INTERNATIONAL TELECOMMUNICATION UNION

SDRF-03-A-0003-V0.00

RADIOCOMMUNICATION STUDY GROUPS

Delayed contribution
Document 8F/863-E
18 March 2003
English only

Received: 16 March 2003

TECHNOLOGY AH WORKPLAN

Software Defined Radio Forum

INFORMATON AND PROPOSED ACTIONS RELATIVE TO ITU-R DOCUMENT ON SOFTWARE DEFINED RADIO

1 Introduction

This contribution provides information relevant to Question ITU-R 230/8, "Software Defined Radio." It is proposed that the contribution be remanded to the Technology Working Group because it is related to information already in the Preliminary Draft Report on Technology Trends which is now assigned to the Technology Working Group of Working Party 8F.

1.1 Background

Attachment 10.3 of the meeting report of the Ninth Meeting of Working Party 8F (Doc. 8F/827) lists input documents that are carried forward to the next meeting. One of the documents carried forward is Document 8F/747, "Correspondence from the SDR Forum" submitted by the IMT-2000 Project Manager on behalf of the Software Defined Radio Forum. Among other things, this Contribution 8F/747 proposed:

1) that WP 8F develop a document M.[IMT-SDR] on software defined radio;
2) that the new document be in the form of an ITU-R Recommendation rather than an ITU-R Report; and
3) that only a very brief summary of the SDR technology be retained in the Technology Trends Report, whilst the details on SDR be inserted in the new ITU-R Recommendation on Software Defined Radio.

During the 9th WP 8F Meeting, Document 8F/747 was remanded to the Vision Working Group. The proposals contained within Doc. 8F/747, including the three listed above, were debated within one Vision Working Group Plenary Session. There was generally strong support for the notion of creating a separate document; however there was one Administration that had some concern that the creation of a separate document on SDR was not justified because it would add to the already busy Workplan of WP 8F. The Vision Working Group Chair therefore proposed that the decision on the creation of a separate document be taken during the 10th WP 8F Meeting and that Document 8F/747 be carried forward to that meeting. Vision WG delegates agreed to this proposal from the Vision WG Chairman.

Subsequent to the 9th WP 8F meeting, the Software Defined Radio Forum has become an associate member of the ITU and wishes to provide additional information regarding software defined radio technology and the need for a separate ITU document on this rapidly evolving technology. The SDR Forum also wishes to provide additional text that is proposed to be included in a new ITU-R Recommendation on software defined radio.

1.2 Purposes of this Contribution

The purposes of this contribution are to:

- Provide additional rationale relative to the need for a separate document on SDR (separated from the draft Technology Trends Report)
- Provide additional text for proposed PDNR Software Defined Radio and Related Technologies including text for the following sections:
  - "Introduction" Section
  - "Scope" Section
  - "Considerings" Section,
  - "Recommends" Section
  - Annex Section which contains detailed information on software defined radio
- Suggest a minor revision to the Working Party 8F Workplan

2 Discussion

The Software Defined Radio Forum is an international, non-profit organization dedicated to promoting the development, deployment and use of SDR technologies for advanced wireless systems. More than 100 organizations throughout the world are members of the SDR Forum. These member entities encompass decision makers, planners, policy makers, technologists, suppliers/manufacturers, educators and program/product managers from a broad range of organizations. Therefore, the SDR Forum is able to bring into the ITU-R Study Group 8 views on software defined radio that are representative of all three Regions of the ITU and from the different perspectives of its diverse membership. This includes the following aspects of SDR:

1. Technical
2. Regulatory
3. Market drivers

The SDR Forum because of its global and diverse membership is able to develop reports and requirements in each of the above areas that are unbiased in regard to any specific commercial wireless technology or associated with the objectives of any single company, i.e., it is an SDR industry-wide perspective.

2.1 SDR Forum and ITU-R Global Perspectives of Software Defined Radio and its Impact on Regulatory and Spectrum Issues

The SDR Forum and the ITU-R have complementary, synergistic views of software defined radio and related spectrum issues and regulatory issues. The SDR Forum for example:

1. Conducts annual international technical workshops on software defined radio and reconfigurable systems.

2. Develops technical reports and requirements for software defined radio including, for example, software download, security, and device reconfiguration.
3. Interacts with regulatory agencies around the world including
   a. Ministry of Public Management, Home Affairs, Posts, and Telecommunications (MPHPT) in Japan; this includes joint workshops between the SDR Forum and MPHPT such as the one scheduled for 14 April 2003.
   b. Telecommunications Conformity Assessment and Market Surveillance Committee (TCAM) in Europe; this includes submissions from the SDR Forum in response to TCAM initiatives.
   c. Federal Communications Commission (FCC) in the United States; this includes many submissions from the SDR Forum which has helped the FCC develop its first Report and Order on Software Defined Radio.
4. Develops marketing reports and publications on software defined radio for wireless mobile communications

The SDR Forum, as a result of the technical, regulatory, and marketing activities illustrated above, recognizes the need for globally coordinated actions that will maximize software defined radio potential for the enhancement of spectrum efficiencies in mobile wireless systems and networks included in IMT-2000 and Systems Beyond IMT-2000.

The ITU-R Study Group 8 with its assigned Question on software defined radio is the only international body that has the mission, expertise, and internationally-recognized authority to bring this global spectrum vision related to SDR to the wireless community. <u>This globally coordinated spectrum vision enabled by SDR technology dictates the need for a separate document on SDR with specific recommendations regarding the use of this technology.</u> Additional rationale for a separate document on SDR is provided in Section 2.2.

2.2 Rationale for the Creation of a Separate Document on Software Defined Radio

This section provides rationale for the creation of a separate document on software defined radio from the perspective of the SDR Forum that has a global view of both the technical and regulatory aspects of SDR applicable to IMT-2000 systems and beyond.

2.2.1 A separate document is needed to be responsive to Question on SDR.

Question ITU-R 230/8, "Software-Defined Radio" has been jointly assigned to ITU-R Working Party 8F and Working Party 8A. The "decides' part of the Question states:

> *"The ITU Radiocommunication Assembly*
>
> *further decides*
>
> *1 that the results of the above studies should be included in one or more Recommendations and in a handbook;*
>
> *2 that the above studies should be completed by the year 2003."*

It is clear that the wishes of the Radiocommunication Assembly are for ITU-R Study Group 8 to develop a separate Recommendation and a handbook on software defined radio. This assigned question will not be adequately addressed by having only a short section in the Technologies Trends report.

It is noted that ITU-R WP 8A is planning on developing one or more Recommendations related to software defined radio. This is described in the WP 8A liaison to WP 8F in Document 8F/811 which was input to the 9th Meeting of WP 8F.

The SDR Forum work in the industry supports deliverables in both WP 8F and WP 8A. A coordinated view of content, scope, and type of deliverable between WP 8F and WP 8A is desirable to ensure consistency in Study Group 8 texts related to jointly assigned Questions and for proper utilizations of resources to avoid duplicated work.

Because the focus of the WP 8A effort will be on SDR applications to mobile systems other than IMT-2000 and Systems Beyond IMT-2000 this does not satisfy, in and by itself, the requirement for a full examination of SDR issues. In particular, there are complex issues associated with the application of SDR to IMT-2000 and to Systems Beyond IMT-2000. Some of these aspects of SDR have already been described in the text that is currently in the WP 8F Preliminary Draft Report on Technology Trends but the brevity borders on causing this material have a diminished value. Furthermore, there is a need to reduce the amount of text in that document thereby making it difficult to provide a full and necessary treatment of this complex subject.

2.2.2 Software defined radio is a tool for spectrum efficiencies and spectrum sharing

There is a need for specific recommendations in regard to SDR because of the technology's potential for spectrum enhancement. Software defined radios with flexible RF front ends provide multimode, multiband capabilities. This provides the possibility of sharing spectrum between different operators on a flexible, real-time basis. This requires mechanisms for jointly managing the radio resource and the spectrum resource.

Spectrum can be shared between service providers based on real-time needs of the service providers in a given geographical area.

All of above is predicated on the establishment of an evolutionary regulatory environment. Regulatory issues must be resolved before reconfigurable radio is brought into the marketplace.

Addressing these complex spectrum topics requires a separate ITU-R Recommendation and not just in a short technology summary.

2.2.3 Separate document should be an ITU-R Recommendation and not an ITU-R Report

The "*considerings*" section of Question ITU-R 230/8 states inter alia that:

- *that SDRs may facilitate spectrum efficiencies in complex mobile radio configurations;*
- *that SDRs may facilitate the regional and global harmonization of wireless communications;*

These are specific topics that can be treated only in an ITU-R Recommendation and not in an ITU-R Report. Whilst the software defined radio technology can be described in ITU-R Reports or ITU-R Handbooks, the following topics needed to be treated in a separate ITU-R Recommendation on software defined radio:

1. Spectrum efficiencies afforded by SDR,
2. Spectrum Sharing,
3. Global circulation, and
4. System harmonization.

The above topics require specific “recommends” from the ITU-R. Therefore, a separate Recommendation on SDR should be created.

2.2.4 Consistent with Decision for a Separate ITU-R Document on Adaptive Antennas

The development of a separate document on SDR is consistent with the decision that has already been taken by the ITU-R to develop a separate document on adaptive antennas in response to Question ITU-R 224/8. Ad Hoc Workplan should consider that this separation of the work on SDR is not new work; it essentially is a new and focused partitioning of work that is already ongoing.

2.2.5 Summary

In summary, the Software Defined Radio Forum believes that it would be beneficial to the members of the ITU and to the evolving wireless and software defined radio industries associated with IMT-2000 and beyond, if a document on software defined is developed by ITU-R WP 8F that is separate from the Technology Trends Report. The advantages of this are:

- Software defined radio is a complex topic involving many aspects including radio aspects, network aspects, and spectrum efficiency considerations; a separate report is needed to describe these complexities.
- Proper treatment of software defined radio requires more pages than currently allocated in the Technology Trends Report.
- A separate document on software defined radio is most directly responsive to Question ITU-R 230/8.
- The document on software defined radio will be of interest to regulators, wireless operators and service providers, manufacturers of radio systems, software developers, and component vendors.
- The document in no way would mandate how SDR should be implemented in the SDR-capable device. Therefore, implementation aspects remain the purview of the manufacturers.

2.3 Impact on WP 8F workplan

Document 8F/747 carried over from the next meeting provides the complete structure of a new PDNR on software defined radio. It incorporates detailed text from the Annex on SDR in the ITU-R Preliminary Draft Report on Technology Trends. Attachment 1 to this present contribution provides additional text for that proposed PDNR. Thus, there is a nearly complete PDNR with which to begin the proposed work of creating a new PDNR on software defined radio. Therefore, this proposal will have only minimal impact on the WP 8F Workplan. It should be viewed as a division of labor and not as new work. In other words, it is a partitioning of work and not a new work item.

The creation of a separate document does NOT set a precedent for the creation of separate documents on each and every technology. The Radiocommunication Assembly emphasized the importance of software defined radio by the creation of a separate Question on this topic. The RA did not create Questions on other technologies other than adaptive antennas and internet protocol applications over mobile systems. The existence of a Question approved by the RA should be used as a primary criterion for the development of a separate technology-specific document. Using this criterion will minimize the impact on the current WP 8F Workplan.

3 Proposed WP 8F Actions

The following actions are proposed:

a) Create a separate ITU-R document on SDR for IMT-2000 systems and beyond; the SDR Forum proposes that this separate document should be a Recommendation not a Report for the reasons provided in Section 2.

b) Set up a drafting group to work on this document during the 10th WP 8F Meeting.

c) The drafting group should insert text from Attachment 1 of this contribution into Doc. 8F/747 (Note that the insertion of this text will create a complete first draft of a new PDNR; in order to save reproduction costs only the new text is provided in Attachment 1 not the complete document that will result from this insertion).

d) The Drafting Group should do substantial editing of text brought forward from the existing Technology Trends document and refine the outline as necessary. The resulting outline and text should make it clear that this document on SDR in no way is an impediment to the flexibility that manufacturers require in their choices regarding the implementation of software defined radio technology.

e) Create a Correspondence Group to work on the PDNR on SDR between the 10th and 11th WP 8F Meetings.

f) Modify the WP 8F plan to indicate that a separate document on SDR will be completed (i.e., a stable document) by the end of the 11th WP 8F meeting (noting that this is not new work, but merely a division of existing work); this document should be stable at the end of the 11th WP 8F in October.

It is proposed that the existence of a Question be a primary criterion for determination as to whether or not an ITU-R Report or Recommendation is needed which is separate from the Preliminary Draft New Report on Technology Trends.

Attachment 1

Modifications of Existing Text in Document 8F/747 on SDR

It is recommended that the following text be inserted into Attachment 1 to Document 8F/747 ("Correspondence from the SDR Forum" which was carried over from the 9th Working Party 8F Meeting (Geneva, Switzerland; 25 September to 2 October 2002).

Text to be Inserted into Introduction Section of Attachment 1 of Document 8F/747:

1 Introduction

Software defined radio (SDR) technology is a technology that provides an efficient and comparatively inexpensive solution to the problem of building multimode, multiband, multifunctional wireless devices that can be adapted, updated, or enhanced by using software upgrades. As such, SDR can be considered an enabling technology that is applicable across a wide range of areas within the wireless industry.

Radios built using SDR technology can allow:

- Improvements in spectrum efficiency
- Spectrum sharing
- Enhanced wireless roaming for consumers by extending the capabilities of current and emerging commercial air-interface standards.
- Over-the-air downloads of new features and services as well as software patches.
- Advanced networking capabilities to allow truly portable networks.
- Standard, open and mobile architectures for a wide range of communications products.

The Radiocommunication Sector has recognized the importance of software defined radio by creating a separate Question on this topic and assigning the question to both ITU-R Working Party 8F and ITU-R Working Party 8A.

Text to be Inserted into Scope Section of Attachment 1 of Document 8F/747:

2 Scope

This Recommendation addresses primarily software defined radio application to IMT-2000 systems and Systems Beyond IMT-2000. It includes network implications of software defined radio on these systems. The implication of software defined radio technology on other types of mobile systems is a mater for consideration by other Study Groups and Working Parties.

This Recommendation includes technical aspects of spectrum implications of software defined radio including spectrum efficiencies and spectrum sharing.

Modify the Text Currently in the Considerings Section of Document 8F/747/Attachment 1 as follows:

4 *Considerings*

The ITU-R

considering

a) the information on software defined radio provided in Annex 1;

b) the need for global coordination of software defined radio technology to facilitate global circulation of terminals;

c) the need for global cooperation in the development of technologies that facilitate interoperability between commercial wireless systems and between commercial wireless systems and mobile systems used for emergency communications; and

d) that software defined radio technology is a technology that should be considered as one of the technologies that possibly could reduce the amount of spectrum needed for systems beyond IMT-2000;

noting

a) the software defined radio has network implications as noted in Annex 1;

b) that because of the increasing number of frequency bands and modes in commercial wireless systems, software implementation is becoming increasingly important thereby increasing the complexity of the wireless devices;

c) that software download to SDR-capable devices is of increasing importance to manufacturers and operators for software "bug fixes" and for implementation of new capabilities and services into both base stations and terminals;

d) that software defined radio is the subject of a vast amount of research;

e) that SDR-capable devices are starting to reach the commercial wireless marketplace;

f) that spectrum resource sharing is a subject of research, and

g) that regulatory agencies throughout the world are beginning to address regulatory issues related to software defined radio;

h) that regulatory agencies are expecting that technical solutions are now or soon will be available to address security issues related to software download to SDR-capable devices and that these technical solutions will be implemented in appropriate standards;

i) that detailed technical specifications for software download to wireless devices are being developed by other standards fora and that the ITU has cooperative agreements with many of these fora and is seeking to enhance these synergistic working relationships ;

and further noting

a) that software defined radio is a technology that could help facilitate efficient use of the spectrum; and

b) the difficulty in finding globally aligned spectrum for commercial wireless systems;

c) SDR technologies will progressively assist with the implementation and availability of IMT-2000 services;

d) that the ITU-R has identified the following spectrum related issues as part of the development of the development of Recommendation [M. xxx], Vision Framework and Overall Objectives of the Future Development of IMT-2000 and Systems Beyond IMT-2000:

(1) What technology developments in the radio access network might reduce the need for additional spectrum for systems beyond IMT-2000?

(2) What technology advances might reduce the need for globally aligned spectrum, while still allowing global roaming?

(3) How should spectrum efficiency be defined and evaluated for systems beyond IMT-2000?

(4) To what extent can techniques for "sharing" or "pooling" of spectrum between operators or for sharing with other radio services affect the amount of spectrum needed?

e) that the software defined radio is a technology enabler that can be applied to addressing the issues in (d) above;

Modify the Text Currently in the Recommends Section of Document 8F/747/Attachment 1 as follows:

5 Recommends

a) that Administrations carefully consider the potential benefits of software defined radio for efficient use of the spectrum;

b) that Administrations encourage technical innovation in the development and deployment of software defined radio technology by minimising regulatory actions that might hamper the development and deployment of SDR-capable devices

c)

d)

[Editor's note: Contributions are needed regarding recommendations on the implications of SDR-capable devices on:

- *Application of SDR technology as an enabler for flexible spectrum utilization and spectrum sharing*
- *Spectral efficiency*
- *Interference management*
- *Network management*
- *Interoperability*
- *Security*
- *Need for additional research*

These recommendations necessarily involve the network and not just the radio. The proposed recommendation will address all aspects of SDR-based IMT-2000 systems and beyond, not just the radio itself.]

Text to be Inserted into Attachment 1, Annex 1, Chapter 1 (General) of Document 8F/747

[Editor's note: The following text should be inserted after the first paragraph in the "General" Chapter of Annex 1 of Doc. 8F/747.]

- Technical Definition of Software Defined Radio

  Software defined radio is a collection of hardware and software technologies that enable reconfigurable system architectures for wireless networks and user terminals.

  Software defined radios are elements of a wireless network whose operational modes and parameters can be changed or augmented, post-manufacturing, via software.

- Regulatory Definition of Software Defined Radio

  By contrast a regulatory definition of SDR that is more focused is: A radio that includes a transmitter in which the operating parameters of frequency range, modulation type or maximum output power (either radiated or conducted) can be altered by making a change in software without making any changes to hardware components that affect the radio frequency emissions.

- Device reconfiguration

  Device reconfiguration is the change of software (programs, parameters, or the software aspects of the processing environment)) or hardware (i.e., the reconfiguration of the hardware aspects of the processing environment). Reconfiguration can in general concern arbitrary parts of communication equipment such as protocol stacks, plug-ins to support different types of content (as voice and video codecs), and applications and the hardware configuration.

Text to be inserted into Attachment 1, Annex 1, new chapter (Benefits of Software Defined Radio) of Document 8F/747

Many parties potentially benefit from reconfigurable systems enabled by software defined radio. Moreover, different parties will have different requirements for SDR-enabled systems. Some examples of potential beneficiaries are:

- Manufacturers
- Network Operators
- Service Providers
- Third party software developers
- Subscribers and users
- Regulators

Manufacturers benefit from the ability to use a common design for multi-functional radios, thereby obtaining a cost benefit from a size-of-market point of view. The commercial wireless, military and civil sectors benefit from this cost reduction due to market size. They also benefit from enhanced interoperability, ease of system upgrades, and ease of "bug" fixes. Subscribers and users benefit from enhanced functionality of their SDR-capable devices. A new market is created by SDR for third party software developers. Finally, regulators benefit from the potential for spectrum efficiency afforded by SDR devices.

Specific benefits of software defined radio include but are not limited to:

1. Terminal flexibility which permits:
   a. Ability to add new services.
   b. Ability to add new capabilities to the device.

c. Ability to update both applications and non-applications software.

d. Ability to add broader communications capabilities to a single device and ease the development of terminals having international roaming capabilities.

e. Ability to make "bug fixes" of software over-the-air

f. Ease of terminal design

g. Economies of scale

h. Improved interoperability

2. Flexible base stations

3. Potential for spectral efficiencies

Regardless of the bands chosen, SDR technologies will progressively assist with the implementation and availability of IMT-2000 services. Most directly, SDR will make it easier for radio equipment to accommodate the various IMT-2000 standards that have been adopted worldwide. SDR technology will also influence future spectrum-allocation demands and decisions in a variety of ways. For example, the early introduction of innovative, SDR-based services and networks may increase the demand for spectrum. Yet other spectrum demands may be eased by SDR's ability to instantaneously reconfigure systems to more efficient standards or to permit greater sharing of lightly used bands.

Technologies such as software-defined radios are sometimes called "smart" or "opportunistic" technologies because in the future they may search the radio spectrum, sense the environment, and operate in spectrum not in use by others. By operating in so-called white – or unused –spaces in the spectrum, software-defined radios could enable better and more intensive use of the radio spectrum. Smart technologies, such as software-defined radios, potentially allow operators to take advantage of the time dimension of the radio spectrum. That is, because their operations are so agile and can be changed nearly instantaneously, they can operate for short periods of time in unused spectrum. However, this capability is a future capability that has implications on the network as well as the radio. Achieving this potential benefit for software defined radio requires advances in spectrum management, network control, as well as the software defined radio itself. It also requires changes in the way that regulators have assigned spectrum. Historically, due in large part to technological limitations in radio performance, regulators have assigned spectrum according to particular operational frequencies and geographic areas of operations. In the future, as network control and spectrum management capabilities associated with SDR are developed, this spectrum assigned model may need to be reexamined. Because of the global nature of commercial wireless devices, the ITU-R should take the lead in examining the historical spectrum assignment model.

Text to be Inserted into Attachment 1, Annex 1, New Chapter on Software Download for Radio Reconfiguration of Document 8F/747

1.1 Definition of Radio Software Download

Radio software download may be defined as:

> *Radio software download:* The process of delivering reconfiguration data and/or new executable code to a SDR device to modify its operation or performance.

Thus, the term "radio software download" as used here is not to be confused with the downloading of any software over the air. In addition, the above definition makes a distinction between radio software download and non-radio software download (e.g., a wide variety of subscription or free news and information, proprietary corporate data, email and multimedia material such as MP3 files[1]).

Examples of reconfiguration data are new parameters for modulation techniques already existing in the radio, new power levels, new operational frequencies or other operational parameters that are used by program code already installed in the SDR device.

Examples of executable code considered to be radio software are programs to be installed in SDR-enabled terminals or base stations that enable new digital signal processing algorithms, "bug" fixes and operational updates or a new radio air interface.

Regulators should be concerned with reconfiguration data and executable code that affect the RF operating characteristics of the device rather than user applications. Service providers, network operators, and manufacturers are interested in all aspects of both radio software download and non-radio software download.

It is important to note that there are standards organizations and private organizations which are interested in both radio software download and non-radio software download, and are developing specifications and standards for end-to-end download protocols that may support one and/or the other.

These end-to-end download protocols include capabilities such as authentication, delivery verification, transaction logging, billing, etc. These same capabilities are of interest to those organizations focused on radio software download of reconfiguration data and executable code that affects key RF parameters within the radios. These protocols and capabilities should also be of interest to regulatory agencies.

1.2 Additional Definitions Relevant to Radio Software Download

Radio Hardware: The basic hardware within a wireless device that performs the radio interface functions and includes the radio RF as well as baseband signal processing.

Radio Software: The primary software within a wireless device that is coupled with the radio hardware to derive the overall "radio" functionality. Ancillary software (such as control) that may be needed as a consequence of the primary software is an inherent part of this definition.

Radio software is not to be confused with user applications and content (such as download of credit card billing information, stock market status, MP3 software, etc.).

2 Scope of Radio Software Download for Software Defined Radio

A SDR device potentially offers ultimate reconfigurability, via radio software download, of part or all of its radio functions. The term "SDR device" is the terminology used herein to mean both terminals and base stations for commercial wireless, military and civil government applications. However, the overall scope of software download extends beyond the terminals and base stations. SDR impacts many layers of a commercial wireless network, as illustrated in Figure 1. Benefits from SDR will be realized from the physical layer to the user applications plane.

---

1 There are authentication and authorization mechanisms that have already been developed for non-radio or content information software download that may have applicability to radio software download as well.

Regulators should be concerned with reconfiguration data and executable code that affect the RF operating characteristics of the device rather than user applications. Service providers, network operators, and manufacturers are interested in all aspects of both radio software download and non-radio software download.

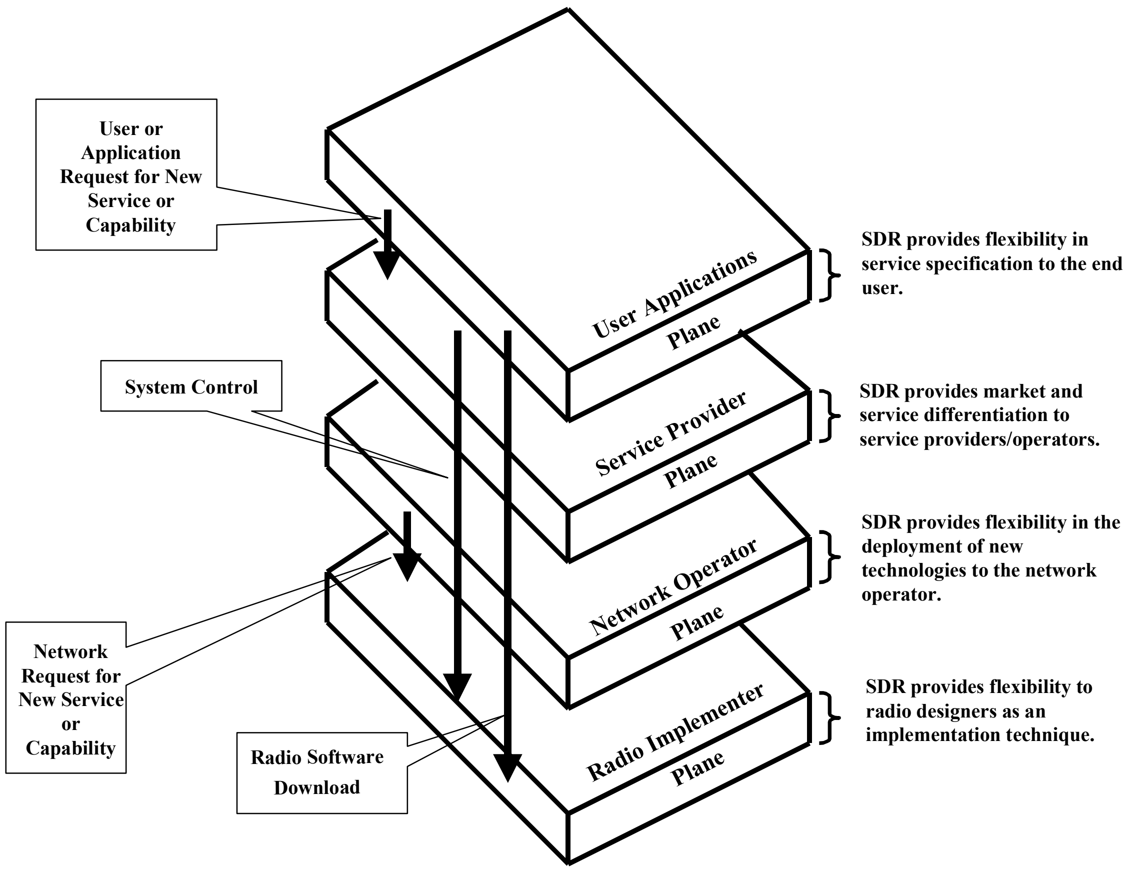

FIGURE 1

Multi-Dimensional Aspects of Software Defined Radio

3 Radio Software Download Categorization

There are a number of ways to categorize the software that can be downloaded into an SDR-capable device. The distinctions that are important for the context of this series of SDR Forum documents on software download are[2]:

- Radio software vs. non-radio software
- Primary radio software vs. supplemental or ancillary software
- Executable code vs. data

[2] Undoubtedly there may be other characterizations. However, as noted above, these are the categories that are important in the context of this series of SDR Forum documents on software download.

Figure 2 provides a view of how the download of software can be characterized using these categories.

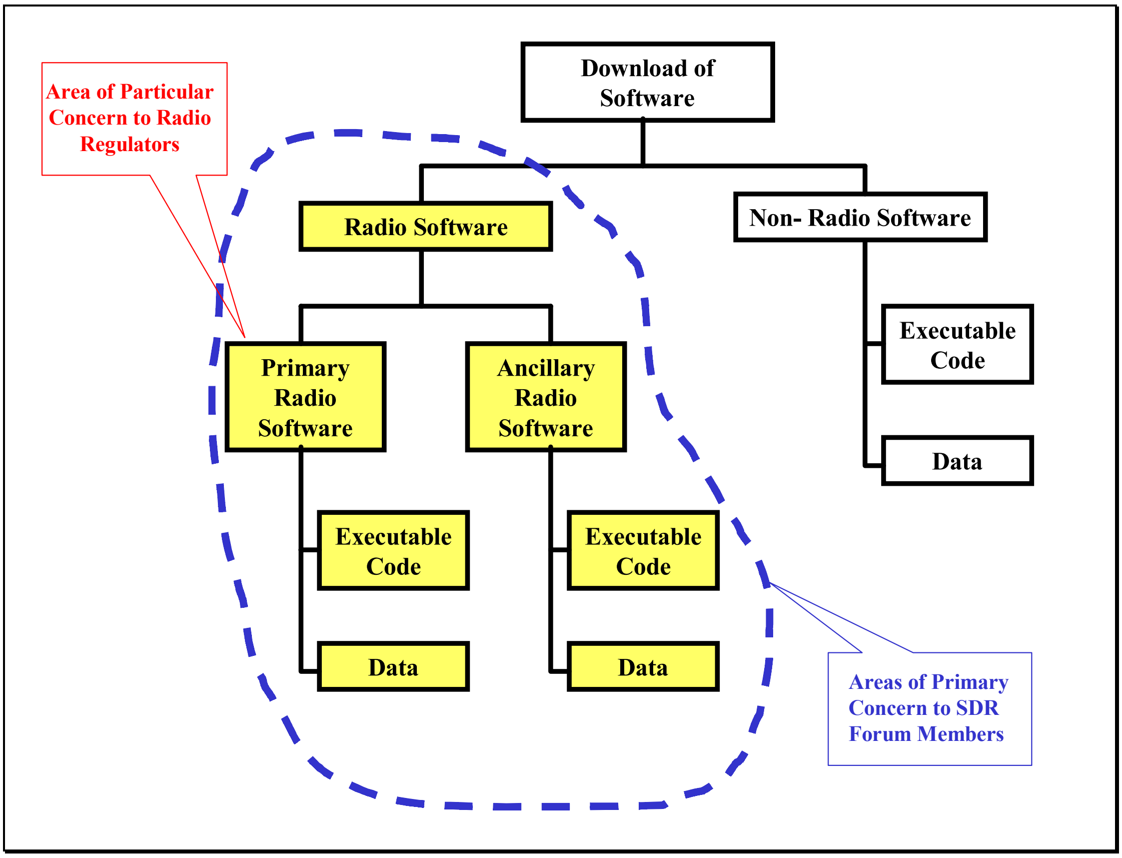

FIGURE 2

Characterizations of Software Download

Download of software can be divided into two main categories:

1. Download of software that reconfigures radio or network connection aspects of the device (referred to herein as *radio software* download), and

2. Download of software that does not affect these areas, such as user applications (referred to herein as *non-radio software* download).

The focus here is on the radio software download rather than the non-radio software download. However, to the extent that some of the security, authorization, and authentication techniques used for non-radio software download (e.g. credit card transactions) may also have applicability to the radio software download, non-radio software will not be entirely ignored.

Radio software may be further divided into *primary* and *ancillary* software. The word “primary” in this context means software that affects the radio functionality (e.g., frequency, power, and modulation). The primary software within a wireless device is tightly coupled with the radio hardware to derive the overall radio functionality. By contrast, the word “ancillary” in this context refers to radio software that affects the use of the device, but does not affect the radio functionality. Input/output drivers and user interfaces are examples of ancillary radio software download.

An additional distinction is between downloading *executable software code* or *data* for use by executable code. This data may affect either the configuration of the SDR device or only user applications that do not have any impact on the configuration of the SDR device.

Two additional aspects of Figure 2 are of note:

1. The SDR Forum is primarily interested in the functionality that is enclosed by the dashed line. However, the Forum does have interest in the download of non-radio software because some of the security, authentication and authorization techniques already developed for download of non-radio software may also be applicable to the download of radio software.

2. Although regulators have the most concern about the download of "primary" radio software, regulators may also have some interest in the download of "ancillary" radio software as will be further explained in Section 6.2.

Examples of each type of software are provided in Table 1.

TABLE 1

Examples of Types of Software Download

Type of Software	**Examples**
Primary radio software executables (program code)	♦ New computing and communication software ♦ New air interface to implement a new standard (inter-standard adaptation) ♦ Air interface modifications to implement different features (e.g., increased bearer data rate) specified within a standard (intra-standard adaptation) ♦ Incremental enhancements (module or entity replacement) ♦ Patches for software bug-fixes
Primary radio software data	♦ Parameters that change the radio operational characteristics (e.g., frequency, power, and modulation parameters) ♦ Acceptable emission masks
Ancillary or supplemental radio software executable code	♦ Radio software download may also affect the control functions of the SDR device ♦ New user interface (look and feel) ♦ I/O Drivers (non RF related)
Ancillary or supplemental radio software data	♦ Reference database information, e.g., locally available services and operators (including capability exchange) ♦ Licenses to activate downloaded applications upon verified receipt of payment
Non-radio software executable code	♦ Programs that permit searches for restaurants in the area, stock analysis programs, MP3 player, etc.
Non-radio software data	♦ Voice packets and application data such as credit card information, stock market data, MP3 music files, etc.

Text to be Inserted into Attachment 1, Annex 1, New Chapter on SDR Enabling Technologies in Document 8F/747

[Editor's note: the following is introductory text – additional more detailed text is needed.]

- Field programmable gate arrays
- Digital signal processors
- Analog to digital and digital to analog processors
- Radio design software development tools
- Reconfigurable architectures

Text to be Inserted into Attachment 1, Annex 1, New Chapter on SDR Technology as a Spectrum Efficiency and Spectrum Sharing Enabler in Doc. 8F/747

[Editor's note: the following is introductory text – additional more detailed text is needed.]

Software defined radios with flexible RF front ends provide multimode, multiband capabilities. This provides the possibility of sharing spectrum between different operators on a flexible, real-time basis. For example, if multiple, heterogeneous radio systems exist in a given geographical area, a reconfigurable terminal can select the most appropriate radio access technology depending upon spectrum availability at the time. Thus the service needed by the user is provided by the system for which spectrum is available. The reconfiguration can be initiated either by the user or by the network. This requires mechanisms for jointly managing the radio resource and the spectrum resource.

In addition, spectrum can be shared between service providers based on real-time needs of the service providers in a given geographical area.

All of above is predicated on the establishment of an evolutionary regulatory environment. Regulatory issues must be resolved before reconfigurable radio is brought into the marketplace. The requirements of all market players including regulators, users, and service players must be considered in resolving these issues. Because commercial wireless systems and standards are global in nature, it is desirable to have a globally coordinated regulatory environment as established by the ITU Radio Regulations and ITU-R Recommendations.
Software defined radio technology is integral to enabling novel new wireless architectures, enhancing existing devices and systems, and facilitating new efficient spectrum management techniques.

SDR has the potential – eventually – to be a highly efficient way to implement advanced "smart" antenna capabilities and enable, and adapt to, highly flexible spectral markets.

SDR has the potential to improve bandwidth utilization. SDR units with software filters and software waveforming techniques will be able to change their characteristics in response to a variety of circumstances—such as signal input rates and environmental factors such as fading and the density of users—while optimizing the use of bandwidth. SDR will lead toward bandwidth on demand rather than dedicated frequency bands, enabling a broader range of services to a more diverse and larger user community while utilizing the same or less bandwidth.

Software Defined Radio has accelerated significantly. The technology is integral to enabling novel new wireless architectures, enhancing existing devices and systems, and facilitating new efficient spectrum management techniques.

<u>Secondary Spectrum Markets</u>

Software defined radio technology enables secondary market use of spectrum by allowing wireless systems to adapt flexibly to the frequency, modulation, bandwidth, and power requirements of various service rules. In addition, this technology will facilitate the introduction of other new technologies such as smart-antenna technology. SDR technology is expected to permit wireless systems to contain the flexibility needed to realize the benefits associated with secondary markets. Furthermore, SDR technology can, in time, enable exactly the sort off feasible, timely adjustments that will be necessary for a leased-spectrum market to thrive.

Text to be Inserted into a Attachment 1, Annex 1, New Chapter on Security for Reconfigurable Systems in Doc. 8F/747

[Editor's note: It is not the intent to have a definitive chapter on security because general aspects of security are the topics of recommendations, standards, and specifications developed by other ITU Study Groups and other standards fora. The objective here is to present only security requirements from the perspective of security aspects of reconfigurable radio systems which are of global concern to regulatory agencies.]

Security can be defined in a broad sense as that system attribute that maintains the privacy and integrity of the system and the information distributed across it. It includes mechanisms to ensure accurate content delivery to intended recipients, denial of interception by intruders, rejection of attempts to gain unauthorized access, mechanisms for configuration management of software download, and record-keeping with non-repudiation of actions taken by all participants.

<u>Security Objectives</u>

A primary security issue is related to the control of the reconfiguration:

– Who has the authority to reconfigure which parts of the communication equipment?

– Who is responsible for the protection of the reconfiguration signaling and how is this accomplished?

– Who is responsible for the privacy of the reconfiguration information taking into account that in some circumstances billing and charging may be involved as the result of new capabilities provided to the user?

– Who is responsible for the correctness and availability of information on which reconfiguration is based?

– Who is responsible for the secure download of software required for reconfiguration?

– Who is responsible for the radio emissions and associated conformance requirements of radio equipment?

Security objectives for software defined radio and reconfigurable systems are the establishment of recommendations, standards and specifications that satisfactorily answer these questions.

A fundamental principle for designing a secure handset is the assumption that all design information is available to the attacker. It should be assumed that the only information that is not available to the attacker is the private encryption keys that are securely kept by the equipment manufacturer or a trusted Public-Key Infrastructure (PKI) service provider.

One important consideration when designing a secure handset is the likelihood that an attack method, developed by a sophisticated hacker, will be made available to a large number of users, possibly via the Internet. For example, a method to increase transmitter output power could become widely distributed as a PC program that accesses a handset through its test port. The handset design should prevent attacks that could easily be implemented by a large number of users. This makes securing the test port, keypad entry, and SIM interface, essential.

Security Framework Requirements

The following security framework specifies the general methods and elements required to ensure robust security for SDR enabled devices. These methods are intended to enhance and strengthen the intrinsic security (by virtue of hardware limitations). If properly implemented, this framework will provide effective counter-measures to the security threats to SDR-enabled reconfigurable devices. The choice of the specific algorithms used for implementation should be left to the device manufacturer. By allowing manufacturers to select the implementation techniques, the commercial wireless industry's responsiveness to an ever-changing security landscape can be ensured. Security framework requirements include:

1. The equipment SHOULD include a unique non-alterable identifier (Serial Number). This enables certificates to be linked securely to the device.
2. A secure configuration control method MUST be used. This prevents a hacker from changing the device configuration.
3. Private cryptographic keys MUST be stored securely. This allows the equipment to securely identify itself.
4. Public cryptographic keys (root keys) used to verify certificates MUST be stored so that the value cannot be modified.
5. A secure infrastructure MUST be provided to verify the integrity of software to control distribution of the software.
6. All software components MUST be cryptographically verified before they are executed. At minimum this should be done at start-up.
7. Watchdog processes MUST be used to insure that processors are executing instructions correctly and that software routines are not locked up.
8. Task separation methodology SHOULD be provided to insure that a non-critical task couldn't access memory or modify operation of a critical task.
9. The cryptographic level of the algorithms used SHOULD be consistent with the current state of the art and designed to prevent a dedicated attacker from using weaknesses in the algorithms to modify the specified operation of the equipment.

Good security design requires that all of these framework requirements be included in order to ensure a secure design. This is a list of "best practices" as established by security experts.
Note that several of these framework requirements require a Public Key Infrastructure (PKI). A PKI is needed to sign the software and configuration parameters for SDR enabled devices. A PKI is needed to create and revocate the digital certificates used to certify compliance.