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A	12-Jan-2021	Uwe Dehne	R&D Electronics & Software Sensus-Xylem Laatzen
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ABBREVIATIONS

ABC	Application Binary Container, this is the application code also mentioned as firmware
ADF	Applications Description File, a file describing the ABC as valid combination of applications including versions and CRCs for one specific firmware release
Breeze	Name of the operating system (Boot loader included) of the Cordonel.
Common	Implementation of commonly used functions
Cordonel™	Water meter with ultra-sonic measurement, initial name GENESIS
Core Revision	The version of the “Breeze Operating System” installed on the Cordonel.
CRC	Cyclic Redundancy Check, used as checksum used to validate a binary file
DB	Data Base
DLL	Dynamic Link Library
FW	Firmware, this is a combination of several applications combined to an ABC.
FW-Update	This is the installation process of the firmware.
FW-Update Builder	Software which collects all data needed for the update process including the “FW-Update SW” and builds out of these the encrypted “FW-Update Safe”.
FW-Update Loader	Software which decrypts the “FW-Update Safe”, starts the “FW-Update SW” and delivers the “FW-Update Packages” to the “FW-Update SW”.
FW-Update Safe	The encrypted container carrying all information needed for the “FW-Update Procedure”.
FW-Update SW	The software doing the real update process
FW-Update Package	The decrypted data (ADF, ABC) needed for the “FW-Update Procedure”.
FW-Update Procedure	The entire FW-Update carried out by the “FW-Update SW”
GENESIS	Legacy name for the Cordonel™
GTB	GENESIS Toolbox, selection of Tools to access to the Cordonel™ internals
HW	Hardware
ID	Identification number
IrDA	Infrared Data Association, used as serial communication interface
LED	Light Emitting Diode, used as serial communication interface
PCB	Printed Circuit Board, the Cordonel™ electronics
Skeleton Key	Initial password for all login levels if the password file is not installed or invalid.
SRS	Software Requirement Specification
SW	Software
tbd	to be defined
TBF	Test Bench Framework, the entire SW for the test benches and meters
UM	User Manual
Validation Date	Date until a user registration is valid and the user can perform all operations
VPN	Virtual Private Network

Table 1.1 Abbreviations

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1. General Part

The requirements are deviated from the “Cordonel™ Service FW-Update Process - Marketing Requirement Document” [FWU_MRD].

1.1 Introduction

The Cordonel™ may need a firmware (FW) update during life time. Before a secure process has been developed, an interim solution is needed to update the first samples.

It is required to update the Cordonel™ offline without any connection to the SENSUS/Xylem network. In advance all data needed for the FW update have to be acquired online.

1.2 Document Content

This document states the requirements for “Cordonel™ Service FW-Update Package”.

The “FW-Update Package” contains three single software modules. These are needed to prepare, load and execute the “FW-Update Process”. As this package of three software’s has many common interfaces and similarities, the requirements are covered by this single software requirement specification. The SW package contents are:

1. The “FW-Update Builder” [2.2],
2. the “FW-Update Loader” [2.3] and
3. the “FW-Update SW” [2.4].

The requirements of the two data containers for the exchange of information between the “online” and “offline” operation are described in detail as there are part of the requirements:

1. The “FW-Update Safe” [3.4] and
2. the “FW-Update Report” [3.7].

An overview of the data exchange between the three software packages will be specified.

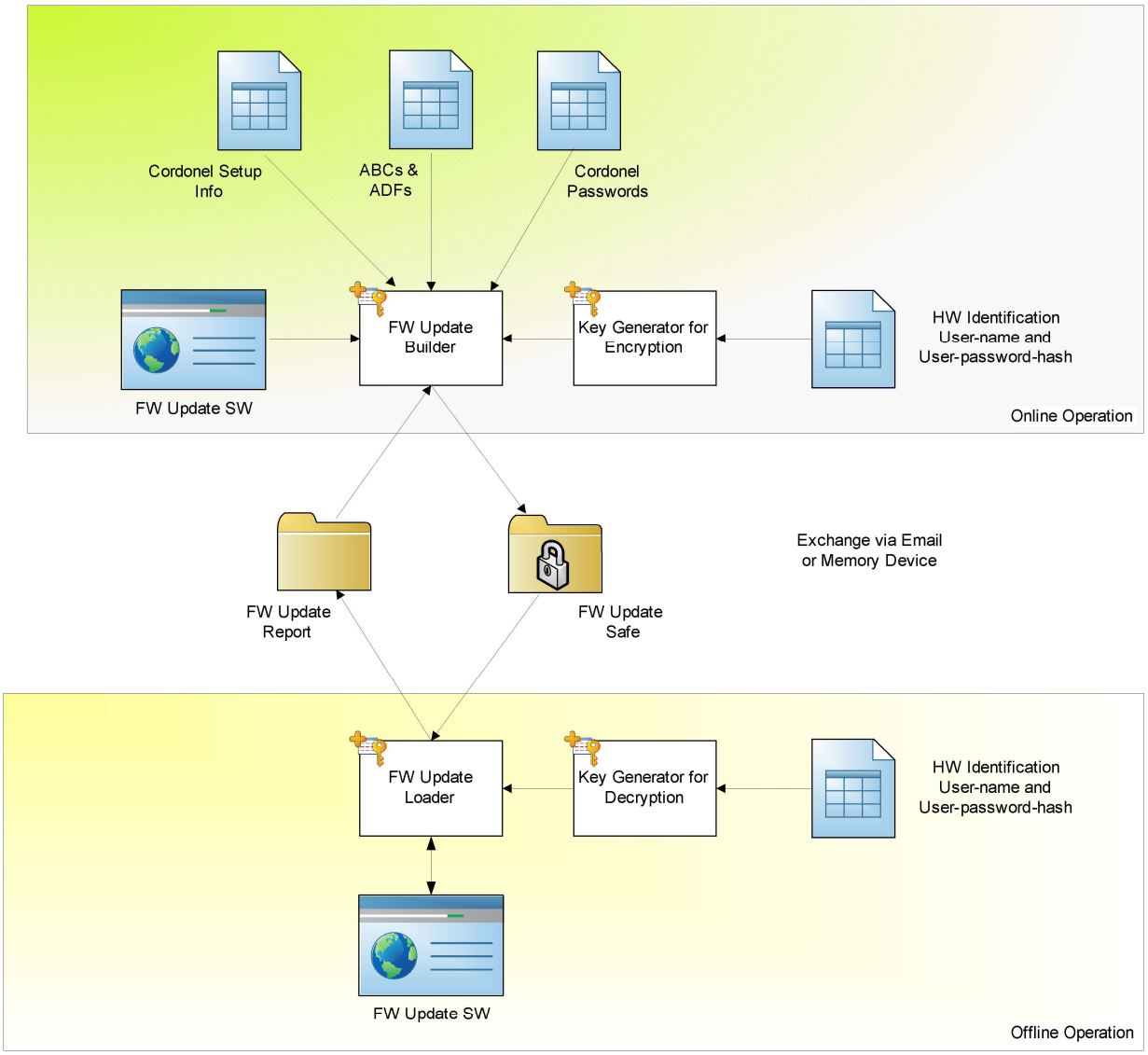
1.3 Intended Audience

This documentation is written for a software developer but can also be used for an interested system administrator or manager to get a closer overview of the software internals.

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1.4 System Overview

The system overview structures the different software parts and shows the data exchange containers between the “online” and “offline” operation. It will give a brief overview for a better understanding of the FW-Update package components.



Picture 1.1 System Overview

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2. Prerequisites

This chapter states the requirements needed for the “Cordonel™ Service FW-Update” package. The requirements are split into “General Required Software”, which applies to all SW modules, and to the specific requirements for each module separately.

2.1 General Required Software

The Microsoft™ .NET framework 4.7.2 or higher has to installed on the PC.

2.2 FW-Update Builder Prerequisites

The “FW-Update Builder” has to check the FW-Update capability, collect all data needed for the update process, build the encryption key and build the “FW-Update Safe”. Additional this software will merge the report of the update procedure to the production DB and print a report protocol.

Therefore the essential information is stored to several DBs being able to retrieve this information.

2.2.1 LaaDB Content

The LaaDB shall store for each Cordonel™:

1. The “Application Binary Container” (ABC), this is the released and validated FW as combination of all needed applications for a specific release,
2. the “Application Description File” (ADF), this is the FW description file of the ABC content,
3. the Cordonel “PCB ID", which is the Cordonel HW identification and can be read out from the Cordonel™ via NFC and IrDA,
4. the Cordonel “Meter ID”, this can be a customer or SENSUS ID,
5. the Order number, giving information which production order is assigned to a specific device,
6. the Cordonel Radio Address, needed to access the LuDB passwords and radio key,
7. the Cordonel™ core revision, the version which is installed on the product, history of installed FW, including the installed Metrology version, essential for update capability,
8. the Cordonel history of registers setups,
9. the Cordonel meter size, needed for specific FW releases,
10. the Service technician Laptop identification (HW identification),
11. the Service technician name and password hash.

2.2.2 LuDB Content

The LuDB shall contain:

1. The Cordonel Passwords for level 1, 2, 4, 5, 6, 7, 8 per Cordonel (level 3 will be generated using the processor hardware identification key), already implemented, and
2. the Cordonel Radio key, already implemented.

2.3 FW-Update Loader - Prerequisites

The “FW-Update Loader” has to be installed on the Laptop which will be used for the FW update process. This loader loads the “FW-Update Safe”, decrypts it and executes the “FW-Update SW”. Additional this SW is going to create the report for all executed FW updates.

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In fact an installation is here just a copy to a folder, the “FW-Update Loader” can be executed from any storage device as mobile application.

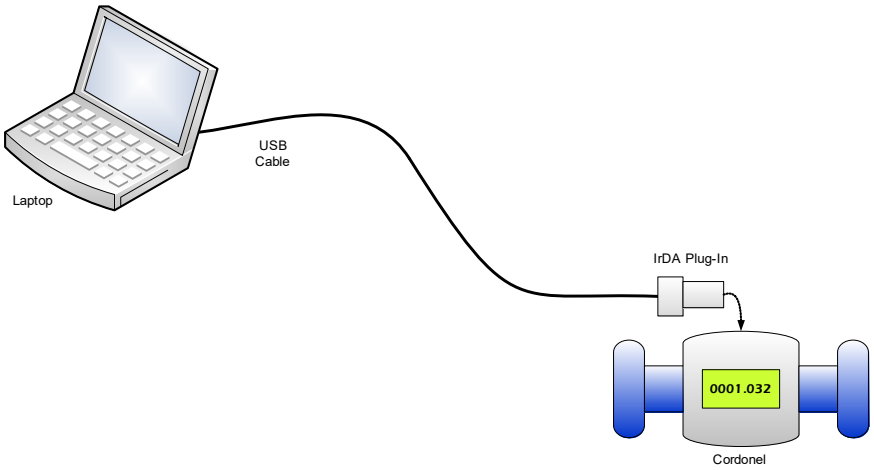
2.4 FW-Update Software - Prerequisites

The “FW-Update SW” is the core of the update process. It communicates with the Cordonel™ and executes the download of the new FW.

2.4.1 FW-Update Software - Hardware Requirements

To execute the “FW-Update SW” a special HW is needed to communicate via IrDA with the Cordonel™:

1. PC or Laptop with 1 free USB port,
2. USB IrDA Plug-In adapter.



Picture 2.1 FW-Update SW – HW Requirements

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3. General Requirements

These “General Requirements” are common for all software modules.

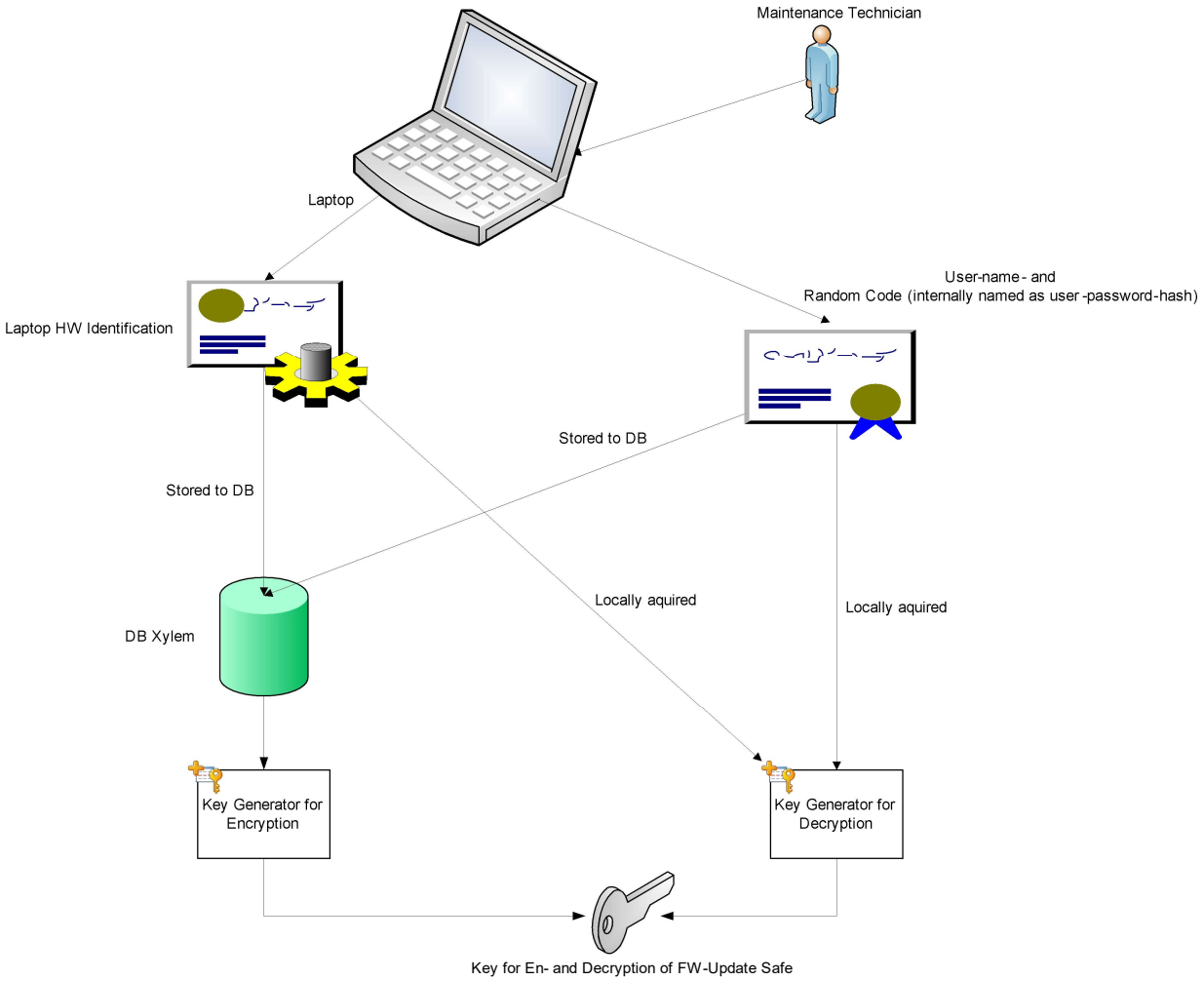
3.1 FW-Update - Software Design

3.1.1 [SRS_FW_UPD_GEN_DESIGN_001] User Interface Language

All user messages and menus shall be prepared for multilingual usage. The implementation shall cover the English and German language.

3.2 FW-Update - Key Generation

The key is required to encrypt and decrypt the “FW-Update Safe”. As input for the key the information stored on the PC shall be used to avoid an unsecure key exchange. This key has to be generated out of the PC HW information, to avoid execution on a unregistered device, the user name and a random code later referred as user password-hash.



Picture 3.1 Key Generation

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3.2.1 [SRS_FW_UPD_GEN_KEY_001] PC Hardware Device Identification

While the HDD or SSD may not be sufficient to identify a computer as unique device, this may be necessary to replace due to a disk failure, the BIOS UUID and Processor ID shall be used to unambiguous specify a specific PC.

3.2.2 [SRS_FW_UPD_GEN_KEY_002] User Name

The user identification shall contain the domain name and the the user name of the technician who should carry out the offline FW update.

3.2.3 [SRS_FW_UPD_GEN_KEY_003] User Password Hash

- Deprecated Requirement – As the password hash could not be acquired from the Win10 system (SAM), a user random code generation will replace this requirement

The user password hash is stored on every machine the user is authenticated. Therefore this information shall be directly accessed by the “FW-Update Loader”. The FW-Update builder has to retrieve this information from a DB.

3.2.4 [SRS_FW_UPD_GEN_KEY_004] User Random Code

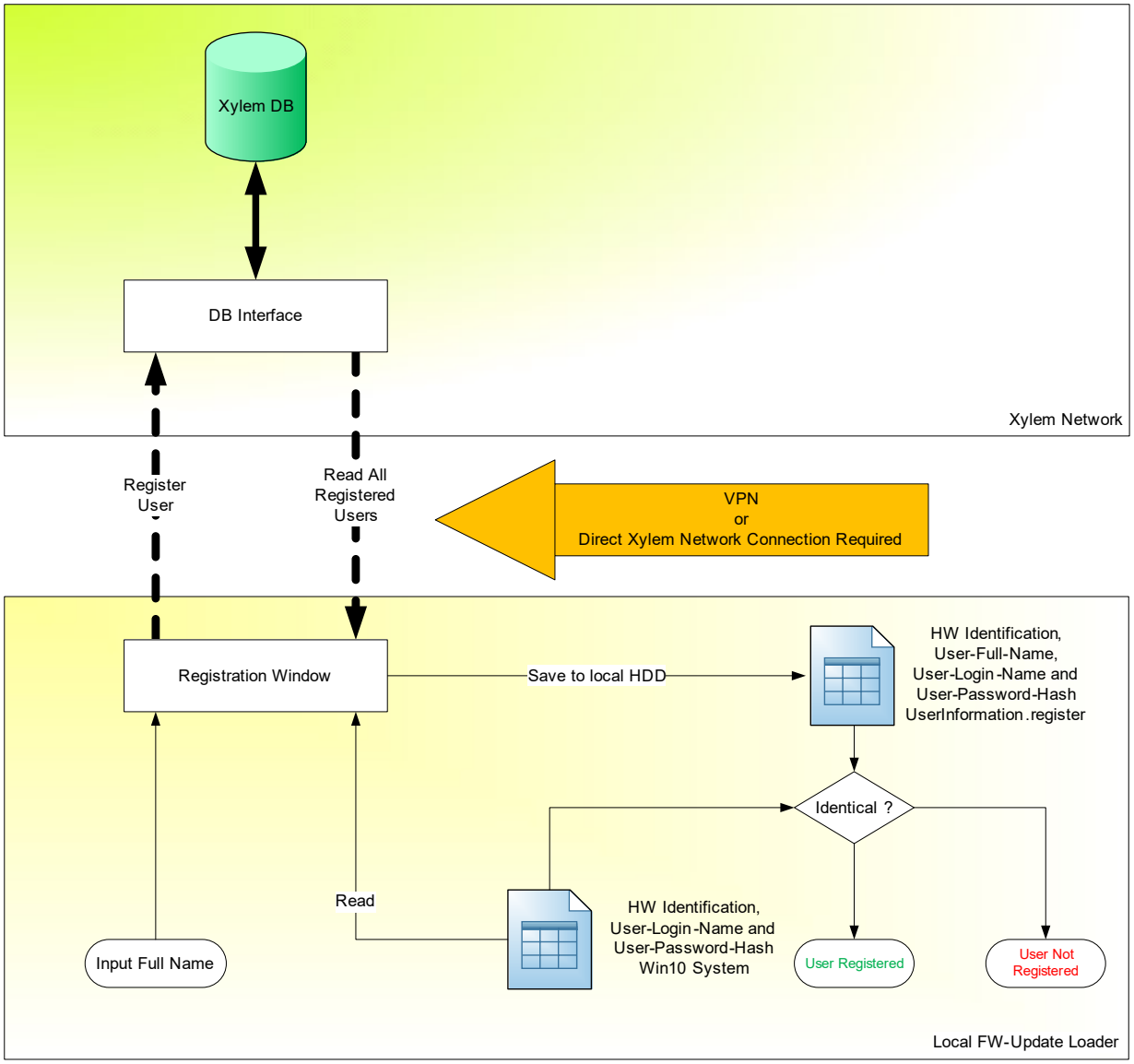
The user random code will be generated on every expiration of the user validation date or refresh of the validation date and stored to the user profile folder in the “UserInformation.register” file. Therefore this information shall be directly accessed by the “FW-Update Loader”. The “FW-Update Builder” needs this information for encryption of the “FW-Update Safe”. It has to retrieve these information from the Xylem DB.

The internal naming for this random code will still remain “user password hash”.

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3.3 FW-Update - User Registration

For the encryption and decryption of the “FW-Update Safe”, the user information needs to be exchanged between the local PC of the technician and the Xylem DB. The registration process has to be executed during the “online” operation, while the “FW-Update Process”, after the registration, does not need an active connection to the Xylem Network.



Picture 3.2 User Registration

3.3.1 [SRS_FW_UPD_GEN_USER_001] User Full Name Naming Convention

As the full name of the user cannot be recaptured from the Win10 System, this has to be input by the user during registration. It should simplify the user selection by the person using the “FW-Update Builder” and assigning a technician for the “FW-Update Procedure”. During the registration process using the “FW-Update Loader”, the user shall be forced to add his full name.

The user naming input mask shall:

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Start with capital letter, one or more lowercase letters, white space and at least one trailing word, double names separated with - or ' are allowed as well as special characters like umlaut in German, Spain or other languages using these special characters.

The regular expression shall be used to specify these convention:

Regex.Match(tbxFullName.Text, @"\b\p{Lu}[-'\w]+(\s[-'\w]+)+$").Success;

3.3.2 [SRS_FW_UPD_GEN_USER_002] User Registration Process

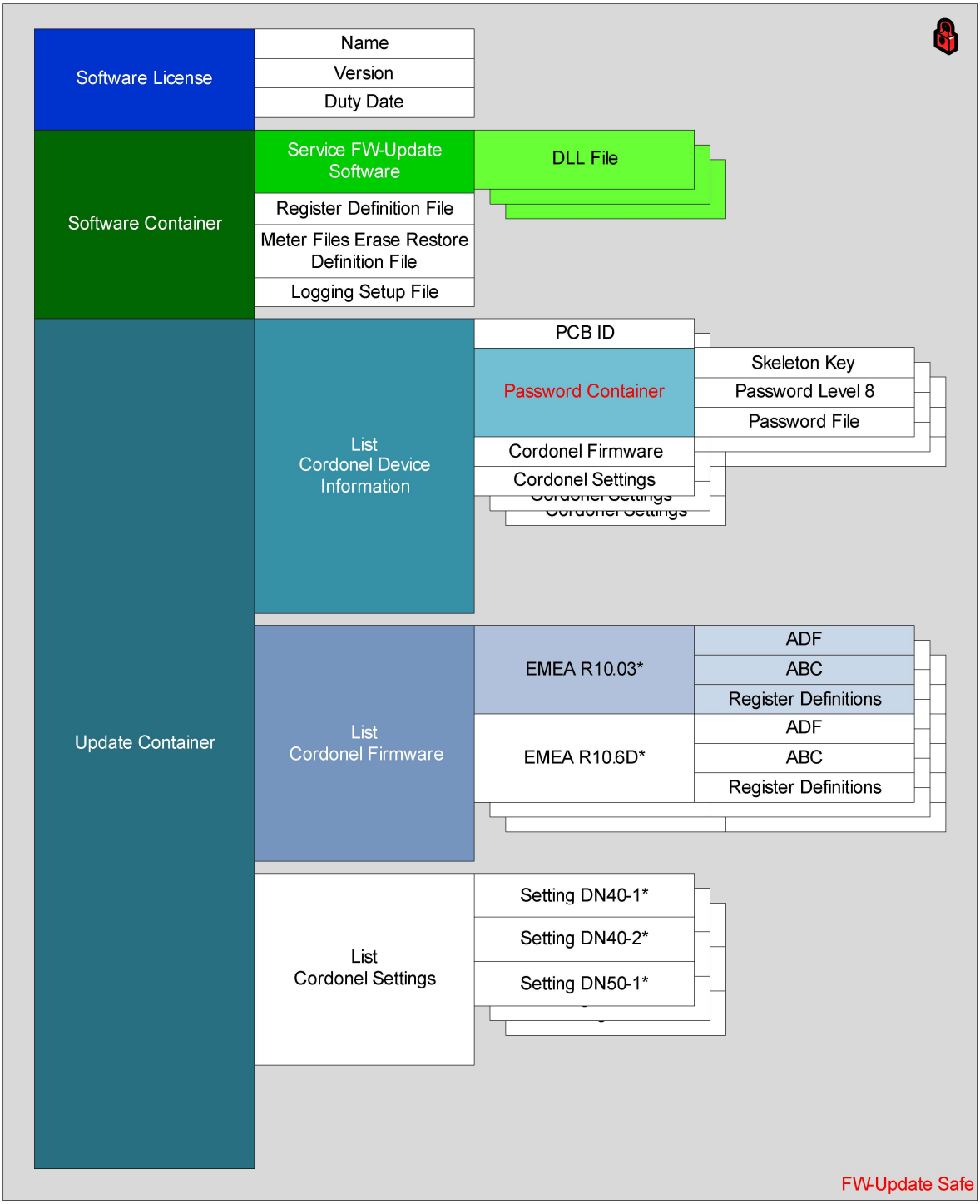
For the registration process the user has to be connected directly or via VPN to the Xylem Network. The registration window in the “FW-Update Loader” displays all information of the user. Here the user can input his full name to enable the registration button.

If the user can be registered, a local information will be saved to the “UserInformation.register” file.

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3.4 FW-Update - Safe

The “FW-Update Safe” structure needs to be specified as it is the interface between all SW modules of the FW update package. This chapter defines the internal structure of the safe.



Legend:
-*Examples
- Padlock for Encrypted Container

Picture 3.3 FW-Update Safe Structure

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As can be seen in [Picture 3.3 FW-Update Safe Structure], the “FW-Update Safe” consists of 3 main elements:

1. The “Software License”,
2. the “Software Container” and
3. the “Update Container”.

3.4.1 [SRS_FW_UPD_GEN_SAFE_001] Software License

The software license information shall be added to the “FW-Update Safe”. With this information all software modules are able to validate the permission to start. This is an essential security issue to avoid an execution of an hijacked software being started without the call from the “FW-Update Loader” containing the correct security information.

The security information shall contain:

1. The “Name” of the software,
2. the validated “Version” and
3. the “Duty Date” as expiration date.

3.4.2 [SRS_FW_UPD_GEN_SAFE_002] Software Container

The “FW-Update SW” shall be stored in the “Software Container” to supply the user with the latest version of it. The advantage is, that only this version can be executed and all others are outdated. This folder shall contain:

1. The “Service FW-Update SW”, which is the executable converted to a DLL and all “DLL Files” needed,
2. a “Register Definition File” (configuration.json),
3. a “Meter Files Erase Restore Definition File” and
4. a “Logging Setup File”.

3.4.3 [SRS_FW_UPD_GEN_SAFE_003] Update Container

The “Update Container” shall be stored to the “FW-Update Safe”. This contains all information needed to identify and authenticate to an update candidate, the firmware to install, the individual device settings and the update report template.

The update container includes:

1. The Cordonel Device Information with:
    a. The “PCB ID”, a unique number which unambiguously identifies the Cordonel,
    b. the “Password Container”,
    c. the string of the required “Cordonel Firmware” to install and
    d. the string of a required “Cordonel Settings”.
    e.
2. the list of “Cordonel Firmware” packages and
3. the list of “Cordonel Settings”.

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3.4.4 [SRS_FW_UPD_GEN_SAFE_004] Cryptology

The en- and decryption shall use the generated key, a salt and an initialization vector randomly generated.

Therefore the AES-GCM from the open-source bouncy castle (Org.BouncyCastle.Crypto） C# library to encrypt the data shall be used. This provides both authentication and encryption with a single Key.

The salt shall be generated using the “System.Security.Cryptography.RNGCryptoServiceProvider” which is part of the .NET framework.

3.4.5 [SRS_FW_UPD_GEN_SAFE_005] FW-Update Safe Name

The “FW-Update Safe” name shall contain the information about the customer and the “FW-Update Order Number” with the extension “safe”:

CustomerName_FwUpdateOrderNumber.safe

(e.g. ThamesWater_1234567890.safe)

3.4.6 [SRS_FW_UPD_GEN_SAFE_006] Default location

By default the “FW-Update Safe” shall be stored, by the “FW-Update Builder”, and loaded, by the “FW-Update Loader”, from the Win10 environment: *C:\Users\[user name]\downloads\FwUpdateSafe*.safe.*

3.5 Cordonel Application Description File

The application description file (ADF) is the description of every application which has been validated working as package together. This is the so called firmware release.

3.5.1 [SRS_FW_UPD_GEN_ADF_001] Application Specification

The filename has to be “product.txt”. Each application shall be identified in the ADF by:

1. Application ID,
2. CRC and
3. Version.

It is essential that every single application, which should be residing in the Cordonel™ meter after the FW update, is listed. This includes already installed applications without change of the version because this is a summarization of a release package and can exclusively be used in this unique combination.

Each entry has to contain the application ID, the CRC and the version information. The important information on which the software is searching for, except the size, is shown in the example below for product R103C (the strings “Id”, “CRC” and “version” have to be written exactly as shown here):

- Id 0x00, CRC 0xDDAB, size 36216 bytes, version 4.78
- Id 0x01, CRC 0x0181, size 3056 bytes, version 0.66
- Id 0x04, CRC 0x2EF1, size 7964 bytes, version 2.10
- Id 0x08, CRC 0xCF43, size 3912 bytes, version 0.16
- Id 0x11, CRC 0xF038, size 12380 bytes, version 0.63
- Id 0x10, CRC 0x7C65, size 77444 bytes, version 3.96
- Id 0x0F, CRC 0x8228, size 23300 bytes, version 2.87

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- Id 0x09, CRC 0xC797, size 5652 bytes, version 1.43
- Id 0x12, CRC 0x1579, size 6576 bytes, version 0.95
- Id 0x14, CRC 0x5D05, size 19752 bytes, version 1.26
- Id 0x15, CRC 0x1DAC, size 6236 bytes, version 0.51
- Id 0x18, CRC 0xE081, size 116 bytes, version 10.3C

The C# code reference is for the validation of the ADF connected to the ABC:

Xylem.Common.Hardware.WaterMeter.Genesis.GenesisFile.MeterFwUpdate.ValidateFileAppsWithPackageFile().

3.5.2 [SRS_FW_UPD_GEN_ADF_002] Core Revision

The information about the compatible “Cordonel Core Revision” shall be stated. Therefore the range of valid cores is of importance. To detect the “Cordonel Core Revision” correctly, the text string has to start exactly as described here with the Cordonel xx.yy in quotation marks where xx is the major version and yy the build number separated by a point (examples of version):

1. Minimum supported core revision: “Cordonel 1.62” and
2. Maximum supported core revision: “Cordonel 1.65”.

3.6 Cordonel Application Binary Container

The application binary container (ABC) is a snap shot of a validated combination of applications which will work together as described in the ADF. This package is the FW which has to be installed.

3.6.1 [SRS_FW_UPD_GEN_ABC_001] Application Files

The ABC shall contain all applications which are described in the ADF. The “Metrology” application (ID 0x12) with the valid CRC and version has to be part of this container even if this is not allowed to update. But as it has to be contained a validation check can be made. An invalid “Metrology” application will deny an update of any application.

All files in the ABC shall have to follow the naming rule: the file name starting with binfile, then the application ID with 2 digits, then an underline and then the version number with four digits, then a point and finally the bin extension. The example here is the R103C release package:

- binfile00_0478.bin
- binfile01_0066.bin
- binfile04_0210.bin
- …

All files with the file extension bin are going to be loaded independent of proceeding naming. The binary files will be parsed and checked for:

1. “APP>” – string at the file start byte position 0
2. Extract the file application ID – at byte position 0x28
3. Extract the version information – at byte position 0x06-0x07
4. Extract the CRC – at byte position 0x04-0x05

The C# code reference is :

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Xylem.Common.Hardware.WaterMeter.Genesis.GenesisFile.MeterFwUpdate.CheckFileApp().

3.7 Register Definition

The register definition is the interface description between the software and the firmware.

3.7.1 [SRS_FW_UPD_GEN_REG_FILE_001] Register Definition File

The register definition file “configuration.json” shall be included in any software distribution. It is essential for the “FW-Update SW” to operate. This will be generated with every firmware release. The file describes all registers of the Cordonel™ which can be accessed. The file contains the information of the registers depending on a specific application version.

For each register the definition of “Read – Restore” capability by the “statictype” - field:

- “null”, for unknown state, will be skipped for “Read – Restore” operation,
- “static”, “Read – Restore” operation can be performed,
- “dynamic”, “Read – Restore” operation shall be skipped, values of registers are unpredictable,
- “infrequentlyupdated”, “Read – Restore” operation shall be skipped, values can be read but cannot be compared after an undefined time.

3.8 Meter Files Handling

The Cordonel file system has an overall size of 512kB. If to many files are occupying this space, a “FW-Update Process” may fail due to the processor is running out-of-memory. All application files, defined in the ADF and contained in the ABC which are different to the installed version, have to be downloaded and therefore stored in the memory space of the processor.

The FW designers identified the following files at the Cordonel™ device and stated the rules that apply to the handling of it:

Application	Disk\\name[mask]	Size [Byte]	Rule	
ConfigExchange	0\\password	160	never delete	password file
ConfigExchange	0\\config	?	never delete	program configuration
SensusRadio	1\\upgrade		delete	upgrade instruction file for breeze
SensusRadio	1\\upg[0-9A-F]	max. 254k	delete	binaries for app update
SensusRadio	1\\img[0-9A-F]	1900	delete	update images , max 138 files
SensusRadio	1\\blklist		delete	block list
SensusRadio	1\\tstfile	262144	delete / restore	place holder for future updates over the air

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Application	Disk\\name[mask]	Size [Byte]	Rule	
Periodiclog	1\\fdrdata	3584	delete	?
Periodiclog	1\\logdata	112640	delete	?
Periodiclog	1\\evtdata	128	never delete	event logging
IrDA	1\\pulsedbg	?	delete	Only in pulse debug mode, this file can be deleted to make space for a firmware upgrade since it's probably just leftover from a debugging session
GenesisFlow	1\\mettable	?	delete	Only in table development builds, this can be deleted to make space for a firmware upgrade since it's probably just left over from a debugging session
NA2WAlarms	1\\NAstate	?	never delete	
NA2WLogger	1\\NAwater	?	never delete	
NA2WLogger	1\\NAtempC	?	never delete	
NA2WLogger	1\\NApress	?	never delete	
NA2WLogger	1\\NAalarm	?	never delete	
NA2WLogger	1\\NAconfig	?	never delete	
Logger	1\\logindex	128	never delete	
Logger	1\\[0-9A-F]	?	never delete	These are the actual log files, the file names are timestamps in hex
FlexNetSerial	*			identical to SensusRadio

Table 3.1 Cordonel Meter Files – Handling Rules

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3.8.1 [SRS_FW_UPD_GEN_METER_FILE_001] Meter File Erase Restore Configuration File

The files for erasure and restore are defined in the “MeterFilesEraseRestore.json”. This configuration file is part of the “FW-Update Safe” and will be intermediately stored to the user settings of the MS-Windows™ environment at the following folder:

C:\Users\[user name]\AppData\Roaming\Genesis\ServiceFwUpdateSw

The format of the “MeterFilesEraseRestore.json” is (example):

```
{
    "Erase": [
        "1\\tstfile",
        "1\\fdrdata",
        "1\\logdata",
        "1\\blklist",
        "1\\mettable",
        "1\\pulsedbg",
        "1\\upg*",
        "1\\img*"
    ],
    "Restore": [
        {
            "Name": "1\\tstfile",
            "ByteSize": 262144,
            "Pattern": null
        }
    ]
}
```

Listing 3.1 Meter File Erase Restore Configuration File - MeterFilesEraseRestore.json

The number before the two backslashes defines the logical drive of the Cordonel file system.

The “Erase” section of this file is the list of all meter files which should be erased before the application download. A wildcard shall be used at the end of the file name to erase all files starting with the previous partial name (e.g. 1\\upg* will erase all files from disk 1 starting with upg).

The “Restore” section of this file is the list of all meter files which should be restored after the FW update.

The “Restore” section includes the “Name” of the file, the “ByteSize” and a “Pattern” to fill in the space. If the “Pattern” equals “null”, the file shall be created, then the file pointer shall be set to the end of the file and finally a “0xFF” shall be written to this position.

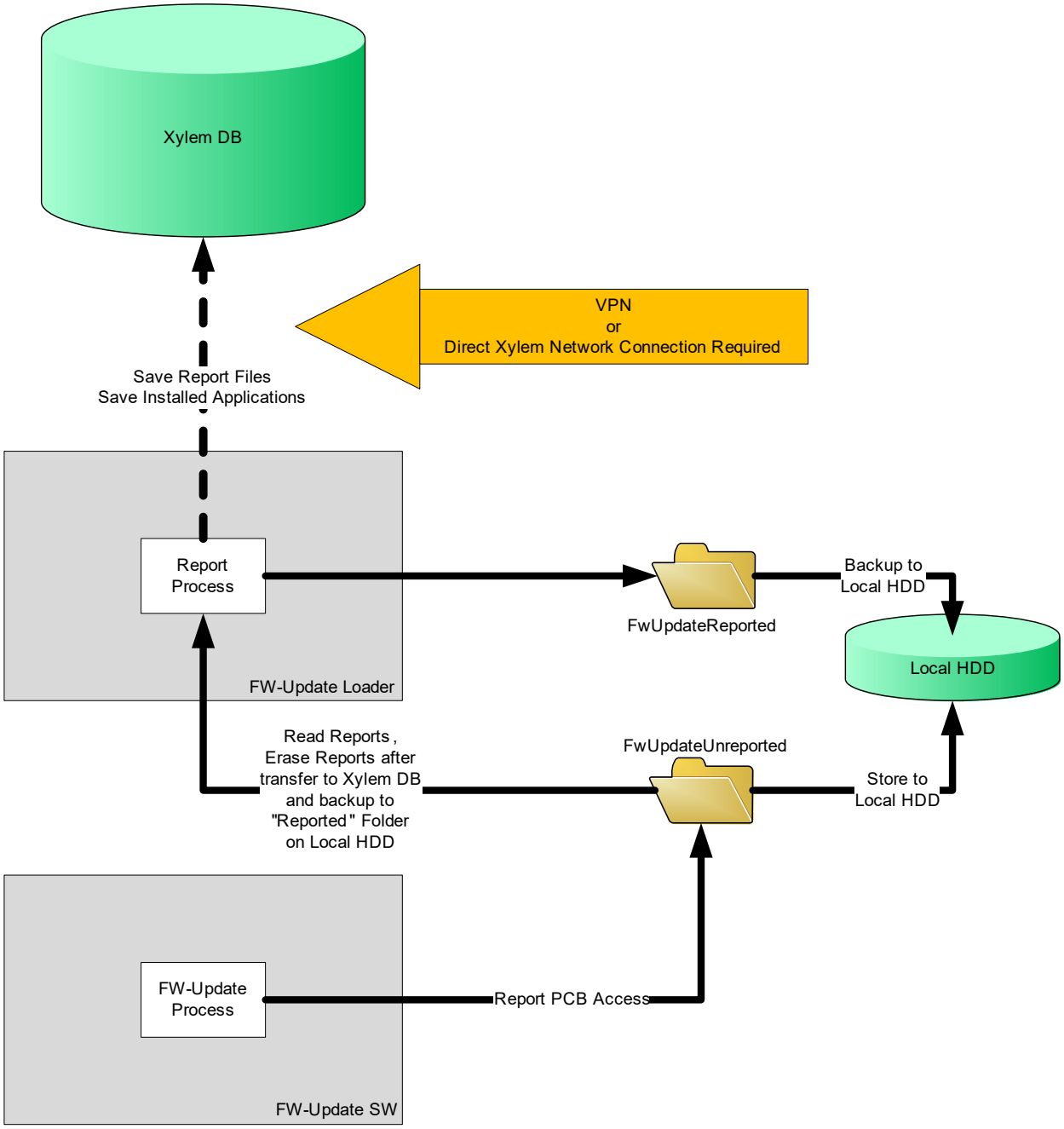
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3.9 FW-Update - Report

The “FW-Update Report” structure needs to be specified as it is the interface between all SW modules of the FW update package.

This chapter defines the internal structure of the report files. A report of the update procedure is needed to keep the production DB up to date. This stores the history of each Cordonel with all register settings and the installed FW version.



Picture 3.4 Report Data Exchange

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3.9.1 [SRS_FW_UPD_GEN_REPORT_001] Report Folders

The “FW-Update SW” shall store all “FW-Update Report” files during the “FW-Update Process” into this folder:

C:\GenesisLog\FwUpdateUnreported

The “FW-Update Loader” shall read all files from there as soon as it is ready for reporting. For this operation it has to be connected to the Xylem network. The “FW-Update Loader” shall transfer all data to the Xylem DB and backup the reported files to:

C:\GenesisLog\FwUpdateReported

3.9.2 [SRS_FW_UPD_GEN_REPORT_002] Report Files

The “FW-Update SW” shall generate an application list file, which informs of the latest installed applications and contains the information of the applied “FW-Update Safe”

(e.g. *ThamesWater _1234567890.safe)*:

PCB ID_[“FW-Update Safe” name].applist

(e.g. 182100041_ThamesWater _1234567890.applist)

The logging file for all processes including all register values before and after the update shall be named:

PCB ID_[“FW-Update Safe” name].report

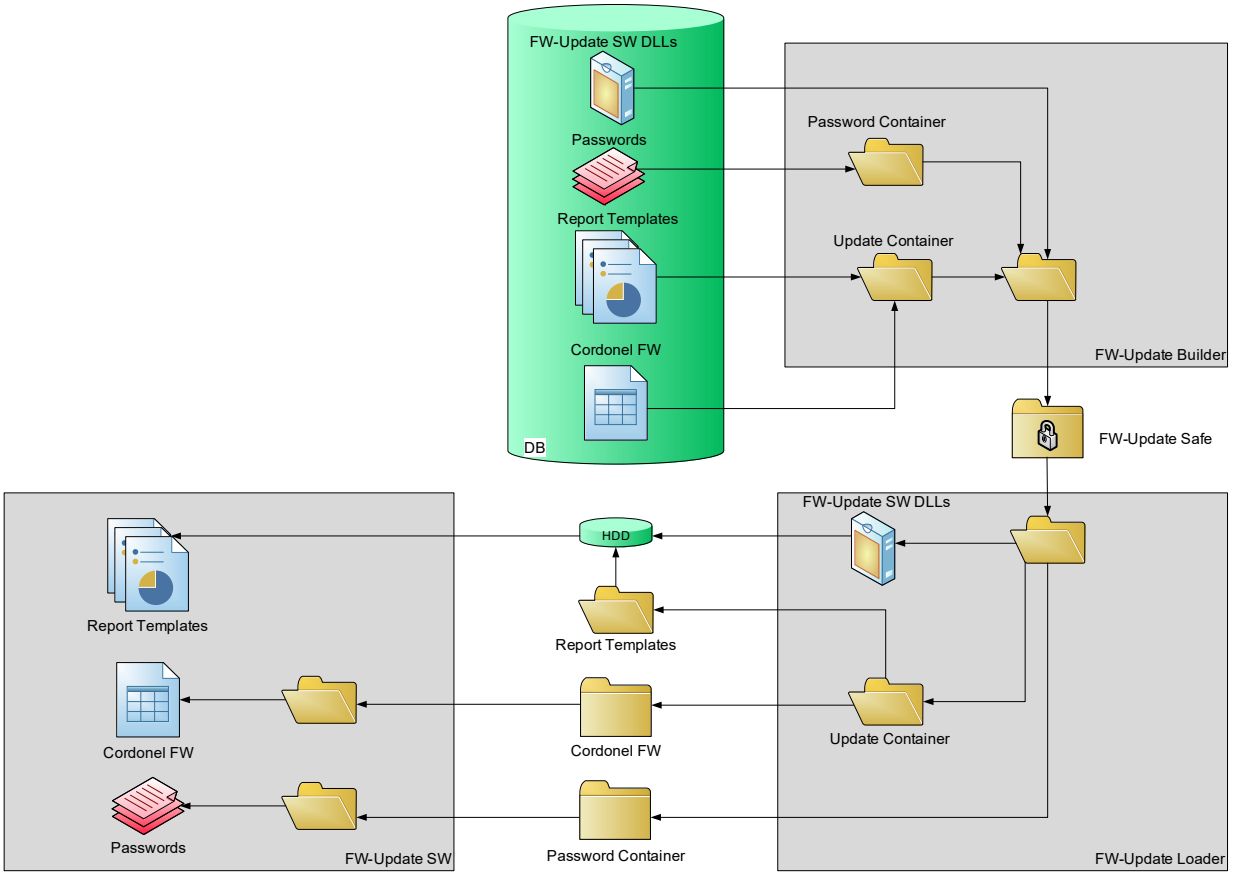
(e.g. 182100041_ThamesWater_1234567890.report)

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3.10 FW-Update - Data Exchange

This chapter describes the handling of the data which are needed for the “FW-Update Process”.



Picture 3.5 FW-Update Data Exchange

The “FW-Update Builder” has to collect all necessary data and DLLs needed for the update process. Out of these data the “FW-Update Safe” has to be built. This “FW-Update Safe” must be encrypted due to the sensitive information stored to it. It has to be transferred to the “FW-Update Loader” via email or by any storage device. The “FW-Update Loader” has to decrypt the “FW-Update Safe”, store and execute the “FW-Update SW". The highly sensitive “Password Container” and the “Cordonel FW” needed to be directly transferred to the “FW-Update SW” without intermediate storage to any HDD.

3.10.1 [SRS_FW_UPD_GEN_DEX_001] FW-Update Safe Exchange

The “FW-Update Safe” shall be downloadable from the DB if the “FW-Update Loader” is connected via the VPN to the Xylem network. Any other exchange via email or on any USB or disk drive can be performed, as this safe is encrypted.

3.10.2 [SRS_FW_UPD_GEN_DEX_002] Password Container Exchange

The list of “Password Containers” shall be directly passed by from the “FW-Update Loader” to the “FW-Update SW” using an interface.

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3.10.3 [SRS_FW_UPD_GEN_DEX_003] License Information Exchange

The “License Information” for the SW shall be directly passed by from the “FW-Update Loader” to the “FW-Update SW” using an interface.

3.10.4 [SRS_FW_UPD_GEN_DEX_004] Cordonel Firmware Packages Exchange

The list of “Cordonel Firmware” packages shall be directly passed by from the “FW-Update Loader” to the “FW-Update SW” using an interface. This will protect the ADF and ABC being changed by user interactions.

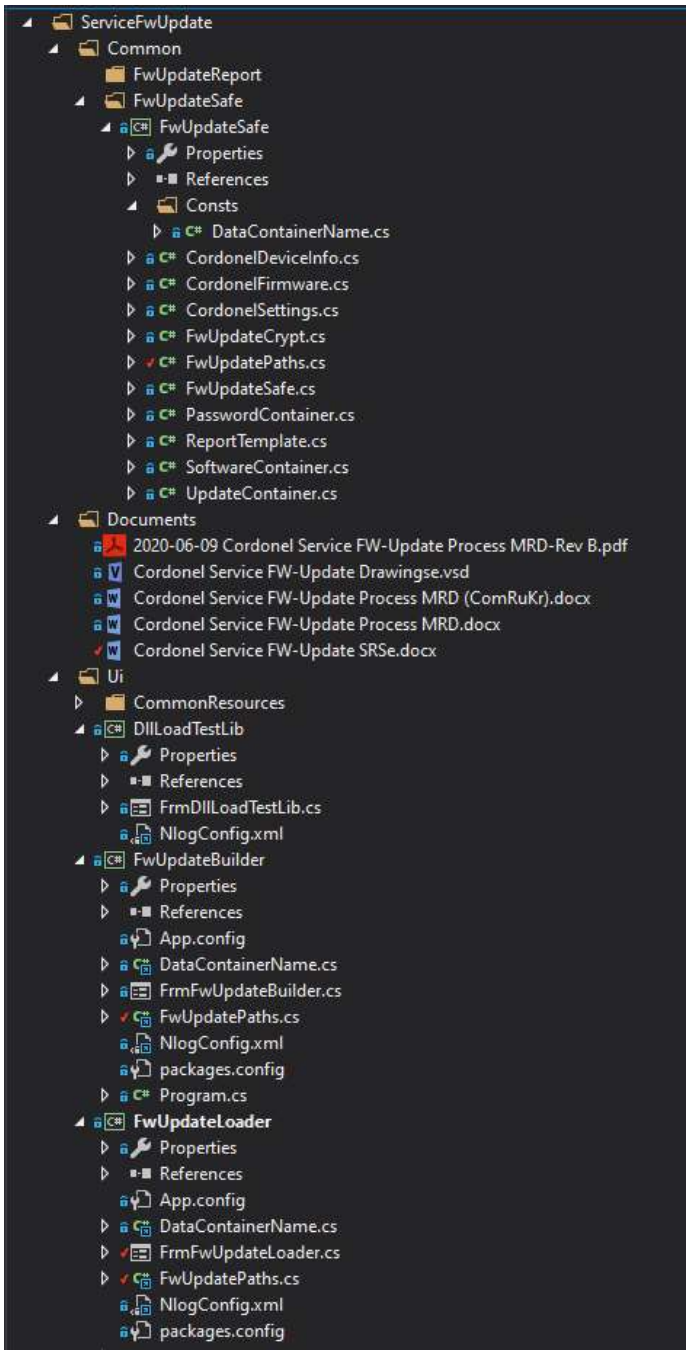
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4. Service FW-Update Solution

The FW-Update solution is the collection of all projects needed to be modified for the software development. This is used in the Microsoft™ Visual Studio environment for the “Cordonel™ Service FW-Update” package. The name of the solution is “ServiceFwUpdate”. This is based on the “Test Bench Framework” (TBF) which is the collection of all software projects needed to support the production test bench for water meters including the Genesis substituting the Cordonel. The naming Genesis is legacy, but will be further used in the software as name.

All project can be accessed by the Team Foundation Server:

10.1.0.164\SensusProjectCollection\WorkBenchV2\Main\ServiceFwUpdate:

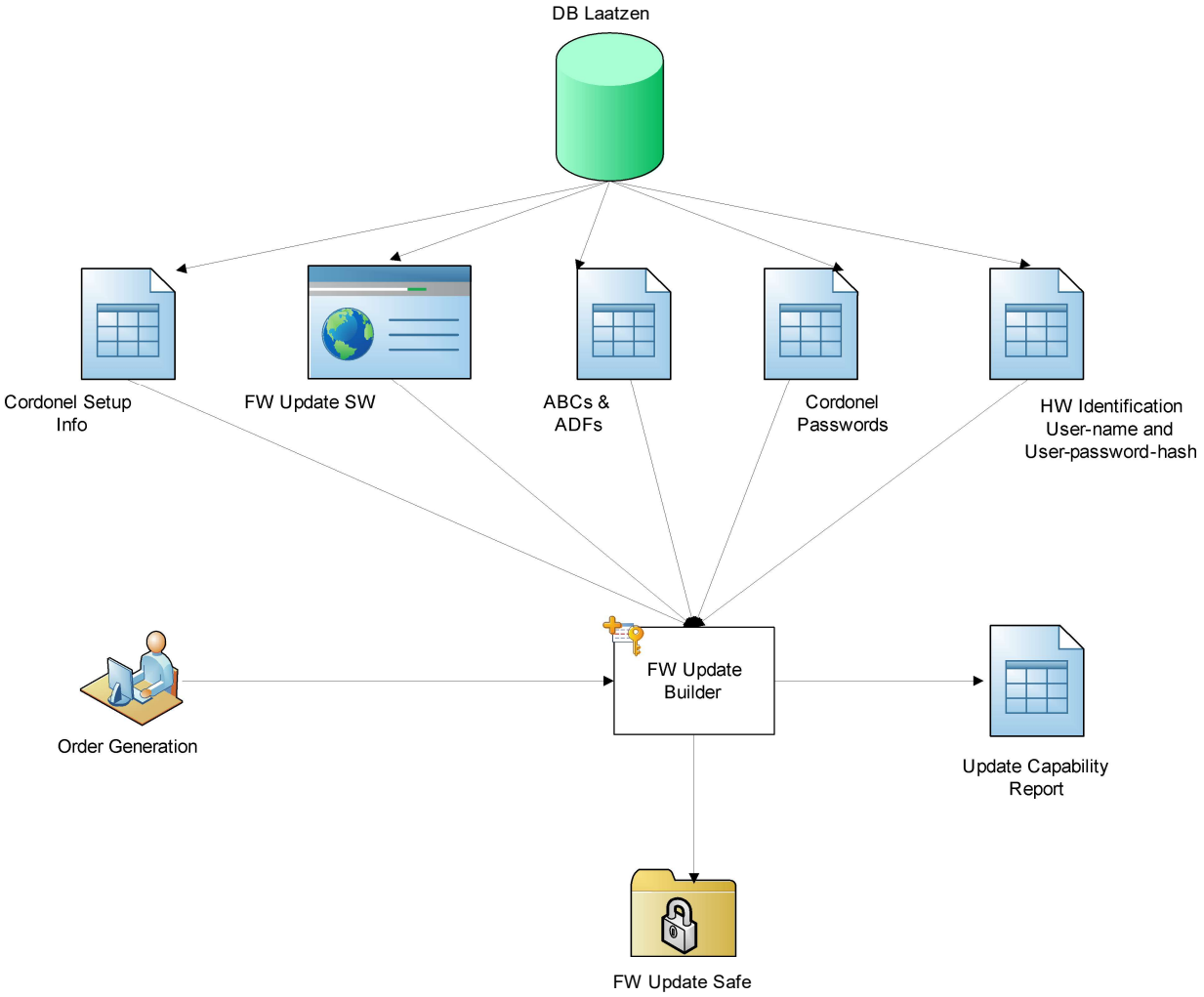


Picture 4.1 Service FW-Update Project Structure

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5. FW-Update Builder - Requirements

The “FW-Update Builder” has to collect and verify all data needed to ensure an offline update of the group of Cordonels™ listed in the “Device List”. It shall build the “FW-Update Safe” which is an encrypted container to be delivered to the “FW-Update Loader”.



Picture 5.1 FW-Update Builder

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5.1 FW-Update Builder – Configuration

As a standard C# application is only feasible to load DLLs from specific folders, the special paths for new sorted needs to be published to the application.

5.1.1 [SRS_FW_UPD_BUILDER_CONFIG_001] Release Output Structure

The "*App.config*" file of the "*FwUpdateBuilder*" project shall include a setting to find the DLLs for the configuration and library folders.

The "<*probing privatePath>*" element will define the sub-folders, relative to the exe-path, to search for these DLLs and other setups. Each sub-folder has to be separated with an semicolon.

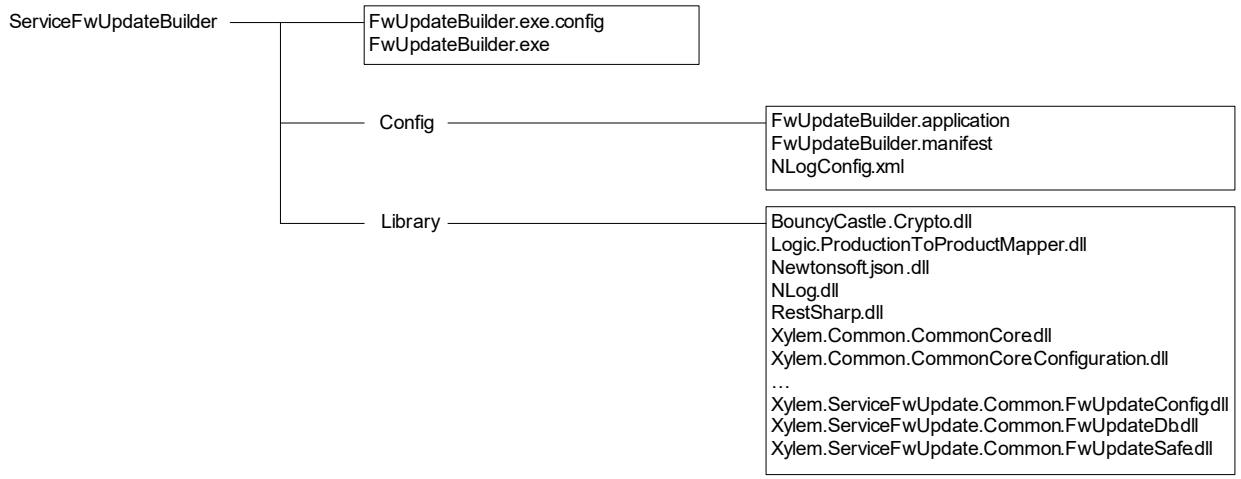
```
<?xml version="1.0" encoding="utf-8" ?>
<configuration>
  <startup>
    <supportedRuntime version="v4.0" sku=".NETFramework,Version=v4.7.2" />
  </startup>
  <runtime>
    <assemblyBinding xmlns="urn:schemas-microsoft-com:asm.v1">
      <probing privatePath="Library;Config"/>
    </assemblyBinding>
  </runtime>
</configuration>
```

Listing 5.1 FW-Update Builder Configuration File – App.config

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5.2 FW-Update Builder – Build

The build process can generate after the build procedure a more sorted output of all files to avoid confusion of the user.



Picture 5.2 FW-Update Builder – Release Structure

5.2.1 [SRS_FW_UPD_ BUILDER _BUILD_001] Release Output Restructuring

For the “FW-Update Builder” the installation folder structure shall be generated with the “Post Build Step” of the VisualStudio Project settings.

Therefore the “*FwUpdateBuilder->Properties->Build->Output->Output path:*” has to be set to “*bin**Release**Library*” and the following “*FwUpdateBuilder->Properties->Build Events”* have to be set:

```
if $(ConfigurationName) == Release erase "$(TargetDir)..\FwUpdateBuilder.*"
```

Listing 5.2 FW-Update Builder Build Events – Pre-build event command line

```
if $(ConfigurationName) == Release mkdir "$(TargetDir)..\Config"
if $(ConfigurationName) == Release move "$(TargetDir)FwUpdateBuilder.application" "$(TargetDir)..\Config\"
if $(ConfigurationName) == Release move "$(TargetDir)FwUpdateBuilder.exe.manifest" "$(TargetDir)..\Config\"
if $(ConfigurationName) == Release move "$(TargetDir)NLogConfig.xml" "$(TargetDir)..\Config\"
if $(ConfigurationName) == Release erase "$(TargetDir)*.xml"
if $(ConfigurationName) == Release erase "$(TargetDir)*.pdb"
if $(ConfigurationName) == Release move "$(TargetDir)FwUpdateBuilder.*" "$(TargetDir)..\"
if $(ConfigurationName) == Release erase  "$(TargetDir)*.config"
```

Listing 5.3 FW-Update Builder Build Events – Post-build event command lines

5.3 FW-Update Builder - Cordonel Device List

Out of the maintenance order, the “Cordonel Device List” for the update candidates has to be built. This device list is essential for automatic collection of all data needed for the update.

As the device list is deprecated, the operator needs to find the Cordonel PCB ID by the customer Cordonel serial number.

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5.3.1 [SRS_FW_UPD_BUILDER_LIST_001] Cordonel Device List Format

- Deprecated Requirement – The Cordonel Device List will be generated using the “FW-Update Builder”! These selections are going to be made manually by the creator of this “FW-Update Safe”.

The “Cordonel Device List” shall be an Excel™ spread sheet containing all devices for this update run. Each Cordonel device is identified by its PCB ID or Meter ID or, for EMEA, the Radio Address or Order Number. The LaaDB has an entry which concatenates all these IDs and addresses.

Required FW

- latest release,

- special release.

5.3.2 [SRS_FW_UPD_BUILDER_LIST_002] Customer Search

To find the customer Cordonel serial number of a specific customer, first the customer needs to be selected. Therefore the “FW-Update Builder” shall use a customer search string to display all customers for pre-selection.

5.3.3 [SRS_FW_UPD_BUILDER_LIST_003] Customer Cordonel Serial Number

As soon as a specific customer is selected, all his Cordonel serial numbers shall be displayed for selection. Therefore all original production order numbers for the selected customer have to be collected. With these order numbers the customer Cordonel serial numbers can be displayed and the Cordonel can be able to select. Attached to the customer Cordonel serial number is the essential PCB ID of the selected device, which is the base for the “FW-Update Process”.

5.4 FW-Update Builder - Cordonel Update Preparation

5.4.1 [SRS_FW_UPD_BUILDER_PREP_001] Cordonel Update Capability Verification

An update capability verification using the LaaDB shall be executed. Therefor the update list has to be fed to the “FW-Update Builder”.

Using the history information of the LaaDB it will be checked for each device the:

1. Core Revision, not every Core Revision of the Cordonel™ can handle new FW releases,
2. Metrology version, update will be denied if intended FW does not contain the identical metrology because the update of the metrology is forbidden,
3. HW check for 433 or 868MHz, a FW is specifically for a dedicated radio frequency,
4. HW revision check, if FW can be used with this specific PCB or HW,
5. Meter size, each meter size has its own FW.

The update capability check shall use the *“MeterFwUpdateRuler.json”* which describes the FW-Releases:

```
[
  {
    "Release": "R1066",
    "Region": "EMEA",
```


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```
    "CoreVersionMin": "162",
    "CoreVersionMax": "164",
    "MetrologyVersion": "287",
    "RadioFrequencyMhz": "433",
    "MeterSizes": [
      "DN50"
    ],
    "ApproverName": "Ami A Arsalan",
    "ApprovalDate": "2020-12-31T00:00:00"
  },
  {
    "Release": "R1100",
    "Region": "EMEA",
    "CoreVersionMin": "162",
    "CoreVersionMax": "167",
    "MetrologyVersion": "287",
    "RadioFrequencyMhz": "433",
    "MeterSizes": null,
    "ApproverName": "Willi Weber",
    "ApprovalDate": "2021-04-01T00:00:00"
  },
  {
    "Release": "R106F",
    "Region": "EMEA",
    "CoreVersionMin": "162",
    "CoreVersionMax": "166",
    "MetrologyVersion": "287",
    "RadioFrequencyMhz": "868",
    "MeterSizes": [
      "DN50",
      "DN60",
      "DN80",
      "DN150"
    ],
    "ApproverName": "Oliver Ohlsen",
    "ApprovalDate": "2021-01-08T00:00:00"
  },
  {
    "Release": "B1070",
    "Region": "NA",
    "CoreVersionMin": "162",
    "CoreVersionMax": "166",
    "MetrologyVersion": "508",
    "RadioFrequencyMhz": null,
    "MeterSizes": [
```


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```
        "DN50"
      ],
      "ApproverName": null,
      "ApprovalDate": null
    }
]
```

Listing 5.4 MeterFwUpdateRuler.json – Example

A null as approver and approval date states an unreleased version, a null for the meter sizes is for all meter sizes.

5.4.2 [SRS_FW_UPD_BUILDER_PREP_002] Cordonel Password Collection

Login on LuDB with Token,

For each device:

- Use order number and radio address to collect password level 8.

5.4.3 [SRS_FW_UPD_BUILDER_PREP_003] Cordonel Firmware Collection

For each device:

- Collection of ADF and ABC from LaaDB.

5.4.4 [SRS_FW_UPD_BUILDER_PREP_004] Cordonel Update SW Download

Specify actual “FW-Update SW” and download version from LaaDB.

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5.4.5 [SRS_FW_UPD_BUILDER_PREP_005] Key Generation

The key for the “FW-Update Safe” encryption shall be build according to chapter [3.2]. The operator of the “FW-Update Builder” has to select a technician, which should carry out the “FW-Update Process”. This selection can be made out of any registered “FW-Update Loader” user which previously has executed the registration process.

5.4.6 [SRS_FW_UPD_BUILDER_PREP_006] FW-Update Safe Encryption

The encryption shall be done according to chapter [3.4.4].

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6. FW-Update Loader - Requirements

6.1 FW-Update Loader – Configuration

As a standard C# application is only feasible to load DLLs from specific folders, the special paths for new sorted needs to be published to the application.

6.1.1 [SRS_FW_UPD_LDR_CONFIG_001] Release Output Structure

The "*App.config*" file of the "*FwUpdateLoader*" project shall include a setting to find the DLLs especially for the "FW-Update SW" and the configuration and library folders.

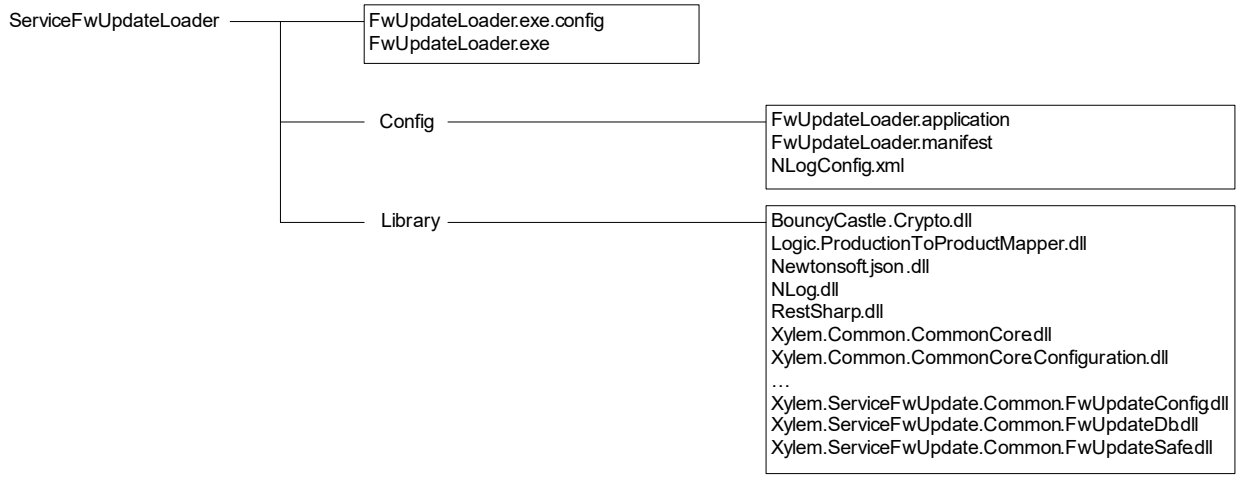
The "<*probing privatePath>*" element will define the sub-folders, relative to the exe-path, to search for these DLLs and other setups. Each sub-folder has to be separated with an semicolon.

```
<?xml version="1.0" encoding="utf-8" ?>
<configuration>
  <startup>
    <supportedRuntime version="v4.0" sku=".NETFramework,Version=v4.7.2" />
  </startup>
  <runtime>
    <assemblyBinding xmlns="urn:schemas-microsoft-com:asm.v1">
      <probing privatePath="ServiceFwUpdateSw;Library;Config"/>
    </assemblyBinding>
  </runtime>
</configuration>
```

Listing 6.1 FW-Update Loader Configuration File – App.config

6.2 FW-Update Loader – Build

The build process can generate after the build procedure a more sorted output of all files to avoid confusion of the user.



Picture 6.1 FW-Update Loader – Release Structure

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6.2.1 [SRS_FW_UPD_LDR_BUILD_001] Release Output Restructuring

For the “FW-Update Loader” the installation folder structure shall be generated with the “Post Build Step” of the VisualStudio Project settings.

Therefore the “*FwUpdateLoader->Properties->Build->Output->Output path:*” has to be set to “*bin**Release**Library*” and the following “*FwUpdateLoader->Properties->Build Events”* have to be set:

```
if $(ConfigurationName) == Release erase "$(TargetDir)..\FwUpdateLoader.*"
```

Listing 6.2 FW-Update Loader Build Events – Pre-build event command line

```
if $(ConfigurationName) == Release mkdir "$(TargetDir)..\Config"
if $(ConfigurationName) == Release move "$(TargetDir)FwUpdateLoader.application" "$(TargetDir)..\Config\"
if $(ConfigurationName) == Release move "$(TargetDir)FwUpdateLoader.exe.manifest" "$(TargetDir)..\Config\"
if $(ConfigurationName) == Release move "$(TargetDir)NLogConfig.xml" "$(TargetDir)..\Config\"
if $(ConfigurationName) == Release erase "$(TargetDir)*.xml"
if $(ConfigurationName) == Release erase "$(TargetDir)*.pdb"
if $(ConfigurationName) == Release move "$(TargetDir)FwUpdateLoader.*" "$(TargetDir)..\"
if $(ConfigurationName) == Release erase  "$(TargetDir)*.config"
```

Listing 6.3 FW-Update Loader Build Events – Post-build event command lines

6.3 FW-Update Loader - Registration

Before the user can execute the FW-Update procedure, he has to register for the operation. This information will be used for encryption of the “FW-Update Safe” on the FW-Update Builder and decryption of this in the “FW-Update Loader”.

6.3.1 [SRS_FW_UPD_LDR_USER_REG_001] Initial Registration

The “FW-Update Loader” shall support the user registration process. It shall transfer the “PC Hardware Information”, the “User Name” and the “User Password Hash”. The registration can only be performed, if the operator of the “FW-Update Loader” is connected with the Xylem network so called “online” operation. If the user can be registered, a local file will be written to the HDD. This local file can be checked against the Win10 System information to have a comparison base for the “offline” usage.

At user registration the due date shall be set to 21 days.

As the user registration file is stored in the Win10 environment under the user specific folder:

C:\Users\[user name]\AppData\Roaming\Genesis\UserInformation.register

multiple users can use the identical PC and register independently.

6.3.2 [SRS_FW_UPD_LDR_USER_REG_002] Valid Date Expiration

If the user registration validation date expires, all “FW-Update Safes” are lost for decryption and cannot be restored. The user has to register again, before new “FW-Update Safes” can be build.

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6.3.3 [SRS_FW_UPD_LDR_USER_REG_003] Validation Date Refresh

The “FW-Update Loader” shall support a date refresh during “online” operation. This shall only be supported, if all “FW-Update Safes” are processed, because an update of the validation date will change the user authentication code, which will be used for the “FW-Update Safe” en-/decryption. All unprocessed files will be become invalid and cannot be restored.

A refresh will always add 21 days to the current local date.

6.3.4 [SRS_FW_UPD_LDR_USER_REG_004] User Validation

At the start up of the “FW-Update Loader” this software shall read the user and hardware information from the Win10 System and compare this with the user registration file. If these are identical, the user is properly registered. A informational field shall display this state to keep the operator informed.

The user validation checks the “user login name”, the “domain”, the “HW ID”, the “user password hash”, the “user full name” and the “validation date”.

6.4 FW-Update Loader – FW-Update Safe

6.4.1 [SRS_FW_UPD_LDR_LOAD_001] FW-Update Safe Load

The “FW-Update Loader” shall contain a file open menu to load the encrypted “FW-Update Safe”.

6.5 FW-Update Loader – FW-Update Safe

6.5.1 [SRS_FW_UPD_LDR_DECRYPT_001] Key Generation

The key for the “FW-Update Safe” decryption shall be build according to chapter [3.2].

6.5.2 [SRS_FW_UPD_LDR_DECRYPT_002] FW-Update Safe Decryption

The decryption shall be done according to chapter [3.4.4].

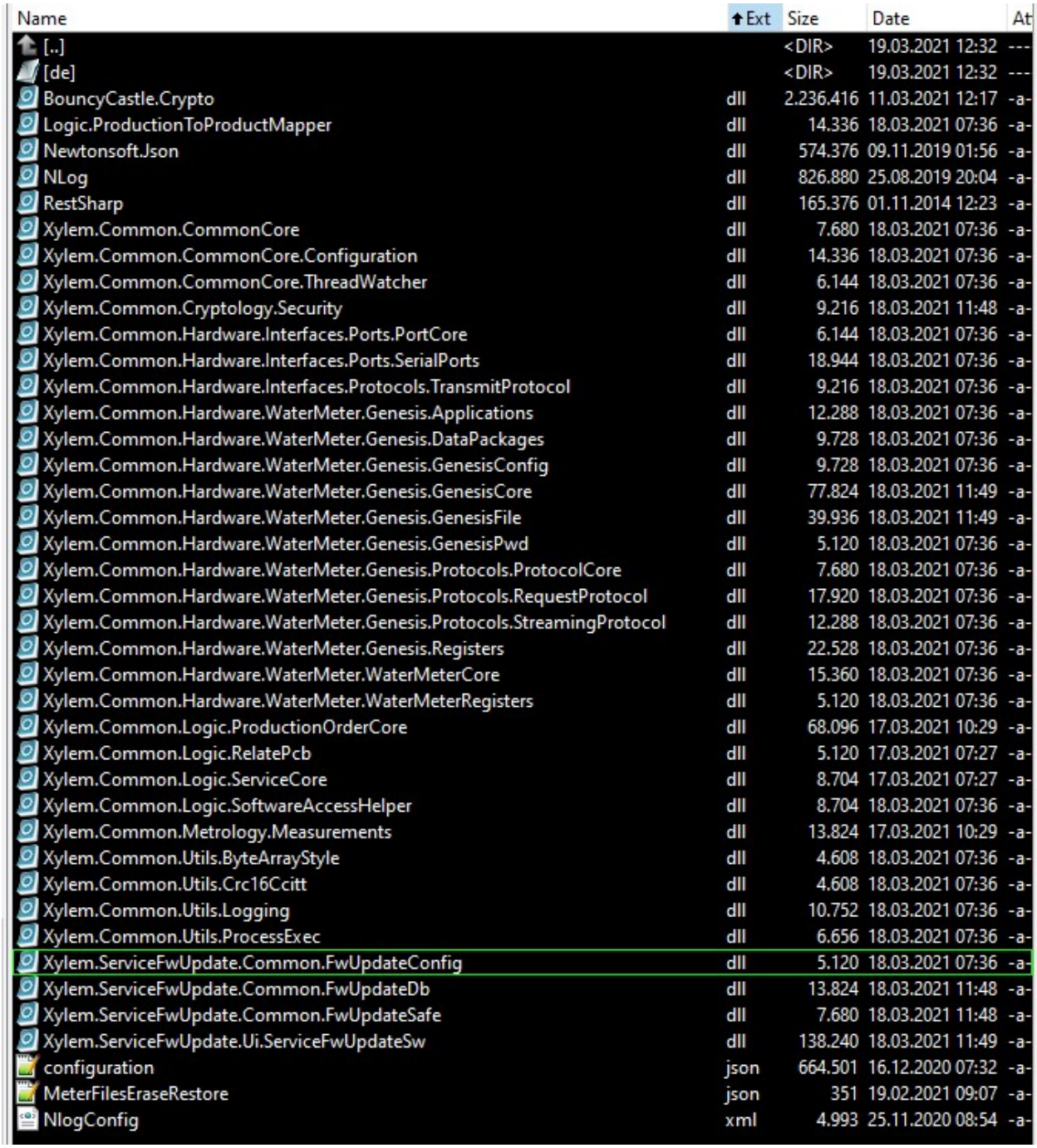
6.6 FW-Update Loader - Software Execution

6.6.1 [SRS_FW_UPD_LDR_EXEC_001] FW-Update Software Copy

The FW-Update SW and all needed DLLs, including 3 special files “configuration.json”, “ MeterFilesEraseRestore.json” and “NLogConfig.xml”, shall be copied to the HDD before execution. These have to be positioned to the sub-folder of the main execution folder for the “FW-update Loader”:

[any drive]\[any folder]\ServiceFwUpdateLoader\ServiceFwUpdateSw

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Name	Ext	Size	Date	At
[..]		<DIR>	19.03.2021 12:32	---
[de]		<DIR>	19.03.2021 12:32	---
BouncyCastle.Crypto	dll	2.236.416	11.03.2021 12:17	-a-
Logic.ProductionToProductMapper	dll	14.336	18.03.2021 07:36	-a-
Newtonsoft.Json	dll	574.376	09.11.2019 01:56	-a-
NLog	dll	826.880	25.08.2019 20:04	-a-
RestSharp	dll	165.376	01.11.2014 12:23	-a-
Xylem.Common.CommonCore	dll	7.680	18.03.2021 07:36	-a-
Xylem.Common.CommonCore.Configuration	dll	14.336	18.03.2021 07:36	-a-
Xylem.Common.CommonCore.ThreadWatcher	dll	6.144	18.03.2021 07:36	-a-
Xylem.Common.Cryptology.Security	dll	9.216	18.03.2021 11:48	-a-
Xylem.Common.Hardware.Interfaces.Ports.PortCore	dll	6.144	18.03.2021 07:36	-a-
Xylem.Common.Hardware.Interfaces.Ports.SerialPorts	dll	18.944	18.03.2021 07:36	-a-
Xylem.Common.Hardware.Interfaces.Protocols.TransmitProtocol	dll	9.216	18.03.2021 07:36	-a-
Xylem.Common.Hardware.WaterMeter.Genesis.Applications	dll	12.288	18.03.2021 07:36	-a-
Xylem.Common.Hardware.WaterMeter.Genesis.DataPackages	dll	9.728	18.03.2021 07:36	-a-
Xylem.Common.Hardware.WaterMeter.Genesis.GenesisConfig	dll	9.728	18.03.2021 07:36	-a-
Xylem.Common.Hardware.WaterMeter.Genesis.GenesisCore	dll	77.824	18.03.2021 11:49	-a-
Xylem.Common.Hardware.WaterMeter.Genesis.GenesisFile	dll	39.936	18.03.2021 11:49	-a-
Xylem.Common.Hardware.WaterMeter.Genesis.GenesisPwd	dll	5.120	18.03.2021 07:36	-a-
Xylem.Common.Hardware.WaterMeter.Genesis.Protocols.ProtocolCore	dll	7.680	18.03.2021 07:36	-a-
Xylem.Common.Hardware.WaterMeter.Genesis.Protocols.RequestProtocol	dll	17.920	18.03.2021 07:36	-a-
Xylem.Common.Hardware.WaterMeter.Genesis.Protocols.StreamingProtocol	dll	12.288	18.03.2021 07:36	-a-
Xylem.Common.Hardware.WaterMeter.Genesis.Registers	dll	22.528	18.03.2021 07:36	-a-
Xylem.Common.Hardware.WaterMeter.WaterMeterCore	dll	15.360	18.03.2021 07:36	-a-
Xylem.Common.Hardware.WaterMeter.WaterMeterRegisters	dll	5.120	18.03.2021 07:36	-a-
Xylem.Common.Logic.ProductionOrderCore	dll	68.096	17.03.2021 10:29	-a-
Xylem.Common.Logic.RelatePcb	dll	5.120	17.03.2021 07:27	-a-
Xylem.Common.Logic.ServiceCore	dll	8.704	17.03.2021 07:27	-a-
Xylem.Common.Logic.SoftwareAccessHelper	dll	8.704	18.03.2021 07:36	-a-
Xylem.Common.Metrology.Measurements	dll	13.824	17.03.2021 10:29	-a-
Xylem.Common.Utils.ByteArrayStyle	dll	4.608	18.03.2021 07:36	-a-
Xylem.Common.Utils.Crc16Ccitt	dll	4.608	18.03.2021 07:36	-a-
Xylem.Common.Utils.Logging	dll	10.752	18.03.2021 07:36	-a-
Xylem.Common.Utils.ProcessExec	dll	6.656	18.03.2021 07:36	-a-
Xylem.ServiceFwUpdate.Common.FwUpdateConfig	dll	5.120	18.03.2021 07:36	-a-
Xylem.ServiceFwUpdate.Common.FwUpdateDb	dll	13.824	18.03.2021 11:48	-a-
Xylem.ServiceFwUpdate.Common.FwUpdateSafe	dll	7.680	18.03.2021 11:48	-a-
Xylem.ServiceFwUpdate.Ui.ServiceFwUpdateSw	dll	138.240	18.03.2021 11:49	-a-
configuration	json	664.501	16.12.2020 07:32	-a-
MeterFilesEraseRestore	json	351	19.02.2021 09:07	-a-
NlogConfig	xml	4.993	25.11.2020 08:54	-a-

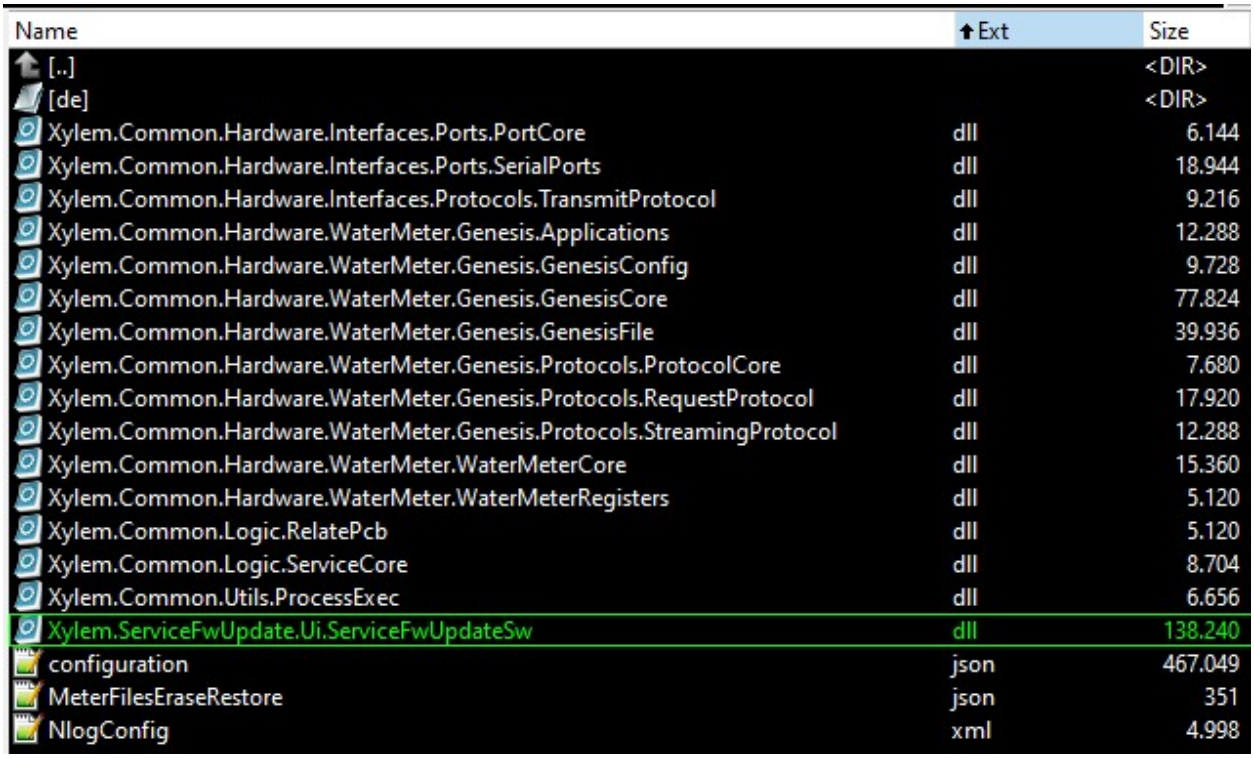
Picture 6.2 FW-Update SW Files All After Build

To reduce the size of the “FW-Update Safe” all libraries which are identical to the “FW-Update Loader” shall be skipped from it.

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This results in the following files needed:



Name	Ext	Size
[..]		<DIR>
[de]		<DIR>
Xylem.Common.Hardware.Interfaces.Ports.PortCore	dll	6.144
Xylem.Common.Hardware.Interfaces.Ports.SerialPorts	dll	18.944
Xylem.Common.Hardware.Interfaces.Protocols.TransmitProtocol	dll	9.216
Xylem.Common.Hardware.WaterMeter.Genesis.Applications	dll	12.288
Xylem.Common.Hardware.WaterMeter.Genesis.GenesisConfig	dll	9.728
Xylem.Common.Hardware.WaterMeter.Genesis.GenesisCore	dll	77.824
Xylem.Common.Hardware.WaterMeter.Genesis.GenesisFile	dll	39.936
Xylem.Common.Hardware.WaterMeter.Genesis.Protocols.ProtocolCore	dll	7.680
Xylem.Common.Hardware.WaterMeter.Genesis.Protocols.RequestProtocol	dll	17.920
Xylem.Common.Hardware.WaterMeter.Genesis.Protocols.StreamingProtocol	dll	12.288
Xylem.Common.Hardware.WaterMeter.WaterMeterCore	dll	15.360
Xylem.Common.Hardware.WaterMeter.WaterMeterRegisters	dll	5.120
Xylem.Common.Logic.RelatePcb	dll	5.120
Xylem.Common.Logic.ServiceCore	dll	8.704
Xylem.Common.Utils.ProcessExec	dll	6.656
Xylem.ServiceFwUpdate.Ui.ServiceFwUpdateSw	dll	138.240
configuration	json	467.049
MeterFilesEraseRestore	json	351
NlogConfig	xml	4.998

Picture 6.3 FW-Update SW Files Exclude

6.6.2 [SRS_FW_UPD_LDR_EXEC_002] FW-Update Software Start

Parameter input using a json-serializer on the routine call `SetDataContainerJson()`:

1. Software License,
2. Paths to configurations and settings,
3. Cordonel Device Information and
4. Cordonel Firmware packages.

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7. FW-Update SW - Requirements

7.1 FW Update SW - Inputs

At the start of the “FW-Update SW” all information needed to validate the execution permission and to perform the update process have to be dispatched.

The input interface is a json-serialized stream with the function name `SetDataContainerJson()`.

7.1.1 [SRS_FW_UPD_SW_IN_001] Software License

The “Software License” shall be dispatched to the “FW-Update SW” with the content as described in chapter [3.4.1].

7.1.2 [SRS_FW_UPD_SW_IN_002] Cordonel Device Information

The list of “Cordonel Device Information” shall be passed to the “FW-Update SW” with the content as described in chapter [3.4.3].

7.1.3 [SRS_FW_UPD_SW_IN_003] Cordonel Firmware

The “FW-Update SW” shall load this package according to the “Cordonel Device Information”, which contains a field for the required “Cordonel Firmware” for this specific update [3.4.3].

7.2 Communication Port Assignment

Before a communication to the Cordonel can be established, a physical communication port of the PC has to be assigned. The port name is identical to the MS-Windows™ device manager information starting with “COM”. The protocol has to be set to “Request” meaning a bi-directional request and answer handling. As port type the “IrdaSerialPort” marker has to be set. The “Request” and “IrdaSerialPort” are program specific definitions in the namespaces:

- Xylem.Common.Hardware.Interfaces.Ports.SerialPorts,
- Xylem.Common.HArdware.WaterMeter.Genesis.Protocols.

7.2.1 [SRS_FW_UPD_SW_PORT_001] Port Configuration File

The port configuration file “SerialConfig.json” speeds up the connection time due to a pre-defined port name. This file will be stored in the user settings of the MS-Windows™ environment in the following folder:

C:\Users\[user name]\AppData\Roaming\Genesis

The file contents at least one slot number and two ports for each slot called “Request and Streaming” with an assigned “PortName” and “Type”. The slot and the streaming interface will not be used for this product, but is part of the production process, which uses the same file, where multiple slots and therefore Cordonels™ can be tested in parallel.

The format of the “SerialConfig.json” is (example):

```
[{
      "Slot": 0,
      "Request": {
```

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```
            "PortName": "COM60",
            "Type": "Xylem.Common.Hardware.Interfaces.Ports.SerialPorts.IrdaSerialPort"
      },
      "Streaming": {
            "PortName": "NA",
            "Type": "Xylem.Common.Hardware.Interfaces.Ports.SerialPorts.UartSerialPort"
      },
      "Type": 0
}]
```

Listing 7.1 Port Configuration File - SerialConfig.json

Note: The standard definition of a communication to the Cordonel™ during production uses two communication ports, one for the IrDA with bi-directional communication (Request on IrdaSerialPort) and one for the measurement streaming (Streaming on UartSerialPort). Slot 0 will be used for the "FW-Update SW".

7.2.2 [SRS_FW_UPD_SW_PORT_002] Automatic Port Detection

The port auto detection is optional. It can be executed if a port description file cannot be found to simplify the port configuration. If a valid port has been detected, the "Port Configuration File" shall be created to speed up the next connection process.

Port auto detection sequence:

Get information from System Device Manager with SerialPort.GetPortNames()

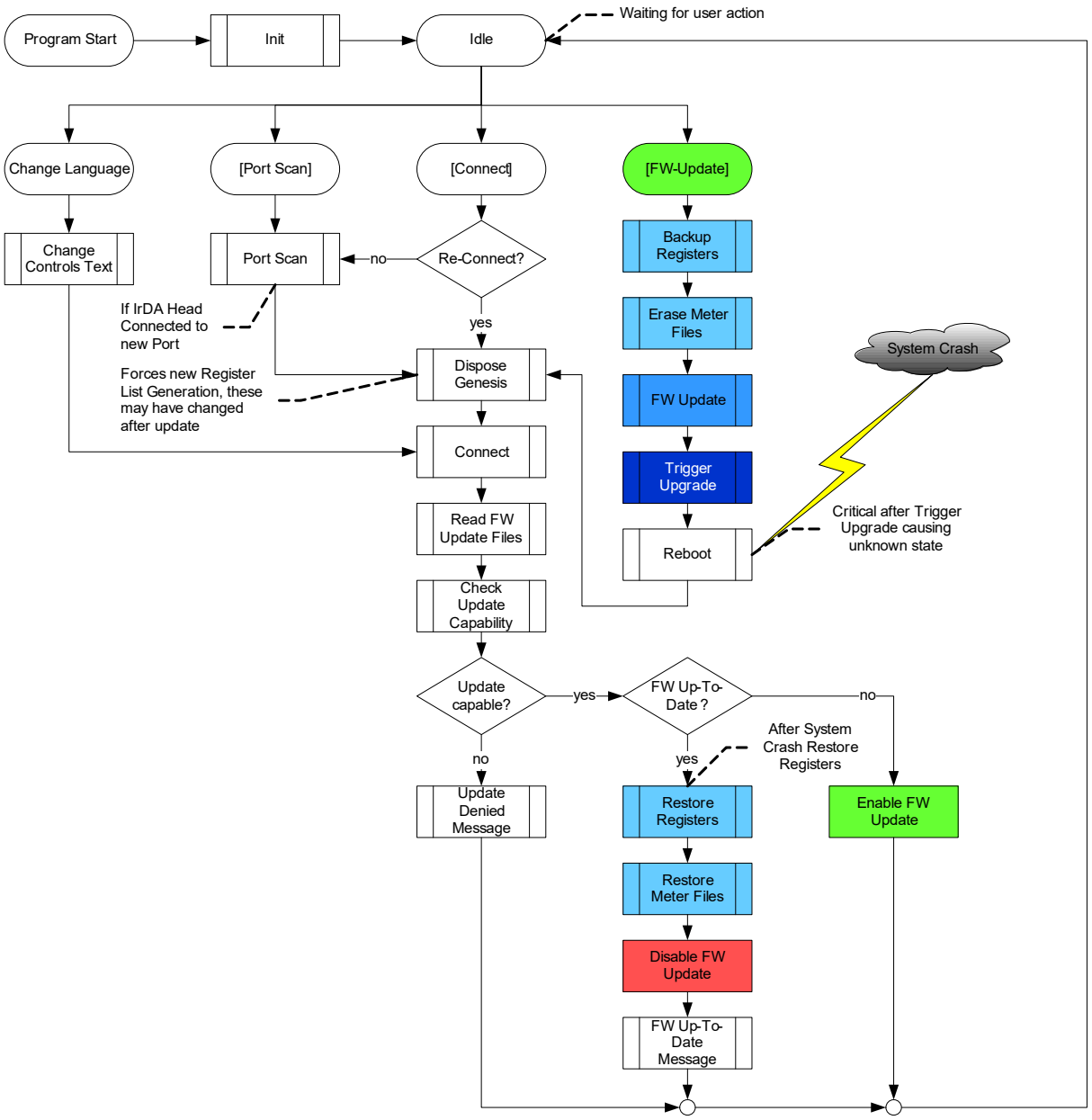
1. Try to open port, this consumes a lot of time and results with an IOException, if the port cannot be opened, the more ports on a PC are defined, the longer it takes (a few minutes at least),
2. Start scan with the highest port number, this might be the last newly attached at connection of the USB-IrDA adapter by the Win10 auto-detection and assignment of port number,
3. Send Cordonel GetPcbId command with request protocol to check for physically connected Cordonel as it replies with his PCB ID.

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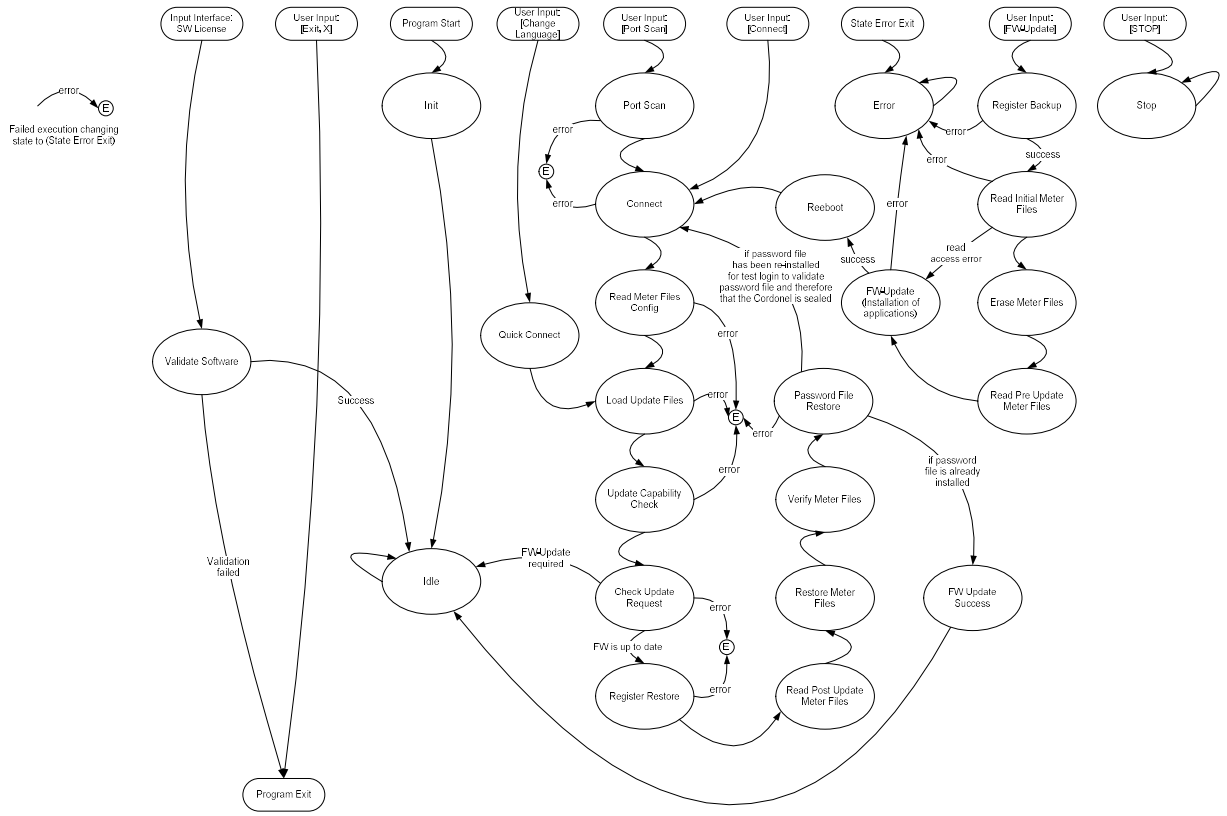
7.3 FW-Update SW - FW Update Process

The following picture imagines the FW-Update SW structure.



Picture 7.1 FW-Update SW Structure

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Picture 7.2 FW-Update SW State Machine

7.3.1 [SRS_FW_UPD_SW_PROC_001] Port Selection

The serial port shall be selected according to chapter [7.2].

7.3.2 [SRS_FW_UPD_SW_PROC_002] Password Container Check

The SW shall open the password container assigned to the PCB ID read from the Cordonel. If it cannot find a password container, or if the Level 8 password or the SkeletonKey is not assigned, the SW cannot update this device. Therefore the SW shall deny further processing of this Cordonel.

7.3.3 [SRS_FW_UPD_SW_PROC_003] Authentication

The “FW-Update SW” shall try to login with the password Level 8. If this fails, it shall try the “Skeleton Key”. If the “Skeleton Key” login succeeded, the password file is corrupted or not installed. This shall be remind and shall force a re-installation of the password file after the “FW-Update”.

Between the unsuccessful login Level 8 trial and the Skeleton Key login a time of 5s shall be held, as the Cordonel locks out the subsequent failed login trials for 1s, 2s, 4s, 8s and so on.

7.3.4 [SRS_FW_UPD_SW_PROC_004] Start Cordonel LCD Setup

With the first login to the Cordonel, the SW shall reset the Cordonel LCD display to the standard operational state.

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This is required as on one failed “FW-Update Process” due to an unpredictable program interruption, the LCD display will show “IdLE 8888” as indication for the ongoing FW-Update procedure. This shall be set in the *FinalConnect()* procedure:

```
_currentGenesis.SetLcdText(true, new Byte[] { 0, 0, 0, 0 });
```

7.3.5 [SRS_FW_UPD_SW_PROC_005] Start Cordonel LED Setup

With the first login to the Cordonel, the SW shall reset the Cordonel LED state to the OFF mode.

The LED, which usually transmits measurement data, is not used during the FW-Update process. This shall be set in the *FinalConnect()* procedure:

```
_currentGenesis.WriteRegister(Register.Genesisflow.LedMode, new[] { (Byte)LedMode.Off });
```

Switching the LED Off will safe energy to enhance the life time of the batteries! This is essential to meet the product specifications. A replacement of the batteries is not possible without disassembly of the entire Cordonel!

7.3.6 [SRS_FW_UPD_SW_PROC_006] Core Revision Check

During the connection process, the “Genesis”-class reads the “Core Revision” of the Cordonel. With the loading of the “FW-Update Package” the application description file (ADF) states the valid core revisions for this release.

The “FW-Update SW” shall check and validate the “Core Revision”. If it is invalid, the FW-Update has to be denied.

7.3.7 [SRS_FW_UPD_SW_PROC_007] Metrology Update Capability Check

The register “*SYSTEM_UpgradePermissions*” defines the metrology update permission. If the value contains 0xFF the update is allowed, else it is denied.

The “FW-Update SW” shall read out the “*SYSTEM_UpgradePermissions*” register and decide on the current metrology version “*GENESISFLOW*” if the update will be enabled.

7.3.8 [SRS_FW_UPD_SW_PROC_008] Region Radio Update Capability Check

During the connection process, the “Genesis”-class reads the “Region and Radio-Frequency” of the Cordonel. With the loading of the “FW-Update Package” the application name states the valid region and/or radio-frequency for this release. It has to contain (as this will be checked for this part of the release name):

- _NA_ for North America e.g. “PROD_NA_ DN50_B1070”
- _EMEA_868_ for Europe, Middle East, Africa with 868 MHz radio frequency e.g. “PROD_EMEA_868_DN50_R106D”
- _EMEA_433_ for Europe, Middle East, Africa with 433 MHz radio frequency e.g. “PROD_EMEA_868_DN50_R106D”

The “FW-Update SW” shall check and validate the “Region Radio”. If it is invalid, the FW-Update has to be denied.

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7.3.9 [SRS_FW_UPD_SW_PROC_009] Register Report Investigation

- Deprecated Requirement – FW Design team stated that a register restorer is not needed!

The SW shall analyse the “Report File” if any “FW-Update” has been executed with this PCB ID. If this file contains values for this PCB ID an previous “FW-Update” had been started . These values are needed in kind of program execution interruption (“System Crash”) after the “Trigger Upgrade” being sent to the Cordonel. If so, the register restoring could not be executed during the finalization procedure. Then all register values after the update may be corrupted. These values from the report file can be used to restore the register contents before the update.

7.3.10 [SRS_FW_UPD_SW_PROC_010] Register Readout

The SW shall readout all defined registers and store the actual content to the “FW-Update Report”. Additionally this operation will secure the register contents if the program flow will be interrupted by power loss, user interaction or any other unpredictable event. If this is the case, all register values can be restored from HDD.

Before execution of the update procedure all registers shall be logged to the “FW-Update Report” which follow the rules:

"lvl8" : "RW" or “RO” – Password level 8 read/write or read only capability ,

"statictype" : not null – Static type is defined,

"version" : "first" and "last" – Version range for this register,

"IsAvailable" : "true" – Register ahs been put to register list,

“DataType” : not “RPC” – Remote Procedure Call Type used for file operations.

7.3.11 [SRS_FW_UPD_SW_PROC_011] Restorable Register List

A list of all registers, which can be restored, shall be generated.

The software shall check for restoring ability all registers which are flagged as:

"lvl8" : "RW" – Password level 8 read/write capability,

"statictype" : "static" – Static register value which will not change during operation,

"version" : "first" and "last" – Version range for this register,

"values" : "minimum" and "maximum" – Value range for this register.

Open issues:

- How to handle accumulators? These are the base for “billing” for the customer. The contents may change during the FW-Update procedure as the water-flow may not be stopped during this operation.
- How to handle register “error responses”?

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7.3.12 [SRS_FW_UPD_SW_PROC_012] Password File Installation Check

The SW shall check the password file. The easiest check is the logon with the level 8 password. If this succeeds, the password file is installed.

If it cannot detect the password file it will mark this as corrupted being able to install it after the FW-Update process.

7.3.13 [SRS_FW_UPD_SW_PROC_013] Erase Cordonel Files

The SW shall erase all unneeded files before the update process can be started to free the space for the upgrade files (applications). These needed to be downloaded to the Cordonel. All these files are defined in the “MeterFilesEraseRestore.json” as defined in chapter [3.8.1].

7.3.14 [SRS_FW_UPD_SW_PROC_014] Firmware Update Process

The “FW-Update Process” shall use a dynamically timeout to speed up the first communications. The initial timeout is 5s. After 4 retries (5 communications) the last retry timeout will be set to 30s.

7.3.15 [SRS_FW_UPD_SW_PROC_015] Register Restore

- Deprecated Requirement – FW Design team stated that a register restorer is not needed!

Instead all register shall be read and stored after the update procedure to the “FW-Update Report”.

7.3.16 [SRS_FW_UPD_SW_PROC_016] Restore Cordonel Files

The SW shall restore all meter files as defined in the “MeterFilesEraseRestore.json” for normal operation listed in the chapter [3.8.1]. The “Restore” section of this file is the list of all meter files which should be restored after the FW update.

7.3.17 [SRS_FW_UPD_SW_PROC_017] Password File Restore

If the password file is corrupted or not installed, the “FW-Update SW” shall install this after the update procedure. The password file is part of the “FW-Update Safe” and therefore present for recovery.

This final step is very important, as an uninstalled password file leaves the Cordonel unsealed!

7.3.18 [SRS_FW_UPD_SW_PROC_018] FW-Update Report Generation

After the update procedure a report container has to be created being able to merge the information to the production data base.

7.3.19 [SRS_FW_UPD_SW_PROC_019] Software Exit

Exit SW with dismount of virtual disk to remove the program.

7.4 FW-Update SW - Program Design

7.4.1 [SRS_FW_UPD_SW_DESIGN_001] Port Scanner

A port scanner shall be used to avoid wrong setup by the user and therefore simplify the port assignment.

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To avoid a repeated port scan, which is very time consuming, the "_currentGenesis.pcbId" can be checked. If this is set if a previously executed scan succeeded.

7.4.2 [SRS_FW_UPD_SW_DESIGN_002] State Machine

A state machine shall control the program sequences.

User Input [START]:

1. Auto detect serial port,
2. Authentication to Cordonel™,
3. Read all registers,
4. Check password file is installed, level 8 password can be used,
5. Erase defined meter files to free space for the FW-Update files,
6. FW-Update process,
7. Restore registers,
8. Restore defined meter files,
9. Restore password file,
10. Test login,
11. Operational test,
12. Generate report,
13. Exit SW.

7.5 FW-Update SW - User Messages

User messages are essential to keep the user informed about the actual processing, status and history of the update process and final overall messages of a (non-)successful update.

7.5.1 [SRS_FW_UPD_SW_MSG_001] Software Start Denied Message

7.5.2 [SRS_FW_UPD_SW_MSG_002] Connect Cordonel Message

After a valid software start, the connect Cordonel™ message shall appear on the screen to keep the user informed about the next required step.

The major information shall display the request to connect the IrDA on the USB port and attach the IrDA-Plugin to the Cordonel™ slot. This is essential to start the communication and read out the PCB ID of the device.

The window shall contain a port selector:

1. port listed in the serial port configuration file,
2. port displayed in from MS-Windows™ device manager
3. perform a port scanning test.

7.5.3 [SRS_FW_UPD_SW_MSG_003] Authentication Failed Message

The authentication failed message shall appear, if a login to the Cordonel™ cannot be established. This may have the reasons:

1. PCB ID not found in the Cordonel "Update Container",

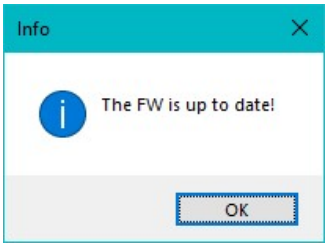
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2. Wrong password.

7.5.4 [SRS_FW_UPD_SW_ MSG_004] FW Up To Date Message

If the FW has been successfully updated or a comparison of the required FW and the already installed FW is identical, a message shall pop up and inform the user of this status.



Picture 7.3 FW Update SW – FW Up To Date Message

7.5.5 [SRS_FW_UPD_SW_MSG_005] Metrology Mismatch Message

7.5.6 [SRS_FW_UPD_SW_MSG_006] Core Mismatch Message

7.5.7 [SRS_FW_UPD_SW_MSG_007] Region Radio Mismatch Message

7.5.8 [SRS_FW_UPD_SW_MSG_008] FW Update Failed Message

7.5.9 [SRS_FW_UPD_SW_MSG_009] FW Update Succeeded Message

7.6 FW Update SW - Outputs

The outputs of the FW update are needed for the report generation and for analysis purposes, if the FW update failed.

7.6.1 [SRS_FW_UPD_SW_OUT_001] Logging

The FU-Update SW shall log information to the hard disk during execution. This shall include the processing steps and the read and written information to the water meter. All logging files shall be stored to

C:\GenesisLog\[date]\[SW name]

The configuration file “NLogConfig.xml”, which setups the logging, shall be stored to the user directory:

C:\Users\[user name]\AppData\Roaming\Genesis

7.6.2 [SRS_FW_UPD_SW_OUT_002] FW-Update Report

The report files shall be generated according to chapter [3.9.2].

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8. Contacts

Name	Function	Mail

Table 8.1 Contacts

9. References

[FWU_MRD] **Cordonel Service FW-Update Process MRD**; *Published: SENSUS GmbH*; Author: Thomas Wiedebusch; Edition: September 2020 - Revision B

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