

# **Perspective on Software Defined Radio Focusing on Reconfiguration and (Radio) Software Download**

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S. M. Blust  
8 Sept 2003  
Version 3.0  
Page 1

# Contents

SDR – How it relates to a Wireless Technology Model?

Aspects of Radio Hardware, Radio Software, and Radio Software Download

Software Download to Terminals

Industry Fora Activities

Conclusion

Bibliography

Note: Not all slides in this package will be covered.

Many are included for review outside of the presentation.

# How Does SDR Fit The Wireless Technology Model?

## Cost Reduction

- Common product line
  - generic hardware platform with software features
- Global purchasing
  - aggregate volume across systems that may be disparate
- Risk management
  - right choices today may not be right choices tomorrow
  - download of product updates and “bug” fixes
- Reduces cost to deploy
  - end user provided systems vs. sharing and leverage public product
- Lower cost of market & acquisition
  - embedded wireless products in computers & autos

# How Does SDR Fit The Wireless Technology Model?

## Revenue Enhancements

- Service differentiation
  - opportunity to customize terminal product more than current generation hardware allows
- Roaming
  - obviate concerns about air interfaces & frequency bands
- Business flexibility
  - ability to deploy “instant” services on demand to one or all subscribers
  - partnerships & market consolidation independent of technology
- New distribution channels
  - promotes embedded wireless products in computers & autos

# How Does SDR Fit The Wireless Technology Model?

## Increased Value for Existing Equipment

- Common product line
  - generic hardware platform with software features
- Sharing of terminals
  - public cellular/private radio systems
- Evolution to third generation
  - base stations
  - terminals

# Impacts Of SDR On Network Operators/Service Providers

- Business Issues
  - Billing systems must accommodate the flexibility offered by SDR
  - Customer record and support systems must accommodate SDR
- Operational Issues
  - Network issues must be managed as they relate to supporting SDR
  - Download must be managed
    - complete air interface functionality
    - services and features
    - upgrades and product fixes
  - Download must be integrated and/or partitioned (may follow Internet model)
    - network operator download “server”
    - service provider download “server”
    - third party download “server”
- Product certification issues
- Regulatory Aspects

# Aspects of Radio Hardware Radio Software and Radio Software Download

# Definitions (1)

- Technical Definition of Software Defined Radio [1]: Software defined radios are elements of a wireless network whose operational modes and parameters can be changed or augmented, post-manufacturing, via software. Software defined radios are a collection of hardware and software technologies that enable reconfigurable system architectures for wireless networks and user terminals.
- Regulatory Definition of Software Defined Radio [2]: 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. This definition was not intended to cover devices that use software simply to control functions such as power or frequency within a range approved by the Commission. Receivers would not be covered under this definition.

## Definitions (2)

- Device reconfiguration: Device reconfiguration is the change of operational 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). In general, reconfiguration can 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.

# Definitions (3)

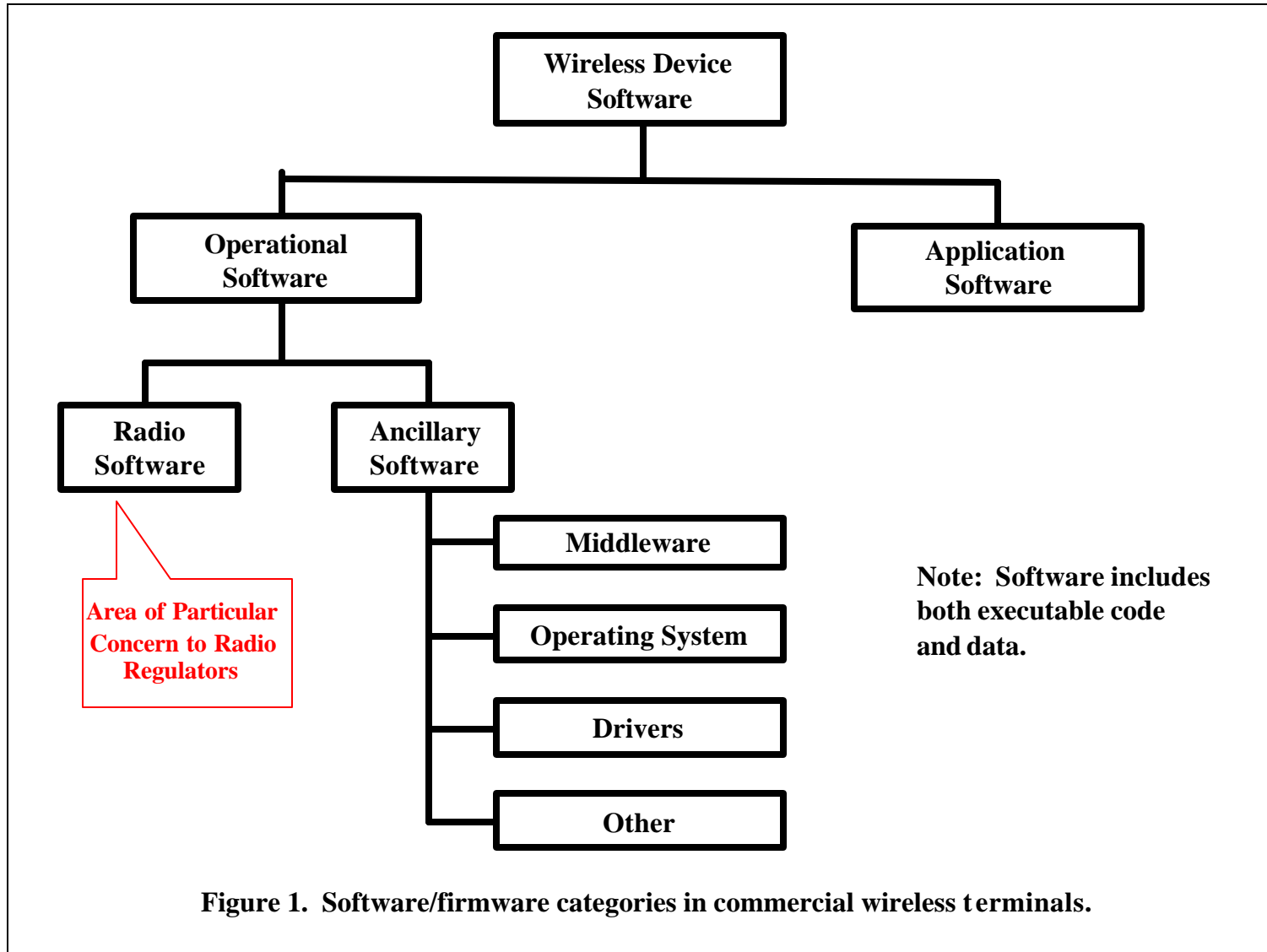
- Application Software: Application software is the software that resides at and deals with the highest layer in the communications protocol stack. Application software is usually directly executable by the device user to satisfy a specific need. For example, web browser software is executed to satisfy the need for browsing the Internet. Application software is usually agnostic of any underlying technologies that the device may use for communications. For example, web browser software does not care whether the device is connected to the Internet via a cabled Ethernet connection or a wireless 802.11b connection.
- Operational Software: The term operational software includes all software other than applications software. It includes the operating system, drivers, radio software, and middleware, i.e., all software needed to support the applications on the wireless device.

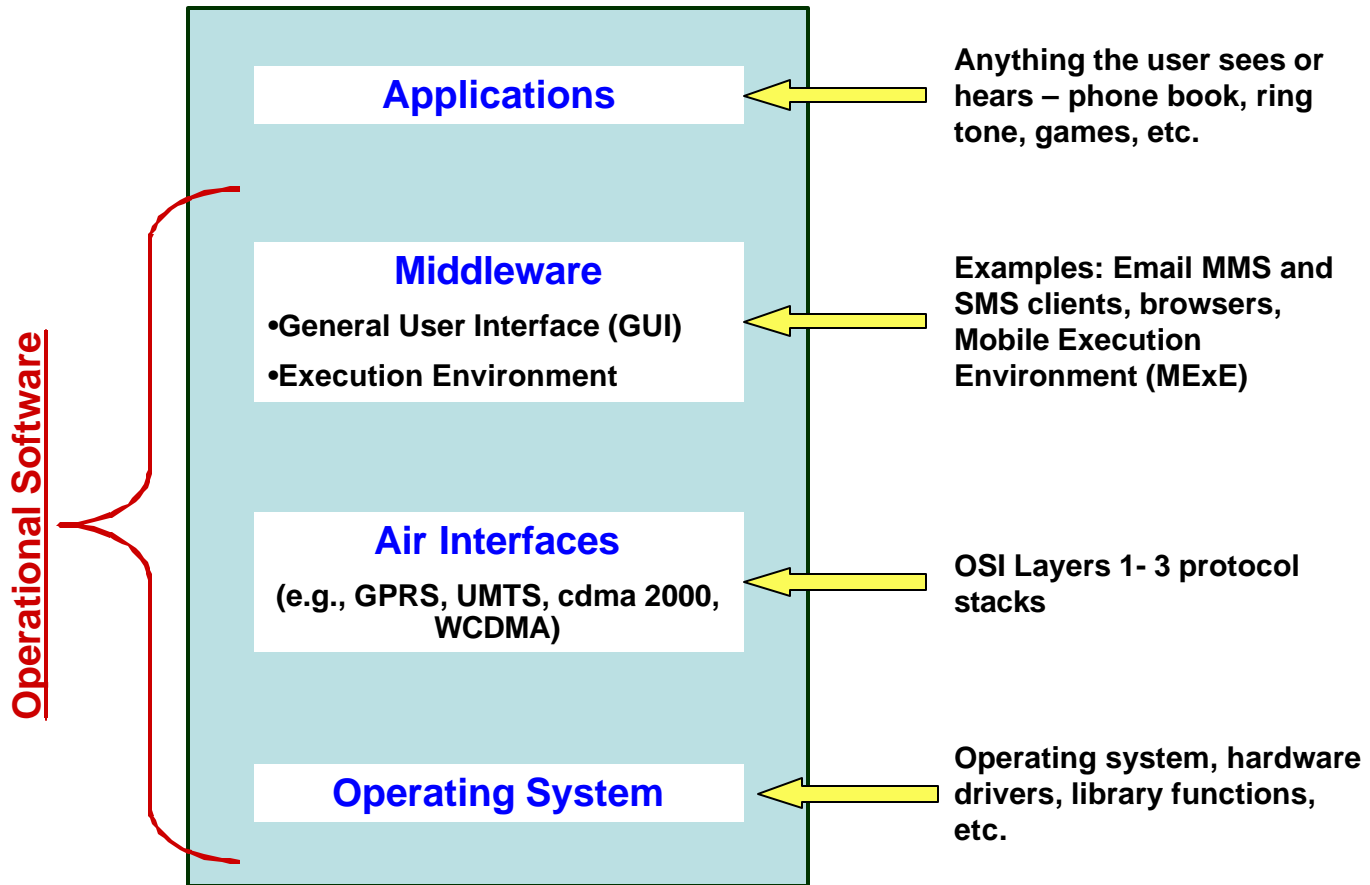
# Definitions (4)

- Radio Hardware [1]:
  - 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 [1]:
  - The primary software within a wireless device that is married 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, content and the like.
- Radio Software Download [1]:
  - The process of delivering information to a wireless device to alter the post manufacture operation, performance, or capabilities by causing changes in the radio hardware or software

Note: These definitions do not presume any particular method of implementation although SDR implementations may be more amenable to enjoying the benefits of these concepts.

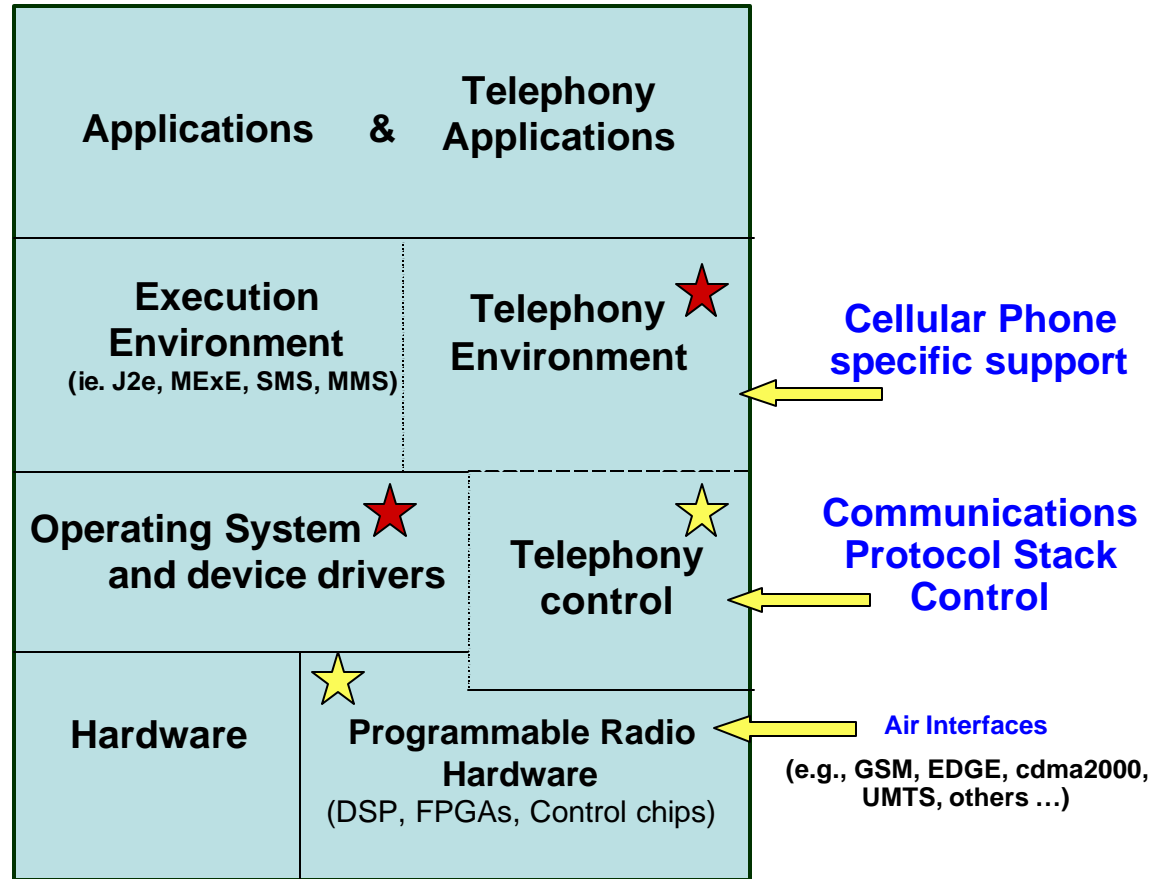
# Software/Firmware Categories in Commercial Wireless Terminals





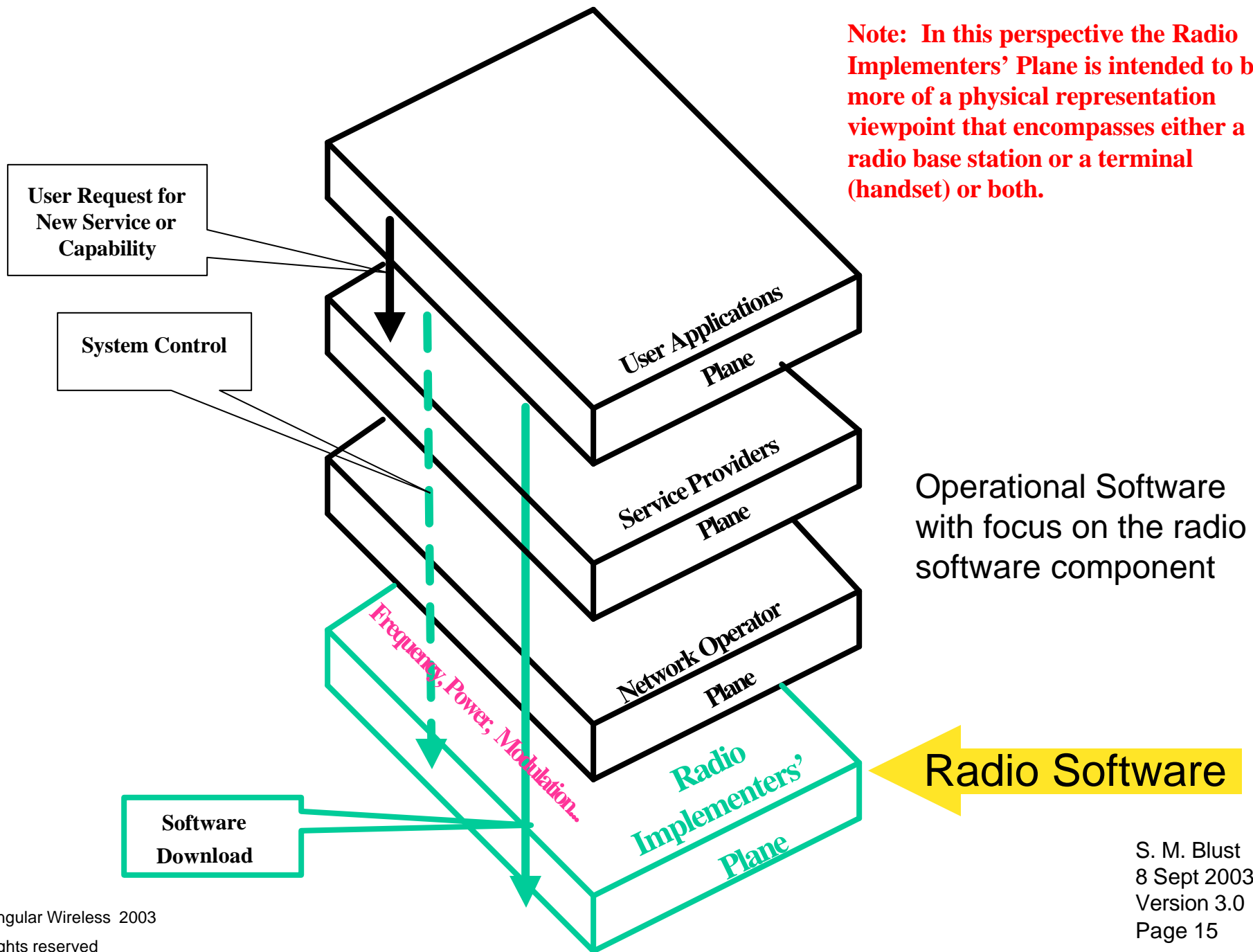
Adapted from material in [4].

★ Radio Operational Software (defines how the transceiver will operate)

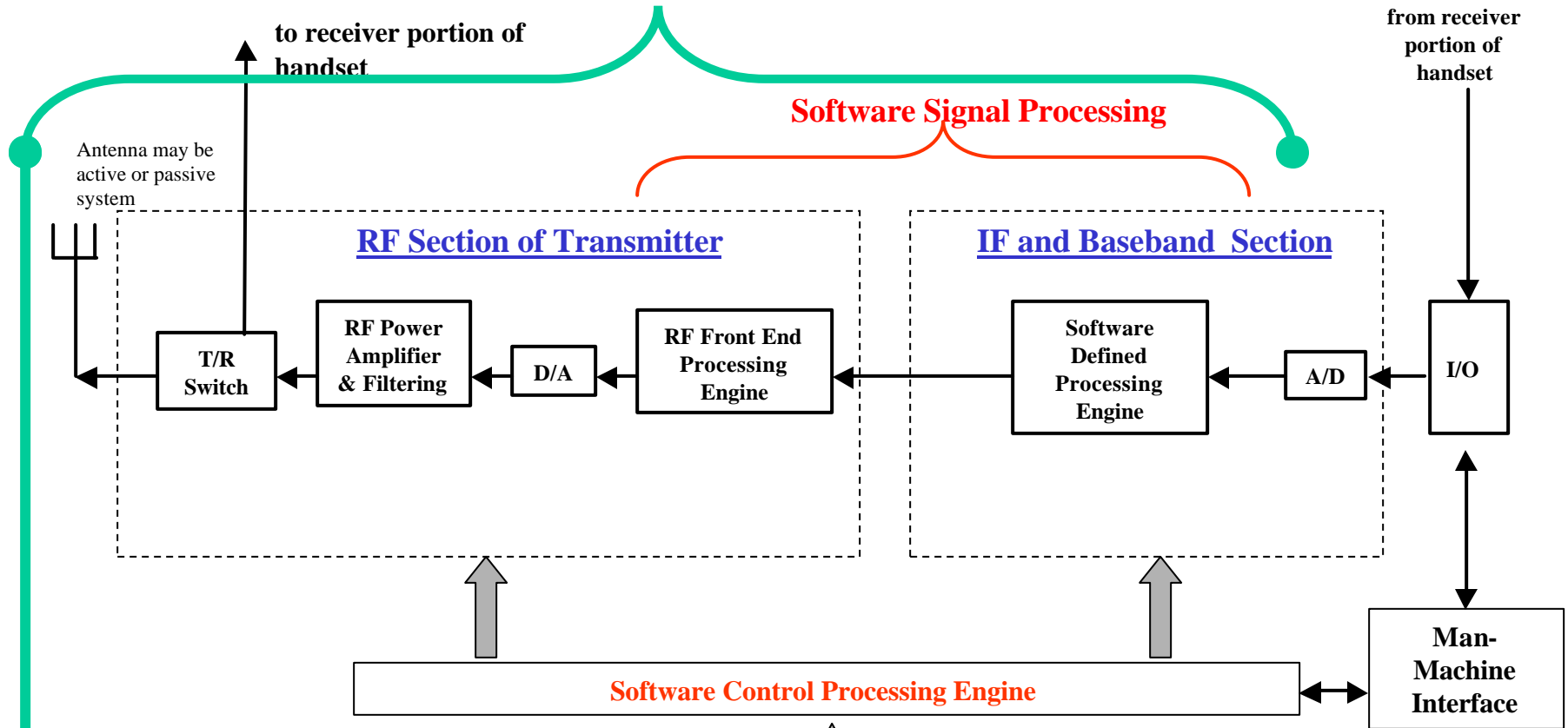


★ & ★ Operational Software (allows the device to function as a phone)

Adapted from unpublished material by J. Hoffmeyer



# Scope within the Software Defined Radio "Box"



- Information from mobile network infrastructure
- Available RF bands
- Available air protocols
- Propagation data
- User needs
- Minimum performance requirements
- Etc.

## Note:

This functional block diagram has been simplified for illustrative purposes.

S. M. Blust  
8 Sept 2003  
Version 3.0  
Page 16

# Radio Hardware and Radio Software Combinations

- Initial radio hardware and radio software set tested together at time of initial manufacture
  - Parameters “established” at time of manufacture
    - Initial type approval, type acceptance, conformance declaration, etc....
- **Business as usual (?)**
- Initial radio hardware and revised radio software post manufacture emplaced in device via download
  - **What is the list of considerations?**
- Revised radio hardware and revised radio software
  - **What is the list of considerations?**

# Radio HW and SW Download Environments

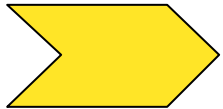
- Local Environment
  - Attached cable,
  - Infrared,
  - Bluetooth,
  - etcbut not over the radio interface
- Remote Environment
  - Over-the-airvia the actual radio interface in the device through the supporting core radio network

# Considerations for Radio Software Download

- Can be categorized in three distinct stages
  - Pre Download (preparatory)
  - During Download (procedural)
  - Post Download (installing)
- Each stage has a set of concerns that must be addressed both individually and collectively
- Common and standardized global solutions for these concerns preferred by stakeholders
  - Manufacturers
  - Regulators
  - Network Operators and Service Providers
  - Users

# What are the implications and tasks?

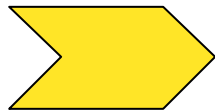
- Developments in the field of testing of radio hardware and radio software combinations
- Developments of download standards for radio software to be globally accepted and common across differing radio air interfaces and core networks to address
  - the combinations (revised sw or revised hw/sw)
  - the environments
  - the three stages (pre, during, and post download)



How do the combinations, environments and stages relate and cause the download solutions to be altered or different in design and definition?

# Pre-Download Stage Implications

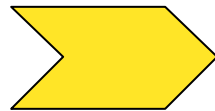
- Has a measure of controllability and can be queried and communicated with
- Security and integrity of the radio hardware and software in current configuration
  - What has been done by whom and when and why in the past
- Knowledge of the state, function, vintage and status of radio hw/sw in current configuration
  - verification and auditing
- Etc.....



Process, protocols, procedures.....

# During Download Stage Implications

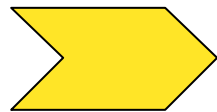
- Integrity
- Authentication
- Security
- Non-repudiation
- Etc.....



Process, protocols, procedures.....

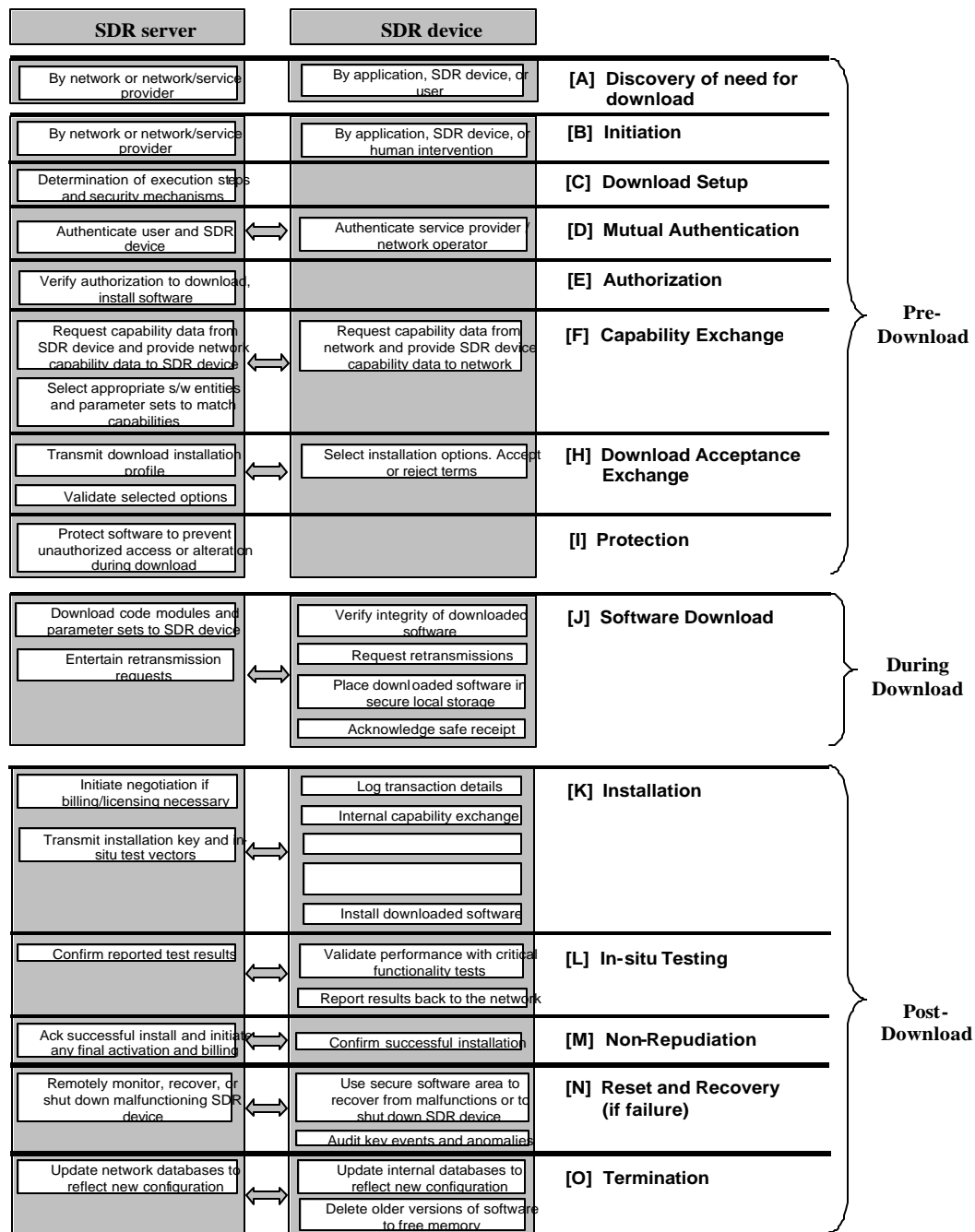
# Post-Download Stage Implications

- Validation of downloaded software
- In-situ testing
- Mechanisms to switch from old to new
- Means to revert back
- Auditing
- Traceability
- Etc.....



Process, protocols, procedures.....

# SDR Forum Perspective on Radio Software Download [3]



Pre-Download

During Download

Post-Download

# **Software Download to Terminals**

(Remote ReFlash)  
The Market Driver

# **The Problem and The Solution**

S. M. Blust  
8 Sept 2003  
Version 3.0  
Page 26

# The Problems

- Product recalls due to software difficulties in the terminal devices (applications and radio)
  - recalls are ranging from 500,000 to 1 million units at a time
  - costs may be up to \$100 Million dollars per event to rectify
  - Plus
    - costs of customer satisfaction
    - potential bad publicity in the press
    - financial analysts response
- Continuing issue of incremental product enhancements and improvements (applications and radio)
  - behind-the-scenes improvements
    - due to the cost associated with a “one-on-one” hands-on upgrade, cannot be universally applied to the entire customer base

# The Solution

- A flexible terminal with “over the air” download is a tool that can mitigate product recalls due to software. It should be applicable to both the “radio software” in a terminal (wireless regime) and to the “non-radio” software (applications regime).
- Because download is an integral part of the solution, it must be fully characterized and defined in conjunction with understanding the flexible device.
  - Standards are critical!!!
    - How to download
    - Security
    - Regulatory
    - etc
  - Green field intellectual property opportunity!!!

# The ‘Why’

- Industry Critical Aspect for Future Business Success
- Right Timing for Marketplace, Technology & Regulatory
- Radio Software Download can be in standards as required and in products – must start NOW!
- Best suited to SDR Implementations and also applicable to many Non-SDR Implementations

**In short: We as a wireless industry will need this to survive in the increasingly competitive marketplace as we deploy evermore complex systems built to complicated standards developed by committee for rapid time to market – We don't have the time and money do keep doing products over and over again until we get it right!**

**How much will our customers put up with before becoming frustrated?**

# **The Objective Remote ReFlash**

S. M. Blust  
8 Sept 2003  
Version 3.0  
Page 30

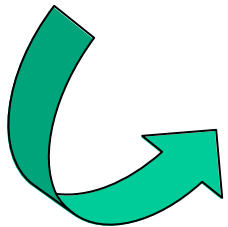
# Remote ReFlash Objectives

- **Marketplace acceptance** (manufacturers, operators, consumers) of a flexible terminal architecture and design that enables over the air download of updates and 'bug fixes'.
- This should address two areas critical to the business:
  - 1) radio operational and performance updates including 'bug fixes' and
  - 2) application software updates and enhancements.

# Software Defined Radio – (SDR) As A Solution ???



- Application and implementation of SDR can range from:
  - As complex as a multi-mode, multi-band radio device,
  - OR
  - As simple as a terminal implementation that is flexible enough within a given radio interface type to support download and reconfiguration for product enhancements, “bug” (defect) fixes, or modest upgrades.



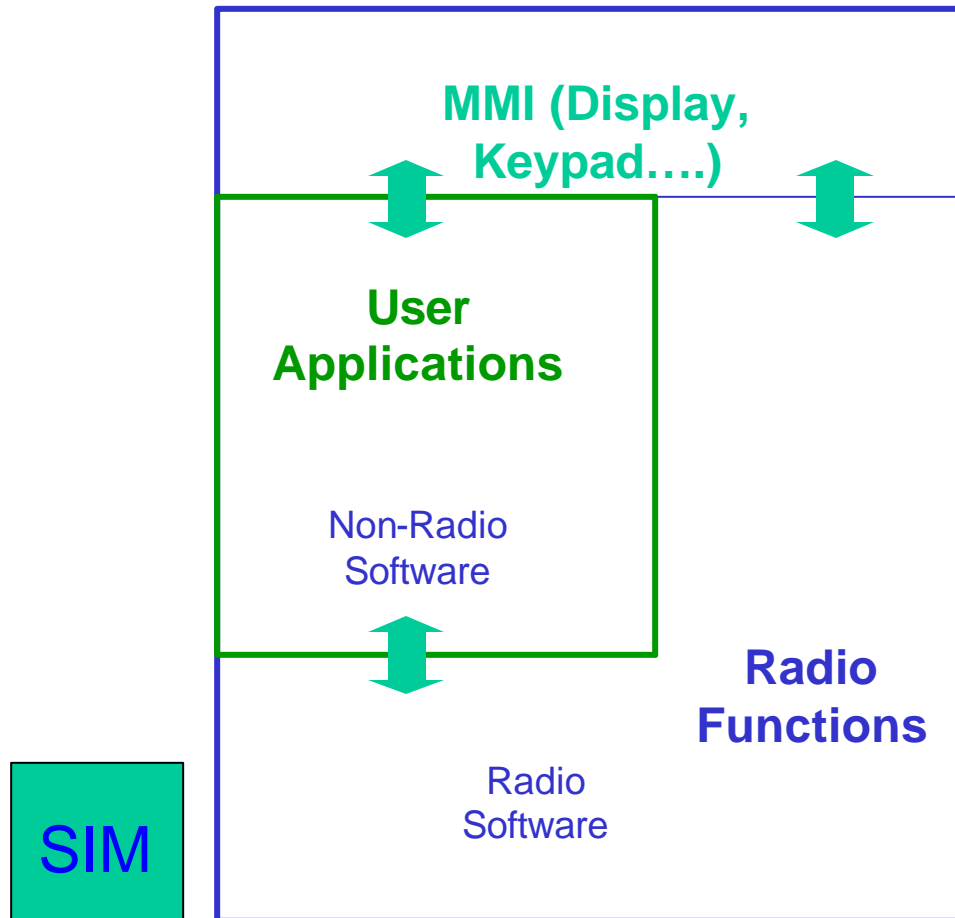
# What do Wireless Operators need today from SDR?

- Due to specific air interface technology choices (use one not many) by operators the simple terminal implementation view of SDR is an excellent entry vector for SDR implementations.
  - tractable in terms of economics and technology
  - has a large economic potential (operators plus manufacturers)
  - large potential to improve customer satisfaction with commercial wireless services.
- Another key enabler that nicely integrates with a terminal device incorporating a modest amount of SDR functionality and helps support the case for SDR is
  - “over the air” download.
- SDR and Download “Over the Air” are a powerful combination that more than ever is, or should be, a baseline requirement for modern commercial wireless systems.

# **A Matter of Perspective on How to Get to the Answer**

# Basic Device Level View

## Terminal View

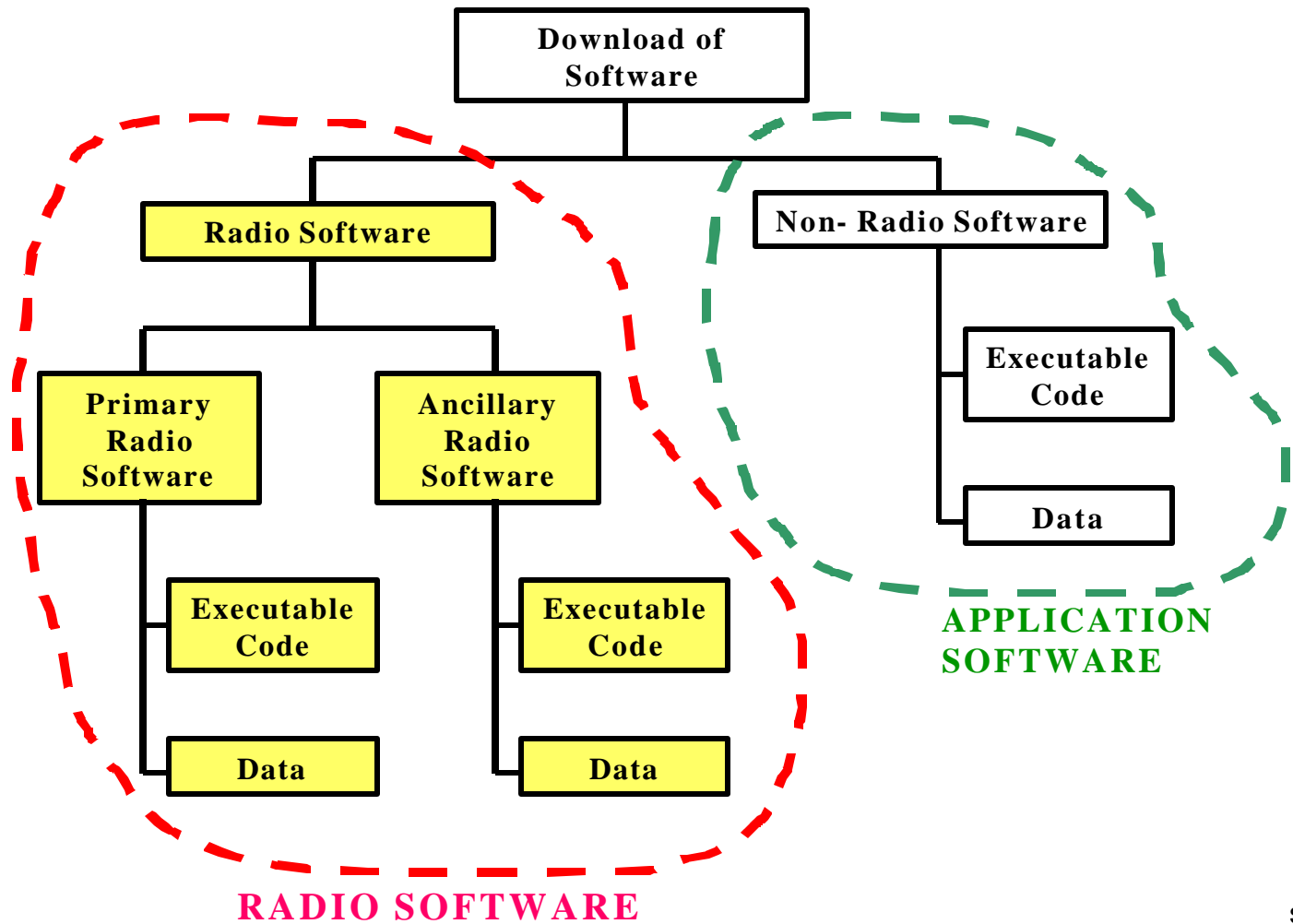


Conceptually we visualize a terminal device in a pragmatic way:

- radio for communications
- a device that performs certain applications

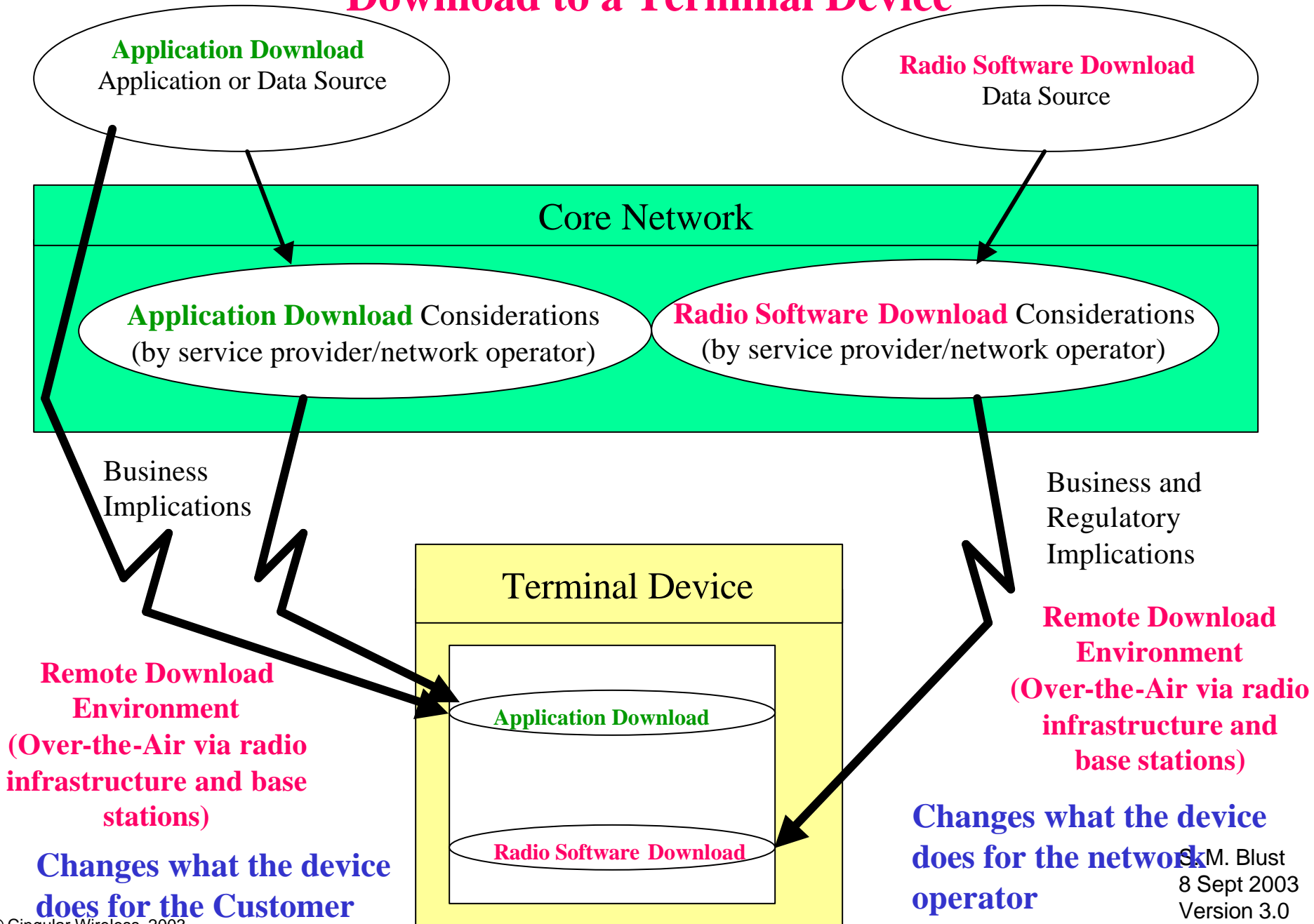
And the two views are often considered to be mutually exclusive!

# Characterizations of Software Download For Remote ReFlash



Radio Software can be thought of in one context as a specialized “application” within the device that causes the device to be a radio.

# Download to a Terminal Device



# “Radio Software” – A Matter of Perspective

- From Radio Expert’s Perspective:
  - Radio Software is the key radio function – radio frequency generation, signal processing, control, etc...
    - Why do I need to worry about “radio software download”?
    - 3GPP, 3GPP2, etc...
- From Application Developer’s Perspective:
  - Radio Software –that stuff is radio functions not applications or content or...
    - Why do I need to worry about “radio software download”?
    - OMA, etc

# “Radio Software” Download

## – The Successful Perspective

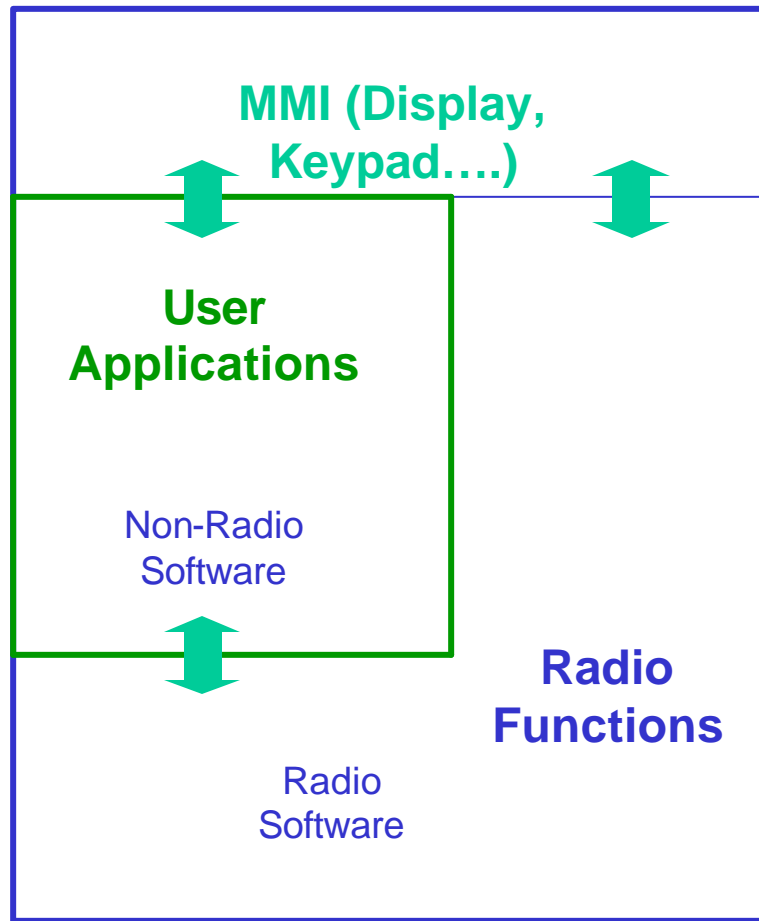
- From an agnostic Download Perspective:
  - Download is download. Different criteria are applicable depending on what is being downloaded.
  - “Radio Software” in the download context is like an “application”
  - Why not utilize ongoing developments in download of applications and content to form basis of download for “radio software”
  - Draw two perspectives together – radio experts tell what is needed to be downloaded and any specific criteria (e.g., regulatory, in situ testing, etc.); applications developers provide the expertise on how to do download and support criteria directly involved in a download (authentication, security, protocols, etc)
  - Download methods and protocols for radio software should be radio technology agnostic. The radio technology (air interface and core network) is important to the actual radio software code itself once it is utilized inside the device, but not to the process of emplacement.

# Basic Device Level View and Industry Organization Perspectives

## DOWNLOAD CENTRIC

### Terminal View

- OMA
- WAPF
- (Content)
- MMS-IOP
- SYNCML
- WIRELESS V.
- LIF
- JCP
- PARLAY
- IETF
- W3C
- LIBERTY
- OASIS



- SDR Forum
- (Download Docs)
- (Regulatory)
- 3GPP
- GSMA
- GSMNA
- 3G AMERICAS...

•[OMA for Download aspects]

GOAL: Leveraging download developments for applications to download "radio software"

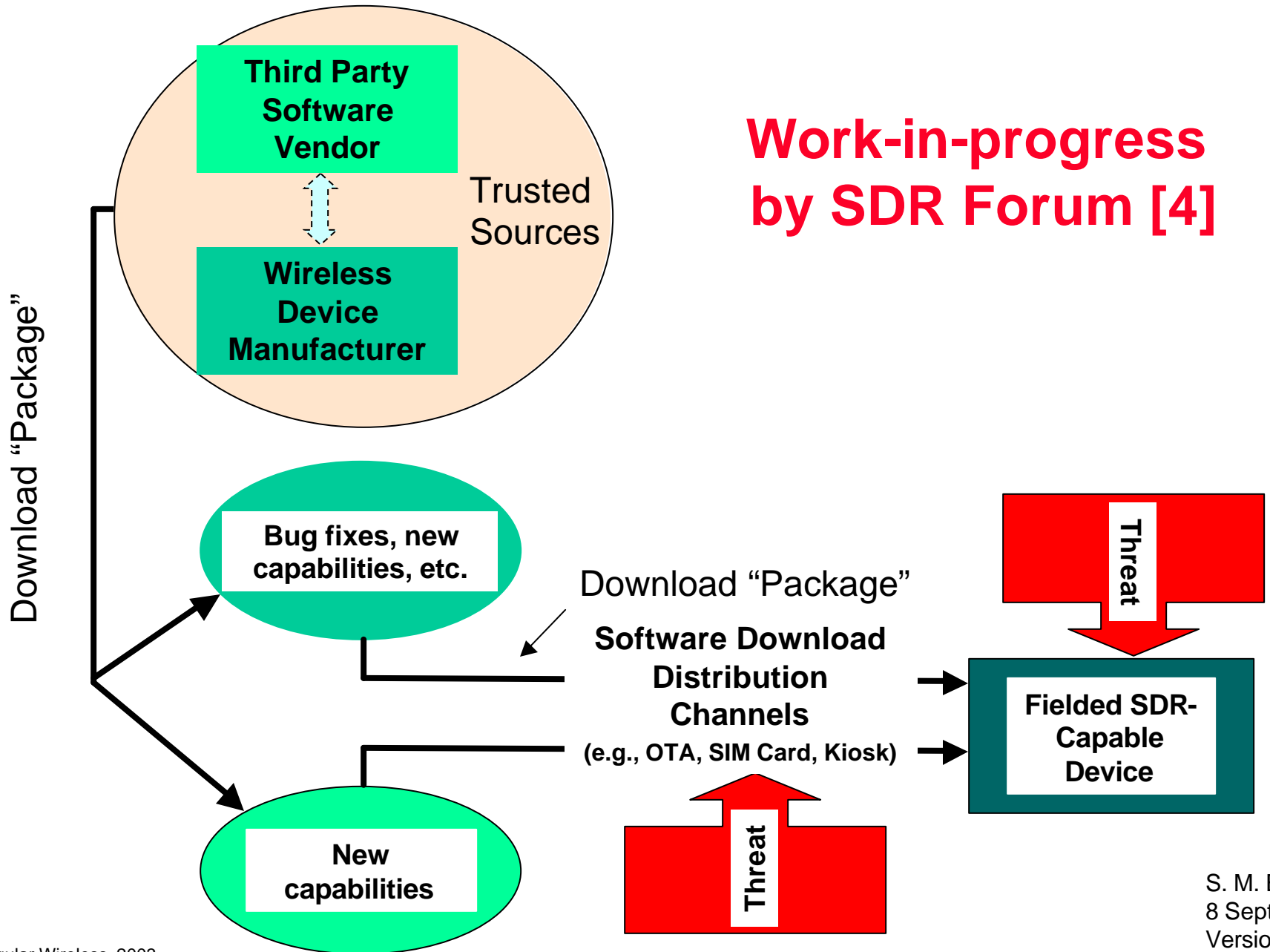
S. M. Blust  
8 Sept 2003  
Version 3.0  
Page 40

# Industry Fora Activities

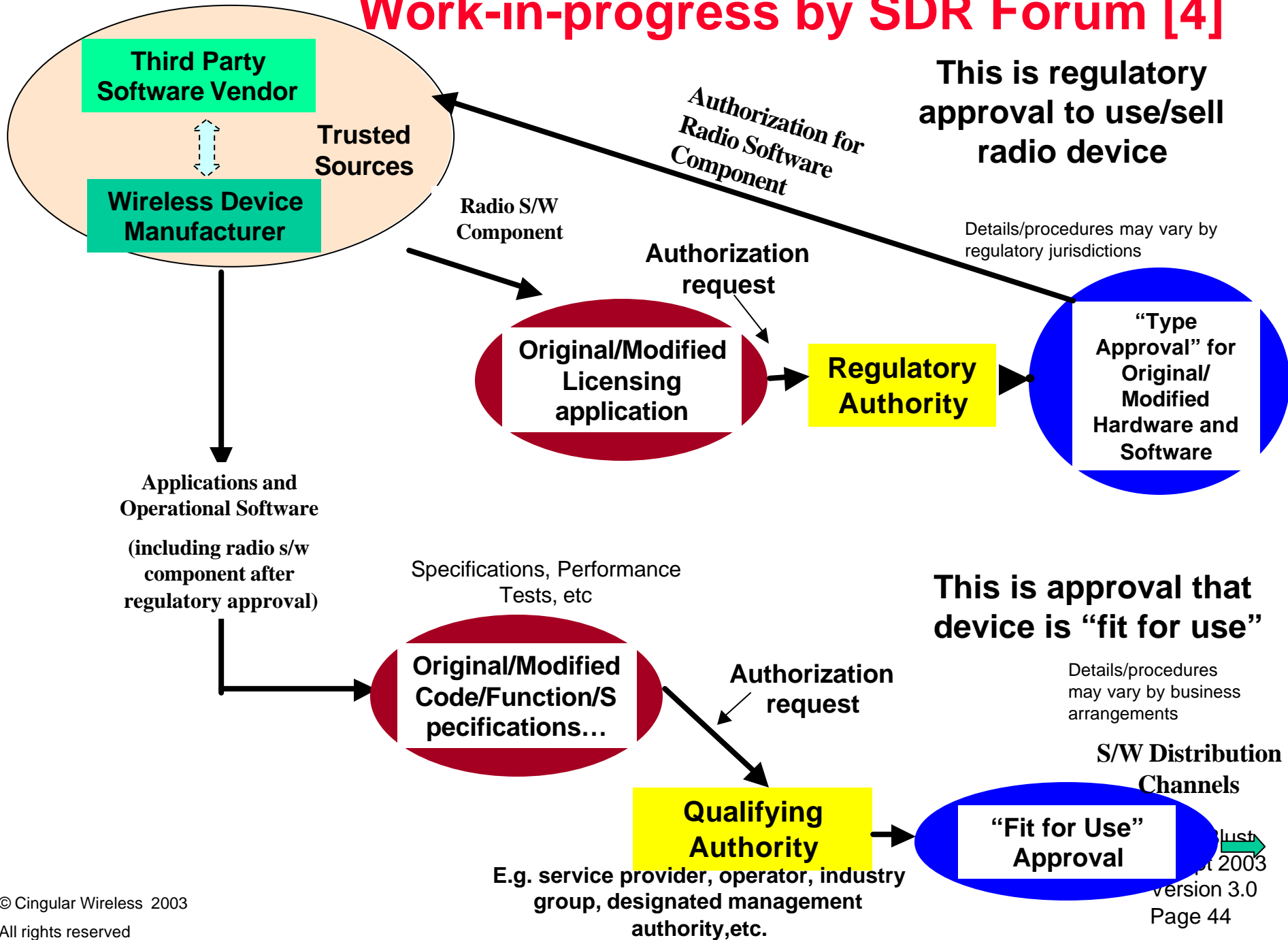
# SDR Forum

- The SDR Forum has been working to facilitate the introduction of equipment capabilities to support the device flexibility and reconfiguration that has been discussed in this paper. In addition they have an aggressive program around the world to work with regulatory authorities to educate and to facilitate the development of regulations that permit the fullest flexibility to be allowed to be deployed (and used) within such reconfigurable devices. Furthermore, the SDR Forum is addressing the aspects of operational software download with particular attention on the radio software download requirements, the identification of any unique aspects pertinent to radio software within the generic operational software framework, the development of high level solutions, and the facilitation of coordination of work among the industry activities.

# Download Threat -Trusted Source to Target Device -



# Work-in-progress by SDR Forum [4]



# Open Mobile Alliance (OMA)

- OMA has developed, among other things, a suite of specifications [5], [6] that address device management, application software download and the like. These key specifications are an important foundation for the detailed solutions and standards required for operational software download. Indeed, through the efforts of a number of forward looking companies in the industry, the OMA material acknowledges the role of download of non-application software (to use their terminology for an operational software view) and suggests that extension of the application software download specifications and device management and synchronization work can be accomplished so that it encompasses aspects such as operational software.

# ITU-R

- Additionally, the ITU-R has a work item on SDR. Question ITU-R 230-1/8 is jointly assigned to Working Party 8F (IMT-2000 and Beyond) and Working Party 8A (Land Mobile Radio). WP 8F has in its list of deliverables a Recommendation on SDR that is scheduled for completion by year-end 2004.

# Conclusion

# Success in the area of operational software download, including the critical radio software component for commercial wireless devices, is possible if the following challenges are met:

- Acknowledging that the wireless industry is in the software business as well as the wireless business.
- Leveraging the application software download space and the radio software download space for cost efficiencies.
- Industry development of requirements and standards (network, radio, terminal, ...) while respecting those areas that are proprietary within the terminal devices.
- Collaborative efforts of several standards fora; and consolidation, to the extent possible, in a single standards fora of a common set of documents which may include cross referencing of industry approved standards materials developed by collaboration.
- Delineation of areas of responsibility among the industry fora for this task. Capitalization on what has already been developed. Extension of existing standards and “borrowing” from similar developments in related fields.
- Establishment of an agreed aggressive timeframe to accomplish the standardization tasks.
- Continued dialog and interaction with regulators to ensure a continuing positive climate for the incorporation of flexible and reconfigurable technology in the implementation of radio devices.

# Bibliography (1)

- [1] Software Defined Radio Forum, “Overview and Definition of Software Download for RF Reconfiguration”, SDR Forum Document SDRF-2002-A2, August 6, 2002, publicly available at [www.sdrforum.org](http://www.sdrforum.org)
- [2] United States of America, Federal Communications Commission, First Report and Order “Authorization and Use of Software Defined Radios” ET Docket No. 00-47, FCC 01-264, Adopted 13 September 2001, <http://www.fcc.gov> (search for 01-2640); pp. 11-13 and Appendix A, para. 2.925
- [3] Software Defined Radio Forum, “Requirements for Radio Software Download for RF Reconfiguration”, SDR Forum Document SDRF-2002-A7, November 13, 2002, publicly available at [www.sdrforum.org](http://www.sdrforum.org)
- [4] Software Defined Radio Forum, “Security Aspects of Operational Software Download for Commercial Wireless Devices”, SDR Forum Document SDRF-02-W-0005, September 2003, [WORK-IN-PROGRESS], available only to SDR Forum members.

## Bibliography (2)

- [5] Open Mobile Alliance, Download Architecture, OMA-Download-ARCH-v1\_0-20020610-p, publicly available at [www.openmobilealliance.com/documents.html](http://www.openmobilealliance.com/documents.html)
- [6] Open Mobile Alliance, Generic Content Download Over The Air Specification, OMA\_Download-OTA-v1\_0-20020620-p, publicly available at [www.openmobilealliance.com/documents.html](http://www.openmobilealliance.com/documents.html)

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Mr. Blust holds a B.Sc. in Electrical Engineering from Tulane University and is a member of Tau Beta Pi and Eta Kappa Nu. Mr. Blust is a member of the IEEE and is a Registered Professional Engineer. He has authored book chapters, a number of articles on software defined radio, and IMT-2000 and is a patent holder.