Automatic Generation of Qualification Documentation at the Example of RTEMS QDPs

Frank Kühndel, Sebastian Huber and Matthias Göbel

embedded brains GmbH & Co. KG
Puchheim, Germany

Overview

Introduction	• RTEMS OS space qualified to category B • Automation for Cheaper and Frequent QDP Updates • Manual Work Is Still Needed
Automation	• RTEMS QDPs build by an automated process • Documents generated with data from the build process
Examples	• Example spec item use • Generated C header files add hyperlinks • Doxygen tag file helps to create traceability matrices
Conclusion	

RTEMS OS Space Qualified to Cat. B

- RTEMS = Real Time OS, Open Source Software
- Qualified Data Package (QDP)
  - Pre-Qualified to Cat. B (ECSS standard; checked by ESA)
  - For Gaisler SPARC processors for aerospace (radiation-hard): GR712RC (LEON3 dual core) and GR740 (LEON4 quad core)
  - Download at https://rtems-qual.io.esa.int/
- Currently qualification update of multi and single core QDPs

Automation for Economic and Frequent QDP Updates

Open source RTEMS code is **continuously** developed

- Many extensions
- Many patches
- Many updates

→ **very dynamic**

Qualification is labor-intensive

→ **very static**

Manual Work Is Still Needed

Automatically Generated (in parts)

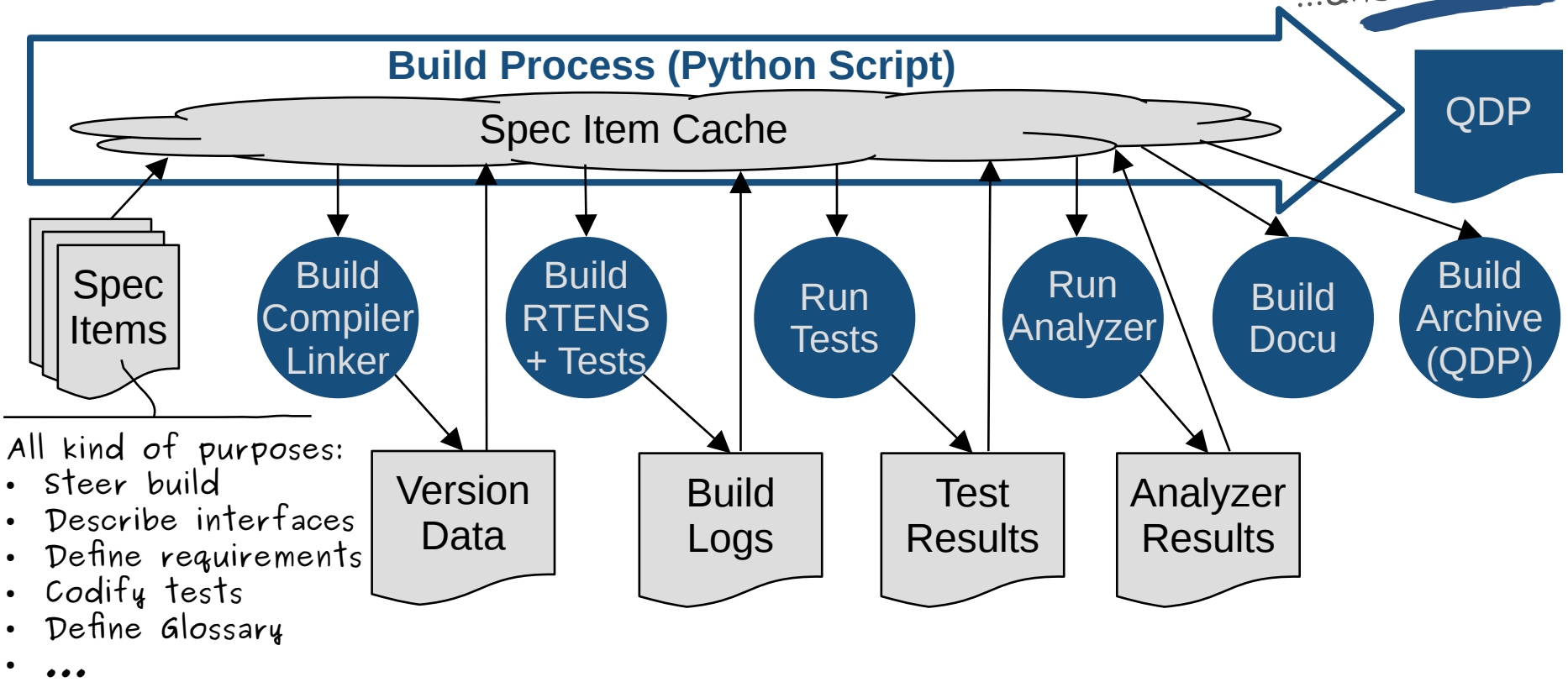
- ICD – Interface Control Document
- SCF – Software Configuration File
- SDD – Software Design Document
- SPAMR – Software Product Assurance Record
- SRELD – Software Release Document
- SRS – Software Requirements Specification
- SUITP – Software Unit and Integration Test Plan
- SVR – Software Verification Record includes
  - SUITR – Software Unit and Integration Test Report
  - SValR – Software Validation Report
- SVS – Software Validation Specification
- SUM – Software User Manual
- RTEMS Software Engineering
- RTEMS CPU Architecture Supplement
- RTEMS Classic API Guide

Manually Written

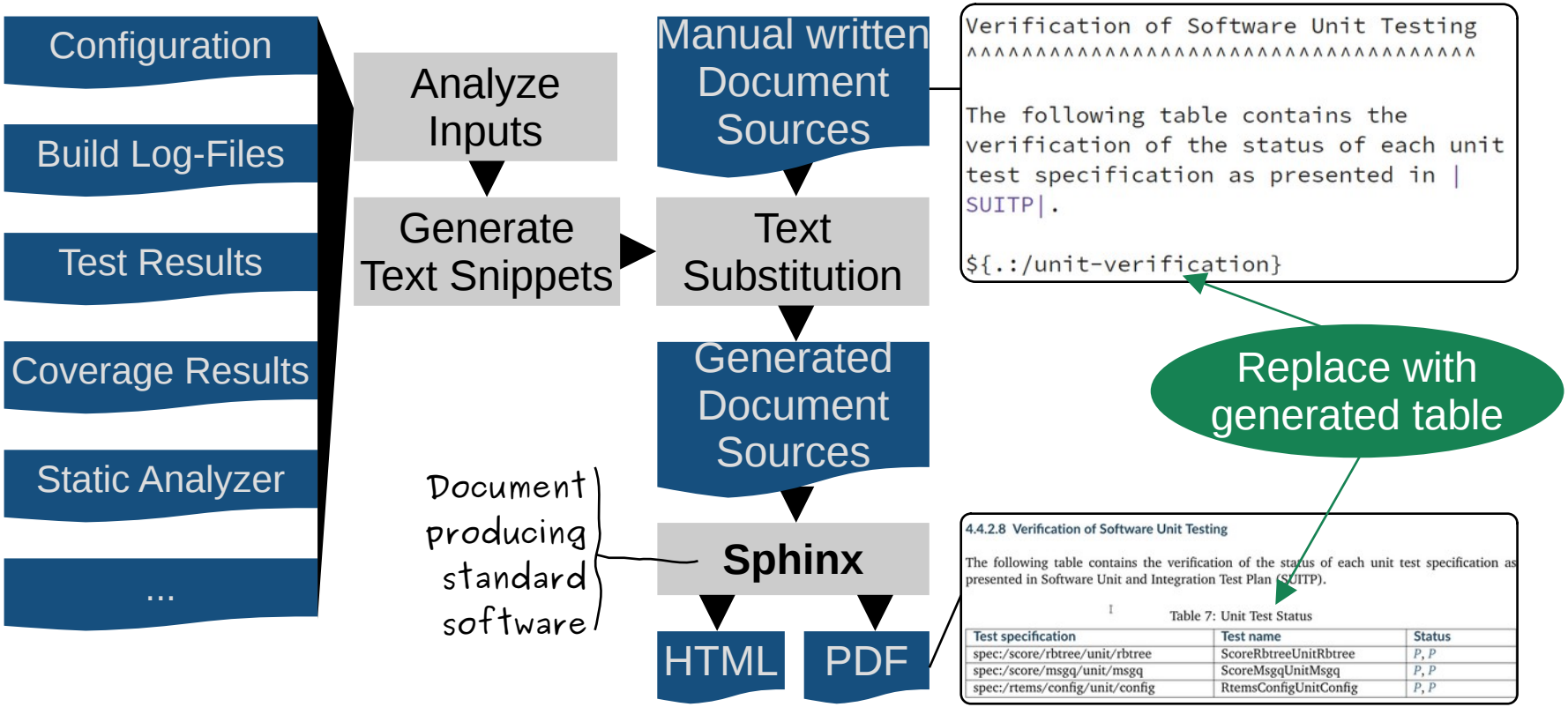
- Formal Verification
- Software Reuse File
- Software Review Plan
- Software Configuration Management Plan
- Software Development Plan
- Software Product Assurance Plan
- Tool Chain Software
- User Manual
- Technical Notes

RTEMS QDPs Build by an Automated Process

...and it works!



Documents Generated with Data from the Build



Example Spec Item Use (1/4)

...and it works!

rtems/timer/if/create.yml — Spec item/YML file

```
brief: |
  Creates a timer.
description: |
  This directive creates a timer
  which resides on the local
  Node. [...]
name: rtems_timer_create
params:
- description: |
    is the object name of the
    timer.
  name: name
[...]
```

ICD

5.2.2.685. spec:/rtems/timer/if/create

interface-type:

function

name:

rtems_timer_create

description:

This directive creates a timer which resides on the local node. object name specified in name. The assigned object identifier used to access the timer with other timer related directives.

function:

```
rtems_status_code rtems_timer_create( rtems_name name, rte
```

Example Spec Item Use (3/4)

...and it works!

rtems/timer/if/create.yml

```
brief: |
  Creates a timer.
description: |
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name: rtems_timer_create
params:
- description: |
    is the object name of the
    timer.
  name: name
[...]
```

RTEMS Classic API Guide

10.4.1. rtems_timer_create()

Creates a timer.

CALLING SEQUENCE:

```
rtems_status_code rtems_timer_create( rtems_name name,
```

PARAMETERS:

name

This parameter is the object name of the timer.

id

This parameter is the pointer to an rtems_id object. It

Example Spec Item Use (2/4)

rtems/timer/if/create.yml

```
brief: |
  Creates a timer.
description: |
  This directive creates a timer
  which resides on the local
  Node. [...]
name: rtems_timer_create
params:
- description: |
    is the object name of the
    timer.
  name: name
[...]
```

rtems/timer.h

```
/* Generated from spec:/rtems/timer/if/create *
.
/**.
 * @ingroup RTEMSAPIClassicTimer.
 *.
 * @brief Creates a timer..
 *.
 * @param name is the object name of the timer.
 *.
 * @param[out] id is the pointer to an ::rtems_
 *   call is successful, the identifier of the
 *   this object..
 *.
 * This directive creates a timer which resides
 * has the user-defined object name specified i
 * identifier is returned in ``id``.  This iden
 * timer with other timer related directives..
 *.
```

Example Spec Item Use (4/4)

rtems/timer/if/create.yml

```
brief: |
  Creates a timer.
description: |
  This directive creates a timer
  which resides on the local
  Node. [...]
name: rtems_timer_create
params:
- description: |
    is the object name of the
    timer.
  name: name
[...]
```

A number of „smaller“ usages (e.g. the function name in requirements)

Traceability matrices (I will show ...)

Hyperlinks between documents (I will show ...)

Avoiding repetition is not the only usage

Generated C Header Files Add Hyperlinks (1/3)

...and it works!

Includes the generated rtems/timer.h
⇒ SDD contains the text from the spec item, too

Source Code

Standard software to create documentation from source code

Doxygen

Software Design Description HTML + PDF

SDD

◆rtems_timer_create()

```
rtems_status_code rtems_timer_create ( rtems_name  name,
                                       rtems_id *  id
                                     )
```

Creates a timer.

Parameters

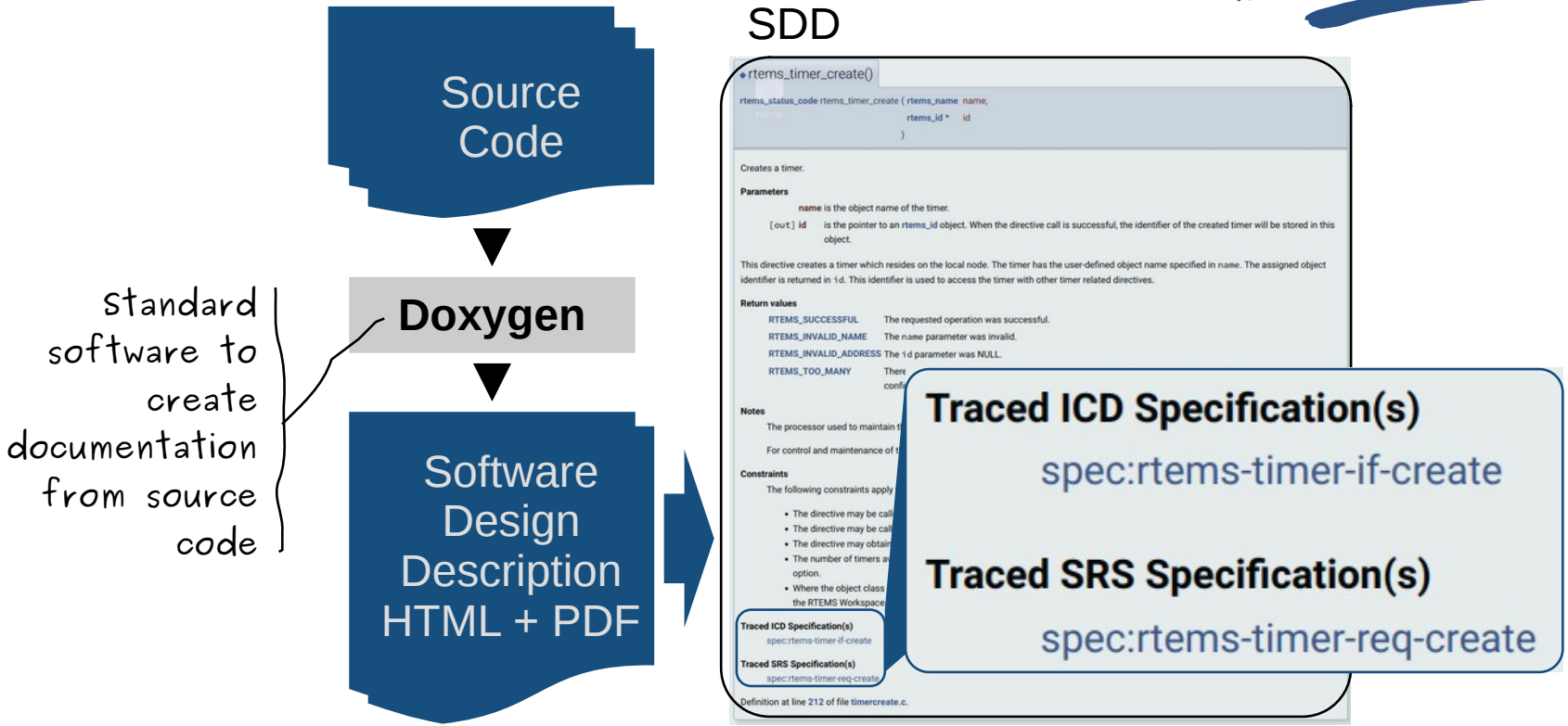
name is the object name of the timer.

[out] **id** is the pointer to an rtems_id object. When the directi
object.

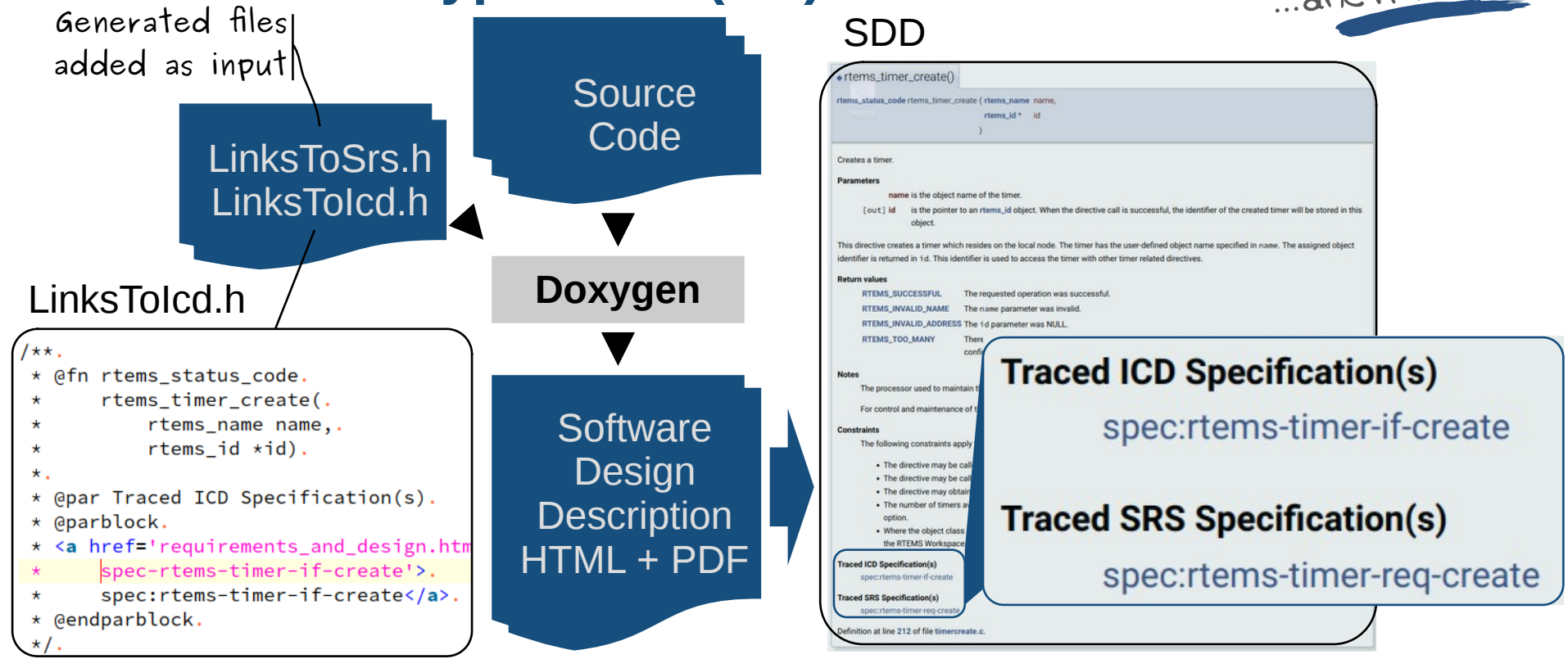
This directive creates a timer which resides on the local node. The timer
identifier is returned in id. This identifier is used to access the timer with

Return values

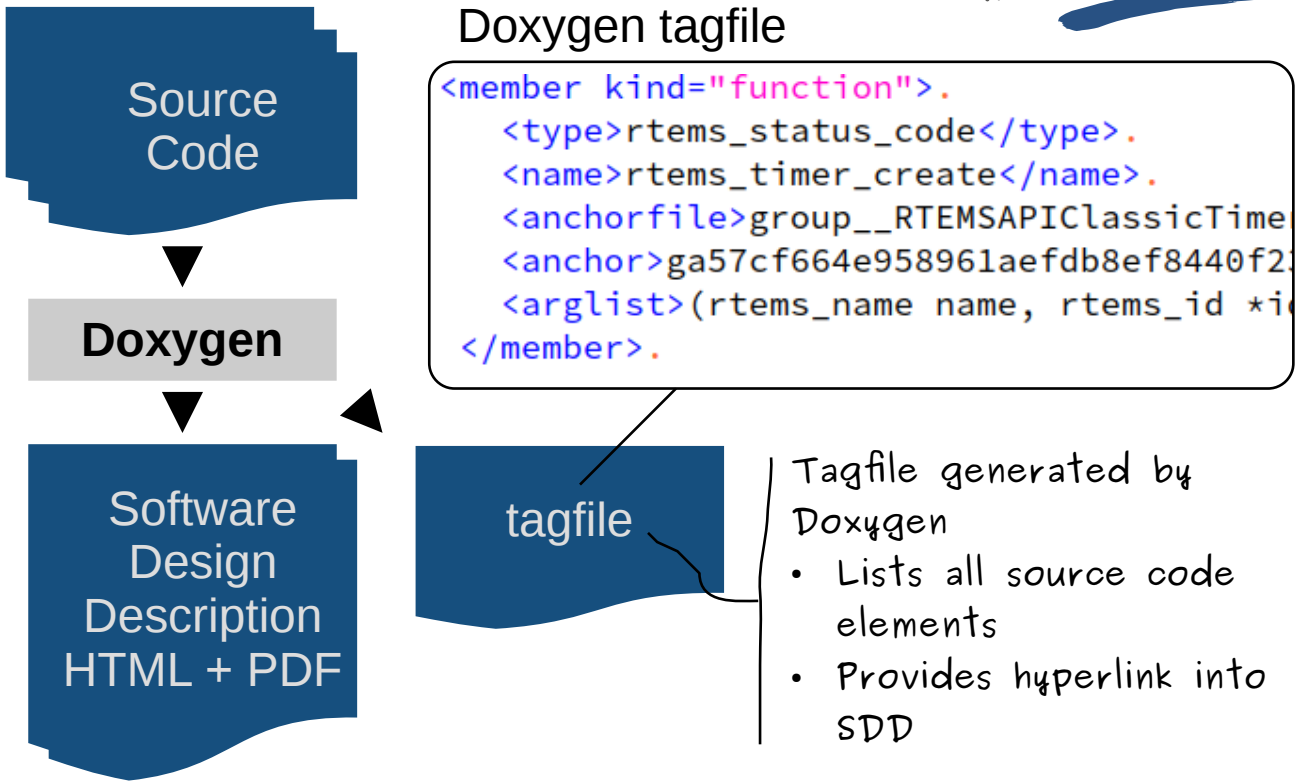
Generated C Header Files Add Hyperlinks (2/3)



Generated C Header Files Add Hyperlinks (3/3)



Doxygen Tag File Helps to Create Traceability Matrices (1/3)



Doxygen Tag File Helps to Create Traceability Matrices (2/3)

...and it works!

Generating the ICD and SRS:
Use tagfile info to create cross references to SDD

ICD

Traced design component:

RTEMSAPIClassicTimer - rtems_timer_create

SRS

Traced design component:

RTEMSAPIClassicTimer - rtems_timer_create

Doxygen tagfile

```
<member kind="function">.
   <type>rtems_status_code</type>.
   <name>rtems_timer_create</name>.
   <anchorfile>group__RTEMSAPIClassicTime
   <anchor>ga57cf664e958961aefdb8ef8440f2
   <arglist>(rtems_name name, rtems_id *i
</member>.
```

tagfile

Tagfile generated by Doxygen

- Lists all source code elements
- Provides hyperlink into SDD

Doxygen Tag File Helps to Create Traceability Matrices (3/3)

embedded brains ...and it works!

⇒ Tagfile helps generate traceability matrices and linking documents

ICD

Traced design component:

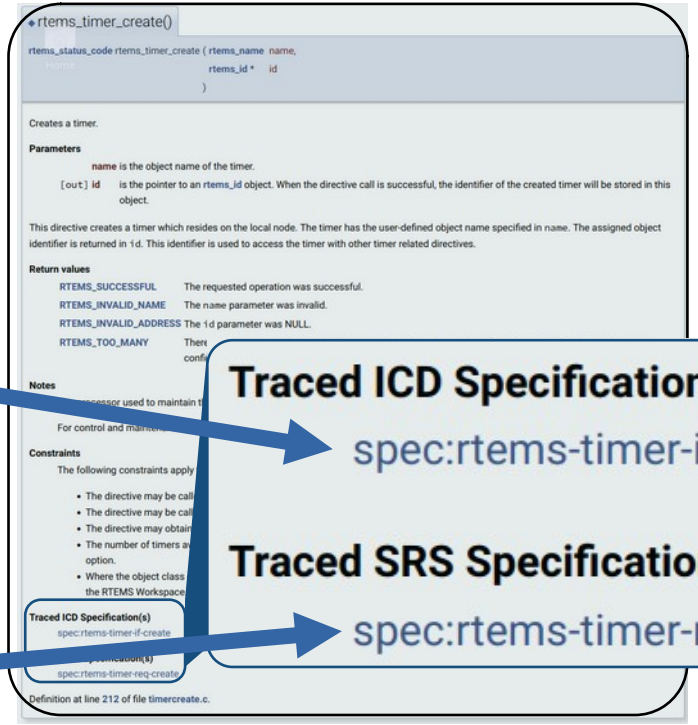
RTEMSAPIClassicTimer - rtems_timer_create

SRS

Traced design component:

RTEMSAPIClassicTimer - rtems_timer_create

SDD



Traced ICD Specification(s)

spec:rtems-timer-if-create

Traced SRS Specification(s)

spec:rtems-timer-req-create

Conclusion

Automated document generation reduces costs of qualification

Automated document generation permits frequent updates of QDPs

Manual writing (parts) of documents is still required

QDPs must still be reviewed and delta qualified

Thank You!

Email: frank.kuehndel@embedded-brains.de

Phone: +49 89 18 94 741 - 23