



## L10 - Embedded Modern C++ Programming

*The Modern C++ Language for Embedded Systems*

### Objectives

- Discover the modern C++ features
- Learn the language changes in C++11, C++14, C++17 and C++20
- Discover the new functionalities added to the standard library
- Learn advanced modern C++ features
- Moving to from traditional C++ to modern C++
- Putting in evidence the essential modern C++ features used in embedded application

### Equipment

- Training manuals and software exercises
- One PC for two trainees
- One target board with ARM Cortex M4 microcontroller (STM32F)
- Eclipse environment and GCC compiler

### Prerequisite

- Basic C++ Language knowledge (see for example our [L3 - Embedded C++ course](#))
- Preferably knowledge of embedded C Language (see for example our [L2 - C language for Embedded MCU course](#))

### Durée

- Totale : 12 heures
- 2 sessions de 6 heures chacune (hors temps de pause)
- De 40% à 50% du temps de formation est consacré aux activités pratiques
- Certains travaux pratiques peuvent être réalisés entre les sessions et sont vérifiés par le formateur lors de la session suivante

### Course Environment

- Theoretical course
  - PDF course material (in English) supplemented by a printed version.
  - The trainer answers trainees' questions during the training and provide technical and pedagogical assistance.
- At the start of each session the trainer will interact with the trainees to ensure the course fits their expectations and correct if needed

### Target Audience

- Any embedded systems engineer or technician with the above prerequisites.

# Course Outline

## First Day

### Introduction to modern C++

- Overview
- Storage class specifiers
- Uniform initialization
- Automatic type deduction
  - The auto keyword
  - The auto keyword as a return type from a function
  - Using auto for declaring function signatures
  - Automatic constant references
  - Forwarding references
  - Advantages of using auto in embedded systems

### Keywords

- enum class
- override and final
- Inline variables
- nullptr
- static\_assert
- noexcept
- constexpr and if constexpr
- decltype
- Defaulted and deleted functions

### New functionalities

- Range-based for loops
- Nested namespaces and namespace aliases
- Structured binding
- Move semantics and r-value references
  - Copy-constructing and Move-constructing
  - r-value references
  - Perfect forwarding
- Alignment
  - Alignas
  - Alignof

### Modern C++ Standard Library

- Standard Library
  - std::optional
  - std::variant
  - std::any
  - std::byte
  - std::hash
  - Filesystem library
- Literals
  - Cooked literals
  - Standard literal operators

- Raw literals
- Raw string literals
- Random number generation
  - Random number generation engines
  - Random number generation distributors
- Containers
  - `std::array`
  - `std::forward_list`
  - Unordered associative containers

## Second Day

### String Manipulation

- New string Types
  - `std::u16string`
  - `std::u32string`
- Basic string view
- Converting between numeric and string types
- Elementary string conversions
- Input/output manipulators
  - `std::get_money`, `std::put_money`
  - `std::get_time`, `std::put_time`
  - `std::quoted`
- Regular expressions
  - Format of a string
  - Parsing the content of a string
  - Replacing the content of a string

### Lambda functions

- Syntax of lambdas
- Defining lambdas
- Using lambdas
  - Using lambdas with standard algorithms
  - Assigning lambdas to function pointers
  - Lambdas and `std::function`
  - Writing a function that accepts a lambda as parameter
- Polymorphic lambdas
- Recursive lambdas

### Dynamic memory management

- Smart Pointers
  - Raw Pointers
  - Automatic pointers
  - Unique Pointers
  - Shared Pointers
  - Weak Pointers

### Concurrency and Multithreading

- Introduction
- Thread
- Implementing a thread-safe singleton
- Atomic operations
  - Atomic features

- Non-class functions
- Atomic flag
- Memory order
- Mutex
  - Avoiding using recursive mutexes
- Sending notifications between threads
- Condition variables
- Future and Promise
- Task and Async
- Modern C++ and RTOS