



Reconfigurable Radio Systems (RRS) ; Use cases for dynamic equipment reconfiguration

Reference

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Reconfigurable Radio Systems (RRS).

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

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1 Scope

The present document outlines the Use Cases which are related to the introduction of mechanisms to enable, for reconfigurable radio systems, the dynamic reconfiguration of equipment and its continuing conformity with the applicable legislation. These Use Cases involve the dynamic reconfiguration of reconfigurable radio equipment after its initial Declaration of Conformity and deployment. Such post-deployment reconfiguration will ensure the continued conformity in the new configuration to the applicable legislation. In some Use Cases, new mechanisms that enable reconfigurable devices to have their Declaration of Conformity dynamically verified may be introduced.

Note that the term "Declaration of Conformity" is typically used in conjunction with the European Radio Equipment Directive. In other regulation domains, other terminology may be employed. While the Use Cases presented in the present document are designed to support the novel radio reconfiguration features of the Radio Equipment Directive [i.3] that is applicable in Europe, the principles and the Use Cases outlined here are not limited to Europe and may also be appropriate for other regions.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

- [i.1] Report Recommendation ITU-R SM.2152: "Definitions of Software Defined Radio (SDR) and Cognitive Radio System (CRS)", 2009.
- [i.2] Void.
- [i.3] Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC.

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

Cognitive Radio System (CRS): Radio system employing technology that allows the system: to obtain knowledge of its operational and geographical environment, established policies and its internal state; to dynamically and autonomously adjust its operational parameters and protocols according to its obtained knowledge in order to achieve predefined objectives; and to learn from the results obtained.

NOTE: This is the current definition as given in Report Recommendation ITU-R SM.2152 [i.1].

RadioApp (RA): software component to be installed and operated on reconfigurable Mobile Devices

NOTE: The operation of the software component impacts the conformity of the reconfigurable equipment to the applicable legislation.

Reconfigurable Equipment (RE): part of a reconfigurable radio system

NOTE: The Reconfigurable Equipment is capable of being dynamically reconfigured to adapt to a wide range of communications conditions. Such reconfiguration may include the band of operation, the radio access technology, the associated networks and the services accessed. The reconfiguration may occur after initial sale, deployment and operation.

Reconfigurable Radio System (RRS): generic term for radio systems encompassing Software Defined and/or Cognitive Radio Systems

Software Defined Radio (SDR): radio transmitter and/or receiver employing a technology that allows the RF operating parameters including, but not limited to, frequency range, modulation type, or output power to be set or altered by software, excluding changes to operating parameters which occur during the normal pre-installed and predetermined operation of a radio according to a system specification or standard

NOTE: This is the current definition as given in Report Recommendation ITU-R SM.2152 [i.1].

user: user of the Reconfigurable Radio System or the Reconfigurable Equipment

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

CRS	Cognitive Radio System
DoC	Declaration of Conformity
EC	European Commission
GSM	Global System for Mobile Communications
HW	HardWare
NRA	National Regulatory Authority
OEM	Original Equipment Manufacturer
PAMR	Public Access Mobile Radio
PMR	Professional Mobile Radio
PPDR	Public Protection and Disaster Relief
RAT	Radio Access Technology
RE	Reconfigurable Equipment
RMP	Reconfiguration Market Platform
RRS	Reconfigurable Radio System
RVM	Radio Virtual Machine
SDR	Software Defined Radio
SM	Software Manufacturer
SP	Service Provider
StoC	Statement of conformity
SW	SoftWare
TCAM	Telecommunication Conformity Assessment and Market Surveillance Committee

4 Principles and Objectives for Reconfigurable Equipment

The present document focuses on the Use Cases and the related procedures applicable to equipment to be placed on the market that is able to be dynamically reconfigured. This includes, for instance, a piece of equipment for which the radio part can be reconfigured after deployment with new software remotely. Very often such a reconfiguration may occur "over-the-air" while the reconfigurable equipment is attached to a network. In the framework of the present document, it is assumed that equipment reconfiguration may include software provided by third party software suppliers. A corresponding legal framework is available in Europe under the Radio Equipment Directive (RED) [i.3]. Other regions may have their specific legal frameworks for placing such reconfigurable equipment on the market and/or putting it into service.

Herein, it is assumed that methods and processes traditionally used in the context of the assessment of conformity to applicable legislation may continue to be applied.

The extensions and standards for dynamically reconfigurable equipment may take into consideration the following principles and objectives:

- i) One single entity, typically but not necessarily the Original Equipment Manufacturer, will ensure and declare that the resulting combination of (third party) software and hardware is in conformity to the applicable requirements.
- ii) The entity responsible for the joint operation of hardware and software will provide all relevant technical documentation on request for market surveillance (including all background information used for the DoC).
- iii) A mechanism may be developed to ensure that reconfigurable equipment will only allow compliant software to be installed and to ensure the externally verifiable integrity of the software. A mechanism may be used to indicate that a Declaration of Conformity has been issued for the combination of the software and hardware equipment in question.
- iv) Third party software may be installed as long as the resulting combination of software and hardware is in conformity with the appropriate applicable legislation.
- v) A history file should be kept inside the dynamically reconfigurable equipment for storing information on previous reconfigurations. This may enable the equipment to go back to a previous (stable) configuration in case of unexpected operation (e.g. creation of interference to other users or systems) and/or to identify which software modifications have been installed onto the equipment (so as to facilitate ex-post equipment monitoring).
- vi) Typically, a Declaration of Conformity may be issued for software and hardware components which are available at the time of the Declaration ("Scenario 1"); additionally, depending on the applicable legislation, a Declaration of Conformity may be issued for hardware components in combination with available software components which can be extended for inclusion of software components to be developed in the future ("Scenario 2"). In the latter case, a future software component is typically made available together with a "Statement of Conformity", indicating that the combination of concerned hardware and software complies with the appropriate requirements. In Scenario 2, the Declaration of Conformity together with the appropriate Statement of Conformity is expected to be equivalent to Scenario 1.

Scenario 2 is expected to reduce the administrative overhead for the responsible entity (typically the Original Equipment Manufacturer), while the legal result would be the same as in Scenario 1. It still needs to be verified whether:

- i) Scenario 2 is finally meeting its objectives; and
- ii) be acceptable from a legal perspective.

Figure 1 positions the application of Scenario 1 and Scenario 2 with respect to the verification needs of an equipment after Software Reconfiguration. Scenario 2 is an alternative to Scenario 1, especially in the case of a very limited access to radio parameters for (third party) software developers - the latter can be addressed by an Radio Virtual Machine (RVM) approach enabling the management of various levels of access to Radio Parameters by Software Components. Finally, together with the limited effort required for verification (i.e. only those test-cases need to be executed which are affected by the reconfiguration), a less complex assessment procedure might be possible.

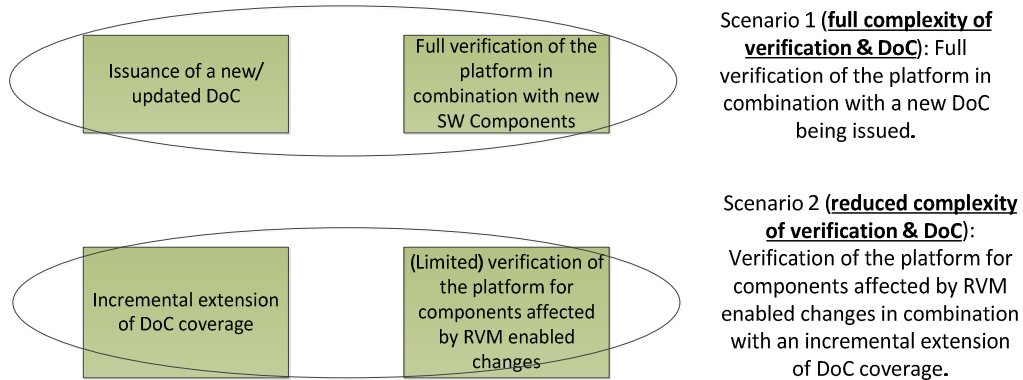


Figure 1: Scenario 1 and Scenario 2 Declaration of Conformity.

Figure 2 highlights that both Scenario 1 and Scenario 2 based Declaration of Conformity lead to an identical situation, i.e. the Declaration of Conformity is finally covering the concerned combination of hardware and software after the Reconfiguration process.

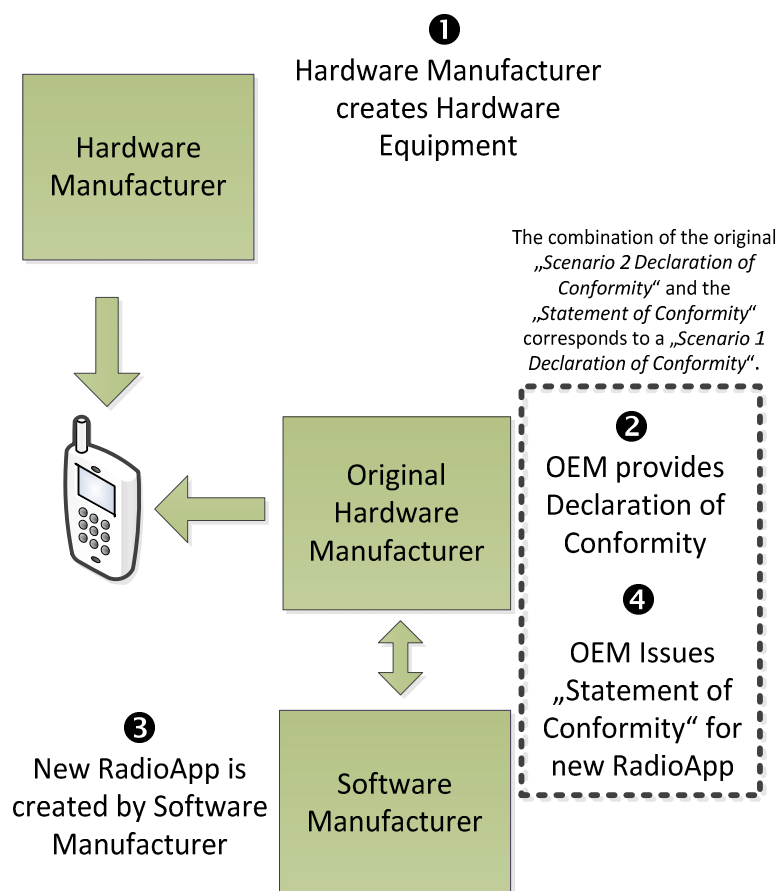


Figure 2: Identical situation for Scenario 1 and Scenario 2 Declaration of Conformity.

5 Stakeholders and Interrelations

5.0 Introduction

The ability to dynamically reconfigure equipment throughout its lifetime is important to enable the rapid and economical upgrading of equipment after initial deployment while at the same time assuring the continued conformity to all the applicable rules and the applicable legislation. It is through providing a climate of dynamic re-configurability that the economic benefits of Cognitive Radio Systems technology and rapid deployment of new innovative reconfigurable radio systems will be fostered. Such re-configurability will enable systems to be designed for the future and to take advantage of new technology and regulatory developments.

However, while it is important that the dynamic reconfiguration process does not hinder the development of new systems, the process should accommodate a wide variety of equipment, be sustainable over decades of regulatory control, be legally sound and be proof against both innocent misuse and malevolent perversion. In some cases, the new Declaration of Conformity may cover regulations that were not in effect at the time of original Declaration of Conformity or involve service aspects that are new capabilities. The reconfiguration may also be performed in a regulatory domain that is different from the initial Declaration of Conformity domain and the reconfiguration may affect features that may be regulated differently in different regulatory domains. It can be anticipated, for example, that in a first phase reconfiguration features are likely to be used only within a single regulatory domain. At a later time, the features could be extended to multiple regulatory domains as needed.

It should be understood that the Use Cases discussed in the present document are not about the conformity testing or "Declaration of Conformity" of equipment that has been upgraded with new software. All upgrades should first be verified by their developers using testing processes that are already established within the industry that conform to the applicable legislation. The reconfiguration Use Cases that are the subject of the present document address the process of assuring that new configurations for reconfigurable equipment are properly and appropriately loaded. The software and equipment design for the new configuration may be tested for conformity through the appropriate entities. Once the conformity testing of the new configuration is successful and a new Declaration of Conformity for the new configuration is issued, the reconfiguration process that is the subject of the Use Cases in the present document may be used to dynamically reconfigure the equipment.

Reconfigurations may involve many layers of software or hardware, and some reconfigurations may rely on presumed operation of previously established configurations. Also, due to the large volumes of deployments of consumer devices, the reconfiguration process should be scalable to accommodate (literally) billions of deployed devices and a similar number of possible new configurations.

This introductory clause outlines key stakeholders and key concepts for dynamically reconfiguring equipment while ensuring its continued conformity/compliance to/applicable legislation and standards. One of the purposes of the present document is to enumerate some of the practical and technical Use Cases that should be accommodated by the dynamic reconfiguration process. For example, due to the equipment long life-cycles, the configuration process requires care and caution in its design to prevent failures or malevolent perversion. Furthermore, security requirements for the reconfigurable equipment should be considered to ensure trustworthy operation.

5.1 Stakeholders, Entities and Statements of Conformity

This clause lists and briefly describes the Stakeholders ([S]) and Entities ([E]) involved in the illustrated reconfiguration Use Cases as well as the "Statement of Conformity"([StoC]).

Note that the requirement for some or all of the below mentioned entities depends on the implementation of the reconfiguration framework. In particular a first implementation of the software reconfiguration framework is expected to limit itself to the most essential features only.

Not all of the listed stakeholders are involved at the same time.

- **Reconfigurable Equipment (RE) [E]:** Equipment that is dynamically reconfigurable through software reconfigurations affecting radio parameters. The Software may be acquired from a Reconfiguration Market Platform (for instance an SP, see below). This reconfiguration may occur after the initial sale, deployment and operation of the equipment. In some situations, the reconfigurable equipment may be physically fixed in location and linked to a communications network (Mobile network base stations are an example of such equipment). In other situations, the reconfigurable equipment may be mobile or in no specific location and linked to communications networks through temporary means such as radio links (User mobile equipment are an example of such equipment). The reconfiguration of fixed and mobile RE may adopt different procedures for dynamic changes. In some cases the RE may be reconfigured using procedures that have previously been used which may, for example, involve human interaction.
- **Reconfigurable Equipment User [S]:** User making use of Reconfigurable Equipment to access services from an SP or to otherwise communicate with equipment that is compliant with the applicable legislation.

NOTE 1: In some cases RE Users may select reconfiguration software components to alter the capabilities and services of their RE.

NOTE 2: Such other communication may include, for example, a private network or a local individual communication.

- **Service Provider [S]:** An SP delivers radio access and network services using equipment including RE. The SP may, for example, be a network operator using licensed spectrum, but may also be a personal or local area network manager. There may be multiple SPs associated with mobile RE through roaming or other commercial arrangements. The SP network may be a public service or a user restricted one (e.g. PMR, PAMR, PPDR network). The SP may require a subscription, for mobile RE to access its network and services. The SP may perform reconfiguration of its network RE, perhaps in concert with the RE's OEM. The SP may also provide the RE User with information on available reconfiguration software (i.e. the SP may also be a 'Reconfiguration' Market Platform provider).
- **'Reconfiguration' Market Platform [E]:** RMP is a Platform where reconfiguration software is advertised and can be downloaded by RE Users in a trustworthy way. The 'Reconfiguration' Market Platform may also inform the RE Users of new, updated or discontinued (no longer supported) software configurations. There may be multiple 'Reconfiguration' Market Platforms which may, or may not, be associated with an equipment or a software provider or an SP. In this context, reconfiguration software refers to software that affects the conformity of the RE to radio or service regulations or to the Service Provider's network. The RE may be reconfigured with software from multiple 'Reconfiguration' Market Platforms. In the present document, the RMP is considered to be generic and covers all relevant market channels (such as the SP, a RadioApp store, etc.).
- **Declaration of Conformity [C]:** The Declaration of Conformity may be made such that the stated version of software in combination with equipment is in conformity with the applicable legislation and standards.
- **Statement of Conformity [C]:** In case of Scenario 2 Declaration of Conformity (Declaration of Conformity may be issued for available hardware components in combination with software components to be developed in the future), a "Statement of conformity" (StoC) is provided after successful completion of testing that proves the conformity of the RE to the applicable legislation and standards. The StoC is the proof that the RE or its reconfiguration is in conformity with all the applicable legislation and it is the basis for the continued operation of the device.

A new StoC is required anytime a new configuration, including a new firmware release, affects, or may affect, the conformity of the RE to the applicable legislation.

- **Original Equipment Manufacturer [S]:** OEM develops Reconfigurable Equipment platforms based on user preferences, service requirements, applicable technical regulations or the facilities of the SP. The platform may consist of only hardware, but may also be a combination of hardware and associated software. Note that if the reconfigurable equipment is not operational without appropriate SW, then it cannot be tested for conformity as such testing requires operational equipment including both hardware and software components.
- **Software Manufacturer [S]:** An SM develops Reconfiguration Software or software components to be used on Reconfigurable Radio System platforms. The software may be distributed to users through the 'Reconfiguration' Market Platform or other relevant channels (such as the SP, or direct to the RE User, or bundling with HW equipment, etc.).

- **National Regulatory Authority [S]:** NRA is a national body, or other designated authority, responsible for administering and assuring that the RE can be put into service and conforms to the applicable legislation.

6 Reconfiguration generic Use Cases

6.0 Introduction

There are a number of possible generic Use Cases for the initial Declaration of Conformity and subsequent reconfiguration of reconfigurable equipment after its initial Declaration of Conformity and deployment. In case of Scenario 1 Declaration of Conformity (Declaration of Conformity may be issued for software and hardware components which are available at the time of the Declaration), a Declaration of Conformity is provided including the combination of the concerned hardware and software components. In case of Scenario 2 Declaration of Conformity (Declaration of Conformity may be issued for available hardware components in combination with software components to be developed in the future), the initial Declaration of Conformity Use Cases follows closely the procedures for non-reconfigurable equipment with the addition of the concept of a dynamic Statement of Conformity. The reconfiguration Use Cases typically involve changes in software for the equipment or databases associated with the reconfigurable equipment. To assure that the equipment remains in conformity with the applicable legislation a form of dynamic conformity declaration may be required. There are 5 basic Use Cases:

- 1) OEM establishing initial conformity of reconfigurable equipment platform.
- 2) DoC/StoC verification of reconfigurable equipment.
- 3) OEM upgrade of reconfigurable equipment (individual or en-masse).
- 4) Third party upgrade of reconfigurable equipment (individual or en-masse).
- 5) Configuration enforcement of reconfigurable equipment.

These Use Cases are discussed generically in this clause. Further details are provided in clause 9.

6.1 OEM Establishing Initial Conformity of RE Platform

The establishment of the initial conformity and Declaration of Conformity of the reconfigurable equipment platform by the OEM is illustrated in figure 3. This Use Case is very similar to the conformity testing and Declaration of Conformity that is currently used for non-reconfigurable equipment. As shown in figure 3 the following steps can be identified:

- 1) The OEM designs and develops the RE platform.
- 2) The RE is then tested, for example, by the OEM and the SP for conformity to applicable legislation and standards and a Declaration of Conformity is made.
- 3) In case of Scenario 2 Declaration of Conformity (Declaration of Conformity may be issued for available hardware components in combination with software components to be developed in the future, if available in the concerned legal framework), the OEM includes the coverage of software components in the Declaration of Conformity for which a Statement of Conformity is issued. The concerned RE may then be placed on the market.

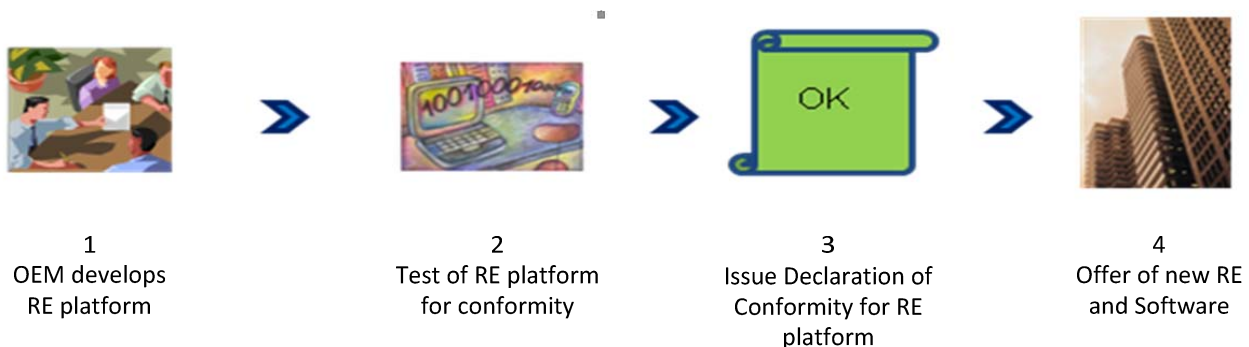


Figure 3: Use Case in which OEM develops, certifies conformity and deploys an RE platform

- 3) In case of Scenario 1 Declaration of Conformity (Declaration of Conformity may be issued for software and hardware components which are available at the time of the Declaration), the entity responsible for the combination of hardware and software updates the existing Declaration(s) of Conformity (directly or in a relevant storage, for example a web-site to which the concerned device is pointing) for some or all RE platforms. Alternatively, in case of Scenario 2 Declaration of Conformity (Declaration of Conformity may be issued for available hardware components in combination with software components to be developed in the future), , (a) new Statement(s) of Conformity are issued indicating that (a) new software component(s) is/are covered by the existing Declaration(s) of Conformity. In the latter case, the existing Declaration(s) of Conformity is/are maintained.

In case that the concerned software component is not compatible with a given RE configuration, corresponding usage conditions are included in the Declaration(s) of Conformity and/or Statement(s) of Conformity.

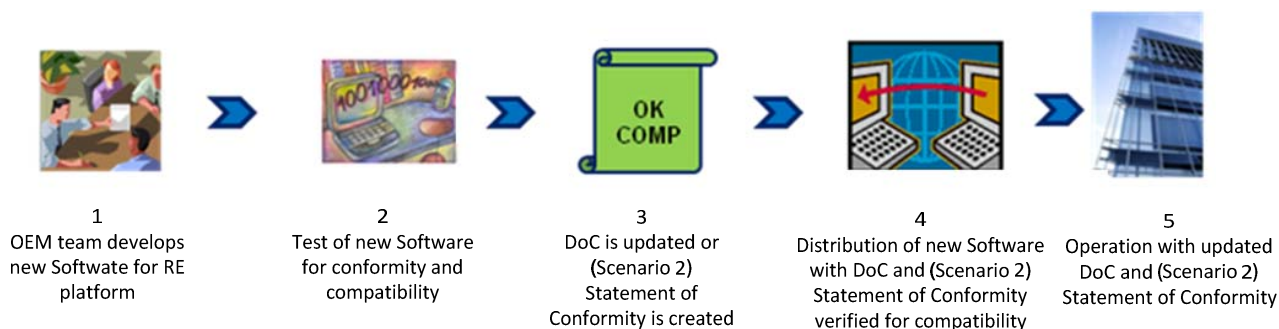


Figure 5: Use Case in which OEM team upgrades applicable reconfigurable equipment en masse

6.4 Third Party reconfiguration (individual or en-masse)

In some Use Cases the reconfiguration components (e.g. software updates) may be provided by a team that is not associated with the original equipment manufacturing team that was responsible for the original Declaration of Conformity. The reconfiguration (new features, SW upgrade, new RAT, operation in a new frequency band, etc.) may be directed to all the REs, a sub-set of REs or to an individual RE. It is therefore necessary to establish and verify the compatibility of the new configuration with the RE's current configuration.

Figure 6 considers the case when an individual RE is reconfigured "on request". The following steps can be identified:

- 1) The user requests a new SW for the reconfigurable platform.
- 2) The current Declaration(s) of Conformity and (in case of Scenario 2) Statement(s) of Conformity are used in order to identify whether the concerned software components are compatible with the RE platform.
- 3) If the new reconfiguration is not compatible with the RE's current configuration, the new configuration is not loaded by the RE.
- 4) If the new reconfiguration is compatible with the RE's current configuration following the current Declaration(s) of Conformity and (if available) Statement(s) of Conformity, the software component(s) may be loaded by the RE for its use and the RE operates with the new SW.

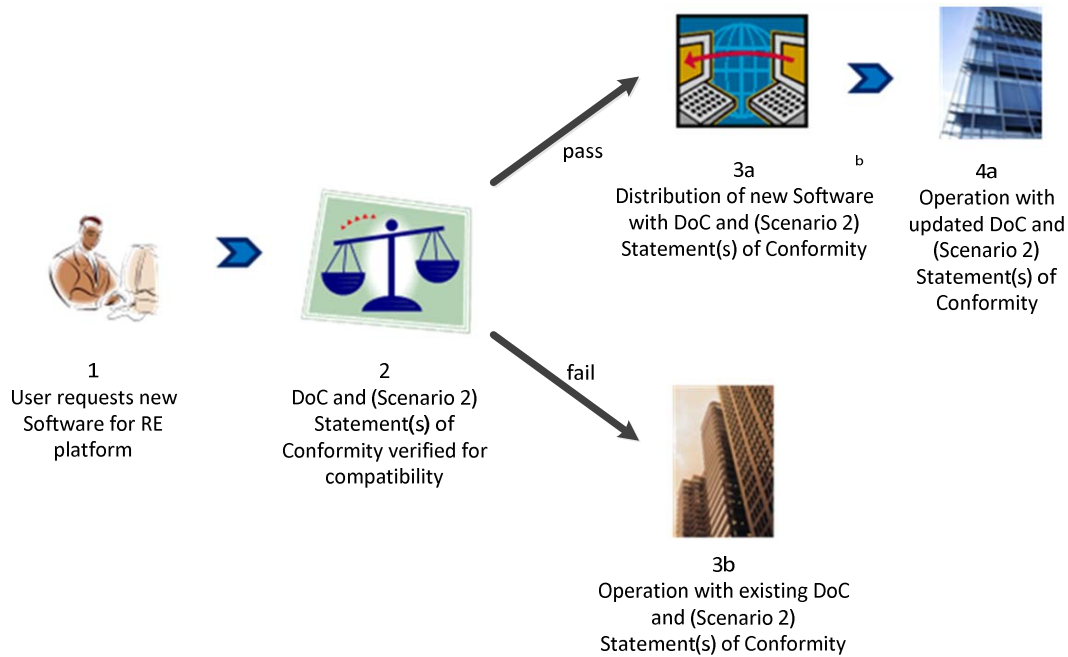


Figure 6: Use Case in which user upgrades SW RE Platform

6.5 Configuration enforcement of reconfigurable equipment

The Use Case for configuration enforcement of reconfigurable equipment (for example to halt an improper operation) is illustrated in figure 7. The following steps can be identified:

- 1) The NRA (or another appropriate body) becomes aware of improper operation of an RE. The NRA may be informed of improper operation by, for example, the SP, the OEM, other RE users or other system users.
- 2) The NRA (or another appropriate body) requests through appropriate channels the RE to cease its operations.
- 3) The RE receives the instructions to cease the current operating mode.
- 4) The RE ceases its improper functions. This may take place, for example, through a complete switch-off or through a reversion to a previous configuration.

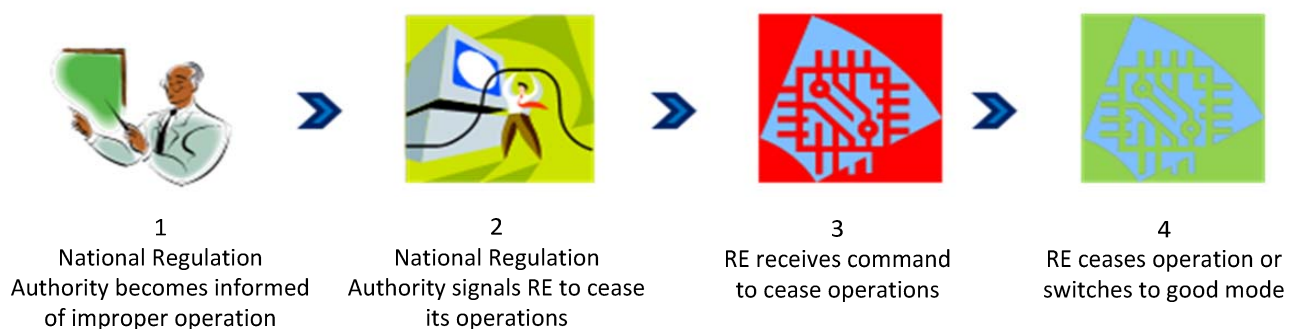


Figure 7: Use Case for enforcement in the event of improper operation of reconfigurable equipment

7 Responsibility

7.1 Overview

From a National Regulatory Authority (NRA)'s perspective, a key requirement for reconfigurable radio systems relates to the issue of Responsibility. In the event that an RE does not operate within the regulatory framework, the NRA typically requires that there be a single, easily identifiable, entity (or contact point) that is responsible for the RE.

For reconfigurable radio systems in Europe, the TCAM (Telecommunications Conformity Assessment and Market Surveillance Committee) has proposed a definition for two market models - horizontal and vertical markets:

- **"Vertical Market:** all hardware and SDR software which is relevant for the Declaration of Conformity with the essential requirements for the intended use during the whole life cycle are controlled by one entity."
- **"Horizontal Market:** independent companies placing hardware and SDR software (3rd party SW providers, etc.) separately on the market which, when used together, are subject to Declaration of Conformity with the essential requirements for the intended use of the equipment."

In the traditional Vertical Market model, the overall responsibility for conformity of the RE remains with the original single entity providing the Declaration of Conformity. Traditionally, this is the original equipment manufacturer (OEM). However, in case of the Horizontal Market model, there may be multiple entities (other than the OEM) that are responsible for the conformity of the RE and for its consequent behaviour. In many cases these multiple entities may not be aware of each other and an RE may contain multiple reconfiguration software products and its behaviour may depend on the combination of software products loaded and their order of loading. Furthermore, the entity responsible for the original Declaration of Conformity may not be aware of the reconfigurations of the RE. In the Horizontal Market model, the challenge is to identify a single entity that is responsible towards the NRA for the total RE behaviour for conformity.

The following clauses illustrate some of the interactions between key stakeholders in the Vertical and Horizontal Market case. Clause 7.2 introduces the classical Vertical Market case, which is successfully applied in practice. However, from a market point of view, it inherently limits the overall flexibility. Clause 7.3 introduces the classical Horizontal Market case, which faces challenges due to an unclear responsibility situation. In order to combine the advantages of the two models, while ensuring clear responsibility as required by national regulatory authorities, a hybrid model is introduced in clause 7.4. This hybrid model combines the Vertical and Horizontal Market approaches into a "Horizontal Market with a single Contact Point". This hybrid combination provides a single, clearly identifiable entity (or contact point) that is responsible for the total RE behaviour for conformity. Further, it should be noted that the "Single Contact Point" should not change during the lifetime of the equipment due to the SW reconfiguration.

7.2 Vertical Market model

In the case of the Vertical Market model, a single entity develops the product RE and is responsible for Declaration of Conformity with the applicable requirements for the intended use and the network compatibility for each reconfiguration during the whole life cycle. Typically, this task is performed by the Original Equipment Manufacturer who controls both new hardware and software components and their possible reconfiguration during the lifetime of the product. This model is illustrated in figure 8 where the OEM, the RadioApp store and the Software Manufacturer are considered to be one entity.

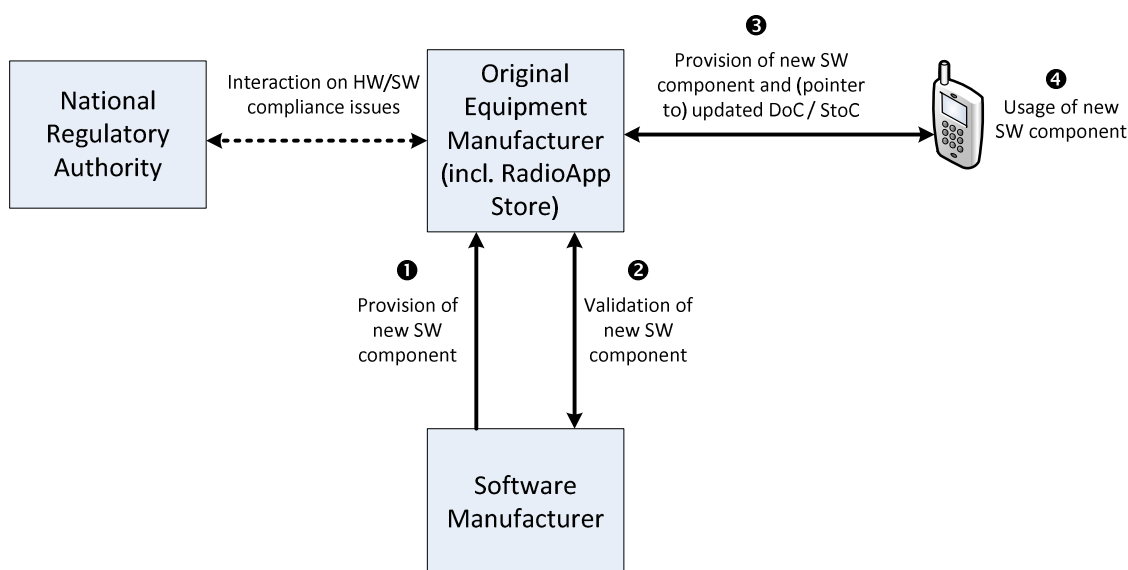


Figure 8: Key interactions in the Vertical Market model

In this model, responsibility clearly remains with the Original Equipment Manufacturer, initially and throughout all subsequent reconfigurations. However the Original Equipment Manufacturer controls the development, testing, approval and deployment of all new software components and thus there is not as open a market for software components as in a horizontal market.

The RadioApp store may be maintained by the Original Equipment Manufacturer as part of its enterprise for distribution of Software components.

7.3 Horizontal Market model

In the case of the Horizontal Market model, independent companies may place hardware and software separately on the market. Typically, a Software Manufacturer may develop new software to operate on a previously compliant RE. In some scenarios in this market, the RE may contain many software components provided by many independent suppliers. When used together the ensemble of components should continue to conform to the applicable requirements for the intended use of the RE. An example of one possible horizontal market scenario in which the hardware and the new software are supplied separately is shown in figure 9.

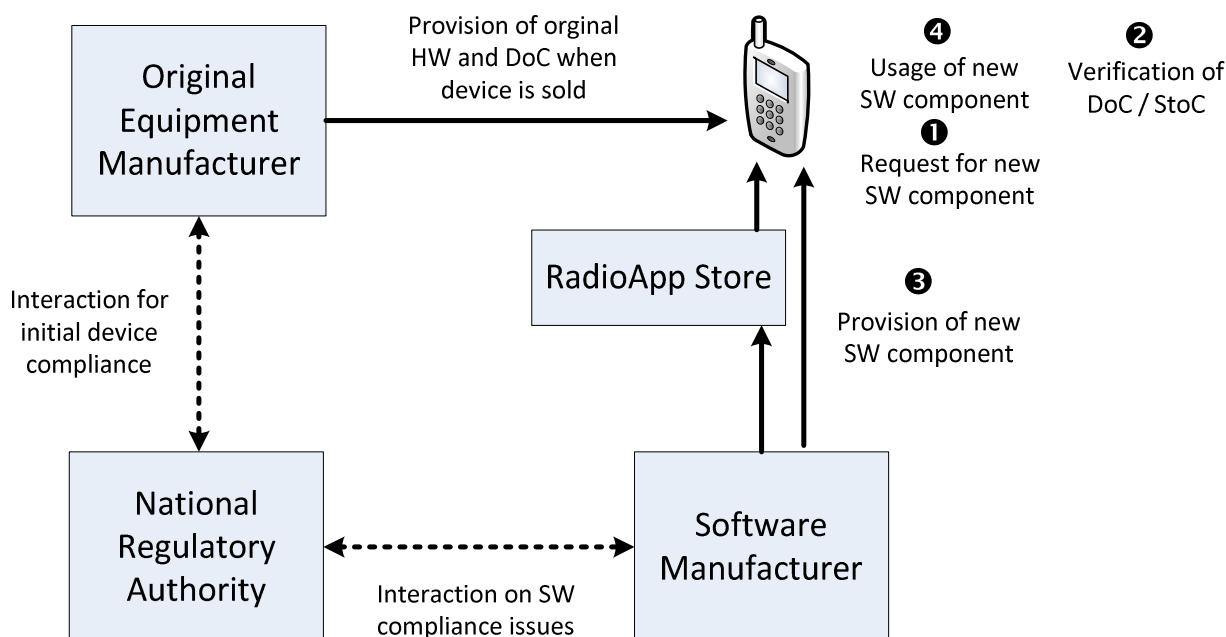


Figure 9: Key interactions in the Horizontal Market model.

The Software Manufacturer may choose to distribute the Software components through a RadioApp Store or directly to the users.

Although this model provides an open market for SW components, there is no longer an easily identifiable single entity that is responsible for conformity and the RE behaviour. As the new components have been installed after initial deployment and perhaps without the knowledge or agreement of the Original Equipment Manufacturer or of the previous entity responsible for conformity, any previous declarations of conformity no longer apply. The OEM, for example, cannot accept responsibility for conformity for REs (Reconfigurable Equipments) that have been reconfigured by third parties without the OEM's knowledge or consent. The NRA typically require that there be a single point of contact that is responsible for the conformity of the equipment and to resolve issues of surveillance and malfunction. A horizontal market model for reconfigurable equipment without an entity taking over the overall responsibility could therefore be difficult to achieve.

7.4 Hybrid Model - Horizontal Market model with a single Contact Point

7.4.0 Introduction

The Horizontal Market model has to provide an entity that is responsible for the total RE behaviour for conformity, thus a hybrid arrangement may be introduced. The model for a hybrid "Horizontal Market with a single Contact Point" is illustrated in figure 10 and figure 11. This configuration enables an open market for software components through the use of a "Conformity Contact Entity". The "Conformity Contact Entity" accepts the overall responsibility and liability for the conformity of the reconfigured hardware and software and provides the single Contact Point entity needed by the NRA.

7.4.1 Hybrid Model - Horizontal Market model with an independent single Contact Point and the OEM involved in the reconfiguration

In the Hybrid Market model illustrated in figure 10, during the lifetime of the equipment, the single Contact Point for Conformity ("Conformity Contact Entity") will take the overall responsibility for the RE.

This entity takes over responsibility for conformity and sorting out the responsibility and liability among the (various) Software Manufacturers. This liability between Software and Hardware manufacturers is an internal matter to be resolved by the single Contact Point for Conformity. It will not affect the overall responsibility of the single Contact Point for Conformity.

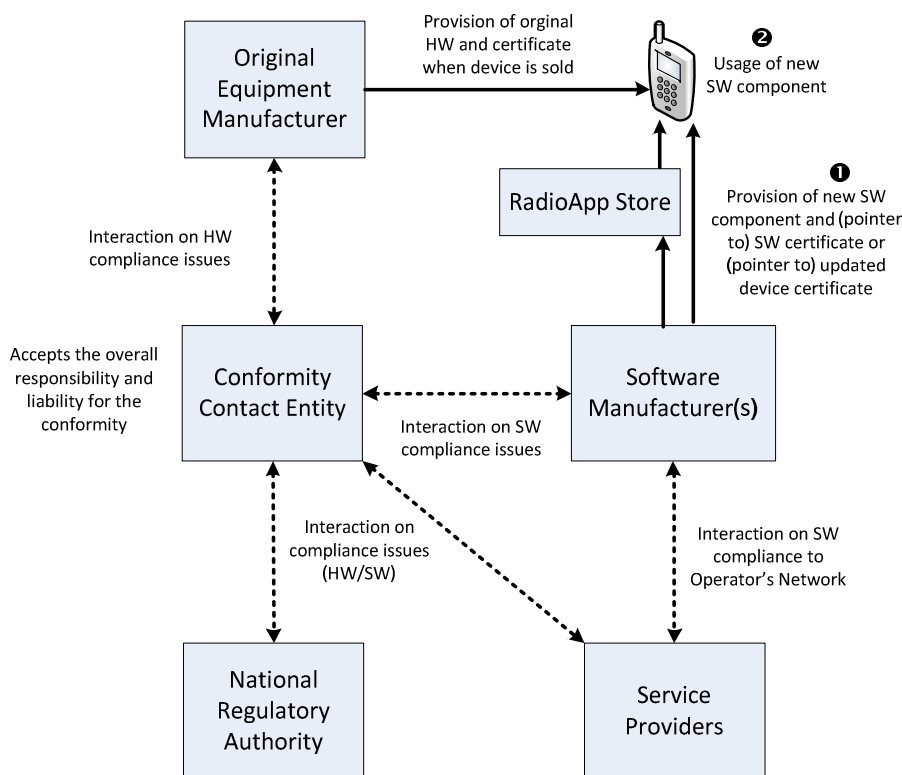
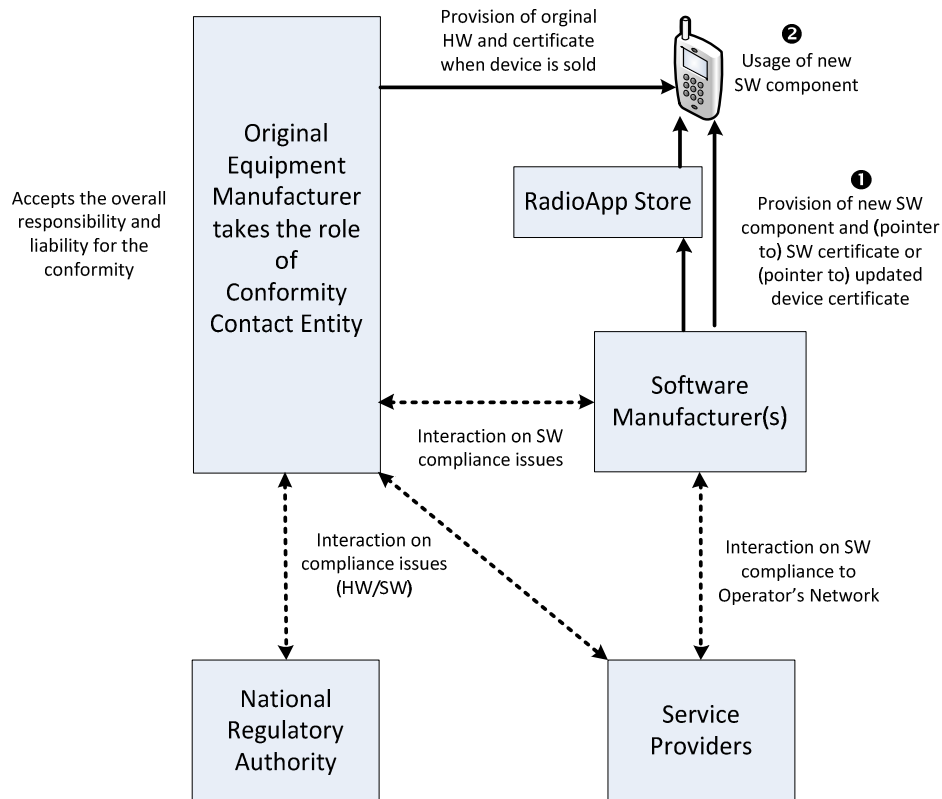


Figure 10: Alternate interactions in the Hybrid Market model with a single Contact Point

7.4.2 Hybrid Model - Horizontal Market with OEM as single Contact Point

Figure 11 shows an alternative Hybrid Market model where the Original Equipment Manufacturer takes over responsibility as the single Contact Point for conformity and the corresponding Declaration(s) of Conformity and/or Statement(s) of Conformity.



NOTE: In this example the Original Equipment Manufacturer takes over the overall responsibility and liability for the conformity in the overall device reconfiguration process.

Figure 11: Alternative interactions in the model of a Hybrid Market with a single Contact Point

8 Declaration of Conformity in the context of Software Reconfiguration in Europe

The Radio Equipment Directive [i.3] provides a mechanism for simplified Declaration of Conformity in Annex VII:

ANNEX VII SIMPLIFIED EU DECLARATION OF CONFORMITY

The simplified EU Declaration of Conformity referred to in Article 10(9) shall be provided as follows: Hereby, [Name of manufacturer] declares that the radio equipment type [designation of type of radio equipment] is in compliance with Directive 2014/53/EU. The full text of the EU Declaration of Conformity is available at the following internet address: _____

The upper approach is considered to be applicable in the context of Reconfigurable Equipment.

9 Further Details on Use Cases

9.0 Introduction

In the sequel, further details are provided on the Reconfiguration generic Use Cases introduced in clause 6.

9.1 Overview

This clause outlines some detailed Use Cases for dynamically "reconfiguring" the equipment of reconfigurable radio systems (RRS) post initial deployment. The Use Cases here described provide further details beyond the description in clause 6, identify key functionalities in the network and equipment entities and illustrate the required interactions between those key entities.

The process for re-configuration has three major phases:

- 1) **initial** development and Declaration of Conformity;
- 2) **operational** reconfiguration;
- 3) **maintenance** query and enforcement of conformity.

9.2 Detailed Description of Use Cases

9.2.1 Use Case "OEM Establishing Initial Conformity of RE Platform"

9.2.1.1 General Use Case Description

The **initial development and Declaration of Conformity** phase establishes the basis for RE platforms which are maintaining its conformity when they are reconfigured in a post initial deployment. In this initial phase, the initial hardware and associated software are created by the OEM, tested, compliance to the applicable Standards is verified (Harmonised Standards for Europe) and a new Declaration of Conformity is issued. The determination of conformity can be achieved, for example, in collaboration with an appropriate testing entity. The development may include a variety of expected bands of operation, SP specific configurations, as well as user features and general RE conformity. The process for a dynamic reconfiguration of the equipment is very similar to the process of initial proof of conformity for equipment that is not reconfigurable. In case of Scenario 1 Declaration of Conformity, a new Declaration of Conformity is issued replacing the previous one. In case of Scenario 2 Declaration of Conformity (Declaration of Conformity may be issued for available hardware components in combination with software components to be developed in the future), a "Statement of conformity" (StoC) is provided after successful completion of testing that proves the conformity of the RE to the applicable legislation and standards.

9.2.1.2 Stakeholders

The general stakeholder descriptions are outlined in clause 5.1. The following ones are relevant:

- Reconfigurable Equipment (RE);

- Original Equipment Manufacturer (OEM).

9.2.1.3 Use Case Description

As illustrated in clause 9.2.1.4, the present Use Case comprises the following key steps:

- The Original Equipment Manufacturer (OEM) verifies the conformity of the newly developed Reconfigurable Equipment (RE) platform and issues a Declaration of Conformity.

9.2.1.4 Information Flow

Figure 12 shows the information flow for the Use Case outlined in clause 9.2.1.3.

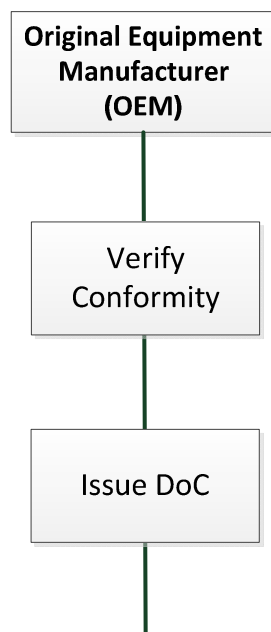


Figure 12: Information Flow for request and issuance of Reconfigurable Equipment (RE)DoC

9.2.1.5 Derived potential system requirements

Potential system requirements related to this use case are shown in table 1.

Table 1: Derived potential system requirements for OEM Establishing Initial Conformity of RE Platform

	Functions in the Reconfigurable Equipment	Functions in the Network
Reconfiguration Features	<ul style="list-style-type: none"> • None 	<ul style="list-style-type: none"> • None
Management of Conformity	<ul style="list-style-type: none"> • Original Equipment Manufacturer (OEM) verifies conformity of the RE and issues a DoC. 	<ul style="list-style-type: none"> • None

9.2.2 Use Case "DoC/StoC Verification of reconfigurable equipment"

9.2.2.1 General Use Case Description

The **maintenance** query and enforcement of conformity phase provides a suitable means for verifying the validity of the DoC and in case of Scenario 2 Declaration of Conformity, any available Statement(s) of Conformity, which demonstrate that the Reconfigurable Equipment (RE) is operating in conformity to the applicable legislation. Typically, the corresponding query may be triggered by an NRA or other relevant stakeholders.

In more details:

An NRA may query the Reconfigurable Equipment (RE) for its current Declaration of Conformity and for any available Statement(s) of Conformity in case of Scenario 2 Declaration of Conformity in order to verify that its current software configuration is in conformity to applicable legislation. While Software typically can only be installed after prior verification of its conformity and compatibility with the RE, a given configuration may not be in conformity to applicable legislation in all regions. The DoC/StoC Verification mechanisms are thus important for Reconfigurable Equipment (RE) that may be operating in various regions.

9.2.2.2 Stakeholders

The general stakeholder descriptions are outlined in clause 5.1. The following ones are relevant:

- Reconfigurable Equipment (RE);
- Original Equipment Manufacturer (OEM);
- National Regulatory Authority (NRA).

9.2.2.3 Use Case Description

As illustrated in clause 9.2.2.4, the present Use Case comprises the following (alternative) key steps:

The NRA queries a target Reconfigurable Equipment (RE) for the Declaration of Conformity and for any available Statement(s) of Conformity in case of Scenario 2 Declaration of Conformity. The Reconfigurable Equipment (RE) provides the corresponding information.

NOTE: These steps do not take place in sequence.

9.2.2.4 Information Flow

Figure 13 shows the information flow for the Use Case outlined in clause 9.2.2.3.

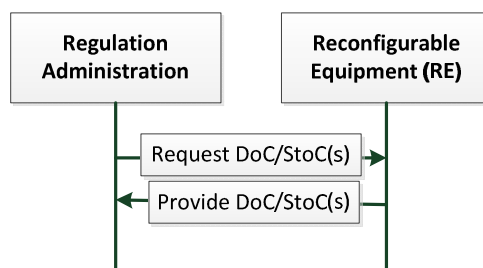


Figure 13: Information Flow for DoC/StoC Verification

9.2.2.5 Derived potential system requirements

Potential system requirements related to this use case are shown in table 2.

Table 2: Derived potential system requirements for Certificate Verification of reconfigurable equipment

	Functions in the Reconfigurable Equipment	Functions in the Network
Reconfiguration Features	<ul style="list-style-type: none"> • None 	<ul style="list-style-type: none"> • None
Management of Conformity	<ul style="list-style-type: none"> • Equipment (RE) stores (pointer to) Declaration of Conformity and any available Statement(s) of Conformity in case of Scenario 2 Declaration of Conformity. • Reconfigurable Equipment (RE) receives query for available DoC/StoC. • Reconfigurable Equipment (RE) provides requested information. 	<ul style="list-style-type: none"> • Transportation of query to concerned Reconfigurable Equipment (RE). • Transportation of corresponding DoC/StoC information to issuer of query.

9.2.3 Void

Table 3: Void

9.2.4 Use Case "OEM Upgrade (individual or en-masse)"

9.2.4.1 General Use Case Description

The reconfiguration components (e.g. software) may be developed by a team that includes the original equipment manufacturer. This Use Case may include, for example "bug fixing", SW Upgrades, new features and enablement of a new technology such as new radio access technologies or new bands of operation. In this case, the reconfiguration components come from the team that provided the initial RE and may be directed to all the Reconfigurable Equipment or to specific product lines or to individual items of equipment. Once the conformity of the reconfigured equipment is confirmed, a new or revised statement of conformity is issued. Figure 14 shows the case when multiple RE are loaded with new software by the OEM.

In more details:

- i) The OEM team develops new SW for the reconfigurable equipment.
- ii) The new SW is tested for conformity and for compatibility with the intended RE platforms and software configuration and a Declaration of Conformity is made in case of Scenario 1 Declaration of Conformity. In case of Scenario 2 Declaration of Conformity (Declaration of Conformity may be issued for available hardware components in combination with software components to be developed in the future), a Statement of Conformity is provided related to the existing DoC.
- iii) If the new reconfiguration is not compatible with the RE's current configuration, the new configuration is not loaded by the RE and the RE may continue using its current SW.
- iv) If the new reconfiguration is compatible with the RE's current configuration, the software components may be loaded by the RE for its use and the RE operates with the new SW.

Before providing the new reconfiguration software, , the combination of HW and SW is checked against the DoC in case of Scenario 1 Declaration of Conformity. In case of Scenario 2 Declaration of Conformity (Declaration of Conformity may be issued for available hardware components in combination with software components to be developed in the future), the combination of HW & SW is checked against the DoC in combination with available Statement(s) of Conformity . The new software is not loaded if the check against the DoC fails (in which case the RE continues its operation with its previous version).

This Use Case is applicable even if the software distribution is not necessarily intended for all RE. The new distribution may be to individual RE, or it may be distributed en-masse to multiple RE.

9.2.4.2 Stakeholders

The general stakeholder descriptions are outlined in clause 5.1. The following ones are relevant:

- Reconfigurable Equipment (RE);
- Original Equipment Manufacturer (OEM);
- 'Reconfiguration' Market Platform (RMP).

9.2.4.3 Use Case Description

As illustrated in clause 9.2.4.4, the present Use Case comprises the following key steps:

- The Original Equipment Manufacturer (OEM) develops software or software components for a target Reconfigurable Equipment (RE).

- Reconfiguration software or software components are tested and verified for compatibility and conformity/compliance to the applicable legislation and standards for operation on the stated Reconfigurable Equipment (RE) by the Original Equipment Manufacturer (OEM). Upon a successful testing, a Declaration of Conformity (DoC) is made in case of Scenario 1 Declaration of Conformity. In case of Scenario 2 Declaration of Conformity (Declaration of Conformity may be issued for available hardware components in combination with software components to be developed in the future), a Statement of Conformity is provided related to the existing DoC.
- The software product can be distributed via a 'Reconfiguration' Market Platform (RMP) or by the Original Equipment Manufacturer (OEM) or other suitable channel in case that a corresponding DoC is available for the combination of HW & SW.

9.2.4.4 Information Flow

Figure 14 shows the information flow for the Use Case outlined in clause 9.2.4.3.

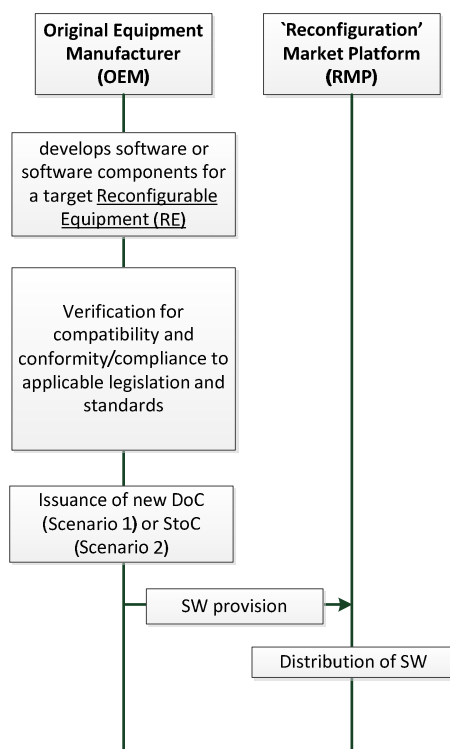


Figure 14: OEM Upgrade (individual or en-masse)

9.2.4.5 Derived potential system requirements

Potential system requirements related to this use case are shown in table 4.

Table 4: Derived potential system requirements for OEM Upgrade (individual or en-masse)

	Functions in the Reconfigurable Equipment	Functions in the Network
Reconfiguration Features	<ul style="list-style-type: none"> • Loading and installation of authorized reconfiguration software. 	<ul style="list-style-type: none"> • Transportation of new reconfiguration software.
Management of Conformity	<ul style="list-style-type: none"> • Upon a successful testing, a Declaration of Conformity (DoC) is issued for the combination of HW & SW in case of Scenario 1 Declaration of Conformity; a Statement of Conformity in case of Scenario 2 is issued related to the existing Declaration of Conformity. 	

9.2.5 Use Case "Third Party reconfiguration (individual or en-masse)"

9.2.5.1 General Use Case Description

Sometimes the reconfiguration components (e.g. software upgrade) may be provided by a team that is not associated with the Original Equipment Manufacturer. In all cases, as also in this case, the compatibility of the RE with the combination of all installed reconfiguration SW components needs to be established.

The reconfiguration SW components may be directed to all the Reconfigurable Equipment, a subset or to individual RE. In this case, once the reconfiguration components are proved to be in conformity/compliant with the applicable legislation, a new Declaration of Conformity (DoC) is made in case of Scenario 1 Declaration of Conformity. In case of Scenario 2 Declaration of Conformity (Declaration of Conformity may be issued for available hardware components in combination with software components to be developed in the future), a Statement of Conformity is provided related to the existing DoC.

If the reconfigurations are compatible with the current configuration of the RE and a valid DoC is available, they may be loaded into the RE.

Figure 15 shows the Use Case with an individual RE "third party" reconfiguration. In more detail:

- i) The third party team develops new SW for the reconfigurable equipment.
- ii) The new SW is tested for conformity and for compatibility with the intended RE platforms and software configuration and a Declaration of Conformity is made in case of Scenario 1 Declaration of Conformity. In case of Scenario 2 Declaration of Conformity (Declaration of Conformity may be issued for available hardware components in combination with software components to be developed in the future), a Statement of Conformity is provided related to the existing DoC.
- iii) If the new reconfiguration is not compatible with the RE's current configuration, the new configuration is not loaded by the RE and the RE may continue using its current SW.
- iv) If the new reconfiguration is compatible with the RE's current configuration, the software components may be loaded by the RE for its use and the RE operates with the new SW.

9.2.5.2 Stakeholders

The general stakeholder descriptions are outlined in clause 5.1. The following ones are relevant:

- Reconfigurable Equipment (RE);
- 'Reconfiguration' Market Platform (RMP).

9.2.5.3 Use Case Description

As illustrated in clause 9.2.5.4, the present Use Case comprises the following key steps:

- A Reconfigurable Equipment (RE) requests SW components from an RMP.
- The RMP verifies if the new reconfiguration is compatible with the Reconfigurable Equipment (RE) current configuration. In particular the availability of a Declaration of Conformity (DoC) is verified in case of Scenario 1 Declaration of Conformity. In case of Scenario 2 Declaration of Conformity (Declaration of Conformity may be issued for available hardware components in combination with software components to be developed in the future), the availability of a Statement of Conformity is verified in combination with a DoC. If this is the case, the RMP distributes the requested SW component to the RE.

9.2.5.4 Information Flow

Figure 15 shows the information flow for the Use Case outlined in clause 9.2.5.3.

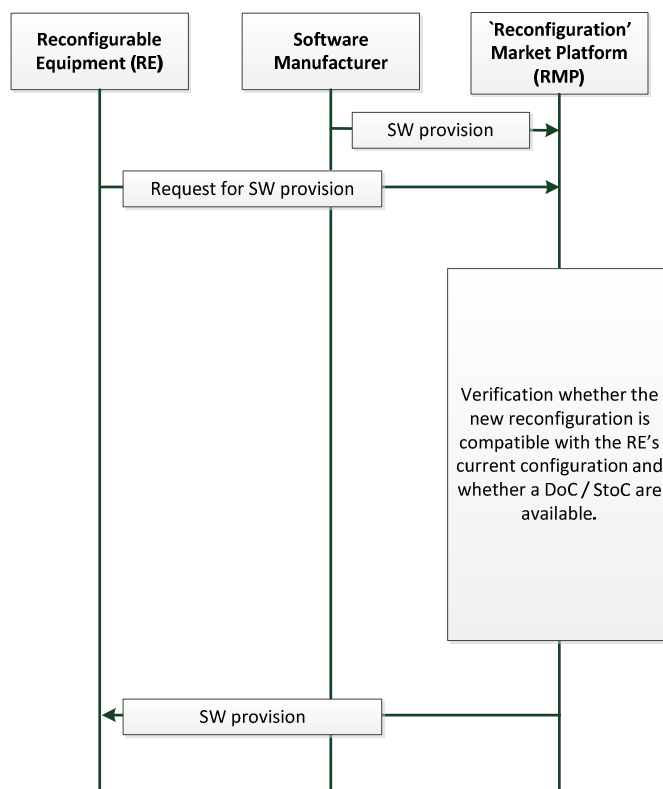


Figure 15: Third Party reconfiguration (individual or en-masse)

9.2.5.5 Derived potential system requirements

Potential system requirements related to this use case are shown in table 5.

Table 5: Derived potential system requirements for Third Party reconfiguration (individual or en-masse)

	Functions in the Reconfigurable Equipment	Functions in the Network
Reconfiguration Features	<ul style="list-style-type: none"> Loading and installation of reconfiguration software. 	<ul style="list-style-type: none"> Transportation of new reconfiguration software.
Management of Conformity	<ul style="list-style-type: none"> None 	

9.2.6 Use Case "Configuration enforcement of reconfigurable equipment"

9.2.6.1 General Use Case Description

Configuration enforcement of reconfigurable equipment, for example to halt improper operations, is illustrated in Figure 16. In this case:

- i) The NRA (or another appropriate body) becomes aware of improper operation of reconfigurable equipment. The NRA may be informed of improper operation by, for example, the SP, the Software Manufacturer, the OEM, other RE users or other system users.
- ii) The NRA (or another appropriate body) requests through appropriate channels the RE to cease its operations.
- iii) The RE receives the instructions to cease the current operating mode.
- iv) The RE ceases its improper functions. This may be, for example, through complete switch-off or by the RE's reversion to a known good operating mode such as a previous software version.

9.2.6.2 Stakeholders

The general stakeholder descriptions are outlined in clause 5.1. The following ones are relevant:

- Reconfigurable Equipment (RE);
- Original Equipment Manufacturer (OEM);
- Service Provider (SP);
- RE User;
- National Regulatory Authority (NRA).

9.2.6.3 Use Case Description

As illustrated in clause 9.2.6.4, the present Use Case comprises the following key steps:

- The NRA (or another appropriate body) becomes aware of improper operation of Reconfigurable Equipment (RE). The corresponding information is typically provided by a Service Provider (SP), the reconfiguration Software Manufacturer, the Original Equipment Manufacturer (OEM), the Reconfigurable Equipment user etc.
- The NRA (or another appropriate body) requests through appropriate channels the Reconfigurable Equipment (RE) to cease its operations.
- The Reconfigurable Equipment (RE) ceases its improper functions.

9.2.6.4 Information Flow

Figure 16 shows the information flow for the Use Case outlined in clause 9.2.6.3.

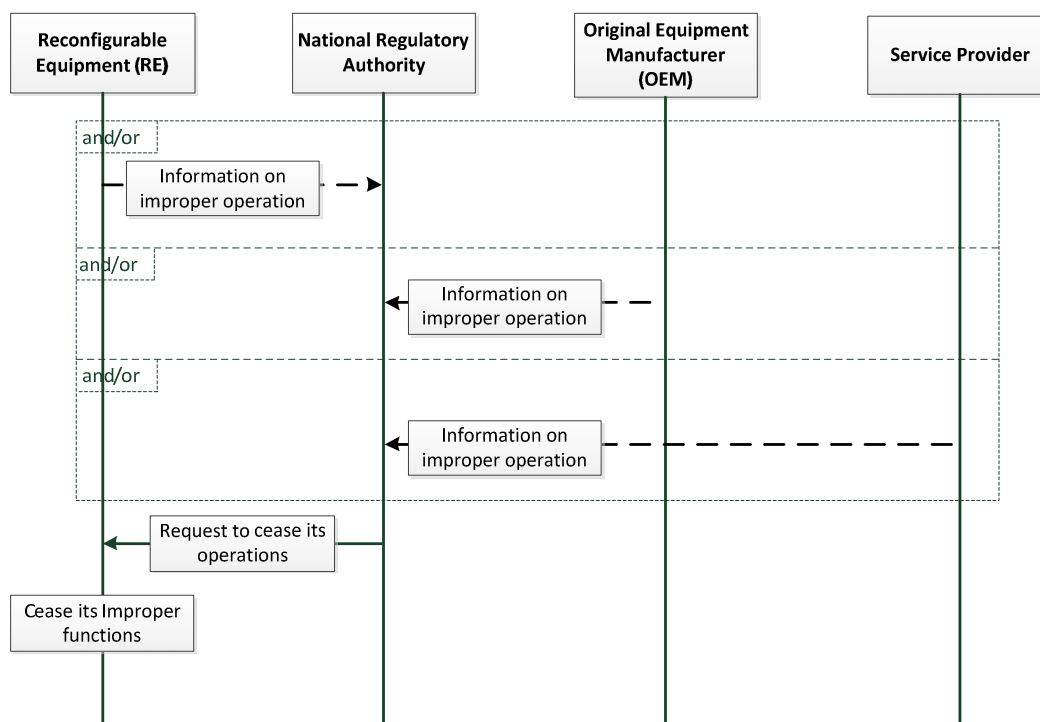


Figure 16: Configuration enforcement of reconfigurable equipment

9.2.6.5 Derived potential system requirements

Potential system requirements related to this use case are shown in table 6.

Table 6: Derived potential system requirements for Configuration enforcement of reconfigurable equipment

	Functions in the Reconfigurable Equipment	Functions in the Network
Reconfiguration Features	<ul style="list-style-type: none"> Cease improper functions. 	<ul style="list-style-type: none"> None
Management of Conformity	<ul style="list-style-type: none"> None 	<ul style="list-style-type: none"> Transportation of information / requests related to improper RE functions

10 Technical Challenges

As noted earlier in clause 6, in order to assure that the RE is in a suitable configuration for the new software to function correctly, the combination of hardware and software components needs to be authorized by a Declaration of Conformity (DoC) in case of Scenario 1 Declaration of Conformity. In case of Scenario 2 Declaration of Conformity (Declaration of Conformity may be issued for available hardware components in combination with software components to be developed in the future), a Statement of Conformity is required related to the existing DoC. This should assure that the RE contains suitable base hardware and firmware to support the new applications of the new software product. The key challenge derived from the upper sections relates to the proof of conformity to the DoC where the equipment which the DoC refers to is mutable. This may require cryptographic proofs to be available in the RE and across the networks in which the RE operates. This may also include cryptographic identification of the NRA and other stakeholders.

11 Conclusion

The present document has identified five Reconfiguration Use Cases which are the basis processes for the dynamic reconfiguration of Reconfigurable Equipment post initial deployment including features developed by the OEM or by 3rd party Software (components) manufacturers affecting radio characteristics.

- 1) OEM Establishing Initial Conformity of reconfigurable equipment (RE);
- 2) DoC/StoC Verification of reconfigurable equipment;
- 3) OEM Upgrade (individual or en-masse);
- 4) Third Party reconfiguration (individual or en-masse);
- 5) Configuration enforcement of reconfigurable equipment.

The proposed Ecosystem enables Equipment to be reconfigured en-mass or individually, so that the RE continues to conform to the applicable legislation. RE users are enabled to acquire Software Components on an individual basis using a mechanism for maintaining continuing conformity for the Reconfigurable Equipment on a per-user basis.

History

Document history		
V1.1.1	March 2014	Publication
V1.2.1	November 2015	Publication