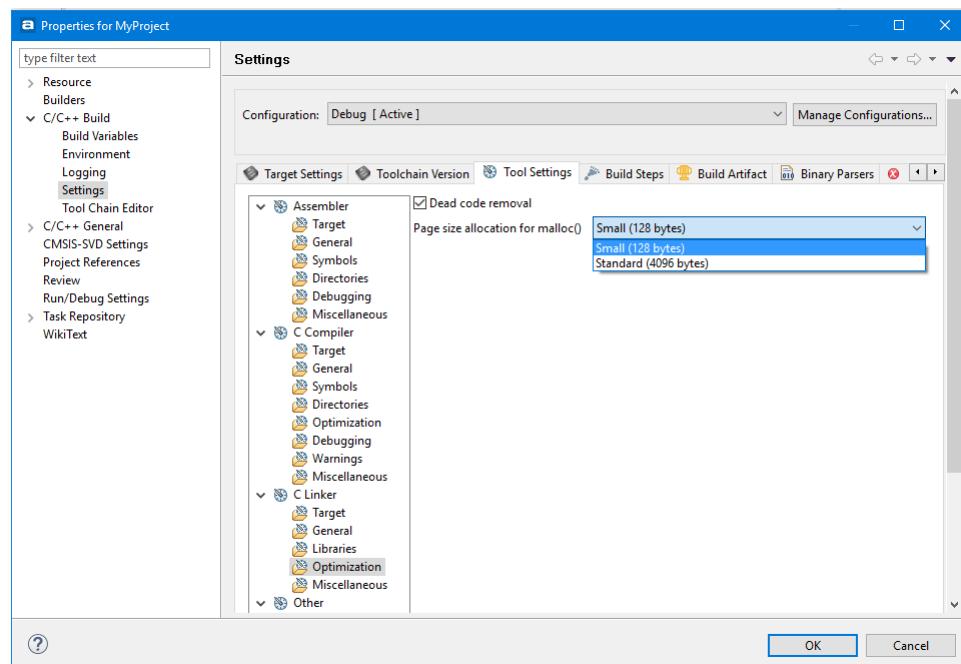


Figure 98 – Linker Page Size Allocation for malloc()

INCLUDE ADDITIONAL OBJECT FILES

In **Atollic TrueSTUDIO** it is easy to include additional object files. It can be files from other projects, precompiled **libraries** where no source code is available or object files created with other compilers.

To do that, open the **Build Settings** panel by pressing the **Build Settings** button.

Then navigate to the **Tool Settings** tab and select the **C Linker, Miscellaneous** node.

Additional object files can either be entered with the **Add file path** dialog or simply cut and pasted into the panel.

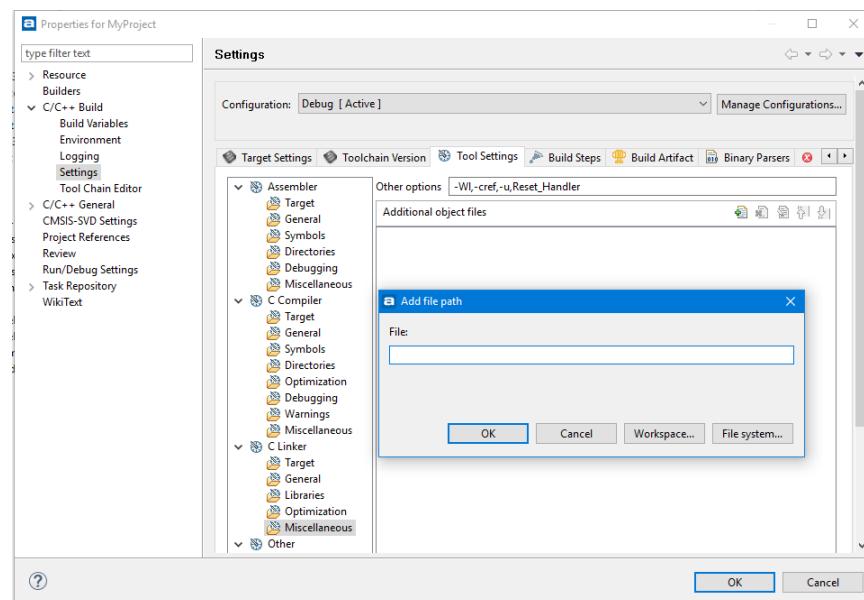


Figure 99 – Add Additional Object Files

If a project has many object files, either created during compilation or added as additional object files, this method is no longer possible. Instead an external list of object files needs to be referred to during linking.

In the Other Options field add `-Wl,@FILENAME` where FILENAME is a file containing a list of object files to be included during linking.

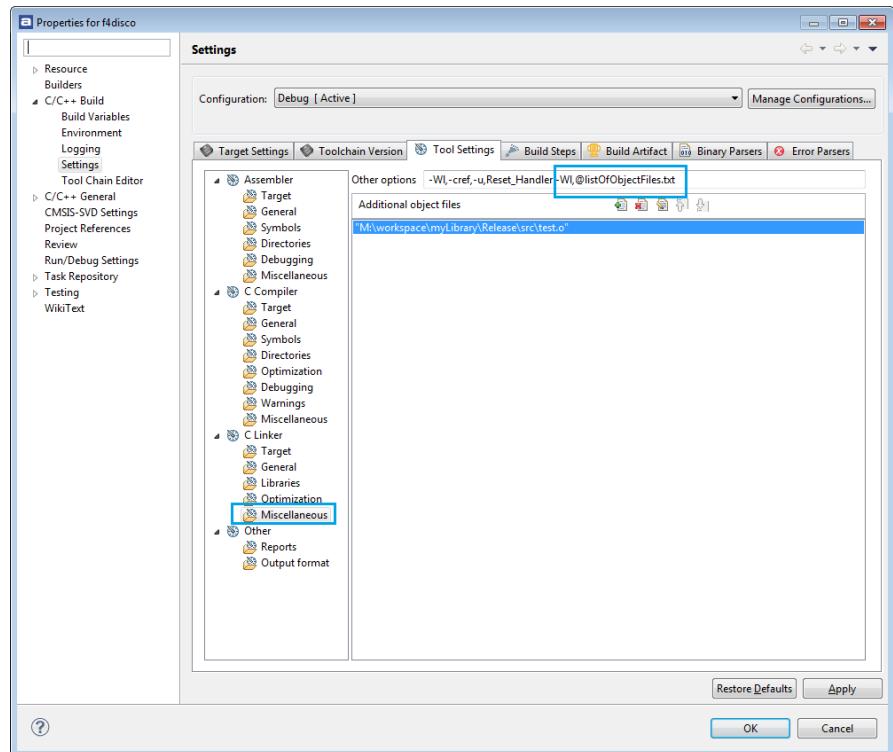


Figure 100 – Add File With a List of Object Files

TREAT LINKER WARNINGS AS ERRORS

The GNU Linker is normally silent for warnings. However, the linker can treat warnings as errors by adding the option **--fatal-warnings**.

One example on how the silent warnings appears is if the startup code containing the normal Reset_Handler function is missing in the project. Then the GNU Linker will in normal silent mode create an elf file and only report a warning output in the Console window about the missing Reset_Handler. Example of warning message:

```
c:/program files (x86)/atollic/truestudio for arm  
7.1.0/armtools/bin/.../lib/gcc/arm-atollic-  
eabi/5.3.1/.../.../arm-atollic-eabi/bin/ld.exe: warning: cannot  
find entry symbol Reset_Handler; defaulting to 08000000
```

When the **--fatal-warnings** option is used the linker will not generate the .elf file but display an error in the console log. Example of error message:

```
arm-atollic-eabi-gcc: error: Wl,--fatal-warnings,-cref,-  
u,Reset_Handler: No such file or directory
```

The easiest way to add the **--fatal-warnings** option is to:

1. Open the **Build Settings** panel by pressing the **Build Settings** button.
2. Navigate to the **Tool Settings** tab and select the **C Linker, Miscellaneous** node.
3. Add the **--fatal-warnings** option to the **Other options** field, e.g.
Update the field from
WI,-cref,-u,Reset_Handler
to
WI,--fatal-warnings,-cref,-u,Reset_Handler

LINKER SCRIPT

The linker (.ld) script file defines where things end up in memory. Some important parts of the linker script file is described below.

1. The ENTRY defines the start of the program.

The first instruction to execute in a program is called is defined with the ENTRY command.

Example:

```
/* Entry Point */  
ENTRY(Reset_Handler)
```



The **ENTRY** information is used by GDB so the program counter (PC) is set to the value of the **ENTRY** address when a program has been loaded. In the described example the program will start to execute from `Reset_Handler` when a step or continue command is given to GDB.

Note! The start of the program can be overridden if the GDB script contains a `monitor reset` command after the load command. Then the code will start to run from reset.

2. The location of stack.

Example:

```
/* Highest address of the user mode stack */  
_estack = 0x20020000; /* end of 128K RAM */
```



The location of stack is normally used by the startup file. The startup code normally initialize the stack pointer with the address given in the linker script. For Cortex-M based devices the stack address is also set at the first address in the interrupt vector table.

3. Define the minimum size of Heap and Stack

It is common to define in the linker script the minimum size of Heap and Stack to be used by the system. Example:

```
/* Generate a link error if heap and stack don't fit into RAM */
_Min_Heap_Size = 0;          /* required amount of heap  */
_Min_Stack_Size = 0x400; /* required amount of stack */
```

The values defined here are normally used later in the linker script to make it possible for the linker to test if the Heap and Stack will fit into memory. The linker can then issue an error if there is not enough memory available.

4. Specify memory regions

The memory regions are specified with name, ORIGIN and LENGTH. It is common also to have an attribute list specifying the usage of a particular memory region, e.g. (rx) , 'r' (Read Only section) and 'x' (Executable section), but there is no need to specify any attribute. Example:

```
/* Specify the memory areas */
MEMORY
{
    FLASH (rx)      : ORIGIN = 0x08000000, LENGTH = 1024K
    RAM (xrw)       : ORIGIN = 0x20000000, LENGTH = 128K
    MEMORY_B1 (rx)  : ORIGIN = 0x60000000, LENGTH = 0K
}
```

5. Specify output sections (.text and .rodata)

The output sections defines where in memory the sections such as '.text', '.data' etc. shall be located. The following example tells the linker to put all .text, .rodata etc. sections in the FLASH region. There are also some glue sections mentioned here and these are used by GCC if there are some mixed code in the program. The glue code is used if there are some arm code which makes a call to thumb code or vice versa. Example:

```
/* The program code and other data goes into FLASH */
```

```
.text :  
{  
    . = ALIGN(4);  
    * (.text) /* .text sections (code) */  
    * (.text*) /* .text* sections (code) */  
    * (.rodata) /* .rodata sections (constants, etc.) */  
    * (.rodata*) /* .rodata* sections (constants, etc.) */  
    * (.glue_7) /* glue arm to thumb code */  
    * (.glue_7t) /* glue thumb to arm code */  
    * (.eh_frame)  
  
    KEEP (*(.init))  
    KEEP (*(.fini))  
  
. = ALIGN(4);  
_etext = .; /* define a global symbol at end of code */  
} >FLASH
```

6. Specify initialized data (.data)

Initialized data values needs some extra handling as the initialization values needs to be placed in flash and the startup code must be able to initialize the RAM variables with correct values. The following example creates symbols _sidata, _sdata and _edata. The startup code can then use these symbols to copy the values from FLASH to RAM during program start. Example:

```
/* used by the startup to initialize data */  
  
_sidata = LOADADDR(.data);  
  
/* Initialized data sections into RAM, load LMA copy after code */  
.data :  
{  
    . = ALIGN(4);  
    _sdata = .;           /* create a global symbol at data start */  
    * (.data)            /* .data sections */  
    * (.data*)           /* .data* sections */  
  
. = ALIGN(4);  
_edata = .;           /* define a global symbol at data end */  
} >RAM AT> FLASH
```

7. Specify uninitialized data (.bss)

Uninitialized data values shall be reset to 0 by the startup code so the linker script file needs to identify the location of these variables. The following example creates symbols `_sbss` and `_ebss`. The startup code can then use these symbols to set the values of the variables to 0.

```
/* Uninitialized data section */

. = ALIGN(4);

.bss :

{
    /* This is used by the startup to initialize the .bss section */

    _sbss = .;           /* define a global symbol at bss start */

    __bss_start__ = _sbss;
    * (.bss)
    * (.bss*)
    * (COMMON)

    . = ALIGN(4);

    _ebss = .;           /* define a global symbol at bss end */

    __bss_end__ = _ebss;
} >RAM
```

When building an **Atollic TrueSTUDIO Project Wizard** generated project, a `.map` and a `.list` file is created in the build output folder (Debug/Release). These files contains detailed information on final location of code/data in the program.



The **Build Analyzer** view can be used to analyse the size and location of a program in detail. Please read more about the [Build Analyzer](#) at page 264

Please read the Linker manual, accessible from the **Atollic TrueSTUDIO Information Center**, for details about how the linker works. Especially section 3.6 and 3.7 could be of interest.

GENERATE A NEW LINKER SCRIPT

From time to time there is the need for a new Linker script, as for instance when changing the target platform for an existing project.

AUTOMATICALLY

This is the recommended method to generate a new Linker script.

Whenever anything in the Target Setting tab is changed a new Linker script can be selected to be generated.

If the script is generated it can also be automatically used in the selected Build Configuration. If possible the path to the script will be set to be relative to the project.

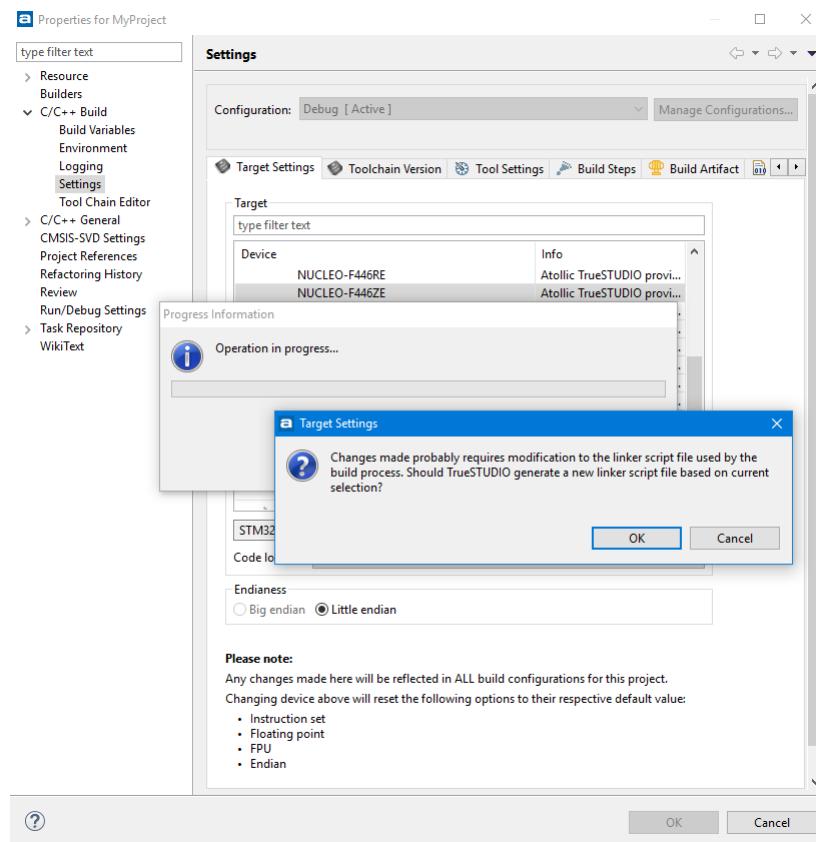


Figure 101 – Automatically Generate a New Linker Script

MANUALLY

The linker scripts can also be manually created. These scripts will not be automatically added to any Build Configuration.

To manually create a new linker script, start by selecting the project to add the script into. Right click the project and select **New, Other...**

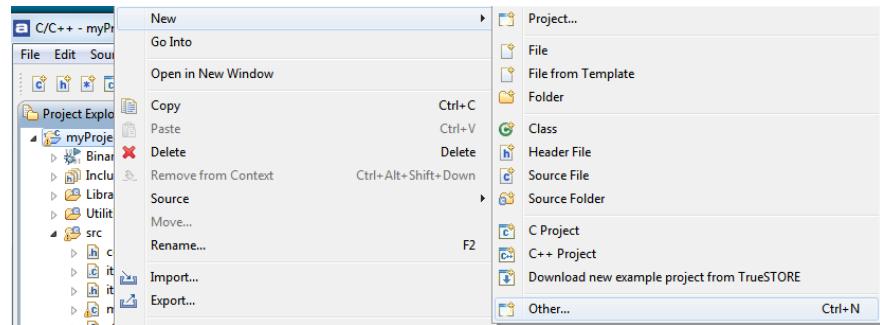


Figure 102 – Select New, Other...

1. In the dialog that then pops up select **C/C++** and then **Linker script**.

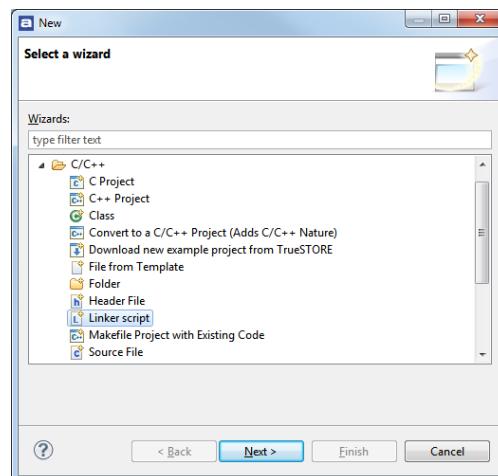


Figure 103 – Select New, Other...

2. Click **Next**.
3. The target must now be select properly. Here is the chance to select a new target. The current settings can be found by right-clicking the project and selecting **Properties, C/C++ Build, Settings**.
4. Click **Finish**.

The script is now generated.

In order to use the new script it needs to be selected in a Build Configuration. Right-click the project and select **Properties** and in the dialog select **C/C++ Build, Settings** and in the panel select the **Tool Settings-tab, C Linker, General**.

Enter the name of the new linker script.

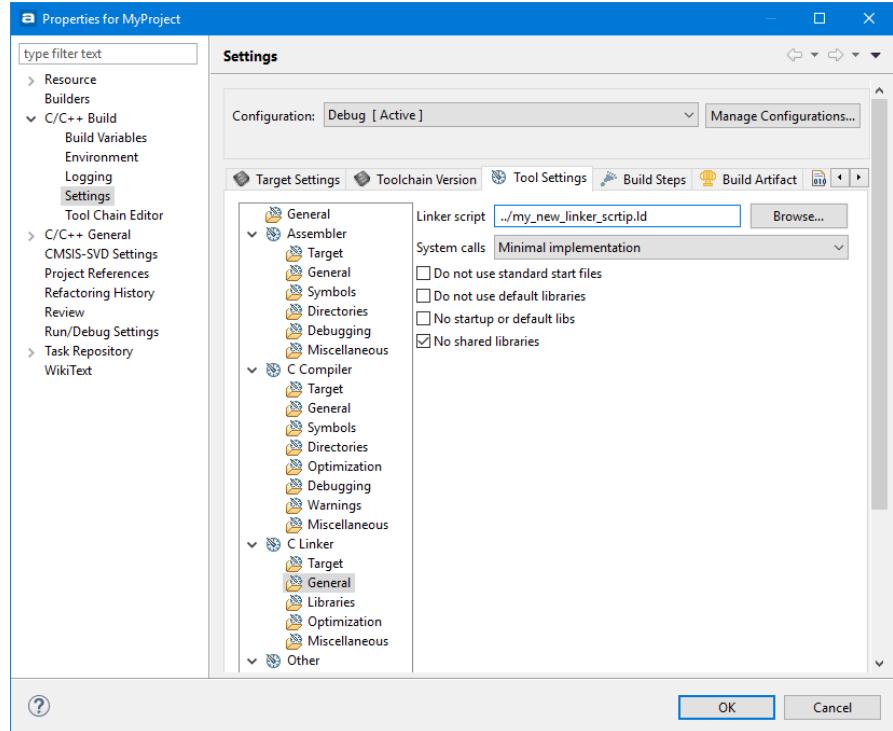


Figure 104 – Enter the name of the script

MODIFY EXISTING LINKER SCRIPT

This chapter includes some common use cases for how to edit the linker script. Editing and managing the script allows for more exact placement of the code and data.

PLACE CODE IN A NEW MEMORY REGION

Many modern devices have more than one memory region. It is possible to use the linker script in **Atollic TrueSTUDIO** to specifically place code in different areas.

Modify the .ld-linker script's memory regions. This is an example of a linker script file containing the following memory regions:

```
MEMORY
```

```
{  
    FLASH (rx) : ORIGIN = 0x08000000, LENGTH = 128K  
    RAM (xrw) : ORIGIN = 0x20000000, LENGTH = 16K  
    MEMORY_B1 (rx) : ORIGIN = 0x60000000, LENGTH = 0K  
}
```

Add a new area by editing the file. In this example the IP-Code region is added.

```
MEMORY  
{  
    FLASH (rx)      : ORIGIN = 0x08000000, LENGTH = 64K  
    IP_CODE (x)      : ORIGIN = 0x08010000, LENGTH = 64K  
    RAM (xrw)       : ORIGIN = 0x20000000, LENGTH = 8K  
    MEMORY_B1 (rx)  : ORIGIN = 0x60000000, LENGTH = 0K  
}
```



Variables and functions may not be placed in the same memory region.

Place the following code a bit further down in the script, between the .data { ... } and the .bss { ... } section:

```
.ip_code :  
{  
    *(.IP_Code*);  
} > IP_CODE
```

This tells the linker to place all sections named .IP_Code* into the IP_CODE memory region which is specified to start at target memory address: 0x8010000.

In the C-code, tell the compiler which functions should go to this section by adding __attribute__((section(".IP_Code"))) before the function declaration.

Example:

```
__attribute__((section(".IP_Code"))) int placed_logic()  
{  
    /* TODO - Add your application code here */  
    return 1;  
}
```

The placed_logic()-function will now be placed in the IP_CODE memory region by the linker.

PLACE CODE IN EXTERNAL RAM

To place code in external ram some modifications of the linker script is needed. In short this is what to do.

Define a new memory region in the MEMORY {} region in the Linker script:

```
MEMORY {  
    ...  
    EXT_RAM (xrw)      : ORIGIN = 0x64000000, LENGTH = 8K  
    ...  
}
```

Then also define an output section for the code/data. This should be placed with a Load Memory Address in EXT_RAM, and a Virtual Memory Address in FLASH:

```
/* used by the startup to initialize the external ram */  
_siextram = LOADADDR(.EXTRAM);  
.EXTRAM :  
{  
    . = ALIGN(4);  
    _sextram = .;           /* create a global symbol at ext_ram start */  
    *(.EXTRAM)             /* .EXTRAM sections */  
    *(.EXTRAM*)            /* .EXTRAM* sections */  
  
    . = ALIGN(4);  
    _eextram = .;           /* define a global symbol at ext_ram end */  
} >EXT_RAM AT> FLASH
```

Startup Code:

Then the external ram needs to be initialized and the code/data copied from flash to external ram. The startup code can access the location information symbols `_siextram`, `_sextram` and `_eextram` by doing something like:

```
extern int _siextram;  
extern int _sextram;  
extern int _eextram;  
  
void copy_fn() {  
    const int *origin = &_siextram;  
    int *dest = &_sextram;  
    const int * const dest_end = &_eextram;  
    .... copy loop ....  
}
```

How to use this in the code:

Mark variables or functions with the correct attribute, for example:

```
__attribute__((section(".EXTRAM"))) int placed_logic()
{
    return 1;
}
```

PLACE VARIABLES AT SPECIFIC ADDRESSES

The first step in order to place variables at a specified address in memory is to create a new memory region in the linker script (the `.ld`-file). Take a look at an example of a linker script file containing the following memory regions:

```
MEMORY
{
    FLASH (rx)      : ORIGIN = 0x08000000, LENGTH = 128K
    RAM (xrw)       : ORIGIN = 0x20000000, LENGTH = 16K
    MEMORY_B1 (rx)  : ORIGIN = 0x60000000, LENGTH = 0K
}
```

A new memory region should be added by editing the file. In this example add the `MYVARS` region.

```
MEMORY
{
    FLASH (rx)      : ORIGIN = 0x08000000, LENGTH = 64K
    MYVARS (x)       : ORIGIN = 0x08010000, LENGTH = 64K
    RAM (xrw)       : ORIGIN = 0x20000000, LENGTH = 8K
    MEMORY_B1 (rx)  : ORIGIN = 0x60000000, LENGTH = 0K
}
```



Variables and functions may not be placed in the same memory region.

Now the memory section should be added. Place the following a bit further down in the script, between the `.data { ... }` and the `.bss { ... }` section:

```
.myvars :
{
    *(.myvars*) ;
} > MYVARS
```

This tells the linker to place all sections named `.myvars*` from input into the `.myvars` output section in the `MYVARS` memory region, which is specified to start at target memory address: `0x8010000`.

A section can be called almost anything except some predefined names such as `data`.

Now the variables need to be put in that region.

To be absolutely certain that the order will stay the same even if they are spread in multiple files, add each variable to its own section. Then map the order of the variables in the linker script.

So for example, the c code could be:

```
__attribute__((section(".myvars.VERSION_NUMBER"))) uint32_t VERSION_N  
UMBER;  
__attribute__((section(".myvars.CRC"))) uint32_t CRC;  
__attribute__((section(".myvars.BUILD_ID"))) uint16_t BUILD_ID;  
__attribute__((section(".myvars.OTHER_VAR"))) uint8_t OTHER_VAR;
```

And then decide the order in the linker script by adding the specially named sections like:

```
.myvars :  
{  
* (.myvars.VERSION_NUMBER)  
* (.myvars.CRC)  
* (.myvars.BUILD_ID)  
* (.myvars*);  
} > MYVARS
```

LINKING IN A BLOCK OF BINARY DATA

The scenario is that there is a file with binary data needs to be put in the memory. It is named `../readme.txt`.

Then the reference in the C file might look like this using the `incbin` directive and the `allocatable ("a")` option on the section.

```
asm(".section .binary_data,\"a\";"  
".incbin \"/..../readme.txt\";"  
) ;
```

That section is then added in the linker script with instructions that the section should be put in flash.

```
.binary_data :  
{  
    _binary_data_start = .;  
    KEEP(*(.binary_data));  
    _binary_data_end = .;  
} > FLASH
```

This block can then be accessed from the C code with code similar to the following:

```
extern int _binary_data_start;  
  
int main(void)  
{  
    int *bin_area = &_binary_data_start;  
    ...  
}
```

LOCATE UNINITIALIZED DATA IN MEMORY

Sometimes there is a need to have variables located into flash, or some other non-volatile memory, which do not shall be initialized at startup. In such cases it is possible to create a specific MEMORY AREA in the linker script and use the NOLOAD directive.

Example

1. Update the linker script with a MY_DATA area.

```
MEMORY  
{  
    FLASH (rx)      : ORIGIN = 0x08000000, LENGTH = 64K  
    MY_DATA (rx)    : ORIGIN = 0x08010000, LENGTH = 64K  
    RAM (rwx)       : ORIGIN = 0x20000000, LENGTH = 128K  
}
```

2. Add a section for MY_DATA using the NOLOAD directive. This can be done using the following code a bit further down in the linker script.

```
.my_data (NOLOAD) :  
/* .my_data : */  
{  
    *(.MY_Data*);  
} > MY_DATA
```

Finally data can be used somewhere in the program by adding a section attribute when declaring variables which shall be located in MY_DATA memory.

```
__attribute__((section(".MY_Data.a"))) int Distance;  
__attribute__((section(".MY_Data.a"))) int Seconds;
```

MANAGING EXISTING WORKSPACES

The workspaces known to **Atollic TrueSTUDIO** can be managed by selecting **Window**, **Preferences** and in the **Preferences Dialog** select **General, Startup and Shutdown, Workspaces**.

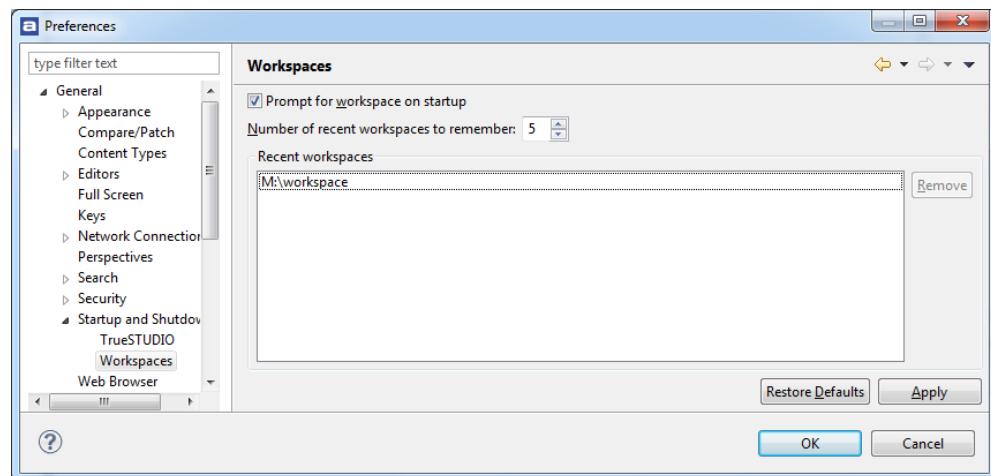


Figure 105 – Manage Workspaces

However, removing a Workspace from that list will not remove the files. Neither will removing the files from the file system remove the workspace from this list.

BACKUP OF PREFERENCES FOR A WORKSPACE

It is generally a very good idea to take a copy of the existing preferences for a workspace. If the workspace crashes and needs to be recreated, they will otherwise need to be set again by hand. A both time-consuming and complicated process.

In the menu select **File, Export**. Then in the panel select **General, Preferences**. Press the **Next** button and in the next page enable **Export All** and a good filename of your choice.

COPY PREFERENCES BETWEEN WORKSPACES

To copy Workspace preferences from one workspace to another, an existing export of preferences should first be created, see above.

Then select **File, Switch Workspace** and your new workspace. **Atollic TrueSTUDIO** will then restart and open with the new workspace.

In the menu select **File, Import** and in the panel select **General, Preferences**. Press the **Next** button and on the next page enable **Import All** and enter your file name. The preferences will now be the same in the two workspaces.

KEEPING TRACK ON JAVA HEAP SPACE

To keep track on how much Java heap space is used, select **Window** in the menu and then **Preferences**.

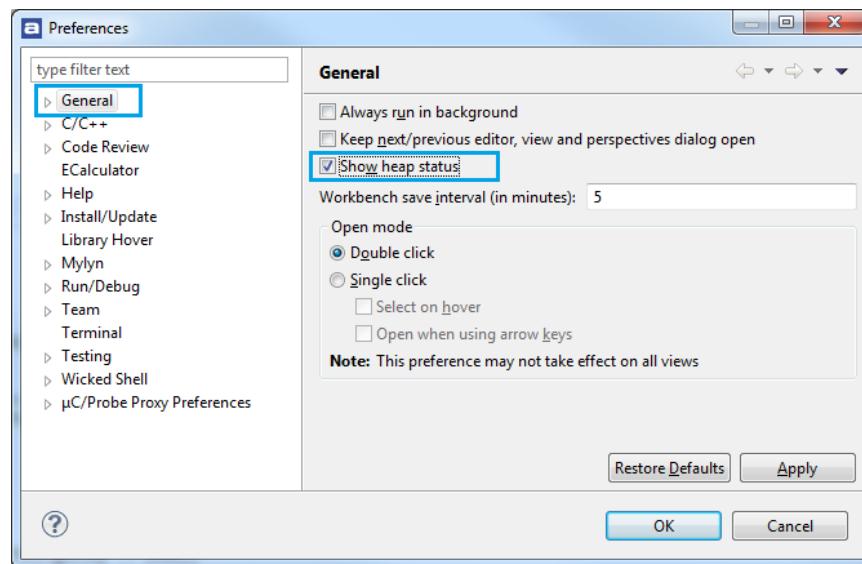


Figure 106 – Display Java Heap Space Status

Select the **General** node and then enable **Show heap status**. The currently used and available Java Heap Space will then be displayed in the lower right corner of the Workspace. The garbage collector can also be manually triggered there.

UNLOCKING LOCKED WORKSPACES

Only one instance of **Atollic TrueSTUDIO** can access one workspace at a time. This is to prevent conflicting changes in the workspace.

If **Atollic TrueSTUDIO** is started with a workspace that already is used by another instance of the program, the following error message is displayed:

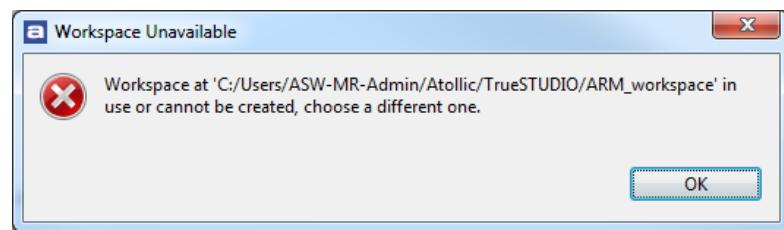


Figure 107 – Workspace Unavailable

MANAGING EXISTING PROJECTS

If no other instance of **Atollic TrueSTUDIO** is accessing the workspace, delete the `.lock` file in the `.metadata` folder in the workspace directory.



It is a good idea to only have the currently active projects opened. Close the rest of the opened projects in the workspace. This will make the indexer work faster and reduce the memory used by **TrueSTUDIO**. It also makes it easier finding errors and bug in the code.

A project is closed by right-clicking it and select **Close Project**.

EDIT

Atollic TrueSTUDIO contains a state-of-the-art editor with almost any feature one can imagine! Noteworthy features are spell checking of C/C++ comments, word- and code completion, content assist, parameter hints and code templates. The editor also includes an include-file dependency browser, code navigation using hypertext-links, bookmark & to-do lists, and powerful search mechanisms.

There are so many features that it is easy to miss some really useful capabilities. While we have simplified the user experience in **Atollic TrueSTUDIO**, there are probably still many features that could be put to good use by more developers.

Below are some of the useful tools that are easily missed.

EDITOR ZOOM IN / ZOOM OUT

It is possible to increase/decrease default font size for text editors by pressing **Ctrl++** and **Ctrl+-**.

Ctrl++ Zoom in text

Ctrl+- Zoom out text

If a keyboard with numeric keypad is used and the + or – keys are pressed on the numeric keypad then also use **Shift** key to make zoom work (**Ctrl+Shift+** or **Ctrl+Shift-**).

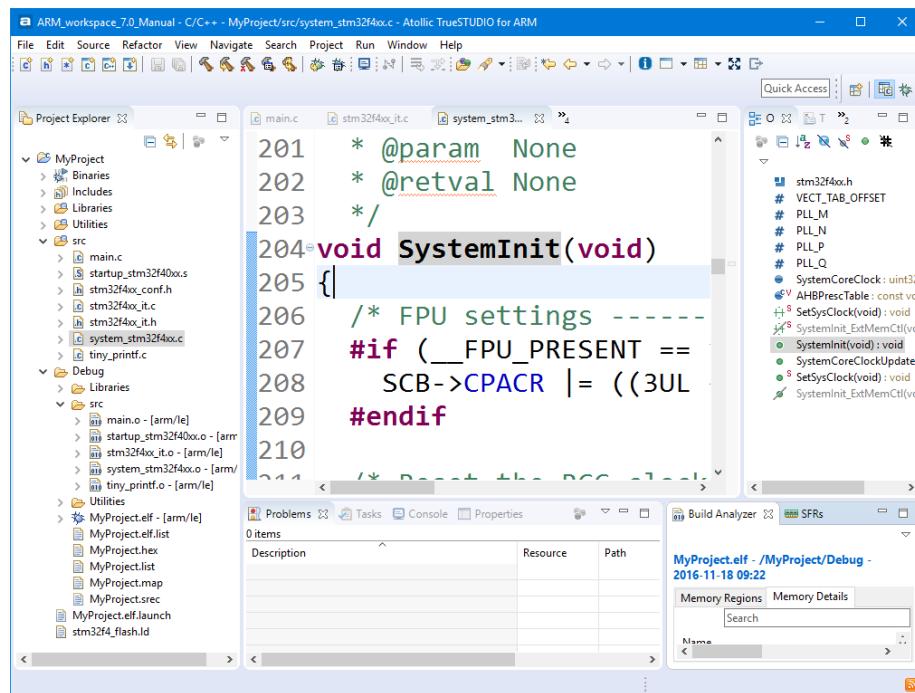


Figure 108 – Editor with text zoomed in

QUICKLY FIND AND OPEN A FILE

Pressing **Ctrl+Shift+R** to find and open a file quickly is one of these features easily missed. Type a couple of characters that is part of the file name to open. It is possible to add * and ? symbols as appropriate for wildcard search as well. The editor then lists the matching. Select the correct file in the matching items search result list, and open the file in any of these 3 ways:

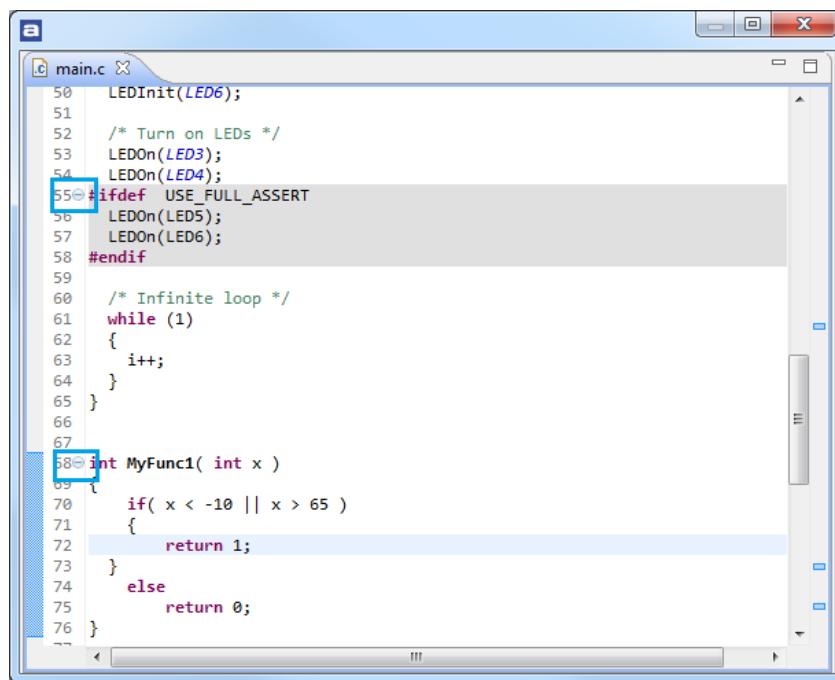
Show In: Sends this file to one of the views chosen in the dropdown list (such as the #include file dependency browser view)

Open With: Opens this file in any of the editors listed in the drop down list.

Open: This is probably the most commonly used option; it just opens the file in the standard C/C++ editor.

BRANCH FOLDING

If a block is enclosed within #if/#endif, it can be folded. To activate the functionality, go to **Window, Preferences, C/C++, Editor, Folding** and check the checkbox **Enable folding of preprocessor branches (#if/#endif)**. After the checkbox has been checked, the editor has to be restarted. Just close the file and open it again and there should be a small icon in the left margin of the editor.



The screenshot shows a code editor window for a file named 'main.c'. The code is as follows:

```
50     LEDInit(LED6);
51     /* Turn on LEDs */
52     LEDOn(LED3);
53     LEDOn(LED4);
54     #ifdef USE_FULL_ASSERT
55     LEDOn(LED5);
56     LEDOn(LED6);
57     #endif
58
59     /* Infinite loop */
60     while (1)
61     {
62         i++;
63     }
64
65
66
67     int MyFunc1( int x )
68     {
69         if( x < -10 || x > 65 )
70         {
71             return 1;
72         }
73         else
74             return 0;
75     }
76 }
```

Folding markers are indicated by small blue squares at the start of lines 55 and 68. The code block starting at line 55 and the function definition starting at line 68 are collapsed, represented by a grey shaded area.

Figure 109 – Folding Markers

BLOCK SELECTION MODE

An often missed feature in **Atollic TrueSTUDIO** is the Block selection mode.

Alt+Shift+A toggles selection mode between normal and block. When block mode is enabled a block of text can be selected by either the mouse or the keyboard using SHIFT and ARROW buttons.

How to use Block selection mode:

Press **Alt+Shift+A**

Press the cursor somewhere in the text and drag it down. A column will now be marked.

The screenshot shows the Atollic TrueSTUDIO for ARM interface. In the center is a code editor window titled "main.c". A specific column of text is selected, indicated by a blue vertical highlight. The code in the main.c file is as follows:

```

28 /**
29 ** Abstract: main program
30 **
31 */
32 int global = 0;
33
34 /**
35 * Initialize LEDs
36 LEDInit(LED3);
37 LEDInit(LED4);
38 LEDInit(LED5);
39 LEDInit(LED6);
40
41 /* Turn on LEDs */
42 LEDOn(LED3);
43 LEDOn(LED4);
44 LEDOn(LED5);
45 LEDOn(LED6);
46
47 /* Infinite loop */
48 while (1)
49 {
50
51 }

```

Figure 110 – Mark a column

Add some text there. It will be entered in all marked rows.

The screenshot shows the same Atollic TrueSTUDIO for ARM interface after text has been added to the marked column. The code in the main.c file now includes the addition "My_" before each of the LEDInit() calls:

```

28 /**
29 ** Abstract: main program
30 **
31 */
32 int global = 0;
33
34 /**
35 * Initialize LEDs
36 My_LEDInit(LED3);
37 My_LEDInit(LED4);
38 My_LEDInit(LED5);
39 My_LEDInit(LED6);
40
41 /* Turn on LEDs */
42 LEDOn(LED3);
43 LEDOn(LED4);
44 LEDOn(LED5);
45 LEDOn(LED6);
46
47 /* Infinite loop */
48 while (1)
49 {
50
51 }

```

Figure 111 – Add text to all rows

Whole areas can also be selected and edited in group.

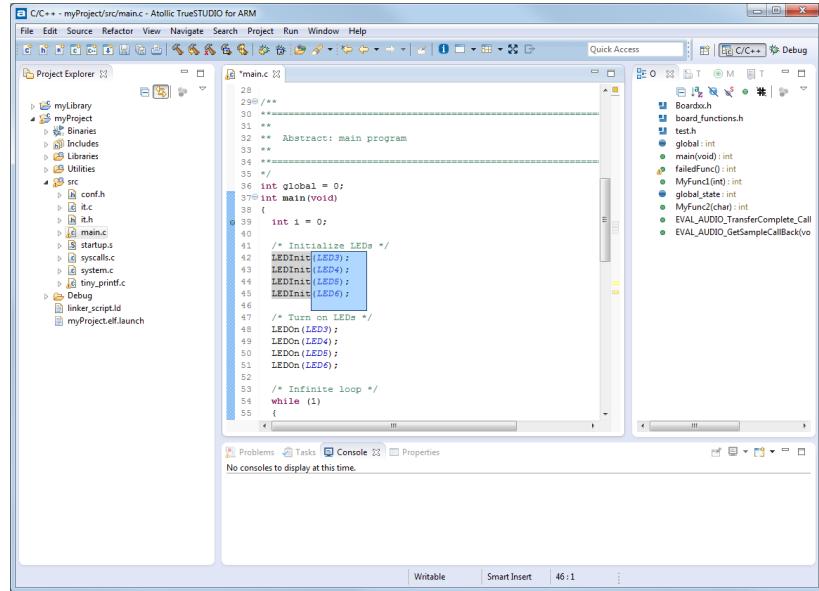


Figure 112 – Select a block of text

FIND ALL KEYBOARD SHORTCUTS

To find all current Keyboard Shortcuts press **Ctrl+Shift+L**. This will open up information about the other shortcuts.

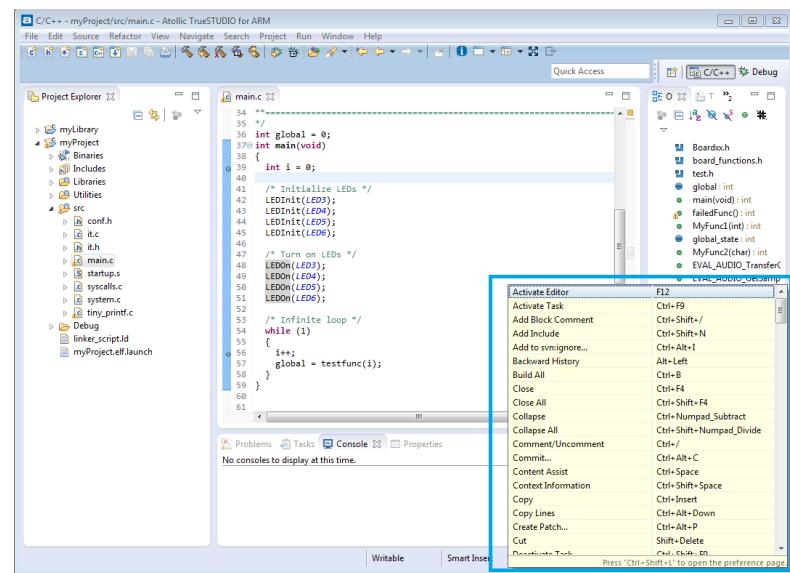


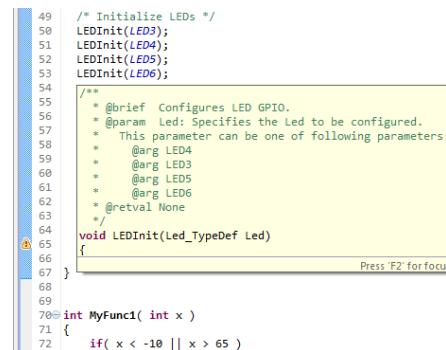
Figure 113 – Find all Shortcuts

Press **Ctrl+Shift+L** again to open up the preferences to change the shortcuts.

THE INDEX

In **Atollic TrueSTUDIO** there is an important mechanism called Indexer that creates a database of the source and header files. That database is called the Index and is used to provide information for all navigation and content assist in **Atollic TrueSTUDIO**. It includes the information about where to find information such as where a function is located and used, where a preprocessor symbol is located and where global variables are defined.

Try pressing **Ctrl** and clicking on a function that is used somewhere in the code. The editor will jump to its definition. Also hovering over it will display its comments and documentation.



The screenshot shows a code editor with C/C++ syntax highlighting. A tooltip is displayed over the word 'LEDInit' in line 64. The tooltip contains the following documentation:

```
49     /* Initialize LEDs */
50     LEDInit(LED3);
51     LEDInit(LED4);
52     LEDInit(LED5);
53     LEDInit(LED6);
54
55     /**
56      * @brief Configures LED GPIO.
57      * @param Led: Specifies the Led to be configured.
58      * This parameter can be one of following parameters:
59      *   @arg LED4
60      *   @arg LED3
61      *   @arg LED5
62      *   @arg LED6
63      * @retval None
64      */
65 void LEDInit(Led_TypeDef Led)
66 {
67 }
```

Below the tooltip, a message says "Press 'F2' for focus".

Figure 114 – The Indexer Picks up the Documentation for a Function

The Indexer is running in the background and keeps track on all changes in the project.

The Indexer is normally customized per Workspace, but can also be set on a per project basis. To customize the Indexer per Workspace in the menu select **Window, Preferences** and in the **Preferences** dialog select **C/C++, Indexer**.

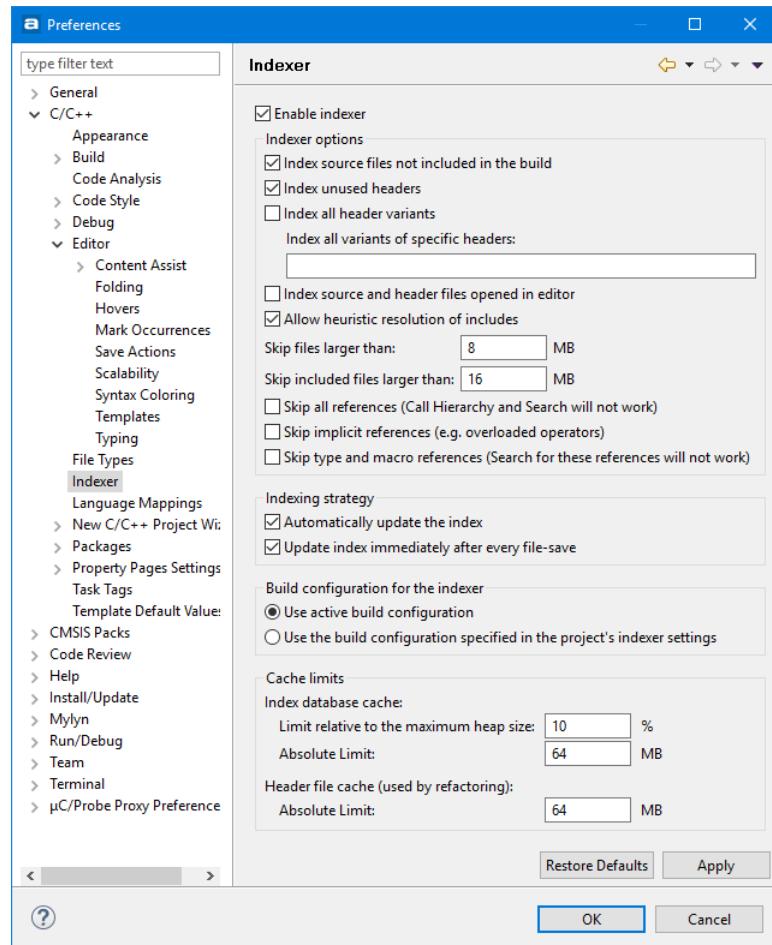


Figure 115 – Workspace Indexer Settings

To customize the Indexer setting per project right-click the project and select **Properties**. In the Properties dialog select **C/C++ General** and then **Indexer**.

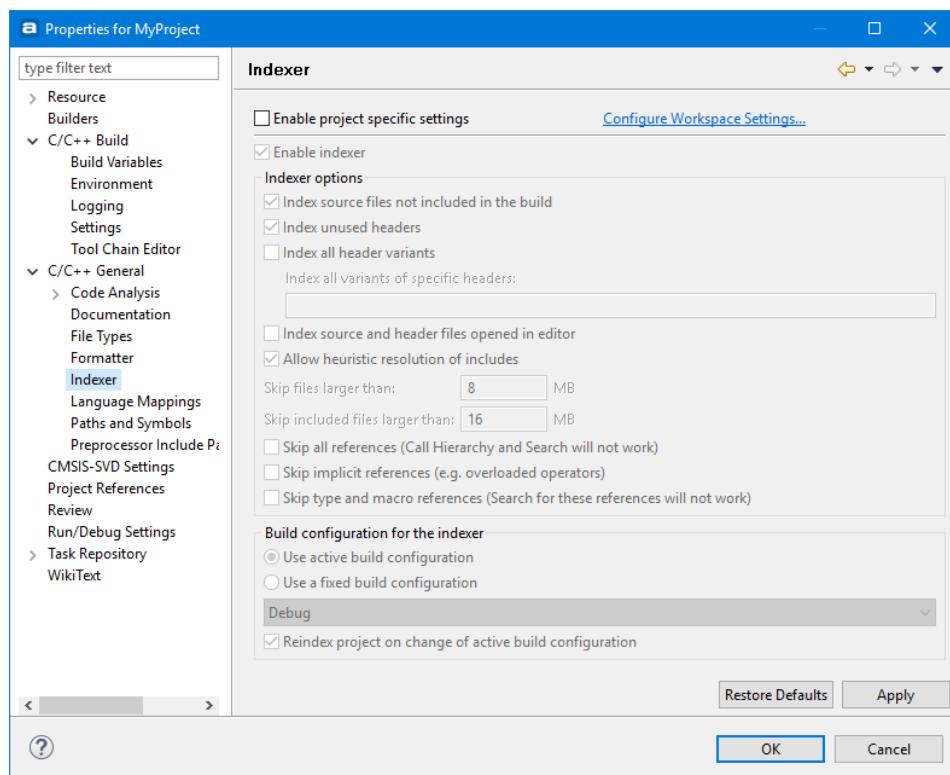


Figure 116 – Project Indexer Settings

Select **Enable project specific settings**. It is a good idea to skip large files and files with many hundreds of includes. This will prevent the Java heap from running out of space. If the project is version controlled, it is also a good idea to store the settings within the project.

From time to time the Index fails to keep track on the changes in the project. Most likely this is due to some includes being changed or missed. Then the Index database needs to be rebuilt. To do that right-click the project and select **Index, Rebuild**.

If this doesn't solve the problem or the indexer's database file (the .pdom-file) is corrupted, open the workspace folder and locate the hidden directory:

`.metadata\.plugins\org.eclipse.cdt.core`

Delete the file: `YOUR_PROJECT_NAME.pdom` and restart **Atollic TrueSTUDIO**. The Index is now rebuilt from scratch.

The most likely reason for a corrupted .pdom-file is that TrueSTUDIO somehow crashed during indexing. That can happen if Atollic TrueSTUDIO runs out of Java heap space, see *Keeping Track on Java Heap Space* on page 141 for more information about the Java Heap.

FINDING INCLUDE PATHS, MACROS ETC.

For the Indexer to work correctly it needs to be fed with information about all the symbols and included files. The process providing that information is called the **Scanner Discovery** mechanism. It uses **Language Setting Providers** to try to automatically provide that information.



The Scanner Discovery mechanism is rewritten and the old property **Discovery Options** for projects is deprecated and replaced with the new **Preprocessor Include Paths, Macros etc.** property.

The preferences for the **Scanner Discovery** mechanism can be found by selecting Window in the menu and then **Preferences**.

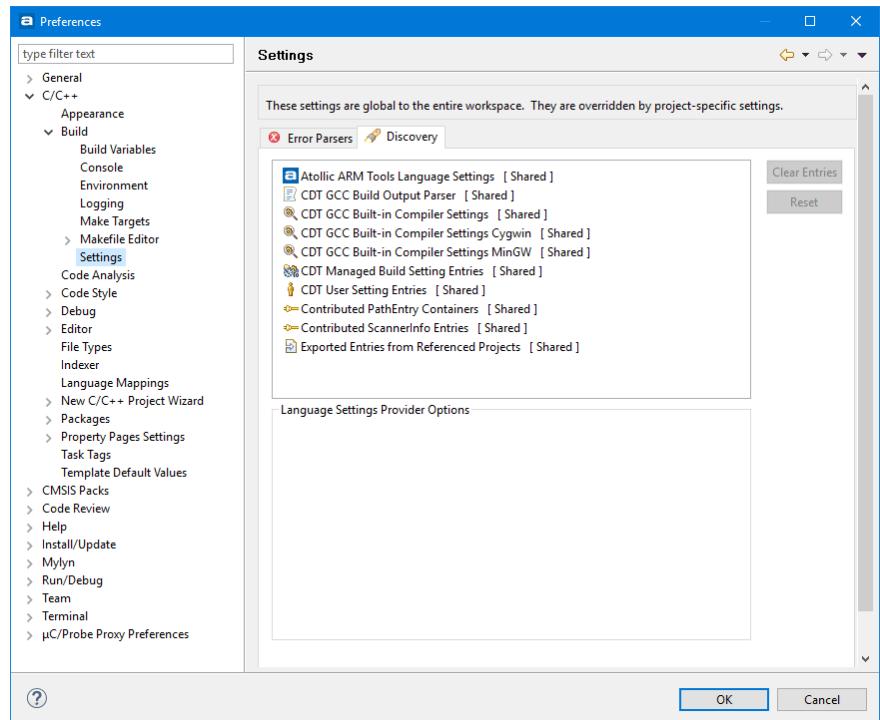


Figure 117 – Scanner Discovery Settings

In the Preferences panel select **C/C++, Build, Settings** and then to the right the **Discovery**-tab.

A list of the available **Language Setting Providers** are then displayed. A **Language Setting Provider** is a specialized mechanism to discover settings. Some providers calls the tool chain for built in compiler symbol and includes. Others scan the build output for that information. The found entries are then stored in the workspace (shared) or for each project.

The **Atollic ARM Tools Language Settings** is by default not shared between projects.

By selecting one provider that individual provider can be configured. If that provider have found and are sharing some entries in the workspace, those entries can be removed by pressing **Clear Entries**. That can be a good idea to do if the path to included files are wrong.

Enable **Allocate console in the Console View** will send output to the console each time the providers runs.

The project and Build Configuration specific settings and entries can be found by selecting the project and then in the menu select **Project, Properties** and in the Properties panel for the project select **C/C++ General, Preprocessor Include Paths, Macros etc.** and select the **Providers** tab first.

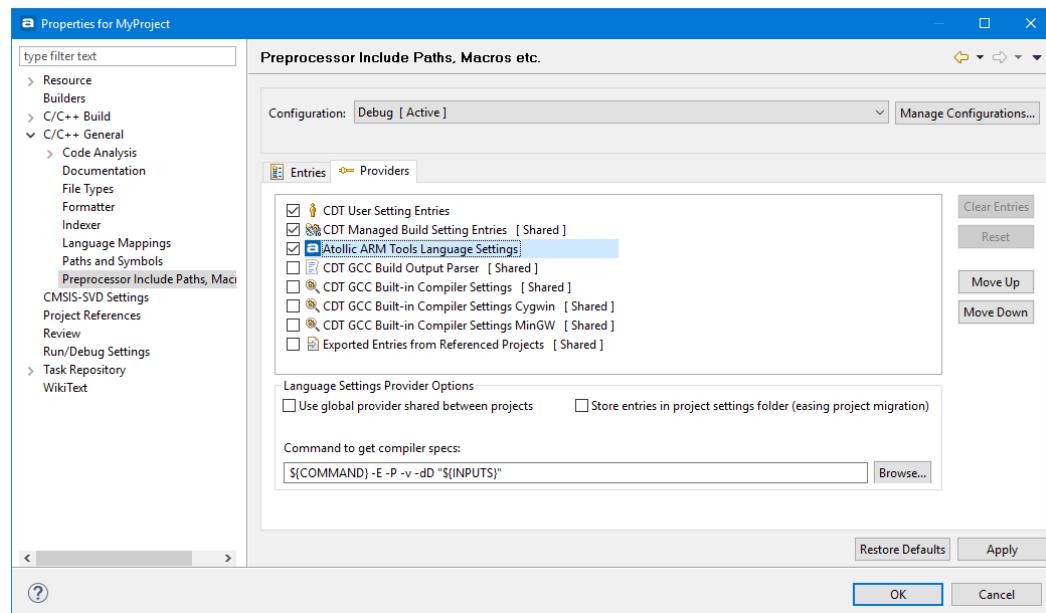


Figure 118 – Preprocessor Include Paths, Macros etc.

When using a version control system it is best to enable **Store entries in project setting folder**.

Do not enable the **Use global provider shared between projects** option! The **Atollic ARM Tools Language Settings** is by default not shared between projects. Since each project has different arguments to the tools based on the Target Settings, sharing between projects will not give a totally accurate result.

The Entries tab displays the found entries for the different providers. At the top is the **CDT User Setting Entries**. By selecting that user defined entries can be added.

By pressing **Restore Default** all locally stored entries will be removed.



It is recommended to always **Restore Default** when changing tool chain version or upgrading **Atollic TrueSTUDIO**. This replaces the old method for clearing of discovered entries found in the deprecated **Discovery Options** properties.



When sharing a project in a version control system, it is a good idea to set the SVN property `svn:ignore` on the file `%PROJECT_LOCATION%/.settings/language.settings.xml` since it includes a hash specific to each individual environment. See more in the chapter about SVN on page 206.

ADD OR REMOVE FOLDER TO INCLUDE PATH

To add or remove folder(s) from the include path, right-click on a folder in the **Project Explorer** view and select **Add/remove include path...**. A dialog is opened and here it is possible to select the configurations that should include the selected directories in their include paths. Select the configurations which shall contain the folder in the include path. Then press **OK** to update the path. This is an easy way to update the include path for a project.

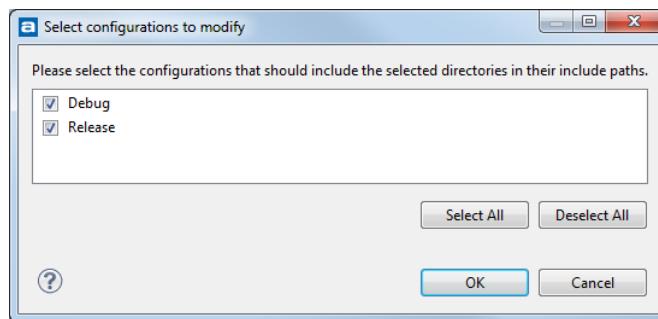


Figure 119 – Add or remove include path

LOCATE WHERE A FILE IS INCLUDED

To locate where in the code a specific file is included, open the **Include Browser** view. From the **Project Explorer** view, click and drag the file you want to know inclusions for to the **Include Brower** view. All the places it is included will be displayed and the inclusion tree for those files also.

The view is also able to display all the files included in the selected file and the name of the folder where the files are located.

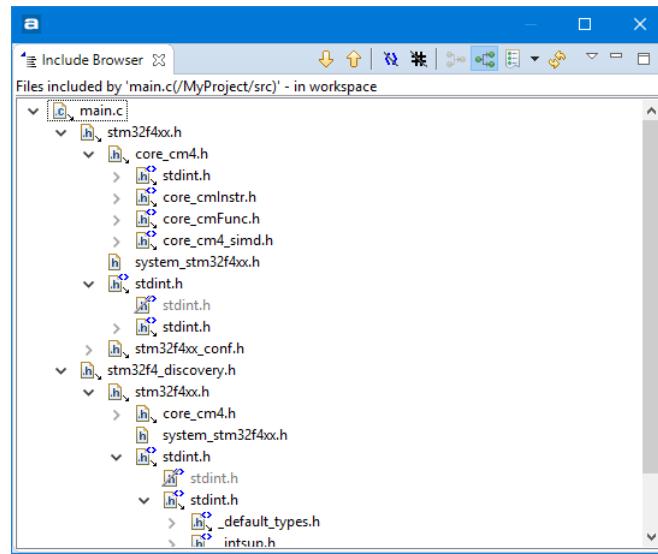


Figure 120 – Include Browser

CREATING LINKS TO EXTERNAL FILES

Even if the Indexer will find external source files and libraries included in other source files, **Atollic TrueSTUDIO** will not keep track on changes in these files.

To be able to keep track on these changes and properly edit external source files in **Atollic TrueSTUDIO**, a link to the folders or to the files needs to be added to the project. To add a link to a file, right-click on a source folder and select **New, File**.

In the dialog click on the **Advanced** button and select **Link to file in the file system**.

Enter the file name and **Browse** to the file you want to create a link to.

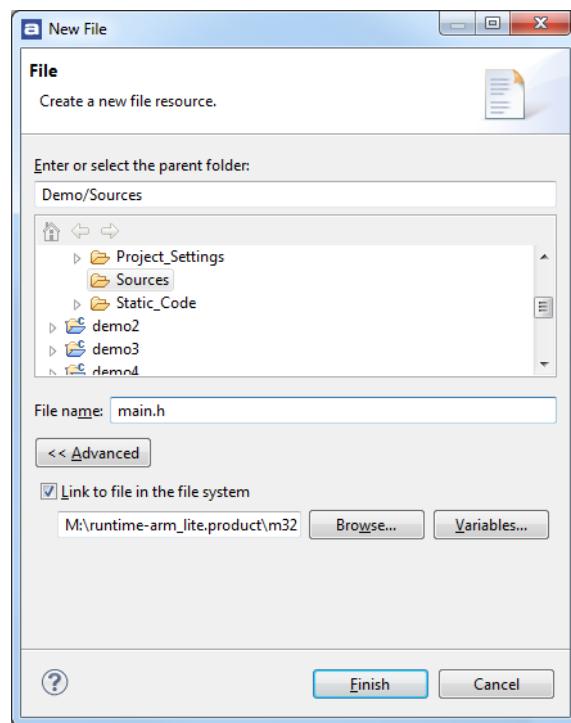


Figure 121 – Create Linked File

When this is done, **Atollic TrueSTUDIO** will keep track of all changes in the file and rebuild when the file is changed.

The process to create a link to a folder is similar.

UPDATE CMSIS MATH LIBRARY

Follow these steps to use the latest version of the CMSIS library provided by ARM. Other libraries from ARM or other source can be added with a similar method.

1. Download the latest version of the library from <https://silver.arm.com/> (registration is needed).
2. Unpack the zip-file.
3. Create a folder in the project in `Libraries\CMSIS` named `lib`.
4. Add the path to the library and the library name by selecting **Project, Properties, C/C++ General, Paths and Symbols** and then use the **Path** tab. (On page 93 another method is explained in *Include Libraries*). Remember not to include the "lib"-prefix and the file extension (.a).

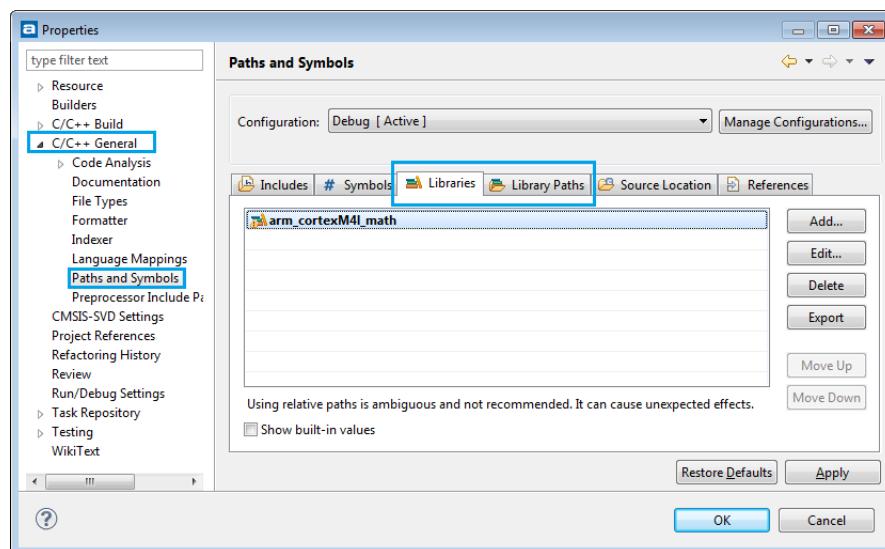


Figure 122 – Create Linked File

5. Add the symbol `ARM_MATH_CM4` or `ARM_MATH_CM3` in the **Symbol** tab.
6. Copy the library files from the extracted folder `CMSIS\lib\GCC` to the folder created in step 3. Very with the FPU settings in the Target Settings that the correct library is used.
7. To be able to debug the library, the source to it must also be added to the known sources, see page 90 for more information about how to do that.

It might also be a good idea to also update the header files with the ones provided in the download.

CONVERTING A C-PROJECT TO A C++-PROJECT

To convert a C-project to a C++-project do the following steps:

- 1.** Open the **Navigator view**.
- 2.** Select the project and open it.
- 3.** Double click the file `.project` to open it in the editor
- 4.** Locate the row `<nature>org.eclipse.cdt.core.cnature</nature>`
- 5.** Insert a row after it that looks almost the same, but with an extra “c”:
- 6.** `<nature>org.eclipse.cdt.core.ccnature</nature>`
- 7.** Do not remove the cnature-row!
- 8.** Save the file and the project will now also compile with the C++ tools.

DISASSEMBLE/LIST OBJECT AND ELF FILES

Sometimes it can be interesting to get detailed information about the content of an object or elf file. This can be done using the build tools included in the Toolchain. To make it even easier to get access to the such information a **Build tools** selection has been added. To use this feature just make a right-click on the object or elf file in the **Project Explorer** view and select **Build tools**.

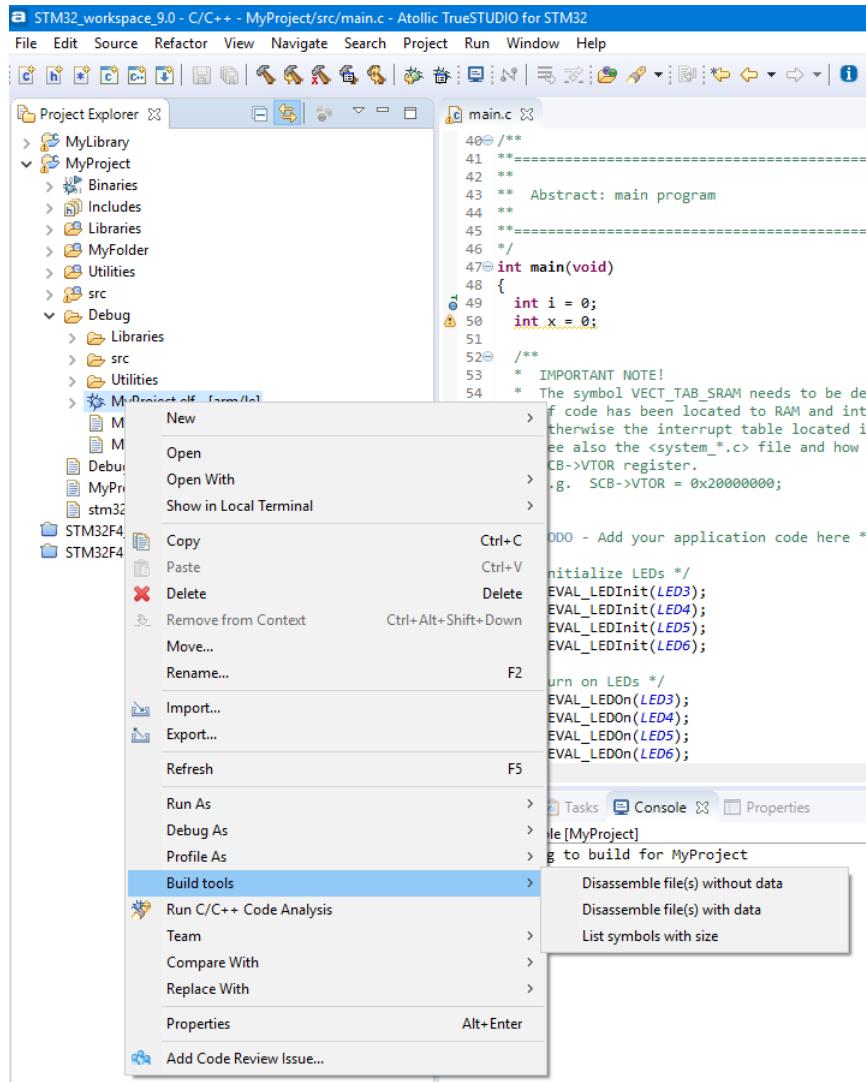


Figure 123 – Build Tools

The **Build tools** selection has three options. Select option depending on your needs and the file will be opened in the editor. The options are:

- **Disassemble file(s) without data**
- **Disassemble file(s) with data**

- **List symbols with size**

Example of a file opened with **Disassemble file(s) without data**.

```

MyProject.elf > MyProject.elf > MyProject.elf
192 8000306: 2300    movs   r3, #0
193 8000308: 73fb    strb   r3, [r7, #15]
194 800030a: 7fbf    ldrb   r3, [r7, #15]
195 800030c: 4618    mov r0, r3
196 800030e: 3714    adds   r7, #20
197 8000310: 46bd    mov sp, r7
198 8000312: f85d 7b04  ldr.w  r7, [sp], #4
199 8000316: 4770    bx lr
200
201 8000318 <DMA_GetFlagStatus>:
202 8000318: b480    push   {r7}
203 800031a: b087    sub sp, #28
204 800031c: af00    add r7, sp, #0
205 800031e: 6078    str r0, [r7, #4]
206 8000320: 6039    str r1, [r7, #8]
207 8000322: 2300    movs   r3, #0
208 8000324: 75fb    strb   r3, [r7, #23]
209 8000326: 2300    movs   r3, #0
210 8000328: 60fb    str r3, [r7, #12]
211 800032a: 687b    ldr r3, [r7, #4]
212 800032c: 4a15    ldr r2, [pc, #84] ; (8000384 <DMA_GetFlagStatus+0x6c>)
213 800032e: 4293    cmp r3, r2
214 8000330: d882    bhi.n  8000338 <DMA_GetFlagStatus+0x20>
215 8000332: 4b15    ldr r3, [pc, #84] ; (8000388 <DMA_GetFlagStatus+0x70>)
216 8000334: 613b    str r3, [r7, #16]
217 8000336: e001    b.n   800033c <DMA_GetFlagStatus+0x24>
218 8000338: 4b14    ldr r3, [pc, #80] ; (800038c <DMA_GetFlagStatus+0x74>)
219 800033a: 613b    str r3, [r7, #16]
220 800033c: 683b    ldr r3, [r7, #0]
221 800033e: f0a3 5300  and w  r3, r3, #536870912 . av>00000000

```

Figure 124 – Disassemble file(s) without data

Example of a file opened with **List symbols with size**.

Symbol Address	Symbol Name	Symbol Type	Symbol Size
1 00000000	A _Min_Heap_Size		
2 00000080	A malloc_getpagesize_P		
3 00000400	A _Min_Stack_Size		
4 00000000	R g_pfnVectors		
5 00000188	t __global_dtors_aux		
6 000001ac	t frame_dummy		
7 000001c8	T DAC_SetChannel1Data		
8 00000200	T DMA_Init		
9 000002b0	T DMA_Cmd		
10 000002e0	T DMA_GetCmdStatus		
11 00000318	T DMA_GetFlagStatus		
12 00000390	T DMA_ClearFlag		
13 000003ec	t GPIO_Init		
14 00000508	T RCC_AHBLPeriphClockCmd		
15 00000548	T SPI_I2S_SendData		
16 00000566	T SPI_I2S_GetFlagStatus		
17 000005a0	T STM_EVAL_LEDInit		
18 000005fc	T STM_EVAL_LEDOn		
19 0000062c	t Audio_MAL_IRQHandler		
20 0000072c	T DMA1_Stream7_IRQHandler		
21 00000738	T DMA1_Stream0_IRQHandler		
22 00000744	T SPI3_IRQHandler		
23 00000788	T main		
24 000007d6	T EVAL_AUDIO_TransferComplete_CallBack		
25 000007ec	T EVAL_AUDIO_GetSampleCallBack		
26 00000800	W Reset_Handler		
27 00000808	t CopyDataInit		
28 00000810	t LoopCopyDataInit		
29 0000081e	t FillZeroBss		
30 0000087d	+ !nonFill7erhcc		

Figure 125 – List symbols with size

I/O REDIRECTION

The C runtime library includes many functions, including some that typically handle I/O. The I/O related runtime functions include `printf()`, `fopen()`, `fclose()`, and many others.

It is common practice to redirect the I/O from these functions to the actual embedded platform, such as redirecting `printf()` output to an LCD display or a serial cable, or to redirect file operations like `fopen()` and `fclose()` to some Flash file system middleware. **Atollic TrueSTUDIO** also comes with an integrated Terminal that can be used to display redirected I/O, see page 247 for more information.

In Atollic TrueSTUDIO three different techniques are generally most used. It is the old UART output, Segger's Real Time Terminal (RTT) that is explained on page 249 and on targets that has support for SWV, the ITM output that is explained on page 302.

A fair comparison between the three techniques to generate debug output:

SWV Low or none CPU overhead but very limited bandwidth. Only supported by some targets.

UART Some CPU overhead and medium bandwidth.

RTT A bit smaller CPU overhead than UART and higher bandwidth. Needs a Segger Probe.

Atollic TrueSTUDIO do support I/O redirection. To enable I/O redirection the file `syscalls.c` should be included and built into the project:

1. In the Project explorer view, Right click on the project and select New, Other...

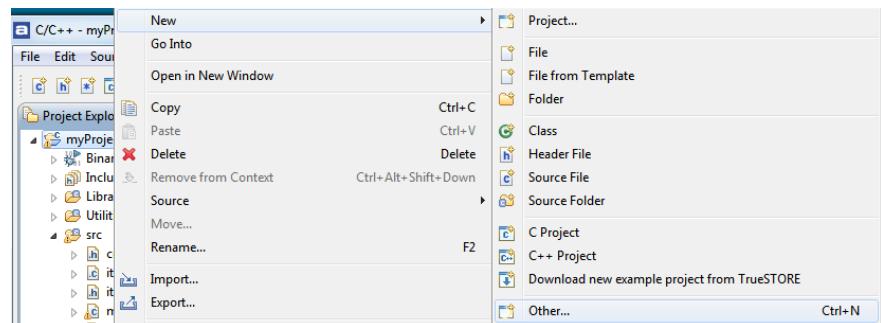


Figure 126 – New, Other...

2. Expand **System calls**.
3. Select **Minimal System Calls Implementation** and click next.

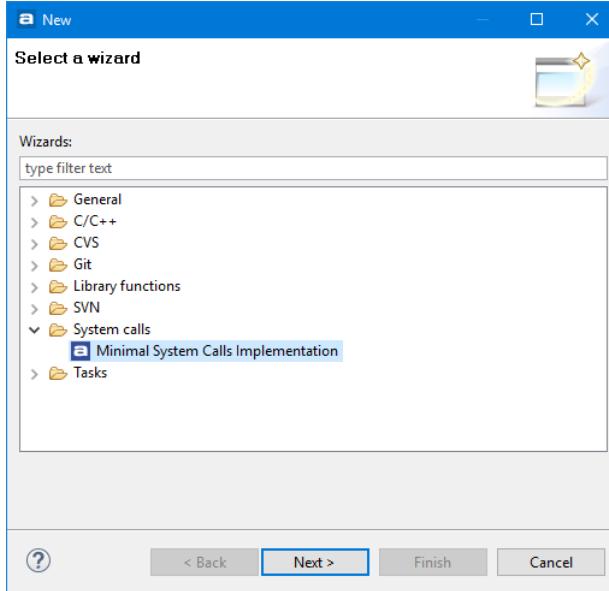


Figure 127 – Select Minimal System Calls Implementation

4. Click **Browse...** and select the `src` folder as new file container. Also select the Heap Implementation. There is one dynamic heap implementation that is default and a fixed one intended for RTOS use. If the latter is selected a modification of the script `linker_script.ld` in accordance with the instructions is also needed.

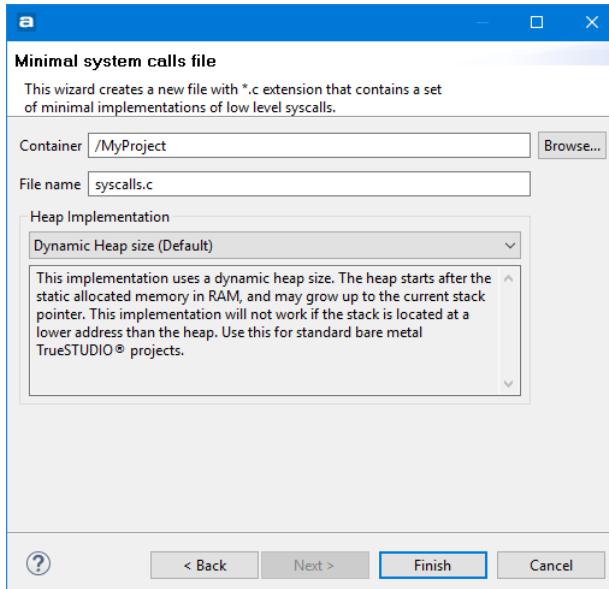


Figure 128 – Select Location and Heap Implementation

5. Click **OK**.

6. Click on Finish and verify that `syscalls.c` is added to the project.

To redirect the `printf()` to the target output, the `_write()` function needs to be modified. Exactly how this is done depends on the hardware and library implementation. Here is an example:

```
int _write(int file, char *ptr, int len)
{
    int index;
    for(index=0 ; index<len ; index++) {
        __io_putchar(*ptr++) /* Your target output function */
    }
}
```

POSITION INDEPENDENT CODE

When for instance working on a bootloader, position independency is a great help. PIC (Position Independent Code) is relative to the program counter. If it is compiled for address 0 but placed at 0x81000 it still runs properly.

The compiler has an option `-fPIE` that enables the compiler to generate position independent code for executable. Add this option into the tool settings for the **Assembler** and **C Compiler** in the **Miscellaneous** settings.

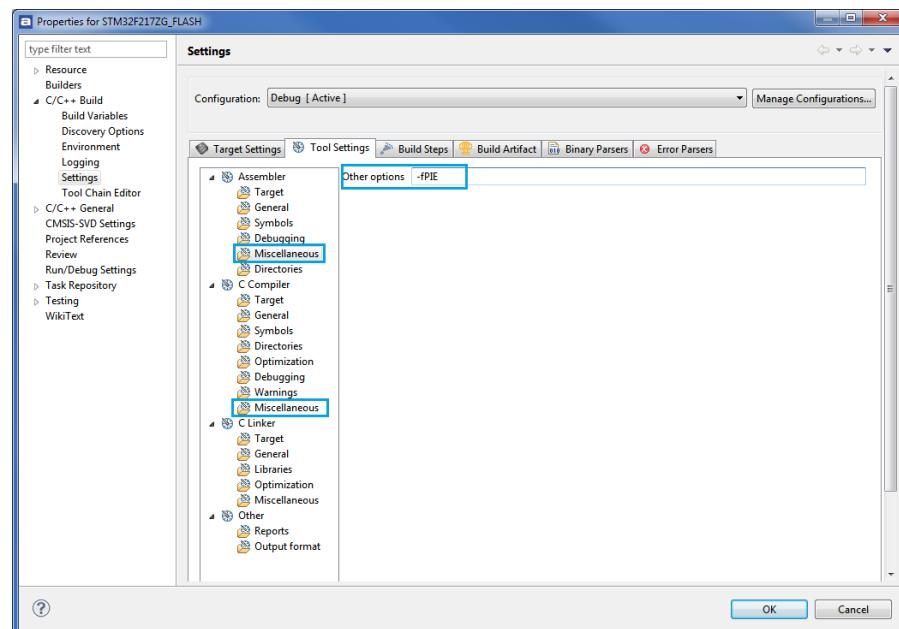


Figure 129 – Add `-fPIE` for Assembler and C Compiler

Also use this `-fPIE` option for the linker. E.g. in the **Miscellaneous** settings the **Other options** field for the **C linker**, the command may look like

```
-Wl,-cref,-u,Reset_Handler -fPIE
```

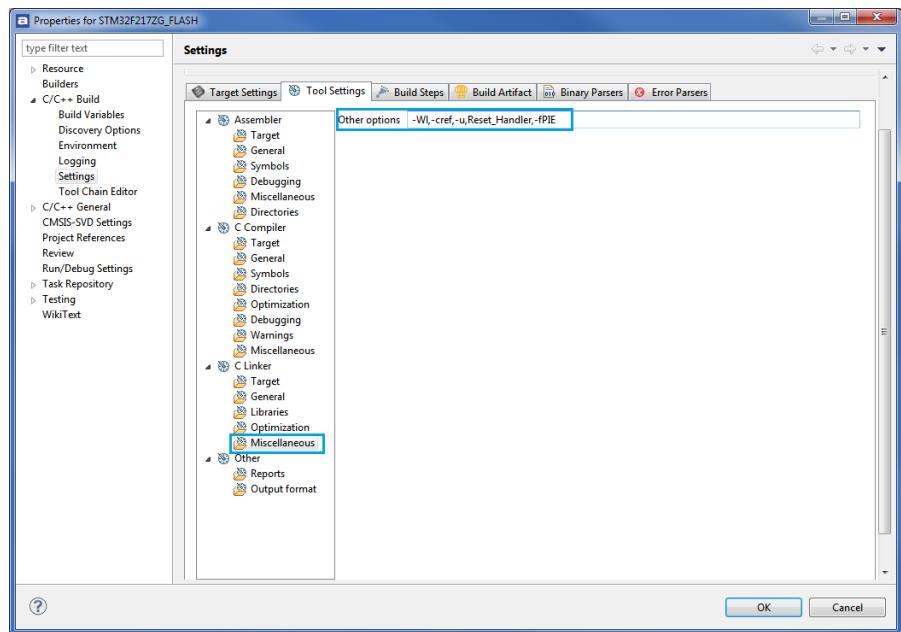


Figure 130 – Use –fPIE for Linker

Make sure that the stack pointer is set up correctly. Normally this is done by issuing a `monitor reset` command as part of the Startup-script for the debug session. However now the start code needs to set the stack pointer instead; do this by adding the following assembly line at the top of the `Reset_Handler()`-function located in the startup file:

```
ldr sp, =_estack
```

This will make sure that the stack pointer is initialized when the `Reset_Handler()`-function runs.

Since the `monitor reset` command is not used any more, it needs to be removed from the Debug Startup Script.

Do this by opening your debug configuration, by pressing the **Debug Configuration** button, switch to the **Startup Scripts** tab.

This contains all commands that are used to launch a debug session. Try commenting the `monitor reset` line out by adding a `#` sign in front.

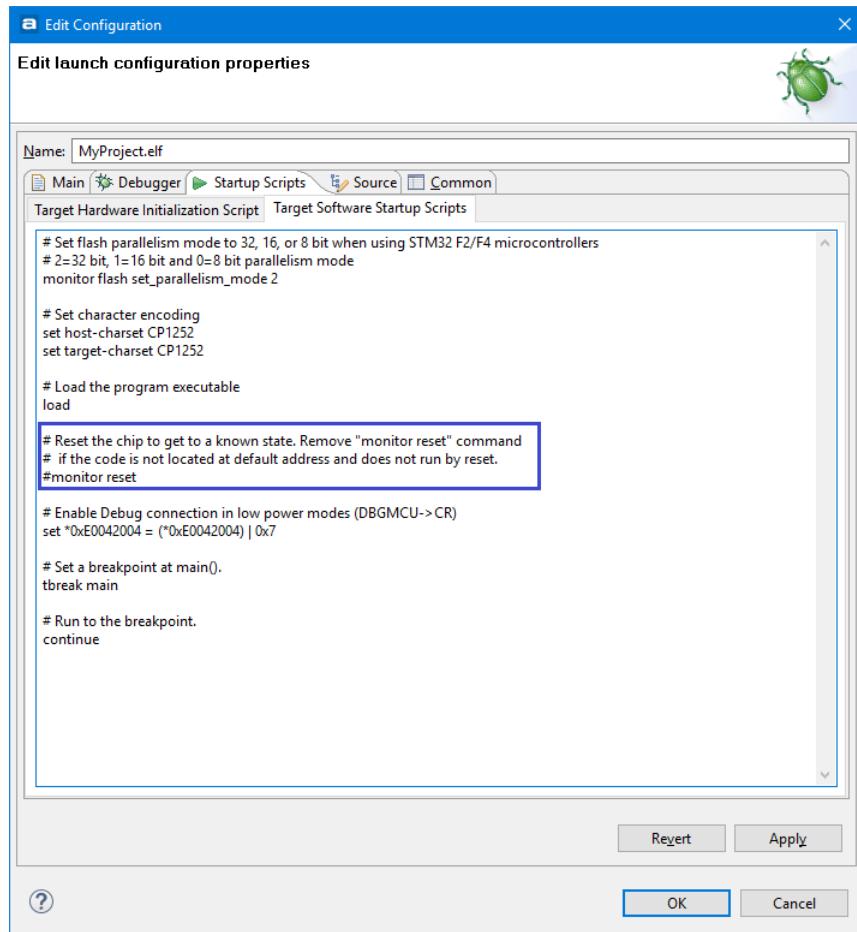


Figure 131 – Remove the monitor reset command

Also in some examples the `SystemInit()`-function for the vector table relocation needs to be changed.

```
SCB->VTOR = FLASH_BASE | 0x20000; /* Vector Table Relocation in  
Internal FLASH */
```

If not, this `SystemInit()`-function will relocate interrupts to flash beginning.

To test that the code is started where it should be, also comment out the `continue` command from the Debug Startup script. This will suspend execution on the first instruction in the `Reset_Handler()`, making it possible to debug the start-up code.

USING CMSIS-PACK IN TRUESTUDIO

The **Cortex Microcontroller Software Interface Standard** (CMSIS) is a vendor-independent hardware abstraction layer for the Cortex-M processor series and defines generic tool interfaces. The CMSIS enables consistent device support and simple software interfaces to the processor and the peripherals, simplifying software re-use, reducing the learning curve for microcontroller developers, and reducing the time to market for new devices.

CMSIS-Pack is one of these components and from version 6.0 **Atollic TrueSTUDIO** supports the CMSIS-Pack standard.



ARM has made the following definition of CMSIS-Pack.

"CMSIS-Pack: describes with a XML based package description (PDSC) file the user and device relevant parts of a file collection (called software pack) that includes source, header, and library files, documentation, Flash programming algorithms, source code templates, and example projects. Development tools and web infrastructures use the PDSC file to extract device parameters, software components, and evaluation board configurations."

More information about CMSIS can be found on the ARM website:

<http://www.arm.com/products/processors/cortex-m/cortex-microcontroller-software-interface-standard.php>

The **CMSIS-Pack Management for Eclipse** v2.0 software created by ARM is integrated into **Atollic TrueSTUDIO** v7.0. and used to:

- Install, remove, delete Packs as well as to import examples
- create and manage CDT-based C/C++ projects

The CMSIS-Pack software also includes:

- an editor for configuration files supporting configuration wizard annotations
- version tracking of configuration files with merge functionality
- integrated help based on Eclipse help framework

CONFIGURATION

Before using CMSIS-Pack the **CMSIS Pack root folder** needs to be configured. In the menu select **Window, Preferences** and in the **Preferences** dialog configure the **CMSIS-Pack root folder** to point to some location on the disk where downloaded Packs shall be stored. For instance in this case the Packs are stored into F:\CMSIS_Pack.

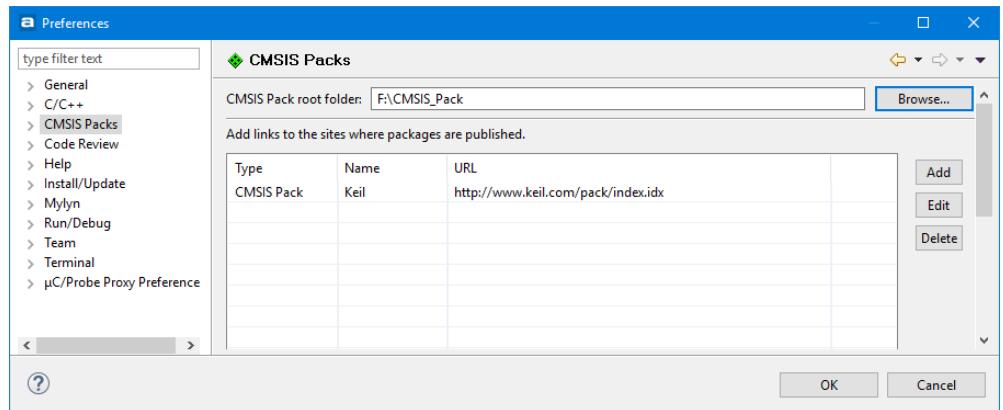


Figure 132 – CMSIS Packs Preferences

The **CMSIS Packs** configuration also contains links to the sites where packages are published. Use **Add**, **Edit** and **Delete** to change the sites which will be searched by the CMSIS Pack plugin.



The configuration of the location of CMSIS-Pack files needs to be done in the preferences each time a new Workspace is used.

Atollic TrueSTUDIO version 6.0 was using the older CMSIS-Pack v1.1 software. Please use a new location as **CMSIS Pack root folder** when using this new CMSIS-Pack v2.0.

CMSIS PACK MANAGER PERSPECTIVE

There is a specific **CMSIS Pack Manager** perspective which is used when downloading and using a new CMSIS-Pack.

Open the **CMSIS Pack Manager** perspective, e.g. this can be done by writing Pack in the **Quick Access** field and select **CMSIS Pack Manager**.

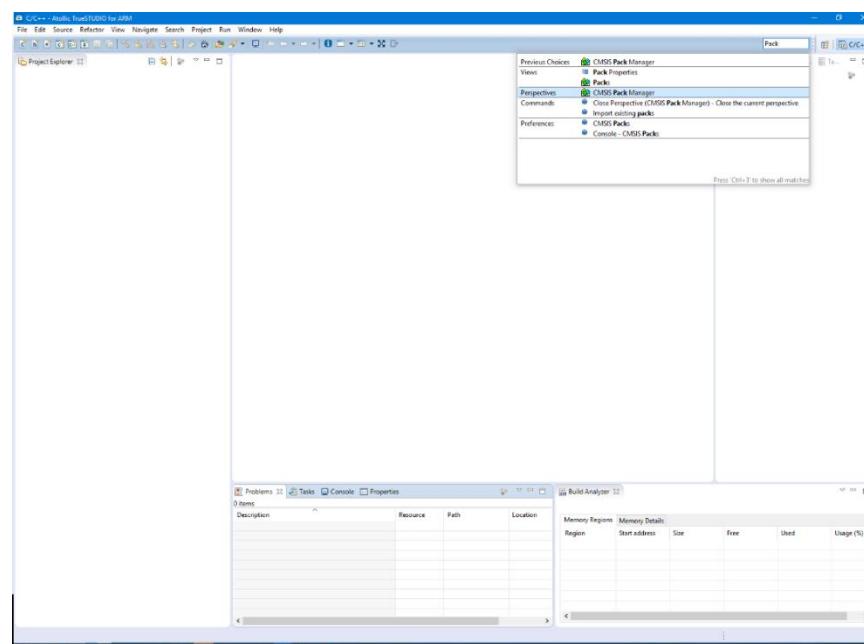


Figure 133 – Open CMSIS Pack Manager Perspective

The **Packs** perspective is now opened and when using it first time the Packs view is empty.

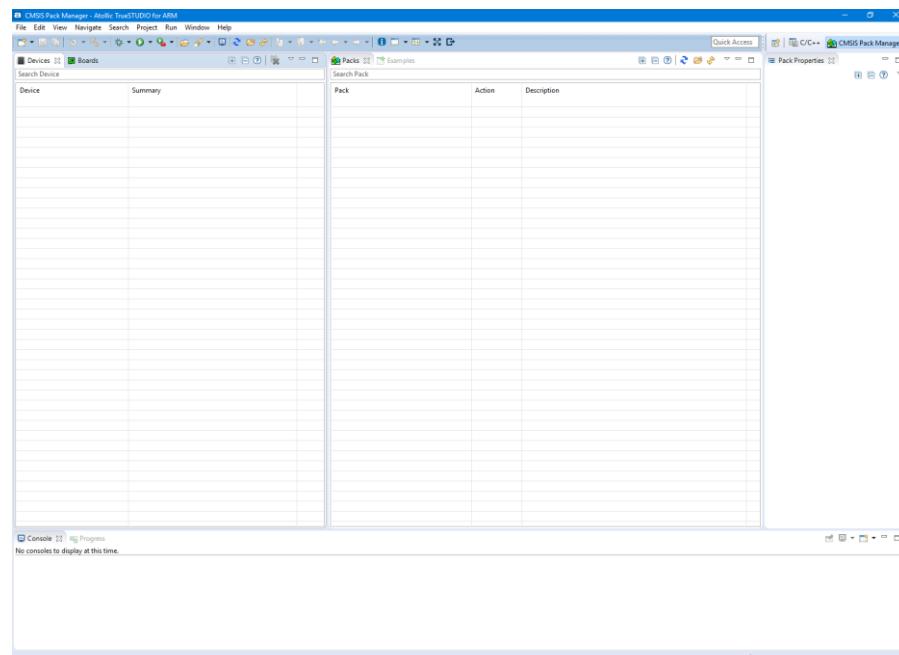


Figure 134 – Packs View Empty

See the figure below and the information about what the Packs view toolbar buttons does.

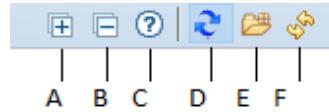


Figure 135 – Packs View Toolbar

- (A) Expands all nodes
- (B) Collapse all expanded nodes
- (C) Help for Packs view
- (D) Check for updates on the web
- (E) Import existing Packs
- (F) Reload Packs in the CMSIS Pack root folder

Use the Blue Arrow icon to check for updates of the packages definitions from all repositories. All packs are now read from the repositories. This may take some minutes

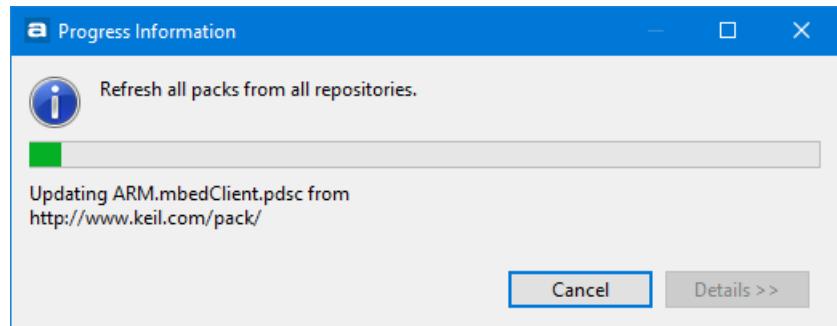


Figure 136 – Refresh all Packs

If any errors occurs press **Yes**, if this does not help then press **No** or **Cancel**.

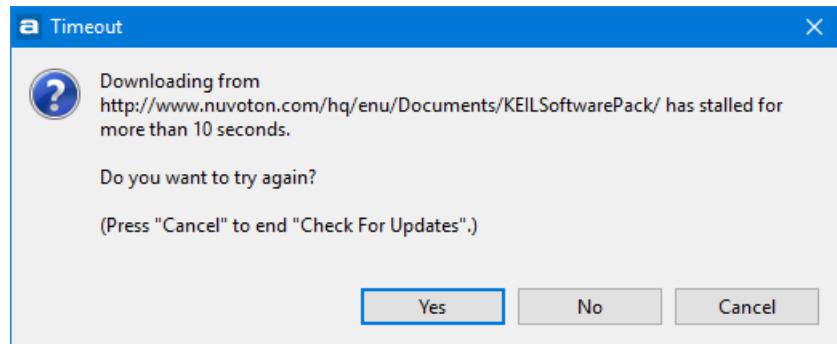


Figure 137 – Read error during refreshing packs

When updating is finished the **Packs** view is populated with new **Device Specific** and **Generic** information. The **Devices** and **Board** tabs are populated with device and board information from different vendors.

The **Packs** view shows the Software Packs available for the selected device or board. Enter a pack name using wildcards into the field Search Pack to narrow the list.

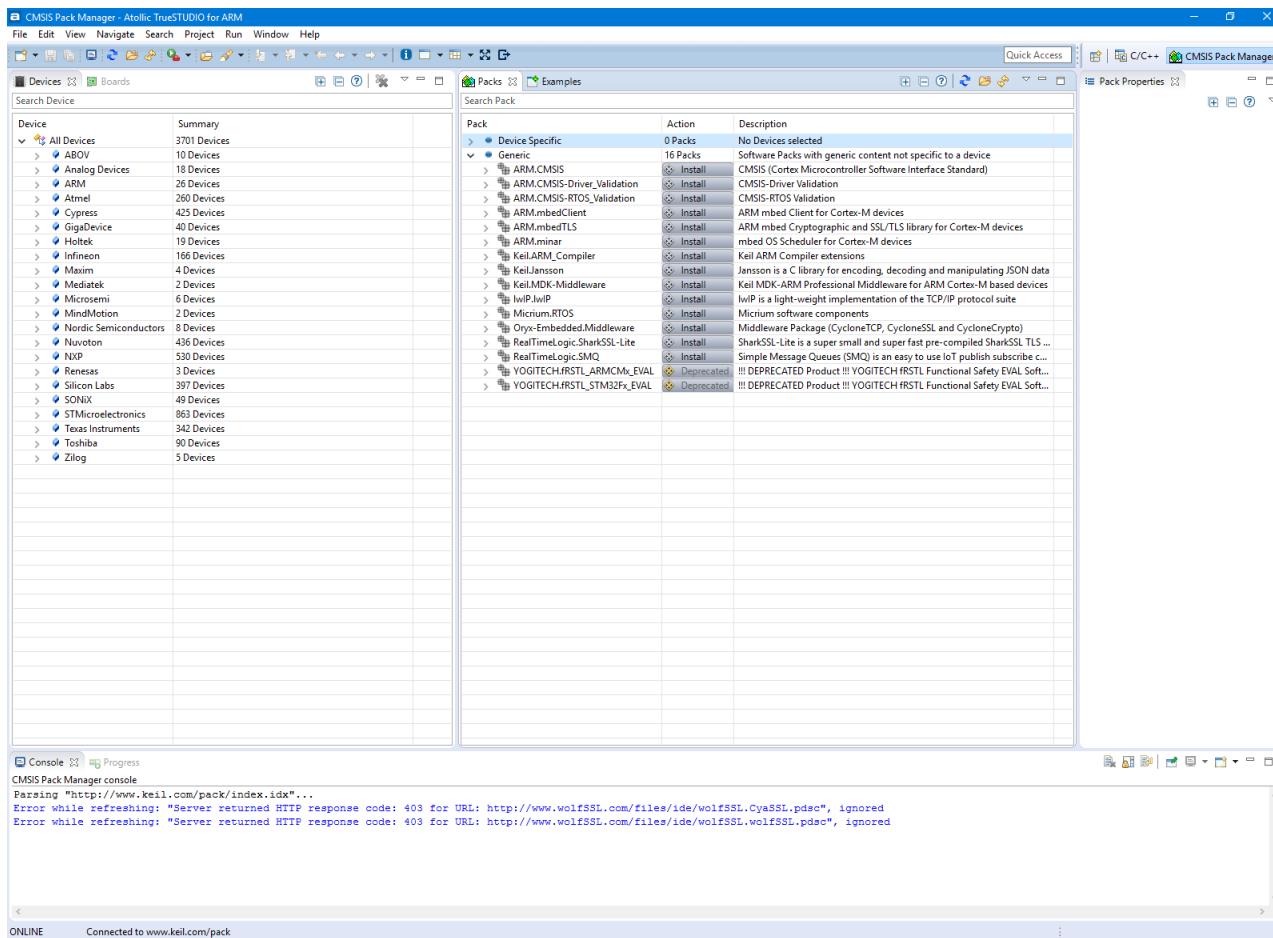


Figure 138 – Packs View Updated

The **Devices** and **Boards** tabs contains information on devices and boards from different vendors.

The **Devices** view lists devices that are supported in available Software Packs. Select a device to narrow the list in the **Packs** and **Examples** view.

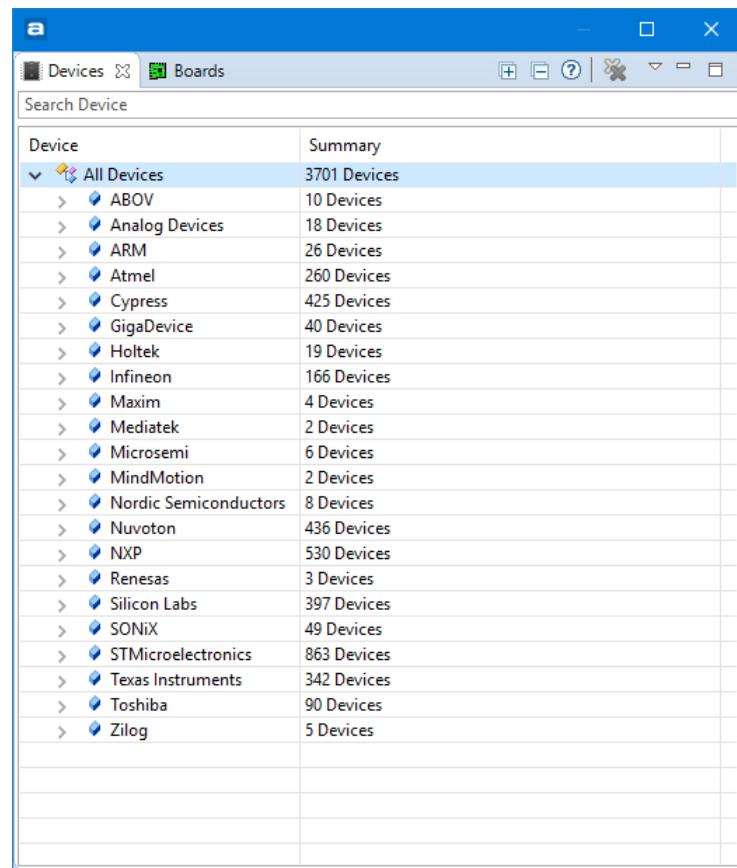


Figure 139 – Devices Software Pack

Enter a device name in the **Devices** tab using wildcards into the field **Search Device** to reduce the list.

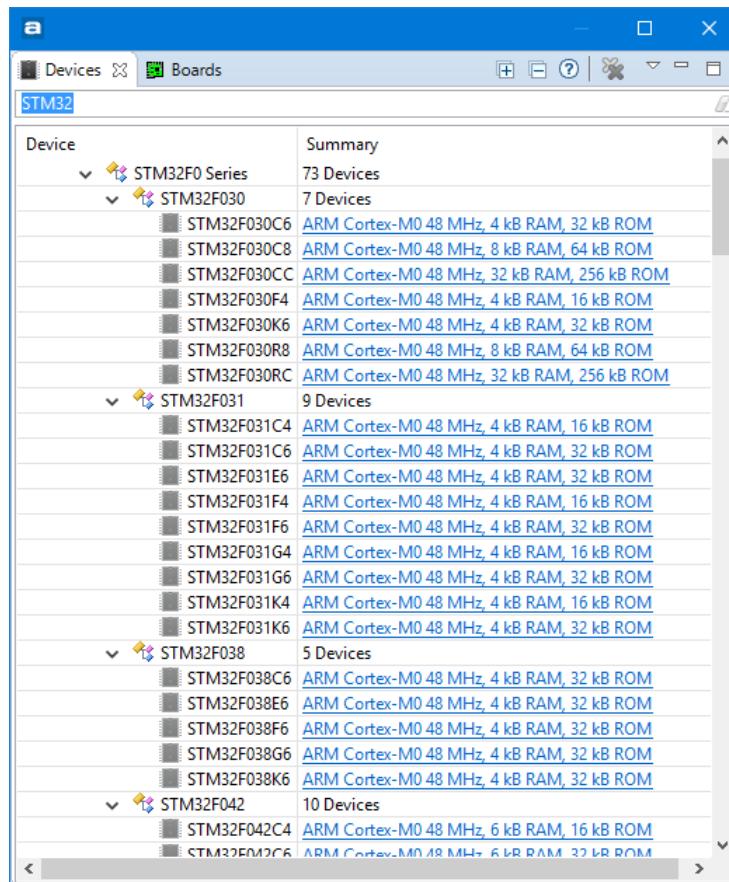


Figure 140 – Search STM32 Devices Software Pack

The **Boards** view lists the boards that are supported in available Software Packs. Select a board to narrow the list in the **Packs** and **Examples** view. E.g. STM32

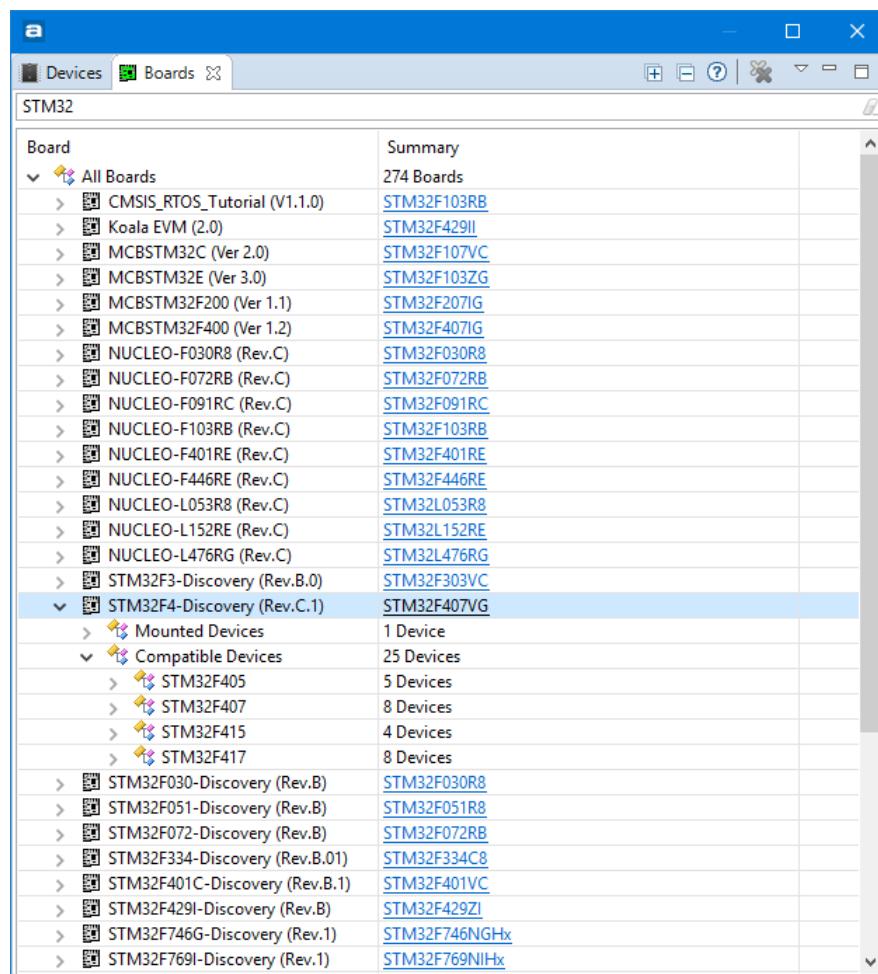


Figure 141 – Boards Software Pack

OPEN INSTALLED CMSIS PACKS VIEW

Open the **Installed CMSIS Packs** view by writing **Installed** in the **Quick Access** field and select **Views Installed CMSIS Packs**.

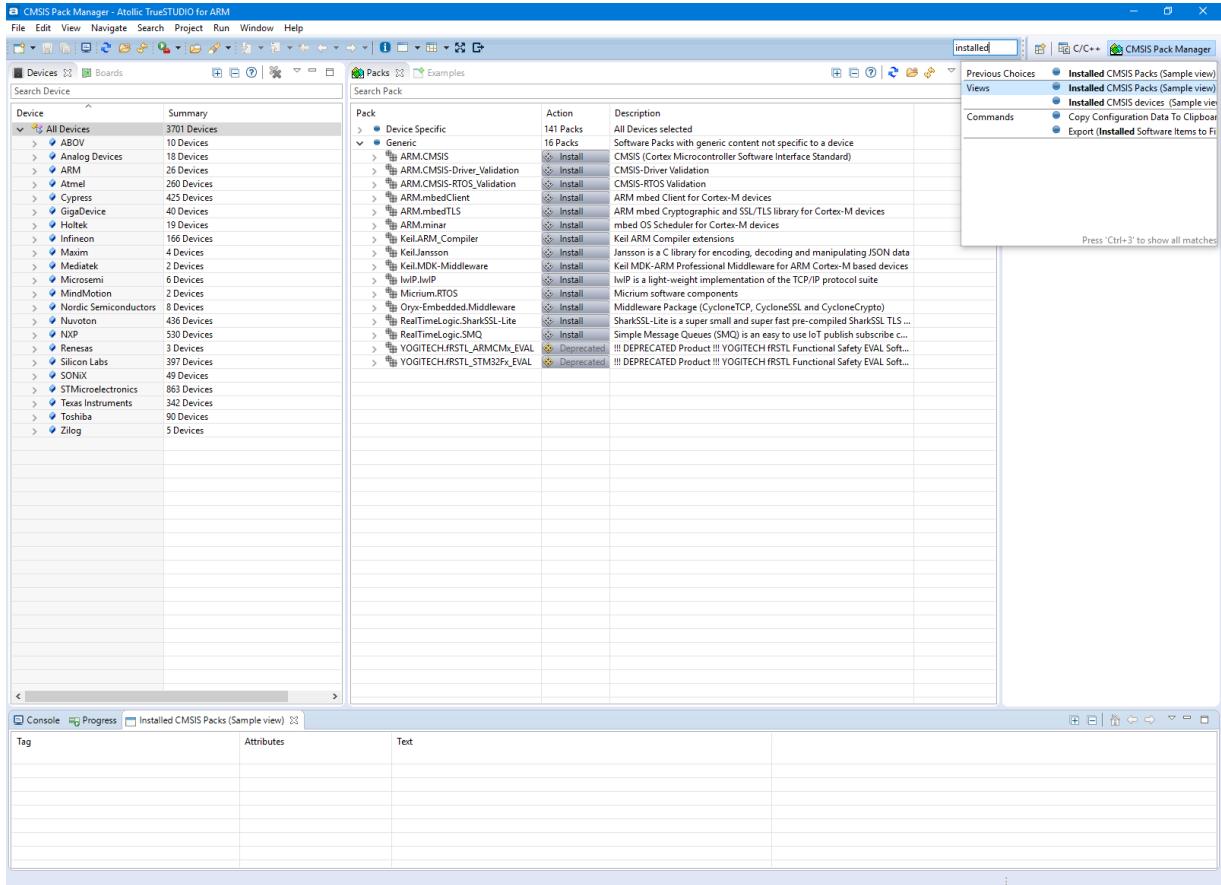


Figure 142 – Open Installed CMSIS Packs View

The **Installed CMSIS Packs (Sample view)** displays the installed packages. Currently no packages have been installed so at this time the view is empty. There is also a similar **Installed CMSIS devices (Sample view)** which displays installed devices.

INSTALL CMSIS PACKAGES

The **Packs** view is used to install new CMSIS Packs. Select a Pack in the view and click on the right mouse button and select **Install**.

It is recommended to install the ARM.CMSIS Pack as this contains basic CMSIS software and is used by most other CMSIS Packs.

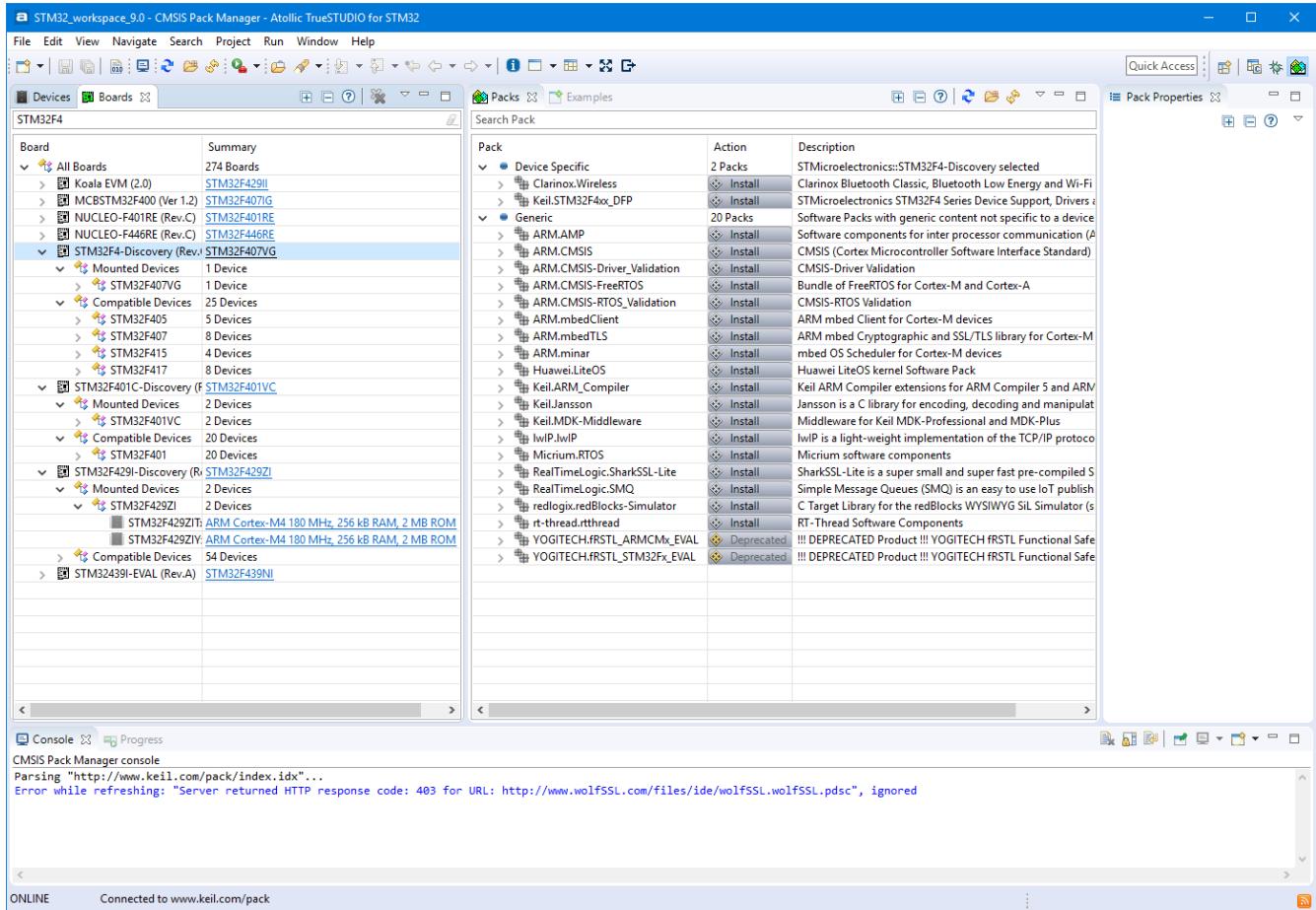


Figure 143 – Install Packs

Select the version of the Pack that shall be installed and press the **Install** button in the action column. The installation will then start. We will now install the Keil.STM32F4xx_DFP and the generic ARM.CMSIS packages.

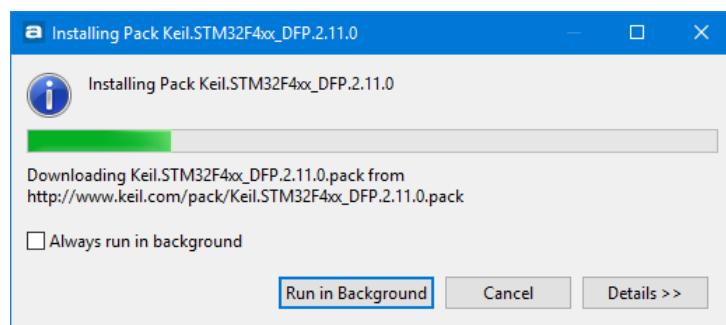


Figure 144 – Installing Pack

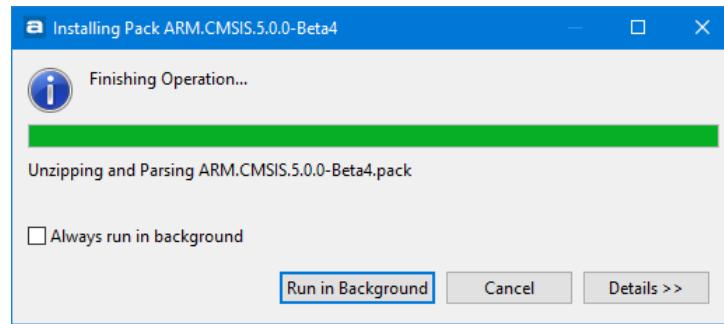


Figure 145 – Installed Pack

When a Pack is installed the color of the icon for the Pack is changed to yellow in the **Packs** view.

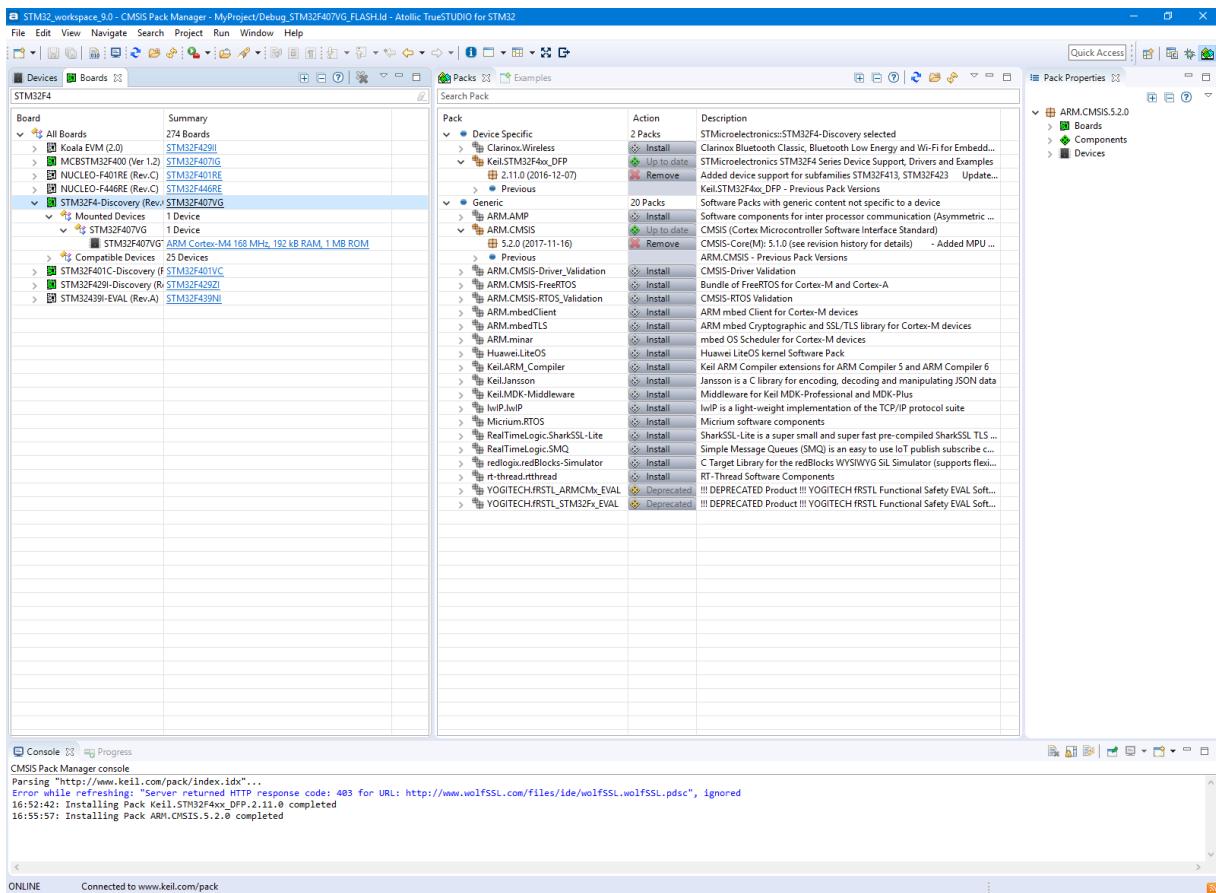


Figure 146 – Installed CMSIS-Packs

CREATE CMSIS-PACK BASED PROJECTS

It is possible to create a new project in **Atollic TrueSTUDIO** based on installed CMSIS-Packs.

There are several ways to create projects based on CMSIS-Pack. One way is to create a CMSIS C/C++ Project and another way is to use the Embedded C Project which will be populated with devices/boards defined also in installed CMSIS-Pack files.

CREATE CMSIS C/C++ PROJECT

Open the C/C++ perspective **Atollic TrueSTUDIO** and create a new project. Enter a project name and select **CMSIS C/C++ Project**.

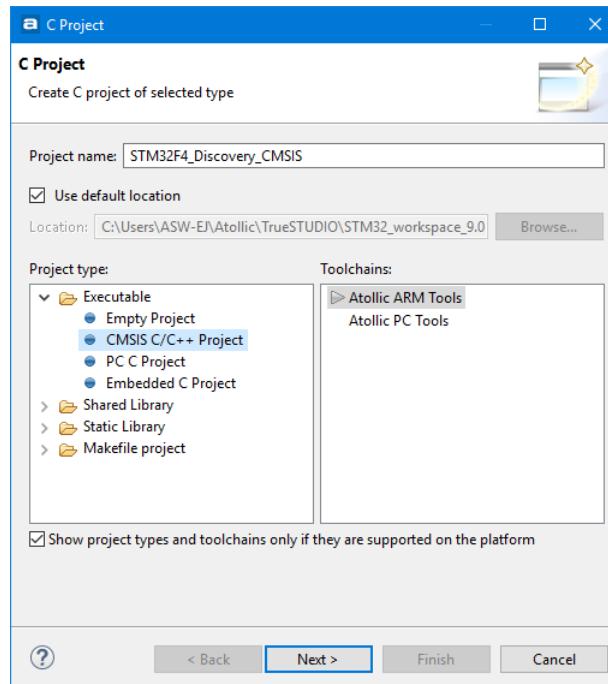


Figure 147 – Create CMSIS C/C++ Project

Press **Next**.

The **CMSIS C/C++ Project** dialog is displayed.

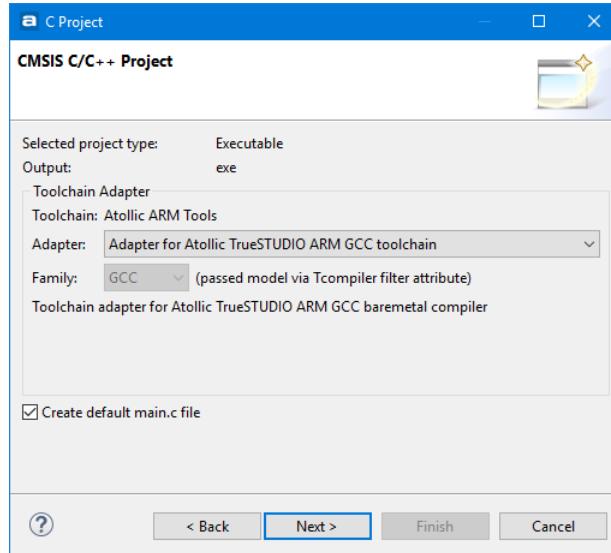


Figure 148 – Create CMSIS C/C++ Project (main)

Select **Create default main.c file**, the **Atollic ARM GCC Toolchain** will be used and **GCC** and software will be taken from the CMSIS-Pack files.



Note! Unfortunately many CMSIS-Pack files are not yet complete with GCC startup and linker files included in the CMSIS-Pack so some manual adaptations may be required after a project is created, to make it build correctly.

If the startup and/or linker script file is missing when the project is generated then investigate if these files are included in the Pack by using a file browser. If the files are found then copy them into the project and rebuild the project.

If the startup and/or linker script file is missing in the Pack then create a TrueSTUDIO project for the device if it is supported by **Atollic TrueSTUDIO** and copy those files to the project. Alternatively create a basic ARM project for a similar ARM core and base the startup and linker script for the CMSIS project on these files. Make sure to update the startup file to include the interrupt vectors and linker script file with the device memory mapping etc.

If the CMSIS-Pack project provides a linker script and you would like to change some information in it there is a need to create a linker script outside the normal folder, see information about this in the Updating Linker Script for CMSIS C/C++ Project chapter at page 184.

Press **Next**.

Select the device from a package to generate the project for. In this case we use the STMicroelectronics STM32F407VGTx device

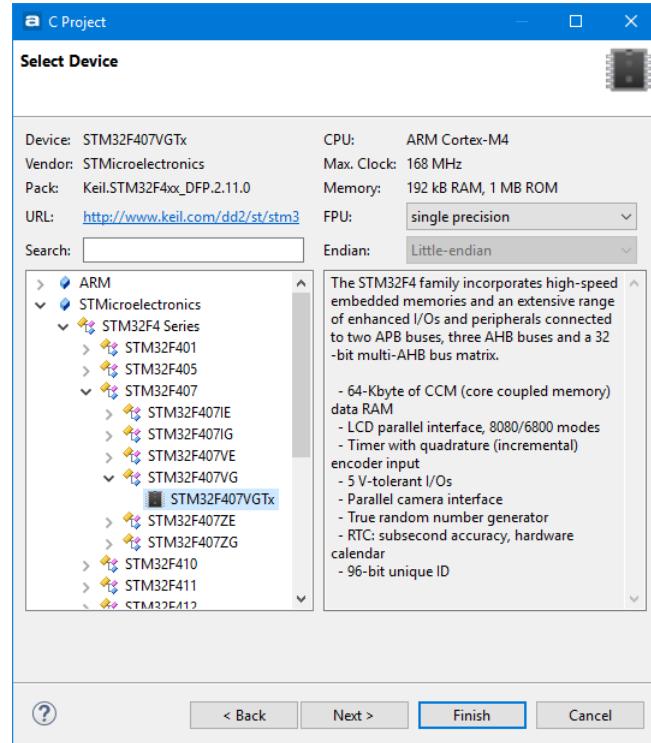


Figure 149 – Create CMSIS C/C++ Project (device)

Press **Next**.

The Select Configurations dialog is displayed. By default a Debug and a Release configurations are prepared.

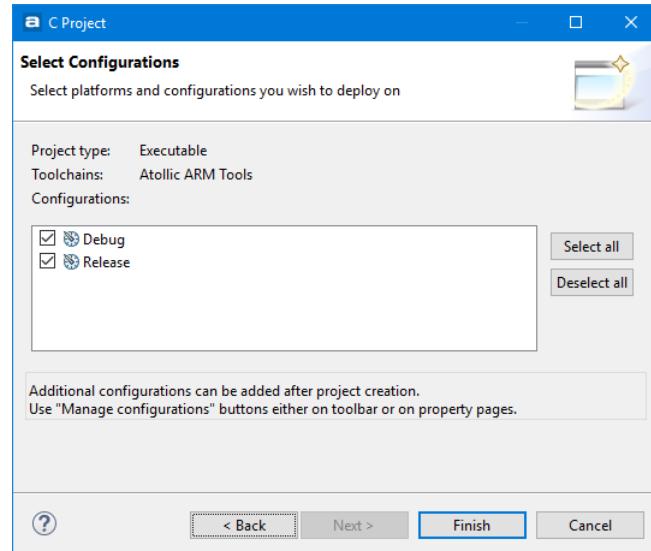


Figure 150 – Create CMSIS C/C++ Project (configurations)

Press **Finish** and the project will be created.

CONFIGURE THE CMSIS C/C++ PROJECT

When a CMSIS C/C++ project has been created it needs to be configured to use the software from the CMSIS-Pack. The configuration of a project is made by selecting needed software using the *.rteconfig file.

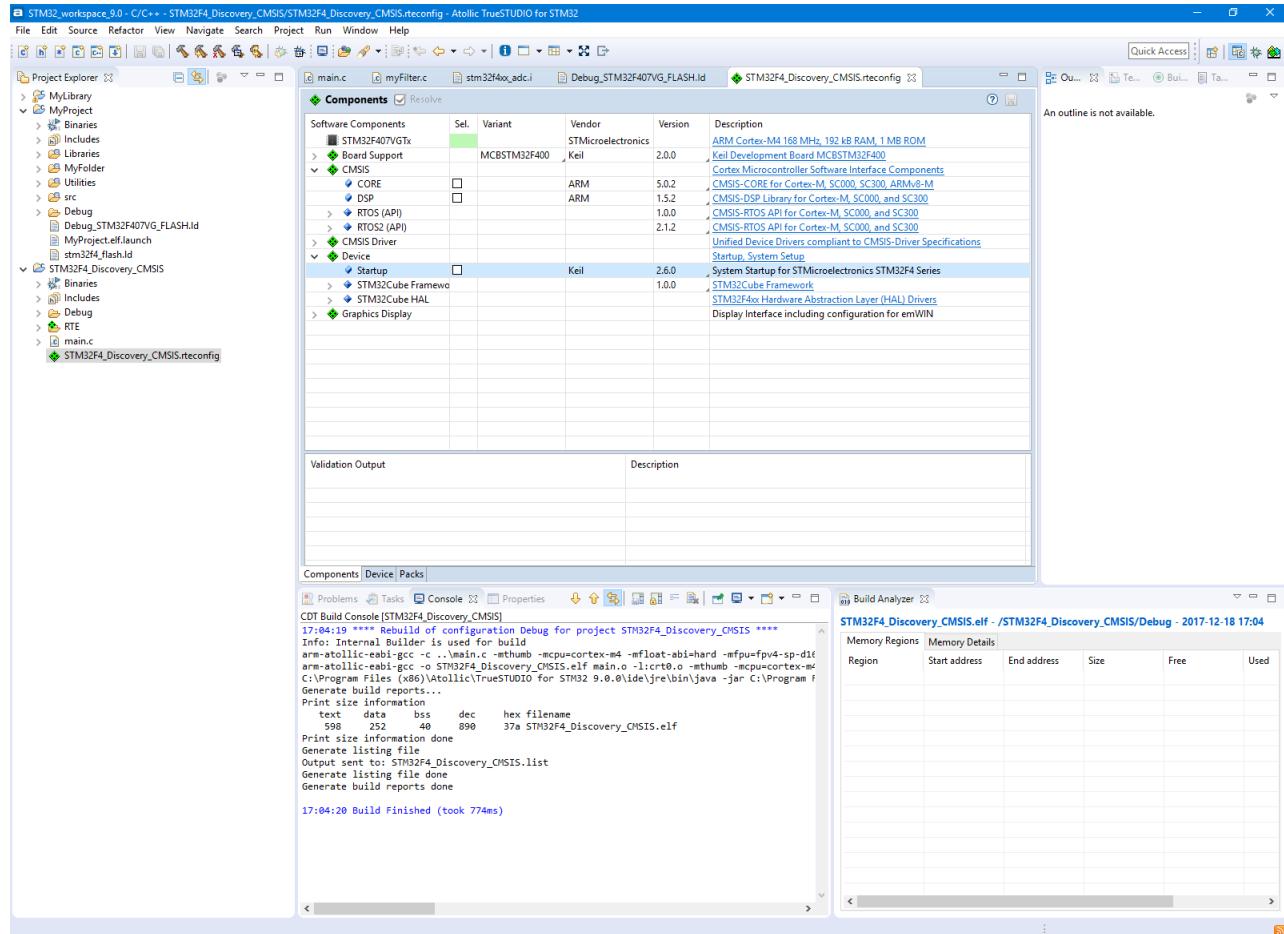


Figure 151 – Configure CMSIS C/C++ Project

For instance we would like use the Startup file from the STM32F407VGTx device.

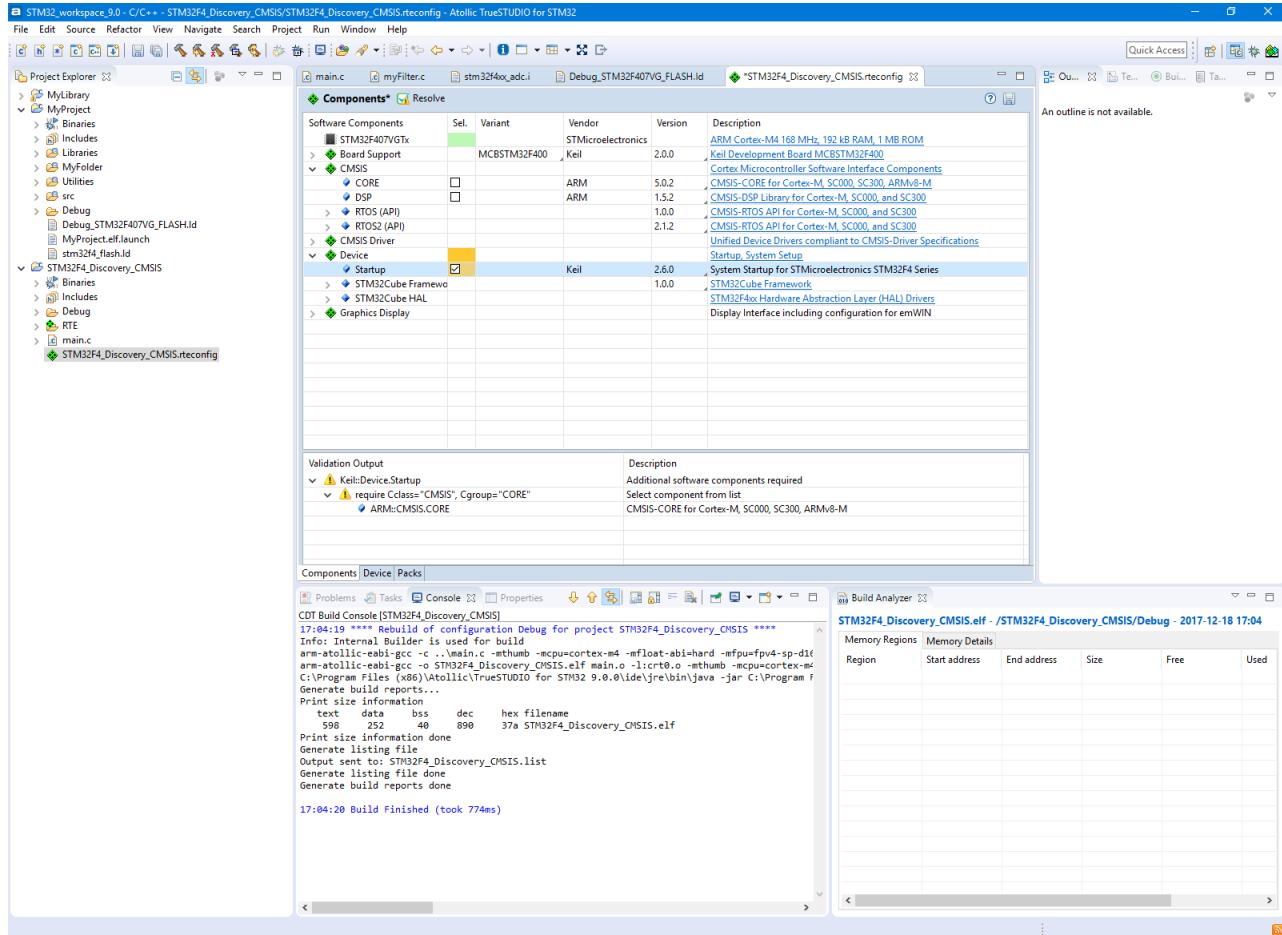


Figure 152 – Configure CMSIS C/C++ Project with Startup file

As seen in the figure above the Startup file depends on files in the CMSIS CORE group so we need to include also the **CMSIS CORE** files to this project.

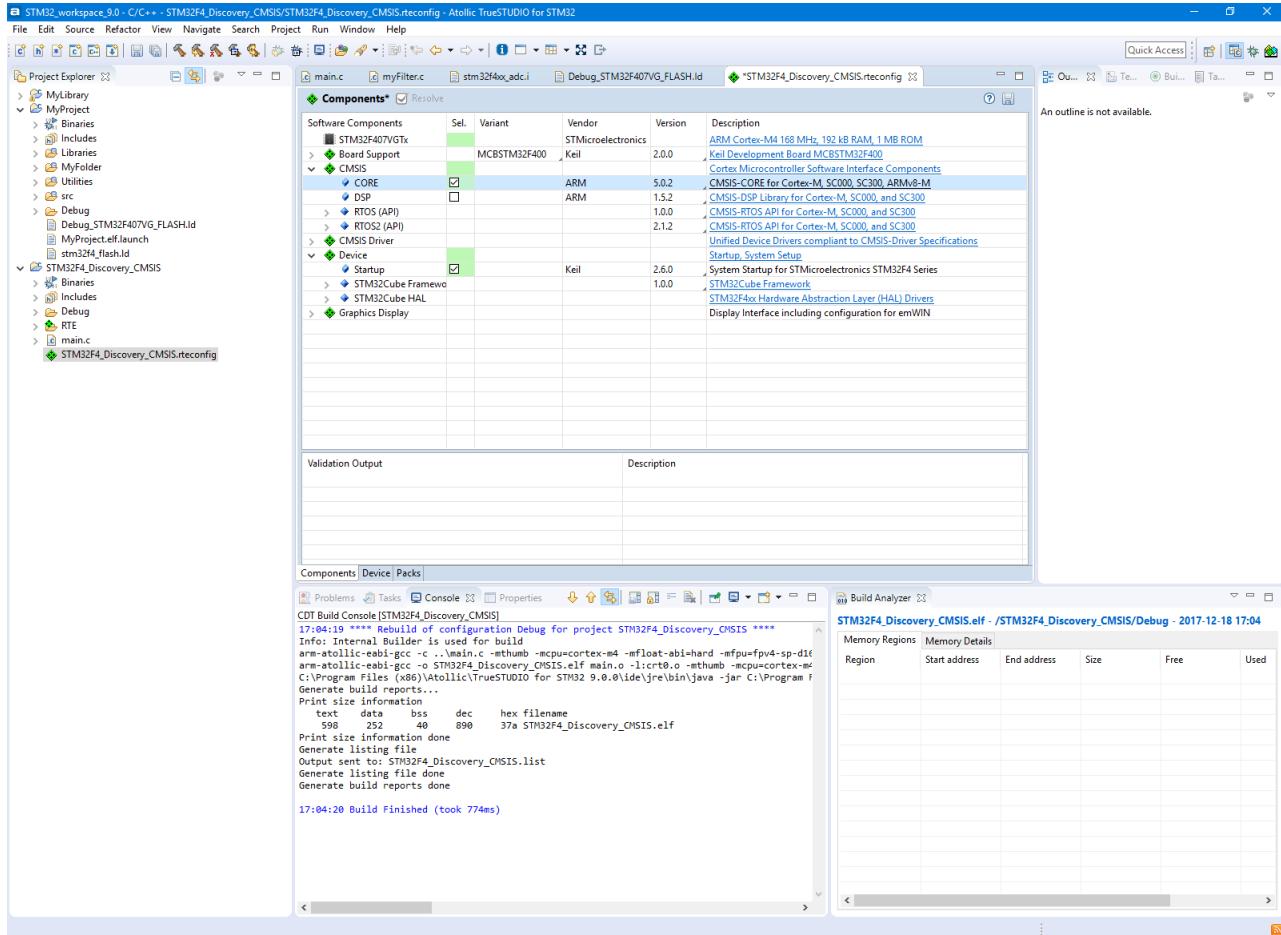


Figure 153 – Configure CMSIS C/C++ Project with CMSIS CORE files

Save the setting by pressing on the **Disk** icon on the toolbar. If we build the project we get the following build result.

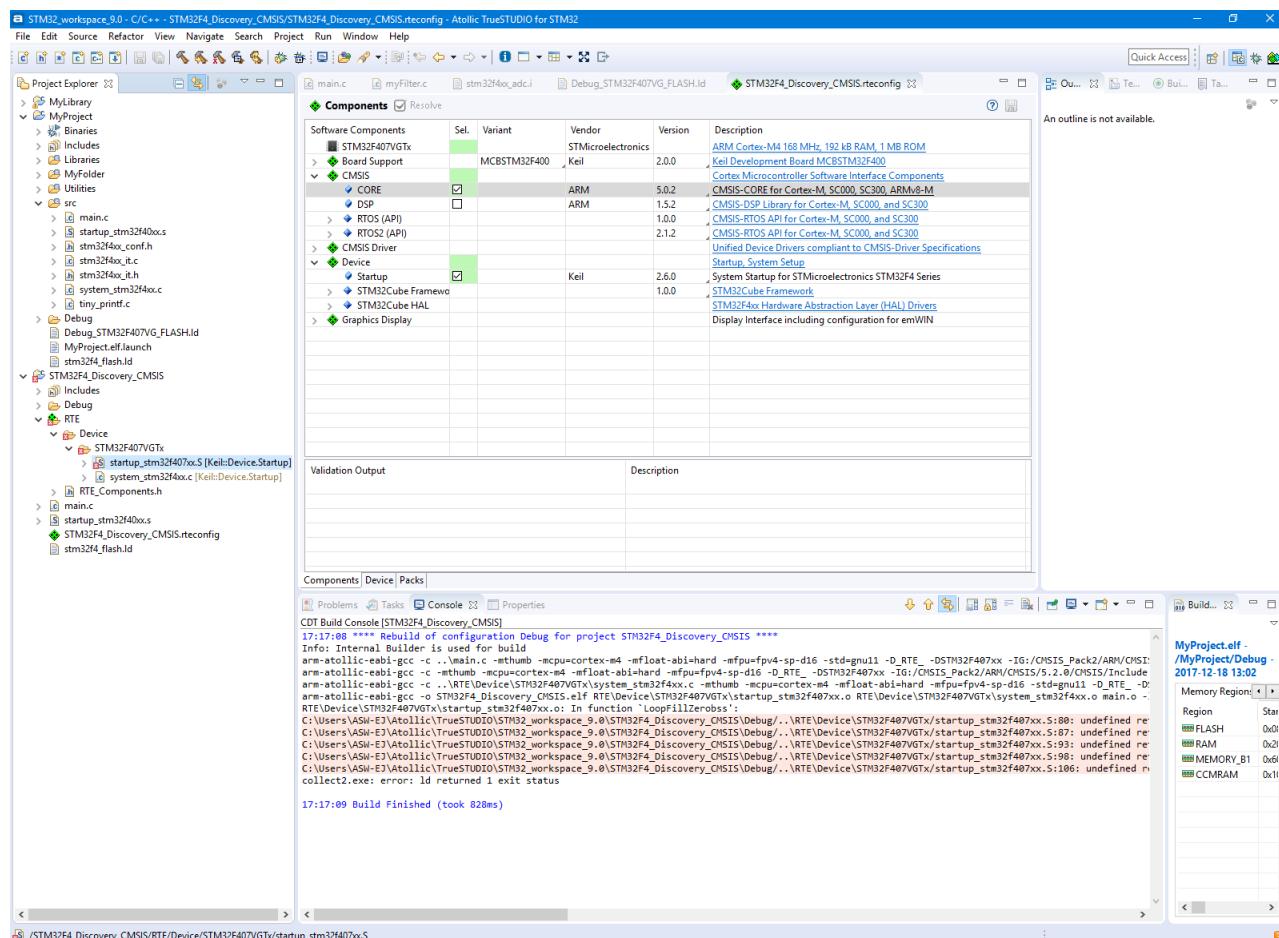


Figure 154 – Build CMSIS C/C++ Project

As seen this project does not build correctly. The reason is that the CMSIS Pack file does not contain correct information to build with gcc.



Note! If there are any build errors please check if the project contains a startup file and a linker script file.

When using GCC the startup file and linker script file is tightly connected as for instance the startup file needs to get information from the linker script where memory and stack should be located.

If the Pack does not contain any startup or linker script file the Atollic TrueSTUDIO wizard will generate and add generic startup and linker script files to the project. In such cases there is a need to manually update the linker script with stack location and memory location and size information. Also the startup script only contains the first 16 generic Cortex-M interrupts so there is a need to add the device specific interrupts into the startup file if such interrupts are used.

To solve the problem in this case copy the startup file from the RTE/Device/STM32F407VGTx folder (Note! This folder was not created as a source folder) to the project root folder were the `main.c` file is located. Also copy the `system_stm32f4xx.c` file to the project root directory.

UPDATING LINKER SCRIPT FOR CMSIS C/C++ PROJECT

CMSIS-Pack components that provides linker scripts will automatically set the linker script used to the one provided from the Pack. To still allow the user to modify and create their own linker scripts, the toolchain linker script option is only updated by CMSIS-Packs if the location of the linker script is not changed.

If the linker script file is missing in the pack it can be copied from some other project for STM32. The best way could be to create a standard **Atollic TrueSTUDIO** project for the board and copy the linker script files from that project into the created CMSIS Pack project. When the linker script file has been copied update the properties for the project so that the linker file is used.

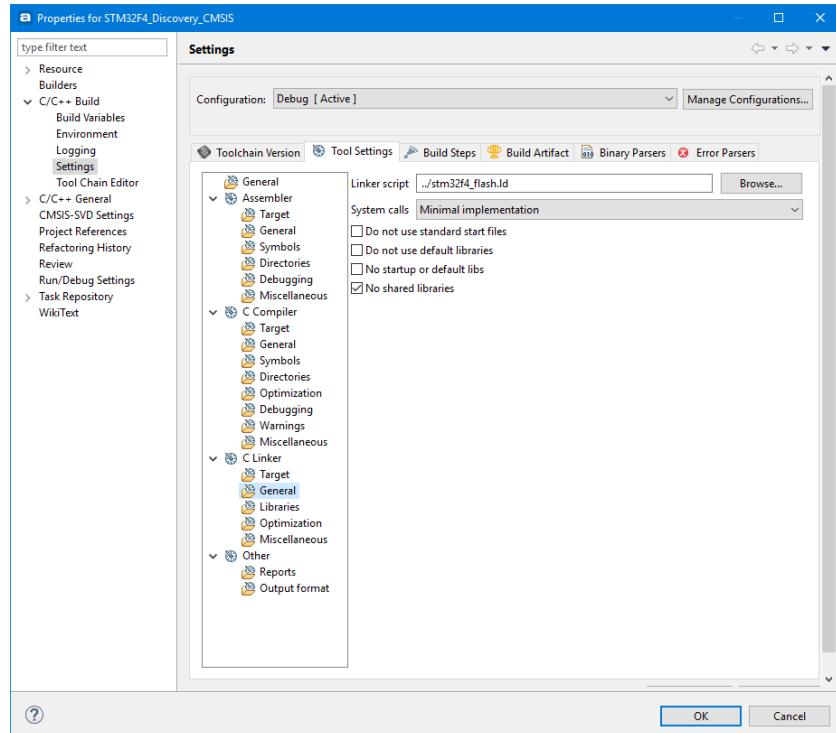


Figure 155 – Setup CMSIS C/C++ Project Linker Script File

If the linker script for this project needs to be updated manually then please take a copy of the linker script and make the updates in this new file. Then update the Linker script setting in the Tool Settings tab in Properties for the project to point to the new script.

DISABLE CMSIS STARTUP FILE

Disable the Startup file from the CMSIS Component configuration if the Startup file has been copied to the project.

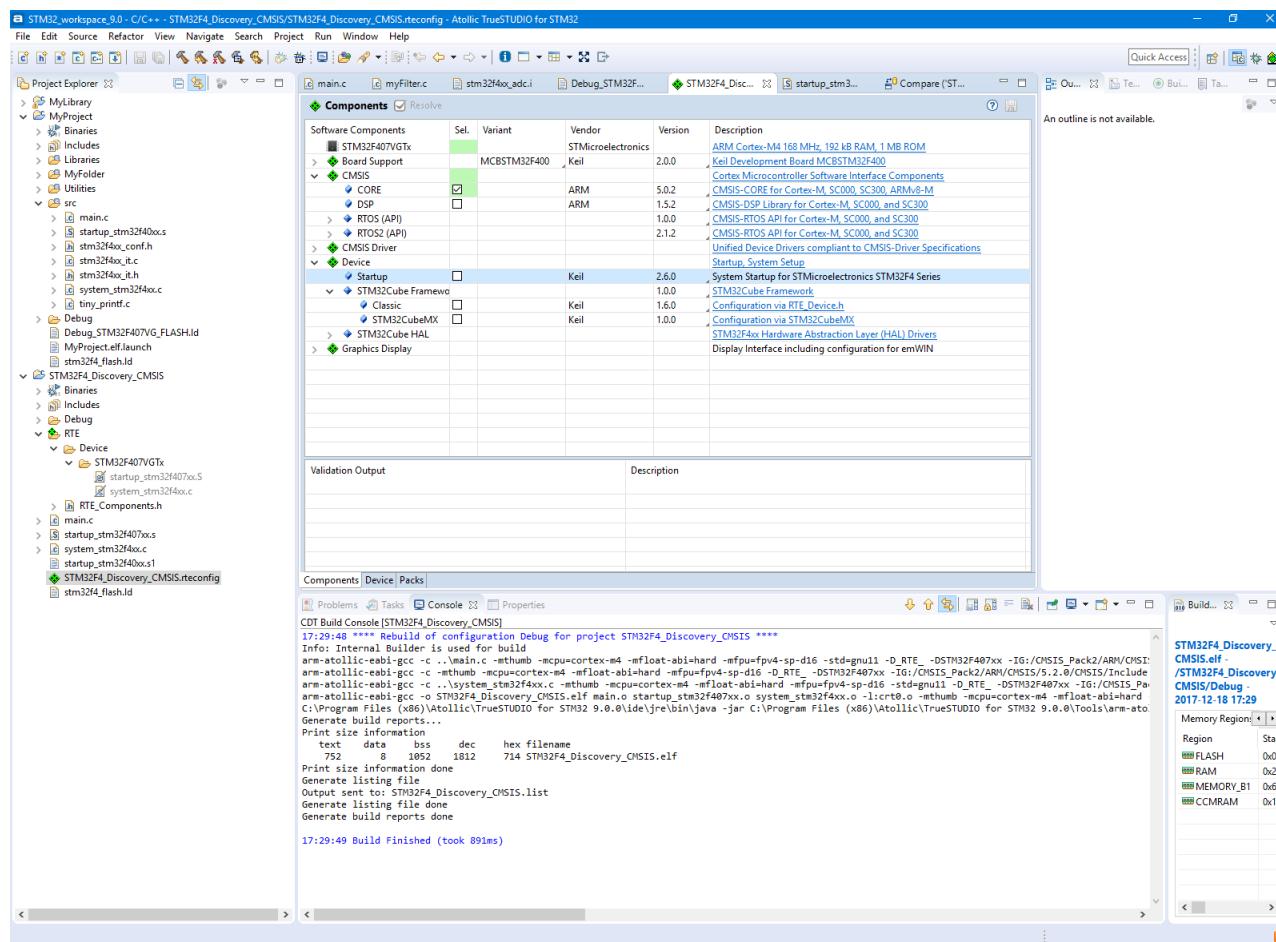


Figure 156 – Disable Startup File from CMSIS C/C++ Project

DEBUGGING THE CMSIS C/C++ PROJECT

Finally when the project builds OK it is ready for testing.

Start a debug session for the project. First time a project is debugged a new Debug Configuration needs to be created. Select ST-LINK as debug probe and make sure that SWD is enabled if the board to be debugged is using ST-LINK and SWD.

The RTE project can be debugged using a debug probe and a board. In this case we will debug the created STM32 project using the STM32F4-Discovery board which includes a ST-LINK onboard.

Press **F11** and the **Edit Configuration** dialog appears. In the **Debugger** tab select Interface **SWD**.

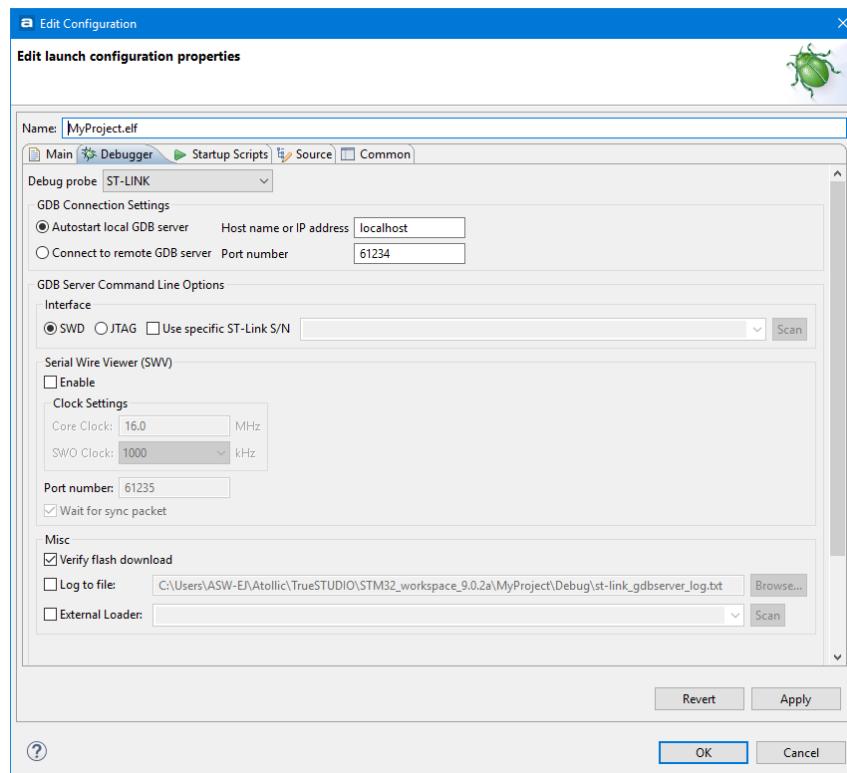


Figure 157 – Debug CMSIS C/C++ Project Configurations

Make sure the board is connected to the PC using the Debug connector on the board and then Press **OK**.

The program is now loaded to the board and the debug session is started.

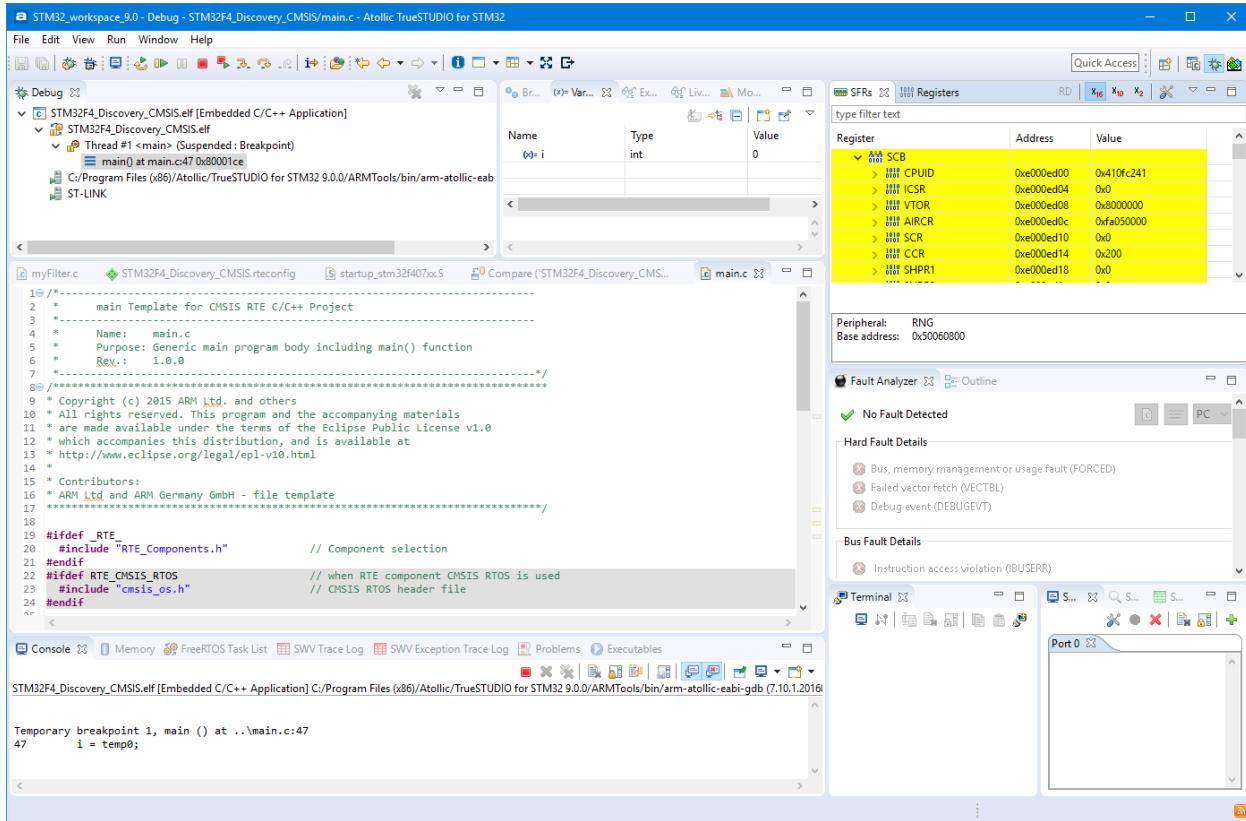


Figure 158 – Debug CMSIS RTE C/C++ Project

ADDING MORE CMSIS-PACK FEATURES INTO PROJECT

The project can be updated according your application needs.

The Keil CMSIS_Pack for STM32 contains many examples for different board. One way to easy test examples is to open the Pack in file explorer and double-click on a .project file in an example. The project will then be imported into TrueSTUDIO. E.g. Open the following folder in the Pack to discover how to use STM32 drivers.

F:\CMSIS_Pack\Keil\STM32F4xx_DFP\2.11.0\Projects\STM32F4-Discovery\Examples\GPIO\GPIO_EXTI\TrueSTUDIO\STM32F4-Discovery

Build and test the program in the Debugger to discover the usage of GPIO drivers on the board.

INSTALLING 3RD PARTY PLUGINS

It is possible to install hundreds of additional third party ECLIPSE™ plugins in **Atollic TrueSTUDIO** for users that want even more functionality in their TrueSTUDIO IDE.



Atollic does not provide support for any third party plugins.

Support for third party plugins are always provided by their respective manufacturer.

ECLIPSE™ plugins are easily found by searching at Eclipse marketplace (<http://marketplace.eclipse.org/>). However, please bear in mind that not all plugins for ECLIPSE™ are compatible with **Atollic TrueSTUDIO**.

INSTALL FROM ECLIPSE MARKETPLACE

To install from Eclipse Marketplace select **Help, Eclipse Marketplace...**

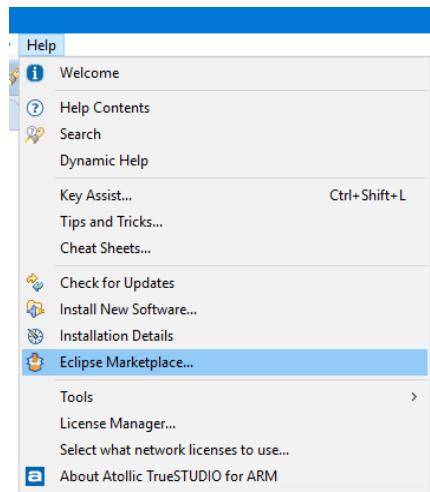


Figure 159 – Select Eclipse Marketplace

Search for the plugin and make the installation.

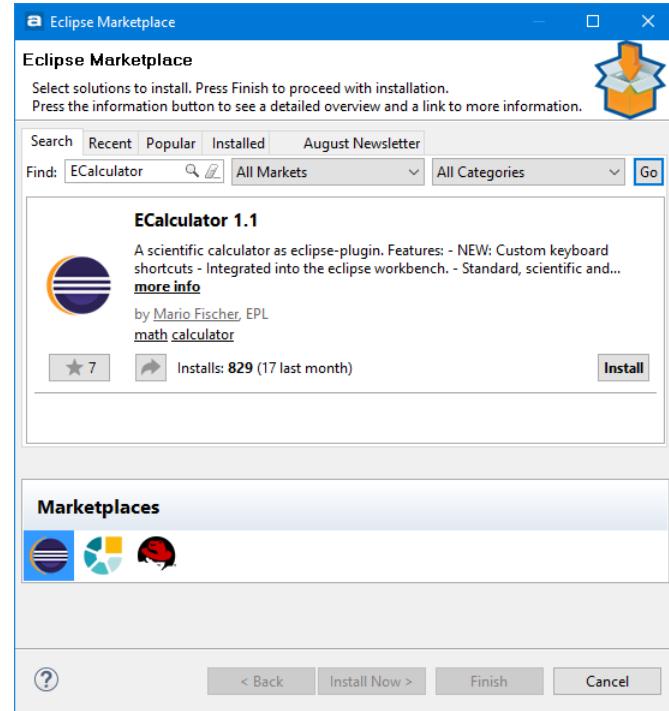


Figure 160 – Install Using Eclipse Marketplace

INSTALL USING “INSTALL NEW SOFTWARE”

2. To install a plugin select **Help, Install New Software...**

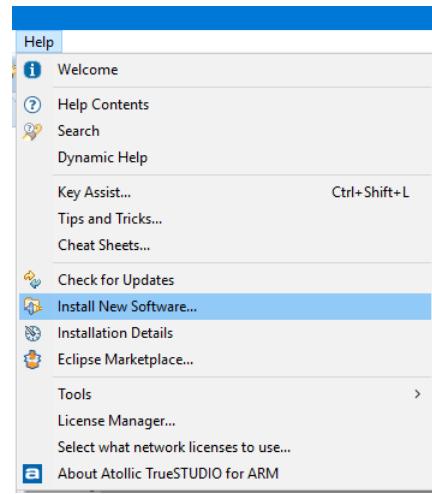


Figure 161 – Select Install New Software

3. Then enter the URL to the update site for the plugin. If the URL is not known, **All Available Sites** can be selected.

Select the appropriate plugins. Please remember that not all ECLIPSE™ plugins are compatible with **Atollc TrueSTUDIO**.

Click the **Next** button.

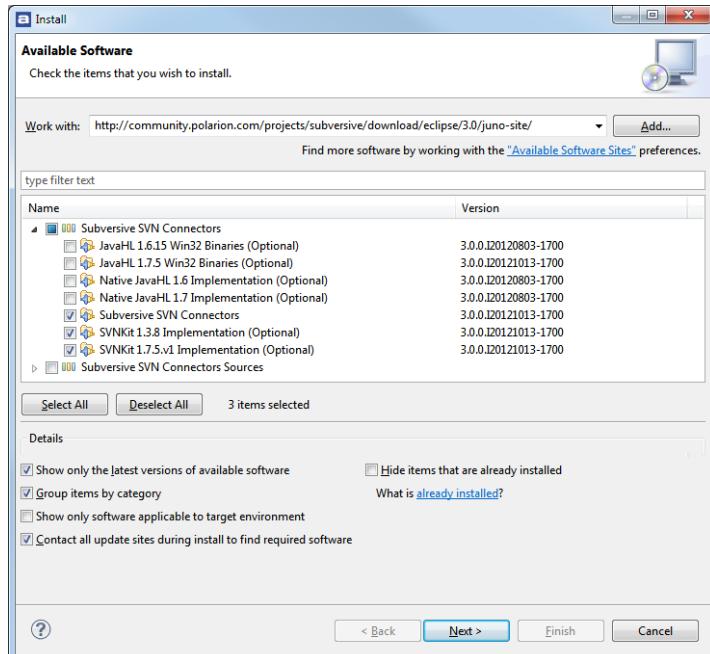


Figure 162 – Enter Download Site and Select Plugins

4. Review the items to be installed and click the **Next** button.
5. Read all the licenses agreements and click accept if the terms are found acceptable. Then click the **Finish** button.

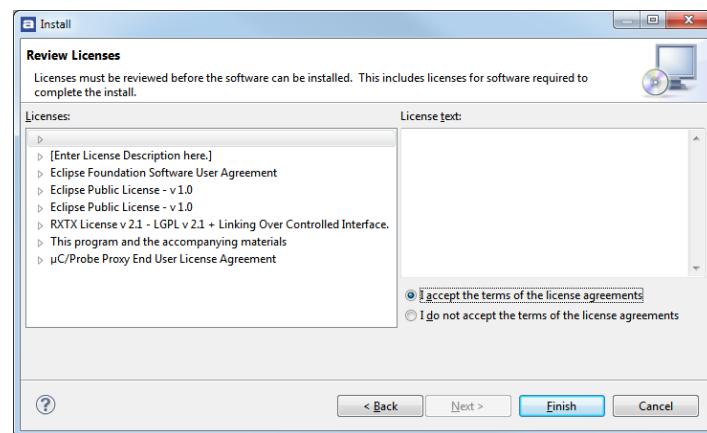


Figure 163 – Accept License Agreements

6. The plugins are now automatically downloaded and installed.

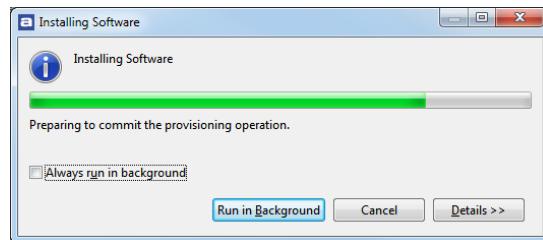


Figure 164 – The Plugins are Installed

7. Restart **Atollic TrueSTUDIO** and the plugins are ready to be used.

UNINSTALLING 3RD PARTY PLUGINS

To uninstall a 3rd Party Plugin that is no longer preferred, in the top menu select **Help**, **About Atollic TrueSTUDIO**, **Installation Details**.

In the new panel select the plugin to uninstall and press **Uninstall...**

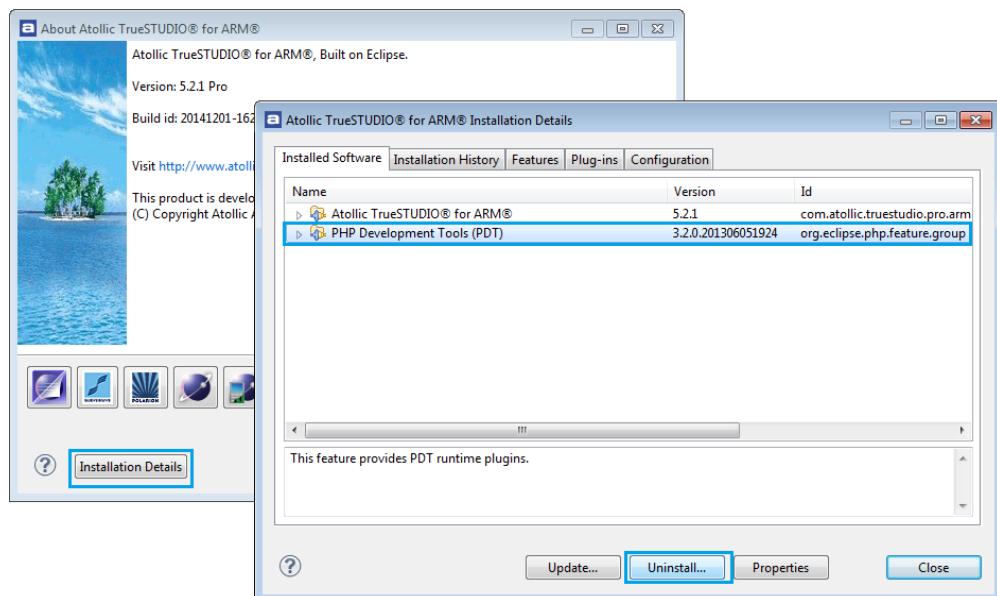


Figure 165 – Uninstalling Plugins

SOLVING UPGRADE PROBLEM

If some problem occurs when upgrading or installing new software into **Atollic TrueSTUDIO** then please try to uninstall the software again and restart the product. If there are problems to run **Atollic TrueSTUDIO** after restarting then try this:

1. Go to the .eclipse directory in your home directory in Windows, Eg. C:\Users\your_name\.eclipse
2. Identify the folder which corresponds to the **Atollic TrueSTUDIO** version you are using.
3. Rename this folder and restart **Atollic TrueSTUDIO**. The product should now start as it was first installed without any updates.

USING ST-LINK UTILITY INSIDE ATOLIC TRUESTUDIO



This chapter shows and explains many useful techniques in **Atollic TrueSTUDIO**. External tools and Launch groups are features that can be used to solve many other problems.

We recommend all users of **Atollic TrueSTUDIO** to read this chapter.

The ST-Link GDB-server used for debugging STM32 devices does not implement all functionality available in the ST-Link utility. It is however possible to call ST-Link Utility from inside the IDE, this can save a lot of time when performing various debugging related tasks.

Typical use cases when this is beneficial:

- When certain parts of the flash need to be erased before loading binary
- When you want to compare the binary file in target with the one just built with **Atollic TrueSTUDIO**.
- For setting option bytes such as read out protection.
- For faster loading into flash than is offered by the ST-Link GDB-server

```

Administrator: C:\Windows\system32\cmd.exe - ST-LINK_CLI.exe
c:\Program Files (<x86>) STMicroelectronics\STM32 ST-LINK Utility\ST-LINK Utility>ST-LINK_CLI.exe
STM32 ST-LINK CLI v2.0.0
STM32 ST-LINK Command Line Interface

Available commands:
=====
-c      Connect to the device using JTAG or SWD.
        Syntax : -c [ID=<id>/SN=<sn>] [JTAG/SWD] [UR/HOTPLUG] [LPM]
        [ID=<id>] : id of ST-LINK [0..9] to use when multiple
                     probes are connected to the host.
        [SN=<sn>] : sn of the chosen ST-LINK probe.
        [UR]       : Connect to target under reset.
        [HOTPLUG]  : Connect to target without halt or reset.
        [LPM]      : Activate/deactivate Low Power mode.

Example1: -c -D=0 SWD UR LPM
Example2: -c SN=55FF6C064892495358622187 SWD UR LPM
Note: when [ID=<id>] and [SN=<sn>] are not specified, the first
      ST-LINK with ID=0 will be selected.
      Selection of ST-LINK by ID or SN should be used with :
      * U1J138x or greater ST-LINK firmware version.
      * U2J285x or greater ST-LINK/U2 firmware version.
      * U2J284x or greater ST-LINK/U2-1 firmware version.

```

Figure 166 – ST-LINK_CLI.exe

REQUIREMENTS

- St-Link Utility (Download it from <http://www.st.com>)
- A working ST-Link

The ST-Link utility does not support elf-files. Use Intel Hex.

STEPS THAT NEEDS TO BE PERFORMED

1. Setup ST-Link Utility with suitable input parameters as an external tool
2. Convert your build output to Intel Hex
3. Create / modify a debug configuration so that the flash operation is *only* performed by ST-Link Utility
4. Create a Launch Group to perform the ST-Link Utility operations before the Atollic TrueSTUDIO debugger starts

SETUP ST-LINK UTILITY AS AN EXTERNAL TOOL

In the main menu select **Run, External Tools..., External Tools Configurations...**

Create a new Launch configuration as shown below.

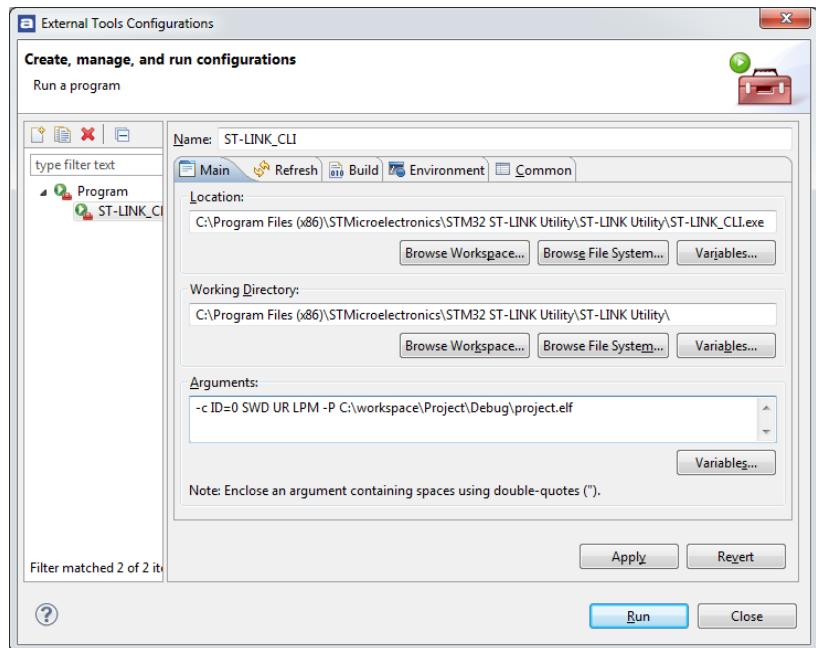


Figure 167 – ST-LINK_CLI.exe

- **Name** i.e. "ST-LINK_CLI"
- **Location** i.e. C:\Program Files (x86)\STMicroelectronics\STM32 ST-LINK Utility\ST-LINK Utility\ST-LINK_CLI.exe

- **Working Directory** i.e. C:\Program Files (x86)\STMicroelectronics\STM32 ST-LINK Utility\ST-LINK Utility\
- **Arguments** i.e. -c ID=0 SWD UR LPM -P C:\workspace\Project\Debug\Project.hex

Press **Apply**

Test that the external tool just setup is working by clicking **Run** or **Run, External Tools..., ST-LINK_CLI**

CONVERT THE BUILD OUTPUT TO INTEL HEX

In the top menu select **Project, Build settings..., C/C++ Settings, Tool Settings, other, Output format.**

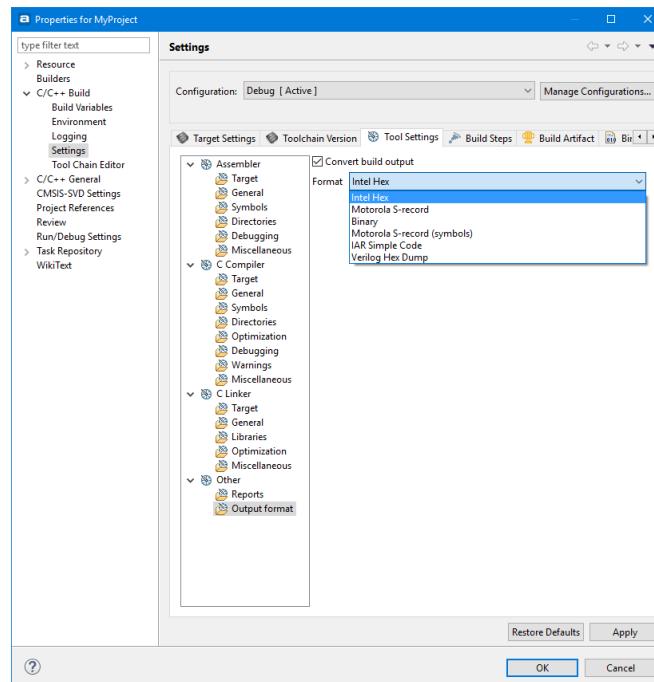


Figure 168 – Convert the Build Output to Intel Hex

Be cautious about which Configuration that is selected! In the screenshot **Debug** was selected so the conversion will not take place when building a **Release** configuration.

- Check the **Convert build output** checkbox
- Select **Intel Hex**
- Click **OK**

Build your project!

The output name will be %PROJECT%.hex. Make sure that this binary is selected when creating the debug configuration. This will not work with an .elf-file.

MODIFY THE DEBUG CONFIGURATION

It is recommended that you make a copy of your current debug configuration as we will need to modify the debug script slightly.

- In the top menu select **Run, Debug Configurations...**

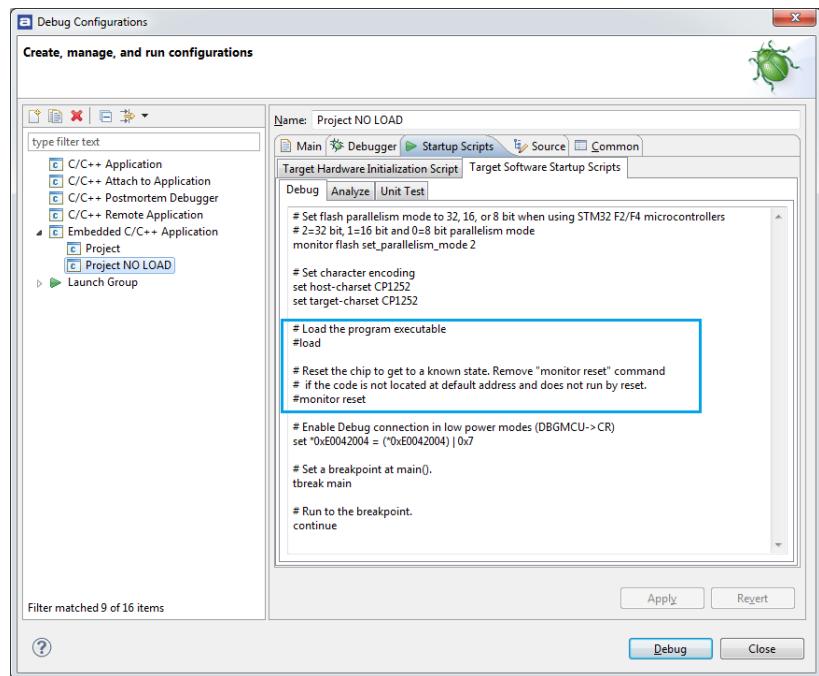


Figure 169 – Modify the Debug Configuration

- Right-click on your debug configuration and select **duplicate**.
- Change the name of this configuration to “... NO LOAD”, this is since GDB will not be used to load the hex.
- Open the **Startup Scripts** tab, comment out the “load” command load, #load. It might also be a good idea to comment out the “monitor reset” command.
- Click **Apply**.

CREATE A LAUNCH GROUP

The Launch Group is used to launch several applications (configurations) by just clicking one button.

Double-click on the **Launch Group** node to create a Launch group and give it a name.

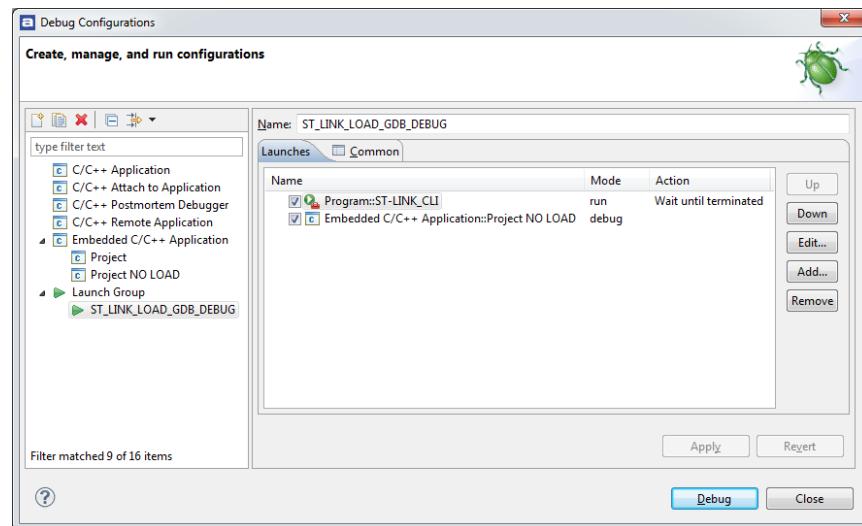


Figure 170 – Create a Launch Group

- Click **Add...**

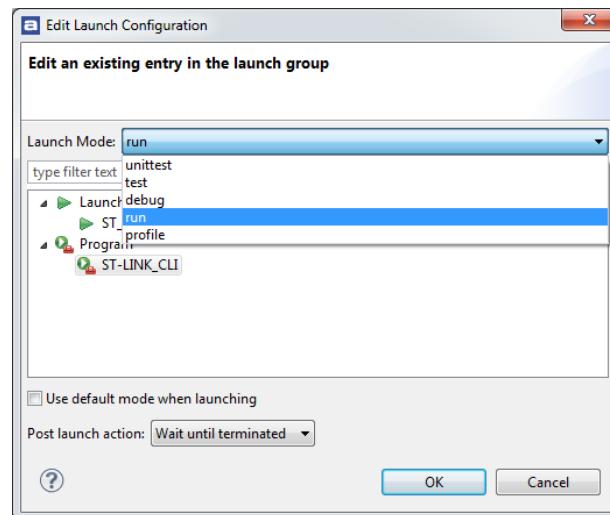


Figure 171 – Edit a Launch Group

- Select **Launch Mode: run**
- Expand Programs and select your external tool configuration, i.e. ST-LINK_CLI.

- Set **Post launch action** to **Wait until terminated**.
- Click **OK** to return to the previous panel.

In that panel click Add...

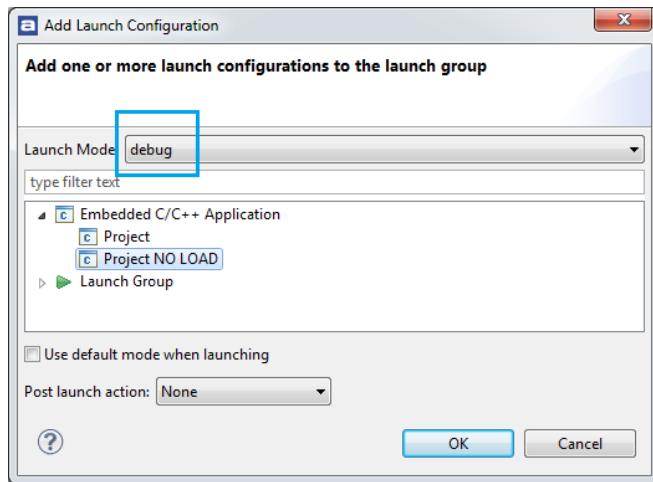


Figure 172 – Select Launch Mode: debug

- Select **Launch Mode: debug**
- Expand Embedded C/C++ Applications and select your debug configuration, i.e. Project NO LOAD.
- Set **Post launch action** to **None**.
- Click **OK** to return to the previous panel.

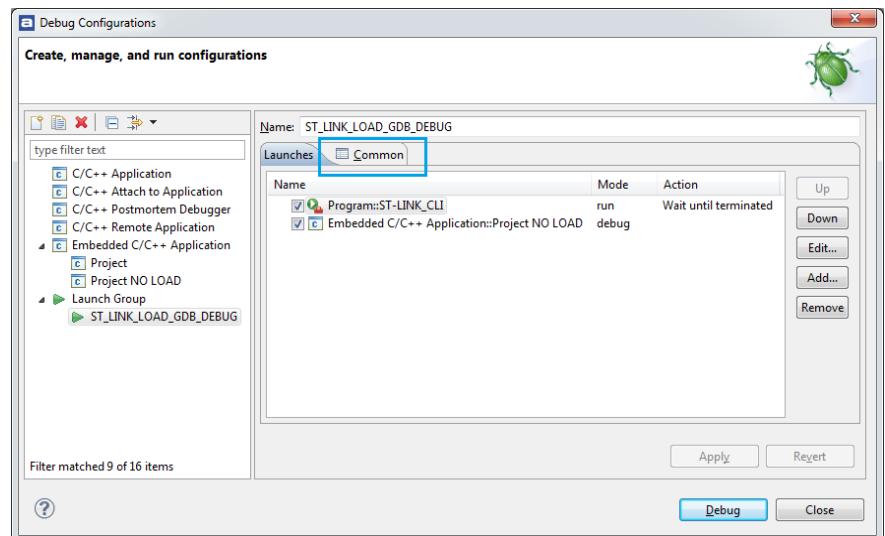


Figure 173 – Select Launch Mode: debug

Open the Common-tab

Enable Display in favorites menu = Run

Enable Display in favorites menu = Debug

Click **Apply**

This will make the launch group available in **Atollic TrueSTUDIO** from the **Run**, **Run-menu** and later the **Run**, **Debug History...**

FINISHED

ST-Link Utility is now flashing the binary into the target memory and the debugger is started as soon as the ST-Link Utility has finished.

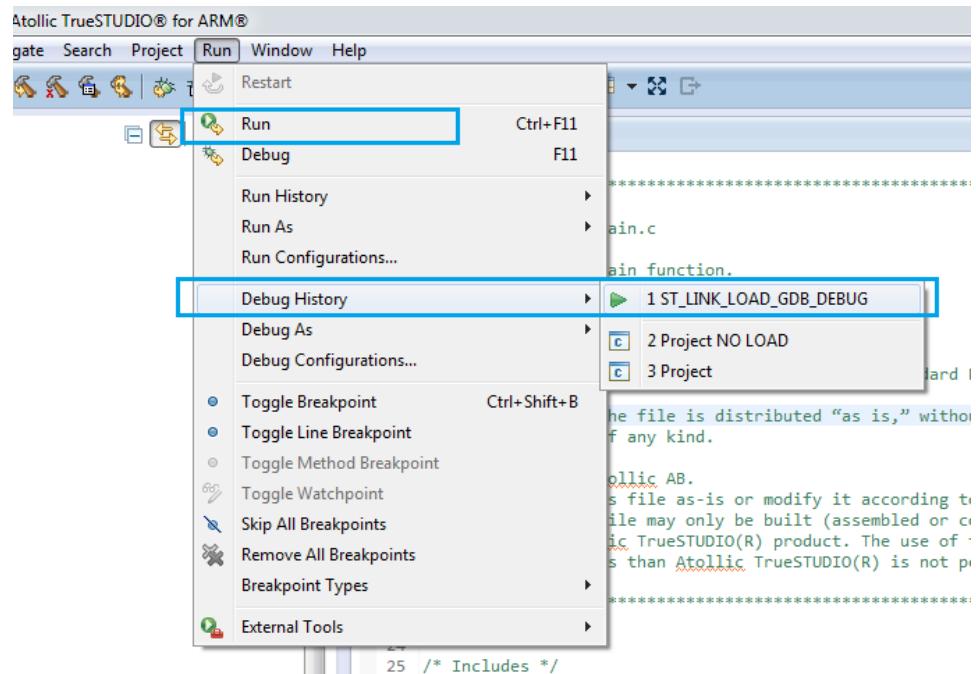


Figure 174 – Debug History

MISCELLANEOUS TOOLS

QUICK ACCESS SEARCH BAR

Quick Access search bar that is a massive time saver.

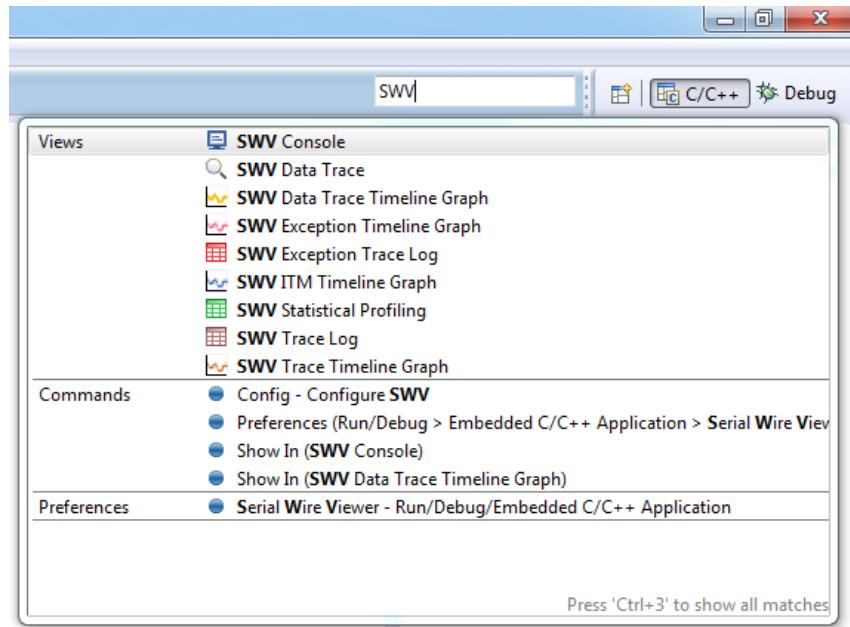


Figure 175 – Quick Access Search Bar

The **Quick Access search bar** is an edit field in the toolbar, where any search phrase or keyword can be entered. GUI objects like menu commands, toolbar buttons, preference settings or views can be found with it.

As any search string is typed, the Quick Access search bar shows all the GUI objects that match the criteria, in “real-time”. Type a couple of more characters and the search results list is refined correspondingly “on-the-fly”.

The Quick Access search bar is an enormous time saver when looking for a specific GUI object that can't be found quickly, such as finding a preference setting deeply buried in the configuration dialogs. Or to just issue a menu command or toolbar button hidden in the currently active perspective.

For example, in the screenshot above the search string “SWV” has been entered and the **Quick Access search bar** immediately provides the list of matching views, GUI commands and preference settings. To open the view or preference setting just click on the GUI object in the search result list

VERSION CONTROL

Atollc TrueSTUDIO includes a basic version-system for projects that works well for a project with just one developer on one computer. It allows users to keep tracks on local file history.

For more information about a local repository see *Local SVN Repository* below.

However if users need to collaborate, keep better track of changes and perhaps work on many workstations, a better version control-system is needed.

Atollc TrueSTUDIO supports three such systems **GIT**, **Concurrent Versions System (CVS)** and **Subversion (SVN)**. The CVS is an older system that **Atollc TrueSTUDIO** supports for those that already have CVS-repositories.

Atollc TrueSTUDIO includes:

- Fully integrated GUI client for SVN & CVS
- Check-in/out and Branch/merge (including a merge-conflict editor)
- Repository & history browser
- File revision annotations, file difference viewer and revision graph viewer
- Full traceability of all lines, in all files, throughout complete project history
- Who did what, when and why?
- What did the code look like at time or version X?
- Who added code line X, when and why?

SUBVERSION - SVN

Subversion (SVN) is an open source version control system that was design to replace the older CVS. It is more or less a de facto standard in the computer industry.

A free and very good online book about SVN can be found here

<http://svnbook.red-bean.com/>

SVN manages files, directories and the changes made to them. That way it is possible to go back to previous version of the code or inspect what changes has been made over time. It also operates over a network and allows the same code to be changed simultaneously on many computers, even over the internet. Thus development can be done faster and with fewer errors. If some incorrect code is entered it can just revert to the previous version.

There are several other clients to use with SVN.



Atollc do not recommend to use different clients within a project, since version-conflicts can occur and will probably cause more problems than it's worth.

To be able to use SVN a Subversion repository is needed. How to set up and maintain a network repository is out of the scope of this manual. On page 206 set up off a local repository is explained. There are also several websites such as Freepository, Google Code and SourceForge provides free source code hosting that can be accessed with **Atollc TrueSTUDIO**'s SVN-integration. A good introduction to how to set up a repository can also be found in chapter 5 in the SVN-book and in several good tutorials on the net.

After making sure a repository exists, the next thing to do to be able to use SVN in a project, is to enable **SVN** in **Atollc TrueSTUDIO**. In the top menu select **Window**, **Customize Perspective**.

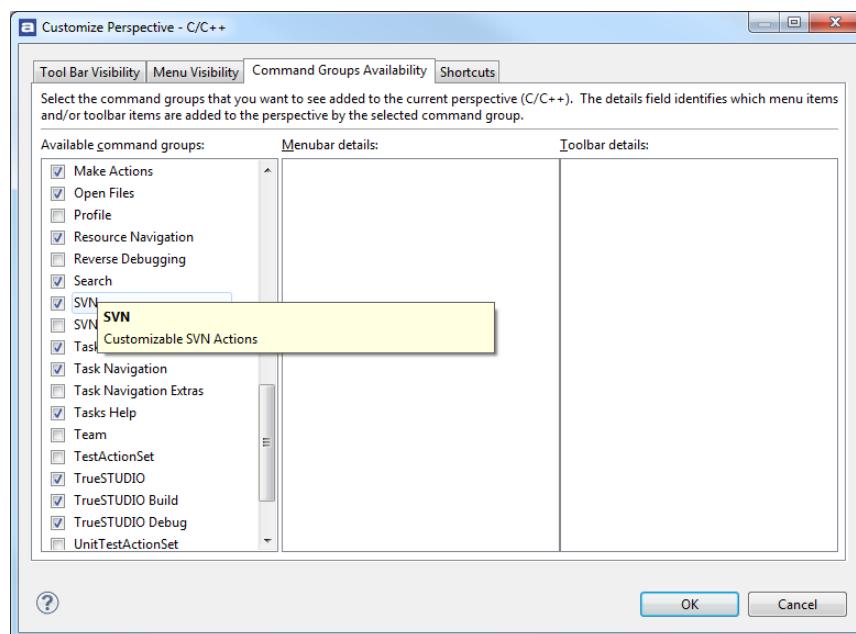


Figure 176 – Enable SVN Command Group

In the dialog that opens up select the **Command Groups Availability**-tab. Find **SVN** in the **Available command groups**-column and make sure it is selected. Click **OK**.

Some extra items are now available in the toolbar. However they should be greyed out. There will also be a new top-menu called **SVN**.

There are several views in **Atollc TrueSTUDIO** for managing **SVN**. They can be found by in the top-menu select **Window**, **Show View**, **Other**.

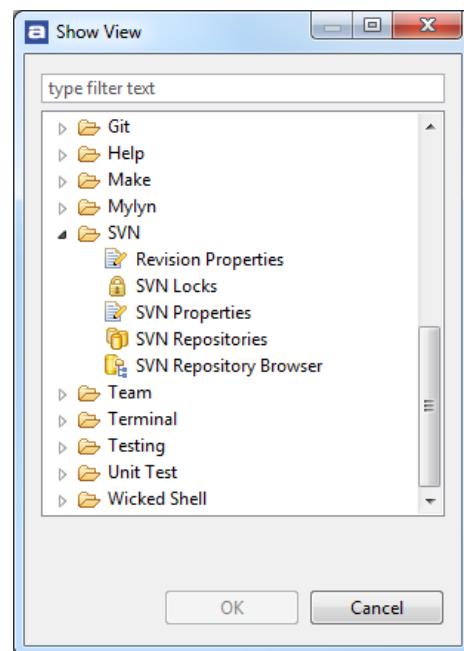


Figure 177 – SVN Views

The first view needed is the **SVN Repositories** since that where repositories are connected.

Connect to an existing repository (in the organization or on the web) by right-clicking in the view and select **New, Repository location**. A new dialog will be displayed. In that dialog enter the URL and other communication-options for the repository.

Next step is to share the project in the repository. Right-click on the project and select **Team, Share Project**. In the dialog that then pops up, select **SVN** and click on **Next**. Select the repository and then **Finish**.

Do the initial commit into the repository.

For more information about how to use **SVN**, see the tutorials at

<http://www.atollic.com/index.php/videotutorials>



For more information about how to use **SVN**, see the tutorials at
<http://www.atollic.com/index.php/videotutorials>

LOCKS IN SVN

In normal cases locks is never used in SVN. SVN is very good in merging different versions and branches of the same file. That way more than one developer can edit the same source-file without fearing to interfere in other developers work.

However in very special cases, such as editing images and other complex file-types, SVN can't merge. In that case we recommend to lock the file before editing it.

Locking is easy. Just right-click on the file, select **Team, Lock** and enter a brief comment on why the file is locked.

If others now want to edit the same file, they will only have a read-only version of the file and can't save or check it in.

Remember to unlock the file after editing it.

To make sure a file is always locked before anyone can edit it, do the following:

- Right-click on it and select Team, Set Property
- Add a property with the name `svn:needs-lock`, no value is needed
- Check in the file.

INCLUDE SVN REVISION-NUMBER IN A STRING

A file can have a string in the source code that is the SVN revision number for the latest time when the file was checked in to the repository.

1. Right-click on the file and select **Team, Set Property**
2. Add the property `svn:keywords` with the value `Revision`

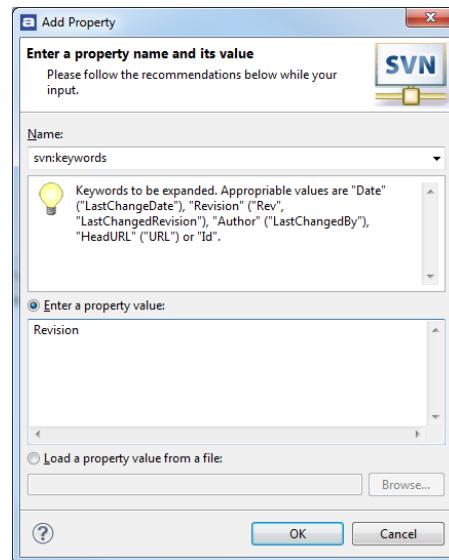


Figure 178 – Add SVN Property

3. Check with **Team, Show Properties** that the property is correctly added
4. Add `$Revision$` anywhere in the code

That string will be replaced with a text showing the revision number of that file.

It can be something like this:

```
define MESSAGE5 "SVN $Revision$"
```

Remember to edit the file and commit it to the repository to update the value to the current revision.

Other possible values to the `svn:keywords` is Date, Author, HeadURL and Id.

To have a fixed length of the `$Revision$`-string, it can be written like

```
"$Revision::: $".
```

IGNORE A FILE

To ignore sharing a specific file in a repository, the property `svn:ignore` needs to be set instead. It is done in the same manner as the other properties above.

When sharing a project in a version control system, it is a good idea to set the SVN property `svn:ignore` on the file `%PROJECT_LOCATION%/.settings/language.settings.xml` since it includes a hash specific to each individual environment.

LOCAL SVN REPOSITORY

A local Subversion repository is easy to set up and is an excellent tool even for developers who don't work in a team. It provides a simple way to go back to older versions of the code and try out ideas. Some sort of version control is strongly recommended for all developers.



Local repositories is not possible if the **SNVKit** SVN connector is selected.

To set up a local repository, do the following:

1. Open the **SVN Repositories** by selecting **Window, Show View, Other...** and in the panel select **SVN, SVN Repositories** and press **OK**.

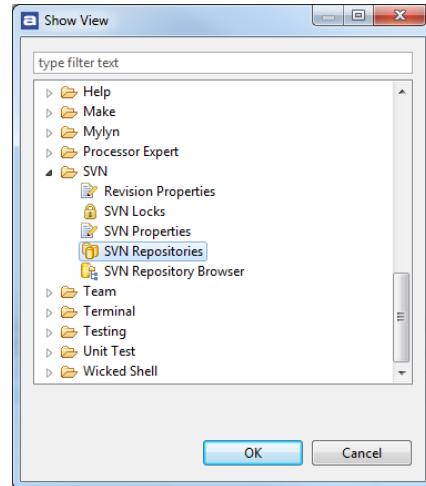


Figure 179 – Open SVN Repositories

2. In the view click the **New Repository** button.



Figure 180 – New Repository Button

3. In the **Create Repository** dialog enter the name and location for the new local repository and make sure **File System** is selected.

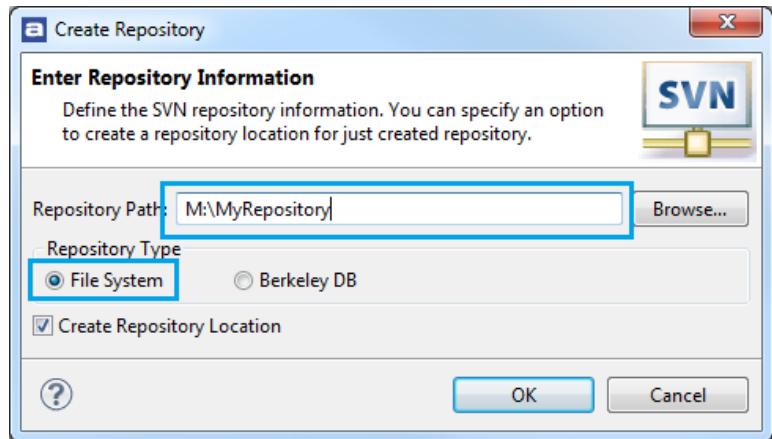


Figure 181 – Create Repository Dialog

When creating a repository in this way, using **Berkley DB** as repository-type is not recommended and can cause problem.

4. The new local repository is now created.

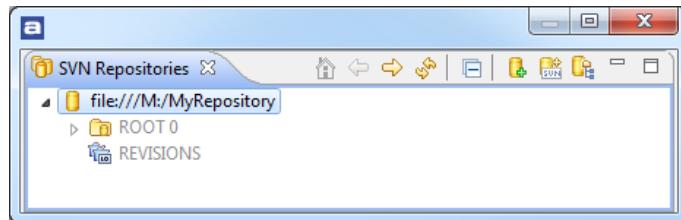


Figure 182 –Repository Created

5. To start version controlling a project in the repository, right click the project and select Team, Share Project...
6. In the Share Project dialog select **SVN** and press **Next**.

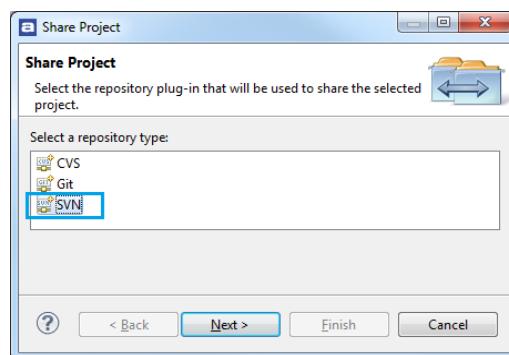


Figure 183 –Share Project Dialog

7. Now select the new repository and **Finish**.
8. Enter an initial comment and the project is version controlled.

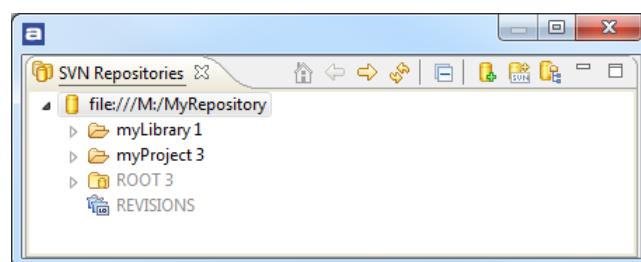


Figure 184 –Projects Version Controlled

USING SVN ON EXTERNAL RESOURCES

Since SVN doesn't commit files that reside physically outside of the project it is necessary to show the files within an **Atollic TrueSTUDIO** project.

This is particularly important to remember when using tools such as STM32CubeMX that creates project with code that are linked into the project and for different downloadable example projects that lets the actual code reside outside the project.

There is however at least two different method to solve this. Since SVN doesn't commit files that reside physically outside of the project it is necessary to show the files within a **Atollic TrueSTUDIO** project. These examples are for STM32CubeMX but can easily be adapted to fit other external resources.

Alternative 1 - Live with linked files/folders

Create a project for version control in the CubeMX-project-root (the folder that contains the `TrueSTUDIO`, `Inc`, `Src` etc) and use it together with the normal development project.

This will set up the workspace with a versioning-project, and a development-project.

Versioning project

In the top menu select **File, New, Project**

In the **New Project wizard** that is opened, select **General, Project**

Input a name for this project, for example `MyVersionedCubeMXProject`

Uncheck the **Use default location**, then browse to the CubeMX-project's-root folder

Commit `MyVersionedCubeMXProject` to SVN

Development project

In the top menu select **File, Import, General, Existing Projects into Workspace**

Select root directory and browse to the `MyVersionedCubeMXProject\TrueSTUDIO` folder

Make sure **Copy projects into workspace** is Unchecked!

Workflow of this setup is to develop/debug using the development project and version control the project using the `MyVersionedCubeMXProject`

Alternative 2 - Resolve the project so that all code reside physically within the project

Export the CubeMX project as an archive, this will resolve all .c source code.

Remove the CubeMX project from the **TrueSTUDIO** workspace. *Do not delete them*, but keep the CubeMX files on the disk a while longer.

Import the project that was exported in step one. This project will now contain all .c files and settings. Lets call this project `CubeMX-resolved` from now on.

However since CubeMX doesn't make references to header files in the generated project these will be missing. Included directories also needs to be manually inspected that they still are intact.

Manually copy the needed header files from the original CubeMX project to the `CubeMX-resolved` project

Open the Build Configuration for the `CubeMX-resolved` project and correct the include paths in the **C-Compiler, Directories** node.

If the same structure for the header files is kept as they were in the original CubeMX project then only `..\\..\\` needs to be removed from the include paths.

For example `..\\..\\..\\Drivers\\STM32F4xx_HAL_Driver\\Inc\\Legacy` becomes `..\\Drivers\\STM32F4xx_HAL_Driver\\Inc\\Legacy`.

Commit the `CubeMX-resolved` to SVN

MULTI MONITOR SUPPORT

The **Atollic TrueSTUDIO** IDE can be dragged between monitors and even extended to cover several monitors.

Individual views can also be de-attached from the IDE by clicking the tab with the view name located in the upper left corner of the view and dragged to a new place on any monitor. This can also be done with open editors, so that individual files can be opened and edited in individual windows.

By in the top menu selecting **Windows, New Editor** the same file can also be edited simultaneously in different editor windows. Changes will be displayed immediately in both windows. One editor-window be dragged to another monitor. This is very practical when editing large files.

If instead in the top menu **Window, New Window** is selected a cloned copy of the current **Atollic TrueSTUDIO** IDE will be opened. It will however always work with the same workspace and all editing done in the projects will be displayed in both opened IDEs. They are after all clones and not individual instantiations **Atollic TrueSTUDIO**.

The individual clones of **Atollic TrueSTUDIO** can however be opened in different perspectives. It is thus possible to open one window for editing and one for debugging.

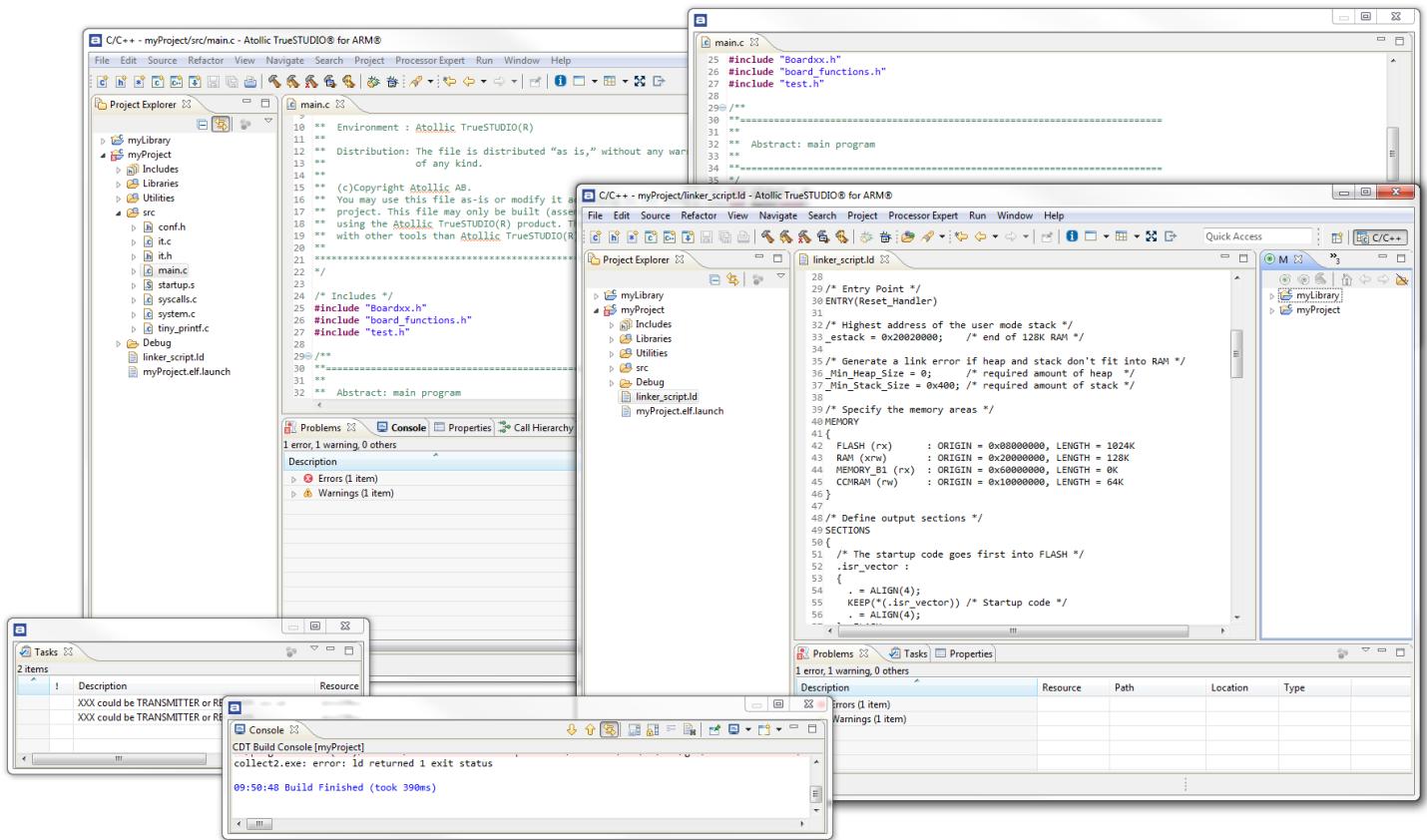


Figure 185 – Multiple Editors, Views and Windows used at the same time

OPEN ADDITIONAL INSTANCE OF TRUESTUDIO

It is possible to open two instances of **Atollic TrueSTUDIO** for the same workspace at the same time. To do that select in the top menu **Window, New Window**.

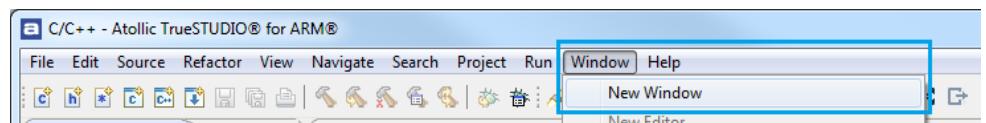


Figure 186 – New Window

Atollic TrueSTUDIO will now be opened in an additional window. This is useful when the workplace is equipped with two screens. It is then possible to edit and debug at the same time. One instance of **Atollic TrueSTUDIO** can then be used for editing and the other for debugging.

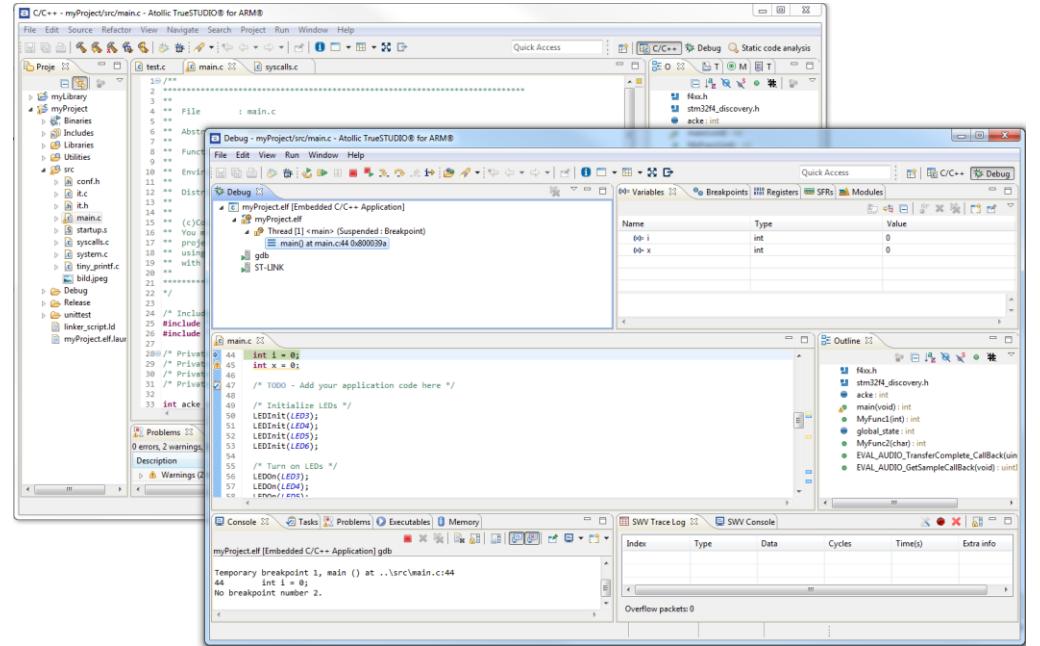


Figure 187 – New Window

SHELL ACCESS

To access Windows Shell (cmd.exe) open the shell by selecting **Window**, **Show View** and select **Terminal** view.

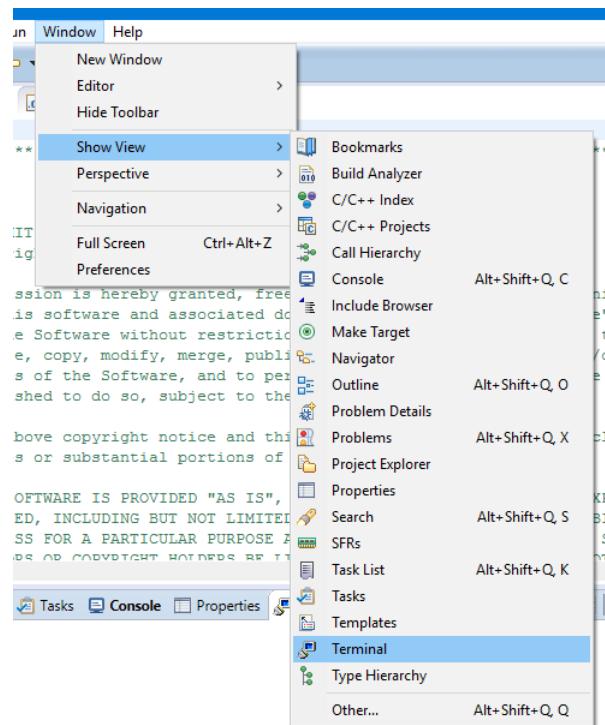


Figure 188 – Terminal

In the **Terminal** view a **Terminal** is launched by clicking the **Open a Terminal** icon.

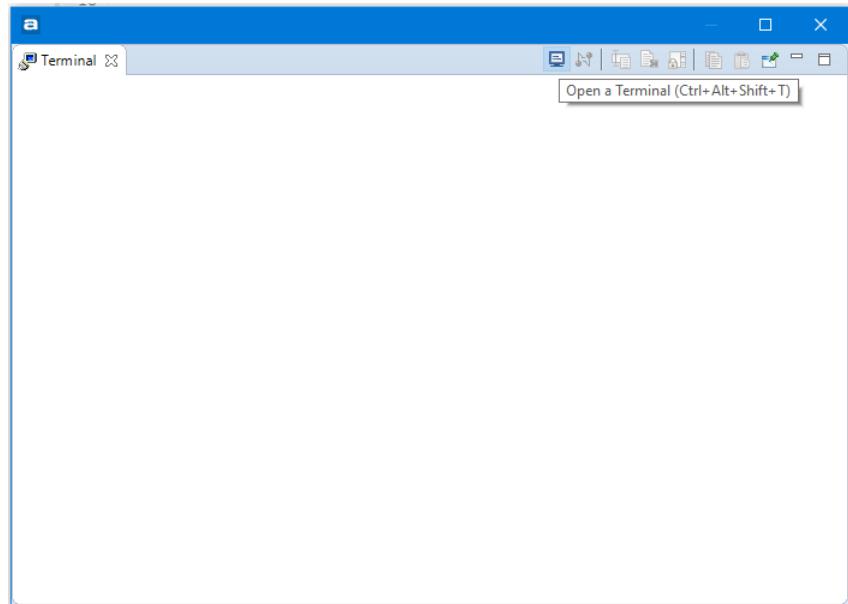


Figure 189 –Terminal View

The **Launch Terminal** dialog is now opened. Select **Local Terminal** and the **Encoding** to use.

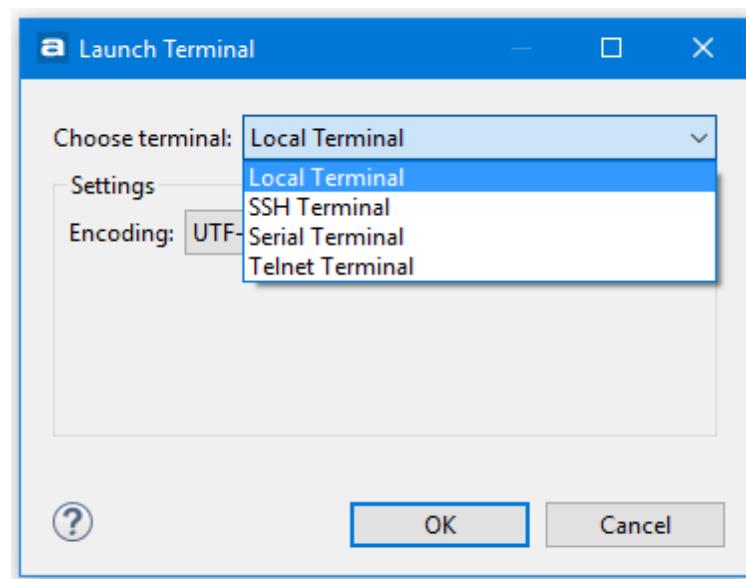


Figure 190 –Launch Terminal

The **Terminal** is now opened and is ready to use.

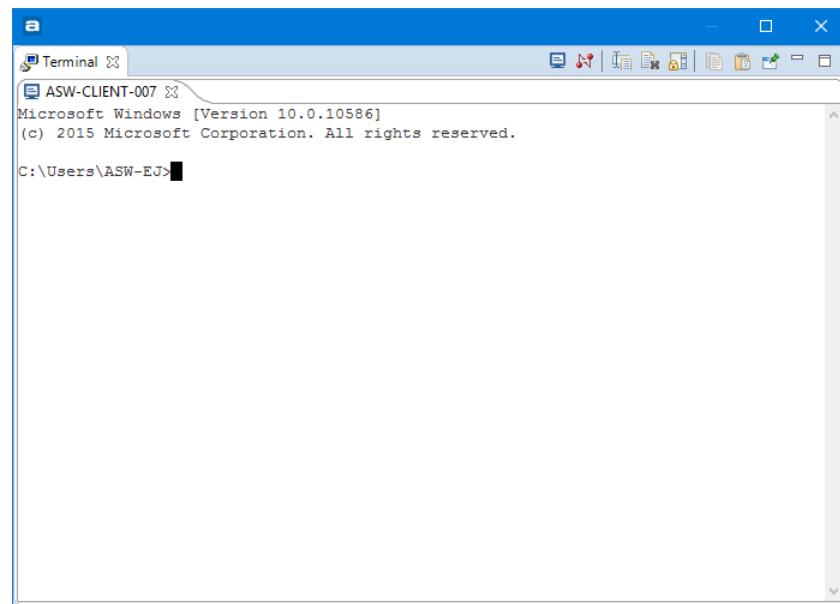


Figure 191 –Terminal Opened



Section 2. DEBUGGING

This section provides information on how to begin using **Atollic TrueSTUDIO for STM32**.

The following topics are covered:

- Introduction to Debugging with TrueSTUDIO
- Starting the Debugger
- Debug Configuration
- Debug Perspective
- Debugging
- Stopping the Debugger
- Upgrading the GDB Server
- Configure the GDB Server
- Advanced Debugging

INTRODUCTION TO DEBUGGING WITH TRUESTUDIO

Atollic TrueSTUDIO includes a very powerful graphical debugger based on the GDB command line debugger. **Atollic TrueSTUDIO** also bundles GDB servers for the ST-LINK and SEGGER J-Link JTAG probes.

Debugging with **Atollic TrueSTUDIO** is done with a GDB Server. The GDB Server is a program that connects GDB (GNU Debugger) on the PC to a target system. It can be started locally or remotely as shown in the two conceptual pictures below:

Local debugging Local mode architecture

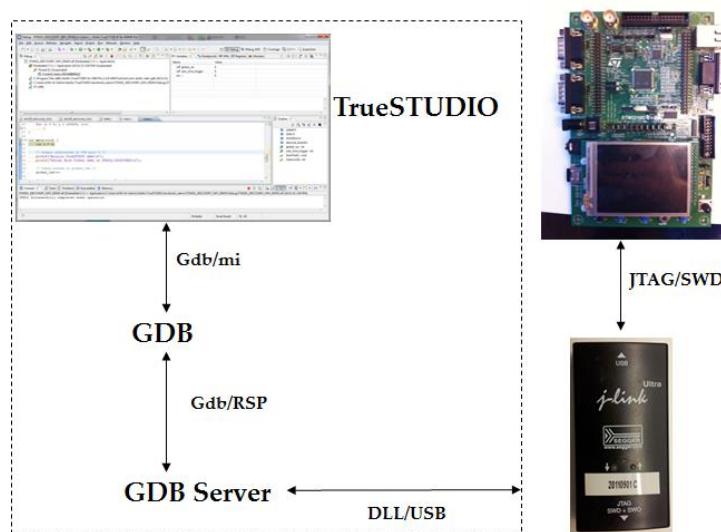


Figure 192 –Local Debugging

Remote debugging

Remote mode architecture

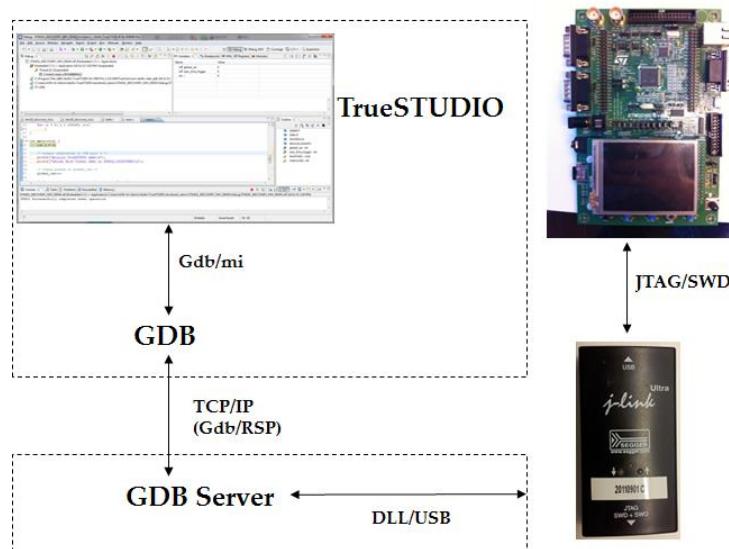


Figure 193 –Remote Debugging

If Local debugging is selected **Atollic TrueSTUDIO** automatically starts and stops the GDB server as required during debugging, thus creating a seamless integration of the GDB server.

To prepare for debugging with an ST-LINK JTAG probe connected to your electronic board, perform the following steps:

- 1.** Verify that the RAM and FLASH configuration switches on the target board is set to match the **Atollic TrueSTUDIO** project configuration, regarding memory. Note: Not all boards have such configuration abilities.
- 2.** Determine whether the board supports JTAG-mode or SWD-mode debugging, or both, and if Serial Wire Viewer (SWV) operation is supported. Note that the physical connector for the JTAG probe may be identical, regardless of the modes supported. Consult the hardware Circuit Diagram or a Hardware Designer within your organization to determine the actual debug modes supported.
- 3.** Connect the JTAG cable between the JTAG probe and the target board.
- 4.** Connect the USB cable between the PC and the JTAG probe.
- 5.** Make sure the target board has a proper power supply attached.

Once the steps above are performed, a debug session in **Atollic TrueSTUDIO** can be started.

STARTING THE DEBUGGER

Perform the following steps to start the debugger locally:

1. Select your project in **Project Explorer** view to the left.
2. Click on the **Debug** toolbar button (the insect icon) or press the **F11** key to start the debug session.



Figure 194 – Start Debug Session Toolbar Button

Alternatively, start the debug session by right-clicking on the project name in the **Project Explorer** view. Then select **Debug As, Embedded C/C++ Debugging** from the context menu.

3. The first time debugging is started for a project; **Atollic TrueSTUDIO** displays a dialog box that enables the user to confirm the debug configuration, before launching the debug session. After the first debug session is started, this dialog box will not be displayed any more.

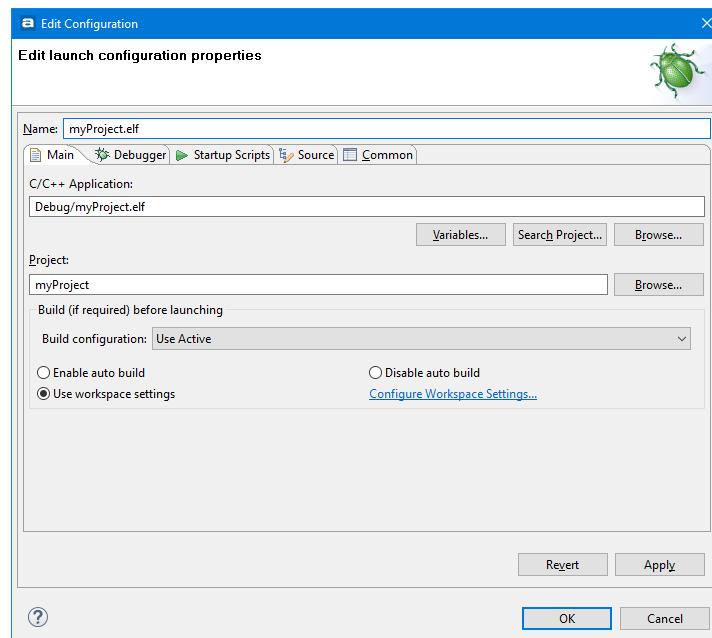


Figure 195 - Debug Configuration Dialog Box

The debug configurations can also be reached by clicking the **Configure Debug** toolbar button.



Figure 196 – The Configure Debug Toolbar Button

4. The **Main** panel contains information on the project and executable to debug. The settings in the **Main** panel do not normally have to be changed.

Make sure the path and name to the binary to debug is correct. See also page 229.

5. Click on the **Debugger** panel to display it. The panel contains information on the JTAG probe to use, its configuration, and how to start it. Some settings are probe-specific.

6. Open the **Debug probe** drop down list. Select the JTAG probe to be used during the debug session.

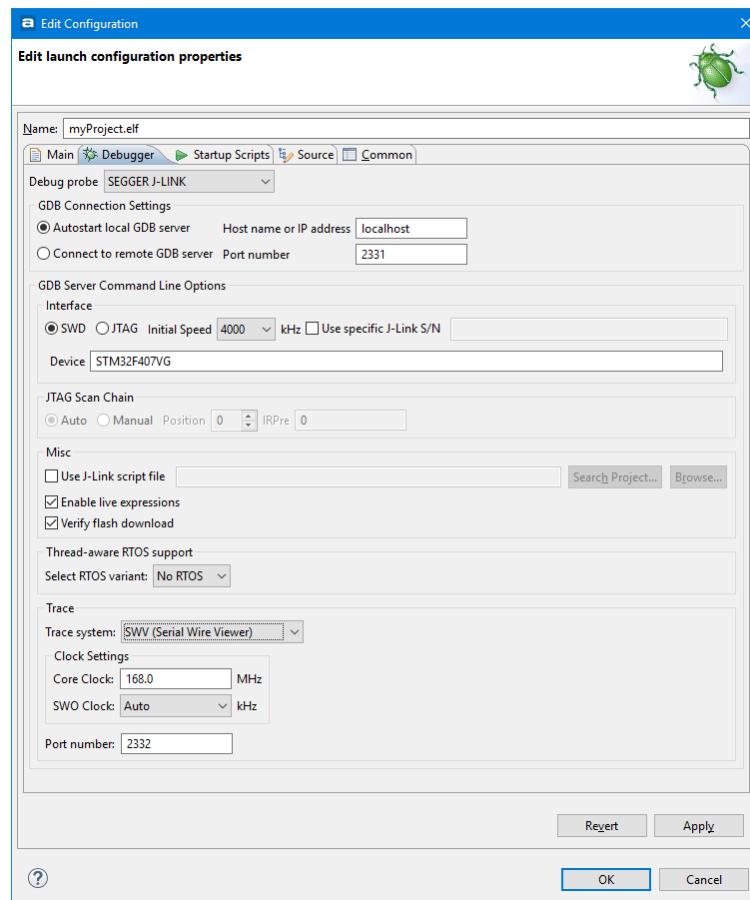


Figure 197 - Debug Configuration, Debugger Panel for the SEGGER J-Link

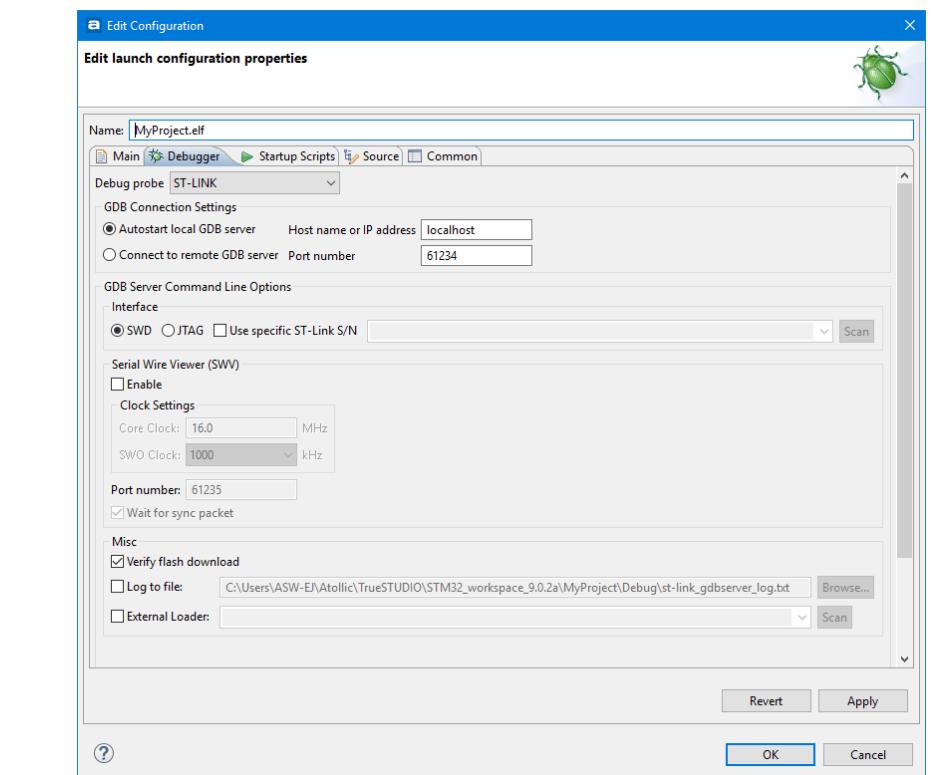
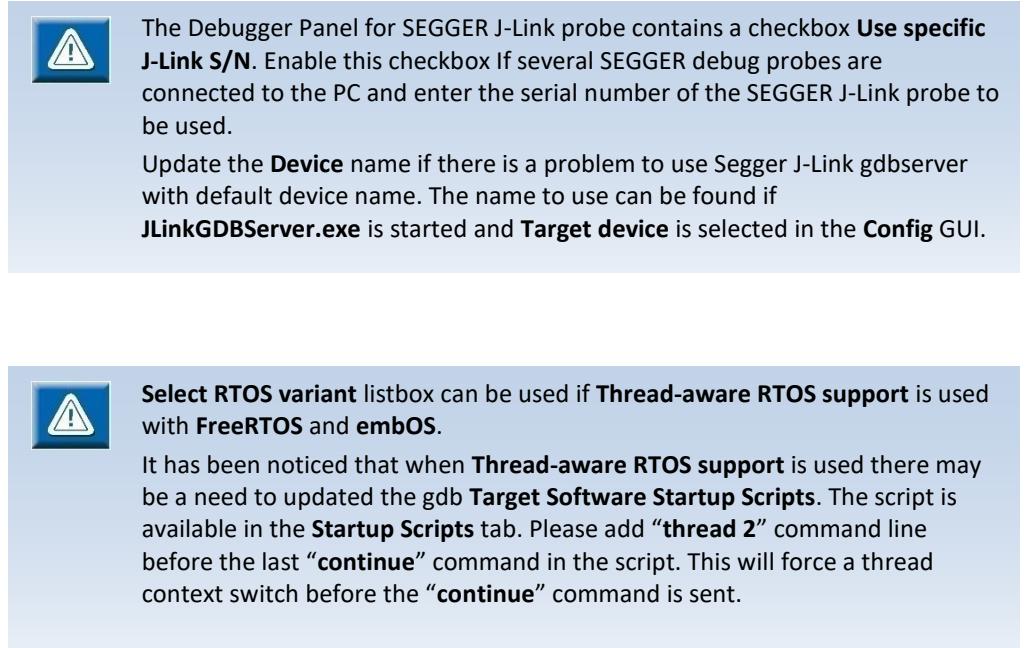


Figure 198 - Debug Configuration, Debugger Panel for the ST-Link



The Debugger Panel for ST-Link probe contains a checkbox **Use specific ST-Link S/N**. Enable this checkbox if several ST-Link debug probes are connected to the PC. The **Scan** button can be used to get the serial numbers of connected ST-Link's. After a scan the serial numbers are presented in the list-box. Use the list-box to select the ST-LINK to be used for debugging.

- 7.** GDB Connection Settings. Normally these don't have to be changed. For remote debugging change the **Autostart** radio-button to **Connect to Remote**, see page 224 for more information.

The port number can always be changed. When the debug session is started, the GDB server will prompt **Atollic TrueSTUDIO** for what port to use in the communication.



When using two GDB servers at the same time, they must both use different port numbers, e.g. 61234 and port 61244.

- 8.** Select debug probe **Interface: SWD or JTAG**, depending on the capabilities of the target board and the selected JTAG probe.

- 9.** If **SWD** interface was selected in step above, please proceed as follows; otherwise skip to step 10.

For the ST-Link JTAG probe:

- The **SWV** settings include the option **Wait for sync packet**. Enabling this option will ensure that a larger part of the received data packages are correct (complete), but may also lead to an increased number of packages being lost. This is especially true if the data load (number of packages) is high.

For the SEGGER J-Link JTAG probe:

- The initial speed of the debug connection can be configured. Atollic recommends starting at an initial speed of **4000 KHz**. If the communication turns out not to work as expected at that speed, please try another value. Proceeding stepwise in this manner, will lead to a quicker launch of the debug session.
- The **JTAG Scan Chain** settings are specific to the **JTAG** interface and are thus disabled, see page 225 for more information about JTAG Scan Chains.
- To be able to use some sort of tracings, select the appropriate Trace system such as the **Serial Wire Viewer (SWV)** feature or the **Embedded Trace Buffer (ETB)**.

10. If the ST-Link JTAG probe was selected in step 6, the **Misc** settings contains a checkbox **External Loader**. Enable this checkbox if the program shall be programmed into an external flash on the board. The **Scan** button can be used to get a list of external flash loader files, “.stldr”, included with **STM32 CubeProgrammer**. Use the list-box to select the “.stldr” file to be used for programming the external flash. It is also possible to manually enter a path and filename to a “.stldr” filename directly into the list-box.

11. If any other debug probe than ST-Link JTAG probe was selected in step 6, the following **Misc** settings are relevant:

Atollic TrueSTUDIO is able to automatically **recognize** and launch J-Link scripts at the start of a debug session. If a script is needed to debug a wizard-created project, the wizard will also automatically create one.

To manually select the J-Link script to be launched, please enable the **Use J-Link script file** option and browse to the desired script file.

To be able to use the **Live Expressions** view during debugging the **Live Expression** mechanism has to be enabled during startup. It is enabled by default.

12. Click on the **Startup Scripts** panel to display it.

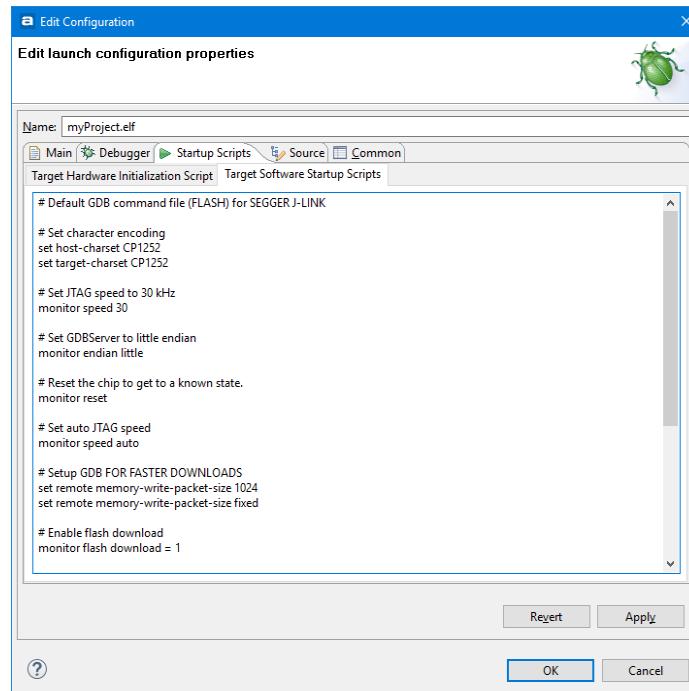


Figure 199 - Debug Configuration, Startup Scripts Panel

13. The **Startup Script** panel contains the initialization scripts that are sent to the GDB debugger upon debugger start. The scripts can contain any GDB or GDB server commands that are compatible with the application, JTAG probe and target board. The **Startup Script** tab is also where GDB script programs are defined.

For more information see *The Startup Script* chapter at page 227.

The **Target Hardware Initialization** tab is for the script used to initialize the hardware and the **Target Software Startup Scripts** tab is for the scripts used to initialize the software.

14. Click on the **OK** button to start the debug session.

15. **Atollie TrueSTUDIO** launches the debugger, and switches to the **Debug** perspective, which provides a number of views and windows suitable for debugging.



If there is a problem for **Atollie TrueSTUDIO** to connect to the GDB Server. Then please check the connection to the hardware.

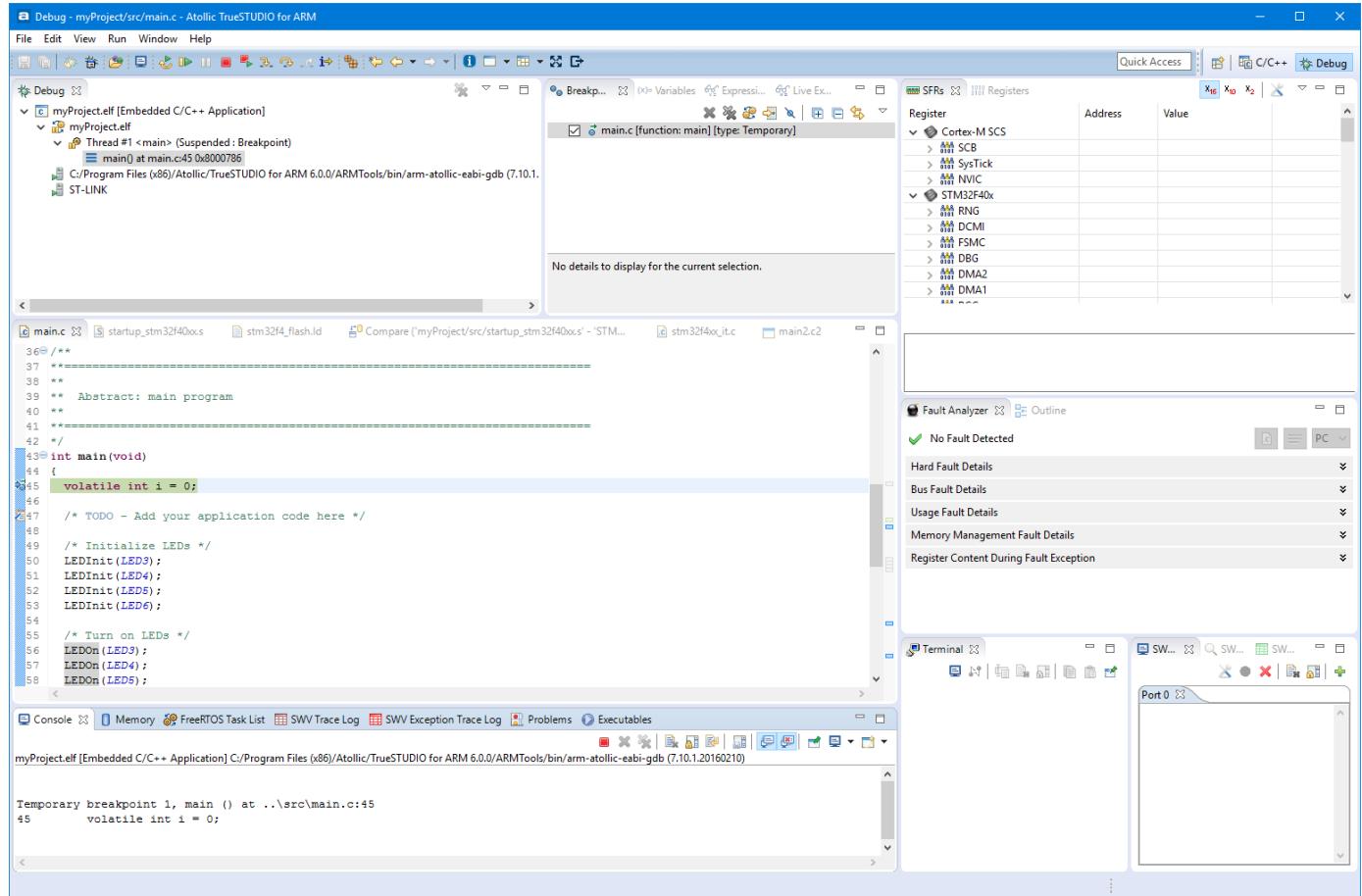


Figure 200 – Debug Perspective

EXTERNAL GDB SERVER

The GDB Server can also be manually started as an external program as seen on page 216.

To do that, open a command console window and change folder to the folder where the GDB server is located (%INSTALLATION_DIR%\Servers\Selected Server).

Manually enter the command to start the GDB server.

- For ST-Link - ST-LINK_gdbserver.exe -v -d -e
- For Segger J-Link - JLinkGDBServer.exe

The GDB Server will now start.

Open the debug configuration for the project and in the Debugger tab change the GDB connection setting to be **Connect to remote GDB server**.

If the setting is made correctly when starting a debug session, some logging will be seen in the command console window.

JTAG SCAN CHAIN

Some JTAG probes can be used for multi target and multi core debugging in a JTAG Scan Chain. This requires the configuration of JTAG Scan Chain settings.

Please note that the JTAG Interface must be selected in the Debug Configuration for JTAG Scan Chain to work.

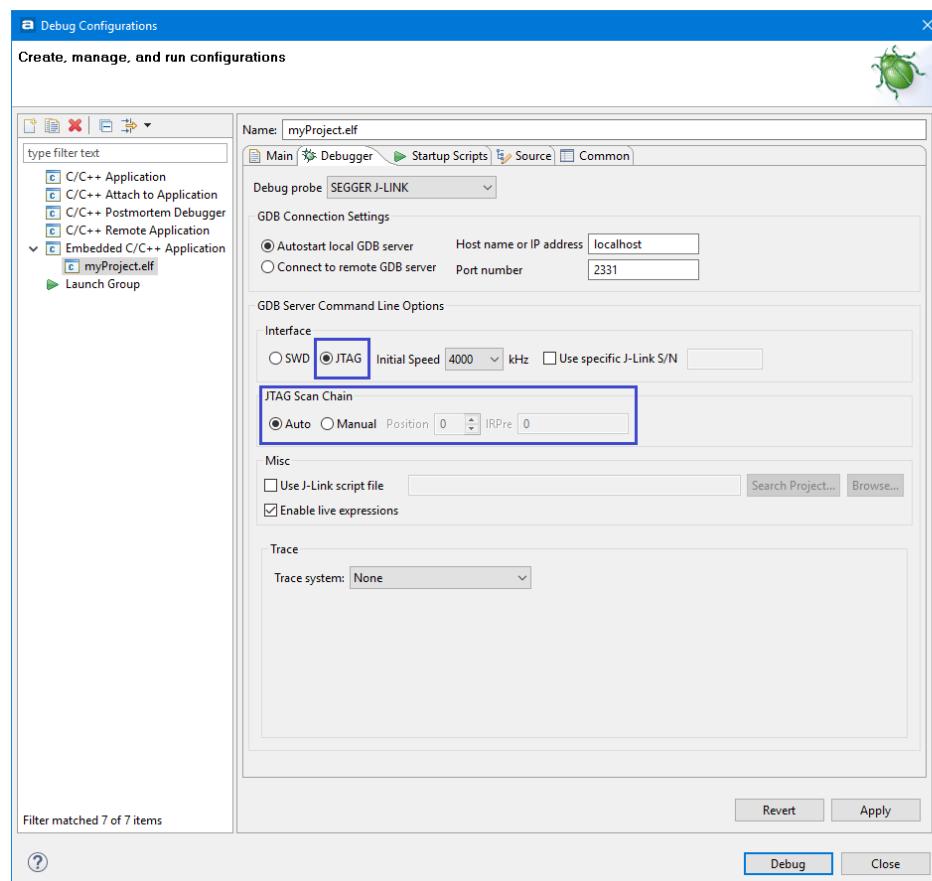


Figure 201 – JTAG Scan Chain Selected

In most cases, **Atollic TrueSTUDIO** is able to automatically detect these settings, in which case the Auto option has been selected.

If manual configuration is required, please select the Manual option. Then select Position and IRPre for each core.

If a Segger JTAG Probe is used, more information can be found in the *J-Link User Guide*, section 5.3.1 and 5.3.3, included with the **Atollic TrueSTUDIO** installation. It can be found by selecting the **Information Center** toolbar button and open the **Information Center** view. Locate **Document center**, **Debugger utilities** in the **Information Center** and press the **J-Link User Guide** link.

For more information, please refer to the documentation from the debugger probe manufacturer, microcontroller manufacturer and/or the manufacturer of the target board.

THE STARTUP SCRIPT

The **Startup Script** panel contains the initialization scripts that are sent to the GDB debugger upon debugger start. The scripts can contain any GDB commands or GDB server commands that are compatible with the application, JTAG probe and target board. The **Startup Script** tab is also where GDB script programs are defined.

More about the GDB script commands can be found in the *Debugger* manual bundled with **Atollic TrueSTUDIO** and found in the **Information Center**.

It is possible to edit the script with the GDB commands needed to start the Debugging in a proper way.

START DEBUGGING AT THE VERY BEGINNING

One common thing to edit is to change the `continue` statement at the end of the GDB script to a comment. When the `continue` statement is removed/commented the program will stop at the `Reset_Handler` where it is possible to step forward in the code.

LOAD THE PROGRAM WITHOUT DEBUGGING

Another possibility is to remove all code after the `load` command and replace it with a `quit` command. **Atollic TrueSTUDIO** will then load the program to the target, but then immediately quit debugging and return to the **C/C++ perspective**.

HARDWARE INITIALIZATION CODE

It is also possible to add the initialization code for external memories, such as SDRAM, here. It is usually done in the **Target Hardware Initialization** script. In most cases the **Target Hardware Initialization** script can be empty but if some hardware needs to be configured before software can be loaded to target commands can be added here. For example in some systems the external data/address bus and DRAM refresh control needs to be initialized before software can be loaded.

MANAGING THE DEBUG CONFIGURATIONS

A majority of **Atollic TrueSTUDIO** users will focus on the Build Configuration for Debug. This is to be able to build, download and investigate the behavior of the software during execution. The build configuration named Debug, has two important properties:

- Complete symbolic information is emitted by the tool chain to help the user navigate the information in the source code, during the debug process.
- The lowest level of optimization is normally used, to maintain a direct relationship between source code and machine code. If too high optimization levels are used, large portions of the generated machine code may be removed during optimization. This limits the abilities to map source code to machine code. Consequently it makes it harder to follow the execution at source code level in a debugger.

When the software is considered to behave as required, a Release build configuration, with no symbolic debug information, and a high level of optimization, is usually built. See *Build Configurations* on page 88 for more information.

After switching from the Debug to the Release build configuration, the target board can be programmed by launching a debug session. During this process, caution must be exercised to prevent unexpected results from occurring.

The **Atollic TrueSTUDIO** philosophy of determining which executable image will be loaded into the target, with the current project settings, must be considered carefully.

It is possible to create multiple debug launch configurations. To do this, click on the **Configure Debug** toolbar button.



Figure 202 – The Configure Debug Toolbar Button

This brings up the list of existing debug launch configurations. By right clicking on an existing configuration, the options to create a new configuration, duplicate the existing, or delete it, appears.

The easiest way to create a new configuration is to duplicate an existing one, edit the configuration settings in the dialog box, and then rename it. In this way multiple debug launch configurations are easily created. The user may toggle among the debug launch configurations in the list, and launch the most suitable session for the task at hand.

If the user does not explicitly choose a debug launch configuration from the existing list, **Atollic TrueSTUDIO** launches the most recently used debug launch configuration.

Assume that a user has created a build configuration named Debug, and a debug launch configuration that loads the ELF-file, created by the Debug build, to the target. Assume further that the user launches a debug session to debug this ELF-file.

Following this, the user switches to the build configuration named Release, and launches a new debug session by clicking on the debugging icon. **Atollic TrueSTUDIO** will fetch the most recent debug launch configuration, which specifies that the ELF-file from the Debug build configuration, and *not* the Release ELF-file, is to be programmed into the target.

Atollic TrueSTUDIO has no means of automatically selecting the ELF-file associated with the currently active build configuration (Debug or Release), when a debug session is started. The build image used will always be the one specified in the debug launch configuration, regardless of the active build configuration.

This behavior is different from some other development environments that automatically reconfigure the debug launch mechanism, to use the ELF-file from the currently active build configuration.

In **Atollic TrueSTUDIO**, the user must create a debug launch configuration that explicitly refers to the particular ELF-file that is to be loaded, when a debug session is started.

Example: The user generates a project from the Project Wizard and builds an ELF-file using the build configuration named Debug. The debug session configuration dialog box shows the location of the ELF-file:

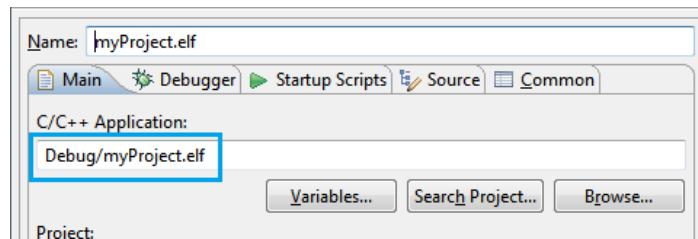


Figure 203 – The target ELF-file in Debug Session Configuration

To create a debug launch configuration that refers to the Release ELF-file, instead of the Debug ELF-file, simply change Debug in the above path to Release. It is recommended to rename the debug launch configuration to clearly mark it as a Release configuration.

To load the Release ELF-file into the target, start a debug session based on this debug launch configuration.

If desired, other properties of the new debug launch configuration can be edited as well. For example, setting the temporary breakpoint at the first line of `main()`, may be omitted by inserting a comment on the corresponding line in the GDB initialization script. This is done via the **Debug** dialog box, in the **Startup Scripts, Target Software Startup Scripts** panel.

GENERIC BINARY PATH

By default the path to the binary used when debugging includes the name to a selected Build Configuration. However generic binary paths is also possible.

It is possible to use different variables in the path to the binary. They can be accessed by pressing the **Variables...** button.

One such variable is `$(build_configuration)`. When using it in the path **Atollic TrueSTUDIO** will attempt to determine the name of the active Build Configuration (normally Debug or Release) and replace the variable with that string. This can be used to create a generic Debug Configuration that can be used in all debugging for all Build Configurations.

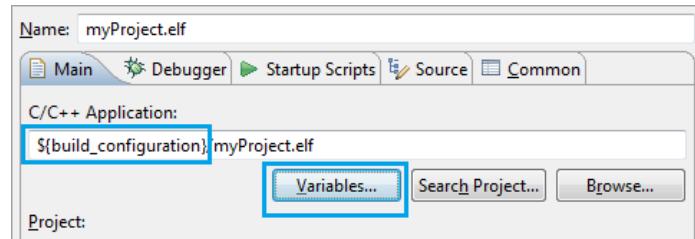


Figure 204 – Using variables in the path

DEBUG LAUNCH CONFIGURATION SETTINGS FILE

The debug launch configuration settings are stored in the `DebugConfigFile.elf.launch` file. Normally in **TrueSTUDIO** project this file is stored in the project folder but `<*.elf.launch>` files can also be stored in the workspace metadata folder.

In the **Debug Configurations** dialog there is a **Common** tab. In this tab the **Save as** selection is used to select to save the debug launch configuration as **Local file** or as **Shared file**. Normally in projects created with **TrueSTUDIO** project wizard the selection is set to save as **Shared file**. The file will then be located by default in the Project folder in the workspace. This makes it easier to export or store the debug configuration setting into a version control system.

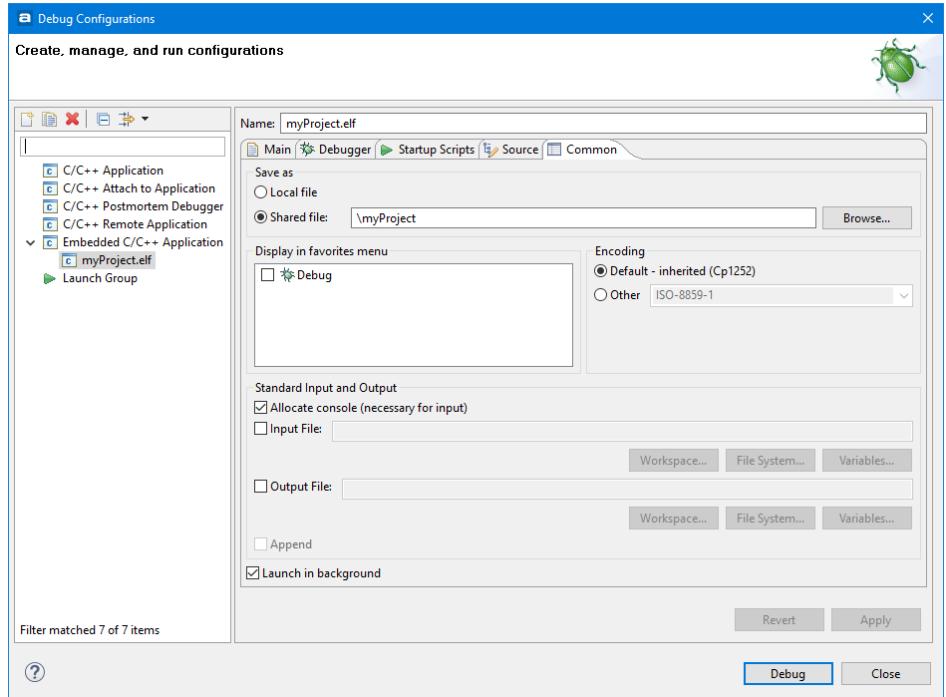


Figure 205 – Debug configuration as shared file

In this way it is possible to have x number of debug launch configurations saved in the project. Each file will be named according to the debug configuration name you specify plus extension. E.g. File name: STM32F3_Discovery.elf.launch

When save as **Local file** is configured the debug configuration will be saved in the workspace instead. E.g. File name:

C:\TrueSTUDIO\ARM_workspace_5.3\.metadata\.plugins\org.eclipse.debug.core\launches

CUSTOMIZE THE DEBUG PERSPECTIVE

The **Debug** perspective and other perspectives in *Atollic TrueSTUDIO* can be enhanced with several toolbar buttons and menus by selecting the **Window**, **Customize Perspective** menu command.

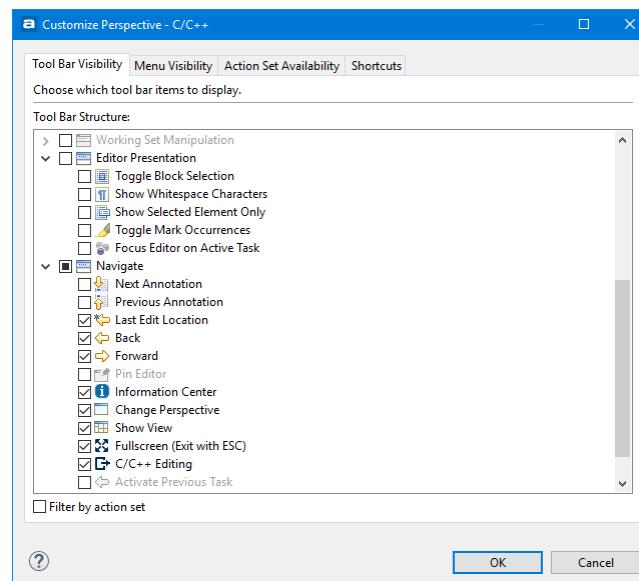


Figure 206 – Customize Perspective Dialog Box

DEBUGGING

Once the debug session has been started, **Atollic TrueSTUDIO** switches automatically to the **Debug** perspective, sets a breakpoint at main(), resets the processor, and executes the startup code until execution stops at the first executable program line inside main().

The **Debug** perspective is now active. The next program line to be executed is highlighted in the source code window. A number of execution control functions are available from the **Run** menu:

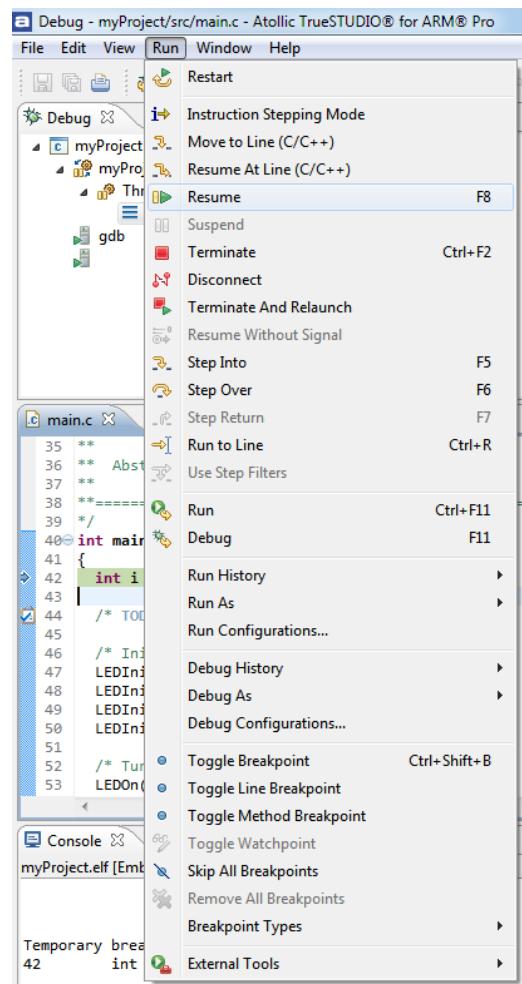


Figure 207 - Run Menu

Alternatively, the execution control commands are available in the **Debug** view toolbar.



Figure 208 - Run Control Command Toolbar

TERMINATE, REBUILD AND RE-LAUNCH

By pressing this toolbar button, the current debug session is terminated, the source code is built (modified source code only), a new build image generated and the debug session is re-launched – all with just one mouse-click.



Figure 209 – Terminate, Rebuild and Re-launch Toolbar Button

DISASSEMBLY VIEW

A common user action, not available from the **Run** menu, is to switch between C/C++ level stepping in the C/C++ source code window, and assembler level instruction stepping in the **Disassembly** view.

Click on the instruction stepping button to activate assembler level instruction stepping in the **Disassembly** view. Click it once more to return to C/C++ level stepping in the C/C++ source code window.



Figure 210 – Instruction Stepping Button

A screenshot of the 'Disassembly' view window. The window title is 'Disassembly'. It contains a list of assembly instructions with addresses on the left and assembly mnemonics and comments on the right. The assembly code shown includes calls to STM_EVAL_LEDInit and STM_EVAL_LEDOn for various LED pins (LED1 to LED4).

```
Disassembly X Enter location here ▾
080004c2: mov.w r3, #0
080004c6: str r3, [r7, #4]
69 STM_EVAL_LEDInit(LED1);
080004c8: mov.w r0, #0
080004cc: bl 0x8001498 <STM_EVAL_LEDInit>
70 STM_EVAL_LEDInit(LED2);
mov.w r0, #1
080004d0: bl 0x8001498 <STM_EVAL_LEDInit>
71 STM_EVAL_LEDInit(LED3);
mov.w r0, #2
080004d8: bl 0x8001498 <STM_EVAL_LEDInit>
72 STM_EVAL_LEDInit(LED4);
mov.w r0, #3
080004dc: bl 0x8001498 <STM_EVAL_LEDInit>
73 STM_EVAL_LEDInit(LED1);
mov.w r0, #0
080004e8: bl 0x8001504 <STM_EVAL_LEDOn>
74 STM_EVAL_LEDOn(LED2);
mov.w r0, #1
080004f0: bl 0x8001504 <STM_EVAL_LEDOn>
75 STM_EVAL_LEDOn(LED3);
mov.w r0, #2
080004f8: bl 0x8001504 <STM_EVAL_LEDOn>
76 STM_EVAL_LEDOn(LED4);
mov.w r0, #3
08000500: bl 0x8001504 <STM_EVAL_LEDOn>
77 STM_EVAL_LEDOn(LED1);
08000504: STM32F407VGTxInit()\n
```

Figure 211 – Disassembly View

By right-clicking in the left part of the view, the Function Offset can also be displayed.

BREAKPOINTS

A standard code breakpoint at a source code line can easily be inserted by double-clicking in the left editor margin, or by right-clicking the mouse in the left margin of the C/C++ source code editor. A context menu will appear in the latter case.

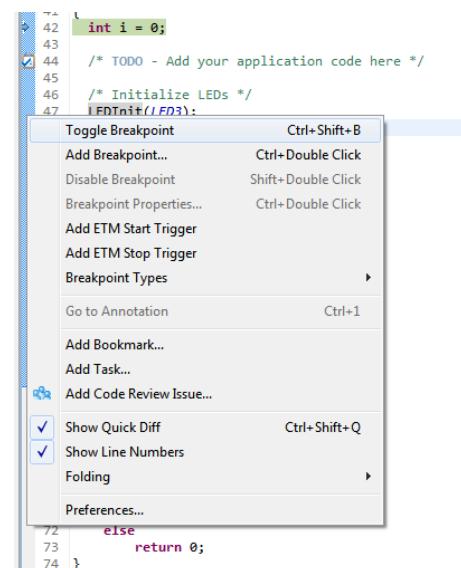


Figure 212 - Toggle Breakpoint Context Menu

Select the **Toggle Breakpoint** menu command to set or remove a breakpoint at the corresponding source code line.

More complicated types of breakpoints, such as Watch Points and Event Breakpoints (for PC projects) are configured in the **Breakpoints** view.

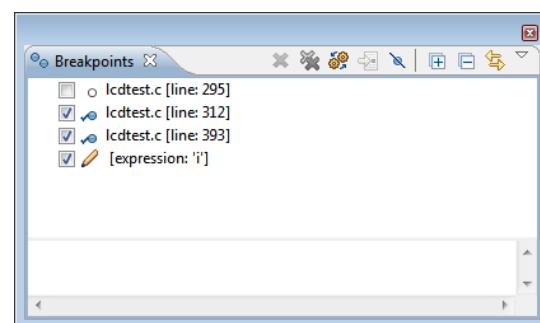


Figure 213 – Breakpoints View

Technically the breakpoints are either a hardware breakpoint or a software breakpoint. The hardware breakpoints are handled by the Debug Unit of the CPU. The number of hardware breakpoints depends on the target implementation, but normally an ARM 7/9 has two breakpoints and Cortex-M has four to six breakpoints (up to eight is possible).

A Software breakpoint is an instruction (BKPT) inserted into the code

Atollic TrueSTUDIO does not decide if a breakpoint should be a hardware breakpoint or a software breakpoint. This is handled seamlessly by the GDB server.

Since this is handled by the GDB server, it is handled slightly different depending on what GDB server is used.

For example: the ST-Link GDB server only uses hardware breakpoints, and is therefore limited to 6 breakpoints.

The SEGGER J-Link GDB server uses both hardware and software breakpoints depending on the number of breakpoints that the user want to set.

The SEGGER J-Link GDB server should therefore be able to support virtually unlimited number of breakpoints using software breakpoints. But even here there is no manual control whether the breakpoint should be set as software or hardware breakpoint.

CONDITIONAL BREAKPOINT

When setting a normal breakpoint the program will break each time reaching that line. If that is not the desired behavior a condition can be set on the breakpoint that regulates if the program should actually break or not on that breakpoint.

Set a breakpoint at a line. Right-click it and open the **Breakpoint Properties...** The Breakpoint Properties can also be opened from the **Breakpoints** view.

The following view is opened.

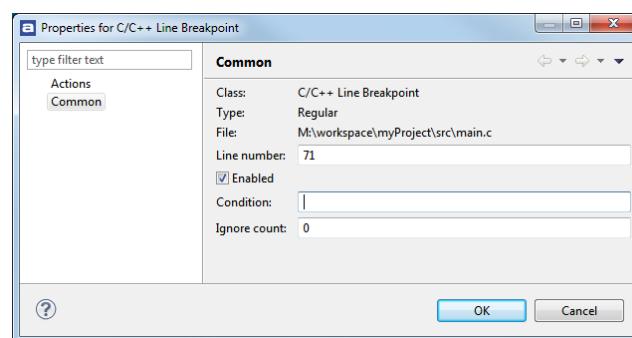


Figure 214 – Breakpoints Properties

Enter a condition. In the example below “g1==100” is a global variable, but the variable can also be a local stack variable.

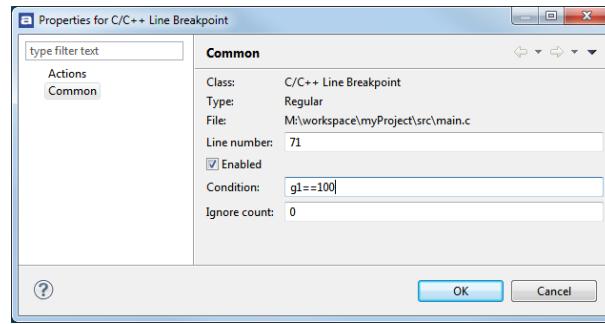


Figure 215 – Conditional Breakpoint

What happens when running now is that the gdbserver will break each time the line is executed but gdb will test the condition and restart running if the variable g1 not is equal to 100. This method could be used when debugging an RTOS with several tasks if the RTOS kernel has a variable that the Breakpoint condition could be tested on to see which task is running. The only problem with this method is that it takes some time for GDB to evaluate the condition.

The conditions are written in C-style so it is possible to write expressions such as "g1%2==0" to get more complex conditions.

EXPRESSIONS

The **Expressions** view displays many different types of data, including global variables, local variables and CPU core registers. The **Expressions** view also allows users to create mathematical expressions that are evaluated automatically, such as *(Index * 4 + Offset)*.

The information is updated whenever the debug execution is halted.

Expression	Type	Value	Name : <i>numberOfIterations</i>
<code>GRP(General Registers).REG(r3)</code>	Unsigned / Readable,Writeable	2	Details:3 Default:3 Decimal:3 Hex:0x3 Binary:11 Octal:03
<code>msTicks</code>	volatile uint32_t	1841	
<code>gpioModePushPull</code>	enum {...}	gpioModePushPull	
<code>numberOfIterations</code>	int	5	
<code>i</code>	int	2	
<code>i+numberOfIterations</code>	int	5	
<code>Add new expression</code>			

Figure 216 – Expressions View

An expression is displayed in many formats simultaneously, and the view can parse complicated data types and display complex data types like a C-language struct.

Furthermore, CPU core registers may be added to the view, in addition to local and global variables. Open the **Register** view and select **Watch** to add the register to the **Expressions** view.



The users may drag and drop variables from the editor into the **Expressions** view. This applies to complex data types as well.

```

/* Get bit position used to enable/disable */
bit = (clock >> CMU_EN_BIT_POS) & CMU_EN_BIT_MASK;

/* LF synchronization required? */
if (sync)
{
    CMU_Sync(sync);
}

/* Set/clear bit as requested */
BITBAND_Peripheral(&reg, bit, (unsigned int)enable);

```

Expression	Type	Value	Name : reg
!!!! GRP(General Registers).REG (R)	Unsigned / Readable,Writeable	1133512856	Details:0x400c8044
(*) msTicks	volatile uint32_t	1000	Default:0x400c8044
(*) gpioModePushPull	enum { ... }	gpioModePushPull	Decimal:1074561092
↳ reg	volatile uint32_t *	0x400c8044	Hex:0x400c8044
(* reg	volatile uint32_t	72	Binary:100000000001:
			Octal:010003100104
+ Add new expression			

Figure 217 – Drag and Drop of Variable to the Expressions View

The value of variables and writeable registers may also be changed via the **Expressions** view.

By starting an expression with “=” regular expressions can be used to display collapsible groups of local variables and arrays.

By starting an expression with “=\$” pattern matched groups of registers can also be created.

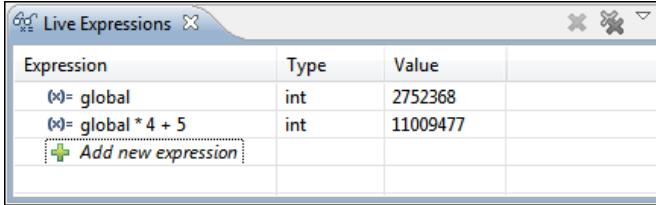
Expression	Name	Type	Value	Description	Address	Name : j
=?	=?	Group-pattern	3 unique matches			Details:316
> array	array	int [30]	0x2001ff78		0x2001fff8	Default:316
(*) i	i	int	63725		0x2001fff4	Decimal:316
(*) j	j	int	316		0x2001ff10	Hex:0x13c
=? \$p?	=Sp?	Group-pattern	3 unique matches			Binary:1001111100
(*) SPRIMASK	SPRIMASK	long	0			Octal:0474
(*) SPSP	SPSP	long	0			
↳ Spc	Spc	void (*)()	0x800046e <main+146>			
!!!! GRP(General Registers).REG	REG	Unsigned / Readable	63725			
> array[1-2]	array[1-2]	Group-pattern	2 unique matches			
(*) array[1]	array[1]	int	7		0x2001ff7c	
(*) array[2]	array[2]	int	14		0x2001ff80	
+ Add new expression						

Figure 218 – Complex Expressions

LIVE EXPRESSIONS

The **Live Expressions** view works a lot like the **Expressions** view with the exceptions that all the expressions are sampled live during the debug execution.

The view displays many different types of global variables. The **Expressions** view also allows users to create mathematical expressions that are evaluated automatically, such as $(Index * 4 + Offset)$.



Expression	Type	Value
(x)= global	int	2752368
(x)= global * 4 + 5	int	11009477
+ Add new expression		

Figure 219 – Live Expressions View

An expression is displayed in many formats simultaneously, and the view can parse complicated data types and display complex data types like a C-language struct.

The sample speed is determined by the number of Expressions being sampled. An increased number of Expressions being sampled will result in a slower sample rate.

Only one format of numbers is used at the same time to speed up the sampling. To change the format, use the **dropdown** arrow.

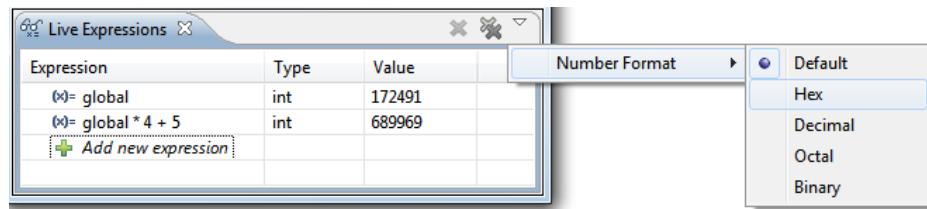


Figure 220 – Live Expressions View Number Format



The **Live Expressions** view requires a Segger J-Link probe and a Segger J-Link GDBServer v4.78h or later.



To be able to use the **Live Expressions** view during debugging the **Live Expression** mechanism has to be enabled during startup. This is by default enabled when Segger J-Link probe is selected in the debug configuration. Please read the *Starting the Debugger* section for more information.

LOCAL VARIABLES

The **Variables** view auto-detects and display the value of local variables. It provides extensive information about each variable, such as value in hex/dec/bin format. The content of complex variable types is also displayed.

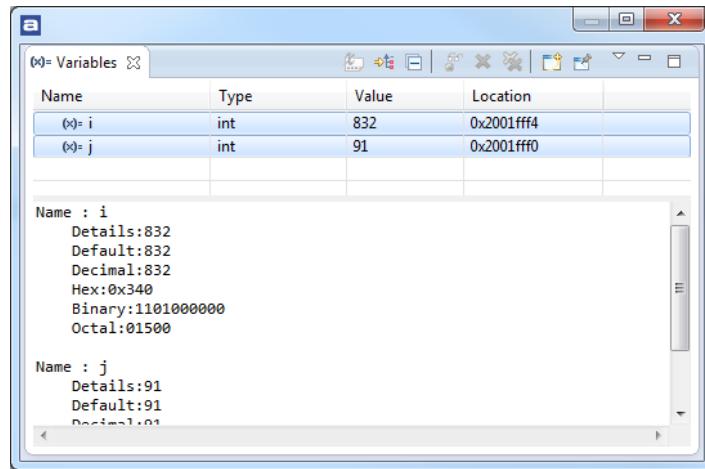


Figure 221 – Variables View

The location column can be displayed by selecting the small arrow in the upper right corner and then layout, Select Columns... A dialog with the selectable columns will then open up.

From the same small arrow, the Number Format can also be changed for the Value column.

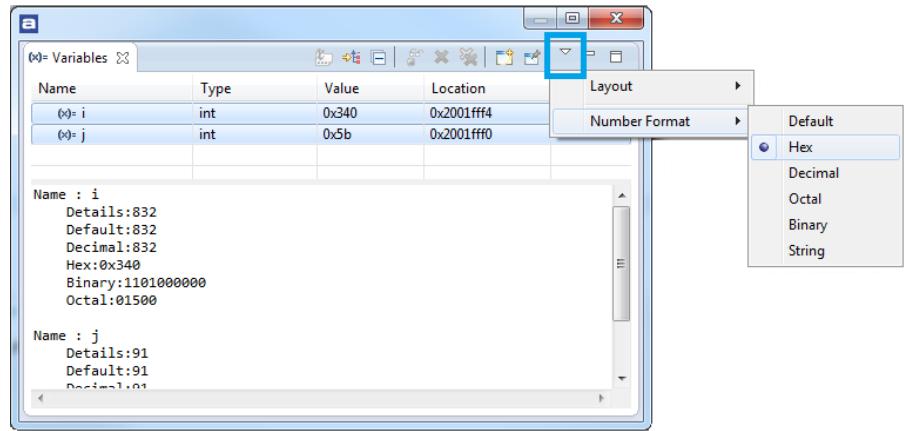


Figure 222 – Variables View – change Number format

By right clicking a variable, it can also be opened in the **Memory** view and also by selecting **Watch** to the **Expression** View.



Global Variables cannot be displayed in the Variables view. Use the Expression view instead. See page 237 - *Expressions* for more information.

FILL MEMORY WITH A BYTE PATTERN

In the **Memory** view and the **Memory Browser** view there is an added toolbar button called **Open Memory Fill dialog**

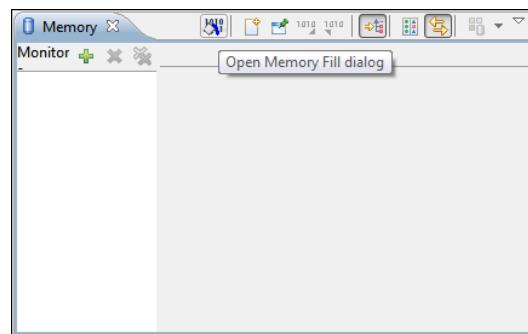


Figure 223 - The Memory Fill Toolbar Button

The **Memory Fill** dialog is opened when the toolbar button is pressed.

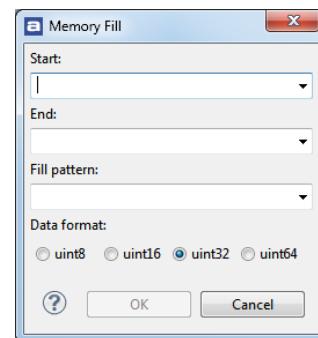


Figure 224 - The Memory Fill dialog

The filled area is up to, but not including, the end address.

SFRs

Special Function Registers (SFRs) can be viewed, accessed and edited via the **SFRs** view. The view displays the information for the current project. It will change its content if another project is selected. To open the view, select the **View, SFRs** menu command.

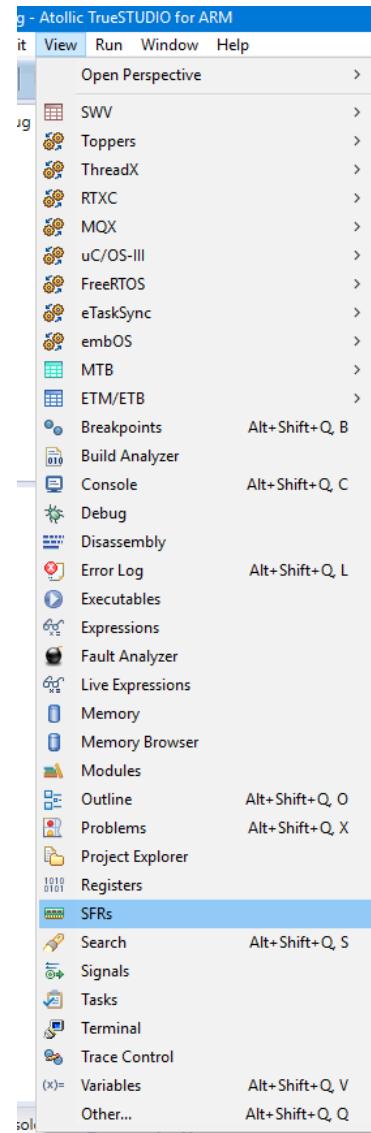


Figure 225 - SFRs Menu Command



The **SFRs** view can also be useful in the **C/C++ Editing Perspective**, however then only the names and addresses of the registers will be displayed.

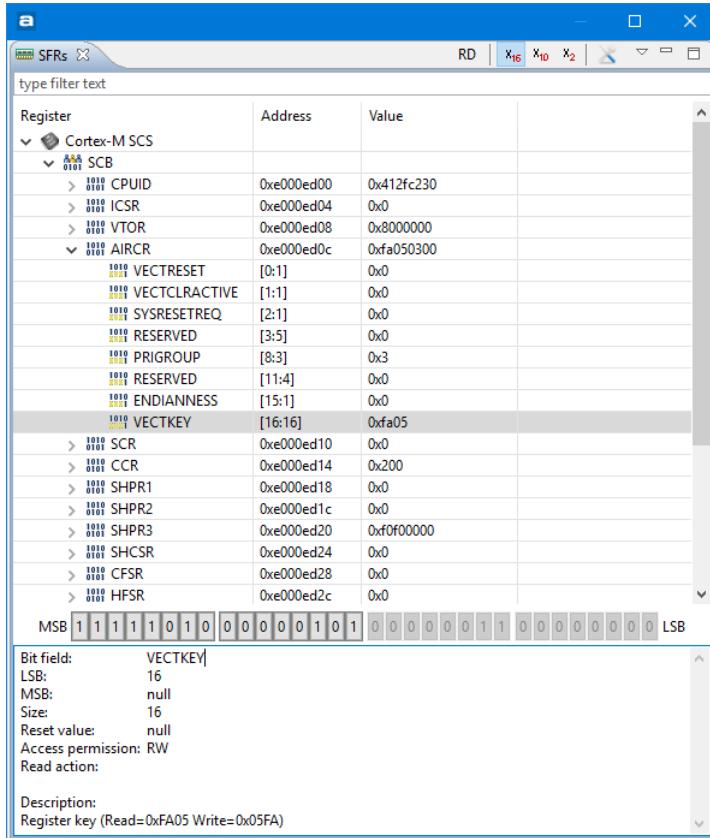


Figure 226 - SFRs View

The top of the **SFRs** view contains a search field to filter visible nodes, e.g. peripherals, registers, bit fields. When some text is entered in the search field only the nodes containing this text will be visible. When the node to view is found, select the node, then press the Clear button to the right of the search field if all elements shall be seen.

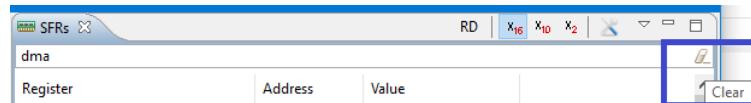


Figure 227 - SFRs Filter Clear

The information at the end of the **SFRs** view displays detailed information of the selected line. For registers and bit fields this include information of **Access permission** and **Read action**.

The **Access permissions** contains the following information:

RO (read-only)
WO (write-only)

RW (read-write)
W1 (writeOnce),
RW1 (read-writeOnce)

The **Read action** contains information only if there is some kind of read action when reading the register/bit field:

clear
set
modify
modifyExternal

The toolbar buttons are found at the top right corner of the **SFRs** view.

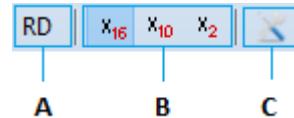


Figure 228 – SFR View Buttons

- The **RD** button (A) is used to force a read of the selected register. This will cause a read of the register even if the register, or some of the bit fields in the register, contains a ReadAction attribute set in the SVD file.



When the register has been read by pressing the **RD** button all other registers visible in the view will also be read again to reflect any other register updates. The program needs to be stopped to perform a read of the registers.

- **Base format buttons** (B) are used to change what base the registers values are displayed in.
- The **Configure SVD settings** button (C) opens up the **CMSIS-SVD Settings Properties Panel** for the current project.

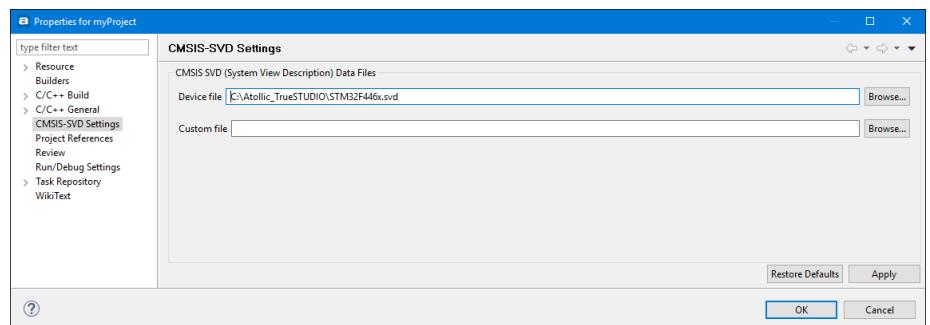


Figure 229 – CMSIS-SVD Settings Properties Panel

Two CMSIS-SVD (System View Description) data files can be pointed out for the project. All SVD-files must comply with the syntax as outlined in the CMSIS-SVD specification found on ARM® website. If this requirement is not met, the SFR-view is likely not to show any register information.

The **Device file** field is typically used to for the System View Description (SVD) file. This file should include the information for the whole device. Other views may fetch information from the SVD file pointed out by this field, therefore Atollic recommends only using this field for SVD-files containing full system description. Updated SVD files can be obtained from STMicroelectronics, see the **HW Model, CAD Libraries and SVD** in the device description section on the ST web-site.

The **Custom file** field can be used to define special function registers related to custom hardware, in order to simplify the viewing of different register states. Another possible use case is to create a SFR favorites' file, containing a subset of the content in the **Device file**. This subset may be frequently checked or registers. If a **Custom file** is pointed out a new top-node in the SFR-view will be created containing the **Custom file** related register information.

Both fields may be changed by the user and both fields may be used at the same time.

FAULT ANALYZER

The **Fault Analyzer** view helps developers to identify and resolve hard-to-find system faults that occur when the CPU has been driven into a fault condition by the application software. The fault analyzer feature interprets information extracted from the Cortex-M nested vector interrupt controller (NVIC) in order to identify the reasons that caused the fault.

Some conditions that trigger faults are:

- accessing invalid memory locations
- accessing memory locations on misaligned boundaries
- executing undefined instruction
- include division by zero errors

Within the debugger, after a fault has occurred, the code line where the fault occurred will be displayed. The user can view the reasons for the error condition. Faults are broadly categorized into bus, usage and memory faults.

Bus faults occur when an invalid access attempt is made across the bus, either of a peripheral register or a memory location.

Usage faults are the result of illegal instructions or other program errors.

Memory faults include attempts of access an illegal location or violations of rules maintained by the memory protection unit (MPU).

To further aid fault analysis, an exception stack frame visualization option provides a snapshot of the MCU register values at the time of the crash. Isolating the fault to an individual instruction allows the developer to reconstruct the MCU condition at the time the faulty instruction was executed.

In the **Debugger** perspective the **Fault Analyzer** view is opened from the menu. Select the menu command **View, Fault Analyzer** or use the toolbar icon **Show View** to open a drop down list; then select **Fault Analyzer**.

FAULT ANALYZER VIEW

The **Fault Analyzer** view has five main sections which can be expanded and collapsed. The sections contain different kind of information to help understand the reason why a particular fault has occurred. The sections are **Hard Fault Details**, **Bus Fault Details**, **Usage Fault Details**, **Memory Management Fault Details** and **Register Content During Fault Exception**. It is possible to **Open editor on fault location** and to **Open disassembly on fault location** by pressing the buttons in the view.

Below is an example of the **Fault Analyzer** view when an error has been detected. In this case the error was caused by a project which configured the stack to be placed outside the RAM of the Cortex-M4 device. This causes a **Hard Fault Detected** and the **Bus Fault Details** present the **Stacking error (STKERR)**. The Register Content During Fault Exception presents the **sp** value **0x2003ffd8** and this device only had RAM available from **0x20000000** to **0x2001ffff**.

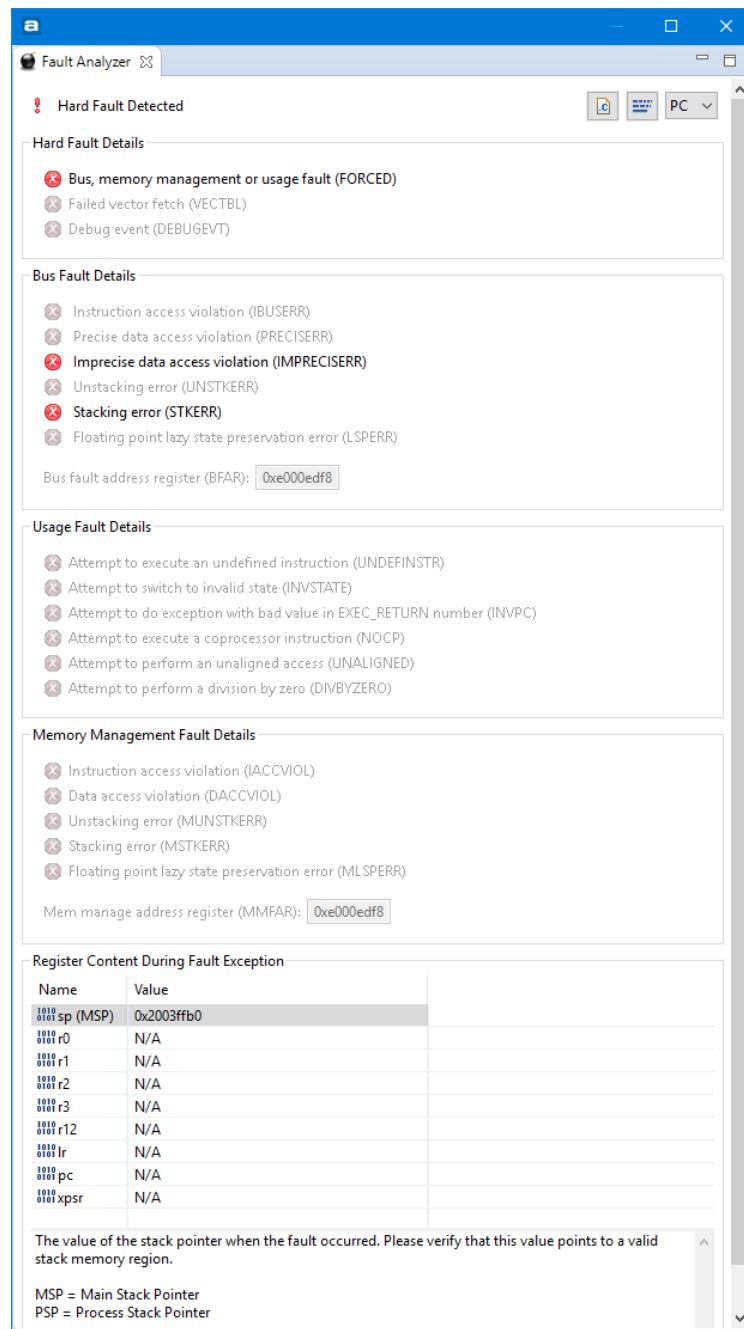


Figure 230 – Fault Analyzer View with STKERR

TERMINAL VIEW

A terminal is included to allow I/O communication with target using Local, SSH, Serial, and Telnet Terminal communication.

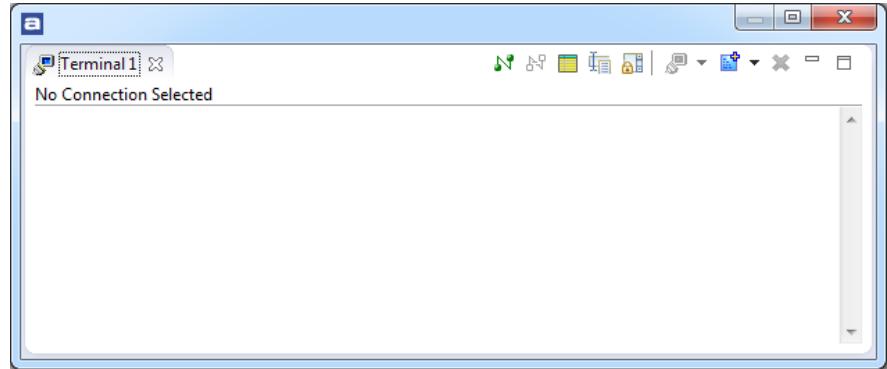


Figure 231 – Terminal View

It can be located by selecting the **Open View** toolbar button and then select **Serial Terminal** in the dropdown list.



Figure 232 – Terminal Toolbars

To start using the terminal, press button A. This will open up the Terminal Settings Dialog.

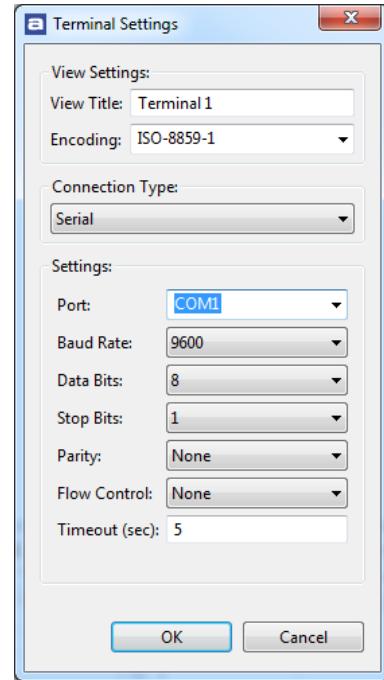


Figure 233 – Terminal Settings

Select what type of connection is preferred. That will most likely be Serial communication.

For more information for how to redirect the I/O to the Terminal, see the chapter about I/O Redirection on page 160.

SEGGER REAL TIME TERMINAL

To use Segger Real Time Terminal (RTT) with a Segger J-Link, do the following steps:

1. Download the RTT-library from <http://segger.com/pr-j-link-real-time.html>
2. Add the source-files from the RTT-pack to the project.
3. Make sure that these folders are treated as source code folders by right-clicking on the c-file or the folder then select **Resource configuration**, **Exclude from build...** and **Deselect all**.
4. Setup include paths by select in the menu **Project**, **Build Settings**, **Tool Settings**, **C Compiler**, **Directories** and add all headers
5. Exclude the `main.c` supplied in the **TrueSTUDIO** example project. Also exclude the `tiny_printf.c` and the `syscalls.c` (if available). This since RTT will override some of these implementations.
6. The RTT-pack comes with three different demonstration examples. This means 3 different `main()` implementation. Make sure only one is built. Again for these (2 of these 3) source files use: right-click on the c-files, **Resource configuration**, **Exclude from build...** and **Select all**.
7. Please note that for some versions of the example package the `SEGGER_RTT_printf()` contains a bug. The `va_start()` call must always be followed by a `va_end` call. The function might then look like this:

```
int SEGGER_RTT_printf(unsigned BufferIndex, const char *  
sFormat, ...) {  
    int ret;  
    va_list ParamList;  
  
    va_start(ParamList, sFormat);  
    ret = SEGGER_RTT_vprintf(BufferIndex, sFormat,  
&ParamList);  
    va_end(ParamList);  
    return ret;  
}
```

8. Build and start a debug session. Open the “Terminal”-view. Setup a connection:

- Encoding: ISO-8859-1
- Connection type: Telnet
- Host: localhost

- Port: 19021

- Ok

9. Connect and run the application

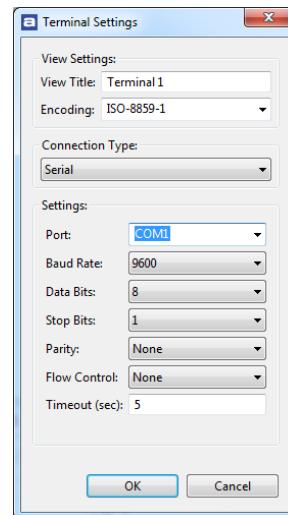


Figure 234 – Terminal Settings

ATTACH TO RUNNING TARGET USING SEGGER PROBE

This approach is useful when trying to resolve problems which occur at rare occasions, often after several days of running your embedded application, by connecting **Atollie TrueSTUDIO** debugger via JTAG/SWD the embedded target using a SEGGER J-Link.

Finding the root cause of the problem in case of a CPU crash is further simplified by learning how to use the Fault Analyzer view, see page 245.

This method is applicable to any **Atollie TrueSTUDIO** user who has a SEGGER J-Link/Trace debugger. Before trying this approach consider whether halting the application in the wrong state could potentially harm the hardware (i.e. in the case of a motor controller application). Why? When GDB connects to the SEGGER J-Link GDB-server the target CPU will be halted. This behavior is currently not possible to change and applies even if the GDB-server is started with the `-nohalt` option.

It is quite simple to make **Atollie TrueSTUDIO** connect using a SEGGER J-Link. Essentially the following three or four steps are needed:

1. Modify the debug configuration
2. Connect the J-Link to the embedded target
3. Start a debug session using the modified debug configuration
4. Optionally analyze the CPU fault condition with the **Fault Analyzer** tool

Step 1 Modify the debug configuration

The default generated debug configurations in **Atollie TrueSTUDIO** contains the GDB commands needed to setup target communication speed, to flash and reset the device and to set some breakpoints. This is not of any use to us when we want to connect to a running system which may, or may not, have crashed. Therefore the first step is to make sure that we have a debug script that will not accidentally flash or reset your CPU, which could be very annoying when you finally have managed to trigger a crash behavior which has been difficult to track down.

In order to create a modified debug configuration perform the steps below:

1. Press the **Debug Configurations** button
2. In the left frame of the *Debug Configurations* GUI, select the debug configuration associated to the project/application that you want to debug and make a copy of this by right-clicking it and click **Duplicate**
3. Give the duplicate Debug Configuration a name
4. Go to the tab called **Startup Script, Target Software Startup Script, Debug**

5. Use the # (hash-key) to comment out all GDB-commands or simply delete all commands. See picture below.

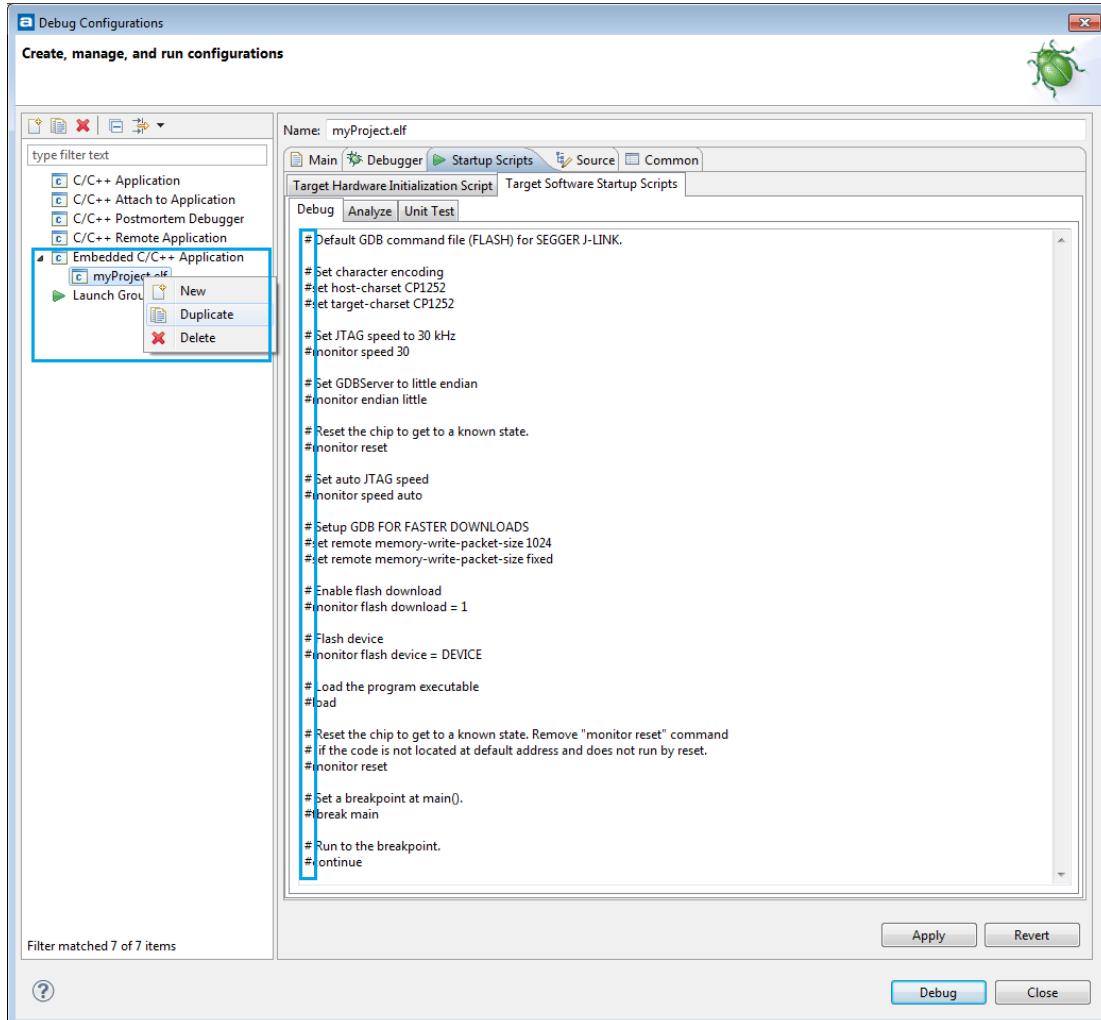


Figure 235 – Modify Startup Script

Step 2: Connect the J-Link to the embedded target

Connect the J-link to the computer. Then connect it to the embedded target. No reset should be issued.

Step 3: Start a debug session using the modified debug configuration

Important! Do not make the mistake of launching the debug session using the wrong debug configuration, that will probably flash and reset the target.

Instead the safest way to launch a debug session with full control of which debug configuration is applied (and thereby preventing a potential reset) is by using the menu selection **Run, Debug Configurations...** Then select the modified debug configuration in the left frame and click **Debug**.

Voilà - the debugger should now be connected to the embedded target which is automatically halted. At this point different status registers and variables can be investigated in the application. If the CPU has crashed, then also use the **Fault Analyzer** to better understand *what* went wrong, *why* and *where*.

STOPPING THE DEBUGGER

When the debug session is completed, the running application *must* be stopped.

1. Stop the target application by selecting the **Run, Terminate** menu command, or by clicking on the **Terminate** toolbar button in the **Debug** view.

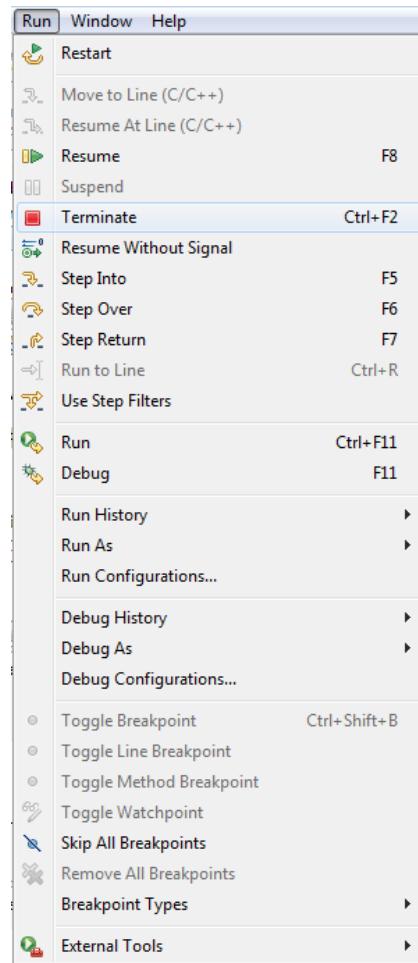


Figure 236 - The Terminate Menu Command

2. Atollic TrueSTUDIO now automatically switches to the C/C++ editing perspective

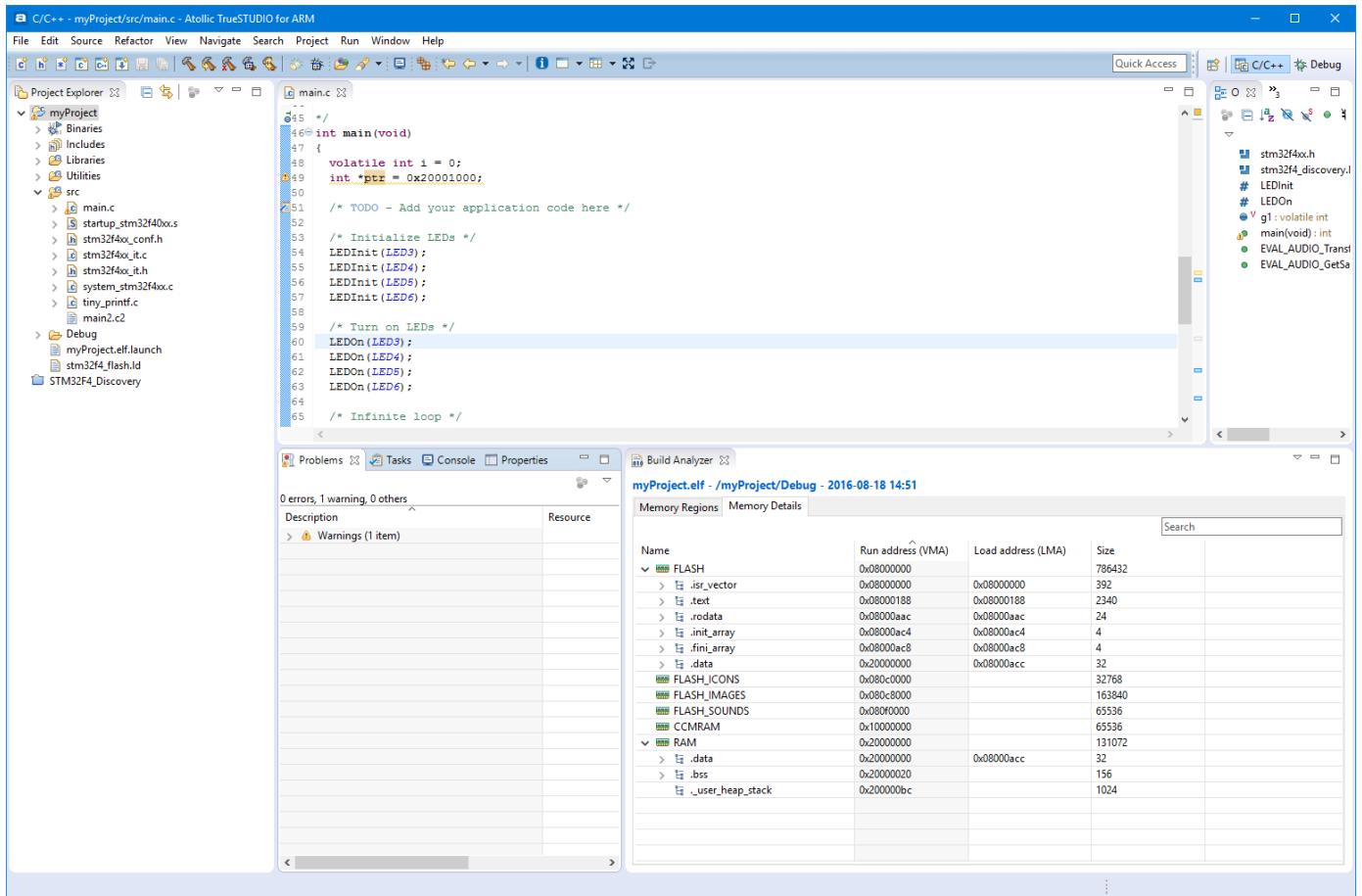


Figure 237 - C/C++ Editing Perspective



Note! If the debugging is stopped in a sudden way, the actual GDB Server process might still be running without doing anything but eating up CPU power and hanging the TCP/IP port. Please make sure that no process name "arm-atollic-eabi-gdb.exe" is running when encountering this problem. It will also eat up the memory and eventually nothing will work on the computer.

UPGRADING THE GDB SERVER

Some GDB probe manufacturer, such as Segger, upgrades their GDB server more frequently than new versions of **Atollic TrueSTUDIO** are released. To use the latest version, download it from the manufacturer website and install it in the preferred folder.

Then change the setting that points out where the server is stored. Select the top-menu **Window, Preferences** and then open **Run/Debug, Embedded C/C++ Application, Debug Hardware**, and the name of the GDB probe used. The path to the newly installed GDB server can be entered there.

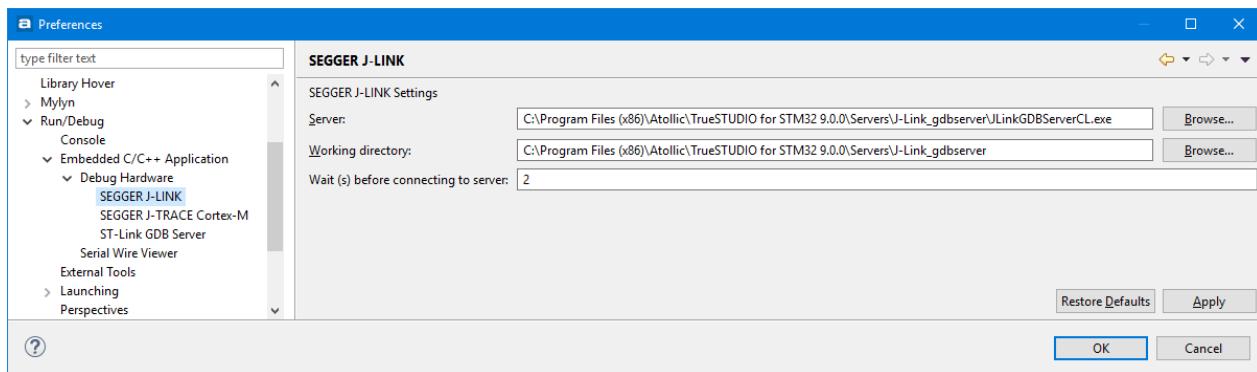


Figure 238 – Changing the Path to the GDB Server

CONFIGURE SEGGER's GDB SERVER

Segger's GDB Server can be configured for such as logging and flashing.

Do the following steps to configure Segger's GDB server.

Connect the JTAG probe to the computer.

Open a command window (`cmd`) in Windows and move to the folder for the installed GDB server:

```
cd %TrueSTUDIO installation folder%\Servers\J-Link_gdbserver
```

(or where the GDB server is installed).

Start the GDB server with

```
JLINK.exe
```

Now there should have a new icon in Windows Notification Area (by default in the lower right corner in Windows) for Segger J-Link GDB server. Right click to open it. The Control panel for the GDB server will then be opened.

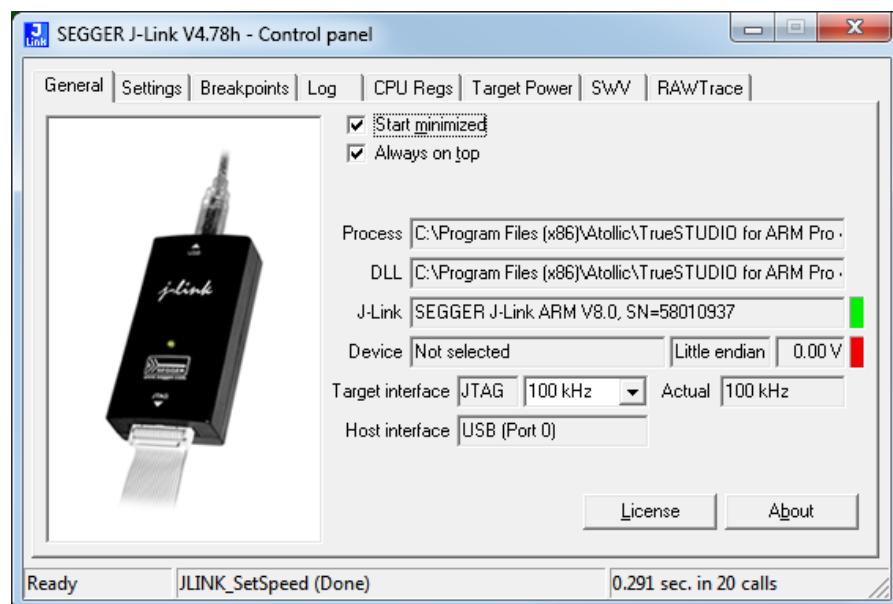


Figure 239 –GDB Server Control Panel – General Tab

A good idea is now to in the **General** tab deselect **Start minimized** and **Always on top**.

CHANGE FLASH CACHING

The Memory View does not always reflect exactly what's flashed on the target.

What does not happen is if the program alters the flash contents, the Memory panel does not reflect that.

To fix this go to the **Settings** tab and deselect the **Allow caching of flash contents**.

ENABLE LOG FILE

Do the following steps to enable logging to a log file in Segger's GDB server

1. Open the Control Panel as described above.
2. Then open the **Settings** tab and enter a name of a log file.
3. Close, stop the running GDB server and restart debugging.
4. The GDB server should now save information in the new log file.

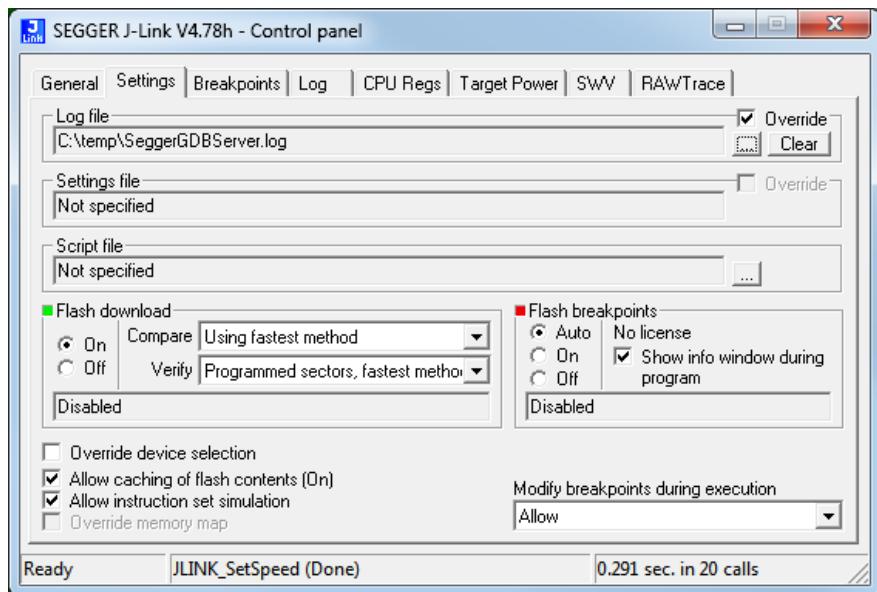


Figure 240 –GDB Server Control Panel – Settings tab

SETTINGS COMMAND LINE OPTION

There is a Command Line option to the Segger GDB server to include a settings file when debugging. In order to make this useful in **Atollic TrueSTUDIO** set the **Debug Configuration** to **Connect to remote GDB server**.

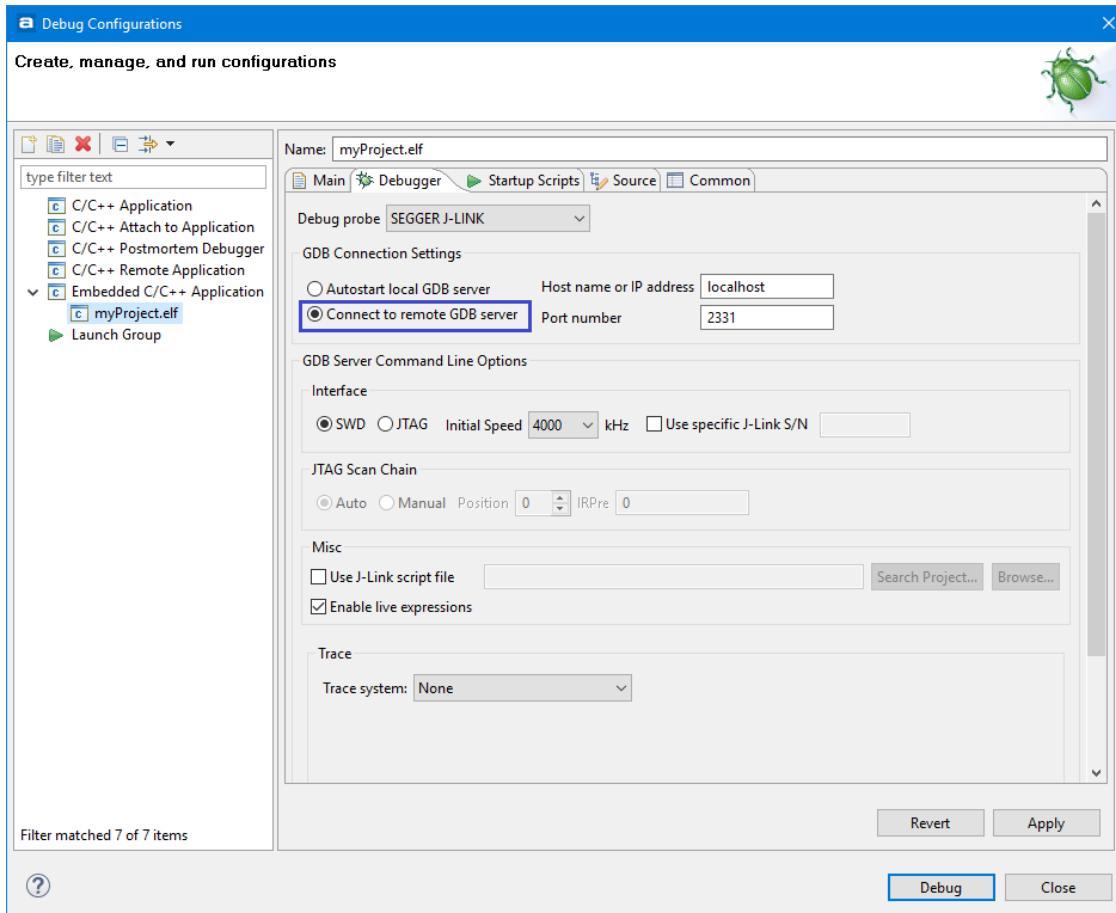


Figure 241 – Debug Configuration – Connect to Remote GDB Server

Then start the GDB server manually from the command line.

A typical command line for a STM32F10C eval board is the following:

```
JLinkGDBServerCL.exe -port 2331 -CPU Cortex-M -device STM32F107VC -  
endian little -speed 4000 -if swd
```

Now add the `-SettingsFile C:\tmp\ExampleSettingsFile.txt` to the command.

DEBUGGING CODE IN RAM

It is possible to debug program in RAM instead of FLASH and debugging in RAM can be done with any kind of debug probe but there are some requirements to do this.

1. First the program needs to be located into the RAM so the program needs to fit into the RAM. In most cases microcontrollers have a smaller RAM compared to the size of the FLASH so unfortunately in many cases it will not be possible to have the complete program, data and stack stored into RAM.
2. Normally for Cortex-M based devices there is a need to set the Vector Base Register (VBR) to the location in RAM where the interrupt vector is located. The Cortex-M0 core does not have any VBR so when a microcontroller which is based on Cortex-M0 is used it will not be possible to use any interrupts when code is located to RAM.



Some STM32-EVAL boards have special Mode switches which shall be set in RAM mode if debugging in RAM. This is a solution in STM32 to configure the device so that it uses address 0x20000000 as the base of interrupt vector. In that case there is no need to setup the vector base register to the RAM start address offset when the Mode switches are in RAM mode.

3. When debugging in RAM the gdb script which loads the code must not have a **monitor reset** command after the **load** command. Remove the **monitor reset** command after the **load** command and gdb will set the Program Counter to the entry of the program which has been loaded.

If there is a **monitor reset** command after **load** a reset will be issued and the code will then execute from FLASH.

DEBUGGING TWO TARGETS AT THE SAME TIME

Multiprocessor debugging is possible using two ST-Link or Segger's J-Links at the same time connected to two different microcontrollers, these probes are both connected to one PC on different USB-ports. For clarity let us say that the developer have two different microcontrollers: HW_A and HW_B.

In **Atollic TrueSTUDIO** this will typically require only running one instance of **Atollic TrueSTUDIO** containing one project for each microcontroller.

The default port to be used for Segger J-Link is 2331 and for ST-Link 61234. This is presented in the Debugger tab in the Debug Configurations dialog. The developer needs to change the port for one of the projects to use another port, e.g. port 2341.

FIRST ALTERNATIVE - LOCAL GDB-SERVER USING GUI OPTIONS

The debug configuration for the project can use GDB connection selection **Autostart local GDBServer**.

However, please note that as two J-Links are connected to the PC the Segger J-Link software will display a GUI where it must be selected which J-Link that is to be associated with which hardware board and the ST-Link a panel with similar functionality where the ST-Link with the correct serial number should be selected.

The developer needs to be quite fast to make the selection here and start the GDB server. When the selection is made, the GDB server will start and connect to the board using the selected probe and GDB will connect to the GDB server.

If this selection is not made fast enough the debug session in **Atollic TrueSTUDIO** will timeout because there was no server to connect to.

When the Debug Configuration has been configured for both projects so that each board is associated to a specific probe, the user may try to debug each board individually first.

When it is confirmed that this is working it is time to debug both targets at the same time. Proceed as follow:

1. First start to debug HW_A.
2. The developer will automatically be switched to the Debug Perspective in **Atollic TrueSTUDIO** when a debug session is started. Switch to C/C++ Perspective.
3. Select the project for HW_B and start debugging this. The Debug perspective will now open again.
4. There will be two application stacks/nodes in the debug view: One for each project (hardware). When changing selected node in the Debug view the depending editor, variable view etc. will be updated to present information valid to the selected project/board.

Second Alternative - Remote GDB-server Using Command-line Options

It may be easier to start the GDB server manually and change the Debug Configurations to **Connect to remote GDB server**. This setting is made in the **Debugger** tab in the **Debug Configurations** dialog.

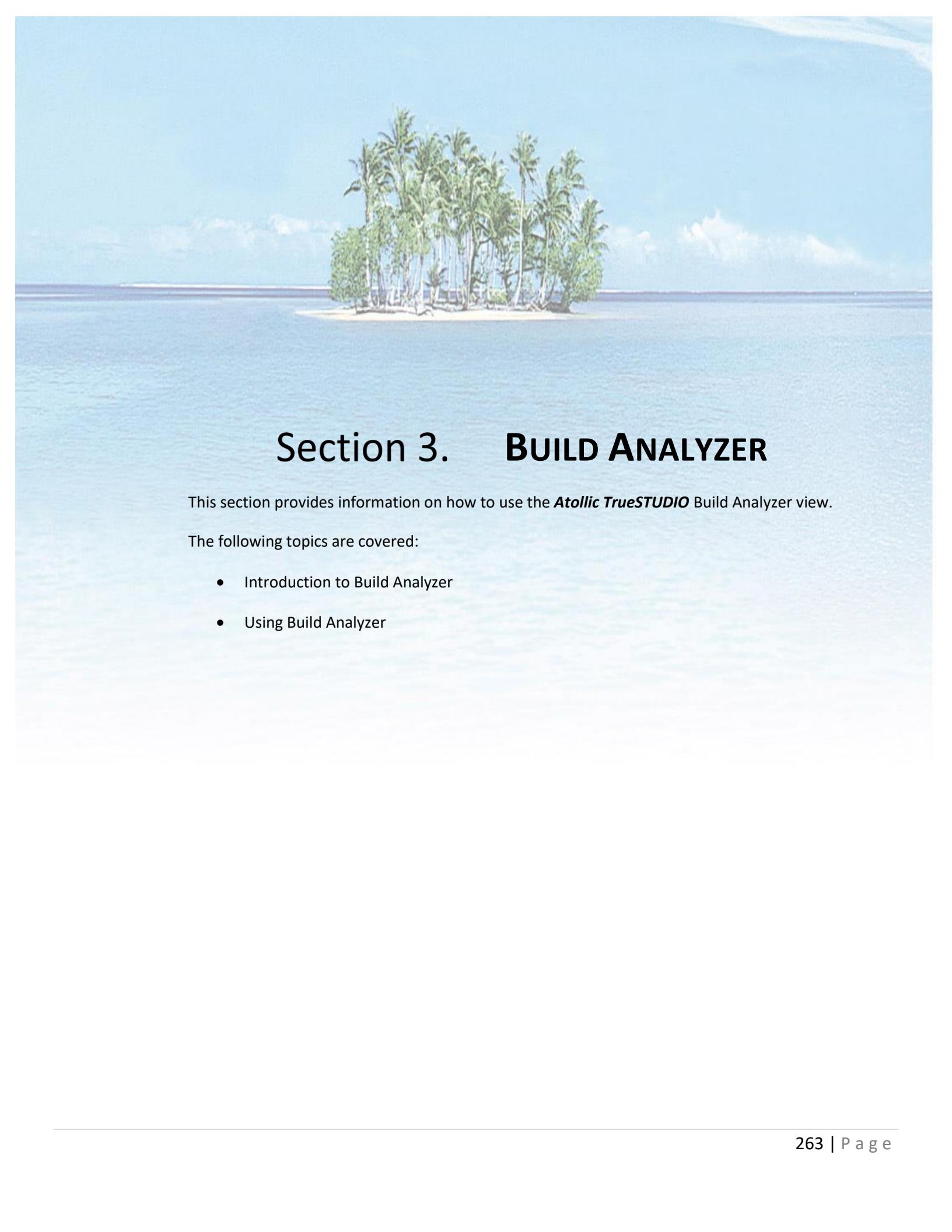
If **Connect to remote GDB server** is selected, the developer must start the GDB server manually before starting the debug session.

To start Segger J-Link GDB server manually please follow this procedure:

1. Open a Windows Console (Command Prompt, cmd.exe)
2. Change directory to the location where the GDB server is located, normally to:
C:\Program Files (x86)\Atollic\TrueSTUDIO for STM32 9.0.0\Servers\J-Link_gdbserver
3. Start the GDB server: E.g start using port 2341 with SWD interface mode:
JLinkGDBServerCL.exe -port 2341 -if SWD -select usb=123456789
(The 123456789 is serial number of dongle.)

Start another GDB server in a second command prompt, using another port number in a similar way and let this connect to the second probe.

Now when both GDB servers are running the developer can debug the two projects individually or multi-target. Please note that the **Debug Configurations** needs to use the same port as the GDB server is listening on and **Connect to remote GDB server** shall be used.



Section 3. BUILD ANALYZER

This section provides information on how to use the **Atollic TrueSTUDIO** Build Analyzer view.

The following topics are covered:

- Introduction to Build Analyzer
- Using Build Analyzer

INTRODUCTION TO BUILD ANALYZER

The **Build Analyzer** view is used to get a visual view on built programs. It analyzes an .elf file in detail and presents the information in the view. If a .map file, with similar name, is found in the same folder as the .elf file also information from the .map file is used and even more information can be presented. The view can also analyze and display information about an object file.

The view contains two tabs. The **Memory Regions** tab and the **Memory Details** tab.

The **Memory Regions** tab is populated with data if the .elf file contains a corresponding .map file. When the .map file is available this tab can be seen as a brief summary of the memory regions with information about region name, start address and size. The size information also comprises total size, free and used part of the region, and a usage number in percentage.

The **Memory Details** tab contains detailed program information based on the .elf file. The different section names are presented with address and size information and each section can be expanded and collapsed. When a section is expanded functions/data in this section is listed (green icons are used to show function names and blue icons are used for data variables). Each presented function/data contains address and size information. The memory details tab also contain information for object files, .o files, when such files are selected.

When there is a need to optimize or simplify a program the **Build Analyzer** view is good to use when there is a need to optimize or simplify a program.

USING BUILD ANALYZER

The **Build Analyzer** view is by default open in the **C/C++** perspective. If the view is closed it can be opened from the menu. Select the menu command **View, Build Analyzer** or use the toolbar icon **Show View** to open a drop down list; then select **Other** and in the **Show View** dialog **C/C++ -> Build Analyzer**. Another way to open the **Build Analyzer** view is to type **Build Analyzer** into the **Quick Access search bar** and select it from the views.

When the **Build Analyzer** view is open select an **.elf** or an **.o** file in the **Project Explorer** view. The **Build Analyzer** view will then be updated with the information it finds in the file. When an **.elf** file is selected and a **.map** file, with similar name, is found in the same folder also information from the **.map** file is used by the view.

The **Build Analyzer** view will also be updated if a project node in the **Project Explorer** view is selected. In this case the **Build Analyzer** uses the **.elf** file which corresponds to the current active build configuration for the project. The view only provides information for embedded projects so it will be empty for PC projects.

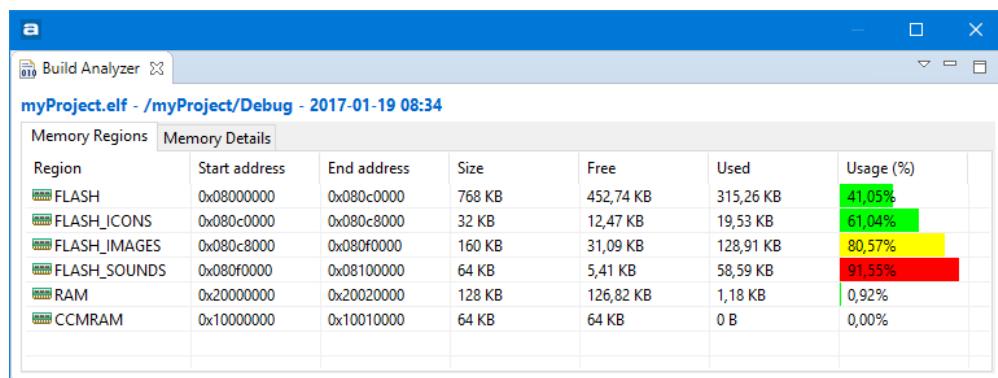


Figure 242 – Build Analyzer

MEMORY REGIONS

The **Memory Regions** tab of the **Build Analyzer** view displays information based on the corresponding **.map** file. If no information is displayed there is no corresponding **.map** file found. When a **.map** file is found the Region names, Start address, End address, Total size of region, Free size, Used size and Usage (%) information is presented.

These regions are normally defined in the linker script **.ld** file used when building the program. If any changes of the location or size of a memory region needs to be done then please update the linker script file.



The **Memory Regions** tab is empty if the `.elf` file does not have a corresponding `.map` file. **Memory Regions** tab is also empty when a `.o` file is selected.

The **Usage (%)** column contains a bar icon corresponding to the percentage value. The bar has different color depending of the percentage of used memory:

Usage Color	Description
Green	Less than 75% of memory used
Yellow	75-90% of memory used
Red	More than 90% of memory used

Table 3 – Memory Regions Usage Color

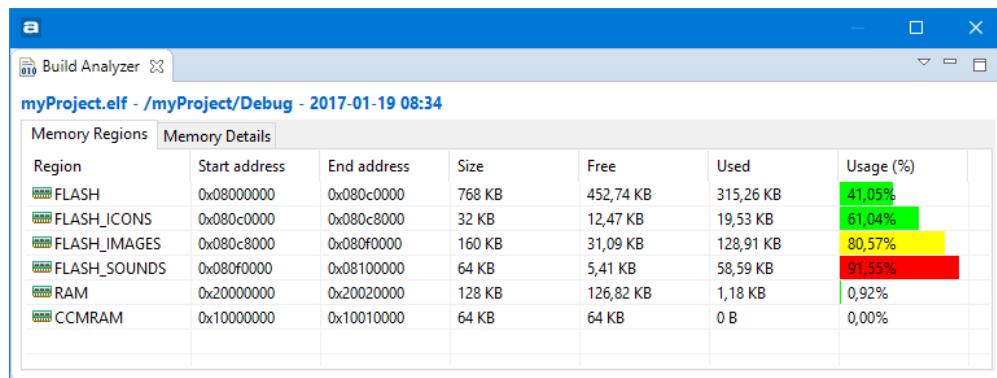


Figure 243 – Memory Regions Tab

MEMORY DETAILS

The **Memory Details** tab of the **Build Analyzer** view contains information for the `.elf` file. The view can also display information about an object file, so if an object file is selected the size information for the object file is updated.

Each section in the **Memory Details** tab can be expanded so that individual functions and data can be seen. The table contains columns with Name, Run Address (VMA), Load Address (LMA) and Size information.

The column information are described in the table below:

Name	Description
Name	Name of Memory Regions (if a corresponding .map file is found), Sections, Symbols, Functions, Variables, ...
Run Address (VMA)	The Virtual Memory Address contains the address used when program is running.
Load Address (LMA)	The Load Memory Address is the address used for load, e.g. Initialization values for global variables.
Size	The used size (total size for Memory Regions)

Table 4 – Memory Details

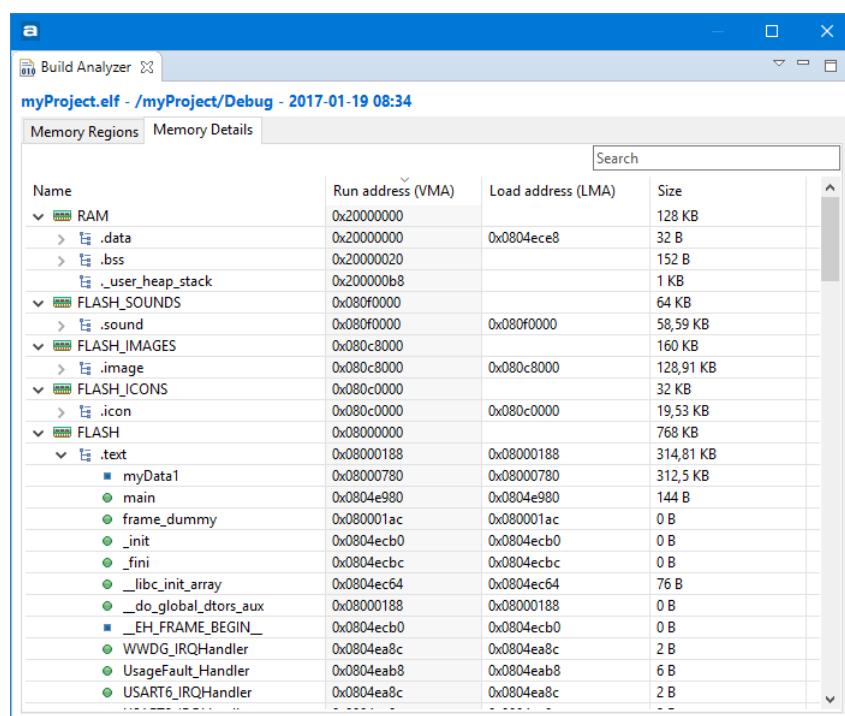


Figure 244 – Memory Details Tab

SIZE INFORMATION

The size information in the **Memory Details** tab is calculated from the symbol size in the **.elf** file. If a corresponding **.map** file is investigated this may contain a different size value. Normally the size is correct for c-files but the value presented for assembler files depends on how the size information is written in the assembler files. The constants used

by the function shall be defined within the .section definition. At the end of the section the .size directive is used by the linker to calculate the size of the function.

Example: Reset_Handler in startup.s file

This is an example on how to write the Reset_Handler in an assembler startup file to include the constants _sidata, _sdata, _edata, _sbss, _ebss in the size information for the Reset_Handler in the .elf file. If these constants are defined outside the Reset_Handler section definition the size of these constants will not be included in the calculated size of the Reset_Handler. To include them in the size of the Reset_Handler these definitions should be placed inside the Reset_Handler section in the following way.

```
.section .text.Reset_Handler
.weak Reset_Handler
.type Reset_Handler, %function

Reset_Handler:
    ldr sp, =_estack /* set stack pointer */

/* Copy the data segment initializers from flash to SRAM */
    movs r1, #0
    b LoopCopyDataInit

CopyDataInit:
    ldr r3, =_sidata

/* initialization code data, bss, ... */
    ...

/* Call the application's entry point.*/
    bl main
    bx lr

/* start address for the initialization values defined in
linker script */
.word _sidata
.word _sdata
.word _edata
.word _sbss
.word _ebss

.size Reset_Handler, .-Reset_Handler
```

SORTING

The sort order of **Memory Details** tab can be changed by clicking on a column name.
E.g. Sort information by size:

Name	Run address (VMA)	Load address (LMA)	Size
FLASH	0x08000000		768 KB
.text	0x08000188	0x08000188	314,81 KB
_isr_vector	0x08000000	0x08000000	392 B
.data	0x20000000	0x0804ecc8	32 B
.rodata	0x0804ecc8	0x0804ecc8	24 B
.init_array	0x0804ece0	0x0804ece0	4 B
.fini_array	0x0804ece4	0x0804ece4	4 B
FLASH_IMAGES	0x080c8000		160 KB
.image	0x080c8000	0x080c8000	128,91 KB
RAM	0x20000000		128 KB
._user_heap_stack	0x200000b8		1 KB
.bss	0x20000020		152 B
AUDIO_MAL_DMA_InitStructure	0x20000040		60 B
DMA_InitStructure	0x2000007c		60 B
CurrentPos	0x2000003c		4 B
.data	0x20000000	0x0804ece8	32 B
GPIO_PORT	0x20000000	0x0804ece8	16 B
AudioRemSize	0x20000010	0x0804ecf8	4 B
CurrAudioInterface	0x20000014	0x0804ecfc	4 B
AUDIO_MAL_DMA_STREAM	0x20000018	0x0804ed00	4 B
AUDIO_MAL_DMA_FLAG_TC	0x2000001c	0x0804ed04	4 B
FLASH_SOUNDS	0x080f0000		64 KB
.sound	0x080f0000	0x080f0000	58,59 KB

Figure 245 – Memory Details Sorted

SEARCH AND FILTER

The information in the **Memory Details** tab can be filtered by entering a string in the search field.

E.g. Search for names including the string “dma”.

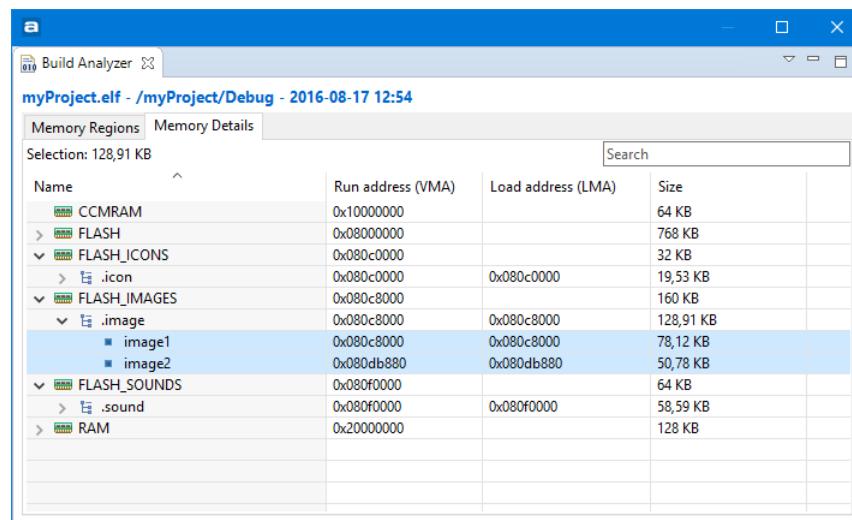
The screenshot shows the Build Analyzer interface with the title bar "Build Analyzer" and the project name "myProject.elf - /myProject/Debug - 2017-01-19 08:34". The "Memory Details" tab is selected. A search bar at the top right contains the text "dma". The table below lists memory regions and their details, with rows containing "dma" in the name column being highlighted. The columns are: Name, Run address (VMA), Load address (LMA), and Size.

Name	Run address (VMA)	Load address (LMA)	Size
FLASH	0x08000000		768 KB
.text	0x08000188	0x08000188	314,81 KB
DMA_Init	0x08000200	0x08000200	176 B
DMA_Cmd	0x080002b0	0x080002b0	56 B
DMA_GetCmdStatus	0x080002e8	0x080002e8	48 B
DMA_GetFlagStatus	0x08000318	0x08000318	120 B
DMA_ClearFlag	0x08000390	0x08000390	92 B
DMA1_Stream7_IRQHandler	0x08000724	0x08000724	12 B
DMA1_Stream0_IRQHandler	0x08000730	0x08000730	12 B
DMA2_Stream5_IRQHandler	0x0804ea8c	0x0804ea8c	2 B
DMA1_Stream5_IRQHandler	0x0804ea8c	0x0804ea8c	2 B
DMA1_Stream2_IRQHandler	0x0804ea8c	0x0804ea8c	2 B
DMA2_Stream2_IRQHandler	0x0804ea8c	0x0804ea8c	2 B
DMA2_Stream3_IRQHandler	0x0804ea8c	0x0804ea8c	2 B
DMA2_Stream0_IRQHandler	0x0804ea8c	0x0804ea8c	2 B
DMA1_Stream6_IRQHandler	0x0804ea8c	0x0804ea8c	2 B
DMA1_Stream1_IRQHandler	0x0804ea8c	0x0804ea8c	2 B
DMA2_Stream7_IRQHandler	0x0804ea8c	0x0804ea8c	2 B
DMA2_Stream1_IRQHandler	0x0804ea8c	0x0804ea8c	2 B
DMA2_Stream4_IRQHandler	0x0804ea8c	0x0804ea8c	2 B
DMA2_Stream6_IRQHandler	0x0804ea8c	0x0804ea8c	2 B
DMA1_Stream3_IRQHandler	0x0804ea8c	0x0804ea8c	2 B
.data	0x20000000	0x0804ec8	32 B
AUDIO_MAL_DMA_STREAM	0x20000018	0x0804ed00	4 B
AUDIO_MAL_DMA_FLAGS	0x2000001	0x0804ed04	1 B

Figure 246 – Memory Details Search/Filter

CALCULATE SUM OF SIZE

The sum of the size of several lines in the **Memory Details** tab can be calculated by selecting several lines in the view. The sum of the selection is presented above the **Name** column in the view.



Name	Run address (VMA)	Load address (LMA)	Size
CCMRAM	0x10000000		64 KB
FLASH	0x08000000		768 KB
FLASH_ICONS	0x080c0000		32 KB
.icon	0x080c0000	0x080c0000	19,53 KB
FLASH_IMAGES	0x080c8000		160 KB
.image	0x080c8000	0x080c8000	128,91 KB
image1	0x080c8000	0x080c8000	78,12 KB
image2	0x080db880	0x080db880	50,78 KB
FLASH_SOUNDS	0x080f0000		64 KB
.sound	0x080f0000	0x080f0000	58,59 KB
RAM	0x20000000		128 KB

Figure 247 – Calculate Sum of Size

DISPLAY SIZE INFORMATION IN BYTE FORMAT

The **Build Analyzer** can display size information in “Byte/Kbyte” format or in “Show Byte Count” format. The icon  in the **Build Analyzer** toolbar is used to switch between these two formats. The **Show byte count** format can be an better option to use when making Copy and Paste of data into an Excel document for later calculations.



Figure 248 – Show Byte Count

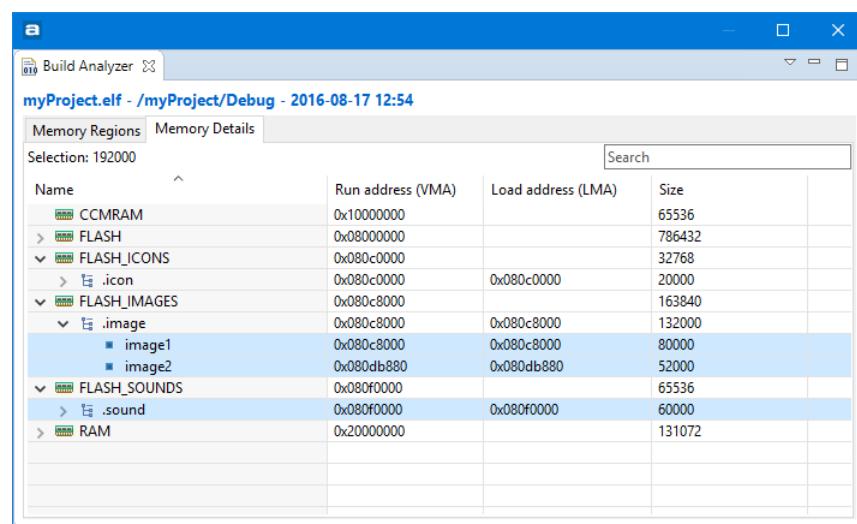


Figure 249 – Size Information in Byte Format

COPY AND PASTE

The data in the **Memory Details** tab can be copied to other applications in CSV-format by selecting the rows to copy and type **Ctrl+C**. The copied data can be pasted into another application with the **Ctrl+V** command.

Name	Run address (VMA)	Load address (LMA)	Size
CCMRAM	0x10000000		65536
FLASH	0x08000000		786432
FLASH_ICONS	0x080c0000		32768
.icon	0x080c0000	0x080c0000	20000
FLASH_IMAGES	0x080c8000		163840
.image	0x080c8000	0x080c8000	132000
image1	0x080c8000	0x080c8000	80000
image2	0x080db880	0x080db880	52000
FLASH_SOUNDS	0x080f0000		65536
.sound	0x080f0000	0x080f0000	60000
RAM	0x20000000		131072

Figure 250 – Copy and Paste

For example when making a copy of the selected lines in previous figure the copied information will be:

```
"image1";"0x080c8000";"0x080c8000";"80000"  
"image2";"0x080db880";"0x080db880";"52000"  
.sound";"0x080f0000";"0x080f0000";"60000"
```



Section 4. STATIC STACK ANALYZER

This section provides information on how to use the ***Atollic TrueSTUDIO*** Static Stack Analyzer view.

The following topics are covered:

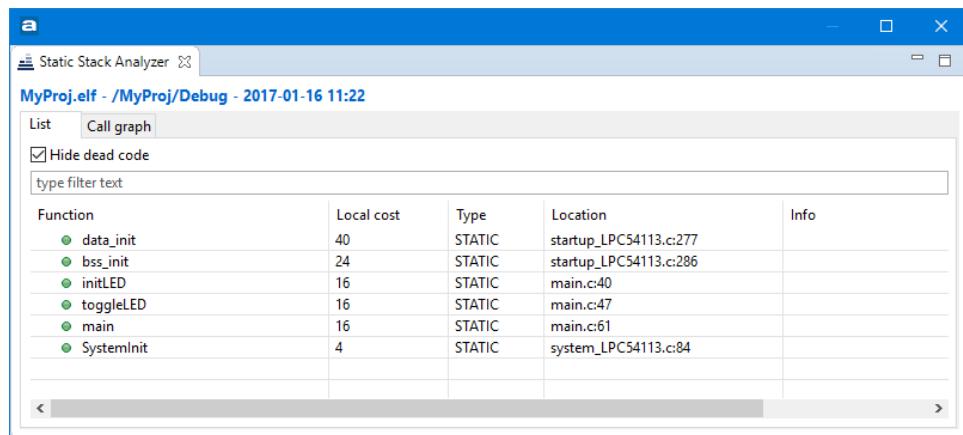
- Introduction to Static Stack Analyzer
- Using Static Stack Analyzer

INTRODUCTION TO STATIC STACK ANALYZER

The **Static Stack Analyzer** view calculates the stack usage based on the built program. It analyzes the .su files, generated by gcc, and the .elf file in detail and presents the information in the view.

The view contains two tabs. The **List** tab and the **Call Graph** tab.

The **List** tab is populated with the stack usage for each function included in the program. There is one line per function and each line consist of Function, Local cost, Type, Location and Info columns.

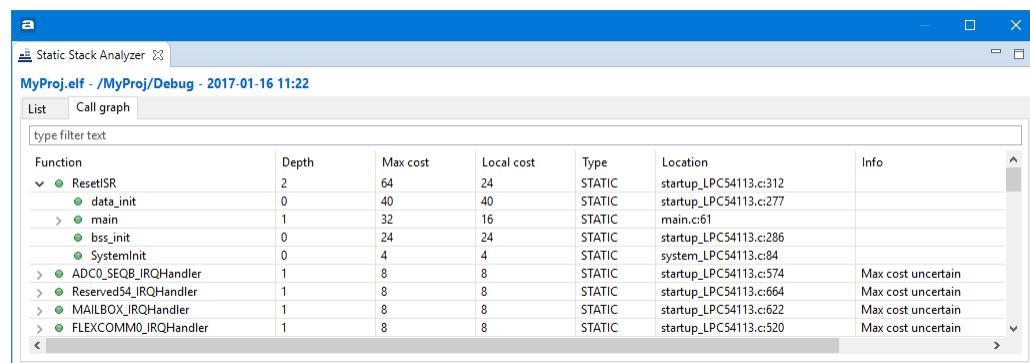


The screenshot shows the 'List' tab of the Static Stack Analyzer. The window title is 'MyProj.elf - /MyProj/Debug - 2017-01-16 11:22'. The table has columns: Function, Local cost, Type, Location, and Info. The data is as follows:

Function	Local cost	Type	Location	Info
data_init	40	STATIC	startup_LPC54113.c:277	
bss_init	24	STATIC	startup_LPC54113.c:286	
initLED	16	STATIC	main.c:40	
toggleLED	16	STATIC	main.c:47	
main	16	STATIC	main.c:61	
SystemInit	4	STATIC	system_LPC54113.c:84	

Figure 251 – Static Stack Analyzer List Tab

The **Call Graph** tab contains an expandable list with functions included in the program. Lines which are representing functions which are calling other functions can be expanded to see the call hierarchy.



The screenshot shows the 'Call graph' tab of the Static Stack Analyzer. The window title is 'MyProj.elf - /MyProj/Debug - 2017-01-16 11:22'. The table has columns: Function, Depth, Max cost, Local cost, Type, Location, and Info. The data is as follows:

Function	Depth	Max cost	Local cost	Type	Location	Info
ResetISR	2	64	24	STATIC	startup_LPC54113.c:312	
data_init	0	40	40	STATIC	startup_LPC54113.c:277	
main	1	32	16	STATIC	main.c:61	
bss_init	0	24	24	STATIC	startup_LPC54113.c:286	
SystemInit	0	4	4	STATIC	system_LPC54113.c:84	
ADC0_SEQB_IRQHandler	1	8	8	STATIC	startup_LPC54113.c:574	Max cost uncertain
Reserved54_IRQHandler	1	8	8	STATIC	startup_LPC54113.c:664	Max cost uncertain
MAILBOX_IRQHandler	1	8	8	STATIC	startup_LPC54113.c:622	Max cost uncertain
FLEXCOMM0_IRQHandler	1	8	8	STATIC	startup_LPC54113.c:520	Max cost uncertain

Figure 252 – Static Stack Analyzer Call Graph Tab

USING STATIC STACK ANALYZER

The **Static Stack Analyzer** view is by default open in the **C/C++** perspective. If the view is closed it can be opened from the menu. Select the menu command **View, Static Stack Analyzer** or use the toolbar icon **Show View** to open a drop down list; then select **Other** and in the **Show View** dialog **C/C++ -> Static Stack Analyzer**. Another way to open the **Static Stack Analyzer** view is to type **Static Stack Analyzer** into the **Quick Access search bar** and select it from the views.

The **Static Stack Analyzer** view will be populated when a project has been built and is selected in the **Project Explorer**. The program needs to be built with option **Generate per function stack usage information** enabled. Otherwise the view will not be able to present any stack information.



How to setup the compiler to generate stack usage information is explained in next chapter.

ENABLE STACK USAGE INFORMATION

If the top of the view displays the message **No stack usage information found, please enable in the compiler settings** then there is a need to update the build configuration for the linker to generate stack information. Open the properties for the project, for instance with a right-click on the project in the **Project Explorer** view. Select **Properties** and in the dialog and select **C/C++ Build, Settings**. Select the **Tool Settings-tab, C Compiler, Debugging** and enable **Generate per function stack usage information**, see figure below. Then save the setting and rebuild the program.

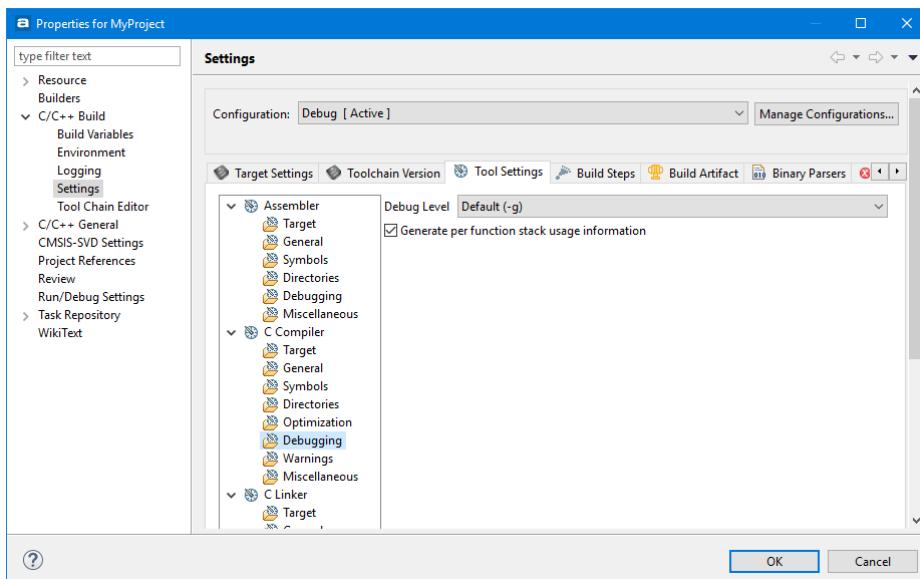


Figure 253 – Enable Generate per Function Stack Usage Information

BASIC COLUMN INFORMATION

The information in the **Static Stack Analyzer** tabs contains the following symbols and definitions in the columns.

FUNCTION COLUMN

Normally there is a small icon to the left of the function name in the **Function** column. The icon is:

- **green dot** when the function uses STATIC stack allocation (fixed stack)
- **blue square** when the function uses DYNAMIC stack allocation (run-time dependent)
- **010 icon** is used if the stack information is not known. This can be the case for library functions or assembler functions.
- **Three arrows in a circle** are used in the Call Graph view when the function makes recursive calls

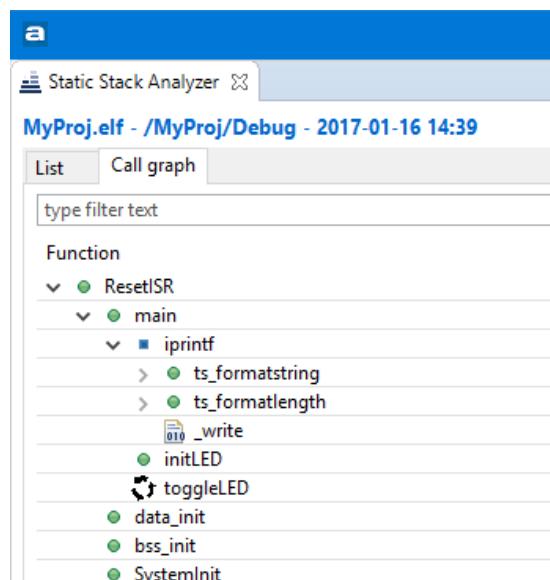


Figure 254 –Function Symbols in Static Stack Analyzer

DEPTH COLUMN

The **Depth** column specifies the call stack depth this function uses

- **0** when function does not call any other functions
- **Number >=1** when function calls other functions
- **?** when function makes recursive calls or the depth could not be calculated

MAX COST COLUMN

The **Max cost** column specifies how many bytes of stack the function will use including stack needed for called functions.

LOCAL COST COLUMN

The **Local cost** column specifies how many bytes of stack the function will use. This column does not take into account any stack which may be needed by functions it may call.

TYPE COLUMN

The **Type** column specifies

- **STATIC** (the function uses a fixed stack)
- **DYNAMIC** (the function uses a run-time dependent stack)
- **Empty field** (no stack usage information available for the function)

INFO COLUMN

The **Info** column contains specific information about the stack usage calculation. For instance it can hold a combination of the following messages.

- **Max cost uncertain** (the reason can be that the function makes a call to some sub function where the stack information is not known or the function makes recursive calls etc.)
- **Recursive** (the function makes recursive calls)
- **No stack usage information available for this function** (no stack usage information available for this function)
- **Local cost uncertain due to dynamic size, verify at run-time** (the function allocates stack dynamically, e.g. depending on parameter)

LIST TAB

The **List** tab contains a list of all functions included in the selected program with options to **Hide dead code** functions and to **Filter** visible functions.

The **Hide dead code** selection is used to enable or disable listing dead code functions.

The **Filter** field works in the way that when some characters are entered into the field only functions matching the characters are displayed.

The column information in the **List** tab is described in the table below:

Name	Description
Function	Function name
Local cost	The number displays how many bytes of stack the function will use.
Type	Tells if the function uses a STATIC or DYNAMIC stack allocation. When DYNAMIC allocation is used the actual stack size is run-time dependent and the Local cost value is uncertain due to the dynamic size of stack.
Location	Indicates where the function is declared. It is possible to double click on a line and open the file with the defined function in the editor.
Info	Additional information about the calculation.

Table 5 – Static Stack Analyzer List tab

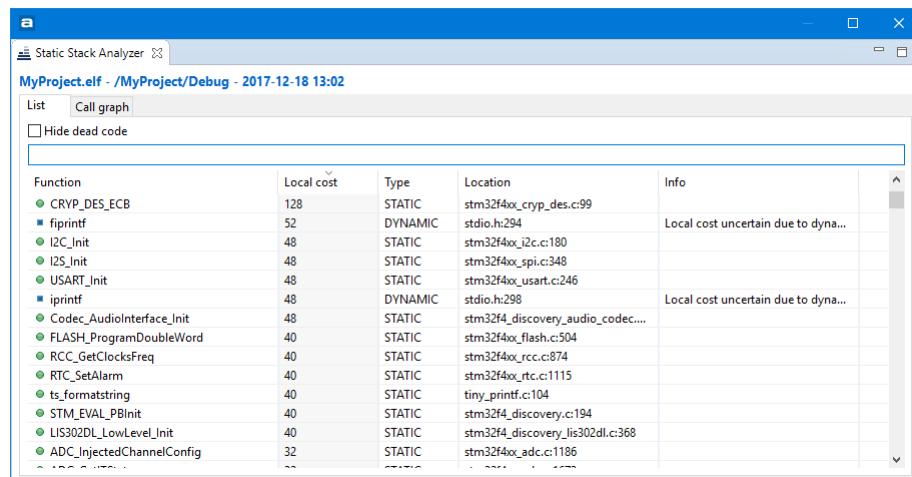


Figure 255 –List tab



By double-clicking on a line which displays the file location and line number in the **List** tab, the function will be opened in the **Editor** view.

CALL GRAPH TAB

The **Call Graph** tab contains detailed program information in a tree view. Each function included in the program but not called by any other function is presented on top level. It is possible to expand the tree to see called functions. Only functions available in the .elf file can be visible in the tab.

The **Filter** field works in the way that when some characters are entered into the field only functions matching the characters are displayed.

The column information in the **Call Graph** tab is described in the table below:

Name	Description
Function	Function name.
Depth	Displays how many nested function levels that will be called by the function. The value is 0 if no functions are called and ? mark is displayed if the number of called functions could not be calculated for instance the source code could not be found or the function makes recursive calls.
Max cost	The number displays how many bytes of stack the function will use including stack needed for called functions.
Local cost	The number displays how many bytes of stack the function will use.
Type	Tells if the function uses a STATIC or DYNAMIC stack allocation. When DYNAMIC allocation is used the actual stack size depends on run-time and then the Local cost value is uncertain due to the dynamic size of stack.
Location	Indicates where the function is declared. It is possible to double click on a line and open the file with the defined function in the editor.
Info	Additional information about the calculation.

Table 6 – Static Stack Analyzer Call Graph tab

The `main` function is normally called by the `Reset_Handler` and can in those cases be seen when expanding the `Reset_Handler` node. In this figure below the reset function name is called `ResetISR`. By expanding the node it can be seen that the `ResetISR` calls the `main` function which calls `initLED` and `toggleLED` functions. The local cost of stack for the `main` function is in this case 16 and the max cost is 32 as the `main` function call `initLED` and `toggleLED` functions which also consumes 16 bytes of stack.

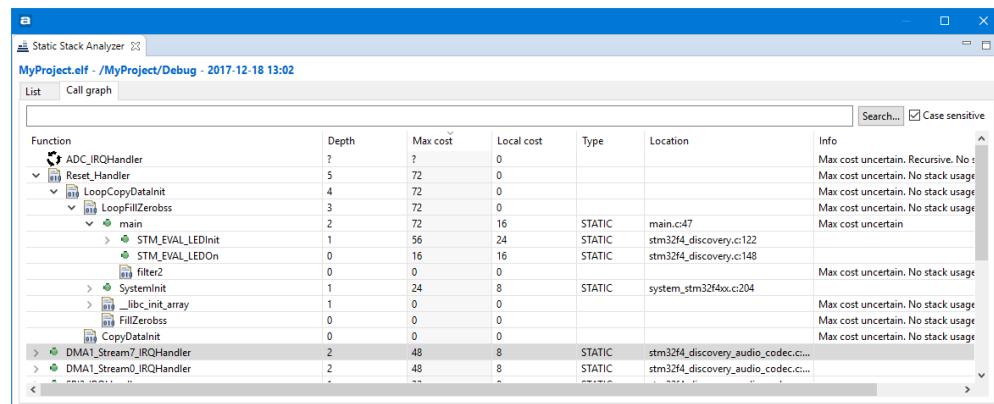


Figure 256 –Call Graph tab

By double-clicking on a line which displays the file location and line number in the tab, the function will be opened in the **Editor** view.



The `main` function is normally called by the `Reset_Handler` and can in those cases be seen when expanding the `Reset_Handler` node.



If unused functions are listed in the tab then please check if the linker option **dead code removal** should be enabled to remove unused code from the program. Read more on this in the Dead Code Removal chapter, page 121.

USING SEARCH FIELD

The **List** tab and the **Call Graph** tab contains a filter/search field which can be used to search a specific function or functions matching the characters entered into the field.

The next figure displays the **List** view using **Filter** field to see functions containing the characters **LED** in the name.

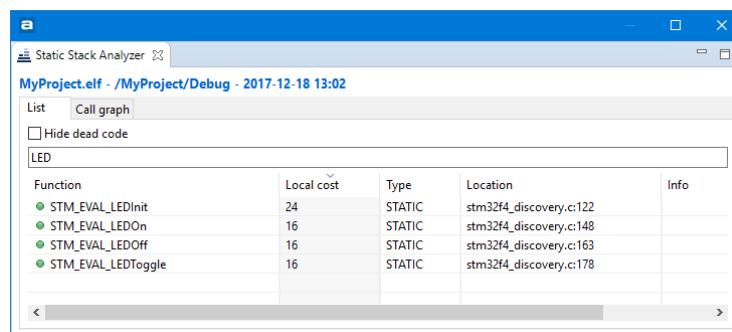


Figure 257 –List tab using filter

Another example is to use the **Search** field in the **Call Graph** tab. The function(s) matching the search field is find, press **Search** to find next function(s).

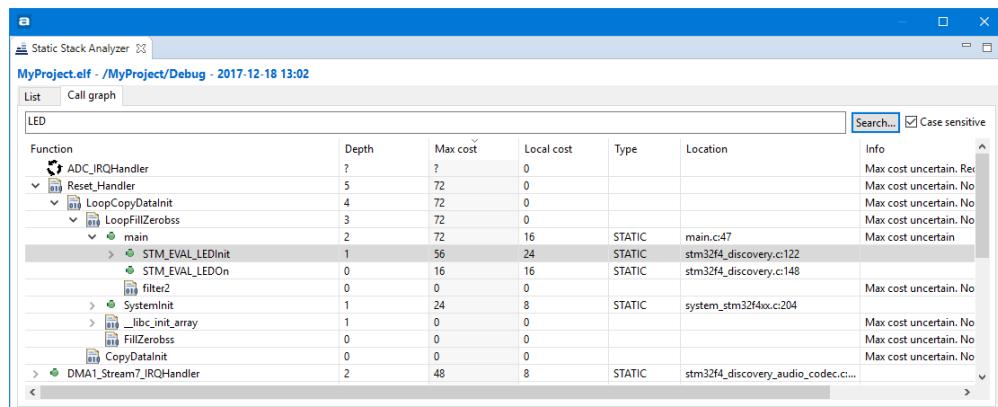


Figure 258 –Call Graph tab using search

COPY AND PASTE

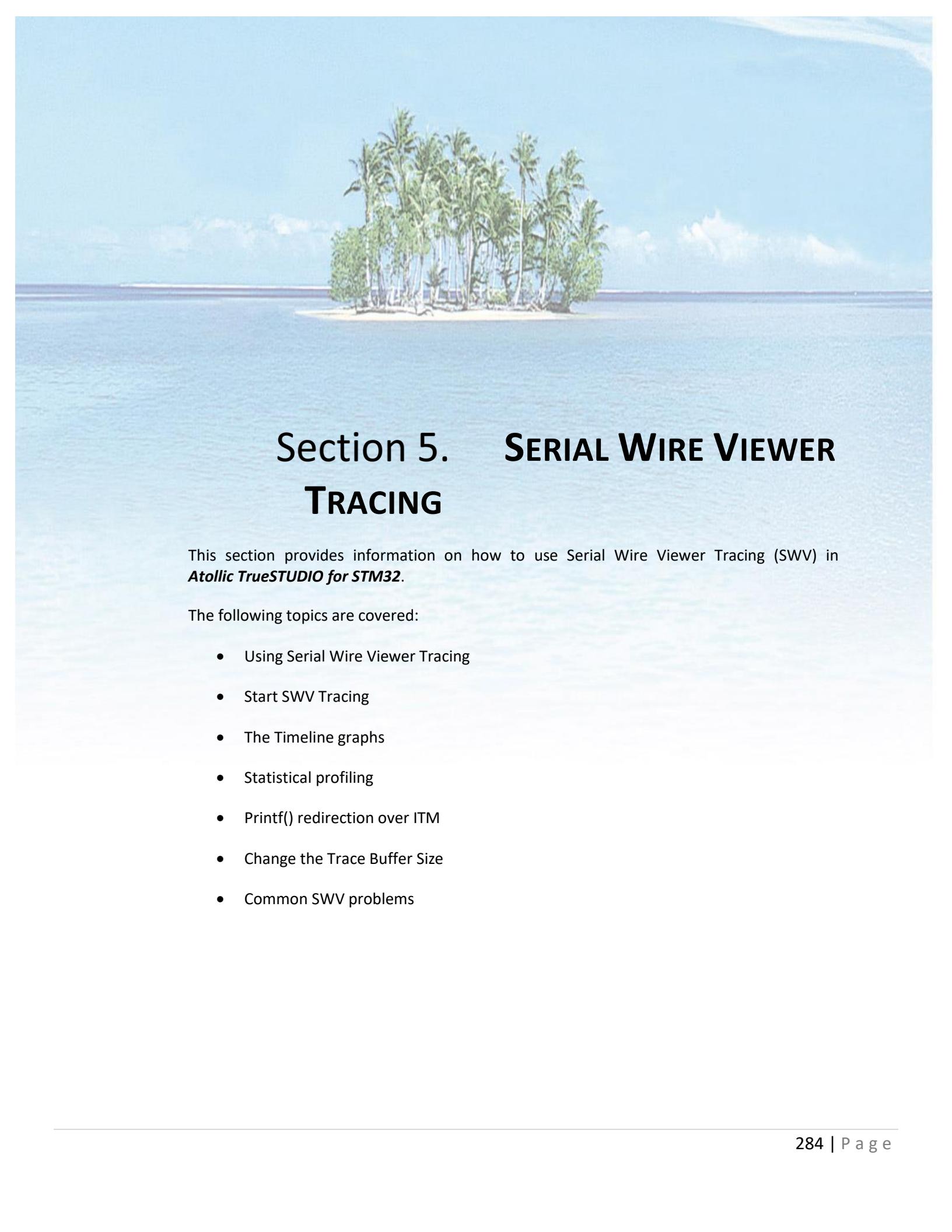
The data in the **List** tab can be copied to other applications in CSV-format by selecting the rows to copy and type **Ctrl+C**. The copied data can be pasted into another application with the **Ctrl+V** command.

Function	Local cost	Type	Location	Info
DMA_GetCmdStatus	24	STATIC	stm32f4xx_dma.c:943	
DMA_GetFlagStatus	32	STATIC	stm32f4xx_dma.c:1004	
DMA_Init	24	STATIC	stm32f4xx_dma.c:319	
EVAL_AUDIO_GetSampleCallBack	4	STATIC	main.c:98	
EVAL_AUDIO_TransferComplete_CallBack	16	STATIC	main.c:89	
GPIO_Init	32	STATIC	stm32f4xx_gpio.c:189	
RCC_AHB1PeriphClockCmd	16	STATIC	stm32f4xx_rcc.c:1130	
SPI_I2S_GetFlagStatus	24	STATIC	stm32f4xx_spi.c:1161	
SPI_I2S_SendData	16	STATIC	stm32f4xx_spi.c:817	
STM_EVAL_LEDInit	24	STATIC	stm32f4_discovery.c:122	
STM_EVAL_LEDOn	16	STATIC	stm32f4_discovery.c:148	
SetSysClock	16	STATIC	system_stm32f4xx.c:338	
SystemInit	8	STATIC	system_stm32f4xx.c:204	
main	16	STATIC	main.c:47	

Figure 259 – Copy and Paste

For example when making a copy of the selected lines in previous figure the copied information will be:

```
"STM_EVAL_LEDInit";"24";"STATIC";"stm32f4_discovery.c:122"""  
"STM_EVAL_LEDOn";"16";"STATIC";"stm32f4_discovery.c:148"""  
"SetSysClock";"16";"STATIC";"system_stm32f4xx.c:338"""  
"SystemInit";"8";"STATIC";"system_stm32f4xx.c:204"""  
"main";"16";"STATIC";"main.c:47""
```



Section 5. SERIAL WIRE VIEWER TRACING

This section provides information on how to use Serial Wire Viewer Tracing (SWV) in **Atollc TrueSTUDIO for STM32**.

The following topics are covered:

- Using Serial Wire Viewer Tracing
- Start SWV Tracing
- The Timeline graphs
- Statistical profiling
- Printf() redirection over ITM
- Change the Trace Buffer Size
- Common SWV problems

USING SERIAL WIRE VIEWER TRACING

To use system analysis and real-time tracing in compatible ARM® processors, a number of different technologies interact; Serial Wire Viewer (SWV), Serial Wire Debug (SWD) and Serial Wire Output (SWO). These technologies are part of the ARM® Coresight™ debugger technology and will be explained below.

SERIAL WIRE DEBUG (SWD)

Serial Wire Debug (SWD) is a debug port similar to JTAG, and provides the same debug capabilities (run, stop on breakpoints, single-step) but with fewer pins. It replaces the JTAG connector with a 2-pin interface (one clock pin and one bi-directional data pin). The SWD port itself does not provide for real-time tracing.

SERIAL WIRE OUTPUT (SWO)

The Serial Wire Output (SWO) pin can be used in combination with SWD and is used by the processor to emit real-time trace data, thus extending the two SWD pins with a third pin. The combination of the two SWD pins and the SWO pin enables Serial Wire Viewer (SWV) real-time tracing in compatible ARM® processors.

Please note that the SWO is just one pin and it is easy to set a configuration that produces more data than the SWO is able to send.

SERIAL WIRE VIEWER (SWV)

Serial Wire Viewer is a real-time trace technology that uses the Serial Wire Debugger (SWD) port and the Serial Wire Output (SWO) pin. Serial Wire Viewer provides advanced system analysis and real-time tracing without the need to halt the processor to extract the debug information.

Serial Wire Viewer (SWV) provides the following types of target information:

- Event notification on data reading and writing
- Event notification on exception entry and exit
- Event counters
- Timestamp and CPU cycle information

Based on this trace data, modern debuggers can provide developers with advanced debugger capabilities.

INSTRUMENTATION TRACE MACROCELL (ITM)

The Instrumentation Trace Macrocell (ITM) enables applications to write arbitrary data to the SWO pin, which can then be interpreted and visualized in the debugger in various ways. For example, ITM can be used to redirect `printf()` output to a console view in the debugger. The standard is to use port 0 for this purpose.

The ITM port has 32 channels, and by writing different types of data to different ITM channels, the debugger can interpret or visualize the data on various channels differently.

Writing a byte to the ITM port only takes one write cycle, thus taking almost no execution time from the application logic.

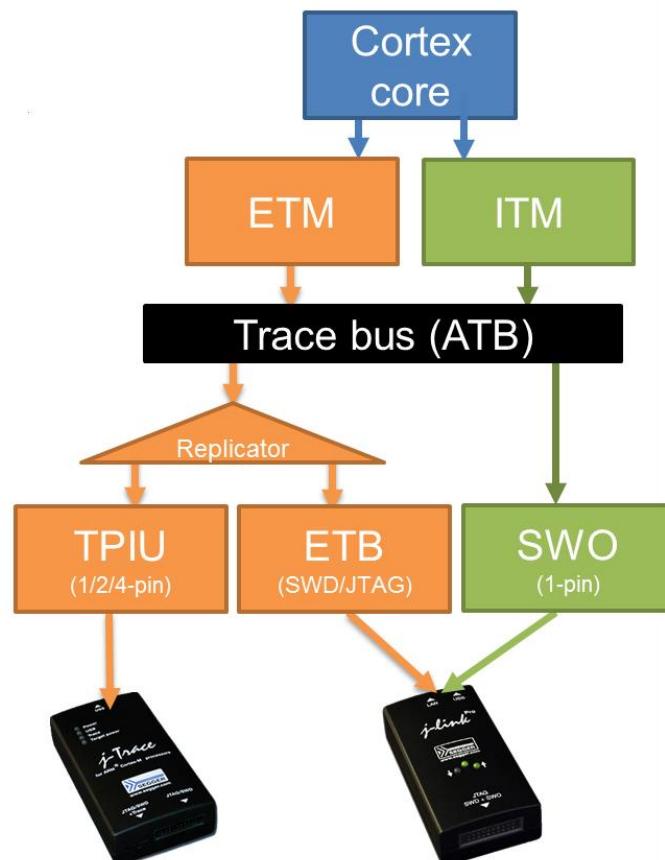


Figure 260 –Different Types of Tracing

STARTING SWV TRACING

To use the Serial Wire Viewer (SWV) in **Atollic TrueSTUDIO**, the JTAG Probe must support SWV. Older JTAG Probes, such as ST-LINK V1, don't.

The GDB server must also support SWV. The ST-LINK gdbserver must be of version 1.4.0 or later, and the SEGGER J-LINK gdbserver must be of version 4.32.A or later. Older GDB server versions that may be installed must be upgraded to the versions included in the **Atollic TrueSTUDIO** product package in order to use SWV tracing.

To use SWV the board must support SWD. Please note that devices based on ARM Cortex-M0 and Cortex-M0+ cores do not support SWV tracing.

1. Open the **Atollic TrueSTUDIO** debug configuration dialog by selecting the current project in the **Project Explorer**, and clicking the **Configure Debug** toolbar button.



Figure 261 – Open Debug Configurations Toolbar Button

The Debug configuration panel is then opened.

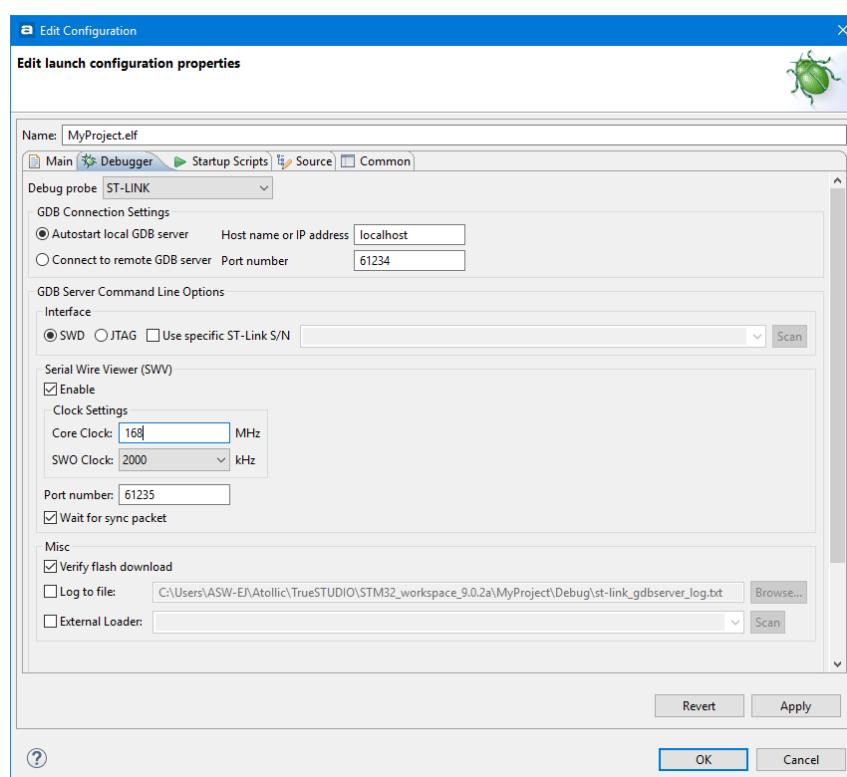


Figure 262 – Change ST-Link Debug Configuration for SWV

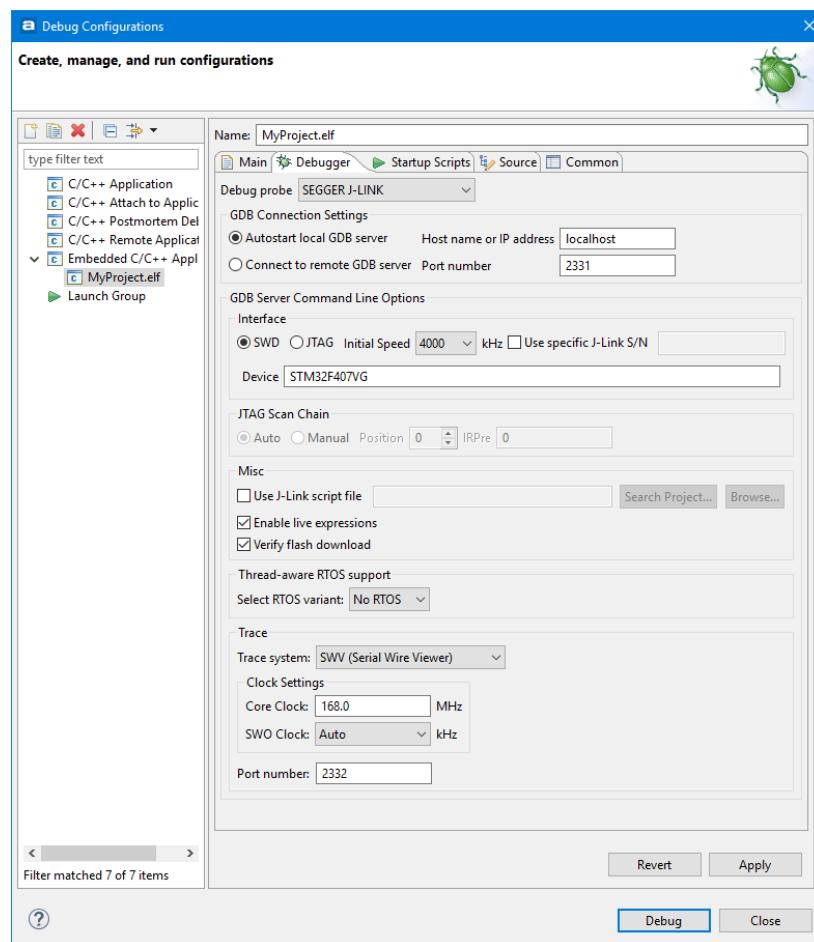


Figure 263 – Change SEGGER J-Link Debug Configuration for SWV

2. Enable SWV by selecting the **SWD** interface.
3. For the ST-Link JTAG probe:
 - Check the **SWV Enable** checkbox.
 For the SEGGER J-Link JTAG probe:
 - Select SWV (Serial Wire Viewer) as the Trace system.
4. Enter the **Core Clock** frequency. This must correspond to the value set by the application program to be executed.
5. Enter the desired **SWO Clock** frequency. The latter depends on the JTAG Probe and must be a multiple of the **Core Clock** value. For Segger J-Link-based probes, it is also possible to select **Auto**, which will automatically use the highest available frequency by taking into account the capacity of the JTAG Probe and the **Core Clock**.
6. Switch to the **Debug** perspective by starting a debug session as described earlier in this document. A debug session must be running to enable

configuration and start of the Serial Wire Viewer tracing capabilities. Please note that switching to the **Debug** perspective alone is not sufficient for SWV to work. A debug session must also be running.

7. Pause the target execution by clicking the yellow **Pause** button.
8. Open one of the SWV views. For first-time users, Atollic recommends the **SWV Trace log** view because it will give a good view of the incoming SWV packages and how well the tracing is working.

Thus, select the **View, SWV, SWV Trace log** menu command.

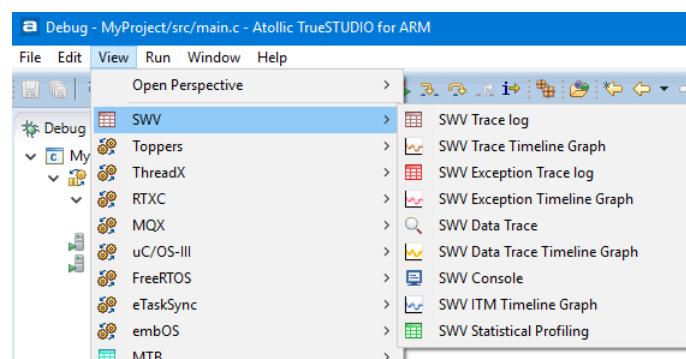


Figure 264 – SWV Data Trace Menu Command

9. Open the **Serial Wire Viewer settings** panel by clicking on the **Configure Serial Wire Viewer** button in the **SWV Trace log** view toolbar.



Figure 265 – Configure Serial Wire Viewer Button

10. Configure the data to be traced, and the trace method.

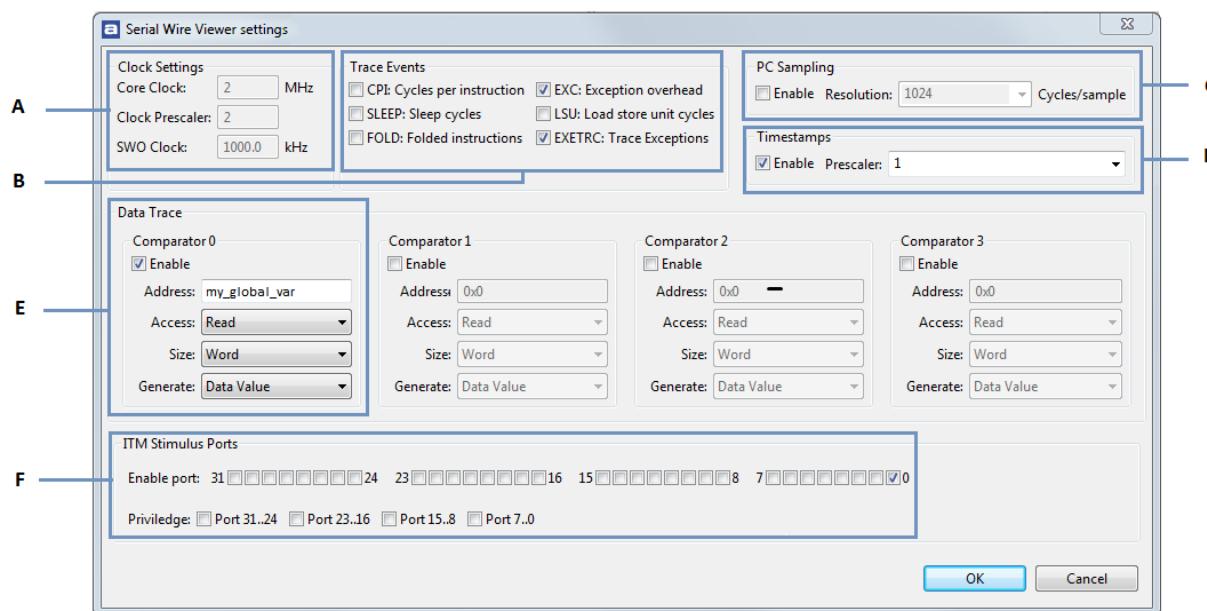


Figure 266 – The Serial Wire Viewer Settings Dialog

A. Information about the current clock settings for this session.

B. Events that can be traced:

CPI – Cycle per instruction. For each cycle beyond the first one that an instruction uses, an internal counter is increased with one. The counter (DWT CPI count) can count up to 256 and is then set to 0. Each time that happens one of these packages are sent. This is one aspect of the processors performance and used to calculate instructions per seconds. The lower the value, the better the performance.

SLEEP – Sleep cycles. The number of cycles the CPU is in sleep mode. Counted in DWT Sleep Count Register. Each time the CPU has been in sleep mode for 256 cycles, one of these packages is sent. This is used when debugging for power consumption or waiting for external devises.

FOLD – Folded instruction. A counter for how many instructions are folded (removed). Every 256 instruction folded (taken zero cycles) you will receive one of these events. Counted in DWT Fold count register.

Branch folding is a technique where, on the prediction of most branches, the branch instruction is completely removed from the instruction stream presented to the execution pipeline. Branch

folding can significantly improve the performance of branches, taking the CPI for branches below 1.

EXC – Exception overhead. The DWT Exception Count register keeps track on the number of cycles the CPU spends in exception overhead. This includes stack operations and returns but not the time spent processing the exception code. When the timer overflows one of these events is sent. Used to calculate what the exception-handling actually costs the program.

LSU – Load Store Unit Cycles. DWT LSU Count Register counts the total number of cycles the processor is processing an LSU operation beyond the first cycle. When the timer overflows one of these events is sent.

With this measurement how much time is spent with memory-operations can be tracked.

EXETRC – Trace exceptions. Whenever an exception occurs one of these events is sent. These events can be monitored in the **SWV Exception Trace view** and the **SWV Exception Timeline view**. From these views you can also jump to the exception handler code for that exception.

- C. **PC Sampling**. Enabling this starts sampling the Program Counter with some cycle interval. Since the SWO-pin has a limited bandwidth it is not a good idea to sample too fast. Experiment with this to be able to sample often, but not too often. The results from the sample are used, among other things, for the **Statistical Profiling view**.
- D. **Timestamps** – Must be enabled to know when an event occurred. The Prescaler should only be changed as a last effort to reduce overflow packages.
- E. **Data Trace** - Up to four different symbols or areas of the memory can be traced, as for an example the value for a global variable. To do that, enable one comparator and enter the name of the variable or the memory-address to trace. The value of the traced variables can be displayed both in the **Data trace view** and the **Data Trace Timeline graph**.
- F. **ITM stimulus ports** – Enable one or more of the 32 ITM ports. The most common way to use this is to send information

programmatically and almost none intrusive. As for an instance the CMSIS function `ITM_SendChar` is used to send characters to port 0, see below.

The packages from the ITM ports is display in the SWV console view and the ITM Timeline Graph.



Atollic recommends limiting the amount of data traced. Most ARM® -based microcontrollers reads and writes data faster than the maximum SWO-pin throughput. Too much trace data result in data overflow, lost packages and possibly corrupt data. For optimum performance, trace only data vital to the task at hand.

Overflow while running SWV is an indication that SWV is configured to trace more data than the SWO-pin is able to process. In such a case, decrease the amount of data traced.

To use any of the timeline views in **Atollic TrueSTUDIO**, enable **Timestamps**. The default **Prescaler** value is 1. Keep this value, unless problems occur related to SWV package overflow.

It is possible to trace up to four different C variable symbols, or fixed numeric areas of the memory.

Below are three examples for the SWV-trace configuration:

Example 1: To trace the value of a global variable, enable a **Comparator** and enter the name of the variable or the memory address to be traced.

The value of the traced variables is displayed both in the **Data Trace** view and the **Data Trace Timeline** graph.

Example 2: To profile the program execution, enable the **PC-sampling**. In the beginning a high value for the Cycles/sample is recommended.

The result from the PC-sampling is then displayed in the **SWV Statistical Profiling** view.

Example 3: To trace the exceptions occurring during program execution, enable the **Trace Event EXETRC: Trace Exceptions**.

Information about the exceptions is then displayed in the **SWV Exception Trace Log** view and the **SWV Exception Timeline Graph**.

11. Save the SWV configuration in **Atollic TrueSTUDIO** by clicking the **OK** button. The configuration is saved together with other debug configurations and will remain effective until changed.

12. Press the **Start/Stop Trace** button to send the SWV configuration to the target board and start SWV trace recoding. The board will not send any

SWV packages until it is properly configured. The SWV Configuration must be resent, if the configuration registers on the target board are reset. Actual tracing will not start until the target starts to execute.



Figure 267 – The Start/Stop Trace Button

Please note the tracing cannot be configured while it is running. Pause debugging before attempting to send a new configuration to the board. Each new, or changed, configuration must be sent to the board to take effect.

The configuration is sent to the board when the **Start/Stop Trace**-button is pressed.

- 13.** Start the target execution again by pressing the green **Resume Debug** button.



Figure 268 – Resume Debug Button

- 14.** Packages should now be arriving in the **SWV Trace Log** view (and possibly other views too, dependent on trace configuration).

Collected data can be cleared by pressing the **Empty SWV-Data** button. All the timers are also restarted when this button is pressed.



Figure 269 – Empty SWV Data Button

THE SWV VIEWS

The views that displays SWV trace data are:

-  **SWV Trace Log** - Lists all incoming SWV packages in a spreadsheet. Useful as a first diagnostic for the trace quality. The data in this view can be copied to other applications in CSV-format by selecting the rows to copy and type **Ctrl+C**. The copied data can be pasted into another application with the **Ctrl+V** command.
-  **SWV Trace Timeline Graph** – A graph displaying all SWV-packages received as a function of time.
-  **SWV Exception Trace Log** – The view has two tabs. The first is similar to the SWV Trace Log, but is restricted to Exception events and also has additional information about the type of event. The data can be copied and pasted into other applications. Each row is linked to the code for the corresponding exception handler. Double click on the event and the corresponding interrupt handler source code is opened in the editor view.

The second tab displays statistical information about the Exception events. This information may be of great value when optimizing the code. Hypertext links to exception handler source code in the editor is included.
-  **SWV Exception Timeline Graph** – A graph displaying the distribution of exceptions over time. Remember that each exception sends up to three SWV-packages. Double click on the event in the tool tip and the code for the exception handler is opened up in the editor view.
-  **SWV Console** - Prints readable text output from the target application. Typically this is done via printf() with output redirected to ITM channel 0. Other ITM channels can get their own console view too.
-  **SWV ITM Timeline Graph** – A graph displaying the distribution of ITM-packages over time. This can be used for code block execution time visualization.
-  **SWV Data Trace** – Tracks up to four different symbols or areas in the memory. For example, global variables can be referenced by name.



- **SWV Data Trace Timeline Graph** – A graphical display that shows the distribution of variable values over time. Applies to the variables or memory areas in the SWV Data Trace.
- **SWV Statistical Profiling** – Statistics based on Program Counter (PC) sampling. Shows the amount of execution time spent within various functions. This is useful when optimizing code. The data can be copied and pasted into other applications. The view is updated when debugging is suspended.

More than one SWV view may be open at the same time, for simultaneous tracking of various events.

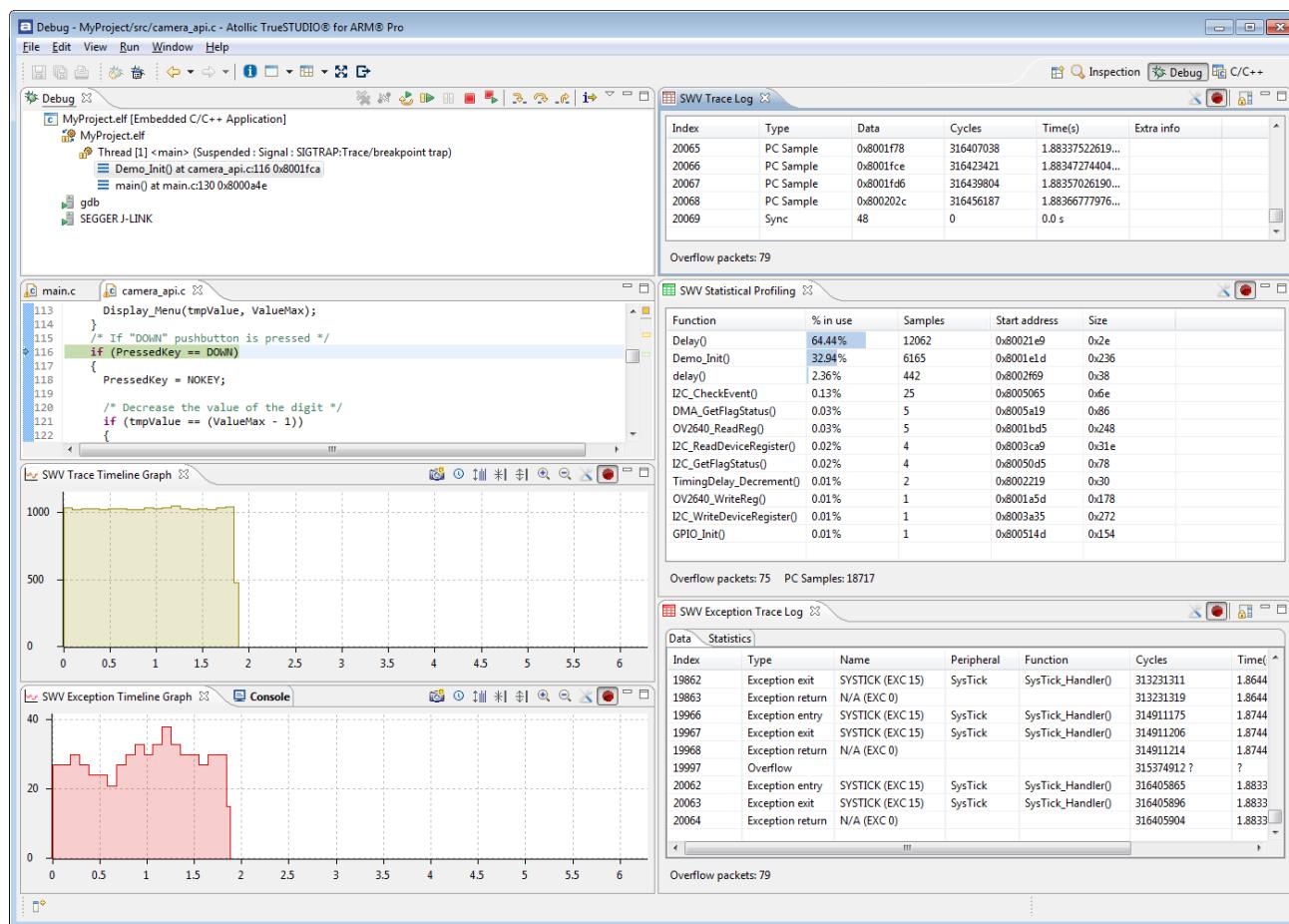


Figure 270 – Several SWV Views Displayed Simultaneously

THE TIMELINE GRAPHS

All the timeline graphs, except the **Data Trace Timeline**, have some common features:

- Any graph can be saved as an image file by clicking the camera icon.
- The graphs show the time in seconds by default.
- The zoom range is limited while debugging is running. More details are available when debugging is paused.
- Zoom in: Double-click on the left mouse button. Zoom out: Double-click on the right button or use the corresponding toolbar buttons in the view.
- The tooltip shows the number of packages in each bar. Except for the **Trace Timeline Graph**, the content of bars with less than 50 packages is showed in a detailed view.

The **Data Trace Timeline** displays distinct values for variables during execution and has different features than the above graphs.

STATISTICAL PROFILING

This is a way to obtain information about the amount of execution time spent within various functions. It is not based on code analysis but on statistical information regarding the part of the code executed. This is a technical limitation of the SWV protocol.

1. Configure SWV to send Program Counter samples, as described below. Enable the PC Sampling (A) and Timestamps.

With the given Core clock cycle intervals, SWV will report the Program Counter values to **Atollic TrueSTUDIO**. Atollic recommends beginning with the PC-sampling set to a high Cycle/sample value. This will ensure that the interface will not overflow.

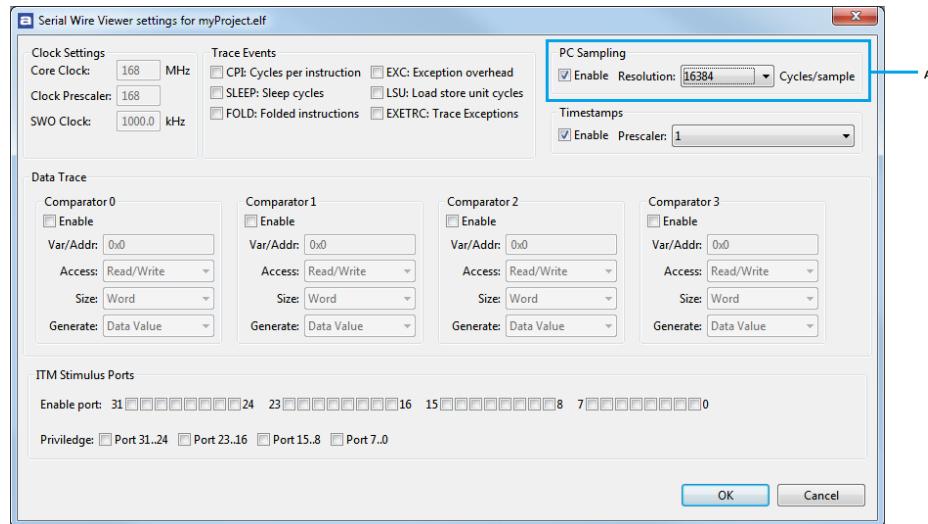


Figure 271 –Statistical Profiling Configuration

2. Open the Statistical Profiling view by selecting **View, SWV Statistical Profiling**. It will be empty, since no data has been collected.
3. Push the red **Start/Stop Trace** button to send the configuration to the board.
4. When you start executing code in the target system, **Atollic TrueSTUDIO** starts collecting statistics about function usage via SWV.
5. Suspend (Pause) the debugging. The collected data is displayed in the view. The longer the debugging session, the more statistics will be collected.

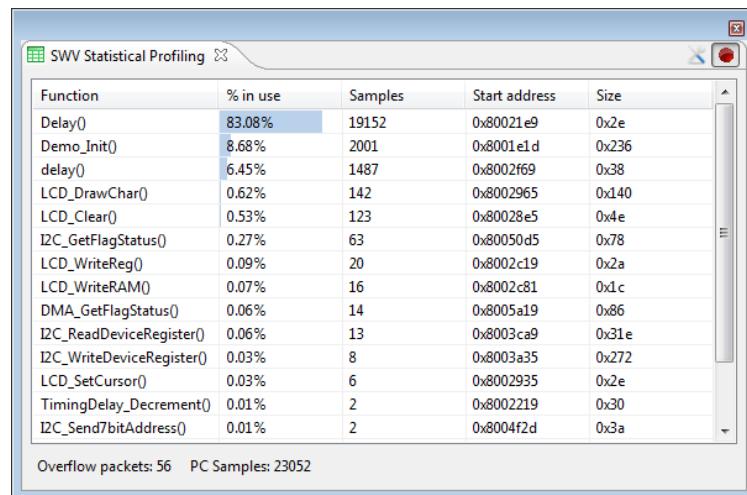


Figure 272 – Statistical Profiling View

EXCEPTION TRACING

To make it possible to trace the exceptions encountered during execution, the exception packages needs to be enabled. Open **SWV Configuration** as described above.

Enable **EXETRC: Trace Exception**. This will generate Trace Exception packages. Disable all other packages not needed at the moment.

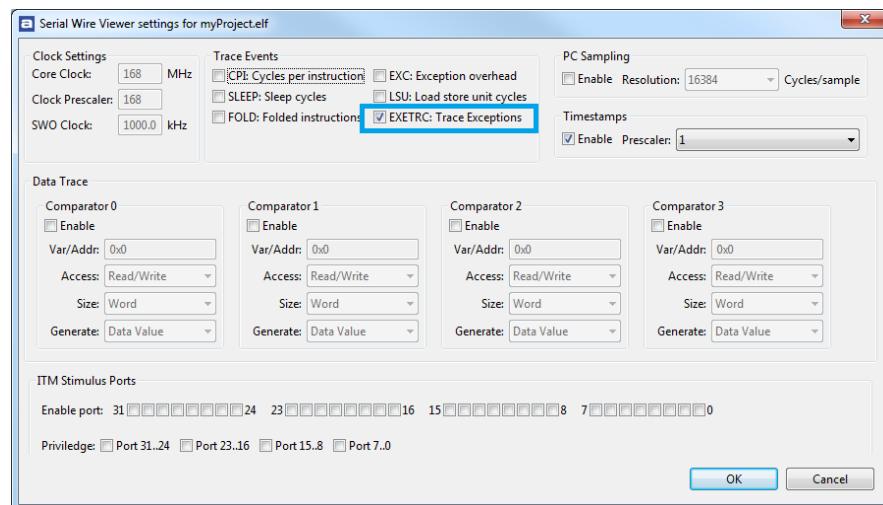


Figure 273 – Exception Tracing Configuration

EXCEPTION DATA

The exception packages are displayed in the **SWV Exception Trace Log** view. The view has two tabs, the Data tab and the Statistics tab.

By double-clicking on an entry in the tab, the function will be opened in the Editor if it is available in the source code.

SWV Exception Trace Log							
	Type	Name	Peripheral	Function	Cycles	Time(s)	Extra info
Index							
2849	Exception exit	SYSTICK (EXC 15)	SysTick	SysTick_Handler()	68876568	956.619 ms	
2850	Exception return	N/A (EXC 0)			68879113	956.654347222222 ms	Timestamp delayed. Packet delayed.
2851	Exception entry	SYSTICK (EXC 15)	SysTick	SysTick_Handler()	68948284	957.6150555555556 ms	
2852	Exception exit	SYSTICK (EXC 15)	SysTick	SysTick_Handler()	68948565	957.618958333334 ms	
2853	Exception return	N/A (EXC 0)			68951110	957.654305555555 ms	Timestamp delayed. Packet delayed.
2854	Exception entry	SYSTICK (EXC 15)	SysTick	SysTick_Handler()	69020281	958.615013888889 ms	
2855	Exception exit	SYSTICK (EXC 15)	SysTick	SysTick_Handler()	69020562	958.6189166666667 ms	
2856	Exception return	N/A (EXC 0)			69023107	958.654263888889 ms	Timestamp delayed. Packet delayed.
2857	Exception entry	SYSTICK (EXC 15)	SysTick	SysTick_Handler()	69092278	959.614972222223 ms	
2858	Exception exit	SYSTICK (EXC 15)	SysTick	SysTick_Handler()	69092559	959.618875 ms	
2859	Exception return	N/A (EXC 0)			69095104	959.654222222222 ms	Timestamp delayed. Packet delayed.

Figure 274 – Exception View, Data Tab

The columns in the **Data** tab are:

Name	Description
Index	The Id for the exception package. Are shared with the other SWV packages.
Type	Normally each exception will generate three packages each; Exception entry, Exception exit and then an Exception return package. TrueSTUDIO displays all three.
Name	The name of the exception provided by the manufacturer. Also the exception or interrupt number.
Peripheral	The peripheral for the exception.
Function	The name of the interrupt handler function for this interrupt. Updated when debug is paused. Is cached during the whole debug session. By double clicking the function, the editor will open that function in the source code.
Cycles	The timestamp for the exception in cycles.
Time(s)	The timestamp for the exception in seconds
Extra info	Optional extra information about that package.

Table 7 – Exception Data Columns

EXCEPTION STATISTICS

The exception statistics is collected whenever Exception packages are received by SWV. It can be found in the **SWV Exception Trace Log** view, in the **Statistics** tab.

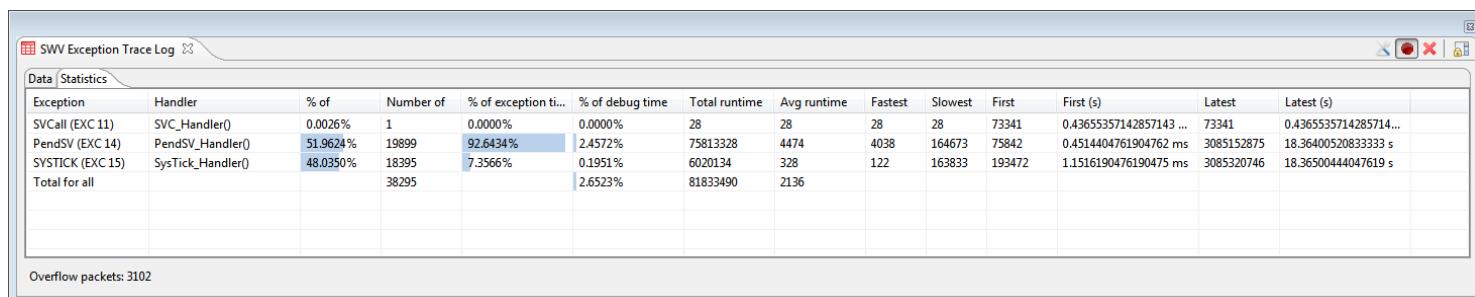


Figure 275 – Exception View, Statistics Tab

The statistics can be access by selecting the Statistics tab in the view.

By double-clicking on an entry in the tab, the function will be opened in the Editor if it is available in the source code.

The available columns are described in the table below:

Name	Description
Exception	The name of the exception provided by the manufacturer. Also the exception or interrupt number.
Handler	The name of the interrupt handler for this interrupt. Updated when debug is paused. Is cached during the whole debug session. By double clicking the handler, the editor will open that function in the source code.
% of	This exception type's share, in percentage, of all exceptions.
Number of	The total number of entry packets received by SWV of this exception type.
% of exception time	How big part of the execution time for all exceptions that this exception type have.
% of debug time	How big part of the total execution time for this debug session that this exception type have. All the timers are restarted when the Empty SWV-Data button is pressed.
Total runtime	The total execution time in cycles for this exception type.
Avg runtime	The average execution time in cycles for this exception type.
Fastest	The execution time in cycles for the fastest exception of this exception type.
Slowest	The execution time in cycles for the slowest exception of this exception type.
First	The first encounter of an entry event for this exception type in cycles.
First(s)	The first encounter of an entry event for this exception type in seconds.
Latest	The latest encounter of an entry event for this exception

Name	Description
	type in cycles.
Latest(s)	The latest encounter of an entry event for this exception type in seconds.

Table 8 – Exception Statistics Columns

PRINTF() REDIRECTION OVER ITM

Since SWV enables target software to send data back to the debugger using any of the 32 ITM channels, this feature can be used to redirect printf() output back to the ITM console view in the debugger (ITM channel 0 is typically used for printf-redirection).

1. To make printf() send ITM-packages, the file `syscalls.c` must be configured. If no `syscalls.c` file was generated when the project where generated, the following steps can be performed to generate it:

- In the **Project explorer**, right click on the project and select **New, Other...**
- Expand **System calls**.
- Select "**Minimal System Calls Implementation**" and click next.
- Click **Browse...** and select the `src` folder as new file container and click **OK**.
- Click on **Finish** and verify that `syscalls.c` is added to the project.

2. Inside the `syscalls.c` file, replace the `_write()`function with the following code:

```
int _write(int file, char *ptr, int len)
{
    /* Implement your write code here, this is used
    by puts and printf for example */
    int i=0;
    for(i=0 ; i<len ; i++)
        ITM_SendChar((*ptr++));
    return len;
}
```

3. Next step is to locate the `core_cmX.h` file which contains the function `ITM_SendChar()`. The `core_cmX.h` file is included by the Device Peripheral Access Layer Header File (i.e. `stm32f4xx.h`). That file in turn needs to be included in the `syscalls.c` file.

If uncertain about where to find the Device Peripheral Access Layer Header File, use the Include Browser. Drop the core file in the **Include Browser** view, and check that which files are including the `core_cmX.h` file.

CHANGE THE TRACE BUFFER SIZE

The incoming SWV-packages are saved in the Serial Wire Viewer Trace buffer. It has a default maximum size of 2 000 000 packages. To trace more packages, this figure must be increased.

Select the menu command **Widows, Preferences**. In the dialog select **Run/Debug, Embedded C/C++ Application** and then **Serial Wire Viewer**.

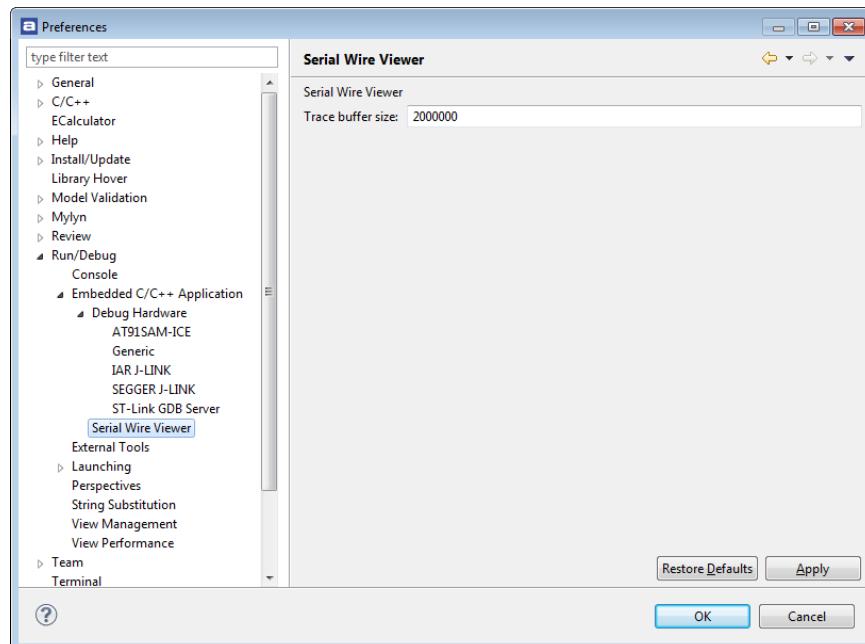


Figure 276 – Serial Wire Viewer Preferences

The buffer is stored in the heap. The allocated heap is displayed by first selecting **Window, Preferences** and **General**; then enabling “**Show heap status**”. The current heap and allocated memory will be displayed in the lower, right corner.

There is an upper limit to the amount of memory **Atollic TrueSTUDIO** can allocate. This limit can be increased to store more information during a debug-session.

Proceed as follows:

- Navigate to the **Atollic TrueSTUDIO** installation directory. Open the folder in which the IDE is stored.
- Edit the `TrueSTUDIO.ini` file and change the `-Xmx1024m` parameter to the desired size in megabytes.
- Save the file and try launching **Atollic TrueSTUDIO** again.

COMMON SWV PROBLEMS

Common reasons for SWV not tracing are:

- The **Core Clock** of the target is incorrectly set. It is very important to select the right **Core Clock**. If the frequency of the target **Core Clock is** unknown, it can sometimes be found by setting a breakpoint in a program loop and open the **Expressions View**, when the breakpoint is hit.

Click on **Add new expression**, type `SystemCoreClock` and press **Enter**. This is a global variable that according to the CMSIS-standard must be set to the correct speed of the Core Clock.

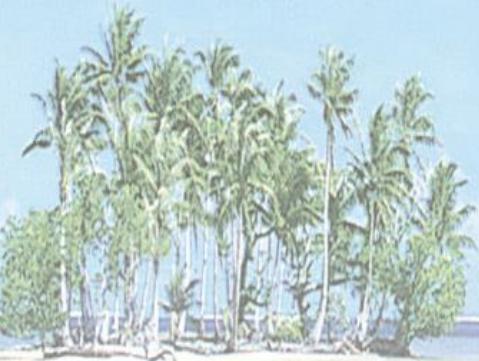
In CMSIS standard libraries there should be a function called `SystemCoreClockUpdate()`. This can be included in `main()` to set the `SystemCoreClock`-variable. Then use the Variable view to track it.

For most devices that do not have libraries that follow the CMSIS-standard, the **Core Clock** can be found in the startup code. It is often named `SYSCLK`, or a similar abbreviation. Also note that if software dynamically change the CPU clock speed during runtime, then SWV might stop as the clocking suddenly becomes wrong during execution.

- SWV is not enabled in the currently used debug configuration.
- The SWV configuration has not been sent to the target board.
- Some manufacturers, such as Energy Micro, disable SWO pin by default. In this case, enable SWO with a function-call, such as `DBG_SWOEnable()`.
- The SWO receives too much data. Reduce the amount of data enabled for tracing.
- The JTAG Probe, the GDB server, the target board, or possibly some other part, does not support SWV.

To make sure that any data is received, do the following steps:

- Open the SWV configuration. Disable all tracing except PS Sampling and Timestamps. Set the Resolution to the highest possible value.
- Save and open the SWV Trace Log.
- Start tracing.
- Make sure that incoming packages can be seen in the SWV Trace Log.



Section 6. **MTB TRACING** **(CORTEX-M0+)**

This section provides information on how to use the CoreSight Micro Trace Buffer (MTB) which is a simple execution trace block available on some Cortex-M0+ devices.

The following topics are covered:

- Introduction to MTB
- Configure MTB
- Using MTB
- Analyzing and Copy MTB Information

INTRODUCTION TO MTB

The CoreSight Micro Trace Buffer (MTB) is an optional hardware included on some Cortex-M0+ processor based devices. MTB contains a simple execution trace block which can log trace information in a memory buffer in the processor RAM. The buffer location and size are configurable. Currently STM32 microcontrollers does not include MTB support.

The **MTB Trace Log** view in **Atollic TrueSTUDIO** is used to configure MTB and view instruction trace data from the device. As the trace data is stored in the processor RAM the **MTB Trace Log** view does not need any special debug probe. A normal debug connection works fine and it works both in Serial Wire Debug mode and in JTAG Debug mode.

To use MTB when debugging a Cortex-M0+ device it needs to be configured. When configuration is made and MTB enabled the MTB module in the processor will capture branches made by the processor into the RAM buffer.

The MTB execution trace packet consists of a pair of 32-bit words generated by the MTB when it detects a branch instruction or an exception entry. The trace packet consist of a source address (current PC location) and a destination address (next PC address). The MTB module stores all such branches into the processor RAM.

Open the **MTB Trace Log** view, for instance by writing **MTB** in the Quick Access field in the toolbar and select views **MTB Trace Log**. The **MTB Trace Log** view reads the trace packets from the processor when the program is stopped and then visualize the executed instructions using program information from the .elf file.

Index	Address	Function	Instruction	Additional	Raw packet
2223	0x726	test()	movs r0, r3		0x6fc - 0x72c
2224	0x728	test()	mov sp, r7		0x6fc - 0x72c
2225	0x72a	test()	add sp, #8		0x6fc - 0x72c
2226	0x72c	test()	pop {r7, pc}		0x6fc - 0x72c
2227	0x752	main()	movs r3, r0		0x752 - 0x760
2228	0x754	main()	str r3, [r7, #4]		0x752 - 0x760
2229	0x756	main()	ldr r3, [r7, #4]		0x752 - 0x760
2230	0x758	main()	cmp r3, #100	; 0x64	0x752 - 0x760
2231	0x75a	main()	bls.n 744 <main+0x14>	X	0x752 - 0x760
2232	0x75c	main()	movs r3, #0		0x752 - 0x760
2233	0x75e	main()	str r3, [r7, #4]		0x752 - 0x760
2234	0x760	main()	b.n 744 <main+0x14>	↑	0x752 - 0x760
2235	0x744	main()	ldr r3, [r7, #4]		0x744 - 0x74e
2236	0x746	main()	adds r3, #1		0x744 - 0x74e
2237	0x748	main()	str r3, [r7, #4]		0x744 - 0x74e
2238	0x74a	main()	ldr r3, [r7, #4]		0x744 - 0x74e
2239	0x74c	main()	movs r0, r3		0x744 - 0x74e
2240	0x74e	main()	bl 6fc <test>	→	0x744 - 0x74e
2241	0x6fc	test()	push {r7, lr}		0x6fc
2242	0x704	test()	ldr r2, [r7, #4]		0x705
2243	0x6cc	SysTick_Handler()	push {r7, lr}		0x6cc
2244					End of Trace ...

Figure 277 –MTB Trace Log View

CONFIGURE MTB

The MTB must be configured before it can be used. Buffer locations and buffer size needs to be set and it is also possible to configure specific behavior on MTB when buffer is full. Configuration of MTB is done after a debug session is started.

Open the **Configure MTB Trace** dialog box by clicking on the **Configure MTB Trace Setting** button in the **MTB Trace Log** view toolbar.



Figure 278 – Configure MTB Trace Setting Button

In the **Configure MTB Trace** dialog configure the Buffer location and Buffer size and the trace operation to be used when/if trace buffer is full. The addresses where to store the configured data is read from the device CMSIS-SVD file. The CMSIS-SVD file needs to have a MTB node including information about the POSITION, FLOW, MASTER, and BASE registers. The reason to read the CMSIS-SVD file to get this information is because the location of MTB registers on the Cortex-M0+ device is defined by the chip manufacturer when designing the chip. The **MTB Trace Log** view updates these registers to control the behavior of the trace features.

If a Cortex-M0+ device is used which includes MTB but does not have these registers specified in the CMSIS-SVD files the registers can be added into a custom CMSIS-SVD file. Make sure to add an MTB node in this custom file containing information about the POSITION, FLOW, MASTER, and BASE registers.

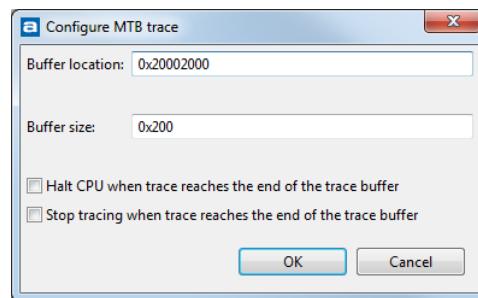


Figure 279 – Configure MTB Trace View

Please note, the buffer must be located to a memory area which is not used by the debugged application. There are also some restriction on the buffer location and the buffer size. For instance the size needs to be a power of 2. (e.g. 32, 64, 128, ...) The configuration dialog will signal if any errors in the settings is made. See example below where wrong configuration is entered.

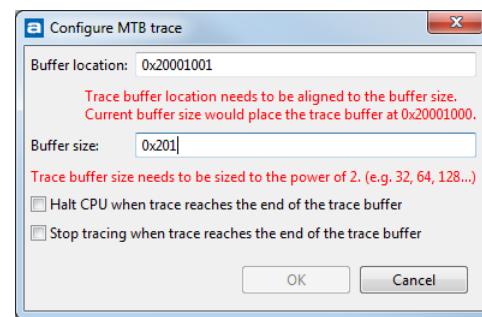


Figure 280 – Configure MTB with Error Setting

The MTB configuration is saved in the debug information for the project and reloaded when a new debug session is started for the project.

USING MTB

Press the **Start/Stop Tracing** button to start/stop MTB trace. Actual tracing will not start until the target starts to execute.



Figure 281 – The Start/Stop MTB Button



Note! If the **Start/Stop MTB** button is disabled, color grey, then the **MTB Trace Log** view has not been able to detect that MTB is available for the device when reading the CMSIS-SVD file. Please verify that the Cortex-M0+ contains MTB.

Please also investigate the CMSIS-SVD file which can be seen in the **SFRs** view. If the MTB node is missing or if the necessary registers in the MTB view are missing then create a custom CMSIS-SVD file containing these registers. If the MTB node with registers are available in the file then please try to restart the debug session again.

When trace is started the trace buffer in the processor will be automatically read by the **MTB Trace Log** view each time the program is stopped, after a step, breakpoint executed or processor stopped by some reason. Each time the buffer has been read by the the **MTB Trace Log** view it will configure the CoreSight MTB unit to store next trace instruction data at the start of the target trace buffer.

Start the target execution by pressing the green **Resume Debug** button or by issuing step commands.

The **MTB Trace Log** view will be updated when new trace data is found in the target trace buffer.

Collected data can be cleared by pressing the **Clear the Buffer** button.



Figure 282 – Clear Buffer Button

The **Scroll Trace on Update** button is used to toggle if the view shall scroll when updated with new data.



Figure 283 – Scroll Trace View on Update Button

ANALYZING MTB INFORMATION

The **MTB Trace Log** view contains the following columns:

Name	Description
Index	An incremental number for each line in the view.
Address	The address of the executed instruction.
Function	The Function name which holds the address of the instruction. The function name is calculated by the MTB Trace Log view using information from the elf-file.
Instruction	Executed instruction.
“”	Branch information. “Arrows” displays if a branch is made by this instruction, “X” indicates that a conditional branch instruction is executed without doing a branch.
Additional	Contains information about the instruction, e.g. data is displayed in hex format. The last line when the view is populated says “End of Trace...”. This makes it easier to find what happened since last execution.
Raw packet	Packet information. E.g. If the Raw packet displays 0x752-0x760 and then 0x744-0x74e. First time 0x752-0x760 is displayed the MTB instruction log signals that an instruction on 0x752 is executed. The MTB then signals at 0x760 that a branch is made to 0x744. The MTB Trace Log view calculates the lines in between.

Table 9 – MTB Trace Log View Columns

Index	Address	Function	Instruction	Additional	Raw packet
737	0x72c	test()	pop {r7, pc}	←	0x72d
738	0x6cc	SysTick_Handler()	push {r7, lr}		0x6cc
739				End of Trace marker	
740	0x6e8	SysTick_Handler()	bl 6fc <test>	→	0x6e8
741	0x6fc	test()	push {r7, lr}		0x6fc
742				End of Trace marker	
743	0x72c	test()	pop {r7, pc}	←	0x72c
744	0x6ec	SysTick_Handler()	ldr r3, [pc, #8]	; (6f8 <SysTick_Handler+0...	0x6ec
745				End of Trace marker	
746				Trace buffer wrapped	
747	0x72c	test()	pop {r7, pc}	←	0x72c
748	0x752	main()	movs r3, r0		0x752 - 0x75a
749	0x754	main()	str r3, [r7, #4]		0x752 - 0x75a
750	0x756	main()	ldr r3, [r7, #4]		0x752 - 0x75a
751	0x758	main()	cmp r3, #100	; 0x64	0x752 - 0x75a
752	0x75a	main()	bls.n 744 <mai...	↑	0x752 - 0x75a
753	0x744	main()	ldr r3, [r7, #4]		0x744 - 0x74e
754	0x746	main()	adds r3, #1		0x744 - 0x74e
755	0x748	main()	str r3, [r7, #4]		0x744 - 0x74e
756	0x74a	main()	ldr r3, [r7, #4]		0x744 - 0x74e
757	0x74c	main()	movs r0, r3		0x744 - 0x74e
758	0x74e	main()	bl 6fc <test>	→	0x744 - 0x74e

Figure 284 –MTB Trace Log Information

The Additional column can also indicate “Trace buffer wrapped” which means that the instruction trace buffer has been wrapped over. When this happens some trace data has been lost since last run.

Index	Address	Function	Instruction	Additional	Raw packet
737	0x72c	test()	pop {r7, pc}	←	0x72d
738	0x6cc	SysTick_Handler()	push {r7, lr}		0x6cc
739				End of Trace marker	
740	0x6e8	SysTick_Handler()	bl 6fc <test>	→	0x6e8
741	0x6fc	test()	push {r7, lr}		0x6fc
742				End of Trace marker	
743	0x72c	test()	pop {r7, pc}	←	0x72c
744	0x6ec	SysTick_Handler()	ldr r3, [pc, #8]	; (6f8 <SysTick_Handler+0...	0x6ec
745				End of Trace marker	
746				Trace buffer wrapped	
747	0x72c	test()	pop {r7, pc}	←	0x72c
748	0x752	main()	movs r3, r0		0x752 - 0x75a
749	0x754	main()	str r3, [r7, #4]		0x752 - 0x75a
750	0x756	main()	ldr r3, [r7, #4]		0x752 - 0x75a
751	0x758	main()	cmp r3, #100	; 0x64	0x752 - 0x75a
752	0x75a	main()	bls.n 744 <mai...	↑	0x752 - 0x75a
753	0x744	main()	ldr r3, [r7, #4]		0x744 - 0x74e
754	0x746	main()	adds r3, #1		0x744 - 0x74e
755	0x748	main()	str r3, [r7, #4]		0x744 - 0x74e
756	0x74a	main()	ldr r3, [r7, #4]		0x744 - 0x74e
757	0x74c	main()	movs r0, r3		0x744 - 0x74e
758	0x74e	main()	bl 6fc <test>	→	0x744 - 0x74e

Figure 285 –MTB Trace Buffer Wrapped

COPY THE MTB LOG

For further analyses of the MTB Log the lines in the view can be copied. This is done using normal windows selection and copy. The log information is copied in csv-format.

Select the lines to be copied (using **Shift**) and scroll down or mark all lines in the view (using **Ctrl+A**). The marked lines are then copied in a comma separated list and placed in a clipboard using **Ctrl+C**. The clipboard can be pasted into another file using an editor.



Section 7. INSTRUCTION TRACING

This section provides information on how to do Instruction Tracing with **Atollic TrueSTUDIO for STM32**.

The following topics are covered:

- Enable Trace
- Configuring Start and Stop Triggers
- Start Trace Recording
- Analyzing the Trace
- Exporting the Trace

INSTRUCTION TRACING

Atollic TrueSTUDIO supports instruction tracing, provided that trace-enabled hardware is being used. Instruction tracing records the execution flow of the processor in real-time. The recorded trace buffer can then be analyzed to locate the cause of software errors. Instruction tracing is particularly useful when debugging problems that only occur sporadically.

Atollic TrueSTUDIO supports instructing tracing using both the ETM and the ETB methods:

- ETM tracing works with many Cortex-M devices but requires using an ETM-trace enabled JTAG probe. **Atollic TrueSTUDIO** supports ETM tracing using the Segger J-Trace JTAG probe. The J-Link and ST-LINK probes cannot be used for ETM tracing as they have no trace buffer. The trace buffer in ETM-compatible trace probes are typically many megabytes in size.
- ETB tracing can only be used with Cortex devices that have this feature enabled in the silicon. ETB tracing can be done using any of the supported JTAG probes, including Segger J-Link, as the trace buffer is not located in the JTAG probe but instead inside the target device. This adds to the chip cost and therefore is not supported by all chip vendors. The on-chip ETB trace buffer is tiny; typically 2KB or 4KB only.

Both ETM and ETB tracing records all executed machine code instructions, until the hardware limits are reached. A trace buffer is filled very quickly even though it is highly compressed. The compressed trace buffer in a JTAG probe with a 16MB of trace buffer typically expands into 200MB of uncompressed machine readable data, and to 2-3GB of human readable data. Instruction tracing thus quickly generates a huge amount of data.



ETM/ETB Trace may not work on max CPU clock speed. Please check the User manual from the board/microcontroller manufacturer if there are any trace clock limitations.

There is also a limitation of the clock speed for **Segger J-Trace for Cortex-M** debug probe. This version of debug probe is specified up to 100 MHz trace clock. This means that, as the trace clock usually is $\frac{1}{2}$ of the speed of the CPU clock, the max CPU clock speed is 200 MHz when using **Segger J-Trace for Cortex-M**. For higher CPU frequencies, the **Segger J-Trace PRO Cortex-M** should be used.

CORTEX-M7 AND ETMv4

Instruction tracing support for Cortex-M7 based cores, using the ARM Embedded Trace Macrocell ETMv4, are supported by **Atollic TrueSTUDIO** from v7.0. Earlier versions of **Atollic TrueSTUDIO** only supported ETMv3.

The ETMv4 uses a much more complex and packed protocol than the ETMv3 and currently **Atollic TrueSTUDIO** only supports basic instruction tracing for ETMv4 based devices. Support for speculated execution and data tracing is not implemented yet and only RAW and Assembly filtering levels in the Trace Log view can be used for Cortex-M7.



As mentioned earlier, the **Segger J-Trace for Cortex-M** debug probe is specified up to 100 MHz trace clock which normally means that the speed of the CPU clock can be up to 200 MHz. For higher CPU frequencies, the **Segger J-Trace PRO Cortex-M** should be used.

ENABLE TRACE

Instruction tracing (using ETM or ETB) must be enabled in the debug configuration. To enable instruction tracing, first open the debug configuration dialog box:

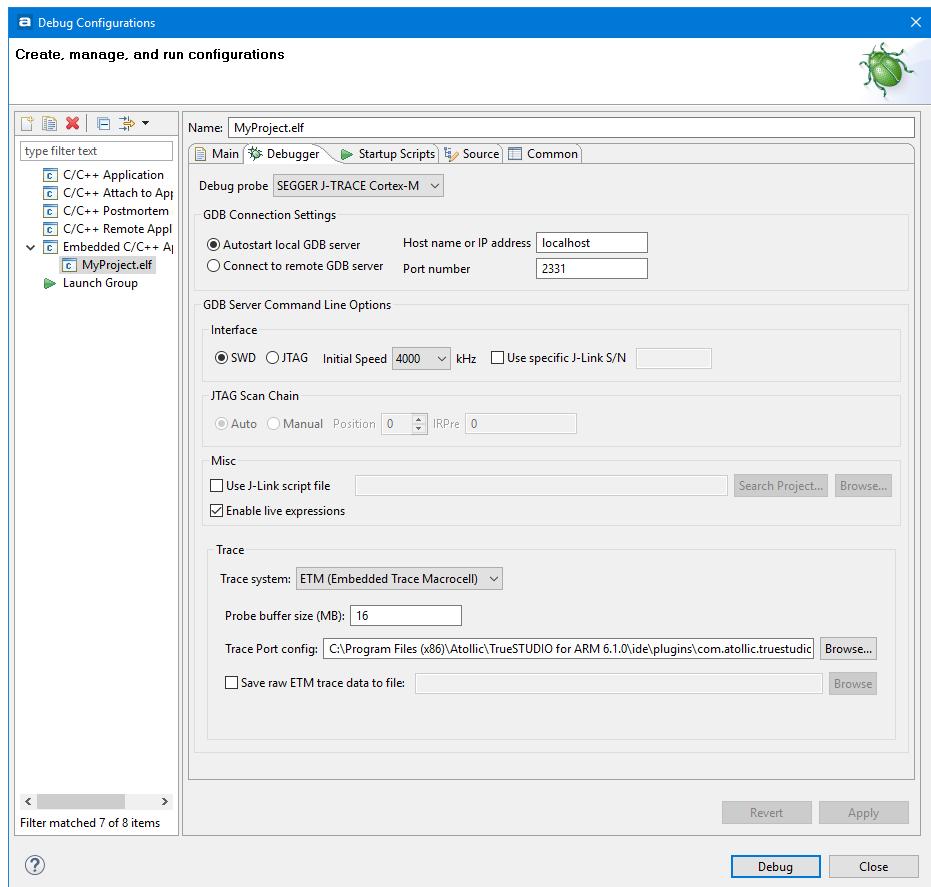


Figure 286 – Enable Tracing in the Debug Configuration

Perform the following steps to configure a project for instruction tracing:

1. In the **Debug probe** dropdown list, select Segger J-Trace (for ETM and ETB tracing) or Segger J-Link (ETB tracing only).
2. In the **Trace systems** dropdown list, select the ETM or ETB trace system.
3. Ensure the **Probe buffer size** setting corresponds to the JTAG probe in use (ETM tracing only).
4. For ETM tracing, make sure the **Trace Port config** selection points to a file that setup the ETM trace pins of the device in a way that works for the target board in use. The commands in the file are sent to the target when trace recording is started first time in a debug session. See the section below for information on how to write a new trace port configuration file for custom designed or unsupported boards.
For ETM tracing it is also possible to **Save raw ETM trace data to file**. Such file contains the raw trace data received from the Cortex-M device and the file can be used for deeper investigation of trace data.
5. Click **OK** to save the settings.

The project is now configured to use ETM or ETB tracing.

WRITING A TRACE PORT CONFIGURATION FILE

To be able to use ETM tracing the trace port pins must be configured. A specific trace port configuration file can be used for this purpose, if the application software does not configure these pins for tracing a device or board. The configuration file is implemented in gdb script syntax, and configures the special function registers (SFR's) related to the ETM trace port pins.

Atollic TrueSTUDIO comes with a readymade trace port configuration file for most of the supported boards, but it is possible to edit them, or create new ones, to enable ETM tracing on new boards. It is recommended to copy such readymade file to the Project or some other folder on the files system if any changes are needed. Make the change in the copied file and make sure to point to the correct file in the **Trace Port Config** selection in the debug configuration.

See the example below for STM32F4xx:

```
#RCC_AHB1ENR: IO port E clock enable
set *((unsigned long*) 0x40023830) |= 0x00000010

if ($tracePortWidth == 1)
    #Trace Port 1-bit configuration
    #Enable trace in 1-pin mode
    set *((unsigned long*) 0xE0042004) &= ~0x000000E0
    set *((unsigned long*) 0xE0042004) |= 0x00000060
```

```
#GPIOE_MODER:    PE2..PE3 = Alternate function mode
set *((unsigned long*) 0x40021000) &= ~0x000000F0
set *((unsigned long*) 0x40021000) |= 0x000000A0

#GPIOE_OTYPER:    PE2..PE3 = Output push-pull
set *((unsigned long*) 0x40021004) &= ~0x0000000C

#GPIOE_OSPEEDR: PE2..PE3 = 50 MHz Fast speed
set *((unsigned long*) 0x40021008) &= ~0x000000F0
set *((unsigned long*) 0x40021008) |= 0x000000F0

#GPIOE_PUPDR:    PE2..PE3 = No pull-up, pull-down
set *((unsigned long*) 0x4002100C) &= ~0x000000F0

#GPIOE_AFRL:    PE2..PE3 = AF0
set *((unsigned long*) 0x40021020) &= ~0x0000FF00
end
if ($tracePortWidth == 2)
    #Trace Port 2-bit configuration
    #Enable trace in 2-pin mode
    set *((unsigned long*) 0xE0042004) &= ~0x000000E0
    set *((unsigned long*) 0xE0042004) |= 0x000000A0

#GPIOE_MODER:    PE2..PE4 = Alternate function mode
set *((unsigned long*) 0x40021000) &= ~0x000003F0
set *((unsigned long*) 0x40021000) |= 0x000002A0

#GPIOE_OTYPER:    PE2..PE4 = Output push-pull
set *((unsigned long*) 0x40021004) &= ~0x0000001C

#GPIOE_OSPEEDR: PE2..PE4 = 50 MHz Fast speed
set *((unsigned long*) 0x40021008) &= ~0x0000003F0
set *((unsigned long*) 0x40021008) |= 0x0000003F0

#GPIOE_PUPDR:    PE2..PE4 = No pull-up, pull-down
set *((unsigned long*) 0x4002100C) &= ~0x0000003F0

#GPIOE_AFRL:    PE2..PE4 = AF0
set *((unsigned long*) 0x40021020) &= ~0x000FFF00
end
if ($tracePortWidth == 4)
    #Trace Port 4-bit configuration
    #Enable trace in 4-pin mode
    set *((unsigned long*) 0xE0042004) &= ~0x000000E0
    set *((unsigned long*) 0xE0042004) |= 0x000000E0

#GPIOE_MODER:    PE2..PE6 = Alternate function mode
```

```

set *((unsigned long*) 0x40021000) &= ~0x00003FF0
set *((unsigned long*) 0x40021000) |= 0x00002AA0

#define GPIOE_OTYPER: PE2..PE6 = Output push-pull
set *((unsigned long*) 0x40021004) &= ~0x00000007C

#define GPIOE_OSPEEDR: PE2..PE6 = 50 MHz Fast speed
set *((unsigned long*) 0x40021008) &= ~0x00003FF0
set *((unsigned long*) 0x40021008) |= 0x00002AA0

#define GPIOE_PUPDR: PE2..PE6 = No pull-up, pull-down
set *((unsigned long*) 0x4002100C) &= ~0x00003FF0

#define GPIOE_AFRL: PE2..PE6 = AF0
set *((unsigned long*) 0x40021020) &= ~0xFFFFF00
end

```

CONFIGURING THE TRACING SESSION

Once the JTAG probe and trace system have been configured, and a debug session has been started, the tracing can be configured.

To configure trace, suspend the debug session and open the **Trace Log** view (Select **View** in the top menu and then **ETM/ETB, Trace Log**).

In the **Trace Log** view toolbar, click on the **Configuration** toolbar button.



Figure 287 – Configuration Toolbar Button

The **Trace Configuration** dialog box will be displayed:

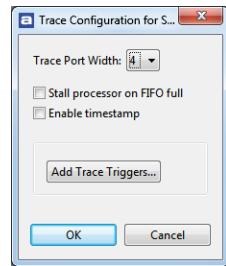


Figure 288 - Trace Configuration

Configure the **Trace Port Width** dropdown list to match the number of pins used for ETM tracing on the hardware board.

Using the **Stall processor on FIFO full** checkbox, select one of these two options:

- Stall the processor when the ETM trace FIFO buffer becomes full. With this setting, no trace data is lost but the timing behavior of the application can be changed.
- Do not stall the processor when the ETM trace FIFO buffer becomes full. With this setting, the processor will always continue to run at full speed but trace data may be lost.

Some devices support timestamps. Enabling the timestamps can be useful if timing information is needed. It will however reduce the amount of other information available.

ETM TRACE PORT CONFIGURATION FILE REFERENCE

When Segger J-TRACE probe is used and ETM tracing selected the **Debugger** tab in the Debug Configurations dialog contains a file reference to a trace port configuration file. This file is by default located in the installation of **Atollic TrueSTUDIO**. This means that if such project made with an older **Atollic TrueSTUDIO** version is imported and used in a new **Atollic TrueSTUDIO** version, the reference requires that the earlier version also is installed. Please update the reference to point to the ETM trace port configuration file available in the new installation.

Example of location of ETM Trace Port configuration file for STM32F1xx:

C:\Program Files (x86)\Atollic\TrueSTUDIO for STM32
9.0.0\ide\plugins\com.atollic.truestudio.tsp.stm32_1.0.0.
201712151711\tsp\etm\stm32f4xx.init



It is recommended to copy the ETM tracing port configuration file to the project and in the Debug Configurations dialog specify that the configuration file located in the project shall be used. With this solution the configuration file will be kept with other files in a project and it will be easier to export/import the project.

ADD TRACE TRIGGER

The trick with Instruction tracing is to trace only where tracing is needed. Otherwise the important information can be impossible to locate in the huge amount of data that will be collected or lost since it occurred to long time before debugging was suspended and the trace information uploaded.

There are four hardware triggers that can be set to starting and stopping the tracing on different conditions.

To access them, open the **Trace Configuration** as above and select **Add Trace Triggers...**

The triggers can also be added from the **Breakpoints** view.

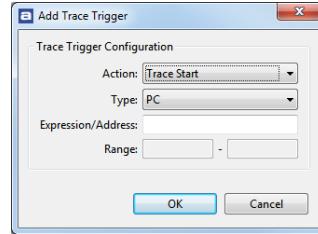


Figure 289 - Trace Configuration

For each of the triggers 0-3, it is possible to define that the trigger shall start or stop tracing, if its configured conditions are met. Each trigger has the following options:

- The **Action** to perform when the condition is triggered:
 - **Trace Start:** Starts collecting trace data
 - **Trace Stop:** Stops collecting trace data
- The **Type** of memory access that triggers the action:
 - **PC:** Triggered when execution reaches an address
 - **Data Read:** Triggered when data is read from an address
 - **Data Write:** Triggered when data is written to an address
 - **Data Read/Write:** Triggered when data is read or written to an address
- Enter the address to trigger on in the **Expression/Address** field. This field accepts:
 - Numeric address constants such as 0xfffff0010
 - Numeric address ranges such as 0xfffff0010 to 0xfffff001f
 - Function symbols such as “main”
 - Variable symbols such as “MyGlobalCounter”
 - It is also possible to define mathematical expressions like “main + 7”

Typically, at least one trigger is configured to start tracing, and another trigger is configured to stop tracing. Once the trace start and stop conditions have been configured, click **OK** to save the trace trigger settings.



When using ETMv4 based devices, Cortex-M7, only **PC** triggered type of events are supported. **Data Read**, **Data Write**, or **Data Read/Write** triggered events are not supported.

ADD TRACE TRIGGER IN THE EDITOR

Start and Stop Trace Triggers can also be added directly in the **C/C++ Editor** Ruler and the **Disassembly** view. These triggers work in line with the Breakpoints, except that they will not suspend the execution. Instead they will start or stop collecting of trace data when execution reaches that line.

Right click on the ruler to the left in the editor window and select **Add Trace Trigger**.

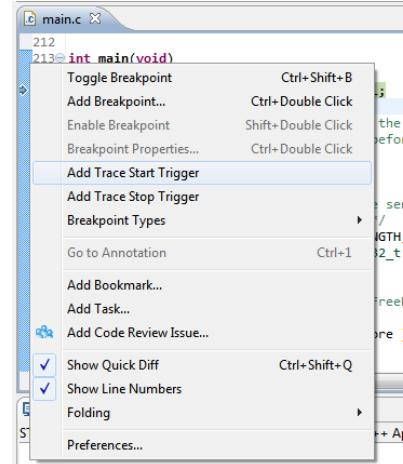


Figure 290 – Add Trace Trigger in the Editor

A new trigger will be created and tracing starts to be collected when execution reaches that line of code.

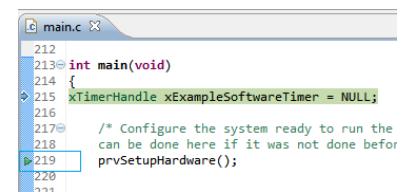


Figure 291 –Trace Trigger in the Editor

MANAGING TRACE TRIGGERS

All the Trace Triggers are visible from the **Breakpoints** view.

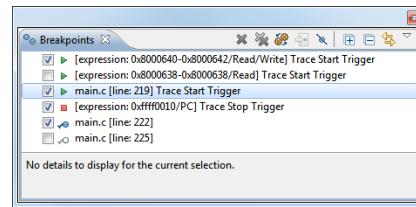


Figure 292 –Trace Trigger in the Editor

From this view the triggers can easily be inactivated, activated, removed and even added.

Bear in mind that the hardware supports up to a maximum of four simultaneous Trace Triggers.

START TRACE RECORDING

Once tracing has been enabled, click the **Record** toolbar button in the **Trace Log** view to enable recording of trace data.



Figure 293 – Record Toolbar Button

With trace recording enabled, start target execution. When execution is suspended, the **Trace Log** view is filled with the recorded instruction trace (provided the trace start trigger condition was fulfilled).

ANALYZING THE TRACE

When suspending execution, the trace buffer is uploaded to the **Trace Log** view. It is filled with the recorded instruction stream, along with other data that is provided by analyzing the trace recording.

Index	Address	Op Code	Instruction	Function	Time
	heap_1...		{		
19873876	08002a24	b480	push {r7}	<xPortGetFreeHea...	N/A
19873877	08002a26	a000	add r7, sp, #0	<xPortGetFreeHea...	N/A
	heap_1...		return (configTOTAL_HEAP_SIZE - xNex...		
19873879	08002a28	f6415380	movw r3, #7552 ; 0xd80	<xPortGetFreeHea...	N/A
19873880	08002a2c	f2c20300	movt r3, #8192 ; 0x2000	<xPortGetFreeHea...	N/A
19873881	08002a30	681b	ldr r3, [r3, #0]	<xPortGetFreeHea...	N/A
19873882	08002a32	f5c353e0	rsb r3, r3, #7168 ; 0xc00	<xPortGetFreeHea...	N/A
	heap_1...		}		
19873884	08002a36	4618	mov r0, r3	<xPortGetFreeHea...	N/A
19873885	08002a38	46bd	mov sp, r7	<xPortGetFreeHea...	N/A
19873886	08002a3a	bc80	pop {r7}	<xPortGetFreeHea...	N/A
19873887	08002a3c	4770	bx lr	<xPortGetFreeHea...	N/A
	main.c...		xFreeStackSpace = xPortGetFreeHeapSiz...		
19873889	080008da	4603	mov r3, r0	<vApplicationIdl...	N/A
19873890	080008de	607b	str r3, [r7, #4]	<vApplicationIdl...	N/A
	main.c...		if(xFreeStackSpace > 100)		
19873892	080008de	687b	ldr r3, [r7, #4]	<vApplicationIdl...	N/A
	main.c...		}		
19873894	080008e0	f1070708	add.w r7, r7, #8	<vApplicationIdl...	N/A
19873895	080008e4	46bd	mov sp, r7	<vApplicationIdl...	N/A
			End of Trace marker		
Total (kB) : 9802				19873875/19873896	

Figure 294 - The Trace Log View

The **Trace Log** view shows detailed information on what the processor was doing up to the point of suspending execution.

Please note the column with graphical icons that annotate the **Trace Log** view with information about execution flow branches:

- Call a new function
- Return from a function
- Jump up in the code
- Jump down in the code
- Iterate on the same instruction
- A conditional branch was not taken

At the end of the view is the **End of Trace marker** displayed. This is added to the Trace Log each time the buffer is overflowed and it indicates that some trace data most likely is lost.

Index	Address	Op Code	Instruction	Function	Time
5585965	080005b4	e7fe	↳ b.n 80005b4 <main+0x4>	<main>:	N/A
5585966	080005b4	e7fe	↳ b.n 80005b4 <main+0x4>	<main>:	N/A
5585967	080005b4	e7fe	↳ b.n 80005b4 <main+0x4>	<main>:	N/A
			Trace restarted		
5585969	080005b4	e7fe	↳ b.n 80005b4 <main+0x4>	<main>:	N/A
5585970	080005b4	e7fe	↳ b.n 80005b4 <main+0x4>	<main>:	N/A
5585971	080005b4	e7fe	↳ b.n 80005b4 <main+0x4>	<main>:	N/A
Total (kB) : 11006				5585965/5589761	

Figure 295 - Trace Restarted



The other important marker is the Trace restarted marker. It indicates that the target wasn't able to generate all the trace information without affecting the performance of the running application. Some data is lost.

To overcome this issue, enable **Stall processor on FIFO full** in the **Trace Configuration**.



Enabling **Stall processor on FIFO full** will slow down the processor in some situation and hence affect the timing of the execution. For some real time applications this is unacceptable.

DISPLAY OPTIONS

The **Log Trace** view supports several different display options:

- Function call tracing
- C tracing
- C/Assembler mixed mode tracing
- Assembler tracing
- Raw trace packet log

Use the different Display Options Toolbar Buttons to switch between the different view-modes.

The Function call tracing displays what function the execution is in and from where it is called or returned from.

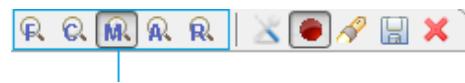


Figure 296 – Display Options Toolbar Button



When using ETMv4 based devices, Cortex-M7, only **Assembler tracing** and **Raw trace packet log** are supported.

SEARCH THE TRACE LOG

The recorded trace buffer can become very large. **Atollic TrueSTUDIO** supports appended trace buffers of a total of 100 million lines. For this reason, a search function is available, to enable users to find important information in the potentially huge dataset.



Figure 297 – Search Toolbar Button



Using the search feature it is possible to search for certain data of particular interest. For example, assume a system crash sometimes happens because a variable has an illegal value. By searching the instruction trace for the address of the variable, it is possible to understand what code modifies the value and gives it the illegal value causing a system crash.

EXPORTING A TRACE LOG

It is possible to save the trace log by clicking on the **Export Trace** toolbar button in the **Trace Log** view.



Figure 298 – Export Toolbar Button

The trace log can be saved to either comma separated value files (*.csv) that can be imported into Microsoft® Excel®, or to human readable ASCII text files (*.txt).

Configure the trace record range to export using the **From Index** and **To Index** fields.

As the saved trace log becomes approximately 200 times larger than its compressed size in the JTAG probe trace buffer, the saved trace log can optionally be split to many files in order to avoid exported trace logs which are several gigabytes in size (for example, the 16MB compressed trace buffer in Segger J-Trace expands to 2-3GB when saved to a human readable trace log file in *.CSV or *.TXT formats).

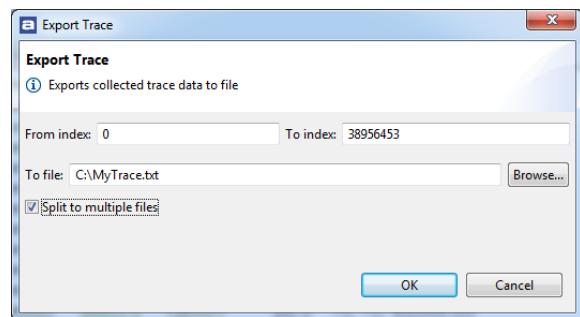


Figure 299 - Exporting the Trace Log

Select the file filename and folder to use for the export using the **Browse** button. In the **Save As** dialog box, select the desired filename and folder, select ***.CSV** or ***.TXT** file format, and click **Save** to return to the **Export Trace** dialog box. Click **OK** to start exporting the trace log.



Section 8. RTOS-AWARE DEBUGGING

This section provides information on how to debug Real Time Operating Systems (RTOS) with **Atollic TrueSTUDIO for STM32**.

The following topics are covered:

- RTOS Kernel Awareness Debugging
- Segger embOS
- FreeRTOS and OpenRTOS
- Express Logic ThreadX
- Micrium uC/OS-III
- HCC Embedded eTaskSync
- Quadros RTXC
- TOPPERS/ASP

RTOS KERNEL AWARENESS DEBUGGING

This chapter provides information regarding the ***Atollic TrueSTUDIO*** Real Time Operating Systems kernel awareness debug features.

Several different Real Time Operating Systems are supported and the current state of the RTOS kernel and the various RTOS kernel objects can easily be inspected in a set of dedicated views, in the ***Atollic TrueSTUDIO Debug*** perspective.

SEGGER embOS

The kernel awareness features for Segger embOS in **Atollic TrueSTUDIO** provide the developer with a detailed insight into the internal data structures of the embOS kernel. During a debug session, the current state of the embOS kernel and the various embOS kernel objects such as tasks, mailboxes, semaphores and software timers, can easily be inspected in a set of dedicated views, in the **Atollic TrueSTUDIO Debug** perspective.

REQUIREMENTS

The kernel awareness features require Segger embOS version 3.80 or later.



Please note that the level of information available in the different views in **Atollic TrueSTUDIO** depends on the options used when the embOS kernel was built. This manual refers to an embOS kernel built with the debug and profiling (DP) build options. Please note that microcontrollers based on the ARM-cores Cortex-M0 and Cortex-M0+ do not support Serial Wire Viewer tracing.

FINDING THE VIEWS

A number of debugger views are available in the **Atollic TrueSTUDIO Debug** perspective when debugging an application containing the embOS real-time operating system.

These views can be opened from the **Show View** toolbar dropdown list button.

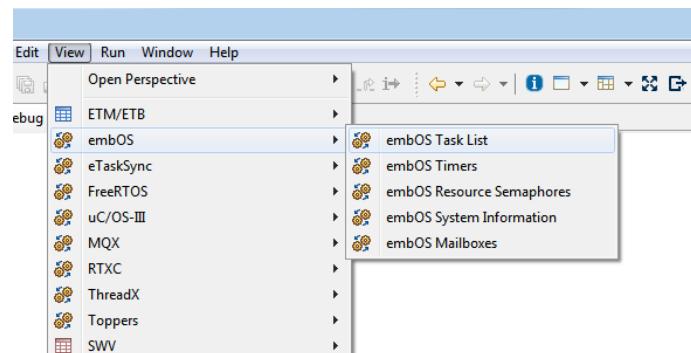


Figure 300 - View Top Level Menu

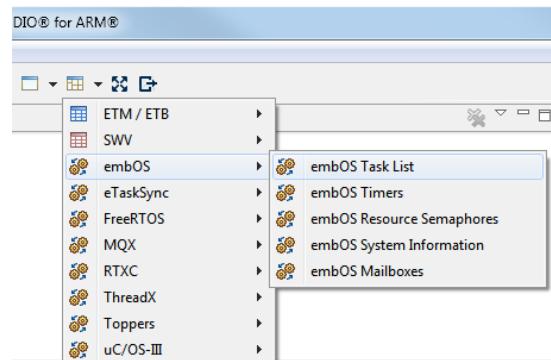


Figure 301 - embOS Show View Toolbar Button

SYSTEM INFORMATION

The **embOS System Information** view displays a number of system variables available in the embOS kernel, such as status, number of tasks, etc.

Name	Value
OS_Status	OK
OS_Time	1086
OS_NumTasks	9
OS_pCurrentTask	0x0 (Idle Task)
OS_pActiveTask	0x0 (Idle Task)
embOS build	Debug + Profiling

Figure 302 - embOS System Information View

This view also provides descriptive fault information messages for any fault conditions detected by the OS kernel.

Name	Value
OS_Status	Task control block has been initialized by calling a create function twice
OS_Time	672
OS_NumTasks	1
OS_pCurrentTask	0x0 (Idle Task)
OS_pActiveTask	0x200004b4 (HP Task)
embOS build	Debug + Profiling

Figure 303 - embOS System Information View (Fault Condition)

The available system variables are described in the table below:

Name	Description
OS_Status	The current status of embOS.
OS_Time	The number of system ticks since program start.
OS_NumTasks	The number of created tasks.
OS_pCurrentTask	The address (TCB) and name of the currently running task.
OS_pActiveTask	The address (TCB) and name of the next running task.
embOS build	The build options of the currently running embOS kernel. In the example, debugging and profiling information (DP) is available.

Table 10 – embOS System Variables

TASK LIST

The **embOS Task List** view displays detailed information regarding all available tasks in the target system. The task list is updated automatically each time the target execution is suspended.

There is one column for each type of task parameter, and one row for each task. If the value of any parameter for a particular task has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

	Prio	Id	Name	Status	Timeout	Preemptions	Waitable Object	Events	Stack Info	Activations	Round Robin
→	100	0x200004b4	HP Task	Ready	0			0x0	156/512 @ 0x200000b4	101	0/2
	50	0x20000e6c	LP Task	Wait (Timeout)	0 (15000)	28		0x0	164/512 @ 0x200009d4	174	0/2
	70	0x20001110	MP Task	Wait (Timeout)	0 (15000)	35		0x0	164/512 @ 0x20000c6c	181	0/2
	50	0x200004fc	Task1	Wait (Event)(Timeout)	5000 (20000)	0		0x1	120/512 @ 0x20000ec8	1	2/2
	50	0x20001220	Task2	Wait (Event)		0		0x1	100/512 @ 0x2000127c	1	2/2
	50	0x20001490	Task3	Wait (Semaphore)	100 (14500)	14	0x200011f0	0x0	144/512 @ 0x20000558	51	2/2
	50	0x200010c8	Task4	Wait (Timeout)	0 (15000)	0		0x0	100/512 @ 0x200007d4	60	2/2
	50	0x200011a8	Task5	Wait (Mailbox)		0	0x20001204	0x0	156/512 @ 0x200002b4	1	2/2
	50	0x200016d8	Task6	Wait (Mailbox)		0	0x200007b8	0x0	152/512 @ 0x200014d8	1	2/2
		Idle									

Figure 304 - embOS Task List View

Please note that due to performance reasons, stack analysis (the **Stack Info** column) is disabled by default. To enable stack analysis, use the **Stack analysis** toggle toolbar button in the **View** toolbar:



The available parameters are described in the table below:

Name	Description
N/A	Indicates the currently running task. The currently running task is indicated by a green arrow symbol.
Prio	The task priority.
Id	The task identifier (TCB address).
Name	The task name.
Status	The current status of the task. The type of object that currently blocks a task is presented in parenthesis.
Timeout	The timeout value (OS_Delay) and in parenthesis the point in time when the timeout will occur.
Preemptions	The number of times the task has been preempted by a higher priority task.
Waitable Object	The address of the object the task is waiting for.
Events	The event mask of the task. A value of 0x0 means that the task is not waiting on any events.
Stack Info	The amount of used stack space, the available stack space and the stack start address. [Used/Total@Address]. Note! This feature must be enabled in the View toolbar.
Activations	The number of times the task has been activated.
Round Robin	The number of remaining time slices (ticks) and the time slice reload value, during round robin scheduling.

Table 11 – embOS Task Parameters

TIMERS

The **embOS Timers** view displays detailed information regarding all available software timers in the target system. The timers view is updated automatically each time the target execution is suspended.

There is one column for each type of timer parameter, and one row for each timer. If the value of any parameter for a particular timer has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

embOS Timers				
Id	Hook	Time	Period	Active
0x20000544	0x8002b65 <timer2Callback>	471 (39000)	500	1
0x20001268	0x8002b51 <timer1Callback>	471 (39000)	1000	1
0x20001720	0x8002b79 <timer3Callback>	71 (38600)	200	1

Figure 305 - embOS Timers View

The available parameters are described in the table below:

Name	Description
Id	The timer identifier (address).
Hook	The address and name of the function that is called when the timer expires.
Time	The current timer value (ticks) and in parenthesis the point in time when the timer expires.
Period	The timer time period (ticks).
Active	Shows whether the timer is active or not. 1 = Active 0 = Not active

Table 12 – embOS Timer Parameters

RESOURCE SEMAPHORES

The **embOS Resource Semaphores** view displays detailed information regarding all available resource semaphores in the target system. The view is updated automatically each time the target execution is suspended.

There is one column for each type of semaphore parameter, and one row for each semaphore. If the value of any parameter for a particular semaphore has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

embOS Resource Semaphores			
Id	Owner	Use counter	Waiting tasks
0x20000eb4		0	
0x200011f0	0x200004b4 (HP Task)	1	0x20001490 (Task3), 0x200010c8 (Task4)
0x200007a4		0	
0x2000147c		0	

Figure 306 - embOS Resource Semaphores View

The available parameters are described in the table below:

Column	Description
Id	The resource semaphore identifier (address).
Owner	The address (TCB) and name of the task currently owning the semaphore.
Use counter	The semaphore use counter. Keeps track of how many times the semaphore has been claimed by a task.
Waiting tasks	The address (TCB) and name of all tasks waiting on the semaphore.

Table 13 – embOS Resource Semaphore Parameters

MAILBOXES

The **embOS Mailboxes** view displays detailed information regarding all available mailboxes in the target system. The view is updated automatically each time the target execution is suspended.

There is one column for each type of mailbox parameter, and one row for each mailbox. If the value of any parameter for a particular mailbox has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

embOS Mailboxes				
Id	Messages	Message size	pBuffer	Waiting tasks
0x20001204	0/100	14	0x20000bd4	0x200011a8 (Task5)
0x2000118c	3/50	1	0x20001158	
0x200007b8	0/47	41	0x20000758	0x200016d8 (Task6)

Figure 307 - embOS Mailboxes View

The available parameters are described in the table below:

Column	Description
Id	The mailbox identifier (address).
Messages	The current number of messages and the maximum number of messages the mailbox can hold.
Message size	The size (in bytes) of a message item.
pBuffer	The address of the message buffer.
Waiting tasks	The address (TCB) and name of all tasks waiting on the mailbox.

Table 14 – embOS Mailbox Parameters

HCC EMBEDDED eTASKSYNC

The kernel awareness features for eTaskSync in **Atollic TrueSTUDIO** provide the developer with a detailed insight into the task structures of the eTaskSync kernel. During a debug session, the current state of the tasks can be easily inspected in a dedicated view, in the **Atollic TrueSTUDIO Debug** perspective.

REQUIREMENTS

The kernel awareness features described in this document is based on eTaskSync Versions 3.01.

FINDING THE VIEW

One view is available in the **Atollic TrueSTUDIO Debug** perspective when debugging an application containing the eTaskSync real-time operating system.

It is available from the **Show View** toolbar dropdown list button.

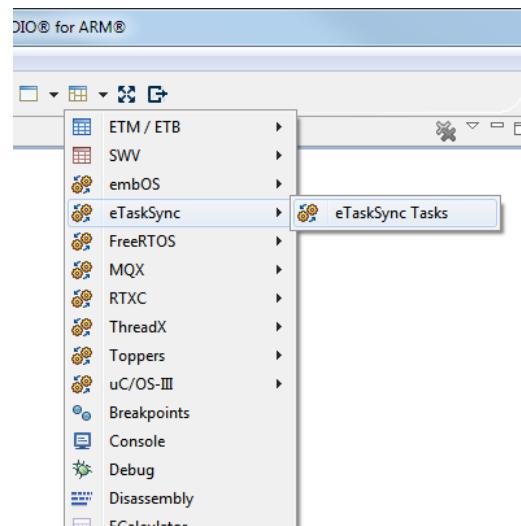


Figure 308 – eTaskSync Show View Toolbar Button

TASK LIST

The **eTaskSync Task List** view displays detailed information regarding all available tasks in the target system. The task list is updated automatically each time the target execution is suspended.

There is one column for each type of task parameter, and one row for each task. If the value of any parameter for a particular task has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

*	Name	ID	Prio	Original Prio	Remaining Ticks	Time Slice	State
	BLINKY_TASK	2	4	4	3	0	READY
→	MAIN_TASK	1	3	3	82	0	RUNNING

Figure 309 - eTaskSync Task List View

The available parameters are described in the table below:

Name	Description
N/A	Indicates the currently running task. The currently running task is indicated by a green arrow symbol.
Name	The name assigned to the task.
ID	The task base ID
Prio	The task actual priority
Original Prio	The original (base) priority of the task
Remaining ticks	Number of remaining ticks
Time Slice	The time slice. This is not always present. Only if SYNC_TIME_SLICE_ENABLE option is set at compile time in hcc/src/config/config_sync.h.
State	The state of the task.

Table 15 – eTaskSync Task Parameters

FREERTOS AND OPENRTOS

As FreeRTOS and OpenRTOS are technically identical, we will only refer to FreeRTOS here, but the information applies equally to both.

The kernel awareness features for FreeRTOS in **Atollic TrueSTUDIO** provide the developer with a detailed insight into the internal data structures of the FreeRTOS kernel. During a debug session, the current state of the FreeRTOS kernel and the various FreeRTOS kernel objects such as tasks, mailboxes, semaphores and software timers, can be easily inspected in a set of dedicated views, in the **Atollic TrueSTUDIO Debug** perspective.

REQUIREMENTS

In order for the **FreeRTOS Queues** and the **FreeRTOS Semaphores** views to be able to locate the appropriate RTOS kernel data structures, the associated kernel objects need to be added to the FreeRTOS queue registry. Please consult the *FreeRTOS reference manual* for details.



The following define fixes so GDB doesn't fail when going through the stack of a task in FreeRTOS 7.6. The same problem might also affect earlier releases.

```
#define configTASK_RETURN_ADDRESS 0x00
```

Also set the define `configUSE_TRACE_FACILITY` in `FreeRTOSconfig.h` to list the type of the semaphore in the semaphore view or it will say "N/A"

FINDING THE VIEWS

A number of debugger views are available in the **Atollic TrueSTUDIO Debug** perspective when debugging an application containing the FreeRTOS real-time operating system.

These views are available from the **Show View** toolbar dropdown list button.

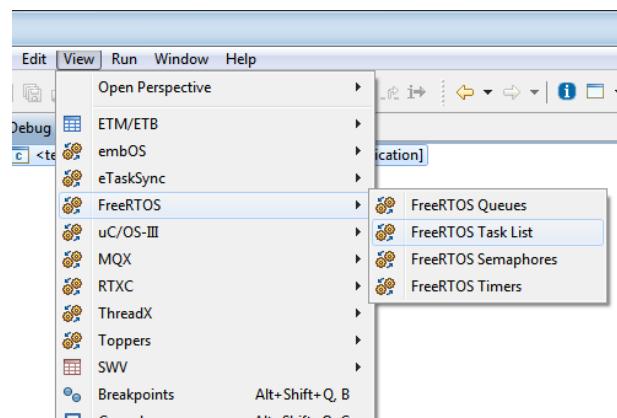


Figure 310 – FreeRTOS View Top Level Menu

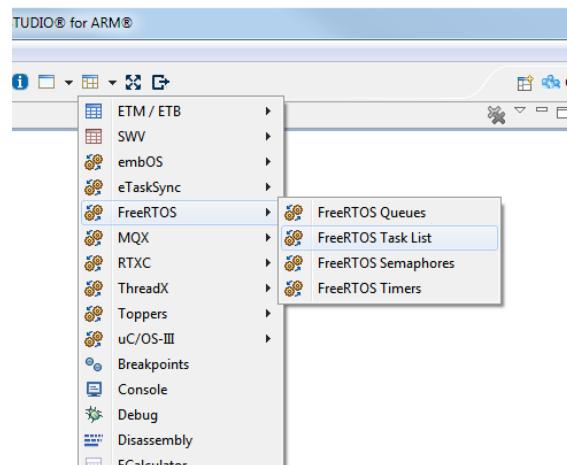


Figure 311 – FreeRTOS Show View Toolbar Button

TASK LIST

The **FreeRTOS Task List** view displays detailed information regarding all available tasks in the target system. The task list is updated automatically each time the target execution is suspended.

There is one column for each type of task parameter, and one row for each task. If the value of any parameter for a particular task has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

Name	Priority (Base/...	Start of Stack	Top of Stack	State	Event Object	Min Free Stack	Run Time (%)
IDLE	0/0	0x200008a8	0x20000a54	RUNNING		>256	11%
Rx	2/2	0x20000d8	0x2000023c	BLOCKED	MainQueue	>256	22%
Sem	4/4	0x20000598	0x20000704	BLOCKED	xEventSemaph...	>256	11%
Tmr Svc	3/3	0x20000b08	0x20000e9c	BLOCKED	TmrQ	>256	22%
TX	1/1	0x20000338	0x200004ac	READY		>256	33%

Figure 312 - FreeRTOS Task List View

Please note that due to performance reasons, stack analysis (the **Min Free Stack** column) is disabled by default. To enable stack analysis, use the **Stack analysis** toggle toolbar button in the **View** toolbar:



The available parameters are described in the table below:

Name	Description
N/A	Indicates the currently running task. The currently running task is indicated by a green arrow symbol.
Name	The name assigned to the task.
Priority (Base/Actual)	The task base priority and actual priority. The base priority is the priority assigned to the task. The actual priority is a temporary priority assigned to the task due to the priority inheritance mechanism.
Start of Stack	The address of the stack region assigned to the task.
Top of Stack	The address of the saved task stack pointer.
State	The current state of the task.
Event Object	The name of the resource that has caused the task to be blocked.
Min Free Stack	The stack “high watermark”. Displays the minimum number of bytes left on the stack for a task. A value of 0 (most likely) indicates that a stack overflow has occurred. Note! This feature must be enabled in the View toolbar.
Run Time (%)	The run-time statistics provide information on the percentage of time the task has been used. This can be used for profiling the system during development.

Name	Description
	Note! A clock is used to generate timer interrupts and macros needs to be defined in <FreeRTOSConfig.h> to get the profiling information. See info below.

Table 16 – FreeRTOS Task Parameters

 To get valid profiling information the run-time statistics profiling clock is recommended to run 10-100 times faster than the frequency of the clock used to handle the tick interrupt.

The <FreeRTOS_Config.h> files can be updated in the following way:

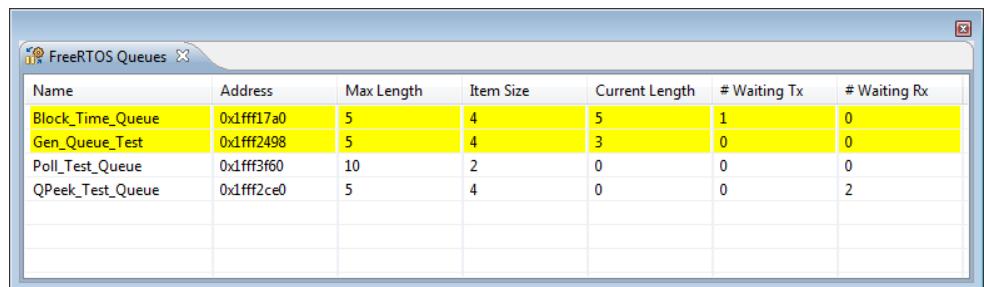
1. Enable collection of run-time statistics by setting the following macro to 1.
`#define configGENERATE_RUN_TIME_STATS 1`
2. Define `portCONFIGURE_TIMER_FOR_RUN_TIME_STATS()` to call the function that configures a timer to be used for profiling.
3. Define `portGET_RUN_TIME_COUNTER_VALUE()` to call the function which reads current value from the profiling timer.

More information on how to configure FreeRTOS for run-time statistics is available in the FreeRTOS documentation.

QUEUES

The **FreeRTOS Queues** view displays detailed information regarding all available queues in the target system. The queues view is updated automatically each time the target execution is suspended.

There is one column for each type of queue parameter, and one row for each queue. If the value of any parameter for a particular queue has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.



Name	Address	Max Length	Item Size	Current Length	# Waiting Tx	# Waiting Rx
Block_Time_Queue	0x1fff17a0	5	4	5	1	0
Gen_Queue_Test	0x1fff2498	5	4	3	0	0
Poll_Test_Queue	0x1fff3f60	10	2	0	0	0
QPeek_Test_Queue	0x1fff2ce0	5	4	0	0	2

Figure 313 - FreeRTOS Queues View

The available parameters are described in the table below:

Name	Description
Name	The name assigned to the queue in the queue registry.
Address	The address of the queue.
Max Length	The maximum number of items that the queue can hold.
Item Size	The size in bytes of each queue item.
Current Length	The number of items currently in the queue.
#Waiting Tx	The number of tasks currently blocked waiting to send to the queue.
#Waiting Rx	The number of tasks currently blocked waiting to receive from the queue.

Table 17 – FreeRTOS Queue Parameters

SEMAPHORES

The **FreeRTOS Semaphores** view displays detailed information regarding all available synchronization objects in the target system, including:

- Mutexes
- Counting semaphores
- Binary semaphores
- Recursive semaphores

The view is updated automatically each time the target execution is suspended.

There is one column for each type of semaphore parameter, and one row for each semaphore. If the value of any parameter for a particular semaphore has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

Name	Address	Type	Size	Free	# Blocked tasks
Gen_Queue_Mutex	0x1fff26f8	MUTEX	1	1	0
Recursive_Mutex	0x1fff34c8	RECURSIVE_MUTEX	1	0	1
Sem_1	0x1fff1bf8	BINARY_SEMAPHORE	1	0	0
Sem_2	0x1fff2058	BINARY_SEMAPHORE	1	1	0

Figure 314 - FreeRTOS Semaphores View

The available parameters are described in the table below:

Column	Description
Name	The name assigned to the object in the queue registry.
Address	The address of the object.
Type	The type of the object.
Size	The maximum number of owning tasks.
Free	The number of free slots currently available.
#Blocked tasks	The number of tasks currently blocked waiting for the object.

Table 18 – FreeRTOS Semaphore Parameters

TIMERS

The **FreeRTOS Timers** view displays detailed information regarding all available software timers in the target system. The timers view is updated automatically each time the target execution is suspended.

There is one column for each type of timer parameter, and one row for each timer. If the value of any parameter for a particular timer has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

Name	Period	Type	Id	Callback
ARPTimer	10000	Auto-Reload	0x0	0x1851 <prvUIPTimerCallback>
CheckTimer	3000	Auto-Reload	0x0	0xfc1 <prvCheckTimerCallback>
FR Timer	500	Auto-Reload	0x9	0xdca9 <prvAutoReloadTimerCallback>
ISR AR	50	Auto-Reload	0x0	0xdd41 <prvISRAutoReloadTimerCallback>
ISR OS	50	One-Shot	0x0	0xdd6d <prvISROneShotTimerCallback>
LED1Timer	200	Auto-Reload	0x0	0x2179 <prvLEDTimerCallback>
LED2Timer	600	Auto-Reload	0x1	0x2179 <prvLEDTimerCallback>
PeriodicTimer	500	Auto-Reload	0x1	0x1851 <prvUIPTimerCallback>

Figure 315 - FreeRTOS Timers View

The available parameters are described in the table below:

Name	Description
Name	The name assigned to the timer.
Period	The time (in ticks) between timer start and the execution of the callback function.
Type	The type of timer. Auto-Reload timers are automatically reactivated after expiration. One-Shot timers expire only once.
Id	The timer identifier.
Callback	The address and name of the callback function executed when the timer expires.

Table 19 – FreeRTOS Timer Parameters

QUADROS RTXC

The kernel awareness features for Quadros RTXC RTOS in **Atollic TrueSTUDIO** provide the developer with a detailed insight into the internal data structures of the RTXC kernel. During a debug session, the current state of the RTXC kernel and the various RTXC kernel objects such as tasks, semaphores, mailboxes, etc, can be easily inspected in a set of dedicated views, in the **Atollic TrueSTUDIO Debug** perspective.

REQUIREMENTS

The kernel awareness features described in this document is based on RTXC Version 2.1.2.

FINDING THE VIEWS

The Quadros RTXC Kernel Awareness views, is available in the **Atollic TrueSTUDIO Debug** perspective when debugging an application containing the RTXC real-time operating system.

The views can be accessed from the **Show View** toolbar dropdown list button.

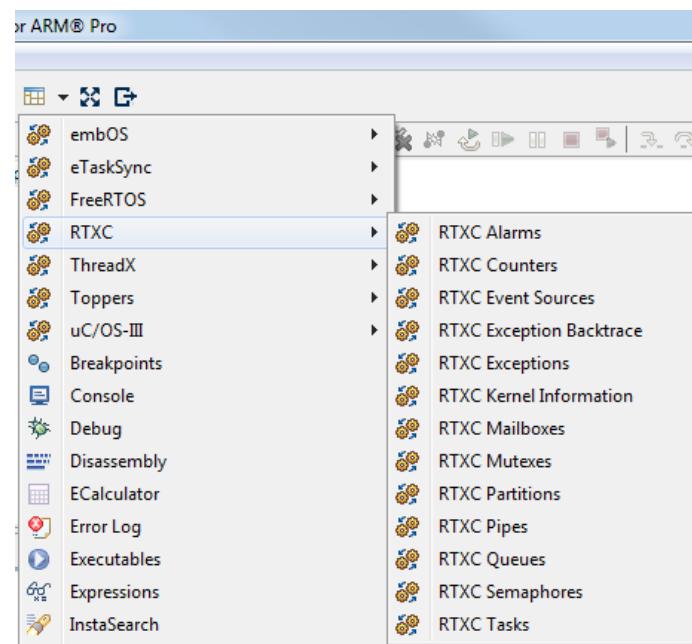


Figure 316 – RTXC Show View Toolbar Button

KERNEL INFORMATION

The **RTXC Kernel Information** view displays general information about the kernel.

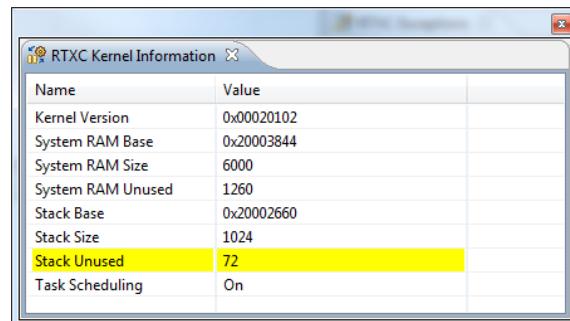


Figure 317 – RTXC Kernel Information View

The available system variables are described in the table below:

Name	Description
Kernel Version	A sixteen-bit quantity defining the version number of the RTXC Quadros kernel.
System RAM Base	The base address of the system RAM.
System RAM Size	The size of the system RAM.
System RAM Unused	The amount of unused system RAM.
Stack Base	The base address of the kernel stack.
Stack Size	Displays the size of the kernel stack.
Stack Unused	The number of bytes unused, high watermark.
Task Scheduling	The task scheduler information (on /off).

Table 20 – RTXC Kernel Information

TASKS (TASK LIST AND STACK INFO)

The **RTXC Tasks** view contains one **Task List** tab and one **Stack Info** tab. Each tab displays detailed information regarding all available tasks in the target system.

TASK LIST TAB

The **RTXC Task List** tab displays detailed information regarding all available tasks in the target system. The task list is updated automatically each time the target execution is suspended.

There is one column for each type of task parameter, and one row for each task. If the value of any parameter for a particular task has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

#	Name	Priority	Entry	Arguments	Tick Slice	State
0	<NullTask>	127	0x00000000	0x00000000	0/0	Ready
1	ECHOTASK	9	0x08005191 <echotask>	0x00000000	0/0	Wait Queue
2	CONAITSK	20	0x080062bd <conitsk>	0x20003e00	0/0	Wait Semaphore(s) <#1:CONAISEM>
3	CONAOTSK	3	0x08006309 <conotsk>	0x20003e00	0/0	Wait Semaphore(s) <#2:CONAOSEM>
4	QMONTASK	126	0x080013cd <qmontask...>	0x00000000	0/0	Ready
5	Dtask1	10	0x08003d05 <dynatask1>	0x11111111	1/1	Sleep 980 ticks<#3:Dcounter2>
6	Dtask2	10	0x08003e21 <dynatask2>	0x22222222	1/2	Wait Queue 1980 ticks<#3:Dcounter2>
7	Dtask3	10	0x08003e81 <dynatask3>	0x33333333	2/3	Wait Semaphore(s) <#7:Dsem1> 2980 ticks<#3:Dcounter2>
8	Dtask4	10	0x08003ed9 <dynatask4>	0x44444444	0/0	Wait Partition 3980 ticks<#3:Dcounter2>
9	Dtask5	10	0x08003f31 <dynatask5>	0x55555555	0/0	Wait Mailbox 4980 ticks<#3:Dcounter2>
10	Dtask6	10	0x08003f91 <dynatask6>	0x66666666	0/0	Wait Semaphore(s) <#8:Dsem2>, <#7:Dsem1>, 5980 ticks<#3:D...
11	Dtask7	10	0x08004021 <dynatask7>	0x77777777	0/0	Wait Alarm 6980 ticks<#3:Dcounter2>
12	Dtask8	10	0x0800407d <dynatask8>	0x88888888	0/0	Wait Mutex 7980 ticks<#3:Dcounter2>
13	Dtask9	10	0x080040d5 <dynatask9>	0x99999999	0/0	Wait MsgAck 8980 ticks<#3:Dcounter2>
14	Dtask10	10	0x08004145 <dynatask10>	0xaaaaaaaa	0/0	Aborted
15	<Not used>					
16	<Not used>					

Figure 318 - RTXC Task List tab in Task view

The available parameters are described in the table below:

Name	Description
N/A	Indicates the currently running task. The currently running task is indicated by a green arrow symbol.
#	The task id.
Name	The name assigned to the task.
Priority	The priority for the task.
Entry	The task's entry point address (in hexadecimal).
Arguments	The task's environment arguments address.
Tick Slice	Ticks remaining / total ticks.
State	The tasks current state.

Table 21 – RTXC Task List Parameters

STACK INFO TAB

The **RTXC Stack info** tab displays detailed stack information for each task. The stack information list is updated automatically each time the target execution is suspended.

There is one column for each type of stack information, and one row for each task. If the value of any parameter for a particular task has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

#	Name	Address	Size	Used	Spare
0	<NullTask>	0x0	0	<N/A>	<N/A>
1	ECHOTASK	0x20001b78	512	164	348
2	CONAITSK	0x20001d78	512	156	356
3	CONAOTSK	0x20001f78	512	172	340
4	QMONTASK	0x20002178	1024	780	244
5	Dtask1	0x20001928	512	152	360
6	Dtask2	0x20001728	512	224	288
7	Dtask3	0x20001528	512	184	328
8	Dtask4	0x20001328	512	192	320
9	Dtask5	0x20001128	512	208	304
10	Dtask6	0x20000f28	512	212	300
11	Dtask7	0x20000d28	512	200	312
12	Dtask8	0x20000b28	512	192	320
13	Dtask9	0x20000928	512	188	324
14	Dtask10	0x20000728	512	108	404
15	<Not used>				
16	<Not used>				

Figure 319 – RTXC Task Stack Info

The available parameters are described in the table below:

Name	Description
#	The task id.
Name	The name assigned to the task.
Address	The base address of the task's stack.
Size	The amount of memory allocated for the stack.
Used	The number of bytes unused, high watermark.
Spare	The amount of stack space left over.

Table 22 – RTXC Stack Info

ALARMS

The **RTXC Alarms** view displays detailed information regarding all available alarms in the target system. The view is updated automatically each time the target execution is suspended.

There is one column for each type of alarm parameter, and one row for each alarm. If the value of any parameter for a particular alarm has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

Figure 320 - RTXC Alarms View

The available parameters are described in the table below:

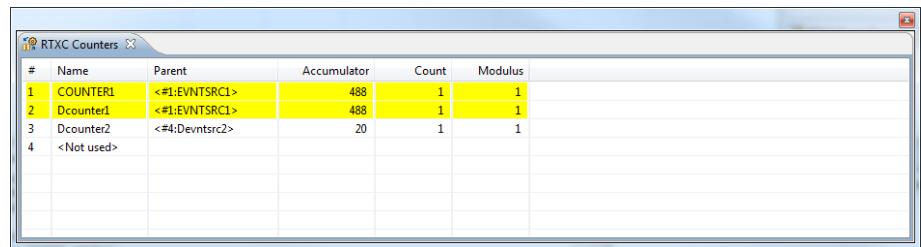
Name	Description
#	The object id.
Name	The name assigned to the alarm.
Wait order	The alarm's wait order that can be either Priority or FIFO.
Counter	The alarm's parent counter.
State	The alarm's current state.
Initial	The alarm's initial period in ticks.
Recycle	The alarm's recycle value.
Remain	The number of remaining ticks.
Waiter(s)	The task(s) that is waiting on the alarm, if any. Only the first 5 tasks are shown.

Table 23 – RTXC Alarm Parameters

COUNTERS

The **RTXC Counters** view displays detailed information regarding all available counters in the target system. The counter information is updated automatically each time the target execution is suspended.

There is one column for each type of parameter, and one row for each counter. If the value of any parameter for a particular task has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.



#	Name	Parent	Accumulator	Count	Modulus
1	COUNTER1	<#1:EVNTSRC1>	488	1	1
2	Dcounter1	<#1:EVNTSRC1>	488	1	1
3	Dcounter2	<#4:Devntsrc2>	20	1	1
4	<Not used>				

Figure 321 - RTXC Counters View

The available parameters are described in the table below:

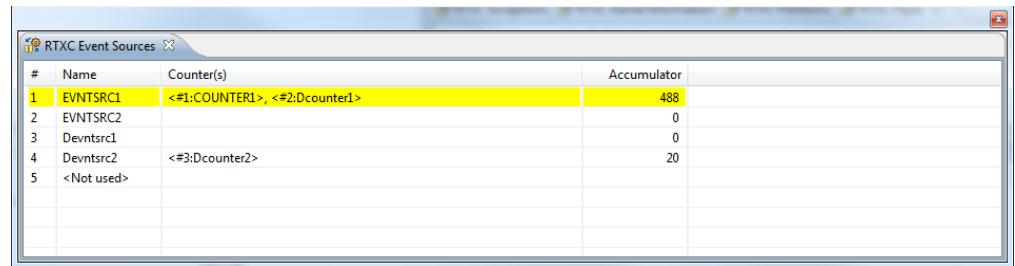
Name	Description
#	The object id.
Name	The name assigned to the counter.
Parent	The parent event source.
Accumulator	The counter's accumulator.
Count	The counter's count value.
Modulus	The counter's modulus.

Table 24 – RTXC Counter Parameters

EVENT SOURCES

The **RTXC Event Sources** view displays detailed information regarding all available event sources in the target system. The event source information is updated automatically each time the target execution is suspended.

There is one column for each type of parameter, and one row for each event source. If the value of any parameter for a particular event source has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.



#	Name	Counter(s)	Accumulator
1	EVNTSRC1	<#1:COUNTER1>, <#2:Dcounter1>	488
2	EVNTSRC2		0
3	Devntsrc1		0
4	Devntsrc2	<#3:Dcounter2>	20
5	<Not used>		

Figure 322 - RTXC Event Sources View

The available parameters are described in the table below:

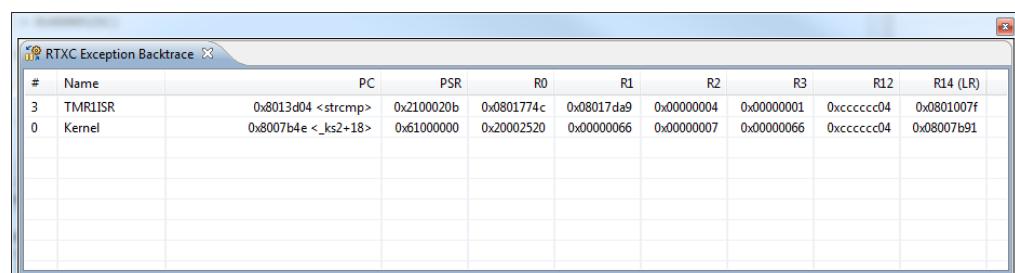
Name	Description
#	The object id.
Name	The name assigned to the event source.
Counter(s)	The counter(s) associated with this event source.
Accumulator	The event source's accumulator.

Table 25 – RTXC Event Source Parameters

EXCEPTION BACKTRACE

The **RTXC Exception Backtrace** view displays detailed backtrace information during an exception.

Each line represents an exception that is either executing, or was preempted by the item above it. The topmost line shows the active component, which preempted the component listed on the second line, which in turn preempted the third, and so on.



#	Name	PC	PSR	R0	R1	R2	R3	R12	R14 (LR)
3	TMRIISR	0x8013d04 <strcmp>	0x2100020b	0x0801774c	0x08017da9	0x00000004	0x00000001	0xcccccc04	0x0801007f
0	Kernel	0x8007b4e <_ks2+18>	0x61000000	0x20002520	0x00000066	0x00000007	0x00000066	0xcccccc04	0x08007b91

Figure 323 - RTXC Exception Backtrace View

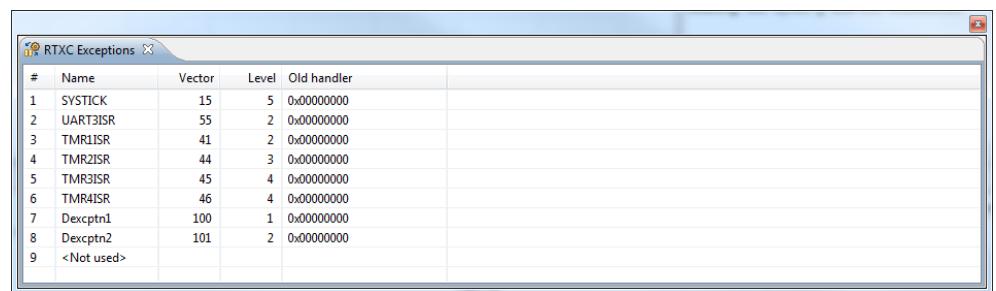
The available parameters are described in the table below:

Name	Description
#	The exception id. A zero represents the Kernel.
Name	The name of the exception.
Registers	The saved register context for the exception (in hexadecimal).

Table 26 – RTXC Exception Backtrace Parameters

EXCEPTIONS

The **RTXC Exceptions** view displays one line entry for each exception in the application.



#	Name	Vector	Level	Old handler
1	SYSTICK	15	5	0x00000000
2	UART3ISR	55	2	0x00000000
3	TMR1ISR	41	2	0x00000000
4	TMR2ISR	44	3	0x00000000
5	TMR3ISR	45	4	0x00000000
6	TMR4ISR	46	4	0x00000000
7	Dexcptn1	100	1	0x00000000
8	Dexcptn2	101	2	0x00000000
9	<Not used>			

Figure 324 - RTXC Exceptions View

The available parameters are described in the table below:

Name	Description
#	The object id.
Name	The name assigned to the exception.
Vector	The vector number.
Level	The interrupt level.
Old Handler	Previous handler address.

Table 27 – RTXC Exception Parameters

MAILBOXES

The **RTXC Mailboxes** view displays detailed information regarding all available mailboxes in the target system. The view is updated automatically each time the target execution is suspended.

There is one column for each type of mailbox parameter, and one row for each mailbox. If the value of any parameter for a particular mailbox has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

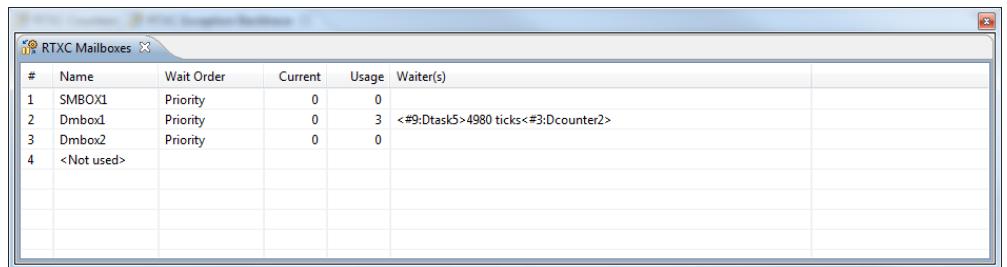


Figure 325 - RTXC Mailboxes View

The available parameters are described in the table below:

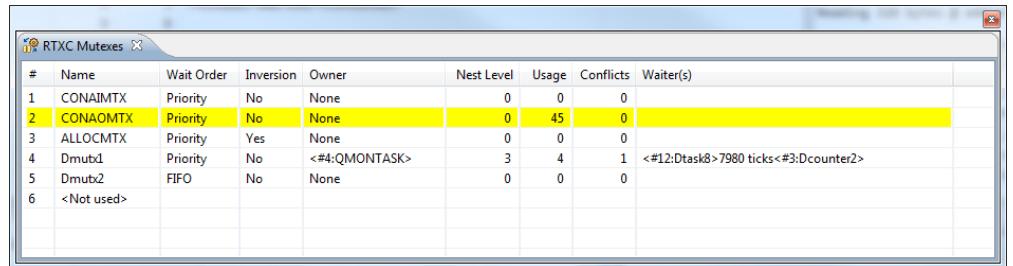
Name	Description
#	The object id.
Name	The name assigned to the mailbox.
Wait order	The mailbox's wait order that can be either Priority or FIFO.
Current	The current number of messages in the mailbox.
Usage	The total number of messages that have been placed in the mailbox. Mailbox statistics must be enabled for displaying this information.
Waiter(s)	The task that is waiting on the mailbox, if any. Only the first 5 tasks are shown.

Table 28 – RTXC Mailbox Parameters

MUTEXES

The **RTXC Mutexes** view displays detailed information regarding all available mutexes in the target system. The view is updated automatically each time the target execution is suspended.

There is one column for each type of mutex parameter, and one row for each mutex. If the value of any parameter for a particular mutex has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.



A screenshot of a Windows application window titled "RTXC Mutexes". The window contains a table with the following data:

#	Name	Wait Order	Inversion	Owner	Nest Level	Usage	Conflicts	Waiter(s)
1	CONA1MTX	Priority	No	None	0	0	0	
2	CONAOMTX	Priority	No	None	0	45	0	
3	ALLOCMTX	Priority	Yes	None	0	0	0	
4	Dmutx1	Priority	No	<#4:QMONTASK>	3	4	1	<#12:Dtask8>7980 ticks<#3:Dcounter2>
5	Dmutx2	FIFO	No	None	0	0	0	
6	<Not used>							

Figure 326 - RTXC Mutexes View

The available parameters are described in the table below:

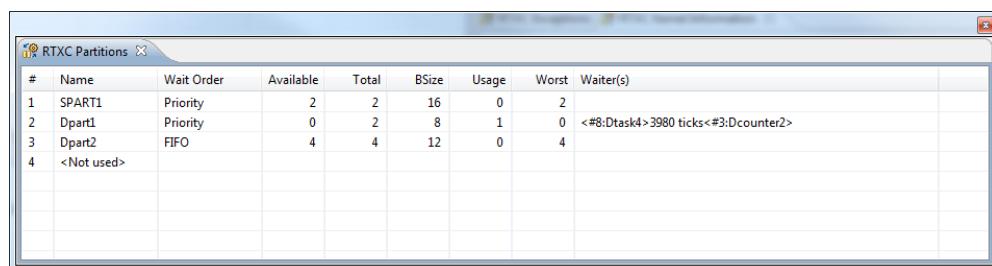
Name	Description
#	The object id.
Name	The name assigned to the mutex.
Wait order	The mutex's wait order that can be either Priority or FIFO.
Inversion	Shows whether or not priority inversion is enabled for the mutex.
Owner	The task currently owning the mutex.
Nest level	The nest level.
Usage	The total number of releases performed on the mutex. Mutex statistics must be enabled for displaying this information.
Conflicts	The number of contentions that have occurred. Mutex statistics must be enabled for displaying this information.
Waiter(s)	The task(s) that is waiting on the mutex, if any. Only the first 5 tasks are shown.

Table 29 – RTXC Mutex Parameters

PARTITIONS

The **RTXC Partitions** view displays detailed information regarding all available partitions in the target system. The view is updated automatically each time the target execution is suspended.

There is one column for each type of parameter, and one row for each partition. If the value of any parameter for a particular partition has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.



The screenshot shows a Windows-style dialog box titled "RTXC Partitions". It contains a table with the following data:

#	Name	Wait Order	Available	Total	BSize	Usage	Worst	Waiter(s)
1	SPART1	Priority	2	2	16	0	2	
2	Dpart1	Priority	0	2	8	1	0	<#8:Dtask4>3980 ticks<#3:Dcounter2>
3	Dpart2	FIFO	4	4	12	0	4	
4	<Not used>							

Figure 327 - RTXC Partitions View

The available parameters are described in the table below:

Name	Description
#	The object id.
Name	The name assigned to the partition.
Wait order	The partition's wait order that can be either Priority or FIFO.
Available	The current number of available blocks in the partition.
Total	The total number of blocks in the partition.
BSize	The size of each block in the partition.
Usage	The usage count for the partition. Partition statistics must be enabled for displaying this information.
Worst	The low watermark for the available blocks in the partition. Partition statistics must be enabled for

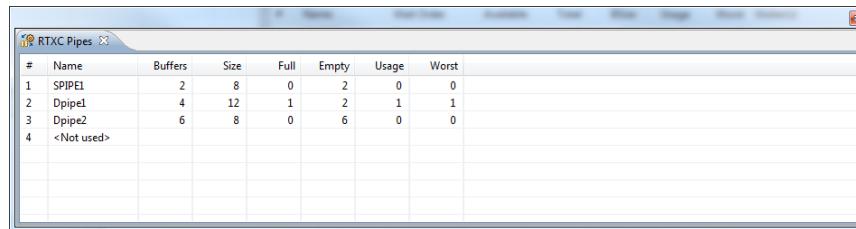
Name	Description
Waiter(s)	The task(s) currently waiting on the partition, if any. Only the first 5 tasks are shown.

Table 30 – RTXC Partition Parameters

PIPES

The **RTXC Pipes** view displays detailed information regarding all available pipes in the target system. The view is updated automatically each time the target execution is suspended.

There is one column for each type of pipe parameter, and one row for each pipe. If the value of any parameter for a particular pipe has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.



#	Name	Buffers	Size	Full	Empty	Usage	Worst
1	SPIPE1	2	8	0	2	0	0
2	Dpipe1	4	12	1	2	1	1
3	Dpipe2	6	8	0	6	0	0
4	<Not used>						

Figure 328 - RTXC Pipes View

The available parameters are described in the table below:

Name	Description
#	The object id.
Name	The name assigned to the pipe.
Buffers	The maximum number of buffers.
Size	The size of each buffer.
Full	The current number of full buffers.

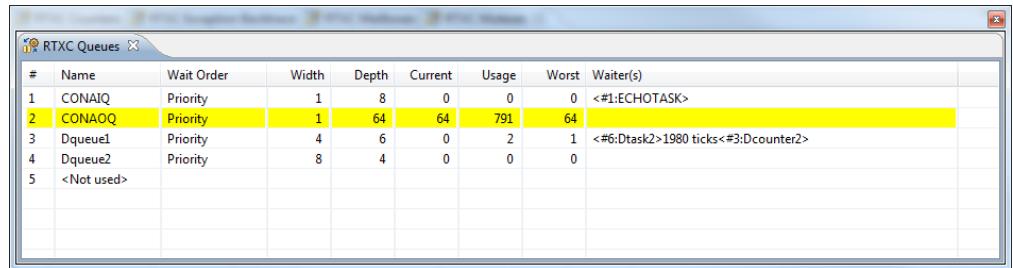
Name	Description
Empty	The current number of empty buffers.
Usage	The usage count for the pipe. Pipe statistics must be enabled for displaying this information.
Worst	The maximum full buffer count. Pipe statistics must be enabled for displaying this information.

Table 31 – RTXC Pipe Parameters

QUEUES

The **RTXC Queues** view displays detailed information regarding all available queues in the target system. The view is updated automatically each time the target execution is suspended.

There is one column for each type of queue parameter, and one row for each queue. If the value of any parameter for a particular queue has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.



The screenshot shows a Windows-style dialog box titled "RTXC Queues". Inside, there is a table with the following columns: #, Name, Wait Order, Width, Depth, Current, Usage, Worst, and Waiter(s). The rows represent different queues:

#	Name	Wait Order	Width	Depth	Current	Usage	Worst	Waiter(s)
1	CONAIQ	Priority	1	8	0	0	0	<#1:ECHOTASK>
2	CONAOQ	Priority	1	64	64	791	64	
3	Dqueue1	Priority	4	6	0	2	1	<#6:Dtask2>1980 ticks<#3:Dcounter2>
4	Dqueue2	Priority	8	4	0	0	0	
5	<Not used>							

Figure 329 - RTXC Queues View

The available parameters are described in the table below:

Name	Description
#	The object id.
Name	The name assigned to the queue.
Wait Order	The queue's wait order that can be either Priority or FIFO.
Width	The size of each entry in the queue.

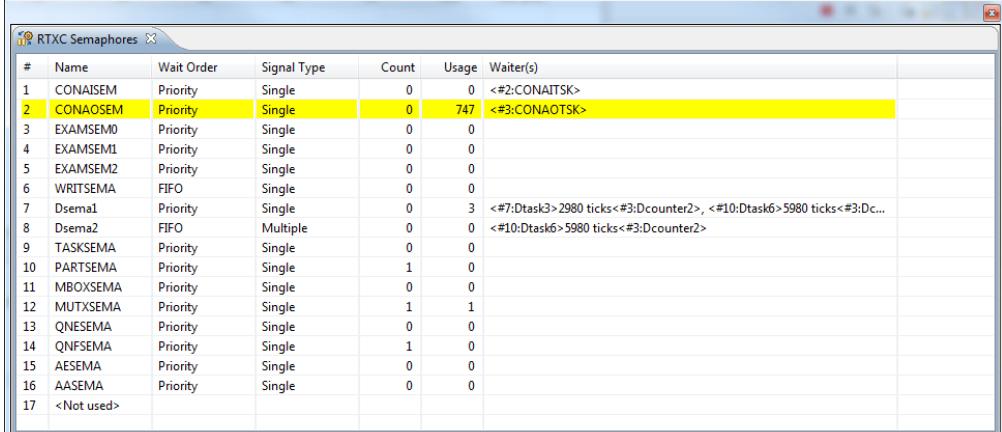
Name	Description
Depth	The maximum number of entries in the queue.
Current	The current number of entries in the queue.
Usage	The total number of accesses to the queue. Queue statistics must be enabled for displaying this information.
Worst	The maximum numbers of entries that has been in the queue. Queue statistics must be enabled for displaying this information.
Waiter(s)	The task(s) currently waiting on the partition, if any. Only the first 5 tasks are shown.

Table 32 – RTXC Queue Parameters

SEMAPHORES

The **RTXC Semaphores** view displays detailed information regarding all available semaphores in the target system. The view is updated automatically each time the target execution is suspended.

There is one column for each type of semaphore parameter, and one row for each semaphore. If the value of any parameter for a particular semaphore has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.



The screenshot shows a Windows-style application window titled "RTXC Semaphores". The window contains a table with 17 rows, each representing a semaphore. The columns are labeled: #, Name, Wait Order, Signal Type, Count, Usage, and Waiter(s). The "Waiter(s)" column for the second row, which corresponds to the semaphore CONAOSEM, is highlighted in yellow, indicating it is currently waiting. The rest of the table rows are standard black text on white background.

#	Name	Wait Order	Signal Type	Count	Usage	Waiter(s)
1	CONAISEM	Priority	Single	0	0	<#2:CONAITSK>
2	CONAOSEM	Priority	Single	0	747	<#3:CONAOTSK>
3	EXAMSEM0	Priority	Single	0	0	
4	EXAMSEM1	Priority	Single	0	0	
5	EXAMSEM2	Priority	Single	0	0	
6	WRITSEMA	FIFO	Single	0	0	
7	Dsema1	Priority	Single	0	3	<#7:Dtask3>2980 ticks<#3:Dcounter2>, <#10:Dtask6>5980 ticks<#3:Dc...
8	Dsema2	FIFO	Multiple	0	0	<#10:Dtask6>5980 ticks<#3:Dcounter2>
9	TASKSEMA	Priority	Single	0	0	
10	PARTSEMA	Priority	Single	1	0	
11	MBOXSEMA	Priority	Single	0	0	
12	MUTXSEMA	Priority	Single	1	1	
13	QNESEMA	Priority	Single	0	0	
14	QNFSEMA	Priority	Single	1	0	
15	AESEMA	Priority	Single	0	0	
16	AASEMA	Priority	Single	0	0	
17	<Not used>					

Figure 330 - RTXC Semaphores View

The available parameters are described in the table below:

Name	Description
#	The object id.
Name	The name assigned to the semaphore.
Wait Order	The semaphore's wait order that can be either Priority or FIFO.
Signal Type	The semaphore's signal type. Can be either Single or Multiple.
Count	The semaphore's current count.
Usage	The semaphore's usage count. Semaphore statistics must be enabled for displaying this information.
Waiter(s)	The task(s) currently waiting on the semaphore, if any. Only the first 5 tasks are shown.

Table 33 – RTXC Semaphore Parameters

EXPRESS LOGIC THREADX

The kernel awareness features for Express Logic ThreadX® real-time operating system in **Atollic TrueSTUDIO** provide the developer with a detailed insight into the internal data structures of the ThreadX kernel. During a debug session, the current state of the ThreadX kernel and the various ThreadX kernel objects such as tasks, mailboxes, semaphores and software timers, can be easily inspected in a set of dedicated views, in the **Atollic TrueSTUDIO Debug** perspective.

REQUIREMENTS

The kernel awareness features described in this document is based on ThreadX Cortex-M4/GNU Version G5.5.5.0.

FINDING THE VIEWS

A number of debugger views are available in the **Atollic TrueSTUDIO Debug** perspective when debugging an application containing the ThreadX real-time operating system.

These views are available from the **Show View** toolbar dropdown list button.

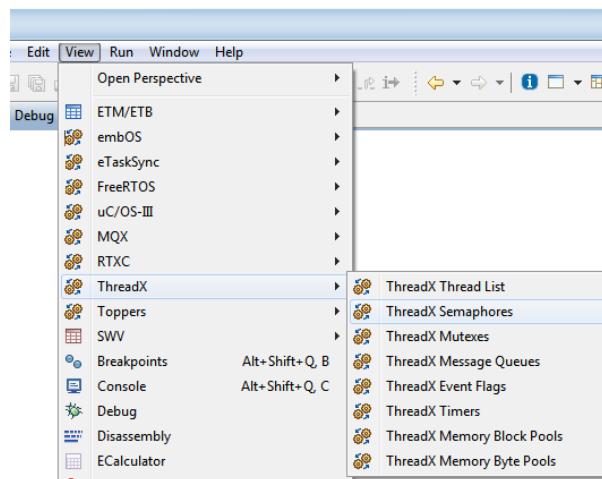


Figure 331 – ThreadX View Top Level Menu

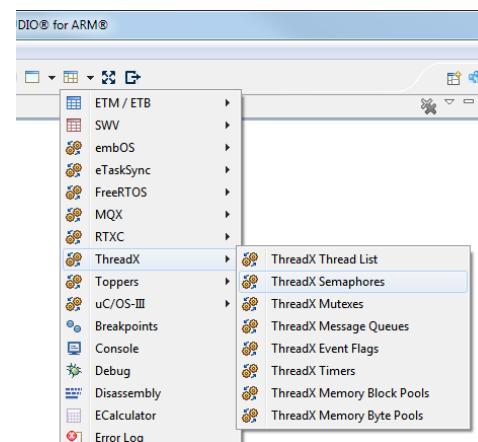


Figure 332 - ThreadX Show View Toolbar Button

THREAD LIST

The **ThreadX Thread List** view displays detailed information regarding all available threads in the target system. The thread list is updated automatically each time the target execution is suspended

There is one column for each type of thread parameter, and one row for each thread. If the value of any parameter for a particular thread has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

Name	Priority	State	Run Count	Stack Start	Stack End	Stack Size	Stack Ptr	Stack Usage
thread 0	1	SUSPENDED (byte pool 0)	7	0x20000990	0x20000d8f	1024	0x20000d00	144
thread 1	16	RUNNING	53044	0x20000d98	0x20001197	1024	0x20001110	152
thread 2	16	READY	53067	0x200011a0	0x2000159f	1024	0x20001510	160
thread 3	8	SUSPENDED (semaphore 0)	390	0x200015a8	0x200019a7	1024	0x20001928	128
thread 4	8	SLEEP (2)	391	0x200019b0	0x20001daf	1024	0x20001d30	128
thread 5	4	SUSPENDED (event flags 0)	7	0x20001db8	0x200021b7	1024	0x20002120	152
thread 6	8	SUSPENDED (mutex 0)	390	0x200021c0	0x200025bf	1024	0x20002538	136
thread 7	8	SLEEP (2)	390	0x200025c8	0x200029c7	1024	0x20002948	136
thread i	1	COMPLETED	1	0x20000588	0x20000987	1024	0x20000938	144
thread system info	1	SLEEP (36)	8	0x200029d0	0x20002dcf	1024	0x20002d30	180
Idle								

Figure 333 - ThreadX Thread List View

Please note that due to performance reasons, stack analysis (the **Stack Usage** column) is disabled by default. To enable stack analysis, use the **Stack analysis** toggle toolbar button in the **View** toolbar:



The available parameters are described in the table below:

Name	Description
N/A	Indicates the currently running thread. The currently running thread is indicated by a green arrow symbol.
Name	The thread name.
Priority	The thread priority.
State	The state of the current thread. The name of the object that currently suspends a thread is presented in parenthesis. For sleeping threads, the remaining sleep time (ticks) is presented.
Run Count	The threads run counter.
Stack Start	The start address of the stack area.
Stack End	The end address of the stack area.
Stack Size	The size of the stack area (bytes).
Stack Ptr	The address of the thread stack pointer.
Stack Usage	The maximum stack usage (bytes).

Table 34 – ThreadX Thread Parameters

SEMAPHORES

The **ThreadX Semaphores** view displays detailed information regarding all available resource semaphores in the target system. The view is updated automatically each time the target execution is suspended.

There is one column for each type of semaphore parameter, and one row for each semaphore. If the value of any parameter for a particular semaphore has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

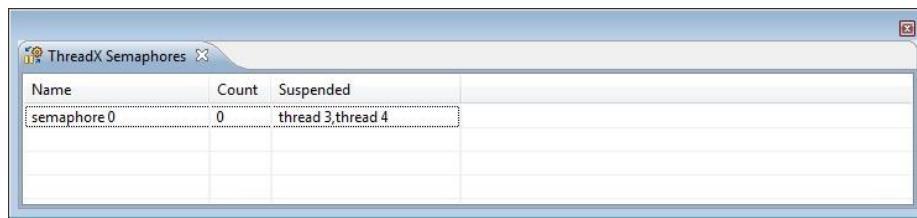


Figure 334 - ThreadX Semaphores View

The available parameters are described in the table below:

Column	Description
Name	The name of the semaphore.
Count	The current semaphore count.
Suspended	The threads currently suspended because of the semaphore state.

Table 35 – ThreadX Semaphore Parameters

MUTEXES

The **ThreadX Mutexes** view displays detailed information regarding all available mutexes in the target system. The view is updated automatically each time the target execution is suspended.

There is one column for each type of mutex parameter, and one row for each mutex. If the value of any parameter for a particular mutex has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

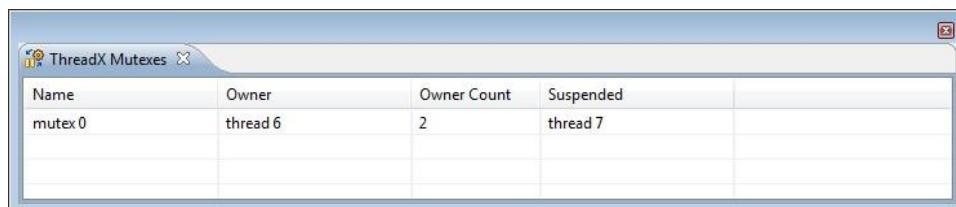


Figure 335 - ThreadX Mutexes View

The available parameters are described in the table below:

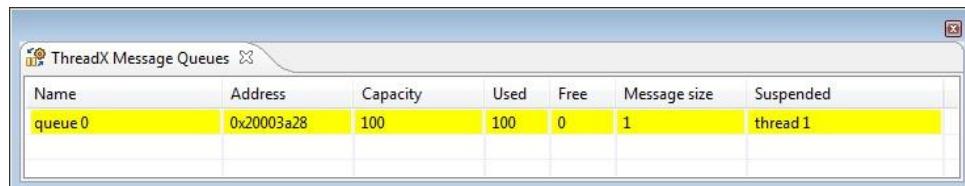
Column	Description
Name	The name of the mutex.
Owner	The thread that currently owns the mutex.
Owner Count	The mutex owner count (number of get operations performed by the owner thread).
Suspended	The threads currently suspended because of the mutex state.

Table 36 – ThreadX Mutex Parameters

MESSAGE QUEUES

The **ThreadX Message Queues** view displays detailed information regarding all available message queues in the target system. The view is updated automatically each time the target execution is suspended.

There is one column for each type of message queue parameter, and one row for each message queue. If the value of any parameter for a particular message queue has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.



A screenshot of a Windows-style dialog box titled "ThreadX Message Queues". The dialog contains a table with the following data:

Name	Address	Capacity	Used	Free	Message size	Suspended
queue 0	0x20003a28	100	100	0	1	thread1

Figure 336 - ThreadX Message Queues View

The available parameters are described in the table below:

Column	Description
Name	The name of the message queue.
Address	The address of the message queue.
Capacity	The maximum number of entries allowed in the queue.
Used	The current number of used entries in the queue.

Column	Description
Free	The current number of free entries in the queue.
Message size	The size (in 32-bit words) of each message entry.
Suspended	The threads currently suspended because of the message queue state.

Table 37 – ThreadX Message Queue Parameters

EVENT FLAGS

The **ThreadX Event Flags** view displays detailed information regarding all available event flag groups in the target system. The view is updated automatically each time the target execution is suspended.

There is one column for each type of parameter, and one row for each event flag group. If the value of any parameter for a particular event flag group has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.



Figure 337 - ThreadX Event Flags View

The available parameters are described in the table below:

Column	Description
Name	The name of the event flag group.
Flags	The current value of the event flag group.
Suspended	The threads currently suspended because of the state of the event flag group.

Table 38 – ThreadX Event Flag Parameters

TIMERS

The **ThreadX Timers** view displays detailed information regarding all available software timers in the target system. The timers view is updated automatically each time the target execution is suspended.

There is one column for each type of timer parameter, and one row for each timer. If the value of any parameter for a particular timer has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

Name	Remaining	Re-init	Function
MyTimer	68	100	0x8000bfd <myTimerCallback>

Figure 338 - ThreadX Timers View

The available parameters are described in the table below:

Name	Description
Name	The name of the software timer.
Remaining	The remaining number of ticks before the timer expires.
Re-init	The timer re-initialization value (ticks) after expiration. Contains value 0 for One-Shot timers.
Functions	The address and name of the function that will be called when the timer expires.

Table 39 – ThreadX Timer Parameters

MEMORY BLOCK POOLS

The **ThreadX Memory Block Pools** view displays detailed information regarding all available memory block pools in the target system. The view is updated automatically each time the target execution is suspended.

There is one column for each type of parameter, and one row for each memory block pool. If the value of any parameter for a particular memory block pool has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

ThreadX Memory Block Pools								
Name	Address	Used	Free	Total	Block size	Pool size	Suspended	
block pool 0	0x20002f70	0	12	12	4	100		

Figure 339 - ThreadX Memory Block Pools View

The available parameters are described in the table below:

Column	Description
Name	The name of the block pool.
Address	The block pool starting address.
Used	The current number of allocated blocks.
Free	The current number of free blocks.
Size	The total number of blocks available.
Block size	The size (bytes) of each block.
Pool size	The total pool size (bytes).
Suspended	The threads currently suspended because of the state of the memory block pool.

Table 40 – ThreadX Memory Block Pool Parameters

MEMORY BYTE POOLS

The **ThreadX Memory Byte Pools** view displays detailed information regarding all available memory byte pools in the target system. The view is updated automatically each time the target execution is suspended.

There is one column for each type of parameter, and one row for each memory byte pool. If the value of any parameter for a particular memory byte pool has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

Name	Address	Used	Free	Size	Fragments	Suspended
byte pool 0	0x20000580	11492	72	11564	20	thread 0

Figure 340 - ThreadX Memory Byte Pools View

The available parameters are described in the table below:

Column	Description
Name	The name of the byte pool.
Address	The byte pool starting address.
Used	The current number of allocated bytes.
Free	The current number of free bytes.
Size	The total number of bytes available.
Fragments	The number of fragments.
Suspended	The threads currently suspended because of the state of the memory byte pool.

Table 41 – ThreadX Memory Pool Parameters

TOPPERS/ASP

The kernel awareness features for TOPPERS RTOS in **Atollic TrueSTUDIO** provide the developer with a detailed insight into the internal data structures of the TOPPERS kernel. During a debug session, the current state of the TOPPERS kernel and the various TOPPERS kernel objects such as tasks, semaphores, mailboxes, etc, can be easily inspected in a set of dedicated views, in the **Atollic TrueSTUDIO Debug** perspective.

Each view for the TOPPERS RTOS contains two tabs - one tab for the hardcoded Static Information and one tab for the Current dynamic status.

REQUIREMENTS

The kernel awareness features described in this document is based on TOPPERS/ASP Release 1.7.0.

FINDING THE VIEWS

The views are available in the **Atollic TrueSTUDIO Debug** perspective when debugging an application containing the TOPPERS real-time operating system.

They are available from the **Show View** toolbar dropdown list button.

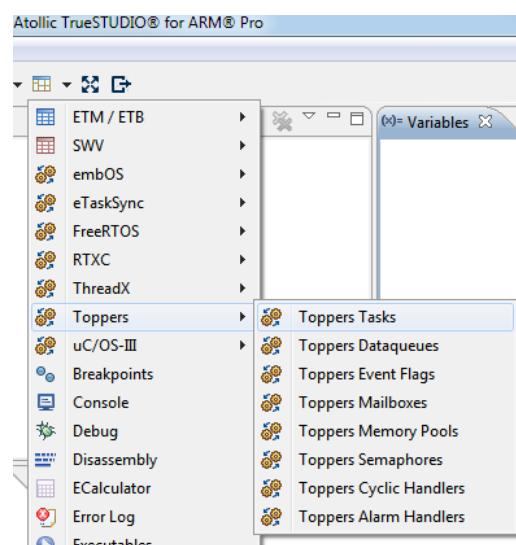


Figure 341 – TOPPERS Show View Toolbar Button

All displayed functions can be double-clicked and opened in the editor if the source file can be found in a source folder located within the Toppers project.

TASKS

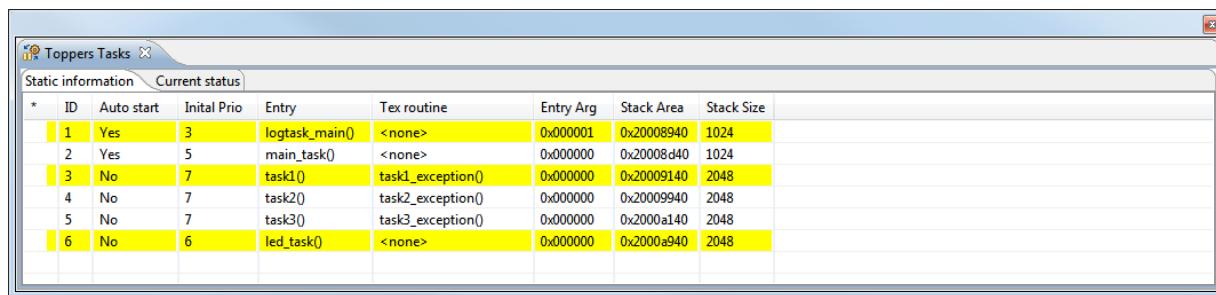
The **TOPPERS Tasks** view displays detailed information regarding all available tasks in the target system. The task list is updated automatically each time the target execution is suspended.

There is one column for each type of task parameter, and one row for each task. If the value of any parameter for a particular task has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

By double-clicking on a task entry, the source code for the entry will be opened in the editor if it can be found in a source folder located within the project.

By double-clicking on a Tex routine, the source code for it will be opened in the editor if it can be found in a source folder located within the project.

STATIC INFORMATION TAB



The screenshot shows a software interface titled "Toppers Tasks". Below the title bar are two tabs: "Static information" (which is selected) and "Current status". The main area is a table with the following data:

*	ID	Auto start	Initial Prio	Entry	Tex routine	Entry Arg	Stack Area	Stack Size
1	Yes	3		logtask_main()	<none>	0x000001	0x20008940	1024
2	Yes	5		main_task()	<none>	0x000000	0x20008d40	1024
3	No	7		task1()	task1_exception()	0x000000	0x20009140	2048
4	No	7		task2()	task2_exception()	0x000000	0x20009940	2048
5	No	7		task3()	task3_exception()	0x000000	0x2000a140	2048
6	No	6		led_task()	<none>	0x000000	0x2000a940	2048

Figure 342 – TOPPERS Tasks Static Information Tab

The available system variables are described in the table below:

Name	Description
ID	The Task base ID
Auto start	If the Task is to auto start or not. Displays yes or No.
Initial Prio	The Initial Prio for the task.
Entry	Task Entry function name or address.
Tex routine	Task exception function name or address.

Name	Description
Entry Arg	Display exinf value as Hex form.
Stack Area	Task Stack bottom address in Hex form.
Stack Size	The tasks stack size in decimal form.

Table 42 – TOPPERS Tasks Static Information

CURRENT STATUS TAB

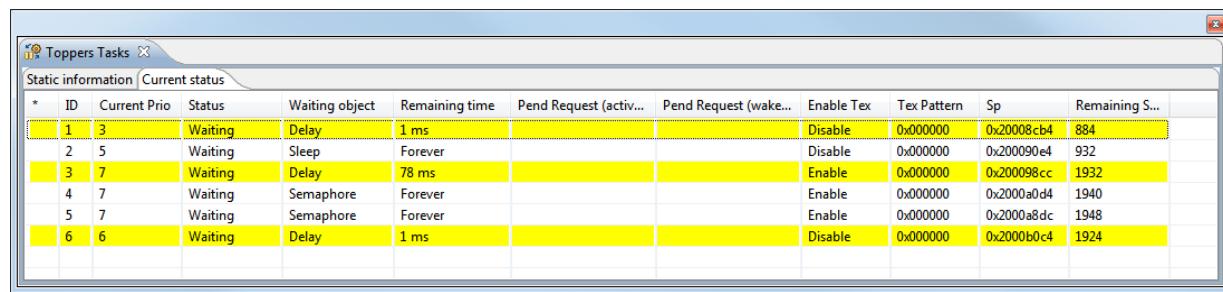


Figure 343 – TOPPERS Tasks Current Status Tab

The available system variables are described in the table below:

Name	Description
ID	The Task base ID
Current Prio	The current Prio for the Task.
Status	Displays Running, Dormant, Ready, Waiting, Suspended, Waiting-Suspended or Unknown
Waiting object	When Status is Waiting, this column displays Delay, Sleep, Recv DTQ, Recv PDTQ, Semaphore, EventFlag, Send DTQ, Send PDTQ, Mailbox or Mempool
Remaining time	When Status is Waiting, this column displays the remaining time waiting or Forever.
Pending Request (active)	Pend or blank.
Pending Request (wake-up)	Pend or blank.

Name	Description
Enable Tex	Enable, Disable or blank.
Tex Pattern	Displays texptn as Hex form or blank.
Sp	The Stack Pointer in hex.
Remaining Stack	The calculated remaining stack as an integer.

Table 43 – TOPPERS Tasks Current Status

DATAQUEUES

The **TOPPERS Dataqueues** view displays detailed information regarding all available data queues in the target system. The list is updated automatically each time the target execution is suspended.

There is one column for each type of data queue parameter, and one row for each data queue. If the value of any parameter for a particular data queue has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

STATIC INFORMATION TAB

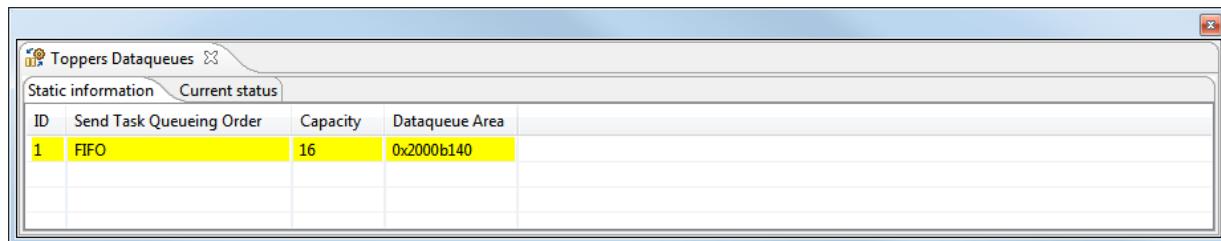


Figure 344 – TOPPERS Dataqueues Static Information Tab

The available system variables are described in the table below:

Name	Description
ID	The Data Queue base ID.
Send Task Queueing Order	Displays Priority or FIFO.
Capacity	The data queue quantity as a decimal value.

Name	Description
Dataqueue Area	The address in Hex form.

Table 44 – TOPPERS Dataqueue Static Information

CURRENT STATUS TAB

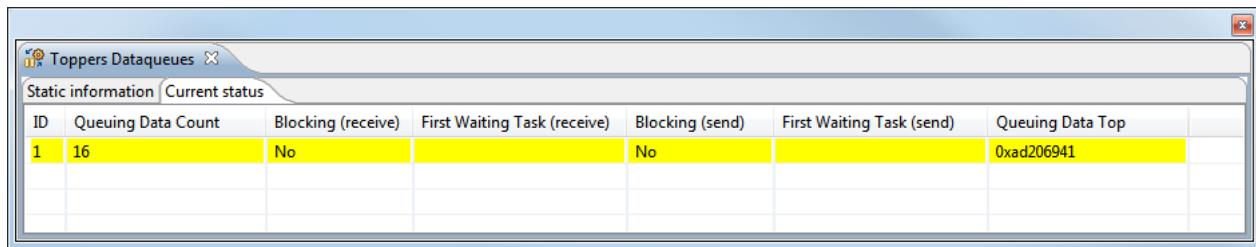


Figure 345 – TOPPERS Dataqueues Current Status Tab

The available system variables are described in the table below:

Name	Description
ID	The Data Queue base ID
Queuing Data Count	Displays count value in decimal form.
Blocking (receive)	If there is a waiting task of this object displays Yes, otherwise displays No.
First Waiting Task (receive)	When there is a waiting task of this object, displays 1st waiting task ID. When there is no waiting task of this object, displays blank space.
Blocking (send)	If there is a waiting task of this object displays Yes, otherwise displays No.
First Waiting Task (send)	When there is a waiting task of this object, displays 1st waiting task ID. When there is no waiting task of this object, displays blank space.
Queuing Data Top	When there is queuing data, display 1st queuing data address as Hex.

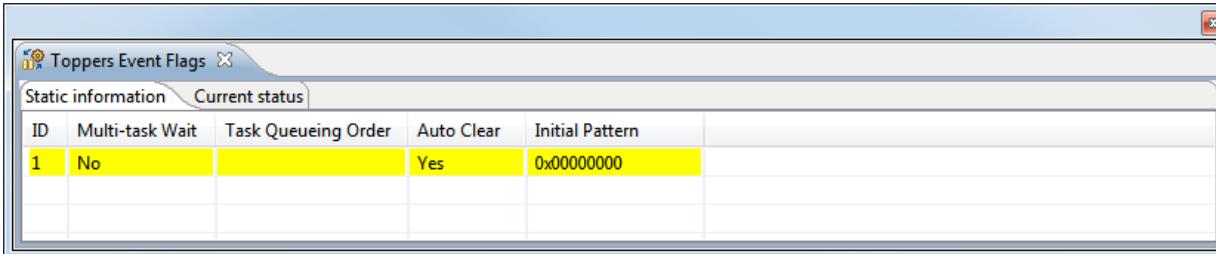
Table 45 – TOPPERS Dataqueues Current Status

EVENT FLAGS

The **TOPPERS Event Flags** view displays detailed information regarding all available event flags in the target system. The list is updated automatically each time the target execution is suspended.

There is one column for each type of event flag parameter, and one row for each event flag. If the value of any parameter for a particular event flag has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

STATIC INFORMATION TAB



The screenshot shows a Windows-style application window titled "Toppers Event Flags". It has two tabs at the top: "Static information" (which is selected) and "Current status". The main area is a table with the following data:

ID	Multi-task Wait	Task Queueing Order	Auto Clear	Initial Pattern
1	No		Yes	0x00000000

Figure 346 – TOPPERS Event Flags Static Information Tab

The available system variables are described in the table below:

Name	Description
ID	The Event Flag ID.
Multi-task Wait	If true displays Yes, otherwise displays No.
Task Queueing Order	Displays Priority or FIFO.
Auto Clear	If true displays Yes, otherwise displays No.
Initial Pattern	Display the iflgptn value as Hex form.

Table 46 – TOPPERS Event Flags Static Information

CURRENT STATUS TAB

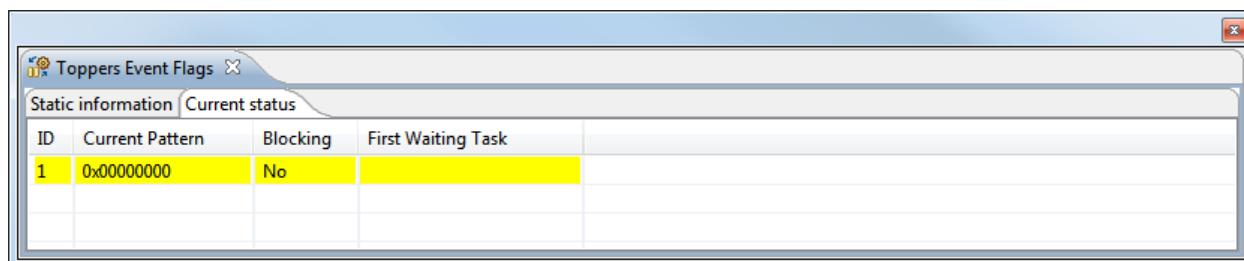


Figure 347 – TOPPERS Event Flags Current Status Tab

The available system variables are described in the table below:

Name	Description
ID	The Event Flag ID
Current Pattern	Display flgptn value as Hex form.
Blocking	If there is a waiting task of this object displays Yes, otherwise displays No.
First Waiting Task	When there is a waiting task of this object, displays 1st waiting task ID. When there is no waiting task of this object, displays blank space.

Table 47 – TOPPERS Event Flags Current Status

MAILBOXES

The **TOPPERS Mailboxes** view displays detailed information regarding all available mailboxes in the target system. The list is updated automatically each time the target execution is suspended.

There is one column for each type of mailbox parameter, and one row for each mailbox. If the value of any parameter for a particular mailbox has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

STATIC INFORMATION TAB

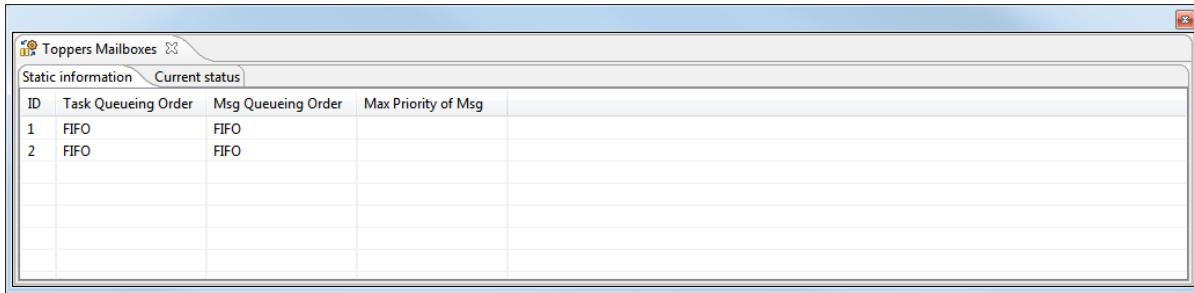


Figure 348 – TOPPERS Mailboxes Static Information Tab

The available system variables are described in the table below:

Name	Description
ID	The Mailbox ID.
Task Queueing Order	Displays Priority or FIFO.
Message Queueing Order	Displays Priority or FIFO.
Max Priority of Message	The maximum prio value in decimal form.

Table 48 – TOPPERS Mailboxes Static Information

CURRENT STATUS TAB

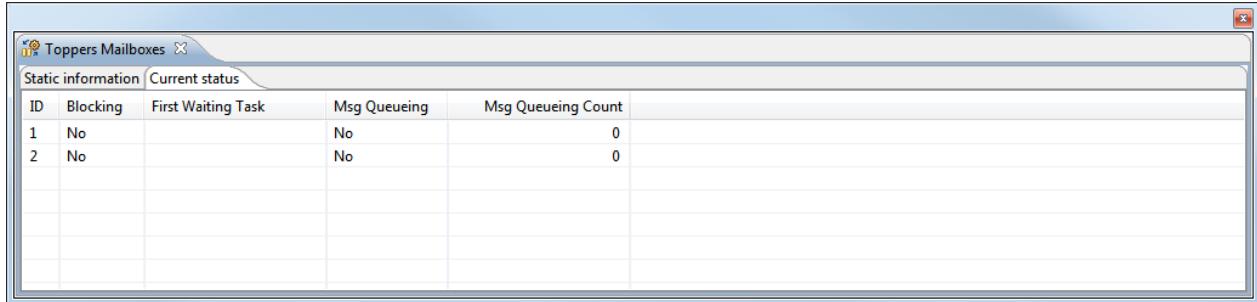


Figure 349 – TOPPERS Mailboxes Current Status Tab

The available system variables are described in the table below:

Name	Description
ID	The Mailbox ID
Blocking	If there is a waiting task of this object displays Yes, otherwise displays No.
First Waiting Task	When there is a waiting task of this object, displays 1st waiting task ID. When there is no waiting task of this object, displays blank space.
Msg Queueing	Displays No if there are no messages in this Mailbox, otherwise displays Yes.
Msg Queueing Count	When there is no message in this Mailbox display 0. Count posted message when there are messages in this Mailbox.

Table 49 – TOPPERS Mailboxes Current Status

MEMORY POOLS

The **TOPPERS Memory Pools** view displays detailed information regarding all available memory pools in the target system. The list is updated automatically each time the target execution is suspended.

There is one column for each type of memory pool parameter, and one row for each memory pool. If the value of any parameter for a particular memory pool has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

STATIC INFORMATION TAB

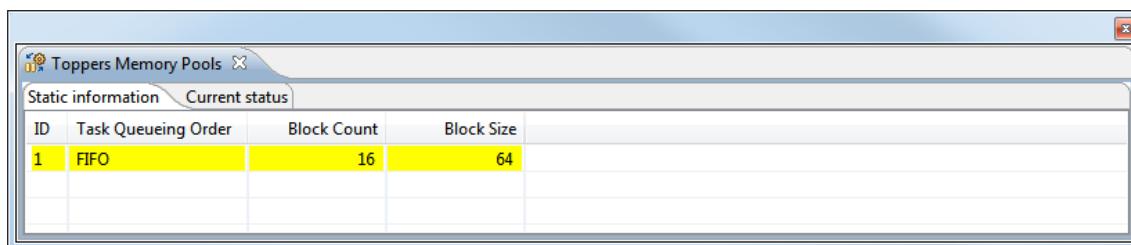


Figure 350 – TOPPERS Memory Pools Static Information Tab

The available system variables are described in the table below:

Name	Description
ID	The Memory Pool ID.
Task Queueing Order	Displays Priority or FIFO.
Block Count	Number of Blocks in this Memory Pool.
Block Size	Byte size of 1-block in decimal form.

Table 50 – TOPPERS Memory Pools Static Information

CURRENT STATUS TAB

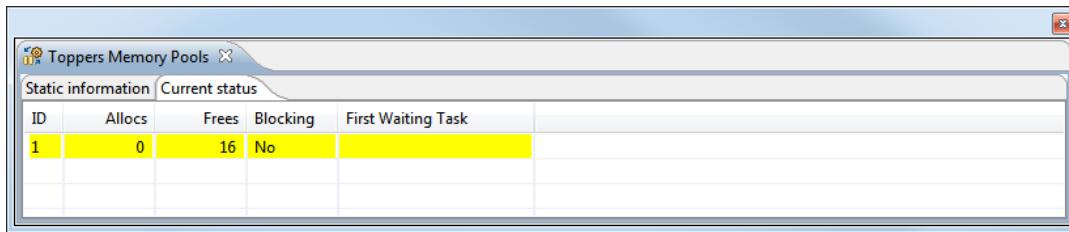


Figure 351 – TOPPERS Memory Pools Current Status Tab

The available system variables are described in the table below:

Name	Description
ID	The Memory Pool ID
Allocs	Number of allocated blocks in decimal form.
Frees	Number of free blocks in decimal form.
Blocking	Display Yes if there is a waiting task of this object, otherwise displays No.
First Waiting Task	Display 1st waiting task ID when there is a waiting task of this object.

Table 51 – TOPPERS Memory Pools Current Status

CYCLIC HANDLERS

The **TOPPERS Cyclic Handlers** view displays detailed information regarding all available cyclic handlers in the target system. The list is updated automatically each time the target execution is suspended.

There is one column for each type of cyclic handler parameter, and one row for each cyclic handler. If the value of any parameter for a particular cyclic handler has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

By double-clicking on a handler, the source code for the handler will be opened in the editor if it can be found in a source folder located within the project.

STATIC INFORMATION TAB

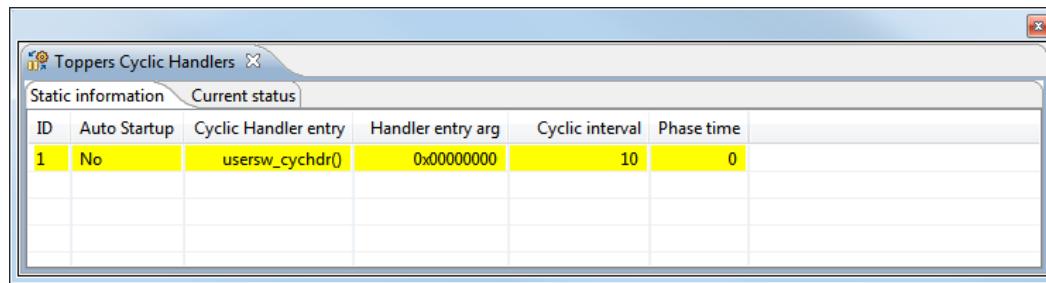


Figure 352 – TOPPERS Cyclic Handlers Static Information Tab

The available system variables are described in the table below:

Name	Description
ID	The Cyclic Handler ID.
Auto Startup	Displays Yes if the Cyclic Handler is set to start automatically, otherwise No.
Cyclic Handler Entry	Cyclic Handler Entry function name or address in hexadecimal form.
Handler Entry Argument	The handler argument value in hex form.
Cyclic Interval	The Cyclic interval in ms.
Phase Time	The Phase interval in ms.

Table 52 – TOPPERS Cyclic Handlers Static Information

CURRENT STATUS TAB

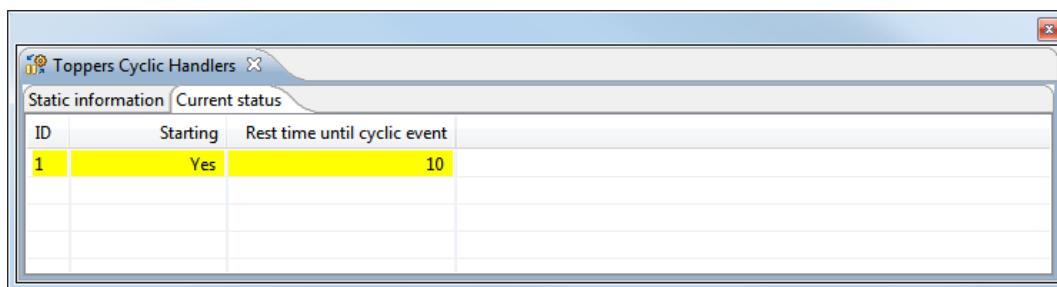


Figure 353 – TOPPERS Cyclic Handlers Current Status Tab

The available system variables are described in the table below:

Name	Description
ID	The Cyclic Handler ID
Starting	If the Cyclic Handler is starting Yes is displayed, otherwise No.
Rest time until cyclic event	Display Remaining time as ms in decimal form when Cyclic event is started.

Table 53 – TOPPERS Cyclic Handlers Current Status

ALARM HANDLERS

The **TOPPERS Alarm Handlers** view displays detailed information regarding all available alarm handlers in the target system. The list is updated automatically each time the target execution is suspended.

There is one column for each type of alarm handler parameter, and one row for each alarm handler. If the value of any parameter for a particular alarm handler has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

By double-clicking on a handler, the source code for the handler will be opened in the editor if it can be found in a source folder located within the project.

STATIC INFORMATION TAB

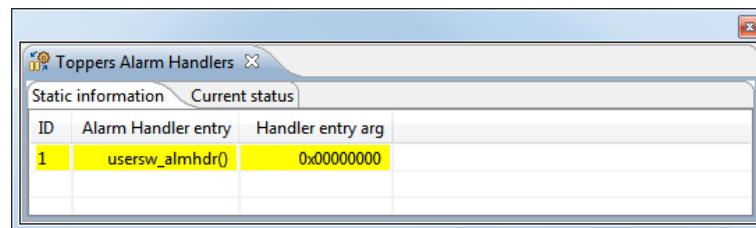


Figure 354 – TOPPERS Alarm Handlers Static Information Tab

The available system variables are described in the table below:

Name	Description
ID	The Alarm Handler ID.
Alarm Handler Entry	Alarm Handler Entry function name or address in hexadecimal form.
Handler Entry Argument	The handler argument value in hex form.

Table 54 – TOPPERS Alarm Handlers Static Information

CURRENT STATUS TAB

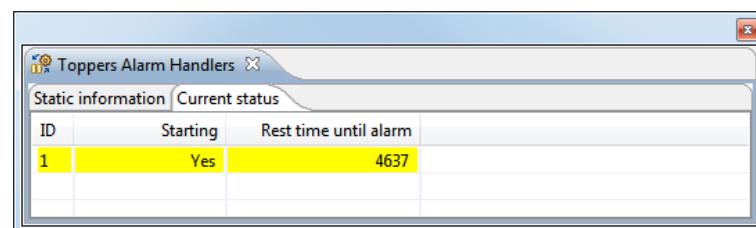


Figure 355 – TOPPERS Alarm Handlers Current Status Tab

The available system variables are described in the table below:

Name	Description
ID	The Alarm Handler ID
Starting	If the Alarm Handler is starting Yes is displayed, otherwise No.

Name	Description
Rest time until alarm	Display Remaining time as ms in decimal form when Alarm is started.

Table 55 – TOPPERS Alarm Handlers Current Status Information

PRIORITIZED DATAQUEUES

The **TOPPERS Prioritized Dataqueues** view displays detailed information regarding all available prioritized data queues in the target system. The list is updated automatically each time the target execution is suspended.

There is one column for each type of prioritized data queue parameter, and one row for each prioritized data queue. If the value of any parameter for a particular prioritized data queue has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

STATIC INFORMATION TAB

ID	Send Task Queueing Order	Capacity	Max Data Priority
1	FIFO	4	16
2	FIFO	8	16
3	FIFO	8	16

Figure 356 – TOPPERS Prioritized Dataqueues Static Information Tab

The available system variables are described in the table below:

Name	Description
ID	The prioritized data queue base ID.
Send Task Queueing Order	Displays Priority or FIFO.
Capacity	The prioritized data queue quantity as a decimal value.

Name	Description
Max Data Priority	Max priority of prioritized-Data.

Table 56 – TOPPERS Prioritized Dataqueue Static Information

CURRENT STATUS TAB

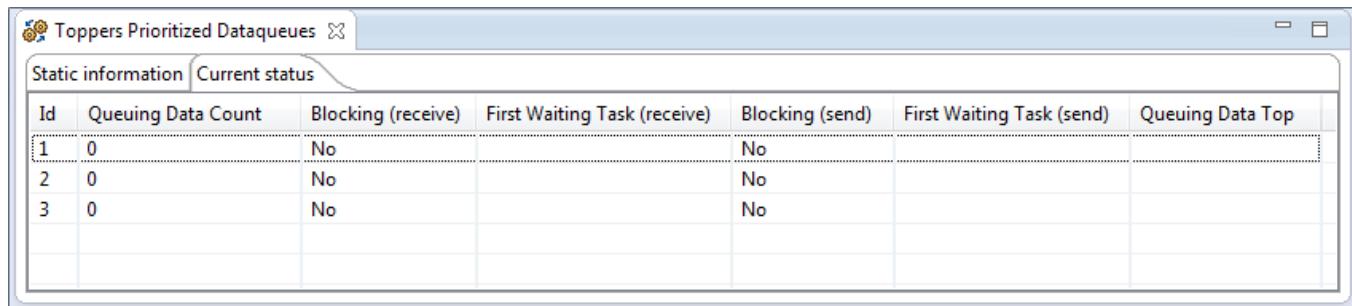


Figure 357 – TOPPERS Prioritized Dataqueues Current Status Tab

The available system variables are described in the table below:

Name	Description
ID	The Data Queue base ID
Queuing Data Count	Displays count value in decimal form.
Blocking (receive)	If there is a waiting task of this object displays Yes, otherwise displays No.
First Waiting Task (receive)	When there is a waiting task of this object, displays 1st waiting task ID. When there is no waiting task of this object, displays blank space.
Blocking (send)	If there is a waiting task of this object displays Yes, otherwise displays No.
First Waiting Task (send)	When there is a waiting task of this object, displays 1st waiting task ID. When there is no waiting task of this object, displays blank space.
Queuing Data Top	When there is queuing data, display 1st queuing data address as Hex.

Table 57 – TOPPERS Prioritized Dataqueues Current Status Information

SYSTEM STATUS

The **TOPPERS System Status** view displays detailed information regarding the system.

There are two columns with status values. If one value has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

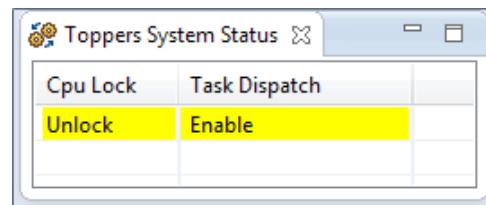


Figure 358 – TOPPERS System Status View

The available system values are described in the table below:

Name	Description
Cpu Lock	CPU lock flag
Task Dispatch	Enable flag of dispatching task

Table 58 – TOPPERS System Status Information

INTERRUPT LINE CONFIGURATION

The **TOPPERS Interrupt Line Config** view displays detailed information regarding all available Interrupts in the target system.

There is one column for each type of interrupt parameter, and one row for each interrupt.

The SWV Exception view is recommended for more information about each interrupt. See Page 298 - *Exception Tracing*.

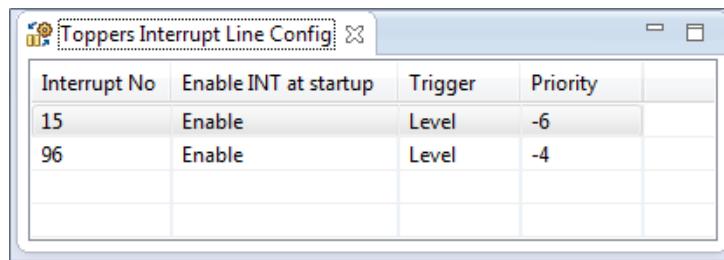


Figure 359 – TOPPERS Interrupt Line Config View

The available system variables are described in the table below:

Name	Description
Interrupt No	The Interrupt Line number
Enable INT at startup	Displays Enable or Disable
Trigger	Displays Edge or Level
Priority	Priority of Interrupt

Table 59 – TOPPERS Interrupt Line Config Information

INTERRUPT HANDLER STATIC INFORMATION

The **TOPPERS Interrupt Handler Static Info** view displays detailed information regarding all available Interrupts in the target system

There is one column for each type of interrupt parameter, and one row for each interrupt.

The SWV Exception view is recommended for more information about each interrupt. See Page 298 - *Exception Tracing*.

By double-clicking on an interrupt handler, the source code for it will be opened in the editor if it can be found in a source folder located within the project.

Interrupt Handler No	Outside Kernel	Interrupt Handler Entry
15	Kernel	target_timer_handler()
96	Kernel	_kernel_inthdr_96()

Figure 360 – TOPPERS Interrupt Handler Static Info View

The available system variables are described in the table below:

Name	Description
Interrupt Handler No	The Interrupt Line number
Outside Kernel	Displays Outside or Kernel
Priority	Handler entry address

Table 60 – TOPPERS Interrupt Handlers Static Information

CPU EXCEPTION HANDLER STATIC INFORMATION

The **TOPPERS Exception Handler Static Info** view displays detailed information regarding all available CPU exception in the target system

There is one column for each type of exception parameter, and one row for each exception.

By double-clicking on an Exception handler, the source code for it will be opened in the editor if it can be found in a source folder located within the project.

Exception Handler ...	Exception Handler Entry
6	cpuexc_handler()

Figure 361 – TOPPERS Exception Handler Static Info View

The available system variables are described in the table below:

Name	Description
Exception Handler No	CPU Exception Handler No.
Exception Handler Entry	Handler entry address

Table 61 – TOPPERS Interrupt Handlers Static Information

MICRIUM µC/OS-III

The kernel awareness features for Micrium µC/OS-III™ in **Atollic TrueSTUDIO** provide the developer with a detailed insight into the internal data structures of the µC/OS-III kernel. During a debug session, the current state of the µC/OS-III kernel and the various µC/OS-III kernel objects such as tasks, memory partitions, message queues, semaphores and software timers, can be easily inspected in a set of dedicated views, in the **Atollic TrueSTUDIO Debug** perspective.

REQUIREMENTS

The kernel awareness features described in this document is based on µC/OS-III V3.02.00.



Please note that the level of information available in the different views in **Atollic TrueSTUDIO** depends on the configuration of the µC/OS-III RTOS. If some feature is not enabled, the views presented in this document may contain columns presenting information such as "N/A" (Not Applicable) or "0" instead of expected values when debugging the target system. The Micrium µC/OS-III Users Guide contains information on how different features can be enabled in the operating system.

E.g. Enable statistics task in os_cfg.h:
`#define OS_CFG_STAT_TASK_EN 1u`

FINDING THE VIEWS

A number of debugger views are available in the **Atollic TrueSTUDIO Debug** perspective when debugging an application containing the µC/OS-III real-time operating system.

These views are available from the **Show View** toolbar dropdown list button.

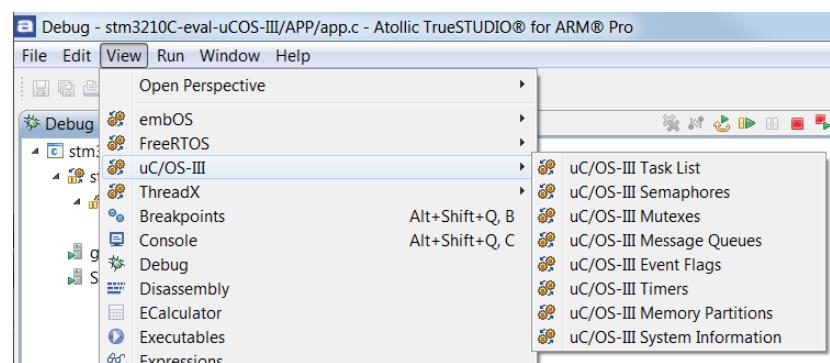


Figure 362 - View Top Level Menu

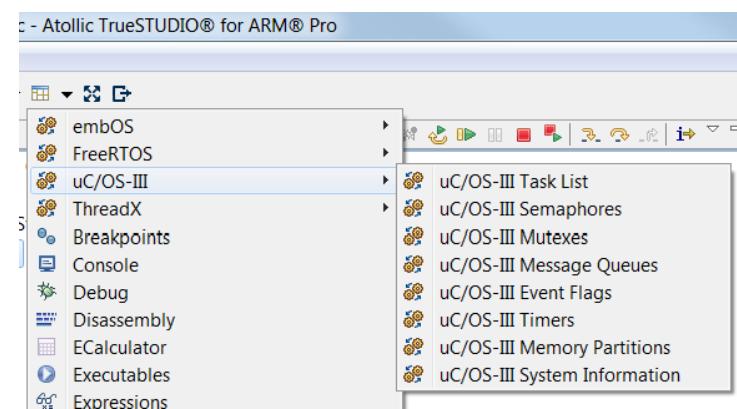


Figure 363 - Show View Toolbar Button

SYSTEM INFORMATION

The **μC/OS-III System Information** view displays a number of system variables available in the μC/OS-III kernel, such as state, version, CPU usage, different counter information, etc.

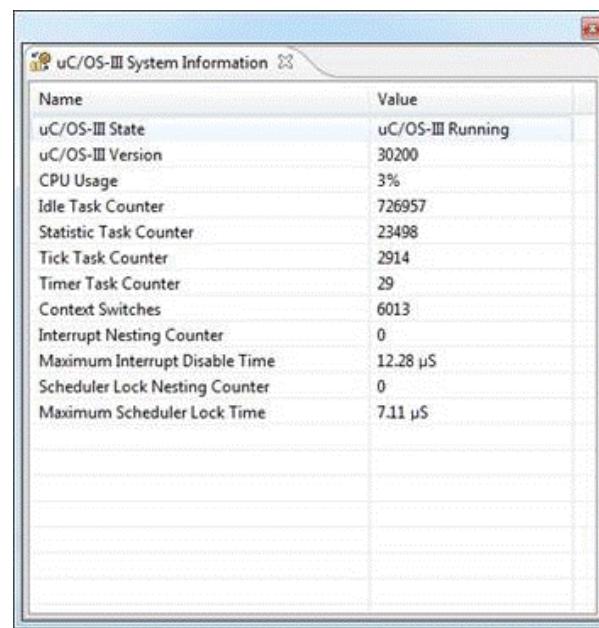


Figure 364 - uC/OS-III System Information View

The available system variables are described in the table below:

Name	Description
uC/OS-III State	The current status of uC/OS-III.
uC/OS-III Version	The version of the RTOS.
CPU Usage	The actual CPU usage of all tasks.
Idle Task Counter	The idle task counter.
Statistic Task Counter	The statistic task counter.
Tick Task Counter	The tick task counter.
Timer Task Counter	The timer task counter.
Context Switches	The total number of context switches.
Interrupt Nesting Counter	The interrupt nesting level counter.
Max Interrupt Disable Time	The maximum interrupt disabled time (µs).

Name	Description
Scheduler Lock Nesting Counter	The counter for the nesting level of the scheduler lock.
Max Scheduler Lock Time	The maximum amount of time the scheduler was locked irrespective of which task did the locking

Table 62 – μC/OS-III System Variables

TASK LIST

The **μC/OS-III Task List** view displays detailed information regarding all available tasks in the target system. The task list is updated automatically each time the target execution is suspended.

There is one column for each type of task parameter, and one row for each task. If the value of any parameter for a particular task has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

Item	Name	Prio	State	Pend On	Ticks Rem	CPU Usage	CtxSwtCtr	IDT	SLT	Stack Info	Stack Usage	Task Queue	Task Queue Sent Times	Task Sem Ctr	Task Sem Signal Times
0	Consumer Task	5	Pending	Message Queue (queue1)	0	0%	1	8.26	0.0	0/0/512	0.0%	0/0/0	0.0/0.0	0	0.0/0.0
1	Producer Task	6	Ready		0	0%	2	4.63	0.0	0/0/512	0.0%	0/0/0	0.0/0.0	0	0.0/0.0
2	Lp Task	4	Pending	Event Flag Group (flag group1)	0	0%	1	8.65	0.0	0/0/512	0.0%	0/0/0	0.0/0.0	0	0.0/0.0
3	Hp Task	3	Delayed		5	0%	11	5.56	0.0	0/0/512	0.0%	0/0/0	0.0/0.0	0	0.0/0.0
4	App Task Start	2	Delayed		51	0%	1	4.63	7.18	60/452/512	11.72%	0/0/0	0.0/0.0	0	0.0/0.0
5	uC/OS-III Timer Task	6	Pending	Task Semaphore (Task Sem)	0	0%	0	0.0	0.0	53/75/128	41.41%	0/0/0	0.0/0.0	0	70.93/0.0
6	uC/OS-III Stat Task	6	Delayed		51	0%	0	4.67	0.0	40/88/128	31.25%	0/0/0	0.0/0.0	0	0.0/0.0
7	uC/OS-III Tick Task	5	Pending	Task Semaphore (Task Sem)	0	0%	44	12.36	0.0	45/83/128	35.16%	0/0/0	0.0/0.0	0	70.82/70.82
8	uC/OS-III Idle Task	7	Ready		0	0%	34	5.49	0.0	24/104/128	18.75%	0/0/0	0.0/0.0	0	0.0/0.0

Figure 365 - μC/OS-III Task List View

The available parameters are described in the table below:

Name	Description
N/A	Indicates the currently running task. The currently running task is indicated by a green arrow symbol.
Name	The task name.
Prio	The task priority. Low number indicates high priority.
State	The current state of the task.
Pend On	The type of the object the task is waiting on and in

Name	Description
	parenthesis the name of the actual object.
Ticks Rem	The amount of time (ticks) remaining for a delayed task to become ready-to-run or for a pending task to timeout
CPU Usage	The task CPU usage.
CtxSwCtr	The number of times the task has executed (switched in).
IDT (Interrupt Disable Time)	The maximum amount of time (μ s) interrupts has been disabled by the task.
SLT (Scheduler Lock Time)	The maximum amount of time (μ s) the scheduler has been locked by the task.
Stack Info	The stack information: Used/Free/Size, expressed in number of stack entries.
Stack Usage	The stack usage.
Task Queue	Task queue information: Current/Maximum/Size.
Task Queue Sent Times	Task queue sent times: Latest/Maximum. The amount of time (μ s) it took for a message to be sent and actually read by the task.
Task Sem Ctr	The number of times the task has been signaled while the task was not able to run.
Task Sem Signal Times	Task semaphore signal times: Latest/Maximum. The amount of time (μ s) it took for the task to execute after the semaphore was signaled.

Table 63 – μC/OS-III Task Parameters

SEMAPHORES

The **μC/OS-III Semaphores** view displays detailed information regarding all available resource semaphores in the target system. The view is updated automatically each time the target execution is suspended.

There is one column for each type of semaphore parameter, and one row for each semaphore. If the value of any parameter for a particular semaphore has changed since

the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

Item	Name	Counter	Time Stamp	Pend List Entries	Pend List
0	Serial Lock	1	0.0	0	
1	Serial Rx Wait	0	0.0	0	
2	Serial Tx Wait	0	0.0	0	
3	semaphore1	0	0.0	0	

Figure 366 - μC/OS-III Semaphores View

The available parameters are described in the table below:

Column	Description
Item	The semaphore item counter.
Name	The name of the semaphore.
Counter	The current semaphore count.
Time Stamp	The semaphore last signal time (μs).
Pend List Entries	The number of tasks pending on the semaphore.
Pend List	List of tasks pending on the semaphore. Highest priority tasks are sorted first in the list.

Table 64 – μC/OS-III Semaphore Parameters

MUTEXES

The **μC/OS-III Mutexes** view displays detailed information regarding all available mutexes in the target system. The view is updated automatically each time the target execution is suspended.

There is one column for each type of mutex parameter, and one row for each mutex. If the value of any parameter for a particular mutex has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

uC/OS-III Mutexes							
Item	Name	Owner	Owner Org Prio	Owner Nest Ctr	Time Stamp	Pend List Entries	Pend List
0	mutex1	Hp Task	3	1	3132736.01	1	Lp Task

Figure 367 - μC/OS-III Mutexes View

The available parameters are described in the table below:

Column	Description
Item	The mutex item counter.
Name	The name of the mutex.
Owner	The name of the task that currently owns the mutex.
Owner Org Prio	The owning task original priority (task priority may have been raised due to priority inheritance).
Owner Nest Ctr	The owning task nesting counter. Number of times the owning task acquired the mutex.
Time Stamp	Latest release time (μs).
Pend List Entries	Number of tasks pending on the mutex.
Pend List	List of tasks pending on the semaphore. Highest priority tasks are sorted first in list.

Table 65 – μC/OS-III Mutexes Parameters

MESSAGE QUEUES

The **μC/OS-III Message Queues** view displays detailed information regarding all available message queues in the target system. The view is updated automatically each time the target execution is suspended.

There is one column for each type of message queue parameter, and one row for each message queue. If the value of any parameter for a particular message queue has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

uC/OS-III Message Queues						
Item	Name	Size	Entries	Max entries	Pend List Entries	Pend List
0	queue1	50	0	0	1	Consumer Task

Figure 368 - μC/OS-III Message Queues View

The available parameters are described in the table below:

Column	Description
Item	The message queue item counter.
Name	The name of the message queue.
Size	The maximum number of entries allowed in the queue.
Entries	The current number of entries in the queue.
Max entries	The peak number of entries in the queue.
Pend List Entries	The number of tasks pending on the queue.
Pend List	List of tasks pending on the queue. Highest priority tasks are sorted first in list.

Table 66 – μC/OS-III Message Queue Parameters

EVENT FLAGS

The **μC/OS-III Event Flags** view displays detailed information regarding all available event flag groups in the target system. The view is updated automatically each time the target execution is suspended.

There is one column for each type of parameter, and one row for each event flag group. If the value of any parameter for a particular event flag group has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

uC/OS-III Event Flags					
Item	Name	Flags	Time Stamp	Pend List Entries	Pend List
0	flag group1	0	0.0	2	Hp Task, Lp Task

Figure 369 - μC/OS-III Event Flags View

The available parameters are described in the table below:

Column	Description
Item	The event flag group item counter.
Name	The name of the event flag group.
Flags	The current value of the event flag group.
Time Stamp	The last time the group was posted to.
Pend List Entries	The number of tasks pending on the event flag group.
Pend List	List of tasks pending on the event flag group. Highest priority tasks are sorted first in list.

Table 67 – μC/OS-III Event Flag Parameters

TIMERS

The **μC/OS-III Timers** view displays detailed information regarding all available software timers in the target system. The timers view is updated automatically each time the target execution is suspended.

There is one column for each type of timer parameter, and one row for each timer. If the value of any parameter for a particular timer has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.

Item	Name	Type	State	Match	Remain	Delay	Period	Callback
0	timer2	One-Shot	Running	101	0	100	0	0x8007e39 <timer2Callback>
1	timer1	Periodic	Running	131	0	0	130	0x8007e25 <timer1Callback>

Figure 370 - μC/OS-III Timers View

The available parameters are described in the table below:

Name	Description
Item	The timer item counter.

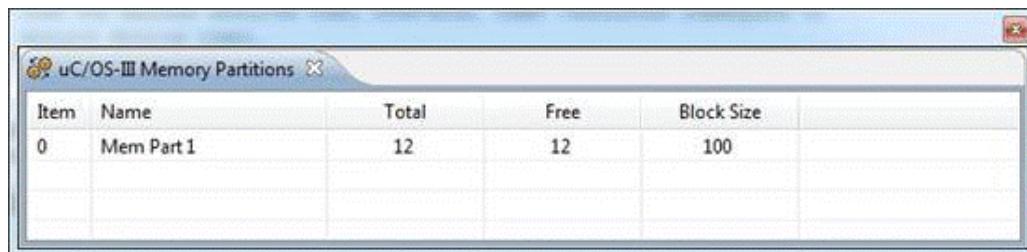
Name	Description
Name	The name of the software timer.
Type	The type of the timer.
State	The state of the timer.
Match	The time when the timer expires.
Remain	The time remaining before the timer expires.
Delay	The expiration time for one-shot timers and initial delay for periodic timers.
Period	The timer period (for periodic timers).
Callback	The address and name of function to call when the timer expires.

Table 68 – μC/OS-III Timer Parameters

MEMORY PARTITIONS

The **μC/OS-III Memory Partitions** view displays detailed information regarding all available memory partitions in the target system. The view is updated automatically each time the target execution is suspended.

There is one column for each type of parameter, and one row for each memory partition. If the value of any parameter for a particular memory partition has changed since the last time the debugger was suspended, the corresponding row will be highlighted in yellow.



Item	Name	Total	Free	Block Size
0	Mem Part 1	12	12	100

Figure 371 - μC/OS-III Memory Partitions View

The available parameters are described in the table below:

Column	Description
Item	The memory partition item counter.
Name	The name of the memory partition.
Total	The number of memory blocks available from the partition.
Free	The number of free memory blocks available from the partition.
Block size	The size of each memory blocks in the partition.

Table 69 – μC/OS-III Memory Partitions Parameters



Section 9. SOURCE CODE REVIEW

This section provides information on how to perform source code reviews and hold code review meetings with ***Atollic TrueSTUDIO for STM32***.

This section covers information on the following topics:

- Introduction to source code reviews and code review meetings
- The Review perspective and related views
- Creating and configuring reviews sessions
- Performing a 3-step source code review
- Additional reading and available templates and appendices

INTRODUCTION TO CODE REVIEWS

Atollic TrueSTUDIO for STM32 has integrated tool support for performing source code reviews and code review meetings. Code review is one of the most cost-effective ways of improving software quality. In order to learn more about code reviews, please visit the white paper section on the Atollic website and read our white paper on source code review. The tool support can be deployed in any project size, ranging from one to several developers. In this chapter, the project is assumed to contain more than one team member.

In order to put the concepts and terminology used in **Atollic TrueSTUDIO** into context, the two flow charts below are provided.

The first flow chart shows a commonly deployed software review workflow. The second flowchart shows the individual source code review steps available in **Atollic TrueSTUDIO**. The dashed lines between the two flow charts, map the steps of one flow chart to the corresponding steps in the other.

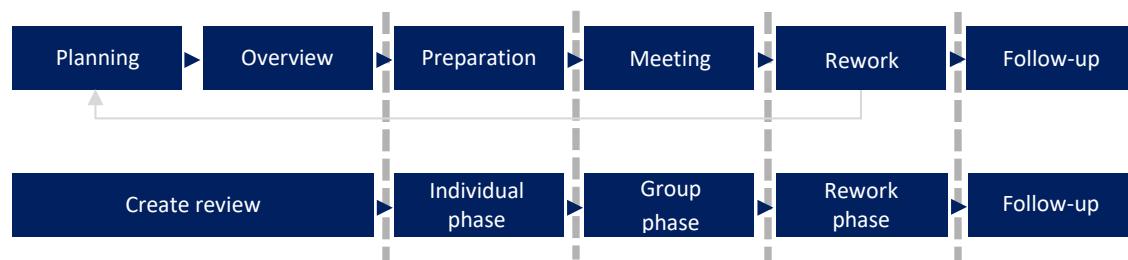


Figure 372 – Atollic TrueSTUDIO Support for the Code Review Workflow

Process step	Traditional content	Tool support in Atollic TrueSTUDIO
Planning / Create review	The review is planned by the moderator. A review topic is determined and the work product is outlined.	Create the review, choose authors, work product and configure problem types, resolution types, severity levels, etc.
Overview / Individual or Group phase	The author describes the background of the work product and the reviewers are educated regarding the work product at hand.	Once a review is created, a start-up meeting may be held where the author and the reviewers go through the work product in order to get an overview.
Preparation / Individual phase	Each reviewer examines the work product to identify possible defects.	Each reviewer examines the work product to identify possible defects.
Review meeting / Group phase	During this meeting the chairman goes through the work product, part by part, and the reviewers point out the defects found for each part.	The accumulated defects found by the group of reviewers are discussed.
Rework	The author makes changes to the work product according to the action plans from the inspection meeting.	The author makes changes to the work product according to the action plans from the review meeting.
Follow-up	The changes made by the author are checked to make sure everything is correct.	

Table 70 – Atollic TrueSTUDIO Support for the Code Review Workflow

PLANNING A REVIEW – REVIEW ID CREATION

A pre-requisite that is necessary in order to efficiently deploy code reviews within your project team is the access to a shared **Atollic TrueSTUDIO** project, either using a version control system, which is recommended, or using a network drive. All review comments are saved as XML formatted files in a selectable folder within the **Atollic TrueSTUDIO** project.

The comments may thus be shared between reviewers using a commonly accessed version control system. This is a big advantage, as no server-side database needs to be installed, configured and administered to perform code reviews. The normal version control system, such as GIT or Subversion, is used for team collaboration.

In order to perform a code review the first step is to create a review ID for this specific code review session. Creating a review ID is typically done by a moderator, which may be a team leader or an employee from the quality assurance department. This is a simple operation where the user is prompted to configure the following options:

- Review ID (= name) and description
- Review comment classification types
- Review comment severities
- Review comment resolution decisions
- Review comment statuses
- Work product content
- Authors/Reviewers for the review

The steps to create a specific code review session can be severely simplified by taking the time to create a project, or company standard, review template. All future reviews that are created later can then be based on this review template. The moderator will thus only be required to configure most of the above options once for each **TrueSTUDIO** workspace. This is described in next chapter.

Review comments are stored as XML formatted files in a selectable folder within the **TrueSTUDIO** project; one file for each reviewer. The overall review settings are saved as a hidden XML formatted file in the project root folder in the workspace.

A review ID is tightly connected to inspection of resources (files) for one **TrueSTUDIO** project. A review ID should preferably not contain any whitespaces as it will be part of the review storage file name.

CREATING A REVIEW ID

In order to create a review ID the user must access the properties for the **Atollie TrueSTUDIO** project that is containing the desired work product. This is done by performing the following steps:

- 1.** Select the project in **Project Explorer** view.
- 2.** Click on the **Build Settings** toolbar button or right-click on the project in the **Project Explorer** view and click **Properties**.

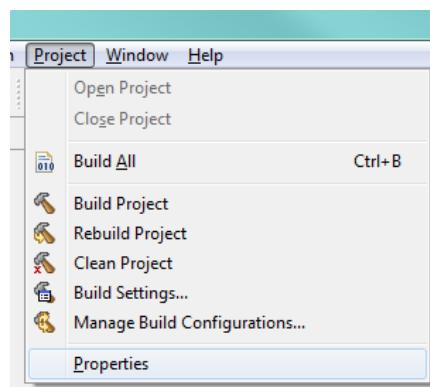


Figure 373 – Project Properties Menu Selection

- 3.** Select the **Review** node

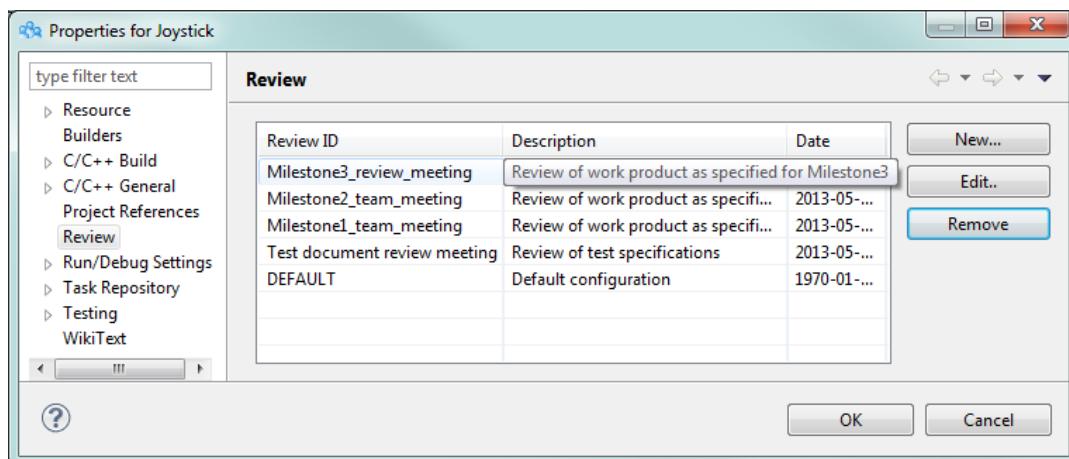


Figure 374 - GUI for Creating and Managing Code Reviews

- 4.** The user may choose to add a **New**, or **Edit** or **Remove** an existing, review in the dialog box.
- 5.** Click **New** to add a new **Review ID**.

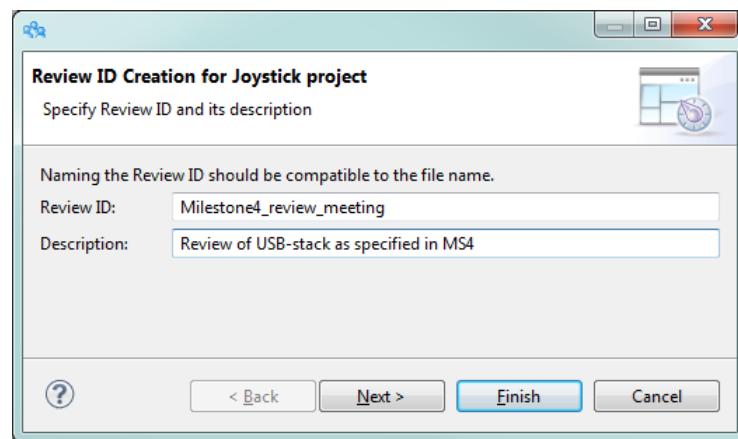


Figure 375 - Dialog for Creating a New Review ID

6. Give the review a Review ID, i.e. a name. It is recommended not to use whitespaces as this will be part of the file name. Also provide a short description for the meeting. Click **Next**.
7. The next step determines the work product for the meeting. Choose which files that will be subject to this review. Use the buttons to **Add** and **Remove** files.

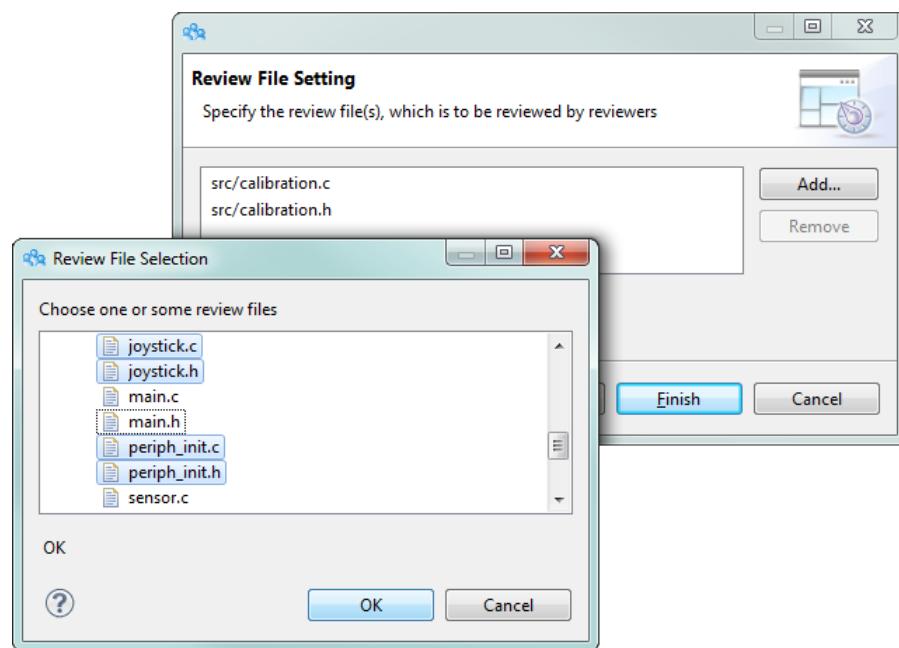


Figure 376 - Dialog for Managing the Work Product of a Review

8. Create a Reviewer ID by clicking **Add** and entering a reviewer name. Repeat for each reviewer that will attend the meeting. The review issues

collected by each reviewer will be stored in corresponding XML-formatted files. It is recommended not to use whitespaces in the reviewer IDs.

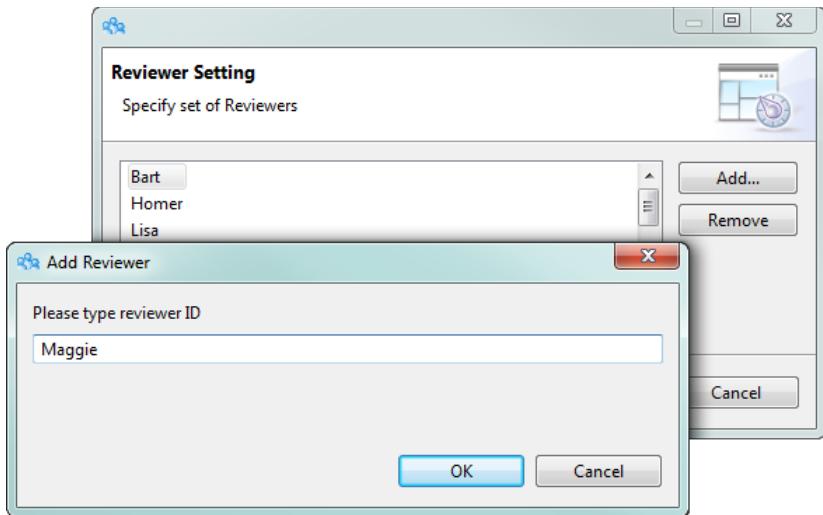


Figure 377 - Add Reviewers to the Review

9. Select an author among the reviewers. The review issues identified in the Team Phase will be assigned to the author as default. Naturally, an explicit assignment overrides the default.

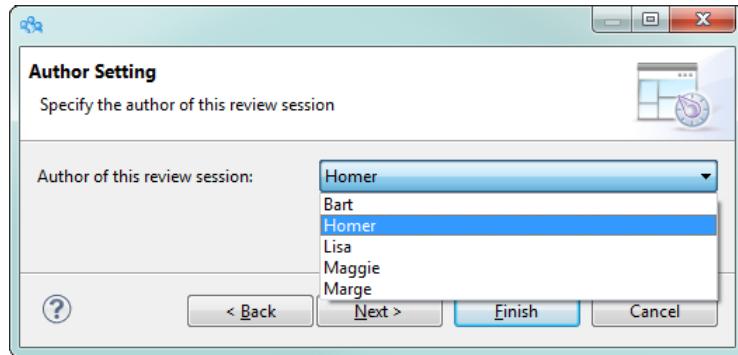


Figure 378 - Choose Author for the Review Session

10. In this step, it is possible to configure available parameter options for the review comments. The parameter options are:

- Review comment classification types
- Review comment severities
- Review comment resolution decisions
- Review comment statuses

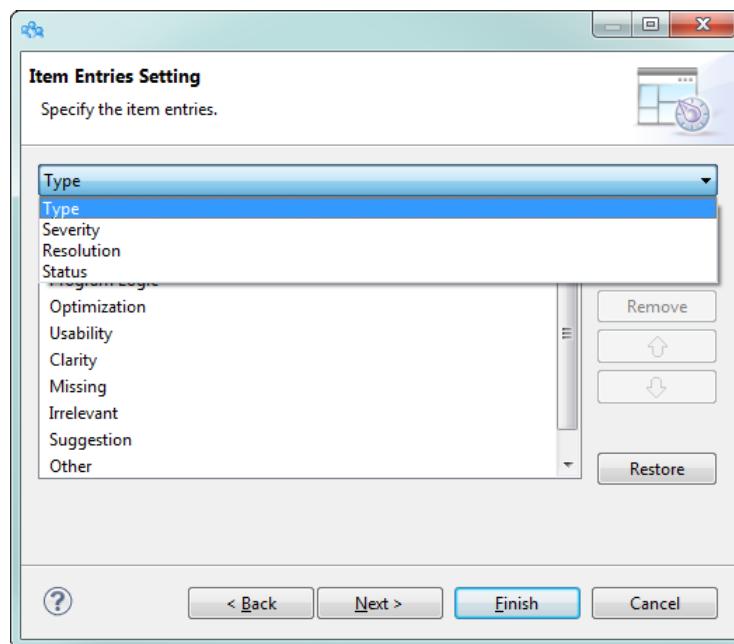


Figure 379 - Review Comment Parameter Options

11.It is possible to set a default option for each of the above review parameters. This will be used unless an option is chosen explicitly when a review comment is created or modified.

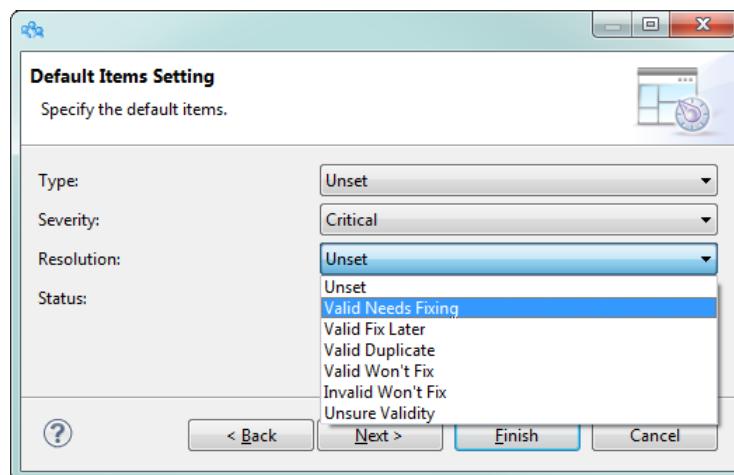


Figure 380 - Setting Default Options for Review Parameters

12.Choose the folder name where review issue data will be saved within the project. This folder will be stored in the root level of the corresponding project. It is possible to put the review issue data in a subfolder, i.e. "ProjectName/reviews/MileStone1_2013-01-02/" by using "/" (forward slash). The previous example would be specified as: "reviews/MileStone1_2013-01-02"

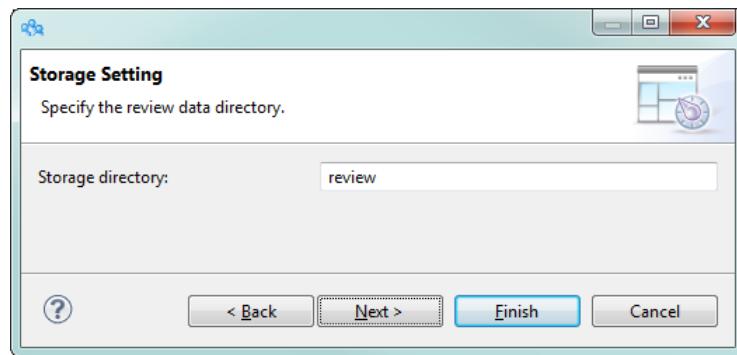


Figure 381 - Naming the Review Issue Data Folder

- 13.** In the final step the user can customize which information shall be shown in the **Review Table** view during the three different phases; Individual, Team, Rework. This is done by setting up filters. These filter can be toggled on and off in the **Code Review Table** view during the inspection.

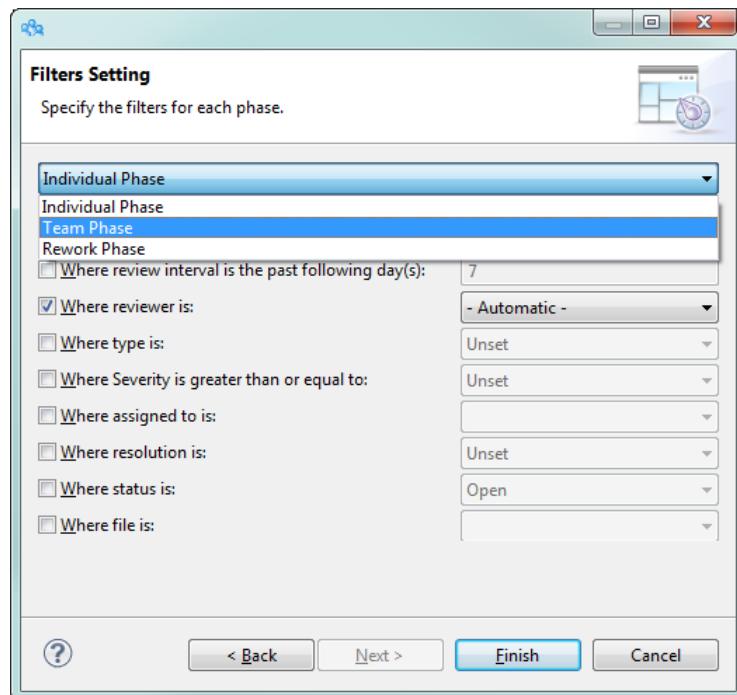


Figure 382 - Filter Settings for the Different Phases

- Individual Phase – The default filter allows the reviewers to view their own comments only. It is recommended is to keep this filter, so that reviewers are not biased by each other's review comments.
- Team Phase – The default filter allows the moderator and the reviewers to view only comments which have “**Resolution: Unset**”. This means that only review comments that still require a decision are shown.

- Rework Phase – This phase is relevant to reviewers that have had review issues assigned to them (typically: the author), during the Team Phase. The default filter allows such a reviewer to view only the issues assigned to him, or her, and in addition have “**Status: Open**”.

Click **Finish** to save all settings for the specific Review ID.

- 14.** As a final, and very important, step, make sure to commit the review settings file which resides in the project root folder and is called `.code_review_properties` to the version control system. Configuration files are typically hidden from the rest of the project resources by using a leading “.” (dot-character) in the filename. A file with a leading “.” in the filename will not be shown by the **Project Explorer** view. In order to commit this file the user must open the **Navigator** view which also shows hidden configuration files.

TAILORING A REVIEW ID TEMPLATE

The **DEFAULT** review ID contains the template settings which all future reviews will be based on. A company conducting regular code reviews can save a lot of time by making sure that the **DEFAULT** Review ID correlates well to the outlined terminology used in company process for code reviews and issue tracking. The following information is transferred from the template to any freshly created review ID:

- Review comment classification types
- Review comment severities
- Review comment resolution decisions
- Review comment statuses
- Default selections
- Authors for the review
- Phase filter selections

The **DEFAULT** review ID template can be edited from the **Review** panel in the **Project Properties** by selecting **DEFAULT** and clicking **Edit...**

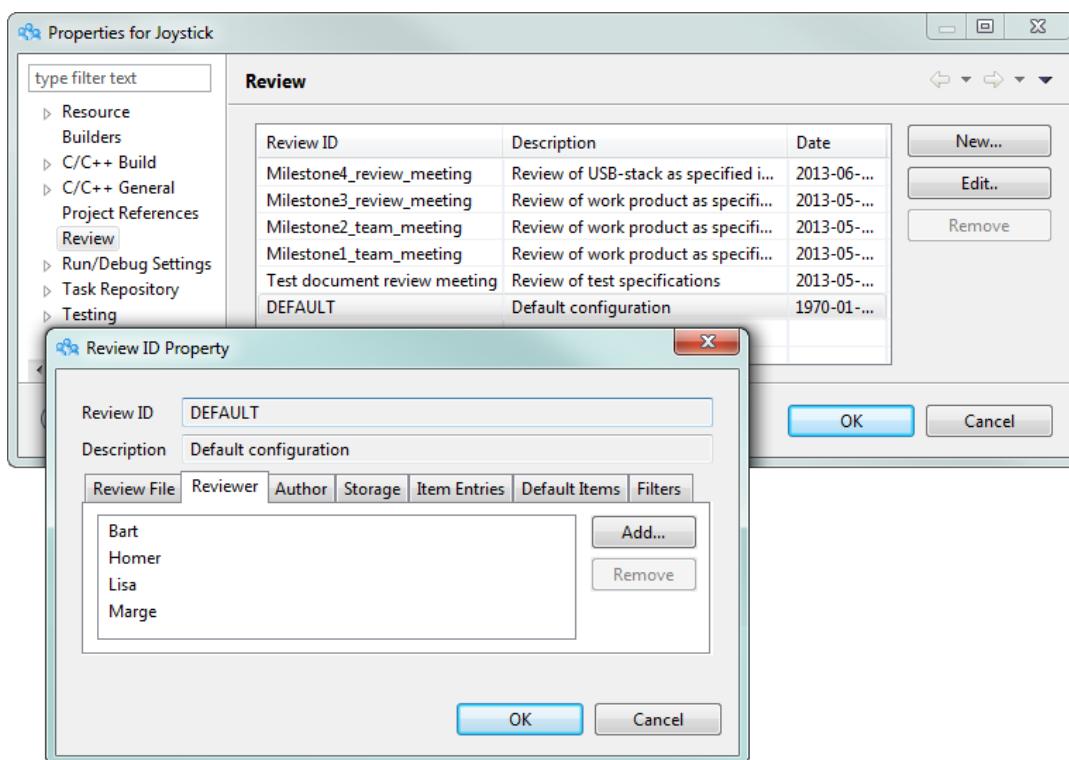


Figure 383 - Editing the DEFAULT Review Template

The user may also choose to remove a Review ID by clicking **Remove...** in the **Review** panel in the **Project Properties**. This will remove the corresponding sections from the review settings file and all individual reviewer files containing the individual review issue data.

CONDUCTING A SOURCE CODE REVIEW

The source code review is conducted in a separate perspective called the **Code Review** perspective. This is accessed from the **Open perspective** toolbar button; or from the menu command **View > Open perspective > Code Review**

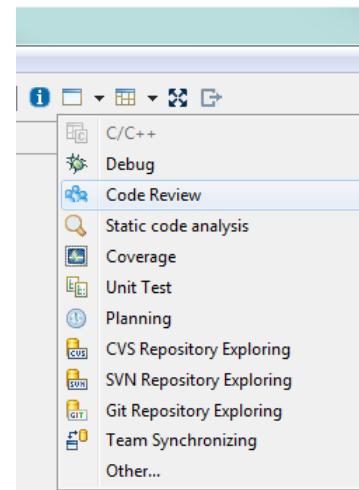


Figure 384 - Code Review Selected via Open Perspective Command

The **Code Review** perspective contains a number of unique views and toolbar buttons.

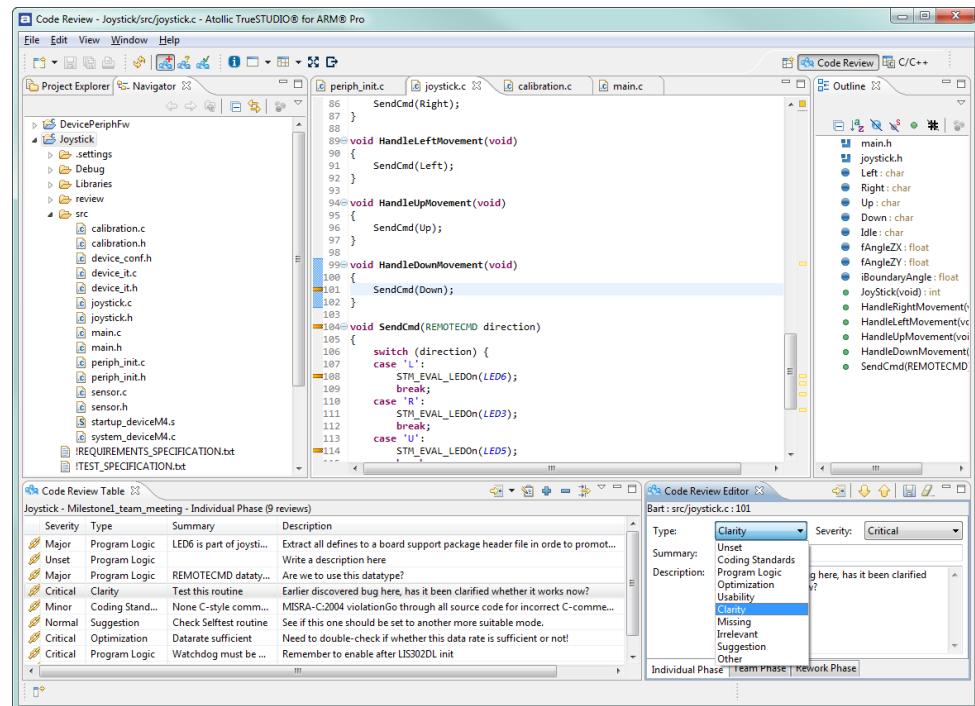


Figure 385 - The Code Review Perspective

The **Code Review** perspective has a toolbar adapted for navigation of review issues. The toolbar has the following buttons and functionality:

Button	Name	Description
	Refresh	Opens/refreshes the code review session
	Individual Phase	Log into the individual phase and add code review comments
	Team Phase	Log into the Team Phase, and perform a code review meeting
	Rework Phase	Log into the Rework Phase, and correct the problems assigned to you at the code review meeting

Table 71 - Code Review Toolbar Buttons

The following views are primarily associated to the code review perspective:

- **The main editor area** – The editor area of the perspective is needed to review the source code files.
- **The Code Review Table view** – This is the list of review issues. Different set of issues will be listed depending on selected Phase and Reviewer.
- **The Code Review Editor view** – An editor showing the current issue being created or modified. The editor view provides different toolbar buttons depending on the current phase of the review.

Joystick - Milestone1_team_meeting - Individual Phase (Review ID filter matched 7 of 7 reviews)				
Severity	Type	Summary	Description	Modified
Major	Clarity	REMOTECMD datatype	Are we to use this datatype?	2013-05-31
Critical	Clarity	Test this routine	Earlier discovered bug here, has it bee...	2013-05-31
Minor	Coding Standards	None C-style comment	MISRA-C:2004 violationGo through al...	2013-05-31
Normal	Suggestion	Check Selftest routine	See if this one should be set to anoth...	2013-05-31
Critical	Optimization	Datarate sufficient	Need to double-check if whether this ...	2013-06-03
Critical	Program Logic	Watchdog must be off durin...	Remember to enable after LIS302DL init	2013-05-31
Minor	Clarity	LIS302DL_Setup refactor	Should perhaps be placed in init code...	2013-05-31

Figure 386 – The Code Review Table View

Button	Name	Description
	Go to the source code	Select a file from the work product to

Button	Name	Description
	review	
	Edit the code review	Edit the settings for this specific code review
	Add code review issue	Adds a code review issue associated to the code line the marker currently is on
	Delete code review issue	Delete the currently selected code review issue
	Filters...	Apply the filter setup for this code review

Table 72 - Code Review Table View Toolbar Button Description

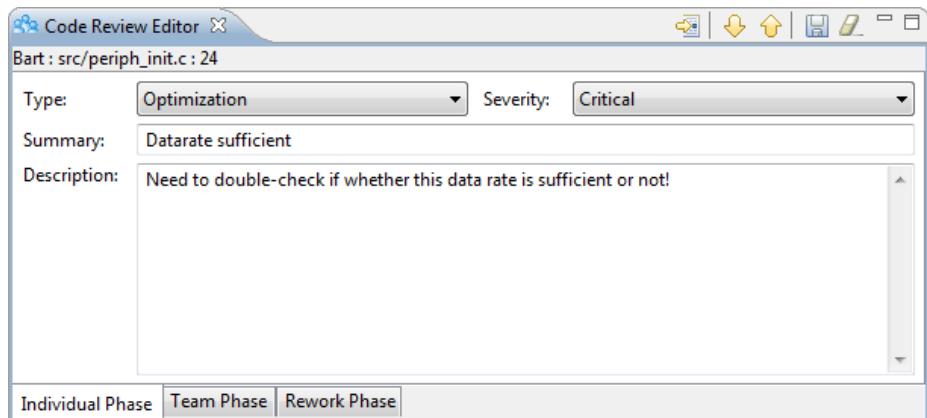


Figure 387 – The Code Review Editor View

Button	Name	Description
	Go to the source code	Select a file from the work product to review
	Next	Next review issue in the review table. Also saves any changes made to the current review issue.
	Previous	Previous review issue in the review table. Also saves any changes made to the current review issue.
	Save	Save changes to current review issue



Button	Name	Description
	Clear	Clears the content of the editor

Table 73 – The Code Review Editor View Toolbar Button Description

INDIVIDUAL PHASE

In order to start working in the individual phase and add review comments, the reviewer must use their own associated reviewer ID to log into a review session. The user does this by clicking on the toolbar button **Individual Phase** in the **Code Review** perspective.



Figure 388 - Individual Phase Selected in the Code Review Toolbar

The Review ID selection dialog will appear when the user clicks on either of the three code review phase related toolbar buttons. Review ID must be chosen so that the associated work **product** is shown to the reviewer. The user must also choose his or her name from the Reviewer ID drop-down menu. This will make sure that all review issues found are associated with the specified Reviewer ID.

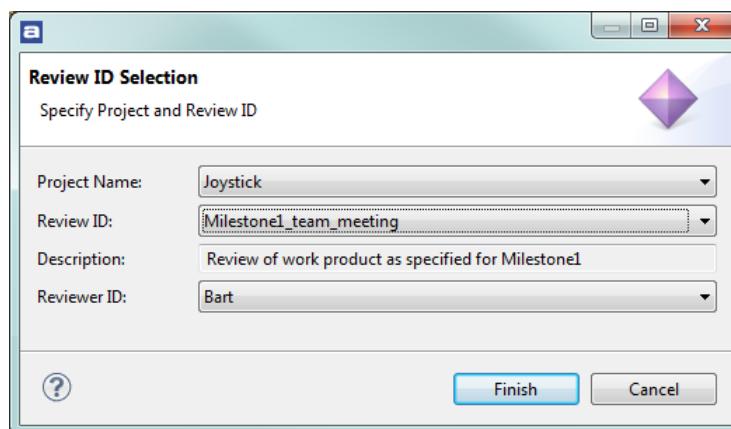


Figure 389 - Reviewer ID Selection Dialog

When a user has logged into the individual phase of a certain Review ID, it is possible for him or her to start adding review comments. This is done by reviewing the work product. The work product can be browsed by using the Go to the source code button in the **Code Review Table**.

Severity	Type	Summary	Description
Major	Program Logic	REMOTECMD datatype	Are we to use this data
Critical	Clarity	Test this routine	Earlier discovered bug
Minor	Coding Standards	None C-style comment	MISRA-C:2004 violation
Normal	Suggestion	Check Selftest routine	See if this one should be
Critical	Optimization	Datarate sufficient	Need to double-check
Critical	Program Logic	Watchdog must be off durin...	Remember to enable at
Minor	Clarity	LIS302DL_Setup refactor	Should perhaps be placed

Figure 390 - The Source Code Button & Drop-Down Menu

By selecting a file from the drop-down menu it will be opened in the Editor window of the IDE.

To add a code review issue perform these two steps:

1. In the editor select a code-line with the mouse cursor, doing so the selected text will be copied into the “description” field of the review issue.
2. Right-click on the line number and choose “Add code Review Issue...”

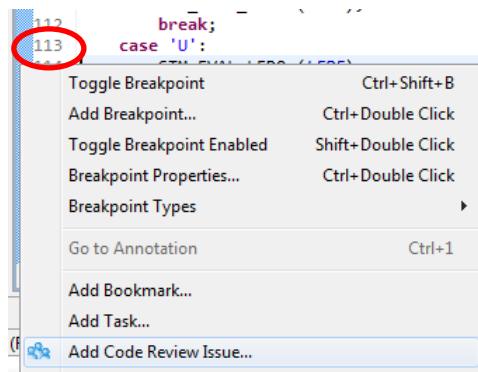


Figure 391 - Add Code Review Issue...



If the user right-clicks in the editor instead of the line number, the review issue may not be associated to the correct line number.
If no text is selected, the review issue description field will be empty.

When clicking **Add Code Review Issue...** the reviewer will be hyper-linked into the **Code Review Editor** view where a new review issue is being created.

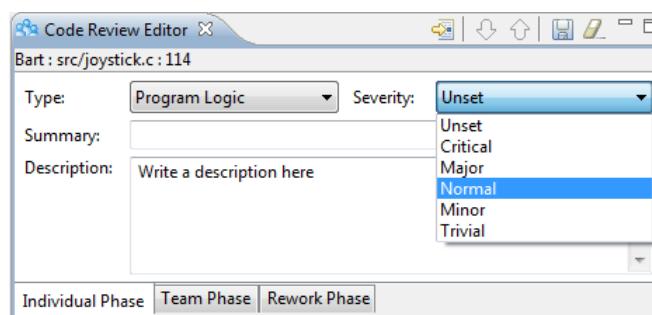


Figure 392 – A Code Review Issue in the Review Editor View

The top of the **Code Review Editor** view shows information about who found the review issue, in which file and at which code line. The user may also choose to select a code block, right-click and then click **Add Cod Review Issue...**. In this case the content of the code block will be copied into the description field of the Review issue. The type and severity fields are mandatory information for each review issue.

The type field identifies the type of review issue and the severity field defines the severity level for the current issue.

After entering all information into the review issue being added, click the **Save** button in the **Code Review Editor** view. Upon saving, the review issue will become visible in the **Code Review Table** view. A review marker will also be added to the left margin of the main editor window.

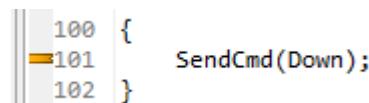


Figure 393 - Review Marker Displayed on Editor Line 101

Go through the different files included in the work product and add review comments. When an individual user has finished reviewing the work product, he/she must remember to commit the `.review` file to the version control system. This enables other reviewers to access the review issues by retrieving the files them from the version control system.

This path to the `.review` file was specified during the review configuration phase. By default the file is saved in the `review` subfolder within the project folder.

TEAM PHASE

In this phase the team members gather in a code review meeting to discuss all the review issues that were found by the individual reviewers. Before starting this phase it is important that the review moderator assures that all reviewers have committed their `.review` file, and subsequently updates his or her own local copy of each `.review` file



from the version control system. If this is not done properly, the issues from one, or more, reviewers are not taken into account, and will not show up in the collaborative **Code Review Table** view.

To start the team phase (code review meeting), click on the **Team Phase** toolbar button in the **Code Review** perspective.



Figure 394 - Team Phase Toolbar Button

The **Review ID Selection** dialog will appear where the user is prompted to select a Project, a Review ID and a Reviewer ID. The Reviewer ID in this phase is typically the author of the work product under review or the moderator hosting the meeting.

All review issues collected by all reviewers are now displayed in the **Code Review Table** view (provided that the review comment files have been committed to the version control system, and have subsequently been updated to the computer being used for the code review meeting).

Click on any review issue in the **Code Review Table** view and its content will be shown in the **Code Review Editor** view. If an already existing review issue is modified in this phase, make sure to click **Save**, **Next**, or **Previous** button to automatically save any changes. By double-clicking on any review issue in the **Code Review Table** view, the associated source code lines are also shown in the editor area of the IDE.

Review issues can also be navigated from the **Code Review Editor** view by using the **Next** and **Previous** buttons. The **Go to the source code** button allows jumping from the **Code Review Editor** view into the source code.

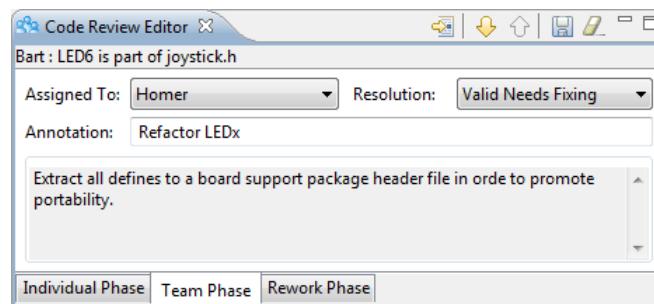


Figure 395 - Code Review Editor View Content in Team Phase

The **Assigned To** field contains the author's Review ID by default, but can be changed to the Reviewer ID of any other team reviewer. When the group has reached a decision on how to handle the review issue at hand, the **Resolution** field must be changed to reflect this decision. The **Annotation** field allows additional information to be added.

By single-clicking on a review marker in the source code, the summary and description of the review issues for the specific code line will be shown in a tooltip.

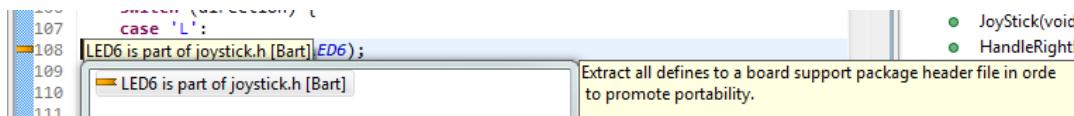


Figure 396 - Review Markers and Tooltip Information in the Editor

Review markers are also subject to the filter that is configured for the current phase of the code review. For example, if the filter is set to show **Resolution: Unset** issues only, then only review markers associated with such review issues will be shown.

When all review issues have been handled in the code review meeting; a reviewer has been assigned and a resolution has been chosen for all review comments, it is important to remember to commit the `.review` files to the version control system. When this is done all reviewers are able to access the decision outcome information from the **Team Phase**, and the code review can enter the **Rework Phase**.

REWORK PHASE

In this phase each reviewer will work on the review issues that were assigned to him/her at the code review meeting, in order to implement the agreed resolution. Before starting this phase it is important that the each reviewer updates the folder containing the `.review` files from the version control system. If this is not done, the reviewer will not be able to access any assigned-to or resolution information from the code review meeting.

To start this phase click on the **Rework Phase** toolbar button in the **Code Review** perspective.



Figure 397 - Team Phase Toolbar Button

The **Review ID Selection** dialog will appear where the user is prompted to select a Project a Review ID and a Reviewer ID.

In the **Code Review Table** view, the user will only see the review issues that were assigned to the reviewer that was selected in the **Review ID Selection** dialog when entering this phase. The purpose of this phase is that each reviewer addresses the review issues that were assigned to him/her respectively.



The **Code Review Editor** view will now contain the fields **Status**, **Resolution** and **Revision**. The **Status** field allows the status of each review issue to be changed. The resolution fields simply states the agreed resolution decided at the code review meeting. It can and should not be changed in this phase. The **Revision** field provides the possibility to write a comment related to the implemented resolution.

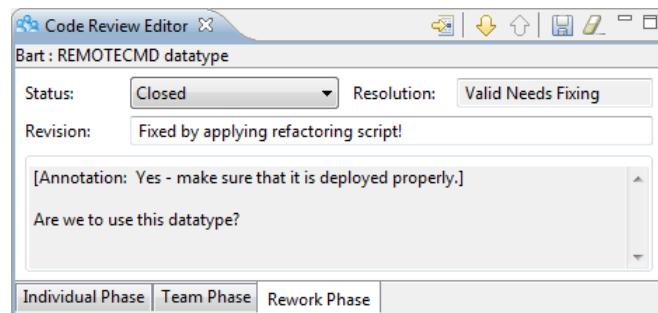


Figure 398 - Code Review Editor View Content in the Rework Phase

When all fields are filled in for the Review issue at hand, the reviewer must click **Save**, before the buttons **Next** and **Previous** can be used to view the next review issue to fix. When updated statuses for all review issues have been saved, the **Code Review Table** view will be empty. The reviewer must then remember to commit the `.review` file to the version control system so that the moderator can verify that everything has been fixed.

ADDITIONAL SETTINGS

The **Code Review Table** view can also be customized temporarily without overwriting the `.code_review_properties` file. This is done from the **Preference** settings found in the **Code Review Table** view toolbar.

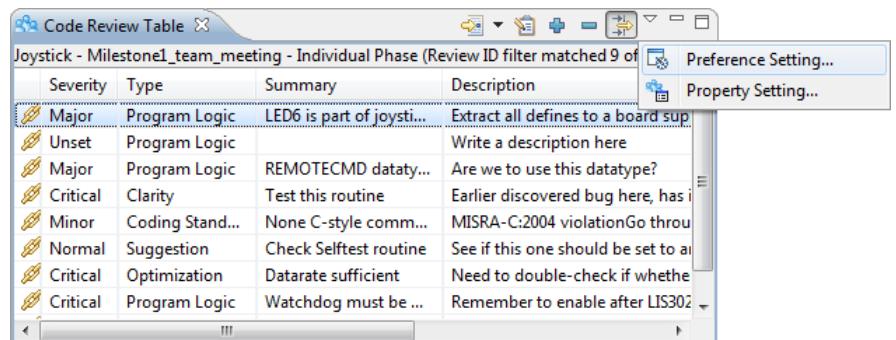


Figure 399 - Accessing Code Review Preference Settings

In this customization dialog the user may change filters that are applied on the **Code Review Table** view in order to show only review issues that have a certain parameter combination. It is also possible to tailor which columns, and thereby which parameters, are visible in each phase.

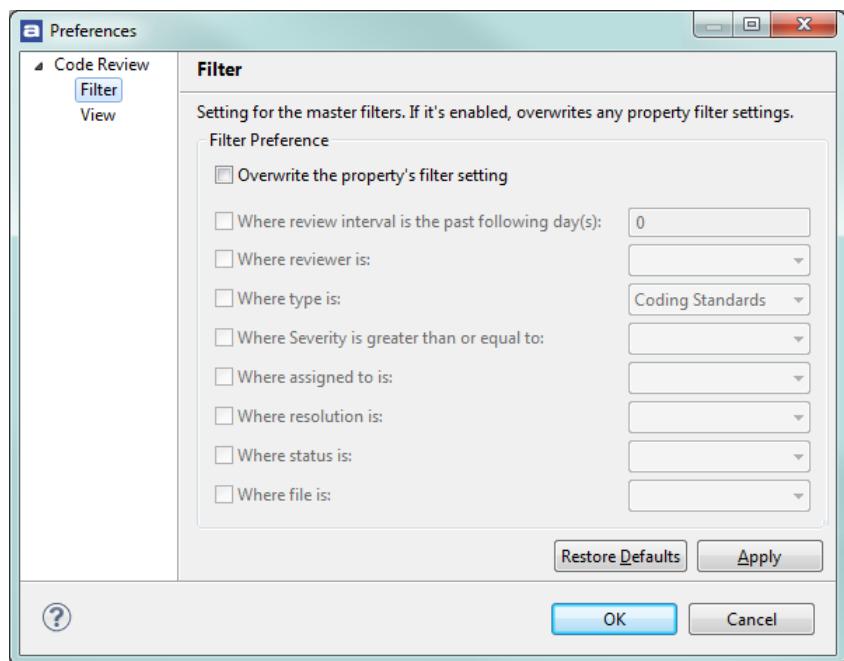


Figure 400 - Customize Filters Applied for All Phases

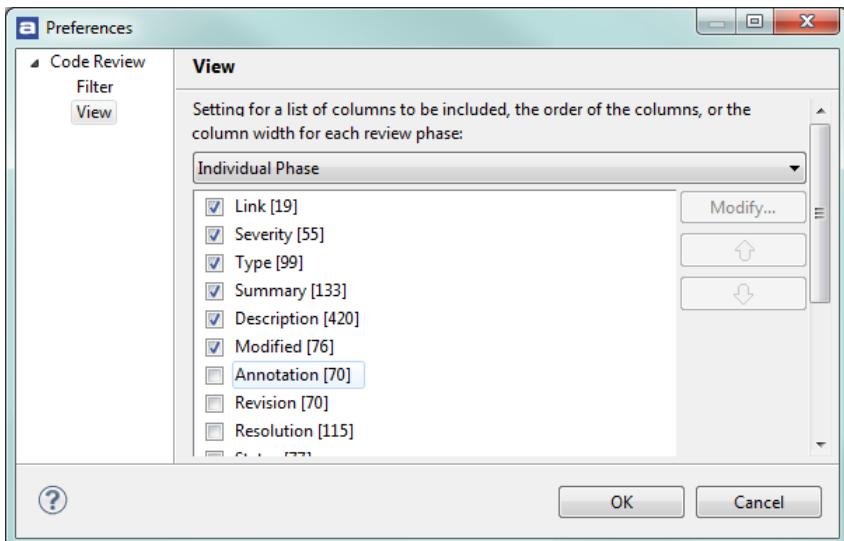


Figure 401 - Customize Visible Code Review Table Columns



Section 10. REVISION HISTORY

This section provides information what's changed in this document in each revision.

REVISION HISTORY

The revision history of this document is briefly described below.

Revision	Change	Page
20	Atollic TrueSTUDIO for STM32 v9.0 updates	
	Updated Static Stack Analyzer Using Search Field	
	Updated text and screen shots to use STM32 examples	
	Removed irrelevant information such as Licensing and Lite/Pro description which no longer exist in the product.	
	Added chapter Disassemble/List Object and Elf Files	
	Updated product name to TrueSTUDIO for STM32	
	Updated Introduction	
	Updated SVD file information (get from ST instead of from ARM)	
	Removed sections regarding license system	
	Removed sections regarding non-ST target devices	
	Removed sections regarding integration of non-ST tools and software	
	Removed sections regarding P&E GDB server	
	Removed sections regarding OpenOCD debug server	
	Updated figure 44 and 238 regarding available debug probes	
	Removed sections regarding connection to web shop	
	Updated sections regarding difference between Lite and Pro mode. All features are now available from start without licensing.	

Revision	Change	Page
21	Atollic TrueSTUDIO for STM32 v9.1 updates Updated Debug Configurations Screen shots (Figure 54, 157, 198, 262) Added information about External Loader option when programming external flash devices using ST-LINK.	218

Table 74 – Revision History