FEABHAS

Advanced Real-Time Modern C++ (C++11/14/17)

Course category	C++ Training Courses
Training area	Programming Languages
Course code	AC++11-502
Duration	5 days
Additional information	Available for on-site delivery only. Can be delivered remotely or Face-to-Face.

The term 'Modern C++' is used to describe the current best practices for the use of C++. In some cases, this may mean new capabilities of the language; in other cases it means more effective ways of performing familiar programming tasks.

This advanced course is designed to transition experienced C++ programmers to the latest incarnation of the C++ language. The focus is to teach good programming practice using Modern C++ and to put the latest features of the language into context.

The course covers C++11, C++14 and C++17.

Course objectives:

- To provide a deep understanding of the C++ programming language.
- To give you practical experience of writing Modern C++ on hosted embedded systems
- To give you the confidence to apply these new concepts to your next project.

Delegates will learn:

- Modern C++ syntax, semantics and library features
- The Application Binary Interface (ABI) and memory model of C++
- Idioms and patterns for building effective C++ programs
- Real-time and concurrency design issues

Pre-requisites:

- A good working knowledge of C++ (knowledge of C++11 onwards is useful, but not essential)
- Some experience of development multi-threaded applications is useful.
- A working understanding of machine architectures is helpful.

Who should attend:

- This course is aimed at C++ programmers who are using earlier standards of C++, and experienced C++ programmers who want to extend and expand their C++ skills.

Duration:

- Five days.

Course materials:

- Delegate manual

Course workshop:

- Attendees perform hands-on exercises during course practicals. Approximately 50% of the course is given over to practical work. The tools used are indicative of current modern working practices in the embedded arena.

Part 1 - Core concepts

Build process

- The C++ build process
- The preprocessor stage
- Compiler and linker stages
- Linking embedded and hosted applications

The C++ object model

- Declaration and definition
- Brace initialisation syntax
- Pointers and references
- Empty pointer validation
- Temporary object materialization

User defined types

- The Single Responsibility Principle (SRP)
- Member variable initialisation
- Constructors

- Re-enabling the default constructor
- Delegating constructors
- Explicit constructors
- Inline initialisation of static member variables

Type deduction

- Automatic type deduction
- Qualifying auto-deduced types
- The decltype operator
- Auto-deduced function return types
- Trailing return-type syntax

Constants

- Numeric and character literals
- Enum classes
- constexpr objects
- constexpr functions and classes
- User-defined literals
- std::string_view

Functions call ABI

- Function declaration and definition
- Procedure Activation Record
- Member functions

Functions

- Function parameters
- Pass-by-value, pointer and reference
- const member functions
- Returning by value
- Named Return Value Optimisation (NRVO)
- Return Value Optimisation (RVO)
- Copy elision
- Factory functions
- Auto-deduced function return types
- Compiler diagnostics

Arrays and iterators

- Arrays of objects
- std::array
- Arrays as parameters
- Iterators
- range-for statement

Vocabulary types

- Structured bindings
- std::pair and std::tuple
- std::optional and std::expected
- std::variant and std::visit
- std::any and small buffer optimisation

Part 2 – Object Oriented Design

Composite objects

- Composition
- Aggregation
- Composite object initialisation
- Optional composite objects

Connecting objects

- Unidirectional Associations
- Bidirectional association
- Forward declarations

Creating substitutable types

- Specialisation vs inheritance
- Substitution
- The Liskov Substitution principle
- The virtual function ABI

Abstract Base Classes

- The Single Responsibility principle
- Pure virtual functions
- Abstract types
- Dynamic cast

Realising interfaces

- The Dependency Inversion principle
- The Interface concept
- Pure virtual functions
- The Interface Segregation principle
- Cross casting

Part 3 - Standard Library

Sequence containers

- std::vector
- std::bitset
- std::list and std::forward_list
- Container classes and std::initializer_list

Associative containers

- std::set
- std::pair and std::map
- std::unordered map

Algorithms

- The Standard Library model
- std::fill and std::sort
- std::find, std::count and std::accumulate
- The Remove-Erase idiom
- std::transform and std::bind
- std::bind placeholders

Callable objects

- Functors
- Lambda functor syntax
- Lambdas as a block-scoped function
- Capture context
- Capture initialisers
- std::function and std::invoke

Part 4 - Resource management

Resource management

- Disabling copy constructor and assignment
- Deep copy constructor and assignment
- The Rule of the Three
- Copy-swap idiom
- Virtual copy constructor

Move semantics

- Compiler generated copy operations
- 'Resource pilfering'
- L-value, R-value and PR-value expressions
- X-value objects
- Move constructor and assignment
- std::move
- Compiler generated move operations

Smart pointers

- The problem with raw pointers for memory management
- std::unique_ptr
- std::shared_ptr
- std_weak_ptr

C++ Strings

- C-Strings (NTBS)
- Raw String Literals
- std::string
- Short String Optimization (SSO)
- std::string_view

Part 5 - Templates

Template functions

- The problems with function-like macros
- Template functions
- Template parameter type deduction
- The forwarding reference idiom
- Template function overloading

Template classes

- Generic classes
- Template type deduction
- Template deduction guidelines

Templates and polymorphism

- The cost of virtual interfaces
- Policy patterns

Perfect forwarding

- Variadic templates
- std::forward
- std::forward vs std::move

Part 6 - Concurrency

Threading

- Concurrency vs parallelism
- std::thread
- Run policies
- Polymorphic threads
- Waiting for threads to finish
- Detaching threads

Mutual exclusion

- Race conditions
- Mutual exclusion
- The scope-locked idiom
- std::lock_guard and std::unique_lock

Condition variables

- Thread synchronisation
- The Guarded Suspension pattern

Atomic types

- Shared objects in multiprocessor environments
- Why volatile is inappropriate

- Atomic types
- Load-acquire / Store-release barriers

Asynchronous tasks

- The Asynchronous Message pattern
- The Promise / Future pattern
- std::async and packaged tasks
- Launch policies