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Chapter 8
Roadmap of IMT-Advanced Development

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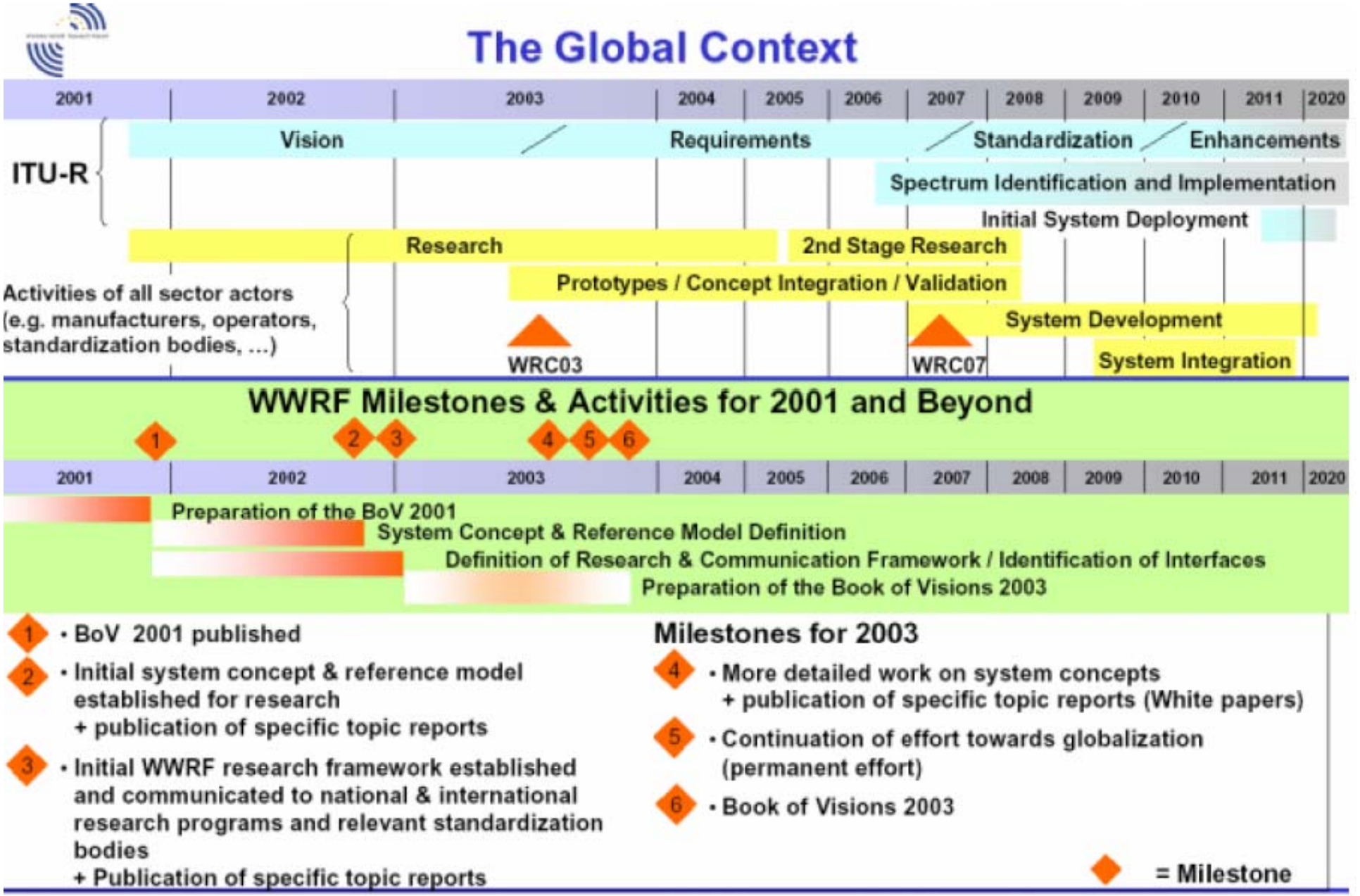
Introduction

- The International Telecommunication Union (ITU) World Radiocommunication Conference (**WRC-07**) adopted new primary allocations to the mobile service and/or new identifications for international mobile telecommunications (IMT) systems in a number of the bands in the **UHF/SHF** ranges, reflecting increasing demands for broadband cellular systems.
- At its Radiocommunication Assembly (RA-07) immediately prior to WRC-07, the ITU also approved Resolution ITU-R 56, which defines the term *IMT-Advanced as the* nomenclature for those systems that support the new capabilities of systems beyond IMT-2000.

Roadmap of ITU-R a d WRC07



Introduction

- This Resolution provides the term *IMT as a root name for* both IMT-2000 and IMT-Advanced. Therefore, the Resolution has clarified what is meant by IMT-Advanced, at least for its initial vision, by referring to Recommendation **ITU-R M.1645**, which defines the new capabilities of systems beyond 3G.
- In light of the recent outcomes above, standardization activities in the ITU-R (the Radiocommunication Sector of the ITU) will focus on the development of Recommendations on radio interface technologies (RITs) for IMT-Advanced using the frequency spectrum available for this application.

Introduction

- The detailed work plan is being considered by the relevant working party of the ITU-R Study Group, and completion of the Recommen-dations is targeted for around the year 2011.

Frequency Resources for IMT Systems

- In the ITU Radio Regulations, the frequency bands in Table 1 have been identified for IMT-2000 (terrestrial component) or its enhanced systems through the decision of the past WRCs.

TABLE 1. Frequency bands already identified for IMT-2000 before WRC-07.

Frequency Band	Bandwidth	Remark
806–960 MHz	154 MHz	In Regions 1 and 2, some parts of the band are not allocated to the mobile service on a primary basis nor identified for IMT-2000.
1,710–1,885 MHz	175 MHz	
1,885–2,025 MHz	140 MHz	Some parts of the band are identified also for use for the satellite component of IMT-2000.
2,110–2,200 MHz	90 MHz	
2,500–2,690 MHz	190 MHz	

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- The total bandwidths in Table 1 amount to about **750 MHz**. It is, however, obviously not sufficient for implementation of IMT-Advanced, which is characterized by broadband cellular systems having a capacity greater than 100 Mb/s in high-mobility environments and 1 Gb/s in low-mobility environments as defined in Recommendation ITU-R M.1645 (see Figure 1).

Figure 1. Development of the IMT systems

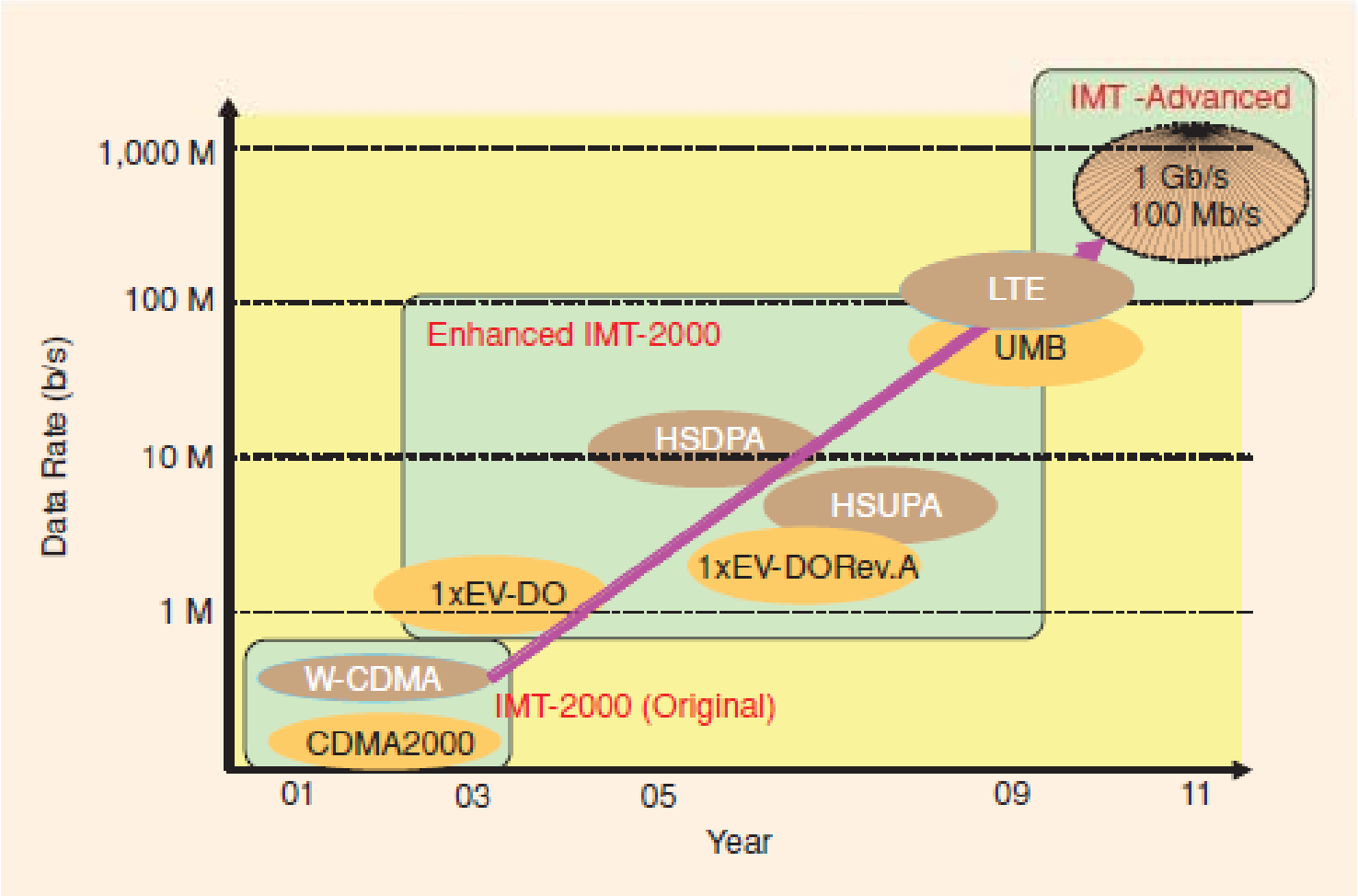

Figure 1. *Development of the IMT systems.*

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- WRC-07 additionally identified the frequency bands shown in Table 2. The total bandwidth of **428 MHz** has been identified for the use of IMT.
- This may not accommodate the spectrum requirement for IMT in the year 2020 since the ITU-R has predicted in its prior study that the **total spectrum bandwidth requirements** for both existing mobile cellular systems, including IMT-2000 and IMT-Advanced, for the year 2010 are **1,280 MHz** and **1,720 MHz** for low and high user demands, respectively.

Table 2. Frequency bands newly identified for IMT at WRC-07.

TABLE 2. Frequency bands newly identified for IMT at WRC-07.

Frequency Band		Bandwidth	Remark
450–470 MHz		20 MHz	
790–862 MHz	Region 1	72 MHz	
698–806 MHz	Region 2	108 MHz	
698–806 MHz	Region 3	108 MHz	In the band 698–790 MHz, the identification for IMT is for nine countries.
2,300–2,400 MHz		100 MHz	
3,400–3,600 MHz		200 MHz	See Figure 2.

Cont.

- The bands below 1 GHz are generally intended for use in the expansion of the service coverage areas.
- ITUR recognizes through its studies that the bands below 1 GHz are **cost-effective frequency ranges** to provide IMT services in sparsely populated areas both in developing and developed countries in an effort to save the unconnected people.

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- ITU-R also notes that the bands above 1 GHz are preferable in that they can provide **wide blocks of spectrum** for future broadband wireless systems, such as IMT-Advanced.
- A sufficiently wide block of spectrum allows the flexible, and finally, the efficient use of the spectrum.
- Among those bands, the newly identified 3,400–3,600 MHz band is the most attractive for the implementation of IMT-Advanced, since it has a widest contiguous block of 200 MHz among all the bands identified for IMT.

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- The key factor to make it a really **global band** for IMT is to establish **proper compatibility** with the existing radio services in the same band, e.g., earth stations of the fixed-satellite service which are widely deployed in this band or the bands above 3,600 MHz in a number of countries.

Figure 2. 3400-3600 MHz band adopted by WRC-07

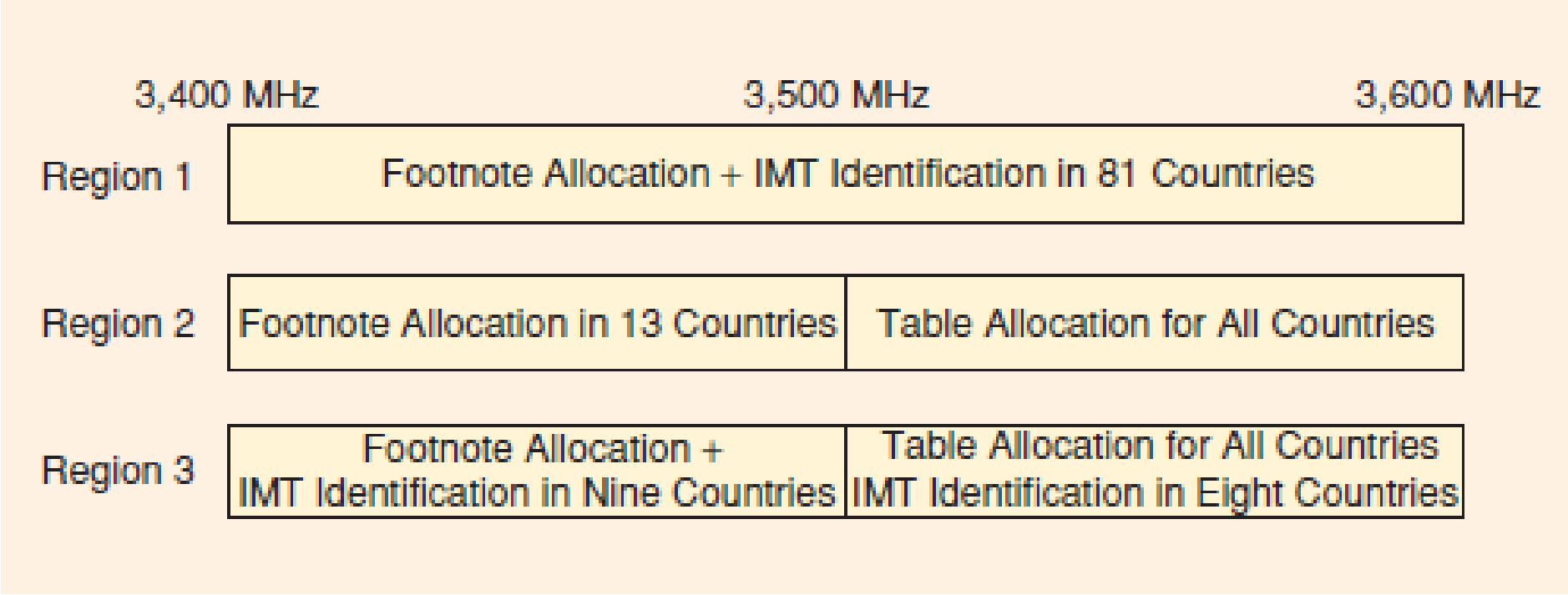

Figure 2. *Mobile service allocation and identification for IMT in the 3,400–3,600 MHz band adopted by WRC-07.*

Standardization Work for IMT-Advanced in ITU-R

Vision and Framework for Future Development of IMT-2000 and IMT-Advanced

- ITU-R has been conducting its studies on the future development of IMT-2000 and systems beyond IMT-2000.
- The first outcome of the studies is **Recommendation ITU-R M.1645**, which provides ITU's vision and framework for future land mobile systems.
  - *Framework and Overall Objectives of the Future Development of IMT-2000 and Systems Beyond IMT-2000, Recommendation ITU-R* M.1645, June 2003.
- It also provides three key objectives for IMT: 1) future development of IMT-2000, 2) new capabilities of IMT-Advanced, and 3) relationship of IMT and other access systems.

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- In the future development of IMT-2000, ITU-R sees that there will be a steady and continuous evolution of IMT-2000 to support new services and applications. The evolved capabilities will be extended up to approximately 30 Mb/s.
- ITU-R also discussed the relationship of IMT and other access systems and projects that the relationships will continue to develop between different radio access and communication systems, e.g., wireless personal area networks, wireless local area networks (LANs), digital broadcast and FWAs, due to the increasing prevalence of IP-based applications. Recommendation ITU-R M.1645 is an overarching document in that it will be followed by several Recommendations to be developed for IMT-Advanced RITs.

According to the Resolution, the standardization process for IMT-Advanced RITs includes:

- The definition of minimum technical requirements and evaluation criteria
- an invitation through a Circular Letter for ITU members and other organizations to propose candidate RITs of IMT-Advanced
- an evaluation by ITU-R to ensure the proposed technologies meet the above requirements and criteria
- consensus building to achieve harmonization
- standardization phase where ITU-R develops the IMT-Advanced radio interface specification in cooperation with relevant organizations outside ITU
- reviews of the minimum technical requirements and criteria

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- ongoing and timely process which has the flexibility to allow proponents to seek evaluation against any version of the approved criteria in force.

Outline of the Schedule for IMT-Advanced Standardization

ITU-R has been conducting its studies on the future development of IMT-2000 and systems beyond IMT-2000.

- Under the new study structure, ITU-R has already started the standardization work for IMT-Advanced at the relevant working party meeting in February 2008.
- The March 2008 Circular Letter (Administrative Circular; 5/LCCE/002) has been published by the ITU-R inviting proposals for RITs for IMT-Advanced from all the members of the ITU.

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- Throughout the process for the standardization activity, emphasis is placed upon collaboration with the external organizations which are planning to contribute to the work for the IMT-Advanced standardization.
- Figure 3 outlines the schedule for the standardization work for IMT-Advanced.
- In response to the Circular Letter, ITU membership In response to the Circular Letter, ITU membership and other organizations will submit their proposed RITs from February until October 2009.
- As soon as ITU receives proposals, the evaluation of candidate RITs will be conducted by independent evaluation groups.

Figure 3. Outline of schedule for the IMT-Advanced

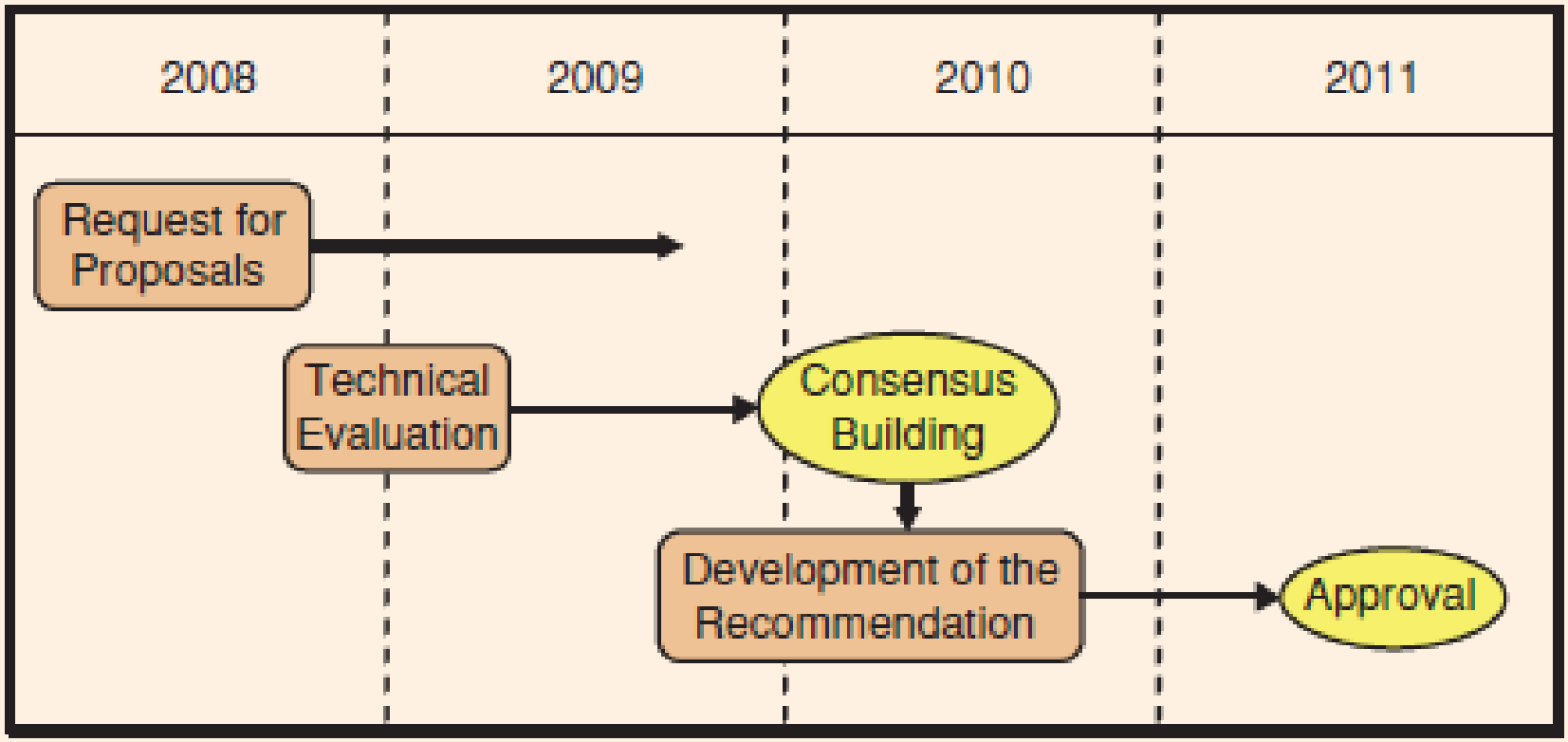

Figure 3. *Outline of the schedule for the IMT-Advanced standardization work.*

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- The evaluation groups are in general ITU members, standards organizations, and other organizations.
- The evaluation groups should register with ITU-R before the end of 2008.
- The evaluation groups will evaluate proposed RITs to check whether or not they meet minimum performance requirements and criteria.
- Each evaluation group will report the evaluation result to ITU-R by June 2010.
- ITU-R will consider results of those RITs which meet the minimum technical requirements and criteria.

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- Then ITU-R will develop a Recommendation on the detailed specifications for IMT-Advanced RITs. The release of the Recommendation is scheduled for February 2011.

Feasibility of 3G-LTE and IMT-Advanced

Transition from 3G-LTE to IMT-Advanced

- Before proceeding to an era of IMT-Advanced after 2010, technical or operational aspects of **broadband cellular systems** will be investigated through implementation of 3G-LTE (long-term evolution) or UMB (ultra mobile broadband), which are regarded as the ultimate applications of future development of IMT-2000.
- The 3G-LTE and UMB specifications are completed in 3GPP or 3GPP2, respectively, and they have been recently incorporated in Recommendation **ITU-R M.1457**, the latest version of which is now under the adoption procedure.

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- In a number of countries including Japan, it is understood that 3G-LTE could be operated within the bands identified before WRC-07 (see Table 1).
- With the understanding that system parameters for IMT-Advanced will be further evolved compared to those for 3G-LTE, Table 3 provides their examples applied to the radio physical layer.

Requirements and Key Technologies for IMT-Advanced

- IMT-Advanced is currently in the process of ITU-R addressing the development of the terrestrial radio interface recommendations.
- As mentioned earlier, ITU-R has issued the Circular Letter to invite submission of candidate RITs or a set of RITs (SRITs) for IMT-Advanced.
- Key technologies to establish feasibility of IMT-Advanced enumerated in the Circular Letter are as follows:
  - a high degree of commonality of functionality worldwide while retaining the flexibility to support a wide range of services and applications in a cost-efficient manner
  - compatibility of services within IMT and with fixed networks
  - capability of interworking with other radio access systems

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- high-quality mobile services
- user equipment suitable for worldwide use
- user-friendly applications, services, and equipment
- worldwide roaming capability
- enhanced peak data rates to support advanced services and applications (100 Mb/s for high mobility and 1 Gb/s for low mobility were established as targets for research).

- With regard to the access technology of IMT-Advanced, OFDMA, CDMA, SDMA, and singlecarrier/multi-carrier operation as well as enhancement and combination of those technologies could be considered. However, among these candidate technologies, OFDMA-based radio access is the most promising technology, in particular in downlink,

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- because of its inherent immunity to multipath interference observed in a broadband channel as well as its flexible capability to employ different transmission bandwidth arrangements.
- In addition to these considerations, in Recommendation ITU-R M.1645, two new capabilities have been identified: new mobile access and new nomadic/local area wireless access.
- In new mobile access, new cellular-based wireless technology will be required which supports a multicell environment, while in new nomadic/local area wireless access, capacity should be maximized in isolated cells, very-small-cell (hotspot), and indoor environments.

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- These two capabilities can be supported either by a single RIT or an SRIT. The former approach is desirable from a cost-efficiency point of view.

Table 3.

TABLE 3. Examples of basic parameters for future IMT systems.

	3G-LTE	IMT-Advanced
Target User Rate	50–100 Mb/s	100 Mb/s (high-mobility environment) 1 Gb/s (low-mobility environment)
RF Channel Bandwidth	1.4, 3, 5, 10, 15, and 20 MHz	e.g., Max. 100 MHz Support scalable bandwidth
Access Technology	Down link: OFDMA + MIMO Up-Link: SC-FDMA	T.B.D. (*)
Potential Frequency Bands	IMT-2000 band (see Table 1)	Above 3 GHz (e.g., 3.4–3.6 GHz)

*VSF-Spread OFDM presented in this article could be a candidate access technology in the downlink.

The Future

- In the initial stage of the IMT-2000 system around the year 1997, **a bit rate of 2 Mb/s** was envisioned as an objective for the indoor environment.
- However, after about ten years, much higher capacity has already been achieved and will be further increased by the implementation of 3G-LTE.
- Figure 7 illustrates long-term developments and the associated capabilities of both generation systems.
- The 3G era will overlap with that of IMT-Advanced as we experienced in the past. From an operator's viewpoint, it is desirable that the radio infrastructure for 3G-LTE could be utilized also for the initial deployment of IMT-Advanced without significant replacement of the equipment.

Figure 7. Long-term prospect of IMT

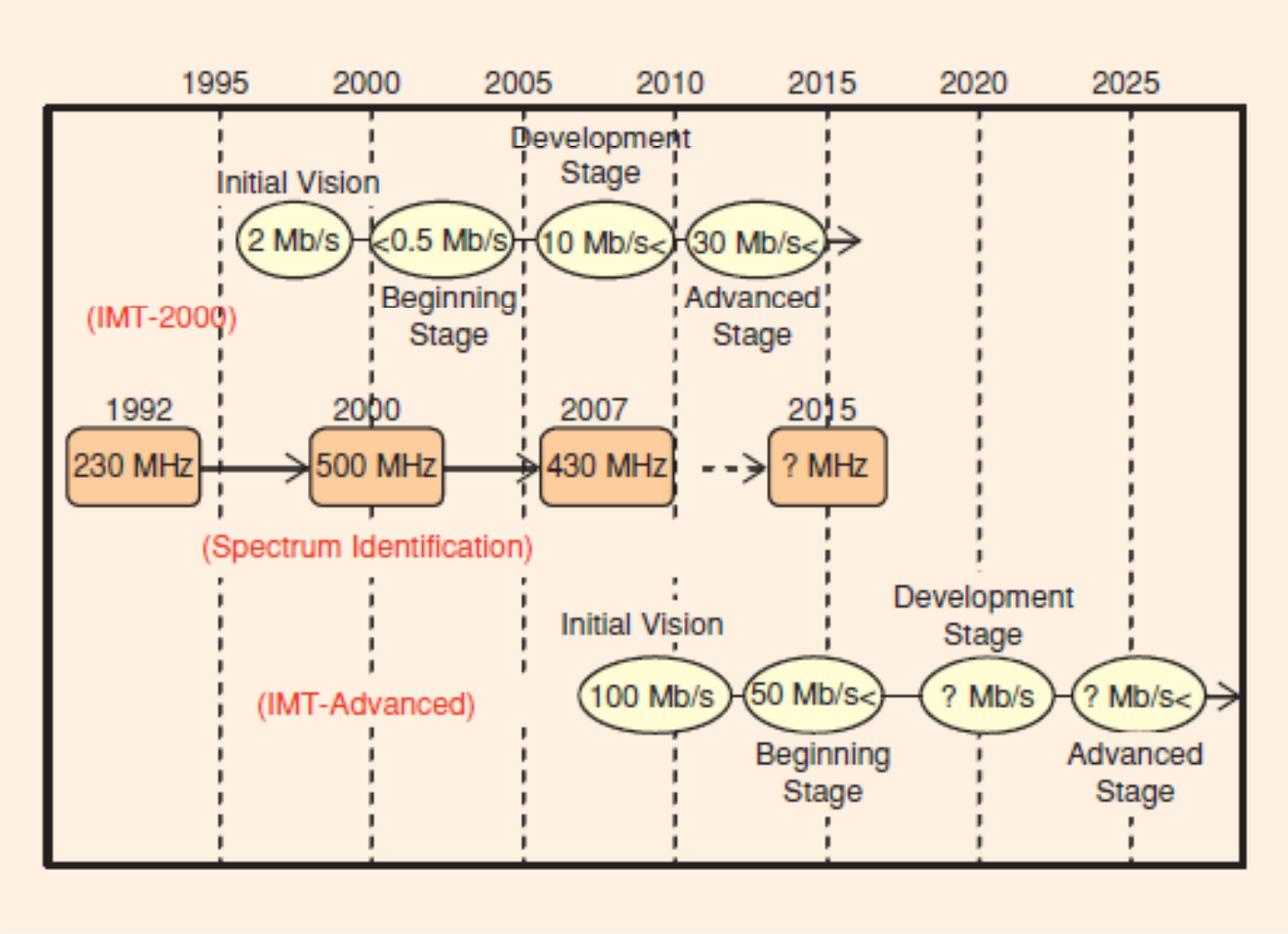

Figure 7. *Long-term prospect of IMT and its spectrum identification.*

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- On the other hand, the beginning of the new system may need to be characterized by certain technical parameters leading to its subsequent development.
- Through the R&D and standardization activities described earlier, we are establishing only the initial target of IMT-Advanced, which may be much elevated as the technology advances. It is noted that the available spectrum for IMT have been increased every seven to eight years (in other words, every two WRCs) over the past 15 years.
- ITU-R will focus its work on the IMT-Advanced specifications in this study cycle (2007–2011) in preparation for its future development of advanced capabilities, which no one can exactly predict for the time being.

Conclusions

- The WRC-07 decisions have paved the way toward the development of IMT-Advanced by identifying a 200-MHz contiguous spectrum above 3 GHz for a number of countries.
- It is also noted that for early implementation of IMT-Advanced there are technical subjects to be studied and solved, in particular for compatible operation with other systems sharing the same frequency bands.
- For the standardization activities, global cooperation between ITU-R and other organizations are required.

Homework#8:

1. What is development of the IMT systems ?
2. What is the long-term prospect of IMT systems ?