Published at the end of 2011, the DO-178C standard mainly differs from its predecessor DO-178B in that it has standard supplements to provide greater scope for using new software development methods. The most important supplements are those on methods for model-based design and model-based verification, which are described in supplement DO-331. These key software design techniques offer great potential for achieving highly efficient software development in the aerospace sector while not only maintaining the high quality and safety requirements for software but actually improving them. This article shows how to use TargetLink together with DO-178C and DO-331 and which aspects to take into account.

Models: Opening the Door to Innovative Methods

The ability to represent requirements by models in accordance with DO-331 is a decisive advance in efficient and quality-oriented software development. The shift from purely textual requirements to formalized requirements expressed as models opens up many new options for automated analysis, source code generation, and verification. There are two different types of software requirements according to DO-178B/C and DO-331:

- *High-level requirements (HLR)*
  These describe what the software has to do, but not how it has to do it (i.e., the software is treated as a black box). HLRs are derived from the requirements for the actual system that are defined in the system process, e.g., according to

>>

Code generator TargetLink for aerospace applications

Safe Code According to DO-178C

dSPACE's production code generator, TargetLink, is suitable not only for automotive production projects, but also for projects in civil and military aviation. dSPACE offers a comprehensive workflow description particularly for using TargetLink in DO-178-compliant aerospace projects. It describes how to use a TargetLink-based tool chain to make software certification easier.

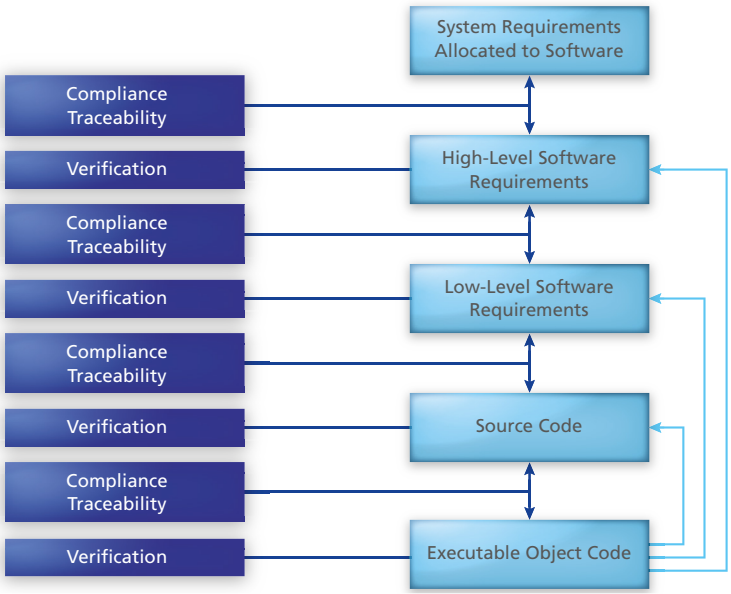


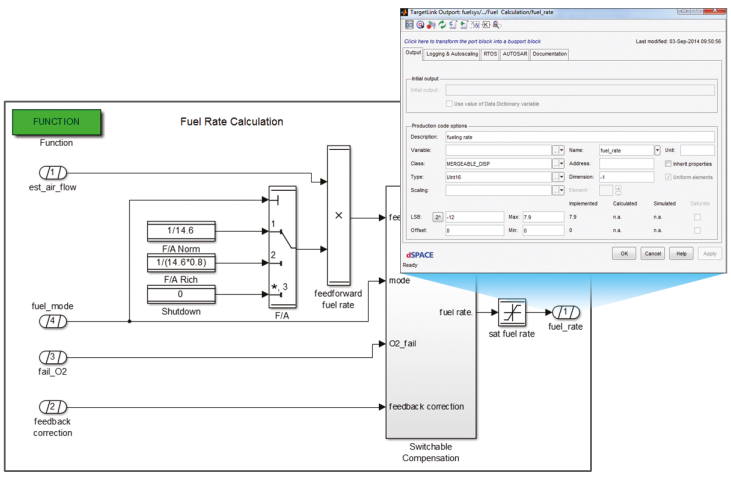
Figure 1: Important development phases according to DO-178C, including the necessary verification steps.

ARP4754 (Aerospace Recommended Practice).

- *Low-level requirements (LLR)*
  These describe the internal workings of the software (viewed as a white box), i.e., how it has to do what it does. LLRs are naturally derived from the HLRs. It must be possible to generate the actual source code directly from the LLRs.

Models can now be used to represent requirements on these two levels (figure 1). Simulink®/TargetLink® models are used particularly often for representing the LLRs from which the actual source code is then generated by means of automated code generation. According to DO-331, such models representing LLRs are called design models. They contain the description of the actual functionality and also all necessary detailed information on the software, such as internal data structures, control flow information, and potential fixed-point representations (figure 2).

Figure 2: Simulink/TargetLink design models are used for direct automatic source code generation with TargetLink.



From Design Model to Source Code at a Click

Design models representing requirements (according to DO-331) offer a direct route to creating the software source code – by using automatic code generation instead of manual coding. In terms of quality and reliability, TargetLink by far surpasses human programmers and produces source code deterministically at the click of a button:

- The source code generated by TargetLink is very readable and suitable for reviews. This is ensured by extensive source code commenting and easy-to-understand symbol names, and by using a subset of the C language.
- The code can be traced straight back to the design model. This provides direct traceability between the source code and the associated model from which it was generated.
- The code to be generated with TargetLink is also highly configurable in order to fulfill the coding guidelines, combine the code generated with TargetLink with existing legacy code, and optimally integrate the generated code into the software architecture.

In general, the quality, configurability, and efficiency of the generated code are outstanding TargetLink features that are visible in all application areas.

Model-Based Verification: the Key to Easier Certification

The great advantages of using models to specify requirements (HLRs and LLRs) are evident not only in automatic production code generation but also in other areas such as verification steps. These have to be performed in parallel to the development process to test the resulting artifacts, such as models, source code, and object code, in each individual development step (figure 1). To prove that the models fulfill the requirements they were derived from (figure 1), a combination of model simulation, coverage analysis, and test case generation can be used. According to DO-178B/C, test cases must be created solely on the basis of requirements. If a requirement is itself expressed as a model, e.g., a Simulink/TargetLink model, techniques for automatic test vector generation such as those provided by BTC EmbeddedTester® can be used. A typical way of verifying that the executable object code is consistent with the HLRs and LLRs (figure 1) is to execute it on the target platform. TargetLink provides extremely powerful mechanisms for this in the form of processor-in-the-loop simulation, in which the automatically generated code is translated directly by the target compiler and executed on an evaluation board with the target processor (figure 3).

DO-178C/DO-331 Workflow Document for TargetLink

dSPACE provides the workflow document "TargetLink – Model-Based Development and Verification of Airborne Software" for using TargetLink in DO-178C/DO-331-compliant projects. The document describes how to meet the individual requirements, called objectives, of DO-178C/DO-331. It focuses not just on TagetLink itself but also the entire TargetLink ecosystem consisting of a complete model-based tool chain that can contain third-party tools. These include tools from TargetLink cooperation partners, such as BTC Embedded Systems, Model Engineering Solutions, and AbsInt.The document can be requested by an e-mail to *TargetLink.Info@dspace.de*.

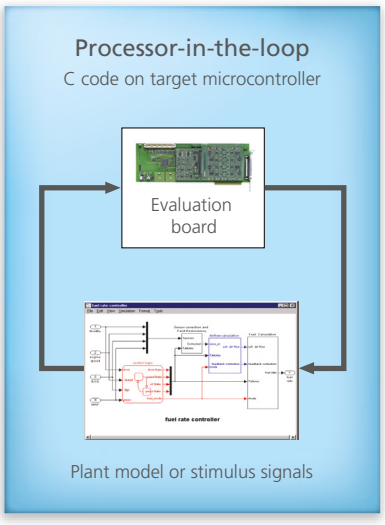


Figure 3: Running the executable object code in processor-in-the-loop simulation to verify that the object code fulfills the requirements.

Conclusion

TargetLink is well suited for DO-178C-compliant aerospace projects, making it possible to generate high-quality source code at the click of a button. Due to its layout commenting and symbol names, the generated code is highly readable, provides seamless traceability to the requirements and is easy to configure, e.g., to fulfill coding guidelines. TargetLink and its integration with third-party tools offer an ideal environment for verification, simulation, analysis, and tests. From the requirements to the final source code – with TargetLink, users have their DO-178C-compliant development projects under control.