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## Getting started with STM32CubeH7 for STM32H7 Series

### Introduction

STM32Cube™ is an STMicroelectronics original initiative to make developers' lives easier by reducing development effort, time and cost. STM32Cube covers the whole STM32 portfolio.

The STM32Cube includes:

- STM32CubeMX, a graphical software configuration tool that allows the generation of C initialization code using graphical wizards.
- A comprehensive embedded software platform, delivered per Series (such as STM32CubeH7 for STM32H7 Series)
  - The STM32Cube HAL, STM32 abstraction layer embedded software ensuring maximized portability across the STM32 portfolio.
  - A consistent set of middleware components such as RTOS, USB, TCP/IP and graphics.
  - All embedded software utilities, delivered with a full set of examples.

This user manual describes how to get started with the STM32CubeH7 MCU Package. [Section 1 STM32CubeH7 main features](#) describes the main features of the STM32CubeH7 MCU Package.

[Section 2 STM32CubeH7 architecture overview](#) and [Section 3 STM32CubeH7 MCU Package overview](#) provide an overview of the STM32CubeH7 architecture and MCU Package structure.



# 1 STM32CubeH7 main features

STM32CubeH7 MCU Package runs on STM32H7 32-bit microcontrollers based on Arm® Cortex®-M processors. STM32CubeH7 gathers together, in a single package, all the generic embedded software components required to develop an application on STM32H7 microcontrollers. This set of components is highly portable, not only within the STM32H7 Series but also to other STM32 Series.

STM32CubeH7 is fully compatible with STM32CubeMX code generator that allows the user to generate initialization code. The package includes the hardware abstraction layer (HAL) APIs that cover the microcontroller hardware, together with an extensive set of examples running on STMicroelectronics boards. The HAL APIs are available in an open-source BSD license for user convenience.

The STM32CubeH7 MCU Package also contains a set of middleware components with the corresponding examples. They come with very permissive license terms:

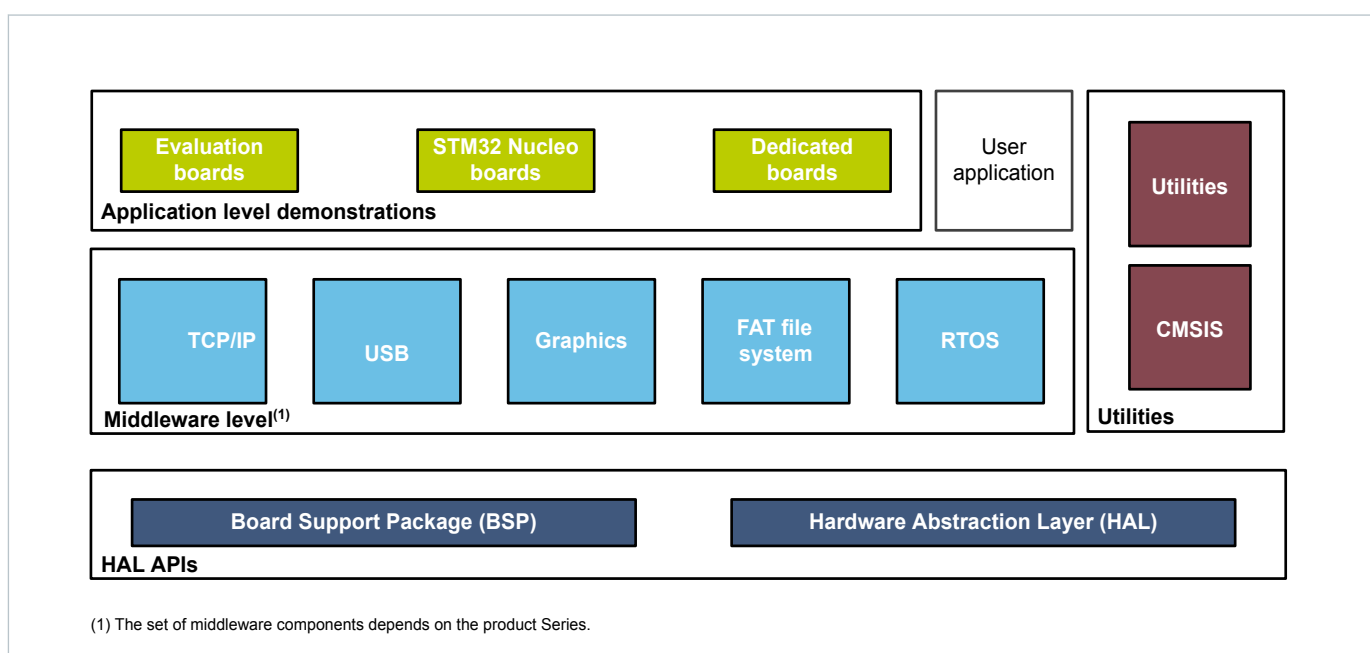
- Full USB Host and Device stack supporting many classes:
  - Host Classes: HID, MSC, CDC, Audio, MTP
  - Device Classes: HID, MSC, CDC, Audio, DFU
- Graphics:
  - STemWin, a professional graphical stack solution available in binary format and based on the emWin solution from ST's partner SEGGER
  - LibJPEG, an open source implementation on STM32 for JPEG images encoding and decoding.
- CMSIS-RTOS implementation with FreeRTOS open source solution
- FAT File system based on open source FatFS solution
- TCP/IP stack based on open source LwIP solution
- SSL/TLS secure layer based on open source mbedTLS

A demonstration implementing all these middleware components is also provided in the STM32CubeH7 MCU Package.

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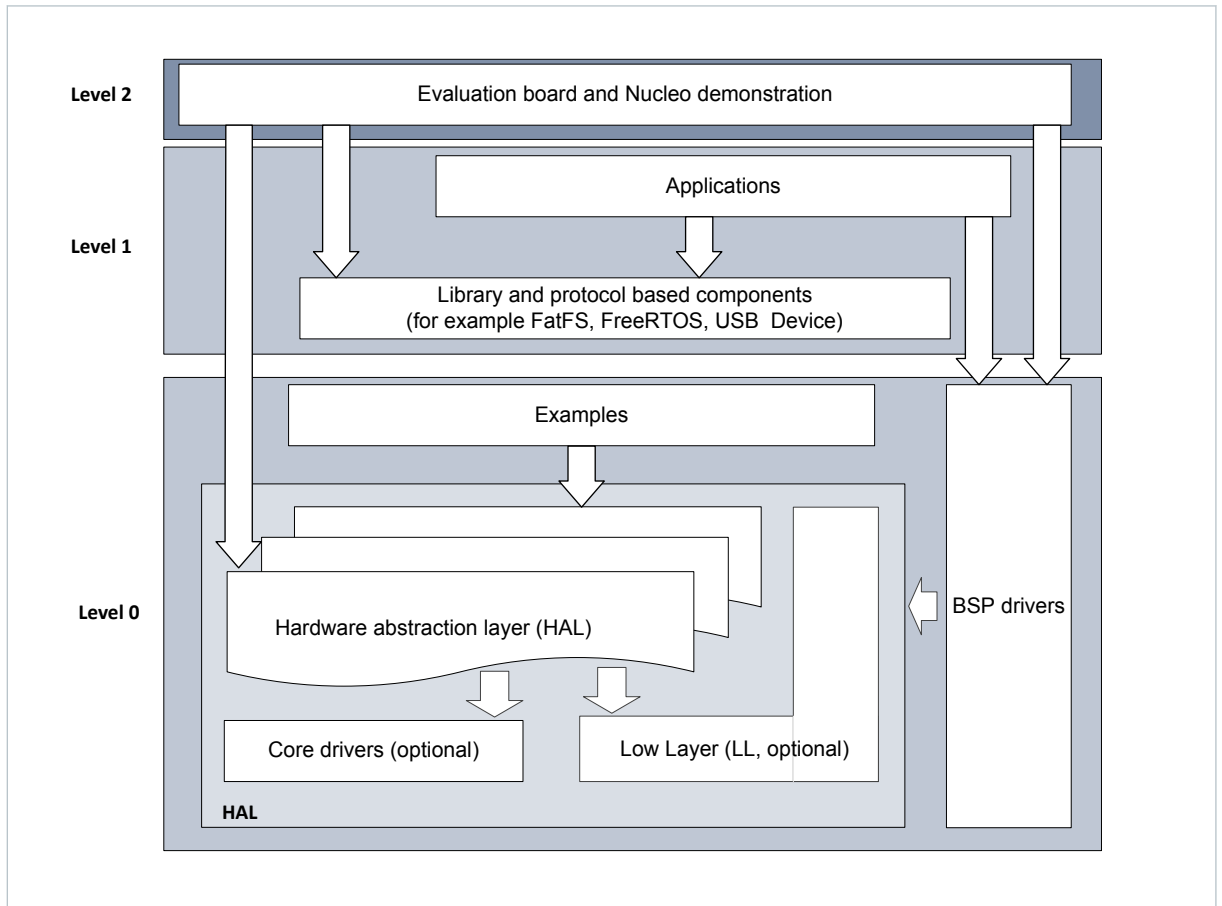
**Figure 2. STM32CubeH7 firmware components**



## 2 STM32CubeH7 architecture overview

The STM32CubeH7 firmware solution is built around three independent levels that can easily interact with each other as described in [Figure 3. STM32CubeH7 firmware architecture](#).

**Figure 3. STM32CubeH7 firmware architecture**



### 2.1 Level 0

This level is divided into three sub-layers:

- Board Support Package (BSP)
- Hardware Abstraction Layer (HAL)
- Basic peripheral usage examples

#### 2.1.1 Board Support Package (BSP)

This layer offers a set of APIs relative to the hardware components in the hardware boards (Audio codec, I/O expander, Touchscreen, SRAM driver, LCD drivers. etc...). It is composed of two parts:

- Component
  - This is the driver related to the external device on the board and not related to the STM32, the component driver provides specific APIs to the BSP driver external components and can be ported to any board.
- BSP driver
  - It allows linking the component driver to a specific board and provides a set of user-friendly APIs. The API naming rule is BSP\_FUNCT\_Action(): ex. BSP\_LED\_Init(),BSP\_LED\_On()

The BSP is based on a modular architecture allowing an easy porting on any hardware by just implementing the low level routines.

### 2.1.2 Hardware Abstraction Layer (HAL)

The HAL layer provides the low level drivers and the hardware interfacing methods to interact with the upper layers (application, libraries and stacks). It provides generic, multi instance and function-oriented APIs which simplify the user application implementation by providing ready-to-use processes. As example, for the communication peripherals (I2S, UART...), it includes APIs allowing to initialize and configure the peripheral, manage data transfer based on polling, interrupt or DMA process, and handle communication errors that may raise during communication. The HAL Drivers APIs are split in two categories:

- Generic APIs which provide common and generic functions to all the STM32 Series
- Extension APIs which provide specific and customized functions for a specific family or a specific part number.

### 2.1.3 Basic peripheral usage examples

This layer contains the examples of the basic operation of the STM32H7 peripherals using either the HAL APIs as well as the BSP resources.

## 2.2 Level 1

This level is divided into two sub-layers:

### 2.2.1 Middleware components

Middleware components are a set of libraries covering USB Host and Device Libraries, STemWin, LibJPEG, FreeRTOS, FatFS, LwIP, and mbedTLS. Horizontal interactions between the components of this layer are performed directly by calling the feature APIs while the vertical interaction with the low level drivers is done through specific callbacks and static macros implemented in the library system call interface. As example, the FatFs implements the disk I/O driver to access microSD drive or the USB Mass Storage Class.

The main features of each middleware component are as follows:

- **USB Host and Device Libraries**
  - Several USB classes supported (Mass-Storage, HID, CDC, DFU, AUDIO, MTP)
  - Support of multipacket transfer features: allows sending big amounts of data without splitting them into max packet size transfers.
  - Use of configuration files to change the core and the library configuration without changing the library code (read-only).
  - 32-bit aligned data structures to handle DMA-based transfer in High-speed modes.
  - Support of multi USB OTG core instances from user level through configuration file (that allows an operation with more than one USB host/device peripheral).
  - RTOS and Standalone operation
  - The link with low-level driver through an abstraction layer using the configuration file to avoid any dependency between the Library and the low-level drivers.
- **STemWin Graphical stack**
  - Professional grade solution for GUI development based on Segger's emWin solution
  - Optimized display drivers
  - Software tools for code generation and bitmap editing (STemWin Builder...)
- **LibJPEG**
  - Open source standard
  - C implementation for JPEG image encoding and decoding.
- **FreeRTOS**
  - Open source standard
  - CMSIS compatibility layer
  - Tickless operation during low-power mode

- Integration with all STM32Cube middleware modules
- **FAT File system**
  - FATFS FAT open source library
  - Long file name support
  - Dynamic multi-drive support
  - RTOS and standalone operation
  - Examples with microSD and USB host mass-storage class
- **LwIP TCP/IP stack**
  - Open source standard
  - RTOS and standalone operation

### 2.2.2 Examples based on the middleware components

Each middleware component comes with one or more examples (called also Applications) showing how to use it. Integration examples that use several middleware components are provided as well.

## 2.3 Level 2

This level is composed of a single layer which is a global real-time and graphical demonstration based on the middleware service layer, the low level abstraction layer and the basic peripheral usage applications for board-based features.

### 3 STM32CubeH7 MCU Package overview

#### 3.1 Supported STM32H7 Series devices and hardware

STM32Cube offers a highly portable Hardware Abstraction Layer (HAL) built around a generic and modular architecture. It allows the upper layers, the middleware and application, to implement its functions without knowing, in-depth, the MCU used. This improves the library code re-usability and guarantees an easy portability from one device to another.

The STM32CubeH7 offers a full support for all the STM32H7 devices. The user only needs to define the right macro in `stm32h7xx.h`.

[Table 1. Macros for STM32H7 Series](#) lists which macro to define depending on the used STM32H7 Series device. This macro can also be defined in the compiler preprocessor.

**Table 1. Macros for STM32H7 Series**

| Macro defined in <code>stm32h7xx.h</code> | STM32H7 part numbers  |
|---|---|
| STM32H743xx                               | STM32H743VI, STM32H743ZI, STM32H743II, STM32H743BI, STM32H743XI |
| STM32H753xx                               | STM32H753VI, STM32H753ZI, STM32H753II, STM32H753BI, STM32H753XI |
| STM32H750xx                               | STM32H750VB, STM32H750IB, STM32H750XB                           |

STM32CubeH7 features a rich set of examples and demonstrations at all levels making it easy to understand and use any HAL driver and/or middleware components. These examples can be run on any of the STMicroelectronics boards as listed in [Table 2. Evaluation and Nucleo boards for STM32H7 Series](#) :

**Table 2. Evaluation and Nucleo boards for STM32H7 Series**

| Board           | Supported STM32H7 lines                                 |
|-----------------|---|
| STM32H743I-EVAL | STM32H743xx, STM32H753xx and STM32H750xx <sup>(1)</sup> |
| NUCLEO-H743ZI   |   |

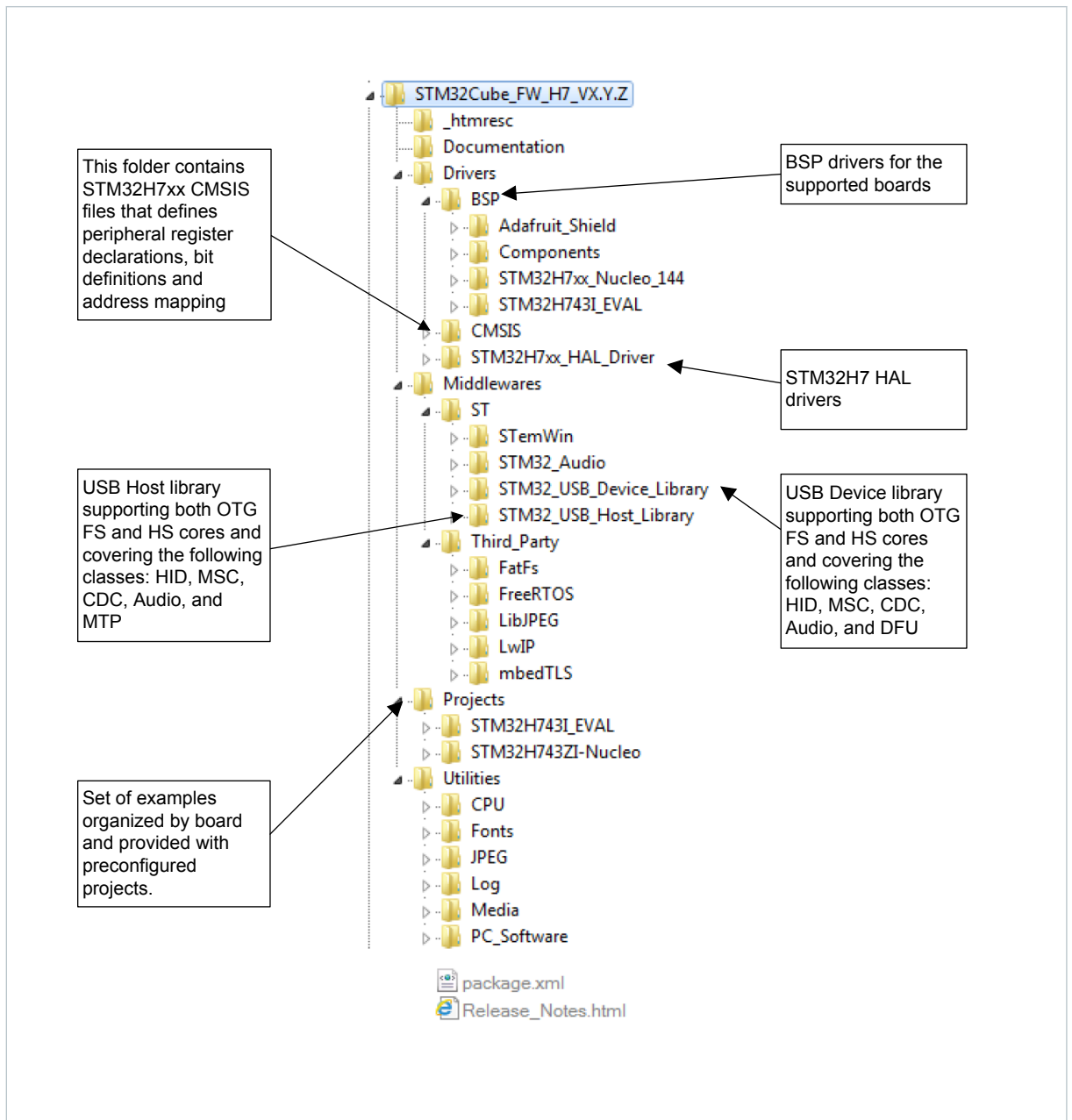
1. The STM32H750xx belong to STM32H750 Value line. They feature only 128 Kbytes of internal Flash memory. These devices are intended for code execution from external memories. Dedicated applications are available under Projects \STM32H743I\_EVAL\Applications\ExtMem\_CodeExecution

The STM32CubeH7 MCU Package can run on any compatible hardware. Simply update the BSP drivers to port the provided examples on the user board if its hardware features are the same (LED, LCD display, pushbuttons).

#### 3.2 MCU Package overview

The STM32CubeH7 firmware solution is provided in a single zip package with the structure shown in [Figure 4. STM32CubeH7 MCU Package structure](#).

Figure 4. STM32CubeH7 MCU Package structure



For each board, a set of examples are provided with preconfigured projects for EWARM, MDK-ARM and SW4STM32 toolchains.

Figure 5. STM32CubeH7 example overview shows the project structure for the STM32H743I-EVAL board. The structure is identical for other boards.

The examples are classified depending on the STM32Cube level they apply to, and are named as follows:

- Examples in level 0 are called Examples. They use the HAL drivers without any middleware component.
- Examples in level 1 are called Applications, that provide typical use cases of each middleware component
- Examples in level 2 are called Demonstration, that implement all the HAL, BSP and middleware components

A template project is provided to allow to quickly build any firmware application on a given board.

All examples have the same structure,

- \Inc folder that contains all header files

- \Src folder for the sources code
- \EWARM, \MDK-ARM and \SW4STM32 folders contain the preconfigured project for each toolchain.
- readme.txt describing the example behavior and the environment required to make it work

Table 3. Number of examples available for each board provides the number of examples, applications and demonstrations available for each board.

**Table 3. Number of examples available for each board**

| Board           | Examples | Applications | Demonstration |
|-----------------|----------|--------------|---------------|
| STM32H743I-EVAL | 131      | 55           | 1             |
| NUCLEO-H743ZI   | 75       | 6            | 1             |



Figure 5. STM32CubeH7 example overview



## 4 Getting started with STM32CubeH7

### 4.1 Running your first example

This section explains how simple it is to run a first example with STM32CubeH7. It uses as an illustration the generation of a simple LED toggling example running on the STM32H743I-EVAL board:

1. After downloading the STM32CubeH7 MCU Package, unzip it into a directory of your choice, make sure not to modify the package structure shown in [Figure 4. STM32CubeH7 MCU Package structure](#).
2. Browse to \\Projects\\STM32H743I\_EVAL\\Examples.
3. Open \\GPIO, then the \\GPIO\_EXTI folder.
4. Open the project with your preferred toolchain.
5. Rebuild all files and load your image into target memory.
6. Run the example: each time you press the Tamper push-button, the LED1 will toggle (for more details, refer to the example readme file).

The following section provides a quick overview on how to open, build and run an example with the supported toolchains.

- EWARM
  - Under the example folder, open the \\EWARM subfolder.
  - Open the Project.eww workspace. The workspace name may change from one example to another.
  - Rebuild all files: Project->Rebuild all.
  - Load project image: Project->Debug.
  - Run program: Debug->Go(F5).
- MDK-ARM
  - Under the example folder, open the \\MDK-ARM subfolder.
  - Open the Project.uvproj workspace. The workspace name may change from one example to another.
  - Rebuild all files: Project->Rebuild all target files.
  - Load project image: Debug->Start/Stop Debug Session.
  - Run program: Debug->Run (F5).
- SW4STM32
  - Open the SW4STM32 toolchain.
  - Click on File->Switch Workspace->Other and browse to the SW4STM32 workspace directory.
  - Click on File->Import, select General->'Existing Projects into Workspace' and then click "Next".
  - Browse to the SW4STM32 workspace directory, select the project.
  - Rebuild all project files: Select the project in the "Project explorer" window then click on Project->build project menu.

### 4.2 Developing your own application

This section describes the required steps needed to create your own application using STM32CubeH7.

1. **Create your project:** to create a new project you can either start from the Template project provided for each board under \\Projects\\<STM32xx\_xxx>\\Templates or from any available project under \\Projects\\<STM32xx\_xxx>\\Examples or \\Projects\\<STM32xx\_xxx>\\Applications (<STM32xx\_xxx> refers to the board name, ex. STM32H743I\_EVAL).

The Template project provides an empty main loop function, it is a good starting point to get familiar with the project settings for STM32CubeH7. The template has the following characteristics:

- a. It contains sources of the HAL, CMSIS and BSP drivers which are the minimum required components to develop code for a given board
- b. It contains the include paths for all the firmware components

- c. It defines the STM32H7 device supported, allowing to have the right configuration for the CMSIS and HAL drivers
- d. It provides ready-to-use user files preconfigured as follows:
  - HAL is initialized
  - SysTick ISR implemented for HAL\_Delay() purpose
  - System clock is configured with the maximum frequency of the device

**Note:** *When copying an existing project to another location, make sure to update the include paths.*

2. **Add the necessary middleware to your project (optional):** the available middleware stacks are: USB Host and Device Libraries, STemWin, LibJPEG, FreeRTOS, FatFS, LwIP, and mbedTLS. To find out which source files you need to add to the project files list, refer to the documentation provided for each middleware, you may also have a look at the applications available under \Projects\STM32xx\_xxx\Applications \<MW\_Stack> (<MW\_Stack> refers to the Middleware stack, for example USB\_Device) to get a better idea of the source files to be added and the include paths.
3. **Configure the firmware components:** the HAL and middleware components offer a set of build time configuration options using macros declared with “#define” in a header file. A template configuration file is provided within each component, it has to be copied to the project folder (usually the configuration file is named xxx\_conf\_template.h. The word “\_template” needs to be removed when copying it to the project folder). The configuration file provides enough information to know the effect of each configuration option. More detailed information is available in the documentation provided for each component.
4. **Start the HAL Library:** after jumping to the main program, the application code needs to call HAL\_Init() API to initialize the HAL Library, which does the following:
  - a. Configure the SysTick to generate an interrupt every 1ms. The SysTick is clocked by the HSI (default configuration after reset).
  - b. Sets NVIC Group Priority to 4.
  - c. Calls the HAL\_MspInit() callback function defined in user file stm32h7xx\_hal\_msp.c to do the global low level hardware initialization.
5. **Configure the system clock:** the system clock configuration is done by calling the following APIs:
  - a. HAL\_RCC\_OscConfig(): configures the internal and/or external oscillators, PLL source and factors. The user may select to configure one oscillator or all oscillators. The PLL configuration can be skipped if there is no need to run the system at high frequency.
  - b. HAL\_RCC\_ClockConfig(): configures the system clock source, Flash latency and AHB and APB prescalers.
6. **Peripheral initialization**
  - a. Start by writing the peripheral HAL\_PPP\_MspInit function. For this function, proceed as follows:
    - Enable the peripheral clock.
    - Configure the peripheral GPIOs.
    - Configure DMA channel and enable DMA interrupt (if needed).
    - Enable peripheral interrupt (if needed).
  - b. Edit the stm32h7xx\_it.c to call the required interrupt handlers (peripheral and DMA), if needed.
  - c. Write process complete callback functions if you plan to use peripheral interrupt or DMA.
  - d. In your main.c file, initialize the peripheral handle structure, then call the function HAL\_PPP\_Init() to initialize your peripheral.
7. **Develop your application process:** at this stage, your system is ready and you can start developing your application code.
  - a. The HAL provides intuitive and ready-to-use APIs for configuring the peripheral, and supports polling, interrupt and DMA programming models, to accommodate any application requirements. For more details on how to use each peripheral, refer to the rich examples set provided.
  - b. If your application has some real-time constraints, you can find a large set of examples showing how to use FreeRTOS and integrate it with all middleware stacks provided within STM32CubeH7, it can be a good starting point for your development.

**Note:** *In the default HAL implementation, the SysTick timer is the timebase source. It is used to generate interrupts at regular time intervals. If HAL\_Delay() is called from peripheral ISR process, the SysTick interrupt must have higher priority (numerically lower) than the peripheral interrupt. Otherwise, the caller ISR process is blocked. Functions affecting timebase configurations are declared as \_\_Weak to make override possible in case of other*

implementations in user file (using a general purpose timer for example or other time source). For more details please refer to *HAL\_TimeBase example*.

### 4.3 Using STM32CubeMX to generate the initialization C code

An alternative to steps 1 to 6 described in [Section 4.2 Developing your own application](#) consists in using the STM32CubeMX tool to easily generate code for the initialization of the system, the peripherals and middleware (steps 1 to 6 above) through a step-by-step process:

1. Select the STMicroelectronics STM32 microcontroller that matches the required set of peripherals.
2. Configure each required embedded software thanks to a pinout-conflict solver, a clock-tree setting helper, a power consumption calculator, and an utility performing MCU peripheral configuration (GPIO, USART...) and middleware stacks (USB, TCP/IP...).
3. Generate the initialization C code based on the configuration selected. This code is ready to be used within several development environments. The user code is kept at the next code generation.

For more information, please refer to “STM32CubeMX for STM32 configuration and initialization C code generation” user manual (UM1718).

### 4.4 Getting STM32CubeH7 release updates

The STM32CubeH7 MCU Package comes with an updater utility: STM32CubeUpdater, also available as a menu within STM32CubeMX code generation tool.

The updater solution detects new firmware releases and patches available on [www.st.com](http://www.st.com) and proposes to download them to the user's computer.

#### 4.4.1 Installing and running the STM32CubeUpdater program

1. Double-click SetupSTM32CubeUpdater.exe file to launch the installation.
2. Accept the license terms and follow the different installation steps.
3. Upon successful installation, STM32CubeUpdater becomes available as an STMicroelectronics program under Program Files and is automatically launched.

The STM32CubeUpdater icon appears in the system tray:



1. Right-click the updater icon and select Updater Settings to configure the Updater connection and to perform manual or automatic checks. For more details on Updater configuration, refer to section 3 of the STM32CubeMX User manual (UM1718).

## 5 FAQs

### **What is the license scheme for the STM32CubeH7 MCU Package?**

The HAL is distributed under a non-restrictive BSD (Berkeley Software Distribution) license.

The middleware stacks made by ST (USB Host and Device Libraries, STemWin) come with a licensing model allowing easy reuse, provided it runs on an ST device.

The middleware based on well-known open-source solutions (FreeRTOS, FatFs, LwIP and mbedTLS) have user-friendly license terms. For more details, refer to the license agreement of each middleware.

### **What boards are supported by the STM32CubeH7 MCU Package?**

The STM32CubeH7 MCU Package provides BSP drivers and ready-to-use examples for the following STM32H7 boards: STM32H743I-EVAL and NUCLEO-H743ZI.

### **Does the HAL take benefit from interrupts or DMA? How can this be controlled?**

Yes. The HAL supports three API programming models: polling, interrupt and DMA (with or without interrupt generation).

### **Are any examples provided with the ready-to-use toolset projects?**

Yes. STM32CubeH7 provides a rich set of examples and applications (around 186 for STM32H743I-EVAL). They come with the preconfigured project of several toolsets: IAR, Keil and GCC.

### **How are the product/peripheral specific features managed?**

The HAL offers extended APIs, i.e. specific functions as add-ons to the common API to support features available on some products/lines only.

### **How can STM32CubeMX generate code based on embedded software?**

STM32CubeMX has a built-in knowledge of STM32 microcontrollers, including their peripherals and software. This enables the tool to provide a graphical representation to the user and generate \*.h/\*.c files based on user configuration.

### **How to get regular updates on the latest STM32CubeH7 firmware releases?**

The STM32CubeH7 MCU Package comes with an updater utility, STM32CubeUpdater, that can be configured for automatic or on-demand checks for new MCU Package updates (new releases or/and patches).

STM32CubeUpdater is integrated as well within the STM32CubeMX tool. When using this tool for STM32H7 configuration and initialization C code generation, the user can benefit from STM32CubeMX self-updates as well as STM32CubeH7 MCU Package updates.

For more details, refer to [Section 4.4 Getting STM32CubeH7 release updates](#).

## Revision history

**Table 4. Document revision history**

| Date        | Revision | Changes   |
|-------------|----------|---|
| 26-Apr-2017 | 1        | Initial release.  |
| 29-Aug-2017 | 2        | Updated number of applications for both boards in <a href="#">Table 3. Number of examples available for each board</a> and <a href="#">Section 5 FAQs</a> .<br>Updated <a href="#">Figure 5. STM32CubeH7 example overview</a> .   |
| 21-Jun-2018 | 3        | Updated <a href="#">Section • Introduction</a> to replace STMCube™ by STM32Cube™ and update STM32Cube logo.<br>Updated <a href="#">Section 1 STM32CubeH7 main features</a> .<br>Firmware package replaced by MCU Package in the whole document.<br>Changed STM32H743I_EVAL into STM32H743I-EVAL in the whole document when referring to the board name.<br>Added STM32H750xx part numbers in <a href="#">Table 1. Macros for STM32H7 Series</a> and <a href="#">Table 2. Evaluation and Nucleo boards for STM32H7 Series</a> .<br>Updated number of STM32H743I-EVAL examples in <a href="#">Table 3. Number of examples available for each board</a> and <a href="#">Section 5 FAQs</a> . |
| 03-Jul-2018 | 4        | Updated <a href="#">Figure 2. STM32CubeH7 firmware components</a> .   |

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