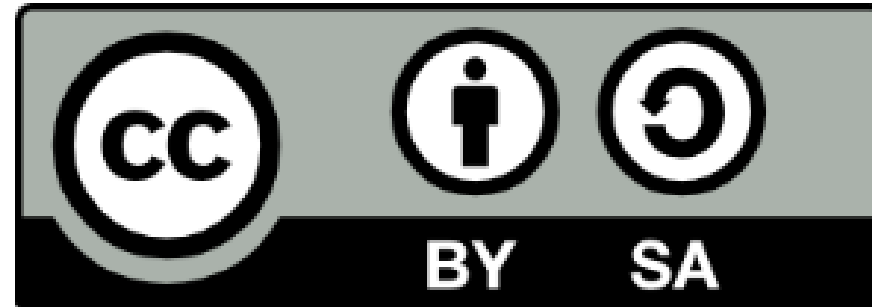




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# eFMI® Tutorial – Agenda

Part 1: eFMI® motivation and overview (40 min)

Part 2: Running use-case introduction (10 min)

Part 3: Hands-on demonstration in Dymola and  
Software Production Engineering (former name CATIA ESP) (25 min)

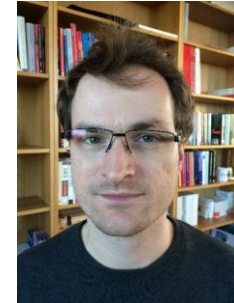
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Part 6: Conclusion (5 min)



Tutorial leader:  
Christoff Bürger



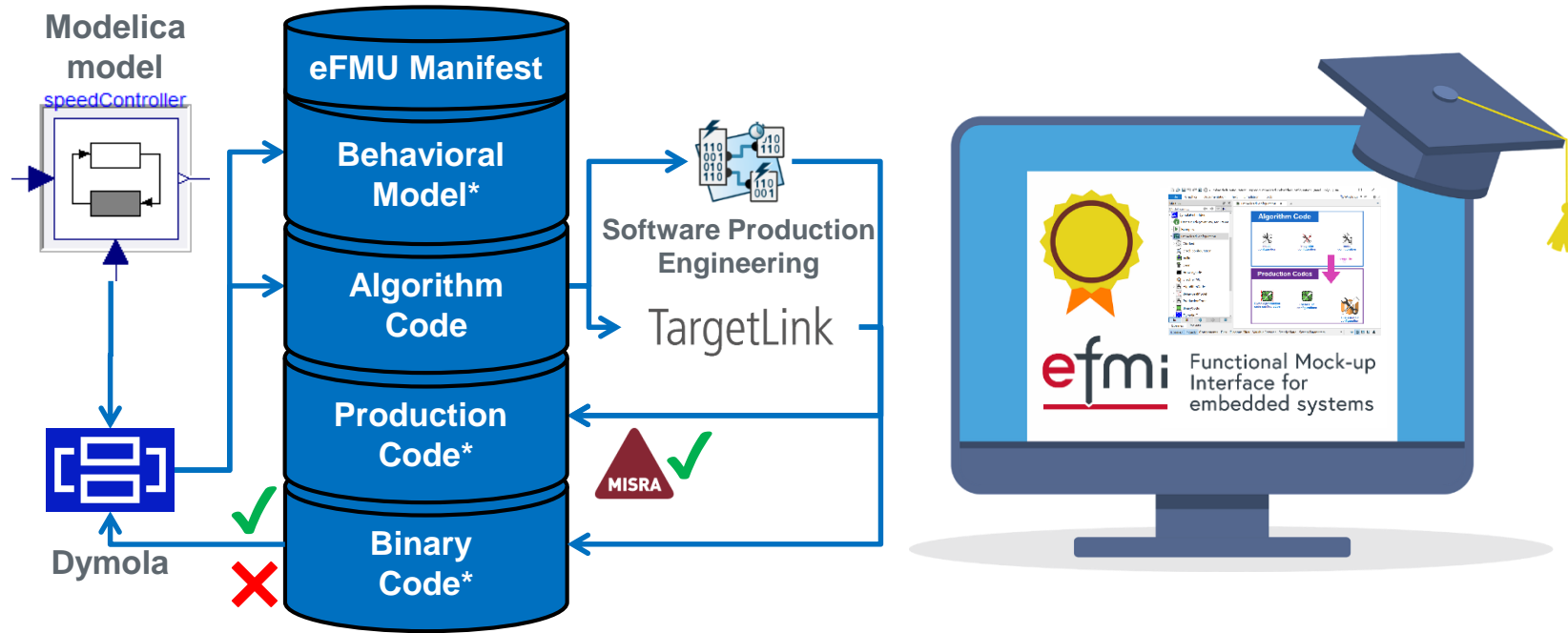
Presenter:  
Oliver Lenord



Presenter:  
Jörg Niere



Functional Mock-up  
Interface for  
embedded systems



## Part 4: Live demonstration in TargetLink

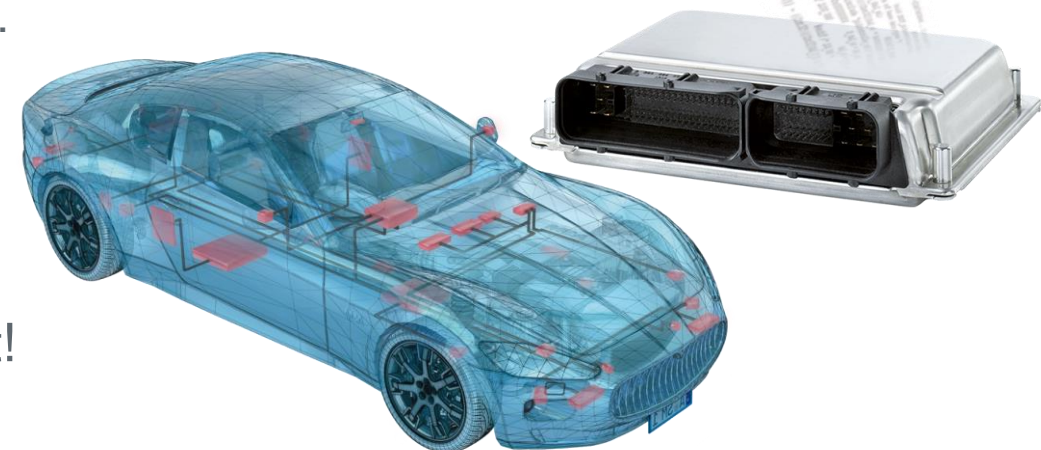
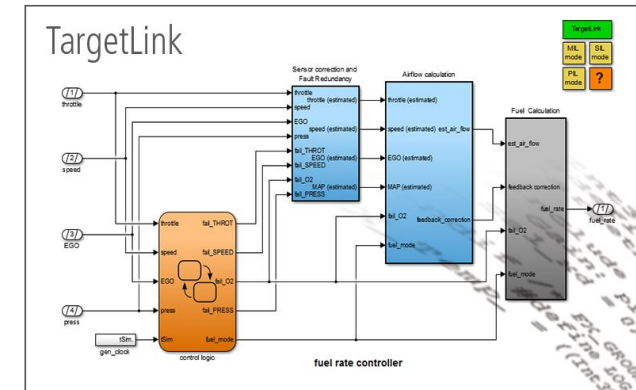
eFMI® Tutorial – 15<sup>th</sup> International Modelica Conference – 9<sup>th</sup> of October 2023



Jörg Niere  
dSPACE GmbH  
[JNiere@dspace.de](mailto:JNiere@dspace.de)

# TargetLink – Driving the Future with Autocode

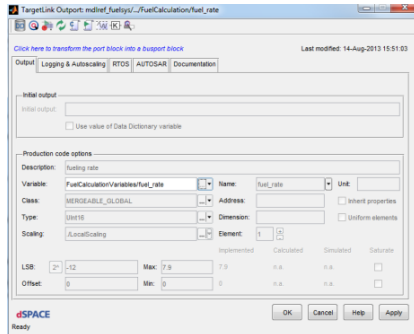
- High-quality production code generation directly from Simulink/Stateflow
  - Highly efficient for fixed-point and floating point
  - Well readable and traceable code
  - Highly configurable
- Powerful software design and testing features
  - MIL/SIL/PIL simulation concept
  - Push-button solution with integrated data logging and plotting concept
  - Code profiling, code coverage analysis and much more ...
- High-performance, native AUTOSAR support
- Certified for IEC 61508, ISO 26262 and ISO 25119
- Powerful Ecosystem for model-based development
- TargetLink - Generates exactly the code that you want!



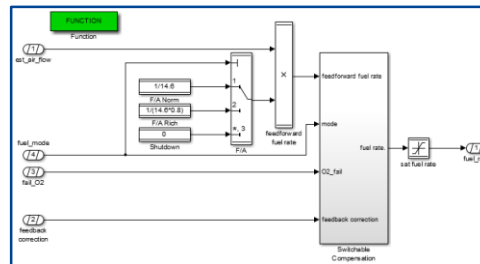
# TargetLink Ecosystem – Powerful MBD Tool Chain



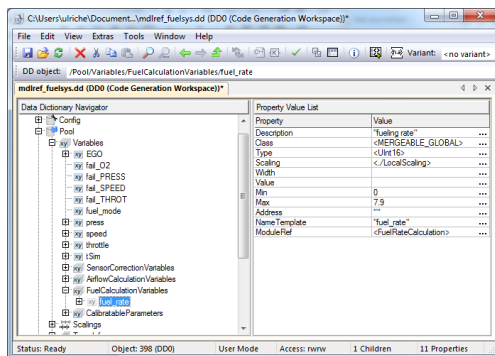
# TargetLink Features (excerpt)



Block dialogs



Separation of model and data



TargetLink Data Dictionary Manager

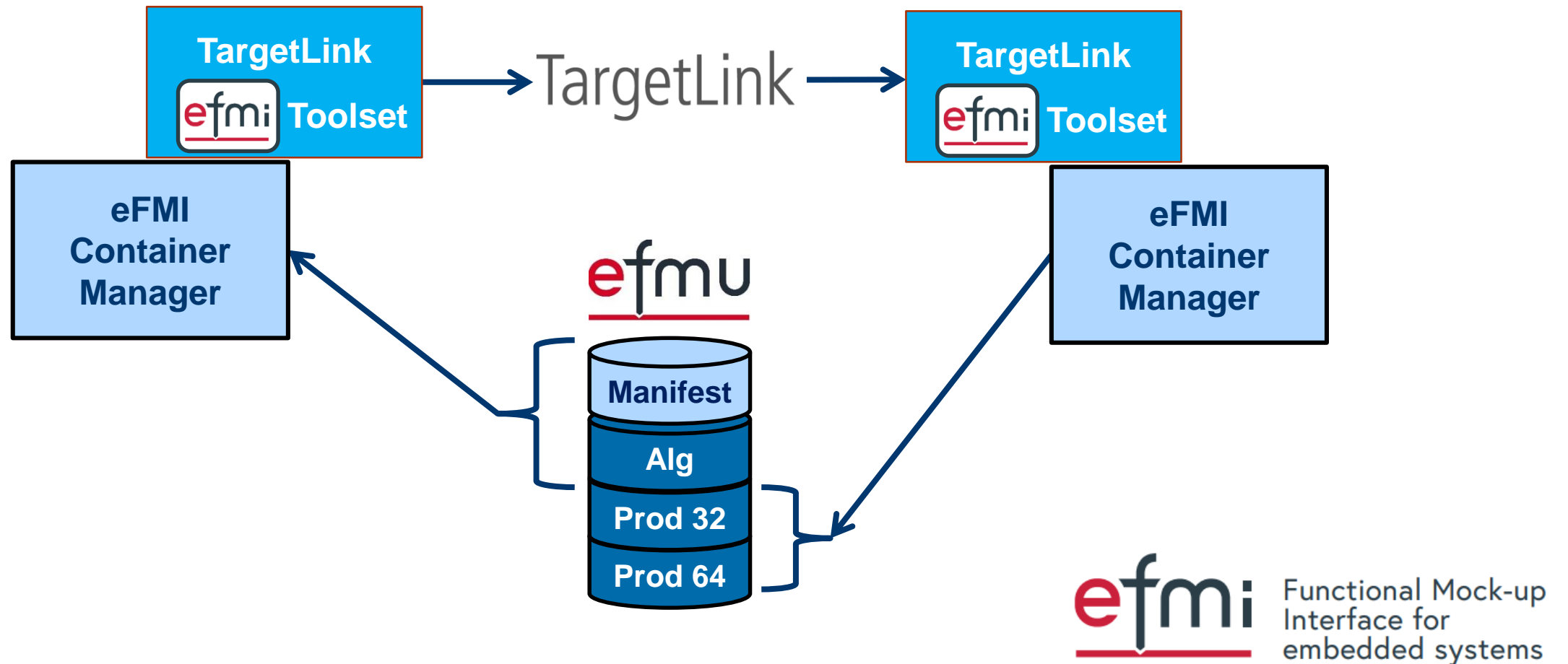


Import  
Export



Dedicated support for AUTOSAR, FMI and other important automotive standards

# TargetLink eFMI Support

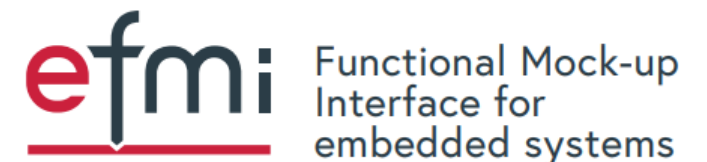
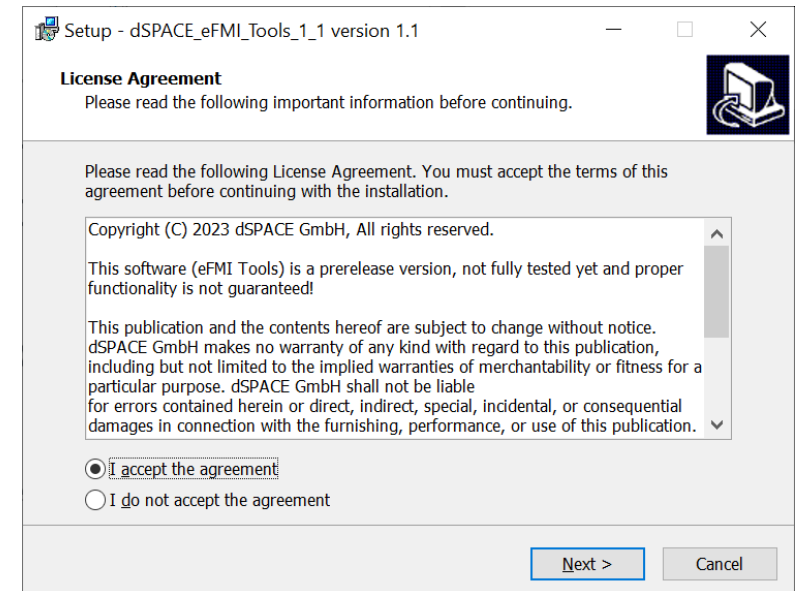




# TargetLink eFMI Toolset

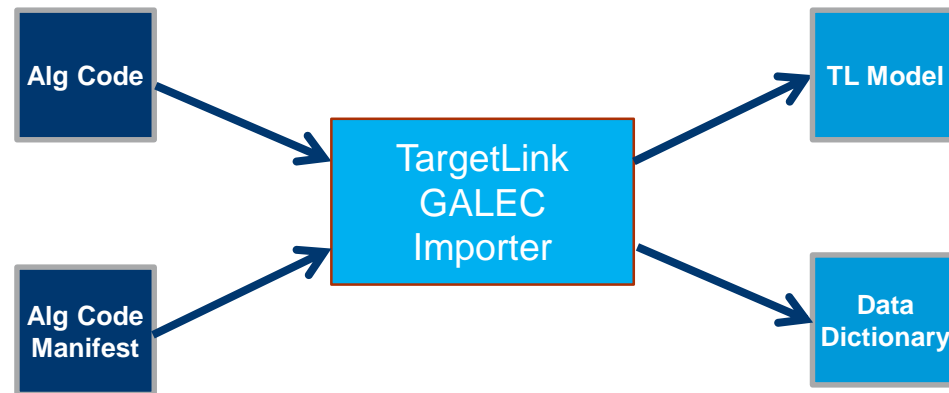


- How to get it?
  - Send mail to [support@dSPACE.de](mailto:support@dSPACE.de) or [efmi-info@googlegroups.com](mailto:efmi-info@googlegroups.com)
- Toolset based on TL22.1 Release/p4 or TL 23.1 Release
- Comes along as .zip file
  - Disclaimer
  - Involved 3<sup>rd</sup> party software
  - dSPACE Eula
  - Installer executable
- Installed toolset
  - Is portable, no registry entry or connection to TL version
  - C# CLI applications, easy integration into tool chain (e.g. Python scripts)
    - .NET framework 4.8 or higher is needed
- eFMI Container Manager needed (open source by MAP eFMI)



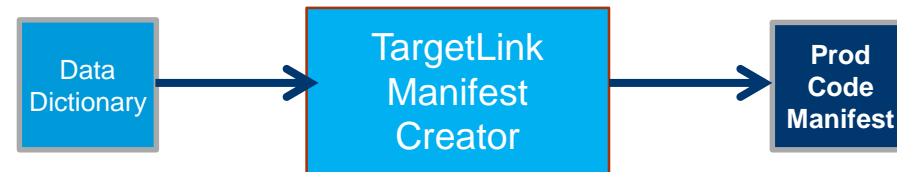
# TargetLink GALEC Importer

- Input: GALEC code file and associated manifest file
- Output: Generated input for the TargetLink code generator



# TargetLink Manifest Creator





- Input: Data Dictionary file augmented by TargetLink code generator
- Output: Manifest file for production code generated by TargetLink



- Consistency checks:
  - Generated XML tree is validated against the schema
  - References within the manifest are checked against the rules of the specification

# Demo: Enhance eFMU with Production Code

sschecks > eFMUs > AlgCode > Dymola > M04\_A > eFMU

<input type="checkbox"/> Name	Date modified	Type	Size
 ACode_Dymola	03.05.2022 08:43	File folder	
 BehavioralModel	03.05.2022 08:43	File folder	
 schemas	03.05.2022 08:43	File folder	
 __content.xml	03.05.2022 08:43	XML Document	1 KB

# Demo: Extract and Compile Algorithm Code

```
>>> Performing semantic analysis
>> Building intermediate code representation from AST (including name analysis)
>> Reading AlgoCode manifest
> Validating XML tree against schema (AlgoCode manifest file)
=> XML tree has been validated successfully
Warning: Found UnitDefinitions element in AlgoCode manifest, but it is not supported yet
>> Checking consistency between AST and manifest
>> Performing type analysis
>>> Generating code generation tree (CGT) from AST and intermediate code representation
>>> Performing analysis and optimization on CGT
>>> Generating input for TargetLink code generator
Generating files to directory: workdir\Dymola\M04_A
IntegrationMode is DISABLED

Note: Interprocedural optimization ignoring initializations in Startup() like constant propagation has been disabled, because no manifest has been provided or some non-interface model variables are missing (maybe due to obfuscation)

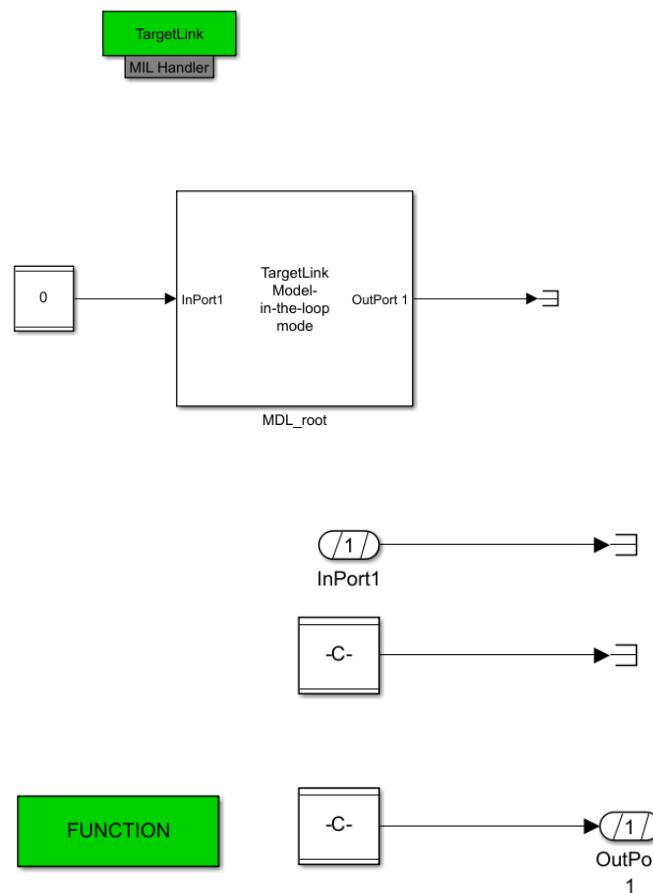
Generating data dictionary ...
Generating model ...
```

TargetLink  
GALEC  
Importer

# Demo: Prepared TargetLink Model and Data Dictionary

t > test > dSPACE\_eFMI\_Tools\_1\_1 > workdir > Dymola > M04\_A >

Name	Date modified	Type	Size
builtin_functions	18.08.2023 11:43	File folder	
_tl_post_codegen.sam	18.08.2023 11:43	SAM File	1 KB
adapt_bus_ports.m	18.08.2023 11:43	MATLAB Code	1 KB
AlgoCodeToTargetLink.dd	18.08.2023 11:43	DataDictionary File	180 KB
AlgoCodeToTargetLink.slx	18.08.2023 11:43	Simulink Model	25 KB
create_bus_objects.m	18.08.2023 11:43	MATLAB Code	2 KB
efmu_locals_map.csv	18.08.2023 11:43	Microsoft Excel Com...	6 KB
efmu_state_map.csv	18.08.2023 11:43	Microsoft Excel Com...	7 KB
generate_sfunction.m	18.08.2023 11:43	MATLAB Code	1 KB
prepare_for_codegen.m	18.08.2023 11:43	MATLAB Code	1 KB
save_dd_with_subsystems.m	18.08.2023 11:43	MATLAB Code	1 KB
set_float_precision.m	18.08.2023 11:43	MATLAB Code	1 KB
set_sample_time.m	18.08.2023 11:43	MATLAB Code	1 KB
start.m	18.08.2023 11:43	MATLAB Code	2 KB
tl_adapter.itfx	18.08.2023 11:43	ITFX File	6 KB
TL_error_signals.itfx	18.08.2023 11:43	ITFX File	1 KB
tl_fm_u_post_setoptions_hook.m	18.08.2023 11:43	MATLAB Code	1 KB
tl_pre_codegen_hook.m	18.08.2023 11:43	MATLAB Code	1 KB
TL_saturation.itfx	18.08.2023 11:43	ITFX File	1 KB
TL_standard_mathematics.itfx	18.08.2023 11:43	ITFX File	1 KB
tl_userblock.itfx	18.08.2023 11:43	ITFX File	24 KB



DD0

- Config
- Pool
  - Variables
    - RTOS
    - TLPredefinedVariables
    - eFMU\_state
      - eFMU\_input
        - Components
          - M\_desired
          - wRel
        - eFMU\_output
          - Components
            - M\_motor
          - eFMU\_constant
          - eFMU\_tunableParameter
            - Components
              - J\_M
              - Ni\_PI
              - Ti\_PI
              - c\_res
              - d\_res
              - f\_cut
              - gearRatio
              - k\_PI
              - k\_accCor
              - tauM\_max
          - eFMU\_dependentParameter
            - eFMU\_Clock
            - eFMU\_err\_INVALID\_ARGUMENT
            - eFMU\_err\_OVERFLOW
            - eFMU\_err\_NAN
            - eFMU\_err\_SOLVE\_LINEAR\_EQUATIONS\_F
            - eFMU\_err\_NO\_SOLUTION\_FOUND
            - eFMU\_err\_UNSPECIFIED\_ERROR
            - eFMU\_err\_all\_predefined\_signals
            - eFMU\_err\_all\_signals
            - eFMU\_ErrorSignalStatus

# Demo: Enhanced eFMU with Production Code

MUs > ProdCode > TargetLink > from\_Dymola > M04\_A > eFMU >

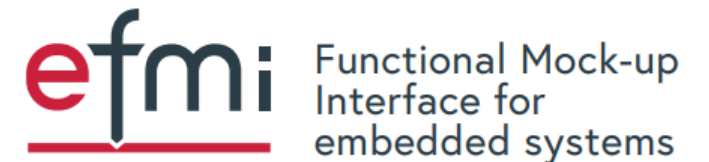
TargetLink  
Manifest  
Creator

<input type="checkbox"/> Name	Date modified
ACode_Dymola	18.08.2023 13:01
BehavioralModel	18.08.2023 13:01
PCode_TargetLink32	18.08.2023 13:01
PCode_TargetLink64	18.08.2023 13:01
schemas	18.08.2023 13:02
__content.xml	18.08.2023 13:01

- PCode\_TargetLink64
  - builtin\_functions ← mathematical library
  - TLFMU
  - FmuMDL\_root.fmu ← included FMU
  - TLProj
    - MDL\_root
      - tl\_basetypes.h
      - tl\_userblock.c
      - tl\_userblock.h
      - udt\_a.h
    - efmu\_locals\_map.csv
    - efmu\_state\_map.csv
    - manifest.xml

generated production code

production code manifest



# Demo: Manifest with FMU entry

```
<?xml version="1.0" encoding="utf-8"?>
<Manifest efmiVersion="1.0.0" xsdVersion="0.17.0" id="{ee0d531e-3d0b-46b6-9ade-019cae7ef0de}" kind="ProductionCode" name="AlgoCodeToTargetLink" generationDateAndTime="2
...<ManifestReferences>
...<ManifestReference id="ID_MNFST_1" manifestRefId="{d447bd03-ec94-4ef6-b6d8-778fd76111c5}" checksum="08c46df1a3351dac864ab9b855acad0e5a373929" origin="true" />
...</ManifestReferences>
...<Files>
...<File id="ID_FILE_tl_basetypes.h_1" name="tl_basetypes.h" path="./TLProj/MDL_root/" needsChecksum="true" checksum="6c48b26c85a43185773e4f6179374896f6c3ca73" role="C
...<File id="ID_FILE_udt_a.h_2" name="udt_a.h" path="./TLProj/MDL_root/" needsChecksum="true" checksum="611d17bf0e156e8d68106b98c3d1dfd50006aaad" role="Code" />
...<File id="ID_FILE_tl_userblock.h_3" name="tl_userblock.h" path="./TLProj/MDL_root/" needsChecksum="true" checksum="26b7387d00056321a071ec36fc33defeb85a99bb" role="C
...<File id="ID_FILE_tl_userblock.c_4" name="tl_userblock.c" path="./TLProj/MDL_root/" needsChecksum="true" checksum="009558e9d38a18da2cf28e393f471c44533a79ff" role="C
...<File id="ID_FILE_TL_error_signals.h_5" name="TL_error_signals.h" path="./builtin_functions/" needsChecksum="true" checksum="f06af138be466b9ff95e603529da944d51efc7a
...<File id="ID_FILE_TL_error_signals.c_6" name="TL_error_signals.c" path="./builtin_functions/" needsChecksum="true" checksum="9fafa841e7610c505745246e6ae95dc5df77bfb
...<File id="ID_FILE_TL_saturation.h_7" name="TL_saturation.h" path="./builtin_functions/" needsChecksum="true" checksum="1f7a6a1f60892ba75872b1e0ef989145a7eb8270" rol
...<File id="ID_FILE_TL_standard_mathematics.h_8" name="TL_standard_mathematics.h" path="./builtin_functions/" needsChecksum="true" checksum="5f34c21ef63318c0d628e2f11
...<File id="ID_FILE_TL_standard_mathematics.c_9" name="TL_standard_mathematics.c" path="./builtin_functions/" needsChecksum="true" checksum="bb0dc80b2cf3fbde891e447f2
...<File id="ID_FILE_TL_float_precision.h_10" name="TL_float_precision.h" path="./builtin_functions/" needsChecksum="true" checksum="6188fe4cf59fc429d0894e061fd423b147
...<File id="ID_FILE_TL_primitive_types.h_11" name="TL_primitive_types.h" path="./builtin_functions/" needsChecksum="true" checksum="cc86ea69ab84280b7cf109a50c5272d919
...<File id="ID_FILE_FmuMDL_root.fmu_12" name="FmuMDL_root.fmu" path="./TLFmu/" needsChecksum="true" checksum="4cbcd48abbeceea1412534748124acbf18d5ff01" role="FMU" />
...</Files>
```

eFMI Container Manager  
unpackFMU

Name	Größe
documentation	1 092
eFMU	8 020 767
sources	102 178
modelDescription.xml	7 809

Name	Größe
builtin_functions	13 510
FmuMDL_root.c	22 515
fmuTemplate.h	1 488
MDL_root_fri.c	880
MDL_root_fri.h	1 899
mdl_root_tlaf.c	8 418
mdl_root_tlaf.h	838
tl_adapter.c	
tl_adapter.h	
tl_basetypes.h	
tl_sim_limits.h	
tl_sim_types.h	
tl_userblock.c	
tl_userblock.h	
udt_a.h	





---

## What else to do with TargetLink?

- Simulate model in TargetLink (SIL) with data from Behavioral Model
  - E.g., single-precision vs. double-precision
- Reconfigure Data Dictionary to generate AUTOSAR Classic/Adaptive code
- Generate .a2l file to be used in calibration tools
- Generate Matlab S-function to be used in MIL mode
- Use block in other models
  - Copy
  - Library
  - Model referencing
- Use TargetLink Custom Code block to integrate generated code
- Generate V-ECU and simulate with dSPACE VEOS
- ...

**dSPACE**


<https://www.dspace.com/en/pub/home.cfm>

TargetLink

<https://www.dspace.com/en/pub/home/products/sw/pcgs/targetlink.cfm>



[support@dspace.com](mailto:support@dspace.com)

 **efmi** Functional Mock-up  
Interface for  
embedded systems

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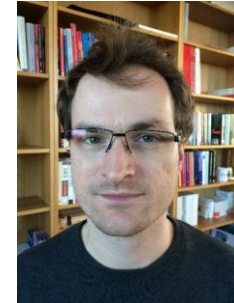
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Interface for  
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